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Guest Editorial

Special Issue: Medium Access Control Protocols for Wireless Ad Hoc Networks

By Xuemin (Sherman) Shen, Hisashi Kobayashi, Xiaohu You, Jianping Pan, Guest Editors

Wireless ad hoc networks enable over-the-air information exchange among (mobile) entities without a fixed infrastructure, and are very attractive for many commercial and military applications where pre-existing infrastructures are either infeasible or too expensive. However, this new form of communications poses new challenges to traditional networking architectures and protocols designed for wired or infrastructure-based wireless networks, and has stimulated considerable research interests in recent years. Medium access control (MAC) is one of the major research interests in wireless ad hoc networks, where neighboring entities may have to share the same radio channel and information flows may be relayed in a hop-by-hop manner. Many new MAC protocols have been proposed and evaluated and, at the same time, existing MAC protocols are tailored and improved for wireless ad hoc networks. These MAC protocols have considerable implications on the performance of upper layer protocols such as packet routing and end-to-end flow and congestion control. In addition, new technologies for the physical layer keep emerging and enable more sophisticated MAC protocols. Other driving factors for this active research area include the desire for high-speed, low-latency, and quality-of-service (QoS)-provisioned communications among mobile entities. This special issue consists of nine papers addressing recent cutting edge research and state-of-the-art technology of MAC for ad hoc networks. It is timely and valuable for future analysis, implementation, and experiments.

In the first paper 'Understanding the key performance issues with MAC protocols for multi-hop wireless networks,' Iyer and Rosenberg demonstrate that the performance of multi-hop networks depends critically on the design of the underlying MAC protocol. A list of problems that affect MAC protocols in multi-hop wireless networks are identified, such as the hidden node, the deaf node, the exposed node problems, and the link layer congestion problem. The performance of three existing MAC protocols is evaluated. Then a simple but robust two-channel MAC protocol (termed 2CM) is proposed, which is based on the IEEE 802.11 protocol augmented with a busy-tone channel. It is shown that the proposed protocol makes effective use of the busy-tone signal to mitigate the hidden node problem considerably. A logical control channel is not required, and a reliable link layer acknowledgement mechanism can be provided as well.

In the second paper 'Access control in ad hoc networks with selfish nodes,' Zhao proposes a game theory-based access control scheme for ad hoc networks where nodes selfishly compete for channel access in order to maximize their own payoffs. An equilibrium transmission probability is derived, and saturation throughput and packet transmission delay performance are analyzed. It is shown that a relatively high transmission throughput is possible using this scheme which allows simultaneous transmissions under low co-channel interference conditions.

The third and fourth papers focus on clustered ad hoc networks. In the paper 'MAPLE: a framework for mobility-aware pro-active low energy clustering in ad hoc mobile wireless networks,' Palit, Hossain, and Thulasiraman present a framework for mobility-aware pro-active low energy clustering in ad hoc mobile wireless networks. The proposed framework uses radio link level information for predicting node mobility and a reservation-based technique for channel access by the mobile nodes. An approximate analytical bound on the maximum number of nodes in the network for bounded clustering delay has been also obtained. Simulation results show that the proposed framework results in superior clustering performance in terms of stability, load distribution, and control overhead compared to existing approaches. In the paper 'Power control and scheduling with minimum rate constraints in clustered multi-hop TD/CDMA wireless ad hoc networks,' Qian *et al.* introduce cluster based architecture to provide centralized control within clusters, and derive the corresponding power control and scheduling schemes to maximize a network utility function and guarantee the minimum rate required by each traffic session. A constrained optimization problem is formulated, and a Multi-link Gradient scheduling algorithm with minimum rate constraints (MGMR) is proposed for solving it.

In ad hoc networks, MAC interacts with routing. In the fifth paper 'Forward focus: using routing information to improve medium access control in ad hoc networks,' Ishibashi and Boutaba develop a modification to 802.11 that focuses on forwarding packets. Routing information is utilized to streamline the sharing of the medium, by allowing forwarding nodes to reuse an already-acquired channel. Nodes are encouraged to participate in the forwarding process and are rewarded for doing so. It is shown that improved efficiency and effectiveness can be achieved. In the sixth paper 'Traffic-aware routing for real time communications in wireless multi-hop networks,' Yin *et al*. propose a prediction-based routing metric named path predicted transmission time (PPTT) to estimate the transmission time for the new coming real time communication (RTC) flow before it is injected into the wireless multi-hop network. Route is selected with minimal PPTT. Packet service time for rate-controlled RTC is analyzed, and the link predicted transmission time (LPTT) is estimated. Experimental results show that the PPTT algorithm outperforms other routing algorithms.

Wireless mesh networks (WMNs) are a special kind of ad hoc networks. In the seventh paper 'Distributed medium access control for wireless mesh networks,' Cheng, Jiang, and Zhuang indicate that, due to new design purposes and new networking structures, existing MAC protocols designed for mobile ad hoc networks may not be effective or efficient for multi-purpose WMNs. They investigate the feasibility and drawbacks of the existing distributed MAC protocols when they are implemented in WMNs, in the avenues of best-effort service support, priority guarantee, resource reservation, fairness enhancement, multi-channel communications support, and cross-layer design. The design of novel distributed MAC protocols for multi-purpose WMNs is necessary to utilize the network resources efficiently, and to achieve good system-wise and user-wise performance. Potential challenges and open research issues are also identified.

In the eighth paper 'Impact of Bluetooth MAC layer on the performance of TCP traffic,' Misic *et al*. analyze the performance of a Bluetooth piconet carrying transmission control protocol (TCP)-Reno traffic. The segment loss probability, the TCP sending rate, and the probability density functions of the congestion window size and the round trip time are analytically modeled. They also investigate the impact of token bucket buffer size, token rate, outgoing baseband buffer size, and scheduling parameters on TCP performance.

In the last paper 'Investigation of the block ACK scheme in wireless ad-hoc networks,' Li and Ni investigate the block transmission and acknowledgement (BTA) scheme in the IEEE 802.11e specification. Multiple data frames are followed by only one acknowledgment frame in a transmission block. A theoretical model is given to evaluate the saturation throughput for the BTA scheme under error channel conditions in the ad hoc mode. It is shown that the number of frames in each block should be negotiated before transmissions to provide better efficiency.

In closing, the guest editors acknowledge the contribution of many experts who have participated in the review process and provided helpful suggestions to the authors on improving the content and presentation of the papers. The advice and support from WCMC Editor-in-Chief and *Wiley* staffs are greatly appreciated.

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Hisashi Kobayashi (hisashi@ee.princeton.edu) is the Sherman Fairchild University professor of Electrical Engineering & Computer Science at Princeton University since 1986, when he joined the Princeton faculty as dean of the School of Engineering and Applied Science (1986–1991). He worked for the IBM Research Center in Yorktown Heights, NY for 15 years (1967–1982), where he was a research staff member of the 'coding and signal conditioning' group in Applied Research Department (1967–1970) and then held managerial positions in the Computer Science Department (1971–1982) on systems measurement & modeling, systems analysis & algorithms, and VLSI design. He served as the founding director of the IBM Tokyo Research Laboratory (1982–1986), where he directed many research projects on computer science and manufacturing technology. He was a radar designer at Toshiba, Japan (1963–1965). He received his Ph.D. from Princeton University in 1967, and his B.E. and M.E. degrees from the University of Tokyo in 1961 and 63, respectively. His research experiences include radar systems, data transmission, coding for high-density digital recording, image compression algorithms, performance modeling and analysis of computers and communication systems, queuing and loss network theory, and wireless geolocation. His current research activities include network security and ultra wideband (UWB) communications. He is the author of 'Modeling and Analysis: an introduction to system performance evaluation,' (Addison Wesley, 1978) and is currently authoring textbooks on the above subject and digital communications & networks, and probability, statistics & random processes. He served as the founding editor-in-chief of an international journal '*Performance Evaluation*' (1979–1986), and an editor of '*Wireless Networks*' (1995–2005), an associate editor of *IEEE Transactions on Information Theory* (1980–1983), and IEEE Transactions on Computers (1977–1980). He is a co-recipient of the 2005 Eduard Rhein Technology Award of Germany for his pioneering work on the high-density digital recording scheme, now widely known as partial response coding, maximum likelihood decoding (PRML). He has been a Fellow (1977) and a Life Fellow (2003) of IEEE, and received the Humboldt Prize from Germany (1979), IFIP's Silver Core (1980) and was elected a member of the Engineering Academy of Japan (1992) and a Fellow of IEICE, Japan (2004). He held visiting professorships at UCLA (1969–1970); Hawaii (1975); Stanford (1976); Technical University of Darmstadt, Germany (1979–1980); Free University of Brussels, Belgium (1980); University of Tokyo (1991–1992); and University of Victoria, Canada (1998–1999). He has also served as a member of the Advisory Boards of many organizations, including SRI International, Menlo Park, CA; NASA of Washington, DC; Institute of System Science (ISS) Kent Ridge Digital Laboratory (KRDL) of Singapore, Advanced System Institute (ASI) of British Columbia, Canada; National Institute of Advanced Industrial Science and Technology (AIST), and Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

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