(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 October 2017 (05.10.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/166190 A1

(51) International Patent Classification:
H04W 36/14 (2009.01)

(21) International Application Number:
PCT/CN2016/078044

(22) International Filing Date:
31 March 2016 (31.03.2016)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **HEWLETT PACKARD ENTERPRISE DEVELOPMENT LP** [US/US]; 3404 E. Harmony Road, Mail Stop 79, Fort Collins, Colorado 80528 (US).

(72) **Inventors; and**
(71) **Applicants** *(for US only)*: **WANG, Shuai** [CN/CN]; Building 20, Universal Business Park, 10 Jiu Xianqiao Road, Chaoyang District, Beijing 100015 (CN). **XIE, Jun-Qing** [CN/CN]; Building 20, Universal Business Park, 10 Jiu Xianqiao Road, Chaoyang District, Beijing 100015 (CN).

(74) Agent: **DEQI INTELLECTUAL PROPERTY LAW CORPORATION**; 7/F, Xueyuan International Tower, No. 1 Zhichun Road, Haidian District, Beijing 100083 (CN).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: HANDOVER REQUESTS IN ACCESS NETWORK

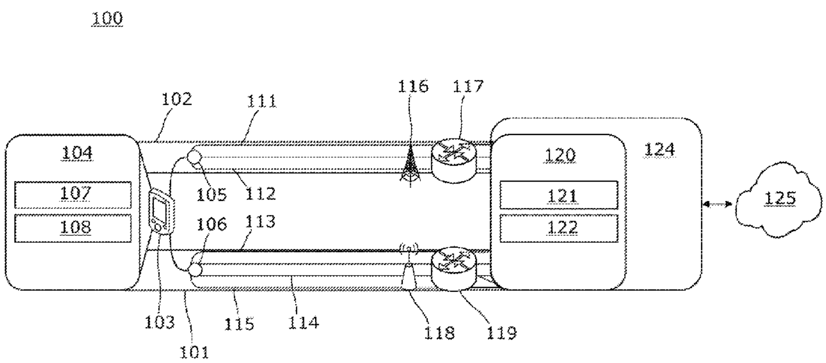

FIG. 1

(57) Abstract: In some examples, a method can include receiving with a Packet Data Network Gateway (PGW) in an application layer and from a mobile device, a handover request in an access network. The handover request requests a bearer for routing an Internet Protocol (IP) data flow. The mobile device comprises a Wireless Cellular Access Technology (WCAT) interface and a Wireless Non-Cellular Access Technology (WNCAT) interface connected to the access network. The WCAT interface and the WNCAT interface having a same IP address and the requested bearer is either a WCAT bearer associated with the mobile device or a WNCAT bearer associated with the mobile device.

WO 2017/166190 A1

HANDOVER REQUESTS IN ACCESS NETWORK

BACKGROUND

[0001] Enterprise wireless network infrastructure can boost enterprise Information Technology (IT) productivity. The enterprise connectivity should satisfy the emerging requirements of guaranteed Quality of Services (QoS) with ever-increasing bandwidth requirements for various applications, at the same time to support continuity, simplicity and security, etc. These technical expectations may suggest a hybrid enterprise access network empowering e.g. Long Term Evolution (LTE) and Wireless Local Area Network (WLAN) serving in parallel. With an entire EPC (Evolved Packet Core) maintained in the enterprise access network, seamless handover capability of heterogeneous networks (e.g. between LTE and WLAN) should be analyzed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 shows an example of a network architecture according to the present disclosure.

[0003] FIG.2 shows examples of signaling at a network layer and in an application layer for handover operation.

[0004] FIG.3 shows an example of a hybrid network where seamless handover can be performed.

[0005] FIG.4 shows an example of routing modules within a user equipment (UE) and a Packet Data Network (PDN) Gateway (PGW).

[0006] FIG.5 shows an example of a flux diagram for performing seamless handover with end-to-end bidirectional signaling carried out in the application layer according to the present disclosure.

[0007] FIG.6 shows examples of modules for performing seamless handover within a UE and a PGW.

[0008] FIG.7 shows an example of a bidirectional signaling and routing between a UE and a PGW.

DETAILED DESCRIPTION

[0009] This disclosure presents an end-to-end bidirectional signaling performed in an application layer for seamless handover operation in an access network or e.g. an enterprise access network. This seamless handover performed with end-to-end bidirectional signaling in the application layer solution can be referred in the present disclosure as Multiple IP flows and Simultaneous connections based Seamless handover with In-band and On-demand signaling of low-lateNcy (MISSION) solution.

[0010] Seamless handover according to MISSION solution can simultaneously use both of a Wireless Cellular Access Technology (WCAT), as e.g. LTE and a Wireless Non-Cellular Access Technology (WNCAT) as e.g. WLAN of a UE. The UE can be e.g. a mobile device. The present disclosure shows examples of network architectures for hybrid solutions that can implement LTE and WLAN access technologies but other access technologies could be used when carrying out in MISSION solution.

[0011] The mobile device can be a client´s mobile device, a user equipment (UE) or a mobile node (MN) within the access network. The mobile device can be a mobile phone, a tablet or a laptop with an adaptor for LTE technology or any other mobile device with cellular and non-cellular technologies accessing capabilities.

[0012] MISSION can be a customized IP flow mobility solution that can simplify the procedures and mechanisms of connectivity, signaling and control for seamless handover. MISSION can maintain the necessary functionalities in performing the full seamless handover capability. MISSION can support a client initiated handover operation and a network initiated handover operation by performing a bi-directional rule provisioning mechanism. At the same time, MISSION solution can also backwardly support a one connection based complete handover.

[0013] In order to enable more flexible and customized policy within an enterprise and to reduce the data traffic going through the carrier's core network, when deploying the hybrid enterprise access network, one of the aspects to consider may be to establish an Evolved Packet Core (EPC) in an access network. The enterprise EPC can run in physical boxes or in virtual machines and can handle the seamless handover of heterogeneous networks (.e.g., between the LTE and the WLAN) to provide a controllable QoS. In the example of the present disclosure, MISSION can handle connectivity of the UE accessing an enterprise access network and being a solution for the UE to enable seamless handover.

[0014] FIG.1 shows an example of an architecture of a hybrid enterprise access network 100 connecting a UE 103 to Internet 125. The hybrid network 100 may comprise a LTE eNodeB 116 and a WLAN Access Point (AP) 118. Furthermore, this example of hybrid network 100 can include an EPC architecture that can comprise a Service Gateway (SGW) 117, an Evolved Packet Data Gateway/Access Network Gateway (ePDG/ANGW) 119 and a PGW 124 accessing the Internet 125.

[0015] The UE 103 can comprise two network interfaces, i.e. a network interface 105 for the LTE traffic and a network interface 106 for the WLAN data traffic. The connections between the UE's network interfaces the LTE interface 105 and the WLAN interface 106 and the PGW 124 in the EPC can be called bearers. A bearer can be a logical tunnel for transmitting data traffics, and all traffics between the UE 103 and the PGW 124 can be further grouped in IP flows inside these bearers based on the general characteristics of flows, such as source IP address, source port, destination IP address, destination port, and protocol (a.k.a., 5-tuple item), etc.

[0016] The bearers of MISSION solution can be treated as an abstraction of the three types of Evolved Packet Switched System (EPS) bearers as Data Radio Bearer (between the UE 103 and the eNodeB 116), S1 Bearer (between the eNodeB 116 and the SGW 117), and S5 Bearer (between the SGW 117 and the PGW 124), and regardless of distinguishing the default or dedicated EPS bearers for simplicity.

[0017] When the UE 103 can connect to the hybrid network 100, bearers may be created between each network interface LTE 105 and the WLAN interface 106 and the PGW 124, i.e., a WLAN bearer 101 can be created when the UE 103 is connected to a

WLAN within the hybrid network 100, and a LTE bearer 102 can be created when the UE 103 is connected to a LTE in the hybrid network 100.

[0018] The LTE bearer 102 and the WLAN bearer 101 may be kept operative and ready to be used for simultaneous transmission. Each bearer can comprise multiple IP flows transmitted and received from and to the UE 103 and the PGW 124, respectively. The LTE bearer 102 can comprise Internet Protocol (IP) data flows 111 and 112. The WLAN bearer 101 can comprise IP data flows 113, 114 and 115.

[0019] Hybrid network 100 further comprises the PGW 124 than can also be specifies as PDN GW. The PGW 124 can provide connectivity from the UE 103 to an external packet data network 125 such as Internet by being the point of exit and entry of traffic for the UE 103. The PGW 124 can perform e.g. policy enforcement, packet filtering, charging support, lawful interception and packet screening.

[0020] For this particular example of the present disclosure, MISSION solution can handle seamless handover with two logical modules: a MISSION UE 104 and a MISSION PGW 120. These two logical modules may comply with several conditions within the hybrid network 100 in order to carry out MISSION. These conditions can be called MISSION HOTLINE conditions. The MISSION UE 104 can handle all operations on the UE 103, while the MISSION PGW 120 may reside at the network side and can be part of the PGW 124.

[0021] The MISSION UE 104 within the UE 103 can be further composed of two logical sub-components: a signaling module 107 and a routing module 108 that may be used to carry out the seamless handover operations of flow routing and bi-directional signaling in the application layer.

[0022] In an example according to the present disclosure, the UE 103 can be a mobile device that can perform end-to-end bidirectional signaling in the application layer in order to carry out seamless handover operation according to the MISSION solution. The UE 103 can comprise a Wireless Cellular Access Technology (WCAT) interface as e.g. the LTE interface 105 connected to the access network and a Wireless Non-Cellular Access Technology (WNCAT) interface as e.g. the WLAN interface 106 connected to the access network.

[0023] The mobile device can comprise a processing resource and a memory resource storing machine readable instructions to cause the processing resource to transmit through an application layer a handover request 210 to a Packet Data Network Gateway as e.g. the PGW 124 in the hybrid network 100. The handover request 210 may request an access bearer (101, 102) for routing an IP data flow as e.g. the IP data flows 111, 112, 113, 114 and 115. The requested bearer can be either a WCAT bearer as e.g. the LTE bearer 102 associated with the mobile device or a WNCAT bearer as e.g. the WLAN bearer 101 associated with the mobile device. The WCAT interface and the WNCAT interface may have the same IP address. The processing resource may route the IP data flow through the requested bearer if the request is granted to the PGW 124 and receive the IP data flow through the requested bearer if the request is granted from the PGW 124.

[0024] The MISSION PGW 120 can comprise similar logical sub-components as a signaling module 121 and a routing module 122. These logical sub-components may comply with MISSION Hotline conditions in order to maintain all the traffic paths used in MISSION during seamless handover.

[0025] In an example according to the present disclosure the PGW 124 can comprise a processing resource and a memory resource storing machine readable instructions to cause the processing resource to receive in an application layer from the UE 103 the handover request 210 in the hybrid network 100. The handover request 210 may request a bearer for uplink routing of an IP data flow. The UE 103 may comprise a Wireless Cellular Access Technology (WCAT) interface as e.g. the LTE interface 105 connected to the access network and a Wireless Non-Cellular Access Technology (WNCAT) interface as e.g. the WLAN interface 106 connected to the hybrid network 100.

[0026] The WCAT interface and the WNCAT interface may have the same IP address and the requested bearer can be either a WCAT bearer associated with the UE 103 or a WNCAT bearer associated with the UE 103. The processing resource of the PGW 124 may route, through the requested bearer and to the UE 103 the IP data flow when the handover request 210 is granted and receive, through the requested bearer and from the UE 103 the IP data flow when the request is granted.

[0027] MISSION hotline conditions can permit seamless handover operations carried out by the MISSION UE 104 comprised in the UE 103 and the MISSION PGW 120 comprised in the PGW 124 for downlink traffic from the PGW 124 to the UE 103 and for uplink traffic from the UE 103 to the PGW 124.

[0028] MISSION hotline conditions can comprise three conditions that may be met by the WLAN interface 106 and the LTE interface 105 and the WLAN bearer 101 and the LTE bearer 102 and by the whole hybrid network 100.

[0029] MISSION hotline conditions that can enable to perform seamless handover according to the MISSION solution using end-to-end bidirectional signaling in the application layer between the UE 103 and the PGW 124 can comprise the following:

[0030] The first condition of the MISSION hotline conditions can be the IP address assignment. When deploying the hybrid enterprise access network 100, the same IP address may be assigned to both the LTE interface 105 and the WLAN interface 106 of the UE 103, which may enable deployment of protocols for dynamically distributing IP addresses to the interfaces LTE interface 105 and the WLAN interface 106 as for example, the Dynamic Host Configuration Protocol (DHCP). Furthermore, the same IP address assignment may also enable centric maintenance of different users in the hybrid network 100.

[0031] The LTE interface 105 and the WLAN interface 106 of the UE 103 may have the same IP address assigned when they connect to the hybrid network 100. Thus IP datagrams sent out from the UE 103 and received from the Internet 125 could have the same IP address identifying the UE 103 making the applications not aware of the underlying hybrid network 100.

[0032] IP address assigned to the LTE interface 105 for LTE data traffic access can be based on an International Mobile Subscriber Identity (IMSI) code of the UE 103, while IP address assigned to the WLAN interface 106 for WLAN data traffic access can be based on the Media Access Control Address (MAC) address of the UE 103.

[0033] To enable the same IP address to be assigned to both the LTE interface 105 and the WLAN interface 106 of the UE 103, the MAC address may automatically be mapped to the IMSI code of the UE 103. This mapping can be carried out by the ePDG/ANGW 119 or the PGW 124.

[0034] The second condition of the MISSION hotline conditions can be keeping both the LTE interface 105 and the WLAN interface 106 of the UE 103 connected to the hybrid enterprise access network 100. Hence, MISSION can provide IP flow based seamless handover with end-to-end bidirectional signaling in the application layer between the UE 103 and the PGW 124. The LTE interface 105 and the WLAN interface 106 may be connected to their respective bearers 102 and 101 simultaneously.

[0035] Since most of the off-the-shelf dual mode mobile devices may not support such capability, in order to keep both the LTE interface 105 and the WLAN interface 106 connected to LTE and WLAN bearers 102 and 101 respectively at the same time, modification may be necessary on mobile device's operating system to enable both interfaces the LTE interface 105 and the WLAN interface 106 turned on and connected to the hybrid network 100 simultaneously with the same IP address. By taking advantages of the multiple interfaces communication capability of latest mobile devices, few changes may be needed in the mobile operating system to enable simultaneously multiple interface connection.

[0036] The third condition of the MISSION hotline conditions can be keeping the bearers operative and ready to be used for transmission simultaneously. MISSION solution may simplify some underlying protocols used during transmission by adopting this condition for access network bearers. By maintaining a mapping relation of bearers and IP flows on both the UE 103 and the PGW 124, seamless handover could be flexibly initiated either from the UE 103 or from PGW in a bidirectional approach. This is also the bidirectional provisioning mechanism of the MISSION solution.

[0037] In order to perform the MISSION solution, the access bearers for UE, the LTE bearer 102 and the WLAN bearer 101 may be kept operative until explicitly destroyed or timed out, which may avoid long message exchanging at control plane for every re-establishment within a specified short period. The living bearer may be instantly reused and switched back and forth for fast seamless handover in MISSION. Both of the LTE and WLAN bearers 102 and 101 can be used for data traffic simultaneously in both directions: the direction from the UE 103 to the PGW 124 can be called uplink and the direction from the PGW 124 to the UE 103 can be called downlink. By coordinating the routing of flows through the uplink and downlink of both LTE and WLAN, MISSION can move the IP flows for some logical connection (basically Transmission Transport Protocol (TCP) connection) between bearers to achieve IP flow based handover with session continuity.

[0038] FIG.2 shows different signaling schemes 200 for signaling between a UE 204 and a PGW 224. The first signaling scheme 201 may be a client-based signaling performed in a network layer. It may require the UE 204 to be involved in the management of the mobility with specialized stack that should be able to detect, signal, and react to changes of a point of attachment. Regarding a handover operation, client-based signaling 201 may indicate the UE 204 to send a first signaling message request 208a to the ePDG/ANGW 219 in order to perform handover for a WNCAT data traffic and in response to this request 208a, the ePDG/ANGW 219 may send a second signal 208b to the PGW 224 requesting handover for the WNCAT data traffic routed towards from the UE 204 towards the PGW 224. Similarly, for handover operation of WCAT data traffic the UE 204 may send an initial request to a SGW 217. A second signal requesting handover should be sent to the PGW 224 from the SGW 217.

[0039] The second signaling scheme 202 may be a network based signaling performed in the network layer. When signaling for flow handover operations initiated from the network side, the PGW 224 may send a first handover request 209a and notify the ePDG/ANGW 219 or the SGW 217 in order to be able to handle flows for WNCAT or WCAT traffic accordingly. A second signaling message or request 209b may be sent from the ePDG/ANGW 219 or the SGW 217 to the UE 204.

[0040] End-to-end bidirectional signaling schemes 203a and 203b in an application layer used in the MISSION solution to carry out handover are shown in FIG.2 and can be performed by the UE 204 and the PGW 224 when the UE 204 may comprise the signaling module 107 and the routing module 108 and the PGW 124 may comprise the signaling module 121 and the routing module 122.

[0041] In signaling scheme 203a, end-to-end bidirectional signaling can be carried out by one signaling request as e.g. the handover request 210 sent in the application layer from the UE 204 to the PGW 224 within the hybrid network 100. When performing end-to-end bidirectional signaling 203a and 203b in the application layer, the network elements ePDG/ANGW 219 and SGW 217 may act as forwarders of the handover request 210 from the UE 204 to the PGW 224. Hence, they are skipped as it is shown in scheme 203a and 203b in the application layer. This end-to-end bidirectional signaling performed in the application layer can permit the ePDG/ANGW 219 and SGW 217 forward the handover request 210 without looking into the logics but performing data packet encapsulation and decapsulation at network layer. Hence, by sending the handover request 210 in the application layer, the handover request 210 can be transmitted directly from the UE 103 to PWG 224. Hence, end-to-end bidirectional signaling in the application layer that can be used during seamless handover of IP data flows in the downlink direction from the PGW 224 to the UE 204 and in the uplink direction from the UE 204 to PGW 224 can be achieved. Regarding handover operation, the network latency for the entire handover operation process may be half the Round Trip Time (RTT). Bi-directional end-to-end bidirectional signaling in the application layer as shown may permit the exchange of signaling messages between elements shown in FIG. 1 as e.g. between the UE 103 and the PGW 124 and vice versa without requiring IP stack changes on the UE 103.

[0042] Similarly to 203a, in 203b end-to-end bidirectional signaling can be carried out in the application layer by sending the handover request 210 directly from the PGW 224 to the UE 204 within the hybrid network 100. The network elements ePDG/ANGW 219 or SGW 217 may forward the handover request 210 as mentioned above. Network elements ePDG/ANGW 219 or SGW 217 may be considered network switches that may encapsulate the handover request 210 in the network layer when receiving the handover request 210. Hence, they may be skipped as it is shown in schemes 203a and 203b in the application layer. This end-to-end bidirectional signaling in the application layer can be used during seamless handover of IP data flows in the downlink direction from the PGW 224 to the UE 204 and in the uplink direction from the UE 204 to the PGW 224. Regarding handover operation, the network latency for the entire handover process when using direct signaling 203a and 203b may only be half the RTT (Round Trip Time).

[0043] The MISSION solution may implement flow rules that can be used for IP flow identification, routing specification and end-to-end bidirectional signaling between the UE 103 and the PGW 124 that may permit communication with each other on the hybrid network 100 for data transmission in accordance with the disclosure. Since the bidirectional signaling between the UE 103 and the PGW 124 can be performed at the application layer, it may be easy for MISSION to extend flow rules that can support any additional attributes. Basically, a flow rule can have the following simplified attributes as listed in Table 1 for performing seamless handover operations according to the MISSION solution.

Attribute	Description
Flow ID	Uniquely identifies an IP flow
Priority	Rules are matched in a prioritized order
UE IP address	IP address of UE
UE port number	Port number on UE
Peer IP address	IP address of remote peer
Peer port number	Port number on peer
Protocol	Specify the protocol of flow
Bearer ID	Specify WLAN or LTE bearer for flow

Table I: Major flow rule attributes

[0044] The MISSION solution may categorize the flow rules in two dimensions: on the first dimension, rules can be grouped into static and dynamic ones. On the second dimension, rules may be categorized as user or network defined. Table II lists the combination of two dimensions and samples on each category.

	Static	Dynamic
User defined	User pre-defined rules, e.g. user manually added rules.	Auto-generated rules on UE, e.g., based on some processes.
Network defined	Network pre-defined rules, e.g., ISRP from ANDSF.	Auto-generated rules at network side, such as on PGW.

Table II: Rules categorized by MISSION

[0045] Based on different flow rules, the IP flows 111, 112, 113, 114 and 115 can be routed using different bearers, i.e. the LTE bearer 102 or the WLAN bearer 101. When any data traffics not specified by specific flow rules, the default bearer for the UE 103 may be used, which can be specified by the UE 103 through signaling in the application layer with the PGW 124.

[0046] The operations of dealing with IP flow based seamless handover with direct signaling between the UE 103 and the PGW 124 can be carried out by the MISSION UE 104 and the MISSION PGW 120. In one example of the present disclosure, the MISSION UE 104 and the MISSION PGW 120 can be further composed of two logical components previously shown in FIG.1: The signaling module 107 and the signaling module 121 and the routing module 108 and the routing module 122, respectively. Each of these modules can manage corresponding work at one edge of the hybrid enterprise access network 100. The routing module 108 and the routing module 122 can connect to the hybrid network 100 for data transmission and the signaling module 107 and the signaling module 121 can connect to the hybrid network 100 for operation control, as e.g. the transmission of the handover requests 210 from the UE 103 to the PGW 124 and Vice versa. These components will be described in detail.

[0047] FIG. 3 shows a hybrid network 300 according an example of to the present disclosure where the MISSION solution can be performed. The hybrid network 300 can enable the IP flows 113, 114 and 115 for a mobile device to be routed either through the access bearer LTE 102 or the access bearer WLAN 101, or at the same time. The PGW and intermediate nodes as e.g. SGW and ePGW/ANGW are omitted for the hybrid network 300. First stage 300a of the hybrid network 300 and second stage 300b can show the seamless handover of uplink traffic (IP flows transmitted towards the Internet 125) and downlink traffic (IP flows transmitted towards the UE 103):

[0048] In this example, the IP flow 113 can be video conference content, the IP flow 114 can be FTP content and the IP flow 115 can be Web content. The IP flows 113, 114 and 115 can be routed uplink and downlink direction using the LTE bearer 102 as shown in stage 300a. After seamless handover operation according to the MISSION solution presented in the present disclosure, in stage 300b the IP flows of FTP 114 and the Web content 115 data traffics can be transferred, i.e. routed through the WLAN bearer 101, the video conference content the IP flow 133 may be kept in the LTE bearer 102, while FTP content 114 and Web content 115 can be switched from the LTE bearer 102 to the WLAN bearer 101 after seamless handover may be performed. The IP flow switch can happen based on further demands. Upper layer applications may not be affected when performing seamless handover according to the MISSION solution. The established connection of the UE 103 in the access network of the hybrid network 300 may not be broken during seamless handover according to the MISSION solution and the session continuity can be preserved.

[0049] FIG.4 shows instructions blocks performed by the routing module 108 in the MISSION UE 104 and the routing module 122 in the MISSION PGW 120. The flow routing are split into uplink handling 405 and downlink handling 406, which can be done by the routing module 108 in the MISSION UE 104 and by the routing module 122 in the MISSION PGW 120. FIG.4 shows blocks performed by the routing module 108 within the MISSION UE 104 for the uplink traffic 405. In particular, the routing module 108 may perform blocks 402, 403 and 404 when receiving a data packet 401a of a specific IP flow. FIG.4 shows blocks performed by the routing module 122 within the MISSION PGW 120 for the downlink traffic 406. In particular, the routing module 122 may perform blocks 407, 408 and 409 when receiving a data packet 401b of a specific IP flow.

[0050] The uplink traffic 405 from the UE 103 can be manipulated by the routing module 108 using a lightweight approach comprising blocks 402, 403 and 404 in order to minimize the burdens of redirecting packets to a specific access bearer 101 or 102. In an example of the present disclosure, this can be accomplished in block 402 by using iptables command to set mark to the data packet 401a of a specific IP flow that can be identified by the flow attributers shown in TABLE I (e.g. 5-tuple items). In block 403 command ip rule may be used to forward the data packet 401a of specific mark to lookup a routing table of specified network interface in block 404, i.e. routing the data packet 401a through the LTE bearer 102 or the WLAN bearer 101. The following example code can be a sample combination of IP flow rules for redirecting uplink packets accessing a destination UE port number 80 using TCP protocol (i.e., normal Hypertext Transfer Protocol (HTTP) server access) to use the LTE bearer 102:

```
$ iptables -I OUTPUT -p tcp --dport 80 -t mangle -j MARK --set-mark 0x180
$ ip rule add from all fwmark 0x180/0x1ffff lookup rmnet_data0
```

[0051] The uplink routing for a default access network can also be specified by ip rule command in block 403 with a lower priority than the IP flow rules. The following example code is a sample on redirecting default uplink packets to WLAN access bearer 101 on the UE 103:

```
$ ip rule add from <IP_ADDRESS> lookup wlan0
```

[0052] The downlink traffic 406 may be processed by the MISSION PGW 120 in the PGW 124 with the routing module 122 for the data packet 401b of specified IP flow and default traffics. The routing module 122 may store the IP flow rules in a routing table. In block 407 the data packet 401b for the downlink traffic may look up the routing table for bearer selection based on the packet characteristics shown in TABLE I (e.g., 5-tuple item). In block 408, if a specific flow rule has been matched, the bearer corresponding to this rule may be used and the data packet 401b can be routed through the corresponding bearer in block 409. If no flow rules had been matched, the default access network, e.g. WLAN access bearer 101 may be used for downlink transmission.

[0053] With the cooperation of uplink routing 405 on the UE 103 and downlink routing 406 on the PGW 124 for IP flow rules or default bearer, the MISSION solution can perform the support for full seamless handover capability. With simultaneous connection of the LTE interface 105 and the WLAN interface 106, and the same IP address, the MISSION solution can manipulate the routing of the data packets 401a and 401b of specific IP flows on both the UE 103 and the PGW 124 and can perform two handover styles: the IP flow based handover and the one connection based complete handover.

[0054] For IP flow based handover, the MISSION solution may add flow rules for packets redirection and packets that fail to match any flow rules may be redirected using a default access network as e.g. WLAN access bearer 101. The default access network can also be changed on demands. As a result of this mechanism, if no IP flow rules are specified, the one connection based complete handover can be achieved by changing the only acting default access bearer. In this way, the MISSION solution can support both IP flow based handover and one connection based handover for backward compatibility.

[0055] The MISSION solution defines three operations on flow rules: add, update and delete. The switching of an IP flow can be accomplished by adding a new flow rule or updating an existed flow rule. Disabling a flow rule is done by deleting operation, which will disable or delete the flow entry in routing table both on the UE 103 and the PGW 124.

[0056] The signaling module 107 and the signaling module 121 can be encountered for the message exchanging between the UE 103 and the PGW 124. They can adopt in-band and on-demand signaling, allowing flexible implementation in the application layer. For our current implementation, the following commands in Table III can be implemented for handover related operations.

Command	Parameters	Description

flow.binding	1)<UE IP> (e.g., 192.168.3.100/32) 2)<Action> (e.g., 1/2/3 for Add/Update/Delete) 3) <Flow ID> (e.g., 100) 4) <Flow Priority> (e.g., 1, the smaller the higher) 5) <Start Source IP> (e.g., 192.168.3.100/32) 6) <End Source IP>(e.g., 192.168.3.100/32) 7) <Start Source Port>(e.g.,1024) 8) <End Source Port>(e.g.,60000) 9) <Start Dest IP>(e.g., 16.190.210.170/32) 10) <End Dest IP> (e.g., 16.190.210.170/32) 11) <Start Dest Port>(e.g., 80) 12) <End Dest Port> (e.g., 81) 13) <Protocol> (e.g., 6 for TCP, 17 for UDP) 14) <Access ID>(e.g., 1)	Command to provision flow rule; one flow is supported each time;
flow.binding.json	<JSON String> (as in Table IV)	Command to provision flow rule in JSON string; multiple flows are supported each time;
routing.switch	1) <UE IP> (e.g., 192.168.3.100/32) 2) <Access ID> (e.g., 1)	Command to switch default access network for specified UE;
routing.printip	<UE IP> (e.g., 192.168.3.100/32)	Get the connected access network IDs using UE's IP address; in collaboration with routing.ext to get the IDs for WLAN and LTE access networks;
routing.ext	No parameters	Get the connected access network type using UE's IP address; in collaboration with routing.printip to get the IDs for WLAN and LTE access networks;

TABLE III: Commands for handover operations.

[0057] JSON string with attributes is shown in Table IV that can be used to encapsulate the flow rules and related operations for communication between the UE 103 and the PGW 124 in an end-to-end bidirectional signaling in the application layer.

```
{"flow.binding":
[
{
"ue":"192.168.3.100/32",
"action":"1", // 1: add, 2: update, 3: delete
```

```
"fid":"2",
"prio":"1",
"src_start":"192.168.3.100/32",
"src_end":"192.168.3.100/32",
"src_port_start":"1024",
"src_port_end":"60000",
"dst_start":"16.190.209.10/32",
"dst_end":"16.190.209.10/32",
"dst_port_start":"80",
"dst_port_end":"81",
"proto":"6", // https://en.wikipedia.org/wiki/List_of_IP_protocol_numbers
"access":"1" // access bearer ID for WLAN or LTE
} // Multiple flow rules are allowed and separated by commas
]}
```


TABLE IV: Sample of implementation as JSON attributes in a sample of one flow rule.

[0058] FIG.5 shows an example of a diagram 500 according to the present disclosure. This diagram shows blocks to perform seamless handover with end-to-end bidirectional signaling through the application layer of IP data flow where a handover request can be received by the PGW 124.

[0059] In block 501, the PGW 124 can receive in the application layer from the UE 103 (that can be a mobile device) the handover request 210 in the hybrid network 100. The handover request 210 may request the access LTE bearer 102 or the WLAN bearer 101 for routing the IP data flows 111, 112, 113, 114 and 115. The UE 103 can comprise a Wireless Cellular Access Technology (WCAT) interface as e.g. the LTE interface 105 and a Wireless Non-Cellular Access Technology (WNCAT) interface as e.g. the WLAN interface 106 connected to the hybrid network 100. The LTE interface 105 and the WLAN interface 106 may have the same IP address. The requested bearer may be the LTE bearer 102 associated with the UE 103 or the WLAN bearer 101 associated with the UE 103.

[0060] Since both of the WLAN bearer and LTE bearer can be kept operative in the access network, and they both have the same IP address assigned, a handover request in the application layer may be sent to the PGW in request to the PGW 124 to redirect downlink packets from one access bearer to another.

[0061] In block 502, the PGW 124 may decide whether the request is granted or not. If the request is not granted the procedure for handover can end in block 505. If the request is granted the procedure can move to blocks 503 and 504. In block 503 the PGW 124 can route the IP data flow through the requested bearer to the mobile device. In block 504 the PGW 124 can receive the IP data flow through the requested bearer from the UE 103. The requested bearer can be either a WCAT bearer associated with the mobile device or a WNCAT bearer associated with the mobile device, and the WCAT interface and the WNCAT interface may have the same IP address.

[0062] In another example of the present disclosure shown in FIG.6, the MISSION UE 104 and the MISSION PGW 120 can comprise a third module specified as decision modules 601 and 602, respectively. The decision modules 601 and 602 can handle triggering conditions and perform decision making. In the MISSION solution, the decision modules 601 and 602 can trigger the handover, which can be associated with various implementation dependent decision making processes or policies without restrictions.

[0063] In an example of the present disclosure shown in FIG.6, once the handover decision has been triggered by the decision modules, the decision modules 601, 602 may transmit the handover decision to the signaling module 107 and the signaling module 121 in order to perform the message exchanging between UE 103 and the PGW 124 and achieve an end-to-end bidirectional signaling between the UE 103 and the PGW 124.

[0064] End-to-end bidirectional signaling in the application layer for handover operation according to the present disclosure may permit a handover request to be transmitted in the application layer by the UE 103 to the PGW 124 and vice versa. Intermediate network devices between the UE 103 and the PGW 124 may perform data packet encapsulation and decapsulation in the network layer. Hence, the handover request can be transmitted in the application layer from the UE 103 to the PGW 124 and vice versa and the request can be received and processed by the PGW 124 or vice versa i.e. the request can be received and processed by the UE 103 when transmitted by the PGW 124. The UE 103 may ask the PGW 124 to redirect downlink packets from one access network bearer to another. Bidirectional signaling performed in the application layer may permit the handover request to be transmitted to the PGW 124. Any network device within the hybrid network 100 may perform data packet encapsulation and decapsulation of the handover request like any other data packet through the data plane. The handover request can be transmitted from the PGW 124 directly to the UE 103 through the application layer of the PGW 124 and the UE 103 and the request can be received and processed by the UE 103, i.e. the PGW 124 may ask the UE 103 to redirect uplink packets from one access network bearer to another.

[0065] FIG.7 shows the general working flows of bi-directional signaling for data packet routing and handover request of the MISSION solution between the MISSION UE 104 and the MISSION PGW 120. The MISSION solution can perform a bi-directional style in-band signaling between the UE 103 and the PGW 124 to provision flow rules under different scenarios. For uplink direction from the UE 103 towards the PGW 124, the UE 103 can inform the PGW 124 to add/update/delete some flow rules, and the PGW may react accordingly by adjusting the downlink routing from the PGW 124 to the UE 103. In this respect, the UE may firstly download ISRP rules from an ANDSF server and then send these rules to the PGW 124.

[0066] The MISSION solution also may use uplink direction to enable user defined rules for flexible handover operations and where during handover operation a handover request can be transmitted from the UE 103 to the PGW 124. For downlink direction, the PGW 124 could also notify the UE 103 of the flow rules provision from the network side. This process may be considered as a notification of the downlink routing and the UE 103 could also react accordingly to adjust the uplink routing from the UE 103 side. In this respect, ISRP rules may be directly retrieved from network side, i.e. from the PGW 124. The MISSION solution can also use downlink direction to provision network defined rules to the UE 103 from the network side. The MISSION solution also uses downlink direction to enable user defined rules for flexible handover and where during handover operation a handover request can be transmitted from the PGW 124 to the UE 103.

[0067] The MISSION UE 104 may initiate the handover request 210 at decision module 601 and ask (a) the signaling module 107 to encapsulate and send (b) the handover request 210. The MISSION UE 104 may send the handover request 210 through the operative bearers 101 or 102 within the hybrid network 100, where the bearers 101 and 102 may comply with the MISSION Hotline conditions.

[0068] The handover request may be received by the signaling module 121 in the MISSION PGW 120. The handover request requesting the WLAN bearer 101 or the LTE 102 for transmission of a specific IP data flow from a plurality of IP flows handled by the UE 103 and the PGW 124. In the MISSION PGW 120, the signaling module 121 may report (c) the received handover request 210 to the decision module 602. When the decision module 602 accepts the handover request 210 in order to carry out seamless handover, the decision module 602 may notify the routing module 122 and provide the flow rule to the routing module 122 for routing the downlink traffics 406. Packets matching the flow rule can be routed (e) through the granted bearer of access network within the hybrid network 100.

[0069] Back at the decision module 601 within the MISSION UE 104, when the MISSION UE 104 receives acknowledgement from the MISSION PGW 120, where the acknowledgment may comprise a response to the request granting the handover request, the decision module 601 may order (f) the routing module 108 to route (g) the packets for the specific IP flow through the granted operative bearer for the uplink data traffic 405. Packets for the uplink may be transmitted with the specified granted bearer of access network consequently. In another example according to the present disclosure, (f) and (g) could be performed right after (a) in order to achieve a minimized handover latency with the assumption of always successful seamless handover.

[0070] When the handover request may be dispatched by the MISSION PGW 120 towards the MISSION UE 104, the handover can be initiated by the PGW 124, the bi-directional signaling procedure can be similar to the procedure shown in FIG.7 where the handover request 210 may be sent by the MISSION PGW 120 to the MISSION UE 104, which may inform about the rearrangement of specific flows (i.e., change the downlink traffic 406 of specified flows). When the MISSION UE 104 receives the notification, it can adjust the uplink 405 traffic of specified flows accordingly.

[0071] The bi-directional direct signaling performed in the MISSION solution and shown in the present disclosure can take the distributed requirements from different UEs into considerations, which also can make centric arrangement based on the overall network conditions. In such way, various network policies and flow rules could be applied under enterprise access network to enable an improved QoE.

[0072] Hence with the collaboration of the MISSION UE 104 and the MISSION PGW 120, an IP flow based seamless handover for enterprise access network with end-to-end bidirectional signaling through the application layer has been described in the present disclosure.

CLAIMS

1. A method comprising:

receiving with a Packet Data Network Gateway (PGW) in an application layer and from a mobile device, a handover request in an access network, wherein:

the handover request requests a bearer for routing an Internet Protocol (IP) data flow,

the mobile device comprises a Wireless Cellular Access Technology (WCAT) interface and a Wireless Non-Cellular Access Technology (WNCAT) interface connected to the access network,

the WCAT interface and the WNCAT interface having a same IP address, and

the requested bearer is either an WCAT bearer associated with the mobile device or an WNCAT bearer associated with the mobile device;

routing, with the PGW and to the mobile device, the IP data flow through the requested bearer; and

receiving, with the PGW and from the mobile device, the IP data flow through the requested bearer.

2. The method of claim 1, further comprising: retrieving, with the PGW, one or more flow rules for routing the IP data flow through the requested bearer.

3. The method of claim 1, further comprising: sending, with the PGW, a second handover request to the mobile device, the second request requests the WCAT bearer or the WNCAT bearer for routing a second IP data flow.

4. The method of claim 1, further comprising: granting, with the PGW, the handover request based on predetermined rules or policies.

5. The method of claim 1, comprising: assigning, with the PGW, the same IP address to the WCAT interface and the WNCAT interface connected to the access network.

6. The method of claim 1, comprising: keeping, with the PGW, the WCAT bearer and the WNCAT bearer associated with the mobile device simultaneously operative.

7. The method of claim 1, comprising: transmitting, with the PGW, the IP data flow from the mobile device to an external network.

8. The method of claim 7, comprising: receiving, with the PGW, a plurality of IP data flows from the external network, the plurality of IP data flows including the IP data flow and the second IP data flow.

9. A Packet Data Network Gateway (PGW) comprising:

a processing resource; and

a memory resource storing machine readable instructions to cause the processing resource to:

obtain in an application layer of the PGW and from a mobile device, a handover request in an access network, wherein:

the handover request requests a bearer for uplink routing of an Internet Protocol (IP) data flow,

the mobile device comprises a Wireless Cellular Access Technology (WCAT) interface and a Wireless Non-Cellular Access Technology (WNCAT) interface connected to the access network,

the WCAT interface and the WNCAT interface have a same IP address, and

the requested bearer is either a WCAT bearer associated with the mobile device or a WNCAT bearer associated with the mobile device; and

transmit, through the requested bearer and to the mobile device, the IP data flow when the request is granted; and obtain, through the requested bearer and from the mobile device, the IP data flow when the request is granted.

10. The PGW of claim 9, wherein the memory resource storing machine readable instructions cause the processing resource to decide whether the handover is granted.

11. The PGW of claim 9, wherein the memory resource storing machine readable instructions cause the processing resource to send a second handover request to the mobile device, the second handover request requests the WCAT bearer or the WNCAT bearer for transmission from the PGW to the mobile device of a second IP data flow.

12. The PGW of claim 9, wherein the memory resource storing machine readable instructions cause the processing resource to assign the same IP address to the WCAT interface and to the WNCAT interface.

13. A mobile device comprising:

a Wireless Cellular Access Technology (WCAT) interface connected to the access network;

a Wireless Non-Cellular Access Technology (WNCAT) interface connected to the access network, wherein the WCAT interface and the WNCAT interface have a same Internet Protocol (IP) address;

a processing resource; and

a memory resource storing machine readable instructions to cause the processing resource to:

send through an application layer of the mobile device, a handover request to a Packet Data Network Gateway (PGW) in the access network, wherein:

the handover request requesting a bearer for routing an IP data flow, and

the requested bearer is either a WCAT bearer associated with the mobile device or a WNCAT bearer associated with the mobile device, and transmit the IP data flow through the requested bearer if the request is granted to the PGW; and

receive the IP data flow through the requested bearer if the request is granted from the PGW.

14. The mobile device of claim 13, wherein the memory resource storing machine readable instructions cause the processing resource to:

receive a permission for handover from the PGW, the permission for handover depends on a predetermined policy or rule of the access network.

15. The mobile device of claim 14, wherein the memory resource storing machine readable instructions cause the processing resource to decide handover of the IP data flow.

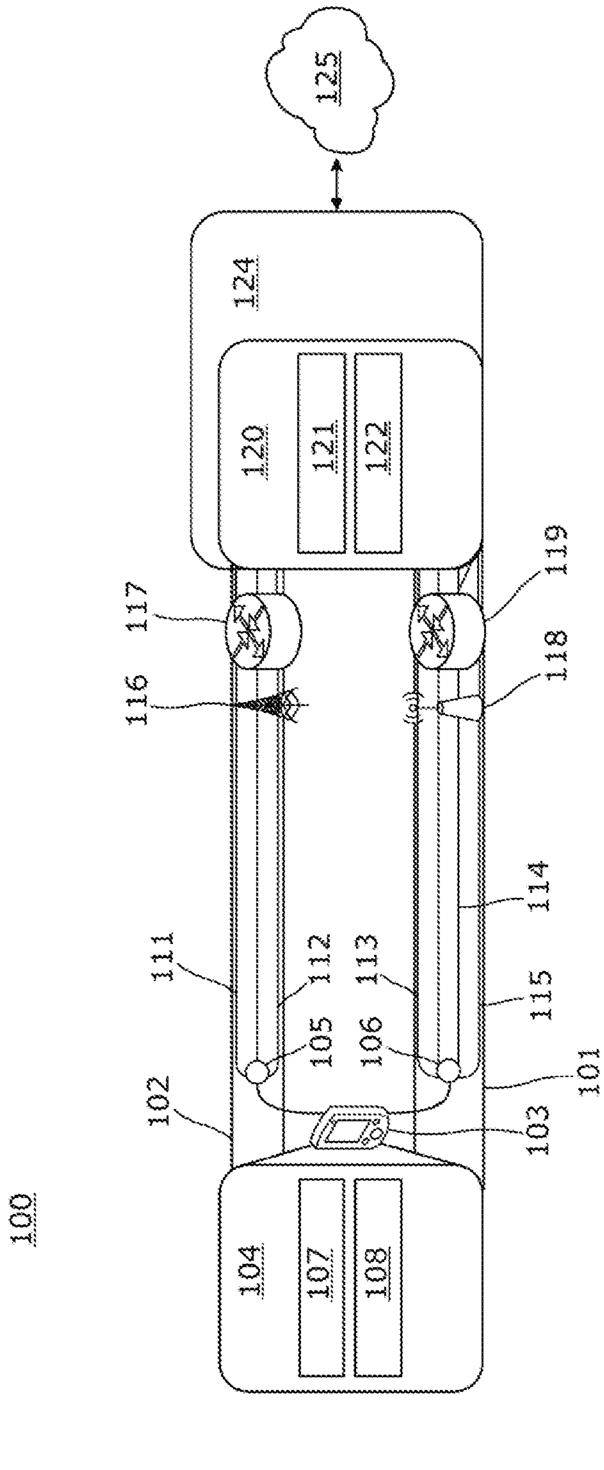
100
101
102
103
104
105
106
107
108
111
112
113
114
115
116
117
118
119
120
121
122
124
125

FIG. 1

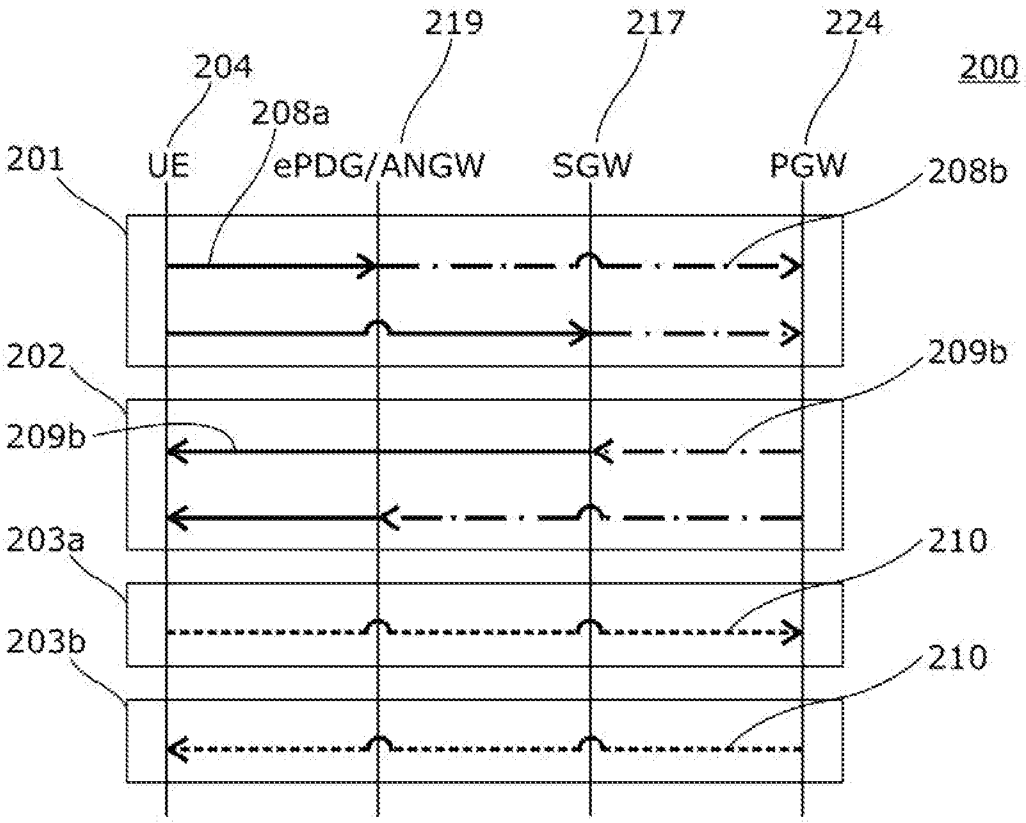
219
217
224
204
200
208a
201
UE
ePDG/ANGW
SGW
PGW
208b
202
209b
209b
203a
210
203b
210

FIG. 2

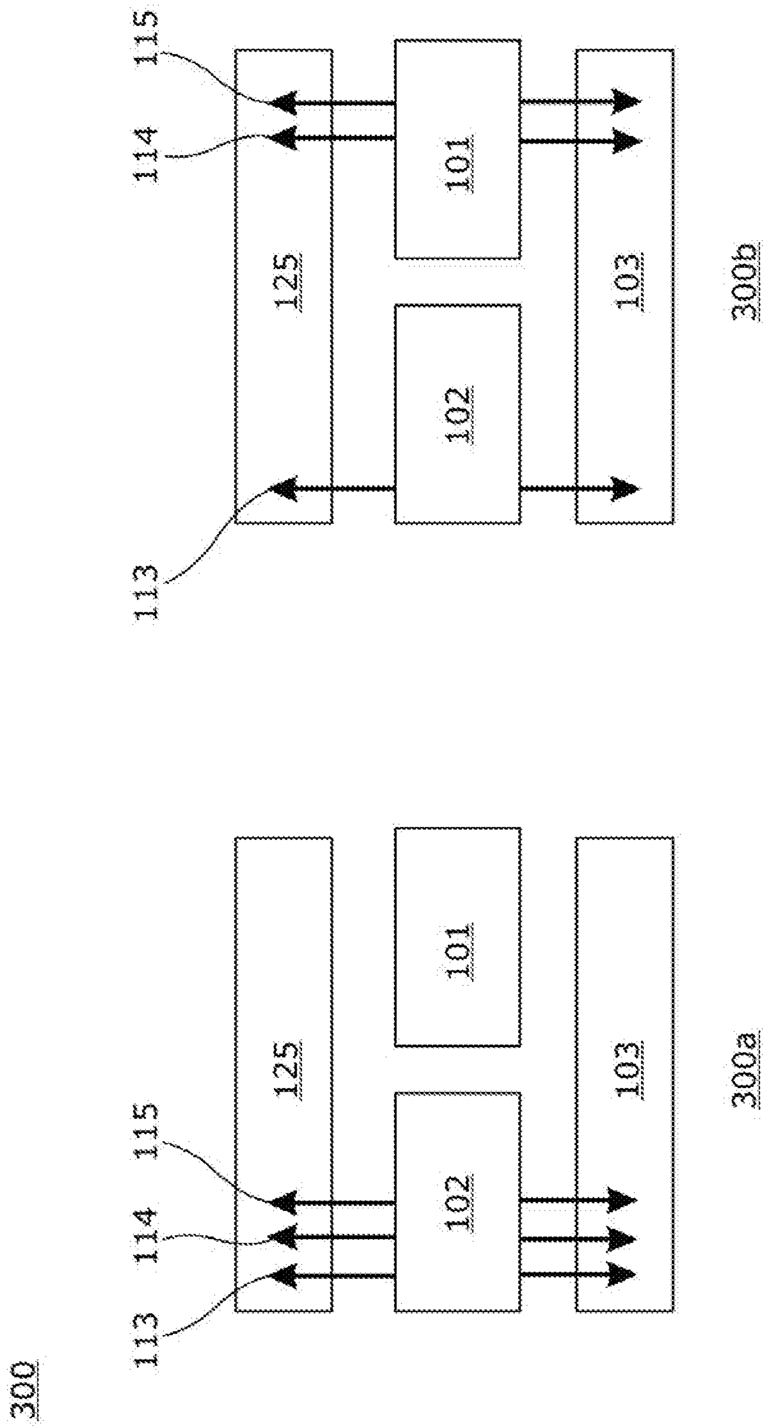

FIG. 3

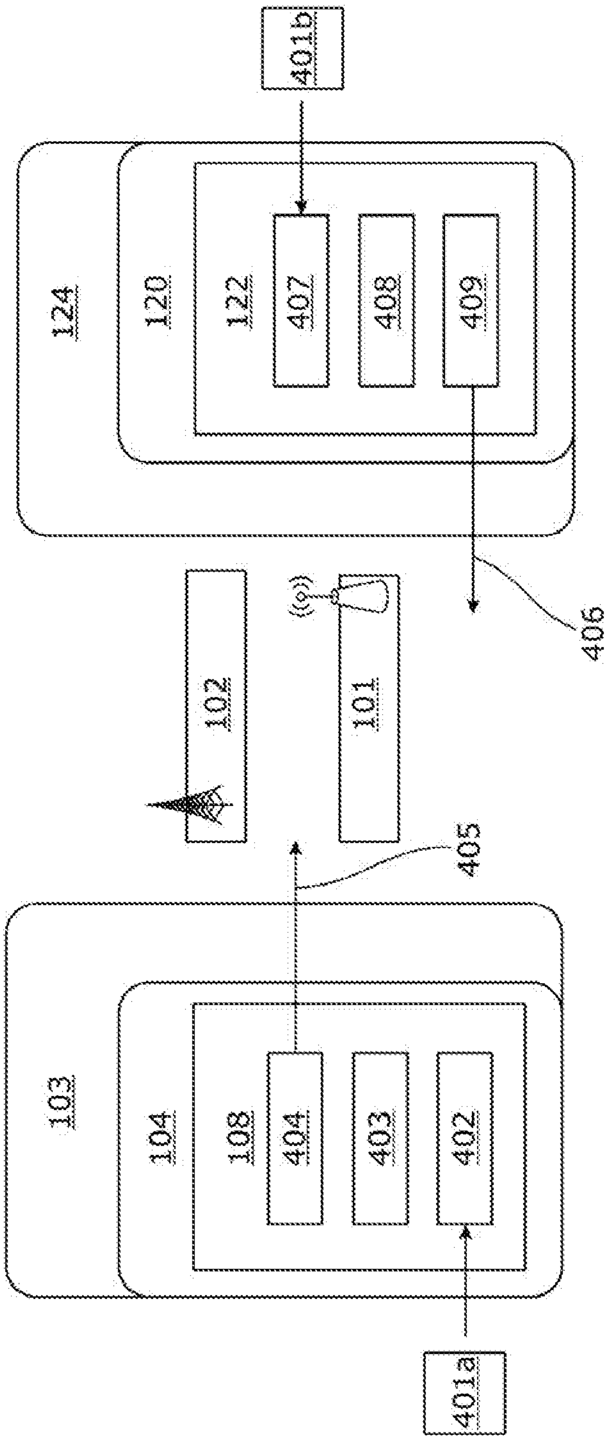
401b
124
120
122
407
408
409
102
101
406
405
103
104
108
404
403
402
401a

FIG. 4

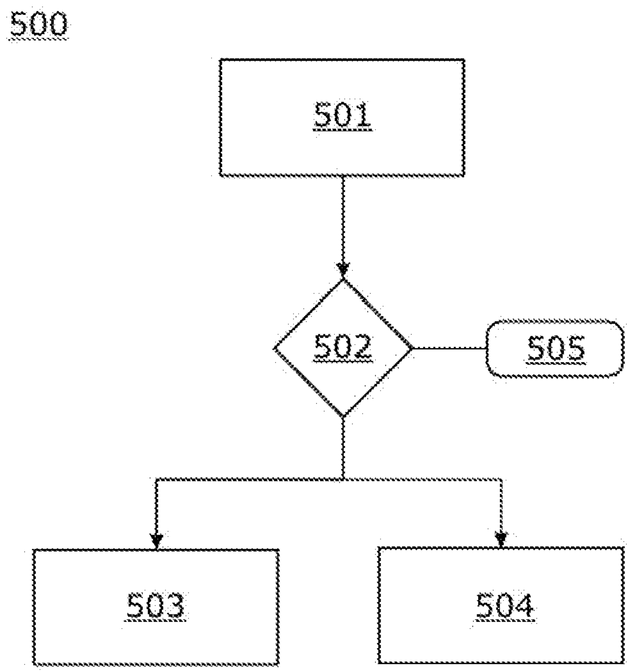

FIG. 5

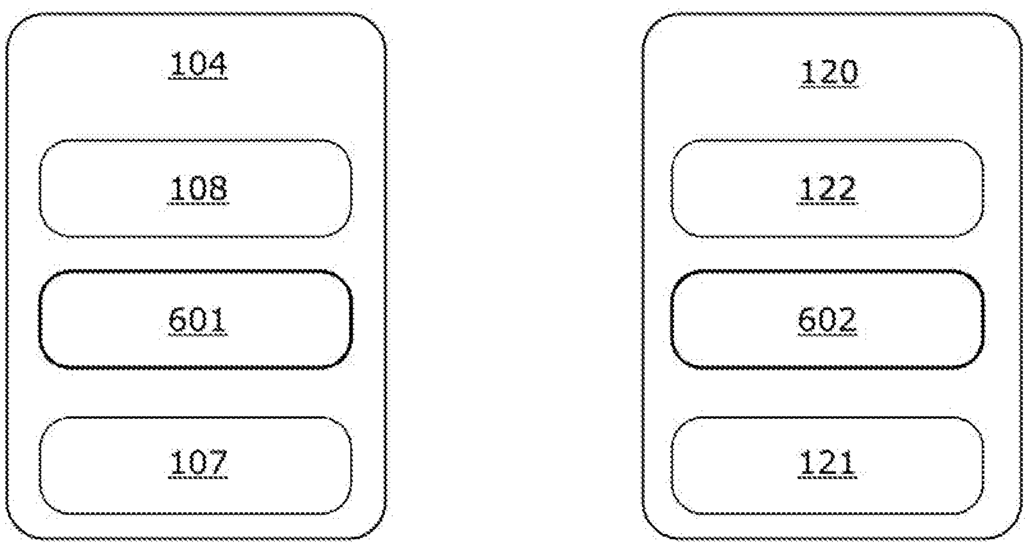

FIG. 6

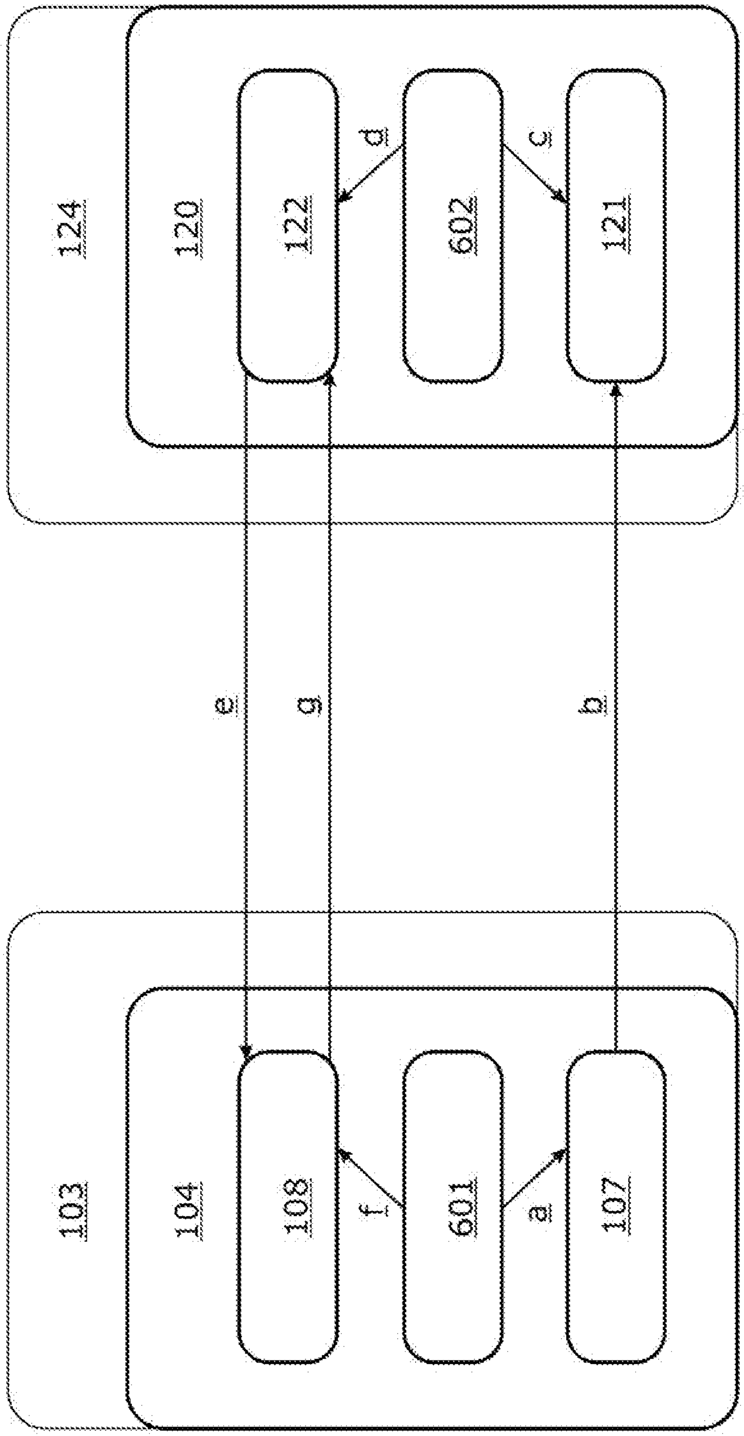

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/078044

A. CLASSIFICATION OF SUBJECT MATTER

H04W 36/14(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L; H04Q

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)

CNPAT,CNKI,WPI,EPODOC: LTE, WLAN, PGW, PDN, WCAT, WNCAT, 3GPP, access, bear, handover, same, IP, flow, interface, request, continuity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103813402 A (ZTE CORP.) 21 May 2014 (2014-05-21) description, paragraphs [0002]-[0007], [0086]-[0129], claims 1-21, and figures 1-10	1-15
A	CN 104427568 A (BEIJING HUAWEI DIGITAL TECHNOLOGY CO. LTD.) 18 March 2015 (2015-03-18) the whole document	1-15
A	CN 103765974 A (INTERDIGITAL PATENT HOLDINGS, INC.) 30 April 2014 (2014-04-30) the whole document	1-15
A	US 2014204927 A1 (QUALCOMM INCORPORATED) 24 July 2014 (2014-07-24) the whole document	1-15

☐ Further documents are listed in the continuation of Box C.

☑ 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
02 December 2016	**27 December 2016**

Name and mailing address of the ISA/CN

STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA
6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088
China

Facsimile No. **(86-10)62019451**

Authorized officer

WANG,Lunjie

Telephone No. **(86-10)62413491**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/078044

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	103813402	A	21 May 2014	WO	2014075534	A1	22 May 2014
CN	104427568	A	18 March 2015	None			
CN	103765974	A	30 April 2014	EP	2745607	A1	25 June 2014
				KR	20140054299	A	08 May 2014
				WO	2013028559	A1	28 February 2013
				US	2013044709	A1	21 February 2013
				JP	2014529240	A	30 October 2014
				TW	201325104	A	16 June 2013
US	2014204927	A1	24 July 2014	EP	2949176	A1	02 December 2015
				JP	2016509422	A	24 March 2016
				TW	201431412	A	01 August 2014
				KR	20150109433	A	01 October 2015
				CN	104938022	A	23 September 2015
				WO	2014116569	A1	31 July 2014