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- (71) **Applicant:** NOKIA SOLUTIONS AND NETWORKS OY [FI/FI]; Karaportti 3, 02610 Espoo (FI).
- (72) **Inventors:** PAWLAK, Krystian; ul. Matejki 13, 63-400 Ostrow Wielkopolski (PL). SHARMA, Amit Kumar; Legnicka 46/48, 53-674 Wrocław (PL). TURPINEN, Samuli Heikki; Poolatie 3A, 91100 Ii (FI). KOSKELA, Timo; Harjapääntäti 32 B 30, 90120 Oulu (FI).
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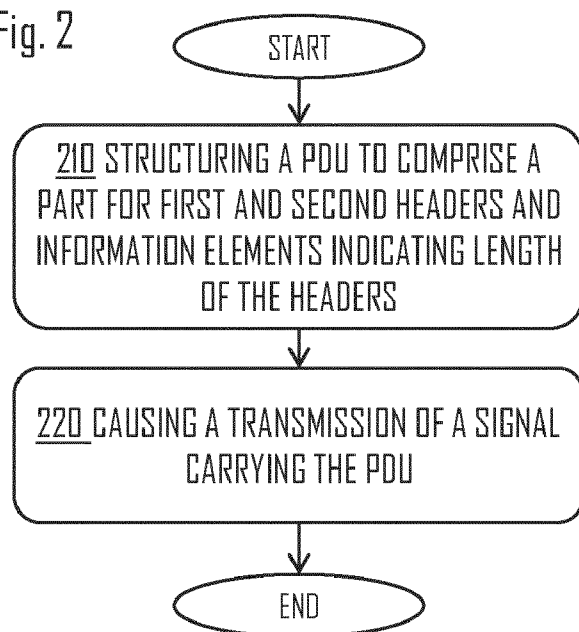
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- (54) **Title:** IMPROVING COMMUNICATION EFFICIENCY INDICATING THE LENGTH OF TWO HEADERS IN THE PDU

Fig. 2



(57) **Abstract:** There is provided a method and an apparatus performing said method, the method comprising: structuring, by a network element of a cellular communication system, a protocol data unit to comprise a header part at least for a first header and for a second header, wherein the protocol data unit comprises a first information element indicating a length of the first header and a second information element indicating a length of the second header; and causing a transmission of a signal carrying the protocol data unit to another network element of the cellular communication system.

IMPROVING COMMUNICATION EFFICIENCY INDICATING THE LENGTH OF TWO HEADERS IN THE PDU

5 TECHNICAL FIELD

The invention relates to communications.

BACKGROUND

In a communication network, data may be transmitted between a transmitter and a receiver. Processing the data may cause delay to the transmission process.
10 Therefore, it may be beneficial to provide solutions which enable reducing latency in the transmission process.

BRIEF DESCRIPTION

According to an aspect, there is provided the subject matter of the independent claims. Some embodiments are defined in the dependent claims.

15 One or more examples of implementations are set forth in more detail in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

In the following embodiments will be described in greater detail with reference
20 to the attached drawings, in which

Figure 1 illustrates an example a cellular communication system to which embodiments of the invention may be applied;

Figures 2 and 3 illustrate flow diagrams according to some embodiments;

Figures 4A to 4F illustrate some embodiments;

25 Figure 5 illustrates an embodiment;

Figures 6A to 6B illustrate some embodiments;

Figure 7 illustrates an embodiment; and

Figures 8 and 9 illustrate block diagrams of apparatuses according to some embodiments.

30 DETAILED DESCRIPTION OF SOME EMBODIMENTS

The following embodiments are exemplifying. Although the specification may refer to “an”, “one”, or “some” embodiment(s) in several locations of the text, this does not necessarily mean that each reference is made to the same embodiment(s), or that a particular feature only applies to a single embodiment. Single features of different

embodiments may also be combined to provide other embodiments.

Embodiments described may be implemented in a radio system, such as in at least one of the following: Worldwide Interoperability for Micro-wave Access (WiMAX), Global System for Mobile communications (GSM, 2G), GSM EDGE radio access Network (GERAN), General Packet Radio Service (GPRS), Universal Mobile Telecommunication System (UMTS, 3G) based on basic wideband-code division multiple access (W-CDMA),
5 high-speed packet access (HSPA), Long Term Evolution (LTE), and/or LTE-Advanced.

The embodiments are not, however, restricted to the system given as an example but a person skilled in the art may apply the solution to other communication
10 systems provided with necessary properties. Another example of a suitable communications system is the 5G concept. 5G is likely to use multiple input – multiple output (MIMO) techniques (including MIMO antennas), many more base stations or nodes than the LTE (a so-called small cell concept), including macro sites operating in co-operation with smaller stations and perhaps also employing a variety of radio technologies for better
15 coverage and enhanced data rates. 5G will likely be comprised of more than one radio access technology (RAT), each optimized for certain use cases and/or spectrum. 5G mobile communications will have a wider range of use cases and related applications including video streaming, augmented reality, different ways of data sharing and various forms of machine type applications, including vehicular safety, different sensors and real-time
20 control. 5G is expected to have multiple radio interfaces, namely below 6GHz, cmWave and mmWave, and also being integratable with existing legacy radio access technologies, such as the LTE. Integration with the LTE may be implemented, at least in the early phase, as a system, where macro coverage is provided by the LTE and 5G radio interface access comes from small cells by aggregation to the LTE. In other words, 5G is planned to support both
25 inter-RAT operability (such as LTE-5G) and inter-RI operability (inter-radio interface operability, such as below 6GHz – cmWave, below 6GHz – cmWave – mmWave). One of the concepts considered to be used in 5G networks is network slicing in which multiple independent and dedicated virtual sub-networks (network instances) may be created within the same infrastructure to run services that have different requirements on latency, reliability, throughput and mobility. It should be appreciated that future networks will most probably utilize network functions virtualization (NFV) which is a network architecture concept that proposes virtualizing network node functions into “building blocks” or entities that may be operationally connected or linked together to provide services. A virtualized network function (VNF) may comprise one or more virtual machines running computer
30 program codes using standard or general type servers instead of customized hardware. Cloud computing or cloud data storage may also be utilized. In radio communications this may mean node operations to be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head. It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. It should also be understood that

the distribution of labor between core network operations and base station operations may differ from that of the LTE or even be non-existent. Some other technology advancements probably to be used are Software-Defined Networking (SDN), Big Data, and all-IP, which may change the way networks are being constructed and managed.

5 Figure 1 illustrates an example of a cellular communication system (also referred to as a radio communication system) to which some embodiments may be applied. Cellular radio communication networks (also referred to as radio communication networks), such as the Long Term Evolution (LTE), the LTE-Advanced (LTE-A) of the 3rd Generation Partnership Project (3GPP), or the predicted future 5G solutions, are typically composed of
10 at least one network element, such as a network element 102 (e.g. a network node), providing a cell 100. The cell 100 may be, e.g., a macro cell, a micro cell, femto, or a pico-cell, for example. The network element 102 may be an evolved Node B (eNB) as in the LTE and LTE-A, a radio network controller (RNC) as in the UMTS, a base station controller (BSC) as in the GSM/GERAN, or any other apparatus capable of controlling radio
15 communication and managing radio resources within the cell 100. For 5G solutions, the implementation may be similar to LTE-A, as described above. The network element 102 may be a base station or an access node. The cellular communication system may be composed of a radio access network of network nodes similar to the network element 102, each controlling a respective cell or cells.

20 The network element 102 may be further connected via a core network interface to a core network 190 of the cellular communication system. In an embodiment, the core network 190 may be called Evolved Packet Core (EPC) according to the LTE terminology. The core network 190 may comprise a mobility management entity (MME) and a data routing network element. In the context of the LTE, the MME may track mobility of terminal
25 devices 110, 120, and may carry out establishment of bearer services between the terminal devices 110, 120 and the core network 190. In the context of the LTE, the data routing network element may be called a System Architecture Evolution Gateway (SAE-GW). It may be configured to carry out packet routing to/from the terminal devices 110, 120 from/to other parts of the cellular communication system and to other systems or networks, e.g. the
30 Internet.

 The terminal devices 110, 120 may comprise, for example, cell phones, smart phones, tablets, and/or Machine Type Communication (MTC) devices. There may be a plurality of terminal devices 110, 120 within the cell 100, and thus the network element 102 may provide service for more than two terminal devices. As shown in Figure 1, the terminal
35 devices may be in communication (i.e. transfer data and/or control information with the network) with the network element 102 using communication links 112, 122 respectively. These communication links 112, 122 may be referred to as conventional communication links in the cellular communication system. It is obvious for a skilled person that the conventional communication links may be used to transmit, for example, voice and packet

data.

The cellular communication system may support Device-to-Device (D2D) communication. This may mean that terminal devices, such as the terminal devices 110, 120, may be able to directly communicate with each other in the system. D2D communication link 114 between the terminal devices 110, 120 may enable data and/or configuration information transfer between the devices. Such may be beneficial, for example, in offloading the network. In one example, a first terminal device 110 has data to transmit to a second terminal device 120. If a D2D communication link is established or may be established between the two devices 110, 120, it may be beneficial to transmit that data directly using the D2D link. This may decrease the load of the network as the data does not need to be transmitted via the network element 102, for example.

Also, as discussed above, the cellular communication system may comprise a number of network elements which are similar to the network element 102, for example. Different network elements, for example, the network element 102 and some other similar network element (e.g. a base station) may be connected to each other wired or wirelessly (e.g. X2-interface in LTE). Data and information may be transmitted between two or more network elements (e.g. base stations), between a network element and a terminal device, and also between terminal devices. In some examples, Carrier Aggregation (CA) and/or dual connectivity techniques may be utilized in the cellular communication system.

The cellular communication and particularly the cellular communication systems may comprise different layers to enable data transfer between entities of said system. For example, the system may utilize a Medium Access Control (MAC) layer that may map logical channels to transport channels. For example, Common Control Channel (CCCH), Dedicated Control Channel (DCCH), and/or Dedicated Traffic Channel (DTCH) may be mapped in the uplink direction to Uplink Shared Channel (UL-SCH). Further, for example, a terminal device may map the UL-SCH to Physical Uplink Shared Channel (PUSCH) in order to enable the physical transfer of data in the uplink direction. Similar logic applies to downlink direction, but there may also be different logical channels to be mapped. It may be that the logical channel(s) are for D2D or base station to base station (e.g. via X2 interface) communication. Thus, the proposed solution may be used to, for example downlink, uplink, D2D and/or base station to base station communication.

The MAC layer may receive data from a Radio Link Control (RLC) layer (i.e. the logical channels are comprised in the RLC layer). Received data may be in the form of MAC Service Data Units (SDUs). That is, SDUs may be used to carry data from one layer to another, for example, from the RLC to MAC layer. Generally, the processing entity (e.g. network element 102 or terminal device 110) performing the transform between layers, may then form a MAC Physical Data Unit (PDU) or PDUs, wherein a MAC PDU (referred to hereinafter also plainly as PDU) may comprise a header (i.e. MAC header), SDUs (i.e. one or more MAC SDUs), and a control elements (i.e. one or more MAC control elements).

One aspect in future communication systems, particularly in cellular systems, is to reduce latency in order to increase communication efficiency (e.g. increase data rates). For example, 5G system may be one example of such system. Further, processing power of a single processor may possibly increase in the future thus enabling faster processing of data, but there may also be some limitations there. That is, processing, for example, elements of a PDU may be beneficial to be performed such that the processing of two or more elements may happen concurrently instead of processing an element after another in a consecutive manner. For example, it may be beneficial to configure a processing unit to process two or more PDU elements (e.g. SDUs or CEs) at the same time, thus reducing latency compared with a scenario where each element is processed consecutively and possibly more than once. In other words, the processing unit may be beneficial to be configured to perform parallel processing of elements of a PDU.

Therefore, there is provided a solution for PDU structure that may support parallel processing of different PDU elements, such as CEs and SDUs. The solution may enable decreasing system latency in a cellular communication system, for example. The solution, at least in some embodiments, may decrease variance of latency, thus making the network latency more predictable. It is further reminded that although some examples and/or embodiments are described as relating to 5G system or specifically to MAC PDUs, it may be possible to utilize the proposed structure in future or legacy communication systems that utilize similar logic. That is, for example, MAC layer may be essentially for the same purpose (e.g. for mapping the logical channels to transport channel(s)) in the future communication system, but not necessarily named as MAC layer. However, in some embodiments, the described solution is particularly suitable for a 5G system.

Figure 2 illustrates a flow diagram according to an embodiment. Referring to Figure 2, in step 210, a network element of a cellular communication system may structure a protocol data unit to comprise a header part at least for a first header and for a second header, wherein the protocol data unit comprises a first information element indicating a length of the first header and a second information element indicating a length of the second header. In step 220, the network element may cause a transmission of a signal carrying the protocol data unit to another network element of the cellular communication system.

Figure 3 illustrates a flow diagram according to an embodiment. Referring to Figure 3, in step 310, a network element of a cellular communication system may obtain a protocol data unit comprising a header part at least for a first header and for a second header, wherein the protocol data unit comprises a first information element indicating a length of the first header and a second information element indicating a length of the second header. In step 320, the network element may determine, based on the first and second information elements, the lengths of the first and second headers. In step 330, the network element may perform an action based on the determined lengths of the first and second headers.

The described solution may be applicable to uplink and/or downlink transmissions. That is, the structured and/or obtained (e.g. received) PDUs may be used to carry downlink and/or uplink information. Thus, the network element performing the steps of Figure 2 may be the network element 102 or the terminal device 110, for example.

5 Similarly, the network element performing the steps of Figure 2 may be the network element 102 or the terminal device 110, for example. A skilled person will understand how the PDU transmission may be performed in a cellular communication system between, for example, eNB and User Equipment (UE). For example, the network element 102 may transmit downlink data to the terminal device 110 utilizing PDU(s). Similarly, the terminal device 110

10 may transmit uplink data to the network element 102 utilizing PDU(s). However, the described structuring of the PDU brings additional benefits for the system as briefly described above.

Let us now look closer on how the PDU may be structured. Figures 4A to 4F illustrate some embodiments. Referring to Figure 4A, a PDU 400 may comprise a first

15 information element 412 and a second information element 422 indicating the lengths of the first header 410 and the second header 420. I.e. first information element 412 may indicate the length 411 of the first header 410 and the second information element 422 may indicate the length 421 of the second header 420. The first and/or second information elements may also be referred to, for example, as first and second fields or first and second special

20 fields.

As described, the PDU 400 may comprise a part for the first and second headers 410, 420. Said part may be continuous or it may be comprised of two or more parts that are separated by some other part of the PDU. For example, there may be CEs between the two headers 410, 420. It needs to be noted that in some cases length of the first and/or the

25 second header 410, 420 is zero. This may be indicated with the information elements 412, 422 accordingly. Thus, the PDU 400 may not necessarily comprise data 440 to which the headers 410, 420 are associated to. On the other hand, the PDU 400 may comprise only one of the headers 410, 420. For example, if the first header 410 is for CEs and the second header 420 is for SDUs, and there is no CEs to be transmitted, the first information element

30 412 may indicate zero. Thus, the receiver of the PDU 400 may know that there are no CEs or the first header 410 in the PDU 400. The receiver may then proceed on processing the SDUs accordingly based at least partly on the length of the second header 420.

However, the PDU 400 may comprise the data part 440. In some embodiment, the data part 440 comprise one or more SDUs and/or one or more CEs. In an embodiment,

35 the data part comprises only SDUs or similar data units. In an embodiment, the second header 420 is for the data part 440. In an embodiment, the second header is for a subpart of the data part 440 and the first header is for another subpart of the data part 440. Thus, the PDU 400 may comprise one or more CEs and/or one or more SDUs. The CE(s) and/or SDU(s) may be situated, for example, in the data part 440 and/or in some cases in the first

header 410 and/or in the second header 420. In one example, the first header 410 comprises all CEs of the PDU 400, whereas all the SDUs of the PDU are comprised in the data part 440. However, the grouping may also be different as discussed below in more detail.

5 In an embodiment, the header part for the first and second headers 410, 420 comprises the first and second information elements 412, 422. Looking at Figure 4A, we can thus see that the header part of the PDU 400 may comprise the information elements 412, 422 and also the headers 410, 420. Also, in some examples with reference to Figure 4B, the header part may comprise, in some embodiments, a PDU control information 402.
10 Purpose of the PDU control information 402 may be to indicate how the receiver should interpret data of the PDU 400 following the PDU control information 402 (e.g. headers, CEs, and/or SDUs).

Referring to Figure 4B, the PDU 400 may comprise one or more control elements 416, 417 and/or one or more service data units 442. In the particular example of
15 Figure 4B, the PDU 400 may comprise the SDUs 442 and the CEs 416, 417, wherein the first header 410 is associated with the CEs 416, and wherein the second header 420 is associated with the SDUs 442.

In an embodiment, the first header 410 comprises one or more sub-headers. In the example of Figure 4B, the first header 410 comprises sub-headers 414, 415, wherein a
20 first sub-header 414 is for a first CE 416, and wherein a second sub-header 415 is for a second CE 417.

In an embodiment, the second header 420 comprises one or more sub-headers. In the example of Figure 4B, the second header 420 comprises sub-headers 424 (i.e. three sub-headers), wherein each sub-header is for a particular SDU 442 (i.e. one sub-header for
25 one SDU).

In an embodiment, the first and second headers 410, 420 each comprise one or more sub-headers 414, 415, 424, each sub-header 414, 415, 424 being associated with CE 416, 417 or a SDU 442 of the PDU 400. This may mean that there is one sub-header for each CE or SDU.

30 Sub-header, like the sub-headers 414, 415, 424, may carry control information of a CE or a SDU. For example, a sub-header for a CE may carry or comprise Logical Channel Identity (LCID) value indicating specific MAC Control Element. . This information (i.e. LCID or similar identifier) may enable the receiver (or a scheduler) to interpret information in MAC CE field. As described, the PDUs, SDUs and/or CEs described may be
35 MAC PDUs, SDUs and/or CEs, for example.

Similarly, for example, a sub-header for a SDU may carry or comprise an identifier (e.g. LCID) indicating a logical channel to which the SDU is related to. Further, a sub-header for a SDU carry or comprise length indicator indicating a length of the SDU. At

least in some embodiments, the length of CE may be predetermined (e.g. defined by radio communication specifications).

In an embodiment, a sub-header, such as the sub-headers 414, 415, 424, does not comprise extension field (E). That is, there may not be a need for the E field because
5 the length of the header, in which the sub-header is comprised, may be known. Also, the length of a sub-header may be known, so the receiver may acquire knowledge how many sub-headers there are in a header. For example in Figure 4B, the second information element 422 may indicate a length of the second header 420. The length of a sub-header 424 may be constant or predetermined by system parameters. Thus, by dividing the overall
10 length of the header 420 with the length of the sub-header 424, the receiver may determine that there are 3 sub-headers 424 in the header 420.

Let us now clarify how the proposed structure may bring benefits, as discussed above, with reference to Figure 6A illustrating an embodiment of the invention. The PDU 400 may be shown to comprise the first header 410, second header 420 and the SDUs 440.
15 Further, the PDU 400 may comprise the first and second information elements 412, 422 indicating the length of the headers 410, 420. Let us further assume that the PDU 400 has been transmitted to a receiver (e.g. to a terminal device) using a transport block (TB) onto which the PDU is mapped. The receiver or some other network element that has obtained the PDU may start to process the PDU 400. The processing may comprise reading the
20 information elements 412, 422.

Now, as the information elements 412, 422 may indicate the length of the first and second headers 410, 420, the processing unit (e.g. the receiver or some part of the receiver) may determine where the second header 420 starts, and further where the SDUs 440 start. For example, the processing unit may determine the first header 410 and its
25 location in the PDU 400, and further separate the first header 410 from the PDU 400. The first header 410 may then, in this example, be processed in consecutive way by processing the elements of the first header 410 (e.g. sub-headers and CEs) one after another. The processing of the first header 410 may be performed by said processing unit or by some other processing unit (e.g. a scheduler).

30 The processing unit may become aware about the location of the first header 410 by first knowing the length of the first header 410, and further by knowing where the first header 410 starts in the PDU 400. Starting point may be known after the second information element 422 is processed, or by knowing the PDU structure and lengths of the information elements 412, 422. The length of the information elements 412, 422 may be
35 predetermined, for example, 8 bits (i.e. 1 byte) each.

Knowing where the second header 420 starts and ends, the processing of the PDU 400 may proceed to the second header 420. Processing of the first and second headers 410, 420 may be performed at least partially in parallel. That is, knowing the lengths 414, 424, the first and second headers 410, 420 may be processed simultaneously or at

least substantially simultaneously. One aspect having an effect to this may be the fact that, for example, the SDUs 442 within the PDU 400 may be actually received at different times. On the other hand the SDUs 442 may be received simultaneously. It is clear that processing of an SDU may not start before receiving the SDU. In some embodiments, TB comprising
5 the SDUs 442 (e.g. carrying the PDU 400) needs to pass CRC check before the TB is mapped back to the MAC layer by the receiver. By mapping the TB back to the MAC layer, the receiver may acquire the PDU 400 and the payload of the PDU 400. Therefore, the SDUs 442 may be processed simultaneously, as the TB may already have been fully received before the mapping back to the MAC layer may happen.

10 The processing of the second header 420 may comprise processing the sub-headers 424A-424C in parallel meaning that the sub-headers may be processed simultaneously. The length of a sub-header within the second header 420 may be fixed, and thus the processing unit may know where the sub-headers are located within the second header 420. In the example of Figure 6A, the sub-header 424A may be associated
15 with the SDU 442A, the sub-header 424B may be associated with the SDU 442B, and the sub-header 424C may be associated with the SDU 442C. Thus, the SDUs 442A-B may be processed in parallel. Thus, in the example of Figure 6A using the described PDU structure, the receiver may start to process the SDUs 442 of the PDU 400 after knowing the length of the second header 420 (e.g. by reading at least the second information element 422). The
20 SDUs 442 may further be transmitted or sent to a RLC layer for further processing.

In an embodiment, with reference to Figure 4B, the first header 410 is a control element header for one or more control elements and the second header 420 is a service data unit header for one or more service data units. That is, the first header 410 may comprise sub-headers which are for CEs and the second header 420 may comprise sub-headers which are for SDUs, for example.
25

In an embodiment, the first header 410 (or the control element header) comprises the one or more CEs 416, 417. This may be beneficial, for example, when the PDU is processed as described with reference to Figure 6A. However, in some embodiments the CEs may also be located in some other part of the PDU 400. That is, not
30 in the first header 410.

Referring to the embodiment of Figure 4C, the PDU comprises a third information element 432. The third information element 432 may indicate a length of a part 430 of the PDU 400 for one or more CEs 416, 417. Additionally or alternatively, the third information element 432 may indicate length of a part for one or more SDUs 442. However,
35 in the example of Figure 4C, the third information element 432 may indicate the length of the part 430 (i.e. comprising the CEs 416, 417). In the case that the part 430 comprises the one or more CEs 416, 417, said part may be associated with the first header 410, for example. In some other examples, said part may be associated with the second header.

Referring to Figure 4C, by reading the first, second, and third information elements 412, 422, 432, the receiver may acquire knowledge of lengths of the first header 410, the CE part 430, and the second header 420. Length of the SDU part 440 may be determined from the sub-headers of the second header 420.

5 Figure 6B illustrates processing of the PDU 400 that has a structure described in relation to Figure 4C. Processing, by the receiver (e.g. a processing unit), of the second header 420 and the associated SDUs 442 may be similar to that of what was described in relation to Figure 6A. That is, the SDUs 442A-B may be processed in parallel, thus possibly reducing latency.

10 Now, the additional third information element 432 may bring further benefits. That is, the receiver may now become aware of the length of the part comprising the CEs 416, 417 (the CEs are not now comprised in the first header 410). Thus, knowing the length of the first header 410 and said part comprising the CEs 416, 417, the receiver may process the CEs in parallel. This may be similar as the parallel processing of the SDUs 442. Also,
15 as explained above, the first header 410 and the CEs 416, 417 may be processed simultaneously (e.g. in parallel) with the second header 420 and the SDUs 442.

To be even clearer, the receiver may process the first, second, and third information elements 412, 422, 432 after obtaining the PDU 400. After processing the first and third information elements 412, 432, the receiver may cause an initiation of processing
20 of the part A shown in Figure 6B. After processing the second information element 422, the receiver may cause an initiation of processing of the part B. The part A and B may be processed in parallel by the receiver or by some other processing unit. For example, the receiver may process the part B, whereas the part A may be processed by a scheduler. Thus, the CEs 416, 417 and the SDUs 442 may be processed in parallel. Hence, latency
25 may be reduced.

The third information element 432 may be, for example, 8 bits long (i.e. 1 byte). That is, the length may be indicated with 8 bits. Similarly, the first and second information elements 412, 422 may indicate lengths with 8 bits, for example. In some embodiments, the length of the header parts 410, 420 and/or some other part of the PDU 400 is indicated in
30 bytes resolution.

Referring to Figure 4D, the headers 410, 420, CE part 430, and the SDU part 440 may be arranged into the PDU in an alternative way compared with the examples of Figures 4B and 4C, for example. The PDU 400 illustrated in Figure 4D according to an embodiment, comprises the first, second and third information elements 412, 422, 432. The
35 PDU 400 may comprise the PDU control information 402. The first and second headers 410, 420 may be arranged, for example by the network element 102 or a terminal device generating or structuring the PDU 400, such that the first and second headers 410, 420 are situated in the PDU 400 after the first, second and third information elements 412, 422, 432. Further, in the embodiment of Figure 4D, the first header 410 does not comprise the CEs

416, 417 which are comprised in the PDU part 430 (i.e. comprising the CEs 416, 417). The last part of the PDU 440 may comprise the SDUs 442.

It may also be that, in some embodiments, the PDU 400 is generated such that the order of part 430 and 440 is reversed. It may also be that, in some embodiments, the PDU 400 is generated such that the order of the first and second headers 410, 420 is reversed. This may apply to, for example, embodiments of Figure 4A, 4B, 4C and 4D. Similarly, the first, second and third information elements 412, 422, 432 may be arranged in the PDU 400 in a different order, e.g. the second information element 422 may be arranged to be situated successive to the PDU 400 control information 402, wherein the first and third information elements 412, 432 may then follow. Therefore, as discussed, the order of different elements in the PDU 400 may vary depending on the implementation. Benefits of the solution may be attained as long as there are the first and second information elements 412, 422 indicating the length of the first header 410 and the second header 420. It needs to be noted at this point that in some cases the length of the first header 410 and/or the second header 420 may be zero. The first and/or second information elements 412, 422 may so indicate.

Referring to an embodiment of Figure 4E, the one or more sub-headers 414, 424 may be arranged, for example by the network element 102, into the first and second headers 410, 420 according to the length of the sub-headers 414, 415, 424 such that the first header 410 comprises one or more sub-headers 414, 415 having a first length (i.e. indicated with L) and the second header 420 comprises one or more sub-headers 424 having a second length (i.e. indicated with 2L). In some examples, L may depict one byte whereas 2L may depict two bytes. That is, L may mean that the field indicating SDU length in a sub-header is one byte and 2L may mean that the field indicating SDU length in a sub-header is two bytes.

In an embodiment, a sub-header for a CE is one byte long. The length of sub-headers for SDUs may vary, e.g. there may be sub-headers having length of 2 bytes (e.g. one for indicating length of SDU and one for LCID) or length of 3 bytes (e.g. 2 bytes for indicating length of SDU).

Each sub-header 414, 415, 424 may be for a CE or a SDU. That is, each sub-header may be associated with a CE or a SDU 452, 462. As the sub-headers 414, 415, 424 may be arranged by their lengths to the first and second headers 410, 420, parts 450, 460 may each comprise both CEs and SDUs at least in cases where sub-headers for CEs have a length of 2 bytes or more. For example, the sub-headers 414 may comprise one sub-header for a CE and one for a SDU, wherein said CE and SDU are comprised in the part 450. For example, the sub-headers 424 may comprise one sub-header for a CE and two for a SDU, wherein said CE and SDUs are comprised in the part 460. In one example, sub-headers 414 have a length of 1 byte and are for CEs. Therefore, the part 450 may comprise

only CEs. The part 460 may then comprise SDUs having a variable length, wherein the sub-headers 424 have a fixed length (e.g. 2 or 3 bytes).

In an embodiment, a length of a sub-header for a CE is fixed. That is, each sub-header for CE has a fixed length which may be determined by, for example, cellular communication specifications. In some embodiments, the length of the first header 410 is
5 indicate with number of sub-headers in the first header 410. Similar logic may apply to the second header 420 if the sub-headers in the second header 420 are of equal length.

In an embodiment, the PDU 400 further comprises the third information element 432 indicating length of a part 450 of the PDU 400 for one or more control elements 452
10 and/or for one or more service data units 452, said part 450 being associated with the first header 410 or the second header 420. As discussed above, the third information element 432 may be, in some embodiments, be used to indicate a length of a part comprising only CEs. However, if the sub-headers 414, 424 are arranged according to their lengths, as illustrated in Figure 4E for example, the third information element 432 may be used to
15 indicate the length of the part 450 or the part 460. This may enable the receiver to determine where the parts 450, 460 are located in the PDU 400. For example, the length of the part 450 may be defined by the CEs and/or SDUs 452 within the part 450. Thus, the length indication by the third information element 432 may further enhance the processing of the PDU at the receiver.

In an embodiment, the PDU 400 comprises a fourth information element indicating a length of a third header, and a fifth information element indicating a length of
20 another part of the PDU 400 comprising one or more CE and/or SDUs associated with the third header. For example, if the first header 410 comprises sub-header(s) having a first length and the second header 420 comprises sub-header(s) having a second length, the third header may comprise sub-header(s) having a third length. There may further be more
25 information elements and headers for similar purposes. For example, there may be sub-headers of four different lengths in the PDU 400, wherein the sub-headers are grouped in the headers according to their lengths. For example, the first length may be 1 byte, the second length may be 2 bytes and the third length may be 3 bytes. In such example, the
30 first header may comprise sub-headers for CEs, and the second and third headers may comprise sub-headers for SDUs.

In an embodiment, the PDU 400 comprises a third information element indicating a length of a third header of the PDU 400. For example, the first information
35 element 412 may indicate length of the first header 410 comprising one or more sub-headers for one or more CEs. Said CEs may be comprised in the first header 410. Further, the second information element 422 may indicate length of the second header 420 comprising one or more sub-headers for one or more SDUs. The third header may comprise one or more sub-headers for one or more SDUs. The sub-headers comprised in the second header 420 may have a first length (e.g. 2 bytes), whereas the sub-headers of the third

header may have a second length (e.g. 3 or 4 bytes). The transmitter may thus arrange the sub-headers for the SDUs according to their lengths within the PDU 400. As described in the previous embodiment, the PDU 400 may also comprise a fourth information element to enable the different SDUs to be processed in parallel. However, in some embodiments, this may not be necessary, and thus the PDU 400 may comprise three headers and three information elements indicating the lengths of the headers.

Referring to Figure 4F, the PDU 400 may further comprise a padding part 470, wherein a length of the padding part 470 is based at least on the indicated lengths of the first and second headers 410, 420. Further, the length of the data part 440 may affect the length of the padding part 470. The data part 440 may comprise, for example, the parts 450 and 460 in some embodiments. The data part 440 may comprise, for example, the parts 450 and 460 in some embodiments. The data part 440 may comprise, for example, the part 430 in some embodiments (e.g. Figure 4D). The data part may generally refer to part(s) of the PDU 400 comprising the CEs and SDUs. In the case that the first header 410 comprises the CEs of the PDU, the length of the padding part 470 may be affected by the first and second headers 410, 420 and by the part of the PDU comprising the one or more SDUs. The padding part 470 may be used to make the PDU 400 to be of certain predetermined length by the transmitter. The length of the padding part 470 may be affected by a TB onto which the PDU 400 is mapped. For example, specification may have some requirement for the length. However, in some embodiments, the length of the PDU may vary, and thus the padding part 470 may not be necessary. It needs to be noted that the predetermined length of the PDU 400, known by the receiver and the transmitter, may enable the receiver to process the PDU 400. For example, referring to Figure 4B, the length of the data part 440 may be known when the length of the first and second headers 410, 420 is known (i.e. indicated by the first and second information elements 412, 422).

In an embodiment, the length of the padding part 470 is further based on the length of the TB onto which the PDU 400 is mapped. That is, padding bits or bytes may be used to fill the PDU 400 such that it is suitable size for a certain sized TB. Therefore, for example, the length of the padding part 470 (i.e. number of padding bits used) may be determined, by the transmitter, by determining TB length or size, deducting lengths of headers of the PDU 400 (e.g. first and second headers 410, 420) from said TB length, and deducting lengths of CE and/or SDU parts of the PDU 400 from the TB length. Thus, the transmitter may know how many padding bits needs to be used to prepare the PDU 400 to be suitable to said TB.

Let us consider for a moment some of the embodiments described with reference to Figures 4A to 4F. In particular, let us assume that in each shown PDU 400 structure there is the control information 402 (e.g. control part 402). The control part 402 may be located, for example, in the beginning of the PDU 400. In some other cases, the location may be something else than the beginning of the PDU 400. However, in some

embodiments, it may be the most beneficial to start the PDU 400 with the control part 402 as it may be used to indicate the following structure of the PDU 400. That is, the receiver may acquire knowledge, by reading the control part 402, whether there is two or three information elements (e.g. 412, 422, 432), for example. Thus, the control part 402 may be generated, by the transmitter, so that the control part 402 indicates how many and/or which information elements (e.g. 412, 422, 432) are present in the PDU 400. Similarly, the control part may indicate number of headers 410, 420 and/or number of sub-headers in a header. Similarly, number of CEs and/or SDUs may be indicated in some embodiments. However, in general terms, the control part 402 may indicate to the receiver which kind of PDU 400 structure is used. That is, if solution of Figure 4B would be solution #1, solution of Figure 4C would be solution #2, and solution of Figure 4D would be solution #3, the control part could indicate which of the three solutions is used for that particular PDU. This may give a benefit of choosing the optimal solution for particular situation when both the transmitter and the receiver know the solutions which may be utilized. In even more general terms, in some embodiments, the control part 402 may indicate structure of the PDU 400, thus enabling the receiver to process the PDU 400 accordingly.

Figure 5 illustrates an embodiment. According to some embodiments, with reference to Figure 5, the first information element 412 indicates the length of the first header 410 by indicating a number of sub-headers 504 in the first header. Additionally or alternatively, the second information element 422 may indicate the length of the second header 420 by indicating a number of sub-headers 504 in the second header 420. Similar logic may apply to the third information element 432, wherein the length of CEs and/or SDUs is predetermined in the part of the PDU 400 comprising said CEs and/or SDUs.

Referring to Figure 5, the length of a header 506 (e.g. first or second headers 410, 420) may be determined by the length of the sub-headers 502 and the number of sub-headers 504. That is, for example, in the first header 410 the length of the sub-headers may be constant or predetermined (i.e. known by the transmitter and the receiver or at least by the receiver). Thus, by indicating the number of sub-headers 504 in the first header 410, the receiver may determine the length of the first header 410. Similarly, the length of the second header 420 may be determined.

It is worth to discuss a little more about the contents of the first, second and/or third information elements 412, 422, 432. As said, the information elements 412, 422, 432 may be used to indicate length of different parts of the PDU 400. The information elements 412, 422, 432 may have a length of 8 bits (i.e. 1 octet or 1 byte), for example. This may mean that there is a reserved space of 8 bits for each information element 412, 422, 432 in the PDU 400. Naturally, if the third information element 432 is not used, the space does not need to be reserved for the third information element. The bits comprised in the first information element 412 may be used to indicate a length of the first header 410, for example. Similar logic may apply to the other information elements 422, 432. In the case of

indicating a number of sub-headers, as discussed in relation to Figure 5, the bits comprised in the first information element 412 may be used to indicate the number of sub-headers in the first header 410. Similar logic may apply to the other information elements 422, 432.

Figure 7 illustrates a signal diagram according to an embodiment. Referring to Figure 7, a scenario of downlink transmission is shown. Similar logic may apply, however, for example to uplink transmission also. In step 702, the network element 102 may acquire one or more SDUs and/or one or more CEs to be mapped to a PDU (e.g. PDU 400). Said SDUs and/or the CEs may be to be transmitted to the terminal device 110.

In step 704, the network element 102 may structure or generate the PDU, wherein the PDU comprises said SDUs and/or CEs. Further, the PDU may comprise the first and second information elements, for example. In some examples, as described, the PDU may comprise the third, fourth and/or fifth information elements. Also, the PDU may comprise the first and second headers.

The network element 102 may map the PDU to a TB, and in step 706, the network element 102 may cause a transmission of signal carrying said TB to the terminal device 110. The terminal device 110 may receive the transmission and acquire the TB and the PDU from the TB.

The terminal device 110 may, in step 710, process the obtained PDU. For example, the terminal device 110, after obtaining the PDU, may cause an initiation of parallel processing of a parallel processing of the first header and the second header of the PDU. This may be enabled by the first and second information elements. That is, the parallel processing may be possible, as described with reference to Figure 6A, for example. For example, the first header may be processed further by a scheduler. The second header and the SDUs may be sent to RLC layer for further processing, i.e. mapping to logical channels.

The parallel processing may comprise processing the one or more control elements and/or one or more service data units associated with the first header and processing the one or more control elements and/or one or more service data units associated with the second header. That is, as described with reference to Figure 6B, the CEs may be processed in parallel with the SDUs by the terminal device 110 or some other network element. In another example, the parallel processing of the headers comprising sub-headers grouped according to their lengths (e.g. Figure 4E) may be possible. Thus, also the CEs and SDUs in different parts (e.g. parts 450, 460) may be possible.

In a case where the PDU 400 comprises the third information element indicating the length of a part 450 of the PDU 400 for one or more control elements and/or for one or more service data units 452, said part being associated with the first header 410, for example, the terminal device 110 may determine the length of the part 450 based on the third information element. This may enable the terminal device 110 start the parallel processing.

In an embodiment, the first information element 412 indicates a number of sub-headers in the first header 410, and/or the second information element indicates 422 a number of sub-headers in the second header 420, the terminal device 110 may further obtain at least one of a sub-header length in the first header, a sub-header length in the
5 second header, wherein the determining the lengths of the first and/or second headers 410, 420 is based on the number and lengths of sub-headers. Example of this is shown in Figure 5.

In an embodiment, the PDU 400 comprises the third information element 432 indicating the length of the part 450 for one or more CEs and/or SDUs 452. The receiver,
10 for example, the terminal device 110 may then further determine a length of another part 460 of the PDU 400 for one or more further CEs and/or SDUs 462, said another part 460 being associated with the first header 410 or the second header 420. In the example of Figure 4E, said another part 460 may be associated with the second header 420, whereas the part 450 (length indicated by the third information element 432) may be associated with
15 the first header 410. It could also be other way around depending on the implementation.

In an embodiment, the PDU 400, as described above, is applicable for D2D communication. That is, the receiver and the transmitter may be terminal devices. Generally, the defined PDU structure may not be restricted to the communication system or network elements described above. This may mean that the PDU structure may be used
20 also in some other systems and with some other network elements, for example.

Figures 8 to 9 provide apparatuses 800, 900 comprising a control circuitry (CTRL) 810, 910, such as at least one processor, and at least one memory 830, 930 including a computer program code (software) 832, 932, wherein the at least one memory and the computer program code (software) 832, 932, are configured, with the at least one
25 processor, to cause the respective apparatus 800, 900 to carry out any one of the embodiments of Figures 2 to 7, or operations thereof.

Referring to Figures 8 to 9, the memory 830, 930, may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems,
30 fixed memory and removable memory. The memory 830, 930 may comprise a database 834, 934 for storing data.

The apparatuses 800, 900 may further comprise radio interface (TRX) 820, 920 comprising hardware and/or software for realizing communication connectivity according to one or more communication protocols. The TRX may provide the apparatus with
35 communication capabilities to access the radio access network, for example. The TRX may comprise standard well-known components such as an amplifier, filter, frequency-converter, (de)modulator, and encoder/decoder circuitries and one or more antennas. For example, the TRX may enable communication between the terminal device 110 and the network element 102 and/or the D2D communication capability. Further, the TRX may provide

access to the X2-interface for the network element 102, for example.

The apparatuses 800, 900 may comprise user interface 840, 940 comprising, for example, at least one keypad, a microphone, a touch display, a display, a speaker, etc. The user interface 840, 940 may be used to control the respective apparatus by a user of the apparatus 800, 900.

In an embodiment, the apparatus 800 may be or be comprised in a terminal device (e.g. the terminal device 110), such as a mobile phone or cellular phone, for example. The apparatus 800 may be or be comprised in the network element 102, for example. The apparatus 800 may be the network element performing the steps of Figure 2, for example.

Referring to Figure 8, the control circuitry 810 may comprise a PDU structuring circuitry 812 configured to structure a PDU 400 to comprise a header part at least for a first header 410 and for a second header 420, wherein the PDU 400 comprises a first information element 412 indicating a length of the first header 410 and a second information element 422 indicating a length of the second header 420. The control circuitry 810 may further comprise a transmission circuitry 814 configured to cause a transmission of a signal carrying the PDU 400 to another network element of a cellular communication system. For example, the transmission circuitry 814 may cause the radio interface 820 to transmit said signal (e.g. comprising a TB to which the PDU 400 is mapped onto). Thus, for example, the terminal device 110 may structure and transmit the PDU 400 to a base station or vice versa.

In an embodiment, the apparatus 900 may be or be comprised in a terminal device (e.g. the terminal device 110), such as a mobile phone or cellular phone, for example. The apparatus 900 may be or be comprised in the network element 102, for example. The apparatus 900 may be the network element performing the steps of Figure 3, for example.

Referring to Figure 9, the control circuitry 910 comprises a PDU obtaining circuitry 912 configured to obtain, a PDU 400 comprising a header part at least for a first header 410 and for a second header 420, wherein the PDU 400 comprises a first information element 412 indicating a length of the first header 410 and a second information element 422 indicating a length of the second header 420; a header length determining circuitry 914 configured to determine, based on the first and second information elements 412, 422, the lengths of the first and second headers 410, 420; and an action performing circuitry 916 configured to perform an action based on the determined lengths of the first and second headers 410, 420. The action may be performed to the PDU 400. The action may comprise, for example, processing the PDU 400. In some embodiments, the action at least comprises processing the first and second information elements 412, 422. In some embodiments, the action comprises processing separating the first header 410 from the PDU 400. The first header 410 may be sent to a scheduler, for example. In some embodiments, the action comprises processing the CE(s) and/or SDUs of the PDU 400 based at least partly on the indicated lengths of the first and second headers 410, 420.

In some embodiments of Figures 8 and 9, at least some of the functionalities of

the apparatus 800 and/or the apparatus 900 (e.g. the network element 102) may be shared between two physically separate devices, forming one operational entity. Therefore, the apparatus may be considered to depict the operational entity comprising one or more physically separate devices for executing at least some of the above-described processes.

5 Thus, the apparatuses of Figures 8 and/or 9, utilizing such a shared architecture, may comprise a remote control unit (RCU), such as a host computer or a server computer, operatively coupled (e.g. via a wireless or wired network) to a remote radio head (RRH) located at a base station site. In an embodiment, at least some of the described processes of the network node may be performed by the RCU. In an embodiment, the execution of at
10 least some of the described processes may be shared among the RRH and the RCU. In such a context, the RCU may comprise the components illustrated in Figure 8 and/or 9, and the radio interface 820 or the radio interface 920 may provide the RCU with the connection to the RRH. The RRH may then comprise radio frequency signal processing circuitries and antennas, for example.

15 In an embodiment, the RCU may generate a virtual network through which the RCU communicates with the RRH. In general, virtual networking may involve a process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Network virtualization may involve platform virtualization, often combined with resource virtualization. Network virtualization
20 may be categorized as external virtual networking which combines many networks, or parts of networks, into the server computer or the host computer (i.e. to the RCU). External network virtualization is targeted to optimized network sharing. Another category is internal virtual networking which provides network-like functionality to the software containers on a single system. Virtual networking may also be used for testing the terminal device.

25 In general, it may be understood that virtual network resources may give potential to apply parallel processing of PDUs (e.g. MAC PDUs). That is, if there are a lot of virtual resources available, the receiver may use them to process the PDUs in a parallel way (e.g. parallel processing of SDUs and/or CEs as described above). However, if the computational resources are scarce, the receiver may only process latency critical data (e.g.
30 some SDUs or some PDUs) in the proposed way (i.e. in parallel), while rest of the data (e.g. CEs or some PDUs) may be processed consecutively. For example, if three PDUs are transferred, some of them may be processed in parallel, but some may be processed in a consecutive manner, thus saving computational resources used simultaneously. Therefore, for example, the receiver may determine whether or not there is enough free processing or
35 computational resources for parallel processing of a PDU (e.g. PDU 400). If there are, the receiver may cause parallel processing of the PDU. However, if the receiver determines that there are not enough radio resources for parallel processing, the receiver may cause consecutive processing of the PDU (i.e. CEs and/or SDUs may be processed consecutively).

In an embodiment, the virtual network may provide flexible distribution of operations between the RRH and the RCU. In practice, any digital signal processing task may be performed in either the RRH or the RCU and the boundary where the responsibility is shifted between the RRH and the RCU may be selected according to implementation.

5 As used in this application, the term 'circuitry' refers to all of the following: (a) hardware-only circuit implementations, such as implementations in only analog and/or digital circuitry, and (b) combinations of circuits and soft-ware (and/or firmware), such as (as applicable): (i) a combination of processor(s) or (ii) portions of processor(s)/software including digital signal processor(s), software, and memory(ies) that work together to cause
10 an apparatus to perform various functions, and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. This definition of 'circuitry' applies to all uses of this term in this application. As a further example, as used in this application, the term 'circuitry' would also cover an implementation of merely a processor (or multiple processors)
15 or a portion of a processor and its (or their) accompanying software and/or firmware. The term 'circuitry' would also cover, for example and if applicable to the particular element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or another network device.

20 In an embodiment, at least some of the processes described in connection with Figures 2 to 7 may be carried out by an apparatus comprising corresponding means for carrying out at least some of the described processes. Some example means for carrying out the processes may include at least one of the following: detector, processor (including dual-core and multiple-core processors), digital signal processor, controller, receiver,
25 transmitter, encoder, decoder, memory, RAM, ROM, software, firmware, display, user interface, display circuitry, user interface circuitry, user interface software, display software, circuit, antenna, antenna circuitry, and circuitry. In an embodiment, the at least one processor, the memory, and the computer program code form processing means or comprises one or more computer program code portions for carrying out one or more
30 operations according to any one of the embodiments of Figures 2 to 7 or operations thereof.

 According to yet another embodiment, the apparatus carrying out the embodiments comprises a circuitry including at least one processor and at least one memory including computer program code. When activated, the circuitry causes the apparatus to perform at least some of the functionalities according to any one of the
35 embodiments of Figures 2 to 7, or operations thereof.

 The techniques and methods described herein may be implemented by various means. For example, these techniques may be implemented in hardware (one or more devices), firmware (one or more devices), software (one or more modules), or combinations thereof. For a hardware implementation, the apparatus(es) of embodiments may be

implemented within one or more application-specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof. For firmware or software, the implementation
5 can be carried out through modules of at least one chip set (e.g. procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit and executed by processors. The memory unit may be implemented within the processor or externally to the processor. In the latter case, it can be communicatively
10 coupled to the processor via various means, as is known in the art. Additionally, the components of the systems described herein may be rearranged and/or complemented by additional components in order to facilitate the achievements of the various aspects, etc., described with regard thereto, and they are not limited to the precise configurations set forth in the given figures, as will be appreciated by one skilled in the art.

15 Embodiments as described may also be carried out in the form of a computer process defined by a computer program or portions thereof. Embodiments of the methods described in connection with Figures 2 to 7 may be carried out by executing at least one portion of a computer program comprising corresponding instructions. The computer program may be in source code form, object code form, or in some intermediate form, and
20 it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. For example, the computer program may be stored on a computer program distribution medium readable by a computer or a processor. The computer program medium may be, for example but not limited to, a record medium, computer memory, read-only memory, electrical carrier signal, telecommunications signal, and
25 software distribution package, for example. The computer program medium may be a non-transitory medium. Coding of software for carrying out the embodiments as shown and described is well within the scope of a person of ordinary skill in the art. In an embodiment, a computer-readable medium comprises said computer program.

Even though the invention has been described above with reference to an
30 example according to the accompanying drawings, it is clear that the invention is not restricted thereto but can be modified in several ways within the scope of the appended claims. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment. It will be obvious to a person skilled in the art that, as technology advances, the inventive concept can be implemented in various
35 ways. Further, it is clear to a person skilled in the art that the described embodiments may, but are not required to, be combined with other embodiments in various ways.

CLAIMS

1. A method comprising:
structuring, by a network element of a cellular communication system, a
protocol data unit to comprise a header part at least for a first header and for a second
5 header,
wherein the protocol data unit comprises a first information element indicating a
length of the first header and a second information element indicating a length of the second
header; and
causing a transmission of a signal carrying the protocol data unit to another
10 network element of the cellular communication system.
2. The method of claim 1, wherein the header part comprises the first and
second information elements.
- 15 3. The method of any preceding claim, wherein the protocol data unit further
comprises one or more control elements and/or one or more service data units.
4. The method of claim 3, wherein the first and second headers each comprise
one or more sub-headers, each sub-header being associated with a control element or a
20 service data unit of the protocol data unit.
5. The method of claim 4, wherein the one or more sub-headers are arranged
into the first and second headers according to the length of the sub-headers such that the
first header comprises one or more sub-headers having a first length and the second header
25 comprises one or more sub-headers having a second length.
6. The method of any preceding claim, wherein the protocol data unit further
comprises a third information element indicating length of a part of the protocol data unit for
one or more control elements and/or for one or more service data units, said part being
30 associated with the first header or the second header.
7. The method of any preceding claim, wherein the first header is a control
element header for one or more control elements and the second header is a service data
unit header for one or more service data units.
- 35 8. The method of claim 7, wherein the control element header comprises the
one or more control elements.

9. The method of any preceding claim, wherein the first information element indicates length of the first header by indicating a number of sub-headers in the first header, and/or

the second information element indicates length of the second header by indicating a number of sub-headers in the second header.

10. A method comprising:

obtaining, by a network element of a cellular communication system, a protocol data unit comprising a header part at least for a first header and for a second header, wherein the protocol data unit comprises a first information element indicating a length of the first header and a second information element indicating a length of the second header;

determining, based on the first and second information elements, the lengths of the first and second headers; and

performing an action based on the determined lengths of the first and second headers.

11. The method of claim 10, wherein the protocol data unit further comprises one or more control elements and/or one or more service data units.

12. The method of any preceding claim 10 to 11, wherein the first and second headers each comprise one or more sub-headers, each sub-header being associated with a control element or a service data unit of the protocol data unit.

13. The method of any preceding claim 10 to 12, wherein the performing the action comprises:

causing an initiation of a parallel processing of the first header and the second header.

14. The method of claim 13, wherein the parallel processing further comprises processing the one or more control elements and/or one or more service data units associated with the first header and processing the one or more control elements and/or one or more service data units associated with the second header.

15. The method of any preceding claim 10 to 14, wherein the protocol data unit further comprises a third information element indicating length of a part of the protocol data unit for one or more control elements and/or for one or more service data units, said part being associated with the first header or the second header.

16. The method of any preceding claim 10 to 15, further comprising:

determining a length of another part of the protocol data unit for one or more further control elements and/or for one or more further service data units, said another part being associated with the first header or the second header.

5

17. The method of any preceding claim 10 to 16, wherein the first information element indicates a number of sub-headers in the first header, and/or the second information element indicates a number of sub-headers in the second header, the method further comprising:

10 obtaining at least one of a sub-header length in the first header, a sub-header length in the second header,

wherein the determining the lengths of the first and/or second headers is based on the number and lengths of sub-headers.

15

18. An apparatus comprising:

at least one processor, and

at least one memory comprising a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause a network element of a cellular communication system to perform operations comprising:

20

structuring a protocol data unit to comprise a header part at least for a first header and for a second header,

wherein the protocol data unit comprises a first information element indicating a length of the first header and a second information element indicating a length of the second header; and

25

causing a transmission of a signal carrying the protocol data unit to another network element of the cellular communication system.

19. The apparatus of claim 18, wherein the header part comprises the first and

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second information elements.

20. The apparatus of any preceding claim 18 to 19, wherein the protocol data unit further comprises one or more control elements and/or one or more service data units.

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21. The apparatus of claim 20, wherein the first and second headers each comprise one or more sub-headers, each sub-header being associated with a control element or a service data unit of the protocol data unit.

22. The apparatus of claim 21, wherein the one or more sub-headers are arranged into the first and second headers according to the length of the sub-headers such that the first header comprises one or more sub-headers having a first length and the second header comprises one or more sub-headers having a second length.

5

23. The apparatus of any preceding claim 18 to 22, wherein the protocol data unit further comprises a third information element indicating length of a part of the protocol data unit for one or more control elements and/or for one or more service data units, said part being associated with the first header or the second header.

10

24. The apparatus of any preceding claim 18 to 23, wherein the first header is a control element header for one or more control elements and the second header is a service data unit header for one or more service data units.

15

25. The apparatus of claim 24, wherein the control element header comprises the one or more control elements.

26. The apparatus of any preceding claim 18 to 25, wherein the first information element indicates length of the first header by indicating a number of sub-headers in the first header, and/or

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the second information element indicates length of the second header by indicating a number of sub-headers in the second header.

27. An apparatus comprising:

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at least one processor, and

at least one memory comprising a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause a network element of a cellular communication system to perform operations comprising:

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obtaining a protocol data unit comprising a header part at least for a first header and for a second header,

wherein the protocol data unit comprises a first information element indicating a length of the first header and a second information element indicating a length of the second header;

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determining, based on the first and second information elements, the lengths of the first and second headers; and

performing an action based on the determined lengths of the first and second headers.

28. The apparatus of claim 27, wherein the protocol data unit further comprises one or more control elements and/or one or more service data units.

29. The apparatus of any preceding claim 27 to 28, wherein the first and second
5 headers each comprise one or more sub-headers, each sub-header being associated with a control element or a service data unit of the protocol data unit.

30. The apparatus of any preceding claim 27 to 29, wherein the performing the
action comprises:
10 causing an initiation of a parallel processing of the first header and the second header.

31. The apparatus of claim 30, wherein the parallel processing further comprises
processing the one or more control elements and/or one or more service data units
15 associated with the first header and processing the one or more control elements and/or one or more service data units associated with the second header.

32. The apparatus of any preceding claim 27 to 31, wherein the protocol data
unit further comprises a third information element indicating length of a part of the protocol
20 data unit for one or more control elements and/or for one or more service data units, said part being associated with the first header or the second header.

33. The apparatus of any preceding claim 27 to 32, wherein the at least one
memory and the computer program code are configured, with the at least one processor, to
25 cause the network element further to perform operations comprising:

determining a length of another part of the protocol data unit for one or more
further control elements and/or for one or more further service data units, said another part
being associated with the first header or the second header.

34. The apparatus of any preceding claim 27 to 33, wherein the first information
element indicates a number of sub-headers in the first header, and/or the second
information element indicates a number of sub-headers in the second header, wherein the
at least one memory and the computer program code are configured, with the at least one
processor, to cause the network element further to perform operations comprising:

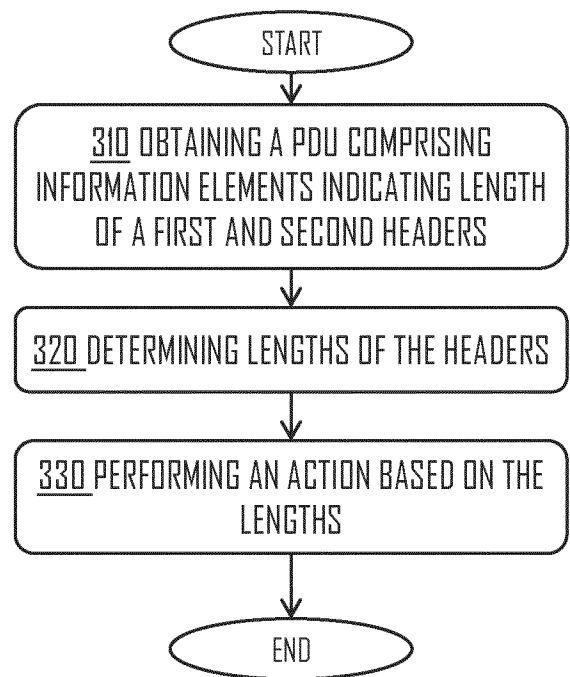
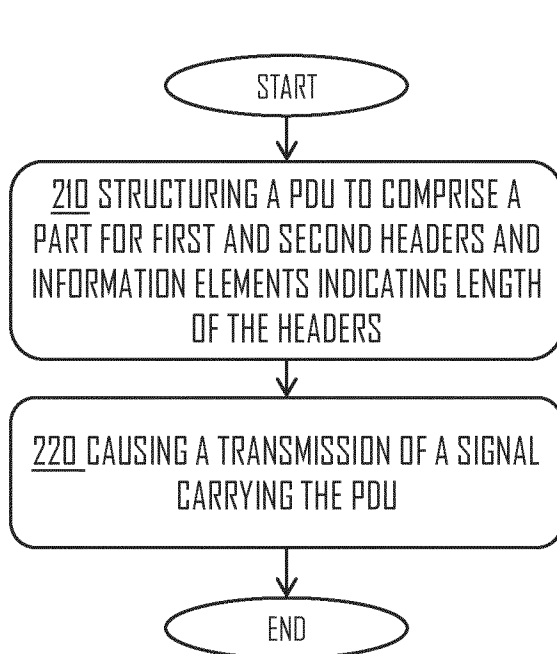
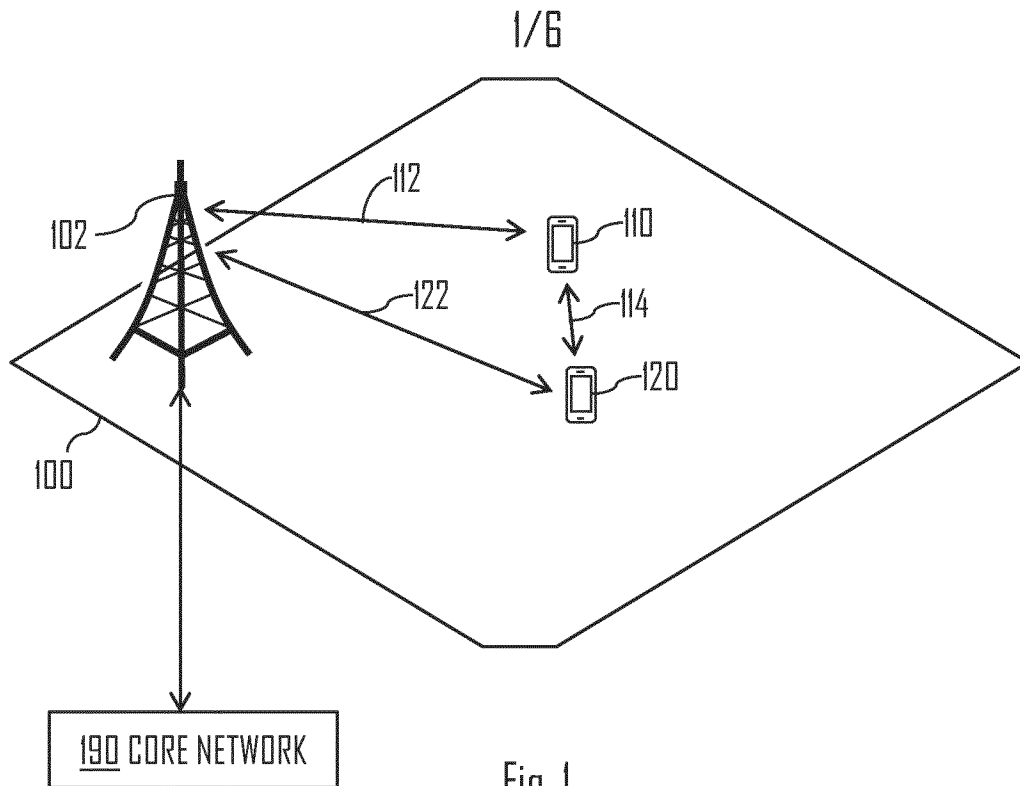
35 obtaining at least one of a sub-header length in the first header, a sub-header
length in the second header,

wherein the determining the lengths of the first and/or second headers is based
on the number and lengths of sub-headers.

35. A system comprising the apparatus according to any preceding claim 18 to 26 and the apparatus according to any preceding claim 27 to 34.

36. An apparatus comprising means for carrying out all the steps of a method
5 according to any preceding claim 1 to 17.

37. A computer program product embodied on a computer-readable medium
and comprising a computer program code readable by a computer, wherein the computer
program code configures the computer to carry out the method according to any preceding
10 claim 1 to 17 when read by the computer.



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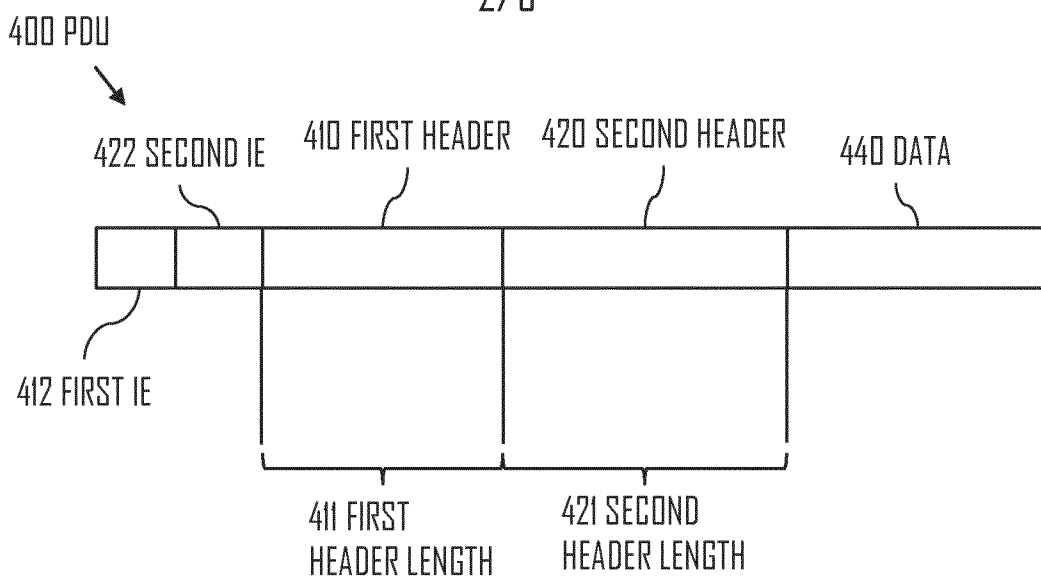


Fig. 4A

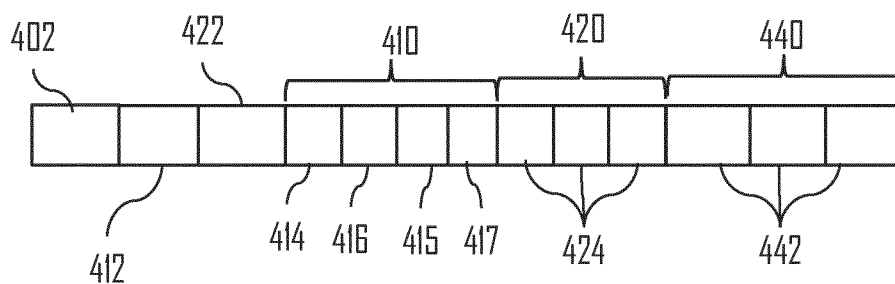


Fig. 4B

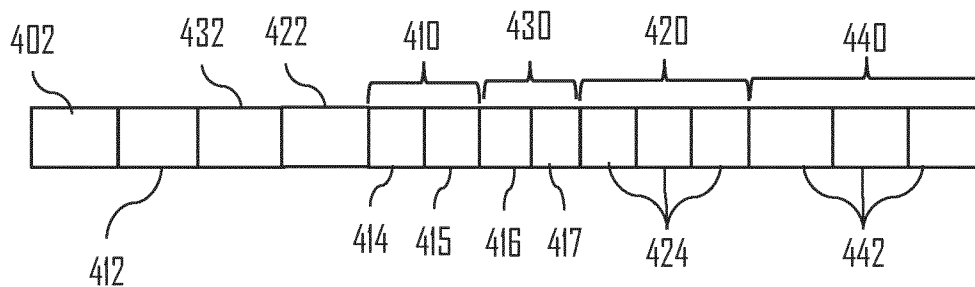


Fig. 4C

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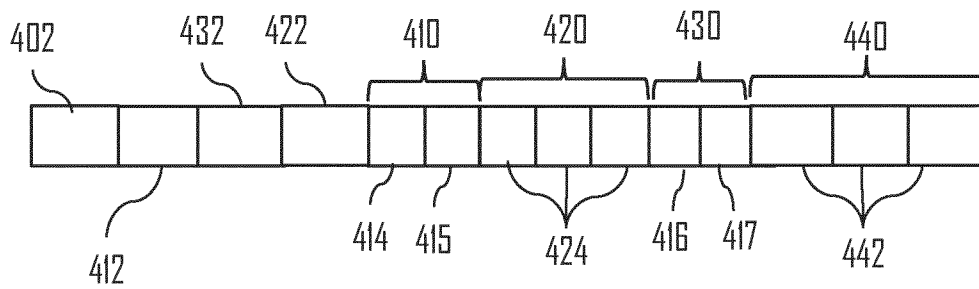


Fig. 4D

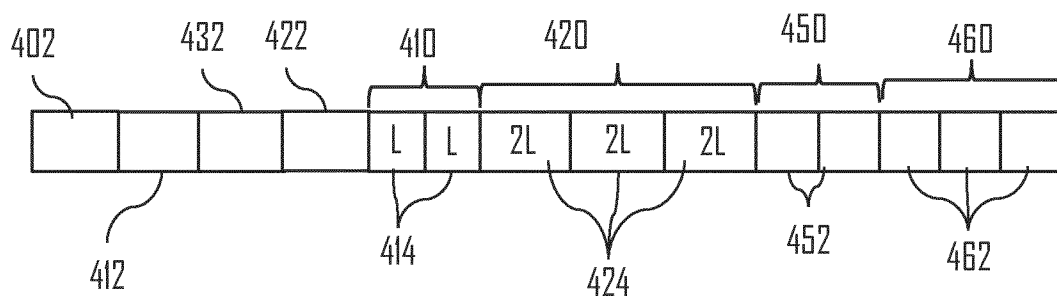


Fig. 4E

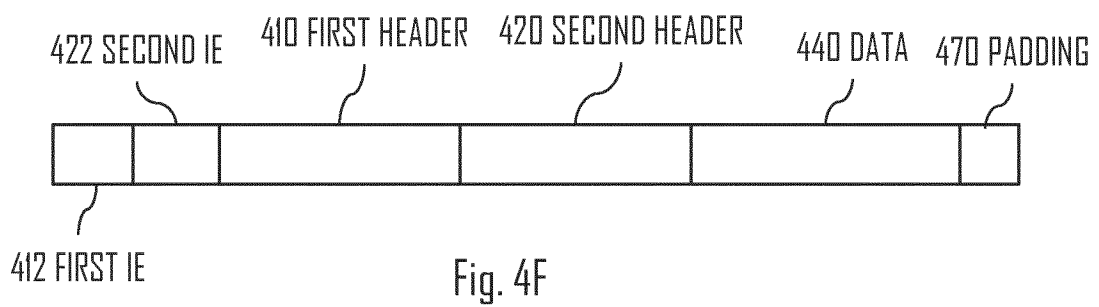


Fig. 4F

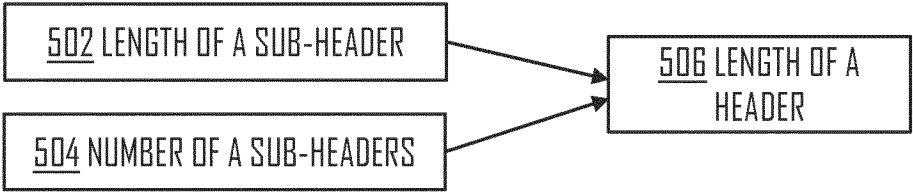


Fig. 5

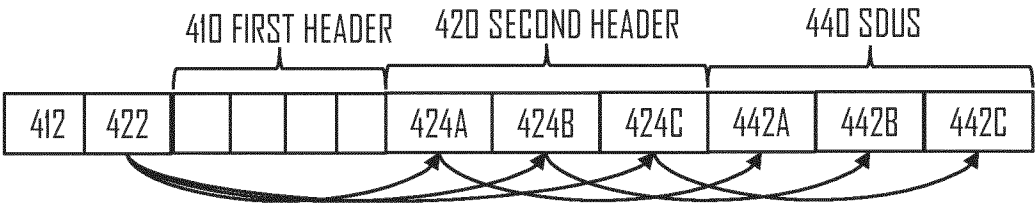


Fig. 6A

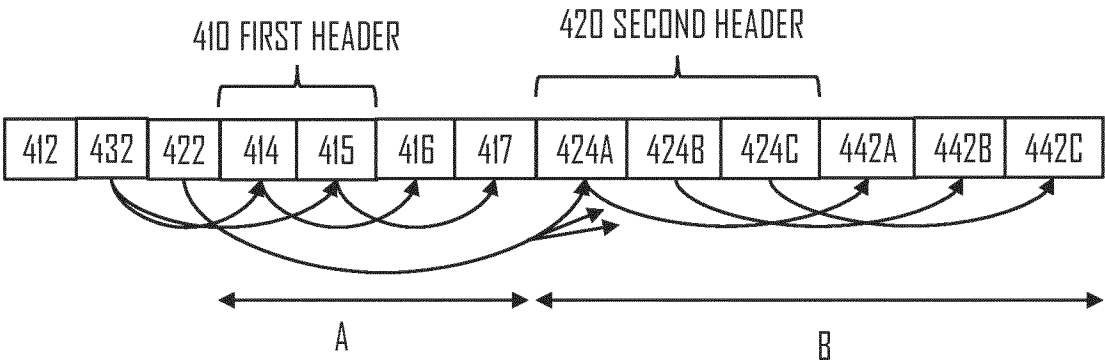


Fig. 6B

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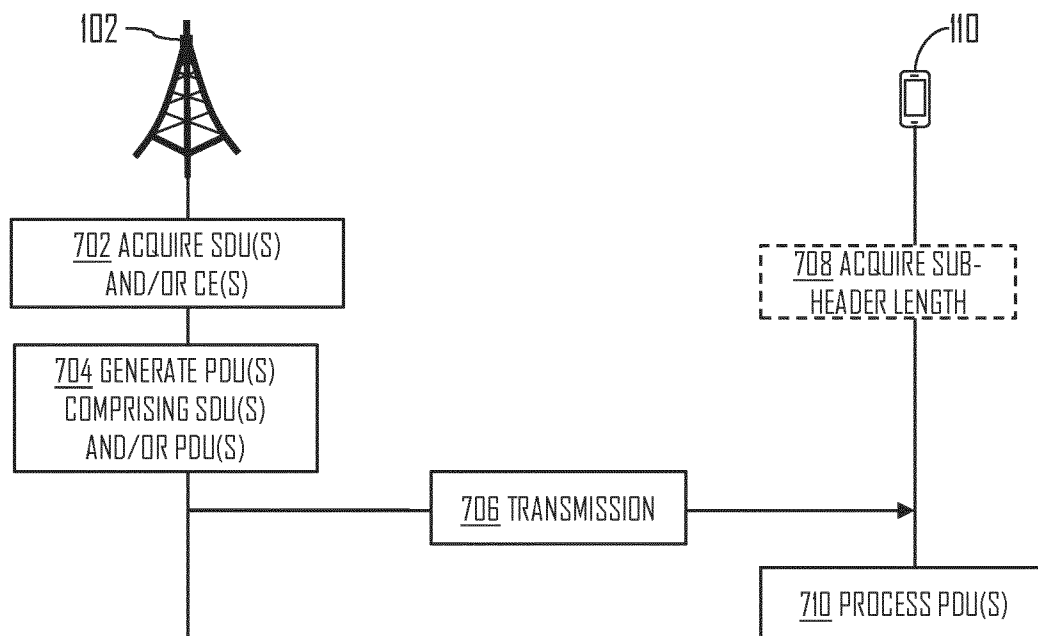


Fig. 7

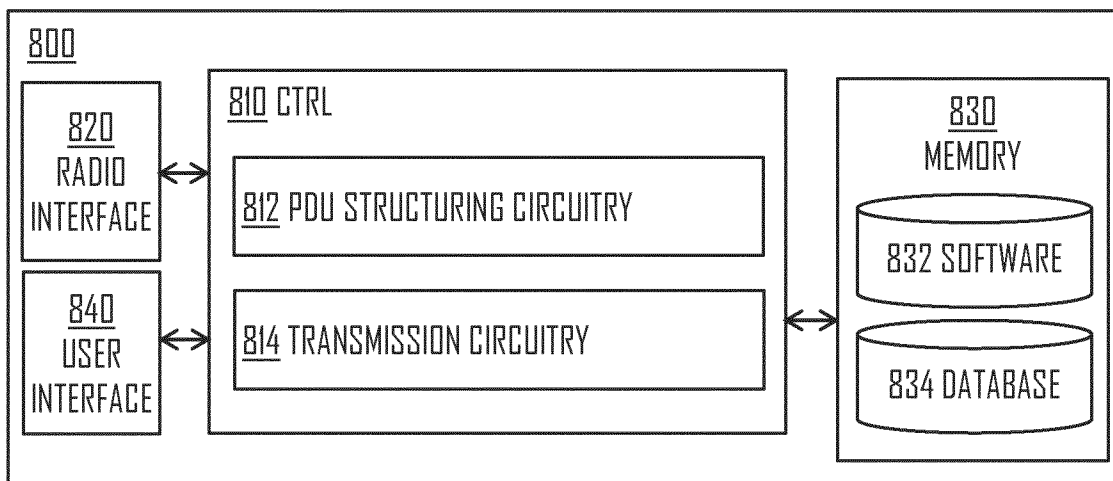


Fig. 8

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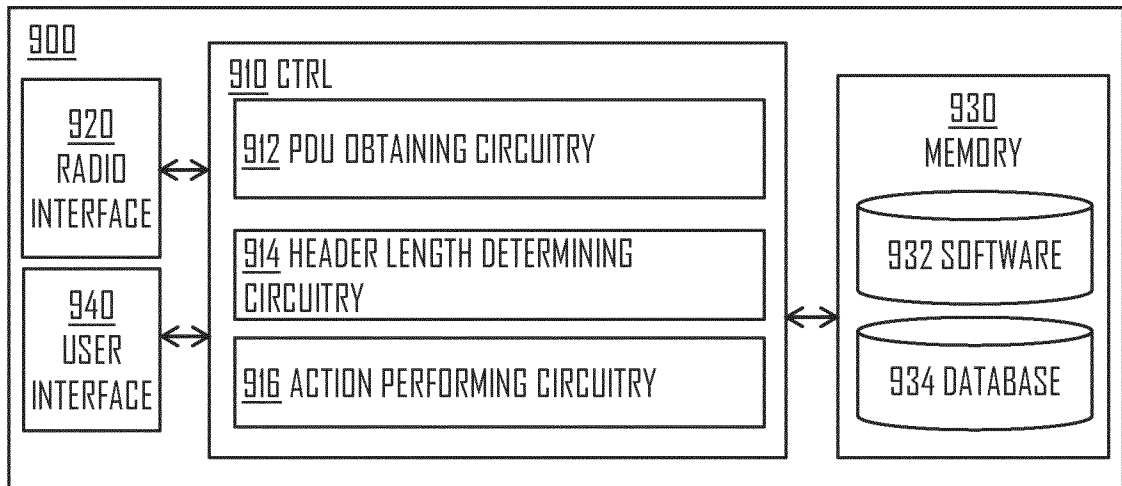


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/056250

A. CLASSIFICATION OF SUBJECT MATTER
 INV. H04L29/06
 ADD.

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

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/047573 A1 (DUNCAN RICHARD JEREMY [US] ET AL) 23 February 2012 (2012-02-23)	1-4,6-8, 10-16, 18-21, 23-25, 27-33, 35-37
Y	paragraph [0002] - paragraph [0004]	9,17,26,
A	paragraph [0014] - paragraph [0039] paragraph [0045] - paragraph [0059] paragraph [0069] - paragraph [0078]; claims 1-11; figures 1,3,5,7,9 ----- -/-	34 5,22



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

8 November 2016

Date of mailing of the international search report

21/11/2016

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Wuillème, Cédric

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/056250

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	paragraph [0001] - paragraph [0029] paragraph [0039] - paragraph [0047] paragraph [0052] - paragraph [0068] paragraph [0085] - paragraph [0091]; claims 1-10; figures 2,4,5,8 -----	4-9, 12-17, 21,26, 29,34
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International application No

PCT/EP2016/056250

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