

PAGING ADAPTATION FOR NETWORK ENERGY SAVING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a user equipment (UE), a network entity, a processor for wireless communication, methods, and a computer readable medium for paging adaptation for network energy saving.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] In new radio (NR), paging allows the network to reach UEs in RRC_IDLE/RRC_INACTIVE state through paging messages, and to notify UEs of system information modification, earthquake and tsunami warning system (ETWS)/commercial mobile alert system (CMAS) indications through paging short messages. The UE may use discontinuous reception (DRX) in RRC_IDLE/RRC_INACTIVE state to reduce power consumption. The UE monitors only one paging occasion (PO) of one paging frame (PF) per DRX cycle (i.e., paging cycle). On the other hand, for energy saving at network, it has

been discussed to apply adaptation of POs including confine the POs in the time domain. Implementations of adaptation of POs need to be further studied and investigated.

SUMMARY

[0004] The present disclosure relates to a user equipment (UE), a network entity, a processor for wireless communication, methods, and a computer readable medium for paging adaptation for network energy saving (NES). Solutions are proposed to enable network energy saving for paging transmission.

[0005] In a first aspect, there is provided a UE. The UE comprises a processor; and a transceiver coupled to the processor, wherein the processor is configured to: report, via the transceiver, support of receiving paging from a first set of paging occasions (POs) configured for a plurality of UEs; and determine, a PO from the first set of POs for paging reception.

[0006] In a second aspect, there is provided a network entity, comprising: a processor; and a transceiver coupled to the processor, wherein the processor is configured to: determine a first set of paging occasions (POs) for a plurality of UEs; and deactivate a PO of the first set of POs based on determining that none of the plurality of UEs is to be paged for the PO.

[0007] In a third aspect, there is provided a processor for wireless communication. The processor comprise at least one memory; and a controller coupled with the at least one memory and configured to cause the controller to: report support of receiving paging from a first set of paging occasions (POs) configured for a plurality of UEs; and determine, a PO from the first set of POs for paging reception.

[0008] In a fourth aspect, there is provided method performed by a user equipment (UE), the method comprising: reporting support of receiving paging from a first set of paging occasions (POs) configured for a plurality of UEs; and determining, a PO from the first set of POs for paging reception.

[0009] In a fifth aspect, there is provided method performed by a network entity, the method comprising: determining a first set of paging occasions (POs) for a plurality of UEs;

and deactivating a PO of the first set of POs based on determining that none of the plurality of UEs is to be paged for the PO.

[0010] In a sixth aspect, there is provided a computer readable medium having instructions stored thereon, the instructions, when executed by a processor of an apparatus, causing the apparatus to perform the method according to the fourth or the fifth aspect of the disclosure.

[0011] In some implementations of the methods, the UE and the network entity described herein, the UE may report the support of receiving paging from the first set of POs to an access and mobility management function (AMF), wherein the AMF may indicate to a network entity that the plurality of UEs support receiving paging from the first set of POs.

[0012] In some implementations of the methods, the UE and the network entity described herein, each of the plurality of UEs supports paging adaptation for network energy saving (NES), and the first set of POs for the plurality of UEs are different from a second set of POs configured in system information.

[0013] In some implementations of the methods, the UE and the network entity described herein, the UE may receive a configuration from the network entity, wherein the first set of POs are determined based on the configuration.

[0014] In some implementations of the methods, the UE and the network entity described herein, the configuration may be a *PCCH-Config* information element and may indicate at least one parameter that is dedicated for the plurality of UEs.

[0015] In some implementations of the methods, the UE and the network entity described herein, the at least one parameter may comprise at least one of the following: a first parameter for deriving the number of paging frames (PFs) in a paging cycle; a second parameter for deriving the first monitoring occasion for paging of each PO of a PF; or a third parameter indicating a number of POs per PF.

[0016] In some implementations of the methods, the UE and the network entity described herein, the first parameter may be determined such that PFs for the first set of POs are allocated next to PFs for the second set of POs.

[0017] In some implementations of the methods, the UE and the network entity described herein, the second parameter, the third parameter or both may be determined such that the first set of POs occupy slots or frames that are time consecutive with the second set of POs.

[0018] In some implementations of the methods, the UE and the network entity described herein, the configuration may be a *PCCH-Config* information element dedicated for the plurality of UEs.

[0019] In some implementations of the methods, the UE and the network entity described herein, the configuration may indicate the first set of POs as a subset of the second set of POs.

[0020] In some implementations of the methods, the UE and the network entity described herein, the configuration may comprise a bitmap, wherein a bit of the bitmap may indicate whether one of the second set of POs belongs to the first set of POs.

[0021] In some implementations of the methods, the UE and the network entity described herein, the configuration indicates a number K , where the first or the last K POs of the second set of POs may belong to the first set of POs.

[0022] In some implementations of the methods, the UE and the network entity described herein, the UE may detect, before paging reception, a set of simplified synchronization signal/PBCH blocks (SSB) or a paging early indication (PEI) indicating if a paging message is to be transmitted to a UE subgroup that the UE belongs to; and may transmit, upon detection of the set of simplified SSBs or the PEI, a feedback signal to the network entity.

[0023] In some implementations of the methods, the UE and the network entity described herein, the set of simplified SSBs or the PEI may be broadcast in a tracking area including multiple cells.

[0024] In some implementations of the methods, the UE and the network entity described herein, each simplified SSB of the set of simplified SSBs may comprise only primary synchronization signal (PSS), or only PSS and secondary synchronization signal (SSS).

[0025] In some implementations of the methods, the UE and the network entity described herein, the UE subgroup may be configured based on support of receiving paging from the first set of POs.

[0026] In some implementations of the methods, the UE and the network entity described herein, the feedback signal may be transmitted using a same beam with the detected set of simplified SSBs or PEI.

[0027] In some implementations of the methods, the UE and the network entity described herein, the network entity may receive, from an access and mobility management function (AMF), an indication indicative of the plurality of UEs supporting receiving paging from the first set of POs.

[0028] In some implementations of the methods, the UE and the network entity described herein, the network entity may determine the first set of POs based on a configuration; and transmit the configuration to the plurality of UEs.

[0029] In some implementations of the methods, the UE and the network entity described herein, the network entity may transmit, before paging transmission at the first set of POs, a set of simplified synchronization signal/PBCH blocks (SSBs) or a paging early indication (PEI) indicating if a paging message is to be transmitted to a UE subgroup; receive, from a UE among the plurality of UEs, a feedback signal responsive to the simplified SSBs or the PEI; and based on reception of the feedback signal, perform paging transmission to the UE.

[0030] In some implementations of the methods, the UE and the network entity described herein, the paging transmission may be performed using a same beam with the detected feedback signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented.

[0032] FIG. 2 illustrates an example of a process flow of reducing network power consumption for paging transmission in accordance with some example embodiments of the present disclosure.

[0033] FIG. 3 illustrates examples of POs configured in a DRX cycle in accordance with some example embodiments of the present disclosure.

[0034] FIG. 4A illustrates one example of a UE feedback for dedicated reference signals (RS) for paging transmission in accordance with some example embodiments of the present disclosure.

[0035] FIG. 4B illustrates one example of a UE feedback for PEI for paging transmission in accordance with some example embodiments of the present disclosure.

[0036] FIG. 5 illustrates an example of a device that is suitable for implementing some embodiments of the present disclosure.

[0037] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure.

[0038] FIG. 7 illustrates a flowchart of a method that performed by a user equipment in accordance with aspects of the present disclosure.

[0039] FIG. 8 illustrates a flowchart of a method that performed by a network entity in accordance with aspects of the present disclosure.

[0040] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0041] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below. In the following description and claims, unless defined otherwise, all

technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0042] References in the present disclosure to “one embodiment,” “an example embodiment,” “an embodiment,” “some embodiments,” and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0043] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as “best,” “lowest,” “highest,” “minimum,” “maximum,” or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0044] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “has,” “having,” “includes” and/or “including,” when used herein, specify the presence of stated features, elements, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term “includes” and its variants are to be

read as open terms that mean “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0045] As mentioned, in 5G NR, paging allows the network to reach UEs in RRC_IDLE/RRC_INACTIVE state through paging messages, and to notify UEs of system information modification and ETWS/CMAS indications through paging short messages. The UE may use discontinuous reception (DRX) in RRC_IDLE/RRC_INACTIVE state to reduce power consumption. The UE monitors only one paging occasion (PO) of one paging frame (PF) per DRX cycle (i.e., paging cycle).

[0046] A PF is one radio frame and may contain one or multiple PO(s) or starting point of a PO. A PO is a set of physical downlink control channel (PDCCH) monitoring occasions and can consist of multiple time slots to send the paging downlink control information (DCI). The paging DCI is per-beam transmitted and the beams for paging transmission are same with those for synchronization/PBCH signal blocks (SSBs) transmission. The PF/PO for UE monitoring is determined by UE ID.

[0047] For RRC_IDLE/RRC_INACTIVE UEs, configurations for paging are broadcasted through information element *PCCH-Config* in system information block 1 (SIB1), which includes paging cycle, the number of PFs per paging cycle, the number of POs per PF, etc. Table 1 shows some of the relevant fields and the descriptions for each configuration filed.

Table1: Relevant fields in paging configuration PCCH-Config

Configuration fields	Descriptions
defaultPagingCycle	Default paging cycle. Candidate values {rf32, rf64, rf 128, rf256}
nAndPagingFrameOffset	Used to derive the number of paging frame in a paging cycle and paging frame offset. Candidate values paging frame derivation {1T,

	halfT, quarterT, oneEighthT, oneSixteenthT}. T is the paging cycle.
ns	Number of paging occasions per paging frame. Candidate values {4, 2, 1}
firstPdcch-MonitoringOccasionOfPO	The first PDCCH monitoring occasion for paging of each PO of the PF.

[0048] From the design, one can observe that POs are evenly distributed in each DRX cycle. While this is good approach to maximize the capacity of paging, it also causes high power consumption of gNB on paging transmission, since the gNB might need to wake up frequently to transmit paging messages.

[0049] For robust paging reception, the UE needs to wake up and perform automatic gain control (AGC) and time-frequency tracking before monitoring paging in the target PO. The AGC and time-frequency tracking are obtained by measuring SSBs that are transmitted before the PO. The number of SSBs measured by the UE is normally dependent on the channel status of the UE. The better the channel status, the smaller number of SSBs may need to be measured. Besides, to reduce the signalling exchange between UEs and gNB for IDLE/INACTIVE UEs, NR supports paging in a tracking area. A tracking area contains one or multiple cells and once a UE is paged, all the cells in the tracking area should broadcast paging message regardless of whether the UE is within its coverage. One can observe that such scheme may cause high gNB power consumption in paging transmission, since gNB might need to wake up to send paging even if the paged UEs are not under the cell coverage.

[0050] To reduce UE power consumption on paging monitoring, NR Rel. 17 introduced paging early indication (PEI). A PEI is associated with one or multiple PFs (and correspondingly one or multiple POs). It is per-beam transmitted before the associated POs and indicates if paging will be transmitted for each specific UE subgroup. From UE point of view, it will monitor paging if PEI indicates that paging message will be transmitted for the UE subgroup that the UE belongs. Otherwise, the UE will not monitor paging in the target PO.

[0051] The UE subgroup is determined either based on configuration from core network (CN), i.e., during UE registration to the network, or is implicitly determined based on UE ID. Besides, the subgroups are determined for the UEs monitoring a same PO. Especially for CN controlled UE subgrouping, the UE need to report to CN on the supporting of CN controlled subgrouping, then CN will indicate UE the assigned subgroup ID. CN also indicates the gNB the assigned subgroup IDs for the UEs. When the paging message for the UE is received from the CN or is generated by the gNB, the gNB determines the PO and the associated PEI for the UE. The gNB transmits the associated PEI and indicates the corresponding CN controlled subgroup of UE that is to be paged in the PEI.

[0052] NR Rel.19 is discussing the solutions for network energy saving (NES), among which one solution is to introduce adaptation of paging occasions including confining the paging occasions in the time domain. The present disclosure invention proposes solutions to reduce paging transmissions for NES purpose. It also solves or at least alleviate the two below issues, which lead to high gNB power consumption on paging transmission as mentioned.

[0053] The first issue is that distributed POs in a DRX cycle results in high gNB power consumption on paging transmission. The second issue is that unnecessary paging transmission from a cell of a track area in case the paged UEs within the coverage of another cell of the same tracking area.

[0054] In view of this, to reduce base station (e.g. gNB) power consumption for paging transmission, it is proposed that when registering the network, UE may indicate the network the supporting of paging adaptation for NES. From this information, the network can determine a set of dedicated POs for those UEs. If such UEs are not paged, the POs are deactivated. The base station may remain or go to sleep mode or inactive mode in the time slots with deactivated POs, and network energy saving can be achieved accordingly.

[0055] Aspects of the present disclosure are described in the context of a wireless communications system. FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also

referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0056] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface. In a 3GPP non-terrestrial network (NTN), a network entity 102 in form of a satellite can directly communicate to UE 104 using NR/LTE Uu interface. The satellite may be a transparent satellite or a regenerative satellite. For NTN with a transparent satellite, a base station on earth may communicate with a UE via the satellite. For NTN with a regenerative satellite, the base station may be on board and directly communicate with the UE.

[0057] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For

example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0058] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0059] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0060] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0061] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0062] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0063] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0064] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0065] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0066] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-c, F1-u), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0067] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a server 117 for performing a location management function (LMF), a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)), and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106. The LMF may be defined in the core network 106 and/or the network entity 102 to provide positioning functionality by means to determine the geographic position of a UE 104 based on downlink and uplink location measuring radio signals. The packet data network 108 may include an application server 118.

[0068] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using

the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0069] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0070] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0071] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each

subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0072] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0073] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 500 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control

information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0074] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0075] FIG. 2 illustrates an example of a process flow of reducing network power consumption for paging transmission in accordance with some example embodiments of the present disclosure. The process flow 200 may involve a UE 201, a network entity (e.g. a base station, such as gNB) 202, and an AMF 203. The process flow 200 may be applied to the wireless communications system 100 with reference to FIG. 1, for example, the UE 201 may be any of UEs 104, and the network entity 202 may be any of the network entities 102, and the AMF 203 may be the server 117 in the core network 106. It would be appreciated that the process flow 200 may be applied to other communication scenarios.

[0076] At 210, the UE 210 may report data 215 indicative of support of paging reception from a first set of paging occasions (POs). The first set of POs are configured for a plurality of UEs each of which supports such paging reception (hereafter, supporting UEs). In this disclosure, the first set of POs may also be referred as dedicated POs, because only UEs capable of supporting paging adaptation for network energy saving (NES) can receive paging messages in the those POs. The supporting UE may support paging adaptation for NES. In some embodiments, the first set of POs for the supporting UEs are different from a second set of POs configured in system information. In some embodiments, the report data 215 may just indicate the UE supporting of paging adaptation or indicate the UE supporting of NES.

[0077] In some embodiments, the UE 201 may transmit the reporting data 215 to the AMF 203 in a core network via non-access stratum (NAS) signalling. Accordingly, at 220, the AMF 203 may receive the reporting data 215. The UE 201 may report this data 215 to the AMF 203 when it receives from SIB that paging adaptation is supported by the cell and the serving network entity 202.

[0078] The AMF 203 may collect such reporting data 215 in the communication network from a plurality of UEs which supports paging reception from dedicated POs (namely, supporting UEs). Then the AMF 203 may indicate the network entity 202 which UE supports paging reception from dedicated POs. As shown in FIG. 2, at 230, the AMF 203 may transmit a message 235 indicating a list of UE IDs of the supporting UEs. Accordingly, at 240, the network entity 202 may receive the message 235 indicating the UE IDs of the supporting UEs.

[0079] At 250, the network entity 202 may determine arrival or generation of paging messages for the UE 201. At 260, the network entity 202 may deactivate a PO of the first set of POs based on determining that none of the supporting UEs is to be paged for the PO. At the UE side, at 270, the UE 201 may determine a PO from the first set of POs. The UE 201 may monitor the determined PO for paging messages. At 280, if there is a paging message for the UE 201, the network entity 202 may transmit the paging message 285 in the PO from the first set of POs to the UE 201. Accordingly, at 290, the UE 201 may receive the paging message 285 in that PO.

[0080] Regarding the determination of the first set of POs as dedicated POs, one solution is that the dedicated POs may be determined based on a configuration transmitted from the network entity to the UE 201. In this way, the dedicated POs may be aligned between the network entity 202 and the supporting UE 201. In some embodiments, the configuration may be a *PCCH-Config* information element, which is applicable to non-supporting UEs (i.e. such UEs cannot use the dedicated POs) but with dedicated parameter(s) for supporting UEs. Calculation of POs based on the dedicated parameter(s) results in dedicated POs (i.e. the first set of POs) different from those configured in system information for the non-supporting UEs (namely, the second set of POs).

[0081] For example, the configuration in form of *PCCH-Config* information element may include at least one of $\{nAndPagingFrameOffset, firstPdcch-MonitoringOccasionOfPO, ns\}$, which is dedicated for the supporting UEs for paging configuration. The parameter *nAndPagingFrameOffset* is used for deriving the number of paging frames (PFs) in a paging cycle. The parameter *firstPdcch-MonitoringOccasionOfPO* is used for deriving the first monitoring occasion for paging of each PO of a PF. The parameter *ns* indicates a number of POs per PF.

[0082] Furthermore, since the first set of POs are dedicated for the supporting UEs and are configured explicitly, they can be flexibly allocated in time domain. In some embodiments, the dedicated POs may be allocated in the slots or frames that are time consecutive with the second set of POs configured in system information. Putting dedicated POs consecutive to the POs configured in system information is beneficial on network energy saving since it achieves more compact PO allocation in time domain. This reduces the on-duration of the network entity 202 and thus achieve power saving. Such allocation can be achieved by careful configuring the dedicated POs.

[0083] In some embodiments, the PF offset via the parameter *nAndPagingFrameOffset* for the dedicated POs may be properly configured, such that PFs for the dedicated POs are allocated next to the PFs for the POs configured in system information. Additionally or alternatively, the PFs for the dedicated POs may be the same for PFs configured in system information, and the dedicated POs of supporting UEs are determined such that in a same PF, they are allocated next to the POs configured in system information. That is, the dedicated POs occupy slots or frames that are time consecutive with the second set of POs. This can be achieved by properly configuring one or more of the parameters *firstPdcch-MonitoringOccasionOfPO* and *ns* for the dedicated POs.

[0084] In some embodiments, the configuration may be a *PCCH-Config* information element dedicated for the supporting UEs. In other words, the number of PFs and/or POs for the supporting UEs can be separate configured via parameter(s).

[0085] FIG. 3 illustrates examples of POs configured in a DRX cycle in accordance with some example embodiments of the present disclosure. In FIG. 3, there are two POs configured in a DRX cycle. In Example 1 as legacy, the two POs are distributed in the time

domain, and PO#0 is used for the UE set {#A, #B} to receive paging and PO#1 is used for the UE set {#C, #D} to receiving paging. The UE set {#A, #C} consists of supporting UEs and the UE set {#B, #D} consists of supporting UEs. In Example 2 as proposed, there are still two POs, but the PO#0 is configured for non-supporting UEs and PO#1 is a dedicated PO for supporting UEs. If none of the supporting UEs #B and #D is not paged, PO#1 will be deactivated. Besides, PO#1 is allocated close to PO#0, such that the network entity 202 has more chance to keep in deep sleep mode if no paging signal is transmitted.

[0086] Still regarding the determination of dedicated POs, another solution is that the dedicated POs for the supporting UEs are determined such that they are a subset of the POs configured in system information. The configuration may comprise an indication indicative of a subset of the POs configured in system information. For example, a subset of PFs configured in system information or a subset of POs configured in system information per PF may be indicated for the supporting UEs for paging purpose.

[0087] The indication can be either via a broadcast signalling such as SIB or can be dynamically indicated through a DCI. In some embodiments, the indication may be in a form of bitmap, where one bit indicates if a PO configured in system information is dedicated and can be used for the supporting UEs. Alternatively, the indication may indicate a specific number K , where the first or the last K POs of a PF are dedicated and can be used for the supporting UEs. From this operation, one subset of POs configured in system information may be associated with more UEs (including both non-supporting UEs and supporting UEs) and another subset of POs are associated with less UEs (including only legacy UEs, i.e. dedicated POs). Compared with distributing the UEs evenly in the POs, this solution enables higher probability of deactivating the subset of POs with less UEs, which is beneficial for network energy saving.

[0088] In addition, for a scenario where a tracking area includes multiple cells, it is beneficial to let the network entity 202 (hereafter, e.g. gNB) know if the paged UEs are within its coverage. If no paging UEs are within its coverage, the network entity 202 will not transmit paging signals, and therefore it can keep longer sleep mode. To achieve this goal, the UE 204 may be configured to provide a feedback upon receiving or detecting signals/channels for receiving paging, e.g., reference signals for AGC/tracking or PEI.

Based on UE feedback, the network entity 202 could know whether the UE is within its coverage.

[0089] To reduce the UE power consumption on transmitting the feedback signal, such scheme is mostly utilized for the case when dedicated signals for the supporting UEs are received before paging. In below two embodiments for UE feedback are proposed to explain how the network and UE power are saved during paging transmission and reception.

[0090] FIG. 4A illustrates one example of a UE feedback for dedicated reference signals (RS) for paging transmission in accordance with some example embodiments of the present disclosure. As the first embodiment, in case long periodicity SSBs are transmitted by the network entity, the supporting UEs may be configured to monitor a set of short periodicity SSBs or simplified SSBs (e.g., include only primary synchronization signal (PSS), or only PSS and secondary synchronization signal (SSS)), or other kind of reference signals before PO to achieve AGC and time-frequency tracking. These kinds of reference signals are dedicated for the UEs which support dedicated POs. The UE and gNB behaviour are as follows.

[0091] From UE point of view, if no dedicated reference signals are received before paging, the UE assumes that no paging signals are transmitted in the following PO and does not feedback anything (This also means that UE will provide a feedback signal only when at least one UE supporting dedicated POs is paged). If a dedicated reference signal is received, the UE will transmit a feedback signal to the gNB for gNB to identify if there are UEs being paged in its coverage. From gNB point of view, if the feedback signal is not received after transmitting the dedicated reference signals, the gNB will not transmit paging in the following dedicated POs for the supporting UEs. Otherwise, paging signal will be transmitted.

[0092] Furthermore, there may be beam correspondence between the reference signal and the feedback signal, i.e., the feedback signal is transmitted using the same beam with the detected reference signal. From gNB point of view, upon a feedback signal is received from a specific beam, the gNB may transmit paging only in the corresponding beam. The gNB will not transmit paging (in the dedicated POs) for other beams. This further reduces the power consumption on paging transmission.

[0093] FIG. 4B illustrates one example of a UE feedback for PEI for paging transmission in accordance with some example embodiments of the present disclosure. As a second embodiment, in case PEI is transmitted for paging, the supporting UEs may be configured with dedicated UE subgroups. Such configuration can be indicated by the core network (e.g. an AMF) when the core network receives the UE reporting that dedicated POs or paging adaptation for NES is supported. The core network may configure the dedicated UE subgroups based on UEs supporting dedicated POs or paging adaptation for NES. The core network may also indicate this information to gNB. The UE and gNB behaviour are as follows.

[0094] From a UE (e.g. UE 204) point of view, if no PEI is received, or if PEI is received but PEI indicates that no paging will be transmitted in the PO for the subgroup of UEs that the UE belongs, the supporting UE will not transmit the feedback signal. The supporting UE will feedback a signal after receiving the PEI if the PEI indicates that a paging message will be transmitted for the UE subgroup (dedicated UE subgroup for the supporting UEs) that the UE belongs. From gNB point of view, if the feedback signal is not received from a UE subgroup for the supporting UEs, the gNB does not transmit paging in the following dedicated POs for the UE subgroup.

[0095] Similar with the first embodiment, there may be beam correspondence between the PEI and the feedback signal, i.e., the feedback signal is transmitted using the same beam with the detected PEI. From gNB point of view, upon a feedback signal is received from a specific beam, the gNB will transmit paging only in the corresponding beam. The gNB will not transmit paging (in the dedicated POs) for other beams. This further reduces the power consumption on paging transmission.

[0096] Regarding the feedback signal from UE, one option is to use a dedicated random access channel (RACH) preamble for the reporting. This RACH preamble may be configured in SIB. The UE may transmit the RACH preamble in a RACH occasion after a predefined/configured time offset with the detected the reference signal(s) or the PEI. Another option is to use a dedicated signal for the reporting, in which case the dedicated signal is transmitted in a time occasion after a predefined/configured time offset with the detected the reference signal(s) or the PEI.

[0097] According to some embodiments discussed with reference to FIGS. 2 to 4B, solutions for reducing paging transmissions for NES purpose are proposed. In some embodiments, dedicated POs are introduced to avoid high network power consumption on paging transmission over distributed POs in a DRX cycle. In some embodiments, unnecessary paging transmissions from a cell in a track area are avoided in case the paged UEs are within the coverage of another cell of the same tracking area.

[0098] FIG. 5 illustrates an example of a device that is suitable for implementing some embodiments of the present disclosure. The device 500 may be an example of a UE 104 or network entity 102 as described herein. The device 500 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0099] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0100] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with

the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[0101] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The device 500 may be an example of a UE 104. In this case, the processor 502 may be configured to operable to support means for reporting support of paging reception from a first set of paging occasions (POs) configured for a plurality of UEs; and means for determining, a PO from the first set of POs for paging reception.

[0102] The device 500 may be an example of a network entity 102, e.g. a network entity. In this case, the processor 502 may be configured to operable to support means for determining a first set of paging occasions (POs) for a plurality of UEs; and means for deactivating a PO of the first set of POs based on determining that none of the plurality of UEs is to be paged for the PO.

[0103] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[0104] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O

system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0105] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[0106] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0107] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over

the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[0108] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0109] FIG. 6 illustrates an example of a processor 600 is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0110] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM),

magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0111] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0112] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[0113] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[0114] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0115] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[0116] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may implemented at a UE 104. In this case, the processor 600 may be configured to operable to support means for reporting support of paging reception from a first set of paging occasions (POs) configured for a

plurality of UEs; and means for determining, a PO from the first set of POs for paging reception.

[0117] The processor 600 may implemented at a network entity 102, e.g. a base station. In this case, the processor 600 may be configured to operable to support means for determining a first set of paging occasions (POs) for a plurality of UEs; and means for deactivating a PO of the first set of POs based on determining that none of the plurality of UEs is to be paged for the PO.

[0118] FIG. 7 illustrates a flowchart of a method 700 performed by a UE in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by a UE 104 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0119] At 710, the method may include reporting support of paging reception from a first set of paging occasions (POs) configured for a plurality of UEs. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by a UE 104 as described with reference to FIG. 1.

[0120] At 720, the method may include performing determining, a PO from the first set of POs for paging reception. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by a UE 104 as described with reference to FIG. 1.

[0121] FIG. 8 illustrates a flowchart of a method 800 performed by a network entity in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by a network entity 102 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or

alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0122] At 810, the method may include determining a first set of paging occasions (POs) for a plurality of UEs. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by a network entity 102 as described with reference to FIG. 1.

[0123] At 820, the method may include deactivating a PO of the first set of POs based on determining that none of the plurality of UEs is to be paged for the PO. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by a network entity 102 as described with reference to FIG. 1.

[0124] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0125] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, 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 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, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0126] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations

are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0127] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[0128] As used herein, including in the claims, an article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[0129] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent

to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

1. A user equipment (UE) comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
report, via the transceiver, support of paging reception from a first set of paging occasions (POs) configured for a plurality of UEs; and
determine, a PO from the first set of POs for paging reception.
2. The UE of claim 1, wherein the processor is configured to report the support of paging reception from a first set of POs for a plurality of UEs by:
reporting the support of paging reception from the first set of POs to an access and mobility management function (AMF), wherein the AMF indicates to a network entity that the plurality of UEs support paging reception from the first set of POs.
3. The UE of claim 1, wherein each of the plurality of UEs supports paging adaptation for network energy saving (NES), and the first set of POs for the plurality of UEs are different from a second set of POs configured in system information.
4. The UE of claim 3, wherein the processor is further configured to:
receive a configuration from the network entity, wherein the first set of POs are determined based on the configuration.
5. The UE of claim 4, wherein the configuration is a *PCCH-Config* information element and indicates at least one parameter that is dedicated for the plurality of UEs.
6. The UE of claims 5, wherein the at least one parameter comprises at least one of the following:
a first parameter for deriving the number of paging frames (PFs) in a paging cycle;
a second parameter for deriving the first monitoring occasion for paging of each PO

of a PF; or

a third parameter indicating a number of POs per PF.

7. The UE of claim 6, wherein the first parameter is determined such that PFs for the first set of POs are allocated next to PFs for the second set of POs.

8. The UE of claim 6, wherein the second parameter, the third parameter or both are determined such that the first set of POs occupy slots or frames that are time consecutive with the second set of POs.

9. The UE of claim 4, wherein the configuration is a *PCCH-Config* information element dedicated for the plurality of UEs.

10. The UE of claim 3, wherein the configuration indicates the first set of POs as a subset of the second set of POs.

11. The UE of claim 10, wherein the configuration comprises a bitmap, wherein a bit of the bitmap indicates whether one of the second set of POs belongs to the first set of POs.

12. The UE of claim 10, wherein the configuration indicates a number K , where the first or the last K POs of the second set of POs belong to the first set of POs.

13. The UE of claim 1, wherein the processor is further configured to:
detect, before paging reception, a set of simplified synchronization signal/PBCH blocks (SSB) or a paging early indication (PEI) indicating if a paging message is to be transmitted to a UE subgroup that the UE belongs to; and

transmit a feedback signal to the network entity upon detection of the set of simplified SSBs or the PEI.

14. The UE of claim 13, wherein the set of simplified SSBs or the PEI is broadcast

in a tracking area including multiple cells.

15. The UE of claim 13, wherein each simplified SSB of the set of simplified SSBs comprises only primary synchronization signal (PSS), or only PSS and secondary synchronization signal (SSS).

16. The UE of claim 13, wherein the UE subgroup is configured based on support of paging reception from the first set of POs.

17. The UE of claim 13, wherein the feedback signal is transmitted using a same beam with the detected set of simplified SSBs or PEI.

18. A network entity comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
determine a first set of paging occasions (POs) for a plurality of UEs; and
deactivate a PO of the first set of POs based on determining that none of the plurality of UEs is to be paged for the PO.

19. A processor for wireless communication, comprising:
at least one memory; and
a controller coupled with the at least one memory and configured to cause the controller to:
report support of paging reception from a first set of paging occasions (POs) configured for a plurality of UEs; and
determine, a PO from the first set of POs for paging reception.

20. A method performed by a user equipment (UE), the method comprising:
reporting support of paging reception from a first set of paging occasions (POs) configured for a plurality of UEs; and

determining, a PO from the first set of POs for paging reception.