Streaming Media Architectures, Techniques, and Applications:
Recent Advances

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This chapter introduces a cross-layer approach to wireless/mobile video streaming system design. Beginning with the introduction to the motivation of the cross-layer design, this chapter covers fundamental issues, challenges and solutions of the cross-layer approach to video streaming systems for its practical employment.

Chapter 7

This chapter proposes a complete streaming framework for a wireless, in particular a 3G/UMTS, network environment. The authors describe choices one can make in terms of network architecture and then focus on the input parameters used to evaluate network conditions and to perform the adaptation. A particular attention is dedicated to the protocol information that can be exploited to infer the channel state. In addition, each implementation choice is a compromise between the industrial feasibility and the adaptation efficiency.

Chapter 8

This chapter studies the technical issues of video streaming over both Mobile Ad Hoc Networks (MANETs) and Vehicular Ad Hoc Networks (VANETs). This chapter shows how streaming can take place in those challenging environments. Error resilience and path diversity are presented as the key to robust streaming. As a form of management of streaming, distributed sourcing via peer-to-peer streaming over diverse paths is explored within VANETs.

Chapter 9

This chapter presents a comprehensive study on the transmission of scalable video over wireless local area networks (WLAN). The authors give an analysis of the mechanisms and principles of the emerging scalable video coding (SVC) standard. Moreover, some studies of SVC over WLAN using cross-layer design techniques are presented. The aim of this chapter is to exploit the unique characteristics of SVC, to enhance personalized experience and to improve system performance in a wireless transmission system.

Preface

The advances in computation and networking, as well as the prevalence of media sharing on the net have significantly increased the availability of multimedia resources. There have been profound changes in the ways of multimedia acquisition, distribution and consumption. Streaming media is one of the most exciting and active research topics with continuing significant progress in the multimedia area, where streaming media has been experiencing dramatic growth and stepped into mainstream media communications. Multimedia data including speech, audio, animation and video is transmitted as a continuous stream in streaming media. As a result, the end user can enjoy on-the-fly representation of multimedia content without downloading the entire file beforehand. Consequently, real-time, interactive and progressive access to multimedia becomes a reality with the advent of streaming media. In the past decade, we have witnessed the great success of streaming media in network broadcasting, distant learning, digital library, and video on demand (VOD) among others. Nowadays, streaming media based services are becoming the mainstream of multimedia consumption. Motivated by its wide-ranging application potential, great efforts have been as well as are being dedicated to the research on steaming media to attack technical challenges as discussed in the following.

Streaming media is inherently a cross-disciplinary subject that involves information theory, signal processing, communication and networking etc. Coding and transmission definitely lie in the core position in streaming media, and these research topics have been extremely active in recent years. The real-time, flexible and progressive natures of streaming media impose demanding requirements on media coding and transmission. It is challenging to maintain the quality-of-service (QoS) of streaming applications over bandwidth constrained, error prone and highly dynamic networks. Extensive research has been conducted to develop effective coding and transmission schemes for streaming media.

During the past decade, the media communication system has evolved from the conventional desktop computing and wired communication to mobile computing and wireless communication. With the excellent mobility, wireless streaming has turned the on-demand access of rich media content anywhere on any device into a reality. It is believed that mobile phones will turn out to be the fourth screen following cinema, television and PC. Apart from the entertainment industry, wireless streaming can also find extensive applications in military and disaster rescue where wireless sensors are widely deployed. However, as the communication paradigm evolves from the conventional point-to-point, wired and centralized communication to the current wireless, distributed, ad hoc, and massive communication, the system becomes more and more complex and challenging. As a result, the research on wireless streaming has drawn tremendous attentions by both academia and industry.

As the Internet is still undergoing unprecedented innovations and expansion, novel network architectures keep emerging, which also sheds new light on streaming media. The emergence of P2P network

leads to an architecture shift from client-server streaming to P2P streaming. P2P streaming has become the most powerful and popular solution for large-scale streaming services due to its decentralization, self-organization, and flexibility. Given the initial success of P2P streaming, streaming media content over P2P networks is still fraught with great challenges. For instance, compared with P2P based file sharing applications, streaming over P2P networks imposes tighter timing requirements. Moreover, the limited and changing bandwidth of peers further complicate the problem of QoS control. Therefore, efficient protocol, coding and scheduling algorithms are desired to tackle the challenges in P2P streaming.

After more than a decade of development, substantial advances have been achieved in the diverse areas of streaming media, and a number of promising research directions are springing up. Following an open call for chapters and a few rounds of extensive peer-review, 17 chapters of good quality have been finally accepted, ranging from technical review and literature survey on a particular topic, solutions to some technical issues, to implementation of a practical streaming system, as well as perspectives of promising applications. According to the scope of those chapters, this book is organized into four sections, namely media coding, wireless/mobile video, P2P media streaming, and applications of streaming media. Below we briefly summarize the chapters in each section.

Section 1 (Chapter 1 to Chapter 5) focuses on media coding that is the key enabler for streaming media.

- Chapter 1 entitled "*Scalable Video Coding: Techniques and Applications for Adaptive Streaming*" covers the topic of making use of scalable video content in streaming frameworks and applications. Specifically, the recent standard H.264/SVC, i.e., the scalable extension of the widely used H.264/AVC coding scheme, and its deployment for adaptive streaming, the combined activities of content adaptation and streaming, are considered.
- Chapter 2 with the title "*Adapting Multimedia Streaming to Changing Network Conditions*" focuses on the application layer techniques that adapt to the changes in network conditions, including layered encoding, rate shaping, adaptive error control, and smoothing. The chapter also discusses operating system methods to support adaptive multimedia.
- Chapter 3 entitled "*2-D Scalable Multiple Description Coding for Robust H.264/SVC Video Communications*" investigates two popular techniques for error-resilient H.264/SVC video transmission over packet erasure networks, i.e., layered video coding (LVC) and scalable multiple description coding (SMDC). The authors compare the respective advantages and disadvantages of these two coding techniques. A comprehensive literature review on latest advancement on SMDC is provided. A two-dimensional scalable multiple description coding (2-D SMDC) scheme is presented.
- In Chapter 4 "*Dirac Video Codec: Introduction*", the authors present the fundamental architecture of the Dirac video encoder that is engineered by British Broadcasting Corporation (BBC) aiming at a wide range of applications from storage of video content to streaming video. The overall encoding structure is discussed followed by the detailed description of each coding component. Finally, the block diagram of Dirac's bitstream syntax is presented.
- Chapter 5 with the title "*3D Mesh Model Coding*" addresses the coding and streaming issues of 3D model. This chapter first surveys the typical algorithms in static and dynamic 3D meshes coding where the coding and streaming of gigantic 3D models are specially introduced. Moreover, the MPEG4 3D mesh model coding standard is also briefed. This chapter concludes with a discussion providing an overall picture of the developments in mesh coding and the directions for future research.

Section 2 (Chapter 6 to Chapter 10) addresses wireless and mobile video.

- Chapter 6 entitled "*A Cross-Layer Design to Wireless/Mobile video Streaming*" introduces a cross-layer approach to wireless/mobile video streaming system design. Beginning with the introduction to the motivation of the cross-layer design, this chapter covers fundamental issues, challenges and solutions of the cross-layer approach to video streaming systems for its practical employment.
- In Chapter 7 "*Bitrate Adaptation of Scalable Bitstreams in a UMTS Environment*", the authors propose a complete streaming framework for a wireless, in particular a 3G/UMTS, network environment. The authors also describe choices one can make in terms of network architecture and then focus on the input parameters used to evaluate network conditions and to perform the adaptation. A particular attention is dedicated to the protocol information that can be exploited to infer the channel state. In addition, each implementation choice is a compromise between the industrial feasibility and the adaptation efficiency.
- Chapter 8 entitled "*Robust Video Streaming over MANET and VANET*" studies the technical issues of video streaming over both Mobile Ad Hoc Networks (MANETs) and Vehicular Ad Hoc Networks (VANETs). This chapter shows how streaming can take place in those challenging environments. Error resilience and path diversity are presented as the key to robust streaming. As a form of management of streaming, distributed sourcing via peer-to-peer streaming over diverse paths is explored within VANETs.
- Chapter 9 with the title "*Scalable Video Delivery over Wireless LANs*" presents a comprehensive study on the transmission of scalable video over wireless local area networks (WLAN). The authors give an analysis of the mechanisms and principles of the emerging scalable video coding (SVC) standard. Moreover, some studies of SVC over WLAN using cross-layer design techniques are presented. The aim of this chapter is to exploit the unique characteristics of SVC, to enhance personalized experience and to improve system performance in a wireless transmission system.
- Chapter 10 entitled "*Video Delivery in Wireless Sensor Networks*" focuses on the analysis of the state of the art video delivery and data routing techniques for wireless video sensor networks. This chapter is intended to inspire additional efforts leading to video routing techniques optimized to different topologies, the physical medium, network channels, and energy constraints.

Section 3 (Chapter 11 to Chapter 14) deals with P2P media streaming.

- Chapter 11 entitled "*Peer-to-Peer Networks: Protocols, Cooperation and Competition*" discusses P2P systems that have been deployed in file sharing and real-time media streaming. The authors discuss the limitations of the implementations for existing P2P-based file sharing and media streaming applications in detail. More advanced resource reciprocation strategies, where peers make foresighted decisions on their resource distribution in a way that maximizes their cumulative utilities are also discussed.
- Chapter 12 with the title "*A Survey of P2P Data-Driven Live Streaming Systems*" presents a survey of "data-driven" or "unstructured" peer-to-peer live media streaming techniques, which have been introduced in the recent years to overcome the limitation of classic application-layer tree overlays.
- Chapter 13 entitled "*Epidemic Live Streaming*" is intended as an introduction of epidemic live streaming. In this chapter, the authors propose some simple metrics to understand the behavior of a diffusion algorithm, and they use elementary diffusion schemes to understand the basics of the

diffusion process, for both homogeneous and heterogeneous systems. The proposed approach mixes theoretical results, when available, with empirical observations in order to give the best possible insights.

- In Chapter 14 "*A Chunkless Peer-to-Peer Transport Protocol for Multimedia Streaming*", the authors describe a P2P transport protocol suited for multimedia streaming. The described protocol is characterized by the robustness to data losses and the low-start times. From the application point of view, the proposed protocol appears as a transport protocol similar to TCP or UDP.

Section 4 (Chapter 15 to Chapter 17) presents some application-driven research on streaming media.

- Chapter 15 with the title "*Low Latency Audio Streaming for Internet-Based Musical Interaction*" covers the technical issues related to the subject of playing live music with musicians distributed over the Internet. In this chapter, the author first outlines purely human cognitive restrictions in context with the problem of latency. Based on these restrictions, a comprehensive technical overview is given, finally leading to a taxonomy of appropriate interaction approaches.
- Chapter 16 entitled "*The 3rd Generation Partnership Project Packet-Switched Streaming (3GPP-PSS): Fundamentals and Applications*" embodies the chronological advances of 3GPP-PSS, whose specifications define the framework for streaming capabilities for 3GPP mobile devices and networks. The discussions on the general specifications of different releases are also provided in this chapter with a focus on the Quality of Service (QoS) support.
- In Chapter 17 "*Perspectives of the Application of Video Streaming to Education*", the author analyses the application of video-streaming in video-lectures. An overview of several related research topics is presented in this chapter, including video-lecture summarization, automatic extraction of text from the audio track, lecture segmentation, search, semantic indexing and multimodal access, gesture analysis, and annotation of the videos.

As can be seen from the above introductions, this book spans a number of interdependent and emerging topics in streaming media. In conclusion, we aim to acquaint the scholars and practitioners involved in the research and development of streaming media with such a most updated reference on a wide range of related topics. The target audience of this book would be those interested in various aspects of streaming media, such as coding, transmission, architecture and applications. This book is meant to be accessible to audiences including researchers, developers, engineers, and innovators working in the relevant areas. It can also serve as a solid advanced-level course supplement to media processing and communications for senior undergraduates and postgraduates.

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