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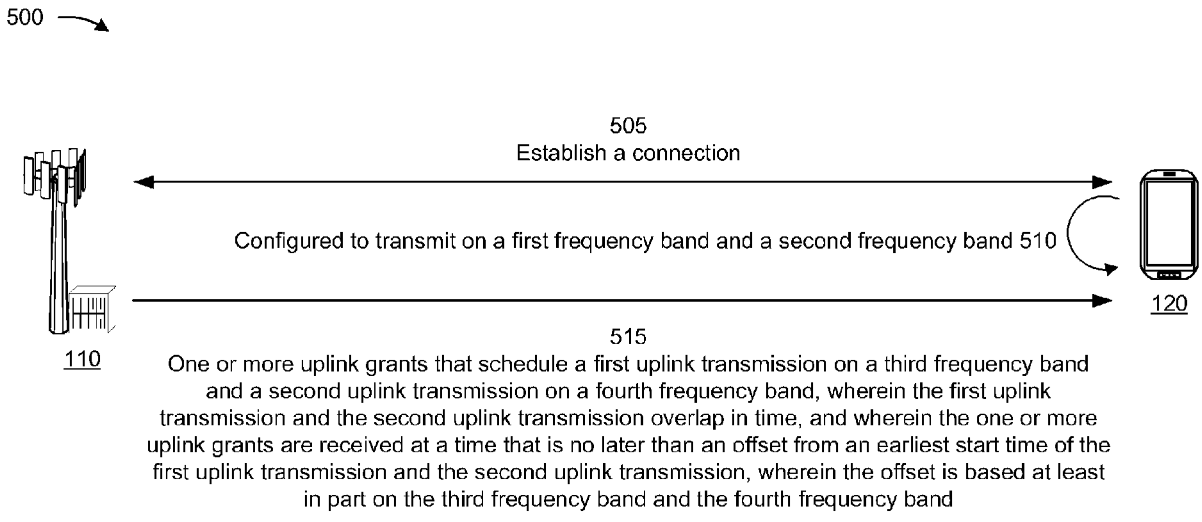

FIG. 5

(57) **Abstract:** Various aspects of the present disclosure generally relate to wireless communication. In some aspects, a user equipment (UE) may establish a connection with a network node. The UE may receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band. Numerous other aspects are described.

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[Continued on next page]

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SCHEDULING UPLINK TRANSMISSIONS ON MULTIPLE FREQUENCY BANDS

FIELD OF THE DISCLOSURE

[0001] Aspects of the present disclosure generally relate to wireless communication and to techniques and apparatuses for scheduling uplink transmissions on multiple frequency bands.

BACKGROUND

[0002] Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources (e.g., bandwidth, transmit power, or the like). Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, time division synchronous code division multiple access (TD-SCDMA) systems, and Long Term Evolution (LTE). LTE/LTE-Advanced is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) mobile standard promulgated by the Third Generation Partnership Project (3GPP).

[0003] A wireless network may include one or more network nodes that support communication for wireless communication devices, such as a user equipment (UE) or multiple UEs. A UE may communicate with a network node via downlink communications and uplink communications. “Downlink” (or “DL”) refers to a communication link from the network node to the UE, and “uplink” (or “UL”) refers to a communication link from the UE to the network node. Some wireless networks may support device-to-device communication, such as via a local link (e.g., a sidelink (SL), a wireless local area network (WLAN) link, and/or a wireless personal area network (WPAN) link, among other examples).

[0004] The above multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different UEs to communicate on a municipal, national, regional, and/or global level. New Radio

(NR), which may be referred to as 5G, is a set of enhancements to the LTE mobile standard promulgated by the 3GPP. NR is designed to better support mobile broadband internet access by improving spectral efficiency, lowering costs, improving services, making use of new spectrum, and better integrating with other open standards using orthogonal frequency division multiplexing (OFDM) with a cyclic prefix (CP) (CP-OFDM) on the downlink, using CP-OFDM and/or single-carrier frequency division multiplexing (SC-FDM) (also known as discrete Fourier transform spread OFDM (DFT-s-OFDM)) on the uplink, as well as supporting beamforming, multiple-input multiple-output (MIMO) antenna technology, and carrier aggregation. As the demand for mobile broadband access continues to increase, further improvements in LTE, NR, and other radio access technologies remain useful.

SUMMARY

[0005] Some aspects described herein relate to a user equipment (UE) for wireless communication. The UE may include a memory and one or more processors coupled to the memory. The one or more processors may be configured to establish a connection with a network node. The one or more processors may be configured to receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0006] Some aspects described herein relate to a UE for wireless communication. The UE may include a memory and one or more processors coupled to the memory. The one or more processors may be configured to establish a connection with a network node. The one or more processors may be configured to receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0007] Some aspects described herein relate to a network node for wireless communication. The network node may include a memory and one or more processors coupled to the memory. The one or more processors may be configured to establish a connection with a UE. The one or more processors may be configured to output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0008] Some aspects described herein relate to a network node for wireless communication. The network node may include a memory and one or more processors coupled to the memory. The one or more processors may be configured to establish a connection with a UE. The one or more processors may be configured to output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0009] Some aspects described herein relate to a method of wireless communication performed by a UE. The method may include establishing a connection with a network node. The method may include receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0010] Some aspects described herein relate to a method of wireless communication performed by a UE. The method may include establishing a connection with a network node. The method may include receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0011] Some aspects described herein relate to a method of wireless communication performed by a network node. The method may include establishing a connection with a UE. The method may include outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0012] Some aspects described herein relate to a method of wireless communication performed by a network node. The method may include establishing a connection with a UE. The method may include outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0013] 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 establish a connection with a network node. The set of instructions, when executed by one or more processors of the UE, may cause the UE to receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0014] 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 establish a connection with a network node. The set of instructions, when executed by one or more processors of the UE, may cause the UE to receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0015] Some aspects described herein relate to a non-transitory computer-readable medium that stores a set of instructions for wireless communication by a network node. The set of instructions, when executed by one or more processors of the network node, may cause the network node to establish a connection with a UE. The set of instructions, when executed by one or more processors of the network node, may cause the network node to output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0016] Some aspects described herein relate to a non-transitory computer-readable medium that stores a set of instructions for wireless communication by a network node. The set of instructions, when executed by one or more processors of the network node, may cause the network node to establish a connection with a UE. The set of instructions, when executed by one or more processors of the network node, may cause the network node to output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0017] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for establishing a connection with a network node. The apparatus may include means for receiving, while the apparatus is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0018] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for establishing a connection with a network node. The apparatus may include means for receiving, while the apparatus is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0019] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for establishing a connection with a UE. The apparatus may include means for outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0020] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for establishing a connection with a UE. The apparatus may include means for outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0021] Aspects generally include a method, apparatus, system, computer program product, non-transitory computer-readable medium, UE, base station, network entity, network node, wireless communication device, and/or processing system as substantially described herein with reference to and as illustrated by the drawings and specification.

[0022] The foregoing has outlined rather broadly the features and technical advantages of examples according to the disclosure in order that the detailed description that follows may be better understood. Additional features and advantages will be described hereinafter. The conception and specific examples disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. Such equivalent constructions do not depart from the scope of the appended claims. Characteristics of the concepts 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 figures. Each of the figures is provided for the purposes of illustration and description, and not as a definition of the limits of the claims.

[0023] While aspects are described in the present disclosure by illustration to some examples, those skilled in the art will understand that such aspects may be implemented in many different arrangements and scenarios. Techniques described herein may be implemented using different platform types, devices, systems, shapes, sizes, and/or packaging arrangements. For example, some aspects may be implemented via integrated chip embodiments or other non-module-component based devices (e.g., end-user devices, vehicles, communication devices, computing devices, industrial equipment, retail/purchasing devices, medical devices, and/or artificial intelligence devices). Aspects may be implemented in chip-level components, modular components, non-modular components, non-chip-level components, device-level components, and/or system-level components. Devices incorporating described aspects and features may include additional components and features for implementation and practice of claimed and described aspects. For example, transmission and reception of wireless signals may include one or more components for analog and digital purposes (e.g., hardware components including antennas, radio frequency (RF) chains, power amplifiers, modulators, buffers, processors, interleavers, adders, and/or summers). It is intended that aspects described herein may be practiced in a wide variety of devices, components, systems, distributed arrangements, and/or end-user devices of varying size, shape, and constitution.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] So that the above-recited features of the present disclosure can be understood in detail, a more particular description, briefly summarized above, may be had by reference to aspects, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only certain typical aspects of this disclosure and are therefore not to be considered limiting of its scope, for the description may admit to other equally effective aspects. The same reference numbers in different drawings may identify the same or similar elements.

[0025] Fig. 1 is a diagram illustrating an example of a wireless network, in accordance with the present disclosure.

[0026] Fig. 2 is a diagram illustrating an example of a network node in communication with a user equipment (UE) in a wireless network, in accordance with the present disclosure.

[0027] Fig. 3 is a diagram illustrating an example disaggregated base station architecture, in accordance with the present disclosure.

[0028] Fig. 4 illustrates an example table of values of physical uplink shared channel (PUSCH) preparation time parameter, in accordance with the present disclosure.

[0029] Fig. 5 is a diagram illustrating an example of scheduling uplink transmissions that overlap in time on multiple frequency bands, in accordance with the present disclosure.

[0030] Fig. 6 is a diagram illustrating an example timeline of scheduling uplink transmissions that overlap in time on multiple frequency bands, in accordance with the present disclosure.

[0031] Fig. 7 is a diagram illustrating an example of scheduling uplink transmissions that do not overlap in time on multiple frequency bands, in accordance with the present disclosure.

[0032] Fig. 8 is a diagram illustrating example timelines of scheduling uplink transmissions that do not overlap in time on multiple frequency bands, in accordance with the present disclosure.

[0033] Fig. 9 is a diagram illustrating an example process performed, for example, by a UE, in accordance with the present disclosure.

[0034] Fig. 10 is a diagram illustrating an example process performed, for example, by a UE, in accordance with the present disclosure.

[0035] Fig. 11 is a diagram illustrating an example process performed, for example, by a network node, in accordance with the present disclosure.

[0036] Fig. 12 is a diagram illustrating an example process performed, for example, by a network node, in accordance with the present disclosure.

[0037] Fig. 13 is a diagram of an example apparatus for wireless communication, in accordance with the present disclosure.

[0038] Fig. 14 is a diagram of an example apparatus for wireless communication, in accordance with the present disclosure.

DETAILED DESCRIPTION

[0039] Transmission switching may enable a user equipment (UE) to transmit uplink transmissions over different frequency bands. For uplink transmission switching involving a single pair of frequency bands, a UE may transmit a first uplink transmission over a first frequency band, perform one or more transmission switching operations to switch to a second frequency band, and transmit a second uplink transmission over the second frequency band. Uplink transmission switching for a single pair of frequency bands may involve a minimum processing time for the UE to switch from the first frequency band to the second frequency band. For example, the minimum processing time may allow time for the UE to prepare the uplink data, prepare a transmit chain (e.g., tuning from the first frequency band to the second frequency band), or the like. Providing the UE with the minimum processing time to perform the transmission switching may help ensure that the UE transmits the second uplink transmission as scheduled.

[0040] A minimum processing time is not well-defined for uplink transmission switching involving multiple pairs of frequency bands. For example, if a UE is initially tuned to a first frequency band and a second frequency band simultaneously, and the UE receives one or more uplink grants that schedule uplink transmissions on a third frequency band and a fourth frequency band, then the UE may have insufficient time to switch to the third frequency band and/or the fourth frequency band in time to transmit one or more of the uplink transmissions. As a result, the UE may fail to transmit the uplink transmission(s) as scheduled.

[0041] Implementations are provided herein for scheduling uplink transmissions (e.g., overlapping uplink transmissions or non-overlapping transmissions) on multiple frequency bands. In some implementations, the uplink transmissions overlap in time (e.g., the uplink transmissions at least partially overlap in time). For example, a UE may establish a connection with a network node and, while the UE is configured to transmit on a first frequency band and a second frequency band, may receive one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band. The first uplink transmission and the second uplink transmission may overlap in time. The UE may receive the one or more uplink grants at a time that is no later than an offset (e.g., a "Y , parameter value) from an earliest start time of the first uplink transmission and the second uplink transmission. The offset may be based at least in part on the third frequency band and the fourth frequency band.

[0042] In some implementations, the uplink transmissions do not overlap in time. For example, the UE may establish a connection with a network node and, while the UE is configured to transmit on a first frequency band and a second frequency band, may receive one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band. The first uplink transmission and the second uplink transmission do not overlap in time. The one or more uplink grants may schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0043] Scheduling the uplink transmissions in accordance with the implementations described herein help to ensure that a UE is afforded at least a minimum processing time to perform uplink transmission switching involving multiple pairs of frequency bands. In the case where the uplink transmissions overlap in time, receiving the one or more uplink grants at the time that is no later than the offset from the earliest start time of the first uplink transmission and the second uplink transmission may help to ensure that the UE has sufficient time to perform transmission switching. In the case where the uplink transmissions do not overlap in time, scheduling the second uplink transmission based at least in part on the minimum separation time between the end time of the first uplink transmission and the start time of the second uplink transmission may help to ensure that the UE has sufficient time to perform transmission switching. In either case, the UE may perform transmission switching and, thus, may transmit the first uplink transmission and/or the second uplink transmission as scheduled.

[0044] Various aspects of the disclosure are described more fully hereinafter with reference to the accompanying drawings. This disclosure may, however, be embodied in many different forms and should not be construed as limited to any specific structure or function presented throughout 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 should appreciate that the scope of the disclosure is intended to cover any aspect of the disclosure disclosed herein, whether implemented independently of or combined with any other aspect of the disclosure. For example, an apparatus may be implemented or a method may be practiced using any number of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover such an apparatus or method which is practiced using other structure, functionality, or structure and functionality in addition to or other than the various aspects of the disclosure set forth herein. It should be understood that any aspect of the disclosure disclosed herein may be embodied by one or more elements of a claim.

[0045] Several aspects of telecommunication systems will now be presented with reference to various apparatuses and techniques. These 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, algorithms, or the like (collectively referred to as "elements"). These elements may be implemented using hardware, software, or combinations thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0046] While aspects may be described herein using terminology commonly associated with a 5G or New Radio (NR) radio access technology (RAT), aspects of the present disclosure can be applied to other RATs, such as a 3G RAT, a 4G RAT, and/or a RAT subsequent to 5G (e.g., 6G).

[0047] Fig. 1 is a diagram illustrating an example of a wireless network 100, in accordance with the present disclosure. The wireless network 100 may be or may include elements of a 5G (e.g., NR) network and/or a 4G (e.g., Long Term Evolution (LTE)) network, among other examples. The wireless network 100 may include one or more network nodes 110 (shown as a network node 110a, a network node 110b, a network node 110c, and a network node 110d), a UE 120 or multiple UEs 120 (shown as a UE 120a, a UE 120b, a UE 120c, a UE 120d, and a UE 120e), and/or other entities. A network node 110 is a network node that communicates with UEs 120. As shown, a network node 110 may include one or more network nodes. For example, a network node 110 may be an aggregated network node, meaning that the aggregated network node is configured to utilize a radio protocol stack that is physically or logically integrated within a single radio access network (RAN) node (e.g., within a single device or unit). As another example, a network node 110 may be a disaggregated network node (sometimes referred to as a disaggregated base station), meaning that the network node 110 is configured to utilize a protocol stack that is physically or logically distributed among two or more nodes (such as one or more central units (CUs), one or more distributed units (DUs), or one or more radio units (RUs)).

[0048] In some examples, a network node 110 is or includes a network node that communicates with UEs 120 via a radio access link, such as an RU. In some examples, a network node 110 is or includes a network node that communicates with other network nodes 110 via a fronthaul link or a midhaul link, such as a DU. In some examples, a network node 110 is or includes a network node that communicates with other network nodes 110 via a midhaul link or a core network via a backhaul link, such as a CU. In some examples, a network node 110 (such as an aggregated network node 110 or a disaggregated network node 110) may include multiple network nodes, such as one or more RUs, one or more CUs, and/or one or more DUs. A network node 110 may include, for example, an NR base station, an LTE base station, a Node B, an eNB (e.g., in 4G), a gNB (e.g., in 5G), an access point, a transmission reception point (TRP), a DU, an RU, a CU, a mobility element of a network, a core network node, a network element, a network equipment, a RAN node, or a combination thereof. In some examples, the network nodes 110 may be interconnected to one another or to one or more other network nodes 110 in the wireless network 100 through various types of fronthaul, midhaul, and/or backhaul interfaces, such as a direct physical connection, an air interface, or a virtual network, using any suitable transport network.

[0049] In some examples, a network node 110 may provide communication coverage for a particular geographic area. In the Third Generation Partnership Project (3GPP), the term “cell” can refer to a coverage area of a network node 110 and/or a network node subsystem serving this coverage area, depending on the context in which the term is used. A network node 110 may provide communication coverage for a macro cell, a pico cell, a femto cell, and/or another type of cell. A macro cell may cover a relatively large geographic area (e.g., 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 (e.g., a home) and may allow restricted access by UEs 120 having association with the femto cell (e.g., 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 the example shown in Fig. 1, the network node 110a may be a macro network node for a macro cell 102a, the network node 110b may be a pico network node for a pico cell 102b, and the network node 110c may be a femto network node for a femto cell 102c. A network node may support one or multiple (e.g., three) cells. In some examples, a cell may not necessarily be stationary, and the geographic area of the cell may move according to the location of a network node 110 that is mobile (e.g., a mobile network node).

[0050] In some aspects, the terms "base station" or "network node" may refer to an aggregated base station, a disaggregated base station, an integrated access and backhaul (IAB) node, a relay node, or one or more components thereof. For example, in some aspects, "base station" or "network node" may refer to a CU, a DU, an RU, a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC), or a Non-Real Time (Non-RT) RIC, or a combination thereof. In some aspects, the terms "base station" or "network node" may refer to one device configured to perform one or more functions, such as those described herein in connection with the network node 110. In some aspects, the terms "base station" or "network node" may refer to a plurality of devices configured to perform the one or more functions. For example, in some distributed systems, each of a quantity of different devices (which may be located in the same geographic location or in different geographic locations) may be configured to perform at least a portion of a function, or to duplicate performance of at least a portion of the function, and the terms "base station" or "network node" may refer to any one or more of those different devices. In some aspects, the terms "base station" or "network node" may refer to one or more virtual base stations or one or more virtual base station functions. For example, in some aspects, two or more base station functions may be instantiated on a single device. In some aspects, the terms "base station" or "network node" may refer to one of the base station functions and not another. In this way, a single device may include more than one base station.

[0051] The wireless network 100 may include one or more relay stations. A relay station is a network node that can receive a transmission of data from an upstream node (e.g., a network node 110 or a UE 120) and send a transmission of the data to a downstream node (e.g., a UE 120 or a network node 110). A relay station may be a UE 120 that can relay transmissions for other UEs 120. In the example shown in Fig. 1, the network node 110d (e.g., a relay network node) may communicate with the network node 110a (e.g., a macro network node) and the UE 120d in order to facilitate communication between the network node 110a and the UE 120d. A network node 110 that relays communications may be referred to as a relay station, a relay base station, a relay network node, a relay node, a relay, or the like.

[0052] The wireless 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, or the like. These different types of network nodes 110 may have different transmit power levels, different coverage areas, and/or different impacts on interference in the wireless network 100. For example, macro network nodes may have a high transmit power level (e.g., 5 to 40 watts) whereas pico network nodes, femto network nodes, and relay network nodes may have lower transmit power levels (e.g., 0.1 to 2 watts).

[0053] A network controller 130 may couple to or communicate with a set of network nodes 110 and may provide coordination and control for these network nodes 110. The network controller 130 may communicate with the network nodes 110 via a backhaul communication link or a midhaul communication link. The network nodes 110 may communicate with one another directly or indirectly via a wireless or wireline backhaul communication link. In some aspects, the network controller 130 may be a CU or a core network device, or may include a CU or a core network device.

[0054] The UEs 120 may be dispersed throughout the wireless network 100, and each UE 120 may be stationary or mobile. A UE 120 may include, for example, an access terminal, a terminal, a mobile station, and/or a subscriber unit. A UE 120 may be a cellular phone (e.g., 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 (e.g., a smart watch, smart clothing, smart glasses, a smart wristband, smart jewelry (e.g., a smart ring or a smart bracelet)), an entertainment device (e.g., a music device, a video device, and/or a satellite radio), a vehicular component or sensor, a smart meter/sensor, industrial manufacturing equipment, a global positioning system device, a UE function of a network node, and/or any other suitable device that is configured to communicate via a wireless or wired medium.

[0055] Some UEs 120 may be considered machine-type communication (MTC) or evolved or enhanced machine-type communication (eMTC) UEs. An MTC UE and/or an eMTC UE may include, for example, a robot, a drone, a remote device, a sensor, a meter, a monitor, and/or a location tag, that may communicate with a network node, another device (e.g., a remote device), or some other entity. Some UEs 120 may be considered Internet-of-Things (IoT) devices, and/or may be implemented as NB-IoT (narrowband IoT) devices. Some UEs 120 may be considered a Customer Premises Equipment. A UE 120 may be included inside a housing that houses components of the UE 120, such as processor components and/or memory components. In some examples, the processor components and the memory components may be coupled together. For example, the processor components (e.g., one or more processors) and the memory components (e.g., a memory) may be operatively coupled, communicatively coupled, electronically coupled, and/or electrically coupled.

[0056] In general, any number of wireless networks 100 may be deployed in a given geographic area. Each wireless network 100 may support a particular RAT and may operate on one or more frequencies. A RAT may be referred to as a radio technology, an air interface, or the like. A frequency may be referred to as a carrier, a frequency channel, or the like. Each frequency may support a single RAT in a given geographic area in order to avoid interference between wireless networks of different RATs. In some cases, NR or 5G RAT networks may be deployed.

[0057] In some examples, two or more UEs 120 (e.g., shown as UE 120a and UE 120e) may communicate directly using one or more sidelink channels (e.g., without using a network node 110 as an intermediary to communicate with one another). For example, the UEs 120 may communicate using peer-to-peer (P2P) communications, device-to-device (D2D) communications, a vehicle-to-everything (V2X) protocol (e.g., which may include a vehicle-to-vehicle (V2V) protocol, a vehicle-to-infrastructure (V2I) protocol, or a vehicle-to-pedestrian (V2P) protocol), and/or a mesh network. In such examples, a UE 120 may perform scheduling operations, resource selection operations, and/or other operations described elsewhere herein as being performed by the network node 110.

[0058] Devices of the wireless network 100 may communicate using the electromagnetic spectrum, which may be subdivided by frequency or wavelength into various classes, bands, channels, or the like. For example, devices of the wireless network 100 may communicate using one or more operating bands. In 5G NR, two initial operating bands have been identified as frequency range designations FR1 (410 MHz – 7.125 GHz) and FR2 (24.25 GHz – 52.6 GHz). It should be understood that although a portion of FR1 is greater than 6 GHz, FR1 is often referred to (interchangeably) as a “Sub-6 GHz” band in various documents and articles. A similar nomenclature issue sometimes occurs with regard to FR2, which is often referred to (interchangeably) as a “millimeter wave” band in documents and articles, despite being different from the extremely high frequency (EHF) band (30 GHz – 300 GHz) which is identified by the International Telecommunications Union (ITU) as a "millimeter wave" band.

[0059] The frequencies between FR1 and FR2 are often referred to as mid-band frequencies. Recent 5G NR studies have identified an operating band for these mid-band frequencies as frequency range designation FR3 (7.125 GHz – 24.25 GHz). Frequency bands falling within FR3 may inherit FR1 characteristics and/or FR2 characteristics, and thus may effectively extend features of FR1 and/or FR2 into mid-band frequencies. In addition, higher frequency bands are currently being explored to extend 5G NR operation beyond 52.6 GHz. For example, three higher operating bands have been identified as frequency range designations FR4a or FR4-1 (52.6 GHz – 71 GHz), FR4 (52.6 GHz – 114.25 GHz), and FR5 (114.25 GHz – 300 GHz). Each of these higher frequency bands falls within the EHF band.

[0060] With the above examples in mind, unless specifically stated otherwise, it should be understood that the term "sub-6 GHz" or the like, if used herein, may broadly represent frequencies that may be less than 6 GHz, may be within FR1, or may include mid-band frequencies. Further, unless specifically stated otherwise, it should be understood that the term "millimeter wave" or the like, if used herein, may broadly represent frequencies that may include mid-band frequencies, may be within FR2, FR4, FR4-a or FR4-1, and/or FR5, or may be within the EHF band. It is contemplated that the frequencies included in these operating bands (e.g., FR1, FR2, FR3, FR4, FR4-a, FR4-1, and/or FR5) may be modified, and techniques described herein are applicable to those modified frequency ranges.

[0061] In some aspects, the UE 120 may include a communication manager 140. As described in more detail elsewhere herein, the communication manager 140 may establish a connection with a network node; and receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0062] In some aspects, the communication manager 140 may establish a connection with a network node; and receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission. Additionally, or alternatively, the communication manager 140 may perform one or more other operations described herein.

[0063] In some aspects, the network node 110 may include a communication manager 150. As described in more detail elsewhere herein, the communication manager 150 may establish a connection with a UE; and output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0064] In some aspects, the communication manager 150 may establish a connection with a UE; and output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission. 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 200 of a network node 110 in communication with a UE 120 in a wireless network 100, in accordance with the present disclosure. The network node 110 may be equipped with a set of antennas 234a through 234t, such as T antennas ($T \geq 1$). The UE 120 may be equipped with a set of antennas 252a through 252r, such as R antennas ($R \geq 1$). The network node 110 of example 200 includes one or more radio frequency components, such as antennas 234 and a modem 232. In some examples, a network node 110 may include an interface, a communication component, or another component that facilitates communication with the UE 120 or another network node. Some network nodes 110 may not include radio frequency components that facilitate direct communication with the UE 120, such as one or more CUs, or one or more DUs.

[0067] At the network node 110, a transmit processor 220 may receive data, from a data source 212, intended for the UE 120 (or a set of UEs 120). The transmit processor 220 may select one or more modulation and coding schemes (MCSs) for the UE 120 based at least in part on one or more channel quality indicators (CQIs) received from that UE 120. The network node 110 may process (e.g., encode and modulate) the data for the UE 120 based at least in part on the MCS(s) selected for the UE 120 and may provide data symbols for the UE 120. The transmit processor 220 may process system information (e.g., for semi-static resource partitioning information (SRPI)) and control information (e.g., CQI requests, grants, and/or upper layer signaling) and provide overhead symbols and control symbols. The transmit processor 220 may generate reference symbols for reference signals (e.g., a cell-specific reference signal (CRS) or a demodulation reference signal (DMRS)) and synchronization signals (e.g., a primary synchronization signal (PSS) or a secondary synchronization signal (SSS)). A transmit (TX) multiple-input multiple-output (MIMO) processor 230 may perform spatial processing (e.g., 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 (e.g., T output symbol streams) to a corresponding set of modems 232 (e.g., T modems), shown as modems 232a through 232t. For example, each output symbol stream may be provided to a modulator component (shown as MOD) of a modem 232. Each modem 232 may use a respective modulator component to process a respective output symbol stream (e.g., for OFDM) to obtain an output sample stream. Each modem 232 may further use a respective modulator component to process (e.g., convert to analog, amplify, filter, and/or upconvert) the output sample stream to obtain a downlink signal. The modems 232a through 232t may transmit a set of downlink signals (e.g., *T* downlink signals) via a corresponding set of antennas 234 (e.g., *T* antennas), shown as antennas 234a through 234t.

[0068] At the UE 120, a set of antennas 252 (shown as antennas 252a through 252r) may receive the downlink signals from the network node 110 and/or other network nodes 110 and may provide a set of received signals (e.g., *R* received signals) to a set of modems 254 (e.g., *R* modems), shown as modems 254a through 254r. For example, each received signal may be provided to a demodulator component (shown as DEMOD) of a modem 254. Each modem 254 may use a respective demodulator component to condition (e.g., filter, amplify, downconvert, and/or digitize) a received signal to obtain input samples. Each modem 254 may use a demodulator component to further process the input samples (e.g., for OFDM) to obtain received symbols. A MIMO detector 256 may obtain received symbols from the modems 254, may perform MIMO detection on the received symbols if applicable, and may provide detected symbols. A receive processor 258 may process (e.g., demodulate and decode) the detected symbols, may provide decoded data for the UE 120 to a data sink 260, and may provide decoded control information and system information to a controller/processor 280. The term "controller/processor" may refer to one or more controllers, one or more processors, or a combination thereof. A channel processor may determine a reference signal received power (RSRP) parameter, a received signal strength indicator (RSSI) parameter, a reference signal received quality (RSRQ) parameter, and/or a CQI parameter, among other examples. In some examples, one or more components of the UE 120 may be included in a housing 284.

[0069] The network controller 130 may include a communication unit 294, a controller/processor 290, and a memory 292. The network controller 130 may include, for example, one or more devices in a core network. The network controller 130 may communicate with the network node 110 via the communication unit 294.

[0070] One or more antennas (e.g., antennas 234a through 234t and/or antennas 252a through 252r) may include, or may be included within, one or more antenna panels, one or more antenna groups, one or more sets of antenna elements, and/or one or more antenna arrays, among other examples. An antenna panel, an antenna group, a set of antenna elements, and/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, and/or one or more antenna elements coupled to one or more transmission and/or reception components, such as one or more components of Fig. 2.

[0071] On the uplink, at the UE 120, a transmit processor 264 may receive and process data from a data source 262 and control information (e.g., for reports that include RSRP, RSSI, RSRQ, and/or CQI) from the controller/processor 280. The transmit processor 264 may generate reference symbols for one or more reference signals. The symbols from the transmit processor 264 may be precoded by a TX MIMO processor 266 if applicable, further processed by the modems 254 (e.g., for DFT-s-OFDM or CP-OFDM), and transmitted to the network node 110. In some examples, the modem 254 of the UE 120 may include a modulator and a demodulator. In some examples, the UE 120 includes a transceiver. The transceiver may include any combination of the antenna(s) 252, the modem(s) 254, the MIMO detector 256, the receive processor 258, the transmit processor 264, and/or the TX MIMO processor 266. The transceiver may be used by a processor (e.g., the controller/processor 280) and the memory 282 to perform aspects of any of the methods described herein (e.g., with reference to Figs. 5-14).

[0072] At the network node 110, the uplink signals from UE 120 and/or other UEs may be received by the antennas 234, processed by the modem 232 (e.g., a demodulator component, shown as DEMOD, of the modem 232), detected by a MIMO detector 236 if applicable, and further processed by a receive processor 238 to obtain decoded data and control information sent by the UE 120. The receive processor 238 may provide the decoded data to a data sink 239 and provide the decoded control information to the controller/processor 240. The network node 110 may include a communication unit 244 and may communicate with the network controller 130 via the communication unit 244. The network node 110 may include a scheduler 246 to schedule one or more UEs 120 for downlink and/or uplink communications. In some examples, the modem 232 of the network node 110 may include a modulator and a demodulator. In some examples, the network node 110 includes a transceiver. The transceiver may include any combination of the antenna(s) 234, the modem(s) 232, the MIMO detector 236, the receive processor 238, the transmit processor 220, and/or the TX MIMO processor 230. The transceiver may be used by a processor (e.g., the controller/processor 240) and the memory 242 to perform aspects of any of the methods described herein (e.g., with reference to Figs. 5-14).

[0073] The controller/processor 240 of the network node 110, the controller/processor 280 of the UE 120, and/or any other component(s) of Fig. 2 may perform one or more techniques associated with scheduling uplink transmissions on multiple frequency bands, 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, and/or any other component(s) of Fig. 2 may perform or direct operations of, for example, process 900 of Fig. 9, process 1000 of Fig. 10, process 1100 of Fig. 11, process 1200 of Fig. 12, and/or other processes as described herein. The memory 242 and the memory 282 may store data and program codes for the network node 110 and the UE 120, respectively. In some examples, the memory 242 and/or the memory 282 may include a non-transitory computer-readable medium storing one or more instructions (e.g., code and/or program code) for wireless communication. For example, the one or more instructions, when executed (e.g., directly, or after compiling, converting, and/or interpreting) by one or more processors of the network node 110 and/or the UE 120, may cause the one or more processors, the UE 120, and/or the network node 110 to perform or direct operations of, for example, process 900 of Fig. 9, process 1000 of Fig. 10, process 1100 of Fig. 11, process 1200 of Fig. 12, and/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.

[0074] In some aspects, the UE 120 includes means for establishing a connection with a network node; and/or means for receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band. The means for the UE 120 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.

[0075] In some aspects, the UE 120 includes means for establishing a connection with a network node; and/or means for receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission. The means for the UE 120 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.

[0076] In some aspects, the network node 110 includes means for establishing a connection with a UE; and/or means for outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band. The means for the network node 110 to perform operations described herein may include, for example, one or more of communication manager 150, transmit processor 220, TX MIMO processor 230, modem 232, antenna 234, MIMO detector 236, receive processor 238, controller/processor 240, memory 242, or scheduler 246.

[0077] In some aspects, the network node 110 includes means for establishing a connection with a UE; and/or means for outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission. The means for the network node 110 to perform operations described herein may include, for example, one or more of communication manager 150, transmit processor 220, TX MIMO processor 230, modem 232, antenna 234, MIMO detector 236, receive processor 238, controller/processor 240, memory 242, or scheduler 246.

[0078] 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.

[0079] As indicated above, Fig. 2 is provided as an example. Other examples may differ from what is described with regard to Fig. 2.

[0080] Deployment of communication systems, such as 5G NR systems, may be arranged in multiple manners with various components or constituent parts. In a 5G NR system, or network, a network node, a network entity, a mobility element of a network, a RAN node, a core network node, a network element, a base station, or a network equipment may be implemented in an aggregated or disaggregated architecture. For example, a base station (such as a Node B (NB), an evolved NB (eNB), an NR base station, a 5G NB, an access point (AP), a TRP, or a cell, among other examples), or one or more units (or one or more components) performing base station functionality, may be implemented as an aggregated base station (also known as a standalone base station or a monolithic base station) or a disaggregated base station. "Network entity" or "network node" may refer to a disaggregated base station, or to one or more units of a disaggregated base station (such as one or more CUs, one or more DUs, one or more RUs, or a combination thereof).

[0081] An aggregated base station (e.g., an aggregated network node) may be configured to utilize a radio protocol stack that is physically or logically integrated within a single RAN node (e.g., within a single device or unit). A disaggregated base station (e.g., a disaggregated network node) may be configured to utilize a protocol stack that is physically or logically distributed among two or more units (such as one or more CUs, one or more DUs, or one or more RUs). In some examples, a CU may be implemented within a network node, and one or more DUs may be co-located with the CU, or alternatively, may be geographically or virtually distributed throughout one or multiple other network nodes. The DUs may be implemented to communicate with one or more RUs. Each of the CU, DU, and RU also can be implemented as virtual units, such as a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU), among other examples.

[0082] Base station-type operation or network design may consider aggregation characteristics of base station functionality. For example, disaggregated base stations may be utilized in an IAB network, an open radio access network (O-RAN (such as the network configuration sponsored by the O-RAN Alliance)), or a virtualized radio access network (vRAN, also known as a cloud radio access network (C-RAN)) to facilitate scaling of communication systems by separating base station functionality into one or more units that can be individually deployed. A disaggregated base station may include functionality implemented across two or more units at various physical locations, as well as functionality implemented for at least one unit virtually, which can enable flexibility in network design. The various units of the disaggregated base station can be configured for wired or wireless communication with at least one other unit of the disaggregated base station.

[0083] Fig. 3 is a diagram illustrating an example disaggregated base station architecture 300, in accordance with the present disclosure. 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 indirectly with the core network 320 through one or more disaggregated control units (such as a Near-RT RIC 325 via an E2 link, or a Non-RT RIC 315 associated with a Service Management and Orchestration (SMO) Framework 305, or both). A CU 310 may communicate with one or more DUs 330 via respective midhaul links, such as through 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 radio frequency (RF) access links. In some implementations, a UE 120 may be simultaneously served by multiple RUs 340.

[0084] Each of the units, including the CUs 310, the DUs 330, the RUs 340, as well as the Near-RT RICs 325, the Non-RT RICs 315, and the SMO Framework 305, may include one or more interfaces or be coupled with one or more interfaces configured to receive or transmit signals, data, or information (collectively, signals) via a wired or wireless transmission medium. Each of the units, or an associated processor or controller providing instructions to one or multiple communication interfaces of the respective unit, can be configured to communicate with one or more of the other units via the transmission medium. In some examples, each of the units can include a wired interface, configured to receive or transmit signals over a wired transmission medium to one or more of the other units, and a wireless interface, which may include a receiver, a transmitter or transceiver (such as an RF transceiver), configured to receive or transmit signals, or both, over a wireless transmission medium to one or more of the other units.

[0085] In some aspects, the CU 310 may host one or more higher layer control functions. Such control functions can include radio resource control (RRC) functions, packet data convergence protocol (PDCP) functions, or service data adaptation protocol (SDAP) functions, among other examples. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU 310. The CU 310 may be configured to handle user plane functionality (for example, Central Unit – User Plane (CU-UP) functionality), control plane functionality (for example, Central Unit – Control Plane (CU-CP) functionality), or a combination thereof. In some implementations, the CU 310 can be logically split into one or more CU-UP units and one or more CU-CP units. A CU-UP unit can 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 can be implemented to communicate with a DU 330, as necessary, for network control and signaling.

[0086] 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. In some aspects, the DU 330 may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers depending, at least in part, on a functional split, such as a functional split defined by the 3GPP. In some aspects, the one or more high PHY layers may be implemented by one or more modules for forward error correction (FEC) encoding and decoding, scrambling, and modulation and demodulation, among other examples. In some aspects, the DU 330 may further host one or more low PHY layers, such as implemented by one or more modules for a fast Fourier transform (FFT), an inverse FFT (iFFT), digital beamforming, or physical random access channel (PRACH) extraction and filtering, among other examples. Each layer (which also may be referred to as a module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU 330, or with the control functions hosted by the CU 310.

[0087] Each RU 340 may implement lower-layer functionality. In some deployments, an RU 340, controlled by a DU 330, may correspond to a logical node that hosts RF processing functions or low-PHY layer functions, such as performing an FFT, performing an iFFT, digital beamforming, or PRACH extraction and filtering, among other examples, based on a functional split (for example, a functional split defined by the 3GPP), such as a lower layer functional split. In such an architecture, each RU 340 can be operated to handle over the air (OTA) communication with one or more UEs 120. In some implementations, real-time and non-real-time aspects of control and user plane communication with the RU(s) 340 can be controlled by the corresponding DU 330. In some scenarios, 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.

[0088] The SMO Framework 305 may be configured to support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework 305 may be configured to support the deployment of dedicated physical resources for RAN coverage requirements, which may be managed via an operations and maintenance interface (such as an O1 interface). For virtualized network elements, the SMO Framework 305 may be configured to 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). Such virtualized network elements can include, but are not limited to, CUs 310, DUs 330, RUs 340, non-RT RICs 315, and Near-RT RICs 325. In some implementations, the SMO Framework 305 can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) 311, via an O1 interface. Additionally, in some implementations, the SMO Framework 305 can communicate directly with each of one or more RUs 340 via a respective O1 interface. The SMO Framework 305 also may include a Non-RT RIC 315 configured to support functionality of the SMO Framework 305.

[0089] The Non-RT RIC 315 may be configured to include a logical function that enables non-real-time control and optimization of RAN elements and resources, Artificial Intelligence/Machine Learning (AI/ML) workflows including model training and updates, or policy-based guidance of applications/features in the Near-RT RIC 325. The Non-RT RIC 315 may be coupled to or communicate with (such as via an A1 interface) the Near-RT RIC 325. The Near-RT RIC 325 may be configured to include a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions over an interface (such as via an E2 interface) connecting one or more CUs 310, one or more DUs 330, or both, as well as an O-eNB, with the Near-RT RIC 325.

[0090] In some implementations, to generate AI/ML models to be deployed in the Near-RT RIC 325, the Non-RT RIC 315 may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC 325 and may be received at the SMO Framework 305 or the Non-RT RIC 315 from non-network data sources or from network functions. In some examples, the Non-RT RIC 315 or the Near-RT RIC 325 may be configured to tune RAN behavior or performance. For example, the Non-RT RIC 315 may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework 305 (such as reconfiguration via an O1 interface) or via creation of RAN management policies (such as A1 interface policies).

[0091] As indicated above, Fig. 3 is provided as an example. Other examples may differ from what is described with regard to Fig. 3.

[0092] Transmission switching may enable a UE to transmit uplink transmissions over different frequency bands. The uplink transmissions may be carried by a physical uplink shared channel (PUSCH) and may be scheduled by an uplink grant transmitted as downlink control information (DCI) carried in a physical downlink control channel (PDCCH). For uplink transmission switching involving a single pair of frequency bands, the UE may transmit a first uplink transmission over a first frequency band, perform one or more transmission switching operations to switch to a second frequency band, and transmit a second uplink transmission over the second frequency band.

[0093] Uplink transmission switching for a single pair of frequency bands may involve a minimum processing time for the UE to switch from the first frequency band to the second frequency band. For example, the minimum processing time may allow time for the UE to prepare the uplink data, prepare a transmit chain (e.g., tuning from the first frequency band to the second frequency band), or the like. Providing the UE with the minimum processing time to perform the transmission switching may help ensure that the UE transmits the second uplink transmission as scheduled.

[0094] Fig. 4 illustrates an example table 400 of values of PUSCH preparation time parameter Ŭ , in accordance with the present disclosure. In some examples, the minimum processing time may depend on Ŭ . As shown in Fig. 4, the value of Ŭ depends on the value of numerology parameter ‘. ‘ corresponds to the one of ‘ or ‘ that results in the largest processing time. ‘ corresponds to the subcarrier spacing of the downlink channel with which the PDCCH carrying the DCI scheduling the PUSCH was transmitted, and ʻ corresponds to the subcarrier spacing of the uplink channel with which the PUSCH is to be transmitted.

[0095] For example, Ű may be mapped to 10 symbols when ʻ 0 and 12 symbols when ʻ 1. For example, if the DCI carrier (e.g., component carrier) corresponds to a subcarrier spacing of 15 kHz (ʻ 0) and the uplink grant carrier (e.g., component carrier) corresponds to a subcarrier spacing of 30 kHz (ʻ 1), then Ű = 12 symbols. In this example, the UE may receive the uplink grant at least the minimum processing time (e.g., calculated based on Ű = 12 symbols) before the scheduled uplink transmission.

[0096] As indicated above, Fig. 4 is provided as an example. Other examples may differ from what is described with respect to Fig. 4.

[0097] A minimum processing time for transmission switching is not well-defined for uplink transmission switching involving multiple pairs of frequency bands. As a result, if a UE is initially tuned to a first frequency band and a second frequency band simultaneously, and the UE receives one or more uplink grants that schedule uplink transmissions on a third frequency band and a fourth frequency band, then the UE may have insufficient time to switch to the third frequency band and/or the fourth frequency band in time to transmit one or more of the uplink transmissions. Therefore, the UE may fail to transmit the uplink transmission(s) as scheduled.

[0098] Implementations are provided herein for scheduling uplink transmissions (e.g., overlapping uplink transmissions or non-overlapping transmissions) on multiple frequency bands. In some implementations, discussed with reference to Figs. 5 and 6, the uplink transmissions overlap in time (e.g., the uplink transmissions at least partially overlap in time). In some implementations, discussed with reference to Figs. 7 and 8, the uplink transmissions do not overlap in time.

[0099] Fig. 5 is a diagram illustrating an example 500 of scheduling uplink transmissions that overlap in time on multiple frequency bands, in accordance with the present disclosure. As shown in Fig. 5, a network node 110 and a UE 120 may communicate with one another.

[0100] As shown by reference number 505, the network node 110 and the UE 120 may establish a connection (e.g., an RRC connection). As shown by reference number 510, the UE 120 may be configured to transmit on a first frequency band and a second frequency band. For example, the UE 120 may be configured to transmit respective uplink transmissions on the first frequency band and the second frequency band. For example, the UE 120 may be configured to transmit the uplink transmissions on the first frequency band and the second frequency band simultaneously, or with at least partial overlap in the time domain.

[0101] As shown by reference number 515, the network node 110 may output, and the UE 120 may receive, while the UE 120 is configured to transmit on the first frequency band and the second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band. The first uplink transmission and the second uplink transmission overlap in time. The one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission. The offset is based at least in part on the third frequency band and the fourth frequency band.

[0102] Scheduling the uplink transmissions in accordance with the implementations described herein may help ensure that the UE 120 is afforded at least a minimum processing time to perform transmission switching involving multiple pairs of frequency bands. For example, based on the offset (e.g., a minimum processing time), the UE 120 may successfully perform transmission switching in cases where the uplink transmissions overlap in time. In a further example, the UE may transmit, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0103] In some examples, the offset may be a value of a ''Y , parameter. The ''Y , parameter may define a minimum processing time involved in performing transmission switching (e.g., a processing time from the last symbol of a PDCCH to the corresponding PUSCH that carries the uplink transmission). In some examples,

''Y , ἀώὼ Ű 'Ω, 'Ω 2048 144 ‖2 ''Y ''Y ''Y ,'Ω, ,

where Ű is a PUSCH preparation time, ''Y represents a switching gap duration for the frequency bands, and 'Ω, ,'Ω , ‖, ''Y , ''Y , and 'Ω, are constants. For example, if the uplink grant arrives a time ''Y , before the uplink transmission is scheduled, then the UE 120 may have sufficient time to successfully perform transmission switching.

[0104] As indicated above, Fig. 5 is provided as an example. Other examples may differ from what is described with respect to Fig. 5.

[0105] The Ŭ and "Y parameters may not be well-defined for uplink transmission switching involving multiple pairs of frequency bands. The Ŭ and "Y parameters may be defined so as to avoid a "Y , parameter value that is too small for the UE to perform the uplink transmission switching. For example, an insufficient "Y , parameter value may result from a scheme in which the Ŭ parameter is defined as a maximum of (‘ , ‘), where ‘ is a minimum of any ‘ s corresponding to respective downlink frequency bands configured to carry DCI (e.g., uplink grants) and ‘ is a minimum of any ‘ s corresponding to respective uplink frequency bands configured to carry uplink transmissions scheduled by the one or more uplink grants.

[0106] For example, if the UE 120 is configured to switch from a first frequency band configured to carry DCI and uplink transmissions (subcarrier spacing of 15 kHz (‘ 0)) to a first frequency band configured to carry at least uplink transmissions (subcarrier spacing of 30 kHz (‘ 1)), and from a second frequency band configured to carry DCI and uplink transmissions (subcarrier spacing of 30 kHz (‘ 1)) to a second frequency band configured to carry at least uplink transmissions (subcarrier spacing of 15 kHz (‘ 0)), then, for uplink transmission switching involving multiple pairs of frequency bands, Ŭ = 10 symbols. However, for uplink transmission switching involving a single pair of frequency bands (e.g., if both frequency band pairs are treated as two independent pairs of frequency bands), then Ŭ = 12 symbols for both frequency band pairs. Thus, the "Y , parameter value may effectively lose two symbols, and as a result, may be insufficient for the UE to perform the uplink transmission switching before the uplink transmissions are scheduled. Accordingly, provided herein are configurations of the Ŭ parameter and the "Y parameter such that the resulting "Y , parameter value may provide the UE 120 with sufficient time to perform the uplink transmission switching. In some examples, ‘ in the equation for the "Y , parameter provided above may correspond to ‘ min ‘ , ‘ .

[0107] Fig. 6 is a diagram illustrating an example timeline 600 of scheduling uplink transmissions that overlap in time on multiple frequency bands, in accordance with the present disclosure. As shown, initially, a UE is configured to transmit uplink transmissions over Band A and Band B via respective transmit chains (“1 Tx”). Upon receiving one or more uplink grants that schedule uplink transmissions on Band C and Band D, the UE may initiate one or more uplink transmission switching operations, which may enable the UE to transmit the uplink transmissions on Band C and Band D via respective transmit chains. The switching operations may or may not occur at the same time (e.g., a switch from Band A to Band C may or may not occur at the same time as a switch from Band B to Band D). As shown, Band C and Band D each have a switching gap duration ("gap") that corresponds to the "Y parameter. The uplink transmission scheduled on Band C has a start time of "Y , and the uplink transmission scheduled on Band D has a start time of "Y '. As shown, "Y occurs before "Y ' (e.g., "Y is the earliest start time of the uplink transmission on Band C and the uplink transmission on Band D).

[0108] The UE may receive the uplink grants at or before "Y "Y , where "Y is "Y , . If the UE receives the uplink grants after "Y "Y , then the UE may not have sufficient time to perform the uplink transmission switching before the earliest start time of the uplink transmission on Band C and the uplink transmission on Band D (here, the start time of the uplink transmission on Band C). Based on the uplink grant(s), the UE may determine how to perform the uplink transmission switching (e.g., when and in what order to switch the frequency bands).

[0109] At least two examples are described with reference to Fig. 6. In a first example, the one or more uplink grants indicate that the UE is to switch from Band A to Band C and from Band B to Band D. For instance, the one or more uplink grants may explicitly identify Band A as a source frequency band and Band C as a target frequency band that corresponds to Band A, and may further explicitly identify Band B as a source frequency band and Band D as a target frequency band that corresponds to Band B. In a second example, the one or more uplink grants indicate that the UE is to switch from Band A and Band B to Band C and Band D. For instance, the one or more uplink grants may not explicitly identify source-target frequency band pairs.

[0110] In the first example, the UE may be triggered to perform transmission switching between two band pairs (e.g., Band A to Band C, and Band B to Band D). Band A and Band C may have different subcarrier spacings (e.g., Band A may have a subcarrier spacing of 15 kHz and Band C may have a subcarrier spacing of 30 kHz), and Band B and Band D may have different subcarrier spacings (e.g., Band B may have a subcarrier spacing of 30 kHz and Band D may have a subcarrier spacing of 15 kHz).

[0111] In some examples, the "Y parameter value may be based at least in part on a maximum value of a first Ŭ parameter value (e.g., a value of an Ŭ , parameter) associated with a first switch from Band A to Band C, and a second Ŭ parameter value (e.g., a value of an Ű , parameter) associated with a second switch from Band B to Band D. For example, the "Y parameter value may be the maximum value of the Ű , parameter value and the Ű , parameter value.

[0112] The Ű , parameter may be a PUSCH preparation time parameter for the first switch, and the Ű , parameter may be a PUSCH preparation time parameter for the second switch. For example, the maximum value of the Ű , parameter value and the Ű , parameter value may be input as the Ű parameter value in the equation for the "Y , parameter provided above. Basing the "Y parameter value at least in part on the maximum value of the Ű , parameter and the Ű , parameter may help ensure that the "Y parameter value is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled.

[0113] The Ű , parameter value may be based at least in part on a larger of a ʻ parameter value associated with Band A and a ʻ parameter value associated with Band C. For example, the Ű , parameter value may be the larger of the ʻ parameter value and the ʻ parameter value. The Ű , parameter value may be based at least in part on a larger of a ʻ parameter value associated with Band B and a ʻ parameter value associated with Band D. For example, the Ű , parameter value may be the larger of the ʻ parameter value and the ʻ parameter value.

[0114] For example, the ʻ parameter value associated with Band A (15 kHz) may be 0; the ʻ parameter value associated with Band C (30 kHz) may be 1; the ʻ parameter value associated with Band B (30 kHz) may be 1; and the ʻ parameter value associated with Band D (15 kHz) may be 0. Thus, the Ű , parameter value and the Ű , parameter value may both be equal to 12 (in contrast to, for example, 10).

[0115] Basing the Ű , parameter value at least in part on a larger of a ʻ parameter value associated with Band A and a ʻ parameter value associated with Band C, and the Ű , parameter value at least in part on a larger of a ʻ parameter value associated with Band B and a ʻ parameter value associated with Band D, may help further ensure that "Y is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled.

[0116] In some examples, the "Y parameter value may be based at least in part on a "Y parameter value that is based at least in part on a largest of a first switching period associated with the first switch (from Band A to Band C) and a second switching period associated with the second switch (from Band B to Band D). For example, the "Y parameter value may be the largest of the first switching period and the second switching period. The first and second switching periods may be reported by the UE to the network node.

[0117] Basing the "Y parameter value at least in part on the largest of the first switching period and the second switching period may help ensure that the "Y parameter value is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled. For example, in cases where the UE internally switches directly from Band A to Band C and from Band B to Band D, basing the "Y parameter value at least in part on the largest of the first switching period and the second switching period may ensure that the "Y parameter value is larger than the time involved in the internal UE operations for uplink transmission switching.

[0118] In some examples, the "Y parameter value may be based at least in part on a "Y parameter value that is based at least in part on a largest of: a first switching period associated with a first switch from Band A to Band C; a second switching period associated with a second switch from Band B to Band C; a third switching period associated with a third switch from Band A to Band D; and a fourth switching period associated with a fourth switch from Band B to Band D. For example, the "Y parameter value may be the largest of the first switching period, the second switching period, the third switching period, and the fourth switching period. The first, second, third, and fourth switching periods may be reported by the UE to the network node.

[0119] Basing the "Y parameter value at least in part on the largest of the first switching period, the second switching period, the third switching period, and the fourth switching period may help ensure that the "Y parameter value is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled. For example, in cases where the UE does not indicate to the network node which transmit chain switches to which target frequency band (e.g., whether the UE switches from Band A to Band C and from Band B to Band D, or from Band B to Band C and from Band A to Band D), basing the

'Y parameter value at least in part on the largest of the first switching period, the second switching period, the third switching period, and the fourth switching period may ensure that the 'Y parameter value is larger than the internal UE operations involved in uplink transmission switching.

[0120] In some examples, the 'Y parameter value may be based at least in part on a 'Y parameter value that is based at least in part on a sum of a first maximum of a first switching period associated with a first switch from Band A to Band C and a second switching period associated with a second switch from Band B to Band C, and a second maximum of a third switching period associated with a third switch from Band A to Band D and a fourth switching period associated with a fourth switch from Band B to Band D. For example, the 'Y parameter value may be the sum of the first maximum and the second maximum. The first, second, third, and fourth switching periods may be reported by the UE to the network node.

[0121] Basing the 'Y parameter value at least in part on the sum of the first maximum and the second maximum may help ensure that the 'Y parameter value is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled. For example, in cases where the UE does not indicate to the network node which transmit chain switches to which target frequency band, and the UE switches from one frequency band to another frequency band via one or more intermediate frequency bands (e.g., the UE switches from Band A to Band D by switching from Band A to Band C to Band D), basing the 'Y parameter value at least in part on the sum of the first maximum and the second maximum may ensure that the 'Y parameter value is larger than the internal UE operations involved in uplink transmission switching.

[0122] In some examples, the 'Y parameter value may be further based at least in part on another sum. The other sum may be a total of the sum (e.g., the sum of the first maximum and the second maximum) and a predefined value. For example, the 'Y parameter value may be the other sum of the sum and the predefined value. The predefined value may be a value reported by the UE to the network node or a value that is fixed in a standards specification. The predefined value may help further ensure that the 'Y parameter value is larger than the internal UE operations involved in uplink transmission switching.

[0123] In some examples, the "Y parameter value may be based at least in part on a "Y parameter value that is based at least in part on a sum of a first switching period associated with a first switch from Band A to Band C, a second switching period associated with a second switch from Band A to Band D, a third switching period associated with a third switch from Band B to Band C and a fourth switching period associated with a fourth switch from Band B to Band D. For example, the "Y parameter value may be the sum of the first, second, third, and fourth switching periods. The first, second, third, and fourth switching periods may be reported by the UE to the network node.

[0124] In some examples, the "Y parameter value may be further based at least in part on another sum of the sum (e.g., the sum of the first, second, third, and fourth switching periods) and a predefined value. For example, the predefined value may be a value reported by the UE to the network node or a value that is fixed in a standards specification.

[0125] In the second example, the one or more uplink grants indicate that the UE is to switch from Band A and Band B to Band C and Band D. For example, the network node may, without explicitly identifying source-target frequency band pairs, configure the UE such that the UE to configured to transmit on Band A and Band B before the switching and on Band C and Band D after the switching. Band A and Band B may have different subcarrier spacings (e.g., Band A may have a subcarrier spacing of 15 kHz and Band B may have a subcarrier spacing of 30 kHz), and Band C and Band D may have different subcarrier spacings (e.g., Band C may have a subcarrier spacing of 30 kHz and Band D may have a subcarrier spacing of 15 kHz).

[0126] In some examples, Band A and Band B may be configured to carry downlink transmissions (e.g., DCI that includes the one or more uplink grants). The "Y parameter value may be based at least in part on an **Ŭ** parameter value. The **Ŭ** parameter value may be based at least in part on a larger of a ʻ parameter value and a ʻ parameter value.

[0127] The ʻ parameter value may be associated with Band A and Band B, and the ʻ parameter value may be associated with Band C and Band D. In some examples, the ʻ parameter value may be based at least in part on a maximum of a ʻ parameter value associated with Band A (e.g., ʻ = 0) and a ʻ parameter value associated with Band B (e.g., ʻ = 1), and the ʻ parameter value may be based at least in part on a maximum of a ‘ parameter value associated with Band C (e.g., ‘ = 1) and a ‘ parameter value associated with Band D (e.g., ‘ = 0). For example, the ‘ parameter value may be the maximum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be the minimum of the ‘ parameter value and the ‘ parameter value.

[0128] In some examples, the ‘ parameter value may be based at least in part on a maximum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be based at least in part on a minimum of the ‘ parameter value and the ‘ parameter value. For example, the ‘ parameter value may be the maximum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be the minimum of the ‘ parameter value and the ‘ parameter value.

[0129] In some examples, the ‘ parameter value may be based at least in part on a minimum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be based at least in part on a minimum of the ‘ parameter value and the ‘ parameter value. For example, the ‘ parameter value may be the minimum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be the minimum of the ‘ parameter value and the ‘ parameter value.

[0130] In some examples, the ‘ parameter value may be based at least in part on a maximum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be based at least in part on a minimum of the ‘ parameter value and the ‘ parameter value. For example, the ‘ parameter value may be the maximum of the ‘ parameter value and the ‘ parameter value, and the ‘ parameter value may be the minimum of the ‘ parameter value and the ‘ parameter value.

[0131] In some examples, the "Y parameter value may be based at least in part on a "Y parameter value that is based at least in part on a largest of: a first switching period associated with a first switch from Band A to Band C; a second switching period associated with a second switch from Band B to Band C; a third switching period associated with a third switch from Band A to Band D; and a fourth switching period associated with a fourth switch from Band B to Band D. For example, the "Y parameter value may be the largest of the first switching period, the second switching period, the third switching period, and the fourth switching period. The first, second, third, and fourth switching periods may be reported by the UE to the network node.

[0132] Basing the "Y parameter value at least in part on the largest of the first switching period, the second switching period, the third switching period, and the fourth switching period may help ensure that the "Y parameter value is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled. For example, in cases where the UE does not indicate to the network node which transmit chain switches to which target frequency band (e.g., whether the UE switches from Band A to Band C and from Band B to Band D, or from Band B to Band C and from Band A to Band D), basing the "Y parameter value at least in part on the largest of the first switching period, the second switching period, the third switching period, and the fourth switching period may ensure that the "Y parameter value is larger than the internal UE operations involved in uplink transmission switching.

[0133] In some examples, the "Y parameter value may be based at least in part on a "Y parameter value that is based at least in part on a sum of a first maximum of a first switching period associated with a first switch from Band A to Band C and a second switching period associated with a second switch from Band B to Band C, and a second maximum of a third switching period associated with a third switch from Band A to Band D and a fourth switching period associated with a fourth switch from Band B to Band D. For example, the "Y parameter value may be the sum of the first maximum and the second maximum. The first, second, third, and fourth switching periods may be reported by the UE to the network node.

[0134] Basing the "Y parameter value at least in part on the sum of the first maximum and the second maximum may help ensure that the "Y parameter value is large enough that the UE has sufficient time to perform the uplink transmission switching before the times at which the uplink transmissions are scheduled. For example, in cases where the UE does not indicate to the network node which transmit chain switches to which target frequency band, and the UE switches from one frequency band to another frequency band via one or more intermediate frequency bands (e.g., the UE switches from Band A to Band D by switching from Band A to Band C to Band D), basing the "Y parameter value at least in part on the sum of the first maximum and the second maximum may ensure that the "Y parameter value is larger than the internal UE operations involved in uplink transmission switching.

[0135] In some examples, the "Y parameter value may be further based at least in part on another sum of the sum (e.g., the sum of the first maximum and the second maximum) and a predefined value. For example, the "Y parameter value may be the other sum of the sum and the predefined value. The predefined value may be a value reported by the UE to the network node or a value that is fixed in a standards specification. The predefined value may help further ensure that the "Y parameter value is larger than the internal UE operations involved in uplink transmission switching.

[0136] In some examples, the "Y parameter value may be based at least in part on a "Y parameter value that is based at least in part on a sum of a first switching period associated with a first switch from Band A to Band C, a second switching period associated with a second switch from Band A to Band D, a third switching period associated with a third switch from Band B to Band C and a fourth switching period associated with a fourth switch from Band B to Band D. For example, the "Y parameter value may be the sum of the first, second, third, and fourth switching periods. The first, second, third, and fourth switching periods may be reported by the UE to the network node.

[0137] In some examples, the "Y parameter value may be further based at least in part on another sum of the sum (e.g., the sum of the first, second, third, and fourth switching periods) and a predefined value. For example, the predefined value may be a value reported by the UE to the network node or a value that is fixed in a standards specification.

[0138] Whether the UE can switch to a frequency band (e.g., to Band D) while transmitting on another frequency band (e.g., Band C) may depend on whether the UE is a baseline UE or a UE with an unchanged-band capability. A baseline UE may be unable to switch to a frequency band while transmitting on another frequency band, and configuring a baseline UE to do so may result in an error or cause a transmission outage on the other frequency while the baseline UE switches to the frequency band (e.g., the UE may stop transmitting on Band C, switch to Band D, and then resume transmitting on Band C). A UE with an unchanged-band capability may be able to switch to a frequency band while transmitting on another frequency band. For example, the UE with the unchanged-band capability may allow the transmission on Band C to remain unchanged for a switching frequency band pair (e.g., from Band A to Band D, and/or from Band B to Band D). For example, the UE with the unchanged-band capability may include a first transmit chain that remains tuned to Band C during the switch, and a second transmit chain that switches to Band D while the first transmit chain transmits over Band C.

[0139] As indicated above, Fig. 6 is provided as an example. Other examples may differ from what is described with respect to Fig. 6.

[0140] Fig. 7 is a diagram illustrating an example 700 of scheduling uplink transmissions that do not overlap in time on multiple frequency bands, in accordance with the present disclosure. As shown in Fig. 7, a network node 110 and a UE 120 may communicate with one another.

[0141] As shown by reference number 705, the network node 110 and the UE 120 may establish a connection (e.g., an RRC connection). As shown by reference number 710, the UE 120 may be configured to transmit on a first frequency band and a second frequency band. For example, the UE 120 may be configured to transmit respective uplink transmissions on the first frequency band and the second frequency band. For example, the UE 120 may be configured to transmit the uplink transmissions on the first frequency band and the second frequency band simultaneously, or with at least partial overlap in the time domain.

[0142] As shown by reference number 715, the network node 110 may output, and the UE 120 may receive, while the UE 120 is configured to transmit on the first frequency band and the second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band. The first uplink transmission and the second uplink transmission do not overlap in time. The one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0143] Scheduling the uplink transmissions in accordance with the implementations described herein may help ensure that the UE 120 is afforded at least a minimum processing time to perform transmission switching involving multiple pairs of frequency bands. For example, scheduling the second uplink transmission based at least in part on the minimum separation time between the end time of the first uplink transmission and the start time of the second uplink transmission may help ensure that the UE has sufficient time to perform transmission switching. In a further example, the UE may transmit, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0144] As indicated above, Fig. 7 is provided as an example. Other examples may differ from what is described with respect to Fig. 7.

[0145] Fig. 8 is a diagram illustrating example timelines (e.g., timeline 800 and timeline 810) of scheduling uplink transmissions that do not overlap in time on multiple frequency bands, in accordance with the present disclosure. In timeline 800 and timeline 810, initially, a UE is configured to transmit uplink transmissions over Band A and Band B via respective transmit chains ("1 Tx"). Upon receiving one or more uplink grants that schedule uplink transmissions on Band C and Band D, the UE may initiate one or more uplink transmission switching operations, which may enable the UE to transmit the uplink transmissions on Band C and Band D via respective transmit chains. As shown, Band C and Band D each have a switching gap duration ("gap") that corresponds to a "Y parameter. The uplink transmission scheduled on Band C has a start time of "Y , and the uplink transmission scheduled on Band D has a start time of "Y '. As shown, "Y occurs before "Y ' (e.g., "Y is the earliest start time of the uplink transmission on Band C and the uplink transmission on Band D).

[0146] The UE may receive an uplink grant that schedules the uplink transmission on Band C at or before "Y "Y . For example, "Y may be "Y , . The value of "Y may be based at least in part on Band A or Band B and based at least in part on Band C (e.g., the "Y value may be based on an Ŭ parameter value and/or a "Y parameter value, where the Ŭ parameter value and/or the "Y parameter value may be determined from properties (e.g., one or more ʻ parameters) associated with Bands A or B and Band C). If the UE receives the uplink grants after "Y "Y , then the UE may not have sufficient time to perform the uplink transmission switching before the start time of the uplink transmission on Band C. Thus, receiving the uplink grant that schedules the uplink transmission on Band C at or before "Y "Y may help ensure that the UE has sufficient time to perform transmission switching to Band C before the transmission on Band C.

[0147] The UE may receive an uplink grant that schedules the uplink transmission on Band D at or before "Y ' "Y . For example, "Y may be "Y , . The value of

"Y may be based at least in part on Band A or Band B and based at least in part on Band D (e.g., the "Y value may be based on an Ŭ parameter value and/or a "Y parameter value, where the Ŭ parameter value and/or the "Y parameter value may be determined from properties (e.g., one or more ‘ parameters) associated with Bands A or B and Band D). If the UE receives the uplink grants after "Y ′ "Y , then the UE may not have sufficient time to perform the uplink transmission switching before the start time of the uplink transmission on Band D. Thus, receiving the uplink grant that schedules the uplink transmission on Band D at or before "Y ′ "Y may help ensure that the UE has sufficient time to perform transmission switching to Band D before the transmission on Band D.

[0148] The minimum separation time between the end time of the uplink transmission scheduled on Band C and the start time of the uplink transmission scheduled on Band D may depend on the transmission state after a first switch to Band C (e.g., in preparation for the transmission over Band C). Timeline 800 involves a scenario in which one transmit chain ("1 Tx") of the UE is configured for operation on Band C, and timeline 810 involves a scenario in which two transmit chains ("2 Tx") of the UE are configured for operation on Band C.

[0149] With reference to timeline 800, Band D may be an associated frequency band of Band C, meaning that when the transmit chain is configured for operation on Band C, another transmit chain of the UE may be configured for operation on Band D. As a result, if Band D is an associated frequency band of Band C, then the minimum separation time may be zero, which may enable the UE to transmit uplink transmissions with low latency.

[0150] With continuing reference to timeline 800, Band C may have an associated frequency band (e.g., an associated frequency band that is not Band D), meaning that when the transmit chain is configured for operation on Band C, another transmit chain of the UE may be configured for operation on the associated frequency band. As a result, in this case, the minimum separation time may be based at least in part on a switching period associated with a switch from the associated frequency band to Band D. For example, the minimum separation time may be the switching period associated with the switch from the associated frequency band to Band D. The switching period may be reported by the UE to the network node. Basing the minimum separation time at least in part on the switching period associated with the switch from the associated frequency band to Band D may help ensure that the UE has sufficient time to perform transmission switching in case Band C has an associated frequency band (e.g., an associated frequency band that is not Band D).

[0151] With continuing reference to timeline 800, in other cases (e.g., cases in which Band C has no associated frequency band), the minimum separation time may be based at least in part on a maximum of a first switching period associated with a first switch from Band A to Band D, a second switching period associated with a second switch from Band B to Band D, and a third switching period associated with a third switch from Band C to Band D. For example, the minimum separation time may be the maximum of the first switching period, the second switching period, and the third switching period. The first, second, and third switching periods may be reported by the UE to the network node. Basing the minimum separation time at least in part on the maximum of the first switching period, the second switching period, and the third switching period may help ensure that the UE has sufficient time to perform transmission switching in case Band C has no associated frequency band.

[0152] With reference to timeline 810, the minimum separation time between the end time of the uplink transmission scheduled on Band C and the start time of the uplink transmission scheduled on Band D may be based at least in part on a switching period associated with a switch from Band C to Band D. For example, the minimum separation time may be the switching period associated with a switch from Band C to Band D. The switching period may be reported by the UE to the network node. Basing the minimum separation time at least in part on the switching period associated with a switch from Band C to Band D may help ensure that the UE has sufficient time to perform transmission switching in case both transmit chains are configured on Band C during the transmission over Band C.

[0153] As indicated above, Fig. 8 is provided as an example. Other examples may differ from what is described with respect to Fig. 8.

[0154] Fig. 9 is a diagram illustrating an example process 900 performed, for example, by a UE, in accordance with the present disclosure. Example process 900 is an example where the UE (e.g., UE 120) performs operations associated with scheduling uplink transmissions on multiple frequency bands.

[0155] As shown in Fig. 9, in some aspects, process 900 may include establishing a connection with a network node (block 910). For example, the UE (e.g., using communication manager 1306, depicted in Fig. 13) may establish a connection with a network node, as described above.

[0156] As further shown in Fig. 9, in some aspects, process 900 may include receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band (block 920). For example, the UE (e.g., using reception component 1302 and/or communication manager 1306, depicted in Fig. 13) may receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band, as described above.

[0157] Process 900 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.

[0158] In a first aspect, the offset is a "Y , parameter value.

[0159] In a second aspect, alone or in combination with the first aspect, the one or more uplink grants indicate that the UE is to switch from the first frequency band to the third frequency band and from the second frequency band to the fourth frequency band.

[0160] In a third aspect, alone or in combination with one or more of the first and second aspects, the offset is based at least in part on a maximum value of a first PUSCH preparation time parameter value associated with a first switch from the first frequency band to the third frequency band, and a second PUSCH preparation time parameter value associated with a second switch from the second frequency band to the fourth frequency band.

[0161] In a fourth aspect, alone or in combination with one or more of the first through third aspects, the first PUSCH preparation time parameter value is based at least in part on a larger of a first numerology parameter value associated with the first frequency band and a second numerology parameter value associated with the third frequency band, and the second PUSCH preparation time parameter value is based at least in part on a larger of a third numerology parameter value associated with the second frequency band and a fourth numerology parameter value associated with the fourth frequency band.

[0162] In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, the offset is based at least in part on a "Υ parameter value that is based at least in part on a largest of a first switching period associated with a first switch from the first frequency band to the third frequency band and a second switching period associated with a second switch from the second frequency band to the fourth frequency band.

[0163] In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, the one or more uplink grants indicate that the UE is to switch from the first frequency band and the second frequency band to the third frequency band and the fourth frequency band.

[0164] In a seventh aspect, alone or in combination with one or more of the first through sixth aspects, the first frequency band and the second frequency band are configured to carry downlink transmissions, and the offset is based at least in part on a PUSCH preparation time parameter value that is based at least in part on a larger of a first numerology parameter value associated with the first frequency band and the second frequency band and a second numerology parameter value associated with the third frequency band and the fourth frequency band.

[0165] In an eighth aspect, alone or in combination with one or more of the first through seventh aspects, the first numerology parameter value is based at least in part on a minimum of a third numerology parameter value associated with the first frequency band and a fourth numerology parameter value associated with the second frequency band, and the second numerology parameter value is based at least in part on a minimum of a fifth numerology parameter value associated with the third frequency band and a sixth numerology parameter value associated with the fourth frequency band.

[0166] In a ninth aspect, alone or in combination with one or more of the first through eighth aspects, the offset is based at least in part on a "Y parameter value that is based at least in part on a largest of a first switching period associated with a first switch from the first frequency band to the third frequency band, a second switching period associated with a second switch from the second frequency band to the third frequency band, a third switching period associated with a third switch from the first frequency band to the fourth frequency band, and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

[0167] In a tenth aspect, alone or in combination with one or more of the first through ninth aspects, the offset is based at least in part on a "Y parameter value that is based at least in part on a sum of a first maximum of a first switching period associated with a first switch from the first frequency band to the third frequency band and a second switching period associated with a second switch from the second frequency band to the third frequency band, and a second maximum of a third switching period associated with a third switch from the first frequency band to the fourth frequency band and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

[0168] In an eleventh aspect, alone or in combination with one or more of the first through tenth aspects, the sum is a first sum, and the "Y parameter value is further based at least in part on a second sum of the first sum and a predefined value.

[0169] In a twelfth aspect, alone or in combination with one or more of the first through eleventh aspects, the offset is based at least in part on a "Y parameter value that is based at least in part on a sum of a first switching period associated with a first switch from the first frequency band to the third frequency band, a second switching period associated with a second switch from the second frequency band to the third frequency band, a third switching period associated with a third switch from the first frequency band to the fourth frequency band, and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

[0170] In a thirteenth aspect, alone or in combination with one or more of the first through twelfth aspects, the sum is a first sum, and the "Y parameter is further based at least in part on a second sum of the first sum and a value.

[0171] In a fourteenth aspect, alone or in combination with one or more of the first through thirteenth aspects, process 900 includes transmitting, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0172] Although Fig. 9 shows example blocks of process 900, in some aspects, process 900 may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in Fig. 9. Additionally, or alternatively, two or more of the blocks of process 900 may be performed in parallel.

[0173] Fig. 10 is a diagram illustrating an example process 1000 performed, for example, by a UE, in accordance with the present disclosure. Example process 1000 is an example where the UE (e.g., UE 120) performs operations associated with scheduling uplink transmissions on multiple frequency bands.

[0174] As shown in Fig. 10, in some aspects, process 1000 may include establishing a connection with a network node (block 1010). For example, the UE (e.g., using communication manager 1306, depicted in Fig. 13) may establish a connection with a network node, as described above.

[0175] As further shown in Fig. 10, in some aspects, process 1000 may include receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission (block 1020). For example, the UE (e.g., using reception component 1302 and/or communication manager 1306, depicted in Fig. 13) may receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission, as described above.

[0176] 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.

[0177] In a first aspect, receiving the one or more uplink grants includes receiving an uplink grant of the one or more uplink grants that schedules the first uplink transmission at a time that is no later than an offset from a start time of the first uplink transmission, wherein the offset is based at least in part on the first frequency band and the third frequency band.

[0178] In a second aspect, alone or in combination with the first aspect, receiving the one or more uplink grants includes receiving an uplink grant of the one or more uplink grants that schedules the second uplink transmission at a time that is no later than an offset from a start time of the second uplink transmission, wherein the offset is based at least in part on the second frequency band and the fourth frequency band.

[0179] In a third aspect, alone or in combination with one or more of the first and second aspects, one transmit chain of the UE is configured for operation on the third frequency band, the fourth frequency band is an associated frequency band of the third frequency band, and the minimum separation time is zero.

[0180] In a fourth aspect, alone or in combination with one or more of the first through third aspects, one transmit chain of the UE is configured for operation on the third frequency band, the third frequency band has an associated frequency band, and the minimum separation time is based at least in part on a switching period associated with a switch from the associated frequency band to the fourth frequency band.

[0181] In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, one transmit chain of the UE is configured for operation on the third frequency band, and the minimum separation time is based at least in part on a maximum of a first switching period associated with a first switch from the first frequency band to the fourth frequency band, a second switching period associated with a second switch from the second frequency band to the fourth frequency band, and a third switching period associated with a third switch from the third frequency band to the fourth frequency band.

[0182] In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, two transmit chains of the UE are configured for operation on the third frequency band, and the minimum separation time is based at least in part on a switching period associated with a switch from the third frequency band to the fourth frequency band.

[0183] In a seventh aspect, alone or in combination with one or more of the first through sixth aspects, process 1000 includes transmitting, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0184] 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.

[0185] Fig. 11 is a diagram illustrating an example process 1100 performed, for example, by a network node, in accordance with the present disclosure. Example process 1100 is an example where the network node (e.g., network node 110) performs operations associated with scheduling uplink transmissions on multiple frequency bands.

[0186] As shown in Fig. 11, in some aspects, process 1100 may include establishing a connection with a UE (block 1110). For example, the network node (e.g., using communication manager 1406, depicted in Fig. 14) may establish a connection with a UE, as described above.

[0187] As further shown in Fig. 11, in some aspects, process 1100 may include outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band (block 1120). For example, the network node (e.g., using transmission component 1404 and/or communication manager 1406, depicted in Fig. 14) may output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band, as described above.

[0188] 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.

[0189] In a first aspect, the offset is a "Y , parameter value.

[0190] In a second aspect, alone or in combination with the first aspect, the one or more uplink grants indicate that the UE is to switch from the first frequency band to the third frequency band and from the second frequency band to the fourth frequency band.

[0191] In a third aspect, alone or in combination with one or more of the first and second aspects, the one or more uplink grants indicate that the UE is to switch from the first frequency band and the second frequency band to the third frequency band and the fourth frequency band.

[0192] 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.

[0193] Fig. 12 is a diagram illustrating an example process 1200 performed, for example, by a network node, in accordance with the present disclosure. Example process 1200 is an example where the network node (e.g., network node 110) performs operations associated with scheduling uplink transmissions on multiple frequency bands.

[0194] As shown in Fig. 12, in some aspects, process 1200 may include establishing a connection with a UE (block 1210). For example, the network node (e.g., using communication manager 1406, depicted in Fig. 14) may establish a connection with a UE, as described above.

[0195] As further shown in Fig. 12, in some aspects, process 1200 may include outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission (block 1220). For example, the network node (e.g., using transmission component 1404 and/or communication manager 1406, depicted in Fig.

14) may output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission, as described above.

[0196] Process 1200 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.

[0197] In a first aspect, outputting the one or more uplink grants includes outputting an uplink grant of the one or more uplink grants that schedules the first uplink transmission such that the uplink grant is received by the UE at a time that is no later than an offset from a start time of the first uplink transmission, wherein the offset is based at least in part on the first frequency band and the third frequency band.

[0198] In a second aspect, alone or in combination with the first aspect, receiving the one or more uplink grants includes outputting an uplink grant of the one or more uplink grants that schedules the second uplink transmission such that the uplink grant is received by the UE at a time that is no later than an offset from a start time of the second uplink transmission, wherein the offset is based at least in part on the second frequency band and the fourth frequency band.

[0199] Although Fig. 12 shows example blocks of process 1200, in some aspects, process 1200 may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in Fig. 12. Additionally, or alternatively, two or more of the blocks of process 1200 may be performed in parallel.

[0200] 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 UE, or a UE 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 140 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.

[0201] In some aspects, the apparatus 1300 may be configured to perform one or more operations described herein in connection with Figs. 5-8. Additionally, or alternatively, the apparatus 1300 may be configured to perform one or more processes described herein, such as process 900 of Fig. 9, process 1000 of Fig. 10, or a combination thereof. In some aspects, the apparatus 1300 and/or one or more components shown in Fig. 13 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. 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 a memory. 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 a controller or a processor to perform the functions or operations of the component.

[0202] 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, a modem, a demodulator, a MIMO detector, a receive processor, a controller/processor, a memory, or a combination thereof, of the UE described in connection with Fig. 2.

[0203] 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, a modem, a modulator, a transmit MIMO processor, a transmit processor, a controller/processor, a memory, or a combination thereof, of the UE described in connection with Fig. 2. In some aspects, the transmission component 1304 may be co-located with the reception component 1302 in a transceiver.

[0204] 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.

[0205] The communication manager 1306 may establish a connection with a network node. The reception component 1302 may receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0206] The transmission component 1304 may transmit, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0207] The communication manager 1306 may establish a connection with a network node. The reception component 1302 may receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0208] The transmission component 1304 may transmit, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0209] 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.

[0210] Fig. 14 is a diagram of an example apparatus 1400 for wireless communication, in accordance with the present disclosure. The apparatus 1400 may be a network node, or a network node may include the apparatus 1400. In some aspects, the apparatus 1400 includes a reception component 1402, a transmission component 1404, and/or a communication manager 1406, 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 1406 is the communication manager 150 described in connection with Fig. 1. As shown, the apparatus 1400 may communicate with another apparatus 1408, such as a UE or a network node (such as a CU, a DU, an RU, or a base station), using the reception component 1402 and the transmission component 1404.

[0211] In some aspects, the apparatus 1400 may be configured to perform one or more operations described herein in connection with Figs. 5-8. Additionally, or alternatively, the apparatus 1400 may be configured to perform one or more processes described herein, such as process 1100 of Fig. 11, process 1200 of Fig. 12, or a combination thereof. In some aspects, the apparatus 1400 and/or one or more components shown in Fig. 14 may include one or more components of the network node described in connection with Fig. 2. Additionally, or alternatively, one or more components shown in Fig. 14 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 a memory. 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 a controller or a processor to perform the functions or operations of the component.

[0212] The reception component 1402 may receive communications, such as reference signals, control information, data communications, or a combination thereof, from the apparatus 1408. The reception component 1402 may provide received communications to one or more other components of the apparatus 1400. In some aspects, the reception component 1402 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 1400. In some aspects, the reception component 1402 may include one or more antennas, a modem, a demodulator, a MIMO detector, a receive processor, a controller/processor, a memory, or a combination thereof, of the network node described in connection with Fig. 2. In some aspects, the reception component 1402 and/or the transmission component 1404 may include or may be included in a network interface. The network interface may be configured to obtain and/or output signals for the apparatus 1400 via one or more communications links, such as a backhaul link, a midhaul link, and/or a fronthaul link.

[0213] The transmission component 1404 may transmit communications, such as reference signals, control information, data communications, or a combination thereof, to the apparatus 1408. In some aspects, one or more other components of the apparatus 1400 may generate communications and may provide the generated communications to the transmission component 1404 for transmission to the apparatus 1408. In some aspects, the transmission component 1404 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 1408. In some aspects, the transmission component 1404 may include one or more antennas, a modem, a modulator, a transmit MIMO processor, a transmit processor, a controller/processor, a memory, or a combination thereof, of the network node described in connection with

Fig. 2. In some aspects, the transmission component 1404 may be co-located with the reception component 1402 in a transceiver.

[0214] The communication manager 1406 may support operations of the reception component 1402 and/or the transmission component 1404. For example, the communication manager 1406 may receive information associated with configuring reception of communications by the reception component 1402 and/or transmission of communications by the transmission component 1404. Additionally, or alternatively, the communication manager 1406 may generate and/or provide control information to the reception component 1402 and/or the transmission component 1404 to control reception and/or transmission of communications.

[0215] The communication manager 1406 may establish a connection with a UE. The transmission component 1404 may output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0216] The communication manager 1406 may establish a connection with a UE. The transmission component 1404 may output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0217] The number and arrangement of components shown in Fig. 14 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. 14. Furthermore, two or more components shown in Fig. 14 may be implemented within a single component, or a single component shown in Fig. 14 may be implemented as multiple, distributed components. Additionally, or alternatively, a set of (one or more) components shown in Fig. 14 may perform one or more functions described as being performed by another set of components shown in Fig. 14.

[0218] The following provides an overview of some Aspects of the present disclosure:

[0219] Aspect 1: A method of wireless communication performed by a UE, comprising: establishing a connection with a network node; and receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0220] Aspect 2: The method of Aspect 1, wherein the offset is a "Y , parameter value.

[0221] Aspect 3: The method of any of Aspects 1-2, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band to the third frequency band and from the second frequency band to the fourth frequency band.

[0222] Aspect 4: The method of Aspect 3, wherein the offset is based at least in part on a maximum value of a first PUSCH preparation time parameter value associated with a first switch from the first frequency band to the third frequency band, and a second PUSCH preparation time parameter value associated with a second switch from the second frequency band to the fourth frequency band.

[0223] Aspect 5: The method of Aspect 4, wherein the first PUSCH preparation time parameter value is based at least in part on a larger of a first numerology parameter value associated with the first frequency band and a second numerology parameter value associated with the third frequency band, and wherein the second PUSCH preparation time parameter value is based at least in part on a larger of a third numerology parameter value associated with the second frequency band and a fourth numerology parameter value associated with the fourth frequency band.

[0224] Aspect 6: The method of Aspect 3, wherein the offset is based at least in part on a "Y parameter value that is based at least in part on a largest of a first switching period associated with a first switch from the first frequency band to the third frequency band and a second switching period associated with a second switch from the second frequency band to the fourth frequency band.

[0225] Aspect 7: The method of any of Aspects 1-6, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band and the second frequency band to the third frequency band and the fourth frequency band.

[0226] Aspect 8: The method of Aspect 7, wherein the first frequency band and the second frequency band are configured to carry downlink transmissions, and wherein the offset is based at least in part on a PUSCH preparation time parameter value that is based at least in part on a larger of a first numerology parameter value associated with the first frequency band and the second frequency band and a second numerology parameter value associated with the third frequency band and the fourth frequency band.

[0227] Aspect 9: The method of Aspect 8, wherein the first numerology parameter value is based at least in part on a minimum of a third numerology parameter value associated with the first frequency band and a fourth numerology parameter value associated with the second frequency band, and wherein the second numerology parameter value is based at least in part on a minimum of a fifth numerology parameter value associated with the third frequency band and a sixth numerology parameter value associated with the fourth frequency band.

[0228] Aspect 10: The method of any of Aspects 1-9, wherein the offset is based at least in part on a "Y parameter value that is based at least in part on a largest of: a first switching period associated with a first switch from the first frequency band to the third frequency band; a second switching period associated with a second switch from the second frequency band to the third frequency band; a third switching period associated with a third switch from the first frequency band to the fourth frequency band; and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

[0229] Aspect 11: The method of any of Aspects 1-10, wherein the offset is based at least in part on a "Y parameter value that is based at least in part on a sum of a first maximum of a first switching period associated with a first switch from the first frequency band to the third frequency band and a second switching period associated with a second switch from the second frequency band to the third frequency band, and a second maximum of a third switching period associated with a third switch from the first frequency band to the fourth frequency band and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

[0230] Aspect 12: The method of Aspect 11, wherein the sum is a first sum, and wherein the ˝Y parameter value is further based at least in part on a second sum of the first sum and a predefined value.

[0231] Aspect 13: The method of any of Aspects 1-12, wherein the offset is based at least in part on a ˝Y parameter value that is based at least in part on a sum of: a first switching period associated with a first switch from the first frequency band to the third frequency band; a second switching period associated with a second switch from the second frequency band to the third frequency band; a third switching period associated with a third switch from the first frequency band to the fourth frequency band; and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

[0232] Aspect 14: The method of Aspect 13, wherein the sum is a first sum, and wherein the ˝Y parameter is further based at least in part on a second sum of the first sum and a value.

[0233] Aspect 15: The method of any of Aspects 1-14, further comprising: transmitting, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0234] Aspect 16: A method of wireless communication performed by a UE, comprising: establishing a connection with a network node; and receiving, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0235] Aspect 17: The method of Aspect 16, wherein receiving the one or more uplink grants includes: receiving an uplink grant of the one or more uplink grants that schedules the first uplink transmission at a time that is no later than an offset from a start time of the first uplink transmission, wherein the offset is based at least in part on the first frequency band and the third frequency band.

[0236] Aspect 18: The method of any of Aspects 16-17, wherein receiving the one or more uplink grants includes: receiving an uplink grant of the one or more uplink grants that schedules the second uplink transmission at a time that is no later than an offset from a start time of the second uplink transmission, wherein the offset is based at least in part on the second frequency band and the fourth frequency band.

[0237] Aspect 19: The method of any of Aspects 16-18, wherein one transmit chain of the UE is configured for operation on the third frequency band, wherein the fourth frequency band is an associated frequency band of the third frequency band, and wherein the minimum separation time is zero.

[0238] Aspect 20: The method of any of Aspects 16-19, wherein one transmit chain of the UE is configured for operation on the third frequency band, wherein the third frequency band has an associated frequency band, and wherein the minimum separation time is based at least in part on a switching period associated with a switch from the associated frequency band to the fourth frequency band.

[0239] Aspect 21: The method of any of Aspects 16-20, wherein one transmit chain of the UE is configured for operation on the third frequency band, and wherein the minimum separation time is based at least in part on a maximum of: a first switching period associated with a first switch from the first frequency band to the fourth frequency band; a second switching period associated with a second switch from the second frequency band to the fourth frequency band; and a third switching period associated with a third switch from the third frequency band to the fourth frequency band.

[0240] Aspect 22: The method of any of Aspects 16-21, wherein two transmit chains of the UE are configured for operation on the third frequency band, and wherein the minimum separation time is based at least in part on a switching period associated with a switch from the third frequency band to the fourth frequency band.

[0241] Aspect 23: The method of any of Aspects 16-22, further comprising: transmitting, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

[0242] Aspect 24: A method of wireless communication performed by a network node, comprising: establishing a connection with a UE; and outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band

and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

[0243] Aspect 25: The method of Aspect 24, wherein the offset is a "Y , parameter value.

[0244] Aspect 26: The method of any of Aspects 24-25, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band to the third frequency band and from the second frequency band to the fourth frequency band.

[0245] Aspect 27: The method of any of Aspects 24-26, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band and the second frequency band to the third frequency band and the fourth frequency band.

[0246] Aspect 28: A method of wireless communication performed by a network node, comprising: establishing a connection with a UE; and outputting, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

[0247] Aspect 29: The method of Aspect 28, wherein outputting the one or more uplink grants includes: outputting an uplink grant of the one or more uplink grants that schedules the first uplink transmission such that the uplink grant is received by the UE at a time that is no later than an offset from a start time of the first uplink transmission, wherein the offset is based at least in part on the first frequency band and the third frequency band.

[0248] Aspect 30: The method of any of Aspects 28-29, wherein receiving the one or more uplink grants includes: outputting an uplink grant of the one or more uplink grants that schedules the second uplink transmission such that the uplink grant is received by the UE at a time that is no later than an offset from a start time of the second uplink transmission, wherein the offset is based at least in part on the second frequency band and the fourth frequency band.

[0249] Aspect 31: An apparatus for wireless communication at a device, comprising a processor; memory coupled with the processor; and instructions stored in the memory and executable by the processor to cause the apparatus to perform the method of one or more of Aspects 1-30.

[0250] Aspect 32: A device for wireless communication, comprising a memory and one or more processors coupled to the memory, the one or more processors configured to perform the method of one or more of Aspects 1-30.

[0251] Aspect 33: An apparatus for wireless communication, comprising at least one means for performing the method of one or more of Aspects 1-30.

[0252] Aspect 34: A non-transitory computer-readable medium storing code for wireless communication, the code comprising instructions executable by a processor to perform the method of one or more of Aspects 1-30.

[0253] Aspect 35: 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 1-30.

[0254] 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.

[0255] As used herein, the term "component" is intended to be broadly construed as hardware and/or a combination of hardware and software. "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, and/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 and/or a combination of hardware and software. It will be apparent that systems and/or methods described herein may be implemented in different forms of hardware and/or a combination of hardware and software. The actual specialized control hardware or software code used to implement these systems and/or methods is not limiting of the aspects. Thus, the operation and behavior of the systems and/or methods are described herein without reference to specific software code, since those skilled in the art will understand that software and hardware can be designed to implement the systems and/or methods based, at least in part, on the description herein.

[0256] 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, not equal to the threshold, or the like.

[0257] Even though particular combinations of features are recited in the claims and/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 and/or disclosed in the specification. The disclosure of various aspects includes each dependent claim in combination with every other claim in the claim set. As used herein, a phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of: a, b, or c" is intended to cover a, b, c, a + b, a + c, b + c, and a + b + c, as well as any combination with multiples of the same element (e.g., a + a, a + a + a, a + a + b, a + a + c, a + b + b, a + c + c, b + b, b + b + b, b + b + c, c + c, and c + c + c, or any other ordering of a, b, and c).

[0258] 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," or the like are intended to be open-ended terms that do not limit an element that they modify (e.g., an element "having" A may also have B). Further, the phrase "based on" is intended to mean "based, at least in part, on" 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 (e.g., if used in combination with "either" or "only one of").

WHAT IS CLAIMED IS:

1. A user equipment (UE) for wireless communication, comprising:

a memory; and

one or more processors, coupled to the memory, configured to:

establish a connection with a network node; and

receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

2. The UE of claim 1, wherein the offset is a "Y , parameter value.

3. The UE of claim 1, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band to the third frequency band and from the second frequency band to the fourth frequency band.

4. The UE of claim 3, wherein the offset is based at least in part on a maximum value of a first physical uplink shared channel (PUSCH) preparation time parameter value associated with a first switch from the first frequency band to the third frequency band, and a second PUSCH preparation time parameter value associated with a second switch from the second frequency band to the fourth frequency band.

5. The UE of claim 4, wherein the first PUSCH preparation time parameter value is based at least in part on a larger of a first numerology parameter value associated with the first frequency band and a second numerology parameter value associated with the third frequency band, and wherein the second PUSCH preparation time parameter value is based at least in part on a larger of a third numerology parameter value associated

with the second frequency band and a fourth numerology parameter value associated with the fourth frequency band.

6. The UE of claim 3, wherein the offset is based at least in part on a ʺϒ parameter value that is based at least in part on a largest of a first switching period associated with a first switch from the first frequency band to the third frequency band and a second switching period associated with a second switch from the second frequency band to the fourth frequency band.

7. The UE of claim 1, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band and the second frequency band to the third frequency band and the fourth frequency band.

8. The UE of claim 7, wherein the first frequency band and the second frequency band are configured to carry downlink transmissions, and wherein the offset is based at least in part on a physical uplink shared channel (PUSCH) preparation time parameter value that is based at least in part on a larger of a first numerology parameter value associated with the first frequency band and the second frequency band and a second numerology parameter value associated with the third frequency band and the fourth frequency band.

9. The UE of claim 8, wherein the first numerology parameter value is based at least in part on a minimum of a third numerology parameter value associated with the first frequency band and a fourth numerology parameter value associated with the second frequency band, and wherein the second numerology parameter value is based at least in part on a minimum of a fifth numerology parameter value associated with the third frequency band and a sixth numerology parameter value associated with the fourth frequency band.

10. The UE of claim 1, wherein the offset is based at least in part on a ʺϒ parameter value that is based at least in part on a largest of: a first switching period associated with a first switch from the first frequency band to the third frequency band; a second switching period associated with a second switch from the second frequency band to the third frequency band; a third switching period associated with a third switch

from the first frequency band to the fourth frequency band; and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

11. The UE of claim 1, wherein the offset is based at least in part on a ″Υ parameter value that is based at least in part on a sum of a first maximum of a first switching period associated with a first switch from the first frequency band to the third frequency band and a second switching period associated with a second switch from the second frequency band to the third frequency band, and a second maximum of a third switching period associated with a third switch from the first frequency band to the fourth frequency band and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

12. The UE of claim 11, wherein the sum is a first sum, and wherein the ″Υ parameter value is further based at least in part on a second sum of the first sum and a predefined value.

13. The UE of claim 1, wherein the offset is based at least in part on a ″Υ parameter value that is based at least in part on a sum of: a first switching period associated with a first switch from the first frequency band to the third frequency band; a second switching period associated with a second switch from the second frequency band to the third frequency band; a third switching period associated with a third switch from the first frequency band to the fourth frequency band; and a fourth switching period associated with a fourth switch from the second frequency band to the fourth frequency band.

14. The UE of claim 13, wherein the sum is a first sum, and wherein the ″Υ parameter value is further based at least in part on a second sum of the first sum and a value.

15. The UE of claim 1, wherein the one or more processors are further configured to:

transmit, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

16. A UE for wireless communication, comprising:

a memory; and

one or more processors, coupled to the memory, configured to:

establish a connection with a network node; and

receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

17. The UE of claim 16, wherein the one or more processors, to receive the one or more uplink grants, are configured to:

receive an uplink grant of the one or more uplink grants that schedules the first uplink transmission at a time that is no later than an offset from a start time of the first uplink transmission, wherein the offset is based at least in part on the first frequency band and the third frequency band.

18. The UE of claim 16, wherein the one or more processors, to receive the one or more uplink grants, are configured to:

receive an uplink grant of the one or more uplink grants that schedules the second uplink transmission at a time that is no later than an offset from a start time of the second uplink transmission, wherein the offset is based at least in part on the second frequency band and the fourth frequency band.

19. The UE of claim 16, wherein one transmit chain of the UE is configured for operation on the third frequency band, wherein the fourth frequency band is an

associated frequency band of the third frequency band, and wherein the minimum separation time is zero.

20. The UE of claim 16, wherein one transmit chain of the UE is configured for operation on the third frequency band, wherein the third frequency band has an associated frequency band, and wherein the minimum separation time is based at least in part on a switching period associated with a switch from the associated frequency band to the fourth frequency band.

21. The UE of claim 16, wherein one transmit chain of the UE is configured for operation on the third frequency band, and wherein the minimum separation time is based at least in part on a maximum of: a first switching period associated with a first switch from the first frequency band to the fourth frequency band; a second switching period associated with a second switch from the second frequency band to the fourth frequency band; and a third switching period associated with a third switch from the third frequency band to the fourth frequency band.

22. The UE of claim 16, wherein two transmit chains of the UE are configured for operation on the third frequency band, and wherein the minimum separation time is based at least in part on a switching period associated with a switch from the third frequency band to the fourth frequency band.

23. The UE of claim 16, wherein the one or more processors are further configured to:

transmit, in accordance with the one or more uplink grants, the first uplink transmission on the third frequency band and the second uplink transmission on the fourth frequency band.

24. A network node for wireless communication, comprising:

a memory; and

one or more processors, coupled to the memory, configured to:

establish a connection with a user equipment (UE); and

output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band.

25. The network node of claim 24, wherein the offset is a "Y , parameter value.

26. The network node of claim 24, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band to the third frequency band and from the second frequency band to the fourth frequency band.

27. The network node of claim 24, wherein the one or more uplink grants indicate that the UE is to switch from the first frequency band and the second frequency band to the third frequency band and the fourth frequency band.

28. A network node for wireless communication, comprising:

a memory; and

one or more processors, coupled to the memory, configured to:

establish a connection with a user equipment (UE); and

output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission.

29. The network node of claim 28, wherein the one or more processors, to output the one or more uplink grants, are configured to:

output an uplink grant of the one or more uplink grants that schedules the first uplink transmission such that the uplink grant is received by the UE at a time that is no later than an offset from a start time of the first uplink transmission, wherein the offset is based at least in part on the first frequency band and the third frequency band.

30. The network node of claim 28, wherein the one or more processors, to receive the one or more uplink grants, are configured to:

output an uplink grant of the one or more uplink grants that schedules the second uplink transmission such that the uplink grant is received by the UE at a time that is no later than an offset from a start time of the second uplink transmission, wherein the offset is based at least in part on the second frequency band and the fourth frequency band.

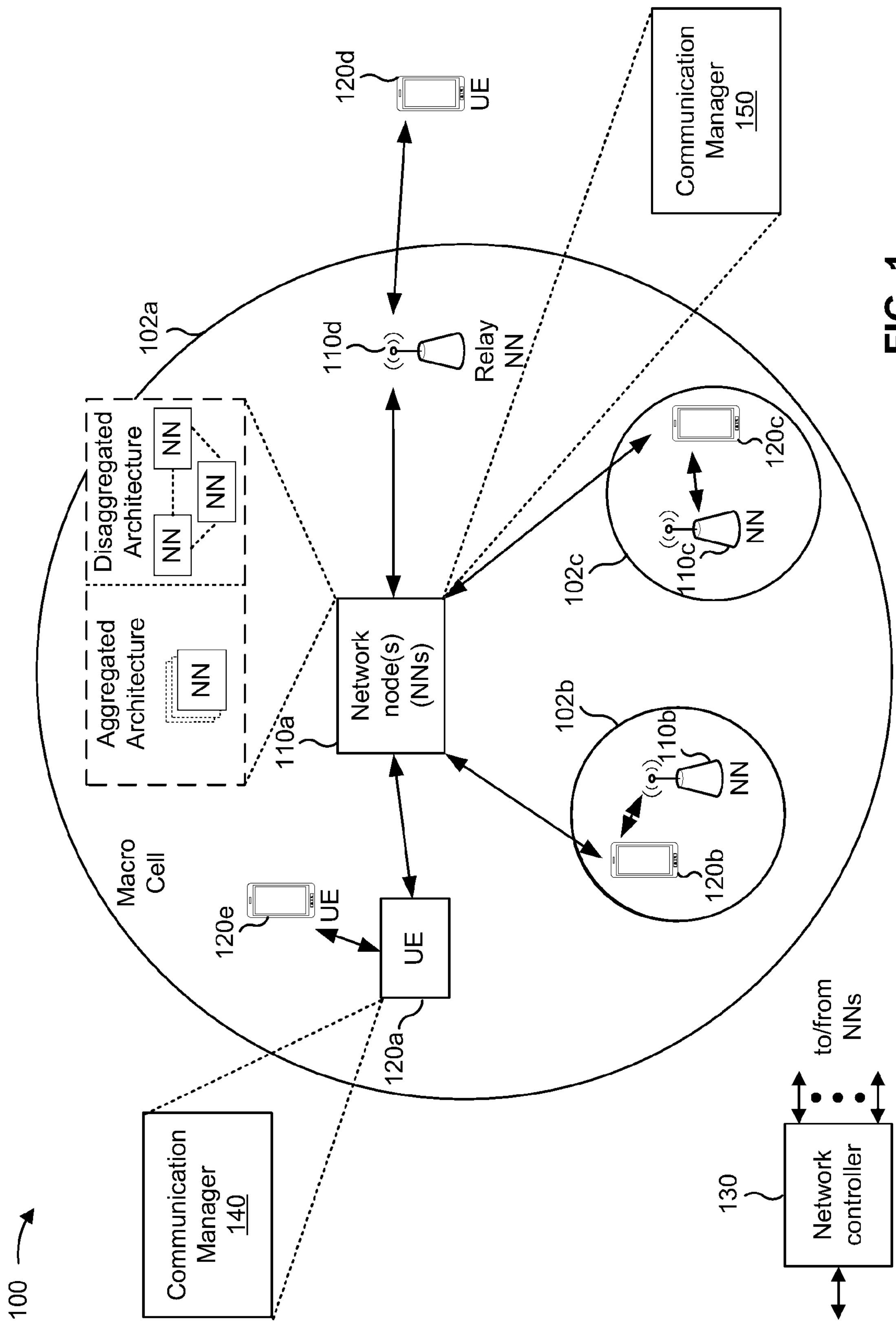
100
Communication Manager 140
Macro Cell
120e
UE
UE
120a
Aggregated Architecture
NN
Disaggregated Architecture
NN
NN
NN
102a
110a
Network node(s) (NNs)
110d
Relay NN
120d
UE
Communication Manager 150
102b
110b
NN
120b
102c
110c
NN
120c
130
Network controller
to/from NNs

FIG. 1

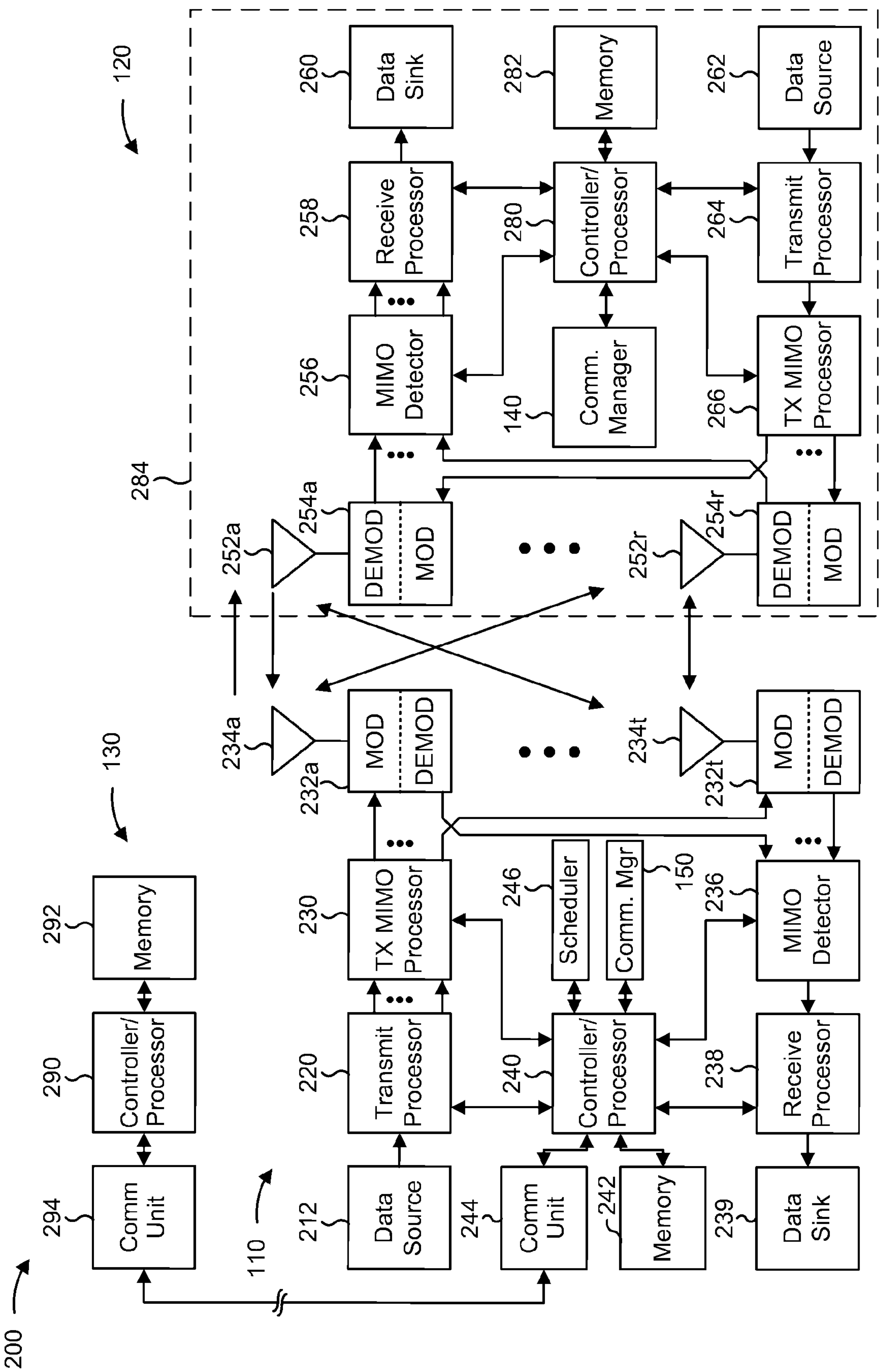
200
130
Memory
292
Controller/ Processor
290
Comm Unit
294
110
Data Source
212
Transmit Processor
220
TX MIMO Processor
230
MOD
DEMOD
232a
234a
Controller/ Processor
240
Scheduler
246
Comm. Mgr
150
Comm Unit
244
Memory
242
MIMO Detector
236
Receive Processor
238
Data Sink
239
MOD
DEMOD
232t
234t
120
284
Data Sink
260
Receive Processor
258
MIMO Detector
256
DEMOD
MOD
254a
252a
Memory
282
Controller/ Processor
280
Comm. Manager
140
Data Source
262
Transmit Processor
264
TX MIMO Processor
266
DEMOD
MOD
254r
252r

FIG. 2

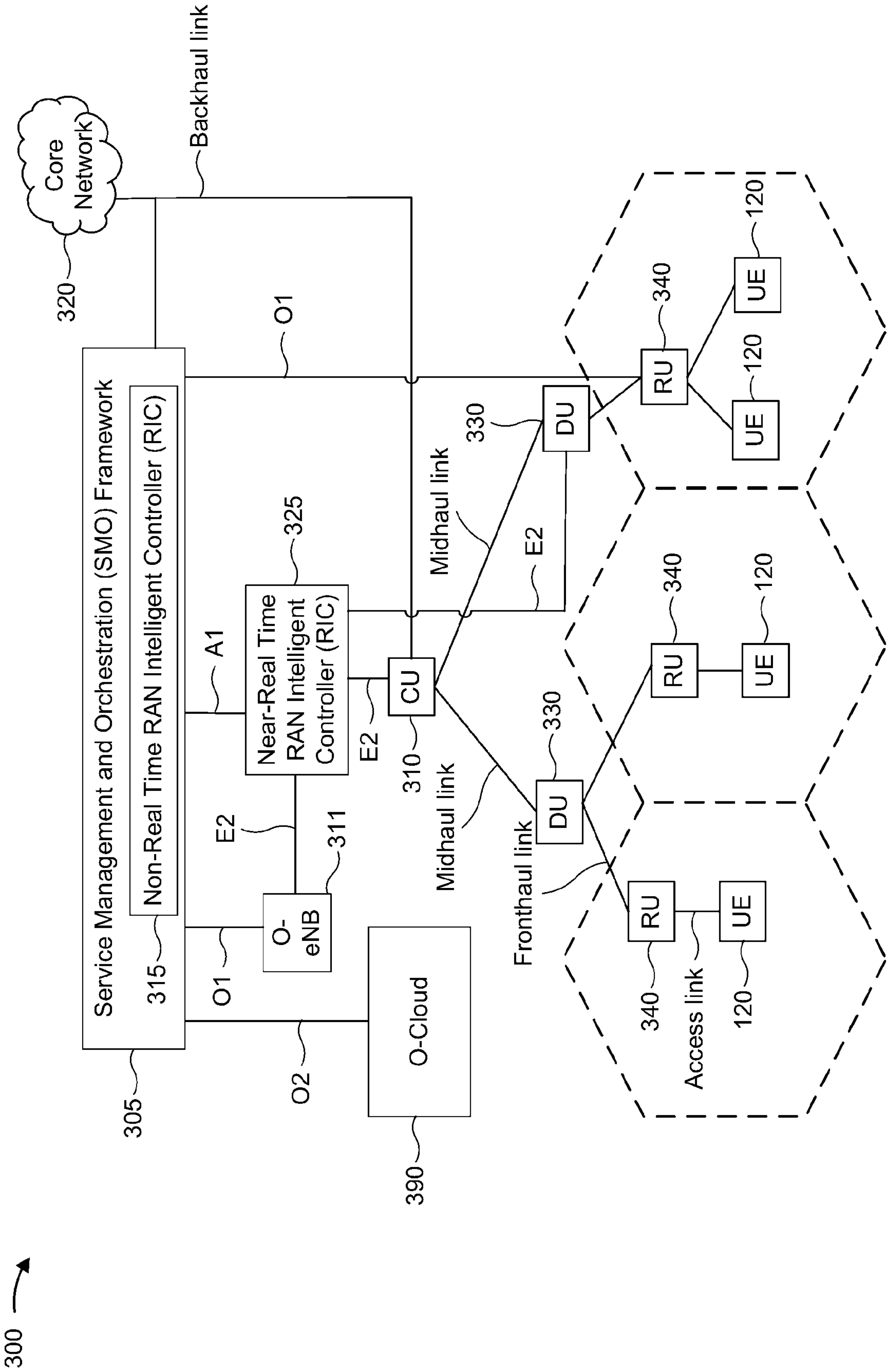
300
Core Network
320
Backhaul link
Service Management and Orchestration (SMO) Framework
Non-Real Time RAN Intelligent Controller (RIC)
315
305
O1
A1
E2
Near-Real Time RAN Intelligent Controller (RIC)
325
CU
310
O-eNB
311
O-Cloud
390
O2
Midhaul link
DU
330
Fronthaul link
RU
340
UE
120
Access link

FIG. 3

400

μ	PUSCH preparation time N2 [symbols]
0	10
1	12
2	23
3	36
5	144
6	288

FIG. 4

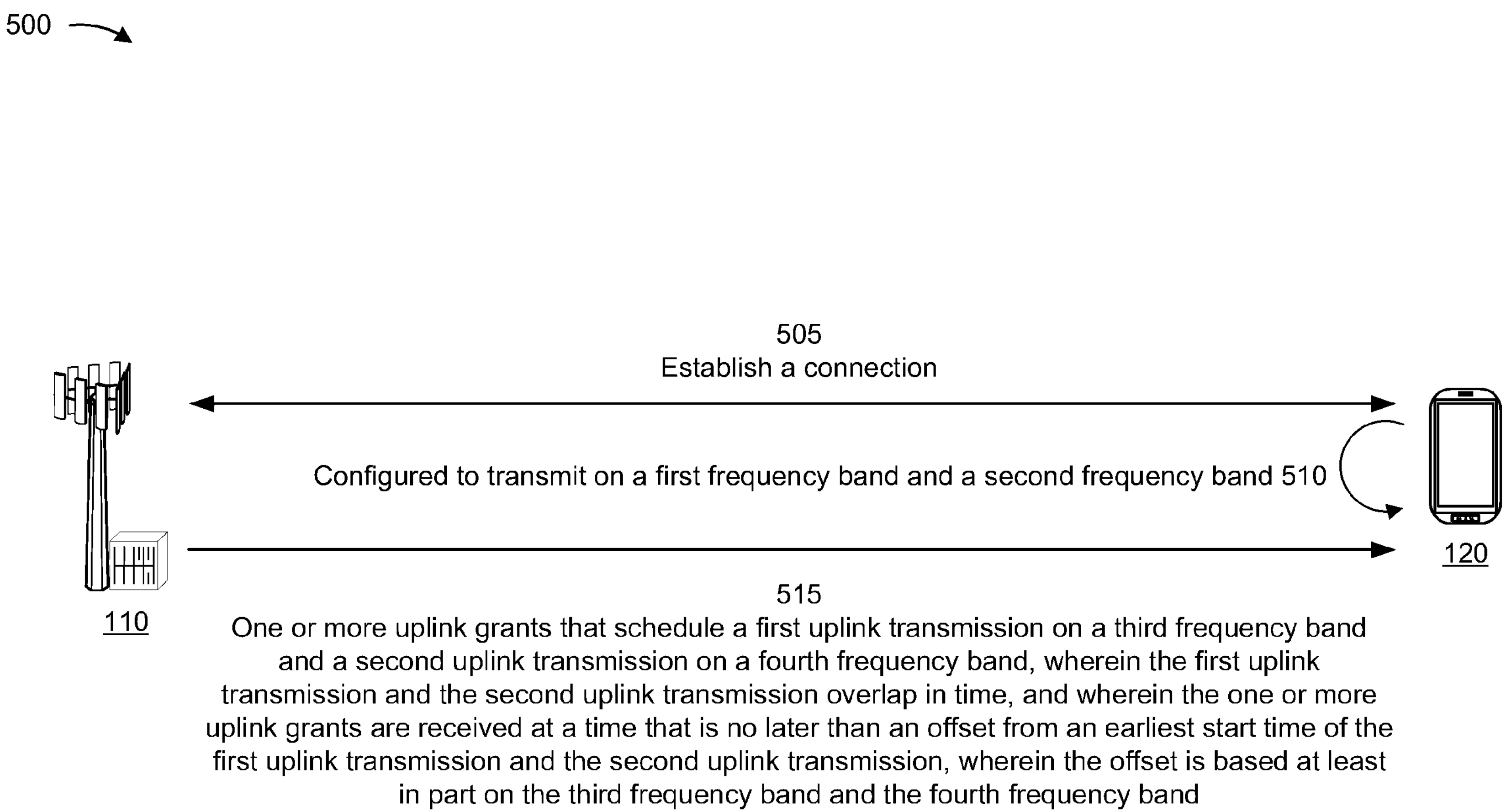
500
505
Establish a connection
Configured to transmit on a first frequency band and a second frequency band 510
120
110
515
One or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band

FIG. 5

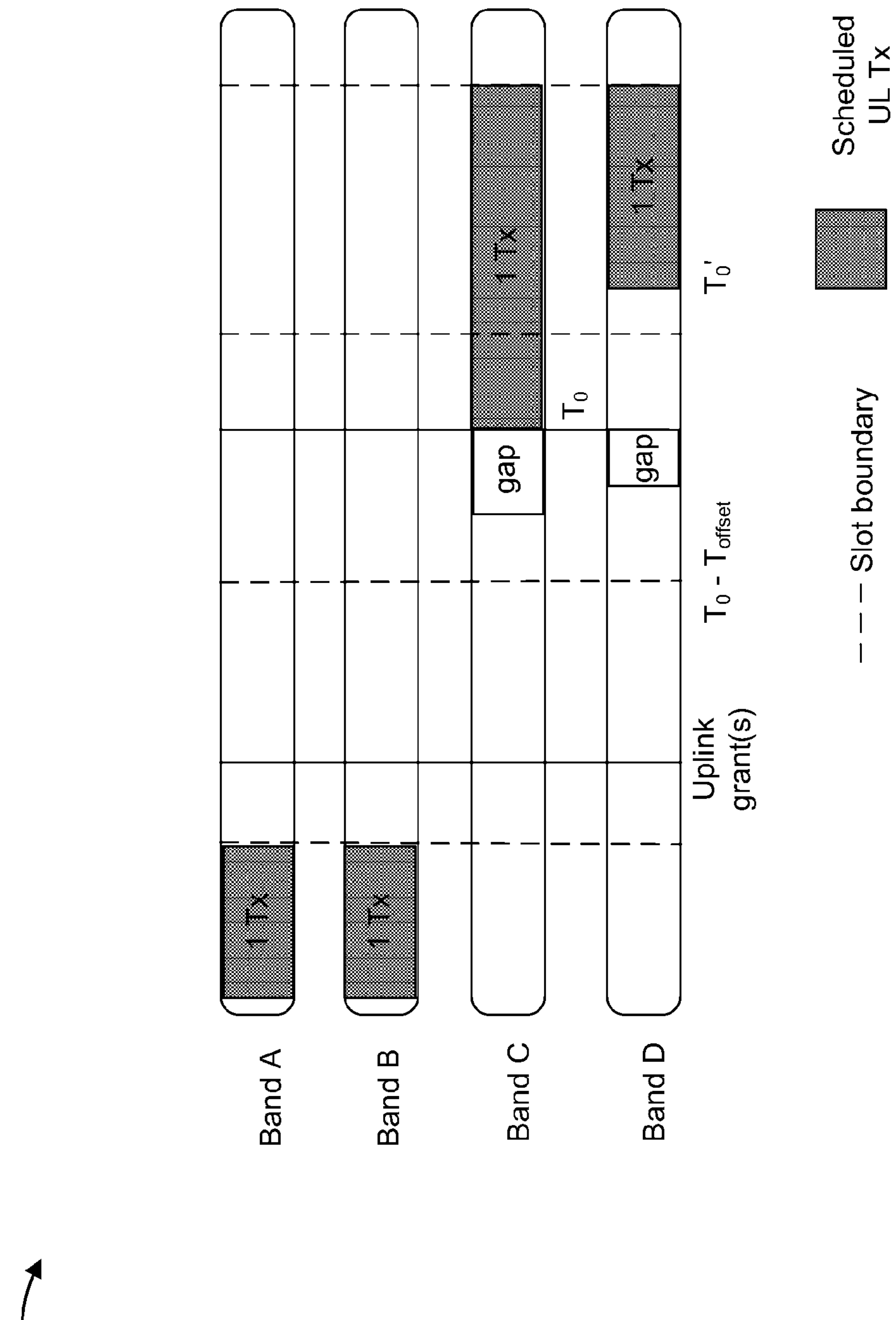
600
Band A
Band B
Band C
Band D
1 Tx
1 Tx
1 Tx
1 Tx
gap
gap
Uplink grant(s)
T_0 - T_{offset}
T_0
T_0'
Slot boundary
Scheduled UL Tx

FIG. 6

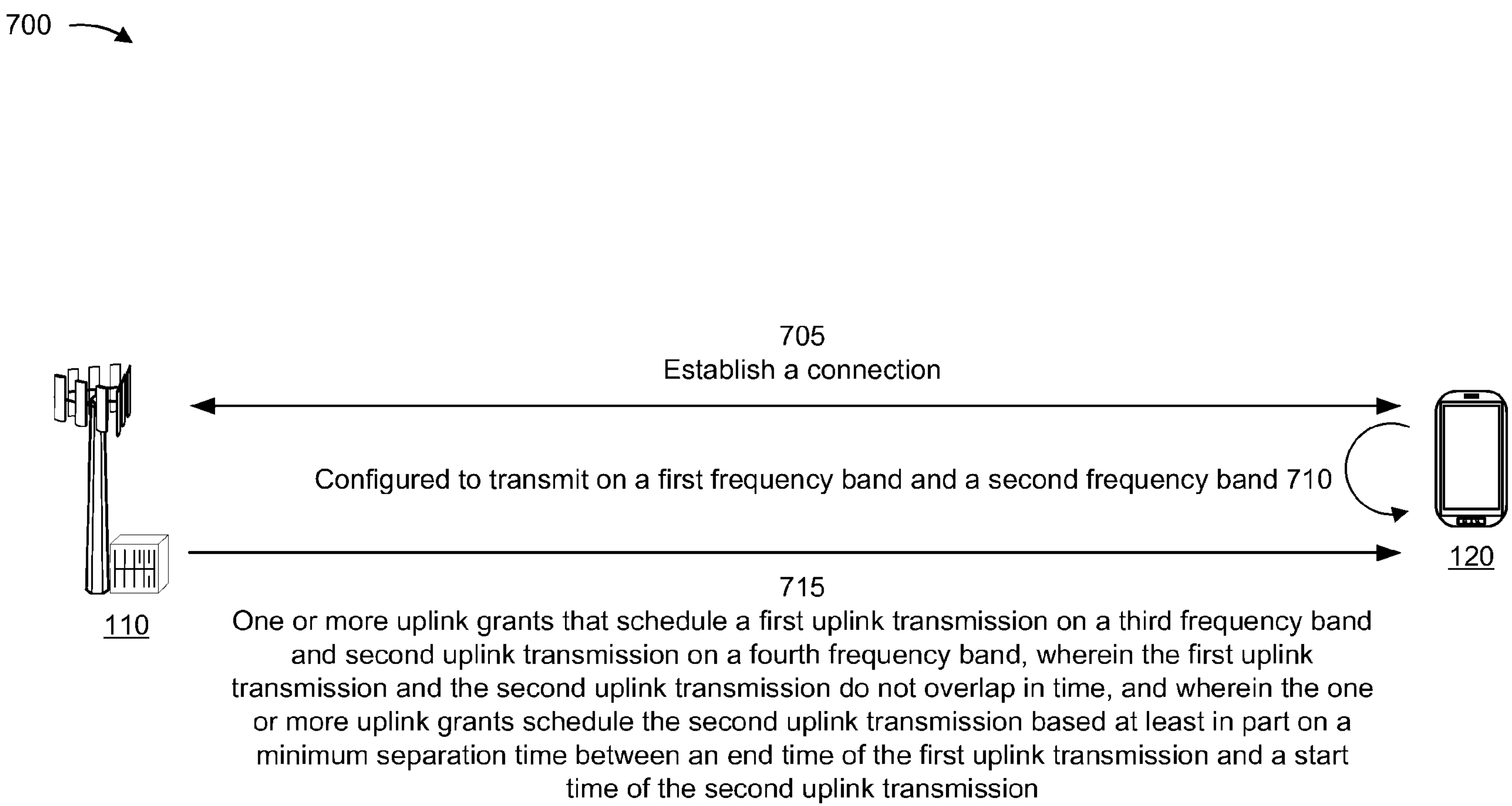
700
705
Establish a connection
Configured to transmit on a first frequency band and a second frequency band 710
715
One or more uplink grants that schedule a first uplink transmission on a third frequency band and second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission
110
120

FIG. 7

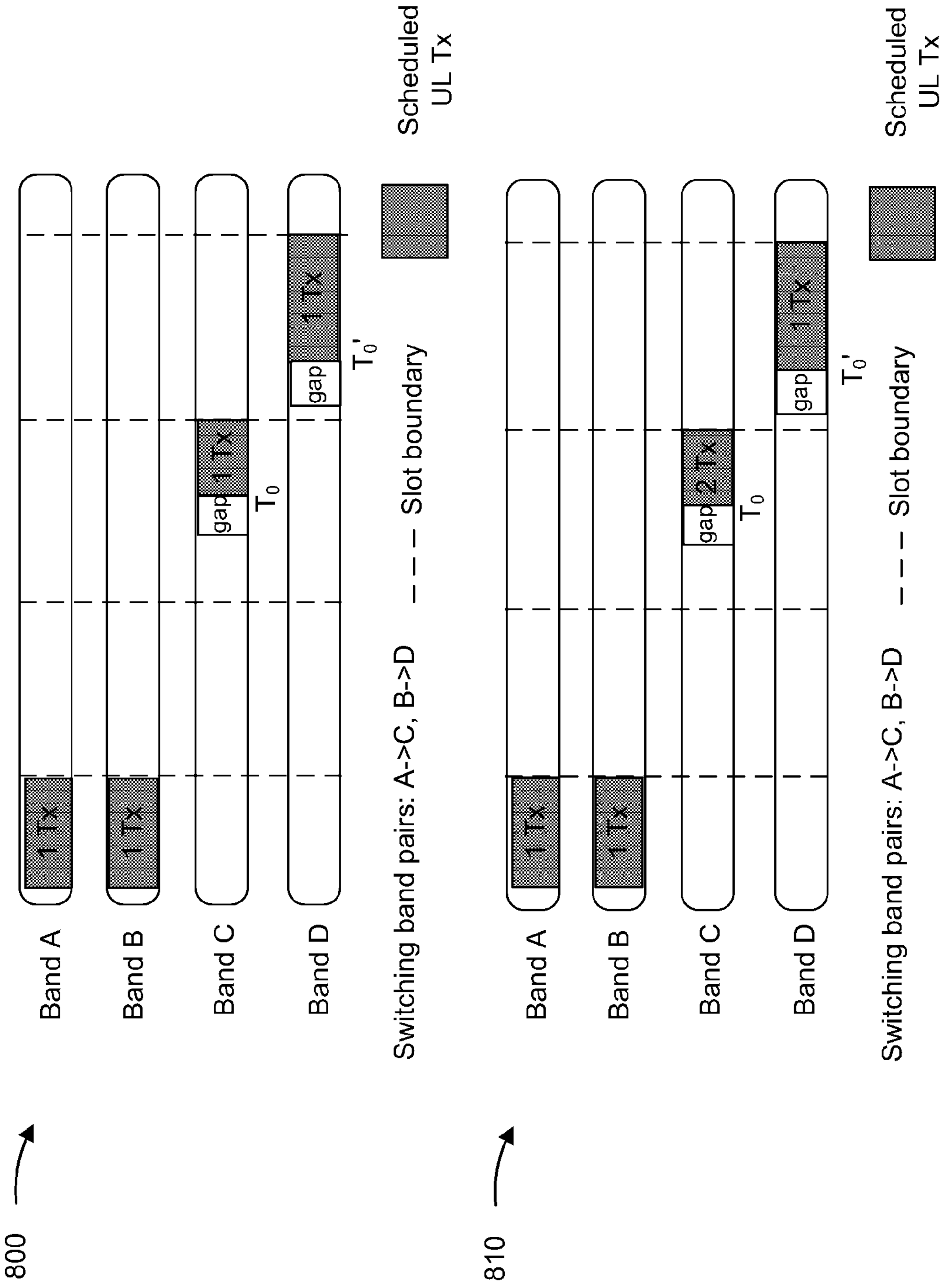
800
Band A
Band B
Band C
Band D
1 Tx
1 Tx
gap
1 Tx
T_0
gap
1 Tx
T_0'
Switching band pairs: A->C, B->D
Slot boundary
Scheduled UL Tx
810
Band A
Band B
Band C
Band D
1 Tx
1 Tx
gap
2 Tx
T_0
gap
1 Tx
T_0'
Switching band pairs: A->C, B->D
Slot boundary
Scheduled UL Tx

FIG. 8

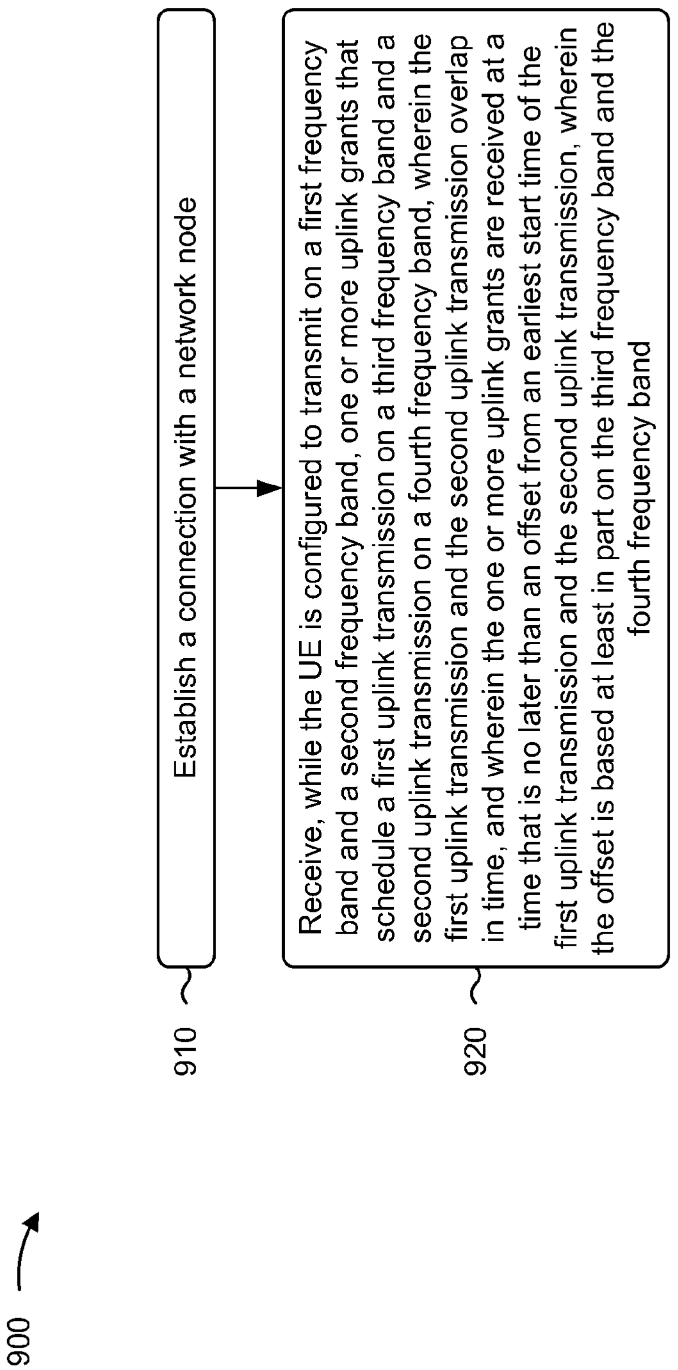
900
910
Establish a connection with a network node
920
Receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band

FIG. 9

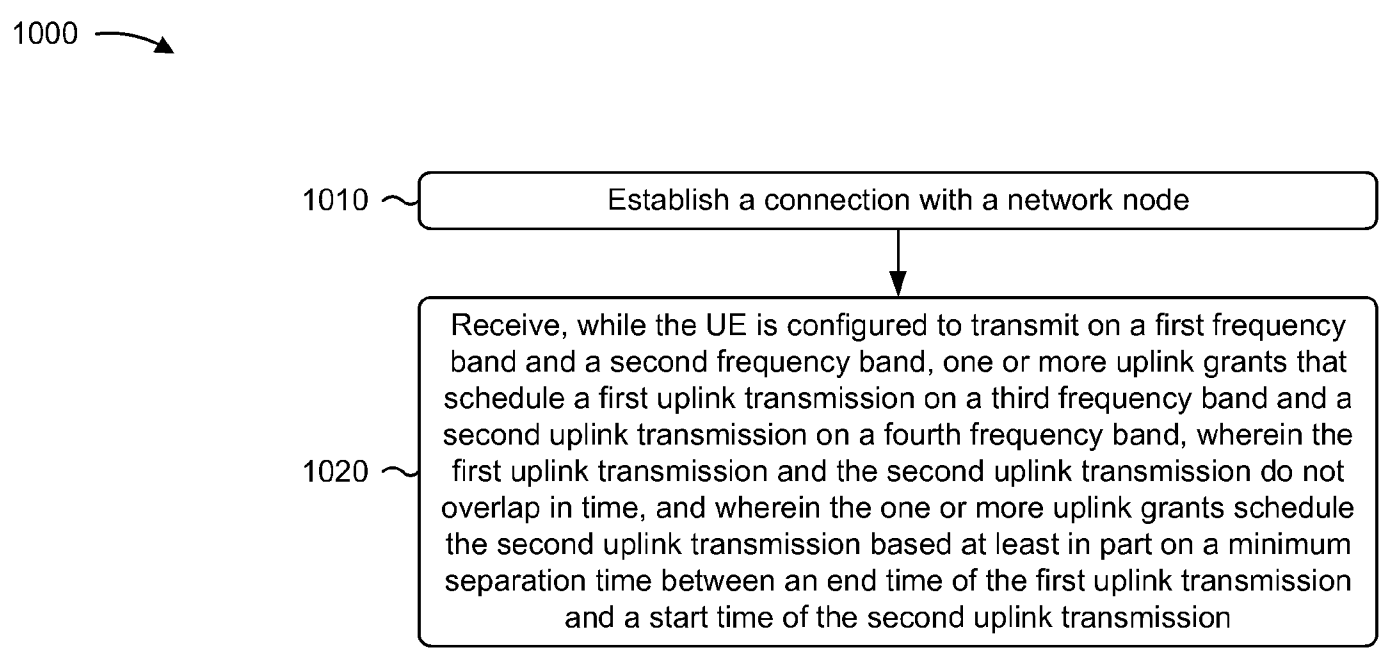
1000
1010
Establish a connection with a network node
1020
Receive, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission

FIG. 10

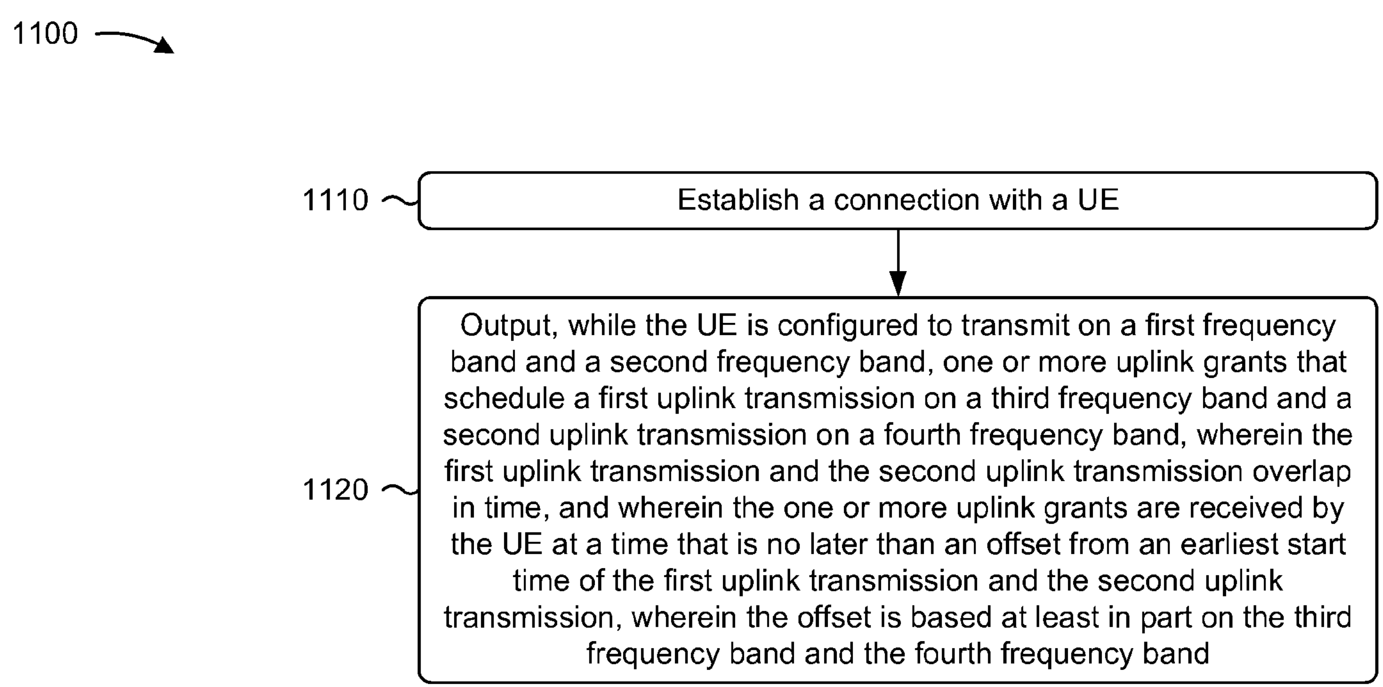
1100
1110
Establish a connection with a UE
1120
Output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission overlap in time, and wherein the one or more uplink grants are received by the UE at a time that is no later than an offset from an earliest start time of the first uplink transmission and the second uplink transmission, wherein the offset is based at least in part on the third frequency band and the fourth frequency band

FIG. 11

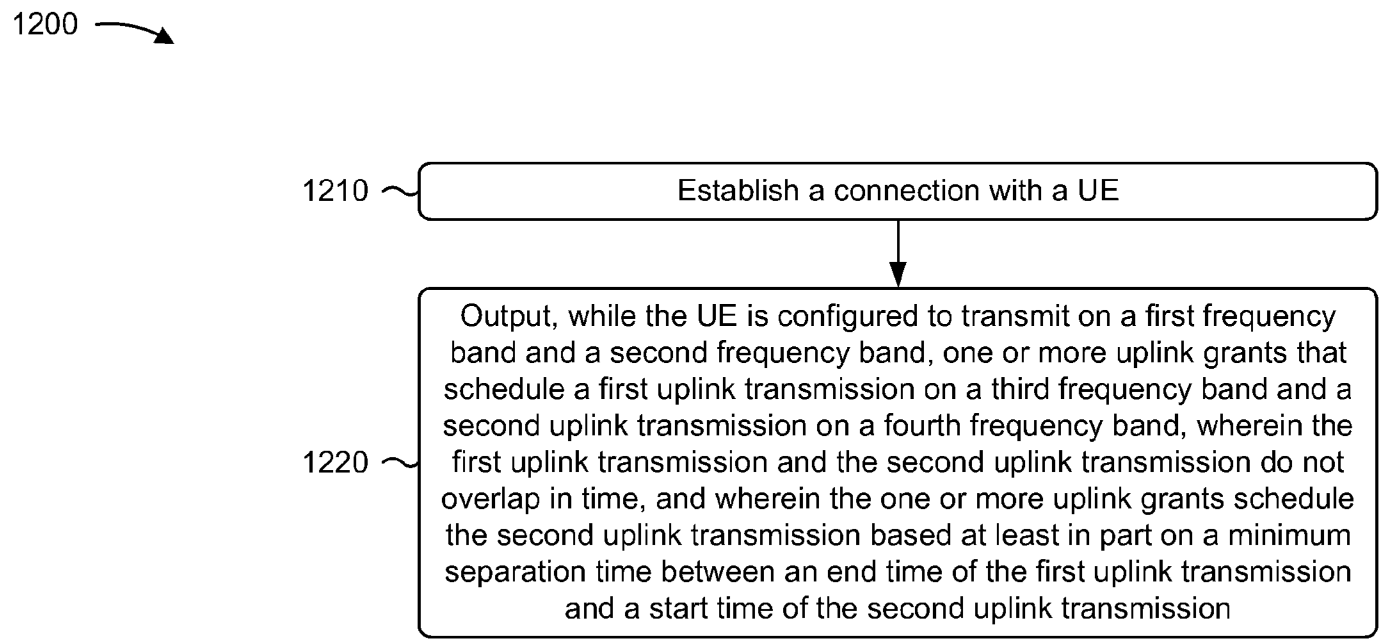
1200
1210
Establish a connection with a UE
1220
Output, while the UE is configured to transmit on a first frequency band and a second frequency band, one or more uplink grants that schedule a first uplink transmission on a third frequency band and a second uplink transmission on a fourth frequency band, wherein the first uplink transmission and the second uplink transmission do not overlap in time, and wherein the one or more uplink grants schedule the second uplink transmission based at least in part on a minimum separation time between an end time of the first uplink transmission and a start time of the second uplink transmission

FIG. 12

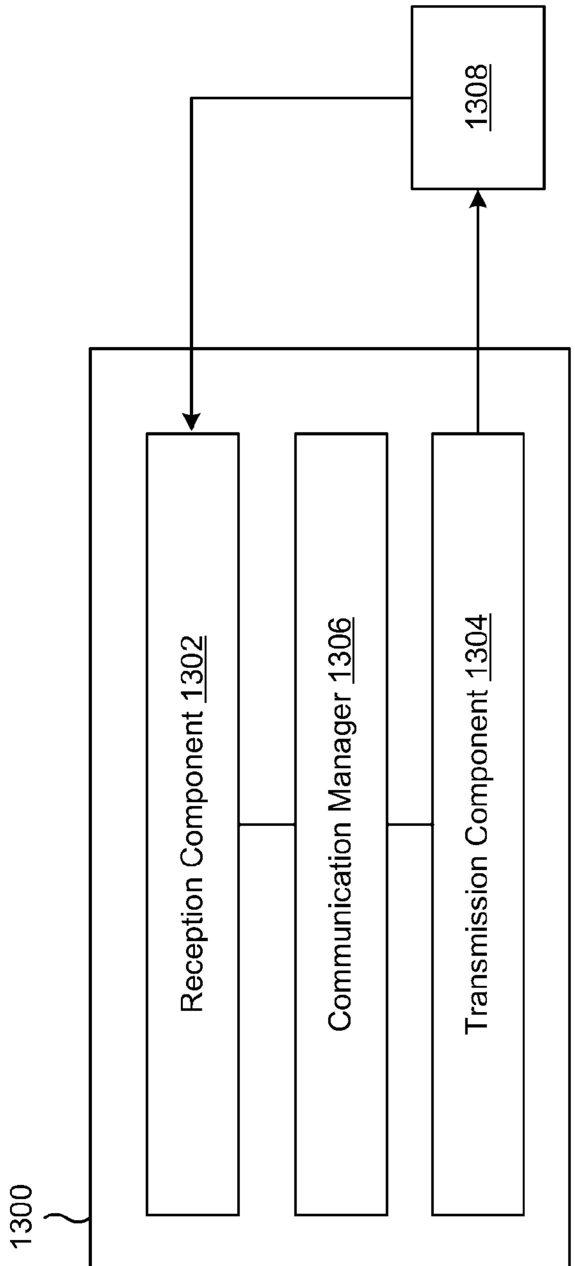
1308
Reception Component 1302
Communication Manager 1306
Transmission Component 1304
1300

FIG. 13

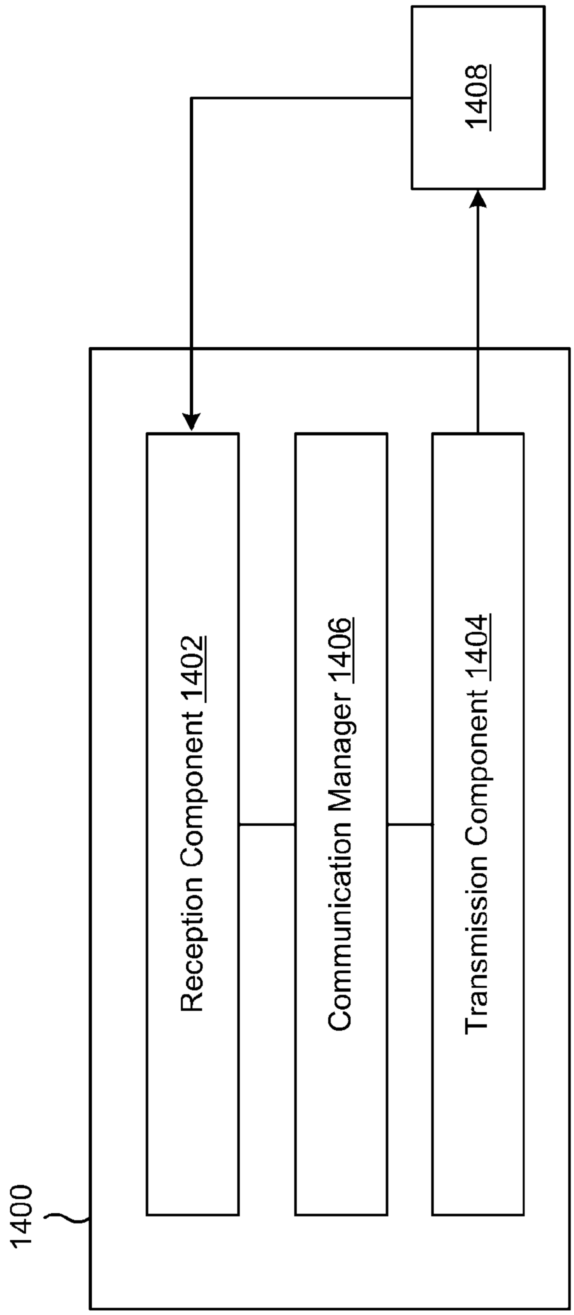
1408
1400
Reception Component 1402
Communication Manager 1406
Transmission Component 1404

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/084666

A. CLASSIFICATION OF SUBJECT MATTER

H04W72/04(2023.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, ENTXT, DWPI, CNKI, 3GPP: multiple, frequency, band, first, second, uplink, UL, transmission, grant, schedule, overlap, time, offset, switch, one, another, later

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2023287088 A1 (SAMSUNG ELECTRONICS CO., LTD.) 19 January 2023 (2023-01-19) claims 1 to 15	1-30
A	WO 2021056232 A1 (QUALCOMM INCORPORATED) 01 April 2021 (2021-04-01) the whole document	1-30
A	WO 2022052015 A1 (QUALCOMM INCORPORATED) 17 March 2022 (2022-03-17) the whole document	1-30
A	CN 115053567 A (BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.) 13 September 2022 (2022-09-13) the whole document	1-30
A	CHINA TELECOM et al. "CR to TS 38.101-3: Switching time mask between two uplink carriers in EN-DC" *3GPP TSG RAN Meeting #88e RP-200880,* 03 July 2020 (2020-07-03), the whole document	1-30

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 October 2023	**20 October 2023**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China	**BAI,XueHui** Telephone No. **(+86) 010-53961635**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/084666

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ERICSSON. "Extending the deployment scenarios for UE TX switching" *3GPP TSG-RAN meeting #93-e RP-212262,* 20 September 2021 (2021-09-20), the whole document	1-30

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/084666

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2023287088	A1	19 January 2023	CN	115623546	A	17 January 2023
WO	2021056232	A1	01 April 2021		None		
WO	2022052015	A1	17 March 2022	WO	2022053011	A1	17 March 2022
				EP	4211859	A1	19 July 2023
CN	115053567	A	13 September 2022		None		