Beyond 3G: 4G Mobile Communication

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Abstract- Based on the study, 4G mobile technologies is in a determining and Standardization stage. Since 4G is still in the cloud of the sensible standards creation, ITU and IEEE form several task forces to work on the possible completion for the 4G mobile standards as well. 3GPP LTE is an Evolution standard from UMTS, and WiMAX is another candidate from IEEE. These technologies have different characteristics and try to meet 4G characteristics to become a leading technology in the future market. Under these circumstances, this paper will present about the current trends and its underlying technologies to implement the 4G mobile technology. This paper also shows some of the possible scenarios that will benefit the 4th generation technology.

I. INTRODUCTION

1.1 EVOLUTIONARY STEPS/PATH

The evolution of mobile service from the 1G (first generation) to fourth generation began as follows:

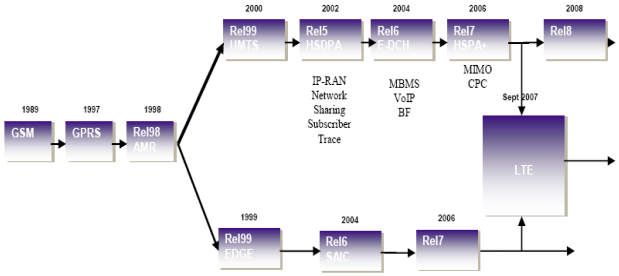
1G: This process began with the designs in the 1970s that have become known as 1G. The earliest systems were implemented based on analog technology and the basic cellular structure of mobile communication. Many fundamental problems were solved by these early systems. Numerous incompatible analog systems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

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.

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. Under the name International Mobile Communications – 2000 (IMT-2000). The IMT-2000 family is composed of five systems: (1) Wideband Code Division Multiple Access (W-CDMA) including TDD and FDD modes, (2) CDMA 2000 1X, (3) Time Division – Synchronous Code Division Multiple Access (TD- SCDMA) (4) EDGE (also called UWC-136) and (5) Digital Enhanced Cordless Telecommunications (DECT). At the end of the selection phase for IMT-2000, two main families of systems have emerged, leading to the creation of two groups of standardization (including operators and manufacturers), namely: (1) 3rd Generation Partnership Project (3GPP), which developed the W-CDMA standard also called Universal Mobile Telecommunication System (UMTS) in FDD and TDD modes, and (2) 3GPP2, which developed the CDMA 2000 standards as an evolution of the IS-95 standards. The terrestrial radio interface of UMTS, called Universal Terrestrial Radio Access Network (UTRAN) has been developed through a series of releases, downlink data rate of 14.4 Mb/s –High Speed Downlink Packet Access (HSDPA).The ITU did set guidelines for "3G systems" in the IMT-2000 framework to support data rate 144 kb/s for high mobility and 2 Mb/s in a fixed location.



3GPP UMTS Evolution Plan

The single biggest disadvantage to cellular networks going forward is that as data rates increase, output power will have to increase, or the size of the cells will have to decrease to support those higher data rates. Since significant increases in output power scare both consumers and regulators, it is far more likely that we will see significantly smaller cells.

4G-Fourth generation (4G) wireless was originally conceived by the Defense Advanced Research Projects Agency (DARPA), the same organization that developed the wired Internet. It is not surprising, then, that DARPA chose the same distributed architecture for the wireless Internet that had proven so successful in the wired Internet. Although experts and policymakers have yet to agree on all the aspects of 4G wireless, two characteristics have emerged as all but certain components of 4G end-to-end Internet Protocol (IP), and peer-to-peer networking.

Sensor on every government-owned vehicle instantly creates a mobile fleet that is the equivalent of an army of highly trained dogs. As these vehicles go about their daily duties of law enforcement, garbage collection, sewage and water maintenance, etc., municipalities get the added benefit of early detection of CBN agents. The sensors on the vehicles can talk to fixed devices mounted on light poles throughout the area, so positive detection can be reported in real time. And since 4G networks can include inherent geo-location without GPS, first responders will know where the vehicle is when it detects a CBN agent.

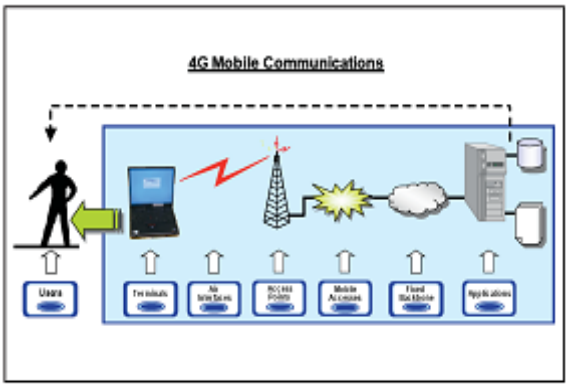
Cameras in Traffic Lights Some major cities have deployed cameras on traffic lights and send those images back to a central command center. This is generally done using fiber, which limits where the cameras can be hung, i.e., no fiber, no camera. 4G networks allow cities to deploy cameras and backhaul them wirelessly. And instead of having to backhaul every camera, cities can backhaul every third or fifth or tenth camera, using the other cameras as router/repeaters. These cameras can also serve as fixed infrastructure devices to support the mobile sensor application described above.

First Responder Route Selection Using fiber to backhaul cameras means that the intelligence collected flows one way: from the camera to the command center. Using a 4G network, those images can also be sent from the command center back out to the streets. Ambulances and fire trucks facing congestion can query various cameras to choose an alternate route. Police, stuck in traffic on major thoroughfares, can look ahead and make a decision as to whether it would be faster to stay on the main roads or exit to the side roads.

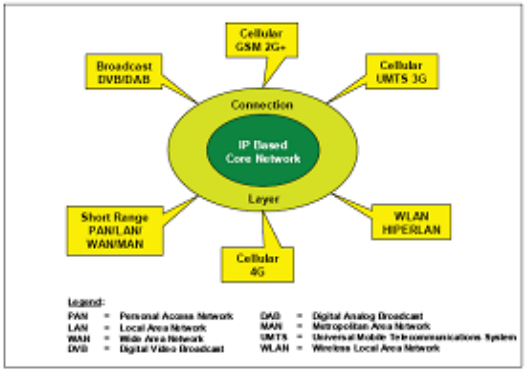
Traffic Control During Disasters If a hurricane hits the Gulf Coast of Florida and cars start driving east, 4G networks can allow officials to access traffic control boxes to change inland traffic lanes to green. Instead of having

to send officers to every box on roads being overwhelmed by civilians who are evacuating, it can all be done remotely, and dynamically. In a September 11 type environment, lights could also be forced to red to prevent civilians from driving into harm's way.

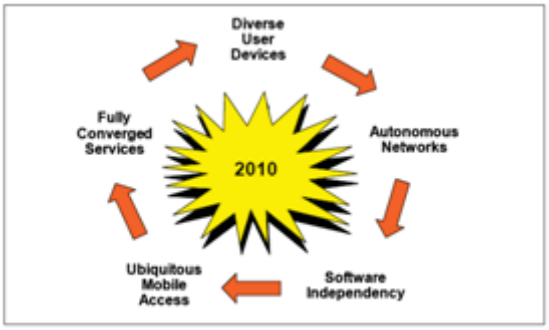
Where am I? Where are My Colleagues? If every emergency response vehicle in a city is equipped with a 4G transceiver, the command center then knows where all potential first responders are during an emergency, as do the individual officers. While GPS would allow management to know where the vehicles are, 4G networks allows them to see where the individuals are even when they have had to leave their vehicles.



4G Visions (Ref. 1)



Seamless Connections of Networks (Ref. 2)



. Key Elements of 4G Vision (Ref. 3)

II. BROADBAND SERVICES

It naturally calls media convergence aspect, based on packet transport, advocating the integration of various media on different qualities. The increasing position of broadband services like Asymmetric Digital Subscriber Line (ADSL) and optical fiber access systems and office or home LANs is expected to lead to a demand for similar services in the mobile communication environment. 4G service application characteristics will give broadband service its advantages;

1) Low cost

To make broadband services available to the user to exchange various kinds of information, it is necessary to lower charges considerably in order to keep the

Cost at or below the cost of existing service.

2) Coverage of Wide Area

One feature of mobile communications is that it's availability and omnipresent. That advantage is important for future mobile communication as well.

3) **Wide Variety of Services Capability** Mobile communication is for various types of users. Functionality to

introduce a variety of services not only the ordinary telephone service. Those services must be made easier for anyone to use.

III. CANDIDATE SERVICES BEYOND 3G

3GPP LTE

Third Generation Partnership Programme – Long Term Evolution is the name given to a project develops the Universal Mobile Telecommunications System (UMTS) mobile phone standard to cope and manage with future requirements in terms of wireless technology. Objectives include improving efficiency, lowering costs, improving services, making use of new spectrum opportunities, and better integration with other open standards. Since the project is currently in progress, it has put itself some specific goals, much of which is leaning around upgrading UMTS to a technology name fourth generation mobile communications technology. The aim of the project comprises of:

1- Download rates of 100Mbps, and upload rates of 50Mbps for every 20MHz of spectrum Sub-5ms latency for small IP packets.

2- Increased spectrum flexibility, with spectrum slices as small as 1.6MHz.

3- Coexistence with legacy standards (users can transparently start a call or transfer of data in an area using an LTE standard, and, should coverage be unavailable, continue the operation without any action on their part using GSM/GPRS or W-CDMA-based UMTS) 3GPP LTE is planned as a development to existing 3GPP standards.

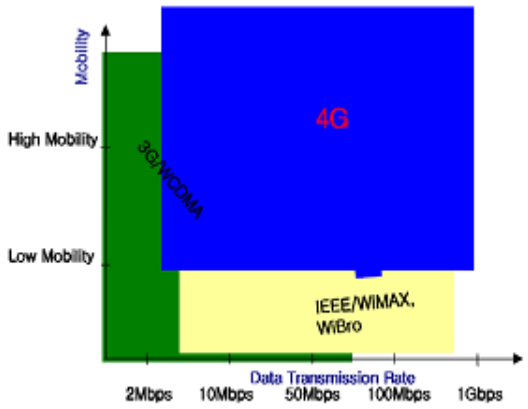
IV. WIMAX AND WIBRO

WiMAX is Worldwide Interoperability for Microwave Access and this technology is a standard created by IEEE to form the IEEE 802.16 standard Based pm this standard, WiBro is the service name for Mobile WiMAX in Korea. WiBro uses the Mobile WiMAX System Profile. The system profile contains a comprehensive list of features that the equipment is required or allowed to support As a result, WiBro offers the same capabilities and features of Mobile WiMAX. It describes this technology as an alternative to cable and DSL and a standards-based technology enabling and allowing the delivery of last mile wireless broadband access. The aim of the project comprises of: Peak downlink sector data rates up to 46 Mbps, assuming a DL/UL ratio of 3:1, and peak uplink sector data rates up to 14 Mbps, assuming a DL/UL ratio of 1:1, in a 10 MHz channel.

WiMAX has a two stage evolution steps. First, the expansion of the overall fixed wireless market will not going to happen as a result of WiMAX technology, slow migration of purchasing behavior from proprietary equipment to WiMAX equipment. In adopting and implementing WiMAX equipment, service providers will be skeptical pending and until prices drop to the point where service providers cannot manage to pay to disregard WiMAX. Currently, users will see the beginning of the 2nd stage of WiMAX, which is the dawn of metro area portability. Since 802.16e or the so called Broadband Wireless Access Standards was approved already,

V. IEEE 802.20

The IEEE 802.20 or so-called Mobile Broadband Wireless Access (MBWA) specification is also the first IEEE standard that explicitly addresses the needs of mobile clients in moving vehicles. The design parameters of the specification include support for vehicular mobility up to 250 Km per hour. This criterion will support use in fleet cars and trucks, as well as in the high-speed commuter trains in use throughout much of the world. Whereas 802.16e's roaming support is generally limited to local and regional areas, 802.20 shares with 3G the ability to 802.20 supports QoS to give good quality for low-latency services, unlike 3G cellular data service, which is an inherently high-latency architecture. Both 802.16e and 802.20 also share synchronous efficiency between uplinks and downlinks, as opposed to the asynchronous nature of 3G cellular networks, which have lower-efficiency uplinks, relative to their downlinks.



OPTIONS OF EVOLUTION PATH TOWARD 4G

SCENARIO OPTIONS

SCENARIO 1

The first scenario is that current 3G service is evolved into 3GPP LTE (long term evolution) which is one of the candidate technologies for 4G. Under the 3GPP LTE, 4G technology will be used basically in 3G spectrum and platform that means existing carriers maintain present customer base and services are integrated 4G. To support broadband service there will be an additional spectrum band with current 3G spectrum band. 3GPP LTE plan to support All-IP based backbone network to connect with other heterogeneous networks seamlessly. In this scenario, 3G incumbent service providers will maintain current subscribers and 3G

Scenario1: Existing service providers maintain current subscribers and services are integrated 4G (3GPP LTE)	**Scenario2:** New service providers control subscriber connections toward 4G (WiMAX, WiBro)
Scenario3: Co-existence and mutual prosperity of existing service providers (3GPP LTE & WiMAX, WiBro)	**Scenario4:** Absence of service providers capable of service integration (Spread of open transmission)

Services will be integrated to 4G. On the other hand, WiMAX and other services will not have a market power but they will be a complement service to 3GPP LTE.

SCENARIO 2

The second scenario is that fixed wireless, led by IEEE, enhances techniques to support mobility and fulfill 4G characteristics. Especially, mobile WiMAX (IEEE 802.16e) technology, WiBro in Korea, is very close to 4G technology which includes OFDM and MIMO. Moreover, there will be a possibility that IEEE 802.20 technology support high mobility to compensate low mobility of WiMAX. In this scenario incumbent service providers based on 3G get smaller market power and there will be a chance for new service providers which control current subscriber connections. In this scenario, a competition structure in the market will be shifted and changed.

SCENARIO 3

The third scenario is that both 3G LTE and WiMAX exist. They are in a complementary relationship with each other. Subscribers would possess both 3GPP LTE and WiMAX terminals, and they will adapt to use either of them according to the usage scene and needs. By the SDR (software defined radio) technology, subscribers will get flexibility between different services. Additionally, there could be s new mobile access service as well in a new spectrum band. Current minor service provider will try to adopt this new radio access technology to get future market power, and also new service providers will appear to enter the market. In this scenario, a number of different service providers will compete for the leadership break out upon introduction of 4G.

SCENARIO 4

The last scenario is that subscribers switch over to cost-free transmission services, due to the fact that 3G LTE and WiMAX do not successfully deployed with high cost and dissatisfied service. Arrival of wireless IP phones utilizing high quality VoIP through various networks would enable free transmission services to absorb the need of both voice calls and multimedia service so that handheld makers will get much power than service providers based on the Software defined Radio (SDR) technology.

SCENARIO ANALYSIS

For the purpose of understanding of each scenario's impact on the wireless communication industry, we analyze each scenario based on feasibilities about technology and expected time plan. In addition that we examine the question as to whether each scenario fulfills 4G characteristics which are expected previous research and market situation.

CONCLUSION

As we come up with the 3G analysis out of this 4G technology, it is inevitable that 4G would completely replace 3G in a long run. Nevertheless, 4G and 3G tend to keep a co-competitive relationship in a short run. In order for 4G to grow in the future market, it is unavoidable to compete with 3G and acquire 3G's customers.

As it was also analyzed and investigated through the scenarios, the comparison was made here that among three candidates for the 4G presented. Every service providers and manufacturers strategize towards high mobility and high data rates whether it is 3GPP, WiMAX or even WiBro oriented.

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