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Analysis and Enhancement of Modified LEACH Algorithm for Wireless Sensor Network

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Abstract— Wireless sensor networks have seen thriving development and its increased usage has made it a keen topic for researchers to explore more. Huge investments and research efforts are going on in this field. It has been used for the purpose of sensing and communicating data without any supervision of human being. There are various areas where research activities are going on in Wireless sensor networks. These are deployment , localization , Synchronization , Calibration , DataAggregation and Data Dissemination , Security , Middleware, Database Centric and Querying,etc. One of popular area of interest is optimizing strategies of routing protocols with respect to energy utilizationof sensor nodes. Custering mechanism is one of the popular WSNs routing mechnisms. In this paper we have proposed a new enhanced MODLEACH protocol after analysing the previous MODLEACH algorithm. The result shows that the network lifetime and rate of transfering packets to BS have improved.

Keywords— ClusterHead,BaseStation,Wireless sensor networks, low energy adaptive cluster hierarchy, Carrier Sense Multiple Access.

I. INTRODUCTION

WSN is defined as a special class of Ad-Hoc network that provides us communication and sensing facility.It allows us to observe and respond to phenomenon in Cyber Infrastructure. Here the number of nodes used for sensing are very large in number which are different for different purpose and applications like Intrusion detection,health care monitoring , Earth or Environmental sensing,Industrial monitoring , Entertainment industry,etc. These sensor nodes are used to measure pressure, humidity , sound , vibrations ,etc. These sensor nodes are basically made of sensors and motes. Motes consist of processors,memory , battery , A/D converter for connecting to sensors.Most popular Mote is Berkeley Motes which are made available by Crossbow Technologies.

The memeory management and the resource management in WSN is done by operating Systems specially designed for WSNs. Some of them are Tiny OS,Mantis OS,nano-Qplus,etc. Amongst them tiny OS is an open source and most popular Operating System implemented in NesC language. Now routing is the major issue in WSNs and this is under network layer issues for sending the data from sensor nodes to BS. Various routing protocols for WSNs are Sensor protocols for Information via Negotiation (SPIN) , Rumor Routing , Direct Diffusion , Low Energy Adaptive Cluster Hierarchy (LEACH), Threshold Sensitive Energy Efficient Sensor network protocol (TEEN),Geographical and energy aware Routing(GEAR), Sequential Assignment Routing(SAR), etc.

Amongst them LEACH protocol is widely used in WSN, because this protocol dissipates the energy in low level. When the battery power is drained in these devices/nodes then the network cannot be used and all the nodes spend most of the energy while transmitting the data. Therefore,to increase the lifespan of the network, each node has to do only minimal work for transmitting the data. Here all the nodes are grouped into the clusters, and in each cluster one of the nodes is assigned as a Cluster Head (CH). CH collects the data from the surrounding nodes and passes it to the base station. Usually, initial assignment of CH is random and the role of CH is rotated for every fixed duration so that each node will act as a CH at least once in its life span. LEACH algorithm has two phases. They are set up phase and steady state phase. Setup phase is used to choose a CH and steady statephase is used to maintain the CH during the transmission of data.

This work focusses on analyzing the optimization strategies of routing protocols with respect to energy utilization of sensor nodes in Wireless Sensor Network (WSNs). In this paper, we have considered MODLEACH protocol as reference and varied the values of the p to further enhance the performance of the MODLEACH protocol.

II. RELATED WORK

Heinzelman, et.al [1] introduced a clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH forms clusters by using a distributed algorithm, where nodes make autonomous decisions without any centralized control. LEACH arranges the nodes in the network into clusters and chooses one of them as CH. The operation of LEACH is divided into rounds. Each round begins with a setup phase when the clusters are organized, followed by a steady-state phase when data is transferred from nodes to the CH and then to the BS.

Junayed Islam et.al [2] presented a AsLEACH (An Advanced Solar Aware Leach Protocol for Energy Efficient Routing in WSNs), a clustering based protocol which introduced the idea of sensor radio model for randomization of local CHs. It enhanced data aggregation by FIFO priority scheme and collision minimized non-persistent Carrier Sense Multiple Access (CSMA).

The authors proposed a clustering routing protocol by the name of Enhanced LEACH [3], which extended LEACH protocol by balancing energy consumption in the network. Their simulation results show that Enhanced LEACH outperforms LEACH in terms of network lifetime and power consumption minimization.

Meena Malik , Dr. Yudhvir Singh[4] This paper states that Wireless Sensor Network is a network of sensor nodes without having any central controller. Its growth is expeditiously increasing and that's why there is an immense field for research in this area. Sensors depend entirely on the trust of their battery for power, which cannot be revitalized or substituted. So the design of energy aware protocol is essential in respect to enhance the network lifetime. LEACH is energy efficient hierarchical based protocol that balances the energy expense, saves the node energy and hence prolongs the lifetime of the network. So this paper presents a detailed review and analysis of LEACH protocol. Comparison of various network parameters is done in the form of tables and graphs. The simulation work has been carried out by using own set of parameters and in the last of the paper conclusions is drawn.

Wang and Yong [5] proposed cluster head selection by the pseudo cluster concept. Load monitor and Load leisure mechanism is used to balance the load and stability of the topology of the network. Simulation result shows that LEACH-P Protocol effectively increase energy utilization efficiency, lengthens network lifetime and balances network load.

Mao Ye et al. [6] proposed EECS: An Energy Efficient Clustering Scheme for periodical data collecting applications in WSNs. During the election phase for CHS, a fixed number of candidate nodes are elected and competitor nodes are checked based on their residual energy. The competition is conducted locally and with no iteration, thus decreasing the message overhead and also helps in the even distribution of the cluster heads. To distribute the energy consumption among the sensors in the cluster formation phase a novel approach is used. EECS is fully distributed and highly energy efficient than LEACH. The simulation results proved that EECS prolonged the network lifetime as much as 135% of LEACH.

In [7], authors have introduced an Ad-LEACH static clustering based heterogeneous routing protocol with a cluster head selection technique adopted from DEEC . It enhances both LEACH and DEEC protocols both in terms of energy efficiency and throughput.

D.Mehmood et.al [8] has given a MODLEACH protocol by introducing efficient cluster head replacement scheme and dual transmitting power levels.

Shou et al. [9] proposed a simulated annealing (SA) algorithm to discover the optimal solution with better position to minimize the energy loss of cluster heads. Initially, a group of CHs are selected by LEACH-C algorithm. For reducing the number of retransmission and considering the acknowledgment, a CH energy consumption model is created. This model use the quadratic sum of the distances from the CH to its member nodes and the largest energy consumption for a single CH for the next round is estimated, and all nodes that has residual energy greater than the computed energy consumption will be used for a new round of SA to give a better solution. Therefore, loss of the energy in CH can be minimized, to increase the lifetime of WSN. In WSN most of the communication links only exist temporally and establishing end to end connection is not possible for data delivery. Therefore routing is done based on the probability of nodal contact

Ramesh and Somasundaram[10] proposed a energy efficient clustering protocol OFZ-LEACH to solve the issue by forming Far-Zone. Far-Zone is a set p of sensor nodes which are moving at the locations where the energies of those nodes are smaller than a threshold. Exponentially Weighted Moving Average (EWMA) scheme is applied for finding and updating nodal contact and based on EWMA; some functions are used for forming clusters and selection of gateway.

Taneja and Bhalla [11] proposed an enhanced version of LEACH: Three Levels Hierarchical Clustering LEACH Protocol (TLHCLP) for Homogeneous WSNs.Base station is considered as the location centre and a pre defined radius is used. Nodes are categorized as nodes inside the radius and remaining nodes in the outside radius. Cluster Heads that are situated in the outside the radius discover the nearest Cluster Head which is inside the radius and forward the data to the CH inside the radius. Then these inside Cluster Heads aggregate the data and send it to the Base Station. The proposed TLHCLP technique is compared with the original LEACH protocol. Simulations were conducted to evaluate the performance of these two protocols and good results are obtained. Simulation results proved that TLHCLP improves network lifetime by an order of magnitude compared with LEACH.

[12] introduce a routing mechanism which carries the network operation in such a way that the network lifetime is enhaced due to their energy hole removal mechanism.

III. PROBLEM DEFINITION

Major limitation of WSN was of Energy consumption and uncontrolled environment.The main responsibility of routing protocol was minimum usage of energy,however environment cannot be controlled fully.Now with emergence of clustered based routing protocol this problem was completely solved where whole network was divided into fixed /variable sized clusters containing sensor nodes in it. Here nodes organized into clusters communicate with local base station, which further transmit it to the global base station and further it is accessed by end user. But with this scheme BS became an energy constraint because as soon as the cluster head node dies all nodes from that cluster effectively die then there is no way to get data from Base station.Hence Adaptive clustering concept was intoduced were CH change as nodes move in order to keep network fully connected. Hence clustering technique prove itself an efficient technique.

In this LEACH became parental protocol received many enhancement.LEACH gave rise to adaptive Clustering mechanism which very efficiently dealed with energy conservation.However there is no way to use residual energy of a node.To overcome this a technique called " Efficient clusterhead replacement" was proposed.

Secondly LEACH used same amplification energy for both kind of transmissions.To address this multi amplified power levels were introduced.So there came MODLEACH algorithm where for every round protocol use to check if energy of the node has fallen to some predefined threshold value,if so then new cluster head with more energy than threshold was elected,elese same CH was used.

Hence energy was saved as cluster head formation was reduced.Secondly it used multipower levels of energy for inter,intra and clusterhead to BS communication to preserve energy,where soft and hard threshold concept further enhanced the efficiency.But here the value of variable i.e p (probability of choosing a CH) was kept constant. By changing this value of p(probability of choosing a CH) showd a drastic change and improved network utilization and performance of network.This experiment was done on MATLAB to check and compare the result.

IV. PROPOSED ENHANCED AND IMPROVED MODLEACH PROTOCOL

This concept is primarily based on LEACH algorithm with was modified futher by MODLEACH algorithm.We have worked on this concept of an efficient MODLEACH algorithm .Here the role of the CH is rotated and randomized to distribute the energy requirements among the nodes of the network.To reduce the total amount of data transmission, local compression techniques are used in the CH . LEACH is suitable for homogeneous network. In this research, very important parameters *p* (probability of choosing a CH) was considered and their impact on net performance of the network are studied and analyzed; both analytically and with simulation.

MODLEACH utilized these parameters by selecting their values fixed at p=0.1. We made certain variations in all these parameters and studied their behavior on the performance of the network and other parameters. Lifetime rising and stability decresses as value of p increases from 0.1 to 0.9 where value of h is kept fixed.

First of all varying the value of *p* from 0.1 to 0.4 and then it was kept 0.9, different experiments were performed in MATLAB and the following readings were noted:

Table I Variation of *p* and its effect on Stability and Network Life-time

S.No	P	Maximum rounds traversed	Packet send to CH	Packet send to BS	First dead node at round
1.	0.1	1095	7386	57253	160
2.	0.4	1537	21374	21117	36
3.	0.9	2121	38836	4269	21

V. RESULTS AND DISCUSSION

We have performed the simulation with certain parameters like **Round Number,Energy**. Experiment is performed in MATLAB and the results that we achieve surprised us.We performed the simulation with 100 nodes.We generate the graphs with different values of p (0.1,0.5,0.9) and finded out the comparision in results.The maximum number of rounds for these values of p are 1095, 1537 and 2121.

5.1 GRAPH

Alive node: Fig 5.1 indicates plots for the alive nodes present in the network reflecting the stability of the network versus the maximum rounds traversed in consideration with the different sink positions. The network lifetime of the sensor network is the lifetime of the network from the starting of the network to the end of the network. It means the time from where the network starts its operation till the phase network has completed its operation. The operation is measured in terms of the rounds. Thus the network lifetime is measured in two ways alive nodes and dead nodes. We find a trade-off between the stability of the network and the maximum rounds after which the network collapses.The variations are comparatively lesser and the sink location in the middle of the network gives more promising results. In Fig 5.1 it is clear that the number of alive nodes are higher between 0 and 500 rounds. Further as the rounds are increasing ranging from 1000 to 1500, the number of alive nodes are decreasing.

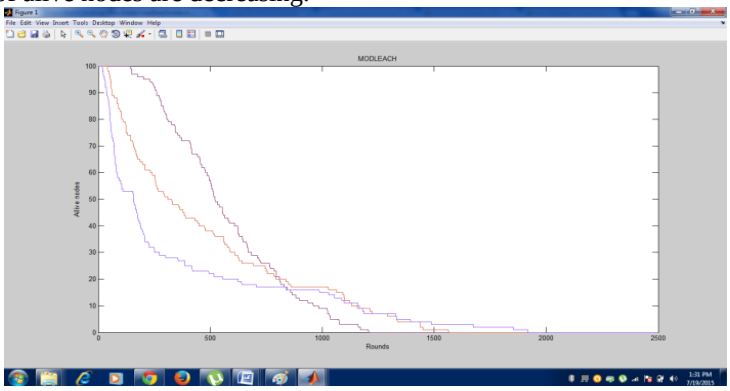

Figure 5.1: No. of Alive Nodes

Dead node: Network lifetime is defined as the time difference when network is set up and time when first node died.We have calculated the network lifetime through certain parameters like Round No on whish first node died. As the nodes are increased ,network lifetime is increased. It is clear that number of dead nodes are low in initial rounds ranging between 0 and 500. Between 1000 and 1500 rounds the range of dead nodes is higher .For value of p 0.1 we find first dead node at 160th round and for 0.5 the dead node comes at 36th round and for the value 0.9 dead node comes in 21th round.

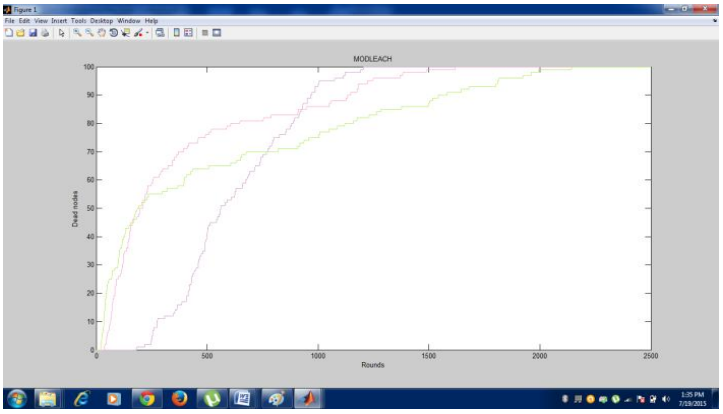

Figure 5.2: Probability of occurence of dead node

Packets to BS: The amount of data received by the base station describes the rate of the accuracy of the nodes, throughput. The more data received means high accuracy. The throughput of the sensor network is measured by the total number of packets sent to base station, packets sent to cluster head during the network lifetime and cluster head formation.The plots in fig:5.3 are plotted for different values of *p* taking into consideration the packets sent to base station versus the rounds for which the network is working. The plots clearly reveal that with the growing value of *p* from 0.1 till 0.8, the number of packets sent to base station are steadily growing and similar are the cases for the number of packets sent to cluster head from different nodes in a cluster with the rise in the values of *p*. But again there are trade-offs between different parameters involved with the variations in the value of *p*. Hence such value be chosen which can balance other parameters as well. The analysis of the number of packets sent to Base station and Cluster head is shown over rounds in order to measure accuracy. In fig it is clear that the packets sent to base station increases as the number of rounds increases. More packets are sent to base station between 1500 and 2500 rounds. For the value of p 0.1 numbers of packets send are 7386 ,for p =0.5 the packets are 21374 and for p = 0.9 packets are 38836.

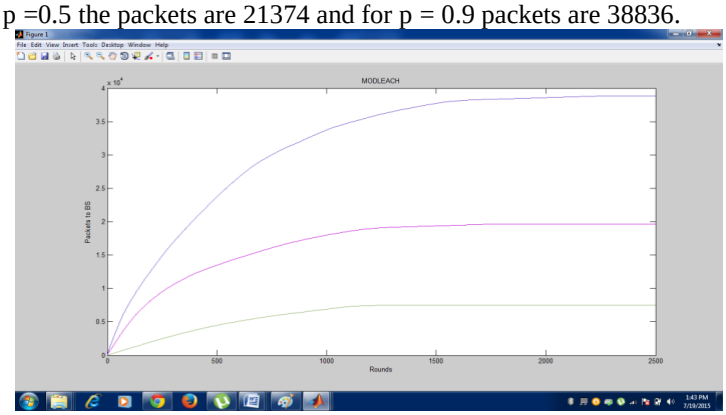

Figure 5.3: Packets send to the Base Station

Number of cluster head: LEACH is a clustering scheme in which nodes arrange themselves as a local clusters and each cluster elects CH. Each node in a cluster sends data to CH. CH process data collected by cluster member nodes and send it to the BS.. CH advertises itself as a CH to sensor nodes within radio range. Sensor nodes within range receive this advertisement and if they are not CH they join cluster. Now those nodes which are not placed in radio range and don't receive any advertisement from any CH they become forced CHs. Energy utilization in network to gather information from sensor nodes and send it to BS depends on number of CHs and the radio range r of algorithm. During one round each non-CH node sends data to CH once. Research shows that the number of cluster nodes has a strong effect on both the life cycle and energy consumption of the network. The original LEACH cluster head selection algorithm depends on the random number which is generated by the sensor node, and instability of random number leads to the instability of the number of the sensor nodes. The graph represents the count of cluster heads with the variation in the value of *p* (probability of choosing a CH). The plots clearly indicate that for the value of *p*=0.1, the CHs generated are too less whereas it is too high (approx reaching 90 in the first 200 rounds); a number too big which can contribute a lot to the consumption of energy; hence a nominal value for the selection of p for a reasonable generation of CHs is *p*=0.4. In fig 5.4 the cluster head formation is shown over rounds. The variation of the cluster head formation is shown between 0 and 1000 rounds.

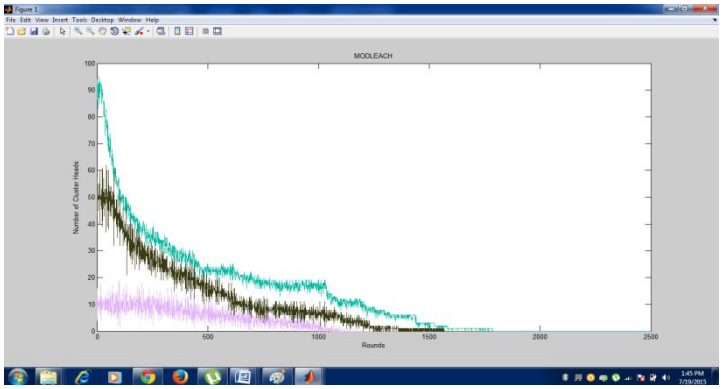

Figure 5.4: Number of cluster Head

Packets to CH : The plots in fig 5.2 are plotted for the packets transferred to cluster heads in various rounds of the network taking into consideration the various positions of the sink i.e. on the origin, on x-axis, on y-axis, in the middle of the network etc. Worst results are obtained when the sink is placed on the origin (1.5x104 packets sent) and best results are obtained when placed in the middle of the network (5.5x104). Rest plots lies in between these extreme ends. In fig the number of packets sent to the cluster head are shown. The number of packets sent to cluster head also increases as the number of rounds increases. The high number of data packets are sent between 1000 and 2500 rounds. The more the data packets sent to the cluster head the more accuracy of the network lifetime is achieved. This transmission shows the accuracy of the network life time. For the value of p 0.1 numbers of packets send are 57253 ,for p 0.5 the packets are 21117 and for p 0.9 packets are 4269.

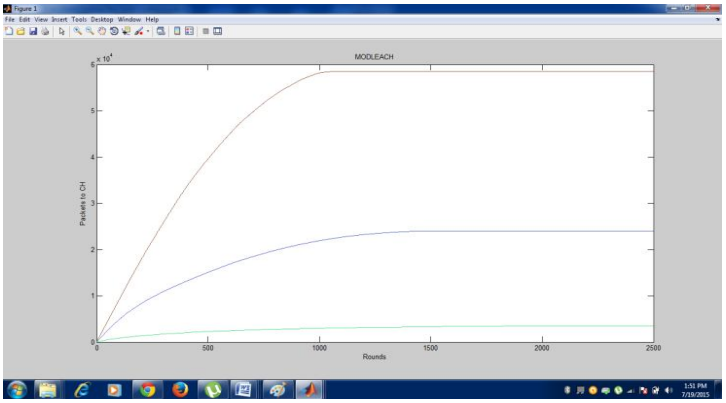

Figure 5.5: Packets sent to CH with sink location

VI. SIMULATION RESULT

Simulations are conducted in MATLAB,where different values of probability caused network efficient transmission by increasing energy of MODLEACH.After this we considered various output graphs and observed that probability of choosing a CH is directly propotional to maximum rounds of a network and packets send to BS.Also probability of choosing CH is inversely proportional to first dead node of the network and packets send to cluster head.

Table III Network Parameters with Specified Values

S.No	Network Parameters	Values
1.	**Network Size**	400 x 400 m2
2.	Number of nodes	100
3.	Sensor nodes initial energy	0.5 J
4.	Amplification energy (intra cluster communication), d≥ d1	Ef s /10 = Efs1
5.	Amplification energy (intra cluster communication), d≤ d1	Emp /10 = Emp1
6.	Energy consumption in idle state	50 nJ/bit
7.	Data aggregation energy consumption	5 nJ/bit/report
8.	Packet Size	4000 bits
9.	Amplification energy (cluster to BS), d≤ d0,	Emp 0.0013 pJ/bit/m2
10.	Amplification energy (cluster to BS), d≥ d0,	Efs 10 pJ/bit/m2
11.	Speed of sensors	0 to 1 m/sec
12.	Initial energy of cluster head	1 J

13.	Power consumption of sensor node in a round	0.01 J
14.	Diameters Of Sensor Network	400
15.	Distance Of Base Station From The Network	200
16.	Hard threshold	100
17.	Soft threshold	2

VII. CONCLUSION AND FUTURE WORK

In this work, we gave a brief discussion on emergence of MODLEACH from LEACH algorithm and used the concept efficient cluster head replacement scheme and dual transmitting power level. Whenever cluster head is selected in first round then the same node can be used as a cluster head in other round if the energy of the node is greater then the threshold,with the purpose that energy of the cluster head should not be wasted. If the energy of the cluster head is less than the threshold then the other node is chosen as a cluster head for next round. In this method the threshold is given priority for the choosing of the cluster head. After analysing MODLEACH algorithm properly we proposed enhanced modleach algorithm by considering the value of p (probability) as a variable with different values and improved the network life time .

In future we would like to further improve its efficiency of this algorithm and can have further modifications on MAC layers improving its efficiency. Also we can work further on hard and soft threshold parameters to enhance network lifetime further more.

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