IDENTIFICATION AND ANALYSIS OF IMPEDIMENTS OF 3RD GENERATION TELECOMMUNICATIONS TECHNOLOGY TO DEVELOP REMEDIAL MEASURES FOR ITS EARLY DEPLOYMENT IN PAKISTAN

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ABSTRACT

Due to consistent and unwavering growth patterns, Pakistan Mobile Industry has achieved land mark target of 100 million subscribers at the end of July 2010. In order to make this sector more efficient and effective in utilizing the telecom resources, Pakistan Telecommunication Authority has implemented the infrastructure sharing Standing Operating Procedure's, which will not only make the operators more efficient but would also give them huge cost saving and reduce environmental hazards in the country.

The much awaited 3G licensing is just around the corner, where all the necessary work has been completed and the Pakistan Telecommunication Authority is waiting for a policy by the Government of Pakistan to initiate the licensing process. In continuation to its efforts Pakistan Telecommunication Authority has been arranging seminars on 3rd Generation Telecommunication Technology for creating awareness about the services and to discuss the feasible challenges that the industry may face with the introduction of 3G services.

In the current rapid flow and development of technology era, telecommunication technology from 1G to 3G has been studied and analyzed thoroughly in pace with the advancements in the world. Impediments have also been highlighted that are delaying deployment of 3rd Generation Telecommunication Technology in Pakistan. Inadequate revenue generation, insecure environment and fear of roll out of 4G are the main concerns of the Operators, political pressures and limited availability of the spectrum are the main concerns of the Government, whereas low buying power and unavailability of the local content base applications are the concerns of the Users. Remedial measures and recommendations have been made (For Government of Pakistan and the Operators) for early deployment of 3G Technology.

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First of all I thank '**ALMIGHTY ALLAH**' the Compassionate; the Merciful the source of all knowledge and wisdom, who gave me enough strength and knowledge to understand things better and enable me to compete this study successfully.

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ABBREVIATIONS

ACK	Acknowledgement
ACLR	Adjacent Channel Leakage Ratio
ARQ	Automatic Repeat Request
AS	Access Stratum
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
CAPEX	Capital Expenditures
CAZAC	Constant Amplitude Zero Auto-Correlation
CCDF	Complementary Cumulative Density Function
CCPCH	Common Control Physical Channel
CP	Cyclic Prefix
C-plane	Control Plane
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
DCCH	Dedicated Control Channel
DFT	Discrete Fourier Transform
DL	Downlink
DL-SCH	Downlink Shared Channel
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
DVB	Digital Video Broadcast
eNB	E-UTRAN NodeB
EPC	Evolved Packet Core
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
FAB	Frequency Allocation Board
FDD	Frequency Division Duplex
FFT	Fast Fourier Transform
GERAN	GSM EDGE Radio Access Network
GSM	Global System for Mobile communication
HARQ	Hybrid Automatic Repeat Request

HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
IFFT	Inverse Fast Fourier Transformation
IP	Internet Protocol
LTE	Long Term Evolution
MAC	Medium Access Control
MU-MIMO	Multi User MIMO
NACK	Negative Acknowledgement
NAS	Non Access Stratum
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OPEX	Operational Expenditures
PAPR	Peak to Average Power Ratio
PAPR	Peak-to-Average Power Ratio
PCCH	Paging Control Channel
PTA	Pakistan Telecommunication Authority
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RACH	Random Access Channel
RAN	Radio Access Network
RAT	Radio Access Technology
RB	Radio Bearer
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
S1	Interface between eNB and aGW
S1-C	S1-Control plane
S1-U	S1-User plane
SAE	System Architecture Evolution
SC-FDMA	Single Carrier – Frequency Division Multiple Access
SCH	Synchronization Channel
SU-MIMO	Single User MIMO
TDD	Time Division Duplex

TS	Technical Specification
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UL-SCH	Uplink Shared Channel
UMTS	Universal Mobile Telecommunications System
UPE	User Plane Entity
U-plane	User plane
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
VoIP	Voice over IP
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network
X2	Interface between eNBs
X2-C	X2-Control plane
3GPP	3rd Generation Partnership Project

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CHAPTER 1
INTRODUCTION

1.1 Background

The history of telephony took birth in 1876 when Graham Bell succeeded in making first ever voice transmission; then we observed 1st public cellular phone in 1946 and the introduction of the very first commercial mobile network in 1992. We've been moving forward, making great discoveries all along, making innovations in different technologies, disciplines and life styles. 1992 was a start of the speech transmission now which stands as a perfect master piece of art and is ready to take a jump into the hyper connectivity. We have jumped into a BW hungry population which have ensued in overturning the technologies and the mobile telephony is no exception to that. Infact data requirement now explicates major revenue pours in any modern mobile network, so we are always hunting for methods to heighten and step-up the data rates. From the infancy mobile networks in 1992 grew to a developed network into the 2nd Generation & then 2.5th Generation networks. Then we observed a transition from GSM technology to UMTS or WCDMA. That was called as 3rd Generation Technology.

1.2 Problem Statement

Progression in Telecom technologies has become an unavoidable phenomenon. Telecom markets are reshaping themselves into 3G networks. 3G UMTS/WCDMA licensing and spectrum auctioning has happened in all the major markets including the developing economies similar to Pakistan. There are almost over 405 million UMTS/WCDMA subscribers in 320 networks in over 130 countries. This number is growing at an exponential pace as more and more networks embrace this technology.

However, There's unfortunately been delay of more than five years now for the 3G licensing and spectrum auction to happen in Pakistan and is still lingering on in offering broadband internet and other value added services / applications such as e-education, e-health, e-commerce, video conferencing etc over the cellular networks. While, the importance of 3G licensing is a key aspect from the consumer point of view but an early adoption by the operators could have resulted in less capex and opex today since most of the sites especially in the larger cities are for providing excess Voice & Data capacity which could have been avoided by deployment of 3G networks

While, some of the operators are still resisting the 3G licensing but most of them have shown this resistance due to likely higher Spectrum Fee being envisaged by the Government for 3G.

The Operators are of the view that the spectrum should be offered at cheaper tariff so that investment goes into infrastructure and not licensing. The other issue confronting the regulator and policy makers is whether to open up the process to new players or limit the auction to only the existing operators.

To Identify and Analyse Impediments of 3rd Generation Telecommunication Technology to Develop Remedial Measures for its Early Deployment in Pakistan.

1.3 Objectives of Research

- To study Mobile Wireless Technologies.
- To Study and Analyse Market and Consumer Requirements for 3G.
- To Study and Analyse the current Telecommunication Policies, Rules and Regulations with regards to the adoption and implementation of Technologies.
- To identify Impediments (Issues and Challenges) in deployment 3G.
- To present Measures and Recommendations for early deployment of 3G in Pakistan.

1.4 Significance of Research

Due to consistent and unwavering growth patterns Pakistan Mobile Industry has achieved land mark of one hundred million subscribers by July last year. In order to make the sector more efficient in utilizing the telecom resources, PTA has implemented the infrastructure sharing SOP's, which will not only make the operators more efficient but also would give them huge cost saving and reduce environmental hazards in the country. The much awaited 3G licensing is just around the corner, where all the necessary work has been completed and the Authority is waiting for a policy by the Government of Pakistan to initiate the licensing process. In continuation to its efforts PTA has been arranging seminars on 3G for creating awareness about the 3G services and to foresee and discuss the challenges that the industry may face with the introduction of 3G services.

3G is known as 'Third generation' telecommunication technology as specified in the ITU standards. Unveiling of this technology has chipped in a new driving force to the mobile concepts. It now extends the user, a broad array of facilities. The most significant among them is the efficient use of the spectrum. Ameliorated efficiency in the system has bestowed upon the availability of broadband internet in the cellular phone. This remarkable invention has also made it possible to accomplish extended wireless telephony, broadband internet and video calls in the cell phone. Strictly speaking, the 3G technology has overturned the requirements to make it a complete, compact device by providing multifaceted applications.

Using internet on the 3G phone has established a new attribute to the all-pervasive internet usage. The 3G technology has successfully attained faster service facilities. Development of a website or making a blog is now simpler then ever before. Desktops, due to its static nature have certain limitations. While mobile phone could accomplish the same result as its similitude, it was a good change for the consumers. Impact of this new technology in the cell phone sphere will be satisfying. Mobile phone industry is functioning in a superb competitive environment. By use of this technology, the user can browse internet and find an online dealer to purchase the products. Other fields that have profited from this technology are; online entertainment, messaging, news and security.

1.5 Limitations of the Research

- Though Officials of PTA were very accommodating and provided with the thorough and comprehensive information about upcoming 3G technology but all was an unofficial version moreover they were hesitant to provide with the definite PTA policy on the adoption of 3G.
- Due to rivalry and cutthroat competition among the Mobile Telecom Operators, access to their information regarding up gradation or operational readiness of 3G infrastructure was somewhat inaccessible.

1.6 Research Methodology

1.6.1 Phase 1

Initially Problem was identified, “Despite having second highest tele-density, Pakistan is the only country left in the region to deploy 3G Technology”

1.6.2 Phase 2

In the second phase it was compulsory to get to know about the 3G technology right from the scratch to learn its economics over the existing technologies. We studied the architecture of the mobile networks of all the technologies from 1G to 3G consulting the web (thanks to the web inventors), the published white papers and the Books on Wireless Technology.

1.6.3 Phase 3

In this phase we paid visits to PTA, FAB and the Mobile Operators, and were able to get unofficial version of their views regarding deployment of long awaited 3G technology in Pakistan. Moreover we pondered over the case studies of different countries who adopted 3G technology. Example in hand is India.

1.6.4 Phase 4

While studying the international trend towards 3G we made a compared the statistics of the market and consumers of Pakistan and more over had a look into the concerns of the regulatory body and the mobile operators.

1.6.5 Phase 5

We then analysed the situation and came up with certain issues / concerns of the government, the mobile operators and the consumers. A solution representing remedial measures have been highlighted, following which will address the issues and create a roadmap for early adoption of 3G technology as there is lot of potential for the operators as well the government to earn fortune.

1.7 Structure of Thesis

1.7.1 Introduction (Chapter-1)

In this chapter Introduction and Background along with significance of research, limitations and methodology has been highlighted.

1.7.2 Literature Review (Chapter-2)

In this chapter Mobile Wireless Technologies including 3G have been thoroughly deliberated upon with an over view on technologies beyond 3G.

1.7.3 Market and Consumer Statistics of Pakistan (Chapter-3)

In this chapter Market and Consumer Statistics of Pakistan are deliberated upon of visualise the scope of deployment of 3G in Pakistan.

1.7.4 Regulations of Mobile Telephony in Pakistan (Chapter-4)

In this chapter we have studied the Regulations of Mobile Telephony in Pakistan and have observed certain flaws that are impeding the motion of deployment of 3G in Pakistan.

1.7.5 Impediments and Issues on 3G Deployment (Chapter-5)

In this chapter we have highlighted the impediments and issues regarding deployment of 3G in the world and as well in Pakistan.

1.7.6 Analysis and Remedial Measures (Chapter-6)

In this chapter we have analysed the issues hindering the launch of new technology and have put across remedial measures to cope up with the world in telecom sector.

1.7.7 Recommendations and Conclusion (Chapter-7)

Lastly we have proposed recommendations for the Government and the Operators to address the issues highlighted and pave a smooth way to deployment of the next generation telecommunication technology.

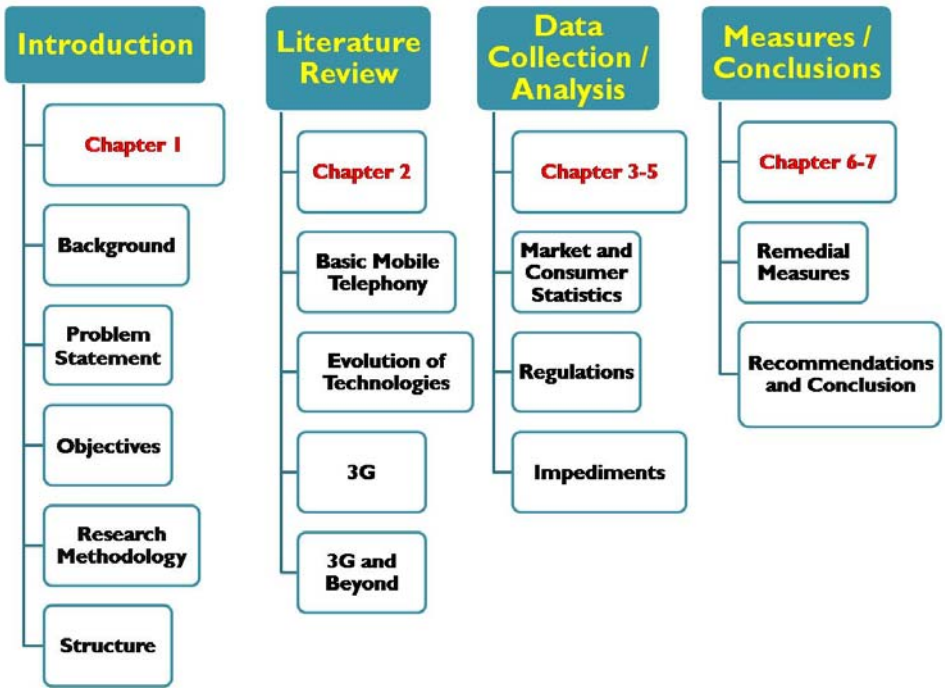

Figure 1 - Structure of Thesis

CHAPTER 2

CELLULAR TECHNOLOGY – LITERATURE REVIEW

2.1 Basics Concepts of Cellular Communication

Basic Concepts of Cellular communication mentioned hereafter, are to have an idea about wireless communication technologies.

2.1.1 Network Architecture - Basics

a. **BSC**: Base Station Controller (BSC) controls different base stations around it and manages call shift from once cell to another.

b. **MSC**: BSCs are connected to the Main Switching Centre. MSC manages call connection and disconnection. Its working is similar to PSTN switch; however it communicates with different BSCs which deal with subscribers, and behaves as a bridge between different HLRs.

c. **HLR**: It is know as Home Location Register (HLR). It has the subscribers number database. It has very important role in keeping and maintaining records of the subscribers. As a subscriber moves from one MSC to another, each MSC in turn notifies the HLR. When a call is received from the PSTN, the MSC that receives the call queries the HLR for the latest information regarding the subscriber location so that the call could be correctly routed to the subscriber[1].

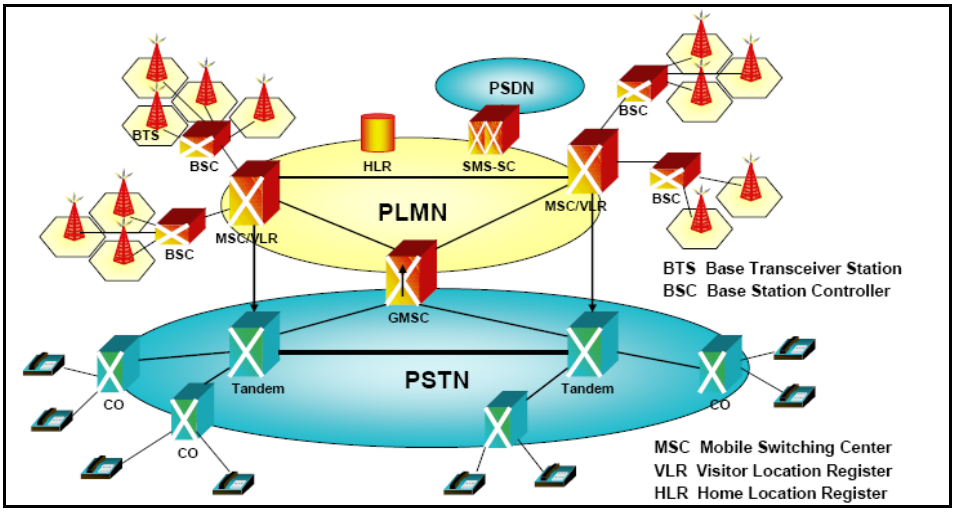

Figure 2 - Basic Network Diagram

Source: Smith, Clint, P.E. 3G wireless networks. New York : McGraw-Hill, c2007

Above diagram is the basic network architecture to provide wireless communication. Other than HLR there are VLR and IN systems as well which are known as visitor locating register and network intelligence which deal with billing, security and authentication etc.

2.1.2 Sectors and Cell

Cellular telephony concept was a breakthrough in the field of communication. Before the advent of cellular technology, capacity was enhanced through a division of frequencies and the resulting addition of available channels. However, this reduced the total bandwidth available to each user, affecting the quality of service. Cellular technology allowed for the division of geographical areas, rather than frequencies, leading to a more efficient use of the radio spectrum. This geographical re-use of radio channels is known as frequency reuse.

2.1.3 Air Interface Access Techniques

Radio spectrum is a precious and finite resource. Unlike other transmission media such as copper or fiber facilities, it is not possible to simply add radio spectrum when needed. Only a certain amount of spectrum is available and it is critical that it be used efficiently, and be reused as much as possible. Such requirements are at the heart of the radio access techniques used in mobile communications.

a. **FDMA:** In FDMA, frequency spectrum is broken down in small pieces of predetermined bandwidths, which are further assigned to the users. As a result only one user is assigned with one frequency band, and this channel remains dedicated for the particular speech as long as the call persists. In most FDMA systems, separate channels are used in each direction one from network to subscriber (downlink) and the other from subscriber to network (uplink). For example, in analog AMPS 30-kHz channels implies two 30-kHz channels, one in each direction. Such an approach is known as Frequency Division Duplex (FDD) and normally a fixed separation exists between the frequency used in the uplink and that used in the downlink. This fixed separation is known as the duplex distance.

b. **TDMA:** Time Division Multiple Access (TDMA) improves spectrum capacity by splitting each frequency into time slots. TDMA allows each user to access the entire radio frequency channel for the short period of a call. Other users share this same frequency channel at different time slots. The base station continually switches from user to user on the channel. TDMA was the dominant technology for the second generation mobile cellular networks.

c. **CDMA:** This technique has originated from the spread spectrum technology in which signal is spread over wide bandwidth. It enhances the frequency utilization by intelligently dividing the band to all users. Data and voice are based on assignment of specific code to each user. CDMA allows for a 'soft hand-off,' which means that terminals can communicate with several base stations at the same time. [1]

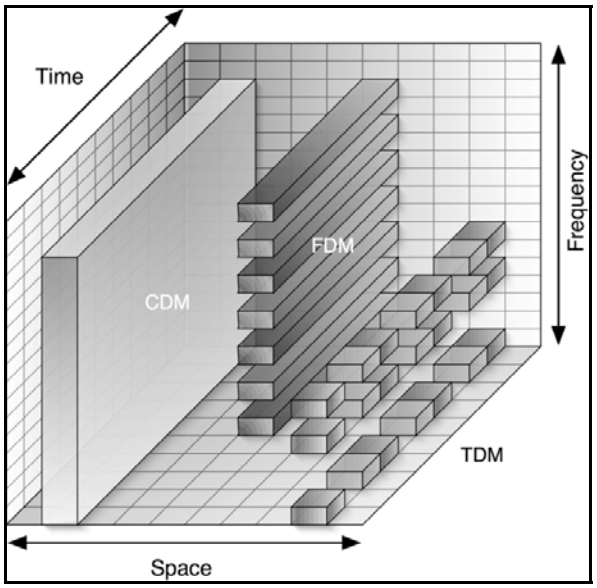

Figure 3 – Technologies Access

Source: www.emeraldinsight.com/content_images/fig/2720080206003.png

2.1.4 Roaming

With this service, mobility can be achieved in wireless communication. Mobility implies that subscribers be capable of transfer freely around the network and from one community to another. This requires that the community tracks the placement of a subscriber to certain accuracy in order that calls destined for the user could also be delivered and allow him to do so whereas engaged in a call. [2]

2.1.5 Handover and Handoff

With this, user can continue his call during roaming remaining within his network. Shift over of subscriber into neighboring cell / sector without call drop or notice of the user is known as handoff or hand over.

2.2 '1G' First Generation of Cellular Technology

2.2.1 Types

This technology was purely analogue, 1G was the first step into the world of wireless technology. Different technologies used in 1G were:

a. **AMPS**: Known as Advanced Mobile Phone Service, it was introduced in 1978 in USA and was operated in 800 MHz band using FDMA.

b. **NMT**: Known as Nordic Mobile Telephony was first launched in Denmark, Finland, Sweden and Norway in 1981 operating in 450 - 900 MHz (NMT900) bands.

c. **TACS**: Known as Total Access Communications System was launched in UK in1985 operating in 900-MHz band.

2.2.2 Limitations

Despite shortcomings, launch of 1G technology was beyond expectations. The programs were in a position to handle massive number of users, however when the subscribers began to number in millions, cracks started to look. Consequently, significant effort was dedicated to the event of second-generation systems [2].

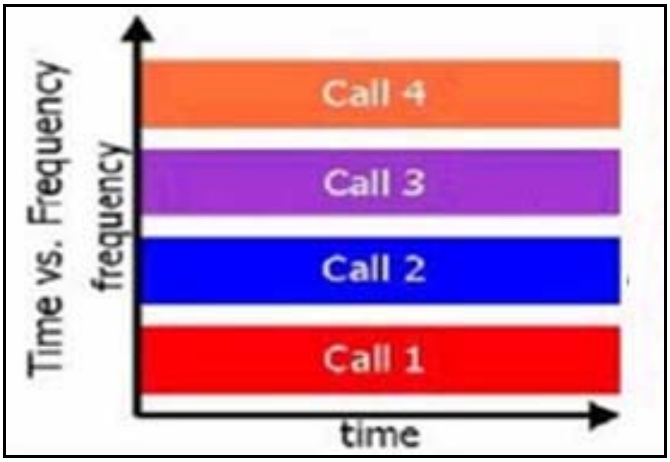

Figure 4 – Frequency Division Multiple Access

Source: www.clear.rice.edu/elec301/Projects01/cdma/compare.html

2.3 '2G' Second Generation of Cellular Technology

2G systems were called as digital mobile networks and were developed in end 80s. It was developed to enhance the capacity of the voice channels in a cell. For enhancing the capacity TDMA technique has to be used instead of FDMA. Eight users can share each channel, and in 200 KHz frequency band there are eight channels. These digital systems controlled the

link, provided more capacity with good quality of voice signal. The process includes compression of digital voice signal and modulation. Intelligent Network (IN) is a telephone network architecture by which the provider good judgment for a call is located separately from the switching facilities, permitting services to be added or modified without having to revamp switching equipment [3].

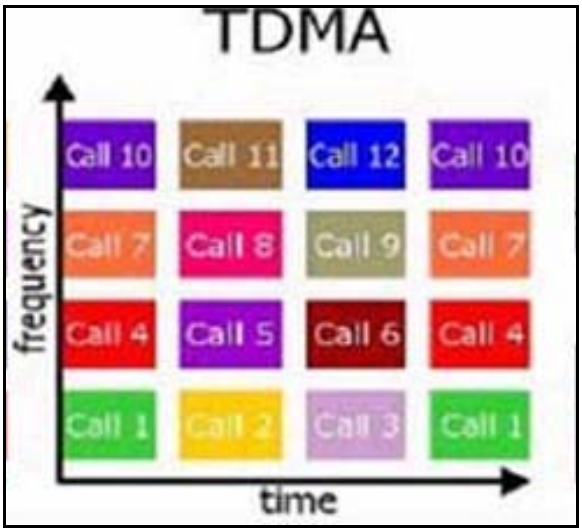

Figure 5 – Time Division Multiple Access

Source: www.clear.rice.edu/elec301/Projects01/cdma/compare.html

Using FDMA, the available bandwidth is split into quite a few smaller channels as in FDMA and it is these channels which might be divided into timeslots. The distinction between a pure FDMA system and a TDMA system that also uses FDMA is that, with the TDMA system, a given person doesn't have exclusive access to the radio channel [2].

2.3.1 Types

a. **Global system for Mobile Communication (GSM)**: It was introduced in 1989 and was Developed by ETSI. Initially 25 MHz frequency spectrum was used in 900 MHz band and later 1.8 GHz and 1.9 GHz were also introduced.

b. **Personal Digital Communication (PDC)**: This technology was mostly used in Japan, it was introduced in 2001 and operates in 800 MHz and 1500 MHz frequencies.

c. **IS-95**: This technique was developed by Qualcomm against existing technologies based on FDMA and TDMA. It was based on CDMA scheme. In this scheme different users are distinguish by different codes sent over the same frequency.

c. **US-TDMA or D-AMPS**: It was enhanced version of AMPS technology but digital. It was mostly used I USA.

d. **Personal Handy Phone System (PHS)**: This system was introduced in Japan and was a mixture of mobile and cordless technologies.

2.3.2 Limitations

However, 2G was a breakthrough in wireless communication but had its limitations:

a. **Less Data Rates**: Designed primarily for voice companies, the given data rates were very less. The data rate fluctuate throughout the system, the typical data rate is within the order to 10 kb/sec.

b. **Less proficiency for packet-switched services**: Great increase in the requirement of internet on the move increased the lust for use of web services. 2G has failed to give the actual flavor of Internet on the GO.

c. **Different Standards**: A large number of competing requirements allowed a consumer restricted mobility; though these were only possible in the regions supporting similar technology. The 2G requirements were semi- international could not permit international roaming [2].

To cater for slow data rates developments were made in standards known as 2.5G (GPRS – General packet radio service (data rate of 115Kbps), and EDGE - Enhanced data rate for Global Evolution (384Kbps). HSCSD - High speed Circuit-Switched Data (data rate of 57.6 Kbps)

2.4 '3G' Third Generation of Cellular Technology

To cope up with enhanced data rates i.e. immense demand for mobile broadband especially on the go, series of technologies known as 2G and 2.5G were insufficient, therefore ITU started pondering over 3G in Europe in 1992. ITU, in late nineties, noticed the expansion of the Web and other packet information purposes as the key to creating third era cellular methods [4]. Initially the name given to this idea was Future Public Land Mobile Telecommunication System (FLMTS), it was because of having better technology, globally accepted (3G) to show the future capabilities of mobile as far as broad bandwidth is concerned. These functions permit better services which also include multimedia [2]. This system was given universal standard having Micro, Macro, and Pico cells and varying coverage areas.

3G will provide speedy communication, together with web, and facsimile on the go, along with international roaming facility. International Telecomm Union's IMT-2000 international

standards for third generation communication have revolutionized the procedures and trends enabling modern functions and companies akin to multimedia leisure, information and GPS services. Third Generation is known as the latest cellular technology providing data and voice communication services along with the knowledge connectivity together with wi-fi entry to the Web, mobile functions and multimedia content material [5].

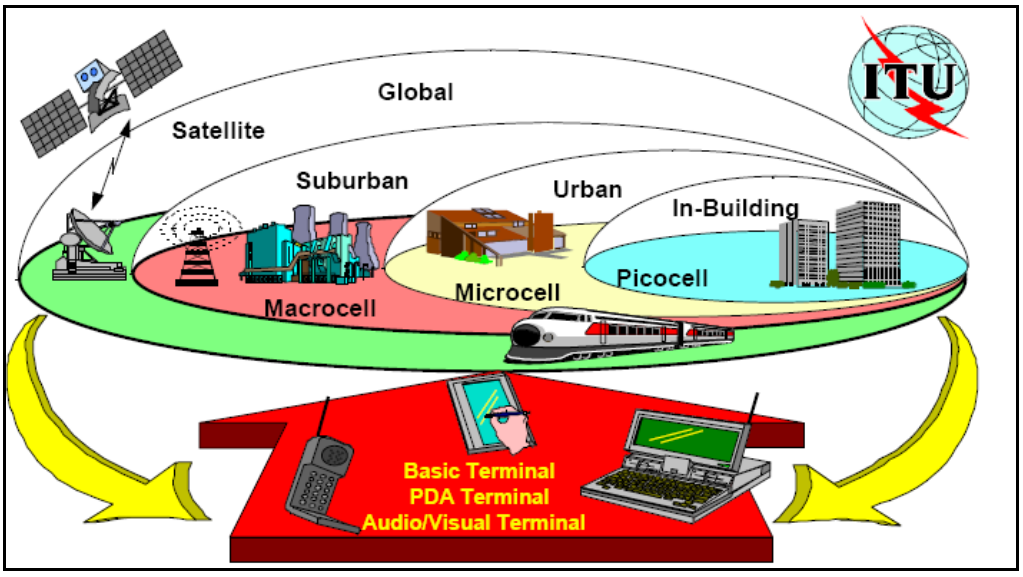

Figure 6 - 3G Concept

Source: hasustorm.com/books/English/Mcgraw.Hill.Wireless.Hotspot.Networks(2003).chm / 5131final / LiB0059. html

2.4.1 IMT-2000

To fulfill 3G requirements, set of radio interface standards are defined in IMT-2000. The characteristics of the concept are mentioned here:

a. **Affordability**: It was agreed upon by industrialists that 3G would be made in the financial reach of the users and the telecomm operators.

b. **Compatibility with existing system**: It has been decided in IMT-2000 that existing systems would remain compatible with the existing systems (i.e. 2G prevalent in other parts of the world).

c. **Modular Design**: The imaginative and prescient for IMT-2000 programs is that they have to be flexible enough for expansion with less cost addition and easily merge able with the prevalent systems/technologies and moreover could be started with meager investment.

d. **Flexibility**: Keeping in view the huge trend of shifting over to 3G and merging technologies in the cellular market operators were interested to escape the dilemma of

interfacing. It was resolved by incorporating extremely flexible systems which could support different applications and services. The IMT-2000 can have five radio interfaces basing mostly on 3 totally different technologies (i.e. CDMA, TDMA and FDMA).

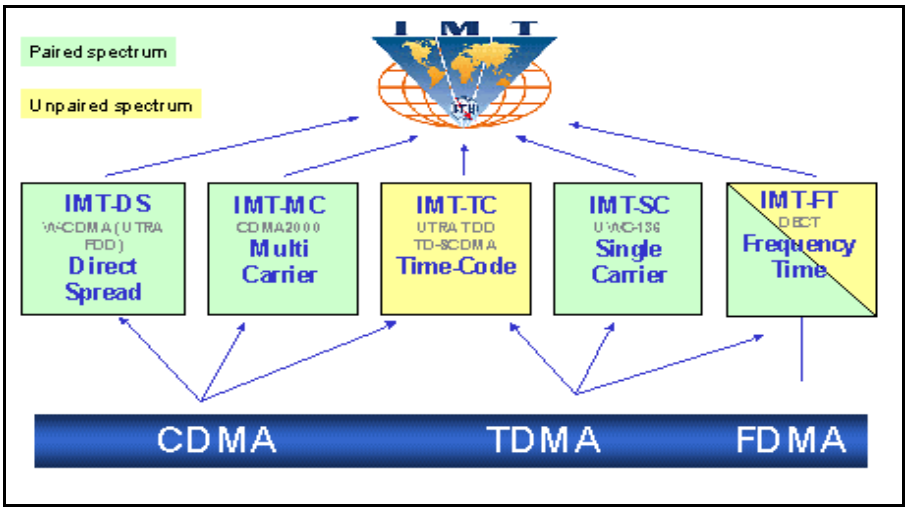

Figure 7 – Cellular Radio Interface Standards - IMT-2000

Source: www.itu.int/osg/spu/imt-2000/technology.html

- IMT-Direct Spread (IMT-DS): CDMA direct unfold is named WCDMA and is meant for functions in public macro cell and microcell environments.
- IMT-Multicarrier (IMT-MC) refers to CDMA2000 1X and CDMA2000 1xEV.
- IMT-Time Code (IMT-TC) is a combination of WCDMA-TDD and TD-SCDMA.
- IMT-Single Carrier (IMT-SC) corresponds to Universal Wireless Communication and EDGE.
- IMT-Frequency Time (IMT-FT) is the European digital enhanced cordless telecommunication proposal (DECT) [1].

IMT-2000 has been developed merging large number of elements, internally the ITU (ITU-R) and (ITU-T) and externally the ITU (3GPP, 3GPP2, UWCC etc.) for mutually operating cellular communication. The IMT-2000 specs have to be the unique specs, to enable cellular and some fastened high-pace data companies to make use of multiple radio channels to deliver following services:

- International standards
- Within IMT-2000, compatibility of services and other networks

- Superior qualities
- Same frequency band throughout the world
- Handy terminals for Global use
- International Roaming Service
- Multimedia applications
- Enhanced efficiency of the spectrum
- Flexibility for evolution to the next generation of wireless systems
- High-speed packet data rates
- 144 Kbps for vehicular traffic, 384 kbps for pedestrian, 2 Mbps for fixed environment [2].

2.4.2 Radio Spectrum

For cellular services, radio spectrum is must and is the most valuable and rare resource in the world of mobile communication. Idea of IMT-2000 demanded standardizing the frequency bands and convergence of old wireless technologies into one globally accepted platform. A new radio spectrum 230 MHz was identified in 1992 at ITU World Radio Conference. And in 2000 at World Radio Conference ,it was decided to use existing 2G spectrum for the 3G services and also use upper limits of 3GHz band for 3G as well. Resultantly three time increase was accepted for the IMT-2000. In year 2007 at World Radio Conference additional band of spectrum were identified for IMT both between 1GHz and 2 GHz, discussed as under:

Band	Freq Range
1	450 – 470 MHz
2	790 – 960 MHz
3	1710 – 2025 MHz
4	2110 – 2200 MHz
5	2300 – 2400 MHz
6	2500 – 2690 MHz

Table 1 – 3G Frequency Bands
Source: www.itu.int/ITU-D/imt-2000/DocumentsIMT2000/Spectrum-IMT.pdf

2.4.3 Standards of 3G

As the 2G technology was rapidly growing therefore, it was difficult to standardize 3G as one global standard. Hence, ITU defined two major routes heading towards convergence that led towards 3G. The two parallel 3G paths are:

a. **3GPP2**: Third Generation Partnership Project 2 (3GPP2) was shaped to assist North American and Asian operators utilizing CDMA2000 transition to 3G. 3GPP2 technologies advanced as 1XRTT, EV-DO, EV-DO Rev. A, EV-DO Rev. B and UMB.

b. **3GPP**: The Third Generation Partnership Project (3GPP) was developed to nurture deployment of 3G networks that derived from GSM. 3GPP technologies emerged from GPRS, EDGE, WCDMA, HSDPA, and LTE [12].

2.4.4 Technologies

At present 3G has been, globally standardized in all respects. Implementation of this technology however would vary from region to region e.g. 3G in Japan has a flavor of WCDMA where as China has TS-CDMA. Technology dictates paths of 3G implementation. Following the word, the initial view would be:

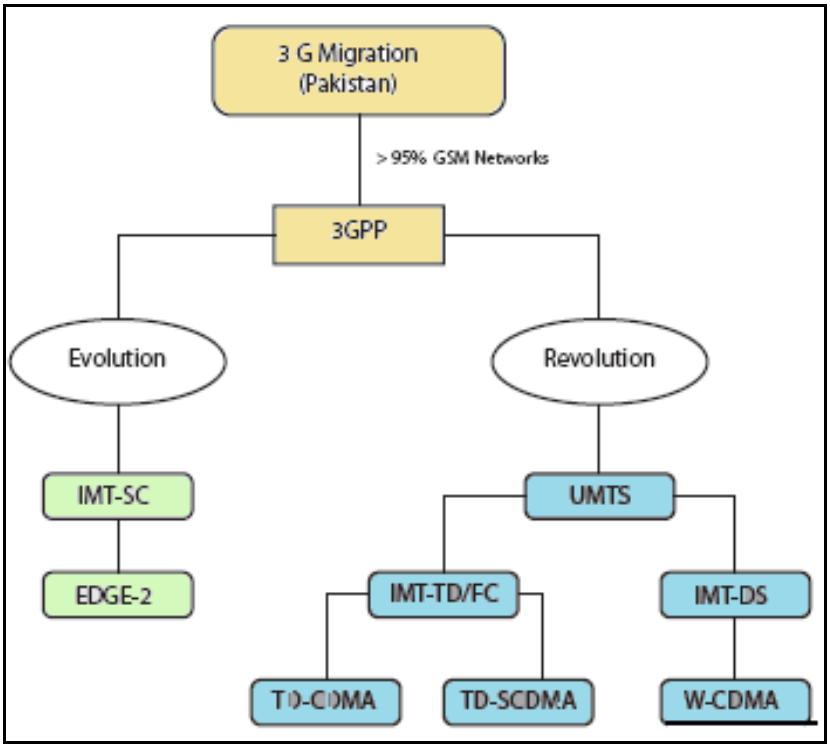

Figure 8 – 3G Technology Paths

Source: 3G Migration in Pakistan, MSc Thesis, Unzila Pervaiz

2.4.5 Revolution

This path will follow the system know as Universal Mobile Telecommunications System (UMTS). It is subset of 3GPP, know as 3G networks, and expands GSM to 3G. It have following air interface standards mentioned in IMT-2000 standard list.

a. **WCDMA-FDD (Direct Sequence Wideband CDMA)**: 5MHZ carriers are utilized as uplink (1920-1980MHz) and downlink (2110-2170) in FDD. Therefore one hundred and ninety MHz difference is between uplink and downlinks.

b. **WCDMA-TDD (Direct Sequence Wideband CDMA)**: Large number of frequencies have been notified for TDD which includes 1900 - 1920 MHz and 2010 - 2025 MHz. There is no frequency separation in uplink and the downlink.

c. **TD-SCDMA (Time Division Synchronous Code Division Multiple Access)**: In the second launch of radio entry interface for UMTS (UTRA), TD-SCDMA was included. Collectively developed by Siemens and the China Academy of Telecommunications Technology (CATT), TDSCDMA 2010 MHz - 2025 MHz in China combines a complicated TDMA/TDD system with an adaptive CDMA element working in a synchronous mode [7].

2.4.6 Network Architecture - UMTS

UMTS network is patterned similar to any other mobile network e.g. GSM/GPRS. The Radio Network Control in Universal Mobile Telecommunication System work similar to the functions as in BSC within GSM/GPRS networks. Node B in UMTS networks works as BTS in GSM/GPRS networks. Like wise by this procedure cellular operators can save huge amount by using existing GSM and GPRS systems. It allows new functions over present interfaces reminiscent of A, Gb, and Abis, and new interfaces that embrace the UTRAN interface linking Node B and the RNC (Iub) and the UTRAN interface between two RNCs (Iur). [14] It has three major portions.

a. **Access network (UTRAN)**

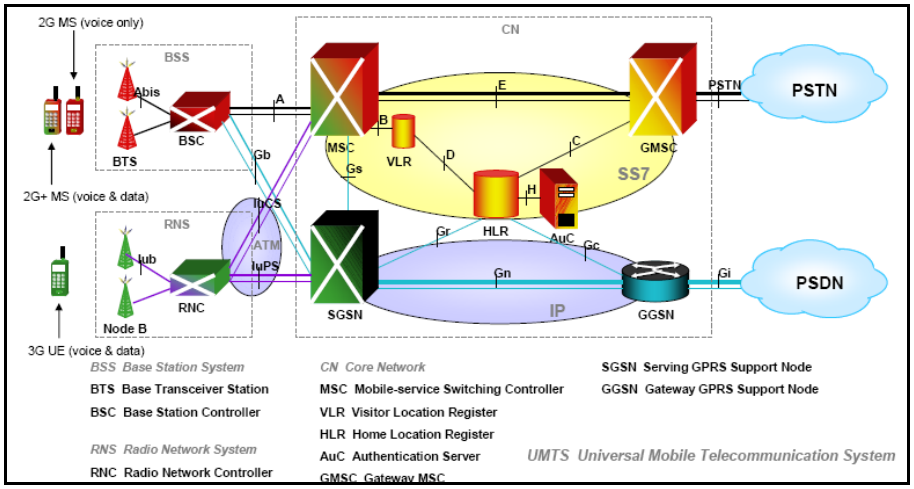

Figure 9 - UMTS Network

Source: www.nmscommunications.com

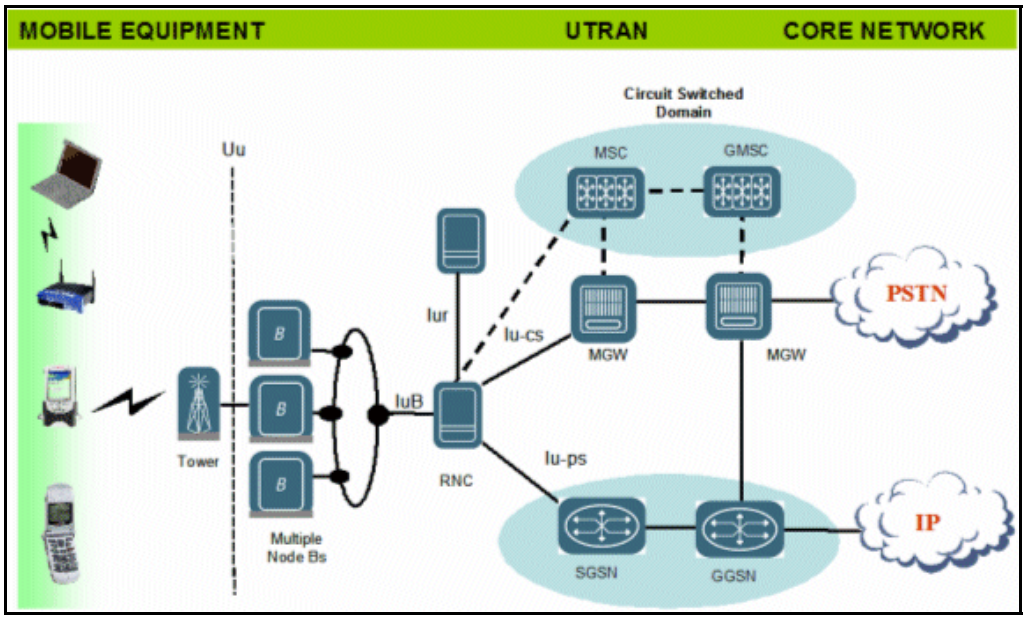

Figure 10 - UTRAN Network

Source: my.opera.com/uchaan/blog/

b. **Radio Network Controller**

Handover management, Power management settings, Channel allocation, Admission management, Radio resource control, Segmentation, Ciphering, Macro diversity, open loop power control, re-assembly and Broadcast signaling are included in RNC capabilities. RNC (CRNC) is controlled by Node B. At Node B all supported radio sources are managed by CRNC. Servicng RNC or SNRC are the RNC management for any connection between the UE and the core community [2].

c. **Node B**

Radio transceiver unit for communication between cell/sectors is called Node B. For one or more sectors one Node B unit service can easily be used. Using WCDMA supported by FDD and TDD. Node B's function is to convert data over Uu Radio Interface.Where as Node B' capability is to house tx and rx over the air, modulate and demodulate, error handling, control the loops and controls [14].

d. **Core Network**

Like wise GSM network, Core network of UMTS is the same i.e. 2G and 3G systems can be supported by the same core network. Core capabilities include mobility administration, call control, switching, session administration, routing, authentication and equipment identification [2].

e. **Modulation**

Totally different type of modulation is used on downlink channel and the uplink channel where QPSK is used on downlink channel where as uplink channel uses 2 different channels so as to avoid interference [15].

f. **Spreading Factor**

The ratio of the chip charge to the person knowledge image rate is known as the spreading factor. The chip rate in WCDMA is 3.eighty four x 106 chips/second (3.eighty four Mcps). The capability to get better a given user's sign is immediately influenced by the spreading issue; the higher the spreading issue, the better the potential to get better a given consumer's signal. In terms of transmission and reception, a higher spreading factor has an equivalent impact as transmitting at a higher power. Thus, the magnitude of the spreading factor might be thought of a kind of gain and is named the processing gain. In dB, the processing acquire is given by 10 x 10Log10 (spreading price/person rate). In some instances, this may be fairly a large number and may also help to beat the effect of interference generated by the presence of different users.

g. **Uplink**

In principle, for a speech service at 12.2 Kbps (and, for now, assuming no extra bandwidth for error correction), the spreading issue could be 3.eighty four x 106/12.2 x 103 = 314.75. This may equate to a processing acquire of 25 dB. In actuality, however, WCDMA does embrace extra coding for error correction. Consequently, a spreading factor as high as 314.75 just isn't supported, no less than not in the uplink. The supported uplink spreading elements are four, eight, 16, 32, 64, 128, and 256. The very best spreading issue (256) is used largely by the assorted management channels. Some management channels can even use lower spreading factors, while person services typically use decrease spreading factors [2].

The bottom spreading factor (4) supplies a gross fee of only 960 Kbps and a usable rate of only 480 Kbps. This doesn't meet the necessities of IMT-2000, which states that a person ought to be capable to obtain speeds of two Mbps. In an effort to meet that requirement, UMTS helps the capability for a given consumer to transmit up to six simultaneous information channels. Thus, if a person needs to transmit consumer knowledge at a person fee higher than 480 Kbps, then multiple channels are used, each with a spreading factor of four. With six parallel channels, every at a spreading issue of 4, a single person can obtain speeds of over 2 Mbps [2].

h. **Downlink**

The uplink successfully makes use of one bit per person symbol, while the downlink successfully uses two bits per person symbol. Consequently, for a given spreading issue, the user bit price within the downlink is larger than the corresponding bit rate within the uplink. The user price within the downlink shouldn't be fairly twice that within the uplink, nonetheless, because of differences in the best way that control channels and visitors channels are multiplexed on the air interface.

An essential capability of WCDMA is that user knowledge charges do not need to be fixed. In WCDMA, channels are transmitted with a ten-ms body structure. It is possible to vary the spreading issue on a frame-by-body basis. Thus, within one body, the person data price is fastened, but the user data fee can change from body to frame. This functionality implies that WCDMA can offer bandwidth on demand. Notice that rate changes each 10 ms do not apply to AMR speech as each speech packet is 20 ms in duration, so that the speech price can change every 20 ms if wanted, but not each 10 ms [2].

2.4.8 UMTS Services

a. **Internet access**

Messaging, video/music download, voice/video over IP, mobile commerce (e.g., banking, buying and selling), journey and information services.

b. **Intranet/extranet access**

Enterprise applications similar to e-mail/messaging, journey help, cellular gross sales, technical services, corporate database access, fleet/warehouse administration, conferencing, and video telephony.

c. **Customized information /entertainment**

Data (photo / video / music download), journey assistance, distance training, mobile messaging, gaming, voice portal providers.

d. **Multimedia messaging**

SMS extensions for pictures, video, and music; unified messaging; document transfer.

e. **Location-based services**

Yellow pages, mobile commerce, navigational service, trade [14].

2.4.9 Traffic Types

In UMTS, superior data rates are achieved, however there is more to be obtained than just data rate. There are four classes of service with its own set of characteristics:

a. **Conversational** is characterized by low delay tolerance, low jitter (delay variation), and low error tolerance. The data rate requirement may be high or low however is mostly symmetrical. Examples are Voice, video telephony, and video gaming.

b. **Interactive** consists of typically request/response-type transactions and is characterized by low tolerance for errors but with a bigger tolerance for delays than conversational services. Jitter (delay variation) is just not a major obstacle to interactive providers, supplied that the general delay does not grow to be excessive. Interactive companies could require low or excessive data rates relying on the service in query, but the knowledge price is generally significant solely in one course at a time. Examples are Web browsing, network gaming, and database access.

c. **Streaming** considerations one-approach companies, utilizing low- to excessive-bit rates. Streaming providers have a low-error tolerance but typically have a excessive tolerance for delay and jitter. That is because the receiving utility normally buffers information in order that it can be played to the consumer in a synchronized manner. Streaming audio and streaming video are typical streaming applications along with Multimedia, video on demand, and webcast.

d. **Background** is characterized by little, if any, delay constraint. Examples embody E-mail, short message service (SMS), file downloading, server-to-server e-mail delivery (as opposed to consumer retrieval of e-mail), and performance/measurement reporting. Background purposes require error-free delivery [2].

2.4.10 UMTS – Quality of Service

An important feature of the Common Cell Telecommunications System (UMTS) is that info generated by impartial sources could be effectively multiplexed on the identical transmission medium. A major problem for the UMTS infrastructure is to hold numerous types of application on the same medium, whereas assembly the QoS objectives. In addition to assembly the person needs in the end-to-finish QoS. This requirement applies not only to the scarce radio spectrum, but additionally to terrestrial transmission resources, and especially the entry half which must present an economical transfer service whereas minimizing investment and working costs. Thus, it is extremely desirable to attain some statistical multiplexing gain. Specifically, transmission links and the radio interface should be loaded as closely as attainable while meeting the QoS requirements. Due to this fact it is very important identify mechanisms that optimize the load [13].

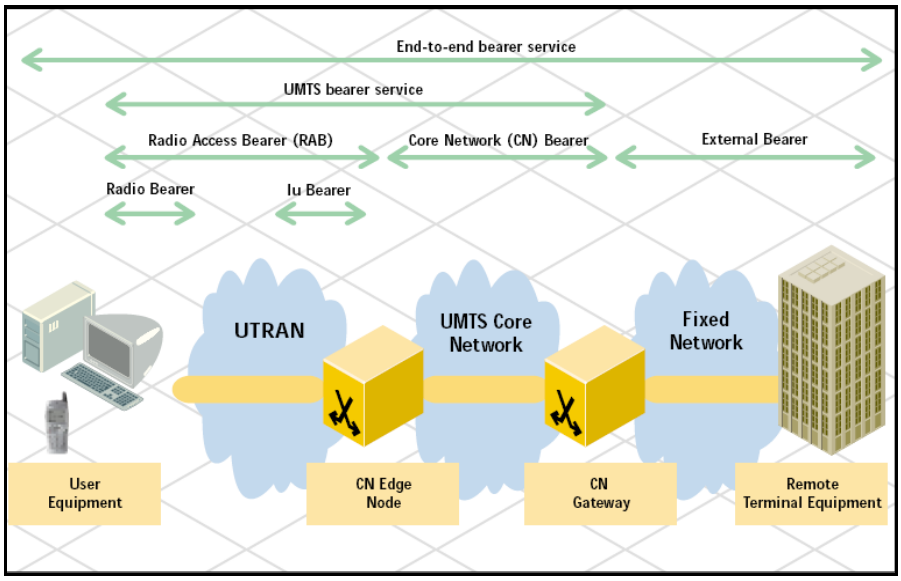

Figure 11 - QoS of UMTS Architecture

Source: http://www1.alcatel-lucent.com/doctypes/articlepaperlibrary/pdf/ATR2001Q1/gb / 09baudetgb.pdf

a. **Handling of QoS in UMTS Network**

There are three basic timescales for traffic management in UMTS networks:

1. Dependant on operators site visitors combine, service stage agreements and network topology matrix, capability planning and network dimensioning determine the numbers and configuration of the core nodes plus required bandwidth of the UMTS interfaces.
2. Initiated with each name setup, CAC determines whether or not or not the brand new name will be accepted whereas guaranteeing the QoS of established calls.
3. Policing, scheduling and congestion mechanisms are carried out every time a packet is shipped and/or acquired (typically microseconds). Policing and buffer acceptance mechanisms are algorithms that decide when a packet arrives, whether or not it can be accepted. Scheduling algorithms decide when (and which) packet to ship first.

The QoS options supported by the UMTS core network decide its capability to distinguish between providers provided to subscribers. This capability is obtainable end-to finish to make sure mandatory sources are allocation and guaranteeing the negotiated high quality of service.

b. **QoS Handling in the UMTS Terrestrial Radio Access Network**

Radio Access Bearer companies, RAB, are established dynamically to assist one or a number of purposes for a given MS. Every RAB is characterized by QoS attributes which are derived from the characteristics of the application. The UTRAN simply obtains the RAB QoS attributes from the core network when the RAB is established and maintains required QoS levels. The RAB is always established at the request of the core community, which retains possession of the RAB all through its life. Once the UTRAN has dedicated to a given QoS level, this should not be downgraded by the UTRAN without a prior modification request from the core network. Specifically, this requirement applies to cellular terminals, which regularly experience various radio situations as they move from cell to cell. Given all WCDAM users share the identical sources each in the frequency and time domains, it is essential to keep up a low degree of radio interference throughout the system. To this end, power management constrains the transmission power to/from each user between applicable limits: not too excessive, to preserve the UMTS cell traffic capacity and not too low, to keep away from extreme transmission errors that may lower the general bit rate. In addition, QoS monitoring is essential to make sure that the QoS requirements are met however not exceeded. Smoothing of the site visitors circulation and congestion avoidance is essential. Radio Admission Management (RAC), radio resource allocation and management, and radio load management functions are key features for dealing with QoS within UTRAN.

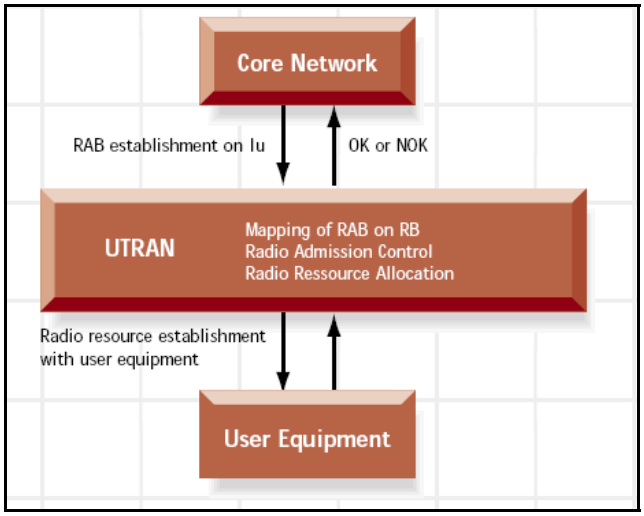

Figure 12 - RAB Service Establishment Principles

Source: http://www1.alcatel-lucent.com/doctypes/articlepaperlibrary/pdf/ATR2001Q1/gb / 09baudetgb.pdf

2.4.11 Hand Over

UTRAN interface Iur exists between the RNCs and supports inter-RNC mobility and mushy handover between Node Bs linked to completely different RNCs. These handovers cop with requirements of load management, protection provisioning and providing quality of services. Because of this, handover failures are lowered considerably [34].

a. **Hard Handover**

Exhausting handover means that all the previous radio links in the UE are removed before the brand new radio hyperlinks are established. Onerous handover will be seamless or non-seamless. Seamless laborious handover signifies that the handover is not perceptible to the user. In observe a handover that requires a change of the carrier frequency (inter-frequency handover) is at all times carried out as onerous handover. The mobile station performs a handover when the signal energy of a neighboring cell exceeds the signal power of the current cell with a given threshold. To decrease blocking probabilities experienced by customers entering a brand new cell and to keep away from poor utilization of cell capacity (mobility issues in 2G networks), WCDMA presents tender and softer handovers. Typically laborious handovers are only used for coverage and cargo causes, while mushy and softer handover are the principle technique of supporting mobility [35].

b. **Soft Handover**

Soft and softer handover are the CDMA revolutionary features. Mushy handover implies that the radio links are added and eliminated in a manner that the UE at all times keeps at least one radio hyperlink to the UTRAN. Gentle handover is performed by means of macro range, which refers to the situation that a number of radio links are energetic at the same time. Usually comfortable handover can be used when cells operated on the same frequency are changed [36].

c. **Softer Handover**

Softer handover is a special case of soft handover where the radio links which might be added and removed belong to the same Node B (i.e. the location of co-located base stations from which several sector-cells are served. In softer handover, macro variety with most ratio combining can be carried out in the Node B, whereas generally in

gentle handover on the downlink, macro diversity with choice combining is utilized [36].

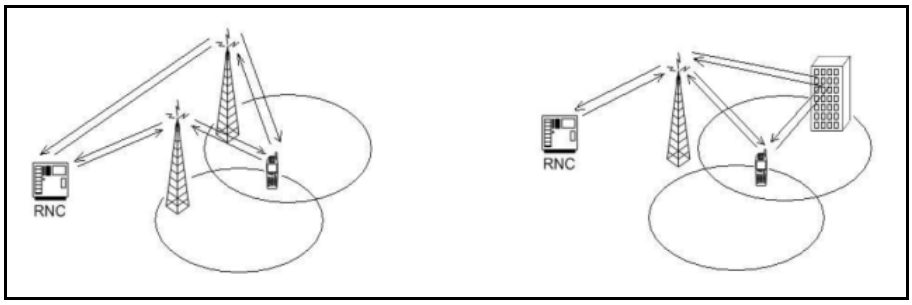

Figure 13 – Process of Handover

Source: www.ustudy.in/node/7179

d. **Inter-system handover**

Inter-system handovers are necessary to support compatibility with other system architectures. The signaling process for handing over a UMTS person to the GSM system is shown below. This example is illustrative for the overall process followed throughout handovers. This procedure usually consists of finishing up of measurements, reserving sources and the performing the actual handover. When switching the connection to another system architecture there's want for a measurement on the frequency used by the other system. When there isn't a full twin receiver accessible the transmission and reception are halted for a short while to perform measurements on the opposite frequencies. This is called the compressed mode. As FDD and TDD mode make use of various frequencies, inter-mode handovers also make use of compressed mode to perform measurements on different frequencies wanted in the course of the handover [31].

2.4.12 Evolution (IMT-SC/EDGE)

EDGE supplies an evolutionary path that enables current 2G systems to deliver 3G providers in current spectrum bands. It reuses the GSM provider bandwidth and time slot construction. [38] To fully outline RAN, capable of 3G, GSM/GPRS and EDGE are are actively taking part in their role. Core network of GSM / GPR and EDGE i.e. GERAN and that of UMTS UTRAN are virtually the identical.

2.4.13 GERAN Architecture

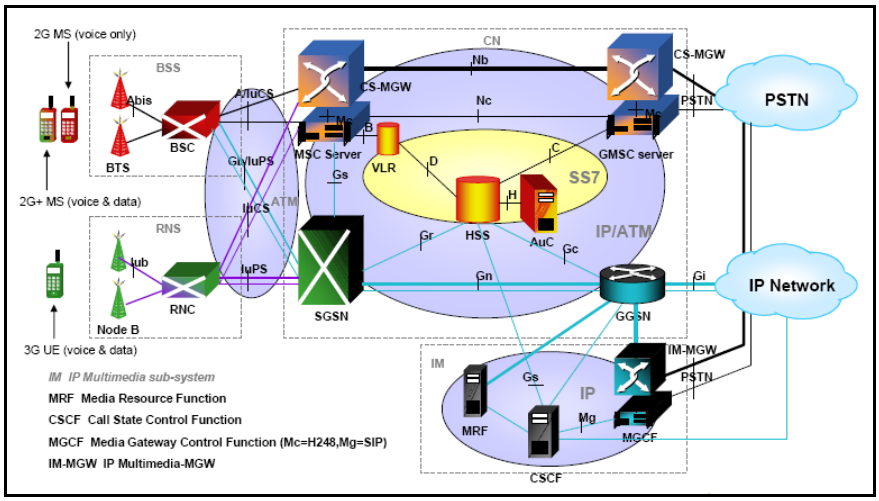

Figure 14 - GERAN Architecture

Source: www.nmscommunications.com

a. **Interfaces of GERAN**

1. **Interfaces - Legacy**

Interface - Gb joins existing GPRS support node SGSN and Base Station Subsystem (BSS)

A Interface connects BSC and MSC [40].

2. **New Interfaces**

The overall protocol model for new interfaces is predicated on the protocol model used in UMTS. The logical independence of layers and planes provides additional flexibility in order that transport layer protocol may be modified if needed with no influence on the radio interface.

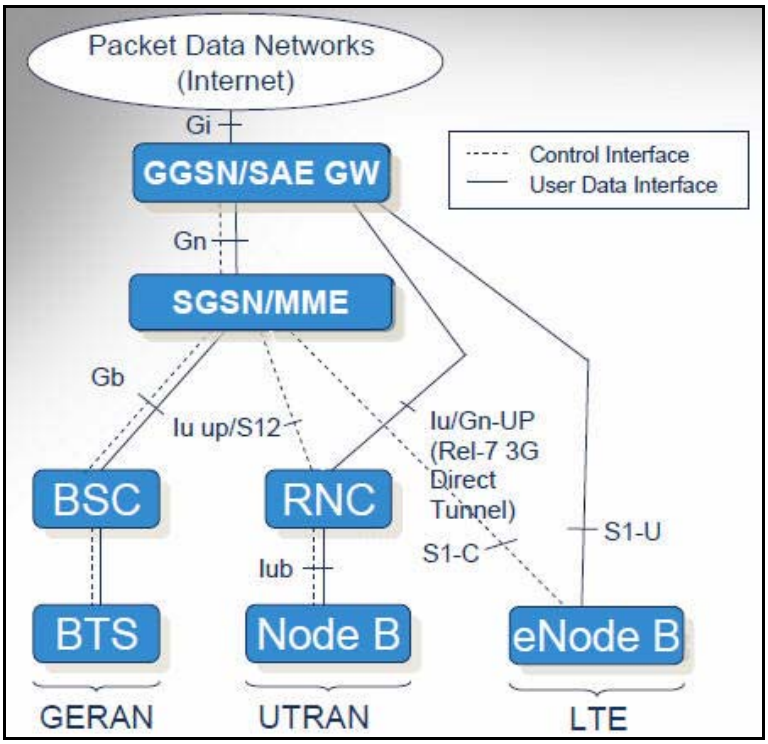

Figure 15 - UTRAN/ GERAN Protocol Model

Source: www.eventhelix.com/lte/lte-tutorials.htm

3. **Iu interface** similar and discussed in UTRAN.
4. **Iur-g interface** is based on UTRAN Iur interface and supports logical connection between any two GERAN.

The performance split throughout these interfaces is aligned with UTRAN-CN split. For GERAN this means that the functionalities like ciphering and header adaptation are moved from the CN and are a part of the radio entry net-work. In addition the cell stage mobility management duties are solely part of the operator deploying each radio entry applied sciences (GERAN and UTRAN) could operate one single core community, and both entry applied sciences can present the identical set of services. This contains provision of all of the UMTS visitors courses also by GERAN. For the network and terminal manufacturers, the harmonization provides benefit in form of synergies in protocol and interface implementation. The harmonization of the GERAN and UTRAN architectures simplifies the long run development of these radio entry applied sciences, e.g., towards an All-IP system. The IP transport is anticipated to offer benefit for the operators by bringing down the transmission costs.

2.4.14 GERAN Radio Protocols

a. **Packet Data Convergence Protocol –** PDCP is for the transfer of consumer knowledge using providers supplied by the RLC and header adaptation of the redundant community PDU management information (IP headers) to be able to make the transport over the RF spectrum efficient.

b. **Radio Resource Control - RRC is** based on each GSM RR and UTRAN RRC specifications. Capabilities embody broadcast of information associated to the non-entry stratum (core community) and the access stratum, paging/notification, routing of upper layer PDUs, management of requested QoS and safety functions, and MS measurement reporting and control of the reporting.

c. **Link Control RLC** permits for the data transfer in varied modes and in addition notifies unrecoverable errors to higher layer. When in clear mode, RLC has no performance and does not alter the data models of the upper layer. In non-clear mode, the RLC is responsible for ciphering RLC PDUs with the intention to stop any unauthorized acquisition of data. In acknowledged mode, Backward Error Correction (BEC) procedures are offered that allow error free transmission of RLC PDUs.

d. **Medium Access Control** – MAC permits the transmission over the physical layer of upper layer PDUs in dedicated or shared mode. A MAC mode is related to a bodily sub channel for use by one or more cell stations (dedicated or shared mode respectively) and handles the access to and multiplexing onto the bodily sub channels of cellular stations and traffic flows.

2.4.15 Quality of Service

RRC realizes the QoS requirements of the RAB by establishing a RB between MS and GERAN. For every RB, RRC allocates either a dedicated or a shared channel. In case of dedicated channels, RRC also takes care of radio sources allocations. In case of shared channels, MAC takes care of radio useful resource allocations. [40] As explained in UTRAN, “QoS is divided into management plane (CAC and QoS preserving) and user aircraft (link adaptation, site visitors conditioning, packet scheduler, and power management).

Modulation and Coding Schemes for EGPRS

Scheme	Modulation	RLC Blocks per Radio Block (20 ms)	Input Data payload (bits)	Data Rate (Kbps)
MCS-1	GMSK	1	176	8.8
MCS-2	GMSK	1	224	11.2
MCS-3	GMSK	1	296	14.8
MCS-4	GMSK	1	352	17.6
MCS-5	8-PSK	1	448	22.4
MCS-6	8-PSK	1	592	29.6
MCS-7	8-PSK	2	2 x 448	44.8
MCS-8	8-PSK	2	2 x 544	54.4
MCS-9	8-PSK	2	2 x 592	59.2

Table 2 - Modulation and Data Rates

Source: Smith, Clint, P.E. 3G wireless networks. New York : McGraw-Hill, c2007

2.4.16 GERAN Evolution

Present EDGE peak knowledge rates of 300 kbps cannot deal with the data charges of 7.2 Mbps supplied by WCDMA/HSPA networks. Still, the enormous GSM/EDGE subscriber base motivates mobile operators to continue investing in network upgrades to supply increased data rates at minimum cost. EDGE Evolution, additionally standardized by 3GPP, consists of a subset of options which permit quadrupling the downlink knowledge rates in comparison with legacy EDGE performance. Introduction of new modulation schemes, e.g., 32 QAM and better image charge will enhance data charges as much as 118.four kbps per timeslot. Together with dual downlink carrier, cellular terminals will be capable to allocate ten downlink timeslots which can allow peak data rates of 1.2 Mbps. Additional improvement of EDGE Evolution finish user efficiency shall be provided by lowered latency, turbo codes and cell obtain variety techniques. All these options collectively will present comparable performances with 3G know-how and more importantly, allow true service transparency between 2G and 3G networks. Implementing EDGE Evolution enhancements will 70 3G wireless community largely impact cellular terminal side. A lot of the proposed enhancements could be carried out in EDGE networks only with software program upgrades, with out requiring any hardware modification.

a. **EGPRS-2**

HOM, turbo codes and HSR enhancements are bundled together by the name of EGPRS-2 Uplink and Downlink. HOM and turbo codes are already supported by latest base stations and may be carried out only with a software program upgrade. Introduction of HSR will most probably require a new pulse shaping filter so transceiver boards on base stations should get replaced.

1. **Turbo code TC**: Already used in 3G WCDMA networks, TC outperforms legacy convolution codes in time period of error correction, improving channel robustness, and additional diminishing the disadvantage of upper BER for HOM.
2. **Higher order modulation (HOM)**: Introduction of HOM schemes, such 16QAM and 32QAM, enabled through MSRD good points, will improve the bit per image fee to 4 and 5 respectively. HOM takes advantage of margin within the radio hyperlink, which may exist in lots of areas within a cell.
3. **Dual Symbol Rate**: DSR enables the use of wider band service for higher average and peak bit rates. The necessity for greater bit rates makes favorable using sooner image rate. Presently, the legacy GSM/EDGE symbol period is 3.sixty nine μs while EDGE evolution standardizes 3.077 μs symbol duration. This reduction of image length allows a 20% improve of the symbol fee, leading to an equivalent information throughput improve.

b. **Downlink Dual Carrier**

DLDC permits one finish person to be assigned the usage of timeslots from two carriers, growing average and peak bit rates. Downlink dual service helps to beat a elementary limitation of GSM, which is the 200 kHz channel bandwidth. Benefits of second carriers contains: fast processing of information in MS resulting in more responsive purposes and an improved subscriber experience, improve flexibility in bandwidth allocation, more efficient use of radio useful resource will increase system efficiency. As well as, with two carriers, only half the slots should be discovered on a single service frequency to get the same throughput. The probability of successfully using ‘stranded’ timeslots increases which improves network efficiency. Introducing the capability to ship information on two carriers concurrently will double the data price in a really easy and backward-compatible way.

c. **MSRD via Dual Antenna Interference Cancellation (DAIC)**

Obtain variety capability in the cell station increases sensitivity and robustness in areas of high interference and dense deployment implying important downlink community capability improvement if the cellular penetration charge is high. In case of low penetration, MS that support MSRD will see higher common throughput throughout all the SNR range. This offers a rise in the average downlink throughput of around 30% compared to typical receivers and pertains to larger coverage by MS. Hence, BTS can use power control to scale back the output power to an MSRD successful cellular station, decreasing interference across the cell which increasing capacity. MSRD offers higher sensitivity because it mitigates results of fast fading. Customers situated in areas with poor EDGE coverage will be able to achieve passable data rates.

d. **Functionality to reduce latency times**

Finish-to-end system latency is without doubt one of the most delicate parameters that affect information by way of put. The 3GPP requirement is to realize latency beneath 100ms (135 ms was lowered to eighty ms) on the radio interface. Two enhancements are mixed to attain an total enchantment in latency: reduction of the transmission time interval (TTI) and increased efficiency of acknowledging received data. Decreasing the TTI offers advantages across all radio circumstances, whereas enhancing the affectivity in acknowledged mode of operation gives the highest profit in poor channel conditions the place the number of retransmissions may be large. Decreasing the overall latency has an vital second order impact on mean/common and peak bit charges as properly, since because the bit charge on the link turns into greater the maximum buffer window measurement can limit the transmission rate. Subsequently there is limited advantage to growing the info throughput without additionally lowering the latency, as the latency turns into a limiting and more and more vital limiting factor [39].

e. **Data Rates**

Predictions present that by combining EGPRS2-A downlink enhancements, MSRD and dual provider on downlink with 5 timeslots every for a total of 10 timeslots, information rates as much as 1 Mbps on downlink could be achieved within the serving cell vicinity. This performance represents the fundament to ensure seamless community operations between GSM/EDGE and WCDMA/HSPA networks. Primarily based on EGPRS2-A enhancements, this prediction doesn’t require any

hardware modification in the base station. Eventual hardware constraints from terminal aspect can be easily surmounted due to simplicity of implementation, decrease value and shorter terminal lifetime. Contemplating that by utilizing 32QAM along with HSR, knowledge fee per timeslot could be elevated as much as 118.four kbps and for state-of-the-art handsets supporting 5 timeslots along with twin downlink service the theoretical peak throughput might be further boosted to the utmost value of 1.184 Mbps on downlink. Multi RAT terminals will have the ability to more readily incorporate options of advanced EDGE with much less influence on price and size as they leverage reuse of 3G elements, thus making them preferred cloth for a possible implementation of EDGE Evolution features.

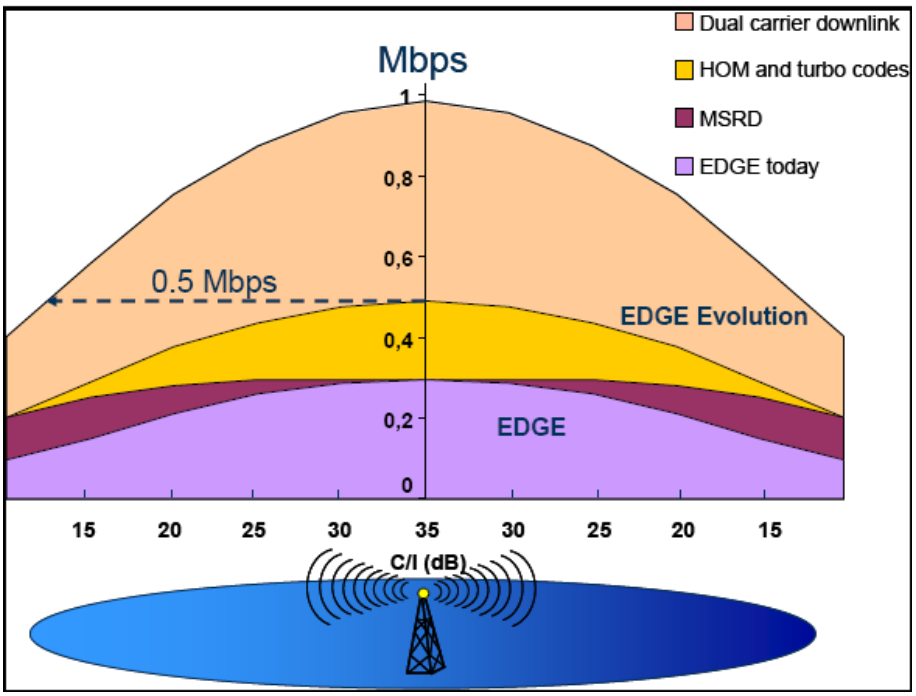

Figure 16 - Predicted user throughput

Source: Capabilities and Impacts of EDGE Evolution toward Seamless Wireless Networks

2.5 3G Technology in Pakistan

In Pakistan, the auction of license to mobile operators is always of the spectrum, without the restriction on use of technology therefore, the obvious choice is for Pakistan is WCDMA (UMTS) i.e. GSM being used by all the mobile operators which can be observed in the following figure:

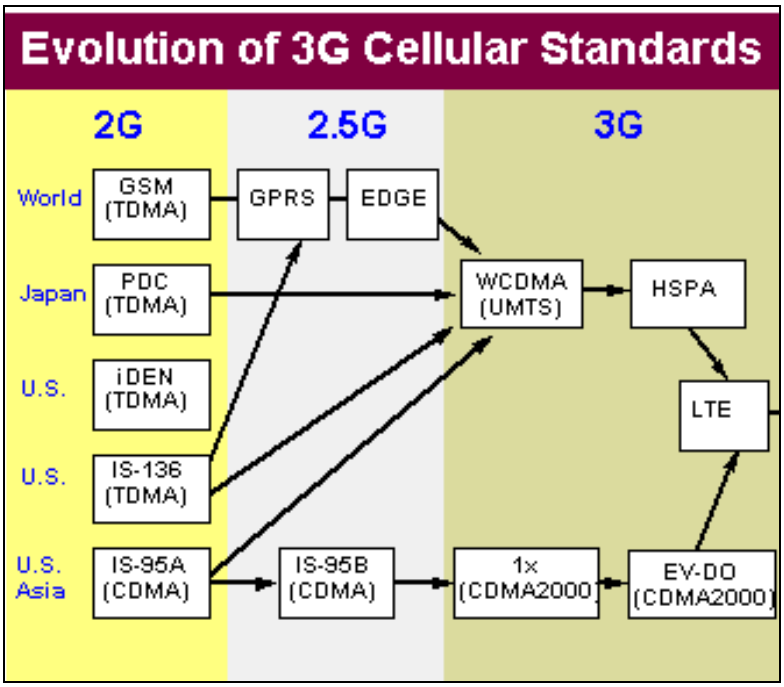

Figure 17 – 3G Technology – Option for Pakistan

Source: www.nqlogic.com

2.6 Beyond 3G

Looking at the technologies, which are beyond 3G, focuses us to the extremely high data rates. Now, instead of going for W-CDMA, or Evolved EDGE, in Pakistan we can head towards HSPA, HSPA+ and LTE, which are also referred to as 3.5 G or 3.75 G.

2.6.1 High Speed Packet Access (HSPA)

HSPA is a 3.5G expertise which gives theoretical download speeds of up to 7.2Mbps with an upgrade path to 80 Mbps and enables information transmission speeds of up to 14.4Mbit/s per user [38].

The problem dealing with the cellular telecommunications trade right this moment is the way to frequently improve the end-person experience, provide interesting services by way of a supply mechanism which affords improved velocity, service attractiveness and repair interaction. HSPA is a generic term to refer to improvements in the UMTS Radio Interface, downlink (HSDPA) and uplink (HSUPA. Both might be applied and co exists in the usual 5 MHz carrier of UMTS networks. There is no change required of the core community outside of the capacity increases that might be required to handle the anticipated increase in visitors generated [33].

a. **High Speed Downlink Packet Access (HSDPA)**

HSDPA introduces numerous new technical capabilities to the radio access network, which when mixed offer a major improvement for both end customers and operators. These capabilities are:

1. A new frequent Excessive Velocity Downlink Shared Channel (HS-DSCH) which could be simultaneously shared by multiple users,
2. The use of a shorter Transmission Time Interval (TTI) of 2ms, which enables increased velocity transmission in the physical layer,
3. Using fast scheduling which allows lodging of variations arising from altering radio condition,
4. The usage of Adaptive Modulation and Coding (AMC), leading to a higher knowledge fee for users with favorable radio conditions,
5. Using fast retransmission based mostly on quick Hybrid Computerized Response request (HARQ) techniques permits erroneous packets to be resent inside a 10ms window, making certain that the TCP throughput remains high [33].

b. **High Speed Uplink Packet Access (HSUPA)**

Enhanced Devoted Channel (E-DCH), name adopted in 3GPP for HSUPA, is subsequent step to HSDPA and the two are complimentary to at least one another. Evidently HSDPA is the extra superior of the 2 technologies, but when function facet-by-side the resulting system will profit with main knowledge transfer pace enhancements for receiving or sending [40].

Key technical capabilities launched with HSUPA are; a brand new dedicated uplink channel, introduction of H-ARQ and fast Node B scheduling. Through E-DCH, HSUPA employs hyperlink adaptation strategies much like these employed by HSDPA including: Greater-order modulation in addition to the present QPSK and sixteen-QAM. Equally to HSDPA, there will likely be a packet scheduler, however it's going to operate on a request-grant principle the place the UE (Person Equipment) requests permission to ship packets and the scheduler decides when and what number of UEs might be allowed to do so. Not like in HSDPA, delicate and softer handovers will likely be allowed for packet transmissions. Both, HSDPA and HSUPA, require no new infrastructure. The network tools want solely be updated with new software.

	ASDL	GERA	UMTS	HSDPA
Typical Throughput (5MHz)	**1 – 15 Mbps**	**1 Mbps**	**1 Mbps**	**10 Mbps**
Average Throughput (kbps / user)	**2048**	**160 – 200**	**128 - 300**	**500 – 700**
Capacity (user / cell)	**-**	**8**	**9**	**40**
Latency (ms for a 32 byte ping)	**5-200**	**260**	**120**	**60**

Table 3 - HSPA Data Rates

Source: www.umts-forum.org/component/option,com.../task.../Itemid,12/

2.6.2 HSPA+

Goal is to boost performance of HSPA primarily based radio networks by way of spectrum efficiency, peak information price and latency, and exploit the total potential of WCDMA based mostly 5 MHz operation. Necessary options of HSPA+ are downlink MIMO (A number of Input Multiple Output), greater order modulation for uplink and downlink, enhancements of layer 2 protocols, and continuous packet connectivity. In LTE portion, MIMO technology can be viewed. With MIMO technologies and higher order modulation, HSPA+ will eventually be able to delivering 42 Mbit/s peak bit fee within the downlink and 11 Mbit/s in the uplink over a 5 MHz channel. HSPA+ introduces an optional all-IP flat structure that reduces latency to around 10 ms and offers backhaul based on IP/MPLS transport. Base stations in IP flat architecture, evolves to an IP router that connects to the community via standard gigabit Ethernet connected to the Internet. By eliminating the need for RNC, the load on SGSN reduces, resulting in a big reduction of the fee per bit. HSPA+ continues to evolve, and future combinations of multicarrier methods and MIMO applied sciences could in precept achieve 84 Mbit/s peak on the downlink and 23 Mbit/s peak uplink. These charges could solely be achieved by operators with access to a number of adjacent paired 5 MHz bands. They're the very best data rates that may very well be achieved in

present 3G networks based mostly on 5 MHz WCDMA technology. Further enhancements can only come with a new cellular community technology. HSPA+ is a logical growth of the 3G/WCDMA approach, leveraging operator investments in HSPA and enabling a decrease cost per bit. It's also the stepping stone to a wholly new radio platform called 3GPP Lengthy Time period Evolution (LTE) [33].

2.6.3 Long Term Evolution (LTE)

In the present (HSxPA) specifications, systems are capable of supporting high-pace packet access for both downlink (up to 14 Mbps) and uplink (up to 5.seventy six Mbps). Although HSxPA programs provide substantial enchantment for packet data transmission over earlier UMTS methods, their designs had been restricted by compatibility necessities with previous generations of UMTS specifications. With the emergence of packet-based mostly mobile broadband programs corresponding to WiMAX 802.16e, it is evident that a complete lengthy

- time period evolution (LTE) of UMTS is required to remain aggressive in the lengthy term. EPS is the offshoot of 3GPP Rel-eight while engaged on Evolution of HSPA. Developed Packet System contains E-UTRAN (Evolved UTRAN) on the entry aspect and EPC (Advanced Packet Core) on the core side. EPC is also referred to as SAE (System Architecture Evolution) and EUTRAN is often known as LTE [38].

a. **Evolved Packet System (EPS) Architecture**

   In its most elementary form, the EPS architecture consists of only two nodes within the user airplane: a base station and a core community Gateway (GW). The node that performs control-aircraft performance (MME) is separated from the node that performs bearer-airplane functionality (GW), with a properly-defined open interface between them (S11), and by utilizing the non-obligatory interface S5, the Gateway (GW) might be split into two separate nodes (Serving Gateway and the PDN Gateway). This allows for independent scaling and development of throughput site visitors and management sign processing, and operators may choose optimized topological places of nodes throughout the network so as to optimize the network in different points [41].

   The essential architecture of the EPS contains the under mentioned network parts:

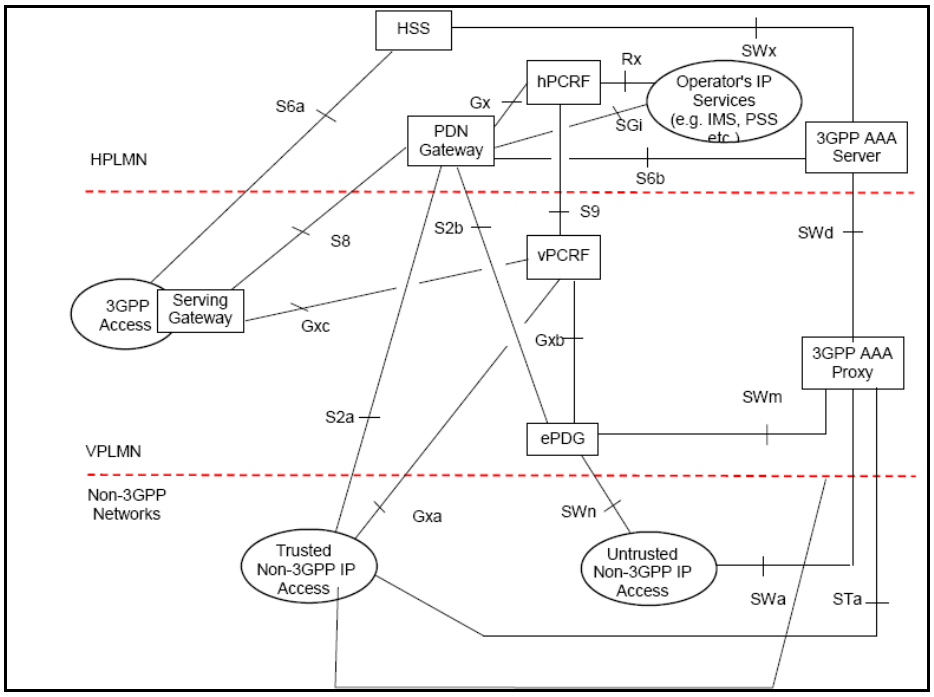

Figure 18 - Detailed EPS architecture view

Source: http://3g4g.blogspot.com/2010/03/ipv6-transition-in-cellular-networks.html

1. **Mobility Management Entity (MME)**

   MME manages mobility, UE identities and security parameters. MME features embody: NAS signaling and associated safety, inter CN node signaling for mobility between 3GPP access networks (terminating S3), Idle mode UE Monitoring and Reach capability (together with control and execution of paging retransmission), Roaming (terminating S6a in the direction of house HSS), GW alternatives (Serving GW and PDN GW choice), MME selection for handovers with MME change, SGSN choice for handovers to 2G or 3G 3GPP entry networks, HRPD entry node (terminating S101 reference point) choice for handovers to HRPD, Authentication, Bearer management capabilities including devoted bearer establishment.

2. **Serving Gateway**

   The Serving Gateway is the node that terminates the interface in direction of EUTRAN. For each UE associated with the EPS, at a given point of time, there is one single Serving Gateway. Serving GW features embody: the native Mobility Anchor point for intere Node B handover, mobility anchoring for inter-3GPP mobility (terminating S4 and relaying the site visitors between 2G/3G system and PDN Gateway), EUTRAN idle mode downlink packet

buffering and initiation of network triggered service request process, transport level packet marking in the uplink and the downlink, e.g., setting the DiffServ Code Point, based on the QCI of the associated EPS bearer, depending on the consumer and QCI granularity for inter-operator charging, lawful Interception, packet routing and forwarding.

3. **PDN Gateway**

   The PDN Gateway is the node that terminates the SGi interface in the direction of the PDN. If a UE is accessing a number of PDNs, there may be a couple of PDN GW for that UE. PDN GW functions embody: mobility anchor for mobility between 3GPP access techniques and non-3GPP access programs, policy enforcement, Per-consumer based packet filtering (by e.g., deep packet inspection), Charging assist, Transport stage packet marking in the uplink and downlink, e.g., setting the DiffServ Code Point, based on the QCI of the associated EPS bearer, lawful Interception, UE IP deal with allocation, packet screening.

4. **Evolved UTRAN (eNodeB)**

   The eNodeB helps the LTE air interface and contains functions for radio resource management, user plane ciphering and Packet Data Convergence Protocol (PDCP) [41].

b. **Evolved UTRAN**

3GPP is growing the evolution of mobile communications programs past GSM/EDGE and WCDMA-HSPA systems. '3G Cellular System Lengthy Time period Evolution (LTE)' targets capability and information rate speed and throughput enhancements and reduced latency to support new companies and features requiring greater levels of functionality and performance. Key characteristic embrace:

1. Reduced cost per bit
2. Enhanced service provisioning - extra providers at lower value with better person experience.
3. Flexibility of use of current/new frequency bands
4. Simplified architecture, open interfaces
5. Permits for cheap terminal energy consumption
6. LTE utilizes a new radio air interface know-how referred to as Orthogonal Frequency Division A number of Access (OFDMA) to supply a number of key advantages, including significantly elevated peak data rates, increased cell

edge performance, diminished latency, scalable bandwidth, co-existence with GSM/EDGE/UMTS methods, and reduced CAPEX/OPEX [38].

LTE is backward compatible with non-3GPP in addition to 3GPP technologies. Its ability to interwork with legacy and new networks, and its seamless integration of Web functions will drive the convergence between fastened and cell techniques and facilitate new kinds of services. LTE heralds a new period with the transition from circuit switched approaches for voice visitors to a totally packet switched model. This transition from current networks that combine circuit and packet switching to all-IP requires considerable simplification of the system architecture. In November 2007, one of the industry's first multi-vendor over-the-air LTE interoperability testing initiatives was conducted successfully. The primary field trials for LTE are planned for 2008, with business availability in 2009/2010 timeframe. LTE provides downlink peak rates of at the least 100Mbit/s, 50 Mbit/s in the uplink and RAN spherical-journey instances of lower than 10ms. LTE helps flexible carrier bandwidths, from 1.4MHz as much as 20MHz as well as both FDD and TDD. The targets for LTE include enhancing spectral efficiency, lowering costs, improving services, making use of recent spectrum and reformed spectrum opportunities and better integration with different open requirements.

The evolved UTRAN consists of interconnected E-Node Bs providing the developed UTRA U-aircraft and C-plane protocol terminations towards the UE. The E-Node B hosts the features for Radio Resource Administration, including Radio Bearer Management, Radio Admission Management, Connection Mobility Management, and Dynamic Resource Allocation [38].

c. **Access Scheme**

The technology resolution chosen by 3GPP for the LTE air interface makes use of Orthogonal Frequency Division Multiplexing (OFDM) and MIMO applied sciences, along with high rate modulation. LTE uses the identical rules as HSPA for scheduling of shared channel knowledge and fast link adaptation, enabling the community to optimize cell efficiency dynamically. In actual fact LTE is predicated fully on shared and broadcast channels and comprises no devoted channels carrying knowledge to specific users. This will increase the affectivity of the air interface as the network no longer has to assign fastened levels of useful resource to every person however can allocate air interface sources based on actual-time demand [31].

d. **LTE Downlink Transmission Scheme OFDMA**

Data Rates in WCDMA networks are constrained by the 5 MHz channel width. At bandwidths beneath 10 MHz, HSPA+ and LTE provide related performance for the same number of antennas. Use of a wider RF band, comparable to 20 MHz, results in group delay problems in WCDMA that restrict the achievable data rate. LTE removes these limitations by deploying OFDM technology to separate the 20 MHz channel into many slender sub-channels. Every narrow sub-channel is pushed to its maximum, and the sub-channels are subsequently mixed to generate the whole knowledge throughput. Assigning different sub-channels to completely different users leads to Orthogonal Frequency Division Multiple Entry (OFDMA) systems. OFDMA avoids problems brought on by multipath reflections by sending message bits slowly enough in order that any delayed copies (reflections) are late by only a small fraction of a bit time. 1000's of slim sub channels are deployed to ship many low pace messages concurrently that are then mixed on the receiver to make up one high velocity message. This avoids the distortion caused by multipath while maintaining a high bit rate. The slim sub-channels in OFDMA are allotted on a burst-by-burst foundation utilizing algorithms that take account of RF environmental elements reminiscent of channel high quality, loading and interference.

The above reveals a sign with 5 MHz bandwidth, but the precept is, after all, the identical for the opposite EUTRA bandwidths. Knowledge symbols are independently modulated and transmitted over a high number of closely spaced orthogonal sub-carriers. In E-UTRA, downlink modulation schemes QPSK, 16QAM, and 64QAM are available. Within the time area, a guard interval may be added to each image to fight inter-OFDM-image-interference resulting from channel delay spread. In EUTRA, the guard interval is a cyclic prefix which is inserted prior to every OFDM image.

e. **LTE Uplink Transmission Scheme SC-FDMA**

OFDMA properties are less favorable for the uplink as a consequence of weaker peak-to-average energy ratio (PAPR) properties of an OFDMA signal, leading to worse uplink coverage. Thus, the LTE uplink transmission scheme for FDD and TDD mode is predicated on SC-FDMA (Single Service Frequency Division Multiple Access) with cyclic prefix. SC-FDMA signals have better PAPR properties compared to an OFDMA signal. This was one of many primary reasons for choosing SCFDMA as LTE uplink access scheme. The PAPR characteristics are important for cost-effective design of UE power amplifiers. Nonetheless, SC-FDMA sign processing has some similarities with OFDMA sign processing, so parameterization of downlink and

uplink will be harmonized. There are completely different possibilities for generating an SC-FDMA signal. DFT spread - OFDM (DFT-s-OFDM) has been chosen for E-UTRA. SC-FDMA is technically just like OFDMA however is best suited for handheld gadgets as a result of it are less demanding on battery energy.

f. **LTE MIMO Concepts**

Multiple Input Multiple Output (MIMO) programs type a vital a part of LTE with a view to obtain the bold necessities for throughput and spectral efficiency. MIMO refers to using a number of antennas at transmitter and receiver facet.

MIMO antenna methods are a magic ingredient in the quest for broadband wi-fi programs with larger capability, performance and reliability. They provide a mechanism for bypassing the constraints imposed by Shannon's Regulation which states that there's a elementary restrict to the amount of knowledge that can be transmitted over a communications link limited by noise. Without noise, an infinite amount of knowledge could possibly be transmitted over a finite amount of spectrum. However, in reality, throughput is limited as a result of power is needed from the transmitter to beat any noise in the channel. Right this moment's technologies are approaching the ceiling imposed by Shannon's Legislation at which any further capability good points are essentially cancelled out by noise. All applied sciences are approaching the theoretical limit for spectral efficiency as all of them use methods reminiscent of efficient schedulers, larger order modulation, and adaptive modulation and coding to achieve roughly the same performance. Further positive aspects in throughput and data charges must come from strategies enabling the usage of larger bandwidths rather than from makes an attempt to squeeze more bit fee right into a channel. Shannon's Regulation applies to a single radio link between a transmitter and a receiver. However MIMO techniques create a number of radio links; each particular person link is proscribed by Shannon's Legislation however, collectively, they will exceed it.

g. **Downlink MIMO**

For the LTE downlink, a 2x2 configuration for MIMO is assumed as baseline configuration, i.e. two transmit antennas on the base station and two obtain antennas at the terminal side. Configurations with 4 antennas are also being considered. Completely different MIMO modes are envisaged. It has to be differentiated between spatial multiplexing and transmit diversity, and it will depend on the channel situation to pick out scheme.

1. **Spatial Multiplexing** allows transmitting different streams of data (single or a number of users) concurrently on the same downlink resource block(s). Whereas SU-MIMO increases the information rate of one user, MU-MIMO permits increasing the general capacity. Spatial multiplexing is just attainable if the cell radio channel allows it.
2. **Transmit Diversity.** As an alternative of accelerating knowledge fee or capacity, MIMO can be used to take advantage of diversity. In case the channel situations don't allow spatial multiplexing, a transmit variety scheme shall be used instead, so switching between these two MIMO modes is possible depending on channel conditions. Transmit variety is used when the chosen variety of streams (rank) is one.

h. **Uplink MIMO**

Uplink MIMO schemes for LTE will differ from downlink MIMO schemes to take into account terminal complexity issues. For the uplink, MU-MIMO could be used. Multiple user terminals may transmit simultaneously on the same resource block. That is additionally referred to as spatial domain multiple access (SDMA). The scheme requires just one transmit antenna at UE side, which is a giant advantage. The UEs sharing the same useful resource block have to use mutually orthogonal pilot patterns. To use the good thing about two or more transmit antennas but nonetheless hold the UE cost low, antenna subset choice will be used. In the beginning, this technique will be used, e.g., a UE could have two transmit antennas but just one transmits chain and amplifier. A swap will then choose the antenna that gives one of the best channels to the eNodeB.

i. **Spectrum flexibility**

The main focus is now on creating more usable frequencies instead of attempts to increase spectral efficiency. Obtain range technologies corresponding to MIMO can do this by sending the same data from two or more separate transmitters to an equal number of receivers, chopping down on the knowledge loss of a single transmission. Beam forming applied sciences are another approach, decreasing interference by steering radio hyperlinks in direction of a particular user. OFDMA is a third strategy that depends on growing flexibility in the usage of spectrum. By splitting a channel into thousands of very slender sub-channels, every on a different frequency, every carrying part of the signal, OFDMA supplies an making certain better support for global roaming and delivering future economies of scale.

j. **IMS - Role**

LTE/EPC has been formulated to assist and develop support for both business models i.e. Generation Community (NGN) and Fixed Cellular Convergence (FMC). This system enables all the technologies within to combine into IP based environment for convergence known as IP Multimedia Subsystem (IMS), to greatly reduce administrative and maintenance efforts. Altering access applied sciences at this time - from WLAN entry to an HSPA knowledge card for instance - can require full connection, registration and authentication on every entry community followed by manual intervention to switch from one to the other. Even when the cellular device helps both entry applied sciences, the information circulate can't be handed over seamlessly with out the person being aware of the change. The solution is to attach 3GPP and non-3GPP mobile networks to the core network by way of IMS. IMS permits seamless handover between multiple access applied sciences and supplies the necessary mobility and routing management. The core network sees the mobile community as one other IP network and does not must handle mobility, authentication or safety management as the consumer modifications access technology. IMS uses the Session Initiation Protocol (SIP) to allow quick connection between cell gadgets and the core network. Initial setup of knowledge sessions in conventional wi-fi networks can take between one and 15 seconds in contrast with milliseconds in a hard and fast network. The marriage of LTE with IMS will provide operators with a cost effective community that permits integration with the core community for customer care, billing and network management. It will present cell customers with an at all times linked excessive pace experience - actually unfettering the desktop [38].

2.7 “4G” Fourth Generation of Mobile Communication

In the market it is still not clear as what comprises of third generation technology, as term 4G is heavily being used in lieu. In fact 4G has come rather evolved from within 3G technology, as already discussed in evolution section above. Defining boundary line between 3G and 4G is no doubt difficult. Flavor of 4G i.e. WiMax (IEEE 802.16e) has already penetrated in the market and is aggressively being used. This flavor of WiMax has been accepted by ITU very recently and has declared it to be used with other technologies of 3G. Apart from this ITU is researching in introducing upcoming broad band mobile technology to be introduced as 4G under the name of IMT - Advanced. ITU recognizes IMT as two different entities known as IMT-2000 and IMT - Advanced to be implemented by potential users implementing 3G or

4G, spectrum. On international level ITU is recognized and authorized to define future wireless technologies. Sub department of ITU known as ITU-R, which deals with radio communication is authorized to define internationally accepted definition of 4G technology with all its parameters. In the phase wise option, first phase will comprise of collection of the parameters and entities of ITU-R process leading towards IMT-Advanced in its initial. Finally it will be called as the 4G technology, or IMT-Advanced.

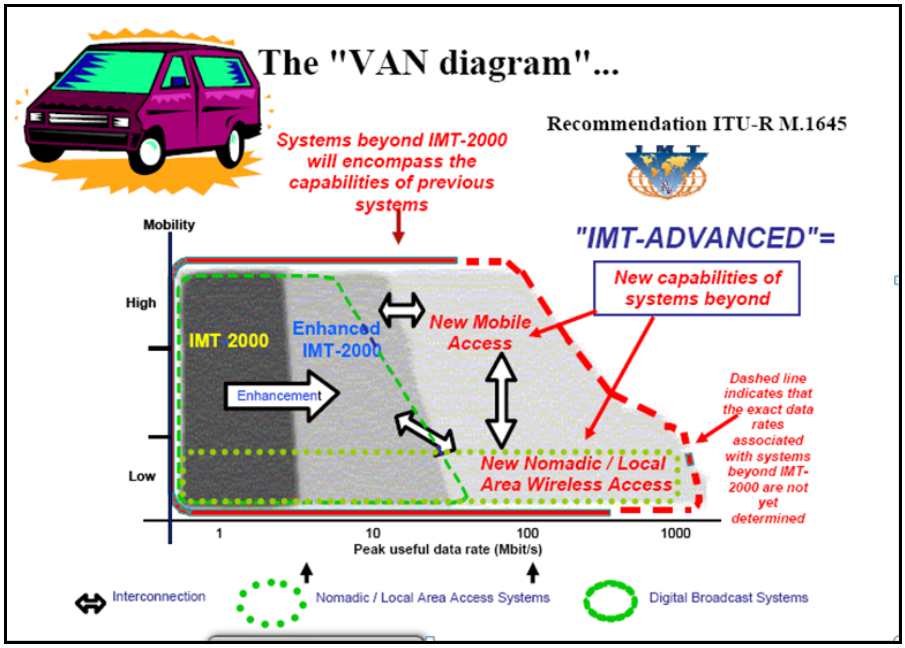

Figure 19 - 4G - Concept

Source: www.itu.int/itunews/manager/display.asp?lang=en&year=2008&issue=10&ipage=39&ext =html

4G group, according to the conventions enlisted for its implementation or to make to be internationally accepted as one of the fastest growing technology in the market which includes all the potentials which may enable its further expansion and growth. Its growth would in fact make it mature by passage of time. In a new era of wireless technologies 4G is still in the state of infancy. Like wise 3G, next generation i.e. 4G will also be implemented in phases and stages. The growth of 4G technology is braced to maneuver into the subsequent phases: i.e. defining rules for IMT-Advanced and secondly defining a barrier to finally decide which all technologies be included in IMT- Advanced technology. This would be the only way to get to know that what precisely 4G technology is [42].

2.8 Advantages of 3G

a. **High Speed Data**

3G provides high speed data right in mobile phone, limit of which presently is only 384kbps.

b. **Faster Connectivity to Internet**

3G will have faster connectivity on the go i.e. 2 mbps.

c. **Entertainment**

3G provides fast download of movies and songs and so much so, live streaming of TV and video.

d. **Video Calling**

Due to broadband facility video conferencing / video calling will be possible.

e. **Access to Important Documents**

If an important document becomes corrupted at very important event, you can immediately access it with 3G right onto your mobile phone.

f. **Online Gaming**

The most lucrative service for the young ones i.e. online gaming where ever you are, don't have to restrict your self to static computers anymore.

g. **Live News and Weather Forecasts**

With 3G value added push service live news and weather forecasts can be obtained daily before an unfortunate incident takes place and get know latest updates right away.

h. **Remote consultancy services**

Distant learning, online legal consultancy, live agriculture consultation etc are the services 3G will give to us sitting right at ones house.

i. **Navigation**

No more being lost, thanks to the navigation services of 3G.

j. **E-Commerce**

Buying items will be few licks away with 3G service.

2.9 Harm Full Effects of Cell Phone Radiations

a. The radiation can lead to memory loss

b. It can cause joint pain, muscle spasms, and tremors

c. It can also damage the nerves in the scalps

d. The blood cells are also more likely to leak hemoglobin due to prolonged exposure to radiation

e. It can also result in the reduced efficiency of white blood cells

f. High radiation can produce histamine in mast cells, which can stimulate asthma [43]

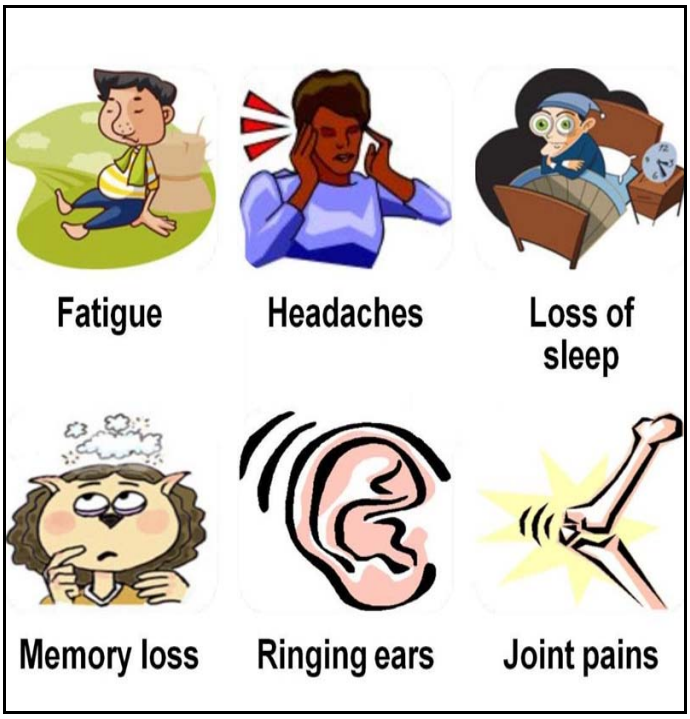

Figure 20 - Harm Full Effects of Cell Phone Radiations

Source: www.dalyit.com/Cell-Phone/Cell-Phone-Library/How-Cell-phone-Radiation-Works-/index.html

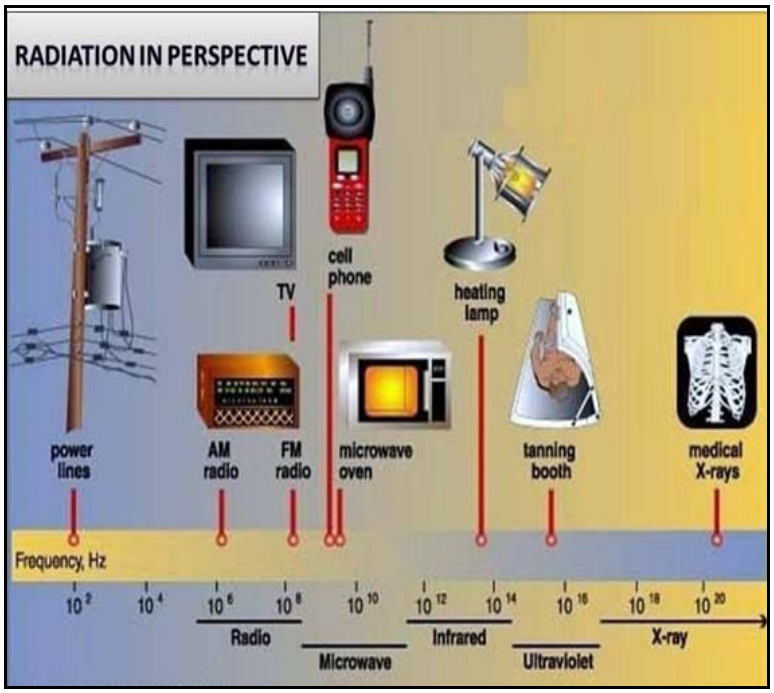

Figure 21 – Radiation in Perspective

Source: www.dalyit.com/Cell-Phone/Cell-Phone-Library/How-Cell-phone-Radiation-Works-/index.html

Electromagnetic radiation is made up of waves of electrical and magnetic power shifting at the pace of sunshine, in line with the Federal Communications Commission (FCC). All electromagnetic energy falls somewhere on the electromagnetic spectrum, which range from extremely low frequency (ELF) to X-rays and gamma rays. These radiations can harm human tissue if it is exposed to high ranges of RF radiation, according to the FCC. RF radiation has the power to warmth human tissue, much like the best way microwave ovens heat food. Damage to tissue could be caused by exposure to RF radiation as a result of the physique will not be equipped to dissipate extreme quantities of heat. The eyes are notably weak because of the lack of blood circulate in that space.

2.10 Ways to Reduce Harm Full Effects of Cell Phone Radiations

If you are worried about the potential hazards of cell-phone radiation, here are few ways to reduce your risk:

a. Use Phones with lower SAR.
b. Use a hands-free headset.
c. Use a phone that places the antenna as far away from you as possible.
d. Extend the antenna during use.

e. Limit calls inside buildings.

f. Use the phone in open spaces as often as possible.

g. Limit use by children [43].

CHAPTER 3

MARKET AND CONSUMER STATISTICS OF PAKISTAN

3.1 Introduction

Since independence, Telecom industry has seen many vicissitudes in Pakistan. The initial epoch of PTCL could be somewhat termed as its monopoly, as it was the sole communication service provider throughout the country. It was four years that took place for the Pakistan to jump into the new world of wireless technology; at last this was an end to the ages old monopoly of PTCL.

End 1990, it was the year when with the government interest and support along with international market interest in Pakistan threw open doors to new technology with utmost quality, cheap and healthy competition. Cellular technology for the investors in communication market was an welcoming indicator which brought about eye catching changes in the communication infrastructure and services. The new born GSM technology was warmly welcomed by all the stakeholders and triggered a lava of economy in Pakistan.

3.2 Pakistan Mobile Market

It is Pakistan's mobile market that is driving the vibrancy of the telecommunications market, and in turn it is high levels of competition and investment, as well as low tariffs and great consumer demand that are powering mobile growth. [44] Shift towards 3G is straightaway associated with the cellular market, by which, it is substantial to observe the present cellular market figures. Unofficial forecast predicts 135 million mobile users by end 2012. Presently tele-density of Pakistan is approximately 60% that is likely to rise to 80% by end 2012.

3.2.1 Market Share

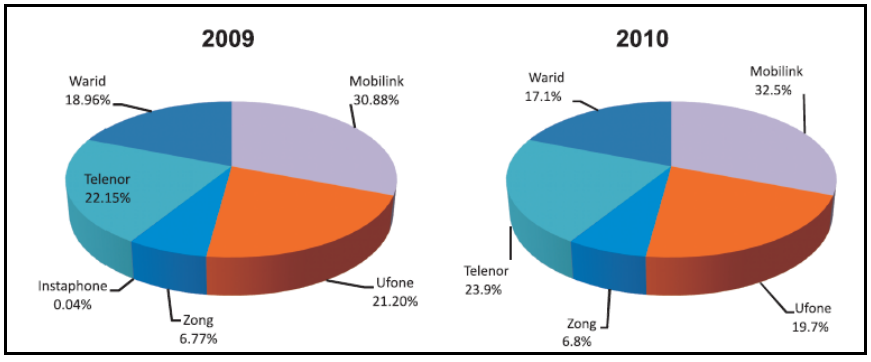

Figure 22 – Subscriber Wise – Cellular Market Share

Source: PTA Annual Report 2010

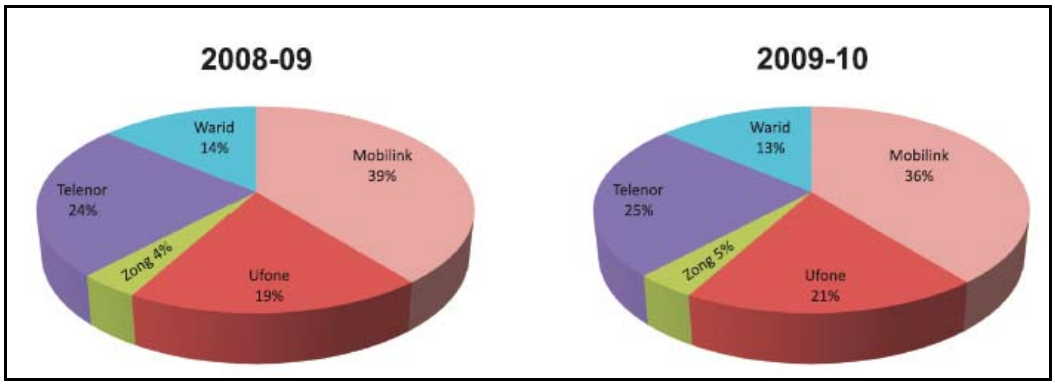

Figure 23 – Revenue Share by Cellular Operators

Source: PTA Annual Report 2010

3.2.2 Foreign Investments

Over 6.3 US$ billion were directly invested in telecom sector by foreign companies during last 5 years, among which UAE, Norway and USA remained the main players. Share distribution is as under:-

- UAE Contributed US$ 2 Billion with 32%
- USA Contributed US$ 890 Million
- Norway Contributed US$ 639 Million
- China Contributed US$582 Million
- Other countries contribution includes Singapore, Netherlands, UK, and Hong Kong [45]

3.2.3 Handset Market

Pakistan has seen tremendous growth in mobile market, with Nokia leading the market by 53 percent, following behind is Samsung with 20 percent and 15 percent share is of Sony Ericsson. China's Huawei and ZTE companies are grabbing the market share at fast pace, in this price sensitive market. Perhaps, Nokia 1110/1112; Samsung E250; are the mostly used handsets by low middle class population in Pakistan.

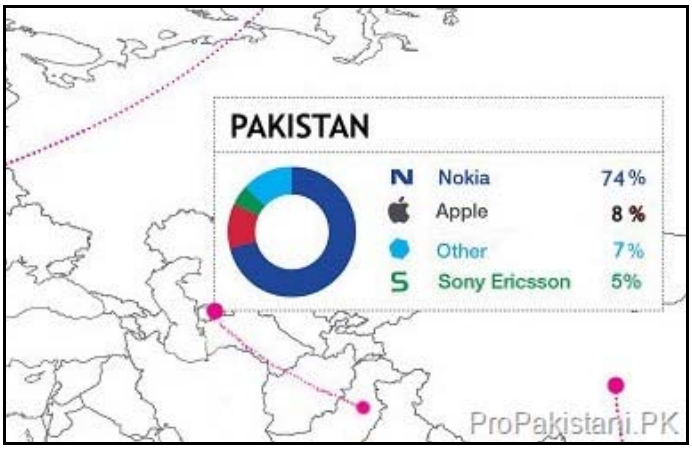

Figure 24 - Mobile Handset Market

Source: propakistani.pk/2011/03/02/74-pakistanis-on-mobile-internet-use-nokia-devices/

3.3 Pakistan Internet Market

Internet is the main gear determining the deployment of 3G in Pakistan; the Internet usage actually will determine the significance of early deployment of 3G in Pakistan. As already mentioned that use of Internet is maturing day by day in Pakistan and 17mn Internet consumers are being predicted by end 2011, with an increasing pace of 11%, although PC owners are very less in our region. Moreover, a un maintained fixed local loop infrastructure indicates tiresome internet speed. There is a lust for broadband internet in Pakistan, however, expensive service entails that this shift may be very slow, but forecast reveals that incursion would stay below 1 percent until 2012 [44].

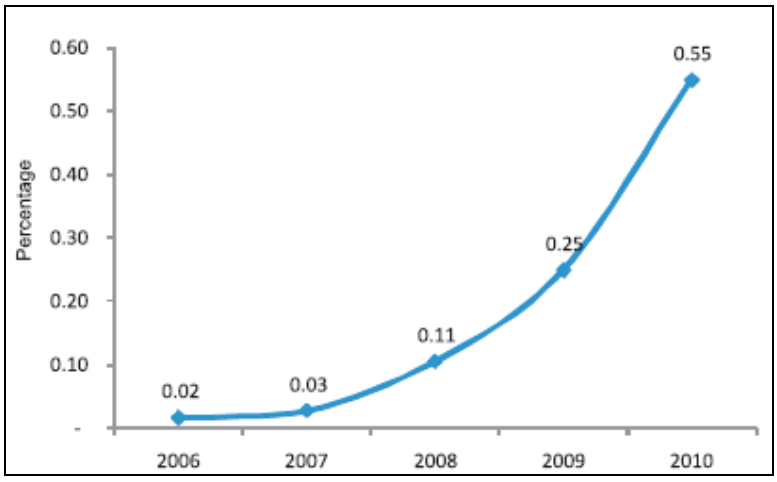

Figure 25 - Broad Band Penetration in Pakistan

Source: PTA Annual Report 2010

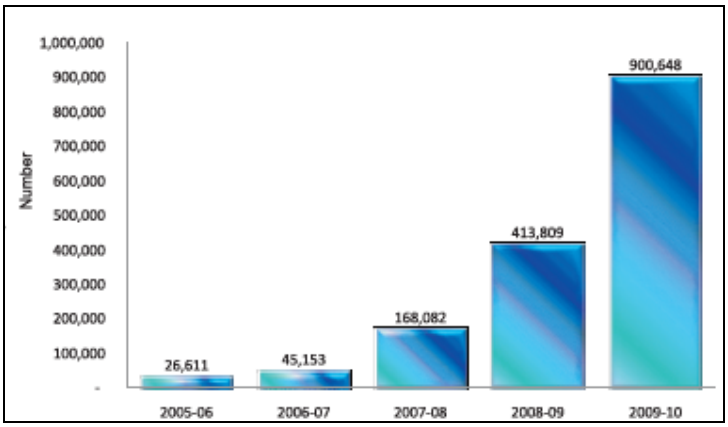

Figure 26 - Broad Band Subscribers in Pakistan

Source: PTA Annual Report 2010

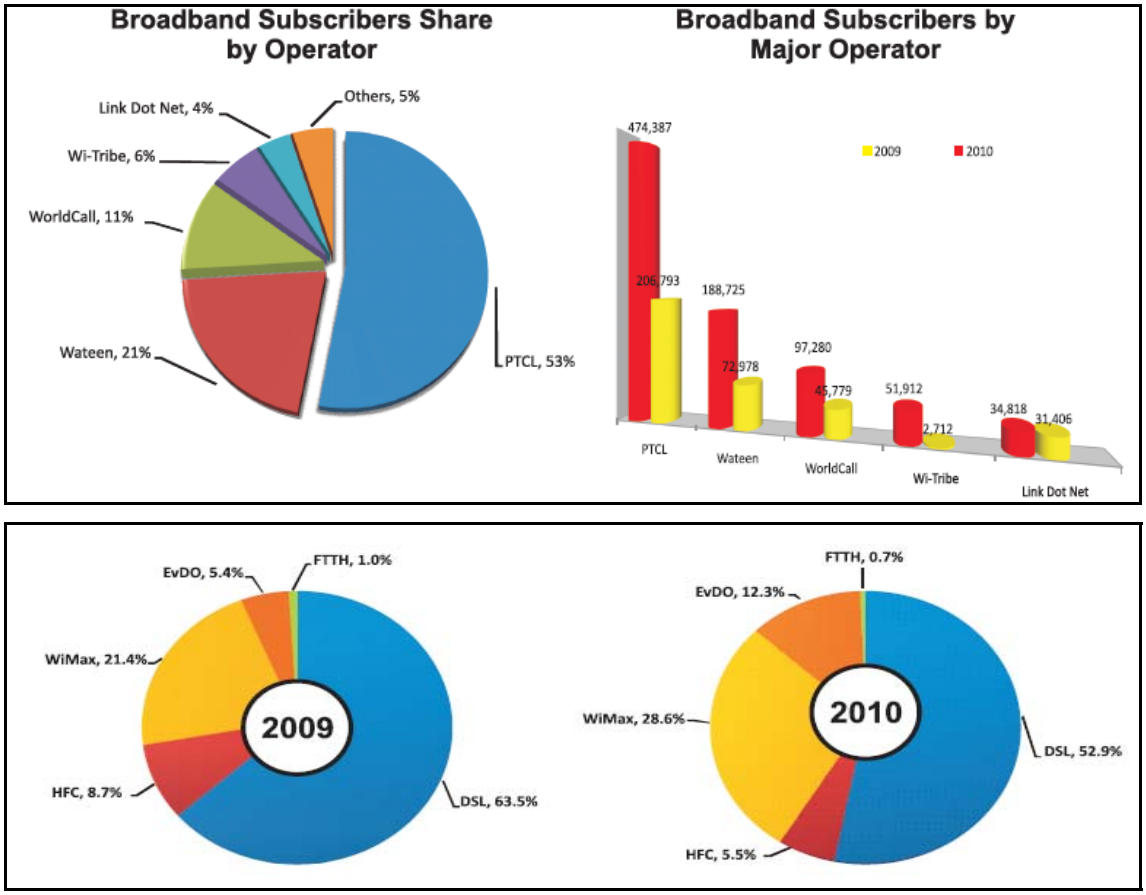

Figure 27 - Broad Band Subscribers Comparison

Source: PTA Annual Report 2010

3.4 Business environments in Pakistan

The immense licensing fees consociated with 3G auction, likewise the gestated CAPEX and OPEX, might foster further FDI in Pakistan. In spite of the speedy development and the huge

investments, Pakistan seems to be at the bum rather than being the crown. Apart from immense increase in taxes and regulations, fees imposed on to the mobile operators region's cellular market do have splendid scope. However, there are concerns that inward investment could be moderated in the short-term at least, by political instability, which could cause economic uncertainties. The government will do all it can to ensure that Pakistan's telecoms sector retains its momentum and this it hopes to do by encouraging investment from the world's largest handset manufacturers.

Pakistan seems to be the hub and motivator of business environment, which is observant providentially by the huge investments welcomed in the wireless technology during the previous few years, however lingering deep down in world ranking statistics. On the other side, PTA accounts first-rate as their part in pouring in FDI, as the market is staggeringly competitive, which offers vast growth potential, not only in the cellular market, but also broadband internet, both DSL and wireless. Nevertheless, Pakistan persists in political turmoil and cannot confidently offer unchanged market, may it be economically or politically. Apart from it, our telecoms sector presently contributes somewhat 2 percent of Pakistan's total GDP and income remained PKR 357.7 billion in 2009-10. This sector got US$ 6.3 billion of Foreign Investment in the current yea. These statistics suggest that Pakistan's telecommunication sector is in excellent condition and extends the investor great opportunities. So much so that the government, having seen a number of carriers enter and transform Pakistan's mobile market in recent years, now aims to offer incentives for the manufacturers of handsets and other telecoms equipment, to make Pakistan a popular manufacturing base [44].

3.4.1 Top Twenty Outsourcing Detonations - Pakistan

Security imbalance and rapid development / deployment of technology in Pakistan is the contradictory phenomenon for the world. As highlighted in a leading magazine an article published on June 4, 2009 by Rachael King, among top twenty outsourcing detonations Pakistan is among them, consorting to consultation firm for management. Despite increasing instability security environment in Pakistan due heavy military operations on western border and continuous migrations from the area Pakistan made a substantial hop from #30 in 2007 to #20 in 2009.

This rise in the ranks happened without much institutional support and lack of coherent policies. In my opinion, this represents the very nature of Pakistani culture. Resilience and the will to carve out ways to succeed is part of the Pakistani fabric. This is one of the many

ways Pakistanis are answering the challenges posed by the current security environment. Consider for example the upcoming gathering of Pakistanis in Silicon Valley. One session is dedicated to discussion of how can entrepreneurship promote development and stability in Pakistan.

3.5 Pakistan Consumer Market of Mobile

To break PTCL's strong monopoly, GSM technology had to be launched in the country, moreover to adopt the most popular, mobile telephony. It emerged and adopted strength with the passage of time by diffusing into the rural and remote areas. Thence, need was produced for GSM by novice consumers who never had opportunity to use any kind of telecommunication service. At that, time there used to be high tariffs, costly cell phones, and restricted mobility. After the entry of the technology giants a breakthrough occurred in the mobile market; creating cheaper handsets and cheaper tariffs with more coverage/mobility. Deployment of 3G in Pakistan, the market may not be present as yet, as there is less demand for the wireless internet services, however 3G applications and services could enable it for Pakistan. Technical aspects of 3G technology and other specifications were discussed in detail in chapters 2 . Consumer is least pushed about the technology being used in his handset rather these are the applications and data rate being offered. Hence the technology is only triggered by the applications provided to the customers.

3.5.1 Consumer Revolution in the Urban Areas

In the urban areas, the 3G talk is believed to be corporate centric. It is often assumed that early adopters will be corporate customers for 3G, but mobile multimedia- games, entertainment and the like are much more consumer oriented than the buttoned down sober suited business people. Applications like VoIP, Moving Images, File transfer , Downloading Software , Virtual Home Environment , Web Browsing, Document Sharing/ Collaborative Working, Audio, Home Automation, Remote LAN Access, Electronic Agents, Dynamic Authoring, Job Dispatch ,Electronic commerce, Vehicle Positioning etc. are few from the current known possibilities and don't limit brand new introduced in the future. [15]

- **Audio**

  3G will offer MP3 files directly to downloadable into the mobile phone from the servers. This service will provide opportunity to the provider to benefit from the copyright owned MP3 material made available to the consumers.

- **VoIP**

3G technology will provide higher rate and VoIP for the first time on handheld devices. VoIP is additional services using the regular voice service which can never be substitute for the standard voice service as VoIP service requires broad bandwidth.

- **Still Images**

  Still images such as photographs, pictures, letters, postcards, greeting cards, presentations, and static web pages can be sent and received over mobile networks just as across fixed telephone networks. Once captured, images can then be sent directly to Internet sites, allowing near real-time desktop publishing.

- **MMS**

  Sending/Receiving small video clips in a cellular technology have manifold market applications, which include security monitoring of parking areas, buildings, parks etc for robberies, continuous monitoring / sending in advance pictures/condition of the patients from an ambulance to a hospital and important video notes taking from the conferences.

- **Virtual Home/Office Environment**

  From the comfort of his home or office, one can easily monitor his other building, or may be from a resort in vacation i.e. your valuable property is right in front of you where ever you go.

- **Electronic Agent**

  Electronic agents are defined as mobile programs that go to places in the network to carry out their owners' instructions. They can be thought of as extensions of the people who dispatch them. Agents are self-contained programs that roam communications networks delivering and receiving messages or looking for information or services. UK’s telecom giant the Orange has a vision of mobiles waking up people, reading emails, purchasing items on the go, receiving/providing consultancy services, finding the best route for destination, and so much so translating conferences into multiple languages with in next few years.

- **Software Downloading**

  Software’s/Applications will be heavily downloaded electronically from the internet instead buying a huge pack box containing a CD from the market. Directly downloading software’s have quite a number of advantages due to its environmental friendly nature as no packing material will be there to throw away, it would be quick and easy which adds value to money i.e. don’t have to pay transportation fee. [15]

3.5.2 Revolution for the users in the Rural Areas

Health and education are the main concerns for any developing country. Likewise, in Pakistan with the deployment of 3G in rural areas, there is great potential for social and economic revolution by merely changing the conditions.

- **Tele-Healthcare**: Also known as e-health and Telemedicine Trends

  In the developed countries, people have changed the traditional way of making simple communication call which they use to make and have gone much beyond it hunting for the new opportunities.

  Examples

  - **Remote Patient Monitoring System** In National University FAST, Islamabad there is a Next Generation Intelligent Networks Research Center working on a project known as "Remote Patient Monitoring System" focusing on Antenatal Care. It is, being funded by National ICT R&D, Government of Pakistan for the last 3 yrs. Their aim is to manufacture all in one, efficient, remote patient monitoring system that can, in the call of emergency can immediately be deployed to provide necessary medical services to the far flung areas of the country right at their door step.
  - **Speech Recognition/Language Translator** Jahanzeb Sherwani did his PhD research in making a software by which it will recognize the local / regional language and immediately translate it into the desired language with out delay. It will be useful to provide health care in rural areas without the need of literacy or language differences.
  - **Vision for Medical Remote Monitoring** In the developed nations, great emphasis is always given on provision of connected services at reduced rates, which is achieved through smart and intelligent devices. Following is AT&T's vision for medical remote monitoring:

Figure 28 - Medical Remote Monitoring

Source: Telecompk.net/2009/06/29/mobiles-and-healthcare-telehealth-and-telemedicine-trends/#more-4513

- **Improved Quality of Education**

  There has always been shortage of the teachers for huge number of student. The ratio for an ideal situation should be one-to-one between the student and the teacher. The gap between the ratios is increasing with the passage of time resulting in losing interest in education. "Learning 2.0 platform is a new comer in the Pakistan education industry. Consider the possibilities for just-in-time learning: educators record their multi-hour lectures with a simple webcam, tag and upload them to the Learning 2.0 Platform as small interactive chunks. Students can repeatedly review the relevant information without enduring the entire session. Deep tagging metadata allows them to jump instantly to that specific section within the video for the information they need to learn.

  Examples

  - Aziz Bhatti, Principal at the Federal Government Model School for Boys G-6/4 in Islamabad was videotaped giving a lecture about Chemistry. Students tag the video while watching and their tags are indexed and made available to all who subsequently

watch the presentation. Students can also comment upon their peers' tags and all comments are emailed to the teacher for response and interaction. Educators can also provide students with links to their lectures and assignments to tag as a class project. With this technology they can tag 'chapters' and 'topics' within the media file with a descriptive text for each tag. Additionally, all tags can be exported and distributed as a blog. [46] How do these deep technologies specifically enhance learning?

- They increase the granularity of indexed media, allowing specific parts of video lectures to be more easily remixed, linked, and reused.
- They engage students to co-create content via annotation of lectures.
- They make media as an instructional tool more efficient since reading or reviewing streaming video is more time consuming than print media.
- Also, these deep technologies enhance the educational content. The more the commenting and annotating, the more valuable the learning asset becomes as the wisdom of numerous and diverse interested parties add layers of collective intelligence to the video. Furthermore, specific moments of time within these videos can be instantaneously identified and retrieved with the Learning 2.0 Platform search engine.
- Consider the opportunity for enhancing the quality of education in Pakistan by harnessing thousands of video lectures produced by the top teachers throughout the country. This digital archive could be searched as indexed meta data by key words within the annotations. Not only would this video library complement and extend traditional learning, but it would also scale giving millions of student's access to a quality education.

- **Distance Learning**

  In Pakistan there is a trend of Ghost's schools. These are the schools which do not exist physically rather exist on papers only. Reason is the pay back of teachers as compared to their expenditures. By the introduction of 3G technology and the required application used, a strong basis could be made to provide good quality of education even in the remotest villages and towns. The developed countries are already providing quality education online and dishing out degrees to the successful students. In our country, the adoption would be in phases. It would demand enhanced resources for providing learning to the students in an optimum fashion.

3.6 Key Telecommunication Parameters

The following are the key parameters of Pakistan Telecommunication:

Category	2010
Fixed-line services:	
Total number of subscribers	6.08 million
Annual growth	-7%
Fixed-line penetration (population)	3.8%
Fixed-line penetration (household)	23%
Internet:	
Total number of subscribers	3.7 million
Annual growth	6%
Internet subscriber penetration (population)	2%
Mobile services:	
Total number of subscribers	100 million
Annual growth	8%
Mobile penetration (population)	60%

Table 4 - Pakistan – key telecom parameters

Source: www.budde.com.au/Research/Pakistan-Telecoms-Mobile-Broadband-and-Forecasts.html

Despite a faltering economy and speculation that the mobile market was saturating, Pakistan still managed to grow its mobile subscriber numbers in 2009 and again in 2010, reaching 100 million subscribers (just over 60% penetration) by the middle of 2010;

Growth in mobile subscribers had slowed to an annual rate of 8% in 2009 and slowed even further in 2010 (to an estimated 5%), modest indeed compared with the earlier boom years;

Importantly, the mobile sector was continuing to grow in the face of a range of challenges;

The deregulated market structure was certainly working well in the mobile segment of the market, with five operators competing vigorously for market share;

Whilst broadband Internet penetration still remained low in relative terms in Pakistan (a broadband subscriber penetration of 0.5% by mid-2010), 2009/10 had witnessed a continuation of the strong surge in broadband services that started in 2007 and looked set to continue;

Growth in the country's fixed-line market remained sluggish; fixed tele-density stood at less than 4% into 2010 with the numbers expected to only edge up slightly in the short term;
One positive factor in the emerging fixed market has been the success of wireless local loop technology which was supporting around 42% of all fixed subscribers by early 2010.

CHAPTER 4

REGULATIONS OF MOBILE TELEPHONY IN PAKISTAN

4.1 Regulation Enabling the Business Environment

This is the era in which regulatory bodies not only handle allocation of the spectrum or technology but their job is much more dynamic and beyond the boundaries of existing parameters. Technology is changing so rapidly, that it cannot stay in the grips of even developed countries. Rules and regulations should be formed in such a flexible manner that may the have the capacity to absorb upcoming technologies smoothly. These were the capabilities of regulators that how well they attracted the entry for auction of 3G spectrum and discouraged collisions. No single formula can be applied to all; regulator has to implement the rules and policies to attract the market and to benefit the Government.

4.2 Pakistan Telecommunication Authority

PTA is the regulating body of telecommunications sector in Pakistan. It came in to being in 1996.

4.2.1 Functions

PTA's functions include:

- To regulate establishment, operation, and maintenance of telecoms systems and services in Pakistan;
- To receive and dispose of applications for the use of radio-frequency spectrum;
- To promote and protect the interests of users of telecoms services in Pakistan;
- To promote the availability of a wide range of high quality, efficient, cost effective, and competitive telecoms services in Pakistan;
- To promote the modernization of telecoms systems and services;
- To investigate and adjudicate complaints and claims made against licensees arising out of alleged contravention of the provisions of the above Act;
- To make recommendations to government on policies with respect to international telecoms, the provision of support for participation in international meetings and arrangements to be executed in relation to the routing of international traffic and accounting settlements [47].

The PTA has helped Pakistan's telecoms industry to attract rising levels of FDI both from existing operators looking to enhance networks, and from foreign companies looking to enter

Pakistan's telecoms market via acquisition. In the year 2006 alone, there were five major international acquisitions. [44]

4.2.2 Mobile Cellular Policy 2004

Mobile Cellular Policy was developed in 2004 to encourage and smoothly function the mobile operators (Annexure A).

- **Functions**
  - Promotion of efficient use of radio spectrum;
  - Increased choice for customers of cellular mobile services at competitive and affordable price;
  - Private investment in the cellular mobile sector;
  - Recognition of the rights and obligations of mobile cellular operators;
  - Fair competition amongst mobile and fixed line operators;
  - An effective and well defined regulatory regime that is consistent with international best practices [48].

Band (MHz)	Uplink (MHz)	Downlink (MHz)	Total Available	Recognised Standards	Notes
800	835 – 845	(none)	(10 + 0) MHz	GSM 850 CDMA 800 AMPS/DAMPS 800	Corresponding band not available
900	890 – 895	935 – 940	5 + 5 MHz	GSM 900	Additional 5 MHz is likely to be available, exact details will be mentioned in IM document.
1800	1710 – 1740	1805 – 1835	30 + 30 MHz	GSM 1800	Potentially more. Under re-farming.
1900	1900--1910	1980-1990	10 + 10 MHz	GSM 1900 CDMA 1900 (IMT 2000)	Small encroachment on lower IMT 2000 guard band. Under re-farming.
2100	Currently fixed links (PTCL, SSGC)			IMT 2000	Under re-farming

Figure 29 – Available mobile cellular bands and spectrum

Source: www.pta.gov.pk/media/Mobile_Cellular_Policy_Jan_28_2004.pdf

FAB was instructed to reschedule the 2100 MHz band to be used for 3G services by end 2005.

- **Policy for Auction of 3G Spectrum**

  As per Mobile Policy 2004 auction price for 3G is suppose to be in reference to 2004 auction price.

The licensees will also be entitled to bid for additional spectrum in the 2100 MHz (3G) band when it becomes available.
In the context of 2100 MHz band, the GoP recognises its importance to enable mobile licensees to upgrade technology as spectrum becomes available. For this reason it is providing a degree of certainty in respect to the third generation mobile cellular technology. While auctioning spectrum in 2100 MHz band, the reserve price per MHz per annum will be set by reference to the 2004 auction price
If there is additional spectrum which is not required by licensees and if any other applicant requests its use for non-cellular services, subject to confirmation of spectrum by FAB, PTA may announce an auction within a reasonable time of the formal request.

Figure 30 – Policy Auction of 3G Spectrum

Source: Section 5.2, PTA's Mobile Cellular Policy, 2004

4.2.3 Broadband Policy

The definition of 'Broadband' varies from country to country, but it is generally accepted as high speed, 'always on' Internet connection. Various organizations like the ITU, OECD and international regulators specify the minimum download speed of a broadband connection ranging from 128 Kbps to 2 Mbps or higher. The 'Always On' facility as opposed to the 'dial up' (10s of KBps) means that the user has access to the net as soon as he switches his internet browser on and does not need to dial the ISP number for a connection. As illustrated in Figure 1, most applications can be adequately supported if the minimum user speed is around 128kbps, accordingly broadband in Pakistan will be defined as 'Always on Internet connection with a download speed of at least 128kbps connectivity'. This download speed target will be subject to an increase as the bandwidth prices reduce, local content becomes available and there is a general increase in awareness of broadband.

- **Objectives**

  The Broadband policy is designed to achieve the following objectives:

  1. Spreading of an affordable, 'always on,' broadband high speed internet service in the corporate/commercial and residential sectors across Pakistan.
  2. Encourage the entry and growth of new service providers while stimulating the growth of the existing ones at the same time.
  3. Encourage private sector investment in local content generation and broadband service provision (Annexure B).

4.3 3G Licenses

It is more than 5 years now that 3G auction in Pakistan is still awaited. It was suggested by PTA in 2007 that 3 licenses of 3G would be auctioned by end 2007. After that it was notified that it would be auctioned by end 2008. Dated 2008, Shehzada Alam Malik of Pakistan Telecommunication Authority said, we will issue three 3G licenses to the already operational cell phone companies in the country for which bidding is expected during September to December this year. Almost all of these companies working in the country are having shown an interest in the new license. Secretary Cabinet Division, Abdur Rauf Chaudhry has said that 3G services would be available to mobile users in Pakistan by the end of 2011 [49].

In between PTA however did suggest delaying of 3G auction as according to them; time is not right as the market is not as yet suitable. Nevertheless, this may remain as such until the launch of 3G technology, and rival of 3G such as WiMAX and EvDO may not let it happen.

CHAPTER 5

IMPEDIMENTS AND ISSUES OF 3G DEPLOYMENT

5.1 International 3G Impediments and Issues

At very slow pace, our country is at the position where the developed countries were long ago. Thence, it is worthwhile noting market views of these developed countries before we deploy 3G services.

As with all new technology standards, there is uncertainty and the fear of displacement. Third Generation (3G) mobile is topical and contentious for several reasons:

- Because the nature and form of mobile communications is so radically changed, many people do not understand how to make money in the non voice world, and do not understand their role in it.
- 3G licenses have been awarded around the world, in many cases at huge cost, necessitating that existing mobile communications companies in the 2G world think about and justify their continued existence.
- 3G is based on a different technology platform- Code Division Multiple Access (CDMA) that is unlike the Time Division Multiple Access (TDMA) technology that is widely used in the 2G world.
- The US, Japanese and European mobile players all have different technology competences and are now unified in this single standard- the separate wireless evolution paths and European wireless leadership are thereby challenged
- Japanese network operators are the first to implement 3G networks in the year 2001, and Japanese terminal manufacturers, who have not had much market share outside their home market, are the first with 3G terminals
- Many industry analysts and other pundits have questioned the return on an investment in 3G technology- questioning whether network operators will be able to earn an adequate return on the capital deployed in acquiring and rolling out a 3G network.
- Many media and Internet companies have shown a strong interest in using 3G technologies as a new channel to distribute their content, opening the opportunity for new entrants and new partnerships and value chains.

5.2 Impediments and Issues in Pakistan

No doubt, Pakistan Telecommunication Authority has put in their best to timely launch and deploys 3G services, but still there's been more than 5 years delay before it could actually

happen merely because of two major reasons, one at the government level and the other at the operators.

5.2.1 Ministry of Information Technology and Telecom

Pakistan Telecommunication Authority forwarded it recommendations to Ministry of Information Technology and Telecom (MoIT&T) mentioning the terms on which 3G spectrum would be auctioned. MoIT&T further submitted these recommendations to the Cabinet Division for deliberations and further approval in April 2009. Unfortunately, the case is still pending at MoIT&T for which PTA seems to be helpless to move ahead prior to a legal affirmation by MoIT&T. Unless, cabinet division takes some decisions, no progress will be evident. In case the cabinet accords its approval, then PTA is more likely to publish the relevant legislation, regulatory processes, and requirements. In the meantime, PTA ought to be working on these, but probably their work is not available to the public at large.

5.2.2 Availability of 3G Frequency Spectrum

Frequency Allocation Board (FAB) was instructed in Mobile Cellular Policy, 2004 to clear 2100 MHz, spectrum for use of 3G services by end 2005, which has still not been made available.

5.2.3 Broadband Requirement

In Pakistan there only 0.9 million population using the broadband facility, this number less than 1% of the tele-density, and there seems to be very less growth expectancy. Following graph shows the annual increase in broadband users and general trend.

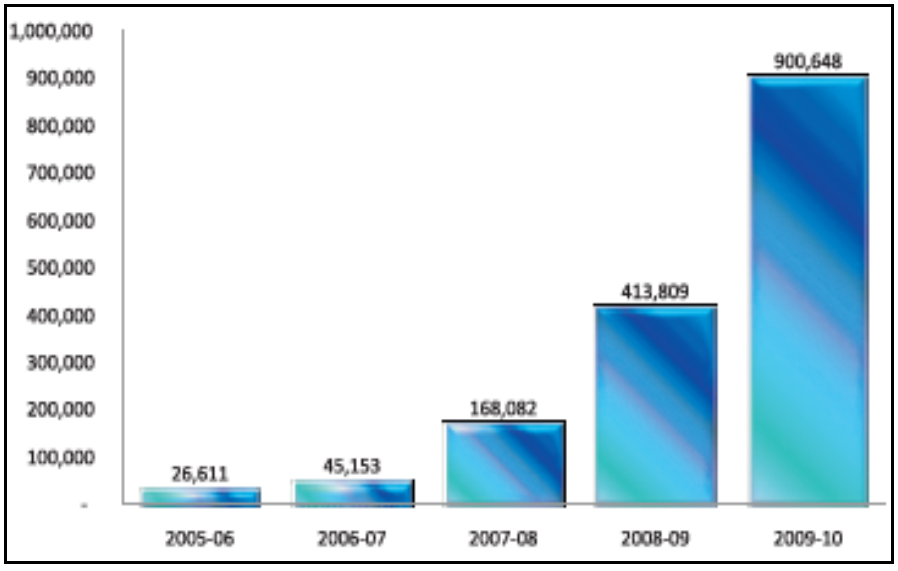

Figure 31 –Broadband Subscribers in Pakistan

Source: PTA Annual Report 2010

5.2.4 4G Technology Momentum (Roadmap / Policy for Launch of 4G)

World is rapidly switching over to 4G as it is becoming necessity of every literate person of the world. In Pakistan if 4G gains momentum right from the outset then it would be difficult for the mobile operators to sustain them selves. Pakistan having low literacy rate dictates less numbers of broadband users, hence less probability of mobile operators to earn revenue in 3G. i.e. Pay huge license fee and install heavy infrastructure. Mobile operators therefore would like switch over to 4G directly to avoid above mentioned cost instead of paying the spectrum and infrastructure fee twice.

5.2.5 Tariff War

Main reason for which mobile operators are hesitant is that they are pushed against the wall in ongoing tariff wars as visible from the figure.

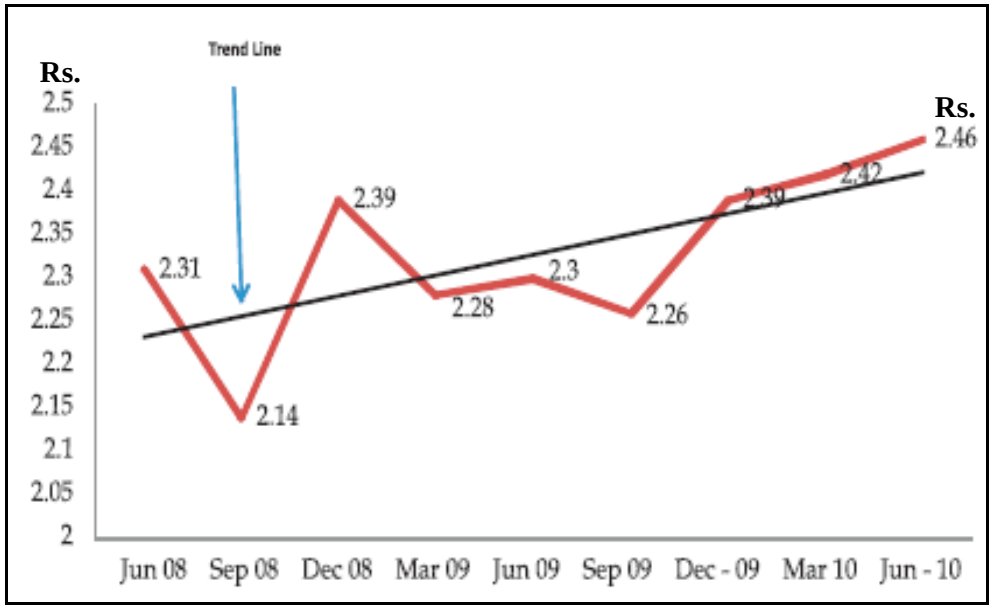

Figure 32 – Average Revenue per user per month

Source: PTA Annual Report 2010

5.2.6 Deployment of 3G Like Services (WiMAX / EVDO)

Since EV DO launched by PTCL is a flavor of 3G Technology which has already been launched along with WiMAX by different operators therefore there is reluctance of acceptance of early deployment of 3G technology as the mobile operators do not see scope in it.

5.2.7 Cost of 3G Handsets

Most of the population of Pakistan is poor. They will find it difficult to buy 3G handset.

5.2.8 Local Language Content Development

Most of the population of Pakistan can only read Urdu or their regional language, it is still difficult for them to read / write a simple text message so what about complicated advanced applications of 3G handsets.

5.2.9 Limited Trial of 3G Services

In Pakistan GPRS/EDGE usage is limited due to it high cost and limited speed, therefore trend of using internet on mobile is not gaining popularity, moreover Pakistani users are unaware of the quality and benefits of 3G services.

5.2.10 Role of Etisalat (MoU with PTCL)

It is anticipated that Etisalat is not letting the government of Pakistan to auction 3G license in Pakistan, due to its agreement of purchase of 26 percent shares in PTCL. We know that 3G license auction has been delayed notably in Pakistan. Earlier it was reported that 3G licenses will be auctioned in February 2009, however, it couldn't happen. We know that there was a section in PTCL's sale-purchase agreement that government of Pakistan will not issue any further Telecom license in Pakistan for next 7 years. Meaning that no further license to any telecom operator till 2013. A source who spoke with high ups at Ministry of IT and Telecom, got it confirmed that 3G license will be a telecom license in nature, with fresh attributes – meaning that if there was this point mentioned in PTCL's sale agreement then government of Pakistan cannot issue any new telecom license (that is a 3G license) till 2013. [50]

CHAPTER 6

ANALYSIS AND REMEDIAL MEASURES

6.1 Introduction

What brings in the change is the innovation and continuous improvement within the existing resources, and with either of the technology. The beauty in auction and shifting to a higher generation service lies within its technology independence. However there are some issues, which are to be catered for, are the market readiness, business issues (e.g., pricing, market segmentation), service issues (e.g., coverage, service portfolio and QoS) and technical challenges (e.g., spectrum availability, maturity of technology, and availability of proper user terminals). This thesis will present a solution to the highlighted issues in sequential manner in order to smoothly shift over to the high demanding technology.

6.2 Analysis of Impediments and Remedial Measures

Essence of the framework originates from the impression that technology exclusively is not sufficient to fall into place a market successfully. As far as technology is concerned, a novice technology may face unsuccessfulness because of the hidden challenges coming up ahead. Apart from this, a ripe technology is umbrageous by upcoming evolutions ahead. However, the achievements go much beyond technology like consumers; market and regulation play substantial functions in resolving reaction within a certain area. These act as catalysts, which define requirements and preparedness of industriousness as receiver. With all this, success can be, achieved in contrast to failure in region and like wise. From a business point of view, it is the consolidation of an unexploited model into an excessively developed environment or vice versa. In the previous case, the result is mostly with high expectations, which are difficult to meet. In the other case, the result is unhealthy as compared to the accurate ones. Both results produced are bedlam.

Third generation (3G) systems promise faster communications services, including voice, fax and Internet, anytime and anywhere with seamless global roaming. 3G is the term used to describe the latest generation of mobile technology which provides enhancements to voice communications and data connectivity including wireless access to the Internet, mobile applications and multimedia content. [38] Learning point here is that 3G is no doubt is future communication technology. What is important here is that how these services can be made available to users transparently. ITU has given comprehensive guidelines for the smooth up gradation. 3G network is not dependant on how the requirements are fulfilled for running of applications and tools over it. The main hindrance of spectrum however can be over come by

technologies such as EDGE2, UMTS 900, and UMTS850 and to some extent LTE too. Adoption of these technologies does confirm that spectrum may not be the only hindrance to deploy 3G. Deployment of a new technology is more productive when modifications are focused more towards users as compared to the operators it self. Success of 3G deployment is only dependant on the end-user demand and expected market growth.

6.3 Analysis of Impediments in Pakistan and their Remedial Measures

6.3.1 Ministry of Information Technology and Telecommunication

PTA forwarded its recommendations based on the Mobile Cellular Policy 2004, suggesting launch of auction of 3G spectrum to Ministry of Information Technology and Telecommunication (MoIT&T) five years back. After lapse of more than five ears still Frequency Allocation Board is able to clear only enough band to occupy three operators at the most. Pakistan is the only country left to shift to 3G as per following statsics by ITU.

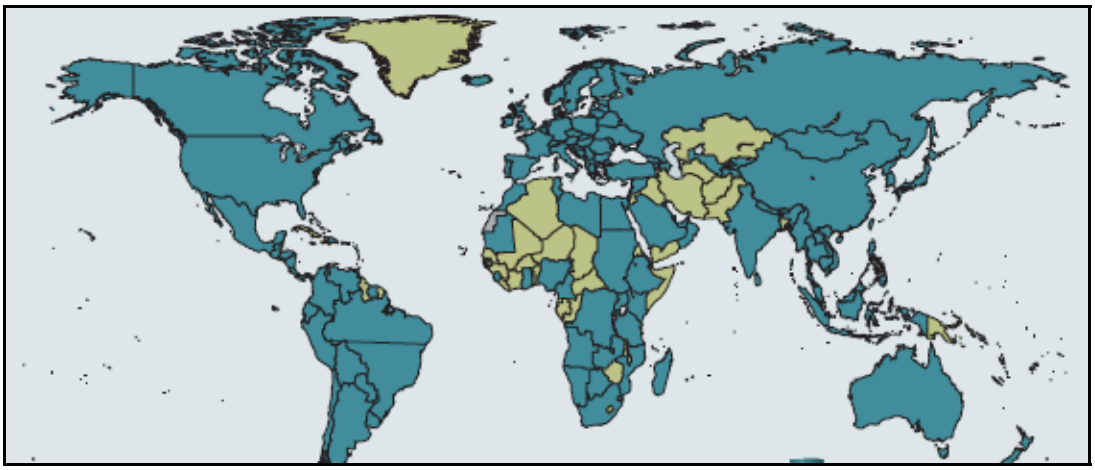

Figure 33 – The Rise of 3G

Source: *ITU World Telecommunication/ICT Indicators database*

PTA must proactively pursue the case with MoIT&T for early decision.

6.3.2 Availability of 3G Frequency Spectrum

FAB functions under two different heads i.e PTA and Defence, later being stronger than the other, it was however instructed by the former according to the Mobile Cellular Policy 2004, to clear 2100MHz band reserved for 3G services as per ITU documentation. Which is still under process, PTA therefore must, in parallel get it cleared before the green signal from MoIT&T.

- **Frequency Reuse (UMTS900)**

  PTA, can however deliberate onto another special chore i.e. frequency reuse, which is known as UMTS-900. This technology incorporates high speed data rate by use within the existing GSM band. "There is a very strong business case and momentum for deploying UMTS900 (WCDMA-HSPA) systems in the 900 MHz band, generally used today by GSM networks, to help operators efficiently extend voice, data and mobile broadband services coverage by leveraging the advantages of lower frequencies.

  Of course, there is no reason why WCDMA could not be deployed at other frequencies. In fact, the use of other frequencies may well be necessary in some countries. For instance, the frequency bands defined previously overlap significantly with frequencies used for PCS in North America. Therefore, in North America, it will be necessary to move some existing users from the PCS band and/or acquire a new spectrum in some other band. The movement of existing PCS users is likely only to happen when a given carrier that wants to implement UMTS already has an existing PCS system and uses some of the spectrum for UMTS. The net result for such an operator will, of course, be limited spectrum for both PCS and UMTS.

- **Technical Specifications – (UMTS900)**

WCDMA-HSDPA	-	900 MHz band (UMTS900)
Technology	-	3GPP
Band	-	Class VIII
Range	-	880 to 915 MHz (uplink)
		925 to 960 MHz (downlink)

- **Benefits – (UMTS900)**
  - It would be expensive to use 2100 MHz band for the full coverage
  - It would not be practical for the mobile operators to deploy 2100 MHz equipment soon enough to be functional.
  - Using 900 MHz Radio equipment propagation path-loss is much lower.
  - More number of sites will required to be installed for the 2100 MHz band equipment as compared with 900 MHz band equipment.
  - Rollout time to install this equipment is lass.
  - Existing band has better indoor coverage.
  - Better service quality and user experienced, is achieved.
  - This system provides enhanced internet experience within much less price.

- Existing infrastructure, assets and management system can effectively be reused to deploy this system.
- Astonishingly 900MHz system and 2100MHz provide same internet speed with less rather ½ the no of cell sites.
- Operators can gain more revenue per cost.
- Cost effective 3G applications can be made available in more area [51].

Important to highlight here is the key enabler for 3G in Pakistan. Regulatory approval is required to clear the way for WCDMA-HSPA 900 MHz deployments in a number of markets. An important political development in Europe concerning regulation of the 900 MHz was announced on March 24, 2009, which would remove restrictions on how the band is used by repealing the 1987 GSM 130 GSM/3G Market/Technology Update Directive. This is a clear signal to all regulators to prepare the path in their respective markets for a new wave of HSPA deployments in the 900 MHz band. Some countries must re-arrange band allocations in order to enable GSM and UMTS900 in 900 MHz spectrum.

6.3.3 Broadband Requirement

- **3G Awareness**

  PTA for the last couple of years is conducting workshops and seminars on 3G for the awareness but they been on very limited scale and to the specific class only. There is a need for extensive general awareness programs.

- **Reduce Broadband / GPRS / EDGE Rates**

  Pakistan is the country where rate on increase in broadband user is very less as compared to the cellular growth. The reason behind is the lack of literacy rate and lack of resources. Though existing mobile operators have provided the facility of internet but with very low speed, which is being utilized by most of the users but its rates are very high. There is need to ,not only to reduce the GPRS rates but also the DSL rates so that users can have the taste of and to enhance broadband usage.

6.3.4 Roadmap / Policy for Launch of 4G

India launched its 3G policy (Roadmap) in 2008 to smoothly launch 3G services. Where as in Pakistan's Mobile Cellular Policy, 2004 PTA issued roadmap / policy for launch of not only 3G but at that time all the up coming technologies, not going into the details that which policy was not adhered to in time. As the 4G gains momentum in the world, mobile operators in Pakistan would be hesitant to go for 3G and invest huge amount into waste, rather would

like directly to jump over to 4G. Therefore, PTA should give out its policy for rollout of 4G not to be before 5-10 years so that Pakistani users can have flavor of 3G before actually shifting over to 4G, moreover Government of Pakistan will also have the opportunity to earn revenue in 3G and 4G.

6.3.5 Tariff War

As ARPU in Pakistan is lower than US$ 3 due to strict tariff war going on, there is need for PTA to play its role as a regulator to look into the interest of the mobile companies to keep a healthy competition as well as pocket of the users, so that mobile operators have the incentive to jump into the 3G auction phase.

Company	Average Prepaid On Net Tariffs
China Mobile	1.75
Mobilink	1.82
Telenor	1.8
Ufone	1.65
Warid	1.50

Table 5 – Average Prepaid On Net Rate per minute

Source: http://www.pta.gov.pk/media/prepaid_080311.xls

6.3.6 Deployment of 3G Like Services (WiMAX/EVDO)

WiMAX and EVDO are the wireless broadband technologies having the flavor of 3G services, but their limitations restrict their portability. Despite PTA's clear instructions, users of both the technologies are enjoying the freedom of roaming. PTA can therefore, strictly impose the existing policy to give incentive to the mobile operators and must instruct PTCL to refrain from such practices.

6.3.7 Cost of 3G Handsets

For use of 3G services there is a requirement of 3G handsets, which are out of the range of common user. Although large ratio of the population have already hands on 3G sets [52] but still most of them cannot afford. The government needs to provide subsidy on 3G hand sets

and wave off of tax/duty as India and all other countries who have recently shifted over to 3G have given taxes off on 3G handsets for promotion.

6.3.8 Local Language Content Development

The focus of regional mobile application challenge should be praised as it is trying to find out the special mobile application for people of rural areas, which can contribute for the development & awareness among them. People of rural areas should get handsets which are modified slightly to their convenient like instead of abc letters on keypad, the letters related to local language should be introduced. Because language should not be barrier and locally relevant content in locally languages will be the key to the growth of mobile 3G services & communication. Phone localization and localised mobile applications are important for improving mobile non-voice usage which will be useful for people of rural areas. Regarding applications, most of the people of rural areas are agricultural workers, farmers & vegetable vendors. Information relating to agriculture, day to day vegetable prices, suggesting the crops according to season, prices of agriculture inputs, should be given to them by operators through3G services, secondly remote rural locations do not have access to basic healthcare services. The information & precautions relating health care should be pre recorded in local languages and people of rural areas should be encouraged to use the information. One of the innovative mobile applications can be "Efficient Lightweight Mobile Records"(EMLR) system. This product has been implemented in African countries; it meets the urgent demands of health sector in rural areas. Next many women of rural areas want to be educated but cant find time due to household work etc. For them vocational training should be provided through mobile service. Because empowerment would become more relevant if women are educated, better informed and can take rational & matured decisions .These applications should be 3G based which are convenient and economical. Many people of rural areas who want to keep their own business or who want loans for agriculture purposes, this information can be provided by the mobile operators along with the combined effort of banks. The Government who have special programmes for people of rural areas, employment opportunities for people of rural areas can also use these applications. Step should be taken for making them to know about information, special easy numbers, figures, letters or words like 000,222,333,444,555,666,777,888,999,###,***,and local words which can be easily remembered should be used for accessing mobile applications. Mobile manufacturing companies should provide rural areas with mobiles at reasonable prices so that it becomes an encouragement for mass adoption of mobile data services. Such awareness of people of rural

areas in education, medical, financial, employment, laws, makes them more powerful and contributes to the healthy people who are representatives of Healthy society and country [53]. Therefore, to grab the 3G market there is need to develop extensive local language based applications for the 3G handsets.

6.3.9 Limited Trial of 3G Services

In India in September 2006, and in Bangkok, permission was given to the Telco's for trial of 3G services at a very limited scale for technical reasons. On same footings to create awareness among users and have better idea of market response to 3G services, PTA must permit one of the mobile operators to launch 3G services at a limited scale.

6.3.10 Role of Etisalat (MoU with PTCL)

It is anticipated that Etisalat is not letting the government of Pakistan to auction 3G license in Pakistan, due to its agreement of purchase of 26 percent shares in PTCL. We know that 3G license auction has been delayed notably in Pakistan. Earlier it was reported that 3G licenses will be auctioned in February 2009, however, it couldn't happen. There was a section in PTCL's sale-purchase agreement that government of Pakistan will not issue any further Telecom license in Pakistan for next 7 years. Meaning that no further license to any telecom operator till 2013. A source who spoke with high ups at Ministry of IT and Telecom, got it confirmed that 3G license will be a telecom license in nature, with fresh attributes – meaning that if there was this point mentioned in PTCL's sale agreement then government of Pakistan cannot issue any new telecom license (that is a 3G license) till 2013.

CHAPTER 7

RECOMMENDTIONS AND CONCLUSION

7.1 Recommendations

7.1.1 For the Government of Pakistan

- **Clear Roadmap for the Operators**

  PTA must devise and issue a comprehensive and transparent road map for the operators so that they can build confidence for early launch of 3G services.

- **Early approval of Launch of 3G Services**

  PTA has already forwarded its recommendations to the MoIT&T for approval, which after lapse of more than 5 years are still unattended. PTA therefore must push the case ahead.

- **Make Available the Required Spectrum for 3G**

  According to the Cellular Policy 2004, FAB was instructed to clear the 3G spectrum by end 2005, is still in its way. MoIT&T must get it cleared as early as possible.

- **Freedom of use of existing GSM spectrum**

  Due to unavailability of the required 3G spectrum, existing mobile operators must be given the flexibility to launch their services within the existing 900/1800 MHz GSM Band.

- **Create Awareness among consumers for use of 3G**

  Although PTA is already conducting seminars and workshops for creating awareness about 3G, but that is restricted purely to a limited class. There is need to educate the subject in general public.

- **Strictly Restrict Mobility of WLL Broadband**

  Officially WLL users are barred from using roaming facility but unofficially this facility has been extended. PTA must put a check on this aspect to encourage GSM operators for provision of their internet services.

- **Force Software Companies to Develop Local Language Based Content Applications for 3G Handsets**

  Most of the Population of Pakistan is illiterate or have the ability only to read Urdu / local language contents. Therefore, it is the responsibility of the MoIT&T to get local language based applications developed for the upcoming 3G handsets.

- **Provide Subsidy to Mobile Operators to Install 3G Infrastructure in Rural Areas to Provide Distant Learning and Remote Medical / Legal / Agriculture Consultancy**

  To promote education and awareness in the rural population through mobile phones there is a need to install extensive mobile network infrastructure in the rural areas. For this Government must give subsidy and discount in taxes for installation of towers and equipment.

- **Simplify Rules and Regulations for deployment of 3G Equipment**

  PTA must devise means to simplify the rigidity in rules and regulations for early deployment of 3G Equipment. In prevailing unstable security environment must provide with the due security they need to install and secure their equipment.

7.1.2 For the Mobile Operators

- **Enhance their Mobile Network Infrastructure**

  Mobile Operators due to the prevailing security environment are reluctant to go to the far flung areas to deploy their network. They must be encouraged to do so to enhance the awareness among the people there.

- **Provide Incentives to the Users**

  Mobile operators must provide incentives / packages to the users for using their existing data services to pave way for the upcoming 3G.

- **Get their Content Prepared in the Local / Regional Language**

  As most of the Pakistan population can only read and understand their local and regional language, therefore it is responsibility of the Operators to get their contents prepared in the local / regional language to grab the market share.

7.2 Future Research Studies

- **Economics of 3G**

  3G networks, devices and services in countries around the world is enhancing quality of life and providing expanded economic opportunities, both in the public and private sectors. The expansion of economic opportunities results in increased competition, the development of innovative new services for consumers and greater productivity for enterprises by workers. After the deployment of 3G, further study will analyze the amount and duration of pay back to the mobile operators of their investment in 3G, with comparison with the companies of the world already using 3G technology.

- **Prospects of 4G**

  'TMT', *Technology, Media and Telecommunications* will be a next BIG thing in the world and it is now not so far to expect that in every part of the world, maximum percentage of the people will be dependent on TMT. Technology is evolving day by day; From TV's to IPTV, Internet TV and now 3D TV and highly innovative mobile phones. From Dialups to Broadband and now Fiber to the home and 4G / LTE mobile networks, People are getting used to high Data speeds and usage of DATA and information Accessibility is much in trend these days.

  As the world has already shifted to 3G and is rapidly shifting onto 4G, there is a requirement to look into the possibility of shifting to 4G bypassing 3G in Pakistan.

- **Regulations / Policies Update**

  The main crib behind the delay in timely deployment of upcoming technologies is that the regulations are not flexible enough to absorb new technologies at the right time. So the requirement that can be explored is to critically study and analyze the existing Telecom Policies, highlight the loop holes/obsolete rules and regulations and propose new policy framework that can timely absorb latest technologies giving enough revenue to the government as well as the investors.

7.3 Conclusion

Reason for delay in launch of upcoming 3G technology is more inclined towards the government policies rather than the technicalities or operators strategies. Efforts of PTA are towards pursuing the deployment of 3G using the existing frequency band and as well as in the new band, in order to pave way for the long awaited 3G deployment. Innovative auction would attract and encourage main cellular technology stakeholders to fearlessly invest in the upcoming technology. PTA's job does not end here, as already hashed out; the altering of existing telecom market is becoming a challenge for the regulatory body. Customers and the market are always the merit of achievement or loser for deployment of new technology in Pakistan. The drifts ascertained in upcoming years will determine local response to it. Apart from technology or regulation gainsays in this regard seem to be much larger. No doubt our country carries much potential for its application which could bring great revenues for the stakeholders as well as economic and social gyration for the populace. To make available the related applications and devices to operate 3G services is another challenge. To make this dream come true regulatory bodies, technology, operators and the users can fully support this easy mission as the existing infrastructure do possess deep roots for the purpose. What 3G

possess is not merely the Internet or a notebook; but a leap in the space of wireless broadband. As per the requirements of the region many tools can be translated into innovative services and applications, which would indeed behave as a catalyst that actuates a change, the change that can be in the form of an upgrade of existing cellular technology.

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Annex - A

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Annex – B

Broadband Policy

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