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Optimized Dual Head Cluster Algorithm for Large-scale Mobile Ad-hoc Networks

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ABSTRACT

Many clustering techniques have been proposed for topology maintenance and routing in the area of mobile ad hoc networks (MANETs), and in addition to this, these techniques are also beneficial in extending the network life time. Energy efficient data aggregation on the other hand, has been one of the key research areas of mobile ad hoc networks (MANETs). Protocols proposed in existing literature to alleviate this problem use only a single Cluster Head (CH) for a group of nodes (Cluster). In these protocols, the CH performs a number of activities (i.e. data gathering, data aggregation and data forwarding), and as a result depletes its energy quickly as compared to its member nodes. Hence, re-clustering is required frequently, which consumes considerable energy. This paper proposes a concept of an Optimized Dual Head Cluster Algorithm (ODHCA) for MANETs. It uses a primary cluster head and a secondary cluster head for route management, inter and intra cluster communication, cluster maintenance and data aggregation. The introduction of these two heads reduces the frequency of re-clustering and end-to-end latency. Simulation results show that the DHCA outperforms conventional clustering protocols in terms of energy conservation, network life time and end- to- end latency.

Key words: Aggregate-Head, Clusters, Cluster-Head, Data Aggregates, Route Management

1. INTRODUCTION

It has become clear that routing in MANET is intrinsically different from traditional routing found in infrastructure networks. Routing in MANET depends on many factors including topology, selection of routers, and initiation of request and specific underlying characteristics that could serve as a heuristic finding the path quickly and efficiently. The low resource availability in these networks demands efficient utilization and hence the motivation for optimal routing in ad hoc networks.

Data aggregation schemes on the other hand, were proposed by Watfa, M, et al, 2009, and Zhigang Chen, et al, 2008, which produce aggregated data information and thus enhance network life time. In clustered networks the CH is also a controller for data collection and aggregation from member nodes. Apart from route management and aggregation a CH can also be responsible for topology management. As a result of aforementioned tasks, the energy of CH depletes quickly which forces frequent re-clustering. In order to avoid frequent re-clustering and to enhance the network life time, the task of route management and aggregation should be performed by two separate nodes within the cluster.

2. RELATED WORKS

The motivation for the present work is three-fold. Firstly, some weakness in P.Vijayakumar et al, 2011, Zhigang Chen et al. 2008, and Aditi Sen et al, 2012, have been identified, where the authors declared that according to their notation, the number of nodes that a cluster head can handle ideally is bounded by a value. Secondly, another weakness in Zhigang Chen et al. 2008, and Aditi Sen et al, 2012, was also identified, where the authors computed for every node the degree difference to ensure that cluster heads are not overloaded. Thirdly, the stability of node is overlooked in Naveen Chauhan et al. (2011).

This paper then focuses on the improvement of the existing single cluster environment using the optimized dual cluster head algorithm (DHCA) to reduce the number of re-clustering, end-to-end latency and network lifetime that occurs in the existing systems. The simulation produced in this paper went on to prove that our proposed DHCA is more efficient than those produced in the existing system.

3. PROPOSED SYSTEM

In this section we proposed an optimized Dual Head Cluster Algorithm (DHCA) for this paper. The DHCA is based on an existing clustering system which uses a single cluster head for distributing and updating data to its member nodes. However, the existing systems were modified to incorporate two cluster heads.

2.1) Cluster Formation

After the network deployment, the base station broadcast a message to all the nodes in clustering environment at a certain power level. Every node calculates its approximate distance X to the base station by using the received signal strength. This X is used for finding the radius of the cluster, which ultimately shows the size of the cluster given by the following formula:

$$R_j = X_j (Rmax - Rmin) / X_{max} + R_{min} \quad (1)$$

Where:

R_{max}, is the maximum radius,

R_{min} is the minimum radius,

X_j is the distance between node j & CH, while

X_{max} represents the distance between the farthest node & the CH.

After finding the cluster size and its radius each node broadcast a metrics consisting of node id and energy, saves the metrics, compares the metrics with its own energy level. Soon after comparing the values, each node elects a node with high energy as its cluster head (CH). After the cluster head selection, the cluster head elects an aggregator head (AH) from its own cluster for data collection, aggregation, topology maintenance and responsible for communication among member nodes of the cluster. After AH selection, the CH broadcast a message to all member nodes to communicate and send data to the aggregator head. The metrics for aggregation head selection is a node with high power node and closer distance to the cluster head.

2.1.2) Route Formation

After the cluster formation, every CH broadcasts a metrics to other cluster heads. This metrics consists of cluster head energy, id, and distance from the CH. On the other hand, every CH calculates the distance to the other CH based on received signal strength and finds shortest distance to the base station for efficient communication of data.

2.1.3) Data Communication

After formation of route, the CH selects a node with higher energy and closest to it from the list of its members, as an AH. After the AH selection, every member node in the cluster sends data to the AH. The AH receives data from the nodes, aggregates it and sends it to the CH for onward transmission. The CH then forwards data received from AH and other cluster heads to the base station.

4. PERFORMANCE EVALUATION

We study the performance of DHCA by using the NS-2.35 simulator to achieve our result in which DHCA assumes error free communication.

This paper has simulated an existing system that uses a single cluster head and that of the proposed system which uses a dual cluster head. Both systems where compared to show that the proposed system is more efficient in terms of energy efficient data aggregation in MANETs. Table 1 below showcased the parameter used in the simulation.

Table1. SIMULATION PARAMETERS

Scenario dimension	1000 x 1000
Traffic Application	CBR
Antenna Type	Omni-Antenna
Transport Protocol	TCP
Number of nodes	20
Wireless MAC interface	IEEE 802.11
Propagation model	Two way ground
Packet size	2000 (bits

4.1. Network Life Time

Network life time is the time between the deployment and the destruction of a network. The graph for the number of nodes alive in a single cluster verses number of rounds using LEACH, and DHCA is shown in Figure 1. It is obvious from the graph that as time passes the number of nodes alive is more in DHCA than LEACH. This occurred because of the load balancing among nodes when the Aggregator Head was introduces into the single cluster environment.

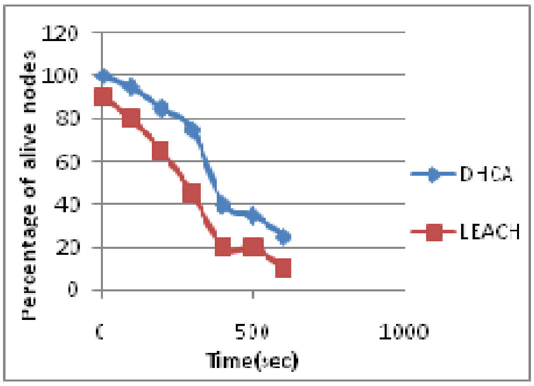

Figure.1. Network Life Time

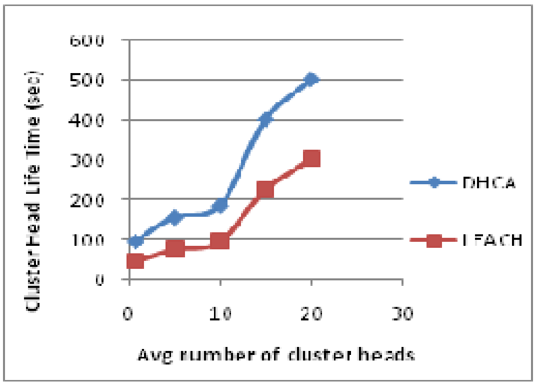

Figure.2.Cluster Head Life Time

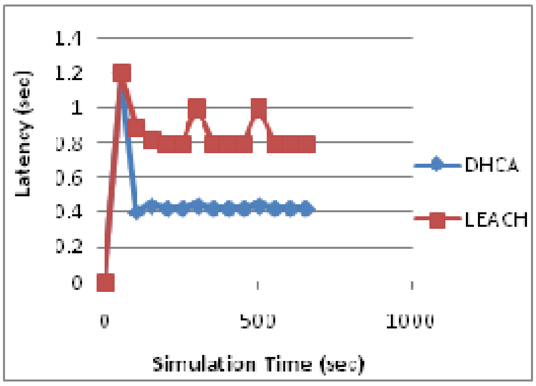

Figure.3. Network Latency

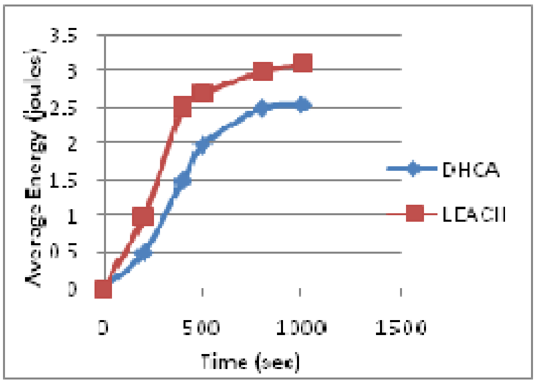

Figure.4. Network Average Energy

4.2. Cluster Head Life Time

Cluster head life time is the time a node remains as the cluster head within the network after it has been elected as the cluster head. The graph for residual energy of a single cluster head verses time using, DHCA and LEACH is shown in Figure 2. It is apparent that as time proceeds, the CH in DHCA conserves more energy than LEACH; this is because of the introduction of AH. On the other hand, LEACH only uses a single cluster head for coordinating data within the group cluster.

4.3. Network Latency

Network latency is the amount of time taken by packet to reach its destination. Figure 3 shows that DHCA performs with low latency as compare to that of a single cluster (LEACH). The network performance was improved and this was as a result of using two different heads within a single cluster environment. The cluster head acts like a router and is not burden with data collection and aggregation which was taken care of by the aggregator head. Therefore, congestion at cluster head in DHCA is low which results in low latency. The Figure 3 clearly shows the low latency graph of the DHCS as compared to LEACH.

4.4. Network Average Energy

Average node energy is the amount of energy consumed by all nodes divided by the number of nodes within the network. The average node energy consumed with the passage of time is shown in Figure 4. It is comprehensible from the graph below that the DHCA consumes less energy as compared to LEACH. The overhead of frequent re-clustering is very low in DHCA but high in LEACH because the single cluster head in LEACH is responsible for a number of activities, such as data gathering, data aggregation and data forwarding. As a result, the CH depletes its energy quickly as compared to its member nodes. Hence, re-clustering is required frequently, which consumes considerable energy.

5. CONCLUSIONS

In this paper, we proposed a novel concept of a Dual Head Clustering Algorithm (DHCA) for MANET. The algorithm selects an efficient dual heads cluster within a single cluster environment, does weight calculations, and performs distributed directory information on mobility of nodes for appropriate routing. The DHCA employs two cluster heads; Cluster Head and Aggregator Head, which existing systems lacks. Both heads divide the duties of the single cluster head. The jobs of a CH are cluster maintenance, data forwarding, while the duties of AH is to collect data from the field via cluster members and aggregate the collected data for transmission. In the selection process, the CH is selected for a specified period of time. The simulation results shows that DHCA outperforms conventional protocols in terms of cluster head life time, network life time, network average energy, and network latency. From our perspective, it was proven DHCA can reduce the problem of inefficient data aggregation in MANETs.

6. REFERENCES

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