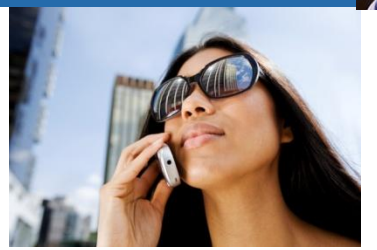
Layering LTE Technology on Existing Systems – Network Interworking Considerations



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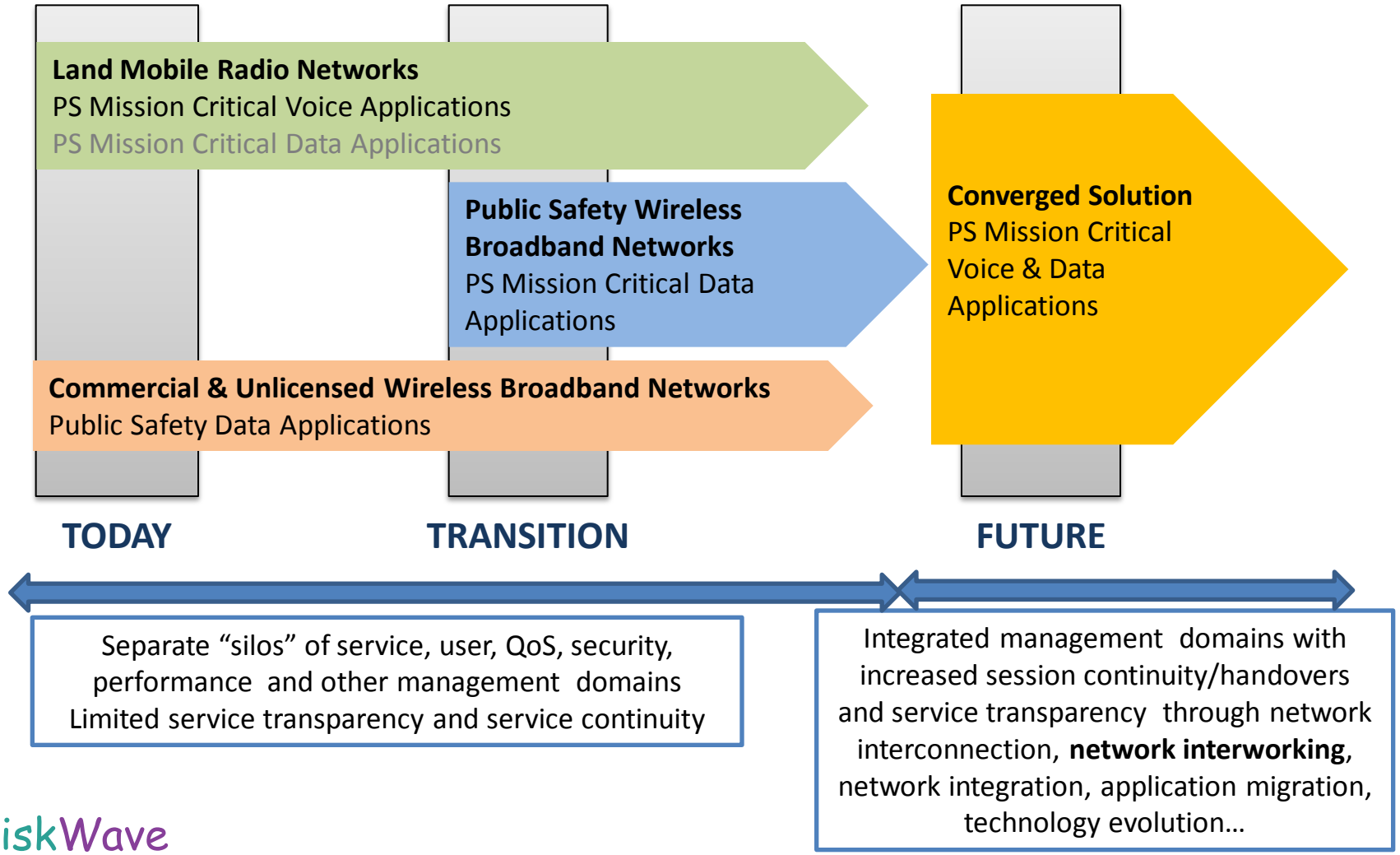
Agenda

- **Network Interworking: The Rationale**
- Roaming
- Handovers
- Interworking with non-3GPP Legacy Networks
- Active Network Sharing

Layered Solutions :
The Need for Convergence



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Network Interworking : The Rationale

- To provide uniform service availability across the coverage areas of the different network layers, **roaming** capabilities need to be established between the layers composing the public safety (PS) network.
- To support mission-critical applications that don't survive a dropped IP connection (e.g. VPN, Video Streaming Session, voice call), session continuity (via network-controlled **handovers**) shall be provided across the different PS network layers
- **Active Network Sharing** effectively provides roaming and handover across the shared eRAN
- The different layers of public safety networks need to interwork, and this, across different Radio Access Technologies (RAT) i.e. LTE, 3G, LMR… to provide seamless service and an "always on" experience.

LTE Interworking improves seamless mobility and session continuity via handovers across the layers of the public safety mobile broadband network.

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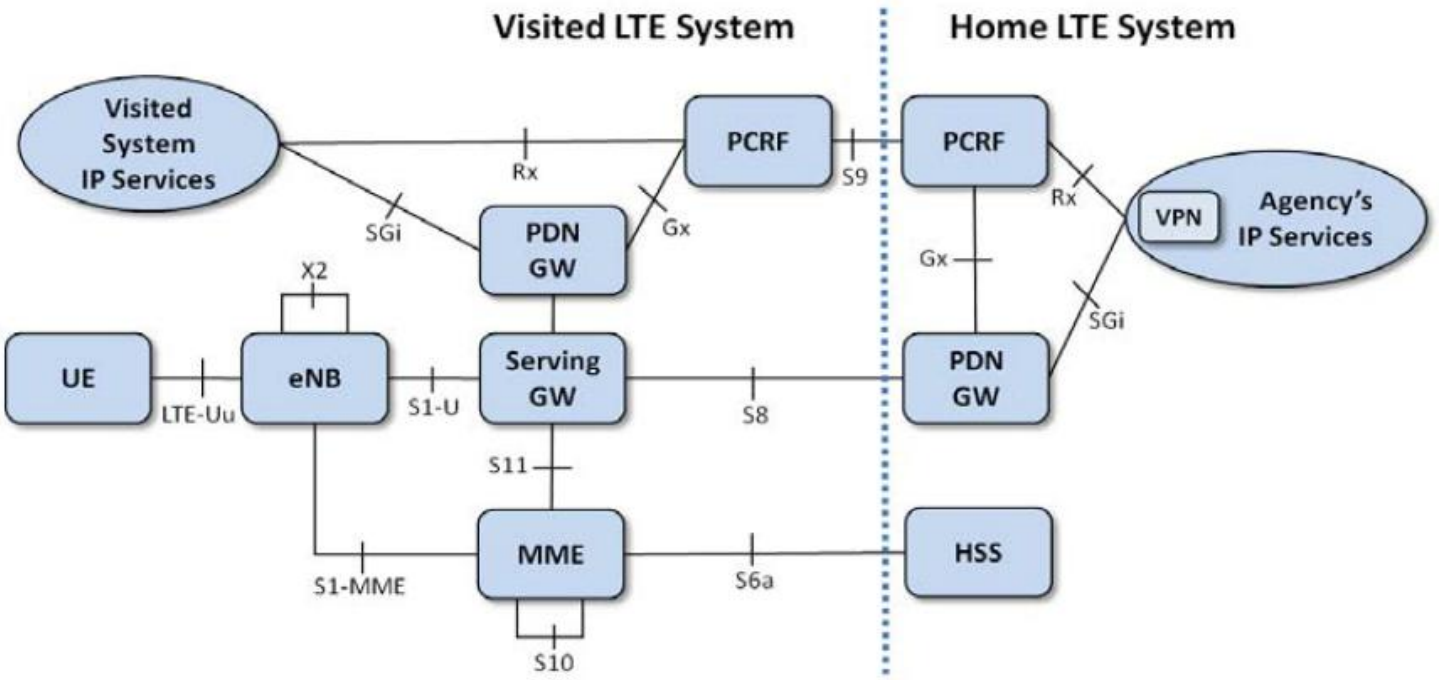
Roaming: The Options

- Roaming vs “Visiting”
  - A public safety user whose service is provided by a network other than his/her home NPSBN is deemed to be roaming. “**Roaming**” specifically refers to movement between networks with different PLMN IDs.
  - When a public safety user moves from one jurisdiction into another jurisdiction of the NPSBN, he/she is “**visiting**”. This assumes the NPSBM is a single-PLMN-ID network.
- Traffic Routing during Roaming
  - **Local Breakout**: the connection remains local to the visited network and avoids “tromboning” to and from the home network. Extensively used for voice calls by commercial operators.
  - **Home-routed**: the connection is routed through the home core network. Extensively used for data connections by commercial operators to provide access to operator-based data services and QoS, and to facilitate charging & rating.
- Roaming Interfaces
  - Using standard 3GPP/GSMA roaming interfaces: used extensively for international roaming through a roaming exchange carrier. Do not support handovers.
  - Using direct core-to-core network interfaces (via NNI): used between high-traffic and/or adjacent roaming partners. Can support handovers.

LTE-to-LTE Roaming via Standard Interfaces (Inter-PLMN)

(PS to Commercial)



Nodes	Interface ID	Protocol
MME - HSS	**S6a**	Diameter Base Protocol (IETF RFC 3588 and 3GPP TS 29.272)
SGW - PGW	**S8**	GTP (GTP-C 3GPP TS 29.274 and GTP-U 3GPP TS 29.281) or PMIP (IETF RFC 5213 and 3GPP TS 29.275)
hPCRF - vPCRF	**S9**	Diameter Base Protocol (IETF RFC 3588 and 3GPP TS 29.125)

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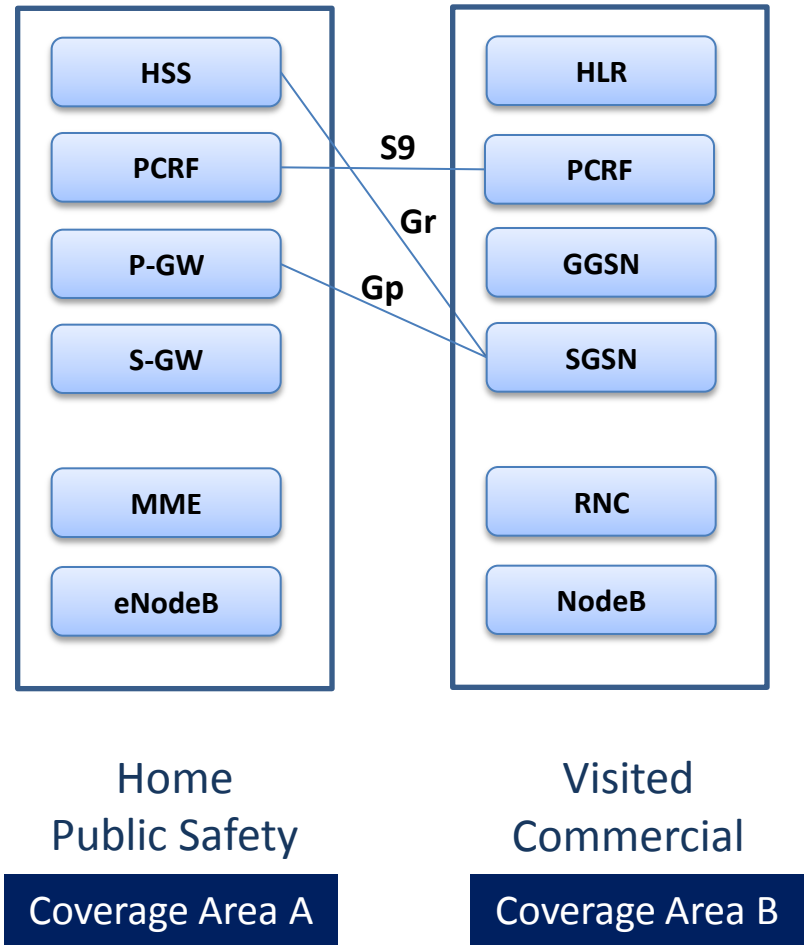
LTE-to-3G Roaming via Standard Interfaces (Inter-PLMN)

(PS to Commercial)

Nodes	Interface ID	Protocol
SGSN - HSS	**Gr**	MAP
SGSN - PGW	**Gp**	GTP
hPCRF - vPCRF	**S9**	Diameter Base Protocol (IETF RFC 3588) and 3GPP TS 29.125)



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LTE Visiting (Intra-PLMN) via Direct Network Connections

Home Routing

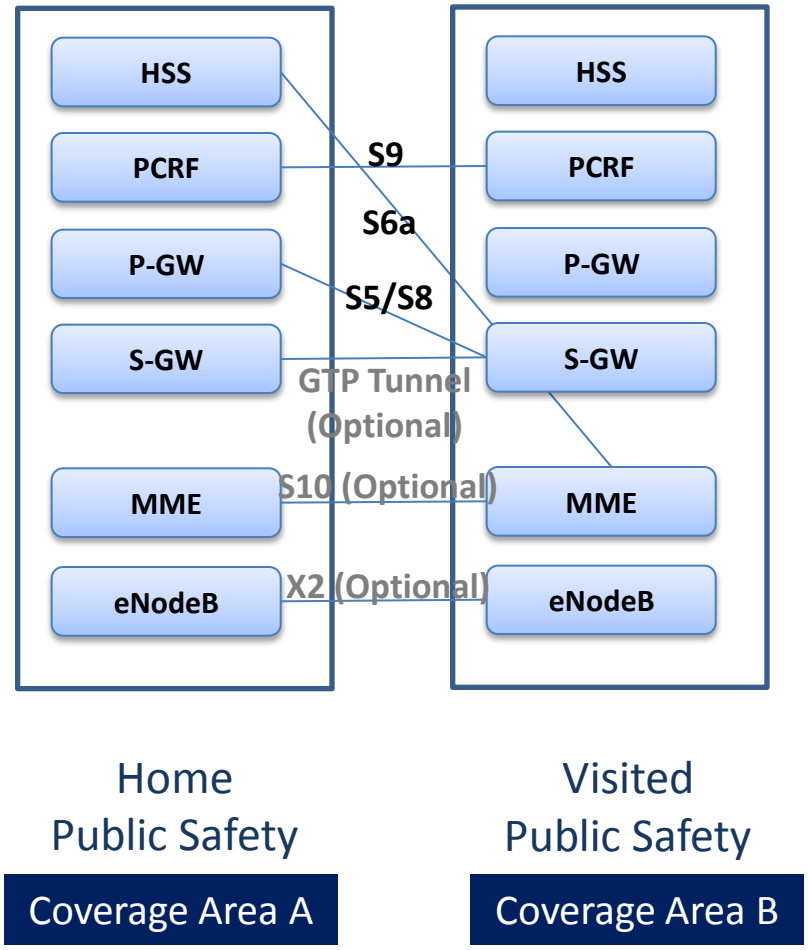
- With Home PGW Access (HPA), the Home P-GW of the user is selected, and the home network assigns an associated IP address to the UE
- With HPA, the visiting user's traffic is routed back to the home network (via S5/S8) to enable the use of the visitor's home resources.
- HPA bearer flows benefit from QoS policies controlled in the home network. In addition, HPA provides : single point of authentication for applications, for security, and for policy control.

Optional Interfaces

- GTP Tunnels, S10, and X2 interfaces are optional to support Handovers

Roaming Partners

- Could be used between regional entities of the PSMBN (Intra-PLMN) that are adjacent and potentially between the PSMBN and commercial carriers (Inter-PLMN)



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- Network Interworking: The Rationale
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- **Handovers**
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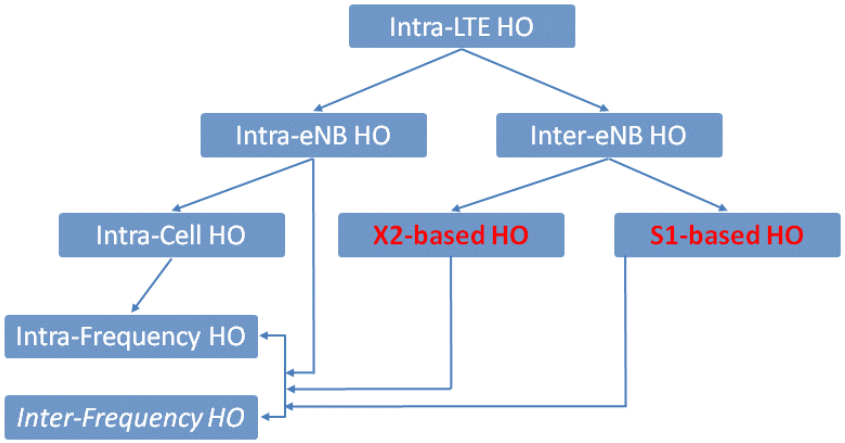
Handovers

- **Handover** (HO) is the process that happens when a User Equipment (UE) in connected state with active sessions moves from the coverage of one cell to the coverage area of another cell without the IP connection being dropped.
- LTE supports the use of two types of handover delivery mechanisms called seamless and lossless handover: **S1-based** and **X2-based** handovers.
- If necessary during inter-Radio Access Technology (RAT) HO (i.e. **LTE to 3G**), the network assistance will make sure that data connections (PDP contexts and EPS bearers) are mapped across the RATs.

Intra-LTE Handover (HO) Types



- LTE HOs are either based on the S1 or the X2 interface.
- The X2-based handover interface provides lower packet loss, but the X2 is an optional interface.
- **Intra-PLMN HOs** can happen between adjacent LTE Regional PS Networks via the S10 interface (MME-to-MME).
- 3GPP standards do not identify the inter-MME S10 interface as a roaming interface (and typically not offered by roaming exchange carriers), and therefore **Inter-PLMN HOs** are typically NOT implemented, as they require direct core-to-core network connections.

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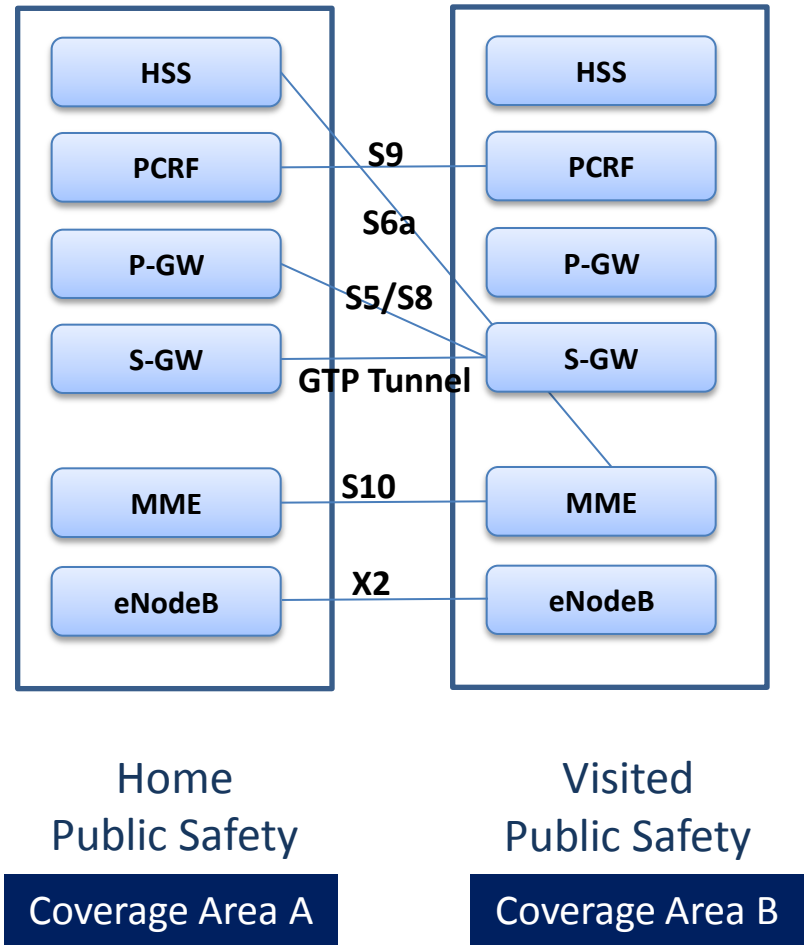
Intra-PLMN HO

- This is an intra-RAT (LTE) handover
- This intra-RAT HO is supported through direct core-to-core interfaces
- Could be used to support handover of active sessions between geographically adjacent public safety LTE networks.



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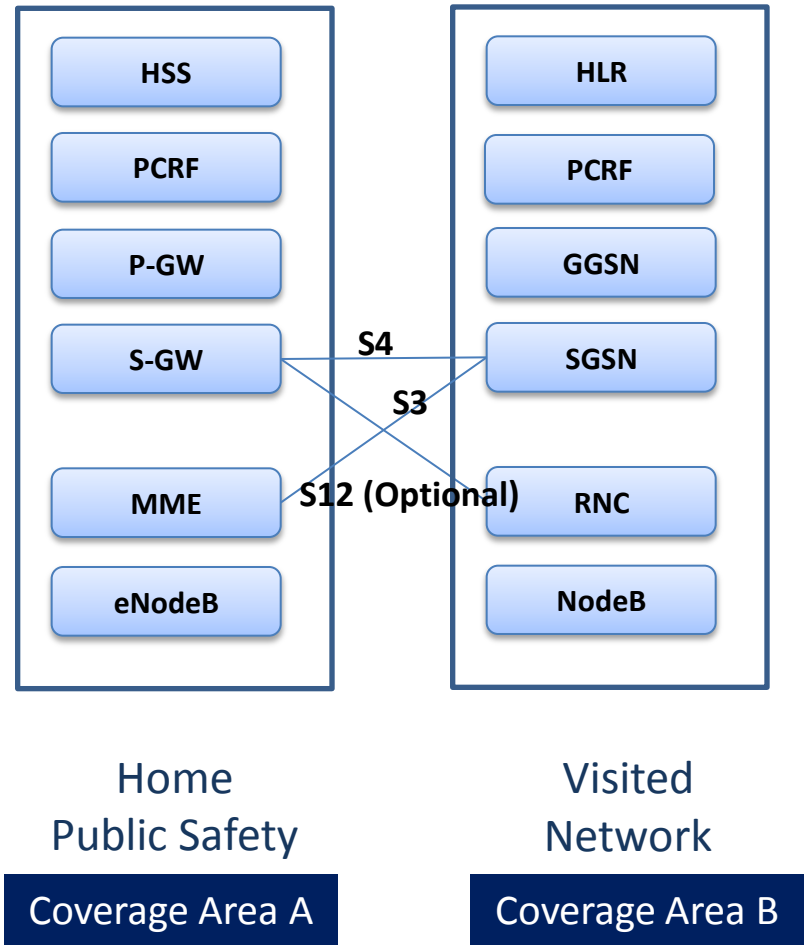
Inter-RAT HO (LTE-2G/3G)

This is an inter-RAT and inter-PLMN handover that can be used to support HO to commercial 3G carriers.

It requires the following interfaces (*)

- S12 – UTRAN to SGW
- S4 – SGSN to SGW
- S3 – SGSN to MME

(*) *Those interfaces are in addition to the interfaces required for roaming. In this case, the visited 3G network exposes LTE interfaces to the Home PS network. Other options exist where the Home LTE network supports 3G interfaces.*



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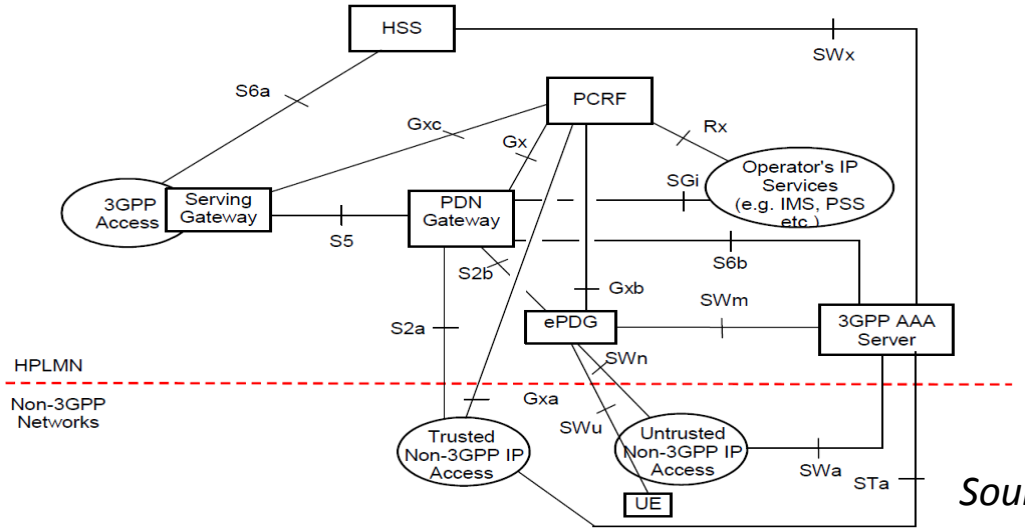
Interworking with Non-3GPP Networks

(Legacy Private)



Source: 3GPP TS 23.402

Component	Name	Description
ePDG	Evolved Packet Data Gateway	The main function of the ePDG is to secure the data transmission with a UE connected to the EPC over an un-trusted non-3GPP access. For this purpose, the ePDG acts as a termination node of IPsec tunnels established with the UE.
3GPP AAA Server	3GPP Authentication, Authorization, and Accounting Server	An AAA server is a server program that handles user requests for access to computer resources and provides authentication, authorization, and accounting (AAA) services. The AAA server typically interacts with network access and gateway servers and with databases and directories containing user information.

Can be/is used to interwork LTE with CDMA, LTE with Wimax, LTE with Wifi and others

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Types of Network Sharing

National Roaming

- Standard Roaming Agreement
- National version of the International Roaming
- Most beneficial in low-traffic & non-overlapping coverage areas

Passive Sharing

- Site Sharing: site, tower, antenna, power, transmission…
- Common in 2G & 3G
- Major Capex Savings

Active Sharing

- RAN & spectrum
- Require operational agreements
- Major Capex & Opex savings

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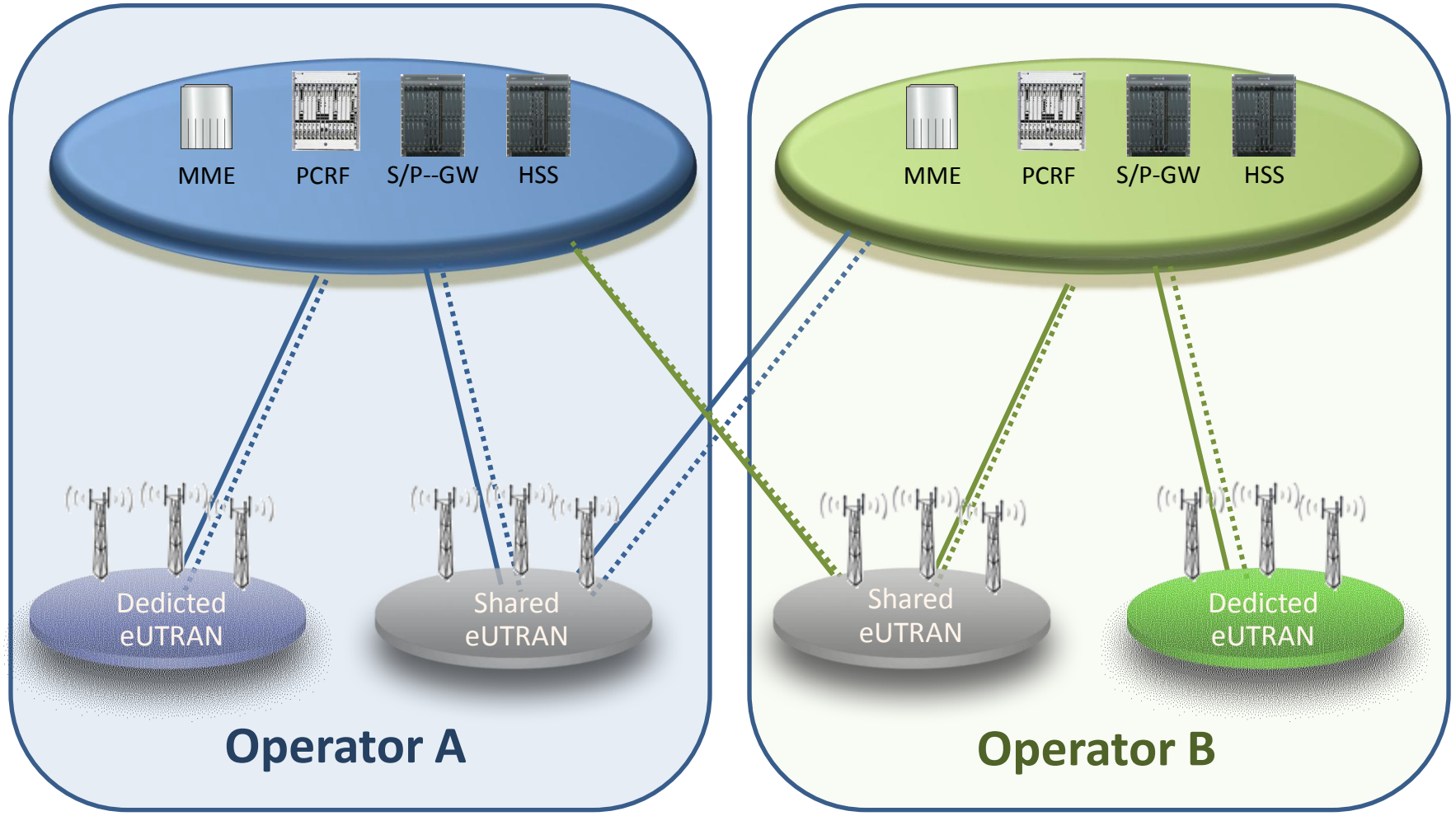
Active Network Sharing (MOCN)

- One entity of the PS network is entering into an active RAN sharing agreement with a commercial LTE operator
  - The shared eNode-B broadcasts both the commercial and the PS PLMN-IDs
  - The shared eNode-B can implement both shared or dedicated spectrum
  - Sharing partners may additionally manage dedicated eNode-bs (in non-overlapping areas or for in-building deployment)
  - A shared eNode-B has connections towards every sharing partner's core network, and this via segregated VLAN connections
- Multiple business scenarios are possible i.e. which users (PS or commercial) are served on which frequency bands (PS or commercial)

Active Sharing – Geographical Split



Each sharing partner can operate a dedicated LTE network in addition to the shared LTE network

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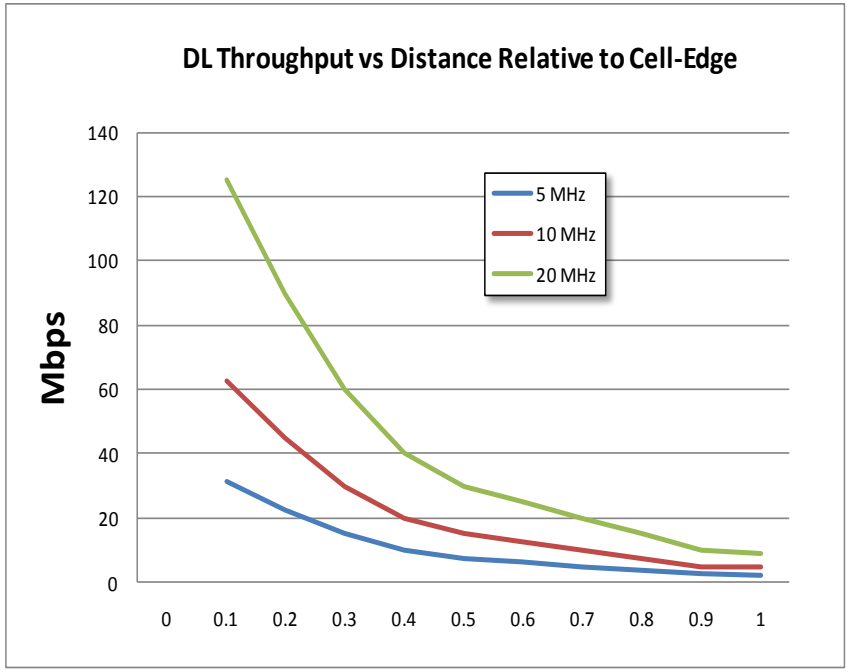
Sharing Spectrum

- Sharing spectrum increases the data throughput across the cell
- Initially, only contiguous channels in the same band can be shared
- With LTE-advanced, non-contiguous channels can also be shared



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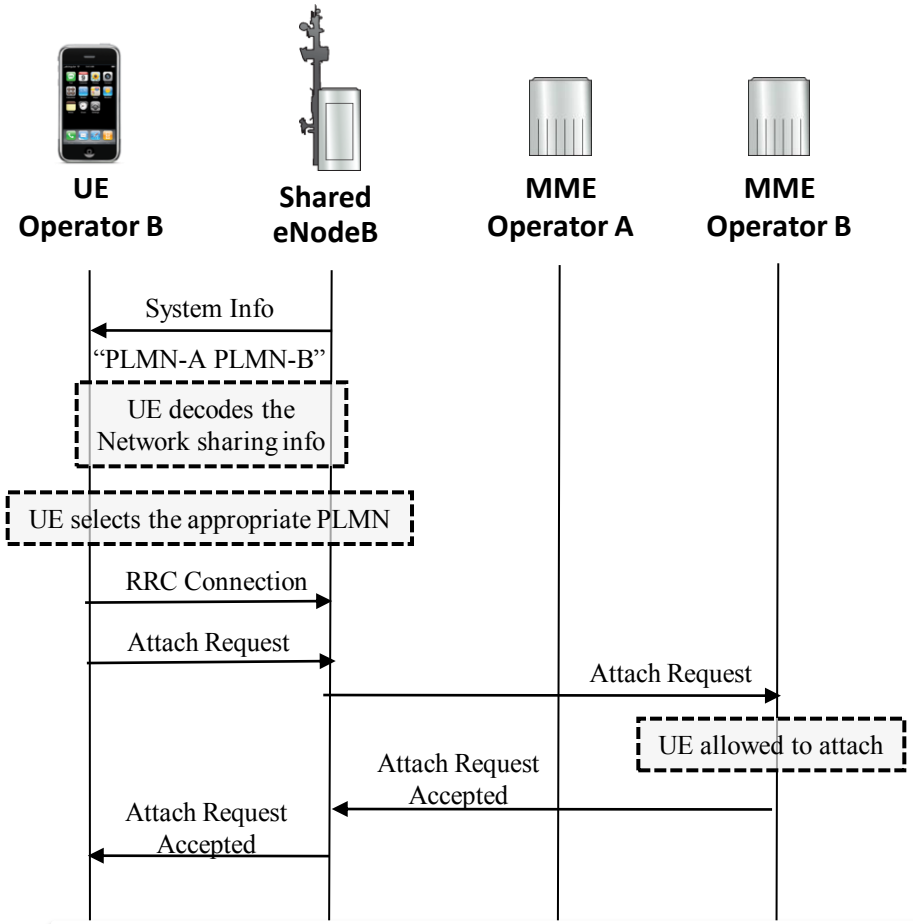
MOCN: How does it work?



- The PLMN-IDs of partners are all broadcasted on the air interface
- The UE selects its operator and indicates the selected PLMN-ID in the RRC Connection request
- The eNodeB forwards the attachment request to an MME belonging to the appropriate operator
- 3GPP TS 23.251 & TR 22.951

The MME is selected based on the PLMN-ID provided by the UE

Active Sharing: The Options

- Sharing at Different Network Levels
  - eUTRAN only (i.e. MOCN)
  - eUTRAN and partially Core (i.e. GWCN)
- Security
  - IPSec-based VLAN per operator
- QOS Management
  - Partners can control QoS via the standard QOS Class Identifier (QCI) values (1-9)
  - Partners can additionally configure operator-specific QCIs
- Dedicated & Shared Spectrum
- Dedicated & Shared Backhaul
- Mobility Profiles – Specific Per Partner
  - Intra-LTE from shared to shared
  - Intra-LTE from shared to dedicated
  - Inter-RAT from shared to dedicated
- Voice Support – Specific Per Partner
  - CSFB
  - VoLTE

The 3GPP LTE standard offers a wide range of network sharing options that enhance the value proposition of active sharing

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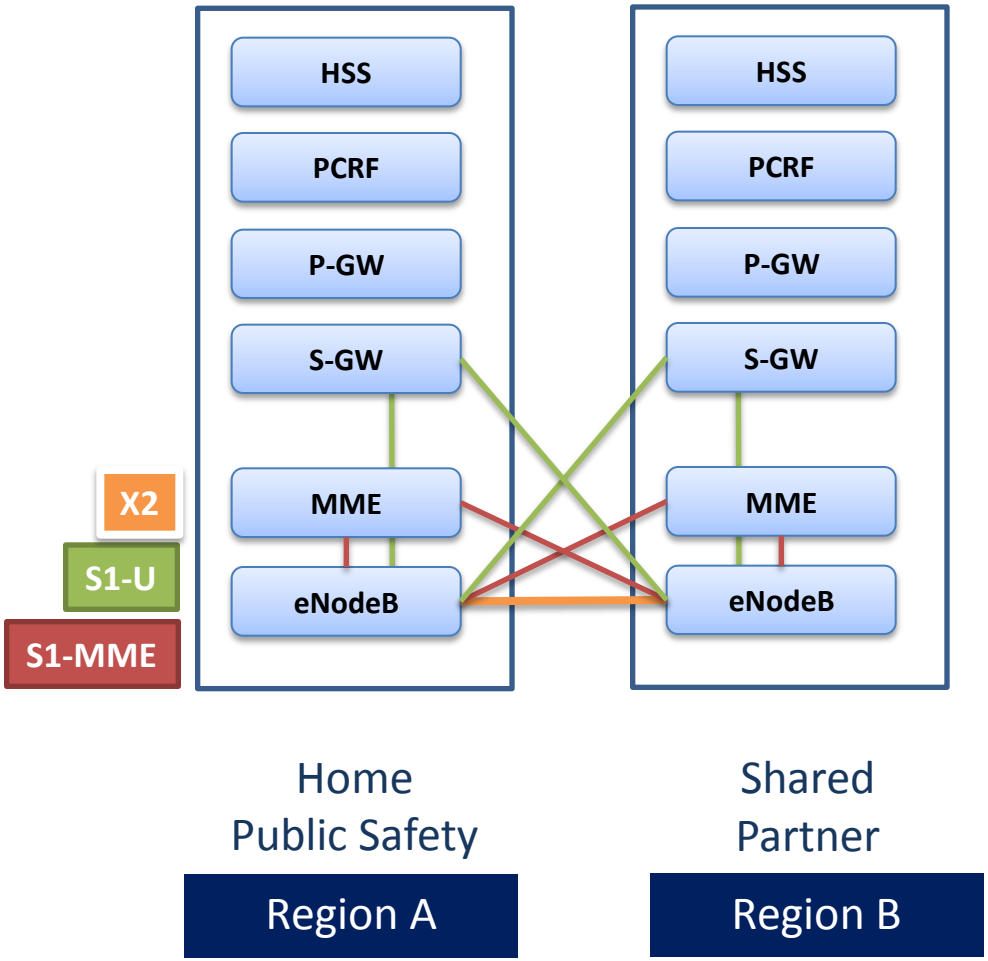
Active Network Sharing (MOCN)

Interfaces

- S1-MME : shared eNB to partner-MME (i.e. potentially both ways)
- S1-U : shared eNBs to partner-S-GW (i.e. potentially both ways)
- X2: shared eNBs to shared/dedicated eNBs; to support inter-operator Inter-cell
- interference coordination (ICIC) and X2-based handovers (optional)

Operational Level Agreement

- Partners in a shared network need to put in lace operational agreements to guarantee the same level of operational efficiency on the shared network than on their dedicated network.



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