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978-0-521-88204-0 - Multimedia Networking: From Theory to Practice
Jenq-Neng Hwang
Excerpt
More information

1 Introduction to multimedia networking

With the rapid paradigm shift from conventional circuit-switching telephone networks to the packet-switching, data-centric, and IP-based Internet, networked multimedia computer applications have created a tremendous impact on computing and network infrastructures. More specifically, most multimedia content providers, such as news, television, and the entertainment industry have started their own streaming infrastructures to deliver their content, either live or on-demand. Numerous multimedia networking applications have also matured in the past few years, ranging from distance learning to desktop video conferencing, instant messaging, workgroup collaboration, multimedia kiosks, entertainment, and imaging [1] [2].

1.1 Paradigm shift of digital media delivery

With the great advances of digital data compression (coding) technologies, traditional analog TV and radio broadcasting is gradually being replaced by digital broadcasting. With better resolution, better quality, and higher noise immunity, digital broadcasting can also potentially be integrated with interaction capabilities.

In the meantime, the use of IP-based Internet is growing rapidly [3], both in business and home usage. The quick deployment of last-mile broadband access, such as DSL/cable/T1 and even optical fiber (see Table 1.1), makes Internet usage even more popular [4]. One convincing example of such popularity is the global use of voice over IP (VoIP), which is replacing traditional public-switched telephone networks (PSTNs) (see Figure 1.1). Moreover, local area networks (LANs, IEEE 802.3 [5]) or wireless LANs (WLANs, also called Wi-Fi, 802.11 [6]), based on office or home networking, enable the connecting integration and content sharing of all office or home electronic appliances (e.g., computers, media centers, set-top boxes, personal digital assistants (PDAs), and smart phones). As outlined in the vision of the Digital Living Network Alliance (DLNA), a digital home should consist of a network of consumer electronics, mobile and PC devices that cooperate transparently, delivering simple, seamless interoperability so as to enhance and enrich user experiences (see Figure 1.2) [7]. Even the recent portable MP3 players (such as the Microsoft Zune, http://www.zune.net/en-US/) are equipped with Wi-Fi connections (see Figure 1.3). Wireless connections are, further, demanded outside the office or home, resulting in the fast-growing use of mobile Internet whenever people are on the move.

These phenomena reflect two societal trends on paradigm shifts: a shift from digital broadcasting to multimedia streaming over IP networks and a shift from wired Internet to wireless Internet. Digital broadcasting services (e.g., digital cable for enhanced definition TV (EDTV) and high-definition TV (HDTV) broadcasting, direct TV via direct broadcast

Table 1.1 The rapid deployment of last-mile broadband access has made Internet usage even more popular

Services/Networks	Data rates
POTS	28.8–56 kbps
ISDN	64–128 kbps
ADSL	1.544–8.448 Mbps (downlink) 16–640 kbps (uplink)
VDSL	12.96–55.2 Mbps
CATV	20–40 Mbps
OC-N/STS-*N*	$N \times 51.84$ Mbps
Ethernet	10 Mbps
Fast Ethernet	100 Mbps
Gigabit Ethernet	1000 Mbps
FDDI	100 Mbps
802.11b	1, 2, 5.5, and 11 Mbps
802.11a/g	6–54 Mbps

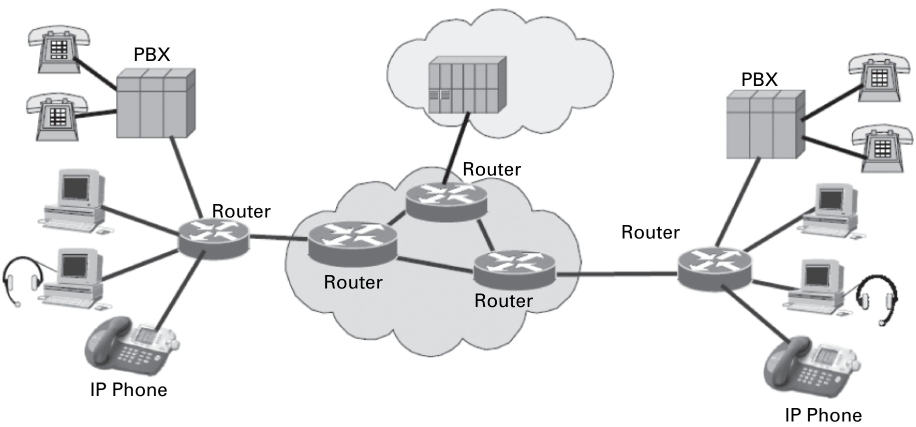

Figure 1.1 The growing use of voice over IP (VoIP) is quickly replacing the usage of traditional public-switched telephone networks (PSTNs): private branch exchanges (PBXs) are used to make connections between the internal telephones of a private business.

satellite (DBS) services [8], and digital video broadcasting (DVB) [9]) are maturing (see Table 1.2), while people also spend more time on the Internet browsing, watching video or movie by means of on-demand services, etc. These indicate that consumer preferences are changing from traditional TV or radio broadcasts to on-demand information requests, i.e., a move from "content push" to "content pull." Potentially more interactive multimedia services are taking advantage of bidirectional communication media using IP networks, as evidenced by the rapidly growing use of video blogs and media podcasting. It can be confidently predicted that soon Internet-based multimedia content will no longer be produced by traditional large-capital-based media and TV stations, because everyone can have a media station that produces multimedia content whenever and wherever they want, as long

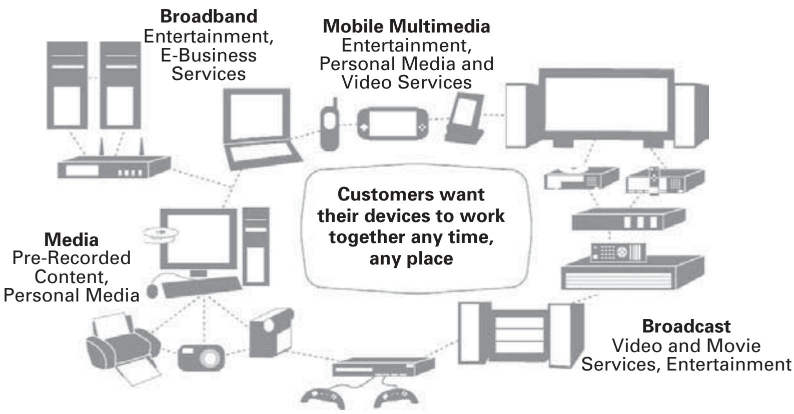

Figure 1.2 The vision of the Digital Living Network Alliance (DLNA) [7].

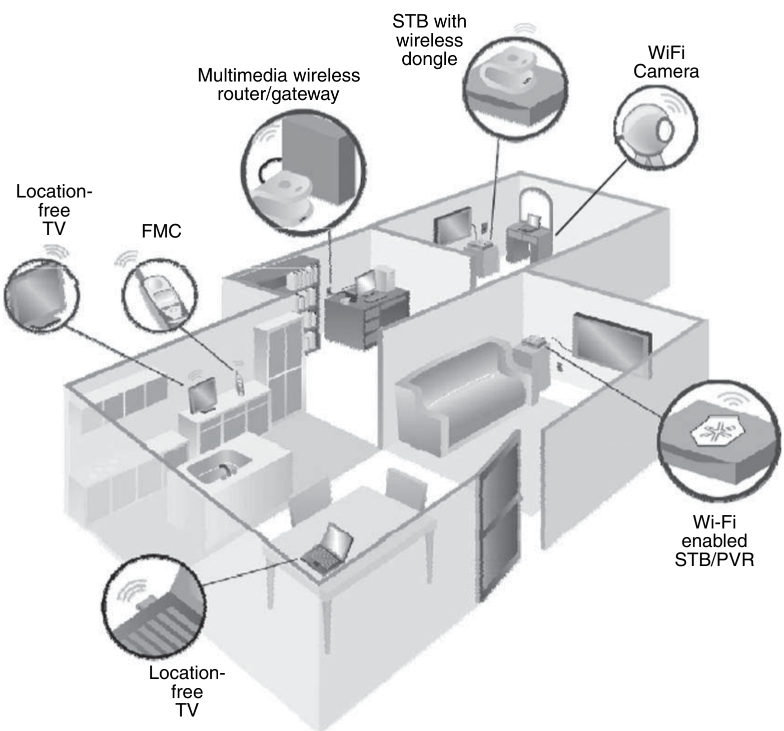

Figure 1.3 WLAN-based office or home networking enables the connecting, integration, and content sharing of all office or home electronic appliances (www.ruckuswireless.com).

as they have media-capturing devices (e.g., digital camera, camcorder, smart phone, etc.) with Internet access (see Figure 1.4). A good indication of this growing trend is the recent formation of a standardization body for TV over IP (IPTV) [10], i.e., the IPTV Interoperability Forum (IIF), which will develop ATIS (Alliance for Telecommunications Industry

Table 1.2 Digital broadcasting is maturing [11]

Region	Fixed reception standards	Mobile reception standards
Europe, India Australia, Southeast Asia	DVB-T	DVB-H
North America	ATSC	DVB-H
Japan	ISDB-T	ISDB-T one-segment
Korea	ATSC	T-DMB
China	DVB-T/T-DMB/CMMB	

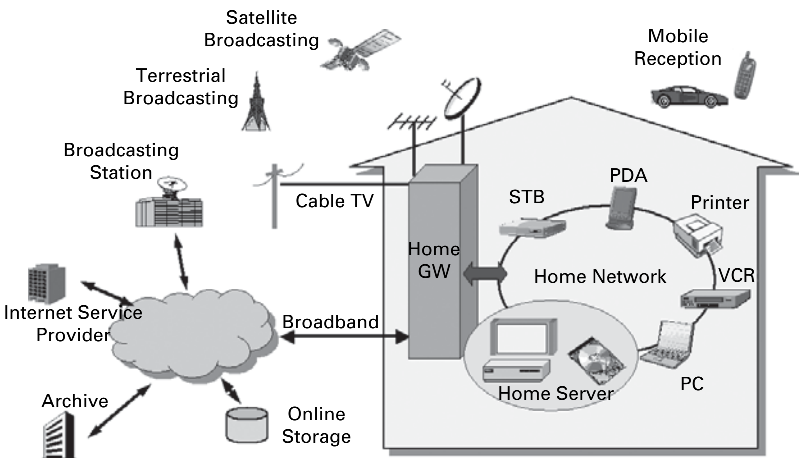

Figure 1.4 Interactive multimedia services take advantage of the bidirectional communication media of IP networks.

Solutions) standards and related technical activities that enable the interoperability, interconnection, and implementation of IPTV systems and services, including video-on-demand and interactive TV services.

The shift from wired to wireless Internet is also coming as a strong wave (see Figure 1.5) [12] [24]. The wireless LAN (WLAN or the so-called Wi-Fi standards) technologies, IEEE 802.11a/b/g and the next generation very-high-data-rate (> 200 Mbps) WLAN product IEEE 802.11n, to be approved in the near future, are being deployed everywhere with very affordable installation costs [6]. Also, almost all newly shipped computer products and more and more consumer electronics come with WLAN receivers for Internet access. Furthermore wireless personal area network (WPAN) technologies, IEEE 802.15.1/3/4 (Bluetooth/UWB/Zigbee), which span short-range data networking of computer peripherals and consumer electronics appliances with various bitrates, provide an easy and convenient mechanism for sending and receiving data to and from the Internet for these end devices [14]. To provide mobility support for Internet access, cellular-based technologies such as third generation (3G) [14] [15] networking are being aggressively deployed, with increased multimedia application services from traditional telecommunication carriers. Furthermore,

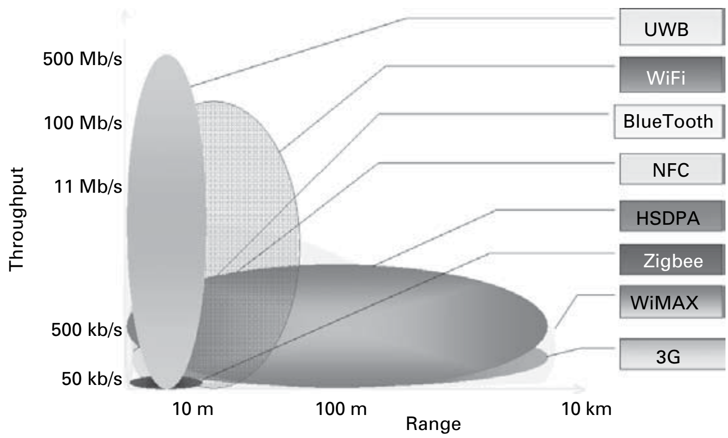

Figure 1.5 The WLAN technologies, IEEE 802.11 a/b/g/n, are being deployed everywhere with very affordable installation costs. Furthermore, the WPAN technologies, IEEE 802.15.1/3/4, provide an easy and convenient mechanism for sending or receiving data to or from the internet for these end devices [24].

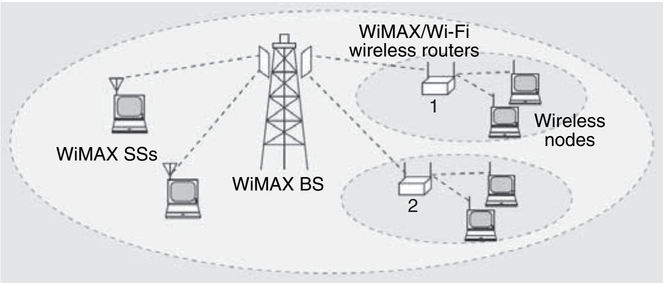

Figure 1.6 Fixed or mobile WiMAX (IEEE 802.16d/e) can serve as an effective backhaul for WLAN [23] (© IEEE 2007).

mobile wireless microwave access (WiMAX) serves as another powerful alternative to mobile Internet access from data communication carriers. Fixed or mobile WiMAX (IEEE 802.16d and 802.16e) [16] [17] can also serve as an effective backhaul for WLAN whenever this is not easily available, such as in remote areas or moving vehicles with compatible IP protocols (see Figure 1.6).

1.2 Telematics: infotainment in automobiles

Another important driving force for wireless and mobile Internet is telematics, the integrated use of telecommunications and informatics for sending, receiving, and storing information via telecommunication devices in road-traveling vehicles [18]. The telematics market is rolling out fast thanks to the growing installation in vehicles of mobile Internet access, such as the general packet radio service (GPRS) or 3G mobile access [12]. It ranges from front-seat information and entertainment (*infotainment*) such as navigation, traffic status, hand-free communication, location-aware services, etc. to back-seat infotainment, such as multimedia entertainment and gaming, Internet browsing, email access, etc. Telematics systems have also been designed for engine and mechanical monitoring, such as remote diagnosis, care data collection, safety and security, and vehicle status and location monitoring. Figure 1.7 shows an example of new vehicles equipped with 3G mobile access (www.jentro.com).

In addition to the growing installation of mobile Internet access in vehicles, it is also important to note the exponentially growing number of WLAN and WPAN installations on vehicles (see Figure 1.8). This provides a good indication of the wireless-access demand for

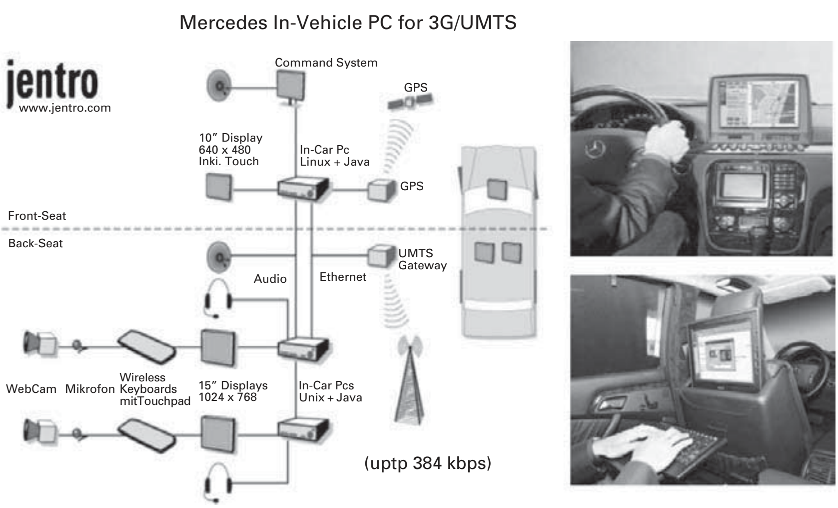

Figure 1.7 An example of new vehicles equipped with 3G mobile access provided by Jentro Technology (www.jentro.com).

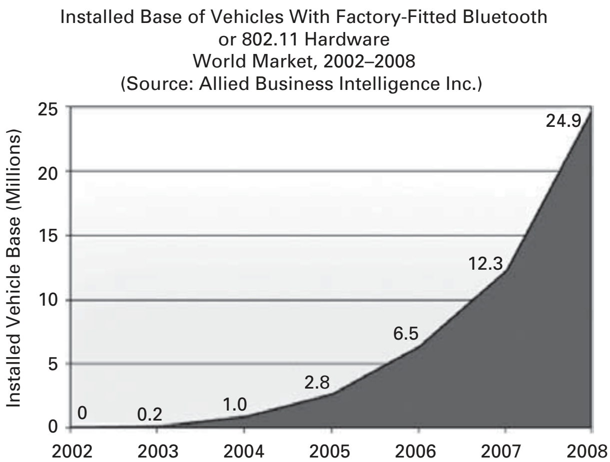

Figure 1.8 The plot shows the exponentially growing number of WLAN and WPAN installations on vehicles (www.linuxdevices.com/news/NS2150004408.html).

Table 1.3 The bandwidth requirement of raw digital data without compression

Source	Bandwidth (Hz)	Sampling rate (Hz)	Bits per sample	Bitrate
Telephone voice	200–3400	8000 samples/s	12	96 kbps
Wideband speech	50–7000	16 000	14	224 kbps
Wideband audio (2 channels)	20–20 000	44 100 samples/s	16 per channel	1.412 Mbps (2 channels)
B/W documents		300 dpi (dots per inch)	1	90 kb per inch^2
Color image		512×512	24	6.3 Mb per image
CCIR-601 (NTSC)		$720 \times 576 \times 25$ (DVD)	24	248.8 Mbps
CCIR-601 (PAL)		$720 \times 576 \times 25$	24	248.8 Mbps
Source input format (SIF)		$352 \times 240 \times 30$ (VCD)	12	30 Mbps
Common intermediate format (CIF)		$352 \times 288 \times 30$	12	37 Mbps
Quarter CIF (QCIF)		$176 \times 144 \times 7.5$	12	2.3 Mbps
High definition DVD		$1920 \times 1080 \times 30$	24	1492 Mbps

vehicles in a local vicinity, e.g., inside a parking lot and moving with a slow speed yet still enjoying location-aware services.

1.3 Major components of multimedia networking

Multimedia is defined as information content that combines and interacts with multiple forms of media data, e.g., text, speech, audio, image, video, graphics, animation, and possibly various formats of documents. There are four major components that have to be carefully dealt with to allow the successful dissemination of multimedia data from one end to the other [1]. Such a large amount of multimedia data is being transmitted through Internet protocol (IP) networks that, even with today's broadband communication ability, the bandwidth is still not enough to accommodate the transmission of uncompressed data (see Table 1.3). The first major component of multimedia networking is the data compression (source encoding) of multimedia data sources (e.g., speech, audio, image, and video). For different end terminals to be able to decode a compressed bitstream, international standards for these data compression schemes have to be introduced for interoperability. Once the data are compressed, the bitstreams will be packetized and sent over the Internet, which is a public, best-effort, wide area network (as shown in Figure 1.9). This brings us to the second major component of multimedia networking, quality of service (QoS) issues [19] [20], which include packet delay, packet loss, jitter, etc. These issues can be dealt with either from the network infrastructure or from an application level.

Furthermore, wireless networks have been deployed widely as the most popular last-mile Internet access technology in homes, offices, and public areas in recent years. At the same time, mobile computing devices such as PDAs, smart phones, and laptops have been improved dramatically in not only their original functionalities but also their communication capabilities. This combination creates new services and an unstoppable trend of

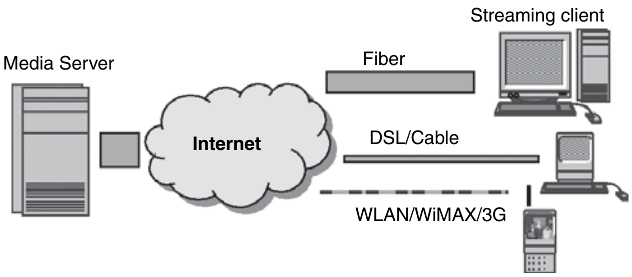

Figure 1.9 The compressed multimedia data are packetized and sent over the Internet, which is a public best-effort wide area network.

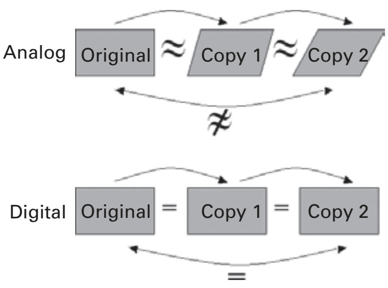

Figure 1.10 The proliferation of digital media makes illegal copying and falsification easy.

converting everything to wireless, for almost everything and everywhere [12]. In ensuring the effective dissemination of compressed multimedia data over IP-based wireless broadband networks, the main challenges result from the integration of wired and wireless heterogeneous networking systems; in the latter the QoS is further degraded by the dynamically changing end-to-end available bandwidth caused by the wireless fading or shadowing and link adaptation. This constitutes the third major component of today's multimedia networking. Moreover, the increased occurrence of wireless radio transmission errors also results in a higher bursty rate of packet loss than for wired IP networks. To overcome all these extra deficiencies due to wireless networks, several additional QoS mechanisms, spanning from physical, media access control (MAC), network and application layers, have to be incorporated.

There are numerous multimedia networking applications: digital broadcasting and IP streaming and meeting and/or messaging have been widely deployed. These applications will continue to be the main driving forces behind multimedia networking. The proliferation of digital media makes interoperability among the various terminals difficult and also makes illegal copying and falsification easy (see Figure 1.10); therefore, the fourth major component of multimedia networking consists of ensuring that the multimedia-networked content is fully interoperable, with ease of management and standardized multimedia content adapted for interoperable delivery, as well as intellectual property management and protection (i.e., digital rights management, DRM [21]), effectively incorporated in the system [22].

Providing an in-depth understanding of the four major components mentioned above, from both theoretical and practical perspectives, was the motivation for writing this book: it covers the fundamental background as well as the practical usage of these four components. To facilitate the learning of these subjects, specially designed multimedia coding and networking laboratory contents have been used in order to provide students with practical and hands-on experience in developing multimedia networking systems. The coverage and materials of this book are appropriate for a one-semester first-year graduate course.

1.4 Organization of the book

This book is organized as follows. Chapters 2–5 cover the first major component of multimedia networking, i.e., standardized multimedia data compression (encoding and decoding). More specifically, we discuss four types of medium, including speech, audio, image and video, each medium being covered in one chapter. The most popular compression standards related to these four media are introduced and compared from a tradeoff perspective. Thanks to the advances in standardized multimedia compression technologies, digital multimedia broadcasting is being deployed all over the world. In Chapter 6 we discuss several types of popular digital multimedia (video) broadcasting that are widely used internationally. Chapters 7 and 8 focus on QoS techniques for multimedia streaming over IP networks, ranging over the MAC, network, transport, and application layers of IP protocols. Several commercially available multimedia streaming systems are also covered in detail. In Chapters 9 and 10 we discuss specifically advances in wireless broadband technologies and the QoS challenges of multimedia over these wireless broadband infrastructures, again in terms of the layers of IP protocols. Chapter 11 deals with digital rights management (DRM) technologies for multimedia networking and the related standardization efforts. To provide readers with a hands-on learning experience of multimedia networking, many development software samples for multimedia data capturing, compression, streaming for PC devices, as well as GUI designs for multimedia applications, are provided in Chapter 12.

References

[1] Jerry D. Gibson, *Multimedia Communications: Directions and Innovations*, Communication, Networking and Multimedia Series, Academic Press, 2000.
[2] K. R. Rao, Z. S. Bojkovic, and D. A. Milovanovic, *Multimedia Communication Systems: Techniques, Standards, and Networks*, Prentice Hall, 2002.
[3] "Internet world stats: usage and population Statistics," http://www.internetworldstats.com/stats.htm.
[4] "Broadband internet access," http://en.wikipedia.org/wiki/Broadband_Internet_access.
[5] "IEEE 802.3 CSMA/CD (Ethernet)," http://grouper.ieee.org/groups/802/3/.
[6] "IEEE 802.11 wireless local area networks," http://grouper.ieee.org/groups/802/11/.
[7] "DLNA overview and vision whitepaper 2007," http://www.dlna.org/en/industry/pressroom/DLNA_white_paper.pdf.
[8] "Direct TV," http://www.directv.com/DTVAPP/index.jsp.
[9] "Digital video broadcasting: the global standard for digital television," http://www.dvb.org/.
[10] "The IPTV interoperability forum (IIF)," http://www.atis.org/iif/.

[11] S. Levi, "Designing encoders and decoders for mobile terrestrial broadcast digital television systems," in *Proc. TI Developer Conf.*, April 2006.

[12] A. Ganz, Z. Ganz, and K. Wongthavarawat, *Multimedia Wireless Networks: Technologies, Standards, and QoS*, Prentice Hall, 2003.

[13] "IEEE 802.15 Working Group for WPAN," http://www.ieee802.org/15/.

[14] "The 3rd Generation Partnership Project (3GPP)" http://www.3gpp.org/.

[15] "The 3rd Generation Partnership Project 2 (3GPP2)," http://www.3gpp2.org/.

[16] "The IEEE 802.16 Working Group on broadband wireless access standards," http://grouper.ieee.org/groups/802/16/.

[17] "The WiMAX forum," http://www.wimaxforum.org/home/.

[18] M. McMorrow, "Telematics – exploiting its potential," *IET Manufacturing Engineer*, 83(1): 46–48, February/March 2004.

[19] A. Tanenbaum, *Computer Networks*, Prentice Hall, 2002.

[20] M. A. El-Gendy, A. Bose, and K. G. Shin, "Evolution of the Internet QoS and support for soft real-time applications," *Proc. IEEE*, 91(7): 1086–1104, July 2003.

[21] S. R. Subramanya, Byung K. Yi, "Digital rights management," *IEEE Potential*, 25(2): 31–34, March/April 2006.

[22] W. Zeng, H. Yu, and C.-Y. Lin, *Multimedia Security Technologies for Digital Rights Management*, Elsevier, 2006.

[23] D. Niyato and E. Hossain, "Integration of WiMAX and WiFi: optimal pricing for bandwidth Sharing," *IEEE Commun. Mag.*, 45(5): 140–146, May 2007.

[24] Y.-Q. Zhang, "Advances in mobile computing," keynote speech in *IEEE Conf. on Multimedia Signal Processing*, Victoria BC, October 2006.