An Overview of Wireless Networks

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ABSTRACT

In choosing between wire and wireless networks; convenience, cost, performance and security issues have to be taken into consideration. The birth of wireless communication was when the first operational cellular communication system was introduced and deployed in Norway in 1981. This was followed by similar systems in the US and the UK. The first generation (1G) systems provided voice transmissions using only analog modulation frequency around 900 MHz. Second generation (2G) is the Global System for Mobile Communications (GSM) and was introduced in 1991 in Europe. At the end of 1997, GSM service was available in more than 100 countries, especially in Europe and Asia. GSM provides voice and limited data services and uses digital modulation with improved audio quality. The 2.5G systems were introduced in 2000 and enhance the data capacity of GSM and mitigate some of its limitations. The third generation (3G) cellular service is the Universal Mobile Telecommunications System (UMTS) also introduced in 2000. The third generation (3G) sustains higher data rates and has opened the door to internet based applications. The challenge of today's wireless systems is to achieve the goals of true broadband cellular service referred to as the fourth generation (4G). This 4G is intended to provide high speed, high capacity, low cost per bit, and IP based services which are necessary to accommodate growing traffic in 2010 and thereafter. In this paper, we present a broad overview of the evolution of wireless systems, examine the limitations of the above mentioned generations of wireless systems, and look at its present and future challenges and applications.

Presented at Knoxville, TN [ISA 51st International Instrumentation Symposium];
http://www.isa.org

1. INTRODUCTION

Networking innovation has developed drastically in improving and providing easy access to data and information (multimedia, voice and video) barrier of distance. In this line has wireless systems developed to provide solution that will guarantee high speed, high capacity, low cost per bit, IP based services. This will ensure that voice, video, multimedia, and broadband data services are integrated into the same network.
Wireless networks include LANs (Local Area Networks) and PANs (Personal Area Networks) etc. They also include wireless LANs based on IEEE 802.11a/b/g, and the three 802.15 PANs - Bluetooth, UWB (Ultra-wideband), and low data-rate personal area network.

Analog cellular was the first generation of wireline systems known as 1G; digital PCS (2G) was the second. PCS is an acronym for Personal communication service i.e. the telecommunication service that bundle voice communications, numeric and text messaging, voicemail and various other features into one device. 2.5G was an enhancement of 2G which led to the development of General Packet Radio Service (GPRS). 2.5G gave birth to 3G for improved performance and Internet based services, while 4G is a challenge to the development of wireless system developers [2, 3, and 4]. 4G is expected to provide high speed; high capacity, low cost per bit, and IP based services [4].

2. WIRELESS SYSTEMS GENERATIONS

2.1 First Generation Systems (1G):1G was the first generation analog cellular technology. Analog Mobile Phone System (AMPS) is an example of a 1G cellular system, first deployed in 1981 in Norway, 1G technology was designed to transmit voice phone calls from wireless handsets. Calls are sent in the clear, and are easy to intercept with a scanner. As analog systems, 1G network do not support wireless data, as a result of this, it is only of historical interest for most Java 2 Platform, Micro Edition (J2ME) developers. 1G technology has been replaced by second generation, or 2G/2.5G, cellular technologies, many of which do support J2ME enabled handsets.

2.2 Second Generation Systems (2G/2.5G): The second generation cellular systems are commonly referred to as 2G. The 2G phase began in the 1991 in Europe when digital voice encoding had replaced analog systems (1G). 2G systems are based on various radio technologies including frequency, code and time division multiple access. 2G is characterized by

- Channelized
- Connection-oriented services
- Fixed bandwidth
- Connection-oriented networks
- Proprietary network infrastructure
- Closed service environment

Examples of 2G systems include global system for mobile communication (GSM) used mostly in Europe and some African countries, Personal Digital Cellular (PDC) used mostly in Japan, and Interim standard-95.(IS-95) the CDMA standard for the U.S. digital cellular service used mostly in the USA

and environs. Data links provided by 2G systems are mostly circuit-switched and have transmission speeds of 10-20 kbps uplink
and downlink. Demand for higher data rates, instant availability and data volume-based charging, as well as lack of radio spectrum allocated for 2G led to the introduction of 2.5G e.g. General Packet Radio Service (GPRS) a radio technology for GSM networks that adds packet-switching protocols, shorter set-up time for ISP connections, and offer the possibility to charge by amount of data sent rather than connection time. GPRS promises to support flexible data transmission rates typically up to 20 or 30 Kbps (with a theoretical maximum of 171.2 Kbps), as well as continuous connection to the network. It is an enhancement to 2G GSM which gave rise to 2.5G networks systems. GPRS is the most significant step towards 3G introduction.

2.3 Third Generation Systems (3G): International Mobile Telecommunications for the year 2000 (IMT-2000) or 3G systems is the brain child of the International Telecommunication Union (ITU) that has one of its responsibilities the integration of various satellite, terrestrial and mobile systems currently being deployed and developed under a family of standards that will promote global service capabilities and interoperability [1,2 and 4]. The development of GPRS leads to introduction of 3G wireless systems. 3G is made up of Wideband CDMA and cdma2000 systems. It combines high-speed mobile access with Internet Protocol (IP) based services. 3G can use a variety of present and future wireless network technologies, including GSM, CDMA, TDMA, WCDMA, CDMA2000, UMTS and EDGE. 3G is characterized by the following features [1, 2, 3,4and5]:

- High-speed, high-bandwidth services that support a variety of applications, including high quality voice, high data rate, multimedia and video.
- Packetsized
- Content-oriented
- Variable bandwidth
- Connectionless network
- Open Network infrastructure
- Open service Environment.

2.4 Fourth Generation Systems (4G): In recent years, there has been a rapidly increasing demand for the development of advanced interactive multimedia applications, such as video telephony, video games and TV broadcasting. This demands led to the challenge of 4G introduction. 4G also known as beyond 3G (B3G) is expected to accommodate the growing traffic of 2010 and beyond. It will address the limitation of 3G. 4G is based on Broadband Wireless Metropolitan IP Network system that supports broadband with high speed data transfer (at 2.5 MB), voice and mobility at a fraction of the current costs, examples of 4G technologies are 802.20 and Ultra Wideband (UWB) radio. 4G networks increases the mobile data transmissions rates and bring higher spectral efficiency, lower cost per transmitted bit, and increased flexibility of mobile terminals and networks. The 4G technology will strive to eliminate the distinction between video over wireless and video over wireline networks

2.4.1 Reasons for Advancing to 4G wireless systems: The following are the reasons for the introduction of 4G wireless systems [3,4and5]:

- Support interactive multimedia services
- teleconferencing
- wireless Internet.
- Wider bandwidths
- higher bit rates.
- Global mobility
- Service portability.
- Low cost.
- Scalability of mobile networks.

2.4.2 The Features of 4G Wireless Systems: The features of 4G includes but not limited to the following**:**

- Adaptive Modulation and Coding
- Speed, capacity and cost per bit
- Global mobility
- Service portability
- Scalable mobile networks
- Seamless switching
- Quality of Service (QoS) requirements
- Scheduling and call admission control techniques
- Ad hoc networks and multi-hop networks
- Location Services (LCS) in 4G Networks.
- Channel Modeling and Measurements for 4G
- Adaptive 4G Networks

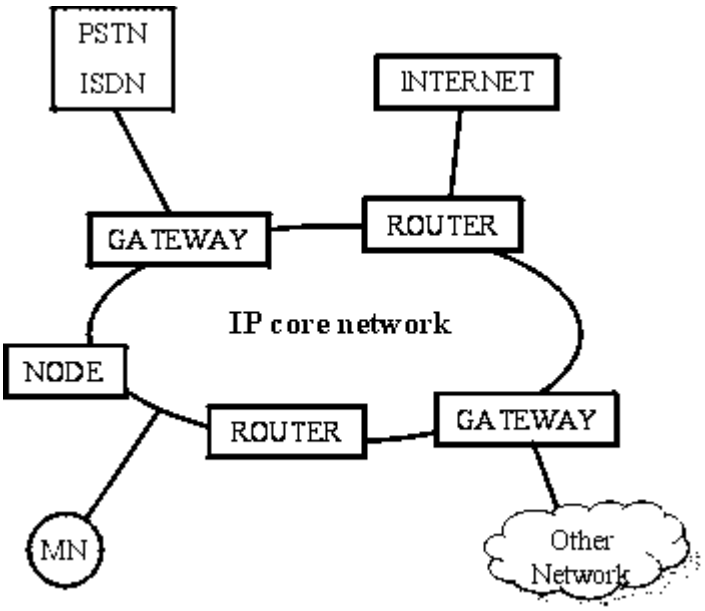
2.4.3 Issues to be addresses by 4G Technology:The following are the issues addresses by 4G technology:

- Multi-access interface, timing and recovery
- Higher frequency reuse
- Issues in the interface with the ad hoc networks
- Voice over multi-hop networks
- Security
- Variable QoS services
- Changing channel conditions
- Seamless roaming
- Seamless transfer of services
- Radio Theory
- Problems in a cellular system
- Interference
- Multipath fading
- Shadowing
- Specific solutions in 4G

- Cell Planning
- Fast power control
- Radio planning aspects of 4G
- Handover
- Bit rate
- 4G Radio Interface
- Different access techniques
- Global roaming
- Software radio approach
- What is multi-carrier modulation (MCM)?
- Ultra Wideband technology in 4G
- 4G processing
- Receiver section
- Transmitter section
- Ultra-wideband (UWB) parameters and characteristics
- Interference results

2.4.4 Mobility in 4G System Wireless Technology: One of the most important features in the 4G wireless network systems is Mobility. Mobility enable users on different networks to switch to another, that is roam among different networks segments irrespective of their base location. The two most common type of Mobility in network management is Link-layer and Network-layer Mobility. Link-layer is used by users in the same or homogeneous networks while Network-layer mobility is used by users in different or heterogonous networks. Internet based mobility is a typical example of Network-layer mobility. With the inclusion of internet Mobility as part of Network-layer mobility it has become an important issue in the Mobility management for the 4G network system.

2.4.5 The 4G Network: The diagram below shows how the 4G network is expected to look like.



3. APPLICATIONS OF WIRELESS NETWORKS

Wireless systems has become more complex over there time, involving higher frequencies, and are implemented in more challenging and demanding environments; this has lead to a great demands placed on the tools and technologies that they are being deployed and developed. Development of wireless system now involves modeling and simulation of the environments in they will be deployed. It also involves database development strategies that will handle the large amounts of data which are collected and generated. Thus there is the need for database that will include all the information on wireless network development, and all the stakeholders in the industry will be allowed access to the database. The IEEE VT-S Propagation Committee is a body that seeks to promote collaboration between propagation researchers, software developers, and wireless system designers in resolving issues arising from information sharing and management with regard to wireless network development and implementation.

In general wireless systems are expected to provide the following service:

- Establish a leadership position in the definition of the 4G standard
- Have strong influence on future technology choices
- Based on intensive simulation & prototyping
- Provide a system context for new technology decisions
- Provide program which consists of system concept development, simulations & prototyping
- Provide 3G benefits
- Deliver appropriate mid-life improvements to 3G systems

- Ensure best evolution strategy from 3G
- Agree amortization / new opportunity window with operators

4. CHALLENGES

As the wireless network industry continues to evolve, stakeholders continue to roll out new services to differentiate their networks and create brand loyalty. The latest network involves wireless data via the Internet from enterprise systems with content from hosted services and applications enabled by advanced broadband capabilities. To achieve this level of service, carriers' electrical systems must deliver availability equal to the public switched-telephone network's uptime measurement of 99.999%. Network Broadband deployment and distribution is now of paramount importance because of fast emerging convergence of multimedia voice, video, and data into one network and also the provision of technology and the economy of service and the competitive environment provided stakeholders in the industry. The number of networked homes in United States is projected to increase from 11 million to 32 million and from 4 million to 15 million in Western Europe by 2008, thus there is the great demand and challenge to meet the need of the networked homes.

Cellular service providers are already deploying third-generation (3G) cellular services. As a result of development in technology and information sharing among stake holders, voice, video, multimedia and broadband data services are becoming integrated into the same network. The drive to have 3G as a true broadband service has reduced. It is obvious that 3G systems, while maintaining the possible 2-Mbps data rate in the standard, will realistically achieve 384-kbps rates. To achieve the goals of true broadband cellular service, a fourth-generation (4G) network, has to come to focus.

4G will provide high speed, high capacity, low cost per bit, IP based services.
The goal is to have data rates up to 20 Mbps, even when used in such scenarios as a vehicle traveling 200 kilometers per hour. New design techniques, however, are needed to make this happen, in terms of achieving 4G performance at a desired target of one-tenth the cost of 3G.

5. CONCLUSION

The integration of Wireless and the Internet is already in the pipeline. The wireless industry is developing higher rate with the introduction of 4G, and higher efficiency 3G product deployments timeframe .All these advances and innovation in technology is properly managed and information shared share among all stake holders can lead to meeting network demands, improved cost effectiveness for existing services. It can also offer new services for increased revenue opportunities and provide optimum leverage of pre-3G investment and post- 3G investment. But there are still more subscribers' expectations to be met in achieving very high speed affordable Internet access at rates comparable to the fixed networks and W-LANs

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