An Overview of 4G Technology

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Abstract -- This is a research paper on Mobile communication play a vital role in the data and voice network front. This paper addresses the fourth generation mobile communication. The Fourth Generation (4G) Mobile Communication not only emphasizes on increase in data rate and new interfaces but it also converse the advanced wireless mobile communication. 4G mobile would deliver the best business to the wireless market and Asia-Pacific which happens to be the most dynamic market of new generation mobile communication with over $100 Billion businesses in the next decade. The 4G mobile technology is the intersection and convergence of wireless mobile and wireless access around the globe. Any single architecture wireless system, including 3G, HSDPA, WIMAX etc., is a transitional solution only, and will be replaced by open wireless architecture system very soon where in various different wireless standards can be integrated and converged on open platform. The advent of 4Gwireless systems has created many research opportunities. The expectations from 4G are high in terms of data rates, spectral efficiency, mobility and integration.

Indexed Terms -OFDMA, WiMAX, LTE, HSDPA

I. INTRODUCTION

4G is short for Fourth (4th) Generation Technology.4G Technology is basically the extension in the 3G technology with more bandwidth and services offers in the 3G. But at this time nobody exactly knows the true 4G definition. Some people say that 4G technology is the future technologies that are mostly in their maturity period. The expectation for the 4G technology is basically the high quality audio/video streaming over end to end Internet Protocol. If the Internet Protocol (IP) multimedia sub-system movement achieves what it going to do, nothing of this possibly will matter. WiMAX or mobile structural design will become progressively more translucent, and therefore the acceptance of several architectures by a particular network operator ever more common. The main features of 4G services of interest to users are application adaptability and high dynamism user's traffic, radio environment, air interfaces, and quality of service.

II. APPLICATIONS OF 4G

Fourth generation (4G) technology will offer many advancements to the wireless market, including downlink data rates well over 100 megabits per second (Mbps), low latency, very efficient spectrum use and low-cost implementations. With impressive network capabilities, 4G enhancements promise to bring the wireless experience to an entirely new level with impressive user applications, such as sophisticated graphical user interfaces, high-end gaming, high-definition video and high-performance Ad hoc and multi hop networks (the strict delay requirements of voice make multi hop network.

- 4G Ultra high speed internet access - E-mail or general web browsing is available.
- 4G Data intensive interactive user services - Services such as online satellite mapping will load instantly.
- 4G Multiple User Video conferencing - subscribers can see as well as talk to more than one person.
- 4G Location-based services - a provider sends wide spread, real time weather or traffic conditions to the computer or phone, or allows the subscriber to find and view nearby businesses or friends whilst communicating with them.
- 4G HDTV - a provider redirects a high definition TV channel directly to the subscriber where it can be watched.
- 4G High Definition Video on demand - a provider sends a movie to the subscriber.
- 4G Video games on demand - a provider sends game data directly to the subscriber where they can play in real time.
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III. WiMAX Network

WiMAX (Worldwide Interoperability for Microwave Access) is a family of wireless communication standards based on the IEEE 802.16 set of standards, which provide multiple physical layer (PHY) and Media Access Control (MAC) options.

The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard, including the definition of predefined system profiles for commercial vendors. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". IEEE 802.16m or WirelessMAN-Advanced was a candidate for the 4G, in competition with the LTE Advanced standard.

WiMAX was initially designed to provide 30 to 40 megabit-per-second data rates,with the 2011 update providing up to 1 Gbit/s for fixed stations.

WiMax Standards

WiMAX is based upon IEEE Std 802.16e-2005, approved in December 2005. It is a supplement to the IEEE Std 802.16-2004, and so the actual standard is 802.16-2004 as amended by 802.16e-2005. Thus, these specifications need to be considered together.

IEEE 802.16e-2005 improves upon IEEE 802.16-2004 by:

- Adding support for mobility (soft and hard handover between base stations). This is seen as one of the most important aspects of 802.16e-2005, and is the very basis of Mobile WiMAX.
- Scaling of the fast Fourier transform (FFT) to the channel bandwidth in order to keep the carrier spacing constant across different channel bandwidths (typically 1.25 MHz, 5 MHz, 10 MHz or 20 MHz). Implementations. Carrier spacing is 10.94 kHz.
- Advanced antenna diversity schemes, and hybrid automatic repeat-request (HARQ)
- Adaptive antenna systems (AAS) and MIMO technology
- Denser sub-channelization, thereby improving indoor penetration
- Intro and low-density parity check (LDPC)
- Introducing downlink sub-channelization, allowing administrators to trade coverage for capacity or vice versa
- Adding an extra quality of service (QoS) class for VoIP applications.

Efficiency

- One of the significant advantages of advanced wireless systems such as WiMAX is spectral efficiency. For example, 802.16-2004 (fixed) has a spectral efficiency of 3.7 (bit/s)/Hertz, and other 3.5–4G wireless systems offer spectral efficiencies that are similar to within a few tenths of a percent.
- Another advantages of WiMAX, is a relatively new technology that enables communication over a maximum distance of 30 miles – compared to 300 feet for WiFi. Of course, the longer the distance, the slower the speed, but it is still faster and has a longer range than WiFi. Ideally, speeds of around 10 MBps could be achieved with a range of 1 – 6 miles (1.6 – 9.7 km).

Limitations

WiMAX cannot deliver 70 Mbit/s over 50 km (31 mi). Like all wireless technologies, WiMAX can operate at higher bitrates or over longer distances but not both. Operating at the maximum range of 50 km (31 mi) increases bit error rate and thus results in a much lower bitrate.

IV. LTE

LTE (Long Term Evolution) is a registered trademark owned by ETSI (European Telecommunications Standards Institute) for the wireless data communications technology and a development of the GSM/UMTS standards. However, other nations and companies do play an active role in the LTE project. The goal of LTE was to increase the capacity and speed of wireless data networks using new DSP(digital signal processing) techniques and modulations that were developed around the turn of the millennium.

LTE Standards

LTE is commonly marketed as 4G LTE, but it does not meet the technical criteria of a 4Gwireless service. According to ITU (International Telecommunications Union)

- Downlink peak rates of 300 Mbit/s, uplink peak rates of 75 Mbit/s and QoS provisions permitting a transfer latency of less than 5 ms in the radio access network
- Ability to manage fast-moving mobiles and supports multi-cast and broadcast streams.
- LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time-division duplexing (TDD).

Features of LTE

- Peak download rates up to 299.6 Mbit/s and upload rates up to 75.4 Mbit/s depending on the user equipment category
- Low data transfer latencies (sub-5 ms latency for small IP packets in optimal conditions), lower latencies for handover and connection setup time than with previous radio access technologies.
- Improved support for mobility, exemplified by support for terminals moving at up to 350 km/h (220 mph) or 500 km/h (310 mph) depending on the frequency band.
- Orthogonal frequency-division multiple access for the downlink, Single-carrier FDMA for the uplink to conserve power.
- Support for both FDD and TDD communication systems as well as half-duplex FDD with the same radio access technology.
- Support for all frequency bands currently used by IMT systems by ITU-R.
- Increased spectrum flexibility: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz wide cells are standardized.
- Packet switched radio interface.

V. OFDMA

Orthogonal frequency-division multiple access (OFDMA) has been recently recognized as an excellent multiple access technique for the next generation of downlink receivers. A multi-carrier transmission technique for high speed bi-directional wireless data communication. All the proposals which have been considered for the fourth generation (4G) wireless technologies has adopted orthogonal frequency division multiple access.

Advantages

- Allows simultaneous low-data-rate transmission from several users.
- Pulsed carrier can be avoided.
- Lower maximal transmission power for low-data-rate users.
- Shorter delay and constant delay.
- Further improves OFDM robustness to fading and interference.
- Combat narrow-band interference.
- Flexibility of deployment across various frequency bands with little needed modification to the air interface. .
- Enables single-frequency network coverage, where coverage problem exists and gives excellent coverage.
- Offers frequency diversity by spreading the carriers all over the used spectrum.

Disadvantages

- Asynchronous data communication services such as web access are characterized by short communication bursts at high data rate. Few users in a base station cell are transferring data simultaneously at low constant data rate.
- The complex OFDM electronics, including the FFT algorithm and forward error correction, are constantly active independent of the data rate, which is inefficient from power-consumption point of view.
- Dealing with co-channel interference from nearby cells is more complex in OFDM than in CDMA. It would require dynamic channel allocation with advanced coordination among adjacent base stations.

- The fast channel feedback information and adaptive sub-carrier assignment is more complex than CDMA fast power control.

VI. CHALLENGES OF 4G

Multimode devices

One configuration uses a single physical terminal with multiple interfaces to access services on different wireless networks. Early examples of this architecture include the existing Advanced Mobile Phone System/Code Division Multiple Access dual-function cell phone, Iridium's dual function satellite-cell phone, and the emerging Global System for Mobile telecommunications/Digital Enhanced Cordless Terminal dual-mode cordless phone. The multimode device architecture may improve call completion and expand effective coverage area. It should also provide reliable wireless coverage in case of network, link, or switch failure. The user, device, or network can initiate handoff between networks. The device itself incorporates most of the additional complexity without requiring wireless network modification or employing interworking devices. Each network can deploy a database that keeps track of user location, device capabilities, network conditions, and user preferences. The handling of quality-of-service (QoS) issues remains an open research question.

Overlay network

In this architecture, a user accesses an overlay network consisting of several universal access points. These UAPs in turn select a wireless network based on availability, QoS specifications, and user defined choices. A UAP performs protocol and frequency translation, content adaptation, and QoS negotiation-renegotiation on behalf of users. The overlay Issues in network, rather than the user or device, performs handoffs as the user moves from one UAP to another. A UAP stores user, network, and device information, capabilities, and preferences. Because UAPs can keep track of the various resources a caller uses, this architecture supports single billing and subscription.

Common access protocol

This protocol becomes viable if wireless networks can support one or two standard access protocols. One possible solution, which will require interworking between different networks, uses wireless asynchronous transfer mode. To implement wireless ATM, every wireless network must allow transmission of ATM cells with additional headers or wireless ATM cells requiring changes in the wireless networks. One or more types of satellite-based networks might use one protocol while one or more terrestrial wireless networks use another protocol.

VII. QUALITY OF SERVICE

Supporting QoS in 4G networks will be a major challenge due to varying bit rates, channel characteristics, bandwidth allocation, fault-tolerance levels, and handoff support among heterogeneous wireless networks. QoS support can occur at the packet, transaction, circuit, user, and network levels.

• Packet-level QoS applies to jitter, throughput, and error rate. Network resources such as buffer space and access protocol are likely influences.

• Transaction-level QoS describes both the time it takes to complete a transaction and the packet loss rate. Certain transactions may be time sensitive, while others cannot tolerate any packet loss.

• Circuit-level QoS includes call blocking for new as well as existing calls. It depends primarily on a network's ability to establish and maintain the end-to-end circuit. Call routing and location management are two important circuit-level attributes.

• User-level QoS depends on user mobility and application type. The new location may not support the minimum QoS needed, even with adaptive applications. In a complete wireless solution, the end-to-end communication between two users will likely involve multiple wireless networks. Because QoS will vary across different networks, the QoS for such users will likely be the minimum level these networks support.

End-to-End QoS

Developers need to do much more work to address end-to-end QoS. They may need to modify many existing QoS schemes, including admission control,dynamic resource reservation, and QoS renegotiation to support 4G users' diverse QoS requirements. The overhead of implementing these QoS schemes at different levels requires careful evaluation. A wireless network could make its current QoS information available to all other wireless networks in either a distributed or centralized fashion so they can effectively use the available network resources. Additionally, deploying a global QoS scheme may support the diverse requirements of users with different mobility patterns. The effect of implementing a single QoS scheme across the networks instead of relying on each network's QoS scheme requires study.

Handoff delay

Handoff delay poses another important QoS-related issue in 4G wireless networks. Although likely to be smaller in intranet work handoffs, the delay can be problematic in internetwork handoffs because of authentication procedures that require message exchange, multiple-database accesses, and negotiation-renegotiation due to a significant difference between needed and available QoS. During the handoff process, the user may experience a significant drop in QoS that will affect the performance of both upper-layer protocols and applications. Deploying a priority-based algorithm and using location-aware adaptive applications can reduce both handoff delay and QoS variability. When there is a potential for considerable variation between senders' and receivers' device capabilities, deploying a receiver-specific filter in part of the network close to the source can effectively reduce the amount of traffic and processing, perhaps satisfying other users' QoS needs. Although 4G wireless technology offers higher bit rates and the ability to roam across multiple heterogeneous wireless networks, several issues require further research and development. It is not clear if existing 1G and 2G providers would upgrade to 3G or wait for it to evolve into 4G, completely bypassing 3G. The answer probably lies in the perceived demand for 3G and the ongoing improvement in 2G networks to meet user demands until 4G arrives.

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