PhD Thesis

ENERGY MANAGEMENT IN WIRELESS SENSOR NETWORKS: A CROSSLAYER, CHANNEL ADAPTIVE APPROACH TOWARDS PERFORMANCE OPTIMIZATION

ABSTRACT

The proliferation of wireless sensor networks in a large spectrum of applications had been spurred by the rapid advances in MEMS (micro-electro-mechanical systems) based sensor technology coupled with low power, low cost digital signal processors and radio frequency circuits. A sensor network is composed of thousands of low cost and portable devices bearing large sensing, computing and wireless communication capabilities. This large collection of tiny sensors can form a robust data computing and communication distributed system for automated information gathering and distributed sensing. The main attractive feature is that such a sensor network can be deployed in remote areas. Since the sensor node is battery powered, all the sensor nodes should collaborate together to form a fault tolerant network so as to provide an efficient utilization of precious network resources like wireless channel, memory and battery capacity. The most crucial constraint is the energy consumption which has become the prime challenge for the design of long lived sensor nodes. So efficient energy management needs to be incorporated without ignoring the effects of varying channel quality existing in a wireless sensor network. In this work, a Channel Adaptive Energy Management protocol is developed that can exploit the time varying nature of the wireless links. It also considers the cross layer interaction between the Physical layer, the MAC layer and the Network layer. The power consumption is reduced by turning OFF the interface of the nodes which are not included in the current routing path. The mandatory awakening of all nodes in the routing path, as adopted in all the power saving schemes, is avoided here. The actual energy saving in a wireless environment is realized by deciding the routing path considering the link quality, the channel quality and the energy resources of each node. This Channel Adaptive MAC algorithm AEMAC implements an efficient packet scheduling and queuing algorithm which also considers the fluctuating channel conditions in wireless sensor networks. Transmission through a bad link is avoided by buffering the packets till the link quality rises above a particular threshold. A wireless sensor network scenario is simulated incorporating the above aspects to explore the performance determining factors in a wireless sensor network like *Energy consumption, Throughput, Delay, Delivery ratio* with respect to varying node densities, Transmission Rates and number of flows. Results indicate that this scheme can achieve a much better performance compared to the traditional protocols which do not adopt channel adaptation, cross layer interaction and intelligent routing. This algorithm could not provide *Fairness* to those nodes having bad link and channel conditions and also may result in buffer overflow at the nodes. To achieve *Fairness,* a Load Prediction algorithm with Adaptive Threshold Adjustment scheme is designed, which implements fair scheduling and queuing in a wireless sensor network by preventing buffer overflow, by the real time monitoring of the queue length and the queue length variations in a particular sampling period. The network is found to achieve better *Fairness* and *Bandwidth.* The overall performance of this scheme is analyzed for a wireless sensor network scenario, with the channel varying property of the wireless channels being taken into account. It is validated that, it has a much superior performance with respect to *Bandwidth, Fairness, Delay* and *Packet Delivery Ratio,* compared to the existing protocols which use only the power conservation schemes. Finally it is validated with a traffic adapted sleep/listening MAC protocol TASL, in an error prone scenario and its superior performance is ascertained.

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