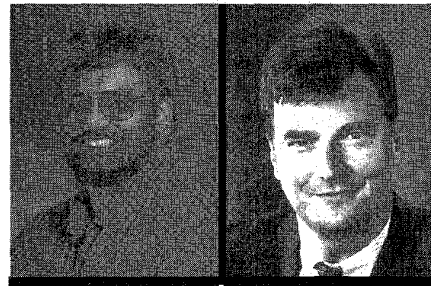


Wireless Video



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In the last decade, two distinct communication technologies have experienced unequalled rapid growth and commercial success: mobile communications and multimedia communications. Naturally, the great success in both areas has attracted and inspired many electrical engineers and computer scientists. Propelled by the powerful vision of being able to communicate from anywhere at any time with any type of data, a natural meshing of mobile and multimedia is currently underway. All indicators suggest that, building on advances in network infrastructure, low-power integrated circuits, and powerful signal processing/compression algorithms, wireless multimedia services will find widespread acceptance over the next decade. Armed with this vision of the future, the objectives that shaped current second-generation cellular and cordless communication standards — supporting integrated voice and data — have been expanded in third-generation wireless information networks to provide truly ubiquitous access and integrated multimedia services.

Real-time visual communication is an integral part of multimedia services envisioned for third-generation personal communication services (PCS). The current vision of PCS includes a small handset that allows the user to communicate from anywhere in the world with anyone in a variety of formats (voice, data, image, and full-motion video) from virtually any geographic location. Wristwatch “Dick Tracy” communicators are expected to follow soon after.

To make the vision of ubiquitous wireless multimedia communications a reality, however, many technical problems remain to be solved. Wireless video is particularly demanding. Due to the limitations of the available radio spectrum and the enormous amounts of data involved, the most advanced compression algorithms must be used in the management and delivery of digital video. Unfortunately, state-of-the-art video compression algorithms adopted as standards by the International Organization for Standardization (ISO) and International Telecommunication Union (ITU) do not work well when used to transmit video over error-prone radio channels. The flip side of the impressive compression they provide is their great vulnerability to transmission errors. Simply put, after efficient compression, every bit counts! Conversely, second-generation standards for cellular and cordless communications are also unsuitable for transporting compressed video from one point to another. These systems were developed for voice and data communications only. Digital video communications was not considered and its characteristics (particularly the higher bit rate required for acceptable picture quality) never accommodated by the designers of these systems. This lack of network

support and the absence of error-robust video compression algorithms have rendered visual communications over wireless radio networks impractical in present-day systems.

The good news is that today while researchers and practitioners clearly acknowledge the importance of supporting video communications over RF networks, they also realize that existing standards relevant to this area are unsuitable for such communications. Consequently they are spending large amounts of time and effort developing new standards that will ensure both interoperability and robustness. As examples, the ITU — Telecommunication Standardization Section (ITU-T) is developing low-bit-rate video coding standards specifically designed for real-time audio-video conversational services over radio networks. Similarly, the ISO’s Motion Picture Experts Group (MPEG-4) is actively engaged in establishing a very-low-bit-rate video coding standard which will make video transmission over bandwidth-constrained radio channels possible. Research on PCS, which has yielded the highly successful second-generation standards such as Global System for Mobile Communications (GSM), PCS 1800, Digital European Cordless Telecommunications (DECT), and Personal Access Communications Systems (PACS), is now focusing on third-generation PCS standards such as the Future Public Mobile Telecommunications (FPMTL) and Universal Mobile Telecommunications System (UMTS), which will provide universal access with support for heterogeneous traffic including low-bit-rate video.

For this feature topic we have invited contributions from colleagues who are active in various aspects of wireless video research. Since standards play such an important role, several of them are also involved in the standardization efforts for new wireless video systems. We selected a group of contributors with diverse backgrounds and viewpoints to address the wide array of technical issues in wireless video, ranging from error-resilient compression to network protocols to low-power hardware to innovative applications. While invited, each article has undergone an anonymous peer review and has been revised accordingly.

The first article, by Paramvir Bahl, sets the stage by highlighting the challenges in “Supporting Digital Video in a Managed Wireless Network.” A managed as opposed to an ad hoc wireless network is one where the control and management of the network is centralized. The author points out that in order to support robust wireless video communications in an inherently hostile environment, innovations are needed in the design of video codecs and in network management software, and that these have to work in

harmony with each other. In his exposition of the subject he presents a content-sensitive joint-source channel video codec that combines segmentation in the spatial domain with segmentation in the frequency domain to achieve a bit-stream that is network-friendly and adaptive to channel impairments. He shows that appropriate bandwidth reservation, allocation, and management algorithms can achieve optimal resource utilization while providing QoS guarantees to variable bit rate data. A novel traffic scheduling algorithm that exploits the regularity in the video packet generation process to provide timely channel access to time-bounded video traffic is also presented.

Strictly speaking, wireless video transmission has been around since the first analog television broadcasts in the 1930s. While we emphasize personal wireless video communication in this feature topic, we feel it would be myopic to not include a discussion of digital video broadcasting. Many of the technical issues surrounding wireless digital video transmission are related, and we expect an increasing convergence of advanced digital broadcasting networks and peer-to-peer communication networks over time. Ulrich Reimers is chair of the Technical Module of the Digital Video Broadcasting (DVB) Project, a consortium of more than 200 member organizations from around the world, which has developed a versatile digital multimedia broadcasting system utilizing the MPEG-2 standard for video compression. The system has now been adopted in many industrialized countries (although not in the United States). In his overview, "Digital Video Broadcasting," he discusses the terrestrial broadcasting aspects of DVB, especially coded orthogonal frequency-division multiplexing (COFDM), which is at the core of DVB-T.

Reliable transmission of highly compressed video signals over error-prone channels is a key problem for wireless video transmission. This requirement did not play a significant role in the standardization of MPEG-1 and MPEG-2, but has been addressed now in the MPEG-4 standard. Raj Talluri has been a leader in the error-resilient coding work done within ISO's MPEG. He summarizes the current status of that work in his contribution, "Error-Resilient Video Coding in the ISO MPEG-4 Standard." Techniques discussed include data partitioning, reversible variable-length codes, and resynchronization.

At the same time as in MPEG, the problem of error-resilient low-bit-rate video compression has also been addressed by ITU-T Study Group 16 for conversational applications. Niko Färber, Bernd Girod, and John Villasenor have all been active contributors to the mobile extensions of Recommendation H.324. An overview of the current status is provided in the article "Extensions of ITU-T Recommendation H.324 for Error-Resilient Video Transmission." It presents the robust extensions for video compression standard H.263, as well as for multiplex Recommendation H.223. The solution adopted by the ITU-T is quite different from that of MPEG-4, since several techniques rely on a feedback channel, a possibility not typically available to MPEG applications.

Personal communicators with wireless video capability will only be possible with future advances in low-power microelectronics. Teresa Meng provides insights into the design principles and future potential of this area with her article, "Low-Power Wireless Video Systems." She presents two low-

power design examples, a single-chip digital video camera with MPEG-2 compression and a terminal of a wireless video-on-demand system. Both integrated circuits dissipate only tens of milliwatts, achieving a power reduction two orders of magnitude below today's standard solutions.

Wireless video systems have to dynamically adapt to changes in the QoS provided by the network, particularly when internetworking of local and wide area networks is considered. In their article "Supporting Adaptive Video Applications in Mobile Environments," Nigel Davies, Joe Finney, Adrian Friday, and Andrew Scott describe lessons learned from a mobile video testbed they have built at Lancaster University. Their testbed supports multicast transmission of stored and live video sequences encoded with H.263 and MPEG, while enabling clients to maintain video connectivity when roaming between a wireless WaveLAN and GSM. The importance of scalable video representations and the problems of seamless handover between networks of very different QoS are discussed.

Finally, Steve Mann adds his own very personal viewpoint to this feature topic with "Headmounted Wireless Video: Computer-Supported Collaboration for Photojournalism and Everyday Use." Steve has explored some of the more radical possibilities of wireless video by wearing head-mounted cameras and displays every day over a period of several years. In this contribution, he describes how research in Personal Imaging has evolved over the last two decades. Personal Imaging systems employ wireless video technology to move images between body-mounted video cameras and wearable computers for the purposes of analysis of the data, photojournalism, security, and most recently computer-supported collaboration.

In conclusion, as guest editors we would like to thank all the authors for their contributions and efforts in pulling this feature topic together. Unlike other issues we have guest edited in the past, this was put together in a very short period of time. Without the commitment, professionalism, and hard work of the authors, reviewers, and *Communications Magazine* staff, this issue would never have happened in time. It has been a pleasure working with these professionals and we hope you enjoy this feature topic as much as we have.

BIOGRAPHIES

PARAMVIR BAHL [SM] (bahl@microsoft.com) holds a Ph.D. in computer systems engineering from the University of Massachusetts-Amherst. He is currently with Microsoft, where he is carrying out research in peripatetic computing, multihop multiservice ad hoc networks, mobility-aware self-configuring operating systems, and real-time audio-visual communications. Prior to Microsoft, he spent nine years at Digital Equipment Corp. where he initiated, led, and contributed to several seminal multimedia projects, including the industry's first desktop hardware adapters for audio/video compression, the world's fastest software implementations of ISO and ITU audio/video codecs, and fast and scalable image and video rendering algorithms.

BERND GIROD [F] (girod@nt.e-technik.uni-erlangen.de) is chaired professor of telecommunications in the Electrical Engineering Dept. of the University of Erlangen-Nuremberg and head of the Telecommunications Institute. He received his M.S. in electrical engineering from Georgia Institute of Technology in 1980 and his doctorate from the University of Hannover, Germany, in 1987. In 1988 he joined MIT, first as visiting scientist with the Research Laboratory of Electronics, then as assistant professor of media technology at the Media Lab. From 1990-1993 he was professor of computer graphics and technical director of the Academy of Media Arts, Cologne, jointly appointed to the Computer Science Section of Cologne University. He was visiting adjunct professor with the Digital Signal Processing Group at Georgia Institute of Technology in 1993. Since 1993 he has been with the University of Erlangen-Nuremberg. He served as chair of the Electrical Engineering Dept. (1995-1997) and as director of the Center of Excellence "3-D Image Analysis and Synthesis" since 1995. His research interests include multidimensional signal processing, information theory, video signal compression, human and machine vision, sensory computing, computer graphics and animation, as well as interactive media.