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Correlation Between Network KPIs and User Experience of GSM Networks in Pakistan

Javed Akhtar Khan, Dr. Irfan Zafar
Institute of Communication Technologies, Islamabad, UET Peshawar

Abstract
Pakistan's Cellular communication industry is now shaping up and companies are now focusing on user experience to retain customers and monetize on products and services offered. Changes in cellular communication landscape and tough competition due to price war and heavy taxation, profit margin is decreasing and hence reducing tariffs for products and services. Operators are now opting for solid network performance and developing new models while keeping quality of services intact. User Experience and Network Key Performance Indications (KPIs) reflects the gap which needs to be filled by offering smart solutions and adapting to customer centric approach. This study attempted to analyze the impact on user experience due to network KPIs considering the variables (1) Understanding of Network and Performance (2) Understanding User Experience (3) Lack of use of reporting tools and best practices (4) Coordination between different teams (5) Customer experience feedback. In this research work, a comprehensive model is developed using which User experience can be enhanced with existing and new tools together.
Keywords: Telecommunications, KPIs, Network performance, User experience

1. INTRODUCTION

Cellular communication revolutionized the way people communicate by providing mobility and seamless connectivity. In short time, momentous progress has been achieved in the history of wireless communication. Cellular communication is now leaping beyond Fourth generation (4G)as shown in table 1.Aimed at performance and efficiency in mobile environment wireless technology has followed different evolutionary paths. First Generation has fulfilled the demand of mobile voice and later Second generation has built capacity and coverage [1]. 2G followed by 3G which brought the facility of data at higher speed which opened new avenues in mobile broadband which is now realized by Fourth generation (4G). Current advancement in 4G has now enabled users with near 150 Mbps of broadband speed with virtue of new technologies available across industry. This research and further advancements enabled users with bandwidth hungry application like video conference and streaming while being mobile. [3]

Pakistan has built up a focused and dynamic business sector which allowed a cell operator to investigate increasingly and conveyance to end user. In 2004, about 5 million subscribers hopped to 100 million in 2010. Voice quality has been the principle center of cell organizations however now center is likewise towards information and worth included administrations. Pakistan cell administrators give minimal effort portable association however exceptionally intense rivalry among various organizations [1].

First generation cellular communication used analog transmission for voice. In 1979, Nippon telephone and telegraph (NTT) first started cellular system in Tokyo, Japan. After 2 years, the cellular era started in Europe. The two popular analog systems at that time used for mobile communication were Nordic mobile telephone & total access communication system. After that, many other analog systems had been introduced. These systems offered handover and roaming capabilities but were unable to provide roaming services across different countries. This accounted as more prominent disadvantage of first generation mobile communication system. This system was allocated with bandwidth of 40 MHZ within the frequency range of 800-900 MHZ by federal communication commission (FCC) [2].

Table 1 Summary of generations (1G to 4G)

Generation	Requirements	Comments
1G	No official requirements. Analog technology.	Deployed in the 1980s.
2G	No official requirements. Digital Technology.	First digital systems. Deployed in the 1990s. New services such as SMS and low-rate data. Primary technologies include IS-95 CDMA and GSM.
3G	ITU's IMT-2000 required 144 kbps mobile, 384 kbps pedestrian, 2 Mbps indoors	Primary technologies include CDMA2000 1X/ EVDO and UMTS-HSPA. WiMAX now an official 3G technology.
4G	ITU's IMT-Advanced requirements include ability to operate in up to 40 MHz radio channels and with very high spectral efficiency.	No technology meets requirements today. IEEE 802.16m and LTE-Advanced being designed to meet requirements.

Comparing first generation systems with second generation cellular communication, time division multiple access (TDMA) and code division multiple access (CDMA) were introduced. It also used wider spectrum band, packet data services and roaming facilities. This led to more advancement in 2G and often called 2.5G systems which are capable of handling packet data.

In second generation there are three line of development in US. In 1991, the first digital system was introduced which was named as IS-54 (NA TDMA digital mobile system) and new additional version was named as IS-136 introduced in 1996 and meanwhile now IS-95(CDMA one) was introduced in 1993.The FCC auctioned a spectrum of GSM 1900MHZ to enter market. [4]

Along with Value added services, intelligent service also played important role in cellular networks, which gave advantage to operators to create new services. General Packet Radio service technology for GSM which adds packet-switching data protocols creates possibility to charge the user according to amount of payload sent and received. GPRS is the necessary step toward third generation systems and provide basis for future communication. The need of GSM and enhance services like EDGE is to provide higher data rates. This was done by using most specialized coding schemes. In 2G for SMS communication it supports lower data rate wireless application and 2G system also support CS (voice) services similar to dial-up connection and later it also evolved to packet switch data services [3,5]

International telecommunication union (ITU) played important role in setting standards for Third Generation networks with IMT-2000. 3G standardization work was further define and documented by organization called 3rd generation partnership project (3GPP) that used and supported IMT-2000 standards. In Europe it was called as Universal Mobile Telecommunication System (UMTS) which is headed and driven by ETSI. ITU-T called it IMT-2000 and US 3G variant named it CDMA 2000. UMTS uses WCDMA as air interface for UMTS and its architecture is split into Node B, RNC, Serving and Gateway GPRS support nodes (SGSN, GGSN). 3G offers high speed data services by efficient utilization of spectrum. This also provided higher systems capacity in terms of network infrastructure deployment. Further technological improvements resulted in HSPA data transmission capabilities and added features. HSPA & HSPA+ support up to 21 Mbps on downlink and 5.8mbps on uplink. [5].

ETSI developed 3G system for IMT-2000 as shown in figure 1 which is based on GSM. In 1998, as it went globally the 3GPP was formed with the collaboration of six telecommunication standards from around the world to continue the development of UMTS and other standards of GSM[7].

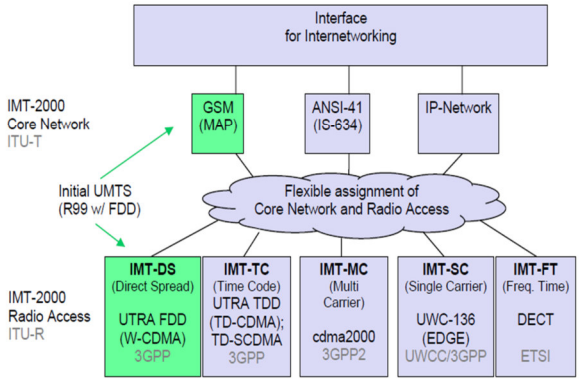

Figure 1 IMT-2000 Umbrella

Important objective of Third Generation (3G) communication system was to provide protocols and platforms those can further enhance the cellular networks users' experience. On the other side 4G structure is established and polish to new level of user experience and also adding capacity in systems in terms of user handling and services.

As in 4G different access technologies and their variants are available, they also differ in user experience and throughput across different regions. Further is being done to improve 4G services. The main objectives of fourth generation network can be stated as:

- Ubiquitous (Universal)
- Multi-service platform
- Low per MB cost

The Ubiquity supplement important factors that services offered by 4G will be available to everyone so that they can achieve their mobility and broadband objectives followed by wide coverage. It also means that 4G standards to be adopted globally to be universal access technology shown in figure 2. Services implemented should be according that needs to be communicate. [9]

The new essential property is to provide multi service to new mobile generation to give telecommunication operators access to new levels of traffic. low bit cost is also an essentials where high volume of data are being transmitted .To achieve the nominated goals a vast network must be created to distribute various radio access technologies and it must provide a high bandwidth 50-100 Mbps for high mobility and 1 Gbps for low mobility.

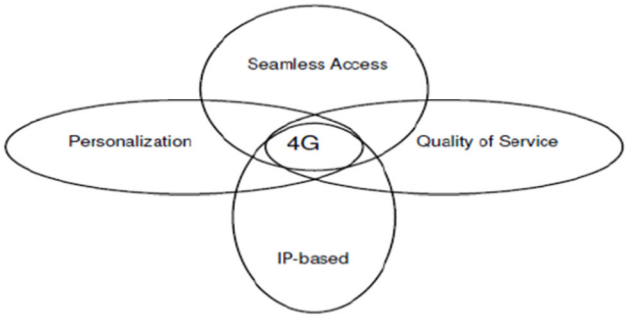

Figure 2 Fourth generation required framework [11]

LTE-advance IMT standard will advance to new era of cellular and mobile communication as per ITU-R. It offers a platform on basis of which next generations of mobile services to be built so that it can give higher data rates, enhance roaming services/capabilities and broadband multimedia[11][12].

Pakistan Cellular industry grown exponentially and added approx. 11 million subscriber by end of December 2015. Subscriber growth is still a basic indicator of economic measures towards awareness and cellular facilities being daily need of people of Pakistan.

Table 2 shows total number of cellular subscribers in Pakistan. Cellular subscriber's growth is evident below and exponential. Number correction was done by PTA to block SIM which were not verified via biometric verification.

Table 2 cellular subscribers in Pakistan

Annual Cellular Subscribers						
Year	Mobilink	Ufone	CMPak	Telenor	Warid	Total
2009	32,202,548	19,549,100	6,704,288	23,798,221	16,931,687	99,185,844
2010-11	33,378,161	20,533,787	10,927,693	26,667,079	17,387,798	108,894,518
2011-12	35,953,434	23,897,261	16,836,983	29,963,722	13,499,835	120,151,235
2012-13	37,121,871	24,547,986	21,177,156	32,183,920	12,706,353	127,737,286
2013-14	38,768,346	24,352,717	27,197,048	36,571,820	13,084,823	139,974,754
2014-15	33,424,268	17,809,315	22,102,968	31,491,263	9,830,620	114,658,434
Dec-15	**36,211,426**	**19,931,821**	**24,133,283**	**34,928,330**	**10,694,778**	**125,899,638**

Cellular networks KPI are benchmarked by PTA on regular basis to ensure that services provided by operators are up to the mark. User experience is being gauged by PTA from such testing and also checked against cellar operator's license agreements.

Looking at the exponential growth of Pakistan's Cellular industry and tough competition it carries in the result there is strong need for addressing user experience challenges. Operators need to work and build more efficient ways to know how well their services being perceived by end user.

This paper looks at the research problem along with discussing the aims and objectives of the research in the light of the selected parameters of Cost Reduction, Organizational Performance, Flexibility, Employee Performance, Access to Specialized Skills & Technology and the Outsourcing Risks.

1.1 ***Research Problem***

Traditional network KPIs are not reflecting user experience in era of competition. Telecom market which is nearly saturated is facing competition due to ongoing price war for their products and services. Cellular networks need to gauge user experience with more diverse KPI model and hence transform KPIs to KQIs. KPIs are measured in following fashion with leads to less customer centric approach

1. Most of the KPIs reflect network performance in terms of capacity and service availability.
2. Users may be suffering and may not be getting perfect services and products
3. KPI does not offer user level performance of the network

1.2 ***Research Objective***

- To develop correlation Network KPIs and User Experience
- Transforming KPIs to KQI for better network performance analysis
- Developing understanding and model network KPI

1.3 ***Research Methodology***

The study involves work on importance of user experience in comparison to existing KPI models followed by staff of cellular networks of Pakistan. A questionnaire will be distributed among relevant teams. Further to enhance study in this area few interviews will be conducted from these teams in field of Telecommunication.

Secondary data sources will include book, published paper in journals & telecommunication standards bodies like 3GPP, TM Forum [6][7][8].

The study involves work on both primary and secondary data resources in which questionnaire will be distributed to the related project teams working in multinational organizations. It findings will further be strengthened by conducting few interviews targeting audience in the field of Telecomm. Secondary data resources will include books, periodicals, published papers in journals and internet. Non-probability sampling design technique will be used in this research which will be followed by 250 samples from locals and virtual team members from Pakistani and international employees of multinational organizations. The collected data will be run through the available tool of statistical package for the social sciences (known widely as SPSS) software to evaluate the results and compare them with initial hypothesis that were built on the theatrical framework.

This research will be based upon the architecture and terminology developed over the last years by Tele-Management Forum. It is distinguished between service/product-oriented Key Quality Indicators (KQIs) and technically oriented Key Performance Indicators (KPIs). The KQIs are dedicated to describing quality of an end-to-end service in parameters that may be directly experienced by an end user, while the KPIs are characterizing purely technical properties in the various parts of the network. This double definition enables precise descriptions/quantifications of both aspects independent of each other. However, defining the relationship between the two for a set of real-world KPIs and KQIs is a very challenging task.A frequently referred figure showing the relationship between KPIs and KQIs is shown in figure 3.

It depicts that from physical network elements (bottom), technical service properties will exist that may be defined and structured into a set of KPIs. These will strongly influence the customer service experience,

characterized by a set of KQIs. But due to the difference in nature between technology and human perception, it is very unlikely that this will be a one-to-one mapping, but rather a many-to-many transition as indicated from the green to the blue boxes in the figure 3. Finally, a native service is not necessarily what is needed for a relevant series of products to the market. So, a similar transition from the blue boxes to the orange boxes must be taken into account.

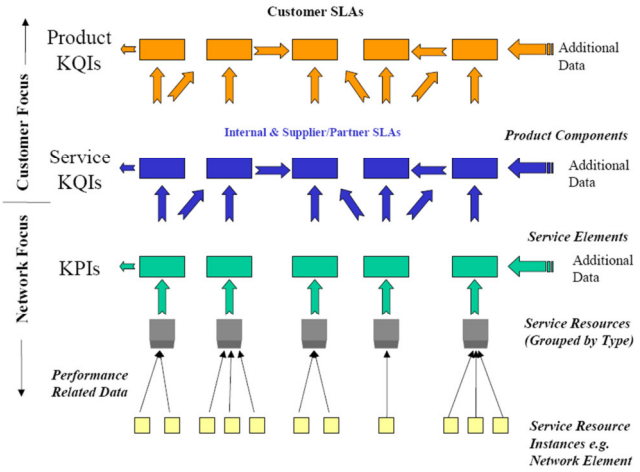

Figure 3 : KQI – KPI – network element relationship [13]

For this report, the "green-blue transition" is surely essential. Product packaging, however, is outside the scope of this report, so the "blue-orange transition" will not be treated further here.

1.4 ***Requirements on end-to-end service KQIs***

The set of KQIs that describe the quality of service delivery as perceived by end users must be thoroughly defined and easily understood also for high level managers and non-engineers. Below we list some important properties we believe the end-to-end service KQIs should have:

- The KQIs must reflect aspects that are important for end-users perception of quality during service usage
- The KQIs must be technical and measure objective performance parameters, i.e. they should not be such that users must take part in the measurement loop.
- The KQIs should cover service quality over the network parts we can control, i.e. the KQIs should not depend on measurements or/and performance of third party or transiting networks.
- KQIs should be network-agnostic, i.e. KQI names and objectives (what we want them to reflect) should be the same for all type of network technologies. However, measurement procedures and target values of the KQIs may be different for different technologies and BUs.
- The set of KQIs should be limited and easy to understand, and non-engineers should be able to understand what the KQIs shows.
- KQI definitions must be stable over time in order to follow up service quality over time, meaning
    - the KQI names and objectives should remain the same

The KQI definitions should if possible not depend on technology details, i.e. any variations in network service implementation should to the least possible extent affect the KQI definitions. However, at a certain level of detail such variations will probably affect how the KQIs are produced from KPIs, measurements and counters [9] [10].

1.5 User Experience Model

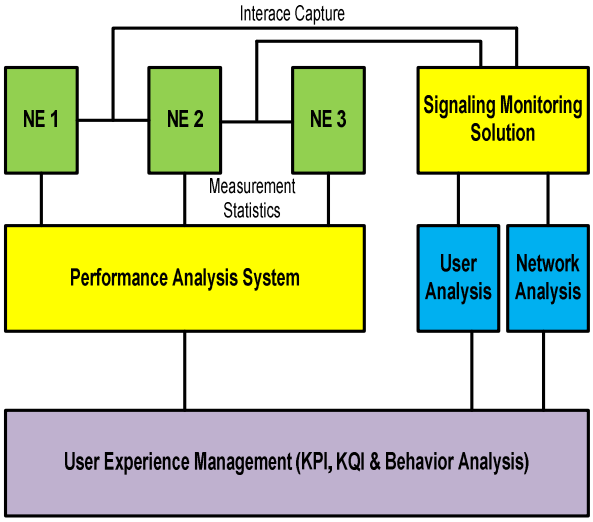

Figure 4 User Experience Model

Information Collection and Analysis:

Detailed in depth analysis was performed on collected data from questionnaire responses. After the collection of the questionnaire from the respondents, a detailed/in-depth analysis was carried out and user experience model is depicted in figure 4.

Understanding of network and performance showed its overall impact to all other areas of hypothesis. 48% of employees have shown understanding of network performance KPIs. However respondents also shown that actual network KPIs don't reflect real user experience. However continuous efforts are being put in work for improving network KPI in target areas. Mix responses were received from respondents against action taken by their respective organization. This analysis also builds perception that user experience improvement may also require further work for result oriented KPI/KQI design. Overall result for this variable is satisfactory and shows that most of the users understand network and performance. (Figure 5)

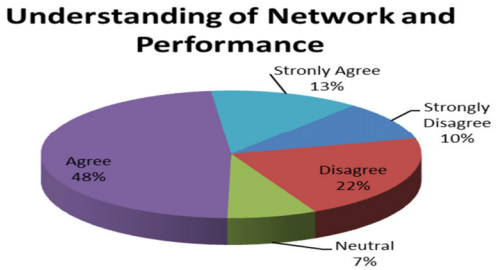

Figure 5 understanding of networks and performance

On similar line questions were asked from respondents about understanding of user experience. Almost same results were achieved for understanding of User Experience. Employees of aware of user experience dynamics however in some questions it was highlighted that most of them are not satisfied with organization mapping of KPI with user experience. This is crux of our current research which shows that most organization may need put further work on building KPIs i.e. transformation to KQI for gauging user experience. Customer experience has one important part of getting feedback from customers and then mapping them to network performance stats. (Fig 6).

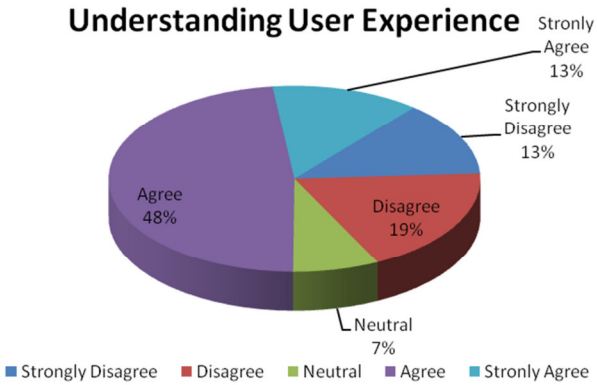

Figure 6 understanding of user experience

In another question regarding lack of use of reporting tools and best practices responded negatively. That shows that much better performance & user experience tools are available in global market and can be adopted to improve user experience. 61% respondents didn't agreed that use of right reporting tools and adopting best practices and studies available in the market can significantly improve user experience.

Only 33% of respondents agreed that right tools and best practices are being used which somehow shows that they still rely on existing infrastructure and tools. This percentage is easily overshadowed by disagreeing respondents for more diverse method of gauging and improving user experience.(Figure7).

Figure 7 lack of use of reporting tools

Lack of coordination between different team is one of the important factors which are primary consideration for knowing how certain problem is tackled in within teams. User experience management requires strong coordination between different cross functional teams. Mostly user experience is gauged on every level of the network. For cellular network in consideration we need to put focus on end to end network layers i.e. Radio Network/Access network, Core network and moving further towards underlying IP backbone. 59% respondents disagreed to face that strong coordination exist between different cross functional domains. These statistics shows that more focus is required in building standard operating procedures (SOPs) to improve coordination followed by strong service level agreements (SLAs)(Fig 8).

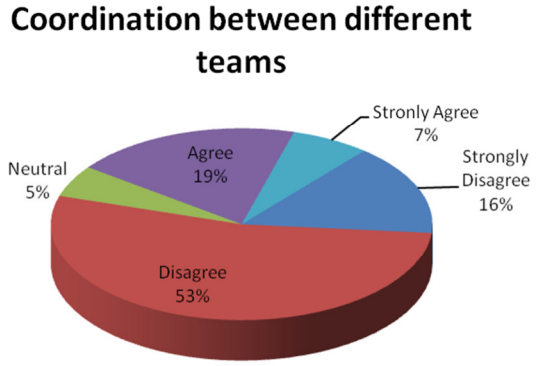

Figure 8 Lack of coordination between different team

Customer experience feedback, which is basis of net promoter scores in modern organizations. There is strong belief among telcos that positive promoters are future of organization. User experience among different users is word of mouth and hence can be an effective tool of marketing and attracting new users. One of the main question that is asked customer experience surveys is that how likely a customer is going to recommend your network to their friends and family? Customers are asked respond from 0-10; 0 for least likely and 10 for most likely.

62% user agree to customer experience feedback which shows that market is moving towards passively gauging user experience. This helps telcos in improving their services in target areas where high revenue users exist. Further resolving customer queries also help in making users more loyal to the network.

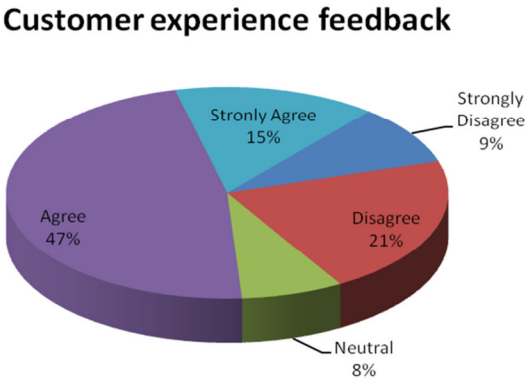

Figure 9 Customer experience feedback

Overall analysis of the questionnaire responses show that 37% respondents agree that user experience and network KPI completely correlate along with 12% strongly agreeing. This however does not depict that overall user experience improves while improving the KPIs. More room is available for operators to bring their user experience up-to the mark. Also with 9% strongly disagreeing we can safely build assumption that networks needs to be more dynamic in approach towards user experience to get benefits. (Fig 10)

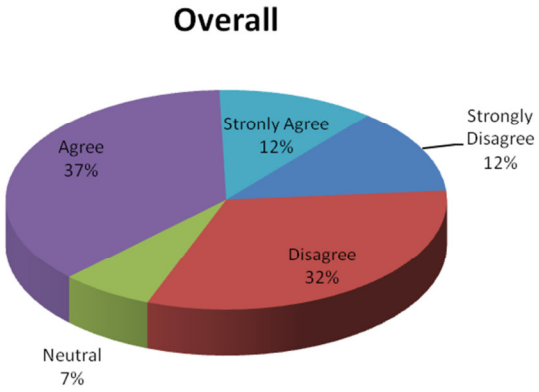

Figure 10 overall analysis

1.6 ***Conclusion***

- Collected data and relevant study shows that Cellular networks in Pakistan need to put more effort in achieving excellent user experience. This implies that organizations should invest in the development of their employees where they have excellent knowledge of Network and performance KPI. Key performance indicator and key quality indicators are first steps towards improving user experience. However as stated earlier in Chapter 3 KPIs alone cannot serve the purpose and hence we need more diversity in achieving our goals. Organizations need to setup dedicated teams for reporting of KPIs and KQIs of the network and also gauge user experience by using newly available tools and method.
- We can see in our collected data that some of organizations may have reporting and diagnostic tools but still missing on User experience front. That's mostly because of the reason that action is not taken against the problems identified in right direction. So we need to work on following to important items
    - **Service Level Agreements**
      Identification of problem is to be logged and assigned to certain cross functional team. This enables employees to better coordinate and time bound problem resolution activities. Strict SLAs also ensure that problem is quickly resolved by front desk teams who need strong coordination with each other specially in translating the problem user is actually face.
    - **Standard Operating Procedures**
      SOPs in any organizations are very important factor and requires swift implementations. Work processes needs to be improved and any change must be carried out in document way i.e. defined Standard Operating Procedures. In cellular networks SOPs are defined in handling any problem or new change which involves multiple teams/ departments.
- Measurement tools and methods are categorized into active and passive methods. Active methods are

executed by injecting certain traffic into test systems placed in specialized environment. Following are passive monitoring systems

- Interface monitoring (signaling messages and data packets)
- Network Element measurements (counters, timers, alarms, etc)
- End Terminal Measurements (e.g. Mobile Service Intelligence - MSI)

Our focus is on using passive monitoring systems and below are few techniques/tools that can be used

- **Signaling Monitoring Systems**
  Signaling monitoring systems are required to monitor interface traffic. However interfaces traffic consists of both user and control plane traffic. For analysis we devise two different channels for measuring user experience. Signaling monitoring systems produce very valuable data sources for mobile operators, enabling a wide range of different applications. They operate by having signaling monitoring probes placed throughout the network at access and core network interfaces. The probes data can be further processed and stored in Big Data environment for Business intelligence and analytics.
  Signaling monitoring systems are able to provide a complete picture of what is going on inside the mobile network, correlating information about users, time, services, network elements, quality etc. They are well-suited for measuring service quality at a granularity ranging from all subscribers down to the individual users, calls, or base stations. Other advantages are troubleshooting and drill-down capabilities on network elements and subscribers. However, unless signaling monitoring probes are placed in phones, they cannot fully capture the coverage part.
  - **User Analytics** – This type of traffic is to be used for user plane traffic. For example we can gauge user experience based on application/services being used by subscriber. This will also help cellular companies to monetize their network resources based on user interest along with the experience they get for certain service/application. TCP success rate, response time, delay and other similar data traffic indicators can be extracted to understand user behavior. These systems are now called as User Behavior Analysis tools.
  - **Network Analytics**–Network analytics are important in knowing user experience in terms of network. Such analytics will become very helpful in troubleshooting problem faced by users. These network analytics tools must have Signaling trace, data record queries and multi-dimensional queries. Multidimensional queries can be Access point being used, location, handset/device, Make, Operating system and model of the device etc.
- **Performance Management Systems**
  Performance Management systems are specially designed for accumulating statistical data from different network elements. This data can be utilized in building end to end network KPIs and KQIs. When gathering measurement data as a basis for computing related KPIs/KQIs, we frequently need input from several measurement techniques. Signaling Monitoring System
- **Drive test systems**
  The drive testing has been most relevant methods of measuring user experience. Drive test systems will help identify areas of high mobile penetration as well as any areas that may be lacking coverage or capacity. Also any problems related to the radio network or handover may be detected. This system will also enable us to view our own and our competitors' mobile voice and data services from the perspective of the subscriber by providing critical quality-of-service (QoS) measurements and true dual-mode operation.
  Types of drive tests:
  - Indicative sample tests using (high-end) ordinary consumer handsets
  - More comprehensive tests complementing handsets with proper instrumentation like network scanners, which are able to fully characterize the mobile wireless interface
- **Mobile Service Intelligence (MSI)**
  MSI is a new method and thus has not been extendedly put in use by most cellular operators. However, with regards to future broadband utilization and its related user experience we include MSI as a potential method for broadband user experience tool.
  This is a process of analyzing data received from the handsets and devices providing insight into mobile service quality and thus measuring user experience and behavior. MSI equipment normally consists of a server for handling the measured data, and a SW client (or a piece of HW e.g. dongles) implemented in the handsets. The server contains a smart database which receives raw data from mobile devices and converts them into reliable and repeatable measures

which feed into analytic applications. This equipment is capable to process data submitted by millions of handsets with outstanding integrity and security.

- Key Quality Indicators are transformed version of Key performance indicators and hence are important element of this research. Below are the suggested KQIs
    - **Accessibility** is measure of network resource availability to end customer through which he/she can setup a connection to the network. For example in case of data services a device/handset must be able to establish network connection though means of Packet Data Protocol (PDP) session
    - **Retainability** is measure of network's retention of active user session. In case of Mobile broadband Data services a session should be retained by network until the user himself teardown a session or user related cause generated by network terminate the session.
    - **Setup Time** is measure of time taken by network to establish a network connection. Service or session setup time counter end when session is successfully established before transmitting or receiving any data.
    - **Service Throughput** is measure of amount of data transmitted or received to/from user. Throughput is important factor in terms of user requirement and hence minimum possible value should be achieved. That also reflect the bandwidth available to user for using certain standard applications
    - **Service Responsiveness** is to measure how quickly network serves user request. For example a user requesting resource from internet and the time it takes to furnish that data to user.

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