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Enhancing network lifetime with an improved MOD-LEACH

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ABSTRACT

Wireless sensor network will be the most dominating field in future era. There are certain issues which wireless sensor network suffers from. The main concern with wireless sensor network is limited energy which directly impact on network lifetime. In this paper we modify the cluster selection procedure of MODLEACH. MODLEACH protocol use threshold value for selecting cluster head. Once a cluster head is selected, it retains its position until it bypasses the threshold limit. In Basic LEACH, it does not use any threshold value but it randomly selects cluster head from the available nodes. We combine the probabilistic nature of LEACH to select the cluster head and threshold base selection of cluster head of MODLEACH. We also apply proposed modification in EAMMH protocol. Our main focus is on the enhancement of network lifetime, and we got significant improvement in network lifetime.

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1. INTRODUCTION

In wireless sensor networks, the root of maximum dissipation of energy is the routing of information [1]. There are certain ways are developed to provide for routing of information with its pros and cons. In general, the routing protocol for the wireless sensor networks classified in four major categories: 1) Data centric Routing algorithm 2) Hierarchical Routing algorithm 3) Geo graphical routing information and 4) QoS based routing algorithm [2, 3]. In the data centric algorithm, routing decision based either data generation from the sensor node or the data demanded by the sink node. In this type of routing protocol, the data generated by the node is more important than the node itself. The main focus is on retrieval and dissemination of information generated by the node. Normally the centric approach comes with flat architecture, where each node of network plays equally important role for routing of information. Gossiping [4-7], SPIN [5], COUCAR [6], CADR [7] etc. are the few examples of Data centric algorithm. Figure 1 illustrate very basic concept of data centric algorithm. Here centre node generates the information and send advertisement packet to the network about newly generated information. The interested node will send the request packet for the information. The centre node will send the information to interested node only. The other way communication is also possible where sink node is looking for some information. So, it will send interest propagation to the entire network. The node which has the required information will send the data to the sink node. Overall in this approach either source node or sink node initiated the data dissemination process.

In Geographical routing approach, node uses the location information of the other node for routing of information. The node will send the data to nearly located node in the direction of destination. For the location information each node is equipped with a GPS or any other local location information algorithm for positioning information of node. It is further divide in two sub categories: Unicast routing protocol and

multicast routing protocol. In unicast routing protocol packet send to particular one node, whereas in multicast routing protocol will send the data to multiple location. GPRS [8], GFA [9], GEAR [10] etc. are the examples of Geographical Routing algorithm. Figure 2 illustrate the basic operation for Geographical information where node uses location information of other node of the network to forward or transmit the data. This figure particularly indicates the GFA algorithm where the entire area of the network divides in virtual grid to simplified location information.

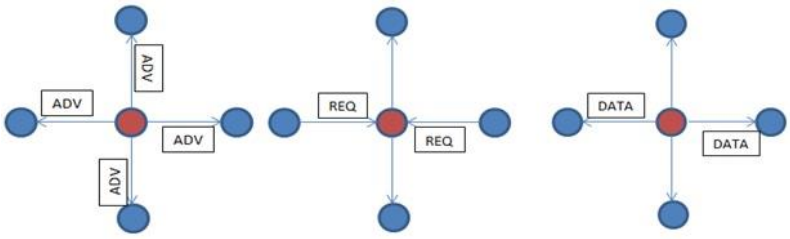

Figure 1. Basic operation of data centric algorithm

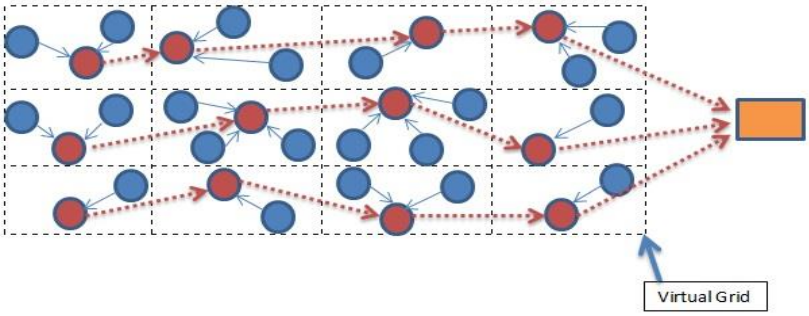

Figure 2. Basic operation of geographical routing operation

The QoS protocol focused on the quality of link rather than the distance or energy consumption. Normally in WSN the Energy consumption is the main concern but, in several application, where the quality of data and prompt delivery of data is more important like military application or medical application. In such a situation QoS protocol is preferred. SAR [11], SPEED [12], MCPF [13] etc. are the example of QoS protocol. In QoS protocol multiple path are created from source to destination so that in if one path fails due to some unpredictable reason the data promptly move to the other path. During the path formation it avoids node with low energy low Quality of metrics. The Quality of metrics may vary with the application. It assured timely delivery of data at cost of energy and resources. In hierarchical routing protocol, cluster head is the key element during the communication process. It is the central node which, connect the cluster node to the other part of the network. Selection of cluster head is the crucial process, which extensively affect the network life time. There are number of algorithms proposed for the clustering-based communication like LEACH [14], PEGASIS [15], TEEN [16], and APTEEN [17] etc. Grid based clustering with mobile sing having predefined path [18] also enhance the network life time. Number of optimization technique like Artificial Bee colony algorithm used for energy efficiency in WSN [19] or fuzzy approach is applied for the cluster head selection. [20]. In this paper we compare and analysed the network lifetime with LEACH [14] and EAMMH [21] and MODLEACH [22] protocol with proposed modification in them.

Low Energy Adaptive Clustering Hierarchy (LEACH) is the prime protocol which gives the idea of the cluster-based communication. LEACH [14] is so popular that after 18 years of its existence it is still holding the dominance in research communities. LEACH [14] has numerous successors with improved version starting from LEACH to Dual Hop LEACH [23]. LEACH [14] operation splits in to two stages. The first stage is known as set up phase, where the cluster is formed and cluster head is selected. Figure 3 illustrate the operation of leach protocol. The second stage is known as steady state stage, which incorporate

the actual data transmission. In a set up phase, entire network consist of randomly deployed sensor node is bifurcate in meagre cell known as cluster. One node from the cluster is selected as cluster head which will work as bridge node between sensor node and the base station. The selection of cluster head is depending on random manner as:

$$T(n) = P/[1 - P * \left(r \; mod \left(\frac{1}{P}\right)\right] \; n \in G \\ = 0 \; otherwise \quad (1)$$

Where: n = random number between 0 to 1
P = Probability of cluster head
G= Set of nodes which where not the cluster node in previous round

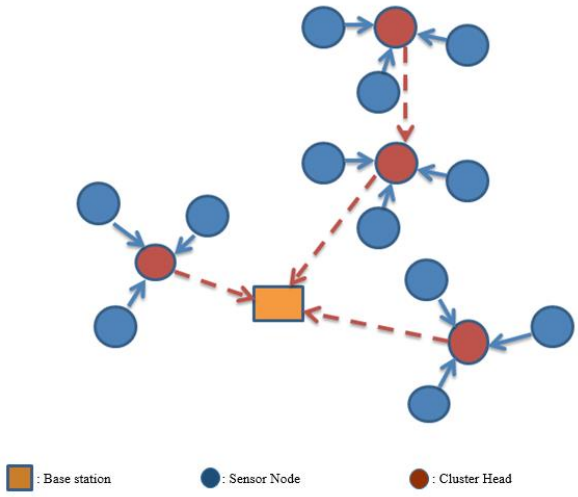

Figure 3. Leach architecture and operation

Each node from the cluster gets the chance to become the cluster head. Once a cluster head is selected, it broadcast the advertisement message regarding its headship. If node received more than one advertisement message, it will select cluster head whose advertisement message contain higher signal strength. In LEACH, the cluster head selection is based on probabilistic manner which gives chance to each node of a cluster to become cluster head. During the cluster head selection process, it does not take energy status of the node. It will randomly select the node. Energy Aware multi hop multi path hierarchical protocol (EAMMH) [21] is also a cluster-based communication protocol. As in LEACH [14], its operation divides in two parts: Set up phase and Data transmission phase. Initially, the deployed nodes find its neighbour using any neighbour discovery algorithm. After the neighbour discovery, clusters are being created and cluster head is selected from the cluster nodes. This process is identical to the LEACH [14] protocol. In data transmission it is assumed that all the nodes had a data to send, so particular time slot is allocated to each node of the cluster. In EAMMH a routing table is preserved by each node which is periodically updated. Now when nodes get data to transfer from its neighbour, it will choose the optimal path based on information available in its routing table. It uses the function:

$$h = K\left(\frac{E_{avg}}{h_{min} * t}\right) \quad (2)$$

Where: K = Constant
E_{avg} = Current path average Energy
h = Minimum hope count in current path
t = Traffic in curren path

A path with the highest value of h is selected for data delivery. So, during the routing of information, EAMMH select energy efficient path.

Problem statement, in a cluster-based communication, cluster head play a key role in data transmission. It is the central point, where each and every data of the cluster is routed through. Data transmission consumes more energy than data processing. Cluster head is likely to consume more energy as it need to transmit the data from all the nodes to base station and some information from base station to each node of the cluster. If the selected node has low energy, it will consume its energy to transfer the data comes from the other nodes of cluster and eventually it leads to dead node. The region of that node is cut off from the network. During the cluster selection it is extremely important that we select a node with higher energy as cluster head. As discussed in above section, LEACH [14] and EAMMH [21] have an identical cluster selection procedure. During the cluster head selection, they did not consider energy level of the node which is selected as cluster head. If the node with low energy is selected, it may result in dead node and eventually a blank spot in network. That blank spot in the network will lead to an unacceptable operation on network.

LEACH [14] name itself a legacy, and has a number so successor. MODLEACH [22] is modified leach protocol. It addresses the problem of cluster head selection cheaking the energy level of node. In MODLEACH [22] author uses the threshold value to select the cluster head during set up phase. If the cluster head holds energy above the threshold value, it will continue as cluster head for next round. It means that cluster head will continue as cluster head until its energy bypass the threshold value. It performs more efficiently than the LEACH [14]. But problem with this approach is the node which is the current cluster head will remain as cluster head untill its energy bypasses the threshold value. This will create a prolem of uneven energy reduction in the network. That may result in vital consequence. For example, during cluster head selection process in first round node which is very near to base station is select as cluster head. Now it remains as cluster head until its energy reached below the threshold value. Once its energy reached below threshold value it will not get change to be a cluster head, which mean now the node which is far from the base station will be a cluster head. Now new cluster head need to send the data from far distance which increases the energy consumption. This phenomenon will lead to quick reduction in energy of network results in dead networks.

2. PROPOSED ALGORITHM

As we discussed in above section LEACH [14] and EAMMH [21] suffers from the early energy reduece know as blank spot problem. MODLEACH [22] solve the problem of early energy reduction in node, but sufferes from the uneven energy reduction which leads to dead network. In our algorithm we address these two problems by using positive part of LEACH [14] and MODLEACH [22]. The early energy drop will result in blank spot, which can be avoided by providing the threshold-based selection of cluster head. The uneven energy reduction problem which occurred in MODLEACH [22] can be avoided by giving equal apportunity to all other nodes for becoming a cluster head. That we can provide, using probabilistic selection of the cluster head after each round of communicaton.

In proposed algorithm we took the probabilistic selection procedure from LEACH [14] and Theshold attribute of MODLEACH [22], where each node which contains the more energy than the threshold energy (Eth) gets equal apportunity in clusterhead selection by appling the probabilistic manner. The PSEUDO code of the algorithm depicted as below. S_{liv} contains the alive nodes of network, S_{ch} contains the nodes which are elegibel for the cluster head, and S_{chf} is the final selected cluster head. First line indicates that at initial stage all the nodes are alive and cluster head is yet to select. Line number 2 to 6 shows that it checks the energy level of node and if the node energy is greater than the threshold value that node will be considered as cluster head. Once we find the all then ode which are elegible for the cluster head, select the cluster head which have the highest probability, which is indicated in last few lines of the code.

Proposed Algorithm: Improved MODLEACH

1: Initially $S_{liv} = S$, $S_{ch} = Ø$, $S_{chf} = Ø$
2: **for** each node ***i*** do
3: calculate E_n for all the node
4: **if** $E_n(i) > E_{th}$
5: S_{ch} U S_{liv} (i)
6: **End if**
7: **End for**
8: **for** all the node in S_{ch}
9: do select r from (0 to 1)
10: compute T(n) for all S_{ch}
11: S_{chf} = Node which have the highest probability
12: **end for**

By doing so, we able to provide equal change to every node to be cluster head, keeping energy level of network equally distributed. This uniform energy reduction throughout the cluster, will avoid the early blank spot and increase the network life time.

3. EXPERIMENTAL RESULTS AND ANALYSIS

We compare the Improved version of MOLEACH with MODLEACH [22], EAMMH [21] and with LEACH [14]. We use MATLAB 2015 as platform for the simulation. The specification is shown in Table 1.

Table 1. Simulation parameter

Parameters	Value
Grid Area	$100*100m^2$
Maximum Transmission Range	100 meter
Maximum Initial Energy of the Node	0.5 Joule
Packet Size Maximum	1000 Byets
Data Aggregation Energy	$5*10^{-5}$ J/Bit/Signal
Threshold Energy	$0.5*10^{-5}$ Joule
Energy Consumed by transmitter	$35*10^{-9}$ J/Bit /m^2
Energy Consumed by Receiver	$15*10^{-9}$ J/Bit /Packet
Energy Consumed by Amplifier	$10*10^{-12}$ J/Bit /m^2

Figure 4 depict the simulation network generated in a100*100 m^2 area. We compare the allive node of network after certain round of communication. Figure 5 indicates the comparision between LEACH [14] and proposed algorithm IMP-MODLEACH. If we carefully observed the graph it clearly indicates that in a first few round LEACH and IMP-MODLEACH perform in equal efficient. But after 200 hundress rounds energy of node in LEACH starts decresing rapidly. The reson behind this is LEACH will not check threshold level and chose randomly a cluster head. Due to insufficient energy this clusterhead will lead to dead node. Where as IMP-MODLECH surpass the LEACH in efficient manner. Figure 6 compare the allive node of EAMMH [21] and IMP-MODLEACH. In that IMP-MODLEACH gives the better output. Figure 7 compare the MODLEACH [22] and IMP-MODLEACH. Up to first few hundress rounds MODLEACH and IMP-MODLEACH perform eqully well. As we know that MODLEACH will keep node as cluster head till its energy goes below the threshold level. This leads the maximum energy drain out from a cluster head and eventually the node will not able to become the cluster head on future. If this node is near to base station, the next cluster head is far from the base station which menas it has to transmit to a long distance. This will consume more energy and leads node to dead node. This will create uneven energy reduction in the network. This phenomenon we can observe from the graph. Figure 8 we compared the dead node after a certain number of rounds. It is very cleare that IMP-MODLEACH will incese the network life time in significant manner when we compare it with LEACH [14]. EAMMH [21] and MODLEACH [22].

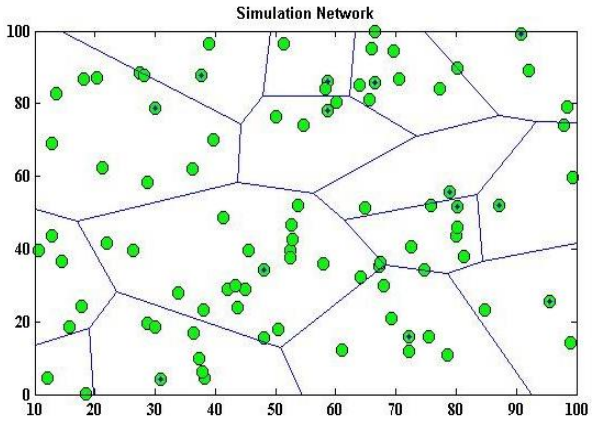

Figure 4. Simulation network

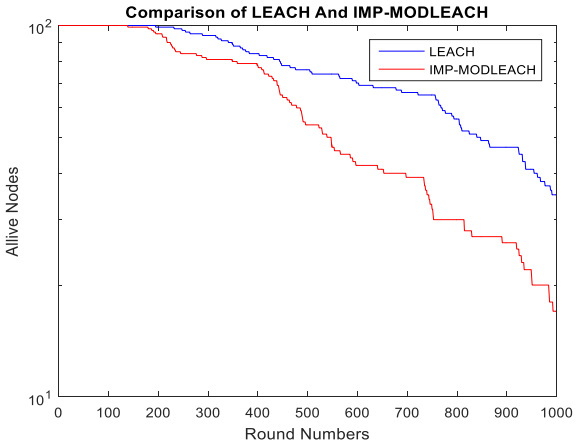

Figure 5. Active node comparision between LEACH and IMP-LEACH

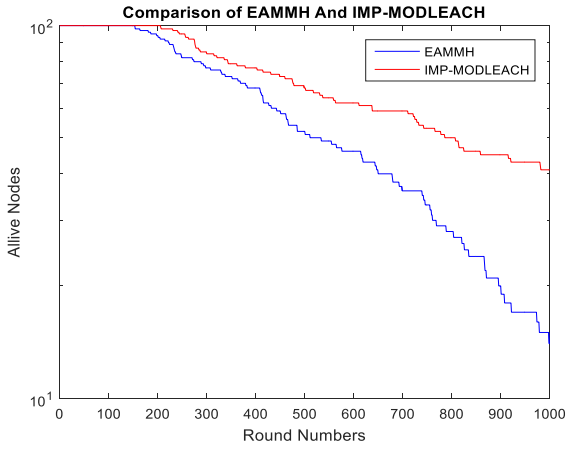

Figure 6. Active node comparison between EAMMH and IMP-MODLEACH

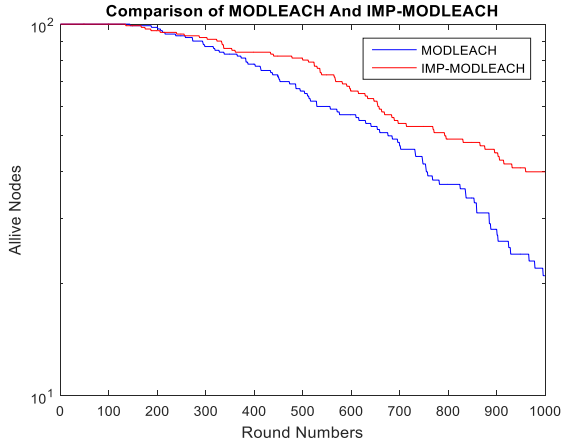

Figure 7. Active node comparision between MODLEACH and IMP-MODLEACH

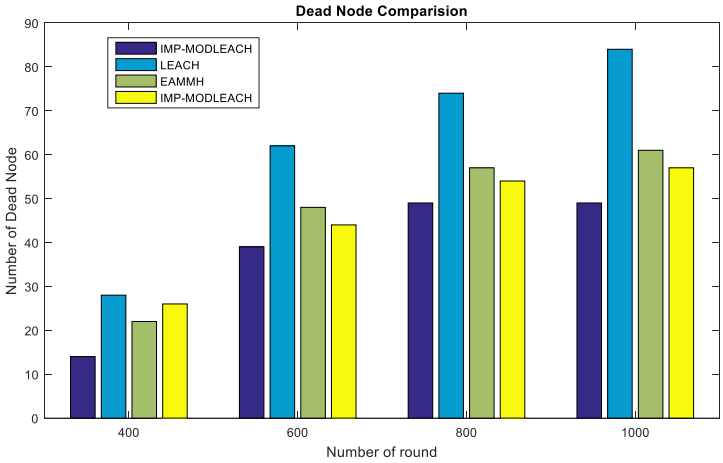

Figure 8. Dead node comparision of LEACH, EAMMH, MODLEACH and IMP-MODLEACH

4. CONCLUSION

Proposed algorithm combines the attributes of LEACH and MODLEACH. We use threshold base selection of cluster head from MODLEACH, which gives chance to node with higher energy to be a cluster head. The probabilistic nature of cluster head selection from LEACH will take care of even energy reduction and avoid the early blind spot in network. Proposed algorithm increased the life time of the network much more than the LEACH and EAMMH algorithm. It also offers significant advantage over MODLEACH in term of life time of the network. We use hard threshold value which is fixed value. In future, adaptive threshold value can for the cluster head selection, which will definitely improve the network life time. One can use optimize algorithm to select best node for the clusterhead which will again improve the network lifetime.

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