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AN ASSESSMENT OF 4G WIRELESS TECHNOLOGY

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Abstract

As there is an increase in demand for speed, multimedia support and other such resources in communication, the wireless world is looking forward to a new generation technology to replace the third generation. 4G wireless technology promises to be that and a lot more. 4G wireless communication is expected to provide not only better speed, high capacity, and lower cost but also IP based services. The main aim of 4G wireless is to replace the existing core technology with a single universal technology based on IP. Yet there are several hurdles that inhibit the progress of 4G and researchers throughout the world are contributing their ideas to solve these problems. 4G wireless technology is a continuously evolving field with immense possibilities if implemented practically. As such, there is a lot of research work dedicated towards overcoming its limitations. This paper aims at studying such research materials which are contributing towards bringing 4G and further generations closer to reality.

Introduction

As soon as we hear the word wireless, we tend to remember the conventional cordless phone, which showed us the hassle free side of communication. Wireless technology is one of the most important inventions in the field of communication. Wireless communication is widely used in daily transactions. In wireless communication, the data which may be voice, image, motion picture, documents or any other is converted to electromagnetic waves and transmitted over a distance. At the receiving end, we have to covert these electromagnetic waves back to their original form. In the year 1867, the existence of EM waves was predicted by Maxwell, later in the year 1887 Hertz proved the existence of EM waves. By 1898, the instance of wireless communication was seen as wireless telegraphic connection was established between England and France. In 1901, Marconi was successful in transmitting radio signal across Atlantic Ocean. In the First World War (1914) the importance of wireless systems was felt. The modulation techniques used at that time were simple such as amplitude modulation. With further technological development, in the year 1934, Armstrong introduced a new modulation technique called frequency modulation. Gradually, there came PSTN (Public Switched Telephone Network), which gave way to IMTS (Improved Mobile Telephone Service) to accommodate more users. It supported full-duplex, auto dial, auto trunking services. From 2G to 3G wireless, we now have circuit switched and packet networks. Yet we find that it falls short of the expected features of a fully secure, smooth and fast wireless communication.

Limitations of 3G and Need for 4G

Why do we need 4G? To answer this question we need to understand some of the major limitations of 3G[4]. Some of the reasons for a new generation of mobile communication are listed below

- It is difficult for CDMA to provide higher data rates
- There is a need to continuously increase data rate and bandwidth to meet the multimedia requirements
- Limited spectrum allocation
- Horizontal handover and inability to automatically switch from wireless LAN to cellular connection whenever required
- Inadequate coverage due to existing access methods.

To overcome these limitations, 4G is introduced. 4G stands for Fourth Generation Cellular Communication System. The Wireless World Research Forum (WWRF) defines 4G as a network that operates on Internet technology, combining it with other applications and technologies such as WLAN, Bluetooth, Wi-Fi. Their speeds range from 100 Mbps to 1 Gbps ,depending upon whether they are cellular phone network or Wi-Fi[7] . Since the first-release versions of Mobile WiMax and LTE have bit rate less than 1 Gbps peak bit rate, they do not completely meet the definition standard put forth by IMT-Advanced , but are often said to be 4G by service providers[1]. The fourth generation (4G) does not really exist yet. However, we can get the general idea about 4G from academic research; 4G is the evolution based on 3G's limitation and it will fulfill the idea of WWWW, World Wide Wireless Web and will offer more services and smooth global roaming with low cost. The fourth generation (4G) is still a conceptual framework. The bodies like TRAI, international telecommunications regulatory and standardization bodies are working for commercial deployment of 4G networks in the near future with all the expected standards. As of now, the real definition of 4G is debatable. Some cite wide bandwidth consideration to be the benchmark while some consider very high data rates to be the answer to the path towards 4G. Although there is risk

associated with the implementation of any new technology, efficient spectrum use and low-cost may make up for this.

Working Technologies

4G networking is expected to be a technology with an integration of many other technologies. It will use the basic framework and spans all the networks in one single body, hence enabling seamless unity and ‘’hand-off’’ among the networks. A WiFi-WiMax integrated architecture is being considered over prely WiFi based network topology. The cost and usage model of WiMax provides an optimum QoS (Quality of Service) as per studies[8].

OFDM (Orthogonal Frequency-Division Multiplexing) is a digital multi-carrier modulation scheme, which uses a large number of closely-spaced sub-carriers whose arrangement is orthogonal. Each sub-carrier is modulated with a conventional modulation scheme at a low symbol rate, maintaining data rates similar to conventional single-carrier modulation schemes like SC-FDMA in the same bandwidth[3]. The Fast Fourier transform algorithm is used to generate OFDM signals. MC-CDMA (Multi-Carrier Code Division Multiple Access) is a multiple access scheme used in OFDM-based telecommunication systems which allows the system to support multiple users at the same time. Unlike single-carrier modulation, MC-CDMA applies DS-CDMA spreading in the frequency domain, where each user is assigned an individual pseudo-noise code to differentiate the signal from other users' signals. WLAN (Wireless Local Area Network) is used to link two or more computers without using wires. In this, the spread-spectrum technology based on radio waves is used to enable communication between devices in a limited area or the basic service set. Base stations act as access points for the wireless network which transmit and receive radio frequencies for devices which support wireless operation to communicate with. Speed of WLAN is seen to be between 1-54 Mbps. 4G networks will be established on an amendment of the IEEE802.16 standards. The IEEE802.21 standard supports algorithms that can enable seamless handover between networks of the same type and handover between different network configurations. With this, users will be able to engage in Ad Hoc communications.

MIMO (Multiple-input multiple-output), is an abstract mathematical model for multi-antenna communication systems. In MIMO, the transmitter has multiple antennas capable of transmitting independent signals and the receiver is equipped with multiple receive antennas[3]. This will allow 4G network to have very high speeds by increasing the link capacity through multipath propagation. IPv6(Internet Protocol version 6) network layer uses packet-switched network. It will replace IPv4 to be used in 4G. UWB (Ultra Wide Band) has bandwidth larger than 500 MHz or 25% of the center frequency (standard upto 10.6GHz practically). UWB or pulse-radio can be used to reduce multipath-fading issues.

4G systems can support two types of video services: bursting and streaming video services. Streaming works in real time, with the server delivering data continuously at a certain playback rate[5]. Streaming has a limitation that it does not take full advantage of available bandwidth. Bursting requires a buffer for high data rate file downloading. But it requires a large memory requirement. So 4G should be improvised such that it takes the best of both bursting and streaming. A simple comparison of the generations as seen from Table 1 will show the actual evolution of 4G[6].

Table 1. Comparison of different generations

Generation	Description
0G	Pre-cellular systems called mobile radio telephone in PSTN network
1G	Only analog radio signals Only modulated to frequency 150MHz and up
2G	Digital voice service 9.6K to 14.4K bit/sec. One-way data transmissions sharing code and time resources. Calling features like caller ID introduced. Data connection not available continuously.
3G	Better voice quality. Upto 2Mbit/sec always-on data. Video and multimedia supported through internet services. Roaming enabled. Circuit and packet switched networks.
4G	Completely digital. Converged data and voice-over IP. Entirely packet switched networks without circuit switched. Higher bandwidth to provide multimedia services at lower costs as specified in 4G standards .

Challenges and Limitations

4G is touted to be the next big thing in communication, but it is not free from drawbacks. As indicated earlier, cost is an important factor for any mobile service provider when

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switching to new technology. If we consider the heavy investment that has already been done in implementation of 3G and its worldwide expansion, then the immediate investment in 4G seems doubtful. Other challenges which this technology will have to overcome are:

1. Lesser dialogue between telecommunications vendors and operators.
2. Higher frequency reuse in SC-FDMA leads to smaller cells. It may lead to low SNR and cause intra-cell interference or higher noise figures due to reduced power levels.
3. The Digital to Analog conversions must be at high data rates and with multi-user detection.
4. Requirement of smart antennas (MIMO) and complex error control techniques with dynamic routing that will need sophisticated signal processing and complex circuitry.
5. The adaptation of multimedia transmission like streaming and bursting methods in video, across 4G networks is important as multimedia will be a main service feature and changing radio, accessing networks may in particular result in drastic changes in the network condition.

Applications of 4G

Few of the applications of 4G wireless technology which include but not limited to those listed here:

Virtual Presence: Even under circumstances when the user cannot be online, the required services will be provided without interruption at all times through 4G.

Virtual navigation: With the expected high data rates of 4G, it will be possible to maintain and provide a database of all cities, countries and remote places for user access as virtual navigation.

Tele-Medicine: 4G will support multi-user video conferencing thus enabling remote health monitoring of patients by number of doctors in real time.

Tele-geo-processing applications: User can get simultaneous information about anything from weather to traffic through instant satellite mapping which is a combination of GIS (Geographical Information System) and GPS (Global Positioning System)

Gaming: High-speed multi-user gaming will be possible with the adoption of 4G.

Cloud computing: Safe and secure cloud computing options unlike those being currently employed.

Crisis detection and prevention: Disasters, both natural and man-made bring down communication, especially being a hurdle in rescue operations. With 4G, it is expected that in case of such crisis, it will be easier to restore communication at a fast rate.

Education: Distance education is a viable option nowadays for many students. 4G will provide them with real-time classroom experience. This will prove beneficial in coming days as it can be instrumental in reducing infrastructure demands of universities and colleges to accommodate the rising number of students.

Vertical handover and BDMA

Assuming that most of the challenges of 4G are or will be overcome either in WiMax or LTE, two major limitations that need to be addressed are bandwidth limitations and throughput. Due to limited bandwidth allocation for any specific region and increasing number of users per channel, sharing of resources is becoming more and more intensive. As a result, interference in the same RF channel will cause reduced channel quality. Similarly, if we consider the throughput, we see that an average individual throughput rate coupled with the source delay (which is usually ignored in most models) cannot beat high data rates. To make up for these limitations, research is going on to implement vertical handover and beam division multiple access in 4G. Vertical handovers refer to the automatic fallover from node to supporting node seamlessly, like wireless LAN to cellular network if required[2]. Unlike horizontal handover, here the vertical handoff changes the data link layer(OSI model). It is expected to be fast, balance traffic and be reliable. BDMA is a multiple access technique that differs from the time and frequency sharing of conventional multiple access techniques. It employs phased array antennas. Each device in the network receives a different antenna beam._System capacity can be improved using BDMA techniques, which involves width and beam direction calculation using position and moving speed of mobile stations in line of sight. 3-dimensional division of the beam further helps in simultaneous transmission to different mobile stations. Technologies like femtocell and picocell are being developed to provide enhanced coverage to users in any network, including mobile roaming[9].

Conclusion

From the research work being conducted, the future for 4G looks bright. 4G wireless communications is a rapidly growing segment of the communications industry, with the potential to provide high-speed ,high-quality information exchange between portable devices located anywhere in the world. This technology has a wide range of applications, ranging from medicine to education, from entertainment to research however, supporting these applications using wireless techniques poses a significant technical challenge. In the next decade, it is poised to replace the existing communication system and extend mankind's view on communication

to unimaginable possibilities. At a time when 5G and 6G are being conceptualized, it is necessary to implement 4G with all the expected standards. With certain methodologies like phased array antennas, MIMO, algorithms to reduce traffic and improve SNR and BER rates using vertical handoffs, 4G wireless systems could replace the 3GPP and LTE systems sooner than we think.

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Biography

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