# 4GWireless Networks: Opportunities and challenges

**Sudhir kumar, Ajay Kumar Yadav**

***Abstract*— Mobile communication is developing very rapidly with passage of time, new technologies are being introduced to facilitate the mobile users more from the technology. The past technologies are replaced by new ones and needs are growing for the new technologies to be developed.**

**One such development is fourth generation networks. Also called future generation or Next Generation Networks. The introduction of 4G has widened the scope of mobile communication. Now mobile is not only a device used for talking but its more or less a portable computer that can serve different purposes. 4G offers higher data rates with seamless roaming. The mobile user can communicate without any disturbance while switching his coverage network.**

**4G is still passing through research and therefore there are some problems that need to be fixed in order to benefit the users from it fully. In this report we discuss various challenges 4G is facing and solutions to those problems are discussed. We propose our own way of improving QoS in 4G by using combination of mobility protocol SMIP and SIP. We propose that by using such scheme we can achieve better QoS during the process of handover.**

***Index Terms*— 4G Wireless Networks, mobile communication, QoS, SMIP, SIP.**

## I. INTRODUCTION

Over the years, there have been consistent improvements in the design of cellular networks. The advancement is necessary in order to cope with increasing number of users, increasing level of traffic (voice, data, etc.,), and increasing level of sophisticated but useful applications on mobile devices. The quest for higher bandwidth, faster connection times, and seamless handoffs, a scalable solution prompted engineers to seek better solutions. Various standardization organizations have taken efforts to work on specific agenda, providing an open forum for ideas, contributions, and convergence to agreed technical specifications. The ITU, IEEE, 3GPP, WWRF, etc., held regular meetings to address these issues and they are mostly well attended by key industry players.

Conventionally, we see the cellular network as **a 3-layer system**, comprising the **core**, the **edge**, and the **access** subsystems. The **core** is the heart of the network system. Essentially, it is the high end switch or a collection of such switches where perform very fast high speed switching, handoffs, and also perform the necessary signaling, traffic control and management, and interaction with essential databases (such as location, AAA, etc). Hence, the core subsystem is mostly controlled and policed by the telecoms. Core subsystems contain the intelligence concerning traffic utilization, users' profile, systems up and down time, etc. To provide round-the-clock services, telecoms monitor the core subsystem daily and regularly gather statistics for performance evaluation and improvement purposes.

The **edge subsystem** (also commonly known as the edge node) consists of a node that specifically acts as the interface between the core subsystem and the access subsystem. The edge node has a wired connection to the core node and a wired connection to the access node.

It is called the edge because it is the node furthest away from the core (wired network) and closest to the access (wireless part) node.

The **access subsystem** (also commonly known as the access node or base station or radio station) consists of a node that specifically acts as an interface between the wired networks (via the edge node) and the wireless networks. It has an interface that provides wireless coverage and connectivity (depending on the radio technologies used) to mobile terminals within its coverage range. Access nodes support both uplink and downlink communications and such communications may be asymmetric in nature. Multiplexing techniques are frequently used to support multiple users within a wireless cell. Advanced modulation and equalization techniques help to boost data rates, increase reliability, and improved on error control. Access nodes can also provide security features to ensure that only legitimate users can access the code network. Access nodes are scattered about an area to provide sufficient air coverage, with overlapping cells. Overlapping cells are needed to ensure smooth handoffs of mobile calls as the users migrate from one location to another. Hence, access subsystem fulfills the role of fixed and mobile convergence.

**LTE Evolution:** 3GPP Release 10 is higher peak rates and provision of relaying solutions. Higher data rates are further achieved through carrier aggregation, spectrum aggregation and additional antennas (up to 8 antennas downlink, 4 antennas uplink), achieving 3Gbps peak data rate uplink and 1.5Gbps downlink.

**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)

**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 (ie., build redundancy into the bits). The 15KHz tones provide a long symbol time, resulting in

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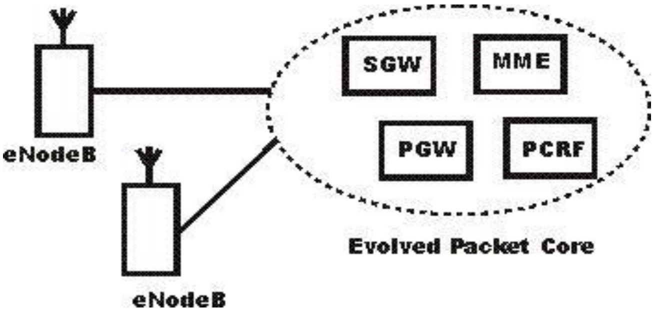
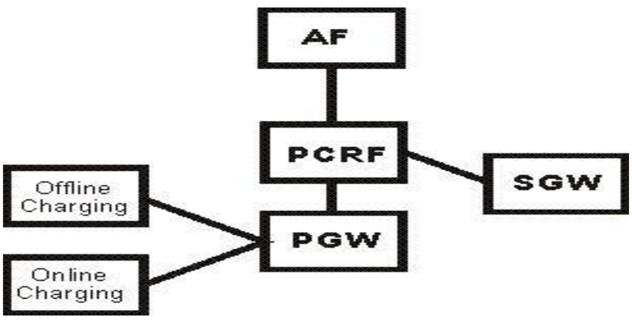
robustness against multipath propagation and time dispersion issues. MIMO provides transmit diversity, receive diversity, and spatial multiplexing characteristics. These greatly boost transmission performance. European
operators will use 2.6GHz band. Reusing GSM bands for LTE is possible. LTE can be 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.

**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, all-IP based systems (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 magaing 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).

**3G LTE Specification:** Earlier LTE specifications are shown in the table below. Different modulation schemes can be used and mobility rate can be as high as vehicular speeds.

| PARAMETER | DETAILS |
|---|---|
| Peak downlink speed 64QAM (Mbps) | 100 (SISO), 172 (2x2 MIMO), 326 (4x4 MIMO) |
| Peak uplink speeds (Mbps) | 50 (QPSK), 57 (16QAM), 86 (64QAM) |
| Data type | All packet switched data (voice and data). No circuit switched. |
| Channel bandwidths (MHz) | 1.4, 3, 5, 10, 15, 20 |
| Duplex schemes | FDD and TDD |
| Mobility | 0 - 15 km/h (optimised),<br>15 - 120 km/h (high performance) |
| Latency | Idle to active less than 100ms<br>Small packets ~10 ms |
| Spectral efficiency | Downlink: 3 - 4 times Rel 6 HSDPA<br>Uplink: 2 -3 x Rel 6 HSUPA |
| Access schemes | OFDMA (Downlink)<br>SC-FDMA (Uplink) |
| Modulation types supported | QPSK, 16QAM, 64QAM (Uplink and downlink) |

**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 signaling 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.

**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.

| | WCDMA (UMTS) | HSPA HSDPA / HSUPA | HSPA+ | LTE | LTE ADVANCED (IMT ADVANCED) |
|---|---|---|---|---|---|
| Max downlink speed bps | 384 k | 14 M | 28 M | 100M | 1G |
| Max uplink speed bps | 128 k | 5.7 M | 11 M | 50 M | 500 M |
| Latency round trip time approx | 150 ms | 100 ms | 50ms (max) | ~10 ms | less than 5 ms |
| 3GPP releases | Rel 99/4 | Rel 5 / 6 | Rel 7 | Rel 8 | Rel 10 |
| Approx years of initial roll out | 2003 / 4 | 2005 / 6 HSDPA<br>2007 / 8 HSUPA | 2008 / 9 | 2009 / 10 | |
| Access methodology | CDMA | CDMA | CDMA | OFDMA / SC-FDMA | OFDMA / SC-FDMA |

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 stations.

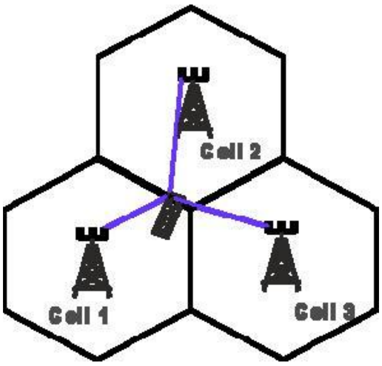



Figure: LTE-CoMP allows multiple eNBs coordination

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 eBN.

**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.

**4G LTE Coverage & Services:** We will now look at the 4G LTE providers in the USA, i.e., VERIZON and AT&T. Verizon claims that its' 4G LTE coverage include over 175 cities and supports over 186 million users in the USA. Verizon identifies several applications of 4G LTE, such as transportation, emergencies, distribution, health care, utility industries, construction sector, financial services, manufacturing, etc. For mobile broadband devices, Verizon charges $30/month for 2GB. Verizon LTE smart phones operate at the LTE 700 MHz band, with CDMA 1xEVDO/3G at 800 and 1900 MHz band.

most 4G markets are targeted at the east coast of USA, in particular, major cities where population concentration is important. Also, Verizon 3G coverage has been predominantly covering the whole of USA, with the exception of some rural areas.

## II. NEW CHALLENGES

### *Security and Privacy*

In the development of 4G Networks, security measures must be established that enable data transmission to be as safe as possible. Specifically, "The 4G core addresses mobility, security, and QoS through reuse of existing mechanisms while still trying to work on some mobility and handover issues" [3]. Therefore, it is necessary for the organization to develop an effective series of tools that support maximum 4G security measures as a means of protecting data that is transmitted across the network from hackers and other security violations. Because of the nature of the 4G network, there is an increased likelihood of security attacks, and therefore, multiple levels of security, including increased requirements for authentication, will be necessary to protect data and information that is transmitted across the network [3].

One of the main goals of G4 networks is to blanket very wide geographic area with seamless service. Obviously, smaller local area networks will run different operating systems. The heterogeneity of these wireless networks exchanging different types of data complicates the security and privacy issues. Furthermore, the encryption and decryption methods being used for 3G networks are not appropriate for 4G networks as new devices and services are introduced for the first time in 4G networks. To overcome these security and privacy issues, two approaches can be followed. The first is to modify the existing security and privacy methods so that they will be applicable to heterogeneous 4G networks. Another approach is to develop new dynamic reconfigurable, adaptive, and lightweight mechanisms whenever the currently utilized methods cannot be adapted to 4G networks [14].

### *Quality of Service*

With respect to network quality, many telecommunications providers are promising that there will be enhanced connectivity, and the quality of data that is transmitted across the network will be of the highest possible quality, as in the case of Ericsson's 4G Network for TeliaSonera [7]. The company promises that "The new 4G network will do for broadband what mobile telephony did for voice. With real-time performance, and about 10 times higher data rates compared to today's mobile broadband networks, consumers can always be connected, even on the move" [7]. As a result, it is important for providers to develop an effective approach to the 4G Network that will enhance quality, provide effective security measures, and will ensure that all users are provided with extensive alternatives for downloading video, music, and picture files without delays.

The main challenge that 4G networks are facing is integrating non-IP-based and IP-based devices. It is known that devices that are not IP address based are generally used for services such as VoIP. On the other hand, devices that are IP address based are used for data delivery. 4G networks will serve both types of devices. Consequently, integrating the mechanisms of providing services to both non-IP-based as well as IP-based devices is one of key challenges 4G networks have to address [17, 19].

## III. Complex Architecture

### *1.Multimode End-User Terminals*

To reduce operating costs, devices that operate on 4G networks should have the capability to operate in different networks. This will not only reduce the operating cost but will also simplify design problems and will reduce power consumption. However, accessing different mobile and wireless networks simultaneously is one of the major issues 4G networks have been addressing. One mechanism that has been proposed to handle this problem is termed "multi-mode devices". This mechanism can be achieved through a software radio that allows the end-user device to adapt itself to various wireless interfaces of the networks. Figure 2 shows an example of such solution.

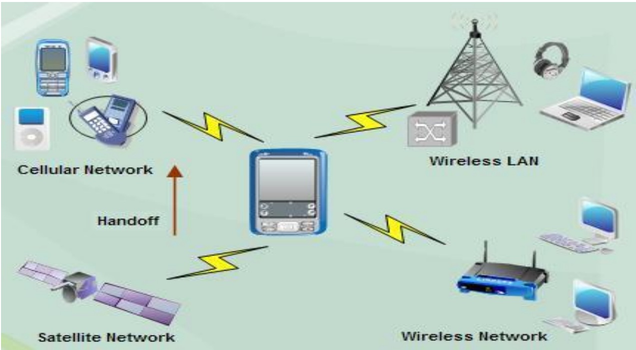



**Figure :** Accessing multiple networks and services through multi-mode software

### *2-System Discovery and Selection*

Due to the heterogeneity of 4G networks, wireless devices have to process signals sent from different systems, discover available services, and connect to appropriate service providers. Various service providers have their own protocols which can be incompatible with each other as well as with the user's device. This issue may complicate the process of selecting the most appropriate technology based on the time, place and service provided, and thus, may affect the Quality of service provided to the end user.

One solution to resolve this issue is called "System-initiated discoveries". This mechanism allows automatic download of software modules based on the wireless system the user is connected to [12]. Another approach to handle this problem is based overlay networks. In such case, the end-user device is connected to different networks through an overlay network. The overlay network performs all necessary tasks such as protocol translation and Quality of service negotiation as depicted in Figure 3.

### *3.Service and Billing*

Managing user accounts and billing them has become much more complicated with 4G networks. This is mainly due to heterogeneity of 4G networks and the frequent interaction of service providers. The research community addressed this concern and proposed several frameworks to handle the customers' billing and user account information [8, 9].

## IV. Conclusion

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, Metro PCS, US Cellular, and Leap Wireless.

4G wireless networks not only enable more efficient, scalable, and reliable wireless services but also provides wider variety of services. These opportunities come with a need for rethinking our security, privacy, architect and billing technologies have been used for previous generations. We believe, however, that future research will overcome these challenges and integrate newly developed services to 4G networks.

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