Volume 5, Issue 4, October 2018 ISSN: 2348-8565 (Online)
International Journal of Modern Engineering and Research Technology
Website: http://www.ijmert.org Email: editor.ijmert@gmail.com

Improved Leach Protocol for Maximizing WSN Lifetime Using Heterogeneous Nodes

Anjali Arora
M.Tech. Research Scholar,
Shri Ram Group of Institutions
Jabalpur, (M.P.) [INDIA]
Email: anjali.arora413@gmail.com

Santosh Sahu
Assistant Professor,
Department of Computer Science & Engineering
Shri Ram Group of Institutions
Jabalpur, (M.P.) [INDIA]
Email: sant303@rediffmail.com

ABSTRACT

The wireless sensor network is the decentralized type of network which can sense the information and pass it to base station. Due to small size of the sensor nodes, the energy consumption is the major issue of the network. The LEACH is the energy efficient protocol which can divide whole network into fixed size clusters. In each cluster, cluster heads are selected which can transmit data to base station. In this research work, the LEACH protocol is improved to reduce energy consumption of the wireless sensor networks. In the proposed improvement, the mean nodes are deployed which can aggregate data from the cluster heads and then pass data to base station and Heterogeneous Multi-hop LEACH routing protocol is used to increase the energy efficiency of WSN. The simulation of the proposed technique is done in MATLAB and results are compared with the existing approach in terms of certain parameters. It is analyzed that proposed technique performs well as compared to existing technique.

Keyword :— *LEACH, MATLAB, MULTI-HOP,*

I. INTRODUCTION

Wireless Sensor Networks: With the advent of technology there is a massive advancement in wireless sensor networks. Today these networks have a high demand in almost every domain all thanks to the unique properties they possess. There have been various challenges being faced in order to design the wireless sensor network due to which different protocols have been presented. There is very less amount of energy being consumed by the sensor nodes with the presence of these protocols however. Numerous high node densities involved in these networks make the system huge. The sensor nodes present within the wireless sensor networks include within them battery sources which them in performing different tasks.

1.2 Wireless sensor network Architecture

It is a wireless network comprised of various autonomous devices which use sensors to test physical or environmental conditions.

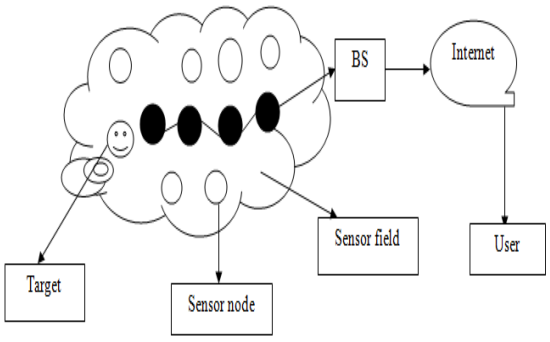

Figure 1: Architecture of Wireless Sensor Network

a. ***Gateway:*** A gateway in WSN is an interface between the application platform and the wireless nodes. The gateway received the information and manipulates it, then further passes it to the application. The application is run by a local as well as a networked computer. This process can be reversible also. The function of gateway is to pass the command from one application to another.

b. ***Base Station:*** A device that connects the user and software in order to transmit important information gathered from sensor nodes to external sources is known as base station.

c. ***Sensor node:*** This device helps to interact with the physical system. These tiny devices are connected in clusters and manage to transfer and gather data present in the environment [3].

d. ***Relay node:*** They are the full-function devices (FFD), also called as routers. The main function of these nodes is to provide Back-ups while there is any congestion in the network. Along with back-ups, they also help to extend the coverage area and to monitor hurdles in the network.

e. ***Clusters:*** These are the organizational units of the network. They fragment the network and collect the data from respective already divided nodes and forward the aggregated data to base station.

II. LITERATURE REVIEW

2.1 Mohamed Elshrkawey, et.al (2017) have presented in this paper [17], wireless sensor networks have been utilized in many applications such as for the monitoring of the environmental conditions. There are large numbers of low power devices that has been utilized in order to sense the information present within the network. Sensors are deployed in the network in order to collect the information and transferred that collected information to the base station. In every network there is different clusters are present, within these cluster a cluster head is present. When the sensor node sense the data it is transferred to the cluster head, after this cluster head transfer this data to the base station. Sensors have in-built batteries that cannot be replaced easily. In wireless sensor networks, energy consumption is considered as the major concern as it degrades the network lifetime. Author proposed the approach that reduce the energy consumption rate and increase the lifetime of the network. In this approach all the energies present in the clusters among the sensors nodes used to mitigate the energy dissipation during network communications.

2.2 Ali Ghaffari, (2014) have presented in this paper [18], the major component used in the wireless sensor network is the sensor node as it provide the significant results. Wireless sensor networks have been utilized in many applications such as for the monitoring of the environmental conditions. It consists of sensor nodes and a base station for the collection of the data that must be transferred to the sink node in a multi-hop and energy-efficient manner. Energy consumption is considered as the critical issue in the wireless network as it degrades the lifetime of the network and also it is impossible to replace battery as it requires more computational cost.

Low-energy adaptive clustering hierarchy (LEACH)

Low-energy adaptive clustering hierarchy (LEACH) (W. Heinzelman et al., 2000) is one of the most popular hierarchical routing algorithms for sensor networks. The basic

concept is to form clusters of the sensor nodes on the basis of strength of received signal and use cluster heads to route data to the sink. This will save energy since the transmissions will only be done by such cluster heads rather than all sensor nodes. All the process on data such as data fusion and aggregation are local in the cluster. Cluster heads selected and change randomly over duration of time to balance the energy dissipation of nodes.

2.2.1 Working of LEACH

The working step of LEACH is broken up into rounds, and each round begins with a phase which is called set-up phase, when the clusters are organized, followed by a steady-state phase, when data (packet) transfers to the base station occur. To minimize overhead, the steady-state phase is long as compared to the set-up phase.

Steady-state phase include sub phase.

1. Advertisement Phase
2. Cluster Set-Up Phase
3. Schedule Creation

Advertisement Phase

Initially, when nodes are being deployed, each node decides whether or not to be a cluster-head for the current running round. This decision is on the basis of suggested percentage of cluster heads for the network and the number of times the node has been a cluster-head so far. This decision is made by the node selecting a random number between 0 and 1. If the number is less than a threshold value the node becomes a cluster-head for the current round. The threshold is set as:

$$T(n) = \begin{cases} \dfrac{p}{(1-p)(r \bmod (1/p))} & \text{If } n \in G \\ 0 & \text{Otherwise} \end{cases}$$

Where P = the desired percentage of node to become cluster heads r is the current round, and G is the set of nodes that have not been cluster-heads in the last 1/P round

Each node which has elected itself a cluster-head for the current running round broadcasts an advertisement message to the rest of the nodes. For this "cluster-head-advertisement" phase, the cluster-heads use a CSMA /MAC protocol, and all cluster-heads transmit their advertisement message using the same transmit energy. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements message of all the cluster-head nodes. After this phase is complete, each non-cluster-head node decides the cluster to which it will belong for current running round. This decision is on the basis of strength of received signal of the advertisement massage. Assuming symmetric propagation channels, the cluster -head advertisement heard with the largest signal strength is the cluster-head to whom the minimum amount of transmitted energy is needed for communication. In the case of ties, a random cluster-head is chosen.

Cluster Set-Up Phase

When each node has decided to which cluster it belongs, it must have to inform the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol. During this phase, all cluster-head nodes must keep their receivers on.

Schedule Creation

The cluster-head node receives all the messages for nodes that would like to be included in the cluster. On the basis number of nodes in the cluster, the cluster-head node creates a TDMA schedule for each node to transmit data. This schedule is

broadcast back to the all the node in the cluster.

Data Transmission

Once when the clusters are created and the TDMA schedule is fixed, data transmission can begin. Assuming 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 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 After a certain time, which is determined a priori, the next round begins with each node determining if it should be a cluster-head for this round and advertising this information.

2.2.2 Disadvantages of LEACH

LEACH assumes a homogeneous distribution of sensor nodes in the given area. This scenario is not very realistic because energy consumed by the CHs is greater than that by the member nodes. So the CHs drain out their energy faster than the members.

III. Problem Formulation

The wireless sensor network is the adhoc type of network in which sensor nodes sense the environmental conditions and pass it to base station. In the sensor network, the sensor nodes can join or leave the network when they want. Due to decentralized nature of the network and small size of the sensor nodes energy consumption is the major issue of sensor network. The clustering is the efficient approach which increase lifetime of the sensor network. In the approach of the clustering, whole network is divided into fixed size clusters and in each cluster, cluster heads are selected in each cluster. The sensor nodes in each cluster will aggregate the data to the cluster head.

In wireless sensor network energy is mainly consumed for three purposes that are data transmission, signal processing and hardware operation. We can said that 72% of the energy is approx consumed in data transmission only. So to maximize the network lifetime data transmission is optimized by using energy-efficient routing protocols .Since the energy required is proportional to the square of distance between the communicating parties, so multi-hop routing needs less energy in compare to direct communication. But maintenance of network topology is an extra overhead in multi-hop routing. So if sensor nodes are close enough to the Base Station direct communication is the best choice due to its simplicity and less overhead. But in most cases sensor nodes are randomly scattered so multi-hop routing cannot be avoided.

IV. Proposed Work

The wireless sensor network is the self configuring network in which sensor nodes sense information and pass it to base station. Due to decentralized nature of the network, energy consumption, data aggregation and security are three major issues of the networks. This research work is focused on the energy consumption of the wireless sensor networks. The energy consumption issues are raised due to small size of the sensor nodes. The clustering is the efficient approach which increase lifetime of the sensor networks. In the clustering approach, the whole network is

divided into fixed size clusters. The cluster heads are selected in each cluster and sensor nodes in each cluster will aggregate data to cluster head. The cluster head will transmit data to the base station. To increase lifetime of the sensor network, the optimization is proposed in the LEACH protocol. In the proposed approach, the gateway nodes are deployed between the cluster head and base station. The cluster heads will transmit the data to nearest gateway node and then gateway send data to the base station. The gateway aggregate data from the nearest cluster head. The distance between the gateway node and cluster head is calculated using Euclidian distance formula. In this research work, the mobility of the base station will be generated to aggregate data from the gateway nodes. The mobility of the base station will be generated using the ant colony optimization algorithm. In the ant colony optimization algorithm, three steps are followed in which initial population are the coordinated of the base station. In the seconds step, the aggregation rate is calculated from each cluster head. In the last step, the base station position will be updated from which maximum data get aggregated. The proposed improvement leads to increase lifetime of the sensor nodes and reduce energy consumption of the network.

So our proposed algorithm selects the best path with minimum hop-count between CH and BS. It also provides scalability feature due to its multi-hop communication option for CHs.

4.1 Operation of LEACH

The operation of LEACH is split into two basic phases: first is Set-up Phase followed by Steady-state Phase.

Set-up Phase:

There are three types of nodes: Traditional, Mean and advanced nodes having different energy levels.

Initially Cluster-heads are selected as same in LEACH from the set of Mean nodes. by using the following formula

$$T(n) = \begin{cases} \dfrac{P}{1-p(\ r \bmod(1/p))} & \text{if } n \in G \\ 0 & \text{Otherwise} \end{cases}$$

Where p is desired percentage of a node to become cluster and r is current round

Each Mean node generate a random number between 0 and 1and compare it with the pre set threshold value T(n), if generated random number is less then threshold value it elect itself as cluster head

After cluster head formation each CH will broadcast a short message containing its own ID to find its neighbors.

Each non-cluster-head node from the set of Traditional nodes determines to which cluster it belongs by choosing the cluster-head that requires the minimum communication energy, based on the received signal strength of the advertisement from each cluster-head.

The selected CH will create a TDMA schedule defining the time slot for each member in its cluster to forward data to it.

Steady-state Phase:

1. Like LEACH all the cluster members (Traditional nodes) will send data to their corresponding cluster-heads (Mean node).
2. Unlike LEACH after aggregation cluster-heads will send the aggregated data to an advanced node which is

closer to the BS than the CH. To find such a node CH will compare the distance between advanced node and BS with that between itself and the BS. Whichever is smaller will be used to transmit data to the BS. If no such advanced node is found then it will send the data directly to the base station.

3. The advance nodes will again aggregate the sensed data and the data received from the CHs. After that it will forward the result to the base station

4.2 Energy Efficiency of Proposed Protocol

Our proposed algorithm provides better connectivity and successful data rate as compare to LEACH. The reason behind this enhancement is multi-hop communication adopted by cluster-heads. As member nodes save energy by sending data to cluster-head in LEACH instead of Base station, similarly in Improved LEACH cluster-head at longer distance from Base station transmit data to advanced nodes closer to the Base station instead of direct transmission to Base station. It is more effective energy efficient routing protocol when network diameter is larger. Energy efficiency of Improved LEACH can be better elaborate with the example of linear network having two cluster heads A and B which are communicating to Base station. A is at a distance 'm' from B and B is at a distance m from the Base station.

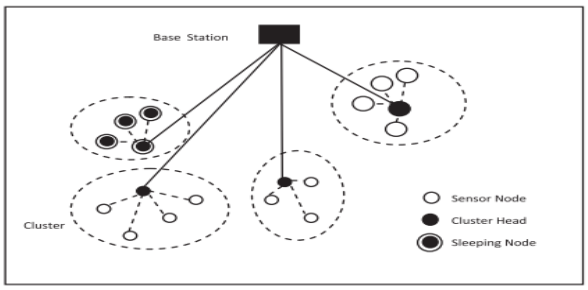

Figure 2: A typical LEACH-CS Network

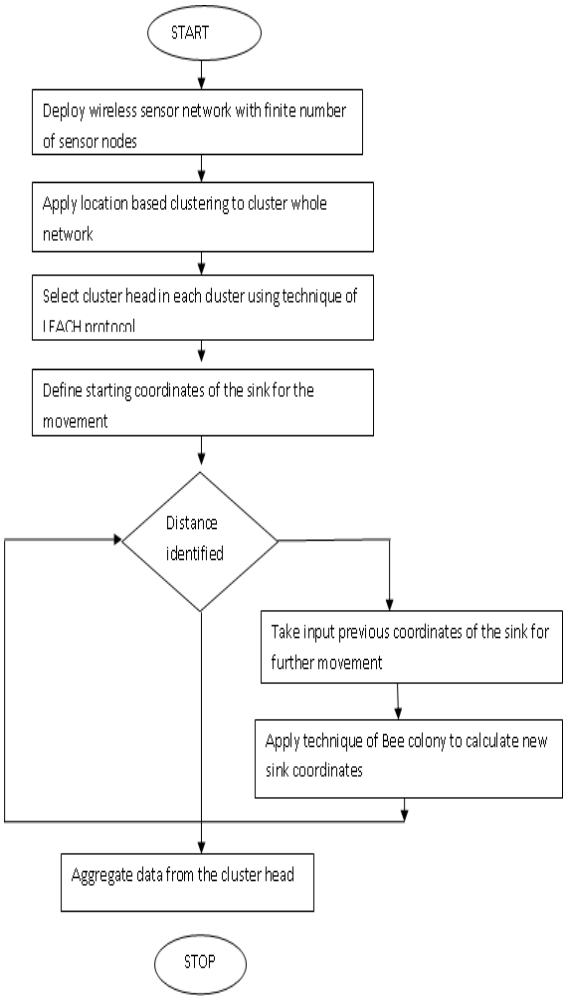

Figure 3: Proposed Flowchart

V. SIMULATION AND RESULT

5.1 Simulation Setting

A simulation environment is designed and implemented in MATLAB 7.10.0 in order to investigate the energy efficiency and lifetime extension of the mentioned protocol. We compare the proposed Modified Leach algorithm with Leach routing protocol. The simulation parameters used in the experiment is shown in Table 5.1. The nodes are randomly distributed between x=0, y=0 and x=100, y=100 with the base station (BS) at location x=50, y=50. BS and all sensor nodes are stationary after deployment. We consider packet size of 2000 bits. The simulation parameters are summarized in Table 1.

Table 1: Characteristics of the test network.

Parameter	Value
Network Size	100m * 100m
Number of nodes	100
Packet Size	2000 bits
Initial Energy	0.5 j
Number of rounds	5000
Transmitter Electronics (ETX)	50nJ/bit
Receiver Electronics (ERX)	50nJ/bit
Data Aggregation Energy	5nJ/bit

Simulation Results

This protocol has the advantage of being distributed, self-configuring and not requiring location information for cluster formation. In addition the steady-state protocol is low-energy. However, the drawback is that there is no guarantee as to the number or placement of cluster-head nodes within the network and number of cluster members within a cluster.

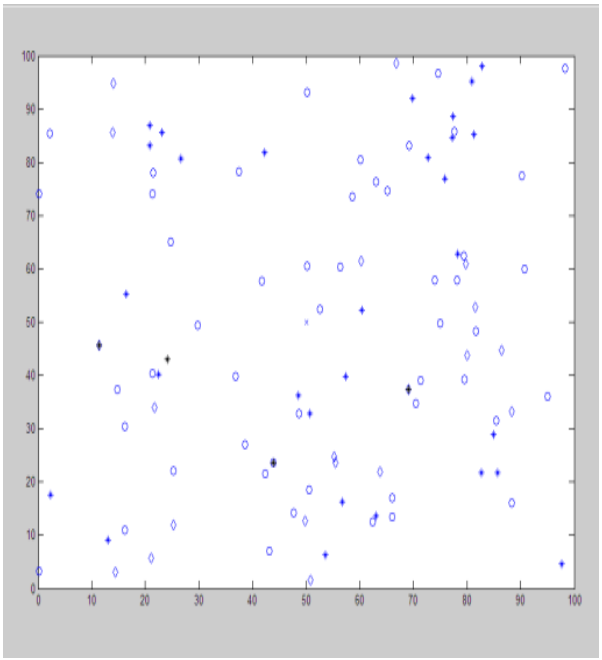

Figure 4: Distribution of Sensor Nodes in LEACH

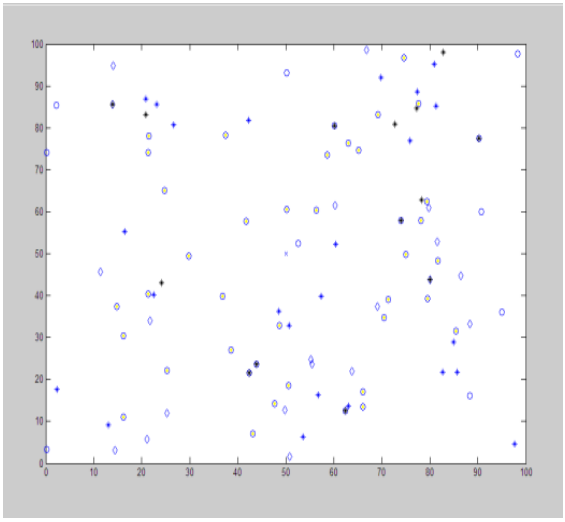

Figure 5: Distribution of Sensor Nodes in Proposed Protocol

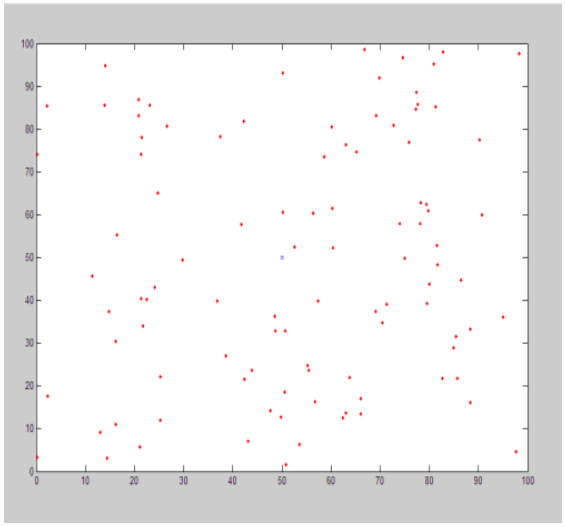

Figure 6: All Sensor Nodes are Dead

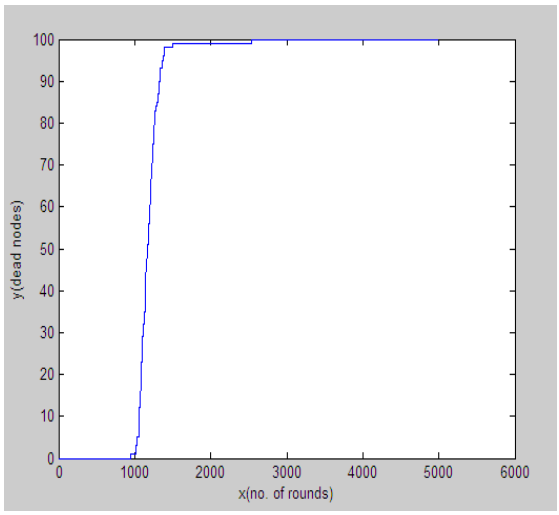

Figure 7: Dead Nodes in LEACH

Figure 6 shows that all sensor nodes have completely drain out their energy and are died. This is shown using red color.

Figure 7 shows the total number of nodes died over the simulation round. If the total number of nodes that are dead after each round is plotted in the proposed protocol then the graph of figure 8 is obtained.

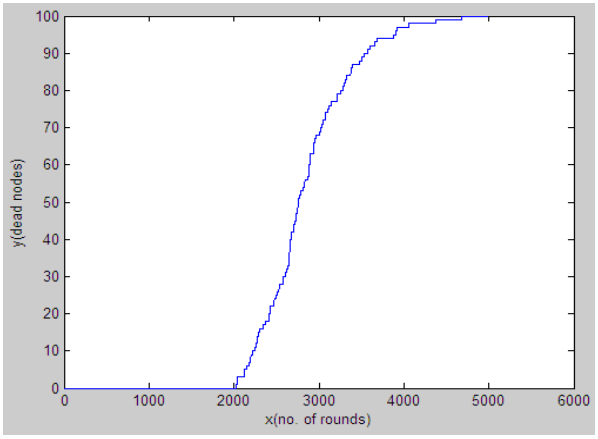

Figure 8: Dead Nodes in Proposed Protocol

Table 2: Comparison of LEACH and Proposed Protocol

Protocol	Rounds when nodes start dying	Rounds when all nodes are dead
LEACH	950	2550
Improved LEACH	2020	4680

VI. CONCLUSION

Use of the wireless channel is growing at an amazing speed. Advances in energy-efficient design have created new portable devices that enable exciting applications for the wireless channel. While the wireless channel makes deployment task easier, it adds constraints that are not found in a wired environment. Specifically, the wireless channel is bandwidth-limited, and the portable devices that use the wireless channel are typically battery-operated and hence energy-constrained. In addition, the wireless channel is error-prone and time-varying. Therefore, it is important to design protocol and algorithms for wireless networks to be bandwidth and energy-efficient as well as robust to channel errors. The work described in this dissertation shows an energy-efficient routing technique which is mainly suitable for application like environment monitoring where sensor nodes located in nearby region collect similar type of data.

6.1 Future Work:

There is still much work to be done in the area of protocols for wireless micro sensor networks. The protocols described in this dissertation are for scenarios where the sensors have correlated data. However, there are important applications of wireless sensor networks where this is not the case. For example, sensor networks for medical monitoring applications may have different sensors located on and/or in the body to monitor vital signs. These networks will not be as large-scale as the ones discussed, but they will have similar requirements to the sensor networks discussed – long system lifetime, low-latency data transfers and high quality data. These networks will most likely focus on maximizing quality above all parameters and loss of information will not be acceptable. Therefore protocol architectures need to be developed to support the unique considerations of these networks.

Finally it will be important to develop secure communication for wireless sensor networks. End-users need to be able to ensure unauthorized users cannot access the data from the sensor networks. Furthermore end-users need to be able to authenticate the data. Application-specific and scalable solutions may be able to provide the level of security required without draining the node's limited energy. Without these security measures in place, the application of sensor networks will be limited.

REFRENCES:

[1] J. Kulik, W. R. Heinzelman, and H. Balakrishnan, "Negotiation-based protocols for disseminating information in wireless sensor networks," Wireless Networks, Volume: 8, pp. 169-185, 2002.

[2] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks," Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00), January 2000.

[3] Sundeep Karthikeyan Vaidynathan, Sayantan Sur and Sinha. Data aggregation techniques in sensor networks. Technical Report,OSU-CISRC-11/04-TR60, 2004.

[4] D. Agrawal N. Shrivastava, C. Buragohain and S. Suri. Medians and beyond: new aggregation techniques for sensor networks. Proceedings of the 2nd international conference on Embedded networked sensor systems, pages 239-249, 2004. ACM Press.75 Bibliography

[5] S. Setia S. Zhu and S. Jajodia. Leap: efficient security mechanisms for large scale distributed sensor networks. Proceedings of the 10th ACM conference on Computer and communications security, pages 62-72, 2003. ACM Press.

[6] Y. Xu, J. Heidemann, D. Estrin, "Geography-informed Energy Conservation for Ad-hoc Routing," In Proceedings of the Seventh Annual ACM/IEEE International Conference on Mobile Computing and Networking 2001, pp. 70-84.

[7] Y. Yu, D. Estrin, and R. Govindan, "Geographical and Energy-Aware Routing: A Recursive Data Dissemination Protocol for Wireless Sensor Networks", UCLA Computer Science Department Technical Report, UCLA-CSD TR-01-0023, May 2001.

[8] Jonathan Jen-Rong Chen Prasan Kumar Sahoo and Ping-Tai Sun. Efficient security mechanisms for the distributed wireless sensor networks. Proceedings of the IEEE Third International Conference on Information Technology and Applications (ICITA'05).

[9] K. Sohrabi, J. Pottie, "Protocols for self-organization of a wireless sensor network", IEEE Personal Communications, Volume 7, Issue 5, pp 16-27, 2000.

[10] Ismail H. Kasimoglui Ian .F. Akyildiz. Wireless sensor and actor :research challenges. (Elsevier) Journal, 2 (38):351- 367, 2004.

[11] S. Tilak et al., "A Taxonomy of Wireless Microsensor Network Models," in ACM Mobile Computing and Communications Review (MC2R), June 2002.

[12] B. Krishnamachari, D. Estrin, S. Wicker, "Modeling Data Centric Routing in Wireless Sensor Networks," in the Proceedings of IEEE INFOCOM, New York, NY, June 2002.

[13] W. Heinzelman, "Application specific protocol architectures for wireless networks", PhD Thesis, MIT, 2000.

[14] C. Schurgers and M.B. Srivastava, "Energy efficient routing in wireless sensor networks," in the MILCOM Proceedings on Communications for

Network-Centric Operations: Creating the

[15] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless sensor networks," in the Proceeding of the Hawaii International Conference System Sciences, Hawaii, January 2000.

[16] Vijay Garg B M.S. Meitei C S. Raman C A. Kumar C N. Tewari R.K. Ghosh A, *. Ad hoc networks. pages 168-185, 2006.

[17] Mohamed Elshrkawey, Samiha M. Elsherif, M. Elsayed Wahed, "An Enhancement Approach for Reducing the Energy Consumption in Wireless Sensor Networks", 2017, Journal of King Saud University – Computer and Information Sciences

* * * * *