International Conference on Control, Engineering & Information Technology (CEIT'14)
Proceedings - Copyright IPCO-2014
ISSN 2356-5608

NETWORK SOLUTION FROM GSM to LTE

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Abstract- **LTE's study phase began in late 2004. The overall goal was to select technology that would keep 3GPP's Universal Mobile Telecommunications System (UMTS) at the forefront of mobile wireless well into the next decade. Key project objectives were set in the following areas: peak data throughput; spectral efficiency; flexible channel bandwidths; latency; device complexity; and overall system cost. The main decision was whether to pursue the objectives by continuing to evolve the existing W-CDMA air interface (which incorporates HSPA (high-speed packet access) or adopt a new air interface based on OFDM.**

Index Terms **The motivation for LTE, OFDM, LTE access network**

I. INTRODUCTION

LTE (both radio and core network evolution) is now on the myti5u7arket. Release 8 was frozen in December 2008 and this has been the basis for the first wave of LTE equipment. LTE specifications are very stable, with the added benefit of enhancements hatu6jving been introduced in all subsequent 3GPP Releases

The motivation for LTE [4]

- Need to ensure the continuity of competitiveness of the 3G system for the future
- User demand for higher data rates and quality of Service
- Packet Switch optimized system
- Continued demand for cost reduction (CAPEX and OPEX)
- Low complexity
- Avoid unnecessary fragmentation of technologies for Paired and unpaired band operation

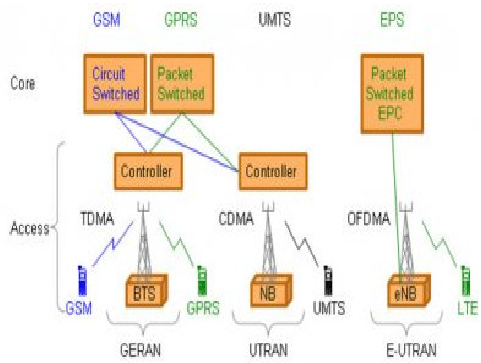

Figure 1 component of LTE

GSM was developed to carry real time services, in a circuit switched manner (in blue in fig.1), and with data services only possible over a circuit switched modem connection, with very low data rates. The first step towards an IP based packet switched (in green in fig.1) solution was made with the evolution of GSM to GPRS, using the same air interface and access method, TDMA (Time Division Multiple Access). [9]

To reach higher data rates and data volume UMTS was developed with a new access network, based on CDMA (Code Division Multiple Access). The access network in UMTS emulates a circuit switched connection for real time services and a packet switched connection for data com services (in black in fig.1). In UMTS the IP address is allocated to the UE when a data com service is established and released when the service is released. Incoming data com services are therefore

Still relying upon the circuit switched core for paging.

LTE or the E-UTRAN (Evolved Universal Terrestrial Access Network) is the access part of the requirements for the new access network are high spectral efficiency, high peak data rates, short round trip time and frequency flexibility.

The Evolved Packet System (EPS) is purely IP based. Both real time services and data com services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off [3].

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The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) to be able to reach even higher data rates and data volumes. High order modulation (up to 64QAM), large bandwidth (up to 20 MHz) and MIMO transmission in the downlink (up to 4x4) is also a part of the solution. The highest theoretical data rate is 170 Mbps in uplink and with MIMO the rate can be as high as.

Other access technologies not developed by 3GPP, like WiMAX and WiFi. Non 3GPP developed access solutions are divided in trusted and non-trusted. This division is not based on the technical solution but the business relation/agreement between the operators

The core network EPC is prepared to work with other access technologies not developed by 3GPP, like WiMAX and WiFi. Non 3GPP developed access solutions are divided in trusted and non-trusted. This division is not based on the technical solution but the business relation/agreement between the operators

The LTE access network is simply a network of base stations, evolved Node (eNB), generating a flat architecture (figure 1). There is no centralized intelligent controller, and the eNBs are normally

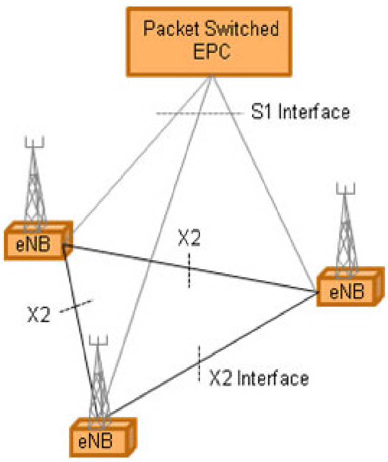

Figure 2 towards the core network by the S1-interface

Inter-connected by the X2-interface and towards the core network by the S1-interface (figure 2)..

The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long.

Another advantage with the distributed solution is that the MAC protocol layer, which is responsible for scheduling, is represented only in the UE and in the base station leading to fast communication and decisions between the eNB and the UE. In UMTS the MAC protocol, and scheduling, is located [7] the controller and when HSDPA was introduced an additional MAC sub-layer, responsible for HSPA scheduling was added in the NB.

The scheduler is a key component for the achievement of a fast adjusted and efficiently utilized radio resource. The Transmission Time Interval (TTI) is set to only 1 ms.

During each TTI the eNB scheduler shall consider the physical radio environment per UE. The UEs report their perceived radio quality, as an input to the scheduler to decide which Modulation and Coding scheme to use. The solution relies on rapid adaptation to channel variations, employing HARQ (Hybrid Automatic Repeat Request) with soft-combining and rate adaptation [1]

Prioritize the QoS service requirements amongst the UEs. LTE supports both delay sensitive real-time services as well as data com services requiring high data peak rates. To schedule a low data rate, real-time service leads to a pleased customer but a low utilized radio spectrum.

Inform the UEs of allocated radio resources. The eNB schedules the UEs both on the downlink and on the uplink. For each UE scheduled in a TTI there will be a Transport Block (TB) generated carrying user data.

In DL there can be a maximum of two TBs generated per UE – if MIMO is used. The TB will be delivered on a transport channel. In LTE the number of channels is decreased compare to UMTS. For the user plane there is only one shared channel in each direction.

The TB sent on the channel, can therefore contain bits from a number of services, multiplexed together. In theory the highest number of users that can be scheduled during 1 ms is 440, presuming 20 MHz band and 4x4 Multi User MIMO.

To achieve high radio spectral efficiency a multicarrier approach for multiple access was chosen by 3GPP. For the downlink, OFDMA (Orthogonal Frequency Division Multiple Access) was selected and for the uplink SC-FDMA (Single Carrier - Frequency Division Multiple Access) also known as DFT (Discrete Fourier Transform) spread OFDMA (figure 3).

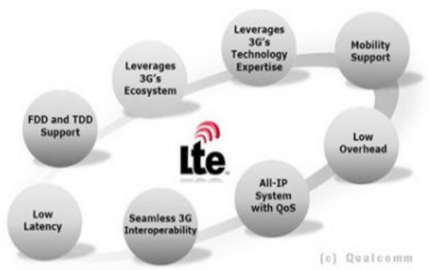

Figure 3 radio spectral efficiency a multicarrier approach for multiple access

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OFDM is a multicarrier technology subdividing the available bandwidth into a multitude of mutual orthogonal narrowband subcarriers. In OFDMA these subcarriers can be shared between multiple users. This solution is achieving very high spectral efficiency, but requires fast processors.

It makes it possible to exploit variations in both frequency and time domains. The OFDMA solution leads to high peak-to-average power ratio requiring expensive power amplifiers with high requirements on linearity, increasing the battery consumption. This is no problem in the eNB, but would lead to very expensive handsets. Hence a different solution with lower requirement on the handset was selected for the UL.

To enable possible deployment around the world, supporting as many regulatory requirements as possible, LTE is developed for a number of frequency bands, ranging from 800 MHz up to 3.5 GHz.

The available bandwidths are also flexible starting with 1.4 MHz up to 20 MHz. LTE is developed to support both the time division duplex technology (TDD) as well as frequency division duplex (FDD).[2]

Since LTE provides high spectral efficiency, supports high data rates and implements flexible access architecture, it is proven to become a success amongst operators as well as customers.

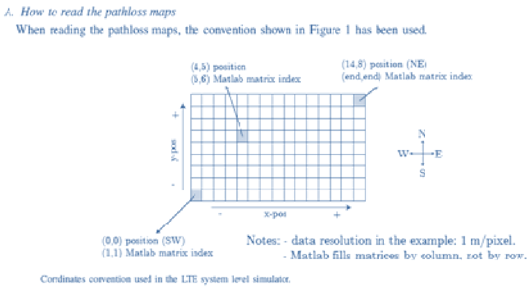

Figure 4 read the path loss maps

Graphical User Interface (GUI) that shows you the available macroscopic path loss models and antenna gain patterns. Does not actually plot results.

- Sector throughput and BLER: for every sector, shows the average throughput (summing both streams, when applicable) and overall BLER. If no users are assigned to the sector, NaN may be displayed as BLER.

Note that all time-dependant data is averaged by using a rectangular window of configurable length

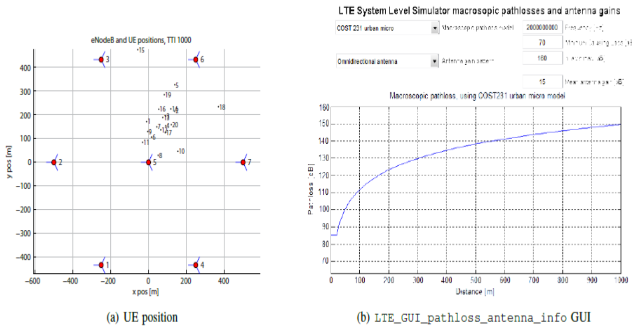

Figure 5 path loss models and antenna gain patterns

Throughput and BLER over time. The blue line depicts the UE throughput in Mb/s for the selected stream and UE, as well as the BLER as measured by the ACK/NACK ratio (green line) and the BLER value applied by the link quality model. Although the system is calibrated to deliver BLERs_0.1, the actual results are influenced by the uplink delay and time variability of the channel.

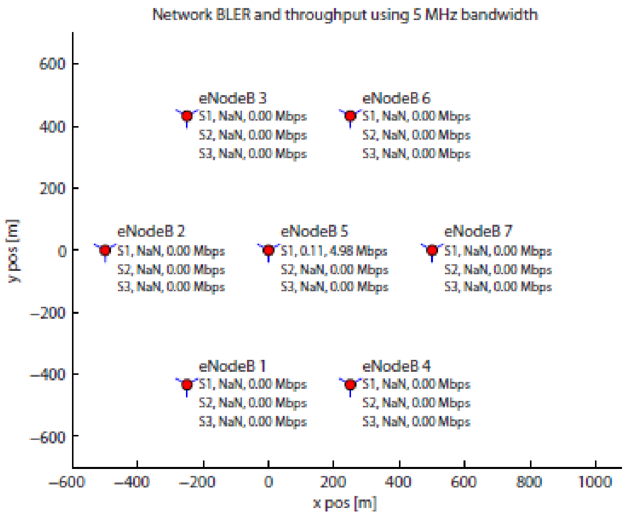

Figure 6 network BLER and throughput using 5MHZ bandwidth

– UE position in the ROI.

– sent CQI report for the selected RB and stream (blue), mean CQI for the whole frequency band (red) and CQI of to the Transport Block (TB) sent to the UE, if scheduled.

– Distribution of the CQIs for the selected UE and RB during the simulation time (blue), and of the TB CQIs (red).

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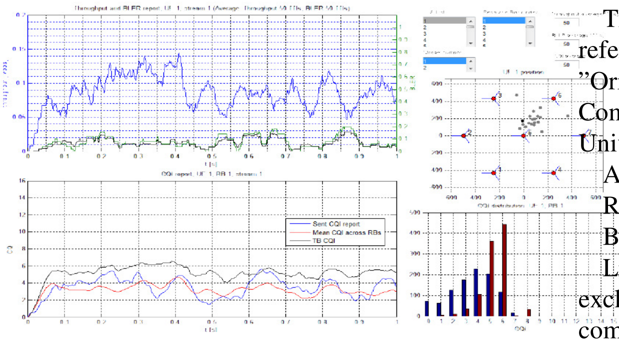

Figure 7 LTE-GUI-show-UE-traces GUI

GUI depicting the cell traces for the selected eNodeB/sector pair. Contains the following figures:

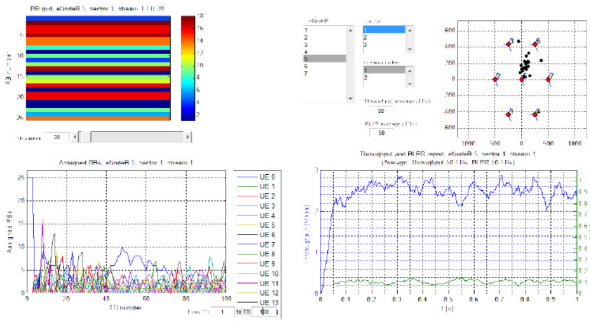

Figure 8 LTE-GUI-show-cell-traces GUI

– Graphical depiction of the RB allocation for the selected TTI.

– Throughput and BLER for the selected stream number. Throughput and BLER are averaged using a rectangular window of configurable length. In order to make the post-processing faster

– Evolution of the number of assigned RBs to each UE during the selected TTI range.

The cell throughput is calculated with the ACKed data from the UEs instead of checking the throughput of every attached UE. Thus, the uplink delay makes you lose the value for some TTIs.

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ISSN 2356-5608

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