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EVALUATING PERFORMANCE OF LEFCA FOR INSIDE BS SITUATION IN WSNS

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Abstract: Wireless Sensor Networks (WSNs) are widely used for a great number of applications such as earthquake measurements, fire rescue, environmental monitoring, health care, smart homes approximately for twenty years. Therefore, researchers still try to design routing and MAC protocols for WSNs. In these studies, authors aim to improve common performance metrics which are energy efficiency, throughput and network lifetime by using several approaches. To achieve these improvements commonly used scheme is clustering. Clustering provides equal load distribution in the network by decreasing communication distances of sensor nodes thereby enhances energy efficiency of the network. LEACH is a fundamental routing protocol that forms clusters in a self-adaptive way to extend the lifetime of the network significantly. However, it has frequent cluster failures which cause network disconnection. This issue can be very critical for vital applications such as fire rescue, health care schemes and earthquake measurements. As a result, we design low energy fixed clustering algorithm (LEFCA) to overcome these issues and prolong network lifetime of LEACH based protocols in a significant manner. In this paper, we aim to investigate performance of LEFCA when base station (BS) is deployed into the sensor field. LEFCA is a fixed clustering algorithm which has threshold based cluster head (CH) determination approach as well as it has intelligent CH election process at the initialization of the protocol by the help of BS. In simulations, LEFCA is compared with LEACH and ModLEACH in terms of network lifetime, variation of total remaining energy and total data delivered to the BS for inside BS situation. According to the results, LEFCA provides remarkable performance improvements when compared with LEACH based protocols.

Keywords: Routing protocols, wireless sensor networks.

Introduction

Wireless Sensor Networks (WSNs) include a large number of sensor nodes distributed over a geographical area with known positions or random deployment. By sensing the environmental events within their respective ranges WSN nodes gather data of interest and communicate the data through the nodes until the data finally transmitted to the base-stations (BSs) for final processing [1].

WSNs are used in numerous applications which may require monitoring and detecting of particular events such as environmental applications, military applications, patient monitoring, disaster relief, smart home, precision agriculture, and smart city systems.

Routing in WSNs is very contentious due to the main characteristics that distinguish these networks from other wireless networks, such as mobile ad-hoc networks. Due to properties of a WSN, the existing routing protocols designed for wireless ad-hoc networks cannot be directly applied to WSNs. The design of a routing protocol for WSNs has to show regard to the insecurity of the wireless channel, the potential dynamic changes in the network

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topology, as well as the limited processing, storage, bandwidth, and energy capacities of the WSN nodes. Thus, special schemes are needed to guarantee efficient routing amongst the nodes of a WSN. The performance of WSNs is measured based on measurable parameters called performance metrics.

Throughput, latency, overhead, energy-efficiency, and network lifetime can be mentioned as extensive performance metrics for WSNs. Especially, energy-efficiency of a WSN can be obtained by calculating energy dissipation in the network. Energy wastage of each node can be defined as the normalized total amount of energy used in receiving or transmitting data.

The fundamental way of providing energy-efficiency in WSNs is clustering. In clustering, sensors are organized into clusters that communicate through a cluster head (CH). The CHs collect data from their members, aggregate the data and send them to the BS. By this way, the average communication distance of the nodes to the BS decreases. The sensed data is received by the BS within just two hops. Therefore, clustering provides significant energy savings in WSNs.

LEACH is well accepted, simple and efficient round based clustering routing protocol for WSNs. In LEACH, clusters are formed randomly in a self-organized way. The nodes in the network form clusters without any help from any external mechanism or a specific node in the network. LEACH protocol includes time frames that are called round. Each round consists of two phases: set-up phase and steady-state phase. In the set-up phase, the CHs are determined based on a probability function. In the CH selection process, percentage of nodes elect themselves as CHs. In the steady-state phase, cluster members gather data continuously and transmit these data to certain CHs in certain slots. The CHs fuse these data and forward the collected data to the BS [2].

On the other hand, in LEACH, a cluster topology changes at every transmission round due to the randomized cluster formation structure. Selection of new CHs and forming new clusters for every round induce more energy consumption and bring extra network costs. The same problem is also observed in other LEACH based protocols.

In this study, to solve this issue, low energy fixed clustering algorithm (LEFCA) for WSNs is proposed. LEFCA [3] not only minimizes the overall energy consumption but also prolongs the network lifetime significantly. Instead of changing CHs in each round, LEFCA has constant clustering scheme. For each round, LEFCA selects the nodes which have maximum energy as a CH in each cluster without changing cluster topologies. Following Section describes the details and working mechanism of LEFCA and its phases. Proposed LEFCA is compared with LEACH and ModLEACH for inside BS situations in Section III. Finally, the conclusion is given in Section IV.

Lefca Protocol

LEFCA splits the WSN into constant clusters whose members do not change through the entire lifetime of the WSN. A CH for each cluster is responsible for gathering and sending the sensed data to the BS.

LEFCA works in two phases. The first phase is the clustering phase where the clusters are formed, and the second phase is the data transmission phase where collected data are sent to the BS via CHs. Different from LEACH and other LEACH variants, the clustering phase is not repeated for each round. This is obtained by using constant clusters, which in turn results in significant energy savings. The initial CHs are determined randomly and the CHs broadcast an announcement message to inform the other sensor nodes in LEFCA. All other nodes join to their nearest clusters at the initial clustering phase.

In data transmission phase, the CHs start to gather the sensed data from their clusters and transfer the collected data to the BS. During data transmission phase, the CH has to keep its receiver on at all times to collect all the data from cluster members in its cluster. Once the CH receives all the data, then data are delivered from the cluster head to the BS. Data transmission phase is divided into time slots designated for each of the cluster members, where the member nodes send their data to the cluster head. The duration for each slot is fixed as in traditional time division multiple access (TDMA) scheme, thus the time to transmit data depends on the number of member nodes in the cluster.

Simulation Environment and Results Lefca Protocol For Inside Bs

Matlab is used as the simulation platform to evaluate the performance of LEFCA for inside BS situation. LEACH and ModLEACH algorithms are selected in order to compare performance of LEFCA. LEACH was summarized in the introduction section. Instead of same amplification energy level usage for all transmissions in

LEACH, ModLEACH uses low energy level for intra cluster communications. If a node is determined as a cluster head, it uses high power amplification level in ModLEACH. Threshold based cluster head changing scheme is also proposed in ModLEACH to improve energy efficiency.

These algorithms are compared in terms of lifetime and energy efficiency. For the simulations, *100* identical sensor nodes are distributed randomly in a *100 m x 100 m* square field. The simulations are conducted with *100* independent iterations for each algorithm. The base station with coordinates (50, 50) is placed centre of the square WSN field.

Network Lifespan

Fig. 1 illustrates the number of alive nodes vs. round number of LEACH, ModLEACH and LEFCA. The network lifetime increases from *3500* rounds to approximately 5500 rounds, a *50%* improvement compared to LEACH. LEFCA provides longer lifetime when compared to LEACH and ModLEACH because it does not change cluster formations for every round. It gets rid of transmitting of cluster formation messages in the network. It does not consume energy for broadcasting cluster joining messages in the network.

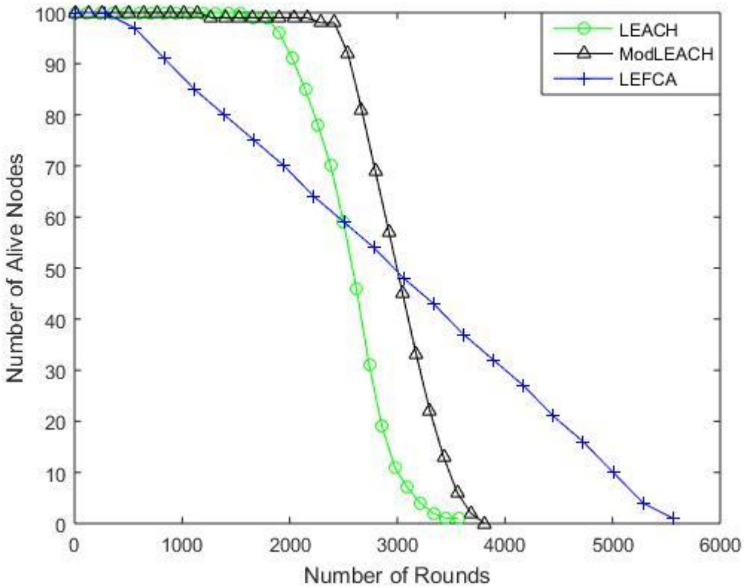

Figure 1. Number of alive nodes with respect to round number for inside BS

In this part, inside BS situation is considered to evaluate the success of LEFCA on other protocols. It is expected that, when BS moves close to the WSN area, the lifetime of all algorithms extend. The decrease in distance factor causes to consume lower energy for transmissions thus the lifetime of all protocols prolong. Also, all nodes in the sensor area are exposed to free space loss thus, their transmission distances become lower than cross over distance (*<87 m*) because the position of BS is (*50, 50*) and the farthest points to this point is (*0, 0*) and (*100, 100*). Thus, their energy loss becomes inversely proportional to d^2 power loss instead of d^4 in multi-path transmission model.

When the results of the simulations are examined, approximately *5%* improvements on lifetime performance for all algorithms can be obtained as shown in Fig. 1 when compared with *100* nodes outside BS situation in [3]. Consequently, LEFCA is still most successful algorithm when compared with other algorithms for inside BS situation.

Remaining Energy of the Nodes

Fig. 2 shows the total remaining energy of the WSN for other protocols and LEFCA for inside BS. With fixed clustering, it can be observed that LEFCA provides a significant energy savings when compared to LEACH and ModLEACH. After *2500* rounds, while LEACH holds *5%* of its initial total energy, LEFCA holds approximately *40%* of their initial total energy. When the network lifetime ends under LEACH, LEFCA still saves approximately *15%* of its total initial energy. LEFCA also outperforms ModLEACH in terms of energy-efficiency.

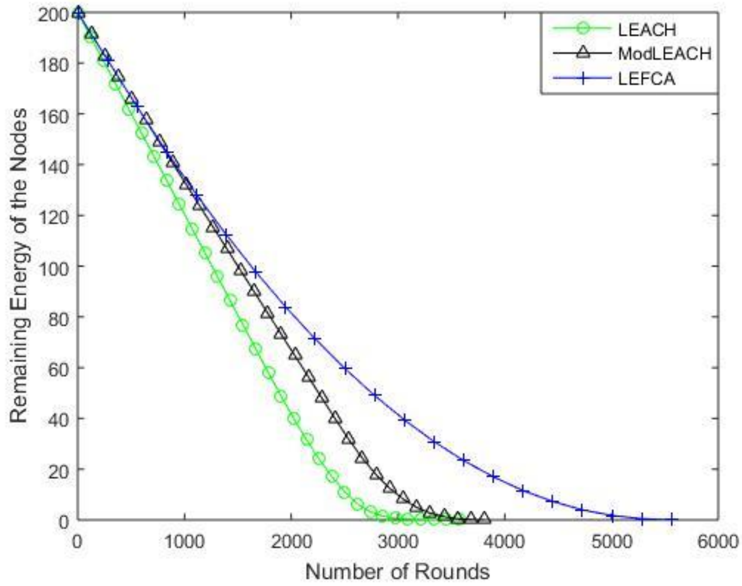

Figure 2. Remaining energy of the nodes according to the round number for inside BS

Conclusion

Trying to provide energy-efficiency, extending lifespan and designing greener networks for WSNs has become a significant research area nowadays. By using fixed number of clusters and reducing the number of CH changes, LEFCA minimizes the cluster formation overhead under inside BS situation. When compared with LEACH and ModLEACH significant enhancements are obtained in terms of energy dissipation and network lifetime. LEFCA extends the lifetime of the WSN, while reducing the energy consumption of the nodes significantly.

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