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Optimizing Bandwidth Utilization in Mobile Ad hoc Network

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Abstract —

Mobile ad hoc networks (MANETs) represent complex distributed systems that encompass wireless mobile nodes that can freely and dynamically self-organize. With the rising progress of real-time and multimedia applications, there is a necessity to provide bandwidth and delay guarantees. Available routing protocols for QoS ad hoc, select path guaranteeing delay and/or bandwidth, but don't deem throughput optimization. This results in a low number of admitted real-time and multimedia flows. The difficulty of calculating bandwidth guaranteed paths for the flow requests in an ad-hoc network is complex because neighboring links share the medium and present the Ad-Hoc Shortest Widest Path (ASWP) routing problem in a network context. In this paper, a Bellman-Ford Distributed Algorithm and k-shortest path approach is used to deal with the ASWP problem. A TDMA-based routing protocol is implemented to meet delay and bandwidth requirements while optimizing network throughput for providing the quality of service.

Keywords— ***MANETs, Quality of Service (QoS), Delay and Bandwidth guarantees, Throughput, Bellman-Ford Distributed***
Algorithm (BFDA)

I. INTRODUCTION

A mobile ad hoc network (MANET), sometimes called a mobile mesh network, is a self-configuring network of mobile devices connected by wireless links. It refers to a multihop packet based wireless network, composed of a set of mobile nodes that can communicate and move at the same time, without using any kind of fixed wired infrastructure. Each device in a MANET will change its links to other devices frequently and is free to move independently in any direction. Each node is a router that can forward traffic unrelated to its own use. The principal challenge in constructing a MANET is to equip each device to continuously maintain the information required to route traffic.

Routing in MANET is tough because of the limitation on the transmission bandwidth battery power and CPU time and the requirement to cope with the frequent topological changes resulting from the mobility of the nodes. Nodes of a MANET cooperate in the task of routing packets to destination nodes since each node of the network is able to communicate only with those nodes located within its transmission radius R, while the source and destination nodes can be located at a distance much higher than R.A first attempt to cope with the mobility is to use the specific techniques aimed to tailoring the conventional routing protocols to the mobile environment while preserving their nature. For this reason the protocol designed around such techniques are referred to as table-driven or proactive protocols. To guarantee that routing tables are up to date and reflect the actual network topology, nodes running a protocol continuously exchange route updates and recalculate paths to all possible destinations.

The characteristics of MANETs differentiate them from other types of wired or wireless network. Mobile ad hoc networks have no separate routers. The devices have limited transmission range. Nodes need to cooperate to forward packets of one another towards their final destinations. The devices used to form such a network are often operated through batteries whose power is limited; Nodes may move about randomly, therefore, existing links between nodes may vanish and new links may be formed.

The rest of this paper is organized as follows: Section II surveys prior work related to this project. Section III presents the design of the proposed architecture. Section IV describes an implementation of the BFDA based Java Swing. Section V produces an experimental results and Section VI Conclusion.

II RELATED WORK

Providing QoS guarantees in MANETs is a very challenging task. A large body of related work exists to provide the QoS in MANETs. It is based on three metrics of each path, end-to-end delay, bandwidth and the number of neighbors of all the nodes included in the path. A TDMA based bandwidth reservation protocol that can reserve routes in a MANET to address both the hidden and exposed terminal problems.

A novel algorithm, Ad-hoc On-demand Distance Vector Routing (AODV), is used for the operation of infrastructureless networks. This scalable approach provides quick response to link breakage in active routes. An Optimized Link State Routing protocol (OLSR) is proposed for mobile wireless networks which are dense. This link state algorithm based protocol is proactive in nature. It is used to reduce the number of retransmissions to flood the messages in entire network. This protocol is adapted, where the communication is assumed to occur frequently between a large number of nodes.

QoS routing protocol is used to address both hidden and exposed terminal problems and enhance the guarantees for bandwidth reservation using multiple node-disjoint paths between a given source and a destination. An on-demand bandwidth reservation QoS routing protocol is to deal with TDMA-based multihop MANETs. It is used to guide the destination, choose the route for satisfying the QoS requirements and also to address the bandwidth calculation problem and bandwidth reservation problem effectively.

The main drawback of the existing systems that we have discussed above is, guaranteed bandwidth and delay, unoptimized throughput, bandwidth reservation problem, hidden problem and exposed-terminal problems. The proposed work aims to minimize the delay, maximize the bandwidth and provides optimum throughput.

III ROUTING ARCHITECTURE

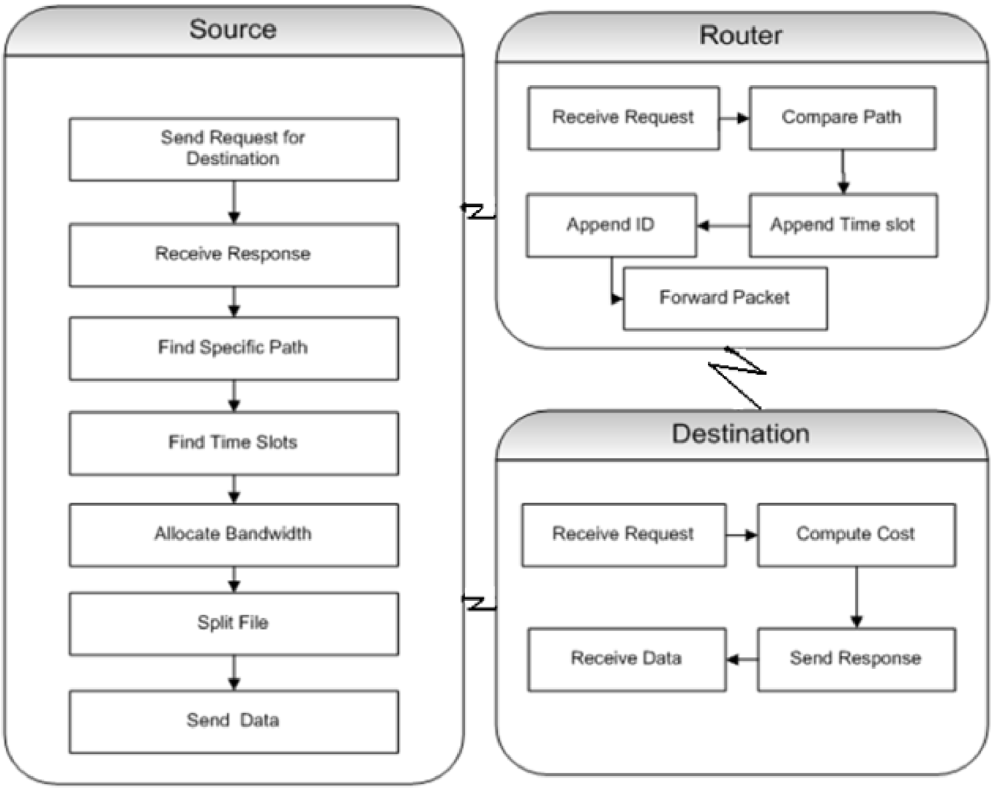

Fig.1 Routing structure in MANET

A MANET contains a set of mobile hosts which can communicate with one another and roam around at their will. A MANET is characterized by its fast changing topology. Some QoS (Quality of Service) issues related to it are guaranteeing bandwidth, delay and thereby enhancing the throughput. In MANET, routing has two procedures. There are Route construction and Route maintenance.

A. Route Construction

During the route discovery, weight function is used to determine the best path. Route discovery and maintenance procedures use three metrics for each path: End-to-end delay, Bandwidth and the number of neighbors of all the nodes included in the path. Each node maintains two tables. They are Routing table and Reverse routing table. It maintains information to reach the destination and also forward the route confirmation from the destination to the source.

B. Source node algorithm

Once sets the path the source nodes checks the bandwidth availability and also depend upon receiving a response packet (RREP). Then, the source node allocates time slots before starting data packet transmission. If no response is received within a fixed time, the source node resends another RREQ (Route Request) packet. A time slot *s* is allocated to send data from a node *x* to a node *y* if the following conditions hold:

1) Slot *s* is not scheduled for receiving or transmitting in both nodes.
2) Slot *s* is not scheduled for receiving in any node *z* which is a 1-hop neighbor of node *x*.
3) Slot *s* is not scheduled for sending in any node *z* which is a 1-hop neighbor of node *y*.

C. *TDMA based routing protocol*

TDMA (Time Division Multiple Access)-based MANETs nodes use their reserved slots to transmit data. This protocol selects bi-directional links for routing, hence avoiding packet transfer over unidirectional links.

D. Intermediate node algorithm

Receiving a RREQ packet, each intermediate node forwards such a request if it meets the QoS constraints. Intermediate node checks if the route included in the request is better than previously received request for the same couple of source and destination nodes. The node updates the reverse path and inserts its transmission-free slots and it's Id in the request if the path weight is better than the already known path weight and if it has sufficient free time slots to fulfill QoS constraints.

E. Weight function

To enable selection of the best path, intermediate nodes compute a cost function to decrease the impact of paths on the network. Path selection must meet the delay requirements and minimize the neighbor number. The path with the lowest weight is selected by the destination.

F. Destination node algorithm

For each received RREQ packet, the total cost of the path is computed by the destination node. The latter maintains a timer for waiting RREQ packets. When the timer expires, the destination node selects the least-cost path. Then, it sends towards the source node a route reply packet (RREP) carrying the list of slots to reserve for the selected path.

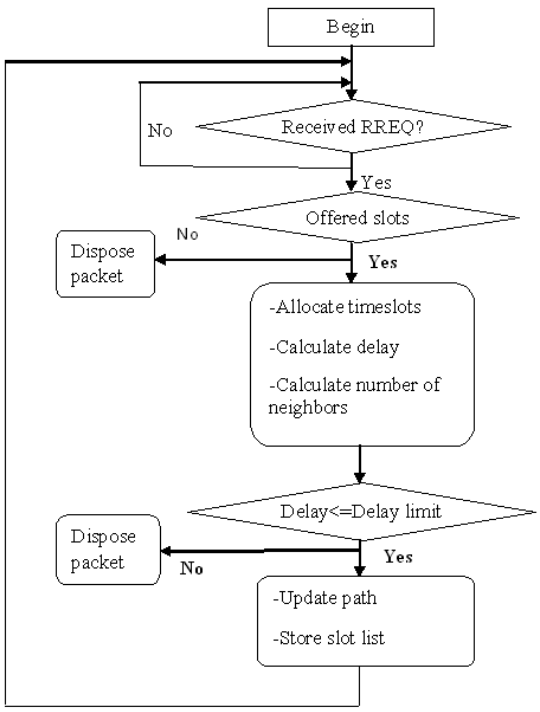

Fig. 2 Destination node algorithm

G. Route Maintenance

Route breakage and degradation of QoS may result due to node mobility. Thus route maintenance is of vital importance for QoS routing in MANET. It follows a simple route maintenance method. Broken route is detected by the upstream node (closer to source) in case of node movement. The upstream node on the route will send a RERR (Route

Error) packet to the source if the existing QoS route is broken. When the connection timer expires downstream nodes release the time slots.

IV IMPLEMENTATION

Data transmission is initiated with the intension of the source node to send the data to the destination node. The usage of BFDA algorithm in the proposed approach is to select the optimum path for the data transmission. The features of BFDA include a path with lowest number of neighbors, link capacity of nodes and optimum cost for hops. The usage of BFDA and K-shortest path approach enables us to result with a shortest and widest path. The best path is being determined by both availability of bandwidth and lowest number of neighbors. As a final process, the TDMA protocol is applied to transmit the data by forming time slots.

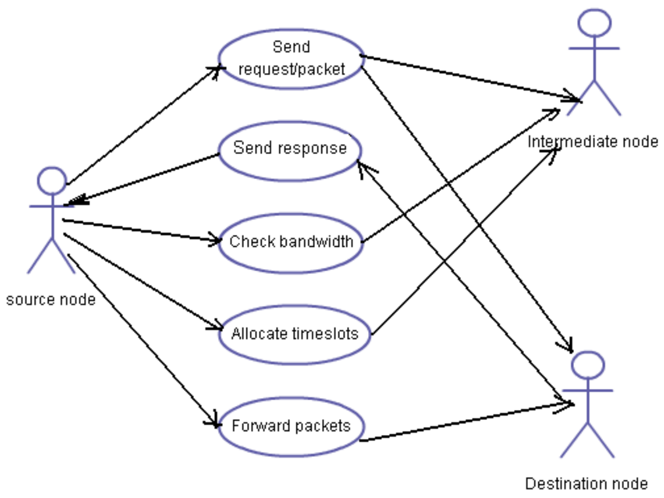

Fig. 3 Use Case between nodes

A. Implementation of Bellman-Ford-Ford distributed algorithm

Bellman-Ford Distributed Algorithm is implemented to define the path. This algorithm computes single-source shortest a weighted digraph.

Input: Number of nodes in a graph is considered as an input.

Output: Find a shortest-widest path between nodes

Steps for implementing BFDA:

Step 1: Select one node in graph
Step 2: Place all arcs connected to that node in set of "available choices"
Step 3: Place all other nodes and arcs in set of "unavailable choices"
Step 4: Repeatedly select an arc from "available hoices".
If it leads to an "unavailable" node,
add that node and arc to the graph,
Add all other arcs connecting to the new node to "available choices" Otherwise, discard the arc.
Step 5: All nodes get included in the graph
Some arcs may be left over.

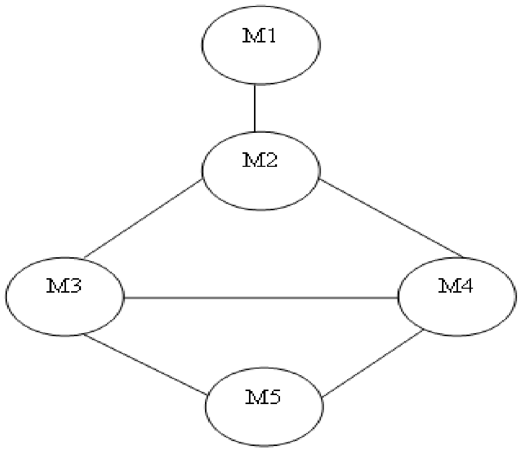

Fig. 4 Construction of nodes using BFDA

In this figure consider the mobile nodes M1, M2, M3, M4 and M5.These nodes form the network. By using BFDA, the shortest path between nodes is defined.

Sample Code

```
 public String BellmanFord(Vector AvailablePath)
{
  int Count=AvailablePath.size();
  int ShortesPath=Count-(Count-1);
return jList1.getComponent(ShortesPath). toString();
}
```

The following diagram shows the flow of data between the nodes in the network. The entities are source node, destination node and other nodes(router). The source node sends the request/packets to the destination node through all possible intermediate nodes. It is done based on the total cost of the path calculation defined by BFDA and k-shortest path approach.

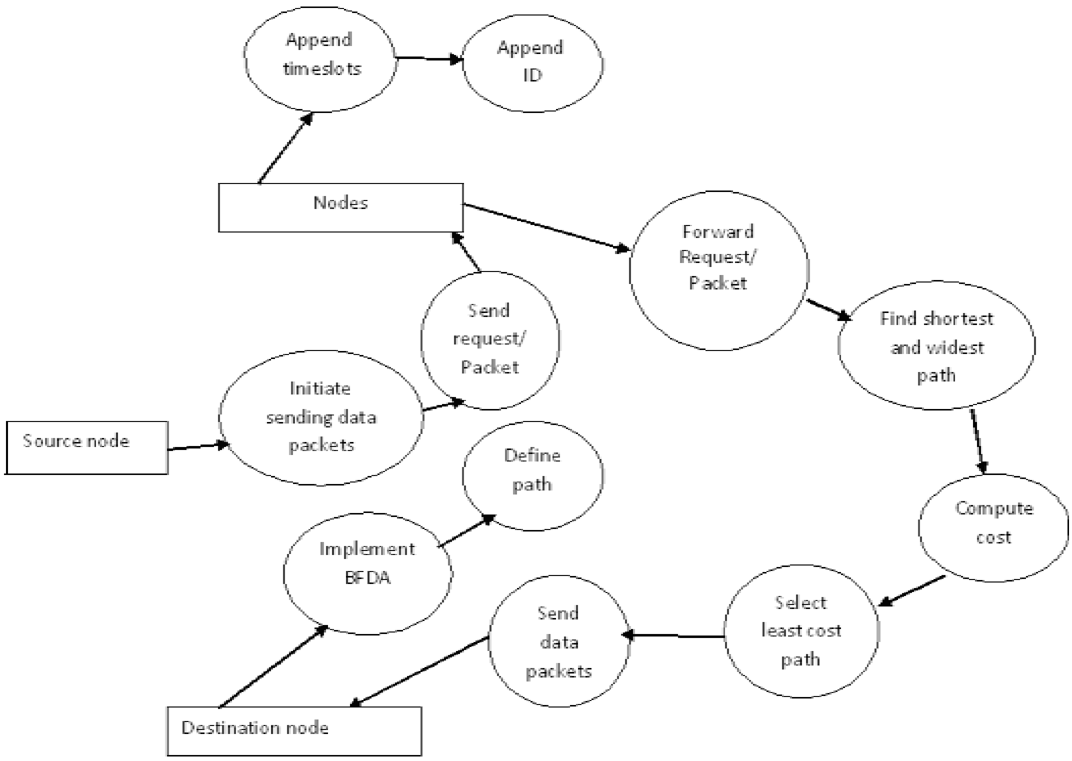

Fig. 5 Data flow between nodes

V EXPERIMENTAL RESULTS

Implementation of the concept is performed using Java Swing with Wi-Fi connection. In node creation, the source node, intermediate node and destination node created.

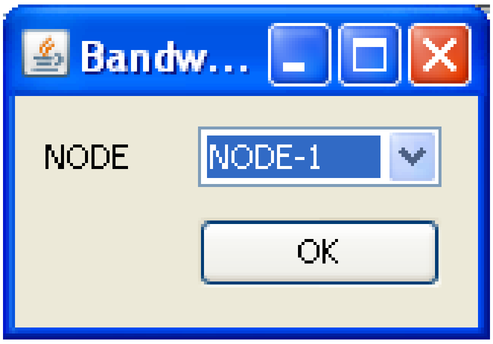

Fig. 6 Node Creation

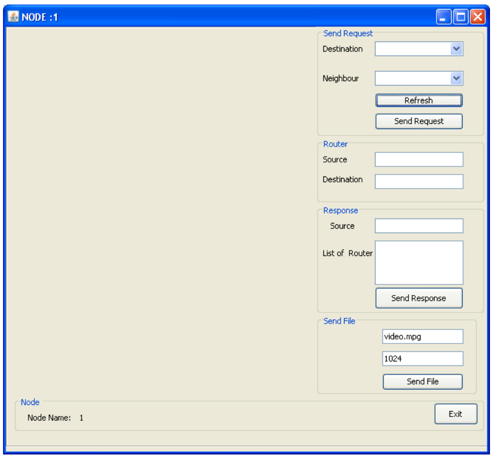

Fig.7 Routing Formation

In routing formation, the information on how data packets are received and forwarded to nodes is defined in routing table.

Fig. 8 Response from Destination

This figure defines the acknowledgement sends from the destination node to the source node.

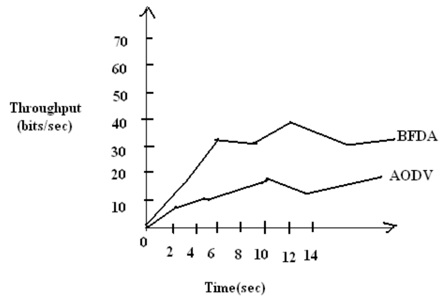

Fig.8 BFDA Vs AODV

Comparison is made between AODV (Ad-hoc On-demand Distance Vector Routing) and BFDA (Bellman Ford Distributed Algorithm) by considering throughput (Kb/sec) and time (Sec).The parameters used: Number of nodes-3, Transmitter range-11 Mbps, Packet size-200 bytes, Packet rate-Depends on TDMA time slot and Traffic rate-Constant Bit Rate.

VI CONCLUSION

In mobile ad hoc network the QoS routing is important. Here the source node sends the RREQ message to the destination node through the all possible intermediate nodes and their destination node will choose all possible paths. For each received RREQ message, the total cost of the path is computed by the destination node. Then, it sends towards the source node a RREP carrying list of slots to reserve for the selected path. Upon receiving a RREP message, the path is setup. Then, the source node allocates time slots before starting data packet transmission. The weight function determines the best path. BFDA algorithm is used to select optimum path .TDMA protocol is applied to transmit the data. The route maintenance is provided by using RERR message. Thus the optimization of bandwidth and QoS in mobile ad-hoc network can be achieved by implementing this approach.

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