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A New Method for Hierarchical Routing in Wireless Sensor Networks by Considering the Packet Deadline

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ABSTRACT

Wireless sensor network is one of the most important technologies of the twenty-first century is well known. Sensor networks is the accumulation of a large number of sensor nodes scattered in the environment are treated with wireless communications. The main goal of this network is a network of sensors to collect information about the environment. One of the challenges in sensor networks, routing and transmission of data in networks, which is of high importance, So having a good routing algorithm can help to improve network performance. In this paper, a new method based on a hierarchical structure (clustering) is introduced in terms of three factors that are considered in the route selection discussion: Interference, energy consumption and deadline. In routing, when a packet is to be sent, the cluster heads depending on the stipulated time sends it. The packet which has less deadline will be sent earlier. The packet will be sent to the sink in one hop or multi-hop manner according to its deadline. If cluster head sends the packet in multi-hop manner, the next cluster head should be selected with these features: Less interference, more energy and less distance to sink. Re clustering together on the same timeline is a learning mode when clustering is done to improve the conditions of packet loss. By applying this algorithm significantly improves the energy consumption and number of lost packets. The proposed algorithm is examined and the results are compared with LEACH which is a hierarchy based method. The results illustrate that the proposed method in comparison whit LEACH has better results in terms of network lifetime, number of lost packets, energy consumption and end-to-end delay.

KEYWORDS: wireless sensor network, lost packets, hierarchical structure

1. INTRODUCTION

In general, the Wireless Sensor Networks consists of a large number of small and cheap sensor nodes that have very limited energy, processing power and storage. They usually monitor areas, collect data and report to the base station (BS). Due to the achievement in low-power digital circuit and wireless communication, many applications of the WSN are developed and already been used in habitat monitoring, military object and object tracking [1]. The energy consumption can be reduced by allowing only a portion of the nodes, which called cluster heads, to communicate with the base station. The data sent by each node is then collected by cluster heads and compressed. After that the aggregated data is transmitted to the base station. Although clustering can reduce energy consumption, it has some problems. The main problem is that energy consumption is concentrated on the cluster heads. In order to overcome this demerit, the issue in cluster routing of how to distribute the energy consumption must be solved [2].

Most of the clustering algorithms utilize two techniques which are selecting cluster-heads with more residual energy and rotating cluster-heads periodically to balance energy consumption of the sensor nodes over the network.

These clustering algorithms do not take the location of the base station into consideration. This lack of consideration causes the hot spots problem in multi-hop wireless sensor networks. The cluster-heads near the base station die earlier, because they will be in a heavier relay traffic than the cluster-heads which are relatively far from the base station.. In order to solve this problem and to balance energy consumption of cluster-heads, a periodically rotating cluster-head mechanism is firstly proposed by [3] namely LEACH is a clustering algorithm that utilizes randomized rotation to balance energy consumption of cluster-heads over the network (Low-Energy Adaptive Clustering Hierarchy). LEACH. Randomized periodical rotation property of LEACH is used in many clustering algorithms. Although periodical rotation is a vital property for clustering algorithms, it is not sufficient by itself. Most of the clustering algorithms use periodical rotation as a base property and build their approach on top of it.

It is a real-time wireless networks where the results are reasonable, the time at which results are produced, is also important. In other words, limiting the performance of critical applications that require real-time latency is referred to as applications. Those wireless sensor networks that can provide guaranteed packet delivery delays are constrained wireless sensor networks in real time as it is called. The majority of WSN applications are real. Wireless sensor network node, at any time or to move people, animals, vehicles or other objects that identifies the type of base station reports. After receiving data from the network, the base station will perform some actions. It is possible to turn on a camera, alert guards or something else is predetermined. If the base station, take messages when they detect moving out of the area where the report originated, The camera cannot take a picture of the object under observation. These networks used for sharing (wireless), provides a means to communication. Thus, the need for media access control protocol (MAC) is a distributor who can provide guaranteed bandwidth over multiple hops. Guarantee end-to-end delay of packet delivery are necessary first step. Support the real-time should be low power and low message overhead to limit interference and

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achieve energy saving. Since the network includes a large number of nodes, the scalability of the solution is important [4]. For real-time implementation, a method is to send a packet deadlines and the media access control layer packets are sent earlier than the deadline. Deadline for application is network dependent. The main objective of this paper is applying a new method for hierarchical routing in wireless sensor networks by considering the stipulated deadline.

2. LEACH: CLUSTERING-ROUTING PROTOCOL

LEACH (Low-Energy Adaptive Clustering Hierarchy) [5] is a distributed algorithm which makes local decisions to elect clusterheads. If the cluster-heads are selected for once and do not change throughout the network lifetime, then it is obvious that these static cluster-heads die earlier than the ordinary nodes. Therefore, LEACH includes randomized rotation of cluster-head locations to evenly distribute the energy dissipation over the network. LEACH also performs local data compression in cluster heads to decrease the amount of data that is forwarded to the base station.

In LEACH, cluster-head election is done periodically to enable randomized rotation of cluster-heads. Every round consists of two phases, namely set-up phase and steady-state phase. In set-up phase, cluster-heads are elected and clusters are formed. In steady-state phase, data transfers to the base station are performed through the clustered network. A particular sensor node decides whether it is going to become a cluster-head or not by generating a random number between 0 and 1. If this number is less than the predefined threshold T(n), then the sensor node becomes a cluster-head. G represents the set of sensor nodes that have not been cluster-heads in the last 1/p where P is the desired percentage of cluster-heads. r represents the current round number. Using these parameters, T(n) is formulated as follows: If the sensor node n belongs to G:

$$T(n) = \frac{P}{1 - P*(r \bmod \frac{1}{p})} \qquad (1)$$

If the sensor node n does not belong to G, then the T (n) is set to 0. Thus, n cannot become a cluster-head. At round 0, the probability of becoming a cluster-head for each node is equal to P. However, this situation changes in the following rounds. The cluster-heads of round 0 cannot become cluster-heads during the following 1/p rounds. This restriction prevents a particular node to become a cluster-head frequently. However, this restriction brings a drawback. It causes rapid decrease in the number of cluster-heads. To handle this drawback, as r increases, the chance of the remaining sensor nodes to be a cluster-head is also increased by adjusting the threshold T(n) for the remaining sensor nodes. This critical balance is a significant property of LEACH.

After cluster-heads are elected for a particular round, each cluster-head broadcasts an advertisement message to the remaining sensor nodes. As each non-cluster-head node receives these advertisement messages, they decide the cluster to which they belong. Each non-cluster-head joins to the cluster from which it has received the largest signal strength. In order to join to the selected cluster, it transmits a Join Cluster Head Message to that cluster. Once all the cluster-heads are selected and the clusters are formed, data transmission continues up to the next round. The simulations in [5] showed that LEACH reduces communication energy as much as 8 times as compared to direct transmission. In other words, the first node death in LEACH occurs 8 times later than the first node death in direct transmission. Since we compare our proposed algorithm with LEACH, we have developed a LEACH simulation.

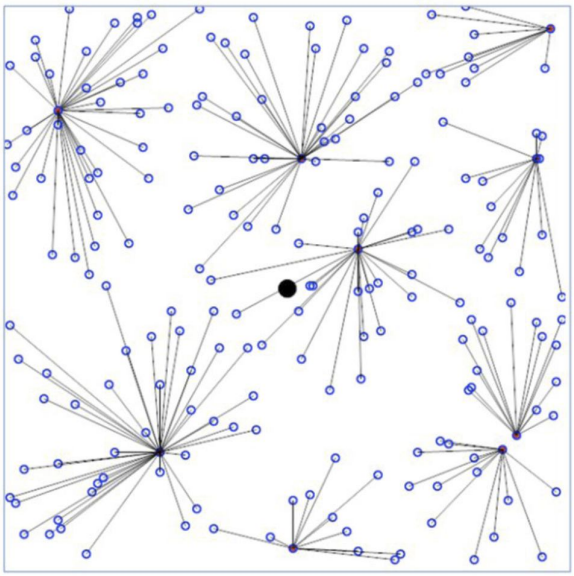

Figure 1. Cluster-head distribution example for LEACH with P = 0.05

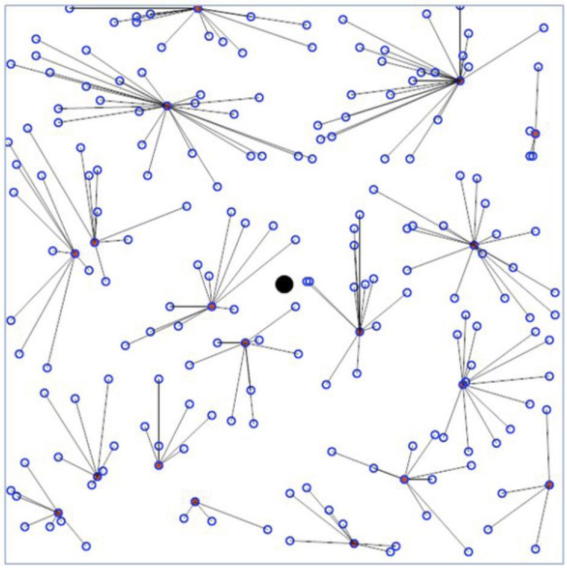

Figure 2. Cluster-head distribution example for LEACH with P = 0.1

Figure 1 and Figure 2 shows two different cluster-head distribution examples over the network for two different particular rounds [6]. In both of the examples, the number of deployed sensor nodes is 200. The desired percentages of cluster-heads are 0.05 and 0.1, respectively for the examples in Figure 1 and Figure 2.

3. PROPOSED METHOD

As already mentioned, the main objective of this research is applying new methods for routing in wireless sensor networks. In routing, the packet will be sent when the cluster heads close to the deadline so that we can send each packet. Depending on the time period is less than the time it is sent and the deadline will be assessed a single step can send one or multi step, If that is multi step it sent to the best cluster head. Re clustering together on the same timeline is a learning mode when clustering is done to improve the conditions of packet loss. By applying this algorithm significantly improves the power of the number of lost packets. Proposed method is formed at the beginning of the following phases:

Selecting cluster head: The cluster heads are initially selected according to LEACH .

Cluster head announcement: when the primary cluster is formed, the cluster head introduces itself as cluster head among the nodes.

Clustering: The nodes which are not selected as cluster head, listen to the messages which are sent by the cluster heads. Then, each node selects a cluster head which needs lowest energy in order to send information according to the received signal straight.

Packet forwarding: There are several ways in order to sending packets in the proposed method. Regarding to the time deadline, the decision is made about next rout. If the ttl (time to live) is less than necessary time in order to directly send to the sink, this packet would not be sent.

However, if it has sufficient time for sending, in order to reach load balancing and reduce interference, a cluster head which is near the sink or the sink is selected and data packet is delivered to it. The process of selecting the proper cluster head is done by a fuzzy system.

There is a function which is defined for each node in order to determine the node chance for being next cluster head in next step. We expect that the number of lost packets significantly decrease. The input of fuzzy system in each node is: remaining energy, distance to sink and interference (or number of lost packets). The output of this fuzzy system is a number which indicates to the chance of a node being cluster head. The more energy, less distance to sink and less packet loss, the more chance for become cluster head.

When conflicts arise, we will give priority to packets that have a limited period of time and send them in order to achieve less unripe and unsuccessful packets.

When members within cluster have high packet loss and high interference, Regarding to defined fuzzy system, a node which is more suitable for become cluster head than other nodes among the nodes of current cluster head is selected as new cluster head and re-clustering is done.

4. SIMULATION RESULTS

The simulation results obtained with MATLAB software[7]. Network deployment is such that initially hundred nodes randomly in a two-dimensional square of 100 × 100 are distributed. Some features of the network and nodes' characteristics are listed below:

Number of nodes: 100; Sink coordination: (50, 50); deployment strategy: Random;

Nodes initial energy: 0.5 joule; Emp: 0.0013*0.000000000001 Joule; Efs :10*0.000000000001 Joule; Eelec :

50*0.000000001 Joule;

Data packet size: 4000bit; Control packet size: 32bit; Sink energy: unlimited; Nodes type: Homogeneous.

Based on the above information, the proposed method and LEACH algorithm are performed. The following results are obtained the after 2000 rounds of the two algorithms:

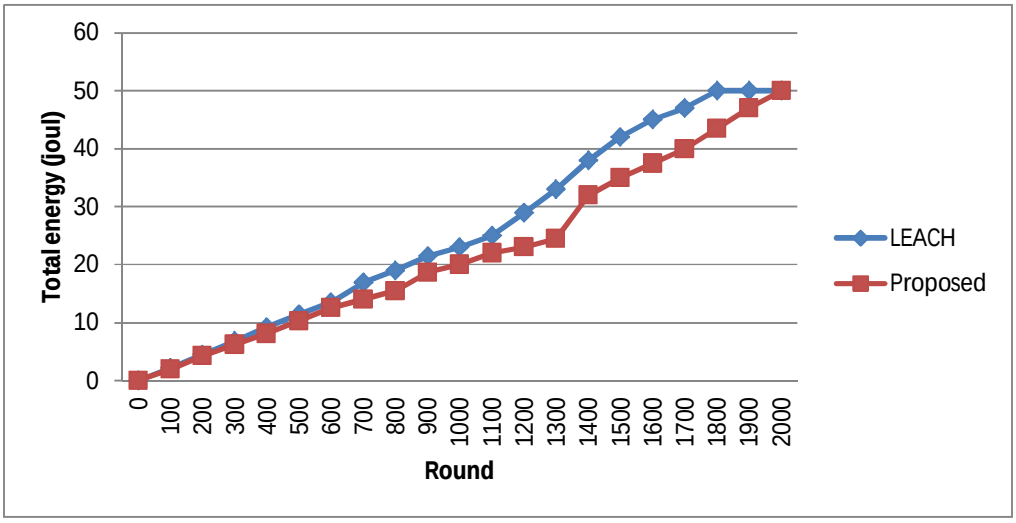

Figure 3. Energy consumption rate

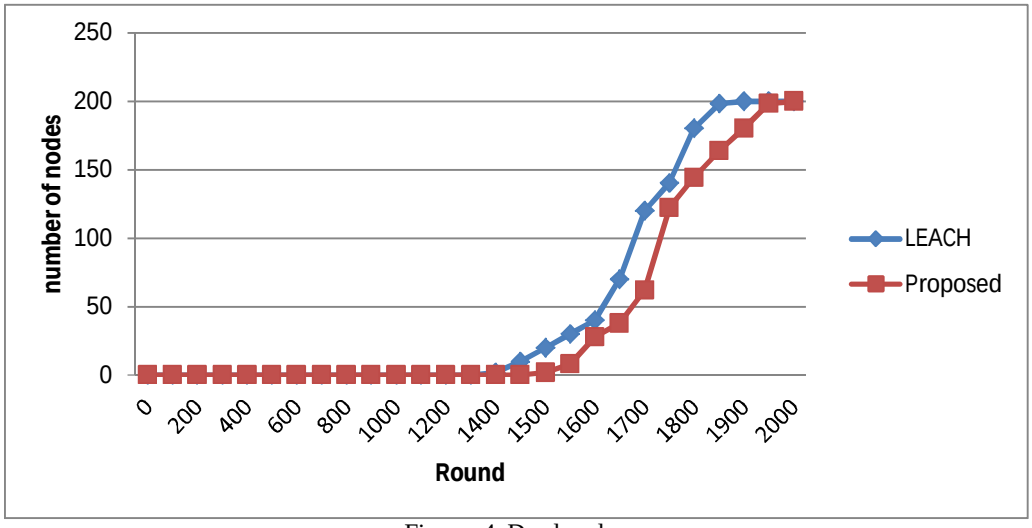

Figure 4. Dead nodes

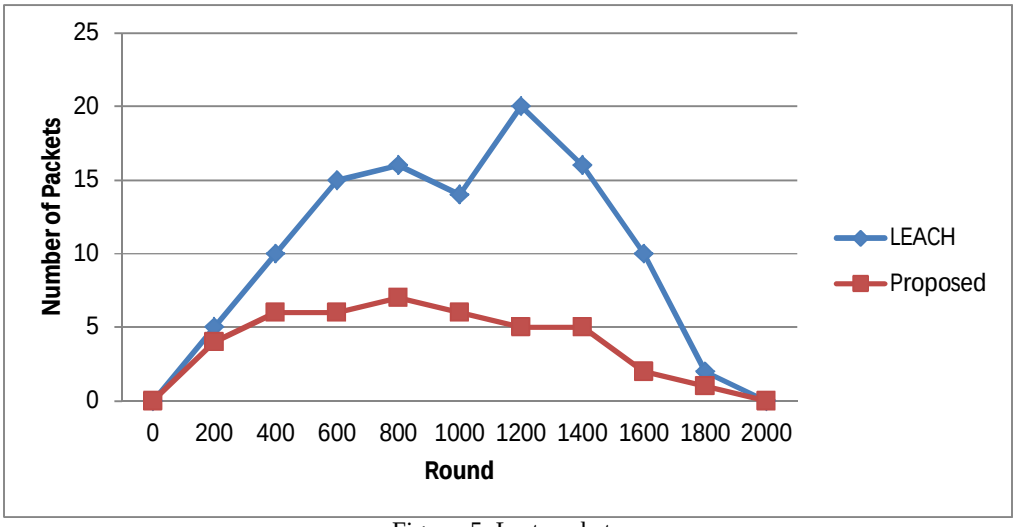

Figure 5. Lost packets

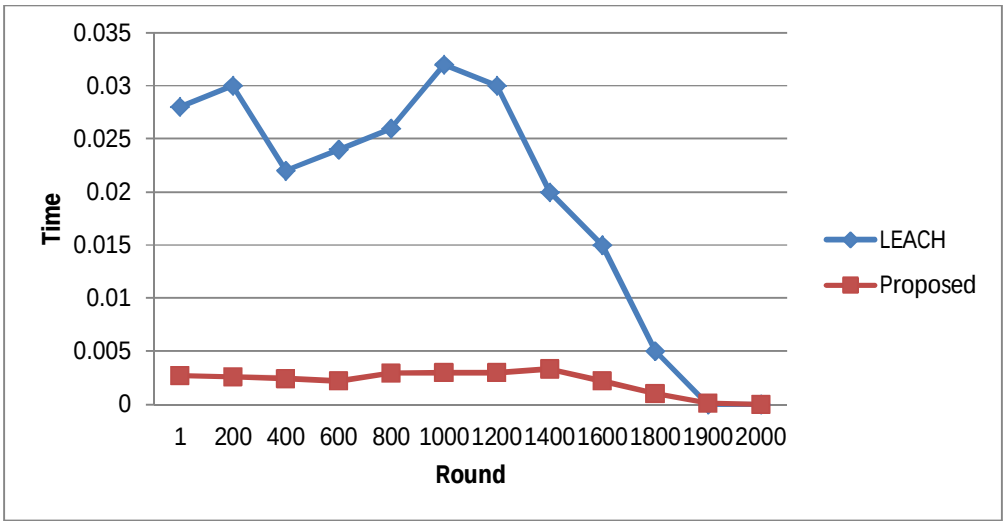

Figure .6 End-to-end delay

5. CONCLUSION

Our aim of doing this research was achieve to a novel approach in order to reduce lost packets, energy consumption and end-to-end delay along with limited time to live in data packets in hierarchical wireless sensor network structure. In the proposed algorithm, the packets have a specific deadline which should be sent before this deadline finished. In comparison with LEACH, energy consumption reduces and network lifetime increase due to multi-hop forwarding and selecting the best cluster head.

Because of re-clustering and multi-hop forwarding, the amount of lost packets in comparison with LEACH significantly decreases.

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