International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 23 No. 2 May 2016, pp. 293-302

http://www.ijisr.issr-journals.org/

ENERGY BALANCED CLUSTERING ALGORITHMS ON LEACH PROTOCOL FOR WSN

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ABSTRACT: The rise of wireless sensor networks (WSN) is one of the leading innovations that postures different breed of intrusions, vitality and better performances in the nearing decades. However, in WSN, energy plays a vital role in transmitting data between sources. Also several communication protocols are available in cluster based for energy conservation and it varies depending on its application. Among the routing protocols, LEACH is chosen so that the vitality problem can be minimized. Few enhancements to improve its efficiency and ability to deliver data without packet loss is achieved to a greater extent. Increasing their energy through Solar means will prolong the network lifetime. Different enhanced LEACH protocols are collated to increase node alive rate, packet delivery ratio, and average residual energy, throughputs. The above parameters are derived for the R-LEACH, solar powered R-S-LEACH and SLEEP LEACH. The results are obtained using Network Simulator-2.

KEYWORDS: WSN, Clustering, LEACH, Solar powered, PDR, number of alive nodes, balanced network.

1 INTRODUCTION

Wireless Sensor Network (WSN) is an emerging technology for attracting the researchers with its challenges and different application domains. Wireless sensor network (WSN) is a self-organized network created by a large number of sensors that are deployed randomly in monitoring regional through wireless communication [2].

With its wide application in military observation, medicinal guide, logistics management, environmental observing, farming and other business regions, Wireless Sensor Networks has turned into the furthermost technology in the field of correspondence and computer research. Sensor nodes depend on battery power supply, their correspondence capacity and energy battery limit are extremely constrained and so how to use the energy of nodes proficiently, adjust the network energy utilization and expand the network lifetime has turned into an essential configuration objective for wireless sensor networks [1].

WSN contains a battery operated sensor device with information handling and handing over parts. Sensor nodes can be utilized in a controlled situation, where inspection and surveillance are discriminated or in an uncontrolled situation. In the latter situation security for sensor nodes is very essential to a great extent. The expense lies on the parameters like battery, memory size etc. The sensor nodes are a system containing hundreds of nodes which upgrade the quality of the system. The sensor nodes do information handling and sense the conditions where they are placed. These also change the information into electronic signals and these signs get transmitted over radio waves to the base station (BS). It is uneconomical to send the respective information uncomplicatedly to the base station as sensor nodes are energy bound. The nodes surrounding the base station (neighboring sensors) produce large amount of information [7]. In these expansive systems, the amount of information created is colossal for the base station. To overcome this problem, information is collected at the nodes. Hence one among the node has to collect all the information and send it to the base station. If the network area is immense, only

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one node acts as the Cluster Head (CH) it drains the battery in few milliseconds. So, the network cannot be operated. To overcome this problem, numerous routing protocols are proposed [4].

2 LEACH PROTOCOL AND ITS SIGNIFICANCE

The primary objectives of the wireless sensor networks routing protocol outline is to adjust system energy utilization and expanding the whole system lifetime. The lifetime of the network is examined by the viability of LEACH protocol in cluster head determination and proposes an enhanced clustering calculation. Indeed the effectiveness of information transmission and extending the system lifetime [4]. LEACH protocol, an emblematic hierarchical protocol is generally self-adaptive, self-organized and cost effective. If a network is painstaking there are many clusters and each cluster contains a cluster head as well as several non cluster heads [7]. Each cycle contains two stages: set-up phase and steady state phase.

2.1 SET-UP PHASE

During the setup phase, clusters are formed and one among them is selected as the Cluster Head. In the steady state phase, data is sensed which is then sent to the BS. LEACH protocol elects the CH from the cluster members randomly based on the energy level. CHs advertise themselves thereby forming a cluster. The CH using Time Division Multiple Access (TDMA) schedules the nodes under its cluster. The communication between various clusters is performed using the CH in a Code Division Multiple Access (CDMA) style. The CHs collect the data from the respective clusters and are aggregated before sending it to the base station (BS) or the CHs.

$$T(n) = \begin{cases} [\, p/(1-p)] * [\, r \bmod (1/p)\,] & \text{if } n \text{Ɛ} G \\ 0 & \text{otherwise} \end{cases}$$

Here n denotes the identity of the nodes in the existing sensor network, p is the percentage of cluster head r is the present round number, G is the set of nodes that have not been elected as the cluster head in the last p1 rounds [2]. After determining the cluster head, it sends a broadcast message into the network, which has already recognized to be a cluster head. Each cluster member node decides to join with any nearby cluster according to the signal strength of the received message; in turn it sends a request message to the corresponding cluster head [11]. The cluster head receives all the messages sent by the nodes that are likely to join in the cluster, confirms them as members of the cluster. Later, it joins them in the routing table and allocated TDMA slots for the non cluster heads giving directions when it should transmit data.

2.2 STEADY STATE PHASE

The cluster members send data to the cluster head using single hop all through the allocated slot according to the TDMA table. The cluster head receives data altogether from all the nodes in the cluster. The CH fuses all the data into a single signal and transmits it to the base station. LEACH protocol comparatively has a trenchant function in energy consumption, while using the dynamic clustering in an active network. It maintains the data transmission in cluster which is responsible for reducing the energy consumed by communicating unswervingly in between the nodes and base station. Nonetheless, scarcity of energy in nodes occurs [6],[8].

3 NEED FOR ENHANCING TO R-LEACH

LEACH protocol uses the cluster head mechanism, the cluster heads are selected in random after several rounds of data transmission. The enduring energy of the nodes will have enormous difference in energy. Cluster heads or the nodes which are far away from the base station will devour additional energy in transmitting data of the same length comparatively. In case, if such nodes are selected as cluster heads, after some period of time they will scamper out of energy and become null. The network performance and the lifetime of the network get slumped if the number of null nodes increases.

Any source node communicates to its CH via intermediate node which might have low energy. 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 unbalanced. This intermediate node with low energy is termed as a Load node.

Therefore this network is called a balanced network, if this load node is replaced by another node with the highest energy in that cluster [9]. The substantial size and little energy that is stored in the sensor node which not only limits the processing speed but also the communication between two nodes.

4 R-LEACH

Every source node communicates with its Cluster Head mainly through intermediate node which may have low energy. The intermediate node which has low energy might lose data packets when its energy falls below the threshold value, hence the network load is unbalanced .Therefore intermediate node with low energy is termed as the load node. Thus, this network is said to be a completely balanced network, if and only if this load node is replaced by an additional node with higher energy which is selected from the same cluster. It is of substantial size and small amount of energy is stored in the sensor node. The processing speed and communication between two nodes are limited.

The problem due to load node is considered and the solution for the former problem is determined. The new proposal is found to be more efficient than the conventional LEACH in many aspects. The results shown below are the simulation results which are determined using Network simulator 2. The proposed R-LEACH has a good Packet Delivery Ratio (PDR) and very good energy conservation capacity. The overall performance and lifetime of the nodes has increased which is followed life of the network. Energy of various nodes is tabulated and an experiment was conducted using the existing traditional LEACH and the proposed R-LEACH. The results show distinctly that the proposed method has low energy dissipation over time. This in turn increases the network lifetime and the data aggregation is found to be good. The algorithm for R-LEACH is explained below.

ALGORITHM FOR R-LEACH

1. The Cluster Head advertises them to be the same into the vast network in turn the Cluster Head sends the signal.
CH → GRP: idCH, advmt
2. All the nodes in the network send their interest towards joining in the Cluster Head.
A_i → CH : idA_i , idCH, req_join
3. The Cluster Head sends the acknowledgement message along with their schedule for transmission
CH →GRP: idCH, (. . . , hidAi , tAi , . . .), schedule
4. All the nodes transmit data to their Cluster Head during their stipulated schedule.
A_i → CH : idA_i , idCH, dA_i
5.Determining the node with maximum energy
for((i=1;i<=n;i++))
do
MAX(E(A_i)
End for
Here E(A_i) stores the node with maximum energy.
6. In the network for any random nodes energy goes below the threshold then,
if(E(A_i) <=$E_{threshold}$) where i →1 to n
then
7. The nodes with more energy may be far away from the node that is about to fail. Nodes that are nearer to the node that is about to be fail has to be chosen for being efficient.
for((i=1;i<=n;i++))
do
MIN (dist(A_i ,CH))
End for
8.Now the energy in the nodes is in descending order and the distance in the ascending order.
9.Opting for the best
if [MAX(E(A_i) && MIN(dist)]
then
CH_{new}=A_i where the node A_i has the maximum Energy E.
fi
done
10. The Cluster Head then aggregates the data and sends to the Base Station.
CH→ BS: idCH, idBS,F(. . . , dA_i , . . .)

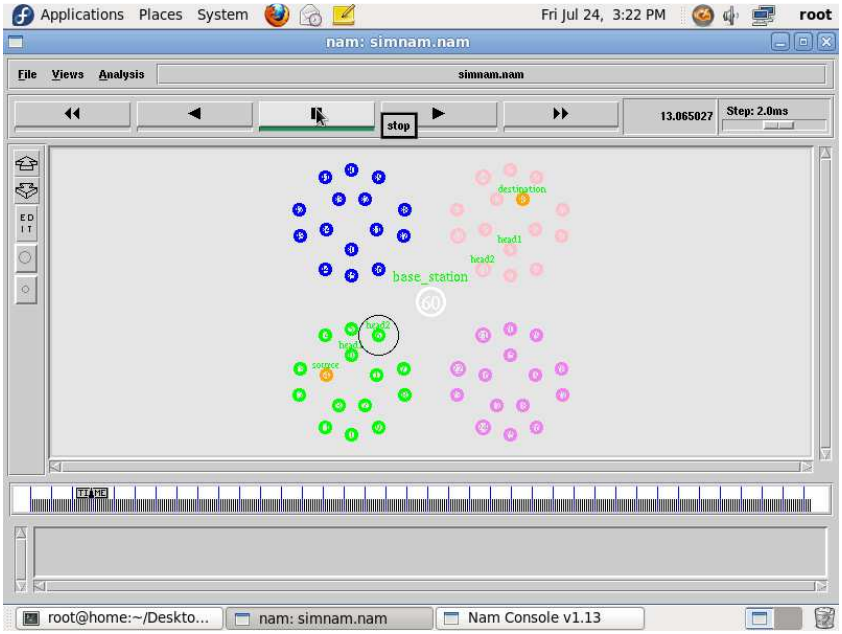

Figure 1 R-LEACH Cluster Formation & Communication

4.1 ENERGY IN 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 utilized .The nodes with energy limitation affect the lifetime of the network. If a proper clustering technique is utilized, 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 the formula

$E_{cur}(t)=\{E_{ini}-E_{res}(t)\}/D$

where E_{ini} denotes initial energy of any node,
E_{res} denotes residual energy of any node and
D denotes current round of any node.

The energy level of load node is compared with the threshold value that has been already set. When the energy level is beyond threshold value then an alternate node replaces the load node. The inferences obtained from simulation for energy consumption of nodes are tabulated below.

5 R-S- LEACH

The solar aware LEACH extends the lifetime of the sensor network by choosing the nodes that are connected with the solar panel. In the R-S-LEACH if the networks are grouped into k clusters thereby k cluster heads are formed respectively. In the first test, few nodes were connected with battery followed by the formation of clusters. In each and every cycle, a battery powered node was selected as the cluster head.

In the first case, 5 clusters were formed and those clusters had a CH. These Cluster Heads (CH) were managed to have a solar panel connected to it. Here the Cluster Head (CH) is found to have enough energy which is sufficient enough to act as the next Cluster Head. Since the LEACH protocol has a condition that once the node is selected it takes p rounds to become the next cluster. This protocol gives the chance for all the nodes to become the Cluster Head (CH) once for each and every round. As the initially elected CH is solar powered even if that particular node is exploited it gets ample amount of time to recharge and gets geared up to become the next cluster. Also these nodes were found to have energy to run successfully for few more rounds. The non Cluster Heads (nCH) alone will dissipate lot of energy when subjected to transmission.

As per the R-LEACH protocol, the nodes(Load node) connecting the Cluster Head to the BS or the BS to the CH are about to fail because of battery retreating below the threshold limit immediately a nearby energy filled node will act as the alternate node replacing the energy deficient load node. Finally, the transmission takes place without any problem and the chance for failure of this transmission network is very less. The results thus indicate that according to the R-S-LEACH, if a load node fails the alternate node will act as the same node , thereby continuing its task of transmitting unless the nCH nodes connecting the path fails due to energy deficiency. The steady improvement has been found especially in the network lifetime, thus the PDR has also increased.

ALGORITHM

1. The Cluster Head advertises them to be the same into the vast network in turn the Cluster Head sends the signal.
CH → GRP: idCH, advmt
2. All the nodes in the network send their interest towards joining in the Cluster Head.
A_i → CH : idA_i , idCH, req_join
3. The Cluster Head sends the acknowledgement message along with their schedule for transmission
CH →GRP: idCH, (. . . , hidAi , tAi , . . .), schedule
4. All the nodes transmit data to their Cluster Head during their stipulated schedule.
A_i → CH : idA_i , idCH, dA_i
5. Opting for the best
if [max(E(A_i) && min($dist_{new}$)]
then
nCH_{new}=A_i where the node A_i has the maximum Energy E.
fi
done
6. The Cluster Head then aggregates the data and sends to the Base Station.
CH→ BS: idCH, idBS,F(. . . , dA_i , . . .)
7. After P rounds if the residual energy is E_{res} in conventional algorithms
8. If a solar panel is connected with initial energy E_{ini} .
Total energy in the node is given by E_{resd}=E_{ini}+ E_{sun}
E_{sun} is the energy stored in the solar powered battery for the sunshine period
sun_{period}= sun_{stop}-sun_{start}
9. Resultant Residual energy after each round in total E_{tot}= E_{resd} – E_{loss} where E_{loss} is the energy utilized for each round, E is the initial energy given in the sensor node, E_{sun} being the solar power and E_{rsed} the residual energy.
10. The traditional LEACH has a residual energy E_{res} and the solar powered LEACH has a residual energy E_{resd} .

The results always show $E_{resd} > E_{res}$. This means that the nodes that are solar powered have a better energy compared to the nodes without solar power. In the above case considering the energy in the nodes of each randomly formed dynamic network the Cluster Head (Node with maximum energy) is chosen and it is solar powered. After few rounds when the tests are performed, it is found that $Energy_c$ is always less than $Energy_{avg}$ as of in the traditional LEACH. After the Cluster Head is solar powered device the energy is found to be less (minor difference).

$$Energy_c < Energy_{avg} \text{ , where } \mathbf{Energy}_{\mathbf{avg}} = \sum_{1}^{n} \mathbf{Energy(i)}$$

Secondly, few nodes, for example, 10 were chosen randomly in different geographical location and those nodes were connected with solar panel. Using the R-S-LEACH in the set-up phase the clusters were formed and almost in every round the battery powered nodes was elected as the Cluster Head (CH).The importance of the battery powered Cluster Head (CH) node is distinct.

$$Energy_c < Energy_{avg} \text{ , where } \mathbf{Energy}_{\mathbf{avg}} = \sum_{1}^{n} \mathrm{Energy(i)}$$

In this case the residual energy in each random node is found to be nearly equal to the average energy for most of the nodes. Very rarely the present status of the energy in the nodes **($Energy_c$**) is found to be less than the average energy **($Energy_{avg}$)**.

Thirdly 60% of the nodes were solar powered which makes the nodes to be live for a longer period, thereby increasing the node alive rate. Most of the nodes (both CH and nCH possess a solar panel the communication takes place uninterruptedly).The sensor nodes always have surplus power, albeit discharging is high when the nodes are frequently exploited and it gets recharged immediately. Although all the nodes are connected with a natural energy source, the residual

energy remains high. Many nodes sustain for prolonged duration since the Cluster Head nodes are not only solar powered but also the non Cluster Head nodes. Eventually the systems lifetime increases, which not only increases the PDR but also the rate of alive nodes.

$$Energy_c > Energy_{avg} \;||\; Energy_c <= Energy_{avg} \text{ , where Energy } _{avg}=\sum_{1}^{n} \text{Energy (i)}$$

In this case most of the time all the nodes will have energy greater than the average energy in the cluster. When a random node is selected the energy in the node will be higher than the average energy. In very few nodes the present status of the residual energy is found to be less than or equal to the average energy.

Using the proposed R-S-LEACH the simulation was conducted and then the node density for various time intervals was plotted and the results clearly indicates the vast difference when compared to that of the traditional LEACH.

When compared with the above mentioned three cases, the last case has many sensor nodes connected to the solar panel, which works trenchantly when compared with the other two cases. Whereas in the first case few random nodes possess the solar panel and in the Second case only the Cluster Head and its alternate node are connected to the solar panel.

Table 1: Energy in Solar LEACH

R-S-LEACH (Solar powered nodes)	Initial Energy	Residual Energy	Average Energy
Case 1(Cluster Head)	50	35	38
Case 2(Random 10 nodes)	50	39	40
Case 3 (60% nodes)	50	45	46

6 SLEEP MECHANISM IN LEACH FOR WSN

After the nodes get split into groups or clusters, the nodes in each cluster will send their information in the stipulated time period one by one and after all the nodes finish sending information then the Cluster Head(CH) aggregates the data and then transmits to the Base Station (BS) .Similarly all the Cluster Heads perform the same. Finally, the Base Station (BS) will transmit the data. Here, the non Cluster Head (nCH) nodes transmit data only during their allocated time period. So the nodes can be made to sleep until their allocated time has arrived. If this procedure is followed for transmitting data then the nodes can conserve more energy.

ALGORITHM

1. The Cluster Head advertises them to be the same into the vast network in turn the Cluster Head sends the signal.
CH → GRP: idCH, advmt
2. All the nodes in the network send their interest towards joining in the Cluster Head.
A_i → CH : idA_i , idCH, req_join
3. The Cluster Head sends the acknowledgement message along with their schedule for transmission
CH →GRP: idCH, (. . . , hidAi , tAi , . . .), schedule
4. All the nodes transmit data to their Cluster Head during their stipulated schedule.
A_i → CH : idA_i , idCH, dA_i
for((i=1;i<=n;i++))
do
Ai=OFF
done
for((i=1;i<=n;i++))
do
if(schedule$_i$==1)
then
A_i=ON for t_x time period
fi
if(A_i!=schedule$_i$)
then
A_i=SLEEP
fi
5. The Cluster Head then aggregates the data and sends to the Base Station.
CH→ BS: idCH, idBS,F(. . . , dA_i , . . .)

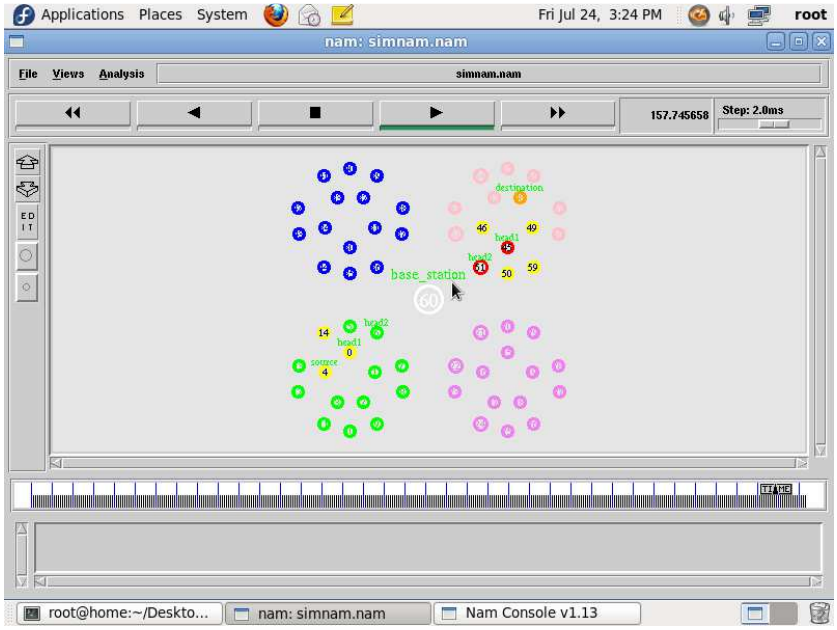

Figure 2: SLEEP-LEACH Cluster Formation & Communication

7 RESULTS AND DISCUSSIONS

The Simulation is performed using Network Simulator-2 also it is assumed that the nodes are randomly deployed in a square region. The Base Station is located in the centre of the deployed region. The other parameters are tabulated below.

Table 2: Simulation Parameters

Simulation Area	200*200
Nodes in number	100
Size of each packet	4000 bits
Energy in each node	1 joule
Cluster Head proportion	p=6%
Base station location	100,100
Number of nodes with 1.5 joules energy	5%
Number of nodes with Solar Panel connected	5%

The Energy consumed by each node using different protocols is listed below. The tabulations show that if the nodes are put in Sleep mode energy is conserved. Similarly when nodes are connected to a Solar panel even if nodes consume energy it automatically recharges. So an optimum level of energy is maintained normally. The Table 3 clearly explains the energy consumed by a Load node, Destination node and an alternate node.

Table 3: Energy Consumed in LEACH and its Descendents

Name of the Node	Traditional LEACH	R- LEACH	R-S-LEACH	SLEEP LEACH
Load Node	79	77	70	65
Destination Node	77	63	59	56
Alternate Node	-	69	65	-

The Figure 3 shown below distinctly explains the node alive rate. This graph is obtained by determining the number of nodes that are alive after each time period.

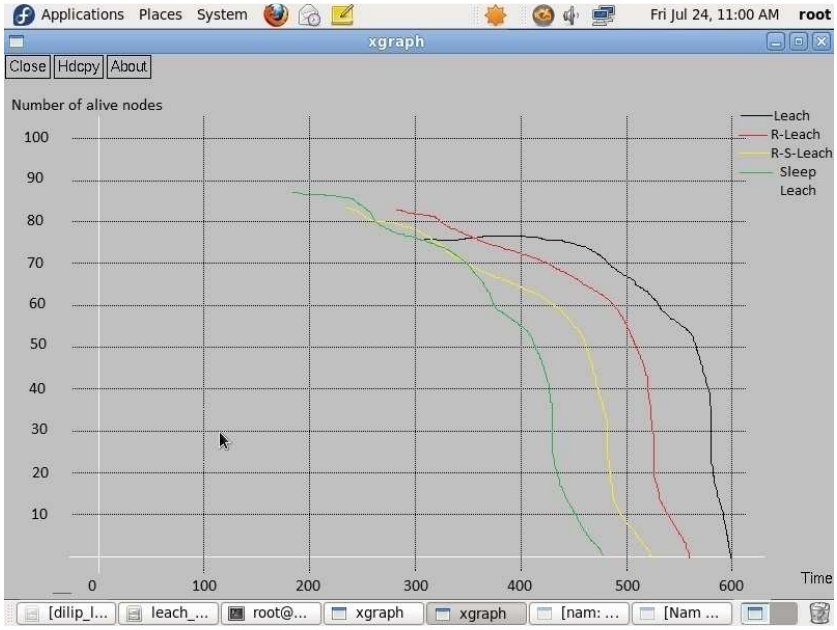

Figure 3: Node Alive rate

The Figure 4 is Number of nodes vs rounds. The output clearly shows that the R-LEACH, R-S-LEACH and SLEEP LEACH performs better than the traditional LEACH.

Figure 4: Number of Nodes vs Rounds

7.1 PACKET DELIVERY RATIO

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 proved that R-LEACH has good PDR compared with the existing LEACH protocol. Further after enhancing the R-S-LEACH and SLEEP LEACH too performs better than the traditional LEACH. The observations made from simulation are tabulated below in the Table 4 and the simulation results for PDR are shown in the Figure 5.

Table 4: Energy in Nodes in Various LEACH.

Name of the Node	Traditional LEACH	R- LEACH	R-S-LEACH	SLEEP LEACH
Load Node	0.75	0.79	0.82	0.84
Destination Node	0.82	0.87	0.90	0.92
Alternate Node	-	0.86	0.91	-

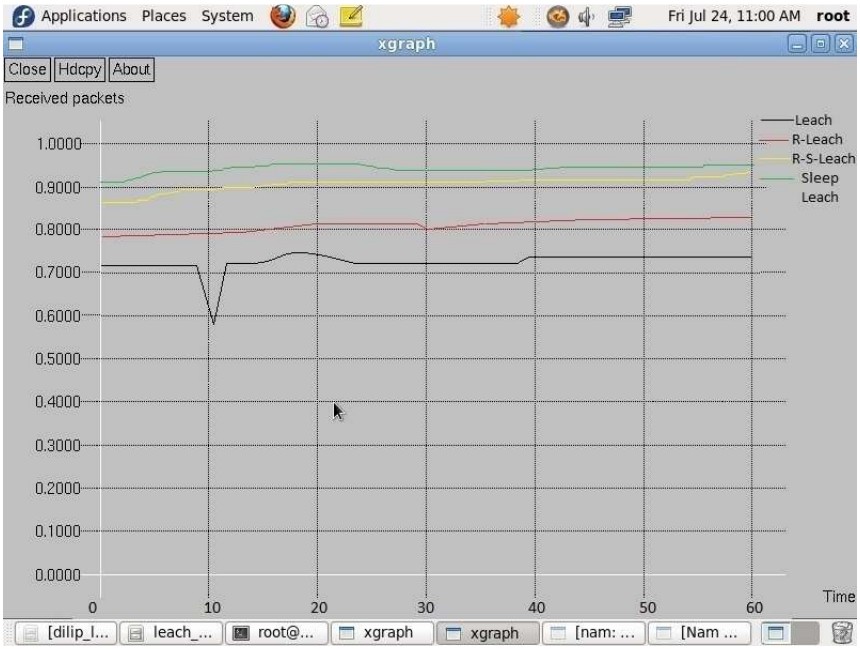

Figure 5: Packet Delivery Ratio

As the wireless sensor nodes are deployed at a remote location and are not maintained by any party, it is vulnerable to many intruders. Depending on the applications used for WSNs, security is the biggest challenges in WSNs and it is essential for WSNs before the design and especially for LEACH protocol usage. The routing protocols for WSNs need security services for transmitting data securely to the users through the network.

8 CONCLUSIONS

Energy efficiency is the main concern in designing protocols for WSNs. The efficient protocol which mainly considers energy is the LEACH as it adopts the cluster based routing. The whole sensor networks have been provided with a better energy conservation protocol by upgrading the conventional LEACH with new techniques. In future, a framework can be designed for different parameters like number of nodes, number of clusters and the protocol used. Even though LEACH is made energy efficient it is vulnerable to attacks. So security is essential for a wireless sensor network. The wireless sensor networks have the security requirement similar to the traditional wireless network. Since the nodes of a sensor networks are deployed in remote locations security is very important in upgrading the traditional LEACH. In future, a network which can bear any kind of attack can be designed over the upgraded LEACH by studying the drawbacks of existing security algorithms.

REFERENCES

[1] Akyildiz LF, Su W, Sankarasubramaniam Y, Cayirci E. ”A survey on sensor networks”, IEEE Communications Magazine, 40(8): 102~114.Vol.25, No.4, 2002, 114-124.

[2] Zuo Chen,Kai Chen “An improved Multi hop Routing protocol for Large Scale Wireless Sensor Network Based on Merging Adjacent Clusters”, Journal of Software,Vol 8 ,No 8,August 2013: 2080-2085

[3] Sun Limin, Li Jianzhong, Chen Yu, —Wireless Sensor Networks , Tsinghua publishing company Beijing, 2005.

[4] Wendi Rabiner, Heinzelman, Anantha Chandrakasan, and Hari Balakrishnan, —Energy-efficient Communication Protocol for Wireless Microsensor Networks, In: Proc. of 33rd Annual Hawaii Inter Cord on System Sciences, Hawaii, USA: IEEE Computer Society, 2000.

[5] Li Han, —LEACH-HPR: An Energy Efficient Routing Algorithm for heterogeneous WSN IEEE 2010.
[6] Huiling Zhou, Chi Zhang, Rongrong Qian ”IMPROVEMENT OF LEACH PROTOCOL BASED ON UNEVEN CLUSTERING ALGORITHM”,pp 22-26 Proceedings ofIC-NIDC,2012
[7] Beibei Wang ; Chong Shen ; Jing Li, ”Study and improvement on LEACH protocol in WSNs“, pp 1941-1943 . Automatic Control and Artificial Intelligence (ACAI 2012), International Conference, 2012
[8] Tan Ming-hao et al “Multipath Routing Protocol with Load Balancing in WSN Considering Interference”, pp 1062-1067, 6th IEEE Conference on Industrial Electronics and Applications
[9] Han Zhang et al “a Load-balancing Clustering Algorithm of WSN for Data Gathering”,pp 915-918.
[10] Thu Ngo Quynh, Kieu-Ha Phung, Hoan Vu Quoc “Improvement of Energy Consumption and Load Balance for LEACH in Wireless Sensors Networks” ICT Convergence (ICTC), International Conference on Digital Object Identifier,pp.583-588, 2012.
[11] M.J. Handy, M. Haas, D. Timmermann; “Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection”; 2002; http://www.vs.inf.ethz.ch/publ/se/IEEE_MWCN2002.pdf
[13] Bandyopadhyay and E. J. Coyle, “An Energy Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks,” IEEE INFOCOM, April 2003.
[14] Laiali Almazaydeh et al “Performance Evaluation of Routing Protocols in Wireless Sensor Networks“, pp 64-73 International Journal of Computer Science and Information Technology, Volume 2, Number 2, April 2010.