LTE

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OVERVIEW

- LTE is the short form of Long Term Evolution.
- It is the project name given to development of a high performance air interface for cellular mobile communication systems.
- It is the last step toward the 4th generation(4G) of radio technologies designed to increase the capacity and speed of mobile telephone networks.
- While the former generation of mobile telecommunication networks are collectively known as 2G or 3G, LTE is marketed as 4G.

- Standard for wireless broadband communication based on GSM/EDGE and UMTS/HSPA technologies.
- Sometimes LTE is also known as 3.95G.
- LTE is marketed as 4G LTE and also as advanced 4G,but it doesn't meet the technical criteria of 4G.
- It is not considered as a generation because there is not much technology revolution involved while developing LTE.

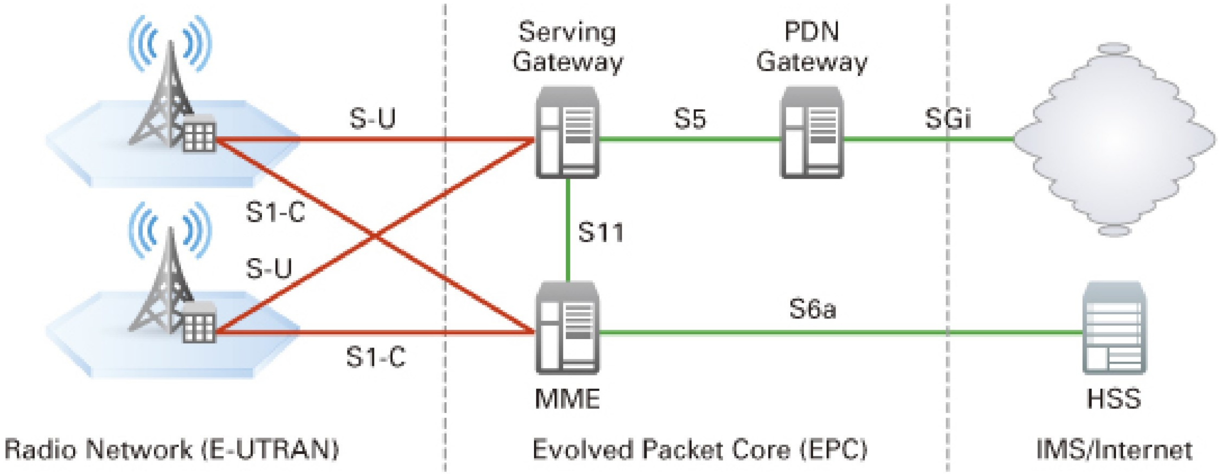
- In 2004, NTT Docomo of Japan proposes LTE as the international standard.
- In February 2007, Ericsson demonstrated for the first time in the world, LTE with bit rates up to 144 Mbit/s.
- A rapid increase of mobile data usage and emergence of new applications such as MMOG (Multimedia Online Gaming), mobile TV, Web 2.0, streaming contents have motivated the 3rd Generation Partnership Project (3GPP) to work on the Long-Term Evolution (LTE) on the way towards fourth-generation mobile.
- The main goal of LTE is to provide a high data rate, low latency and packet optimized radioaccess technology supporting flexible bandwidth deployments.

- According to 3GPP, a set of advanced requirements was identified:
- Reduced cost per bit.
- Increased service provisioning – more services at lower cost with better user experience.
- Flexibility use of existing and new frequency bands
- Simplified architecture, Open interfaces.
- Allow for reasonable terminal power consumption.

- LTE specification provides downlink rates of 300Mbits/sec and uplink rates of 75MBits/sec.
- LTE has ability to manage fast moving mobiles and supports multicast and broadcast streams.
- It supports scalable bandwidth from 1.4 MHZ to 20 MHZ.
- It supports both frequency division duplexing (FDD) and time division duplexing(TDD).
- It also supports half duplex FDD with same radio access technology.

SAE Architecture

- System architecture evolution(SAE)is a new network architecture designed to simplify LTE networks and establish a flat architecture similar to other IP based communications networks.
- SAE uses an eNB and Access Gateway (aGW) and removes the RNC and SGSN from the equivalent 3G network architecture to create a simpler mobile network.
- This allows the network to be built with an "All-IP" based network architecture.
- SAE also includes entities to allow full inter-working with other related wireless technology (WCDMA, WiMAX, WLAN, etc.).



The EPC is a key part of SAE. Major subcomponents of the LTE EPC include the MME, SGW, and PGW.

The MME is an important controller node in the LTE network. It is responsible for:

- Idle mode UE (User Equipment) tracking
- Paging procedure such as re-transmissions
- Bearer activation and deactivation process
- S-GW selection for a UE at the initial attach

Intra-LTE handover with Core Network node relocation User authentication with HSS

SGW (Serving Gateway):

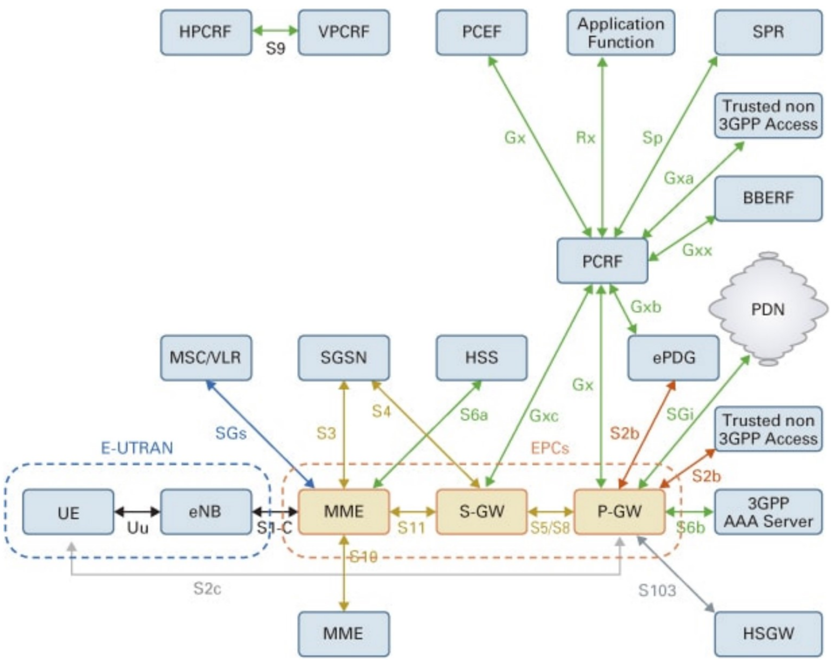
- The main function of the Serving Gateway is routing and forwarding of user data packets.
- It is also responsible for inter-eNB handovers in the U-plane and provides mobility between LTE and other types of networks, such as between 2G/3G and P-GW.
- The SGW keeps context information such as parameters of the IP bearer and routing information, and stores the UE contexts when paging happens.
- It is also responsible for replicating user traffic for lawful interception.

PGW (PDN Gateway):

The PDN Gateway is the connecting node between UEs and external networks. It is the entry point of data traffic for UEs. In order to access multiple PDNs, UEs can connect to several PGWs at the same time. The functions of the PGW include:

- Policy enforcement
- Packet filtering
- Charging support
- Lawful interception
- Packet screening

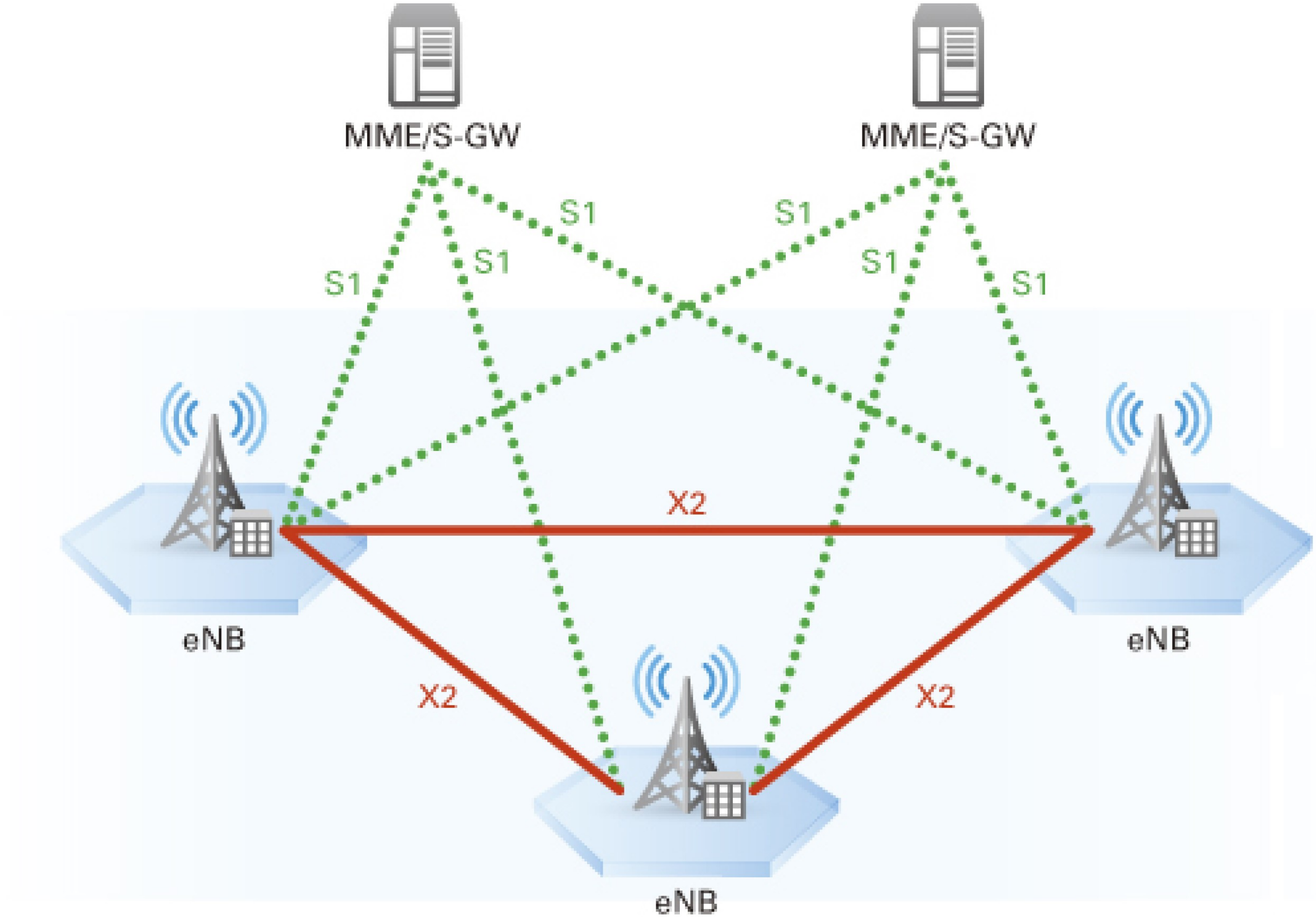
Another important role of the PGW is to provide mobility between 3GPP and non-3GPP networks. For example, mobility between WiMAX and 3GPP2 or between CMDA 1X and EVDO are supported by the PGW.



The above figure shows LTE network and EPC details

UTRAN Architecture

- In order to meet the requirements for LTE networks, the evolved UTRAN (E-UTRAN) architecture has been improved dramatically from the 3G/3.5G radio access network (UTRAN).
- While legacy networks employed a hierarchical architecture, E-UTRAN uses a flat architecture.
- The functions of the eNB in E-UTRAN systems include not only base station (NodeB) functions to terminate the radio interface but also the functions of the Radio Network Controller (RNC) to manage radio resources.



E-UTRAN Architecture

OFDM

- Orthogonal frequency-division multiplexing (OFDM), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method.
- OFDM meets the LTE requirement for spectrum flexibility and enables cost-efficient solutions for very wide carriers with high peak rates.
- The OFDM symbols are grouped into resource blocks. The resource blocks have a total size of 180kHz in the frequency domain and 0.5ms in the time domain. Each 1ms Transmission Time Interval (TTI) consists of two slots (Tslot).
- The scheduling mechanisms in LTE are similar to those used in HSPA.

Advantages of OFDM

- The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters.
- Channel equalization is simplified because OFDM may be viewed as using many slowly-modulated narrowband signals rather than one rapidly-modulated wideband signal.
- The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI).

Drawbacks of OFDM

- High peak-to-average ratio
- Sensitive to frequency offset, hence to Doppler-shift as well

SC-FDMA

- LTE uses a pre-coded version of OFDM called Single Carrier Frequency Division Multiple Access (SC-FDMA) in the uplink. This is to compensate for a drawback with normal OFDM, which has a very high Peak to Average Power Ratio (PAPR).
- High PAPR requires expensive and inefficient power amplifiers with high requirements on linearity, which increases the cost of the terminal and drains the battery faster.
- SC-FDMA solves this problem by grouping together the resource blocks in such a way that reduces the need for linearity, and so power consumption, in the power amplifier. A low PAPR also improves coverage and the cell-edge performance.

4G LTE has some inherent advantages over previous generation (3G) of mobile communications which makes it suitable for connectivity for enterprises.

- Higher bandwidth (data speeds), 4G LTE provides true broadband speeds in comparison to 3G. Low latency, lower idle-to-active times (improved network responsiveness)
- High spectrum efficiency means higher network capacity, improved cost efficiency.
- Backwards compatibility and future-proofing.
- All IP network means easier integration, improved cost efficiency
- Enhancements to security and Quality of Service differentiation

SRSLTE: It is Sound Reference Signal LTE
srsLTE is a free and open-source 4G LTE software suite. Using srsLTE, you can build an end-to-end software radio mobile network.

The srsLTE suite includes:

- srsUE - a complete SDR LTE UE (User Equipment) application
- srsENB - a complete SDR LTE eNodeB (Basestation) application
- srsEPC - a light-weight LTE EPC (Core Network) implementation with MME, HSS and S/P-GW

All srsLTE software runs in linux with off-the-shelf compute and radio hardware.

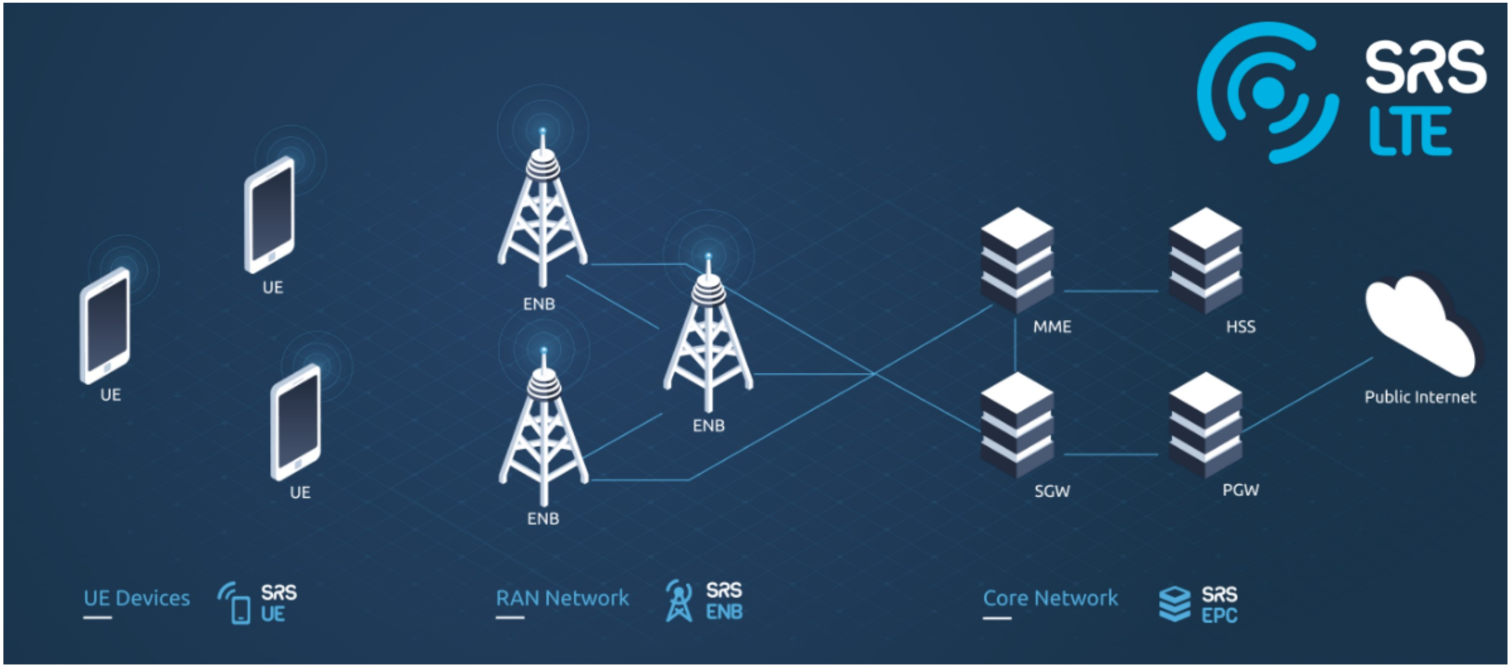
- SRS is the Sounding Reference Signal and can be transmitted by each uplink user. SRS is used by the base station to get a more accurate calculation of a particular user's uplink channel.
- The sounding reference signal (SRS) is transmitted separately from PUCCH and PUSCH. SRS can be transmitted on any number of subcarriers in the last symbol in a subframe. SRS takes precedence over all other allocated channels except PUCCH Format 1 transmissions.
- In TDD mode, SRS can also be transmitted in the last two symbols of the special subframe when UpPTS is configured to be long enough.
- SRS is transmitted by a UE to give the base station an idea of the uplink channel characteristics for that UE. The base station can use the information to assign good uplink allocations for the UE to transmit on.

There are two types of SRS transmission defined for the LTE uplink:

1. Periodic SRS transmission,which has been available from the first release of LTE (release 8).
2. Aperiodic SRS transmission,introduced in LTE release .Triggered by signaling on PDCCH as part of the scheduling grant.

Power Control for SRS:

The SRS transmit power basically follows that of the PUSCH, compensating for the exact bandwidth of the SRS transmission and with an additional power offset



Above figure shows the architcture of srsLTE.

SRS Multiplexing:

- Different phase rotations (for SRS, typically referred to as "cyclic shifts") can be used to generate different SRS that are orthogonal to each other. Multiple SRS can thus be transmitted in parallel in the same subframe by configuring Ue's in different cyclic shift cs.

- Another way to allow for SRS to be simultaneously transmitted from different terminals is to rely on the fact that each SRS only occupies every second subcarrier. Thus, SRS transmissions from two terminals can be frequency multiplexed by assigning them to different frequency shifts or "combs".

OAI:

- OpenAirInterface wireless technology platform is a flexible platform towards an open LTE ecosystem.

- It can be used to build and customize a LTE base station (OAI eNB), a user equipment (OAI UE) and a core network (OAI EPC) on a PC.

- The OAI eNB can be connected either to a commercial UEs or OAI UEs to test different configurations and network setups and monitor the network and mobile device in real-time.

- OAI is based on a PC hosted software radio frontend architecture. With OAI, the transceiver functionality is realized via a software radio front end connected to a host computer for processing.
- OAI is written in standard C for several real-time Linux variants optimized for Intel x86 and ARM processors and released as free software under the OAI License Model.
- OAI provides a rich development environment with a range of built-in tools such as highly realistic emulation modes, soft monitoring and debugging tools, protocol analyzer, performance profiler, and configurable logging system for all layers and channels.

Towards building an open cellular ecosystem for flexible and low-cost 4G/5G deployment and experimentations, OAI aims at the following objectives:

- Open and integrated development environment under the control of the experimenters.
- **On the network side:** Fully software-based network functions offering flexibility to architect, instantiate, and reconfigure the network components (at the edge, core, or cloud using the same or different addressing space).

- **On UE side :** Fully software-based UE functions which can be used by modem designers with upgrading and/or developing LTE and 5G advanced features.
- Playground for commercial handsets as well as application, service, and content providers.
- Rapid prototyping of 3GPP compliant and non-compliant use-cases as well as new concepts towards 5G systems ranging from M2M/IoT and software-defined networking to cloud-RAN and massive MIMO.

- Within the OFDM signal it is possible to choose between three types of modulation for the LTE signal:
    1. QPSK (= 4QAM) 2 bits per symbol
    2. 16QAM 4 bits per symbol
    3. 64QAM 6 bits per symbol

- The LTE signal format, modulation and use of OFDM has enabled LTE to provide reliable high speed data communications.

- The use of OFDM has enabled LTE to provide reliable link quality even in the presence of reflections and the adaptive modulation provided the ability to modify the link according to the prevailing signal quality.

THANK YOU