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Ubiquitous Multimedia Computing

Edited by
Qing Li
Timothy K. Shih

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Ubiquitous Multimedia Computing

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Qing Li and Timothy K. Shih

Foreword

"Computing is ubiquitous" has become a cliché that is now used without much thought. The phrase, while undoubtedly true, hides a considerable amount of complexity. Ubiquity is not only due to the fact that we use computing in our daily lives, but it is also a function of the characteristic of the computing environment. Today's computing environment is rich, consisting of multiple media types accessed over distributed environments.

Consider what "modern" computing meant only a decade ago. We were excited that we could do textual searches over the World Wide Web, even if the precision of the results received were not high and even if it was slow (thus the phrase "World Wide Wait"). Image processing techniques that would scale up to large data sets were still uncommon, and delivery of video over wide area networks was thought to be only possible with special broadband networks such as Asynchronous Transfer Mode (ATM), in many cases separate from the more commonplace Internet connections. Although we talked about multimedia, what we had was, at best, multiple systems dealing with different media types. Certainly integrated systems that could handle multiple media types and provide users with a clean interface were not common.

Consider the environment today. Many of the computing systems that we use every day ubiquitously handle multiple media types, and the ability to search across (at least) text and images in a uniform way is being built into browsers whose accuracies have improved considerably. Sites such as YouTube have become repositories of user-supplied video that is now delivered ubiquitously over the Internet. The networks that now make up the Internet have widely implemented the above mentioned broadband network protocols in their core, making it possible to run many applications with heavy media demands (e.g., remote sensing, remote surgery, and the like). Social networking sites such as Facebook, Picassa, and Flickr are repositories of large amounts of images that can be shared, tagged, and searched. Most certainly the computing environment of today is richer involving multimedia more ubiquitously.

This should not be taken to mean that all is done and all of the major problems are solved. Far from it; there is still much work to do on a wide variety of fronts. We still need to find better ways of storing and accessing multimedia data, better precision and recall of retrieval systems, better user interfaces to access this media including ways to consider user preferences and context, better handling of mobile devices in this environment, and the list goes on.

This book contains chapters that address many of these issues. The wide coverage of the book is an indication of the complexity of finding an integrated solution to these problems. The book will undoubtedly be very welcome by both practitioners and researchers in this area that continues to occupy many of us.

M. Tamer Özsu

Introduction

Events in cyberspace can be modeled in a spatiotemporal continuity by computing devices, communication channels, and multimodal interactions. Contemporary ubiquitous devices unleash the boundary of one-to-one human–computer interaction. Someone using a device somewhere through multimodal interactions has now become a *de facto* style of facilitating social events. How people access multimodal media in different contexts is an interesting yet challenging problem. Ubi-Media Computing, as it is bravely defined, brings together technologies for location–context adaptation, inter-device interaction–reaction, and media–data communication.

This book aims at revealing the fundamental technologies and potential research focuses of Ubi-Media Computing. The notion of context is not new. Context may include semantics information as defined in information retrieval. However, with the rise of mobile personal device use, the meaning of context could be extended to include location information, types of personal devices and their capacities, personal preferences, as well as the scenario where events occur between machines and the real world (i.e., searching for nearby restaurants). The new scenario of *interaction* under different types of contexts is more complicated. The multimodality need should be defined between different contexts and types of interactions. On the other hand, interaction among a group of people relies on typical *multimedia* communication technologies. Although communication via audio became popular on cellular phones, the need for short messages, file transfer, and video streaming was recognized by mobile device vendors. How to efficiently use media for communications and how to design a generic-friendly, multimodal user interface for easy use remains a challenge. The development of a new style of multimodal multimedia interaction will need sophisticated adaptation techniques for different mobile devices under different contexts.

The book discusses Ubi-Media Computing on three levels: infrastructures, where fundamental technologies need to be developed; middleware, where the integration of technologies and software systems need to be defined, and applications, where usage cases in the real world need to be realized.

Part I (Ubi-Media Infrastructure) contains five chapters. Chapter 1 is a survey to discuss various architectures for delivering multimedia content to users. The discussion starts from a uni-cast architecture. Challenges in multicast architecture follow, with a comparison to traditional uni-casting. The authors finally point out the advantages of using peer-to-peer (P2P) streaming technologies to reduce server load and network bottlenecks. With a focus on audio communication, Chapter 2 studies parameter values of control schemes on two-party VoIP (Voice over Internet Protocol) systems. The study and experiments suggest that the subjective preferences of users could be tested against different parameters and evaluated to review the impact-to-user satisfaction. The accuracy and efficiency of conducting subjective tests are also addressed. Chapter 3 is about architecture for video communication over wireless networks. Especially, the standard of 3G circuit-switched mobile video (3G-324M) is discussed. In addition, Chapter 3 discusses usages of video sensor devices to be connected to networks like UMTS and WiMAX. As a result, the hybrid network is able to deliver sensor video streaming to terminals anywhere. In contrast to the first three chapters focusing on communication, Chapter 4 discusses the security issues of peer-to-peer networks. A reputation-based mechanism, without centralized control, points out the importance of automatically recording, analyzing, and even adjusting the metrics of reputation, trust, and credibility among peers. Chapter 5 points out the three main tasks of a sensor (i.e., sensing, processing, and transmitting data), by providing a task-flow graph as a theoretical model to evaluate the upper and the lower bounds of using a different number of data collection sensors under different scheduling algorithms.

Part II of this book (Ubi-Media Middleware) has six chapters on various software technologies for interaction, message embedding, and indexing. Chapter 6 presents a project that involves the use of a wearable computer and static sensor networks as remote sensing devices in a large-scale factory, especially in security control. Access points of the wireless network are used to connect sensors and wearable computers. In addition, a middleware developed under Linux is presented to enable seamless connections. The next two chapters demonstrate the usage of finger gestures and advanced devices to provide friendly human–computer interactions. Chapter 7 presents a set of finger gesture commands on multitouch screens to control document accessing among multiple users, as well as providing a set of interactive commands for resizing documents and creating user working areas. A practical implementation called JuTable is also presented. In addition to using a gesture interface of a stick shape object (enhanced based on a Wii controller), the authors of Chapter 8 create a two-dimensional sound display called Sound Table (with 16 speakers) for supporting collaborative work. Feedback to users can also be presented using video. Applications of this system include creating music by manipulating a number of sound objects. A digitally enhanced printout concept, called *newsputers*, is introduced in Chapter 9. Newsputers are applicable to conventional printed materials by providing embedded image information, which does not interfere with ordinary reading. The interaction through a scanner allows users to access multimedia information. It is also possible to extend the technique to include semantic information such that an object with newsputers has self-awareness functionality. Chapter 10 discusses mechanisms to embed secret messages into innocuous looking objects, known as covers. An efficient message embedding method for minimizing the embedding impact is presented. Chapter 11 is a survey of using color, shape, texture, motion, and additional information in searching for multimedia objects. Applications of such a retrieval technique include a Web image search on mobile devices.

Part III (Ubi-Media Applications) contains six chapters of applications using ubiquitous and multimedia technologies. Chapter 12 presents a system that allows users to save, retrieve, and share so-called serendipitous moments by means of location-aware multimedia objects. The application can be developed based on technologies such as P2P communication on mobile devices and the usage of Google Map. Chapter 13 presents a similar intelligent travel book management system using a PDA or cellular phone. Multimedia information supported in the system includes photos, audios, videos, and notes taken on the journey. A traffic congestion alleviation system discussed in Chapter 14 uses Vehicular Ad hoc NETworks (VANET) and GPS-enabled devices. Two types of communication modes: vehicle-to-roadside and vehicle-to-vehicle, are addressed. Chapter 15 presents a system using RFID in emergency room operations. The chapter reports on the findings of a case-based research investigation in a hospital. The RFID is applied in emergency room workflow as a new service to ease patient waiting time, and accuracy for patient treatment, and prevent human errors. The last two chapters discuss practical usages of ubiquitous and multimedia technologies in education. Chapter 16 presents a multiagent architecture for supporting users learning the ubiquitous environment. The agents sense users' physical locations automatically, find the suitable learning map, plan the learning route, and guide the users in the real world. Chapter 17 presents alternatives of using intelligent tutoring techniques with adaptive media. The authors conclude that the learning experiences will come to users in response to their strengths and prior learning, interests, and aspirations.

With the continued and increasingly attracted attention on ubiquitous multimedia computing, we foresee that this fast growing field will flourish as successfully as what the Web has achieved over the past decade and a half. We hope the readers will like this book and enjoy the journey of studying the fundamental technologies and possible research focuses of Ubi-Media Computing. While the book is intended to be a timely handbook for researchers and senior-postgraduate students, it can also be a useful reference book for other professionals and industrial practitioners who are interested in learning the latest technology and application development in this increasingly important field.

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Part I

Ubi-Media Infrastructure

1

Peer-to-Peer Streaming Systems

Victor Gau, Peng-Jung Wu, Yi-Hsien Wang, and Jenq-Neng Hwang

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1.1 Introduction

For more than a decade, content providers have been trying to deliver multimedia content to end users via the Internet. Before the introduction of streaming technology, users needed to first download complete multimedia content from the Internet down to their own storage before being able to play back the content. Owing to the development of streaming technology, users can playback content while downloading.

In an earlier age, multimedia content was only delivered via client/server architecture. One of the reasons is that at that time the computing power of a regular PC was insufficient to be a server. A server needs to serve requests from many users and requires much computing power. Most end users could not afford to buy computers with such server capabilities. As users' demand for multimedia content grew and the power of their machines increased, Internet Service Providers (ISP) and Internet Content Providers (ICP) figured that there will always be scalability and cost problems from only deploying client/server architectures. Subsequently, Peer-to-Peer (P2P) technologies started to receive the spotlight.

The idea of P2P networks is in contrast to client/server architectures. In a client/server architecture, dedicated servers are deployed to serve clients. However, as common PCs have increasingly more computing power, a lot more processing load can be distributed to the client side. Therefore, the roles of clients and servers have changed. In P2P networks, there are not clear roles for servers and clients; instead, peers share duties with both. At times, peers act as servers, and at times, as clients. By using P2P technologies, the load and cost of the servers are distributed to and shared by peers. Especially after the impact of Skype and BitTorrent on telephony and file sharing, ISPs and ICPs are more and more interested in P2P technologies.

1.1.1 Peer-to-Peer Streaming Systems

P2P streaming systems have been recently garnering more and more attention, because most people believe that IPTV is the next killer application and that P2P technologies will be the key to solve the scalability and cost problem. Basically, there are two ways of applying P2P technologies to reduce the cost and load on the server side. First, the media content can be distributed into peer networks, rather than being stored in centralized repositories. In such cases, peers are used as shared storage and requests for the content are directed to the peers that keep the content. Second, the media content can be relayed by peers instead of servers.

Typical modules within P2P streaming systems are shown in Figure 1.1. The *content lookup substrate* is in charge of content lookup or content discovery. The *streaming control module* is in charge of peer management and multicast

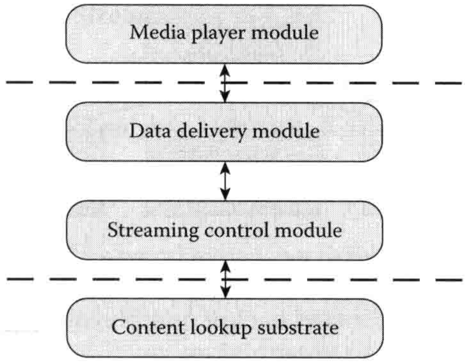

FIGURE 1.1
Modules within a peer of a P2P streaming system.

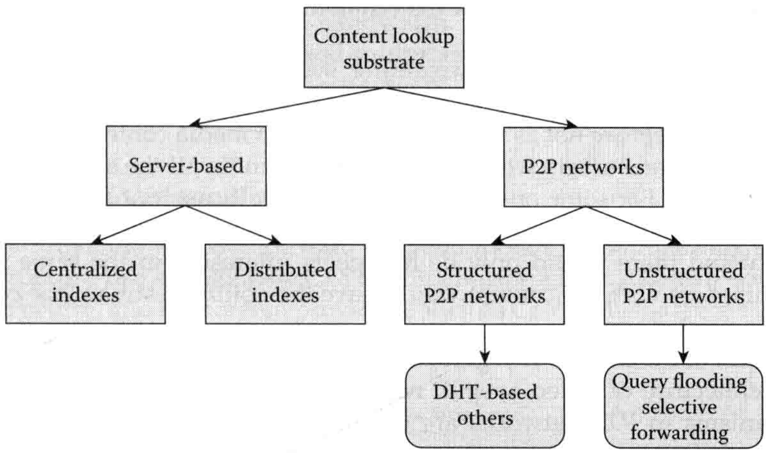

FIGURE 1.2
Categories of content lookup substrates.

topology maintenance. The *data delivery module* is in charge of data exchange among peers. The *media player module* is in charge of media playback.

Based on the way the protocols distribute and discover the content in the content lookup substrate, P2P networks can be categorized into structured P2P networks and unstructured P2P networks (see Figure 1.2). In structured P2P networks almost all protocols use a Distributed Hash Table (DHT) to manage content distribution and discovery. In unstructured P2P networks, most protocols simply flood the network with requests to discover content.

Based on the data delivery mechanisms of the networks controlled by the streaming control layer, the P2P networks can be categorized by whether they use tree-push, mesh-pull, or push-pull methods (see Figure 1.3).