3GPP

Release 99
Release 4
Release 5
Release 6
Release 7
Release 8

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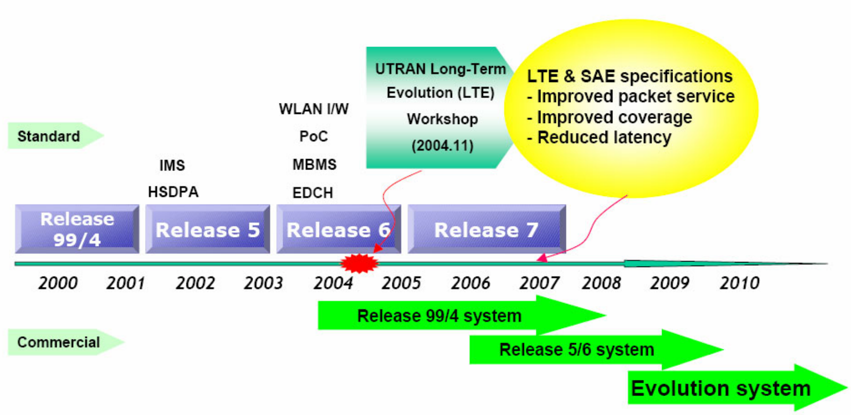
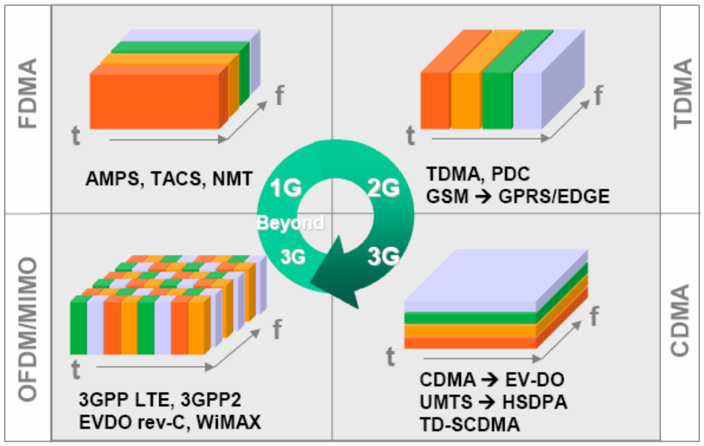
3GPP Roadmap



Radio Access Air Interface Principles



Release99

- The main improvement of UMTS compared to GSM in this first step is the completely redesigned radio access network, which the UMTS standards call the UMTS terrestrial radio access network (UTRAN).
- Instead of using the time- and frequency-multiplexing method of the GSM air interface, a new method called WCDMA was introduced.
- In WCDMA, users are no longer separated from each other by timeslots and frequencies but are assigned a unique code.
- Furthermore, the bandwidth of a single carrier was substantially increased compared to GSM, which enables a much faster data transfer than previously possible.
- This allows a Release 99 UTRAN to send data with a speed of up to 384 kbit/s per user in the downlink (network to user) direction and up to 64–128 kbit/s in the uplink direction .
- The standard also foresees uplink speeds of up to 384 kbit/s.
- However, while they are called BTS and BSC in the GSM network, the corresponding UTRAN network elements are called Node-B and radio network controller (RNC). Also, the mobile station (MS) has also received a new name and is now called user equipment (UE).

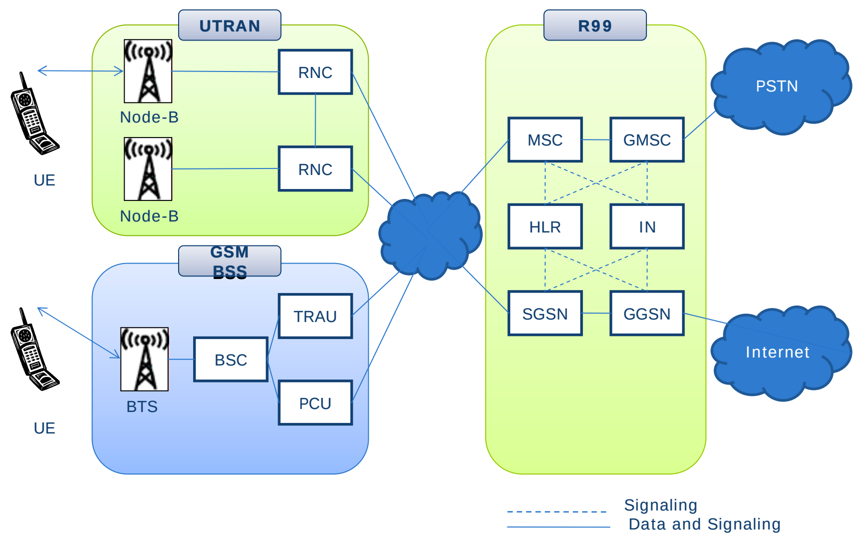
Release99 Cont.

- In R99, the current technology for the GSM circuit-switched core network continues to be the basis for UMTS.
- It was decided not to specify major changes in this area but rather concentrate on the access network.
- Therefore , the changes in the circuit core network to support UMTS Release 99 are mainly software enhancements in order to support the new Iu(cs) interface between the MSC and the UTRAN.
- While it is quite similar to the GSM A-interface on the upper layers, the lower layers redesigned and are now based on ATM.
- The HLR and authentication center software have been enhanced in order to support the new UMTS features.
- No major changes were necessary for the packet core because GPRS was a relatively new technology at the time of the Release 99 specification, and was already ideally suited to a high-speed packet-oriented access network.
- Changes mostly impact the interface between the SGSN and the radio access network, which is now called the Iu(ps) interface.

Release99 Cont

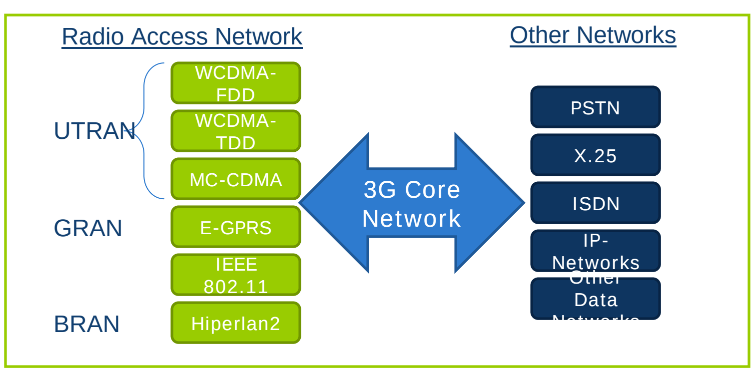
- The biggest difference to its GSM/GPRS counterpart, the Gb interface, is the use of ATM instead of frame relay on lower layers of the protocol stack.
- The SGSN software has been modified in order to tunnel GTP user data packets transparently to and from the RNC instead of analyzing the contents of the packets and reorganizing them onto a new protocol stack as was previously done in GSM/GPRS.
- The MSCs and SGSNs only require a software update and new interface cards in order to support the Iu(cs) and Iu(ps) interfaces. This is an advantage especially for those operators that already have an existing network infrastructure.
- A common GSM and UMTS network furthermore simplifies the seamless roaming of users between GSM and UMTS. This is especially important during the first few years after the initial rollout of UMTS, as the new networks only cover big cities at first and expand into smaller cities and the rest of the country afterwards.
- UMTS Release 99 networks can of course be used for voice telephony, but the main goal of UMTS beyond this service was the introduction of fast packet data services.

UMTS Release 99 Network

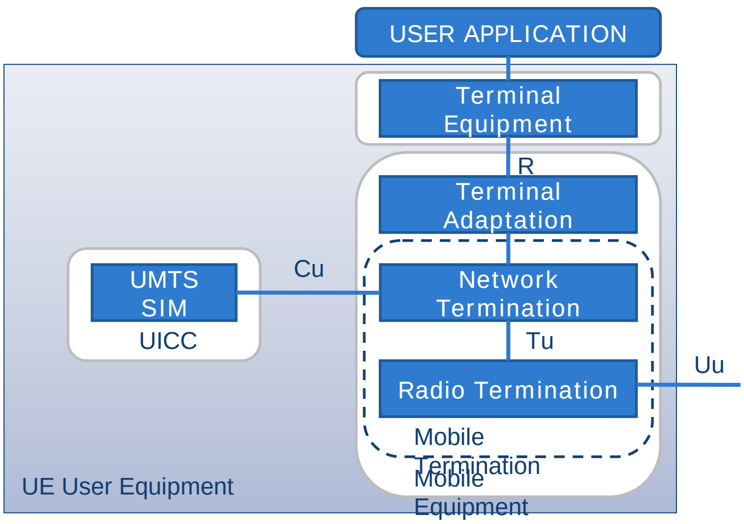


CN, Core network

- The goal of 3G CN is to act as universal core for connecting different radio access and fixed networks.



UE, User Equipment



Functions of UE

- An interface for USIM.
- Support for emergency calls without USIM.
- An unalterable equipment identification (IMEI).
- Service provider and network registration and deregistration.
- Location update.
- Originating and receiving both connection oriented and connectionless services.
- Basic identification of the terminal capabilities.
- Support for authentication and encryption algorithms.

UTRAN, UMTS Terrestrial Radio Access Network

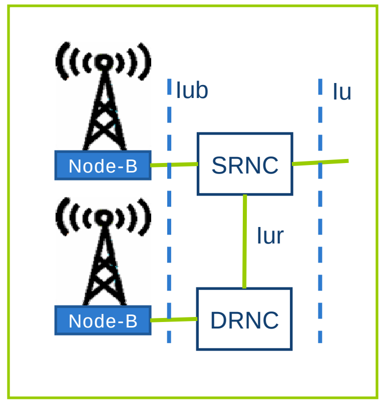
- Node-B: Base station
  - Layer one (Air interface) processing (Channel coding,interleaving, rate adaptation, spreading and modulation etc.)
  - Participates in radio resource management
- RNC, Radio Network Controller
  - In charge of radio resource management (admission, load, congestion control etc.)
  - Handles mobility (handovers)
  - Acts as a service access point (SAP) for the core network
  - A set of Node B:s connected to one RNC is called Radio Network Subsystem (RNS)

Interfaces of UTRAN

- Iub is the interface between Node B and RNC
- Unlike in Abis-interface of GSM interface Iub is open interface and allows the interoperability of different vendors Node-Bs and RNCs.
- Iur denotes the interface between two RNCs and it is utilized to relay data and control information in case of intra-RNS handover.
- Iu-interface connects UTRAN to CN
- It is notable that the single interface deals with both CS and PS traffic

Logical role of RNC

- RNC controlling one Node B is indicated as Controlling NRC (CNRC)
- RNC that is in charge of controlling a mobile is called serving RNC (SRNC)
- Any other RNC controlling a cell used by the mobile is called drift RNC (DRNC). It can perform macro diversity combining and splitting of the signals. It does not perform layer 1 processing of the user plane, but instead routes the data transparently via Iur and Iub.



Release 4

- A major enhancement for circuit-switched voice and data services has been specified with UMTS Release 4.
- The most important enhancement of UMTS Release 4 is a new concept called the bearer independent core network (BICN).
- Instead of using circuit-switched 64 kbit/s timeslots, traffic is now carried inside ATM or IP packets .
- In order to do this, the MSC has been split into
  - an MSC server which is responsible for call control and mobility management (see Chapter 1)
  - and a media gateway which is responsible for handling the actual bearer (user traffic).
  - The media gateway is also responsible for the transcoding of the user data for different transmission methods.

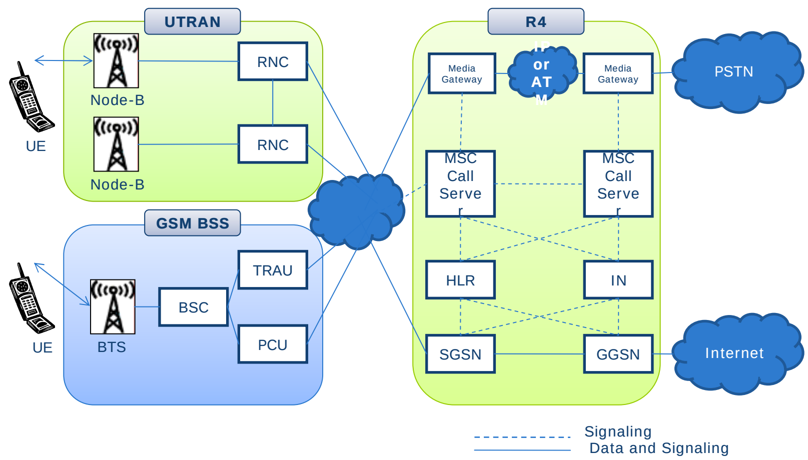
Release 4 Cont.

- A major enhancement for circuit-switched voice and data services has been specified with UMTS Release 4.
- Up to and including Release 99, all circuit-switched connections have been routed through the core network via E-1 connections inside 64 kbit/s timeslots.
- The most important enhancement of UMTS Release 4 is a new concept called the bearer independent core network (BICN).
- Instead of using circuit-switched 64 kbit/s timeslots, traffic is now carried inside ATM or IP packets .
- In order to do this, the MSC has been split into an MSC server which is responsible for call control and mobility management and a media gateway which is responsible for handling the actual bearer (user traffic).
- The media gateway is also responsible for the transcoding of the user data for different transmission methods.
- This way it is possible for example to receive voice calls via the GSM A-interface via E-1 64 kbit/s timeslots at the MSC media gateway which will then convert the digital voice data stream onto a packet-switched ATM or IP connection towards another media gateway in the network.

Release 4 Cont.

- The remote media gateway will then again convert the incoming user data packets if necessary, to send them for example to a remote party via the UMTS radio access network (Iu(cs) interface) or back to a circuit-switched E-1 timeslot if a connection is established into the fixed-line telephone network.
- The introduction of this new architecture is driven by network operators that want to combine the circuit- and packet-switched core networks into a single converged network for all traffic.
- This is desirable as mobile network operators no longer only need a strong circuit-switched backbone but also have to invest in packet-switched backbones for the GPRS and UMTS user data traffic.
- As packet-switched data continues to increase so does the need for investment into the packet-switched core network.
- By using the packet-switch core network for the voice traffic as well, operators expect noticeable cost reductions.

UMTS Release 4 Network



Release 5

- UMTS Release 5 takes the core network one step further and defines an architecture for an end-to-end all-IP network.
- The circuit-switched MSC and the Iu(cs) interface are no longer required in a pure Release 5 network.
- The MSC is replaced by the IP multimedia subsystem (IMS) with which the user equipment communicates via the SGSN and GGSN.
- The core of the IMS comprises a number of nodes that form the call session control function (CSCF).
- The CSCF is basically a SIP (session initiation protocol) architecture which was initially developed for the fixed-line world and is one of the core protocols for most voice over IP telephony services available on the market .

Release 5 Cont.

- While the CSCF is responsible for the call setup and call control, the user data packets which for example include voice or video conversations are directly exchanged between the end-user devices.
- A media gateway control function (MGCF) is only necessary if one of the users still uses a circuit-switched phone.
- With the UMTS radio access network it is possible for the first time to implement an IP-based mobile voice and video telephony architecture.
- With GPRS in the GSM access network, the roaming from one cell to another (mobility management) for packet-switched connections is controlled by the mobile station.

Release 5 Cont.

- With UMTS, the mobility management for packet-switched connections can now also be controlled by the network.
- This ensures uninterrupted packet traffic even while the user is roaming from one cell to another.
- The overhead of an IP connection for voice telephony, however, remains a problem for the wireless world.
- As the delay must be as short as possible, only a few bytes of voice data are put into a single IP packet.
- This means that the overhead for the header part of the IP packet is about 50%. Circuit-switched voice connections on the other hand do not need any header information and are transported very efficiently over the UMTS network today.

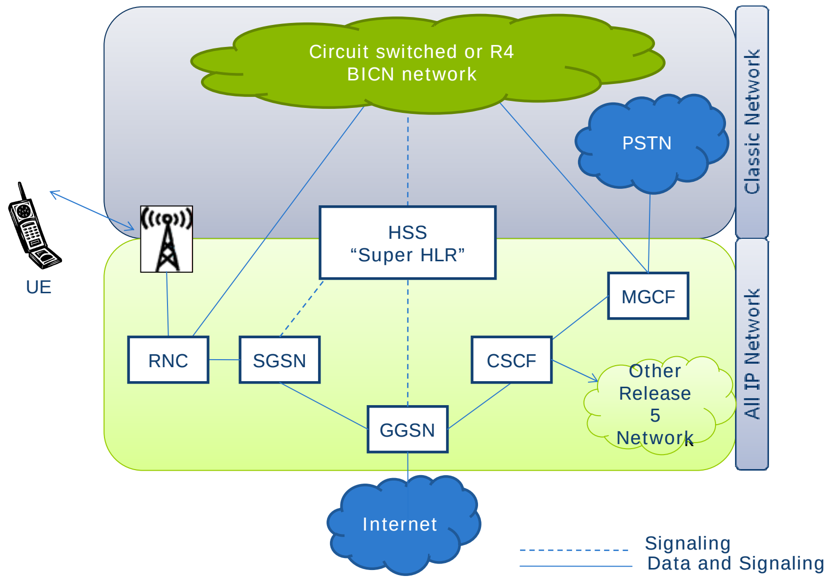
Release 5 Cont.

- Despite the evolution of voice telephony towards IP it has to be ensured that every user can talk to every other user regardless of which kind of telephony architecture they use.
- As optimizing and improving mobile networks for IMS VoIP calls is an evolutionary process, the different architectures will coexist in operational networks for many years to come.
- As the IMS has been designed to serve as a universal communication platform, the architecture offers a far greater variety of services then just voice and video calls, which are undoubtedly the most important applications for the IMS in the long term.
- By using the IMS as a platform for a standardized Push to talk (PTT) application, it is possible to include people in talk groups who have subscriptions with different operators.

High Speed Downlink Packet Access (HSDPA)

- Supports services requiring instantaneous high data rates in the downlink
  - e.g. Internet browsing; video on demand
- May be deployed in both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes (both high and low chip rates)
- Various configurations defined, offering data rates of up to 10Mbit/s

UMTS Release 5 Network



Release 6

- The uplink is still limited to 64–128 kbit/s and to 384 kbit/s in some networks under ideal conditions.
- The emergence of the IMS, however, triggers the widespread use of a number of direct user-to-user applications such as multimedia conferencing.
- UMTS Release 6 introduces an uplink transmission speed enhancement called high speed uplink packet access (HSUPA).
- In theory HSUPA allows data rates of several Mbit/s for a single user under ideal conditions.
- HSUPA also increases the maximum number of users that can simultaneously send data via the same cell and thus further reduces the overall cost of the network.

High Speed Uplink Packet Access (HSUPA)

- Whereas HSDPA optimizes downlink performance, High Speed Uplink Packet Access (HSUPA) constitutes a set of improvements that optimizes uplink performance.
- These improvements include higher throughputs, reduced latency, and increased spectral efficiency.
- HSUPA will result in an approximately 85 percent increase in overall cell throughput on the uplink and an approximately 50 percent gain in user throughput.
- HSUPA also reduces packet delays.
- Such an improved uplink will benefit users in a number of ways. For instance, some user applications transmit large amounts of data from the mobile station, such as sending
- video clips or large presentation files.
- For future applications such as VoIP, improvements will balance the capacity of the uplink with the capacity of the downlink.

High Speed Uplink Packet Access (HSUPA)

- HSUPA achieves its performance gains through the following approaches:
  - An enhanced dedicated physical channel
  - A short TTI, as low as 2 msec, which allows faster responses to changing radio conditions and error conditions
  - Fast Node-B-based scheduling, which allows the base station to efficiently allocate radio resources
  - Fast Hybrid ARQ, which improves the efficiency of error processing
- The combination of TTI, fast scheduling, and Fast Hybrid ARQ also serves to reduce latency, which can benefit many applications as much as improved throughput.
- HSUPA can operate with or without HSDPA in the downlink, though it is likely that most networks will use the two approaches together.
- The improved uplink mechanisms also translate to better coverage, and for rural deployments, larger cell sizes.

IP Multimedia Subsystem (IMS)

- IMS provides:
  - IP Transport in the Core network
  - IP Transport in the UTRAN
- And this therefore provides the possibility for:
  - End to end IP services
  - Increased potential for service integration
  - Easy adoption and integration of instant messaging, presence and real time conversational services
- The Mobile world has based its IP future on the IMS platform
  - in 3GPP2 called MMD, but ostensibly the same thing
- The Fixed world has made a commitment to IMS for its future

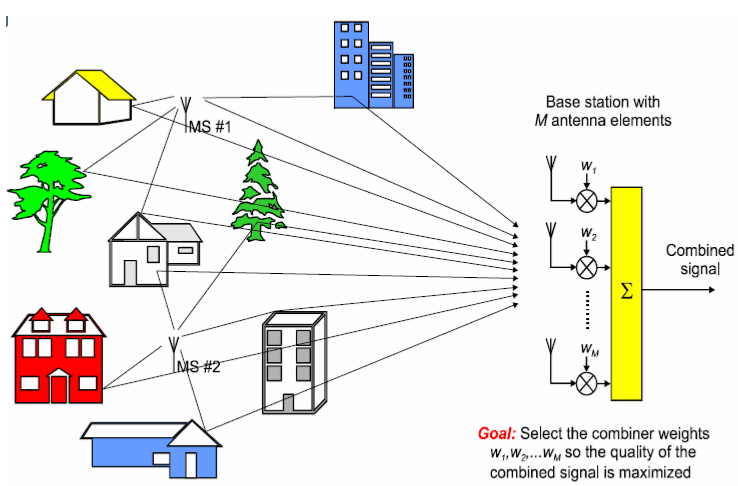
WCDMA CDMA Mobile Broadcast Multicast Service (MBMS)

- Full Multimedia Broadcast architecture support for multicast service
- New logical channels are designed to offer more efficient distribution of popular-demand multimedia content
- Can set to use a portion of a cell carrier, leaving the rest for other services such as regular voice and data.
- OMA BCAST specifies broadcast/multicast-related service layer functionalities, such as
  - Service & content protection (including DRM)
  - Service discovery & service guides
  - Service & terminal provisioning

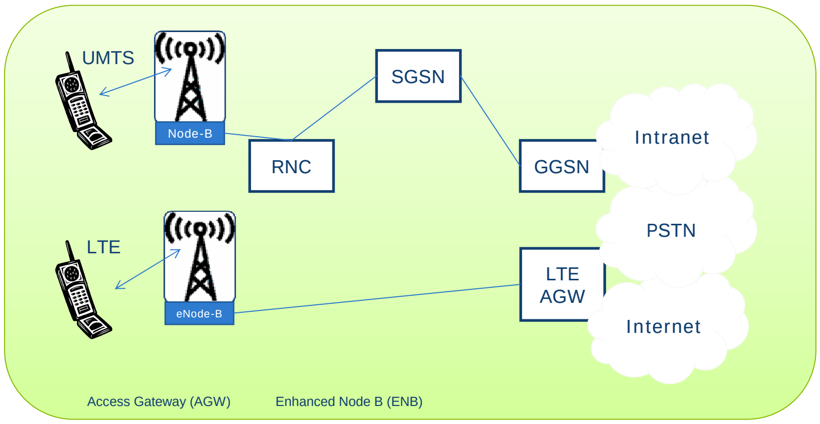
Release 7

- Multiple-Input Multiple-Output (MIMO)
- MIMO is a very promising technology for empowering UMTS networks by providing more throughput than HSDPA/HSUPA.
- MIMO increases capacity through multi stream transmissions, code reuse, and transmit diversity using multiple antennas on both the transmitter and receiver sides.
- Although MIMO has been studied for a long time, the very high processing power it needs to recover transmitted signals has made it impossible to implement using earlier processors.

Antenna Array Principle



Release8:Network Architecture for LTE



LTE Goals

- Downlink peak data rates up to 100 Mbps with 20 MHz bandwidth
- Uplink peak data rates up to 50 Mbps with 20 MHz bandwidth
- Operation in both TDD and FDD modes
- Scalable bandwidth up to 20 MHz, covering 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz in the study phase. 1.6 MHz wide channels are under consideration for the unpaired frequency band, where a TDD approach will be used
- Increase spectral efficiency over Release 6 HSPA by a factor of two to four
- Reduce latency to 10 msec round-trip time between user equipment and the base station and to less than 100 msec transition time from inactive to active
- Deployable in 2009

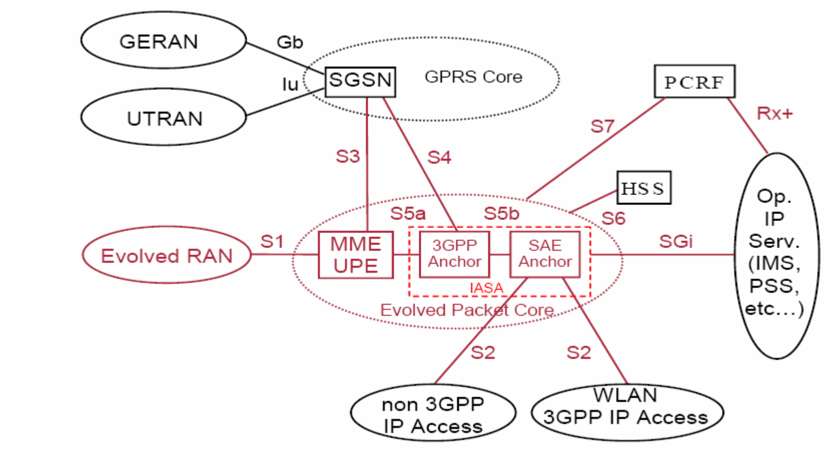
E-UTRAN Architecture

- The E-UTRAN consists of eNBs, providing
  - the E-UTRA U-plane (RLC/MAC/PHY) and
  - the C-plane (RRC) protocol terminations towards the UE.
  - the eNBs interface to the aGW via the S1
- eNodeB
  - All Radio-related issues
  - Decentralized mobility management
  - MAC and RRM
  - Simplified RRC
- aGW
  - Paging origination
  - LTE_IDLE mode management
  - Ciphering of the user plane
  - Header Compression (ROHC)

SAE :System Architecture Evolution

- Objectives
  - New core network architecture to support the high-throughput / low latency LTE access system
    - Simplified network architecture
  - All IP network
    - All services are via PS domain only, No CS domain
  - Support mobility between multiple heterogeneous access system
    - 2G/3G, LTE, non 3GPP access systems (e.g. WLAN, WiMAX)
    - Inter-3GPP handover (GPRS <> E-UTRAN): Using GTP-C based interface for exchange of Radio info/context to prepare handover
    - Inter 3GPP non-3GPP mobility: Evaluation of host based (MIPv4, MIPv6, DSMIPv6) and network based (NetLMM, PMIPv4, PMIPv6) protocols

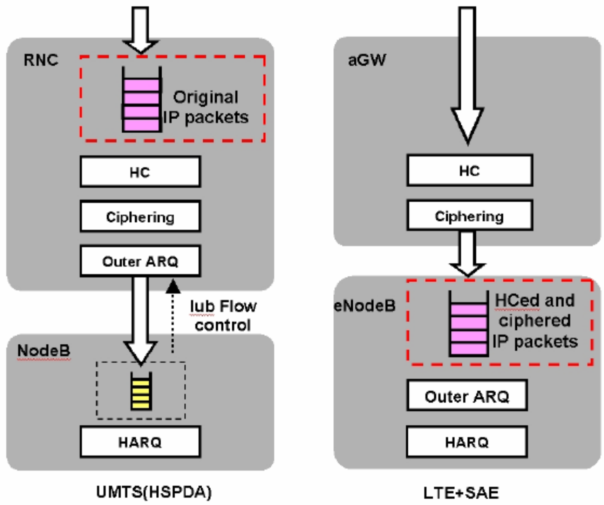
Baseline of SAE architecture



SAE Elements

- Support for legacy GSM/EDGE (GERAN) and UMTS Terrestrial Radio Access Network (UTRAN) connected via SGSN
- Support for new radio-access networks such as LTE
- The Mobile Management Entity (MME) that supports user equipment context and identity as well as authenticates and authorizes users
- The User Plane Entity (UPE) that manages the user data path, including parameters of the IP service and routing
- The 3GPP Anchor that manages mobility between the 2G/3G access system and the LTE access system
- The SAE Anchor that manages mobility between 3GPP access systems and non-3GPP access systems, such as WLANs
- The Policy Control and Charging Rules Function (PCRF) that manages QoS aspects
- The Home Subscriber Server (HSS), which is the database of user subscription information

Differences between UMTS (HSDPA) and LTE/SAE



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