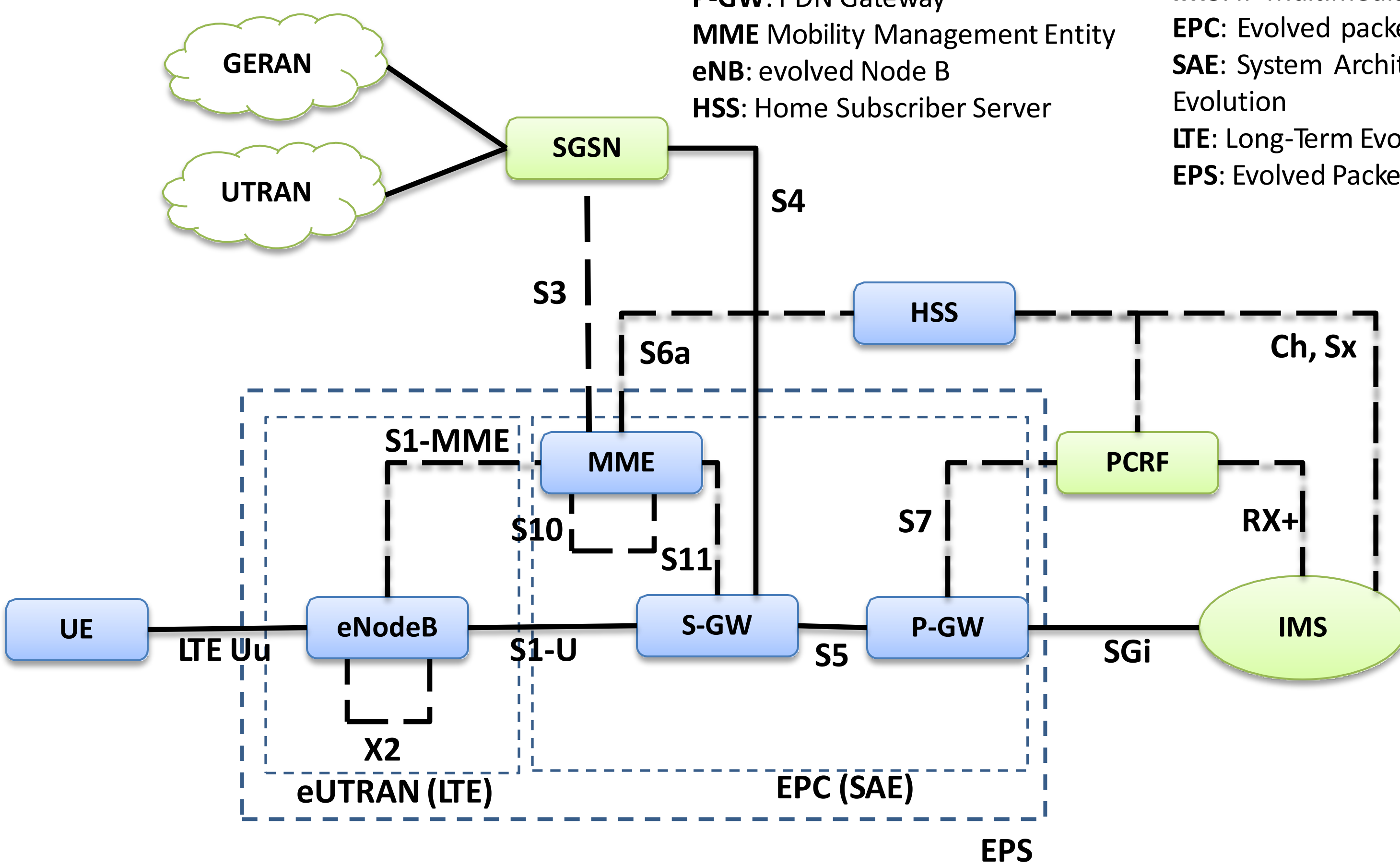
LTE System Architecture & Protocols

LTE Basic Reference Model

UE: User Equipment
S-GW: Serving Gateway
P-GW: PDN Gateway
MME Mobility Management Entity
eNB: evolved Node B
HSS: Home Subscriber Server

PCRF: Policy Control and Charging Rule Function
IMS: IP Multimedia Subsystem
EPC: Evolved packet Core
SAE: System Architecture Evolution
LTE: Long-Term Evolution
EPS: Evolved Packet System



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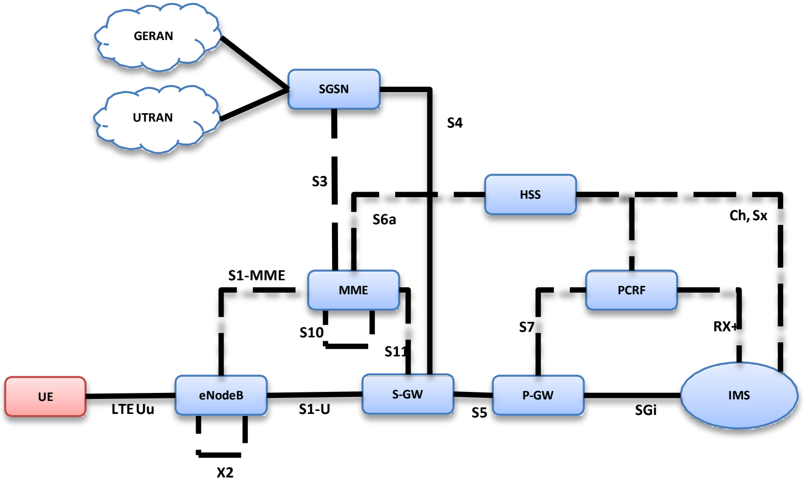
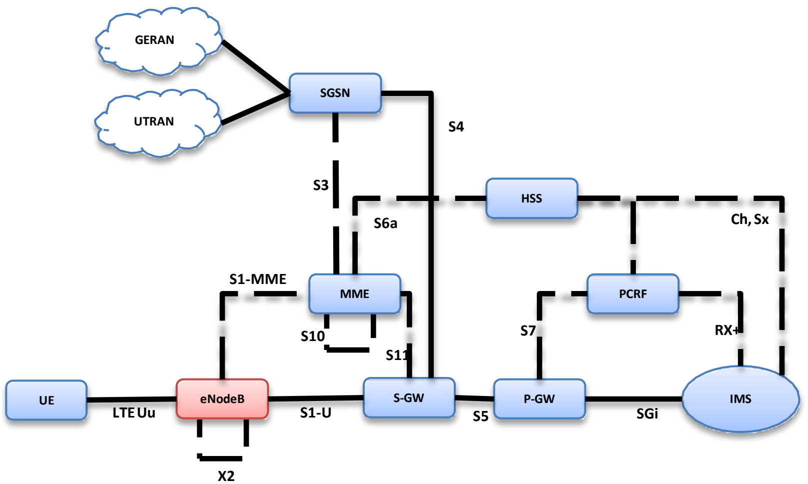
User Equipment (UE)

- Access device for user.
- Provides measurements that indicate channel conditions to the network.



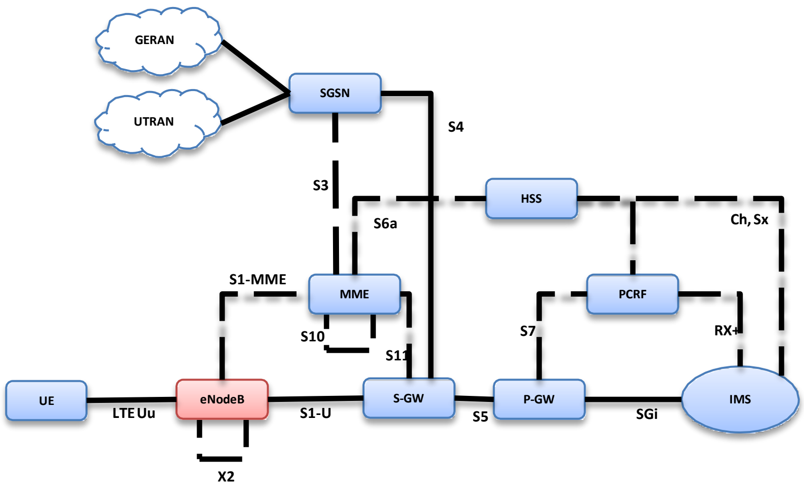
eNodeB (1/2)

- Hosts the PHYsical (PHY), Medium Access Control (MAC), Radio Link Control (RLC), and Packet Data Convergence Protocol (PDCP) layers.
- Controls user-plane header-compression and encryption.
- Provides Radio Resource Control (RRC) functionality for the control plane.
- Functions include radio resource management, admission control, scheduling, enforcement of negotiated uplink QoS, cell information broadcast, ciphering/deciphering of user and control plane data, and compression and decompression of downlink and uplink user-plane packet headers.



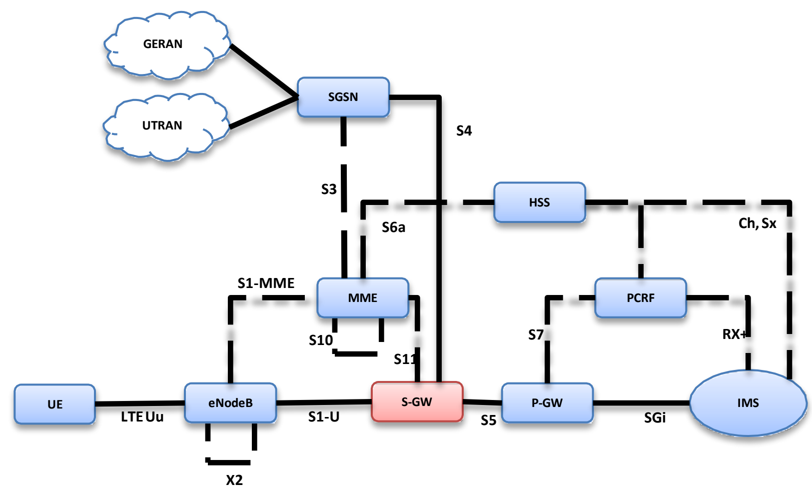
eNodeB (2/2)

- Cell control and MME pool support
- Mobility control
- Control and User Plane security
- Shared Channel handling
- Packet Segmentation/Concatenation
- HARQ
- Scheduling
- Multiplexing and Mapping.
- Physical layer functionality
- Measurements and reporting
- Automated operation and maintenance



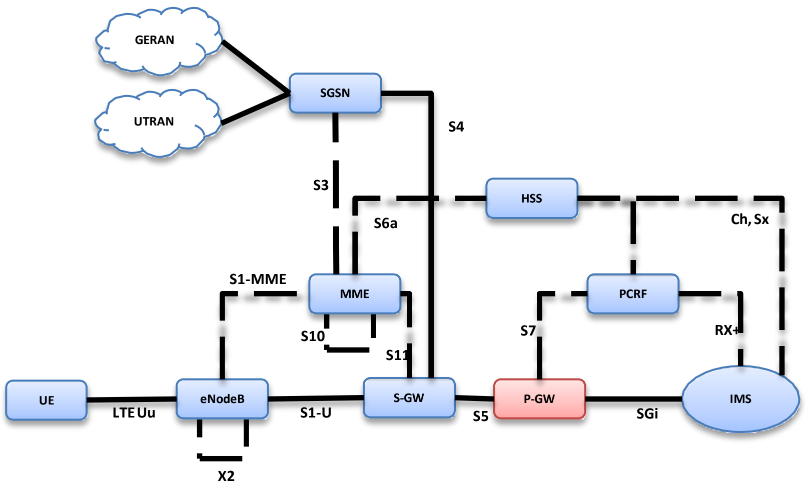
Serving Gateway (S-GW)

- Routes and forwards user data packets.
- Acts as the mobility anchor for the user plane during inter-eNB handovers and as the anchor for mobility between LTE and other 3GPP technologies.
- Terminates the downlink data path for idle state UEs and triggers paging when DL data arrives for the UE.
- Manages and stores UE contexts, e.g. parameters of the IP bearer service and network internal routing inform



PDN Gateway (P-GW)

- Provides connectivity between the UE and external packet data networks (PDNs) by being the point of exit and entry for UE traffic (A UE may have simultaneous connectivity with more than one P-GW for accessing multiple PDNs).
- Performs policy enforcement, packet filtering for each user, charging support, lawful Interception, and packet screening.
- Acts as the anchor for mobility between 3GPP and non- 3GPP technologies such as WiMAX and 3GPP2 (CDMA 1X and EvDO).



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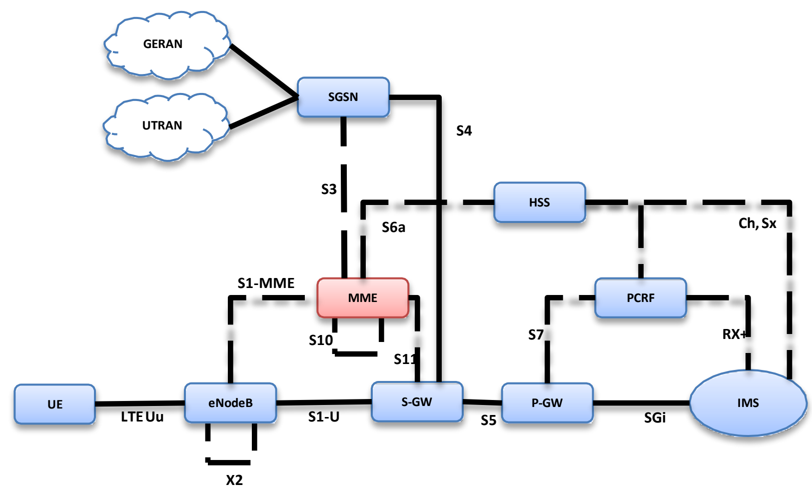
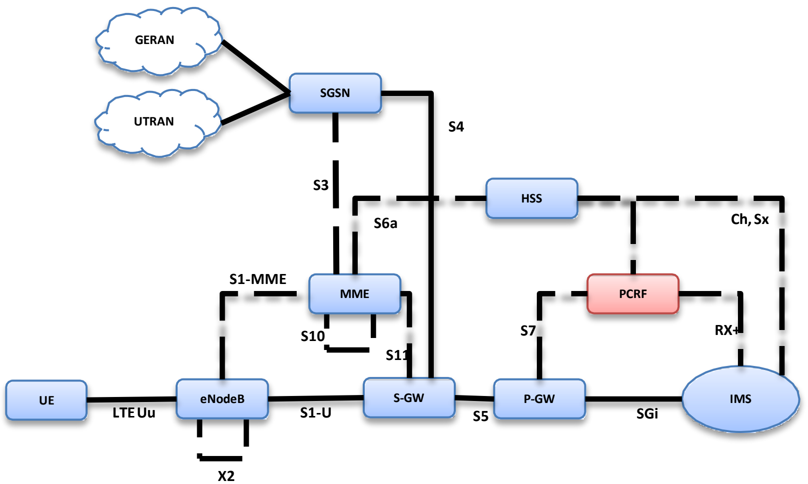
MME (Mobility Management Entity)

- Acts as the key control node for the LTE network. Responsible for idle mode UE tracking and paging procedure including retransmissions.
- Controls bearer activation/deactivation process. Chooses the Serving Gateway (S-GW) for a UE at initial attachment and at the time of intra-LTE handover.
- Authenticates the user by interacting with the Home Subscriber Server (HSS).
- Serves as the termination point for the Non-Access Stratum (NAS) signaling. NAS signaling is responsible for generation and allocation of temporary identities to UEs and checks the authorization of the UE to camp on the system.
- Serves as the termination point for ciphering and integrity protection for NAS signaling.
- Handles security key management.
- Provides control plane function for mobility between LTE and other access networks.



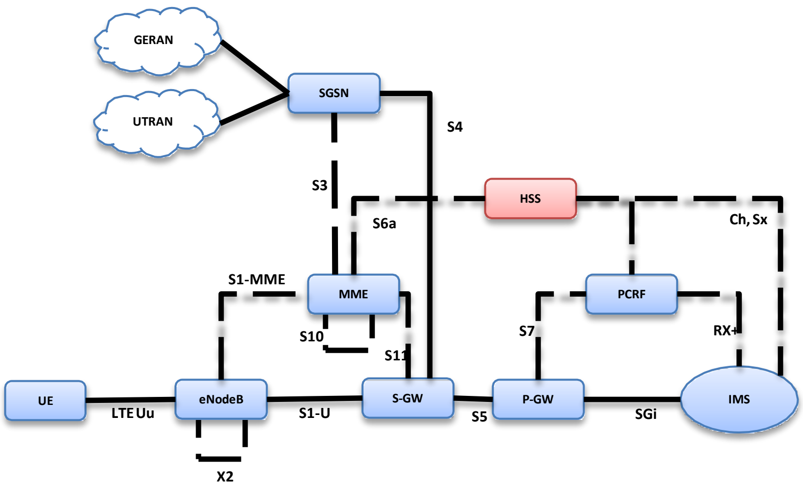
PCRF

- The Policy and Charging Rules Function (PCRF) acts as a policy decision point for policy and charging control of service data flows and IP bearer resources.
- The PCRF selects and provides the applicable policy and charging control decision to the PCEF (i.e. P-GW).
- PCRF is the policy and charging control element.
- PCRF functions are described in more detail in TS 23.203 [73].
- A single logical PCRF entity may be deployed by means of multiple and separately addressable PCRFs in the PLMN.
- In this case, the PCRF discovery and selection is enabled by Diameter Routing Agency (DRA).



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.
- Some changes in the database as well as in the HSS protocol (DIAMETER) will be necessary to enable HSS for LTE/SAE.
- The HSS can be accessed by the MME via S6a interface.
- The HSS acts as the permanent and central subscriber database; it stores mobility and service data for every subscriber, and contains the Authentication Center (AuC) functionality.

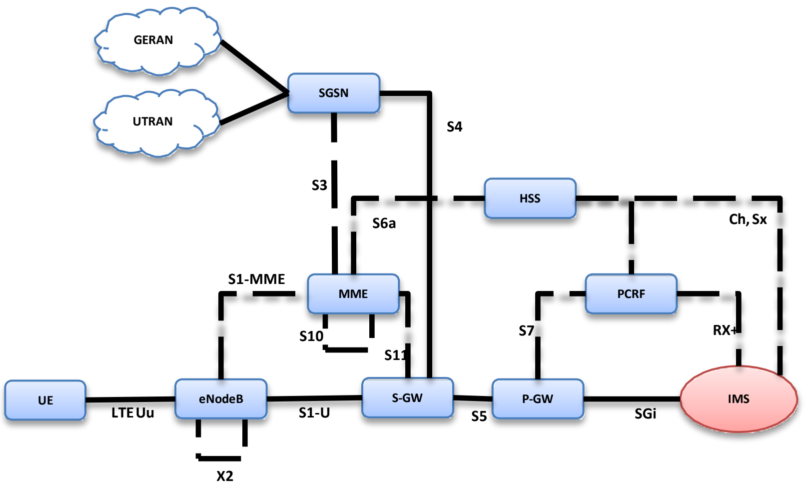


IMS

- The CSCF can act as Proxy CSCF (P-CSCF), Serving CSCF (S-CSCF), Emergency CSCF (E-CSCF), or Interrogating CSCF (I-CSCF).
- The P-CSCF is the first contact point for the UE within the IM subsystem (IMS);

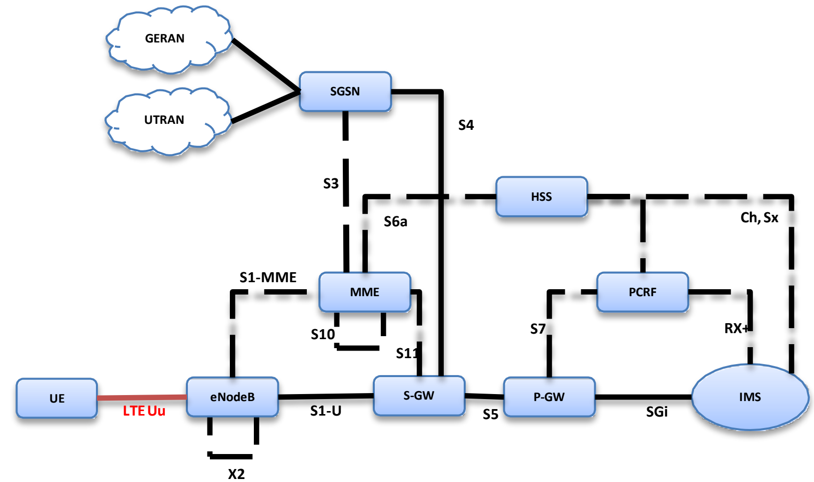
  the S-CSCF actually handles the session states in the network; the E-CSCF handles certain aspects of emergency sessions such as routing an emergency request to the correct emergency centre or PSAP;

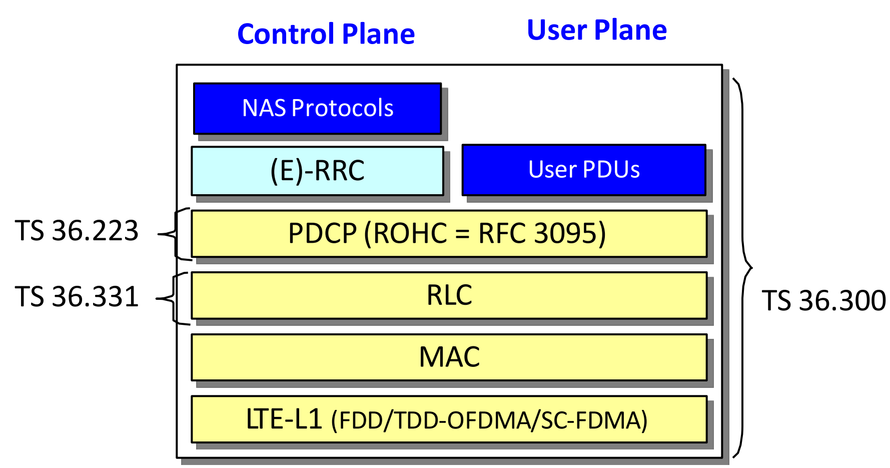
  the I-CSCF is mainly the contact point within an operator's network for all IMS connections destined to a subscriber of that network operator, or a roaming subscriber currently located within that network operator's service area. Further definitions of the P-, S- and I-CSCF are provided in TS 23.228 [34]. Further definitions of the E-CSCF is provided in TS 23.167 [74].



LTE-Uu Interface

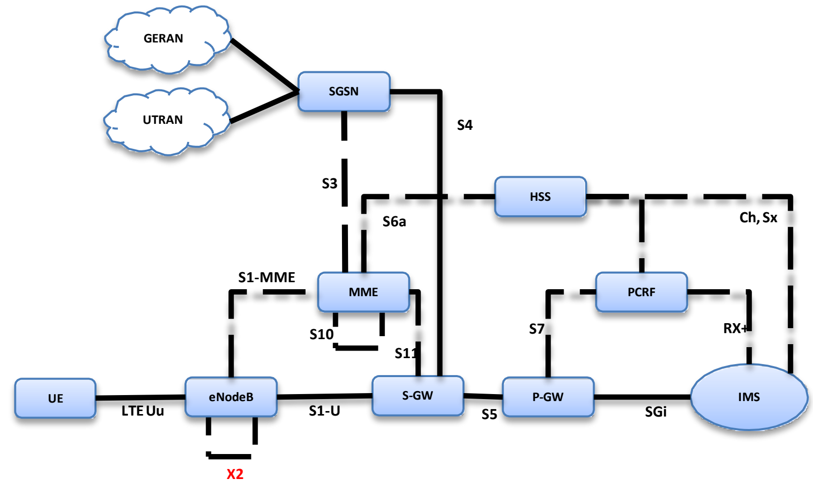
- Air interface of EUTRAN
- Based on OFDMA in downlink and SC-FDMA in uplink
- FDD and TDD duplex methods
- Scalable bandwidth 1.4MHz to currently 20 MHz
- Data rates up to 100 Mbps in DL
- MIMO (Multiple Input Multiple Output)

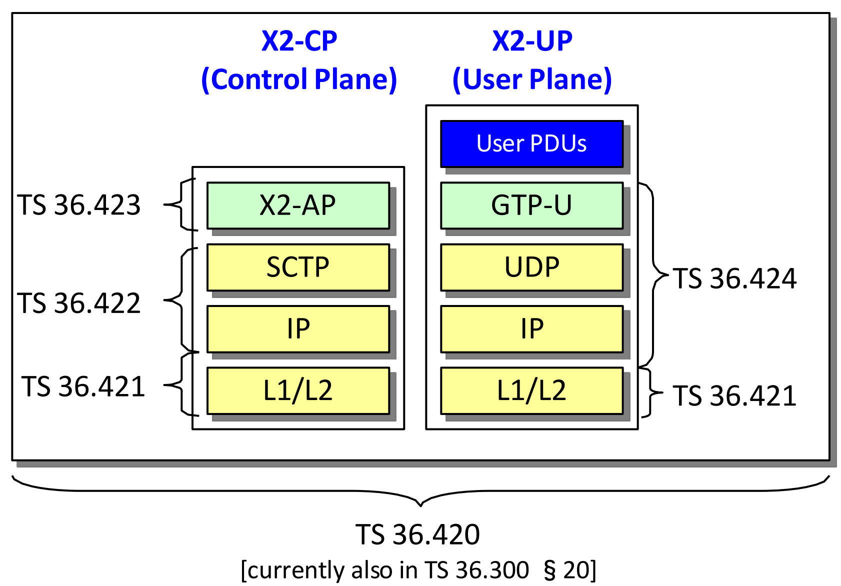




X2 Interface

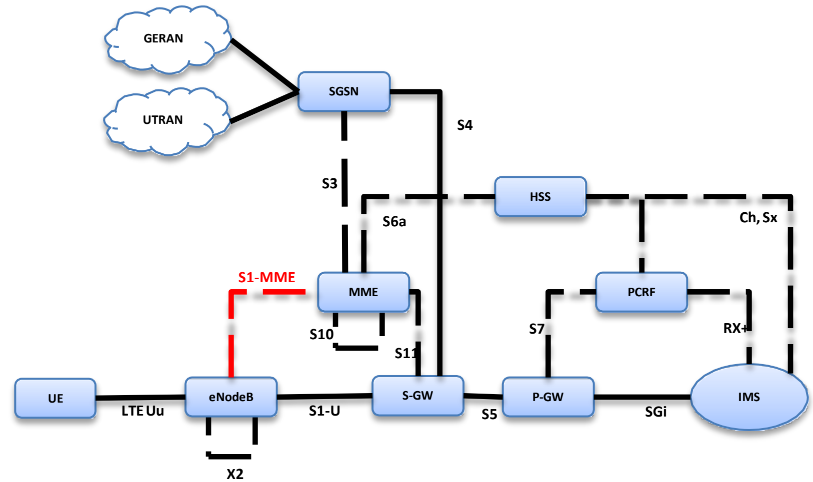
- Inter eNB interface
- Handover coordination without involving the EPC
- X2AP: special signalling protocol
- During HO, Source eNB can use the X2 interface to forward downlink packets still buffered or arriving from the serving gateway to the target eNB.
- This will avoid loss of a huge amount of packets during inter-eNB handover.

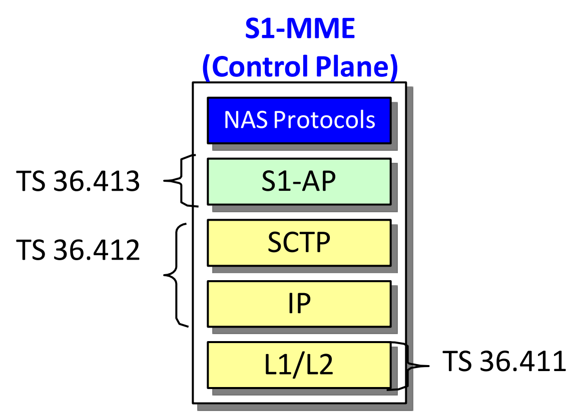




S1-MME Interface

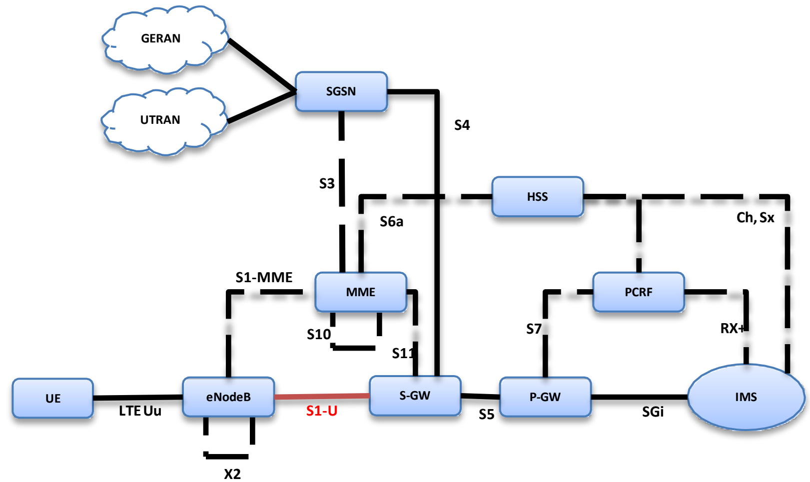
- Control interface between eNB and MME
- MME and UE will exchange non-access stratum signaling via eNB through this interface.
- E.g.: if a UE performs a tracking area update the TRACKING AREA UPDATE REQUEST message will be sent from UE to eNB and the eNB will forward the message via S1-MME to the MME.
- S1AP:S1 Application Protocol

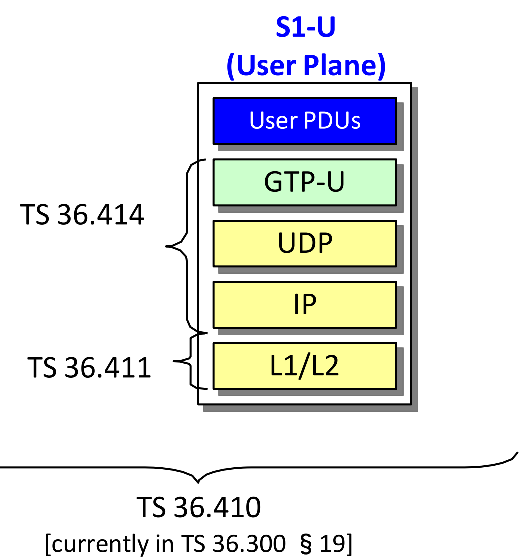




S1-U Interface

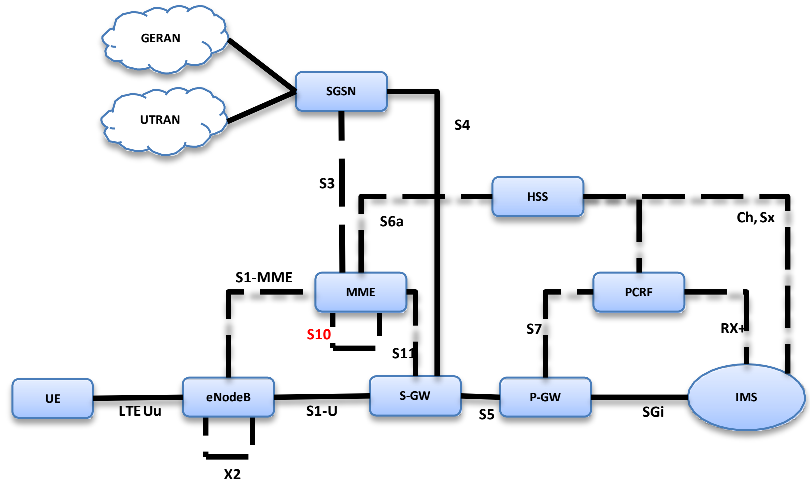
- User plane interface between eNB and serving gateway.
- It is a pure user data interface (U=User plane).
- S1flex-U also supported: a single eNB can connect to several Serving GWs.
- Which Serving GW a user's SAE bearer will have to use is signaled from the MME of this user.

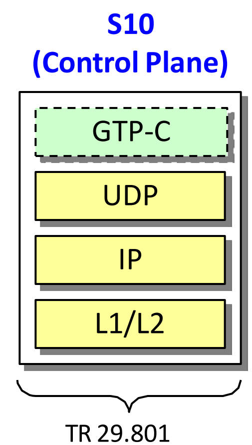




S10 Interface

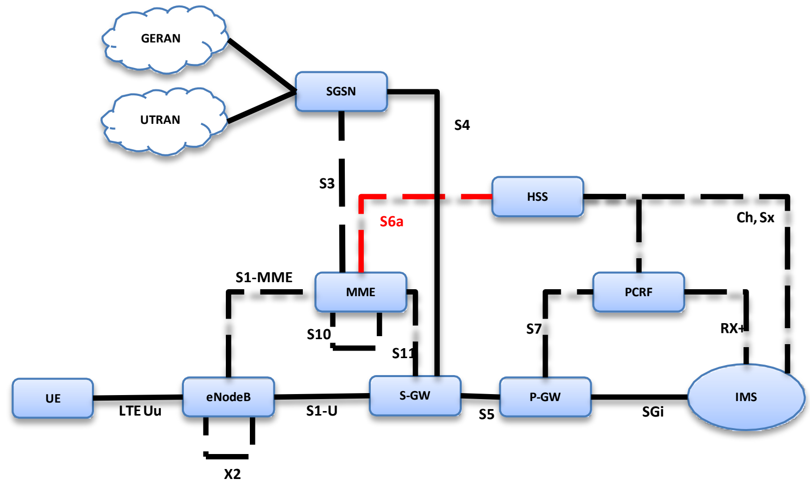
- Interface between different MMEs
- Used during inter-MME tracking area updates
- The new MME can contact the old MME the user had been registered before to retrieve data about identity (IMSI), security information (security context, authentication vectors) and active SAE bearers (PDN gateways to contact, QoS, etc.)
- Obviously S10 is a pure signaling interface, no user data runs on it.



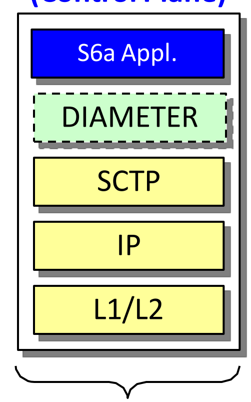


S6a Interface

- Interface between the MME and the HSS
- The MME uses it to retrieve subscription information from HSS (handover/tracking area restrictions, external PDN allowed, QoS, etc.) during attaches and updates
- The HSS can during these procedures also store the user’s current MME address in its database.



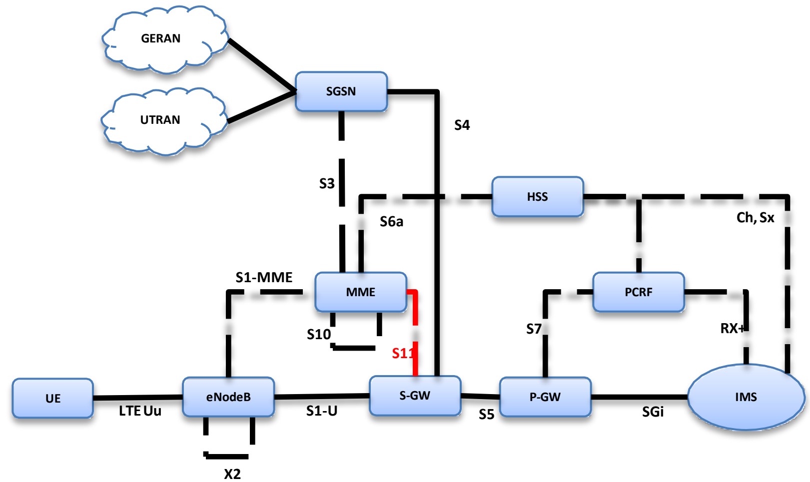
S6a
(Control Plane)



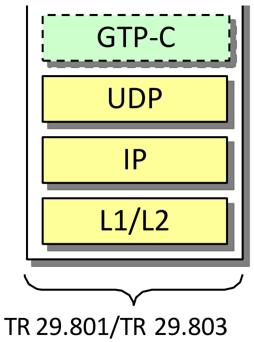
TR 29.801

S11 Interface

- Interface between MME and a Serving GW
- A single MME can handle multiple Serving GW each one with its own S11 interface
- Used to coordinate the establishment of SAE bearers within the EPC
- SAE bearer setup can be started by the MME (default SAE bearer) or by the PDN Gateway.

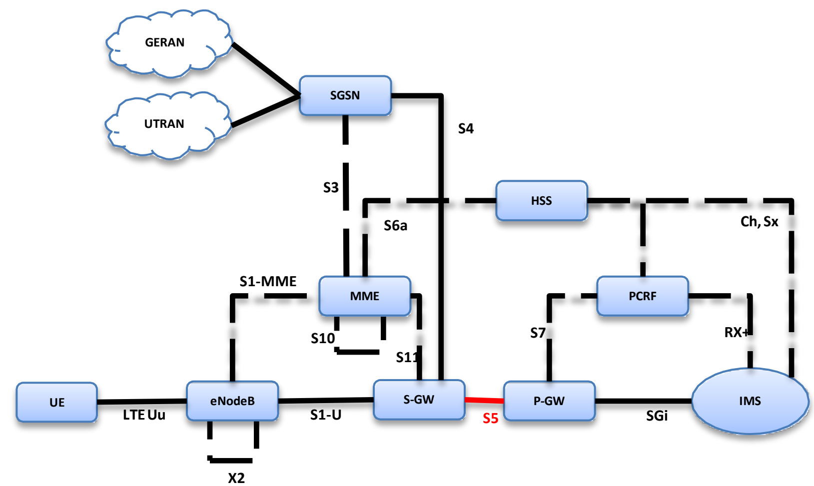


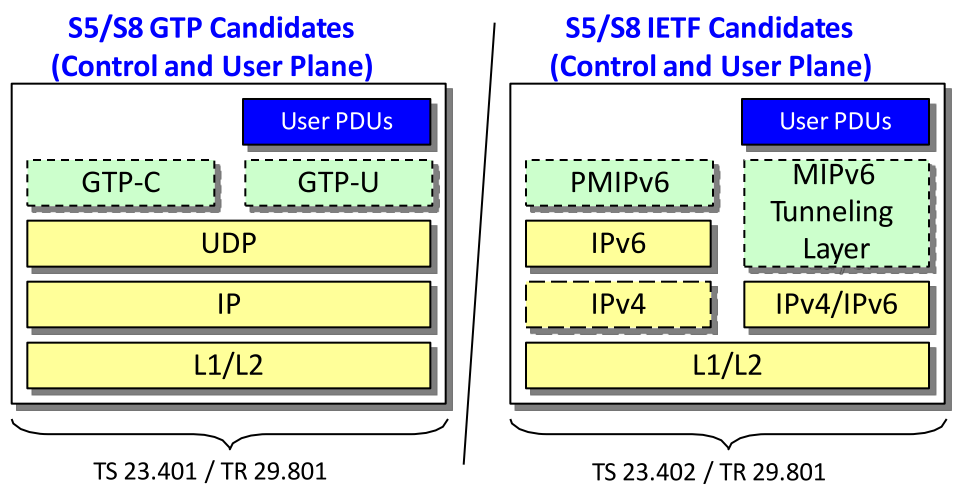
S11
(Control Plane)



S5/S8 Interface

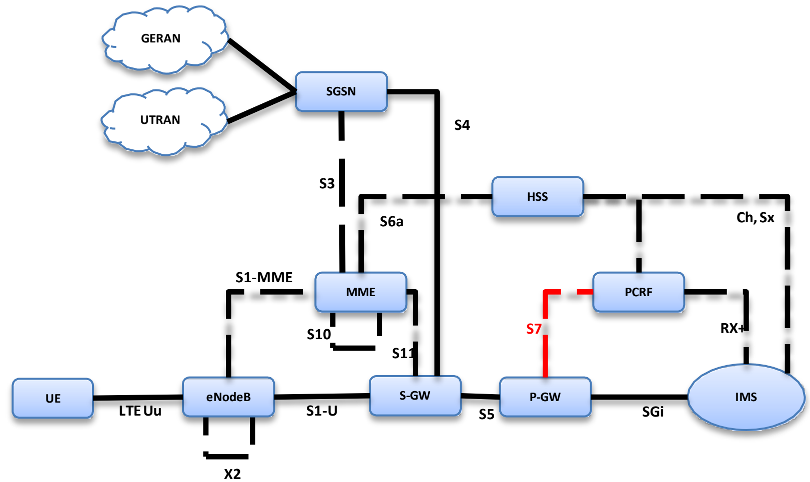
- Interface between Serving GW and PDN GW
- S5: If Serving GW and PDN GW belong to the same network (non-roaming case)
- S8:If this is not the case (roaming case)
- S8 = S5 + inter-operator security functions
- Mainly used to transfer user packet data between PDN GW and Serving GW
- Signaling on S5/S8 is used to setup the associated bearer resources
- S5/S8 can be implemented either by reuse of the GTP protocol from 2G/3G or by using Mobile IPv6 with some IETF enhancements.



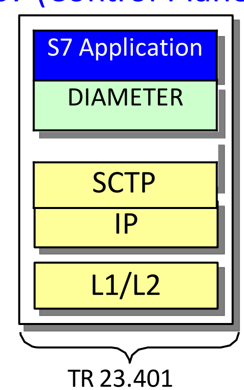


S7 (alias Gx) Interface

- Interface between PDN GW and PCRF (Policy and Charging Rule Function)
- It allows the PCRF to request the setup of a SAE bearer with appropriate QoS
- It allows the PDN GW to ask for the QoS of an SAE bearer to setup
- It allows to indicate EPC status changes to the PCRF to apply a new policy rule.



S7 (Control Plane)



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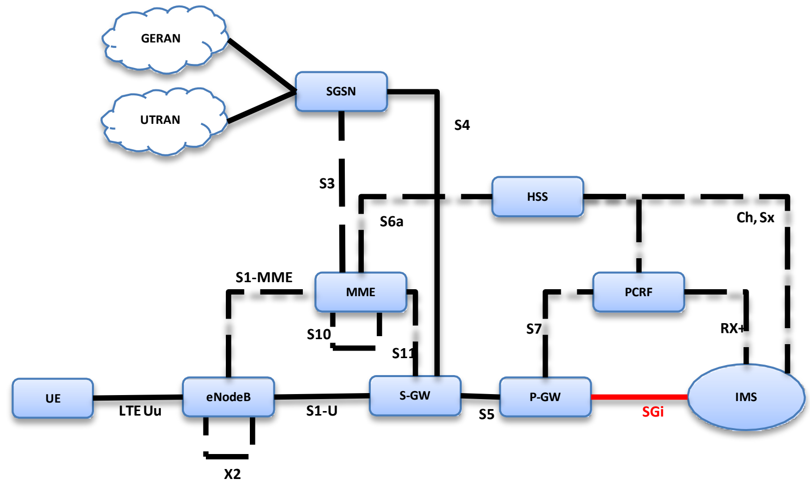
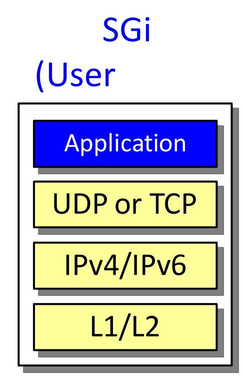
SGi Interface

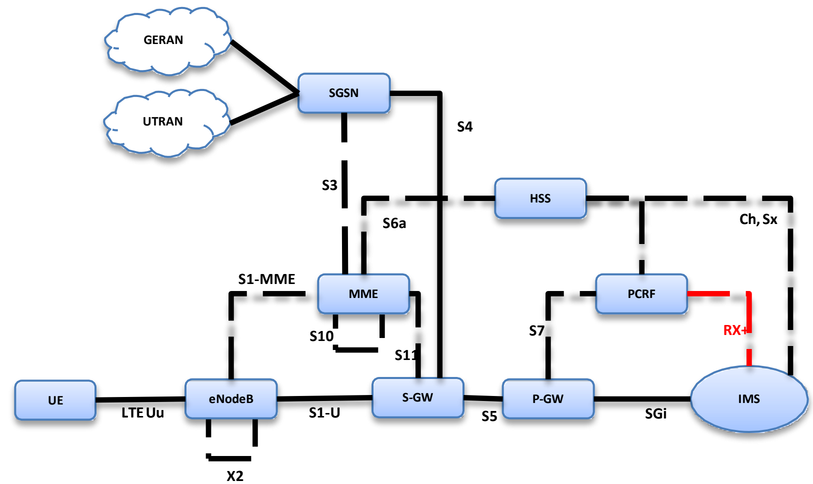
- Interface used by the PDN GW to send and receive data to and from the external data network
- It is typically either IPv4 or IPv6 based
- Downlink data coming from the external PDN must be assigned to the right SAE bearer of the right user by analysis of the incoming packet's IP addresses, port numbers, etc.
- This interface corresponds to the Gi interface in 2G/3G networks

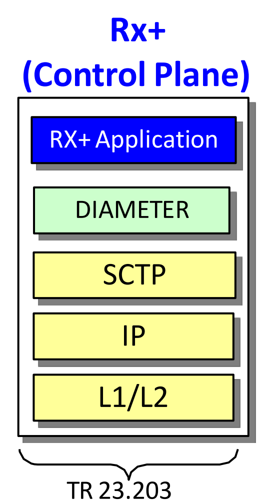




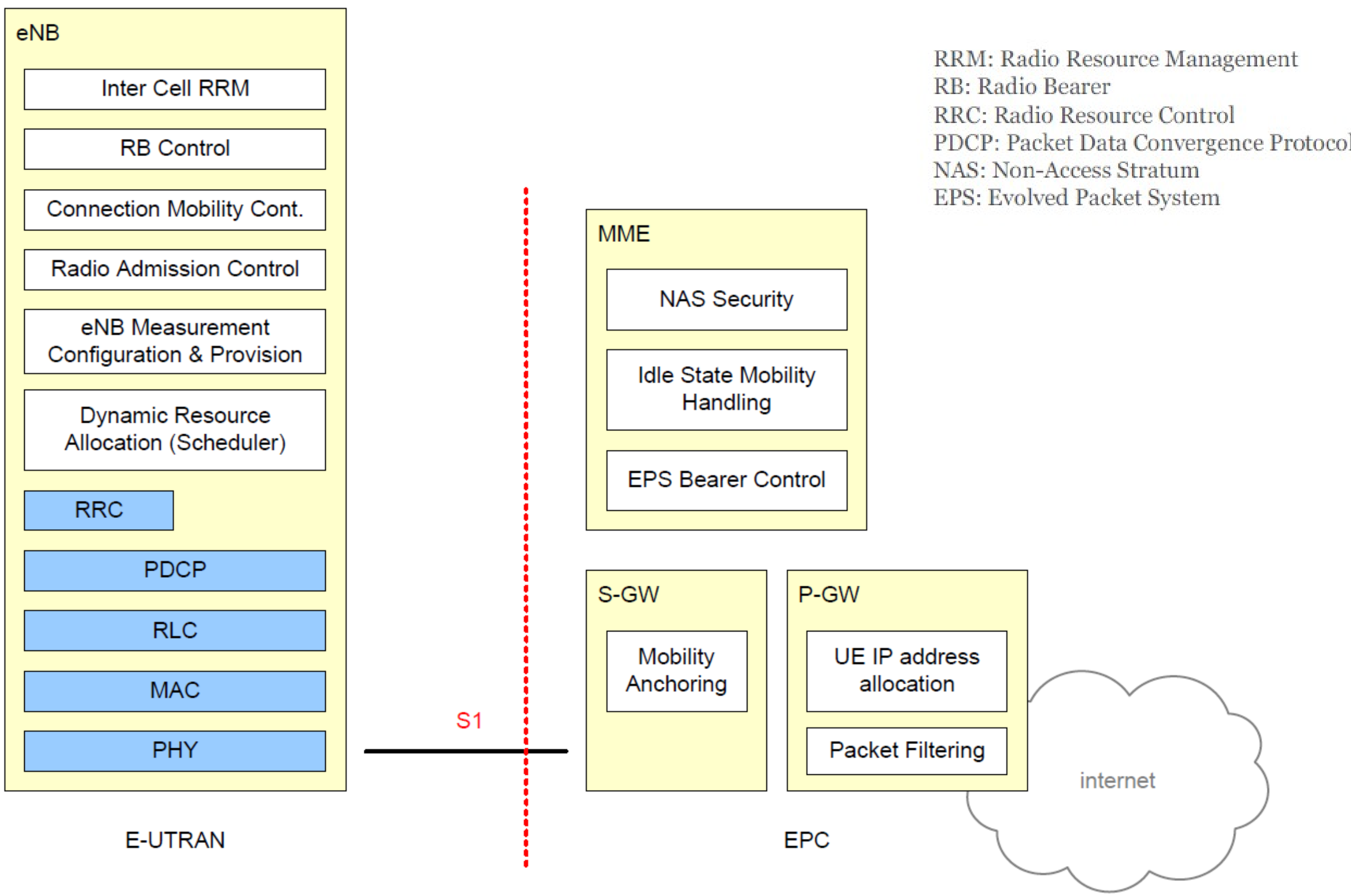
Rx Interface

- Interface between PCRF(Policy & Charging Rules Function) and the external PDN network/operators IMS
- Standardized in 3GPP TS 23.203.





Functional Split between eUTRAN and EPC



Source: 3GPP TS 36.300

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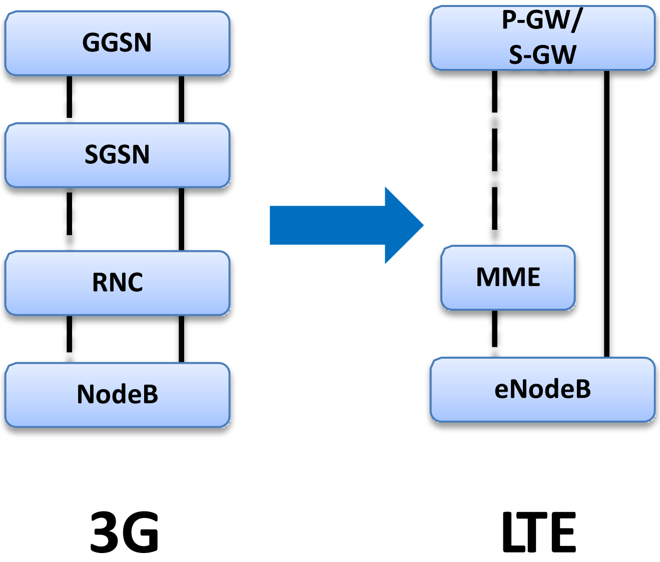
Network Evolution

RNC functions migrated to eNB and MME

- eNB Control Plane aggregation => MME
- eNB User Plane aggregation => SGW
- User Plane ciphering => eNB
- NAS Signaling ciphering => MME



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3GPP Standard Specifications Key Protocols

Protocol	Description of contents	Some Key Specifications
GTP-C		3GPP TS 29.274-850
MAC	E-UTRA MAC Protocol Specification	3GPP TS 36.321-860
NAS	Non-Access Protocol (NAS) for Evolved Packet System (EPS)	3GPP TS 24.301-840
PDCP	Packet Data Convergence (PDCP) Specification	3GPP TS 36.323-860
PHY 36.211	E-UTRA Physical Channels and Procedures	3GPP TS 36.211-880
PHY 36.212	E-UTRA Multiplexing and Channel Coding	3GPP TS 36.212-870
PHY 36.213	E-UTRA Physical Layer Procedures	3GPP TS 36.213-870
RLC	E-UTRA Radio Link Control (RLC) Protocol Specification	3GPP TS 36.322-860
RRC	RRC	3GPP TS 36.331-870

3GPP Standard Specifications Key Interfaces

Specification Index	Description of contents	Some Key Specifications
Uu	Air Interface between Device (aka, UE) and eNB.	3GPP TS 36.101, 36.104, 36.133, 36.141, 36.201, 36.211, 36.212, 36.213, 36.214, 36.314, 36.321, 36.322, 36.323, 36.331
S1	Comprised of two interfaces: S1-U user plane between eNB and S-GW; S1-MME signaling plane between eNB and MME, UE and MME.	3GPP TS 23.122, 24.301, 29.281, 36.410, 36.411, 36.412, 36.413, 36.414, 33.210, 33.310
S6a	Signaling plane interface between MME and HSS.	3GPP TS 29.272
S5/S8	User plane interface between S-GW and P-GW.	3GPP TS 29.274, 29.281
S9	Signaling plane interface between PCRF in home network and PCRF in visited network.	3GPP TS 29.215
S10	Signaling plane interface between MMEs.	3GPP TS 29.274
S11	Signaling plane interface between MME and S-GW.	3GPP TS 29.274
SGi	User plane interface between P-GW and external IP networks.	3GPP TS 29.061
Gx	Signaling plane interface between PCRF and P-GW.	3GPP TS 29.212, 29.213
Rx	Signaling plane interface between PCRF and external Application Functions.	3GPP TS 29.214
X2	User plane and Signaling plane interface between eNBs.	3GPP TS 29.281, 36.420, 36.421, 36.422, 36.423, 36.424

THANK YOU