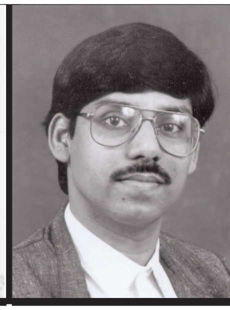
WIRELESS MESH NETWORKS

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Wireless mesh networks (WMNs) are expected to be a key enabling technology for fourth-generation wireless systems, providing flexible, high-capacity wireless backhaul over large geographic areas. In a WMN no cabling is needed to connect routers together. Mesh routers self-organize and establish rich radio mesh connectivity in a way that has never been possible within purely wired networks. Wireless connectivity significantly reduces the upfront deployment and subsequent maintenance costs; after initial deployment, rich mesh connectivity delivers a high level of reliability and robustness. Due to these attractive features, WMNs are being considered for a wide variety of application scenarios such as backhaul connectivity for cellular radio access networks, high-speed metropolitan area mobile networks, community networking, building automation, intelligent transport system networks, and wide-area monitoring and sensor systems.

Despite significant advances in the last few years, many issues remain to be resolved before the promise of WMNs is fully realized. The performance of unicast, multicast, and broadcast traffic remains a topic of ongoing research. There are issues with physical layer performance and effective medium access control in a multihop environment. Channel assignment in multiradio networks (to minimize interference) has also attracted its share of attention. Industry, academia, and standards bodies are all actively working together toward bringing this technology to the market. In this feature topic we have brought together eight high-quality articles contributing to advancing the physical, MAC, network, and application layers of wireless mesh networks.

The first article, by L.P. Tung, T.C Cho, Y.S. Sun, M.C. Chen and W.K. Shih, explores the impact of the hidden node problem on TCP-based unicast communications over WMNs. The authors discover that although the hidden node problem has been successfully counteracted in single-hop wireless networks using well-known RTS/CTS signaling, the problem remains troublesome in multihop WMNs. Unless adequate measures are taken, the performance of unicast communication can be seriously degraded. The authors also show that by using multiple channels and assigning them appropriately, it is possible to construct a mesh network that is free from hidden node problems.

From unicast, the focus is shifted to multicast in the second article by U. T. Nguyen and J. Xu. The article compares two approaches to multicast routing: shortest path tree (SPT) that minimizes cost from a sender to each receiver, and minimum cost tree (MCT) that is known to minimize the cost of the entire tree. Unlike the Internet, which commonly employs SPT, WMNs are often much smaller, and the topology can be made known to all nodes in the network. This observation motivates the authors to consider the MCT approach for multicasting in mesh networks. Using computer simulation, the authors present performance comparisons of these two approaches under different scenarios.

The issue of data broadcast in wireless mesh networks is investigated by C. T. Chou, A. Misra, J. Qadir, and J. G. Lim in the third article. The authors use the multirate and multichannel features of mesh networks to minimize broadcast latency. This study reports that when multiple radio interfaces are used in wireless mesh nodes, a channel assignment algorithm optimized for unicast communication often performs poorly for data broadcast. Given that practical mesh networks are likely to carry both unicast and broadcast traffic over the same infrastructure, channel assignment becomes an interesting and challenging problem to solve.

The next article, by H. Skalli, S. Ghosh, S. K. Das, L. Lenzini, and M. Conti, delivers a comprehensive treatment of the channel assignment problem in WMNs. Specifically, the authors study the unique constraints of channel assignment in mesh networks and identify three key factors influencing the assignment policies: interference, traffic patterns, and multipath connectivity. A novel channel assignment scheme is proposed that minimizes interference in multiradio mesh networks.

The authors of the fifth article, J. Zhang, Y. P. Chen and I. Marsic, point out that wireless mesh networks can suffer from serious throughput problems due to head of line blocking (HOL) at the MAC layer. The problem occurs at a hotspot node that is trying to relay packets to many receivers, but the receiver of the first packet in the queue remains temporarily unavailable. Although other receivers may be available, the sender remains in backoff stage until the first packet is transmitted successfully. It is shown that under certain conditions, a sender can spend up to 70 percent of its time in backoff stage. To address this problem, the authors propose a multicast RTS extension to IEEE 802.11 MAC that allows a busy sender to probe multiple receivers simultaneously and selectively transmit packets from the queue depending on the receiver availability.

Multiple-input multiple-output (MIMO) is an enabling physical layer technology that can provide high-capacity wireless links between the mesh nodes. MIMO is often used in combination with OFDM to deal with interference problems. The MIMO-OFDM combination has been adopted by both IEEE 802.16 and IEEE 802.11n, two key standards for wireless mesh networks. The article by D. Niyato and E. Hossain analyzes the admission control problem in IEEE 802.11n-based mesh networks. A game-theoretic solution is proposed that aims to maximize the utilities of all mesh nodes along a routing path.

The article by P. Alexander, D. Haley, and A. Grant further analyzes the performance issues with 802.11 OFDM and reveals that in outdoor mobile scenarios, the standard OFDM receivers perform poorly. The authors describe advanced receiver technologies for 802.11 that can reliably support vehicular mobility. The increased performance is achieved through accurate channel estimation and tracking, effective combining of useful received signal energy, and cancellation of self-interference.

We conclude the feature topic with an article by Ö. Oyman, J. N. Laneman, and S. Sandhu on the application of wireless mesh technology. In particular, the authors study relay-assisted cellular mesh networks where additional wireless relay nodes are deployed to extend the coverage of cellular infrastructure. Key design goals are examined and performance results presented for different parameter settings. The article ends with a note on future challenges facing the next generation of multihop cellular networks.

We hope that these eight peer-reviewed articles help readers understand the issues and solutions for wireless mesh networks. We take this opportunity to thank the Editor-in-Chief for his encouragement and support throughout the editorial process. Finally, we sincerely acknowledge the contributions of the reviewers who volunteered their valuable time to review the articles in a timely fashion.

BIOGRAPHIES

MAHBUB HASSAN [SM] (mahbub@cse.unsw.edu.au) is a full professor in the School of Computer Science and Engineering, University of New South Wales, Sydney, Australia. He earned his Ph.D. in computer science from Monash University, Australia, in 1997. He has co-authored IETF drafts, published numerous research articles, and written three books. His recent book, *High Performance TCP/IP Networking*, has been widely adopted across the world with translations into foreign languages. He serves on the Editorial Advisory Board of *Computer Communications* (Elsevier Science) and previously (1999–2001) served as an Associate Technical Editor for *IEEE Communications Magazine*. He was guest editor of *IEEE Communications Magazine*'s Feature Topic on TCP Performance (April 2001 issue). He organized and guest edited special issues for *Journal of Supercomputing and Real Time Imaging*. He was organizer and chair of IEEE ICON Wireless Workshop held in Sydney, 2003, and co-chair for the SPIE Conference on Internet Quality of Service for three consecutive years (2001, 2002, and 2003). He has worked closely with large industrial research laboratories (Canon and Vodafone) in collaborative projects and developed industry short courses on leading edge networking topics (for Telstra, Lucent, and NEC). He was an invited professor at the University of Nantes, France, working on INRIA's ATLAS project (Apr-May 2005). He was a seconded principal researcher and project leader at the National ICT Australia (NICTA) where he led a team of researchers and engineers to build a city-wide wireless mesh network as part of NICTA's Smart Transport and Roads (STAR) mega project. He was the recipient of the School of Computer Science (Monash University) Teaching Excellence Award in 2000, and was nominated for the Faculty of Engineering (UNSW) Research Excellence Award in 2004.

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