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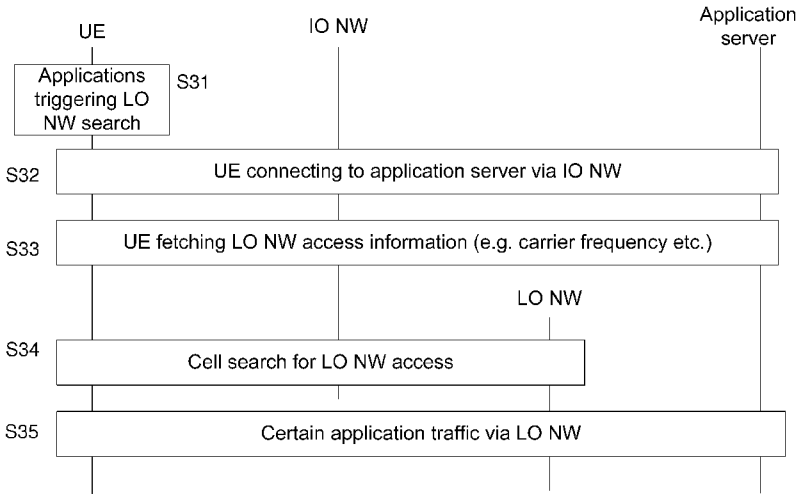

Fig. 3

(57) Abstract: It is provided a method, comprising monitoring if a network information from a server part of an application is received by a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, the network parameter is related to a second network, and the second network is of the radio access technology, and the second network is different from the first network; and controlling a cellular radio layer such that it interworks with the second network based on the network information if the network information is received.

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DESCRIPTION

TITLE

Service provisioning by local operator

Field of the invention

Some embodiments of the present invention relate to an apparatus, a method, and a computer program product related to coexistence of two network operators (for e.g. local operator and incumbent operator). The network operators may be independent from each other but need not to be independent from each other. More particularly, the present invention relates to an apparatus, a method, and a computer program product related to service provisioning by the local operator in the presence of the incumbent operator.

Abbreviations

3GPP	3rd Generation Partnership Project
5G	5th Generation
5GNB	NodeB of 5th Generation
App	Application
CN	Core Network
EPC	Evolved Packet Core
GPS	Global Positioning System
ID	Identification
IO	Incumbent Operator
IoT	Internet of Things
LO	Local Operator
LTE	Long Term Evolution
LTE-A	LTE Advanced
MC	Multi-Connectivity
NW	Network
OS	Operating System
P-GW	Packet Data Network Gateway
PLMN	Public Land Mobile Network
QCI	QoS Class Identifier
QoS	Quality of Service
RAP	Radio Access Point

RAT	Radio Access Technology
SIB	System Information Block
SIM	Subscriber Identity Module
TFT	Traffic Flow Templates
UE	User Equipment
UICC	Universal Integrated Circuit Card
USIM	Universal Subscriber Identity Module
WiFi	Wireless Fidelity

Background of the invention

Local operators (LOs) are considered to be one of the key enablers for network deployments and specialized service provisioning in the fifth generation (5G) networks, mainly due to need for ultra-dense networks addressing high capacity needs. Local operators will also have increasing opportunities for their operation via spectrum sharing, like Google in US on 3.5 GHz. For example, a local operator can be an operator who leases a certain portion of a spectrum and provides certain services, typically in a limited area, while an incumbent operator (IO) provides its services over a larger area (e.g. substantially the whole or even the whole of a country). Incumbent operators (or service providers acting insofar in the name of the incumbent operator), issue SIM cards or UICC comprising a USIM application in order to identify users of their network and to allow roaming of the own users to other incumbent networks if a roaming agreement exists. An LO typically does not issue SIM cards or UICCs. The LO may deploy any RAT suitable for its spectrum while the IO deploys a 3GPP network (such as LTE, LTE-A, 5G).

While there are various modes of operation currently being studied for the local operators, there are two main most feasible approaches:

(a) The LOs and IOs operate jointly with bilateral revenue sharing agreements;

(b) LOs and IOs operate independently without any interactions between them.

The first approach has various advantages such as better inter-working between IO and LO with better mobility support, optimized network deployment density (when multiple IOs cooperate with a LO), etc. But this would also mean that the LOs would need to have bilateral agreements with all the IOs for deploying the network.

In this application, the second approach is considered, where the IOs and LOs are uncoordinated, with the LOs leasing the spectrum from regulatory authorities, within finite

geographic area(s). This enables easy deployment and service provisioning by the LOs, without depending on cooperation / coordination from the IOs. The LO may provide specialized services such as high-performance gaming or virtual reality arenas, ultra-low latency robotics arena, network for an industrial plant, etc., where the services are provisioned using 5G-UEs. Using 5G-radio access points (5G-RAP, also named 5GNB) for providing such services provides the LOs access to a wide variety of features such as extreme mobile broadband with significantly high capacity and ultra-low latency with very high levels of reliability. There are obvious cost benefits of using widely available 5G-RAPs as compared to using proprietary base stations, with access to the 5G-UEs. By removing the mandatory requirement for having SIM cards (UICC with USIM application) for accessing the 5G-RAP, the LOs have more flexibility in having access to a wide variety of users with innovating charging functionalities.

Some related work for doing a manual PLMN scan to enable the user to select an appropriate PLMN based on the scanning of all PLMNs is discussed in [1]. In [2], a method for storing PLMN and related information in case of failures such as radio link or handover in a mobile device is disclosed. The basic assumption in existing work remains that the PLMN identity is always pre-configured in the UE or included in SIM card, which is a valid case for IO network selection scenario. But for the randomly deployed LOs considered in this application, mechanisms for PLMN selection, authentication and charging are currently not available. Another related work is ongoing in MulteFire project [3] where industry standards are being developed for unlicensed band deployments. Here the focus is mainly on providing concepts on top of 3GPP network to enable operators deploy networks in unlicensed band which can tightly interwork with the LTE network.

References:

[1] A. Swaminathan, et al. "Apparatus and method for implementing a manual PLMN scan." U.S. Patent Application No. 14/229,247.

[2] Lee, Youngdae, et al. "Method and device for storing PLMN information on user equipment in wireless communication system." U.S. Patent Application No. 14/344,027.

[3] http://multefire.org/

Summary of the invention

It is an object of the some embodiments of the invention to improve the prior art.

According to a first aspect of the invention, there is provided an apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least monitoring if a network information from a server part of an application is received by a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, the network parameter is related to a second network, the second network is of the radio access technology, and the second network is different from the first network; and controlling a cellular radio layer such that it interworks with the second network based on the network information if the network information is received.

The network information may comprise a request to connect the client part to the server part via the second network; and the controlling may comprise controlling the cellular radio layer to access the second network if the network information comprises the request, wherein the at least one processor, with the at least one memory, may be further arranged to perform connecting the client part to the server part via the second network after the second network has been accessed.

The network information may comprise an access parameter of the second network; and the controlling may comprise controlling the cellular radio layer to access the second network using the access parameter.

A user of the client part may be authenticated to the application by credentials, the user may be authenticated to the first network by user information different from the credentials, and the at least one processor, with the at least one memory, may be further arranged to perform authenticating the user to the second network by the credentials.

The user may be authenticated to the second network without using the user information.

The user information may be stored on an identity module and the credentials may not be stored on the identity module.

The network information may comprise a traffic flow parameter; and the controlling may comprise steering a traffic to the first network and to the second network according to the traffic flow parameter if the cellular radio layer is served by the first network and the second network.

The network information may comprise at least one of a discovery information of the second network and a synchronization information of the second network; and the controlling may comprise controlling the cellular radio layer such that it searches the second network based on the at least one of the discovery information and the synchronization information.

According to a second aspect of the invention, there is provided an apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least providing, by a server part of an application, a network information to a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, and the network information is related to a predetermined second network, the second network is of the radio access technology, and the second network is different from the first network.

The network information may comprise at least one of an access parameter of the second network and a request to connect the client part to the server part via the second network.

The network information may comprise the request, and the at least one processor, with the at least one memory, may be further arranged to perform evaluating, based on at least one of a received location information and a received measurement information, if a device on which the client part is running is close to the second network; and inhibiting the providing of the request if the device is not close to the second network.

The network information may comprise at least one of a discovery information and a synchronization information, and the at least one processor, with the at least one memory, may be further arranged to perform informing a base station of the second network to start transmitting the at least one of the discovery information and the synchronization information.

According to a third aspect of the invention, there is provided an apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least checking if a client part of an application is connected to a server part of the application via a first network of a radio access technology; monitoring if the client part becomes connected to the server part via a predetermined second network of the radio access technology if the client part is connected

to the server part via the first network, wherein the second network is different from the first network; providing, by the server part to a charging device, an information on a usage of the second network for the communication between the server part and the client part if the client part becomes connected to the server part via the second network.

According to a fourth aspect of the invention, there is provided an apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least monitoring if a user authenticates to a radio network by credentials in order to access the radio network; checking if the user is authenticated to a predetermined application by the credentials, if the user authenticates to the radio network by the credentials; granting access to the radio network for the user if the user is authenticated to the predetermined application by the credentials.

According to a fifth aspect of the invention, there is provided a method, comprising monitoring if a network information from a server part of an application is received by a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, the network parameter is related to a second network, and the second network is of the radio access technology, and the second network is different from the first network; and controlling a cellular radio layer such that it interworks with the second network based on the network information if the network information is received.

The network information may comprise a request to connect the client part to the server part via the second network; and the controlling may comprise controlling the cellular radio layer to access the second network if the network information comprises the request, wherein the method further comprises: connecting the client part to the server part via the second network after the second network has been accessed.

The network information may comprise an access parameter of the second network; and the controlling may comprise controlling the cellular radio layer to access the second network using the access parameter.

A user of the client part may be authenticated to the application by credentials, the user may be authenticated to the first network by user information different from the credentials, and the method may further comprise: authenticating the user to the second network by the credentials.

The user may be authenticated to the second network without using the user information.

The user information may be stored on an identity module and the credentials may not be stored on the identity module.

The network information may comprise a traffic flow parameter; and the controlling may comprise steering a traffic to the first network and to the second network according to the traffic flow parameter if the cellular radio layer is served by the first network and the second network.

The network information may comprise at least one of a discovery information of the second network and a synchronization information of the second network; and the controlling may comprise controlling the cellular radio layer such that it searches the second network based on the at least one of the discovery information and the synchronization information.

According to a sixth aspect of the invention, there is provided a method, comprising providing, by a server part of an application, a network information to a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, and the network information is related to a predetermined second network, the second network is of the radio access technology, and the second network is different from the first network.

The network information may comprise at least one of an access parameter of the second network and a request to connect the client part to the server part via the second network.

The network information may comprise the request, and the method may further comprise: evaluating, based on at least one of a received location information and a received measurement information, if a device on which the client part is running is close to the second network; and inhibiting the providing of the request if the device is not close to the second network.

The network information may comprise at least one of a discovery information and a synchronization information, and the method may further comprise: informing a base station of the second network on to start transmitting the at least one of the discovery information and the synchronization information.

According to a seventh aspect of the invention, there is provided a method, comprising checking if a client part of an application is connected to a server part of the application via a first network of a radio access technology; monitoring if the client part becomes connected to the server part via a predetermined second network of the radio access technology if the client part is connected to the server part via the first network, wherein the second network is different from the first network; providing, by the server part to a charging device, an information on a usage of the second network for the communication between the server part and the client part if the client part becomes connected to the server part via the second network.

According to an eighth aspect of the invention, there is provided a method, comprising monitoring if a user authenticates to a radio network by credentials in order to access the radio network; checking if the user is authenticated to a predetermined application by the credentials, if the user authenticates to the radio network by the credentials; granting access to the radio network for the user if the user is authenticated to the predetermined application by the credentials.

Each of the methods of the fifth to eighth aspects may be a method of service provisioning.

According to a ninth aspect of the invention, there is provided a computer program product comprising a set of instructions which, when executed on an apparatus, is configured to cause the apparatus to carry out the method according to any of the fifth to eighth aspects. The computer program product may be embodied as a computer-readable medium or directly loadable into a computer.

According to some example embodiments of the invention, at least one of the following technical effects may be provided:

- LO may use 5GNB, thus achieving economy of scale;
- Flexibility in network and service deployment for the LO;
- Reduced administration effort for LO and IO compared to a solution coordinated between LO and IO;
- Less error prone network configuration compared to a solution coordinated between LO and IO;
- Standardized access to LO's network;
- Higher user satisfaction for specialized services;
- Network of IO is not challenged by specialized services;

- Easy (or even seamless) accessibility of LO's network for user.

Brief description of the drawings

Further details, features, objects, and advantages are apparent from the following detailed description of example embodiments of the present invention which is to be taken in conjunction with the appended drawings, wherein

Fig. 1 shows a basic scenario according to some embodiments of the invention;
Fig. 2 shows an overview of the multi-operator multi-connectivity concept according to some embodiments of the invention;
Fig. 3 shows a signaling diagram for cell detection, selection, and access according to some embodiments of the invention;
Fig. 4 shows a cell search procedure according to some embodiments of the invention;
Fig. 5 shows a cell search procedure with beam discovery according to some embodiments of the invention;
Fig. 6 shows a traffic steering procedure according to some embodiments of the invention;
Fig. 7 shows a flow diagram according to a method of some embodiments of the invention;
Fig. 8 shows an apparatus according to an example embodiment of the invention;
Fig. 9 shows a method according to an example embodiment of the invention;
Fig. 10 shows an apparatus according to an example embodiment of the invention;
Fig. 11 shows a method according to an example embodiment of the invention;
Fig. 12 shows an apparatus according to an example embodiment of the invention;
Fig. 13 shows a method according to an example embodiment of the invention;
Fig. 14 shows an apparatus according to an example embodiment of the invention;
Fig. 15 shows a method according to an example embodiment of the invention;
Fig. 16 shows an apparatus according to an example embodiment of the invention; and
Fig. 17 shows a protocol stack with interfaces according to some embodiments of the invention.

Detailed description of certain example embodiments

Herein below, certain example embodiments of the present invention are described in detail with reference to the accompanying drawings, wherein the features of the example embodiments can be freely combined with each other unless otherwise described. However, it is to be expressly understood that the description of certain embodiments is given for by

way of example only, and that it is by no way intended to be understood as limiting the invention to the disclosed details.

Moreover, it is to be understood that the apparatus is configured to perform the corresponding method, although in some cases only the apparatus or only the method are described.

If a same reference sign is used in plural figures, it denotes a same or corresponding entity.

Motivation:

The motivation for the LO to use 5G instead of other RATs such as WiFi is that 5G provides unique features such as ultra-reliability and low-latency communications, along with extreme mobile broadband data rates. This would be ideal for the LOs seeking to deploy high-performance gaming arenas, virtual reality centers, and potentially new business cases where the LOs can make use of such unique 5G features to create new business opportunities. The virtual reality centers could provide end users with access to live football games, concerts, etc., with the users using their smartphones to access such services. If the access for the end user to the LO network is made easier, this would enable users irrespective of the IO to be able to access the services provided by the LO. From industrial drivers perspective, currently Google is planning to provide network at 3.5 GHz in US using the Citizen Broadband Radio System (CBRS). In future, such networks could be provided by other industrial players such as industrial IoT, with explicit focus on various services as well.

Conventionally, users of the IO may roam into the LO network based on the user identity provided on the SIM card (e.g. USIM). The user identity on the SIM card (e.g. USIM) is an example of “user information”. However, according to some embodiments of the invention, this roaming may be replaced by a use of application level details for authentication, instead of the SIM card. The application level details are an example of “credentials”.

An example of a basic scenario according to some embodiments of the invention is shown in Fig. 1, where the 5G-UE 11 has multi-operator multi-connectivity with the LO and IO with both networks potentially carrying traffic from and to the UE simultaneously. That is, the 5G-UE can be connected simultaneously to both 5G-RAP 12 of the IO and 5G-RAP 13 of the LO, and traffic can be carried on both of these connections. The RAPs are connected to the respective core networks (CN) 14, 15. In one example, the IO-core network provides connectivity to basic services such as voice calls, internet, etc., and the LO-CN provides

connectivity for special services and use cases. There may not be a separate SIM at the UE for the LO, but there is a logical link 16 between the policy, charging and user information functions within the LO-CN to the IO-CN, potentially over the Internet, or over some other network. This means that there may be a logical link via the application layer between the LO-CN user-specific functions and the 5G-UE application layer. Thus, new users can be created, prepaid / post-paid charging functions configured for the LO using the IO-CN as well. The 5G-UE is assumed to have multiple transmit-receive chains and related functionalities to support multi-operator multi-connectivity. UEs having a single transmit-receive chain could operate with a lower performance level as well, at least for some of the scenarios described below.

In some embodiments of the invention, one network is different from another network if the respective core networks are different from each other.

One problem to be solved is: How to provide the 5G-UE multi-operator multi-connectivity in a standardized manner, so that the LO operators can deploy their network using 5G-RAPs and provide ultra-reliability, low latency, high capacity and other key 5G features? With the new localized spectrum licensing/sublicensing agreements, the LOs can have access to large amounts of spectrum due to local usage only, without depending on the IOs.

In an obvious solution the LO would cooperate with IOs in order to provide support for system access and charging functionalities. However, this would limit the flexibility from the LO perspective in fast (and possibly random) deployment of networks and new models for revenue creation. Having a solution that can work with standardized procedures would enable reduced deployment costs as compared to proprietary solutions. Currently there are no solutions which provide easy LO deployment where the focus of the network deployment is on tailored service provisioning. Especially with a SIM-less access to LO network, there needs to be a solution for issues such as cell selection, authentication, etc.

According to some embodiments of the invention, operators are enabled to deploy networks in unlicensed band which can tightly interwork with the LTE network, based on an application layer method.

According to some embodiments of the invention, it is provided a method enabling multi-operator multi-connectivity operation, with normal cell selection and related procedures for the IOs and to use application specific criteria for the LOs. For example, the UE application layer provides assistance/trigger in one or more of the following operations:

- Cell Search: The application layer initiates and provides the frequency bands and centre frequencies for searching at the appropriate conditions.
- Cell Selection: The cell selection criteria, with appropriate IDs for example PLMN IDs or other application related IDs, Random Access Channel preambles, etc., would be provided by the application layer, based on the dynamic information available from the application server, which may be in the cloud.
- Traffic Steering between IO and LO: The application layer provides an indication to the UE buffers about routing certain traffic types over the LO network and the IO network, respectively.
- Charging: Based on the application layer user information and authentication information provided during cell selection and connection establishment, the charging of the usage of the LO network is done by the LO on the application that is providing the service.

Fig. 2 gives an overview of the multi-operator multi-connectivity concept on which some embodiments of the invention are based. As shown in the bottom part of Fig. 2, a 5G-UE 21 is connected to 5GNBs of the IO (IO-5GNB 22) and the LO (LO-5GNB 23), respectively, via multi-connectivity links. The 5G-UE itself has a layered software structure comprising an application layer 24 and a cellular radio layer 25. Each of these layers may comprise one or more sub-layers. For example, the cellular radio layer 25 may comprise a physical layer, a radio resource control layer, and a radio link control layer. The application layer 24 typically comprises client parts of one or more applications.

A protocol architecture according to some embodiments of the invention is shown in Fig. 17. Here the LO Application 177 provides the cell search and selection parameters (including the initiation of the process) to the physical layer 171 of the UE protocol stack, for example, using a new interface 1711, which could for e.g., be implementation specific or through newly defined open Application Programming Interface (API). For traffic steering, the LO Application 177 could route either the IP layer 175 packets meant for the LO network, to the appropriate radio interfaces or providing the rules to the PDCP layer 174 of the protocol stack (interface 1712). Newly defined interface 1713 may be used towards the charging function 178, in order to enable the charging of the user for services used in the LO network and/or the usage of the LO network for the services. Medium Access Control (MAC) 172, Radio Link Control (RLC) 173, and Transmission Control Protocol (TCP) 176 layers are conventionally known and may not be affected by some embodiments of the invention. Fig. 17 is given as one example for IP packet, similarly the described method can be extended to other use cases as well for example Ethernet packet.

In the top part of Fig. 2, an example embodiment of the invention is shown according to which the 5G-UE 21 selects the IO-5GNB 22 based on conventional (regular) 3GPP procedures. On the other hand, the LO-5GNB 23 is selected by a selection procedure in which the UE (e.g. the application layer thereof) is involved. This selection procedure is named as “UE defined cell selection procedure” and is explained at greater detail further below.

Fig. 3 shows a message flow according to some example embodiments of the invention. In the UE, an application such as Google Playstore (client part of the application) is running (S31), wherein the application may trigger a search for a LO network. Since the UE is served by the IO network (conventional 3GPP process), the UE connects to the server part of the application running on an application server via IO network (S32). The application server provides to the UE access information (such as carrier frequency) (S33). The application server may provide this information either on its own volition or because of a request from the client part of the application. Then, UE (e.g. the cellular radio layer) searches for the LO NW access (S34), based on the access information received from the application server. For example, the application layer may provide the received access information to the cellular radio layer, or the application layer may generate some control commands in order to control the cellular radio layer based on the received access information. In some cases, the application server can trigger LO NW cell search as well for example in case that the application server is aware of the geographical coverage information of LO NW and the location information of 5G UE. If LO NW grants access to the UE, the UE may steer some traffic (in particular traffic related to the application mentioned with respect to S31) via LO NW to the application server (S35). That is, the UE can be connected to both IO network and LO network simultaneously.

In some cases, e.g. if other services than the above mentioned application are not requested by the UE, the UE may disconnect from the IO network.

Some of these steps according to some embodiments of the invention are explained at greater detail further below.

Cell Search:

As shown in Fig. 4, according to some embodiments of the invention, the UE application layer 24 (client part) interacts with the application server 46 (server part) to provide the access parameters to the cellular radio layer 25 of the UE 21, for example parameters 44

needed for cell search according to a search function 45. Here, the parameters may include e.g. one or more of the frequency bands and/or center frequencies to listen for the discovery/synchronization signals and when/where to initiate cell search. This enables a dynamic provisioning of information to the UE, where the frequency bands and other related radio parameters may be configurable.

The application server could also provide radio fingerprint information to help optimizing the cell search procedure by searching only when required, thereby saving UE battery power. For the radio fingerprint information, the application server could do crowdsourcing (collecting information from all the UEs subscribing to a particular application for accessing LO networks), based on the cell search information provided by all the UEs subscribed to that application.

Here the application could be an aggregation point where multiple local operators collaborate to provision service to the end users. One example could be to use the popular social media sites such as Facebook or Google to provide authentication and cell search information, where multiple LOs can collaborate and reuse the available information. Thus, a generic application such as an application store from the UE's OS provider could provide the access to the charging and authentication functions it inherently has, to enable the LOs provide their connectivity solutions. The application (e.g., the Google Playstore) may provide the charging and authentication function for the LO network, if it already has the credentials of the user and credit card information.

In 5G, the cell search and discovery may be based on beam-specific system design. Some embodiments of the invention provide a discovery signal and/or system information broadcast over specific beams in the LO network which is application context aware, based on the LO-App (server part) determining the UE proximity to the LO network and possible location information. In 5G, the 5GNB 23 may not send the system access and discovery signal information all the time, due to the optimization of always-on signals for energy savings and due to the avoidance of unnecessary information broadcasting, in order to optimize for spectral efficiency and capacity. According to some embodiments of the invention, the LO-App configures the appropriate beams 51, 52 (based on beam IDs) in the LO-5GNB 23 to send discovery and synchronization information, along with the system information, so that the 5G-UE 21 can discover the LO-network, and provides the same information to the client part of the application 24 on the UE 21, which informs the cellular radio layer 25. An overview of this procedure is shown in Fig. 5, where the LO-App (server part on (cloud) application server 46) sends the LO-5GNB discovery information, which

informs the 5GNB 21 to configure discovery and system information broadcast through Beam-1 51 and Beam-2 52. Note that the application server may be a separate application server or may be installed on the cloud (cloud application server).

Cell Selection:

In some embodiments of the invention, the application layer provides the cell selection parameters such as the PLMN selection criteria, and the application layer may also provide radio parameter information (such as signal strength and quality criteria). The LO cellular radio layer uses this information and compares it with the information available in for example SIB1 *cellAccessRelatedInfo* parameter to decide whether or not to select the detected cell. The information related to the random access procedure, especially using application layer random access preambles could also be provided. In some embodiments, the application layer may provide the cellular radio layer with the possible random access preambles that needs to be used for cell initial access.

Traffic Steering between IO and LO:

Due to the use of multi-operator multi-connectivity, efficient traffic steering mechanisms are required to steer traffic between the LO and IO. Here, a typical assumption is that the traffic meant for IO may be prioritized and routed to the IO using legacy traffic flow templates (TFT). For the LO, according to some embodiments of the invention, the traffic flow templates are provided by the application server directly to the client part of the application on the UE, which then influences the UE application scheduler which decides which network the traffic should be routed to, to route traffic according to the available rules. Such traffic steering mechanisms can be particularly useful, since the LO network could be tailored for provisioning very specialized services such as high-performance gaming or virtual reality arenas which imposes strict limitations on the throughput and latency requirements of the traffic, for example. A traffic flow template is an example of a traffic flow parameter.

The LO network may also use concepts like mobile edge computing, whereby the core network is collocated with the radio access network, to minimize the end-to-end latency for the services provided over the LO network. Since the IO can be deployed for all the services possible, such tailored service provisioning may not be possible or desired in the IO network. The LO providing access to a limited set of services can provide the UE with the application ID parameters in order to enable the traffic steering.

Some of the steps involved in a method according to some embodiments of the invention are shown in Fig. 6. Namely, the application server 46 (e.g. cloud application server)

provides the TFT 68 to the client part in the application layer 24 of the UE 21. Based on the TFT, the UE application scheduler 67 controls the cellular radio layer 25 to route certain traffic (LO traffic) to the LO-5GNB 23, and certain traffic (IO traffic) to the IO-5GNB 22, which forward this traffic to the respective CN 14, 15. 61 and 62 designate the respective traffic buffers.

Charging:
Here the charging function can be based on the UE application subscription information that is provided during the service flow establishment. This may simplify the LO network architecture by removing the concept of roaming based on information on the SIM card, as discussed hereinabove, although roaming is not excluded. It may enable use cases where end users from anywhere of the globe subscribing to a particular service can access the LO network. Here the charging policies may depend on the traffic volume, service type, etc., used by the end user. The LO Packet Data Network – Gateway (P-GW) could enforce the bearer level QoS class identifier values (QCI) based on the UE application (UE App) subscription type. The LO-RAN may enforce these QCI values, similar to the mechanisms used in LTE evolved packet core (EPC).

Since the application layer knows the user identity (e.g. MSISDN) from the time when the user (client part) accessed the application (server part) via the IO network, it may still apply the same charging mechanism (e.g. prepaid/postpaid) even if the client part access the server part via the LO network. Furthermore, the application may charge the user for usage of the LO network by the same charging mechanisms.

Fig. 7 shows a further message flow according to an example embodiment of the invention. In the beginning, the UE is connected to the IO network (conventionally) (S71). Then, the UE sends a measurement report of the IO network and/or GPS information to the application server via the client part of the application on the UE (S72) using the IO network. Instead of or in addition to GPS information, data of another positioning system (e.g. Galileo) or other location information may be transmitted.

Based on the provided measurement report and/or location information, the application detects that the UE is in the proximity of the LO network. For example, the LO application server may have the radio fingerprint information in the vicinity of the areas where the LO 5GNBs are deployed. The radio fingerprint information comprises information about the IO network in the vicinity of the LO network. The IO network measurements that the UE conducts as part of its normal operation, especially for enabling mobility and service

continuity, may comprise corresponding information. For example, the radio fingerprint information may contain the IO network cell IDs and corresponding signal strengths, which are normally measured by the UE. Thus, the UE conducts IO network measurements and conveys this information to the client side of the LO application in the UE, which passes on this information to the application server, via the IO network. The application server, based on matching the radio fingerprint information with IO measurements performed by the UE, estimates the proximity of the UE to the LO network. If the server estimates that the UE is indeed in the proximity of LO network, it configures the LO App in the UE to configure the UE radio layer to initiate cell search and selection procedure. Accordingly, the application configures the UE (the cellular radio layer thereof) to perform measurements to detect the LO network (S73).

If the UE detects the LO network based on the measurements, it initiates a cell selection procedure (S74). The cell selection procedure may be based on parameters provided by the application, as outlined hereinabove (S75).

If the UE has accessed the LO network and is still served by the IO network, traffic steering may be performed in order to route the traffic to the appropriate network (S76). The traffic steering may be based on parameters (such as a traffic flow template (TFT), which is a template provided (e.g. by the core network) to the UE informing about the relative priorities of the applications requesting resources for uplink transmissions. This information may be enhanced to inform the UE as to which traffic should be routed to the LO or IO network, respectively) provided to the cellular radio layer by the application.

Charging of the traffic in the LO network may be done on the application server, based on the information (e.g. credentials) provided by the UE. The information may include any information that the charging functions require to charge the user, via the client part of the application.

Fig. 8 shows an apparatus according to an example embodiment of the invention. The apparatus may be a terminal such as a UE, or an element thereof. Fig. 9 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 8 may perform the method of Fig. 9 but is not limited to this method. The method of Fig. 9 may be performed by the apparatus of Fig. 8 but is not limited to being performed by this apparatus.

The apparatus comprises monitoring means 110 and controlling means 120. The monitoring means 110 and controlling means 120 may be a monitoring circuitry and controlling circuitry, respectively.

The monitoring means 110 monitors if a network information from a server part of an application is received by a client part of the application (S110). The network parameter is related to a second network (e.g. LO network). The client part, which is typically installed on a terminal (UE), is connected to the server part via a first network (e.g. IO network). The first network and the second network are different from each other but of a same radio access technology such as 5G, LTE, or LTE-A.

If the network information is received (S110 = "Yes"), the controlling means 120 controls a cellular radio layer (e.g. of the UE on which the client part is installed) such that it interworks with the second network based on the network information (S120).

Fig. 10 shows an apparatus according to an example embodiment of the invention. The apparatus may be an application (or application server), or an element thereof such as a server part of the application. Fig. 11 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 10 may perform the method of Fig. 11 but is not limited to this method. The method of Fig. 11 may be performed by the apparatus of Fig. 10 but is not limited to being performed by this apparatus.

The apparatus comprises providing means 210. The providing means 210 may be a providing circuitry.

The providing means 210 provides, by a server part of an application, a network information to a client part of the application (S210). The network information is related to a predetermined second network (e.g. LO network). The client part is connected to the server part via a first network (e.g. IO network), the first network and the second network are different from each other but both of a same radio access technology such as 5G, LTE, or LTE-A.

Fig. 12 shows an apparatus according to an example embodiment of the invention. The apparatus may be an application (or application server), or an element thereof such as a server part of the application. Fig. 13 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 12 may perform the method of Fig. 13 but

is not limited to this method. The method of Fig. 13 may be performed by the apparatus of Fig. 12 but is not limited to being performed by this apparatus.

The apparatus according to Fig. 12 comprises checking means 310, monitoring means 320, and providing means 330. The checking means 310, monitoring means 320, and providing means 330 may be a checking circuitry, monitoring circuitry, and providing circuitry, respectively. The apparatus of Fig. 12 may comprise the features of the apparatus of Fig. 10, too.

The checking means 310 checks if a client part of an application is connected to a server part of the application via a first network (e.g. IO network) of a radio access technology such as 5G, LTE, or LTE-A (S310).

If the client part is connected to the server part via the first network (S310 = “yes”), the monitoring means 320 monitors if the client part becomes connected to the server part via a predetermined second network (e.g. LO network) different from the first network but of the same radio access technology (S320).

If the client part becomes connected to the second network (S320 = “yes”), the providing means 330 provides to a charging device an information on a usage of the second network for the communication between the server part and the client part (S330). The providing means 330 may be a portion of (integrated with) the server part of the application. The providing means 330 keeps informing on the usage of the second network while the client part is connected to the server part via the second network.

Fig. 14 shows an apparatus according to an example embodiment of the invention. The apparatus may be a radio network, or an element thereof such as a base station (NodeB, e.g. 5GNB). Fig. 15 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 14 may perform the method of Fig. 15 but is not limited to this method. The method of Fig. 15 may be performed by the apparatus of Fig. 14 but is not limited to being performed by this apparatus.

The apparatus according to Fig. 14 comprises monitoring means 410, checking means 420, and granting means 430. The monitoring means 410, checking means 420, and granting means 430 may be a monitoring circuitry, checking circuitry, and granting circuitry, respectively.

The monitoring means 410 monitors if a user authenticates to a radio network by credentials in order to access the radio network (S410). For example, the credentials may be used to authenticate to an application.

If the user authenticates to the radio network by the credentials (S410 = yes), the checking means 420 checks if the user is authenticated to a predetermined application by the credentials (S420).

If the user is authenticated to the predetermined application by the credentials (S420 = "yes"), the granting means 430 grants access to the radio network for the user (S430).

Fig. 16 shows an apparatus according to an example embodiment of the invention. The apparatus comprises at least one processor 610, at least one memory 620 including computer program code, and the at least one processor 610, with the at least one memory 620 and the computer program code, being arranged to cause the apparatus to perform at least one of the methods according to Figs. 9, 11, 13, and 15 and related description or perform at least one of the embodiments described in this application.

Embodiments of the invention are described where the LO network is used for some dedicated (specialized) services, while the IO network is a kind of "general purpose" network. However, the services which may be offered via each of these networks are not limited in any way. For example, LO network may offer telephony, or IO network may offer real time gaming, too.

Embodiments of the invention may be employed not only in 3GPP networks (such as LTE, LTE-A, 5G) but also in other radio networks where the terminals may access plural networks simultaneously.

One piece of information may be transmitted in one or plural messages from one entity to another entity. Each of these messages may comprise further (different) pieces of information.

Names of network elements, protocols, and methods are based on current standards. In other versions or other technologies, the names of these network elements and/or protocols and/or methods may be different, as long as they provide a corresponding functionality.

A terminal may be any device which may connect to the respective network. For example, a terminal may be a UE, a mobile phone, a laptop, a smartphone, a machine-type communication device, etc.

If not otherwise stated or otherwise made clear from the context, the statement that two entities are different means that they perform different functions. It does not necessarily mean that they are based on different hardware. That is, each of the entities described in the present description may be based on a different hardware, or some or all of the entities may be based on the same hardware. It does not necessarily mean that they are based on different software. That is, each of the entities described in the present description may be based on different software, or some or all of the entities may be based on the same software. Embodiments of the invention may be employed fully or partly in the cloud, wherein a resource (e.g. processor, software, memory, network) for the respective task may be shared with other applications.

According to the above description, it should thus be apparent that example embodiments of the present invention provide, for example a base station such as a NodeB, a eNodeB, or a 5GNB, or a component thereof, an apparatus embodying the same, a method for controlling and/or operating the same, and computer program(s) controlling and/or operating the same as well as mediums carrying such computer program(s) and forming computer program product(s). According to the above description, it should thus be apparent that example embodiments of the present invention provide, for example a terminal such as a UE, or a component thereof, an apparatus embodying the same, a method for controlling and/or operating the same, and computer program(s) controlling and/or operating the same as well as mediums carrying such computer program(s) and forming computer program product(s). According to the above description, it should thus be apparent that example embodiments of the present invention provide, for example an application server or a server part of an application, or a component thereof, an apparatus embodying the same, a method for controlling and/or operating the same, and computer program(s) controlling and/or operating the same as well as mediums carrying such computer program(s) and forming computer program product(s).

Implementations of any of the above described blocks, apparatuses, systems, techniques, means, entities, units, devices, or methods include, as non-limiting examples, implementations as hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, a virtual machine, or some combination thereof.

It should be noted that the description of the embodiments is given by way of example only and that various modifications may be made without departing from the scope of the invention as defined by the appended claims.

Claims:

1. Apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least

monitoring if a network information from a server part of an application is received by a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, the network parameter is related to a second network, the second network is of the radio access technology, and the second network is different from the first network; and

controlling a cellular radio layer such that it interworks with the second network based on the network information if the network information is received.

2. The apparatus according to claim 1, wherein

the network information comprises a request to connect the client part to the server part via the second network; and

the controlling comprises controlling the cellular radio layer to access the second network if the network information comprises the request, wherein the at least one processor, with the at least one memory, is further arranged to perform

connecting the client part to the server part via the second network after the second network has been accessed.

3. The apparatus according to any of claims 1 and 2, wherein

the network information comprises an access parameter of the second network; and

the controlling comprises controlling the cellular radio layer to access the second network using the access parameter.

4. The apparatus according to any of claims 2 and 3, wherein a user of the client part is authenticated to the application by credentials, the user is authenticated to the first network by user information different from the credentials, and the at least one processor, with the at least one memory, is further arranged to perform

authenticating the user to the second network by the credentials.

5. The apparatus according to claim 4, wherein the user is authenticated to the second network without using the user information.

6. The apparatus according to any of claims 4 to 5, wherein the user information is stored on an identity module and the credentials are not stored on the identity module.

7. The apparatus according to any of claims 1 to 6, wherein

the network information comprises a traffic flow parameter; and

the controlling comprises steering a traffic to the first network and to the second network according to the traffic flow parameter if the cellular radio layer is served by the first network and the second network.

8. The apparatus according to any of claims 1 to 7, wherein

the network information comprises at least one of a discovery information of the second network and a synchronization information of the second network; and

the controlling comprises controlling the cellular radio layer such that it searches the second network based on the at least one of the discovery information and the synchronization information.

9. Apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least

providing, by a server part of an application, a network information to a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, and the network information is related to a predetermined second network, the second network is of the radio access technology, and the second network is different from the first network.

10. The apparatus according to claim 9, wherein the network information comprises at least one of an access parameter of the second network and a request to connect the client part to the server part via the second network.

11. The apparatus according to claim 10, wherein the network information comprises the request, and the at least one processor, with the at least one memory, is further arranged to perform

evaluating, based on at least one of a received location information and a received measurement information, if a device on which the client part is running is close to the second network; and

inhibiting the providing of the request if the device is not close to the second network.

12. The apparatus according to any of claims 9 to 11, wherein the network information comprises at least one of a discovery information and a synchronization information, and the at least one processor, with the at least one memory, is further arranged to perform

informing a base station of the second network to start transmitting the at least one of the discovery information and the synchronization information.

13. Apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least

checking if a client part of an application is connected to a server part of the application via a first network of a radio access technology;

monitoring if the client part becomes connected to the server part via a predetermined second network of the radio access technology if the client part is connected to the server part via the first network, wherein the second network is different from the first network;

providing, by the server part to a charging device, an information on a usage of the second network for the communication between the server part and the client part if the client part becomes connected to the server part via the second network.

14. Apparatus, comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform at least

monitoring if a user authenticates to a radio network by credentials in order to access the radio network;

checking if the user is authenticated to a predetermined application by the credentials, if the user authenticates to the radio network by the credentials;

granting access to the radio network for the user if the user is authenticated to the predetermined application by the credentials.

15. Method, comprising

monitoring if a network information from a server part of an application is received by a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, the network parameter is related to a second network, and the second network is of the radio access technology, and the second network is different from the first network; and

controlling a cellular radio layer such that it interworks with the second network based on the network information if the network information is received.

16. The method according to claim 15, wherein

the network information comprises a request to connect the client part to the server part via the second network; and

the controlling comprises controlling the cellular radio layer to access the second network if the network information comprises the request, wherein the method further comprises:

connecting the client part to the server part via the second network after the second network has been accessed.

17. The method according to any of claims 15 and 16, wherein

the network information comprises an access parameter of the second network; and

the controlling comprises controlling the cellular radio layer to access the second network using the access parameter.

18. The method according to any of claims 16 and 17, wherein a user of the client part is authenticated to the application by credentials, the user is authenticated to the first network by user information different from the credentials, and the method further comprises:

authenticating the user to the second network by the credentials.

19. The method according to claim 18, wherein the user is authenticated to the second network without using the user information.

20. The method according to any of claims 18 to 19, wherein the user information is stored on an identity module and the credentials are not stored on the identity module.

21. The method according to any of claims 15 to 20, wherein

the network information comprises a traffic flow parameter; and

the controlling comprises steering a traffic to the first network and to the second network according to the traffic flow parameter if the cellular radio layer is served by the first network and the second network.

22. The method according to any of claims 15 to 21, wherein

the network information comprises at least one of a discovery information of the second network and a synchronization information of the second network; and

the controlling comprises controlling the cellular radio layer such that it searches the second network based on the at least one of the discovery information and the synchronization information.

23. Method, comprising

providing, by a server part of an application, a network information to a client part of the application, wherein the client part is connected to the server part via a first network, the first network is of a radio access technology, and the network information is related to a predetermined second network, the second network is of the radio access technology, and the second network is different from the first network.

24. The method according to claim 23, wherein the network information comprises at least one of an access parameter of the second network and a request to connect the client part to the server part via the second network.

25. The method according to claim 24, wherein the network information comprises the request, and the method further comprises:

evaluating, based on at least one of a received location information and a received measurement information, if a device on which the client part is running is close to the second network; and

inhibiting the providing of the request if the device is not close to the second network.

26. The method according to any of claims 23 to 25, wherein the network information comprises at least one of a discovery information and a synchronization information, and the method further comprises:

informing a base station of the second network on to start transmitting the at least one of the discovery information and the synchronization information.

27. Method, comprising

checking if a client part of an application is connected to a server part of the application via a first network of a radio access technology;

monitoring if the client part becomes connected to the server part via a predetermined second network of the radio access technology if the client part is connected to the server part via the first network, wherein the second network is different from the first network;

providing, by the server part to a charging device, an information on a usage of the second network for the communication between the server part and the client part if the client part becomes connected to the server part via the second network.

28. Method, comprising

monitoring if a user authenticates to a radio network by credentials in order to access the radio network;

checking if the user is authenticated to a predetermined application by the credentials, if the user authenticates to the radio network by the credentials;

granting access to the radio network for the user if the user is authenticated to the predetermined application by the credentials.

29. A computer program product comprising a set of instructions which, when executed on an apparatus, is configured to cause the apparatus to carry out the method according to any of claims 15 to 28.

30. The computer program product according to claim 29, embodied as a computer-readable medium or directly loadable into a computer.

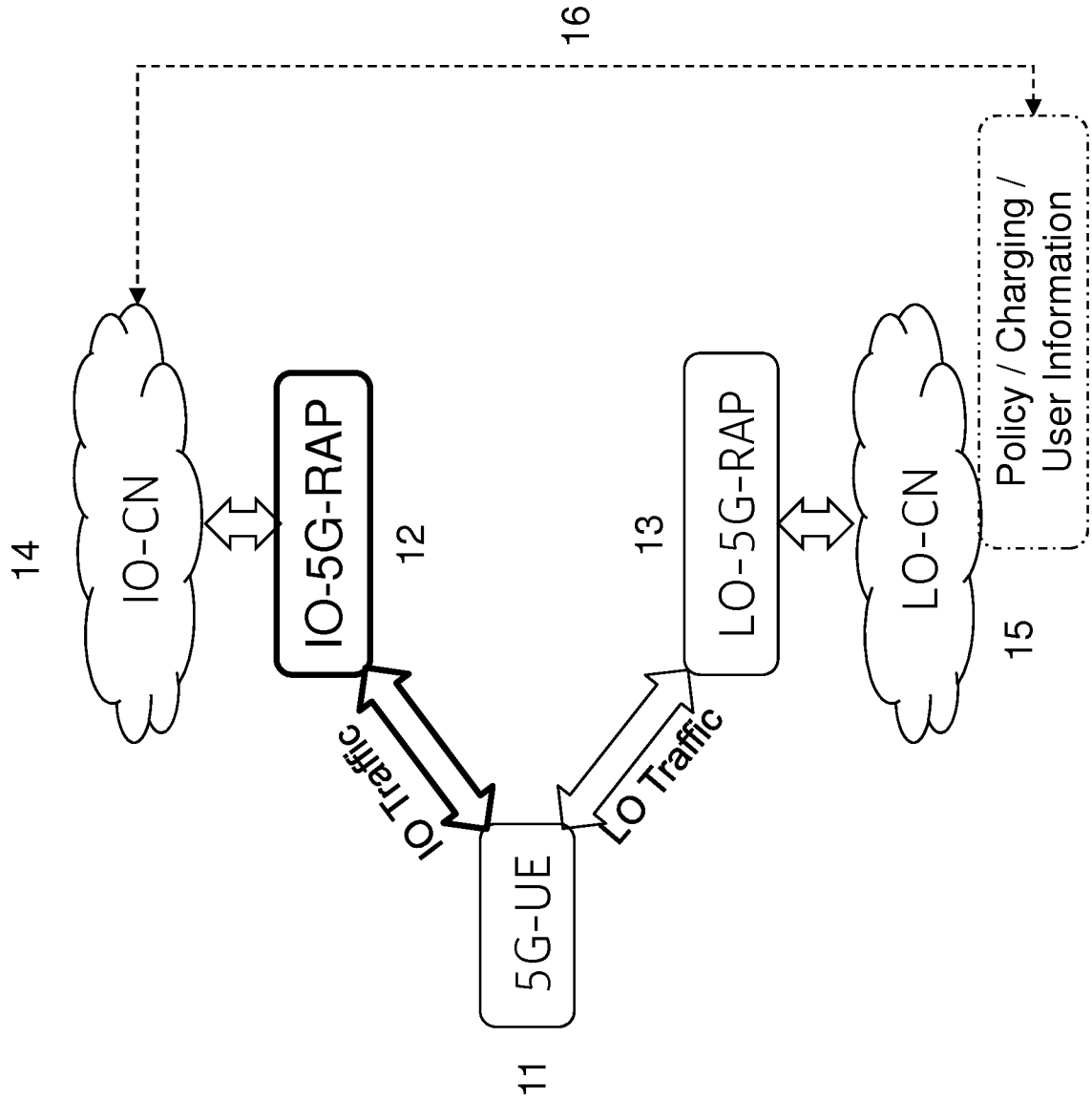
16
IO-CN
14
IO-5G-RAP
12
IO Traffic
5G-UE
11
LO Traffic
13
LO-5G-RAP
LO-CN
15
Policy / Charging / User Information

Fig. 1

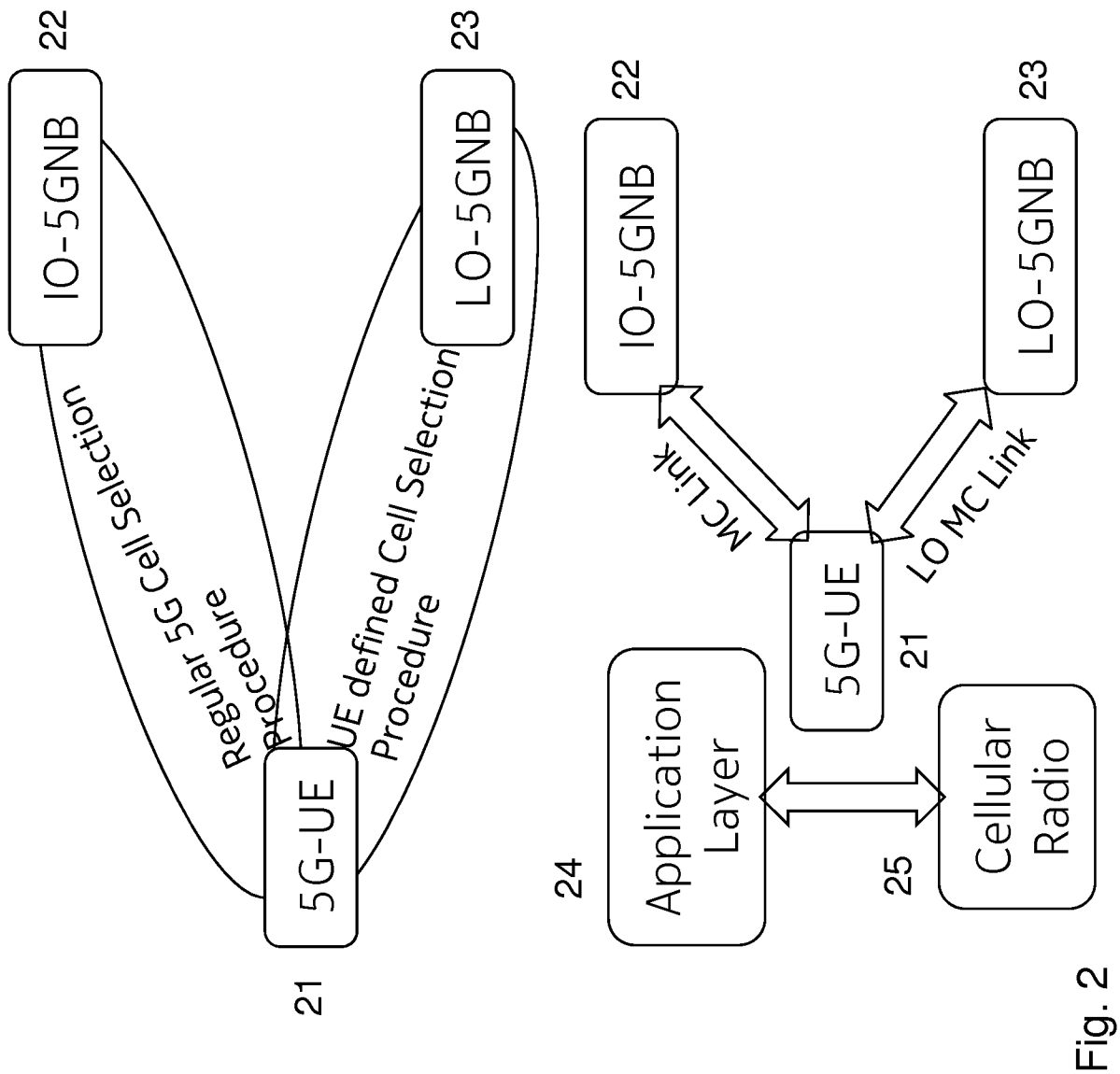
22
IO-5GNB
23
LO-5GNB
Regular 5G Cell Selection Procedure
UE defined Cell Selection Procedure
5G-UE
21
22
IO-5GNB
23
LO-5GNB
MC Link
LO MC Link
5G-UE
21
Application Layer
24
Cellular Radio
25

Fig. 2

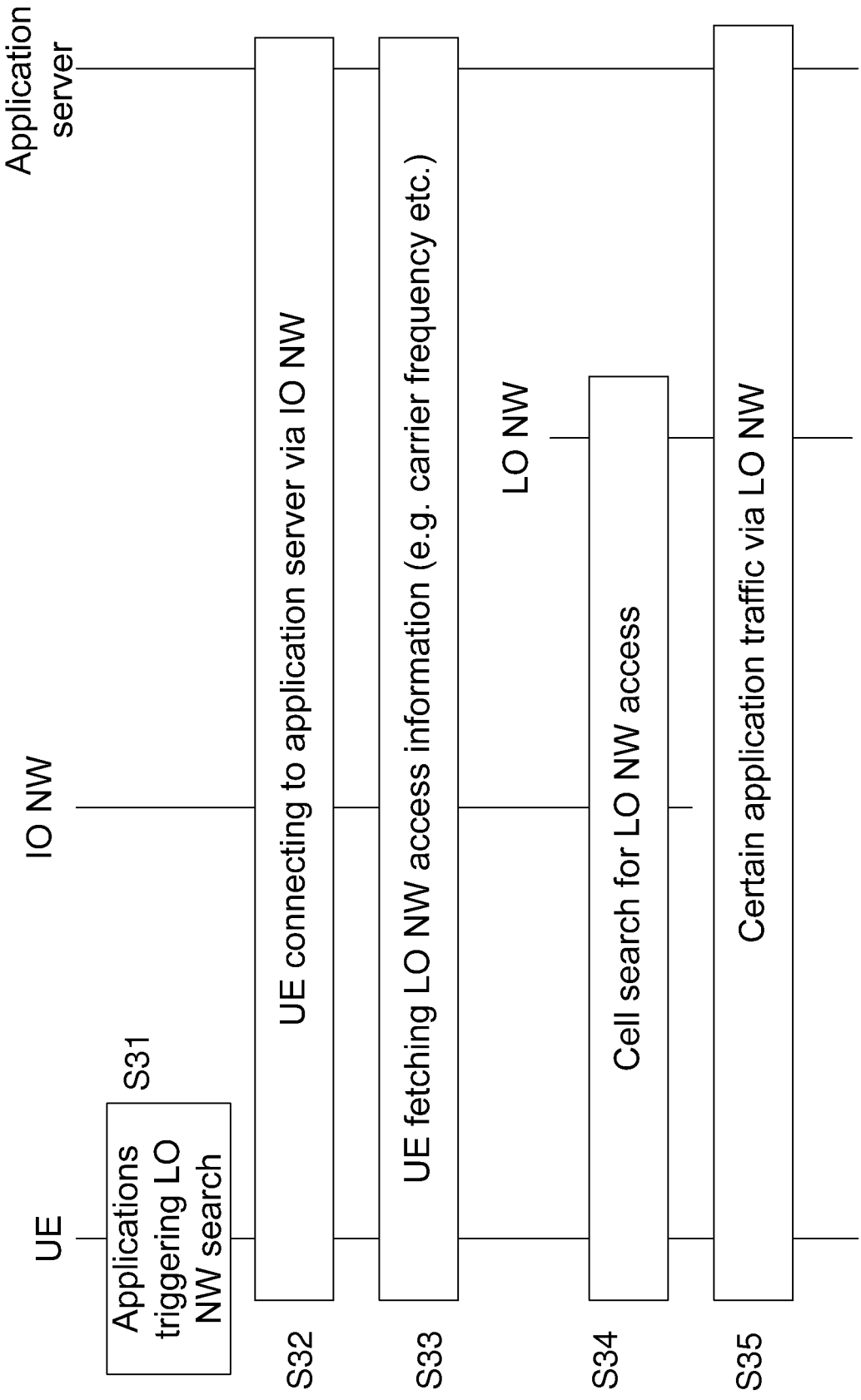
UE
IO NW
Application server
LO NW
Applications triggering LO NW search
S31
UE connecting to application server via IO NW
S32
UE fetching LO NW access information (e.g. carrier frequency etc.)
S33
Cell search for LO NW access
S34
Certain application traffic via LO NW
S35

Fig. 3

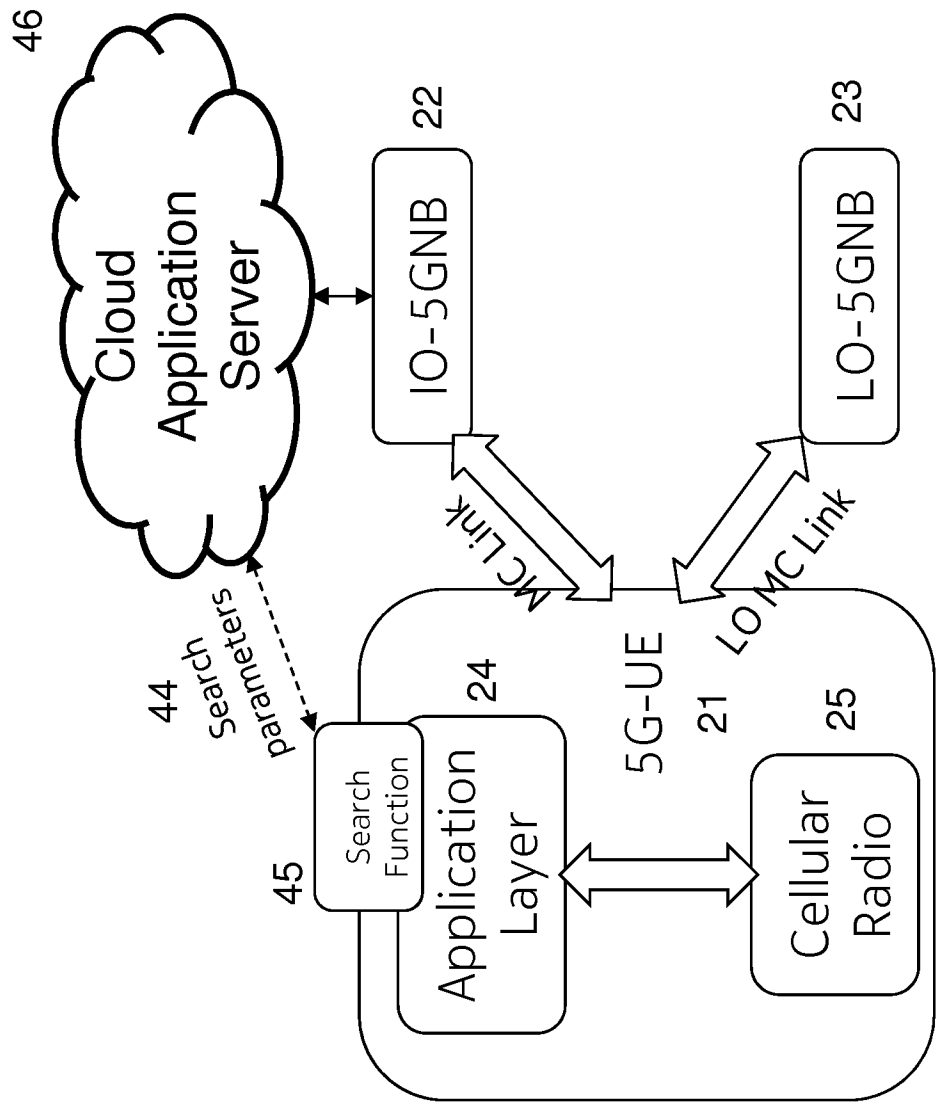
46
Cloud Application Server
22
IO-5GNB
23
LO-5GNB
MC Link
LO MC Link
44
Search parameters
45
Search Function
24
Application Layer
5G-UE
21
25
Cellular Radio

Fig. 4

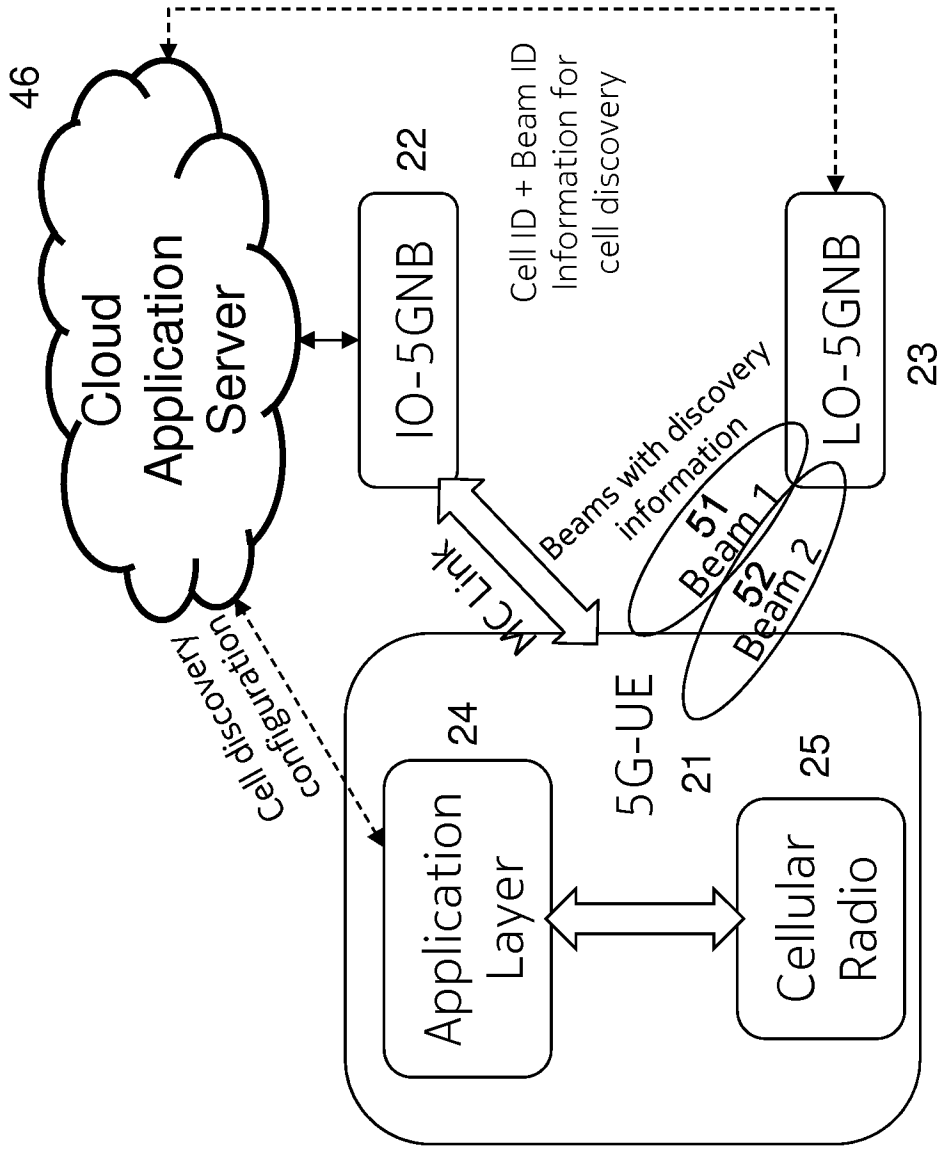
46
Cloud Application Server
22
IO-5GNB
Cell ID + Beam ID Information for cell discovery
LO-5GNB
23
Beams with discovery information
51 Beam 1
52 Beam 2
MC Link
Cell discovery configuration
5G-UE
21
24
Application Layer
25
Cellular Radio

Fig. 5

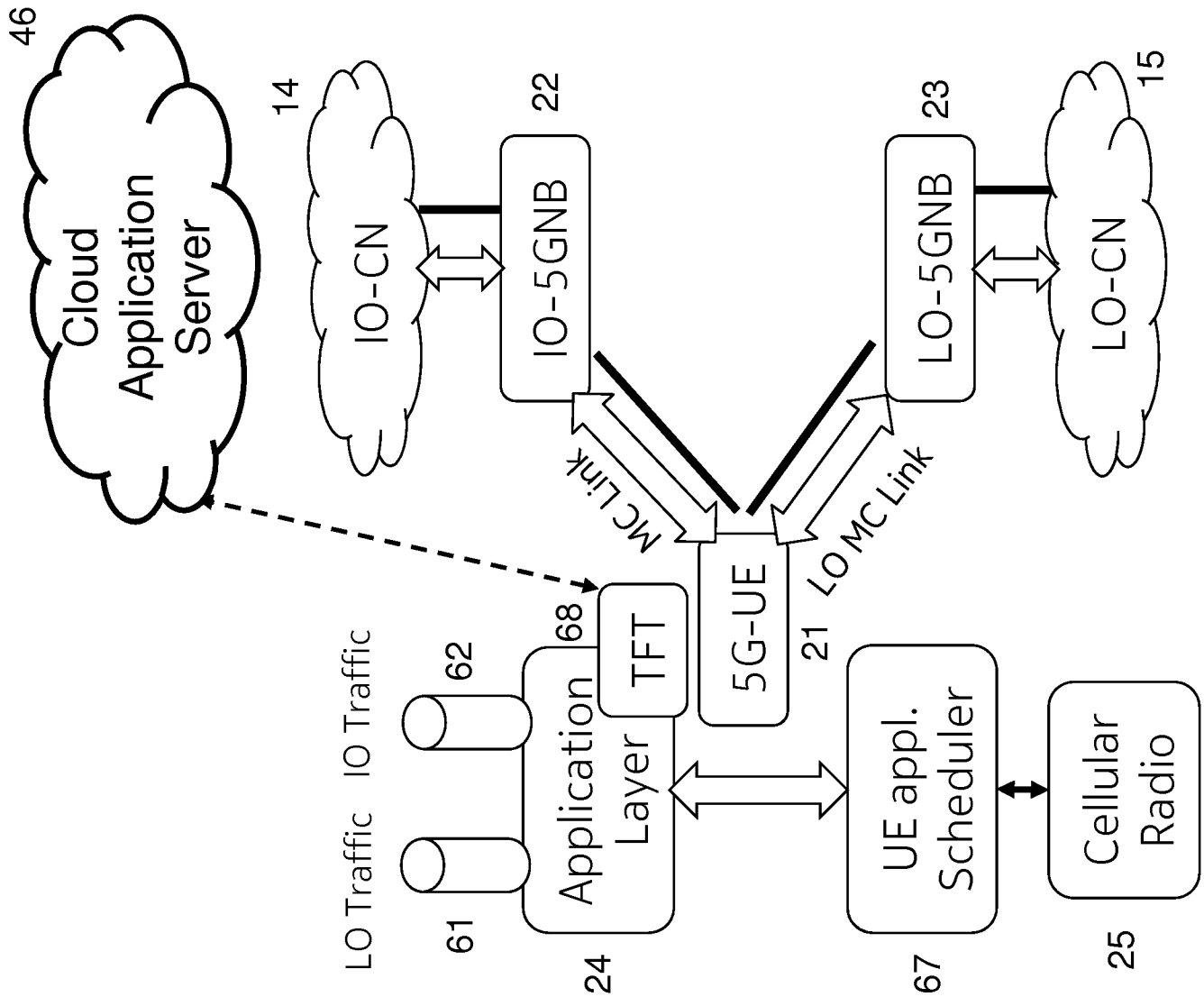
46
Cloud Application Server
14
IO-CN
22
IO-5GNB
23
LO-5GNB
15
LO-CN
MC Link
LO MC Link
5G-UE
21
68
TFT
Application Layer
24
IO Traffic
LO Traffic
62
61
UE appl. Scheduler
67
Cellular Radio
25

Fig. 6

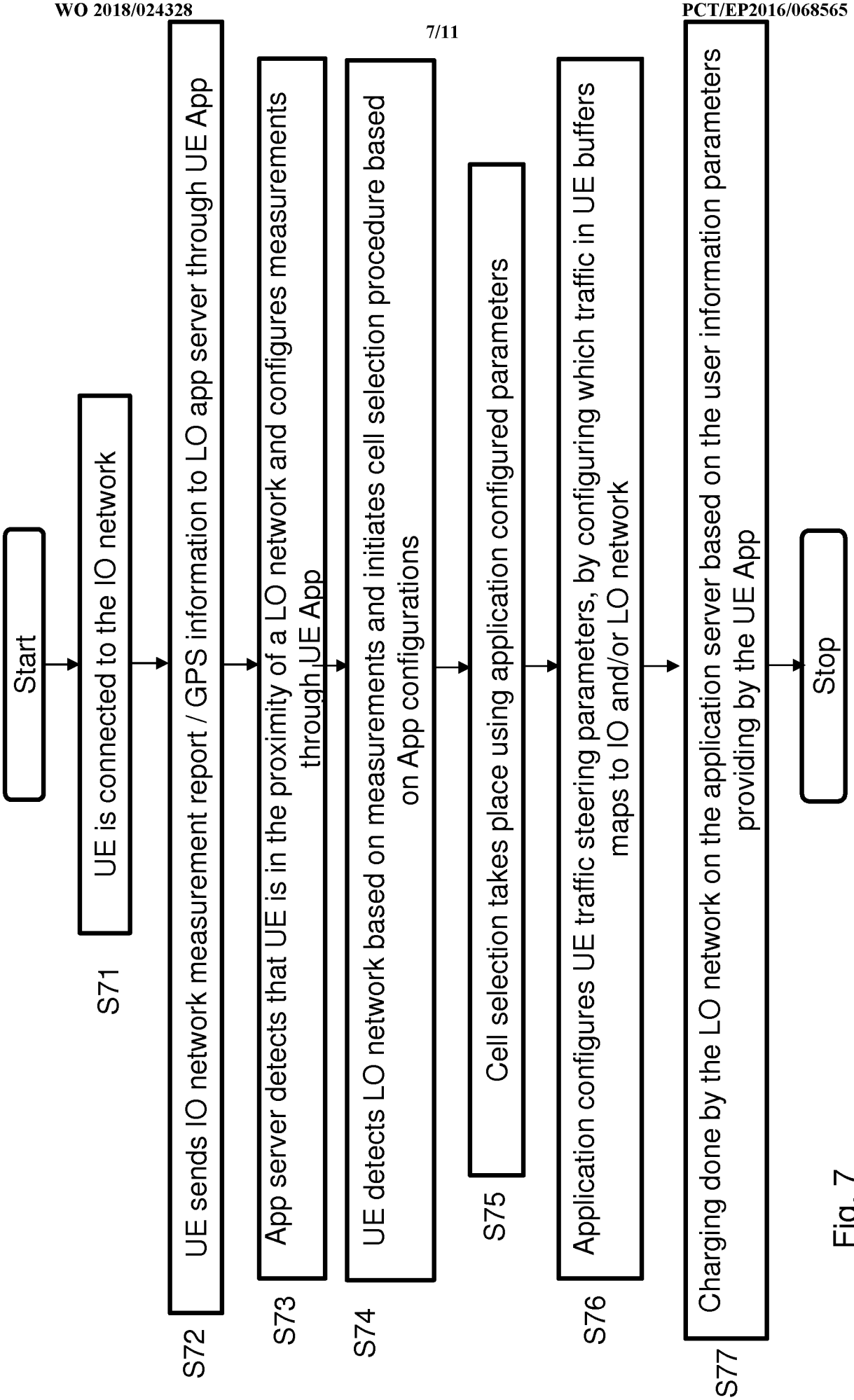
Start
UE is connected to the IO network
S71
UE sends IO network measurement report / GPS information to LO app server through UE App
S72
App server detects that UE is in the proximity of a LO network and configures measurements through UE App
S73
UE detects LO network based on measurements and initiates cell selection procedure based on App configurations
S74
Cell selection takes place using application configured parameters
S75
Application configures UE traffic steering parameters, by configuring which traffic in UE buffers maps to IO and/or LO network
S76
Charging done by the LO network on the application server based on the user information parameters providing by the UE App
S77
Stop

Fig. 7

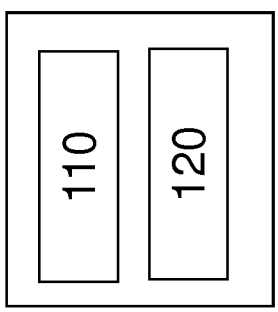

Fig. 8

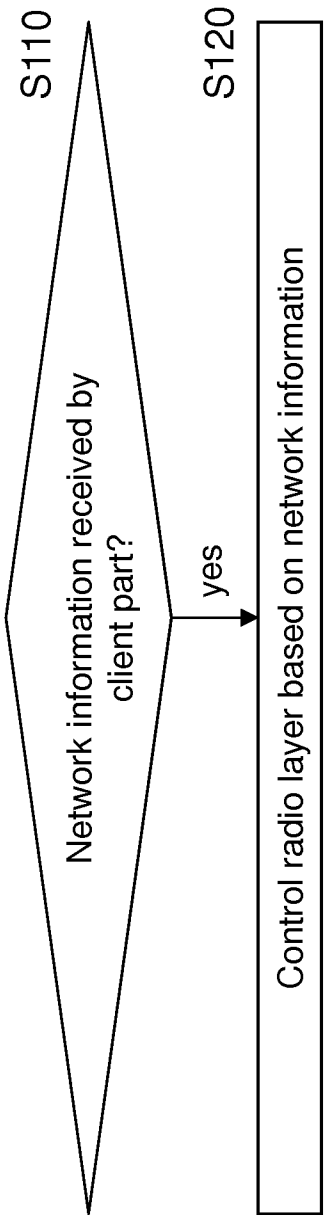

Fig. 9

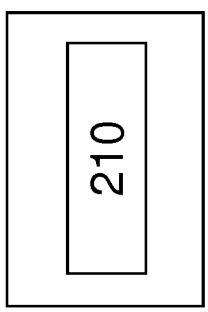

Fig. 10

Fig. 11

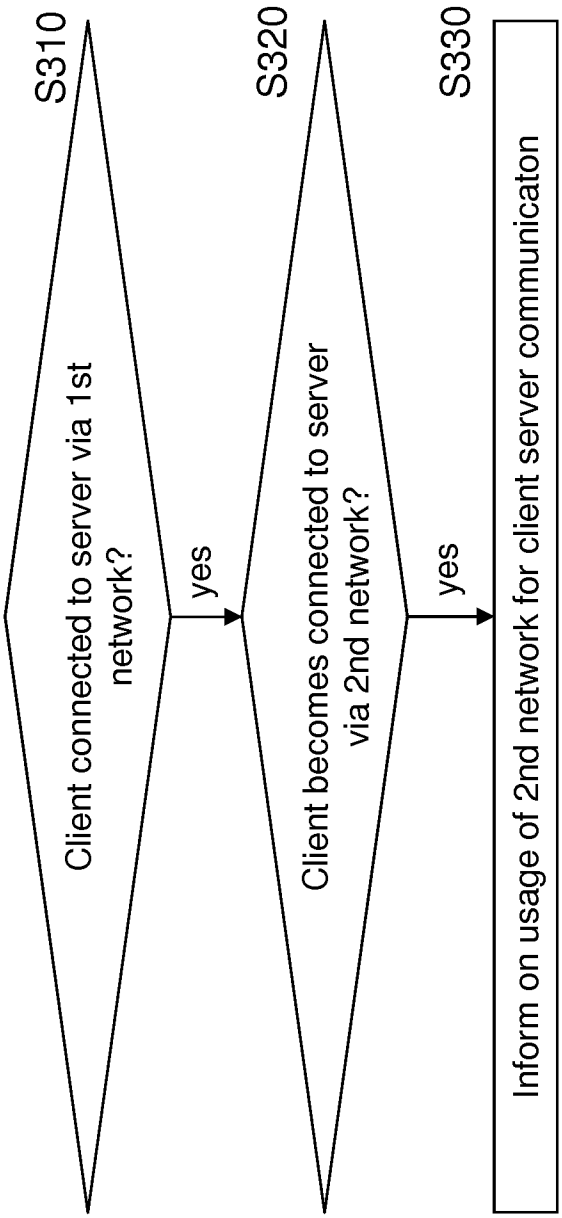
S310
Client connected to server via 1st network?
yes
S320
Client becomes connected to server via 2nd network?
yes
S330
Inform on usage of 2nd network for client server communicaton

Fig. 13

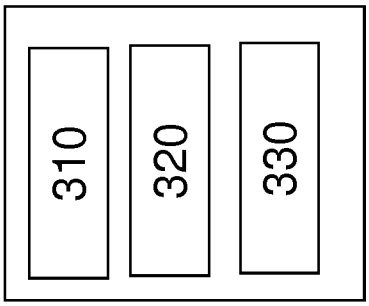
310
320
330

Fig. 12

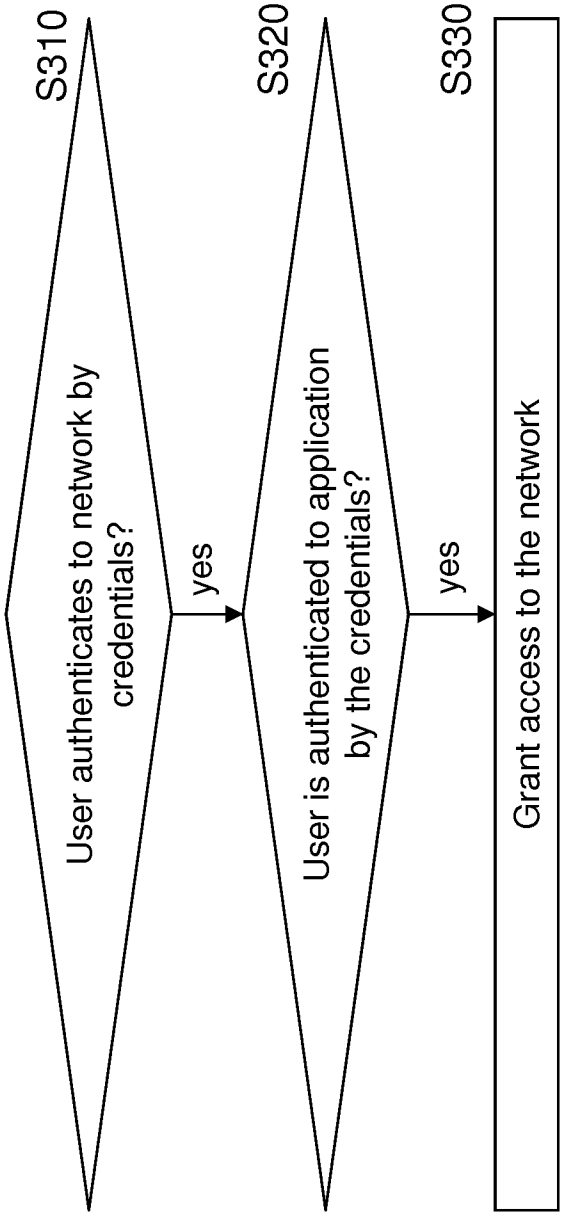

Fig. 15

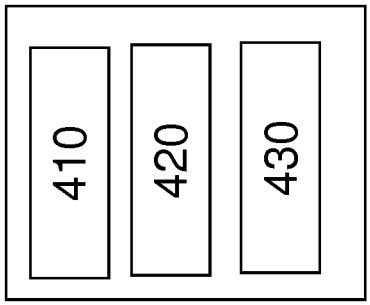

Fig. 14

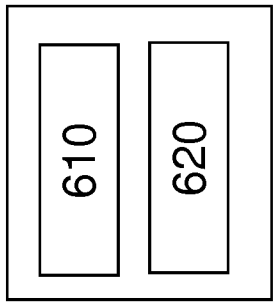

Fig. 16

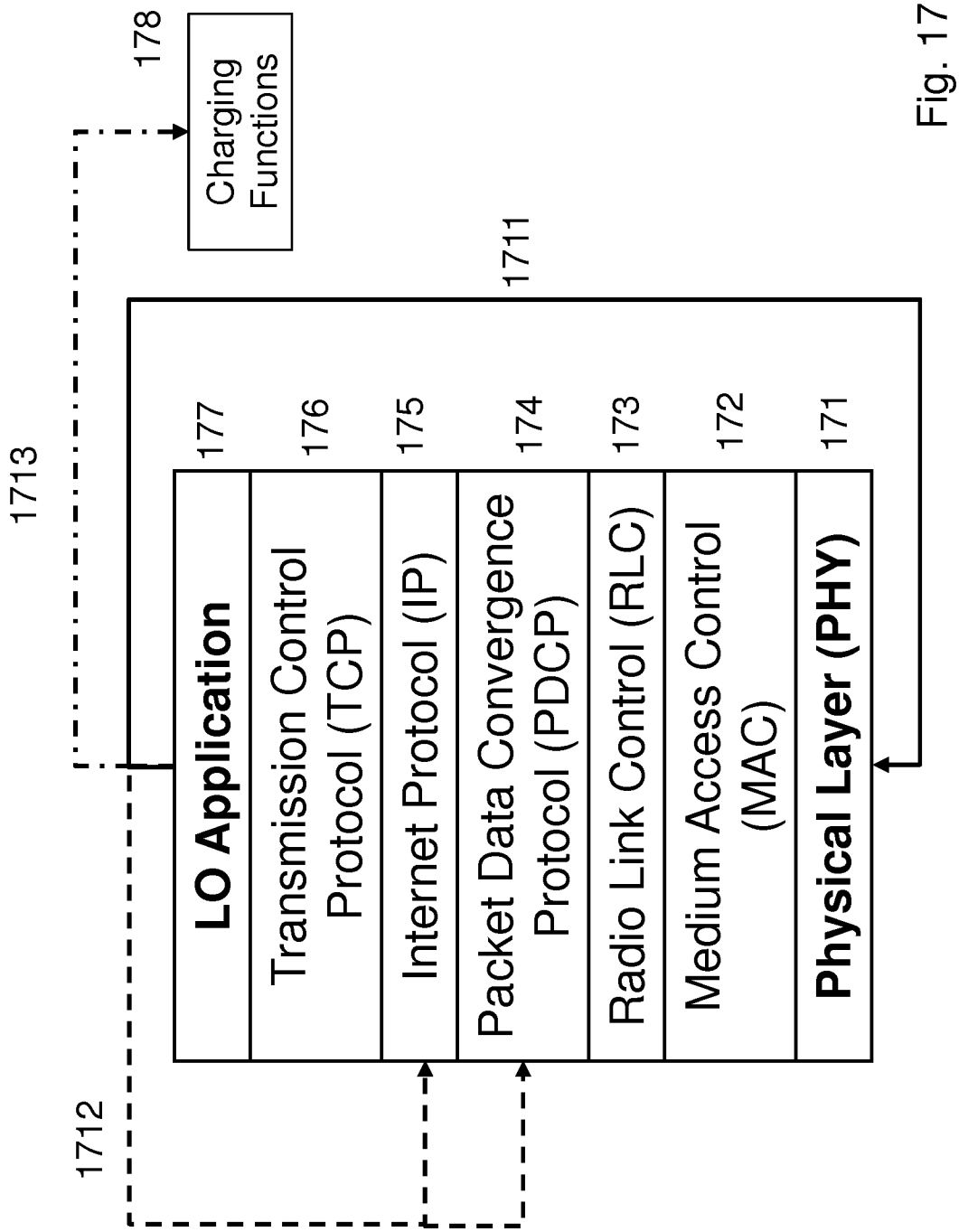
178
Charging Functions
1711
1713
177
176
175
174
173
172
171
LO Application
Transmission Control Protocol (TCP)
Internet Protocol (IP)
Packet Data Convergence Protocol (PDCP)
Radio Link Control (RLC)
Medium Access Control (MAC)
Physical Layer (PHY)
1712

Fig. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/068565

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/16 H04W48/18 H04L29/06
ADD. H04W12/06 H04W76/02 H04W88/06

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/067434 A1 (SIU ISAAC TA-YAN [US] ET AL) 18 March 2010 (2010-03-18) figures 7A, 7B paragraph [0038] - paragraph [0039]; figure 2 paragraph [0060] - paragraph [0063]; figures 6, 6A paragraph [0086] - paragraph [0089]; figures 12, 14 paragraph [0096] ----- -/--	1-3, 7-12, 15-17, 21-26, 29,30

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 2016	09/02/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Badoi, Cornelia

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/068565

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/009676 A1 (CORMIER JEAN-PHILIPPE [CA] ET AL) 14 January 2010 (2010-01-14) paragraph [0025]; figures 1A, 1B paragraph [0050] paragraph [0052]; figure 3 paragraph [0068] - paragraph [0072]; figure 7 -----	1-3, 7-12, 15-17, 21-26, 29,30

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2016/068565

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-3, 7-12, 15-17, 21-26, 29, 30

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-3, 7-12, 15-17, 21-26, 29, 30

   Apparatus, method and computer program for concurrently accessing an application server via two radio access networks

   ---

2. claims: 4-6, 14, 18-20, 28

   Apparatus and method for authenticating the user to a radio network based on application credentials

   ---

3. claims: 13, 27

   Apparatus and method for charging a user based on information regrading its network usage

   ---

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/068565

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010067434 A1	18-03-2010	CN 102160424 A	17-08-2011
		EP 2351427 A1	03-08-2011
		JP 5237456 B2	17-07-2013
		JP 2012503432 A	02-02-2012
		KR 20110073524 A	29-06-2011
		TW 201125389 A	16-07-2011
		US 2010067434 A1	18-03-2010
		WO 2010033438 A1	25-03-2010
US 2010009676 A1	14-01-2010	NONE	