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(54) **DESCRIPTOR AGGREGATION ACROSS MULTIPLE TRANSMISSION TIME INTERVALS**

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H04W 80/02 (2009.01)

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CPC ***H04W 72/0446*** (2013.01); ***H04W 80/02*** (2013.01)

(58) **Field of Classification Search**
CPC H04W 72/0446; H04W 80/02
USPC 370/336
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,271,243	B2 *	4/2019	Phuyal	H04W 28/0819
2015/0085878	A1 *	3/2015	Kangarlou	H04L 49/9047 370/465
2016/0380861	A1	12/2016	Ali et al.	
2018/0324821	A1 *	11/2018	Dai	H04L 5/001
2020/0382397	A1 *	12/2020	Adams	H04L 43/0829

OTHER PUBLICATIONS

International Search Report and Written Opinion—PCT/US2022/072622—ISA/EPO—dated Sep. 12, 2022.

* cited by examiner

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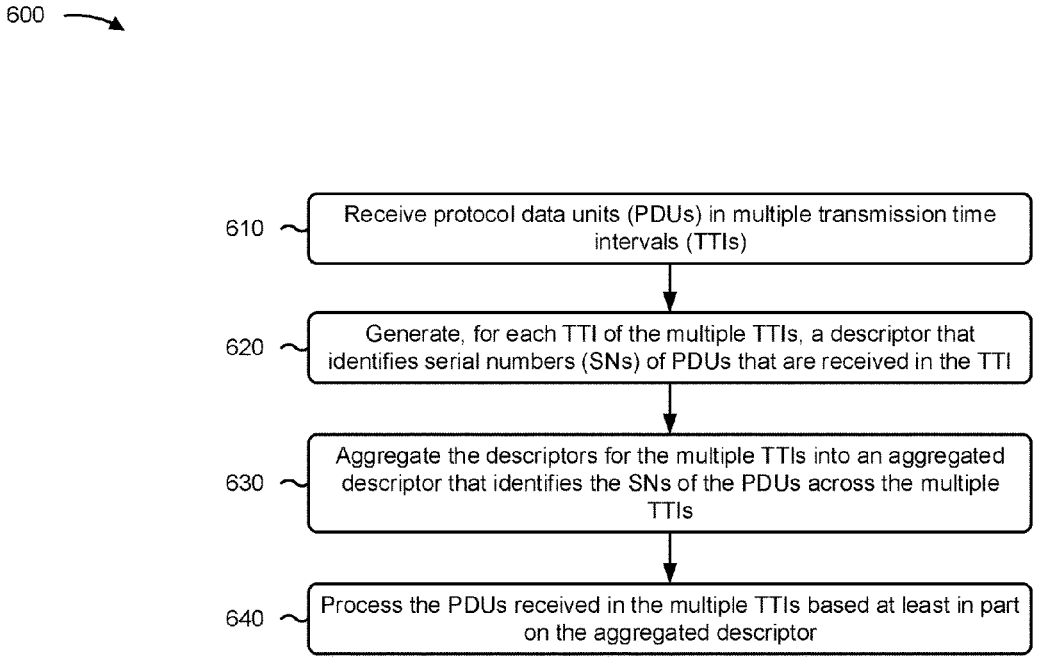
(57) **ABSTRACT**

Various aspects of the present disclosure generally relate to wireless communication. In some aspects, a wireless communication device may receive protocol data units (PDUs) in multiple TTIs (e.g., slots). The wireless communication device may generate, for each TTI of the multiple TTIs, a descriptor that identifies serial numbers (SNs) of PDUs that are received in the TTI. The wireless communication device may aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs. The wireless communication device may process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor. Numerous other aspects are described.

30 Claims, 7 Drawing Sheets



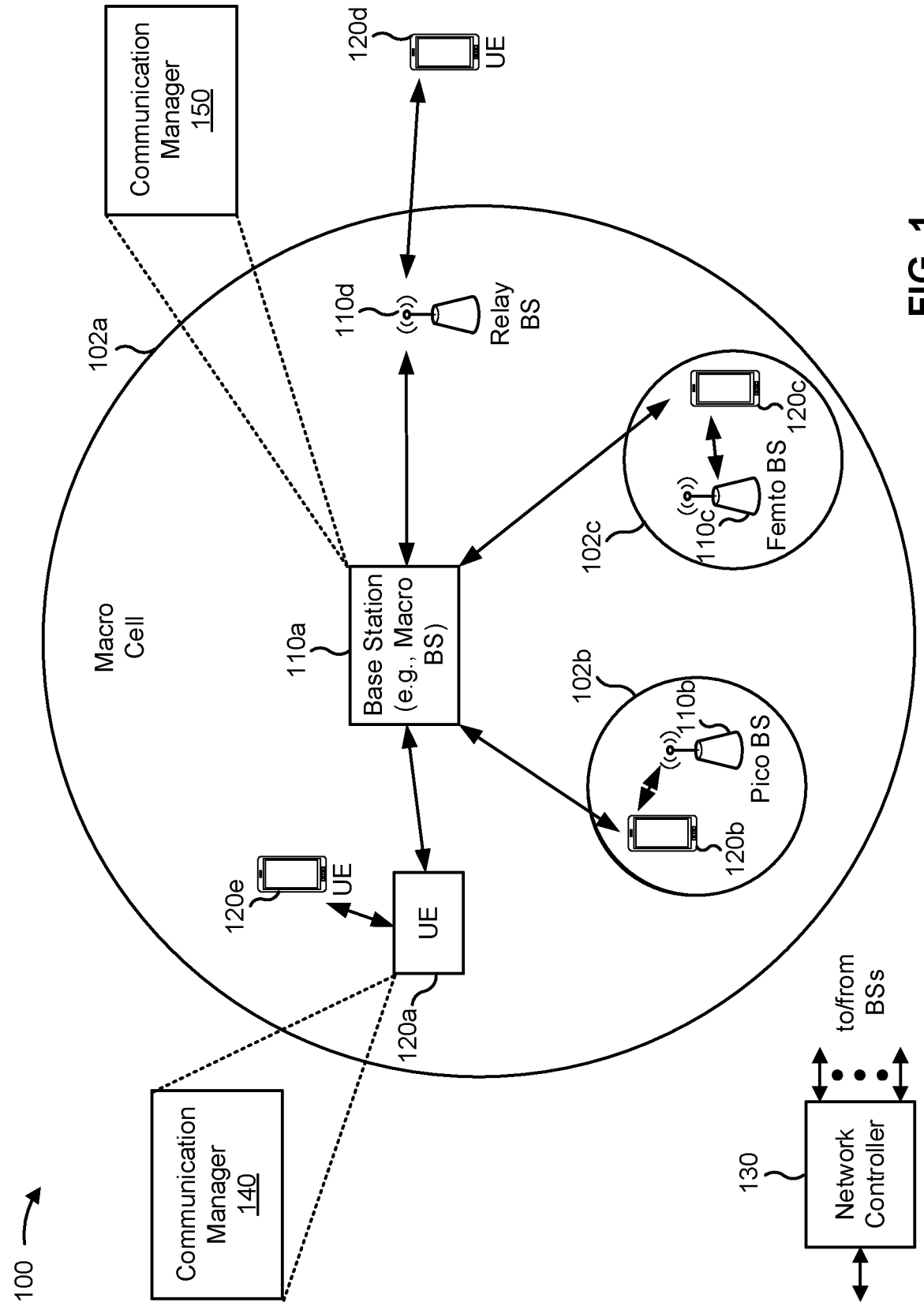

100
Communication Manager 140
Communication Manager 150
120d UE
110d Relay BS
102a
Macro Cell
110a Base Station (e.g., Macro BS)
102c
110c Femto BS
120c
102b
110b Pico BS
120b
120e UE
UE
120a
130 Network Controller
to/from BSs

FIG. 1

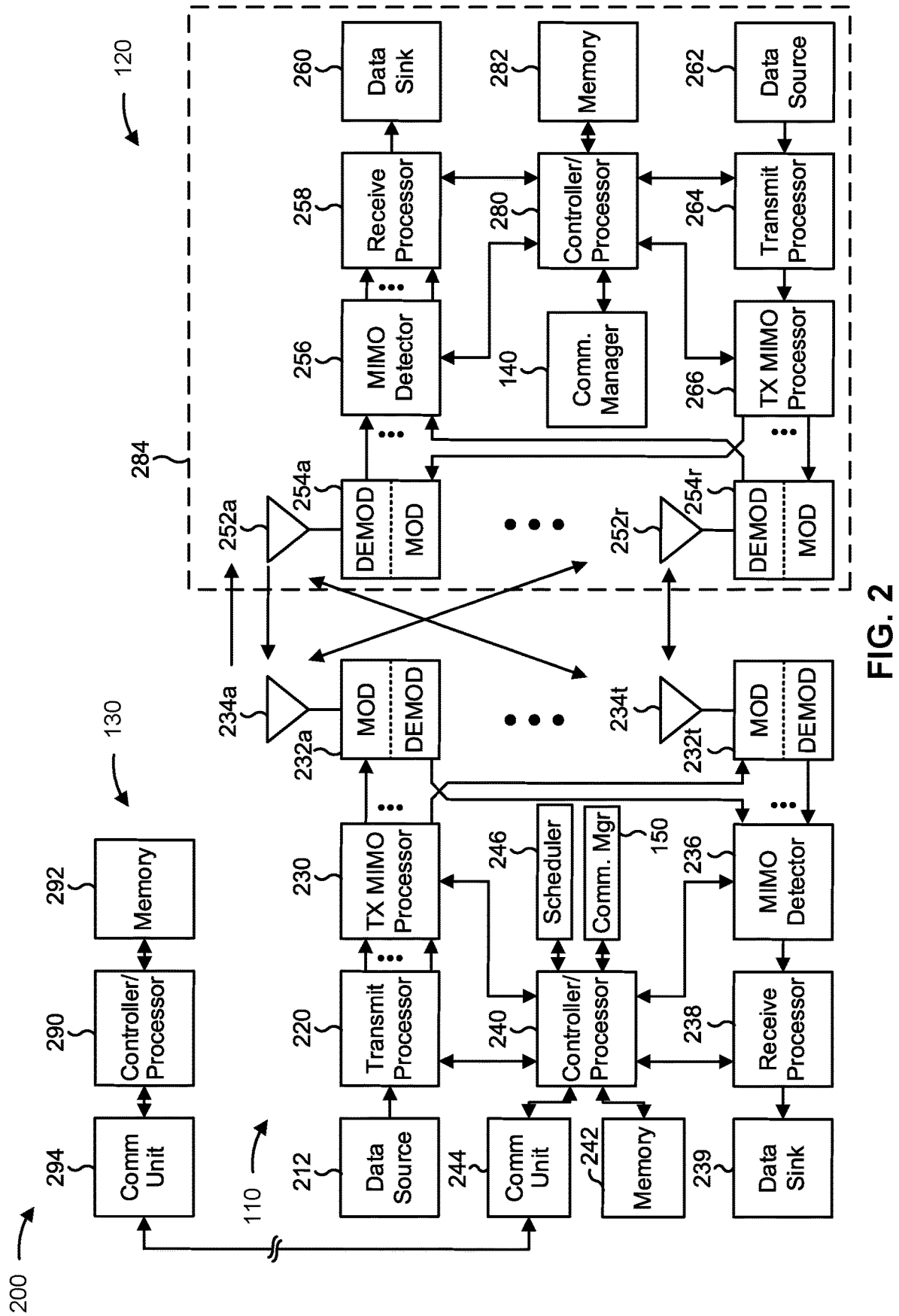

200
110
120
130
140
150
212
Data Source
220
Transmit Processor
230
TX MIMO Processor
232a
MOD
DEMOD
234a
234t
232t
240
Controller/ Processor
242
Memory
244
Comm Unit
246
Scheduler
Comm. Mgr
236
MIMO Detector
238
Receive Processor
239
Data Sink
252a
252r
254a
254r
DEMOD
MOD
256
MIMO Detector
258
Receive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

FIG. 2

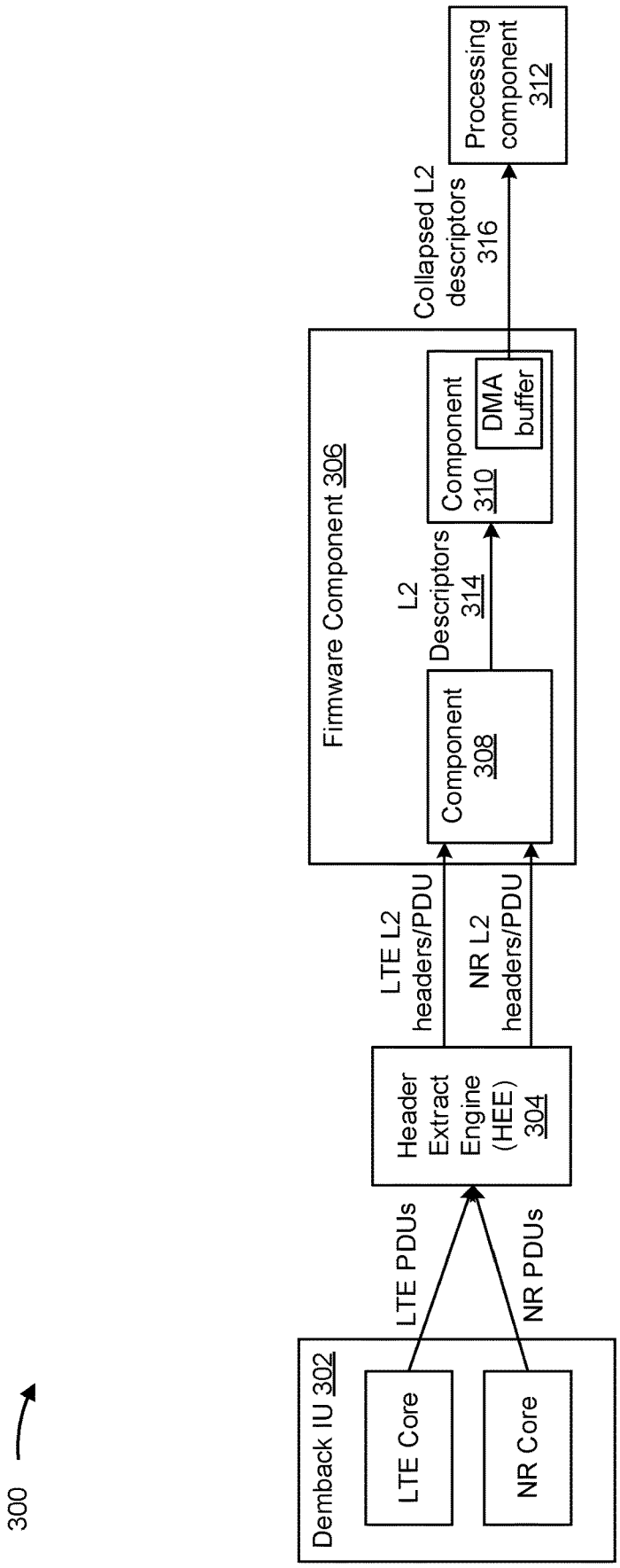

300
Demback IU 302
LTE Core
NR Core
LTE PDUs
NR PDUs
Header Extract Engine (HEE) 304
LTE L2 headers/PDU
NR L2 headers/PDU
Firmware Component 306
Component 308
L2 Descriptors 314
Component 310
DMA buffer
Collapsed L2 descriptors 316
Processing component 312

FIG. 3

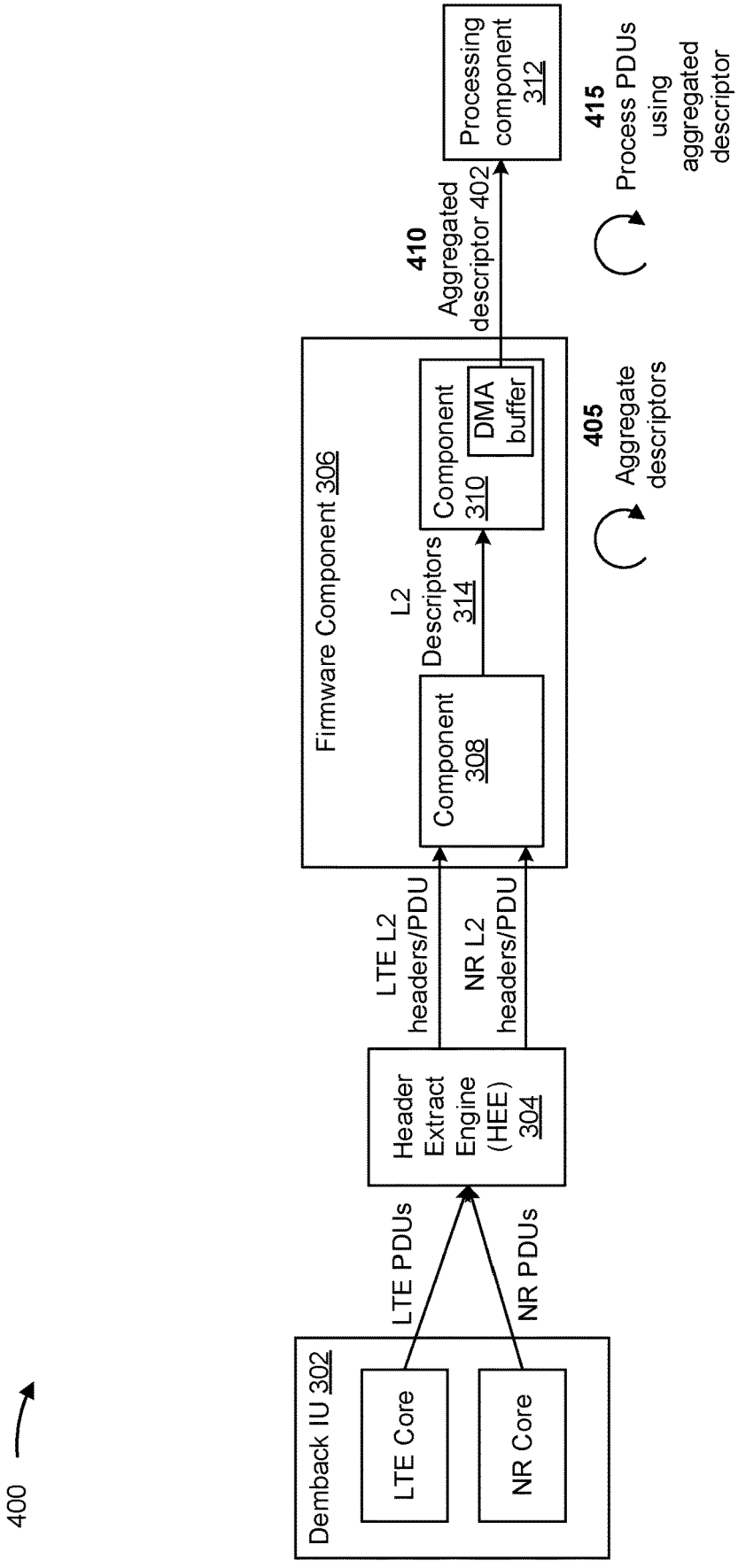

400
Demback IU 302
LTE Core
NR Core
LTE PDUs
NR PDUs
Header Extract Engine (HEE) 304
LTE L2 headers/PDU
NR L2 headers/PDU
Firmware Component 306
Component 308
L2 Descriptors 314
Component 310
DMA buffer
405 Aggregate descriptors
410 Aggregated descriptor 402
Processing component 312
415 Process PDUs using aggregated descriptor

FIG. 4

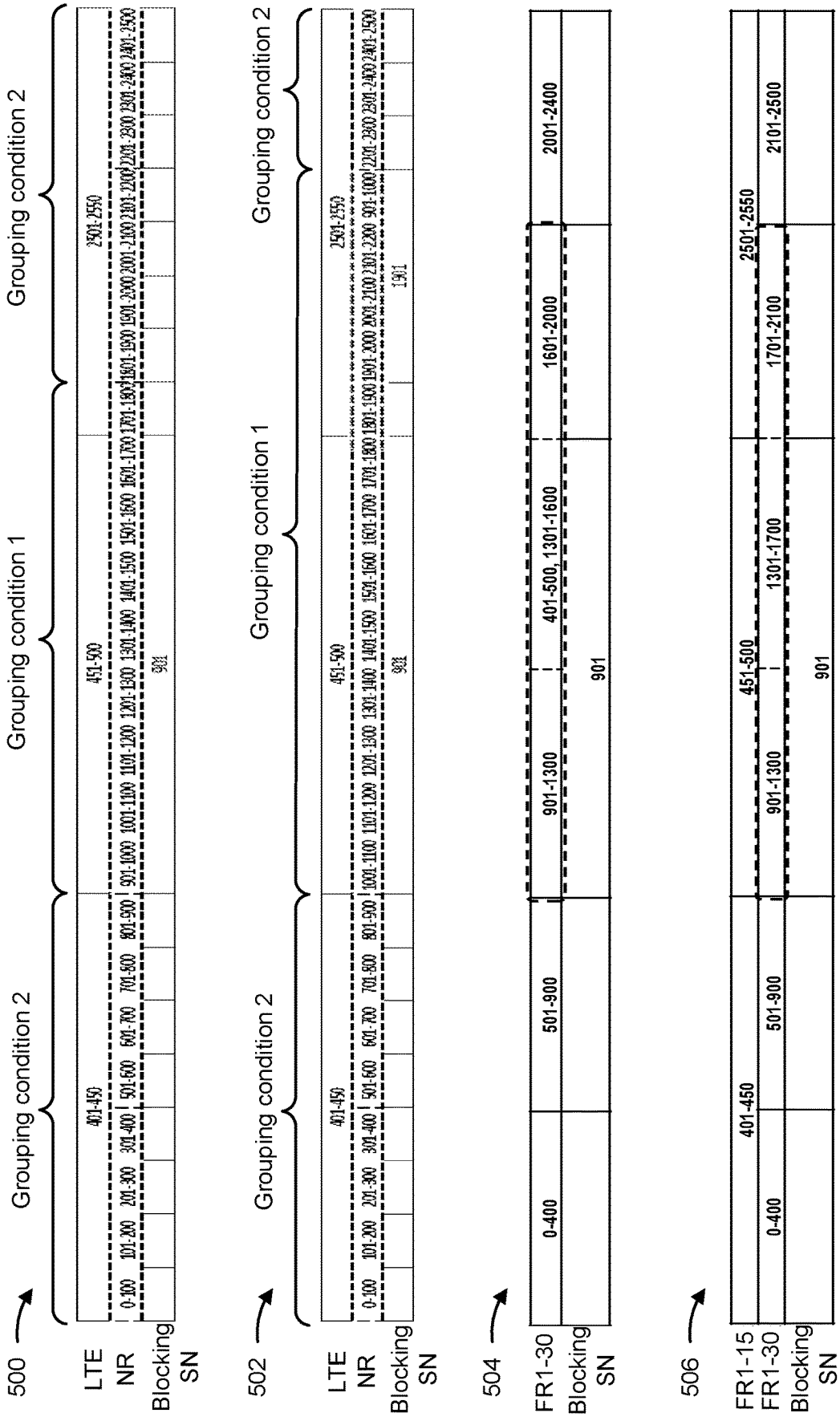

500
Grouping condition 2
Grouping condition 1
Grouping condition 2
LTE
NR
Blocking SN
0-100
101-200
201-300
301-400
401-450
451-500
501-600
601-700
701-800
801-900
901-1000
1001-1100
1101-1200
1201-1300
1301-1400
1401-1500
1501-1600
1601-1700
1701-1800
1801-1900
1901-2000
2001-2100
2101-2200
2201-2300
2301-2400
2401-2500
2501-2550
901
502
Grouping condition 2
Grouping condition 1
Grouping condition 2
LTE
NR
Blocking SN
0-100
101-200
201-300
301-400
401-450
451-500
501-600
601-700
701-800
801-900
901-1000
1001-1100
1101-1200
1201-1300
1301-1400
1401-1500
1501-1600
1601-1700
1701-1800
1801-1900
1901-2000
2001-2100
2101-2200
2201-2300
2301-2400
2401-2500
2501-2550
933
1961
504
FR1-30
Blocking SN
0-400
501-900
901-1300
401-500, 1301-1600
1601-2000
2001-2400
901
506
FR1-15
FR1-30
Blocking SN
401-450
451-500
2501-2550
0-400
501-900
901-1300
1301-1700
1701-2100
2101-2500
901

FIG. 5

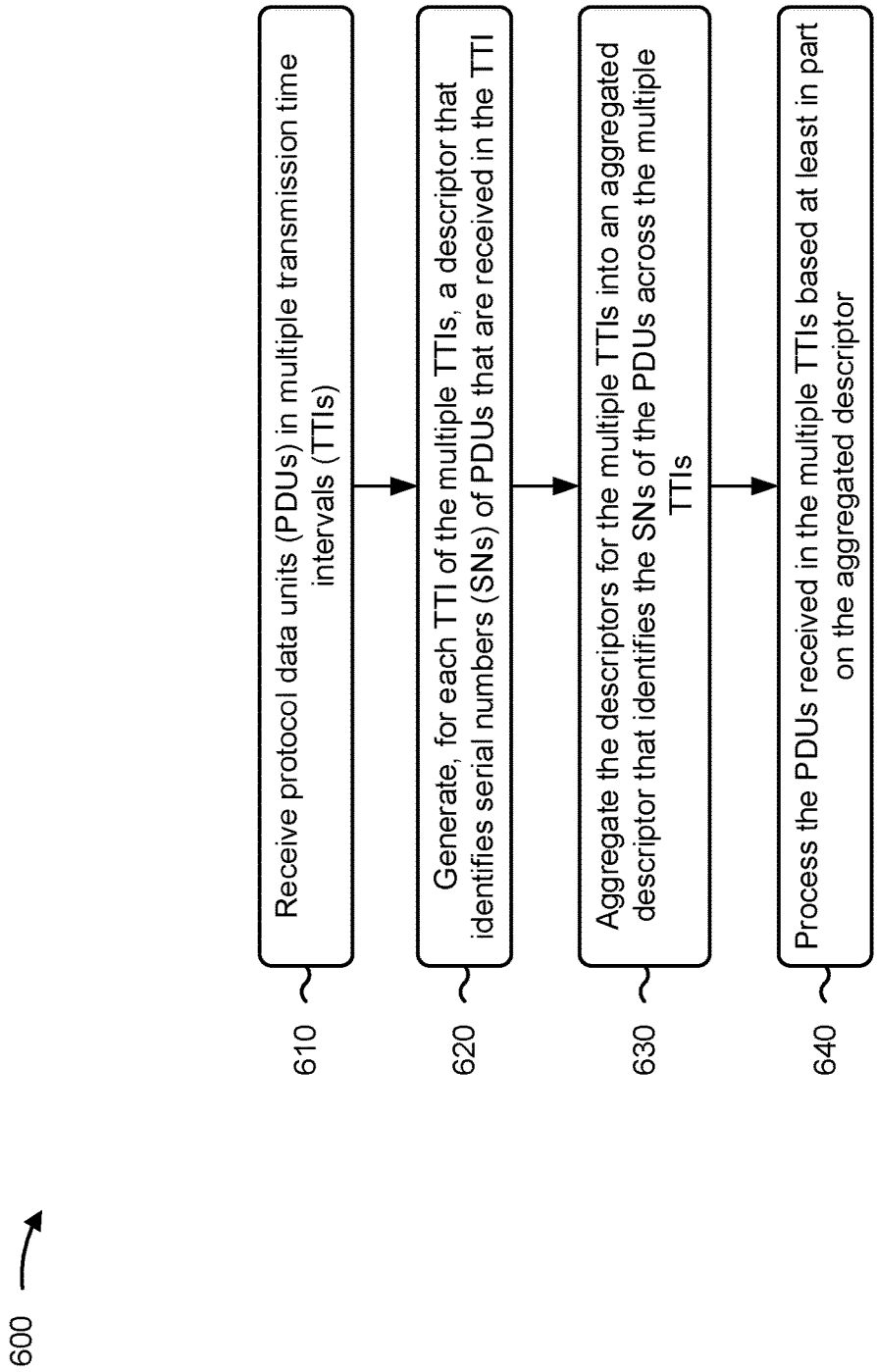

600
Receive protocol data units (PDUs) in multiple transmission time intervals (TTIs)
610
Generate, for each TTI of the multiple TTIs, a descriptor that identifies serial numbers (SNs) of PDUs that are received in the TTI
620
Aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs
630
Process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor
640

FIG. 6

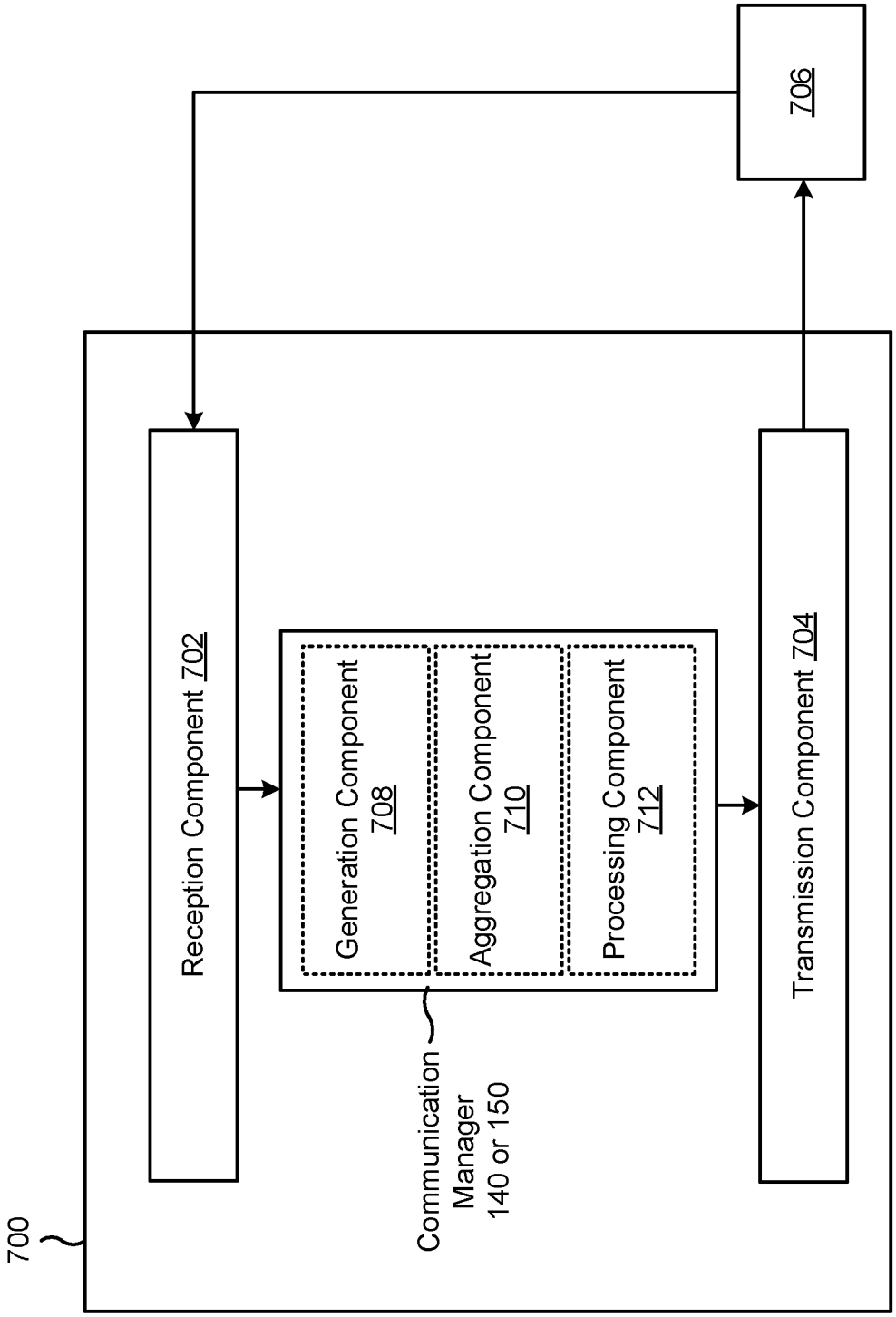

706
Reception Component 702
Generation Component 708
Aggregation Component 710
Processing Component 712
Transmission Component 704
Communication Manager 140 or 150
700

FIG. 7

DESCRIPTOR AGGREGATION ACROSS MULTIPLE TRANSMISSION TIME INTERVALS

FIELD OF THE DISCLOSURE

Aspects of the present disclosure generally relate to wireless communication and to techniques and apparatuses for aggregating descriptors across multiple transmission time intervals.

BACKGROUND

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).

A wireless network may include a number of base stations (BSs) that can support communication for a number of user equipment (UEs). A UE may communicate with a BS via the downlink and uplink. "Downlink" or "forward link" refers to the communication link from the BS to the UE, and "uplink" or "reverse link" refers to the communication link from the UE to the BS. As will be described in more detail herein, a BS may be referred to as a Node B, a gNB, an access point (AP), a radio head, a transmit receive point (TRP), a New Radio (NR) BS, a 5G Node B, or the like.

The above multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different user equipment to communicate on a municipal, national, regional, and even global level. NR, which may also 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 (DL), using CP-OFDM and/or SC-FDM (e.g., also known as discrete Fourier transform spread OFDM (DFT-s-OFDM)) on the uplink (UL), 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

In some aspects, a method of wireless communication performed by a wireless communication device includes receiving protocol data units (PDUs) in multiple transmission time intervals (TTIs) and generating, for each TTI of the multiple TTIs, a descriptor that identifies serial numbers (SNs) of PDUs that are received in the TTI. The method may include aggregating the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs and processing the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

In some aspects, a wireless communication device for wireless communication includes a memory and one or more processors, coupled to the memory, configured to receive PDUs in multiple TTIs, generate, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI, aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs, and process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

In some aspects, a non-transitory computer-readable medium storing a set of instructions for wireless communication includes one or more instructions that, when executed by one or more processors of a wireless communication device, cause the wireless communication device to receive PDUs in multiple TTIs, generate, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI, aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs, and process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

In some aspects, an apparatus for wireless communication includes means for receiving PDUs in multiple TTIs; means for generating, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI, means for aggregating the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs, and means for processing the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

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

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.

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 arrange-

ments. 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, or artificial intelligence-enabled devices). Aspects may be implemented in chip-level components, modular components, non-modular components, non-chip-level components, device-level components, 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 a number of components for analog and digital purposes (e.g., hardware components including antennas, radio frequency (RF) chains, power amplifiers, modulators, buffers, processor(s), interleavers, adders, or summers). It is intended that aspects described herein may be practiced in a wide variety of devices, components, systems, distributed arrangements, or end-user devices of varying size, shape, and constitution.

BRIEF DESCRIPTION OF THE DRAWINGS

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.

FIG. **1** is a diagram illustrating an example of a wireless network, in accordance with the present disclosure.

FIG. **2** is a diagram illustrating an example of a base station in communication with a user equipment (UE) in a wireless network, in accordance with the present disclosure.

FIG. **3** is a diagram illustrating an example of a system for processing headers, in accordance with the present disclosure.

FIG. **4** is a diagram illustrating an example of aggregating descriptors, in accordance with the present disclosure.

FIG. **5** is a diagram illustrating examples of grouping serial numbers, in accordance with the present disclosure.

FIG. **6** is a diagram illustrating an example process performed, for example, by a wireless communication device, in accordance with the present disclosure.

FIG. **7** is a block diagram of an example apparatus for wireless communication.

DETAILED DESCRIPTION

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. Based on the teachings herein, 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.

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.

It should be noted that while aspects may be described herein using terminology commonly associated with a 5G or 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).

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 (NR) network and/or an LTE network, among other examples. The wireless network **100** may include a number of base stations **110** (shown as BS **110***a*, BS **110***b*, BS **110***c*, and BS **110***d*) and other network entities. A base station (BS) is an entity that communicates with user equipment (UEs) and may also be referred to as an NR BS, a Node B, a gNB, a 5G node B (NB), an access point, a transmit receive point (TRP), or the like. Each BS may provide communication coverage for a particular geographic area. In 3GPP, the term "cell" can refer to a coverage area of a BS and/or a BS subsystem serving this coverage area, depending on the context in which the term is used.

A BS 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 with service subscription. A pico cell may cover a relatively small geographic area and may allow unrestricted access by UEs with service subscription. A femto cell may cover a relatively small geographic area (e.g., a home) and may allow restricted access by UEs having association with the femto cell (e.g., UEs in a closed subscriber group (CSG)). ABS for a macro cell may be referred to as a macro BS. ABS for a pico cell may be referred to as a pico BS. A BS for a femto cell may be referred to as a femto BS or a home BS. In the example shown in FIG. **1**, a BS **110***a* may be a macro BS for a macro cell **102***a*, a BS **110***b* may be a pico BS for a pico cell **102***b*, and a BS **110***c* may be a femto BS for a femto cell **102***c*. A BS may support one or multiple (e.g., three) cells. The terms "eNB", "base station", "NR BS", "gNB", "TRP", "AP", "node B", "5G NB", and "cell" may be used interchangeably herein.

In some aspects, a cell may not necessarily be stationary, and the geographic area of the cell may move according to the location of a mobile BS. In some aspects, the BSs may be interconnected to one another and/or to one or more other BSs or network nodes (not shown) in the wireless network

100 through various types of backhaul interfaces, such as a direct physical connection or a virtual network, using any suitable transport network.

Wireless network **100** may also include relay stations. A relay station is an entity that can receive a transmission of data from an upstream station (e.g., a BS or a UE) and send a transmission of the data to a downstream station (e.g., a UE or a BS). A relay station may also be a UE that can relay transmissions for other UEs. In the example shown in FIG. **1**, a relay BS **110***d* may communicate with macro BS **110***a* and a UE **120***d* in order to facilitate communication between BS **110***a* and UE **120***d*. A relay BS may also be referred to as a relay station, a relay base station, a relay, or the like.

Wireless network **100** may be a heterogeneous network that includes BSs of different types, such as macro BSs, pico BSs, femto BSs, relay BSs, or the like. These different types of BSs may have different transmit power levels, different coverage areas, and different impacts on interference in wireless network **100**. For example, macro BSs may have a high transmit power level (e.g., 5 to 40 watts) whereas pico BSs, femto BSs, and relay BSs may have lower transmit power levels (e.g., 0.1 to 2 watts).

A network controller **130** may couple to a set of BSs and may provide coordination and control for these BSs. Network controller **130** may communicate with the BSs via a backhaul. The BSs may also communicate with one another, e.g., directly or indirectly via a wireless or wireline backhaul.

UEs **120** (e.g., **120***a*, **120***b*, **120***c*) may be dispersed throughout wireless network **100**, and each UE may be stationary or mobile. A UE may also be referred to as an access terminal, a terminal, a mobile station, a subscriber unit, a station, or the like. A UE 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 or equipment, biometric sensors/devices, wearable devices (smart watches, smart clothing, smart glasses, smart wrist bands, smart jewelry (e.g., smart ring, smart bracelet)), an entertainment device (e.g., a music or video device, or a satellite radio), a vehicular component or sensor, smart meters/sensors, industrial manufacturing equipment, a global positioning system device, or any other suitable device that is configured to communicate via a wireless or wired medium.

Some UEs may be considered machine-type communication (MTC) or evolved or enhanced machine-type communication (eMTC) UEs. MTC and eMTC UEs include, for example, robots, drones, remote devices, sensors, meters, monitors, and/or location tags, that may communicate with a base station, another device (e.g., remote device), or some other entity. A wireless node may provide, for example, connectivity for or to a network (e.g., a wide area network such as Internet or a cellular network) via a wired or wireless communication link. Some UEs may be considered Internet-of-Things (IoT) devices, and/or may be implemented as NB-IoT (narrowband internet of things) devices. Some UEs may be considered a Customer Premises Equipment (CPE). UE **120** may be included inside a housing that houses components of UE **120**, such as processor components and/or memory components. In some aspects, 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.

In general, any number of wireless networks may be deployed in a given geographic area. Each wireless network may support a particular RAT and may operate on one or more frequencies. A RAT may also be referred to as a radio technology, an air interface, or the like. A frequency may also 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.

In some aspects, two or more UEs **120** (e.g., shown as UE **120***a* and UE **120***e*) may communicate directly using one or more sidelink channels (e.g., without using a base station **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 or a vehicle-to-infrastructure (V2I) protocol), and/or a mesh network. In this case, the UE **120** may perform scheduling operations, resource selection operations, and/or other operations described elsewhere herein as being performed by the base station **110**.

Devices of wireless network **100** may communicate using the electromagnetic spectrum, which may be subdivided based on frequency or wavelength into various classes, bands, channels, or the like. For example, devices of wireless network **100** may communicate using an operating band having a first frequency range (FR**1**), which may span from 410 MHz to 7.125 GHz, and/or may communicate using an operating band having a second frequency range (FR**2**), which may span from 24.25 GHz to 52.6 GHz. The frequencies between FR**1** and FR**2** are sometimes referred to as mid-band frequencies. Although a portion of FR**1** is greater than 6 GHz, FR**1** is often referred to as a "sub-6 GHz" band. Similarly, FR**2** is often referred to as a "millimeter wave" band 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. Thus, unless specifically stated otherwise, it should be understood that the term "sub-6 GHz" or the like, if used herein, may broadly represent frequencies less than 6 GHz, frequencies within FR**1**, and/or mid-band frequencies (e.g., greater than 7.125 GHz). Similarly, unless specifically stated otherwise, it should be understood that the term "millimeter wave" or the like, if used herein, may broadly represent frequencies within the EHF band, frequencies within FR**2**, and/or mid-band frequencies (e.g., less than 24.25 GHz). It is contemplated that the frequencies included in FR**1** and FR**2** may be modified, and techniques described herein are applicable to those modified frequency ranges.

In some aspects, the wireless communication device may include a communication manager **140** or **150**. As described in more detail elsewhere herein, the communication manager **140** or **150** may receive protocol data units (PDUs) in multiple transmission time intervals (TTIs), generate, for each TTI of the multiple TTIs, a descriptor that identifies serial numbers (SNs) of PDUs that are received in the TTI, aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs, and process the PDUs received in the multiple TTIs based at least in part on the aggregated

descriptor. Additionally, or alternatively, the communication manager **140** or **150** may perform one or more other operations described herein.

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

FIG. **2** is a diagram illustrating an example **200** of a base station **110** in communication with a UE **120** in a wireless network **100**, in accordance with the present disclosure. Base station **110** may be equipped with T antennas **234***a* through **234***t*, and UE **120** may be equipped with R antennas **252***a* through **252***r*, where in general T≥1 and R≥1.

At base station **110**, a transmit processor **220** may receive data from a data source **212** for one or more UEs, select one or more modulation and coding schemes (MCS) for each UE based at least in part on channel quality indicators (CQIs) received from the UE, process (e.g., encode and modulate) the data for each UE based at least in part on the MCS(s) selected for the UE, and provide data symbols for all UEs. Transmit processor **220** may also 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. Transmit processor **220** may also 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 T output symbol streams to T modulators (MODs) **232***a* through **232***t*. Each modulator **232** may process a respective output symbol stream (e.g., for OFDM) to obtain an output sample stream. Each modulator **232** may further process (e.g., convert to analog, amplify, filter, and upconvert) the output sample stream to obtain a downlink signal. T downlink signals from modulators **232***a* through **232***t* may be transmitted via T antennas **234***a* through **234***t*, respectively.

At UE **120**, antennas **252***a* through **252***r* may receive the downlink signals from base station **110** and/or other base stations and may provide received signals to demodulators (DEMODs) **254***a* through **254***r*, respectively. Each demodulator **254** may condition (e.g., filter, amplify, downconvert, and digitize) a received signal to obtain input samples. Each demodulator **254** may further process the input samples (e.g., for OFDM) to obtain received symbols. A MIMO detector **256** may obtain received symbols from all R demodulators **254***a* through **254***r*, perform MIMO detection on the received symbols if applicable, and provide detected symbols. A receive processor **258** may process (e.g., demodulate and decode) the detected symbols, provide decoded data for UE **120** to a data sink **260**, and 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 aspects, one or more components of UE **120** may be included in a housing **284**.

Network controller **130** may include communication unit **294**, controller/processor **290**, and memory **292**. Network controller **130** may include, for example, one or more devices in a core network. Network controller **130** may communicate with base station **110** via communication unit **294**.

Antennas (e.g., antennas **234***a* through **234***t* and/or antennas **252***a* through **252***r*) may include, or may be included within, one or more antenna panels, antenna groups, sets of antenna elements, and/or 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. An antenna panel, an antenna group, a set of antenna elements, and/or an antenna array may include a set of coplanar antenna elements and/or a set of non-coplanar antenna elements. An antenna panel, an antenna group, a set of antenna elements, and/or an antenna array may include antenna elements within a single housing and/or antenna elements within multiple housings. An antenna panel, an antenna group, a set of antenna elements, and/or an antenna array may include one or more antenna elements coupled to one or more transmission and/or reception components, such as one or more components of FIG. **2**.

On the uplink, at 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 controller/processor **280**. Transmit processor **264** may also generate reference symbols for one or more reference signals. The symbols from transmit processor **264** may be precoded by a TX MIMO processor **266** if applicable, further processed by modulators **254***a* through **254***r* (e.g., for DFT-s-OFDM or CP-OFDM), and transmitted to base station **110**. In some aspects, a modulator and a demodulator (e.g., MOD/DEMOD **254**) of the UE **120** may be included in a modem of the UE **120**. In some aspects, the UE **120** includes a transceiver. The transceiver may include any combination of antenna(s) **252**, modulators and/or demodulators **254**, MIMO detector **256**, receive processor **258**, transmit processor **264**, and/or TX MIMO processor **266**. The transceiver may be used by a processor (e.g., controller/processor **280**) and memory **282** to perform aspects of any of the methods described herein (for example, as described with reference to FIGS. **1-7**).

At base station **110**, the uplink signals from UE **120** and other UEs may be received by antennas **234**, processed by demodulators **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 UE **120**. Receive processor **238** may provide the decoded data to a data sink **239** and the decoded control information to controller/processor **240**. Base station **110** may include communication unit **244** and communicate to network controller **130** via communication unit **244**. Base station **110** may include a scheduler **246** to schedule UEs **120** for downlink and/or uplink communications. In some aspects, a modulator and a demodulator (e.g., MOD/DEMOD **232**) of the base station **110** may be included in a modem of the base station **110**. In some aspects, the base station **110** includes a transceiver. The transceiver may include any combination of antenna(s) **234**, modulators and/or demodulators **232**, MIMO detector **236**, receive processor **238**, transmit processor **220**, and/or TX MIMO processor **230**. The transceiver may be used by a processor (e.g., controller/processor **240**) and memory **242** to perform aspects of any of the methods described herein (for example, as described with reference to FIGS. **1-7**).

A controller/processor of a wireless communication device, such as controller/processor **240** of base station **110**,

controller/processor **280** of UE **120**, and/or any other component(s) of FIG. **2** may perform one or more techniques associated with aggregating descriptors across multiple TTIs, as described in more detail elsewhere herein. In some aspects, the wireless communication device described herein is the base station **110**, is included in the base station **110**, or includes one or more components of the base station **110** shown in FIG. **2**. In some aspects, the wireless communication device described herein is the UE **120**, is included in the UE **120**, or includes one or more components of the UE **120** shown in FIG. **2**. For example, controller/processor **240** of base station **110**, controller/processor **280** of UE **120**, and/or any other component(s) of FIG. **2** may perform or direct operations of, for example, process **600** of FIG. **6**, and/or other processes as described herein. Memories **242** and **282** may store data and program codes for base station **110** and UE **120**, respectively. In some aspects, memory **242** and/or 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 base station **110** and/or the UE **120**, may cause the one or more processors, the UE **120**, and/or the base station **110** to perform or direct operations of, for example, process **600** of FIG. **6**, and/or other processes as described herein. In some aspects, executing instructions may include running the instructions, converting the instructions, compiling the instructions, and/or interpreting the instructions, among other examples.

In some aspects, the wireless communication device includes means for receiving PDUs in multiple TTIs, means for generating, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI, means for aggregating the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs, and/or means for processing the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor. In some aspects, the means for the wireless communication device to perform operations described herein may include, for example, one or more of communication manager **150**, transmit processor **220**, TX MIMO processor **230**, modulator **232**, antenna **234**, demodulator **232**, MIMO detector **236**, receive processor **238**, controller/processor **240**, memory **242**, or scheduler **246**. In some aspects, the means for the wireless communication device to perform operations described herein may include, for example, one or more of communication manager **140**, antenna **252**, demodulator **254**, MIMO detector **256**, receive processor **258**, transmit processor **264**, TX MIMO processor **266**, modulator **254**, controller/processor **280**, or memory **282**.

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 controller/processor **280**.

As indicated above, FIG. **2** is provided as an example. Other examples may differ from what is described with regards to FIG. **2**.

FIG. **3** is a diagram illustrating an example **300** of a system for processing headers, in accordance with the present disclosure. The system (e.g., for a modem) may be included in a wireless communication device (e.g., a UE **120**, a CPE, base station **110**) that receives PDUs in transport blocks (TBs) from other wireless communication devices. The wireless communication device may operate in a wireless network, such as wireless network **100**.

The wireless communication device may receive and demodulate PDUs. The PDUs may have headers (e.g., radio link control (RLC) headers and packet data convergence protocol (PDCP) headers) with information that is used for processing the PDUs. The system shown by example **300** extracts the headers, generates a descriptor (metadata) for the headers for each TTI, collapses or compresses the descriptors, and provides the descriptors to a processing component. The processing component may use the descriptors to process the PDUs, including checking integrity protection for the PDUs, deciphering the PDUs, or reordering the PDUs. These actions may help with processing of the data payloads of the PDUs.

In more detail, example **300** shows a demodulation back-end (demback) instruction unit (IU) **302**, a header extraction engine (HEE) **304**, and a component **306**, which may be a firmware component that executes instructions. In some aspects, component **306** may be a hardware component or a software component. Component **306** may include a first component **308** and a second component **310**. In some aspects, component **306**, component **308**, and component **310** may be one component or another combination of components. Example **300** also shows a processing component **312**, which may be a software processing component. In some aspects, the processing component **312** may be a firmware component, or a hardware component. The demback IU **302** may perform a cyclic redundancy check (CRC) check on Long Term Evolution (LTE) and NR PDUs received in each TTI (e.g., slot). If the CRC is successful, the demback IU **302** may provide the PDUs to the HEE **304**. The HEE **304** may extract the headers from the PDUs and provide them to component **308** of component **306**. Component **306** may generate descriptors (metadata) for the headers. A descriptor may identify a group of SNs for PDUs received in a slot, for example, including a starting SN, an ending SN, and/or a quantity of SNs. The descriptors may include RLC descriptors and/or PDCP descriptors. Component **310** may collapse the descriptors and store the collapsed descriptors **316** in a direct memory access (DMA) buffer. Component **310** may provide the collapsed descriptors **316** to the processing component **312**.

Component **308** may be a first component of a wireless communication device, component **310** may be a second component, and the processing component **312** may be considered a third component. Component **308** and component **310** may include firmware, and the processing component **312** may include firmware or may include software executed by a processor. The descriptors may help to alleviate the load on the processing component **312** by avoiding per-packet processing if the L2 packets are continuous in sequence number and are the same size.

The processing component **312** may share processing resources (measured as available massively parallel processing units, or Mega Packets Per Second (MPPS)) between a modem and other applications (e.g., a location service application, a video application, an audio application). If the wireless communication device is operating in an Evolved Universal Terrestrial Radio Access (E-UTRA)-NR Dual Connectivity (EN-DC) mode, the PDUs may be reordered across LTE and NR legs. Reordering may involve building a single ordered list of packets in the processing component **312**. The efficiency of processing component **312** may be increased by amortizing the cost of inserting the descriptor

into the list across multiple packets. The efficiency of the descriptors may correspond to how fast a scheduler switches data between LTE and NR. If the scheduler causes large chunks of data (several milliseconds) for each leg, this may consume memory and increase latency.

Component **308** and component **310** may sequentially process LTE and NR traffic. Component **308** may prepare and accumulate RLC/PDCP descriptors for each PDU that is received until a memory of component **310** reaches a storage limit or a last PDU is processed. Component **308** may provide the descriptors to component **310** to collapse before providing the collapsed descriptors **316** to the processing component **312**. However, the more descriptors that the processing component **312** has to process (e.g., list insertion), the more processing resources that are consumed.

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

FIG. **4** is a diagram illustrating an example **400** of aggregating descriptors, in accordance with the present disclosure. Example **400** shows the components described in connection with example **300**.

According to various aspects described herein, the wireless communication device may aggregate descriptors for PDUs across multiple TTIs (e.g., slots) into an aggregated descriptor **402**. The descriptors may be aggregated by component **310**, and component **310** may provide the aggregated descriptor **402** to the processing component **312**. The aggregated descriptor **402** may indicate a group of PDUs, where the PDUs have corresponding SNs. For example, the aggregated descriptor **402** may indicate a starting SN for a starting PDU of the group, an ending SN for an ending PDU of the group, a quantity of SNs for the group, or another indicator of a size or SN range of the group. In this way, the processing component **312** inserts fewer descriptors in a list for processing the PDUs while obtaining the same amount of information. This increase in descriptor efficiency conserves processing resources. The aggregated descriptor **402** may also group PDUs to help with in-order PDU processing when a PDU arrives later (SNs are missing or arrive out of order). For example, if SNs **451-500** are received after SN **901**, SNs may be grouped such that SNs **451-500** are included in the same group as SN **901**.

As shown by example **400**, component **310** may receive descriptors **314** from component **308**. As shown by reference number **405**, component **310** may aggregate the descriptors. For example, if a first descriptor of the descriptors **314** provides information for SNs **1-200**, a second descriptor provides information for SNs **201-400**, and a third descriptor provides information for SNs **401-450**, the aggregated descriptor **402** may be a single descriptor that provides information for SNs **1-450**. The aggregated descriptor **402** may be stored in a DMA buffer for delivery to the processing component **312**.

Component **310** may group SNs based on a blocking SN, which may be an SN that is used to mark a start of a block or grouping of SNs. The blocking SN may be identified based at least in part on a determination that some SNs are missing or arrived late. For example, if some SNs are missing, a blocking SN may be set and the group of SNs to be associated with an aggregated descriptor may be enlarged to include the missing SNs that arrive later. In some aspects, the blocking SN may be identified based at least in part on a reordering parameter (e.g., PDCP SN RX_REORD) or the first missing SN (e.g., PDCP SN RX_DELIV). The blocking SN may also be set based at least in part on one half of a PDCP reordering window size. By grouping SNs with a blocking SN, the SNs may be reordered and the aggregated descriptor **402** may reflect the reordering. This may reduce the processing resources used by the processing component **312** for reordering and for handling late arriving SNs. As a result, the processing component **312** may increase efficiency without increasing the memory that is needed for component **306**.

In some aspects, if descriptor aggregation is not started, the wireless communication device may start the descriptor aggregation (or grouping of PDUs for descriptor aggregation) if a blocking SN is identified and if PDUs received in a current TTI have SNs that are equal to or greater than the blocking SN (e.g., for RX_REORD) or greater than the blocking SN (e.g., for RX_DELIV). Aggregation may be stopped if an SN for a received PDU is less than a blocking SN (e.g., for RX_REORD), less than or equal to the blocking SN (e.g., for RX_DELIV), or if the blocking SN is undefined. Aggregation may be stopped (current group ended and new group started) if a storage level of a memory for component **310** satisfies a storage threshold (e.g., reaches a storage limit).

In some aspects, a group of SNs may be specified as a quantity of TTIs. For example, every 4 slots may be a group and the aggregated descriptor **402** may be an aggregation of descriptors for the 4 slots. The specified quantity may be obtained from stored configuration information or indicated by the network. The use of a specified quantity of TTIs may be based on whether the wireless communication device is operating in FR**2**. Using a specified quantity of TTIs may have little impact on end-to-end packet latency, as an internet protocol accelerator (IPA) accumulates and delivers data in traffic bursts to an application protocol component or a host.

As shown by reference number **410**, component **310** may provide the aggregated descriptor **402** to the processing component **312**. As shown by reference number **415**, the processing component **312** may use the aggregated descriptor **402** to process the PDUs. This may include checking integrity protection for the PDUs, deciphering the PDUs, or reordering the PDUs. By processing the single aggregated descriptor **402** for multiple TTIs rather than processing multiple descriptors for the multiple TTIs, the processing component **312** may conserve processing resources.

In some aspects, a group of SNs may be aligned with a temporal parameter. The temporal parameter may be an IPA accumulation interval for PDUs being passed between a modem and a host. The wireless communication device may enable descriptor aggregation if the temporal parameter satisfies a temporal parameter threshold (e.g., is below the temporal parameter threshold). This may lead to significant SN grouping gain without incurring additional end-to-end packet delay. This may also be useful for peak throughput EN-DC scenarios where load optimization of the processing component **312** will help to deliver a high throughput.

In some aspects, the processing component **312** may determine a mode of operation for component **306** with regard to enabling or disabling grouping for cross-TTI or cross-slot descriptor aggregation. The processing component **312** may enable or disable the grouping. For example, grouping for descriptor aggregation may be enabled if a processing parameter satisfies a processing threshold (e.g., MPPS exceed a threshold MPPS value). Note that this may be applicable if the wireless communication device is operating at least in an EN-DC mode, an NR carrier aggregation mode, an LTE stand-alone mode, or an NR stand-alone mode.

Grouping for descriptor aggregation may be enabled if there is a block error rate (BLER) on an LTE leg and/or an NR leg or if the BLER satisfies a BLER threshold (e.g., reaches a maximum BLER). The grouping may be possible on both legs. If there is no BLER on either leg or if the BLER satisfies another BLER threshold (e.g., minimum BLER), grouping for descriptor aggregation (e.g., on NR leg) may be enabled only when the leg that is ahead with SNs (e.g., NR leg) has a higher numerology than the leg that is behind with SNs (e.g., LTE leg). For example, if the LTE leg (with numerology of 15 kilohertz (kHz) subcarrier spacing (SCS)) has a block of SNs **1-10** and the NR leg (with numerology of 30 kHz SCS) has a block of SNs **11-55** and a block of SNs **55-100** in the same slot, grouping is possible on the NR leg. However, if the LTE leg has a block of SNs **91-100** and the NR leg has a block of SNs **1-45** and a block of SNs **46-90** in the same slot, grouping on the NR leg may not be possible because the NR leg is behind the LTE leg. Grouping on the LTE leg may not be possible if the LTE leg has a lower numerology.

Grouping for aggregation may be disabled if one or more of a throughput parameter satisfies a throughput threshold (e.g., throughput is less than peak throughput for an envelope mode, available double data rate (DDR)), or a ping test is to be performed. The peak throughput may be multiplied by a specified fraction (i.e., $0<X<1$) that controls how aggressive component **310** will approach when to enable of the grouping for descriptor aggregation.

In some embodiments, the processing component **312** may adjust the blocking SN based at least in part on a size and/or status (e.g., storage level) of a PDCP ReOrdering Window (ROW). For example, when the ROW is full or if an overall modem memory level falls below a threshold, the processing component **312** may deliver PDCP PDUs (along with missing SNs) to the host. Component **306** may flush half of the total buffer (i.e., SNs below a half ROW mark, or $SN_{0.5*ROW}$). Component **306** may aggregate descriptors held for aggregation and deliver the aggregated descriptor to the processing component **312** for SNs that are less than or equal to $SN_{0.5*ROW}$. The processing component **312** may update the blocking SN to $SN_{0.5*ROW}$ when the processing component **312** is about to flush the ROW. When the ROW or system memory is freed up, the processing component **312** may update the blocking SN to be an SN indicated by RX_REORD if the SN of RX_REORD is greater than the blocking SN. That is the blocking SN may be the maximum of the SN of RX_REORD and the blocking SN).

In other words, if a PDCP ROW in the processing component **312** becomes full, the processing component **312** may adjust the blocking SN to terminate the current group and start a next group. If the memory of component **306** becomes full, the current group is closed and a next group is started. By providing the processing component **312** a single aggregated descriptor for multiple TTIs, instead of a descriptor for each TTI, the processing component **312** may conserve processing resources.

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

FIG. **5** is a diagram illustrating examples **500**, **502**, **504**, and **506** of grouping SNs, in accordance with the present disclosure.

Example **500** shows an example of blocking SNs for grouping SNs for LTE, where some LTE SNs have fallen behind NR SNs, such as millimeter wave (mmW) SNs. There may be no BLER on either the LTE leg or the NR (mmW) leg. Example **500** also shows a group of SNs for a first grouping condition (condition **1**) and a second grouping condition (condition **2**). Grouping condition **1** may be used to start a group if a blocking SN exists (e.g., SN **901**) and all PDUs received in a TTI have SNs that are equal to or greater than the blocking SN. Grouping condition **1** may be applicable to mmW rather than LTE or FR**1**. Grouping condition **2** may group SNs based on a specified quantity of TTIs (e.g., 4 slots of unconditional grouping). There may be no blocking SN for grouping condition **2**.

In some aspects, component **310** may use a blocking SN to start a group of SNs. Component **310** may identify the blocking SN based at least in part on some SNs that are missing or have arrived late. For example, as shown by example **500**, if SNs **451-500** are determined to be missing, component **310** may end a current group of SNs and start a new group with a new blocking SN, such as SN **901**. The missing SNs **451-500** may then be included in the new group for descriptor aggregation. If the missing SNs arrive on the LTE leg, the processing component **312** may send a stop indication to component **306**. Grouping may stop **1** slot after the indication (e.g., at SN **1700**).

Example **502** shows an example of blocking SNs for grouping SNs for both an LTE leg and an NR leg, where the SNs reflect a block error rate for NR and some LTE SNs have fallen behind NR SNs (mmW SNs). For example, there may be a HARQ error on the component carrier with SN **901-1000**. The grouping condition **1** may be used due to delayed SNs on the LTE leg. Component **306** may deliver descriptors. If the processing component **312** detects missing SNs **901-1000**, SN **1901** may be used as a blocking SN. In this way, a group may involve LTE and NR PDUs. SNs **1901** to SN **1000** may be another grouping due to the missing SNs **901-1000** on the NR leg. The SNs **901-1000** may arrive as a HARQ retransmission success within the grouping.

Example **504** shows grouping SNs across TTIs (e.g., slots) for NR standalone (SA) in a carrier aggregation (CA) scenario (30 kHz SCS time division duplex (TDD)). There is no blocking or grouping for SNs **0-900**. However, if there is a HARQ error on the component carrier for missing SNs **401-500**, the processing component **312** may set blocking SN to SN **901**. SNs greater than SN **901** on an NR leg may be grouped. If the missing SNs **401-500** arrive (HARQ retransmission success), there may be no new blocking SN. An indication to stop grouping may be provided at SN **1600**. Component **306** may continue the grouping until a slot later (to include SNs **1601-2000**), if SNs are contiguous with an aggregated descriptor.

Example **506** shows grouping SNs across TTIs (e.g., slots) for NR SA in a dual connectivity (DC) scenario (15 kHz SCS frequency division duplex (FDD) and 30 kHz SCS TDD) where one leg may be ahead. There is no blocking or grouping for SNs **0-900**. However, if the process component **312** detects that SNs **451-500** are missing, the processing component **312** may set a blocking SN to SN **901**. SNs greater than SN **901** on an NR leg may be grouped. If the missing SNs **401-500** arrive on an LTE leg, there may be no new blocking SN. An indication to stop grouping may be provided at SN **1700**. Component **306** may continue the grouping until a slot later (to include SNs **1701-2100**), if SNs are contiguous with an aggregated descriptor.

As indicated above, FIG. **5** provides some examples. Other examples may differ from what is described with regard to FIG. **5**.

FIG. **6** is a diagram illustrating an example process **600** performed, for example, by a wireless communication device, in accordance with the present disclosure. Example

process **600** is an example where the wireless communication device (e.g., a UE **120**, a CPE, base station **110**) performs operations associated with aggregating descriptors across multiple TTIs.

As shown in FIG. **6**, in some aspects, process **600** may include receiving PDUs in multiple TTIs (block **610**). For example, the wireless communication device (e.g., using communication manager **140** or **150** and/or reception component **702** depicted in FIG. **7**) may receive PDUs in multiple TTIs, as described above.

As further shown in FIG. **6**, in some aspects, process **600** may include generating, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI (block **620**). For example, the wireless communication device (e.g., using communication manager **140** or **150** and/or generation component **708** depicted in FIG. **7**) may generate, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI, as described above.

As further shown in FIG. **6**, in some aspects, process **600** may include aggregating the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs (block **630**). For example, the wireless communication device (e.g., using communication manager **140** or **150** and/or aggregation component **710** depicted in FIG. **7**) may aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs, as described above.

As further shown in FIG. **6**, in some aspects, process **600** may include processing the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor (block **640**). For example, the wireless communication device (e.g., using communication manager **140** or **150** and/or processing component **712** depicted in FIG. **7**) may process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor, as described above.

Process **600** 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.

In a first aspect, the aggregating is started if a blocking SN is identified and if PDUs received in a current TTI have SNs that are greater than (or equal to) the blocking SN.

In a second aspect, alone or in combination with the first aspect, the aggregating is stopped if an SN for a received PDU is less than (or equal to) a blocking SN or if the blocking SN is undefined.

In a third aspect, alone or in combination with one or more of the first and second aspects, a quantity of the multiple TTIs for the aggregating is specified in stored configuration information or by a received indication.

In a fourth aspect, alone or in combination with one or more of the first through third aspects, the aggregating is stopped if a storage level satisfies a storage threshold.

In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, process **600** includes identifying a blocking SN based at least in part on a determination that an SN for a PDU is missing or arrived late.

In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, the determination is based at least in part on a reordering parameter or on a lowest or first missing SN that is blocking in order delivery of PDCP service data units (SDUs) to an upper layer.

In a seventh aspect, alone or in combination with one or more of the first through sixth aspects, the aggregating is enabled if a temporal parameter of the PDUs for being moved between a modem and a host satisfies a temporal parameter threshold.

In an eighth aspect, alone or in combination with one or more of the first through seventh aspects, the aggregating is enabled if one or if a block error rate (BLER) satisfies a BLER threshold.

In a ninth aspect, alone or in combination with one or more of the first through eighth aspects, the aggregating is disabled if one or more of a throughput parameter satisfies a throughput threshold, a memory parameter satisfies a memory threshold, or a ping test is to be performed.

In a tenth aspect, alone or in combination with one or more of the first through ninth aspects, the aggregating includes aggregating descriptors for PDUs received via both an LTE network and an NR network.

In an eleventh aspect, alone or in combination with one or more of the first through tenth aspects, processing the PDUs includes one or more of checking integrity protection, deciphering, or reordering the PDUs.

In a twelfth aspect, alone or in combination with one or more of the first through eleventh aspects, the descriptors are generated in a first component of the wireless communication device, the descriptors are aggerated in a second component of the wireless communication device, and the aggregated descriptor is used for processing the PDUs in a third component of the wireless communication device.

In a thirteenth aspect, alone or in combination with one or more of the first through twelfth aspects, process **600** includes adjusting a blocking SN based at least in part on a size or status of a PDCP ROW.

In a fourteenth aspect, alone or in combination with one or more of the first through thirteenth aspects, the wireless communication device is a UE.

In a fifteenth aspect, alone or in combination with one or more of the first through fourteenth aspects, the wireless communication device is a CPE.

In a sixteenth aspect, alone or in combination with one or more of the first through fifteenth aspects, the wireless communication device is a base station.

Although FIG. **6** shows example blocks of process **600**, in some aspects, process **600** may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in FIG. **6**. Additionally, or alternatively, two or more of the blocks of process **600** may be performed in parallel.

FIG. **7** is a block diagram of an example apparatus **700** for wireless communication. The apparatus **700** may be a wireless communication device (e.g., a UE **120**, a CPE, base station **110**), or a wireless communication device may include the apparatus **700**. In some aspects, the apparatus **700** includes a reception component **702** and a transmission component **704**, which may be in communication with one another (for example, via one or more buses and/or one or more other components). As shown, the apparatus **700** may communicate with another apparatus **706** (such as a UE, a base station, or another wireless communication device) using the reception component **702** and the transmission component **704**. As further shown, the apparatus **700** may include the communication manager **140** or **150**. The communication manager **140** or **150** may include a generation component **708**, an aggregation component **710**, and/or a processing component **712**, among other examples.

In some aspects, the apparatus **700** may be configured to perform one or more operations described herein in connec-

tion with FIGS. **1-5**. Additionally, or alternatively, the apparatus **700** may be configured to perform one or more processes described herein, such as process **600** of FIG. **6**. In some aspects, the apparatus **700** and/or one or more components shown in FIG. **7** may include one or more components of the wireless communication device described in connection with FIG. **2**. Additionally, or alternatively, one or more components shown in FIG. **7** 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.

The reception component **702** may receive communications, such as reference signals, control information, data communications, or a combination thereof, from the apparatus **706**. The reception component **702** may provide received communications to one or more other components of the apparatus **700**. In some aspects, the reception component **702** 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 **706**. In some aspects, the reception component **702** may include one or more antennas, a demodulator, a MIMO detector, a receive processor, a controller/processor, a memory, or a combination thereof, of the wireless communication device described in connection with FIG. **2**.

The transmission component **704** may transmit communications, such as reference signals, control information, data communications, or a combination thereof, to the apparatus **706**. In some aspects, one or more other components of the apparatus **706** may generate communications and may provide the generated communications to the transmission component **704** for transmission to the apparatus **706**. In some aspects, the transmission component **704** 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 **706**. In some aspects, the transmission component **704** may include one or more antennas, a modulator, a transmit MIMO processor, a transmit processor, a controller/processor, a memory, or a combination thereof, of the wireless communication device described in connection with FIG. **2**. In some aspects, the transmission component **704** may be co-located with the reception component **702** in a transceiver.

The reception component **702** may receive PDUs in multiple TTIs. The generation component **708** may generate, for each TTI of the multiple TTIs, a descriptor that identifies SNs of PDUs that are received in the TTI. The aggregation component **710** may aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs. The processing component **712** may process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor. The aggregation component **710** may identify a blocking SN based at least in part on a determination that an SN for a PDU is missing or arrived late.

The number and arrangement of components shown in FIG. **7** 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. **7**. Furthermore, two or more components shown in FIG. **7** may be implemented within a single component, or a single component shown in FIG. **7** may be implemented as multiple, distributed components. Additionally, or alternatively, a set of (one or more) components shown in FIG. **7** may perform one or more functions described as being performed by another set of components shown in FIG. **7**.

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

Aspect 1: A method of wireless communication performed by a wireless communication device, comprising: receiving protocol data units (PDUs) in multiple TTIs; generating, for each TTI of the multiple TTIs, a descriptor that identifies serial numbers (SNs) of PDUs that are received in the TTI; aggregating the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs; and processing the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

Aspect 2: The method of Aspect 1, wherein the aggregating is started if a blocking SN is identified and if PDUs received in a current TTI have SNs that are greater than the blocking SN.

Aspect 3: The method of Aspect 1 or 2, wherein the aggregating is stopped if an SN for a received PDU is less than or equal to a blocking SN or if the blocking SN is undefined.

Aspect 4: The method of any of Aspects 1-3, wherein a quantity of the multiple TTIs for the aggregating is specified in stored configuration information or by a received indication.

Aspect 5: The method of any of Aspects 1-4, wherein the aggregating is stopped if a storage level satisfies a storage threshold.

Aspect 6: The method of any of Aspects 1-5, further comprising identifying a blocking SN based at least in part on a determination that an SN for a PDU is missing or arrived late.

Aspect 7: The method of Aspect 6, wherein the determination is based at least in part on a reordering parameter or on a lowest or first missing SN that is blocking in order delivery of PDCP service data units (SDUs) to an upper layer.

Aspect 8: The method of any of Aspects 1-7, wherein the aggregating is enabled if a temporal parameter of the PDUs for being moved between a modem and a host satisfies a temporal parameter threshold.

Aspect 9: The method of any of Aspects 1-8, wherein the aggregating is enabled if one or more of a processing parameter satisfies a processing threshold or if a block error rate (BLER) satisfies a BLER threshold.

Aspect 10: The method of any of Aspects 1-9, wherein the aggregating is disabled if one or more of a throughput parameter satisfies a throughput threshold, a memory parameter satisfies a memory threshold, or a ping test is to be performed.

Aspect 11: The method of any of Aspects 1-10, wherein the aggregating includes aggregating descriptors for PDUs received via both a Long Term Evolution network and a New Radio network.

Aspect 12: The method of any of Aspects 1-11, wherein processing the PDUs includes one or more of checking integrity protection, deciphering, or reordering the PDUs.

Aspect 13: The method of any of Aspects 1-12, wherein the descriptors are generated in a first component of the wireless communication device, the descriptors are aggerated in a second component of the wireless communication device, and the aggregated descriptor is used for processing the PDUs in a third component of the wireless communication device.

Aspect 14: The method of any of Aspects 1-12, further comprising adjusting a blocking SN based at least in part on a size or status of a packet data convergence protocol reordering window.

Aspect 15: The method of any of Aspects 1-14, wherein the wireless communication device is a user equipment.

Aspect 16: The method of any of Aspects 1-14, wherein the wireless communication device is a computer premises equipment.

Aspect 17: The method of any of Aspects 1-14, wherein the wireless communication device is a base station.

Aspect 18: 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 1-17.

Aspect 18: 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 1-17.

Aspect 19: An apparatus for wireless communication, comprising at least one means for performing the method of one or more of Aspects 1-17.

Aspect 20: 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 1-17.

Aspect 21: 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 1-17.

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.

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 were described herein without reference to specific software code—it being understood that software and hardware can be designed to implement the systems and/or methods based, at least in part, on the description herein.

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.

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. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, 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).

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 (e.g., related items, unrelated items, or a combination of related and unrelated 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. 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 wireless communication device for wireless communication, comprising:

a memory; and

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

receive protocol data units (PDUs) in multiple transmission time intervals (TTIs);

generate descriptors for the multiple TTIs comprising a descriptor for each TTI of the multiple TTIs, wherein the descriptor for a particular TTI of the multiple TTIs identifies serial numbers (SNs) of PDUs that are received in the particular TTI;

aggregate the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs; and

process the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

2. The wireless communication device of claim **1**, wherein the aggregating is started if a blocking SN is

identified and if PDUs received in a current TTI have SNs that are greater than the blocking SN.

3. The wireless communication device of claim 1, wherein the aggregating is stopped if an SN for a received PDU is less than or equal to blocking SN or if the blocking SN is undefined.

4. The wireless communication device of claim 1, wherein a quantity of the multiple TTIs for the aggregating is specified in stored configuration information or by a received indication.

5. The wireless communication device of claim 1, wherein the aggregating is stopped if a storage level satisfies a storage threshold.

6. The wireless communication device of claim 1, wherein the one or more processors are configured to identify a blocking SN based at least in part on a determination that an SN for a PDU is missing or arrived late.

7. The wireless communication device of claim 6, wherein the determination is based at least in part on a reordering parameter or on a lowest or first missing SN that is blocking in order delivery of packet data convergence protocol service data units to an upper layer.

8. The wireless communication device of claim 1, wherein the aggregating is enabled if a temporal parameter of the PDUs for being moved between a modem and a host satisfies a temporal parameter threshold.

9. The wireless communication device of claim 1, wherein the aggregating is enabled if one or more of a processing parameter satisfies a processing threshold or if a block error rate (BLER) satisfies a BLER threshold.

10. The wireless communication device of claim 1, wherein the aggregating is disabled if one or more of a throughput parameter satisfies a throughput threshold, a memory parameter satisfies a memory threshold, or a ping test is to be performed.

11. The wireless communication device of claim 1, wherein the one or more processors are configured to aggregate descriptors for PDUs received via both a Long Term Evolution network and a New Radio network.

12. The wireless communication device of claim 1, wherein the one or more processors, to process the PDUs, are configured to check integrity protection, decipher, or reorder the PDUs.

13. The wireless communication device of claim 1, wherein the descriptors for the multiple TTIs are generated in a first component of the wireless communication device, the descriptors for the multiple TTIs are aggregated in a second component of the wireless communication device, and the aggregated descriptor is used for processing the PDUs in a third component of the wireless communication device.

14. The wireless communication device of claim 1, further comprising adjusting a blocking SN based at least in part on a size or status of a packet data convergence protocol reordering window.

15. The wireless communication device of claim 1, wherein the wireless communication device is a user equipment.

16. The wireless communication device of claim 1, wherein the wireless communication device is a computer premises equipment.

17. The wireless communication device of claim 1, wherein the wireless communication device is a base station.

18. A method of wireless communication performed by a wireless communication device, comprising:

receiving protocol data units (PDUs) in multiple transmission time intervals (TTIs);

generating descriptors for the multiple TTIs comprising a descriptor for each TTI of the multiple TTIs, wherein the descriptor for a particular TTI of the multiple TTIs identifies serial numbers (SNs) of PDUs that are received in the particular TTI;

aggregating the descriptors for the multiple TTIs into an aggregated descriptor that identifies the SNs of the PDUs across the multiple TTIs; and

processing the PDUs received in the multiple TTIs based at least in part on the aggregated descriptor.

19. The method of claim 18, wherein the aggregating is started if a blocking SN is identified and if PDUs received in a current TTI have SNs that are equal to or greater than the blocking SN.

20. The method of claim 18, wherein the aggregating is stopped if an SN for a received PDU is less than or equal to a blocking SN or if the blocking SN is undefined.

21. The method of claim 18, wherein a quantity of the multiple TTIs for the aggregating is specified in stored configuration information or by a received indication.

22. The method of claim 18, wherein the aggregating is stopped if a storage level satisfies a storage threshold.

23. The method of claim 18, further comprising identifying a blocking SN based at least in part on a determination that an SN for a PDU is missing or arrived late.

24. The method of claim 23, wherein the determination is based at least in part on a reordering parameter or on a lowest or first missing SN that is blocking in order delivery of packet data convergence protocol service data units to an upper layer.

25. The method of claim 18, wherein the aggregating is enabled if a temporal parameter of the PDUs for being moved between a modem and a host satisfies a temporal parameter threshold.

26. The method of claim 18, wherein the aggregating is enabled if one or more of a processing parameter satisfies a processing threshold or if a block error rate (BLER) satisfies a BLER threshold.

27. The method of claim 18, wherein the aggregating is disabled if one or more of a throughput parameter satisfies a throughput threshold, a memory parameter satisfies a memory threshold, or a ping test is to be performed.

28. The method of claim 18, wherein the aggregating includes aggregating descriptors for PDUs received via both a Long Term Evolution network and a New Radio network.

29. The method of claim 18, wherein processing the PDUs includes one or more of checking integrity protection, deciphering, or reordering the PDUs.

30. The method of claim 18, wherein the descriptors for the multiple TTIs are generated in a first component of the wireless communication device, the descriptors for the multiple TTIs are aggregated in a second component of the wireless communication device, and the aggregated descriptor is used for processing the PDUs in a third component of the wireless communication device.

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