To extend the lifetime of cluster head node by applying SEP Protocol

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Abstract: A Mobile Ad hoc Network (MANET) is a temporary network formed by a number of mobile nodes without a centralized administration or wired infrastructure. The dynamic nature of these ad hoc networks makes support of QoS (Quality of Service) a challenging and difficult task where nodes may leave and join the network or move around anytime. In this paper, we present a stable election protocol (SEP) for extending the lifetime of cluster head node. In mobile ad hoc networks, the movement of the network nodes may quickly change the topology resulting in the increase of the overhead message in topology maintenance and changing of the cluster head node. Protocols try to keep the number of nodes in a cluster around a pre-defined threshold to facilitate the optimal operation of the medium access control protocol. The cluster head election is invoked on-demand, and is aimed to reduce the computation and communication costs. A large variety of approaches for ad hoc clustering have been developed by researchers which focus on different performance metrics.

Keywords: mobile adhoc network, stable election protocol, clusters head.

I. Introduction: MANETs (Mobile Ad hoc Networks) consist of wireless hosts that communicate with each other in the absence of a fixed infrastructure. Examples include battlefield scenarios, disaster relief and short term scenarios such as public events. The hosts in the MANET have a limited battery power. In the case of large MANETs, a flat structure may not be the most efficient organization for routing between nodes. Instead, many clustering schemes have been proposed that organize the MANET into a hierarchy, with a view to improve the efficiency of routing. It is important that cluster formation and maintenance should not be costly, in terms of resources used such as bandwidth, battery power etc. Otherwise, the purpose of clustering is defeated.

In this paper, we try to present a scheme that leads to cluster formation which efficiently uses the resources of the MANETs. We first of all (a) create the nodes in specified region (ii) secondly; form the clusters of created nodes (iii) finally, applying the SEP protocol for the election of the cluster head node and this created cluster head node will be of larger lifespan. So for this, we define below, some of the terminology used in the paper.

Cluster Head: A cluster head, as defined in the literature, serves as a local coordinator for its cluster, performing inter-cluster routing, data forwarding and so on. In our self-organized clustering scheme the cluster head only serves the purpose of providing a unique ID for the cluster, limiting the cluster boundaries.

Cluster Gateway: A cluster gateway is a non cluster-head node with inter-cluster links, so it can access neighboring clusters and forward information between clusters.

Cluster Member: A cluster member is a node that is neither a cluster head nor a cluster gateway. In MANET, clustering has two phases: first is the cluster creation and second is the cluster maintenance.

II. Basic concept for the election of cluster head node by SEP Protocol

A. Creation of different nodes in the network

In this for the election of cluster head node and to extend the lifetime first of all we create the network with different nodes and these nodes are intermediate nodes, advanced nodes and normal nodes. In the network for identification these are denoted as follows:

Normal node – ○

Intermediate node -- ☼

Advanced node -- ◇

By creating the network of different nodes we can form the clusters because of we are working in mobile ad hoc network nodes always move from one cluster to another.

B. Creation of clusters of different nodes which are on moving

When network is formed with no. of different nodes like normal, intermediate and advanced then by applying do loop and computations we form the clusters up to till when greater energetic node can't elect by the loop as cluster head node. This loop will give us cluster head node which the more power efficient and forming the clusters by electing that particular node as cluster head node.

C. Election of Cluster head node which has more power than other nodes

The cluster head will be chooses on the basis of power parameter, which node has more power than other nodes it will be elected as the cluster head node and this process is done by using the clustering protocol which used here is the Stable Election Protocol (SEP).

III. Previous Work

There are various protocols which are being used for selecting cluster head in cluster creation process and these are LEACH protocol, SEP protocol etc. By the theoretical study of LEACH protocol we learn that it is a TDMA-based MAC protocol which is the integration of clustering with routing protocol in the networks. Its goal is to achieve data aggregation while providing efficient energy communication. It is hierarchical protocol in which most nodes transmit to cluster heads and after this cluster head nodes aggregate and compress the data and forward it to the base stations. LEACH also uses the CDMA to minimize interference between clusters. There are several properties of this algorithm like it is cluster based; there is random cluster head selection in each round with rotation, communication can be done with cluster head via TDMA, cluster head can communicate directly with sink, etc. If we consider the same scenario and same parameter values for LEACH as well it results that in this case the selecting cluster head node release the energy very fast and become dead node as compare to the SEP protocol. So by making comparison of these two algorithms the conclusion is that by using LEACH the lifetime of cluster head reduces as by using SEP. So Stable Election Protocol Algorithm enhances the lifetime of cluster head. These two algorithms use different approaches and methods for the selection of cluster head.

IV. Clustering

Clustering techniques have been employed to deal with energy management in Sensor networks. Low Energy Adaptive Clustering Hierarchy (LEACH), a clustering based protocol that utilizes randomized rotation of local cluster base station (cluster-heads) to evenly distribute the energy load among the sensors in the network. These sensors organize themselves into clusters using a probabilistic approach to randomly elect themselves as heads in an epoch. However, LEACH protocol is not heterogeneity-aware, in the sense that when there is an energy imbalance between these nodes in the network, the sensors die out faster than they normally should have if they were to maintain their energy uniformly. In real life situation it is difficult for the sensors to maintain their energy uniformly, thus, introducing energy imbalances. LEACH assumes that the energy usage of each node with respect to the overall energy of the system or network is homogeneous. Conventional protocols such as Minimum Transmission Energy (MTE) and Direct Transmission (DT) do not also assure a balanced and uniformly use of the sensor's respective energies as the network evolves.

In MANET, clustering has two phases:

Cluster Creation: Cluster head also maintains member table as well as it also maintains a gateway table which stores the address of gateway nodes in the decreasing order of distance from the center head node. This gateway table stores address as well as the available bandwidth of the gateway nodes. The cluster formation starts when a node boots up and broadcasts a cluster solicitation message to its immediate neighbors. If it does not get any reply within the maximum attempts, it declares itself a cluster head. If it receives a cluster advertisement, in response to its solicitation it examines the hop count value and if it is less than ***k*** then, it joins the cluster with the minimum hop count to the cluster head. However if the hop count advertised is ***k***, then it declares itself as a cluster head. Assume an optimal number of clusters k in each round. It is expected that as a cluster head, more energy will be expended than being a cluster member. Each node can become cluster head with a probability $Popt$. and every node must become cluster head once every $1/Popt$ rounds. Intuitively, it means we have $n \cdot Popt$. Clusters and cluster heads per round. Let the non-elected nodes be a member of set G in the past $1/Popt$ rounds. Each sensor chooses a random number between 0 and 1 inclusive. If this is lower than the threshold for node n, (n), the sensor node becomes a cluster head. The threshold (n) is given by:

$$T(n) = P_{opt}/1-P_{opt}[r*mod(1/P_{opt})] \quad \text{if } n \in G$$
$$0 \quad \text{otherwise} \qquad (1)$$

Cluster Maintenance: Because of the nodes mobility, the network topology will change over time. A node may join or leave an existing cluster at a time. Two CHs may come within one hop, which may trigger a cluster head change event. Unfortunately, the moment that two CHs hear LIVE message from each other, it may be frequently due to rapid node mobility in mobile ad hoc networks.

IV. Stable Election Protocol (SEP)

Stable Election Protocol (SEP), a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node assuring a uniform use of the nodes energy. In the SEP, two types of nodes (two tier in-clustering) and two level hierarchies were considered. But an extension of SEP approach called SEP-Enhanced, by considering three types of nodes which we refer to as three tiers in-clustering, in two level of hierarchy network. The goal is to achieve a robust self configured Network that maximizes lifetime. We can choose the intermediate node by a relative distance of the advance nodes positions to the normal nodes position in the network, or by a threshold of energy level between the advanced nodes and the normal nodes. The intermediate node is chosen as in Eq. (2) below. As in SEP, the initial energy for normal nodes is Eo, and for advanced nodes, $Eadv$= $1+\alpha$ Eo. Assume for intermediate nodes, $Eint$= $1+\mu$ Eo. We have:

$$\mu = \alpha/2 \quad (2)$$

The total initial energy of the system is increased by the introduction of both advanced and intermediate nodes:

$$n.E_0(1-mb)+n.m.E_0(1+\alpha)+n.b.E_0(1+\mu) = n.E_0(1+m.\alpha+b.\mu) \quad (3)$$

Where n is the number of nodes, m is the proportion of advanced nodes to the total number of nodes n with energy more than the rest of the nodes and b is the proportion of intermediate nodes. We proceed with the overall energy of the network is increased by a fraction of $(1+m\cdot\alpha+b\cdot\mu)$ and the new epoch of the system must be equal to $1/Popt\cdot(1+m\cdot\alpha+b\cdot\mu)$.

If we choose P, $Pint$ and $Padv$ for probabilities of becoming normal, intermediate and advanced nodes respectively. Hence we have:

$$P_{nrm}=P_{opt}/(1+m.\alpha+b.\mu) \quad (4)$$

$$P_{int}=(P_{opt})*(1+\mu)/(1+m.\alpha+b.\mu) \quad (5)$$

$$P_{adv}=(P_{opt})*(1+\alpha)/(1+m.\alpha+b.\mu) \quad (6)$$

To guarantee that the sensor nodes must become cluster heads as we have assumed above, we must define a new threshold for the election processes, referring back to Eq. (3). The threshold $(nnrm)$, $(nint)$, $(nadv)$ for normal, intermediate and advanced respectively becomes:

$$T(n_{nrm})=\{P_{nrm}/1-P_{nrm}[r*mod(1/P_{nrm})]$$

if n_{nrm} ***ε G'***
0 , Otherwise (7)

From above we have n × $1-m-b$ normal node, Where G' is the set of normal nodes that has not become cluster head in the past $1/Pnrm$ round r. The same analogy follows for the intermediate and advanced nodes,

$$T(n_{int})=P_{int}/1-P_{int}[r*mod(1/P_{int})]$$
$$\text{if } n_{int}\ \varepsilon\ G''$$
$$0, \text{otherwise} \quad (8)$$

We have $n\times b$ intermediate nodes; with G'' as the set of intermediate nodes that has not become cluster head in the past $1/Pint$ round r.

$$T(n_{adv})=P_{adv}/1-P_{adv}[r*mod(1/P_{adv})]$$
$$\text{if } n_{adv}\ \varepsilon\ G'''$$
$$0, \text{otherwise} \quad (9)$$

We have $n\times m$ advanced nodes; with G''' as the set of advanced nodes that has not become cluster head in the past $1/Padv$ round r

From Eq. (4), (5), and (6), the average total number of cluster heads per round will be:

$$n.(1-m-b)*P_{nrm}+n.b*P_{int}+n.m*P_{adv} = n*P_{opt} \quad (10)$$

This gives us the same number of cluster heads having long life span and because of the heterogeneity energy setting; energy dissipation is better controlled, yielding more desirable results as shown in simulation.

V. Simulation Results

We simulate a clustered wireless ad hoc network in a field with dimensions $100m \times 100m$. The total number of sensors n = 100. The nodes are randomly (uniformly) distributed over the field. This means that the horizontal and vertical coordinates of each node are randomly selected between 0 and the maximum value of the dimension. The sink is in the center and so, the maximum distance of any node from the sink is approximately $70m$. The initial energy of a normal node is set to $E0$ = 0.5 *Joules*—although this value is arbitrary for the purpose of this study, this does not affect the behavior of our SEP protocol. The below result snapshot shows the network of nodes.

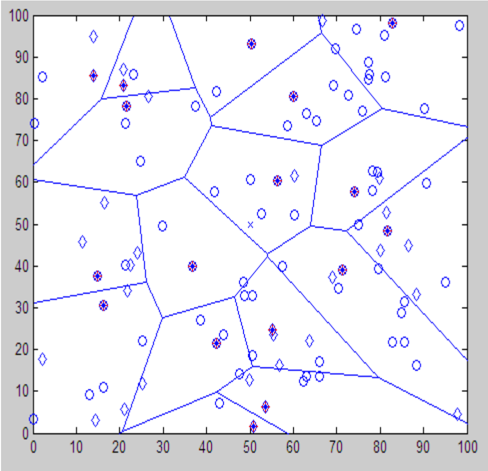

Fig 1.Network of different nodes

The following snapshot shows the network with half dead nodes which are denoted by yellow nodes. The x and y dimensions of 100*100 and the total nodes are also 100 which are plotted on the graph. For this snapshot the maximum rounds performed –1000.

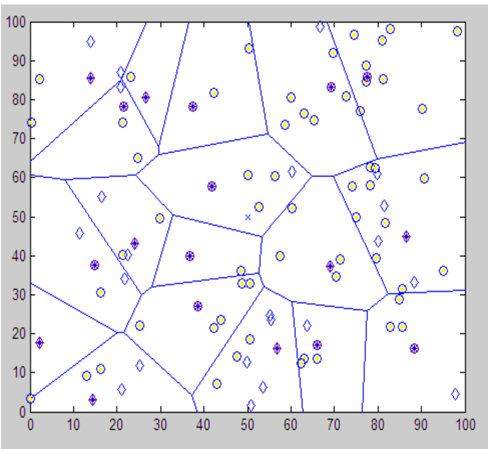

Fig 2.Network of half yellow dead nodes

The following simulation snapshot shows the cluster head of each cluster of maximum power and less energetic nodes become dead nodes. The red nodes show the dead nodes in the network. The filled blue nodes show the cluster head node of the maximum power. In different clusters, different nodes become cluster head node.

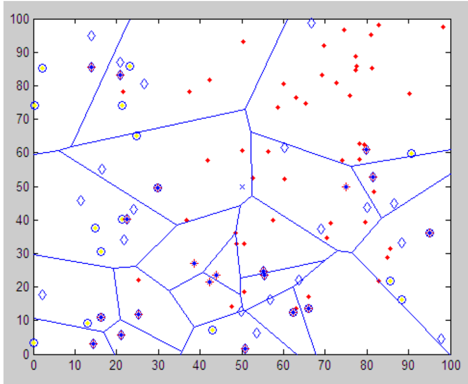

Fig 3.Network of maximum power Node as CH

VI. Conclusion

This study concludes that the election of cluster head node severe the power constraints of the nodes. The used stable election protocol is heterogeneous aware protocol and based on the distributed environment and uses the distributed algorithm for the election of cluster head. When electing the power aware node as cluster head designing protocol architectures for ad hoc networks, it is important to consider the function of the application, the need for ease of deployment, and the severe power constraints of the nodes. These features led the design of SEP, a protocol architecture where computation is performed locally to reduce the amount of power by some particular nodes. Results from experiments show that SEP provides the greater life time to the CH node. If the cluster heads were chosen a priori and fixed throughout the system lifetime, these nodes would quickly use up their limited energy. Once the cluster head runs out of energy, it is no longer operational, and all the nodes that belong to the cluster lose communication ability. So with the approach used in this paper the lifetime of cluster head node could be increased.

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