Efficient Set Routing for Continuous Patient Monitoring Wireless Sensor Network with Mobile Sensor Nodes

M.S. Godwin Premi, Betty Martin and S. Maflin Shaby

Abstract Static sensor nodes are effectively and efficiently replaced by mobile sensor nodes in WSN applications like tracking, periodic weather monitoring, etc. In this paper, challenges in WSN routing are focused with mobile nodes. A new routing protocol called as set routing is proposed for wireless sensor networks with mobile nodes. In set routing, the sets of nodes are constructed after deployment. Routing overhead is fully given to static sink node or base station. Direction based linear mobility pattern is chosen for its greater coverage area with low energy spent and is used in set routing. Set routing is simulated using Omnet++ and Matlab and the performance is studied. The results are compared with cluster based routing and mobile leach protocols and found that delivery ratio is higher in our set routing.

Keywords Direction based linear mobility · Master nodes · Neighbouring sets · Sink node

1 Introduction

The wireless sensor network is a data centric multi-hop network [1]. Motes are playing vital role in wireless sensor networks to collect the data as well as to transmit the same to the sink node. These motes sense the data or receive the data from neighbors, process and store the same, and at last transmit/forward to the sink node. After deployment, all the sensor nodes or motes self organize them and start sense the data. Then all these data are transmitted to the sink [2–4]. There are many advantages of mobile wireless sensor networks when compared to static wireless sensor networks like increased coverage area and highly improved target tracking. When mobility is introduced in the motes generally the energy will drop. But this can be avoided by using solar power harvesting. With respect to applications the

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number of mobile nodes required may vary. Also depend on the scenario all the nodes can be mobile or only few nodes can be mobile. In order to reduce the propagation delay, energy and path loss new routing schemes are developed based on different conditions for the third logical layer.

2 Related Work

Jonathan Henderson introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH) [5]. The extension of LEACH protocol is the solar-aware LEACH (sLEACH) protocol [6]. To enhance the network lifetime solar powered nodes are introduced. However, in simulation both sLEACH and the original LEACH used the same algorithm and so both protocols are affected in the same manner. The Cluster Based Routing (CBR Mobile) protocol [7−11] for WSN is proposed by Awwad (2009) [12] to avoid that packet loss. The proposed protocol is implemented in two phases similar to LEACH. They are setup phase or registration phase and steady state phase. Like LEACH, the stages of setup phase are cluster head election, advertisement, decision, schedule creation. In this protocol, always a cluster head is made free to receive the data from unconnected sensor nodes. Each cluster head takes turn to be free for this operation. Since the unconnected nodes are joined in the newly formed cluster with a free cluster head as the cluster head, the data loss is very much reduced. In normal situation the protocol works as proactive, and sends data to cluster head in advance. If the sensor nodes did not receive data request message from its cluster head, it will send the message to a free cluster head. In LEACH-Mobile, sensor nodes wait for the request message for two consecutive failure frames. But CBR mobile protocol immediately sets up the registration phase to avoid accumulation of packet losses.

3 System Description

In this paper, a scenario is considered in such a way that the mobile sensor nodes are deployed in one end of hospital. The sink node or the base station is present in the centre of the hospital. The mobile sensor nodes are static until they receive START message from the sink node. The sink node sends the sample REQ message to all nodes. All mobile nodes send the REPLY message with their identity. Based on the time of arrival, using low cost localization algorithm sink node calculates the initial location of all the mobile nodes. After the initial locations of all the mobile nodes are determined, different sets are formed by sink node. For the initial position, master node(s) for each set is determined by the sink node. Moreover the nearby sets are noted by the sink node. After the set formation the sink node send the START message. START message contains the next stop position for all the mobile nodes.

Route information in every position is given to individual sets by the sink node. After receiving the START message from sink node they start moving in the prescribed direction. In order to cover all eight directions the direction of movement of sensor nodes should be as below (NW → N → NE → E → SE → S → SW → W): Left → Left → Down → Down → Right → Right → Up → Up. At regular intervals of time all the nodes are static in order to forward or transmit the data. The data are sensed by the sensor nodes when they are mobile and the data are transmitted or forwarded to the sink node when they are static. It is considered that there are no collisions during the movement and the entire nodes are free to move with equal speed. Also, the sink node initially calculates the location of the nodes using low cost localization algorithm and the nodes are named/addressed. Entire network is controlled by the sink node i.e.; when to move, when to stop, which direction to choose, whom to forward the data, speed, etc. For a mobile node the sink node selects minimum of eight stop positions around the sink. At every stop position, route and the next stop position are informed to all nodes via master node. Route discovery message flow is shown in Fig. 1. In this technique as the computing overhead is taken by sink node, route computing overhead is reduced at individual sensor nodes. As the sink node computes the route for each stop point and informs about the new route, energy spent for controlled mobility is partially compensated at individual sensor node. Thus patients in each room are monitored regularly by the sensor node and the data is transmitted to the base station. Patients in each room in every block will be monitored by same set of nodes in the next rounds providing the continuous measurement.

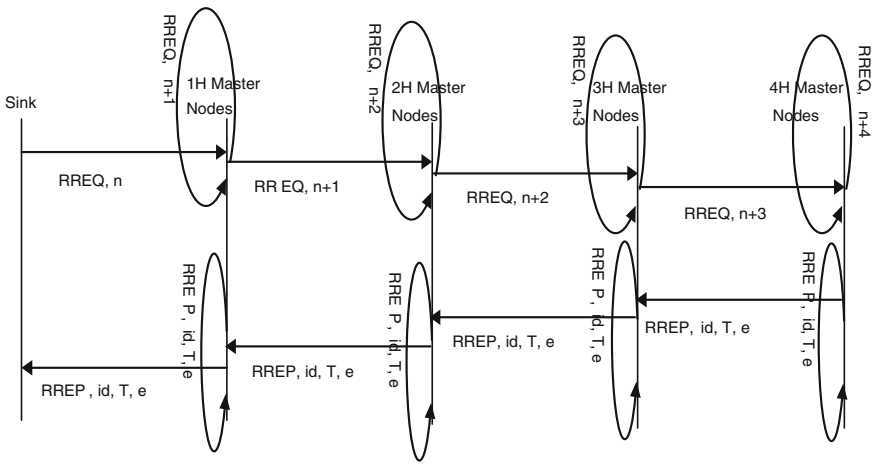

Fig. 1 Route discovery message flow

4 Simulation Results

Simulations are carried out in OMNeT++ 4.1 IDE with MiXiM Framework. Each sensor node is designed by understanding the logical layers of WSN and is developed as a NED using the supporting files. Results obtained using OMNet++ and Matlab are shown in Figs. 2, 3 and 4. It is found from the results that the

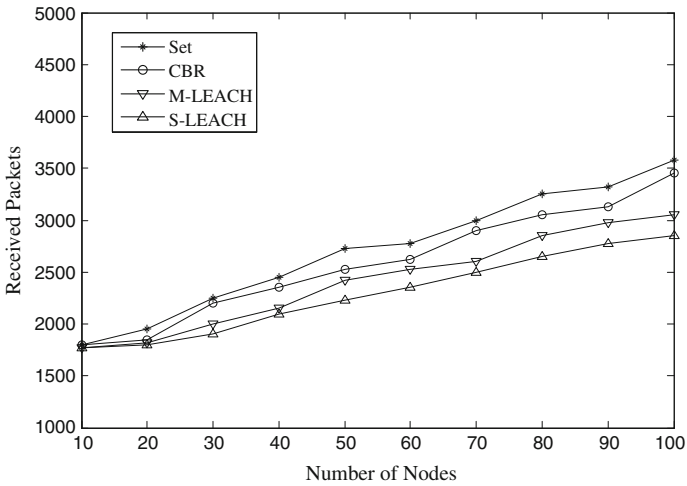

Fig. 2 Received packets

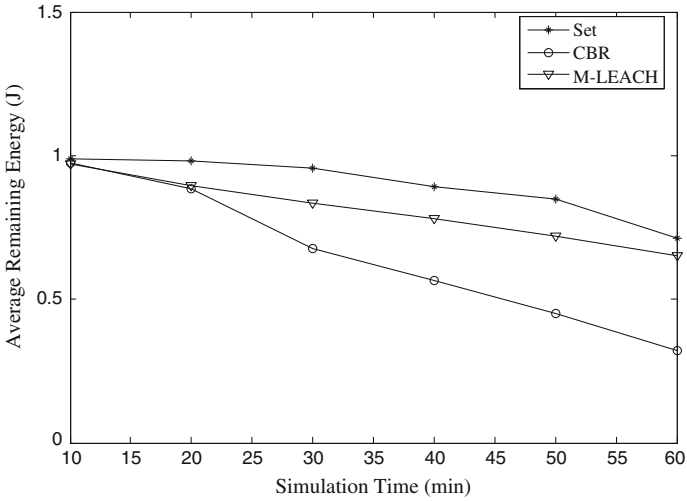

Fig. 3 Average remaining energy

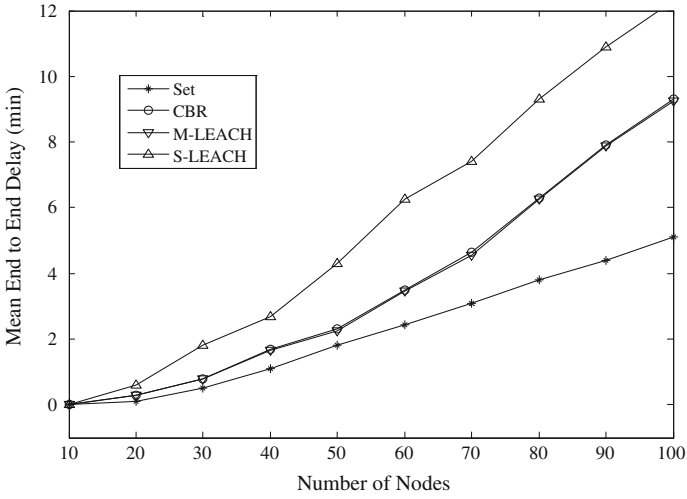

Fig. 4 Mean end to end delay

number of packets received and the remaining energy are high in set routing compared to existing cluster based routing, mobile LEACH and solar LEACH. Also the mean end to end delay is reduced in set routing. It is observed that received packets are more in set routing compared with other protocols. Moreover from Fig. 3 it is proved that energy spent is minimized in set routing. Also from Fig. 4 it is clear that mean end to end delay is minimized in set routing.

5 Conclusion

It is observed that set routing is the best suitable routing protocol for the continuous patient monitoring in the hospital. It is also observed that minimum number of nodes is required for maximum efficiency. Thus rather than spending for lot of sensor nodes, the required data can be gathered with a minimum number of mobile nodes. From the setup suggested in the study, it is observed that the network is energy efficient for the required amount of data collection.

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