Challenges been faced by Mobile Operators in Pakistan for transition from 2G to 3G & 4G Mobile Services.

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Abstract

Mobile communication has been transformed in Pakistan by issuance of Third Generation (3G) and Fourth Generation (4G) licenses. Introduction of new technologies has changed the mobile users existing lust for more data and at an extremely high transmission rate. The third and fourth generation technology transitions have enormously improved network performance as compared to old and legacy Time Division Multiple Access (TDMA) technology. Especially, the Long Term Evolution wireless network is all set to convert the existing mobile networks into end-to-end IP networks. In this paper, it will be considered what challenges are been faced by the mobile companies in Pakistan for migration of mobile wireless networks from existing technology to 3G CDMA (Code Division Multiple Access) and 4G LTE (Orthogonal frequency division multiplex) networks. The main challenges faced by managers for shifting from existing 2G infra-structures to new 3G and 4G infra-structures are network planning and achieving Quality of Service (QoS) parameter's for this transition.

Keywords: Second Generation, Third Generation, Fourth Generation, wireless network planning, Long Term Evolution, Quality of Service.

Introduction of Mobile Services in Pakistan

In Pakistan mobile cellular companies started their operations in early 1990's. Initially two licenses were granted to Paktel and PakCom. Mobilink joined cellular market in 1998. The trio offered services through Advance Mobile Phone Service AMPS. It was the first generation mobile technology. This system used single frequency or channel for each call. Therefore AMPS needed considerable bandwidth for large quantity of users. All the three mobile companies switched over to Global System For Mobile Communications (GSM) in early 2000. This standard was developed to describe protocols for Second Generation (2G) digital mobile networks. 2G networks are digital circuit switched system optimized for full duplex voice transmission.

Ufone joined the cellular market in 2001. Thereafter, Government of Pakistan started deregulation of telecom industry in 2003-2004, due to this deregulation telecom industry revolutionized and market opened for new entrants. Two international companies Telenor (Norway) and Warid (Abu Dhabi) set up operations in the country in 2005.

Rank	Operator	Technology	Subscribers (in millions)
1	Mobilink	GSM-900/1800 MHz (GPRS, EDGE) 2100 MHz UMTS, WiMAX	41.2 (December 2016)
2	Telenor	GSM-900/1800 MHz (GPRS, EDGE) 2100 MHz UMTS, HSPA, HSPA+, 1800 MHz LTE	39.4 (December 2016)
3	Zong	GSM-900/1800 MHz (GPRS, EDGE) 2100 MHz UMTS, HSPA, DC-HSPA+ 1800 MHz LTE	27.5 (December 2016)
4	Ufone	GSM-900/1800 MHz (GPRS, EDGE) 2100 MHz UMTS, HSPA, HSPA+	18.5 (December 2016)
5	Warid	GSM-900/1800 MHz (GPRS, EDGE) 1800 MHz LTE	10.2 (December 2016)

Table 2: Showing comparison of frequency spectrum used and number of users of mobile operators. [16]

On 14 April 2014, Pakistan's first spectrum auction was held for 3G and 4G mobile telecom spectrum by Pakistan Telecommunication Authority (PTA). Four companies submitted their bids to PTA, includes Zong, Ufone, Telenor and Mobilink, while Warid Telecom did not participated in the bidding. The Government of Pakistan earned $903 million from 3G auction and $210 million from 4G auction with total revenue of $1.1 billion from both auctions. Zong won the first ever 4G license in Pakistan in 1800 MHz band. Another license for 4G could not be auctioned since no mobile operator participated in this auction. In 3G category, Zong along with Mobilink won 2x10 MHz license from 2100 MHz band. Ufone and Telenor won 2x5 MHz license for 3G from the same band. [1]

In June 2016 Pakistan Telecommunication Authority (PTA) again offered auction 4G license in 850MHz spectrum. In this auction Telenor was the only bidder, hence it was awarded 10MHz block at a price of $395 million [2].

PTA gave a time frame to mobile operators for rollout of 3G services within six months from auction. First phase contained cities of Karachi, Lahore, Islamabad, Peshawar and Quetta. Subsequently in second phase covering eighteen months eighty more cities of all the four provinces will be covered. In third phase, ninety percent cities of all tehsils in Pakistan will be covered by 3G services. Zong launched 3G and 4G services almost simultaneously in big cities of Pakistan and now it covers almost all the big and medium scale cities [3]. Mobilink, Telenor and Ufone started 3G services starting from big cities and then subsequently to smaller cities.

Warid did not participated in 3G and 4G bidding due to its weak financial and market position, but it started operation of LTE services in 2016, due to the fact that its GSM services license allocated in 2004 was from 1800 MHz frequency band which supported LTE services. Warid allocated 3.5 MHz

bandwidth in this band to launch LTE services and had its license amended from PTA and launched the services. [4]

In a very short span of time the 3G and 4G users have increased at a tremendous pace nearing almost 34.56 million 3G users and 3.71 million 4G users (Jan'2017) [16]. The utilization of bandwidth for data users has sky rocketed from 100's of mega-bits to 100's of giga-bits. This incredible data usage has put extreme on the mobile operators network.

Different Phases of mobile technology evolution

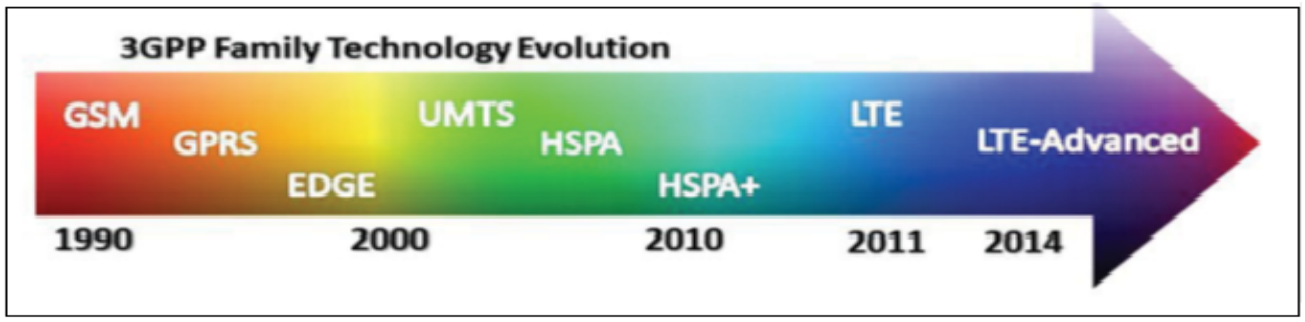

Figure.1: Evolution phases of different mobile technologies [5]

- **First Generation Mobile Technology (1G)**

Mobile communications began in early 1981 with the advent of analogue mobile cellular services called AMPS. This first generation wireless mobile technology only supported voice calls. This technology had many limitations like data signal was not encrypted, poor sound quality and very slow data rate of 9.6 Kpbs only. This technology used Frequency Division Multiplexing technique for communication. [5]

- **Second Generation Mobile Technologies (2G)**

The second generation mobile technology is first digital cellular services introduced in 1990 called Digital-AMPS (D-AMPS). This second generation wireless mobile technology supported SMS services alongwith voice calls. This technology was based on Global System for Mobile Communication based on Time Division Multiplexing Access (TDMA) standards and in North America many mobile operators adopted Code Division Multiples Access (CDMA). It could transfer data rates of 14.4 Kbps. [6]

- **General Packet Radio Service (GPRS) (2.5 G)**

GPRS deployment began in year 2000. Due to demand of higher rate data transfer services 2.5 generation wireless mobile technology GPRS was introduced having packet switched domain in addition to voice carried on circuit domain. The data rate was enhanced to 115 Kbps. This type of services demanded greater bandwidth for data transfer.

- **Enhanced Data Rates for GSM Evolution (EDGE) (2.75 G)**

Enhanced Data Rates for GSM Evolution (EDGE) deployment began in 2003, this technology supported fast data transfer rates of upto 384 Kbps. It was an extended version of GSM system.

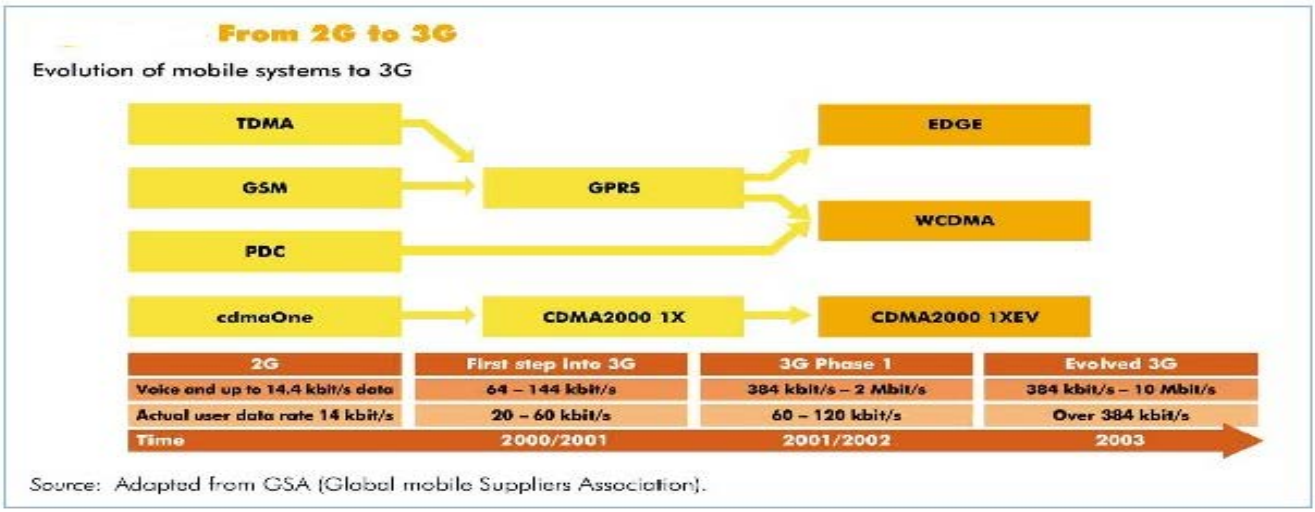

Figure 2: Mobile technologies with corresponding data transfer rates. [7]

- **Third Generation Mobile Technology (3G)**

International Telecommunication Union (ITU) formed a group 3rd Generation Partnership Project (3GPP) for research and development of 3G specifications and standards. All the Governments and telecommunication companies approved 3G standards named IMT-2000 and its implementation started in year 2001. 3G technology is called Universal Mobile Telecommunication System (UMTS) network is based on W-CDMA access technology and offers larger spectral efficiency and bandwidth to network operators. UMTS is a complete mobile network system, this system compromise of radio access network (UMTS Terrestrial Radio Access Network, UTRAN), a core network (Mobile Application Part, MAP) and Subscriber Identity Module (SIM) cards. It provided a data speed upto 2 Mbps to its users. 3G technology became an instant success due to good user packages offered by mobile companies, alongwith low price 3G handsets being available in the market.

- **Fourth Generation Mobile Technology (4G)**

International Telecommunication Union-R (ITU-R) in year 2008 specified the International Mobile Telecommunication Advance (IMT-Advance) standards for Fourth Generation (4G) mobile systems. This technology is also referred as Long Term Evolution (LTE).

The 4G mobile system is based on all Internet Protocol (IP) network system. The foremost of 4G technology is to offer high speed, good quality, large data transfer capacity, service security and cost effective services for voice, multimedia and internet access.

4G voice calls are either circuit switched or these can also be transported via Voice over LTE (VoLTE) based on IP Multimedia subsystem network. With VoLTE the voice calls are transported as data in LTE data bearer. [7]

4G mobile network is much faster than 3G mobile networks due to the fact that 4G networks are based on Orthogonal Frequency-Division Multiplexing (OFDM) or Orthogonal Frequency-Division Multiple Access (OFDMA) technologies. With these technologies more data is transported on the same amount of radio frequency. With this technology both latency and interference is reduced. Data is sent as small chunks of frequency in parallel, thus increasing the capacity of network [8]. 4G technology gave an extremely high data rates from 2Mbps to 100 Mbps to its users.

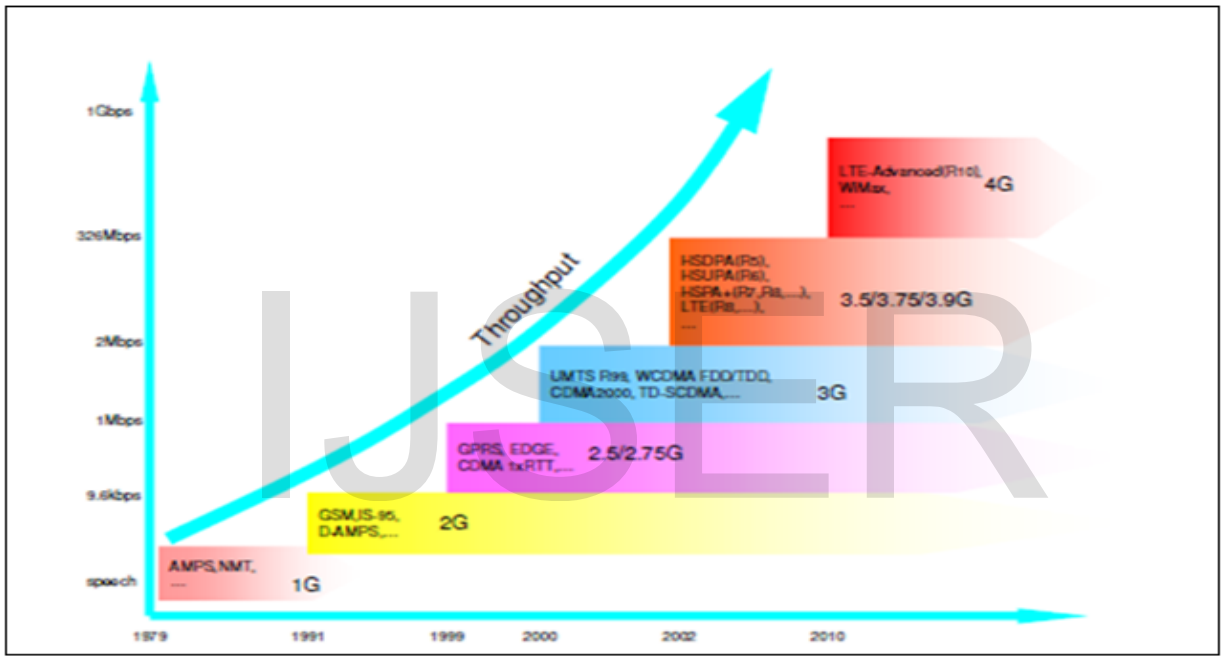

Figure 3: Showing year-wise evolution of mobile technologies

3G & 4G networks; COMPARISON

- **3G**

At first third generation mobile networks seemed attractive to everybody. The users will be getting high quality services such as good sound quality, fast internet speed, new innovative services like video chats, VoIP call and many different types of multimedia services. The mobile network operators will get access to great number of data hungry users and can count on receiving good profits within a short span of time.

Nonetheless there are some drawbacks that need to be considered.
The 3G technology is UMTS based and is completely new, requiring installation of new equipment at every Base Transceiver Station (BTS) and the requires very large bandwidth backbone connectivity with

Mobile Switching Center (MSC) through optical fiber or Digital Radio Links having large bandwidths. This is a very difficult proposition considering the numbers of BTS's in every big and small cities and covering large geographical areas along the intercity motorways. Therefore, if you are not living a big city, new technology may take some time to reach the users. That is why all the mobile operating companies in Pakistan started delivery of 3G services by installing 3G equipment in the existing GSM networks BTS sites at first and increased the BTS sites where signal strength needed to be increased for catering to the demands and needs of their customers. The changes in associated BTS equipment and software up-graduation for 3G transition had considerable cost impact for the operators. The low data transfer rate of 3G network restricted the ability of its user's to take full advantage of the rich multimedia services been offered. [9] It was foreseen that 3G network data rates will not be sufficient enough to meet the needs of video-conferencing, full motion video services in terms of QoS of the future applications. [10]

Statistical Comparison of 3G and 4G Network Technologies		
Key Features	***3G Networks***	***4G Networks***
Data transfer rate	**384 kbps to 2 Mbps**	**2 to 100 Mbps**
Frequency Band used	**1.8 to 2.4 GHz**	**2 to 8 GHz**
Bandwidth requirement	**5 to 10 MHz**	**10 to 100 MHz**
Switching technique	**Circuit & Packet Switched**	**Packet Switched**
Radio Technology	**WCDMA, CDMA-2000 etc**	**OFDMA etc**
Internet Protocol Version	**IPv4.0, IPv5.0**	**IPv6.0**

Table 2: Showing statistical comparison of 3G and 4G Technologies

- **4G**

The door to 4G services was opened up in 2014 in Pakistan and initially one mobile operator bought the 4G spectrum. Subsequently two more mobile operators opted for introduction of 4G services in 2015. 4G services have become a general winner within 13.5 million mobile users in Pakistan, if the mobile companies get it right the first time. The mobile users are expecting low cost per bit rate, faster speed and reliable services, something which is greatly desired in mobile services. For mobile operators, 4G networks implementation and Next Generation Networks (NGN) are becoming very cost effective solutions for IP networks built for high speed data delivery.

At the moment 3G users are greater in numbers than 4G mobile users in Pakistan due to the fact that 4G mobile handset is still expansive and out of reach for low earning user. Once the price of 4G handset reduces to an affordable level the penetration of 4G will increase rapidly. Faster data transfer rate / higher bit rate and bandwidth of 4G services are ideal for many business applications and commercial applications. 4G services have many advantages for implementing personalized multimedia communication tools and will provide 4G users new levels of multi-service experiences. (11)

Main features of 4G mobile networks which have attracted the users are:

- Autonomous network
- Software Independence
- Fully coated service
- Scalability
- Interoperability and simple roaming

Impacts and drawbacks of 3G and 4G deployment.

The mobile operators have invested millions of dollars for installation of new 3G and 4G equipment's for up-gradation of their mobile network. In the beginning the cost of new equipment and services will be reflected in the customer tariffs. Another main issue for the mobile companies which are introducing new technologies is to buy new broadband frequencies, which are very costly and subsequently the mobile companies and their mobile user have to pay higher prices.

To cover whole of Pakistan geographically by mobile operators will take a lot of investment and deployment time. These drawbacks may seem temporary and insignificant due to the fact that demand for such type of new mobile services is constantly rising in Pakistan. The number of 3G subscribers has increased many folds and to a small instant 4G customers in a very short span of time and the turnover in revenue of mobile operators is significantly on the rise. The level of competition within mobile companies offering these services is very high. For users this type of competition between operators has a very positive effect, it brings the tariffs down and within reach of all customers, but sometimes the operators compromises on quality of service parameters.

Everyone wants to have access to the World Wide Web instantaneously and from anywhere. The question is how soon the mobile companies in Pakistan will be able to meet this demand through better coverage and superior QoS as per customer perception.

Mobile Network Planning Challenges and Quality of Service Management

- **Mobile Network Planning Challenges**

The fact that 3G and especially 4G mobile networks intends to integrate almost every wireless standard already in use thus allowing there simultaneous use and network interconnection. This integration poses many questions for network planners for provision of effective quality of service to mobile users.
The growing gap between quantity of mobile spectrum / network capacity available and the quantity required due to increasing demand of mobile data is expanding at a very rapid pace. Mobile data traffic is increasing at a rate of almost 50% per year. This increase has created huge data traffic and signaling burdens on existing mobile networks.
The traditional methods of 3G planning is to increase network capacity by upgrading air interface and adding new base station sites, but for 4G planning these remedies will not be adequate enough to meet the challenges for 4G networks. For introduction of 4G (LTE) services, increase in capacity will come from radical rethinking in the mobile network structure by involving use of large quantity of small cells to increase network capacities and signal coverage, this will relieve the pressure on existing macro

network structure. These cells will evolve into heterogeneous networks (HetNet), supporting a wide range of air interfaces and spectrum bands. All the mobile operators will be pressed for manifold increase of cell sites in next couple of years to cover large portion of geographical areas. Due to this fact, operators will face unexpected challenges in terms of network planning, network performance measurement and network management. The mobile operators have to ensure that only delivery of addition in capacity is not enough but the network should provide best performance, with optimal cost inputs which supports key business objectives.

Mobile operators are faced with a wide range of network planning challenges which affects the performance and quality of service of the network.

These challenges are listed below:
• Finding the right cell site position and planning their spot relative to each other
• Backhaul up-gradation for carrying large quantity of data
• Integration with Core Networks (CN) having intelligent data delivery system
• Legal framework for buying/leasing/renting small cell sites, it has a major issue in urban areas and especially army maintained cantonment areas in Pakistan where installation of new towers have been totally banned by the authorities. (12)

- **Quality of Service Management**

Quality of Service (QoS) parameters in mobile network are defined as the capability of mobile operators to make available good voice quality, high signal strength, low call dropage, committed data rates for multimedia applications for their customers.

For mobile networks QoS depends on the following main factors:

- **Throughput:** The data packets delivered through the network. Committed maximum data rate is always desired.
- **Delay:** The time which a packet takes to travel from end to end.
- **Packet Loss Rate:** The rate loss of packets. This loss should be as minimum as possible.
- **Packet Error Rate:** This is the error due to corrupted bits in a packet.
- **Reliability:** The availability of up & down links.
- **Handsoff Support:** Providing seamless mobility.

Due to above reasons, providing good network coverage and satisfactory QoS in 3G & 4G mobile networks has become a great challenge for mobile operators. To achieve ideal QoS parameters in the mobile networks different new Core Network (CN) and Radio Access Network (RAN) techniques are being developed and deployed in mobile networks to provide better quality and service standards. (14)

Conclusion

In this review paper we have presented the evolvement of mobile operators in Pakistan and cellular technology evolution through its generations. Starting from the early voice based mobile technology (AMPS) to present day latest IP-based (LTE) voice and data mobile networks. The mobile teledensity in Pakistan was 8.3 in 2005 which has increased to 63.5 in 2015 [16]. Pakistan has seen a rapid increase of

3G and 4G users in a very short span of time to almost 37.7 million out of a total 63.8 million mobile users. The usage of data bandwidth by multimedia hungry customers has sky rocketed to 100's of giga-bites and this increase has put a lot pressure on mobile operator's networks in Pakistan. To overcome this pressure network planning challenges and their causes have been identified in this paper. The provision of highly satisfactory quality of service to mobile users by service providers is another main factor in its rapid growth. To provide standard quality of service to the user's mobile operators need to take remedial measures to counter the main factors affecting the network planning.

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