Embodiments enable local IP access or local breakout wherein a base station may add a packet network address to a connectivity request received from a terminal without a packet network address.
Local Breakout and IP address selection

FIELD
The present invention generally relates to access such as radio access and also relates to methods, apparatuses and computer program products for providing access via a radio access network to a network such as a packet-switched network, for example - but not limited to - universal mobile communications system (UMTS) or long term evolution, LTE, networks, such as LTE/ evolved universal terrestrial radio access network, EUTRAN, (incl. LTE time division duplex, TDD), or local area networks, LANs

BACKGROUND
Base stations such as home base stations, home NodeBs, femto eNodeBs (enhanced NodeBs, eNBs) or any type of access device such as an home access device (in the following generally referred to as "HNB") allow, e.g. when deployed in homes and offices, subscribers to use their existing handsets - for example in a building - with significantly improved coverage and increased broadband wireless performance. Moreover, Internet Protocol (IP) based architecture allows deployment and management in virtually any environment with e.g. broadband internet service.

In current standardization activities, deployment scenarios involving femto base stations in the context of e.g. 3G and LTE are of interest e.g. for manufacturers and operators. In 3GPP specification TS 22.220, local IP access in home based networks has been described, wherein local IP breakout (LBO) from HNB to home based networks or to the Internet has been suggested in addition to ordinary IP based services via the operator's core network. Local breakout may be used for base stations such as nodeBs, home NodeBs, enhanced NodeBs, femto base stations etc. Local breakout, LBO, means that traffic is directly routed from eNodeB to the services, e.g. to internet, home network, and vice versa. This allows bypassing operator core on the user plane and avoiding unnecessary delays and costs.
Allowing for local breakout (also referred to as "route optimization") of IP traffic enables both shortening the end-to-end route and reducing the load on relatively expensive IP backbones which inherently provides a high quality of service. Local IP access may differentiate user's local IP traffic in the base station, e.g. HNB so that local IP traffic to/from IP devices connected to home based networks may e.g. be forwarded on the shortest path so that it does not transit outside the home based network and remains intranet traffic. Moreover, local IP access traffic to the Internet does not need to transit across the operator’s evolved packet core (EPC), i.e., the Internet traffic may be forwarded to and received from the Internet via a gateway local to a base station without having to transit through the operator’s core nodes.

**SUMMARY**

Among others, it is an object of the present invention to provide a local breakout functionality allowing local handling.

In accordance with one or more embodiments of the invention, a base station such as a nodeB or eNodeB is configured to allocate at least one packet network address such as an IP address for a terminal, e.g. a mobile or stationary user equipment, UE, and to signal the allocated address to a control entity such as a mobility management entity, MME, in an easy and effective way.

The terminal does not need to have or use address allocation such a dynamic host configuration protocol, DHCP, functionality.

One or more implementations of the proposed local breakout solution are able to work without UE modifications, e.g. when IP address can be delivered in the existing messages.

The implementation allows fully transparent local breakout or IP usage for the terminal. The terminal does not need to be modified at all. The terminal does not need to risk NAS signalling security.
In accordance with one or more embodiments, a base station such as eNB supporting local breakout or local IP access allocates IP addresses for the terminals from the local area network. When a terminal sends a message to a control entity via its home cell or local IP access cell, the base station includes an address such as a selected or pre-allocated IP address for the terminal into a message to the control entity. The control entity can include this IP address value to a response or setup request message. The terminal may get a proper IP address for the local IP access service included into a packet data unit and does not need to start an address selection process such as DHCP or IPv6 address autoconfiguration process.

Advantageously, the proposed solution is suitable for simpler or lower cost terminals as well, e.g. for terminals that may not support or use IETF specified automatic IP address configuration but rely just on 3GPP proprietary signaling mechanisms.

The control entity such as mobility management, MME, may allocate the IP address after being informed by the eNodeB on the at least one local IP address assigned to the terminal.

In accordance with one or more embodiments, a base station such as nodeB supporting local breakout or local IP access allocates one or more IP addresses for the UEs from the local area network. When a terminal such as user equipment sends a message such as a NAS message to the control entity such as MME via its home cell or local IP access cell, the base station may include a pre-allocated or selected IP address for the UE into the message to the control entity, such as a S1AP: UPLINK NAS Transfer message. The control entity such as MME can now include this IP address value to a request message such as S1AP: E-RAB Setup Request message, so that the terminal gets a proper IP address for the local IP access service included into NAS-packet data unit, PDU. The terminal 10 thus does not need to start an address generation or allocation process such as a DHCP or IPv6 Address Autoconfiguration process.
The proposed solution works also with lower cost UEs that may not support IETF specified automatic IP address configuration but rely just on 3GPP proprietary signaling mechanisms.

In accordance with one or more embodiments, the proposed solution can be used in a control entity such as a mobility management entity, MME, and in a base station such as eNodeB (e.g. HomeNodeB, eNodeB).

At least some of the proposed implementations are fully transparent to the user equipment UE. No modifications are needed due to local or IP breakout.

In accordance with one or more embodiments an apparatus is provided, comprising a receiver configured to receive a connectivity request from a terminal, the connectivity request not comprising a packet network address for a packet data network for local breakout. The apparatus further comprises means for, or is configured to at least one of adding, to the received connectivity request, a packet network address assigned to the terminal for local breakout, or for generating, based on the received connectivity request, a connectivity request having a packet network address assigned to the terminal for local breakout.

In accordance with one or more embodiments, the apparatus may comprise means for, or be configured for, sending the connectivity request comprising the packet network address to a control entity, receiving a response from the control entity comprising said, or another, packet network address for local breakout, and sending the packet network address received from the control entity to the terminal for use for local breakout.

In accordance with one or more embodiments the control entity may be is a mobility management entity. The packet network address may be an internet protocol address. The apparatus may comprise a pool of local packet network addresses, and means for selecting at least one of the local packet network addresses to be added to the received or a newly generated connectivity request.
In accordance with one or more embodiments, the apparatus may comprise at least one, more or all of the following:
the apparatus is configured to generate the at least one packet network address using an external, local, or internal dynamic host configuration protocol device,
the apparatus is configured to provide a network address translation function;
the apparatus is configured to provide an address resolution protocol;
the apparatus is configured to allocate the same packet network address to all terminals attached to the apparatus;
the apparatus is configured to provide a field for the packet network address in an uplink message;
the apparatus is configured to add at least one of further information, an access point, or an access point name to the connectivity request;
the apparatus is configured to recommend whether or not local breakout is to be used.

In accordance with one or more embodiments the apparatus may be a base station device for a cellular network, or a part, module or chipset of or for a base station.

In accordance with one or more embodiments an apparatus may be configured to, or comprise means configured to send a connectivity request to a base station, the connectivity request not comprising a packet network address for a packet data network for local breakout; means for receiving a response to the connectivity request, means for checking validity of address information for local breakout included in the received response, means for deriving a valid packet network address depending on the result of the validity check.

In accordance with one or more embodiments the apparatus may be a terminal device for a cellular network, or a part, module or chipset of or for a terminal device.

In accordance with one or more embodiments, an apparatus may be configured to, or comprise a receiver configured to receive a connectivity request, the
connectivity request comprising a packet network address for local breakout for a terminal; means for checking whether local breakout is to be allowed for said terminal, means for returning a response indicating acceptance, a packet network address for said terminal for local breakout, or denial of local breakout, depending on the check result.

The apparatus may e.g. be a control entity or mobility management entity, or a part, module or chipset of or for a control device.

In accordance with one or more embodiments a method comprises:
receiving a connectivity request from a terminal, the connectivity request not comprising a packet network address for a packet data network for local breakout; at least one of adding, to the received connectivity request, a packet network address assigned to the terminal for local breakout, or for generating, based on the received connectivity request, a connectivity request having a packet network address assigned to the terminal for local breakout.

In accordance with one or more embodiments a method comprises
sending a connectivity request to a base station, the connectivity request not comprising a packet network address for a packet data network for local breakout; receiving a response to the connectivity request, checking validity of address information for local breakout included in the received response, deriving a valid packet network address depending on the result of the validity check.

In accordance with one or more embodiments a method comprises
receiving a connectivity request, the connectivity request comprising a packet network address for local breakout for a terminal; checking whether local breakout is to be allowed for said terminal, returning a response indicating acceptance, a packet network address for said terminal for local breakout, or denial of local breakout, depending on the check result.
In accordance with one or more embodiments a computer program product may comprise code means for carrying out a method as defined above or in the following description or attached drawings, when run on a computing device. The program or product may e.g. be stored on a data carrier or recording medium.

Other advantageous modifications are defined in the further claims, the description and drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The invention will now be described in greater detail based on embodiments with reference to the accompanying drawings in which:

- Fig. 1 shows a schematic network architecture with a HNB;
- Fig. 2 shows a more detailed architecture of the network system and involved network elements;
- Fig. 3 shows another implementation of a basic network configuration,
- Fig. 4 shows a signalling and processing diagram indicating signalling messages and specific processings performed at involved entities in accordance with one or more embodiments;
- Fig. 5 shows schematic block diagrams of embodiments of entities;
- Fig. 6 shows a schematic flow diagram of a processing at a terminal side;
- Fig. 7 shows a schematic flow diagram of a procedure at an access device side;
- Fig. 8 shows a schematic flow diagram of a processing at a core network side; and
- Fig. 9 shows a schematic block diagram of a software based implementation according to another embodiment.
DESCRIPTION OF EMBODIMENTS

In the following, embodiments in accordance with implementations of the present invention will be described based on an exemplary and non-limiting LTE network architecture.

Fig. 1 shows a schematic network architecture comprising at least one base station such as a home nodeB, HNB, 20 with a memory 220 for storing at least one local IP address for a terminal 10 such as a stationary or mobile user equipment in a subscriber home environment, e.g. within a building, and connected to at least one of an operator's core network (CN) 600, an IP network 500 and a home based local area network, LAN, 300 comprising an access router (AR) 30. The HNB 20 may comprise an IP switch (IP-SW) for switching IP traffic directly to the IP network 500 or the LAN 300 without involvement of the CN 600. The IP traffic may originate from or terminate at the UE 10 which optionally is wirelessly connected to the HNB 20 via an air interface. The HNB 20 which serves the UE 10 comprises an interface towards the LAN 300 and the IP network 500, which provides a termination point for the UE 10 from the LAN 300 and the IP network 500.

The gateway functionality at the HNB 20 may be simplified to operate as a switching or bridging function for user IP traffic between the LAN 300 (home based network) or the IP network 500 and an UE specific point-to-point link over the radio interface (bearer service). The switching or bridging functionality may be an IP aware functionality.

Fig. 2 shows a more detailed block diagram of network entities involved in a local IP access or local breakout, LBO, procedure and corresponding interfaces between those network entities. The exemplary network architecture of Fig. 2 is based on an evolved universal terrestrial radio access network, EUTRAN. Local breakout, \( LBO_1 \) of IP traffic via a visited public land mobile network (PLMN) is supported, when network policies and user subscription allow it. LBO
may be combined with support for multiple simultaneous packet data network (PDN) connections.

The bold dashed line in Fig. 2 separates the EUTRAN part of the network system from the evolved packet core (EPC) of the network system. The terminal or user equipment, UE, 10 is connected via a LTE-Uu interface to the base station HNB 20. The base station HNB 20 is connected via a IPv4/IPv6 interface to a Home/Local LAN 300. Additionally, the HNB 20 is connected via a S1-MME interface to at least one control entity such as a mobility management entity, MME, 30 of the EPC. This S1-MME interface forms a reference point for the control plane protocol between the EUTRAN and the MME. The MME 30 is connected via a S3 interface to a serving node such as a serving general packet radio services (GPRS) support node (SGSN) 40. The S3 interface enables user and bearer information exchange for inter 3GPP access network mobility in idle and/or active state. Furthermore, the MME 30 is connected via a S6a interface to a home subscriber server (HSS) 50 in which subscriber data are stored. The S6a interface enables transfer of subscription and authentication data for authenticating/authorizing user access to the evolved system between the MME 30 and the HSS 50. The HSS 50 is also connected to an authentication, authorization, and accounting (AAA) server 60 which manages fundamental system access functions.

The core network EPC may comprise as additional entities a serving gateway of a system architecture evolution, SAE gateway (S-GW), 70 and a packet data network, PDN SAE, gateway (P-GW) 80 which provide a gateway function to external IP networks 500. The S-GW 70 is connected via a S11 interface to the MME 30, wherein the S11 interface provides a reference point between the MME 30 and the S-GW 70. Additionally, the S-GW 70 is connected via a S1_U interface to the HNB 20, wherein the S1-U interface provides a reference point between the EUTRAN and the S-GW 70 for the per bearer user plane tunnelling and inter-HNB path switching during handover.

At the MME 30, a S10 interface provides a reference point between MMEs for MME relocation and MME to MME information transfer. The S-GW 70 and P-
GW 80 are connected via a S5 interface which provides user plane tunnelling and tunnel management between these gateways. It can be used for S-GW relocation due to UE mobility and if the S-GW 70 needs to connect to a non-co-located PDN gateway for the required PDN connectivity. It is noted that the P-GW 80 and the S-GW 70 may be implemented in one physical node or separate physical nodes. The S-GW 70 is the gateway which terminates the interface towards the EUTRAN. For each UE associated with the EPS, at a given point of time, there may be a single S-GW as a local mobility anchor point for inter-HNB handover, responsible for packet routing, forwarding and lots of other gateway functions. The P-GW 80 is the gateway which terminates the interface towards the PDN, e.g., the external IP network 500. The PDN may be any operator external public or private packet data network or an intra-operator packet data network, e.g. for provision of IP multimedia subsystem (IMS) services. If the UE 10 is accessing multiple PDNs, there may be more than one P-GW for that UE 10.

According to one or more of the embodiments, instead of terminating core network interfaces (like S5, S11, Gn or Gx for example) in the HNB 20 for controlling a subset of gateway functions (like gateway GPRS support node (GGSN) or S-/P-GW functions) for local IP access services, a simple local IP access feature may be controlled with modifications in the existing S1 control plane interface (or Iu interface for 3G systems), keeping the RRC and NAS protocols unmodified.

In such a local IP access or LBO, the LBO session management can be handled at NAS level using multiple PDN support. From the UE point of view local U-plane handling can be made transparent and LBO sessions can be mapped to an UE requested PDN connectivity if the access point name (APN) is associated to the local virtual gateway provided at the HNB 20. Then, the MME 30 can still work according to the 3GPP specifications with a modified gateway handling procedure.

Users that have no local IP access subscription (LBO subscription) or HNBs that do not support LBO can use conventional EPS bearer services provided by
the core network. The UE 10 may be anchored to the MME 30 on the control plane. The default EPS bearer service may be activated and handled from the S-GW 70 and/or the P-GW 80 of the core network (EPC). Thus, according to some embodiments, the S11 control interface may be omitted at the HNB 20.

Fig. 3 shows another implementation of a basic network configuration wherein a base station 20 such as a nodeB or enhanced nodeB is connectable, or able to communicate, with one or more IP-based networks 500 via a local breakout LBO, a gateway such as gateway 70 of Fig. 2, and a server such as a mobility management entity 30.

Fig. 4 shows a signalling and processing diagram which indicates messages, procedures and processing in connection with a terminal requested PDN connectivity procedure for local IP access or LBO setup, in accordance with one or more embodiments of the invention.

In accordance with one or more embodiments, a base station such as nodeB 20 supporting local breakout or local IP access allocates one or more packet data network addresses such as IP addresses for the terminals 10 from or for the local area network. When a terminal such as user equipment 10 sends a connectivity request message such as a NAS message to a control entity such as a mobility management entity MME 30 via its home cell or local IP access cell, the base station eNB 20 may include a selected or pre-allocated packet data network address such as an IP address for the UE 10 into the message to the control entity 30, such as a S1AP: UPLINK NAS Transfer message. The control entity 30 can now include this packet data network address such as IP address value to a request message such as S1AP: E-RAB Setup Request message, so that the terminal 10 gets a proper packet network address such as IP address for the local packet network, e.g. IP, access service included into NAS-packet data unit, PDU. The terminal 10 thus does not need to start an address generation or allocation process such as a DHCP or IPv6 address autoconfiguration process.
The proposed solution may be applied to terminals of any kind and works also with lower cost UEs that may not support IETF specified automatic IP address configuration but rely just on 3GPP proprietary signaling mechanisms.

The proposed solution may be fully transparent to the terminal, and no modifications are needed due to local breakout.

In accordance with one or more embodiments, the base station such as a nodeB or eNodeB keeps at least one, some or a pool of free local packet network addresses such as IP addresses. The at least one free local free address can be provided or generated e.g. using a local DHCP server. In accordance with one or more embodiments, the base station such as the nodeB or eNodeB can keep the pool ready, or allocate a new address using e.g. DHCP only when needed. The base station may alternatively or additionally allocate one or more free packet network addresses by itself, e.g. when the base station is, or has the function of, a local DHCP server by itself.

The base station may additionally or alternatively use network address translation, NAT, and may allocate always the same packet network address such as IP address to all terminals attached to the base station.

Other means can also be used e.g. address resolution protocol ARP.

When the base station receives a connectivity request such as a packet data network, PDN, connectivity request from the terminal, the base station such as eNodeB may insert a valid IP address that can be used, to the connectivity request sent to the the control entity such as MME and/or to a response sent to the terminal, if the control entity, MME, decides to use or allow LBO. A new field may be provided for this packet network address which may be the only mandatory addition to the whole signalling. This field optionally is additional to UPLINK NAS transfer message part.

Additionally or alternatively, it is possible to add also other information to the connectivity request that the base station can use to inform e.g. about an
access point or access point name, APN. In principle, most of the extra information can be similar to the information that the control entity MME receives from a gateway of the network, e.g. PDN GW, when LBO is not used.

The base station 20 may even recommend that local breakout is or can be used.

Additionally or alternatively, the control entity 30 such as MME makes a decision whether it wants to allocate LBO for a requesting user. If not, then the control entity may just omit or disregard the extra values the base station has inserted.

If local breakout, LBO, is to be used or allowed for the requesting user, the control entity 30 can add the correct IP address that the control entity had received in the connectivity request, e.g. PDN connectivity, from the base station, to the response to the base station, e.g. an E-RAB Setup request. This allows that the terminal can receive a response message such as a reconfiguration message, e.g. a NAS message, with a correct IP address. Local breakout then works without any modifications to the terminal 10.

As can be gathered from Fig. 4, when the UE 10 detects, in a process or step 1, an LBO service e.g. based on a corresponding broadcast information, it starts network entry. In a subsequent or earlier or parallel process or step 2, the base 20 gets one or more local IP addresses for one or more possible terminals 10, and optionally stores these local IP addresses. The user equipment 10 sends a packet data network, PDN, connectivity request message 3, e.g. via a radio resource control, RRC, direct transfer in uplink (UL) direction to the HNB 20 (step 3) which can act as a dynamic host configuration protocol, DHCP, relay. The HNB 20 adds in step or process 4, one or more local IP addresses that can be used for the user equipment 20, e.g. by selecting one or more IP addresses as derived or stored in step 2. The base station 20 forwards the received connectivity request together with the added IP addresses via the S1 interface as an uplink NAS transfer to the MME 30 (step 5). The connectivity request may include an access point name, APN pointing to a virtual gateway at the HNB 20.
The MME 30 verifies in a step 6. the UE subscription for LBO e.g. by initiating a query to the HSS 50 or a corresponding subscriber data base. Based on the result of the query, the MME 30 issues an E-RAB Setup Request message 7 including a NAS packet data unit (PDU) via the S1 interface (step 7).

In accordance with one or more embodiments, in a step or process 8, the base station 20 detects that the user equipment 10 is requesting for local breakout, e.g. due to tunneling end point identifier TEID and transmission network layer TNL address being zero, and configures a gateway such as a virtual S-/P-GW.

E.g. based on the information given in the E-RAB Setup Request message 7, the base station HNB 20 modifies its user equipment radio access network, UE RAN, context, optionally initializes a dynamic host configuration protocol, DHCP client (step or process 9) and sends an RRC connection reconfiguration message 10. including the NAS-PDU to the UE 10. The user equipment 10 thus gets the correct IP address from the MME entity 30. In step 11, the UE 10 responds with a RRC Connection Reconfiguration Complete message based on which the HNB 20 enables user plane connectivity.

If the E-RAB Setup Request message 7. from the MME 30 does not contain valid network address and TEID (Tunnel End Point Identifier) value for establishing a GTP tunnel on the S1 user-plane, the HNB 20 detects that bearer setup is for a Local IP Access service using a HNB internal virtual gateway function.

The connection reconfiguration message 10. from the HNB 20 comprises one or more IP addresses for the UE 10, so that the UE 10 does not need to initiates an address configuration procedure at a DHCP client. Based on the received IP address, the UE 10 may configure its packet data network context, access point name, and IP stack in a step or process 13.
The base station HNB 20 may store the IP context of the UE 10. Of course, other address configuration procedures, such as IPv6 address auto-configuration or the like may be used in the base station 20 as well. The base station HNB 20 may forward in step 12 a E-RAB Setup Response message to the MME 30 and broadcasts in step 14 to all nodes a notification or request with the own IP address allocated to the UE 10 as a target address in order to check whether this IP address is used more than once and/or to update tables or stacks in other nodes. This notification 14. may be a gratuitous address resolution protocol, ARP, request packet, wherein "gratuitous" in this case means a request/reply that is not normally needed according to the ARP specification but may be used in some cases. As an alternative, a corresponding IPv6-N-adv (Neighbor Advertisement) message may be sent.

In accordance with one or more embodiments the control entity such as MME may send one or more zero addresses as local IP addresses to the base station which may forward the one or more zero addresses to the terminal. When the terminal receives the one or more zero addresses, the terminal may start to use a process such as e.g. DHCP for deriving a valid IP address.

The base station may keep some pool of free local IP addresses. This can be done e.g. using local DHCP server, or even eNodeB can allocate those addresses by itself, e.g. if it is local DHCP server by itself. It can even use NAT and allocate always same address to all UEs.

Other means can also be used e.g. ARP.

Regarding the connectivity request such as a packet data network, PDN, connectivity request, the base station such as eNodeB optionally inserts a valid IP address that can be used, if MME decides to use or allow local breakout, LBO. This new field is the only mandatory addition to whole signalling in this embodiment. This field is additional to UPLINK NAS transfer message part.

It is also possible in this or other embodiments, to add other information so that the base station eNodeB can inform e.g. about access point or access point
name, APN. In principle, most of the extra information may be similar to the information the control entity such as MME will receive from a packet data network gateway PDN GW, when LBO is not used.

In accordance with one or more embodiments, the base station may even recommend that LBO can or is to be used.

In accordance with one or more embodiments, the control entity such as MME makes a decision, if it wants to allocate LBO for that user(s). If not, the control entity may just omit the extra values such as IP address or other information inserted by the base station involved.

If LBO will be used, the control entity can add the correct IP address that was received in the e.g. PDN connectivity request to the setup request, e.g. E-RAB Setup request (step 7 of Fig. 4). This allows the terminal 10 to receive the NAS message (step 10) with correct IP address (and then LBO works without any modifications to terminal UE.)

Since the virtual gateway functions may be co-located in the HNB 20, the S1-U and S5-U GTP tunnels become internal issues of the HNB 20 and are thus not needed, which means that all related GTP tunnel configuration data (e.g. TEIDs) can be omitted. The base station 20, or the MME 30, may act as a decision manager and may know all local IP access bearer service parameters which can be used by or delivered to the HNB 20.

An enhancement for the E-RAB Setup Request via the S1 interface could be the use of the APN aggregate maximum bitrate (AMBR) parameter for LBO bearer(s). This would allow guaranteeing a certain relation of the resource usage of the LBO bearer(s) compared to the bearers carried via the operator network. This or other traffic shaping parameters can be provided to the HNB 20 by management or manual configuration generally for all APNs. E.g., n percent of the backhaul of RAN capacity of core network based bearers (e.g. default EPS bearers) could be reserved. IP address(es) for the UE 10 are assigned from the IP subnet or LAN where the HNB 20 is connected, i.e., locally.
with assistance of the HNB 20 or itself by the UE 10. In case flatrate charging is used in connection with the local IP access or LBO, charging functions can be omitted in the HNB 20.

The local IP access or LBO bearer service can be configured in the HNB 20 without S11 interface or other interfaces with core network gateways by using only the S1 interface ("S1+") requiring minimal modifications of the use of the S1 setup protocol and for example in the Bearer setup request and bearer setup response messages (e.g. E-RAB Setup Request and E-RAB Setup Response).

Fig. 5 shows schematic block diagrams of the terminal, UE, 10, the base station HNB 20 and the control entity MME 30. It is noted that this block diagram is a simplified representation without separation of control plane and user plane connections.

The UE 10 comprises a radio frequency (RF) unit 101 which is configured to transmit and receive radio signals via the radio interface (e.g. LTE-Uu interface) towards the HNB 20 of the radio access network, RAN. Furthermore, the UE 10 comprises a LBO control function or unit 104 configured to perform LBO related processing and detect LBO related signalling. The LBO control unit 104 checks received messages or broadcast information from the RAN, detects LBO services and initiates LBO related network entry if it has detected an LBO service. Furthermore, the initial LBO related message exchange with the MME 30 via the HNB 20 indicates that at least one IP address has been reserved or proposed for the UE 10. Otherwise, an address selection procedure may be initiated by an address selection function or unit (AS) 102 which provides information to a message generator (MG) function or unit 105 to initiate an address configuration operation, e.g., based on DHCP or IPv6. Messages generated at the message generator unit 105 are transmitted via the RF unit 101 to the radio interface. The address selection unit 102 can access an access point name, APN, storage 103 where APNs can be stored for various connections or purposes.
The HNB 20 also comprises a RF unit 201 in order to enable communication to UEs or other terminal devices via the radio interface. Traffic received via the RF unit 201 can be monitored in a traffic monitoring function or unit (TrM) 202. Additionally, traffic received from the RF unit 201 or sent to the RF unit 201 can be forwarded via a traffic bridging function or unit (TrB) 203 which provides a bridging function between radio bearer services and PDN related connections.

Thereby, a direct bridging or switching function can be achieved between the MME 30 and the UE 10.

Furthermore, the HNB 20 comprises a LBO control function or unit 204 which is configured to control a gateway configuring function or unit (GWC) 205 which can access a context storage unit (CT) 208. The storage unit 208, or another memory, can additionally or alternatively store one or more local IP addresses which can be used for a user equipment 10 requesting local breakout, as described above. The traffic monitoring unit 202 and the gateway configuring unit 205 both can control the traffic bridging unit 203. Traffic flowing through the traffic bridging unit 203 is routed to or from a transceiver unit (TRX) 301 of the MME 30 via the S1 interface. The traffic received from or transmitted to the transceiver unit 301 can be supplied to a LBO control function or unit 304 which controls a tunnel configuration function or unit (TC) 305 configured to provide tunnel configuration signalling towards the core network. The LBO control unit 304 accesses the HSS 50 or another subscriber-related data base 90 in order to derive LBO-related parameters needed to establish local IP access or LBO.

It is noted that the functions or unit described in connection with Fig. 5 can be implemented as discrete hardware units or circuits or as software routines controlling a processor unit or several processor units provided at the UE 10, the HNB 20 and/or the MME 30.

In the following, flow diagrams describing the LBO or local IP access related functions at the UE 10, the HNB 20, and the MME 30 are described in more detail based on Figs. 6 to 8.
Fig. 6 shows a schematic flow diagram of an LBO or local IP access related processing at the UE 10. When the UE 10 (e.g. the LBO control unit 104) detects a LBO service, an APN which points to the virtual gateway at the HNB 20 is selected in step S101 (e.g. by the address selecting unit 102). Then, a connectivity request (e.g. generated by the message generator 105) is sent with the related APN to the network targeted to MME 30 in step S102.

Now, the UE 10 waits for receipt of a reconfiguration message (step S103). If a reconfiguration message is received, the NAS PDU provided in the reconfiguration message is checked in step S104 (e.g. by the LBO control unit 104). Further, an IP address assigned to the user equipment 10 and received with the reconfiguration message is checked, and the received IP address is used, step S105. Finally, the UE 10 responds to its application layer that IP connectivity is available with the selected APN and IP address, step S108, using the local IP access or LBO with virtual gateway function at the HNB 20.

Fig. 7 shows a schematic flow diagram of a local IP access or LBO related processing at the HNB 20. The procedure of Fig. 7 may be initiated when the HNB 20 receives a connectivity request, e.g. a packet data connectivity request, from the user equipment 10, e.g. message 3. of Fig. 4, or may also start when receiving a bearer setup request from the MME 30. In step S201, the HNB 20 selects an IP address, e.g. from a pool of free local IP addresses stored for one or more user equipment 10, and inserts or adds the selected IP address to the connectivity request message to be sent to the entity 30. The base station 20 may also detect bearer-related parameters (e.g. at the LBO control unit 204) and check in step S202 whether a local access type is requested e.g. based on the received IP address or a predetermined network address and TEID values (e.g. zeroes) in the message (e.g. by the LBO control unit 204).

If so, a virtual gateway at the HNB 20 may be configured in step S203 (e.g. under control of the LBO control unit 204).

In step S204, the context of the UE 10 to which the LBO is related is modified (e.g. in the context storage 208 under control of the gateway configuring unit 205). Then, in step S205, a connection reconfiguration request is generated
based on the detected bearer-related parameters (e.g. by the LBO control unit 204) and sent to the UE 10.

Now the HNB 20 waits for receipt of a connection reconfiguration complete message (step 206). If a reconfiguration complete message is received and local access type is determined to be set (step 207), the procedure continues in step S208, where the UE traffic is monitored and the local IP address selected for the user equipment 10 in step S201, or a received local UE IP address is added to the UE context (e.g. by the traffic monitoring unit 202). Then, in step S209 user traffic between the radio bearer service and the IP based PDN is transmitted for the local IP access or LBO. In step S210, local traffic may be aligned with allowed Quality of Service (QoS) according to the allowed maximum bitrate if defined in the bearer-related parameters. The base station 20 may broadcast a gratuitous or IPv6 neighbor advertisement in step S211.

Fig. 8 shows a schematic flow diagram of a local IP access or LBO related processing at the MME 30.

When a connection request is received from the UE 10 via the HNB 20, the procedure is triggered. In step S301 LBO subscription is verified (e.g. by the LBO control unit 304 based on a query of the HSS 50). If it is determined in step S302 that LBO is not allowed, the MME 30 may optionally respond to the UE 10 via HNB 20 with a connectivity rejection message, and the procedure ends. Otherwise, a corresponding parameter setting which indicates connectivity rejection may be signalled in subsequent steps. If LBO is allowed, an IP address received for the user equipment 10 in the connection request is used and subscription parameters are obtained in step S304 (e.g. based on a query at the HSS 50 or the other data base 90).

Based on the obtained subscriber parameters, a corresponding LBO profile is selected in step S305 (e.g. by the LBO control unit 304). Then, in step S306 a bearer setup request with corresponding default parameter values and the received local IP address, or a revised IP address for the user equipment 10, is
sent. The default parameter values indicate the LBO profile (e.g. whether GPRS tunnel protocol, GTP, tunnelling is required, etc.).

Then, the procedure checks in step S307 whether tunnelling is required, e.g. based on a corresponding parameter provided in the setup response. If tunnelling is required, e.g. since the virtual gateway at the HNB 20 is not used, a GTP tunnel is setup in step S308 (e.g. by the tunnel configuration unit 305). Furthermore, the S11 bearer between the external gateway of the core network and the HNB 20 is updated in step S309. If no tunnelling is required, the procedure ends directly after step S307.

In the following, implementation options for the above embodiments are described in more detail.

The HNB may detect based on received predefined (e.g. zero) values in the transport layer address and TEID information elements that this bearer setup is intended to use a co-located (internal) virtual gateway for the local IP access or LBO service. Thus, instead of setting up a GTP tunnel endpoint for the S1-U connection, the HNB configures its local virtual gateway function according to the received bearer parameters.

Then, the HNB can send the connection reconfiguration message in order to configure the radio bearer service for the requested radio bearer with the given parameters. In this message the HNB can forward among other information the NAS PDU that is the response from the MME to the UE's connectivity request. The UE configures its EPS bearer service according to the parameters received in the reconfiguration message and the NAS PDU and responds to the HNB with the connection reconfiguration complete message. The message can include the LBO addresses and DHCP or other means are not needed to get IP address or addresses to the UE. If the received PDN address in the NAS PDU had a value zero, the UE can prepare itself to configure an IP address for this PDN connectivity (local IP access or LBO) using either DHCP or IPv6 address auto-configuration or the like over the newly established EPS bearer service. Correspondingly, the HNB can prepare to monitor UE traffic over the newly
established bearer service in order to assist the UE either as a DHCP relay or a proxy function in IPv6 neighbour discovery procedures towards the LAN.

The proposed approach provides the advantage of a simplified LBO control procedure with minimal number of messages using an interface between the access network and the core network with no need for terminating additional core network interfaces at the access node (e.g. HNB) of the access network. Additionally, a simplified implementation of a local IP mobility function is enabled in inter-HNB handovers with LBO in L2 switched LAN networks like home/office/campus LANs without a need to perform S-/P-GW relocation procedures on every handover, as it would be the case if other interfaces (like the S11 interface) would be terminated at the HNB. Now, the management of the co-located virtual gateway for a simple local IP access can be handled locally after the local IP access service has been setup. In inter-HNB handovers there is no need to perform tunnel path switching for local IP access bearer services via the MME to the S-GW. Furthermore, NAS and RRC interfaces do not need to be modified.

Implementation of the MME functionality can be based on an attach to a home cell or a use of UE requested PDN connectivity procedure in the home cell (with APN or default APN indicator). The MME can check if a local breakout bearer (LBB) shall be established. Criteria for this check are whether the UE is in the home cell (according to the cell identifier) or whether it accesses a network that can provide a local IP access. Additionally, a criteria could be whether the APN is allowed for LBO (e.g. a dedicated APN or a default APN), or whether the UE is allowed for LBO (by checking the subscription data). Additionally, the MME can check if the UE is allowed for CSG access (e.g. located in a home cell based on the cell identifier or the HNB address information) or is located in a HNB area with LBO possibility. In this case, the MME may perform optionally a gateway selection procedure, wherein a reserved value of the S-/P-GW address (e.g. 127.0.0.1) may indicate that the UE requests LBO and that LBO is allowed for this APN. Or, the MME may decide if LBO is allowed for that APN with a new procedure. The MME may apply operator policies for LBO allowed APNs (like for the Internet) to allow LBO or not. In certain conditions, the LBO possibility
may be overruled and the MME may assign a gateway address of the mobile network operator.

Additionally, the MME may check if LBO is allowed for that user (based on subscription data stored in the HSS). For this purpose, the subscription data in the HSS could be enhanced and/or a maximum APN restriction feature could be used to decide whether LBO is allowed in parallel to other mobile network operator bearers if other bearers of that UE are established through the operators S-GW and P-GW (for the UE requested PDN connectivity procedure). To setup the LBO, the MME may setup a session management context for that bearer that can be identified in later procedures as LBO (e.g. by an LBO indicator, a reserved S-/P-GW address or a stored APN). This contact triggers a special LBO handling in the MME for later actions for that bearer. The MME may skip gateway selection procedures and may assign a reserved value for the P- and S-GW addresses. Additionally, the MME may skip a create default bearer request procedure.

Furthermore, the MME may select the right LBO profile to setup the message parameters for the bearer setup request. The reserved S-GW address or a LBO indicator may indicate to the HNB that an LBB shall be used.

In case of a handover from a home to a macro cell, the handover can be performed for the bearers that are terminated in the operator network only. In case of an EUTRAN internal handover, the HNB may remove the LBB from the list of bearers to be handed over (SAE bearer setup list) and releases the bearer towards the UE. The MME removes those bearers marked as LBB from the UE session management context.

Fig. 9 shows a schematic block diagram of an alternative software-based implementation according to another embodiment. The required functionality can be implemented in any base station type network entity 400 with a processing unit 410, which may be any processor or computing device with a control unit which performs control based on software routines of a control program stored in a memory 412. The control program may also be stored separately on a computer readable medium. Program code instructions are
fetched from the memory 412 and are loaded to a control unit of the processing unit 410 in order to perform the processing steps of the device-specific functionalities described in connection with Figs. 3 to 8, which may be implemented as the above mentioned software routines.

The processing steps may be performed on the basis of input data DI and may generate output data DO. In case of the processing performed at the terminal device (e.g. UE), the input data DI may correspond to a signalling received via the radio interface and the output data DO may correspond to the connectivity request and/or connection reconfiguration complete message. In case of the processing performed at the access device (e.g. HNB), the input data DI may correspond to messages received from the core network (e.g. MME) and the output data DO may correspond to the bearer setup response issued to the core network. In case of the processing at the core network entity (e.g. MME), the input data DI may correspond to messages received via the S1 interface and the output data DO may correspond to the bearer setup request issued to the access device.

Consequently, the functionalities of the above embodiments of the terminal device, access device and core network entity may be implemented as respective computer program products comprising code means for generating each individual step of the processing and/or signalling procedures for the respective entities or functions when run on a computer device or data processor of the respective entity.

Embodiments of the present invention thus relate to methods, apparatuses, and computer program products for interrelated entities of a network system for providing access via a cellular access network to a packet network, wherein a local IP access or local breakout (LBO) feature is provided, which may use a bridging function between a packet data network interface and a radio interface at an access device (e.g. base station device or (H)NB) that can be controlled by a single control plane interface.
It is apparent that the invention can easily be extended to any network environment where an access device of a radio access network is connected to a core network having a mobility management entity or a similar entity and corresponding gateway functionalities for providing access to other PDN networks. Any of the features described above or shown in the drawings may be used alone or in any arbitrary combination, and may represent respective implementations of the invention. The sequence of any one of the steps described above or shown in the drawings may be freely altered. The invention is not intended to be restricted to the specific messages explained in connection with the drawings but can be extended to any corresponding messages having the same or similar or other functionalities. In addition, the invention is not limited to the described interfaces and can be extended to any interface between an access device of a radio access network and a mobility management entity or similar entity of a core network.
Claims

1. An apparatus comprising:
a receiver configured to receive a connectivity request from a terminal, the
connectivity request not comprising a packet network address for a packet data
network for local breakout;
means for at least one of adding, to the received connectivity request, a packet
network address assigned to the terminal for local breakout, or for generating,
based on the received connectivity request, a connectivity request having a
packet network address assigned to the terminal for local breakout.

2. An apparatus according to claim 1, comprising
means for sending the connectivity request comprising the packet network
address to a control entity,
means for receiving a response from the control entity comprising said, or
another, packet network address for local breakout, and
means for sending the packet network address received from the control entity
to the terminal for use for local breakout.

3. An apparatus according to any one of the preceding claims
wherein the control entity is a mobility management entity.

4. An apparatus according to any one of the preceding claims
wherein the packet network address is an internet protocol address.

5. An apparatus according to any one of the preceding claims,
comprising a pool of local packet network addresses, and means for selecting
at least one of the local packet network addresses to be added to the received
or a newly generated connectivity request.

6. Apparatus according to any one of the preceding claims,
comprising at least one of:
the apparatus is configured to generate the at least one packet network address using an external, local, or internal dynamic host configuration protocol device; the apparatus is configured to provide a network address translation function; the apparatus is configured to provide an address resolution protocol; the apparatus is configured to allocate the same packet network address to all terminals attached to the apparatus; the apparatus is configured to provide a network address translation function; the apparatus is configured to provide an address resolution protocol; the apparatus is configured to allocate the same packet network address to all terminals attached to the apparatus; the apparatus is configured to provide a field for the packet network address in an uplink message; the apparatus is configured to add at least one of further information, an access point, or an access point name to the connectivity request; the apparatus is configured to recommend whether or not local breakout is to be used.

7. The apparatus according to any one of the preceding claims, wherein said apparatus is a base station device, or a part, module or chipset of or for a base station.

8. An apparatus, comprising means configured to send a connectivity request to a base station, the connectivity request not comprising a packet network address for a packet data network for local breakout; means for receiving a response to the connectivity request, means for checking validity of address information for local breakout included in the received response, means for deriving a valid packet network address depending on the result of the validity check.

9. The apparatus according to claim 8, wherein said apparatus is a terminal device, or a part, module or chipset of or for a terminal device.

10. An apparatus comprising:
a receiver (204) configured to receive a connectivity request, the connectivity request comprising a packet network address for local breakout for a terminal; means (205) for checking whether local breakout is to be allowed for said terminal,
means for returning a response indicating acceptance, a packet network address for said terminal for local breakout, or denial of local breakout, depending on the check result.

11. An apparatus according to claim 10 wherein the apparatus is a control entity or mobility management entity, or a part, module or chipset of or for a control device.

12. A method comprising:
receiving a connectivity request from a terminal, the connectivity request not comprising a packet network address for a packet data network for local breakout;
at least one of adding, to the received connectivity request, a packet network address assigned to the terminal for local breakout, or for generating, based on the received connectivity request, a connectivity request having a packet network address assigned to the terminal for local breakout.

13. A method, comprising
sending a connectivity request to a base station, the connectivity request not comprising a packet network address for a packet data network for local breakout;
receiving a response to the connectivity request,
checking validity of address information for local breakout included in the received response,
deriving a valid packet network address depending on the result of the validity check.

14. A method comprising:
receiving a connectivity request, the connectivity request comprising a packet network address for local breakout for a terminal;
checking whether local breakout is to be allowed for said terminal,
returning a response indicating acceptance, a packet network address for said terminal for local breakout, or denial of local breakout, depending on the check result.
15. A computer program product comprising code means for carrying out a method as defined in any one of claims 12, 13, or 14, when run on a computing device.
UE gets the correct IP address from MME and it will be used RRC message without problems.

10. RRC: RRC Connection Reconfiguration (..., NAS-PDU)
11. RRC: RRC Connection Reconfiguration Complete (,...)

13. Configure PDN Context APN and IP Stack

12. S1AP: E-RAB Setup Response (,...)

14. Broadcast Gratuitous ARP or IPv6 Neighbor Advertisement

Local IP Connectivity Local IP Breakout

Fig. 4
LBO service detected

S101
Select APN which points to virtual GW

S102
Send connectivity request with related APN

Reconfig. message received?
S103

Yes

S104
Check NAS PDU

S105
Use Received IP address

S106
Respond with IP address

End

Fig. 6
Connectivity request received

S201 Select and Insert IP Address

Local access type? S202

Yes

S203 Configure virtual GW

No

S204 Modify UE Context

S205 Generate and send connection reconfiguration request based on detected bearer-related parameters

Connection reconfiguration complete received? S206

Yes

Local access type? S207

No

S208 Monitor UE traffic and add local UE IP address to UE context

S209 Bridge user traffic between radio bearer service and IP based PDN for local IP access

Yes

S210 Align local traffic with allowed QoS according to maximum bitrate

S211 Broadcast Gratuitous ARP or Neighbor Advertisement

End

Fig. 7
Connection request received

S301 Verify LBO subscription

LBO allowed? S302

No

Obtain subscriber parameters S304

Select LBO profile S305

Send setup request with default values and local IP address S306

Tunneling required? S307

Yes

Setup GTP tunnel S308

Update S11 bearer S309

End

Yes

Respond with connectivity rejection message S303

Fig. 8
Fig. 9
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INVT. H04W8/08  H04L29/12

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 practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<th>Relevant to claim No</th>
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<td>WO 2009/024182 A (ERICSSON TELEFON AB L M [SE]; SUGIMOTO SHINTA [JP]; KATO RYOJI [JP]) 0) 26 February 2009 (2009-02-26) abstract page 2, line 1 - page 2, line 9 page 14, line 14 - page 16, line 25</td>
<td>1-7, 12, 15</td>
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<td>A</td>
<td>GUNDAVELLI K LEUNG CISCO V DEVARAPALLI AZAIRE NETWORKS K CHOWDHURY STARENT NETWORKS B PATIL NOKIA SIEMENS NETWORKS S: &quot;Proxy Mobile IPv6; draft-i.etf-net.lmm.proxymi.p6-00 .txt.&quot; IETF STANDARD-WORKING-DRAFT, INTERNET ENGINEERING TASK FORCE, IETF, CH, vol. net1r1m, 8 April 2007 (2007-04-08), XP015049635 ISSN: 0000-0004 paragraphs [0003], [0006], [06.3]</td>
<td>1-7, 12, 15</td>
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**X** Further documents are listed in the continuation of Box C

**X** See patent family annex

- Special categories of cited documents
  - `A` document defining the general state of the art which is not considered to be of particular relevance
  - `E` earlier document 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

- Other special categories of cited documents
  - `T` later document published after the international filing date or priority date and 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
  - `Z` document member of the same patent family

**Date of the actual completion of the international search**

19 January 2010

**Date of mailing of the international search report**

23/03/2010

**Name and mailing address of the ISA/Authorized officer**

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

GoI er, Wolfgang
<table>
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INTERNATIONAL SEARCH REPORT

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

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

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

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

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

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

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

see additional sheet

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

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

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

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-9,12,13,15(part)

Remark on Protest

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

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

[ ] No protest accompanied the payment of additional search fees.
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9,12,13,15(part)
   
   Receiving a connectivity request not comprising a packet network address and adding a packet network address thereto.

2. claims: 10,11,14,15(part)
   
   Checking whether local breakout is to be allowed for a terminal.
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<td>WO 2009024182 A</td>
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