Editorial

The network protocols and applications in use in the Internet today were designed largely in a world of wired networks and stationary computers. However, mobile computers such as laptops and handheld personal computers are now quite common, and the use of wireless networks, such as cellular systems and wireless LANs, for communication with these computers is growing rapidly, presenting significant challenges to current protocols and applications and to designers of new ones. In particular, wireless networks have fundamentally different properties than typical wired networks, including higher error rates, lower bandwidths, nonuniform transmission characteristics, increased usage costs, increased susceptibility to interference and eavesdropping, and higher variability of performance. Similarly, mobile computers behave differently and have fundamentally different limitations than stationary computers. For example, mobile nodes generally operate on limited battery power and may move and change their point of connection to the network at any time.

In this special issue, we present a collection of papers representing some of the ongoing research addressing the support for wireless networking and mobile computers in the Internet. To begin this issue, Perkins gives a broad overview of the area, to set the context for the other papers contained here. We then present seven research papers covering specific current issues in mobile networking in the Internet.

In the first of these papers, "Vertical handoffs in wireless overlay networks," Stemm and Katz describe an architecture of *wireless overlay networks*, in which a hierarchy of wireless networks, such as a room-size, building-size, and wide area network, give overlapping coverage to an area; lower levels in the hierarchy give high bandwidth service to relatively small areas, while higher levels give coverage over a wide area but at lower bandwidths. This work extends the traditional notion of "horizontal" handoff to support handoff between these levels of network hierarchy, to provide a user with the best possible connectivity regardless of location.

Following this, Cáceres and Padmanabhan present "Fast and scalable wireless handoffs in support of mobile Internet audio." This paper uses a different notion of hierarchy in handoffs, in which locality in user mobility is exploited to restrict mobile node handoff processing to the vicinity of node as it moves about. The goal of this work is to reduce the latency required for handoff, for example to avoid noticeable disruptions in interactive audio communication. Such local handoffs also reduce the overhead caused by the necessary control traffic on the Internet.

The third research paper in this issue is "Multicast support for mobile hosts using Mobile IP: Design issues and proposed architecture," by Chikarmane, Williamson, Bunt, and Mackrell. Most current work in network layer support for mobile users, such as Mobile IP, concentrates primarily on unicast traffic. This paper, instead, focuses on providing multicast support, giving an architecture based on Mobile IP tunneling, but extended to efficiently handle multicast source or destination mobility and to solve the *tunnel convergence problem*, the *duplication problem*, and the *scoping problem* identified by the authors.

In the next paper, Gupta and Montenegro present "Secure and mobile networking," in which Sun's SKIP protocol (Simple Key-Management for Internet Protocols) is used to solve a number of problems in support of what the authors call a Mobile Virtual Private Network (MVPN). These problems include the movement of mobile nodes from private (non-global) IP address spaces into the general Internet and the traversal of packets to and from a mobile node through a firewall around the mobile node's home network. The SKIP protocol elegantly solves these problems through its use of in-line keying, its ability to separate a node's true identity from its current address, and the use of "nomadic" entries in the SKIP firewall Access Control List.

Murthy and Garcia-Luna-Aceves then present "A routing architecture for mobile integrated services networks," which provides performance guarantees for providing QoS while the network topology can change continuously. This work is based on a hop-by-hop credit mechanism for routing packets toward their destination, coupled with a loop-free multipath routing algorithm. A packet intended for some given destination is allowed to enter the network only if there is at least one path of routers to that destination with sufficient resources to deliver the packet in finite time.

The paper "Interaction of TCP and data access control in an integrated voice/data CDMA system," by Ramakrishna and Holtzman, analyzes the problem of assigning slots for data transmission via TCP, in a CDMA system that is already sustaining a variable number of voice calls. The CDMA system considered is that defined by IS-99. The authors show that one can indeed manage to transmit delay-intolerant voice traffic and delay-tolerant data on the same channel. This can be done while achieving throughput targets that can be predicted depending upon the probability of correct reception, and thus the probability of TCP retransmission. Simulations are reported that validate the results of the analysis. The

paper establishes analytic properties of combined voice and data traffic which can be used to estimate how many data slots to allocate.

The final research paper in this issue is "Web*Express*: A client/intercept based system for optimizing Web browsing in a wireless environment," by Housel, Samaras, and Lindquist. Access to the Web is often slow and tedious for many users today, and the constrained bit-rate available to many wireless users can just make a bad problem worse. This final paper tackles the problem and offers a multifaceted solution that utilizes *intercept* services on both sides of the air interface, modeling the mobile terminal as a client that needs access to a Web server in the wired infrastructure. By combining the techniques of *caching*, *protocol translation*, *differencing*, and introducing state to eliminate repetitive HTTP protocol actions, the authors achieve impress reductions in the amount of traffic going over the wireless medium.

It is our sincere hope that you enjoy the varied articles contained herein at least as much as we, the editors, have enjoyed the process of selection and production of this special issue. We have enjoyed being in the position to combine these research results together in a way that hints at the diversity characterizing the Internet research community. Thank you for your interest.

Charles E. Perkins and David B. Johnson
Editors
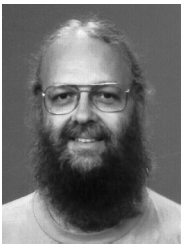
Charles E. Perkins is a Senior Staff Engineer at Sun Microsystems, developing Service Location Protocol and investigating dynamic configuration protocols for mobile networking. He is an editor for ACM/IEEE Transactions on Networking, for ACM/Baltzer/URSI Wireless Networks in the area of wireless networking, and for ACM/Baltzer Mobile Networks and Applications. He is serving as document editor for the mobile-IP working group of the Internet Engineering Task Force (IETF), and is author or co-author of standards-track documents in the mobileip, svrloc, dhc (Dynamic Host Configuration) and IPng working groups. Charles is also associate editor for Mobile Communications and Computing Review, the official publication of ACM SIGMOBILE. He is serving on the Internet Architecture Board (IAB) of the IETF. Charles has authored a book on Mobile IP, and has published a number of papers in the areas of mobile networking, ad-hoc networking, route optimization for mobile networking, resource discovery, and automatic configuration for mobile computers. Charles has served on various committees for the National Research Council, and is currently the chairperson of the Nomadicity Working Team of the Cross-Industry Working Team (XIWT). Charles holds a B.A. in mathematics and a M.E.E. degree from Rice University, and a M.A. in mathematics from Columbia University. He is a member of ISOC, ACM, IEEE, and the IETF.
E-mail: cperkins@eng.sun.com

David B. Johnson is an Assistant Professor in the School of Computer Science at Carnegie Mellon University. He also holds a courtesy faculty appointment in the Electrical and Computer Engineering Department at Carnegie Mellon, and is a member of CMU's Information Networking Institute. His research interests include network protocols, distributed systems, and operating systems. Prior to joining the faculty at CMU in 1992, he was on the faculty at Rice University for three years as a Research Scientist and Lecturer in the Computer Science Department. He received a B.A. in computer science and mathematical sciences in 1982, an M.S. in computer science in 1985, and a Ph.D. in computer science in 1990, all from Rice University. Professor Johnson is currently leading the Monarch Project at Carnegie Mellon University, developing adaptive networking protocols and architectures to allow truly seamless wireless and mobile host networking. Related to this research, he has been active in the IETF for many years, and is one of the principal designers of the IETF Mobile IP protocol for IPv4. More recently, he has been the primary designer of the IETF Mobile IP protocol for IPv6, and is the designer of one of the leading proposed protocols in the IETF Mobile Ad Hoc Networks (MANET) Working Group. Professor Johnson was Program Chair for MobiCom'97 and Technical Vice Chair for Mobile Systems for ICDCS'99, and has served as a member of the Technical Program Committee for over 15 international conferences and workshops. He is an Executive Committee member and the Treasurer for ACM SIGMOBILE, is an Area Editor for the ACM/Baltzer journal *Mobile Networks and Applications* (MONET) and the ACM SIGMOBILE magazine *Mobile Computing and Communications Review* (MC2R), and is a Guest Editor for an upcoming issue of *IEEE Journal on Selected Areas in Communications* (J-SAC) on mobile ad hoc networking. He is a member of the ACM, IEEE Computer Society, IEEE Communications Society, USENIX, Sigma Xi, and the Internet Society.
E-mail: dbj@cs.cmu.edu