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TITLE OF INVENTION SERVER AND METHODS PERFORMED
IN A WIRELESS COMMUNICATION
NETWORK

局长

COMMISSIONER

申长雨

2023年11月17日

PCT REQUEST

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V	DESIGNATIONS	
V-1	The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.	
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VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	Check list	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	4	✓
IX-2	Description	41	✓
IX-3	Claims	3	✓
IX-4	Abstract	1	✓
IX-5	Drawings	17	✓
IX-6a	Sequence listing part of the description	-	-
IX-7	TOTAL	66	
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IX-8	Fee calculation sheet	-	✓
IX-11	Copy of general power of attorney	-	Reference no. ZW0016111615
IX-20	Figure of the drawings which should accompany the abstract	5	
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X-1-1	Name	ZHONGZI LAW OFFICE	
X-1-2	Name of signatory	ZHONGZI LAW OFFICE	
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SERVER NODE, CLIENT NODE, VAL SERVER AND METHODS PERFORMED IN A WIRELESS COMMUNICATION NETWORK

TECHNICAL FIELD

Embodiments herein relate to a server node, a client node, a vertical application layer (VAL) server and methods performed therein regarding wireless communication. Furthermore, a computer program product and a computer-readable storage medium are also provided herein. Especially, embodiments herein relate to handling or enabling communication, such as managing data delivery, in a communication network.

BACKGROUND

In a typical communication network, user equipments (UEs), also known as wireless communication devices, mobile stations, stations (STA) and/or wireless devices, communicate via a Radio Access Network (RAN) to one or more core networks (CN). The RAN covers a geographical area which is divided into service areas or cell areas, with each service area or cell area being served by a network node such as an access node e.g. a Wi-Fi access point or a radio base station (RBS), which in some radio access technologies (RAT) may also be called, for example, a NodeB, an evolved NodeB (eNodeB) and a gNodeB (gNB). The service area or cell area is a geographical area where radio coverage is provided by a network node. The network node operates on radio frequencies to communicate over an air interface with the UEs within range of the access node. The network node communicates over a downlink (DL) to the UE, and the UE communicates over an uplink (UL) to the access node.

A Universal Mobile Telecommunications System (UMTS) is a third generation telecommunication network, which evolved from the second generation (2G) Global System for Mobile Communications (GSM). The UMTS terrestrial radio access network (UTRAN) is essentially a RAN using wideband code division multiple access (WCDMA) and/or High-Speed Packet Access (HSPA) for communication with user equipments. In a forum known as the Third Generation Partnership Project (3GPP), telecommunications suppliers propose and agree upon standards for present and future generation networks and UTRAN specifically, and investigate enhanced data rate and radio capacity. In some RANs, e.g., as in UMTS, several network nodes may be connected, e.g., by landlines or microwave, to a controller node, such as a radio network controller (RNC) or a base station controller (BSC),

which supervises and coordinates various activities of the plural network nodes connected thereto. The RNCs are typically connected to one or more CNs.

Specifications for the Evolved Packet System (EPS) have been completed within the 3rd Generation Partnership Project (3GPP) and this work continues in the coming 3GPP releases, such as fifth generation (5G) and sixth generation (6G) networks. The EPS comprises the Evolved Universal Terrestrial Radio Access Network (E-UTRAN), also known as the Long-Term Evolution (LTE) radio access network, and the Evolved Packet Core (EPC), also known as System Architecture Evolution (SAE) core network. E-UTRAN/LTE is a 3GPP radio access technology wherein the network nodes are directly connected to the EPC core network. As such, the RAN of an EPS has an essentially non-hierarchical architecture comprising network nodes connected directly to one or more CNs.

With the emerging 5G technologies also known as new radio (NR) and/or upcoming 6G RAN the use of very many transmit- and receive-antenna elements may utilize beamforming, such as transmit-side and receive-side beamforming. Transmit-side beamforming means that the transmitter can amplify the transmitted signals in a selected direction or directions, while suppressing the transmitted signals in other directions. Similarly, on the receive-side, a receiver can amplify signals from a selected direction or directions, while suppressing unwanted signals from other directions. The benefit is to increase the cell capacity and coverage.

Furthermore, Vehicle to everything (V2X) communication is also supported, which includes any combination of direct communication between vehicles, pedestrians, and infrastructure. V2X communication may take advantage of a Network (NW) infrastructure, when available, but at least basic V2X connectivity should be possible even in case of lack of coverage. Providing an LTE-based V2X interface may be economically advantageous because of the LTE economies of scale and it may enable tighter integration between communications with the NW infrastructure e.g. Vehicle to Infrastructure (V2I) and Vehicle to Pedestrians (V2P) and Vehicle to Vehicle (V2V) communications, as compared to using a dedicated V2X technology.

There are many research projects and field tests of connected vehicles in various countries or regions, including projects that are based on the use of existing cellular infrastructure.

V2X communications may carry both non-safety and safety information, where each of the applications and services may be associated with specific requirements, in terms of e.g. latency, reliability, capacity, etc. From an application point of view, V2X includes the following types of communication/services shown with reference to **Fig. 1**.

Vehicle to vehicle (V2V): This covers communication between vehicles using V2V applications and is predominantly broadcast-based. V2V may be realized by either direct communication between the devices in the respective vehicles, or via infrastructure such as a cellular network. An example of V2V is the transmission of a cooperative awareness message (CAM) with vehicle status information, such as position, direction, and speed, transmitted to other vehicles in the proximity repeatedly e.g. every 100ms-1s. Another example is the transmission of a decentralized environmental notification message (DENM), which is an event-triggered message to alert vehicles. These two examples are taken from the ETSI Intelligent Transport Systems (ITS) specification of V2X applications, which also specifies the conditions under which the messages are generated. Main characteristic of V2V applications is the tight requirements on latency that can vary from 20ms (for pre-crash warning messages) to 100ms for other road safety services.

Vehicle to infrastructure (V2I): This comprises communication between vehicles and a Roadside Unit (RSU). The RSU may be a stationary transportation infrastructure entity which communicates with vehicles in its proximity. An example of V2I is transmission of speed notifications from the RSU to vehicles, as well as queue information, collision risk alerts, curve speed warnings. Due to the safety related nature of V2I, delay requirements are similar to V2V requirements.

Vehicle to pedestrian (V2P): This covers communication between vehicles and vulnerable road users, such as pedestrians, using V2P applications. V2P typically takes place between distinct vehicles and pedestrians either directly or via infrastructure such as a cellular network.

Vehicle to network (V2N): This covers communication between a vehicle and a centralized application server (or an Intelligent transportation systems (ITS) Traffic Management Center) both using V2N applications, via infrastructure (such as a cellular network). One example is a bad road condition warning sent to all vehicles in a wide area, or traffic flow optimization in which V2N application suggests speeds to vehicles and coordinates traffic lights. Therefore, V2N messages are supposed to be controlled by a centralized entity, such as a Traffic Management Center, and may be provisioned to vehicles in a large geographical area, rather than in a small area. Additionally, unlike V2V/V2I, latency requirements are more relaxed in V2N because it is not meant to be used for non-safety purposes, e.g. a latency requirement of 1s is typically considered.

Since 3GPP Release 16, Service Enablement Architecture Layer for Verticals (SEAL) has been introduced to support vertical applications such as V2X applications. 3GPP TS 23.434 v.18.5.0 specifies application plane and signaling plane entities for

application-enabling services, e.g., group management, configuration management, location management, identity/key management, network resource management, that can be reused across vertical applications. SEAL also specifies the northbound application programming interfaces (API) for its individual services to enable flexible integration with vertical applications.

Fig. 2 illustrates the generic on-network functional model of SEAL:

In the vertical application layer (VAL), the VAL client communicates with the VAL server over VAL-UU reference point. VAL-UU supports both unicast and multicast delivery modes.

The SEAL functional entities on the UE and the server are grouped into SEAL client(s) and SEAL server(s) respectively. The SEAL consists of a common set of services, e.g., group management, location management, and reference points. The SEAL offers its services to the vertical application layer (VAL).

The SEAL client(s) communicates with the SEAL server(s) over the SEAL-UU reference points. SEAL-UU supports both unicast and multicast delivery modes. The SEAL client(s) provides the service enabler layer support functions to the VAL client(s) over SEAL-C reference points. The VAL server(s) communicate with the SEAL server(s) over the SEAL-S reference points. The SEAL server(s) may communicate with the underlying 3GPP network systems using the respective 3GPP interfaces specified by the 3GPP network system.

Data Delivery (DD)

One of the capabilities that SEAL provides is Data Delivery (DD).

Fig. 3 illustrates the on-network functional model of SEAL for DD:

For uplink traffic, VAL client sends application data traffic to Service Enablement Architecture Layer for Verticals Data Delivery (SEALDD) client for SEALDD service over interface SEALDD-C. After data plane packet processing by SEALDD client, the application data traffic is converted to SEALDD data traffic and transferred to SEALDD server over SEALDD-UU. The SEALDD server restores the application data traffic and sends it to VAL server over SEALDD-S. For downlink traffic, VAL server sends application data traffic to SEALDD server for SEALDD service over SEALDD-S. After data plane packet processing by SEALDD server, the application data traffic is converted to SEALDD data traffic and transferred to SEALDD client over interface SEALDD-UU. The SEALDD client restores the application data traffic and sends it to VAL client over SEALDD-C. Optionally, VAL deployments may choose to route application signalling traffic and application data traffic

for some or all functions it offers using SEALDD service and **Fig. 4** illustrates the architecture for achieving this. In this case the VAL client and VAL server may choose not to maintain application connection by themselves and transfer all the application traffic over SEALDD connections for those functions.

NOTE: SEALDD capabilities are provided as APIs to the VAL Layer, it is up to VAL layer to decide which traffic to be transferred (e.g. application signalling, application data).

The SEAL Data Delivery client interacts with the SEAL data delivery server to establish application layer data transport path.

Through this path, the SEALDD server and client provides data transport service capabilities such as data plane packet processing, e.g. packet duplication, elimination or transport coordination, data forwarding, data caching, background data transfer, etc. to support the VAL server and client.

SEALDD connection establishment

SEALDD connection can be established by either SEALDD client or SEALDD server, as described in clause 9.2 and clause 9.3 of 3GPP TS 23.433 v.18.1.0.

SEALDD transmission quality assurance

TS 23.433 also specifies some transmission quality assurance methods, e.g., using redundant transmission, see clause 9.9 of 3GPP TS 23.433.

SUMMARY

As part of developing embodiments herein one or more problems was first identified. As part of the Release 19 scope, the SEALDD layer can utilize new capability exposed by 3GPP network and such information can be used by SEALDD (as application handling the VAL traffic) for adjust data transmission.

An object of embodiments herein is, thus, to provide a mechanism that improves the performance of a wireless communication network.

According to an aspect the object is achieved by providing a method performed by a server node for handling data delivery in a wireless communication network. The server node obtains burst arrival time (BAT) offset and/or a proposed periodicity, for example, from the wireless communication network. The server node sends an indication of the obtained BAT offset and/or the proposed periodicity to the client node. The indication may indicate UL periodicity and/or BAT offset for UL data.

According to another aspect the object is achieved by providing a method performed by a client node for handling data delivery in a wireless communication network. The client node receives an indication of an obtained BAT offset and/or proposed periodicity from a

server node. The indication may indicate UL periodicity and/or BAT offset for UL data. The client node may use the BAT offset and/or proposed periodicity in adjusting data transmission.

According to yet another aspect the object is achieved by providing a method performed by a VAL server for handling data delivery in a wireless communication network. The VAL server requests a server node to apply data transmission adjustment, or a data transmission adjustment policy and indicates a data transmission adjustment need in SEALDD layer.

It is furthermore provided herein a computer program product comprising instructions, which, when executed on at least one processor, cause the at least one processor to carry out the methods herein, as performed by the server node, client node, and VAL server, respectively.

It is additionally provided herein a computer-readable storage medium, having stored thereon a computer program product comprising instructions which, when executed on at least one processor, cause the at least one processor to carry out the methods herein, as performed by the server node, client node, and VAL server, respectively.

According to still another aspect the object is achieved by providing a server node, such as SEALDD server, for handling data delivery in a wireless communication network. The server node is configured to obtain a BAT offset and/or a proposed periodicity, and to send an indication of the obtained BAT offset and/or proposed periodicity to the client node.

According to yet still another aspect the object is achieved by providing a client node, such as SEALDD client, for handling data delivery in a wireless communication network. The client node is configured to receive from a server node, an indication of an obtained BAT offset and/or a proposed periodicity.

According to another aspect the object is achieved by providing a VAL server for handling data delivery in a wireless communication network, wherein the VAL server is configured to request a server node to apply data transmission adjustment, or a data transmission adjustment policy and indicates a data transmission adjustment need in SEALDD layer.

It is herein proposed a solution that describes a new transmission quality guarantee approach to optimize the data transmission via SEALDD considering the network capability and application adaptation. Thus, this will result in an improved performance of the wireless communication network.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described in more detail in relation to the enclosed drawings, in which:

Fig. 1 shows an overview of V2X services according to prior art;

Fig. 2 shows a schematic overview of a generic on-network functional model of SEAL according to prior art;

Fig. 3 shows a schematic overview of an Architecture for SEAL Data Delivery Service according to prior art;

Fig. 4 shows a schematic overview of an architecture for application traffic transfer;

Fig. 5 shows a schematic overview of a wireless communication network according to embodiments herein;

Fig. 6 shows a combined flowchart and signalling scheme according to embodiments herein;

Fig. 7 shows a flowchart depicting a method performed by a server node according to embodiments herein;

Fig. 8 shows a flowchart depicting a method performed by a client node according to embodiments herein;

Fig. 9 shows a flowchart depicting a method performed by a VAL server according to embodiments herein;

Fig. 10 shows a combined flowchart and signalling scheme according to embodiments herein;

Fig. 11 is a block diagram depicting a server node according to embodiments herein;

Fig. 12 is a block diagram depicting a client node according to embodiments herein;

Fig. 13 is a block diagram depicting a VAL server according to embodiments herein;

Fig. 14 shows an example of a communication system QQ100 in accordance with some embodiments;

Fig. 15 shows a UE QQ200 in accordance with some embodiments;

Fig. 16 shows a network node QQ300 in accordance with some embodiments;

Fig. 17 is a block diagram of a host QQ400, which may be an embodiment of the host QQ116 of Fig. 14, in accordance with various aspects described herein;

Fig. 18 is a block diagram illustrating a virtualization environment QQ500 in which functions implemented by some embodiments may be virtualized; and

Fig. 19 shows a communication diagram of a host QQ602 communicating via a network node QQ604 with a UE QQ606 over a partially wireless connection in accordance with some embodiments.

DETAILED DESCRIPTION

Embodiments herein are described within the context of 3GPP NR radio technology. It is understood that the problems and solutions described herein are equally applicable to wireless access networks and UEs implementing other access technologies and standards. NR is used as an example technology where embodiments are suitable, and using NR in the description therefore is particularly useful for understanding the problem and solutions solving the problem. In particular, embodiments are applicable also to 6G, 3GPP LTE, or 3GPP LTE and NR integration, also denoted as non-standalone NR.

Embodiments herein relate to wireless communication networks in general. **Fig. 5** is a schematic overview depicting **a wireless communication network 1**. The wireless communication network 1 comprises one or more RANs and one or more CNs. The wireless communication network 1 may use one or a number of different technologies. Embodiments herein relate to recent technology trends that are of particular interest in a NR context, however, embodiments are also applicable in further developments of existing wireless communications systems such as e.g. 6G, LTE or WCDMA.

In the wireless communication network 1, **a user equipment (UE) 10**, such as a mobile station, a wireless device, a non-access point (non-AP) STA, a STA, and/or a wireless terminal, is communicating via, e.g., one or more Access Networks (AN), e.g., RAN, to one or more CNs. It should be understood by the skilled in the art that “UE” is a non-limiting term which means any terminal, wireless communications terminal or device, user equipment, narrowband (NB)- internet of things (IoT) device, Machine Type Communication (MTC) device, Device to Device (D2D) terminal, or node, e.g., smart phone, laptop, mobile phone, sensor, relay, mobile tablets or even a small base station capable of communicating using radio communication with a network node within an area served by the network node.

The wireless communication network 10 comprises **a radio network node 12**, e.g., an access node, an access controller, a base station, e.g. a radio base station such as a gNodeB (gNB), an evolved Node B (eNB, eNode B), a NodeB, a base transceiver station, a radio remote unit, an Access Point Base Station, a base station router, a Wireless Local Area Network (WLAN) access point or an Access Point Station (AP STA), a stand-alone access point, or any other network unit or node capable of communicating with a UE within **a service area 11**, such as a cell, served by the network node 12 depending e.g., on a radio access technology and terminology used. The service area 11 may also be referred to as a cell, a beam or a beam group of a first radio access technology (RAT), such as 6G,

5G, LTE, Wi-Fi, or similar. The radio network node 12 may be associated with a first Public Land Mobile Network (PLMN) and/or a first Non-Public Network (NPN).

The wireless communication network 10 further comprises a network node 13 handling service data. The network node 13 may comprise a **VAL server 14** and a SEALDD server, also referred to as **server node 15**. It should be understood that these nodes may be separated nodes or co-located nodes.

The UE 10 may comprise a **VAL client 16** and a SEALDD client, also referred to as a **client node 17**. It should be understood that these clients may be separated clients or co-located clients.

According to embodiments herein the SEALDD layer can utilize new capability exposed by 3GPP network and such information can be used by SEALDD (as application handling the VAL traffic) for adjust data transmission.

The client node 17 is informed about indication of BAT offset and/or proposed periodicity. The client node 17 may then use this indication in a data transmission adjustment for the VAL client/server. Add a new transmission quality guarantee approach to optimize the data transmission via SEALDD considering the network capability and application adaptation.

Fig. 6 is a combined flowchart and signalling scheme according to some embodiments herein. Fig. 6 illustrates a procedure of using 3GPP CN capability for BAT and periodicity report and application layer adjustment in SEALDD layer for data transmission.

Action 601. The VAL client 16 may request the client node 17 to apply data transmission adjustment.

Action 602. Additionally, or alternatively, the VAL server 14 may request the server node 15 to apply data transmission adjustment. Alternatively, the VAL server 14 may indicate a data transmission adjustment policy. The request may comprise a data transmission adjustment indication that indicates the data transmission adjustment need in SEALDD layer. The data transmission adjustment policy may indicate quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

Action 603. The client node 17 may transmit a capability indication to the server node 15. The capability indication indicates the client node's capability for BAT and/or periodicity adaptation, and/or transmission assistance information. BAT stands for Burst Arrival Time. Capability indications may be exchanged between the client node 17 and the server node 15. The capability indication may indicate capability for BAT and periodicity

adaptation and/or transmission assistance info. The capability for BAT and periodicity adaptation indicates BAT and periodicity adaptation capability for SEALDD client in client side initiated request. The transmission assistance info indicates transmission assistance information for uplink SEALDD traffic in client side initiated request. This may include BAT, BAT window, periodicity, and periodicity range.

Action 604. The server node 15 may subscribe to session with quality of service (QoS) with capability for BAT adaptation.

Action 605. The server node 15 may obtain BAT offset and/or proposed periodicity, for example, from the wireless communication network 1. Note: an SMF is responsible for mapping the BAT, BAT Window, Periodicity and Periodicity Range from an external clock (when available) to the 5G clock based on the time offset and cumulative rateRatio (when available) between the external clock time and 5GS time as measured and reported by the UPF.

Action 606. The server node 15 may then send an indication of the obtained BAT offset and/or proposed periodicity to the client node 17. The indication may indicate UL periodicity and/or BAT offset for UL data.

Action 607. The client node 17 may then use the BAT offset and/or proposed periodicity in a data delivery adjustment, for example, in UL delivery.

Action 608. The server node 15 may then use the BAT offset and/or proposed periodicity in a data delivery adjustment, for example, in DL delivery.

Fig. 7 illustrates an example of a method performed by the server node 15, such as SEALDD server, for handling data delivery in the wireless communication network 1 in accordance with embodiments herein. Optional actions are shown using a dashed line. The acts in Fig. 7 may be performed in any suitable order.

Action 701. The server node 15 may receive a request from the VAL server 14 to apply data transmission adjustment. Alternatively, server node 15 may receive a request for a data transmission adjustment policy. The request may comprise a data transmission adjustment indication that indicates the data transmission adjustment need in SEALDD layer. The data transmission adjustment policy may indicate quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

Action 702. The server node 15 may receive the capability indication from the client node 17. The capability indication may indicate capability for BAT and periodicity adaptation and/or transmission assistance info. The capability for BAT and periodicity adaptation

indicates BAT and periodicity adaptation capability for SEALDD client. This may include BAT, BAT window, periodicity, and periodicity range.

Action 703. The server node 15 may subscribe to session with QoS with capability for BAT adaptation and/or transmission assistance info. This may be based on the capability indication as well as its own capability.

Action 704. The server node 15 obtains BAT offset and/or proposed periodicity, for example, from the wireless communication network 1.

Action 705. The server node 15 sends an indication of the obtained BAT offset and/or proposed periodicity to the client node 17. The indication may indicate UL periodicity and/or BAT offset for UL data.

Action 706. The server node 15 may then use or apply the obtained BAT offset and/or proposed periodicity, such as BAT, BAT window, periodicity, and periodicity range, in a data delivery adjustment, for example, in DL delivery. The BAT offset and/or periodicity may be used by a SEALDD server to adjust a packet sending time and its internal packet buffering/scheduling.

Fig. 8 illustrates an example of a method performed by the client node 17, such as SEALDD client, for handling data delivery in the wireless communication network 1 in accordance with embodiments herein. Optional actions are shown using a dashed line. The acts in Fig. 8 may be performed in any suitable order.

Action 801. The client node 17 may receive a request from the VAL client 16 to apply data transmission adjustment. The request may comprise a data transmission adjustment indication that indicates the data transmission adjustment need in SEALDD layer, and/or quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

Action 802. The client node 17 may transmit a capability indication to the server node 15. The capability indication indicates the client node's capability for BAT and/or periodicity adaptation, and/or transmission assistance information. Capability indications may be exchanged between the client node 17 and the server node 15, upon request or retrieval. The capability indication may indicate capability for BAT and periodicity adaptation and/or transmission assistance info. The capability for BAT and periodicity adaptation indicates BAT and periodicity adaptation capability for SEALDD client in client side initiated request. The transmission assistance info indicates transmission assistance information for uplink SEALDD traffic in client side initiated request. This may include BAT, BAT window, periodicity, and periodicity range.

Action 803. The client node 17 receives, from the server node 15, the indication of the obtained BAT offset and/or proposed periodicity. The indication may indicate UL periodicity and/or BAT offset for UL data.

Action 804. The client node 17 may then use the BAT offset and/or proposed periodicity in a data delivery adjustment, for example, in UL delivery. The BAT offset and/or periodicity may be used by a SEALDD client to adjust a packet sending time and its internal packet buffering/scheduling.

Fig. 9 illustrates an example of a method performed by the VAL server 14 for handling data delivery in the wireless communication network 1 in accordance with embodiments herein. Optional actions are shown using a dashed line. The acts in Fig. 9 may be performed in any suitable order.

Action 901. The VAL server 14 requests the server node 15 to apply data transmission adjustment. Alternatively, the VAL server 14 may indicate a data transmission adjustment policy. The request may comprise a data transmission adjustment indication that indicates the data transmission adjustment need in SEALDD layer. The data transmission adjustment policy may indicate quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

Proposed changes in 23.433 underlined:

* * * First Change * * * *

9.9.2.x SEALDD enabled data transmission quality guarantee with BAT and periodicity adaptation

Figure 9.9.2.x-1 illustrates the procedure of using 3GPP CN (5GS) capability for BAT and periodicity report and application layer adjustment in SEALDD layer for data transmission.

Pre-conditions:

1. Either VAL client or VAL server needs to have data transmission optimization when using SEALDD service.

Figure 10: SEALDD data transmission quality guarantee with BAT and periodicity adaptation

1. A VAL client and server establish a SEALDD regular or redundant connection to transport the application data as described in clause 9.2 or clause 9.3. During the connection establishment, VAL may request SEALDD layer to apply data transmission adjustment:
 - The VAL client may request the SEALDD client to apply data transmission adjustment, then the SEALDD client includes an indication for data transmission adjustment request as part of the connection establishment over SEALDD-UU reference point.

- The VAL server may request the SEALDD server to apply data transmission adjustment in SEALDD regular or URLLC transmission request. Alternatively, the VAL server may indicate the data transmission adjustment policy to be performed in SEALDD policy configuration request.

In SEALDD-UU connection establishment, the SEALDD client also includes its capability for BAT and periodicity adaptation, or transmission assistance info to the SEALDD server in the connection establishment request (SEALDD client triggered establishment) or response (SEALDD server triggered establishment).

2. The SEALDD server, based on received data transmission adjustment request from VAL server or SEALDD client, its own capability and/or received capability from SEALDD client for BAT and periodicity adaptation, and its own DL transmission assistance info and/or received transmission assistance info from SEALDD client, subscribes to 5GS AF session with QoS service with capability for BAT adaptation or transmission assistance info.
3. The SEALDD server receives BAT offset and proposed periodicity (which was adjusted in 5GS) in AF session with QoS notification from 5GS.
4. If the SEALDD client indicated its BAT and periodicity adaptation capability in step 1 during SEALDD connection establishment, the SEALDD server sends UL periodicity and BAT window to the SEALDD client in Transmission quality management request with transmission parameter adjustment action.
5. The SEALDD client applies UL periodicity and BAT offset for uplink SEALDD data.
6. The SEALDD server locally applies DL periodicity and BAT offset for downlink SEALDD data.

NOTE: Step 6 can happen before step 5.

* * * Next Change * * * *

9.2.3.1 SEALDD enabled regular transmission request

Table 9.2.3.1-1 describes the information flow from the VAL server to the SEALDD server for requesting the regular application transmission service.

Table 9.2.3.1-1: SEALDD enabled Regular transmission request

Information element	Status	Description
VAL server ID	M	Identity of the VAL server
VAL service ID	O	Identity of the VAL service
UE identity	O	Identifier of specific UE, e.g. UE ID, UE address
SEALDD-S Data transmission connection information	M	Address/port and/or URL of the VAL server to receive the application packets from the SEALDD server
QoS information	O	QoS information provided by VAL server
VAL server's total bandwidth limit	O (See NOTE)	The total bandwidth limit of VAL server, including UL/DL
VAL users' bandwidth limit	O (See NOTE)	The bandwidth limits (i.e. minimum bandwidth requirement and maximum bandwidth limit) for VAL users, including UL/DL
<u>Data transmission adjustment Indication</u>	<u>O</u>	<u>Indicates the data transmission adjustment need in SEALDD layer.</u>
NOTE: These IEs are used for the SEALDD enabled bandwidth control for different VAL users.		

* * * Next Change * * * *

9.2.3.3 SEALDD regular transmission connection establishment request

Table 9.2.3.3-1 describes the information flow from the SEALDD client to the SEALDD server or from the SEALDD server to the SEALDD client for requesting the regular SEALDD connection establishment.

Table 9.2.3.3-1: SEALDD regular transmission connection establishment request

Information element	Status	Description
Requestor ID	M	Identity of the requestor (SEALDD client or SEALDD server).
SEALDD flow ID	M (See NOTE 1)	Identity of the SEALDD flow.
VAL server ID	O	Identity of the VAL server, applicable for SEALDD client side initiated request.
VAL service ID	O	Identity of the VAL service
Selected VAL server endpoint	M	Endpoint of the selected VAL server
SEALDD traffic descriptor	O	SEALDD traffic descriptor (e.g. address, port, URL, transport layer protocol) of the SEALDD client side (for client side initiated request) or the SEALDD server side (for server side initiated request) used to establish SEALDD connection.
VAL UE/user identity	O	The VAL user ID of the VAL user or VAL UE ID.
SEALDD communication lifetime	O	Identifies the DD communication lifetime, applicable for SEALDD server side initiated request.
Capability for BAT and periodicity adaptation	O (See NOTE 2)	Indicates BAT and periodicity adaptation capability for SEALDD client in client side initiated request.
Transmission assistance info	O (See NOTE 2)	Indicates transmission assistance information for uplink SEALDD traffic in client side initiated request. It includes BAT, BAT window, periodicity, and periodicity range.
NOTE 1: The SEALDD flow ID is used by the SEALDD client and SEALDD server to identify different application traffic, and it is mapped to the identifiers of the application traffic and data transmission session.		
NOTE 2: One of these IEs may be present in the message.		

9.2.3.4 SEALDD regular transmission connection establishment response

Table 9.2.3.4-1 describes the information flow from the SEALDD server to the SEALDD client or from the SEALDD client to the SEALDD server for responding to the regular SEALDD connection establishment.

Table 9.2.3.4-1: SEALDD regular transmission connection establishment response

Information element	Status	Description
Result	M	Indicates the success or failure of establishing the SEALDD connection.
SEALDD traffic descriptor	O	SEALDD traffic descriptor (e.g. address, port, URL, transport layer protocol) of the SEALDD server side (for client side initiated request) or the SEALDD client side (for server side initiated request) used to establish SEALDD connection.
Pending timer	O (See NOTE 1)	The pending timer to trigger the re-connection from SEALDD client when bandwidth limit check is failed.
Suggested traffic transmission bandwidth	O (See NOTE 1)	The suggested traffic transmission bandwidth used by SEALDD client or SEALDD server to perform bandwidth control for VAL users, including UL/DL.
<u>Capability for BAT and periodicity adaptation</u>	<u>O</u> (See NOTE 2)	<u>Indicates BAT and periodicity adaptation capability for SEALDD client in server side initiated request.</u>
<u>Transmission assistance info</u>	<u>O</u> (See NOTE 2)	<u>Indicates transmission assistance information for uplink SEALDD traffic in server side initiated request.</u> <u>It includes BAT, BAT window, periodicity, and periodicity range.</u>
NOTE 1: These IEs are used for the SEALDD enabled bandwidth control for different VAL users, applicable for client side initiated request.		
NOTE 2: One of these IEs may be present in the message.		

* * * Next Change * * * *

9.3.3.3 SEALDD URLLC transmission connection establishment request

Table 9.3.3.3-1 describes the information flow from the SEALDD client to the SEALDD server for requesting the URLLC transmission connection establishment.

Table 9.3.3.3-1: SEALDD URLLC transmission connection establishment request

Information element	Status	Description
SEALDD client ID	M	Identity of the SEALDD client.
VAL UE/user identity	O	The VAL user ID of the VAL user or VAL UE ID
SEALDD flow ID	M (See NOTE 1)	Identity of the SEALDD flow.
VAL server ID	O (See NOTE 1)	Identity of the VAL server.
VAL service ID	O (See NOTE 1)	Identity of the VAL service.
SEALDD traffic descriptors	O	A pair of SEALDD traffic descriptors (e.g. address, port, transport layer protocol) of the SEALDD client side used to establish redundant SEALDD connection.
<u>Capability for BAT and periodicity adaptation</u>	O (See NOTE 2)	<u>Indicates BAT and periodicity adaptation capability for SEALDD client in client side initiated request.</u>
<u>Transmission assistance info</u>	O (See NOTE 2)	<u>Indicates transmission assistance information for uplink SEALDD traffic in client side initiated request.</u> <u>It includes BAT, BAT window, periodicity, and periodicity range.</u> <u>For URLLC transmission, it includes assistance information per SEALDD traffic descriptor.</u>
NOTE 1: The SEALDD flow ID is used by the SEALDD client and SEALDD server to identify different application traffic, and it is mapped from the VAL service ID.		
NOTE 2: One of these IEs may be present in the message.		

9.3.3.4 SEALDD URLLC transmission connection establishment response

Table 9.3.3.4-1 describes the information flow from the SEALDD server to the SEALDD client for responding to the URLLC transmission connection establishment.

Table 9.3.3.4-1: SEALDD URLLC transmission connection establishment response

Information element	Status	Description
Result	M	Indicates the success or failure of establishing the SEALDD connection.
SEALDD traffic descriptors	O	A pair of SEALDD traffic descriptors (e.g. address, port, transport layer protocol) of the SEALDD server side used to establish redundant SEALDD connection.
<u>Capability for BAT and periodicity adaptation</u>	O (See NOTE)	<u>Indicates BAT and periodicity adaptation capability for SEALDD client in server side initiated request.</u>
<u>Transmission assistance info</u>	O (See NOTE)	<u>Indicates transmission assistance information for uplink SEALDD traffic in server side initiated request.</u> <u>It includes BAT, BAT window, periodicity, and periodicity range.</u> <u>For URLLC transmission, it includes assistance information per SEALDD traffic descriptor.</u>
NOTE: One of these IEs may be present in the message.		

* * * Next Change * * * *

9.9.3.1 Transmission quality guarantee request

Table 9.9.3.1-1 describes the information flow from the SEALDD server to the SEALDD client for requesting data transmission quality guarantee.

Table 9.9.3.1-1: Transmission quality guarantee request

Information element	Status	Description
SEALDD flow ID	M	Identifier of the SEALDD flow.
Transmission quality guarantee action	M	Indicates the data transmission quality guarantee action (e.g. redundant transmission path, re-establish transmission path, switch to backup transmission path) or <u>optimization action (return back to single transmission path, transmission parameter adjustment)</u> that triggering by event (e.g. measurement threshold).
UL periodicity	O	<u>Uplink periodicity.</u>
BAT offset for UL	O	<u>BAT offset for Uplink data.</u>

NOTE: The triggering event (e.g. measurement threshold) is changeable with the transmission quality guarantee event.

Editor's Note: The Transmission quality guarantee action is to be changed to the quality guarantee policy in Table 9.7.3.6. The SEALDD policy configuration request in table 9.10.3.1-1 is to be aligned by adding the Transmission quality guarantee policy in this table.

* * * Next Change * * * *

9.10.3.1 SEALDD policy configuration request

Table 9.10.3.1-1 describes the information flow from the VAL server to the SEALDD server for requesting the SEALDD policy configuration.

Table 9.10.3.1-1: SEALDD policy configuration request

Information element	Status	Description
Application traffic identifiers	M	Identify of the application traffic (e.g. VAL server ID, VAL service ID)
VAL UE identity	O	Identifier of the VAL UE for which SEALDD policy applies
SEALDD policy	M	The SEALDD policy associated with application traffic identifiers, VAL UE identify
> Quality guarantee policy	O (See NOTE 1)	Indicates the action to be performed when the measurement event (e.g. measurement threshold) occurs, in order to meet the quality guarantee.
> <u>Quality optimization policy</u>	O	<u>Indicates the data transmission adjustment policy (e.g., adjustment need) to be performed in SEALDD layer.</u>
> Bandwidth control policy	O (See NOTE 2)	The bandwidth control policy from VAL server, e.g. re-allocating the bandwidth limit between different VAL users, including UL/DL
NOTE 1: This IE is used for the SEALDD enabled transmission quality guarantee, as specified in clause 9.9.		
NOTE 2: This IE is used for the SEALDD enabled bandwidth control, as specified in clause 9.8.		

Fig. 11 depicts embodiment of the server node 15 for handling data delivery in the wireless communication network according to embodiments herein.

The server node 15 may comprise **processing circuitry 1101**, e.g. one or more processors, configured to perform the methods herein.

The server node 15 and/or the processing circuitry 1101 may be configured to receive the request from the VAL server 14 to apply data transmission adjustment.

Alternatively, the server node 15 and/or the processing circuitry 1101 may be configured to receive a request for a data transmission adjustment policy. The request may comprise a data transmission adjustment indication that indicates the data transmission adjustment need in SEALDD layer. The data transmission adjustment policy may indicate quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

The server node 15 and/or the processing circuitry 1101 may be configured to receive the capability indication from the client node 17. The capability indication may indicate capability for BAT and periodicity adaptation and/or transmission assistance info. The capability for BAT and periodicity adaptation indicates BAT and periodicity adaptation capability for SEALDD client. This may include BAT, BAT window, periodicity, and periodicity range.

The server node 15 and/or the processing circuitry 1101 may be configured to subscribe to a session with QoS with capability for BAT adaptation and/or transmission assistance info. This may be based on the capability indication as well as its own capability.

The server node 15 and/or the processing circuitry 1101 is configured to obtain the BAT offset and/or the proposed periodicity, for example, from the wireless communication network 1.

The server node 15 and/or the processing circuitry 1101 is configured to send the indication of the obtained BAT offset and/or the proposed periodicity to the client node 17. The indication may indicate UL periodicity and/or BAT offset for UL data.

The server node 15 and/or the processing circuitry 1101 may be configured to use or apply the obtained BAT offset and/or proposed periodicity, such as BAT, BAT window, periodicity, and periodicity range, in a data delivery adjustment, for example, in DL delivery.

The server node 15 further comprises **a memory 1105**. The memory 1105 comprises one or more units to be used to store data on, such as indications, mapping, capability indication, capability, measurements, packets, BAT information, transmission assistance information, data related to nodes, and applications to perform the methods disclosed herein when being executed, and similar. Furthermore, the server node 15 may comprise **a communication interface 1106** such as comprising a transmitter, a receiver, a transceiver and/or one or more antennas, such as antenna arrays.

The methods according to the embodiments described herein for the server node 15 are respectively implemented using e.g., **a computer program product 1107** or a computer program, comprising instructions, i.e., software code portions, which, when executed on at least one processor, cause the at least one processor to carry out the actions

described herein, as performed by the server node 15. The computer program product 1107 may be stored on a **computer-readable storage medium 1108**, e.g., a disc, a universal serial bus (USB) stick or similar. The computer-readable storage medium 1108, having stored thereon the computer program product, may comprise the instructions which, when executed on at least one processor, cause the at least one processor to carry out the actions described herein, as performed by the server node 15. In some embodiments, the computer-readable storage medium may be a transitory or a non-transitory computer-readable storage medium. Thus, embodiments herein may disclose a server node 15 for handling data delivery in a wireless communication network, wherein the server node 15 comprises processing circuitry and a memory, the memory comprising instructions executable by the processing circuitry whereby the server node 15 is operative to perform any of the methods herein.

Fig. 12 depicts embodiment of the client node 17 for handling data delivery in the wireless communication network according to embodiments herein.

The client node 17 may comprise **processing circuitry 1201**, e.g., one or more processors, configured to perform the methods herein.

The client node 17 and/or the processing circuitry 1201 may be configured to receive the request from the VAL client 16 to apply data transmission adjustment. The request may comprise the data transmission adjustment indication that indicates the data transmission adjustment need in SEALDD layer, and/or the quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

The client node 17 and/or the processing circuitry 1201 may be configured to transmit the capability indication to the server node 15. The capability indication indicates the client node's capability for BAT and/or periodicity adaptation, and/or transmission assistance information. Capability indications may be exchanged between the client node 17 and the server node 15, upon request or retrieval. The capability indication may indicate capability for BAT and periodicity adaptation and/or transmission assistance info. The capability for BAT and periodicity adaptation indicates BAT and periodicity adaptation capability for SEALDD client in client side initiated request. The transmission assistance info indicates transmission assistance information for uplink SEALDD traffic in client side initiated request. This may include BAT, BAT window, periodicity, and periodicity range.

The client node 17 and/or the processing circuitry 1201 is configured to receive, from the server node 15, the indication of the obtained BAT offset and/or the proposed periodicity. The indication may indicate UL periodicity and/or BAT offset for UL data.

The client node 17 and/or the processing circuitry 1201 may be configured to use the BAT offset and/or proposed periodicity in a data delivery adjustment, for example, in UL delivery.

The client node 17 further comprises **a memory 1205**. The memory 1205 comprises one or more units to be used to store data on, such as indications, mapping, capability indication, capability, measurements, packets, BAT information, transmission assistance information, data related to nodes, and applications to perform the methods disclosed herein when being executed, and similar. Furthermore, the client node 17 may comprise **a communication interface 1206** such as comprising a transmitter, a receiver, a transceiver and/or one or more antennas, such as antenna arrays.

The methods according to the embodiments described herein for the client node 17 are respectively implemented using e.g., **a computer program product 1207** or a computer program, comprising instructions, i.e., software code portions, which, when executed on at least one processor, cause the at least one processor to carry out the actions described herein, as performed by the client node 17. The computer program product 1207 may be stored on **a computer-readable storage medium 1208**, e.g., a disc, a universal serial bus (USB) stick or similar. The computer-readable storage medium 1208, having stored thereon the computer program product, may comprise the instructions which, when executed on at least one processor, cause the at least one processor to carry out the actions described herein, as performed by the client node 17. In some embodiments, the computer-readable storage medium may be a transitory or a non-transitory computer-readable storage medium. Thus, embodiments herein may disclose a client node 17 for handling data delivery in a wireless communication network, wherein the client node 17 comprises processing circuitry and a memory, the memory comprising instructions executable by the processing circuitry whereby the client node 17 is operative to perform any of the methods herein.

Fig. 13 depicts embodiment of the VAL server 14 for handling data delivery in the wireless communication network according to embodiments herein.

The VAL server 14 may comprise **processing circuitry 1301**, e.g. one or more processors, configured to perform the methods herein.

The VAL server 14 and/or the processing circuitry 1301 is configured to request the server node 15 to apply data transmission adjustment. Alternatively, the VAL server 14 and/or the processing circuitry 1301 is configured to indicate the data transmission adjustment policy. The request may comprise a data transmission adjustment indication

that indicates the data transmission adjustment need in SEALDD layer. The data transmission adjustment policy may indicate quality optimization policy indicating the data transmission adjustment policy to be performed in SEALDD layer.

The VAL server 14 further comprises **a memory 1305**. The memory 1305 comprises one or more units to be used to store data on, such as indications, mapping, capability indication, capability, measurements, packets, BAT information, transmission assistance information, data related to nodes, and applications to perform the methods disclosed herein when being executed, and similar. Furthermore, the VAL server 14 may comprise **a communication interface 1306** such as comprising a transmitter, a receiver, a transceiver and/or one or more antennas, such as antenna arrays.

The methods according to the embodiments described herein for the VAL server 14 are respectively implemented using e.g., **a computer program product 1307** or a computer program, comprising instructions, i.e., software code portions, which, when executed on at least one processor, cause the at least one processor to carry out the actions described herein, as performed by the VAL server 14. The computer program product 1307 may be stored on **a computer-readable storage medium 1308**, e.g., a disc, a universal serial bus (USB) stick or similar. The computer-readable storage medium 1308, having stored thereon the computer program product, may comprise the instructions which, when executed on at least one processor, cause the at least one processor to carry out the actions described herein, as performed by the VAL server 14. In some embodiments, the computer-readable storage medium may be a transitory or a non-transitory computer-readable storage medium. Thus, embodiments herein may disclose a VAL server 14 for handling data delivery in a wireless communication network, wherein the VAL server 14 comprises processing circuitry and a memory, the memory comprising instructions executable by the processing circuitry whereby the VAL server 14 is operative to perform any of the methods herein.

In some embodiments, a more general term “network node” is used and it can correspond to any type of radio network node or any network node, which communicates with a UE and/or with another network node. Examples of network nodes are NodeB, Master eNB, Secondary eNB, a network node belonging to Master cell group (MCG) or Secondary cell group (SCG), base station (BS), multi-standard radio (MSR) radio node such as MSR BS, eNodeB, network controller, radio-network controller (RNC), base station controller (BSC), relay, donor node controlling relay, base transceiver station (BTS), access point (AP), transmission points, transmission nodes, Remote radio Unit (RRU), Remote Radio Head (RRH), nodes in distributed antenna system (DAS), etc.

In some embodiments, the non-limiting term wireless device or UE is used and it refers to any type of wireless device communicating with a network node and/or with another wireless device in a cellular or mobile communication system. Examples of UE are IoT capable device, target device, device to device (D2D) UE, proximity capable UE (aka ProSe UE), machine type UE or UE capable of machine to machine (M2M) communication, Tablet, mobile terminals, smart phone, laptop embedded equipped (LEE), laptop mounted equipment (LME), USB dongles, etc.

Embodiments are applicable to any RAT or multi-RAT systems, where the wireless device receives and/or transmit signals (e.g. data) e.g. New Radio (NR), Wi-Fi, Long Term Evolution (LTE), LTE-Advanced, Wideband Code Division Multiple Access (WCDMA), Global System for Mobile communications/enhanced Data rate for GSM Evolution (GSM/EDGE), Worldwide Interoperability for Microwave Access (WiMax), or Ultra Mobile Broadband (UMB), just to mention a few possible implementations.

As will be readily understood by those familiar with communications design, that functions means or circuits may be implemented using digital logic and/or one or more microcontrollers, microprocessors, or other digital hardware. In some embodiments, several or all of the various functions may be implemented together, such as in a single application-specific integrated circuit (ASIC), or in two or more separate devices with appropriate hardware and/or software interfaces between them. Several of the functions may be implemented on a processor shared with other functional components of a wireless device or network node, for example.

Alternatively, several of the functional elements of the processing means discussed may be provided through the use of dedicated hardware, while others are provided with hardware for executing software, in association with the appropriate software or firmware. Thus, the term “processor” or “controller” as used herein does not exclusively refer to hardware capable of executing software and may implicitly include, without limitation, digital signal processor (DSP) hardware and/or program or application data. Other hardware, conventional and/or custom, may also be included. Designers of communications devices will appreciate the cost, performance, and maintenance trade-offs inherent in these design choices.

Fig. 14 shows an example of a communication system QQ100 in accordance with some embodiments.

In the example, the communication system QQ100 includes a telecommunication network QQ102 that includes an access network QQ104, such as a radio access network

(RAN), and a core network QQ106, which includes one or more core network nodes QQ108. The access network QQ104 includes one or more access network nodes, such as network nodes QQ110a and QQ110b (one or more of which may be generally referred to as network nodes QQ110 or network node 12), or any other similar 3rd Generation Partnership Project (3GPP) access nodes or non-3GPP access points. Moreover, as will be appreciated by those of skill in the art, a network node, being examples of the entities herein, is not necessarily limited to an implementation in which a radio portion and a baseband portion are supplied and integrated by a single vendor. Thus, it will be understood that network nodes include disaggregated implementations or portions thereof. For example, in some embodiments, the telecommunication network QQ102 includes one or more Open-RAN (ORAN) network nodes. An ORAN network node is a node in the telecommunication network QQ102 that supports an ORAN specification (e.g., a specification published by the O-RAN Alliance, or any similar organization) and may operate alone or together with other nodes to implement one or more functionalities of any node in the telecommunication network QQ102, including one or more network nodes QQ110 and/or core network nodes QQ108.

Examples of an ORAN network node include an open radio unit (O-RU), an open distributed unit (O-DU), an open central unit (O-CU), including an O-CU control plane (O-CU-CP) or an O-CU user plane (O-CU-UP), a RAN intelligent controller (near-real time or non-real time) hosting software or software plug-ins, such as a near-real time control application (e.g., xApp) or a non-real time control application (e.g., rApp), or any combination thereof (the adjective “open” designating support of an ORAN specification). The network node may support a specification by, for example, supporting an interface defined by the ORAN specification, such as an A1, F1, W1, E1, E2, X2, Xn interface, an open fronthaul user plane interface, or an open fronthaul management plane interface. Moreover, an ORAN access node may be a logical node in a physical node. Furthermore, an ORAN network node may be implemented in a virtualization environment (described further below) in which one or more network functions are virtualized. For example, the virtualization environment may include an O-Cloud computing platform orchestrated by a Service Management and Orchestration Framework via an O-2 interface defined by the O-RAN Alliance or comparable technologies. The network nodes QQ110 facilitate direct or indirect connection of user equipment (UE), such as by connecting UEs QQ112a, QQ112b, QQ112c, and QQ112d (one or more of which may be generally referred to as UEs QQ112 or UE 10) to the core network QQ106 over one or more wireless connections.

Example wireless communications over a wireless connection include transmitting and/or receiving wireless signals using electromagnetic waves, radio waves, infrared waves, and/or other types of signals suitable for conveying information without the use of wires, cables, or other material conductors. Moreover, in different embodiments, the communication system QQ100 may include any number of wired or wireless networks, network nodes, UEs, and/or any other components or systems that may facilitate or participate in the communication of data and/or signals whether via wired or wireless connections. The communication system QQ100 may include and/or interface with any type of communication, telecommunication, data, cellular, radio network, and/or other similar type of system.

The UEs QQ112 may be any of a wide variety of communication devices, including wireless devices arranged, configured, and/or operable to communicate wirelessly with the network nodes QQ110 and other communication devices. Similarly, the network nodes QQ110 are arranged, capable, configured, and/or operable to communicate directly or indirectly with the UEs QQ112 and/or with other network nodes or equipment in the telecommunication network QQ102 to enable and/or provide network access, such as wireless network access, and/or to perform other functions, such as administration in the telecommunication network QQ102.

In the depicted example, the core network QQ106 connects the network nodes QQ110 to one or more hosts, such as host QQ116. These connections may be direct or indirect via one or more intermediary networks or devices. In other examples, network nodes may be directly coupled to hosts. The core network QQ106 includes one more core network nodes (e.g., core network node QQ108) that are structured with hardware and software components. Features of these components may be substantially similar to those described with respect to the UEs, network nodes, and/or hosts, such that the descriptions thereof are generally applicable to the corresponding components of the core network node QQ108. Example core network nodes include functions of one or more of a Mobile Switching Center (MSC), Mobility Management Entity (MME), Home Subscriber Server (HSS), Access and Mobility Management Function (AMF), Session Management Function (SMF), Authentication Server Function (AUSF), Subscription Identifier De-concealing function (SIDF), Unified Data Management (UDM), Security Edge Protection Proxy (SEPP), Network Exposure Function (NEF), and/or a User Plane Function (UPF).

The host QQ116 may be under the ownership or control of a service provider other than an operator or provider of the access network QQ104 and/or the telecommunication network QQ102, and may be operated by the service provider or on behalf of the service

provider. The host QQ116 may host a variety of applications to provide one or more service. Examples of such applications include live and pre-recorded audio/video content, data collection services such as retrieving and compiling data on various ambient conditions detected by a plurality of UEs, analytics functionality, social media, functions for controlling or otherwise interacting with remote devices, functions for an alarm and surveillance center, or any other such function performed by a server.

As a whole, the communication system QQ100 of Fig. 14 enables connectivity between the UEs, network nodes, and hosts. In that sense, the communication system may be configured to operate according to predefined rules or procedures, such as specific standards that include, but are not limited to: Global System for Mobile Communications (GSM); Universal Mobile Telecommunications System (UMTS); Long Term Evolution (LTE), and/or other suitable 2G, 3G, 4G, 5G standards, or any applicable future generation standard (e.g., 6G); wireless local area network (WLAN) standards, such as the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards (WiFi); and/or any other appropriate wireless communication standard, such as the Worldwide Interoperability for Microwave Access (WiMax), Bluetooth, Z-Wave, Near Field Communication (NFC) ZigBee, LiFi, and/or any low-power wide-area network (LPWAN) standards such as LoRa and Sigfox.

In some examples, the telecommunication network QQ102 is a cellular network that implements 3GPP standardized features. Accordingly, the telecommunications network QQ102 may support network slicing to provide different logical networks to different devices that are connected to the telecommunication network QQ102. For example, the telecommunications network QQ102 may provide Ultra Reliable Low Latency Communication (URLLC) services to some UEs, while providing Enhanced Mobile Broadband (eMBB) services to other UEs, and/or Massive Machine Type Communication (mMTC)/Massive IoT services to yet further UEs.

In some examples, the UEs QQ112 are configured to transmit and/or receive information without direct human interaction. For instance, a UE may be designed to transmit information to the access network QQ104 on a predetermined schedule, when triggered by an internal or external event, or in response to requests from the access network QQ104. Additionally, a UE may be configured for operating in single- or multi-RAT or multi-standard mode. For example, a UE may operate with any one or combination of Wi-Fi, NR (New Radio) and LTE, i.e. being configured for multi-radio dual connectivity (MR-DC), such as E-UTRAN (Evolved-UMTS Terrestrial Radio Access Network) New Radio – Dual Connectivity (EN-DC).

In the example, the hub QQ114 communicates with the access network QQ104 to facilitate indirect communication between one or more UEs (e.g., UE QQ112c and/or QQ112d) and network nodes (e.g., network node QQ110b). In some examples, the hub QQ114 may be a controller, router, content source and analytics, or any of the other communication devices described herein regarding UEs. For example, the hub QQ114 may be a broadband router enabling access to the core network QQ106 for the UEs. As another example, the hub QQ114 may be a controller that sends commands or instructions to one or more actuators in the UEs. Commands or instructions may be received from the UEs, network nodes QQ110, or by executable code, script, process, or other instructions in the hub QQ114. As another example, the hub QQ114 may be a data collector that acts as temporary storage for UE data and, in some embodiments, may perform analysis or other processing of the data. As another example, the hub QQ114 may be a content source. For example, for a UE that is a VR headset, display, loudspeaker or other media delivery device, the hub QQ114 may retrieve VR assets, video, audio, or other media or data related to sensory information via a network node, which the hub QQ114 then provides to the UE either directly, after performing local processing, and/or after adding additional local content. In still another example, the hub QQ114 acts as a proxy server or orchestrator for the UEs, in particular if one or more of the UEs are low energy IoT devices.

The hub QQ114 may have a constant/persistent or intermittent connection to the network node QQ110b. The hub QQ114 may also allow for a different communication scheme and/or schedule between the hub QQ114 and UEs (e.g., UE QQ112c and/or QQ112d), and between the hub QQ114 and the core network QQ106. In other examples, the hub QQ114 is connected to the core network QQ106 and/or one or more UEs via a wired connection. Moreover, the hub QQ114 may be configured to connect to an M2M service provider over the access network QQ104 and/or to another UE over a direct connection. In some scenarios, UEs may establish a wireless connection with the network nodes QQ110 while still connected via the hub QQ114 via a wired or wireless connection. In some embodiments, the hub QQ114 may be a dedicated hub – that is, a hub whose primary function is to route communications to/from the UEs from/to the network node QQ110b. In other embodiments, the hub QQ114 may be a non-dedicated hub – that is, a device which is capable of operating to route communications between the UEs and network node QQ110b, but which is additionally capable of operating as a communication start and/or end point for certain data channels.

Fig. 15 shows a UE QQ200 in accordance with some embodiments. As used herein, a UE refers to a device capable, configured, arranged and/or operable to communicate

wirelessly with network nodes and/or other UEs. Examples of a UE include, but are not limited to, a smart phone, mobile phone, cell phone, voice over IP (VoIP) phone, wireless local loop phone, desktop computer, personal digital assistant (PDA), wireless cameras, gaming console or device, music storage device, playback appliance, wearable terminal device, wireless endpoint, mobile station, tablet, laptop, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), smart device, wireless customer-premise equipment (CPE), vehicle, vehicle-mounted or vehicle embedded/integrated wireless device, etc. Other examples include any UE identified by the 3rd Generation Partnership Project (3GPP), including a narrow band internet of things (NB-IoT) UE, a machine type communication (MTC) UE, and/or an enhanced MTC (eMTC) UE.

A UE may support device-to-device (D2D) communication, for example by implementing a 3GPP standard for sidelink communication, Dedicated Short-Range Communication (DSRC), vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), or vehicle-to-everything (V2X). In other examples, a UE may not necessarily have a user in the sense of a human user who owns and/or operates the relevant device. Instead, a UE may represent a device that is intended for sale to, or operation by, a human user but which may not, or which may not initially, be associated with a specific human user (e.g., a smart sprinkler controller). Alternatively, a UE may represent a device that is not intended for sale to, or operation by, an end user but which may be associated with or operated for the benefit of a user (e.g., a smart power meter).

The UE QQ200 includes processing circuitry QQ202 that is operatively coupled via a bus QQ204 to an input/output interface QQ206, a power source QQ208, a memory QQ210, a communication interface QQ212, and/or any other component, or any combination thereof. Certain UEs may utilize all or a subset of the components shown in Fig. 15. The level of integration between the components may vary from one UE to another UE. Further, certain UEs may contain multiple instances of a component, such as multiple processors, memories, transceivers, transmitters, receivers, etc.

The processing circuitry QQ202 is configured to process instructions and data and may be configured to implement any sequential state machine operative to execute instructions stored as machine-readable computer programs in the memory QQ210. The processing circuitry QQ202 may be implemented as one or more hardware-implemented state machines (e.g., in discrete logic, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), etc.); programmable logic together with appropriate firmware; one or more stored computer programs, general-purpose processors, such as a microprocessor or digital signal processor (DSP), together with appropriate software; or any

combination of the above. For example, the processing circuitry QQ202 may include multiple central processing units (CPUs).

In the example, the input/output interface QQ206 may be configured to provide an interface or interfaces to an input device, output device, or one or more input and/or output devices. Examples of an output device include a speaker, a sound card, a video card, a display, a monitor, a printer, an actuator, an emitter, a smartcard, another output device, or any combination thereof. An input device may allow a user to capture information into the UE QQ200. Examples of an input device include a touch-sensitive or presence-sensitive display, a camera (e.g., a digital camera, a digital video camera, a web camera, etc.), a microphone, a sensor, a mouse, a trackball, a directional pad, a trackpad, a scroll wheel, a smartcard, and the like. The presence-sensitive display may include a capacitive or resistive touch sensor to sense input from a user. A sensor may be, for instance, an accelerometer, a gyroscope, a tilt sensor, a force sensor, a magnetometer, an optical sensor, a proximity sensor, a biometric sensor, etc., or any combination thereof. An output device may use the same type of interface port as an input device. For example, a Universal Serial Bus (USB) port may be used to provide an input device and an output device.

In some embodiments, the power source QQ208 is structured as a battery or battery pack. Other types of power sources, such as an external power source (e.g., an electricity outlet), photovoltaic device, or power cell, may be used. The power source QQ208 may further include power circuitry for delivering power from the power source QQ208 itself, and/or an external power source, to the various parts of the UE QQ200 via input circuitry or an interface such as an electrical power cable. Delivering power may be, for example, for charging of the power source QQ208. Power circuitry may perform any formatting, converting, or other modification to the power from the power source QQ208 to make the power suitable for the respective components of the UE QQ200 to which power is supplied.

The memory QQ210 may be or be configured to include memory such as random access memory (RAM), read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), magnetic disks, optical disks, hard disks, removable cartridges, flash drives, and so forth. In one example, the memory QQ210 includes one or more application programs QQ214, such as an operating system, web browser application, a widget, gadget engine, or other application, and corresponding data QQ216. The memory QQ210 may store, for use by the UE QQ200, any of a variety of various operating systems or combinations of operating systems.

The memory QQ210 may be configured to include a number of physical drive units, such as redundant array of independent disks (RAID), flash memory, USB flash drive, external hard disk drive, thumb drive, pen drive, key drive, high-density digital versatile disc (HD-DVD) optical disc drive, internal hard disk drive, Blu-Ray optical disc drive, holographic digital data storage (HDDS) optical disc drive, external mini-dual in-line memory module (DIMM), synchronous dynamic random access memory (SDRAM), external micro-DIMM SDRAM, smartcard memory such as tamper resistant module in the form of a universal integrated circuit card (UICC) including one or more subscriber identity modules (SIMs), such as a USIM and/or ISIM, other memory, or any combination thereof. The UICC may for example be an embedded UICC (eUICC), integrated UICC (iUICC) or a removable UICC commonly known as 'SIM card.' The memory QQ210 may allow the UE QQ200 to access instructions, application programs and the like, stored on transitory or non-transitory memory media, to off-load data, or to upload data. An article of manufacture, such as one utilizing a communication system may be tangibly embodied as or in the memory QQ210, which may be or comprise a device-readable storage medium.

The processing circuitry QQ202 may be configured to communicate with an access network or other network using the communication interface QQ212. The communication interface QQ212 may comprise one or more communication subsystems and may include or be communicatively coupled to an antenna QQ222. The communication interface QQ212 may include one or more transceivers used to communicate, such as by communicating with one or more remote transceivers of another device capable of wireless communication (e.g., another UE or a network node in an access network). Each transceiver may include a transmitter QQ218 and/or a receiver QQ220 appropriate to provide network communications (e.g., optical, electrical, frequency allocations, and so forth). Moreover, the transmitter QQ218 and receiver QQ220 may be coupled to one or more antennas (e.g., antenna QQ222) and may share circuit components, software or firmware, or alternatively be implemented separately.

In the illustrated embodiment, communication functions of the communication interface QQ212 may include cellular communication, Wi-Fi communication, LPWAN communication, data communication, voice communication, multimedia communication, short-range communications such as Bluetooth, near-field communication, location-based communication such as the use of the global positioning system (GPS) to determine a location, another like communication function, or any combination thereof. Communications may be implemented in according to one or more communication protocols and/or standards, such as IEEE 802.11, Code Division Multiplexing Access (CDMA), Wideband

Code Division Multiple Access (WCDMA), GSM, LTE, New Radio (NR), UMTS, WiMax, Ethernet, transmission control protocol/internet protocol (TCP/IP), synchronous optical networking (SONET), Asynchronous Transfer Mode (ATM), QUIC, Hypertext Transfer Protocol (HTTP), and so forth.

Regardless of the type of sensor, a UE may provide an output of data captured by its sensors, through its communication interface QQ212, via a wireless connection to a network node. Data captured by sensors of a UE can be communicated through a wireless connection to a network node via another UE. The output may be periodic (e.g., once every 15 minutes if it reports the sensed temperature), random (e.g., to even out the load from reporting from several sensors), in response to a triggering event (e.g., when moisture is detected, an alert is sent), in response to a request (e.g., a user initiated request), or a continuous stream (e.g., a live video feed of a patient).

As another example, a UE comprises an actuator, a motor, or a switch, related to a communication interface configured to receive wireless input from a network node via a wireless connection. In response to the received wireless input the states of the actuator, the motor, or the switch may change. For example, the UE may comprise a motor that adjusts the control surfaces or rotors of a drone in flight according to the received input or to a robotic arm performing a medical procedure according to the received input.

A UE, when in the form of an Internet of Things (IoT) device, may be a device for use in one or more application domains, these domains comprising, but not limited to, city wearable technology, extended industrial application and healthcare. Non-limiting examples of such an IoT device are a device which is or which is embedded in: a connected refrigerator or freezer, a TV, a connected lighting device, an electricity meter, a robot vacuum cleaner, a voice controlled smart speaker, a home security camera, a motion detector, a thermostat, a smoke detector, a door/window sensor, a flood/moisture sensor, an electrical door lock, a connected doorbell, an air conditioning system like a heat pump, an autonomous vehicle, a surveillance system, a weather monitoring device, a vehicle parking monitoring device, an electric vehicle charging station, a smart watch, a fitness tracker, a head-mounted display for Augmented Reality (AR) or Virtual Reality (VR), a wearable for tactile augmentation or sensory enhancement, a water sprinkler, an animal- or item-tracking device, a sensor for monitoring a plant or animal, an industrial robot, an Unmanned Aerial Vehicle (UAV), and any kind of medical device, like a heart rate monitor or a remote controlled surgical robot. A UE in the form of an IoT device comprises circuitry and/or software in dependence of the intended application of the IoT device in addition to other components as described in relation to the UE QQ200 shown in Fig. 15.

As yet another specific example, in an IoT scenario, a UE may represent a machine or other device that performs monitoring and/or measurements, and transmits the results of such monitoring and/or measurements to another UE and/or a network node. The UE may in this case be an M2M device, which may in a 3GPP context be referred to as an MTC device. As one particular example, the UE may implement the 3GPP NB-IoT standard. In other scenarios, a UE may represent a vehicle, such as a car, a bus, a truck, a ship and an airplane, or other equipment that is capable of monitoring and/or reporting on its operational status or other functions associated with its operation.

In practice, any number of UEs may be used together with respect to a single use case. For example, a first UE might be or be integrated in a drone and provide the drone's speed information (obtained through a speed sensor) to a second UE that is a remote controller operating the drone. When the user makes changes from the remote controller, the first UE may adjust the throttle on the drone (e.g. by controlling an actuator) to increase or decrease the drone's speed. The first and/or the second UE can also include more than one of the functionalities described above. For example, a UE might comprise the sensor and the actuator, and handle communication of data for both the speed sensor and the actuators.

Fig. 16 shows a network node QQ300 in accordance with some embodiments. As used herein, network node refers to equipment capable, configured, arranged and/or operable to communicate directly or indirectly with a UE and/or with other network nodes or equipment, in a telecommunication network. Examples of network nodes include, but are not limited to, access points (APs) (e.g., radio access points), base stations (BSs) (e.g., radio base stations, Node Bs, evolved Node Bs (eNBs) and NR NodeBs (gNBs)), O-RAN nodes or components of an O-RAN node (e.g., O-RU, O-DU, O-CU).

Base stations may be categorized based on the amount of coverage they provide (or, stated differently, their transmit power level) and so, depending on the provided amount of coverage, may be referred to as femto base stations, pico base stations, micro base stations, or macro base stations. A base station may be a relay node or a relay donor node controlling a relay. A network node may also include one or more (or all) parts of a distributed radio base station such as centralized digital units, distributed units (e.g., in an O-RAN access node) and/or remote radio units (RRUs), sometimes referred to as Remote Radio Heads (RRHs). Such remote radio units may or may not be integrated with an antenna as an antenna integrated radio. Parts of a distributed radio base station may also be referred to as nodes in a distributed antenna system (DAS).

Other examples of network nodes include multiple transmission point (multi-TRP) 5G access nodes, multi-standard radio (MSR) equipment such as MSR BSs, network controllers such as radio network controllers (RNCs) or base station controllers (BSCs), base transceiver stations (BTSs), transmission points, transmission nodes, multi-cell/multicast coordination entities (MCEs), Operation and Maintenance (O&M) nodes, Operations Support System (OSS) nodes, Self-Organizing Network (SON) nodes, positioning nodes (e.g., Evolved Serving Mobile Location Centers (E-SMLCs)), and/or Minimization of Drive Tests (MDTs).

The network node QQ300 includes a processing circuitry QQ302, a memory QQ304, a communication interface QQ306, and a power source QQ308. The network node QQ300 may be composed of multiple physically separate components (e.g., a NodeB component and a RNC component, or a BTS component and a BSC component, etc.), which may each have their own respective components. In certain scenarios in which the network node QQ300 comprises multiple separate components (e.g., BTS and BSC components), one or more of the separate components may be shared among several network nodes. For example, a single RNC may control multiple NodeBs. In such a scenario, each unique NodeB and RNC pair, may in some instances be considered a single separate network node. In some embodiments, the network node QQ300 may be configured to support multiple radio access technologies (RATs). In such embodiments, some components may be duplicated (e.g., separate memory QQ304 for different RATs) and some components may be reused (e.g., a same antenna QQ310 may be shared by different RATs). The network node QQ300 may also include multiple sets of the various illustrated components for different wireless technologies integrated into network node QQ300, for example GSM, WCDMA, LTE, NR, WiFi, Zigbee, Z-wave, LoRaWAN, Radio Frequency Identification (RFID) or Bluetooth wireless technologies. These wireless technologies may be integrated into the same or different chip or set of chips and other components within network node QQ300.

The processing circuitry QQ302 may comprise a combination of one or more of a microprocessor, controller, microcontroller, central processing unit, digital signal processor, application-specific integrated circuit, field programmable gate array, or any other suitable computing device, resource, or combination of hardware, software and/or encoded logic operable to provide, either alone or in conjunction with other network node QQ300 components, such as the memory QQ304, to provide network node QQ300 functionality.

In some embodiments, the processing circuitry QQ302 includes a system on a chip (SOC). In some embodiments, the processing circuitry QQ302 includes one or more of radio frequency (RF) transceiver circuitry QQ312 and baseband processing circuitry QQ314. In

some embodiments, the radio frequency (RF) transceiver circuitry QQ312 and the baseband processing circuitry QQ314 may be on separate chips (or sets of chips), boards, or units, such as radio units and digital units. In alternative embodiments, part or all of RF transceiver circuitry QQ312 and baseband processing circuitry QQ314 may be on the same chip or set of chips, boards, or units.

The memory QQ304 may comprise any form of volatile or non-volatile computer-readable memory including, without limitation, persistent storage, solid-state memory, remotely mounted memory, magnetic media, optical media, random access memory (RAM), read-only memory (ROM), mass storage media (for example, a hard disk), removable storage media (for example, a flash drive, a Compact Disk (CD) or a Digital Video Disk (DVD)), and/or any other volatile or non-volatile, non-transitory device-readable and/or computer-executable memory devices that store information, data, and/or instructions that may be used by the processing circuitry QQ302. The memory QQ304 may store any suitable instructions, data, or information, including a computer program, software, an application including one or more of logic, rules, code, tables, and/or other instructions capable of being executed by the processing circuitry QQ302 and utilized by the network node QQ300. The memory QQ304 may be used to store any calculations made by the processing circuitry QQ302 and/or any data received via the communication interface QQ306. In some embodiments, the processing circuitry QQ302 and memory QQ304 is integrated.

The communication interface QQ306 is used in wired or wireless communication of signalling and/or data between a network node, access network, and/or UE. As illustrated, the communication interface QQ306 comprises port(s)/terminal(s) QQ316 to send and receive data, for example to and from a network over a wired connection. The communication interface QQ306 also includes radio front-end circuitry QQ318 that may be coupled to, or in certain embodiments a part of, the antenna QQ310. Radio front-end circuitry QQ318 comprises filters QQ320 and amplifiers QQ322. The radio front-end circuitry QQ318 may be connected to an antenna QQ310 and processing circuitry QQ302. The radio front-end circuitry may be configured to condition signals communicated between antenna QQ310 and processing circuitry QQ302. The radio front-end circuitry QQ318 may receive digital data that is to be sent out to other network nodes or UEs via a wireless connection. The radio front-end circuitry QQ318 may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters QQ320 and/or amplifiers QQ322. The radio signal may then be transmitted via the antenna QQ310. Similarly, when receiving data, the antenna QQ310 may collect radio

signals which are then converted into digital data by the radio front-end circuitry QQ318. The digital data may be passed to the processing circuitry QQ302. In other embodiments, the communication interface may comprise different components and/or different combinations of components.

In certain alternative embodiments, the network node QQ300 does not include separate radio front-end circuitry QQ318, instead, the processing circuitry QQ302 includes radio front-end circuitry and is connected to the antenna QQ310. Similarly, in some embodiments, all or some of the RF transceiver circuitry QQ312 is part of the communication interface QQ306. In still other embodiments, the communication interface QQ306 includes one or more ports or terminals QQ316, the radio front-end circuitry QQ318, and the RF transceiver circuitry QQ312, as part of a radio unit (not shown), and the communication interface QQ306 communicates with the baseband processing circuitry QQ314, which is part of a digital unit (not shown).

The antenna QQ310 may include one or more antennas, or antenna arrays, configured to send and/or receive wireless signals. The antenna QQ310 may be coupled to the radio front-end circuitry QQ318 and may be any type of antenna capable of transmitting and receiving data and/or signals wirelessly. In certain embodiments, the antenna QQ310 is separate from the network node QQ300 and connectable to the network node QQ300 through an interface or port.

The antenna QQ310, communication interface QQ306, and/or the processing circuitry QQ302 may be configured to perform any receiving operations and/or certain obtaining operations described herein as being performed by the network node. Any information, data and/or signals may be received from a UE, another network node and/or any other network equipment. Similarly, the antenna QQ310, the communication interface QQ306, and/or the processing circuitry QQ302 may be configured to perform any transmitting operations described herein as being performed by the network node. Any information, data and/or signals may be transmitted to a UE, another network node and/or any other network equipment.

The power source QQ308 provides power to the various components of network node QQ300 in a form suitable for the respective components (e.g., at a voltage and current level needed for each respective component). The power source QQ308 may further comprise, or be coupled to, power management circuitry to supply the components of the network node QQ300 with power for performing the functionality described herein. For example, the network node QQ300 may be connectable to an external power source (e.g., the power grid, an electricity outlet) via an input circuitry or interface such as an electrical

cable, whereby the external power source supplies power to power circuitry of the power source QQ308. As a further example, the power source QQ308 may comprise a source of power in the form of a battery or battery pack which is connected to, or integrated in, power circuitry. The battery may provide backup power should the external power source fail.

Embodiments of the network node QQ300 may include additional components beyond those shown in Fig. 16 for providing certain aspects of the network node's functionality, including any of the functionality described herein and/or any functionality necessary to support the subject matter described herein. For example, the network node QQ300 may include user interface equipment to allow input of information into the network node QQ300 and to allow output of information from the network node QQ300. This may allow a user to perform diagnostic, maintenance, repair, and other administrative functions for the network node QQ300.

Fig. 17 is a block diagram of a host QQ400, which may be an embodiment of the host QQ116 of Fig. 14, in accordance with various aspects described herein. As used herein, the host QQ400 may be or comprise various combinations hardware and/or software, including a standalone server, a blade server, a cloud-implemented server, a distributed server, a virtual machine, container, or processing resources in a server farm. The host QQ400 may provide one or more services to one or more UEs.

The host QQ400 includes processing circuitry QQ402 that is operatively coupled via a bus QQ404 to an input/output interface QQ406, a network interface QQ408, a power source QQ410, and a memory QQ412. Other components may be included in other embodiments. Features of these components may be substantially similar to those described with respect to the devices of previous figures, such as Fig. 15 and 16, such that the descriptions thereof are generally applicable to the corresponding components of host QQ400.

The memory QQ412 may include one or more computer programs including one or more host application programs QQ414 and data QQ416, which may include user data, e.g., data generated by a UE for the host QQ400 or data generated by the host QQ400 for a UE. Embodiments of the host QQ400 may utilize only a subset or all of the components shown. The host application programs QQ414 may be implemented in a container-based architecture and may provide support for video codecs (e.g., Versatile Video Coding (VVC), High Efficiency Video Coding (HEVC), Advanced Video Coding (AVC), MPEG, VP9) and audio codecs (e.g., FLAC, Advanced Audio Coding (AAC), MPEG, G.711), including transcoding for multiple different classes, types, or implementations of UEs (e.g., handsets, desktop computers, wearable display systems, heads-up display systems). The host

application programs QQ414 may also provide for user authentication and licensing checks and may periodically report health, routes, and content availability to a central node, such as a device in or on the edge of a core network. Accordingly, the host QQ400 may select and/or indicate a different host for over-the-top services for a UE. The host application programs QQ414 may support various protocols, such as the HTTP Live Streaming (HLS) protocol, Real-Time Messaging Protocol (RTMP), Real-Time Streaming Protocol (RTSP), Dynamic Adaptive Streaming over HTTP (MPEG-DASH), etc.

Fig. 18 is a block diagram illustrating a virtualization environment QQ500 in which functions implemented by some embodiments may be virtualized. In the present context, virtualizing means creating virtual versions of apparatuses or devices which may include virtualizing hardware platforms, storage devices and networking resources. As used herein, virtualization can be applied to any device described herein, or components thereof, and relates to an implementation in which at least a portion of the functionality is implemented as one or more virtual components. Some or all of the functions described herein may be implemented as virtual components executed by one or more virtual machines (VMs) implemented in one or more virtual environments QQ500 hosted by one or more of hardware nodes, such as a hardware computing device that operates as a network node, UE, core network node, or host. Further, in embodiments in which the virtual node does not require radio connectivity (e.g., a core network node or host), then the node may be entirely virtualized. In some embodiments, the virtualization environment QQ500 includes components defined by the O-RAN Alliance, such as an O-Cloud environment orchestrated by a Service Management and Orchestration Framework via an O-2 interface.

Applications QQ502 (which may alternatively be called software instances, virtual appliances, network functions, virtual nodes, virtual network functions, etc.) are run in the virtualization environment Q400 to implement some of the features, functions, and/or benefits of some of the embodiments disclosed herein.

Hardware QQ504 includes processing circuitry, memory that stores software and/or instructions executable by hardware processing circuitry, and/or other hardware devices as described herein, such as a network interface, input/output interface, and so forth. Software may be executed by the processing circuitry to instantiate one or more virtualization layers QQ506 (also referred to as hypervisors or virtual machine monitors (VMMs)), provide VMs QQ508a and QQ508b (one or more of which may be generally referred to as VMs QQ508), and/or perform any of the functions, features and/or benefits described in relation with some embodiments described herein. The virtualization layer QQ506 may present a virtual operating platform that appears like networking hardware to the VMs QQ508.

The VMs QQ508 comprise virtual processing, virtual memory, virtual networking or interface and virtual storage, and may be run by a corresponding virtualization layer QQ506. Different embodiments of the instance of a virtual appliance QQ502 may be implemented on one or more of VMs QQ508, and the implementations may be made in different ways. Virtualization of the hardware is in some contexts referred to as network function virtualization (NFV). NFV may be used to consolidate many network equipment types onto industry standard high volume server hardware, physical switches, and physical storage, which can be located in data centers, and customer premise equipment.

In the context of NFV, a VM QQ508 may be a software implementation of a physical machine that runs programs as if they were executing on a physical, non-virtualized machine. Each of the VMs QQ508, and that part of hardware QQ504 that executes that VM, be it hardware dedicated to that VM and/or hardware shared by that VM with others of the VMs, forms separate virtual network elements. Still in the context of NFV, a virtual network function is responsible for handling specific network functions that run in one or more VMs QQ508 on top of the hardware QQ504 and corresponds to the application QQ502.

Hardware QQ504 may be implemented in a standalone network node with generic or specific components. Hardware QQ504 may implement some functions via virtualization. Alternatively, hardware QQ504 may be part of a larger cluster of hardware (e.g. such as in a data center or CPE) where many hardware nodes work together and are managed via management and orchestration QQ510, which, among others, oversees lifecycle management of applications QQ502. In some embodiments, hardware QQ504 is coupled to one or more radio units that each include one or more transmitters and one or more receivers that may be coupled to one or more antennas. Radio units may communicate directly with other hardware nodes via one or more appropriate network interfaces and may be used in combination with the virtual components to provide a virtual node with radio capabilities, such as a radio access node or a base station. In some embodiments, some signalling can be provided with the use of a control system QQ512 which may alternatively be used for communication between hardware nodes and radio units.

Fig. 19 shows a communication diagram of a host QQ602 communicating via a network node QQ604 with a UE QQ606 over a partially wireless connection in accordance with some embodiments. Example implementations, in accordance with various embodiments, of the UE (such as a UE QQ112a of Figure 14 and/or UE QQ200 of Figure 15), network node (such as network node QQ110a of Figure 14 and/or network node QQ300 of Figure 16), and host (such as host QQ116 of Figure 14 and/or host QQ400 of Figure 17) discussed in the preceding paragraphs will now be described with reference to Figure 19.

Like host QQ400, embodiments of host QQ602 include hardware, such as a communication interface, processing circuitry, and memory. The host QQ602 also includes software, which is stored in or accessible by the host QQ602 and executable by the processing circuitry. The software includes a host application that may be operable to provide a service to a remote user, such as the UE QQ606 connecting via an over-the-top (OTT) connection QQ650 extending between the UE QQ606 and host QQ602. In providing the service to the remote user, a host application may provide user data which is transmitted using the OTT connection QQ650.

The network node QQ604 includes hardware enabling it to communicate with the host QQ602 and UE QQ606. The connection QQ660 may be direct or pass through a core network (like core network QQ106 of Figure 14) and/or one or more other intermediate networks, such as one or more public, private, or hosted networks. For example, an intermediate network may be a backbone network or the Internet.

The UE QQ606 includes hardware and software, which is stored in or accessible by UE QQ606 and executable by the UE's processing circuitry. The software includes a client application, such as a web browser or operator-specific "app" that may be operable to provide a service to a human or non-human user via UE QQ606 with the support of the host QQ602. In the host QQ602, an executing host application may communicate with the executing client application via the OTT connection QQ650 terminating at the UE QQ606 and host QQ602. In providing the service to the user, the UE's client application may receive request data from the host's host application and provide user data in response to the request data. The OTT connection QQ650 may transfer both the request data and the user data. The UE's client application may interact with the user to generate the user data that it provides to the host application through the OTT connection QQ650.

The OTT connection QQ650 may extend via a connection QQ660 between the host QQ602 and the network node QQ604 and via a wireless connection QQ670 between the network node QQ604 and the UE QQ606 to provide the connection between the host QQ602 and the UE QQ606. The connection QQ660 and wireless connection QQ670, over which the OTT connection QQ650 may be provided, have been drawn abstractly to illustrate the communication between the host QQ602 and the UE QQ606 via the network node QQ604, without explicit reference to any intermediary devices and the precise routing of messages via these devices.

As an example of transmitting data via the OTT connection QQ650, in step QQ608, the host QQ602 provides user data, which may be performed by executing a host application. In some embodiments, the user data is associated with a particular human user

interacting with the UE QQ606. In other embodiments, the user data is associated with a UE QQ606 that shares data with the host QQ602 without explicit human interaction. In step QQ610, the host QQ602 initiates a transmission carrying the user data towards the UE QQ606. The host QQ602 may initiate the transmission responsive to a request transmitted by the UE QQ606. The request may be caused by human interaction with the UE QQ606 or by operation of the client application executing on the UE QQ606. The transmission may pass via the network node QQ604, in accordance with the teachings of the embodiments described throughout this disclosure. Accordingly, in step QQ612, the network node QQ604 transmits to the UE QQ606 the user data that was carried in the transmission that the host QQ602 initiated, in accordance with the teachings of the embodiments described throughout this disclosure. In step QQ614, the UE QQ606 receives the user data carried in the transmission, which may be performed by a client application executed on the UE QQ606 associated with the host application executed by the host QQ602.

In some examples, the UE QQ606 executes a client application which provides user data to the host QQ602. The user data may be provided in reaction or response to the data received from the host QQ602. Accordingly, in step QQ616, the UE QQ606 may provide user data, which may be performed by executing the client application. In providing the user data, the client application may further consider user input received from the user via an input/output interface of the UE QQ606. Regardless of the specific manner in which the user data was provided, the UE QQ606 initiates, in step QQ618, transmission of the user data towards the host QQ602 via the network node QQ604. In step QQ620, in accordance with the teachings of the embodiments described throughout this disclosure, the network node QQ604 receives user data from the UE QQ606 and initiates transmission of the received user data towards the host QQ602. In step QQ622, the host QQ602 receives the user data carried in the transmission initiated by the UE QQ606.

One or more of the various embodiments improve the performance of OTT services provided to the UE QQ606 using the OTT connection QQ650, in which the wireless connection QQ670 forms the last segment. More precisely, the teachings of these embodiments may improve the data delivery to VAL UEs and/or servers and thereby provide benefits such as reduced user waiting time, better energy savings, better responsiveness or similar.

In an example scenario, factory status information may be collected and analyzed by the host QQ602. As another example, the host QQ602 may process audio and video data which may have been retrieved from a UE for use in creating maps. As another example, the host QQ602 may collect and analyze real-time data to assist in controlling

vehicle congestion (e.g., controlling traffic lights). As another example, the host QQ602 may store surveillance video uploaded by a UE. As another example, the host QQ602 may store or control access to media content such as video, audio, VR or AR which it can broadcast, multicast or unicast to UEs. As other examples, the host QQ602 may be used for energy pricing, remote control of non-time critical electrical load to balance power generation needs, location services, presentation services (such as compiling diagrams etc. from data collected from remote devices), or any other function of collecting, retrieving, storing, analyzing and/or transmitting data.

In some examples, a measurement procedure may be provided for the purpose of monitoring data rate, latency and other factors on which the one or more embodiments improve. There may further be an optional network functionality for reconfiguring the OTT connection QQ650 between the host QQ602 and UE QQ606, in response to variations in the measurement results. The measurement procedure and/or the network functionality for reconfiguring the OTT connection may be implemented in software and hardware of the host QQ602 and/or UE QQ606. In some embodiments, sensors (not shown) may be deployed in or in association with other devices through which the OTT connection QQ650 passes; the sensors may participate in the measurement procedure by supplying values of the monitored quantities exemplified above, or supplying values of other physical quantities from which software may compute or estimate the monitored quantities. The reconfiguring of the OTT connection QQ650 may include message format, retransmission settings, preferred routing etc.; the reconfiguring need not directly alter the operation of the network node QQ604. Such procedures and functionalities may be known and practiced in the art. In certain embodiments, measurements may involve proprietary UE signalling that facilitates measurements of throughput, propagation times, latency and the like, by the host QQ602. The measurements may be implemented in that software causes messages to be transmitted, in particular empty or 'dummy' messages, using the OTT connection QQ650 while monitoring propagation times, errors, etc.

Although the computing devices described herein (e.g., UEs, network nodes, hosts) may include the illustrated combination of hardware components, other embodiments may comprise computing devices with different combinations of components. It is to be understood that these computing devices may comprise any suitable combination of hardware and/or software needed to perform the tasks, features, functions and methods disclosed herein. Determining, calculating, obtaining or similar operations described herein may be performed by processing circuitry, which may process information by, for example, converting the obtained information into other information, comparing the obtained

information or converted information to information stored in the network node, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination. Moreover, while components are depicted as single boxes located within a larger box, or nested within multiple boxes, in practice, computing devices may comprise multiple different physical components that make up a single illustrated component, and functionality may be partitioned between separate components. For example, a communication interface may be configured to include any of the components described herein, and/or the functionality of the components may be partitioned between the processing circuitry and the communication interface. In another example, non-computationally intensive functions of any of such components may be implemented in software or firmware and computationally intensive functions may be implemented in hardware.

In certain embodiments, some or all of the functionality described herein may be provided by processing circuitry executing instructions stored on in memory, which in certain embodiments may be a computer program product in the form of a non-transitory computer-readable storage medium. In alternative embodiments, some or all of the functionality may be provided by the processing circuitry without executing instructions stored on a separate or discrete device-readable storage medium, such as in a hard-wired manner. In any of those particular embodiments, whether executing instructions stored on a non-transitory computer-readable storage medium or not, the processing circuitry can be configured to perform the described functionality. The benefits provided by such functionality are not limited to the processing circuitry alone or to other components of the computing device, but are enjoyed by the computing device as a whole, and/or by end users and a wireless network generally.

It will be appreciated that the foregoing description and the accompanying drawings represent non-limiting examples of the methods and apparatus taught herein. As such, the apparatus and techniques taught herein are not limited by the foregoing description and accompanying drawings. Instead, the embodiments herein are limited only by the following claims and their legal equivalents.

CLAIMS

1. A method performed by a server node, such as SEALDD server, for handling data delivery in a wireless communication network (1), the method comprising:
 - obtaining (704) a BAT offset and/or a proposed periodicity, and
 - sending (705) an indication of the obtained BAT offset and/or proposed periodicity to the client node 17
2. The method according to claim 1, further comprising:
 - receiving (701) from a VAL server a request for a data transmission adjustment or an indication indicating a data transmission adjustment policy.
3. The method according to any of the claims 1-2, further comprising:
 - receiving (702) a capability indication from the client node, wherein the capability indication indicates capability for BAT and periodicity adaptation and/or transmission assistance info.
4. The method according to any of the claims 1-3, further comprising:
 - subscribing (703) to a session with QoS with capability for BAT adaptation and/or transmission assistance info.
5. The method according to any of the claims 1-4, further comprising:
 - applying (706) the obtained BAT offset and/or proposed periodicity in a data delivery adjustment.
6. A method performed by a client node, such as SEALDD client, for handling data delivery in a wireless communication network (1), the method comprising:
 - receiving (803), from a server node, an indication of an obtained BAT offset and/or a proposed periodicity.
7. The method according to claim 6, further comprising:
 - receiving (801) a request from a VAL client to apply data transmission adjustment.
8. The method according to any of the claims 6-7, further comprising:

- transmitting (802) a capability indication to the server node, wherein the capability indication indicates the client node's capability for BAT and/or periodicity adaptation, and/or transmission assistance information.
9. The method according to any of the claims 6-8, further comprising:
- applying (804) the obtained BAT offset and/or proposed periodicity in a data delivery adjustment.
10. A method performed by a VAL server for handling data delivery in a wireless communication network (1), the method comprising
- requesting (901) a server node to apply data transmission adjustment, or a data transmission adjustment policy and indicates a data transmission adjustment need in SEALDD layer.
11. A server node, such as SEALDD server, for handling data delivery in a wireless communication network (1), wherein the server node is configured to
- obtain a BAT offset and/or a proposed periodicity, and
 - send an indication of the obtained BAT offset and/or proposed periodicity to the client node 17.
12. The server node (15) according to claim 11, wherein the server node is configured to perform the method according to any of the claims 2-5.
13. A client node, such as SEALDD client, for handling data delivery in a wireless communication network (1), wherein the client node is configured to
- receive from a server node, an indication of an obtained BAT offset and/or a proposed periodicity.
14. The client node (17) according to claim 13, wherein the client node is configured to perform the method according to any of the claims 7-9.
15. A VAL server for handling data delivery in a wireless communication network (1), wherein the VAL server is configured to

request a server node to apply data transmission adjustment, or a data transmission adjustment policy and indicates a data transmission adjustment need in SEALDD layer.

16. A computer program product comprising instructions, which, when executed on at least one processor, cause the at least one processor to carry out the method according to any of the claims 1-10, as performed by the server node, client node, and VAL server, respectively.
17. A computer-readable storage medium, having stored thereon a computer program product comprising instructions which, when executed on at least one processor, cause the at least one processor to carry out the method according to any of the claims 1-10, as performed by the server node, client node, and VAL server, respectively.

ABSTRACT

Embodiments herein relates to, for example, a method performed by a server node, such as SEALDD server, for handling data delivery in a wireless communication network (1). The server node obtains a burst arrival time (BAT) offset and/or a proposed periodicity, and sends an indication of the obtained BAT offset and/or proposed periodicity to a client node (17).

(Fig. 5)

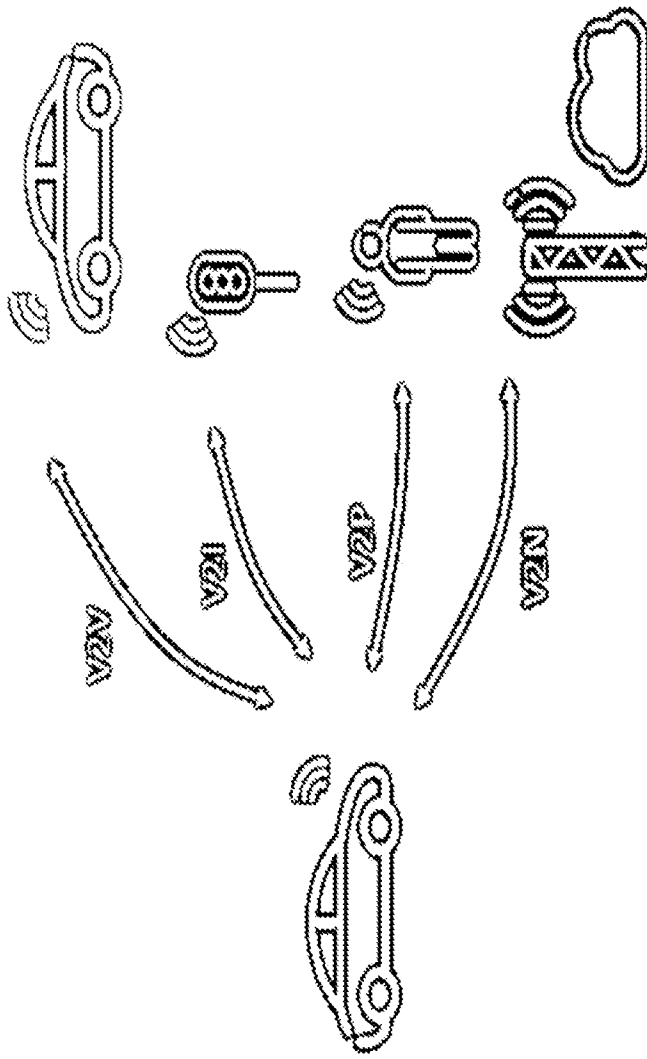


Fig. 1

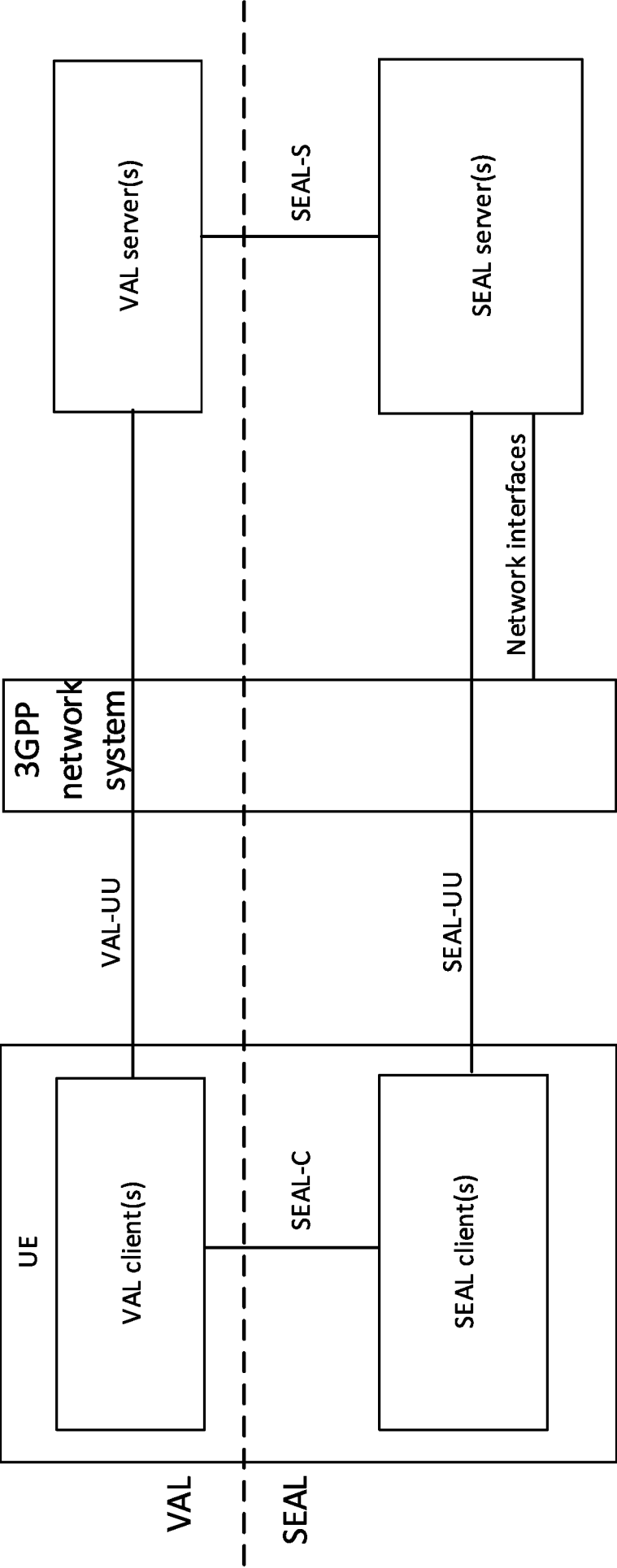


Fig. 2

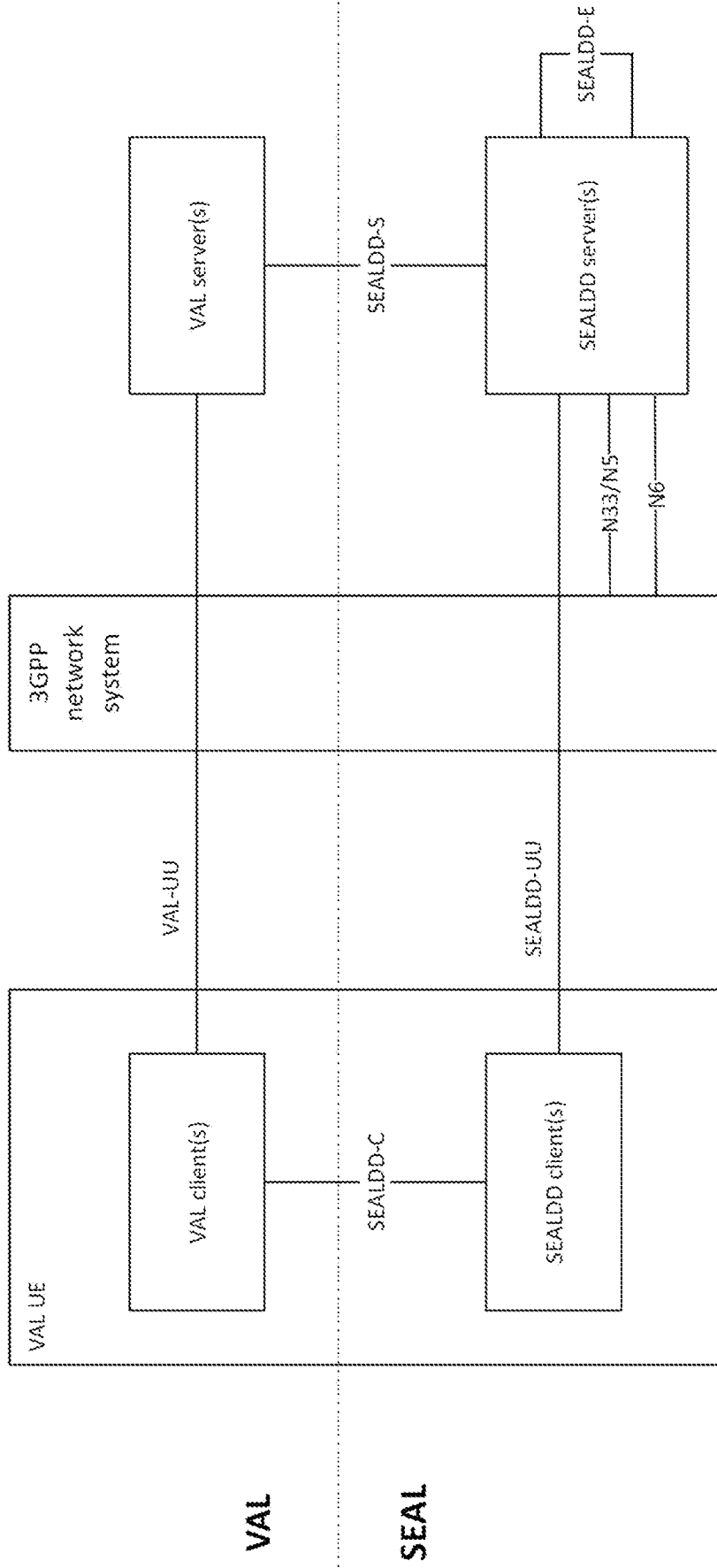


Fig. 3

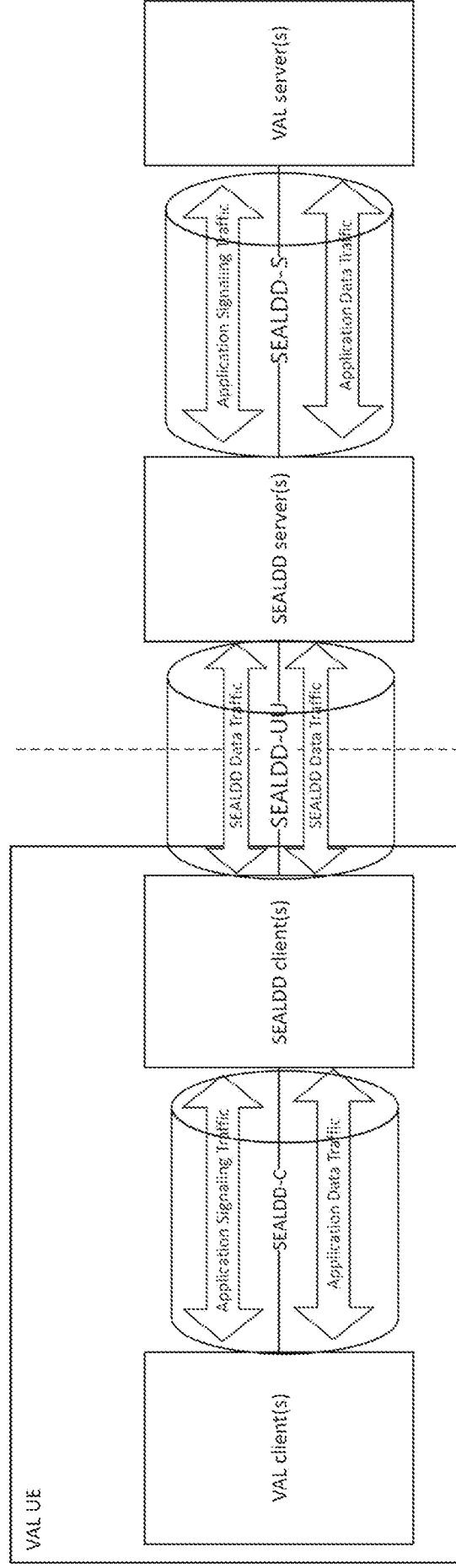


Fig. 4

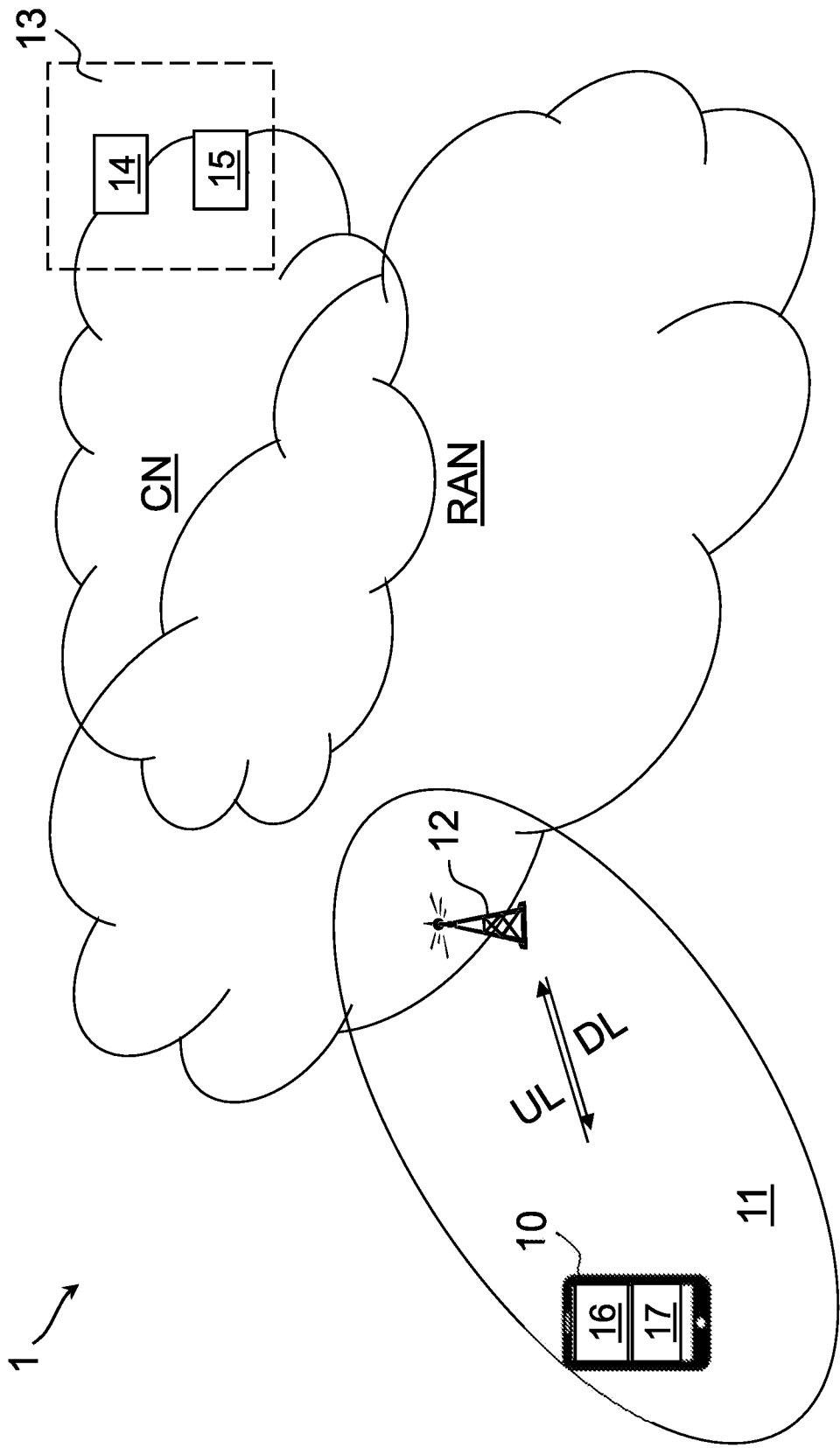


Fig. 5

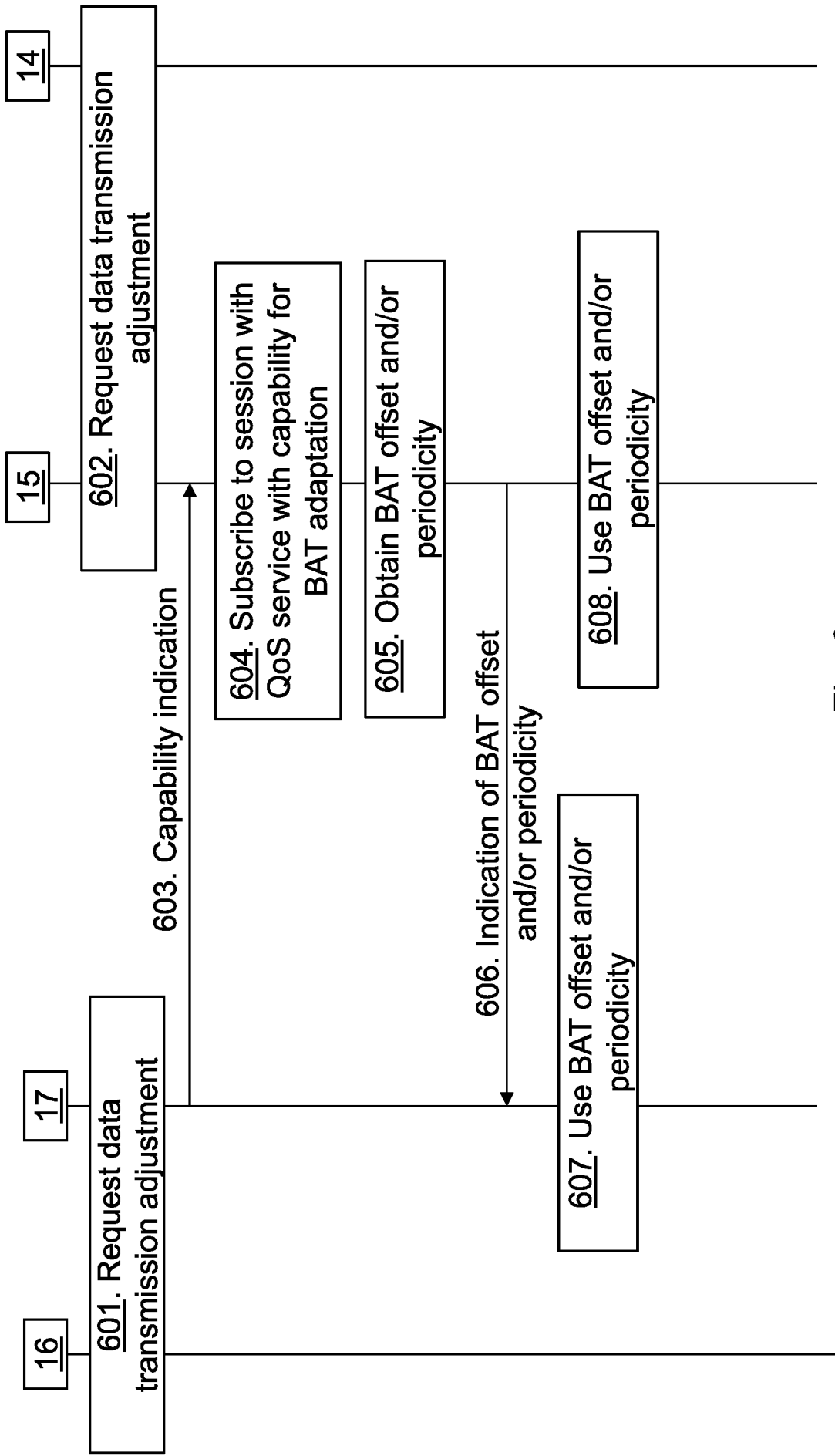


Fig. 6

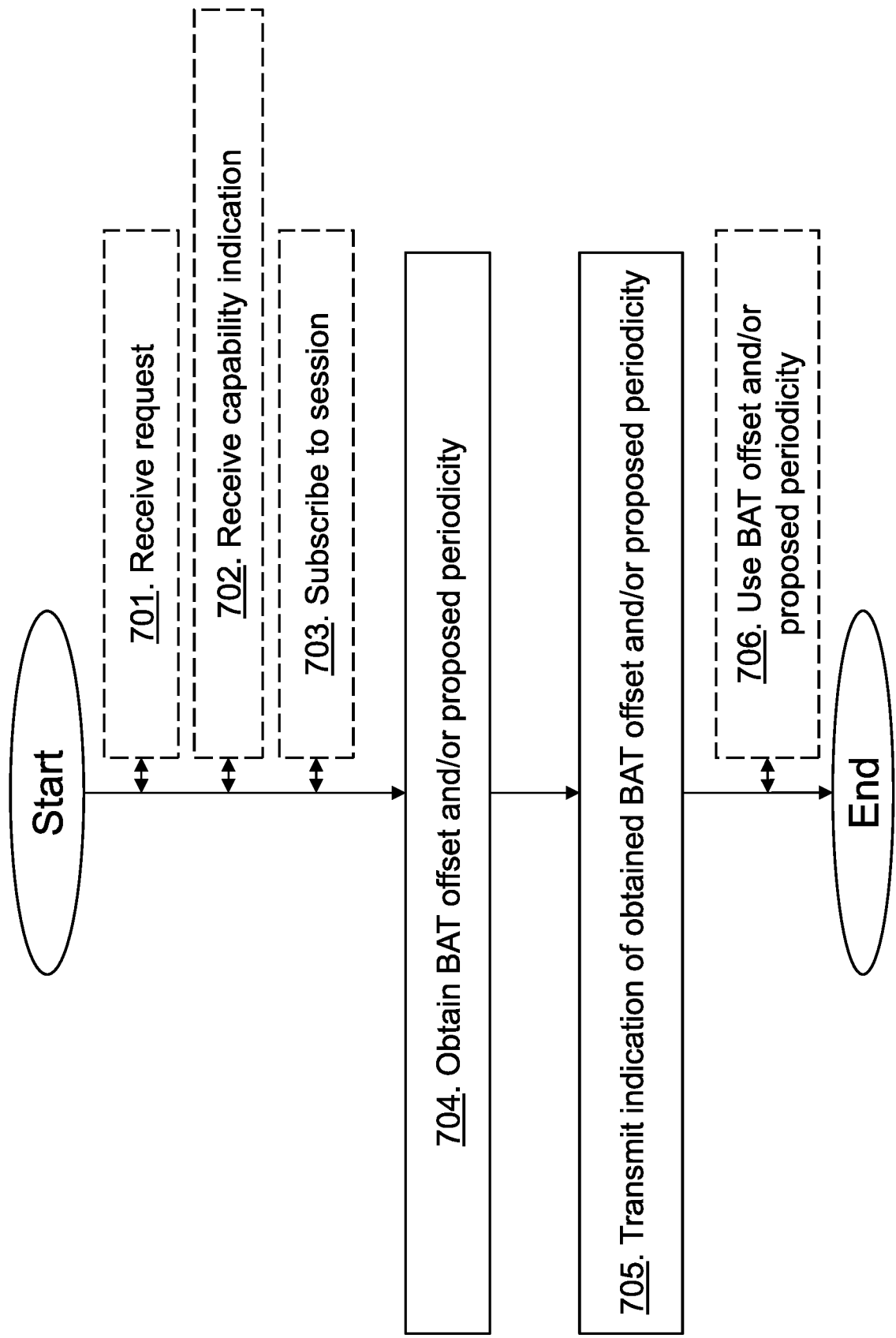


Fig. 7

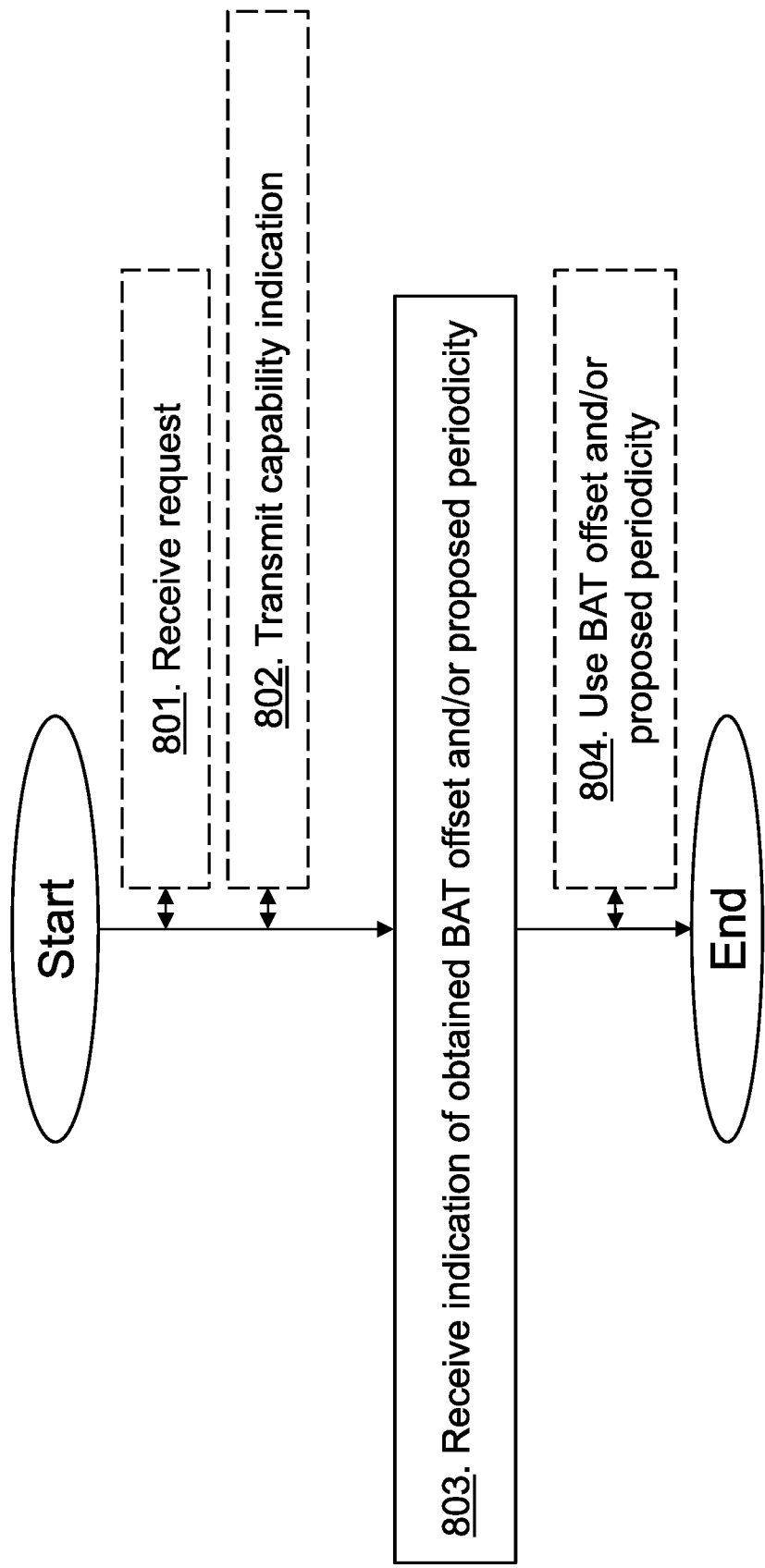


Fig. 8

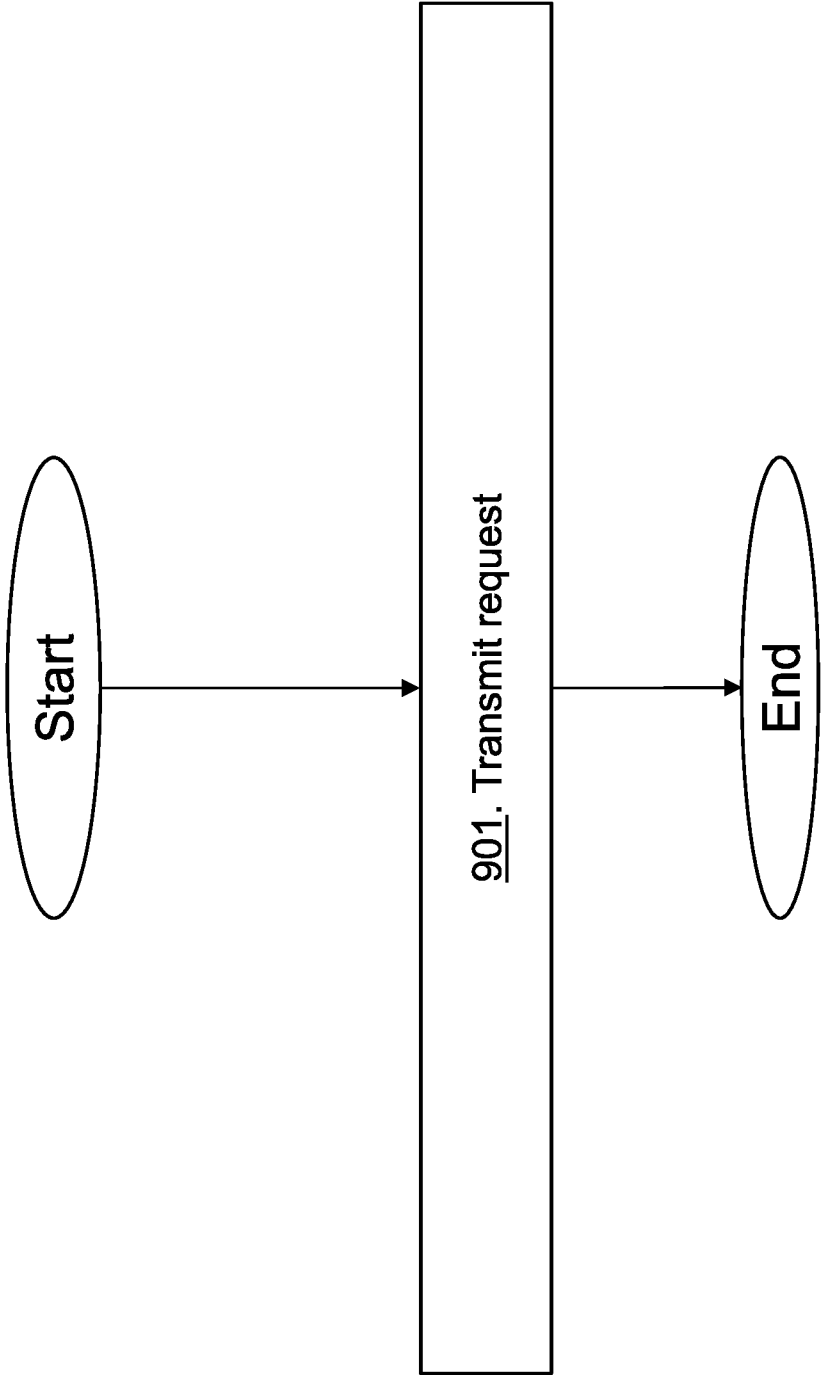


Fig. 9

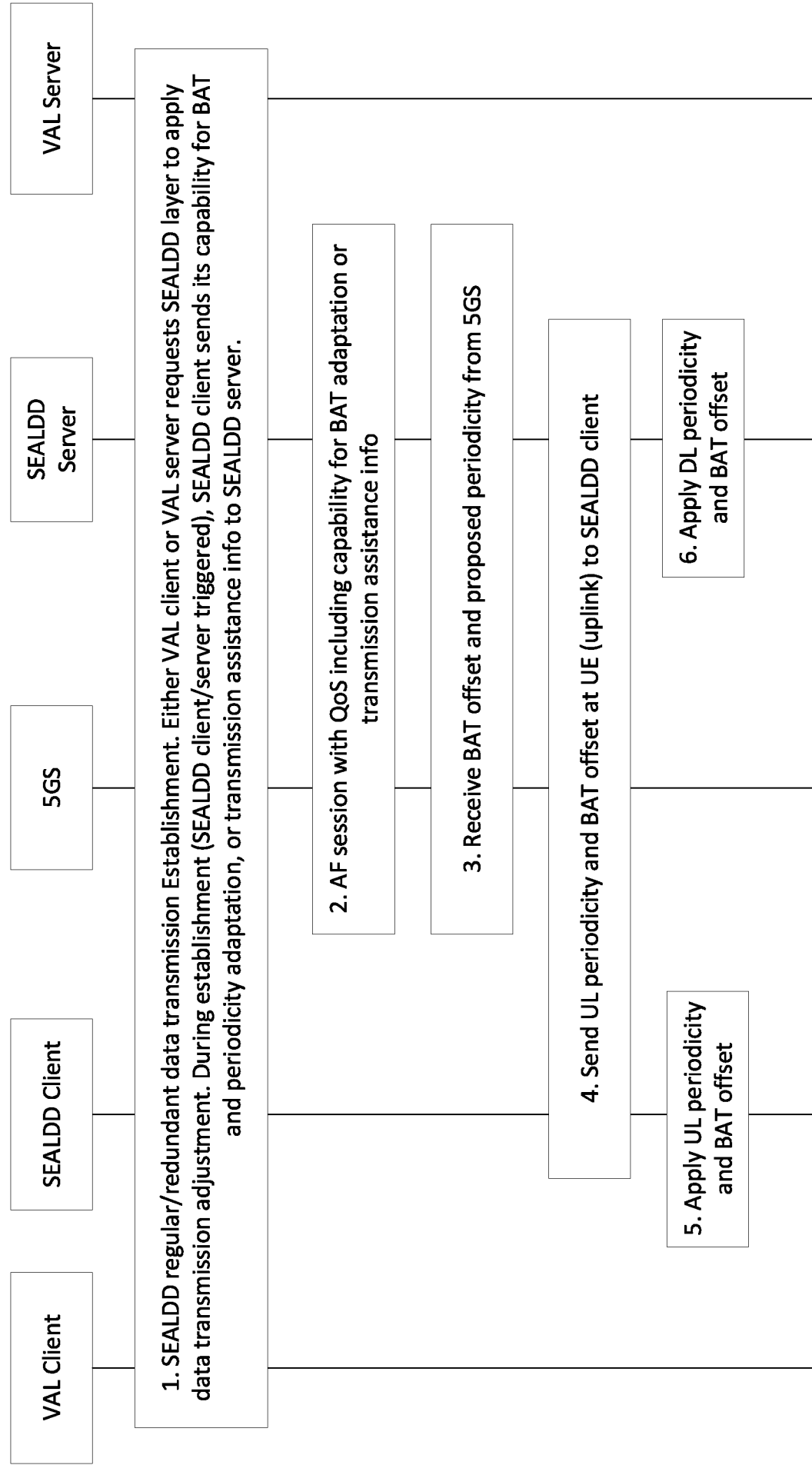


Fig. 10

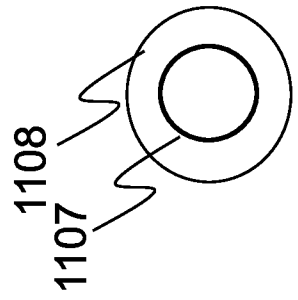
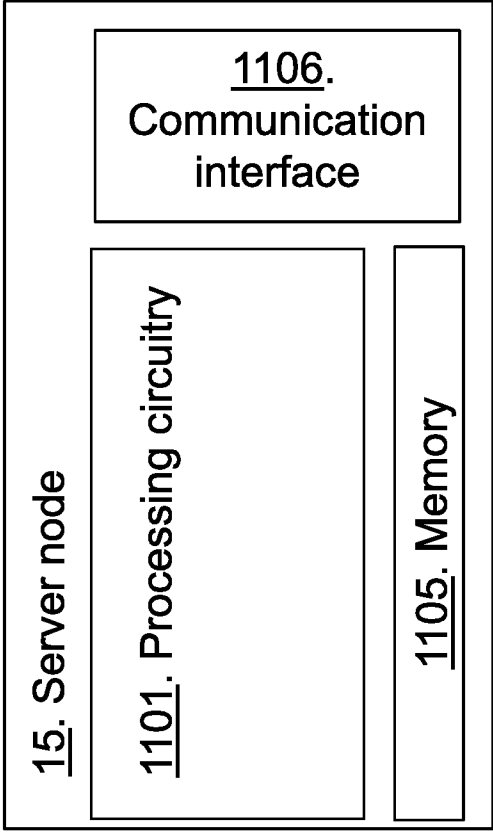


Fig. 11

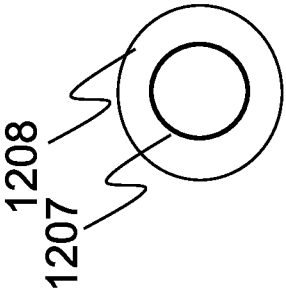
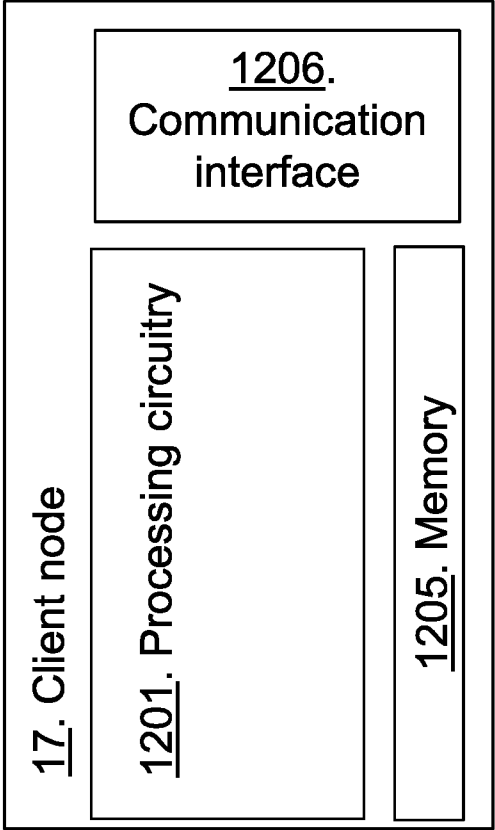


Fig. 12

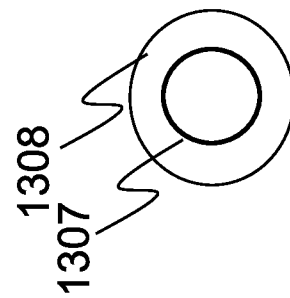
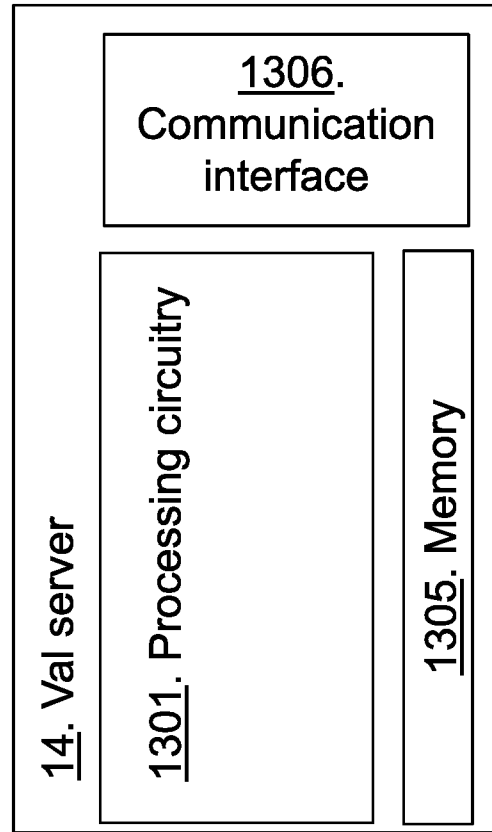


Fig. 13

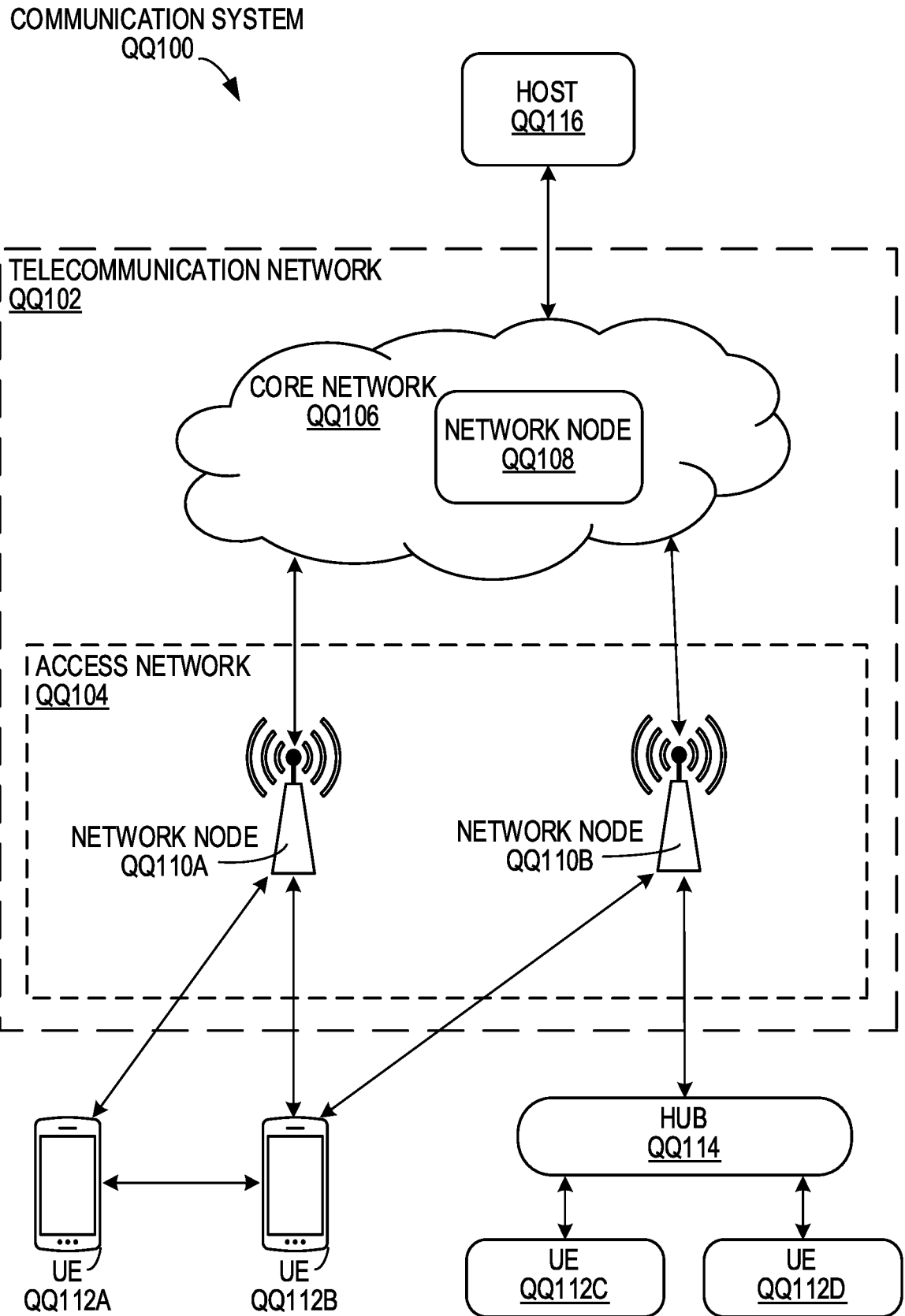


Fig. 14

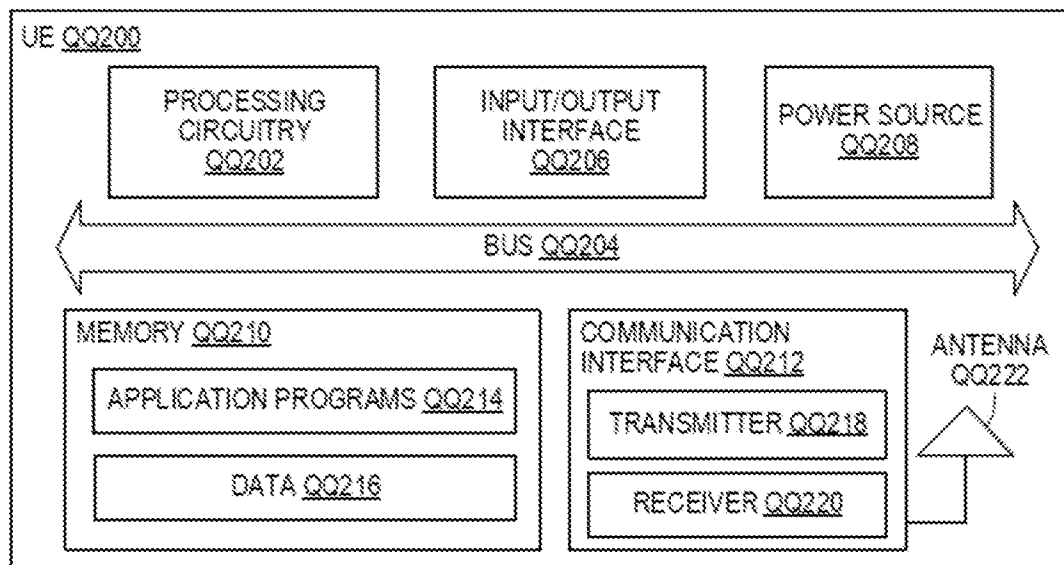


Fig. 15

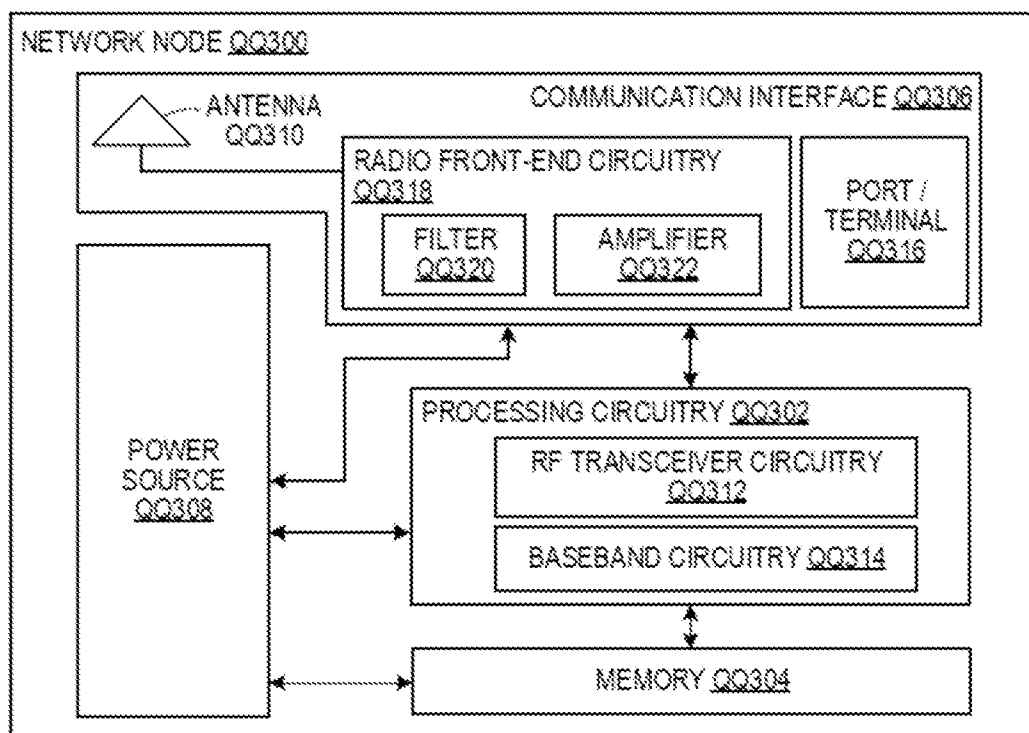


Fig. 16

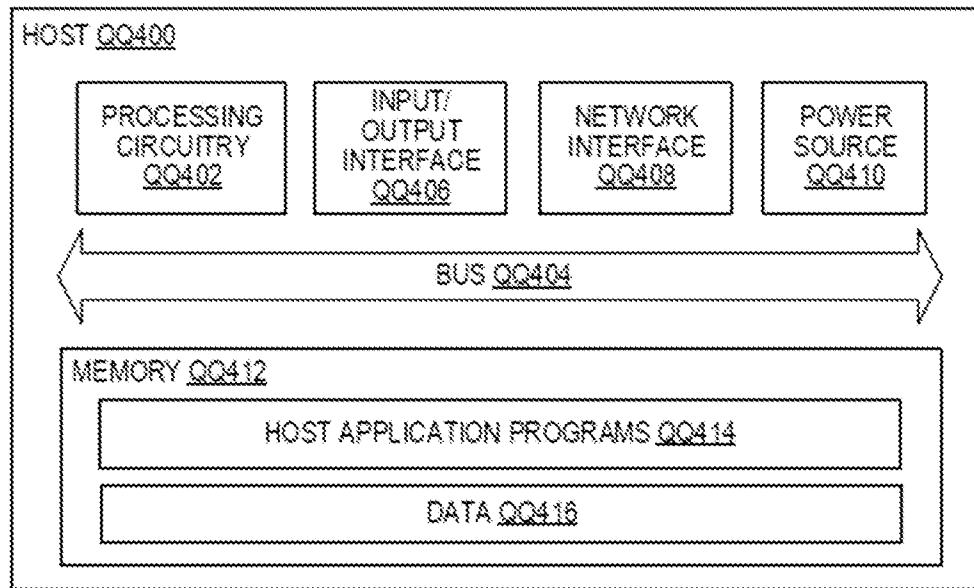


Fig. 17

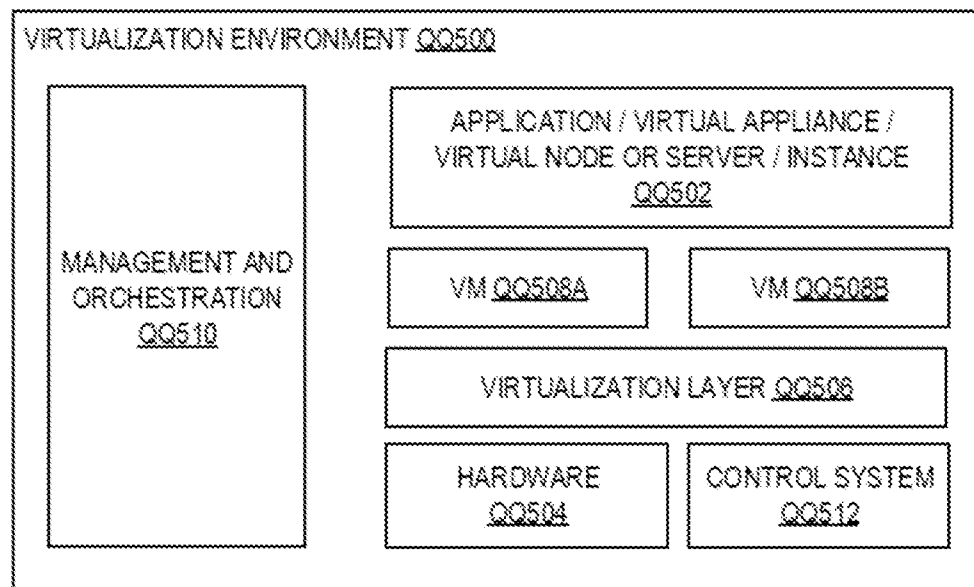


Fig. 18

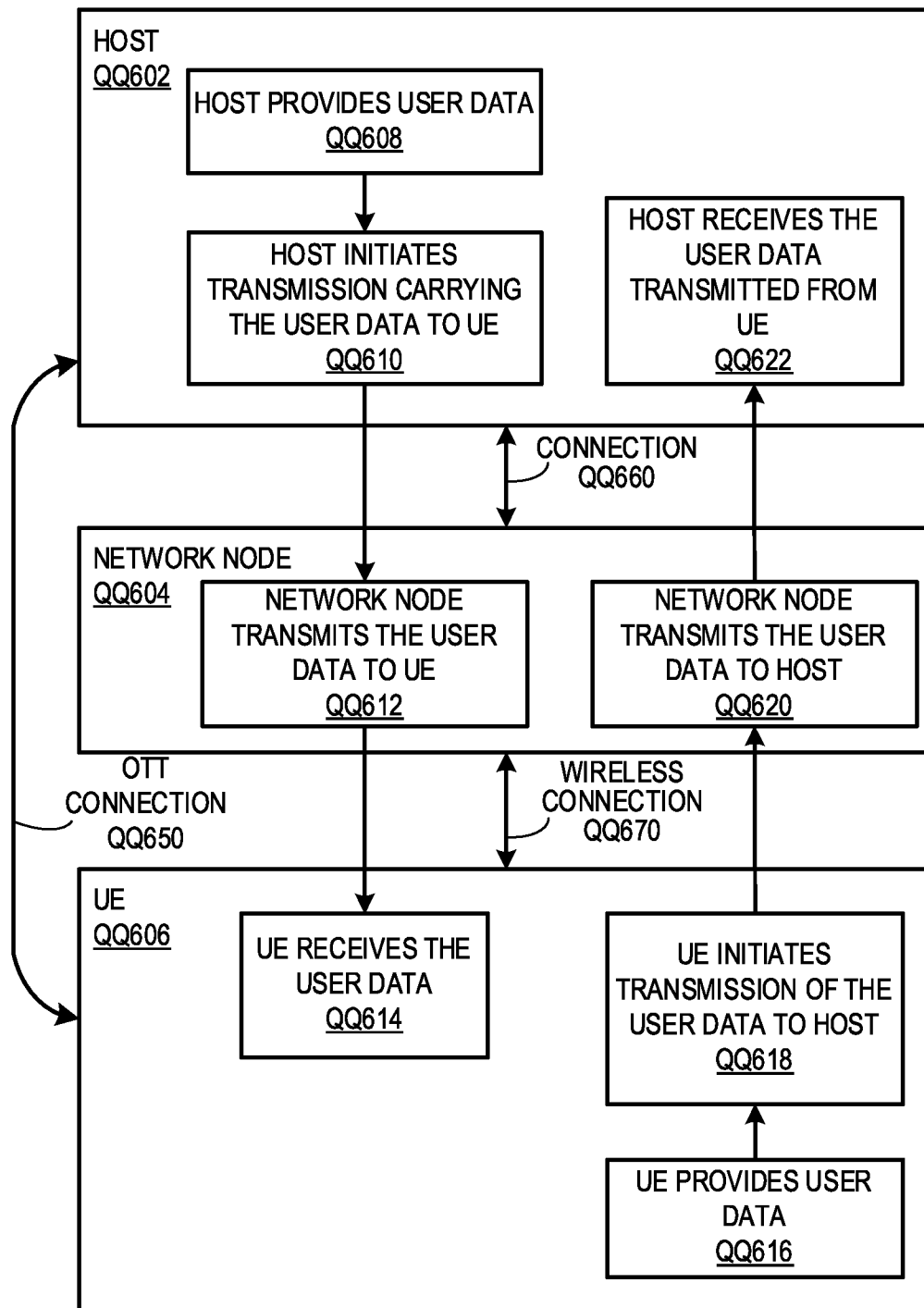


Fig. 19