

SAE and Evolved Packet Core



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SAE/EPS Background

- ❑ Around 2005, 3GPP RAN groups initiated the LTE work and in parallel the SAE work was started in SA2 to address the system and core network aspects
- ❑ Main Objectives
 - To ensure competitiveness of the 3GPP systems in a time frame of the next 10 years and beyond
 - to enhance the capability of the 3GPP system to cope with the rapid growth in IP data traffic
 - A mechanism to support seamless mobility between heterogeneous access networks
- ❑ Important parts of such a long-term evolution included reduced latency, higher user data rates, improved system capacity and coverage, and reduced overall cost for the operator
- ❑ A key aspect of SAE vision was “flat IP Architecture” and the new LTE/SAE system was to be packet only system
- ❑ Migration aspects were to be taken into account for the above, i.e. how to migrate from the existing architecture

Brief status of Work

- 3GPP SA2 SAE/EPS work resulted in two new stage 2 technical specifications:
 - TS 23.401:GPRS Enhancements for E-UTRAN Access
 - TS 23.402:Architecture enhancements for non-3GPP accesses
- In addition several other specifications (e.g. TS 23.203 for policy Control and Charging) were updated to accommodate EPS architecture.
- Stage 2 completed June 2008
- Target completion date for stage 3 is December 2008

Evolved Packet System: EPC & EUTRAN

- ❑ Evolved Packet System (EPS) provides IP connectivity using the EPC and E-UTRAN.
- ❑ High Level Functions of EPC
 - Network Access Control Functions
 - Packet Routing and Transfer Functions
 - Mobility Management Functions
 - Security Functions
 - Radio Resource Management Functions

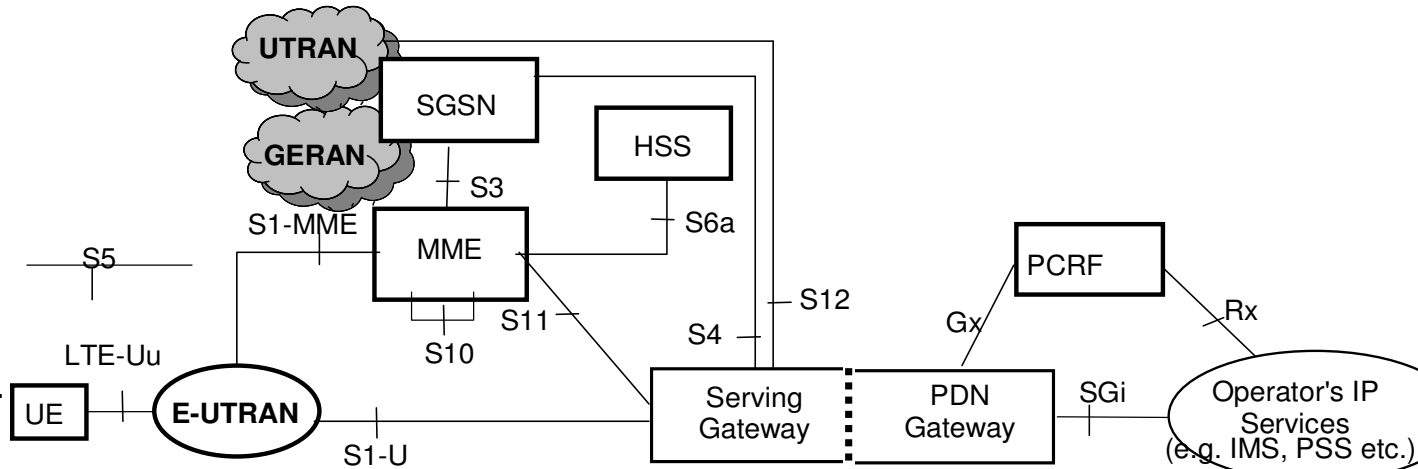
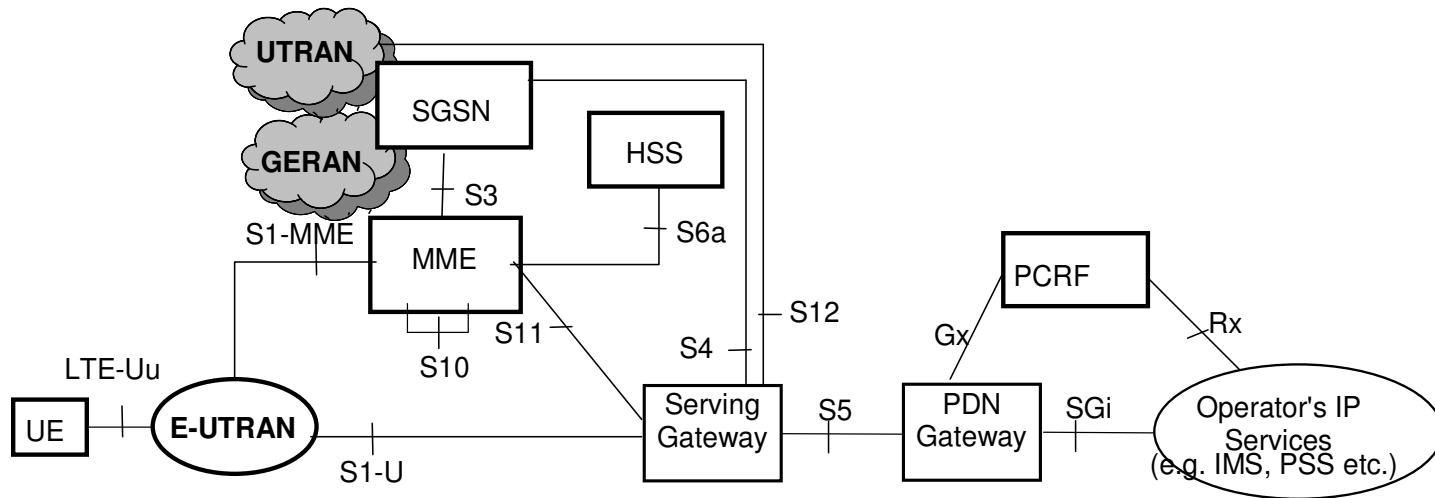
 - Network Management Functions
- ❑ Covers both roaming and non-roaming scenarios and covers all aspects, including mobility between E-UTRAN and pre-E-UTRAN 3GPP radio access technologies, policy control and charging, and authentication
- ❑ Local breakout of IP traffic via the visited PLMN is supported, when network policies and user subscription allow it. Local breakout may be combined with support for multiple simultaneous PDN connections

TS 23.401



GPRS Enhancements for E- UTRAN Access

Non-Roaming Architecture



Ref: TS 23.401

Key Evolved Packet Core Entities

Mobility Management Entity (MME)

- ❑ MME is similar in function to control plane of legacy SGSN. It manages mobility aspects in 3GPP accesses such as gateway selection, tracking area list management etc.

Serving Gateway (SGW)

- ❑ SGW terminates the interface towards E-UTRAN. It is the local mobility anchor point for inter-eNodeB handovers and also provides an anchor for inter-3GPP mobility. Other responsibilities include lawful intercept, charging and some policy enforcement.

Packet Data Network Gateway (PGW)

- ❑ PGW terminates the SGi interface towards the PDN. It is the key node for policy enforcement and charging data collection. It also provides the anchor point for mobility with non-3GPP accesses.
- ❑ SGW and PGW can be implemented in a single box.

GW selection process

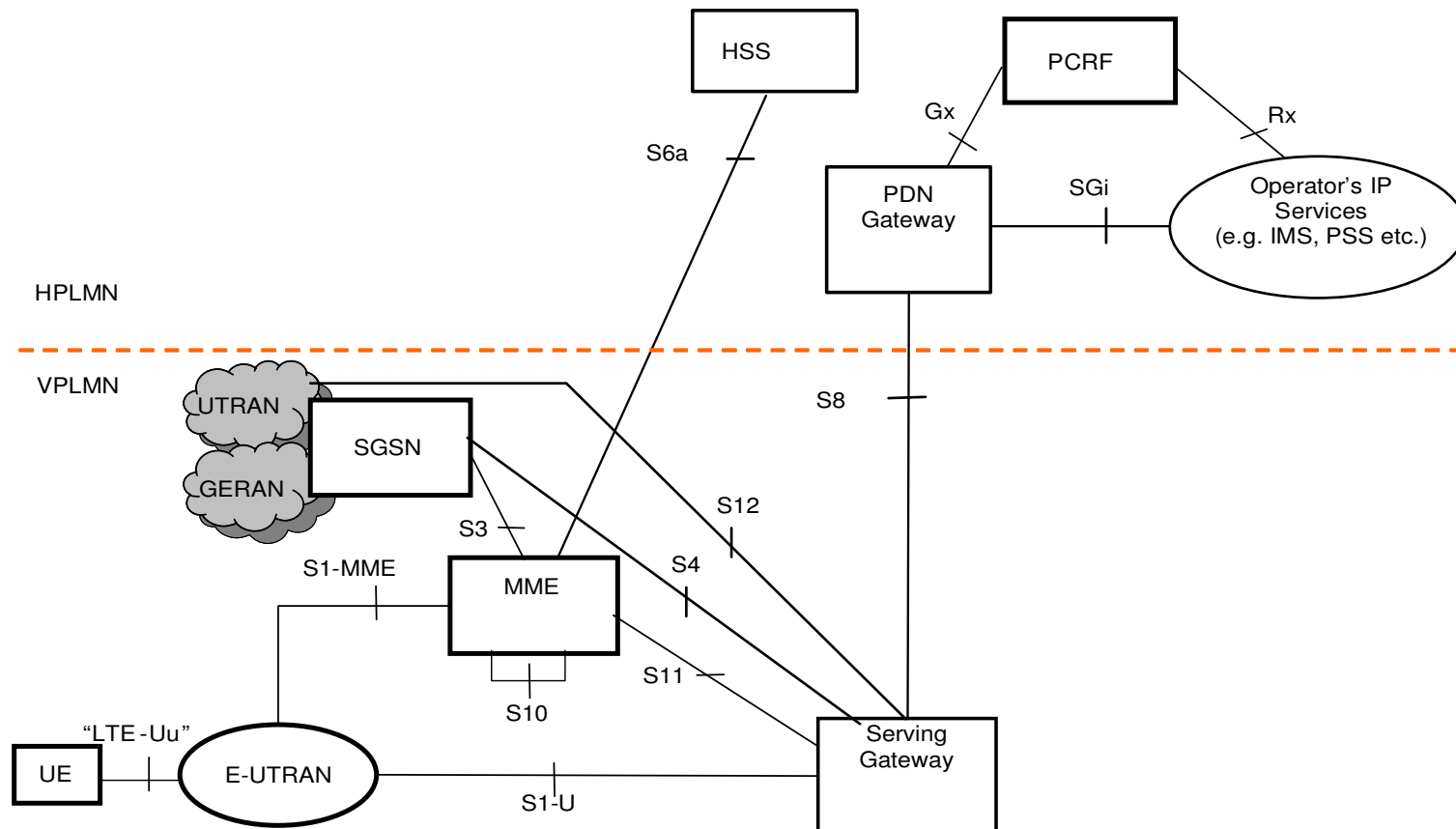
□ PDN GW selection function:

- The PDN GW selection function allocates a PDN GW that shall provide the PDN connectivity for the 3GPP access
- The function uses subscriber information provided by the HSS and possibly additional criteria. For each of the subscribed PDNs, the HSS provides:
 - an IP address of a PDN GW and an APN, or
 - an APN and an indication for this APN whether the allocation of a PDN GW from the visited PLMN is allowed or whether a PDN GW from the home PLMN shall be allocated.
- Serving GW selection function
 - The Serving GW selection function selects an available Serving GW to serve a UE
 - The selection based on network topology
 - Other criteria for Serving GW selection include load balancing between Serving GWs

PCRF

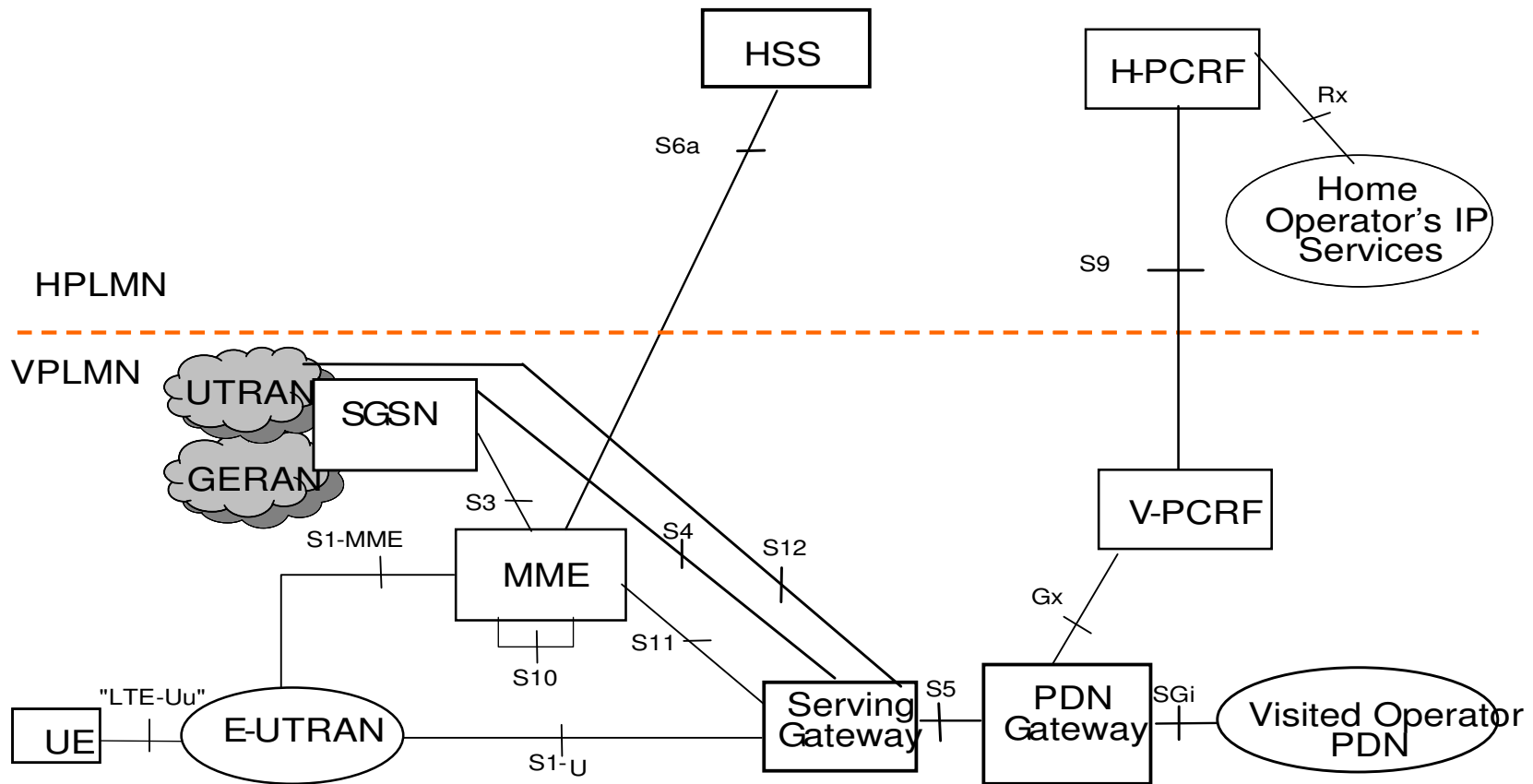
- ❑ PCRF is the policy and charging control element
- ❑ In non-roaming scenario, there is only a single PCRF in the HPLMN associated with one UE's IP-CAN session
- ❑ In a roaming scenario with local breakout of traffic there may be two PCRFs associated with one UE's IP-CAN session
 - H-PCRF that resides within the H-PLMN
 - ❑ terminates the Rx reference point for home network services
 - ❑ terminates the S9 reference point for roaming with local breakout
 - V-PCRF that resides within the V-PLMN
 - ❑ terminates the Gx and S9 reference points for roaming with local breakout
 - ❑ terminates Rx for roaming with local breakout and visited operator's Application Function

Roaming Architecture 1



Roaming architecture for 3GPP accesses. Home routed traffic

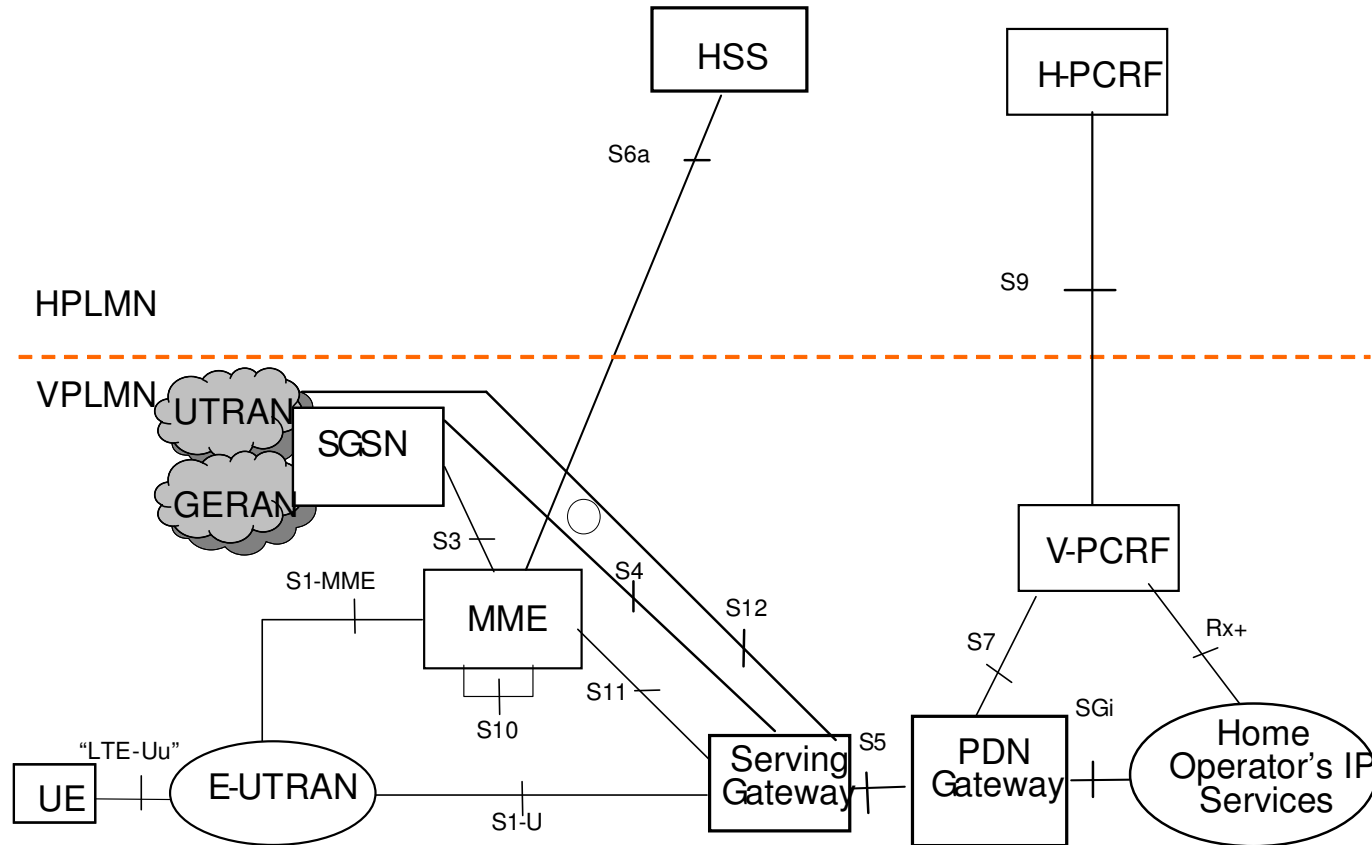
Roaming Architecture 2



Ref: TS 23.401

Roaming architecture for local breakout, with home operator's application functions only

Roaming Architecture 3



Roaming architecture for local breakout, with visited operator's application functions only

Ref: TS 23.401

SAE QoS Concepts

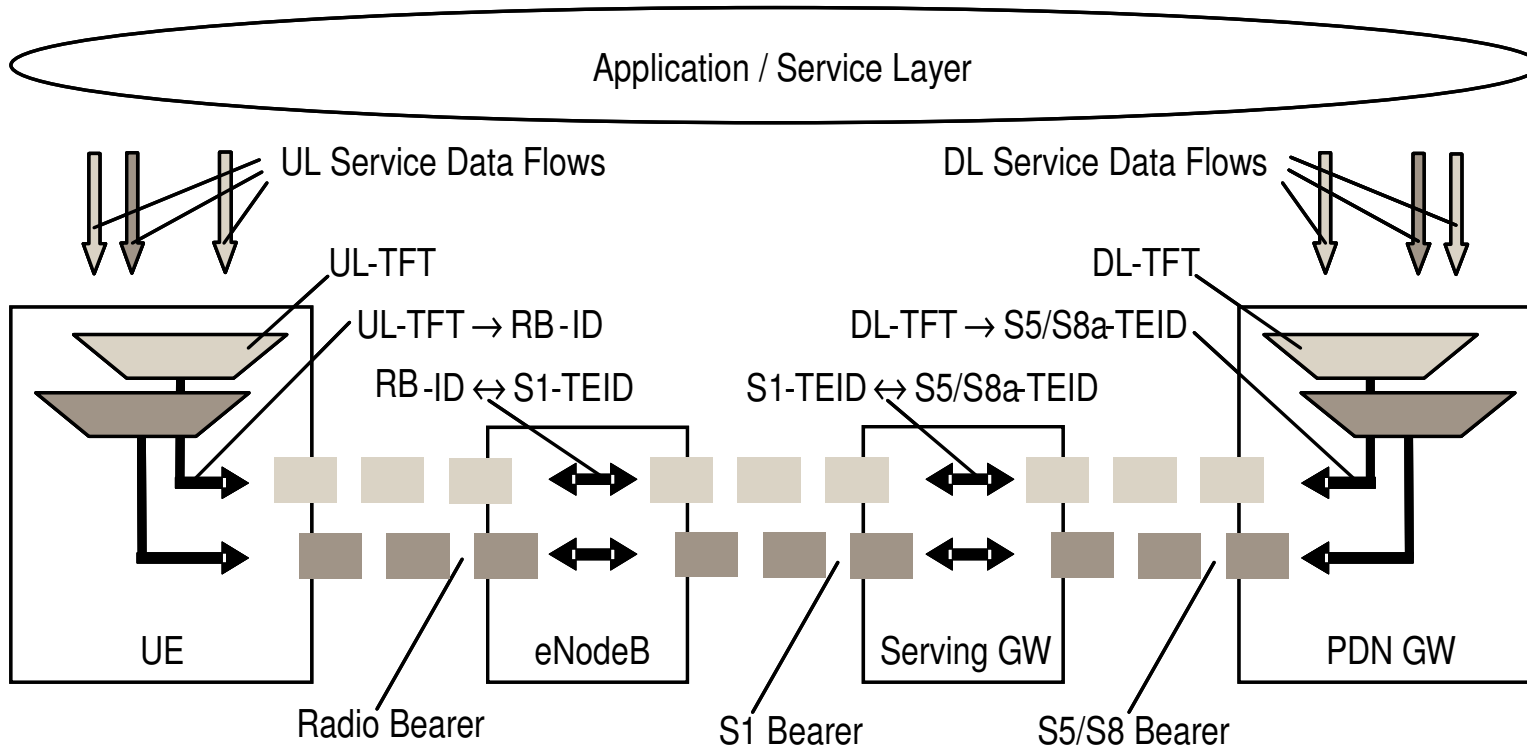
□ The EPS bearer

- For E-UTRAN access to the EPC the PDN connectivity service is provided by an EPS bearer in case of GTP-based S5/S8, and by an EPS bearer concatenated with IP connectivity between Serving GW and PDN GW in case of PMIP-based S5/S8
- An EPS bearer is the level of granularity for bearer level QoS control in the EPC/E-UTRAN
- The initial bearer level QoS parameter values of the default bearer are assigned by the network, based on subscription data
- The decision to establish or modify a dedicated bearer can only be taken by the EPC, and the bearer level QoS parameter values are always assigned by the EPC

□ Bearer level QoS parameters

- The bearer level (i.e. per bearer or per bearer aggregate) QoS parameters are QCI, ARP, GBR, MBR, and AMBR
- Each EPS bearer is associated with the following bearer level QoS parameters:
 - QoS Class Identifier (QCI);
 - Allocation and Retention Priority (ARP).
- Each GBR bearer is additionally associated with the following bearer level QoS parameters:
 - Guaranteed Bit Rate (GBR);
 - Maximum Bit Rate (MBR).
- Each APN is associated with an Aggregate Maximum Bit Rate (APN AMBR).
- Each UE is associated with UE Aggregate Maximum Bit Rate (UE AMBR).

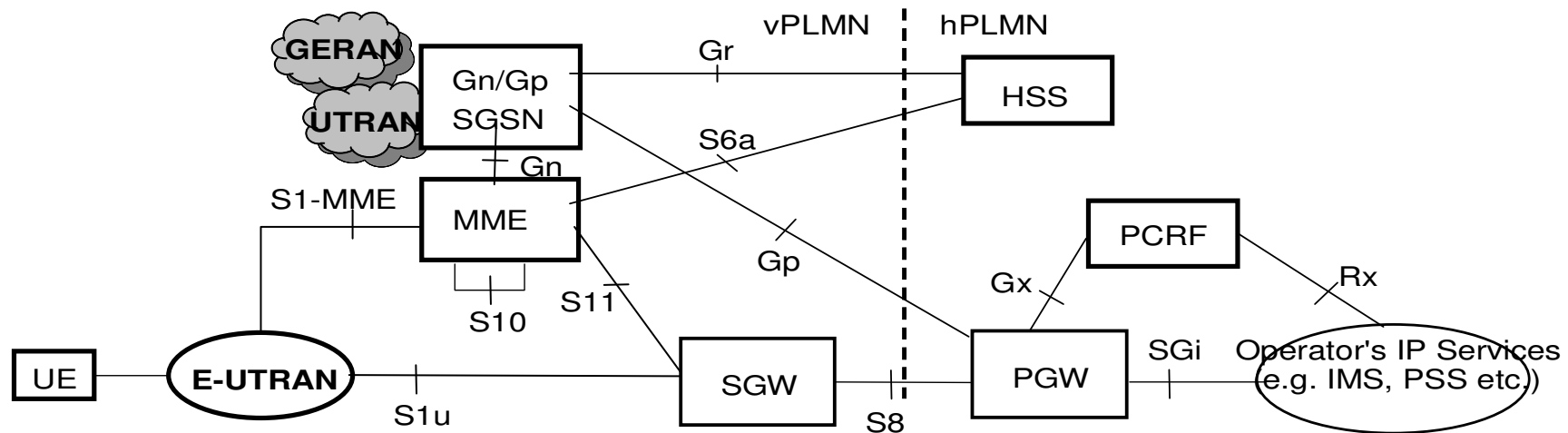
The EPS bearer with GTP-based S5/S8



Support for multiple PDNs and local breakout

- ❑ **Multiple PDN support:**
 - Simultaneous exchange of IP traffic to multiple PDNs is supported in the EPS, when the network policies and user subscription allow it
 - It shall be possible to support in the EPS simultaneous exchange of IP traffic to multiple PDNs through the use of separate PDN GWs or single PDN GW
 - The EPS also supports an UE-initiated connectivity establishment to separate PDN GWs or single PDN GW in order to allow parallel access to multiple PDNs
- ❑ **Support of Local Breakout**
 - Local breakout of IP traffic via the visited PLMN is supported, when network policies and user subscription allow it
- ❑ **Local breakout may be combined with support for multiple simultaneous PDN connections**

Inter-working with Legacy 3GPP systems



Roaming and inter access mobility between Gn/Gp 2G and/or 3G SGSNs and an MME/S-GW are enabled by:

- - Gn functionality as specified between two Gn/Gp SGSNs, which is provided by the MME, and
- - Gp functionality as specified between Gn/Gp SGSN and Gn/Gp GGSN that is provided by the P-GW.
- All this Gp and Gn functionality bases on GTP version 1 only.

Key concepts in mapping between EPS and pre-Rel-8 QoS parameters

- There is a one-to-one mapping between an EPS bearer and a PDP context.
- The EPS bearer parameters ARP is mapped one-to-one to/from the pre-Rel-8 bearer parameter ARP.
- The EPS bearer parameters GBR and MBR of a GBR EPS bearer are mapped one-to-one to/from the pre-Rel-8 bearer parameters GBR and MBR of a PDP context associated with Traffic class 'conversational' or 'streaming'

QCI	Traffic Class	Traffic Handling Priority	Signalling Indication	Source Statistics Descriptor
1	Conversational	N/A	N/A	Speech
2	Conversational	N/A	N/A	Unknown
FFS	Streaming	N/A	N/A	Speech
3	Streaming	N/A	N/A	Unknown
5	Interactive	1	Yes	N/A
7	Interactive	1	No	N/A
6	Interactive	2	No	N/A
8	Interactive	3	No	N/A
9	Background	N/A	N/A	N/A

TS 23.402



Architecture enhancements for
non-3GPP accesses

TS 23.402 : Architecture enhancements for non-3GPP accesses

- ❑ The specification defines an architecture based on IETF based protocols for
 - ❑ eUTRAN (LTE) access
 - ❑ Non-3GPP accesses such as WLAN, WIMAX, 3GPP2
- ❑ The architecture using IETF based mobility protocol for eUTRAN better suited for operators with legacy non-3GPP accesses that are transitioning over to 3GPP
- ❑ Besides dealing with some specific inter-working issues for 3GPP2 systems, the specification provides multiple ways for legacy 3GPP and LTE accesses to inter-work with non-3GPP accesses which can in general be classified into
 - ❑ client based mobility mechanisms and
 - ❑ network based mobility mechanisms
- ❑ Although this allows flexibility but this also makes the inter-working much more complex

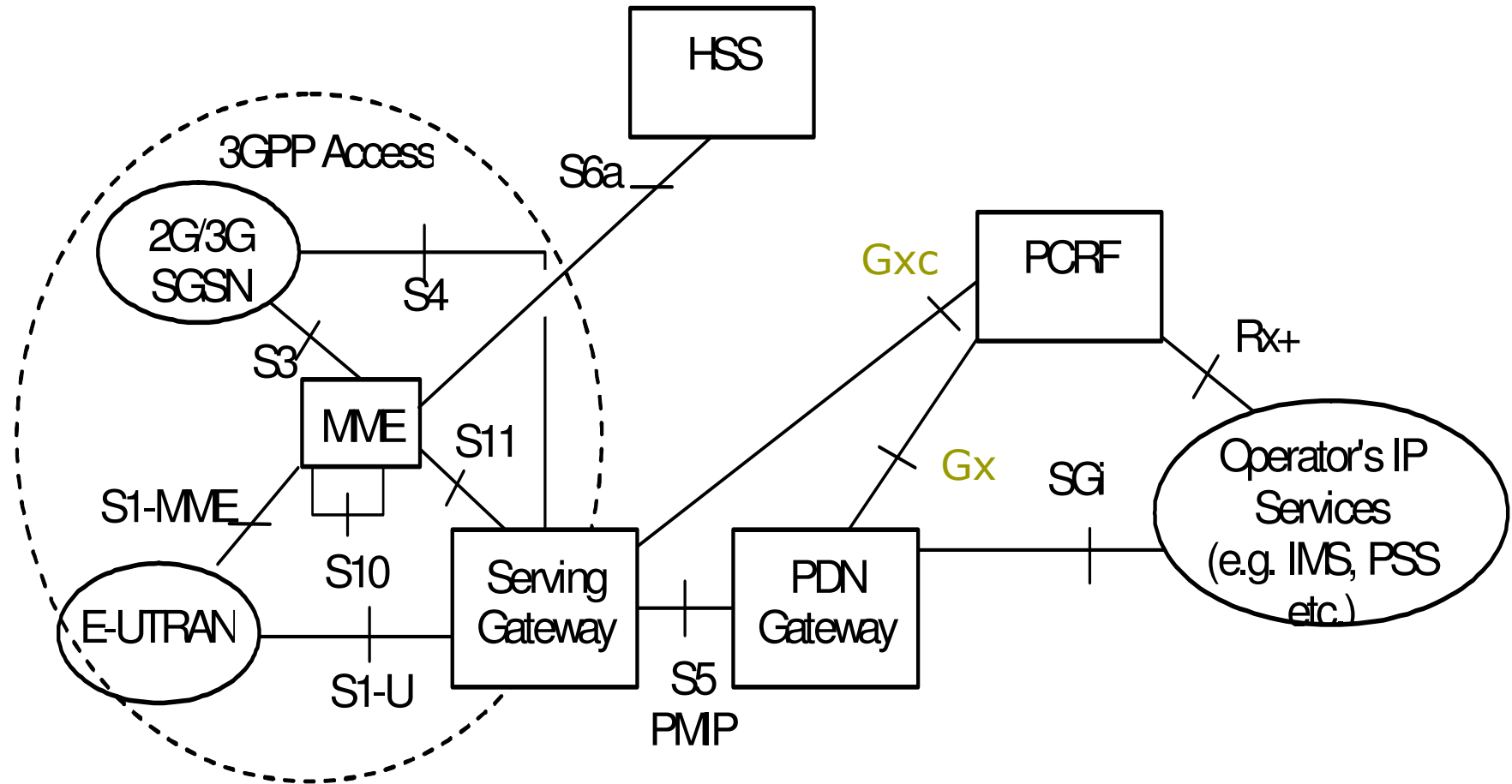
Mobility Management Selection

- No Mobility Mode or protocol is currently mandated for inter-working with non-3GPP accesses
 - Static Configuration
 - For networks deploying a single IP mobility management mechanism, the statically configured mobility mechanism can be access type and/or roaming agreement specific. The information about the mechanism to be used in such scenario is expected to be provisioned into the terminal (or the UICC) and the network
 - Networks Supporting Multiple IP
 - IP MM protocol selection between Network Based Mobility (NBM) and DSMIPv6
 - Decision on IP address preservation if NBM is selected
 - Example uses of IPMS include
 - initial attach to a non-3GPP access, when the IP MM protocol selection is performed to decide how to establish IP connectivity for the UE.
 - handover without optimization from a 3GPP access to a non-3GPP access, where the IP MM protocol selection is performed to decide how to establish IP connectivity for the UE over non-3GPP access.
 - change of access between between two non-3GPP accesses

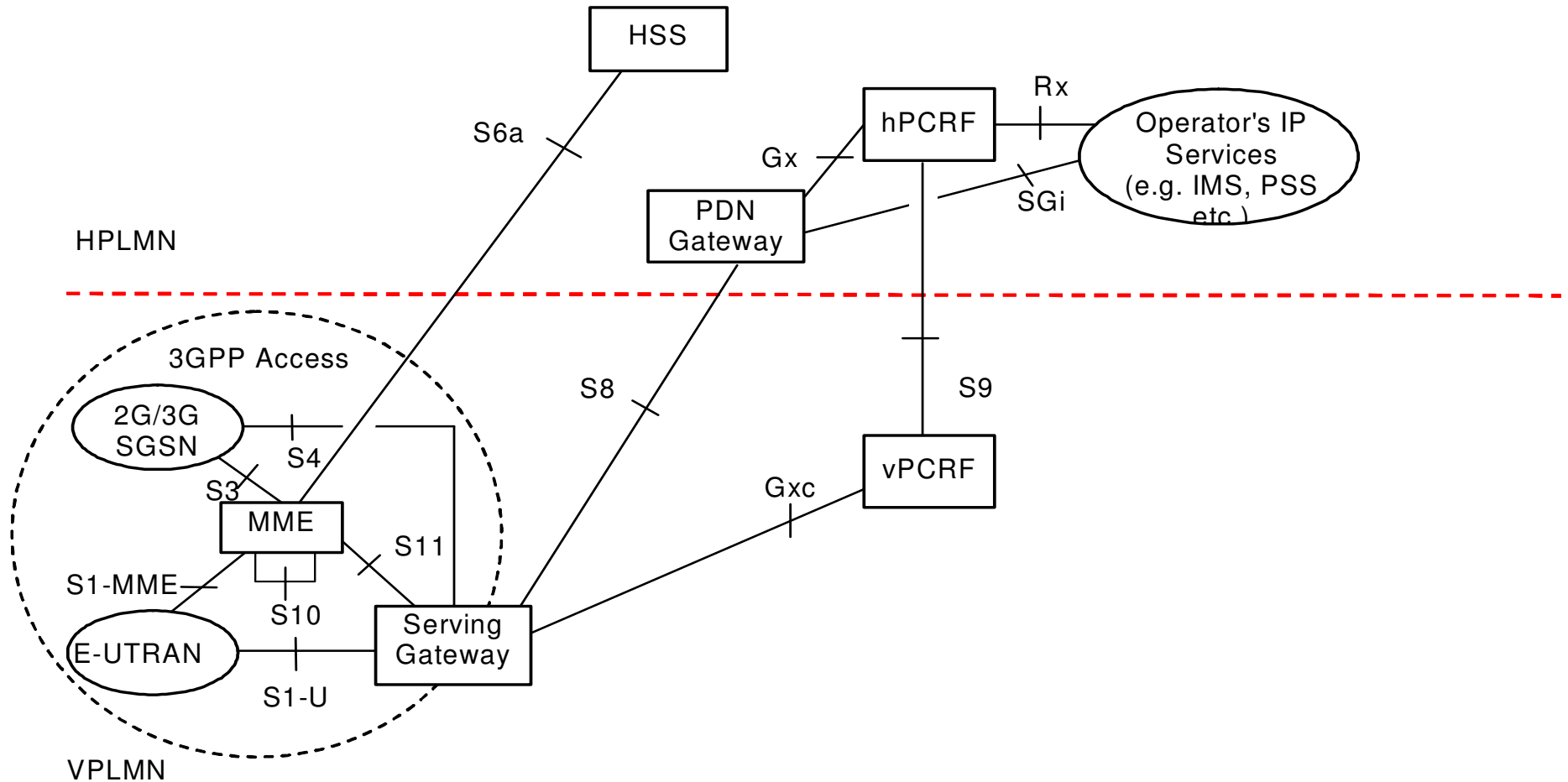
Terminology: Trusted and un trusted non-3GPP accesses

- ❑ No precise definition but it can be safely assumed that
- ❑ Trusted non-3GPP accesses can be the one that is owned and operated by the LTE HPLMN. An example of this can be the inter-working of a LTE operator with its legacy 3GPP2 network.
- ❑ Untrusted non-3GPP accesses can be the one that is not owned and/or operated by the LTE HPLMN. An example of this can be a 3rd party WLAN inter-working with an LTE HPLMN.
- ❑ The trust relationship of a non-3GPP access network is made known to the UE with one of the following options:
 - 1) If the non-3GPP access supports 3GPP-based access authentication, the UE discovers the trust relationship during the 3GPP-based access authentication.
 - 2) The UE operates on the basis of pre-configured policy in the UE.

3GPP Accesses within EPS using PMIP-based S5

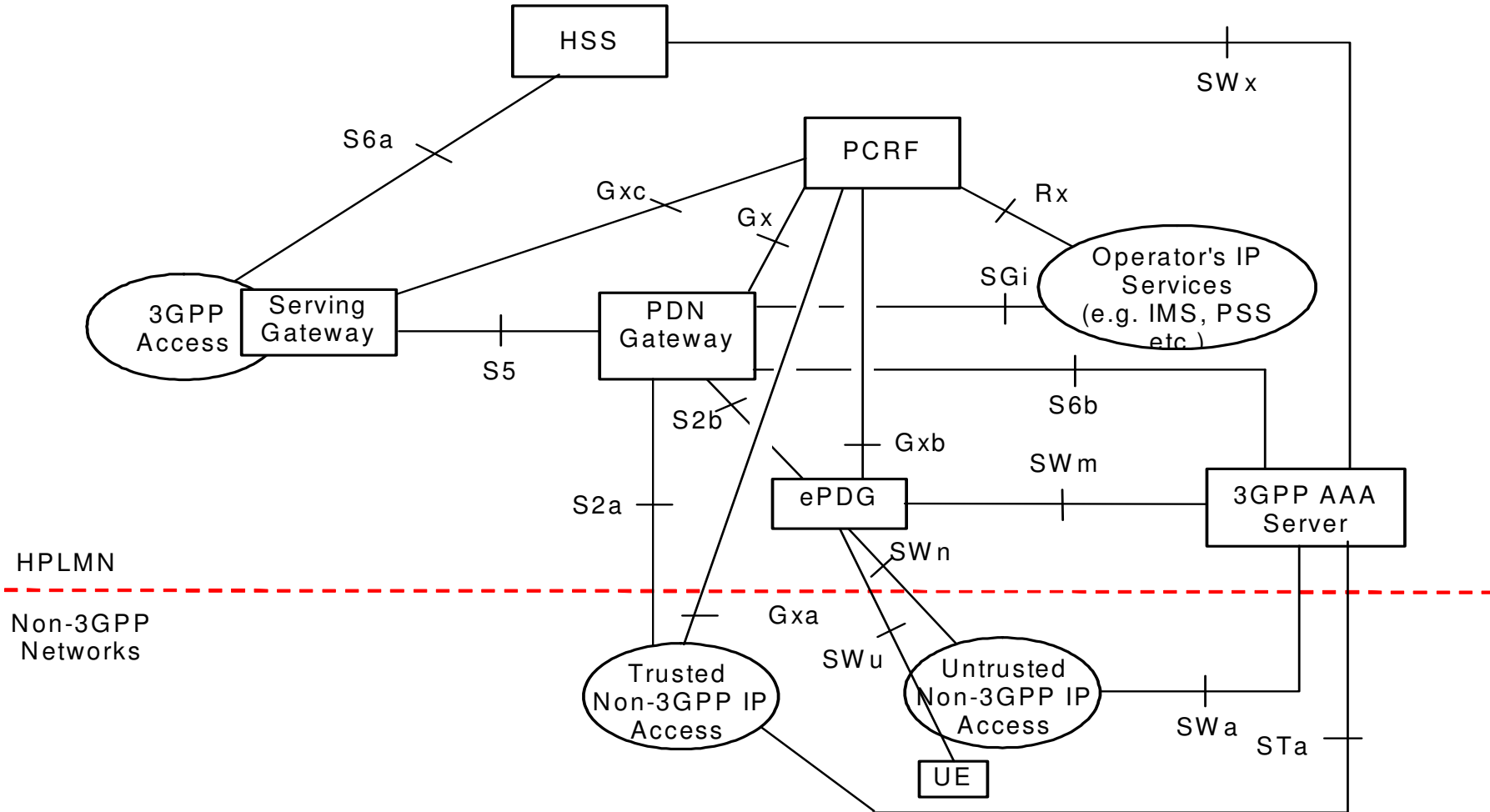


Accesses within EPS using PMIP-based S8



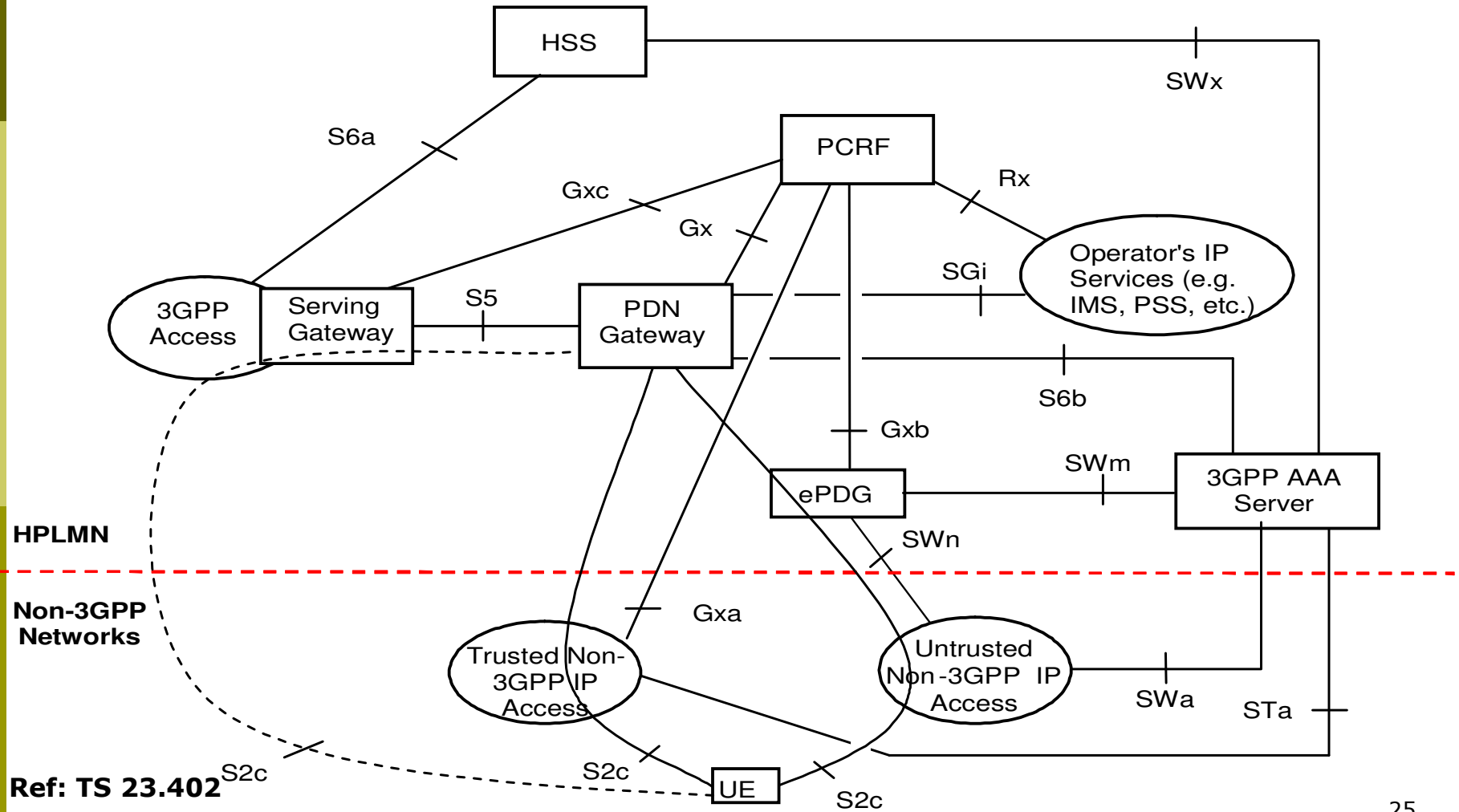
Ref: TS 23.402

Non-Roaming Architecture using S5, S2a, S2b

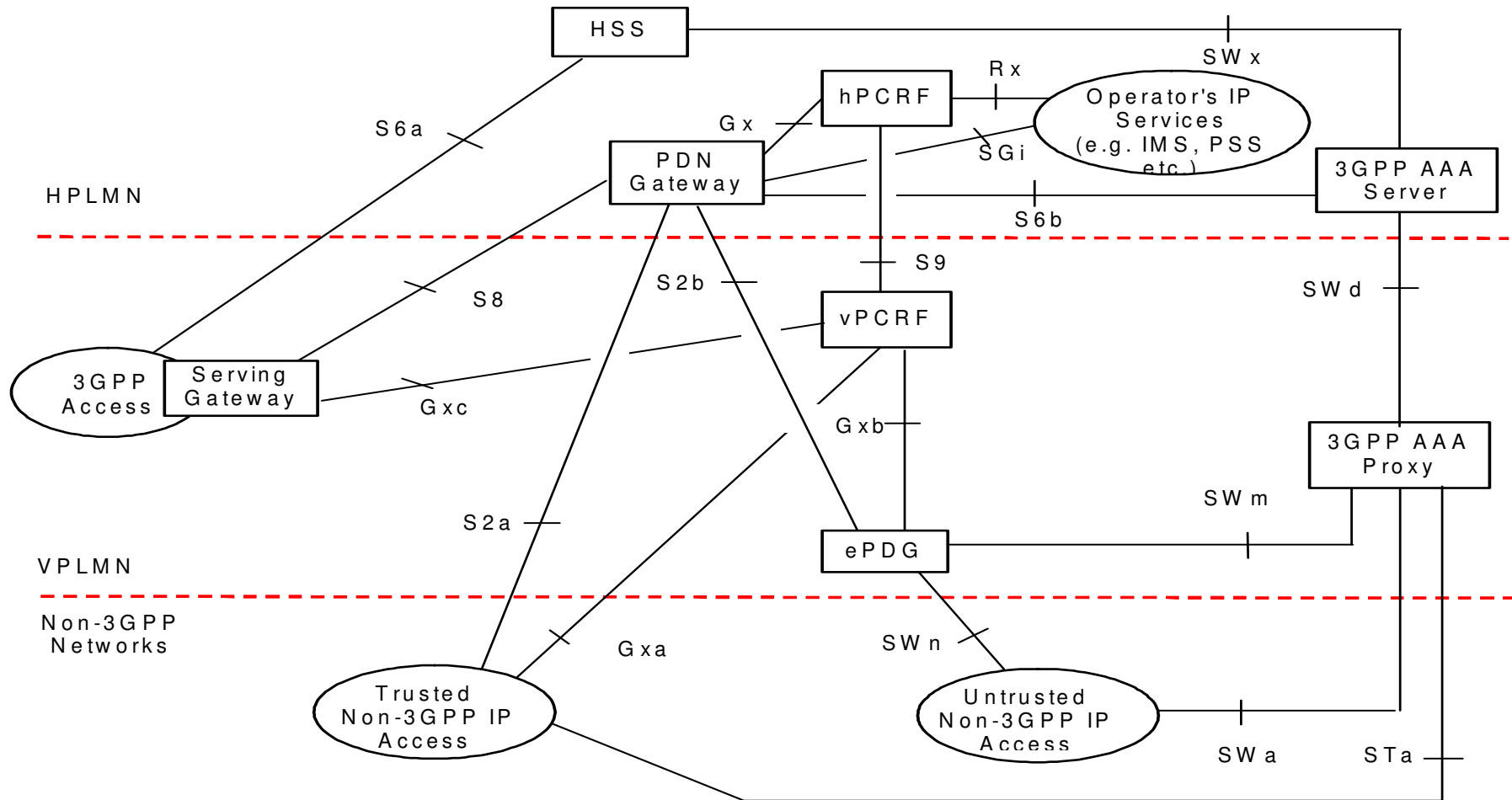


Ref: TS 23.402

Non-Roaming Architecture using S5, S2c



Six possible roaming scenarios in specifications



Ref: TS 23.402

Additional functionalities or variations in architectural entities

- **Serving GW**

1. local non-3GPP anchor for the case of roaming when the non-3GPP IP accesses connected to the VPLMN.
2. Event reporting (change of RAT, etc.)
3. Uplink bearer binding and verification with packet dropping.
4. Mobile Access Gateway (MAG) DHCPv4 and DHCPv6 functions
5. Handling of Router Solicitation and Router Advertisement messages if PMIP based S5 and S8 is used

1. PDN GW

1. user plane anchor for mobility between 3GPP access and non-3GPP access.
2. LMA if PMIP-based S5 or S8 is used.
3. DSMIPv6 Home Agent if S2c is used.

variations in architectural entities because of PMIP

MME

1. Support for HRPD

PCRF

Home PCRF

1. Terminates the Gx reference point for roaming with home routed traffic;
2. Terminates the Gxa, Gxb or Gxc/S9 reference points as appropriate for the IP-CAN type.

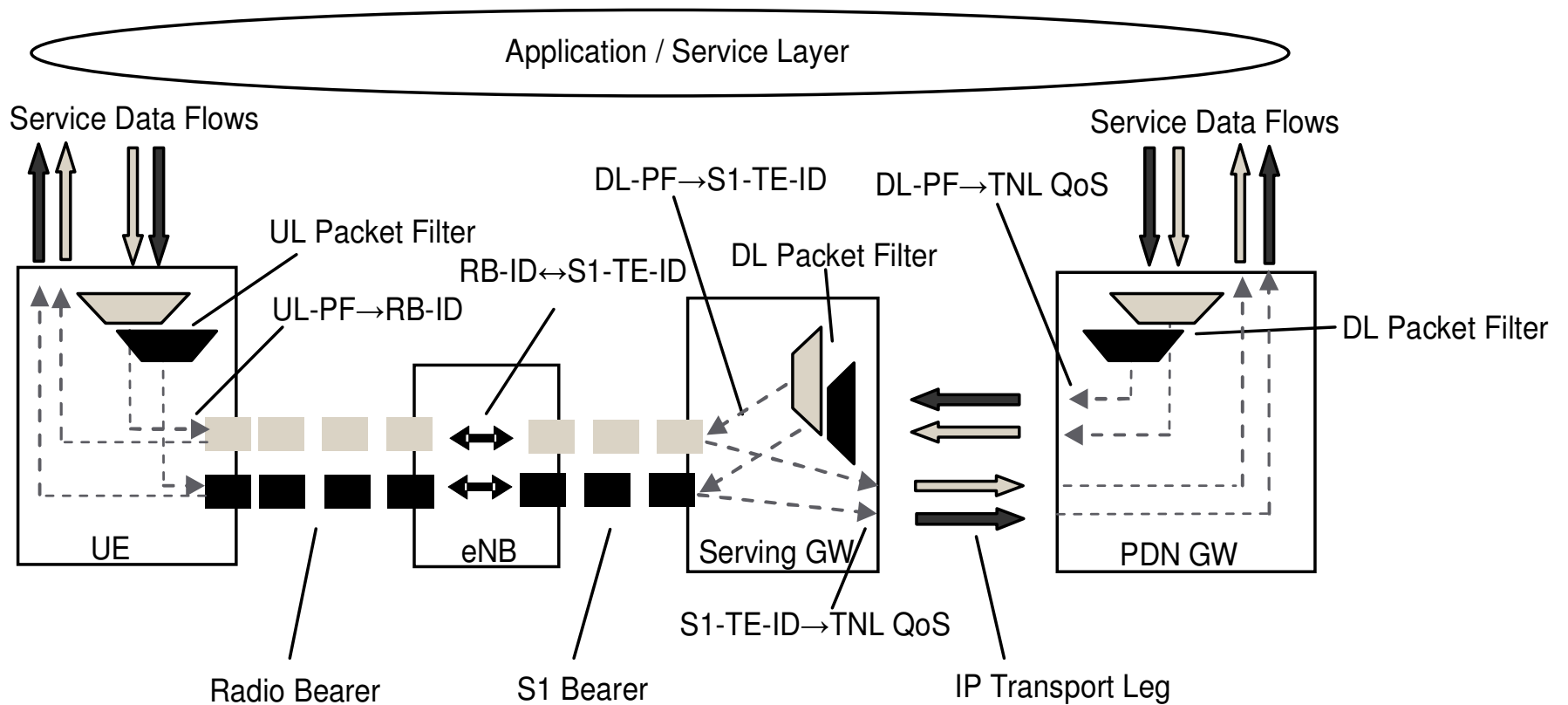
Visited PCRF

1. Terminates the Gxa, Gxb or Gxc reference points as appropriate for the IP-CAN type;
2. Terminates the S9 reference point.

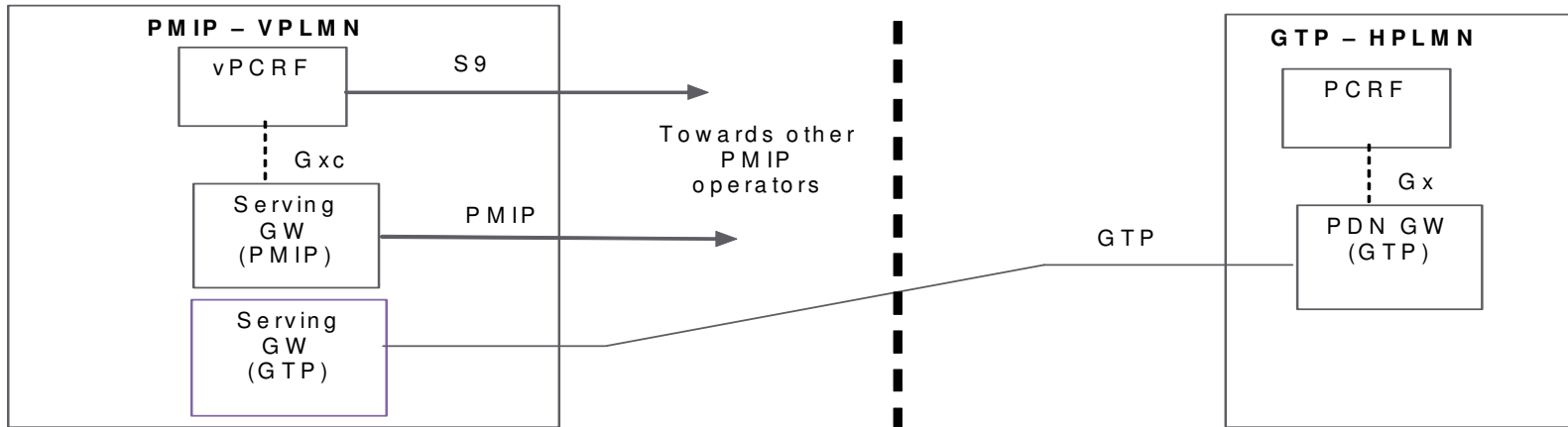
Evolved Packet Data Gateway (ePDG)

1. Functionality defined for the PDG in TS 23.234 for the allocation of a remote IP address:
 - An IP address local to the ePDG which can be used as CoA for S2c;
 - An IP address specific to a PDN when S2b is used;
2. Routing of packets from/to PDN GW (and from/to Serving GW if it is used as local anchor in VPLMN) to/from UE;
3. De-capsulation/Encapsulation of packets for IPSec and PMIP tunnels (the latter only if network based mobility (S2b) is used);
4. Mobile Access Gateway (MAG) if network based mobility (S2b) is used;
5. Tunnel authentication and authorization (termination of IKEv2 signaling and relay via AAA messages);
6. Local mobility anchor within untrusted non-3GPP access networks using MOBIKE (if needed);
7. Transport level packet marking in the uplink;
 - Enforcement of QoS policies based on information received via AAA infrastructure;
 - Lawful Interception.

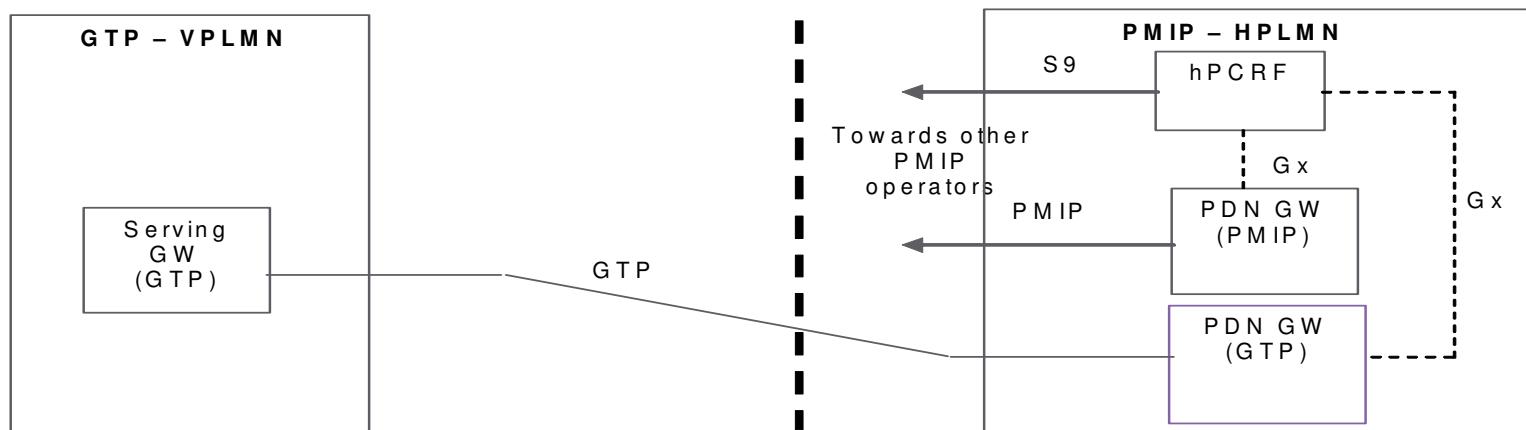
PMIP (S5/S8) QoS and Policy Aspects



PMIP-GTP roaming using direct peering

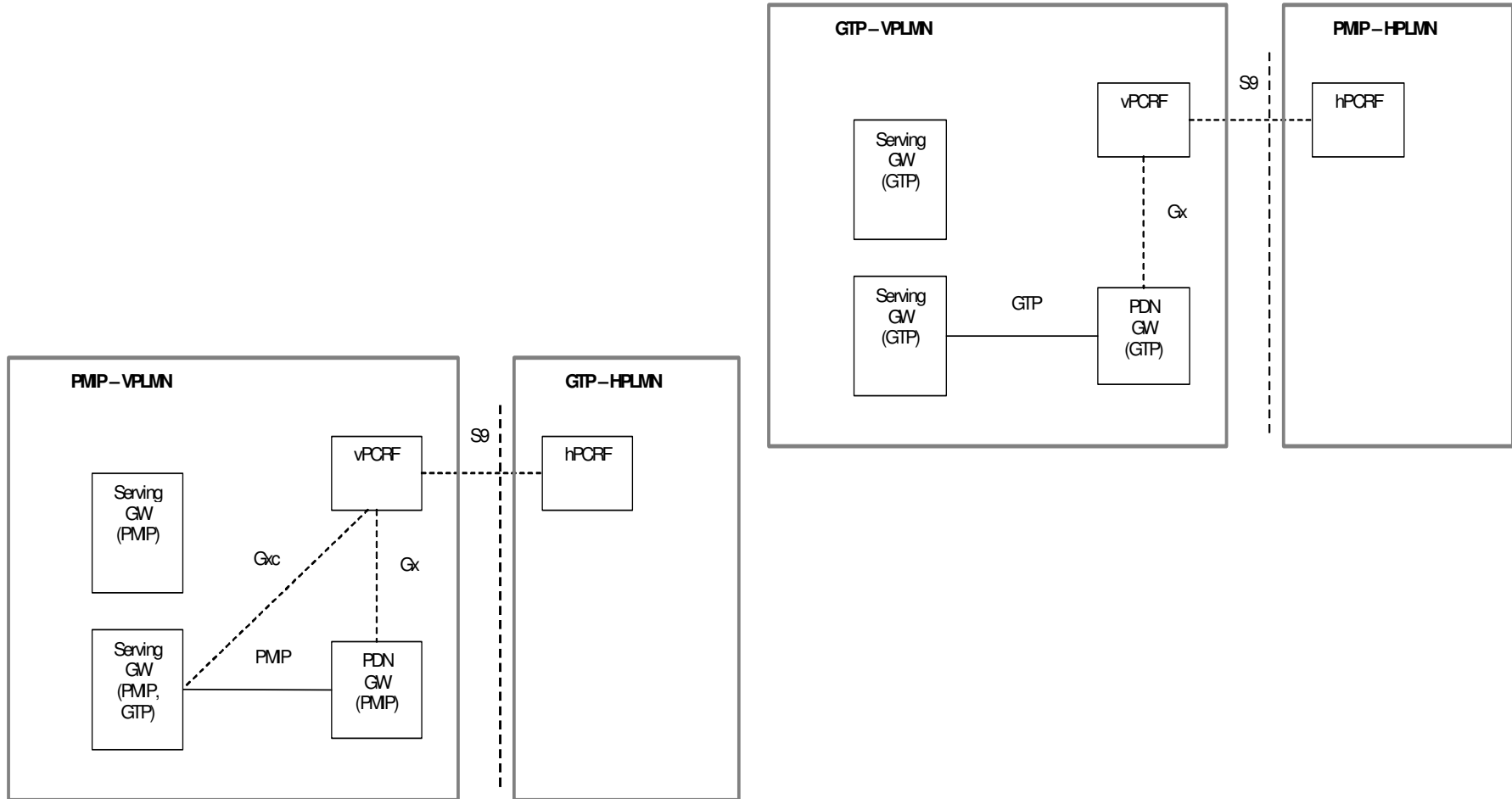


a) PMIP VPLMN - GTP HPLMN



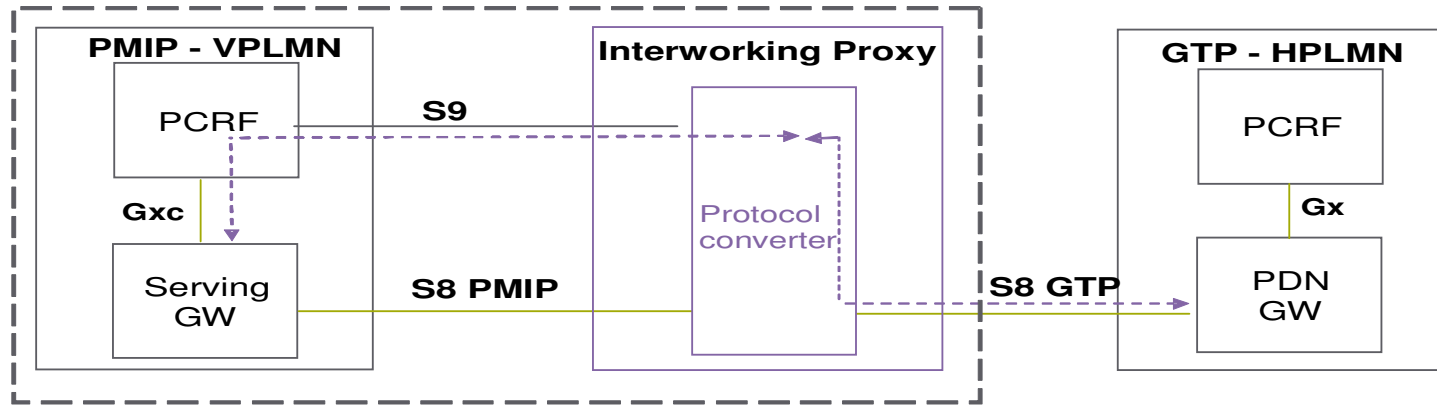
b) GTP VPLMN - PMIP HPLMN

PMIP-GTP roaming using direct peering with local breakout

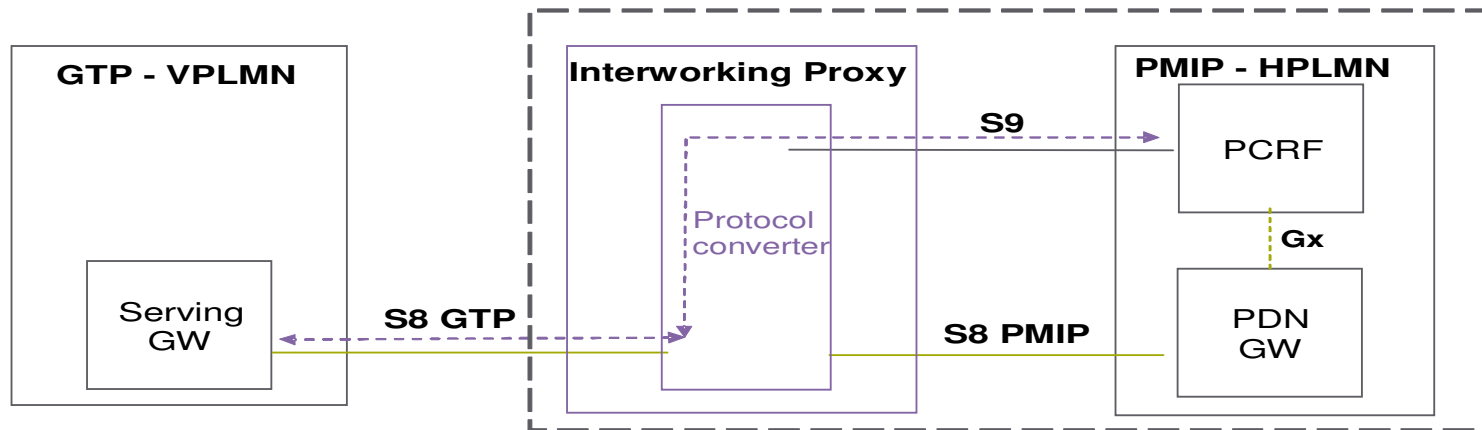


Ref: TS 23.402

PMIP-GTP roaming using interworking proxy



a) GTP HPLMN - PMIP VPLMN



b) PMIP HPLMN - GTP VPLMN

Network discovery and selection



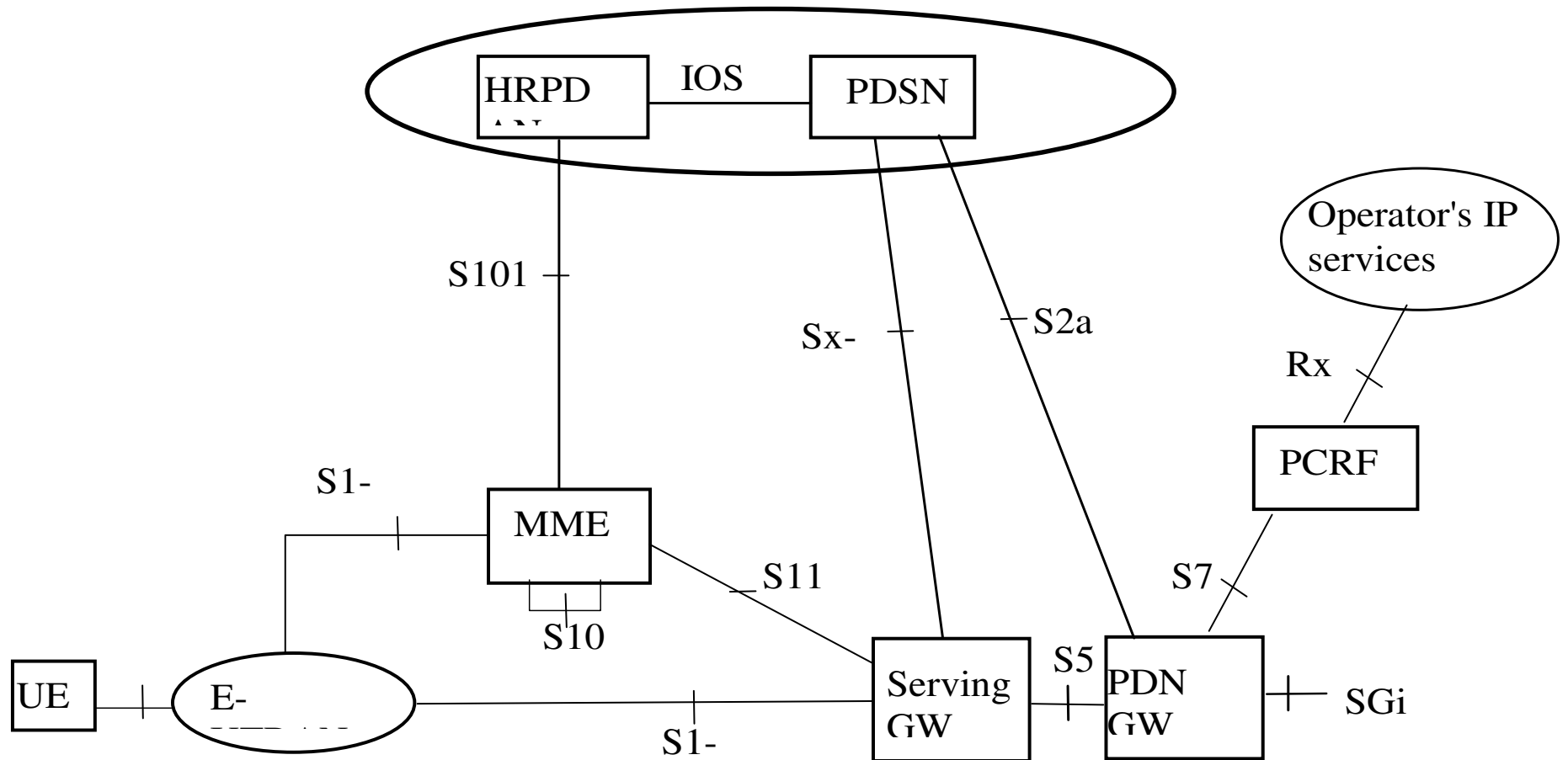
Non-3GPP Identities

- ❑ NAI RFC 4282 based user identification defined in TS 23.003 shall be used.
- ❑ The username part of NAI shall be based on IMSI. This applies to S2a, S2b and S2c reference points.
- ❑ User identification in non-3GPP accesses may require additional identities that are out of the scope of 3GPP. These user identities, if not compliant to TS 23.003 are however not sufficient to identify a user in the 3GPP Evolved Packet Core.

WiMAX inter-working

- In Release, 8 WiMAX support is based on the following principles
 - The EPS shall support mechanisms for delivery of inter-system mobility, network discovery and selection policies over the Sx interface.
 - The policies shall contain information e.g. on availability of WiMax access networks that control the UE selection of available WiMax access network and the UE decision and triggering of 3GPP - WiMax handovers
 - The handover procedure will be executed according to the S2a/S2c procedures.

CDMA inter-working



Ref: TS 23.402

3GPP Releases and SAE Features

- Current plan is to

- Meet the completion deadline of December 2008 by including only the SAE essentials and a shortened list of non-essentials in Release 8
- Aim for a Short Release 9 (~1 year after release 8) to address remaining SAE features that could not be included in release 8
- Aim for a Short Release 10 (~1 year after Release 9) for handling IMT/LTE Advanced features

List of Release 8 SAE Features

- High level and common (for all accesses) functions (e.g. Roaming, QoS, etc...)
- SAE for LTE - GTP variant
- SAE LTE - PMIP variant
- Interoperation between LTE and 2G/3G
LTE and CDMA2000
- Single Radio Voice Call Continuity (SRVCC)
- Circuit Switched Fall Back (CSFB)

List of expected Release 9 SAE Features

- SAE aspects of Emergency Calls
- Functions and procedures for SAE to support LTE MBMS
- Functions and procedures for SAE to support Control Plane LCS
- CS over EPS
- Single Radio Aspects of SAE for Optimised Handover with WiMAX
- Home Node B
-

Backup



Reference Points

Ref: TS 23.401

- ❑ S1-MME: Reference point for the control plane protocol between E-UTRAN and MME.
- ❑ S1-U: Reference point between E-UTRAN and Serving GW for the per bearer user plane tunnelling and inter eNodeB path switching during handover.
- ❑ S3: It enables user and bearer information exchange for inter 3GPP access network mobility in idle and/or active state.
- ❑ S4: It provides related control and mobility support between GPRS Core and the 3GPP Anchor function of Serving GW. In addition, if Direct Tunnel is not established, it provides the user plane tunnelling.
- ❑ S5: It provides user plane tunneling and tunnel management between Serving GW and PDN GW. It is used for Serving GW relocation due to UE mobility and if the Serving GW needs to connect to a non-collocated PDN GW for the required PDN connectivity.
- ❑ S6a: It enables transfer of subscription and authentication data for authenticating/authorizing user access to the evolved system (AAA interface) between MME and HSS.
- ❑ Gx: It provides transfer of (QoS) policy and charging rules from PCRF to Policy and Charging Enforcement Function (PCEF) in the PDN GW.
- ❑ S8: Inter-PLMN reference point providing user and control plane between the Serving GW in the VPLMN and the PDN GW in the HPLMN. S8 is the inter PLMN variant of S5.
- ❑ S9: It provides transfer of (QoS) policy and charging control information between the Home PCRF and the Visited PCRF in order to support local breakout function.
- ❑ S10: Reference point between MMEs for MME relocation and MME to MME information transfer.
- ❑ S11: Reference point between MME and Serving GW.
- ❑ S12: Reference point between UTRAN and Serving GW for user plane tunneling when Direct Tunnel is established. It is based on the Iu-u/Gn-u reference point using the GTP-U protocol as defined between SGSN and UTRAN or respectively between SGSN and GGSN. Usage of S12 is an operator configuration option.
- ❑ S13: It enables UE identity check procedure between MME and EIR.
- ❑ SGi: It is the reference point between the PDN GW and the packet data network. Packet data network may be an operator external public or private packet data network or an intra operator packet data network, e.g. for provision of IMS services. This reference point corresponds to Gi for 3GPP accesses.
- ❑ Rx The Rx reference point resides between the AF and the PCRF in the TS 23.203.

Protocol assumptions

- The S1-U is based on GTP-U protocol
- The S3 is based on GTP protocol
- The S4 is based on GTP protocol
- The S5 is based on GTP protocol. PMIP variant of S5 is described in TS 23.402
- The S8 is based on GTP protocol. PMIP variant of S8 is described in TS 23.402

Key interfaces for inter-working with non 3GPP accesses

- ❑ **S2a** It provides the user plane with related control and mobility support between trusted non 3GPP IP access and the Gateway.
- ❑ **S2b** It provides the user plane with related control and mobility support between ePDG and the Gateway.
- ❑ **S2c** It provides the user plane with related control and mobility support between UE and the Gateway.
- ❑ **Gxa** It provides transfer of (QoS) policy information from PCRF to the Trusted Non-3GPP accesses.
- ❑ **Gxb** This interface is not specified within this release of the specification.
- ❑ **Gxc** It provides transfer of (QoS) policy information from PCRF to the Serving Gateway

- ❑ Note: names of some of the interfaces are currently being changed in the specification

Protocols for inter-working with non 3GPP accesses

- S2a is based on Proxy Mobile IP. To enable access via Trusted Non 3GPP IP accesses that do not support PMIP, S2a also supports Client Mobile IPv4 FA mode
- S2b is based on Proxy Mobile IP
- S2c is based on DSMIPv6
- Gx/a/b/c interfaces will be using DIAMETER

Current status of critical IETF dependencies

- Proxy Mobile IP draft (draft-ietf-netlmm-proxymip6-16.txt) is in RFC Ed. Queue
- DSMIVP6 draft (draft-ietf-mext-nemo-v4traversal-05.txt) is in IETF WG last call (?)