LTE Network Architecture

Mobile Faculty
Advanced Level Telecom Training Centre

What is LTE ?

- In Nov. 2004, 3GPP began a project to define the long-term evolution (LTE) of Universal Mobile Telecommunications System (UMTS) cellular technology :
  - Higher performance
  - Backwards compatible
  - Wide application

LTE Basic Concepts

- LTE employs Orthogonal Frequency Division Multiple Access (OFDMA) for downlink data transmission.

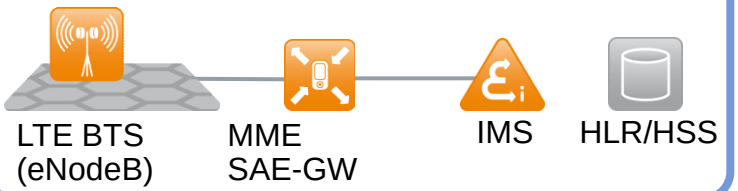
- Single Carrier FDMA (SC-FDMA) for uplink transmission.

LTE : Basic Concepts / Architecture

Connecting India faster

Flat Overall Architecture

- 2-node architecture
- IP routable transport architecture

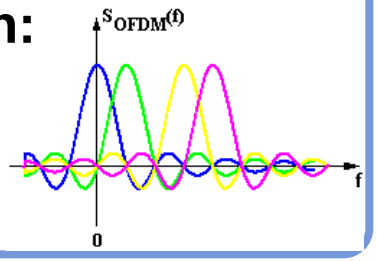


Improved Radio Principles

- peak data rates [Mbps] 173 DL , 58 UL
- Scalable BW: 1.4, 3, 5, 10, 15, 20 MHz
- Short latency: 10 – 20 ms

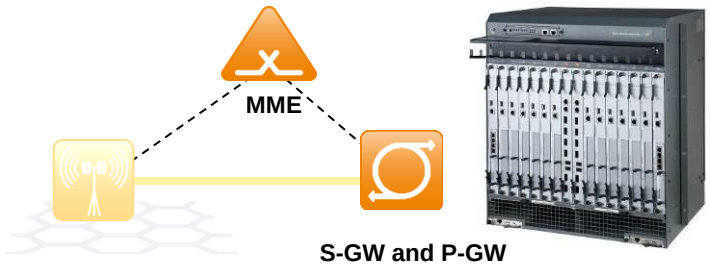
RF Modulation:

- OFDMA in DL
- SC-FDMA in UL



New Core Architecture

- Simplified Protocol Stack
- Simple, more efficient QoS
- UMTS backward compatible security



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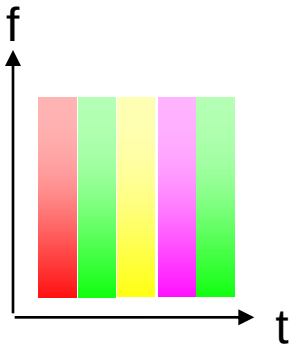
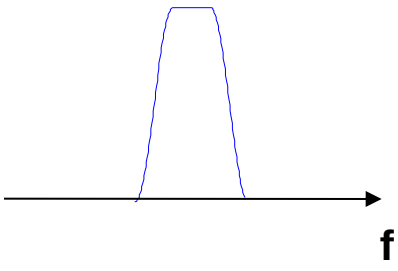
Multiple Access Methods

TDMA

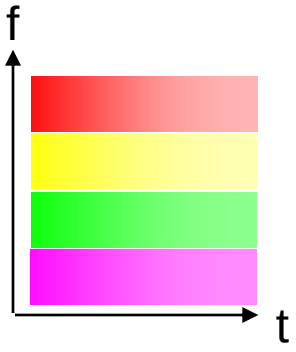
- **Time Division**

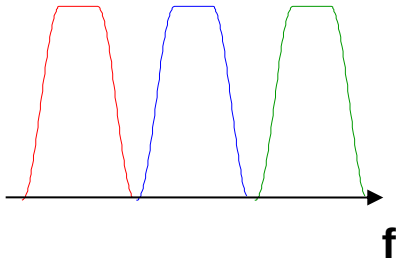




FDMA

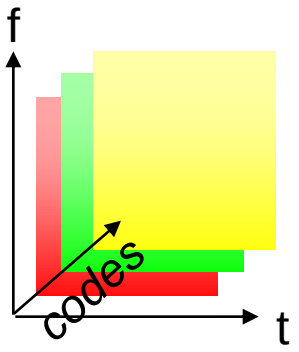
- **Frequency Division**

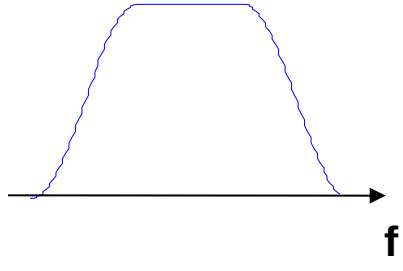




CDMA

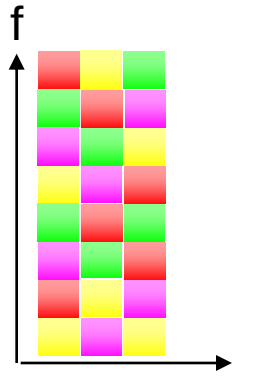
- **Code Division**

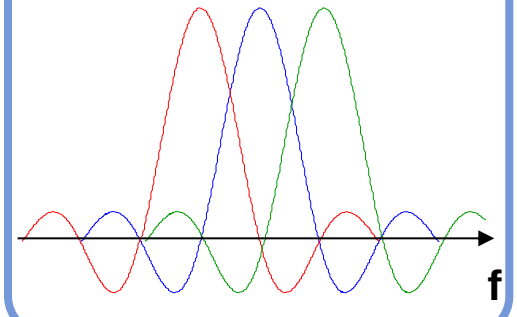




OFDMA

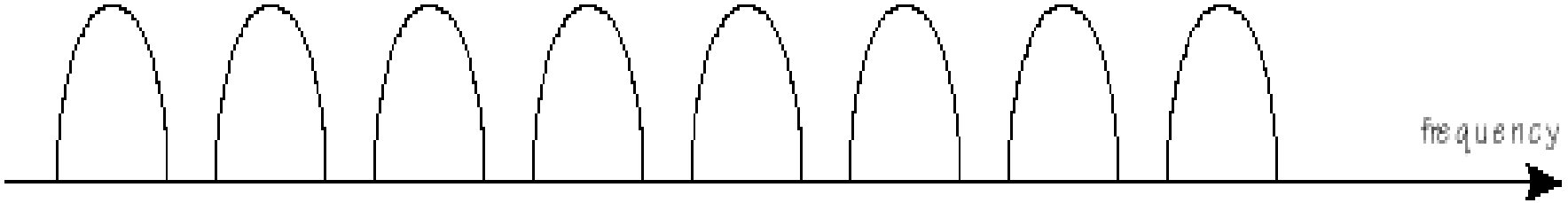
- **Frequency Division**
- **Orthogonal subcarriers**



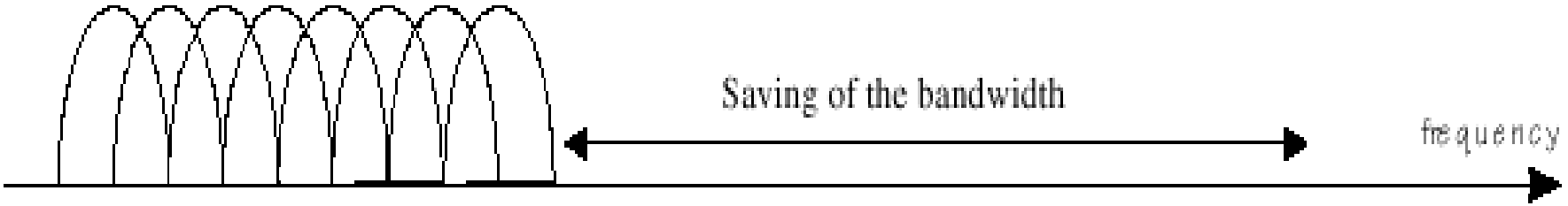


User 1 User 2 User 3 User ..

FDM vs. OFDM

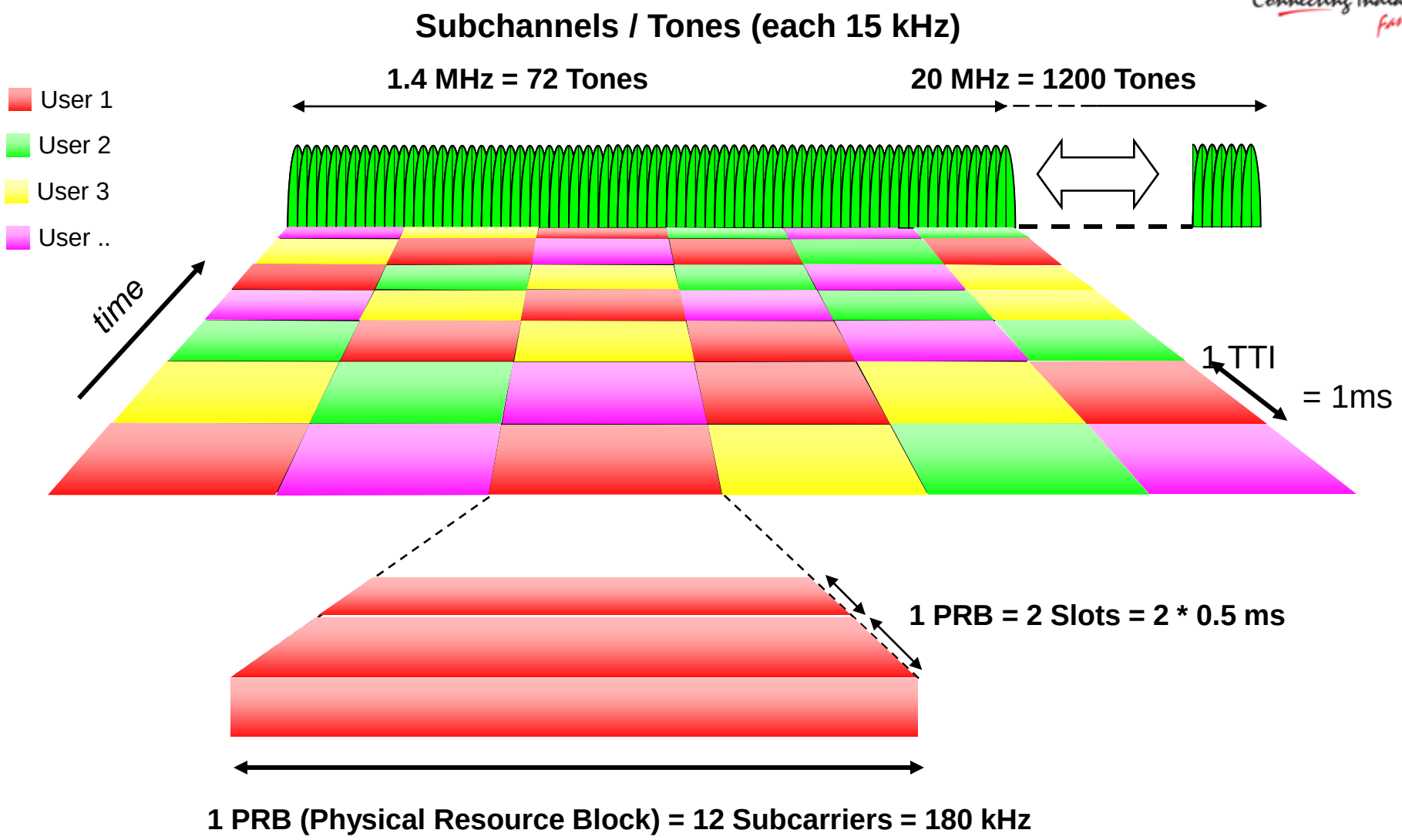


Conventional Frequency Division Multiplex (FDM) multicarrier modulation technique



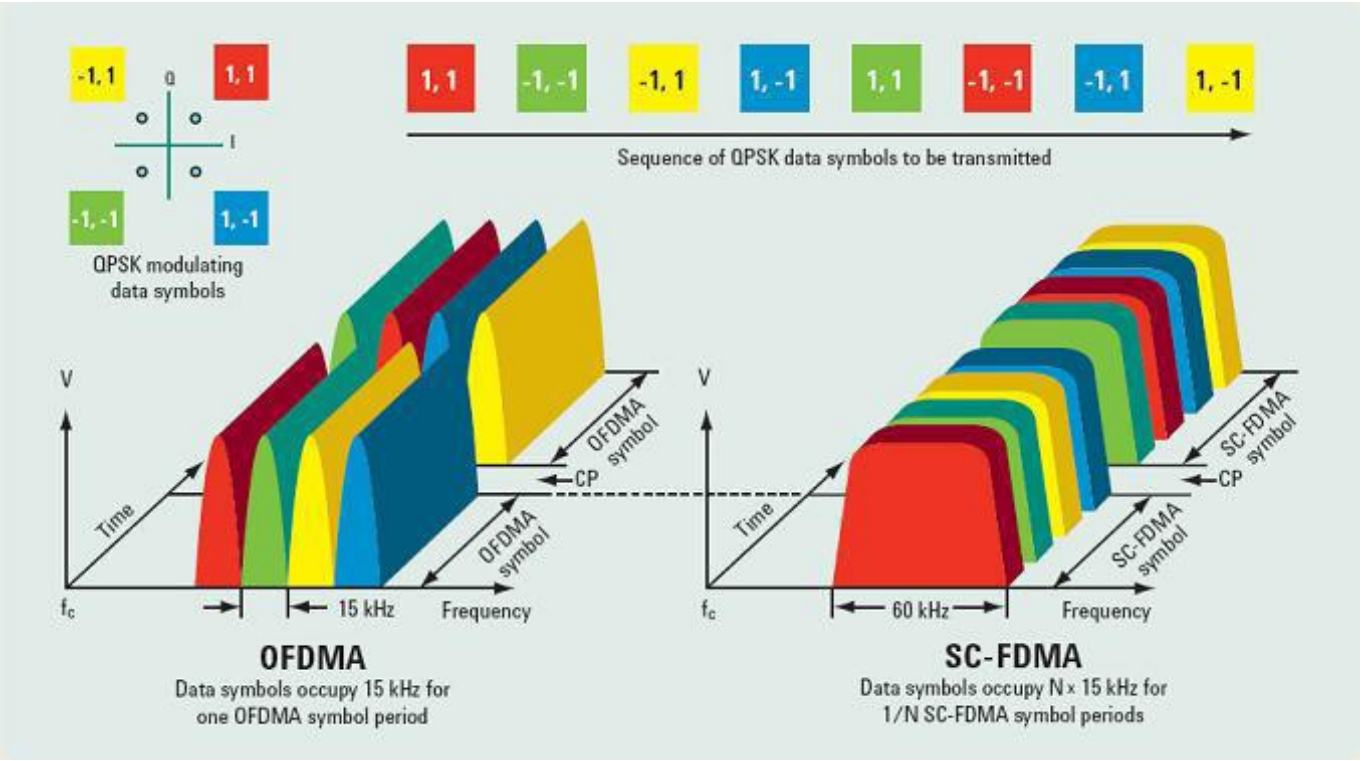
Orthogonal Frequency Division Multiplex (OFDM) multicarrier modulation technique

Downlink - OFDM



LTE Uplink (SC-FDMA)

- SC-FDMA is a new single carrier multiple access technique which has similar structure and performance to OFDMA



A salient advantage of SC-FDMA over OFDM is low to Peak to Average Power Ratio (PAPR) :

Increasing battery life

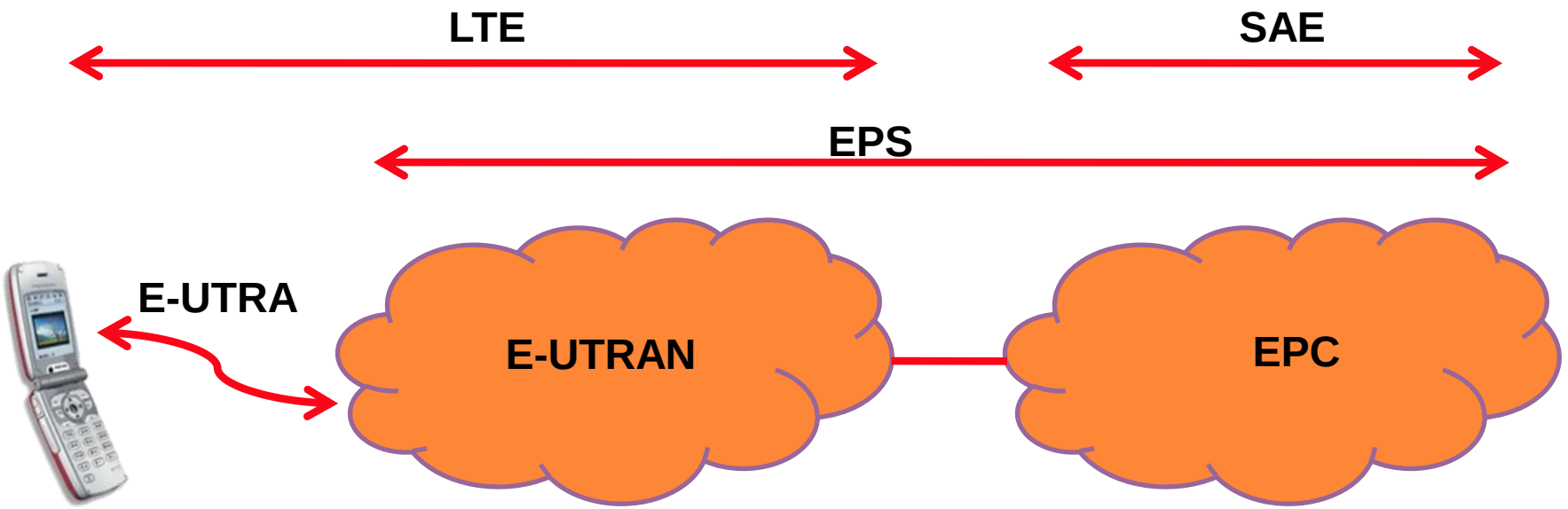
LTE and SAE

Long Term Evolution (LTE) is the term used to describe collectively the evolution of the radio access network into Evolved Universal Terrestrial Radio Access Network (E-UTRAN) and the radio access technology into Evolved Universal Terrestrial Radio Access (E-UTRA).

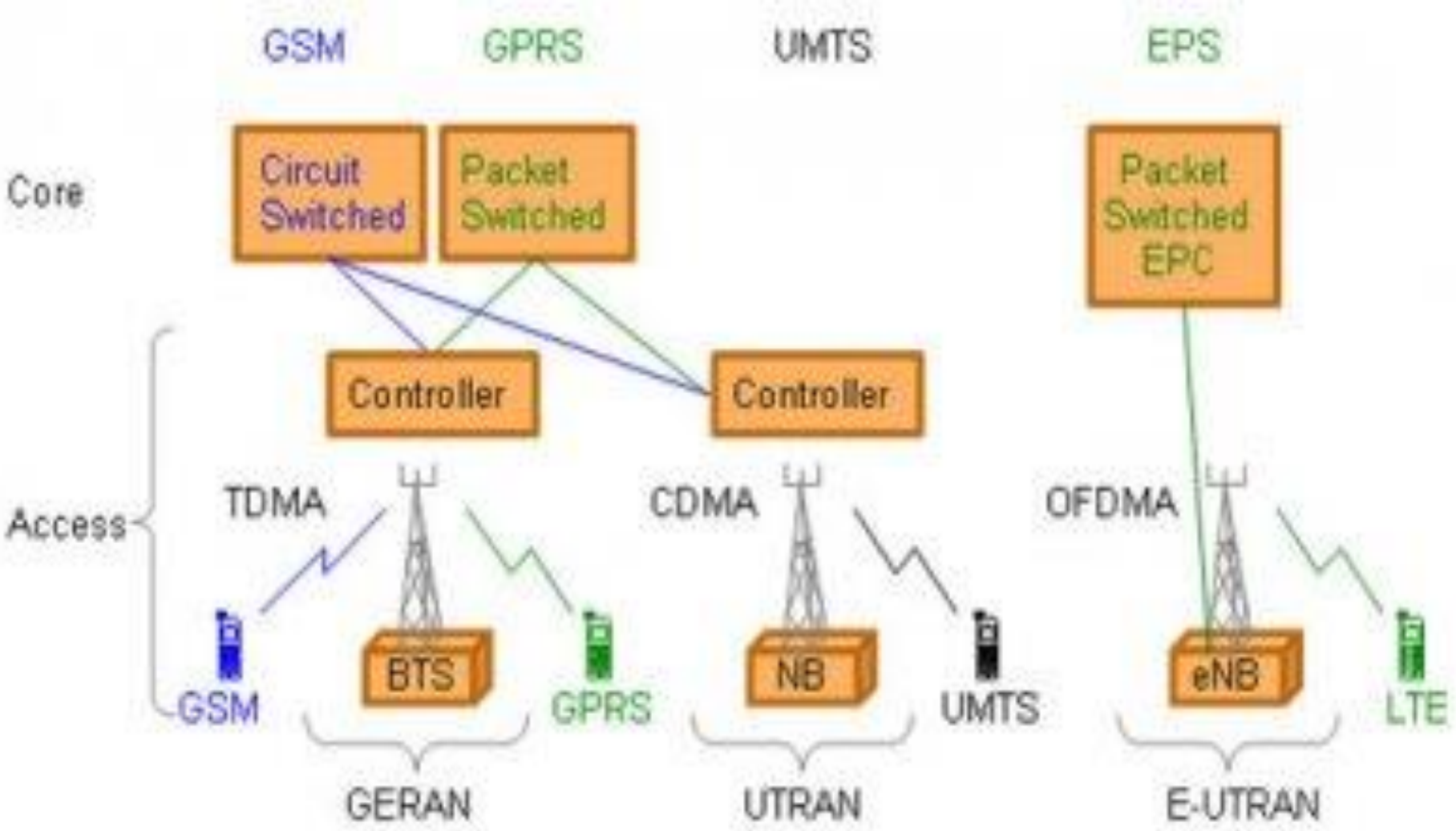
System Architecture Evolution (SAE) is the term used to describe the evolution of the core network into the Evolved Packet Core (EPC).

There is also a collective term, Evolved packet System (EPS), which refers to the combined E-UTRAN and EPC.

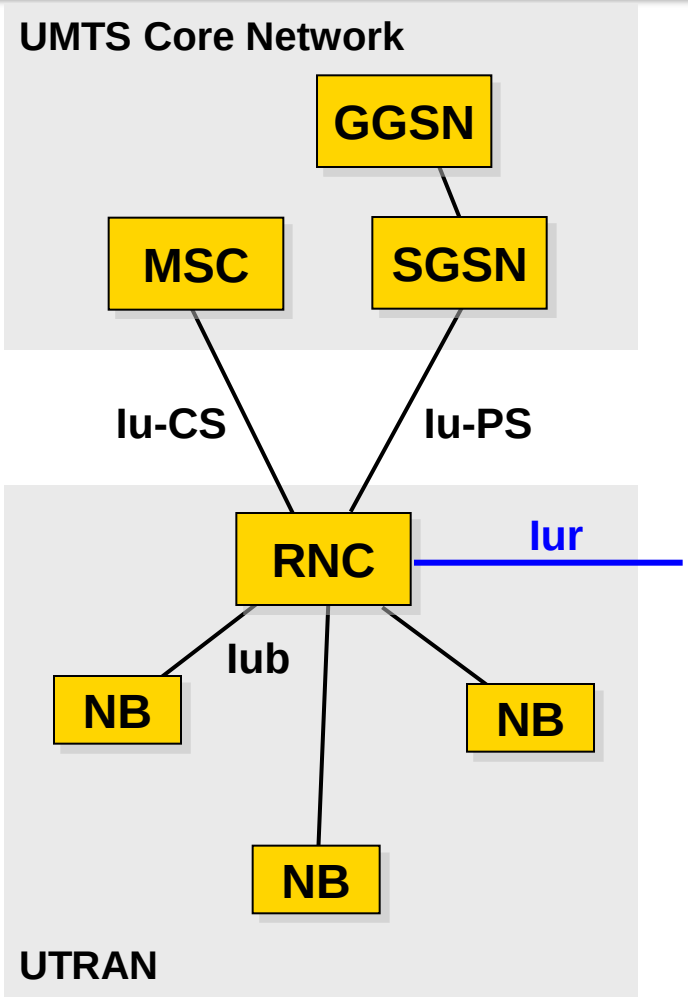
LTE and SAE

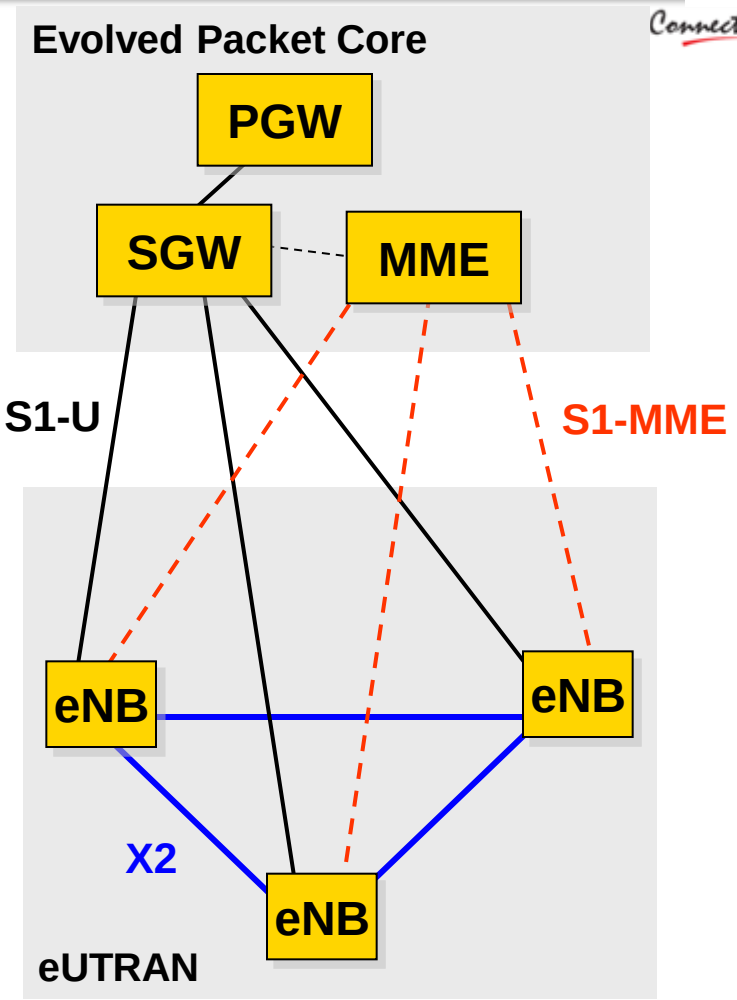


Network Solutions from GSM to LTE



Comparison of UMTS and EPS





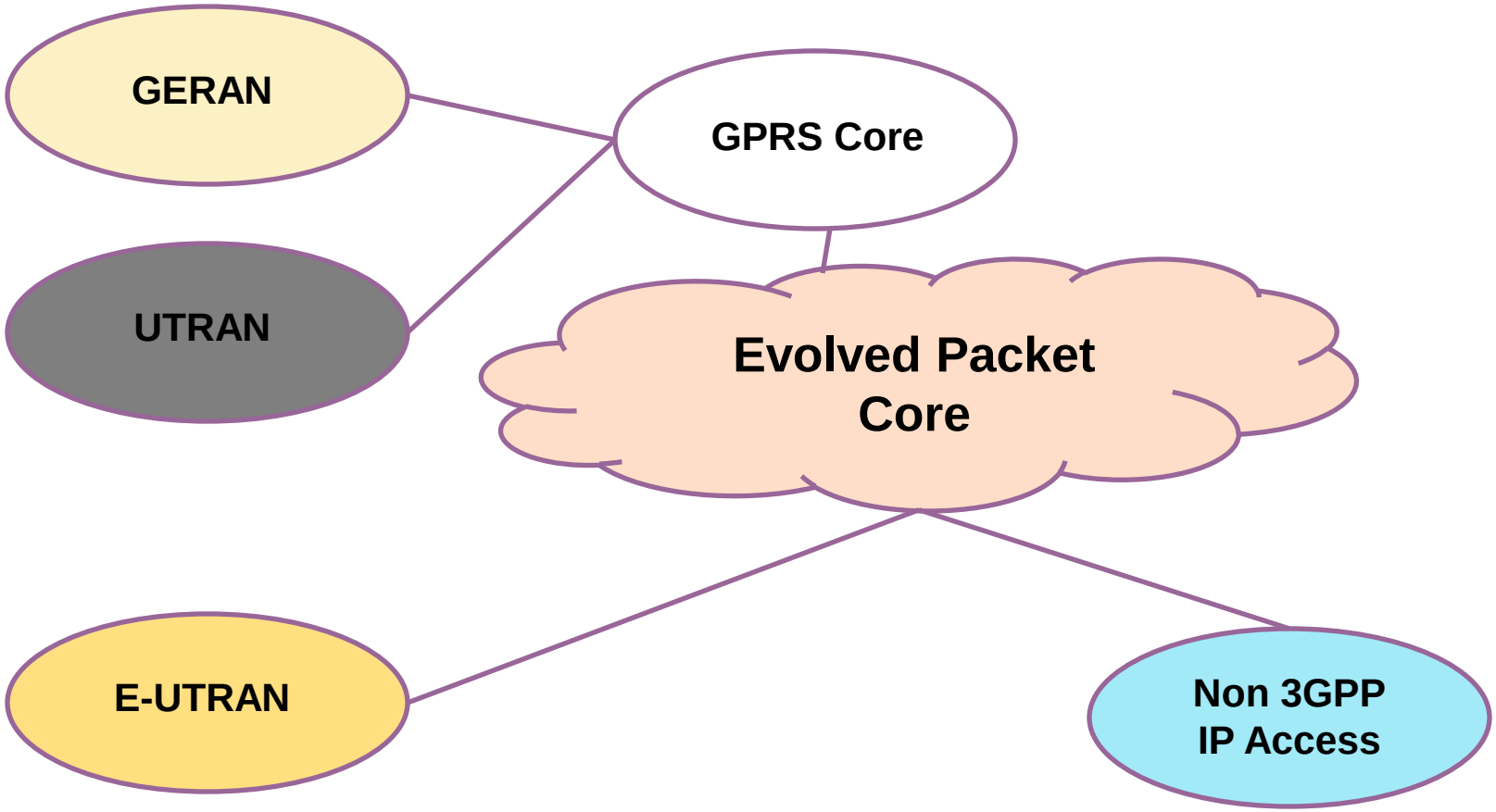
MSC	Mobile Switching Center
NB	NodeB
RNC	Radio Network Controller
SGSN	Serving GPRS Support Node
GGSN	Gateway GPRS Support Node

- eNB evolved NodeB
- MME Mobility Management Entity
- SGW Serving Gateway
- PGW PDN Gateway

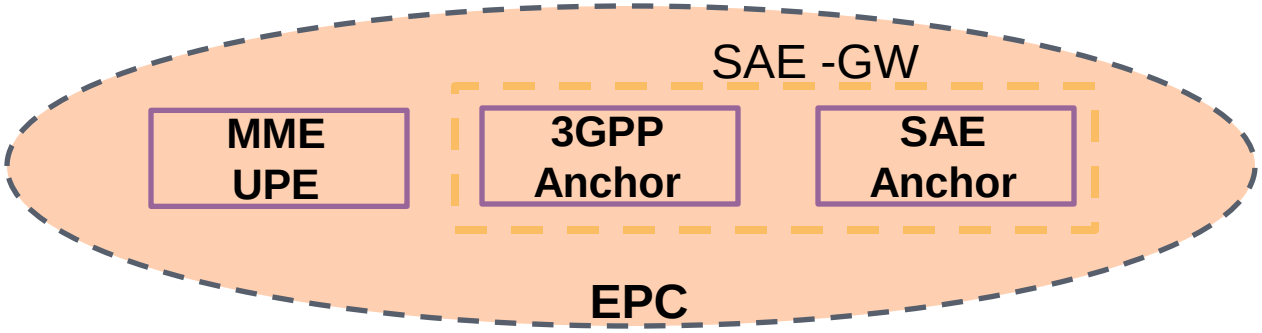
Architecture features

- LTE/SAE architecture is driven by the goal to optimize the system for packet data transfer.
- No circuit switched components.
- New approach in the inter-connection between radio access network and core network.
- The EPS architecture is an EPC and an UTRAN .
- The CN provides access to external packet IP networks and performs a number of CN related functions.
- The RAN performs all radio interface related functions.

System Architecture Evolution

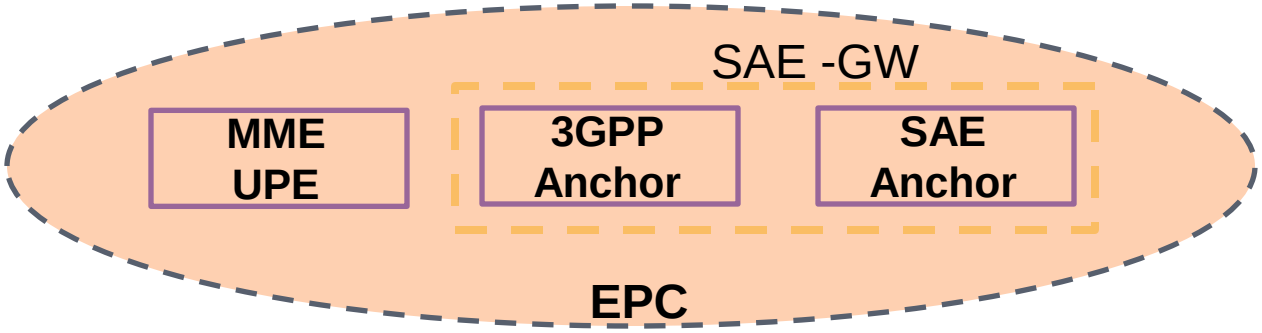


Evolved Packet Core(EPC)



- **MME (Mobility Management Entity):**
  - **Manages and stores the UE control plane context, generates temporary Id, provides UE authentication, authorization, mobility management**
- **UPE (User Plane Entity):**
  - **Manages and stores UE context, ciphering, mobility anchor, packet routing and forwarding, initiation of paging.**

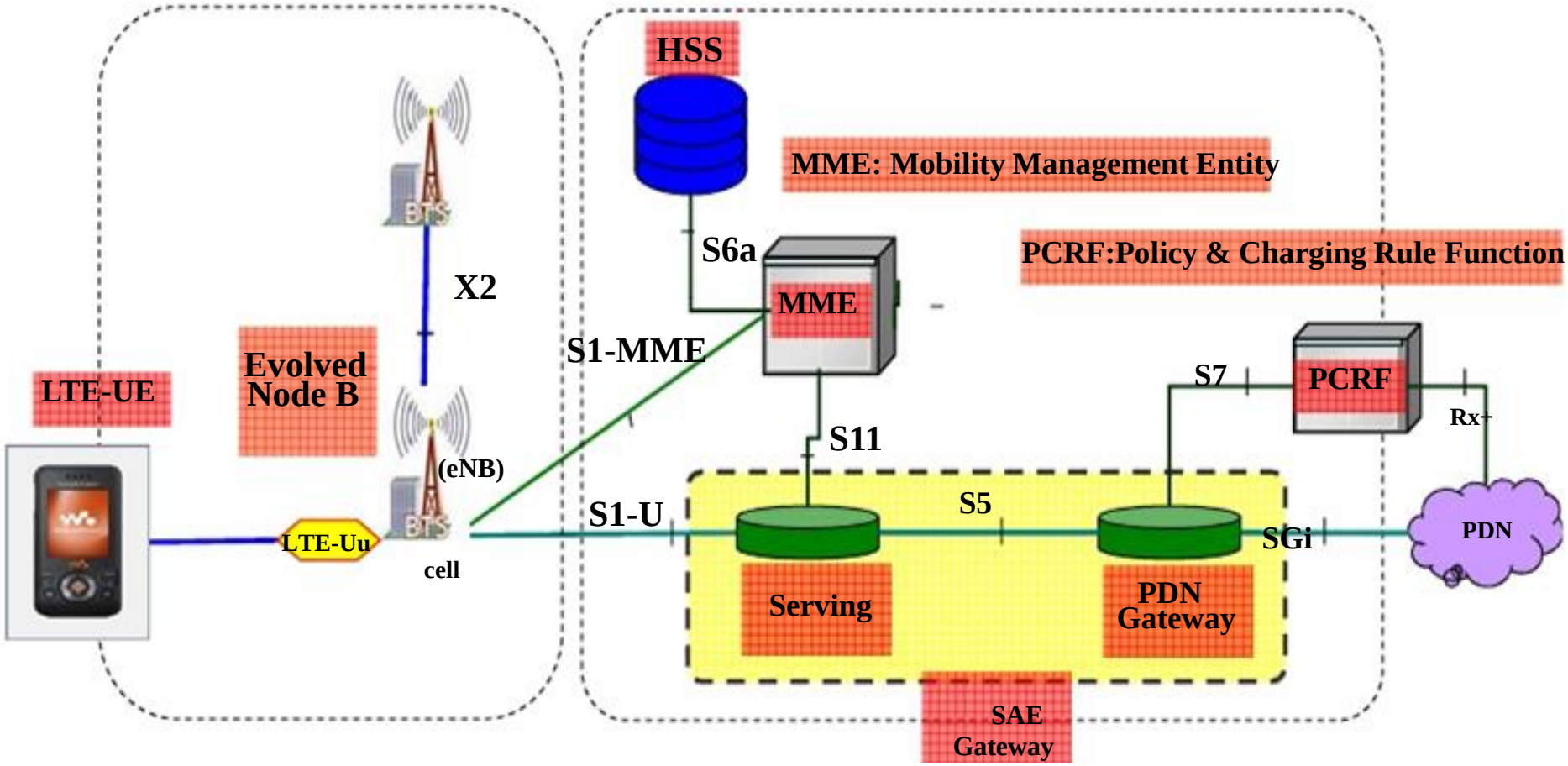
Evolved Packet Core(EPC)



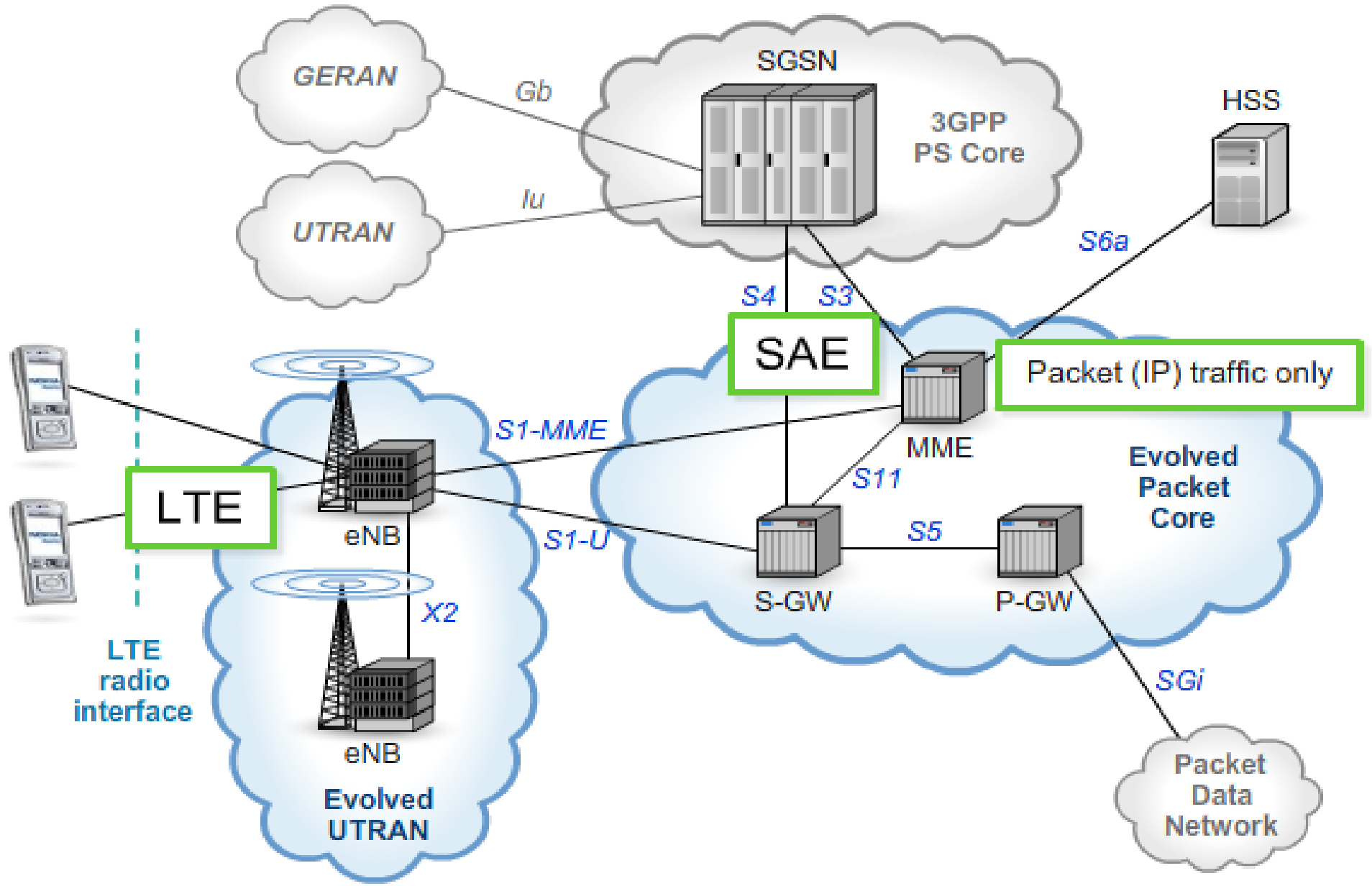
- 3GPP anchor:
  - Mobility anchor between 2G/3G and LTE.

- SAE anchor:
  - Mobility anchor between 3GPP and non 3GPP.

LTE/SAE Network Elements



LTE / SAE Architecture



LTE INTERFACE

- **The LTE radio interface (air interface, LTE-Uu) is between the user equipment (UE) and the eNB.**
- **The evolved Node B (eNodeB, eNB) supports the LTE radio interface and provides the packet-switched functionality of a traditional radio network controller (RNC). As a result, the Evolved UTRAN does not require a separate RNC network element, in other words the architecture is "flat" (architecture contains fewer types of network entities and interfaces)**
- **The X2 interface between two eNB network elements is used during an inter-eNB handover.**
- **The S1-MME interface carries control plane signalling information between the eNodeB and Mobility Management Entity.**
- **The S1-U interface between the eNodeB and Serving Gateway carries the user plane data over a so-called GTP tunnel.**

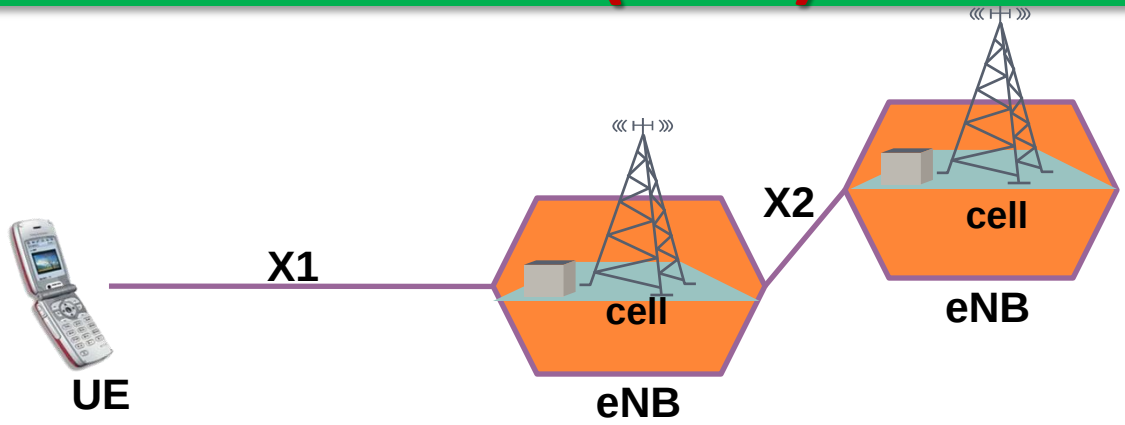
LTE INTERFACE

- The S4 interface between the S-GW and SGSN provides a GTP tunnel for the user plane during an inter-system handover.
- The S3 interface carries signalling between the MME and Serving GPRS Support Node (SGSN) located in a 2G/3G packet-switched core network.
- The S11 interface carries signalling messages between the Serving Gateway and the Mobility Management Entity.
- The S6a interface is used for transferring subscription and authentication data between the Home Subscriber Server (HSS) and MME.
- The SGi interface is between the PDN Gateway and the packet data network (PDN). The packet data network may be an operator-external public or private IP network, or an IP network belonging to the operator, for instance providing IP Multimedia Subsystem (IMS) services. Legacy Gn/Gp interface connectivity to the EPS is also supported.

LTE INTERFACE

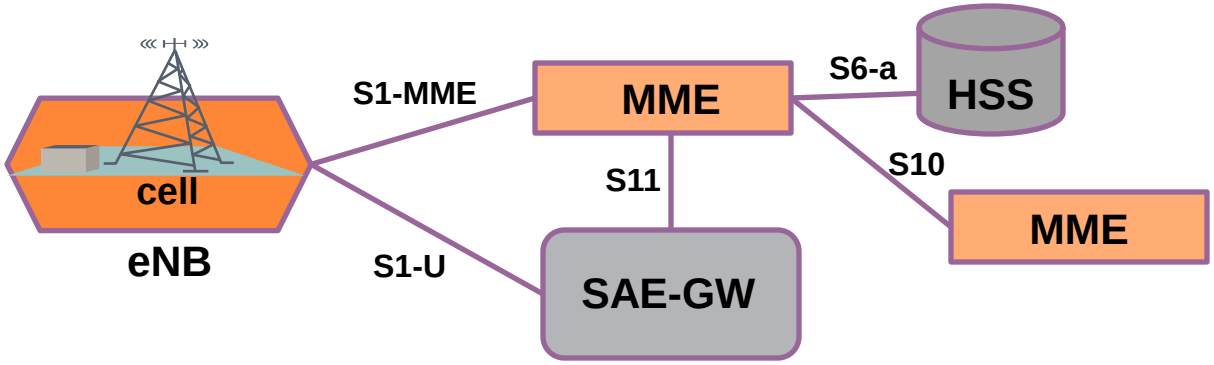
- **The SGi interface is between the PDN Gateway and the packet data network (PDN). The packet data network may be an operator-external public or private IP network, or an IP network belonging to the operator, for instance providing IP Multimedia Subsystem (IMS) services. Legacy Gn/Gp interface connectivity to the EPS is also supported.**
- **The Serving Gateway (S-GW) and PDN Gateway (P-GW) provide the user plane connectivity between the access network and the external packet data network (PDN). In the Nokia Siemens Networks LTE solution, it is possible to implement these functional entities within a single node.**
- **The Mobility Management Entity (MME) provides the basic control plane functionality in the Evolved Packet Core network. Note that user plane traffic does not go through the MME.**

Evolved Node B (eNB)



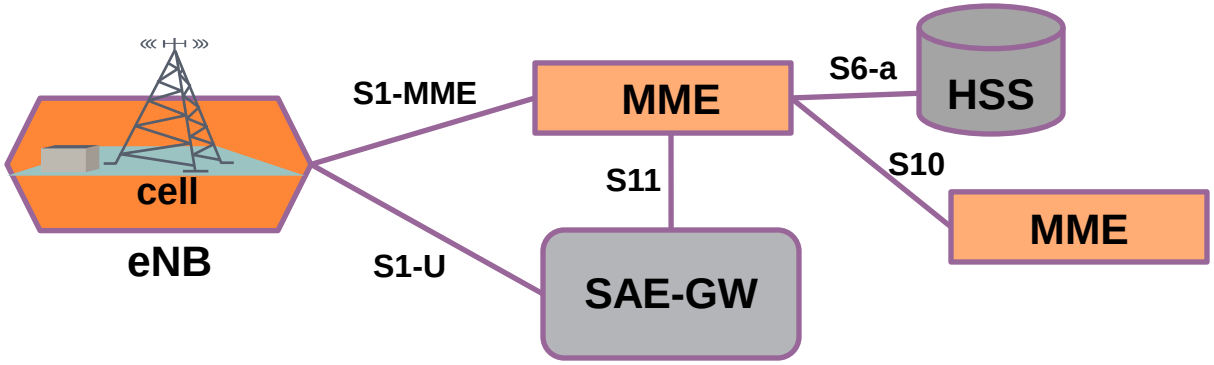
- It is the only network element defined as part of EUTRAN.
- It replaces the old Node B / RNC combination from 3G.
- It terminates the complete radio interface including physical layer.
- It provides all radio management functions.
- An eNB can handle several cells.
- There is a inter-eNB interface X2 specified.
- It is connected to EPC nodes by means of S1 interface.

Mobility Management Entity (MME)



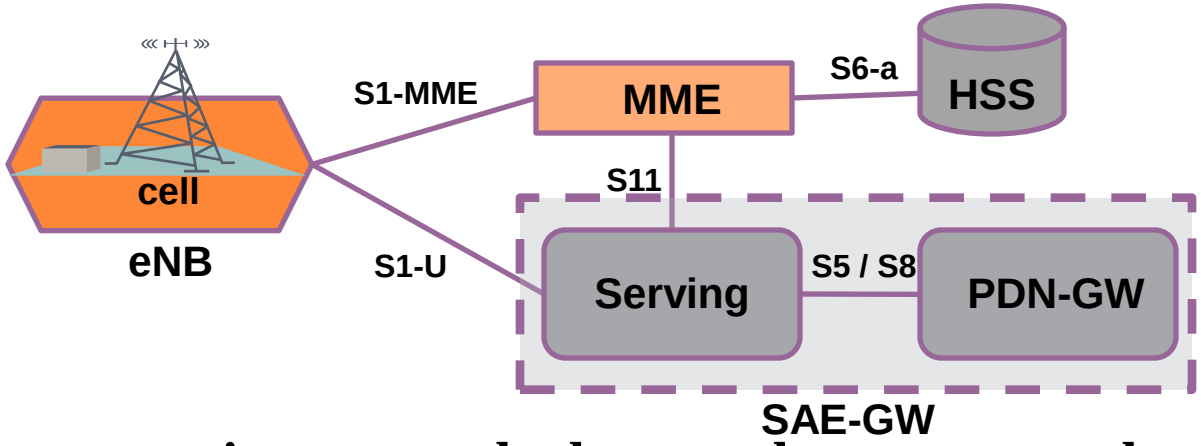
- It is a pure signaling entity inside the EPC.
- SAE uses tracking areas to track the position of idle UEs. The basic principle is identical to location or routing areas from 2G/3G.
- MME handles attaches and detaches to the SAE system, as well as tracking area updates .Therefore it possesses an interface towards the HSS (home subscriber server) which stores the subscription relevant information and the currently assigned MME in its permanent data base.

Mobility Management Entity (MME)



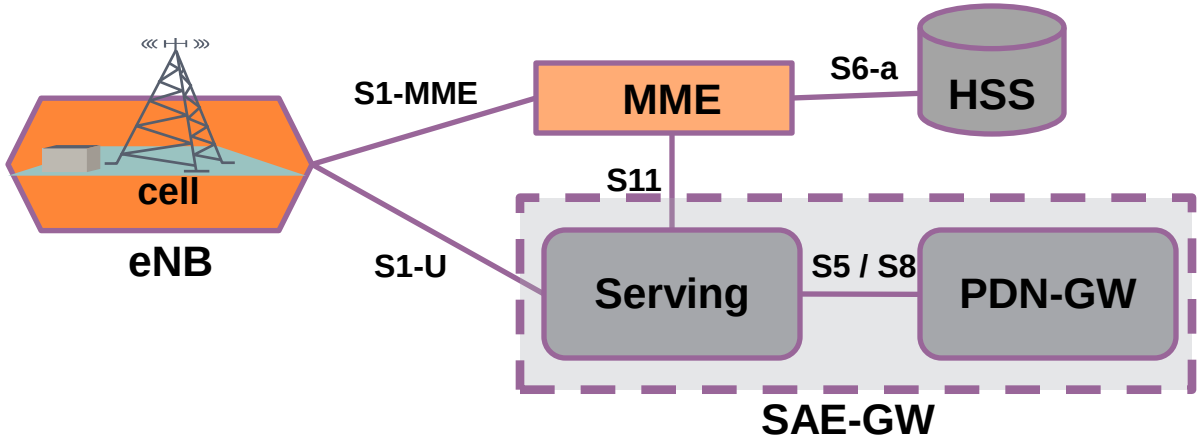
- **Functionality of the MME is the signaling coordination to setup transport bearers (SAE bearers) through the EPC for a UE.**
- **It is connected to eNB via the S1-MME interface.**
- **MMEs can be interconnected via the S10 interface.**
- **MME handles SGW via the S11 interface.**

Serving SAE Gateway (SAE-GW)



- The serving gateway is a network element that manages the user data path (SAE bearers) within EPC.
- It is connected to eNB via the S1-U interface. It receives uplink packet data from here and transmits downlink packet data on it.
- Thus the serving gateway is some kind of distribution and packet data anchoring function within EPC.
- It relays the packet data within EPC via the S5/S8 interface to or from the PDN gateway.
- A serving gateway is controlled by one or more MMEs via S11 interface.

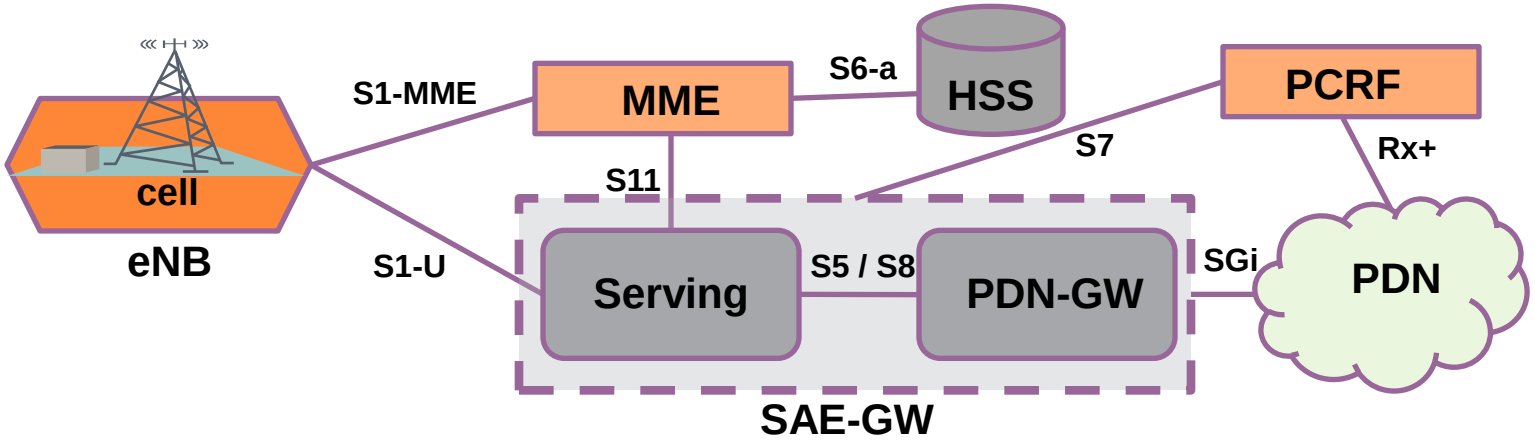
Serving SAE Gateway (SAE-GW)



SAE-GW Functions

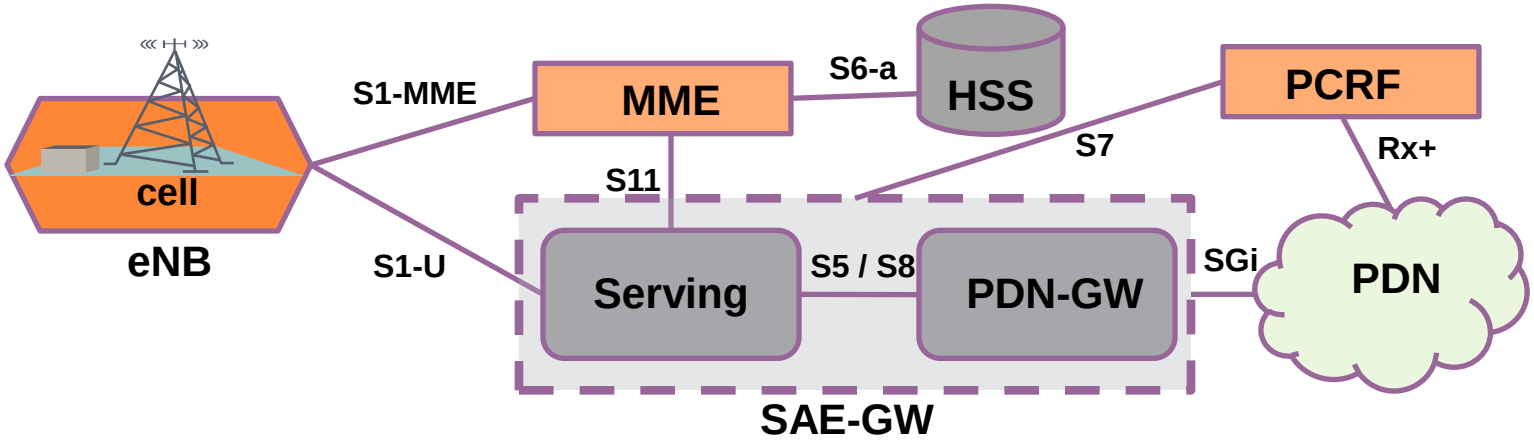
- **Local mobility anchor point:** Switching the user plane path to a new eNB in case of handover.
- **Mobility anchoring for inter-3GPP mobility:** This is sometimes referred to as the 3GPP Anchor function.
- **Idle Mode Packet Buffering and notification to MME.**
- **Packet Routing/Forwarding between eNB, PDN GW**
- **Lawful Interception support**

PDN SAE Gateway (PDN-GW)



- The PDN gateway provides the connection between EPC and a number of external data networks.
- It is comparable to GGSN in 2G/3G networks.
- A major functionality provided by a PDN gateway is the QoS coordination between the external PDN and EPC.
- PDN gateway can be connected via S7 to a PCRF(Policy and Charging Rule Function).

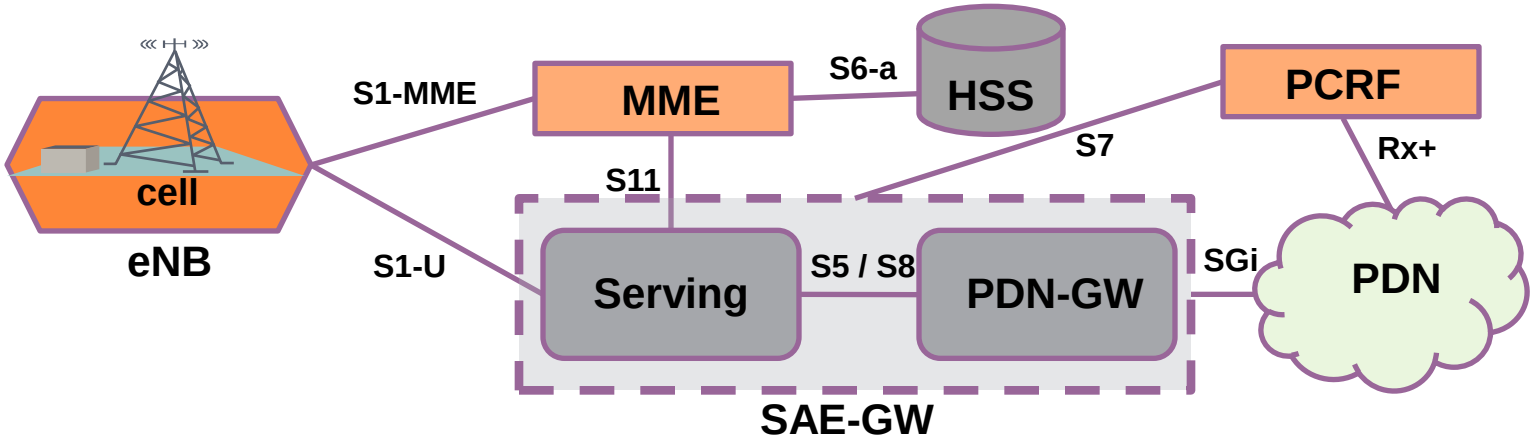
PDN SAE Gateway (PDN-GW)



PDN Gateway Functions

- Charging & Lawful Interception support.
- IP Address Allocation for UE.
- Packet Routing/Forwarding between Serving GW and external Data Network.
- Packet screening (firewall functionality).

Policy and Chargifg Function (PCRF)



- The PCRF major functionality is the Quality of Service (QoS) coordination between the external PDN and EPC.
- PCRF is connected via Rx+ interface to the external Data network .
- PCRF can be used to check and modify the QoS associated with a SAE bearer setup from SAE or to request the setup of a SAE bearer from the PDN.

Home Subscriber Server (HSS)

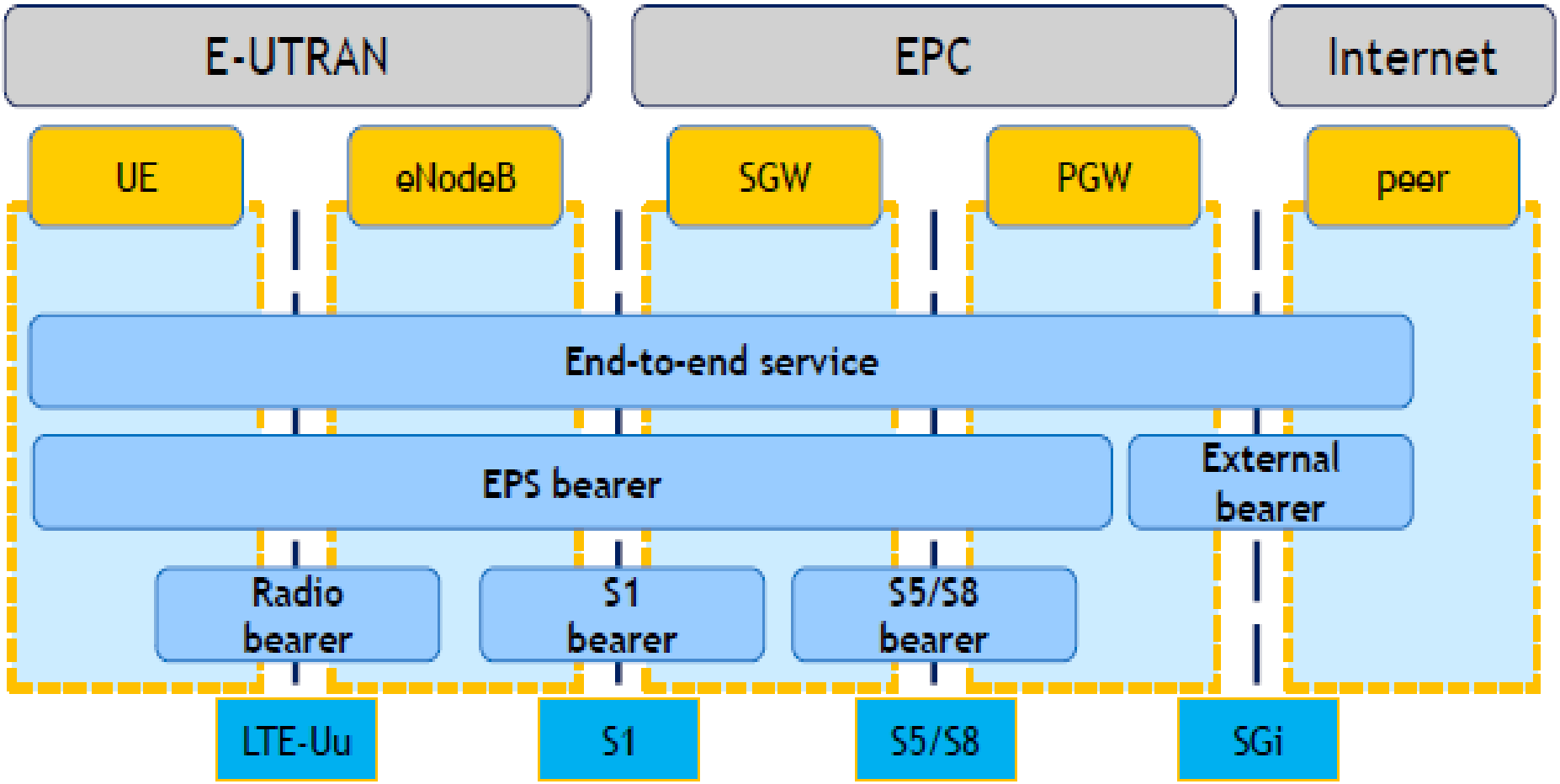
- The HSS is already introduced by UMTS release 5.
- With LTE/SAE the HSS will get additionally data per subscriber for SAE mobility and service handling.
- The HSS can be accessed by the MME via S6a interface.

Home Subscriber Server (HSS)

HSS Functions

- Permanent and central subscriber database.
- Stores mobility and service data for every subscriber.
- Contains the Authentication Center (AuC) functionality.

EPC bearer management



Terminology in LTE and in 3G

3G	LTE
Connection management	
GPRS attached	EMM registered
PDP context	EPS bearer
Radio access bearer	Radio bearer + S1 bearer
Mobility management	
Location area	Not relevant (no CS core)
Routing area	Tracking area
Handovers (DCH) and cell reselections (PCH) when RRC connected	Handovers when RRC connected
RNC hides mobility from core network	Core network sees every handover

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