4G Wireless Network: A Review

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Abstract: **These days, mobility is one of the most important features in communication networks. It has such an enormous impact that wireless communication has become an inevitable part of our life. The need has fueled rapid innovation in the technology and as a result we acknowledge a significant change in the wireless technologies which are known as 1G, 2G, 3G and 4G. However, no single network and no single technology dominate the wireless communication. Therefore, seamless global network connectivity is a significant challenge facing wireless and mobile network. It demands for rapid innovation and more rapid rollout of global connectivity. In this paper, we present technological advancements in different generations in wireless networking with a special focus on some significant changes in the 3G and 4G wireless technology for implementation of data transfer and voice communication.**

Index term**: wireless technology, mobile network.**

I. INTRODUCTION

The 3rd Generation wireless network, commonly known as 3G, is a family of different mobile telecommunication techniques defined by the International Telecommunication Union (ITU), which include GSM, UMTS, WiMAX, and CDMA2000. The services which are including in this generation's network are wide-area wireless voice telephone, video calls, and wireless data, all in a mobile environment. Compared to 2G and 2.5G services, 3G allows simultaneous use of speech and data services and higher data rates (up to 14.0 mbps on the downlink and 5.8 mbps on the uplink). The 3G networks enable network operators to offer users a wider range of more advanced services and features while achieving greater network capacity through improved spectral efficiency.

A typical wireless network structure is shown in Fig.1. The satellite covers a large geographical region which usually contains different metropolitan areas. A metropolitan area consists of several campuses which contain buildings, houses, and other places and then a router cover a particular office or building. The 4G is the most advanced generation of cellular wireless standards. It is a successor of the 3G technology with an aim to provide high data rate to broadband Internet access to mobile as well as stationary users. The 4G mobile network must have target peak data rates of up to 100 Mbit/s for high mobility such as mobile access and up to 1 Gbit/s for low mobility such as local wireless access. Scalable bandwidth up to at least 40 MHz should be provided. A 4G system is expected to provide a comprehensive and secure all-IP based solution where facilities such as IP telephony, ultra-broadband internet access, online gaming services and HDTV streamed multimedia may be provided to users [14].

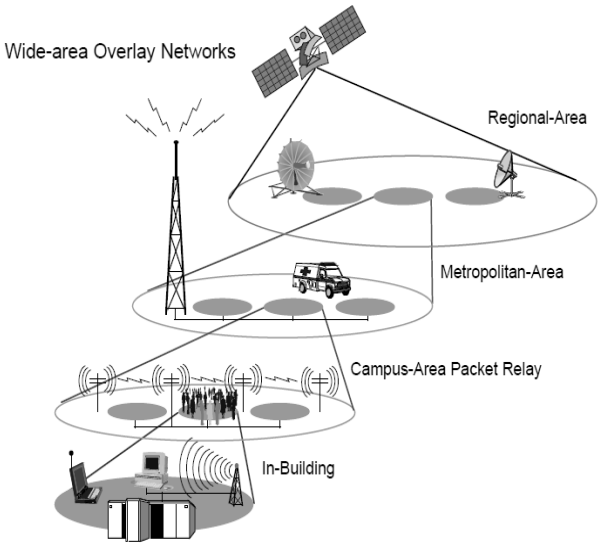

Fig-1- Wireless Network Structure

II. EVOLUTION AND REVOLUTION OF WIRELESS TECHNOLOGIES

The demand for networked consumer systems and devices is large and growing rapidly where the wireless technology and technological standard are evolving according to the world. Wireless telecommunications has evolved from 2G in the 20th century to the current 3G in the 21st century; and current work being done is leading to 4G. The 4G, also known as Fourth-Generation, is a term used to describe the next complete evolution in wireless communications. A 4G system is a complete replacement for current 3G networks and will be able to provide a comprehensive and secure IP solution where voice, data, and streamed multimedia can be given to users on an "anytime, anywhere" basis at much higher data rates than previously known generations.

India is one of the countries where the market of wireless is growing at a very fast pace. In India, about 490 million users has been adding about 14 million subscribers each month and the government has penciled in revenue of 350 billion rupees ($7.6 billion) from the auction of 3G spectrum [1].

After getting the 3G licenses, China Mobile, the world's top mobile carrier with 500 million subscribers, is already looking for the next generation, planning to build a trial LTE network in multiple cities next year, Chairman Wang Jinzhou said in the press conference on November 2009 [1].

AT&T, one of the world's largest telecommunications providers, will begin its own rollout of a 4G Network in 2011, enabling its vast user base 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 [3].

In Japan the success of the I-mode combined with the overall demand for continuing technological enhancements and customer demand for specific services such as mobile broadband access, suggests strongly that 3G network must eventually take off elsewhere[2].

In 4G network to accommodate the requirements such as high usability and personalization of 4G (mobile) networks, conventional handheld single network-interface mobile devices are evolving into multihued devices. Moreover, owing to the recent advances in the mobile middleware technologies, hardware technologies and association with the human user, handheld mobile devices are evolving into data producers and in turn acting as Nomadic Mobile Service (NMS) providers [4].

The success of wireless access technologies, such as wireless LANs, has forced mobile operators and manufacturers to consider their integration into 3G infrastructures. Nowadays, several research groups and standardization bodies are working to provide such integrated architectures. One of the main aims of these architectures is to provide seamless service continuity to users that move from one access system to another [5].

In the vision of mobile networks, integrated and personalized services are envisaged at any desired time and any location. This vision is, partly, to be realized by making use of the mobile, often handheld or otherwise wearable devices, connected to the Internet using one or more of the network interfaces embedded in these devices [6]. We investigate mathematical programming models for supporting the decisions on where to install new base stations and how to select their configuration (antenna height and tilt, sector orientations, maximum emission power, pilot signal, etc.) so as to find a trade-off between maximizing coverage and minimizing costs [8].

4G mobile communication system has steeped the race in its implementation at the earliest. 4G wireless being an upcoming standard witnesses burgeoning interest amongst researchers and vendors. It is being designed to allow seamless integration and communication between wireless devices across diverse wireless standards as well as broadband networks wirelessly [9]. As 3G wireless systems evolve towards 4G, various wireless network technology organizations looking at network architectures for 4G are considering a redesign of the network away from the traditional centralized, hierarchical design towards a more distributed operation of network functions [10].

The practical success of the future generation mobile systems such as 4G relies largely in its flexibility in providing adaptive and cost-effective services. Service discovery is an essential mechanism to achieve this goal [11]. The past and recent research efforts investigated the gathering of low-level information, implementation- and domain-driven approaches for context frameworks and conceptual models of context, vertical approaches combining the aspects of modeling but the implementation is still missing [12].The integration of a multitude of wireless networks is expected to lead to the emergence of the 4G wireless technologies. Under the motivation of increasing technology the levels of user satisfaction maintaining seamless connectivity and a satisfactory level of quality of service is also increasing [13].

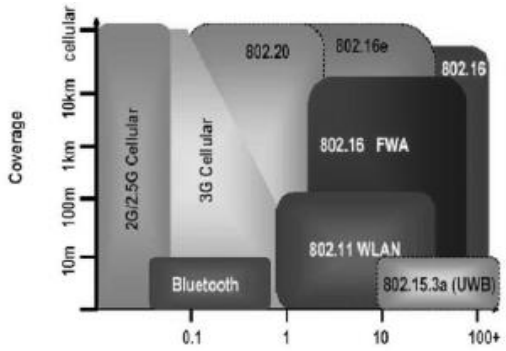

Fig-2- Different Wireless Technologies

Fig. 2 shows difference between all existing wireless technologies according to there coverage area and bandwidth availability. The existence of 4G Networks in today's technology-driven society is important indicator of advancement and change. The 4Gnetworks are designed to facilitate improved wireless capabilities, network speeds, and visual technologies. It is anticipated that as these networks continue to thrive, the demand for advanced related technologies will also grow, thereby creating new

alternatives for savvy technology users to exceed their desired expectations.

III. COMPARISION OF WIRELESS TECHNOLOGIES

A *3G Features*

*1 Data rates:*ITU has not provided a clear definition of the data rate users can expect from 3G equipment or providers. Thus, users of 3G service may not be able to point to the standards and say that the specified rates are not being met. While stating that "it is expected that IMT-2000 will provide higher transmission rates minimum data rate of 2 Mbit/s for stationary or walking users, and 348 kbit/s for moving vehicle, the ITU does not actually clearly specify minimum or average rates or what modes of the interfaces qualify as 3G, so various rates are sold as 3G intended to meet customers expectations of broadband data [2].

2 Access schemes: In 1999, ITU approved five radio interfaces for IMT-2000 as a part of the ITU-R M.1457 recommendation in which Wi-Max was added in 2007.There are evolutionary standards that are backward compatible to pre-existing 2G networks as well as revolutionary standards that require all-new networks and frequency allocations. The later group is the UMTS family, which consists of standards developed for IMT-2000, as well as the independently developed standards DERT and WiMax, which were included because they fit the IMT-2000 definition. Some of access schemes in 3G networks are TDMA Single-Carrier (IMT-SC), CDMA Multi-Carrier (IMT-MC), CDMA Direct Spread(IMT-DS),FDMA/TDMA (IMT-FT), and IP-OFDMA [2].

*3 Security:*3G networks offer a greater degree of security than 2G networks. Authentication to the network assures the user that he is connecting to the intended network. 3G networks use more robust block crypto instead of the older stream cipher. In addition, it offers infrastructure security, and end-to-end security while accessing the application frameworks [2].

4 Applications: The bandwidth and location information available to 3G devices give rise to applications that were not previously available to mobile phone users. Some of the applications are:

- Mobile TV – a TV channel may be provided on a mobile handset directly.
- Video on demand–a video may be transmitted to the subscriber or a provider can send a movie to the subscriber.
- Video conferencing–a subscriber can see the person to whom he is talking to.
- Tele-medicine - a medical provider can monitors and provides advice to the patients.
- Location-based services- a provider can send localized weather or traffic conditions through phone, or the phone allows the subscriber to find nearby locations.

B *4G Features*

According to the members of the 4G working group, the infrastructure and the terminals of 4G will have almost all the standards from 2G to 3G implemented. Although the infrastructure of 4G is packet-based the existing 2G and 3G users may easily adopt to it. Some proposals suggest it has an open Internet platform. Major technologies which are included in 4G are Flash-OFDM, 802.16e - mobile version of Wi-Max, and HC-SDMA.

1 Data rates: The 4G defines a clear picture of the data rates. In 4G wireless communication standard there is flexible channel bandwidth, between 5 and 20 MHz, optionally up to 40 MHz.The minimum data rate of 100 Mbit/s while the client physically moves at high speeds relative to the station, and 1 Gbit/s while client and station are in relatively fixed positions as defined by the ITU. The data rate of at least 100 Mbit/s between any two points in the world and peak link spectral efficiency of 15 bit/s/Hz in the downlink, and 6.75 bit/s/Hz in the uplink (meaning that 1000 Mbit/s in the downlink should be possible over less than 67 MHz bandwidth). System spectral efficiency of up to 3 bit/s/Hz/cell in the downlink and 2.25 bit/s/Hz/cell for indoor usage [3].

*2 Access schemes:*As the wireless standards evolved, the access techniques used also exhibited increase in efficiency, capacity and scalability. The first generation wireless standards used TDMA and FDMA. In the wireless system, TDMA is proved to be less efficient in handling the high data rate system as it requires large guard band to avoid the inter channel interference and FDMA consumed more bandwidth for guard to avoid inter carrier interference. So, in second generation a set of standard which is the combination of FDMA and TDMA and the other set introduced an access scheme called CDMA. Use of CDMA technique for multiplexing increases the system capacity. But there is a drawback of CDMA system. A CDMA network does not reject new client even if it approaches its limits, resulting in a denial of service to all clients when the network overloads. However, CDMA network prevents the overloading problem by not allowing the system to reach to its capacity. Moreover, it is efficient enough to handle the multipath channels. It enabled the third generation systems, such as IS 2000, UMTS, TD-CDMA andTD-SCDMA, to use CDMA as the access scheme. However, the issue with CDMA is that it suffers from poor spectral flexibility and computationally intensive time-domain equalization for wideband channels [9].

Recently, new access schemes like OFDMA, SC-FDMA, interleaved FDMA and MC-CDMA are gaining more importance for the next generation systems. These are based on efficient algorithm and frequency domain equalization, resulting lower number of multiplications per second. They also make it possible to control the bandwidth and form the spectrum in different possible way. They require advanced dynamic channel allocation and traffic scheduling.

WiMAX is using OFDMA as the downlink and uplink as well. For the next generation wireless network OFDMA is used for the downlink and IFDMA is being considered for the uplink since OFDMA contributes more issues and results in nonlinear operation of amplifiers. IFDMA is useful as it provides less power fluctuation and thus avoids amplifier issues. These access schemes offer the same efficiencies which can be obtained by the older technologies like CDMA and they can also achieve greater scalability and higher data rates [3].

TABLE1:
COMPARITIVE FEATURES

Key Features	Access Protocols	Key Features	Level of Evolution
1G	FDMA	Analog, primarily voice, less secure, support for low bit rate data	Access to and roaming across single type of analog wireless networks
2G and 2.5G	TDMA, CDMA	Digital, more secure, voice and data	Access to and roaming across single type of digital wireless networks and access to 1G
3G and 3.5G	CDMA2000, W-CDMA, HSDPA, TD-SCDMA	Digital, multimedia, global roaming across a single type of wireless network (for example, cellular), limited IP interoperability, 144Kbps to several Mbps	Access to and roaming across digital multimedia wireless networks and access to 2G and 1G
4G	TBD	Global roaming across multiple wireless networks, 10Mbps-100Mbps, IP interoperability for seamless mobile Internet	Access to and roaming across diverse and heterogeneous mobile and wireless broadband networks and access to 3G, 2G, and 1G

Table 1: explain the comparative feature of 3G and 4G mobile networks in respect of access protocols, key features and the evolution. The other important advantage of the above mentioned access techniques are that they require less complexity for equalization at the receiver. This is the advantage of MIMO environment since the spatial multiplexing transmission of MIMO system inherently requires high complexity equalization at the receiver.

3 IPv6 support: 3G is based on two parallel infrastructures consisting of circuit switched and packet switched networks. 4G is based only on packet switching technique. This provides low latency in data transmission.

The problem with 4G is that by the time of its deployment the IPv4 addresses would have been exhausted. So, IPv6 support is essential to support a large number of wireless-enabled devices. By increasing the number of IP address, IPv6 removes the need for Network Address Translation (a method of sharing a limited number of addresses among a larger group of devices) which is a necessity to communicate even today because of depletion of IPv4 addresses.

IV. Primary Challenges

A. *Low Latency Handoff*: An importantgoal is to allow a user to use fully-interactive communication across all the available networks, even though the networks provide different levels of service [9].

B. *Power Savings:* Power requirement should be minimized as managing multiple wireless networksavailable in the areaand keep all of them updated all the timeis very costly affair. At all levels the power consumption matters and effective management of the network interfaces is crucial [9].

C. *Bandwidth Overhead:* Implementing handoffs in wireless network requires additional traffic in the form of packets and handoff messages that are necessary to provide service for users in roaming, and we need to minimize these costs and also provide less disruption possible while user moves between networks.

D. *Discover the right time to perform handoffs*It is difficult to predict when the mobile will disconnect from the current network and connect to other network according to its characteristics. It is difficult to obtain higher level network characteristics such as packet error rate, signal strength and quality.

E. *Work with all commercially available devices over which we do not have direct control.*For handoff we must depend on existing network technologies to provide the full range of wireless networks. Although we assume that we can control certain

room-size and building-size network, we also assume that the wide-area network is owned and administered by a third party and that we cannot directly control.

Table 2:
SWOT ANALYSES FOR 3G AND 4G

	Strength	**Weakness**	**Opportunity**	**Threat**
3G	Provide data and speech services under high mobility environment with high security, widest ally of telecom operators and equipment suppliers, mature techniques and equipment.	Comparatively small bandwidth, limited number of end user equipment, large investments, network updating at high cost	Has a high market demand, combined with WLAN to provide a larger variety of services, can be combined with WiMAX to save investments on fiber networking and improve implementation speed in the meanwhile	Threatened by the co-development of WLAN + VoIP, WiMAX
4G	Large coverage with high capacity, unified standards, comparatively low equipment costs, fast and flexible networking, licensed frequency band	Immature technique and user equipment, complex wireless environment, unstable performance in kind distance transmission, suffering from lots of interference on the licensed band	Can be combined with WLAN, 3G and ADSL etc, serve as the last mile solution for both fixed access and wireless access.	ADSL, CABLE ,fiberMAN, WLAN and 3G.

Table 2: explain the strength and weakness of other technologies. It also show the opportunity and threats for 3G and 4G technologies in the current environment.

V. CONCLUSION

4G and 3G will coexist. However, 4G will be the dominating technology, since on one hand equipment suppliers andTelecom operators have invested less money in 4G in comparison to 3G; on the other hand, 4G technologies is very efficient and contain all the property that is contain by the previous technologies. Being the complementary of 3G, 4G will serves an important wideband internet access method for both indoor scenario and hot-spot areas. 4G is containing a new wireless metropolitan access technique with many favorable features like flexibility, cost-efficiency and fastnetworking, etc. There are both competition and cooperation among the two techniques. It's advisable that the two of them cooperate and complement with each other while developing together. Thus a brand-new future for mobile communication is highly expectable.

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