4G Wireless Technology

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ABSTRACT

With the emerging innovations in wireless communication networks, it is anticipated that fourth generation (4G) mobile systems will be launched within a decade or before. 4G mobile systems focus on seamlessly integrating the existing wireless technologies including WCDMA, HSUPA/HSDPA, 1xEVDO, Wireless LANs, and Bluetooth. 4G systems aspire to support comprehensive and personalized services, providing stable system performance and quality services. However, with ever-changing specifications and standards, developing a prototype that provides the 4G system's capabilities requires a flexible process. Besides, migrating current systems to 4G present's enormous challenges. This paper is an attempt to give a brief description of fundamentals like dangers, challenges of 4G and about the visions that the network operators and service providers see for the evolution of 4G mobile systems. The paper endeavors to make an evaluation on development, transition and roadmap for fourth generation mobile communication system with a perspective of wireless convergence domain. Finally, a brief discussion on future research issues in 4G is presented.

Index Terms—3G Networks, 4G Mobile Communications, IP

INTRODUCTION

With the deployment of 3G (3rd generation mobile communication systems) in process, the interest of many research bodies shifts towards future systems beyond 3G. Depending on the time such new systems are planned to be introduced and on the characteristic of improving or replacing existing systems they are called B3G (beyond 3G) or 4G communication system. There is no formal definition for what 4G is; however, there are certain objectives that are projected for 4G. These objectives include that 4G will be a fully IP-based integrated system. 4G will be capable of providing between 100Mbit/s and 1Gbit/s speeds both indoors and outdoors, with premium quality and high security. The term 4G is used broadly to include several types of broadband wireless access communication systems, not only cellular telephone systems. While neither standards bodies nor carriers have concretely defined or agreed upon what exactly 4G will be, fourth generation networks are likely to use a combination of WiMAX and Wi-Fi technologies.

HISTORY:

The history and evolution of mobile service from the 1G (First generation) to fourth generation is discussed in this section.

First generation

The process began with the designs in the 1970s that have become known as 1G. Almost all of the systems from this generation were analog systems where voice was considered to be the main traffic. The first generation wireless standards used plain TDMA and FDMA. These systems could often be listened to by third parties. Some of the standards are NMT, AMPS, Hicap, CDPD, Mobitex, DataTac, TACS and ETACS.

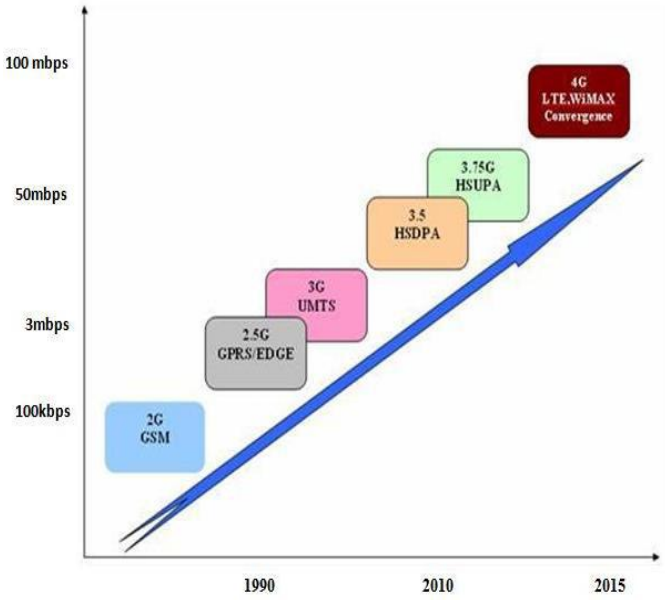

Fig. 1. Evolution of 4G technology

SYSTEMS

At present, plethora of wireless technologies with their own merits and demerits exist globally, the upcoming 4G mobile communications system is foreseeing potentially a smooth merger of these technologies with a goal to support cost effective seamless communication at high data rate supported with global roaming and user customized personal services. Technically, 4G stands for one integrated, IP-based environment for all telecommunications requirements including voice, video, broadcasting media and Internet that utilizes both fixed and wireless networks. Users being central focus in 4G, by means of intelligent terminals, can get simple broadband access to a range of services that take into account his personal preferences and context. Even without interrupting ongoing conversation, work or video viewing, the user can change terminals or switch unnoticeably between the underlying fixed and mobile networks (UMTS, WLAN, etc.). And by means of ad-hoc networking, his mobile terminals can form networks among themselves or with the terminals of third parties. Throughout all this complex procedures, the user always maintains full control over privacy, security risks and costs. This extraordinary vision regarding 4G networks and services is a natural extension of the current development of broadband Internet and 3G mobile networks like UMTS.

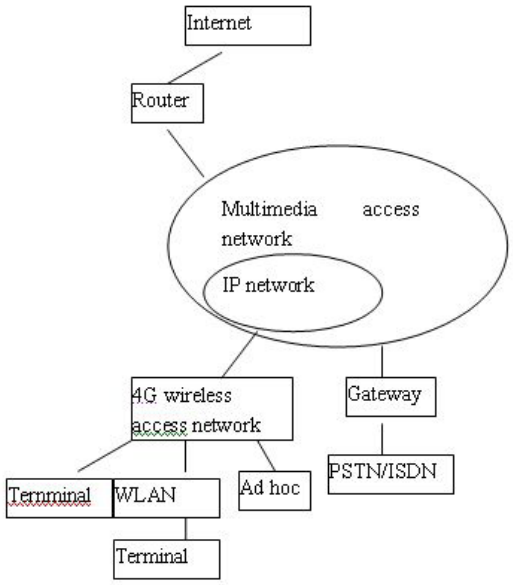

Fig. 2. The network Structure

FEATURES OF FOURTH GENERATION TECHNOLOGY

There are several reasons which are sufficient to answer a simple question- why do we need to adopt 4G technology? Below are some of the features of 4G which make it an "above all" technology.

A. High performance

Industry experts say that users will not be able to take advantages of rich multimedia content across wireless networks with 3G. In contrast to this 4G will feature extremely high quality video of quality comparable to HD (high definition) TV. Wireless downloads at speeds reaching 100 Mbps, i.e. 50 times of 3G, are possible with 4G.

B. Interoperability and easy roaming

Multiple standards of 3G make it difficult to roam and interoperate across various networks, whereas 4G provides a global standard that provides global mobility. Various heterogeneous wireless access networks typically differ in terms of coverage, data rate, latency, and loss rate. Therefore, each of them is practically designed to support a different set of specific services and devices, 4G will encompass various types of terminals, which may have to provide common services independently of their capabilities. This concept is referred to as service personalization

C. Fully converged services.

If a user want to be able to access the network from lots of different platforms: cell phones, laptops, PDAs he is free to do so in 4G which delivers connectivity intelligent and flexible enough to support streaming video, VoIP telephony, still or moving images, e-mail, Web browsing, e-commerce, and location-based services through a wide variety of devices. That means Freedom for consumers.

D. Low cost

4G systems will prove far cheaper than 3G, since they can be built atop existing networks and won't require operators to completely retool and won't require carriers to purchase costly extra spectrum. In addition to being a lot more cost efficient, 4G is spectrally efficient, so carriers can do more with less.

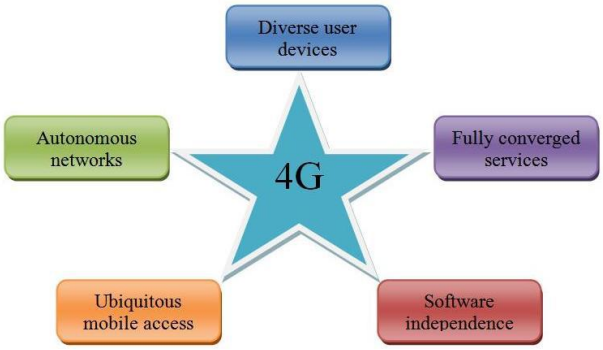

Fig. 3. Key features of 4G

E. Devices: more user friendly interface

4G devices are expected to be more visual and intuitive rather than today's text and menu based systems. They will be able to interact with the environment around it and act accordingly.

F. Enhanced GPS Services

In addition to locating individuals, a 4G version of GPS tech might be able to let people be virtually present in a variety of places.

G. Scalability

It is most challenging aspect of the mobile networks. It refers to ability to handle ever increasing number of users and services. Since an all IP core layer of 4G is easily

scalable, it is ideally suited to meet this challenge.

H. Crisis-Management applications

Natural disasters can affect the entire communications infrastructure is in disarray. Restoring communications quickly is essential. With wideband wireless mobile communications Internet and video services, could be set up.

Dangers Associated with 4G

Following are enumerated the dangers associated with 4G:

1)Mobile devices will be complex:

New layers of technological abstraction will be added, lower layers may be fairly secure, and software at higher layer may introduce vulnerabilities or vice-versa.

2) Attacks on application level:

4G cellular wireless devices will be known for software applications which will provide innovative feature to the user but will introduce new holes, leading to more attacks at the application level.

3) Jamming and spoofing:

Jamming is happens when a transmitter sending out signals at the same frequency displaces a GPS signal. Spoofing refers to fake GPS signals being sent out, in which case the GPS receiver thinks that the signals comes from a satellite and calculates the wrong co-ordinates. Criminals can use such techniques to interfere with police work.

4) Location Based Services (LBS)

Law Enforcement Agencies with the help GPS receiver can quickly determined which unit is closest to the location of a reported incident and can get there fast. Alternatively criminals can deceive the Law Enforcement Agencies by using smart methods.

5) Encryption:

If a GPS receiver has to communicate with the central transmitter then the communication link between these two components is not hard to break and there is a need of using encrypted data.

6) Wi-Fi, Hotspots and WLANs:

4G technology will lead to the development of mobile devices with multiple applications and the misuse will increase, particularly when devices that communicate with Wi-Fi, Hotspots and WLANs. Data transmitted over such networks can often be intercepted quite easily, resulting in real security risk.

TECHNOLOGIES SUPPROT 4G:

The revolution in 4G will be the optical networking, the new air interface, the portable device etc.

A. The Transmission Protocols

1) OFDM: OFDM is a digital modulation technology in which in one time symbol waveform, thousands of orthogonal waves are multiplexed. This is good for high bandwidth digital data transition.

2) W-OFDM: W-OFDM enables data to be encoded on multiple high-speed radio frequencies concurrently. This allows for greater security, increased amounts of data being sent, and the industries most efficient use of bandwidth. W-OFDM enables the implementation of low power multipoint RF networks that minimize interference with adjacent networks. This enables independent channels to operate within the same band allowing multipoint networks and point-to-point backbone systems to be overlaid in the same frequency band.

3) MC-CDMA: MC-CDMA is actually OFDM with a CDMA overlay. Similar to single-carrier CDMA systems, the users are multiplexed with orthogonal codes to distinguish users in (multi-carrier) MC-CDMA. However in MC-CDMA, each user can be allocated several codes, where the data is spread in time or frequency.

4) LAS-CDMA: Link Air Communications is developer of LAS-CDMA (Large Area Synchronized Code Division Multiple Access) a patented 4G wireless technology. LAS-CDMA enables high-speed data and increases voice capacity and latest innovative solution, CDD, merges the highly spectral efficient LAS-CDMA technology with the superior data transmission characteristics of TDD. This resulting combination makes CDD the most spectrally efficient, high-capacity duplexing system available today

ROADMAP FOR ACHIEVING 4G TECHNOLOGY:-

Brief description of various road map for achieving 4G are:

1) Advanced adaptive modem*:* In OFDM and related modulations techniques, multiple coherent sub-carriers are modulated and codes are used to insure that encoded bits can be decoded even if some of the sub-carriers arrive at very low signal-to-noise ratio rendering OFDM is more resistant to inter-symbol interference . The main advantages of OFDM over other communication modes are that it solves the problem of Inter Symbol Interference (ISI), has high bandwidth efficiency, scalable to high data rates, flexible modulation scheme which can be made adaptive, good at minimizing the effects of time-dispersion, no requirement of channel equalization, no need for phase lock of the local oscillators stem. Besides, OFDM is easier to implement then CDMA by small companies, as CDMA networks need more experienced engineers [8].

2) Software defined radios (SDR)*:* SDR is one form of open wireless architecture (OWA). Since 4G is the collection of wireless standards, the final form of the 4G device will constitute all standards. This can be realized using SDR technology. Software-defined radio (SDR) is a radio communication technology that is based on software defined wireless communication protocols instead of hardwired implementations; frequency band, air interface protocol and functionality can be upgraded with software download and update instead of a complete hardware replacement.

3) All IP-based core networks: 4G will resemble a convergence of existing technologies rather than an entirely new standard.

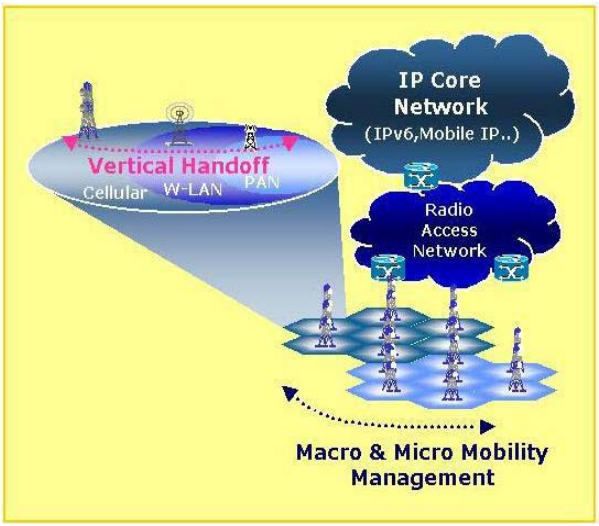

Fig. 4. 4G Network Architecture

CHALLENGES IN MIGRATION TO 4G

A. Multimode user terminals

With 4G there will be a need to design a single user terminal that can operate in different wireless networks and overcome the design problems such as limitations in size of the device, its cost and power consumption. This problem can be solved by using software radio approach i.e. user terminal adapts itself to the wireless interfaces of the network.

B. Selection among various wireless systems.

Every wireless system has its unique characteristics and roles. The proliferation of wireless technologies complicates the selection of most suitable technology for a particular service at a particular place and time. This can be handled by making the selection according to the best possible fit of user QoS requirements and available network resources.

C. Security

Heterogeneity of wireless networks complicates the security issue. Dynamic reconfigurable, adaptive and lightweight security mechanisms should be developed.

D. Network infrastructure and QoS support

Integrating the existing non-IP and IP-based systems and providing QoS guarantee for end-to-end services that involve different systems is also a big challenge.

E. Charging/ billing

It is troublesome to collect, manage and store the customers' accounts information from multiple service providers. Similarly, billing customers with simple but information is not an easy task.

F. Attacks on application level

4G cellular wireless devices will be known for software applications which will provide innovative feature to the user but will introduce new holes, leading to more attacks at the application level.

G. Jamming and spoofing

Spoofing refers to fake GPS signals being sent out, in which case the GPS receiver thinks that the signals comes from a satellite and calculates the wrong co-ordinates. Criminals can use such techniques to interfere with police work. Jamming happens when a transmitter sending out signals at the same frequency displaces a GPS signal.

H. Data encription

If a GPS receiver has to communicate with the central transmitter then the communication link between these two components is not hard to break and there is a need of using encrypted data.

RESEARCH AREAS FOR FUTURE WIRELESS SYSTEMS

The following emerging areas are considered pith of future wireless communication systems:

(i) New decoding algorithms for turbo codes for wireless channels.

(ii) New coding and modulation techniques for reducing the peak-to-mean envelope ratio, maximizing the data rate and providing large coding gain.

(iii) New approaches to jointly designing modulation techniques, and power amplifiers to simultaneously obtain high power efficiency along with bandwidth efficiency.

(iv) New demodulation and decoding techniques to simultaneously combat the near-far problem and channel decoding in multi-rate DS-CDMA systems

(v) Joint channel estimation.

(vi) Multiple-access techniques for multi-rate systems with variable quality of service requirements.

(vii) Space-time coding for systems with multiple antennas

(viii) Ultra wideband systems and hardware design.

(ix) Other Research in methodologies for an integrated approach to wireless communications.

CONCLUSION

As the history of mobile communications shows, attempts have been made to reduce a number of Technologies to a single global standard. Projected 4G systems offer this promise. Future wireless networks will need to support diverse IP multimedia applications to allow sharing of resources among multiple users. There must be a low complexity of implementation and an efficient means of negotiation between the end users and the wireless infrastructure. The fourth generation promises to fulfill the goal of PCC (personal computing and communication)—a vision that affordably provides high data rates everywhere over a wireless network. Customers want the features delivered to them, simple and straightforward.

Wireless providers want to make money in a cutthroat industry. If the U.S. government wants to help, the best way to help all parties is to enforce 4G as the next wireless standard. The software that consumers desire is already in wide use. The transmission hardware to take it wireless is ready to go. And we have the security practices to make sure it all works safely. The government need only push in the right direction; the FCC need only standardize 4G in order to make the transition economically viable for all involved. This is a need that demands a solution. Today's wired society is going wireless, and it has a problem. 4G is the answer.

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