EVOLUTON OF 4G WITH REFERENCE TO 3G

Ruby Sharma[1], Bharti Saneja[2], Tarun Sharma[3]

[1] M.tech, KSOU, Mysore (India)
[2]M.tech, UIET,Kurukshetra University Kurukshetra(India)
[3]B.tech, BBDIT, GBTU, Lucknow (India)

ABSTRACT

This paper first describe the evolution and comparison of broadband wireless ,why we leap towards 4G and technologies that support 4G.To address these advanced application HSDP promises to provide services of upto 10Mbps and higher spectral efficiency for packet data.

As access technology increases, voice, video, multimedia, and broadband data services are becoming integrated into the same network. Fourth Generation (4G) is the next generation of wireless networks that will replace third Generation (3G) networks sometimes in future. 4G is

*Intended to provide high speed, high capacity, low cost per bit, IP based services.4G is all about an integrated, global network that's based on an open system approach. The goal of 4G is to "**Replace the current proliferation of core cellular networks**" with a single worldwide cellular core network standard based on IP for control, video, packet data and VoIP.*

KEYWORDS: - Wireless, HSDPA, 4G, OFDM, TDD, CDMA

I INTRODUCTION

In recent several years, wireless high speed packet data has received enormous attention in wireless industry under the context of 3G standardization (third generation). This trend is believed to be driven by the wireless internet although the "killer application" is not so obvious yet. Recent 3G standardization and related technology development reflects the need of the high-speed packet data of wireless internet. For 3G, there are two standard organizations studying the relevant concepts and defining the relevant system specifications. They are 3GPP (third generat-ion partnership project) defining WCDMA and 3GPP2 defining CDMA2000. While carriers and handset manufacturers obviously have their hands full with 3G, some companies are already looking beyond this next generation of wireless technology and networks. 4G is simply an initiative by academic R&D labs to move beyond the limitations and problems of 3G which is having trouble getting deployed and meeting its promised performance and throughput. While this 3G has not completely reached researchers and vendors are expressing growing interest in 4G why? Two main areas are addressed in these initiatives: An increase of capacity in the radio link and seamless

mobility across heterogeneous access networks. Our vision of the 4G systems is a wide-area coverage distributed base station system with dissimilar modulations between uplink and downlink. We believe the duplex mode will be TDD. These will be evolved versions of the 3G TDD CDMA based standards for services associated with 4G. Several TDD-specific techniques have enabled the system to provide downlink bit rates of 10–20 Mb/s in 10 MHz bandwidth. These can rightly claim to be 3.5G systems. Furthermore, flexible uplink and downlink capacity allocation, downlink adaptive antenna configuration, advanced detector techniques in both uplink and downlink, and combination with MC-DS-CDMA technology and OFDM make TDD CDMA a strong candidate for evolving 4G systems. The main goal of this paper is to review the most recent development of new technologies related to the topic of the high-speed packet data of wireless Internet and potential applications.

II EVOLUTION AND COMPARISON OF BROADBAND WIRELESS

Figure 1 shows the evolution of wireless technologies.

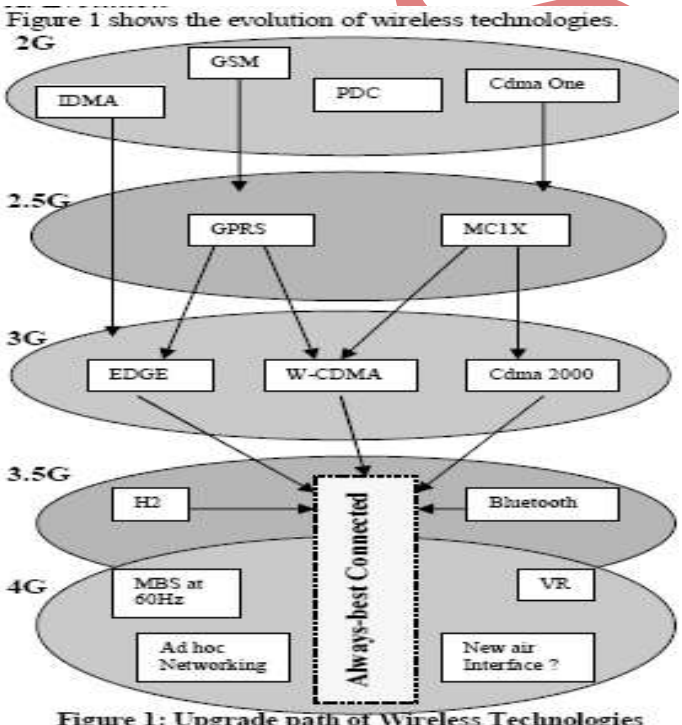

Figure 1: Upgrade path of Wireless Technologies

2.1 Evolution

i. **First Generation (1G):** 1G wireless mobile communication systems, was introduced in the early 1980s. 1G wireless was analog and supported the first generation of analog cell phones. They include a signaling protocol known as SS7 (Signaling System 7).

ii. ***Second Generation (2G):*** 2G systems, fielded in the late 1980s, were intended primarily for voice transmission and was all about digital PCS.

iii. ***Third Generation (3G):*** 3G in wireless will be a deliberate migration to faster, data-centric wireless networks. The immediate goal is to raise transmission speeds from 125kbps to 2M bit/sec.

iv. ***Fourth Generation (4G):*** In reality, as of first half of 2002, 4G is a conceptual framework for or a discussion point to address future needs of a universal high speed wireless network that will interface with wire line backbone network seamlessly.

2.2 Comparison

GENERATION	ACCESS TECHNOLOGY	FEATURES
1 G Wireless	Advanced mobile phone service(AMPS)	Analog voice service
		No data service
2G Wireless	CDMA(Code division multiple access) GSM(Global system for mobile) PDC (personal digital cellular)	Digital voice service 9.6k to 14.4K bits/sec
		CDMA, TDMA & PDC offered one way data transmission only.
		Enhance calling feature like caller ID
		No always-ON data connection
3 G Wireless	WCDMA (Wide-band Code Division Multiple Access) CDMA 2000(Based on the interim standard 95 CDMA Standard) TD-SDMA (Time Division-Synchronous Code Division Multiple Access)	Superior voice quality and data always add-on.
		Up to 2 Mbps always on data.
		Broadband data service like video and multimedia enhanced roaming.
		Circuit & packet switched network.
4 G Wireless	W-OFDM (Wavelength -Orthogonal Frequency Division Multiplexing.) MC-CDMA (Multiple Carrier Code Division Multiple Access)	Converged data and voice over IP.
		Entirely packed switched network
		All network elements are digital.
		Higher bandwidth to provide multimedia service at lower cost.

III MARKET OVERVIEW

Entering the 21st century, markets will require higher and higher bandwidth, as in the case of Internet in wireline modems. Wireless Internet will make wire line and wireless converge. New applications will demand higher bandwidth. In the future a data rate of up to 10-20Mbps will be needed for some applications like real-time streaming video. The mobile office concept will be one of drivers behind this bandwidth need. All major service providers and equipment vendors have accepted the evolution model. Beyond 3G WCDMA there is a phase called WCDMA/HSDPA (High Speed Downlink Packet Access) or 3.5G called first in this paper. HSDPA promises a date rate of up to lOMbps and higher spectrum efficiency.

IV NEED OF LEAP TOWARDS 4G

3G networks are in a very painful phase of their development, with early trials yielding disappointing results, costs ballooning, technical glitches, and network operators being forced to deflate expectations based on unrealistic hype. Despite the hype surrounding the higher-speed 3G mobile networks now under construction, the reasons for the leap towards 4G are:

i. **Performance:** Industry skeptics say that users will not be able to take advantage of rich multimedia content across wireless networks with 3G. 4G communications will feature extremely high-quality video equal to that of high definition television. In addition, it will enable wireless downloads at speeds exceeding 100 Mbps, about 260 times than 3G wireless network.

ii. **Interoperability:** There are multiple standards for 3G making it difficult to roam and interoperate across networks. We need a global standard that provides global mobility and service portability so that service provider would no longer be bound by single-system vendors of proprietary equipment.

iii. **Networking:**3G are based on primarily a wide-area concept. We need hybrid networks that utilize both wireless LAN (hot spot) concept and cell or base-station WAN design. With 4G, the world would have base stations everywhere, ensuring phone users' connection to a high-speed network anywhere, anytime.

iv. **Bandwidth:** We need wider bandwidth and higher bit rates. The 4G technology, with its transmission speeds of more than 20 mbps, would offer high-bandwidth services within the reach of LAN "hotspots," installed in offices, homes, coffee shops, and airport lounges. Away from these hotspots, customers could connect to souped-up 2G networks for voice and rudimentary data coverage.

v. **Technology:** Unlike 3G, 4G will more resemble a conglomeration of existing technologies rather than an entirely new standard. Analysts define 4G as a seamless combination of existing 2G wireless networks with local-area networks (LANs) or Bluetooth.

vi. **Convergence:** Convergence involves more than mere technology; it is a coming together of services and markets. We need all network that utilizes IP in its fullest form with converged voice and data capability, which the 4G will achieve.

vii. **Cost:** 4G systems will prove far cheaper than 3G, since they can be built atop existing network sand won't require operators to completely retool and won't require carriers to purchase costly extra spectrum. Also an open system IP wireless environment would probably further reduces costs for service providers by ushering in an era of real equipment interoperability.

viii. **Scalability:**Scalability, or the ability to handle increasing numbers of users and diversity of services, is more challenging with mobile networks. “Design for Scalability,” includes information that can help you meet changing usage demands. Because an all IP core layer of 4G is easily scalable, it is ideally suited to meet this challenge.

V THE 4G NETWORK THAT THE CELLHEADS DREAM ABOUT

4G can be imagined of as an integrated wireless system that enables seamless roaming between technologies. A user can be operating in cellular technology network and get handed over to a satellite-based network and back to a fixed wireless network, depending upon the network coverage and preference of charging.

5.1 The Goals

Open Mobile Alliance’s (OMA) main goal is to make sure different wireless services and devices work together, and across countries, operators, and mobile terminals. Other plans in the group's charter include:

i. Deliver open standards and specifications based on market and customer requirements.

ii. Establish "centers of excellence" for best practices..

iii. Create and promote a common industry view on an architectural framework.

iv. Help consolidate standards groups and work in conjunction with other existing standards organizations and groups.

5.2 The Composite Vision

i. 20 Mbps data rates

ii. Streaming Audio/Video

iii. Asymmetric Access

iv. Adaptive Modulation/Coding

v. Dynamic packet assignment

vi. Smart/Adaptive antennas supported

5.3 The working Principle

In 4G-style mobile IP, each cell phone is assigned a permanent "home" IP address, along with a "care-of" address that represents its actual location. When a computer somewhere on the Internet wants to communicate with the cell phone, it first sends a packet to the phone's home address. A directory server on the home network forwards this to the care-of address via a tunnel, as in regular mobile IP. However, the directory server also sends a message to the computer informing it of the correct care-of address, so future packets can be sent directly. This should enable TCP

sessions and HTTP downloads to be maintained as users move between different types of networks. Because of the many addresses and the multiple layers of sub netting, IPv6 is needed for this type of mobility.

VI DEVELOPMENTS IN 4G

We have described an evolutionary path from the 3G standards to what can be called a 3.5G system. UTRA TDD mode as standardized by 3GPP in Release 5 is capable of providing 10.2 Mb/s in 12 downlink time slots at 3.84 Mchips/s. Moreover, more than 20 Mb/s is possible with a 7.68 Mchips/s chip rate, which is delivered in a 10 MHz bandwidth. A corresponding increase in bandwidth can increase the throughput by a respective factor. The following MC transmission technologies have been proposed for 4G systems. One is the DS-MC-CDMA as a simple extension of the present CDMA techniques, in which each sub-band operates as an independent direct sequence (DS) CDMA system. Two other methods use orthogonal frequency-division multiplexing (OFDM) and achieve a near doubling of system capacity. These are MC-OFDM and MC-OFCDM. Since (we expect) these techniques are well discussed in another article of this issue, we only discuss the usefulness of the TDD mode of operation to these 4G technologies. It will be very likely that the downlink transmission will follow some form of OFDM, as this is capable of improving capacity. However, uplink will likely be an MC system without an OFDM component as lack of synchronous multiuser transmission in the uplink makes such implementation difficult. We refer to these as dissimilar uplink/downlink systems. These systems are highly likely to use TDD as their mode of duplex transmission. The same characteristics that make TDD a leading contender for 3.5G systems are expected to be important reasons for making TDD a significant part of the 4G standards. These are flexible allocation of capacity in up and downlink, as well as frequency utilization efficiency in continuous bands, where 4G systems are most likely to be located.

VII TECHNOLOGIES THAT SUPPORT 4G

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

7.1 The Transmission Protocols

i. **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.

ii. **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.

iii. **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.

iv. **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.

7.2 The Radio Interface-UWB Radio

To make 4G really work carries will need to migrate to Ultra Wideband (UWB) technology.UWB radio [15] will deliver essential new wireless and wired bandwidth inexpensively, without using precious and scarce radio frequencies. Instead, digital video, voice and data are enabled using modulated pulses of energy that peacefully co-exist alongside traditional communications. UWB radio solves the multipath fading issues and is 1,000% more process efficient than CDMA.

7.3 The Network-LMDS

Local multipoint distribution system (LMDS) is the broadband wireless technology used to deliver voice, data, Internet, and video services in the 25-GHz and higher spectrum (depending on licensing). Figure 4 shows the LMDS system [16].The acronym [16] LMDS is derived from the following:

***L* (local)** denotes that propagation characteristics of signals in this frequency range limit the potential coverage area of a single cell site;

M (multipoint) indicates that signals are transmitted in a point-to-multipoint or broadcast method;

***D* (distribution)** refers to the distribution of signals, which may consist of simultaneous voice, data, Internet, and video traffic

***S* (service)** implies the subscriber nature of the relationship between the operator and the customer

VIII HSDPA

HSDPA increases peak rate to an individual user and cell throughput. Peak rates of 5 Mb/s or higher are feasible with HSDPA. The three principal techniques employed in HSDPA are adaptive modulation and coding, hybrid automatic repeat request (HARQ), and fast scheduling. All these techniques can benefit

from channel reciprocity and adaptive communications provided by the TDD mode. A channel quality indication of the uplink is used in adaptive modulation and coding (AMC). The channel quality indication allows the BS to optimize resource usage by varying the coding rate and modulation applied for transmissions to a user. The channel coding applied to HSDPA is based on 1/3 rate turbo coding. The BS can vary the modulation and the channel coding by rate matching (puncturing or repetition). The goal of adaptive coding and modulation is to choose a coding rate and modulation just sufficient to achieve the target block error rate at the user equipment. HARQ within HSDPA supports combining and incremental redundancy. By combining retransmissions with previous transmissions, retransmissions can use less physical resources (e.g., more puncturing may be applied in the rate matcher) than if retransmissions had to be self-decodable. Support of parallel HARQ processes enables high throughput to be maintained with realistic system latencies. WCDMA HSDPA provides unprecedented speed and mobility:

i. IP-based network, optimized for packet data;
ii. Complementary to existing and future voice networks;
iii. Enabling wireless web lifestyle;
iv. Next generation performance.

8.1 Physical Layer Structure of HSDPA

There are two alternatives to HS-DSCH mapping to physical channels (codes). First, physical channels to which HS-DSCH is mapped are shared between “users” in the time domain (“time multiplex”) as well as in the code domain (“code multiplex”). Physical channels to which HS-DSCH is used may have different spreading factors (as in Release- 99). The physical channels to which HS-DSCH is mapped has a fixed spreading factor. Second, physical channels to which HS-DSCH is mapped can still be shared between “users” in the time domain as well as in the code domain

8.2 HSDPA TTI shorter than one radio frame (10ms)

Another concept is shorter TTI. Shorter TT should be selected from the set {Tslot, 3‘Tslot, 5‘Tslot). Depending on the typical payload size, signaling load with shorter TTI, e.g. TTI=lslot, may be too high. No power margin necessary when scheduling data users in an integrated voice and data system with TTI of 1 slot. There are three approaches for TTI in HSDPA: fixed and semi-static TTI (inline with Release-99) as well as dynamic TTI.

8.3 Basic Principles for Signaling for HSDPA

For Downlink Signaling, We can use a two Stage Approach. This approach conserves code resource and interference and Quality of Service can be maintained independently of the HS-DSCH. It is also robust to undetected errors. The basic concept is as follows. First, UE is notified of the assignment status of the HS-DSCH

and the shared associated control channel attributes through an indicator on the associated DPCH. Second, the associated shared control channel conveys for e.g. MCS, Hybrid ARQ states, HS-DSCH gain in case of 16/64QAM and code allocations to the **UE** for proper demodulation of the data. Finally, the timing structure of the indicator on the associated DPCH and the shared control channel should match the TTI of the HS-DSCH. Uplink signaling is used to convey measurement report and signaling related to HARQ. In the system design, timing structure should match the TTI of the HS-DSCH. Also channel should be designed to reduce the miss probability and to increase the detection probability.

IX POTENTIAL APPLICATIONS OF 4G

i. **Virtual Presence:** 4G system gives mobile users a "virtual presence" -- for example, always-on connections that keep people involved in business activities regardless of whether they are on-site or off.

ii. **Virtual navigation:** A remote database contains the graphical representation of streets, buildings, and physical characteristics of a large metropolis. Blocks of this database are transmitted in rapid sequence to a vehicle, where a rendering program permits the occupants to visualize the environment ahead.

iii. **Tele-medicine:** 4G will support remote health monitoring of patients. For e.g. the paramedic assisting the victim of traffic accident in a remote location must access medical records and may need videoconference assistance from a surgeon for an emergency intervention. The paramedic may need to relay back to the hospital the victim's x-rays taken locally.

iv. **Tele-reprocessing applications:** The combination of geographical information systems (GIS), global positioning systems (GPS), and high-capacity wireless mobile systems will enable a new type of application referred to as tele-reprocessing. Queries dependent on location information of several users, in addition to temporal aspects have many applications.

v. **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 in hours instead of days or even weeks required for restoration of wire line communications.

vi. **Education:** Educational opportunities available on the internet, for individuals interested in life-long education, will be unavailable to client in remote areas because of the economic unfeasibility of providing wideband wire line internet access. 4G wireless communications provides a cost-effective alternative in these situations.

X ROLE OF THE WIRELESS INDUSTRY RECOMMENDATIONS

i. We are bringing to the attention of professionals following issues and problems that must be analyzed and resolved:

ii. **Standardization**: Standardization of wireless networks in terms of modulation techniques, switching schemes and roaming is an absolute necessity for 4G. We must pay more attention to general meaning advanced technologies.

iii. **Lower Price Points Only Slightly Higher than Alternatives:** The business visionaries should do some economic modeling before they start 4G hype. They should understand that 4G data applications like streaming video must compete with very low cost wireline applications.

iv. **More Coordination Among Spectrum Regulators Around the World:** We must demand almost free spectrum NOT necessarily unlicensed Spectrum regulation bodies must get involved in guiding the researchers by indicating which frequency band might be used for 4G.

v. **Regulatory frameworks:** Policy and Regulatory Environment which Provides Transparency, Certainty and a Level Playing Field are necessary. The most important thing is that we should recognize that regulatory framework is as much an evolving matter as technology, and be prepared to meet changes with an open-minded and pragmatic attitude, always keeping the interests of the industry and consumers in mind.

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

vii. **Voice-independent Business Justification Thinking:** Business 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.

viii. **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.

ix. **Non-disruptive Implementation:** Upgrading from 3G to 4G is expected to be seamless to end-users with no device upgrades required.

XI CONCLUSION

4G should make a significant difference and add perceived benefit to an ordinary person's life over 3G. We should drop the 2.5G, 3G, 4G speak altogether where an additional "G" means merely an increase in capacity. What really means something for the users are new services, integration of services, applications etc. Our goal is to struggle to get a "G"eneration of standards so that we can take our phone anywhere in the world and access any service or

communicate with any other user any way we want that will offer connectivity so inexpensively. In short, 4G or WWWW (World Wide Wireless web) should be a more intelligent technology that interconnects the entire world without limits.

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