Ain Shams University
Faculty of Engineering
Computer & Systems Engineering Department

Energy Efficient Routing Protocol for Wireless Sensor Networks

Thesis submitted for the partial fulfillment of Degree of
Doctor of Philosophy (Ph.D.) in Computer & Systems Engineering

Submitted by

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In the Name of

Allah,

Most Gracious,

Most Merciful

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Abstract

In the last few years, wireless sensor networks (WSNs) have gained a lot of interest in both research and industrial fields. Recent advances in wireless communications and electronics have enabled the development of low power, low cost, multifunctional sensor nodes that are small and able to communicate in short distances. A WSN consists of small nodes with sensing, computation, and wireless communications capabilities. These sensors have the ability to communicate either among each other or directly to a sink.

WSN are currently used for gathering data in many applications and according to this, many routing protocols have been proposed for WSNs. Most of the hierarchical protocols proposed for WSNs concentrate mainly on maximizing the lifetime of the network by trying to minimize the power consumption. Delay is almost not considered, while it is an important metric especially in time critical applications. In addition, previous protocols assume that all sensor nodes have the same energy level at startup, which is not always the case.

We propose Pairs Energy Efficient Routing (PEER) protocol, a new routing protocol for wireless sensor networks that uses dual power management and focuses on minimizing both the energy dissipated and the transmission delay. The protocol consists of three phases: joining pair phase, transmission phase, and changing pair phase.

The joining pair phase is based on grouping the randomly deployed sensor nodes into pairs. Each two nodes forming a pair should be chosen to be close to each other to ensure minimum energy consumption for the transmission between both nodes. We have used random graph theory as a mathematical model for forming pairs.

In the transmission phase, each node has a dual power assignment. One node of a pair transmits data toward the sink using high power level, and the other node transmits data to its partner using low power level. The roles of two nodes forming a pair should be changed periodically to fairly distribute the far-transmission load between both nodes.

The third phase is the changing pair phase. Only nodes that loose their partners due to partner death will be concerned with this phase to form a new pair.

In the simulations, four important metrics have been taken into consideration, namely, energy consumption, network lifetime, distribution of nodes alive, and average delay. In addition, two models have been simulated for the protocol. In the first model, all the sensor nodes have been given the same amount of energy at startup; while in the second model, sensors start the simulation with different energy levels.

We have compared our results with LEACH, a well-known recognized hierarchical wireless sensor protocol. In terms of energy consumption, network lifetime, and average delay, our protocol has performed better than LEACH by more than 200%, 200%, and 400%, respectively. Moreover, in PEER protocol the nodes alive are distributed over all regions, while in LEACH nodes alive are always concentrated near the sink with all nodes in far regions dead. Finally, PEER with nodes having different power levels at startup has almost the same performance as PEER with an insignificant difference of about 5% increase in energy consumed and less than 5% decrease for the network lifetime. In LEACH, the change in energy levels will lead to a significant change of about 25% increase in energy consumption and 20% decrease in network lifetime.

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