Implementation of Load Balancing in Leach Protocol for Wireless Sensor Networks

R. Ramesh, R. M. Dilip Charaan, N. T. Mohan Kumar, and E. Uma

Abstract**—**Wireless sensor network is a kind of ad-hoc network which consists of distributed sensors to monitor physical and environmental conditions which are of autonomous type. WSN is not yet implemented widely for such applications due to its energy consumption, challenges in environmental conditions etc. LEACH protocol is one such protocol to extend the lifetime of WSN by forming clusters for routing in a large scale network. The proposed modification in LEACH protocol enables an alternative node to get replaced in place of node which loses its energy such that it extends the lifetime of entire network and avoids data loss. The modified R-LEACH protocol has been implemented with 40 nodes in network simulator-2 and its Packet Delivery Ratio(PDR) and energy level has been observed which is better than that of existing LEACH.

Keywords**—** WSN, LEACH, Cluster Head, Packet Delivery Ratio

I. Introduction

A. *Wireless Sensor Networks*

A wireless sensor network (WSN) consists of distributed sensors to monitor physical and environmental conditions which are of autonomous type. The wireless sensors were initially used in military applications but nowadays, it is used in many industrial and consumer applications for monitoring and controlling. The WSN has a group of nodes ranging from few to several hundred or even thousands. It consists of small light weighted wireless nodes called sensor nodes. A sensor node varies from the size of a shoebox to a grain of dust. The cost of sensor nodes is ranges from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. The size and cost constraints on sensor nodes results in changes in constraints on resources such as energy, memory, computational speed and bandwidth. The topology of the WSNs can vary from a simple star network to multihop mesh network. The propagation technique between the hops of the network can either be routing or flooding. Energy, computation, memory and limited communication capabilities are the resource constraints of wireless sensor networks. All sensor nodes in the wireless sensor network are interacting with each other or by intermediate sensor nodes.

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B. *Literature Survey:*

[1] Network partitioned into annular rings by using various power levels at base Station. Also considered the residual energy of each node and distance from the BS of nodes as the principle of cluster-head election. [2] For handling the hot spot problem with better connectivity and lifetime for a sensor network a new approach has been proposed. Variety of strategies has been experimented and concluded with optimal solutions. [3]The performance metrics traditionally considered are power consumption, connectivity, scalability etc. The Triple Umpiring System has been modified and better performance (energy wise) is claimed. [4]To prolong the lifetime of the network the time length of each node is set and this increases the throughput. The lifetime and throughput functions related to the time length of each round is deduced. To enhance the performance of cluster based wireless sensor networks these functions are used. [5]The network load balance, residual energy and protocol overhead factors are considered for designing a new protocol. It has been suggested that new protocol draws a stable number of cluster head than that of the former Leach protocol. The network lifetime also gets extended using the improved Leach protocol. [6]An improved protocol named Leach-R is proposed based on traditional Leach protocol. This protocol improves the selection of cluster heads and residual energy is considered, the possibility of selecting low energy node as cluster head is reduced drastically. The results suggest that this protocol balances network energy consumption and extends the life cycle of the network. [7]The cluster based routing exploits the threshold level based load balancing. The multihop and direct routing will improve the energy utilisation of this protocol in simulation.[8]The multipath routing protocol is proposed where two paths are established between source and destination which finds the next hop node minimising the linking cost and node energy consumption also gets balanced.[9]Load balancing clustering algorithm for Data Gathering(LCA-GA) is proposed where the distance between head and members and residual energy to improve the cluster nodes choice for balancing using the threshold value for

avoiding load imbalance. [10]Proposed new protocol called EL-LEACH-Energy and Load balance LEACH and increased energy efficiency and load balance.

C. Challenges in Deployment of WSN

Sensor networks may consists of different types sensors such as seismic, visual, infrared, RADAR, thermal, magnetic etc to monitor wide range of parameters in real time. But WSN is not yet implemented in real time due to its various drawbacks such as low power transmitter, poor battery backup, large energy consumption and lack of security features etc. The main objective of this paper is it does modifications in LEACH protocol such that it increases the network lifetime by replacing lifeless nodes by nodes having higher energy level. Various problems in deployment of WSN are listed below:

- When sensor nodes are deployed there is a chance for either of the two will be accountable for node death either the energy depletion is caused by normal battery discharge or due to short circuit. To minimize data loss problems affecting sink nodes should be detected.
- Deployment of sensor network leads to network congestion due to many concurrent transmission attempts made of quite a lot of sensor nodes.
- Another issue is the physical length of a link. Two nodes may be nearby, still they may not be able to communicate due to physical interfering in the real world while nodes which are far away may communicate with each other.
- The network delivers insufficient amount of information which is also called as low data yield is a common problem.

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II. CLUSTERING

A. Clustering & Needs

WSN nodes can be partitioned into a number of small groups called clusters. Each cluster has a coordinator, referred to as a cluster head, and a number of member nodes. Clustering results in a two-tier hierarchy in which cluster heads (CHs) form the superior tier while member nodes form the inferior tier. Clustering has proven to be an efficient approach for organizing the network into a connected ladder. The member nodes report their data to the respective CHs. The CHs aggregate the data and send them to the central base through other CHs. Because CHs often broadcast data over longer distances, they lose more energy compared to member nodes. The network may be reclustered periodically in order to select energy-abundant nodes to serve as CHs, thus distributing the load uniformly on all the nodes. Besides achieving energy efficiency, clustering reduces channel contention and packet collisions, resulting in better network throughput under high load.

B. Existing Routing Protocols

There are lot of routing protocols in practice for Wireless sensor networks such as SPIN, DD, RR, TEEN, APTEEN, PEGASIS, SPEED, LEACH etc. Among all these protocols LEACH is considered to be good protocol meeting most of the requirements [ ].The existing protocols are studied.

SPIN: Sensor Protocols for Information via Negotiation uses Data Centric routing where the network scalability is limited. It cannot be applied over a large network structure.

DD: Data Driven Routing protocol uses a Destination initiated data transmission where the network scalability is limited and data delivery model is demand driven due to which delay increases.

RR: Rumor Routing uses flat based routing in which the network structure has good scalability but the data delivery model is demand driven due to which delay increases.

TEEN & APTEEN: [Adaptive] Threshold sensitive Energy Efficient sensor Network uses Hierarchical routing model in which power usage is high and data delivery model is Active threshold.

PEGASIS: The Power-Efficient Gathering in Sensor Information Systems uses a Hierarchical routing model which has a maximum power usage among all routing protocols. The data delivery model employed is Active threshold.

LEACH: Low Energy Adaptive Clustering Hierarchy uses hierarchical routing model which uses Cluster Head data delivery model. This protocol has a good network scalability compared with all other routing protocols.

Thus comparing most widely used routing protocols, LEACH protocol found to best suit for WSN. The various reasons for employing LEACH protocol in WSN are

- ✓ Employs Cluster Head mechanism.
- ✓ Network Scalability is good.
- ✓ Load Balancing among all nodes inside a cluster.
- ✓ Supports hierarchical/ Destination Initiated/ Node centric Routing.
- ✓ Supports Data Aggregation.

C. Drawbacks in Leach

Sensor nodes typically use irreplaceable power with the limited capacity, the nodes Capacity of computing, communicating, and storage is very limited, which requires WSN Protocols need to conserve energy as the main objective of maximizing the network lifetime. An energy-efficient communication protocol called LEACH, conserves energy by changing the Cluster Head periodically and also their clusters members.

In each round of the cluster formation, network needs to follow the two steps to select Cluster head and transfer the aggregated data**.** Step(1) Set-Up Phase, which is again

subdivided in to Advertisement of energy level, Cluster Set-Up & Schedule Creation phases. Steady-State Phase, which provides data transmission using Time Division Multiple Access (TDMA).

The CH collects and aggregates information from sensors in its own cluster and passes on information to the destination node via other CH's. By rotating the cluster-head randomly, energy consumption is expected to be uniformly distributed. However, LEACH considers all the nodes in clusters to have equal amount of energy and rotates CH in random manner. So there is a possibility of lower energy node to become as a cluster head which results in reducing the lifetime of the entire network.

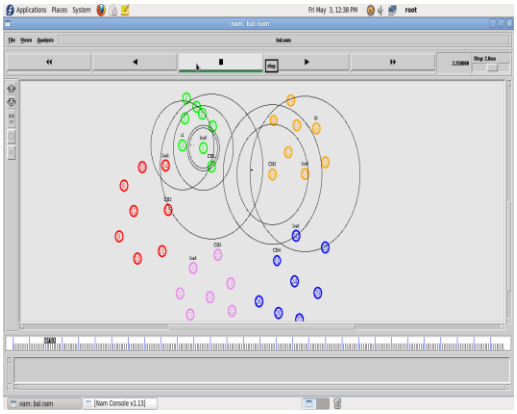

Fig. 1 Transmission via Load Node

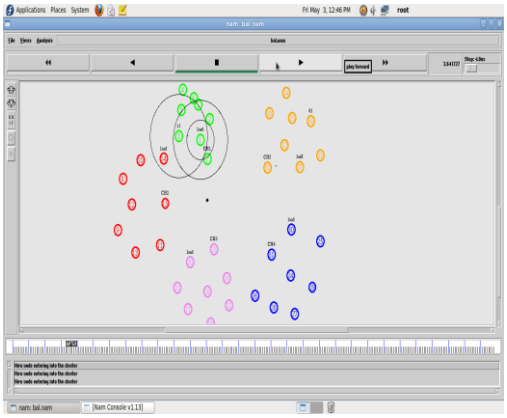

Fig. 2 Packet Drop from Load Node

Figure 1 Illustrates Any source node communicates to its CH via intermediate node which may have low energy. This intermediate node with low energy may lose data packets when its energy falls below the threshold value and so the network load is said to be not balanced as shown in **Figure 2**.This intermediate node with low energy is said to be Load node. Therefore this network can be said to be a balanced network if this load node is been replaced by another node with next higher energy in the same cluster.

D. R-Leach (Proposed Leach)

The problem due to load node is considered in this paper and a new proposal is made which is proved to be better in most aspects. The result is been proved using simulation and the result obtained proves that proposed R-LEACH has good Packet Delivery Ratio and Good energy conservation than that of the existing LEACH protocol.

Energy of various nodes are taken into account and they are compared for existing LEACH and proposed R-LEACH and it is proved that the proposed method has low energy conservation over time. This in turn increases the network lifetime and also data aggregation is good.

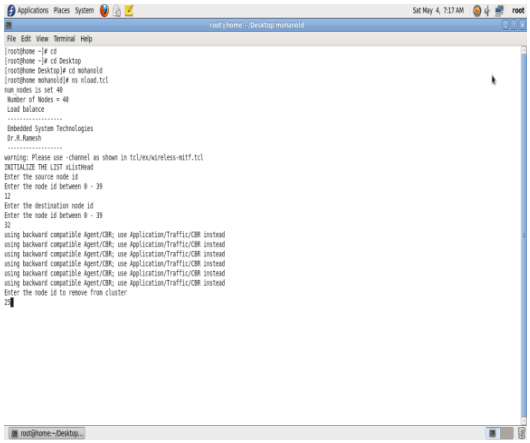

Fig. 3 Terminal Window to select Source & Destination Node

Figure 3 illustrates setting up of threshold level for load node. When energy of this load node goes beyond this threshold value then packets get dropped from the load node**.** **Figure 4** shows the output obtained in terminal window. The packet Delivery Ratio, Energy consumed by each node can be obtained from this terminal window.

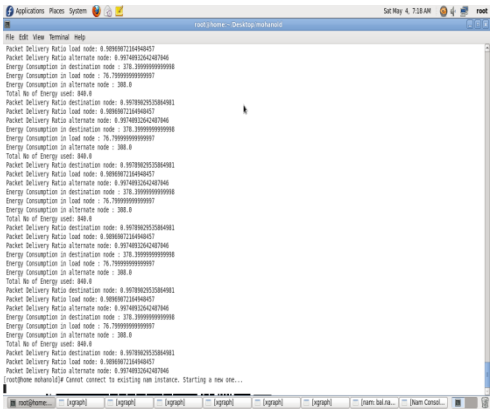

Fig. 4 Output in Terminal Window

III. Results & Discussion

A. Energy Graph

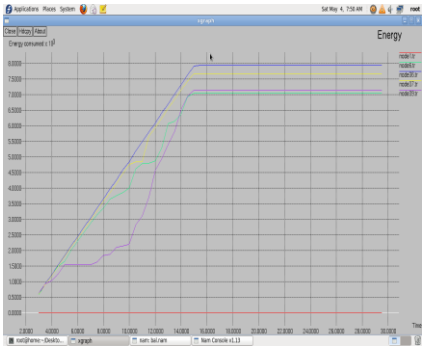

Fig. 5 Energy of Load Node- Existing LEACH

Figure 5 illustrates about energy consumed by Load node, Destination node and Alternate node in existing LEACH protocol. The energy consumed should be reduced so as to increase the network lifetime.

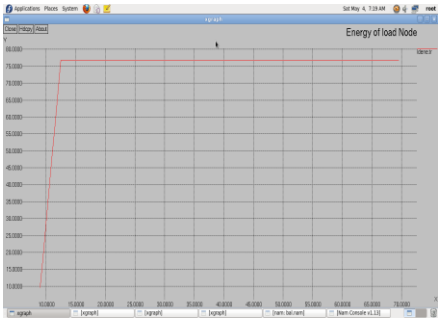

Fig. 6 Energy of Load Node- R-LEACH

Figure 6 illustrates the energy of load node in our proposed R-LEACH protocol. The energy consumed is successively increased so as to increase the network lifetime.

B. Packet Delivery Ratio

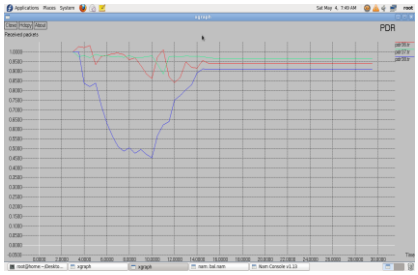

Fig. 7 PDR of Load Node- Existing LEACH

Figure 7 illustrates the PDR of load node, destination node and Alternate node in which PDR has to be increased to make our network more efficient. The PDR of Destination node can be increased by our proposed R-LEACH protocol.

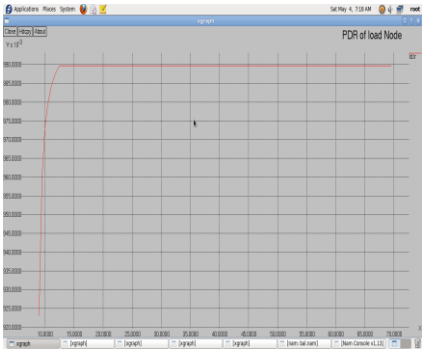

Fig. 8 PDR of Load Node- R-LEACH

Figure 8 illustrates that the PDR of load node is been increased by our proposed R-LEACH protocol that in turn increases the overall efficiency of the network.

IV. Comparision Between Leach (Leach & R-Leach)

A. PDR

The Packet Delivery Ratio is the ratio of number of data packets received at destination to the number of data packets sent from source. It is been proved that R-LEACH has good PDR than existing LEACH protocol. The observations made from simulation are tabulated below:

TABLE 1
PACKET DELIVERY RATIO OF NODES

Name of the node	Existing leach	Proposed leach
Load Node	0.94	0.98
Destination Node	0.97	0.99
Alternate Node	-	0.99

B. Energy of Nodes

The energy of any sensor node can be defined as either total power consumed by any sensor node or power remaining for a sensor node after some cycles of transmission. Our proposed R-LEACH has good power conservation such that it results in prolonged network lifetime. The energy consumed by any node for each cycle can be calculated by using our formula

$E_C(t)=\{E_I-E_R(t)\}/D$ where

E_I denotes initial energy of any node,

E_R denotes residual energy of any node and D denotes current cycle of any node.

```
while {$m} {
set vall($i) [expr int(rand()*100)]
if {$vall($i) >= 75 && $vall($i) <= 100} {
set m 0
}
}
```

This set of code is used to calculate the energy level of any load node. The energy level of load node is been compared with the threshold value that is been already set. When the energy level is beyond threshold value then a alternate node replaces tha load node. The inferences obtained from simulation for energy consumption of nodes are tabulated below:

TABLE 2
ENERGY CONSUMPTION OF NODES

Name of the node	Existing leach	Proposed leach
Load Node	79	77
Destination Node	77	63
Alternate Node	71	69

The following piece of code is used to elect cluster head inside clusters.

```
# cluster head election
#proc celect { } {
exec awk -f chead.awk Energy.tr
set tmp [open temp.tr r]
set i 1
while {!([eof $tmp])} {
set ne [gets $tmp]
set ch($i) $ne
set nl [gets $tmp]
set cl($i) $nl
incr i
}
```

Where, ***i*** represents the nodes inside clusters. Energy level of ith node is compared with that of node in temp file. When i^{th} node has higher energy then it is elected as cluster head otherwise it is incremented.

V. Conclusion and Future Work

The modifications made in LEACH protocol has improved its Load Balancing which in turn increases over all network life time. Thus LEACH protocol appears to be efficient in most aspects such as data aggregation, Packet Delivery Ratio, Load Balancing etc. In future a sleep mechanism can be induced among the nodes in clusters which in turn can further increase the network lifetime. The awaken nodes with no data transfer can be taken into sleep node using ASLEEP (Adaptive Staggered LEEP Protocol) which in turn increase the lifetime of Sensor nodes. The integration of ASLEEP protocol into LEACH can yield a prolonged network lifetime and good data aggregation policy.

VI. Acknowldegment

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