



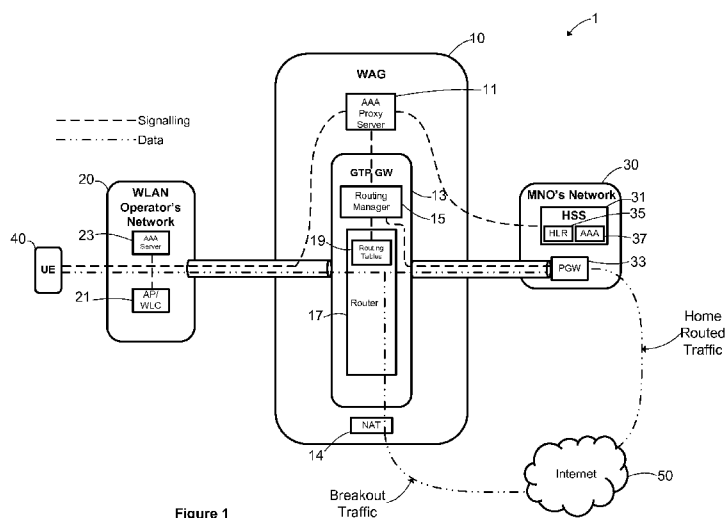
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- (71) **Applicant:** **BRITISH TELECOMMUNICATIONS PUBLIC LIMITED COMPANY** [GB/GB]; 81 Newgate Street, London EC1A 7AJ (GB).
- (72) **Inventor:** **JOHNSON, Stephen**; PP:C5A BT Centre, London EC1A 7AJ (GB).
- (74) **Agent:** **TUCKETT, William**; Intellectual Property Department, Ground Floor, BT Faraday Building, 1 Knightrider Street, London EC4V 5BT (GB).

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(54) **Title:** WIRELESS ACCESS GATEWAY

(57) **Abstract:** The present invention provides a method of controlling a Wireless Access Gateway, WAG, the WAG interconnecting a non-cellular network and a first and second cellular network, wherein data traffic between a User Equipment, UE, connected to the non-cellular network is routable by the WAG towards either the first or second cellular networks or towards an external packet-switched network, the method comprising the steps of: the WAG storing a plurality of profiles; the WAG receiving a signalling message relating to a User Equipment, UE, connected to the non-cellular network; the WAG analysing the signalling message to determine a traffic breakout rule for the UE, including the WAG determining that the signalling message relating to the UE is for the first cellular network, and the WAG selecting a first profile of the stored plurality of profiles, the first profile being for the first cellular network and including the traffic breakout rule; and the WAG selectively routing a first data traffic portion associated with the UE towards the cellular network and a second data traffic portion associated with the UE towards the external packet-switched network based on the traffic breakout rule.

WIRELESS ACCESS GATEWAY

Field of the Invention

The present invention relates to a wireless access gateway interconnecting a cellular network and a non-cellular network.

Background

In recent years, it has become increasingly desirable for Mobile Network Operators (MNOs), to integrate their cellular and non-cellular (e.g. Wireless Local Access Network, WLAN) networks. This provides a mechanism for the MNO to both offload cellular data traffic onto a WLAN network having a wired data connection (which is generally more suited to high data demands) and “onload” traffic seamlessly back onto the cellular network. Accordingly, modern cellular technologies, such as the 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) networks, have evolved to include a tight integration between the cellular and non-cellular networks, such that handovers between the two networks are correctly authenticated and maintain consistent policy and charging control.

The current 3GPP standards describe a scenario of a single non-cellular network (usually a WLAN network, such as an IEEE 802.11n network commonly known as “Wi-Fi”) connecting to a single cellular network. The IP address for a UE in the non-cellular network is allocated by the MNO. However, in some scenarios the UE is allocated an IP address in both the cellular and non-cellular domains, such as when the two networks are owned by different entities. In this case, a Wireless Access Gateway (WAG) is used to map control and data plane traffic between the two IP addresses, such that each network can continue using the allocated IP address for the UE. The Applicant’s pending European patent applications, having application numbers 14250040.4 and 14250039.6 tackle the IP address allocation issues for the WAG in such a multi-operator environment.

The WAG typically also has a connection directly to a packet-switched network, such as the Internet. With this connection, the WAG may selectively route traffic from the UE directly to the Internet in a process known as “local breakout”, rather than being routed via the cellular network. This has the benefit that some traffic doesn’t have to be passed on to the cellular network for onward connection to the Internet, thus reducing the amount of traffic flowing through the cellular network.

One prior art disclosure which discusses local breakout by a WAG is an Internet draft entitled, "Lawful Intercept Support for SP Wi-Fi Deployments", submitted to the Internet Engineering Task Force on 13 March 2013 by B. Pularikkal et al. This document is in the field of Lawful Intercept (LI), in which communications from a particular subscriber may be intercepted by a Law Enforcement Agency (LEA). In this article, an LI request is registered with an Authentication, Authorisation and Accounting (AAA) server of a cellular network. When a UE connects to a non-cellular network (Wi-Fi in this example), a WAG sends an Authorisation Request message to the cellular network's AAA server. The AAA server sends an Authorisation Accept message back to the WAG, and, in response, the WAG installs the relevant policies to allow network access for the subscriber. The WAG establishes a data connection with the Home Gateway of the cellular network and with the Internet, and, if local breakout is allowed, will locally route any traffic matching a local breakout rule to the Internet and all other traffic to the Home Gateway.

In this disclosure, there is no teaching of how the WAG installs the local breakout policy. The LI article discloses that RADIUS and DIAMETER messages are used for interaction between the WAG and the AAA server. A first possible message the WAG and AAA server could use is the RADIUS WBA WRIX-i message. The WBA WRIX-i standard specifies messages for use when roaming between WLAN networks, which may be transmitted over RADIUS. However, there is no provision for policy control so these messages can't be used for installing local breakout rules. Alternatively, the WAG and AAA server may communicate using the DIAMETER SWa/STa message (sometimes known as "applications"). This is typically used to allow a WLAN network to authenticate with a cellular network. However, again, these messages also have no provision for policy control.

Thus, both the RADIUS WBA WRIX-i and the DIAMETER SWa/STa messages cannot be used for policy control according to the standards. However, it is possible to modify these messages to include Vendor Specific Attributes (VSAs). Accordingly, the AAA server could send modified versions of these messages, with VSAs including the local breakout rules for a particular UE, to the WAG, which the WAG may then install. However, a problem with this approach is that a large number of local breakout rules would have a significant impact on the size of the Authorisation Accept messages, and

may require additional processing in the cellular network to build the Authorisation Accept message in response to each Authorisation Request message. This method would therefore add a significant delay to the authorisation process.

5 Lastly, the WAG and AAA server may communicate using DIAMETER S9 messages. This is a specific interface allowing exchange of policy control information between various elements of an evolved packet core. There are two problems when using this message. Firstly, the WAG would require an additional interface to support this form of message, which would add complexity. Secondly, this is an LTE specific interface and
10 so wouldn't support local breakout for alternative networks.

It is therefore desirable to alleviate some or all of the above problems. In particular, it is desirable to alleviate the problem of installing appropriate traffic breakout rules on a WAG.

15 **Summary of the Invention**

According to a first aspect of the invention, there is provided a method of controlling a Wireless Access Gateway, WAG, the WAG interconnecting a non-cellular network and a first and second cellular network, wherein data traffic between a User Equipment, UE,
20 connected to the non-cellular network is routable by the WAG towards either the first or second cellular networks or towards an external packet-switched network, the method comprising the steps of: the WAG storing a plurality of profiles; the WAG receiving a signalling message relating to a User Equipment, UE, connected to the non-cellular network; the WAG analysing the signalling message to determine a traffic breakout rule
25 for the UE, including the WAG determining that the signalling message relating to the UE is for the first cellular network, and the WAG selecting a first profile of the stored plurality of profiles, the first profile being for the first cellular network and including the traffic breakout rule; and the WAG selectively routing a first data traffic portion associated with the UE towards the cellular network and a second data traffic portion associated
30 with the UE towards the external packet-switched network based on the traffic breakout rule.

Accordingly, signalling messages passing between a UE and a MNO when establishing a data session may be analysed to determine an appropriate traffic breakout rule to use
35 for that data session. In this manner, there are no modifications to the signalling

messages as the analysis may be based on the contents of these pre-existing messages. The present invention therefore provides a user-specific traffic breakout rule, but without having to store individual policies for each UE at the MNO and without any modifications to existing signalling messages. Furthermore, the WAG may analyse the signalling
5 messages to determine if they match a particular selection criterion for that profile. If there is a match, then the traffic breakout rule of that profile may be applied to the associated data session.

Furthermore, the WAG may store a profile (or a plurality of profiles) for each MNO it is
10 connected to, and the WAG may be configured to analyse signalling messages to determine which profile (for the MNO the UE is connecting to) it matches. In this manner, the MNO may set up a number of profiles to match particular traffic usage characteristics.

The WAG may select the first profile based on an attribute of the signalling message
15 from the UE. The attribute may be an identifier for the first profile.

The profiles may be editable. The MNO may therefore edit the selection criterion/criteria
20 for each profile, or may edit or add new profiles having a different selection criterion/criteria.

A non-transitory computer-readable storage medium is also provided, storing a computer
program or suite of computer programs, which upon execution by a computer system performs the method of the first aspect of the invention.

According to a second aspect of the invention, there is provided a Wireless Access
25 Gateway, WAG, interconnecting a non-cellular network and a first and second cellular network, the WAG comprising memory configured to store a plurality of profiles; a receiver configured to receive a signalling message related to a User Equipment, UE, connected to the non-cellular network; a processor configured to analyse the signalling
30 message to determine a traffic breakout rule for the UE, including analysing the signalling message and determining that it is for the first cellular network, and selecting a first profile of the plurality of profiles stored in memory, the first profile being for the first cellular network and including the traffic breakout rule; and a router configured to route a first data traffic portion associated with the UE towards the cellular network and a second

data traffic portion associated with the UE towards the external packet-switched network based on the traffic breakout rule.

The processor may be configured to select the first profile based on an attribute of the signalling message from the UE. The attribute may be an identifier for the first profile.

Brief Description of the Figures

In order that the present invention may be better understood, embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of an embodiment of a communications network of the present invention, including a Wireless Access Gateway, WAG;

Figure 2 is a message flow diagram of an embodiment of a method of the present invention;

Figure 3 is a schematic diagram of a routing manager of the WAG of Figure 1;

Figure 4 is a flow diagram of the method of Figure 2; and

Figure 5 is a flow diagram of a second embodiment of a method of the present invention.

Detailed Description of Embodiments

A first embodiment of a communications network 1 of the present invention will now be described with reference to Figures 1 to 4. The communications network 1 includes a Wireless Access Gateway (WAG) 10, a first WLAN operator's network 20 (in this case, implementing an IEEE 802.11n network, commonly known as "Wi-Fi"), a first Mobile Network Operator's (MNO) network 30 and a first User Equipment (UE) 40. The WAG 10 interconnects the first WLAN operator's network 20 and the first MNO's network 30. The skilled person will understand that the WAG 10 may also interconnect at least one WLAN operator network with at least one MNO network in a one-to-many relationship (e.g. one or more WLAN operator networks to a plurality of MNO networks, or a plurality of WLAN operator networks to one or more MNO networks), but a one-to-one relationship is illustrated for simplicity.

The WAG 10 includes an Authentication, Authorisation and Accounting (AAA) proxy server 11, a GPRS Gateway (GTP GW) 13 and a Network Address Translation (NAT) module 14. The GTP GW 13 includes a routing manager 15 and a router 17 having

routing tables 19. The function of all these elements will be described below. The WAG 10 includes a first communications interface adapted to communicate with the WLAN operator's network 20, and a second communications interface adapted to communicate with the MNO's network 30.

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The WLAN operator's network 20 includes an Access Point (AP) 21 and an AAA server 23. The Access Point 21 includes an antenna, adapted to communicate with the UE 40, and a Wireless LAN controller, WLC. The Access Point 21 also has a fixed data connection (such as a DSL data connection), which may be used to communicate with the WAG 10.

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The MNO's network 30 includes a Home Subscriber Service (HSS) 31 and a Packet Data Network Gateway (PGW) 33. The HSS 31 includes the Home Location Register (HLR) 35 and also includes an AAA server 37. The MNO's network 30 also includes a first communications interface adapted to communicate with the WAG 10.

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The communications network 1 also includes the Internet 50 (an example of a packet-switched network). Both the WAG 10 and PGW 33 (of the MNO's network) include communications interfaces to connect to the Internet 50. Accordingly, a connection may be established between the UE 40 and the Internet 50 through the WLAN operator's network 20 towards the WAG 10 with an onward connection either through the MNO's network 30 (via the PGW 33) or via a "local breakout" at the WAG 10 (via the NAT 14). The WAG 10 determines whether traffic from a particular UE 40 should be routed to the Internet 50 from the WAG 10 or via the MNO's network 30 according to a predetermined local breakout rule applied by the router 17 and stored in the routing table 19.

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The present invention includes a method of establishing a connection between the UE 40 and the MNO's network 30 such that the WAG 10 implements a local breakout rule for traffic from that UE 40. A first embodiment of this method will now be described with reference to Figures 1 and 2.

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Figure 2 is a diagram illustrating a message flow for establishing a connection between the UE 40 and the MNO's network 30. As a first step (step S1.1), the UE 40 requests a connection to the WLAN operator's network 20, using a SIM-based authentication, by sending an EAP Start message to the AAA server 23. The EAP Start message includes

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the UE's MAC address and, in this embodiment, an International Mobile Subscriber Identity (IMSI).

Authentication messages are then exchanged between the WLAN operator's AAA server 23 and the MNO's HSS 31 (step S1.2). During this exchange, authentication messages are passed between the AAA proxy server 11 and the routing manager 15 at the WAG 10. The WAG 10 stores an association between the MAC address and the IMSI for a UE 40. Furthermore, the WAG 10 stores these signalling messages for later analysis in order to determine which local breakout policy to apply to traffic from the UE 40 (as will be described in more detail, below).

Once the UE 40 is authenticated, the AAA server 23 of the WLAN operator's network 20 sends an EAP Success message to the UE 40. The UE 40 then requests an IP address by sending a DHCP Discover message to the WLC 21 of the WLAN operator's network 20 (step S1.3), which includes the MAC address of the UE 40. On receipt of this DHCP Discover message, the WLC 21 sends a GPRS Tunnelling Protocol (GTP) Create Session Request message to the PGW 33 of the MNO's network 30, via the WAG's routing manager 15 and GTP GW 13 (step S1.4), which includes the International Mobile Subscriber Identity, IMSI, of the UE 40 (retrieved from the stored association between MAC address and IMSI, as noted above).

In this embodiment, the GTP Create Session Request message is sent to the PGW 33 of the MNO 30 via the routing manager 15. Again, this allows the WAG 10 to store and analyse these signalling messages, which in turn allows the WAG 10 to determine which local breakout policy to apply to traffic from the UE 40 (described in more detail below).

Upon receipt of the GTP Create Session Request message, the PGW 33 allocates a first IP address (IP_{MNO}) for the UE (step S1.5). This IP address is allocated from an IP address pool by a DHCP exchange with the MNO's DHCP server. The PGW 33 then sends a GTP Create Session Response message to the GTP GW 13, including the UE's IP address, IP_{MNO} . Upon receipt of this response message, the WAG 10 establishes a first GTP tunnel with the PGW 33 of the MNO 30.

This first IP address, IP_{MNO} , may then be passed from the WAG 10 to the UE 40 via the WLAN network 20. However, in this embodiment, the WAG 10 is also responsible for

allocating a second IP address (IP_{WLAN}) to be used by the UE 40 in the WLAN domain. This is achieved by the GTP GW 13 requesting the second IP address (IP_{WLAN}) for the UE 40 on behalf of the WLAN operator's network 20. The second IP address is allocated from an IP address pool dedicated to that WLAN operator, by a DHCP exchange with the WAG's DHCP server (step S1.6). The GTP GW 13 is preconfigured with a dedicated IP address pool for the WLAN operator's network 20 (such that it does not conflict with a range of IP addresses reserved for other UEs on the WLAN operator's network 20).

The GTP GW 13 then responds to the GTP Create Session Request message by sending the second IP address to the first WLAN operator's WLC 21 via the routing manager 15 (step S1.7). This establishes a second GTP tunnel between the WAG 10 and the WLC 21.

The GTP GW 13 also sends an Update Routing Request message to the routing manager 15 in order to set up an appropriate routing rule for the UE (step S1.8). The routing rule (which will be explained in more detail below) is stored in a routing table 19 in router 17, and is represented in the following table:

<u>UE ID</u>	<u>WLAN-side IP address</u>	<u>MNO-side IP address</u>	<u>MNO ID</u>	<u>Local Breakout Rule(s)</u>	<u>Access Point Name</u>
$IMSI_1$	IP_{WLAN}	IP_{MNO}	MNO_1	-66.220.556.2; -226.58.258.46	Default(MNO_1)
...	...	...		...	...

Table 1: Table represented routing rule in routing table 19

As shown in Table 1, the routing rule includes the IMSI for the UE (obtained by the routing manager 15 from the GTP Create Session Request message in step S1.4, or alternatively from the EAP exchange in step S1.2)) and the IP addresses for the UE in both the WLAN and MNO domains (allowing the GTP GW 13 to translate between IP_{WLAN} and IP_{MNO} for all traffic from the UE 40 towards the MNO, and vice versa). The routing rule also includes a local breakout rule, which defines what traffic arriving at the WAG 10 from the UE 40 should be directed towards the first MNO's network (via the first GTP tunnel) or towards the Internet (bypassing the MNO's network), and specifies an Access Point Name (APN) identifying the network node the traffic should be routed to. The

routing manager 15 creates these local breakout rules when it receives the Update Routing Request message, which will be described in more detail below.

Finally, in step S1.9 of Figure 2, the WLC 21 sends a DHCP Offer/Request/Acknowledgement message to the UE 40, including the UE's IP address IP_{WLAN} . The UE 40 may now transmit data via the second GTP Tunnel to the WAG 10, which may be routed towards either the MNO's network or towards the Internet according to the local breakout rule, established by the routing manager 15.

The routing manager 15 is shown in Figure 3. The routing manager 15 includes an interface 15a, a profile selector 15b (including memory module 15f), a profile database 15c, a routing table builder 15d and a profile management web server 15e. These elements are used to process signalling messages (such as any message used in the authentication exchange between the WLAN operator's network 20 and the MNO's network 30, or any message used in the session creation exchange between the WLAN operator's network 20 and the MNO's network 30) in order to determine which local breakout rule should be applied to the UE 40. This method will be described with reference to both Figures 3 and 4.

The routing manager 15 receives signalling messages (including any of those noted above) during the authentication or session creation processes via the interface 15a. In step S2.1 in Figure 4, the signalling messages are received at the profile selector 15b, which parses the messages and stores them in memory 15f. Each message is parsed into the form <protocol>.<message type>.<attribute>, such that it may be easily referenced and searched. The profile selector 15b also allocates a session ID to each received message, which, in this embodiment, is achieved by determining the IMSI associated with each message and attributing the same session ID to each message having the same IMSI (and this association is stored in memory). The skilled person will understand that some message types having the IMSI as an attribute may therefore be simply parsed and stored by the profile selector 15b, but in further examples (such as RADIUS messages) the signalling message may be a collection of multiple sub-messages (each having a particular sub-message type and attribute), in which case the profile selector 15b may parse any one of these sub-messages and associate them with the same session ID so long as the same common identifier (e.g. IMSI) is used in at least one of these sub-messages.

The profile selector 15b also determines which MNO the signalling messages are associated with (e.g. by analysing the country code and network code of the IMSI, or the realm of a signalling message), and associates each message with an MNO ID. The profile selector 15b therefore stores a number of parsed signalling messages in memory 15f (step S2.2), wherein each message is associated with a particular session ID and MNO ID. This data is represented in the following table:

<u>Parsed Message</u>	<u>Session ID</u>	<u>MNO ID</u>
map.sendAuthenticationInfoRequest.imsi = 310150123456789 (IMSI ₁)	1	MNO ₁
diameter.Diameter-EAP-Request.User-Name = 0234150999999999@wlan.mnc015.mcc234.3gppnetwork.k.org (IMSI ₂)	2	MNO ₂
radius.AccessRequest.User-Name = 310150123456789@wlan.mnc0150.mcc310.3gppnetwork.k.org (IMSI ₁)	1	MNO ₁

Table 2: Table illustrating data stored in memory in the profile selector 15b

In step S2.3, the profile selector 15b receives the Update Routing Request message from the GTP GW 13, including the IMSI for the UE 40 and the IP addresses for the UE 40 in the WLAN and MNO domains. The profile selector 15b determines which session ID is associated with that IMSI (step S2.4).

In step S2.5, the profile selector 15b identifies the MNO associated with the session ID (stored in memory), and retrieves one or more profiles for that MNO from the profile database 15c. The profile database 15c contains a number of profiles, which are represented in the following table:

<u>MNO ID</u>	<u>Profile ID</u>	<u>Order</u>	<u>Selection Creation/a</u>	<u>LBO Rule(s)</u>	<u>APN</u>
MNO ₁	"APN1"	1	map.insertSubscriberData.apn = "ggsn1.mno1.com"	-10.21.3.*:6970; -youtube.com	Default
				-10.166.8.22	portal.mno1.com

MNO ₁	"APN2"	2	map.insertSubscriberData.apn = "ggsn2.mno1.com"	-facebook.com; -youtube.com;	Default
MNO ₁	"IMSI"	3	Script= "imsiSelector.pss"	-facebook.com; -youtube.com;	Default
MNO ₁	"Default"	4	<empty>	.*	Default
MNO ₂	"Default"	1	<empty>	+customerportal. mno2.com;	Default
...	...	...	...	...	...

Table 3: Table representing a plurality of profiles stored in profile database 15c

Accordingly, if the profile selector 15b determines that the session ID is 1, which is attributed to MNO₁, it retrieves all profiles (APN1, APN2, IMSI and Default) associated with that MNO from the profile database 15c. These profiles include an order number, which assigns a priority for that profile. The profile selector 15b then determines if the signalling messages for that session ID match the selection criteria for the 1st order profile, then the 2nd order profile, etc., until the profile selector 15b finds a match (step S2.6). This is achieved in the following manner.

Each session ID has one or more parsed signalling messages attributed to it (stored in memory). Each parsed signalling message is then compared to the selection criterion using logical operators. If one or more of these parsed signalling messages for a session ID matches the selection criterion, then the profile selector 15b has found a match and the profile associated with the matched selection criterion is selected. In another example, the profile selector may compare each parsed signalling message to a plurality of selection criteria, and a profile is selected if each one of these selection criteria are matched by one or more parsed signalling messages for a session ID. Furthermore, the selection criteria may be a Profile Selection Script (PSS), which may be used to report a match if one or more parsed signalling messages match more complicated selection criteria (i.e. the script may include mathematical functions, variables, program flow control such as conditional statements and loops, etc.).

The profile database 15c includes a "Default" profile for each MNO, which is used if no parsed signalling message for a session ID matches the selection criterion for a higher order profile.

Accordingly, the profile selector 15b selects a profile from the plurality of profiles available for a particular MNO for a session ID. As shown in Table 3, each profile has one or more LBO rules, in which “-” indicates that any traffic matching that rule should be locally broken out, and “+” indicates that any traffic matching that rule should be routed to the cellular network. Any traffic which doesn’t match the LBO rules for a profile is routed in the alternative manner (e.g. if the rule only specifies that particular traffic is locally broken out, then all other traffic is routed to the cellular network; and if the rule only specifies that particular traffic is routed to the cellular network, then all other traffic is locally broken out). Upon selecting a particular profile following the processing detailed above, the profile selector 15b retrieves the LBO rule(s) and APN from the profile database 15c, and passes them to the routing table builder 15d along with a session ID (step S2.7). At this point, all stored data relating to that session ID is deleted from the profile selector 15b.

The routing table builder 15d receives the LBO rule(s) and APN from the profile database 15c (via profile selector 15b) and builds a set of routable breakout rules. This involves parsing any wildcards in the LBO rule(s) to produce routable IP address subnets and translating domain names into routing IP addresses (using a DNS). These routable breakout rules are then sent to the routing tables module 19 (part of the router 17 of GTP GW 13), which is used to update the relevant entry (step S2.8):

<u>UE ID</u>	<u>WLAN-side IP address</u>	<u>MNO-side IP address</u>	<u>MNO ID</u>	<u>Local Breakout Rule(s)</u>	<u>Access Point Name</u>
IMSI ₁	IP _{WLAN}	IP _{MNO}	MNO ₁	-66.220.556.2; -226.58.258.46	Default(MNO ₁)
...	...	...		...	...

Table 4: Table representing an updated routing table entry stored in routing table 19

In the above example routing table entry, the profile selector 15b received and parsed a number of signalling messages between the UE 40 (having IMSI₁) and the MNO’s network. The profile selector 15b retrieved the profiles for the MNO’s network, and determined that no parsed signalling messages matched the selection criterion for the first ordered profile (APN1), but one or more parsed signalling messages matched the selection criterion for the second ordered profile for that MNO (APN2). The routing table

builder 15d then built two routing rules according to the LBO rules specified in the profile database 15c, by translating the domain names into routable IP addresses.

5 With the routing table 19 in router 17 of GTP GW 13 now populated with these routing rules, any traffic arriving at the router 17 having a source IP address matching IP_{WLAN} (thus arriving via the second GTP tunnel) is analysed to determine the destination IP address. If the destination IP address matches one of the routing rules, it is locally broken out and directed towards the NAT 14 for onward connection to the Internet 50 (i.e. it bypasses the MNO's network 30) via the default APN. All other traffic (i.e. any
10 traffic having a source IP address matching IP_{WLAN} but a destination address which does not match any of those in the routing rules) is routed towards the MNO's network 30 via the first GTP tunnel (and its IP address is translated to IP_{MNO}).

15 As noted above, the routing manager 15 includes a profile management web server 15e. This is an interface between each MNO and the routing manager 15 allowing each MNO to access the profile database and edit their profiles (e.g. to add further profiles, to add/edit/delete the LBO rules for any one of their profiles, to add/edit/delete selection criteria for any of their profiles, or to change the order of profiles).

20 A second embodiment of a method of the present invention will now be described with reference to Figure 5. In a similar manner to the first embodiment, the routing manager 15 of the WAG 10 includes a profile database including a plurality of profiles for each MNO (wherein each profile includes one or more local breakout rules). Each profile in the profile database is associated with a profile ID (e.g. "APN1", "APN2", "Default", etc.
25 as shown in Table 3 above).

The GTP Create Session Response message (which, as shown in Figure 2, is sent from the PGW 33 to the GTP GW 13 in step S1.5) includes both the IP address for the UE in the cellular domain, IP_{MNO} , and, in this embodiment, a profile ID. This profile ID identifies
30 one of the plurality of profiles of a particular MNO. On receipt of the GTP Create Session Response message, the GTP GW allocates the IP address for the UE in the WLAN domain, IP_{WLAN} . Referring back to Figure 5, the GTP GW 13 sends an Update Routing Request message to the routing manager 15 (step S3.1). In this embodiment, the Update Routing Request message includes the profile ID (from the GTP Create Session
35 Response message), in addition to the IMSI for the UE.

On receipt of the Update Routing Request message, the profile selector 15b determines which session ID is associated with the IMSI in the Update Routing Request message (step S3.2), and determines which MNO is associated with that session ID. The profile selector 15b then retrieves the profiles for that MNO from the profile database 15c (step S3.3). The profile selector 15b then determines if the Update Routing Request message includes a profile ID (step S3.4). In step S3.5 of this embodiment, the Update Routing Request message does include a profile ID, and so the profile selector 15b automatically selects that profile (thus bypassing the selection process of the first embodiment), and builds local breakout rules based on the LBO rules associated with that profile (steps S3.6, S3.7).

In an alternative example of the second embodiment (also shown in Figure 5), the GTP Create Session Response message does not include a profile ID but instead includes one or more routing attributes. In this case, the GTP GW sends an Update Routing Request message to the routing manager 15 including the IMSI for the UE and the routing attributes. The routing manager 15 then builds local breakout rules based on the routing attributes in the Update Routing Request message.

Figure 5 also illustrates that the profile selector 15b selects a profile based on the method of the first embodiment of the invention (by analysing parsed signalling messages) if the Update Routing Request message does not include a profile ID or routing attribute.

In this second embodiment, the signalling message from the MNO to the WAG includes an identifier for a profile, wherein the profile includes one or more local breakout rules. However, the skilled person will understand that the signalling message may include one or more identifiers for one or more local breakout rules respectively, which causes the WAG to install each of those rules. Furthermore, the skilled person will understand that the profile ID doesn't necessarily have to be in the GTP Create Session Response message (for example, it may be contained as part of the EAP authentication exchange).

In the above embodiments, the routing manager 15 receives signalling messages and stores them in memory together with a session ID. The skilled person will understand that the routing manager 15 may therefore act as a signalling proxy that all messages

pass through, or, alternatively, each network element may include an API allowing it to duplicate a signalling message and pass the duplicate to the routing manager 15.

Furthermore, the routing manager 15 may process the signalling messages as they arrive (to determine if they match the selection criteria of a profile), rather than wait until it receives an Update Routing Request message, although this may involve processing more signalling messages than necessary. The skilled person will also understand that the profile selector 15b need only parse a portion of a signalling message to determine whether or not it should be stored for further analysis. Thus, if a signalling message is destined for a particular MNO, and that MNO only includes certain message types in the selection criteria for its profiles, then only signalling messages of that message type should be fully parsed and stored.

Furthermore, in the above embodiments, the routing manager 15 associates all signalling messages with a session ID as they include the same IMSI. However, the skilled person will understand that each message may not include the IMSI, and so other methods of associating signalling messages with the same session may be used. For example, different protocols may use different identifiers for the UE, so the routing manager 15 may also include a further table mapping a session ID with these various identifiers.

Furthermore, the skilled person will understand that the GTP protocol is used as an example in the above embodiments, and other forms of protocols (e.g. RADIUS, DIAMETER, MAP) may be used.

The skilled person will also understand that, once the local breakout rule has been established, then this may thereafter be applied to any traffic from that UE or a subset of traffic (e.g. relating to a particular data session) from that UE. This may be applied for the current data session, or for a limited period of time.

In a further enhancement to the embodiments above, the WAG may be configured to select particular profiles based on both the signalling messages matching the selection criteria and also based on the time of day. An MNO may therefore establish different profiles having the same selection criteria, but with differing local breakout rules depending on the time of day.

The skilled person will understand that any combination of features is possible with the scope of the invention, as claimed.

CLAIMS

1. A method of controlling a Wireless Access Gateway, WAG, the WAG interconnecting a non-cellular network and a first and second cellular network, wherein data traffic between a User Equipment, UE, connected to the non-cellular network is routable by the WAG towards either the first or second cellular networks or towards an external packet-switched network, the method comprising the steps of:

the WAG storing a plurality of profiles;

the WAG receiving a signalling message relating to a User Equipment, UE, connected to the non-cellular network;

the WAG analysing the signalling message to determine a traffic breakout rule for the UE, including

the WAG determining that the signalling message relating to the UE is for the first cellular network, and

the WAG selecting a first profile of the stored plurality of profiles, the first profile being for the first cellular network and including the traffic breakout rule; and

the WAG selectively routing a first data traffic portion associated with the UE towards the cellular network and a second data traffic portion associated with the UE towards the external packet-switched network based on the traffic breakout rule.

2. A method as claimed in Claim 1, wherein the WAG selects the first profile based on an attribute of the signalling message from the UE.

3. A method as claimed in Claim 2, wherein the attribute is an identifier for the first profile.

4. A method as claimed in any one of the preceding claims, wherein the profiles are editable.

5. A non-transitory computer-readable storage medium storing a computer program or suite of computer programs, which upon execution by a computer system performs the method of any one of the preceding claims.

6. A Wireless Access Gateway, WAG, interconnecting a non-cellular network and a first and second cellular network, the WAG comprising

memory configured to store a plurality of profiles;
a receiver configured to receive a signalling message related to a User Equipment, UE,
connected to the non-cellular network;
a processor configured to analyse the signalling message to determine a traffic breakout
5 rule for the UE, including
 analysing the signalling message and determining that it is for the first cellular
network, and
 selecting a first profile of the plurality of profiles stored in memory, the first profile
being for the first cellular network and including the traffic breakout rule; and
10 a router configured to route a first data traffic portion associated with the UE towards the
cellular network and a second data traffic portion associated with the UE towards the
external packet-switched network based on the traffic breakout rule.

7. A WAG as claimed in Claim 6, wherein the processor is configured to select the
15 first profile based on an attribute of the signalling message from the UE.

8. A WAG as claimed in Claim 7, wherein the attribute is an identifier for the first
profile.

9. A WAG as claimed in any one of Claims 6 to 8, wherein the profiles are editable.
20

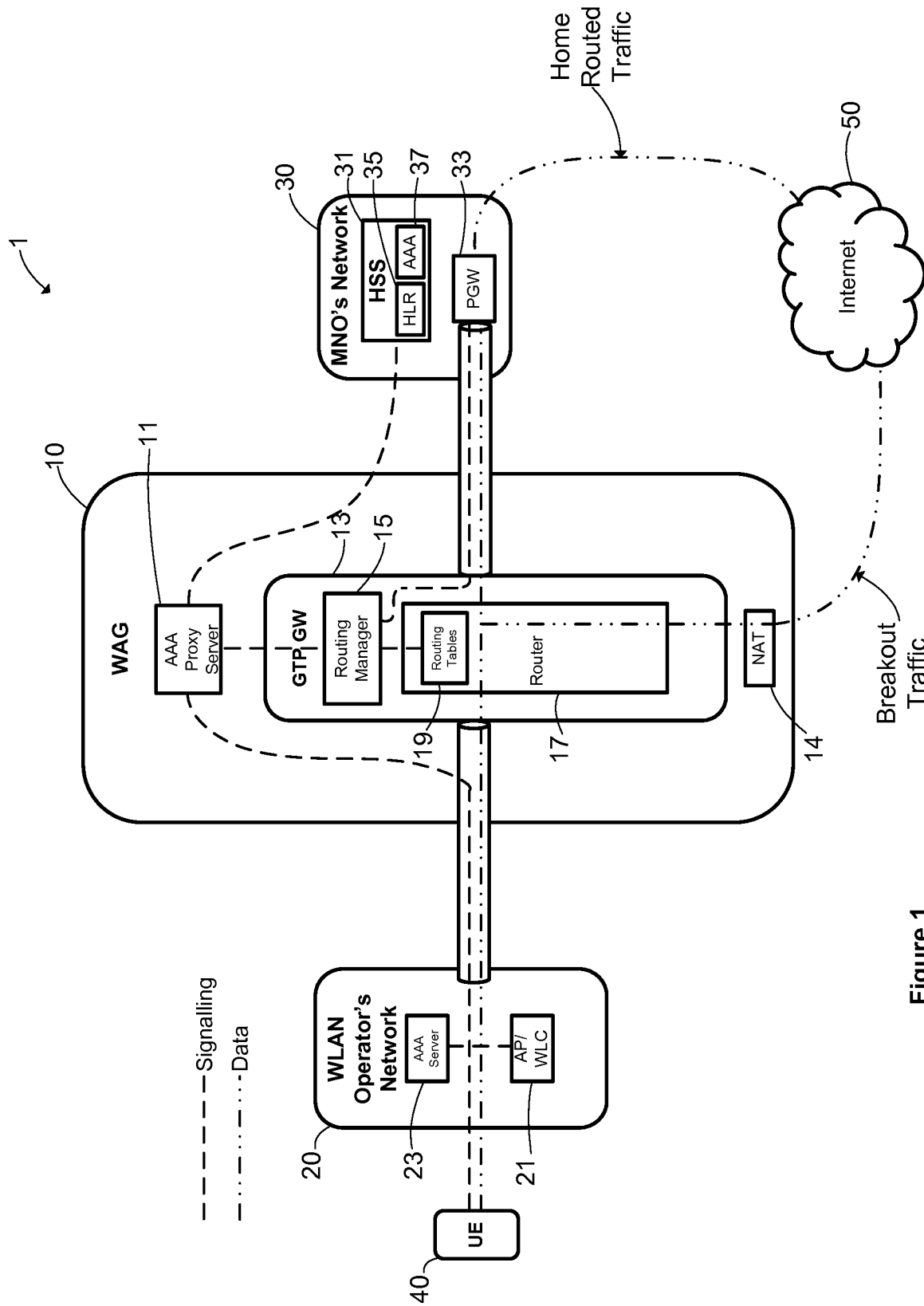


Figure 1

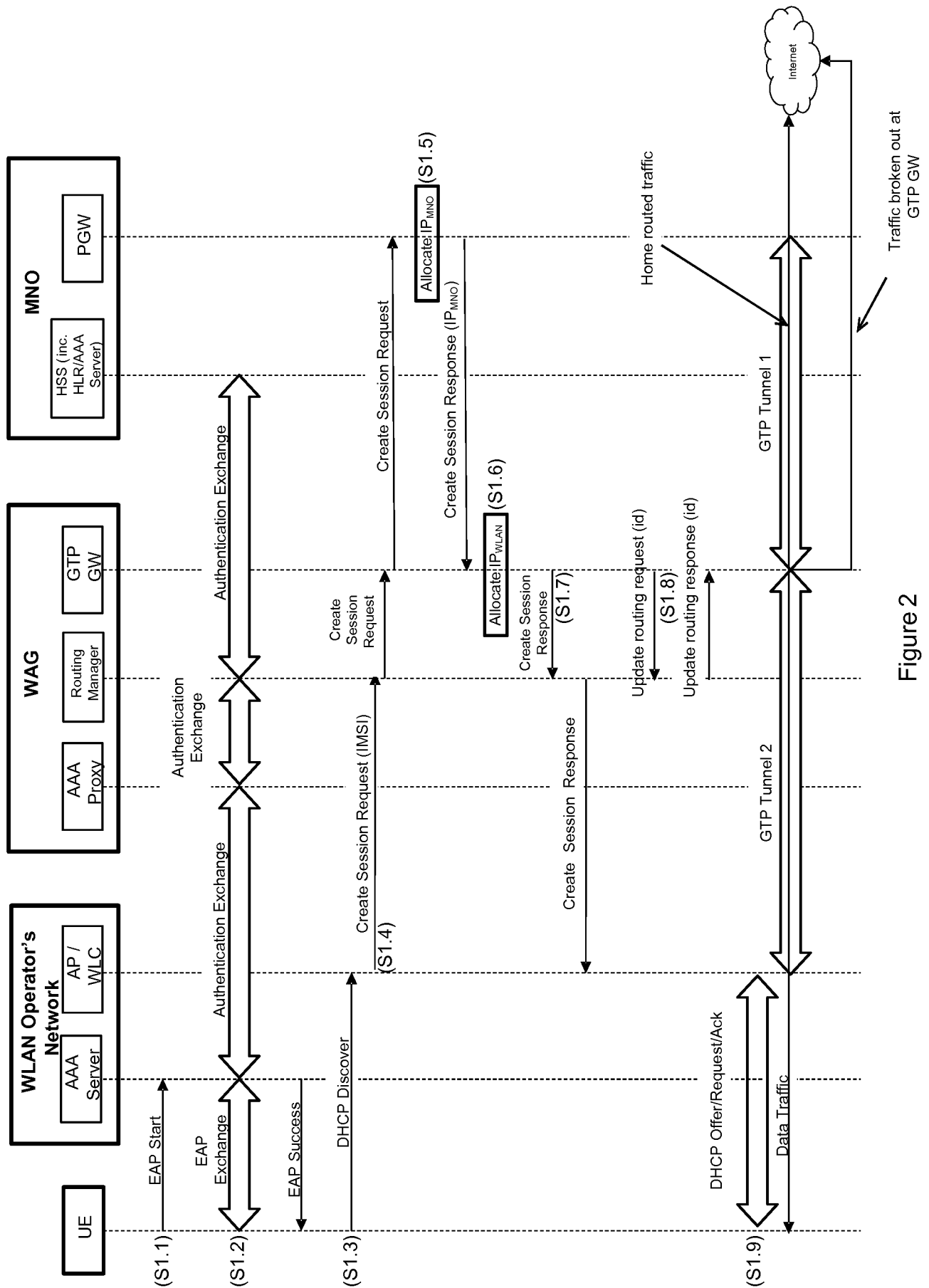


Figure 2

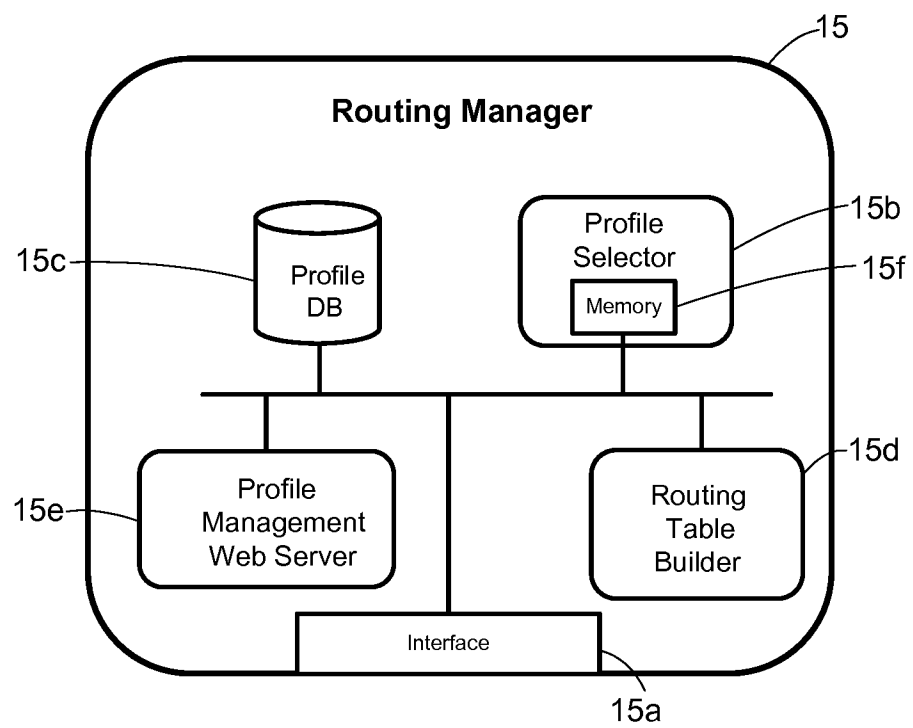


Figure 3

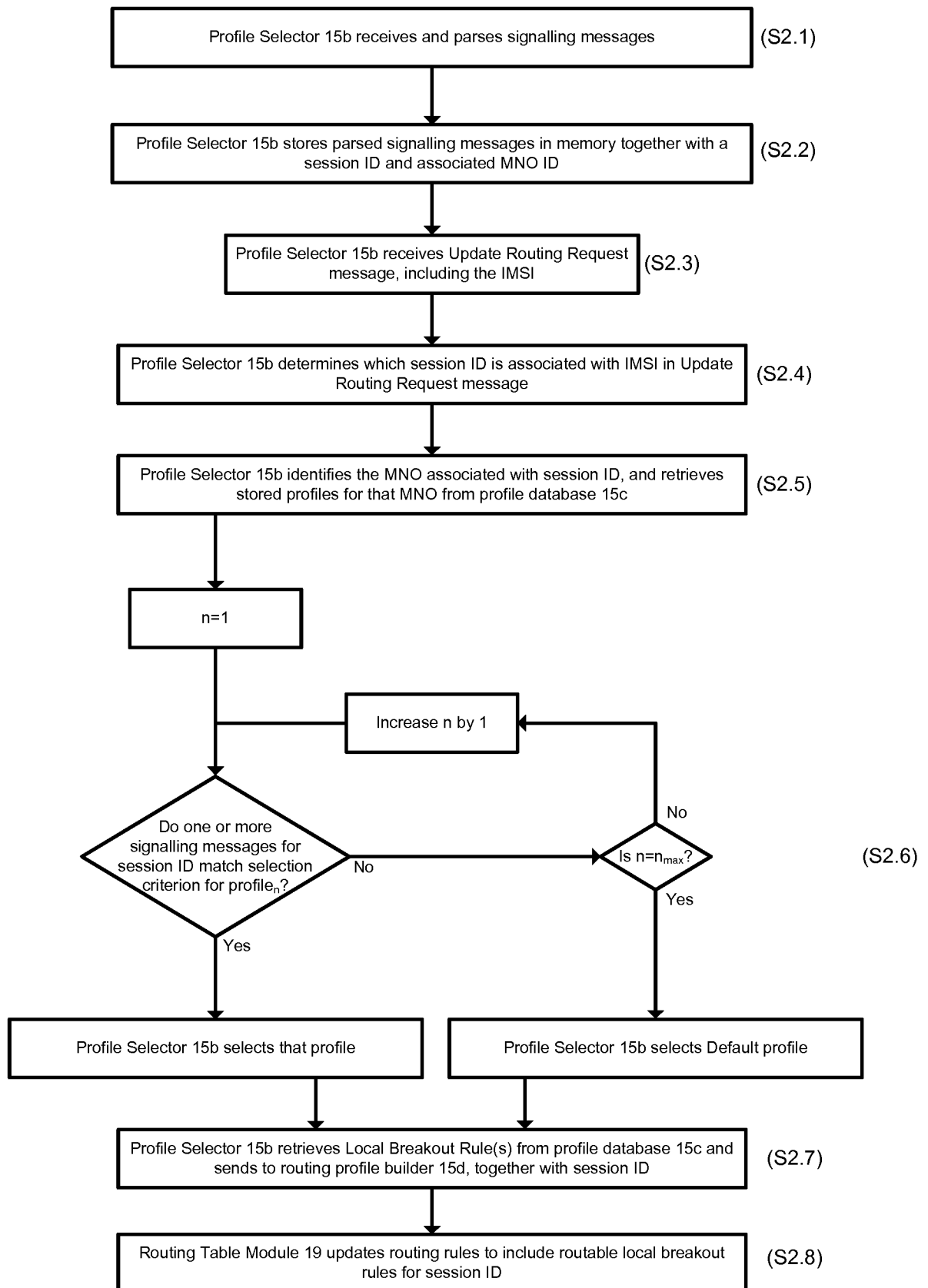


Figure 4

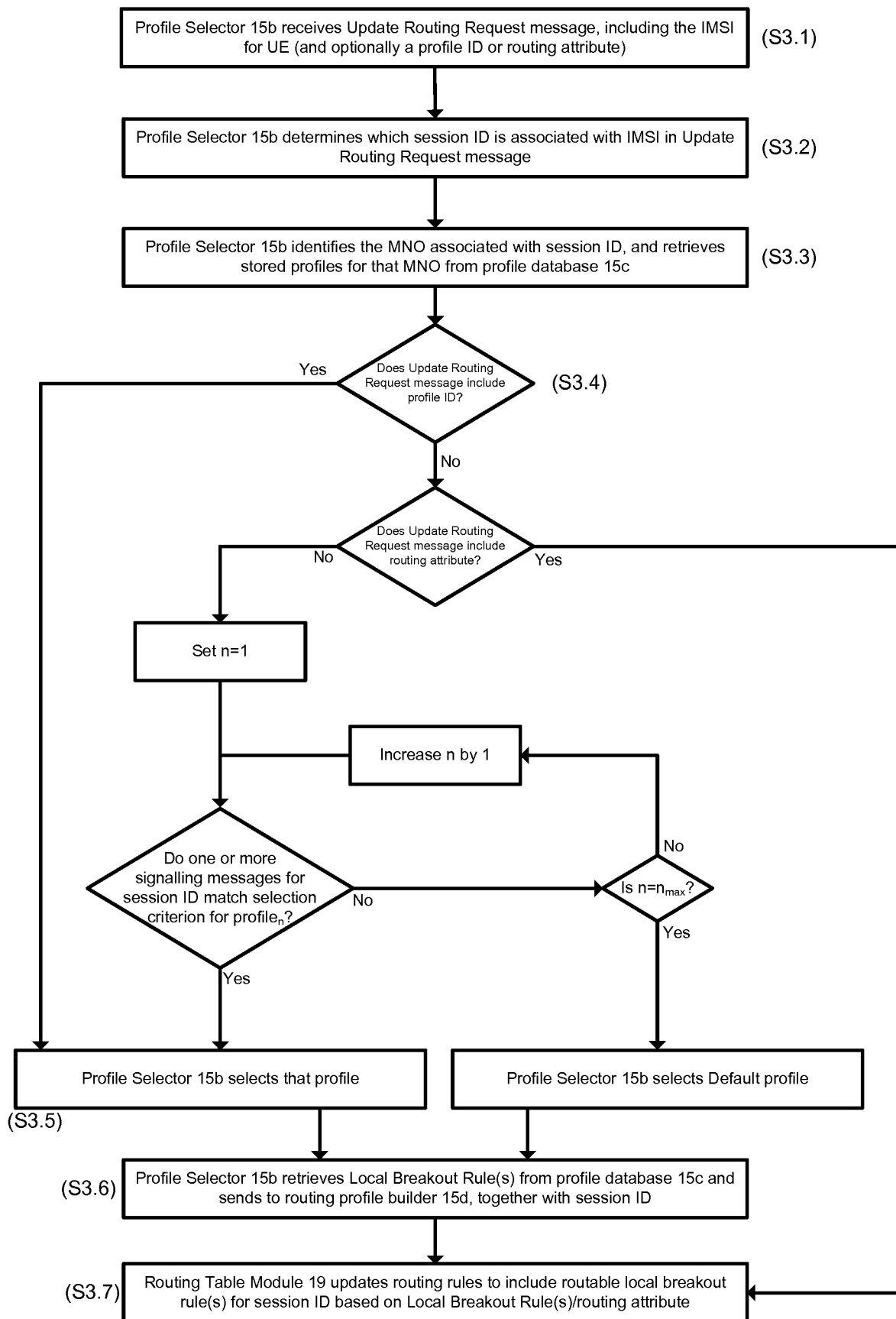


Figure 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/059455

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W88/16 H04W92/02
ADD.

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

B. FIELDS SEARCHED

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

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/126918 A1 (RUCKUS WIRELESS INC [US]) 29 August 2013 (2013-08-29) abstract paragraph [0003] - paragraph [0006] paragraph [0035] - paragraph [0040] paragraph [0084] paragraph [0137] paragraph [0183] paragraph [0186] - paragraph [0187] paragraph [0191] - paragraph [0192] claims 60-70 figures 6-11, 13-14 ----- -/-	1-9



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

14 June 2016

Date of mailing of the international search report

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Name and mailing address of the ISA/

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

Authorized officer

Lombardi, Giuseppe

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/059455

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2009/024182 A1 (ERICSSON TELEFON AB L M [SE]; SUGIMOTO SHINTA [JP]; KATO RYOJI [JP]; 0) 26 February 2009 (2009-02-26) abstract page 4, line 23 - line 31 page 5, line 14 - page 6, line 18 page 9, line 21 - page 10, line 16 page 11, line 30 - page 14, line 13 figures 1-5 -----	1-9
A	US 2011/235595 A1 (MEHTA APURVA [US] ET AL) 29 September 2011 (2011-09-29) abstract paragraph [0008] - paragraph [0012] paragraph [0016] - paragraph [0020] paragraph [0033] paragraph [0040] - paragraph [0042] paragraph [0062] - paragraph [0063] paragraph [0069] paragraph [0086] paragraph [0092] - paragraph [0096] paragraph [0108] - paragraph [0111] paragraph [0127] - paragraph [0129] claims 1, 3, 17 figures 1, 3, 9, 10, 12 -----	1-9
A	US 8 295 830 B1 (FACCIN STEFANO [US]) 23 October 2012 (2012-10-23) abstract column 12, line 49 - column 16, line 21 -----	1-9
A	EP 2 597 925 A1 (CISCO TECH INC [US]) 29 May 2013 (2013-05-29) abstract paragraph [0013] - paragraph [0018] paragraph [0036] - paragraph [0037] paragraph [0045] -----	1-9
A	CISCO: "SP WIFI Packet Core Integration", INTERNET CITATION, 21 March 2012 (2012-03-21), pages 27-34, XP002727066, Retrieved from the Internet: URL:www.cisco.com/assets/global/YU/expo.20 12/pdfs/sp_wifi_sesija_1_core.pdf [retrieved on 2014-07-11] the whole document -----	1-9

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Information on patent family members

International application No

PCT/EP2016/059455

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