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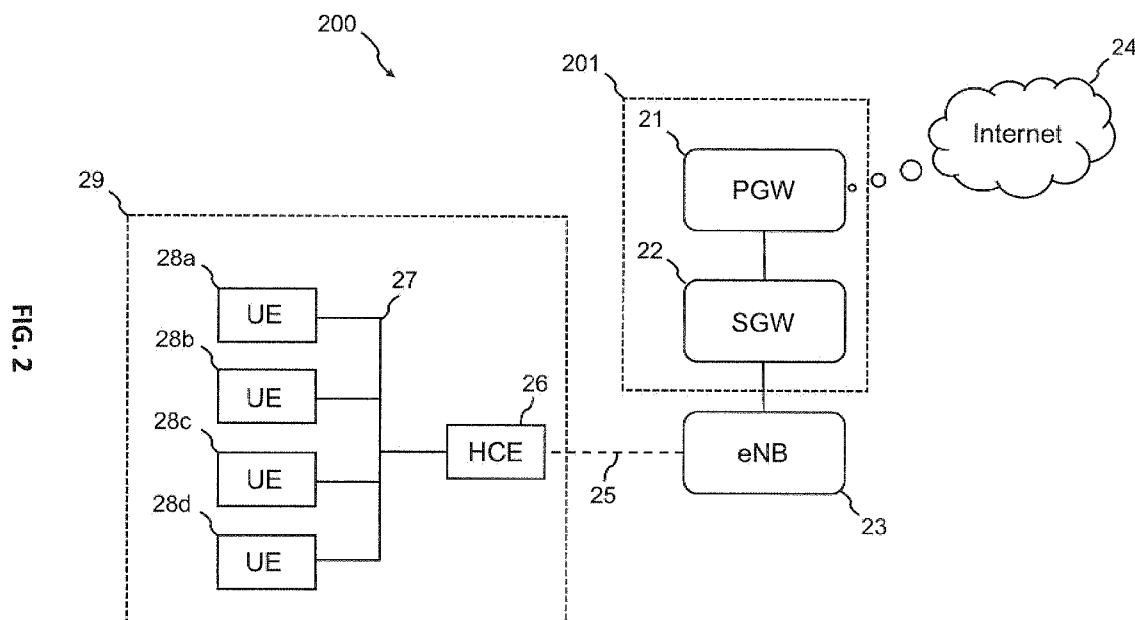
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(54) Title: PACKET FORWARDING TO SUBNETS HOSTED BY LTE CELLULAR EQUIPMENTS



(57) Abstract: There is described therein a method of forwarding packets to at least one subnet hosted by a LTE cellular equipment. The forwarding of packets destined to subnets hosted by cellular equipment's is accomplished by defining relationships between subnets and cellular equipment's IP addresses at the PGW level and by using a bearer to transport the data from the PGW to a hosting cellular equipment associated to the destination.

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PACKET FORWARDING TO SUBNETS HOSTED BY LTE CELLULAR EQUIPMENTS

BACKGROUND

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Technical Field

The present invention relates to a method of forwarding packets to at least one subnet hosted by a LTE cellular equipment. It finds applications, in particular, in LTE networks wherein downlink packets originating from the core of the network are routed to subnets behind cellular equipments used as routers.

10

Related Art

The approaches described in this section could be pursued, but are not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in this application and are not admitted to be prior art by inclusion in this section.

15

LTE networks have an architecture composed of two parts: the core network and the access network.

The core network, called the Evolved Packet Core (ePC) in the System Architecture Evolution (SAE), comprises three main logical nodes:

20

- the Packet Gateways (PGW) which give access to the Internet and are responsible for IP address allocation;
- the Serving Gateways (SGW) which manage the data traffic through the core network; and,
- the Mobility Management Entity (MME) which handle the signalling

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between entities of the radio access network and the core network.

The access network, called Evolved Universal Terrestrial Radio Access Network (EUTRAN), comprises a network of evolved Nodes B (eNodeB), which are the

base stations forming the radio interface between the core network and the User Equipment's (UE's).

The UE's are the mobile devices used by end-users which can be, for instance, cell phones, smartphones, laptops with a mobile adapter, or personal computers (PCs) with a wireless modem. In any case, in the context of the invention, UE's
5 are wireless end-user equipment's with a radio cellular means of connection up to the core network.

The PGW operates as the Internet Protocol (IP) endpoint of any cellular equipment having a cellular connection up to the core network. As such, it is in
10 charge of delivering downlink packets from the Internet to the cellular equipment and, reciprocally, of transmitting uplink packets from the cellular equipment to the Internet.

In some applications, however, a cellular equipment is not an end-user but rather a router that serves other pieces of equipment connected through a distinct
15 network interface. In other words, this cellular equipment hosts a subnet, namely an IP subnet, formed by the hosting cellular equipment and the connected pieces of equipment. This IP subnet is managed solely by the hosting cellular equipment.

In such applications, the subnets need to be addressable by the PGW so that a packet received by the PGW and intended for any specific subnet hosted by a
20 cellular equipment can be forwarded by the PGW to this cellular equipment.

However, the forwarding mechanism is neither defined nor allowed by the Core Network Protocols defined by the 3rd Generation Partnership Project (3GPP) standards. Indeed, the PGW can only forward packets on the basis of a destination IP address. Besides, the PGW only allocates IP addresses to cellular
25 equipment's. It implies that when a downlink packet having a destination IP address corresponding to a subnet is received by the PGW, it is dropped by said PGW.

Finally, even though uplink packets are natively forwarded from subnets to cellular equipment's and from cellular equipment's to the PGW and the Internet, a

problem remains for downlink packets that cannot be routed to the end-user equipment of destination.

A possible solution to the afore mentioned problem would consist in building a specific tunnel between the PGW and the cellular equipment hosting the subnet.

5 Such tunnel could be created, in possible implementations, by using IP-in-IP encapsulation (also called IP tunnelling) wherein an IP packet is encapsulated in another IP packet. The original packet (i.e., the inner packet) would keep unmodified but encapsulated in the other packet, meaning that an outer IP header would be used to open a tunnel to the desired destination.

10 However, such encapsulation is not available on all computing platforms (for instance it is not available on Windows systems) and, more importantly, tunnelling generates significant overhead in the data plane (typically more than 20 bytes) and requires cumbersome operations for its configuration. In addition, tunnel encapsulation might also imply packet losses.

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SUMMARY

To address these problems, the present invention proposes a method of forwarding packets to at least one subnet hosted by a LTE cellular equipment. The forwarding of packets intended for subnets respectively hosted by cellular equipment's is accomplished by defining relationships at the PGW level between
20 subnets and respective IP addresses of the cellular equipment's, and by using a bearer to transport data from the PGW to a hosting cellular equipment associated to the destination IP address.

According to embodiments of the proposed invention, a first aspect relates to a
25 method of forwarding packets from a LTE network comprising a core network with a Packet Gateway, PGW and a plurality of LTE cellular equipment's connected to said core network, down to at least one subnet comprising, and hosted by, a given one of said plurality of LTE cellular equipment's which manages at least one other, associated cellular equipment further comprised in said subnet, the method
30 comprising:

- defining, in the PGW, subnet relationships between the subnet and a cellular equipment address of the hosting cellular equipment, and upon receipt at the PGW of a downlink packet with a destination address:
 - checking whether the destination address is part of a subnet relationship and, if so, locate the associated cellular equipment which is part of this subnet relationship; and,
 - checking whether the located cellular equipment is connected to the core network or not and, if yes, forwarding the downlink packet over a bearer to the hosting cellular equipment and the subnet which are part of said subnet relationship.

The above method ultimately allows the direct forwarding of downlink packets intended for a subnet behind a LTE mobile equipment. Such packet received by the PGW from the Internet will therefore not be dropped. As long as a destination IP address of a packet matches a subnet relationship, the PGW performs forwarding to the cellular equipment which is part of this subnet relationship.

This solution does not imply more definition than these relationships and guaranties efficient forwarding if downlink packets. In addition, no overhead in the data plane is generated.

Furthermore, according to embodiments taken alone or in combination:

- the core network of the LTE network is an evolved Packet Core, ePC, and comprises the PGW, a Serving Gateway, SGW, and a Mobility Management Entity, MME, and the LTE network further comprises an access network comprising Evolved Nodes B, eNodeB, and the LTE cellular equipment's.
- the cellular equipment's of the LTE network are Commercial Off-The-Shelf, COTS, equipment's.
- the at least one subnet is a 5G subnet or a Local Area Network, LAN, subnet.
- the hosting cellular equipment manages a plurality of subnets being 5G subnets, LAN subnets or a mixed combination of 5G and LAN subnets.

- the subnet relationships are logical relationships associating the addresses of the hosting cellular equipment's and the other connected equipment's of the subnet.
 - the subnet relationships are defined, modified or deleted before or after, respectively the receipt of downlink packets by the PGW.
 - the subnet relationships are defined by loading said subnet relationships in a PGW configuration system of the PGW.
 - the method further comprises, upon receipt of the downlink packet at the PGW, checking the validity of the subnet relationships by determining which subnets are associated to which cellular equipment address by a subnet relationship, and forwarding the downlink packet only in case of validity.
 - the checking of the validity of the subnet relationships comprises checking that a subnet does not conflict with a cellular equipment address, checking that the cellular equipment address matches an address allocated by the PGW and checking that subnet relationships do not conflict with each other.
 - the destination and the cellular equipment's addresses are IP addresses.
 - the IP addresses of the cellular equipment's are IPv4 addresses or IPv6 addresses or a mixed combination of IPv4 and IPv6 addresses.
 - the bearer is a default bearer or a dedicated bearer.
- A second aspect of the invention relates to a computer program product comprising one or more stored sequences of instructions that are accessible to a processor and which, when executed by the processor, cause the processor to perform the steps of a method according to the first aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which like reference numerals refer to similar elements and in which:

- Figure 1 is a simplified schematic description of a typical LTE network architecture;
- Figure 2 is a simplified schematic description of a LTE network architecture focused on network entities involved by the method of the invention;
- 5 - Figure 3 is a functional diagram showing an embodiment of the method of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to Figure 1, there is shown therein a simplified schematic diagram
10 of a typical LTE network architecture. The LTE network comprises two parts: the core network 11 which is for instance an Evolved Packet Core (ePC), and the access network 12 which is for instance an Evolved Universal Terrestrial Radio Access Network (EUTRAN).

The core network can comprise at least one Packet Gateway (PGW) 13 and one
15 or more Serving Gateways (SGW) such as gateways 14a and 14b as shown. The PGW is the gateway access to the switched packet network (i.e. to the Internet in one example) as it is partially illustrated by the link 15 as shown in Figure 1.

A plurality of Evolved Nodes B (eNB) 16a, 16b and 16c belong to the access network 12 and interface with the core network 11. In one example, all eNB's are
20 base stations of the access network 12 having cellular connections with the end-user equipment's also known as User Equipment's (UE's). In Figure 1, such UE's 17a to 17h are connected to either one of the eNB's 16a, 16b and 16c through respective LTE cellular connections, which are radio interfaces. Hence, the UEs are cellular equipment's such as, for instance, PCs with LTE modem, mobile
25 phones, smartphones, or laptops with a mobile adapter.

Referring now to Figure 2, there is shown therein a simplified schematic diagram of a LTE network 200 architecture, with a focus on network entities involved by the implementation of the method according to embodiments.

The PGW 21 acts as a gateway to the Internet 24, and is in charge of delivering packets from the Internet to cellular equipment's and from cellular equipment's to the Internet. In particular, a hosting cellular equipment (HCE) 26 is linked to the PGW 21 through an eNB 23 and a SGW 22. In the present example of
5 implementation of the method, the connection 25 of the HCE 26 up to the core network 201 of the LTE network 200 is a LTE cellular connection.

The HCE 26 is connected to other equipment's 28a, 28b, 28c and 28d and, altogether they form a distinct network referred to as a subnet 29 in the context of the present disclosure. In embodiments, subnet 29 is an IP subnet. Subnet 29 can
10 be managed solely by the HCE 26, for instance based on a client-server protocol.

Connection link 27 between the HCE 26 and the connected equipment's 28 can be of different types. For instance, it can comprise 5G connections, or form a Local Area Network (LAN, or any of its variations such as WLAN, WVLAN, etc,) connection to a subnet where regular IP hosts are located.

15 It should be appreciated by the one with ordinary skills in the art that whereas Figure 2 shows an embodiment with only one subnet, embodiments of the method can be applied to a configuration in which a plurality of subnets are hosted by the HCE 26.

The HCE 26 and the connected equipment's 28 belonging to the subnet 29 can
20 have various addressing schemes, or be any combination of addressing schemes. Indeed, the addressing can be of the IPv4 type (with for instance any subnet having an IPv4 address and an IPv4 mask) or of the IPv6 type, or it can be a combination of both (with, for instance, an IPv6 addressing for subnet 29 and an IPv4 addressing for the HCE 26).

25 Finally, it will be noted that embodiments can advantageously be implemented in applications having standard cellular network (eNB) and Commercial Off-The-Shelf cellular equipment's.

Referring now to Figure 3, there is shown therein a block diagram illustrating steps of embodiments of the method.

Block 31 corresponds to the receiving by the PGW 21 of a downlink packet. This downlink packet has a specific destination address, and comes from the switched packet network 24.

Another step of the method consists in defining subnet relationships 32 between one or more subnets and a HCE. These subnet relationships can be logical relationship associating the addresses of the HCE and the subnet being part of the relationship. The PGW is extended with the definitions of these relationships. This can be achieved by loading the subnet relationships in the PGW configuration system.

It will be further appreciated that the block diagram of Figure 3 illustrates embodiments of the method only, and that the relationships established in the PGW can be defined, modified or deleted at any time during the running of the steps of the method. For instance, a relevant relationship can be defined before or after the PGW receives a downlink packet.

In addition, such subnet relationships can be checked for validity. In one example, a given subnet relationship is held valid if and only if the corresponding subnet does not conflict with cellular equipment IP addresses allocated by the PGW and/or, further, the cellular equipment IP address matches IP addresses allocated by the PGW for cellular equipment's. Furthermore, the PGW can check that there is no conflict between relationships loaded in the configuration system. In particular, this implies checking that a specific subnet is associated to a single hosting cellular equipment.

After the receiving 31 of a packet, which is not intended for a connected cellular equipment, the PGW check its destination address and verify whether or not this address is part of a subnet relationship. If not, the packet can be dropped 34a and, if so, the next step 35 consists in locating in the network the cellular equipment (the hosting cellular equipment) which is part of this relationship.

It is then controlled whether the associated cellular equipment that has been located is connected or not 36. If not connected the packet can be dropped 34b whereas if the equipment is connected it is possible to proceed to the final step.

The final step of the method consists in forwarding the packet 37 over a bearer. Said bearer allows data of the packet to travel across the SGW to the destination of the packet. Advantageously the bearer can be either the default bearer or a dedicated bearer whose characteristics can, for instance, fit more specifically a
5 desired quality of service for a specific service.

The method of the invention exhibits numerous advantages such as the fact that the PGW can mix downlink packets destined to the hosting cellular equipment and to an associated subnet on the same bearer. In addition, it offers the possibility of forwarding packets to multiple subnets behind the same cellular
10 equipment and in doing so to adapt to specific needs by choosing default or dedicated bearers. The method is transparent and proposes an efficient forwarding to subnets through a LTE connection.

Expressions such as "comprise", "include", "incorporate", "contain", "is" and "have" are to be construed in a non-exclusive manner when interpreting the
15 description and its associated claims, namely construed to allow for other items or components which are not explicitly defined also to be present. Reference to the singular is also to be construed in be a reference to the plural and vice versa.

While there has been illustrated and described what are presently considered to be the preferred embodiments of the present invention, it will be understood by
20 those skilled in the art that various other modifications may be made, and equivalents may be substituted, without departing from the true scope of the present invention. Additionally, many modifications may be made to adapt a particular situation to the teachings of the present invention without departing from the central inventive concept described herein. Furthermore, an embodiment of
25 the present invention may not include all of the features described above. Therefore, it is intended that the present invention not be limited to the particular embodiments disclosed, but that the invention include all embodiments falling within the scope of the appended claims.

A person skilled in the art will appreciate that various parameters disclosed in the
30 description may be modified and that various embodiments disclosed and/or claimed may be combined without departing from the scope of the invention.

It is stipulated that the reference signs in the claims do not limit the scope of the claims, but are merely inserted to enhance the legibility of the claims.

CLAIMS

1. A method of forwarding packets from a LTE network (200) comprising a
5 core network (201) with a Packet Gateway (21), PGW and a plurality of LTE
cellular equipment's connected to said core network, down to at least one subnet
(29) comprising, and hosted by, a given one of said plurality of LTE cellular
equipment's (26) which manages at least one other, associated cellular
equipment further comprised in said subnet, the method comprising:
- 10 - defining, in the PGW, subnet relationships (32) between the subnet and a
cellular equipment address of the hosting cellular equipment, and upon
receipt (31) at the PGW of a downlink packet with a destination address:
- checking whether the destination address is part of a subnet
relationship (33) and, if so, locate the associated cellular equipment
15 (35) which is part of this subnet relationship; and,
 - checking whether the located cellular equipment is connected (36) to
the core network or not and, if yes, forwarding the downlink packet
(37) over a bearer to the hosting cellular equipment and the subnet
which are part of said subnet relationship.
- 20
2. The method of claim 1 wherein the core network of the LTE network is an
evolved Packet Core, ePC, and comprises the PGW, a Serving Gateway, SGW,
and a Mobility Management Entity, MME, and the LTE network further comprises
an access network comprising Evolved Nodes B, eNodeB, and the LTE cellular
25 equipment's.
3. The method of the claims 1 and 2 wherein the cellular equipment's of the
LTE network are Commercial Off-The-Shelf, COTS, equipment's.

4. The method of the claims 1 to 3 wherein the at least one subnet is a 5G subnet or a Local Area Network, LAN, subnet.
5. The method of the claims 1 to 4 wherein the hosting cellular equipment
5 manages a plurality of subnets being 5G subnets, LAN subnets or a mixed combination of 5G and LAN subnets.
6. The method of the claims 1 to 5 wherein subnet relationships are logical relationships associating the addresses of the hosting cellular equipment's and
10 the other connected equipment's of the subnet.
7. The method of the claims 1 to 6 wherein subnet relationships are defined, modified or deleted before or after, respectively the receipt of a downlink packet by the PGW.
- 15
8. The method of the claims 1 to 7 wherein the subnet relationships are defined by loading said subnet relationships in a PGW configuration system of the PGW.
- 20 9. The method of the claims 1 to 8 further comprising, upon receipt of the downlink packet at the PGW, checking the validity of the subnet relationships by determining which subnets are associated to which cellular equipment address by a subnet relationship, and forwarding the downlink packet only in case of validity.
- 25 10. The method of the claim 9 wherein the checking of the validity of the subnet relationships comprises checking that a subnet does not conflict with a cellular equipment address, checking that the cellular equipment address

matches an address allocated by the PGW and checking that subnet relationships do not conflict with each other.

11. The method of the claims 1 to 10, wherein the destination and the cellular
5 equipment's addresses are IP addresses.

12. The method of claim 11, wherein the IP addresses of the cellular
equipment's are IPv4 addresses or IPv6 addresses or a mixed combination of
10 IPv4 and IPv6 addresses.

13. The method of the claims 1 to 12, wherein the bearer is a default bearer or
a dedicated bearer.

14. A computer program product comprising one or more stored sequences of
15 instructions that are accessible to a processor and which, when executed by the
processor, cause the processor to perform the steps of the method of any one of
Claims 1 to 13.

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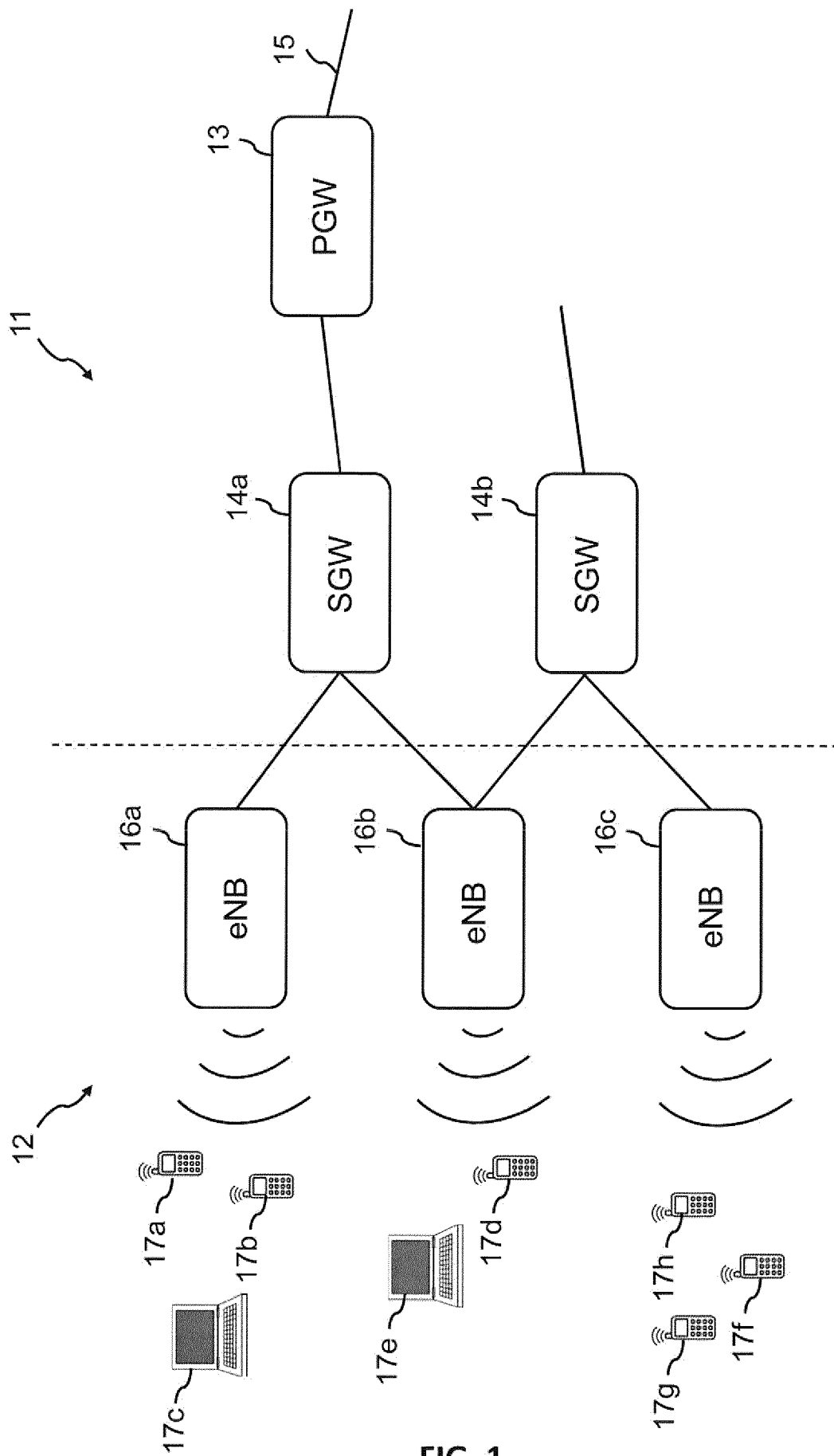


FIG. 1

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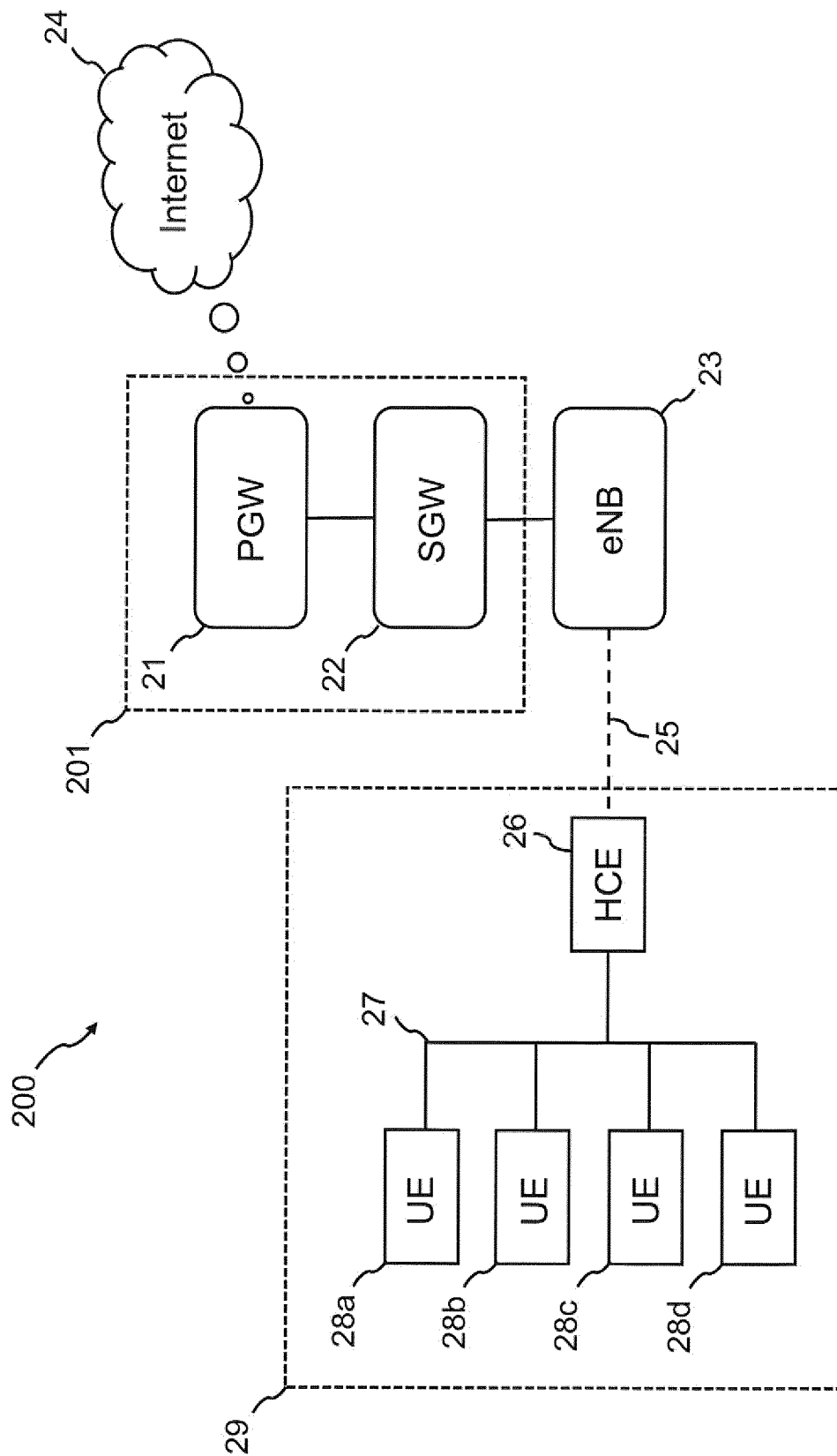


FIG. 2

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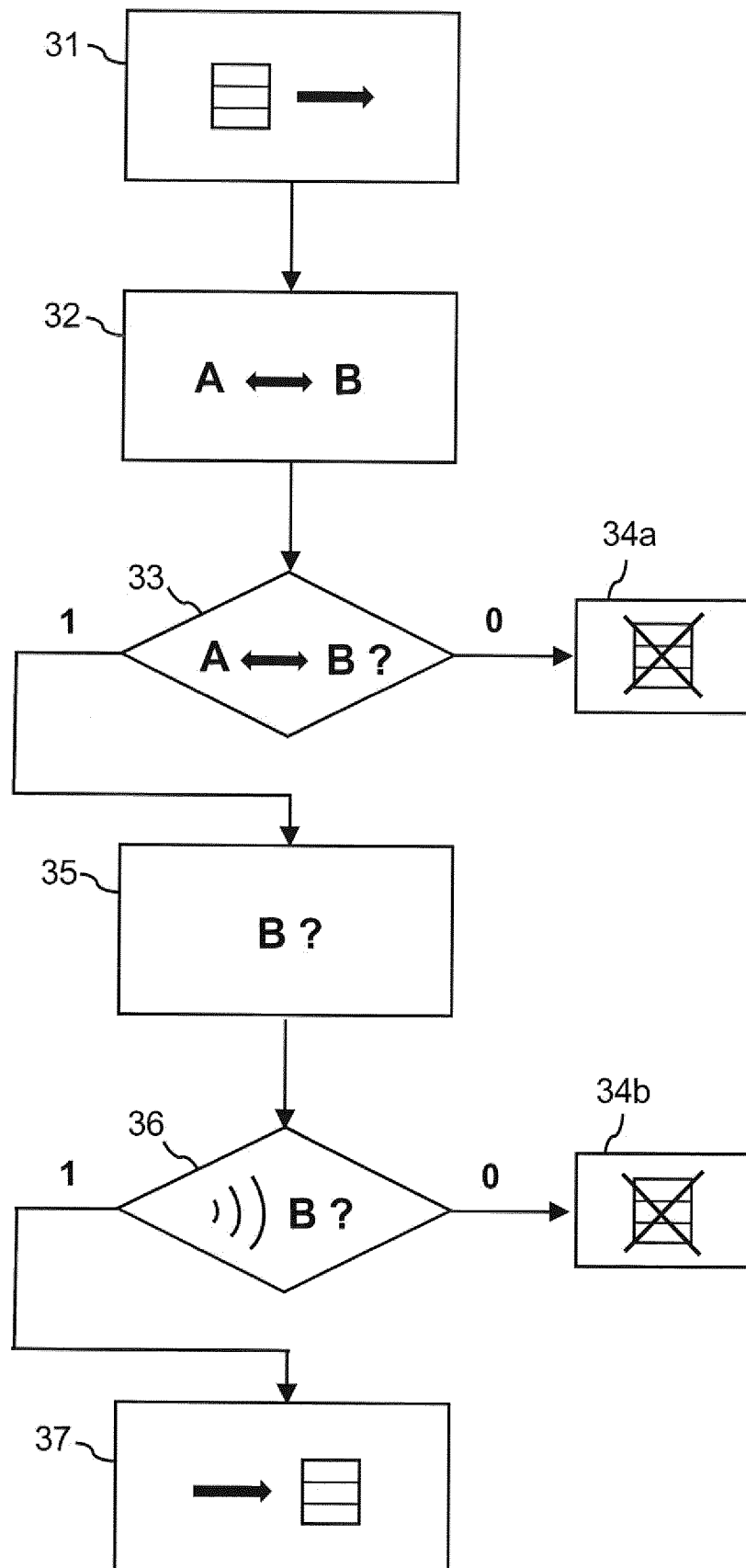


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/081112

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W8/26 H04L29/12 H04L12/28
ADD. H04W80/04

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W H04L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/148129 A1 (LUNDSTROM ANDERS [SE]) 29 May 2014 (2014-05-29) abstract; figures 1,2 paragraphs [0006] - [0014], [0029] - [0049]	1-9, 11-14
A	----- US 8 391 218 B1 (JOSHI KIRITKUMAR [US] ET AL) 5 March 2013 (2013-03-05) column 4, line 43 - column 12, line 3; figure 1	1-14
A	----- US 2016/182683 A1 (WEAR TYLER BYRON [US] ET AL) 23 June 2016 (2016-06-23) paragraphs [0030] - [0055]; figure 1 -----	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

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

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"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

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"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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