

Multimedia Communications: Paradigm Shifting Technologies and Applications



Today, with the continued advances of digital media and networking technologies, multimedia has become an indispensable attribute in our daily life. Animation, audio and video clips are becoming increasingly popular on the Internet and are being accessed by a variety of mobile devices through wireless links. A large number of distributed multimedia applications have been created, including Internet telephony, Internet videoconferencing, on demand streaming or broadcasting, IPTV, distance learning, entertainment and gaming, multimedia messaging, etc. Streaming real-time and on-demand audio and video over the Internet, the commercial cellular phone systems, personal, local and wide area wireless networks, and home networks have become a reality and will soon become a mainstream means of communication. The widespread deployment of new multimedia communication applications has been the main driving force for the research and development of numerous paradigm shifting technologies.

Innovative networking and communication technologies continue to be the enablers for the deployment of multimedia applications, creating new distribution channels and business opportunities. While the Internet is still undergoing significant development and expansion, new networking and communication paradigms continue to emerge with both wires and wireless links. The new peer-to-peer networking paradigm has prompted the revisit of many technical issues related to multimedia communications and promised significant performance improvement of multimedia applications beyond what is supported by the current Internet. The increasingly widespread use of low power wireless mobile devices and sensors demands a paradigm shift in the design of the next generation multimedia communication systems. One such an excellent example is the recent proliferation of distributed source coding techniques. The demand for networked consumer systems and devices is already strong and will continue to grow rapidly. Consumer communications and networking have been attracting many researchers in diverse areas from networking to consumer electronics. Progress in wireless communication systems is enabling pervasive multimedia communications, reaching the consumers anywhere at anytime. Together with these emerging multimedia applications come the important issues of network and multimedia security, Quality of Service provisioning, cost effectiveness, and so on.

New array of applications naturally demands a new class of advanced technology to meet the technical challenges in these paradigm shift developments. However, the development of any new technology will have to be based on the existing technologies. To this end, we have recruited a team of world renowned researchers to contribute to this feature issue to share with the readers recent advances in several key technologies for the contemporary multimedia communication applications. These technologies for advanced multimedia communications include all aspects of the end-to-end system, ranging from creation, encoding, processing, analysis, communication and networking, encryption, authentication, reception and display. In the following, we will briefly introduce each paper in this feature issue to give the readers a panorama view of these key technologies that constitute the technical foundation for contemporary multimedia communication applications. The papers of this feature issue can be divided into two parts. The first five papers of this feature issue are some overview papers addressing broader perspectives related to one or more areas of research in multimedia communications. For the rest of the papers, each addresses some particular research topics with more detailed analysis and implementations. Together, these papers offer the readers to understand both broader technical challenges and some specific technology advances.



The first paper of this feature issue addresses one of the major technologies for multimedia communication: the MPEG (motion picture expert group) media coding standards. The MPEG standards have been developed by the International Standardization Organization (ISO) and have been considered as the key factor to the growth of modern multimedia

communications. This paper provides an evolutionary overview of MPEG standards, discussing and explaining why certain choices were made, and thus a certain vision of the multimedia world was followed.

The second paper presents several signal processing challenges in the next generation multimedia communication systems, in particular multimedia over mobile wireless links. Through the analysis of recent advances in multimedia communications, the authors identified technical challenges and highlighted some research opportunities. In particular, this paper presents in more detail some signal processing challenges in (1) intelligent video adaptation for mobile devices, (2) distributed coding for mobile video applications, (3) signal processing for scalable video transmission over multi input multi output (MIMO) wireless systems, and (4) energy-constrained video encoding and wireless communication.

The third paper provides an overview of several core technologies involved in the next generation mobile media communications system from both the media codecs and media transport perspectives. This paper first introduces several video codecs that are suitable for mobile communications, with an emphasis on state-of-the-art in scalable video coding and the scalable extension of the H.264/MPEG-4 AVC standard. This paper then discusses several key topics regarding media transport, including error-resilient transport, congestion control, and service discovery for ad hoc and peer-to-peer (P2P) networks. The authors point out some forward-looking new mobile media application scenarios that could be enabled by these core technologies, especially by scalable coding technology and the system built based on it. The authors also propose several futuristic yet thought-provoking research directions that could have substantial impacts in future mobile multimedia communications.

The next paper addresses the critical technologies in power consumption in the design of media delivery to portable appliances. For a battery-operated mobile device to support high-complexity multimedia functions, low-power and power-aware techniques are the key to a successful design. This article offers an overview of typical techniques for a low-power video IC design. More importantly, the authors introduce emerging power-aware concepts toward a more power-efficient video codec to be implemented on mobile devices.

The last paper in the first part presents an overview of the recent advances in peer-to-peer (P2P) network for media streaming. This emerging area of research represents the paradigm shift from conventional networking applications. A great number of P2P media streaming systems have been developed in recent years. This paper first provides a brief survey on some key techniques and algorithms in the field of P2P streaming research. Then, it offers some interesting market view of P2P streaming media service. Finally, the paper presents a brief description about the current mainstream P2P streaming systems deployed in China.



The second part of this feature issue includes papers with more detailed report on the development of several specific technologies in multimedia communications. The first of these papers addresses a key challenge to the vision of ubiquitous mobile multimedia access. This paper first reviews several source adaptation techniques and wireless collaboration schemes. The paper then presents the formulation of the multi-user video communication problem as a network utility maximization (NUM) problem, and the solution to this problem using a pricing scheme. The pricing scheme coordinates resource allocation, source adaptation in a distributed manner, and leads to efficient packet scheduling to achieve better utilization of communication resources and end-to-end video quality.

The second paper in this part addresses the critical problem in multimedia security. This paper employs the fine example of JPEG2000 compressed images to demonstrate the technical challenges in multimedia security. This paper first introduces a unified digital-signature and watermarking based authentication system for JPEG2000 images. The proposed approach can protect the image at different robustness levels ranging from code-stream to visual content, targeting at different application scenarios. The proposed authentication system has already been included in the JPEG2000 Security Part (JPSEC). The paper also describes briefly an overview of JPSEC and shows how the proposed system works with the JPSEC syntax.

The third paper addresses another important aspect of multimedia communications: Quality-of-Service issues in wireless video transmission. In particular, this paper intends to answer the following question: given the traffic characteristics of the video stream, the tolerable queuing delay and loss rate of the video data, how much channel bandwidth should be provided to satisfy the QoS requirements? The authors propose to model the layered video traffic using the discrete time batch Markovian arrival process (DBMAP) with marked transitions. The authors also assume the wireless channel can be modeled by a hidden Markov model (HMM), and the network can support automatic repeat request (ARQ) operation in order to reduce the transmission errors. This shows that the video data transmission buffer can be modeled as a G/D/c queue with time dependent feedback, and approximate the ARQ feedback traffic by an HMM modulated DBMAP process. Based on the effective bandwidth approach, the authors derive the required channel capacity for delivering both the input and feedback video data under the given QoS targets.

The next paper is on another emerging front in multimedia communications: Digital entertainment delivery in a wireless house. The authors contend that current networking architecture and protocols are not optimized for an efficient coexistence of downloading flows and real-time ones. Therefore, real-time applications suffer from delays caused by the interference with the transmission behaviors of downloading ones. In particular, this paper investigates the impact of MAC layer design choices on the distribution of in-house entertainment contents and concludes that current settings in the IEEE 802.11 protocol do not correspond to the optimal choice in this context. The authors then provide directions to set MAC layer parameters in order to solve the tradeoff relationship between the performance requirements of downloading and real-time applications.

The final paper in this issue addresses another emerging area in multimedia communications: video over multiple input multiple output (MIMO) systems. It is expected that future generation of wireless multimedia networks will be equipped with devices of multiple antennas. This paper presents an improved video transmission system derived from an unequal error protection (UEP) transmission scheme based on coded adaptive modulation. Specifically, the authors developed an innovative solution to utilize the excess power which is wasted in normal adaptive modulation schemes. Furthermore, a low density parity code (LDPC) is applied to the important bits to provide unequal error protection. As a result, the proposed scheme is able to achieve both transmission efficiency and video reception quality.

This feature issue really brings together a team of international experts to share with the readers of China Communications Journal in this emerging topic in multimedia communications. We have been able to recruit experts from North America, Europe, and Asia, all three centers of excellence in multimedia communication research and development, with true global perspectives on technical challenges and opportunities.

We would like to thank all the authors for their enthusiasm to share their expertise and their accommodating spirit to follow the stringent review and publication schedules. We hope the readers will enjoy these outstanding authoritative papers as much as we do.

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September 2006