

ESTABLISHMENT OF CONNECTIONS TO A NETWORK

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to user equipment (UE), network architectures, and methods that support multiple packet data network (PDN) connections.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as 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, or the like). 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)).

SUMMARY

[0003] 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.

[0004] Some implementations of the method and apparatuses described herein may include a UE for wireless communication, comprising at least one memory and at least one processor coupled with the at least one memory. The at least one processor is configured to cause the UE to transmit, to a first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS. The at least one processor causes the UE to receive, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and indicates a first network entity capability for the ePCO IE. The at least one processor causes the UE to transmit, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS. The at least one processor causes the UE to receive, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0005] The at least one processor may be configured to cause the UE to receive, via the second PDN connection, URSP provisioning data.

[0006] The at least one processor may be configured to cause the UE to transmit, to the second network entity, a third request message to modify the second PDN connection, a UE STATE INDICATION message to trigger a UE policy association for the UE, or a combination thereof. Said UE policy association may be to be performed by a third network entity, and to this end the second network entity may transmit to the third network entity the UE STATE INDICATION message. The at least one processor may be configured to receive, from a fourth network entity with which the third network entity has established

the UE policy association, one or more policy sections in respect of the second PDN connection.

[0007] The first network entity may comprise a mobility management entity, MME, a first serving gateway, SGW-1, a first session management function and packet data network gateway control plane function, SMF+PGW-C-1, or a combination thereof.

[0008] The second network entity may comprise at least one of: the MME, the SGW-1, a second session management function and packet data network gateway control plane function, SMF+PGW-C-2, or a combination thereof; and the MME, a second serving gateway, SGW-2, or the SMF+PGW-C-2, or a combination thereof.

[0009] The third network entity may comprise a session management policy control function, SM-PCF. The fourth network entity may comprise a UE policy control function, UE-PCF.

[0010] The first PDN connection may comprise one of a default PDN connection, a dedicated PDN connection, or a combination thereof.

[0011] The first PDN connection may comprise a default PDN connection, the second PDN connection may comprise a dedicated PDN connection, the first PDN connection may comprise a dedicated PDN connection, the second PDN connection may comprise a default PDN connection or a dedicated PDN connection.

[0012] Where the first PDN connection is a default PDN connection, the second PDN connection may be a dedicated PDN connection. Where the first PDN connection is a dedicated PDN connection, the second PDN connection may be either a default PDN connection or a dedicated PDN connection.

[0013] The UE capability for the ePCO IE may be indicative that the ePCO IE is supported by the UE, and the first network entity capability for the ePCO IE may be indicative that the ePCO IE is supported by the first network entity.

[0014] The at least one processor may be configured to cause the UE to determine that the ePCO IE is supported end-to-end in response to the UE capability for the ePCO IE being indicative that the ePCO IE is supported by the IE and the first network entity

capability for the ePCO being indicative that the ePCO IE is supported by the first network entity.

[0015] The at least one processor may be configured to cause the UE to include in the second request message the UE capability for URSP provisioning based at least in part on the ePCO IE being supported end-to-end.

[0016] The first request message may comprise an initial attachment request message, and the first response message may thus comprise an attachment acceptance message.

[0017] The first request message may be a request from the UE to establish a default EPS bearer, the second request message may be a request from the UE to establish a dedicated EPS bearer, and the second response may be an acceptance of the dedicated EPS bearer.

[0018] The first request message may be a request from the UE to establish a dedicated EPS bearer, the second request message may be a request from the UE to establish one of a default EPS bearer and a dedicated EPS bearer, and the second response message may thus be an acceptance of said one of the default EPS bearer and the dedicated EPS bearer.

[0019] The second request message may exclude an indication of the UE capability for an ePCO IE.

[0020] In some implementations of the method and apparatuses described herein, a processor for wireless communication comprises at least one controller coupled with at least one memory and configured to cause the processor to output, to a first network entity, a first request message comprising to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS. The controller causes the processor to obtain, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE. The controller causes the processor to output, to a second network entity, a second request message to establish a second PDN

connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS. The controller causes the processor to obtain, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0021] In some implementations of the method and apparatuses described herein, a method performed by a UE comprises a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS. The method comprises receiving, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE. The method comprises transmitting, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS. The method comprises receiving, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0022] In some implementations of the present disclosure, system comprises a UE, a first network entity, and a second network entity. The UE is configured to transmit, to the first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS. The first network entity is configured to transmit, to the UE, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first

PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE. The UE is configured to transmit, to the second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS. The second network entity is configured to transmit, to the UE, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0023] The system may further comprise a third network entity and a fourth network entity. In this example, the UE is configured to transmit, to the second network entity, a third request message to modify the second PDN connection, wherein the third request message comprises a UE STATE INDICATION message to trigger a UE policy association for the UE by the third network entity. The second network entity is configured to transmit, to the third network entity, the UE STATE INDICATION message. The third network entity and the fourth network entity are configured to establish the UE policy association. The fourth network entity is configured to transmit, to the UE, one or more policy sections by modification of the second PDN connection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0025] Figure 2 illustrates a network architecture in accordance with aspects of the present disclosure.

[0026] Figures 3A and 3B illustrates a method for establishing PDN connections in accordance with aspects of the present disclosure.

[0027] Figure 4 illustrates a communication flow in accordance with aspects of the present disclosure.

[0028] Figure 5 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0029] Figure 6 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0030] Figure 7 illustrates a flowchart of a method performed by a UE in accordance with aspects of the present disclosure.

[0031] Figure 8 illustrates a system in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0032] In some comparative systems which do not implement aspects of the present disclosure, URSP provisioning for a UE can be established when the UE attaches to the network. However, if URSP provisioning is not supported at initial attachment, the UE's connection will proceed without URSP provisioning. Aspects of the present disclosure allow for URSP provisioning to be established on subsequent connections, even if it was not supported at initial attachment. This increases the likelihood that URSP provisioning can be established for a given UE, thereby improving network performance.

[0033] Aspects of the present disclosure are described in the context of a wireless communications system.

[0034] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities (NE) 102, one or more user equipments (UE) 104, and a core network (CN) 106. 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 NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) 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, for example, 6G.

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.

[0035] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0036] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 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, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). 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 may be associated with different NE 102.

[0037] The one or more UE 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 remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver 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.

[0038] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. 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.

[0039] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more NE 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).

[0040] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include 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 NE 102 associated with the CN 106.

[0041] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106

may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 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 CN 106 (e.g., one or more network functions of the CN 106).

[0042] In the wireless communications system 100, the NEs 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 NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 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 NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] 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 – 300 GHz). In some implementations, the NEs 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 NEs 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 NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0047] 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.

[0048] As explained in more detail below, aspects of the present disclosure provide for URSP provisioning to be established for a UE 104: even if a first NE 102, to which the UE 104 initially attaches, does not support URSP provisioning, aspects of the present disclosure allow for URSP provisioning to be established on a subsequent connection between the UE 104 and for example a different NE 102.

[0049] Figure 2, illustrates a network architecture 200 in accordance with aspects of the present disclosure, for example as described in 3GPP TR 23.700-85 “Study on enhancement of 5G User Equipment (UE) policy”. The network architecture 200 may include a UE 205 in communication with a mobility management entity (MME) 215 via an Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) 210. The MME 215 is in communication with a serving gateway (SGW) 220 which provides communication with a user plane function plus packet data network user plane function (UPF+PGW-U) 225 and a session management function plus packet data network gateway control plane function (SMF+PGW-C) 230. The SMF+PGW-C 230 is in communication with a session management policy control function (SM-PCF) 235 and a home subscriber server plus unified data management (HSS+UDM) 240 which is also in communication with the MME 215. The SM-PCF 235 is in communication with a UE-PCF 245.

[0050] The network architecture 200 further supports an access and mobility management function (AMF) 250 in communication with the MME 215. SMF+PGW-C 230, HSS+UDM 240 and UE-PCF 245. The AMF 250 is further in communication with a

Next-Generation Radio Access Network (NG-RAN) (which is in communication with the UPF+PFGW-U) and UE 260.

[0051] In general, the communication between the UE 205 and the network via the E-UTRAN 210 and MME 215 may be via an S1 connection mode, and the communication between the UE 260 and the network via the NG-RAN and AMF 250 may be via an N1 connection mode.

[0052] Policy management for access and mobility can include policy control for session management and service data flow. This may for example include quality-of-service (QoS) control, gating control, and so on. In one such example, the network can provide a UE Route Selection Policy (URSP) which is a set of rules including traffic descriptors and route selection descriptors for the UE to establish a PDU session in a system such as a 5G system (5GS).

[0053] In the illustrated architecture of Figure 2, a URSP can be delivered to the UE 205 via the SM-PCF 235, SMF+PGW-C 230, SGW 220, and MME 215. The connection to the UE in question is via the E-UTRAN 210.

[0054] In a comparative example which does not implement aspects of the present disclosure, in order for the network to provide the URSP to the UE 205, the UE 205 can perform a UE-initiated UE state indication procedure according to 3GPP TS 24.501; Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3". This procedure can be performed when the UE registers to the 5GS at the time of initial registration, or when there is an inter-system change from the S1 connection mode to the N1 mode (see Figure 2). As part of the UE-initiated UE state indication procedure, the UE 205 provides several information elements to the PCF so that the PCF can arrange one or more URSP rules for the UE 205. The information elements that the UE 205 provides in the UE STATE INDICATION message are defined in 3GPP TS 24.501 [2] V18.2.1 and are as follows:

- a) A UE Policy Section Identifier (UPSI) list information element which contains a number of UE policy section codes (UPSC) assigned by the Registered PLMN (RPLMN);
- b) A UE policy classmark information element comprising information about policy aspects of the UE; and
- c) A UE OS Ids information element that which OSs the UE supports.

[0055] The length of the UE STATE INDICATION message can therefore be up to two octets or 65K octets.

[0056] The 3rd Generation Partnership Project (3GPP), which is an umbrella term for a number of standards organizations which develop protocols for mobile telecommunications technologies, has recently introduced the above-mentioned UE-initiated UE state indication procedure for EPS. For that purpose the working item enhanced UE policy (eUEPO) allows the UE to receive UE policy sections when the UE registers to the EPS network. This can be performed within the network architecture depicted in Figure 2.

[0057] This method, which allows a UE 205 to trigger UE policy association establishment by the SM-PCF 235, relies on:

a) There is end-to-end support for the Extended Protocol Configuration Options information element (ePCO IE) (i.e. this IE is supported by each of the UE 205, MME 215, SGW 220, and PGW, noting that the SMF+PGW-C 230 supports the ePCO IE by default in a 5GS); and

b) the SMF+PGW-C 230 has an interface with SM-PCF 235 (as shown in Figure 2).

[0058] By way of explanation of point (a), if the ePCO IE is not supported end-to-end, neither the UE-initiated UE state indication procedure nor the network-requested UE policy management procedure can be performed by the UE 205 and the network even if the UE 205 and the network support the URSP provisioning. Thus, the UE policy association cannot be established and the URSP provisioning cannot be done.

[0059] The main reason for a lack of end-to-end support of the ePCO IE is if the RAN does not have a mechanism to choose an MME with ePCO IE support. Moreover, if the MME 215 supports the ePCO IE, it will most likely choose the SGW and PGW supporting the ePCO IE if the UE indicates support for ePCO IE by setting the ePCO bit in the UE network capability IE in an ATTACH REQUEST message.

[0060] Regarding point (b), as described in more detail below the SM-PCF 235 provides URSP provisioning data such that the provisioning cannot be performed without said interface.

[0061] At the time of initial attachment to the EPS network, the UE 205 can request establishment of a PDN connectivity by:

- including a PDN CONNECTIVITY REQUEST message in the ESM message container information element (IE) of an ATTACH REQUEST message; and
- inserting a container with the container identifier identifying “URSP provisioning is supported” in the Protocol Configuration Options information element (PCO IE) of the PDN CONNECTIVITY REQUEST message,

[0062] When establishing such PDN connectivity, it is desired for the UE 205 to verify whether the ePCO IE is supported end-to-end and whether the SMF+PGW-C 230 has an interface with the SM-PCF 235. As explained above, if both of these conditions are met, then the UE policy association establishment can be triggered by the UE 205.

[0063] When attachment is successful, the UE 205 receives an ATTACH ACCEPT message. This can include an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message included in the ESM message container IE of the ATTACH ACCEPT message. If the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message contains an ePCO IE containing a container with the container identifier identifying “URSP provisioning is supported”, both of the above-described are confirmed. The UE 205 then initiates the UE requested bearer resource modification procedure and uses the ePCO IE of the BEARER RESOURCE MODIFICATION REQUEST message for sending a container with container identifier identifying “UE policy container with the length of two octets”. This container contains the UE STATE INDICATION message to the SMF+PGW-C, which will later be forwarded to SM-PCF 235 to establish the UE policy associations with UE-PCF 245 over Nx interface, per the architecture depicted in Figure 2.

Table 10.5.154/3GPP in 3GPP TS 24.008 “Mobile radio interface Layer 3 specification; Core network protocols; Stage 3” defines the container with container ID 0056H as “UE policy container with the length of two octets”.

[0064] If the ePCO IE is supported end-to-end and the UE 205 can successfully send the UE STATE INDICATION message to the SM-PCF 235, the UE 205 triggers the establishment of the UE policy association and thereby arrangement of the UE policy section management list that should be transmitted by the SM-PCF 235 to the UE 205.

[0065] The container with the container identifier “UE policy container with the length of two octets” is used for transmission of:

- a) the UE STATE INDICATION message from the UE 205 to the SM-PCF 235; and
- b) the URSP rules from the SM-PCF 235 to the UE 205.

[0066] For the network to provision the UE 205 with the URSP rules, the network uses the dedicated EPS bearer context activation procedure or EPS bearer context modification procedure to transmit the URSP rules in the ePCO IE within the container with the container identifier “UE policy container with the length of two octets” towards the UE 205. Upon receipt of the container with the container identifier “UE policy container with the length of two octets” in the ePCO IE, it parses the UE policy sections and attempts to execute them.

[0067] The above-described method thereby allows for the UE 205 to trigger the UE policy association establishment by the SM-PCF 235. However, as explained above, this relies on two conditions being met: the ePCO IE being supported end-to-end, and the SMF+PGW-C 230 having an interface with the SM-PCF 235. In the above-described comparative example, these are tested by the UE 205 during the initial attachment process and, if either condition is not met, from the UE’s perspective the network cannot support URSP provisioning.

[0068] However, even if the initial attachment routes towards a SMF+PGW-C 230 which does not have an interface with the SM-PCF 235 and thus does not support URSP provisioning, the UE 205 may make subsequent connections with new PDNs. For example, following a first connection to a first PDN (which may, or may not, be a default connection), the UE 205 may make an additional dedicated connection to a second PDN. Such a new PDN connection may route toward a new SMF+PGW-C 230 which does have an interface with the SM-PCF 235 and thus could support URSP provisioning.

[0069] Aspects of the present disclosure make use of this observation to allow the UE 205 to determine the URSP support by the network at the time of any new default or dedicated PDN connection, once the UE 205 is aware that the ePCO IE is supported end-to-end. This significantly increases the likelihood that URSP provisioning can be established: even if it is not supported on the initial connection, the present disclosure allows subsequent establishment of URSP provisioning if it is supported by a subsequent connection.

[0070] These aspects of the present disclosure will now be described in more detail with reference to Figures 3A and 3B.

[0071] Figure 3A illustrates a method for establishing a PDN connection in accordance with aspects of the present disclosure. The method may for example be implemented within the network architecture of Figure 2.

[0072] In Figure 3A, a UE 305 attaches to a network via a MME 310 and first SGW 315 by establishing PDN connection 1 using a default access point name (APN). In this example it is assumed that the ePCO IE is supported end-to-end. However, it can be seen that the SMF+PGW-C, termed SMF+PGW-C-1 320, has no interface to any SM-PCF. Thus, whilst the first condition is met, the second condition is not and PDN connection 1 cannot be used for URSP provisioning.

[0073] However, since the ePCO IE is supported end-to-end, by definition the MME 310 supports the ePCO IE and thus the UE 305 may establish an additional PDN connection towards another SMF+PGW-C.

[0074] Figure 3B illustrates a method for establishing a PDN connection in accordance with aspects of the present disclosure. The method may for example be implemented within the network architecture of Figure 2.

[0075] In Figure 3B, in addition to PDN connection 1, the UE 305 has subsequently made two additional PDN connections, to a second SMF+PGW-C termed SMF+PGW-C-2 330. PDN connection 2 is established via SGW-1 315, and PDN connection 3 is established via a second SGW-2 325. It can be seen in Figure 3B that SMF+PGW-C-2 330 has an interface to the SM-PCF 335. SMF+PGW-C-2 330 therefore supports URSP provisioning. Since additionally in this example the ePCO IE is supported end-to-end, both of the above-discussed conditions are met and therefore the UE-initiated UE state indication procedure, and the network-requested UE policy management procedure which additionally forms part of the URSP provisioning, can be performed.

[0076] In the above-described comparative example, URSP provisioning could only be set up during initial attachment and thus could not be performed, despite a subsequent connection being established to SMF+PGW-C-2 330 which supports URSP provisioning. In examples of the present disclosure, in contrast, URSP provisioning can be performed via the second or third PDN connection. The present disclosure thus provides for URSP

provisioning to be performed in situations which would not be possible in the comparative example.

[0077] Figure 4 shows a flow diagram for establishment of URSP provisioning in the system of Figure 3B, according to an example of the present disclosure.

[0078] In this diagram, PDN connection 1 corresponds to PDN connection 1 in Figures 3A and 3B, and is established via MME 310 - SGW-1 315 - SMF+PGW-C-1 320. PDN connection 2/3 can correspond to either PDN connection 2 in Figure 3 (established via MME 310 - SGW-1 315 - SMF+PGW-C-2 330), or PDN connection 3 in Figure 3 (established via MME 310 - SGW-2 325 - SMF+PGW-C-2 330).

[0079] Figure 4 illustrates a process flow 400 in accordance with aspects of the present disclosure. The process flow 400 may implement aspects of the wireless communications system 100 as described with reference to Figure 1. The process flow 400 may include the UE 305, MME 310, SGW-1 315, SGW-2 325, SMF+PGW-C-1 320, SMF+PGW-C-2 330, the SM-PCF 335, and a UE-PCF 405, which may be examples of a UE, MME, SGW, and PCF as described herein for example with reference to Figures 2 and 3A-3B. In the following description of the process flow 400, the operations between the UE 305, the MME 310, the SGW-1 315, the SGW-2 325, the SMF+PGW-C-1 320, the SMF+PGW-C-2 330, the SM-PCF 335, and the UE-PCF 405 may be transmitted in a different order than the example order shown, or the operations may be performed in different orders or at different times. Some operations may also be omitted from the process flow 400, and other operations may be added to the process flow 400.

[0080] At 410, the UE 305 initiates an initial attach procedure with PDN connectivity as described in step 1 of Figure 5.3.2.1-1 of 3GPP TS 23.401 “General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access”. The initial attach procedure is to establish a default EPS bearer or a dedicated EPS bearer. The communication from the UE 305 includes (among other parameters and information elements):

a) an indication of support for ePCO IE by setting an ePCO bit in the UE network capability IE in the ATTACH REQUEST message; and

b) a container with the container identifier identifying “URSP provisioning is supported” in the Protocol configuration options information element (PCO IE) of the PDN CONNECTIVITY REQUEST message.

[0081] Upon acceptance of the default EPS bearer, the UE 305 receives the ATTACH ACCEPT message which includes (among other parameters and information elements):

a) an indication of support for the ePCO IE as the ePCO bit in the EPS network feature support IE is set to the value “1”; and

b) an EPS session management (ESM) message which includes an IE comprising the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message; the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message comprises an ePCO IE which does not have any container with the container identifier identifying “URSP provisioning is supported”. This means that the SMF+PGW-C-1 320 does not have any interface with SM-PCF 335 and thus that it does not support the URSP provisioning in EPS.

[0082] At 415, after the attach procedure, the UE 305 may request that the network establish a dedicated EPS bearer by initiating the UE requested bearer resource allocation procedure, as described in 3GPP TS 24.301 “Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3”. Alternatively, the UE 305 can initiate the EPS default bearer if the default bearer was not established during the attach procedure. During this procedure, the UE 305 inserts a container with the container identifier identifying “URSP provisioning is supported” in the ePCO IE. During this attach procedure, the UE 305 is aware of the end-to-end support for the ePCO IE, and thus might not include the indication of ePCO IE support as this has already been established and is thus superfluous.

[0083] Upon acceptance of the EPS bearer, the UE 305 receives an ePCO IE with a container with the container identifier identifying “URSP provisioning is supported”; meaning that the SMF+PGW-C-2 330 has an interface with SM-PCF 335, and thus that it supports the URSP provisioning in EPS.

[0084] At 420, responsive to determining that the SMF+PGW-C-2 330 supports the URSP provisioning in EPS, the UE 305 initiates the UE-initiated UE state indication procedure by performing the UE requested bearer resource modification procedure. The UE 305 uses the ePCO IE of the BEARER RESOURCE MODIFICATION REQUEST

message for sending, to the SMF+PGW-C-2 330, a container with container identifier identifying "UE policy container with the length of two octets". This includes the UE STATE INDICATION message which comprises, among other information elements:

- a) the UPSI list;
- b) UE policy classmark including the UE's support for ANDSP; and
- c) optionally the supporting OS Ids.

[0085] Thus, the UE 305 can request to modify the second (or third) PDN connection (i.e. for the network to transmit UE policies to the UE 305, as discussed below).

[0086] At 425, upon receipt of the ePCO IE comprising the UE STATE INDICATION message, the SMF+PGW-C-2 330 determines that the UE 305 is requesting URSP in the EPS and forwards the UE STATE INDICATION message toward the SM-PCF 335 by using an HTTP POST request, as described in 3GPP TS 29.512 "5G System; Session Management Policy Control Service; Stage 3".

[0087] At 430 the SM-PCF 335, based on the information provided by the SMF+PGW-C-2 330, determines that the UE 305 supports the UE policy section management list in the EPS. The SM-PCF 335 may check the UE's support for the UE policy section management list including receiving the URSP by the UE context policy control subscription information in the unified data repository (UDR) and may, based on that, decide to establish a UE policy association towards the PCF-UE 405.

[0088] The SM-PCF 335 selects the UE-PCF 405 with which to establish the UE policy association in the EPS. The new UE policy association is requested by the SM-PCF 335 by transmitting the UE STATE INDICATION message to the UE-PCF 405. The stage 3 implementation of this transmit is described in 3GPP TS 29.525 "5G System; UE Policy Control Service; Stage 3".

[0089] At 435 the UE policy association is established, and the UE-PCF 335 may determine to transmit the new policy section management including the URSP toward the UE 305 by performing the network requested UE policy management procedure as described in 3GPP TS 24.501 "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3". The UE policies may be transmitted to the UE 305 by way of the EPS bearer context modification procedure (i.e. modification of the bearer). The UE policies may be

transmitted to the UE 305 by way of the dedicated EPS bearer context activation procedures (i.e. establishment of a new bearer). Both of these procedures are described in 3GPP TS 24.301.

[0090] In summary, it is noted that even if the ePCO IE is supported end-to-end, URSP provisioning in EPS may or may not be supported depending on whether the SMF+PGW-C has interface toward the SM-PCF. However, even if an initial PDN connection is routed towards a SMF+PGW-C which does not have an interface with the SM-PCF, any new PDN connection may be routed toward a new SMF+PGW-C which does have an interface with SM-PCF. In aspects of the present disclosure, once the ePCO IE is supported end-to-end, a UE that supports URSP provisioning in EPS can determine whether the SMF+PGW-C supports URSP provisioning with each new PDN connection, including dedicated or default PDN connections. Conversely, in comparative examples which do not implement the present disclosure, the UE determines the network's support for URSP in EPS only during the attach procedure when establishing a default PDN connection, and does not perform any further determination in respect of subsequent PDN connections (noting also that the UE is not required to establish a default PDN connection during the attach procedure).

[0091] As described above, in aspects of the present disclosure, the UE can determine during the attach procedure that the ePCO IE is supported end-to-end. If so, and if the UE supports URSP provisioning in the EPS, the UE can attempt to determine whether the network (SMF+PGW-C) supports URSP provisioning in the EPS during any subsequent PDN connection. In this manner, URSP provisioning can be performed, even though the initial attachment to SMF+PGW-C-1 did not permit URSP provisioning.

[0092] Figure 5 illustrates an example of a UE 500 in accordance with aspects of the present disclosure. The UE 500 may include a processor 502, a memory 504, a controller 506, and a transceiver 508. The processor 502, the memory 504, the controller 506, or the transceiver 508, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0093] The processor 502, the memory 504, the controller 506, or the transceiver 508, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0094] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 502 may be configured to operate the memory 504. In some other implementations, the memory 504 may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in the memory 504 to cause the UE 500 to perform various functions of the present disclosure.

[0095] The memory 504 may include volatile or non-volatile memory. The memory 504 may store computer-readable, computer-executable code including instructions when executed by the processor 502 cause the UE 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 504 or another type of memory. 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.

[0096] In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to cause the UE 500 to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504). For example, the processor 502 may support wireless communication at the UE 500 in accordance with examples as disclosed herein. The UE 500 may be configured to support a means for performing a method comprising transmitting, to a first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route

selection policy, URSP, provisioning in an evolved packet system, EPS. The method comprises receiving, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE. The method comprises transmitting, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS. The method comprises receiving, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS

[0097] The controller 506 may manage input and output signals for the UE 500. The controller 506 may also manage peripherals not integrated into the UE 500. In some implementations, the controller 506 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 506 may be implemented as part of the processor 502.

[0098] In some implementations, the UE 500 may include at least one transceiver 508. In some other implementations, the UE 500 may have more than one transceiver 508. The transceiver 508 may represent a wireless transceiver. The transceiver 508 may include one or more receiver chains 510, one or more transmitter chains 512, or a combination thereof.

[0099] A receiver chain 510 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 510 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 510 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 510 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 receiver chain 510 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0100] A transmitter chain 512 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 512 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 transmitter chain 512 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 transmitter chain 512 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0101] Figure 6 illustrates an example of a processor 600 in accordance with aspects 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, which may be, for example, an L1/L2/L3 cache. 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).

[0102] 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).

[0103] 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.

[0104] 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.

[0105] 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 implementations, 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).

[0106] 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. 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.

[0107] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, 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.

[0108] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for outputting, to a first network entity, a first request message comprising to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS. The processor supports means for obtaining, from the first

network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE. The processor supports means for outputting, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS. The processor supports means for obtaining, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0109] Figure 7 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method, or aspects thereof, may be implemented by a UE as described herein, for example as described with reference to Figure 5. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions.

[0110] At 705, the method may include transmitting, to a first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS.

[0111] At 710, the method may include receiving, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE.

[0112] At 715, the method may include transmitting, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS.

[0113] At 720, the method may include receiving, from the second network entity, a second response message in response to the second request message, wherein the second

response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0114] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0115] Figure 8 depicts a system according to examples of the present disclosure. The system comprises a UE 805, for example as described above in relation to Figure 5. The system further comprises two network entities 810a, 810b, which may for example implement SMF+PGW-C functionality as described above.

[0116] The UE 805 is configured to transmit, to the first network entity 810a, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS.

[0117] The first network entity 810a is configured to transmit, to the UE 805, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE.

[0118] The UE 805 is configured to transmit, to the second network entity 810b, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS.

[0119] The second network entity 810b is configured to transmit, to the UE 805, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

[0120] 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

What is claimed is:

1. A UE for wireless communication, comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause the UE to:
transmit, to a first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS;
receive, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE;
transmit, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS; and
receive, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.
2. The UE of claim 1, wherein the at least one processor is configured to cause the UE to receive, via the second PDN connection, URSP provisioning data.
3. The UE of claim 1 or claim 2, wherein the at least one processor is configured to cause the UE to transmit, to the second network entity, a third request message to modify the second PDN connection, a UE STATE INDICATION message to trigger a UE policy association for the UE, or a combination thereof.

4. The UE of any preceding claim, wherein the first network entity comprises a mobility management entity, MME, a first serving gateway, SGW-1, a first session management function and packet data network gateway control plane function, SMF+PGW-C-1, or a combination thereof.
5. The UE of any preceding claim, wherein the second network entity comprises at least one of:
 - the MME, the SGW-1, a second session management function and packet data network gateway control plane function, SMF+PGW-C-2, or a combination thereof; and
 - the MME, a second serving gateway, SGW-2, or the SMF+PGW-C-2, or a combination thereof.
6. The UE of any preceding claim, wherein the first PDN connection comprises a default PDN connection or a dedicated PDN connection, or a combination thereof.
7. The UE of claim 6, wherein:
 - the first PDN connection comprises a default PDN connection;
 - the second PDN connection comprises a dedicated PDN connection;
 - the first PDN connection comprises a dedicated PDN connection;
 - the second PDN connection comprises a default PDN connection or a dedicated PDN connection; or
 - a combination thereof.
8. The UE of any preceding claim, wherein the UE capability for the ePCO IE is indicative that the ePCO IE is supported by the UE, and wherein the first network entity capability for the ePCO IE is indicative that the ePCO IE is supported by the first network entity.
9. The UE of claim 8, wherein the at least one processor is configured to cause the UE to determine that the ePCO IE is supported end-to-end, in response to the UE capability for

the ePCO IE being indicative that the ePCO IE is supported by the UE and the first network entity capability being indicative that the ePCO IE is supported by the first network entity.

10. The UE of claim 8 or claim 9, wherein the at least one processor is configured to cause the UE to include in the second request message the UE capability for URSP provisioning based at least in part on the ePCO IE being supported end-to-end.
11. The UE of any preceding claim, wherein the first request message comprises an initial attachment request message, and wherein the first response message comprises an attachment acceptance message.
12. The UE of claim 11, wherein:
 - the first request message is a request from the UE to establish a default EPS bearer;
 - the second request message is a request from the UE to establish a dedicated EPS bearer;
 - the second response message is an acceptance of the dedicated EPS bearer, or a combination thereof;
 - or a combination thereof.
13. The UE of any claim 11, wherein:
 - the first request message is a request from the UE to establish a dedicated EPS bearer;
 - the second request message is a request from the UE to establish a default EPS bearer or a dedicated EPS bearer;
 - the second response message is an acceptance of the default EPS bearer or the dedicated EPS bearer;
 - or a combination thereof.
14. The UE of any preceding claim, wherein the second request excludes an indication of the UE capability for an ePCO IE.

15. A processor for wireless communication, comprising:

at least one controller coupled with at least one memory and configured to cause the processor to:

output, to a first network entity, a first request message comprising to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS,

obtain, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE,

output, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS, and

obtain, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

16. A method performed by a user equipment (UE), the method comprising:

transmitting, to a first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS;

receiving, from the first network entity, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE;

transmitting, to a second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS; and

receiving, from the second network entity, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

17. A system comprising a UE, a first network entity, and a second network entity, wherein:

the UE is configured to transmit, to the first network entity, a first request message to establish a first packet data network, PDN, connection, wherein the first request message indicates a UE capability for an extended protocol configuration options information element, ePCO IE, and for user equipment route selection policy, URSP, provisioning in an evolved packet system, EPS,

the first network entity is configured to transmit, to the UE, a first response message in response to the first request message, wherein the first response message indicates an establishment of the first PDN connection, and wherein the first response message indicates a first network entity capability for the ePCO IE,

the UE is configured to transmit, to the second network entity, a second request message to establish a second PDN connection, wherein the second request message indicates the UE capability for the URSP provisioning in the EPS, and

the second network entity is configured to transmit, to the UE, a second response message in response to the second request message, wherein the second response message indicates an establishment of the second PDN connection, and wherein the second response message indicates a second network entity capability for the URSP provisioning in the EPS.

18. The system of claim 17, further comprising a third network entity and a fourth network entity, wherein:

the UE is configured to transmit, to the second network entity, a third request message to modify the second PDN connection, wherein the third request message

comprises a UE STATE INDICATION message to trigger a UE policy association for the UE by the third network entity,

the second network entity is configured to transmit, to the third network entity, the UE STATE INDICATION message;

the third network entity and the fourth network entity are configured to establish the UE policy association; and

the fourth network entity is configured to transmit, to the UE, one or more policy sections by modification of the second PDN connection.