

Chapter 5:

Overview of 3GPP LTE

Presented by
Prof. Yuh-Shyan Chen
Department of Computer Science and
Information Engineering
National Taipei University

Cellular Wireless System Evolution

- 1G (Early 1980s)
 - Analog speech communications.
 - Analog FDMA.
 - Ex: AMPS
- 2G (Early 1990s)
 - Digital modulation of speech communications.
 - Advanced security and roaming.
 - TDMA and narrowband CDMA.
 - Ex: GSM, IS-95 (cdmaOne), and PDC
- 3G (Late 1990s)
 - Global harmonization and roaming.
 - Wideband CDMA
 - Ex: UMTS, cdma2000, and TD-SCDMA

Beyond 3G

- International Mobile Telecommunications (IMT)-2000 introduced global standard for 3G.
- Systems beyond IMT-2000 (IMT-Advanced) is set to introduce evolutionary path beyond 3G.
 - Mobile class targets 100 Mbps with high mobility and nomadic/local area class targets 1 Gbps with low mobility.
- 3GPP and 3GPP2 are currently developing evolutionary/revolutionary systems beyond 3G.
 - 3GPP Long Term Evolution (LTE)
 - 3GPP2 Ultra Mobile Broadband (UMB)
- IEEE 802.16-based WiMAX is also evolving towards 4G through 802.16m.

From

http://en.wikipedia.org/wiki/Ultra_Mobile_Broadband

- **UMB (Ultra Mobile Broadband)** is the brand name for the project within 3GPP2 to improve the CDMA2000 mobile phone standard for next generation applications and requirements.
- The system is based upon Internet (TCP/IP) networking technologies running over a next generation radio system, with peak rates of up to 280 Mbit/s.
- Its designers intend for the system to be more efficient and capable of providing more services than the technologies it replaces.
- Commercialization is unlikely as Qualcomm, its main developer, 3GPP2 and major CDMA carriers are concentrating on LTE instead.

Cont.

- To provide compatibility with the systems it replaces, UMB supports handoffs with other technologies including existing CDMA2000 1X and 1xEV-DO systems.
- However 3GPP2 added this functionality to LTE, allowing LTE to become the single upgrade path for all wireless networks.
- According to the technology market research firm ABI Research, Ultra-Mobile Broadband might be "dead on arrival"[2]. No carrier has announced plans to adopt UMB, and most CDMA carriers in Australia, USA, China, Japan and Korea have already announced plans to adopt HSPA or LTE.

From

http://en.wikipedia.org/wiki/High-Speed_Packet_Access

- **High Speed Packet Access (HSPA)** is a collection of mobile telephony protocols that extend and improve the performance of existing UMTS protocols. Two standards, HSDPA and HSUPA, have been established and a further standard, HSPA+, is soon to be released.
 - **HSDPA (High Speed Downlink Packet Access)** provides improved theoretical down-link performance of up to 14.4 Mbit/s.
 - **HSUPA (High Speed Uplink Packet Access)** provides improved up-link performance of up to 5.76 Mbit/s theoretically.

Cont.

- Evolved High Speed Packet Access (HSPA+)
 - HSPA+ is defined in 3GPP release 7.
 - It introduces a simpler IP-centric architecture for the mobile network bypassing most of the legacy equipment.
 - HSPA+ boosts peak data rates to 42 Mbit/s on the downlink and 22 Mbit/s on the uplink.

3GPP Evolution

- Release 99 (Mar. 2000): UMTS/WCDMA
- Rel-5 (Mar. 2002): HSDPA
- Rel-6 (Mar. 2005): HSUPA
- Rel-7 (2007): DL MIMO, IMS (IP Multimedia Subsystem), optimized real-time services (VoIP, gaming, push-to-talk).
- Long Term Evolution (LTE)
 - 3GPP work on the Evolution of the 3G Mobile System started in November 2004.
 - Standardized in the form of Rel-8.
 - Spec finalized and approved in January 2008.
 - Target deployment in 2010.
 - LTE-Advanced study phase in progress.

版本	釋出日期	資訊
Release 98	1998	早期的 pre-3G GSM networks
Release 99	2000 Q1	Specified the first UMTS 3G networks, incorporating a CDMA air interface
Release 4	2001 Q2	早期稱之為 Release 2000 - 加上一些新的特色 all-IP Core Network
Release 5	2002 Q1	介紹 IMS 與 HSDPA
Release 6	2004 Q4	Integrated operation with Wireless LAN networks and adds HSUPA, MBMS, enhancements to IMS such as Push to Talk over Cellular (PoC), GAN
Release 7	2007 Q4	Focuses on decreasing latency, improvements to QoS and real-time applications such as VoIP. This specification also focus on HSPA+ (High Speed Packet Access Evolution), SIM high-speed protocol and contactless front-end interface (Near Field Communication enabling operators to deliver contactless services like Mobile Payments), EDGE Evolution.
Release 8	In progress, not ready before Mar 2009	LTE , All-IP Network (SAE). Release 8 constitutes a refactoring of UMTS as an entirely IP based fourth-generation network.
Release 9	本計畫將於於2009年12月遭到凍結	SAES Enhancements, Wimax and LTE/UMTS Interoperability
Release 10	In progress	LTE Advanced

3GPP2 Evolution

- CDMA2000 1X (1999)
- CDMA2000 1xEV-DO (2000)
- EV-DO Rev. A (2004): VoIP
- EV-DO Rev. B (2006): Multi-carrier
- Ultra Mobile Broadband (UMB)
 - Based on EV-DO, IEEE 802.20, and FLASH-OFDM
 - **IEEE 802.20 or Mobile Broadband Wireless Access (MBWA)** is an IEEE Standard to enable worldwide deployment of multi-vendor interoperable mobile broadband wireless access networks
 - Spec finalized in April 2007.
 - Commercially available in early 2009.

IEEE 802.16 Evolution

- 802.16 (2002): Line-of-sight fixed operation in 10 to 66 GHz
- 802.16a (2003): Air interface support for 2 to 11 GHz
- 802.16d (2004): Minor improvements to fixes to 16a
- 802.16e (2006): Support for vehicular mobility and asymmetrical link
- 802.16m : Higher data rate, reduced latency, and efficient security mechanism
- 802.16j-2009: Multihop relay

Requirements of LTE

- Peak data rate
 - 100 Mbps DL/ 50 Mbps UL within 20 MHz bandwidth.
- Up to 200 active users in a cell (5 MHz)
- Less than 5 ms user-plane latency
- Mobility
 - Optimized for 0 ~ 15 km/h.
 - 15 ~ 120 km/h supported with high performance.
 - Supported up to 350 km/h or even up to 500 km/h.
- Enhanced multimedia broadcast multicast service (E-MBMS)
- Spectrum flexibility: 1.25 ~ 20 MHz
- Enhanced support for end-to-end QoS

LTE Enabling Technologies

- OFDM (Orthogonal Frequency Division Multiplexing)
- Frequency domain equalization
- SC-FDMA (Single Carrier FDMA)
- MIMO (Multi-Input Multi-Output)
- Multicarrier channel-dependent resource scheduling
- Fractional frequency reuse

LTE Enabling Technologies

■ Single Carrier FDMA (SC-FDMA)

- SC-FDMA is a new single carrier multiple access technique which has similar structure and performance to OFDMA.
 - Utilizes single carrier modulation and orthogonal frequency multiplexing using DFT-spreading in the transmitter and frequency domain equalization in the receiver.
- A salient advantage of SC-FDMA over OFDM/OFDMA is low PAPR (**Peak-to-Average Power Ratio**).
 - Efficient transmitter and improved cell-edge performance.
- H. G. Myung et al., "Single Carrier FDMA for Uplink Wireless Transmission," IEEE Vehic. Tech. Mag., vol. 1, no. 3, Sep. 2006
- A comprehensive tutorial available at <http://hgmyung.googlepages.com/scfdma.pdf>.

Key Features of LTE

- Multiple access scheme
 - **DL**: OFDMA with CP.
 - **UL**: Single Carrier FDMA (SC-FDMA) with CP.
- Adaptive modulation and coding
 - DL/UL modulations: QPSK, 16QAM, and 64QAM
 - Convolutional code and **Rel-6** turbo code
- Advanced MIMO spatial multiplexing techniques
 - (2 or 4)x(2 or 4) downlink and uplink supported.
 - Multi-user MIMO also supported.
- Support for both FDD and TDD
- H-ARQ (**Hybrid automatic repeat-request**), mobility support, rate control, security, and etc.

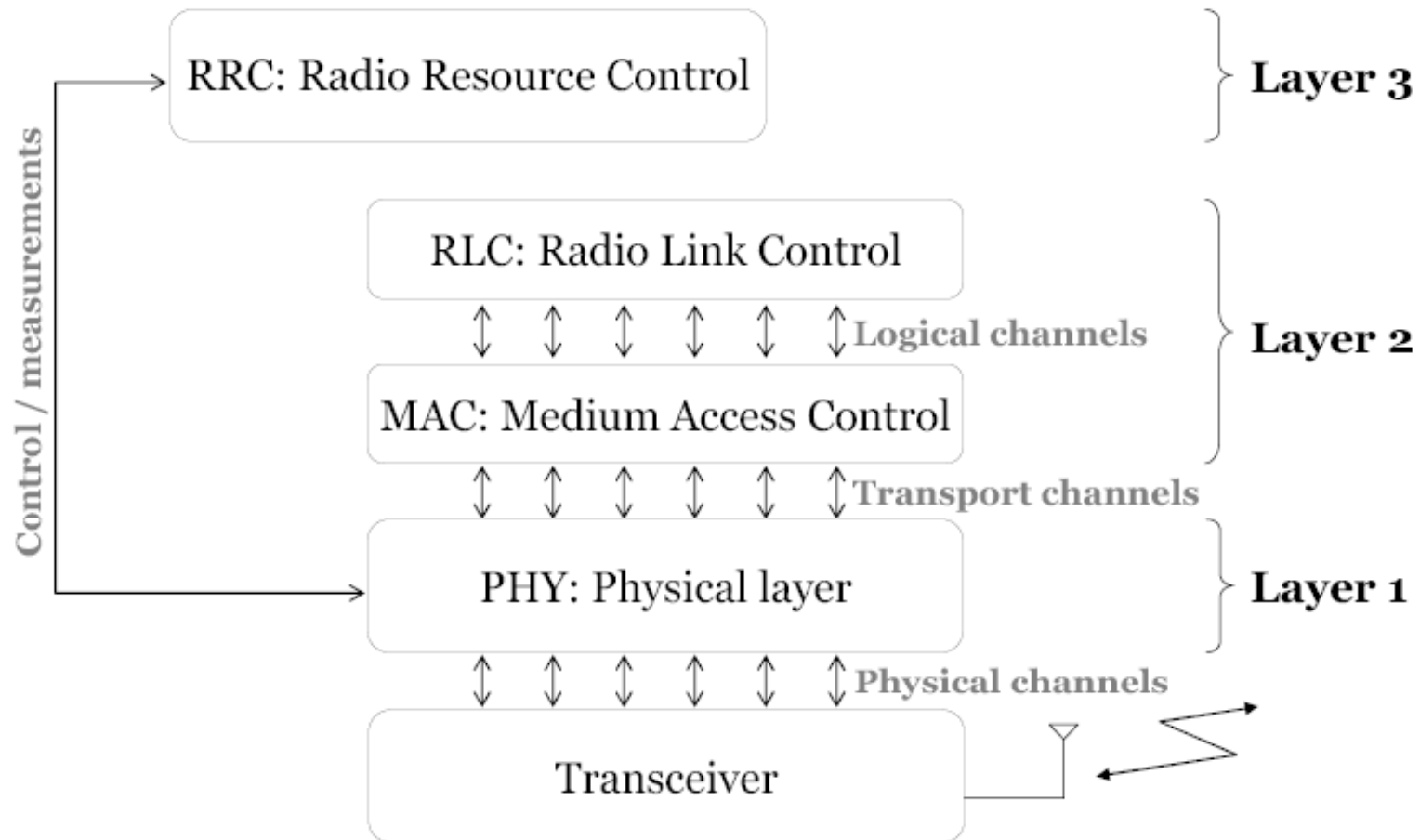
LTE Standard Specifications

■ Freely downloadable from

<http://www.3gpp.org/ftp/Specs/html-info/36-series.htm>

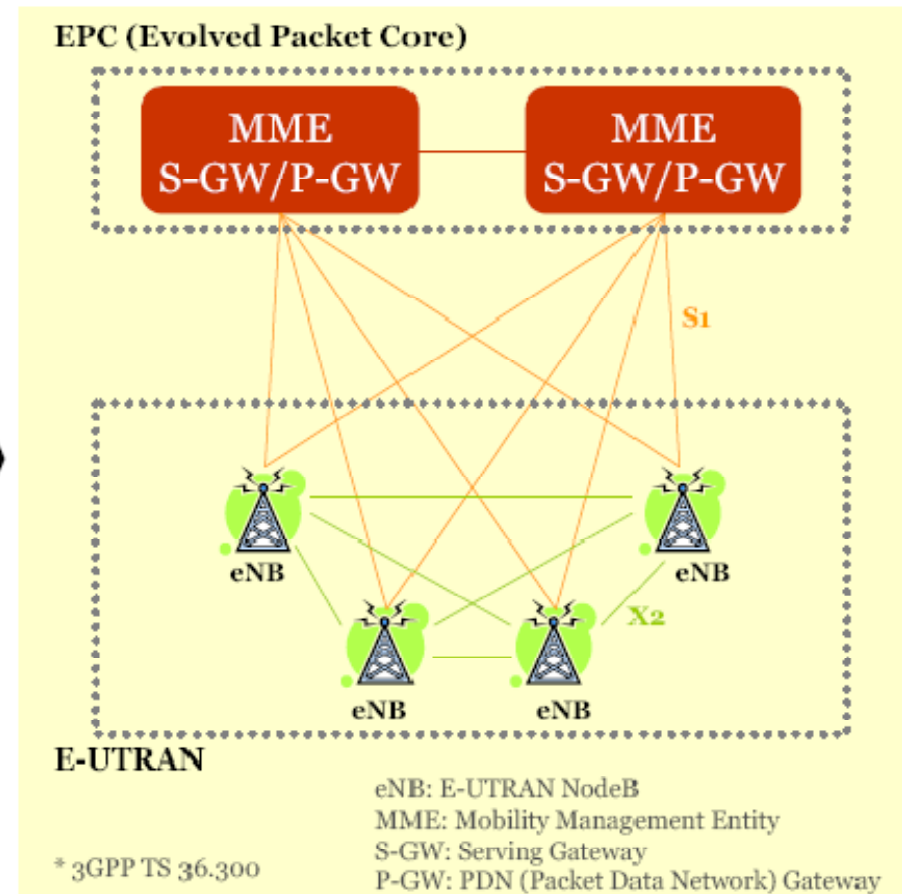
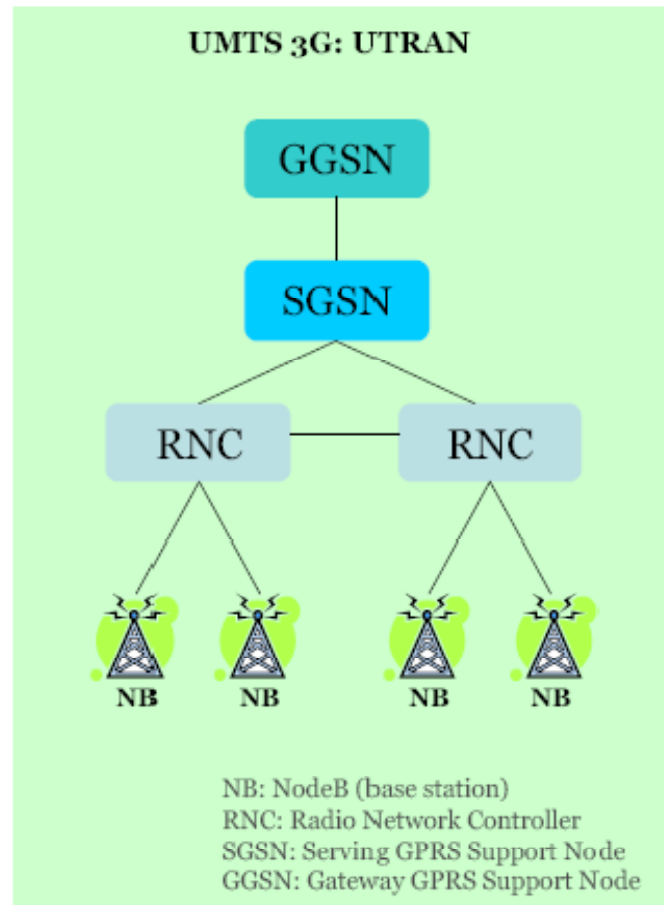
Specification index	Description of contents
TS 36.1xx	Equipment requirements: Terminals, base stations, and repeaters.
TS 36.2xx	Physical layer.
TS 36.3xx	Layers 2 and 3: Medium access control, radio link control, and radio resource control.
TS 36.4xx	Infrastructure communications (UTRAN = UTRA Network) including base stations and mobile management entities.
TS 36.5xx	Conformance testing.

Protocol Architecture



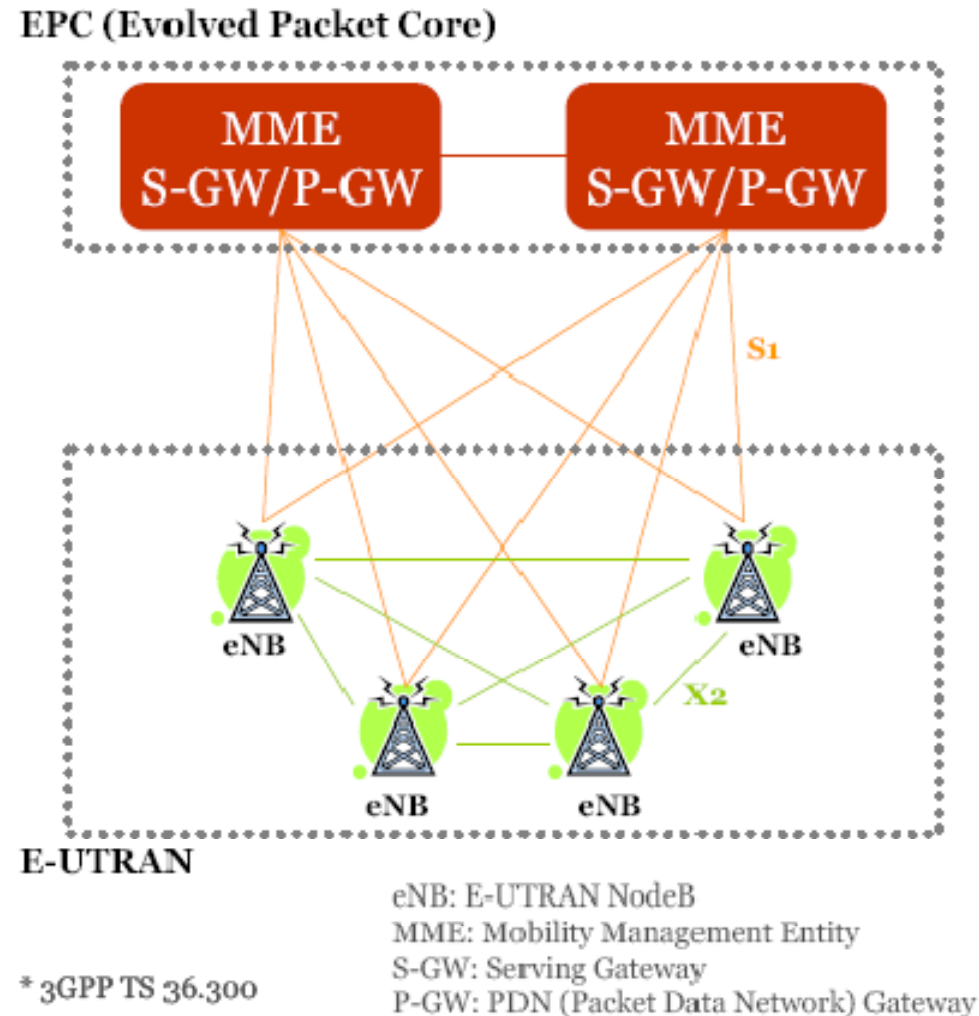
LTE Network Architecture

■ E-UTRAN (Evolved Universal Terrestrial Radio Access Network)

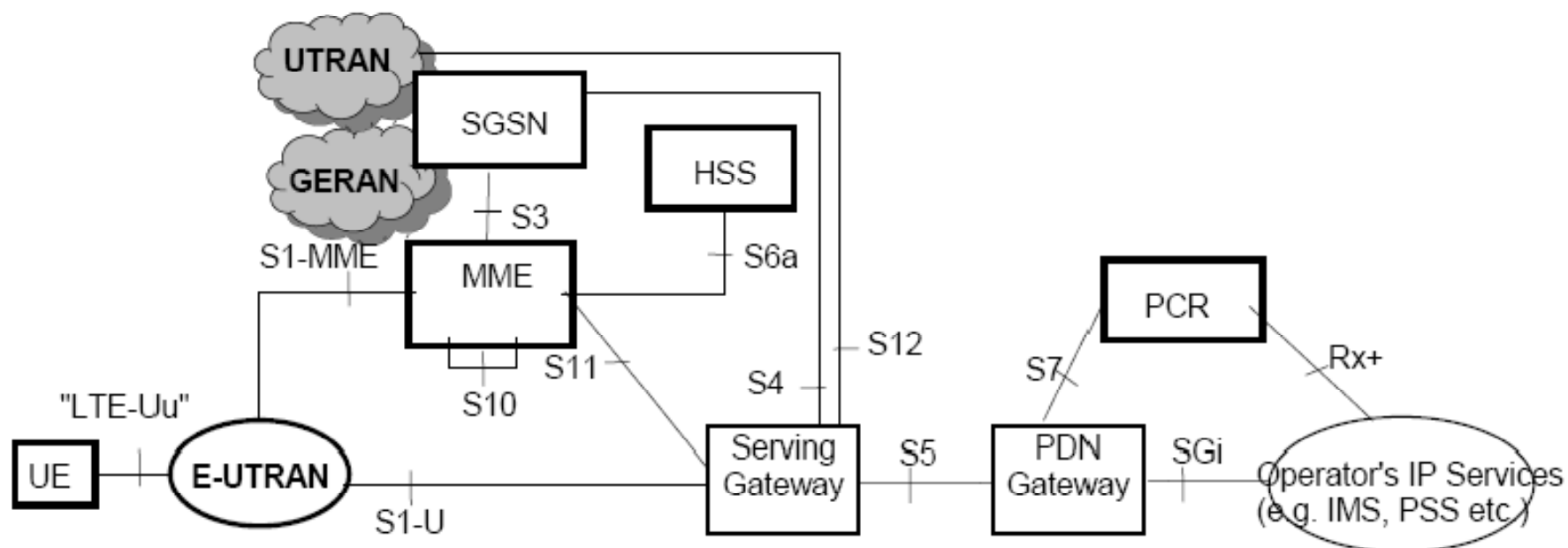


LTE Network Architecture

- eNB
 - All radio interface-related functions
- MME
 - Manages mobility, UE identity, and security parameters.
- S-GW
 - Node that terminates the interface towards E-UTRAN.
- P-GW
 - Node that terminates the interface towards PDN.

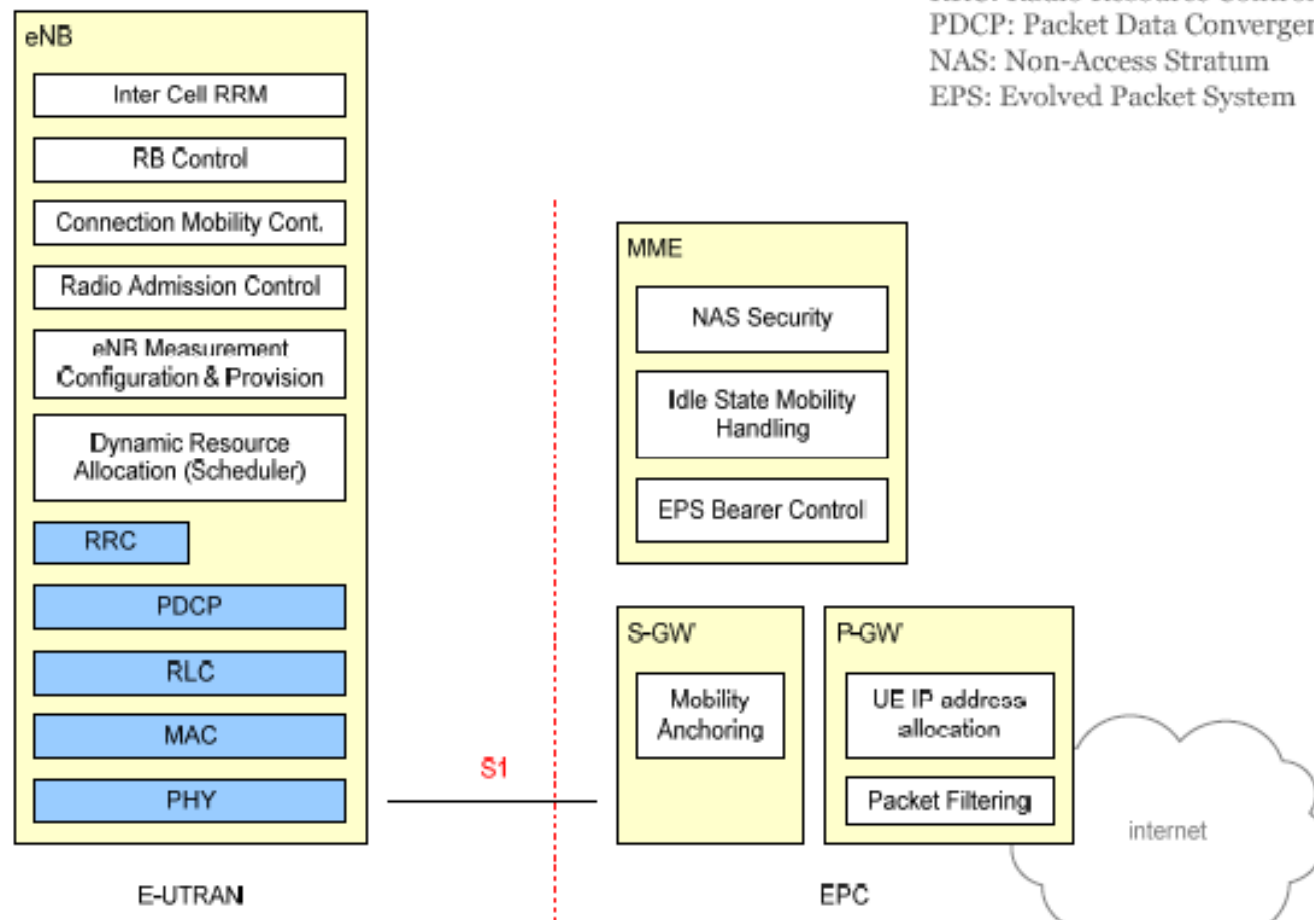


LTE Network Architecture



* Non-roaming architecture
* 3GPP TS 23.401

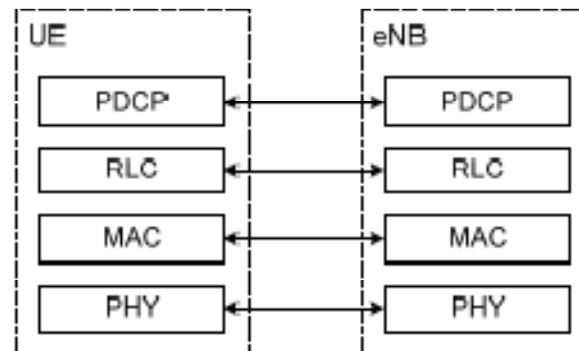
LTE Network Architecture



RRM: Radio Resource Management
RB: Radio Bearer
RRC: Radio Resource Control
PDCP: Packet Data Convergence Protocol
NAS: Non-Access Stratum
EPS: Evolved Packet System

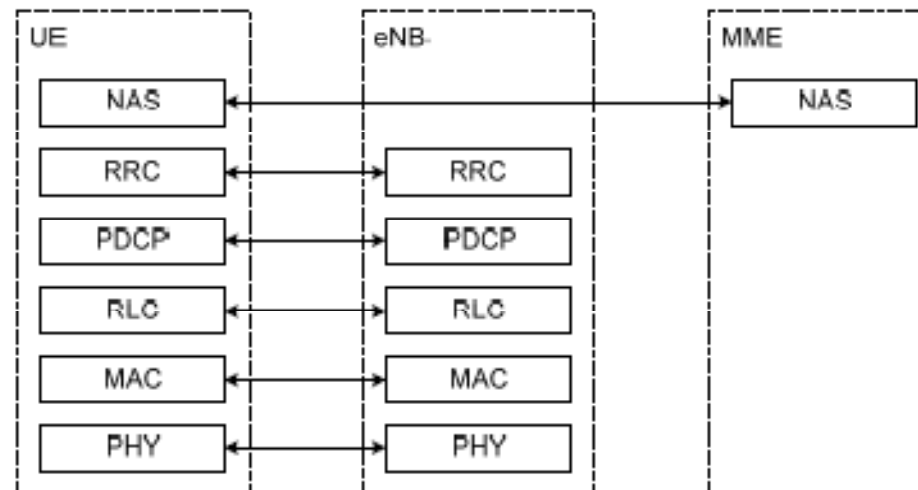
LTE Network Architecture

**User-Plane
Protocol
Stack**



PDCP is an abbreviation for Packet Data Convergence Protocol. It is one of the layers of the Radio Traffic Stack in **UMTS** and performs **IP** header compression and decompression, transfer of user data and maintenance of sequence numbers for Radio Bearers which are configured for **lossless** serving radio network subsystem (SRNS) relocation.

**Control-Plane
Protocol
Stack**



Non Access Stratum (NAS) is a functional layer in the **UMTS protocol stack** between Core Network and User Equipment **UE**. The layer supports signalling and traffic between those two elements.