Next-Generation Mobile Technologies

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INTRODUCTION

Mobile communications and the Internet have experienced rapid and largely unexpected growth during the last decade of the 20th century. Consequently, the mobile triple-play services (voice, video, data) will be the major demand drivers for the emerging 21st century networks. In this view, the convergence of mobile communications, multimedia, and the Internet would produce innovations, novel applications, and new services that would not otherwise be possible (ITU, 2002). Rapid technological innovations have successfully characterised and encouraged the evolutions of various mobile access technologies, leading to the development of various interworking solutions across heterogeneous networks, as well as the transformation of the market structure and business model. The interworking of heterogeneous networks and technologies is where convergence is really exploding, and it is part of the Internet and multimedia movement that has shaped the future world more than the invention of the automobile (Vanjoki, 2005).

This article aims to present the trends of convergence of different mobile technologies in order to meet the requirements in the provisioning of wireless broadband services, followed by an assessment of its impact to the telecommunications community. The discussions will include an insight into the potential collaborations between various technologies, as well as an exploration of possible technical and economical challenges along the convergence trail.

BACKGROUND

Towards the 21st century, there is a strong need to bring the desktop experience to a mobile environment that allows freedom of movement at any speed while connected to the best network. While the advances of Internet have motivated the research and development (R&D) of wireless technologies that adopt network architecture based on Internet protocol (IP), migration of telephony from circuit-based to voice-over IP (VoIP) might transform the traditional telephony business and change the economics of carrying voice traffic. The emergence of various innovative technologies that support VoIP applications would allow service providers and operators to penetrate into the voice market that was previously inaccessible. In addition, the increased demands for mobile entertainment have motivated the evolution of revenue-producing and bandwidth-hungry multimedia applications such as the digital TV, mobile TV, and Internet (or IP) TV [e.g., TV data, TV telephony (Nortel, 2005)]. Mobile entertainments enable an increasingly compelling content offering as well as new methods to deliver video programming and advertisements to mobile consumers, introducing new business models for both live and on-demand video content. These enhancements are changing how telecommunication networks can be used to enrich subscribers' quality of living as well as to generate additional revenue streams for content providers and network operators. It can be foreseen that the emerging technologies would support various high-end communications, where the requirement of full support for mobile triple-play services is of the ultimate importance.

Following that, various new broadband technologies have been (or are being) developed to address the demands of high-definition multimedia services in future wireless environments. These technologies include Wi-Fi[1], WiMAX[2], 3G evolutions (HSDPA[3]/HSUPA[4], and EV-DO[5]), FLASH-OFDM[6], Mobile-Fi, DVB-H[7], DMB[8], FLO[9], ISDB-T[10], and so forth, to name a few most popular ones. Wireless operators have been spending billions to upgrade their infrastructure and networks, especially during the period of analog-to-digital transition. Today, in order to counter the threats from new technologies like WiMAX particularly in terms of coverage range and data rates, Wi-Fi players are now deploying the mesh topology to enlarge their hotspot coverage range for the deployment of citywide wireless network (MuniWireless, 2006). The Enhanced Wireless Consortium (EWC, 2006) has also published the high-throughput (over 100 Mbps) specifications for the physical and medium access control layers of the Wi-Fi system. It is likely that the IEEE 802.11n standard will be based on the EWC proposals. Further, the IEEE 802.11e standard has also been developed to improve

the quality of service (QoS) of the legacy Wi-Fi system in provisioning multimedia services, which in turn is able to challenge the QoS-guaranteed technologies like WiMAX and evolved 3G from securing a leading market position in multimedia last mile delivery.

The high demand for mobile broadband and the rapid adoption of multimedia applications have motivated service providers and operators to deploy various networks to cater to the needs of tomorrow. To some extent, some may believe that these technologies are competing with each other, as many of them have been developed or customised to support a same application category or service offering. Technological wars are likely to be waged over the next few years, especially between WiMAX and evolved 3G, as well as between DVB-H and FLO, although no technology is yet in a leadership position. Moreover, as mobile operators have made vast investments in 3G spectrum, they do not wish to see other technologies penetrating into their cellular territories, cannibalising their revenue and profits, especially in the voice markets. However, some parties actually believe that these technologies could complement and strengthen each other in many aspects (Tan et al., 2006). These technologies can run alongside one another bridging the gaps of applications and services rather than overlapping with neighbouring technologies. With careful planning, different technologies can be deployed to demonstrate the interworking and convergence of various service functionalities, and hence interacting in ever more important roles.

The common goals and functionalities of these technologies include the supports for mobility, QoS, ubiquitous access (large coverage range), low error rates, high-speed connections, seamless handover between cells or base stations, and high capacity for simultaneous users. Although these technologies have different capabilities and marketplaces, the convergence of different networks is not far off as most advanced technologies are (being) developed to address data-centric and IP-based applications. The convergence phenomenon is not just in terms of similarity in functionalities, it is also about several networks coming together to further enrich user experience for "always-on" data and multimedia content delivery. This must also be complemented by enhanced user device capabilities, such that a basic device like a mobile phone can become an all-in-one telecommunications, media and computer handheld machine. Carrier operators and service providers all recognise that to sustain their business long-term, they need to devise the right mix of technologies at the right price to lock in subscriber loyalty, entice new customers and increase their average revenue per unit. The shift to new generation networks for mobile entertainments will take this phenomenon even further, and will essentially involve convergence and interoperability in terms of harmonisation and consolidation of technological strengths, functionalities, service offerings, and mobile broadband market segmentation.

CONVERGENCE PHENOMENA

The activities along the convergence trails have revolutionised and created many new technologies, and the wireless R&D community has already begun to glue the broadband Internet, high-definition multimedia, and mobile communications onto a more common ground. On a technical level, the viability of next-generation networks will rely on continued efforts towards the provisioning of ubiquitous access, definite guarantees on QoS supports, high transmission speeds for downlink and uplink, and evolution to IP-based core networks. Despite the availability of various wireless technologies, it can be observed that most technologies have been developed (or upgraded) to fulfill the above requirements, that is, the convergence of technical trends. In order to offer ubiquitous access, Wi-Fi coverage areas are being expanded to form a metropolitan network via the mesh topology. The process is being accelerated with the aid of WiMAX that supports point-to-multipoint architecture and serves as wireless backhaul for several Wi-Fi access points (Intel, 2004a). The rapid growth of VoIP and multimedia applications has placed QoS issues to be part of the network selection criteria, and hence all new technologies in the future would somehow incorporate QoS supports into the system.

In terms of radio access, the design of the latest wireless air interface can be seen to be gradually converging to the use of orthogonal frequency division multiplexing (OFDM) (Intel, 2004b) technology as the preferred radio transceiver technique. The phenomenon can be observed in various systems such as Wi-Fi, WiMAX, FLASH-OFDM, DVB-H, FLO, ISDB-T, and so forth. Further, it is anticipated that future releases of 3G standards would adopt OFDM technology, where the move can be seen in various proposals amongst the industries. These include the high-speed OFDM packet access (HSOPA) by Nortel (Duplessis, 2005) and the Super 3G vision [or long-term evolution (LTE), 3.99G] by NTT DoCoMo (3G Mobile, 2005). In addition, in order to address the problems of bandwidth and transmission speed limitations, most new wireless technologies have been adopting multiple-input multiple-output (MIMO) and smart antenna techniques. It can be foreseen that future consumer devices would employ multiple antennas as one of the key solutions to boost data rates, transmission reliability, and spectral efficiency.

At the service level, convergence between various wireless networks is already happening through new technologies such as unlicensed mobile access (UMA), interworking and interoperability solutions for co-existing networks ("always-on" communications), mobile TV, interactive end-user applications via alternative networks, and so forth. Currently, this form of convergence is at the height of its technology and is strengthening with further developments and innovations. With the advent of VoIP applications, the threats of mobile operators suffering from falling revenues for voice