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(54) **SYNCHRONIZATION SIGNAL BLOCK PUNCTURING FOR CHANNEL BANDWIDTH**

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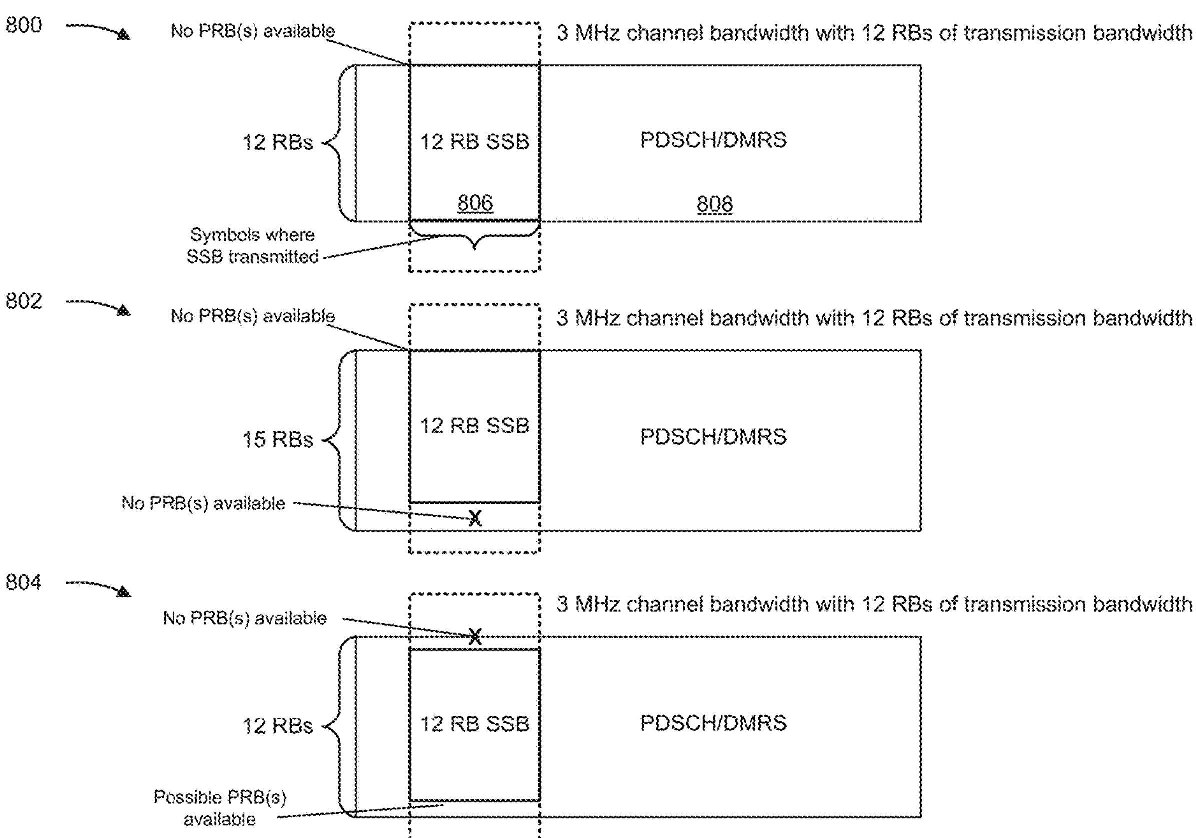
(57) **ABSTRACT**

Various aspects of the present disclosure generally relate to wireless communication. In some aspects, a user equipment (UE) may receive a synchronization signal block (SSB). The UE may identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point. The UE may receive a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured. Numerous other aspects are described.



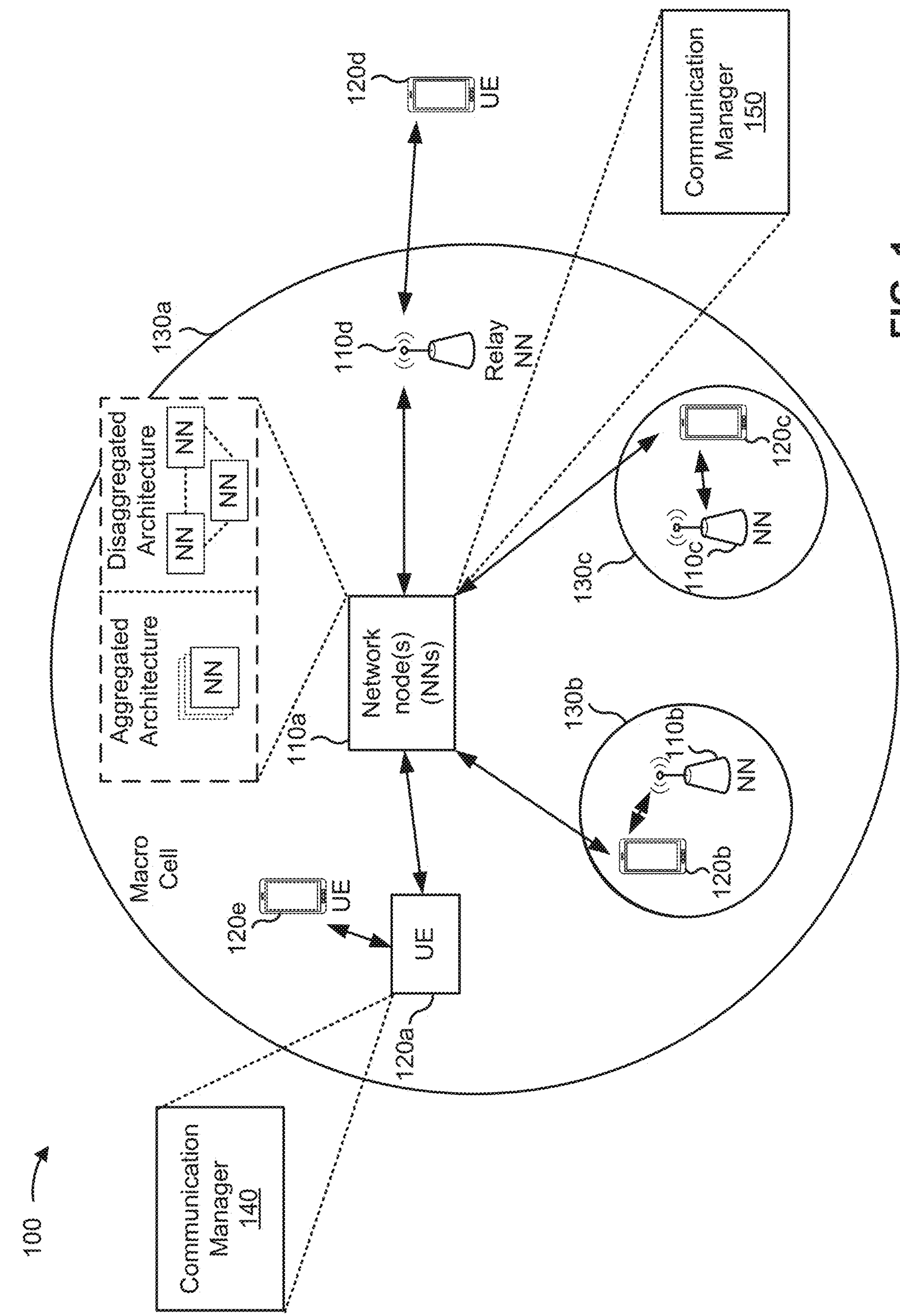

100
Communication Manager 140
120a
UE
120e
UE
Macro Cell
Aggregated Architecture
NN
Disaggregated Architecture
NN
NN
NN
110a
Network node(s) (NNs)
130a
110d
Relay NN
120d
UE
Communication Manager 150
130b
110b
NN
120b
130c
110c
NN
120c

FIG. 1

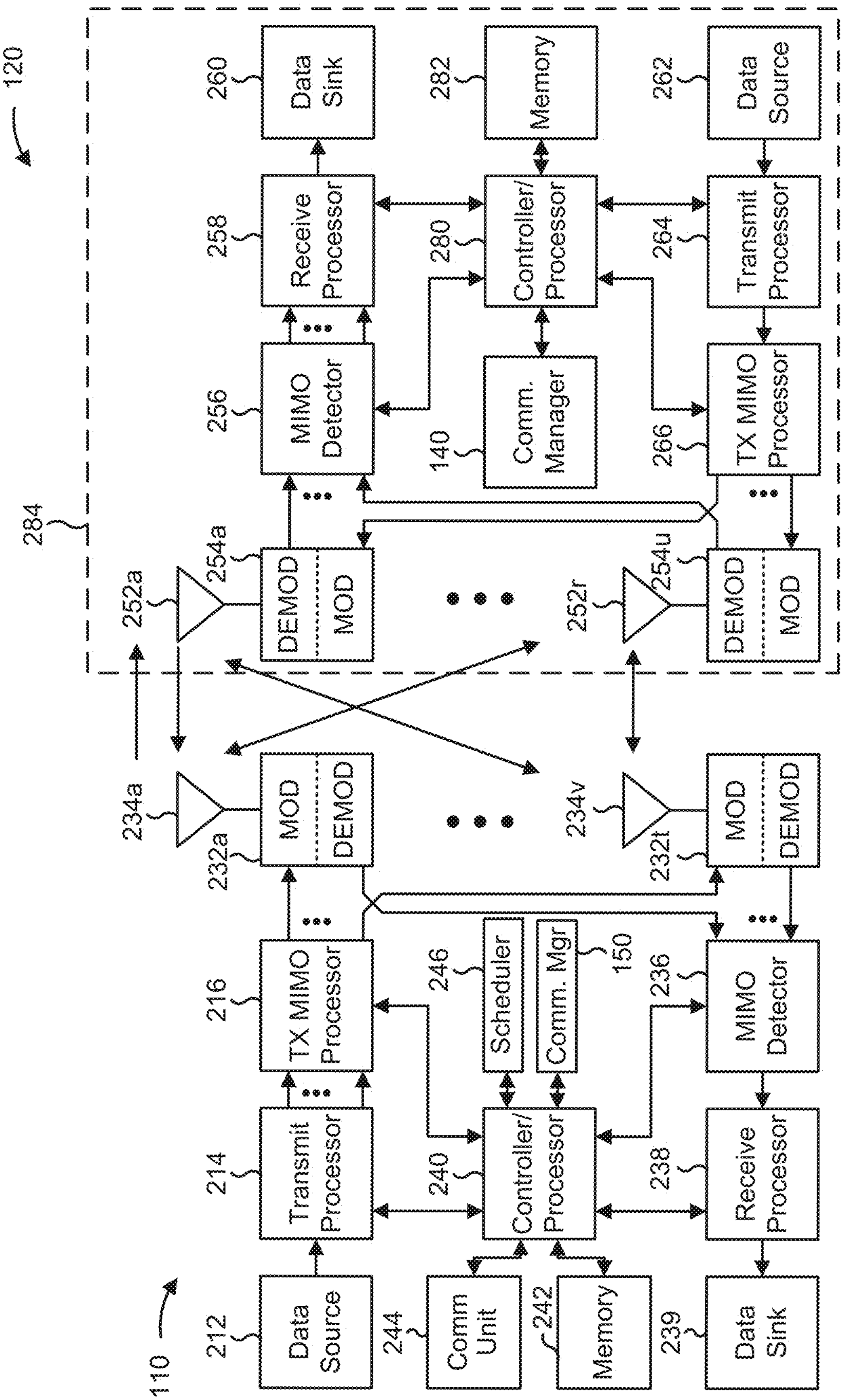

120
284
260
Data Sink
282
Memory
262
Data Source
258
Receive Processor
280
Controller/ Processor
264
Transmit Processor
256
MIMO Detector
140
Comm. Manager
266
TX MIMO Processor
252a
254a
DEMOD
MOD
252r
254u
DEMOD
MOD
234a
232a
MOD
DEMOD
234v
232t
MOD
DEMOD
216
TX MIMO Processor
246
Scheduler
Comm. Mgr
150
236
MIMO Detector
214
Transmit Processor
240
Controller/ Processor
238
Receive Processor
110
212
Data Source
244
Comm Unit
242
Memory
239
Data Sink

FIG. 2

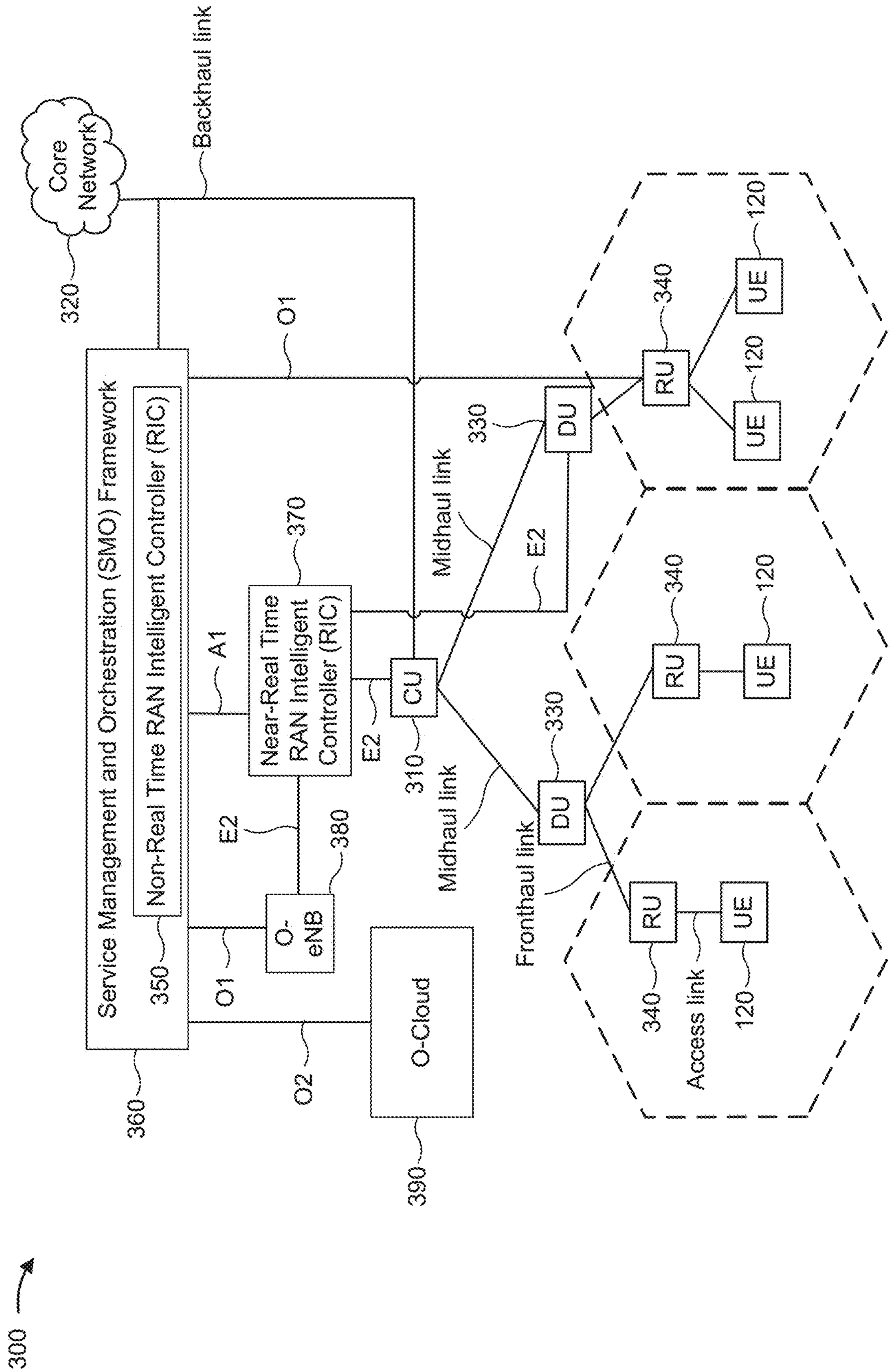

300
Core Network
320
Backhaul link
Service Management and Orchestration (SMO) Framework
Non-Real Time RAN Intelligent Controller (RIC)
350
360
O1
A1
Near-Real Time RAN Intelligent Controller (RIC)
370
E2
O-eNB
380
O1
O2
O-Cloud
390
CU
310
E2
Midhaul link
Midhaul link
E2
DU
330
DU
330
Fronthaul link
RU
340
RU
340
RU
340
UE
120
UE
120
UE
120
UE
120
Access link

FIG. 3

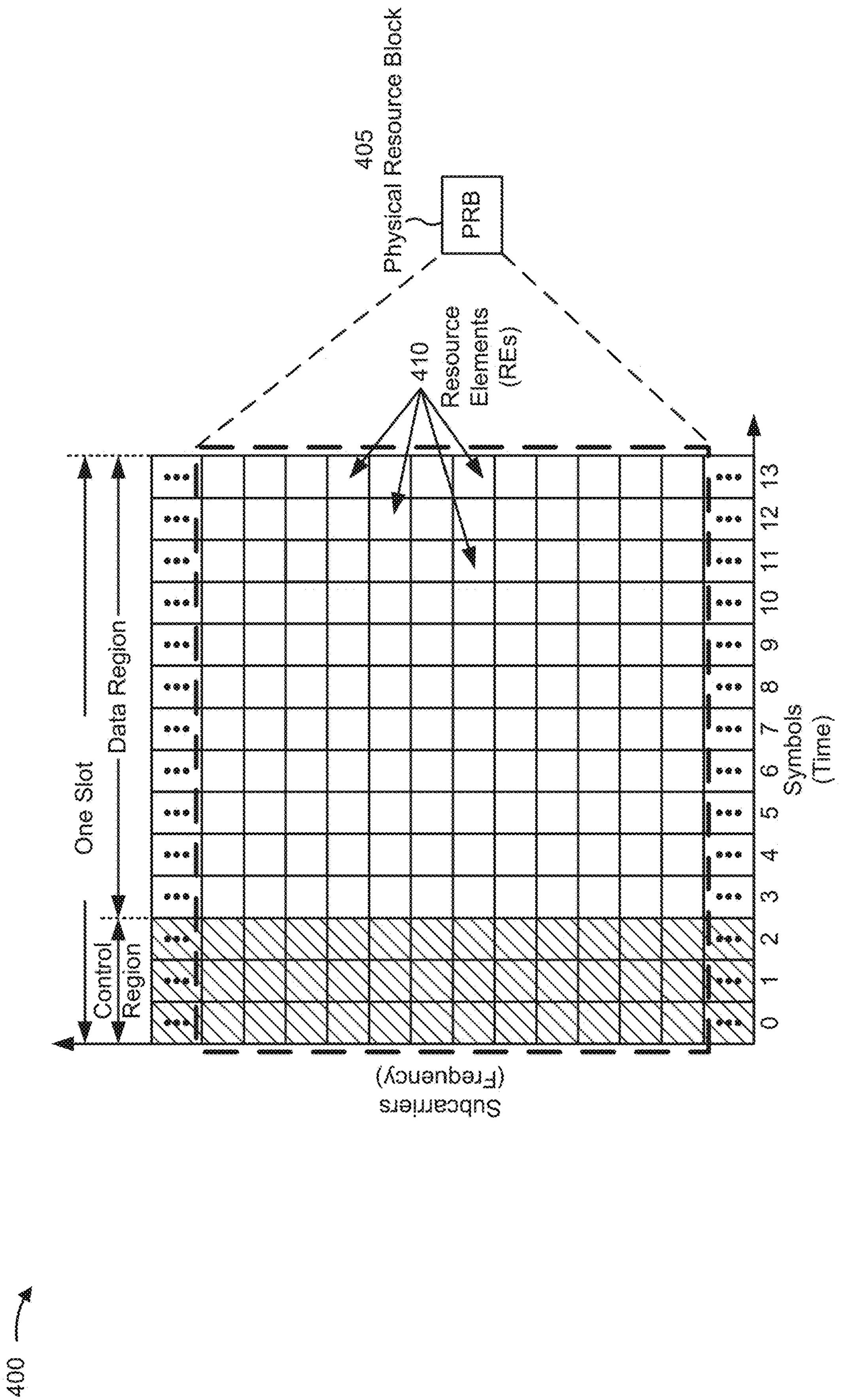

400
405
Physical Resource Block
PRB
410
Resource
Elements
(REs)
One Slot
Control
Region
Data Region
Subcarriers
(Frequency)
Symbols
(Time)
0
1
2
3
4
5
6
7
8
9
10
11
12
13

FIG. 4

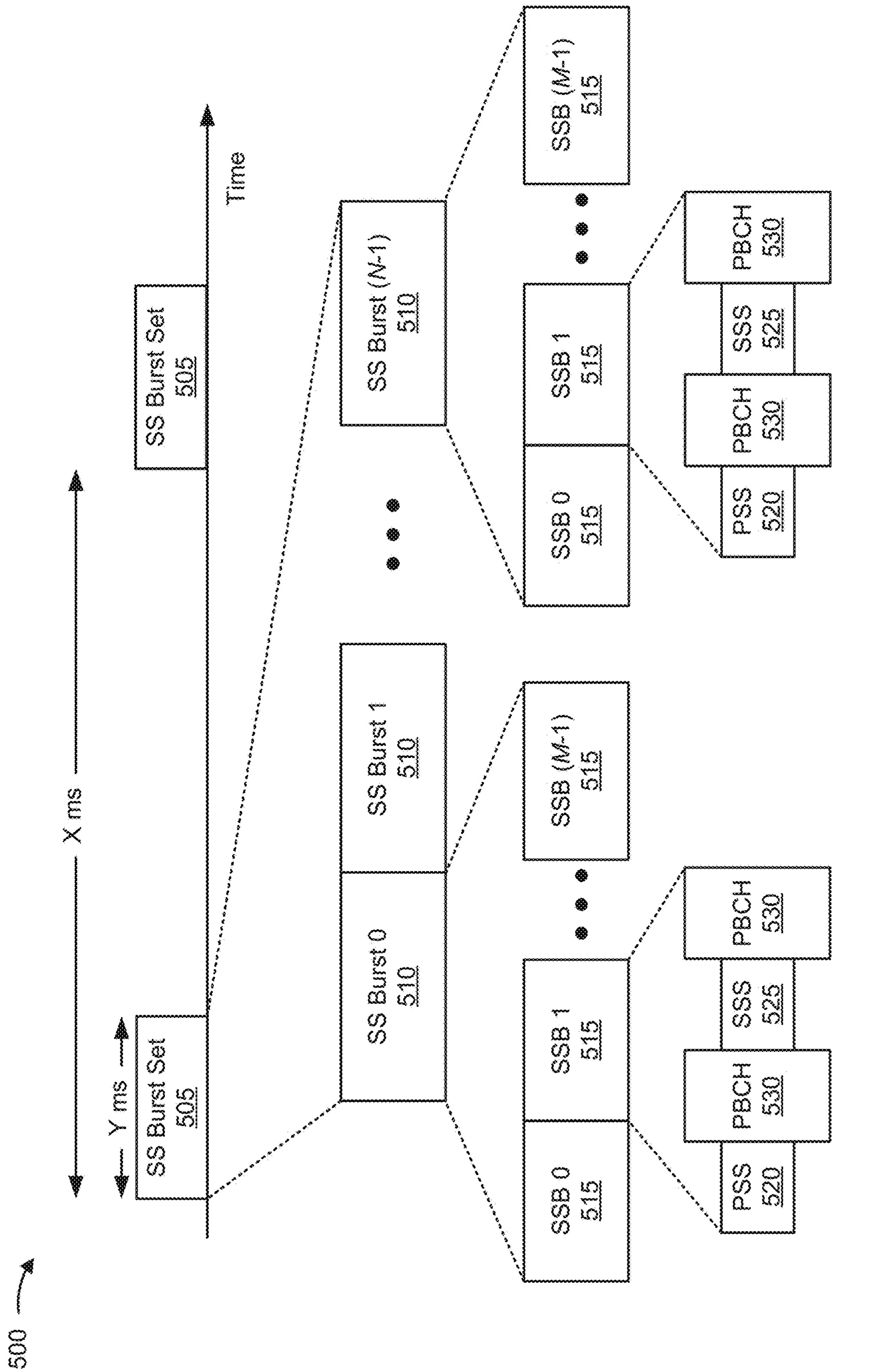

500
Time
X ms
Y ms
SS Burst Set
505
SS Burst Set
505
SS Burst 0
510
SS Burst 1
510
SS Burst (N-1)
510
SSB 0
515
SSB 1
515
SSB (M-1)
515
SSB 0
515
SSB 1
515
SSB (M-1)
515
PSS
520
PBCH
530
SSS
525
PBCH
530
PSS
520
PBCH
530
SSS
525
PBCH
530

FIG. 5

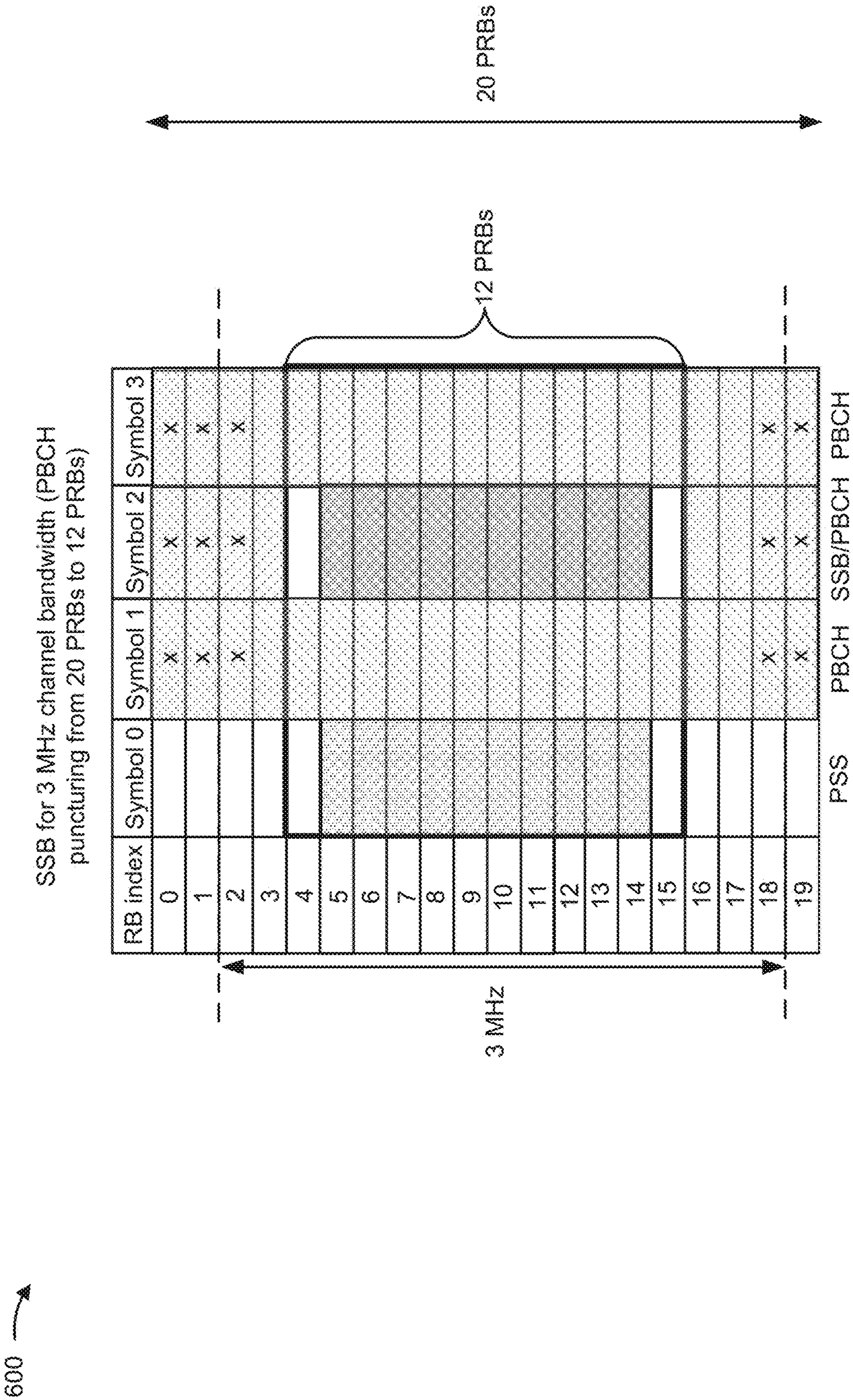

600
SSB for 3 MHz channel bandwidth (PBCH puncturing from 20 PRBs to 12 PRBs)
RB index
Symbol 0
Symbol 1
Symbol 2
Symbol 3
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
PSS
PBCH
SSB/PBCH
PBCH
12 PRBs
20 PRBs
3 MHz

FIG. 6

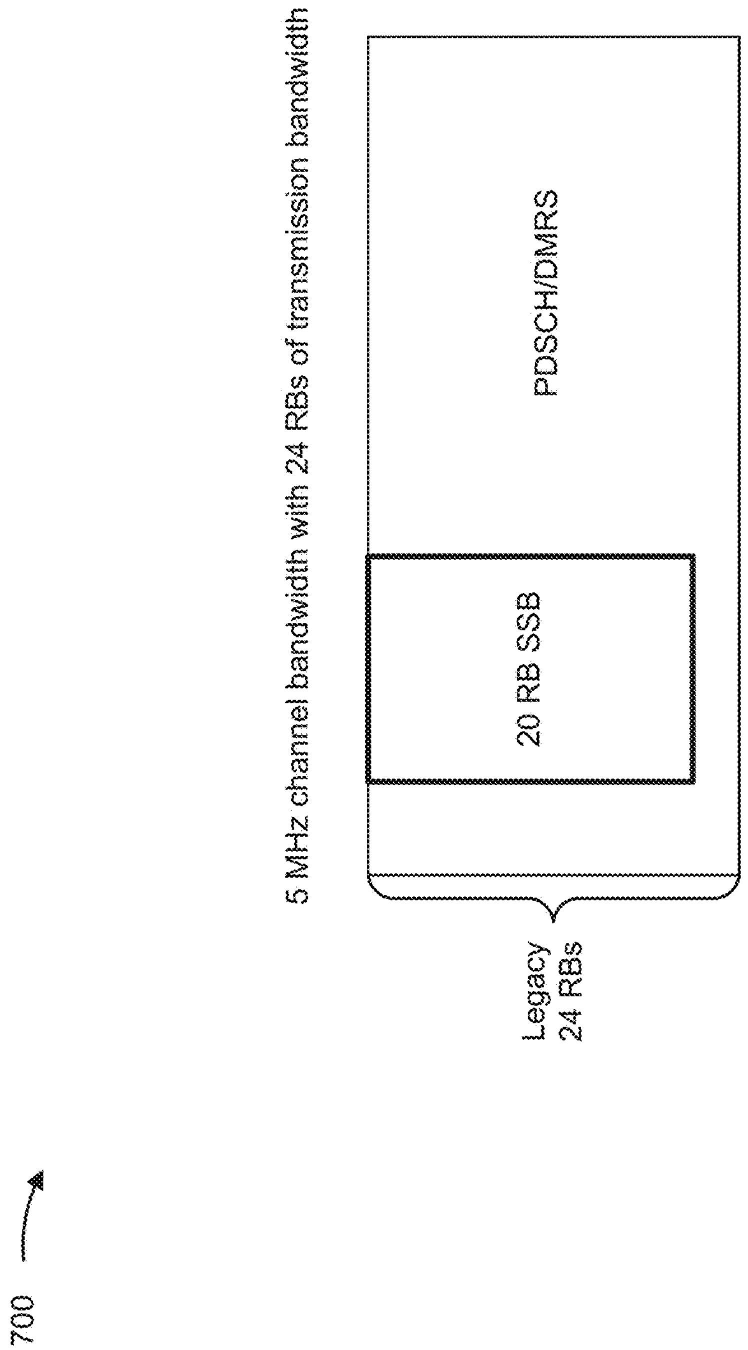
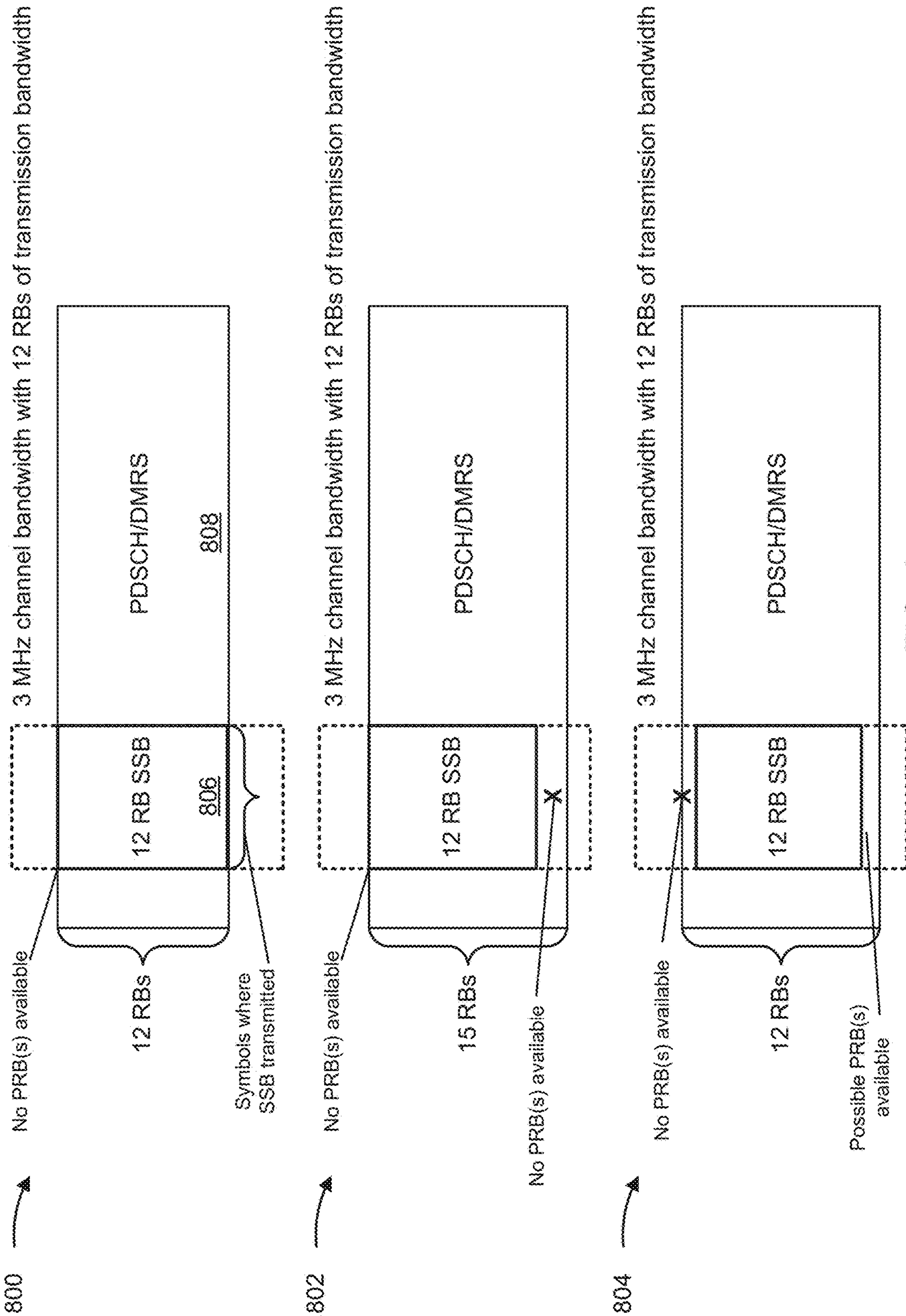

5 MHz channel bandwidth with 24 RBs of transmission bandwidth
PDSCH/DMRS
20 RB SSB
Legacy
24 RBs
700

FIG. 7



800
No PRB(s) available
12 RBs
Symbols where SSB transmitted
12 RB SSB
806
PDSCH/DMRS
808
3 MHz channel bandwidth with 12 RBs of transmission bandwidth
802
No PRB(s) available
15 RBs
No PRB(s) available
12 RB SSB
PDSCH/DMRS
3 MHz channel bandwidth with 12 RBs of transmission bandwidth
804
No PRB(s) available
12 RBs
Possible PRB(s) available
12 RB SSB
PDSCH/DMRS
3 MHz channel bandwidth with 12 RBs of transmission bandwidth

FIG. 8

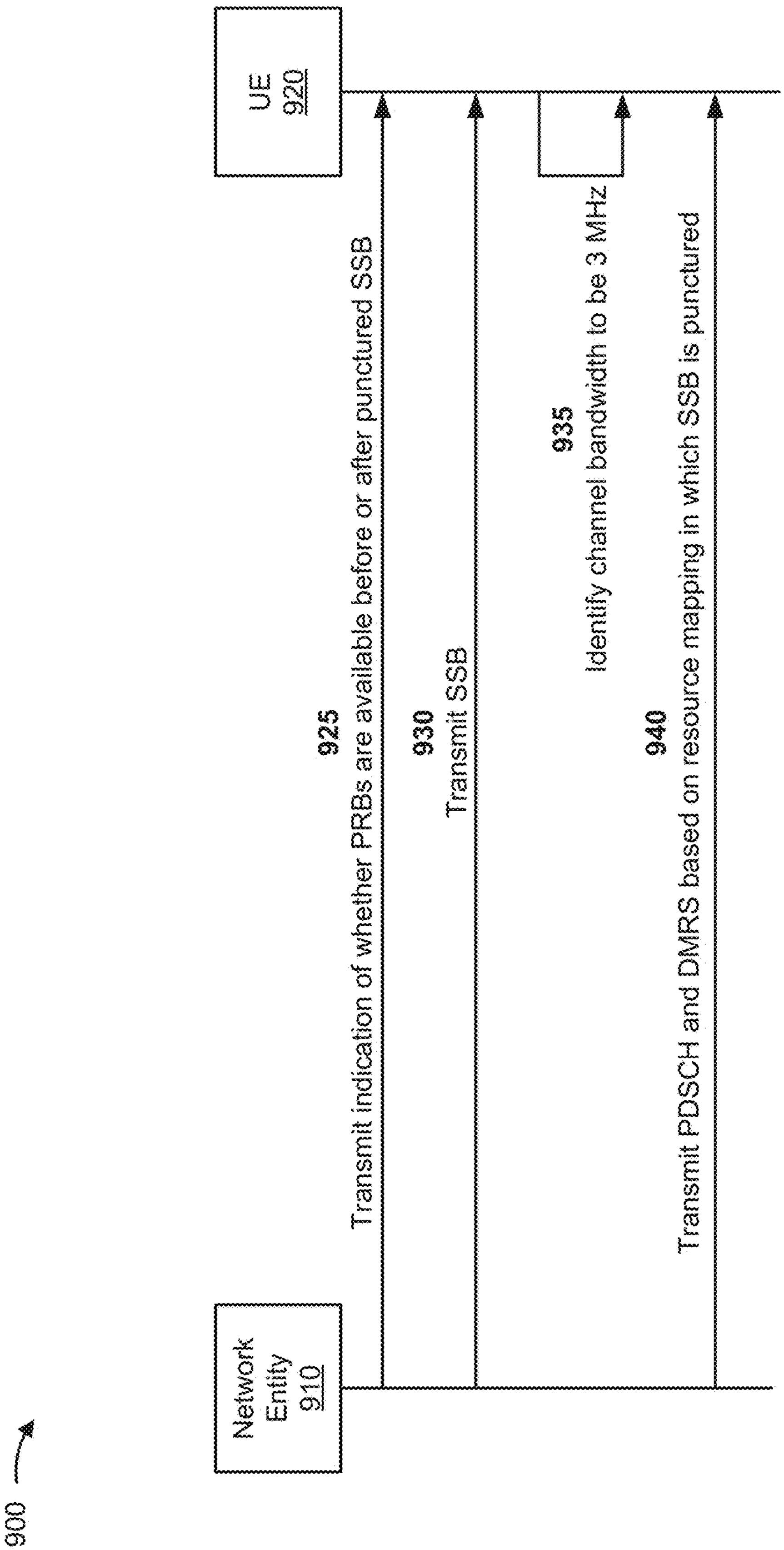

900
Network Entity 910
UE 920
925
Transmit indication of whether PRBs are available before or after punctured SSB
930
Transmit SSB
935
Identify channel bandwidth to be 3 MHz
940
Transmit PDSCH and DMRS based on resource mapping in which SSB is punctured

FIG. 9

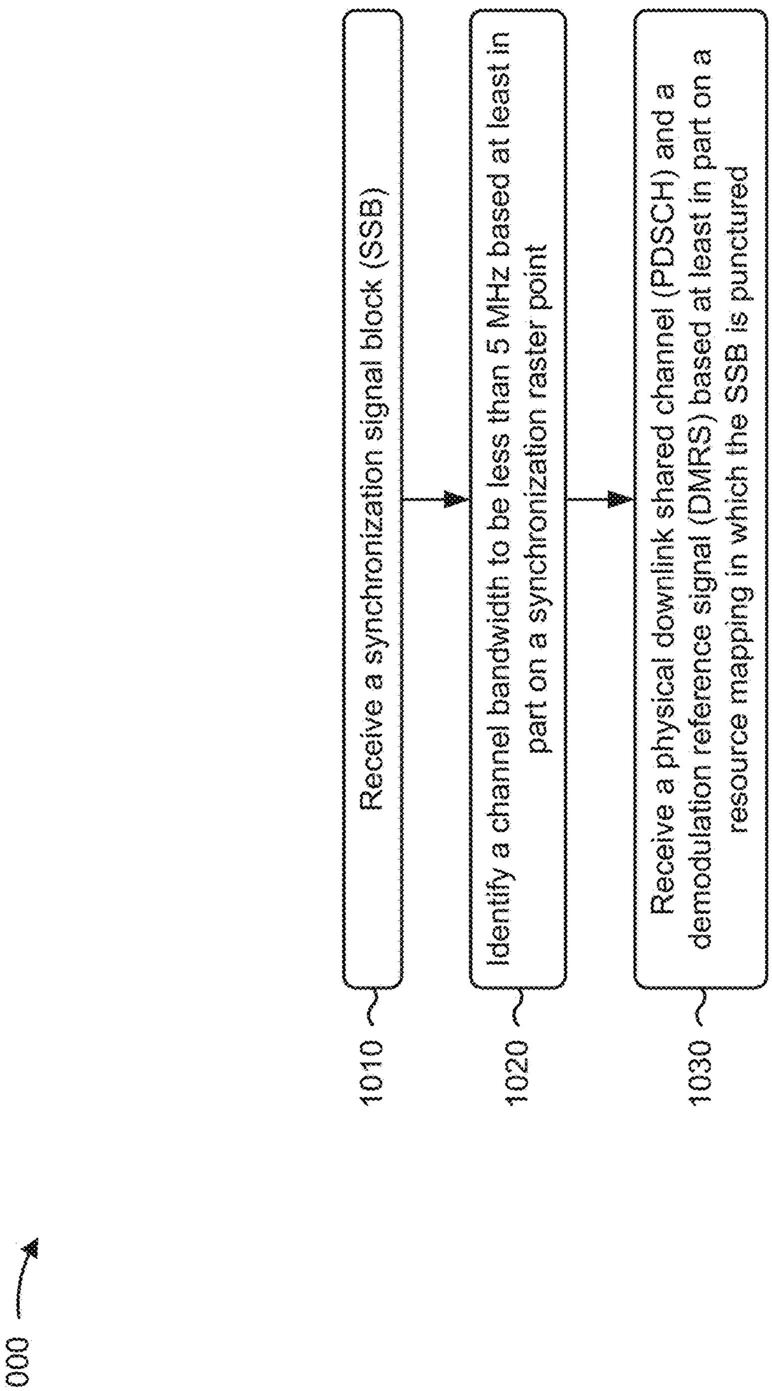

1000
1010
Receive a synchronization signal block (SSB)
1020
Identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point
1030
Receive a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured

FIG. 10

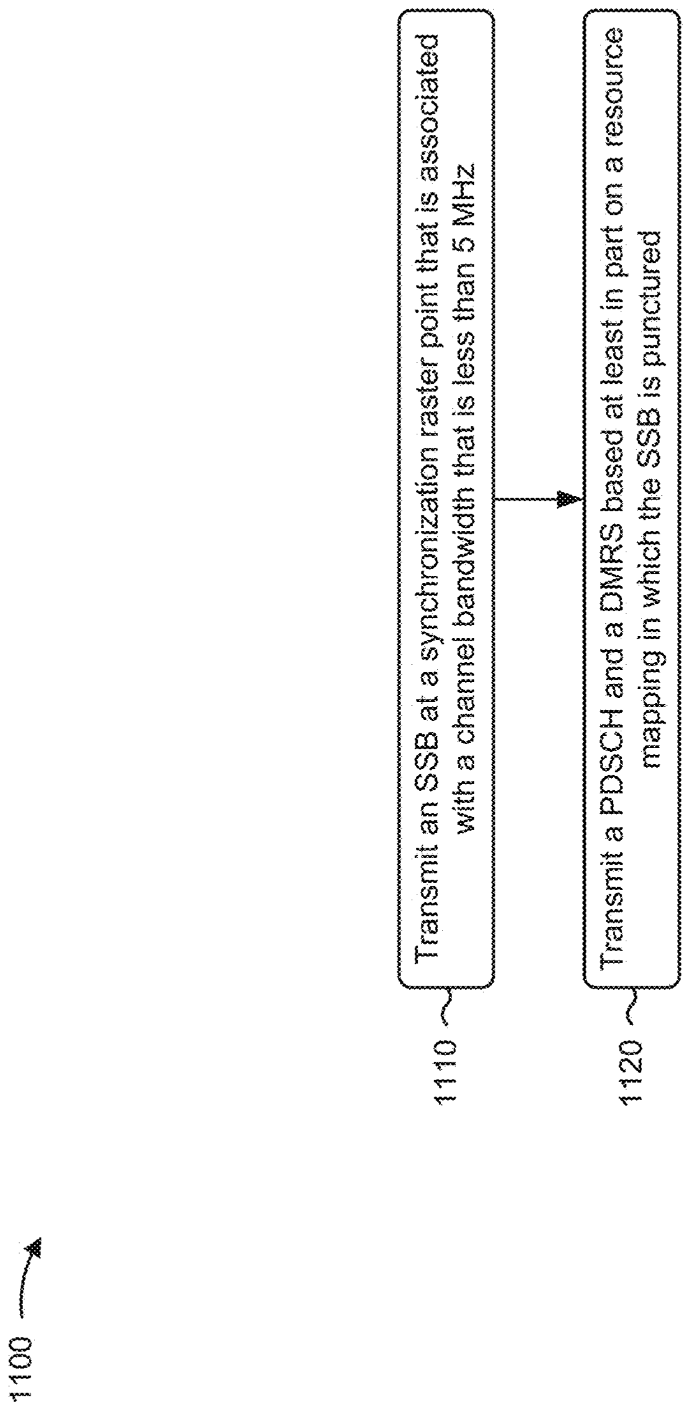

1100
1110
Transmit an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz
1120
Transmit a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured

FIG. 11

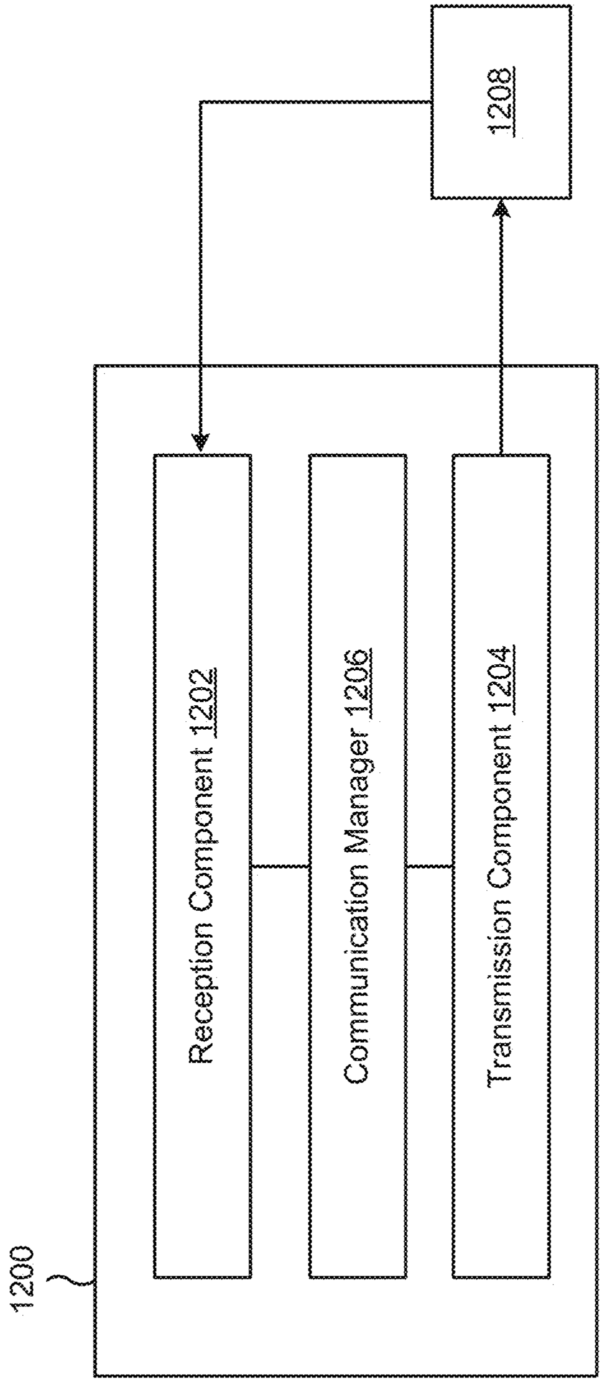

1200
Reception Component 1202
Communication Manager 1206
Transmission Component 1204
1208

FIG. 12

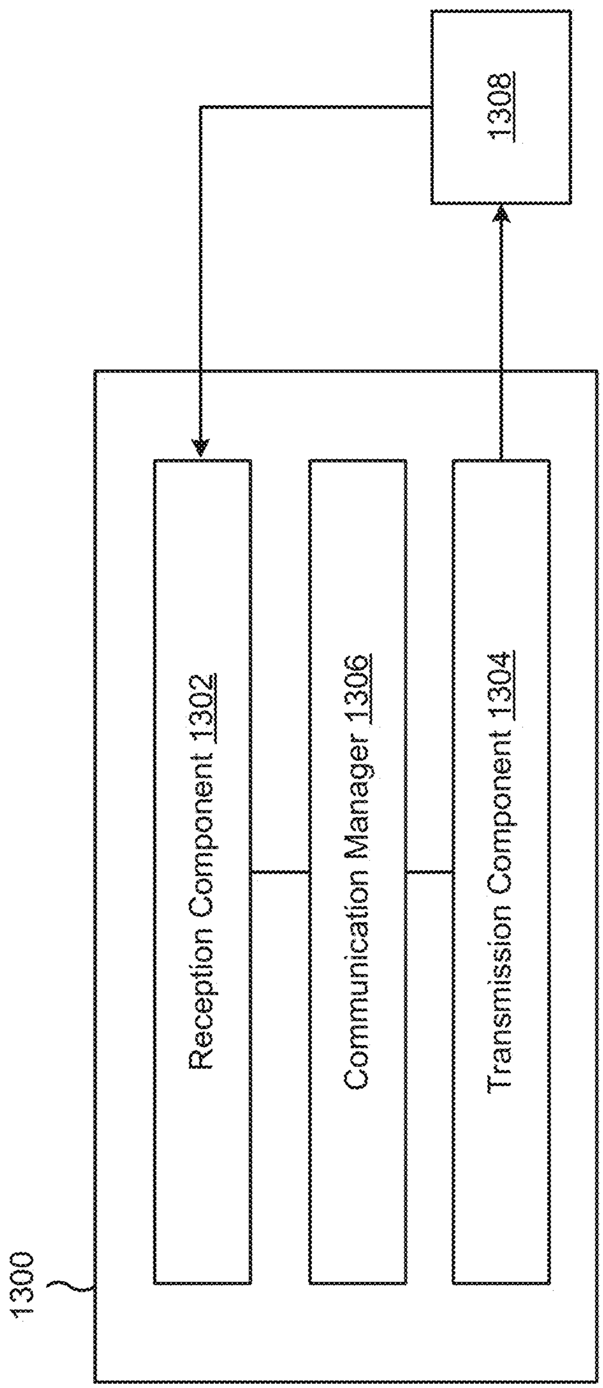

1300
Reception Component 1302
Communication Manager 1306
Transmission Component 1304
1308

FIG. 13

SYNCHRONIZATION SIGNAL BLOCK PUNCTURING FOR CHANNEL BANDWIDTH

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This patent application claims priority to U.S. Provisional Patent Application No. 63/554,455, filed on Feb. 16, 2024, entitled "SYNCHRONIZATION SIGNAL BLOCK PUNCTURING FOR CHANNEL BANDWIDTH," and assigned to the assignee hereof. The disclosure of the prior application is considered part of and is incorporated by reference into this patent application.

FIELD OF THE DISCLOSURE

[0002] Aspects of the present disclosure generally relate to wireless communication and specifically relate to techniques, apparatuses, and methods for synchronization signal block puncturing for a specified channel bandwidth.

BACKGROUND

[0003] Wireless communication systems are widely deployed to provide various services that may include carrying voice, text, messaging, video, data, and/or other traffic. The services may include unicast, multicast, and/or broadcast services, among other examples. Typical wireless communication systems may employ multiple-access radio access technologies (RATs) capable of supporting communication with multiple users by sharing available system resources (for example, time domain resources, frequency domain resources, spatial domain resources, and/or device transmit power, among other examples). Examples of such multiple-access RATs include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0004] The above multiple-access RATs have been adopted in various telecommunication standards to provide common protocols that enable different wireless communication devices to communicate on a municipal, national, regional, or global level. An example telecommunication standard is New Radio (NR). NR, which may also be referred to as 5G, is part of a continuous mobile broadband evolution promulgated by the Third Generation Partnership Project (3GPP). NR (and other mobile broadband evolutions beyond NR) may be designed to better support Internet of things (IoT) and reduced capability device deployments, industrial connectivity, millimeter wave (mmWave) expansion, licensed and unlicensed spectrum access, non-terrestrial network (NTN) deployment, sidelink and other device-to-device direct communication technologies (for example, cellular vehicle-to-everything (CV2X) communication), massive multiple-input multiple-output (MIMO), disaggregated network architectures and network topology expansions, multiple-subscriber implementations, high-precision positioning, and/or radio frequency (RF) sensing, among other examples. As the demand for mobile broadband access continues to increase, further improvements in NR may be implemented, and other radio access technologies such as 6G may be introduced, to further advance mobile broadband evolution.

SUMMARY

[0005] Some aspects described herein relate to a method of wireless communication performed by a user equipment (UE). The method may include receiving a synchronization signal block (SSB). The method may include identifying a channel bandwidth to be less than 5 megahertz (MHz) based at least in part on a synchronization raster point. The method may include receiving a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured.

[0006] Some aspects described herein relate to a method of wireless communication performed by a network entity. The method may include transmitting an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz. The method may include transmitting a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0007] Some aspects described herein relate to an apparatus for wireless communication at a UE. The apparatus may include one or more memories and one or more processors coupled to the one or more memories. The one or more processors may be individually or collectively configured to receive an SSB. The one or more processors may be configured to identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point. The one or more processors May be individually or collectively configured to receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0008] Some aspects described herein relate to an apparatus for wireless communication at a network entity. The apparatus may include one or more memories and one or more processors coupled to the one or more memories. The one or more processors may be individually or collectively configured to transmit an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz. The one or more processors may be individually or collectively configured to transmit a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0009] Some aspects described herein relate to a non-transitory computer-readable medium that stores a set of instructions for wireless communication by a UE. The set of instructions, when executed by one or more processors of the UE, may cause the UE to receive an SSB. The set of instructions, when executed by one or more processors of the UE, may cause the UE to identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point. The set of instructions, when executed by one or more processors of the UE, may cause the UE to receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0010] Some aspects described herein relate to a non-transitory computer-readable medium that stores a set of instructions for wireless communication by a network entity. The set of instructions, when executed by one or more processors of the network entity, may cause the network entity to transmit an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than

5 MHz. The set of instructions, when executed by one or more processors of the network entity, may cause the network entity to transmit a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0011] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for receiving an SSB. The apparatus may include means for identifying a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point. The apparatus may include means for receiving a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0012] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for transmitting an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz. The apparatus may include means for transmitting a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0013] Aspects of the present disclosure may generally be implemented by or as a method, apparatus, system, computer program product, non-transitory computer-readable medium, user equipment, base station, network node, network entity, wireless communication device, and/or processing system as substantially described with reference to, and as illustrated by, the specification and accompanying drawings.

[0014] The foregoing paragraphs of this section have broadly summarized some aspects of the present disclosure. These and additional aspects and associated advantages will be described hereinafter. The disclosed aspects may be used as a basis for modifying or designing other aspects for carrying out the same or similar purposes of the present disclosure. Such equivalent aspects do not depart from the scope of the appended claims. Characteristics of the aspects disclosed herein, both their organization and method of operation, together with associated advantages, will be better understood from the following description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The appended drawings illustrate some aspects of the present disclosure, but are not limiting of the scope of the present disclosure because the description may enable other aspects. Each of the drawings is provided for purposes of illustration and description, and not as a definition of the limits of the claims. The same or similar reference numbers in different drawings may identify the same or similar elements.

[0016] FIG. **1** is a diagram illustrating an example of a wireless communication network in accordance with the present disclosure.

[0017] FIG. **2** is a diagram illustrating an example network node in communication with an example user equipment (UE) in a wireless network in accordance with the present disclosure.

[0018] FIG. **3** is a diagram illustrating an example disaggregated base station architecture in accordance with the present disclosure.

[0019] FIG. **4** is a diagram illustrating an example of a slot format, in accordance with the present disclosure.

[0020] FIG. **5** is a diagram illustrating an example of a synchronization signal (SS) hierarchy, in accordance with the present disclosure.

[0021] FIG. **6** is a diagram illustrating an example of a synchronization signal block (SSB) for 3 MHz channel bandwidth, in accordance with the present disclosure.

[0022] FIG. **7** is a diagram illustrating an example of a punctured SSB for 5 MHZ channel bandwidth, in accordance with the present disclosure.

[0023] FIG. **8** is a diagram illustrating examples of punctured SSBs for 3 MHz channel bandwidth, in accordance with the present disclosure.

[0024] FIG. **9** is a diagram illustrating an example associated with determining available physical resource blocks, in accordance with the present disclosure.

[0025] FIG. **10** is a diagram illustrating an example process performed, for example, at a UE or an apparatus of a UE, in accordance with the present disclosure.

[0026] FIG. **11** is a diagram illustrating an example process performed, for example, at a network entity or an apparatus of a network entity, in accordance with the present disclosure.

[0027] FIG. **12** is a diagram of an example apparatus for wireless communication, in accordance with the present disclosure.

[0028] FIG. **13** is a diagram of an example apparatus for wireless communication, in accordance with the present disclosure.

DETAILED DESCRIPTION

[0029] Various aspects of the present disclosure are described hereinafter with reference to the accompanying drawings. However, aspects of the present disclosure may be embodied in many different forms and is not to be construed as limited to any specific aspect illustrated by or described with reference to an accompanying drawing or otherwise presented in this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. One skilled in the art may appreciate that the scope of the disclosure is intended to cover any aspect of the disclosure disclosed herein, whether implemented independently of or in combination with any other aspect of the disclosure. For example, an apparatus may be implemented or a method may be practiced using various combinations or quantities of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover an apparatus having, or a method that is practiced using, other structures and/or functionalities in addition to or other than the structures and/or functionalities with which various aspects of the disclosure set forth herein may be practiced. Any aspect of the disclosure disclosed herein may be embodied by one or more elements of a claim.

[0030] Several aspects of telecommunication systems will now be presented with reference to various methods, operations, apparatuses, and techniques. These methods, operations, apparatuses, and techniques will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, modules, components, circuits, steps, processes, or algorithms (collectively referred to as "elements"). These elements may be implemented using hardware, software, or a combination of hardware and software. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0031] Before Third Generation Partnership Project (3GPP) Release 18, the minimum channel bandwidth for spectrum allocations in the physical layer for New Radio (NR) was 5 megahertz (MHz). Going forward, the NR physical layer may be able to operate in channel bandwidths from approximately 3 MHz up to below 5 MHz, including in bands n100, n106, n26, n28, and n85.

[0032] The 5 MHz channel bandwidth may have a maximum transmission bandwidth of 25 physical resource blocks (PRBs) and the synchronization signal block (SSB), which includes a primary synchronization signal (PSS), a secondary synchronization signal (SSS) and a physical broadcast channel (PBCH) transmission, may have 20 PRBs. For a channel bandwidth of less than 5 MHz, the maximum transmission bandwidth may be less than 25 PRBs and the available PRBs for SS/PBCH transmission may be less than 20 PRBs. For a 3 MHz channel bandwidth in all bands, the maximum channel utilization may be 15 PRBs, and a SS/PBCH transmission bandwidth may be 12 PRBs.

[0033] "Puncturing" may include not transmitting bits for PRBs in a punctured area. This may include deleting bits of the punctured area before transmission or transmitting different bits in the PRBs, such as for the puncturing transmission. The encoded bits and a demodulation reference signal (DMRS) may be mapped to 20 PRBs based on a legacy SSB structure, and the PRBs that fall outside of the available PRBs for SSB transmission is punctured. With 12 PRBs being used for the SSB transmission bandwidth for a 3 MHz channel bandwidth, the PSS/SSS with 12 PRBs may not be punctured but the upper 4 PRBs and the lower 4 PRBs of the NR 20 PRBs for PBCH may be punctured.

[0034] In a 3 MHz channel bandwidth, the SSB is punctured from 20 PRBs to 12 PRBs. It is not clear whether the PRBs including the SSB before or after puncturing can be used for physical downlink shared channel (PDSCH) and DMRS with transmission bandwidth up to 15 PRBs in the 3 MHz channel bandwidth. If the UE does not have such information, the UE may not know how the PDSCH/DMRS resource mapping is performed at the transmitter side. For example, at the network entity (e.g., base station) side, the PRBs containing the SSB before puncturing are not used for PDSCH/DMRS transmission in the orthogonal frequency division multiplexing (OFDM) symbols that transmit the SSB, but the UE may assume there is DMRS in the punctured PRBs, which will result in wrong channel estimation based on the fake DMRS due to misalignment. In addition, the misalignment may also lead to incorrect counting of the PDSCH decoding bits at the UE receiver side, which results in error detection of the transmitted data packet in PDSCH.

[0035] Various aspects relate generally to SSB transmission. Some aspects more specifically relate to a UE that may receive an SSB and identify a channel bandwidth to be less than 5 MHZ (e.g., 3 MHz) based at least in part on a synchronization (sync) raster point defined per operating bands. For example, the sync raster point may be associated with a 3 MHz channel bandwidth. The sync raster for channel bandwidth 3 MHz for each band is given in Table 5.4.3.3-2 in 3GPP Technical Specification (TS) 38.101-1. In addition, different sync raster points may be associated with different transmission bandwidths. For example, the sync raster point at global synchronization channel number (GSCN) 41637 corresponds to a 12 PRB transmission bandwidth within the 3 MHz channel bandwidth. The sync raster points at a GSCN other than GSCN 41637 in Table 5.4.3.3-2 in TS 38.101-1 correspond to a 15 PRB transmission bandwidth within the 3 MHz channel bandwidth. The UE may receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured in the OFDM symbols where SSB is transmitted. The UE may have information about whether the SSB punctured PRBs are available in symbols used to transmit the SSB.

[0036] In some aspects, if the transmission bandwidth is 12 PRBs within a 3 MHZ channel bandwidth, the PDSCH bandwidth can be scheduled in up to 12 PRBs. Since the SSB after puncturing has 12 PRBs, which has used the full transmission bandwidth, the punctured PRBs in the OFDM symbols where SSB is transmitted may not be available for the PDSCH. In other words, the PRBs containing the SSB before and after puncturing are not available for the PDSCH transmission resources. In some aspects, as a first alternative, if the transmission bandwidth is 15 PRBs within the 3 MHz channel bandwidth, the PDSCH bandwidth may be scheduled in up to 15 PRBs. Since the SSB after puncturing has 12 PRBs, which has not used the full transmission bandwidth, the punctured PRBs may or may not be available for the PDSCH. In some aspects, if the transmission bandwidth is 15 PRBs within the 3 MHz channel bandwidth, the PRBs containing the SSB before puncturing may not be available for the PDSCH transmission resources in symbols where the SSB is transmitted (before the puncturing). In some aspects, as a second alternative, if the transmission bandwidth is 15 PRBs within the 3 MHz channel bandwidth, the PRBs containing the SSB after puncturing are not available for the PDSCH transmission resources. There may be PRBs containing the SSB before puncturing that are available for PDSCH transmission resources.

[0037] Particular aspects of the subject matter described in this disclosure can be implemented to realize one or more of the following potential advantages. By being configured for the first alternative or the second alternative (e.g., only the second alternative and not both), the UE may have more clarity as to whether PRBs containing the SSB before or after puncturing are available for the PDSCH/DMRS in the OFDM symbols that transmit the SSB. As a result, the UE may not have wrong DMRS/PDSCH detection due to uncertainty about available PRBs when the SSB is punctured. That is, if the second alternative is not specified, and each alternative is possible at the same time, where PRBs containing the SSB before and after puncturing can or cannot be available, the UE will have to perform the DMRS/PDSCH detection blindly.

[0038] In an example, if the network entity transmits the DMRS/PDSCH, the network entity assumes that the UE is to blindly detect DMRS/PDSCH and that punctured PRBs contain not the DMRS/PDSCH but noise and interference. If the noise and interference on the punctured PRBs are used for DMRS/PDSCH detection, this will degrade the DMRS-based channel estimation and degrade the PDSCH detection performance due to the wrong log likelihood ratio (LLR) of the PDSCH information bits on the punctured PRBs included for PDSCH decoding. If the network entity assumes that the punctured PRBs contain the DMRS/PDSCH and if the DMRS/PDSCH in the punctured PRBs are not used for DMRS/PDSCH detection, the network entity will miss the DMRS-based channel estimation and degrade the PDSCH detection performance due to the LLR. By being configured for the second alternative only (the PRBs containing the SSB after puncturing are not available for the PDSCH transmission resources), the UE may receive the DA DSCH without performing blind detection.

[0039] Multiple-access radio access technologies (RATs) have been adopted in various telecommunication standards to provide common protocols that enable wireless communication devices to communicate on a municipal, enterprise, national, regional, or global level. For example, 5G New Radio (NR) is part of a continuous mobile broadband evolution promulgated by the 3GPP. 5G NR supports various technologies and use cases including enhanced mobile broadband (eMBB), ultra-reliable low-latency communication (URLLC), massive machine-type communication (mMTC), millimeter wave (mmWave) technology, beamforming, network slicing, edge computing, Internet of Things (IoT) connectivity and management, and network function virtualization (NFV).

[0040] As the demand for broadband access increases and as technologies supported by wireless communication networks evolve, further technological improvements may be adopted in or implemented for 5G NR or future RATs, such as 6G, to further advance the evolution of wireless communication for a wide variety of existing and new use cases and applications. Such technological improvements may be associated with new frequency band expansion, licensed and unlicensed spectrum access, overlapping spectrum use, small cell deployments, non-terrestrial network (NTN) deployments, disaggregated network architectures and network topology expansion, device aggregation, advanced duplex communication, sidelink and other device-to-device direct communication, IoT (including passive or ambient IoT) networks, reduced capability (RedCap) UE functionality, industrial connectivity, multiple-subscriber implementations, high-precision positioning, radio frequency (RF) sensing, and/or artificial intelligence or machine learning (AI/ML), among other examples. These technological improvements may support use cases such as wireless backhauls, wireless data centers, extended reality (XR) and metaverse applications, meta services for supporting vehicle connectivity, holographic and mixed reality communication, autonomous and collaborative robots, vehicle platooning and cooperative maneuvering, sensing networks, gesture monitoring, human-brain interfacing, digital twin applications, asset management, and universal coverage applications using non-terrestrial and/or aerial platforms, among other examples. The methods, operations, apparatuses, and techniques described herein may enable one or more of the foregoing technologies and/or support one or more of the foregoing use cases.

[0041] FIG. **1** is a diagram illustrating an example of a wireless communication network **100** in accordance with the present disclosure. The wireless communication network **100** may be or may include elements of a 5G (or NR) network or a 6G network, among other examples. The wireless communication network **100** may include multiple network nodes **110**, shown as a network node (NN) **110***a*, a network node **110***b*, a network node **110***c*, and a network node **110***d*. The network nodes **110** may support communications with multiple UEs **120**, shown as a UE **120***a*, a UE **120***b*, a UE **120***c*, a UE **120***d*, and a UE **120***e*.

[0042] The network nodes **110** and the UEs **120** of the wireless communication network **100** may communicate using the electromagnetic spectrum, which may be subdivided by frequency or wavelength into various classes, bands, carriers, and/or channels. For example, devices of the wireless communication network **100** may communicate using one or more operating bands. In some aspects, multiple wireless networks **100** may be deployed in a given geographic area. Each wireless communication network **100** may support a particular RAT (which may also be referred to as an air interface) and may operate on one or more carrier frequencies in one or more frequency ranges. Examples of RATs include a 4G RAT, a 5G/NR RAT, and/or a 6G RAT, among other examples. In some examples, when multiple RATs are deployed in a given geographic area, each RAT in the geographic area may operate on different frequencies to avoid interference with one another.

[0043] Various operating bands have been defined as frequency range designations FR1 (410 MHz through 7.125 GHz), FR2 (24.25 GHz through 52.6 GHz), FR3 (7.125 GHz through 24.25 GHz), FR4a or FR4-1 (52.6 GHz through 71 GHz), FR4 (52.6 GHz through 114.25 GHZ), and FR5 (114.25 GHz through 300 GHz). Although a portion of FR1 is greater than 6 GHz, FR1 is often referred to (interchangeably) as a "Sub-6 GHZ" band in some documents and articles. Similarly, FR2 is often referred to (interchangeably) as a "millimeter wave" band in some documents and articles, despite being different than the extremely high frequency (EHF) band (30 GHz through 300 GHz), which is identified by the International Telecommunications Union (ITU) as a "millimeter wave" band. The frequencies between FR1 and FR2 are often referred to as mid-band frequencies, which include FR3. Frequency bands falling within FR3 may inherit FR1 characteristics or FR2 characteristics, and thus may effectively extend features of FR1 or FR2 into mid-band frequencies. Thus, "sub-6 GHZ," if used herein, may broadly refer to frequencies that are less than 6 GHZ, that are within FR1, and/or that are included in mid-band frequencies. Similarly, the term "millimeter wave," if used herein, may broadly refer to frequencies that are included in mid-band frequencies, that are within FR2, FR4, FR4-a or FR4-1, or FR5, and/or that are within the EHF band. Higher frequency bands may extend 5G NR operation, 6G operation, and/or other RATs beyond 52.6 GHz. For example, each of FR4a, FR4-1, FR4, and FR5 falls within the EHF band. In some examples, the wireless communication network **100** may implement dynamic spectrum sharing (DSS), in which multiple RATs (for example, 4G/LTE and 5G/NR) are implemented with dynamic bandwidth allocation (for example, based on user demand) in a single frequency band. It is contemplated that the frequencies included in these operating bands (for example, FR1, FR2, FR3, FR4, FR4-a, FR4-1, and/or FR5) may be modified, and techniques described herein may be applicable to those modified frequency ranges.

[0044] A network node **110** may include one or more devices, components, or systems that enable communication between a UE **120** and one or more devices, components, or systems of the wireless communication network **100**. A network node **110** may be, may include, or may also be referred to as an NR network node, a 5G network node, a 6G network node, a Node B, an eNB, a gNB, an access point (AP), a transmission reception point (TRP), a mobility element, a core, a network entity, a network element, a network equipment, and/or another type of device, component, or system included in a radio access network (RAN).

[0045] A network node **110** may be implemented as a single physical node (for example, a single physical structure) or may be implemented as two or more physical nodes (for example, two or more distinct physical structures). For example, a network node **110** may be a device or system that implements part of a radio protocol stack, a device or system that implements a full radio protocol stack (such as a full gNB protocol stack), or a collection of devices or systems that collectively implement the full radio protocol stack. For example, and as shown, a network node **110** may be an aggregated network node (having an aggregated architecture), meaning that the network node **110** may implement a full radio protocol stack that is physically and logically integrated within a single node (for example, a single physical structure) in the wireless communication network **100**. For example, an aggregated network node **110** may consist of a single standalone base station or a single TRP that uses a full radio protocol stack to enable or facilitate communication between a UE **120** and a core network of the wireless communication network **100**.

[0046] Alternatively, and as also shown, a network node **110** may be a disaggregated network node (sometimes referred to as a disaggregated base station), meaning that the network node **110** may implement a radio protocol stack that is physically distributed and/or logically distributed among two or more nodes in the same geographic location or in different geographic locations. For example, a disaggregated network node may have a disaggregated architecture. In some deployments, disaggregated network nodes **110** may be used in an integrated access and backhaul (IAB) network, in an open radio access network (O-RAN) (such as a network configuration in compliance with the O-RAN Alliance), or in a virtualized radio access network (vRAN), also known as a cloud radio access network (C-RAN), to facilitate scaling by separating base station functionality into multiple units that can be individually deployed.

[0047] The network nodes **110** of the wireless communication network **100** may include one or more central units (CUs), one or more distributed units (DUs), and/or one or more radio units (RUs). A CU may host one or more higher layer control functions, such as radio resource control (RRC) functions, packet data convergence protocol (PDCP) functions, and/or service data adaptation protocol (SDAP) functions, among other examples. A DU may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and/or one or more higher physical (PHY) layers depending, at least in part, on a functional split, such as a functional split defined by the 3GPP. In some examples, a DU also may host one or more lower PHY layer functions, such as a fast Fourier transform (FFT), an inverse FFT (iFFT), beamforming, physical random access channel (PRACH) extraction and filtering, and/or scheduling of resources for one or more UEs **120**, among other examples. An RU may host RF processing functions or lower PHY layer functions, such as an FFT, an iFFT, beamforming, or PRACH extraction and filtering, among other examples, according to a functional split, such as a lower layer functional split. In such an architecture, each RU can be operated to handle over the air (OTA) communication with one or more UEs **120**.

[0048] In some aspects, a single network node **110** may include a combination of one or more CUs, one or more DUs, and/or one or more RUs. Additionally or alternatively, a network node **110** may include one or more Near-Real Time (Near-RT) RAN Intelligent Controllers (RICs) and/or one or more Non-Real Time (Non-RT) RICs. In some examples, a CU, a DU, and/or an RU may be implemented as a virtual unit, such as a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU), among other examples. A virtual unit may be implemented as a virtual network function, such as associated with a cloud deployment.

[0049] Some network nodes **110** (for example, a base station, an RU, or a TRP) may provide communication coverage for a particular geographic area. In the 3GPP, the term "cell" can refer to a coverage area of a network node **110** or to a network node **110** itself, depending on the context in which the term is used. A network node **110** may support one or multiple (for example, three) cells. In some examples, a network node **110** may provide communication coverage for a macro cell, a pico cell, a femto cell, or another type of cell. A macro cell may cover a relatively large geographic area (for example, several kilometers in radius) and may allow unrestricted access by UEs **120** with service subscriptions. A pico cell may cover a relatively small geographic area and may allow unrestricted access by UEs **120** with service subscriptions. A femto cell may cover a relatively small geographic area (for example, a home) and may allow restricted access by UEs **120** having association with the femto cell (for example, UEs **120** in a closed subscriber group (CSG)). A network node **110** for a macro cell may be referred to as a macro network node. A network node **110** for a pico cell may be referred to as a pico network node. A network node **110** for a femto cell may be referred to as a femto network node or an in-home network node. In some examples, a cell may not necessarily be stationary. For example, the geographic area of the cell may move according to the location of an associated mobile network node **110** (for example, a train, a satellite base station, an unmanned aerial vehicle, or an NTN network node).

[0050] The wireless communication network **100** may be a heterogeneous network that includes network nodes **110** of different types, such as macro network nodes, pico network nodes, femto network nodes, relay network nodes, aggregated network nodes, and/or disaggregated network nodes, among other examples. In the example shown in FIG. **1**, the network node **110***a* may be a macro network node for a macro cell **130***a*, the network node **110***b* may be a pico network node for a pico cell **130***b*, and the network node **110***c* may be a femto network node for a femto cell **130***c*. Various different types of network nodes **110** may generally transmit at different power levels, serve different coverage areas, and/or have different impacts on interference in the wireless communication network **100** than other types of network nodes **110**. For example, macro network nodes may have a high transmit power level (for example, 5 to 40 watts), whereas pico network nodes, femto network nodes, and relay network nodes may have lower transmit power levels (for example, 0.1 to 2 watts).

[0051] In some examples, a network node **110** may be, may include, or may operate as an RU, a TRP, or a base station that communicates with one or more UEs **120** via a radio access link (which may be referred to as a "Uu" link). The radio access link may include a downlink and an uplink. "Downlink" (or "DL") refers to a communication direction from a network node **110** to a UE **120**, and "uplink" (or "UL") refers to a communication direction from a UE **120** to a network node **110**. Downlink channels may include one or more control channels and one or more data channels. A downlink control channel may be used to transmit downlink control information (DCI) (for example, scheduling information, reference signals, and/or configuration information) from a network node **110** to a UE **120**. A downlink data channel may be used to transmit downlink data (for example, user data associated with a UE **120**) from a network node **110** to a UE **120**. Downlink control channels may include one or more physical downlink control channels (PDCCHs), and downlink data channels may include one or more physical downlink shared channels (PDSCHs). Uplink channels may similarly include one or more control channels and one or more data channels. An uplink control channel may be used to transmit uplink control information (UCI) (for example, reference signals and/or feedback corresponding to one or more downlink transmissions) from a UE **120** to a network node **110**. An uplink data channel may be used to transmit uplink data (for example, user data associated with a UE **120**) from a UE **120** to a network node **110**. Uplink control channels may include one or more physical uplink control channels (PUCCHs), and uplink data channels may include one or more physical uplink shared channels (PUSCHs). The downlink and the uplink may each include a set of resources on which the network node **110** and the UE **120** may communicate.

[0052] Downlink and uplink resources may include time domain resources (frames, subframes, slots, and/or symbols), frequency domain resources (frequency bands, component carriers, subcarriers, resource blocks, and/or resource elements), and/or spatial domain resources (particular transmit directions and/or beam parameters). Frequency domain resources of some bands may be subdivided into bandwidth parts (BWPs). A BWP may be a continuous block of frequency domain resources (for example, a continuous block of resource blocks) that are allocated for one or more UEs **120**. A UE **120** may be configured with both an uplink BWP and a downlink BWP (where the uplink BWP and the downlink BWP may be the same BWP or different BWPs). A BWP may be dynamically configured (for example, by a network node **110** transmitting a DCI configuration to the one or more UEs **120**) and/or reconfigured, which means that a BWP can be adjusted in real-time (or near-real-time) based on changing network conditions in the wireless communication network **100** and/or based on the specific requirements of the one or more UEs **120**. This enables more efficient use of the available frequency domain resources in the wireless communication network **100** because fewer frequency domain resources may be allocated to a BWP for a UE **120** (which may reduce the quantity of frequency domain resources that a UE **120** is required to monitor), leaving more frequency domain resources to be spread across multiple UEs **120**. Thus, BWPs may also assist in the implementation of lower-capability UEs **120** by facilitating the configuration of smaller bandwidths for communication by such UEs **120**.

[0053] As described above, in some aspects, the wireless communication network **100** may be, may include, or may be included in, an IAB network. In an IAB network, at least one network node **110** is an anchor network node that communicates with a core network. An anchor network node **110** may also be referred to as an IAB donor (or "IAB-donor"). The anchor network node **110** may connect to the core network via a wired backhaul link. For example, an Ng interface of the anchor network node **110** may terminate at the core network. Additionally or alternatively, an anchor network node **110** may connect to one or more devices of the core network that provide a core access and mobility management function (AMF). An IAB network also generally includes multiple non-anchor network nodes **110**, which may also be referred to as relay network nodes or simply as IAB nodes (or "IAB-nodes"). Each non-anchor network node **110** may communicate directly with the anchor network node **110** via a wireless backhaul link to access the core network, or may communicate indirectly with the anchor network node **110** via one or more other non-anchor network nodes **110** and associated wireless backhaul links that form a backhaul path to the core network. Some anchor network node **110** or other non-anchor network node **110** may also communicate directly with one or more UEs **120** via wireless access links that carry access traffic. In some examples, network resources for wireless communication (such as time resources, frequency resources, and/or spatial resources) may be shared between access links and backhaul links.

[0054] In some examples, any network node **110** that relays communications may be referred to as a relay network node, a relay station, or simply as a relay. A relay may receive a transmission of a communication from an upstream station (for example, another network node **110** or a UE **120**) and transmit the communication to a downstream station (for example, a UE **120** or another network node **110**). In this case, the wireless communication network **100** may include or be referred to as a "multi-hop network." In the example shown in FIG. **1**, the network node **110*d*** (for example, a relay network node) may communicate with the network node **110*a*** (for example, a macro network node) and the UE **120*d*** in order to facilitate communication between the network node **110*a*** and the UE **120*d***. Additionally or alternatively, a UE **120** may be or may operate as a relay station that can relay transmissions to or from other UEs **120**. A UE **120** that relays communications may be referred to as a UE relay or a relay UE, among other examples.

[0055] The UEs **120** may be physically dispersed throughout the wireless communication network **100**, and each UE **120** may be stationary or mobile. A UE **120** may be, may include, or may be included in an access terminal, another terminal, a mobile station, or a subscriber unit. A UE **120** may be, include, or be coupled with a cellular phone (for example, a smart phone), a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a laptop computer, a cordless phone, a wireless local loop (WLL) station, a tablet, a camera, a gaming device, a netbook, a smartbook, an ultrabook, a medical device, a biometric device, a wearable device (for example, a smart watch, smart clothing, smart glasses, a smart wristband, and/or smart jewelry, such as a smart ring or a smart bracelet), an entertainment device (for example, a music device, a video device, and/or a satellite radio), an XR device, a vehicular component or sensor, a smart meter or sensor, industrial manufacturing equipment, a Global Navigation Satellite System (GNSS) device (such as a Global Positioning System device or another type of positioning device), a UE function of a network node, and/or any other suitable device or function that may communicate via a wireless medium.

[0056] A UE **120** and/or a network node **110** may include one or more chips, system-on-chips (SoCs), chipsets, packages, or devices that individually or collectively constitute or comprise a processing system. The processing system includes processor (or "processing") circuitry in the form of one or multiple processors, microprocessors, processing units (such as central processing units (CPUs), graphics processing units (GPUs), neural processing units (NPUs) and/or digital signal processors (DSPs)), processing blocks, application-specific integrated circuits (ASIC), programmable logic devices (PLDs) (such as field programmable gate arrays (FPGAs)), or other discrete gate or transistor logic or circuitry (all of which may be generally referred to herein individually as "processors" or collectively as "the processor" or "the processor circuitry"). One or more of the processors may be individually or collectively configurable or configured to perform various functions or operations described herein. A group of processors collectively configurable or configured to perform a set of functions may include a first processor configurable or configured to perform a first function of the set and a second processor configurable or configured to perform a second function of the set, or may include the group of processors all being configured or configurable to perform the set of functions.

[0057] The processing system may further include memory circuitry in the form of one or more memory devices, memory blocks, memory elements or other discrete gate or transistor logic or circuitry, each of which may include tangible storage media such as random-access memory (RAM) or read-only memory (ROM), or combinations thereof (all of which may be generally referred to herein individually as "memories" or collectively as "the memory" or "the memory circuitry"). One or more of the memories may be coupled (for example, operatively coupled, communicatively coupled, electronically coupled, or electrically coupled) with one or more of the processors and may individually or collectively store processor-executable code (such as software) that, when executed by one or more of the processors, may configure one or more of the processors to perform various functions or operations described herein. Additionally or alternatively, in some examples, one or more of the processors may be preconfigured to perform various functions or operations described herein without requiring configuration by software. The processing system may further include or be coupled with one or more modems (such as a Wi-Fi (for example, IEEE compliant) modem or a cellular (for example, 3GPP 4G LTE, 5G, or 6G compliant) modem). In some implementations, one or more processors of the processing system include or implement one or more of the modems. The processing system may further include or be coupled with multiple radios (collectively "the radio"), multiple RF chains, or multiple transceivers, each of which may in turn be coupled with one or more of multiple antennas. In some implementations, one or more processors of the processing system include or implement one or more of the radios, RF chains or transceivers. The UE **120** may include or may be included in a housing that houses components associated with the UE **120** including the processing system.

[0058] Some UEs **120** may be considered machine-type communication (MTC) UEs, evolved or enhanced machine-type communication (eMTC), UEs, further enhanced eMTC (feMTC) UEs, or enhanced feMTC (efeMTC) UEs, or further evolutions thereof, all of which may be simply referred to as "MTC UEs"). An MTC UE may be, may include, or may be included in or coupled with a robot, an uncrewed aerial vehicle, a remote device, a sensor, a meter, a monitor, and/or a location tag. Some UEs **120** may be considered IoT devices and/or may be implemented as NB-IoT (narrowband IoT) devices. An IoT UE or NB-IoT device may be, may include, or may be included in or coupled with an industrial machine, an appliance, a refrigerator, a doorbell camera device, a home automation device, and/or a light fixture, among other examples. Some UEs **120** may be considered Customer Premises Equipment, which may include telecommunications devices that are installed at a customer location (such as a home or office) to enable access to a service provider's network (such as included in or in communication with the wireless communication network **100**).

[0059] Some UEs **120** may be classified according to different categories in association with different complexities and/or different capabilities. UEs **120** in a first category may facilitate massive IoT in the wireless communication network **100**, and may offer low complexity and/or cost relative to UEs **120** in a second category. UEs **120** in a second category may include mission-critical IoT devices, legacy UEs, baseline UEs, high-tier UEs, advanced UEs, full-capability UEs, and/or premium UEs that are capable of URLLC, enhanced mobile broadband (eMBB), and/or precise positioning in the wireless communication network **100**, among other examples. A third category of UEs **120** may have mid-tier complexity and/or capability (for example, a capability between UEs **120** of the first category and UEs **120** of the second capability). A UE **120** of the third category may be referred to as a reduced capacity UE ("RedCap UE"), a mid-tier UE, an NR-Light UE, and/or an NR-Lite UE, among other examples. RedCap UEs may bridge a gap between the capability and complexity of NB-IoT devices and/or eMTC UEs, and mission-critical IoT devices and/or premium UEs. RedCap UEs may include, for example, wearable devices, IoT devices, industrial sensors, and/or cameras that are associated with a limited bandwidth, power capacity, and/or transmission range, among other examples. RedCap UEs may support healthcare environments, building automation, electrical distribution, process automation, transport and logistics, and/or smart city deployments, among other examples.

[0060] In some examples, two or more UEs **120** (for example, shown as UE **120*a*** and UE **120*e***) may communicate directly with one another using sidelink communications (for example, without communicating by way of a network node **110** as an intermediary). As an example, the UE **120*a*** may directly transmit data, control information, or other signaling as a sidelink communication to the UE **120*e***. This is in contrast to, for example, the UE **120*a*** first transmitting data in an UL communication to a network node **110**, which then transmits the data to the UE **120*e*** in a DL communication. In various examples, the UEs **120** may transmit and receive sidelink communications using peer-to-peer (P2P) communication protocols, device-to-device (D2D) communication protocols, vehicle-to-everything (V2X) communication protocols (which may include vehicle-to-vehicle (V2V) protocols, vehicle-to-infrastructure (V2I) protocols, and/or vehicle-to-pedestrian (V2P) protocols), and/or mesh network communication protocols. In some deployments and configurations, a network node **110** may schedule and/or allocate resources for sidelink communications between UEs **120** in the wireless communication network **100**. In some other deployments and configurations, a UE **120** (instead of a network node **110**) may perform, or collaborate or negotiate with one or more other UEs to perform, scheduling operations, resource selection operations, and/or other operations for sidelink communications.

[0061] In various examples, some of the network nodes **110** and the UEs **120** of the wireless communication network **100** may be configured for full-duplex operation in addition to half-duplex operation. A network node **110** or a UE **120** operating in a half-duplex mode may perform only one of transmission or reception during particular time resources, such as during particular slots, symbols, or other time periods. Half-duplex operation may involve time-division duplexing (TDD), in which DL transmissions of the network node **110** and UL transmissions of the UE **120** do not occur in the same time resources (that is, the transmissions do not overlap in time). In contrast, a network node **110** or a UE **120** operating in a full-duplex mode can transmit and receive communications concurrently (for example, in the same time resources). By operating in a full-duplex mode, network nodes **110** and/or UEs **120** may generally increase the capacity of the network and the radio access link. In some examples, full-duplex operation may involve frequency-division duplexing (FDD), in which DL transmissions of the network node **110** are performed in a first frequency band or on a first component carrier and transmissions of the UE **120** are performed in a second frequency band or on a second component carrier different than the first frequency band or the first component carrier, respectively. In some examples, full-duplex operation may be enabled for a UE **120** but not for a network node **110**. For example, a UE **120** may simultaneously transmit an UL transmission to a first network node **110** and receive a DL transmission from a second network node **110** in the same time resources. In some other examples, full-duplex operation may be enabled for a network node **110** but not for a UE **120**. For example, a network node **110** may simultaneously transmit a DL transmission to a first UE **120** and receive an UL transmission from a second UE **120** in the same time resources. In some other examples, full-duplex operation may be enabled for both a network node **110** and a UE **120**.

[0062] In some examples, the UEs **120** and the network nodes **110** may perform MIMO communication. "MIMO" generally refers to transmitting or receiving multiple signals (such as multiple layers or multiple data streams) simultaneously over the same time and frequency resources. MIMO techniques generally exploit multipath propagation. MIMO may be implemented using various spatial processing or spatial multiplexing operations. In some examples, MIMO may support simultaneous transmission to multiple receivers, referred to as multi-user MIMO (MU-MIMO). Some RATs may employ advanced MIMO techniques, such as mTRP operation (including redundant transmission or reception on multiple TRPs), reciprocity in the time domain or the frequency domain, single-frequency-network (SFN) transmission, or non-coherent joint transmission (NCJT).

[0063] In some aspects, a UE (e.g., a UE **120**) may include a communication manager **140**. As described in more detail elsewhere herein, the communication manager **140** may receive an SSB. The communication manager **140** may identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point of a spectrum. The communication manager **140** may receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured. Additionally, or alternatively, the communication manager **140** may perform one or more other operations described herein.

[0064] In some aspects, a network entity (e.g., a network node **110**) may include a communication manager **150**. As described in more detail elsewhere herein, the communication manager **150** may transmit an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz. The communication manager **150** may transmit a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured. Additionally, or alternatively, the communication manager **150** may perform one or more other operations described herein.

[0065] As indicated above, FIG. **1** is provided as an example. Other examples may differ from what is described with regard to FIG. **1**.

[0066] FIG. **2** is a diagram illustrating an example network node **110** in communication with an example UE **120** in a wireless network in accordance with the present disclosure.

[0067] As shown in FIG. **2**, the network node **110** may include a data source **212**, a transmit processor **214**, a transmit (TX) MIMO processor **216**, a set of modems **232** (shown as **232***a* through **232***t*, where t≥1), a set of antennas **234** (shown as **234***a* through **234***v*, where v≥1), a MIMO detector **236**, a receive processor **238**, a data sink **239**, a controller/processor **240**, a memory **242**, a communication unit **244**, a scheduler **246**, and/or a communication manager **150**, among other examples. In some configurations, one or a combination of the antenna(s) **234**, the modem(s) **232**, the MIMO detector **236**, the receive processor **238**, the transmit processor **214**, and/or the TX MIMO processor **216** may be included in a transceiver of the network node **110**. The transceiver may be under control of and used by one or more processors, such as the controller/processor **240**, and in some aspects in conjunction with processor-readable code stored in the memory **242**, to perform aspects of the methods, processes, and/or operations described herein. In some aspects, the network node **110** may include one or more interfaces, communication components, and/or other components that facilitate communication with the UE **120** or another network node.

[0068] The terms "processor," "controller," or "controller/processor" may refer to one or more controllers and/or one or more processors. For example, reference to "a/the processor," "a/the controller/processor," or the like (in the singular) should be understood to refer to any one or more of the processors described in connection with FIG. **2**, such as a single processor or a combination of multiple different processors. Reference to "one or more processors" should be understood to refer to any one or more of the processors described in connection with FIG. **2**. For example, one or more processors of the network node **110** may include transmit processor **214**, TX MIMO processor **216**, MIMO detector **236**, receive processor **238**, and/or controller/processor **240**. Similarly, one or more processors of the UE **120** may include MIMO detector **256**, receive processor **258**, transmit processor **264**, TX MIMO processor **266**, and/or controller/processor **280**.

[0069] In some aspects, a single processor may perform all of the operations described as being performed by the one or more processors. In some aspects, a first set of (one or more) processors of the one or more processors may perform a first operation described as being performed by the one or more processors, and a second set of (one or more) processors of the one or more processors may perform a second operation described as being performed by the one or more processors. The first set of processors and the second set of processors may be the same set of processors or may be different sets of processors. Reference to "one or more memories" should be understood to refer to any one or more memories of a corresponding device, such as the memory described in connection with FIG. **2**. For example, operation described as being performed by one or more memories can be performed by the same subset of the one or more memories or different subsets of the one or more memories.

[0070] For downlink communication from the network node **110** to the UE **120**, the transmit processor **214** may receive data ("downlink data") intended for the UE **120** (or a set of UEs that includes the UE **120**) from the data source **212** (such as a data pipeline or a data queue). In some examples, the transmit processor **214** may select one or more MCSs for the UE **120** in accordance with one or more channel quality indicators (CQIs) received from the UE **120**. The network node **110** may process the data (for example, including encoding the data) for transmission to the UE **120** on a downlink in accordance with the MCS(s) selected for the UE **120** to generate data symbols. The transmit processor **214** may process system information (for example, semi-static resource partitioning information (SRPI)) and/or control information (for example, CQI requests, grants, and/or upper layer signaling) and provide overhead symbols and/or control symbols. The transmit processor **214** may generate reference symbols for reference signals (for example, a cell-specific reference signal (CRS), a DMRS, or a channel state information (CSI) reference signal (CSI-RS)) and/or synchronization signals (for example, a primary synchronization signal (PSS) or a secondary synchronization signals (SSS)).

[0071] The TX MIMO processor **216** may perform spatial processing (for example, precoding) on the data symbols, the control symbols, the overhead symbols, and/or the reference symbols, if applicable, and may provide a set of output symbol streams (for example, T output symbol streams) to the set of modems **232**. For example, each output symbol stream may be provided to a respective modulator component (shown as MOD) of a modem **232**. Each modem **232** may use the respective modulator component to process (for example, to modulate) a respective output symbol stream (for example, for orthogonal frequency division multiplexing (OFDM)) to obtain an output sample stream. Each modem **232** may further use the respective modulator component to process (for example, convert to analog, amplify, filter, and/or upconvert) the output sample stream to obtain a time domain downlink signal. The modems **232***a* through **232***t* may together transmit a set of downlink signals (for example, T downlink signals) via the corresponding set of antennas **234**.

[0072] A downlink signal may include a DCI communication, a MAC control element (MAC-CE) communication, an RRC communication, a downlink reference signal, or another type of downlink communication. Downlink signals may be transmitted on a PDCCH, a PDSCH, and/or on another downlink channel. A downlink signal may carry one or more transport blocks (TBs) of data. A TB may be a unit of data that is transmitted over an air interface in the wireless communication network **100**. A data stream (for example, from the data source **212**) may be encoded into multiple TBs for transmission over the air interface. The quantity of TBs used to carry the data associated with a particular data stream may be associated with a TB size common to the multiple TBs. The TB size may be based on or otherwise associated with radio channel conditions of the air interface, the MCS used for encoding the data, the downlink resources allocated for transmitting the data, and/or another parameter. In general, the larger the TB size, the greater the amount of data that can be transmitted in a single transmission, which reduces signaling overhead. However, larger TB sizes may be more prone to transmission and/or reception errors than smaller TB sizes, but such errors may be mitigated by more robust error correction techniques.

[0073] For uplink communication from the UE **120** to the network node **110**, uplink signals from the UE **120** may be received by an antenna **234**, may be processed by a modem **232** (for example, a demodulator component, shown as DEMOD, of a modem **232**), may be detected by the MIMO detector **236** (for example, a receive (Rx) MIMO processor) if applicable, and/or may be further processed by the receive processor **238** to obtain decoded data and/or control information. The receive processor **238** may provide the decoded data to a data sink **239** (which may be a data pipeline, a data queue, and/or another type of data sink) and provide the decoded control information to a processor, such as the controller/processor **240**.

[0074] The network node **110** may use the scheduler **246** to schedule one or more UEs **120** for downlink or uplink communications. In some aspects, the scheduler **246** may use DCI to dynamically schedule DL transmissions to the UE **120** and/or UL transmissions from the UE **120**. In some examples, the scheduler **246** may allocate recurring time domain resources and/or frequency domain resources that the UE **120** may use to transmit and/or receive communications using an RRC configuration (for example, a semi-static configuration), for example, to perform semi-persistent scheduling (SPS) or to configure a configured grant (CG) for the UE **120**.

[0075] One or more of the transmit processor **214**, the TX MIMO processor **216**, the modem **232**, the antenna **234**, the MIMO detector **236**, the receive processor **238**, and/or the controller/processor **240** may be included in an RF chain of the network node **110**. An RF chain may include one or more filters, mixers, oscillators, amplifiers, analog-to-digital converters (ADCs), and/or other devices that convert between an analog signal (such as for transmission or reception via an air interface) and a digital signal (such as for processing by one or more processors of the network node **110**). In some aspects, the RF chain may be or may be included in a transceiver of the network node **110**.

[0076] In some examples, the network node **110** may use the communication unit **244** to communicate with a core network and/or with other network nodes. The communication unit **244** may support wired and/or wireless communication protocols and/or connections, such as Ethernet, optical fiber, common public radio interface (CPRI), and/or a wired or wireless backhaul, among other examples. The network node **110** may use the communication unit **244** to transmit and/or receive data associated with the UE **120** or to perform network control signaling, among other examples. The communication unit **244** may include a transceiver and/or an interface, such as a network interface.

[0077] The UE **120** may include a set of antennas **252** (shown as antennas **252***a* through **252***r*, where $r \geq 1$), a set of modems **254** (shown as modems **254***a* through **254***u*, where u≥1), a MIMO detector **256**, a receive processor **258**, a data sink **260**, a data source **262**, a transmit processor **264**, a TX MIMO processor **266**, a controller/processor **280**, a memory **282**, and/or a communication manager **140**, among other examples. One or more of the components of the UE **120** may be included in a housing **284**. In some aspects, one or a combination of the antenna(s) **252**, the modem(s) **254**, the MIMO detector **256**, the receive processor **258**, the transmit processor **264**, or the TX MIMO processor **266** may be included in a transceiver that is included in the UE **120**. The transceiver may be under control of and used by one or more processors, such as the controller/processor **280**, and in some aspects in conjunction with processor-readable code stored in the memory **282**, to perform aspects of the methods, processes, or operations described herein. In some aspects, the UE **120** may include another interface, another communication component, and/or another component that facilitates communication with the network node **110** and/or another UE **120**.

[0078] For downlink communication from the network node **110** to the UE **120**, the set of antennas **252** may receive the downlink communications or signals from the network node **110** and may provide a set of received downlink signals (for example, R received signals) to the set of modems **254**. For example, each received signal may be provided to a respective demodulator component (shown as DEMOD) of a modem **254**. Each modem **254** may use the respective demodulator component to condition (for example, filter, amplify, downconvert, and/or digitize) a received signal to obtain input samples. Each modem **254** may use the respective demodulator component to further demodulate or process the input samples (for example, for OFDM) to obtain received symbols. The MIMO detector **256** may obtain received symbols from the set of modems **254**, may perform MIMO detection on the received symbols if applicable, and may provide detected symbols. The receive processor **258** may process (for example, decode) the detected symbols, may provide decoded data for the UE **120** to the data sink **260** (which may include a data pipeline, a data queue, and/or an application executed on the UE **120**), and may provide decoded control information and system information to the controller/processor **280**.

[0079] For uplink communication from the UE **120** to the network node **110**, the transmit processor **264** may receive and process data ("uplink data") from a data source **262** (such as a data pipeline, a data queue, and/or an application executed on the UE **120**) and control information from the controller/processor **280**. The control information may include one or more parameters, feedback, one or more signal measurements, and/or other types of control information. In some aspects, the receive processor **258** and/or the controller/processor **280** may determine, for a received signal (such as received from the network node **110** or another UE), one or more parameters relating to transmission of the uplink communication. The one or more parameters may include a reference signal received power (RSRP) parameter, a received signal strength indicator (RSSI) parameter, a reference signal received quality (RSRQ) parameter, a CQI parameter, or a transmit power control (TPC) parameter, among other examples. The control information may include an indication of the RSRP parameter, the RSSI parameter, the RSRQ parameter, the CQI parameter, the TPC parameter, and/or another parameter. The control information may facilitate parameter selection and/or scheduling for the UE **120** by the network node **110**.

[0080] The transmit processor **264** may generate reference symbols for one or more reference signals, such as an uplink DMRS, an uplink sounding reference signal (SRS), and/or another type of reference signal. The symbols from the transmit processor **264** may be precoded by the TX MIMO processor **266**, if applicable, and further processed by the set of modems **254** (for example, for DFT-s-OFDM or CP-OFDM). The TX MIMO processor **266** may perform spatial processing (for example, precoding) on the data symbols, the control symbols, the overhead symbols, and/or the reference symbols, if applicable, and may provide a set of output symbol streams (for example, U output symbol streams) to the set of modems **254**. For example, each output symbol stream may be provided to a respective modulator component (shown as MOD) of a modem **254**. Each modem **254** may use the respective modulator component to process (for example, to modulate) a respective output symbol stream (for example, for OFDM) to obtain an output sample stream. Each modem **254** may further use the respective modulator component to process (for example, convert to analog, amplify, filter, and/or upconvert) the output sample stream to obtain an uplink signal.

[0081] The modems **254*a*** through **254*u*** may transmit a set of uplink signals (for example, R uplink signals or U uplink symbols) via the corresponding set of antennas **252**. An uplink signal may include a UCI communication, a MAC-CE communication, an RRC communication, or another type of uplink communication. Uplink signals may be transmitted on a PUSCH, a PUCCH, and/or another type of uplink channel. An uplink signal may carry one or more TBs of data. Sidelink data and control transmissions (that is, transmissions directly between two or more UEs **120**) may generally use similar techniques as were described for uplink data and control transmission, and may use sidelink-specific channels such as a physical sidelink shared channel (PSSCH), a physical sidelink control channel (PSCCH), and/or a physical sidelink feedback channel (PSFCH).

[0082] One or more antennas of the set of antennas **252** or the set of antennas **234** may include, or may be included within, one or more antenna panels, one or more antenna groups, one or more sets of antenna elements, or one or more antenna arrays, among other examples. An antenna panel, an antenna group, a set of antenna elements, or an antenna array may include one or more antenna elements (within a single housing or multiple housings), a set of coplanar antenna elements, a set of non-coplanar antenna elements, or one or more antenna elements coupled with one or more transmission or reception components, such as one or more components of FIG. **2**. As used herein, "antenna" can refer to one or more antennas, one or more antenna panels, one or more antenna groups, one or more sets of antenna elements, or one or more antenna arrays. "Antenna panel" can refer to a group of antennas (such as antenna elements) arranged in an array or panel, which may facilitate beamforming by manipulating parameters of the group of antennas. "Antenna module" may refer to circuitry including one or more antennas, which may also include one or more other components (such as filters, amplifiers, or processors) associated with integrating the antenna module into a wireless communication device.

[0083] In some examples, each of the antenna elements of an antenna **234** or an antenna **252** may include one or more sub-elements for radiating or receiving radio frequency signals. For example, a single antenna element may include a first sub-element cross-polarized with a second sub-element that can be used to independently transmit cross-polarized signals. The antenna elements may include patch antennas, dipole antennas, and/or other types of antennas arranged in a linear pattern, a two-dimensional pattern, or another pattern. A spacing between antenna elements may be such that signals with a desired wavelength transmitted separately by the antenna elements may interact or interfere constructively and destructively along various directions (such as to form a desired beam). For example, given an expected range of wavelengths or frequencies, the spacing may provide a quarter wavelength, a half wavelength, or another fraction of a wavelength of spacing between neighboring antenna elements to allow for the desired constructive and destructive interference patterns of signals transmitted by the separate antenna elements within that expected range.

[0084] The amplitudes and/or phases of signals transmitted via antenna elements and/or sub-elements may be modulated and shifted relative to each other (such as by manipulating phase shift, phase offset, and/or amplitude) to generate one or more beams, which is referred to as beamforming. The term "beam" may refer to a directional transmission of a wireless signal toward a receiving device or otherwise in a desired direction. "Beam" may also generally refer to a direction associated with such a directional signal transmission, a set of directional resources associated with the signal transmission (for example, an angle of arrival, a horizontal direction, and/or a vertical direction), and/or a set of parameters that indicate one or more aspects of a directional signal, a direction associated with the signal, and/or a set of directional resources associated with the signal. In some implementations, antenna elements may be individually selected or deselected for directional transmission of a signal (or signals) by controlling amplitudes of one or more corresponding amplifiers and/or phases of the signal(s) to form one or more beams. The shape of a beam (such as the amplitude, width, and/or presence of side lobes) and/or the direction of a beam (such as an angle of the beam relative to a surface of an antenna array) can be dynamically controlled by modifying the phase shifts, phase offsets, and/or amplitudes of the multiple signals relative to each other.

[0085] Different UEs **120** or network nodes **110** may include different numbers of antenna elements. For example, a UE **120** may include a single antenna element, two antenna elements, four antenna elements, eight antenna elements, or a different number of antenna elements. As another example, a network node **110** may include eight antenna elements, 24 antenna elements, 64 antenna elements, 128 antenna elements, or a different number of antenna elements. Generally, a larger number of antenna elements may provide increased control over parameters for beam generation relative to a smaller number of antenna elements, whereas a smaller number of antenna elements may be less complex to implement and may use less power than a larger number of antenna elements. Multiple antenna elements may support multiple-layer transmission, in which a first layer of a communication (which may include a first data stream) and a second layer of a communication (which may include a second data stream) are transmitted using the same time and frequency resources with spatial multiplexing.

[0086] While blocks in FIG. **2** are illustrated as distinct components, the functions described above with respect to the blocks may be implemented in a single hardware, software, or combination component or in various combinations of components. For example, the functions described with respect to the transmit processor **264**, the receive processor **258**, and/or the TX MIMO processor **266** may be performed by or under the control of the controller/processor **280**.

[0087] FIG. **3** is a diagram illustrating an example disaggregated base station architecture **300** in accordance with the present disclosure. One or more components of the example disaggregated base station architecture **300** may be, may include, or may be included in one or more network nodes (such one or more network nodes **110**). The disaggregated base station architecture **300** may include a CU **310** that can communicate directly with a core network **320** via a backhaul link, or that can communicate indirectly with the core network **320** via one or more disaggregated control units, such as a Non-RT RIC **350** associated with a Service Management and Orchestration (SMO) Framework **360** and/or a Near-RT RIC **370** (for example, via an E2 link). The CU **310** may communicate with one or more DUs **330** via respective midhaul links, such as via F1 interfaces. Each of the DUs **330** may communicate with one or more RUs **340** via respective fronthaul links. Each of the RUs **340** may communicate with one or more UEs **120** via respective RF access links. In some deployments, a UE **120** may be simultaneously served by multiple RUs **340**.

[0088] Each of the components of the disaggregated base station architecture **300**, including the CUs **310**, the DUs **330**, the RUs **340**, the Near-RT RICs **370**, the Non-RT RICs **350**, and the SMO Framework **360**, may include one or more interfaces or may be coupled with one or more interfaces for receiving or transmitting signals, such as data or information, via a wired or wireless transmission medium.

[0089] In some aspects, the CU **310** may be logically split into one or more CU user plane (CU-UP) units and one or more CU control plane (CU-CP) units. A CU-UP unit may communicate bidirectionally with a CU-CP unit via an interface, such as the E1 interface when implemented in an O-RAN configuration. The CU **310** may be deployed to communicate with one or more DUs **330**, as necessary, for network control and signaling. Each DU **330** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **340**. For example, a DU **330** may host various layers, such as an RLC layer, a MAC layer, or one or more PHY layers, such as one or more high PHY layers or one or more low PHY layers. Each layer (which also may be referred to as a module) may be implemented with an interface for communicating signals with other layers (and modules) hosted by the DU **330**, or for communicating signals with the control functions hosted by the CU **310**. Each RU **340** may implement lower layer functionality. In some aspects, real-time and non-real-time aspects of control and user plane communication with the RU(s) **340** may be controlled by the corresponding DU **330**.

[0090] The SMO Framework **360** may support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **360** may support the deployment of dedicated physical resources for RAN coverage requirements, which may be managed via an operations and maintenance interface, such as an O1 interface. For virtualized network elements, the SMO Framework **360** may interact with a cloud computing platform (such as an open cloud (O-Cloud) platform **390**) to perform network element life cycle management (such as to instantiate virtualized network elements) via a cloud computing platform interface, such as an O2 interface. A virtualized network element may include, but is not limited to, a CU **310**, a DU **330**, an RU **340**, a non-RT RIC **350**, and/or a Near-RT RIC **370**. In some aspects, the SMO Framework **360** may communicate with a hardware aspect of a 4G RAN, a 5G NR RAN, and/or a 6G RAN, such as an open eNB (O-eNB) **380**, via an O1 interface. Additionally or alternatively, the SMO Framework **360** may communicate directly with each of one or more RUs **340** via a respective O1 interface. In some deployments, this configuration can enable each DU **330** and the CU **310** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

[0091] The Non-RT RIC **350** may include or may implement a logical function that enables non-real-time control and optimization of RAN elements and resources, AI/ML workflows including model training and updates, and/or policy-based guidance of applications and/or features in the Near-RT RIC **370**. The Non-RT RIC **350** may be coupled to or may communicate with (such as via an A1 interface) the Near-RT RIC **370**. The Near-RT RIC **370** may include or may implement a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions via an interface (such as via an E2 interface) connecting one or more CUs **310**, one or more DUs **330**, and/or an O-eNB with the Near-RT RIC **370**.

[0092] In some aspects, to generate AI/ML models to be deployed in the Near-RT RIC **370**, the Non-RT RIC **350** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **370** and may be received at the SMO Framework **360** or the Non-RT RIC **350** from non-network data sources or from network functions. In some examples, the Non-RT RIC **350** or the Near-RT RIC **370** may tune RAN behavior or performance. For example, the Non-RT RIC **350** may monitor long-term trends and patterns for performance and may employ AI/ML models to perform corrective actions via the SMO Framework **360** (such as reconfiguration via an O1 interface) or via creation of RAN management policies (such as A1 interface policies).

[0093] As indicated above, FIG. **3** is provided as an example. Other examples may differ from what is described with regard to FIG. **3**.

[0094] The network node **110**, the controller/processor **240** of the network node **110**, the UE **120**, the controller/processor **280** of the UE **120**, the CU **310**, the DU **330**, the RU **340**, or any other component(s) of FIG. **1**, **2**, or **3** may implement one or more techniques or perform one or more operations associated with SSB puncturing for a specified channel bandwidth, such as 3 MHz, as described in more detail elsewhere herein. For example, the controller/processor **240** of the network node **110**, the controller/processor **280** of the UE **120**, any other component(s) of FIG. **2**, the CU **310**, the DU **330**, or the RU **340** may perform or direct operations of, for example, process **1000** of FIG. **10**, process **1100** of FIG. **11**, or other processes as described herein (alone or in conjunction with one or more other processors). The memory **242** may store data and program codes for the network node **110**, the network node **110**, the CU **310**, the DU **330**, or the RU **340**. The memory **282** may store data and program codes for the UE **120**. In some examples, the memory **242** or the memory **282** may include a non-transitory computer-readable medium storing a set of instructions (for example, code or program code) for wireless communication. The memory **242** may include one or more memories, such as a single memory or multiple different memories (of the same type or of different types). The memory **282** may include one or more memories, such as a single memory or multiple different memories (of the same type or of different types). For example, the set of instructions, when executed (for example, directly, or after compiling, converting, or interpreting) by one or more processors of the network node **110**, the UE **120**, the CU **310**, the DU **330**, or the RU **340**, may cause the one or more processors to perform process **1000** of FIG. **10**, process **1100** of FIG. **11**, or other processes as described herein. In some examples, executing instructions may include running the instructions, converting the instructions, compiling the instructions, and/or interpreting the instructions, among other examples.

[0095] In some aspects, a UE (e.g., a UE **120**) includes means for receiving an SSB; means for identifying a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point; and/or means for receiving a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured. The means for the UE to perform operations described herein may include, for example, one or more of communication manager **140**, antenna **252**, modem **254**, MIMO detector **256**, receive processor **258**, transmit processor **264**, TX MIMO processor **266**, controller/processor **280**, or memory **282**.

[0096] In some aspects, a network entity (e.g. a network node **110**) includes means for transmitting an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz; and/or means for transmitting a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured. In some aspects, the means for the network entity to perform operations described herein may include, for example, one or more of communication manager **150**, transmit processor **214**, TX MIMO processor **216**, modem **232**, antenna **234**, MIMO detector **236**, receive processor **238**, controller/processor **240**, memory **242**, or scheduler **246**.

[0097] As indicated above, FIG. **3** is provided as an example. Other examples may differ from what is described with regard to FIG. **3**.

[0098] FIG. **4** is a diagram illustrating an example **400** of a slot format, in accordance with the present disclosure. As shown in FIG. **4**, time-frequency resources in a radio access network may be partitioned into resource blocks (sometime referred to as PRBs), shown by a single PRB **405**. A PRB **405** includes a set of subcarriers (e.g., **12** subcarriers) and a set of symbols (e.g., 14 symbols) that are schedulable by a network node **110** as a unit. In some aspects, a PRB **405** may include a set of subcarriers in a single slot. As shown, a single time-frequency resource included in a PRB **405** may be referred to as a resource element (RE) **410**. An RE **410** may include a single subcarrier (e.g., in frequency) and a single symbol (e.g., in time). A symbol may be referred to as an orthogonal frequency division multiplexing (OFDM) symbol. An RE **410** may be used to transmit one modulated symbol, which may be a real value or a complex value.

[0099] In some telecommunication systems (e.g., NR), PRBs **405** may span **12** subcarriers with a subcarrier spacing

(SCS) of, for example, 15 kilohertz (kHz), 30 kHz, 60 kHz, or 120 kHz, among other examples, over a 0.1 millisecond (ms) duration. A radio frame may include 40 slots and may have a length of 10 ms. Consequently, each slot may have a length of 0.25 ms. However, a slot length may vary depending on a numerology used to communicate (e.g., a subcarrier spacing and/or a cyclic prefix format). A slot may be configured with a link direction (e.g., downlink or uplink) for transmission. In some aspects, the link direction for a slot may be dynamically configured.

[0100] As indicated above, FIG. **4** is provided as an example. Other examples may differ from what is described with respect to FIG. **4**.

[0101] FIG. **5** is a diagram illustrating an example **500** of a synchronization signal (SS) hierarchy, in accordance with the present disclosure. As shown in FIG. **5**, the SS hierarchy may include an SS burst set **505**, which may include multiple SS bursts **510**, shown as SS burst 0 through SS burst N−1, where N is a maximum number of repetitions of the SS burst **510** that may be transmitted by one or more network nodes. As further shown, each SS burst **510** may include one or more SS blocks (SSBs) **515**, shown as SSB 0 through SSB M−1, where M is a maximum number of SSBs **515** that can be carried by an SS burst **510**. In some aspects, different SSBs **515** may be beam-formed differently (e.g., transmitted using different beams), and may be used for cell search, cell acquisition, beam management, and/or beam selection (e.g., as part of an initial network access procedure). An SS burst set **505** may be periodically transmitted by a wireless node (e.g., a network node **110**), such as every X milliseconds, as shown in FIG. **5**. In some aspects, an SS burst set **505** may have a fixed or dynamic length, shown as Y milliseconds in FIG. **5**. In some cases, an SS burst set **505** or an SS burst **510** may be referred to as a discovery reference signal (DRS) transmission window or an SSB measurement time configuration (SMTC) window.

[0102] In some aspects, an SSB **515** may include resources that carry a primary synchronization signal (PSS) **520**, a secondary synchronization signal (SSS) **525**, and/or a PBCH **530**. In some aspects, multiple SSBs **515** are included in an SS burst **510** (e.g., with transmission on different beams), and the PSS **520**, the SSS **525**, and/or the PBCH **530** may be the same across each SSB **515** of the SS burst **510**. In some aspects, a single SSB **515** may be included in an SS burst **510**. In some aspects, the SSB **515** may be at least four symbols (e.g., OFDM symbols) in length, where each symbol carries one or more of the PSS **520** (e.g., occupying one symbol), the SSS **525** (e.g., occupying one symbol), and/or the PBCH **530** (e.g., occupying two symbols). In some aspects, an SSB **515** may be referred to as an SS/PBCH block.

[0103] In some aspects, the symbols of an SSB **515** are consecutive, as shown in FIG. **5**. In some aspects, the symbols of an SSB **515** are non-consecutive. Similarly, in some aspects, one or more SSBs **515** of the SS burst **510** may be transmitted in consecutive radio resources (e.g., consecutive symbols) during one or more slots. Additionally, or alternatively, one or more SSBs **515** of the SS burst **510** may be transmitted in non-consecutive radio resources.

[0104] In some aspects, the SS bursts **510** may have a burst period, and the SSBs **515** of the SS burst **510** may be transmitted by a wireless node (e.g., a network node **110**) according to the burst period. In this case, the SSBs **515** may be repeated during each SS burst **510**. In some aspects, the SS burst set **505** may have a burst set periodicity, whereby the SS bursts **510** of the SS burst set **505** are transmitted by the wireless node according to the fixed burst set periodicity. In other words, the SS bursts **510** may be repeated during each SS burst set **505**.

[0105] In some aspects, an SSB **515** may include an SSB index, which may correspond to a beam used to carry the SSB **515**. A UE **120** may monitor for and/or measure SSBs **515** using different receive (Rx) beams during an initial network access procedure and/or a cell search procedure, among other examples. Based at least in part on the monitoring and/or measuring, the UE **120** may indicate one or more SSBs **515** with a best signal parameter (e.g., an RSRP parameter) to a network node **110** (e.g., directly or via one or more other network nodes). The network node **110** and the UE **120** may use the one or more indicated SSBs **515** to select one or more beams to be used for communication between the network node **110** and the UE **120** (e.g., for a random access channel (RACH) procedure). Additionally, or alternatively, the UE **120** may use the SSB **515** and/or the SSB index to determine a cell timing for a cell via which the SSB **515** is received (e.g., a serving cell).

[0106] As indicated above, FIG. **5** is provided as an example. Other examples may differ from what is described with regard to FIG. **5**.

[0107] FIG. **6** is a diagram illustrating an example **600** of an SSB for 3 MHz channel bandwidth, in accordance with the present disclosure.

[0108] Before 3GPP Release 18, the minimum channel bandwidth for spectrum allocations in the physical layer for NR was 5 MHz. Going forward, the NR physical layer may be able to operate in channel bandwidths from approximately 3 MHz up to below 5 MHz, including in bands n100, n106, n26, n28, and n85.

[0109] The 5 MHz channel bandwidth for PBCH transmission may have 20 PRBs as a transmission bandwidth. For a channel bandwidth of less than 5 MHz, the available PRBs for PBCH transmission may be less than 20 PRBs. For a 3 MHz channel bandwidth in all bands, the maximum channel utilization may be 15 PRBs, and a PBCH transmission bandwidth may be 12 PRBs.

[0110] A PBCH may be based on PRB-level puncturing (i.e., PBCH encoding is based on 20 PRBs). "Puncturing" may include not transmitting bits for PRBs in a punctured area. This may include deleting bits of the punctured area before transmission or transmitting different bits in the PRBs, such as for the puncturing transmission. The encoded bits and the DMRS may be mapped to 20 PRBs based on a legacy SSB structure, and the PRBs that fall outside of the available PRBs for PBCH transmission are punctured. With 12 PRBs being used for the PBCH transmission bandwidth for a 3 MHz channel bandwidth, the upper 4 PRBs and the lower 4 PRBs of the NR 20 PRBs for PBCH may be punctured, as shown by example **600**.

[0111] A synchronization raster divides the carrier bandwidth into locations where SSBs can be transmitted. The synchronization raster indicates frequency positions that can be used for an SSB. A GSCN may specify a center frequency of an SSB with a BWP. For a synchronization raster point associated with 3 MHz, such as 920.73 MHz (GSCN 41637 on band n100), a UE may support a transmission bandwidth of 12 PRBs. For all bands except the synchronization raster point or for other synchronization raster points associated with 3 MHz, the UE may support a transmission bandwidth of 15 PRBs.

[0112] Ak_SSB may be a subcarrier offset from subcarrier 0 of a common resource block to the SSB. Values for k_SSB may include 0 for 12 PRBs, 8 or 20 for 15 PRBs, or 4 or 16 for 15 PRBs with a 2 PRB offset. For a 3 MHz channel bandwidth for k_SSB, the PRB offset for a control resource set (CORESET) #0 position in the frequency domain may be 0 for 12 PRBs and 0 or 2 for 15 PRBs.

[0113] As indicated above, FIG. **6** is provided as an example. Other examples may differ from what is described with regard to FIG. **6**.

[0114] FIG. **7** is a diagram illustrating an example **700** of a punctured SSB for 5 MHz channel bandwidth, in accordance with the present disclosure.

[0115] Example **700** shows a transmission bandwidth for PDSCH and DMRS of 24 PRBs for a 5 MHz channel bandwidth. An SSB may include 20 PRBs. In legacy NR, the PRBs that include the SSB with 20 PRBs are not available for PDSCH and DMRS in the symbols where the SSB is transmitted. PRBs containing SSB transmission resources are not available for PDSCH in the OFDM symbols where an SSB associated with the same physical cell identity (PCI) is transmitted. A UE is not expected to handle the case where PDSCH DMRS REs are overlapping, even partially, with any RE(s) not available for PDSCH.

[0116] In a 3 MHz channel bandwidth, the SSB is punctured from 20 PRBs to 12 PRBs. It is not clear whether the PRBs including the SSB before or after puncturing can be used for PDSCH and DMRS in the 3 MHz channel bandwidth. If the UE does not have such information, the UE may not utilize available resources or may try to use unavailable resources. This may lead to an increase in latency or wasted signaling resources.

[0117] As indicated above, FIG. **7** is provided as an example. Other examples may differ from what is described with regard to FIG. **7**.

[0118] FIG. **8** is a diagram illustrating examples **800**, **802**, and **804** of punctured SSBs for 3 MHz channel bandwidth, in accordance with the present disclosure.

[0119] According to various aspects described herein, a UE may receive an SSB and identify a channel bandwidth to be less than 5 MHZ (e.g., 3 MHz) based at least in part on a synchronization (sync) raster point defined per operating bands. For example, the sync raster point may be associated with a 3 MHz channel bandwidth. For example, the sync raster for channel bandwidth of 3 MHz for each band is given in Table 5.4.3.3-2 in TS 38.101-1. In addition, different sync raster points may be associated with different transmission bandwidths. For example, the sync raster point at GSCN 41637 corresponds to a 12 PRB transmission bandwidth within the 3 MHz channel bandwidth. The sync raster points at a GSCN other than GSCN 41637 in Table 5.4.3.3-2 in TS 38.101-1 may correspond to a 15 PRB transmission bandwidth within the 3 MHz channel bandwidth. The UE may receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured in the PDSCH. The UE may have information about whether PRBs are available in symbols used to transmit the SSB.

[0120] A reason to puncture an SSB for the 3 MHz channel bandwidth is that the original 20 PRB SSB (size shown by the rectangles with the dotted lines in examples **800**, **802**, and **804**) cannot fit into the maximum 15 PRB or 12 PRB transmission bandwidth. The reason to puncture the SSB from 20 PRBs to 12 PRBs for 3 MHz is because a 12 PRB SSB can be used for a maximum 12 PRB or maximum 15 PRB transmission bandwidth as a single SSB pattern. In some aspects, if the transmission bandwidth for the PDSCH is 12 PRBs, PRBs may not be available for the PDSCH in symbols where the SSB is transmitted before or after the puncturing, as shown by example **800**. Example **800** shows that there are no PRBs available for PDSCH/DMRS in the OFDM symbols that transmit the SSB before (PRBs underneath the SSB **806** in the PDSCH/DMRS **808**) or after (above the SSB **806** in the PDSCH/DMRS **808**) the SSB that is punctured. That is, SSB REs after puncturing are not available for PDSCH/DMRS mapping, and since k_SSB=0 for the 12 PRB SSB relative to the 12 PRB transmission bandwidth in the 3 MHz channel bandwidth, there are no remaining PRBs (outside of the SSB) after puncturing in the SSB symbols within the 12 PRB transmission bandwidth.

[0121] In some aspects, as a first alternative, if the transmission bandwidth is 15 PRBs within a 3 MHz channel bandwidth, the PRBs containing the SSB before puncturing may not be available for the PDSCH in symbols where the SSB is transmitted, as shown by the "X" in example **802**. That is, the SSB REs after puncturing are not available for PDSCH/DMRS mapping, and because k_SSB=4 or 8 for a 12 PRB SSB relative to the 15 PRB transmission bandwidth, there may be only one remaining PRB not including the SSB after puncturing in the SSB symbols within the transmission bandwidth. If the only one remaining PRB in the OFDM symbols that transmit an SSS is not used for PDSCH/DMRS, the one PRB may not have a significant impact on the performance of the PDSCH.

[0122] In some aspects, as a second alternative, if the transmission bandwidth is 15 PRBs within the 3 MHz channel bandwidth, the PRBs containing the SSB after puncturing may not be available for the PDSCH in symbols where the SSB is transmitted, as shown by the "X" example **804**. There may be PRBs before the puncturing that are available. By being configured for either the first alternative or the second alternative (e.g., second alternative only), the UE may have more clarity as to whether PRBs are available when the SSB is punctured in the PDSCH/DMRS. As a result, the UE may not have misalignment with the transmitter side for the PDSCH/DMRS transmission resource due to uncertainty about available PRBs when the SSB is punctured. Furthermore, the UE may not have wrong DMRS/PDSCH detection due to uncertainty about available PRBs when the SSB is punctured. That is, if the second alternative is not specified, and each alternative is possible at the same time, where PRBs containing the SSB before and after puncturing can or cannot be available, the UE will have to perform the DMRS/PDSCH detection blindly. By being configured for the second alternative only (the PRBs containing the SSB after puncturing are not available for the PDSCH transmission resources), the UE may received the DMRS/PDSCH without performing blind detection.

[0123] In some aspects, a network entity may transmit an indication of whether the UE is to expect the first alternative or the second alternative. The indication may be included in an RRC message, a MAC-CE, or a DCI bit.

[0124] In some aspects, the first or second alternative may be used for the PDSCH and the DMRS for all UEs, including UEs associated or scrambled with a system information radio network temporary identifier (RNTI) (SI-RNTI), a random access RNTI (RA-RNTI), a msgB RNTI (MSGB-RNTI), a paging RNTI (P-RNTI), or a temporary cell RNTI (TC-RNTI). In some aspects, the first or second alternative may be used for the PDSCH and the DMRS for multicast or broadcast services (MBS), including UEs associated or scrambled with a group RNTI (G-RNTI), a group configured scheduling RNTI (G-CS-RNTI), or a multi-cast control channel RNTI (MCCH-RNTI). In some aspects, the first or second alternative may be used for the PDSCH and the DMRS for unicast in an RRC connected state. In such a case, the use of the first alternative or the second alternative may be based at least in part on a UE capability. The UE may indicate a UE capability for using the first alternative or the second alternative.

[0125] In some aspects, when receiving the PDSCH scheduled with SI-RNTI and the system information indicator in DCI is set to 1, RA-RNTI, MSGB-RNTI, P-RNTI or TC-RNTI, the UE assumes SSB transmission according to ssb-PositionsInBurst, and if the PDSCH resource allocation overlaps with PRBs containing SSB transmission resources, the UE may expect that the PRBs containing SSB transmission resources before puncturing, if applicable, are not available for PDSCH in the OFDM symbols where the SSB (associated with the same PCI) is transmitted.

[0126] In some aspects, when receiving the PDSCH scheduled with SI-RNTI and the system information indicator in DCI is set to 1, RA-RNTI, MSGB-RNTI, P-RNTI or TC-RNTI, the UE assumes SSB transmission according to ssb-PositionsInBurst, and if the PDSCH resource allocation overlaps with PRBs containing SSB transmission resources, the UE may expect that the PRBs containing SSB transmission resources after puncturing, if applicable, are not available for PDSCH in the OFDM symbols where the SSB (associated with the same PCI) is transmitted.

[0127] As indicated above, FIG. **8** is provided as an example. Other examples may differ from what is described with regard to FIG. **8**.

[0128] FIG. **9** is a diagram illustrating an example **900** associated with determining available PRBs, in accordance with the present disclosure. As shown in FIG. **9**, a network entity **910** (e.g., network node **110**) and a UE **920** (e.g., UE **120**) may communicate with one another via a wireless network (e.g., wireless communication network **100**).

[0129] As shown by reference number **925**, the network entity **910** may transmit an indication of whether PRBs are available before or after an SSB is punctured. This May include an indication of the first alternative or the second alternative described in connection with FIG. **8**. The network entity **910** may transmit the indication in DCI, a MAC-CE, or RRC signaling.

[0130] As shown by reference number **930**, the network entity **910** may transmit an SSB. The SSB may puncture PRBs for transmission of a PDSCH and DMRS. In some aspects, the PDSCH may be for unicast or multicast in an RRC connected mode. As shown by reference number **935**, the UE **920** may receive the SSB and identify a channel bandwidth to be a specific bandwidth less than 5 MHz. In example **900**, the channel bandwidth is 3 MHz. The UE **920** may identify the channel bandwidth to be 3 MHz based at least in part on a sync raster point of the SSB, which may be a synchronization raster point associated with 3 MHz. For example, the sync raster point may be associated with a 3 MHz channel bandwidth. The sync raster for a channel bandwidth of 3 MHz for each band is given in Table 5.4.3.3-2 in TS 38.101-1. In addition, different sync raster points may be associated with different transmission bandwidths. The UE **920** may identify the transmission bandwidth within the 3 MHz channel bandwidth based at least in part on the sync raster point of the SSB. For example, the sync raster point at GSCN 41637 corresponds to a 12 PRB transmission bandwidth within the 3 MHz channel bandwidth. The sync raster points at GSCN other than GSCN 41637 in Table 5.4.3.3-2 in TS 38.101-1 correspond to a 15 PRB transmission bandwidth within the 3 MHz channel bandwidth.

[0131] The UE **920** may determine whether PRBs are available based at least in part on the indicated alternative. For example, if a transmission bandwidth for the PDSCH is up to 12 PRBs, PRBs containing the SSB transmission resources before or after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted. The UE **920** may know not to expect PDSCH or DMRS in those PRBs when the PDSCH and the DMRS are transmitted, as shown by reference number **940**. The network entity **910** may transmit the PDSCH and the DMRS based at least in part on a resource mapping in which the SSB is punctured. The resource mapping may include symbols for an SSB and symbols for a PDSCH and DMRS. The resource mapping may or may not include PRBs that are available for the PDSCH and the DMRS in the symbols where the SSB is transmitted.

[0132] In some aspects associated with the first alternative, if the transmission bandwidth for the PDSCH is up to 15 PRBs, PRBs containing the SSB transmission resources before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted. The PRBs are not available based at least in part on a capability of the UE (which may be indicated to the network entity **910**).

[0133] In some aspects associated with the second alternative, if the transmission bandwidth for the PDSCH is up to 15 PRBs, PRBs containing the SSB transmission resources after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted. The PRBs may not be available based at least in part on a capability of the UE.

[0134] As indicated above, FIG. **9** is provided as an example. Other examples may differ from what is described with respect to FIG. **9**.

[0135] FIG. **10** is a diagram illustrating an example process **1000** performed, for example, at a UE or an apparatus of a UE, in accordance with the present disclosure. Example process **1000** is an example where the apparatus or the UE (e.g., UE **120**, UE **920**) performs operations associated with SSB puncturing for a channel bandwidth of less than 5 MHz (e.g., 3 MHz).

[0136] As shown in FIG. **10**, in some aspects, process **1000** may include receiving an SSB (block **1010**). For example, the UE (e.g., using reception component **1202** and/or communication manager **1206**, depicted in FIG. **12**) may receive an SSB, as described above.

[0137] As further shown in FIG. **10**, in some aspects, process **1000** may include identifying a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point (block **1020**). For example, the UE (e.g., using communication manager **1206**, depicted in FIG.

12) may identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point, as described above.

[0138] As further shown in FIG. **10**, in some aspects, process **1000** may include receiving a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured (block **1030**). For example, the UE (e.g., using reception component **1202** and/or communication manager **1206**, depicted in FIG. **12**) may receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured, as described above.

[0139] Process **1000** may include additional aspects, such as any single aspect or any combination of aspects described below and/or in connection with one or more other processes described elsewhere herein.

[0140] In a first aspect, the channel bandwidth is 3 MHz.

[0141] In a second aspect, alone or in combination with the first aspect, a transmission bandwidth for the PDSCH is up to 12 PRBs, and PRBs containing the SSB transmission resources before or after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted. For example, the PRBs containing the SSB transmission resources only before puncturing or only after puncturing are not available (and not both before and after the puncturing).

[0142] In a third aspect, alone or in combination with one or more of the first and second aspects, a transmission bandwidth for the PDSCH is up to 15 PRBs, and PRBs containing the SSB transmission resources before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0143] In a fourth aspect, alone or in combination with one or more of the first through third aspects, the PRBs are not available based at least in part on a capability of the UE. In some aspects, the process may include receiving the PDSCH and the DMRS without performing blind detection.

[0144] In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, a transmission bandwidth for the PDSCH is up to 15 PRBs, PRBs containing the SSB transmission resources after the puncturing are not available for the PDSCH, and PRBs not containing the SSB transmission resources after puncturing are available for the PDSCH in symbols where the SSB is transmitted.

[0145] In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, the PRBs are available based at least in part on a capability of the UE.

[0146] In a seventh aspect, alone or in combination with one or more of the first through sixth aspects, the PDSCH is at least for unicast in an RRC connected mode.

[0147] In an eighth aspect, alone or in combination with one or more of the first through seventh aspects, process **1000** includes receiving an indication of whether PRBs containing the SSB transmission resources before or after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

[0148] Although FIG. **10** shows example blocks of process **1000**, in some aspects, process **1000** may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in FIG. **10**. Additionally, or alternatively, two or more of the blocks of process **1000** may be performed in parallel.

[0149] FIG. **11** is a diagram illustrating an example process **1100** performed, for example, at a network entity or an apparatus of a network entity, in accordance with the present disclosure. Example process **1100** is an example where the apparatus or the network entity (e.g., network node **110**, network entity **910**) performs operations associated with SSB puncturing for a channel bandwidth less than 5 MHz (e.g., 3 MHz).

[0150] As shown in FIG. **11**, in some aspects, process **1100** may include transmitting an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz (block **1110**). For example, the network entity (e.g., using transmission component **1304** and/or communication manager **1306**, depicted in FIG. **13**) may transmit an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz, as described above.

[0151] As further shown in FIG. **11**, in some aspects, process **1100** may include transmitting a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured (block **1120**). For example, the network entity (e.g., using transmission component **1304** and/or communication manager **1306**, depicted in FIG. **13**) may transmit a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured, as described above.

[0152] Process **1100** may include additional aspects, such as any single aspect or any combination of aspects described below and/or in connection with one or more other processes described elsewhere herein.

[0153] In a first aspect, the channel bandwidth is 3 MHz.

[0154] In a second aspect, alone or in combination with the first aspect, a transmission bandwidth for the PDSCH is up to 12 PRBs, and PRBs containing the SSB transmission resources before or after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0155] In a third aspect, alone or in combination with one or more of the first and second aspects, a transmission bandwidth for the PDSCH is up to 15 PRBs, and PRBs containing the SSB transmission resources before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0156] In a fourth aspect, alone or in combination with one or more of the first through third aspects, the PRBs are not available based at least in part on a capability of a UE.

[0157] In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, a transmission bandwidth for the PDSCH is up to 15 PRBs, PRBs containing the SSB transmission resources after the puncturing are not available for the PDSCH, and PRBs not containing the SSB transmission resources after puncturing are available for the PDSCH in symbols where the SSB is transmitted.

[0158] In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, the PRBs are available based at least in part on a capability of a UE.

[0159] In a seventh aspect, alone or in combination with one or more of the first through sixth aspects, the PDSCH is at least for unicast in a radio resource control connected mode.

[0160] In an eighth aspect, alone or in combination with one or more of the first through seventh aspects, process **1100** includes transmitting an indication of whether PRBs containing the SSB transmission resources before or after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

[0161] Although FIG. **11** shows example blocks of process **1100**, in some aspects, process **1100** may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in FIG. **11**. Additionally, or alternatively, two or more of the blocks of process **1100** may be performed in parallel.

[0162] FIG. **12** is a diagram of an example apparatus **1200** for wireless communication, in accordance with the present disclosure. The apparatus **1200** may be a UE, or a UE may include the apparatus **1200**. In some aspects, the apparatus **1200** includes a reception component **1202**, a transmission component **1204**, and/or a communication manager **1206**, which may be in communication with one another (for example, via one or more buses and/or one or more other components). In some aspects, the communication manager **1206** is the communication manager **140** described in connection with FIG. **1**. As shown, the apparatus **1200** may communicate with another apparatus **1208**, such as a UE or a network node (such as a CU, a DU, an RU, or a base station), using the reception component **1202** and the transmission component **1204**.

[0163] In some aspects, the apparatus **1200** may be configured to perform one or more operations described herein in connection with FIGS. **1-9**. Additionally, or alternatively, the apparatus **1200** may be configured to perform one or more processes described herein, such as process **1000** of FIG. **10**. In some aspects, the apparatus **1200** and/or one or more components shown in FIG. **12** may include one or more components of the UE described in connection with FIG. **2**. Additionally, or alternatively, one or more components shown in FIG. **12** may be implemented within one or more components described in connection with FIG. **2**. Additionally, or alternatively, one or more components of the set of components may be implemented at least in part as software stored in one or more memories. For example, a component (or a portion of a component) may be implemented as instructions or code stored in a non-transitory computer-readable medium and executable by one or more controllers or one or more processors to perform the functions or operations of the component.

[0164] The reception component **1202** may receive communications, such as reference signals, control information, data communications, or a combination thereof, from the apparatus **1208**. The reception component **1202** may provide received communications to one or more other components of the apparatus **1200**. In some aspects, the reception component **1202** may perform signal processing on the received communications (such as filtering, amplification, demodulation, analog-to-digital conversion, demultiplexing, deinterleaving, de-mapping, equalization, interference cancellation, or decoding, among other examples), and may provide the processed signals to the one or more other components of the apparatus **1200**. In some aspects, the reception component **1202** may include one or more antennas, one or more modems, one or more demodulators, one or more MIMO detectors, one or more receive processors, one or more controllers/processors, one or more memories, or a combination thereof, of the UE described in connection with FIG. **2**.

[0165] The transmission component **1204** may transmit communications, such as reference signals, control information, data communications, or a combination thereof, to the apparatus **1208**. In some aspects, one or more other components of the apparatus **1200** may generate communications and may provide the generated communications to the transmission component **1204** for transmission to the apparatus **1208**. In some aspects, the transmission component **1204** may perform signal processing on the generated communications (such as filtering, amplification, modulation, digital-to-analog conversion, multiplexing, interleaving, mapping, or encoding, among other examples), and may transmit the processed signals to the apparatus **1208**. In some aspects, the transmission component **1204** may include one or more antennas, one or more modems, one or more modulators, one or more transmit MIMO processors, one or more transmit processors, one or more controllers/processors, one or more memories, or a combination thereof, of the UE described in connection with FIG. **2**. In some aspects, the transmission component **1204** may be co-located with the reception component **1202** in one or more transceivers.

[0166] The communication manager **1206** may support operations of the reception component **1202** and/or the transmission component **1204**. For example, the communication manager **1206** may receive information associated with configuring reception of communications by the reception component **1202** and/or transmission of communications by the transmission component **1204**. Additionally, or alternatively, the communication manager **1206** may generate and/or provide control information to the reception component **1202** and/or the transmission component **1204** to control reception and/or transmission of communications.

[0167] The reception component **1202** may receive an SSB. The communication manager **1206** may identify a channel bandwidth to be less than 5 MHz based at least in part on a synchronization raster point. The reception component **1202** may receive a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0168] The reception component **1202** may receive an indication of whether PRBs containing the SSB transmission resources before or after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

[0169] The number and arrangement of components shown in FIG. **12** are provided as an example. In practice, there may be additional components, fewer components, different components, or differently arranged components than those shown in FIG. **12**. Furthermore, two or more components shown in FIG. **12** may be implemented within a single component, or a single component shown in FIG. **12** may be implemented as multiple, distributed components. Additionally, or alternatively, a set of (one or more) components shown in FIG. **12** may perform one or more functions described as being performed by another set of components shown in FIG. **12**.

[0170] FIG. **13** is a diagram of an example apparatus **1300** for wireless communication, in accordance with the present disclosure. The apparatus **1300** may be a network entity, or a network entity may include the apparatus **1300**. In some aspects, the apparatus **1300** includes a reception component **1302**, a transmission component **1304**, and/or a communication manager **1306**, which may be in communication with one another (for example, via one or more buses and/or one or more other components). In some aspects, the communication manager **1306** is the communication manager **150** described in connection with FIG. **1**. As shown, the apparatus **1300** may communicate with another apparatus **1308**, such as a UE or a network node (such as a CU, a DU, an RU, or a base station), using the reception component **1302** and the transmission component **1304**.

[0171] In some aspects, the apparatus **1300** may be configured to perform one or more operations described herein in connection with FIGS. **1-9**. Additionally, or alternatively, the apparatus **1300** may be configured to perform one or more processes described herein, such as process **1100** of FIG. **11**. In some aspects, the apparatus **1300** and/or one or more components shown in FIG. **13** may include one or more components of the network entity described in connection with FIG. **2**. Additionally, or alternatively, one or more components shown in FIG. **13** may be implemented within one or more components described in connection with FIG. **2**. Additionally, or alternatively, one or more components of the set of components may be implemented at least in part as software stored in one or more memories. For example, a component (or a portion of a component) may be implemented as instructions or code stored in a non-transitory computer-readable medium and executable by one or more controllers or one or more processors to perform the functions or operations of the component.

[0172] The reception component **1302** may receive communications, such as reference signals, control information, data communications, or a combination thereof, from the apparatus **1308**. The reception component **1302** may provide received communications to one or more other components of the apparatus **1300**. In some aspects, the reception component **1302** may perform signal processing on the received communications (such as filtering, amplification, demodulation, analog-to-digital conversion, demultiplexing, deinterleaving, de-mapping, equalization, interference cancellation, or decoding, among other examples), and may provide the processed signals to the one or more other components of the apparatus **1300**. In some aspects, the reception component **1302** may include one or more antennas, one or more modems, one or more demodulators, one or more MIMO detectors, one or more receive processors, one or more controllers/processors, one or more memories, or a combination thereof, of the network entity described in connection with FIG. **2**.

[0173] The transmission component **1304** may transmit communications, such as reference signals, control information, data communications, or a combination thereof, to the apparatus **1308**. In some aspects, one or more other components of the apparatus **1300** may generate communications and may provide the generated communications to the transmission component **1304** for transmission to the apparatus **1308**. In some aspects, the transmission component **1304** may perform signal processing on the generated communications (such as filtering, amplification, modulation, digital-to-analog conversion, multiplexing, interleaving, mapping, or encoding, among other examples), and may transmit the processed signals to the apparatus **1308**. In some aspects, the transmission component **1304** may include one or more antennas, one or more modems, one or more modulators, one or more transmit MIMO processors, one or more transmit processors, one or more controllers/processors, one or more memories, or a combination thereof, of the network entity described in connection with FIG. **2**. In some aspects, the transmission component **1304** may be co-located with the reception component **1302** in one or more transceivers.

[0174] The communication manager **1306** may support operations of the reception component **1302** and/or the transmission component **1304**. For example, the communication manager **1306** may receive information associated with configuring reception of communications by the reception component **1302** and/or transmission of communications by the transmission component **1304**. Additionally, or alternatively, the communication manager **1306** may generate and/or provide control information to the reception component **1302** and/or the transmission component **1304** to control reception and/or transmission of communications.

[0175] The transmission component **1304** may transmit an SSB at a synchronization raster point that is associated with a channel bandwidth that is less than 5 MHz. The transmission component **1304** may transmit a PDSCH and a DMRS based at least in part on a resource mapping in which the SSB is punctured.

[0176] The transmission component **1304** may transmit an indication of whether PRBs containing the SSB transmission resources before or after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

[0177] The number and arrangement of components shown in FIG. **13** are provided as an example. In practice, there may be additional components, fewer components, different components, or differently arranged components than those shown in FIG. **13**. Furthermore, two or more components shown in FIG. **13** may be implemented within a single component, or a single component shown in FIG. **13** may be implemented as multiple, distributed components. Additionally, or alternatively, a set of (one or more) components shown in FIG. **13** may perform one or more functions described as being performed by another set of components shown in FIG. **13**.

[0178] The following provides an overview of some Aspects of the present disclosure:

[0179] Aspect 1: A method of wireless communication performed by a user equipment (UE), comprising: receiving a synchronization signal block (SSB); identifying a channel bandwidth to be less than 5 megahertz (MHz) based at least in part on a synchronization raster point; and receiving a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured.

[0180] Aspect 2: The method of Aspect 1, wherein the channel bandwidth is 3 MHz.

[0181] Aspect 3: The method of any of Aspects 1-2, wherein a transmission bandwidth for the PDSCH is up to 12 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0182] Aspect 4: The method of any of Aspects 1-2, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0183] Aspect 5: The method of Aspect 1, wherein receiving the PDSCH and the DMRS includes receiving the PDSCH and the DMRS without performing blind detection.

[0184] Aspect 6: The method of any of Aspects 1-2, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH, and PRBs not containing the SSB after puncturing are available for the PDSCH in symbols where the SSB is transmitted.

[0185] Aspect 7: The method of Aspect 6, wherein the PRBs are available based at least in part on a capability of the UE.

[0186] Aspect 8: The method of Aspect 6, wherein the PDSCH is at least for unicast in a radio resource control connected mode.

[0187] Aspect 9: The method of any of Aspects 1-8, further comprising receiving an indication of whether PRBs containing the SSB after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

[0188] Aspect 10: A method of wireless communication performed by a network entity, comprising: transmitting a synchronization signal block (SSB) at a synchronization raster point that is associated with a channel bandwidth that is less than 5 megahertz (MHz); and transmitting a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured.

[0189] Aspect 11: The method of Aspect 10, wherein the channel bandwidth is 3 MHz.

[0190] Aspect 12: The method of any of Aspects 10-11, wherein a transmission bandwidth for the PDSCH is up to 12 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0191] Aspect 13: The method of any of Aspects 10-11, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

[0192] Aspect 14: The method of Aspect 13, wherein the PRBs are not available based at least in part on a capability of a user equipment (UE).

[0193] Aspect 15: The method of any of Aspects 10-11, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH, and PRBs not containing the SSB after puncturing are available for the PDSCH in symbols where the SSB is transmitted.

[0194] Aspect 16: The method of Aspect 15, wherein the PRBs are available based at least in part on a capability of a user equipment (UE).

[0195] Aspect 17: The method of Aspect 15, wherein the PDSCH is at least for unicast in a radio resource control connected mode.

[0196] Aspect 18: The method of any of Aspects 10-17, further comprising transmitting an indication of whether PRBs containing the SSB before or after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

[0197] Aspect 19: An apparatus for wireless communication at a device, the apparatus comprising one or more processors; one or more memories coupled with the one or more processors; and instructions stored in the one or more memories and executable by the one or more processors to cause the apparatus to perform the method of one or more of Aspects 1-18.

[0198] Aspect 20: An apparatus for wireless communication at a device, the apparatus comprising one or more memories and one or more processors coupled to the one or more memories, the one or more processors configured to cause the device to perform the method of one or more of Aspects 1-18.

[0199] Aspect 21: An apparatus for wireless communication, the apparatus comprising at least one means for performing the method of one or more of Aspects 1-18.

[0200] Aspect 22: A non-transitory computer-readable medium storing code for wireless communication, the code comprising instructions executable by one or more processors to perform the method of one or more of Aspects 1-18.

[0201] Aspect 23: A non-transitory computer-readable medium storing a set of instructions for wireless communication, the set of instructions comprising one or more instructions that, when executed by one or more processors of a device, cause the device to perform the method of one or more of Aspects 1-18.

[0202] Aspect 24: A device for wireless communication, the device comprising a processing system that includes one or more processors and one or more memories coupled with the one or more processors, the processing system configured to cause the device to perform the method of one or more of Aspects 1-18.

[0203] Aspect 25: An apparatus for wireless communication at a device, the apparatus comprising one or more memories and one or more processors coupled to the one or more memories, the one or more processors individually or collectively configured to cause the device to perform the method of one or more of Aspects 1-18.

[0204] The foregoing disclosure provides illustration and description but is not intended to be exhaustive or to limit the aspects to the precise forms disclosed. Modifications and variations may be made in light of the above disclosure or may be acquired from practice of the aspects.

[0205] As used herein, the term "component" is intended to be broadly construed as hardware or a combination of hardware and at least one of software or firmware. "Software" shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, or functions, among other examples, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. As used herein, a "processor" is implemented in hardware or a combination of hardware and software. It will be apparent that systems or methods described herein may be implemented in different forms of hardware or a combination of hardware and software. The actual specialized control hardware or software code used to implement these systems or methods is not limiting of the aspects. Thus, the operation and behavior of the systems or methods are described herein without reference to specific software code, because those skilled in the art will understand that software and hardware can be designed to implement the systems or methods based, at least in part, on the description herein. A component being configured to perform a function means that the component has a capability to perform the function, and does not require the function to be actually performed by the component, unless noted otherwise.

[0206] As used herein, "satisfying a threshold" may, depending on the context, refer to a value being greater than the threshold, greater than or equal to the threshold, less than the threshold, less than or equal to the threshold, equal to the threshold, or not equal to the threshold, among other examples.

[0207] As used herein, a phrase referring to “at least one of” a list of items refers to any combination of those items, including single members. As an example, “at least one of: a, b, or c” is intended to cover a, b, c, a+b, a+c, b+c, and a+b+c, as well as any combination with multiples of the same element (for example, a+a, a+a+a, a+a+b, a+a+c, a+b+b, a+c+c, b+b, b+b+b, b+b+c, c+c, and c+c+c, or any other ordering of a, b, and c).

[0208] No element, act, or instruction used herein should be construed as critical or essential unless explicitly described as such. Also, as used herein, the articles “a” and “an” are intended to include one or more items and may be used interchangeably with “one or more.” Further, as used herein, the article “the” is intended to include one or more items referenced in connection with the article “the” and may be used interchangeably with “the one or more.” Furthermore, as used herein, the terms “set” and “group” are intended to include one or more items and may be used interchangeably with “one or more.” Where only one item is intended, the phrase “only one” or similar language is used. Also, as used herein, the terms “has,” “have,” “having,” and similar terms are intended to be open-ended terms that do not limit an element that they modify (for example, an element “having” A may also have B). Further, the phrase “based on” is intended to mean “based on or otherwise in association with” unless explicitly stated otherwise. Also, as used herein, the term “or” is intended to be inclusive when used in a series and may be used interchangeably with “and/or,” unless explicitly stated otherwise (for example, if used in combination with “either” or “only one of”). It should be understood that “one or more” is equivalent to “at least one.”

[0209] Even though particular combinations of features are recited in the claims or disclosed in the specification, these combinations are not intended to limit the disclosure of various aspects. Many of these features may be combined in ways not specifically recited in the claims or disclosed in the specification. The disclosure of various aspects includes each dependent claim in combination with every other claim in the claim set.

What is claimed is:

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

one or more memories; and

one or more processors, coupled to the one or more memories, individually or collectively configured to cause the UE to:

receive a synchronization signal block (SSB);

identify a channel bandwidth to be less than 5 megahertz (MHz) based at least in part on a synchronization raster point; and

receive a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured.

2. The apparatus of claim **1**, wherein the channel bandwidth is 3 MHz.

3. The apparatus of claim **1**, wherein a transmission bandwidth for the PDSCH is up to 12 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

4. The apparatus of claim **1**, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

5. The apparatus of claim **1**, wherein to receive the PDSCH and the DMRS, the one or more processors are individually or collectively configured to cause the UE to receive the PDSCH and the DMRS without performing blind detection.

6. The apparatus of claim **1**, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

7. The apparatus of claim **6**, wherein PRBs not containing the SSB after puncturing are available for the PDSCH.

8. The apparatus of claim **6**, wherein the PRBs are available based at least in part on a capability of the UE.

9. The apparatus of claim **6**, wherein the PDSCH is at least for unicast in a radio resource control connected mode.

10. The apparatus of claim **1**, wherein the one or more processors are individually or collectively configured to cause the UE to receive an indication of whether PRBs containing the SSB after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

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

one or more memories; and

one or more processors, coupled to the one or more memories, individually or collectively configured to cause the network entity to:

transmit a synchronization signal block (SSB) at a synchronization raster point that is associated with a channel bandwidth that is less than 5 megahertz (MHz); and

transmit a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured.

12. The apparatus of claim **11**, wherein the channel bandwidth is 3 MHz.

13. The apparatus of claim **11**, wherein a transmission bandwidth for the PDSCH is up to 12 physical resource blocks (PRBs), and wherein PRBs containing the SSB after the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

14. The apparatus of claim **11**, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB before the puncturing are not available for the PDSCH in symbols where the SSB is transmitted.

15. The apparatus of claim **11**, wherein a transmission bandwidth for the PDSCH is up to 15 physical resource blocks (PRBs), and wherein PRBs containing the SSB after puncturing are available for the PDSCH in symbols where the SSB is transmitted.

16. The apparatus of claim **15**, wherein the PRBs are available based at least in part on a capability of a user equipment (UE).

17. The apparatus of claim **15**, wherein the PDSCH is at least for unicast in a radio resource control connected mode.

18. The apparatus of claim **11**, wherein the one or more processors are individually or collectively configured to cause the network entity to transmit an indication of whether PRBs containing the SSB before or after the puncturing are to be not available for PDSCH in symbols where the SSB is transmitted.

19. A method of wireless communication performed by a user equipment (UE), comprising:

receiving a synchronization signal block (SSB);

identifying a channel bandwidth to be less than 5 megahertz (MHz) based at least in part on a synchronization raster point; and

receiving a physical downlink shared channel (PDSCH) and a demodulation reference signal (DMRS) based at least in part on a resource mapping in which the SSB is punctured.

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