EFFECTIVE ANALYSIS ON R-LEACH PROTOCOL FOR WIRELESS SENSOR NETWORKS

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Abstract---Wireless sensor network is a kind of ad-hoc network where enormous number of nodes are distributed to monitor physical and habitat conditions.These are generally of autonomous type. WSN has been a difficult job to implement widely for some applications because of its energy consumption, challenges in environmental conditions etc. To extend the lifetime of WSN the LEACH protocol is implemented by forming clusters for routing in a large scale network. LEACH protocol utilises the technique of selecting the cluster head through random rotations of a local cluster to distribute evenly the energy load among the wireless sensor network. In cluster communication distributed nodes transmit data packets to its cluster head through intermediate nodes. Below a threshold energy level these nodes loses its energy and packets get dropped. In the proposed system an amendment in LEACH protocol in order to extend the lifetime of entire network and to avoid the data loss an alternative node is made to replace the original. This increases the number of data packets delivered to the base station.

Keywords: WSN,LEACH,Cluster,Data packet delivery, routing.

I. INTRODUCTION

A. Wireless Sensor Networks

A Wireless Sensor Networks (WSN) is a set of thousands of micro sensor nodes that are capable of sensing and establishing wireless communication. A wireless sensor network consists of distributed sensors to monitor physical and environmental conditions which are of autonomous type. These types of sensors are used to measure temperature,pressure etc. The wireless sensors were initially used in military applications but nowadays it is used in many industrial and consumer applications for monitoring and controlling. It performs the computational and processing operations between two nodes. Wireless sensor networks generally provides us unique benefits in order to reduce the power consumed and in reducing the cost. The nodes in WSN are battery operated with sensing devices where energy resources are limited. When designing a power-efficient protocols the main issue that is wholly considered is to prolong the life time or to make the system energy efficient.

The WSN has a group of nodes which ranges 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 back-pack to the size of grain dust. The cost of sensor nodes depending upon the complexity it ranges from a few dollars to hundreds of dollars, depending on the complexity of the individual sensor nodes. The size and cost constraints on sensor nodes results in changes with the resources such as energy, memory, computational speed and bandwidth. The topology of the WSNs can vary from a simple star network to multi-hop 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. Nodes sends their report towards a processing of energy compared to data processing. Protocols designed for the network should be prolong the lifetime of the network.

B. Challenges in Deployment:

Sensor networks may consists of different types sensors such as seismic, visual, infra red, RADAR, thermal, magnetic etc to monitor wide range of parameters in real time. Deployment of nodes in a wireless sensor node application will be in a random style or this can also be planted physically.Wireless sensor network smooth the progress of monitoring and controlling of physical environment from remote locality with most perfect accuracy. Advancements have been achieved in wireless sensor networks which led to lot of new protocols which is specially designed for sensor networks. Many routing protocols have been designed where energy awareness is an indispensable consideration.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. Our paper

proposes a modification in LEACH protocol such that it increases the network lifetime by replacing lifeless nodes by nodes having higher energy level. Various other problems in deployment of WSN include:

- 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 networks 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.

C. Literature Survey

At the base station networks are partioned into annular rings by using various power rings.The residual energy of each node and distance from the BS of nodes are considered as the principle for cluster head selection [1].LEACH is a fundamental protocol in the clustering in routing protocol which minimises the energy consumed. The lifespan of the nodes increases as the battery power in the sensor node increases [2].The Triple Umpiring System has been tailored and better energy stamina is claimed. The performance metrics conventionally measured are connectivity, power consumption etc [3]. The lifetime and throughput functions related to the time length is found for each round.In order to prolong the lifetime of the network the time length of each node is set and this increases the throughput.cluster based wireless sensor networks[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 suggestions was made that new protocols draws a stable number of cluster head than that of the previous LEACH protocol.The network load balance,residual energy and overhead are the factors that are considered for desigining a new protocol.The lifetime of the network gets extended using the new improved LEACH protocol[6].In the proposed multipath routing protocol two paths are established between source and destination.This finds the next hop node reducing the linking cost and node energy consumtion also gets balanced[7].A protocol named LEACH-R is proposed based on conventional LEACH protocol.This protocol improves the selection of cluster heads and residual energy is considered,the posibility of mselecting low energy node as cluster head is considerably reduced.This protocol balances network energy consumption and extends ths life cycle of the network[8].Load balancing clustering algorithm for Data Gathering(LCA-GA) is proposed where the distance between cluster head and the cluster members.To improve the cluster nodes for balancing with the help of threhold value to avoid the load imbalance[9].A protocol named LEACH-R is proposed based on conventional LEACH protocol.This protocol improves the selection of cluster heads and residual energy is considered,the posibility of mselecting low energy node as cluster head is considerably reduced.This protocol balances network energy consumption and extends ths life cycle of the network[10].The threshold level based load balancing is maximum utilised with the help of cluster based routing.Energy utilisation of this protocol will improve using multihop and direct routing[11].

II Clustering

A . Need for Clustering

Usage of wireless sensor networks has grown massive in the recent years which is used for energy-efficient routing, data aggregation and data-gathering protocols in significant networks. The routing protocols performance is affected by the number of cluster heads a network have. If the cluster head is less in number it is difficult to cover the members that are far away from the cluster heads.Few clustering doesnot cover the entire network it merely covers a few part or incomplete network. In this case it will consume lot of energy. To increase the scalability, lifetime and energy efficiency clustering is utilised in sensor networks.The challenges that are encountered in clustering are energy which is limited to some extent and capability of the network.Wireless sensor network 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

A routing protocol that is designed for a sensor network should meet the following conditions

- ✓ Reliable
- ✓ Integrating awake/sleep nodes
- ✓ Mobile
- ✓ Secured network establishment
- ✓ Power management
- ✓ Congestion control.
- ✓ Real-time oriented

There are lot of routing protocols in practice for Wireless sensor networks such as SPIN, DD, RR, TEEN, APTEEN, PEGASIS, SPEED, LEACH etc. Each protocol has their own advantages and drawbacks. Among all these protocols LEACH is considered to be good protocol meeting most of the requirements. The advantages and disadvantages of all existing protocols are as follows.

- ✓ **SPIN:** Sensor Protocols for Information via Negotiation uses Data Centric routing here the network scalability is limited. This 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 Wireless sensor network.

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.
- ➢ Adaptive cluster members.
- ➢ Random selection of cluster head in rotation.

C. LEACH and its Problems

Hierarchical clustering is a less power consumption which is achieved using this topology in a high coverage area. Instead of each source node sending data directly to the sink node it will send to the higher level neighbouring node.A sink node is the one which requires an information.A sink node can be a node in the sensor network it might be a node outside the network too.This can also be a gateway to another larger network. In a hierarchical node its easy to access the data from lower level node to higher level node. Data aggregation is done at the sink node to reduce the traffic. Also in the hierarchical clustering network redundant information can be filtered out using relay nodes. In this network power consumption gets reduced as it utilises the bandwidth to the maximum.

Low Energy Adaptive Cluster Hierarchy(LEACH) is a hierarchical clustering algorithm. Heinzelman et al introduced this hierarchical clustering algorithm for sensor networks.Eventhough lot of protocols are available the LEACH is one of the major improvement from the traditional clustering algorithm in WSN. Many protocols adhere and utilises the idea of LEACH. The LEACH clustering mainly depends on cluster head selection. Fluctuation in the number of cluster heads and that nodes residual energy is also a characteristic of the LEACH protocol.In LEACH the operation is divided as rounds,during each round a different set of nodes are elected as the cluster head.Nodes that are once elected as the cluster head cannot be elected again for K rounds.Each node has a probability of 1/K to become the next cluster head.

LEACH protocol homogeneously allocates the energy in the sensor node. While the heterogeneous sensor nodes consist of different capabilities of different energy levels. For a homogeneous sensor networks energy levels, sensing range and computational power are considered to be the same. In the case of heterogeneous network each node has different capabilities in different aspects. Cluster head consumes lot of energy when compared to the non-cluster head node. This makes the cluster head to die soon. LEACH is a kind of cluster based routing protocols which is maximum used for cluster formation in a distributed network.LEACH randomly selects the cluster head and rotates this role to evenly distribute the energy among the sensors in the network.All the nodes other than the cluster heads communicate with the cluster head in a TDMA fashion.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 clusters members.

D. Development of Cluster and Cluster Heads

In each round of the cluster formation, network needs to follow the two steps to select Cluster head and transfer the aggregated data**.** (1) Set-Up Phase, which is again subdivided in to Advertisement, Cluster Set-Up & Schedule Creation phases (2) Steady-State Phase, which Provides data transmission using Time Division Multiple Access (TDMA).

The criteria of selecting cluster head in LEACH protocol randomly selects a new cluster head at each round. Due to this some nodes get wear out of energy too quickly. This happens because some nodes get selected as the cluster head repeatedly. So if the node with more residual energy is made the cluster head and this will prevent the whole network to die early. The sink node gets directly get communicated with cluster heads. The energy consumption between cluster head and sink is greater than that of the energy consumed among the cluster heads.This makes the cluster head will exhaust energy soon. By balancing the energy consumption among the network this avoids the whole network from dying quickly. Multi-hop communication avoids the nodes from early death.

Cluster heads can be located even at the edge of the cluster as they are not uniformly distributed.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 consider 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. Cluster head selection is randomly performed this does not consider the energy consumption . No overhead is wasted in electing the cluster head from the group of nodes.LEACH is an advanced of the conventional networks.

The parameters that are involved in the clustering of a network are as follows

- ✓ Cluster count
- ✓ Interaction between members in a cluster.
- ✓ Cluster heads should be portable.
- ✓ Cluster head selection method.

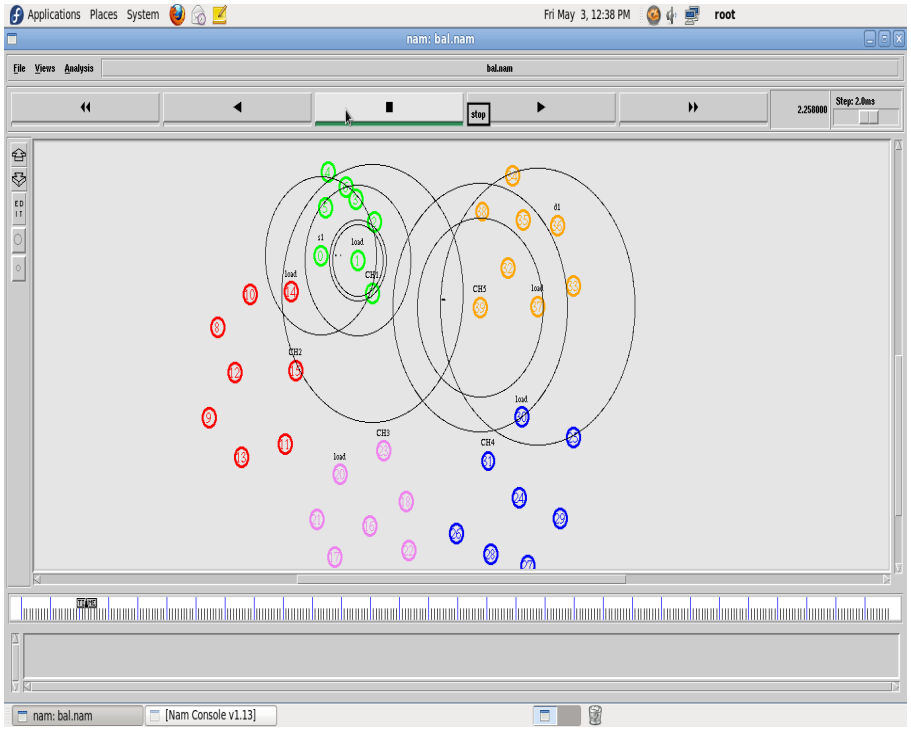

Fig 1. Transmission via Load Node

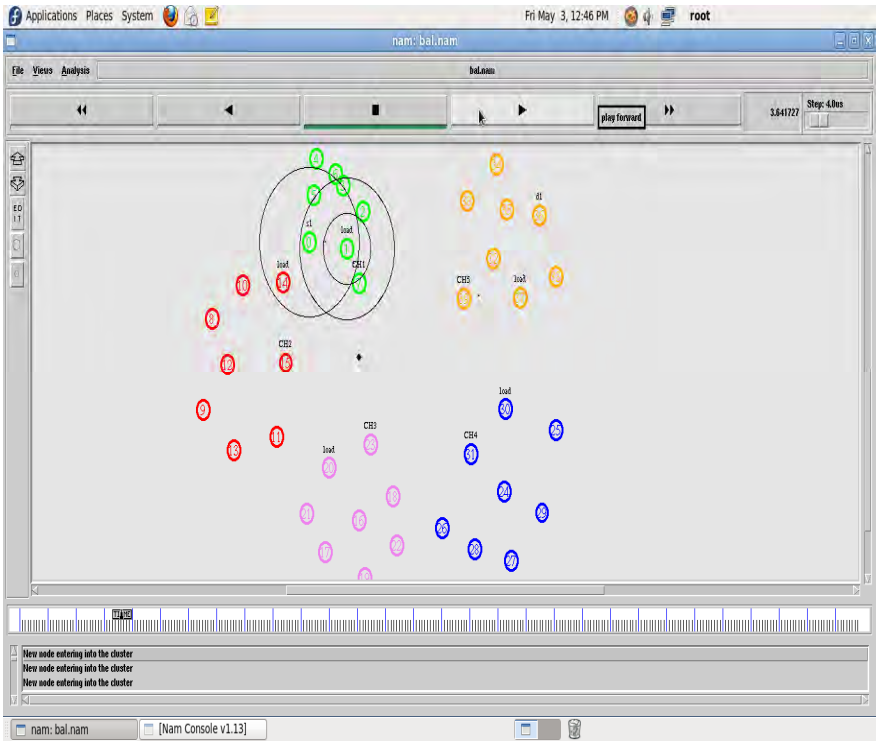

Fig 2. Packet Drop from Load Node

Fig 1 Illustrates Any source node communicates to its CH via intermediate node which may have low energy. Fig 2 in this the 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. 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. The substantial size and little energy that is stored in the sensor node. This limits the processing speed and communication between two nodes.

E R-LEACH (Proposed LEACH)

The problem due to load node is considered in our 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 our 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.

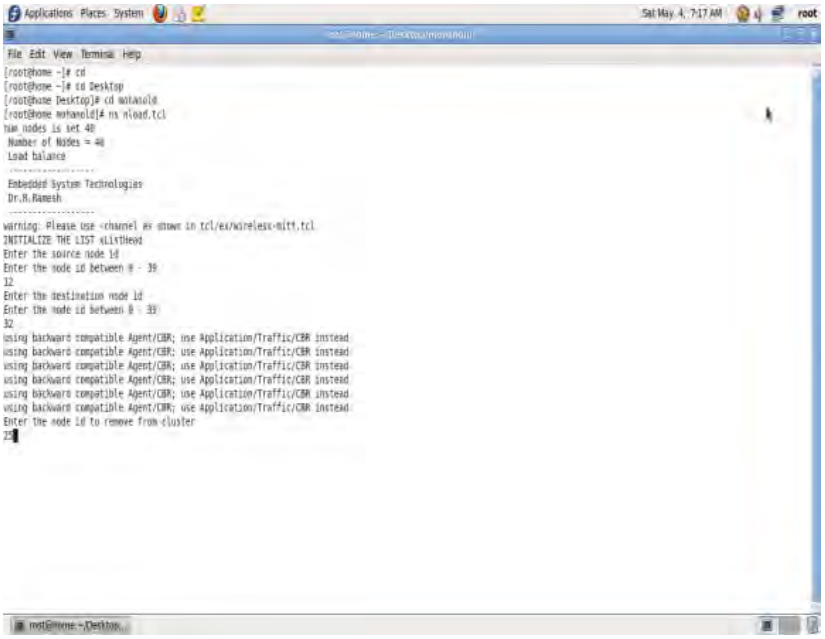

Fig 3: Terminal Window to select Source & Destination Node

Fig 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. Fig 4 shows the output obtained in terminal window. The packet Delivery Ratio, Energy consumed by each node can be obtained from this terminal window.

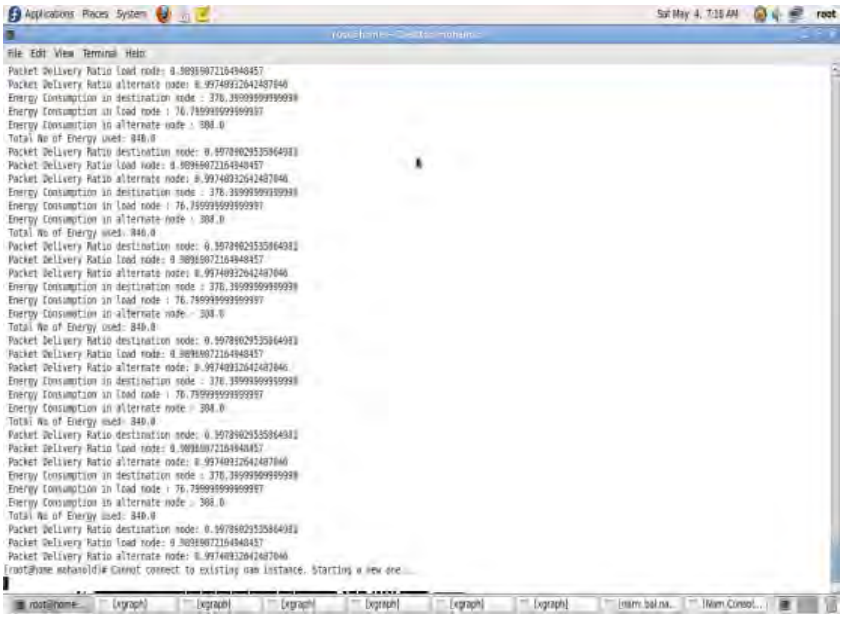

Fig 4. Output in Terminal Window

III Simulation Scenario

The simulation environment that we have used is ns-2 which stands for Network Simulator-2. It is a discrete event simulator for doing research at packet level. All types of network can be simulated using this tool and it gives a wide support to do research under various protocols such TCP, UDP, FTP, HTTP and DSR. It uses Tool Command Language as scripting language and the tool is fully based on Unix basis. It supports both wired &

Wireless Networks.

We have chosen NS-2 as it has a wide range of protocol support and mainly to analyse the network behaviour at discrete time intervals.

IV Comparison 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 is tabulated below:

Table 1 Packet Delivery Ratio Of Nodes

Name of the Node	Existing LEACH	Proposed LEACH
Load Node	0.75	0.79
Destination Node	0.82	0.89
Alternate Node	-	0.88

B. Energy of Nodes

Nodes that are deployed in the sensor networks are homogeneous and they are found to be dependent on energy. The sensor networks are stationary and symmetric communication channel is utilised .The nodes with energy limitation affects the lifetime of the network.If a proper clustering technique is utilised the network lifetime will get increased.

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 the clusters.

Energy level of i^{th} 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 Results and Discussion

A Energy Graph

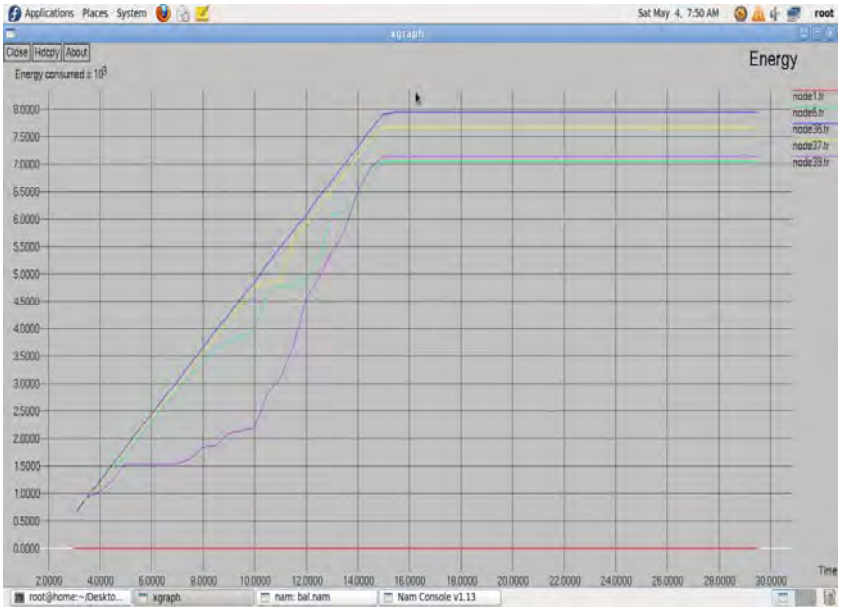

Fig 5. Energy of Load Nodes R-LEACH

Fig 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 .

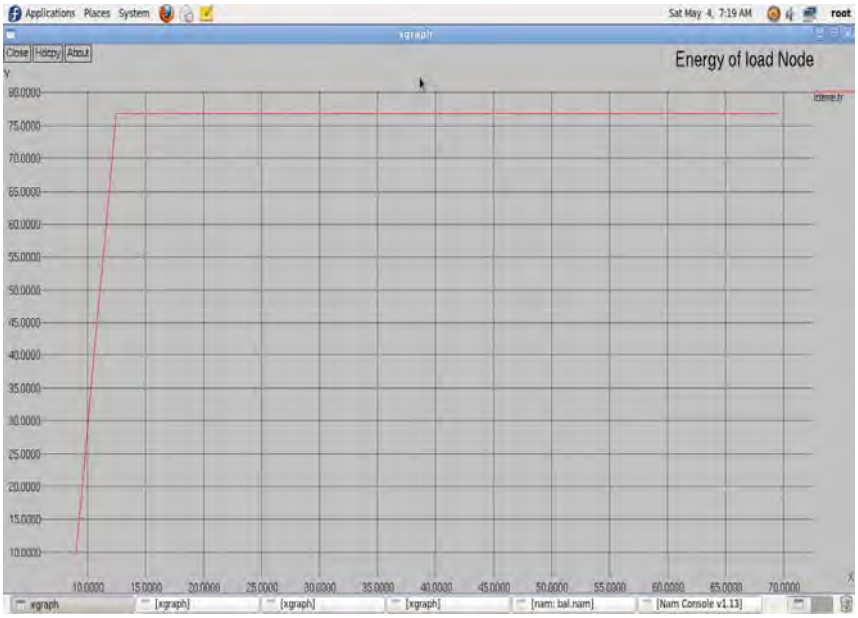

Fig 6. Energy of Load Node R-LEACH

Fig 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.

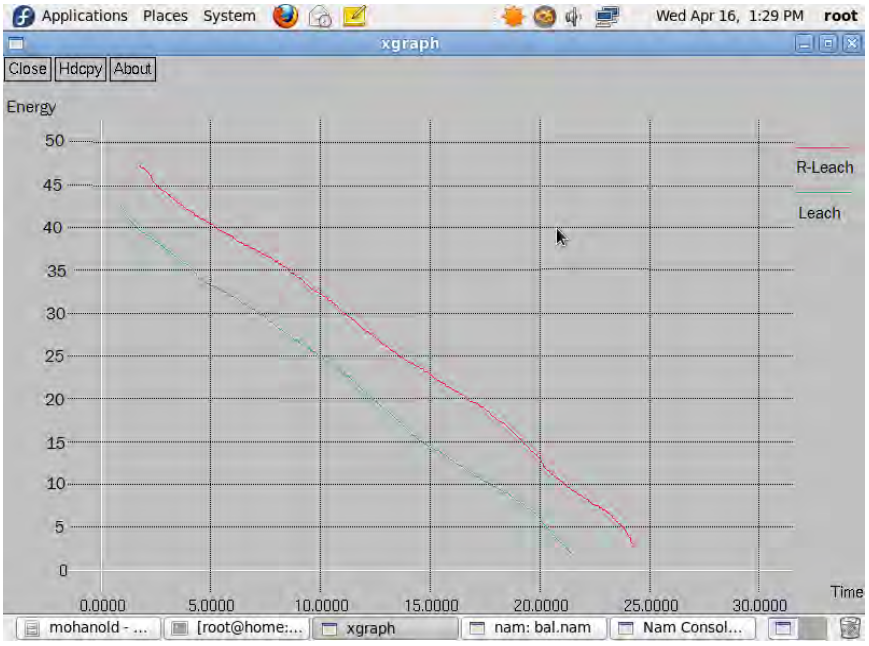

Fig 7. Energy of Load Node- LEACH and R-LEACH

B. Packet Delivery Ratio

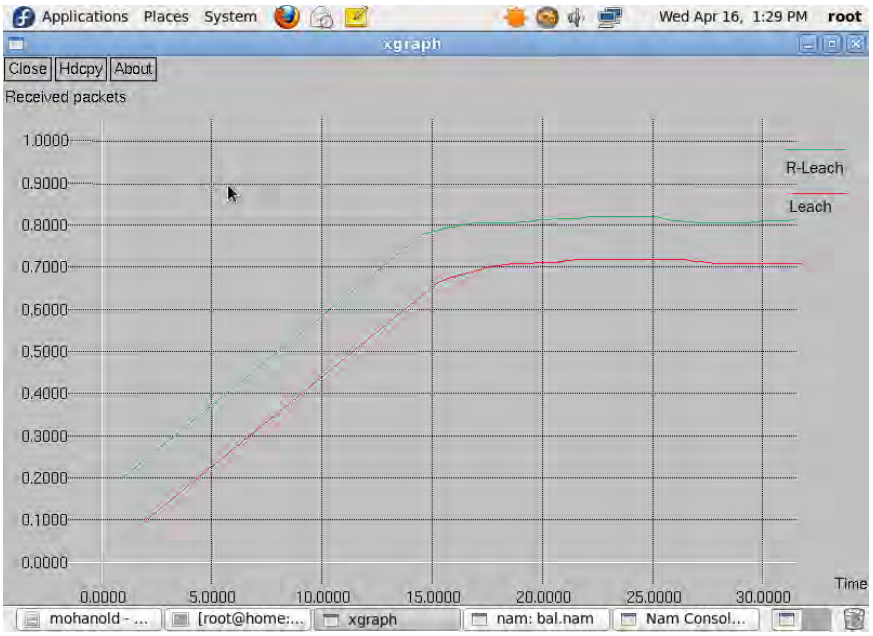

Fig 8. PDR of Load Node- LEACH and R-LEACH

Fig 7 illustrates the Packet Delivery Ratio 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. The above green line illustrates that the Packet Delivery Ratio of load node is been increased by our proposed R-LEACH protocol that in turn increases the overall efficiency of the network.

C. Network Density

For a group of nodes in a network,a finite number of relationship is possible .Each node can act as the source or the destination with every other node.Each node is expected to have a relationship i.e connection with each and every other nodes.In real time there exists few nodes without any relationship with the other nodes.They are isolated as they are unwanted for framing a particular network.

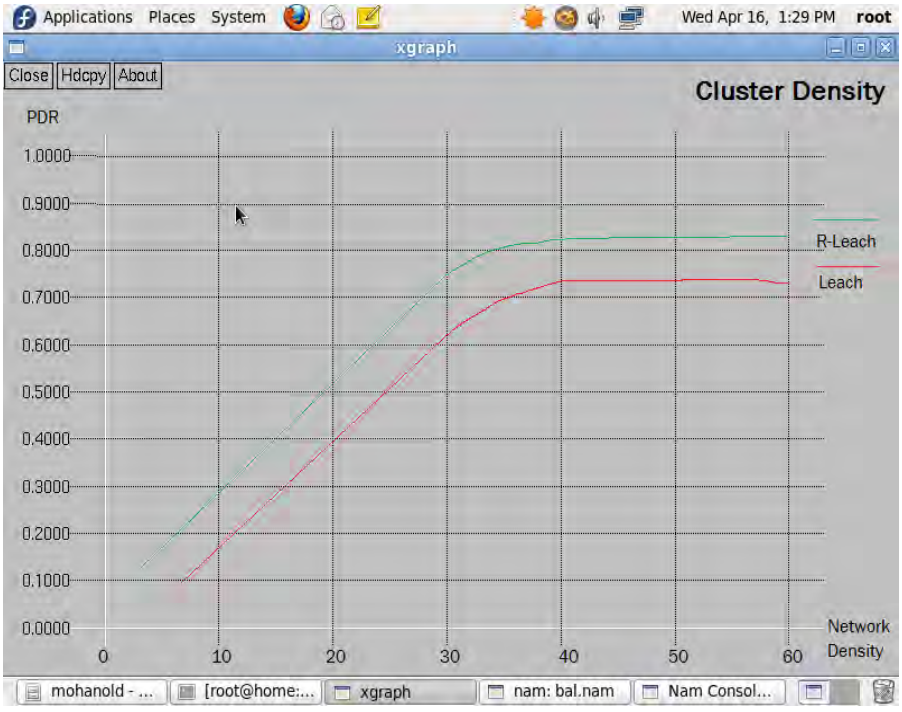

Fig 9 Network Density for LEACH and R-LEACH

Fig 8 illustrates the packet delivery ratio through the number of nodes.This is achieved by finding the average of 10,20,30,40,50,60 nodes respectively.Firstly, the Number of packets delivered to 10 nodes is deduced.Similarly the number of packets delivered for 20,30,40,50,60 nodes are achieved from the received packets vs time.These PDR's are then plotted against number of clusters.Variations in the PDR increases the network density.Also the cluster head selection increases.Hence the chances for cluster head selection increases and also the Packet delivery ratio increases.Our proposed R-LEACH increases the efficiency of the network.

VI 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.

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