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Extending the Network Lifetime in Wireless Sensor Networks using RBR Algorithm

Lalit Kumar Saraswat[1] and Dr. Sachin Kumar[2]

[1]Department of Computer Science, Bhagwant UniversityAjmer, Rajasthan, INDIA.
[2]Department of IT, AKG Engineering College, Ghaziabad (U.P.), INDIA.

Abstract

Wireless Sensor Networks (WSNs) are energy constrained. Every operation reduces the reserve energy of the nodes. Network lifetime is the most important metric for the evaluation of wireless sensor networks. In a resource-constrained environment, the consumption of every limited resource must be considered. However, network lifetime as a measure for energy consumption occupies the exceptional position that it forms an upper bound for the utility of the wireless sensor network. The sensor network can only fulfill its purpose as long as it is considered alive, but not after that. It is an indicator for the maximum utility a wireless sensor network can provide. The goal of this paper is to show that the proposed Resource Biased Routing (RBR) algorithm performs better as compared to other routing algorithms in terms of network lifetime.

Keywords: Wireless Sensor Networks, Load balancing, Network lifetime, Castalia simulator.

1. Introduction

A wireless sensor network consists of a large number of sensor nodes and one or more base stations. The nodes are deployed inside the area of interest to collect information from the surrounding environment and report it to a base station located generally at the extremity of the area of interest The role of the base station is to collect the information sent by the sensor nodes and send it back to the user, and eventually send queries to the sensor nodes. Generally, the base station is much more powerful in terms of resources than the sensor nodes.

A sensor node is a small device that includes four basic components: a data acquisition unit, a processing unit, a communication unit and a power supply unit. The sensor node consists of low-power batteries which minimize the ability of the sensor node in terms of processing, storage and transmission. Normally the sensor nodes should last until their energy runs out. Thus, the energy is the most precious resource in a wireless sensor network. When the sensor nodes communicate with the base station directly , the sensor nodes far away from the base station will have a higher energy load due to the long range communication. However when the sensor nodes uses multi-hop communication to reach to the base station, the sensor nodes which are closer to the base station will have a higher energy load because they relay the packets of other nodes .

Every work done by a sensor node uses some proportion of the node's reserve energy. The type of works done by each node affect the lifetime of a sensor node. Selection of the route is the most significant factor in determining the lifetime of a node. Because radio usage is costly and must occur in order to effect routing between sources and base stations.

The purpose of the most routing protocols in Wireless Sensor Networks is to extend the lifetime of a network through the careful selection of a route. However, a no. of these protocols measure network lifetime in such a way that they are useless. Where routing paths are selected intelligently, they are typically optimal only for a single source and do not consider the requirements of other sources.

2. Related Work

Singh presents various energy-aware heuristics that optimize for sensor node and lifetime of the wireless sensor network. Singh's solution makes use of techniques such as "minimizing variance in node power levels". However, the heuristics are hard to synchronize as they vary constantly; energy must be expanded in order to collect the heuristics. It is very difficult to determine how this data varies with time due to the non-deterministic cost of radio transmissions. External factors also make such predictions difficult, such as various sources using the same node for routing. Dai proposed a system in which a balanced routing tree is constructed iteratively, starting at the base station. Once complete, workload experienced by each node from routing should be balanced. Each node shares information about how much data it generates, which may not be known. Lee gives a solution in which routes are formed on demand from sources to base stations, based on the path of minimum workload. As intermediate nodes route data from source stations to base stations, they periodically tag their present status of workload. If the base station considers one node to be overloaded, it can cause path discovery to begin again from the source. If a path of lower workload exists, then it may be selected. Lee assume that a path of lower routing load is always available, which may not be true. Tran's congestion adaptive routing allows nodes to bypass a downstream neighbour that is heavily loaded by forming a bypass around that node. A proportion of all data is then sent down the bypass rather than the original path. This protocol has the advantage that global data is not required. However, as with other protocols, hang, examines how energy aware routing might be better carried out by modelling the network as a network flow problem, with edges representing the capacity of links between each pair of nodes. Lin demonstrates a static routing system which uses traffic patterns and energy replenishment statistics, rather than instantaneous energy heuristics of nodes. This solution is close to the optimal solution when the energy used by each packet is relatively small compared to the battery capacity.. Kalpakis allows the use of data aggregation from various sources to reduce the amount of communication required in a network. Once a network flow has been established, a schedule can be produced which shows how every future packet should be routed.

3. Proposed RBR Algorithm

We consider a Wireless Sensor Network that consists of large number of sensors that are uniformly distributed and a base station in order to collect data from other sensor nodes. In the proposed model, each node s has some data to send to the base station. All nodes are assumed static. The Base station is much more powerful as compared to other sensor nodes. All the nodes use multi-hop method for routing. Each node has a constant data rate to carry data. The proposed system consists of source node S, a number of intermediate nodes and a destination base station D. All other nodes have limited available energy. Each node has three parameters (Available Energy Indicator, Hop Count Indicator, and Node Usage Indicator). The Node Usages indicator (NUI) specifies how many times a specific sensor node has been used during the routing purpose. Available Energy indicator (AEI) specifies the remaining available energy at the node. Hop Count Indicator (HCI) specifies the distance of a specific sensor node from the base station in terms of Hops. The base station is initialized with the hop value “0” while all other sensor nodes are initialized with infinite hop value. The base station is also has unlimited energy available as it is externally powered. All the other nodes have an initial energy level $E_{initial}$(in Joule). All the sensor nodes in the proposed network are assigned with a unique ID and all the nodes are participating in the network and forward the given data.

The proposed Resource Biased Routing (RBR) algorithm is used for selecting the neighbour nodes to which the data is to be forwarded. According to the proposed algorithm, ideally a sensor node is selected as next hop in which the available energy level indicator is high, having low value of hop count indicator as well as having the low value of node usage indicator. Each node maintains a Sensor Node Information (SNI) table for the routing function to perform. The SNI table consists of entries of all the neighbor nodes through which the node can transfer data. A minimum Energy threshold level (E_{th}) will be required to be maintained at each sensor nodes, and if du The energy required for transmission of data (E_{tr}) as well as the energy required for receiving of data (E_{re}) at a specific node can be determined using the Radio model. The radios have power control and can expand the minimum energy required to reach the intended recipients. The radios can be turned off to avoid receiving unintended transmission. The transmitting Node Energy is given by

$$E_{tr}(m, d) = E_{elec}(m) + E_{amp}(m, d)$$
$$E_{tr}(m,d)=(E_{elec}+E_{amp}*d^2)*m \quad (1)$$

Where m=no of bits in the data packet and d= distance between any two nodes (assumed to be same for all nodes.)

The receiving node energy is given by

$$E_{re}(m) = E_{elec}(m)$$

$$E_{re}(m)=E_{elec}*m \quad (2)$$

The amount of energy required $E_{rq}(m)$ for a specific node to transfer data of size m is given by

$$E_{rq}(m) = E_{tr}(m) + E_{re}(m) \quad (3)$$

Where $E_{tr}(m)$ = Energy required for transmission of data.
$E_{re}(m)$ = Energy required for receiving of data

The current remaining energy level of a sensor node after relaying one packet of m bits can be calculated by deducting the initial or previous energy value from the value of the energy dissipated by the sensor node.

4. Simulation Setup and Results

Castalia WSN Simulator is used to evaluate the performance of proposed RBR algorithm which provides realistic wireless channel and radio models. Castalia is an OMNeT++ based framework designed specifically for wireless sensor networks .To analyze the network lifetime, we have chosen the following four definitions: the time until the first sensor node dies, the time until half of the sensor nodes die, the time until 80 % of the sensor nodes die and the time until the all sensor nodes die. The simulations were executed in a square area of 100 × 100 meters, with 100 to 250 sensor nodes randomly deployed. Each sensor node has an initial energy of 100 J. The size of the data packets is fixed at 2000 bytes and the size of the control packets at 25 bytes.

From the simulation experiments, it is clear that proposed RBR algorithm gives better network lifetime as compared to Directed Diffusion (DD) and LEACH. This is shown in figure 1.The no. of rounds taken by RBR algorithm for first node death and other percentage of node deaths are more than DD and LEACH (node count=100).

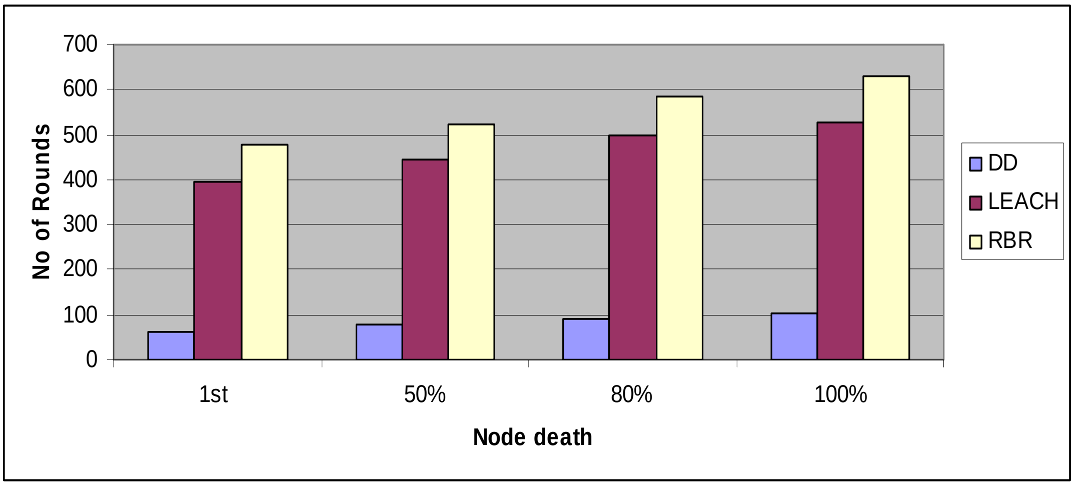

Figure 1: Network lifetime comparison of RBR algorithm with other routing protocols (Node Count=100).

From the figure 2 it is clear that RBR algorithm also gives better network lifetime in terms of first node death when the total number of sensor node count varies from 100 to 250.

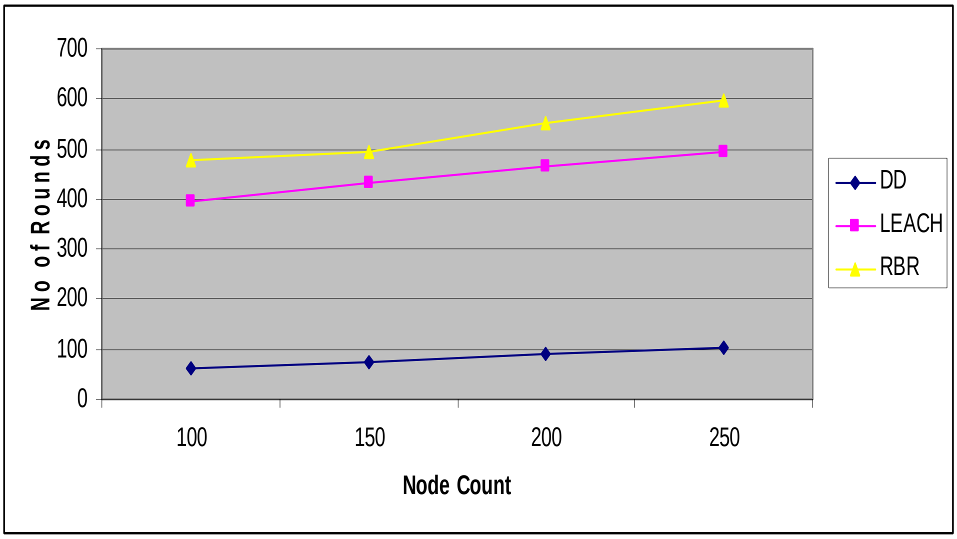

Figure 2: Network lifetime as a function of node count (no of nodes) based on first node death.

5. Conclusion and Future Work

In this paper, we proposed a routing protocol, which aims to evenly distribute the energy consumption among the sensor nodes and extend the lifetime of wireless sensor networks. Simulation results show that the proposed protocol is better than Directed Diffusion (DD) and LEACH in terms of energy consumption and maximization of the network lifetime. The main objective of our approach is to extend the network lifetime. Our future work is to improve the protocol as well as compare it with other routing protocols used in the wireless sensor networks.

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