Preface

Computing systems are playing an essential role as an indispensable nervous system of modern society. The ubiquitous use of computing systems for the operation of our society, such as in our banking, public transportation, and healthcare systems, and in our daily lives for meeting our personal learning, entertainment and productivity needs, has resulted in them being of fundamental importance to keeping our modern society alive and thriving. The subsequent trend of integrating computing systems with communication networks such as the Internet further extended the reach of computing systems beyond geographical boundaries, ushering in an era of networked computing systems.

Computer-mediated communication for distant human-to-human interaction, that is computer telephony systems, has become a cost-effective alternative to traditional telephone networks (Yarberry, 2002). Distant human-to-machine interaction has also benefited from the advent of networked computing, such as by enabling remote access to computing resources such as shared printers and databases. More recently, machine-to-machine (M2M) interaction has been a subject of interest in networked computing where machines leverage on their network (wired or wireless) connectivity to directly interact with each other and in some cases make their own decisions without human intervention (Lawton, 2004).

Networked computing systems have traditionally been based on the client-server model (Goodyear et al., 1999). In this architecture, the network consists of a server, typically a high-performance computer, and a group of clients. The server is the only provider of resources or services in the network, while the clients only request for resources or the execution of services from the server. It is apparent that each addition of a new client to the network is a new load added to the server. As the number of clients grows, the server capacity must increase to avoid becoming a bottleneck in the system. It is also apparent that in this model, the server represents a single point of failure in the network, and thus can be a major cause of downtime and a vulnerable target for security attacks.

In recent years, the development of networked computing has evolved from the centralized and hierarchical model of client-server computing to encompass a more decentralized and distributed model of peer-to-peer (P2P) computing (Subramanian & Goodman, 2005). Using the widely-accepted definition by Schollmeier (2001), P2P is a network where the participants share a part of their own resources, which can be hardware resources such as processing power, storage capacity, network link capacity, printers, and so forth, or software resources such as media content, (e.g., pictures, videos and music files, and other digital content) information stored on databases, necessary to provide the service or content offered by the network. These resources on independent peers are in turn accessible by other peers directly without going through intermediate central control entities (i.e. the servers). The participants of such a network are thus serving as resource (service and content) providers as well as resource (service and content) consumers.

Due to its promising potential to resolve the above issues of scalability and fault-tolerance in client-server computing, this radical and contrasting approach to computing has gained significant attention from both industry and academic research communities, and is suited for applications that have a mass of users in complex open distributed environments such as the Internet. Today, P2P technologies have been widely embraced by Internet users, and are best exemplified by popular file sharing systems such as eMule or BitTorrent, and Voice-over-P2P (VoP2P) applications such as Skype. Other emerging applications based on P2P that are gaining popularity include live or on-demand media (TV and video) streaming applications, for example, Joost, Zattoo, and PPLive (Krieger & Schwessinger, 2008; Mushtaq, & Ahmed, 2008; Akkanen, Karonen, & Porio, 2008), and large-scale distributed online storage systems such as Wuala (Caleido AG, 2008), which provides its users with free online storage service for private or shared data by exploiting the unused disk space of participating computers on the Internet.

In a parallel development with Internet P2P computing from late 1990s, the landscape of telecommunications also experienced profound changes with the rapid proliferation of a plethora of wireless technologies ranging from technologies for wide area networks (e.g., UMTS, HSDPA, HSPA+), metropolitan area networks (e.g., Mobile WiMAX [802.16e], Mobile-Fi [802.20]), local area networks (e.g., 802.11a/g/n/p/s), personal area networks (e.g., Bluetooth, ZigBee, WiMedia), to more recently regional area networks based on emerging cognitive radios (802.22). Today, wireless-enabled laptops and PDAs, and cellular handsets with Internet access have become widely available and increasingly affordable. It is also not uncommon to find *multi-mode* terminals where computing devices or handsets have multiple modes of wireless connectivity such as 3G UMTS, WiFi (802.11) and Bluetooth. These technological advances are believed to have fueled the uptake of a *mobile lifestyle* where the daily lives of people are increasingly empowered by and dependent on wireless technologies. For instance, the increasing need of people to stay connected to the Internet at anytime from anywhere for work or for play. This brings forth a prediction that a significant portion of future users of P2P systems will be mobile, which calls for a need to investigate the suitability of developed P2P technologies for mobile and wireless networks, such as mobile cellular networks, infrastructured wireless local area networks (WLAN), and the infrastructureless mobile ad hoc networks (MANET).

Early investigations along this direction (such as Klemm, Lindemann, & Waldhorst, 2004; Ding & Bhargava, 2004) for MANET, and (such as Eberspächer, Schollmeier, Zöls, Kunzmann, & Für, 2004) for a heterogeneous mobile and fixed environment, have shown that contemporary P2P technologies performed neither well nor efficiently as they were designed for a relatively stable and resource-rich environment where hosts are stationary, *well-endowed* (i.e., in terms of processing power, memory, and energy) and connected by high bandwidth links. Thus, research is needed to innovate new approaches to P2P computing in a mobile environment. Specifically, the design of the mobile P2P systems should address the new challenges of dynamic changes in connectivity and resource availability, the new constraints in mobile devices as well as wireless capacity, and respond to these constraints and changes in an intelligent, timely, and adaptive manner. However, the research possibilities of Mobile P2P computing are not limited to extending conventional P2P systems to perform effectively and efficiently under mobile conditions, but include, for instance, turning the new constraints into strengths by finding new usages of unique characteristics of mobile P2P, or creating new patterns of collaboration and sharing that can potentially move mobile applications and services into a new dimension for next generation distributed environments.

This book is dedicated to the coverage of research issues, findings, and approaches to mobile P2P computing from both conceptual and algorithmic perspectives. Authored by some of the most leading

experts in the field, and guided by an Editorial Advisory Board of prominent international researchers, the overall aim of this book is to serve as a valuable resource that captures the present state of the field, and to inspire ideas for future challenges through presenting the latest insights and thoughts of expert researchers on major topics of this emerging discipline.

The key contribution of this book is in providing a much needed body of knowledge on mobile P2P computing in a single reference source, which to the best of our knowledge, is still largely missing from currently available book titles. Through a careful selection of topics that address some of the most important and essential issues in the field, including topics of both theoretical (e.g., models, algorithms, architectures) and practical interests (e.g., tools, platforms, applications), this book seeks to fill the gap in available titles with its dedicated and comprehensive coverage on mobile P2P computing. Readers would also benefit from the scholarly value of the book through its balanced and quality coverage of theoretical ideas and practical research. This book therefore comes as a timely contribution to the growing and flourishing research community in mobile P2P computing.

The book is intended to provide an up-to-date advanced reading of important topics for academic researchers, graduate students, and senior undergraduate students in computer science, electrical and electronic engineering, and telecommunications, to enhance their research or studies. It is also intended for industry professionals such as R&D engineers, application developers, and technology business managers who wish to keep abreast of the recent developments in the field, and who are interested or involved in the research, use, design, development, and deployment of mobile P2P technologies.

This book is organized into eight sections comprising a total of 21 chapters. Each section addresses a specific topic area or relates to works of a specific nature. Under each section, the chapters are generally self-contained, thus readers are not required to read in the order in which they are listed, but could focus directly on those chapters that interest them. The following is a summary of contents covered in each section, including a brief description of each chapter listed under the section.

Section I: Information Retrieval and Dissemination

This section includes two chapters that look at the issue of information retrieval and dissemination, each exploring a different approach to addressing the issue.

Chapter I presents an enhanced Distributed Hash Table (DHT) to facilitate information retrieval (or lookup), and a new multicast tree construction algorithm built on top of the proposed DHT to construct a multicast tree distribution infrastructure for efficient information dissemination in mobile ad hoc networks.

Chapter II proposes to adaptively disseminate special information called content synopses and presents a content-driven routing protocol that utilizes this information to efficiently guide the queries for actual content or information retrieval.

Section II: Overlay and Mobility Management

This section includes three chapters covering overlay construction, mobility support in overlay networks in the context of publish/subscribe systems, and performance study of P2P overlay and MANET routing protocols. Specifically:

Chapter III reviews P2P overlay construction techniques for mobile networks, including tree- and mesh-based mobile P2P streaming networks. The authors also discuss advanced design issues, such as session mobility, robustness to high churn, incentive mechanism and content integrity, with relation to managing mobility in P2P overlays.

Chapter IV examines the issue of subscriber mobility in publish/subscribe systems and presents a new mobility support solution through proactive context distribution, which is shown to perform better in terms of message loss/duplication, processing overhead and handoff latency than the conventional reactive approach.

Chapter V investigates the performance of three MANET routing protocols: AODV, DSR, and DSDV under a Gnutella P2P network, and two P2P overlay protocols: Gnutella and Chord, over MANET with AODV as the underlying routing protocol through extensive computer simulations.

Section III: Cooperative Mechanisms

This section includes four chapters devoted to discussing the different mechanisms and applications of peer-to-peer cooperation in mobile networks.

Chapter VI outlines the current methods for cooperation in standard and MANET-based P2P networks. The authors also describe a number of use cases to illustrate the potential of peer-to-peer cooperation technology for mobile networks, including for such applications as knowledge sharing and social networking.

Chapter VII identifies selfish peers as a factor that degrades performance of P2P content distribution systems in cellular mobile networks and studies several cooperation strategies, including a new strategy CyPriM proposed by the authors to improve performance in the presence of selfish peers and heterogeneous peer resources.

Chapter VIII extends the discussion in the preceding chapter to consider the impact of mobility and vertical handover in a B3G network. The authors evaluate solutions such as mobile IP in the context of P2P content distribution, and present new strategies to manage mobility and improve utilization of scarce resources in such heterogeneous networks.

Chapter IX reviews the problem of cooperative cache management in mobile environments that support data broadcast, and presents two peer-to-peer based schemes: CPIX and ACP for caching and pre-fetching information, respectively, to improve the data availability and access latency in mobile environments.

Section IV: Resource Management

This section includes two chapters on methods to foster resource sharing among peers: one in the context of P2P media streaming in hybrid wireless networks; the other on general resource sharing in ad-hoc networks.

Chapter X focuses on energy cost sharing in wireless P2P media streaming, and presents two energy efficient protocols based on game-theoretic concepts to improve collaboration and streaming performance of peers in hybrid wireless networks.

Chapter XI present the case for social incentives to be used to foster resource sharing in ad hoc networks, and proposes a new *cross-layer* concept that considers both social and economic solutions in application layer and network layer, respectively, in the design of incentive mechanisms.

Section V: Security

This section includes two chapters that concern security: one relates to the design of group key management schemes for mobile ad hoc networks; the other looks at the development of secure mobile P2P applications.

Chapter XII provides a comprehensive coverage of conventional group key management schemes for dynamic peer groups, and discusses their design challenges and potential for MANET through an analysis of their communication and computation costs.

Chapter XIII presents a development tool that considers the user's security, mobility, and P2P technology requirements, and proposes a suitable system architecture and sub-system designs for developing secure mobile P2P applications.

Section VI: Standards and Protocols

This section includes two chapters that cover current standards and protocols of interest to the research and development of mobile P2P systems. Specifically:

Chapter XIV discusses the relevance of ITU standard architecture for next generation networks, and presents an overlay architecture for integrating P2P systems in interoperable fixed-mobile environments based on the IP Multimedia Sub-system (IMS) technology.

Chapter XV reviews the current IETF standard for P2P-SIP (Session Initiation Protocol), which is designed to serve as a lightweight P2P based protocol for communication, session management, and service provisioning in infrastructured mobile networks such as wireless LAN and 3G cellular networks.

Section VII: Architectures and Platforms

This section includes three chapters on new architectures and platforms, including a new content-distribution architecture for cellular networks, a P2P networking platform for mobile phones, and a platform for emulation of P2P algorithms for MANET.

Chapter XVI first discusses the current incompatibilities between cellular mobile and P2P networks, and then presents a new P2P architecture for cellular mobile networks using content-distribution as an example application. The authors also investigate extensively the proposed architecture using analytical and simulation-based evaluation.

Chapter XVII describes the architecture and protocols of a new P2P networking platform for mobile phones, and discusses the experimentation of the platform using three classes of mobile phone applications namely, multimedia content search, instant messaging over Bluetooth, and remote access to networked home appliances.

Chapter XVIII presents Freemote, a Java-based emulation platform that could integrate emulated and real nodes such as the Berkeley motes to enable large-scale emulation of P2P algorithms for MANET with a high level of realism.

Section VIII: Applications and Services

This section includes three chapters that look at the development of collaborative applications, service discovery, and context-awareness in mobile P2P services. Specifically:

Chapter XIX describes the Peer2Me software framework for developing P2P applications that support collaboration on mobile phones with JavaME and Bluetooth. The authors also illustrate the potential use of the framework through a portfolio of developed applications that demonstrate a wide spectrum of collaborative functions.

Chapter XX presents a comprehensive coverage and comparative analysis of the current service discovery approaches in P2P systems for a variety of mobile networks, including infrastructured wireless networks, single-hop and multi-hop ad hoc networks.

Chapter XXI discusses the use of context to enhance distributed services in opportunistic networks, and describes two context management architectures and their use in a context-aware opportunistic file sharing application that considers not only the social context of user, but also the utility of data objects for the context the user is in.

REFERENCES

Akkanen, J., Karonen, O., & Porio, J. (2008). Peer-to-peer video streaming on mobile phones, In *Proceedings of the IEEE Consumer Communications and Networking Conference*.

Caleido AG (2008). *Wuala – The social online storage*, Retrieved December 28, 2008, from http://wuala.com/en/

Ding, G., & Bhargava, B. (2004). Peer-to-peer file-sharing over mobile ad hoc networks. In *Proceedings of the Second IEEE Annual Conference on Pervasive Computing and Communications Workshops*.

Eberspächer, J., Schollmeier, R., Zöls, S., Kunzmann, G., & Für, L. (2004). Structured P2P networks in mobile and fixed environments, In *Proceedings of the International Working Conference on Performance Modeling and Evaluation of Heterogeneous Networks*.

Goodyear, M. et al., (1999).Netcentric *and client/server computing: A practical guide*. USA: Auerbach Publications.

Klemm, A., Lindemann, C., & Waldhorst, O. P. (2004). Peer-to-peer computing in mobile ad hoc networks. In *Proceedings of the 11th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems*.

Krieger, U. R., & Schwessinger, R. (2008). Analysis and quality assessment of peer-to-peer IPTV systems. In *Proceedings of the IEEE International Symposium on Consumer Electronics (ISCE)*.

Lawton, G. (2004). Machine-to-machine technology gears up for growth. *Computer, 37*(9), 12-15.

Mushtaq, M., & Ahmed, T. (2008). P2P-based mobile IPTV: Challenges and opportunities. In *Proceedings of the IEEE/ACS International Conference on Computer Systems and Applications*.

Schollmeier, R. (2001). A definition of peer-to-peer networking for the classification of peer-to-peer architecture and applications. In *Proceedings of the First International Conference on Peer-to-Peer Computing*.

Subramanian, R., & Goodman, B. D. (Eds.). (2005). *Peer-to-peer computing: The evolution of a disruptive technology*. Hershey, PA: Idea Group Publishing.

Yarberry, W. A. (2002). *Computer telephony integration*. Boca Raton, Florida: CRC Press.