

~Research on Embedded Sensor Networks~

Energy Efficient Networking for Embedded Wireless Systems in the Networked Embedded and Wireless Systems (NEEWS) Laboratory

How do you design a network that uses hundreds of tiny matchbox-sized wireless sensors to collect and transport real-time ecological data from the middle of the Amazon rainforest or data on the nesting conditions of geese burrows from the Galapagos Islands to a computational ecology laboratory at MSU? Professor Subir Biswas and his graduate students are doing research on embedded wireless networking to design such systems.

“The problem is particularly challenging,” Biswas says, “because these tiny disposable sensor nodes are typically powered by only a couple of regular AA batteries and they are expected to be operational in the field for months, if not years. During its lifetime, each node has to perform sensing, carry out self-organization for network formation, and transport sensed data to the Internet through suitably located base stations. Energy management is a key problem in designing such systems.”

“The solution to this,” he says, “would require us to break out of the paradigm of delay-bandwidth tradeoff in conventional wireless networks and to look at embedded networking more from a perspective of energy-bandwidth and energy-delay tradeoffs. Within this new framework the research problem is transformed into developing energy syntaxes in wireless network protocols, middleware, and algorithms, as well as mapping them into energy-efficient and network-centric hardware systems.” Below is a brief description of a few projects in the NSF-funded NEEWS laboratory that address this and other related research problems.

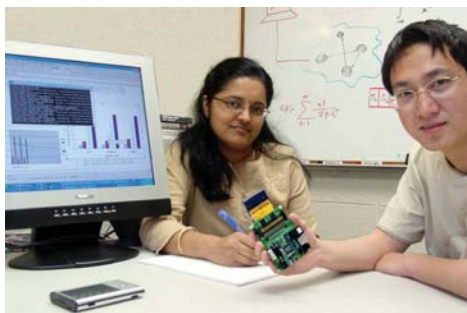
Energy-Aware Medium Access Control (MAC) for Wireless Networks

The aim of this project is to model

and design energy-specific protocol syntaxes for wireless MAC protocols. So far, the main focus has been on a new traffic measurement-based energy-conservation paradigm in which a wireless node uses signal processing techniques for inferring MAC protocol states at nearby nodes based on overheard transmissions. Based on its own MAC protocol state and the inferred neighbors’ protocol states, a wireless node finds the estimated duration of inactivity during which it is allowed to put its network interface hardware to a low energy state for reducing energy consumption. In addition to controlling the energy budget, this technique is currently being investigated with transmission power control for throughput enhancement in contention-based MAC protocols. This research is being done in collaboration with the WINLAB at Rutgers University.

Self-Reorganizing TDMA for Sensor Networks

The goal of this project is to develop an architectural model that would allow cluster-based time division multiple access (TDMA) without using spectrum-heavy code division multiple access (CDMA) or frequency division multiple access (FDMA) in cost-constrained sensor networks. The main idea behind this architecture is to develop a self reorganizing slot allocation (SRSA) mechanism and a hierarchical routing protocol that leverages SRSA in multi-cluster sensor networks. Researchers in the NEEWS laboratory are developing models and algorithms for adaptive MAC slot allocation that can minimize inter-cluster TDMA interference



under low sensor traffic situations. Successful development of such distributed algorithms will allow low-cost sensor nodes to do away with CDMA and FDMA for avoiding inter-cluster interference. Being able to avoid these wideband mechanisms, while leveraging the inherent energy advantages of TDMA, will have far-reaching implications for energy-aware networking in many sensor applications.

Protocols for Networked Vehicle Services (NVS)

The objective of this project is to develop a conceptual as well as experimental framework for vehicle-to-vehicle information networking to enable Networked Vehicle Services (NVS). Examples of NVS applications include intelligent transportation systems (ITS), local driving information retrieval (LDIR), highway driving information back-propagation (HDIB), and commercial information delivery system (CIDS). The key enabler for NVS applications is a highly mobile wireless ad hoc network that can be used for information retrieval from fixed roadside access points and its selective dissemination among NVS enabled vehicles. Researchers in the NEEWS laboratory are designing NVS-specific wireless access and network layer protocols that can be implemented on top of an IEEE-specified dedicated short range communication (DSRC) radio physical layer. The main challenge of this work is to design and develop broadcast-based protocols while maintaining low data delivery latency in networks with nodes moving at 60 to 90 miles per hour. This research is being done in collaboration with the transportation engineering group in the civil and environmental engineering department. For more information about this research, contact Subir Biswas.

Graduate students, Jayanthi Rao (left) and Tao Wu (right) in the NEEWS laboratory are working on developing energy-efficient network protocols for an Intel X-scale processor-based sensor node with an ISM-band radio interface.