Future and Challenges of 4G Wireless Technology

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Abstract-—The next stage of progression in wireless communications, after 2G and 3G,i.e the Fourth Generation wireless network consists of the new technologies with all IP based, high data rate services providing internet access anytime , anywhere, with higher bandwidth, better visual technologies and wider hold for multimedia applications. The 4G network technologies ensure high speed accessibility through any wireless device by integrating non IP based and IP based devices. This paper presents the 4G network technologies and services as a whole that the industry is confronting and eventually, unfurling some of the projected suggestions. The paper enunciates the thriving prospects of 4G ahead with technologies such as LTE, LTE Advanced, MIMO, WiMAX, WiMAX2.0 etc.

This paper describes how 4G is easy to deploy and thus, cost effective as well. The idea of multimode software for maintaining different networks simultaneously is explained, along with the mechanisms of system initiated discoveries. Also, the challenge of managing user accounts is discussed. The paper describes the concept of security that should be given heed. This paper explores what 4G network technology actually is , along with some of the propositions in order to fully figure out the advantages and challenges of effectively implementing 4G.

Index Terms— 4G network technologies, LTE, LTE Advanced, MIMO, WiMAX, wireless network, WiMAX2.0

1. Introduction

Information technology along with the telecommunication, wireless communication industry has taken a great leap with the introduction of 4G technology in the new tech based scenario. After the much used 2G and 3G network technologies, the 4G technology consists of all the basic standards of both of these with advanced modifications and changes. 4G or most often called MAGIC (Mobile multimedia , Anytime anywhere, Global mobility support , integrated wireless solution and Customised personal service)
sounds very promising with better propositions for the internet access. According to the ITU, International Telecommunication Union, the 4G network technologies must be capable of transmitting a data speed of approximately 100Mbps in mobile phones and approximately 1Gbps in stationary local networks. Officially, 4G is named as Beyond3G or B3G by IEEE (Institute of Electrical and Electronics Engineers, USA). In the fourth-generation wireless system, cellular providers have the opportunity to offer data access to a variety of devices. The cellular network would become a data network on which cellular phones will be able operate — as well as any other data device. Sending data over the cell phone network is a productive business. The best example is augmentation of the Internet over the past few years

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2. Evolution of 4G : Background

The development and augmentation of 4G Networks and related technologies in today's scenario is imperative indicator of advancement in the field of wireless communication and technology. This progress started back from 1970s when the expertise just learnt how to crawl on the path of development with the evolution of basic first generation networks.

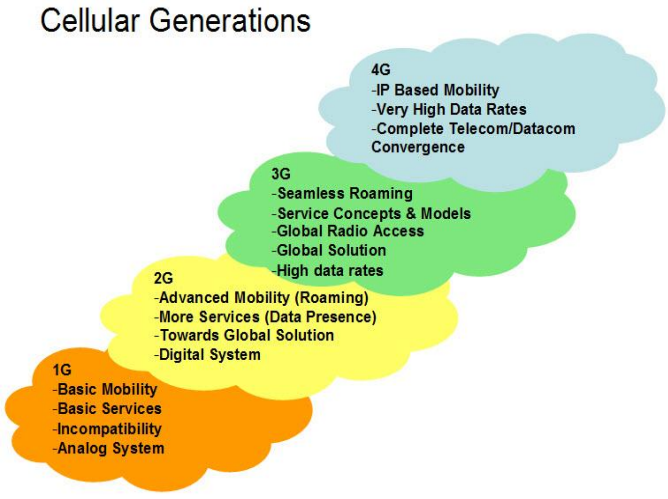

Fig1. Different Generations at a glance

1G or the first generation wireless networks were based on analog technology, designed in 1970s.This generation used the basic cellular structures and architectures for the purpose of mobile communications.

After the first step of 1G in the path of progress, the second step was of the 2G or second generation networks which marked a transformation from the analog technology

of 1G to the digital technology using digital signals. 2G networks made digital communications possible at low speeds with the introduction of GSM (Global Mobile System), TDMA, PDC (Personal Digital Cellular) and CDMA (Code Division Multiple Access).

Then came 2.5G and 3G in the 1990s with higher qualities of services and better communication speeds.2.5G acted as an interim between the 2G and the 3G services. After the facility of 3G of providing higher data rates for fulfilling the data demanding needs of users, the new leap in the telecommunication industry is that of 4G. The first operating 4G Network was established by Clearwire and Intel in Portland, Oregon in January 2009, marking the beginning of a new era. 4G has much promises and expectations to keep.

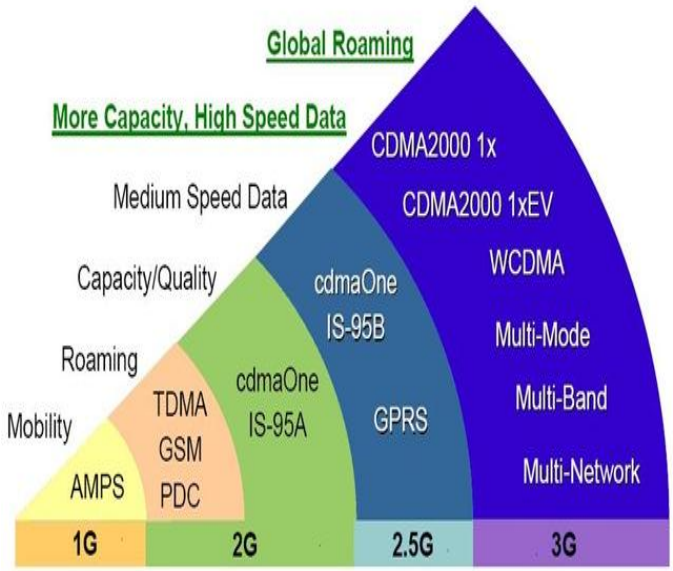

Fig2. WIRELESS GENERATIONS: progression

3. 4G TECHNOLOGIES AND FEATURES

The basic idea of 4G networks is to provide services to users based on an architecture which is packet based i.e. IP based. This means that each and every user connected to the internet anytime and anywhere must have a unique IP address.

ITU (International Telecommunication Union) has officially specified the data rates for 4G networks as 1Gbps for mobile networks and 1Mbps for stationary networks that meet the LTE and WiMAX *IMT*-Advanced compliant versions of technologies. 4G can be described in a nutshell as a integration of different advanced technologies to satisfy user demands. These technologies are discussed here elaborately in detail.

3.1 Open Wireless Architecture

The 4G Mobile communications will be based on the Open Wireless Architecture (OWA) to ensure the single terminal can seamlessly and automatically connect to the local high-speed wireless access systems when the users are in the offices, homes, airports or shopping centers where the wireless access networks (i.e. Wireless LAN, Broadband Wireless Access, Wireless Local Loop, HomeRF, Wireless ATM, etc) are available. When the users move to the mobile zone (i.e. Highway, Beach, Remote area, etc.), the same terminal can automatically switch to the wireless mobile networks (i.e. GPRS, W-CDMA, cdma2000,TD-SCDMA, etc.). Based on this OWA model, 4G mobile will deliver the best business cases to the wireless and mobile industries, i.e. cdma2000/WLAN/ GPRS 3-in-1 product, WCDMA/OFDM/ WLAN 3-in-1 product, etc. The converged wireless communications can provide the following advantages:

1. Greatly increase the spectrum efficiency
2. Mostly ensure the highest data-rate to the wireless terminal
3. Best share the network resources and channel utilization
4. Optimally manage the service quality and multimedia applications

With the appropriate combination of resources, it is possible for 4G Networks to create alternatives that exceed consumer and industry expectations. Therefore, 4G developers must consider the appropriate security measures, the promotion of high-speed data transmission across the network, and must also consider the ways in which data quality and integrity might be preserved in order to provide the most satisfactory results.

This 4G is intended to replace the current 3G systems within few years. The ambitious goal of 4G is to allow everyone to access the Internet anytime and everywhere. The provided connection to Internet will allow users to access all type of services including text, databases, and multimedia. 4G, unlike 3G, is IP based, that is every user connected to the Internet will have an IP address. This feature makes it easier to integrate the infrastructure of all current networks and consequently it will be easier for users to access services and applications regardless of the environment. 4G will also provide higher bandwidth, data rate, lower authentication overhead, and will ensure that the service is constantly provided to the user without any distruption.

Another key feature of 4G networks is high level of user-friendly customization. That is, each user can choose the preferred level of quality of service, radio environment, etc. Accessing 4G networks will be possible virtually by using any wireless device such as PDAs, cell phones, and laptops.

3.2 LTE-Long Term Evolution

It is one of the proposed technologies by ITU in order to feature as 4G. LTE, a radio platform technology, provides

higher bandwidths with better and faster data rates than HSPA+. LTE has a whole Internet Protocol (IP) network architecture's structure and is intended to support voice, favoring visual or voice blogs online. LTE consists of a net bit rate capacity of approximately 100 Mbit/s in the downlink and 50 Mbit/s in the uplink if a 20 MHz channel is used, theoretically. As LTE is based on the same technology of GSM, it is assumed that it will dominate the market in the coming future. The world's first available LTE-service was opened in Stockholm and Oslo on 14 December 2009, marking beginning of LTE in Scandinavia. LTE Advanced (Long-term-evolution Advanced), formally submitted by the 3GPP organization to ITU-T in the fall 2009, is a candidate for IMT-Advanced standard.

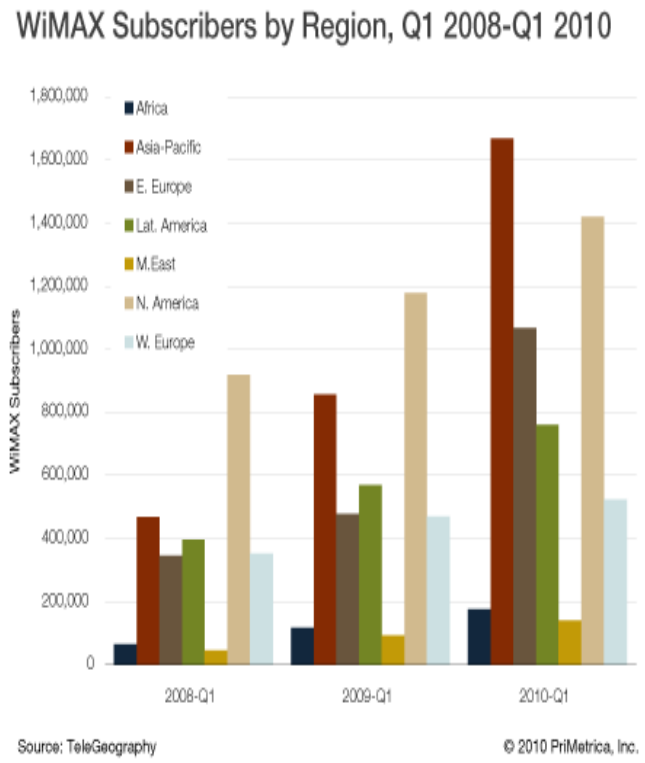

Fig3. WiMax Development

3.3 WiMAX

WiMAX, an acronym of "Worldwide Interoperability for Microwave Access, is an IP based, wireless broadband access technology which can be taken as a developed version of Wi-Fi. The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard.

The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL It provides maximum data rates of 128 Mbps downlink and 56 Mbps uplink over a 20 MHz wide channel. WiMAX is a wireless digital communications system, also known as IEEE 802.16. It is proposed for wireless MANs or Metropolitan Area Networks. WiMAX can provide broadband wireless access (BWA) up to 50 km for stationary sites and 5 - 15 km for mobile sites.

3.4 OFDMA

OFDMA or Orthogonal Frequency –division multiplexing which is also known as Discrete Multitone Modulation (DMT),is a modulation method for the modulation of a frequency channel based on the FDM(frequency division multiplexing) .In this technique, the frequencies and modulations of frequency division multiplexing are arranged orthogonally to each other to eliminate any interference between the channels. The main aim of OFDMA is to send the low rate modulations in a parallel stream rather than sending a high rate wave front, as low rate modulations are less sensitive to multipath. With OFDM technology already proved and embraced, 4G development will gain momentum.

3.5 TDMA

TDMA, or Time Division Multiple Access, is a technique for dividing the time domain up into sub channels for use by multiple devices. Each device gets a single time slot in a procession of devices on the network. During that particular time slot, one device is allowed to utilize the entire bandwidth of the spectrum, and every other device is in the quiescent state. The time is divided into frames in which each device on the network gets one time slot.

There are n time slots in each frame, one each for n devices on the network. In practice, every device gets a timeslot in every frame. One optimization that makes TDMA much more efficient is the addition of a registration period at the beginning of the frame. During this period, each device indicates how much data it has to send. Through this registration period, devices with nothing to send waste no time by having a timeslot allocated to them, and devices with lots of pending data can have extra time with which to send it. This is called ETDMA (Extended TDMA) and can increase the efficiency of TDMA to ten times the capacity of the original analog cellular phone network. The benefit of using TDMA with this optimization for network access comes when data is "bursty." That means, at an arbitrary time, it is not possible to predict the rate or amount of pending data from a particular host. This type of data is seen often in voice transmission, where the rate of speech, the volume of speech, and the amount of background noise are constantly varying.

Thus, for this type of data, very little capacity is wasted by excessive allocation.

3.6 CDMA

CDMA, or Code Division Multiple Access, allows every device in a cell to transmit over the entire bandwidth at all times. Each mobile device has a unique and orthogonal code that is used to encode and recover the signal (Leon-Garcia and Widjaja 2000). The mobile phone digitizes the voice data as it is received, and encodes the data with the unique code for that phone. This is accomplished by taking each bit of the signal and multiplying it by all bits in the unique code for the phone. Thus, one data bit is transformed into a sequence of bits of the same length as the code for the mobile phone. This makes it possible to combine with other signals on the same frequency range and still recover the original signal from an arbitrary mobile phone as long as the code for that phone is known.

Once encoded, the data is modulated for transmission over the bandwidth allocated for that transmission. CDMA has been patented in the United States by Qualcomm, making it more expensive to implement due to royalty fees. This has been a factor for cellular phone providers when choosing which system to implement. By keeping security in mind while designing the new system, the creators of 2G wireless were able to produce a usable system that is still in use today. Unfortunately, 2G technology is beginning to feel its age. Consumers now demand more features, which in turn require higher data rates than 2G can handle. A new system is needed that merges voice and data into the same digital stream, conserving bandwidth to enable fast data access.

3.7 IP Based Technology

An all IP-based 4G wireless technology has fundamental benefits over its forerunners like 2G and 3G. For beginners, IP is compatible with, and independent of, the actual radio access technology.Moreover,4G IP wireless network has a financial advantage over 3G as well, being cost effective. The fourth-generation wireless network will have WLAN architecture and IP standards to convey wireless multimedia.

There are many advantages of packets. They are more secure and the data in packets can be encrypted using conventional data encryption methods. There are many ways to encrypt data, including ROT-13, PGP, and RSA; the information in a packet can be encoded using any one of them, because a packet doesn't care what kind of data it carries. They are more reliable. Packets know general things about the information they contain and can be checked for errors at their destination. Error correction data is encoded in the last part of the packet, so if the transmission garbles even one bit of the information, the receiving device will know and ask for the data to be retransmitted.

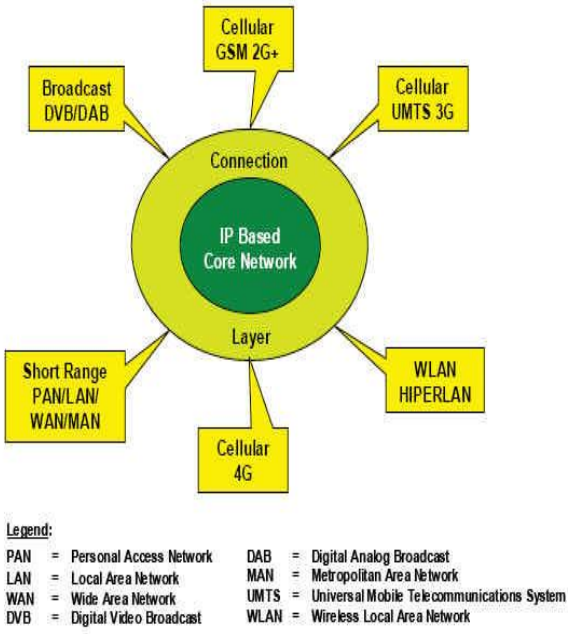

Fig4.Seamless Connection of Networks

3.8 Service-Oriented Architecture and Open OS Platform

The success of future wireless communications rely mostly on the services provided and the applications the users require, rather than the underlying wireless transmission technologies. The users will dislike different boring names of various wireless standards, such as 802.11, 802.16 or cdma2000, etc, and therefore the service-oriented architecture (SOA) is extremely important for the system design and product development of future wireless communications. To support this SOA platform, OWA is required to converge various radio transmission technologies onto an open system platform, including baseband processing platform, operating system platform, RF platform and infrastructure platform, to facilitate the future wireless terminal and base-station to handle different communications needs with same open equipment and same number - a truly unique and global personal communication identifier.

4. CHALLENGES

4.1 Security

The first step in analyzing cellular wireless security is to identify the security objectives. These are the goals that the security policy and corresponding technology should achieve.
Howard, Walker, and Wright, of the British company Vodafone, created objectives for 3G wireless that are applicable to 4G as well:

• To ensure that information generated by or relating to a user is adequately protected against misuse or misappropriation.

• To ensure that the security features are compatible with world-wide availability.

• To ensure that the security features are adequately standardized to ensure world-wide interoperability and roaming between different providers.

• To ensure that the level of protection afforded to users and providers of services is considered to be better than that provided in contemporary fixed and mobile networks.

• To ensure that the implementation of security features and mechanisms can be extended and enhanced as required by new threats and services.

• To ensure that security features enable new 'e-commerce' services and other advanced Applications (Howard, Walker, and Wright 2001, 22)

These goals will help to direct security efforts, especially when the system is faced with specific threats.
In 4G Networks, security measures must be established such that they enable data transmission to be as safe and secure as possible. The nature of the 4G network, gives an increased likelihood of security attacks due to vast facilities. Hence, multiple levels of security, including authentication, will be necessary to protect the data that gets transmitted across the network.

Wireless systems face a number of security challenges, one of which comes from interference. As more wireless devices begin to use the same section of electromagnetic spectrum, the possibility of interference increases. This can result in a loss of signal for users. Moreover, an abuser can intentionally mount a denial-of-service attack (lowering availability) by jamming the frequencies used. Iowa State University professor Steve Russell comments that "an RF engineer using $50 worth of readily-available components can build a simple short-range jammer for any of the common microwave frequencies" (Russell 2001, 174).The need of the hour is an efficient, user friendly, effective, extensible and complete 4G-architecture to confront the problems being faced.

4.2 Integration of IP Devices

To provide better facilities with high data rates and higher bandwidths, 4G technologies provide integration of non IP devices and IP devices. This feature makes it easier to integrate the infrastructure of all current networks and consequently it will be easier for users to access services and applications regardless of the environment. By this, one can easily access different mobile and wireless networks simultaneously. Multimode software is the best solution to this problem. This is software that allows the user device to adapt itself to various wireless interfaces networks in order to provide constant net access with high data rate. This is all packet based. Unfortunately, to use packet, all cellular hardware will need to be upgraded or replaced. Consumers will be required to purchase new phones, and providers will need to install new equipment in towers. Essentially, the communication system will need to be rebuilt from the ground up, running off of data packets instead of voice information. However, given the current pace of technological development, most consumers buy new phones every six to twelve months, and providers are constantly rolling out new equipment to either meet expanding demand or to provide new or high-end services. All networks will be compatible once the switch is completed, eliminating roaming and areas where only one type of phone is supported. Because of this natural pace of hardware replacement, a mandated upgrade in a reasonable timeframe should not incur undue additional costs on cellular companies or consumers. The technological disadvantage of using packets is not really a disadvantage, but more of an obstacle to overcome. As the voice and data networks are merged, there will suddenly be millions of new devices on the data network. This will require either rethinking the address space for the entire Internet or using separate address spaces for the wireless and existing networks.

4.3 Cost Affordability and Managing User Accounts

With 4G networks, maintaining user accounts has become complicated. Due to heterogeneity of 4G networks and the frequent interaction of service providers, the billing system is not able to be figured out and managed. In terms of 4G Network cost and affordability, there are a number of issues to consider that reflect some degree of risk, as well as opportunity, so that these networks are successful once rolled out to the general public, and in general, 4G Networks are designed in order to create an environment that supports high-speed data transmission and increased profit margins for organizations that utilize these capabilities. Developing a successful 4G Network platform is a positive step towards the creation of a wireless and broadband environment that possesses rapid transmission speeds, data integrity modules, and other related events that encourage users to take additional risks in promoting successful utilization of these 4G tools.

4.4 Meeting Consumer Expectation

With the appropriate combination of resources, it is possible for 4G Networks to create alternatives that exceed consumer and industry expectations. Another key feature of 4G networks is high level of user-level customization. That is,

each user can choose the preferred level of quality of service, radio environment, etc. Accessing 4G networks will be possible virtually by using any wireless device such as PDAs, cell phones, and laptops. In general, the possibilities associated with 4G Networks are endless, as high-speed data transmission and associated capabilities are more feasible than ever. This supports the notion that the demand for more complex networks and related capabilities are stronger than ever, as a greater number of consumers continue to buy into the potential that exists with advanced networks, such as 4G.

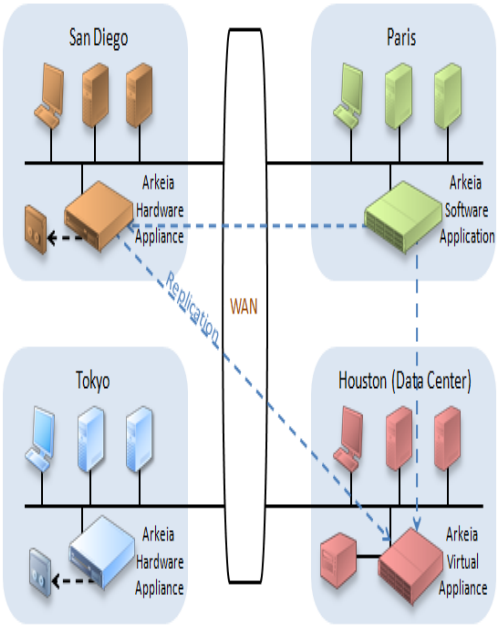

Fig5. Accessing multiple networks and services through Multi-mode software

5. CONCLUSION

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

4G Technology offers high data rates that will generate new trends for the market and prospects for established as well as for new telecommunication businesses. 4G networks, when tied together with mobile phones with in-built higher resolution digital cameras and also High Definition capabilities will facilitate video blogs. After successful implementation, 4G technology is likely to enable ubiquitous computing, that will simultaneously connect to numerous high date speed networks offers faultless handoffs all over the geographical regions. Many network operators possibly utilize technologies for example; wireless mesh networks and cognitive radio network to guarantee secure connection & competently allocates equally network traffic and bandwidth.

Today's wired society is going wireless, and it has a problem. 4G is the answer.

REFERENCES

I. Glisic, Savo. Advanced Wireless Communications: 4G Technologies. Hoboken, NJ, John Wiley & Sons, 2004 • Lightman, Alex. Brave New Unwired World; the Digital Big Bang and the Infinite Internet. New York, John Wiley & Sons, 2002

II. Willie Lu, Fourth-generation mobile initiatives and technologies, IEEE Communications Magazine, Volume: 40 Issue: 3, Mar 2002.

III. Hsiao-Hwa Chen; Chang-Xin Fan; Willie LU,China's perspectives on 3G mobile communications and beyond: TD-SCDMA technology, IEEE WirelessCommunications, Volume: 9 Issue: 2 , Apr 2002, Pp. 48 -59

IV. J. Fleck, "A Distributed Near Real-time Billing Environment," Telecomm. Info. Net. Architecture, 1999, pp. 142–48.

V. E. Buracchini, "The Software Radio Concept," IEEE Commun. Mag., vol. 38, no. 9, 2000, pp. 138–43.

VI. P. Taylor, AT&T to roll out 4G network, 2009.

VII. 3GPP TS 23.107 v.5.9.0, "Quality of Service (QoS) Concept and Architecture," June 2003.

VIII. Amy Cole, The Future of 4G Technologies: New Opportunities and Changing Business Models for the Emergence of LTE and WiMAX