International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 12 (2015) pp. 30659-30670

http://www.ripublication.com

Implementation of LEACH and LEACH-C Protocols in NS2

K.Thangaraj and Dr.M.Chitra

Research Scholar, Anna University
thangarajkesavan@gmail.com
Professor, Dept. of IT, Sona College of Technology
Salem, INDIA

Abstract

Wireless Sensor Network (WSN) are widely used to monitor physical or environmental conditions, such as temperature, sound, pressure, etc which consists of spatially distributed autonomous sensors and cooperatively pass their data through the network to a main location called sink. Power consumption has been one of the important factors in mobile wireless network. In this Internship work initially we are going to do the study of overall architecture and operations of the unique featured routing protocols for Wireless Sensor Network LEACH and LEACH-C, because LEACH (distributed) is the first clustering routing protocol which is proven to be better compared to other such algorithms and the leading simulation tool NS2 which provide maximum equivalent results as real time environments. By using NS2 we are plan to do the testing of these two communication protocols and analyze the results with the existing results and to generate a nam animation for these protocols to deep learning of NS2

Index Terms— Leach, Leach-c, NS2, Sensor Networks

I. INTRODUCTION

Wireless Sensor Network (WSN) is widely used to monitor physical or environmental conditions, such as temperature, sound, pressure; etc which consists of spatially distributed autonomous sensors. Sensor nodes establish a network that they can exchange data and transmit data back to a base station (BS). Sensor node has a limited battery power and capability. Power consumption has been one of the important factors in Wireless Sensor Network. To make a wireless sensor network operate autonomously, each node in the network must be able to provide adequate

communication while consuming as minimum power as possible. There have been many research works in this field that address such an issue and propose their own algorithm to efficiently minimize the power consumption and effectively maximize the lifespan of the network. The protocol for communication starts from the conventional protocols such as direct transmission protocol that sensor node sends data directly to a distant base station and consumes its energy rapidly.

Depending upon the network structure, routing in wireless sensor networks can be classified as flat-based routing, hierarchical-based routing, and location-based routing.

- In flat-based routing, all the nodes in the topology are assigned the same functionality or role.
- In hierarchical-based routing, nodes are assigned different roles or functionalities according to the hierarchy.
- In location-based routing, routing path for the data is decided according to the sensor nodes position in the field.

Depending on how the source finds a route to the destination, routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols.

- In proactive protocols, all routes are computed before they are actually needed.
- In reactive protocols, routes are computed only when they are needed.
- While hybrid protocols are combination of the above two ideas.

Depending on the protocol operation, routing protocols can be classified into multipath- based, query-based, negotiation-based, QoS-based, or coherent-based routing.

- In multipath-based routing, multiple paths are used to enhance network performance i.e. fault tolerance, balance energy consumption, energy-efficiency and reliability.
- In query-based routing, destination nodes propagate a query for data. Usually these queries are described in natural language or high-level query language.
- In negotiation-based routing, high-level data descriptors are used in order to eliminate redundant data transmissions through negotiation. Communication decisions are also made based on the resources available to them.
- In QoS based routing, a balance between energy consumption and data quality is maintained.
- In coherent based routing, the data is aggregated with minimum processing before forwarding. Here, energy efficiency is achieved by path optimality.

Apart from these protocols, a number of protocols exist that depend upon timing and position information. That leads to Minimum-transmission-energy (MTE) routing protocol that reduces distance for transmitting packet to BS by routing a data

packet through multiple intermediate nodes. The two classical energy-efficient algorithms, which is LEACH (low-Energy Adaptive Clustering Hierarchy) and LEACH C uses a Cluster based communication approach.

II. UNDERSTANDING LEACH AND LEACH-C PROTOCOLS

A.LEACH Protocol

Heinzelman, et.al [1] introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH arranges the nodes in the network into small clusters and chooses one of them as the cluster-head. Node first senses its target and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station. The nodes chosen as the cluster head drain out more energy as compared to the other nodes as it is required to send data to the base station which may be far located. Hence LEACH uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. After a number of simulations by the author, it was found that only 5% of the total number of nodes needs to act as the cluster-heads. TDMA/CDMA MAC is used to reduce inter-cluster and intra-cluster collisions. This protocol is used were a constant monitoring by the sensor nodes are required as data collection is centralized (at the base station) and is performed periodically.

LEACH operations can be divided into two phases:

a. Setup phase
b. Steady phase

In the setup phase, the clusters are formed and a cluster-head (CH) is chosen for each cluster. While in the steady phase, data is sensed and sent to the central base station. The steady phase is longer than the setup phase. This is done in order to minimize the overhead cost.

a. Setup phase:

During the setup phase, a predetermined fraction of nodes, p, choose themselves as cluster-heads. This is done according to a threshold value, T (n). The threshold value depends upon the desired percentage to become a cluster-head- p, the current round r, and the set of nodes that have not become the cluster-head in the last 1/p rounds, which is denoted by G.

Every node wanting to be the cluster-head chooses a value, between 0 and 1. If this random number is less than the threshold value, T (n), then the node becomes the cluster- head for the current round. Then each elected CH broadcasts an advertisement message to the rest of the nodes in the network to invite them to join their clusters. Based upon the strength of the advertisement signal, the non-cluster head nodes decide to join the clusters. The non-cluster head nodes then informs their respective cluster-heads that they will be under their cluster by sending an acknowledgement message. After receiving the acknowledgement message,

depending upon the number of nodes under their cluster and the type of information required by the system, the cluster-heads creates a TDMA schedule and assigns each node a time slot in which it can transmit the sensed data. The TDMA schedule is broadcasted to all the cluster-members. If the size of any cluster becomes too large, the cluster-head may choose another cluster- head for its cluster. The cluster-head chosen for the current round cannot again become the cluster-head until all the other nodes in the network haven't become the cluster-head.

b. Steady phase:

During the steady phase, the sensor nodes i.e. the non-cluster head nodes starts sensing data and sends it to their cluster-head according to the TDMA schedule. The cluster-head node, after receiving data from all the member nodes, aggregates it and then sends it to the base station. After a certain time, which is determined a priori, the network again goes back into the setup phase and new cluster-heads are chosen. Each cluster communicates using different CDMA codes in order to reduce interference from nodes belonging to other clusters.

B.LEACH-C Protocol

LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location using GPS and residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines which nodes have energy below this average and selects the Cluster Head.

C. NS2 Simulator

NS2 is a most popular non-commercial discrete event packet level simulator. Though NS2 we can simulate wired networks, wireless networks, Error modules, Tracing, Visualization, emulation and various utilities. NS2 is consists components like NS the simulator, NAM the network Animator, NSE the network emulator etc., Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless local and satellite networks. Ns together with its companion, nam, form a very powerful set of tools. NS2 also contains all the IP protocols and many experimental protocols contributed by its ever-expanding user's base. With nam, these protocols can visualize as animations.Ns-2 is an open source discrete event simulator used by the research community for research in networking. It has support for both wired and wireless networks and can simulate several network protocols such as TCP, UDP, multicast routing, etc. More recently, support has been added for simulation of large satellite and ad hoc wireless networks. The ns-2 simulation software was developed at the University of Berkeley. It is constantly under development by an active community of researchers.

III. CONFIGURING NS2 TO IMPLEMENT LEACH AND LEACH-C PROTOCOL

LEACH introduces clustering based protocol, where sensor nodes are grouped in several clusters and have randomized rotation of cluster-heads that will transmit a data to Base Station. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. These two protocols are mainly forwarding the low energy consumptions tradeoffs. In this Internship work we are going to do the implementation of two communication protocols LEACH and LEACH-C using NS2.

A.Leach Algorithm

The algorithm for the Low Energy Adaptive Clustering Hierarchy (LEACH) implemented is:

Setup phase:

1. CN⇒ r
2. If r < T (n) then, CH = CN else, goto step1
3. CH ⇒ G: id (CH), join_adv
4. A(i) → CH(j) : id(A(i)) , id(CH(j)) , join_req
5. CH(j) → A(i) : id(CH(j)) , < t(i) , id(A(i)) >

Steady phase:

1. A(i) → CH(j) : id(A(i)) , id(CH(j)) , info
2. CH → BS: id (CH), id (BS), aggr_info

The various symbols used here are:
CN: candidate node to become the cluster head.
r: random variable(0 < r < 1) T(n): threshold value
CH: cluster head
G: all nodes in the network id: identification number
join_adv: advertisement to join the cluster
A: normal node
join_adv: request to join the cluster t: time slot to send the sensed data
⇒ : broadcast
→ : unicast

B. Cluster Formation Algorithm:

1. After cluster head selection, each Cluster Heads broadcasts an advertisement message using CSMA MAC protocol. During this period other non-cluster heads must keep their receivers on to get the message.

ADVERTISEMENT MESSAGE = node's ID + distinguishable header.

2. Based on the received signal strength of ADV message, each non-Cluster Head node determines it's Cluster Head for this round.

3. Each non-Cluster Head transmits a join-request message back to its chosen Cluster Head using a CSMA MAC protocol.

Join-REQ = node's ID + cluster-head ID + header.

4. Cluster Head creates a TDMA schedule to assign a time slot for each node in which it can transmit the data.
5. TDMA Schedule

a. Prevents collision among data messages.

b. Energy conservation in non cluster-head nodes.

C. Network Configuration

Here we have considered a heterogeneous network. A heterogeneous network is one in which all the nodes doesn't have equal energy. Let us assume that m fraction of the nodes has α time more energy than the other nodes and the total number of nodes is n. They are called as advanced nodes. Therefore,

Number of normal nodes = (1-m) × n

Energy per normal node = e0

Number of advanced nodes = m × n

Energy per advanced node = e0 × (1 + α)

Hence the total energy of the network = ((1-m) × n) × e0 + (m × n) × (e0 × (1 + α)

The network configuration for the first simulation is as follows:

Field size = 100m * 100m

Number of nodes = 100

Energy per node = 2 joules

Election probability for a node to become the cluster-head = 0.1

Message size = 500 bytes

5% of the nodes have double energy.

A few of the above parameters were changed for the required analysis. The energy spend by any transmitter to send a L-bit message over a distance d is,

$$E_{Tx}(l,d) = \begin{cases} L \cdot E_{elec} + L \cdot \epsilon_{fs} \cdot d^2 & \text{if } d \le d_0 \\ L \cdot E_{elec} + L \cdot \epsilon_{mp} \cdot d^4 & \text{if } d > d_0 \end{cases} \quad (1)$$

where Eelec is the amount of energy spent to run the circuit (of receiver or sender) for 1-bit data, fs and mp are the transmitter constants and depend upon the type of transmitter used.

$$d_0 = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \quad (2)$$

A few of the nodes in the network were compromised and selective forwarding was done. The cluster-heads were the nodes that were compromised. Now, the malicious nodes would only forward only certain messages and dump the other. Hence the network throughput is expected to decrease and also abnormal characteristics of the network lifetime. In general both of these LEACH and LEACH-C work in rounds. There are two distinct operational phases in each round, namely Cluster Set up phase and Steady-State phases. Cluster Set up phase includes cluster head advertisements and Scheduling of nodes within each cluster by respective cluster heads. Steady-State phase involves transmission of data from nodes to their respective cluster heads at scheduled time intervals. Common aspects applicable to both of these protocols and important ones to be understood are:

1. Randomized rotation of the cluster "base stations" or "cluster heads" and the corresponding clusters.
2. Local compression to reduce global communication

IV. SIMULATION RESULTS

Both LEACH & LEACH-C protocols are simulated for several chosen scenarios, and analysis of simulation results against chosen performance metrics with latency and network lifetime being major among them using NS2. Results obtained for parameters of interest are shown in following figures (with 100 nodes & number of clusters = 5).

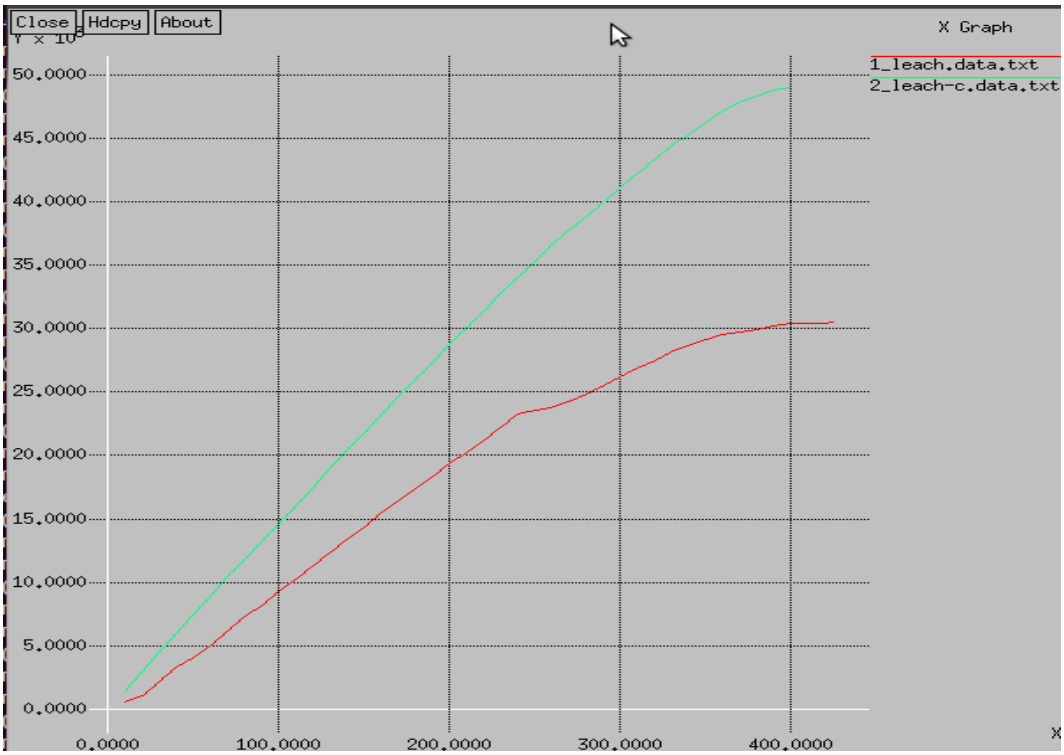

Figure 6.1. Time v/s No of data signals received

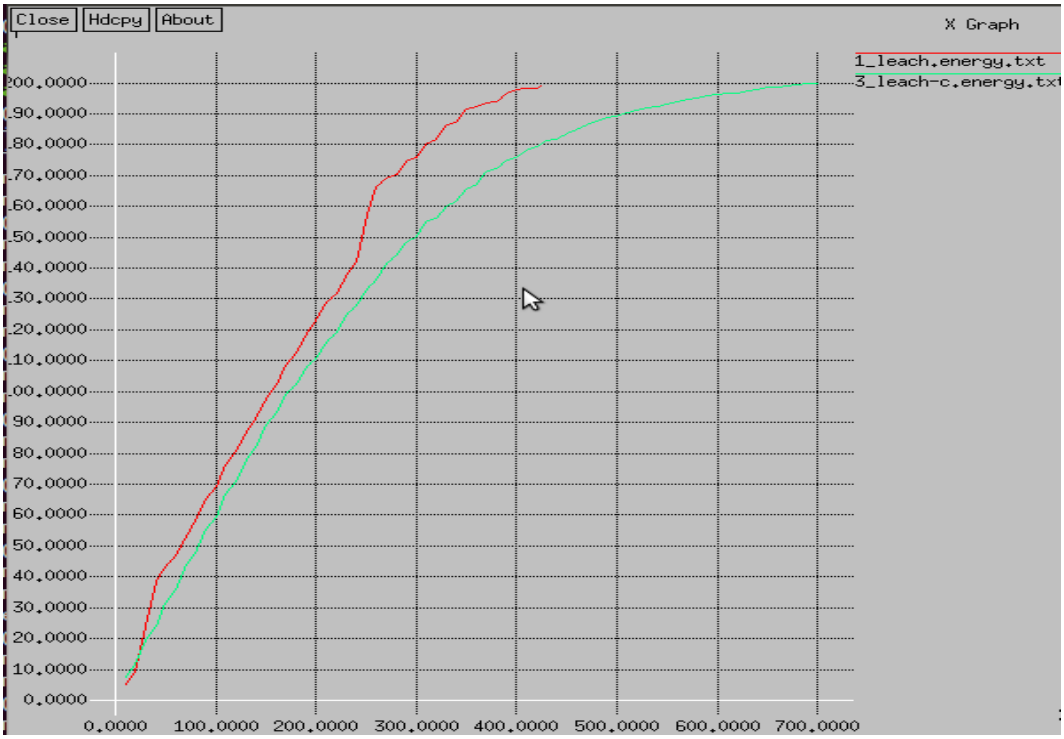

Figure 6.2. Time Vs Total energy dissipation

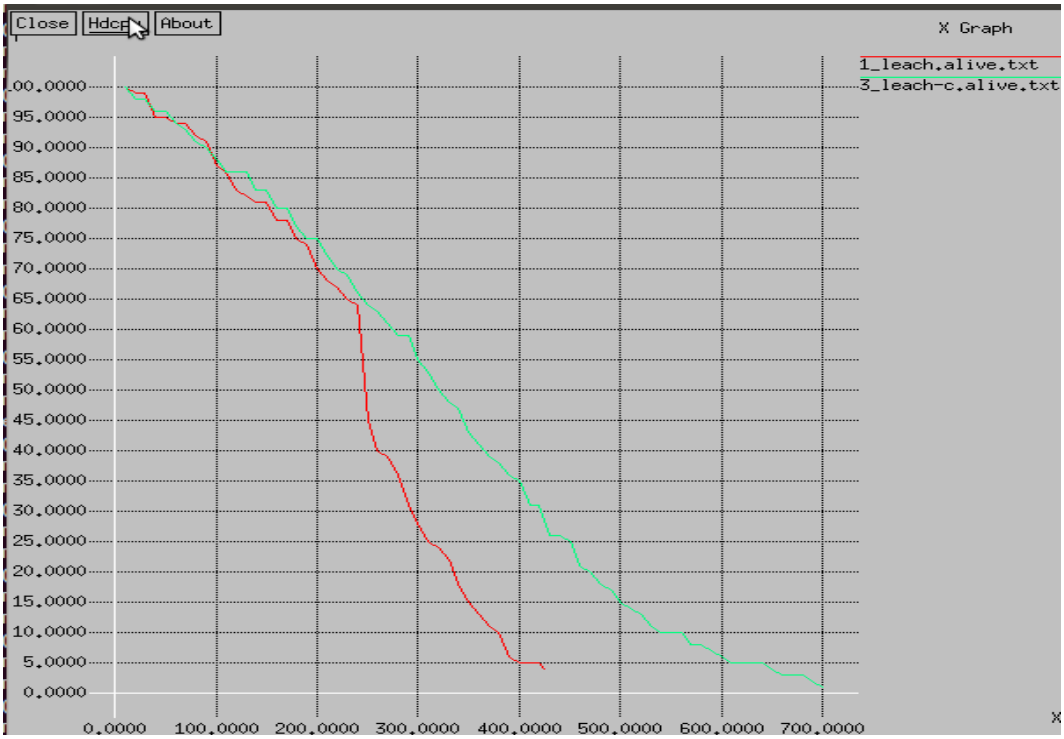

Figure.6.3. Time VS No. of nodes alive

It is observed from the graph in Fig. 6.1 that as the time increases, no of data signals received at BS through LEACH-C linearly increase compared to that of LEACH and able to deliver more no of data signals compared to that of LEACH because, in LEACH-C, BS knows the network topology and hence it can form good clusters compared to that of LEACH. From Fig. 6.2 it can be observed that start up energy dissipation is constant and more compared to that of LEACH, because of overhead in cluster set up formation in LEACH-C. Graph in Fig.6. 2 conveys that total energy dissipation linearly increases in LEACH-C compared to that of LEACH, because BS creates desired number of cluster heads and evenly distributes them so that appropriate cluster sizes can be formed and hence change in total energy dissipation will be less compared to that of LEACH. LEACH uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions. However, data collection is centralized and is performed periodically. Therefore, this protocol is most appropriate when there is a need for constant monitoring by the sensor network. A user may not need all the data immediately. Hence, periodic data transmissions are unnecessary which may drain the limited energy of the sensor nodes. After a given interval of time, a randomized rotation of the role of the CH is conducted so that uniform energy dissipation in the sensor network is obtained.

Table.1: Summery of the parameters used in the simulation experiments

Number of Nodes	100
Network size	100m * 100m
Base station location	(50,175)
Radio propagation speed	$3*10^8$ m/s
Processing delay	50 μs
Radio speed	1 Mbps
Data size	500 bytes
Initial node power	2 Joules
Simulation time	900 sec

As LEACH follows probabilistic method of selection, uneven distribution of cluster heads may be possible sometimes which leads to sudden increase in energy dissipation. We can also see from Fig.6.3 that no of nodes alive decreases slowly in LEACH-C compared to that in LEACH reasoning the same that uneven distribution and undesired no of cluster heads might be formed in LEACH. And the following fig.6.4 shows the animation of LEACH Protocol using NAM tool of NS2.35.

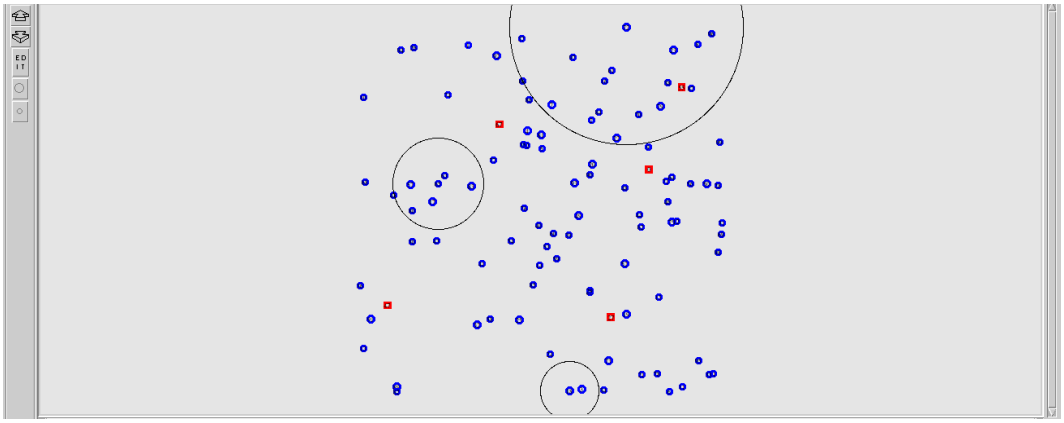

Figure 6.4. NS 2 nam animator partial animation of LEACH Protocol

V. CONCLUSION

Wireless Sensor Networks, which may be spread over vast geographical area, are finding applications in many areas. In this context, there is need of approaches which can manage these WSNs in better way. In this regard, this internship work, presented the need for clustering to overcome several limitations of WSNs. We implemented brief working of chosen clustering protocols, namely LEACH & LEACH-C. We also presented the simulation results and analyses of these protocols. As a conclusion of observation from results, it can be mentioned that LEACH can be preferred if localized coordination of nodes in clustering without involving BS is of high priority than other factors like assurance over desired number of clusters etc.; and LEACH-C can be chosen when centralized and deterministic approach covering entire network is expected still bringing in increased network lifetime and desired number of clusters. And partially we designed a nam animation for LEACH and LEACH-C.

REFERENCES

[1] W. R. Heinzelman, A. P. Chandrakasan, and H. Bala-krishnan, "An application-specific protocol architecture of wireless micro sensor networks," IEEE Transactions on Wireless Communications, Vol. 1, No. 4, pp. 660–670, 2002.

[2] http://www.isi.edu/nsnam/ns/

[3] http://www.cse.iitb.ac.in/~cs641/slides/ns-tutorial.pdf

[4] Jamal N. Al-karaki and Ahmed E. Kamal. Routing techniques in wireless sensor networks: A survey. IEEE Wireless Communications, 11:6–28, 2004.

[5] Y. Geng C. Hong-bing and H. Su-jun. Nhrpa: a novel hierarchical routing protocol algorithm for wireless sensor networks. China Universities of Posts and Telecommunications, September 2008.

[6] G. Hu D. Wu and G. Ni. Research and improve on secure routing protocols in wireless sensor networks. In 4th IEEE International Conference on Circuits and Systems for Communications (ICCSC 2008).

[7] Wendi Rabiner Heinzelman, Anantha Ch, and Hari Balakrishnan. Energy-efficient communication protocol for wireless micro sensor networks. Pages 3005–3014, 2000.

[8] C. Wang K. Zhang and C. Wang. A secure routing protocol for cluster-based wireless sensor networks using group key management. In 4th IEEE International conference on Wireless Communications, Networking and Mobile Computing (WiCOM08).

[9] ns-2 Home page : http://www.isi.edu/nsnam/ns/

[10] ns-2 Tutorial: http://www.isi.edu/nsnam/ns/ tutorial/ nsindex.html

[11] Thangaraj K, Kanimozhi.K, Kanimozhi.M, Kavitha.P, Keerthana.R, "IPV6 In Visual Sensor Network", International Journal of Communications and Engineering,Volume 03– No.3, Issue: 03 March2012

[12] K.Thangaraj and M.Chitra,"Sensors Lifetime Enhancement Techniques In Visual Sensor Networks - A Survey", Third International Conference on Sensors and Related Networks (SENNET-12), VIT University, Vellore, India. Jan. 19-21, 2012. pp.264-267.

[13] Mr.K.Thangaraj, Prof.M.Chitra, "Sensors Lifetime Enhancement Techniques In Wireless Visual Sensor Networks - A Survey", ISSN: 2278 – 1323,International Journal of Advanced Research in Computer Engineering & Technology,Volume 1, Issue 3, May2012

[14] K.Thangaraj, S.Karthik, SR Kamalraj, M.Janani, "Best Parameter For Congestion Detection During Video Transmission In Wireless Sensor Networks", International Journal of Innovations in Engineering and Technology (IJIET)Vol2 Issue 1 April 2013 Page No. 284 ISSN 2319-105

[15] M. Yebari, T. Addali, A.Z.Sadouq and M. Essaaidi,"Energy Conservation Challenges In Communication Protocols For Wireless Sensors Networks: State-Of-The- Art Study", International journal on Information and Communication Technologies, Vol. 1, No. 1-2, January-June 2008, pp. 29-35

[16] M.J. Handy, M. Haase, D. Timmermann, "Low Energy Clustering Hierarchy With Deterministic Cluster Head Selection", Proceedings of IEEE MWCN, 2002.

[17] A. Manjeshwar and D. P. Agrawal, "APTEEN: A Hybrid Protocol for Efficient Routing And Comprehensive Information Retrieval In Wireless Sensor Networks", Proc. Int'l. Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April 2002.

[18] Chitra M, Padmavathy T.V "PELLMAC: A Power Efficient and Low-Latency MAC Protocol for Wireless Sensor Networks Using Hybrid Algorithms" CiiT International Journal of Wireless Communication, Jan 2011 Print: ISSN 0974 – 9756.

[19] Chitra M , Padmavathy T.V. "EERR: Performance Evaluation of Energy Efficient and Reliable Routing Protocol for Wireless Sensor Networks" Accepted in International Journal of Computer Networks, Volume (0): Issue (0) ,pp14-31, 2011