Scanning the Issue

Special Issue on Video Transmission for Mobile Multimedia Applications

One hundred years after Marconi's ground-breaking radio experiment and 50 years following Shannon's pioneering contributions in information theory, the communications community is witnessing unprecedented growth in both the quality and quantity of communications services. While wireless communications practitioners are endeavoring to translate exciting recent developments into international standards, researchers continue scanning the horizon for new ideas and solutions in order to approach information theoretical performance predictions. Burst-by-burst adaptive turbo-coded, turbo-equalized single-carrier, multicarrier, and code division multiple access (CDMA) schemes constitute just a few examples of the potential techniques which facilitate the approach towards Shannonian predictions over wireless channels.

Against a backcloth of emerging third-generation (3G) wireless personal communications standards and broadband access network standard proposals, this special issue is dedicated to a range of topical wireless multimedia and video communications aspects. The transmission of multimedia information over wireline-based links can now be considered a mature area, where a range of interactive and distributive services are offered by various providers across the globe.

On the distributive wireless video scene, a range of broadcast services appeared in the past few years which were contrived for stationary applications. Specifically, in Europe a set of mutually compatible cable-, terrestrial-, and satellite-based digital video broadcasting (DVB) schemes were standardized which employ the Motion Pictures Expert Group (MPEG-2) standard for video compression and Reed–Solomon (RS) forward error correction (FEC). The FEC performance can be further improved upon by invoking turbo coding and iterative decoding, especially when using a high turbo interleaving depth, since the distributive multimedia environment is not delay sensitive. The more hostile propagation environment of the terrestrial DVB system is combated using concatenated RS and rate-compatible, punctured, convolutional coding (RCPCC) combined with an orthogonal frequency division multiplexing (OFDM) based scheme. By contrast, the more benign cable- and satellite-based media facilitate the employment of blind-equalized multilevel modems using up to 256 modulation levels. These schemes are capable of delivering high-definition video at bit rates of up to 20 Mb/s in stationary broadcast-mode distributive wireless scenarios. The near future is likely to witness the emergence of DVB research and standards for business and ultimately private mobile users for various professionals in in-home wireless networks. For such systems the OFDM-based terrestrial DVB standard is a good starting point, since the blind-equalized DVB solutions are not sufficiently robust against channel fading. Research in iterative turbo equalization schemes, which are also related to the family of the so-called per-survivor processing-based joint channel decoding and equalization arrangement, has also been advanced in recent years. These schemes may have a practical role to play in future wireless systems, which rely on other means of user separation, rather than on OFDM-based multicarrier solutions. A variety of DVB and wireless local area network (LAN) oriented OFDM-based solutions will be discussed by Rohling *et al.*, while Hagenauer *et al.* focus their attention on joint source and channel coding.

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A range of interactive mobile multimedia communications services are also realistic in technical terms at the time of writing; however, their variety, quality and market penetration is not—as yet—comparable to that of the wireline-oriented services. The existing second-generation cordless systems, such as the Digital European Cordless Telephone (DECT) system and its Japanese counterpart, the so-called PHS scheme, and the Pan-American Personal Access Communications System (PACS), are amenable to interactive video communications at frame rates of 10–30 frames/s using 176×144-pixel quarter common intermediate format (QCIF) video resolution. Both proprietary- and H.263-based video compression can be used. However, proprietary video codecs can be rendered more error resilient than their standard-based counterparts, which extensively employ error-sensitive entropy coding techniques in an attempt to achieve the highest possible compression ratio. Hence, existing standard-based video codecs require efficient system-level transport solutions in order to address the above mentioned deficiencies. This issue will be discussed in more depth by Girod and Faerber. For the sake of supporting a larger video frame size, such as the 352×288-pixel common intermediate format (CIF), higher bit rates must be supported, which is possible over the DECT system upon linking a number of slots to support a transmission rate in excess of 500 kb/s.

The second-generation cellular systems, such as the global system of mobile communications (GSM), have a typically lower bit rate available for the transmission of both speech and data than the above cordless telephone schemes. Hence, these systems are less amenable to video telephony and other multimedia services. Nonetheless, a suite of error-resilient, fixed-rate video codecs were proposed in the literature—for example, for QCIF video telephony at 13 kb/s, which is the speech coding rate of the GSM system. Such a videophone system would require an additional speech channel for the transmission of the QCIF or sub-QCIF (SQCIF) format video signals, which would also imply the appropriate modification of the standards. Further multimedia services suggested in the literature for second-generation cellular systems are based on electronic mail, facsimile, short messages, and telewriting for handwriting as well as for white-board applications transmitting hand-drawn graphics. A further advantage of these second-generation systems is that they support full mobility and roaming. The Pan-American second-generation cellular scheme, referred to as the Digital Advanced Mobile Phone (DAMPS) system, also known as the IS-54 scheme—superseded by the IS-136 standard—has a speech coding rate of 7.95 kb/s, and hence its multimedia capability is limited to very low rate proprietary QCIF-based video codecs. This would require an additional speech channel that could be dedicated to its transmission in the future—again, upon modifying the standard. The Pan-American IS-95 and the second-generation Japanese system are also limited in terms of multimedia services due to their low speech bit rate.

The wireless multimedia era is, however, likely to witness a tremendous growth with the emergence of the 3G personal communications networks (PCN) and wireless asynchronous transfer mode (WATM) systems, which constitute a wireless extension of the existing ATM networks. Most of the global 3G terrestrial standard proposals, which originate from the United States, Europe, and Japan, are based on CDMA and are capable of providing high bit-rate data services up to 2 Mb/s depending on the radio environment. The so-called W-CDMA system is used as a transmission testbed by Gharavi and Alamouti in this issue. Furthermore, the Third Generation Partnership Project (3GPP) W-CDMA proposal was also designed to support multiple simultaneous calls and services. The WATM solutions often favor OFDM as their modulation technique, and indeed the imminent so-called Broad-Band Radio Access Network (BRAN) standard also advocates OFDM. WATM systems are reviewed by Raychaudhuri in this issue.

Research is also well under way toward the definition of a whole host of new modulation and signal processing techniques, and a further trend is likely to dominate this new era, namely the merger of wireless communications, consumer electronics, and computer technologies. These trends are likely to hallmark our future research. This special issue is naturally limited in terms of its coverage of these aspects, simply due to space limitations. However, it offers a range of interesting contributions, while acknowledging its limited coverage and the absence of numerous highly acclaimed experts in the field. Below we attempt to raise interest in the contributions presented in this issue by providing a brief guided tour, noting that although most papers touch upon virtually all system aspects, the main focus of the various contributions broadly fit into three categories: 1) video compression and error-resilience coding; 2) transmission and channel coding issues; and 3) networking aspects.

Let us commence our excursion by considering the contributions related to source and channel coding first. In "Feedback-Based Error Control for Mobile Video Transmission," Girod and Färber consider feedback-based low bit-rate video coding techniques for robust transmission in mobile multimedia networks. In order to support powerful error control at the source coding level, the source decoder has to make provisions for error detection, resynchronization, and error concealment, and the paper provides a comprehensive review of the various techniques suitable for this purpose. Specifically, the paper reviews error tracking, error confinement, and reference picture selection techniques for channel-adaptive source coding. The authors advocate techniques applicable to most interframe coding-based video compression standards.

The second paper, "Robust Video Coding Algorithms and Systems" by Villasenor *et al.*, is also related to the topic of robust video compression. Specifically, the authors present an overview of robust video compression techniques and systems, with emphasis on the long-awaited MPEG-4 standard and on the codecs standardized by the International Telecommunications Union (ITU). The techniques on which the authors elaborate include a range of proposed error-resilience improvements as well as packetization and multiplexing schemes.

The third paper, "Transport of Wireless Video Using Separate, Concatenated, and Joint Source-Channel Coding" by Van Dyck and Miller, continues the sequel on video and source coding with an emphasis on video transmission over time-varying wireless channels, which can benefit substantially from the use of joint source-channel coding (JSC). The authors center their discussions around the topic of estimation-based techniques; such techniques exploit the residual redundancy present at the output of source encoders. The paper concludes by incorporating modulation, channel coding, as well as rate allocation within the JSC design.

The paper "Multipriority Video Transmission for Third-Generation Wireless Communication Systems" by Gharavi and Alamouti presents a robust dual-priority video partitioning method suitable for twin-class unequal protected video transmission over wireless systems. This paper provides contributions across the whole spectrum of the special issue, touching upon source and channel coding, as well as transmission aspects. The proposed exemplary scheme is suitable for constant bit-rate (CBR) transmission, where the fraction of bits assigned to each of the two partitions can be adjusted according to the requirements of the unequal error protection scheme employed. As a transport vehicle, the authors have considered one of the leading third-generation cellular radio standard proposals, which is often referred to as the IMT-2000 wideband code division multiple access (W-CDMA) system.

Moving on from video source compression to channel coding, in "Channel Coding and Transmission Aspects for Wireless Multimedia" Hagenauer and Stockhammer concentrate mainly on the channel coding and transmission aspects of multimedia traffic. The authors argue that, due to the prevalent high error rates of wireless, the employment of joint source and channel coding techniques is promising. They emphasize that the system architecture must adapt to the hostile channel conditions and illustrate their argument through a joint system design example. Rate-compatible punctured systematic recursive convolutional codes are introduced and are shown to lead to a straightforward and versatile unequal error protection scheme. The authors conclude by stating that "high-end receivers" could use soft outputs and source-controlled channel decoding to further enhance the system performance.

The next treatise, "Broad-Band OFDM Radio Transmission for Multimedia Applications" by Rohling *et al.*, addresses mainly multicarrier transmission schemes. The authors review a range of aspects associated with high-rate multimedia, multicarrier radio transmissions to mobile receivers. This technique is also often referred to as OFDM, which has recently found favor in a range of diverse applications, such as DVB, digital audio broadcasting (DAB), and wireless local area networks (WLAN's). OFDM is renowned for its ability to cope with highly dispersive transmission media, especially when combined with time-variant, channel-adaptive modulation techniques. The authors focus their attention on the use of differential modulation techniques and on comparison of different demodulation and soft decision decoding strategies.

The next contribution, "Wireless ATM Networks: Technology Status and Future Directions" by Raychaudhuri, addresses mainly networking and other high-layer issues. The author has been instrumental in the conception and development of WATM systems, which constitute a tetherless extension of the existing ATM backbone. Following a basic outline of the technological rationale of WATM systems, the author provides a system-level portrayal of the switching architecture and the associated radio access subsystems. The specific WATM radio access layer issues covered in this treatise include: spectrum allocation; spectrum etiquette; modem technology; and medium access/data link control (MAC/DLC) protocols. Other WATM aspects such as ATM signaling extensions for handoff control, location management, and mobile quality of service (QoS) control are also discussed, along with pertinent standardization issues The paper concludes with a brief discussion of the expected future directions for WATM.

In "Wireless ATM-Based Multicode CDMA Transport Architecture for MPEG-2 Video Transmission," Chang and Lin advocate an ATM-based multicode CDMA transport architecture for transmitting variable-rate MPEG-2 compressed video services over band-limited mobile channels. The authors emphasize WATM cell design and spreading code management, while analyzing the impact of CDMA systems on video services. They propose twin-class channel coding in order to protect the header and payload of ATM cells.

Here we curtail our discussion of the various contributions and invite you to continue sampling them according to your requirements and at your leisure. We sincerely hope that you will find the issue enlightening and above all enjoyable.

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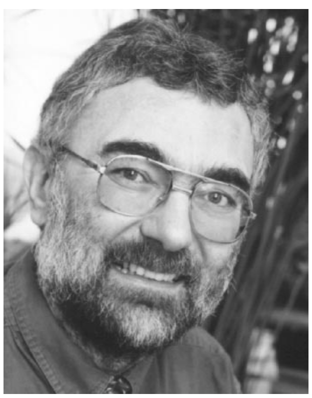
After serving as a Research Fellow at Loughborough University and Lecturer at Auckland University, New Zealand, he joined AT&T Bell Laboratories in February 1982. He moved to Bell Communication Research (Bellcore), Red Bank, NJ, after the AT&T-Bell divestiture, where he became a consultant on video technology and a Distinguished Member of Research Staff. While at Bellcore he was an Adjunct Professor at Polytechnic University, Brooklyn, NY. In August 1993, he joined Loughborough University as Professor and Chair of Communication Engineering. Since September 1998, he has been with the National Institute of Standards and Technology (NIST), Gaithersburg, MD. His research interest includes video transmission, image coding and processing, and wireless multimedia communications. He holds eight U.S. patents related to these topics.

Dr. Gharavi received the 1986 Charles Babbage Premium award from the Institute of Electronics and Radio engineering and the 1989 IEEE CAS Society Darlington Award for Best Paper. He served as Associate Editor of IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS *from 1987 to 1989. Since 1996 he has been an Associate Editor of* IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY *and a Guest Editor of a number of special issues. From 1989 to 1991, he was Chairman of the VLSI Systems and Applications Committee of the IEEE Circuits and Systems Society. He was a core member of the Study Group XV (Specialist Group on Coding for Visual Telephony) of the International Communications Standardization Body CCITT (ITU-T). While in the United Kingdom he was selected as one of the six university academics to be appointed to the Government's Technology Foresight Panel in Communications to consider the future to 2015 and to make recommendations for allocation of key research funds. He was also elected as a Member of Colleges of EPSRC (NSF equivalent) 1996–1999.*



Lajos Hanzo *(Senior Member, IEEE) has held various research and academic posts in Hungary, Germany, and the United Kingdom during his 23-year career in telecommunications. Since 1986, he has been a Member of the Academic Staff of the Department of Electronics and Computer Science, University of Southampton, U.K., and he has been a consultant to Multiple Access Communications Ltd.. Currently, he holds a Chair in Telecommunications and manages a team of academics and researchers. As a member of two multinational consortia and funded by the European Community as well as the Engineering and Physical Sciences Research Council (EPSRC) U.K., he is currently conducting research toward the next generation of wireless multimedia systems. He has published widely in the area of wireless multimedia communications, including three monographs and in excess of 200 research papers.*

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