MULTIPATH QOS AWARE ROUTING PROTOCOL FOR ADHOC NETWORK

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ABSTRACT

Packet delivery ratio, delay, throughput, routing overhead etc are the strict quality of service requirements for applications in Ad hoc networks. So, the routing protocol not only finds a suitable path but also the path should satisfy the QoS constraints also. Quality of services (QoS) aware routing is performed on the basis of resource availability in the network and the flow of QoS requirement. In this paper we developed a source routing protocol which satisfying the link bandwidth and end –to- end delay factor. Our protocol will find multiple paths between the source and the destination, out of those one will be selected for data transfer and others are reserve at the source node those can be used for route maintenance purpose. The path selection is strictly based on the bandwidth and end-to-end delay in case two or more then two paths are having the same values for QoS constraints then we will use hop as a parameter for path selection.

KEYWORDS

QoS Routing; Mobile Ad hoc Networks; Energy-Aware Routing; Multipath Routing, Node disjoint Routing

1. INTRODUCTION

A wireless ad-hoc network [1, 2] does not require an infrastructure. In ad hoc network mobile nodes form a temporary network and every node will forward the packet to the node, so every node behaves like a router. Mobile Ad hoc network is characterized by Dynamic topologies, Bandwidth-constrained, Energy-constrained and Limited Physical Security. Due to these characteristic routing in ad hoc network is a major issue.

The routing protocols in ad hoc network have been classified as Proactive/table driven e.g. Destination Sequenced Distance Vector (DSDV) [3], Wireless routing protocol[4],Optimized Link State Routing (OLSR)[5], Fisheye state routing (FSR)[6], Reactive/On-demand, e.g. Dynamic Source Routing Protocol (DSR) [**7**], Ad hoc on-demand distance vector [8] , Temporally ordered routing algorithm [9], and Hybrid, e.g. Zone Routing Protocol (ZRP) [10], Distributed spanning trees based routing protocol (DST)[11], , Distributed dynamic routing (DDR)[12].

International Telecommunications Union (ITU) defined a service as "a service provided by the service plane to an end user (e.g. a host [end system] or a network element) and which utilizes the IP transfer capabilities and associated control and management function for delivery of the user information specified by the service level agreement [13**]".**

There is confusion due to the different meaning of the QoS. To clarify the confusion [**79**] gave three notations of QoS: Intrinsic QoS, Perceived QoS and Assessed QoS [**79**]. Network

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architecture and its development, dependability, and effectiveness are related with Intrinsic QoS. If we concern about the view of the end user about a service then it is handeled by the Perceived QoS. a service with the same intrinsic QoS features may have different perceived QoS with different customers.A customer can decide whether to continue using a service or not depend on the perceived quality, service price, and responses of the provider to submitted complaints and problems [79] is relate with accessed QoS.Due to the mobility factors, where node can move from one location to another, topology of the network will change. In this scenario the protocol will execute the route discovery process again to find out the route, that affects the QoS. When a path is discovered between two nodes, resources are reserved for the path. Due to the change in the topology a new path is discovered that also require resources those may be not available or may be reserved for with another path. So change in topology is a big issue to be considered during the provision of QoS. Another challenge is the less number of resources associated with nodes those are involved in the communication over ad hoc network.

By considering the above facts, a protocol that is good for wired or infrastructure base networks will not be suitable for this type of network.

2. Challenges of QOS Routing in AD HOC Networks

In case of Mobile ad hoc networks there are various factors like shared resources. Dynamically change topology, shared channel and availability of limited resources which make it difficult to provide QoS for routing. These are discussed below.

2.1 Dynamically varying network topology

As nodes are mobile in ad hoc network and due to mobility, topology of the network will change. Provision of QoS in such a situation is a difficult job. As there is a loss of QoS, this information should be forwarded to all source nodes whose transmission is going through the victim node. This forwarding mechanism will help the source nodes to execute the route discovery process again to find out another path for data transmission.

2.2 Lack of precise state information

All the nodes in the network share there information to there respective neighbours. This information of the node will change as there is a change in the topology of the network due to the mobility factors.

2.3 Shared radio channel

In ad hoc network nodes have to share channel with there neighbours, so data send by a node will be received by all nodes those are within the range of the transmitter. Due to the broadcasting, interference becomes a big issue that should be taken care of effectively.

2.4 Limited resource availability

There are limited numbers of resources those are available in ad hoc network, so resources management is also a key area that should be taken care of effectively. If we take an example of sensors, those are having very less power so routing with power consumption is not a good area to work on.

2.5 Hidden Route Problem

During the route discovery of a QoS-aware routing protocol we face a hidden route problem. This is due to the consideration of local information by the route discovery procedure of a routing protocol

2.6 Error-Prone Shared Medium:

Congestion is the main reason of loss in wired networks but in wireless networks error-prone shared medium cause losses. Fading is an area that is responsible for loss in wireless network, in which multiple versions of the same signal are received at the destination.

2.7 Lack of Central Control

In ad hoc network there is no center controller that can control MANET's' limited resources, nodes must negotiate with each other to manage the resources required for QoS routes.

3. RELATED WORK

Quality of services (QoS) aware routing is performed on the basis of resource availability in the network and the flow of QoS requirement. Many attempts were made in the past to develop routing protocols that satisfying the link bandwidth and end –to- end delay factor.The multiple Source Routing (MSR) Protocol [14] is a multipath extension of DSR uses weighted round robin packet distribution to improve delay and the throughput.

The past studies focused on the development of enhance data transfer, high route discovery and frequent route discovery of on-demand routing protocols like AODV [1] and DSR [2]. AOMDV [15] is a Multipath extension to AODV. These provide link-disjoint and loop free paths in AODV.

Cross-layered Multipath AODV (CM-AODV) [16] Selects multiple routes on demand based on the signal-to-interference plus noise ratio (SINR) measured at the physical layer. The Multipath Source Routing (MSR) protocol [17] is a Multipath extension to DSR uses weighted round robin packet distribution to improve the delay and throughput. Perkins [18] proposed a QoS version for AODV routing protocol. The main idea behind this protocol was to add extensions to the route messages during the phase of route discovery. When a node receives a RREQ quality of service extension must be checked and if satisfied then node will take a decision to either rebroadcast the RREQ or unicast a RREP to the source.

4. GOAL OF QOS ROUTING

Path selection according to the traffic requirements is the primary objective for a QoS aware routing. It is heavily depend on the information about the network.As Ad hoc network is having a limited number of resources so there should be an effective utilization of the resources to achieve QoS aware routing. When a path is discovered by the QoS routing protocol, it should consume less number of resources. Resource management function manages the availability of resources. As dynamic change in topology is a big threat for routing protocol. So node must maintain the topology information and whenever there is a change in the topology of the network, node must send link state message to reduce the effect of varying network topology otherwise it affects the performance of the QoS routing protocol because of link failure. This is not a case in wired network where link goes down rarel

5. Network Modeled

A communication network is considered as a set v of node s that are interconnected by a set e of link, as in MANET'S nodes frequently change their location so v and e changing over time. We assume that the transmission range of each node is same and the two nodes those are in the transmission range of each other it shows that the nodes are immediate neighbour and there exist an undirected link between them. A node is assumed to keep the up-to-date local link state about its entire outgoing link.

The link state of a link (i,j) include the following.

a) Delay of the link v delay (i,j)
b) Bandwidth of the link v Bw (i,j)
c) Hop count v H(i,j)
d)

The above mentioned information can be better understood by the following formula.

Let P be a path
Delay (P) = delay (i,j) + ………………….. delay (k,l)
Bandwidth (P) = Bandwidth (i,j) + …………. Bandwidth (k,l)

Hop count will simply indicate how many intermediate nodes should be covered by a packet which is generated at source and reached at destination.

6. METRICS USED

The Proposed Protocol will used two metric one is bandwidth and the other is delay

To calculate delay between two nodes we can use the following formula

D (A, B) = T (B) - T (A)

Where T (B) is the time at which packet is received at node B and T (A) is the time at which Packet is send by the node A. End-to- end delay is the time taken by a packet to move from source and the destination.

For bandwidth measurement between a links we can use either hello message method or listen bandwidth estimation.

7. PROPOSED PROTOCOL

Our proposed QoS aware protocol will use multiple QoS constraint to provide QoS guarantee for Ad hoc network. The constraints used for QoS are delay and the bandwidth, and we can use the hop count to provide the short path. This protocol can generate multiple paths out of those only one is selected to deliver the data packet from a source to the destination.

Proposed protocol has three phases:

a) Route Discovery
b) Route selection
c) Route maintenance

BW (i,j)	Available Bandwidth on a link (i,j)
D(i,j)	Available delay on a link (i,j)
H	No.of hop on a Path P(i,j)
B_t	Threshold value for Bandwidth
D_t	Threshold value of delay
P(i,j)	Path between node i to node j

Notation for the network model:

6.1 Route Discovery

Suppose on application wishes to establish a connection between a source ‘s’ and destination ‘d’ with a delay constraint D_t and bandwidth constraint B_t then the following algorithm will be used by source s to discover a path toward a destination d.

1. Source s sends a RREQ packet to its immediate neighbour. The RREQ packet of the protocol contains type field, Source address, destination address, unique identification number, hope field, delay and bandwidth.

   SA (Source address) field: It carries the source address of the node, ID Field: Unique identification number generated by the source to identify the packet. DS (Destination Address) field: It carries the destination address of the node, Hope Field: It carries the hop count; the value of hop count is incremented by one at each node through which packet passes. Initially, by default this field contains zero value. D (delay) field; Indicate the duration of time taken by a packet to move from one node to another node. BW (Bandwidth) field: carries the bandwidth of the links through which the packet will pass. P (Path) field: It carries the path accumulation, when the packet passes through a node; its address is appended at the end of the field. The Fig 1 shows the RREQ packet. Contain the following information.

SA	DA	Type	ID	D	BW	P

   Fig 1: RREQ Packet

   RREQ packet will contain the following values initially, SA=S, DA=D, BW=0, D=0. It indicates that initially the path is null with zero bandwidth and zero delay.

2. Every node maintains a Information table(IT), to keep track of multiple RREQs with following entries Source Address, Destination Address, Hops, Delay, Bandwidth

SA	DA	Hops	BW	Delay

   Fig 2: Node Information Table

   As a RREQ reach at a node it enters its information in the IT. It makes all the entries for the requests till the timer is expiring. After the timer goes off it accepts the request with the highest bandwidth and minimum delay. If these two parameter are same then it use Hope count as a base for acceptance .In the worst case the RREQ will be accept on the basic of first come first serve by doing this we are able to prevent loops and unnecessary flooding of RREQ packets

3. Any node which receive the RREQ packet will do following

   a. It first check its address with the destination address if there is a match then the node check the QoS constraint

If Dealy (P(s,d)) ≤ D_t
And BW (P(s,d)) ≥ Bt then destination node return a RREP to the source that indicate the presence of an optimal path between source to destination.

b. **If** the immediate neighbour is not the destination **then** the immediate neighbour set a timer after receiving a RREQ for the subsequent packets if any, with same identification number, traveling through different path. Then it updates its IT (Information Table) and follows the following algorithm. Let v be the intermediate neighbour then
   - Dealy(P) ← D (P(s,v)) + D (P)
   - If D(P) ≤ Dt
   - And BW(P(s,v) >=BWt then a path with satisfied QoS constraint is found
   - BW(P) ← BW (P(s,v)) + B (P)
   - H ← H+1
   - Then it will update RREQ packet by adding the updated delay, Hope count and bandwidth with the route cache of RREQ by adding a path (s→v) and forward RREQ to its neighbors
 - If the QoS constraints does not match then the immediate neighbour send a RERR packet to source s which indicate that path is found but path is not satisfying the qos constraints.

c. Step b is repeated for each immediate neighbour until a path is found from source to destination until.

d. If source does not get any reply from the destination and timer is expire then source can perform a qos re-negotiation process by making proper changing in QoS constraints value.

6.2 Route Selection

If source gets only one RREP that indicate the presence of single path from source s to destination d and the path is selected for data transfer from source s to the destination d.

If source get more then one RREP it indicate the presence of multiple paths from source s to destination d Then the source node will sort the path in the order of increasing bandwidth and decreasing delay, so path with maximum bandwidth and minimum delay will be accepted for data transfer and others are reserved at source node.

If bandwidth is same then delay will be used for selecting the path and if delay is same then bandwidth is a base for selecting the path if both are same then no. of hop will be used to select the path.

Keeping paths reserve provide flexibility in case of link broken and if source node is aware about the broken link then source node can use alternate path from the paths it reserve.

6.3 Route maintenance

There are two approaches for the route maintenance when a path is established between a source s and the destination d then all the nodes on the path sends hello message to each other after duration if node does not get response from another after sending hello message then it indicates broken of the link. So node send this information to the source node, now if source node still have some data to send then again establish the path by using the route discovery process.

Let P is the path from s to d v

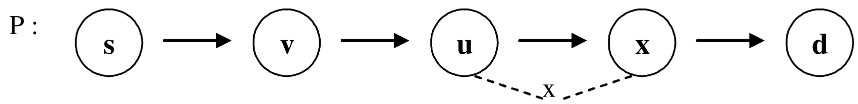

Figure 3: Route Maintenance

If link between u and x is broken u will not get any response from x after sending the hello message then by using its route cache node u will send this information to source s, now s is having multiple path from s to d so s will use path to send data from the source s to destination.
The other approach for route maintenance is to use delay and bandwidth check regularly after some duration source s will send a probe message to destination d to enquire the value for delay and the bandwidth after selecting the path between source s and d. if source encounter any change in the bandwidth or delay that indicate a broken link in between the path so source s will delete this path from its route and select another path for sending data from source s to destination if it has still some data to send.

Figure 4 explain the route discovery process. source Node will send the RREQ packets to the neighbour node,any intermediate node after receving the RREQ packet will check the destination address with its address if a match is found then the intermediate node is the detination node.Intermediate node will update the delay and bandwidth. If bandwidth is more then or equal to the thershoald and delay is less then or equal to the end-to-end delay then it send a RREP packet to the source node .

If the bandwidth and delay constraints are not satisfying then the intermediate node will send a RERR message to the source node which indicate a path is found but not satisfying the QoS constraints.

If the intermediate node is not the detination node then node will update the delay and compare it with the delay thershoald if it is less then the thersholad then node will compare the bandwidth to the bandwidth thershold if it is more or equal to the thershold, it will update the bandwidth and the hop count. So an updated RREQ with updated bandwidth,Delay and hop will be further rebroadcast.

The above exercise will be repeated untill the RREQ packet will reach to the destination

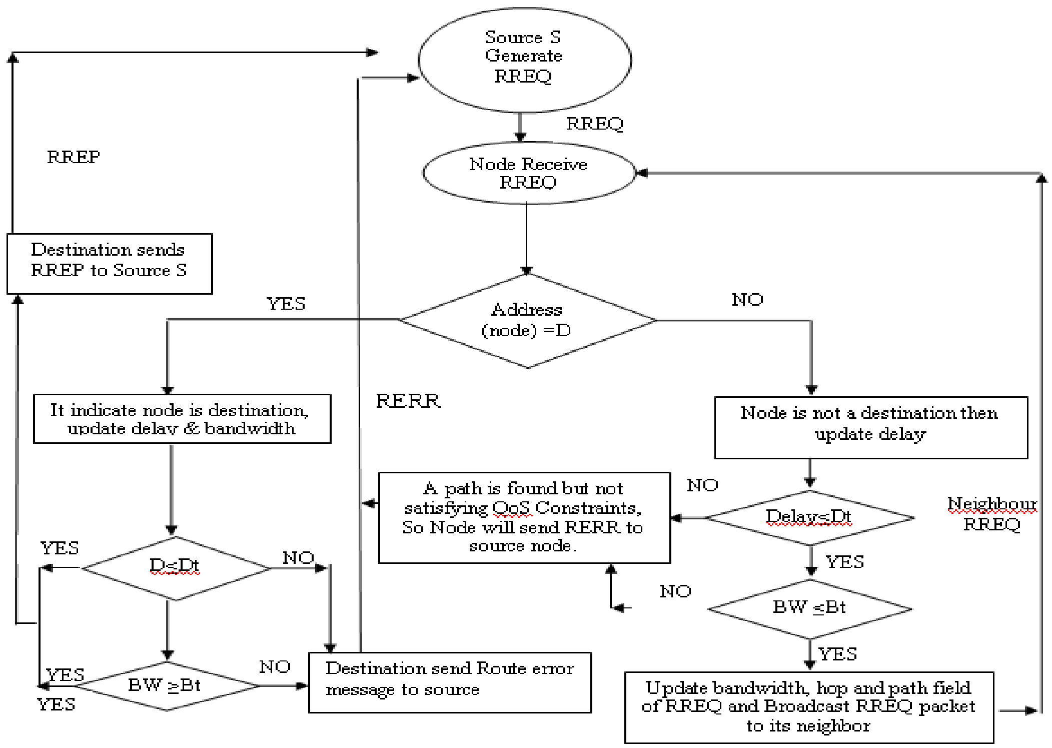

Figure 4: Route Discovery

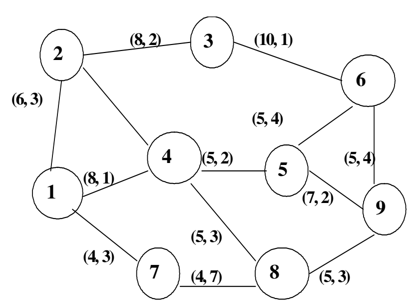

Figure: 5: An Example Network With edges (Bandwidth, Delay)

7. EXAMPLE

To explain the working of above proposed protocol consider the figure 5, where the node represents the mobile node and the edge represent the channel between the nodes through which the packet will travel, every edge is having a set of parameter (a, b), where **'a'** is the bandwidth of the link and **'b'** represent the delay. Node 1 is the source node and the node 6 is the destination node. The bandwidth threshold is 5 and the end-end delay threshold is 10.

To send the packet node 1 send RREQ to its neighbours (2, 4, 7).

When node 2 receives the packet it has enters in its IT (1, 6, 1, 6, 3) it checks the QOS constraints i.e. 6> 5 & 3 <4 so it updates the bandwidth field of RREQ to 6 and delay field to 3 and hop count to 1,Path field to (1-2) and rebroadcast the RREQ to its neighbours.

At node 4 it receives two RREQ packet one from node 2 and one from 1 so it has two entries in its IT (1,6,1,5,2) and (1,6,1,8,1) at this moment it select the one from node one with highest bandwidth and minimum delay, so it will accept the RREQ packets from node1 and discard the RREQ packet from node 2. Then it checks the QOS constraints as 8>5 and 1<4 so it add the bandwidth field of RREQ to 8 and delay field to 1 , Hop count to 1 and path field to (1-4) it broadcast the RREQ packet to its neighbours.

At node 7 it receives the RREQ packet from node 1 and it has a entry in its IT (1,6,1,4,3) but QOS constraints is not satisfying as 4<5 so node 7 send a RERR packet to node 1 which indicate that route is found but does not satisfying the QOS constraints.

At node 3 it receives a RREQ from node 2 then it has an entry in its IT (1,6,1,8,2) then QOS constraints will be checked i.e. 8>5 and 5> 12 so it update the bandwidth field of RREQ to 12 ,delay to 5, hop count to 2 and path field to (1-2-3) and rebroadcast RREQ to its neighbours.
At node 5 it receives a RREQ packet from node 4 so it update its IT (1,6,1,5,2) QoS constraints is satisfied as 5 >= 5 and 3<10 so it update bandwidth field of RREQ to 13, delay to 3, hop count to 2 and path field as (1-4-5) and rebroadcast it to its neighbours.

At node 8 it receives a RREQ packet from node 4 so it has a entries in its IT (1,6,1,5,3) QOS constraints is satisfying as 5>5 and 4<10 so it update bandwidth field of RREQ to 13, delay to 4 , hop count to 2 and path field as (1-4-8) and rebroadcast its to its neighbours.

At node 9 it receives two RREQ , one from node 5 and one from node 8 so it carries two entries in its IT (1,6,1,7,2) and (1,6,1,5,3) it will select the one from node 5 with higher bandwidth and minimum delay and discard the RREQ packet from node 8 . Then it update the bandwidth field of RREQ to 20, delay to 5, hop count to 3 and path field as (1-4-5-9) and rebroadcast RREQ to its neighbours .

At node 6 it receives three RREQ packets, one from node3, one from node 5 and one from node 9. It has three entries in its IT (1,6,1,12,1) , (1,6,1,5,4) and (1,6,1,3,4). Node 6 is the destination node so first QoS constraints is checked for all the three entries which is satisfied as all are satisfying the bandwidth and delay constraints so node 6 will send three RREP packets to node 1 by adding accumulative bandwidth and delay for the complete path as (1,6,1,26,6,{1-2-3-6}, {1,6,1,25,9,{1-4-5-9-6} and (1,6,1,18,7,{1-4-5-6} .

When the source node will receive the RREP packets from node 6(Destination) then it will select the RREP with maximum bandwidth and minimum delay (1-2-3-6) for sending the data.

8. CONCLUSION

Proposed protocol provides multiple paths from source to destination; our protocol not only finds a path from the source to the destination but also provides quality of services in terms of bandwidth and the delay. Multiple paths provide a backup for source node. Any how, any how if there is a link failure, then the source node can use another path for sending the data to destination. In future we will implement this protocol on simulator and analyze its performance. We will also compare our protocol with other existing protocols those provide multiple path from the source and the destination.

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