ABSTRACT

The emerging field of wireless sensor networks combines sensing, computation, and communication into a single tiny device. Wireless sensor networks (WSNs) contain hundreds or thousands of sensor nodes equipped with sensing, computing and communication abilities. Each node has the ability to sense elements of its environment, perform simple computations, and communicate among its peers or directly to an external base station (BS). The core of a sensor node is a small, lowcost, low-power microprocessor. The microprocessor monitors one or more sensors and connects to the outside world with a radio link. Many popular radio transceivers allow a mote to transmit to a distance of a few hundred meters. Each sensor node is driven by one or two 1.5 V cells. The microprocessor, sensors, antenna and batteries are all packaged in small containers, typically a few millimeters thick. Deployment of a sensor network can be in random fashion (e.g., dropped from an airplane) or planted anually (e.g., fire alarm sensors in a facility). These networks promise a maintenance-free, fault-tolerant platform for gathering different kinds of data. Because a sensor node needs to operate for a long time on a tiny battery, innovative techniques to eliminate energy inefficiencies that would shorten the lifetime of the network must be used.

The basic operation of sensor networks is to gather the sensed data and transmit it to the base station for further processing or as result to a given query. The general scenario in these networks is that during data gathering the intermediate nodes can aggregate the data in order to avoid redundant transfers. The order in which the data or the aggregated data is transmitted from the source node to the base station is the problem of routing. Severe resource constraints in the form of limited computation, memory and power make the problem of routing interesting and challenging.

The primary objective of this thesis is to do comparative investigation of the performance of routing protocols like: Constrained Flooding (CF), Real-Time Search (RTS) and Adaptive Tree (AT) for wireless sensor networks in a simulated environment for realistic radio models to provide a quality assessment of the effect of channel characteristics on the protocols for the Persuader Evader Game (PEG) application. The quantitative performance metrics used to evaluate the performance of protocols are atency, throughput, loss rate, energy consumption, energy efficiency and lifetime. The evaluations are done by means of simulations using PROWLER, an event-driven simulator written in MATLAB developed by Simon et al., Vanderbilt University. RMASE, a Routing Modeling Application Simulation Environment developed by Dr. Ying Zhang, Palo Alto Research Center (PARC), built as an application in PROWLER, provides network generation and performance evaluations for routing algorithms.

The main objectives of this research were five fold. The first focus was the development of simulation environment suitable for performance evaluation of wireless sensor network routing protocols for the PEG application. We developed models with Rician Fading (RMRCF), Weibull Fading (RMWBF), Lognormal Fading (RMLNF) and Gamma Function Fading (RMGMF) in ddition to the Normal Radio Model (NRM), Radio Model with SINR (RMSINR) and Radio Model with Rayleigh Fading (RMRYF) already available in the PROWLER.

Secondly to simulate and comparatively analyze the wireless sensor network routing protocols in the presence of aforementioned realistic models. We have carried out comparative investigations on performance metrics: throughput, energy consumption, energy efficiency and lifetime. Our simulation results show that the AT protocol can be applied to achieve better lifetime in real time for wireless sensor networks. The simulation results indicated that the RTS protocol is more energy efficient than AT and CF protocols. Thus it has been concluded that the RTS protocol can be applied to achieve energy efficient routing in wireless sensor networks in case of NRM. Further, it has been inferred that the routing protocols behave differently in presence of different channel conditions.

Thirdly to simulate and comparatively evaluate the performance of wireless sensor network routing protocol based on path loss exponent. We have done the comparative investigations using the latency, throughput, loss rate, energy consumption and lifetime performance metric. Our simulation results depict that the path loss exponent 4.10 increases the network lifetime by 1.58 % and decreases the energy consumption by 5.5 % for the CF routing protocol. Moreover, it gives 5.1 % more throughput. However, it increases the latency by 43 %. With the knowledge of distance and path loss, the exact transmit power required to maintain a good link to the receiver could be found without wasting energy. This in turn leads to good throughput, decreased energy consumption and improved lifetime.

Fourthly to propose and comparatively analyze Fuzzy Cost Metric based Adaptive (FCMA) wireless sensor network routing protocols. The comparative investigations have been done using the performance metrics latency, energy consumption, energy efficiency and lifetime. Our simulation results show that there is a decrease in energy consumption by 95%, 75% and 80% in case FCMA-CF, FCMA-RTS and FCMA-AT respectively. Consequently, the network lifetime is increased by 10.5 years, 2.5 years, and 4 years for FCMA-CF, FCMA-RTS and FCMA-AT respectively. Moreover, the latency of the network is reduced by 85%, 70%, and 67% in case of FCMA-CF, FCMA-RTS and FCMA-AT respectively. Further in case of FCMA-CF and FCMA-AT the use of Fuzzy cost metric leads to low energy efficiency at the beginning of the network that increases with the increase in simulation time. However, in case of FCMA-RTS it can be observed that the use of the Fuzzy cost metric makes the network less energy efficient. This is due to less number of packets being received by the destination nodes running FCMARTS.

Finally to simulate and comparatively investigate the performance of wireless sensor network routing protocols for commercial sensor motes Mica, Micaz, Fleck 3 and Tiny Node for all the seven radio models viz., NRM, RMSINR, RMRYF, RMRCF, RMWBF, RMLNF and RMGMF. We have carried out comparative investigations on energy consumption performance metric. Our simulation results indicate that the TINY NODE consumes highest energy per round (3.75 for CF, 7.5 for RTS and 4 for AT) amongst all the four sensor node technologies followed by MICAz. However, FLECK 3 mote consumes lowest energy per round (0.002 for CF, 0.01 for RTS and 0.004 for AT) amongst all the sensor node platforms followed by MICA. It has been, thus, concluded that in case of all the radio models FLECK 3 and MICA are preferably better than TINY NODE and MICAz keeping in consideration the energy savings obtained using them in case of all the three routing protocols. The performance investigations indicate that the energy consumption in WSNs depends on the mote hardware and the software running on them. This in turn varies with different physical channel conditions.