Improvement of Energy Consumption Using Multi-Hop Routing With Channel Utilization In WSN

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Abstract - Currently in Wireless Sensor Network (WSN), energy consumption and network lifetime improvement are the most challenging tasks. Thus, a good WSN design needs to be energy efficient. This paper proposes a new technique which improves the lifetime throughput of the networks. In the proposed method, channel utilization with multi-hop routing is used that improves the number of live nodes as well as reduces the routing load. A brief performance comparison of LEACH and our proposed method is undertaken considering Packet Delivery Ratio, routing load, throughput and alive nodes.

Keywords— LEACH, Wireless Sensor Networks (WSN), multi-hop routing, cluster head, channel utilization.

I. INTRODUCTION

For reducing energy consumption in a Wireless Sensor Network (WSN), researchers have developed many protocols over the past decade. One amongst them is a prominent hierarchical routing protocol called as Low Energy Adaptive Clustering Hierarchy (LEACH)[1]protocol. To transmit data to the base station LEACH protocol employs cluster formation. Here, each local cluster has a cluster head and each non cluster head node in the cluster forwards its data to the cluster head. The cluster head collects the data from all nodes in the cluster and then transmits the data to the base station. In this way, only a small number of nodes are required to send the data to far distances and most nodes would transmit only over the small distance. Furthermore, LEACH uses adaptive clusters and rotating cluster-heads, thus, effectively increasing the network lifetime and greatly reducing the total energy consumption.

Furthermore, many improvements are made in LEACH protocol by researchers from various demographics. An enhancement over LEACH protocol was proposed in [2]called as P-LEACH, which suggests the usage of the combination of LEACH and PEGASIS [3]protocol. The proposed energy efficient routing algorithm uses the dynamicity of cluster formation in LEACH and chain based architecture in PEGASIS. The resulting protocol performs better than original LEACH protocol. Percentage LEACH (PR-LEACH) protocol is proposed in [4]. The proposed system minimizes the dead spots occurrence by lessening the variation in the sensor nodes' energy. Cluster heads in LEACH are selected by random probability wherein the [4]residual energy of sensor nodes is used to decide the cluster head which balances the dissipation of energy among all sensor nodes.

[5]proposed a modified LEACH protocol which employs dual transmitting power levels and efficient cluster head replacement scheme. In the proposed system, a new cluster is formed when existing cluster head's energy goes below the set threshold voltage. In this way, the shortcoming of LEACH protocol where for each round, a new cluster head was required is avoided. Additionally, two different levels of power is used by the system to amplify signals depending on the distance of a node from the base station. In LEACH, however, same signal amplification energy was used for all the nodes. Thus, all these protocols are an enhancement to LEACH and provide energy efficient routing solution in a WSN. [6] proposed an Energy-Zone LEACH protocol in which the network is logically divided into zones and depending on the location of nodes, acluster head is selected. This facilitates the even geographical distribution of cluster heads unlike in traditional LEACH where cluster heads were concentrated only in one area and energy in one part of the network was discharged sooner than the other part of the network. The proposed system in [6] has a longer network lifetime compared to LEACH and PR-LEACH. The scope of this paper is to reduce the consumption of energy with the help of proposed architecture in LEACH protocol. In the proposed method, channel utilization with multi-hop routing is used that improves the number of live nodes as well as reduces the routing load.

II. PROPOSED METHODOLOGY

The performance of LEACH algorithm is enhanced by the proposed method in terms of packet delivery ratio and energy consumption in real time networks. Each node is not provided with data to send every time. The data in these sensor nodes appear in a random order. The proposed system is optimized with the aid of utilizing the slots allocated to a node which does not have any data to send. This improved procedure turns free time slots into useful slots without making any alterations in the prescribed multi-channel slot allotment in different nodes schedule. It is additionally going to scale down sensor

nodes' waiting time because now there is a chance that sensor nodes receive more than onetime slot per frame to transfer their data. Additionally, Multi-hop routing is used to transfer data to the BS on the grounds that when adata packet is sent directly by CH to the BS then because of increased distance in between them it can lead to increase path loss exponent due to multipath fading. Thus, multi-hop routing will minimize the packet drops and improvethroughput of the network.

Proposed system takes place in rounds likewise in traditional LEACH but with some more improvements. Two main phases constitute each round: cluster setup phase and steady state transmission phase similar to that in LEACH but with a slight modification. Cluster set-up phase involves cluster head selection and cluster formation. Data transmission from sensor nodes to CH and then data transmission from CH to BS constitute steady phase.

A. Cluster Set-Up Phase

As its name suggests, the cluster setup phase is required to set up the clusters. According to LEACH protocol, this phase is divided into two sub phases:

1) Cluster Head Selection

In the preliminary phase of each round, the probability of each node is advertised to become the cluster head (CH) of the given cluster which depends upon its current energy level. Sensor nodes having higher probabilities are selected as the Cluster Heads[1]. An advertisement message is broadcasts by CH using CSMA MAC protocol. Cluster Head advertisement message carries two fields: node's id and aheader part. Each node is uniquely identified based on its Node ID andcontrol information is contained in header part. Depending on received signal strength, every non-CH node learns it's Cluster Head for the ongoing round. CHsare changed randomly over time with the intention to maintain a balance of energy dissipation among the nodes[1].

2) Cluster Formation

According to the strength of received signal of advertisement message from CH, a cluster join-request message is transmitted by each non-CH node to its chosen Cluster Head (CH). This message is also sent using CSMA MAC protocol[1]. Join Request message contains three fields. Node's ID which uniquely identifies each node. Cluster head ID identifies each cluster head uniquely and aheadercontaining control information like destination address and source address. Multi-channel allotment schedule is created by CH node for each non-CH node for data transmission coordination within the cluster. The created schedule is broadcast to all sensors within a cluster. As the message is received by sensor nodes, the duty cycle of sensor nodes to be set as turn on or turn off is arranged as per the allotted time[1].

B. Data Transfer Models

The process of data transmission is done in steady state phase. Proposed algorithm divides the working of this phase in following two sub-phases:

There are two kinds of data transfer:

Data transmission to a coordinator from a device

Data transmission from a coordinator to a device

1) Data Transfer from Nodes to Cluster Head

In this sub-phase, the clock of the device is synchronized on a regular basis and the data to the coordinator is sent using different channel in different time slot method. Further, each node time to time use a particular channel and send the data if nodes have no data at that time send the reserved channel to the next node. This process in similar for all the nodes and all the clusters.

Algorithm for steady state phase is as below:

```
Start
If (CH(s) = True) then
    Receive (IDi, Data packets);
Aggregate (IDi, Data packets);
    Transfer to BS (IDi, Data pck); // Part of Data
    Transfer Phase
else
for (i=1; i< total assigned channel; i++)
{if (Mytimeslot = True && DatatoSend = true) then
    Transfer to CH (IDi, Data packet);
. else
if (DatatoSend = false) then
TransferSlottoNextNode (IDi)
end if
Off mode = true;
end if
}
end if
Transfer Slot to Next Node (IDi);
My time slot = false;
```

2) Data Transmit from cluster-head to base station

In the last phase cluster head transmits the data to the next cluster head using multi-hop routing. Data from all nodes within a cluster is sent to their respective CHs with the help of channel allotment process and then one CH sends the data to the next nearest CH, then again data from this cluster head is sent to the next closest cluster head in the direction of the base station.

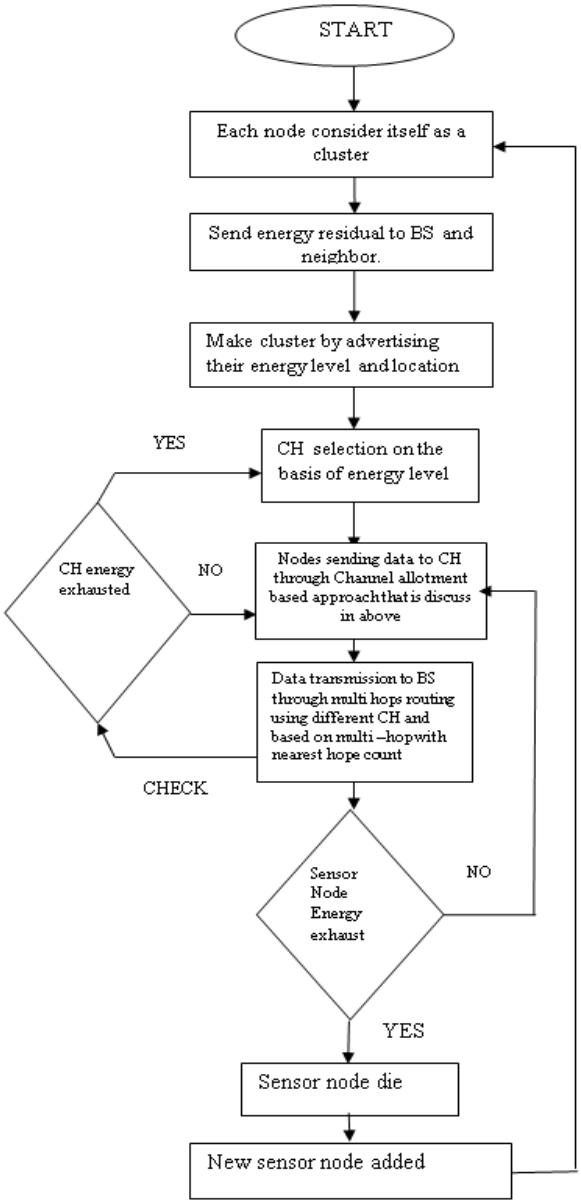

Fig 1 Flow Chart of Proposed Method

C. Flow Chart

The input of proposed LEACH consists of a random number of energy nodes. The energy of this network is fixed equals to 100KJ. Clustered network with cluster-heads is expected as an output using cluster formation algorithm.

Proposed LEACH (Fig 1) is used to improve the network lifetime and it reduces the energy usage in the network. In order to get the desired result firstly each node is considered to be a cluster and each cluster formed sends its residual energy to the BS and neighbor. CH selection takes place on the basis of their energy level. On the basis of proposed channel allotment based approach, each non-CH node sends data to its cluster head. If CH is exhausted then a new CH is formed, otherwise, the transmission between CH and BS takes place through multi-hop routing which is based on multi-hop with nearest hop counts.

After transmission, if the energy of sensor nodes is exhausted then it dies and the new sensor nodes are formed, if not then the data transmission process continues like before.

III. SIMULATION RESULTS

The proposed method uses Network Simulator NS2 as experiment platform.In the proposed work, some nodes are fixed while others are movable. The decentralized base station is considered. The energy of all the nodes are equals to 100KJ.

D. Packet Delivery Ratio (PDR)

PDR =Total number of packet received / Total number of packet sent

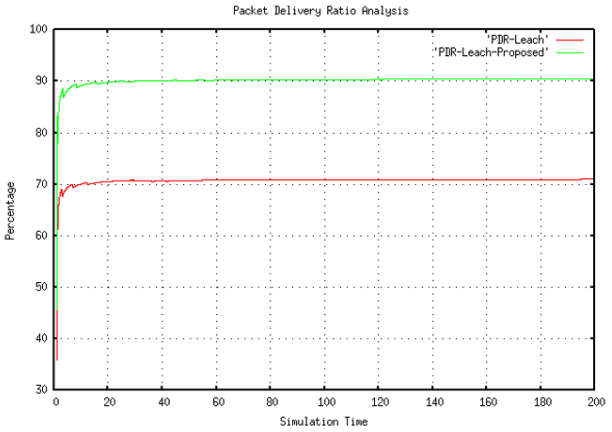

Fig 2 Packet Delivery Ratio Analysis

Mostly in the multi-hop routing PDR plays an important role in checking the performance of network.A high value of PDR denotes the better performance of the protocol. Here we can clearly see that the PDR of our proposed method is much higher as compared to LEACH.

E. Routing Load

Routing load= number of routing packets / number of received data packets

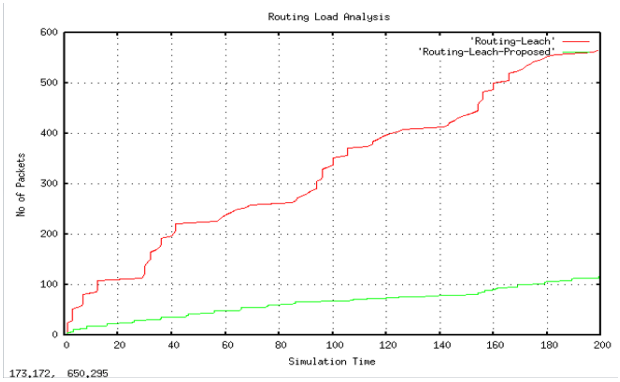

Fig 3 Routing Load Analysis

Lower the value of a number of packets required for routing path information, efficient will be the data transmission in the network. Decreased routing load in the graph, Fig 3 shows that our proposed method uses less number of packets for routing path information as compared to LEACH in the same simulation time. Hence proposed method requires less no. of Data packets for routing path information, thus the efficiency of data transmission increases.

F. Throughput

Throughput= number of packet received / unit time

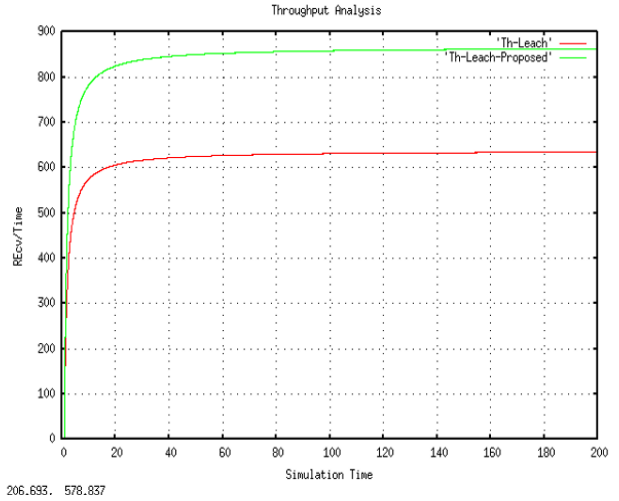

Fig 4 Throughput Analysis

The increase in throughput means decrease in packet loss, hence better the performance of the network. It is clear from the graph Fig 4 using proposed algorithm no. of a data packet received at the destination successfully over a simulation is more as compared to LEACH. Therefore, Efficiency and performance of the network are improved.

G. Alive Nodes

This graph visibly shows that a number of alive nodes in proposed algorithm is greater than the LEACH algorithm. Therefore, a longer life is obtained through the proposed algorithm in WSN. It is evident from the graph that performance of network using proposed algorithm improves as the number of alive nodes increases.

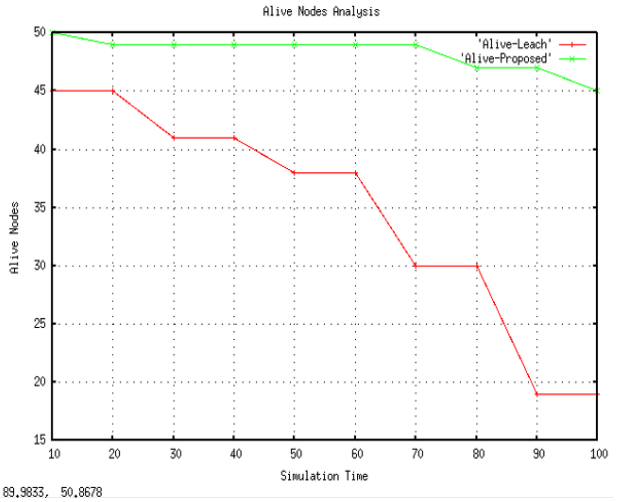

Fig 5 Alive Nodes Analysis

H. Final Analysis

The result of overall analysis of our proposed method i.e., multi-hop routing using channel utilization is summarized in the form of tabular form with the help of some parameters which clearly shows that efficiency of the network is improved hence lifetime also increases (Table 1).

Table 1 Final Analysis Of Parameters of LEACH and Proposed Algorithm

Parameters	LEACH Algorithm	Proposed Algorithm
Data Send	20842	20847
Data Received	14783	18815
Routing Packets	567	122
PDF	70.91	90.25
Normal Routing load	0.04	0.01
Number of Dropped Data	6063	2031

IV. CONCLUSION

WSN are extensively applicable, important rising technology. They carry a whole host of novel studies pertaining to extend the network lifetime and performance of the network. These challenges should be tackled at a couple of levels via distinct protocols and mechanisms. Present partial solutions offer hope for the future, however immense research is still required.

In our proposed algorithm, channel utilization with multi-hop routing is used that improves the number of live nodes as well as improves the data aggregation and reduces the routing load. Proposed method further reduces the energy consumption problem with the help of multi-hop routing protocol that improves the network efficiency and lifetime of wireless sensor network.

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