International Journal of Research in Advent Technology, Special Issue, March 2019
E-ISSN: 2321-9637
International Conference on Technological Emerging Challenges (ICTEC-2019)
Available online at www.ijrat.org

Energy and Throughput Analysis of Hierarchical Routing Protocol (LEACH) for Wireless Sensor Network

J.Bhargav[1], N.Jagajeevan[2,] Sk.John Sydhulu[3,] P.Venkata Siva[4]

[1,2,3,4]*Asst professor,CSE Department,chalapathi Institute of engineering and Technology*

Abstract: Wireless sensor networks (WSNs) have gained increasing attention from both the research community and actual users. The efficient utilization of energy source in a sensor node is very important criteria to prolong the life time of wireless sensor network. Wireless sensor networks have explored to many new protocols specifically designed for sensor networks where energy consideration is very crucial. Most of importance, given to hierarchical routing protocols based on clustering has better scalability. As sensor nodes are generally battery-powered devices, the critical aspects to face concern how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. There are several energy efficient hierarchical routing protocols among this LEACH is famous protocol, we have simulated LEACH in NS2 and analyzed performance of LEACH in terms of energy, throughput and lifetime.

Keywords: LEACH, Hierarchical Routing Algorithms,clustering, wireless sensor networks.

1. INTRODUCTION

A Wireless Sensor Network (WSN) is a set of hundreds or thousands of micro sensor nodes that have capabilities of sensing, establishing wireless

Communication between each other and doing computational and processing operations. The important requirements [1] of a WSN are :

(1) Use of a large number of sensors

(2) Attachment of stationary sensors

(3) Low energy consumption

(4) Self-organization capability

(5) Collaborative signal processing, and

(6) Querying ability. Some of the important applications domains of WSN's are listed below.

- Military environment
- Disaster management
- Habitat monitoring
- Medical and health care,
- Industrial Fields, Home networks
- Biological, Radiological, nuclear and explosive material etc.

Sensor nodes are equipped with small, often irreplaceable batteries with limited power capacities. They can be deployed manually or be randomly dropped. They are self configuring containing one or more sensors, with embedded wireless Communications and data processing components and a limited energy source. The use of wireless sensor networks is increasing day by day but the problem of energy constraints prevails as there is limited battery life. In order to save energy dissipation caused by communication in wireless sensor networks, it is necessary to schedule the state of the nodes, changing the transmission range between the sensing nodes, use f efficient routing and data routing methods and avoiding the handling of unwanted data. In general, routing in WSN's [2] can be divided into flat, hierarchical, and location based routing depending on the network structure.

Hierarchical Routing is the well-known technique with special advantages related to scalability and efficient communication. LEACH, PEGASIS, TEEN [3] and APTEEN use this technique for routing. In hierarchical architecture, higher nodes can be used to process and send the information, while low-energy nodes can be used to perform the sensing in the proximity of the target. Location- Based Routing Protocols like MECN [4] sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors. The Low-Energy Adaptive Clustering Hierarchy (LEACH) is a cluster based routing protocol. In this paper section 2 will introduce the LEACH routing protocol in detail, Section 3 will cover the simulation of LEACH protocol and the section 4 shows the simulation analysis by varying the percentage of cluster heads in the network in analyzed in terms of the network and section 5 concludes this paper.

2. REVIEW OF LEACH PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol for sensor networks is proposed by W.R. Heinzelman et.al [5] which minimizes energy dissipation in sensor networks. It is very famous hierarchical routing algorithms for sensor networks which make clusters of the sensor nodes based on the received signal strength shown in figure 1. The 5% of the total number of nodes becomes the cluster head which act as router to the sink. Energy consumption is less as transmission will only done by cluster head.

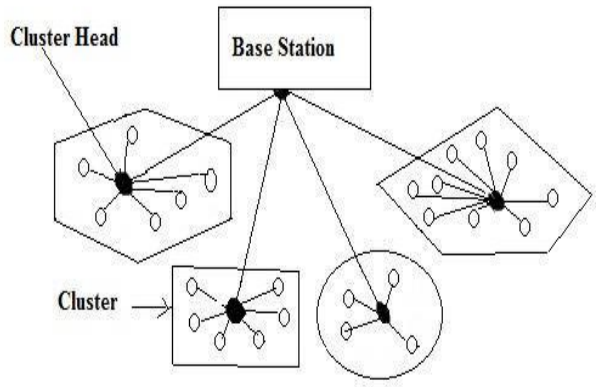


Fig. 1: cluster based mechanism of LEACH in WSN

Data fusion and aggregation are local to the cluster. Cluster heads change randomly over time to balance the energy dissipation of nodes. The node chooses a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n \in G \\ 0 & \text{otheriwse} \end{cases} \quad (1)$$

Where p is the desired percentage of cluster heads (e.g.0.05), r is = the current round, and G is the set of nodes that have not been cluster heads in the last I/p rounds.

Set-up phase: During this phase, each node decides whether or not to become a cluster head(CH) for the current round. This decision is based on choosing a random number between 0 and 1, if number is less than a threshold T(n), the node become a cluster head for the current round.

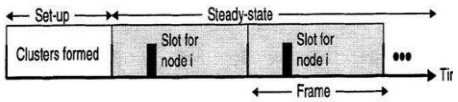


Fig. 2: Time Line operation of LEACH

The cluster head node sets up a TDMA schedule and transmits this schedule to all the nodes in the cluster, completing the setup phase which is then followed by aSteady-state operation.

Steady-state phase: The steady-state [4] operation is broken into frames, where nodes send their data to cluster head at most once per frame during their allocated slot as shown in figure 2. It assumes nodes always have data to send , they send it during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster head advertisement). The radio of each non-cluster-head node can

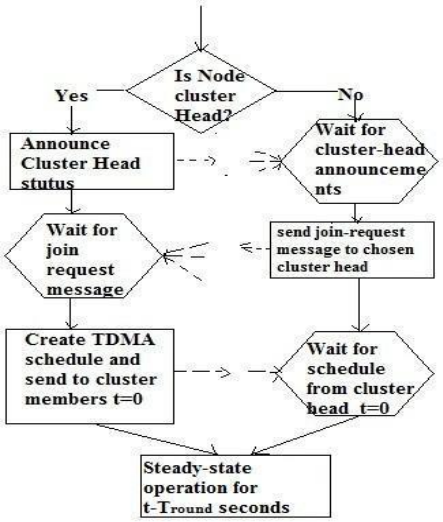


Fig. 3: Flow chart of the Set-up phase of the LEACH protocol

be turned off until the node's allocated transmission time, thus minimizing energy dissipation in these nodes. The cluster-head node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal. For example, if the data are audio or seismic signals, the cluster-head node can beam form the individual signals to generate a composite signal. This composite signal is sent to the base station. Since the base station is far away, this is a high energy transmission.

3. SIMULATION OF LEACH PROTOCOL

To stimulate the LEACH protocol, MIT's NS2 extension for LEACH simulator [7][8] is used. The models were used for channel propagation and energy dissipation is as described below:

3.1 Channel Propagation Model

In the wireless channel, the electromagnetic wave propagation can be modeled as falling off as a power law function of the distance between the transmitter and receiver. The free space model which is considered direct line-of-sight and two-ray ground propagation model which considered ground reflected signal also, were considered depending upon the distance between transmitter and receiver. If the distance is greater than $d_{crossover,}$ two-ray ground propagation model is used. The crossover is defined as follows.

$$d_{crossover} = \frac{4 * \pi * \sqrt{L} * h_r * h_t}{\lambda}$$

Where, L>=1 is system loss factor. Here equation 2, $h_r$is the height of the transmitting antenna, h_t is the height of the transmitting antenna and λ is the wavelength of the carrier signal. Now transmit power is attenuated on following formula:

$$P_r(d) = \begin{cases} \frac{P_t * G_t * G_r * \lambda^2}{(4*\pi*d)^2 * L} & \text{if } d < d_{crossover} \\ \frac{P_t * G_t * G_r * h_t^2 * h_r^2}{d^4} & \text{if } d \geq d_{crossover} \end{cases} \quad (3)$$

Where P_r is the received power at distance d. $P_t$is transmitted power. G_t is gain of the transmitting antenna and G_r is gain of the receiving antenna.

3.2 Radio Energy Dissipation Model

We assumed a simple model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics as shown in figure 4. Using this radio model, to transmit k-bit message at distance d the radio expends:

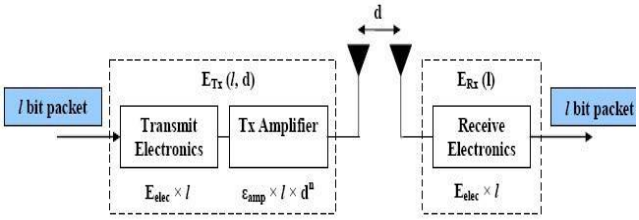


Fig. 4: Radio energy dissipation model [8]

(4)

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$
$$E_{Tx}(k,d) = E_{elec} * k + \epsilon_{amp} * k * d^2$$

and to receive this message, the radio expends

(5)

$$E_{Rx}(k) = E_{Rx-elec}(k)$$
$$E_{Rx}(k) = E_{ele} * k$$

4.SIMULATIONANALYSIS

4.1 Simulation Parameters

Table 1. Simulation Parameters

No. Item	No. Item Description Specification	No. Item Description Specification
1	Simulation Area	1000X1000
2	No. of nodes	100
3	Transmitter Amplifier Energy Dissipation (a) $E_{fs\ amp}$ (b) $E_{two\ ray\ amp}$	10 pJ/bit/m^2 0.0013 nJ/bit/m^4
4	Radio bit rate-Rb	1mbps
5	Channel Type	Channel/wireless channel
6	Radio Propagation Model	Two ray ground
7	Simulation time	600 s
8	Antennae model	Antenna/omniantenna
9	Energy model	Battery
10	Interface queue Type	Queue/Drop tail/ priqueue
11	Link layer type	LL
12	Communication Model	Bi-direction
13	Min packet in ifq	30

We simulated the MIT's LEACH cluster based routing protocol using NS 2.27[9] .

$$\lambda = \frac{3 * 10^8}{914 * 10^6} = 0.328\text{m}.$$

By varying the parameter percentage of cluster head in the MIT's LEACH configuration file, analyzed the performance of the network in terms of lifetime of the sensor network, throughput achieved and total energy consumption by the sensor network. For the experiment, percentage of cluster heads 2,3,4,5,6,7 and 8 of the total sensor nodes are taken. For the simulation experiment, following parameter was used. T_x antenna gain G_t= R_x antenna gain G_r=1 Antenna

height h_t = 1.5,No system loss (L=1), 914 MH_z radios and Base station location was (50,175)

4.2 Simulation Results

The Results of the simulation as shown in the Table 2, which shows the Lifetime , Energy and Throughput of the different no. of cluster heads in the sensor network, here 5% cluster heads of total network nodes are more energy efficient and also throughput is good as compare to others. Figure 5,6 and 7 shows the simulation graphs for percentage of cluster heads verses lifetime, throughput and average energy dissipation respectively.

No. of clusters/ %Cluster Head	**Lifetime (s)**	**Throughput**	**Energy Consumption on (J)**
2	361.00	30097	395.00
3	285.09	32279	425.00
4	464.10	35897	338.00
5	542.30	52127	292.03
6	464.00	42041	348.64
7	353.53	29426	323.99
8	181.39	8301	294.49

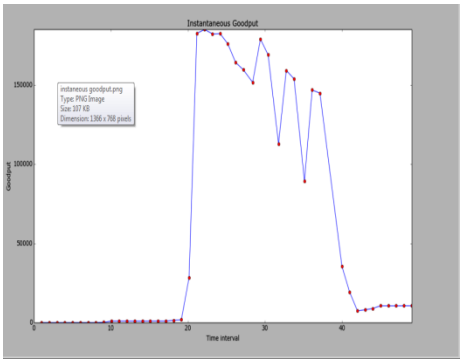
Table 2. Simulation Results

4.3 LEACH Assumption/Limitations

Although LEACH is able to increase the network lifetime, there are still a number of issues about the assumptions used in this protocol. LEACCH [9] assumes a homogeneous distribution of sensor nodes in the given area. This scenario is not very realistic.

LEACH assumes that all the nodes can transmit with enough power to reach the BS if needed and that each node as computational power to support different MAC protocols. Therefore it is not applicable to networks deployed in large regions.

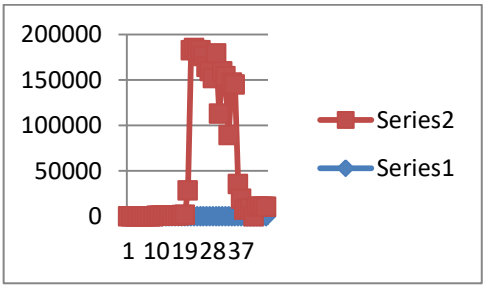
It also assumes that nodes always have data to send and nodes located close to each other have correlated data. It is not obvious how the number f predetermined Cluster Heads [CH(p)] is going to be uniformly distributed throughout the network. Therefore, there is a possibility that the elected CHs will be considered one part of the network. Hence some nodes will not have any CHs in their vicinity.

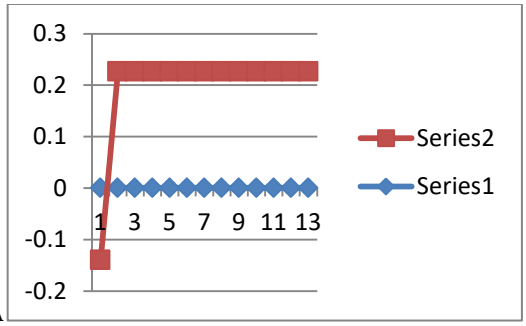


--Instantaneous goodput—

1.00454	0
2.01238	0
3.02038	0
4.02838	0
5.03638	0
6.04438	0
7.05238	0
8.06038	0
9.06838	198.413
10.0764	920.635
11.0844	920.635
12.0924	920.635
13.1004	920.635
14.1168	889.414
15.1248	920.635
16.1328	920.635
17.1408	920.635
18.1488	1444.44
19.1568	1841.27
20.1579	28479.7
21.1637	182575
22.1689	185037
23.1743	182278
24.1799	182429
25.1816	176027
26.1875	164311

27.194	159604
28.4095	151685
29.4152	179025
31.7694	112913
32.7763	159194
33.7837	153854
35.1302	89265
36.1369	146861
37.1446	144824
40.0003	35474.3
41.0025	19181.2
42.0081	7470
43.01	8025.4
44.018	8920.63
45.026	45.026
46.034	10634.9
47.042	10603.2
48.05	10666.7
49.058	10634.9



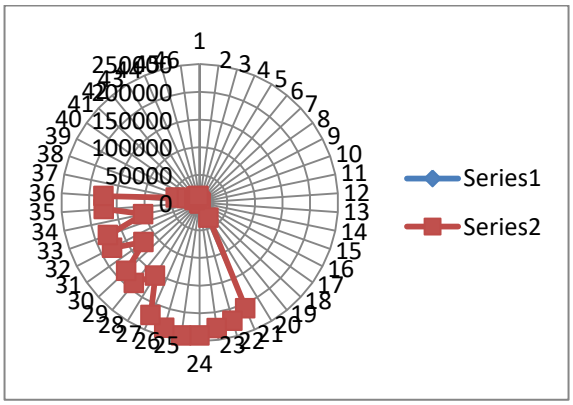


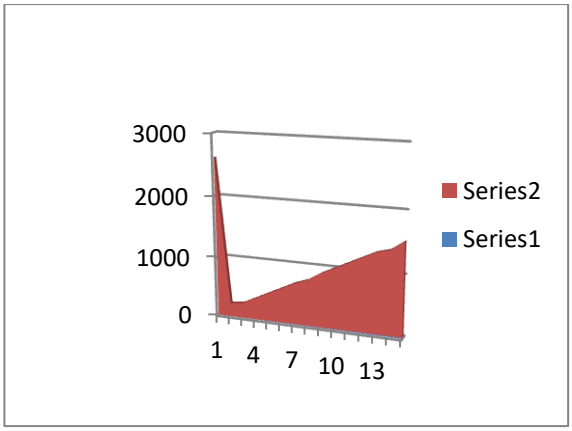
A

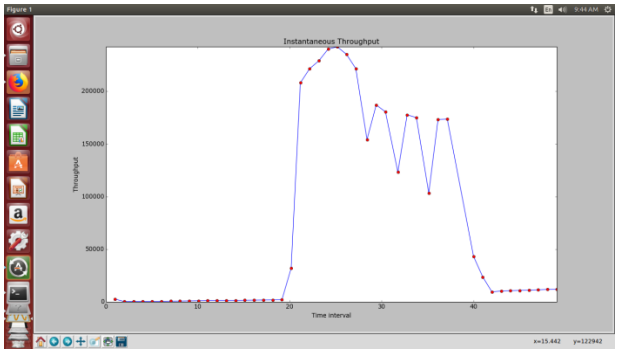
A

1.00454	2616.1
2.01238	223.733
3.02038	252.714
4.02838	359.508
5.03638	466.302
6.04438	573.095
7.05238	679.889
8.06038	757.778
11.0844	1103.38
12.0924	1210.17
13.1004	1316.97
14.1168	1374.14

15.1248	1527.79
16.1328	1634.59
17.1408	1741.38
18.1488	1848.17
19.1568	1954.97
20.1579	31903.6
21.1637	208145
22.1689	221530
23.1743	229074
24.1799	240191
25.1816	242368
26.1875	235112
27.194	221651
28.4095	154230
29.4152	187105
30.4152	180584
31.7694	123354
32.7763	177722
33.7837	175066
35.1302	103414
36.1369	173204
37.1446	173647
40.0003	43203.6
41.0025	23644.7
42.0081	9369.98
43.01	10351.5
44.018	10579.7
45.026	10871.4
46.034	11163.1
47.042	11420.1
48.05	11781.1
49.058	12038.1







Packet Delivery Ratio
GeneratedPackets = 1

ReceivedPackets = 152790

Packet Delivery Ratio = 15279000

Total Dropped Packets = 0

Residual Energy for particular node
Residual energy of node 1 is : 0.000000

5. CONCLUSION

The Hierarchical routing protocol LEACH is energy efficient for the sensor network. By varying the different no. of clusters heads/clusters in the network the performance of network changed in terms of lifetime, throughput and average energy dissipation. From the above results we concluded that if the clusters in network or cluster heads in network are below or above 5 percentage of the total no. of nodes the performance of the network is degraded in terms of energy, throughput and lifetime so, when the no. of clusters heads are 5 percentage of the sensor nodes then the performance is good.

ACKNOWLEDGEMENT

We thank to Dr. K.R.R.Mohan rao to provide us important material to simulate this protocol.

REFERENCES

[1] Nitaigour P. Mahalik, “Sensor Networks and Configuration: Fundamentals, Standards, Platforms, and Applications”, Chapter 1, 7 &Spinger, 2007.

[2] Jamal N . Al-Karaki, Ahmed E. Kamal. “Routing Techniques in Wireless Sensor Networks: A survey “, IEEE Wireless Communications. December 2004.

[3] . A. Manjeshwar and D. Agarwal, “TEEN: a routing protocol for enhanced efficiency in wireless sensor networks”, In proceedings 15th International Parallel and Distributed Processing Symposium, pp.2009-2015. 23-27 April 2001.

[4] .V. Rodoplu, T.H. Ming, “Minimum energy mobile wireless networks”, IEEE journal of Selected Areas in Communications.Vol.17. No. 8,pp.1333-1334,1999.

[5] .W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy Efficient Communication Protocol for Wireless Micro Sensor Networks”, Proceedings of IEEE HICSS. Jan 2000

[6] P.T.V. Bhuvaneswari and V. Vaidehi, “Enhancement techniques incorporated in LEACH-A Survey”, Indian Journal of Science and Technology Vol.2 No 5 (May 2009)

[7] .Massachusetts Institute of Technology, Cambridge, “The MIT uAMPSns Code Extensions, Version 1.0” August, 2000.

[8] SanjeevSaini, Ram Sewak Singh & V.K. Gupta “Analysis of Energy Efficient Routing Protocols in Wireless Sensor Networks Communication”, UCSC vol.1, No.1.January-June 2010, pp.113-118.

[9] .Liu Linato Yang Ping, “Routing Protocols Simulation Based on NS2”, Ship Electronic Engineering [j],2008.4 vo.1 28 No. 4:132-134.

[10] .LanTien Nguyen Xavier Defago, RazvanBeuran, Yoichi Shinoda, “An Energy Efficient Routing Scheme for Mobile Sensor Networks”, IEEE ISWCS 2008.