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Handover between terrestrial network and nonterrestrial network

Abstract

Certain aspects of the present disclosure provide a method of wireless communication by a user equipment (UE). The method generally includes performing a mobility procedure to establish a connection in a target radio access technology (RAT) while maintaining a context established in a source RAT, wherein one of the source RAT or target RAT is a terrestrial network (TN) RAT and the other is a non-terrestrial network (NTN) RAT and sending a tracking area update (TAU) request after establishing the connection in the target RAT.

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Background/Summary

BACKGROUND

Field of the Disclosure

(1) Aspects of the present disclosure relate to wireless communications, and more particularly, to techniques for transitioning a user equipment (UE) from a terrestrial network (TN) and a non-terrestrial network (NTN).

Description of Related Art

(2) Wireless communications systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, broadcasts, or other similar types of services. These wireless communications systems may employ multiple-access technologies capable of supporting communications with multiple users by sharing available wireless communications system resources with those users.

(3) Although wireless communications systems have made great technological advancements over many years, challenges still exist. For example, complex and dynamic environments can still attenuate or block signals between wireless transmitters and wireless receivers. Accordingly, there is a continuous desire to improve the technical performance of wireless communications systems, including, for example: improving speed and data carrying capacity of communications, improving efficiency of the use of shared communications mediums, reducing power used by transmitters and receivers while performing communications, improving reliability of wireless communications, avoiding redundant transmissions and/or receptions and related processing, improving the coverage area of wireless communications, increasing the number and types of devices that can access wireless communications systems, increasing the ability for different types of devices to intercommunicate, increasing the number and type of wireless communications mediums available for use, and the like. Consequently, there exists a need for further improvements in wireless communications systems to overcome the aforementioned technical challenges and others.

SUMMARY

(4) One aspect provides a method of wireless communications by a user equipment (UE). The method includes performing a mobility procedure to establish a connection in a target radio access technology (RAT) while maintaining a context established in a source RAT, wherein one of the source RAT or target RAT is a terrestrial network (TN) RAT and the other is a non-terrestrial network (NTN) RAT; and sending a tracking area update (TAU) request after establishing the connection in the target RAT.

(5) Another aspect provides a method of wireless communications by a network entity. The method includes transmitting a system information block (SIB) indicating support of radio resource control (RRC) connection re-establishment procedure of a UE between a target RAT and a source RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT; and participating in the RRC connection re-establishment procedure with the UE to maintain a context

established in a source RAT.

(6) Another aspect provides a method of wireless communications by a network entity. The method includes participating in a mobility procedure to transition a UE from a source RAT to a target RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT; retrieving a context of the UE from the source RAT; and forwarding data from the source RAT to the UE.

(7) Other aspects provide: an apparatus operable, configured, or otherwise adapted to perform any one or more of the aforementioned methods and/or those described elsewhere herein; a non-transitory, computer-readable media comprising instructions that, when executed by a processor of an apparatus, cause the apparatus to perform the aforementioned methods as well as those described elsewhere herein; a computer program product embodied on a computer-readable storage medium comprising code for performing the aforementioned methods as well as those described elsewhere herein; and/or an apparatus comprising means for performing the aforementioned methods as well as those described elsewhere herein. By way of example, an apparatus may comprise a processing system, a device with a processing system, or processing systems cooperating over one or more networks.

(8) The following description and the appended figures set forth certain features for purposes of illustration.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) The appended figures depict certain features of the various aspects described herein and are not to be considered limiting of the scope of this disclosure.

(2) FIG. 1 depicts an example wireless communications network.

(3) FIG. 2 depicts an example disaggregated base station architecture.

(4) FIG. 3 depicts aspects of an example base station and an example user equipment.

(5) FIGS. 4A, 4B, 4C, and 4D depict various example aspects of data structures for a wireless communications network.

(6) FIG. 5 depicts a diagram illustrating an example wireless communication network having a non-terrestrial network entity.

(7) FIG. 6 depicts an example conventional mobility scenario.

(8) FIG. 7 depicts an example conventional multi-RAT mobility scenario.

(9) FIG. 8 depicts an example mobility scenario between RATs that share a common core network (CN).

(10) FIG. 9 depicts an example Global Unique Temporary Identifier (GUTI) format.

(11) FIG. 10 depicts an example mobility scenario of a UE between a terrestrial network (TN) and a non-terrestrial network (NTN), in which aspects of the present disclosure may be applied.

(12) FIG. 11 depicts an example structure for signaling a handover (access change) update type via a tracking area update (TAU) request.

(13) FIG. 12 depicts a method for wireless communications.

(14) FIG. 13 depicts a method for wireless communications.

(15) FIG. 14 depicts a method for wireless communications.

(16) FIG. 15 depicts aspects of an example communications device.

(17) FIG. 16 depicts aspects of an example communications device.

(18) FIG. 17 depicts aspects of an example communications device.

DETAILED DESCRIPTION

(19) Aspects of the present disclosure provide apparatuses, methods, processing systems, and computer-readable mediums for performing a handover of a user equipment (UE) between a

terrestrial network (TN) and a non-terrestrial network (NTN).

(20) In certain cases, an NTN may provide extended radio coverage to a user equipment (UE), for example, in rural areas where reliable coverage by a TN is not possible or is cost prohibitive. In some cases, when a UE is connected (in a radio resource control RRC connected state) and moves from an NTN to a TN (or vice-versa) a conventional connection re-establishment procedure may not be supported. As a result, the UE network context may be lost and the UE may have to establish a new connection in a target network, resulting in increased latency and interruption of service. Further, data that was available at the source network (which could otherwise be retrieved and forwarded using the UE context) may be lost.

(21) A connection re-establishment typically occurs, for example, when a UE detects a radio link failure (RLF) or when a handover procedure fails. If the UE recovers, the UE initiates connection re-establishment procedures unless the UE recovers in a different radio access technology (RAT), in which case the UE gives up and goes to an idle state (e.g., RRC_IDLE). This is generally because the other RAT will not be “prepared” for the UE as it will not have the UE context, which includes the UE identity. NTNs and TNs are typically considered to be different RATs and, connection re-establishment when moving between NTNs and TNs is typically not supported.

(22) Aspects of the present disclosure, however, provide techniques that allow a UE to perform RRC connection re-establishment when transitioning between an NTN and TN. As a result, the techniques provided herein may allow a UE to maintain network context and avoid having to establish a new connection in a target network. As a result, the techniques may allow a UE to reduce latency and avoid an interruption of service. Further, data that was available at the source network may be retrieved from the source network and forwarded to the UE.

Introduction to Wireless Communications Networks

(23) The techniques and methods described herein may be used for various wireless communications networks. While aspects may be described herein using terminology commonly associated with 3G, 4G, and/or 5G wireless technologies, aspects of the present disclosure may likewise be applicable to other communications systems and standards not explicitly mentioned herein.

(24) FIG. 1 depicts an example of a wireless communications network **100**, in which aspects described herein may be implemented.

(25) Generally, wireless communications network **100** includes various network entities (alternatively, network elements or network nodes). A network entity is generally a communications device and/or a communications function performed by a communications device (e.g., a user equipment (UE), a base station (BS), a component of a BS, a server, etc.). For example, various functions of a network as well as various devices associated with and interacting with a network may be considered network entities. Further, wireless communications network **100** includes terrestrial aspects, such as ground-based network entities (e.g., BSs **102**), and non-terrestrial aspects, such as satellite **140** and aircraft **145**, which may include network entities on-board (e.g., one or more BSs) capable of communicating with other network elements (e.g., terrestrial BSs) and user equipments.

(26) In the depicted example, wireless communications network **100** includes BSs **102**, UEs **104**, and one or more core networks, such as an Evolved Packet Core (EPC) **160** and 5G Core (5GC) network **190**, which interoperate to provide communications services over various communications links, including wired and wireless links.

(27) FIG. 1 depicts various example UEs **104**, which may more generally include: a cellular phone, smart phone, session initiation protocol (SIP) phone, laptop, personal digital assistant (PDA), satellite radio, global positioning system, multimedia device, video device, digital audio player, camera, game console, tablet, smart device, wearable device, vehicle, electric meter, gas pump, large or small kitchen appliance, healthcare device, implant, sensor/actuator, display, internet of things (IoT) devices, always on (AON) devices, edge processing devices, or other similar devices.

UEs **104** may also be referred to more generally as a mobile device, a wireless device, a wireless communications device, a station, a mobile station, a subscriber station, a mobile subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a remote device, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, and others.

(28) BSs **102** wirelessly communicate with (e.g., transmit signals to or receive signals from) UEs **104** via communications links **120**. The communications links **120** between BSs **102** and UEs **104** may include uplink (UL) (also referred to as reverse link) transmissions from a UE **104** to a BS **102** and/or downlink (DL) (also referred to as forward link) transmissions from a BS **102** to a UE **104**. The communications links **120** may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity in various aspects.

(29) BSs **102** may generally include: a NodeB, enhanced NodeB (eNB), next generation enhanced NodeB (ng-eNB), next generation NodeB (gNB or gNodeB), access point, base transceiver station, radio base station, radio transceiver, transceiver function, transmission reception point, and/or others. Each of BSs **102** may provide communications coverage for a respective geographic coverage area **110**, which may sometimes be referred to as a cell, and which may overlap in some cases (e.g., small cell **102'** may have a coverage area **110'** that overlaps the coverage area **110** of a macro cell). A BS may, for example, provide communications coverage for a macro cell (covering relatively large geographic area), a pico cell (covering relatively smaller geographic area, such as a sports stadium), a femto cell (relatively smaller geographic area (e.g., a home)), and/or other types of cells.

(30) While BSs **102** are depicted in various aspects as unitary communications devices, BSs **102** may be implemented in various configurations. For example, one or more components of a base station may be disaggregated, including a central unit (CU), one or more distributed units (DUs), one or more radio units (RUs), a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC), or a Non-Real Time (Non-RT) RIC, to name a few examples. In another example, various aspects of a base station may be virtualized. More generally, a base station (e.g., BS **102**) may include components that are located at a single physical location or components located at various physical locations. In examples in which a base station includes components that are located at various physical locations, the various components may each perform functions such that, collectively, the various components achieve functionality that is similar to a base station that is located at a single physical location. In some aspects, a base station including components that are located at various physical locations may be referred to as a disaggregated radio access network architecture, such as an Open RAN (O-RAN) or Virtualized RAN (VRAN) architecture. FIG. 2 depicts and describes an example disaggregated base station architecture.

(31) Different BSs **102** within wireless communications network **100** may also be configured to support different radio access technologies, such as 3G, 4G, and/or 5G. For example, BSs **102** configured for 4G LTE (collectively referred to as Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN)) may interface with the EPC **160** through first backhaul links **132** (e.g., an S1 interface). BSs **102** configured for 5G (e.g., 5G NR or Next Generation RAN (NG-RAN)) may interface with 5GC **190** through second backhaul links **184**. BSs **102** may communicate directly or indirectly (e.g., through the EPC **160** or 5GC **190**) with each other over third backhaul links **134** (e.g., X2 interface), which may be wired or wireless.

(32) Wireless communications network **100** may subdivide the electromagnetic spectrum into various classes, bands, channels, or other features. In some aspects, the subdivision is provided based on wavelength and frequency, where frequency may also be referred to as a carrier, a subcarrier, a frequency channel, a tone, or a subband. For example, 3GPP currently defines Frequency Range 1 (FR1) as including 410 MHz-7125 MHz, which is often referred to (interchangeably) as “Sub-6 GHz”. Similarly, 3GPP currently defines Frequency Range 2 (FR2) as including 24,250 MHz-52,600 MHz, which is sometimes referred to (interchangeably) as a

“millimeter wave” (“mmW” or “mmWave”). A base station configured to communicate using mmWave/near mmWave radio frequency bands (e.g., a mmWave base station such as BS **180**) may utilize beamforming (e.g., **182**) with a UE (e.g., **104**) to improve path loss and range.

(33) The communications links **120** between BSs **102** and, for example, UEs **104**, may be through one or more carriers, which may have different bandwidths (e.g., 5, 10, 15, 20, 100, 400, and/or other MHz), and which may be aggregated in various aspects. Carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL).

(34) Communications using higher frequency bands may have higher path loss and a shorter range compared to lower frequency communications. Accordingly, certain base stations (e.g., **180** in FIG. **1**) may utilize beamforming **182** with a UE **104** to improve path loss and range. For example, BS **180** and the UE **104** may each include a plurality of antennas, such as antenna elements, antenna panels, and/or antenna arrays to facilitate the beamforming. In some cases, BS **180** may transmit a beamformed signal to UE **104** in one or more transmit directions **182'**. UE **104** may receive the beamformed signal from the BS **180** in one or more receive directions **182''**. UE **104** may also transmit a beamformed signal to the BS **180** in one or more transmit directions **182''**. BS **180** may also receive the beamformed signal from UE **104** in one or more receive directions **182'**. BS **180** and UE **104** may then perform beam training to determine the best receive and transmit directions for each of BS **180** and UE **104**. Notably, the transmit and receive directions for BS **180** may or may not be the same. Similarly, the transmit and receive directions for UE **104** may or may not be the same.

(35) Wireless communications network **100** further includes a Wi-Fi AP **150** in communication with Wi-Fi stations (STAs) **152** via communications links **154** in, for example, a 2.4 GHz and/or 5 GHz unlicensed frequency spectrum.

(36) Certain UEs **104** may communicate with each other using device-to-device (D2D) communications link **158**. D2D communications link **158** may use one or more sidelink channels, such as a physical sidelink broadcast channel (PSBCH), a physical sidelink discovery channel (PSDCH), a physical sidelink shared channel (PSSCH), a physical sidelink control channel (PSCCH), and/or a physical sidelink feedback channel (PSFCH).

(37) EPC **160** may include various functional components, including: a Mobility Management Entity (MME) **162**, other MMES **164**, a Serving Gateway **166**, a Multimedia Broadcast Multicast Service (MBMS) Gateway **168**, a Broadcast Multicast Service Center (BM-SC) **170**, and/or a Packet Data Network (PDN) Gateway **172**, such as in the depicted example. MME **162** may be in communication with a Home Subscriber Server (HSS) **174**. MME **162** is the control node that processes the signaling between the UEs **104** and the EPC **160**. Generally, MME **162** provides bearer and connection management.

(38) Generally, user Internet protocol (IP) packets are transferred through Serving Gateway **166**, which itself is connected to PDN Gateway **172**. PDN Gateway **172** provides UE IP address allocation as well as other functions. PDN Gateway **172** and the BM-SC **170** are connected to IP Services **176**, which may include, for example, the Internet, an intranet, an IP Multimedia Subsystem (IMS), a Packet Switched (PS) streaming service, and/or other IP services.

(39) BM-SC **170** may provide functions for MBMS user service provisioning and delivery. BM-SC **170** may serve as an entry point for content provider MBMS transmission, may be used to authorize and initiate MBMS Bearer Services within a public land mobile network (PLMN), and/or may be used to schedule MBMS transmissions. MBMS Gateway **168** may be used to distribute MBMS traffic to the BSs **102** belonging to a Multicast Broadcast Single Frequency Network (MBSFN) area broadcasting a particular service, and/or may be responsible for session management (start/stop) and for collecting eMBMS related charging information.

(40) 5GC **190** may include various functional components, including: an Access and Mobility Management Function (AMF) **192**, other AMFs **193**, a Session Management Function (SMF) **194**,

and a User Plane Function (UPF) **195**. AMF **192** may be in communication with Unified Data Management (UDM) **196**.

(41) AMF **192** is a control node that processes signaling between UEs **104** and 5GC **190**. AMF **192** provides, for example, quality of service (QoS) flow and session management.

(42) Internet protocol (IP) packets are transferred through UPF **195**, which is connected to the IP Services **197**, and which provides UE IP address allocation as well as other functions for 5GC **190**. IP Services **197** may include, for example, the Internet, an intranet, an IMS, a PS streaming service, and/or other IP services.

(43) In various aspects, a network entity or network node can be implemented as an aggregated base station, as a disaggregated base station, a component of a base station, an integrated access and backhaul (IAB) node, a relay node, a sidelink node, to name a few examples.

(44) FIG. 2 depicts an example disaggregated base station **200** architecture. The disaggregated base station **200** architecture may include one or more central units (CUs) **210** that can communicate directly with a core network **220** via a backhaul link, or indirectly with the core network **220** through one or more disaggregated base station units (such as a Near-Real Time (Near-RT) RAN Intelligent Controller (MC) **225** via an E2 link, or a Non-Real Time (Non-RT) MC **215** associated with a Service Management and Orchestration (SMO) Framework **205**, or both). A CU **210** may communicate with one or more distributed units (DUs) **230** via respective midhaul links, such as an F1 interface. The DUs **230** may communicate with one or more radio units (RUs) **240** via respective fronthaul links. The RUs **240** may communicate with respective UEs **104** via one or more radio frequency (RF) access links. In some implementations, the UE **104** may be simultaneously served by multiple RUs **240**.

(45) Each of the units, e.g., the CUs **210**, the DUs **230**, the RUs **240**, as well as the Near-RT RICs **225**, the Non-RT RICs **215** and the SMO Framework **205**, may include one or more interfaces or be coupled to 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 the communications interfaces of the units, can be configured to communicate with one or more of the other units via the transmission medium. For example, the units can include a wired interface configured to receive or transmit signals over a wired transmission medium to one or more of the other units. Additionally or alternatively, the units can include a wireless interface, which may include a receiver, a transmitter or transceiver (such as a radio frequency (RF) transceiver), configured to receive or transmit signals, or both, over a wireless transmission medium to one or more of the other units.

(46) In some aspects, the CU **210** may host one or more higher layer control functions. Such control functions can include radio resource control (RRC), packet data convergence protocol (PDCP), service data adaptation protocol (SDAP), or the like. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU **210**. The CU **210** may be configured to handle user plane functionality (e.g., Central Unit-User Plane (CU-UP)), control plane functionality (e.g., Central Unit-Control Plane (CU-CP)), or a combination thereof. In some implementations, the CU **210** can be logically split into one or more CU-UP units and one or more CU-CP units. The CU-UP unit can communicate bidirectionally with the CU-CP unit via an interface, such as the E1 interface when implemented in an O-RAN configuration. The CU **210** can be implemented to communicate with the DU **230**, as necessary, for network control and signaling.

(47) The DU **230** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **240**. In some aspects, the DU **230** may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers (such as modules for forward error correction (FEC) encoding and decoding, scrambling, modulation and demodulation, or the like) depending, at least in part, on a functional split, such as those defined by the 3.sup.rd Generation Partnership Project (3GPP). In

some aspects, the DU **230** may further host one or more low PHY layers. Each layer (or module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU **230**, or with the control functions hosted by the CU **210**.

(48) Lower-layer functionality can be implemented by one or more RUs **240**. In some deployments, an RU **240**, controlled by a DU **230**, may correspond to a logical node that hosts RF processing functions, or low-PHY layer functions (such as performing fast Fourier transform (FFT), inverse FFT (iFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, or the like), or both, based at least in part on the functional split, such as a lower layer functional split. In such an architecture, the RU(s) **240** can be implemented to handle over the air (OTA) communications with one or more UEs **104**. In some implementations, real-time and non-real-time aspects of control and user plane communications with the RU(s) **240** can be controlled by the corresponding DU **230**. In some scenarios, this configuration can enable the DU(s) **230** and the CU **210** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

(49) The SMO Framework **205** may be configured to support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **205** 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 **205** may be configured to interact with a cloud computing platform (such as an open cloud (O-Cloud) **290**) 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 **210**, DUs **230**, RUs **240** and Near-RT RICs **225**. In some implementations, the SMO Framework **205** can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) **211**, via an O1 interface. Additionally, in some implementations, the SMO Framework **205** can communicate directly with one or more RUs **240** via an O1 interface. The SMO Framework **205** also may include a Non-RT RIC **215** configured to support functionality of the SMO Framework **205**.

(50) The Non-RT RIC **215** 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 **225**. The Non-RT RIC **215** may be coupled to or communicate with (such as via an A1 interface) the Near-RT RIC **225**. The Near-RT RIC **225** 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 **210**, one or more DUs **230**, or both, as well as an O-eNB, with the Near-RT RIC **225**.

(51) In some implementations, to generate AI/ML models to be deployed in the Near-RT RIC **225**, the Non-RT RIC **215** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **225** and may be received at the SMO Framework **205** or the Non-RT RIC **215** from non-network data sources or from network functions. In some examples, the Non-RT RIC **215** or the Near-RT RIC **225** may be configured to tune RAN behavior or performance. For example, the Non-RT RIC **215** may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework **205** (such as reconfiguration via O1) or via creation of RAN management policies (such as A1 policies).

(52) FIG. 3 depicts aspects of an example BS **102** and a UE **104**.

(53) Generally, BS **102** includes various processors (e.g., **320**, **330**, **338**, and **340**), antennas **334a-t** (collectively **334**), transceivers **332a-t** (collectively **332**), which include modulators and demodulators, and other aspects, which enable wireless transmission of data (e.g., data source **312**) and wireless reception of data (e.g., data sink **339**). For example, BS **102** may send and receive data

between BS **102** and UE **104**. BS **102** includes controller/processor **340**, which may be configured to implement various functions described herein related to wireless communications.

(54) Generally, UE **104** includes various processors (e.g., **358**, **364**, **366**, and **380**), antennas **352a-r** (collectively **352**), transceivers **354a-r** (collectively **354**), which include modulators and demodulators, and other aspects, which enable wireless transmission of data (e.g., retrieved from data source **362**) and wireless reception of data (e.g., provided to data sink **360**). UE **104** includes controller/processor **380**, which may be configured to implement various functions described herein related to wireless communications.

(55) In regards to an example downlink transmission, BS **102** includes a transmit processor **320** that may receive data from a data source **312** and control information from a controller/processor **340**. The control information may be for the physical broadcast channel (PBCH), physical control format indicator channel (PCFICH), physical HARQ indicator channel (PHICH), physical downlink control channel (PDCCH), group common PDCCH (GC PDCCH), and/or others. The data may be for the physical downlink shared channel (PDSCH), in some examples.

(56) Transmit processor **320** may process (e.g., encode and symbol map) the data and control information to obtain data symbols and control symbols, respectively. Transmit processor **320** may also generate reference symbols, such as for the primary synchronization signal (PSS), secondary synchronization signal (SSS), PBCH demodulation reference signal (DMRS), and channel state information reference signal (CSI-RS).

(57) Transmit (TX) multiple-input multiple-output (MIMO) processor **330** may perform spatial processing (e.g., precoding) on the data symbols, the control symbols, and/or the reference symbols, if applicable, and may provide output symbol streams to the modulators (MODs) in transceivers **332a-332t**. Each modulator in transceivers **332a-332t** may process a respective output symbol stream to obtain an output sample stream. Each modulator may further process (e.g., convert to analog, amplify, filter, and upconvert) the output sample stream to obtain a downlink signal. Downlink signals from the modulators in transceivers **332a-332t** may be transmitted via the antennas **334a-334t**, respectively.

(58) In order to receive the downlink transmission, UE **104** includes antennas **352a-352r** that may receive the downlink signals from the BS **102** and may provide received signals to the demodulators (DEMODOs) in transceivers **354a-354r**, respectively. Each demodulator in transceivers **354a-354r** may condition (e.g., filter, amplify, downconvert, and digitize) a respective received signal to obtain input samples. Each demodulator may further process the input samples to obtain received symbols.

(59) MIMO detector **356** may obtain received symbols from all the demodulators in transceivers **354a-354r**, perform MIMO detection on the received symbols if applicable, and provide detected symbols. Receive processor **358** may process (e.g., demodulate, deinterleave, and decode) the detected symbols, provide decoded data for the UE **104** to a data sink **360**, and provide decoded control information to a controller/processor **380**.

(60) In regards to an example uplink transmission, UE **104** further includes a transmit processor **364** that may receive and process data (e.g., for the PUSCH) from a data source **362** and control information (e.g., for the physical uplink control channel (PUCCH)) from the controller/processor **380**. Transmit processor **364** may also generate reference symbols for a reference signal (e.g., for the sounding reference signal (SRS)). The symbols from the transmit processor **364** may be precoded by a TX MIMO processor **366** if applicable, further processed by the modulators in transceivers **354a-354r** (e.g., for SC-FDM), and transmitted to BS **102**.

(61) At BS **102**, the uplink signals from UE **104** may be received by antennas **334a-t**, processed by the demodulators in transceivers **332a-332t**, detected by a MIMO detector **336** if applicable, and further processed by a receive processor **338** to obtain decoded data and control information sent by UE **104**. Receive processor **338** may provide the decoded data to a data sink **339** and the decoded control information to the controller/processor **340**.

(62) Memories **342** and **382** may store data and program codes for BS **102** and UE **104**, respectively.

(63) Scheduler **344** may schedule UEs for data transmission on the downlink and/or uplink.

(64) In various aspects, BS **102** may be described as transmitting and receiving various types of data associated with the methods described herein. In these contexts, “transmitting” may refer to various mechanisms of outputting data, such as outputting data from data source **312**, scheduler **344**, memory **342**, transmit processor **320**, controller/processor **340**, TX MIMO processor **330**, transceivers **332a-t**, antenna **334a-t**, and/or other aspects described herein. Similarly, “receiving” may refer to various mechanisms of obtaining data, such as obtaining data from antennas **334a-t**, transceivers **332a-t**, RX MIMO detector **336**, controller/processor **340**, receive processor **338**, scheduler **344**, memory **342**, and/or other aspects described herein.

(65) In various aspects, UE **104** may likewise be described as transmitting and receiving various types of data associated with the methods described herein. In these contexts, “transmitting” may refer to various mechanisms of outputting data, such as outputting data from data source **362**, memory **382**, transmit processor **364**, controller/processor **380**, TX MIMO processor **366**, transceivers **354a-t**, antenna **352a-t**, and/or other aspects described herein. Similarly, “receiving” may refer to various mechanisms of obtaining data, such as obtaining data from antennas **352a-t**, transceivers **354a-t**, RX MIMO detector **356**, controller/processor **380**, receive processor **358**, memory **382**, and/or other aspects described herein.

(66) In some aspects, a processor may be configured to perform various operations, such as those associated with the methods described herein, and transmit (output) to or receive (obtain) data from another interface that is configured to transmit or receive, respectively, the data.

(67) FIGS. **4A**, **4B**, **4C**, and **4D** depict aspects of data structures for a wireless communications network, such as wireless communications network **100** of FIG. **1**.

(68) In particular, FIG. **4A** is a diagram **400** illustrating an example of a first subframe within a 5G (e.g., 5G NR) frame structure, FIG. **4B** is a diagram **430** illustrating an example of DL channels within a 5G subframe, FIG. **4C** is a diagram **450** illustrating an example of a second subframe within a 5G frame structure, and FIG. **4D** is a diagram **480** illustrating an example of UL channels within a 5G subframe.

(69) Wireless communications systems may utilize orthogonal frequency division multiplexing (OFDM) with a cyclic prefix (CP) on the uplink and downlink. Such systems may also support half-duplex operation using time division duplexing (TDD). OFDM and single-carrier frequency division multiplexing (SC-FDM) partition the system bandwidth (e.g., as depicted in FIGS. **4B** and **4D**) into multiple orthogonal subcarriers. Each subcarrier may be modulated with data. Modulation symbols may be sent in the frequency domain with OFDM and/or in the time domain with SC-FDM.

(70) A wireless communications frame structure may be frequency division duplex (FDD), in which, for a particular set of subcarriers, subframes within the set of subcarriers are dedicated for either DL or UL. Wireless communications frame structures may also be time division duplex (TDD), in which, for a particular set of subcarriers, subframes within the set of subcarriers are dedicated for both DL and UL.

(71) In FIGS. **4A** and **4C**, the wireless communications frame structure is TDD where D is DL, U is UL, and X is flexible for use between DL/UL. UEs may be configured with a slot format through a received slot format indicator (SFI) (dynamically through DL control information (DCI), or semi-statically/statically through radio resource control (RRC) signaling). In the depicted examples, a 10 ms frame is divided into 10 equally sized 1 ms subframes. Each subframe may include one or more time slots. In some examples, each slot may include 7 or 14 symbols, depending on the slot format. Subframes may also include mini-slots, which generally have fewer symbols than an entire slot. Other wireless communications technologies may have a different frame structure and/or different channels.

(72) In certain aspects, the number of slots within a subframe is based on a slot configuration and a numerology. For example, for slot configuration **0**, different numerologies (μ) **0** to **5** allow for 1, 2, 4, 8, 16, and 32 slots, respectively, per subframe. For slot configuration **1**, different numerologies **0** to **2** allow for 2, 4, and 8 slots, respectively, per subframe. Accordingly, for slot configuration **0** and numerology μ , there are 14 symbols/slot and 2μ slots/subframe. The subcarrier spacing and symbol length/duration are a function of the numerology. The subcarrier spacing may be equal to $2^{\mu} \times 15$ kHz, where μ is the numerology **0** to **5**. As such, the numerology $\mu=0$ has a subcarrier spacing of 15 kHz and the numerology $\mu=5$ has a subcarrier spacing of 480 kHz. The symbol length/duration is inversely related to the subcarrier spacing. FIGS. **4A**, **4B**, **4C**, and **4D** provide an example of slot configuration **0** with 14 symbols per slot and numerology $\mu=2$ with 4 slots per subframe. The slot duration is 0.25 ms, the subcarrier spacing is 60 kHz, and the symbol duration is approximately 16.67 μ s.

(73) As depicted in FIGS. **4A**, **4B**, **4C**, and **4D**, a resource grid may be used to represent the frame structure. Each time slot includes a resource block (RB) (also referred to as physical RBs (PRBs)) that extends, for example, 12 consecutive subcarriers. The resource grid is divided into multiple resource elements (REs). The number of bits carried by each RE depends on the modulation scheme.

(74) As illustrated in FIG. **4A**, some of the REs carry reference (pilot) signals (RS) for a UE (e.g., UE **104** of FIGS. **1** and **3**). The RS may include demodulation RS (DMRS) and/or channel state information reference signals (CSI-RS) for channel estimation at the UE. The RS may also include beam measurement RS (BRS), beam refinement RS (BRRS), and/or phase tracking RS (PT-RS).

(75) FIG. **4B** illustrates an example of various DL channels within a subframe of a frame. The physical downlink control channel (PDCCH) carries DCI within one or more control channel elements (CCEs), each CCE including, for example, nine RE groups (REGs), each REG including, for example, four consecutive REs in an OFDM symbol.

(76) A primary synchronization signal (PSS) may be within symbol **2** of particular subframes of a frame. The PSS is used by a UE (e.g., **104** of FIGS. **1** and **3**) to determine subframe/symbol timing and a physical layer identity.

(77) A secondary synchronization signal (SSS) may be within symbol **4** of particular subframes of a frame. The SSS is used by a UE to determine a physical layer cell identity group number and radio frame timing.

(78) Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a physical cell identifier (PCI). Based on the PCI, the UE can determine the locations of the aforementioned DMRS. The physical broadcast channel (PBCH), which carries a master information block (MIB), may be logically grouped with the PSS and SSS to form a synchronization signal (SS)/PBCH block. The MIB provides a number of RBs in the system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and/or paging messages.

(79) As illustrated in FIG. **4C**, some of the REs carry DMRS (indicated as R for one particular configuration, but other DMRS configurations are possible) for channel estimation at the base station. The UE may transmit DMRS for the PUCCH and DMRS for the PUSCH. The PUSCH DMRS may be transmitted, for example, in the first one or two symbols of the PUSCH. The PUCCH DMRS may be transmitted in different configurations depending on whether short or long PUCCHs are transmitted and depending on the particular PUCCH format used. UE **104** may transmit sounding reference signals (SRS). The SRS may be transmitted, for example, in the last symbol of a subframe. The SRS may have a comb structure, and a UE may transmit SRS on one of the combs. The SRS may be used by a base station for channel quality estimation to enable frequency-dependent scheduling on the UL.

(80) FIG. **4D** illustrates an example of various UL channels within a subframe of a frame. The

PUCCH may be located as indicated in one configuration. The PUCCH carries uplink control information (UCI), such as scheduling requests, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and HARQ ACK/NACK feedback. The PUSCH carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

Example Non-Terrestrial Network

(81) FIG. 5 illustrates an example of a wireless communications network **500** including a non-terrestrial network (NTN) entity **140** (which may be generally referred to as NTN **140**), in which aspects of the present disclosure may be practiced. In some examples, the wireless communications network **500** may implement aspects of the wireless communication network **100**. For example, the wireless communications network **500** may include BS **102**, UE **104**, and the non-terrestrial network entity **140**, such as a satellite. BS **102** may serve a coverage area or cell **110a** in cases of a terrestrial network, and non-terrestrial network entity **140** may serve the coverage area **110b** in cases of a non-terrestrial network (NTN). Some NTNs may employ airborne platforms (e.g., a drone or balloon) and/or spaceborne platforms (e.g., a satellite).

(82) The non-terrestrial network entity **140** may communicate with the BS **102** and UE **104** as part of wireless communications in an NTN. In cases of a terrestrial network, the UE **104** may communicate with the BS **102** over a communication link **514**. In the case of NTN wireless communications, the non-terrestrial network entity **140** may be a serving cell for the UE **104** via a communication link **516**. In certain aspects, the non-terrestrial network entity **140** may act as a relay (or a remote radio head) for the BS **102** and the UE **104**. For example, the BS **102** may communicate with the non-terrestrial network entity **140** via a communication link **518**, and the non-terrestrial network entity may relay signaling between the BS **102** and UE **104** via the communication links **516**, **518**.

Aspects Related to Handover Between TN and NTN

(83) As noted above, when a UE is connected (RRC_CONNECTED state) and moves within the same radio access technology (RAT), such as 5G in the example shown in FIG. 6, a connection re-establishment occurs, for example, when the UE detects radio link failure or when the handover procedure fails. If the UE recovers, the UE initiates connection re-establishment procedures and the target is able to retrieve any pending data from the source, using the UE context, and forward it to the UE.

(84) When the UE is connected and moves from one radio access technology (RAT) to another, as in the example shown in FIG. 7, the connection re-establishment procedure is typically not supported. In such cases, when the UE recovers in a different RAT, the UE typically gives re-establishment procedures and goes to RRC_IDLE. This is because the target RAT will not have the UE context of the UE (e.g., including the UE identity).

(85) As shown in FIG. 8, for certain devices, such as a non-control plane (CP)-cellular internet of things (CIoT) UE, connection re-establishment may be handled in the radio network. In such cases, the core network (CN) may not be aware of connection re-establishment if it succeeds.

(86) As also illustrated, for CP-CIoT UE, on the other hand, connection re-establishment is handled in the core network. For CP-CIoT UE there may be no radio network access security. The security may be handled in the core network. So the core NW handles the security context and the related identities, and its preservation upon re-establishment. Also, any pending data packets may be forwarded to the UE by the CN upon connection re-establishment.

(87) In conventional systems, for CP-CIoT UE, the connection re-establishment is still not supported upon RAT change. Typically, different RATs are connected to different core networks and there is no support for connection re-establishment across different core NWs.

(88) Upon recovering from an RLF, the CP-CIoT UE may send an RRC Connection Re-establishment Request message including the UE identity, such as a serving temporary mobile subscriber identity (S-TMSI). As illustrated in FIG. 9, the S-TMSI may be embedded in (and

extracted from) a Global Unique Temporary Identifier (GUTI). S-TMSI generally refers to an identifier assigned by an MME, which is unique within an MME pool. There may be an indication in the SIB indicating whether RRC connection Reestablishment using S-TMSI is allowed or not. MME authenticates the UE based on the security parameters included in the message (ul-NAS-MAC and ul-NAS-Count).

(89) As noted above, RRC connection re-establishment is typically not supported upon RAT change. In some cases, though, there may be less reason for this lack of support than in conventional systems. For example, in Rel-17, an internet of things (IoT) non-terrestrial network (NTN) RAT is specified, which generally defines a satellite access network for IoT devices.

(90) Although formally defined as another RAT (mostly due to core network aspects e.g. Quality of Service (QoS), charging etc.), in some ways IoT NTN RAT may not really be a different RAT.

(91) Therefore, as illustrated in FIG. 10, it may be possible for IoT terrestrial network (TN) and IoT NTN RAT to be served by the same core network (i.e. same Evolved Packet Core (EPC) mobility management entity (MME)). In this case, the conventional reasons for not allowing RRC connection re-establishment for IoT UE upon RAT change may no longer exist. In other words, UE context may still be kept in the same MME or MME pool, even when moving between TN and NTN. Thus, in this case, there seems to be no reason to not allow RRC connection re-establishment for CP CIoT UE upon RAT change (IoT TN-to-IoT NTN or vice versa).

(92) IoT TN RAT and IoT NTN RAT can (and likely will) be deployed in different tracking areas (TA) that are not in the same Tracking Area Identity (TAI) list (i.e. registration area). This means the UE may need to perform a TA update (TAU) upon RAT change. The MME may assign a new Serving Temporary Mobile Subscriber Identity (S-TMSI, sometimes referred to as a shortened TMSI) to the UE in the target RAT and, in such cases, one of the potential benefits of re-establishing the Radio Resource Control (RRC) connection may vanish. The old security context cannot be preserved if the UE identity has changed. Any pending data forwarding may still benefit from connection re-establishment.

(93) There are various options for how to allow RRC connection re-establishment for a UE (e.g., a CP CIoT UE), upon RAT change (e.g., from IoT TN-to-IoT NTN or vice versa), in accordance with aspects of the present disclosure.

(94) For example, according to a first option, a UE may perform RRC connection re-establishment using an old S-TMSI upon inter-RAT (IRAT) change from IoT TN to IoT NTN, followed by TAU request. In such cases, the purpose of the TAU request may be to update the TA list. If the MME is not the same, the (target) RAN may intercept the RRC re-establishment procedure (messages) and send the RRC Connection Setup message to the UE.

(95) Potential benefits of this approach are that the pending data can be forwarded, and it may result in no Non-Access Stratum (NAS) layer impact.

(96) In some cases, the IoT NTN RAN may broadcast a System Information Block (SIB) indication indicating whether RRC re-establishment using s-TMSI is supported upon RAT change. If the re-establishment using s-TMSI is allowed, the UE may be allowed to send a RRC connection re-establishment request. In some cases, a UE may attempt RRC re-establishment using s-TMSI only if it detects a SIB indicating this is supported.

(97) In some cases, upon recovery, a UE may establish a new RRC connection in a target (TN or NTN). In such cases, the UE may send a TAU request and uses a new code point indicating “handover” for the Update type IE in the TAU REQUEST message. For example, as illustrated in FIG. 11, there one of two previously unused code points (‘100’ and ‘101’) in the Update type IE in the TAU REQUEST message may be used to indicate a handover or access change (e.g., a change from TN to NTN or vice-versa).

(98) Based on the new update type, the MME may check for any pending data for the UE and forward that pending data (if found). The MME may identify the UE based on the S-TMSI extracted from the Global Unique Temporary Identifier (GUTI) received in the TAU REQUEST

message (see FIG. 9).

(99) Potential benefits of this approach, indicating an access change via a TAU request, include that pending data may be forwarded and there may be no RAN impact (e.g., no need for RRC connection re-establishment upon RAT change).

(100) In some cases, if the MME is not the same, the MME may reject the TAU request. In some cases, if the MME is not the same, the MME may accept the TAU request as if it were sent with update type “mobility update.” In such cases, pending data may not be forwarded in this case. This is consistent with conventional (legacy) behavior when unused code points are used for Update type IE in the TAU REQUEST message.

Example Operations of a User Equipment

(101) FIG. 12 shows a method 1200 for wireless communications by a UE, such as UE 104 of FIGS. 1 and 3.

(102) Method 1200 begins at 1205 with performing a mobility procedure to establish a connection in a target RAT while maintaining a context established in a source RAT, where one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT. In some cases, the operations of this step refer to, or may be performed by, mobility procedure circuitry as described with reference to FIG. 15.

(103) Method 1200 then proceeds to step 1210 with sending a TAU request after establishing the connection in the target RAT. In some cases, the operations of this step refer to, or may be performed by, TAU request circuitry as described with reference to FIG. 15.

(104) In some aspects, the UE comprises a CIoT wireless device. In some aspects, the UE performs the mobility procedure after detecting a RLF in the source RAT. In some aspects, the performing the mobility procedure comprises performing a RRC connection re-establishment procedure. In some aspects, the method 1200 further includes receiving an updated TA list in response to the TAU request. In some aspects, the method 1200 further includes receiving an RRC connection setup message if the target RAT is served by a different CN than the source RAT.

(105) In some aspects, the RRC connection re-establishment procedure is performed using a S-TMSI. In some aspects, the method 1200 further includes receiving a SIB indicating the target RAT supports RRC connection re-establishment using an S-TMSI prior to performing the RRC connection re-establishment procedure using the S-TMSI.

(106) In some aspects, the TAU request includes an update type indicating a handover from the source RAT to the target RAT. In some aspects, the update type comprises an EPS update type access change.

(107) In one aspect, method 1200, or any aspect related to it, may be performed by an apparatus, such as communications device 1500 of FIG. 15, which includes various components operable, configured, or adapted to perform the method 1200. Communications device 1500 is described below in further detail.

(108) Note that FIG. 12 is just one example of a method, and other methods including fewer, additional, or alternative steps are possible consistent with this disclosure.

Example Operations of a Network Entity

(109) FIG. 13 shows a method 1300 for wireless communications by a network entity, such as BS 102 of FIGS. 1 and 3, or a disaggregated base station as discussed with respect to FIG. 2.

(110) Method 1300 begins at 1305 with transmitting a SIB indicating support of RRC connection re-establishment procedure of a UE between a target RAT and a source RAT, where one of the source RAT or target RAT is a TN RAT and the other is NTN RAT. In some cases, the operations of this step refer to, or may be performed by, SIB transmission circuitry as described with reference to FIG. 16.

(111) Method 1300 then proceeds to step 1310 with participating in the RRC connection re-establishment procedure with the UE to maintain a context established in a source RAT. In some cases, the operations of this step refer to, or may be performed by, RRC connection procedure

circuitry as described with reference to FIG. 16.

(112) In some aspects, the UE comprises a CIoT wireless device. In some aspects, if the target RAT is served by a different CN than the source RAT, the method **1300** further includes receiving an RRC reestablishment procedure message transmitted by the UE and transmitting a RRC connection setup message to the UE.

(113) In one aspect, method **1300**, or any aspect related to it, may be performed by an apparatus, such as communications device **1600** of FIG. 16, which includes various components operable, configured, or adapted to perform the method **1300**. Communications device **1600** is described below in further detail.

(114) Note that FIG. 13 is just one example of a method, and other methods including fewer, additional, or alternative steps are possible consistent with this disclosure.

(115) FIG. 14 shows a method **1400** for wireless communications by a network entity, such as BS **102** of FIGS. 1 and 3, or a disaggregated base station as discussed with respect to FIG. 2.

(116) Method **1400** begins at **1405** with participating in a mobility procedure to transition a UE from a source RAT to a target RAT, where one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT. In some cases, the operations of this step refer to, or may be performed by, UE mobility procedure circuitry as described with reference to FIG. 17.

(117) Method **1400** then proceeds to step **1410** with retrieving a context of the UE from the source RAT. In some cases, the operations of this step refer to, or may be performed by, UE context processing circuitry as described with reference to FIG. 17.

(118) Method **1400** then proceeds to step **1415** with forwarding data from the source RAT to the UE. In some cases, the operations of this step refer to, or may be performed by, data forwarding circuitry as described with reference to FIG. 17.

(119) In some aspects, the UE comprises a CIoT wireless device. In some aspects, the mobility procedure comprises a RRC connection re-establishment procedure. In some aspects, the RRC connection re-establishment procedure is performed using a S-TMSI. In some aspects, the S-TMSI is used to retrieve the context.

(120) In some aspects, the method **1400** further includes receiving a TAU request transmitted from the UE. In some aspects, the TAU request includes an update type indicating a handover from the source RAT to the target RAT. In some aspects, the update type comprises an EPS update type access change. Some examples of the method, apparatus, non-transitory computer readable medium, and system further include extracting a S-TMSI in the TAU request. In some aspects, if the S-TMSI is not found when performing a context retrieval, the method **1400** further includes rejecting the TAU request or performing a backup TAU update with an update type other than the update type indicating the handover.

(121) In one aspect, method **1400**, or any aspect related to it, may be performed by an apparatus, such as communications device **1700** of FIG. 17, which includes various components operable, configured, or adapted to perform the method **1400**. Communications device **1700** is described below in further detail.

(122) Note that FIG. 14 is just one example of a method, and other methods including fewer, additional, or alternative steps are possible consistent with this disclosure.

Example Communications Devices

(123) FIG. 15 depicts aspects of an example communications device **1500**. In some aspects, communications device **1500** is a user equipment, such as UE **104** described above with respect to FIGS. 1 and 3.

(124) The communications device **1500** includes a processing system **1505** coupled to the transceiver **1565** (e.g., a transmitter and/or a receiver). The transceiver **1565** is configured to transmit and receive signals for the communications device **1500** via the antenna **1570**, such as the various signals as described herein. The processing system **1505** may be configured to perform processing functions for the communications device **1500**, including processing signals received

and/or to be transmitted by the communications device **1500**.

(125) The processing system **1505** includes one or more processors **1510**. In various aspects, the one or more processors **1510** may be representative of one or more of receive processor **358**, transmit processor **364**, TX MIMO processor **366**, and/or controller/processor **380**, as described with respect to FIG. **3**. The one or more processors **1510** are coupled to a computer-readable medium/memory **1535** via a bus **1560**. In certain aspects, the computer-readable medium/memory **1535** is configured to store instructions (e.g., computer-executable code) that when executed by the one or more processors **1510**, cause the one or more processors **1510** to perform the method **1200** described with respect to FIG. **12**, or any aspect related to it. Note that reference to a processor performing a function of communications device **1500** may include one or more processors **1510** performing that function of communications device **1500**.

(126) In the depicted example, computer-readable medium/memory **1535** stores code (e.g., executable instructions), such as mobility procedure code **1540**, TAU request code **1545**, TA list management code **1550**, and RRC connection management code **1555**. Processing of the mobility procedure code **1540**, TAU request code **1545**, TA list management code **1550**, and RRC connection management code **1555** may cause the communications device **1500** to perform the method **1200** described with respect to FIG. **12**, or any aspect related to it.

(127) The one or more processors **1510** include circuitry configured to implement (e.g., execute) the code stored in the computer-readable medium/memory **1535**, including circuitry such as mobility procedure circuitry **1515**, TAU request circuitry **1520**, TA list management circuitry **1525**, and RRC connection management circuitry **1530**. Processing with mobility procedure circuitry **1515**, TAU request circuitry **1520**, TA list management circuitry **1525**, and RRC connection management circuitry **1530** may cause the communications device **1500** to perform the method **1200** described with respect to FIG. **12**, or any aspect related to it.

(128) Various components of the communications device **1500** may provide means for performing the method **1200** described with respect to FIG. **12**, or any aspect related to it. For example, means for transmitting, sending or outputting for transmission may include transceivers **354** and/or antenna(s) **352** of the UE **104** illustrated in FIG. **3** and/or the transceiver **1565** and the antenna **1570** of the communications device **1500** in FIG. **15**. Means for receiving or obtaining may include transceivers **354** and/or antenna(s) **352** of the UE **104** illustrated in FIG. **3** and/or the transceiver **1565** and the antenna **1570** of the communications device **1500** in FIG. **15**.

(129) According to some aspects, mobility procedure circuitry **1515** performs a mobility procedure to establish a connection in a target RAT while maintaining a context established in a source RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT. According to some aspects, TAU request circuitry **1520** sends a TAU request after establishing the connection in the target RAT.

(130) In some aspects, the UE comprises a CIoT wireless device. In some aspects, the UE performs the mobility procedure after detecting a RLF in the source RAT. In some aspects, the performing the mobility procedure comprises performing a RRC connection re-establishment procedure.

(131) According to some aspects, TA list management circuitry **1525** receives an updated TA list in response to the TAU request.

(132) According to some aspects, RRC connection management circuitry **1530** receives an RRC connection setup message if the target RAT is served by a different CN than the source RAT. In some aspects, the RRC connection re-establishment procedure is performed using a S-TMSI. In some examples, RRC connection management circuitry **1530** receives a SIB indicating the target RAT supports RRC connection re-establishment using an S-TMSI prior to performing the RRC connection re-establishment procedure using the S-TMSI. In some aspects, the TAU request includes an update type indicating a handover from the source RAT to the target RAT. In some aspects, the update type comprises an EPS update type access change.

(133) FIG. **16** depicts aspects of an example communications device **1600**. In some aspects,

communications device **1600** is a network entity, such as BS **102** of FIGS. **1** and **3**, or a disaggregated base station as discussed with respect to FIG. **2**.

(134) The communications device **1600** includes a processing system **1605** coupled to the transceiver **1645** (e.g., a transmitter and/or a receiver) and/or a network interface **1655**. The transceiver **1645** is configured to transmit and receive signals for the communications device **1600** via the antenna **1650**, such as the various signals as described herein. The network interface **1655** is configured to obtain and send signals for the communications device **1600** via communication link(s), such as a backhaul link, midhaul link, and/or fronthaul link as described herein, such as with respect to FIG. **2**. The processing system **1605** may be configured to perform processing functions for the communications device **1600**, including processing signals received and/or to be transmitted by the communications device **1600**.

(135) The processing system **1605** includes one or more processors **1610**. In various aspects, one or more processors **1610** may be representative of one or more of receive processor **338**, transmit processor **320**, TX MIMO processor **330**, and/or controller/processor **340**, as described with respect to FIG. **3**. The one or more processors **1610** are coupled to a computer-readable medium/memory **1625** via a bus **1640**. In certain aspects, the computer-readable medium/memory **1625** is configured to store instructions (e.g., computer-executable code) that when executed by the one or more processors **1610**, cause the one or more processors **1610** to perform the method **1300** described with respect to FIG. **13**, or any aspect related to it. Note that reference to a processor of communications device **1600** performing a function may include one or more processors **1610** of communications device **1600** performing that function.

(136) In the depicted example, the computer-readable medium/memory **1625** stores code (e.g., executable instructions), such as SIB transmission code **1630** and RRC connection procedure code **1635**. Processing of the SIB transmission code **1630** and RRC connection procedure code **1635** may cause the communications device **1600** to perform the method **1300** described with respect to FIG. **13**, or any aspect related to it.

(137) The one or more processors **1610** include circuitry configured to implement (e.g., execute) the code stored in the computer-readable medium/memory **1625**, including circuitry such as SIB transmission circuitry **1615** and RRC connection procedure circuitry **1620**. Processing with SIB transmission circuitry **1615** and RRC connection procedure circuitry **1620** may cause the communications device **1600** to perform the method **1300** as described with respect to FIG. **13**, or any aspect related to it.

(138) Various components of the communications device **1600** may provide means for performing the method **1300** as described with respect to FIG. **13**, or any aspect related to it. Means for transmitting, sending or outputting for transmission may include transceivers **332** and/or antenna(s) **334** of the BS **102** illustrated in FIG. **3** and/or the transceiver **1645** and the antenna **1650** of the communications device **1600** in FIG. **16**. Means for receiving or obtaining may include transceivers **332** and/or antenna(s) **334** of the BS **102** illustrated in FIG. **3** and/or the transceiver **1645** and the antenna **1650** of the communications device **1600** in FIG. **16**.

(139) According to some aspects, SIB transmission circuitry **1615** transmits a SIB indicating support of RRC connection re-establishment procedure of a UE between a target RAT and a source RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is NTN RAT. According to some aspects, RRC connection procedure circuitry **1620** participates in the RRC connection re-establishment procedure with the UE to maintain a context established in a source RAT.

(140) In some aspects, the UE comprises a CIoT wireless device. In some examples, if the target RAT is served by a different CN than the source RAT, RRC connection procedure circuitry **1620** receives an RRC reestablishment procedure message transmitted by the UE and transmits a RRC connection setup message to the UE.

(141) FIG. **17** depicts aspects of an example communications device **1700**. In some aspects,

communications device **1700** is a network entity, such as BS **102** of FIGS. **1** and **3**, or a disaggregated base station as discussed with respect to FIG. **2**.

(142) The communications device **1700** includes a processing system **1705** coupled to the transceiver **1765** (e.g., a transmitter and/or a receiver) and/or a network interface **1775**. The transceiver **1765** is configured to transmit and receive signals for the communications device **1700** via the antenna **1770**, such as the various signals as described herein. The network interface **1775** is configured to obtain and send signals for the communications device **1700** via communication link(s), such as a backhaul link, midhaul link, and/or fronthaul link as described herein, such as with respect to FIG. **2**. The processing system **1705** may be configured to perform processing functions for the communications device **1700**, including processing signals received and/or to be transmitted by the communications device **1700**.

(143) The processing system **1705** includes one or more processors **1710**. In various aspects, one or more processors **1710** may be representative of one or more of receive processor **338**, transmit processor **320**, TX MIMO processor **330**, and/or controller/processor **340**, as described with respect to FIG. **3**. The one or more processors **1710** are coupled to a computer-readable medium/memory **1735** via a bus **1760**. In certain aspects, the computer-readable medium/memory **1735** is configured to store instructions (e.g., computer-executable code) that when executed by the one or more processors **1710**, cause the one or more processors **1710** to perform the method **1400** described with respect to FIG. **14**, or any aspect related to it. Note that reference to a processor of communications device **1700** performing a function may include one or more processors **1710** of communications device **1700** performing that function.

(144) In the depicted example, the computer-readable medium/memory **1735** stores code (e.g., executable instructions), such as UE mobility procedure code **1740**, UE context processing code **1745**, data forwarding code **1750**, and TAU request processing code **1755**. Processing of the UE mobility procedure code **1740**, UE context processing code **1745**, data forwarding code **1750**, and TAU request processing code **1755** may cause the communications device **1700** to perform the method **1400** described with respect to FIG. **14**, or any aspect related to it.

(145) The one or more processors **1710** include circuitry configured to implement (e.g., execute) the code stored in the computer-readable medium/memory **1735**, including circuitry such as UE mobility procedure circuitry **1715**, UE context processing circuitry **1720**, data forwarding circuitry **1725**, and TAU request processing circuitry **1730**. Processing with UE mobility procedure circuitry **1715**, UE context processing circuitry **1720**, data forwarding circuitry **1725**, and TAU request processing circuitry **1730** may cause the communications device **1700** to perform the method **1400** as described with respect to FIG. **14**, or any aspect related to it.

(146) Various components of the communications device **1700** may provide means for performing the method **1400** as described with respect to FIG. **14**, or any aspect related to it. Means for transmitting, sending or outputting for transmission may include transceivers **332** and/or antenna(s) **334** of the BS **102** illustrated in FIG. **3** and/or the transceiver **1765** and the antenna **1770** of the communications device **1700** in FIG. **17**. Means for receiving or obtaining may include transceivers **332** and/or antenna(s) **334** of the BS **102** illustrated in FIG. **3** and/or the transceiver **1765** and the antenna **1770** of the communications device **1700** in FIG. **17**.

(147) According to some aspects, UE mobility procedure circuitry **1715** participates in a mobility procedure to transition a UE from a source RAT to a target RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT. According to some aspects, UE context processing circuitry **1720** retrieves a context of the UE from the source RAT. According to some aspects, data forwarding circuitry **1725** forwards data from the source RAT to the UE.

(148) In some aspects, the UE comprises a CIoT wireless device. In some aspects, the mobility procedure comprises a RRC connection re-establishment procedure. In some aspects, the RRC connection re-establishment procedure is performed using a S-TMSI. In some aspects, the S-TMSI is used to retrieve the context.

(149) According to some aspects, TAU request processing circuitry **1730** receives a TAU request transmitted from the UE. In some aspects, the TAU request includes an update type indicating a handover from the source RAT to the target RAT. In some aspects, the update type comprises an EPS update type access change. In some examples, TAU request processing circuitry **1730** extracts a S-TMSI a in the TAU request. In some examples, if the S-TMSI is not found when performing a context retrieval, TAU request processing circuitry **1730** rejects the TAU request or performing a backup TAU update with an update type other than the update type indicating the handover.

Example Clauses

(150) Implementation examples are described in the following numbered clauses:

(151) Clause 1: A method of wireless communication by a UE, comprising: performing a mobility procedure to establish a connection in a target RAT while maintaining a context established in a source RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT; and sending a TAU request after establishing the connection in the target RAT.

(152) Clause 2: The method of Clause 1, wherein the UE comprises a CIoT wireless device.

(153) Clause 3: The method of any one of Clauses 1 and 2, wherein the UE performs the mobility procedure after detecting a RLF in the source RAT.

(154) Clause 4: The method of any one of Clauses 1-3, wherein performing the mobility procedure comprises performing a RRC connection re-establishment procedure.

(155) Clause 5: The method of Clause 4, further comprising: receiving an updated TA list in response to the TAU request.

(156) Clause 6: The method of Clause 4, further comprising: receiving an RRC connection setup message if the target RAT is served by a different CN than the source RAT.

(157) Clause 7: The method of Clause 4, wherein the RRC connection re-establishment procedure is performed using a S-TMSI.

(158) Clause 8: The method of Clause 7, further comprising: receiving a SIB indicating the target RAT supports RRC connection re-establishment using an S-TMSI prior to performing the RRC connection re-establishment procedure using the S-TMSI.

(159) Clause 9: The method of any one of Clauses 1-8, wherein the TAU request includes an update type indicating a handover from the source RAT to the target RAT.

(160) Clause 10: The method of Clause 9, wherein the update type comprises an EPS update type access change.

(161) Clause 11: A method of wireless communication by a network entity, comprising: transmitting a SIB indicating support of RRC connection re-establishment procedure of a UE between a target RAT and a source RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is NTN RAT; and participating in the RRC connection re-establishment procedure with the UE to maintain a context established in a source RAT.

(162) Clause 12: The method of Clause 11, wherein the UE comprises a CIoT wireless device.

(163) Clause 13: The method of any one of Clauses 11 and 12, further comprising, if the target RAT is served by a different CN than the source RAT: receiving an RRC reestablishment procedure message transmitted by the UE; and transmitting a RRC connection setup message to the UE.

(164) Clause 14: A method of wireless communication by a network entity, comprising: participating in a mobility procedure to transition a UE from a source RAT to a target RAT, wherein one of the source RAT or target RAT is a TN RAT and the other is a NTN RAT; retrieving a context of the UE from the source RAT; and forwarding data from the source RAT to the UE.

(165) Clause 15: The method of Clause 14, wherein the UE comprises a CIoT wireless device.

(166) Clause 16: The method of any one of Clauses 14 and 15, wherein the mobility procedure comprises a RRC connection re-establishment procedure.

(167) Clause 17: The method of Clause 16, wherein the RRC connection re-establishment procedure is performed using a S-TMSI.

(168) Clause 18: The method of Clause 17, wherein the S-TMSI is used to retrieve the context.

(169) Clause 19: The method of Clause 16, further comprising: receiving a TAU request transmitted from the UE.

(170) Clause 20: The method of Clause 19, wherein the TAU request includes an update type indicating a handover from the source RAT to the target RAT.

(171) Clause 21: The method of Clause 20, wherein the update type comprises an EPS update type access change.

(172) Clause 22: The method of Clause 20, further comprising: extracting a S-TMSI in the TAU request.

(173) Clause 23: The method of Clause 22, further comprising, if the S-TMSI is not found when performing a context retrieval: rejecting the TAU request or performing a backup TAU update with an update type other than the update type indicating the handover.

(174) Clause 24: A processing system, comprising: a memory comprising computer-executable instructions; one or more processors configured to execute the computer-executable instructions and cause the processing system to perform a method in accordance with any one of Clauses 1-23.

(175) Clause 25: A processing system, comprising means for performing a method in accordance with any one of Clauses 1-23.

(176) Clause 26: A non-transitory computer-readable medium comprising computer-executable instructions that, when executed by one or more processors of a processing system, cause the processing system to perform a method in accordance with any one of Clauses 1-23.

(177) Clause 27: A computer program product embodied on a computer-readable storage medium comprising code for performing a method in accordance with any one of Clauses 1-23.

Additional Considerations

(178) The preceding description is provided to enable any person skilled in the art to practice the various aspects described herein. The examples discussed herein are not limiting of the scope, applicability, or aspects set forth in the claims. Various modifications to these aspects will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other aspects. For example, changes may be made in the function and arrangement of elements discussed without departing from the scope of the disclosure. Various examples may omit, substitute, or add various procedures or components as appropriate. For instance, the methods described may be performed in an order different from that described, and various actions may be added, omitted, or combined. Also, features described with respect to some examples may be combined in some other examples. 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 that 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.

(179) The various illustrative logical blocks, modules and circuits described in connection with the present disclosure may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an ASIC, a field programmable gate array (FPGA) or other programmable logic device (PLD), discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any commercially available processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, a system on a chip (SoC), or any other such configuration.

(180) 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).

(181) As used herein, the term “determining” encompasses a wide variety of actions. For example, “determining” may include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, “determining” may include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, “determining” may include resolving, selecting, choosing, establishing and the like.

(182) The methods disclosed herein comprise one or more actions for achieving the methods. The method actions may be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of actions is specified, the order and/or use of specific actions may be modified without departing from the scope of the claims. Further, the various operations of methods described above may be performed by any suitable means capable of performing the corresponding functions. The means may include various hardware and/or software component(s) and/or module(s), including, but not limited to a circuit, an application specific integrated circuit (ASIC), or processor.

(183) The following claims are not intended to be limited to the aspects shown herein, but are to be accorded the full scope consistent with the language of the claims. Within a claim, reference to an element in the singular is not intended to mean “one and only one” unless specifically so stated, but rather “one or more.” Unless specifically stated otherwise, the term “some” refers to one or more. No claim element is to be construed under the provisions of 35 U.S.C. § 112(f) unless the element is expressly recited using the phrase “means for”. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims.

Claims

1. An apparatus for wireless communication at a user equipment (UE), comprising: memory comprising instructions; and one or more processors configured, individually or in any combination, to execute the instructions and cause the apparatus to: perform a mobility procedure to establish a connection in a target radio access technology (RAT) while maintaining a context established in a source RAT, wherein one of the source RAT or target RAT is a terrestrial network (TN) RAT and the other is a non-terrestrial network (NTN) RAT; and send a tracking area update (TAU) request comprising one or more code points indicating a handover to the target RAT after establishing the connection in the target RAT.
2. The apparatus of claim 1, wherein the UE comprises a cellular Internet of Things (CIOT) wireless device.
3. The apparatus of claim 1, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to perform the mobility procedure after detecting a radio link failure (RLF) in the source RAT.
4. The apparatus of claim 1, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to perform the mobility procedure based on performing a radio resource control (RRC) connection re-establishment procedure.
5. The apparatus of claim 4, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to receive an updated tracking areas (TA) list in response to the TAU request.
6. The apparatus of claim 4, wherein the one or more processors are configured, individually or in

any combination, to execute the instructions and cause the apparatus to receive an RRC connection setup message if the target RAT is served by a different core network (CN) than the source RAT.

7. The apparatus of claim 4, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to perform the RRC connection re-establishment procedure using a serving temporary mobile subscriber identity (S-TMSI).

8. The apparatus of claim 7, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to receive a system information block (SIB) indicating the target RAT supports RRC connection re-establishment using the S-TMSI prior to performing the RRC connection re-establishment procedure using the S-TMSI.

9. The apparatus of claim 1, wherein the TAU request includes an update type indicating the handover from the source RAT to the target RAT.

10. The apparatus of claim 9, wherein the update type comprises an evolved packet system (EPS) update type access change.

11. An apparatus for wireless communication at a network entity, comprising: memory comprising instructions; and one or more processors configured, individually or in any combination, to execute the instructions and cause the apparatus to: transmit a system information block (SIB) indicating support of radio resource control (RRC) connection re-establishment procedure of a user equipment (UE) transitioning between a target radio access technology (RAT) and a source RAT, wherein one of the source RAT or target RAT is a terrestrial network (TN) RAT and the other is a non-terrestrial network (NTN) RAT; receive from the UE after transitioning from the source RAT to the target RAT a tracking area update (TAU) request comprising one or more code points indicating a handover to the target RAT; and participate in the RRC connection re-establishment procedure with the UE to maintain a context established in the source RAT.

12. The apparatus of claim 11, wherein the UE comprises a cellular Internet of Things (CIOT) wireless device.

13. The apparatus of claim 11, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to, if the target RAT is served by a different core network (CN) than the source RAT: receive an RRC reestablishment procedure message transmitted by the UE; and transmit an RRC connection setup message to the UE.

14. An apparatus for wireless communication by at a network entity, comprising: memory comprising instructions; and one or more processors configured, individually or in any combination, to execute the instructions and cause the apparatus to: participate in a mobility procedure to transition a user equipment (UE) from a source radio access technology (RAT) to a target RAT, wherein one of the source RAT or target RAT is a terrestrial network (TN) RAT and the other is a non-terrestrial network (NTN) RAT; receive from the UE after establishing a connection in the target RAT a tracking area update (TAU) request comprising one or more code points indicating a handover to the target RAT; retrieve a context of the UE from the source RAT; and forward data from the source RAT to the UE.

15. The apparatus of claim 14, wherein the UE comprises a cellular Internet of Things (CIOT) wireless device.

16. The apparatus of claim 14, wherein the mobility procedure comprises a radio resource control (RRC) connection re-establishment procedure.

17. The apparatus of claim 16, wherein the RRC connection re-establishment procedure is performed using a serving temporary mobile subscriber identity (S-TMSI).

18. The apparatus of claim 17, wherein the S-TMSI is used to retrieve the context.

19. The apparatus of claim 14, wherein the TAU request includes an update type indicating the handover from the source RAT to the target RAT.

20. The apparatus of claim 19, wherein the update type comprises an evolved packet system (EPS)

update type access change.

21. The apparatus of claim 19, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to extract a serving temporary mobile subscriber identity (S-TMSI) a in the TAU request.

22. The apparatus of claim 21, wherein the one or more processors are configured, individually or in any combination, to execute the instructions and cause the apparatus to, if the S-TMSI is not found when performing a context retrieval: reject the TAU request or performing a backup TAU update with an update type other than the update type indicating the handover.
