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An Energy Optimized Path Selection and cluster head selection for Wireless Mesh Network

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Abstract: In any Wireless Mesh network, an energy efficient routing protocol is the main field of concerns, as we know that nodes of the WMN works, based on the limited battery power, so routing protocol has to be designed in such a manner that it utilize minimum battery power and it routs data efficiently, which maximize the overall life time of the network. Many existing works shows the energy efficient protocol during the selection of cluster head (CH). In this paper we have proposed an energy optimized cluster head (CH) selection in a wireless mesh network dynamically. In proposed model we considered a protocol for the selection of cluster head, which is based on the maximum remaining energy and minimum draining rate of every node. The protocol predicts the most efficient node and based on that result it will select the cluster head dynamically and periodically, which will have sufficient energy and low depletion rate. The protocol will evaluate under static nature of the nodes. Simulation is carried out in Network Simulator-3(NS-3).

Keywords: wireless mesh network, cluster head, remaining energy, draining energy, path selection.

I. INTRODUCTION

Wireless mesh network (WMN) is the communication network which is made up of mobile nodes arranged in a mesh topology. Wireless mesh network is the form of wireless Ad-hoc network, which consist of mesh router, mesh clients, and gateways. Laptops, cell phone and other wireless devices are often known as mesh clients and mesh routers, used for forwarding traffic to and from the gateways. These types of networks are self-configuring and self-healing. There are some technologies for the implementation of these networks like 802.11, 802.15, 802.16 & cellules technology [1]. In these networks, there are no restriction to any technology and protocol. There are many characteristics of WMN such as Bandwidth limitation, link instability, dynamic behaviour, and energy limitation. Among these, energy limitation plays a big role in deciding the efficient energy protocol, because battery is the limited resource of energy and it affects the lifetime of any network. Cluster Mechanism is used in the WMN. In cluster mechanism, all the nodes are divided in different clusters in distributed fashion. Each node in the network belongs to only one cluster at a given time. Each cluster has its cluster head which is chosen by those nodes which are member of that particular cluster. It is the responsibility of the cluster head to manage data transmission within the cluster and in the other cluster.[2]
In figure no.1 there are four clusters c1, c2, c3,& c4. c1 & c2 are connected just with access server; there is no need for gateways or internet, because both belongs to same network. c3 & c4 are also interconnected with access serve. But if c1 wants to communicate with c3 or c4 then, internet or gateways are required. That is, clusters are interconnected with access server in the same network. But clusters in different network are interconnected with each other by internet which has several kind of gateways. Each cluster has its cluster head, which is responsible for the intra communication as well as inter communication.

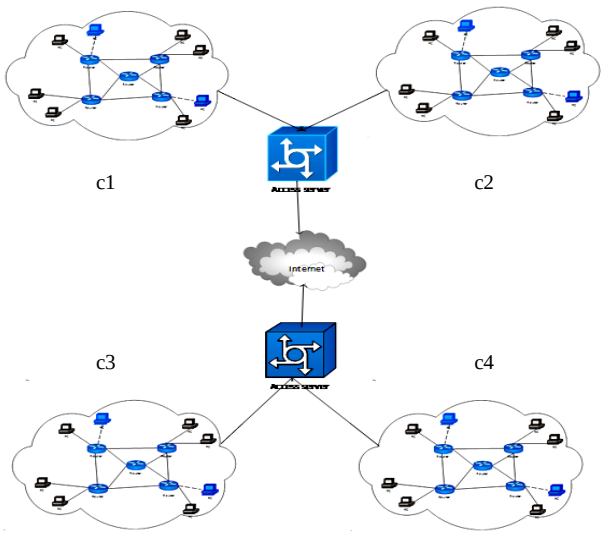

Fig 1: Example of a mesh network model

II. LITRETURE SURVEY

Author Singh proposed the Min-Max Battery Cost Routing (MMBCR) , the main operative metric is to consider the residual battery power capacity of each node. The priority is given to those nodes which have high residual capacity in comparison with low residual capacity. There is a probability of the existence of the weakest node in every possible route, with min residual battery capacity. The MMBCR tries to select a path which contains weakest

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node but has maximum remaining power among the weakest one.[3]

Authors Heizelman proposed low energy adaptive clustering Hierarchy (LEACH) routing protocol for the wireless mesh network. It is a clustering based application protocol, which is used for energy optimization in mesh network. By the use of the LEACH protocol, network life time improved significantly. In clustering based protocol every node is involve in the decision. Centralized control is not required because every node in a particular cluster periodically elects its cluster head and all the decisions are made by that cluster head (CH) , which is elected by those nodes which are the part of the cluster. In LEACH protocol, first, energy is distributed among all the nodes in random fashion and then all non-cluster head nodes elects a new cluster head on the basis of remaining energy. Whichever node has maximum remaining energy will be the next cluster head (CH). [4]

Author T.O.Olwal proposed Scalable Power Selection method used in wireless mesh network. In this method, all the network parameters are used to calculate the dynamic power of every network node. These parameters are scalable on the basis of data rate, packet size, channel Bandwidth and code spectrum. Scalable dynamic power Selection is suitable for Wireless Mesh Network(WNS). [5]

Author Singh M proposed cluster based routing protocol (CRP) for wireless mesh network. The author came up with the concept of mesh portal point and the cluster head of the every cluster in the network. CRP is totally a different kind of protocol used in cluster based network in which they gave some extra power and responsibility to the cluster head and mesh portal point (MPP). Cluster head has all information of the neighbour's node and paths. On the request of any node, cluster head provides the information of asked node. As cluster head involved in every communication, the energy used by the cluster head has more than the other nodes. So, cluster head are given extra battery life to improve the overall life time of the network. Cluster head is fixed and not changed periodically in this protocol. Cluster head was selected by the manufacturer. [6]

Author A.M. Aktar proposed an energy efficient adaptive routing, which is used in Wireless mesh network and Wireless ad-hoc network. In the routing protocol author came up with a power saving routing (PSR) algorithm, which used multipath fading effects. Author has considered three parameters like APAR-M1 (Adaptive power aware routing metrix-1), APAR-M2(Adaptive power aware routing metrix-2) and number of nodes in the network where APAR-M1 is the first metric of its category which compares the network gain to calculate the next hop destination and, but, APAR-M2 compares the ratio of channel gain to remaining distance to calculate the next hop destination. [7]

It has been found that no work has been carried out till date considering draining rate of a node as a parameter in selection of cluster head for improving the network life time. Author Shiva Prakash proposed the maximum remaining energy and minimum draining rate – cluster head (MRMD-CH) selection protocol. With the help of this protocol, cluster head is selected on the basis of maximum remaining energy and minimum draining rate of energy resource. The author suggested cluster head, which has maximum remaining energy and has minimum draining rate, so that the network life time is increased. For path selection author used shortest path algorithm which is the most efficient protocol in static scenario. Whole work is done for static nature of nodes. [2]

In proposed model we are trying to improve PDR, Throughput, Overhead and End-to-End delay by using MRMD protocol for the selection of cluster head (CH) and OLSR & AODV protocol as path selector protocol. We will conduct the experiment with varying the number of packets, packet size and the distance between the source and destination. We will compare both the path selector protocol OLSR and AODV. And will show that which is better in static scenario.

III. PROBLEM STATEMENT

In Wireless Mesh network energy efficiency plays a major role because almost all the network is dependent on the battery, so battery life decides the life cycle of that network. It is not feasible to change or recharge the battery regularly in remote areas, so an energy optimized protocol is required for the improvement of the network life cycle. To increase energy efficiency, scalability, and lifetime of the network, we propose a protocol MRMD for the selection of cluster head. MRMD-CH is based on Maximum remaining energy and minimum draining rate of the battery to select cluster head.

IV. PROPOSED MODEL

Here we propose MRMD model. There are many protocols designed to optimize the energy of the WMN. These protocols can be achieved by so many methods like, by rotating the cluster head according to remaining energy or give extra power to the cluster head. But all these network protocols do not state anything about the draining rate of particular node. If we calculate the draining rate of the battery then we can predict the life cycle of that node. So in proposed model we consider two parameters remaining energy of the node and draining rate of the battery. On the basis of these two parameters, we select the cluster head and then connect it with the AP (Access point) or MPP(Mesh portal point). The selection of cluster head in that cluster is a periodic process, that is after a certain period remaining energy and draining rates are calculated for each node in that cluster and new cluster head is selected on the basis of the result.

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After selecting the new cluster head, all the responsibilities are handed over to the new cluster head. Now, the new cluster head (CH) decides the paths for forwarding the data from source node to destination node. For path selection we used OLSR (Optimized Link State Routing Protocol) & AODV (Ad_hoc On_Demand Distance Vector) protocol. OLSR is a proactive link state protocol, whereas AODV is reactive protocol. IOLSR protocol uses hello packets to discover the shortest path and publish the same link state information throughout the network. In AODV protocol, maintenance of routing table is not required until and unless any node wants to communicate with other node in the network. This protocol works on-demand requirement, if communication is not required then there is no path information at the node.

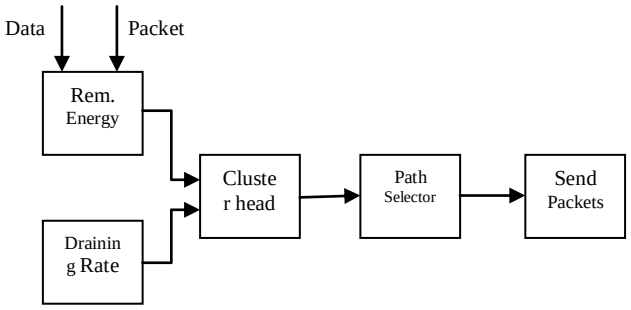

Fig.2 Block diagram for cluster head & path selector

V. PROCESS MODEL

In the process model, we distribute the whole process in two major phase :-

A. Identification phase for cluster head (CH).
B. Selection phase for path determination

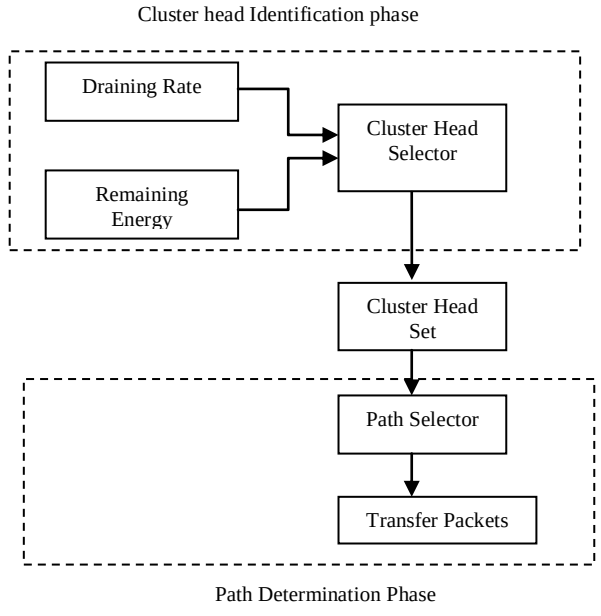

Fig 3: Process model for CH & path selector

1. Identification phase for cluster head (CH):
For the identification of the cluster head, we apply MRMD (maximum remaining energy & minimum draining rate). It is a three step process:

1.1 Calculation of remaining energy of nodes:
In MDMR protocol, first of all we calculate the maximum remaining energy. For each node in a cluster, the difference between the initial energy and the consumed energy of each node is considered. We already know the initial energy given to the every node. For consumed energy we considering the rate of the data flow and the size of the packet .Based on these parameters we calculate the consumed energy of every node. Then we calculate the difference between initial and the consumed energy. After calculating the remaining energy of every node it is passed to the cluster head selection process. The remaining energy is given as:

$$E_R = Ei - Ec \qquad [1]$$

where Ei is initial energy and Ec is consumed energy. Consumed energy is given as

$$Ec = I * V * Tp * Ps / dr \qquad [2]$$

where I is current , V is Voltage , Tp is Transmission Power , Ps is Packet Size and dr is Data Rate

1.2 Calculation of Draining Rate:
It is the most significant parameter in our proposed model. If draining rate of every node is predetermined then it is easy to predict the weakest node which expires earlier than other nodes. So we can ensure that the weakest node is not used in any process frequently. Draining rate of a node is calculated on the bases of change in energy over a given period of time. After calculating the draining rate of every node, it is passed to the cluster head selecting process. Draining rate is given as

$$DR = \delta E / \delta T \qquad [3]$$

where δE is the change in available energy over the fixed timeδT

1.3 Selection of cluster head:
Cluster head selector gets both the parameters, reaming energy and the draining rate of every node. It is the responsibility of cluster head selector to select that node as cluster head (CH) which has maximum remaining energy and minimum daring rate. Chosen cluster heads are sent to cluster head set.

$$CH(i) = Max(Cost(i)) \qquad [4]$$

where CHi indicates that node i is a cluster head and cost(i) is a parameter that determines a node as a cluster head. cost(i) is determined as given in the equation [5].

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$$Cost(i) = E_R(i) / D_R(i) \quad [5]$$

where E_R and D_R is the remaining energy and draining rate of the node i respectively. The node which maximum cost is chosen as cluster head.

2. Selection phase for Path determination:
After selected the appropriate cluster head the next step is selection phase for path determination. Whenever a source node wants to send a packet, it sends a request to cluster head. For path selection OLSR protocol is used in which cluster head broadcast a message to other cluster head in other clusters and find the all possible paths for the establishment of link in between source and destination. Now cluster head select one of possible paths which has minimum no of hops. After find most efficient path communication starts between the willing source and desire destination.

VI. RESULT AND ANALYSIS

A. Simulation setup: In proposed model all the setup is done in NS3 (Network Simulator-3). NS3 is open sources software, available on NS3 site for free use. Ubuntu is used as a operating system & NS-3.17 version is used for simulation of proposed model. In setup there is nxn mesh is used in specific area of WMN. IP addresses are provided to all the nodes in random manner from "10.1.1.0" to "255.255.255.0".

IPv4 addressing is used as physical addressing of nodes. All nodes are wifi enabled. UDP is used for interconnection of nodes. Proposed protocol is used to calculate remaining energy and the draining rate of each node in a cluster. Here odd nodes like (1,3,,5,7…) take as sender nodes and even nodes like(2,4,,6,8…) take as destination nodes. Any source node can send data to any destination at any time.

B. Parameters & its values:

Table 1: parameters & values

Parameters	Values
Network size	300x1500
Topology	Mesh topology
Nodes	3x3 metrics
Size of packets	150,240,300,512 (bytes)
Number of packets	5000,10000,15000,50000
Distance between nodes	50,100,150,200 (meters)
Simulation Time	20 sec
Software used	NS-3.17

C. Analysis:
In our analysis of result, we considered throughput, latency, network life time, end to end delay, energy consumption and, packet delivery ratio (PDR) and energy consumption.

The analysis is done in such a way that:

1. All above described parameters are calculated for various packet numbers (5000,10000,15000,50000) & various packet sizes (150,240,300,512 in bytes)
2. For PDR, it is important to check which protocols deliver the maximum packets; hence a comparison is done between OLSR & AODV.

1.Throughput: figure 4 shows the throughput graph for different values of packet size and no of packets. For higher values of packets the throughput increased linearly and became constant after all the transmission was done. That is for higher data size the throughtput is also higher. [8]

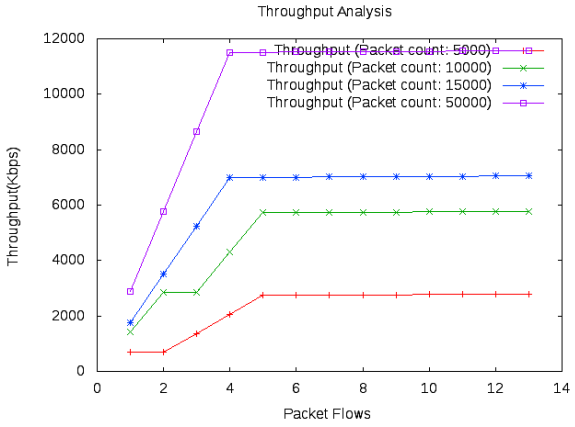

fig4: Throughput graphs for olsr protocol

2. latency : Figure 5 shows the latency ghraphs of the network. latency for a particular packet size a is almost constant throughout the simulation.[9]

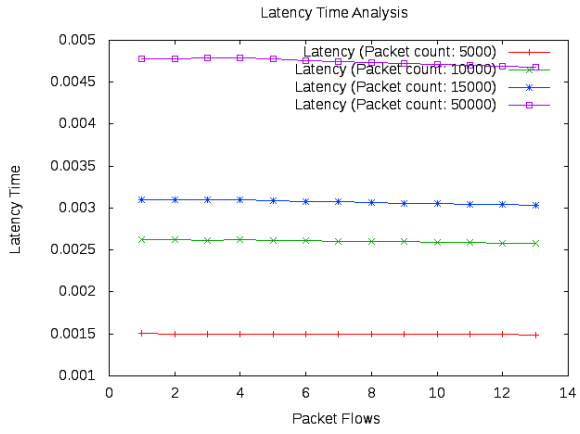

Fig 5: Latency graphs for olsr prortocol

3.Network life time: Time until the first sensor node or group of sensor nodes in the network runs out of energy[10]. Figure 6 shows network life time graphs. It was linear until the transmission stopped, after that it became constant.

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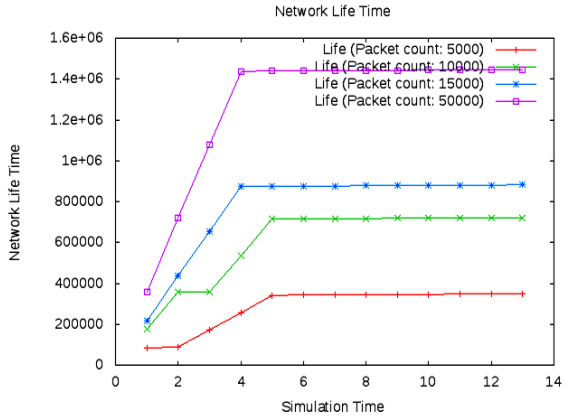

Fig 6: Network life time garphs for olsr protocol

4. Energy consumption: Figure 7 shows energy consumption protocol. For higer values of packet size the energy consumption is also high.

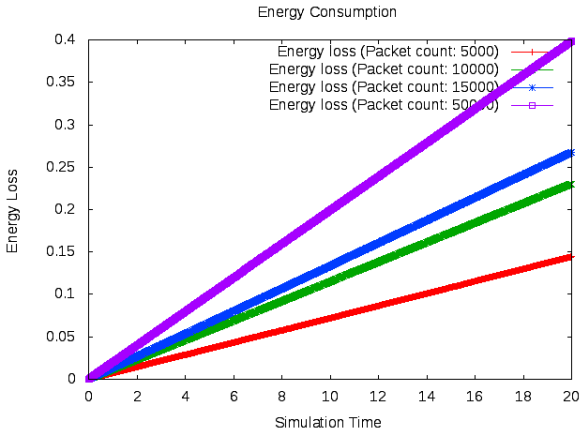

Fig7: Energy consumption garphs for olsr protocol

5. Packet delivery Ratio(PDR): Figure 8 & 9 shows the PDR garphs for two different path selecting protocol. In figure 8 , for all the values of packet size the PDR is 99%, that is the packet loss is 1%. Which is near about ideal communication.

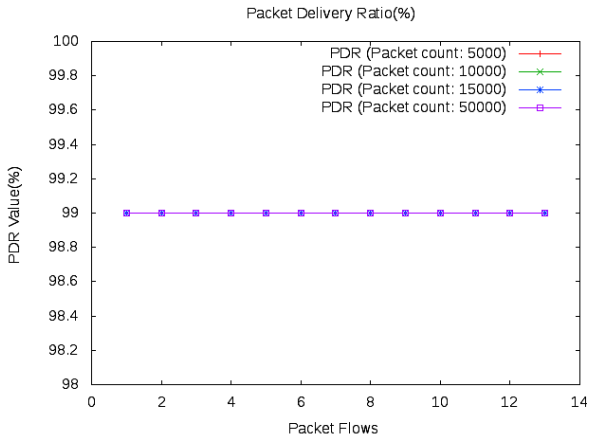

Fig 8: PDR graphs for olsr protocol

But in figure 9, the value of PDR varies with varying packet size. For low packet size it is 99% and for medium packet size it is 98% and for higher packet size it is 97%, which is less than the result that achived by OLSR protocol. Due to this reason OLSR is prefferd over AODV for static senerio.[11]

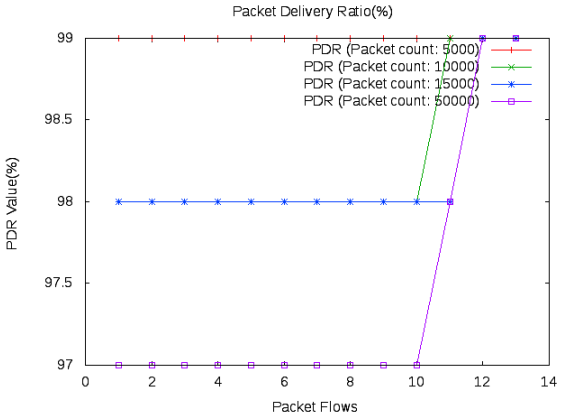

Fig 9: PDR graphs for Aodv protocol

VII. CONCLUSION AND FUTURE WORK

Currently we observe that, most of the work has been done for optimizing energy in Mesh network by using only remaining energy as a parameter, but in our work we have also included draining rate of each node as a parameter for optimization in Wireless Mesh Network. The selection of cluster head (CH) based on maximum remaining energy and minimum draining rate (MRMD) protocol. For path selection, OLSR protocol is used over AODV protocol, because the PDR achieved by using OLSR protocol is much better than that of achieved by using AODV protocol. We found that if we increased the packet size and number of packets per simulation then, it directly effects energy consumption rather than any other parameters. Simulation is carried out in NS-3 simulator tool.

In future we are going to explore MRMD protocol for dynamic nature of nodes in wireless mesh network and also consider the handover process of nodes from one cluster to other, and registry process of new nodes which enters in the new clusters. The effects of moving nodes on energy consumption need to be analyzed in future.

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BIOGRAPHY

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