A STUDY OF EVOLUTION: WCDMA TO 4G

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Abstract

Mobile communication is continuously one of the live-wire areas that are developing at a vigorous momentum. The latest techniques are growing in all the wings of mobile and wireless communications. It makes its presence undoubtedly meaningful in the world. With such rapid development of wireless communication technology, fourth generation wireless system (4G) technology has undoubtedly become a hot topic. This topic gives you basic idea about the 3G and 4G technologies used for mobile communication, evolution from the 3G to 4G standards and intermediate technologies providing path to reach the 4G standards as well as the entire 4G sphere of influence, into which almost all the features in the composition are deeply discussed from a technical point of view, in which latest techniques and achievable technical research issues for adequate support of adaptability are also proposed. The difference between this paper and other related pieces of research articles is that I am presenting overall visions on the features of 3G and 4G mobile communications, and provide detailed proposals to respective intermediate technologies.

Introduction

The very first goal of enhanced technology is to seamlessly provide a wide variety of communication services to anybody, placed anywhere, and working anytime during connection. The proposed services for next generation mobile phone users include services like transmitting data at very high speed, video conferencing without buffering as well as voice communication. To fulfill such tasks and make these services available to users is greatly known as the Third Generation (3G) and Fourth Generation(4G).

Since 1985, ITU (International Telecommunications Union) has been developing IMT-2000. In 1992, for terrestrial as well as satellite communication, the World Administrative Radio Conference (WARC) of the ITU specified the frequencies around 2 GHz wide for future.

(1) International Mobile Telephony 2000 (IMT-2000).
(2) UMTS (Universal Mobile Telephone Service). (Eu rope)

Its original target was to create a unique and common air interface that is global IMT-2000. For the same the advanced specification was been created in 3GPP (the 3rd Generation Partnership Project), the joint standardization project of the standardized bodies from Europe, China, Korea, USA and Japan.

3GPP was founded in 1998. It has four Technical Specification Group (TSG).

(1) Core Network TSG
(2) Radio Access Network (RAN) TSG
(3) Service and System Aspects TSG
(4) Terminals TSG

Within the TSGs, the RAN TSG is the most pertinent to the WCDMA standard.

The international organization called Third Generation Partnership Project (3GPP), developed the widely used UMTS WCDMA/HSPA 3G standards. It has also developed Long-Term Evolution (LTE). Some multiple standards were developed, specially WCDMA by the 3GPP and cdma2000 by the Qualcomm. Both of the technologies have still survived to prove the existence. A company of Japan called DoCOMo has first introduced the WCDMA technology to mobile operators.

WCDMA(3G) Parameters

Table 1. WCDMA parameters[5]

Channel Bandwidth	5 MHz
Duplex Mode	FDD and TDD
Spread Spectrum Technique	Direct Spread
Chip Rate	3.84 MHz
Frame Length	10 ms (38400 chips/sec)
Slot Length	15 Slots per Frame (2560 chips/slot)
Spreading Modulation	Balanced QPSK (downlink) and Dual-Channel QPSK (uplink) with complex spreading circuit.
Data Modulation	QPSK (downlink) and BPSK(uplink).
Channel Coding:	Turbo code, Convolution code
Spreading Factors	4-256 for uplink and 4-512 for downlink.
Spreading (downlink)	OVSF sequences for channel separation.
Gold sequences	(2^18)-1 for cell and user separation (truncated cycle: 10 ms).
Spreading (uplink)	OVSF sequences for channel separation
Gold sequences	225-1 for user separation (truncated cycle: 10ms).

CDMA can transmit multiple signals over the same frequency simultaneously and is the underlying technology in three 3G systems: **CDMA 2000**, **HSDPA**, **WCDMA**. The latter two of which are used by GSM (Global System for Mobile communication) carriers.[6]

UMTS Architecture

(1) Core Network (CN)

(2) UTRAN
(3) User Equipment (UE)

UTRAN (UMTS terrestrial Radio Access Network) consists of two elements.
(1) **Node B:** Converts data-flow between interfaces
(2) **Radio Network Controller (RNC):** Possess, maintains and controls the radio resources in its domain.

Comparison of WCDMA and CDMA

1) The major difference between CDMA and WCDMA is both use different technological groups.
2) WCDMA can offer much more faster speed. It can take advantage of the most recent user centered services that have not been found within entire basic 2G technology
3) To allow more no of users WCDMA uses 5 Mhz wide frequency band which is more than basic CDMA where each frequency band is allocated only 1.25Mhz.

Limitations and difficulties of 3G

3G still have some unsolved problems that it needs to think upon them.
The limitations and difficulties of 3G include:
1) Difficulty in continuously demanding more amounts of bandwidth and high data rate to provide multimedia services requirements of different services demanding different bandwidth and QoS. Providing such with the coexistence of users of old generations.
2) Limited spectrum availability and its allocation.
3) Difficult in hand-off for distinct service environment in different frequency bands.
4) Lack of end-to-end rapid transport mechanism wrapping a mobile sub-network with fixed architecture.

HSPA (3.5G)

The incorporation of two diverse mobile telephony protocols that are; First one is High Speed Downlink Packet Access (HSDPA) and second one is High Speed Uplink Packet Access (HSUPA) results the High Speed Packet Access (HSPA). It overcomes the technical challenges, extends the vision and improves the practical performance of the existing WCDMA technology.

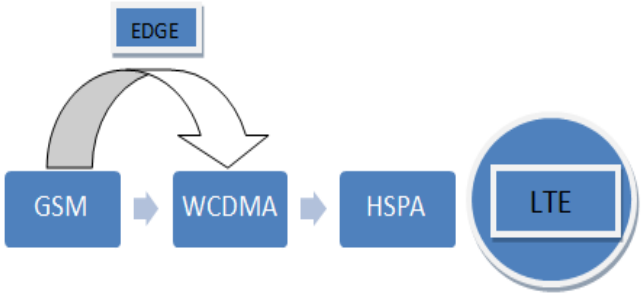

Figure 1: upgrade path to wireless broadband

Long Term Evolution(LTE)

We have grown accustomed to the wealth of information available through the Internet and the mobility provided with wireless communications. Now the amalgamation of these two forces will enable the mobile Internet. With this convergence, mobile data services have grown significantly each year.[7]
Most of us consider LTE as 4G but in realities it is just an advanced 3G standard. People widely and madly marketing as it as 3.9G.[7] LTE was created as an advanced version or simply the upgrade to the 3G standards. LTE uses a completely different radio technology compared with the CDMA., that is Orthogonal Frequency Division Multiplexing (OFDM) and OFDM Access instead of CDMA.[3] With the use of Orthogonal Frequency Division Multiple Access (OFDMA), LTE is able to provide download rates of 150 Mbps for multi-finger multiple-input multiple-output (MIMO) antennas for the peak category terminals.[7] For such terminals uploading rate is around 50 Mbps in better environment and it will allow an efficient transfer of data that uses several transmitter-receiver-antennas. The stream of data is further divided between the different antennas to enhance the speed and to make the link more dependable. The combination of OFDM and MIMO allows LTE to deliver data rate of 100 Mb/s downlink and 50 Mb/s uplink under the best suitable conditions. [1]

4G

Fourth-Generation universal mobile telecommunications system, often abbreviated as 4G UMTS, is a wireless telecommunication data transfer standard. Though there are several devices claiming use 4G UMTS, the unconditional standards set by the ITU Network are not yet met by existing devices.
It is funny and rather easy for anyone to predict advanced 4G characteristics, but it is more difficult to provide such stated description. as we need sufficient investigations and the new ideas especially to support the existing technology and make them advanced techniques and widely available to the users.
The basic explanation of 4G as stated by the ITU-T and the 3GPP is nothing but the Long Term Evolution-Advanced (LTE-A)
4G UMTS uses several features such as same devices and bit of same infrastructure as used in Third-Generation UMTS (3G UMTS) which is shown in figure 2

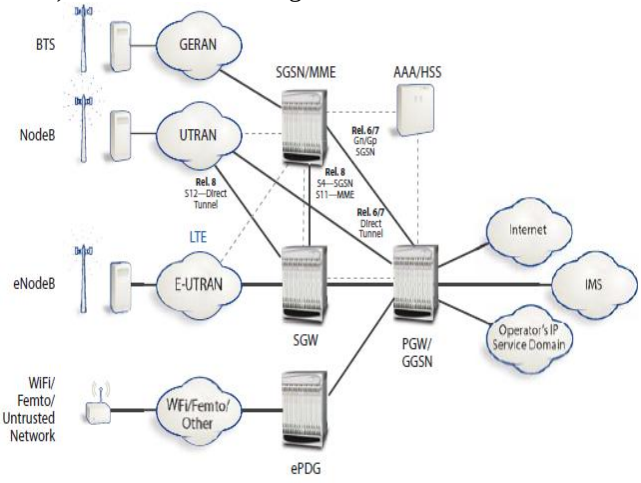

Figure 2:LTE network[4]

4G standards are completely based on packet switching as circuit switching is completely omitted from it. Voice and data both are transmitted through packet switching only. With existing 3G technology, only single user is served on the downlink path in any random time slot where as LTE can serve 30 to 40 users in any random time slot, which provides you a uncompetable, real-time experience. In wireless network latency is what we describe as the time it takes to complete the task from when it is requested and when it is actually completed. In 3.5G networks, it is common that when a mobile is in idol mode and wants to initiate a connection, it takes several hundred ms delay. but for advanced standards such as 4G only 50 ms one-way latency is the norm to transmit data packets.[7] Data speed of LTE-A is around 1Gbps for peak download and around 500Mbps for peak upload.

Advantages

1) **Enhanced Security:-**
LTE offers enhanced security through strong mutual authentication. It keeps user identity confidential along with other security enhancements hence making it even more secure than existing 3G technologies. 4G is equipped with the world's first Bearer Independent Protocol (BIP) implementation. SO we are able to update devices quickly, easily and securely over the Internet.

2) **Wide market covered:-**
With the help of LTE, mass deployment of wire-less services and applications, such as VoIP, video conferencing, online shopping, e-trading are practical nowadays.

3) **Implementation of IPV-6:-**
The future IP addressing is IPV-6 and LTE is inherently supporting the IPv6 Dual Stack addressing. It also provides backward compatibility with existing IPv4 systems is truly commendable.

4) **Large No of users:-**
It uses IMSI-based telephone number identifiers, making mass implementations over LTE more easily achievable. LTE uses 15-digit IMSI telephone number identifiers instead of 10-digit as in 3G, for large-scale deployments of devices.

Application

A. A great extent to faster web browsing:
4G offers theoretical data speeds up to 100 Mbps. It is far better than 7.2Mbps for 3G and 21MBps for more advanced 3.5G networks. Certainly that results in much more faster web browsing and a significantly better experience for surfing. In past and even in present we are waiting impatiently for a web page to load on our mobile or seen our browser time out; but now with 4G, as long as you are in an area with good mobile coverage or even far area from the tower we can enjoy the live streaming

B. Live Video streaming:
4G being so fast that you can enjoy the video streaming without buffering anytime, anywhere.

C. Internet calls and voice over IP (VOIP):
An apparent benefit of high speed data connection is that, we can make a call using the data which we have subscribed, we can enjoy video calls over an app like Skype Viber or audio calls over an app like Facebook, WeChat and Viber with more call quality and significantly reduced threat of dropping a call due to meager coverage.

D. Maps and Satellite navigation:
4G does not mean only the fast internet access but the great data coverage. Network should have more area to be covered with more no of BTSs. This is particularly important for those who use GPS on their smart phones with apps like Google Maps which helps them in finding the way. For us it is not only to follow the route but it's the quick access of the map provided to us.

E. Photo sharing:
A great benefit of 4G is that one can directly upload original higher resolution photos via apps like Instagram, Facebook and Whats-app without reducing the quality. We can sync our photos to the Cloud in real time with full resolution. As the technology upgrades our photos are gaining more details than ever. So we need to share those photos in their original resolution.

F. Mobile hotspots:
One of the most exciting features of 4G is the capability to create a high speed mobile hotspot from a smart phone. With the use of it other devices such as laptops or mobiles can access the net with a bit of reduced speed. More the connection more reduced speed. To use this with older technology better we choose to remain unconnected. But now with 4G network and 4G enabled mobile hotspots are just like enjoying connection of a high speed wi-fi network at home.

G. Mobile/Portable Gaming:
Nowadays most gaming platforms have in-built Wi-Fi connectivity; we can easily use the portable modem or router to share a 4G connection with six to seven different devices thus broadening the use of 4G for swift portable gaming experience.

H. Cloud-Based computing:
Implementation of 4G will make use of cloud-computing so easy that one can access and store the data on cloud server.

I. Quick Response and Tele-medicine:
As we can exchange the large video so quickly on the internet, tele-medicine has become possible to provide fast and better treatment for remote area patients. One can interact live from the operation theatre.

J. Quality of Service:
To improve Qos it apply reliable application of admission control hence re- scheduling the default algorithms regardless of inbuilt infrastructure. Hence operator diversity to have more ways of transmission leads to an increased quality of service (QoS) to the users.

K. Seamless Handover and Service Continuity:
A base station that provides intra- and inter-technology handovers, without service discontinuity with zero or minimal interruption, with a few loss in service quality. Support for this function requires continuous transparent maintenance of active

service instances and inclusion of various access technologies, including from basic Wi-Fi to upgraded OFDMA.

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Conclusion

This article summarizes the requirements, availability and benefits of having all such technologies as well as the journey from 1G to fully fledged 4G.

References

[1] History of 3G generation is available on: http://en.wikipedia.org/wiki/3G

[2] Shah, Ishan, Nupur Mehta, Shiv Shukla, Nirja Mehta, Rohan Shrotriya, and Shivang Bakliwal. "Comparative Study of 4G Technology, Applications and Compat bility in Prevailing Networks." International Journal of Electronics Communication and Computer Technology (IJECCT) Volume 2.

[3] Differences between 3G and 4G available: http://www.differencebetween.net/technology/ difference-between-3g-and-4g/#ixzz3BONLE1Sh

[4] LTE network available on: http://www.cisco.com/c/dam/en/us/solutions/service-provider/mobile-internet/whitepaper_c11-577763_v1.pdf

[5] w-cdma parameters available on: http://wits.ice.nsysu.edu.tw/course/ pdfdownload/963G/3G-05- Oveview%20of%20WCDMA.pdf

[6] CDMA information available on: http://wits.ice.nsysu.edu.tw/course/pdfdownload /963G/3G-05-Oveview%20of%20WCDMA.pdf

[7] Krenik, B., "4G wireless technology: When will it happen? What does it offer?," Solid-State Circuits Conference, 2008. A-SSCC '08. IEEE Asian , vol., no., pp.141,144, 3-5 Nov. 2008

[8] Jun-Zhao Sun; Sauvola, J.; Howie, D., "Features in future: 4G visions from a technical perspective," Global Telecommunications Conference, 2001. GLOBECOM '01. IEEE , vol.6, no., pp.3533,3537 vol.6, 2001

[9] Yangzi Li; Gengguo Cheng, "Fourth generation wireless communication network," Consumer Electronics, Communications and Networks (CECNet), 2013 3rd International Conference on , vol., no., pp.312,315, 20-22 Nov. 2013

[10] Seung-Ku Hwang; Deuk-Su Lyu; KyungHi Chang, "4G vision and technology development in Korea," Communication Technology Proceedings, 2003. ICCT 2003. International Conference on , vol.1, no., pp.26,27 vol.1, 9-11 April 2003

[11] Vergados, D.D.; Gizelis, C.; Vergados, D.J., "The 3G wireless technology in tactical communication net works," Vehicular Technology Conference, 2004. VTC2004-Fall. 2004 IEEE 60th , vol.7, no., pp.4883,4887 Vol. 7, 26 29 Sept. 2004

[12] Safwat, A.M.; Mouftah, H., "4G network technologies for mobile telecommunications," Network, IEEE, vol.19, no.5, pp.3,4, Sept.-Oct. 2005

[13] Glisic, S.; Makela, J.-P., "Advanced Wireless Networks: 4G Technologies," Spread Spectrum Tech niques and Applications, 2006 IEEE Ninth Interntional Symposium on , vol., no., pp.442,446, 28-31Aug. 2006

[14] Qing Xiuhua; Cheng Chuanhui; Wang Li, "A study of some key technologies of 4G system," Industrial Electronics and Applications, 2008. ICIEA 2008. 3rd IEEE Conference on , vol., no., pp.2292,2295, 3-5 June 2008

[15] Jamil, M.; Shaikh, S.P.; Shahzad, M.; Awais, Q., "4G: The future mobile technology," TENCON 2008 - 2008 IEEE Region 10 Conference , vol., no., pp.1,6, 19-21 Nov .2008

[16] Li Zhuang; Chen Xiaoyan; Du Yan, "Mobile Learning Applied Research Based on 3G Technology," Software Engineering Research, Management and Applications, 2009. SERA '09. 7th ACIS International Conference on , vol., no., pp.173,175, 2-4 Dec. 2009

[17] Zhou Fan; Lv Yan, "Analysis of the 4G technologic requirements and key technology," IT in Medicine and Education (ITME), 2011 International Symposium on , vol.2, no., pp.494,497, 9-11 Dec. 2011

[18] Yangzi Li; Gengguo Cheng, "Fourth generation wireless communication network," Consumer Electronics, Communications and Networks (CECNet), 2013 3rd International Conference on , vol., no., pp.312,315, 20-22 Nov. 2013

[19] Datta, P.; Kaushal, S., "Exploration and comparison of different 4G technologies implementations: A survey," Engineering and Computational Sciences (RAECS), 2014 Recent Advances in , vol., no., pp.1,6, 6-8 March 2014