4G, Solution for Convergence?

Jinsung Choi

LG Electronics Inc., 533 Hogyedong Donganku Anyangci, 431-080, Rep. of Korea

Abstract **— 4G issue has been addressed since 3G disappointed the investor and users and has been getting a lot of attention from both academia society and industry sector as an ultimate solution for ubiquitous mobile broadband service. However, at the same time, 4G has been criticized as a yet another hype by media. In this paper, the 4G definition and its key requirements are discussed and see how it can provide new values and tools to the players in mobile communication ecosystem.**

Index Terms **— 4G, Mobile Communication, Mobile Broadband Convergence, Spectrum.**

I. Introduction

The internet revolution using Internet infrastructure together with xDSL access network and WiFi has created a huge demand for broadband access across the world, and as a result users started to look for similar types of broadband services on the road using their laptop, PDA and even smart phone. Operators of 3G mobile systems can introduce a range of competitive broadband internet access services to address this fast growing demand by drawing on existing assets and end-to-end mobile broadband offering. However, due to the limitations of 3G and its evolution, the quality of service and its prices cannot compete with those of wireline Internet service. In other words, despite the indication of huge growth in 3G during the past few years, mobile operators have been unable to attract a competitive share of the market, mainly because of relative low bit rates like 384Kbps and high costs of providing the required capacity. A number of technical limitations in currently deployed 3G networks restricted capacity and pushed up costs. Thus, some mobile operators have thus focused their attention on a variety of new mobile broadband technology such as WiMAX and 4G whereby mobile operators can provide a variety of high speed data services that in turn generate high data revenue per megabyte of traffic.

In future mobile communication networks, there are four different types of access networks, namely, Wide Area Cellular, WLAN, WMAN, and WPAN. Wireless Access Network is gradually becoming diversified. Generally, people predict convergence as a mega trend in IT industry, but in reality, it is both convergence and divergence. The reason being that the convergence, from the device standpoint, it is a convergence because everything goes inside the device. Not only are MP3 and camera functions embedded inside the cellular phone, but in the near future, phone, portable media player(PMP) will have handset capability and newly emerging mobile broadband such as WiMax functions as well. From the device standpoint, the fact the various functions are embedded in one machine suggests convergence and from another perspective, its services, that is, broadcasting, telecommunication and Internet are provided in one platform, suggesting another form of convergence.

In reality, excluding terminal and end-to-end service delivery and signaling layer, divergence is occurring in low layers in the networks, mostly in the access networks. Although the trend indicates convergence through All-IP based heterogeneous networks that have personal, mobile, broadband, and ubiquitous characteristics, and that is evolving into IP network, converged network, in reality, it is actually showing divergence as well. For example, in case of PAN, technology such as RFID, Bluetooth, and UWB are making appearances and for Wide Area side, various cellular technologies are widely available. Intermediate technologies such as WLAN or WMAN is playing a critical role in filling up the gap and gradually, especially in the case of newly developed mobile broadband technology such as WiMax, it is overlapping with, in narrow range, with WPAN, and for broader range, with Wide area cellular. We can say that convergence trend that supports various functions in one device and divergence trend from network side that is evolving into various access networks, it has resulted in the development of multimode handset that can support various access network. In the forthcoming 4G era, it is anticipated that this trend will be realized more smoothly in the market.

II. 4G Requirements

The main objectives of 4G are to improve radio technology dramatically thus providing high QoS and very low CAPEX and OPEX. More specifically, some key performance and capability targets of 4G are

- The potential to provide significantly higher data rates compared to 3G with the target peak data rate of 100Mbps in moving environment, and 1Gbps in stationary environment for the downlink and at least half of those peak data rates for the uplink
- The potential to significantly reduce latency in the user plane in the interest of improving the performance of higher layer protocols such as TCP as well as reducing the

0-7803-9542-5/06/$20.00 ©2006 IEEE

delay associated with control plane procedures such as session setup and more importantly session reestablishment

- Greater system capacity – at least threefold capacity compared to 3G

To reach the performance, capacity and capability targets, the followings are being considered as enabling technologies for 4G; IP based simplified system architecture, evolved Qos and link layer concepts such as Hybrid ARQ, the use of multicarrier modulation such as OFDM, advanced multi-antenna solutions such as MIMO

A. Spectrum Consideration

WP8F views that future services will be much more diverse than current services and the use of individual services may be no more than mutually independent. This means that mixture of services can be varied over different areas in the future even if these areas have common radio propagation conditions. Taking this into consideration, sub working group methodology identified the needs for new definition of environments in the service oriented aspects and also introduced service environments defined as areas representing common service conditions. Service environments should be distinct to conventional radio environments described in the Recommendation M.1390; however in the working document towards methodology, there are still ambiguities in clearly understanding the service environments as well as difference between service environments in new methodology and topographic areas divided by density in the existing methodology, which have common names such as dense urban, urban, sub-urban and rural. Therefore the service environments should be more clearly redefined and then the relationship between service environments and topographic area such as dense urban, urban, etc., should be clarified to estimate spectrum requirements correctly as well. New relationships among environments and RATs in spectrum requirement calculation are also necessary.

B. Candidate Spectrum for 4G

In ITU-R WP8F, 4G candidate spectrum has been discussed aiming to reach a consensus amongst members at the forthcoming WRC2007 conference.

III. MOBILE COMMUNICATION SYSTEM EVOLUTION

A. Network Convergence

Current telecommunication environment is divided into wireless, fixed line, telecommunication and broadcasting, causing many inconvenience for the users. For instance, users have to receive bills from different sources and since the types of business and service are different, users have no choice but to use various devices. That means, they are burdened with possessing more than two portable devices like a cellular phone, PDA, laptop, MP3, Game player and portable TV. Once fixed-mobile convergence is in placed in 4G, as overlapping occurs, the distinctions among types of business and service will diminish and so do between different portable devices. Secondly, from the perspective of fixed line business, as they realize the only way to overcome the limitation in revenue is to enter the wireless market, they will either enter this competitive wireless market or will create new mobile broadband market with 4G. At the same time, it is anticipated that wireless incumbent also will enter the fixed line market in response to fixed line operators movement. Consequently, boundaries in these markets will gradually disappear. Following that, from the end-user device standpoint, as one business offers variety of services, the convergence of device and its market for such trend will take place.

The player that is greatly influencing the changes in the market is foremost the end-users. That means, that the end-users are increasingly demanding services that are convergent. As a result of this increasing demand, performance of radio network was enhanced and it had influence on the mobile network operator. More importantly is the effect on the new wireless entrants, also known as the greenfield operator. Existing companies have vested rights and so therefore it is profitable in their business, and thus, their activities still are conservative. An element that can change its conservative business style is the entrance of new business. Once the operator has firm establishment in market share, it is very hard to change. One can safely predict that new business entrance will stimulate the activities of the existing company and this in turn, will greatly benefit the interest of the end-users. There can be a following case, for instance, where KT, fixed-line operator in Korea, has existing business of WiBro service, and this can be positively changed due to entrance of the Greenfield operator. At any rate, these factors are stimulating the markets and are playing great roles as a catalyst. This all leads to the Fixed Mobile Convergence (FMC).

Now let us take a look at FMC solutions in details. IP Multimedia Service (IMS) core network and services appear in the highest level. Originally, IMS appeared in mobile telecommunication IP core network but currently, is adopted in both fixed and wireless network as a unified platform of core network in convergence network. IP multimedia service is possible in the IMS based platform, and the network is designed in such a way that real-time IP traffic can be transferred via guaranteed QoS. In comparison to existing Internet network, it is a network that has upgraded QoS. As a single authority did not exist in the current Internet that could control the whole, QoS security was difficult, but on the other hand, although IMS network belongs in the same IP network, it is nevertheless a controlled network that can control Qos. To advance this network to global IMS network, operator will have increasing influences, and as a result, there will be

changes in the alignment of those involved. Also, in IP mobility, mobile IP solution will become available and with further development, not only is macro mobility will be supported but micro mobility as well.

B. Benefits of Network Convergence

For the future, network convergence will be independent of access network, that is, device can receive various services such as access network agnostic and to support above services, mobile is gradually developing into multimode. Representative is a voice data of multimode, a multimode that supports the IP technology that has different protocol among WLAN, WMAN, and WWAN, and multimode terminal that supports broadcasting. From the business perspective, benefits gained from the convergence trend can be different, depending on whether it is wireless or fixed line. That is, from user's point of view, if the user uses cellular phone outdoor and then comes back inside, he or she is no longer using cellular, but rather fixed line network, meaning that traffic, as well as the revenue derived from usage of the traffic, will be transferred from the cellular business to fixed line business. From the cellular business point of view, the users will enjoy the benefit of using seamless data service and broadband service indoor but also will develop habit that will permit them to use multimedia outdoor. Thus, the cellular business will reap the benefit of new traffic. In terms of such flow, it is predicted that both cellular and fixed line will be in win-win situation, and in reality, such occurrence is currently taking place.

IV. ENABLING TECHNOLOGIES FOR CONVERGENCE

A. Unlicensed Mobile Access Technology for Convergence

Currently, the hottest subject in the communications market is fixed/wireless convergence at the link level, namely, the UMA (unlicensed-mobile access) solution. This means, an access network that uses unlicensed spectrum such as WiFi and Bluetooth. Thus, if you have a dual mode handset that has UMA functionality, you can use the existing cellular radio network as well as take advantage of the technology that enables you to use unlicensed mobile access network of either Bluetooth or WiFi, to seamlessly handover or roam between IMS core network and existing core network. For example, if you are communicating through UMA device and if you are outside the UMA accessible building, you are using the cellular network. But if you come in to the building then the communication is seamlessly handed over to the IP network in the building. This technology does not just apply to roaming, but also applies in the case of data service. You use the cellular based data service outdoor but if you decide to come indoor that has WiFi access installed, data service is seamlessly and transparently handed over to WiFi (or WiMax), which is an IP access network. Of course this is not possible just by including this feature in the handsets alone. It involves new network structure called UNC (UMA Network Controller) that performs the role similar to the BSC (Base Station Controller) in the Cellular Radio Access Network (existing RAN), to support handovers between cellular and static IP network. Before the advent of UMA, KT (Korea Telecom) provided one-phone service, BT (British Telecom) provided blue-phone service, Japan's NTT DoCOMo provided 3G/Wi-Fi phones as an integrated fixed/wireless service. However, these services failed to provide seamless handovers. Even if it did provide seamless handovers, it was still far from genuine fixed/wireless integration because of the handset compatibility problems with different types of access networks. UMA handsets, however, are not dependent on type of fixed/wireless access network and can make their integrated fixed/wireless service and applications dominate the communications market since they can be used for seamless voice and data sessions anytime and anywhere. Therefore, they are considered to be the most heralded solution among fixed/wireless convergence solutions.

The existing technology, that is, VoIP, Broadband, Wireless LAN, Broadcasting, and Radio access is seamlessly provided to users through UMA solution. As a result, it has advantages concerning cost and coverage factors. Similarly, UMA enabled mobile converges wireless radio access, which has various coverage, thus, have numerous advantages in terms of providing service to operators

In order to support multimode from the handheld, the emerging solutions for base band and RF are to integrate them in a single chip. If you look at the process that goes into producing handhelds, every type of handheld consist of different components. Most of the regular type of handheld phone use one-chip solution while the high-end handheld phones emphasizing multimedia functions mostly use two-chip solutions.

In these high end handheld phones, application processor is additionally installed besides the basic base band chip. The future trend is the integration of both base band and application processor into a single chip. Currently, however, we are talking about various types of base band or RF solutions being integrated into a single chip. So far, there are one chip solution for GSM/GPRS/WCDMA and another solution often referred to as "world phone" which supports CDMA in addition to GSM/GPRS/WCDMA. Although we have not seen fully integrated platform that include WiFi or Bluetooth or GPS, these kinds of platforms are expected to appear in the nearer future. In particular, in the case where WiFi is included as a base component for fixed/wireless convergence, the cellular base band and WiFi will gradually be integrated as an SoC. Furthermore, it is expected that broadcasting related solutions such as T-DMB or S-DMB receiver will either be stacked as an MCP solution or integrated in the same layout as a single SoC in the future.

VII. Conclusion

In meeting fixed/wireless convergence era, from the terminal side, multimode handset is gradually making appearance and this trend can be largely divided into three themes. First is previously mentioned, access divergence type, business environment through convergence of core network, that is, whether it is indoor or outdoor; and if it is indoor, what environment it is, and furthermore, if it is outdoor, whether it is urban or rural. Following the size of base station and AP, it will take various forms. It can be predicted that there will be further slimness of device and in terminal side, there will be more convergence. In service, both divergence and convergence will occur and from service type standpoint, there will be divergence, and from service's platform, there will be convergence of triple play in appearance.

References

[1] Jinsung Choi, "What is 4G?" *TTA Journal.*, vol. 101, December 2004.

[2] S.Y.Hui and K.H. Yeung, "Challenges in the Migration to 4G Mobile Sytems," *IEEE Communications Magazine* vol. 41, No.12, pp. 54-59, 2003.