Comparison: 3G Wireless Networks with 4G Wireless Networks Technology Wise

M. Ramzan[1] and Javed Ahmed Shaheen[2]

[1]HOD CS Department
[2]Ph.D (Scholar) GCUF
[1,2]Computer Science Department, GC University Faisalabad
javedmatyana@gmail.com, ramzan.talib@gcuf.edu.pk

Abstract

Opportunities and challenges compel us to throw light on the differences between the two 3G and 4G networks. This task is being done in order to list out the drawbacks and merits of these 3G and 4G evolutions of the networks and further to implement R&D research to bring out their sparks in this modern era. If we look into 4G, objective of 4th generation is to enhance specifications for a new radio-access technology for higher data rates, low latency and greater spectral efficiency so 4G (also known as LTE-Advanced) is therefore not a new technology; it is actually an evolutionary step in the continuing development of LTE. The differences of 3G and 4G are done on the following Index terms: Background difference, definitions, technologies progress, speed/ rate of transmission, switching technologies used, network, band width, design specification, QoS, service and billing, features and capabilities.

Keywords: SGSN, SONET, UTRAN, FLASH OFDM, RAN, CORE NETWORK

1. Introduction

3G is also called third generation. It is named as such because it is the third generation of the standards of telecommunication hardware. It is also the general technology for mobile networking, passing the recent 2.5G. The technology is founded on the ITU or International Telecommunication Union group of standards which belongs to the IMT-2000. 3G mobile telephony protocols support higher data rates, measured in kbps or Mbps intended for applications other than voice-centric and this shift from 2G to 3G not only gives users fresh ways to communicate but also a variety of new services such as browsing the Internet, e-mail, instant messaging, video-conferencing and digital television. 3G also makes guidance, presence, and location-based services available to mobile users as cameras and personal time management systems are expected to develop. 3G trials since 2001, across the world have shown that the main development from 2G and 2.5G to 3G is faster connection speed is referring to wider bandwidth. The uniqueness of 3G is to provide mobile multimedia services at a transmission rate of 144kbps at the high speed and 384kbps at the speed of walking and 2Mbps indoors. This theoretical maximum 2Mbps is close to the speed of LAN connections that many households nowadays have in their Networks. 4G is the fourth generation of mobile phone mobile communications standards. It is a successor of the third generation (3G) standards. A 4G system provides mobile ultra-broadband Internet access under LTE and WCDMA. The development of 4G is started in 2002 but the real new revolution started with 3GPP in December 1998. 3G systems are designed for multimedia communication that is for the higher data rates and new flexible communication capabilities of third generation systems

[14].The next step was 3GPP Long-Term Evolution (LTE) with aims to improving the Universal Mobile Telecommunication System (UMTS), mobile phone standard to cope with future requirements. The LTE project is not a standard but it will result in the new evolved Release of the UMTS standard, including most or all of the extensions and modifications of the UMTS system. With the deployment of LTE wireless revolution will achieve a milestone i.e. for the first time; a wide-area wireless network will be universally deployed that has been primarily designed for IP based broadband data from the very beginning. LTE is rapidly becoming the dominant global standard for fourth generation cellular networks and all the major cellular players behind it and working toward its success. The 4G (fourth generation of cellular communication systems) is the emerging technology of future wireless networks.

2. Background Difference

In 3g technology which is founded on the ITU or International Telecommunication Union group of a standard which belongs to the IMT-2000 use W-CDMA technology. It allows operators to provide users a bigger range of the latest services, as it gets bigger network capacity via heightened spectral efficiency. The included services are video calls, wide-area wireless voice telephone and broadband wireless information all included within the mobile environment. Whereas 4G technology which was started within cable television industry in 2009 which make users to explore new downloading speeds and capabilities. The utilization of LTE mobile broadband technology is an opportunity for the corporation to expand its horizons into 4G territory, upstaging current 3G capabilities. The necessity for 4G networks is associated with the increased utilization of data websites such as You Tube and Facebook, which require tremendous bandwidth in order to be used successfully.

2.1. 3G Stands for 3rd Generation while 4G Stands for 4th Generation:

3G is currently the world's best connection method when it comes to mobile phones, and especially mobile Internet. 3G stands for 3rd generation as it is just that in terms of the evolutionary path of the mobile phone industry. 4G means 4th generation. This is a set of standard that is being developed as a future successor of 3G in the very near future.

2.2 Architectural Difference:

Both the Figures below provide the key components of these two architectures.
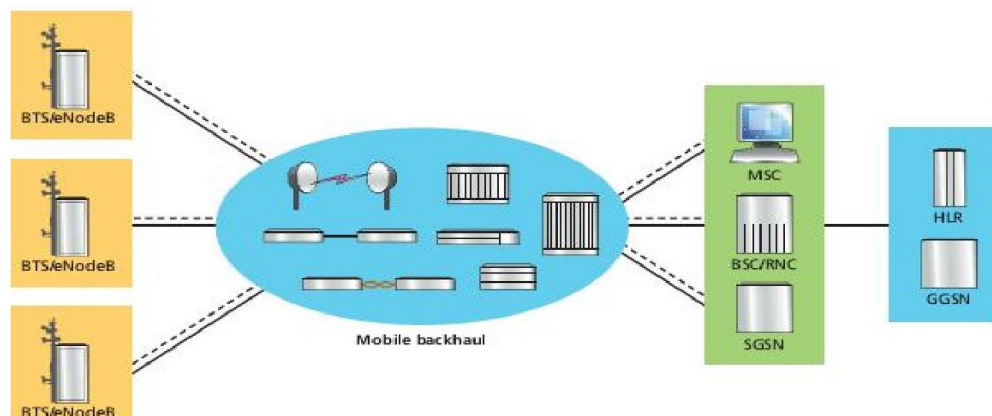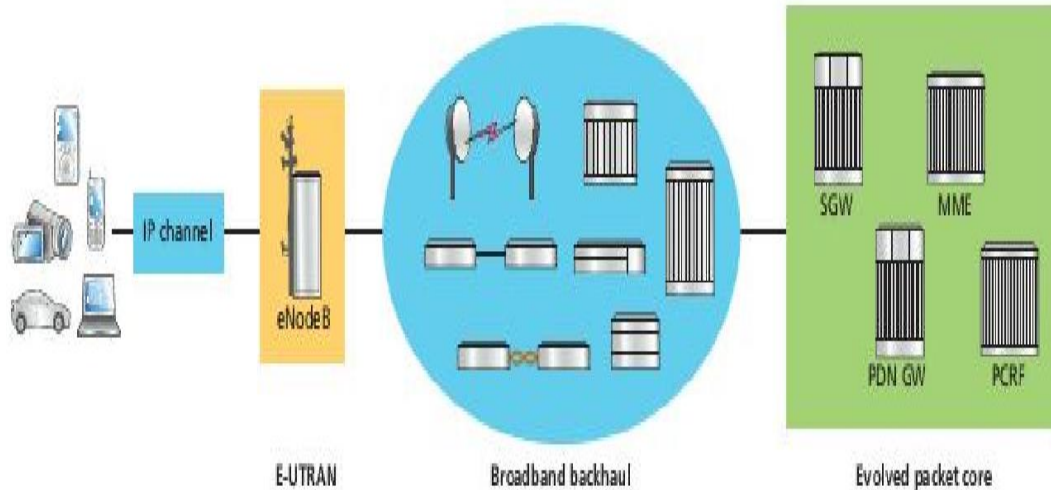

Figure 1. 3G Architecture

Figure 2. 4G Architecture

Several key differences in a LTE network enable more flexibility in its architecture than in a 3G. A functional representation of 3G network architecture is shown in Figure 1. In this network, the Base Terminal Station (BTS) or NodeBs aggregate the radio access network (RAN) traffic and transport it over a mobile backhaul network to the Radio Network Controllers (RNCs) or Base Station Controller (BSCs). Typically this transport is over T1/E1 copper facilities. If fiber is available at cell or near the cell site then the cell traffic is transported over SDH/SONET rings or more recently a carrier Ethernet network when the eNodeBs are equipped with IP/Ethernet interfaces. The bearer traffic from a number of RNCs/BSCs is multiplexed at the Mobile Telephone Switching Office (MTSO) and then transported via direct tunneling to the Gateway GPRS Serving Nodes (GGSNs) in the hub data center. This transport is normally over a SDH/SONET ring or a carrier Ethernet network. This tiered aggregation and transport structure lends itself to a point-to-point network topology to minimize both the amount of aggregation equipment required and the transport backhaul expense. In a 3G pre-Release 8 network, the RNCs and SGSNs are designed to support both the signaling and bearer plane processing and bandwidth requirements. The emphasis in the design for these network elements is in providing the processing necessary to support the high subscriber counts and Packet Data Protocol PDP contexts as the bandwidth requirements for delivery of the initial 3G data services (text and e-mail) were not significant. Since the data services that typically ran over these systems is not real-time neither QoS nor latency was an issue. Therefore, the placement of these elements is usually in locations that primarily meet the PDP context and network latency requirements. Thus, the current 3G packet core architecture is typically a centralized network design with the GGSNs deployed in major data centers, and all the data services are backhauled from the SGSNs which are strategically deployed in regional serving offices. Because the aggregate bandwidth for these services did not increase significantly until the past few years, the backhaul transport costs were manageable and could be supported with leased TDM or lower rate OC-n/STM-n interfaces.

Above Figure 2 provides a high-level functional representation of a LTE/4G network. This network is composed of three major sub-networks: the Evolved Universal Terrestrial Radio Access Networks (eUTRAN),which provides the air interface and local mobility management of the user equipment (UE), the evolved packet core (EPC), and the broadband backhaul network that provides the aggregation of cell traffic and transport back to the EPC. The 3GPP LTE standards defined the EPC as a set of logical data and control plane functions that can be implemented either as integrated or as separate network elements. The four EPC functions are: the Serving Gateway (SGW), the Packet

Data Network Gateway (PGW) that supports the data or bearer traffic; and the Mobility Management Entity (MME) and the Policy Charging and Rules Function (PCRF) which support the dynamic mobility management and policy control traffic. The backhaul network either is owned by the wireless operator or is leased from a third party backhaul access provider. Any number of transport technologies can be used for backhaul including packet microwave, packet optical, Carrier Ethernet, IP/MPLS, GPON and xDSL.

3. Network

3G technologies are in widespread use while 4G compliant technologies are still in the horizon: The biggest difference between the two is in the existence of compliant technologies. There are a bunch of technologies that fall under 3G, including WCDMA, EV-DO, and HSPA among others. Although a lot of mobile phone companies are quick to dub their technologies as 4G, such as LTE, WiMax, and UMB, none of these are actually compliant to the specifications set forth by the 4G standard. These technologies are often referred to as Pre-4G or 3.9G.

3.1 Speed Comparison of 4G and 3G:

4G speeds are meant to exceed that of 3G. Current 3G speeds are topped out at 14Mbps downlink and 5.8Mbps uplink. To be able to qualify as a 4G technology, speeds of up to 100Mbps must be reached for a moving user and 1Gbps for a stationary user. So far, these speeds are only reachable with wired LANs. The fourth generation is faster, it is said to be four times faster than its predecessor. This allows for a connection speed more comparable to DSL and home cable networks. It is great news for those completing work and accomplishing important tasks away from their home and office. When uploading large documents and communicating via the internet, a fast connection is important whereas 3G doesn't favor such speed as compared to that of 4G.

Symbol	Standard	Full Name	Maximum Download Speed (Theoretical)	Maximum Upload Speed (Theoretical)	
2G	GSM	Global System for Mobile Communications	14.4 Kbits/s	14.4 Kbits/s	
G	GPRS	General Packet Radio Service	53.6 Kbits/s	26.8 Kbits/s	
E	EDGE	Enhanced Data rates for GSM Evolution	217.6 Kbits/s	108.8 Kbits/s	
3G	UMTS	Universal Mobile Telecommunications System	384 Kbits/s	128 Kbits/s	
H	HSPA	High-Speed Packet Access	7.2 Mbits/s	3.6 Mbits/s	
H+	HSPA+	Evolved High-Speed Packet Access - Release 6	14.4 Mbits/s	5.76 Mbits/s	
H+	HSPA+	Evolved High-Speed Packet Access - Release 7	21.1 Mbits/s or 28.0 Mbits/s	11.5 Mbits/s	Speed Comparison of All
H+	HSPA+	Evolved High-Speed Packet Access - Release 8	42.2 Mbits/s	11.5 Mbits/s	Generations
H+	HSPA+	Evolved High-Speed Packet Access - Release 9	84.4 Mbits/s	11.5 Mbits/s	with 3G
H+	HSPA+	Evolved High-Speed Packet Access - Release 10	168.8 Mbits/s	23.0 Mbits/s	and 4G
4G	LTE	Long Term Evolution	100 Mbits/s	50 Mbits/s	
4G	LTE-A	Long Term Evolution - Advanced	1 Gbits/s	500 Mbits/s	

Figure 3. 3G and 4G Speed Comparison

3.2 Switching Techniques in 3G and 4G

Another key change in 4G is the abandonment of circuit switching. 3G technologies use a hybrid of circuit switching and packet switching. Circuit switching is a very old technology that has been used in telephone systems for a very long time. The downside to this technology is that it ties up the resource for as long as the connection is kept up. Packet switching is a technology that is very prevalent in computer networks but has since appeared in mobile phones as well. With packet switching, resources are only used when there is information to be sent across. The efficiency of packet switching allows the mobile phone company to squeeze more conversations into the same bandwidth. 4G technologies would no longer utilize circuit switching even for voice calls and video calls. All information that is passed around would be packet switched to enhance efficiency.

3.3 Internetworking of 3G and 4G:

Another difference between the two is the network. When the 3G was introduced, cell phone users were finally able to talk and access data at the same time and with higher data rates. This allowed for a better full service for cell phone users wishing to access the internet. And what is even greater is the 4G data rates are expected to be even higher. Users will have the capability of accessing more data at higher speeds while talking on their cell phone. In addition, the fourth generation permits more data transmission of such services as games and multimedia. It also allows a larger amount of internet support.

3.4 Bandwidth Difference:

The next difference between the third and fourth generation to is bandwidth. At first glance, the bandwidth of both 3G and 4G are the same, numbered at between 5 and 20 MHz. However, the rate of data is what makes the difference between the two. While the data rate of the third generation only goes up to 2 Mbps, the fourth goes all the way up to between 100 Mbps to 1 Gbps.

4. Design specification:

The 3G technology provides both circuit design and packet design. Circuit design, being the oldest, has greater ability to hold the connection for a longer duration. On the other hand the packet design is a wireless technology and is the core part of internet data transmission. The combination of these two patterns helps 3G technology to perform better and faster. However, the 4G technology is kept free from circuit design with an intention to gives nanosecond wings to data transfer and so has packet design only.

4.1 Data transmission rate

3G system is based on wideband CDMA that operates in 5 MHz of bandwidth and can produce download data rates of typically 384 kb/s under normal conditions and up to 2 Mb/s in some instances.3g phone standards have been expanded and enhanced to further expand data speed and capacity. The WCDMA phones have added high speed packet access (HSPA) that use higher level QAM modulation to get speeds up to 21 or 42 Mb/s downlink (cell site to phone) and up to 7 and/or 14 Mb/s uplink (phone to cell site).whereas in 4G also known as LTE uses a completely different radio technology. Instead of CDMA, it uses orthogonal frequency division multiplexing (OFDM) and OFDM access. This modulation technique divides a channel usually 5, 10 or 20 MHz wide into smaller subchannels or subcarriers each 15 kHz wide. Each is modulated with part of the data. The fast data is divided into slower streams that modulate the subcarriers with one of several modulation schemes like QPSK or 16QAM. It also defines multiple input multiple output (MIMO) operation that uses several transmitter-

receiver-antennas. The data stream is divided between the antennas to boost speed and to make the link more reliable. Using OFDM and MIMO lets LTE deliver data at a rate to 100 Mb/s downstream and 50 Mb/s upstream under the best conditions. In 4G the theoretical upper data rate is 1 GB/s. That remains to be seen in practice.

4.2 Quality of service:

In **3G**, network based Qos depends on following factor to provide a satisfactorily service as: Throughput, Packet Loss Rate, Packet Loss Rate, reliability and delay. Where as in **4G** With respect to network quality, many telecommunications providers are promising that there will be enhanced connectivity, and the quality of data that is transmitted across the network will be of the highest possible quality. The main challenge that 4G networks are facing is integrating non-IP-based and IP-based devices. It is known that devices that are not IP address based are generally used for services such as VoIP. On the other hand, devices that are IP address based are used for data delivery. 4G networks will serve both types of devices.

4.3 Service and Billing:

3G networks that are capable of supporting an ever-increasing variety of data services from streaming video, to gaming, to proprietary business applications, to mobile commerce transactions for tangible goods and services. However, as 3G finally makes it into the mainstream, its success is inextricably linked to how the CSPs (Communications Service Providers) charge and bill for services in ways that are both intuitive and acceptable to the end user while also being relevant to the CSP's costs and billing capabilities Where as in 4G managing user accounts and billing them has become much more complicated with 4G networks. This is mainly due to heterogeneity of 4G networks and the frequent interaction of service providers.

4.4 Features and capabilities:

3G has features with Speed of mobile communication in 3G ranges from 600-800 Kbit/sec. Also it provides high quality wireless sound and facilitates with global roaming. It accommodates distance surveillance and enables mobile TV Whereas the ambitious goal of 4G is to allow everyone to access the Internet anytime and everywhere. The provided connection to Internet will allow users to access all type of services including text, databases, and multimedia. 4G will also provide higher bandwidth, data rate, lower authentication overhead, and will ensure the service is constantly provided to the user without any disruption.

Table 1. Comparison of Different Aspects of 3G and 4G

Specifications	3G	4G
Frequency Band	1.8 – 2.5 GHz	2 – 8 GHz
Bandwidth	5-20 MHz	5-20 MHz
Data rate	Up to 2Mbps	20 Mbps or more
Access	Wideband CDMA	Multi-carrier – CDMA or OFDM(TDMA)
FEC	Turbo-codes	Concatenated codes
Switching	Circuit/Packet	Packet

Table2: Comparison in brief

Attributes ↓	3G	4G
Data Throughput:	Up to 3.1mbps	3to5mbps but potential estimated at a range of 10 to300 mbps.
Peak Upload Rate:	50 Mbit/s	50 Mbit/s
Peak Download Rate:	100Mbit/s	1Gbit/s
Switching Technique:	packet switching /circuit switch	packet switching, message switching
Network Architecture:	Wide Area Cell Based	Integration of wireless LAN and Wide area.
Services And Applications:	CDMA 2000, UMTS, EDGE etc	Wimax2 and LTE-Advance
Forward error correction (FEC):	3G uses Turbo codes for error correction	Concatenated codes are used for error correctionsin4G.
Frequency Band:	1.8 – 2.5GHz	2 – 8GHz

5. Applications of 3G and 4G

The emerging applications for 3G and 4G wireless systems typically require highly Heterogeneous and time varying quality of service from the underlying protocol layers. So adaptability will be one of the basic requirements to the development and delivery of new mobile services. Promising techniques and possible topics may include: Mobile application should refer to a user's profile so that it can be delivered in a way most preferred by the subscriber, such as context-based personalized services. This also brings the applications with adaptability to terminals that are moving in varying locations and speeds. Techniques such as adaptive multimedia and unified messaging take the terminal characteristics into account and ensure that the service can be received and run on a terminal with the most suitable form to the host type. The 4G technology will be able to support Interactive services like Video Conferencing (with more than 2 sites simultaneously), Wireless Internet, etc. The bandwidth would be much wider (100 MHz) and data would be transferred at much higher rates. The cost of the data transfer would be comparatively very less and global mobility would be possible. The networks will be all IP networks based on IPv6. The antennas will be much smarter and improved access technologies like OFDM and MC-CDMA (Multi Carrier CDMA) will be used. Also the security features will be much better. Long-Term (Radio) Evolution or LTE is also part of 3G technology. It's a 3GPP its research item for Release 8. It's also known as 3.9G or "Super 3G" by some researchers. It's planned to commercialize in 2009. It was aims at peak data rates of 200 Mbps (DL) and 100 Mbps (UL).

6. Multiple Access Techniques in 3G & 4G

3G wireless multiple access techniques are widely based on CDMA and WCDMA. But 4G demands a better multiple access technique for reducing the MAI (Multiple Access Interference) and ISI (Inter Symbol Interference) and thus improve the bit error rate performance. MC-CDMA is the best candidate that would satisfy the demands of 4G

wireless systems. Moreover adaptive modulation techniques have been proposed for 4G, where the modulation scheme is changed dynamically based on the current channel estimates. MCCDMA is the hybrid combination of OFDM (Orthogonal Frequency Division Multiplexing) and CDMA. MC-CDMA with adaptive modulation promises to meet the demands of 4G regarding high data rate with a lower BER (Bit Error Rate). OFDM has the capability to cancel multipath distortion in a spectrally efficient manner. Rapid variation in channel characteristics are caused by multi-path and Doppler spread (due to the different speeds of mobile). Sometimes these time varying channels are characterized by very good SNR (Signal to Noise Ratio), but worse SNR at other times. So a fixed modulation technique cannot achieve the best Spectral efficiency as the system has to be built with a modulation scheme considering the worst case scenario. Hence during good channel conditions the system would not be able to obtain the best possible spectral efficiency. This is where adaptive modulation shows its role. Adaptive Modulation techniques takes advantage of the time varying channel characteristics and adjust the transmission power, data rate, coding and modulation scheme for the best spectral efficiency.

7. Multimedia & Video Services in 3G/4G

Wireless systems are expected to deliver efficient multimedia services at very high data rates. Basically there are two types of video services: bursting and streaming video Services. Streaming is performed when a user requires real time video services, in which the server delivers data continuously at a playback rate. Streaming has little memory requirement as compared to bursting. The drawback of streaming video is that it does not take advantage of available Bandwidth. Even if the entire system bandwidth is available for the user, streaming video service will transmit data only at a particular playback rate. Bursting is basically file downloading using a buffer and this is done at the highest data rate taking advantage of the whole available bandwidth. The flaw with this type of transmission is that it demands a large memory requirement. So work is being done to come up with a new scheme that limits the memory requirements and can exploit the available bandwidth of the system.

8. Applications of 4G which are not present in 3G

8.1. Virtual Presence:

This means that 4G provides user services at all times, even if the user is off-site. Virtual navigation is also embedded in 4G mean provides users with virtual navigation through which a user can access a database of the streets, buildings etc of large cities. This requires high speed data transmission.

8.2. Tele-Medicine:

4G will support remote health monitoring of patients. A user need not go to the hospital instead a user can get videoconference assistance for a doctor at anytime and anywhere.

8.3. Tele-Geoprocessing Applications:

This is a combination of GIS (Geographical Information System) and GPS (Global Positioning System) in which a user can get the location by querying.

9. Conclusion

For better performance we have to make 3G as IP based which will allow higher data transmission rate. We have to use only packet switching so that we can achieve higher internet speed eliminating circuit switching which makes internet speed slow. To have the better performance we have to use OFDM technology with QPSK and 16 QAM modulation rather than simple QAM modulation technology. The 3G should be integrated with the IP based technology so that it can have the tremendous data transmission and support VoIP as well. We have to increase the band width of the 3G networks by using technology such as orthogonal frequency division if we are able to integrate it with the wireless LAN for better quality of service. At an early stage the Flash-OFDM (Fast low-latency access with seamless handoff orthogonal frequency division multiplexing (Flash-OFDM also referred to as F-OFDM) system was expected to be further developed into a 4G standard. No source suggests peak download and upload rates of more than the 1 Gbps to be offered by ITU-R's definition of 4G systems. If any further generation appears, and reflects these prognoses, the major difference from a user point of view between 4G and next Generation techniques must be something else than increased maximum throughput; for example lower battery consumption, lower outage probability / better coverage, high bit rates in larger portions of the coverage area, cheaper or no traffic fees due to low infrastructure deployment costs, or higher aggregate capacity for many simultaneous users *i.e.*, higher system level spectral efficiency.

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Authors

Dr. M. Ramzan Talib, Chairperson, Computer Science Department GCU Faisalabad

Javed Ahmed Shaheen is presently Studying Ph.D (CS) in from GC University Faisalabad Pakistan under the supervision of sir M.Ramzan sb.