Wireless communication

Samanvay Gupta

Abstract
Analyzing the attractive evolution of wireless communication, wireless communications has emerged as one of the largest sectors of the telecommunications, industry, evolving from a niche business in the last decade to one of the most promising areas for growth in the 21st century. This paper includes few key points which came into existence in recent years. This paper presents vision of wireless communication, evolution of mobile communication, it future challenges, advantages and disadvantages, and security analysis.
Keywords-Mobile communication,Technical challenges, 3G and 4G, Network infrastructure, Benefits of Wireless versus Wired & wireless 2020.

Introduction
In 1895, Guglielmo Marconi opened the way for modern wireless communications by transmitting the three-dot Morse code for the letter 'S' over a distance of three kilometers using electromagnetic waves. From this beginning, wireless communications has developed into a key element of modern society. From satellite transmission, radio and television broadcasting to the now ubiquitous mobile telephone, wireless communications has revolutionized the way societies function. Wireless operations permit services, such as long range communications, that are impossible or impractical to implement with the use of wires. The term is commonly used in the telecommunications industry to refer to telecommunications systems (e.g. radio transmitters and receivers, remote controls, computer networks, network terminals, etc.) which use some form of energy (e.g. radio frequency (RF),acoustic energy, etc.) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances. Ever increasing demands for high data rate packet-based services and high spectral efficiency are the main driving forces for the continued evolution of wireless communications technology. Although second generation (2G) wireless communication systems (e.g., GSM, IS-95) were highly successful in the last decade, they have very limited capabilities of supporting high data rate packet-based services. As a result, third generation (3G) wireless communication systems have been developed and standardized in the late 90's. 3G systems are capable of offering much higher data rates than 2G systems. The minimum data rates supported in wideband code division multiple access (WCDMA) systems in different communication environments: 144 Kbit/s for high mobility (vehicular) traffic, 384 Kbit/s for pedestrian traffic and 2 Mbit/s for indoor traffic [2]. There are three main radio interface standards proposed for 3G: WCDMA based on direct spread (DS)-CDMA with frequency division duplex (FDD), cdma2000 based on multicarrier-CDMA and TDD (time division duplex)-CDMA [3]. 3G wireless systems have already been commercially deployed in certain parts of the word (e.g., in Japan, North America).

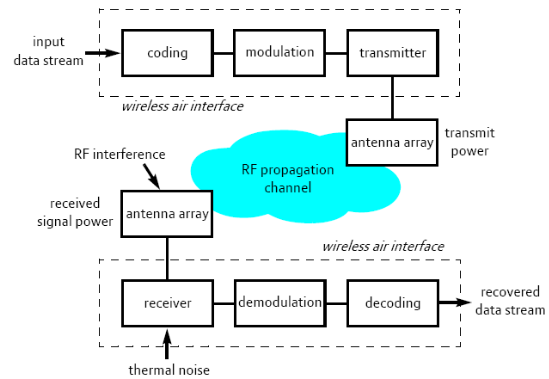
Wireless
Wireless telecommunications is the transfer of information between two or more points that are not physically connected. Distances can be short, such as a few meters for television remote control, or as far as thousands or even millions of kilometers for deep-space radio communications. It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of *wireless technology* include GPS units, Garage door openers or garage doors, wireless computer mice, keyboards and Headset (audio), headphones, radio receivers, satellite television, broadcast television and cordless telephones.

The rise of wireless
From 1900 the near-monopoly on international communications enjoyed by the cable companies came under threat from the development of wireless radio technology. Marconi's Wireless Telegraph Company gradually developed a chain of ships using short-wave radio communications which could commercially compete with undersea cables. In 1924 Marconi succeeded in telephoning Australia using short wave radio and in the same year was given a contract by the British Post Office to set up circuits with Canada, Australia, South Africa and India (called the Post Office beam wireless service). The 1928 Imperial Wireless & Cable Conference was convened to establish the best way to manage these two technologies and protect British interests. This led to a decision to merge the communications methods of the British Empire into one operating company, initially known as the Imperial and International Communications Ltd, and changed to Cable and Wireless Limited in 1934.

Wireless Vision
The vision of wireless communication is information exchange between people or devices is the communication frontier of the next few decades and much of them exist in some or the other form. This vision will allow the multimedia communication from anywhere in the world using a small handled device or laptop.

Overview of the wireless fundamentals
Following four categories:
• Radio propagation,
• Wireless air interface,
• Advanced antenna systems,
• Interference effects

Block diagram for wireless communication



Wireless networks
Wireless networking (i.e. the various types of unlicensed 2.4 GHz WiFi devices) is used to meet many needs. Perhaps the most common use is to connect laptop users who travel from location to location. Another common use is for mobile networks that connect via satellite. A wireless transmission method is a logical choice to network a LAN segment that must frequently change locations. The following situations justify the use of wireless technology:
To span a distance beyond the capabilities of typical cabling,
To provide a backup communications link in case of normal network failure,
To link portable or temporary workstations,
To overcome situations where normal cabling is difficult or financially impractical, or
To remotely connect mobile users or networks

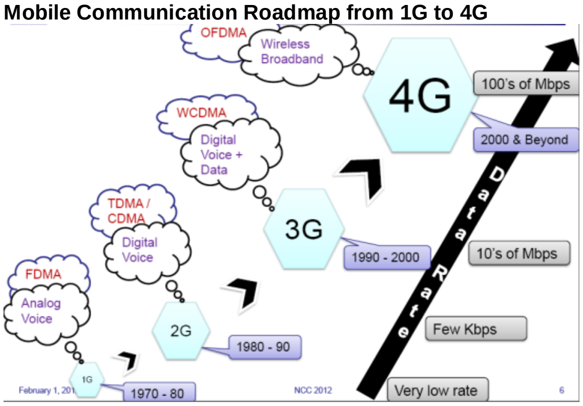
Key history milestones [1]

Operator Requirements on future wireless networks
The requirements on future networks were outlined by NGMN, the group of mobile operators, in [4]. These include average and cell edge spectral efficiency, low latency, simplicity, total cost of ownership, reliability, quality-of-service and seamless interworking with existing wireless standards. For the radio air interface, a unified evaluation methodology was established in [5] which allows for an apples-to-apples comparison of different standards and concepts.

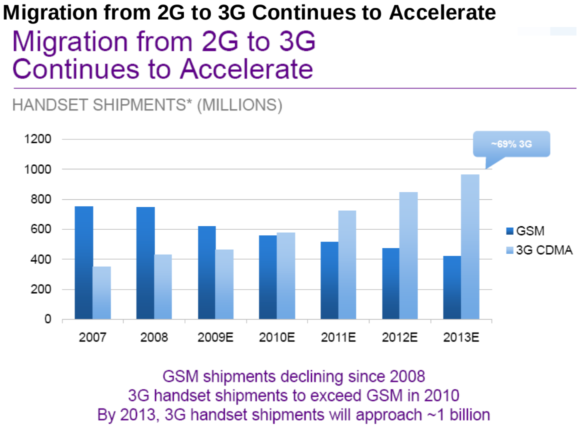
Challenges in Future Communications Systems – Wireless Networks 2020
Wireless communication has demonstrated its importance in the past decade as a fundamental driver of economic growth, first in the form of cellular networks and more recently for computer networks (WiFi, WiMAX). The next decade is likely to bring equally dramatic developments, driven by:
• increasing demand for bandwidth-hungry services such as HDTV and access to data files of rapidly increasing size;
• increasing rates available from fixed networks (DSL at increased rates, 1000-base-T,
FTTH and FTTB), which users will then expect wireless to match;
• The efficiency gains available from coordinated networks of autonomous devices and sensors, for example for security and surveillance.
The full extent of these developments cannot be predicted, but they are sure to include:
• Converged broadband services: “triple-play” services (speech, data, and video) at rates up to
1 Gbit/s for users in any environment, delivered by standard/system-agnostic means;
• Ubiquitous computing: distributed intelligence in a multitude of devices operating autonomously;
• Wireless sensor networks for surveillance and environmental sensing.
These applications pose a number of severe challenges for wireless communications:
• Increase in system bandwidth efficiency by around an order of magnitude;
• QoS-aware networks;
• Coping with new and heterogeneous system architectures, such as mesh networks, multi-hop networks; peer-to-peer communication and multi-standard networks;
• Coordination of a multiplicity of autonomous devices using heterogeneous standards; Efficient, timely transmission of very large volumes of short messages.

Evolution of mobile communication system
Evolution of Wireless Communication has been rapid. Demands for further development have surfaced even faster. These demands have instigated innovations. From the age of pre-cellular mobile telephone technology, referred to as 0G in some literatures, till date wireless communication has been through remarkable changes.
1G technology replaced 0G technology, 1G stands for "first generation", refers to the first generation of wireless telecommunication technology, more popularly known as cell phones. A set of wireless standards developed in the 1980’s [14]. The first generation of wireless mobile communications was based on analog signaling. Analog systems, implemented in North America, were known as Analog Mobile Phone Systems (AMPS), while systems implemented in Europe and the rest of the world was typically identified as a variation of Total Access Communication Systems (TACS). Analog systems were primarily based on circuit-switched technology and designed for voice, not data [15]. This Phone System AMPS was a frequency modulated analog mobile radio system using frequency Division Multiple Access (FDMA) with 30kHz channels occupying the 824MHz − 894MHz frequency band and a first commercial cellular system deployed until the early 1990’s [16].
Second Generation rapid growth in the number of subscribers and the proliferation of many incompatible first generation systems were the main reason behind the evolution towards second generation cellular systems. Second generation systems take the advantage of compression and coding techniques associated with digital technology. All the second generation systems employ digital modulation schemes. Multiple access techniques like Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) are used along with FDMA in the second generation systems.
Second generation cellular systems include:
• United States Digital Cellular (USDC) standards IS-54 and IS-136
• Global System for Mobile communications (GSM)
• Pacific Digital Cellular (PDC)
• Cdma One [17].
2G based on the two techniques, there were three primary 2G mobile communication systems. They are TDMA (IS-136), CDMA (IS-95), and GSM [18]. TDMA (IS-136), as a completely digital system, was deployed in North America in 1993, but operated in the AMPS frequency band of 824MHz-894MHz. CDMA (IS-95) systems using Direct Sequence Spread Spectrum (DSSS) are working on the 1850-1990 MHz frequency band to support CDMA carriers. This spectrum is commonly called Personal Communications Services (PCS). GSM is the most widely used 2G standard, accounting for about 66 percent of the world market in the year 2004 [19]. Standards were developed to provide both data service, and increase the data rate in GSM networks. General Packet Radio Service (GPRS) was a packet overlay network designed to provide data services in a GSM network. GPRS utilized the same frame structure as GSM, and supported a maximum data rate of 21.4kbps [20].
2.5G GPRS (General Packet Radio Service) Until the late nineteen-nineties wireless mobile networks focused primarily on voice service, evolving from the well-known “bag telephone” in the late eighties to the newer, clearer digital networks, such as GSM. With the advent of smaller, more powerful devices, user sophistication has grown and with it the demand for faster wireless data services has also grown. In an attempt to address this, the European Telecommunications Standards Institute (ETSI) developed a new wireless data network, designed to integrate with existing digital networks, known as General Packet Radio Service or GPRS. GPRS offers speeds from 9 to 115 Kbps and support for multiple bandwidths, make it an ideal solution for carriers on the path to the 3G.

Mobile Communication Roadmap from 1G to 4G

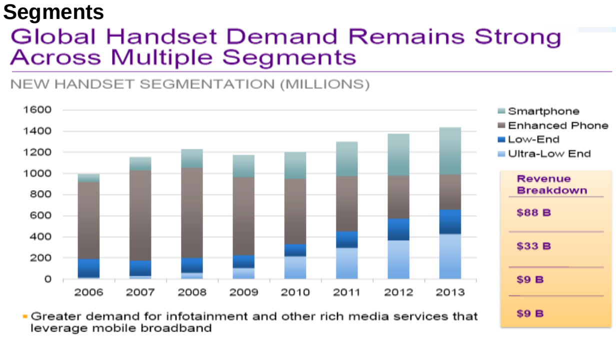


Migration from 2G to 3G Continues to Accelerate



~4.6B Total Wireless Subscribers~945M 3G Subscribers Today. Expected to be **~2.7B** by **2014**

Global Handset Demand Remains Strong across Multiple Segments



Reason behind the growth in just 25 years

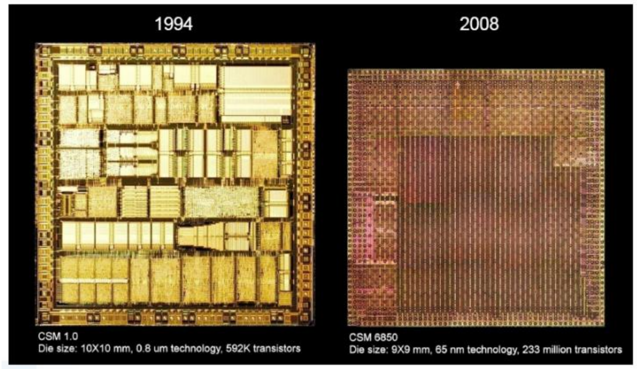
1. Relentless progress in silicon technology

(a)Higher integration, lower costs ($20 phones readily available in emerging markets), more capabilities

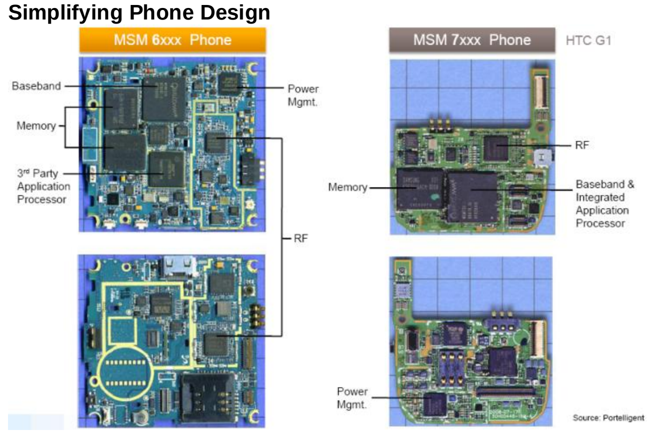
2. Technical advances in air interfaces

(b)Higher efficiency for voice and data services, lower infrastructure capital costs.

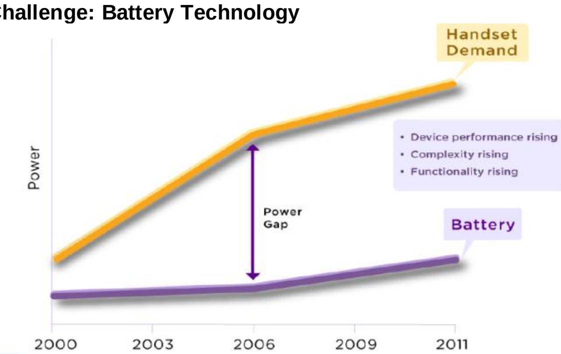
Network Modems: 14 Years Apart



Simplifying Phone Design



Challenge: Battery Technology



What is 4G?

4G stands for Fourth Generation Mobile Communication which provides '*anytime*', '*anywhere*' wireless broadband services. Along with high quality voice, high data rates 4G supports HD videos even in very high speed.

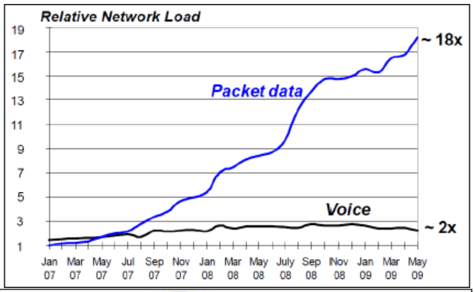
Goals of 4G

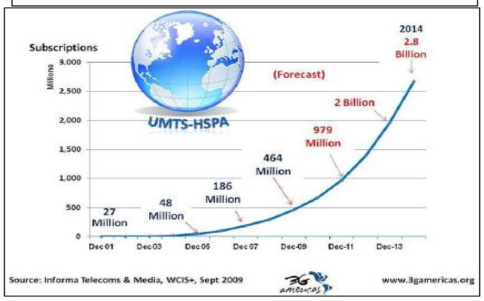
1. Improvement of Spectral Efficiency
2. Different Traffic Support e.g. Real-Time & Non-Real-Time application
3. Efficient operation with instantaneous access to network resources
4. Re-use of existing cell site infrastructure.
5. Flexible spectrum allocation
6. Lower cost per bit
7. Improved Quality of Service (QoS)
8. Increasing Coverage

Improvement in Network Side

1. Improvement in Latency, Capacity & Throughput
2. Simplified Core Network
3. Optimized IP Traffic & Services

Why 4G is needed?





History of cellular telephony

This detail given below shows the change of telephonic generation time to time.

1G	2G	2.5G	3G	Beyond 3G	4G
Analog voice	Digital voice	Voice + data	Multimedia services	Broadband multimedia	Ubiquitous networks
NMT AMPS	GSM PDC IS-95A IS-136	GPRS HSCSD EDGE IS-95B	WCDMA CDMA 2000	HSPA WiMAX UMTS-LTE CDMA 2000 1xEV	IMT-A ??
FM modulation Analog switching Cellular concept Hard handover	Digital modulation Error control Data compression Soft handover High quality voice	Voice + data Higher rate than 2G	'Any time any where' multimedia Packet based data Dynamic RRM Increased capacity	Broadband multimedia High data rate High QoS support broadband wide area	Heterogeneous networks Adaptive air interface Guaranteed QoS Real broadband at wide-area
FDMA	TDMA/CDMA	TDMA/CDMA	WCDMA	WCDMA/OFDMA	OFDMA
very low rate	9.6-28.8kbps	57-115kbps	0.144~2Mbps	~10's of Mbps	~100's of Mbps
1970s/1980s	1982/1992		1992/2001	..../2007,2012,	2017

Physical layer

1. Proposal from Japan W-CDMA {DS-CDMA FDD/TDD, 1.25,5,10,20 MHz}
2. 3G in Europe ETSI
Universal Mobile Telecommunications System (UMTS)
UMTS Terrestrial Radio Access (UTRA),
a. W-CDMA
b. UTRA FDD paired bands
c. TD-CDMA *UTRA TDD unpaired band*
3. China Wireless Telecommunication Standard (CWTS)
a. TDD system, Time-Division Synchronous CDMA (TD-SCDMA),
b. Similar to UTRA TDD.

4. TIA (South Korea) CDMA 2000
a. IMT-2000 Multi Carrier

Difference between 3G and 4G

	3G	4G
Air Interface	CDMA	OFDMA, SC-FDMA
Data Rate	DL: 14 Mbps UL: 5Mbps	DL: 100 Mbps-1Gbps UL: 50Mbps-500 Mbps
Technology	Both Circuit Switched and Packet Switched	Only Packet Switched
Frequency Band	1.8 – 2.5GHz	2 – 8GHz
Forward error correction (FEC)	3G uses Turbo codes for error correction	Concatenated codes are used for error corrections in 4G
Examples	EDGE, CDMA2000, UMTS (WCDMA)	3GPP LTE-A, IEEE 802.16m WiMAX

Network Infrastructure

Network energy consumption is a major cost element for mobile operators, especially at remote sites which have to be powered by diesel generators. It is also a large contributor to CO2 emissions, which impact our environment and contribute to climate change. Mobile operators have started initiatives to reduce the energy consumption of base stations, and to use renewable energy sources such as solar and wind power. The GSMA, the global trade body for the mobile industry, has launched a "Green power for Mobile" programmer to power 118,000 new and existing off-grid base stations in developing countries with alternative energy supplies by 2012. Vodafone has pledged to reduce its global CO2 emission by 50%, against the 2006/2007 total, by 2020. To achieve these goals, the most important measures such as switching-off air conditioning when it is not necessary are relatively low-tech. Ones these sources of energy-waste are eliminated, innovation is necessary to improve the energy-efficiency further – where signal processing will play a very important role:

Core Network

As more traffic generated by end user energy consumption by switches, application servers, data centers and their associated cooling will continue to escalate. In order to reduce the energydemand, newer generation of servers tend to reduce the number of interfaces through software and hardware integration, adoption of more energy efficient processors as well as adding dynamic power management techniques to wake up clusters of servers only when required. Processors also employ technology such as frequency and voltage scaling and aggressive circuit gating. Blocks of cache and floating point unit may be turned off while the server is idle and then turn on quickly when called into action.

Macro Base Stations

Many techniques have been used to reduce energy consumption of conventional macro base stations over the past decade. These include the use of more efficient radio frequency power amplifiers, introducing solar shielding to the equipment, utilizing natural convection cooling rather than the traditional forced cooling, elimination of the air conditioner, as well as adding intelligence to selectively switch-off radio channels and baseband circuitries during times of low traffic volume. Remote radio heads and amplifiers integrated directly into antennas are upcoming technologies with the potential to reduce power consumption. In addition, more power efficient electronic components have to be designed into the subsystems to enable lower power consumption. The overall system-integration of often heterogeneous systems including backhaul has to take this into account.

Micro Base Stations and Relays

The current generations of macro base stations are mostly optimized for wide area coverage. However, as we evolve to higher data rate applications, we need much smaller cells to support the increased data rates. The flexibility of such deployment would be dependent on the power supply as well as backhaul. To solve the power supply issue, the energy demand for these small network elements should be sufficiently low such that it can be powered by sustainable energy sources such as small solar panels. Likewise backhaul may need to be provided through a self-contained relay network using either in-band or out-of-band radio relays. This will eliminate the need to access fiber at every base station but only at locations that is either collocated with a fire drop or have access to a fiber point of presence.

Femto Base Stations

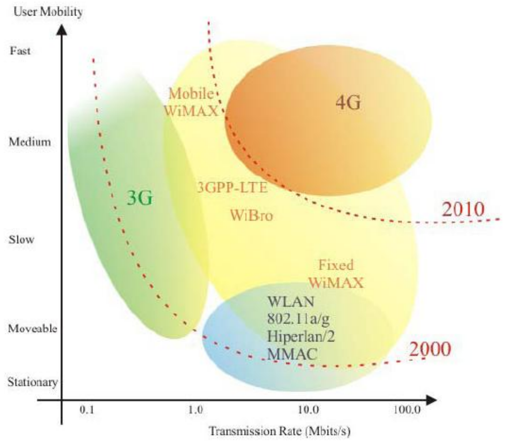
Femto base stations exploit the proliferation of fixed DSL and cable modem deployment in urban and suburban areas to provide indoor radio coverage. Femto base stations are small, low power cellular base stations, typically designed for use in residential and business environments. It connects to the service provider via fixed broadband access. As femto base stations are deployed in indoor locations, it does not have to circumvent high building loss. Thus, low output power is sufficient to provide adequate indoor coverage. By the nature of the small cell structure, it can improve both network capacity and coverage. There are, however, known challenges associated with femto base station deployment that include spectrum allocation, interference handling, access control, lawful interception, emergency calls and equipment location, quality of service, handover and network integration. In addition, the requirement of access fixed broadband precludes the deployment of femto base stations in many of the emerging markets where fixed infrastructure is effectively non-existent. Smart signal processing solutions have the potential to solve some of the femto cell issues.

Off-grid locations

Providing sustainable energy source to base station infrastructure at locations beyond the power grid is particularly challenging. Conventional methods of using diesel generations and lead-acid batteries are relatively low cost but cause high maintenance overhead and environmental impact. The industry is looking to renewable energy sources including solar and wind as the primary energy sources and regenerative fuel cell technology as a means of backup. More specifically, a fuel cell normally requires some kind of fuel, such as hydrogen, to generate electricity and provide water as a by-product. Regenerative fuel cells are designed to recycle the water output and through the use of electrolysis to extract the hydrogen. Together with oxygen from the air, and power supplied by the solar and wind, a near-closed cycle can be formed. The process is completely environmentally friendly but the economics of such a setup has yet to be refined before it can be sufficiently attractive to compete with lower cost conventional solutions. Interworking between power supply, power storage and network equipment power demand poses a challenge with the need for innovative solutions.

Future wireless communication

This graph shows growth of mobile communication.



Advantages

- Mobility - user device can be moved easily within the wireless range
- Neat and easy Installation - since no cable running here and there, just start up the wireless device and you're ready to rumble
- Less cost for cabling infrastructure and device
- More users supported - cable device have limited slots whereas wireless does not.
- Easy maintenance
- Avoided ground potential rise problems
- Safety due to remote operations
- Warmth of a van outside a freezing substation
- More data and additional capabilities

Disadvantages

- Relatively lower bandwidth speed - example: although currently 802.11/n could reach 128 Mbps, UTP cable can reach 1 Gbps. And more user mean each bandwidth get smaller. That is why currently wired backbone network is still preferred.
- Ease of access means more security also necessary to protect data and/or bandwidth, since people can connect anywhere within range without seeking network plug.
- Eavesdropping on data
- Unauthorized control commands
- Unreliable, disrupted communications in the noisy substation environment
- Hackers, viruses, and worms

Benefits of Wireless versus Wired

• **Less expensive** because cabling does not need to be installed. While fiber optic cables cost about $25k per mile, wireless media is "free"

• **More rapid implementation**, since no trenching through and around substation equipment is required.

• **Less experienced technicians** can often be used, because they do not need to be concerned with ground potential rise or have to run cables around HV equipment.

• **More mobile and portable** so that the same equipment with wireless communications can easily be moved from one spot to another, either continuously (e.g. in a truck) or periodically (e.g. for spot maintenance).

• **Additional wireless equipment can automatically interconnect** with only the appropriate security features enabled.

• **Less susceptible to ground potential rise** because no cabling is needed.

• **Failure location** in wireless systems can be easier, since only need to test the end devices.

• **New wireless applications may be feasible** that were not cost-effective with wired communications. These applications might improve power system reliability and efficiency, or provide increased personnel safety.

Technical challenges

Following are the technical challenges and barriers.

A) Security and Privacy

In the development of 4G Networks, security measures must be established that enable data transmission to be as safe as possible. Specifically, "The 4G core addresses mobility, security, and QoS through reuse of existing mechanisms while still trying to work on some mobility and handover issues". Therefore, it is necessary for the organization to develop an effective series of tools that support maximum 4G security measures as a means of protecting data that is transmitted across the network from hackers and other security violations. Because of the nature of the 4G network, there is an increased likelihood of security attacks, and therefore, multiple levels of security, including increased requirements for authentication, will be necessary to protect data and information that is transmitted across the network [6]. To overcome these security and privacy issues, two approaches can be followed. The first is to modify the existing security and privacy methods so that they will be applicable to heterogeneous 4G networks Another approach is to develop new dynamic reconfigurable, adaptive, and lightweight mechanisms whenever the currently utilized methods cannot be adapted to 4G networks [7].

B) Technologies for Cost Reduction

The use of higher frequency band to achieve higher transmission rate with conventional system configuration technology generally reduces the radius of the cell that one base station can cover. To retain the original coverage area, more base stations are required and network cost is increased. To avert that problem, it is necessary to expand cell radii by means of higher performance radio transmission and circuit technology, such as improved modulation/demodulation techniques that can cope with low S/N, the use of adaptive array antennas, and low noise receivers [8].

C) Quality of Services

What QoS does 4G provide to us they are as follows:-

(1) Traffic generated by the different services will not only increase traffic loads on the networks, but will also require different quality of service (QoS) requirements (e.g., cell loss rate, delay, and jitter) for different streams (e.g., video, voice, data).

(2) Providing QoS guarantees in 4G networks is a non-trivial issue where both QoS signaling across different networks and service differentiation between mobile flows will have to be addressed.

(3) One of the most difficult problems that are to be solved, when it comes to IP mobility, is how to insure the constant QoS level during the handover.

(4) Depending on whether the new access router is in the same or some other sub network, we recognize the horizontal and vertical handover.

(5) However, the mobile terminal cannot receive IP packets while the process of handover is finished. This time is called the handover latency.

(6) Handover latency has a great influence on the flow of multimedia applications in real-time.

D) Complex Architecture

1) Multimode End-User Terminals

To reduce operating costs, devices that operate on 4G networks should have the capability to operate in different networks. This will not only reduce the operating cost but will also simplify design problems and will reduce power consumption. However, accessing different mobile and wireless networks simultaneously is one of the major issues 4G networks have been addressing [9].

2) System Discovery and Selection

Due to the heterogeneity of 4G networks, wireless devices have to process signals sent from different systems, discover available services, and connect to appropriate service providers. Various service providers have their own protocols which can be incompatible with each other as well as with the user's device. This issue may complicate the process of selecting the most appropriate technology based on the time, place and service provided, and thus, may affect the Quality of service provided to the end user. One solution to resolve this issue iscalled "System initiated discoveries". This mechanism allows automatic download of software modules based on the wireless system the user is connected to [10].

3) Service and Billing

Managing user accounts and billing them has become much more complicated with 4G networks. This is mainly due to heterogeneity of 4G networks and the frequent interaction of service providers. The research community addressed this concern and proposed several frameworks to handle the customers' billing and user account information [11, 12].

Security analysis

A) Objectives

The first step in analyzing cellular wireless security is to identify the security objectives. These are the goals that the security policy and corresponding technology should achieve. Howard, Walker, and Wright, of the British company Vodafone, created objectives for 3G wireless that are applicable to 4G as well:

• To ensure that information generated by or relating to a user is adequately protected against misuse or misappropriation.

• To ensure that the resources and services provided to users are adequately protected against misuse or misappropriation.

• To ensure that the security features are compatible with world-wide availability...

• To ensure that the security features are adequately standardized to ensure world-wide interoperability and roaming between different providers.

• To ensure that the implementation of security features and mechanisms can be extended and enhanced as required by new threats and services.

• To ensure that security features enable new 'e-commerce' services and other advanced applications (Howard, Walker, and Wright 2001, 22)

B) Threats

Because instances of 4G wireless systems currently only exist in a few laboratories, it is difficult to know exactly what security threats may be present in the future. However, one can still extrapolate based on past experience in wired network technology and wireless transmission. For instance, as mobile handheld devices become more complex, new layers of technological abstraction will be added. Thus, while lower layers may be fairly secure, software at a higher layer may introduce vulnerabilities, or vice-versa. Future cellular wireless devices will be known for their software applications, which will provide innovative new features to the user. Unfortunately, these applications will likely introduce new security holes, leading to more attacks on the application level (Howard, Walker, and Wright 2001, 22). Just as attacks over the Internet may currently take advantage of flaws in applications like Internet Explorer, so too may attacks in the future take advantage of popular applications on cellular phones. In addition, the aforementioned radio jammers may be adapted to use IP technology to masquerade as legitimate network devices [13].

Conclusion

Evolution of wireless communication in the form of mobile communication was a drastic change in the field of communication. Current trends in the evolution of wireless data services are either in the direction of high-speed wireless LAN's or low-speed wide-coverage mobile data services. The direction for the future is toward flexible multi rate services for multimedia applications, adjusting the specifications of the service with the user requirement and the environment. There are many technical details which could not be included in this paper which help in understand the growth of wireless communication. An extensive list of references is included which will provide the reader with more detailed information on the topics covered in the paper.

References

1. EBook-the complete wireless communications professional by William Webb

2. F. Adachi, "Evolution towards broadband wireless systems," *The 5th International Symposium on Wireless Personal Multimedia Communications, 2002,* vol. 1, pp. 19-26, 27-30 Oct. 2002.

3. J. De Vriendt, P. Laine, C. Lerouge, and X. Xiaofeng, "Mobile network evolution: a revolution on the move," *IEEE Communications Magazine,* vol. 40, no. 4, pp. 104-111, April 2002.

4. H. Akhavan, V. Badrinath, T. Geitner, H. Lennertz, Y. Sha, T. Utano, B. West: *"Next Generation MobileNetworks Beyond HSPA and EvDO"*, NGMN Alliance White Paper, www.ngmn.org, 3.0, December 2006

5. G. Wannemacher, A. Buldorini, S. Xiadong: *"Next Generation Mobile Networks Radio Access Networks Evaluation Methodology"*, NGMN Alliance WhitePaper, www.ngmn.org, 1.3, January 2008

[6] E. Buracchini, "The Software Radio Concept," IEEE Commun. Mag., 2000 vol. 38, no. 9, pp. 138–43.

[7] N. Montavont and T. Noel, "Handover Management for Mobile Nodes in IPv6 Networks," IEEE Commun. Mag., Aug. 2002, vol. 40, no. 8, pp. 38–43.

[8] T. Miki, T. Ohya, H. Yoshino, N. Umeda, "The Overview of the 4th Generation Mobile Communication System", IEEE 2005. Pp. 1551-1555.

[9] K.P. Makhecha, K.P. Wandra, "4G Wireless Networks: Opportunities and Challenges", IEEE INDICON 2009. Pp. 1-4

[10] A. Lyle, Clear, first 4G network launched, 2009.

[11] F. Ghys and A. Vaaraniemi, "Component-based Charging in a Next generation Multimedia Network," IEEE Commun. Mag., Jan. 2003, vol. 41, no. 1, pp. 99–102.

[12] S. Higgenbotham, Countdown to 4G: who's doing what, when, 2008.

[13] J. Ahmad, B. Garrison, J. Gruen, C. Kelly, and Hunter Pankey, "4G Wireless Systems", Feb. 2003.

[14] H.H. Chen, M. Guizani, W. Mohr, "Evolution toward 4G wireless networking", IEEE Network, 2005. Volume: 21 Issue: 1 pp. 4-5.

[15] T.D. Systems, "Third Generation (3G) Wireless", White Paper Inc. March 2000 Inc.

[16] C. Yiping, Y. Yuhang; "A new 4G architecture providing multimode terminals always best connected services", IEEE Wireless Communications, Volume: 14 Issue: 2 pp. 36-41.

ISSN 2229-5518

[17] F. Alam, "Simulation of Third Generation CDMA Systems", MSc thesis, Dept of Electrical and Eng, Polytechnic Institute & State University, 1999. Virginia.
[18] S. Frattasi, A. Gimmler, "Potentials and limits of cooperation in wireless communications: Toward 4G wireless", IEEE Technology and Society Magazine, 2005. Volume: 27 Issue: 1 pp. 8-12.
[19] 3GPP. Feasibility study on 3GPP system to Wireless Local Area Network (WLAN) interworking (Release 6). 3GPP, TR 22.934 V6.1.0. http://www.3gpp.org/ftp/Specs/2002-12/Rel- 6/22_series/22934-610.zip.
[20] R, JP, "Mapping the wireless technology migration path: The evolution to 4G systems", Enriching Communications, Volume: 2 Issue: 1 pp. 73-79.

Samanvay Gupta

Samanvaygupta18@gmail.com

4th year 1st semester

Computer Science Department

Visvesvaraya College of Engineering & Technology

Hyderabad, Andra Pradesh, INDIA

Residential Address:

Samanvay Gupta

S/o Mr. A.C Gupta

113/185 swaroopnagar, near K.V.M College

Kanpur, Uttar Pradesh INDIA

PIN-208002