QoS aware Hierarchical Multi-hop Routing Protocols in MANETs

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ABSTRACT

Ad hoc wireless networks are multi-hop networks that are dynamic, and are formed by a group of nodes which are mobile in nature, on a shared wireless links. Mobile ad hoc network (MANET) is a collection of autonomous nodes that communicate with each other by forming a multi hop radio network. The analysis and design of routing protocols is a significant issue in ad- hoc wireless networks. Since the previously proposed routing algorithms have not considered the multi-hop flow with an end-to-end scenario, and had shown to perform well in providing blond sharing of bandwidths among the single-hop wireless flow. Compared to host- based routing, Hierarchical Multi-hop routing significantly reduces the routing table sizes and the amount of routing related signalling traffic, at the expense of reducing path efficiency and generating some management traffic.

This paper focuses on QoS aware Hierarchical Multi-hop routing schemes for mobile ad hoc networks. The best path from a source to a destination is calculated using the QoS information available with either group heads or with each member. Separate clusters are created using the cluster creation algorithm. Depending on the QoS information available with each gateway node, packets are routed. Because of the hierarchical architecture, the performance is unaffected by the increase in the number of mobile nodes, at the same time the Packet Loss is reduced. The proposed dynamic clustering algorithm manages the handover dynamically and hence the efficiency is not degraded by node mobility.

KEYWORDS

Mobile ad hoc network, MANET, Quality of Service, QoS enabled Routing, FQMM, Dynamic Cluster Creation Algorithm

1.INTRODUCTION

Ad hoc network nodes are self-organized and can communicate directly with other nodes in the network. Ad hoc mobile network is consists of mobile nodes that communicate with each other through broadcast radio transmissions in the limited transmission range. Due to radio transmission range limitations, we may require a multi-hop scenario, where packets are routed through intermediate nodes. There are many applications of mobile ad hoc networks ranging from battle field communications, which needs immediate network setup without the support of wired

and fixed network infrastructures, to inter-vehicle communications, designed for both traffic safeties and enhanced entertainment purposes. Due to dynamically changing topology and to provide a continuous exchange of broadcast information in support of traffic control, the inter-vehicle communications application poses the firm requirements.

MANET is has a character of rapidly changing topology. The wireless ad hoc networks throw elementary challenges to the design of an effective resource allocation algorithm to maximize the utility of flows and the maintenance of basic fairness among the multiple flows, because of its shared medium and the multi-hop nature. Ad hoc wireless network is a collection of wireless mobile nodes forming a temporary network without any centralized administration. Here, each node operates not only as a host but also as a router, which broadcasts the route request packet and the neighbouring nodes exchange the QoS parameters using the broadcast packets. These broadcast packets increase the network traffic. Cluster formation can reduce this unnecessary network traffic. The main network design problem is to find a least cost or a maximum revenue network, reducing the redundant broadcast packets.

The mobile nodes of the network can be grouped as clusters depending on the position and the QoS availability of each node. The cluster heads functions as local coordinators and maintains the QoS values of all cluster members. Few Clustering algorithms prefer to maintain the QoS values among each member in the cluster. Real-time applications require rigorous requirements on delay, delay-jitter, cost, bandwidth, and other Quality of Service metrics. QoS aware routing protocols finds an optimum route that satisfies the QoS needs. To specify the set of QoS constraints, a multi-constrained set is used. The set of constraints might be link constraints or path constraints or both. For instance, a delay constraint might be set as, “the aggregate delay on all links along the route” should be less than the average delay requirement. The bandwidth constraint needs each link along the path to support definite minimal bandwidth.

This paper focuses on various QoS aware Hierarchical based routing protocols for ad hoc wireless networks which involves the creation of clusters and gateway nodes dynamically. Forming clusters reduces the broadcast redundancy. The rest of the paper is organized as follows. Section 2 discusses the Related Work which includes, routing protocols in MANET, QoS Routing, QoS Support in MANET, Dynamic clustering algorithm etc,. Section 3 concludes the paper.

2. RELATED WORK

2.1. Routing Protocols in MANET

Many routing protocols are proposed for MANETs, and are classified into three main categories, namely:

- Proactive table-based routing schemes
- Reactive on-demand source-based routing schemes
- Constraint-based routing schemes

In the proactive table-based routing schemes, the nodes in the network maintain routing information tables, which are used to determine the next hop for the packet transmission to reach

the destination. This protocol maintains the table information consistently by sending updates throughout the network periodically. Some examples of proactive table driven routing schemes, are (DSDV) [5], wireless routing protocol (WRP) [5].

With respect to On-demand source-based routing schemes, routes are created based on a query-reply approach. If a node wishes to communicate with other node, it begin a route discovery process. The route information is maintained by a route maintenance process, after a route is identified. Examples of on-demand source-based routing schemes include ad hoc on-demand distance vector (AODV) [1] routing protocol, dynamic source routing (DSR) [2], and the Temporary Ordered Routing Algorithm (TORA) [5].

Metrics are used instead of shortest path, to find a suitable feasible route in Constraint-based routing protocols. Where as in Associatively-based routing (ABR) [5] and signal stability routing (SSR) [5], the signal strength and location stability are considered, in order to make the path to be long-lived.

The above routing schemes introduced are not sufficient for applications which require QoS support. In the next section we review the routing schemes that support QoS in MANETs.

2.2. QoS Routing

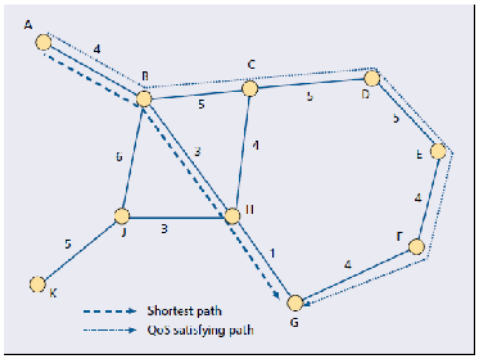

Figure1. A sample QoS Routing in MANET

The above figure shows the wireless network derived from a sample Mobile Ad hoc Network. A – K are the mobile nodes. The numbers beside each link depicts the available bandwidths of the wireless links. Assume that, we want to find a route from node A to node G. The route A-B-H-G would be chosen if the shortest path is considered. But, the QoS-based route selection process might select a completely different path. The feasible route will be A-B-C-D-E-F-G, if the QoS metric is considered as the minimum bandwidth of 4. The shortest path route AB- H-G will not be enough to provide the required bandwidth.

Even though a lot of research is conducted for achieving the required QoS in internet and traditional wireless networks, the existing results are not suitable for MANETs. Appropriate QoS for delivery of realtime communications such as audio/video, raise a number of several technical challenges. Here, we introduce several QoS structures for MANETs that are proposed for improving QoS in MANETs.

The reservation procedure for priority traffic and low-priority traffic is combined in FQMM [3]. Iit cannot solve problems such as, traffic classification depending on decision, allotment of bandwidth flow or combined services for specified bandwidth, traffic belonging to flow, and rescheduling or sending back the messages by the intermediate nodes.

Least throughput and delay limits for each flow, to achieve highest allocation of the shared wireless bandwidth is described in "A packet scheduling approach for QoS provisioning in multihop wireless networks" [6]. By the coordination between different layers of the network to solve the problems introduced by scarce and dynamic network resources are described in [7].

INSIGNIA protocol uses a combination of QoS limits with signaling carried in the data packet headers, as an approach to provide QoS in a mobile ad hoc network [9]. This IP-based QoS framework is designed to be highly responsive for the dynamic network traffic. Applications that require a least QoS guarantee (called base QoS)are supported in Adaptive services [10].

2.3. QoS Support in MANET

Quality of Service is generally defined as a set of provisional conditions that need to be met by the network for transporting a set of packets from a source to a destination. Some of the QoS requirements can be measured in terms of end-to-end performance, such as delay, bandwidth, packet loss probability, and jitter also termed as delay variance. The other two QoS attributes with respect to MANETs are power consumption and service coverage range. QoS metrics can be concave or additive. Bandwidth is a concave metric, whereas Delay and delay jitter are additive metrics.

Traditional wired Internet infrastructures are different from Mobile multi-hop wireless networks. So some difficulties for supporting QoS in MANET environments need to be addressed [1]. These issues include *features* and *consequences*. For instance, unpredictable line properties, node mobility, and limited battery life, are features, and examples of consequences include hidden and exposed terminal issues, maintenance of the route, and security.

The dynamic nature of the ad hoc networks and the changing behaviour of the wireless radio transmission, make the precise maintenance of network state information very difficult. So, the routing algorithms in MANETs are to be designed with less predictable information. In addition, nodes in the network can join or leave at any time with ad hoc networking environments. The established routes may be broken at the process of data transfer. Therefore, for maintaining rescheduling of routing paths require minimum overhead and delay.

2.4. Need for Maintaining the QoS Parameters Table

When each node in the network already acquires the QoS values of the its nearby nodes the packet can be routed according to the QoS constraints. This may reduce the network traffic [1]. But by increasing the number of nodes in the network, the QoS parameter table size also increases. There by, increasing the global QoS parameter table size also. Another problem is because of the dynamic nature of the network, where the number of nodes in the network and the

links connecting them changes randomly. The neighbouring nodes have to broadcast these changes to all other nodes in the network.
By grouping the neighbouring nodes to from cluster, we propose a solution to the above problems. Specifically, each node of the cluster preserves the QoS data of all the members of that cluster. In this scenario, by increasing the number of nodes will not demand for the amplifying in memory obligation at each node. Also the algorithm can converge faster. Within the cluster each member preserves a QoS parameter table and a gateway table. If a node can be added or deleted from the cluster the cluster maintenance algorithm dynamically updates the QoS parameter table [1].

2.5. Dynamic Clustering Algorithm

To provide scalability and to improve the availability, the network is divided into separate Clusters. Every cluster has exactly one cluster head, which is responsible for organizing and establishing the cluster.

Clusters are formed using a Dynamic cluster creation algorithm which is given below, and each cluster head keeps a QoS parameter table (about its cluster members) and a gateway table. Cluster-head voting algorithms are used to select the cluster heads [1]. Communication with adjacent clusters is possible by the Gateway nodes. Some routing protocols in ad hoc networks are proposed based on clusters or zones. Routing can be divided into two forms: Intra-cluster routing (within the cluster routing) and Inter-cluster routing (routing within different clusters).

The following figure demonstrates the dynamic clustering algorithm. Based on the location of the mobile nodes, non overlapping clusters are created. The nodes are grouped together based on their location. Nearby neighbouring nodes are formed into a cluster. The algorithm automatically terminates by leaving only the farthest isolated nodes as non members.

1. S: set of ID's of neighbors based on the hop count including the current node ID.
2. if (id_curr = = minimum(S)) cluster_id = cur-id;
   forward set S (id_curr, cluster_id, loc, bw, delay, jitter, buff_size) to all nodes in the Set S

   S = S - {id_curr};
3. while (S != empty)
   on receiving neighbors(id, cid, loc)
   if ((id = = cid) && (cluster_id = = UNKNOWN || cluster_id > cid) && (md = = NOTSET or md > (cur_loc - loc))
   cluster_id = cid;
   md = diff(cur_loc - loc);
   S = S - {id};
   if (id_curr == min(S))
   if (cluster_id = = UNKNOWN) cluster_id = id_curr
   forward set S (id_curr, cluster_id, loc, bw, delay, jitter, buff_size) to all nodes in Set S
   S = S - {id_curr};

Fig. 2 Dynamic Clustering Algorithm

2.6. QoS Aware Route Table Construction Process

QoS requirements of a member are exchanged with its neighbouring nodes while sending the cluster ID to the next nodes. So no additional packet transfer is required for the exchanging the QoS parameter values within a single cluster. Every node keeps a QoS aware routing table and a gateway table. Using the QoS values received at the time of the cluster formation procedure, the QoS aware routing table is built. The QoS parameter table entries comprise of:

- Destination Address
- Bandwidth
- Delay
- Jitter
- Buffer size.

Using the QoS parameter table information, the QoS aware path can be revealed if the source and destination nodes are within same cluster. The gateway nodes send the packets through the best possible path to the destination, if the sender and receiver nodes are in different clusters. Clusters are generated based on the bandwidth and delay factors of each link. So, by using their local cache data, middle gateway nodes will discover the QoS aware path.

A new mobile node probes its neighbourhood. Upon listening the probe, the node sends its identification along with its number of members of its cluster. The new node computes the fitness parameter f(i), based on the strength of the cluster and the distance factor, as

$$f(i) = n(i) + dist(cur\_loc - loc),$$

where
n(i) is the strength of the cluster i,
cur_loc is the location of the node and
loc is the location of the next node.

The new node which wish to join the cluster with minimum f(i) sends its QoS values to the matching member. After that the cluster member sends an UPDATE ROUTE message to all other members of the cluster (as a multicast packet).

After a member becoming a gateway node, it sends this information to the other members of the cluster. The QoS parameters of the other gateway members are maintained by each gateway node.

4.CONCLUSIONS

Plenty of research has been tackling a variety of topics associated with MANETs. Routing plays a vital role in MANET's performance. One of the related topics is QoS aware routing protocols.

Many cluster based hierarchical algorithms have been proposed for improving QoS Parameters in the ad hoc networks.
In this paper, we provided basic concepts about clustering, which include the definitions of cluster, dynamic clustering, Quality of Service, and QoS requirements, etc. The need for clustering and the techniques for improving Quality of Service in dynamic MANETs, and various QoS aware Schemes were discussed.

Readers can have a comprehensive understanding of MANET QoS, with this survey, especially those schemes discussed in this article. Even though each scheme is well suitable for certain situations, it is not guaranteed that any one of them can be implemented for all situations. So, for providing efficient Quality of Service in MANETs, there is a concrete requirement to propose new architectures and services for regular network controls. This paper can facilitate a study which gives several Hierarchical techniques that improve QoS in MANETs.

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