

TRANSPORT LAYER ENHANCEMENT

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to apparatuses and methods supporting PDU set based handling in non-Third Generation Partnership Project (3GPP) access network.

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] Extended Reality (XR) including Augmented Reality (AR) and Virtual Reality (VR), as well as Cloud Gaming (CG), are important media applications for 5G. In media layer, the frame or video slice may only be decoded in case all or certain amount of the packets carrying the frame or video slice are successfully delivered.

[0004] For XR and media traffic, a concept of a Protocol Data Unit (PDU) Set is introduced. A PDU set may comprise one or more PDUs carrying a payload of one unit of information generated at an application level. For example, the unit of information may be a frame or video slice for XR services. All the PDUs of a PDU set are transmitted within the same Quality of Service (QoS) flow. There is a need to study how to extend PDU set QoS control mechanisms to non-3GPP access networks.

SUMMARY

[0005] The present disclosure relates to apparatuses, UE and methods supporting PDU set based handling in non-3GPP access network. The apparatuses, UE and methods enable differentiated handling of PDUs or PDU sets with different PDU Set Importance (PSI) values for one QoS flow associated with one Internet Protocol Security (IPsec) Child Security Association (SA) or among multiple IPsec Child SAs.

[0006] Some implementations of a first apparatus described herein may comprise 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 first apparatus to: obtain at least one mapping of at least one PDU set importance value for a Quality of Service (QoS) flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child Security Association (SA) to be established between the first apparatus and a UE; and provide the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value.

[0007] In some implementations, the first apparatus is further caused to: receive, from a second apparatus, PDU set QoS parameters for the QoS flow; and bind the QoS flow associated with the PDU set QoS parameters to the first IPsec Child SA.

[0008] In some implementations, the first apparatus is further caused to: receive a first indication from the second apparatus, the first indication indicating to bind the QoS flow to the first IPsec Child SA. The first apparatus is caused to bind the QoS flow associated with the PDU set QoS parameters to the first IPsec Child SA based on the first indication.

[0009] In some implementations, the first apparatus is further caused to: receive, from a second apparatus, PDU set QoS parameters for the QoS flow; split the QoS flow into multiple sub-QoS flows based on PDU set importance values for the QoS flow; and bind each of the multiple sub-QoS flows associated with the PDU set QoS parameters to one of multiple IPsec Child SAs to be established between the first apparatus and the UE, the multiple IPsec Child SAs comprising the first IPsec Child SA, and the PDU set importance values comprising the at least one PDU set importance value.

[0010] In some implementations, the first apparatus is further caused to: receive a second indication from the second apparatus, the second indication indicating to bind each of the multiple sub-QoS flows to one of multiple IPsec Child SAs. The first apparatus is

caused to bind each of the multiple sub-QoS flows associated with the PDU set QoS parameters to one of multiple IPsec Child SAs based on the second indication.

[0011] In some implementations, the first apparatus is caused to obtain the at least one mapping of the at least one PDU set importance value and the transport layer marking value by: determining the at least one mapping.

[0012] In some implementations, the first apparatus is caused to obtain the at least one mapping of the at least one PDU set importance value and the transport layer marking value by: receiving information about the at least one mapping from a second apparatus.

[0013] In some implementations, the first apparatus is further caused to provide the UE with the PDU set QoS parameters.

[0014] In some implementations, the first apparatus is further caused to: provide the UE with PDU set information in a Generic Routing Encapsulation (GRE) header for each of downlink packets within the QoS flow, the PDU set information being about at least one PDU set comprising the downlink packets.

[0015] In some implementations, the first apparatus is further caused to: receive, from the UE, feedback information about transmission of the at least one PDU set; and handle the downlink packets based on the feedback information about transmission of the at least one PDU set.

[0016] In some implementations, the feedback information comprises a sequence number of a first PDU set among the at least one PDU set, the first PDU set being successfully received by the UE.

[0017] In some implementations, the feedback information comprises: sequence numbers of PDUs within a first PDU set among the at least one PDU set, the PDUs being successfully received by the UE; and a sequence number of the first PDU set.

[0018] In some implementations, the first apparatus is further caused to: provide the UE with information about Forward Error Correction (FEC) ratio for the QoS flow.

[0019] In some implementations, the feedback information comprises a sequence number of a first PDU set among the at least one PDU set. In such implementations, at least a first percentage of PDUs within the first PDU set is successfully received by the UE, and the first percentage is associated with the FEC ratio.

[0020] Some implementations of a UE described herein may comprise a processor and a transceiver coupled to the processor. The processor is configured to: receive, via the transceiver from a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and determine the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping, the at least one PDU set importance value comprising the first PDU set importance value.

[0021] In some implementations, the processor is further configured to: transmit, via the transceiver to the first apparatus, the uplink PDU with the transport layer marking value through the first IPsec Child SA.

[0022] In some implementations, the processor is further configured to: receive, via the transceiver from the first apparatus, PDU set QoS parameters for the QoS flow.

[0023] In some implementations, the processor is further caused to: receive, via the transceiver from the first apparatus, PDU set information in a Generic Routing Encapsulation (GRE) header for each of downlink packets within the QoS flow, the PDU set information being about at least one PDU set comprising the downlink packets.

[0024] In some implementations, the processor is further caused to: transmit, via the transceiver to the first apparatus, feedback information about transmission of the at least one PDU set.

[0025] In some implementations, the feedback information comprises a sequence number of a first PDU set among the at least one PDU set, the first PDU set being successfully received by the UE.

[0026] In some implementations, the feedback information comprises: sequence numbers of PDUs within a first PDU set among the at least one PDU set, the PDUs being successfully received by the UE; and a sequence number of the first PDU set.

[0027] In some implementations, the processor is further caused to: receive, via the transceiver from the first apparatus, information about FEC ratio for the QoS flow.

[0028] In some implementations, the feedback information comprises a sequence

number of a first PDU set among the at least one PDU set. In such implementations, a first percentage of PDUs within the first PDU set is successfully received by the UE, and the first percentage is associated with the FEC ratio.

[0029] Some implementations of a second apparatus described herein may comprise 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 second apparatus to: receive an identity of a first apparatus, the identity of the first apparatus being related with a non-Third Generation Partnership Project (3GPP) access network; and provide the first apparatus with at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE.

[0030] In some implementations, the second apparatus is caused to receive the identity of the first apparatus by: receiving the identity of the first apparatus from a third apparatus; or receiving the identity of the first apparatus from the first apparatus via the third apparatus.

[0031] In some implementations, the second apparatus is further caused to provide the first apparatus with at least one of the following: an identity of a PDU session for the QoS flow, an identity of the QoS flow, or PDU set QoS parameters for the QoS flow.

[0032] Some implementations of a method described herein may comprise: obtaining, at a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and providing the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value.

[0033] Some implementations of a method described herein may comprise: receiving, at a UE from a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and determining the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping, the at least one PDU set importance value comprising the first PDU

set importance value.

[0034] Some implementations of a method described herein may comprise: receiving, at a second apparatus, an identity of a first apparatus, the identity of the first apparatus being related with a non-Third Generation Partnership Project (3GPP) access network; and providing the first apparatus with at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE.

[0035] It is to be understood that the summary section is not intended to identify key or essential features of implementations of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Figs. 1A, 1B and 1C illustrate an example of a wireless communications system that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure, respectively;

[0037] Figs. 2, 3, 4, 5, 6 and 7 illustrates a signaling diagram illustrating an example process 700 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure, respectively;

[0038] Fig. 8 illustrates an example of a device that supports PDU set based handling in non-3GPP access network in accordance with some aspects of the present disclosure;

[0039] Fig. 9 illustrates an example of a processor that supports PDU set based handling in non-3GPP access network in accordance with other aspects of the present disclosure; and

[0040] Figs. 10, 11 and 12 illustrate a flowchart of a method that supports PDU set based handling in non-3GPP access network in accordance with other aspects of the present disclosure, respectively.

DETAILED DESCRIPTION

[0041] Principles of the present disclosure will now be described with reference to

some implementations. It is to be understood that these implementations 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 may be implemented in various manners other than the ones described below.

[0042] 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.

[0043] References in the present disclosure to “one implementation,” “an example implementation,” “an implementation,” “some implementations,” and the like indicate that the implementation(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every implementation includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same implementation(s). Further, when a particular feature, structure, or characteristic is described in connection with an implementation, 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 implementations whether or not explicitly described.

[0044] 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 implementations. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms.

[0045] The terminology used herein is for the purpose of describing particular implementations only and is not intended to be limiting of example implementations. 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, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0046] Aspects of the present disclosure are described in the context of a wireless communications system.

[0047] Fig. 1A illustrates an example of a wireless communications system 100A that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The wireless communications system 100A may include one or more network entities 102 (also referred to as network equipment (NE)), one or more terminal devices or UEs 104, a core network 106, and a data network (DN) 108. The wireless communications system 100A may support various radio access technologies. In some implementations, the wireless communications system 100A 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 100A may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100A 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 100A may support radio access technologies beyond 5G. Additionally, the wireless communications system 100A may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0048] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100A. 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. Hereinafter, some implementations of the present disclosure will be described by taking an RAN node as an example of the network entity 102. Thus, the network entity 102 may be used interchangeably with the RAN node 102.

[0049] 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.

[0050] 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.

[0051] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100A. 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 100A. In some other implementations, a UE 104 may be mobile in the wireless communications system 100A.

[0052] 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 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 100A.

[0053] 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.

[0054] 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).

[0055] 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.

[0056] 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)).

[0057] 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.

[0058] 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).

[0059] 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.

[0060] 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 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.

[0061] The core network 106 may communicate with the data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The 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).

[0062] In the wireless communications system 100A, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100A (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.

[0063] One or more numerologies may be supported in the wireless communications system 100A, 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., 130 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.

[0064] 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.

[0065] 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 100A. 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, 130 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.

[0066] In the wireless communications system 100A, 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 100A 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 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.

[0067] 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., $=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $=2$), 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., $=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $=3$), which includes 130 kHz subcarrier spacing.

[0068] Fig. 1B illustrates an example of a wireless communications system 100B that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. Specifically, Fig. 1B illustrates a non-roaming architecture for

a core network with an untrusted non-3GPP access.

[0069] As shown in Fig. 1B, the wireless communications system 100B may comprise at least the UE 104, a Non-3GPP InterWorking Function (N3IWF) 120, a Session Management Function (SMF) 130, a User Plane Function (UPF) 140, an Access and Mobility management Function (AMF) 150, an untrusted non-3GPP access point 160, a 3GPP access point 170 and the data network 108.

[0070] In some implementations, the SMF 130, the UPF 140 and the AMF 150 may be comprised in the core network 106 as shown in Fig. 1A.

[0071] In some implementations, the UE 104 may communicate with the AMF 150 via the 3GPP access point 170. For example, the RAN node 102 may implement the 3GPP access point 170. The AMF 150 may communicate with the UE 104 and the 3GPP access point 170 via N1 interface and N2 interface, respectively.

[0072] In some implementations, the UE 104 and the untrusted non-3GPP access point 160 may be comprised in a non-3GPP network.

[0073] In some implementations, the UE 104 may connect with the N3IWF 120 via the untrusted non-3GPP access point 160. There is an NWu interface established between the UE 104 and the N3IWF 120. Similar to the RAN node 102 in 3GPP, the N3IWF 120 connects to the AMF 150 for control plane signaling transferring with the AMF 150 or the SMF 130 and connects to the UPF 140 for user plane data transmission. For example, the N3IWF 120 may communicate with the AMF 150 and the UPF 140 via N2 interface and N3 interface, respectively.

[0074] In some implementations, the SMF 130 may communicate with the UPF 140 and the AMF 150 via N4 interface and N11 interface, respectively.

[0075] In some implementations, the SMF 130 may provide N2 session management (SM) information to the N3IWF 120 via the AMF 150.

[0076] In some implementations, the UPF 140 may communicate with the data network 108 via N6 interface. In some implementations, the UPF 140 may comprise a PDU Session Anchor (PSA) UPF.

[0077] Fig. 1C illustrates an example of a wireless communications system 100C that supports PDU set based handling in non-3GPP access network in accordance with aspects

of the present disclosure. Specifically, Fig. 1C illustrates a non-roaming architecture for a core network with a trusted non-3GPP access.

[0078] The wireless communications system 100C is different from the wireless communications system 100B in that the wireless communications system 100C does not comprise the untrusted non-3GPP access point 160 and the N3IWF 120. Instead, the wireless communications system 100C comprises a trusted non-3GPP access network (TNAN) 180. The TNAN 180 comprises a trusted non-3GPP access point (TNAP) 182 and a trusted non-3GPP gateway function (TNGF) 184.

[0079] In some implementations, the UE 104 connects with the TNGF 184 via the TNAP 182. There is an NWt interface established between the UE 104 and the TNGF 184. Similar to the RAN node 102 in 3GPP, the TNGF 184 connects to the AMF 150 for control plane signaling transferring with the AMF 150 or the SMF 130 and connects to the UPF 140 for user plane data transmission. For example, the TNGF 184 may communicate with the AMF 150 and the UPF 140 via N2 interface and N3 interface, respectively.

[0080] In some implementations, the SMF 130 may provide N2 SM information to the TNGF 184 via the AMF 150.

[0081] As described above, there is a need to study how to extend PDU set QoS control mechanisms to non-3GPP access networks. For example, it needs to study how to support PDU set QoS (or PDU set based handling) in untrusted or trusted access (e.g. N3IWF or TNGF).

[0082] For untrusted or trusted non-3GPP access, N3IWF or TNGF may be equivalent to a RAN node. For example, an SMF may provide N2 SM information to an N3IWF or a TNGF via an AMF. Besides, there is an N3 interface between the N3IWF/TNGF and a UPF.

[0083] Internet Protocol Security (IPsec) Child Security Association (SA) is established for user plane between UE and N3IWF/TNGF, which is operated in a tunnel mode. One IPsec Child SA is associated with at least one QoS flow. The N3IWF or the TNGF may provide a Differentiated Service Codepoint (DSCP) value associated with one IPsec Child SA. If the DSCP value is provided, a UE and the N3IWF/TNGF shall mark all IP packets sent over this IPsec Child SA with this DSCP value. For example, the UE

and a TNAP may map the DSCP value to a QoS level (e.g., to an Enhanced Distributed Channel Access (EDCA) Access Class) supported by the underlying non-3GPP Access Network. Besides, the N3IWF or the TNGF will take DSCP value into consideration when sending DL PDUs towards non-3GPP Access point. Correspondingly, non-3GPP Access point (e.g., untrusted non-3GPP access point, TNAP) will take DSCP value into consideration when forwarding UL PDUs towards N3IWF or TNGF.

[0084] There is only IP layer and lower layer for user plane between the N3IWF/TNGF and the untrusted non-3GPP access network/TNAP. IP layer and lower layer are relatively stable and not easy to be enhanced to support PDU set QoS. Meanwhile, Generic Routing Encapsulation (GRE) layer is established for user plane between UE and N3IWF/TNGF, which contains QoS Flow Identifier (QFI) and optionally the Reflective QoS Indicator (RQI) associated with the PDU. It is better to enhance GRE layer to support PDU set QoS.

[0085] Thus, the following issue should be considered to support PDU set QoS in untrusted/trusted non-3GPP access. Each PDU set within one QoS flow may be associated with different PDU set Importance (PSI) values. Therefore, it needs to study how the N3IWF or TNGF enables differentiated handling of PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA or among multiple IPsec Child SAs.

[0086] In view of the above, implementations of the present disclosure provide a solution that supports PDU set based handling in non-3GPP access network. In one aspect of the solution, a first apparatus obtains at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value. The transport layer marking value is associated with a first IPsec Child SA to be established between the first apparatus and a UE. In turn, the first apparatus provides the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value. This solution enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA or multiple IPsec Child SAs.

[0087] Hereinafter, principle of the present disclosure will be described with reference to Figs. 2 to 12.

[0088] Fig. 2 illustrates a signaling diagram illustrating an example process 200 that supports PDU set based handling in non-3GPP access network in accordance with aspects

of the present disclosure. The process 200 may involve the UE 104 in Fig. 1A, 1B or 1C and a first apparatus. In some implementations, the first apparatus may perform the N3IWF 120 in Fig. 1B. Alternatively, the first apparatus may perform the TNGF 184 in Fig. 1C. For the purpose of discussion, the process 200 will be described with reference to Fig. 1B. Thus, the process 200 may involve the UE 104 and the N3IWF 120 in Fig. 1B. It shall be understood that the process 200 may be applied to the wireless communications system 100C in Fig. 1C. In that case, the process 200 may involve the UE 104 and the TNGF 184 in Fig. 1C.

[0089] As shown in Fig. 2, the N3IWF 120 obtains 210 at least one mapping of at least one PSI value for a QoS flow and a transport layer marking (TLM) value. The TLM is associated with a first IPsec Child SA to be established between the N3IWF 120 and the UE 104.

[0090] In some implementations, an IPsec Child SA may be operated in a tunnel mode. Internet Key Exchange (IKE) performs mutual authentication between two parties (here referred to as UE and N3IWF/TNGF) and establishes an IKE security association (SA) that includes shared secret information that can be used to efficiently establish SAs for Encapsulating Security Payload (ESP) or Authentication Header (AH) and a set of cryptographic algorithms to be used by the SAs to protect the traffic that they carry.

[0091] In turn, the N3IWF 120 provides 220 the UE 104 with the at least one mapping of the at least one PSI value and the TLM.

[0092] Upon receiving the at least one mapping of at least one PSI value for the QoS flow and the TLM, the UE 104 determines 230 the TLM for an uplink (UL) PDU based on a first PSI value for the UL PDU and the at least one mapping. The at least one PSI value comprises the first PSI value.

[0093] The process 200 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA or among multiple IPsec Child SAs.

[0094] In some implementations, the TLM value may comprise a Differentiated Services Code Point (DSCP) value or a flow label. For example, a DSCP value is used in Internet Protocol Version 4 (IPv4) to indicate a QoS priority of an IPv4 packet, which only uses 6bits out of 8bits. For Internet Protocol Version 6 (IPv6), a flow label is used

instead of (or in addition to) a DSCP value to indicate a QoS priority of an IPv6 packet, which has 20bits. Hereinafter, a flow label is also referred to as an IPv6 flow label.

[0095] In some implementations, in order to obtain the at least one mapping of the at least one PSI value for the QoS flow and the TLM value, the N3IWF 120 may determine the at least one mapping by itself. This will be described with reference to Fig. 3 and Fig. 5.

[0096] Fig. 3 illustrates a signaling diagram illustrating an example process 300 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The process 300 may be considered as an example implementation of the process 200.

[0097] The process 300 may involve the UE 104 in Fig. 1A, 1B or 1C, a non-3GPP access node in Fig. 1B or 1C and the UPF 140 in Fig. 1B or 1C. The process 300 may also involve a first apparatus, a second apparatus and a third apparatus.

[0098] In some implementations, the first apparatus may perform the N3IWF 120 in Fig. 1B and the non-3GPP access node may comprise the untrusted non-3GPP access point 160 in Fig. 1B. Alternatively, the first apparatus may perform the TNGF 184 in Fig. 1C and the non-3GPP access node may comprise the TNAP 182 in Fig. 1C.

[0099] In some implementations, the second apparatus may perform the SMF 130 in Fig. 1B or 1C. Alternatively, the second apparatus may perform other network function than the SMF 130 in Fig. 1B or 1C.

[0100] In some implementations, the third apparatus may perform the AMF 150 in Fig. 1B or 1C. Alternatively, the third apparatus may perform other network function than the AMF 150 in Fig. 1B or 1C.

[0101] For the purpose of discussion, the process 300 will be described with reference to Fig. 1B. Thus, the process 300 may involve the UE 104, the N3IWF 120, the SMF 130, the AMF 150 and the untrusted non-3GPP access point 160 in Fig. 1B. It shall be understood that the process 300 may be applied to the wireless communications system 100C in Fig. 1C. In that case, the process 300 may involve the UE 104, the TNGF 184, the SMF 130, the AMF 150 and the TNAP 182 in Fig. 1C.

[0102] Generally, in the process 300, the N3IWF 120 may determine the at least one

mapping of the at least one PSI value for the QoS flow and the TLM value by itself. In addition, the at least one mapping comprises multiple mapping of at least one PSI value for the QoS flow and a TLM value. For example, the N3IWF 120 may determine a mapping list of at least one PSI value for the QoS flow and a TLM value. The mapping list comprises the multiple mapping.

[0103] Specifically, as shown in Fig. 3, the SMF 130 provides 310 the N3IWF 120 with PDU set QoS parameters for a QoS flow. For example, the PDU set QoS parameters may comprise at least one of the following: PDU Set Delay Budget (PSDB), PDU Set Error Rate (PSER) and PDU Set Integrated Handling Information (PSIHI).

[0104] In some implementations, optionally, the SMF 130 may also provide the N3IWF 120 with candidate PSI values for the QoS flow. Alternatively, the candidate PSI values may be pre-configured in the N3IWF 120. For example, the candidate PSI values may be pre-configured with specific flow description or application identifier. Alternatively, the candidate PSI values are defined in specification.

[0105] In some implementations, optionally, the SMF 130 may also provide the N3IWF 120 with at least one of the following: PDU session identity (ID), QFI of the QoS flow, or information about a Forward Error Correction (FEC) ratio for the QoS flow.

[0106] In some implementations, the SMF 130 may provide the above parameters to the N3IWF 120 via the AMF 150 upon PDU session establishment procedure or PDU session modification procedure.

[0107] Upon receiving the PDU set QoS parameters for the QoS flow, the N3IWF 120 binds 320 the QoS flow associated with the PDU set QoS parameters to a first IPsec Child SA to be established between the N3IWF 120 and the UE 104. In other words, the N3IWF 120 associates (or map), the QoS flow associated with the PDU set QoS parameters with the first IPsec Child SA. In the present disclosure, an IPsec Child SA to be established between the N3IWF 120 and the UE 104 is also referred to a new IPsec Child SA.

[0108] In some implementations, when the SMF 130 provides QFI with the PDU set QoS parameters to the N3IWF 120, the N3IWF 120 binds the QoS flow identified by the QFI to the first IPsec Child SA. In some implementations, only the QoS flow identified by the QFI is bound to the first IPsec Child SA and no other QoS flow is bound to this

IPsec Child SA.

[0109] In addition, the N3IWF 120 determines 330 a mapping list of at least one PSI value for the QoS flow and a TLM value associated with the first IPsec Child SA.

[0110] In some implementations, the mapping list comprises multiple mapping of at least one PSI value for the QoS flow and a TLM value. In such implementations, multiple TLM values are associated with the first IPsec Child SA.

[0111] In some implementations, one PSI value may be mapped into one TLM value. For example, the mapping list may comprise: the mapping of PSI value#1 and DSCP/IPv6 flow label value#1, and the mapping of PSI value#2 and DSCP/IPv6 flow label value#2. DSCP/IPv6 flow label value#1 and DSCP/IPv6 flow label value#2 are associated with the first IPsec Child SA. Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA.

[0112] Alternatively, in some implementations, more than one PSI values may be mapped into one TLM value. In such implementations, multiple TLM values are associated with the first IPsec Child SA. For example, the mapping list may comprise: the mapping of PSI values#1, #2, #3, #4 and DSCP/IPv6 flow label value#1, and the mapping of PSI values#5, #6, #7, #8 and DSCP/IPv6 flow label value#2. DSCP/IPv6 flow label value#1 and DSCP/IPv6 flow label value#2 are associated with the first IPsec Child SA. Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA.

[0113] In turn, the N3IWF 120 provides 340 the mapping list of at least one PSI value for the QoS flow and a TLM value to the UE 104.

[0114] In some implementations, optionally, the N3IWF 120 may also provide the UE 104 with at least one of the following: PDU session ID, QFI of the QoS flow, or the information about the FEC ratio for the QoS flow.

[0115] In some implementations, optionally, the N3IWF 120 may also provide the UE 104 with additional QoS information associated with the first IPsec Child SA. The additional QoS information may comprise the PDU set QoS parameters for the QoS flow (e.g., PSDB, PSER, PSIH).

[0116] In some implementations, the N3IWF 120 may transmit, to the UE 104, a

request message for establishing a new IPsec Child SA (such as the first IPsec Child SA). For example, the request message may comprise an IKE_Create_Child_SA Request message, which includes SA, Notify (PDU session ID, QFI, mapping list of PSI and TLM value, additional QoS parameter with PDU set QoS parameters) and Notify (UP_IP_ADDRESS).

[0117] In some implementations, the N3IWF 120 may transmit the above parameters to the UE 104 via the untrusted non-3GPP access point 160.

[0118] Upon receiving the mapping list of at least one PSI value for the QoS flow and a TLM value, the UE 104 determines 350 the TLM value for a UL PDU of the QoS flow based on a first PSI value for the UL PDU and the mapping list. In some implementations, the UE 104 may mark the UL PDU with the TLM value based on a first PSI value for the UL PDU and the mapping list.

[0119] In some implementations, the UE 104 may obtain PDU set information of each UL PDU of the QoS flow. The PDU set information may comprise PDU Set Sequence Number (SN), Indication of End PDU of the PDU Set, PDU Sequence Number within a PDU Set, PDU Set Size in bytes and PDU Set importance. Then, the UE 104 may mark the UL PDU with a TLM value based on the PSI value associated with the UL PDU, and the mapping of at least one PSI value and the TLM value provided by the N3IWF 120.

[0120] For example, the mapping list may comprise: the mapping of PSI values#1, #2, #3, #4 and DSCP/IPv6 flow label value#1, and the mapping of PSI values#5, #6, #7, #8 and DSCP/IPv6 flow label value#2. A first PSI value for a UL PDU of the QoS flow is equal to PSI values#5. Thus, the UE 104 determines a DSCP/IPv6 flow label value for the UL PDU to be DSCP/IPv6 flow label value#2. Then, the UE 104 may mark the UL PDU with DSCP/IPv6 flow label value#2.

[0121] After that, the UE 104 may transmit the UL PDU marked with the TLM value through the first IPsec Child SA associated with the QoS flow towards the N3IWF 120.

[0122] In some implementations, the N3IWF 120 may obtain the at least one mapping of the at least one PSI value and the TLM by receiving information about the at least one mapping from a second apparatus. This will be described with reference to Fig. 4 and Fig. 6.

[0123] Fig. 4 illustrates a signaling diagram illustrating an example process 400 that

supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The process 400 may be considered as another example implementation of the process 200.

[0124] For the purpose of discussion, the process 400 will be described with reference to Fig. 1B. Thus, the process 400 may involve the UE 104, the N3IWF 120, the SMF 130, the AMF 150 and the untrusted non-3GPP access point 160 in Fig. 1B. It shall be understood that the process 400 may be applied to the wireless communications system 100C in Fig. 1C. In that case, the process 400 may involve the UE 104, the TNGF 184, the SMF 130, the AMF 150 and the TNAP 182 in Fig. 1C.

[0125] Generally, in the process 400, the N3IWF 120 may receive information about at least one mapping of at least one PSI value for the QoS flow and a TLM value from the SMF 130. In addition, the at least one mapping comprises multiple mapping of at least one PSI value for the QoS flow and a TLM value. For example, the N3IWF 120 may receive, from the SMF 130, a mapping list of at least one PSI value for the QoS flow and a TLM value. The mapping list comprises the multiple mapping.

[0126] Specifically, as shown in Fig. 4, the SMF 130 provides 410 the N3IWF 120 with information about at least one mapping of at least one PSI value for the QoS flow and a TLM value. For example, the SMF 130 may provide the N3IWF 120 with a mapping list of at least one PSI value for the QoS flow and a TLM value.

[0127] In some implementations, before providing the information about at least one mapping, the SMF 130 may receive an ID of the N3IWF 120 from the N3IWF 120 via the AMF 150, or from the AMF 150 directly. The ID of the N3IWF 120 indicates the type of access network, from which the SMF 130 knows that the node with the ID is related with a non-3GPP access network. For example, the ID of the N3IWF 120 may include but is not limited to a Global ID of the N3IWF 120. Based on the ID of the N3IWF 120 which is related with a non-3GPP access network, the SMF 130 may determine to provide the N3IWF 120 with the information about at least one mapping.

[0128] In some implementations, one PSI value may be mapped into one TLM value. For example, the mapping list may comprise: the mapping of PSI value#1 and DSCP/IPv6 flow label value#1, and the mapping of PSI value#2 and DSCP/IPv6 flow label value#2. DSCP/IPv6 flow label value#1 and DSCP/IPv6 flow label value#2 are associated with

the first IPsec Child SA. Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA.

[0129] Alternatively, in some implementations, more than one PSI values may be mapped into one TLM value. In such implementations, multiple TLM values are associated with the first IPsec Child SA. For example, the mapping list may comprise: the mapping of PSI values#1, #2, #3, #4 and DSCP/IPv6 flow label value#1, and the mapping of PSI values#5, #6, #7, #8 and DSCP/IPv6 flow label value#2. DSCP/IPv6 flow label value#1 and DSCP/IPv6 flow label value#2 are associated with the first IPsec Child SA. Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow within one IPsec Child SA.

[0130] Similar to the process 300, in the process 400, the SMF 130 may provide the N3IWF 120 with PDU set QoS parameters for a QoS flow.

[0131] Similar to the process 300, in the process 400, optionally, the SMF 130 may also provide the N3IWF 120 with at least one of the following: PDU session ID, QFI of the QoS flow, or information about a FEC ratio for the QoS flow.

[0132] In some implementations, the SMF 130 may provide the above parameters to the N3IWF 120 via the AMF 150 upon PDU session establishment procedure or PDU session modification procedure.

[0133] Similar to the process 300, in the process 400, upon receiving the PDU set QoS parameters for the QoS flow, the N3IWF 120 binds 320 the QoS flow associated with the PDU set QoS parameters to a first IPsec Child SA to be established between the N3IWF 120 and the UE 104.

[0134] Different from the process 300, in the process 400, the SMF 130 may also provide the N3IWF 120 with a first indication. The first indication may indicate the N3IWF 120 to bind the QoS flow to the first IPsec Child SA. Alternatively, the first indication may indicate the N3IWF 120 not to split the QoS flow into multiple sub-QoS flows or not to bind each of the multiple sub-QoS flows to an IPsec Child SA.

[0135] In turn, the N3IWF 120 may bind the QoS flow associated with the PDU set QoS parameters to the first IPsec Child SA based on the first indication.

[0136] Actions 340 and 350 in the process 400 are the same as those in the process

300. Details of these actions are omitted for brevity.

[0137] Fig. 5 illustrates a signaling diagram illustrating an example process 500 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The process 500 may be considered as a further example implementation of the process 200.

[0138] For the purpose of discussion, the process 500 will be described with reference to Fig. 1B. Thus, the process 500 may involve the UE 104, the N3IWF 120, the SMF 130, the AMF 150 and the untrusted non-3GPP access point 160 in Fig. 1B. It shall be understood that the process 500 may be applied to the wireless communications system 100C in Fig. 1C. In that case, the process 500 may involve the UE 104, the TNGF 184, the SMF 130, the AMF 150 and the TNAP 182 in Fig. 1C.

[0139] Generally, similar to the process 300, in the process 500, the N3IWF 120 may determine the at least one mapping of the at least one PSI value for the QoS flow and the TLM value by itself. In addition, the at least one mapping comprises multiple mapping of at least one PSI value for the QoS flow and a TLM value. Different from the process 300, in the process 500, the N3IWF 120 may split the QoS flow into multiple sub-QoS flows and bind each of the multiple sub-QoS flows to one of multiple IPsec Child SAs.

[0140] Action 310 in the process 500 is the same as that in the process 300. Details of this action are omitted for brevity.

[0141] The process 500 is different from the process 300 in actions 520, 525, 530, 540, 545 and 550.

[0142] Specifically, as shown in Fig. 5, the N3IWF 120 splits 520 a QoS flow into multiple sub-QoS flows based on PSI values for the QoS flow.

[0143] The N3IWF 120 binds 525, based on PSI values for the QoS flow, each of the multiple sub-QoS flows to one of multiple IPsec Child SAs to be established between the N3IWF 120 and the UE 104. The multiple IPsec Child SAs comprises the first IPsec Child SA.

[0144] In some implementations, the N3IWF 120 may bind the PDU sets with at least one specific PSI value of one QoS flow to a new IPsec Child SA. For example, when the SMF 130 provides QFI with PDU set QoS parameters (e.g., PSDB, PSER, PSIHI) to the

N3IWF 120, the N3IWF 120 splits the QoS flow into more than one sub-QoS flows, and bind each of them to a new IPsec Child SA. The split of the QoS flow into more than one sub-QoS flows is based on PSI values for the QoS flow. No other QoS flow is bound to these IPsec Child SAs.

[0145] In addition, the N3IWF 120 determines 530 multiple mapping of at least one PSI value and a TLM value associated with an IPsec Child SA.

[0146] In some implementations, one PSI value may be mapped into one TLM value associated with one IPsec Child SA. For example, the QoS flow with QFI#1 may comprise a first type of PDU sets with PSI value#1 and a second type of PDU sets with PSI value#2. The N3IWF 120 may split the QoS flow into two sub-QoS flows (such as sub-QoS flow#1 and sub-QoS flow#2) based on PSI value#1 and PSI value#2. The N3IWF 120 may bind sub-QoS flow#1 to a new IPsec Child SA#1 (with associated PSI value#1) and sub-QoS flow#2 to a new IPsec Child SA#2 (with associated PSI value#2). Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow among multiple IPsec Child SAs.

[0147] Alternatively, in some implementations, more than one PSI values may be mapped into one TLM value associated with one IPsec Child SA. For example, the QoS flow with QFI#1 may comprise a first type of PDU sets with PSI values#1, #2, #3, #4 and a second type of PDU sets with PSI values#5, #6, #7, #8. The N3IWF 120 may split the QoS flow into two sub-QoS flows (such as sub-QoS flow#1 and sub-QoS flow#2) based on PSI value#1 to PSI value#8. The N3IWF 120 may bind sub-QoS flow#1 to a new IPsec Child SA#1 (with associated PSI values#1, #2, #3, #4) and sub-QoS flow#2 to a new IPsec Child SA#2 (with associated PSI values#5, #6, #7, #8). Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow among multiple IPsec Child SAs.

[0148] In turn, the N3IWF 120 provides 540, to the UE 104, a mapping of at least one PSI value for the QoS flow and a TLM value associated with a new IPsec Child SA.

[0149] In some implementations, the N3IWF 120 may transmit, to the UE 104, a request message for establishing a new IPsec Child SA. The request message may comprise an IKE_Create_Child_SA Request message. For example, the N3IWF 120 transmits, to the UE 104, a request message for establishing a new IPsec Child SA#1

(with associated PSI value#1). The request message may comprise a mapping of PSI value#1 and a TLM value associated with the new IPsec Child SA#1. Alternatively, the request message may comprise a mapping of PSI values#1, #2, #3, #4 and a TLM value associated with the new IPsec Child SA#1.

[0150] In some implementations, the N3IWF 120 may transmit the above parameters to the UE 104 via the untrusted non-3GPP access point 160.

[0151] Similar to the process 300, in the process 500, optionally, the N3IWF 120 may also provide the UE 104 with at least one of the following: PDU session ID, QFI of the QoS flow, or the information about the FEC ratio for the QoS flow.

[0152] In some implementations, optionally, the N3IWF 120 may also provide the UE 104 with additional QoS information associated with the new IPsec Child SA. The additional QoS information may comprise the PDU set QoS parameters for the QoS flow (e.g., PSDB, PSER, PSIH).

[0153] In some implementations, the request message for establishing the new IPsec Child SA may comprise an IKE_Create_Child_SA Request message. The IKE_Create_Child_SA Request message may comprise SA, Notify (PDU session ID, QFI, at least one PSI value, TLM value associated with the at least one PSI value, Additional QoS parameter with PDU set QoS parameters) and Notify(UP_IP_ADDRESS).

[0154] In some implementations, if the N3IWF 120 decides to establish multiple IPsec Child SAs for the QoS flow, additional one or more IPsec Child SAs shall be established. Each of the multiple IPsec Child SAs is associated with one or more PSI values. For example, if the N3IWF 120 splits one QoS flow into two IPsec Child SAs based on PSI values, the N3IWF 120 transmits two request messages (such as Message#1 and Message#2) to the UE 104. Message#1 includes PDU session ID#1, QFI#1, PSI value#1 and TLM value#1 associated with IPsec Child SA#1. Message#2 includes PDU session ID#1, QFI#1, PSI value#2 and TLM value#2 associated with IPsec Child SA#2. Alternatively, Message#1 includes PDU session ID#1, QFI#1, PSI values#1, #2, #3, #4 and TLM value#1 associated with IPsec Child SA#1. Message#2 includes PDU session ID#1, QFI#1, PSI values #5, #6, #7, #8 and TLM value#2 associated with IPsec Child SA#2.

[0155] In turn, based on a first PSI value of a UL PDU as well as a mapping of at

least one PSI value and a TLM value associated with a new IPsec Child SA, the UE 104 maps 545, the UL PDU into the new IPsec Child SA.

[0156] For example, a QoS flow comprises UL PDUs with PSI value#1 and PSI values#2. PSI value#1 is mapped to TLM value#1 associated with IPsec Child SA#1. And PSI value #2 is mapped to TLM value#2 associated with IPsec Child SA#2. The UE 104 may map the UL PDU with PSI value#1 and PSI value#2 into the IPsec Child SA#1 and IPsec Child SA#2 respectively.

[0157] For another example, a QoS flow comprises UL PDUs with PSI values#1, #2, #3, #4 and PSI value#5, #6, #7, #8. PSI values#1, #2, #3, #4 are mapped to TLM value#1 associated with IPsec Child SA#1. And PSI value#5, #6, #7, #8 are mapped to TLM value#2 associated with IPsec Child SA#2. The UE 104 may map a UL PDU with one of PSI values#1, #2, #3, #4 and PSI values#5, #6, #7, #8 into the IPsec Child SA#1 and IPsec Child SA#2 respectively.

[0158] In addition, the UE 104 determines 550 the TLM value for the UL PDU based on the first PSI value for the UL PDU and the mapping of at least one PSI value and a TLM value. The at least one PSI value comprises the first PSI value.

[0159] In some implementations, the UE 104 may mark the UL PDU with the TLM value based on the first PSI value for the UL PDU and the mapping of the at least one PSI value and the TLM value.

[0160] In some implementations, the UE 104 may obtain PDU set information of each UL PDU of the QoS flow. Then, the UE 104 may mark the UL PDU with a TLM value based on the PSI value associated with the UL PDU, and the mapping of at least one PSI value and the TLM value provided by the N3IWF 120.

[0161] After that, the UE 104 may transmit the UL PDU marked with the TLM value through the IPsec Child SA associated with the TLM value towards the N3IWF 120.

[0162] Fig. 6 illustrates a signaling diagram illustrating an example process 600 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The process 600 may be considered as another example implementation of the process 200.

[0163] For the purpose of discussion, the process 600 will be described with reference

to Fig. 1B. Thus, the process 600 may involve the UE 104, the N3IWF 120, the SMF 130, the AMF 150 and the untrusted non-3GPP access point 160 in Fig. 1B. It shall be understood that the process 600 may be applied to the wireless communications system 100C in Fig. 1C. In that case, the process 600 may involve the UE 104, the TNGF 184, the SMF 130, the AMF 150 and the TNAP 182 in Fig. 1C.

[0164] Generally, similar to the process 400, in the process 600, the N3IWF 120 may receive, from the SMF 130, a mapping list of at least one PSI value for the QoS flow and a TLM value. The mapping list comprises the multiple mapping. Similar to the process 500, in the process 600, the N3IWF 120 may split the QoS flow into multiple sub-QoS flows and bind each of the multiple sub-QoS flows to one of multiple IPsec Child SAs.

[0165] Action 410 in the process 600 is the same as that in the process 400, actions 540, 545 and 550 are the same as that in the process 500. Details of these actions are omitted for brevity.

[0166] The process 600 is different from the processes 300, 400 and 500 in actions 620 and 625.

[0167] Specifically, as shown in Fig. 6, the N3IWF 120 splits 620 a QoS flow into multiple sub-QoS flows based on PSI values for the QoS flow.

[0168] The N3IWF 120 binds 625, based on PSI values for the QoS flow, each of the multiple sub-QoS flows to one of multiple IPsec Child SAs to be established between the N3IWF 120 and the UE 104.

[0169] In some implementations, one PSI value may be mapped into one TLM value associated with one IPsec Child SA. For example, the QoS flow with QFI#1 may comprise a first type of PDU sets with PSI value#1 and a second type of PDU sets with PSI value#2. The mapping list provided by the SMF 130 may comprise: the mapping of PSI value#1 and DSCP value#1, and the mapping of PSI value#2 and DSCP value#2.

[0170] The N3IWF 120 may split the QoS flow into two sub-QoS flows (such as sub-QoS flow#1 and sub-QoS flow#2) based on the mapping list provided by the SMF 130. In other words, the N3IWF 120 may split the QoS flow into two sub-QoS flows (such as sub-QoS flow#1 and sub-QoS flow#2) based on PSI value#1 and PSI value#2 in the mapping list. Each of the two sub-QoS flows is associated with one of DSCP value#1 and DSCP value#2.

[0171] The N3IWF 120 may bind sub-QoS flow#1 to a new IPsec Child SA#1 associated with DSCP value#1 and sub-QoS flow#2 to a new IPsec Child SA#2 associated with DSCP value#2. Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow among multiple IPsec Child SAs.

[0172] Alternatively, in some implementations, more than one PSI values may be mapped into one TLM value associated with one IPsec Child SA. For example, the QoS flow with QFI#1 may comprise a first type of PDU sets with PSI values#1, #2, #3, #4 and a second type of PDU sets with PSI values#5, #6, #7, #8. The mapping list provided by the SMF 130 may comprise: the mapping of PSI values#1, #2, #3, #4 and DSCP value#1, and the mapping of PSI values#5, #6, #7, #8 and DSCP value#2.

[0173] The N3IWF 120 may split the QoS flow into two sub-QoS flows (such as sub-QoS flow#1 and sub-QoS flow#2) based on the mapping list provided by the SMF 130. In other words, the N3IWF 120 may split the QoS flow into two sub-QoS flows (such as sub-QoS flow#1 and sub-QoS flow#2) based on PSI value#1 to PSI value#8 in the mapping list. The N3IWF 120 may bind sub-QoS flow#1 to a new IPsec Child SA#1 (with associated PSI values#1, #2, #3, #4) and sub-QoS flow#2 to a new IPsec Child SA#2 (with associated PSI values#5, #6, #7, #8).

[0174] The N3IWF 120 may bind sub-QoS flow#1 to a new IPsec Child SA#1 associated with DSCP value#1 and sub-QoS flow#2 to a new IPsec Child SA#2 associated with DSCP value#2. Thus, the N3IWF 120 enables differentiated handling for PDUs or PDU sets with different PSI values for one QoS flow among multiple IPsec Child SAs.

[0175] In the process 600, the SMF 130 may also provide the N3IWF 120 with a second indication. The second indication may indicate the N3IWF 120 to bind the QoS flow to multiple IPsec Child SA. Alternatively, the second indication may indicate the N3IWF 120 to split the QoS flow into multiple sub-QoS flows and to bind each of the multiple sub-QoS flows to an IPsec Child SA.

[0176] In turn, the N3IWF 120 may split the QoS flow into multiple sub-QoS flows based on the second indication. In addition, the N3IWF 120 may bind each of the multiple sub-QoS flows associated with the PDU set QoS parameters to an IPsec Child SA based on the second indication.

[0177] In some implementations, the at least one mapping of at least one PSI value

and a TLM value may be replaced by at least one mapping of other type of PDU set information or PDU set QoS parameters for the QoS flow and a TLM value. The scope of the present disclosure is not limited in this regard.

[0178] Fig. 7 illustrates a signaling diagram illustrating an example process 700 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The process 700 may involve the UE 104 in Fig. 1A, 1B or 1C and a first apparatus. In some implementations, the first apparatus may perform the N3IWF 120 in Fig. 1B. Alternatively, the first apparatus may perform the TNGF 184 in Fig. 1C. For the purpose of discussion, the process 700 will be described with reference to Fig. 1B. Thus, the process 700 may involve the UE 104 and the N3IWF 120 in Fig. 1B. It shall be understood that the process 700 may be applied to the wireless communications system 100C in Fig. 1C. In that case, the process 700 may involve the UE 104 and the TNGF 184 in Fig. 1C.

[0179] As shown in Fig. 7, the N3IWF 120 provides 710 the UE 104 with PDU set information in a GRE header for each of downlink packets within the QoS flow. The PDU set information is about at least one PDU set comprising the downlink packets. For example, the N3IWF 120 provides the UE 104 with the PDU set information via the untrusted non-3GPP access point 160.

[0180] In some implementations, a PSA UPF (such as the UPF 140) may provide, via N3 interface, the N3IWF 120 with the PDU set information in a General Packet Radio Service (GPRS) Tunnel Protocol-User Plane (GTP-U) header for each of downlink packets within the QoS flow. For example, the PDU set information may comprise at least one of the following: PDU set sequence number (SN), PDU SN within the PDU set, Indication of End PDU of the PDU set, PDU set size in bytes, or PSI value.

[0181] Then, the UE 104 provides 720 the N3IWF 120 with feedback information about transmission of the at least one PDU set. For example, the UE 104 may provide the N3IWF 120 with the feedback information via the untrusted non-3GPP access point 160.

[0182] In some implementations, the UE 104 may provide the N3IWF 120 with the feedback information in a UL data packet or dummy UL packet.

[0183] In some implementations, for UL packets transmission, the UE 104 may also include the PDU set information in the GRE header of the UL packets towards the N3IWF

120.

[0184] In turn, the N3IWF 120 handles 730 the downlink packets based on the feedback information about transmission of the at least one PDU set. For example, the N3IWF 120 may perform PDU set based handling of the downlink packets based on the feedback information.

[0185] With the process 700, GRE layer between the UE 104 and the N3IWF 120 is enhanced to support PDU set based handling.

[0186] In some implementations, the feedback information may comprise an SN of a first PDU set (i.e., PDU set SN of the first PDU set) among the at least one PDU set. The first PDU set is successfully received by the UE 104. For example, the UE 104 may include the PDU set SN of the first PDU set in a “successfully received PDU set” information element (IE) in a GRE header of a UL packet, or the UE 104 may provide the PDU set SN and additionally provide an indication of “successfully received PDU set”. There may be inter-PDU set dependency, for example, the decoding of P frame depends on I frame or previous P frame. If I frame or P frame is not successfully received, then the N3IWF 120 may decide to discard the PDU sets that depends on the lost one.

[0187] Alternatively, in some implementations, the feedback information may comprise SNs of PDUs within a first PDU set, and an SN of the first PDU set. The PDUs are successfully received by the UE 104. In some implementations, the UE 104 may provide the N3IWF 120 with the feedback information in a GRE header for a UL packet. Based on the feedback information in the GRE header, the N3IWF 120 is able to decide whether the remaining PDUs of the first PDU set can be discarded.

[0188] Alternatively, in some implementations, the N3IWF 120 may provide the UE 104 with information about Forward Error Correction (FEC) ratio for the QoS flow.

[0189] In some implementations, the information about the FEC ratio may be FEC ratio for the QoS flow, or FEC ratio for different frame types, or FEC ratio for different PSI values. For example, the FEC ratio may be represented by X, where X is in a range of 0 to 100. If the FEC ratio is applied to XRM traffic, it means X% error of a PDU set can be tolerated. That is, if more than (1-x%) packets have already been successfully delivered to the UE 104 from the N3IWF 120, the N3IWF 120 may discard or inform the untrusted non-3GPP access point 160 to discard the remaining PDUs of the PDU set. Alternatively,

in some implementations, the information about the FEC ratio may be the basic reception ratio for the QoS flow (which is actually 1 minus FEC ratio for the QoS flow), or the basic reception ratio for different frame types, or FEC ratio for different PSI values. In such implementations, the feedback information comprises an SN of a first PDU set, wherein a first percentage of PDUs within the first PDU set is successfully received by the UE 104, and the first percentage is associated with the FEC ratio.

[0190] For example, the N3IWF 120 provides PDU set size in a GRE header for the first PDU set. The UE 104 counts the successfully received data volume of the first PDU set. The UE 104 determines the FEC ratio for the first PDU set by QFI, or by QFI and the frame type of the first PDU set, or by QFI and PSI value of the first PDU set. If the ratio of successfully received data volume of the first PDU set to PDU set size of the first PDU set is larger than (1-FEC ratio) or basic reception ratio, the UE 104 provides the SN of the first PDU set to the N3IWF 120 in a GRE header. For example, the SN of the first PDU set may be included in an “enough PDUs successfully received” IE in the GRE header. Thus, providing the SN of the first PDU set to the N3IWF 120 may indicate that enough PDUs of the first PDU set have been successfully received by the UE 104. Alternatively, the UE 104 may provide the PDU set SN and additionally provide an indication of “enough PDUs successfully received” to the N3IWF 120.

[0191] In some implementations, the process 700 may be performed in combination with any of the processes 200, 300, 400, 500 and 600.

[0192] Fig. 8 illustrates an example of a device 800 that supports transport layer enhancement or UL PDU set identification in accordance with some aspects of the present disclosure. The device 800 may be an example of a first apparatus, a second apparatus or the UE 104 as described herein. The device 800 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 800 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 802, a memory 804, a transceiver 806, and, optionally, an I/O controller 808. 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).

[0193] The processor 802, the memory 804, the transceiver 806, 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 802, the memory 804, the transceiver 806, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0194] In some implementations, the processor 802, the memory 804, the transceiver 806, 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 802 and the memory 804 coupled with the processor 802 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804).

[0195] For example, the processor 802 may support wireless communication at the device 800 in accordance with examples as disclosed herein. The processor 802 may be configured to operable to support a means for performing the following: obtaining, at a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and providing the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value.

[0196] Alternatively, in some implementations, the processor 802 may be configured to operable to support a means for performing the following: receiving, at a UE from a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and determining the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping, the at least one PDU set importance value comprising the first PDU set importance value.

[0197] Alternatively, in some implementations, the processor 802 may be configured

to operable to support a means for performing the following: receiving, at a second apparatus, an identity of a first apparatus, the identity of the first apparatus being related with a non-Third Generation Partnership Project (3GPP) access network; and providing the first apparatus with at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE.

[0198] The processor 802 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 802 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 802. The processor 802 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 804) to cause the device 800 to perform various functions of the present disclosure.

[0199] The memory 804 may include random access memory (RAM) and read-only memory (ROM). The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 802 cause the device 800 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 802 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 804 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.

[0200] The I/O controller 808 may manage input and output signals for the device 800. The I/O controller 808 may also manage peripherals not integrated into the device 800. In some implementations, the I/O controller 808 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 808 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 808 may be implemented as part of a processor, such as the processor 806. In some implementations, a user may interact with the device 800 via the I/O controller 808 or via hardware components controlled by the I/O controller 808.

[0201] In some implementations, the device 800 may include a single antenna 810. However, in some other implementations, the device 800 may have more than one antenna 810 (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 806 may communicate bi-directionally, via the one or more antennas 810, wired, or wireless links as described herein. For example, the transceiver 806 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 806 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 810 for transmission, and to demodulate packets received from the one or more antennas 810. The transceiver 806 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0202] 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 810 for transmitting the amplified signal into the air or wireless medium.

[0203] 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 810 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.

[0204] Fig. 9 illustrates an example of a processor 900 that supports transport layer enhancement or UL PDU set identification in accordance with other aspects of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 906. 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).

[0205] The processor 900 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 900) 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).

[0206] The controller 902 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 900 to cause the processor 900 to support various operations in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0207] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

[0208] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

[0209] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 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 902 and/or the processor 900 may be configured to execute computer-readable instructions stored in the memory 904 to cause the processor 900 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 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.

[0210] The one or more ALUs 906 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 906 may reside within or on a processor chipset (e.g., the processor 900). In some other implementations, the one or more ALUs 906 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 906 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 906 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 906 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 906 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 906 to handle conditional operations, comparisons, and bitwise operations.

[0211] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The processor 900 may be configured to operable to support a means for performing the following: obtaining, at a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and providing the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value.

[0212] Alternatively, in some implementations, the processor 900 may be configured to operable to support a means for performing the following: receiving, at a UE from a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE; and determining the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping, the at least one PDU set importance value comprising the first PDU set importance value.

[0213] Alternatively, in some implementations, the processor 900 may be configured to operable to support a means for performing the following: receiving, at a second

apparatus, an identity of a first apparatus, the identity of the first apparatus being related with a non-Third Generation Partnership Project (3GPP) access network; and providing the first apparatus with at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value, the transport layer marking value being associated with a first IPsec Child SA to be established between the first apparatus and a UE.

[0214] Fig. 10 illustrates a flowchart of a method 1000 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The operations of the method 1000 may be implemented by a device or its components as described herein. For example, the operations of the method 1000 may be performed by a first apparatus 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.

[0215] At 1010, the method may include obtaining, at a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value. The transport layer marking value is associated with a first IPsec Child SA to be established between the first apparatus and a UE. The operations of 1010 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by a device as described with reference to Fig. 1B or 1C.

[0216] At 1020, the method may include providing the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value. The operations of 1020 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by a device as described with reference to Fig. 1B or 1C.

[0217] Fig. 11 illustrates a flowchart of a method 1100 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by a UE 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.

[0218] At 1110, the method may include receiving, at a UE from a first apparatus, at least one mapping of at least one PDU set importance value for a QoS flow and a transport layer marking value. The transport layer marking value is associated with a first IPsec Child SA to be established between the first apparatus and a UE. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by a device as described with reference to Fig. 1A, 1B or 1C.

[0219] At 1120, the method may include determining the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping. The at least one PDU set importance value comprises the first PDU set importance value. The operations of 1120 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1120 may be performed by a device as described with reference to Fig. 1A, 1B or 1C.

[0220] Fig. 12 illustrates a flowchart of a method 1200 that supports PDU set based handling in non-3GPP access network in accordance with aspects of the present disclosure. The operations of the method 1200 may be implemented by a device or its components as described herein. For example, the operations of the method 1200 may be performed by a second apparatus 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.

[0221] At 1210, the method may include receiving, at a second apparatus, an identity of a first apparatus. The identity of the first apparatus is related with a non-3GPP access network. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by a device as described with reference to Fig. 1B or 1C.

[0222] At 1220, the method may include providing the first apparatus with at least one mapping of at least one PDU set importance value for a QoS flow and a transport

layer marking value. The transport layer marking value is associated with a first IPsec Child SA to be established between the first apparatus and a UE. The operations of 1220 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1220 may be performed by a device as described with reference to Fig. 1B or 1C.

[0223] It shall be understood that the implementations described with reference to Figs. 2 to 7 are also applicable to the device 800, the processor 900 as well as the methods 1000, 1100 and 1200. Details of these implementations are omitted for brevity.

[0224] 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.

[0225] 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.

[0226] 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.

[0227] 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.

[0228] 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.

[0229] 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 first apparatus, comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause the first apparatus to:
obtain at least one mapping of at least one Protocol Data Unit (PDU) set importance value for a Quality of Service (QoS) flow and a transport layer marking value, the transport layer marking value being associated with a first Internet Protocol Security (IPsec) Child Security Association (SA) to be established between the first apparatus and a user equipment (UE); and
provide the UE with the at least one mapping of the at least one PDU set importance value and the transport layer marking value.
2. The first apparatus of claim 1, wherein the first apparatus is further caused to:
receive, from a second apparatus, PDU set QoS parameters for the QoS flow; and
bind the QoS flow associated with the PDU set QoS parameters to the first IPsec Child SA.
3. The first apparatus of claim 1, wherein the first apparatus is further caused to:
receive, from a second apparatus, PDU set QoS parameters for the QoS flow;
split the QoS flow into multiple sub-QoS flows based on PDU set importance values for the QoS flow; and
bind each of the multiple sub-QoS flows associated with the PDU set QoS parameters to one of multiple IPsec Child SAs to be established between the first apparatus and the UE, the multiple IPsec Child SAs comprising the first IPsec Child SA, and the PDU set importance values comprising the at least one PDU set importance value.
4. The first apparatus of claim 1, wherein the first apparatus is caused to obtain the at least one mapping of the at least one PDU set importance value and the transport layer marking value by:
receiving information about the at least one mapping from a second apparatus.

5. The first apparatus of claim 2 or 3, wherein the first apparatus is further caused to:

provide the UE with the PDU set QoS parameters.

6. The first apparatus of claim 1, wherein the first apparatus is further caused to: provide the UE with PDU set information in a Generic Routing Encapsulation (GRE) header for each of downlink packets within the QoS flow, the PDU set information being about at least one PDU set comprising the downlink packets.

7. The first apparatus of claim 6, wherein the first apparatus is further caused to: receive, from the UE, feedback information about transmission of the at least one PDU set; and

handle the downlink packets based on the feedback information about transmission of the at least one PDU set.

8. The first apparatus of claim 7, wherein the first apparatus is further caused to: provide the UE with information about Forward Error Correction (FEC) ratio for the QoS flow.

9. The first apparatus of claim 8, wherein the feedback information comprises a sequence number of a first PDU set among the at least one PDU set, wherein at least a first percentage of PDUs within the first PDU set is successfully received by the UE, and the first percentage is associated with the FEC ratio.

10. A user equipment (UE), comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

receive, via the transceiver from a first apparatus, at least one mapping of at least one Protocol Data Unit (PDU) set importance value for a Quality of Service (QoS) flow and a transport layer marking value, the transport layer marking value being associated with a first Internet Protocol Security (IPsec) Child Security Association (SA) to be established between the first apparatus and a user equipment (UE); and

determine the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping, the at least one PDU set importance value comprising the first PDU set importance value.

11. The UE of claim 10, wherein the processor is further configured to:
transmit, via the transceiver to the first apparatus, the uplink PDU with the transport layer marking value through the first IPsec Child SA.

12. The UE of claim 10, wherein the processor is further configured to:
receive, via the transceiver from the first apparatus, PDU set QoS parameters for the QoS flow.

13. The UE of claim 10, wherein the processor is further caused to:
receive, via the transceiver from the first apparatus, PDU set information in a Generic Routing Encapsulation (GRE) header for each of downlink packets within the QoS flow, the PDU set information being about at least one PDU set comprising the downlink packets.

14. The UE of claim 13, wherein the processor is further caused to:
transmit, via the transceiver to the first apparatus, feedback information about transmission of the at least one PDU set.

15. The UE of claim 14, wherein the processor is further caused to:
receive, via the transceiver from the first apparatus, information about Forward Error Correction (FEC) ratio for the QoS flow.

16. The UE of claim 15, wherein the feedback information comprises a sequence number of a first PDU set among the at least one PDU set, wherein a first percentage of PDUs within the first PDU set is successfully received by the UE, and the first percentage is associated with the FEC ratio.

17. A second apparatus, comprising:

at least one memory; and

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

receive an identity of a first apparatus, the identity of the first apparatus being related with a non-Third Generation Partnership Project (3GPP) access network; and

provide the first apparatus with at least one mapping of at least one Protocol Data Unit (PDU) set importance value for a Quality of Service (QoS) flow and a transport layer marking value, the transport layer marking value being associated with a first Internet Protocol Security (IPsec) Child Security Association (SA) to be established between the first apparatus and a user equipment (UE).

18. The second apparatus of claim 17, wherein the second apparatus is caused to receive the identity of the first apparatus by:

receiving the identity of the first apparatus from a third apparatus; or

receiving the identity of the first apparatus from the first apparatus via the third apparatus.

19. The second apparatus of claim 17, wherein the second apparatus is further caused to:

provide the first apparatus with at least one of the following:

an identity of a PDU session for the QoS flow,

an identity of the QoS flow, or

PDU set QoS parameters for the QoS flow.

20. 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:

receive, from a first apparatus, at least one mapping of at least one Protocol Data Unit (PDU) set importance value for a Quality of Service (QoS) flow and a transport layer marking value, the transport layer marking value being associated with a first

Internet Protocol Security (IPsec) Child Security Association (SA) to be established between the first apparatus and a user equipment (UE); and

determine the transport layer marking value for an uplink PDU of the QoS flow based on a first PDU set importance value for the uplink PDU and the at least one mapping, the at least one PDU set importance value comprising the first PDU set importance value.