White Paper

4G-Quadruple Play High Speed Mobile Broadband Technologies

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Abstract:

4G or the 4th generation technologies promise the full mobility with high speed internet data rates. 4G technologies like Mobile WiMAX and UMB (Ultra Mobile Broadband) are emerging strongly to provide the industry best mobile broadband technologies to the end users. This paper focuses on 4G networks and will include the introduction of 4G technologies, 4G networks, its history, standards, business perspectives, strategy and challenges faced.

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INTRODUCTION

4G, an acronym for Fourth-Generation Communications System, is a term used to describe the next step in wireless communications. A 4G system will be able to provide a comprehensive Quadruple IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis featuring the full mobility, and at higher data rates than previous generations. There is no formal definition for what 4G is; however, there are certain objectives that are projected for 4G.

4G TECHNOLOGIES

4G will be a fully IP-based integrated system as shown below in Fig-1. This will be achieved after wired and wireless technologies converge and will be capable of providing 100 mbps and 1 gbps speeds both indoors and outdoors, with premium quality and high security. 4G will offer all types of services at an affordable cost.4G is being developed to accommodate the quality of service (QoS) and rate requirements set by forthcoming applications like Wireless Broadband Access, Multimedia Messaging Service, Video Chat, Mobile TV, High definition TV content, DVB, minimal service like voice and data, and other streaming services for "anytime-anywhere" mobility. The 4G working group has defined the following as objectives for 4G wireless communication standards:

Baseband Techniques

- **OFDM**: To exploit the frequency selective channel property
- **MIMO**: To attain ultra high spectral efficiency
    - Turbo principle: To minimize the required SNR at the reception side
    - Adaptive Radio Interface
    - Modulation, MIMO spatial processing including multi-antenna and multi-user MIMO, relaying including fixed relay networks (FRNs) and the cooperative relaying concept, multi-mode protocol

It introduces a single new ubiquitous radio access system concept, which is flexible to variety levels of beyond 3G wireless systems.

4G NETWORKS

The 4G network will encompass all systems from various networks, public to private; operator-driven broadband networks to personal areas; and ad hoc networks. The 4G systems will interoperate with 2G and 3G systems, as well as with digital (broadband) broadcasting systems. In addition, 4G systems will be fully IP-based wireless Internet. This all-encompassing integrated perspective shows the broad range of systems that the fourth generation intends to integrate, from satellite broadband to high altitude platform to cellular 3G and 3G systems to WLL (wireless local loop) and FWA (fixed wireless access) to WLAN (wireless local area network) and PAN (personal area network), all with IP as the integrating mechanism. With 4G, a range of new services and models will be available. These services and models need to be further examined for their interface with the design of 4G systems.

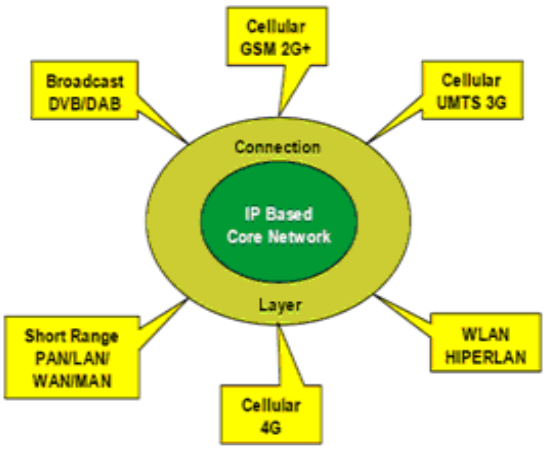


Fig- 1

EVOLUTIONARY STEPS/PATH

The evolution of mobile service from the 1G (first generation) to fourth generation is discussed in this section and from Fig-2 technology evolution began as follows:

1G: This process began with the designs in the 1970s that have become known as 1G. The earliest systems were implemented based on analog technology and the basic cellular structure of mobile communication. Many fundamental problems were solved by these early systems. Numerous incompatible analog systems were placed in service around the world during the 1980s.

2G: The 2G (second generation) systems designed in the 1980s were still used mainly for voice applications but were based on digital technology, including digital signal processing techniques. These 2G systems provided circuit- switched data communication services at a low speed. The competitive rush to design and implement digital systems led again to a variety of different and incompatible standards such as GSM (global system mobile), mainly in Europe; TDMA (time division multiple access) (IS-54/IS-136) in the U.S.; PDC (personal digital cellular) in Japan; and CDMA (code division multiple access) (IS-95), another

U.S. system. These systems operate nationwide or internationally and are today's mainstream systems, although the data rate for users in these system is very limited.

2.5G: An interim step is being taken between 2G and 3G, the 2.5G. It is basically an enhancement of the two major 2G technologies to provide increased capacity on the 2G RF (radio frequency) channels and to introduce higher throughput for data service, up to 384 kbps. A very important aspect of 2.5G is that the data channels are optimized for packet data, which introduces access to the Internet from mobile devices, whether telephone, PDA (personal digital assistant), or laptop

3G: During the 1990s, two organizations worked to define the next, or 3G, mobile system, which would eliminate previous incompatibilities and become a truly global system. The 3G system would have higher quality voice channels, as well as broadband data capabilities, up to 2 Mbps. unfortunately, the two groups could not reconcile their differences, and this decade will see the introduction of two mobile standards for 3G. In addition, China is on the verge of implementing a third 3G systems.

4G: However, the demand for higher access speed multimedia communication in today's society, which greatly depends on computer communication in digital format, seems unlimited. According to the historical indication of a generation revolution occurring once a decade, the present appears to be the right time to begin the research on a 4G mobile communication system.

Fig-2

Technology	1G	2G	2.5G	3G	4G
Design Began	1970	1980	1985	1990	2000
Implementation	1984	1991	1999	2002	2010?
Service	Analog voice, synchronous data to 9.6 kbps	Digital voice, short messages	Higher capacity, packetized data	Higher capacity, broadband data up to 2 Mbps	Higher capacity, completely IP-oriented, multimedia, data to hundreds of megabits
Standards	AMPS, TACS, NMT, etc.	TDMA, CDMA, GSM, PDC	GPRS, EDGE, 1xRTT	WCDMA, CDMA2000	Single standard
Data Bandwidth	1.9 kbps	14.4 kbps	384 kbps	2 Mbps	200 Mbps
Multiplexing	FDMA	TDMA, CDMA	TDMA, CDMA	CDMA	CDMA?
Core Network	PSTN	PSTN	PSTN, packet network	Packet network	Internet

SPECTRUM

A number of spectrum allocation decisions, spectrum standardization decisions, spectrum availability decisions, technology innovations, component development, signal processing and switching enhancements and inter-vendor cooperation have to take place before the vision of 4G will materialize. We think that 3G experiences - good or bad, technological or business - will be useful in guiding the industry in this effort. We are bringing to the attention of professionals in telecommunications industry following issues and problems that must be analyzed and resolved:

Lower Price Points Only Slightly Higher than Alternatives - The business visionaries should do some economic modeling before they start 4G hype on the same lines as 3G hype. They should understand that 4G data applications like streaming video must compete with very low cost Wireline applications. The users would pay only a delta premium (not a multiple) for most wireless applications.

Coordination among Spectrum Regulators around the World - Spectrum regulation bodies must get involved in guiding the researchers by indicating which frequency band might be used for 4G. FCC in USA must cooperate more actively with International bodies like ITU and perhaps modify its hands-off policy in guiding the industry. When public interest, national security interest and economic interest (inter-industry a la TV versus Telecommunications) are at stake, leadership must come from regulators. At appropriate time, industry builds its own self-regulation mechanisms.

Academic Research: Universities must spend more effort in solving fundamental problems in radio communications (especially multiband and wideband radios, intelligent antennas and signal processing.

Standardization of wireless networks in terms of modulation techniques, switching schemes and roaming is an absolute necessity for 4G.

A Voice-independent Business Justification Thinking: Business development and technology executives should not bias their business models by using voice channels as economic determinant for data applications. Voice has a built-in demand limit - data applications do not.

Integration Across Different Network Topologies: Network architects must base their architecture on hybrid network concepts that integrates wireless wide area networks, wireless LANS (IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.15 and IEEE 802.16, Bluetooth with fiber-based Internet backbone. Broadband wireless networks must be a part of this integrated network architecture.

BANDWIDTH

Channel Bandwidth: 2G systems such as GSM use a channel bandwidth of 0.2 MHz. UMTS made a great leap forward and uses 5 MHz. 4G systems will use a bandwidth of up to 20 MHz, i.e. the channel offers four times more bandwidth than channels of current systems. As 20 MHz channels might not be available everywhere, most 4G systems will be scalable, for example in steps of 1.25 MHz. It can therefore be expected that 4G channel sizes will range from 5 to 20 MHz.

Fig-3 below shows the projected Bandwidth trends vs. Personal wireless

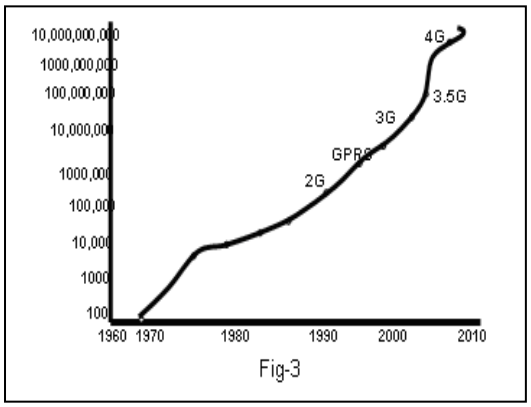


Fig-3

NETWORK CAPACITIES & DATA RATES

Below Fig-4 provides the comparison for emerging network technologies and their data rate support for high speed internet access.

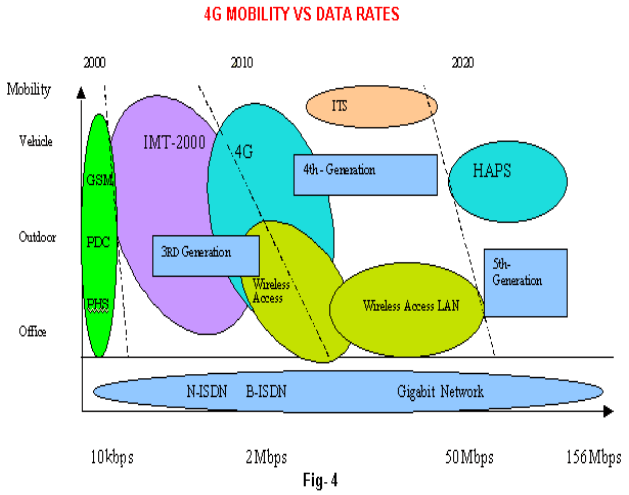


Fig- 4

BUSINESS STRATEGIES

4G is the successor of 3G wireless access technology. It describes two different but overlapping ideas. 4G is being developed to accommodate the quality of service (QoS) and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service, video chat, mobile TV, High definition TV content, DVB, minimal service like voice and data, and other streaming services. It is estimated that 4G will be deployed in the 2010-2015 period.

4G's unregulated, it requires no license, and will go into almost every present and future electronic device. It can play a large role in bypassing low-capacity wired connections from the street to the home, thereby re-firing markets for PCs, consumer electronics, microprocessors, and software with the kind of cheap bandwidth that will end the recession in which we now find ourselves.

SERVICES ENABLED

Emerging deployment of high-capacity broadband wireless will enable a new set of customer services focused on the convergence of data, video, voice and mobility. 4G in principle will allow high-quality smooth video transmission. WiMAX & UMB, which allows for higher data rates, more scalability, broader coverage and lower latency than Wi-Fi, has the backing of some big players in the industry. Some vendors are also anxious to exploit WiMAX's & UMB's flexible architecture.

PUBLIC POLICY

Public Policy is usually the Wireless Industry issues that deal around with technology & consumers. For solving such problems in future 4G devices, some policy based solutions are available. A policy-based solution for 4G Mobile devices wilt allows users to seamlessly connect to highly integrate heterogeneous wireless networks. The key motivation behind these stems from the statement that handover process complexity will increase in 4G systems, creating the need for augmented knowledge about context, as well as more flexibility.

The 4G architecture demands highly flexible and adaptive mobile clients that can cope with diverse, heterogeneous, and dynamic environments. More technologies, services, and devices join the fray every day, we can be sure that as the QoS gap offered by new access networks closes hard-coded handover algorithms will become obsolete and more flexible solutions will gain importance.
Diversity and heterogeneity in wireless systems' evolution have placed the integration of hybrid mobile data networks as an enormous barrier towards the success of seamless networking. This challenge outstrips embedded system hard-coded policies (e.g. *handover to the strongest signal* or *always handover to the lowest available overlay*).

BUSINESS CASE

Certain high speed wireless broadband technologies like HSxPA, Mobile WiMAX & UMB are competing and complementing each other under 4G technologies to provide quadruple feature set like data, voice, video & seamless mobility. Deploying these 4G technologies have an impact at various levels like Consumers, Network Operators & Service Providers. Therefore, the view of leapfrogging to 4G experience lacks clear understanding of the concept of 4G. The future of WiMAX lies in the fact that it can prove to be an essential building block in meeting demand for wireless broadband.

No one technology is superior and it's only the environment, application and business case that are the key deciding factors for choosing the appropriate technology.

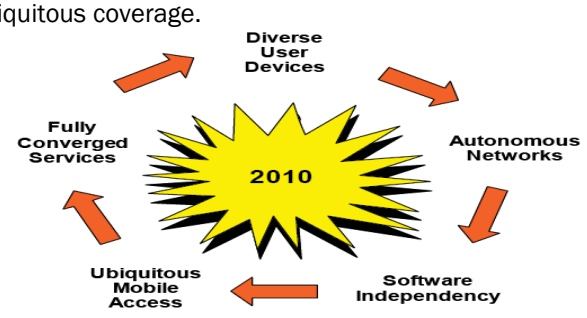
Business case analysis of 4G in different deployment situations:

-Developing market urban area
-Developed market rural area
-Developed market urban area

4G MARKETS

The primary 4G technologies of the future are expected to be Long Term Evolution (LTE), Ultra Mobile Broadband (UMB), and IEEE 802.16m WiMAX, the market research firm says.

Research finds that 4G technologies will be OFDMA-based and will support 100 megabits per second for wide-area mobile applications. In addition, 4G technology roll-outs will most likely start between 2010 and 2012 from Fig-5, and mobile operators will deploy 4G slowly at first, and rely on their EV-DO or HSPA networks to provide for more ubiquitous coverage.



Mobile WiMAX is likely to have the most success among new market entrants looking to enter the market in the near term, such as landline operators seeking to include mobility in their service bundles.

The worldwide broadband subscriber base has increased to nearly 250 million and the continued increase in broadband penetration will be an extremely important driver, as it is a vital requirement to enhance end-user experience.

MULTIMEDIA DELIVERY OF CONTENT

Analysts said the explosion in rich media content, such as audio, video and gaming, will significantly add to the growth of the market. Advances in compression technologies, along with broadband penetration, have made it easier for millions of end-users to access rich media, thereby magnifying demand for such content.

In addition, multi-platform devices such as wireless handsets, portable media players and gaming consoles are adding to the demand for broadband content.

The growing convergence among broadband, traditional television, emerging Internet protocol television (IPTV) and mobile networks has many service providers attempting to provide content on all platforms. While Internet's ubiquity has enabled this to an extent, the growing loads of content over it will pose challenges related to customization for other platforms besides the computer.

While the high growth of content over the Internet has fueled the demand for 4G technologies, it is not without its share of challenges, along with the all-round emphasis on quality, security, as well as delivery of large-sized content and a gradual move toward convergence will heighten the pressure on 4G technology vendors to strike a fine balance between technical issues and seamless delivery of multimedia content.

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 of a standard that can be embraced worldwide through its key concept of integration. 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.

GLOSSARY

1XRTT	Single Carrier Radio Transmission Technology
AMPS	Advanced Mobile Phone Service
CDMA	Code Division Multiple Access
DVB	Digital Video Broadcasting
EDGE	Enhanced Data rates for Global Evolution
EV-DO	Evolution Data Only
FDMA	Frequency Division Multiple Access
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HSPA	High Speed Packet Access
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
LAN	Local Area Network
MIMO	Multiple Input Multiple Output
NMT	Nordic Mobile Telephone
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PDC	Personal Digital Communications
PSTN	Public Switched Telephone Network
SNR	Signal to Noise Ratio
TACS	Total Access Communication System
TDMA	Time Division Multiple Access
UMB	Ultra Mobile Broadband
WCDMA	Wideband CDMA
WiMAX	Worldwide Interoperability for Microwave Access

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