A

Seminar report

on

"4G TECHNOLOGY"

Submitted in partial fulfillment of the requirement for the award of degree of Bachelor of Technology in Computer Science

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C.S.E 4th Year

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It is my pleasure to be indebted to various people, who directly or indirectly helped me in the seminar on "4G Technology".

I would like to express my gratefulness to……**,** who has given me the opportunity to carry out this seminar.

Lastly, I would like to thank the almighty and my parents for their moral support.

Student Name

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Introduction :

The First generation wireless mobile communication systems were introduced in early eighties and second generations systems in the late 1980s were intended primarily for transmission of voice. The initial systems used analog frequency modulation where as the second as well as the subsequent mobile systems use digital communication techniques with time division multiplexing (TDM), frequency division multiplexing (FDM) or the code division multiple access (CDMA).

The third generation wireless systems which are just getting introduced in the world markets offer considerably higher data rates, and allow significant improvements over the 2G systems. The 3G Wireless systems were proposed to provide voice and paging services to provide interactive multimedia including teleconferencing and internet access and variety of other services.

However, these systems offer wide area network (WAN) coverage of 384 kbps peak rate and limited coverage for 2 Mbps. Hence providing broadband services would be one of the major goals of the 4G Wireless systems.

A descendant to 2G and 3G aiming to provide the very high data transfer rates. This technology can provide very speedy wireless internet access to not only stationary users but also to mobile users.

This technology is expected to trounce the deficiencies of 3G technology in terms of speed and quality. 4G can be best described in one word "MAGIC", which stands for Mobile multimedia Anytime Anywhere Global mobility support, integrated wireless and personalized services

4G, short for fourth-generation wireless communication systems, has engaged the attention of wireless operators, equipment makers (OEMs), investors, and industry watchers around the world. 4G refers to the next generation of wireless technology that promises higher data rates and expanded multimedia services. Since, at this point, 4G is more of an aspiration than a standard, there is not an agreement yet on what should constitute 4G.

Since the ITU is a major force in the standardization of telecommunications technologies, it's worth looking at the ITU's performance goals for 4G:

- The framework for 4G systems should fuse elements of current cellular systems with nomadic wireless-access systems and personal-area networks in a seamless layered architecture that is transparent to the user.
- Data rates of 100 Mbps for mobile applications and 1 Gbps for nomadic applications should be achievable by the year 2010.
- Worldwide common spectrum and open, global standardization should be pursued.

As another viewpoint, the Wireless World Research Forum (WWRF) defines a 4G network as one that operates on Internet technology, combines it with other applications and technologies such as WiFi and WiMAX, and runs at speeds ranging from 100 Mbps (in cell-phone networks) to 1 Gbps (in local WiFi networks). There is some debate among standards bodies and industry watchers as to whether WiMAX is, or will become, a full-fledged 4G technology competitive with 4G wireless.

The telecommunication companies like NTT Docomo from Japan and Sprint Nextel were also deploying 4G wireless technologies from the early 2006 along with 3G mobile technologies. The flexibility of 4G technologies to be used in combination with GSM and CDMA has provided it an edge over other technologies. The reason is that the high broadband capability of 4G not only increases data streaming for stationary users but also for mobile users.4G can be efficiently combined with cellular technologies to make consistent use of smart phones. The digital cameras attached in smart phones can be used to establish video blogs in scattered geographical regions. This gives the manufactures the opportunity to produce more affordable user friendly 4G compatible devices. Famous iPod is one such device that supports the working of video blogs. Hence 4G is capable of providing new horizon of opportunity for both existing and startup telephone companies.

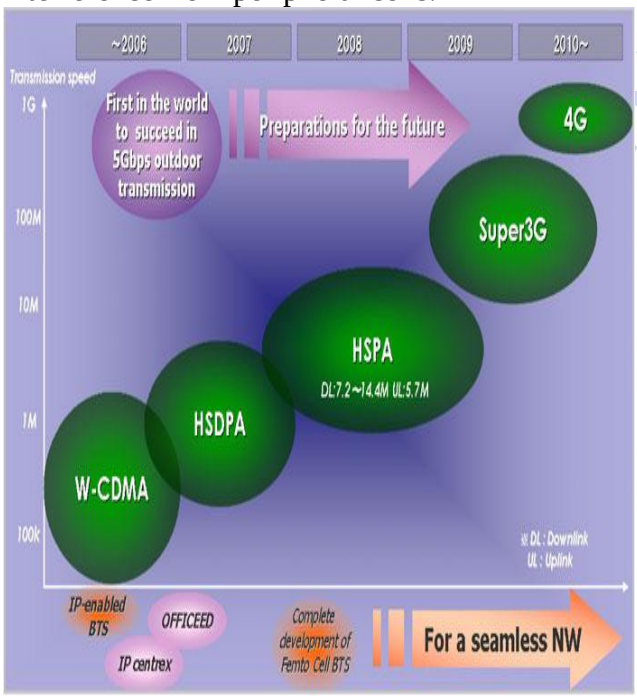
Currently marketed technologies such as LTE (Long Term Evolution) and WiMAX have been around for a few years and are being marketed as 4G whilst not meeting the requirements set by the ITU. It was recently announced that these services could continue to be marketed as 4G as they are precursors to the IMT-Advanced, 4G standard whilst also operating on the same basis of technology; however, these should really be considered as "Pre-4G" or "3.9G" as they technically do not offer the required data rates of (stationary) 1Gbps.

The ITU has recognised two standards that are planned to meet the 4G IMT-Advanced requirements put forward by the two groups, 3GPP and IEEE. These are the LTE Advanced and WirelessMAN-Advanced (WiMAX-Advanced) standards and will almost certainly abandon the old spread system technology found in 3G systems for OFDMA and other equalisation schemes, use MIMO technology, channel-dependant scheduling and dynamic channel allocation all technologies that are being found on new, modern wireless networking equipment.

Still 4G is not clearly defined or documented anywhere what are the basic requirements to build 4G wireless technology, like 3G is clearly defined in IMT-2000 (International Mobile Telecommunications 2000). IMT-Advanced is the closest where some of the 4G requirements can be found. For supporting ***high data rate*** and ***high mobility*** in fast moving car (60kilometers/hours) or fast moving trains (250 km/hr) and it is predicted that the new potential wireless system will support 100 Mbps on mobility and 1 Gbps approximately on without mobility at ***lower cost***. This potential new wireless system could be developed by 2010. Its characteristics should be like high degree of commonality of design worldwide to provide backward compatibility, compatibility of services within IMT-Advanced and with the fixed networks, high quality, and small terminal suitable for worldwide use, worldwide roaming capability, capability to run high data rate multimedia applications within a wide range of services and terminals.

Evolution of 4G Technology :

In order to make smooth transition from 3G to 4G the mobile communication companies are promoting Super 3G/LTE. The companies are upgrading 3G Technology by initializing the introduction of High Speed Downlink Packet Access (HSDPA) service, which increases the downlink data rate of packet services, and by finalizing specifications for High Speed Uplink Packet Access (HSUPA), which enhances uplink speed. HSDPA and HSUPA cover area by 3-4 times relative to W-CDMA and by providing the high transmission rate with low cost per bit transmission. The main objective of the Super 3G is to construct simple, low cost system by removing the complexity from wireless network and mobile handsets. The 3G provides packet and voice services separately where as Super 3G is based on ALL-IP network covering both packet and voice services. As from diagram we can infer that by the 2010 we would be able to achieve the 1 Gbps in motion at low speed and 100 Mbps at high speed. On December 25, 2006, ***NTT DOCOMO*** became the first in the world to achieve a packet signal speed of ***5 Gbps*** in an outdoor test in a low-speed environment (10 km/h). The test was undertaken to demonstrate the expected maximum transmission speed in an actual cell environment, taking into account interference from peripheral cells.



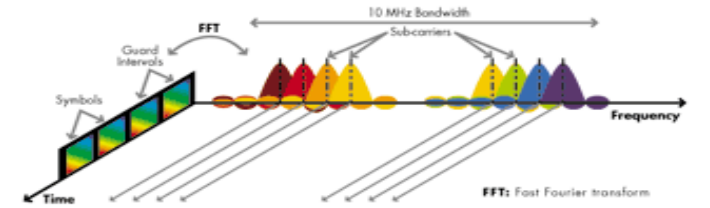
We are steadily approaching towards 4G wireless technologies by upgrading the current 3G technology by increasing the data rate speed and by reducing the cost of transmission which is the main objective of 4G wireless technology.
There are some key components for the successful deployment of the 4G wireless technology.

(A) OFDMA (Orthogonal Frequency Division Multiple Access) modulation

Multipath phenomena in CDMA can tolerate long delay but it does not capture the entire energy, only fraction of the energy of the multipath signal because of limited no. of capability of taking the signal. In OFDM as from the below figure it can be understand the long guard band interval is long enough to absorb all inter-symbols-interference.

Orthogonal Frequency Division Multiplexing (OFDM) not only provides clear advantages for physical layer performance, but also a framework for improving layer 2 performance by proposing an additional degree of freedom. Using ODFM, it is possible to exploit the time domain, the space domain, the frequency domain and even the code domain to optimize radio channel usage. It ensures very robust transmission in multi-path environments with reduced receiver complexity.

Figure 5: OFDM principles



In OFDM, a data stream is split into Nc parallel lower data streams (a few kHz) that are modulated on separate subcarriers. The split the signal is called ***orthogonal subcarriers*** and these subcarriers are modulated by ***Inverse Discrete Fourier Transformation (IDFT)*** and hence it does not affect the signals on multipath effects. The ***long guard band*** is inserted between each OFDM symbol to absorb all inter signal symbols interference. This significantly improves the physical layer performance. The OFDM signal is also compatible with other enhancement technologies like smart antennas and MIMO.

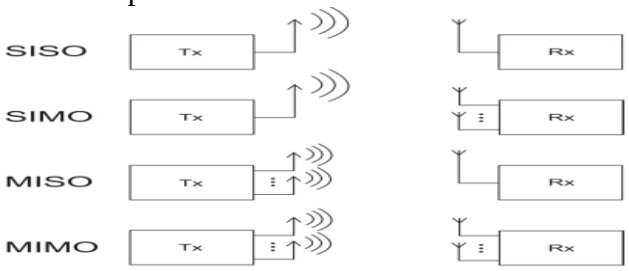
Multiple access technology (Orthogonal Frequency Division Multiple Access; OFDMA) can also be used for modulation of OFDM. In this case, each OFDM signal symbol can transmit information to/from several users using a different set of subcarriers (subchannels). This not only provides additional flexibility for resource allocation (increasing the capacity), but also enables cross-layer optimization of radio link usage.

(B) Implementation of MIMO (multiple inputs, multiple outputs).

In order to improve the communication performance between sender and receiver, the multiple antennas are used at both transmitter and receiver end. MIMO multiplex the signals from the multiple transmitting antennas as it is suitable for OFDM because time symbols can be processed independently after OFDM waveform is correctly designed for the channel. This aspects of OFDM reduces the complexity while transmission and makes processing simple. The signal transmitted by m antennas and signal received by n antennas and the processing of the received signal may produce significant performance improvement such as ***range***, ***quality of received signal*** and ***spectrum efficiency***. Hence MIMO is more efficient when many multiple path signals are received. The gain in spectrum efficiency is directly related to the minimum number of antennas in the link. The MIMO enables significant increase in the data throughput and link range with additional bandwidth or transmit power. It achieves this by higher spectral efficiency more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading). Because of these properties MIMO has become current theme of wireless research.

(C) Smart antenna enhancements.

The main purpose of the radio communication depends on the advancements of the antennas which refer to smart or intelligent antennas. In early 90s, in order to meet growing data rate needs of the data communication, many transmission techniques were proposed such as spatial multiplexing which increases the bandwidth conservation and power efficiency. ***Spatial multiplexing*** provides the multiple deployment of antennas at the transmitting and receiving end and then independent streams of data can be transmitted as requested by the user can be transmitted simultaneously from the all transmitting antennas. Thus increasing the throughput into multiple folds with minimum number of the transmitting and receiving antennas.



There are two types of smart antennas which are switched beam smart antennas and adaptive array smart antennas. Switched beam systems have several available fixed beam patterns which help in making decisions as to which beam to access at any given point of time based on the requirements of the system. While adaptive arrays allow the antenna to steer the beam to any direction of interest while simultaneously nulling interfering signals.

The reliability in transmitting high speed data in the fading channel can be improved by using more antennas at the transmitter or at the receiver. This is called transmit or receive diversity. Both transmit/receive diversity and transmit spatial multiplexing are categorized into the space-time coding techniques, which does not necessarily require the channel knowledge at the time of transmitting the signals. The other category is closed-loop multiple antenna technologies which use the channel knowledge at the transmitter.

(D) SDR (Software-Defined Radio)

A basic SDR produces a radio that is capable of receiving and transmitting a different form of radio protocol (sometimes referred to as a waveform) as per the needs just by ***running different software***. A SDR will allow to increase network capacity at specific time (e.g. during a sports event) and the operator can ***reconfigure*** its network by adding several modems at a given Base Transceiver Station (BTS). SDR will allow reconfigure network structure as per the needs. At the present SDR implementation is done by the infrastructure which develops multi-band, multi-standard base stations and terminals. SDR can be a powerful aid for manufacturer by providing multi-standard, multi-band equipment with ***reduced development effort*** and ***costs*** through simultaneous multi-channel processing. Software radios have significant utility for the military and cell phone services, both of which must serve a wide variety of ***changing radio protocols*** in real time. In the long term, software-defined radio is expected by its proponents to become the ***dominant technology*** in radio communications.

4G Technology Features :

(A)Incomparable Speed

The majority of internet users choose a particular ISP over another because of the speed it offers. Even though I've used some slow and frustrating internet connections before I've also used a lot of super fast internet connections and I'm a great fan of the 3G technology. With all I've read so far the 4G mobile internet technology will be at least 10 times faster than the 3G mobile internet technology and that alone is enough speed than any individual will need.

(B) Advanced Security

One thing about most forms of broadband internet technology despite their great speed is their security weakness. A lot of them have one or two features that make them highly vulnerable and even though the 4G internet technology is not perfect when it comes to security it has been designed in a way that makes it cover the weakness of other technologies.

If you're an internet user concerned a lot about security, with 4G, you really have no need to worry.

(C) Reliability and Effectiveness Irrespective of the Weather Condition

The final thing I love the most about the 4G mobile internet technology is how reliable it is and also the fact that it isn't affected by the weather.

It can be really frustrating to be enjoying your broadband internet connection only to start experiencing problems due to harsh weather conditions. The 4G technology addresses all these and it won't in any way be affected by the weather.

(D) Transfer Rate

One of the things that changes from each generation of computers to the next is the speed at which they can transfer and process data. For instance, a third generation computer and computer network could transfer data up to 2 megabits per second. Fourth generation computers improved on that speed, with the ability to transfer data at up to 100 megabits per second. This higher bandwidth sets these two generations apart from previous ones, which could barely transfer data fast enough for streaming video.

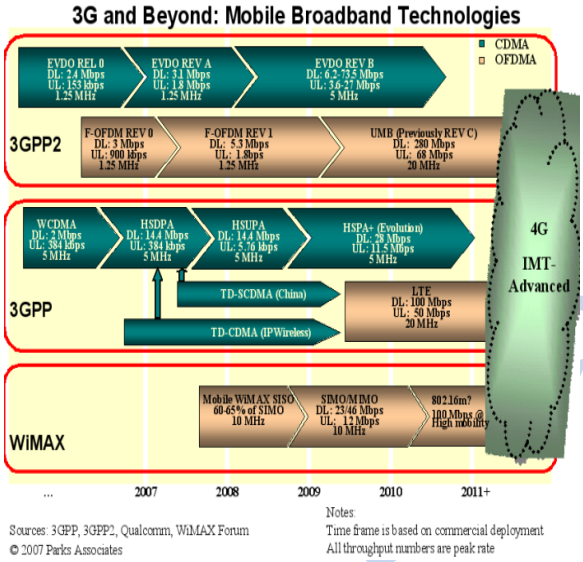
(E) Wireless Technology

3G and 4G computers and computer networks are some of the first to offer truly wireless capabilities. Wireless Internet works off of radio signals, the same kind used by cell phones. 3G computers have the ability to use and receive these wireless signals and thus you can make calls over a 3G computer or you can use wireless Internet. 4G computers and their networks take this further, adding power to the amount of data that can be transferred and the additional reception that 4G systems can provide.

Working groups on 4G wireless technology:

There are many groups who work together for the enhancement of the cellular technology. There are 3 groups who are working for deployment of 4G wireless technology.

4.1 3GPP (The Third Generation Partnership Project)
4.2 3GPP2 (The Third Generation Partnership Project 2)
4.3 WiMAX



3GPP (The 3rd Generation Partnership Project):

The 3rd Generation Partnership Project (3GPP) is body which is formed by collaborating the groups of the telecommunications associations to develop upcoming a globally applicable third generation (3G) mobile phone specification within the scope of International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU). 3GPP standardization major focus is on Radio, Core Network and Service architecture. 3GPP is working to ***upgrade the mobile communication*** by increasing the data rate and reducing the cost. As from the figure above it states that 3GPP focus on mobile communication since 2007 and 3GPP is working in that direction which will lead to enter in the 4G technology by the 2011.

3GPP2 (The 3rd Generation Partnership Project):

Again there is another working group on mobile communication is called the Third Generation Partnership Project 2 (3GPP2) is formed by collaborating third generation (3G) telecommunications specifications-setting project comprising North American and Asian

interests developing global specifications for ANSI/TIA/EIA-41. Cellular Radio telecommunication Intersystem Operations network evolution to 3G and global specifications for the radio transmission technologies (RTTs) supported by ANSI/TIA/EIA-41. 3GPP2 is the standardization group focuses on CDMA 2000 which includes the set of 3G standard based on earlier 2G CDMA technology.

WiMAX:

As we can see in the above figure that WiMAX is using the some of the major key component of 4G technology which is defined in IMT-Advance. WiMAX is using the OFDM modulation technique for transmission of the signals but other features of the 4G technology such as MIMO, smart antennas capabilities and IP mobility which are not available in the WiMAX. As it is shown in figure in the WiMAX section in 2008 Mobile WiMAX is using SISO and 60-65% of SIMO with frequency spectrum of the10MHz. And in 2009 WiMAX will be using SIMO/MIMO and data rate of 23/46 Mbps in downlink and data rate of 12 Mbps in uplink with frequency spectrum of 10 MHz In 2011 WiMAX will be able to achieve the 100 Mbps with high mobility which is defined in the IMT Advance. In 2011 WiMAX will fully enter into 4G technology because it is expected that the WiMAX will using all the major key component of the 4G technology. At present WiMAX is one of the potential candidate for the 4G technology. WiMAX has served as a catalyst for 3GPP (Third Generation Partnership Project) and 3GPP2 to accelerate their next round of innovation, adopting ***OFDM*** modulation and implementing ***MIMO*** and other ***smart antenna*** technologies with ***high mobility***. Both 3GPP and 3GPP2 camps have clearly defined their paths toward 4G.

Mobile WiMAX was being commercialized in 2007 and It had been expected that the WiMAX will have several advantages, including throughput, cost, time-to-market. It does seem to have a time-to-market advantage over LTE (Long Term Evolution) and UMB (Ultra Mobile Broadband). However, the first generation of mobile WiMAX technologies without MIMO enhancements will not be able to deliver significantly ***higher throughput*** as compare to 3.5G technologies such as HSDPA (High-Speed Downlink Packet Access), which has already been deployed commercially. WiMAX vendor had predicted the cost advantages of the WiMAX. Mobile company sprint claims that Mobile WiMAX will deliver a cost-per-bit performance of 10 times EVDO (Evolution-Data Optimized). The spectral efficiency of WiMAX is better but the coverage area of the WiMAX is ***smaller***, possibly at only half to one-quarter the cell radius of an equivalent HSPA (High-Speed Packet Access) cell.

Over period of time WiMAX will improve by ***increasing throughput*** and ***lower cost***, but 3GPP and 3GPP2 technologies are also evolving to support higher throughput, lower latency and better economics by leveraging MIMO and other smart antenna technologies, wider spectrum bands and eventually OFDM modulation. 3GPP and 3GPP2 are still getting stronger support from technology companies, and they are already being integrated into laptops and other embedded devices.

Demonstration of 4G wireless technology :

There are companies who have successfully tested and implemented the 4G technology. The companies are NTT DoCoMo, Mobile and Nortel Networks, and Nokia Siemens Networks.

(A)NTT DoCoMo

NTT DoCoMo after successful experimentation in February 2007 announced the completion of a 4G trial where they achieved a maximum packet transmission rate of approximately 5Gbps in the downlink using 100MHz frequency bandwidth to a mobile station moving at 10km/h. Fourth generation (4G) technology implementation is in the laboratory now and also in the field trials in certain areas of the world. Some people define the 4G goal as increasing data transfer rates to 100Mb/sec. Recently, NTT DoCoMo, the Japanese telecommunications giant and Japan's largest wireless carrier, has claimed to achieve a maximum packet transmission rate of approximately 5Gb/sec in a downlink transmission. The transmission used a 100MHz channel bandwidth and the target receiving device was a mobile device moving at 10km/hour. Since the maximum transmission rates closest to commercialization today are approaching 10Mb/sec.

(B)T-Mobile and Nortel Networks

Mobile operator T-Mobile and Nortel Networks after successfully testing a new high-speed wireless technology, designed to make mobile connections as fast as fixed fiber links. A connection was maintained while driving in a car in range of three cell sites on a highway in Bonn, Germany at an average speed of 67 kmph. The experiment achieved data rates of up to 170 Mbit/s for downloads and up to 50 Mbit/s for uploads, the operator said, about three times faster than the new high-speed broadband technology VDSL it is currently rolling out across the country. If the Long-Term Evolution (LTE) technology proved promising in more everyday situations, the Bonn-based company would consider upgrading its network with it, said Philipp Humm, head of T-Mobile Germany. A decision would be made within six months. There is increasing urgency for fourth-generation (4G) wireless networks, where growing demand for mobile data is driven by such tools as smart phones and embedded laptops.

Canada's Nortel Networks has said it sees LTE as the most likely upgrade path for about 80 percent of the world's existing mobile phone providers, with others going for WiMAX.

(C)Nokia Siemens Networks

Nokia Siemens Network announced after testing that achieved theoretical data rates of up to 173 megabits per second, LTE is in something of a race to market with mobile WiMAX, which only promises around 70Mbps but has a significant head start. The fastest currently available mobile broadband, HSDPA, offers around 7.2Mbps.

Both LTE and mobile WiMAX use the OFDM modulation scheme and multiple-input multiple-output (MIMO) technology, which is based on the use of multiple antennae. Mobile WiMAX's recent inclusion to the 3GPP family of standards has raised the possibility of both technologies becoming part of what will be known as 4G.

In its announcement, Nokia Siemens Networks said it had completed the world's first multiuser field trial of LTE in an urban environment. The trial, which was in Berlin, utilized 20MHz of bandwidth in the 2.6GHz spectrum, which is set for a hotly contested auction in the U.K. next year. The trial confirmed that LTE performance requirements can be met using 3GPP standardized technologies and it realized data rates of more than 100Mbps over distances of several hundred meters, while maintaining excellent throughput at the edge of typical urban mobile radio cells, the company's statement read. Calling the trial an important initial proof of concept for LTE, Nokia Siemens Networks' chief technology officer, Stephan Scholz, said that LTE would further the company's goal of connecting 5 billion users by 2015, due to LTE's efficient use of spectrum.

4G Wireless Standards:

Recently the FCC endorsed long term evolution (LTE) as the required standard for any government participating in the budding nationwide interoperable public safety wireless network. In 2007, the FCC issued a single license for all public safety agencies to jointly operate such a network within 12 MHz of spectrum in the upper 700 MHz band.

The license is held by the Public Safety Spectrum Trust, a nonprofit formed to lobby for the regulatory victories necessary to make the national network a reality. The FCC usually avoids mandating standards, but it made an exception in this case.

The National Broadband Plan the FCC submitted to Congress in 2010 mandated that the public safety network be interoperable, and FCC officials said interoperability wouldn't be realistic without a single standard. LTE is popularly referred to as a 4G standard, although it doesn't actually meet the speed requirements for 4G, which are 100 Mbps for both downloads and uploads, according to the FCC's Public Safety and Homeland Security Bureau.

While LTE generates 100 Mbps for downloads, it only facilitates 50 Mbps for uploads. Nevertheless, the FCC views LTE as being close enough to 4G to make significant improvements for public safety. Of the 12 MHz the FCC designated for public safety, 10 MHz can be used for broadband. Harlin McEwen, chairman of the Public Safety Spectrum Trust, said endorsing LTE made sense because a large portion of the 700 MHz band was already occupied by AT&T and Verizon, which are deploying LTE networks.

An obstacle to deploying the network still remains, however. The bulk of public safety officials insist their current allotment of 10 MHz of broadband spectrum is not enough to give public safety the coverage it needs.

They say they'll have enough spectrum if Congress gives them an additional 10 MHz of spectrum called the D Block, which is set to be auctioned to private providers. McEwen and others are lobbying Congress aggressively for the D Block, but caution that if Congress gives the D Block to public safety, it must include a funding stream to pay for local network equipment.

McEwen said giving the D Block to public safety wouldn't make sense without that funding because insufficient state and local tax revenue exists to pay for the local networks. President Barack Obama recently voiced his support for giving the D Block and equipment funding to public safety.

Bills for making that a reality have been proposed in both houses of Congress, but it remains to be seen how deficit hawks in the House of Representatives will react. Auctioning the D Block to private providers would generate between $2 billion to $3 billion for the U.S. Treasury Department, according to some estimates.

McEwen says the approaching 10-year anniversary of 9/11 could give public safety lobbyists an advantage. Politicians, McEwen said, would not want to face voters at that time saying they hadn't accomplished an interoperable public safety communications plan ready for deployment.

Conclusion:

There has been constant development in the cellular as we have seen in 2G technology to 3G technology which includes GSM, GPRS, EDGE, CDMA, CDMA200, HSPDA, WiMAX etc. 2G only supports the voice communicate and 2.5G supports voice and data communication and 3G supports voice and data communication but at higher rate as compare to the 2.5G. But today there is high demand of multimedia applications like online video, video conferencing. And there is need of better quality of service (QoS) and device mobility from one network to network at high speed. There is strong need of technology better than 3G.

A 4G technology which is an upgraded version of 3G technology, will be introduced in the market by 2011 which will meet the needs which were not found in the 3G technology while maintaining its backward compatibility. As we have seen in the working group of 4G technology namely ***3GGP, 3GGP2 and WiMAX*** technologies will continue to evolve and ***enhance*** its capability, with a clear roadmap of reaching ***1 Gbps in motion at low speed and 100 Mbps at high speed at lower cost***. The successful demonstration of the 4G technology has been done by the companies such as ***NTT DoCoMo, Mobile and Nortel Networks, and Nokia Siemens Networks***.

Abbreviations

(Alphabetically Arranged)

3GGP : The Third Generation Partnership Project
3GGP2: The Third Generation Partnership Project2
EVDO: Evolution-Data Optimized
HSPA: High-Speed Packet Access
IMT: International Mobile Telecommunications
ITU: International Telecommunication Union
LTE: Long Term Evolution
MIMO: Multiple Input Multiple Output
OFDM: Orthogonal Frequency Division Multiplexing
SDR: Software Defined Radio
UMB: Ultra Mobile Broad Band
WiMAX: Worldwide Interoperability for Microwave Access