

# Guest Editorial: Networking and Performance Issues of Personal Mobile Communications

**I**N recent years, there has been a surge of interest in personal mobile communications systems and services, fueled by the availability and exploitation of wireless spectrum, and the development of low-cost, low-power communications devices. Various types of such systems and services have been referred to as personal communications networks (PCN's), personal communications services (PCS's), universal personal telecommunication (UPT), universal mobile telecommunication system (UMTS), future public land mobile telecommunication systems (FPLMTS's), etc.

The development and deployment of these personal mobile communications systems raise significant technical issues at all protocol layers of these systems. There has been a tremendous amount of research and development work at the low-level protocols, aimed at meeting the challenges posed by the fundamental characteristics of personal mobile communications, namely, user mobility, and the physical and link behavior and capacity of the wireless medium. However, these fundamental characteristics have significant impacts on the network and higher protocol layers as well. Network design and performance issues for personal mobile communications include: mobility modeling and characterization, tracking of user locations, resource allocation, network architecture, and security, to name a few. In addition, several challenges are also raised for the wired infrastructure required to support personal communications, in areas such as signaling, network database, service software and architecture, internetworking between wireless and wired networks, etc. Many of these issues are still open, although personal mobile communications is becoming popular.

The focus of this issue is on the networking and performance issues posed by personal mobile communications at the network and higher protocol layers of the communications networks and also to highlight solution approaches. Our goal is to provide a forum for the exchange of results and ideas among researchers and engineers in industries and universities.

It is worth noting that some of the topics addressed in this issue have been studied and reported in previous, related issues of this JOURNAL; for example, the issue on "Wireless and Mobile High-Speed Communication Networks: Architecture, Modeling, and Analysis" in October 1994 and on "Wireless ATM" in January 1997.

For this issue, we used a two-stage evaluation process. Prospective authors were first requested to submit summaries of their research results. We were surprised by the overwhelming responses: a total of 121 summaries were received. Each summary was reviewed by all of the Guest Editors to assess its quality and relevance to the topics covered by this issue. Consequently, authors of 60 papers were invited to submit their full papers for detailed review, and we received

56 of them. Based on review reports by experts in the field, we selected 15 papers for publication in this issue. As discussed in the following, these papers address issues such as resource allocation, mobility modeling and management, network configuration, network architecture, protocol design, performance analysis, and security.

One of the important design issues for networks providing personal mobile communications is the allocation and management of network resources. In the first paper on this issue, Konishi *et al.* present in their paper "Flexible Transmission Bandwidth Manage with Effective Channel Reservation Techniques for NGSO MSS Networks," an efficient transmission bandwidth management scheme based on flexible channel assignment and effective grade-of-service control for non-geostationary orbit mobile satellite networks. In the second paper, entitled "Adaptive Resource Allocation for Prioritized Call Admission over an ATM-Based Wireless PCN," Yu and Leung propose a dynamic scheme using guard channels for reducing the blocking probability of handoff calls where the number of guard channels is chosen according to an estimate of nonstationary traffic load. While radio bandwidth is important, from a user's perspective, latency and quality-of-service issues are also very important. The paper by Tassiulas and Su, "Optimal Memory Management Strategies for a Mobile User in a Broadcast Delivery System," proposes a method for disseminating information to users while conserving bandwidth and minimizing access time. They propose strategies for memory management in the user's terminal device, which are optimal in terms of minimizing mean aggregated latency and the number of deadline misses.

As mentioned earlier, a defining characteristic of personal mobile communications is user mobility. While users move from location to location, the traffic load that they place on the network changes accordingly. Thus, understanding user mobility is very important for network design and engineering so that adequate capacity can be provided to meet the traffic demand. In the paper entitled "User Mobility Modeling and Characterization of Mobility Patterns" by Zonoozi and Dasanayake, a mathematical model is developed for the tracking and characterization of random movement of mobile stations in a cellular network. The model can be used to obtain parameters needed for network planning and engineering. In addition, user mobility also introduces the need of locating users for call setup. In the paper by Rezaiifar and Makowski, "From Optimal Search Theory to Sequential Paging in Cellular Networks," a paging strategy based on the theory of optimal search is proposed.

Another important issue is to devise appropriate network configurations such that calls can be routed or handed off to neighboring cells efficiently. In their paper entitled "Adaptive Clustering for Mobile Wireless Networks," Lin and Gerla

examine the issue for a self-organizing, multihop, mobile radio network using CDMA for multiple access. Nodes are organized into nonoverlapping clusters, which are independently controlled and reconfigured as the nodes move. Cheung and Leung propose, in "Network Configurations for Seamless Support of CDMA Soft Handoffs Between Cell Clusters," three network configurations to enable soft handoffs between cell clusters served by different mobile switching centers (MSC's). In all three configurations, diversity combining of signals is used. In the first two configurations, crosslinks between clusters are employed, while in the last one, MSC's serving adjacent clusters are linked.

On network architecture, Cheng and Holtzman propose a wireless ATM network architecture and related protocol design in their paper, "Wireless Intelligent ATM Network and Protocol Design for Future Personal Communication Systems." They also examine the air interface, MAC layer protocol, and quality-of-service issues in their proposed design. In the paper entitled "Beyond IN and UPT—A Personal Communications Support System Based on TMN Concepts," Eckardt *et al.* give an overview of a personal communication support system, which is a platform for providing enhanced intelligent network (IN) and universal personal telecommunication (UPT) capabilities with respect to user addressing and control. In their paper, "A Low-Cost Cellular Mobile Communication System: A Hierarchical Optimization Network Resource Planning Approach," Hao *et al.* present a model for cellular network planning and cost optimization. Using a hierarchical combinatorial optimization model, they determine the radio network architecture planning that considers number of cells, cell size, cell allocation, and antenna parameters. Since a significant cost component in deploying personal mobile communications systems is the cost of the wired base station network, Yanikomeroglu and Sousa discuss in their paper, "Antenna Interconnection Strategies for Personal Communication Systems," the conduit and cable lengths for deploying distributed antenna and microcellular systems, and they propose using results from graph theory to design low-cost antenna interconnection networks.

Yet another issue that has been receiving considerable attention is how to provide data services over a system comprised of a low-data-rate cellular network connected to a high-speed wired backbone. The paper by Kojo *et al.*, "An Efficient Transport Service for Slow Wireless Telephone Links," proposes a data channel protocol which transparently replaces TCP/IP over the low-speed wireless link and presents results of performance measurements.

It is well recognized that performance analysis is very helpful in network design and planning. In this issue, we have two papers on performance analysis. In the paper, "Performance Analysis of Multicast Flow Control Algorithm over Combined Wired/Wireless Networks," Wang and Schwartz study several ad hoc flow control algorithms for point-to-multipoint connections over wired/wireless networks using both analysis and simulation techniques. They also provide guidance about the relative value of different policies based on rate-based flow control algorithms. Massey and Srinivasan in their paper, "A Packet Delay Analysis for Cellular Digital

Packet Data," formulate and analyze a model of voice and data burst traffic for cellular digital packet data (CDPD). The model is useful for determining the optimal number of logical CDPD channels for a given traffic setting.

Last but not least, Samfat and Molva in their paper, "IDAMN: An Intrusion Detection Architecture for Mobile Networks," address the important issue of network security. Mobile users can access wireless networks at a multitude of access points, but there is no physical protection of the access points and of the transmission on the radio path. This introduces new security issues compared to traditional fixed networks. Samfat and Molva propose a method to track and detect mobile intruders in real time.

Finally, we would like to express our sincere thanks to our reviewers for their dedicated efforts in providing timely and constructive reviews of the manuscripts. Without their help, maintaining the high quality of this issue would not be possible. We also thank Prof. L. Milstein, the JSAC Board Representative for this issue, and S. McDonald, Executive Editor of JSAC, for their help and support.

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Dr. Ahmadi is currently an Editorial Member of the *International Journal of Wireless Networks*. He was also a founding Editor-in-Chief of the IEEE PERSONAL COMMUNICATIONS MAGAZINE and a Technical Editor of the IEEE TRANSACTIONS ON COMMUNICATIONS.



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Special Issue on Databases and Mobile Computing, and is an Area Editor for MONET, MC2R and IEEE PERSONAL COMMUNICATIONS. He has several issued and pending patents, mostly in the area of wireless and personal communications.

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**Paul J. Kuehn** (F'89) was born in Gruessau, Germany, in 1940. He received the Dipl.-Ing. and Dr.-Ing. degrees in electrical engineering from the University of Stuttgart, Germany, in 1967 and 1972, respectively.

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Dr. Leung has served on the Technical Program Committee for a number of conferences. In particular, he was an Area Technical Program Coordinator for IEEE INFOCOM'96 and '97. Currently, he is a Program Committee member for the Workshop on Multiaccess, Mobility and Teletraffic for Personal Communications (MMT'97) and for the International Conference on Performance and Management of Complex Communication Networks. He received the Distinguished Member of Technical Staff Award from AT&T Bell Laboratories in 1994 for his research work on performance analysis methodologies and their applications to enhance AT&T switching products and communication services.



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Dr. Li chaired the Computer Communications Technical Committee of the IEEE Communications Society from 1987 to 1989 and the Los Angeles Chapter of the IEEE Information Theory Group from 1983 to 1985. He chaired the Steering Committee of the International Conference on Computer Communications and Networks (IC<sup>3</sup>N) from 1992 to 1997, and was General Chair of the First Annual IC<sup>3</sup>N in June 1992, Technical Program Chair of the Institution of Electrical Engineers (IEE) Personal Communication Services Symposium in June 1995, and Chair of the Fourth IEEE Workshop on Computer Communications in October 1989. He is a member of ACM. He has served as an Editor of IEEE NETWORK and of *Telecommunication Systems*, Guest Editor of IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS and of *Computer Networks and ISDN Systems*, and is now serving as an Editor of *ACM Wireless Networks*. He served on the International Advisory Board of IEEE TENCON'90, IEEE TENCON'94, IEEE SICON'91, IEEE SICON'93, IEEE SICON/ICIE'95, the International Conference on Microwaves and Communications '92, and the International Symposium on Communications '91.