ROUTING PROTOCOL BEHAVIOUR WITH MULTIPLE CLUSTER HEAD GATEWAY IN MOBILE AD HOC NETWORK

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ABSTRACT

As we know in Mobile Ad hoc network our Nodes are highly mobile. They move around the Network. Due to this network topology and number of neighboring nodes in each node frequently change. Movement of nodes from one to another network also affect to the communication between them. As the number of nodes increases complexity of MANET increases in various issues. Nodes within the cluster communicate directly. However, nodes communicate outside the cluster through a centralized node that is called a Cluster Head Gateway (CHG) [1]. Ad hoc wireless network is a dynamic multi-hop network, which is established by a group of mobile nodes on a shared wireless channel. The shared medium and the multi-hop nature of the wireless ad hoc networks pose fundamental challenges to the design of an effective resource allocation algorithm to maximize the aggregated utility of flows, maintaining basic fairness among the multiple flows. An elected Cluster Head Gateway (CHG) is assigned for communication with all other clusters. The centralized Cluster Head Gateway can become a bottleneck and possibly cause a lower connectivity for the clustering system. In this paper we propose a mechanism in which communication outside the cluster is distributed through separate Cluster Head Gateways with appropriate routing protocols. Here considering are AODV, DSR, OLSR and TORA routing protocols. We are comparing protocols behaviour on the basis of following parameters: delay, throughput, traffic sent, traffic received, data dropped and network load and then check who is giving better performance. Finally, this paper conducts simulation experiments in the conditions where we are using Multiple CHG to the nodes within a network.

KEYWORDS

Cluster Head Gateway, Throughput, AODV, DSR, OLSR, TORA.

1. INTRODUCTION

A wireless ad hoc network consists of mobile nodes that move freely and communicate with each other using wireless links. A MANET system does not require a predetermined infrastructure and nodes act as hosts and as routers for other nodes. Nodes are grouped into distinct or overlapping clusters. Clustering provides a Hierarchical MANET system which assists in making the routing scalable. Some of the nodes are elected to be part of the backbone for the MANET system [2] [3] [10] [12-14]. These nodes are called Cluster Head Gateway. Cluster Head Gateways are elected according to several techniques [1]. The Cluster Head Gateway allows for minimizing routing details overhead from other nodes within the cluster. MANET requires efficient routing algorithm in order to reduce the amount of signalling introduced due to maintaining valid routes[4][5], and

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therefore enhance the overall performance of the MANET system. As the Cluster Head Gateway is the central node of routing for packets destined outside the cluster in the distinct clustering configuration, the Cluster Head Gateway computing machine pays a penalty of unfair resource utilization such as battery [15], CPU, and memory. As we can say a Cluster Head Gateway election in order to distribute the load among multiple hosts in the cluster [1]. Our approach can use any of them to elect a Cluster Head Gateway with suitable routing protocol.

In this paper we have developed a mobile ad-hoc network and this network is divided into clusters. Each cluster has Manet node with CHG. From one cluster to another cluster or within the cluster we applied different routing protocols like AODV, DSR, OLSR and TORA to evaluate their behaviour and analyze the performance of each protocol individually and check who is giving better performance for MANET communication.

The rest of the paper is organized as follows: Section II presents the related work. Section III describes our proposed working model. Section IV presents the simulation experiment setup and gives the performance evaluation of our proposed strategy. Section V concludes the paper.

2. RELATED WORK

Several mechanisms of Cluster Head election exist with an objective to provide stable and efficient routing in the MANET system [4] [8] [13-14]. Some mechanism assigns the Cluster Head based on the node id as in the Linked Cluster Algorithm (LCA) which selects as the Cluster Head the node with the highest ID [3]. Other mechanisms favour allowing some type of fair share of Cluster Head responsibility by changing the Cluster Head based on an assigned ID to the Cluster Head [2]. A node with a high mobility rate is higher than the duration of Cluster Head rotation may not get the chance to become a Cluster Head. Other Cluster Head election mechanisms consider relative node mobility to ensure routing path availability [3] [9] [11]. However, causing an added signalling overload and causing the elected Cluster Head to pay the higher resource utilization penalty. We can conclude from the existing research that several tradeoffs exist for the elected Cluster Head and the other cluster nodes.

- Firstly, the Cluster Head has to bear higher resource utilization such as power, which may deplete its battery sooner than other nodes in the cluster.

- Secondly, despite fair share responsibility of Cluster Head role, it is possible that heavy burst of traffic takes place causing some Cluster Heads to use maximum resources.

- Thirdly, the fair share or load balancing technique [2], might result in a Cluster Head that will not provide the optimal path for routing, or yet a link breakage.

There is no one common Cluster Head election mechanism that is best for MANET systems, without some tradeoffs.

The Zone Routing Protocol, ZRP, in [7], provides a hybrid approach which produces added routing control messages in the network due to keeping up to date routes [7]. ZRP divides the network into overlapping zones, while clustering can have distinct, non overlapping clusters. In addition, the authors in [6-7] claim this hybrid approach is suited for large networks, enhances the system throughput, but adds more complexity. As discussed above, the main focus of the previous work focuses on an election of one Cluster Head for a cluster. Even though this minimizes the overall signalling overhead in the cluster, but it mainly can make the central Cluster Head a bottleneck.

3. PROPOSED WORKING MODEL

The base of our Paper is distributing the load of the Cluster Head Gateway amongst multiple Cluster Head Gateways in the same cluster and also provide link between nodes as shown in figure 2 with the architecture of multiple Cluster Head Gateways, one for each neighboring clusters. Any of the prior work can be used to select the Cluster Head Gateways for a cluster. In the case of one Cluster Head Gateway per cluster, a link breakage caused by the failure of the Cluster Head Gateway isolates all cluster nodes from communicating to/from outside the cluster. However, our approach reduces the link breakage to be only in the direction towards a path where the failed Cluster Head Gateway forwards the data. Therefore, the reliability of routing in the MANET system is increased. Our architecture does not state the routing protocol as in [7], but leaves the decision as done in the original designs of clustering [2] [3][10][12-14]. Our MANET system consists of 4 distinct non-overlapping clusters as shown in figure 1.

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As shown in figure 1 Cluster 1, 2, 3 & 4 all have one Cluster Head Gateway. Our traffic included FTP traffic generated between nodes in cluster 1 and nodes in all other clusters in the MANET system. In order to focus on the objective of distributing the Cluster Head Gateway load. Here we have one Cluster Head Gateway in cluster 1, to send a packet from a node S1 in cluster 1 to a node D2 in cluster 2, the packet is routed via the single Cluster Head Gateway N1 in cluster 1 and finally via the Cluster Head Gateway N2 in cluster 2 to cluster node D2. Then routing from cluster 1 to cluster 3 was from cluster node S2 to Cluster Head Gateway N1 in cluster 1 passes to the Cluster Head Gateway N3 in cluster 3 to cluster node D3. However, routing from cluster 1 to cluster 4 was also done directly from cluster node S3 to Cluster Head Gateway N1 in cluster 1 passes to the Cluster Head Gateway N4 in cluster 4 to cluster node D4.

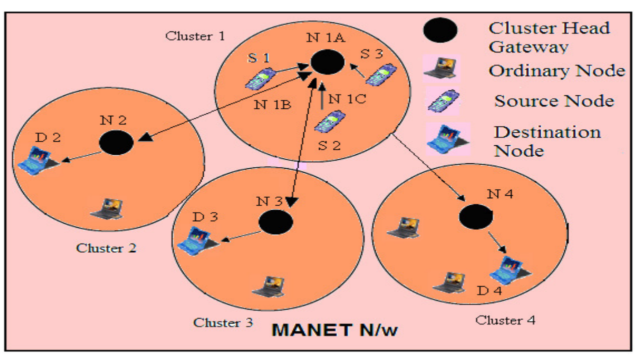

Figure 1. Showing the Previous Clustering Approach

In figure1, suppose the links between N1 & N2, N1 & N4 are ok but N1 to N3 is break due to the more traffic occurrence and occurred traffic is not handled by assign Band width of this link (N1

& N3). Due to this Connectivity of this link reduce or approximate zero using the Single Cluster Head Gateways. And suppose CHG of cluster-1 (N1) fails then all the communication with other CHG's via N1 will break like S1-D2, S2-D3 & S3-D4. This previous MANET system approach is not capable of handling more No. of users if traffic increases and also not providing better connectivity if CHG like N1 for cluster-1 fails. Which show the lower Connectivity when using single Cluster Head Gateway.

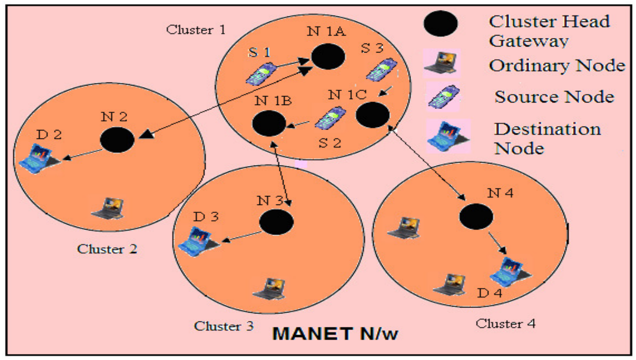

Figure 2. Showing the New Clustering Approach

As shown in figure 2, Cluster 1 is the one which has a cluster with multiple Cluster Heads Gateways. The remaining clusters 2, 3 and 4 operated with one Cluster Head Gateway. When using multiple Cluster Head Gateways in cluster 1, a different Cluster Head Gateway was used for routing to each of the neighboring clusters. For example, routing from cluster 1 to cluster 2 uses a Cluster Head Gateway N1A that is different when routing from cluster 1 to cluster 3 & cluster 4 use N1B & N1C respectively. Therefore, since there are 3 neighboring clusters to cluster 1, the system allowed for the use of 3 Cluster Head Gateways, one for routing to/from each neighboring cluster.

In our topology taking figure2 under consideration where links between N1A to N2, N1B to N3 & N1C to N4 are OK via using different CHG's (N1A, N1B & N1C). We increased the number of Cluster Head Gateways to 3 i.e. if any CHG fail it will not effect other CHG communication due to using multiple CHG. However, our Connectivity will increase. In addition, as the traffic arrival rate increased due to having the 3 Cluster Head Gateways, the service rate also increased, resulting in the same utilization rate for the MANET system. Therefore, we conclude that the number of Cluster Head Gateways increase should improve connectivity by a factor equals to the number of added Cluster Head Gateways.

So after analyzed all results we can say

- (Connectivity) $\propto$ (No. of Cluster Head Gateway).

And for communication between one cluster to another or within the same cluster we are focusing over appropriate routing protocols which will be helpful to find out the desire route for data communication. Here we are analysing the behaviour of AODV, DSR, OLSR and TORA routing protocols and check who is best.

3.1. Routing Protocols of Ad-hoc Network-

AODV (AD HOC ON-DEMAND DISTANCE VECTOR)

AODV-node informs its neighbours about its own existence by constantly sending “hello messages” at a defined interval. This enables all nodes to know the status about their neighbours, i.e. if they gone down or moved out of reach. To resolve a route to another node in the network AODV floods its neighbours with a route request (RREQ). A RREQ contain the senders’ address, the address of the sought node and the last sequence number received from that node if there exist one. The receiving node checks if it has a route to the specified node. If a route exists and the sequence-number for this is higher than the supplied a new route is found. The node replies to the requesting by sending a route reply (RREP). If on the other hand a route does not exist the receiving node sends a RREQ itself to try to find a route for the requesting node.

DSR (DYNAMIC SOURCE ROUTING)

The Dynamic Source Routing protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. The protocol allows multiple routes to any destination and allows each sender to select and control the routes used in routing its packets, for example for use in load balancing or for increased robustness. Other advantages of the DSR protocol include easily guaranteed loop-free routing, support for use in networks containing unidirectional links, use of only "soft state" in routing, and very rapid recovery when routes in the network change.

OLSR (OPTIMIZED LINK STATE ROUTING)

It is a proactive routing protocol and is also called as table driven protocol because it permanently stores and updates its routing table. OLSR keeps track of routing table in order to provide a route if needed. OLSR can be implemented in any ad hoc network. Due to its nature OLSR is called as proactive routing protocol. Multipoint relay (MPR) nodes. All the nodes in the network do not broadcast the route packets. Just Multipoint Relay (MPR) nodes broadcast route packets. These MPR nodes can be selected in the neighbour of source node. Each node in the network keeps a list of MPR nodes.

TORA (TEMPORALLY-ORDERED ROUTING ALGORITHM)

The Temporally-Ordered Routing Algorithm (TORA) is an algorithm for routing data across Wireless Mesh Networks or networks. The TORA attempts to achieve a high degree of scalability using a "flat", non-hierarchical routing algorithm. In its operation the algorithm attempts to suppress, to the greatest extent possible, the generation of far-reaching control message propagation. In order to achieve this, the TORA does not use a shortest path solution, an approach which is unusual for routing algorithms of this type. The key design concept of TORA is localization of control messages to a very small set of nodes near the occurrence of a topological change. To accomplish this, nodes need to maintain the routing information about adjacent (one hop) nodes. The protocol performs three basic functions: Route creation, Route maintenance and Route erasure.

4. SIMULATION SETUP AND RESULTS DISCUSSION

4.1. Simulation Setup

To simulate our Cluster Head Gateway Network, we used Opnet 14.0 v. The simulation parameters and their values are given in Table 1.

TABLE 1 Simulation Parameters

PARAMETER	VALUE
Number of MANET Nodes	30
Number of Packet (Traffic) Sources	4
Number of Cluster Head Gateway (CHG)	15
Size of Area	1000*1000 (m.)
Transmission Range	250 (m.)
Traffic Type	Constant Bit Rate (CBR)
Protocols	AODV, DSR, OLSR, TORA
Standard Ad hoc Speed	10 m/s
Address	IP v4
Simulation Time	300 (sec)
Wireless Channel Bandwidth	1000 (KHz)
Beacon Interval	0.02 (sec)
Node Mobility Model	Default Random Way Point
Data rate	1 (Mbps)
Buffer Size	256000 (Bits)
Frame Size	4 (m.sec)
Maxi. Receive Life time	0.5 (sec)
Datagram switching rate	500,000 (packets/sec)

- **Performance Metrics**

The following metrics are used in varying scenarios to evaluate the different protocols:

1) **Throughput –** Throughput or network throughput is the average rate of successful message delivery over a communication channel
2) **End-End Delay -** The packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network
3) **Packet delivery rate -** The total number of data packets received divided by the total number of data packets originated.
4) **Data Dropped –** This is the difference between total number of packet transmitted by transmitter and total number of packet received by receiver at receiver end.
5) **Network load -** The total number of routing messages transmitted divided by the total number of data packets received.

4.2. Result Discussion

The Performance of the proposed CHG N/w is analyzed with respect to Throughput, End-End Delay, Traffic Sent, Traffic Received, Data Dropped and Network Load.

Figure 3 to 8 shows the performance with respect to the throughput, end-end delay, traffic sent, traffic received, data dropped and network load respectively. The performance is first evaluated by CHG connectivity.

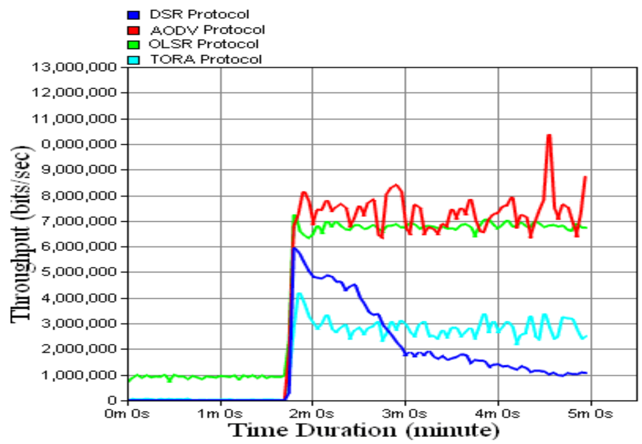

Figure 3. Throughput Vs Time Duration

Figure 3 showing the Throughput of the whole network with respect to time period. The value of throughput should be high and from figure we may conclude that the value is highest for AODV protocol graph i.e. between 7,000,000 – 8,000,000 (bits/sec) up to 5 min. time periods due to this it will also provide better connectivity between the nodes. For others protocols this value is low.

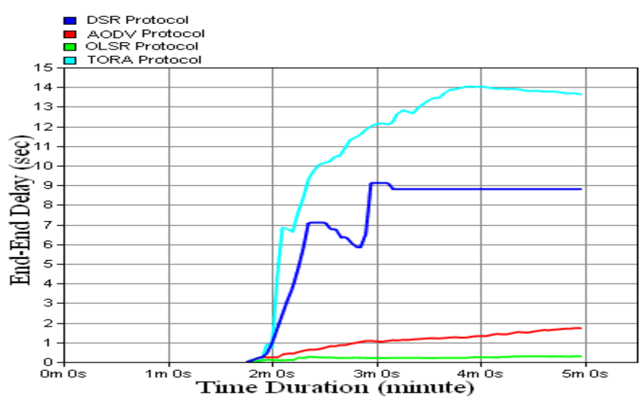

Figure 4. End-End Delay Vs Time Duration

Figure 4 showing End-End Delay Vs time Duration graph. As we know the value of delay should be as small as possible. With the help of given figure we can say End-End Delay is less in OLSR protocol graph as compare to other protocols graph which is below than 1 sec till 5 min. time period. But for AODV End-End Delay is acceptable and lower and better with respect to DSR & TORA protocols as shown in figure 4.

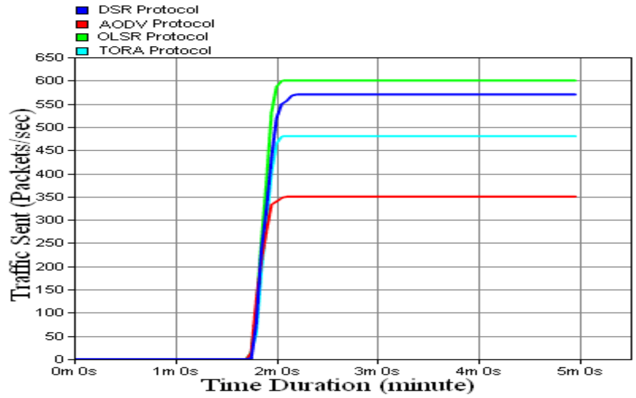

Figure 5. Traffic Sent Vs Time Duration

Figure 5 shows Traffic Sent Vs time Duration graph. In the given figure OLSR protocol is transmitting large number of packets per sec. around 600 (packets/sec) till 5 min. time period. Figure 6 shows Traffic Received Vs time Duration graph. Here DSR protocol graphs receiving most of the packets. Using Figure 5 and 6 we can analyze the graph between Transmit data and Received data. And also calculate the data loss (packet drops).

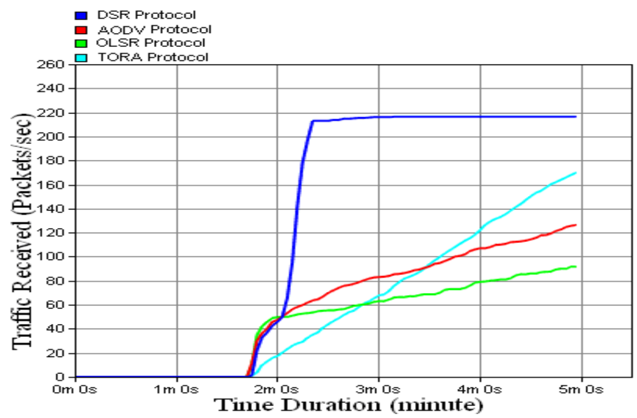

Figure 6. Traffic Received Vs Time Duration

Figure 7 shows Data Dropped Vs time Duration graph. Figure shows AODV protocol has lesser number of packet drops as compare to other protocols graph. The performance of AODV protocol is better among the protocols. And AODV routing protocol is also reasonable for this type of scenario.

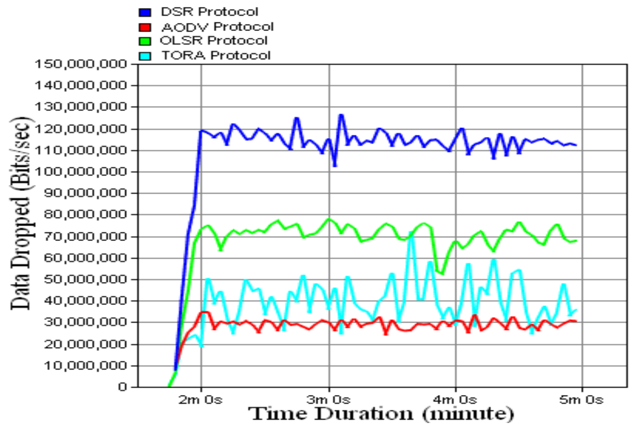

Figure 7. Data Dropped Vs Time Duration

Figure 8 shows Network Load Vs time Duration graph. Here Network Load is increasing with respect to time period which is responsible for network congestion and it should be as minimum as possible. Here AODV protocol having lesser network load than other given protocols.

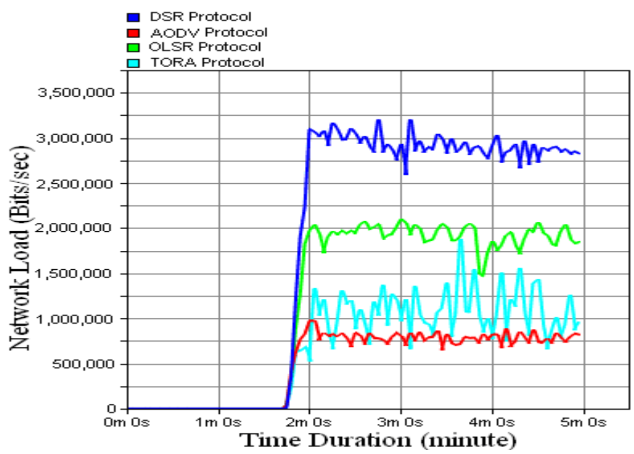

Figure 8. Network Load Vs Time Duration

5. CONCLUSIONS

In this paper, we have proposed Routing Protocol Behaviour with Multiple Cluster Head Gateway in Mobile Ad hoc Network. One of the distinguishing characteristics of our strategy is that, the MANET node is provided a better connectivity with appropriate routing protocol. In addition, routing reliability is increased since a failure of one Cluster Head Gateway (CHG) does not break all routing to outside the cluster due to use of Multiple CHG. Analyzing figures, in case of Throughput, End-End Delay, Packet drops & Network load for the four protocols AODV, DSR, OLSR and TORA in our simulation. Finally, simulation results confirm that AODV giving better performs among the four routing protocols, providing better connectivity, good throughput and less End-End Delay, N/w load. One of the notable features of this AODV protocol strategy is that, it reduces our network load which can be responsible for congestion at the time of communication. Therefore it can be used to extend the network coverage. In future the CHG approach can be evaluated under different mobility scenarios and the performance can be measured with other large N/w's.

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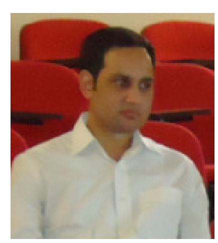

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