High Performance LTE Technology: The Future of Mobile Broadband Technology

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Abstract— The main objective of LTE is to provide high performance radio-access technology which offers full vehicular speed mobility that can readily coexist with HSPA and earlier networks. Because of high bandwidth, operators will be able to easily migrate their networks and users from HSPA to LTE over the time. In order to address such challenges, researches are carried out for defining algorithms which can be able to handle various hand over/hand off decisions which is based on user equipment (UE) requirements and various expectations of quality of service (QoS). The particular LTE network used to support mobility for speed till 500 km/h.

Index Terms— LTE, PBCH, HSPA, IMT, HO, UE, TTT

I. INTRODUCTION

Long Term Evolution (LTE) is radio platform based technology which allows operators for achieving high throughputs than HSPA+ which is having high spectrum bandwidth. LTE is basically a part of the GSM evolutionary path for a mobile broadband, which follows EDGE, UMTS, HSPA (HSDPA and HSUPA combined) and HSPA Evolution (HSPA+[1]). Though HSPA and their evolution is basically positioned to be the most dominant mobile data technology for the future decade, the 3GPP family of standards should evolve towards the near future. HSPA+ is going to provide one of the stepping-stones for LTE. This basically assumes Internet Protocol (IP) network architecture which is actually designed for supporting voice in particular packet domain. This will incorporate top-of-the-line radio techniques for achieving high performance levels which is more practical than CDMA approaches, more particular for larger channel bandwidths. However, the way 3G coexists with 2G systems in all integrated networks,[3] LTE systems generally coexist with 3G and 2G systems. Multimode devices are used to function across LTE/3G or even LTE/3G/2G depending upon market circumstances.

II. HISTORY

Standards development combined with 3GPP Release 9 (Rel-9) got functionally freezied in December 2009. 3GPP Rel-9 focus on enhancements of HSPA+ and LTE while Rel-10 basically focus on the next generation of LTE for the International Telecommunication Union’s (ITU) IMT-Advanced requirements and both got developed together by 3GPP standards working groups. Several milestones are achieved by vendors for Rel-9 and Rel-10. Most important is the final ratification due to ITU of LTE-Advanced (Rel-10) as IMT-Advanced in November 2010. Firstly LTE networks are launched by Sonera in Norway and Sweden in December 2009[2]; as of October 2011, there are 33 commercial LTE networks in different stages of service. Many trials were taken for 50 LTE deployments in 2011. For so many years from now, top world cellular standard is one of the industry’s goals. GSM dominates 2G technologies but this is fragmentation of CDMA with TDMA and iDEN. With the move to 3G, nearly all TDMA operators migrated to the 3GPP technology path. In 3GPP technology path, Long Term Evolution (LTE) evolved as the world class technology. Most of the leading operators, device manufacturer and infrastructure providers will basically support LTE as one of the mobile technology for future. Operators along with GSM-HSPA and CDMA EVDO operators with WiMAX are forming strategic,
long-term commitments for LTE networks. In June 2008, the Next Generation Mobile Networks Alliance (NGMN) used LTE as the first technology and thus achieved their basic requirements successfully. 4G Americas, GSMA, UMTS Forum and various other global organizations have been reiterated support for LTE.

### III. LTE ARCHITECTURE

The entire LTE architecture is very complex; a complete structure will show the entire Internet and various other aspects of network connectivity which is supporting handoffs among 3G, 2G, WiMAX and various other standards. The eNodeB, a second name for the base station, interfaces between the eNodeB and UEs. The E-UTRAN is the complete network.

![LTE Architecture Diagram](image)

**Table I. History**

<table>
<thead>
<tr>
<th>Technology</th>
<th>1GTT</th>
<th>1.5G HSPA+</th>
<th>2100 MHz 3GPP UMTS</th>
<th>3GPP UMTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak speed</td>
<td>30 kbps</td>
<td>up to 14.4 kbps</td>
<td>384 kbps</td>
<td>320 kbps</td>
</tr>
<tr>
<td>Technology</td>
<td>60 kbps</td>
<td>1.2 Mbps</td>
<td>14.4 kbps</td>
<td>360 kbps</td>
</tr>
</tbody>
</table>

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**Fig. 2. LTE Architecture**


### IV. LTE PHY

LTE is basically designed for full duplex operation in paired spectrum. However, WiMAX only operates in half duplex which is in unpaired spectrum, where information is being transmitted in one direction only.

LTE will support TDD operation which is in unpaired spectrum; however, this is not a primary focus of design. The PHY layer will operate continuously for downlink along with interspersed sync, which provides multiple channels simultaneously along with modulation. The downlink channel will operate as a continuous stream. Unlike IEEE® 802 family standards, so there is not any [4] relation between the air interface—transmitted frames on the air—and their actual service data unit (SDU) packets which comes from the top of the protocol stack. LTE will use the concept of a resource block, which has a block of 12 subcarriers in a single slot. A transport block is basically a group of resource blocks along with common modulation/coding[1]. The physical interface is transport block, which will correspond to the data that is carried in a period of time for the allocation of the particular UE. Each radio subframe is of 1 millisecond (ms) long; where each frame is 10 milliseconds. Multiple UEs can be used to service on the downlink for a particular time in one of the transport block. The MAC controls what is to be send in a given time. The LTE standard will specify these physical channels:

**A. Physical broadcast channel (PBCH)**
- The coded BCH transport block is used to map to four subframes within a 40 ms interval
- 40 ms timing is blindly detected i.e. there is not any explicit signaling which indicates 40 ms timing
- Each subframe is basically assumed to be self decodable, that is the BCH which is decoded from a single reception assuming that sufficiently good channel conditions.

**B. Physical control format indicator channel (PCFICH)**
- This will inform the UE about the number of OFDM symbols which are required for the PDCCHs.
- Transmitted in all subframes.

**C. Physical downlink control channel (PDCCH)**
- This will inform the UE about the resource allocation of PCH and DL-SCH, and Hybrid ARQ information will relate to DL-SCH.
- This will carry the uplink scheduling grant.

### V. LTE DOWNLINK

At the bottom of LTE Downlink structure basically all radio frames are shown. A full frame is generally of 10 ms but it is in terms of the 1-ms subframe, that is the entity that contains the transport block. Within the transport block their is MAC header
and any extra space (padding). Inside that we have RLC header, then inside the RLC header we have number of PDCPs. There is a somewhat contrast relationship between the IP packets coming inside, which forms the SDUs and how the RLC PDUs are then formed. Therefore we can make the most effective use of radio resources in a fixed period of time.

Fig. 3. Time Domain View Of LTE

Stacks are generally shown graphically alongwith the higher layers, so the downlink flow will progress upward through the stack in Figure. Start delivering a transport block from the physical layer into the MAC— which basically contain the information which was decoded off the air in the previous radio sub-frame. There is contrast relationship between the transport block and the actual packets sent to higher layers. The transport block, transferred from the PHY to the MAC, will contain data from the older radio sub-frame. This can have multiple or partial packets, which depends on scheduling and modulation.

A. MAC LAYER

The MAC, is basically responsible in order to manage the hybrid ARQ function, that is a transport-block level automatic retry. This also performs the transport just like logical mapping—its function is to break down different logical channels from the transport block for the higher layers. Format selection and different measurements will be providing information of the network required for management of the complete network.

B. HYBRID ARQ

1) The Hybrid Automatic Repeat-reQuest (HARQ) process, is basically done in between the MAC and the PHY, that will retransmit transport blocks (TBs). The PHY layer will perform the retention and recombination (incremental redundancy) and the MAC layer will perform the management and signalling.[5] The MAC layer will indicate a NACK when we have transport block CRC failure; the PHY layer will define that failure. Retransmission can be done by the eNodeB. This coding is sent and balanced between buffers in the eNodeB. After many attempts, there is large amount of data for reconstructing the signal. In HARQ operation, the retransmission is not necessary to be correct. It has to be correct inorder to combine mathematically with the previous transport block for generating good transport block. This is the most important way of providing this ARQ function. It will operate at the transport block level, there is different ARQ process mechanism which operates at the RLC. These are the basic steps of the HARQ process:

- MAC sends “NACK” message when TB fails CRC
- Transport blocks alongwith errors are to be retained
- PHY will be retransmitting with different puncturing code
- Retransmission is also combined with saved transport block(s)
- When correct transport block is being decoded, MAC signals “ACK”
- Multiple HARQ processes will be running in parallel to retry several outstanding TBs.

Fig. 4. Downlink Flow

Fig. 5. Simplified HARQ Operation
C. MAC DOWNLINK MAPPING

When a valid transport block is provided from the HARQ process, the transport channels will be mapped to logical channels.[6] Figure shows the physical layer control channel that is at the bottom of the picture; working up, it will terminate in the MAC layer. This is used for scheduling, signaling and other low-level functions. The downlink shared channel has both a transport channel for paging and for downlink.

![Layer Architecture Downlink Flow](image)

Transport channels are using different modulations and coding techniques. Paging and broadcast channels should be received everywhere in the cell. The DL-SCH is basically optimized by the UE. Figure illustrates the following logical channels:

- **Dedicated Traffic Channel (DTCH):** A point-to-point channel, which is connected to one UE, for the transferring user information. A DTCH is existing in both uplink and downlink.
- **Broadcast Control Channel (BCCH):** A downlink channel is used for broadcasting system control information.
- **Paging Control Channel (PCCH):** A downlink channel is going to transfer paging information. This channel is generally used when the network does not have information for the location of cell.
- **Common Control Channel (CCCH):** Uplink channel is used for transmitting control information between UEs and network.
- **Dedicated Control Channel (DCCH):** A point-to-point bi-directional channel is going to transmit dedicated control information between a UE and the network.

![Concatenation Process](image)

D. RANDOM ACCESS PROCEDURE

The RACH procedure is used in four cases:
• Initial access is from (RRC_IDLE) state or radio failure
• Handover requires random access procedure
• DL or UL data arrives during RRC_CONNECTED after UL PHY that has already lost synchronization (possibly due to power save operation)
• UL data will arrive when there is no dedicated scheduling request (PUCCH) channels which is available. Timing is very critical as the UE can move to different distances from the different base stations, and LTE will require micro second level precision; the speed-of-light propagation delay singly will cause large change for causing a collision or a timing problem if this is not maintained. There are two forms of the RACH procedure: Contention-based, that can apply to all four events and non contention based, will apply to only handover and DL data arrival.

VII. CONCLUSION

The main aim of LTE is that the LTE network, like different cellular systems, is basically designed for operating in scarce and valuable licensed spectrum. This means that this is highly optimized and a lot of complexity is required for the highest possible efficiency. When the standards have to be chosen between efficiency and simplicity, they are going to choose efficiency to make the best use of this spectrum. LTE will use time on the downlink for conveying data; the downlink PHY is fully scheduled so that there are no gaps left due to contention. The downlink is going to carry multiple logical channels over a single link, so a large amount of information is multiplexed inside one transport block.

REFERENCES