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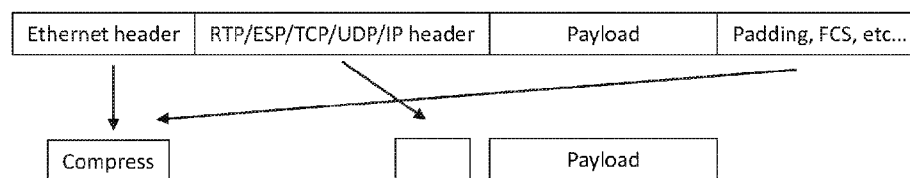


FIG. 3

(57) Abstract: Systems and methods of compressing Ethernet headers for transmission through a 5G network are described. A first Ethernet packet transmitted to a destination uses ROHC on a non-Ethernet header but has an uncompressed Ethernet header. After feedback is received from the destination, subsequent Ethernet packets transmitted to the destination use a compressed header in which the source and destination addresses are replaced by a connection identity and a type field indicates that the header is compressed. The connection identity is unique to the DRB and may further depend on the type field and an 802.1Q tag of the packet.

5G NR METHODS FOR ETHERNET HEADER COMPRESSION

5 [0001] This application claims the benefit of priority to US Provisional Patent Application Serial No. 62/753,779, filed October 31, 2018, and to US Provisional Application Serial No. 62/824,905, filed March 27, 2019, all of which are incorporated herein by reference in their entirety.

10 TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks (RANs). Some embodiments relate to cellular networks, including Third Generation Partnership Project (3GPP) Long Term Evolution (LTE), 4th generation (4G) and 5th generation (5G) New Radio (NR) (or next generation (NG)) networks. Some
15 embodiments relate to the use of ethernet protocols in NG networks.

BACKGROUND

[0003] The use of various types of systems has increased due to both an increase in the number and types of user equipment (UEs) using network
20 resources as well as the amount of data and bandwidth being used by various applications, such as video streaming, operating on these UEs. Bandwidth, latency, and data rate enhancement may be used to deliver the continuously-increasing demand for network resources. The next generation wireless communication system will provide ubiquitous connectivity and access to
25 information, as well as ability to share data, by various users and applications. NG systems are expected to have a unified framework in which different and sometimes conflicting performance criteria and services are to be met. In general, NG systems will evolve based on 3GPP LTE-Advanced technology with additional enhanced radio access technologies (RATs) and functionalities to
30 enable seamless wireless connectivity solutions. A wide variety of use cases, including those related to not only user interaction but also factory automation, transport industry applications, and electrical power distribution, may lead to an increased desire for supporting Time Sensitive Networking (TSN). While the Ethernet protocol is widely used in TSN, adjustments to the Ethernet protocol
35 for use in NG systems may be desirable however, as substantial overhead exists

due to the use of the Ethernet header. This may be especially problematic when the payload size of the Ethernet packet is small.

BRIEF DESCRIPTION OF THE FIGURES

- 5 [0004] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various aspects discussed in the present document.
- 10 [0005] FIG. 1 illustrates combined communication system in accordance with some embodiments.
- [0006] FIG. 2 illustrates a block diagram of a communication device in accordance with some embodiments.
- [0007] FIG. 3 illustrates Ethernet header compression and Robust
15 Header Compression (ROHC) in accordance with some embodiments.
- [0008] FIG. 4 illustrates a Data Convergence Protocol (PDCP) entity in accordance with some embodiments.
- [0009] FIG. 5 illustrates a mapping between connection identity and Ethernet header fields in accordance with some embodiments.
- 20 [0010] FIG. 6 illustrates an uncompressed Ethernet header format in accordance with some embodiments.
- [0011] FIG. 7 illustrates a compressed Ethernet header format in accordance with some embodiments.
- [0012] FIG. 8 illustrates another compressed Ethernet header format in
25 accordance with some embodiments.
- [0013] FIG. 9 illustrates payload content in accordance with some embodiments.
- [0014] FIG. 10 illustrates messaging in accordance with some
embodiments.

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DETAILED DESCRIPTION

[0015] The following description and the drawings sufficiently illustrate specific aspects to enable those skilled in the art to practice them. Other aspects

may incorporate structural, logical, electrical, process, and other changes. Portions and features of some aspects may be included in, or substituted for, those of other aspects. Aspects set forth in the claims encompass all available equivalents of those claims.

5 [0016] FIG. 1 illustrates a combined communication system in accordance with some embodiments. The system 100 includes 3GPP LTE/4G and NG network functions. A network function can be implemented as a discrete network element on a dedicated hardware, as a software instance running on dedicated hardware, or as a virtualized function instantiated on an
10 appropriate platform, e.g., dedicated hardware or a cloud infrastructure.

[0017] The evolved packet core (EPC) of the LTE/4G network contains protocol and reference points defined for each entity. These core network (CN) entities may include a mobility management entity (MME) 122, serving gateway (S-GW) 124, and paging gateway (P-GW) 126.

15 [0018] In the NG network, the control plane and the user plane may be separated, which may permit independent scaling and distribution of the resources of each plane. The UE 102 may be connected to either an access network or radio access network (RAN) 110 and/or may be connected to the NG-RAN 130 (gNB) or an Access and Mobility Function (AMF) 142. The
20 RAN 110 may be an eNB or a general non-3GPP access point, such as that for Wi-Fi. The NG core network may contain multiple network functions besides the AMF 112. The UE 102 may generate, encode and perhaps encrypt uplink transmissions to, and decode (and decrypt) downlink transmissions from, the RAN 110 and/or gNB 130 (with the reverse being true by the RAN 110/gNB
25 130).

[0019] The network functions may include a User Plane Function (UPF) 146, a Session Management Function (SMF) 144, a Policy Control Function (PCF) 132, an Application Function (AF) 148, an Authentication Server Function (AUSF) 152 and User Data Management (UDM) 128. The various
30 elements are connected by the NG reference points shown in FIG. 1.

[0020] The AMF 142 may provide UE-based authentication, authorization, mobility management, etc. The AMF 142 may be independent of the access technologies. The SMF 144 may be responsible for session

management and allocation of IP addresses to the UE 102. The SMF 144 may also select and control the UPF 146 for data transfer. The SMF 144 may be associated with a single session of the UE 102 or multiple sessions of the UE 102. This is to say that the UE 102 may have multiple 5G sessions. Different
5 SMFs may be allocated to each session. The use of different SMFs may permit each session to be individually managed. As a consequence, the functionalities of each session may be independent of each other. The UPF 126 may be connected with a data network, with which the UE 102 may communicate, the UE 102 transmitting uplink data to or receiving downlink data from the data
10 network.

[0021] The AF 148 may provide information on the packet flow to the PCF 132 responsible for policy control to support a desired QoS. The PCF 132 may set mobility and session management policies for the UE 102. To this end, the PCF 132 may use the packet flow information to determine the appropriate
15 policies for proper operation of the AMF 142 and SMF 144. The AUSF 152 may store data for UE authentication. The UDM 128 may similarly store the UE subscription data.

[0022] The gNB 130 may be a standalone gNB or a non-standalone gNB, e.g., operating in Dual Connectivity (DC) mode as a booster controlled by
20 the eNB 110 through an X2 or Xn interface. At least some of functionality of the EPC and the NG CN may be shared (alternatively, separate components may be used for each of the combined component shown). The eNB 110 may be connected with an MME 122 of the EPC through an S1 interface and with a SGW 124 of the EPC 120 through an S1-U interface. The MME 122 may be
25 connected with an HSS 128 through an S6a interface while the UDM is connected to the AMF 142 through the N8 interface. The SGW 124 may be connected with the PGW 126 through an S5 interface (control plane PGW-C through S5-C and user plane PGW-U through S5-U). The PGW 126 may serve as an IP anchor for data through the internet.

[0023] The NG CN, as above, may contain an AMF 142, SMF 144 and UPF 146, among others. The eNB 110 and gNB 130 may communicate data with the SGW 124 of the EPC 120 and the UPF 146 of the NG CN. The MME 122 and the AMF 142 may be connected via the N26 interface to provide control
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information there between, if the N26 interface is supported by the EPC 120. In some embodiments, when the gNB 130 is a standalone gNB, the 5G CN and the EPC 120 may be connected via the N26 interface.

[0024] FIG. 2 illustrates a block diagram of a communication device in accordance with some embodiments. In some embodiments, the communication device may be a UE (including an IoT device and NB-IoT device), eNB, gNB or other equipment used in the 4G/LTE or NG network environment. For example, the communication device 200 may be a specialized computer, a personal or laptop computer (PC), a tablet PC, a mobile telephone, a smart phone, a network router, switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. In some embodiments, the communication device 200 may be embedded within other, non-communication-based devices such as vehicles and appliances.

[0025] Examples, as described herein, may include, or may operate on, logic or a number of components, modules, or mechanisms. Modules and components are tangible entities (e.g., hardware) capable of performing specified operations and may be configured or arranged in a certain manner. In an example, circuits may be arranged (e.g., internally or with respect to external entities such as other circuits) in a specified manner as a module. In an example, the whole or part of one or more computer systems (e.g., a standalone, client or server computer system) or one or more hardware processors may be configured by firmware or software (e.g., instructions, an application portion, or an application) as a module that operates to perform specified operations. In an example, the software may reside on a machine readable medium. In an example, the software, when executed by the underlying hardware of the module, causes the hardware to perform the specified operations.

[0026] Accordingly, the term “module” (and “component”) is understood to encompass a tangible entity, be that an entity that is physically constructed, specifically configured (e.g., hardwired), or temporarily (e.g., transitorily) configured (e.g., programmed) to operate in a specified manner or to perform part or all of any operation described herein. Considering examples in which modules are temporarily configured, each of the modules need not be instantiated at any one moment in time. For example, where the modules

comprise a general-purpose hardware processor configured using software, the general-purpose hardware processor may be configured as respective different modules at different times. Software may accordingly configure a hardware processor, for example, to constitute a particular module at one instance of time
5 and to constitute a different module at a different instance of time.

[0027] The communication device 200 may include a hardware processor 202 (e.g., a central processing unit (CPU), a GPU, a hardware processor core, or any combination thereof), a main memory 204 and a static memory 206, some or all of which may communicate with each other via an
10 interlink (e.g., bus) 208. The main memory 204 may contain any or all of removable storage and non-removable storage, volatile memory or non-volatile memory. The communication device 200 may further include a display unit 210 such as a video display, an alphanumeric input device 212 (e.g., a keyboard), and a user interface (UI) navigation device 214 (e.g., a mouse). In an example, the
15 display unit 210, input device 212 and UI navigation device 214 may be a touch screen display. The communication device 200 may additionally include a storage device (e.g., drive unit) 216, a signal generation device 218 (e.g., a speaker), a network interface device 220, and one or more sensors, such as a global positioning system (GPS) sensor, compass, accelerometer, or other
20 sensor. The communication device 200 may further include an output controller, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate or control one or more peripheral devices (e.g., a printer, card reader, etc.).

[0028] The storage device 216 may include a non-transitory machine readable medium 222 (hereinafter simply referred to as machine readable medium) on which is stored one or more sets of data structures or instructions 224 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 224 may also reside, successfully
25 or at least partially, within the main memory 204, within static memory 206, and/or within the hardware processor 202 during execution thereof by the communication device 200. While the machine readable medium 222 is illustrated as a single medium, the term "machine readable medium" may
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include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 224.

[0029] The term “machine readable medium” may include any medium
5 that is capable of storing, encoding, or carrying instructions for execution by the communication device 200 and that cause the communication device 200 to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. Non-limiting machine-readable medium examples may
10 include solid-state memories, and optical and magnetic media. Specific examples of machine-readable media may include: non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard
15 disks and removable disks; magneto-optical disks; Random Access Memory (RAM); and CD-ROM and DVD-ROM disks.

[0030] The instructions 224 may further be transmitted or received over a communications network using a transmission medium 226 via the network interface device 220 utilizing any one of a number of transfer protocols (e.g.,
20 frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communication networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, and
25 wireless data networks. Communications over the networks may include one or more different protocols, such as Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi, IEEE 802.16 family of standards known as WiMax, IEEE 802.15.4 family of standards, a Long Term Evolution (LTE) family of standards, a Universal Mobile
30 Telecommunications System (UMTS) family of standards, peer-to-peer (P2P) networks, a NG/NR standards among others. In an example, the network interface device 220 may include one or more physical jacks (e.g., Ethernet,

coaxial, or phone jacks) or one or more antennas to connect to the transmission medium 226.

[0031] The communication device 200 may be an IoT device (also referred to as a “Machine-Type Communication device” or “MTC device”), a narrowband IoT (NB-IoT) device, or a non-IoT device (e.g., smart phone, vehicular UE), any which may communicate with the core network via the eNB or gNB shown in FIG. 1. The communication device 200 may be an autonomous or semiautonomous device that performs one or more functions, such as sensing or control, among others, in communication with other communication devices and a wider network, such as the Internet. If the communication device 200 is IoT device, in some embodiments, the communication device 200 may be limited in memory, size, or functionality, allowing larger numbers to be deployed for a similar cost to smaller numbers of larger devices. The communication device 200 may, in some embodiments, be a virtual device, such as an application on a smart phone or other computing device.

[0032] As above, the use of Ethernet protocol for TSN is desirable for NR. To this end, the Ethernet header overhead therefore may be reduced to increase packet resource efficiency and reliability, and reduce packet latency. This may also contribute to increased system capacity and improved spectral usage footprint. The compression can be applied to one or more (up to all) fields added in the Ethernet protocol, including header (including source/destination address, length/type etc.), and trailer (including padding, frame check sequence etc.). For simplicity, the term “Ethernet header” is used herein to denote both header and trailer.

[0033] Note that, as used herein, the Ethernet protocol is a local area network (LAN) protocol that is in compliance with the IEEE 802.3 LAN standards which supports an IEEE 802.1Q tag. IEEE 802.1Q is IEEE standard that supports virtual LANs (VLANs) on an IEEE 802.3 Ethernet network. Portions of the network which are VLAN-aware (i.e., IEEE 802.1Q conformant) can include VLAN tags. When an Ethernet frame enters the VLAN-aware portion of the network, a tag is added to a Layer 2 packet to represent the VLAN membership. The tag contains the tag value, which identifies the data as a tag,

and also contains the VLAN ID of the VLAN from which the packet is sent. Note also that although Ethernet headers (and trailers) are described herein, the embodiments may be used in other LAN networks and protocols.

[0034] The description for the Ethernet header compression is mainly described for 3GPP NR standards. The same principle can be applied to 3GPP LTE standards, or other communication systems. In NR, the layer 2 user plane protocol stack includes the Service Data Adaptation Protocol (SDAP), Packet Data Convergence Protocol (PDCP), Radio Link Control (RLC), and Medium Access Control (MAC) layers. In some embodiments, Ethernet packet compression may be incorporated in the PDCP layer. In other embodiments, Ethernet packet compression may be incorporated in the SDAP layer, or in a new layer.

[0035] The Ethernet packet may carry a payload with protocols of the combination of Internet Protocol (IP), UDP (User Datagram Protocol), TCP (Transmission Control Protocol), Realtime Transport Protocol (RTP), IP Encapsulating Security Payload (ESP). As used herein RTP/ESP/TCP/UDP/IP denotes one of a combination of the protocols, e.g. IP, TCP/IP, UDP/IP, ESP/IP, RTP/UDP/IP. In some embodiments, Robust Header Compression (ROHC) may be applied to compress the RTP/ESP/TCP/UDP/IP headers. FIG. 3 illustrates Ethernet header compression and ROHC in accordance with some embodiments. Compression may be performed by any entity, such as the UE or gNB. For ROHC operation, the starting position of the RTP/ESP/TCP/UDP/IP headers should be known. This can be accomplished, e.g., by performing Ethernet header compression and ROHC separately. Ethernet header compression and ROHC may be similar handling ROHC in the presence of the SDAP layer, where ROHC is aware of the length of the SDAP header (zero bytes or one byte).

[0036] FIG. 4 illustrates a Packet Data Convergence Protocol (PDCP) entity in accordance with some embodiments. In particular, FIG. 4 may represent a functional view of the PDCP entity for the PDCP sublayer. As shown, the PDCP entity may perform header compression at the transmitter side and header decompression at the receiver side of the Ethernet header, in addition to ROHC.

[0037] Ethernet frames may contain the following fields: Preamble, Start Frame Delimiter (SFD), Destination address and Source address, Length/Type field and 802.1A tag, Pad(ding) and Frame Check Sequence (FCS). The preamble field may permit the Physical Layer Signaling (PLS) circuitry to reach its steady-state synchronization with the received packet's timing. Given that the preamble is fixed sequence, the field may not be transmitted after compression. The SFD field may be a sequence 10101011. This field may also not be transmitted after compression. Compression of the destination address and source address is discussed in more detail below, as will compression of the length/type field and 802.1Q tag. The pad(ding) field may be used to satisfy a minimum MAC frame size constraint and can be eliminated if the length of payload is available either via the Ethernet header or packet inspection of the payload. The FCS field may be used for error detection and may be eliminated after compression since the lower layers may provide cyclic redundancy check (CRC) detection.

[0038] To compress the destination and source addresses, a connection identity (ID) may be introduced to represent the pair of a source address and destination address. In the following description, (x, y) is used to denote the pair of a source address x and destination address y . In implementation, a table stored in a memory of each communication device can be used to map the connection ID to the pair of source address and destination address. Entries in the table may be retained until a predetermined condition is met, e.g., the data radio bearer (DRB) to the UE is deactivated.

[0039] In wireless communications, there are two ways regarding the relationship of connection identity and link direction. In a joint option, the connection identity may apply for both downlink and uplink communications. In the joint option, if connection identity n corresponds to a source/destination address pair (x, y) for downlink communications, then same connection identity n may correspond to the source/destination address pair (y, x) in uplink communications. In an independent option, the connection identity for downlink and uplink communications may be independent. That is, in the independent option, there may be no relationship between the source/destination address pairs

associated to the same connection identity for downlink and uplink communications.

[0040] In addition to the link direction, the connection ID may be associated with other network functionality. For example, the connection ID
5 may also be unique within a DRB. This can increase the usage of connection identities since the same connection identity can be reused across different DRBs to indicate different source/destination address pairs.

[0041] In the above, the connection ID may represent a pair of source address and destination address. In other embodiments, the connection ID may
10 be used to represent a subset of Ethernet header fields. For example, the connection ID can represent the unique combination of the following Ethernet header fields: destination address, source address, type/length, and 802.1Q tag, or a unique combination of the following Ethernet header fields: destination address, source address, and type/length.

[0042] In some embodiments, the connection ID space in DL and UL can be independent, which means that the same connection ID can refer to a different unique combination of Ethernet header fields.

[0043] In some embodiments, the connection identity refers to the Ethernet header fields presented when uncompressed Ethernet header is
20 transmitted, instead of representing a fixed set of Ethernet header fields. FIG. 5 illustrates a mapping between connection identity and Ethernet header fields in accordance with some embodiments. For example, when connection identity m is first used and the Ethernet header fields destination address, source address, and type/length are present (while 802.1Q flag is not present), then connection
25 identity m may represent the values of destination address, source address, and type/length when the compressed header is sent (i.e., when such Ethernet header fields are not present). Similarly, when the connection identity n is first used and the Ethernet header fields destination address, source address, type/length, and 802.1Q flag are present, then connection identity n may represent the values
30 of destination address, source address, type/length, and 802.1Q flag when compressed header is sent (i.e., when such Ethernet header fields are not present). Such an embodiment may support multiple Ethernet frame formats dynamically without reconfiguration.

[0044] Various embodiments may be used to signal the mapping between connection identity and source/destination address pair. For example, in some embodiments, the UE and gNB may use RRC signalling to add, modify, and remove the mapping between connection identity and source/destination
5 address pair. The signalling can be added as new fields in information elements (IEs) such as *PDCCP-Config* or *DRB-ToAddMod*. Alternatively, a new IE may be used.

[0045] In another embodiment, the mapping may be conveyed using a PDCCP control packet data unit (PDU). In this approach, a new PDCCP control
10 PDU can be introduced to alter (add, modify, or remove) the mapping between connection identity and source/destination address pair. In such an embodiment, the “PDU type” field for the PDCCP control PDU could be 010 or higher values. Note that if Ethernet header compression is performed in SDAP layer, then the mapping relationship can be signaled in a SDAP control PDU. If Ethernet
15 header compression is performed in a new layer, the mapping relationship can be signaled in the control PDU of the corresponding layer.

[0046] In another embodiment, the mapping may be conveyed within the PDCCP data PDU. This option can be considered as “in-band” signalling. As
20 above, if Ethernet header compression is performed in SDAP layer, then the mapping relationship can be signaled in SDAP data PDU. If Ethernet header compression is performed in a new layer, the mapping relationship can be signaled in the control PDU of the corresponding layer.

[0047] To indicate the mapping between connection identity and source/destination address pair in the data PDU, the packet format after Ethernet
25 header compression is described below. FIGS. 6-8 illustrate an Ethernet header format in accordance with some embodiments. An example header format for Ethernet header compression includes a connection identity in a first octet. The length of the connection identity may be fixed, may be configured by RRC signalling, or may be signaled in the data PDU itself. As shown in FIGS. 6-8,
30 the connection identity has a length of 6 bit connection identity; this value is however merely exemplary, other connection identity lengths may be used.

[0048] The first octet of the header may also include a “Type” field. The “Type” field may have different values in different examples, in the different

embodiments pictured in FIGS. 6-8. For example, the “Type” field may have a value of 0 in the embodiment of FIG. 6, 1 in the embodiment of FIG. 7, etc. As shown in FIGS. 6-8, the “Type” field may be 2 bits (the last two bits of the first octet, sharing the first octet with the connection identity); in other embodiments, however, the length of “Type” field may be determined by how many types of headers are supported. In such embodiments, the length of “Type” field may take different values, e.g., 3 bits, 4 bits.

[0049] Specifically, FIG. 6 illustrates an uncompressed Ethernet header format in accordance with some embodiments. As shown in FIG. 6, multiple fields are contained within the octets of the Ethernet header. In particular, the Destination Address may be 6 bytes in length and signaled in octets 2-7, the Source Address may be 6 bytes in length and signaled in octets 8-13, and the Length/type, 802.1Q tag may be signaled in octets 14-19. The various fields may thus be signaled as is, without any compression. As illustrated, one 802.1Q tag may be inserted in the Ethernet header. Note that other fields, such as the preamble, SFD, and FCS may not be transmitted. Such an uncompressed header can be transmitted when a connection is initially used, e.g., a new source/destination address pair is used in the link. This corresponds to the option of indicating the mapping between connection identity and source/destination address pair in the PDCP data PDU above. The transmitter may include such uncompressed header for one or more packets to increase the reliability. The decision for sending uncompressed headers in one or more packets may be configurable and can be made at runtime by the transmitter, e.g., based on the link quality, desired target for reliability, etc.

[0050] FIG. 7 illustrates a compressed Ethernet header format in accordance with some embodiments. As shown in this compressed embodiment, neither the Destination Address nor the Source Address is transmitted. However, the Ethernet headers for a 4 byte Length/type field and a 2 byte 802.1Q tag(s) may be signaled without any compression. As above, in some embodiments only a single 802.1Q tag may be inserted. The transmitter may have already sent the Source and Destination addresses before to establish the connection identity; these fields are therefore not present in the compressed header format.

[0051] FIG. 8 illustrates another compressed Ethernet header format in accordance with some embodiments. As shown in FIG. 8, similar to FIG. 7, transmission of both the Destination Address and the Source Address may be avoided. The 802.1Q tag may, in FIGS. 6 and 7, contain a tag protocol identifier (TPID) that has a fixed value for 802.1Q (0x8100). In FIG. 8, the TPID may be removed from the 802.1Q tag, reducing the size of this field from 4 octets to 2 octets. In addition, if the Length/type field indicates the payload size, the Length/type field may not be transmitted since it is possible to derive the payload size from lower layers. If the Length/type field indicates the payload type (i.e., length/type field is EtherType), a mapping table from long EtherType (2 bytes) to a short list of IDs can be designed. For example, a 4 bit Short Payload Type field may be used to represent the EtherType. In this case, value 0 may indicate an IPv4 payload (EtherType 0x0800), while value 1 may indicate IPv6 payload (EtherType 0x86DD). In some embodiments, a special value (such as 15) can be used to indicate an EtherType not in the mapping table. In this case, the actual EtherType can follow the Short Payload Type field. In FIG. 8, the Short Payload Type field is not present and only a single 802.1Q tag is inserted.

[0052] In some embodiments, the VLAN identifier (VID) in 802.1Q tag may be compressed. For example, the VID can be considered as part of the connection identity, together with the Source Address and Destination Address. Alternatively, a delta encoding can be introduced for the VID, e.g., to only encode the difference between the current VID and the VID signalling in the previous packet.

[0053] As above, the connection identity may represent a unique combination of the Ethernet header fields: destination address, source address, type/length, and optionally 802.1Q tag. After the transmission of the uncompressed header, for the subsequent packets corresponding to a connection identity whose uncompressed headers have been sent, the transmitter can transmit a compressed header. FIG. 9 illustrates payload content in accordance with some embodiments. The payload content excludes the PDCP header and Message Authentication Code - Integrity (MAC-I). In the PDCP PDU payload shown in FIG. 9, only the fields "Connection ID" and "Type" may be present;

the Ethernet header fields (Destination/Source Address, Length/type, and optionally 802.1Q tag) may be represented by the “Connection ID” and therefore may not be present in the PDCP payload. As above, a 2 bit “Type” field is shown in FIG. 9; in other embodiments, however the “Type” field may be 1 bit to differentiate between compressed and uncompressed Ethernet header fields. In addition, the length of “Connection ID” field can be different from that shown, e.g., 7 bits, 15 bits, 14 bits.

[0054] It should be noted that the embodiments shown in FIGS. 6-9 illustrate only a few non-limiting examples to illustrate the header formats for Ethernet header compression. Other combinations/variations of Ethernet header compression may also be used. For example, a compressed header format may, in other embodiments, also include a CRC for the original Ethernet header before compression. This may permit the receiver to be able to verify that the decompression operation is correct.

[0055] In some embodiments, a trigger may be used to determine whether the compressed Ethernet headers may be used. FIG. 10 illustrates messaging in accordance with some embodiments. As shown in FIG. 10, feedback can be provided from the receiver to the transmitter to indicate the status of receiver side, which may be provided even in an unacknowledged mode (in which data acknowledgement is not transmitted). The status may include whether the uncompressed headers have been correctly received. The feedback can be transmitted in the PDCP data PDU, utilizing the header format above. In this case, a dedicated Type for feedback can be used. Alternatively, the feedback can be sent with a PDCP control PDU, with a new value for “PDU type” to indicate the Ethernet header compression feedback.

[0056] The network can configure the number of transmissions for the feedback for a specific connection identity; the number of transmissions for each connection identity may be independent of the number of transmissions for each other connection identity and may depend, for example, on application or quality of service (QoS) associated with the connection identity. Alternatively, the network may configure a criterion to the UE to permit the UE to select the number of transmissions for the feedback. The criterion may be based on, for example, the UE’s mobility state, measured reference signal received power

(RSRP)/reference signal received quality (RSRQ)/signal-to-interference-plus-noise ratio (SINR) value from the gNB, source/destination address pair, UL/DL direction, and/or desired degree of reliability, among others. The configuration can be provided in RRC signalling or in a PDCP control PDU. When the UE
5 initially receives an uncompressed header for a certain connection identity, the UE may transmit the feedback for that connection identity after the number of transmissions from the gNB or other entity as configured by the network. Similarly, after transmitting the uncompressed Ethernet header for a specific connection identity, the UE can transmit compressed header if feedback for the
10 connection identity is received from the gNB or other entity.

[0057] In some embodiments, transmission of the compressed header may be initiated from the source without feedback from the destination. For example, the UE may transmit a compressed header for the connection after a number of transmissions of the uncompressed header has been completed. The
15 number of transmissions of the uncompressed header can be either fixed in the specification (e.g., fixed to 2 or 3) or may be configured by the network. The network can configure the number of transmissions of the uncompressed header in RRC signalling or a PDCP control PDU. The number of transmissions of the uncompressed header can be configured per UE, per cell group, per DRB, per
20 cell, per link direction (UL or DL) or any combination of above. The number of transmissions of the uncompressed header can be defined or configured depending on specific conditions. The conditions, as above, may be based on UE's mobility state, measured RSRP/RSRQ/SINR values, source/destination address pair, UL/DL direction, and/or desired degree of reliability, among
25 others.

[0058] As shown in FIG. 10, the transmitter may send one or more packets with an uncompressed Ethernet header, followed by packets with a compressed Ethernet header. The receiver may optionally send feedback on the successful reception of the uncompressed transmission to trigger follow-up
30 packet transmissions with compressed Ethernet header. During PDCP re-establishment (e.g. handover), the network can inform the UE whether to reset the Ethernet header compression operation (e.g., the maintenance of the

connection identities). This can be done by RRC signalling, PDCP control PDU etc.

[0059] An example of the RRC signalling to configure Ethernet header compression is provided below.

```

5  PDCP-Config ::= SEQUENCE {
    ...,
    [[
      cipheringDisabled ENUMERATED {true}
      OPTIONAL -- Cond ConnectedTo5GC
10  ]],
    [[
      ethernetHeaderCompression CHOICE {
        notUsed NULL,
        compression SEQUENCE {
15      maxCID INTEGER (1..16383)
      DEFAULT 15,

      drb-ContinueEthernetCompression ENUMERATED { true }
      OPTIONAL -- Need N
20      },
      ...
      },
    ]],
25  }

```

[0060] The above is a modification to the *PDCP-config* IE in 3GPP TS 38.331; similar changes may be applicable for other IEs in other embodiments, however. In the above, when *compression* is signaled instead of *notUsed*,
 30 Ethernet header compression may be enabled for the DRB. The field *maxCID* may be used to configure the maximum number of connection identities. If the field *drb-ContinueEthernetCompression* is signaled, then the UE may continue the Ethernet header compression operation without resetting the mapping relationship between the connection identities to the source/destination address
 35 (and potential other fields like VLAN identifier). Otherwise, the Ethernet header compression operation may be reset as discussed above. Although the configuration of Ethernet header compression is per DRB, in other embodiments Ethernet header compression may be configured independently for DL and UL transmissions in a DRB.

[0061] Although an aspect has been described with reference to specific example aspects, it will be evident that various modifications and changes may be made to these aspects without departing from the broader scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific aspects in which the subject matter may be practiced. The aspects illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other aspects may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various aspects is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0062] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single aspect for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed aspects require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed aspect. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate aspect.

CLAIMS

What is claimed is:

1. An apparatus of a user equipment (UE), the apparatus comprising:
5 processing circuitry configured to:
determine, based on compression rules, whether to compress a
local area network (LAN) header of a LAN packet for transmission of the
LAN packet to a destination;
in response to a determination to compress the LAN header, form
10 a compressed LAN header by removal, from the LAN header, of a source
address of the UE and a destination address of the destination of the LAN
packet; and
encode the LAN packet comprising the compressed LAN header
for transmission to the destination through a 5th generation NodeB
15 (gNB); and
a memory configured to store the compression rules.
2. The apparatus of claim 1, wherein the processing circuitry is further
configured to use a connection identity in place of a pair of the source address
20 and the destination address, and the LAN header is an Ethernet header.
3. The apparatus of claim 2, wherein the processing circuitry is further
configured to store a mapping of the connection identity to the pair of the source
address and the destination address in a connection mapping table in the
25 memory.
4. The apparatus of claim 3, wherein the processing circuitry is further
configured to alter the mapping in the connection mapping table based on at
least one of Radio Resource Control (RRC) signaling, a Packet Data
30 Convergence Protocol (PDCP) control packet data unit (PDU), or a Service Data
Adaptation Protocol (SDAP) control PDU.
5. The apparatus of claim 2, wherein the processing circuitry is further
configured to use the connection identity for compression of an uplink Ethernet

header in an uplink Ethernet packet and for decompression of an Ethernet header in a downlink Ethernet packet.

6. The apparatus of claim 2, wherein the processing circuitry is further
5 configured to use the connection identity for compression of an uplink Ethernet header in an uplink Ethernet packet and another connection identity for decompression of an Ethernet header in a downlink Ethernet packet, the other connection identity used in place of the pair of the source address and the destination address and being independent of the connection identity.

10

7. The apparatus of claim 2, wherein the processing circuitry is further configured to use a unique connection identity, within a data radio bearer, for the pair and is able to reuse the connection identity for another pair in another data radio bearer.

15

8. The apparatus of claim 2, wherein the processing circuitry is further configured to use the connection identity to represent a unique combination of the source address, the destination address, and a type/length field of the Ethernet packet.

20

9. The apparatus of claim 2, wherein the processing circuitry is further configured to use the connection identity to represent a unique combination of the source address, the destination address, a type/length field, and an 802.1Q tag of the Ethernet packet.

25

10. The apparatus of claim 9, wherein the processing circuitry is further configured to use the unique combination in the compressed Ethernet header dependent on which of the source address, the destination address, the type/length field, and the 802.1Q tag are present in an uncompressed Ethernet
30 header sent to the destination address.

11. The apparatus of claim 2, wherein the processing circuitry is further configured to use the connection identity and a type field in an octet of the

Ethernet header, the type field configured to indicate a type of the Ethernet header, including whether the Ethernet header is the compressed Ethernet header or an uncompressed Ethernet header.

5 12. The apparatus of claim 1, wherein the processing circuitry is further configured to perform Ethernet header compression or decompression in a Packet Data Convergence Protocol (PDCP) entity of the UE.

10 13. The apparatus of claim 1, wherein the processing circuitry is further configured to:

perform Robust Header Compression (ROHC) on at least one of an Internet Protocol (IP), User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Realtime Transport Protocol (RTP), or IP Encapsulating Security Payload (ESP) header separately from compression of the Ethernet
15 header.

14. The apparatus of claim 1, wherein:
the LAN header is an Ethernet header, and
the processing circuitry is further configured to determine whether to
20 compress the Ethernet header based on reception of feedback from the destination, the feedback indicating successful reception of an Ethernet packet comprising an uncompressed Ethernet header at the destination.

15. The apparatus of claim 14, wherein the processing circuitry is further
25 configured to:

determine to compress the Ethernet header based on reception of feedback from the destination indicating successful reception of a plurality of Ethernet packets each comprising the uncompressed Ethernet header.

30 16. The apparatus of claim 15, wherein the processing circuitry is further configured to:

determine a number of the plurality of Ethernet packets based on one of the connection identity or criteria comprising at least one of:

- mobility state of the UE,
reference signal received power (RSRP), reference signal
received quality (RSRQ), or signal-to-interference-plus-noise ratio
(SINR) value of reference signals from the gNB,
5 Ethernet packet travel direction, or
desired reliability.
17. An apparatus of a user equipment (UE), the apparatus comprising:
processing circuitry configured to:
10 encode a plurality of Ethernet packets each comprising an
uncompressed Ethernet header that comprises a source address of the UE
and a destination address of a destination of the Ethernet packet for
transmission through the 5G network;
decode, from the destination, feedback indicating successful
15 reception of one of the Ethernet packets at the destination;
in response to reception of the feedback, form a compressed
Ethernet header by replacement of the source address and the destination
address in an Ethernet header of each of a plurality of subsequent
Ethernet packets by a connection identity that maps a pair of the source
20 address and the destination address, the connection identity having a byte
length less than that of a combination of the source address and the
destination address, the compressed Ethernet header further comprising a
type field configured to indicate whether the Ethernet header is the
compressed Ethernet header or the uncompressed Ethernet header, the
25 connection identity and the type field disposed in a same octet; and
encode each of the subsequent Ethernet packets for transmission
to the destination; and
a memory configured to store the connection identity in a connection
mapping table.
30
18. The apparatus of claim 17, wherein:
the connection identity is unique within a data radio bearer used for the
UE,

the connection identity is reusable for another destination in another data radio bearer, and

the connection identity represents a unique combination of one of:

the source address, the destination address, and a type field of the

5 Ethernet packet, or

the source address, the destination address, the type field, and an

802.1Q tag of the Ethernet packet.

19. A non-transitory computer-readable storage medium that stores
10 instructions for execution by one or more processors of a user equipment (UE),
the one or more processors to configure the UE to, when the instructions are
executed:

perform Robust Header Compression (ROHC) on a non-Ethernet header
of a first Ethernet packet, the first Ethernet packet comprising an uncompressed
15 Ethernet header, the uncompressed Ethernet header comprising a source address
of the UE and a destination address of a destination;

transmit the first Ethernet packet to the destination through a fifth
generation NodeB (gNB);

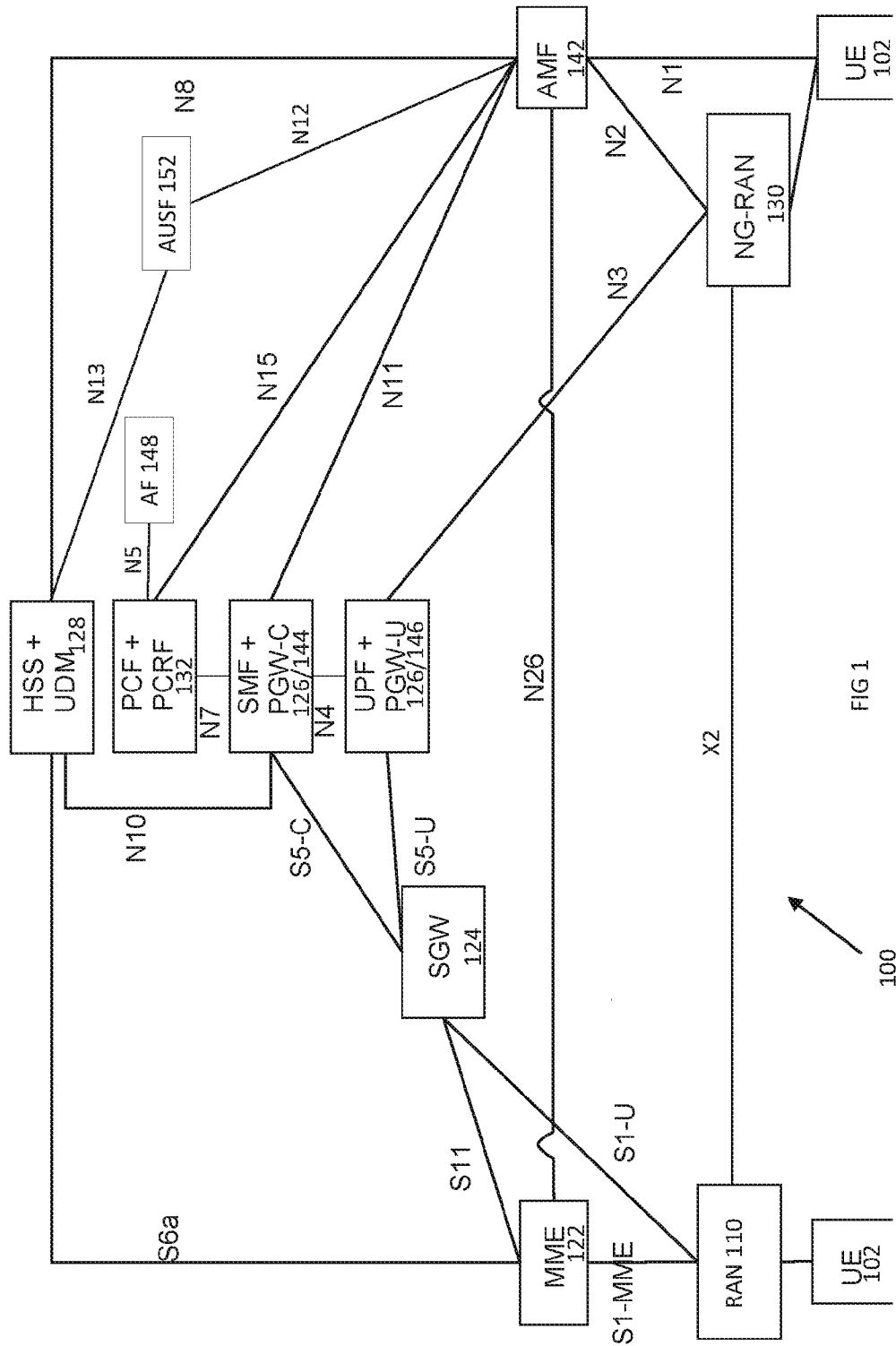
receive feedback indicating successful reception of the first Ethernet
20 packet at the destination;

in response to reception of the feedback, form a compressed Ethernet
header and Ethernet trailer, the compressed Ethernet header formed by replacing,
in an Ethernet header of a second Ethernet packet, the source address and the
destination address with a connection identity that maps a pair of the source
25 address and the destination address, the compressed Ethernet header further
comprising a type field that indicates whether the Ethernet header is the
compressed Ethernet header or the uncompressed Ethernet header,; and
transmit the second Ethernet packet to the destination.

30 20. The medium of claim 19, wherein:

the connection identity is unique within a data radio bearer used for the
UE, and

the connection identity is reusable for another destination in another data radio bearer.



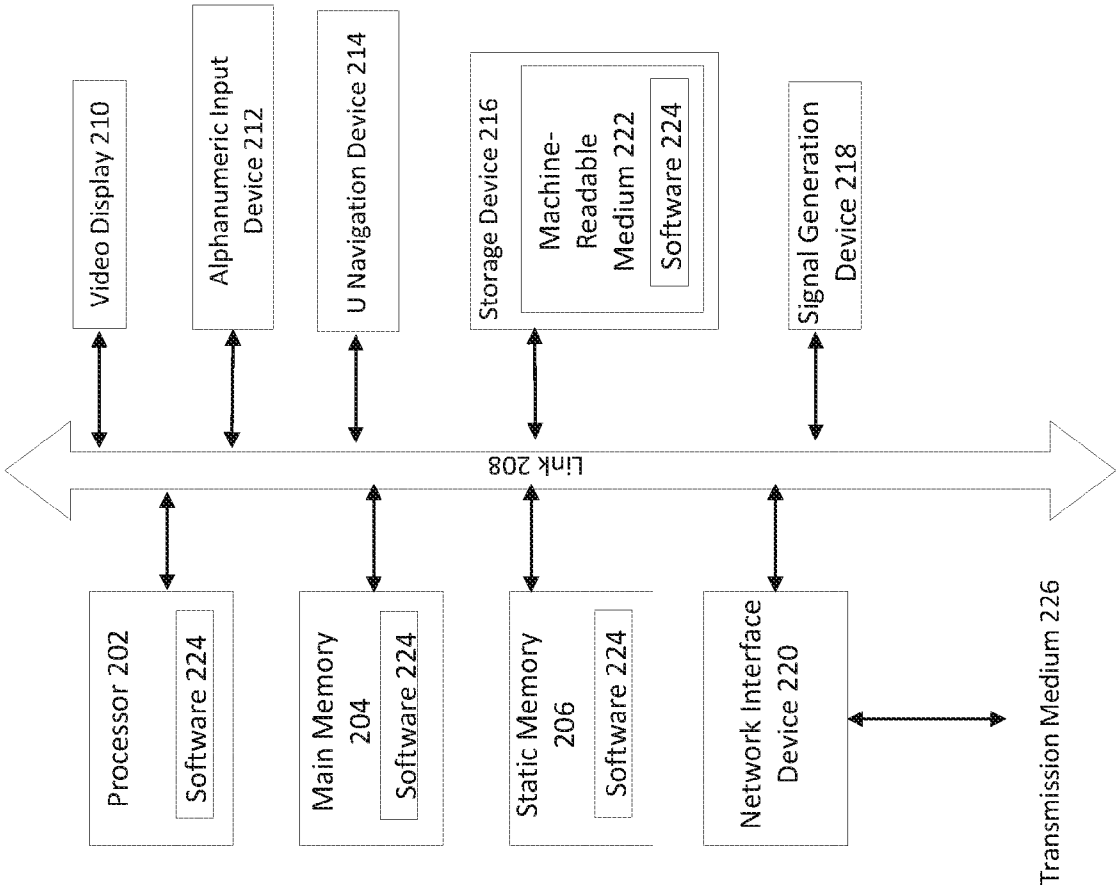


FIG. 2

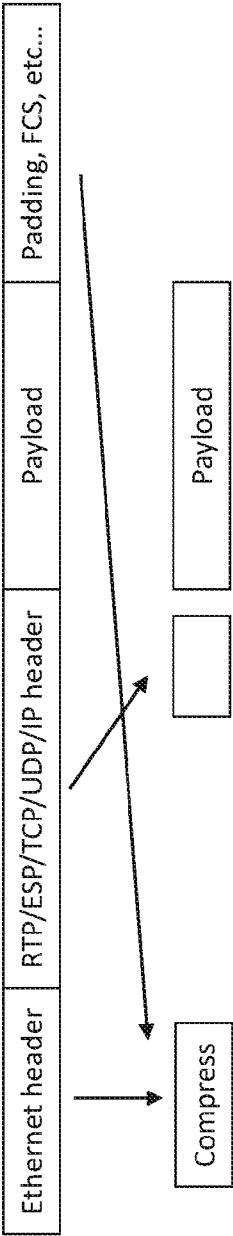


FIG. 3

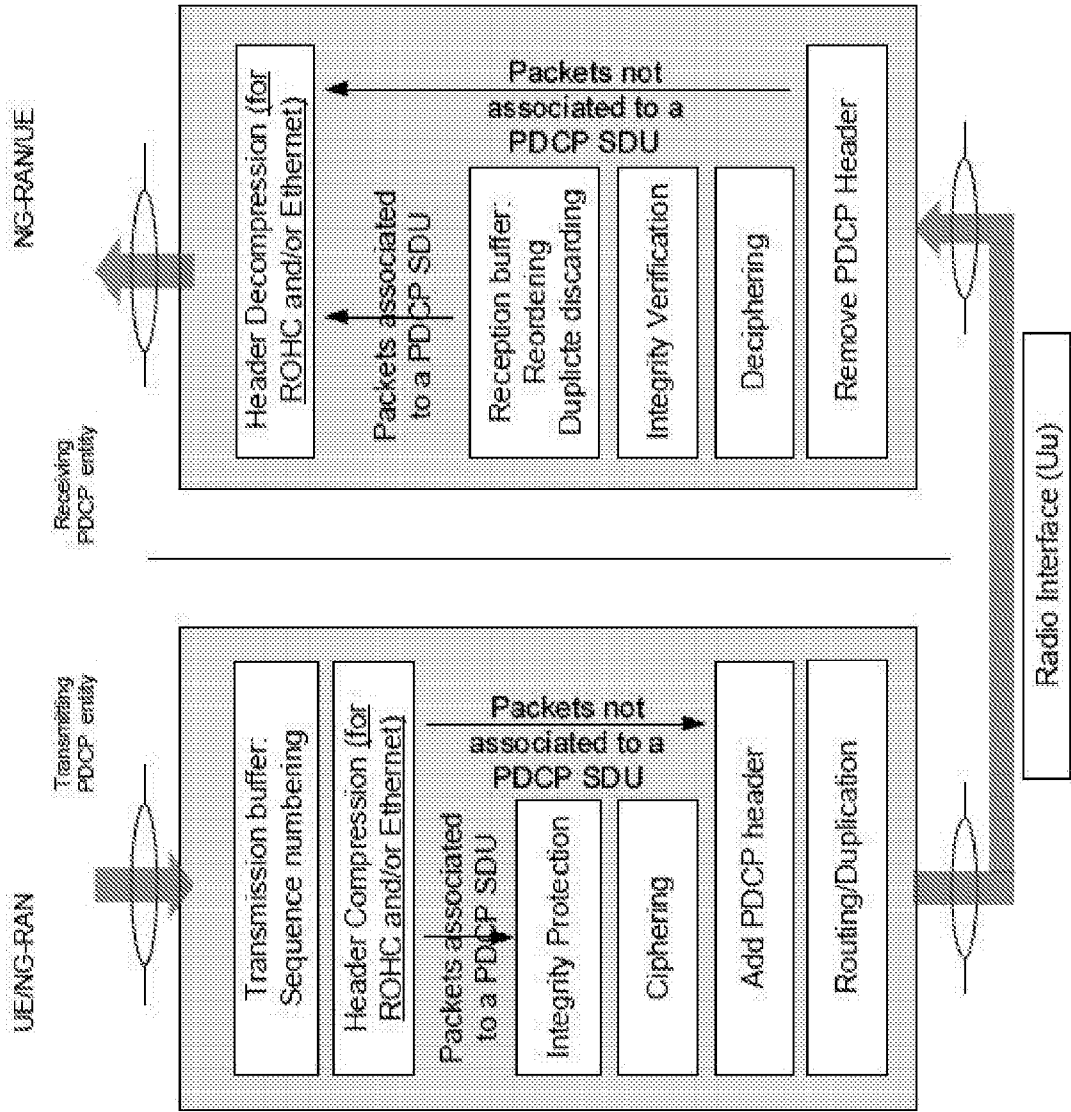


FIG. 4

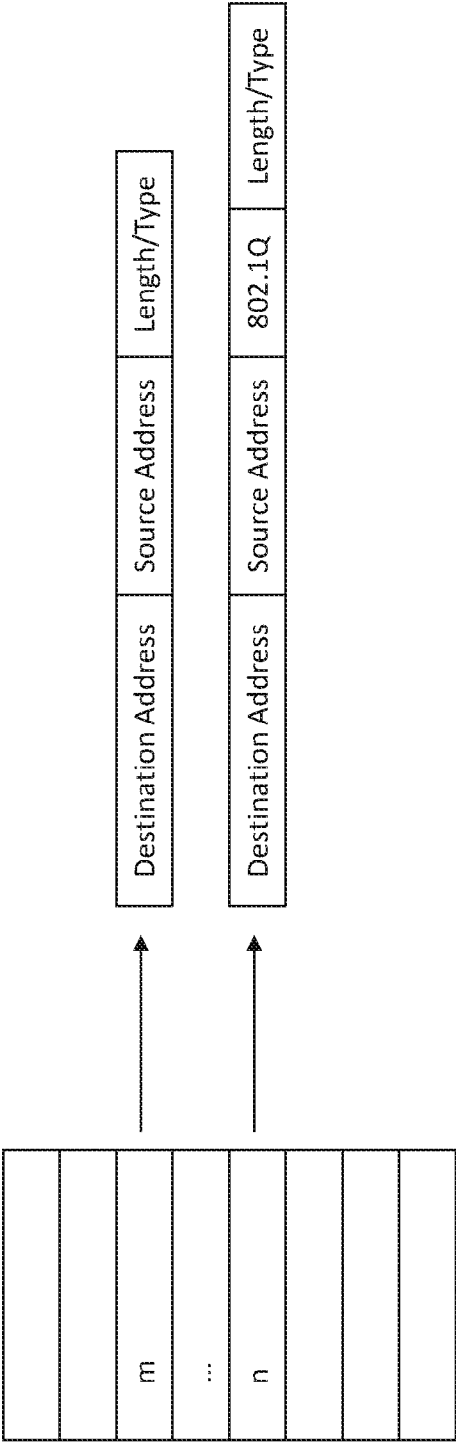


FIG. 5

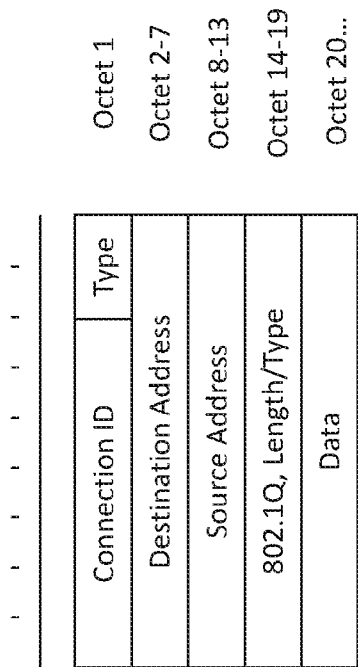


FIG. 6

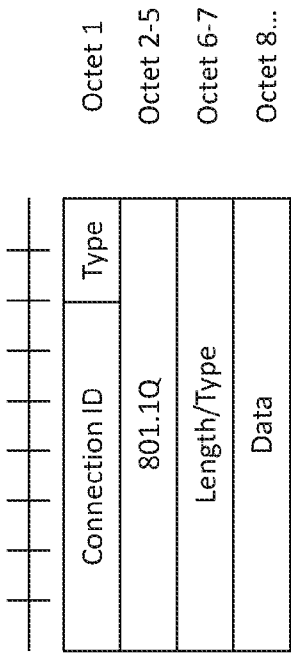


FIG. 7

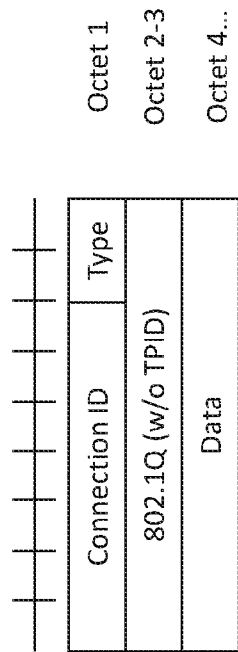


FIG. 8

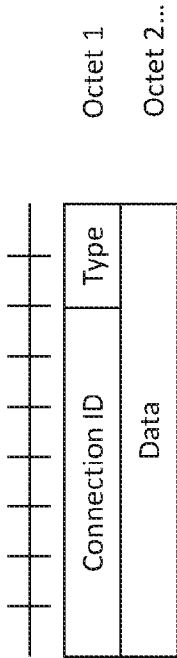


FIG. 9

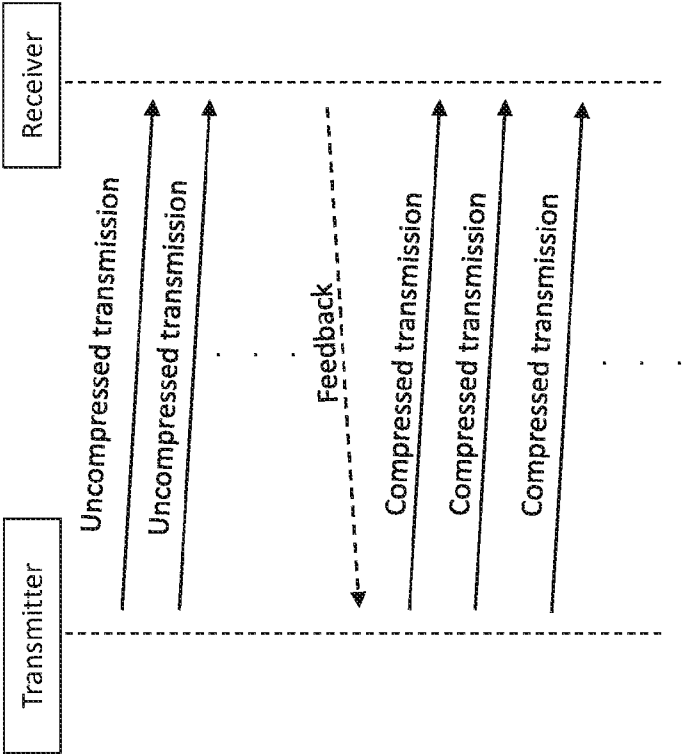


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/059177**A. CLASSIFICATION OF SUBJECT MATTER****H04L 29/06(2006.01)i, H04L 12/833(2013.01)i, H04W 28/06(2009.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L 29/06; H04L 012/28; H04L 12/805; H04L 12/861; H04L 12/833; H04W 28/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords:local area network (LAN) header, compression, source address, destination address, ethernet packet, feedback, 5G, robust header compression (ROHC)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ERICSSON, 'Ethernet Header Compression', R2-1814811, 3GPP TSG-RAN WG2 #103bis, Chengdu, China, 27 September 2018 section 2; and figures 1-2	1, 12-13
Y		2-6, 8-9, 11
A		7, 10, 14-20
Y	US 2005-0271066 A1 (YOAV VALADARSKY) 08 December 2005 paragraphs [0012], [0065], [0129]-[0131], [0142]-[0143]; and figure 8	2-6, 8-9, 11
Y	US 2013-0128808 A1 (MAARTEN MENZO WENTINK et al.) 23 May 2013 paragraphs [0088], [0107]-[0108], [0116]; claims 1, 12; and figure 4	11
A	KR 10-1724231 B1 (KONKUK UNIVERSITY INDUSTRY ACADEMIC COOPERATION FOUNDATION) 06 April 2017 paragraphs [0008]-[0025]; and claims 1-6	1-20
A	VIVO, 'Consideration on Ethernet header compression for supporting IIOT', R2-1814273, 3GPP TSG-RAN WG2 Meeting #103bis, Chengdu, China, 28 September 2018 section 2.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 February 2020 (20.02.2020)

Date of mailing of the international search report

20 February 2020 (20.02.2020)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/059177

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005-0271066 A1	08/12/2005	EP 1603304 A1 IL 162305 A US 8160106 B2	07/12/2005 16/06/2010 17/04/2012
US 2013-0128808 A1	23/05/2013	AU 2012254990 A1 AU 2012254990 B2 AU 2012255064 A1 AU 2012255064 B2 BR 112013029619 A2 BR 112013029697 A2 BR 112014004146 A2 CA 2835441 A1 CA 2835447 A1 CA 2835447 C CA 2844696 A1 CA 2844696 C CN 103748856 A CN 103748856 B CN 103765847 A CN 103765848 A CN 103765848 B EP 2710783 A2 EP 2710840 A2 EP 2710840 B1 ES 2710320 T3 HU E042265 T2 IL 229264 A IL 229264 B IL 229266 A IL 229266 B IN 755CHN2014 A JP 2014-515572 A JP 2014-520426 A JP 2014-529242 A JP 2016-015774 A JP 5746425 B2 JP 5893739 B2 JP 6195879 B2 KR 10-1557686 B1 KR 10-1789204 B1 KR 10-2014-0013090 A KR 10-2014-0016389 A KR 10-2014-0059254 A KR 10-2015-0090260 A KR 10-2016-0048220 A MX 2013013367 A MX 2013013376 A MY 164876 A RU 2013156045 A	05/12/2013 16/07/2015 12/12/2013 05/11/2015 13/12/2016 17/01/2017 21/02/2017 22/11/2012 22/11/2012 31/07/2018 28/02/2013 06/12/2016 23/04/2014 12/09/2017 30/04/2014 30/04/2014 17/08/2016 26/03/2014 26/03/2014 07/11/2018 24/04/2019 28/06/2019 30/01/2014 28/06/2018 30/01/2014 30/11/2016 03/04/2015 30/06/2014 21/08/2014 30/10/2014 28/01/2016 08/07/2015 23/03/2016 13/09/2017 06/10/2015 23/10/2017 04/02/2014 07/02/2014 15/05/2014 05/08/2015 03/05/2016 08/01/2014 08/01/2014 30/01/2018 27/06/2015

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/059177

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		RU 2013156404 A	27/06/2015
		RU 2014110974 A	27/09/2015
		RU 2579622 C2	10/04/2016
		SG 194890 A1	30/12/2013
		SG 194891 A1	30/12/2013
		UA 112773 C2	25/10/2016
		UA 113286 C2	10/01/2017
		US 10464459 B2	05/11/2019
		US 2013-0093220 A1	18/04/2013
		US 2013-0128809 A1	23/05/2013
		US 2013-0215836 A1	22/08/2013
		US 2013-0327255 A1	12/12/2013
		US 2014-0191005 A1	10/07/2014
		US 2014-0373758 A1	25/12/2014
		US 2015-0068434 A1	12/03/2015
		WO 2012-159082 A2	22/11/2012
		WO 2012-159082 A3	07/02/2013
		WO 2012-159094 A2	22/11/2012
		WO 2012-159094 A3	14/11/2013
		WO 2013-028777 A2	28/02/2013
		WO 2013-028777 A3	25/04/2013
		WO 2016-076921 A1	19/05/2016
		ZA 201309547 B	27/01/2016
		ZA 201309548 B	23/12/2015
KR 10-1724231 B1	06/04/2017	None	