Multipath Routing Algorithm for Multimedia Applications in Ad Hoc Wireless Networks

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Abstract: In the next years, one of the most significant technological developments that will lead to the new broadband wireless generation is the communication via Multiple-Input Multiple-Output (MIMO) systems. MIMO systems are known to provide an increase of the maximum rate, reliability and coverage of current wireless communications, without additional bandwidth or transmit power.

Keywords- *MIMO systems, MIMO detection, coordinated MU-MIMO, SCM, SNR*

I. INTRODUCTION

The ability to communicate from anywhere and at any time is mankind's dream for a long time. Wireless is the only medium that can fulfill this need. With the recent advances in the technologies and the mobility of the wireless systems it is possible for "anyone, anywhere, anytime" paradigm of mobile ad hoc network to become reality.

For any multimedia application the Quality of Service (QoS) parameters are the Bandwidth, Jitter and Delay. The task for QoS provisioning becomes more challenging when it comes for the ad hoc wireless networks due to the dynamically changing topology. The routing protocol available such as AODV, DSR and DSDV does not provide any guarantee to be used for multimedia application. AODV protocol provides single path and is on-demand. It requires periodic updates of the adjacent neighbors. DSDV protocol provides single path and periodic updates whenever there is change in routing table. DSR protocol is based on source routing, suffers from the scalability problem.

Multimedia applications place stringent requirements on networks for delivering multimedia content in real-time. Compared to the requirements of traditional data-only applications, these new requirements generally include high bandwidth availability, low packet loss rate, and a low variation in packet delivery time [9]. Unfortunately, in a wireless environment, no guarantee on these requirements can be safely made in the fact of mobility. Therefore, in order to maintain same level of acceptable quality over such networks, needed is to take a new look at QoS support.

The main focus of this new proposed research paper is to reduce the delay that incurred in the AODV and DSR routing protocol and to decrease the packet loss ratio that incurred in the DSDV routing protocol. This protocol is based on on-demand basis. Delay is reduced by establishing more than one path to destination and transmitting the packets to the path where the hop count is less than other available paths. The packet loss ratio is decreased by controlling on the dissemination of control information into the network, which has higher priority than the data packets.

This new protocol will be implemented in NS-2. This protocol discovers multiple paths towards destination and the packets are transmitted to path where hop count to reach the destination is less. Delay is also reduced in terms of time needed to find a new path to the destination when the link breaks which occurs in other routing protocols like AODV and DSR. This work will also support concept of operating system as well as intelligent algorithms in high performance network.

II. LITERATURE SURVEY

Mobile Ad Hoc Networks are characterized by constantly changing network topology and the absence of central coordinator. The absence of central coordination results in the node to be acted as the router and all other functions required from transmission to receiving.

Routing is the key to efficient operation of MANETs. For this efficient operation routing is the one of the main operation that can handle different challenges of the MANETs such as the mobility pattern, time varying topology, imprecise state information, bandwidth constrained links, scalability of the network and many more.

Thus for the efficient operation of the MANETs the following features are required in the routing protocol.

- It should be scalable to increase the reliability and availability i. e. to reduce the chance that any node is isolated from rest of the network.
- Adaptive routing algorithm should be used for adjusting with the frequent changes in the topology, radio propagation and network conditions [11].
- The routing protocol should be of low overhead because of the scarce resources of the wireless network.

A. Routing Methods

Each node in the mobile ad hoc networks maintains a preferred neighbor for the destination through whom it transmits the data packets. The forwarding of these packets continuous until the packet reaches the destination. The manner in which the routing table are constructed, updated or deleted of the entry differs from one routing method to another. This research paper mainly concerns about the next hop routing mechanism so the methods for the next hop routing methods are described.

1) Link-State
2) Distance Vector
3) Routing Protocols

The three different routing protocol AODV, DSDV and DSR are studied and compared the performance. All these routing protocols are for the MANETs. The operation of these routing protocols differs in their routing algorithm and the maintenance of the routing table. This protocol has been proposed for solving the multi-hop problem in ad hoc wireless network. There are two types of routing differ in routing table building for the ad hoc network (1) Table Driven [5] e. g. DSR. (2) On-demand [5] e. g. AODV, DSDV, DSR

- In AODV routing protocol the source first find the destination and then sends the packets with the same route even if the node is first five nodes away reaches to it until the route breaks. The drawback found is that even if the shortest path is available after the route request i. e. when the destination node comes nearer to the source node the packets are transmitted through the longer route.
- In DSDV (Destination Source Distance Vector) routing protocol routing messages are exchanged between neighboring mobile nodes (i. e. mobile nodes that are within range of one another). DSDV is a proactive or table driven routing protocol. That is the protocol maintains a correct route to any node in the network. The DSDV routing algorithm is based on the idea of the classical Bellman-Ford Routing [14], with some major improvements to make it suitable for wireless schemes and specifically solve the count-to-infinity problem.
- 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 mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to

arbitrary destinations in the ad hoc network [14].

B. Comparison of Protocols

The difference between the three protocols can be seen in the results: The scenario for the network is given below:

- Area = 670 x 670 meters
- Node movement = Random
- Packet size = 512 bytes for constant bit rate
- Number of connection = 8

Table 1
Comparison of AODV, DSR and DSDV Routing Protocols

Parameters	**AODV**	**DSR**	**DSDV**
No. of Nodes	30	30	30
Mobility Max	20	20	40
Packets Type	CBR	CBR	CBR
Packets Sent	3577	3585	3578
Packets Received	3566	3577	2103
Packets Dropped	11	7	1467
Efficiency(%)	99. 69	99. 77	58. 77
Avg Delay(ms)	27. 4615	112. 706	15. 4584
Min Delay(ms)	5. 449	5. 4495	5. 449
Max Delay(ms)	1985. 16	7963. 78	216. 192

As shown in above Table 1, 1 the comparison is mainly on the throughput and the delay incurred during the packets transmission. The simulation testbed is of area 670 x 670 and the number of nodes used during the simulation is 31.

From the results it can be clearly seen that the maximum packets are dropped in DSDV protocol and then comes the AODV followed by DSR. In DSDV the packet dropped are 1467, in AODV with 11 and DSR with 7 only. So it can be concluded that the application where packet loss constraint is present it is better to use DSR or AODV protocol than using DSR protocol. The packet drop in DSDV routing protocol is due to the control information of the network that is transmitted more than that of the AODV and DSR routing protocol.

From the results it can be concluded that the application whose packets loss ratio are more stringent to QoS than DSDV cannot be used. In that case either AODV or DSR can be used where packet loss is very less. In case if the application that are more stringent to delay for example conversation voice, where some of the packet loss doesn’t make any difference than DSDV protocol can be used. From the conclusion it is required to have a new routing protocol that is having the packet loss ratio less than that of DSDV routing protocol and the Delay parameter to be less than that of AODV and DSR routing protocol.

C. Issues and Challenges in Manets

Providing QoS support in Ad Hoc Wireless Networks (AWNs) is an active research area. AWNs have certain unique characteristics that pose several difficulties in provisioning QoS [5]. Following are some of the challenges faced by MANETS.

- Dynamic topology
- Imprecise state information
- Lack of central coordination
- Error prone shared radio channel
- Hidden terminal problem
- Limited resource availability
- Insecure medium

D. Design Choices for QOS SUPPORT

Since the absolute QoS is very difficult task as far as the MANET is considered, the next subsection introduces what the QoS and the framework for the QoS in MANET.

Hard state vs. soft state resource reservation

Stateful vs. stateless approach

Hard QoS vs. soft QoS approach

Table 2
Data Rate and Delay in Transmission

Multimedia	Application	Typical Data Rate	Delay
Audio	Conversation voice	4-64 kbps	<150 ms
Audio	Voice messaging	4-32 kbps	<ls for playback & <2s for recording
Audio	High quality streaming audio	16-128 kbps	<10s
Video	Video phone	16-384 kbps	<150 ms preferred <400 ms limit
Video	One way	16-384 kbps	<10s
Data	Web browsing	~10 kbps	Preferred 2 s per page Acceptable 4 s per page

E. Comparison of Multimedia Applications

As this research paper is concerned about the multimedia traffic in the Mobile Ad Hoc Network the key parameters that should be satisfied are specified in table 2.

F. Routing

The bandwidth reservation and real-time traffic support capability of MAC protocols can ensure reservation at the link level only, hence the network layer support for ensuring end-to-end resource negotiation, reservation, and reconfiguration is very essential [5]. QoS is very difficult in ad hoc network because of the dynamic network topology and the wireless medium that is shared by many nodes.

III. PROBLEM STATEMENT

The transmission of real-time, multimedia or any type of data to the wireless medium introduces many technical obstacles. The protocols available for the wired medium cannot be easily migrated to the wireless network because of the error-prone medium and the mobility of the devices. This is true for Mobile Ad Hoc Networks (MANETs) where mobile devices move in an unpredictable manner and at arbitrary time with random mobility.

Video or multimedia transport over wireless ad hoc networks is a challenging subject, since the wireless links are unreliable and have limited bandwidth. Typical multimedia applications, such as streaming, may require higher reliability connections than that provided by a single link. In a network consisting of mobile nodes, the connection between a source and destination may break down and has to be updated regularly. Although, when a path fails, one could switch over to an alternative path; this may take an unacceptably long period of time, causing a temporary disruption in the multimedia signal. Instead of transporting a multimedia stream through a “single” communication pipe, the stream is split up into multiple sub-streams, each of which takes a separate route through the network. At the destination all sub-streams received properly are merged in a clever way.

In this proposed research the network layer protocol for the transmission of multimedia data is focused more. The main idea is to provide continuous connection to the destination even when the path breaks. Continuous connection is provided by establishing multiple paths from source to destination, so that when one of the paths breaks than also other paths are available through which the data can be transmitted.

Unlike traditional protocols that will choose a single path through the network, the protocol used must deliver multiple paths from a source to a destination. Also, the Quality of Service (QoS) aspects of each path (e. g. delay, bandwidth, and cost) must be taken into account. Finally, care must be taken that the different routes do not share nodes other than the source and destination nodes.

The advantages of this are given below

First, multipath transport distributes traffic load in the network more evenly. For example, a large burst of data, e. g. , an Intra or I video frame, can be partitioned into several smaller bursts, each transmitted on a different path. A high rate video can be partitioned into several sub-flows, each with a lower rate and sent on a different path. Such balanced load results in less congestion inside the network. Thus the video packet losses caused by router buffer overflow can be effectively reduced.

Second, Multipath transport provides a larger aggregate capacity for a multimedia session. In an ad hoc network, since the available link bandwidth may be limited and time varying, a high rate flow may not find enough available capacity on a single path. With Multipath transport, the flow can be partitioned into several thinner sub-flows, each of which can be accommodated by a path.

Third, if a set of disjoint paths are used in Multipath transport, losses experienced by the sub-flows may be independent to each other. When a path is down because of a link failure, which happens more often in an ad hoc network than in a wired network, it is likely that some other paths are still in good condition. Thus the receiver can always receive some data during any period.

IV. IMPLEMENTATION

The Quality of Service is a challenging task for any type of network whether it is wired or wireless. The task becomes even more challenging when it comes to the mobile ad hoc network. The proposed research contribution is to provide at least minimum QoS requirements for the multimedia application. The brief introduction to the new routing protocol for the multimedia application is given below.

When stared the research, the routing protocols that were commonly used were AODV, DSR and DSDV. With the studies of these routing protocols and looking at the advantages and the disadvantages a new routing protocol for multimedia application is to be designed. As the DSR lacks in scalability, and the AODV with the control packets dissemination into the network, a new multipath routing using the AODV approach for the routing table update mechanism along with route discovery and maintaining the continuous path from source to destination.

A. Maintaining The Neighbours

In the distance vector routing algorithm the neighbor's list are maintained and the packets are transmitted by multi-hop using the neighbor information. This neighbor information is not permanent because of the dynamic nature of the mobile ad hoc network [4]. So the information that is in the neighboring table is to be updated periodically. The periodic updates of these neighbors are done with the hello packets. The hello packets are broadcast by every node in the network with the ttl set to 1. The ttl value of 1 indicates that the hello packet should not travel in the network for more than 1 hop. As shown in the figure 1 the hello packets are transmitted to all the neighbors which are in the direct range of the node 1 and then the table for the neighbours at different nodes is shown in the figure 1

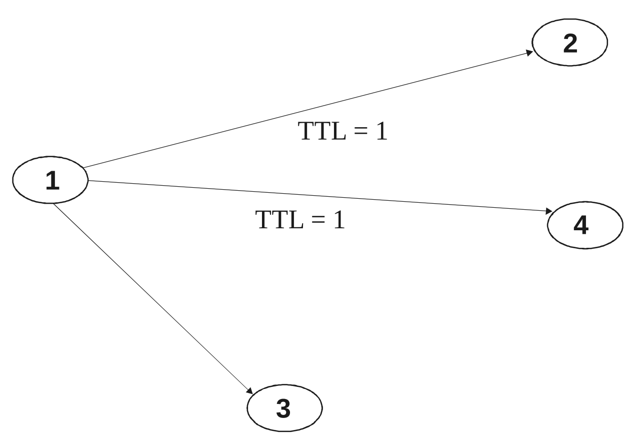

Fig. 1 Hello packet transmission

B. Request For Route

The request is made by the node whenever the node does not find any entry or the routing table entry for the destination to which it has to send the packets are not more than one so, we can have more than one route at any time. This topic is about how to handle the request at the source, intermediate and the destination node when the request packet is to be sent, the routing table and ID table entries made at these nodes

C. Forwarding Packets

Whenever there is data to be sent and the route is available, the data is forwarded. During the request when forwarding the packets, it will change the source IP address of the packets so that the node receiving the packets can update the routing table for the next hop address. This is only added when the reverse route is to be built up. The other fields update is increase the hop-count by one, decrease the TTL field, etc.

D. Maintaing Local Connectivity

Each node should continuously keep track of its continued connectivity to its active next hops. The node maintains the local connectivity by the network or the link layer mechanism.

Here the link layer is used for the connectivity of the next hop. This is provided by the IEEE 802. 11 [5][8]. The absence of the ACK or failure to get CTS after sending the RTS even after the maximum number of retransmission attempts indicates the loss of link to the next hop.

The node not getting the RTS will now send error message to the network about the failure of the link. All the nodes receiving will now delete the entries from the routing table whose next hop is the source address of the error message. The node after deleting the entry will now forward the message to other nodes and so on until it reaches to the source node of the data packets that is transmitting the packets.

E. Actions After Reboot

A node participating in the ad hoc network must take certain action after reboot as it might lose all sequence number records for all destinations, including its own sequence number. However, there may be neighboring nodes that are using this node as an active next hop. This might create routing loops. To prevent this, the node does not transmit any control packets until the fixed interval that is DELETE_PERIOD. When the node receives any control packets like hello, request or the reply packet, the will update its routing table entries. When it receives any data packet, it will broadcast an error message to the network, so the source node knows about the failure of the link.

F. Timers

Timers are used when any regular execution of certain event or function is desired. The timers used in the protocol are the hello timers, Neighbor timers, Route Cache timers, and Broadcast ID timers.

In this section the complete protocol implementation is described starting from when the data packets arrived and the initiation of the request for the destination is handled. The flow chart of this protocol is shown in the figure below.

The flow chart as shown in Figure 2 shown the implementation of the protocol from the start when the data comes at the nodes and the node sends the request to the destination.

When the data comes to the node, if it is the source node than it first sends the route request to the destination. Before forwarding is done by the source node it adds the routing table entry for the destination, BroadcasMd, expire time and the other information that are required in the routing table. The ID management table is also added with the required information. In case of the routing table the flags which are used to indicate whether the route to the destination is active i. e. it can transmit the data packets to the destination by this route are set to DOWN. DOWN here means that the route is not available currently only the routing table entry is made. In case of ID management table the information for the source and destination are added along with ID and the recv_reply flag is set to false i. e. the reply has not been received for this source-destination request packet.

When the request reaches to the intermediate node the node first adds the reverse route to the source i. e. the routing table entry for the path towards the source. It than adds the ID table entries with the recv_reply Boolean as false, this says that the reply is not received for this entry. The intermediate node then broadcast the request packet into the network with hop count incremented by one. The intermediate node also adds the entry in the routing table with the destination address and hop count to Infinity. Along with all these entries there are also entries made for the expiration of the route. This expiration field is only used for the ad hoc network since the node move now and then so the topology changes every time. So for any entries made in the database of the node is associated with the expire field.

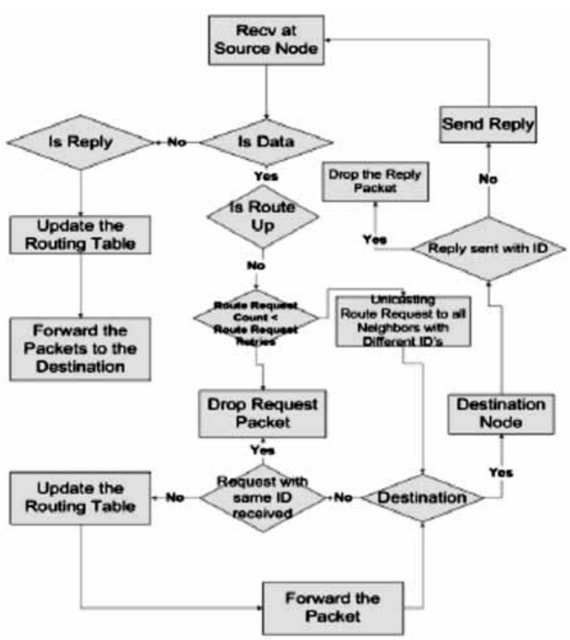

Fig. 2 Protocol flow chart

When request reaches to the destination the destination node sends single reply for each id that is associated with the request packet i. e. if two requests come with the same id, the destination node replies only for one request. This is to maintain the routing table information consistent. The destination node replies with the reply packet with the fields fill with the information. This information includes the request source, id, hop_count, sequence number, etc. The destination also adds into the ID management table with the reply sent equal to true.

When the reply is received at the intermediate node the intermediate nodes update the routing table as well as the ID table from the reply packet. The ID table entries for the recv_reply are set to true so that the other entries from the same source is not to be handled by this intermediate node. The routing table entries are also updated with the routing flag set to UP if it is DOWN. When the routing flag is UP than the packets can be transmitted by this route because now the route is active.

When the reply reaches the source node of the request packet, the node first updates it ID table and than the routing table. The ID table is similarly updated as the intermediate node i. e. the recv_reply flag which was set false when the request was made is set true. The routing table is updated by setting the route flag to UP, after the update if there are packets in the queue waiting for the transmission whose destination is in the routing table and the route flag is UP are transmitted. The route is now valid until the source, intermediate and the destination node are within the range of each other.

This protocol searches for the multiple routes for the destination. All the routes are with the different ID's. The ID is the only field that can differentiate the routes towards the destination. The ID's are unique for all the nodes. Means there is no central administration that maintains the ID's. When the reply is received by the source node the packets are transmitted to all the routes or can be transmitted to the single route whose hop count is less than all the routes that are available.

For the experiment purpose of this research paper NS2 (Network Simulator 2) has been used. NS2 is a discrete event simulator targeted at networking research. NS provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks.

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