MAC Protocols for Infrastructure-based Wireless Networks: 
Exploiting Uniformity and Diversity

Project Summary:
The edge of the internet continues to extend over the wireless medium. Technologies such as wireless LANs are being deployed dramatically in homes, offices, and public facilities. Multi-hop mesh networks are being envisioned to further extend the reach of wireless connectivity. The demand for wireless access will only escalate as users increasingly adopt wireless services in their daily lifestyle. The future is likely to see extremely dense deployments of uncoordinated wireless networks, managed by independent individuals or groups of administrators. In such a setting, efficient utilization of the wireless channel will be of utmost importance. This proposal visits the design of MAC protocols that will suit the performance needs of next-generation infrastructure-based wireless networks.

As a first step, this proposal will concentrate on medium access control in chaotically deployed wireless LANs (WLAN). Specific characteristics of WLANs present new opportunities that can be effectively exploited. For example, out-of-band communication between wireless access points (perhaps over the wired infrastructure) may enable new paradigms in medium access. APs can be coordinated by a central controller to perform a concurrent interference measurement – a “rehearsal”. The results of the rehearsal may reveal the available concurrency in the WLAN network, which in turn can guide MAC layer decisions. As another example, the dominance of download traffic, in conjunction with macro level uniformity in client’s usage patterns, can be leveraged for better channel utilization. Opportunities to exploit network diversity could be realized through adoption of smart antennas and multi-channel capabilities. An efficient MAC-layer architecture (perhaps based on TDMA, or hybrid CSMA-TDMA) may evolve from the focused investigation of wireless LANs. Since WLANs are proving to be the common case toward wireless proliferation, guided research toward these networks is necessary. This necessity will probably become conspicuous in future when these networks will be expected to support an extremely dense user base. Moreover, the improved understanding of WLAN medium access control may instigate new directions for the regime of multi-hop networks.

These research directions, and potentially others that originate from them, will be studied in this proposal. It is unlikely that a single solution will apply across all network conditions. In certain contexts, the standard IEEE 802.11 framework may prove to be cost-effective, while in others, new channel access mechanisms may be convincingly more efficient. Understanding this relation between network environment and the protocol modality is vital – a cognitive MAC layer is of interest that will intelligently switch between these modes as and when necessary. This project will strive to design a MAC layer architecture that approaches this objective.

Intellectual Merit:
Extensive research on wireless MAC protocols have been performed in the context of mobile ad hoc networks. However, this proposal will refrain from designing protocols for such generalized multihop networks. Instead this project will concentrate on infrastructure-based wireless LANs, and explore the space of MAC layer possibilities in such networks. Many opportunities in wireless LANs have not been studied adequately in the past, and this project is anticipated to make contributions in this direction. Based on improved understanding of infrastructure-based WLANs, the proposal will consider extensions to small-scale mesh networks. The proliferation of infrastructure-based networks presents a wide range of real-life challenges and requires separate research attention. Drawing on emerging technology trends, and on lessons from the past, this project will develop practical MAC layer solutions for this class of wireless networks.

Broader Impact:
The proposed research will explore the possibility of alternate technologies suitable for next generation wireless networks. The research findings will be disseminated via publications and presentations in technical conferences, journals, and seminars. The project will also reinforce efforts toward a new wireless research area in the ECE department of Duke University. Further, the project will strengthen collaboration with the Duke SmartHome project, exposing a broad student community to an immersive research environment.