ABSTRACT

In this review paper states that there is a rapid advancement in wireless communication technology providing the network services anywhere and anytime. 4G communication systems are being developed to solve the various problems the current communication systems (3G, 2.5G) are facing. 4G will be an intelligent technology that will reduce the number of different technologies to a single global standard. Based on the study, 4G mobile technologies is in a determining and Standardization stage. Since 4G is still in the cloud of the sensible standards creation, ITU and IEEE form several task forces to work on the possible completion for the 4G mobile standards as well. 3GPP LTE is an Evolution standard from UMTS, and WiMAX is another candidate from IEEE form. These technologies have different characteristics and try to meet 4G characteristics to become a leading technology in the future market. Under these circumstances, this paper will present about the current trends and its underlying technologies to implement the 4G mobile technology. This paper also shows some of the possible scenarios that will benefit the 4th generation technology.

Recently, we have witnessed the roll out of LTE (Long Term Evolution, or so called 4G) services from major US telcos, such as VERIZON, AT&T, T-Mobile, etc. These broadband wireless services claim to surpass current 3G cellular networks, paving the way to true wide area mobility, multimedia services while on-the-go and greater interactivity. In this white paper, we present the technical aspects of Long Term Evolution, its architecture, and its differences with earlier 3G systems.

Keywords: UTRAN (Universal Terrestrial Radio Access Network), GERAN (GSM EDGE Radio Access Network), UMTS (Universal Mobile Telecommunications System), EPS (Evolved Packet System), HSPA (High Speed Packet Access), EDGE (Enhanced Data rates for GSM Evolution).
1. INTRODUCTION

In telecommunication systems, 4G is the fourth generation of mobile phone mobile communication technology standards. It is a successor to the third generation (3G) standards. A 4G system provides mobile ultra-broadband Internet access, for example to laptops with USB wireless modems, to smart phones, and to other mobile devices. Conceivable applications include amended mobile access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

Two 4G candidate systems are commercially deployed: the Mobile WiMAX standard (first used in South Korea in 2006), and the first-release Long Term Evolution (LTE) standard (in Oslo, Norway and Stockholm, Sweden since 2009). It has however been debated if these first-release versions should be considered to be 4G or not, as discussed in the technical definition section below.

In the United States, Sprint (previously Clear wire) has deployed Mobile WiMAX networks since 2008, and MetroPCS was the first operator to offer LTE service in 2010. USB wireless modems have been available since the start, while WiMAX Smartphone’s have been available since 2010 and LTE Smartphone’s since 2011. Equipment made for different continents is not always compatible, because of different frequency bands. Mobile WiMAX is currently (April 2012) not available for the European market.

2. LITERATURE REVIEW

The author Phond Phunchongharn, Ekram Hossain, And Dong IN Kim have proposed that the Long Term Evolution-Advanced (LTE-Advanced) networks are being developed to provide mobile broadband services for the fourth generation (4G) cellular wireless systems. Device-to-device (D2D) communications is a promising technique to provide wireless peer-to-peer services and enhance spectrum utilization in the LTE-Advanced networks. In D2D communications, the user equipments (UEs) are allowed to directly communicate between each other by reusing the cellular resources rather than using uplink and downlink resources in the cellular mode when communicating via the base station. However, enabling D2D communications in a cellular network poses two major challenges. First, the interference caused to the cellular users By D2D devices could critically affect the performances of the cellular devices. Second, the minimum quality-of-service (QoS) requirements of D2D communications need to be guaranteed.

The author Shaohui Sun, Qiubin Gao, Ying Peng, Yingmin Wang, and Ling yang Song have proposed that Intercell interference management has become a critical issue for future cellular mobile systems. Coordinated multipoint transmission/reception, or Comp, is an effective way of managing intercell interference, and has been regarded as a key technology of LTE-Advanced. This article first provides an overview of downlink CoMP (co-ordinated multipoint) techniques specified in 3GPP LTE Rel-11, which mainly focuses on transmission schemes, channel state information reporting, interference measurement, and reference signal design. Then uplink CoMP is discussed in brief as most of the coordination gain can be achieved by implementation with little standardization support. Evaluation results are provided to show the efficiency of CoMP. The challenges as well as possible solutions for future CoMP standardization are also discussed.

The author Junfeng Xiao, Rose Qingyang Hu, Yi Qian, Lei Gong and Bo Wang have proposed that aims to provide abundant new spectrum opportunities by exploiting underutilized or unutilized spectrum opportunistically. In this article, we discuss the technical solutions to expand LTE spectrum with CR (cognitive radio) technology (LTE-CR), and survey the advancements in LTE-CR from both research and implementation aspects. We present detailed key technologies that enable LTE-CR in the TV white space (TVWS); and related standards and regulatory progress. To demonstrate the feasibility of deploying LTE-CR in TVWS, we have conducted extensive system level simulations and also developed a LTE-CR prototype. Both simulation and laboratory testing results show that applying LTE-CR in TVWS can achieve satisfactory performance.

The author Yun Rui, Peng Cheng, MingQi Li, Q.T. Zhang, Mohsen Guizani have proposed that Multiple access and transmission enhancement in support of carrier aggregation techniques has been actively studied in the 3GPP LTE-Advanced standardization process of the next generation mobile broadband communication systems. By means of carrier aggregation, users can access a total bandwidth of up to 100 MHz in order to meet the IMT-Advanced requirements. This article first introduces and compares several uplink multiple access schemes in LTE-Advanced standard. Technical challenges arising from the use of carrier aggregation is then addressed, with focus on reference signals design for uplink transmission. Meanwhile, various candidate options are summarized and compared in terms of their system performance, computational complexity, and design flexibility. The article further proceeds to investigate the link performance with carrier aggregation, taking into account the presence of frequency offset and fast fading in the uplink channel. Numerical results are also presented, which indicate that advanced signal processing algorithms should be further studied and optimized to ensure reliable operation of the 3GPP LTE-Advanced in high mobility.

The author Beatriz Soret and Hua Wang, Klaus I. Pedersen and Claudio Rosa have proposed that two promising practicable cases for simple multicell cooperation for LTE-Advanced heterogeneous network scenarios with macro and small cells. For co-channel deployment cases, we recommend the use of enhanced interference coordination, to mitigate cross-tier interference and ensure sufficient offload of users from macro to small cells. It is shown how it benefit is
maximized by using a distributed inter-base station control framework for dynamic adjustment of essential parameters. Second, for scenarios where macro and small cells are deployed at different carriers an efficient use of the fragmented spectrum can be achieved by using collaborative Inter-site carrier aggregation. In addition to distributed coordination/collaboration between base station nodes, the importance of explicit terminal assistance is highlighted. Comprehensive system-level simulation results illustrate the performance benefits of the presented techniques.

3. LTE Evolution

Long Term Evolution (LTE) is a radio platform technology that will allow operators to achieve even higher peak throughputs than HSPA+ in higher spectrum bandwidth. Work on LTE began at 3GPP in 2004, with an official LTE work item started in 2006 and a completed 3GPP Release 8 specification in March 2009. Initial deployments of LTE began in late 2009.

LTE is part of the GSM evolutionary path for mobile broadband, following EDGE, UMTS, HSPA (HSDPA and HSUPA combined) and HSPA Evolution (HSPA+). Although HSPA and its evolution are strongly positioned to be the dominant mobile data technology for the next decade, the 3GPP family of standards must evolve toward the future. HSPA+ will provide the stepping-stone to LTE for many operators.

The overall objective for LTE is to provide an extremely high performance radio-access technology that offers full vehicular speed mobility and that can readily coexist with HSPA and earlier networks. Because of scalable bandwidth, operators will be able to easily migrate their networks and users from HSPA to LTE over time.

LTE assumes a full Internet Protocol (IP) network architecture and is designed to support voice in the packet domain. It incorporates top-of-the-line radio techniques to achieve performance levels beyond what will be practical with CDMA approaches, particularly in larger channel bandwidths. However, in the same way that 3G coexists with second generation (2G) systems in integrated networks, LTE systems will coexist with 3G and 2G systems. Multimode devices will function across LTE/3G or even LTE/3G/2G, depending on market circumstances.

![Figure 1: LTE EVOLUTION](image)

Standards development for LTE continued with 3GPP Release 9 (Rel-9), which was functionally frozen in December 2009. 3GPP Rel-9 focuses on enhancements to HSPA+ and LTE while Rel-10 focuses on the next generation of LTE for the International Telecommunication Union’s (ITU) IMT-Advanced requirements and both were developed nearly simultaneously by 3GPP standards working groups. Several milestones have been achieved by vendors in recent years for both Rel-9 and Rel-10. Most significant was the final ratification by the ITU of LTE-Advanced (Rel-10) as IMT-Advanced in November 2010. The first commercial LTE networks were launched by TeliaSonera in Norway and Sweden in December 2009; as of November 2012, there were 117 commercial LTE networks in various stages of commercial service. Many trials are underway with up to 130 LTE deployments expected in 2012.

LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) on the downlink, which is well suited to achieve high peak data rates in high spectrum bandwidth. WCDMA radio technology is, essentially, as efficient as Orthogonal Frequency Division Multiplexing (OFDM) for delivering peak data rates of about 10 Mbps in 5 MHz of bandwidth. Achieving peak rates in the 100 Mbps range with wider radio channels, however, would result in highly complex terminals and is not practical with current technology. This is where OFDM provides a practical implementation advantage. The OFDMA approach is also highly flexible in channelization, and LTE will operate in various radio channel sizes ranging from 1.4 to 20MHz. LTE also boosts spectral efficiency. On the uplink, however, a pure OFDMA approach results in high Peak to Average Ratio (PAR) of the signal, which compromises power efficiency and, ultimately, battery life. Hence, LTE uses an approach for the uplink called Single Carrier FDMA (SC-FDMA), which is somewhat similar to OFDMA, but has a 2 to 6dB PAR advantage over the OFDMA method used by other technologies such as WiMAX IEEE 802.16e.
LTE capabilities include:

- Downlink peak data rates up to 326 Mbps with 20 MHz bandwidth
- Uplink peak data rates up to 86.4 Mbps with 20 MHz bandwidth
- Operation in both TDD and FDD modes
- Scalable bandwidth up to 20 MHz, covering 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz in the study phase
- Increased spectral efficiency over Release 6 HSPA by two to four times
- Reduced latency, up to 10 milliseconds (ms) round-trip times between user equipment and the base station, and to less than 100 ms transition times from inactive to active.

i) LTE is an all-IP based Network: It supports both IPv4 and IPv6. LTE is different from 3G by these aspects:
   - Use of OFDM technology
   - Use of MIMO technology
   - A new System Architecture Evolution (SAE)

ii) LTE Advance Radio Technology: Use of MIMO, OFDM, SIMO, TDD, FDD, Channel Coding and GSA. Downlink is OFDMA (Orthogonal Frequency Division Multiple Access), uplink is SC-FDMA (Single Carrier-Frequency Division Multiple Access) or also known as DFTS-OFDM. Advanced antenna solutions provide more signal diversity, beam-forming capability and multi-layer transmissions (through MIMO). There is considerable flexibility in the use of spectrum for LTE. LTE can work on new and existing bands and over FDD and TDD. In terms of link adaptation, LTE can use QPSK, 16QAM or 64QAM modulation schemes and it performs channel coding to provide robustness against poor channel conditions (i.e., build redundancy into the bits). The 15 KHz tones provide a long symbol time, resulting in robustness against multipath propagation and time dispersion issues. MIMO provides transmit diversity, receive diversity, and spatial multiplexing characteristics. These greatly boost transmission performance. European operators will use 2.6GHz band. Reusing GSM bands for LTE is possible. LTE can be used in both TDD and FDD modes. LTE provides flexible channel bandwidth: the smallest being 1.4MHz, followed by 3, 5, 10, 15, and 20 MHz.

iii) LTE SAE (System Architecture Evolution): SAE essentially moves some of the core network functions to the edge (periphery) to achieve a “flatter” network and lower latency. SAE provides different advantages over 3G architectures, such as: (a) improved data capacity, (b) all-IP architectures, (c) reduced latency, and (d) reduced operation and capital costs. SAE uses a common gateway node, an all IP based system (with IP-based protocols), an MME (mobility management entity) and a radio access network and core network functional split. The main element of LTE SAW is the EPC (Evolved Packet Core). The EPC connects to several eNodeBs.

Within the EPC, there are 4 elements. MME handles intra-LTE handoffs, bearer activation and de-activation, and interacts with HSS to authenticate user. Hence, MME provides control plane functionality. The SGW (Serving Gateway) is a data plane element for the managing of user plane mobility and acts as the gateway between RAN (Radio Access Network) and the Core Network. When mobile station move across areas served by different eNodeBs, the SGW serves as the anchor point, ensure continuity of data path. The third element is the PGW (PDN Gateway) which provides connectivity to the mobile station to external PDN (Packet Data Networks). The PCRF (Policy & Charging Rules Function) detects service flow, and enforces charging policy.
Compared to the 3G UMTS / WCDMA with UTRAN, in LTE SAE, the RNC (Radio Network Controller) and radio resource management is moved to the base stations. Such base stations are also called the eNodeB or eNB. eNB are connected to the core network gateway via a S1 interface while eNBs can be connected to other eNBs in a mesh manner via an X2 interface. This rich interconnection provides faster handoff of connections during roaming by mobile stations. The radio resource control handled by the eNB includes: (a) admissions control, (b) load balancing, and (c) mobility control (handoff decisions).

### 3.1 FEATURES OF LTE

- **Voice over LTE (VoLTE):** Mobile operators receive over 80% of their revenues from SMS and voice traffic, which implies that operators want LTE to support Voice differently than just using VoIP. VoLTE utilizes IMS (IP Multimedia Subsystem). VoLTE was developed by a collaboration of over 40 operators, including Verizon, AT&T, Nokia, and Alcatel-Lucent. VoLTE is an IMS-based specification. 3 new signalling interfaces are defined in VoLTE: (a) UNI, (b) Roaming R-NNI, and (c) Interconnection I-NNI.

- **LTE Security:** SIM is one of the key elements of GSM security. The SIM allows one to keep the identity of the subscriber in an encrypted manner. In LTE, UMTS Subscriber Identity Module was introduced (USIM) which has similar functionality as the GSM SIM.

### 3.2 4G LTE SPECIFICATION

4G LTE = IMT-A = LTE-A: Is the new 4G technology. As shown in the table below, LTE-A can provide as much as 10x the speed (both uplink and downlink) of LTE. In addition, latency is also lower.

<table>
<thead>
<tr>
<th></th>
<th>WCDMA (UMTS)</th>
<th>HSPA HSDPA / HSUPA</th>
<th>HSPA+</th>
<th>LTE</th>
<th>LTE ADVANCED (IMT ADVANCED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max downlink speed bps</td>
<td>384 k</td>
<td>14 M</td>
<td>28 M</td>
<td>100M</td>
<td>1G</td>
</tr>
<tr>
<td>Max uplink speed bps</td>
<td>120 k</td>
<td>5.7 M</td>
<td>11 M</td>
<td>50 M</td>
<td>500 M</td>
</tr>
<tr>
<td>Latency round trip time approx</td>
<td>150 ms</td>
<td>100 ms</td>
<td>50ms (max)</td>
<td>~10 ms</td>
<td>less than 5 ms</td>
</tr>
<tr>
<td>3GPP releases</td>
<td>Rel 9/4</td>
<td>Rel 5 / 6</td>
<td>Rel 7</td>
<td>Rel 8</td>
<td>Rel 10</td>
</tr>
<tr>
<td>Approx years of initial roll out</td>
<td>2003 / 4</td>
<td>2005 / 6 HSDPA 2007 / 8 HSUPA</td>
<td>2008 / 9</td>
<td>2009 / 10</td>
<td></td>
</tr>
<tr>
<td>Access methodology</td>
<td>CDMA</td>
<td>CDMA</td>
<td>CDMA</td>
<td>OFDMA / SC-FDMA</td>
<td>OFDMA / SC-FDMA</td>
</tr>
</tbody>
</table>

WiMax is the other alternative to LTE-A, but WiMax is less appealing compared to LTE-A. LTE-A will use OFDMA and MIMO technologies, with more antenna additions. LTE-A utilizes carrier aggregation technique to boost transmission capacity. IMT-A sets the maximum channel bandwidth as 100MHz.
**LTE-CoMP:** LTE-A includes LTE-CoMP (co-ordinated multipoint) which turns inter-cell interference into useful signal. LTE-CoMP refers to the dynamic coordination of transmission and reception among different base station.

![Diagram of LTE-CoMP](image)

**Figure 4:** LTE-CoMP allows multiple eNBs coordination

LTE-CoMP allows the mobile at the edge of a cell to be served by 2 or more eNBs to improve signal transmission and reception thereby increasing throughput especially under cell edge situations. Intelligence is added to LTE-CoMP such that multiple simultaneous transmission of user data from multiple eNBs to a single mobile station and the dynamic cell selection with data transmission from a single eNB.

**LTE-A Relaying:** Its purpose is to enhance wireless coverage and capacity. One of the hard issues is dealing with poor signal conditions at cell edges. LTE relays actually demodulate and decode the received signal, apply any necessary error correction and then retransmit an entirely new signal. This "relay" provides a clean signal to be propagated out again. A mobile station actually talks to the relay node, which in turn communicates with an eNB, hence the term "relay". Relay nodes are fixed elements, they do not move unlike the mobile station.

### 3.3 LTE architecture

![Diagram of LTE Architecture](image)

**Figure 5:** LTE Architecture
4. RESULT OF SIMULATION

Figure 4.1: Plots resulting from running the LTE

Figure 4.2: Plots resulting from running the LTE-A

5. CONCLUSION AND FUTURE SCOPE

The adoption, deployment, and usage of 4G LTE technologies are now in full swing. Major telecoms operators are offering such services. Consumers have readily jumped the queue to acquire 4G phones and services. The provision of high speed and low latency features will certainly empower smart-phone and mobile-device users to run sophisticated applications (Social networks, maps, banking, search, etc.) In addition to our normal voice calls, SMS and MMS. The top 8 wireless carriers in USA are: Verizon, AT&T, Sprint Nextel, T-Mobile, Clear wire, MetroPCS, US Cellular, and Leap Wireless.
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