

Guest Editorial

Mobile Computing and Networking

ADVANCES in the technologies of networking, wireless communications, and miniaturization of computers have led to rapid development in *mobile communication* infrastructure, and have engendered a new paradigm of computing. Different wireless technologies, such as general packet radio service (GPRS), IEEE 802.11-based local area networks (LANs), and Bluetooth, have been providing wide area, local area, and short-range connectivity, respectively. In such an environment, users are not tethered to a network; rather, they communicate through a wireless medium. Meanwhile, access devices have been getting smaller and smaller. There is an array of devices including laptops, palmtops, and cell phones. Applications are becoming heavier, and user density is on the rise. Users carrying portable devices can freely move around, while still being connected to the network. This provides flexibility in accessing information anywhere and anytime. On the other hand, this flexibility has introduced new levels of complexity that were not encountered in software and protocol design in wired networks. Data and resource management, power conservation, mobile middleware, and security are among the key problems for which new solutions are needed. In addition, multidimensional trade-offs among energy utilization, bandwidth allocation, and various performance criteria must be considered. System designers have been facing the challenges of using constrained bandwidth, limited battery power, and unreliable wireless channels to develop protocols and application software systems.

This special issue focuses on applications, services, middleware support, and protocol design in mobile computing. We received more than 50 submissions from around the world, and many good quality papers could not be accommodated. The 14 accepted papers cover several important topics in mobile computing and networking: services, mobile middleware, wireless access, resource management, security, and infrastructure. These papers include both theoretical results—analysis, modeling, and simulations—and system implementation. We present these papers in the order of the listed topics.

There are three papers addressing some important issues in services provided by wireless systems. In “Event-Driven Messaging Services Over Integrated Cellular and Wireless Sensor Networks: Prototyping Experiences of a Visitor System,” Tseng *et al.* propose to establish an event-driven messaging service over an integrated network, which adopts the GSM as a cellular network and Bluetooth technology as a sensor network. In the prototyped system, Bluetooth is used for surveillance and GSM is used to support instant messaging services. The detection latency of the sensor network is modeled via performance analysis. The proposed system justifies the potential of cross-network applications and services. In “MultiServ: A Service-Oriented Framework for Multihop

Wireless Networks,” Zhang *et al.* present a service-oriented framework called MultiServ, which is built upon the overlay concept, to provide enhanced quality-of-service (QoS) for multiple services in wireless networks. Overlay network construction that deals with the neighbor selection, and multipath routing in the overlay network, are addressed. The proposed framework employs a distributed rate-based forwarding algorithm that can reduce the burst of different traffic streams and, hence, the service fluctuation. In “A Service-Centric Model for Wireless Sensor Networks,” Gračanin *et al.* introduce a novel framework for modeling sensor networks. The bulk of the published research takes a microlevel view of the network and nodes, focusing on resource and data attributes. The paper promotes a higher level view of the network that captures the provided services. A mapping of this network abstraction to the microlevel view is also suggested.

The next three papers address some important issues in mobile middleware. In “Joint Connection-Level and Packet-Level Quality-of-Service Support for VBR Traffic in Wireless Multimedia Networks,” Huang and Kuo investigate the QoS provisioning problem at both the connection-level and the packet-level for multimedia applications in the next-generation (i.e., packet-switching) wireless networks. The authors propose call admission control (CAC) schemes that can jointly provide connection-level QoS (in terms of the new call blocking probability and the handoff dropping probability) and packet-level QoS (in terms of the packet loss probability) for wireless multimedia networks. Stationary CAC schemes are proposed as the results of the solution to constrained optimization problems. A dynamic CAC scheme that can be adapted to varied and varying traffic conditions is also proposed. In communication protocol design, in general, there is a tradeoff between smoothness and responsiveness. However, in “The Dynamics of Responsiveness and Smoothness in Heterogeneous Networks,” Tsaoussidis and Zhang uncover undesirable dynamics of the protocols in the context of wireless/mobile networks with high error rate or frequent handoffs, i.e., low responsiveness is not counterbalanced by gains in smoothness but instead, produces a conservative behavior that degrades protocol performance with both delay-tolerant and delay-sensitive applications. Based on their observations, as well as on further analysis of the impact of the bottleneck queue on channel utilization, the authors seek an alternative strategy for smooth window adjustments. They introduce a new parameter to implement a congestion avoidance tactic and reaches better smoothness without damaging responsiveness. The next paper, “Using TCP Flow-Aggregation to Enhance Data Experience of Cellular Wireless Users,” by Chakravorty *et al.*, describes the design and implementation of a transparent transmission control protocol (TCP) proxy for improving the performance of wireless data users of GPRS networks. The authors demonstrate significant performance gains using their architecture by using real traces and conducting experiments on a commercial GPRS network.

Packet interference is an important issue in wireless access networks. In "Analysis of Packet Interference and Aggregated Throughput in a Cluster of Bluetooth Piconets Under Different Traffic Conditions," Naik *et al.* present a novel technique for analyzing packet interference in a heterogeneous cluster of Bluetooth piconets that use multislot packets. The technique is based on the concept of probabilistic graphs. The authors explain how to construct such graphs, and how to use them to compute packet interference in a heterogeneous cluster of piconets. The developed model can be employed to help form the optimal (or near-optimal) configuration of a cluster of piconets to gain maximum (or close to maximum) aggregated throughput. The next paper, "Adaptive and Predictive Downlink Resource Management in Next-Generation CDMA Networks," Wang *et al.* studied the issue of resource management in code-division multiple-access (CDMA) networks. Two schemes for guard channel reservation in CDMA cellular systems are proposed to minimize handoff call dropping. The first scheme adaptively adjusts the guard channel based on the measurement of handoff dropping probability, and the second scheme extends the first by predicting the handoff rates. In the context of Third-Generation Partnership Project (3GPP), the paper, "One-Pass GPRS and IMS Authentication Procedure for UMTS," by Lin *et al.*, proposes an authentication solution. The solution uses the authentication protocol at the GPRS level, originally proposed in the 3GPP specifications, to verify that the mobile station (MS) is a legal GPRS user. The GPRS authentication protocol is extended to verify that the MS is a legal IP multimedia core network subsystem (IMS) user. The paper presents cost models and a proof of correctness.

The next five papers address some important problems in mobile communication infrastructures. In "Quality-of-Service Provisioning System for Multimedia Transmission in IEEE 802.11 Wireless LANs," Deng and Yen propose a scheme for ensuring QoS over wireless LANs by using an adaptive prioritization approach. A random backoff and resource management policy is proposed and analyzed. Simulation results show that the proposed scheme outperforms the conventional IEEE 802.11 medium access control (MAC) for real-time traffic. The paper, "A Software Support Infrastructure for Wireless Access Routers," by Zerfos *et al.*, presents DIRAC, a software-based distributed router system. DIRAC has a sophisticated router core serving as a point of aggregation for many router agents that run on the access points. The router core collects statistics from all the router agents to enable centralized decision-making, supporting features such as fast handover, channel adaptive scheduling, and policing. In "Hop Count Optimal Position-Based Packet Routing Algorithms for Ad Hoc Wireless Networks With a Realistic Physical Layer," Kuruvila *et al.* first use shadowing propagation as a realistic physical-layer model to calculate the successful reception probability of each wireless link. Several localized routing protocols for wireless ad hoc networks are proposed according to this probability. An interesting result is that the proposed localized algorithms perform nearly as well as the one requiring global information. In "Two-Step Multipolling MAC Protocol for Wireless LANs," Kim *et al.* propose an interesting approach to improving the efficiency of polling in IEEE 802.11 PCF. The proposed two-step multipolling scheme uses two multipolling frames. The first frame is for

collecting information about pending frames and channel conditions for the MSs, and the second one is for broadcasting a polling sequence based on the collected information. Efficient real-time transmission can be achieved as shown by the simulation results. The proposed scheme can also help implement rate adaptation over time-varying wireless channel. The last paper, "Adaptive Downlink Scheduling and Rate Selection: A Cross-Layer Design," by Haleem and Chandramouli, proposes a cross-layer design for joint user scheduling and adaptive rate control for downlink wireless transmission. They take a stochastic learning-based approach to achieve it. The scheduling is performed at the MAC layer, whereas the rate selection takes place at the physical/link layer. These two components residing in the two layers exchange information to ensure that user defined rate requests are satisfied by the right combination of transmission schedules and rate selections. Theoretical results are validated via simulations using a 3G wireless system.

In conclusion, the Guest Editors sincerely hope that this special issue does provide an up-to-date and valuable research information repository on a broad range of topics relevant to applications, services, middleware, and infrastructure in mobile computing. We would like to thank all authors who submitted their papers to this special issue, and thank all reviewers for their efforts and valuable reviews. We are grateful to Prof. N. Maxemchuk, JSAC Editor-in-Chief, and the Editorial Board for their advice and encouragement. Our special thanks go to Prof. P. Cosman, JSAC Board Representative, and S. McDonald, JSAC Executive Editor, who rendered prompt advice and assistance during the preparation of this special issue.

DAVID S. L. WEI, *Guest Editor*
Fordham University
Department of Computer and Information Sciences
Bronx, NY 10458 USA

KSHIRASAGAR NAIK, *Guest Editor*
University of Waterloo
Department of Electrical and Computer Engineering
Waterloo, ON N2L 3G1, Canada

YI-BING LIN, *Guest Editor*
National Chiao-Tung University
Department of Computer Science and Information
Engineering
Hsinchu, 30050 Taiwan

STEPHAN OLARIU, *Guest Editor*
Old Dominion University
Department of Computer Science
Norfolk, VA 23529 USA

LI-CHUN WANG, *Guest Editor*
National Chiao-Tung University
Department of Communications Engineering
Hsinchu, 30050 Taiwan

RAMACHANDRAN RAMJEE, *Guest Editor*
Lucent Technologies
Bell Laboratories
Holmdel, NJ 07733 USA

P. COSMAN, *J-SAC Board Representative*



David S. L. Wei (S'87–M'94) received the Ph.D. degree in computer and information science from the University of Pennsylvania, Philadelphia, in 1991.

He is currently an Associate Professor of Computer and Information Science at Fordham University, Bronx, NY. From May 1993 to August 1997, he was on the Faculty of the School of Computer Science and Engineering, University of Aizu, Aizu, Japan, as an Associate Professor and then a Professor. He has authored and coauthored more than 70 technical papers in the areas of distributed and parallel processing, wireless networks and mobile computing, and optical networks in various archival journals and conference proceedings. He served on the program committee and was a session chair for several reputed international conferences. He served as a Co-Chair of Power Aware Communication and Software, Minitrack in the Software Track at the 34th Hawaii International Conference on Systems Sciences (HICSS-34). Currently, he focuses his research effort on wireless networks, mobile computing, and peer-to-peer communications.

Dr. Wei is a Lead Guest Editor of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS (Special Issue on Mobile Computing and Networking).



Kshirasagar Naik (M'94) received the B.S. degree from Sambalpur University, Sambalpur, India, the M.Tech. degree from the Indian Institute of Technology, Kharagpur, India, the M.Math. degree in computer science from the University of Waterloo, Waterloo, ON, Canada, and the Ph.D. degree in electrical and computer engineering from Concordia University, Montreal, QC, Canada.

He was a Faculty Member at the University of Aizu, Aizu, Japan, and Carleton University, Ottawa, ON, Canada. At present, he is an Associate Professor in the Department of Electrical and Computer Engineering, University of Waterloo. He was a Program Co-Chair of the 5th International Conference on Information Technology, Bhubaneswar, India, December 2002. He is on the program committee of several international conferences in the area of wireless communication and mobile computing. His research interests are testing of communication protocols, wireless communication, resource allocation in cellular and 3G systems, sensor networks, ad hoc networks, MAC protocols for wireless LAN, Bluetooth networks, mobile

computing, and peer-to-peer communication.

Dr. Naik is a Co-Guest Editor of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS (Special Issue on Mobile Computing and Networking).



Yi-Bing Lin (M'96–SM'96–F'04) is Chair Professor of Computer Science and Information Engineering, National Chiao-Tung University (NCTU), Hsinchu, Taiwan. He also serves as Vice President of the Office of Research and Development, NCTU. He is an Adjunct Research Fellow of Academia Sinica and is an Adjunct Chair Professor at Providence University. He is coauthor of *Wireless and Mobile Network Architecture* (New York: Wiley, 2001) with I. Chlamtac. He has published over 180 journal articles and more than 200 conference papers. His current research interests include wireless communications and mobile computing.

Dr. Lin is a Fellow of the Association for Computing Machinery (ACM), and a Fellow of the American Association for the Advancement of Science (AAAS). He received the 1998, 2000, and 2002 Outstanding Research Awards from the National Science Council, R.O.C., the 1998 Outstanding Youth Electrical Engineer Award from CIEE, R.O.C., and the NCTU Outstanding Teaching Award in 2002. He is a Senior Technical Editor of the *IEEE Network*, an Editor of the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, an Associate Editor of the IEEE

TRANSACTIONS ON VEHICULAR TECHNOLOGY, an Editor of the *IEEE Wireless Communications Magazine*, and *ACM/Baltzer Wireless Networks*. He is Guest Editor of the *ACM/Baltzer MONET* (Special Issue on Personal Communications), the IEEE TRANSACTIONS ON COMPUTERS (Special Issue on Mobile Computing), the IEEE TRANSACTIONS ON COMPUTERS (Special Issue on Wireless Internet), and the *IEEE Communications Magazine* (Special Issue on Active, Programmable, and Mobile Code Networking). He is Program Chair for the 8th Workshop on Distributed and Parallel Simulation, General Chair for the 9th Workshop on Distributed and Parallel Simulation, and Program Chair for the 2nd International Mobile Computing Conference.



Stephan Olariu received the Ph.D. degree in computer science from McGill University, Montreal, QC, Canada.

He is a Tenured Full Professor of Computer Science and Director of the Sensor Networks Research Group, Old Dominion University, Norfolk, VA. He is a world-renowned technologist in the areas of parallel and distributed systems, parallel and distributed architectures and networks. He was invited and visited more than 120 universities and research institutes around the world lecturing on topics ranging from wireless networks and mobile computing, to biology-inspired algorithms and applications, to telemedicine, to wireless location systems, and demining. He has coauthored four books *Solutions to Parallel and Distributed Computing Problems: Lessons From Biological Sciences* with A. Zomaya and F. Ercal (New York: Wiley, 2000) (ISBN 0471353523), *Parallel Computation in Image Processing* with S. Tanimoto (Cambridge, U.K.: Cambridge Univ. Press, 2006), *Wireless Sensor Networks and Applications* (New York: Wiley, 2005), and *Numerical Simulations* with S. Salleh, A. Zomaya, and B. Sanugi (New York: Wiley,

2005), with four more books in preparation. He has also published over 200 journal articles and over 100 conference articles.

Prof. Olariu is an Associate Editor of *Networks*, *International Journal of Foundations of Computer Science*, and serves on the Editorial Board of the *Journal of Parallel and Distributed Computing*, and served (until January 2003) as an Associate Editor of the IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS and *VLSI Design*.



Li-Chun Wang received the B.S. degree from the National Chiao-Tung University, Hsinchu, Taiwan, in 1986, the M.S. degree from the National Taiwan University, Taipei, Taiwan, in 1988, and the Ms.Sci. and Ph.D. degrees in electrical engineering from the Georgia Institute of Technology, Atlanta, in 1995, and 1996, respectively.

From 1990 to 1992, he was with the Telecommunications Laboratories, Ministry of Transportation and Communications, Taiwan (currently, the Telecom Laboratories, Chunghwa Telecom Company). In 1995, he was affiliated with Bell Northern Research of Northern Telecom, Inc., Richardson, TX. From 1996 to 2000, he was with AT&T Laboratories, where he was a Senior Technical Staff Member in the Wireless Communications Research Department. Since August 2000, he has been an Associate Professor in the Department of Communication Engineering, National Chiao-Tung University. He holds three U.S. patents and one more pending. His current research interests are in the areas of cellular architectures, radio network resource management, cross-layer optimization, and cooperation wireless communications networks.

Dr. Wang was a corecipient of the Jack Neubauer Memorial Award in 1997 recognizing the best systems paper published in the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY. Currently, he is the Editor of the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS.



Ramachandran Ramjee (S'95–M'97–SM'02) received the B.Tech. degree in computer science and engineering from the Indian Institute of Technology, Madras, and the M.S. and Ph.D. degrees in computer science from the University of Massachusetts, Amherst.

He has been at Bell Laboratories, Lucent Technologies, Holmdel, NJ, since 1996, where he is currently a Distinguished Member of Technical Staff. He is also an Adjunct Faculty Member in the Electrical Engineering Department, Columbia University, New York, where he teaches graduate courses in wireless networks. He has published over 30 papers in premier conferences and journals and holds 11 U.S. patents. His research interests include protocols, architecture, and performance issues in wireless and high-speed networks.

Dr. Ramjee is an Associate Editor of the IEEE TRANSACTIONS ON MOBILE COMPUTING, a Technical Editor of the *IEEE Wireless Communications Magazine*, and an Area Editor of *ACM Mobile Communications Review*.