Research On Energy Efficient Routing Protocol LEACH For Wireless Sensor Networks

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Abstract

In recent era of Wireless Technology, energy efficient design and latest wireless technologies have enabled new exciting applications for wireless devices. These types of applications covers a wide range including real time and streaming video and audio delivery, transfer of large amount of data from one device to another. These applications require high performance on the network, they usually suffering from resource constraints. Wireless devices are often having limited energy resource because nodes are battery operated. This makes application with limited bandwidth & making the transfer error prone. A wireless sensor network which consists of a group of sensor nodes enables the monitoring of a variety of environments for applications. In WSNs, it is very critical to operate sensor network for a long time. In this case, data fusion is helpful to reduce the amount of data transmitted between sensor nodes and base station. The LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is an elegant solution to this problem. In this paper, LEACH protocol is discussed.

1. Introduction

In recent years we have seen growth of wireless devices including cellular phone, mobiles, laptops and personal digital assistants. The advances in the wireless technology are also one of the major motivations for the growth of the wireless devices or mobile computing. And for this, basically we would like the Wireless Sensor Network to perform its functionality as long as possible.

A number of routing protocols have been proposed for WSN [2, 3, 4]. Few of them are cluster based. Two of the most well known hierarchical protocols are LEACH, and PEGASIS. Both of these show significant reduction in the overall network energy over other non-clustering protocol.

Hierarchical routing protocols designed to reduce energy consumption by localizing communication within the cluster and aggregate data to reduce transmissions to the BS. Leach is considered as the most popular routing protocol that use cluster based routing in order to minimize the energy consumption; Following section describes LEACH protocol, its architecture, analysis & its simulation.

2. Cluster based Routing

In WSNs, broadcasting is the important process for data transmission. Broadcasting is the process in which a source node transmits a message to all other nodes in the network. Clustering is one of the methods for Broadcasting. Our main concern is only about clustering because LEACH is using this.

LEACH (Low Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster based station (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station.

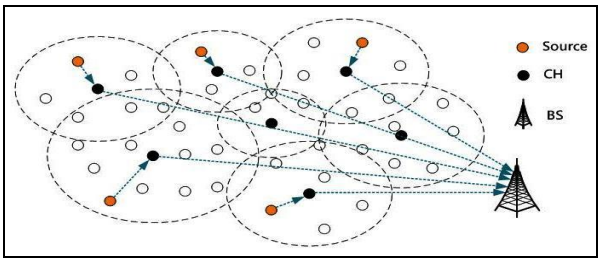

Figure 1 : Clustering based routing in WSN

2.1 Working mechanism of Cluster based Routing

In clustering schemes, there are two kinds of nodes in one cluster, one cluster head (CH) and several other cluster members (CMs). Cluster members gather data from the environment periodically and send the data to cluster heads. As shown in Figure 1, Cluster heads aggregate the data from their cluster members, and send the aggregated data to the base station (BS). There are two kinds of communications between cluster heads and the BS, single-hop communication and multi-hop communication. In multi-hop communication clustering algorithms, the energy consumption of cluster heads consists of the energy for receiving, aggregating and sending the data from their cluster members, known as intra-cluster energy consumption and the energy for forwarding data for their neighbor cluster heads known as inter-cluster energy consumption.[11]
The main goal of cluster-based routing protocol is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a cluster. Also, it uses data aggregation and data fusion in order to decrease the number of transmitted messages to the sink and transmission distance of sensor nodes.

3. LEACH – Low Energy Adaptive Clustering Hierarchy

LEACH is a cluster-based protocol, which includes distributed cluster formation. LEACH randomly selects a few sensor nodes as cluster-heads and rotates this role to evenly distribute the energy load among the sensors in the network. In LEACH, the cluster-heads compress data arriving from nodes that belong to the respective cluster, and send an aggregated packet to the BS in order to reduce the amount of information that must be transmitted to the BS.

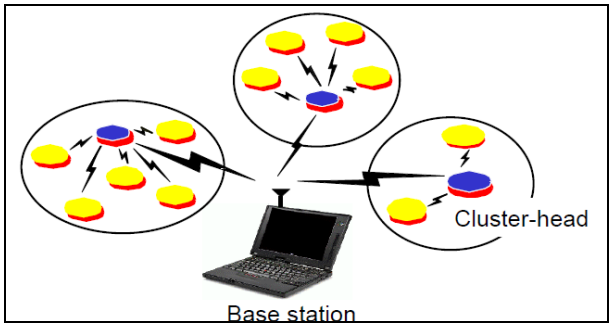

Figure 2: LEACH Protocol with CH & BS

3.1 LEACH Phases:

This protocol is divided into rounds; as shown in Figure 3, each round consists of two phases;
(i) Set-up Phase (ii) Steady Phase

Figure 3: LEACH Phases

3.1.1 Set-up Phase:

Set-up phase is further divided into 2 parts:

- Advertisement Phase
- Cluster Set-up Phase

LEACH forms clusters by using a distributed algorithm where nodes make autonomous decisions without any centralized control.
As shown in Figure 4, In the Advertisement Phase, CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.
Each node decides independent of other nodes if it will become a CH or not.
This decision is made by looking into account when the node served as a CH for the last time (means the node that hasn't been a CH for long time is more likely to elect itself than nodes that have been a CH recently). This is done according to a threshold value, T (n).
The threshold value depends upon the desired percentage to become a cluster-head- p, the current round r, and the set of nodes that have not become the cluster-head in the last 1/p rounds, which is denoted by G. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members every node wanting to be the cluster-head chooses a value, between 0 and 1.
If this random number is less than the threshold value, T (n), then the node becomes the cluster- head for the current round.
Then each elected CH broadcasts an advertisement message to the rest of the nodes in the network to invite them to join their clusters.
Based upon the strength of the advertisement signal, the non-cluster head nodes decide to join the clusters.
In the set-up phase, the cluster head nodes are randomly selected from all the sensor nodes and several clusters are constructed dynamically.
Following flowchart shows the procedure for the set-up phase:

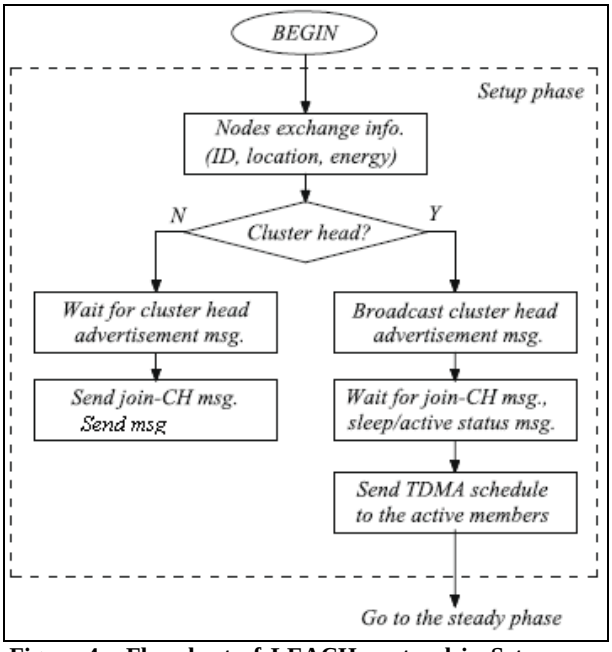

Figure 4: Flowchart of LEACH protocol in Set-up phase

3.1.2 Steady Phase:

Steady phase is further divided into 2 parts:

- Schedule Creation
- Data Transmission

Figure 5 shows the flowchart for the steady phase.
Once the nodes have elected themselves to be cluster heads the cluster head nodes must let all the other nodes in the network know that they have chosen this role for the current round.
To do this each cluster head node broadcasts an advertisement message ADV using a non persistent carrier sense multiple access CSMA. This message is a small message containing the nodes ID and a header that distinguishes this message as an announcement message.
Each non cluster head node determines to which cluster it belongs by choosing the cluster head, that requires the minimum communication energy based on the received signal strength of the advertisement from each cluster head.
After each node has decided to which cluster it belongs, it must inform the cluster head node that it will be a member of the cluster. Each node transmits a join request message (Join_REQ) back to the chosen cluster head using a non persistent CSMA.
After schedule creation sub phase, the CH knows the number of member nodes and their IDs. Based on all messages
received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members.
After that Data Transmission phase begins. Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement) the radio of
Each non-CH node can be turned off until the nodes allocated TDMA slot. This will minimize energy dissipation in nodes. once all the data has been received

from the cluster nodes, the CH aggregate these data and send it to the BS.

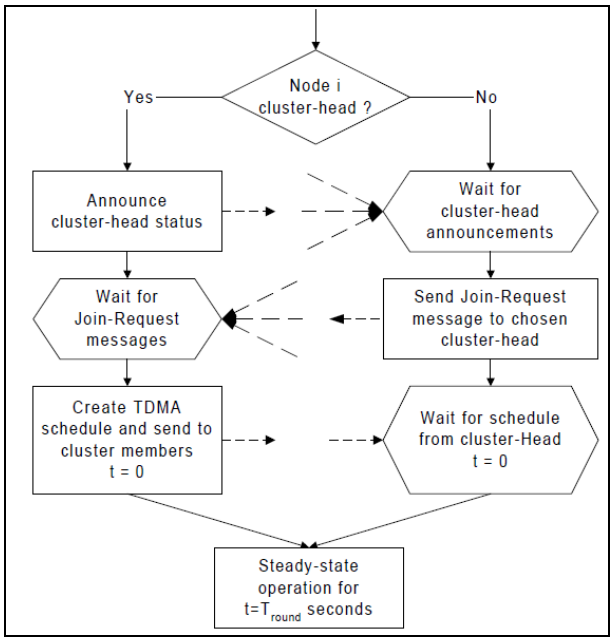

Figure 5: Flowchart of LEACH protocol in Steady phase

LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that transmitted to the base station.

4. Comparison with other Routing Protocol

In [12] there is comparison of different protocols in WSNs.

In WSNs, AODV, DSDV, TORA, LEACH protocols are taken. Performance of AODV, LEACH is better but AODV is less reliable than LEACH because the result of AODV is fluctuated but that of LEACH is not.

In [12] new version of LEACH is created called VLEACH. We concluded that no. of messages created by VLEACH is less than the messages created by original LEACH. If messages created by VLEACH are less that mean the network energy remaining using VLEACH is more than the remaining network energy using original LEACH. Therefore version of LEACH performs much better.

5. Simulation & Result

5.1 Simulation Environment

The simulation experiment is carried out in LINUX (Ubuntu 10.10). The detailed simulation model is based on network simulator-2 (ver-2.34), is used in the evaluation. The NS instructions can be used to define the topology structure of the network and the motion mode of the nodes, to configure the service source and the receiver, to create the statistical data track file and so on.

5.2 Traffic Model

Continuous bit rate (CBR) traffic sources are used. The source-destination pairs are spread randomly over the network. Only 512-byte data packets are used. The number of source-destination pairs and the packet sending rate in each pair is varied to change the offered load in the network.

5.3 Mobility Model

The mobility model uses the random waypoint model in a rectangular field. The field configurations used is: 500 m × 500 m field with 20 nodes. Here, each packet starts its journey from a random location to a random destination with a randomly chosen speed (uniformly distributed between 0–5/10/15/20 Mbps/s). Once the destination is reached, another random destination is targeted after a pause. The pause time, which affects the relative speeds of the mobiles, is varied. Simulations are run for 150 simulated seconds. Identical mobility and traffic scenarios are used across protocols to gather fair results. Mobility models were created for the simulations using 20 nodes, with pause times of 0, 30, 60, 90, 120, 150 seconds, maximum speed of 5/10/15/20 Mbps, topology boundary of 500 × 500 and simulation time of 150 secs.

5.4 Results

Figure 6: Graph for No. of Packets Sent

The above graph shows the result of Number of packets sent from node to node in given Time between 20 nodes with 5 Mbps speed.

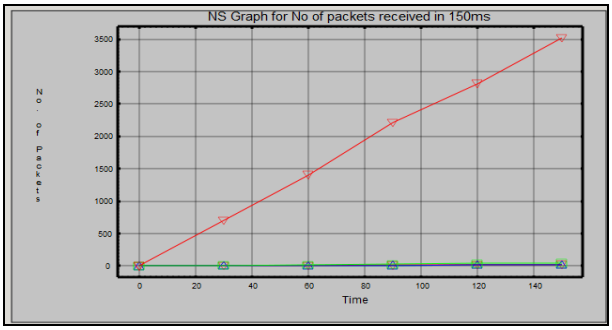

Figure 7: Graph for No of packets received

The above graph shows the result of Number of packets received from node to node within 150ms between 20 nodes with 5 Mbps speed.

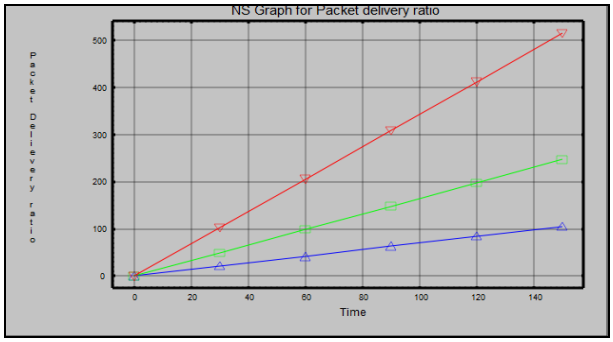

Figure 8: Graph for Packet ratio

The above graph shows the result of Number of packet delivery ratio from node to node in given Time between 20 nodes with 5 Mbps speed.

6. References

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