Location Based Energy-Efficient Reliable Routing Protocol for Wireless Sensor Networks

RAFE ALASEM[1], AHMED REDA[2] AND MAHMUD MANSOUR[3]
(1) Computer Science Department
Imam Muhammad ibn Saud Islamic University
Riyadh, 11432 , Saudi Arabia
rafe.alasem@gmail.com

(2) Information System Department
Imam Muhammad ibn Saud Islamic University
Riyadh, 11432, Saudi Arabia
waellena@gmail.com

(3) Electrical Engineering Department
Imam Muhammad ibn Saud Islamic University
Riyadh, 11432, Saudi Arabia
mmmansour@ieee.com

Abstract: Minimizing Energy consumption is considered as one of the most important principles in the development of routing protocols for Wireless Sensor Networks (WSN). In this study, we propose a Location based Energy-Aware Reliable routing protocol (LEAR) for WSN based on sensor position and clustering. Geographical routing protocols are efficient and convenient for optimum energy consumption and bandwidth utilization. Most of the existing geographic routing protocols make use of greedy routing to forward packets from source to destination. Enhance Greedy Forwarding is proposed to perform a geographic, efficient and reliable routing for WSN. A comprehensive simulation study illustrates that the lifetime of WSN can be consequentially extended with LEAR. Finally, LEAR algorithm has been developed, tested and validated through a set of experiments to illustrate the relative advantages and capabilities of a proposed algorithm.

Key-words: Wireless sensor networks, geographic routing, energy efficiency, Wireless Sensor Network (WSN), Location based Energy-Aware Reliable (LEAR).

1 Introduction

Wireless sensor networks are often deployed to sense, process and disseminate information (e.g., temperature, humidity, or sound) of targeted physical environments. In many of these applicatio Minimizing Energy consumption is considered as one of the most important principles in the development of routing protocols for Wireless Sensor Networks (WSN). In this study, we propose a Location based Energy-Aware Reliable routing protocol (LEAR) for WSN based on sensor position and clustering. Geographical routing protocols are efficient and convenient for optimum energy consumption and bandwidth utilization. Most of the existing geographic routing protocols make use of greedy routing to forward packets from source to destination. Enhance Greedy Forwarding is proposed to perform a geographic, efficient and reliable routing for WSN. A comprehensive simulation study illustrates that the lifetime of WSN can be consequentially extended with LEAR. Finally, LEAR algorithm has been developed, tested and validated through a set of experiments to illustrate the relative advantages and capabilities of a proposed algorithm.ns real-time data mining sensor data to promptly make intelligent decisions is essential. A

Wireless Sensor Network (WSN) usually consists of a huge number of small, low- cost sensor nodes spread over a large area and high density with one or possibly more powerful sink nodes gathering readings of sensor nodes. The sensor nodes are equipped with data processing and communication capabilities. Each node is usually integrated with a wireless radio transceiver, a small microcontroller, a power source and multi-type sensors. These sensors have the ability to communicate either among each other or directly to an external Base Station (BS). A greater number of sensors allows for sensing over larger geographical regions with greater accuracy (Akyildiz *et al*., 2002).

These sensors measure ambient conditions in the environment surrounding them and then transform these measurements into signals that can be processed to reveal some characteristics about phenomena located in the area around these sensors. The sensor sends such collected data typically via radio transmitter, either directly or through a data concentration center (a gateway) to a command center (sink). The decrease in the size and cost of sensors, resulting from such technological advances, has fueled interest in the possible use of large set of disposable unattended sensors (Al-Karaki and Kamal, 2004).

However, sensor nodes are constrained in energy supply and bandwidth. Such constraints shared with a typical operation of huge number of sensor nodes have posed many challenges to the design and management of sensor networks. These challenges necessitate energy-awareness at all layers of networking protocol stack. At the network layer, the main aim is to find ways for energy efficient route setup and reliable relaying of data from the sensor nodes to the sink so that the lifetime of the network is maximized (Sohrabi, 2000; Akkaya and Younis, 2005).

2 Related works

Wireless Sensor Network (WSN) is an emerging technology that received much attention from research community in the recent years. It provides the possibility to monitor different kind of environment by sensing physical phenomenon. However the consumption of energy by WSN devices is considered as one of important issues that need to be aware due to the batteries lifetime.

In this context, many researches have focused on methods of reducing energy consumption of WSN nodes. Authors in (Ito and Yoshigoe, 2009), investigated ways of preserving the energy of actively sensing nodes in WSN. They proposed a consumed Energy-Type-Aware Routing (CETAR) method. The idea is to discourage some active node in participating in routing task in order to preserve their energy. By collecting statistics of energy consumption per type of activities at each sensor node such as sensing and data processing, data transmission as a source node and data receiving or transmission as routing node, CETAR encourages a node which plays a role of source node as routing node to preserve the energy of active source node in order to prolong the WSN device life time.

Through extensive simulation, the adaptability of CETAR on GEAR (Yu *et al*., 2001) has demonstrated that the lifetime of WSN with CETAR improves better than that of GEAR.

Another energy aware dual-path routing is proposed for real time traffic in (Mahapatra *et al*., 2006). In this scheme, the process of routing takes into consideration packet deadline, energy of the forwarding nodes and congestion at intermediate nodes. By ways of periodic beacon message exchange with neighbours, each node maintain a neighbour table that contains the geographic location of a neighbouring node, the energy left, the estimated time delay and the mobility factor. To increase reliability, data packets are duplicated at the source node. Through simulation authors show an improvement in performance for high traffic real-time packets as compared to other geographic routing scheme.

As an example of geographic routing protocol we find the Learning-based Prioritized Geographical Routing (LPGR) (Arroyo-Valles *et al*., 2007). This latter takes into consideration the importance of messages in term of priority of the transmitted message such as the quality of the estimation, the relevance of the information or Quality of Service (QoS). By exploiting local information from signal detected at each node, sensor nodes may learn from the success or failures past routing decision and estimate the available energy at neighbours to minimise the signalling protocol between nodes.

3 LEAR routing protocol

3.1 Hop by hop routing

LEAR: takes the advantages of location information to make routing mechanism more efficient. In LEAR, each node sends its location coordinates to its neighbors. The location information that has been used in LEAR algorithm could be extracted from devices such as Global Positioning System (GPS). Each node in this geographic area starts constructing its routing table based on the distances to its neighbors. As in other routing algorithms, each node makes a decision about forwarding the message to the selected candidate. If the node holding the message decides not to transmit it to a given candidate, the following candidate is chosen from the list and a new decision is made. A node decides about the transmission path based on the position of its neighbors. Once the distance vector is constructed for each node, it compares the localization of the next hop destination. The source node propagates its message to the neighbor which has the shortest distance to its location. Many different concepts of closeness have been proposed for this context. The most common approach is comparing the Euclidean distances and selecting the shortest one to the source node. This process is repeated for each active node until the message reaches the intended destination.

3.2 Enhance greedy forwarding

Energy aware concepts should be taken into any design consideration. Each sensor node is driven by its battery and has very low energy resources. This puts together energy optimization principle more complex in sensor networks because it involves not only decreasing of energy consumption but also extending the life of the network as much as possible. This can be prepared by having energy awareness in every phase of design and operation. For this purpose, Enhanced Greedy Forwarding (EGF) algorithm is selected to be the core of LEAR protocol. Most of the existing geographic routing protocols make use of greedy routing to forward packets from source to destination. Greedy routing is a simple, efficient and scalable approach for geographic. It is robust under topological changes, because a node can make correct forwarding decisions without requiring up-to-date state of nodes beyond a single hop.

EGF protocol selects the nearest node to the active node based on its distance. Choosing the shortest geographic distance to next hop node attempts to minimize the transmission energy consumption. As shown in Fig. 1, the enhancement in greedy algorithm is made by selecting only and only the forward nodes in routing path on the way to the destination and pruning all the nodes in the backward routing path. The pruning of the nodes behind the active node in the routing path minimizes the number of hops to get to the destination sink and consequently minimizes the energy consumption. Therefore, the network lifetime is increased as a result of increasing the number of energetic nodes and more energy is conserved.

3.3 Cluster based LEAR

In LEAR, sensors are deployed randomly in a clustered geographical area. As shown in Fig. 2, each cluster contains a random number of sensors based on their initial locations. Clustering or hierarchical routing protocol are proposed to produce an efficient energy aware algorithm for sensor networks. For example, In LEACH (Akkaya and Younis, 2005), one node per cluster is randomly elected to be the cluster head. Each cluster head gathers and aggregates all data it receives from its cluster nodes and forwards the collected data immediately to the base station. The selection of cluster heads is rotated among the cluster nodes and it is based on the determined a priori suggested quantity of cluster heads for the network and the number of times a node has been a cluster head so far. After the end of each round, the new elected cluster head sends to each one of the rest of its cluster nodes a consequent notification.

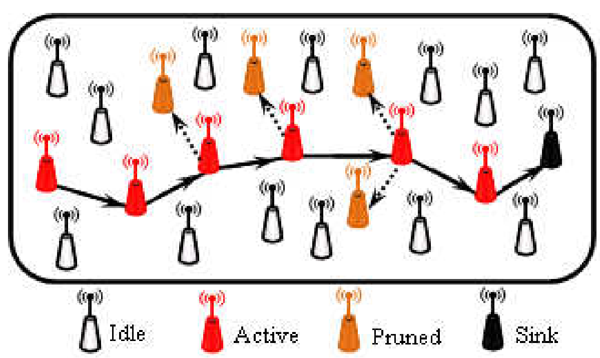

Fig. 1: Enhanced Greedy Forwarding

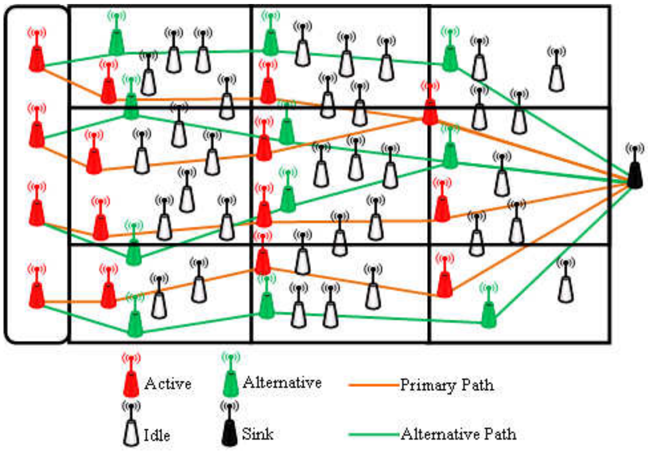

Fig. 2: LEAR protocol with clustering

In the opposite, in LEAR, there is no node is designated as a cluster head, the nodes that have been contained minimal distances to the sources are selected to be the next hop destinations. In one cluster, more than one node might be selected to be the target node. Moreover, LEAR supposes that all nodes contain dissimilar quantity of energy capacity at every selection round.

Furthermore, it is also undertaken that every node has a sufficient amount of transmission power in order to directly get in touch with the sink if required. The node holding the packets only needs to be aware of the location of its neighbors and the packets are forwarded locally and greedily to the neighbor closest to the source as the next hop destination in the next cluster. Each time the distance of the next hop node is compared with distance to the sink, if it is greater than the distance to the sink, the packets are forwarded directly to the sink instead of the next node destination.

4 Performance evaluation

In this section, we evaluate the performance of LEAR protocol through a set of experiments and simulations.

As shown in Fig. 3, the sensor nodes are deployed at arbitrary in an area of 800*1000 m^2 and two hundreds are also used in the repeated simulations.

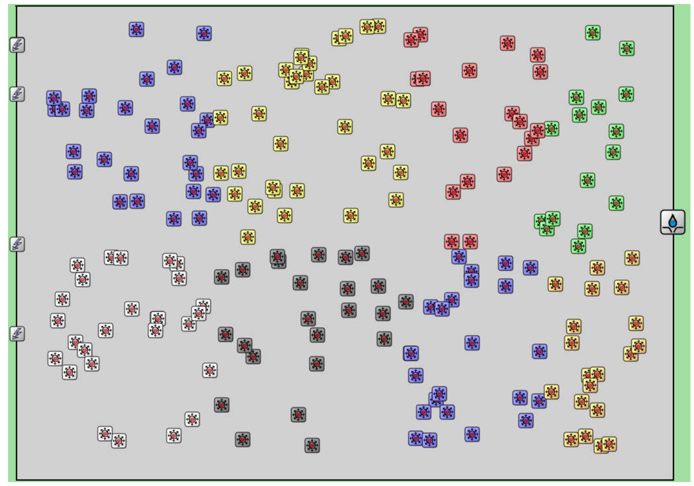

Fig. 3: Wireless sensor network

All nodes are positioned into eight clusters randomly. We use the discrete event simulator OMNET++ for our simulations. We generate and evaluate different possible random and predefined scenarios for simulation.

For the simulations that follow, we have considered CBR traffic with payload size set to 100 bytes. Each simulation runs for 2000 s and there is no network partition during the course of simulation.

The key performance measures are network lifetime, end to end delay and throughput. An extensive set of simulations has been done for the three routing protocols LEAR, LEACH and EGF to demonstrate the superiorities of the proposed LEAR algorithm.

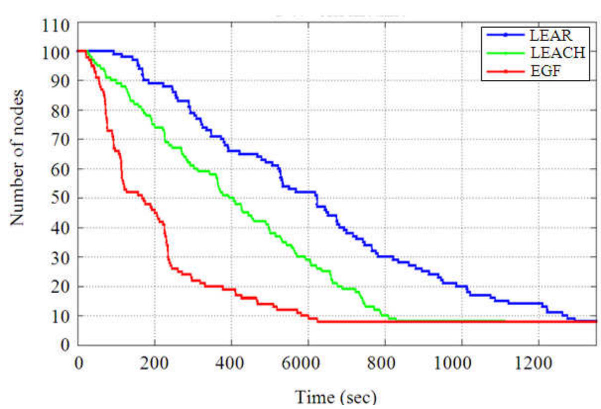

Fig. 4: Network lifetime comparison for 100 nodes

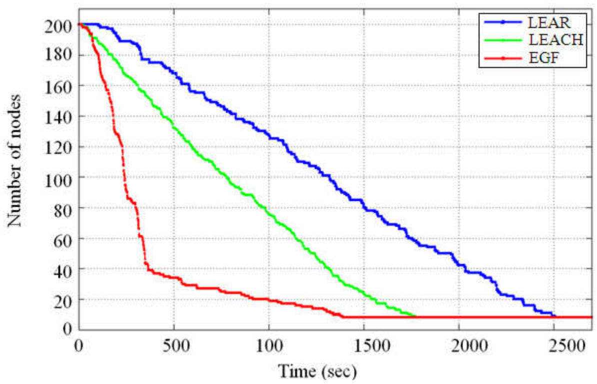

Fig. 5: Network lifetime comparison for 200 nodes

4.1 Lifetime measurements

Fig. 4 and 5 shows a comparison in a lifetime for LEAR protocol, LEACH and EGF protocols which is extremely critical for a wireless sensor network. It is noting that the energy consumption is decreased significantly when implementing LEAR routing protocol. LEAR extends the network lifetime significantly rather than other existed protocol such as LEACH and EGF. In LEAR, As a result, load balancing advantages have been gained because there is no node is elected as a cluster head, more than one node could be chosen when constructing the shortest path to the destination. In each cluster, the load has been distributed between the nodes that have shortest distances to the sources.

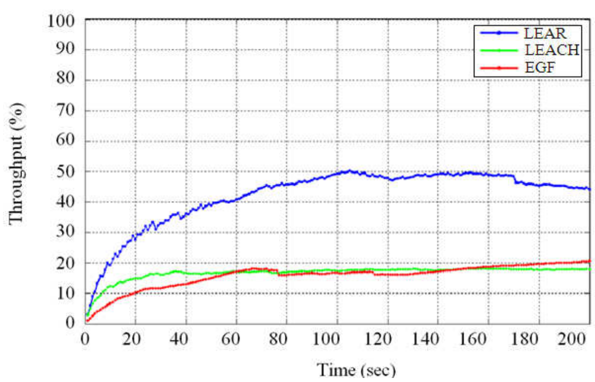

Fig. 6: Throughput comparison for 100 nodes

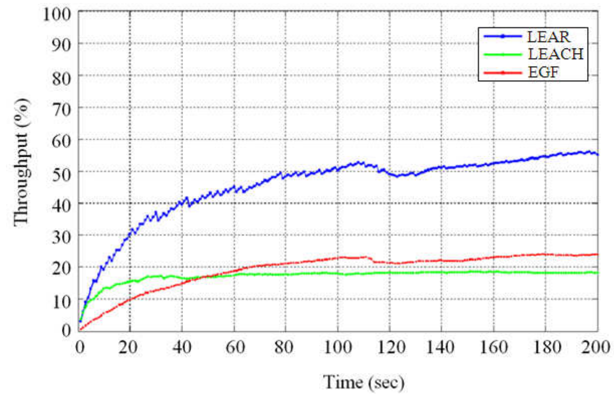

Fig. 7: Throughput comparison for 200 nodes

Also LEAR approach is more reliable in terms of energy consumption as it has less number of nodes dead as compared to LEACH or EGF algorithms. Hence, it provides longer the life to the sensor network as compared to the LEACH or EGF algorithms.

4.2 Throughput

In Fig. 6 and 7, we compare the overall network throughput for the three protocols. As shown in these two figures, LEAR performs the best in data delivery compared to LEACH and EGF protocols. The successful packet delivery of LEAR is 50%, while 20% of the travelled packets reached their destination in the case of LEACH or EGF. This result is accomplish because of the alternative selecting of nodes for transporting packets and the achieved load balancing.

5 Conclusion

In this study, we proposed a novel routing protocol for wireless sensor networks named LEAR. The network is handled in hierarchical clustering. Each cluster is occupied randomly with sensor nodes. The originality in the suggested protocol is by exploiting the Enhanced Greedy Forwarding and Clustering structure. LEAR enables us to enhance the network flexibility, lifetime, end to end delay and load balancing throughout the choosing of various cluster heads in each round. Energy consumption is the top-priority issue that has been taken into consideration in the investigation. A comprehensible comparison has been done between LEAR and the LEACH protocols to demonstrate the aspects of the proposed protocol. It has been noted that, LEAR is efficiently and effectively extends the network lifetime and data delivery rate in comparison to other existing protocols.

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