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LTE RAN architecture aspects

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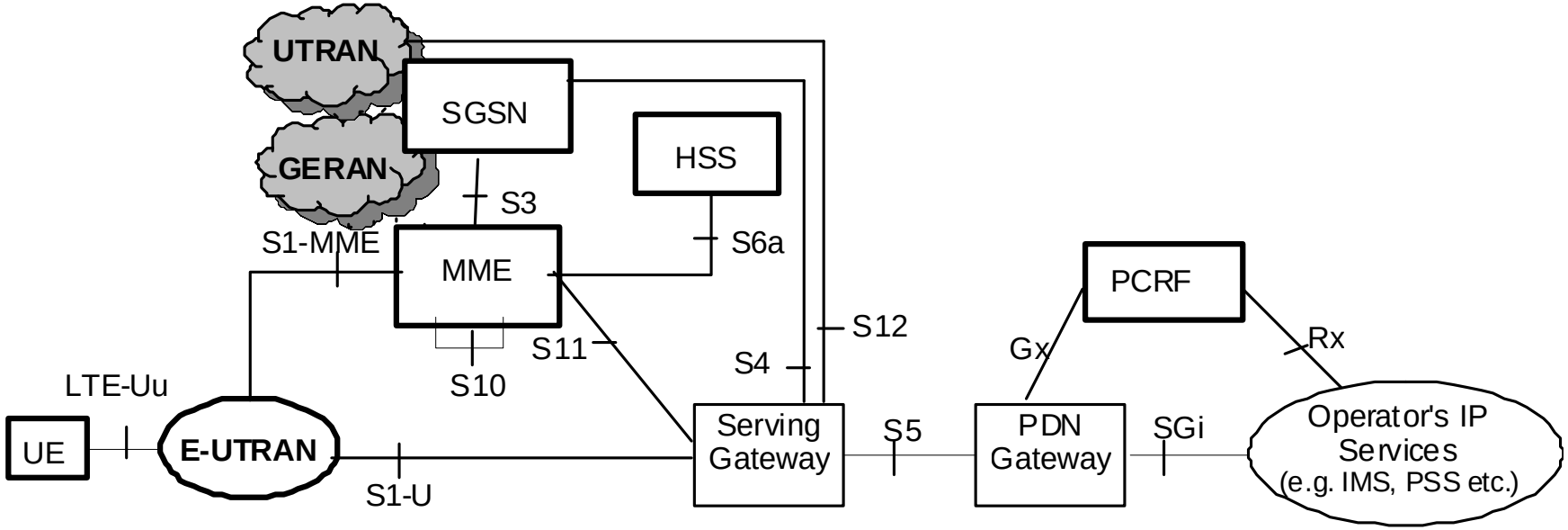
Outline

- EPS architecture
- E-UTRAN architecture
- Functional split between eNB – MME – S/PDN-GW
- EPS Berarer Service Architecture/QoS model
- Inter-cell interference control
- HeNB/CSG operation
- SON
- Interoperability with legacy systems
- Positioning
- E-MBMS support in E-UTRAN

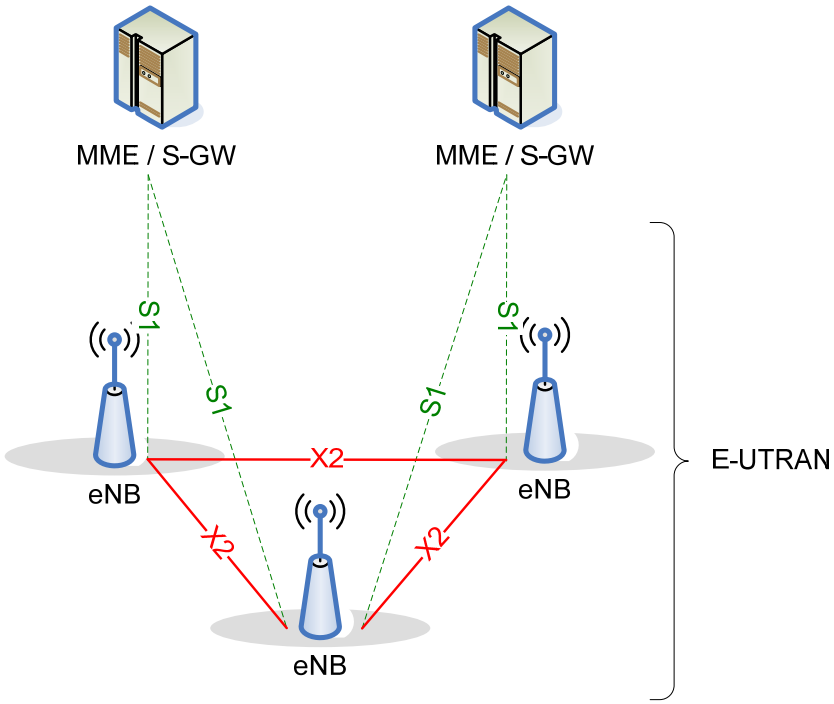
EPS architecture



non-roaming architecture for 3GPP accesses

- The Evolved Packet Switched System (EPS) provides IP connectivity between a UE and an external packet data network using the Evolved Universal Terrestrial Radio Access Network (E-UTRAN)
- Constists of an Evolved Packet Core (EPC) and Evolved UTRAN (E-UTRAN)
- The focus of this presentation is mostly on E-UTRAN functions

E-UTRAN architecture



- E-UTRAN consists of eNBs, providing the E-UTRA user plane and control plane protocol terminations towards the UE
  - Fully distributed radio access network architecture
- eNBs may be interconnected with each other by means of the X2 interface
  - X2 supports enhanced mobility, inter-cell interference management, and SON functionalities
- eNBs are connected by means of the S1 interface to the Evolved Packet Core (EPC)

Functional split

- eNB hosts the following functions:
  - Radio Resource Management functions
    - Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in both uplink and downlink (scheduling)
  - Measurement and measurement reporting configuration for mobility and scheduling
  - AS security
  - IP header compression and encryption of user data stream
  - Selection of an MME at UE attachment when no routing to an MME can be determined from the information provided by the UE
  - Routing of User Plane data towards Serving Gateway
  - Scheduling and transmission of paging messages (originated from the MME)
  - Scheduling and transmission of broadcast information (originated from the MME or O&M)
  - Scheduling and transmission of PWS (which includes ETWS and CMAS) messages (originated from the MME)

Functional split (cont'd)

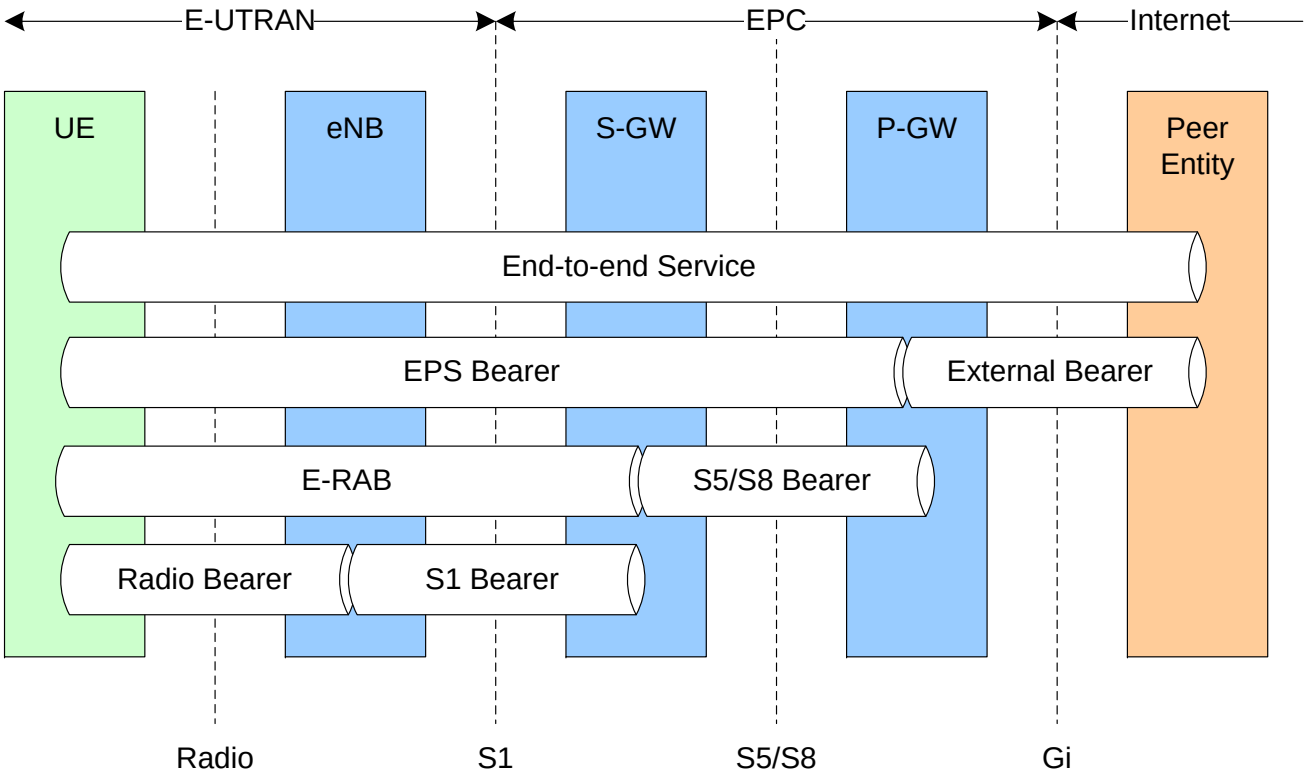
- MME host the following functions:
  - NAS signalling
  - NAS signalling security
  - AS security control
  - Inter CN node signalling for mobility between 3GPP access networks
  - Tracking Area list management
  - PDN GW and Serving GW selection
  - MME selection for handovers with MME change
  - SGSN selection for handovers to 2G or 3G 3GPP access networks
  - Roaming
  - Authentication
  - Bearer management functions including dedicated bearer establishment
  - Support for PWS (which includes ETWS and CMAS) message transmission
  - UE reachability in idle state (including control and execution of paging retransmission)

Functional split (cont'd)

- Serving Gateway (S-GW) hosts the following functions:
  - The local Mobility Anchor point for inter-eNB handover
  - Mobility anchoring for inter-3GPP mobility
  - E-UTRAN idle mode downlink packet buffering and initiation of network triggered service request procedure
  - Lawful Interception
  - Packet routeing and forwarding
  - Transport level packet marking in the uplink and the downlink
  - Accounting on user and QCI granularity for inter-operator charging
  - UL and DL charging per UE, PDN, and QCI

- PDN Gateway hosts the following functions:
  - Per-user based packet filtering (by e.g. deep packet inspection)
  - Lawful Interception
  - UE IP address allocation
  - Transport level packet marking in the downlink
  - UL and DL service level charging, gating and rate enforcement
  - DL rate enforcement based on APN-AMBR
  - Credit control for online charging

EPS Bearer Service Architecture



There is a one-to-one mapping EPS Bearer ⇔ E-RAB ⇔ Radio Bearer over the radio interface

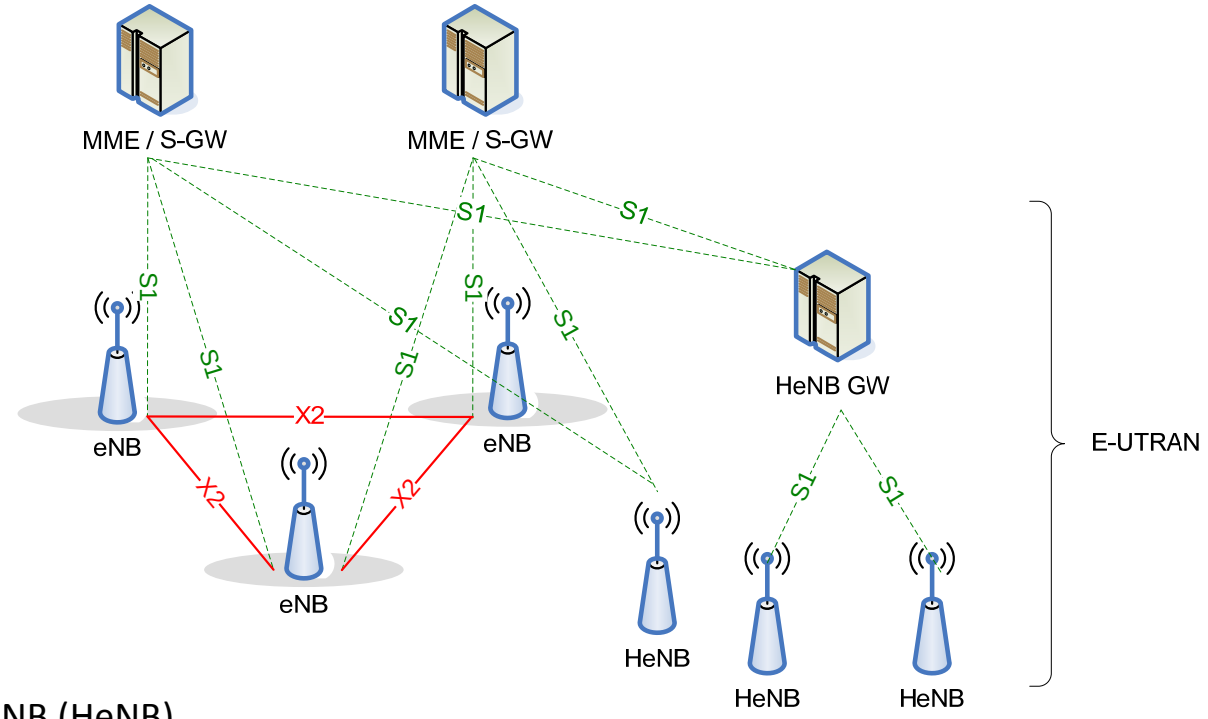
QoS handling at the eNB

- QoS paramers per EPS-bearer
  - QoS Class Identifier (QCI)
    - Scalar value used for scheduling/RRM decisions
    - Typically identifies a particular service or class of services
    - Few values to be standardized (others will be proprietary)
  - Allocation and Retention Priority (ARP)
    - Used to accept/modify/drop bearers in case of resource limitation
  - Guaranteed Bit Rate (GBR)
    - Only for GBR-bearers
- QoS paramers per group of EPS-bearers
  - Aggregate Maximum Bit Rate (AMBR)
    - Aggregate max bit rate per group of bearers (of a single user)
    - Only for non-GBR bearers

Inter-cell interference control over X2

- Dynamic inter-cell interference management is supported in E-UTRAN based on messages exchanged between neighbour eNBs over X2
  - Uplink interference
    - Overload Indicator message (reactive scheme)
      - Indicates the interference level experienced by the eNB in certain PRBs
      - Typically used to indicate high interference situations experienced by eNBs
    - High Interference Indicator message (proactive scheme)
      - Indicates that the eNB is going to schedule some cell-edge users in certain PRBs
  - Downlink interference
    - Relative Narrowband Tx Power message
      - Indicates, per PRB, whether the downlink Tx power is lower than a certain threshold

HeNB/CSG operation



- Home eNB (HeNB)
  - Customer-premises equipment that uses the operator's licenced spectrum
  - Can be used to enhance network coverage/capacity
  - Includes the functions of an eNB as well as some additional HeNB-specific configuration/security functions

- HeNB-Gateway (HeNB GW)
  - Optional and transparent gateway through which the HeNB accesses the core network
  - Addresses the issue of supporting a large number of S1 interfaces in the core network

HeNB/CSG operation (cont'd)

- Three different access modes are defined for HeNBs
  - Closed access mode: HeNB provides services only to its associated Closed Subscriber Group (CSG) members
  - Hybrid access mode: HeNB provides services to its associated CSG members and to non-members (CSG members are prioritized over non-members)
  - Open access mode: HeNB appears as a normal eNB
- Two categories of parameters are broadcast by HeNB cells operating in closed/hybrid acces mode:
  - Parameters to support the UE in the identification of closed/hybrid cells
    - CSG Indicator, CSG Identity (CSG ID), HNB Name
  - Parameters to support an efficient search of closed/hybrid cells at the UE
    - Range of Physical Cell-IDs (PCIs) reserved for closed cells
- CSG provisioning functions manage how the CSG information is stored in the UE and the network
  - Provisioning of the CSG lists on the UE to avoid forbidden closed cells
  - Network storage of the CSG subscription for access control, per CSG charging, etc.
- Mobility management supports different access modes
  - Access Control procedures for establishing a connection and for handover
  - Differentiating between a member and a non-member at a hybrid cell
  - Automatic (re-)selection in idle mode if the CSG ID broadcast by the closed or hybird cell is in the UE CSG lists
  - Manual user selection of a closed or hybrid cell

Self Organizing Networks (SON)

- E-UTRAN supports multiple SON functions
  - Allow to automate network configuration/optimization processes and thus reduce the need for centralized planning and human intervention

- SON functions are mostly enabled by the exchange of information between neighbour eNBs
  - Some functions rely also on UE assistance

SON functions supported in the standard

- Automatic Neighbor Relation function
  - Allows the eNB to build and maintain its neighbour relations based on UE reports (Function relies on connected mode UEs that can read and report the Cell Global Identity (CGI) of a neighbor cell)
- Automatic PCI selection
  - Allows the eNB to select its own PCI based on UE reports and information received from neighbour eNBs
- Dynamic configuration of X2/S1 interfaces
  - Allows the eNB to dynamically configure the S1-MME interface with the serving MMEs and the X2 interface with neighbour eNBs
- RACH parameters optimization
  - Allows neighbor eNBs to exchange information about their used PRACH resources (and thus avoid interference and RACH collisions)
- Mobility parameters optimization
  - Allows to adapt the mobility-related parameters of an eNB to enhance mobility robustness or for load-balancing reasons

Inter-operability with legacy systems

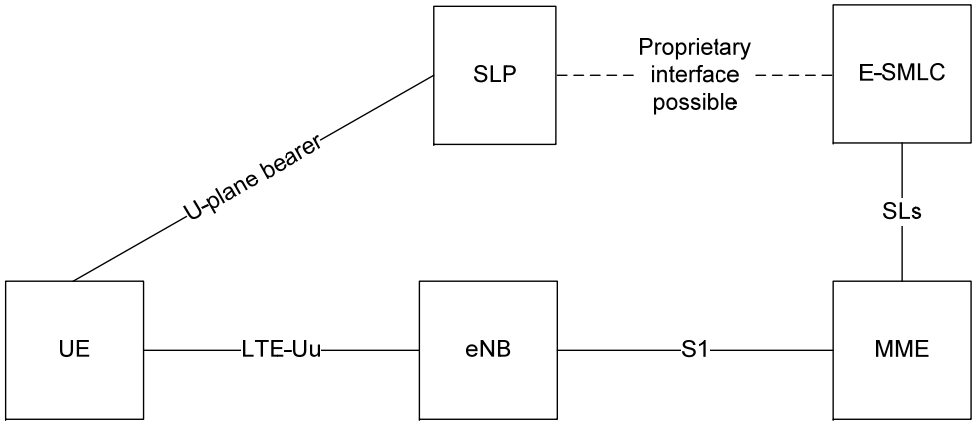
- E-UTRAN inter-operates with GERAN, UTRAN, 1xRTT and eHRPD
  - Inter-operability with further Radio Access Technologies (RATs) is possible at the IP level. However it is not visible to E-UTRAN and it will not be mentioned in the following.

- Different inter-operability mechanisms have been standardized to cater for different deployment options
  - Inter-RAT handover
  - Network Assisted Cell Change (NACC)
  - Single-Radio Voice Call Continuity (SR-VCC)
  - Circuit Switched (CS) fallback

Inter-operability with legacy systems (cont'd)

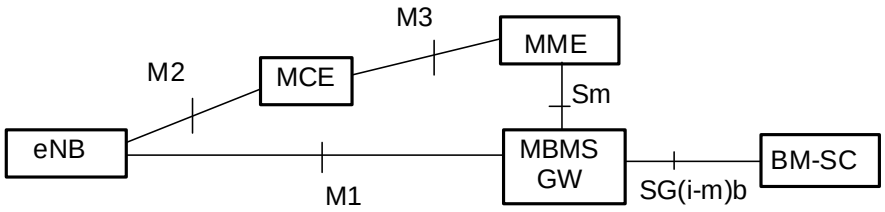
- Inter-RAT handover
  - Framework allowing optimized (seamless/lossless) handovers of packet data sessions from E-UTRAN to UTRAN/GERAN and from E-UTRAN to eHRPD
- Network Assisted Cell Change (NACC)
  - Framework allowing handovers of packet data sessions from E-UTRAN to GERAN, for GERAN networks that do not support PS handover
- Single-Radio Voice Call Continuity (SR-VCC)
  - Framework allowing the network to handover a voice call from the IM CN Subsystem (PS domain) to the CS domain of a legacy system
    - The function allows to perform a PS to CS domain transfer together with a radio link handover
  - SR-VCC handovers supported from E-UTRAN to UTRAN/GERAN and E-UTRAN to 1xRTT
- CS fallback
  - Framework allowing the provisioning of voice services by reuse of CS infrastructure when the UE is served by E-UTRAN
    - The function allows to perform tunneling of CS domain paging over E-UTRAN, and subsequent handover to an overlapping CS-capable legacy RAT to handle the voice call over CS
  - CS fallback supported from E-UTRAN to GERAN/GERAN and E-UTRAN to 1xRTT

UE positioning in LTE



- EPS supports both a C-plane based and U-plane based positioning mechanism to cater for different deployment options
  - Both mechanisms operate via end-to-end protocol between UE and a positioning server i.e. E-SMLC (C-plane)/SPL (U-plane)
  - The same end-to-end protocol is used in both mechanisms, LPP
    - A supporting protocol, LPPa, operates between eNode B and E-SMLC
- LPP acts as a method-agnostic supporting protocol for various UE positioning methods
  - OTDOA (downlink positioning method based on measured time differences observed by the UE from different eNode Bs)
  - A-GNSS (satellite positioning: GPS and similar systems)
  - Enhanced Cell ID methods
  - Extensible both in future 3GPP releases and via external definition of additional positioning methods

E-MBMS support in E-UTRAN



- Multimedia Broadcast Single Frequency Network (MBSFN) mode of operation is supported by E-UTRAN to enable efficient multi-cell transmission of E-MBMS services
  - Transmission of identical waveforms at the same time from multiple cells (seen as a single transmission by a UE)
  - MCE coordinates multi-cell transmissions in case of MBSFN operation
    - Allocates radio resources used by all eNBs to transmt MBMS packets over the air, including time/ frequency resources, modulation, coding etc…
  - Content synchronization is ensured via synch protocol running between eNB and Broadcast Multicast Service Centre (BS-SC)
  - Single transmission mode (i.e. no HARQ or RLC repetitions)
- MBSFN mode of operation is provided only on a frequency layer shared with non-MBMS services
  - Cells supporting both unicast and MBMS transmissions are called "MBMS/Unicast-mixed" cells
- E-MBMS reception is possible for UEs in connected or idle state
  - While receiving E-MBMS services, a UE shall be notified of an incoming call; originating calls shall also be possible

Thank you