Int. J. Advance. Soft Comput. Appl., Vol. 3, No. 2, July 2011
ISSN 2074-8523;
www.i-csrs.org

An Ant Colony Based Multi Objective Approach to Source-Initiated QoS Multicasting Method for Ad Hoc Networks

P.Deepalakshmi, Dr.S.Radhakrishnan

Department of Computer Science and Engineering,
Kalasalingam University, Tamil Nadu, India.
e-mail: deepa79mca@yahoo.co.in

Department of Computer Science and Engineering,
Kalasalingam University, Tamil Nadu, India.
e-mail: srk@klu.ac.in

Abstract

Multicasting protocols can be used to improve the efficiency of the wireless links in Mobile Ad hoc Networks when sending multiple copies of messages from multiple sources to multiple receivers. In this paper, a Source initiated Mesh based QoS Probabilistic multicast routing protocol (SQMP) for MANETs is proposed. SQMP is inspired from the ant colony's route finding algorithm in which an ant chooses the best path to its destination while searching the food through the cooperation with other ants. Similar to the behavior of the ant for searching food, SQMP introduces probabilistic forwarding and soft state for making forwarding decisions with QoS satisfaction which are automatically adaptive to mobility of nodes in MANETs. The simulation results indicate that proposed work achieves better packet delivery ratio by finding a feasible multi objective optimized path which satisfies the QoS constraints, bandwidth and end-to-end delay.

Keywords: *MANET, Mesh, Multicast, QoS, ACO, Source-initiated.*

1 Introduction

Mobile Ad hoc network (MANET) is an autonomous collection of mobile nodes that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized where all network activities including discovering topology and delivering messages must be executed by nodes themselves.

Multicasting is a promising technique to provide a subset of network nodes with the service they demand while not jeopardizing the bandwidth requirement of others. Multicasting in Mobile Ad Hoc Networks applications' plays an increasing role. Multicast can effectively decrease network and server loads and improve transfer capability. For example, applications like multimedia communication with bandwidth limitation need effective multicast services. Meanwhile, multicast is an important way to enhance the working efficiency. With the development of Ad Hoc networks, the demands of providing QoS (Quality of Service) [1-4] support for some real-time and multimedia[5,6] applications in a dynamic, multi-hop environment[6] are research hotspots in Ad Hoc networks.

QoS implemented in the network aims to find routes which can provide the required quality imposed by the applications. The metrics used to select a best route are not only the number of hops along the route but also other metrics like delay, bandwidth [2,4] network or link life time and data rate. QoS routing is a scheme that takes into consideration the appropriate information about each link. Based upon this information, it selects paths that satisfy QoS requirements for a flow. QoS routing protocols have a key part in a QoS mechanism, because it is their function to find nodes that can serve the application's requirements. But this is complex and difficult issue [7] in MANETs because of the dynamic nature of the network topology.

Multicast routing protocols [8] for mobile ad hoc networks are classified into distinct categories according to connectivity management as "Source Vs Receiver-initiated", operation and maintenance as "Proactive Vs Reactive" and most popularly multicast topology as "Tree Vs Mesh- based". In a tree based multicast routing protocol, node accepts packets only when they come from another node with which a tree branch has been established for a particular multicast group. Since there is only a single path between a sender and a receiver, the tree based multicast routing protocols are vulnerable to the dynamic nature of ad hoc networks such as node mobility and subsequent link breaks. In contrast, mesh based multicast protocols maintain a mesh consisting of a reliable and robust connected component of the network containing all the receivers of the group. They construct a mesh that allows data packets to be transmitted over more than one path from a sender to a receiver to increase the robustness.

The ACO metaheuristic [9] is based on generic problem representation and the definition of the ant's behavior. ACO adopts the foraging behavior of real ants. When multiple paths are available from nest to food, ants do random walk initially. During their trip to food as well as their return trip to nest, they lay a chemical substance called pheromone, which serves as a route mark that the ants have taken. Subsequently, the newer ants will take a path which has higher pheromone concentration and also will reinforce the path they have taken. As a result of this autocatalytic effect, the solution emerges rapidly. By using the concept of ACO, multicast algorithms [10, 11] are proposed to address the multimedia traffic for MANETs. By appropriate parameter selections, ACO finds shortest paths not only in terms of distance but also environment related parameters like current traffic and expected delay on the considered paths.

In this paper, we propose Source initiated Mesh based QoS Probabilistic multicast routing protocol (SQMP) based on ant's food foraging behavior. To assist QoS routing, the multicast mesh information is maintained at the nodes of MANET. The multicast mesh information is refreshed frequently by sending the Query ant. Being a mesh based protocol, as path breaks occur frequently in ad hoc wireless networks, the path satisfying the QoS requirements in multicast mesh is recomputed during every time the current path breaks where more alternate paths are available between the multicast source and multicast receivers of a multicast group. The rest of the paper is organized as follows. Section II describes the related works about QoS multicasting in MANETs and in Section III, we have elaborated our proposed work "SQMP" and in section IV, we show the efficiency of our proposed protocol through simulations and finally in section V, we conclude with possible future extensions.

2 Related Study

The set of QoS multicast protocols proposed in the literature for MANET are listed in [12-14]. QoS- ODMRP [15] extends the basic source initiated mesh based multicast algorithm ODMRP [16] to support QoS by letting the source to find paths to multiple destinations based on the bandwidth required by the underlying application. Also, QoS-ODMRP uses soft state for route maintenance. The consumed bandwidth, available bandwidth and released bandwidth of a link are shared by neighbors through hello messages. QoS-ODMRP is further improved in IQoS-ODMRP [17] by making two changes to it. One is if the network can't satisfy requested bandwidth of an underlying application during route discovery phase, the source node can still continue the route discovery by reducing the required bandwidth. This gives more importance to data sending even though with lower QoS. Another change is the adjustment of periodic time intervals for hello messages and join-request messages based on nodes mobility. If mobility is high, these messages have to be forwarded frequently leading to shorter time intervals. In case of low mobility, the timers can have longer intervals. These intervals are allowed to vary between maximum and minimum thresholds.

A cluster based tree structured multicast protocol is proposed as QMRPCAH [18] that can support QoS in terms of bandwidth and delay. Each node periodically measures the delay in outgoing links and shares this information within its cluster. Each node maintains only intracluster routing information and border nodes called as bridge nodes maintain intercluster routing information. In case of mobility, nodes may enter to new cluster and thus require hand off mechanisms. This forces newly entered cluster to learn about multicasting group if it is not yet aware of that group. Bridge nodes definitely have to be part of multicast tree if the underlying cluster members participate in the multicast group. So, if bridge nodes move to different clusters, this requires tree reconfiguration. QMRP [19], a mesh based QoS multicast method considers residual bandwidth as QoS metric. Also, waiting or non-waiting scheme is adopted at receiver nodes before forwarding replies. Routes are maintained either by periodic or on-demand method. Non waiting at receiver to send replies and periodic maintenance of routes gives better performance.

AQM [20], a receiver –initiated QoS multicasting with table driven session management and on-demand verification of QoS information upon the initialization of a join process basically uses the hard state for reserving resources. The route request is accepted and further forwarded by intermediate nodes based on the residual bandwidth which is computed by subtracting the bandwidth usage of the node and all its neighbors from the maximum bandwidth. MACO [21] is also a QoS based Multicast scheme which uses ant algorithm similar to our proposed work. In addition to the pheromone laid, the additionally considered metric is the direction towards destination which is determined by a heuristic method based on location. MACO constructs multiple multicast trees where the links satisfy bandwidth, delay and jitter constraints. Then a best multicast tree is selected based on the value of cost function of these trees. QAMNET [22] introduces service differentiation as "Real Time (RT) and Best Effort (BT)", distributed probing and admission control mechanisms as well as adaptive control of non-real time traffic based on MAC layer feedback. Real time traffic is handled by intermediate nodes if required bandwidth is available. Otherwise the traffic is shaped to be handled as best effort traffic.

QMR [23] is another mesh based QoS multicast protocol which estimates bandwidth at MAC layer using CDMA/TDMA channel model with passive listening method. QMR provides load balancing and contention prevention scheme by updating the forwarding nodes and use intermediate nodes with enough bandwidth to forward the data especially when a single path is used to forward data from multiple resources. ODQMM [24], an extension of MAODV [25] protocol provides QoS based multicasting with one of the two reservation styles. The first one, Fixed Filter (FF) makes distinct reservation for each source of the group and hence making it suitable for applications like video streaming. The second one, Shared-bandwidth filter (SF) makes a single reservation which is shared by flows within all senders at the same session. This is very much suitable for audio conferencing. For normal data, ODQMM offers best effort services.

3 The Proposed Algorithm

3.1 Network Model

Let G be the given mobile ad hoc network represented as a graph G= (V,E), where V represents set of vertices and E is set of links representing neighborhood connectivity between the wireless nodes. Now the source-initiated QoS based multicast problem (SQMP) can be stated as follows: For a given set of source nodes $S \subset V$ and a set of receiver nodes $R \subset V$, proposed algorithm has to establish multicast communication by identifying a multicast mesh M(S, F, R) where $F \subset V$ is a set of forwarding nodes such that $S \cup F \cup R$ is connected and the constructed mesh satisfies the QoS parameters such as Demanding Bandwidth (DB) and Demanding Delay (DD) imposed by the applications running on multicast source nodes. Each link $(i, j) \in E$ is associated with a parameter B_{ij}, the available bandwidth of that link. Let P(S, R) be the set of all paths between the multicast source and receiver R of the multicast group. For any path $P' \in P(S, R)$, let $B_{P'}$ be its path bandwidth, defined as the minimum bandwidth among all the links along the path. Let $D_{P'}$ be the end-to-end delay of the path P'. Path P' is selected with demanding bandwidth bound DB and demanding delay bound DD, if $D_{P'} \leq DD$ and $B_{P'} \geq DB$.

3.2 Multicast Mesh Creation

For multicasting in MANETs, nodes are classified in to two types based on whether they are multicast group members or non-group members. Group members include multicast sources, receivers and non-group members include intermediate nodes called as forwarding nodes in the network that help to create multicast routes from source to receivers. A sample MANET setup is considered and shown in Fig. 1. In our proposed algorithm, mesh creation involves two phases namely query phase and reply phase. Query phase is invoked by the multicast source nodes to initiate the mesh route discovery process. During the route discovery process, the availability of QoS is verified at each node to find the routes to multicast group members to satisfy the QoS requirements. The reply phase is initiated by the multicast group receivers based on the queries they have received from multicast sources through different QoS satisfied paths. When a node on the path to the source receives a reply from the receiver, it sets its forwarding flag. This leads to a possibility of setting up different routes for the multicast group members from the multicast sources by improving the efficiency of multicast mesh. Multicast source nodes periodically forward join query messages to keep the multicast group alive and invite new members to join the group and also to keep the mesh updated by satisfying demanding QoS parameters. Every node in the network will have one of the following functions and its associated codes for the created multicast mesh as in Table 1.

Table 1: Role of Nodes in Mesh

Mesh Code	Functions in Mesh
0	Non forwarding, Non multicast group member nodes
1	Non forwarding, Multicast group member nodes
2	Forwarding on selected multicast route , Non-member nodes
3	Forwarding on the selected multicast route, Member nodes

3.2.1 Join Query Phase

The multicast source finds the multicast routes to its receivers by forwarding Join Query messages called as JQ_ANT. When a multicast source has data packets to send but no route is available, it prepares a member advertising packet called JQ_ANT which contains the information, <Multicast group IP address, Source IP address, Sequence number, Time To Live, Previous hop IP address (initially set as NULL), Hop Count (initially set as 0), Minimum available bandwidth (MAB initially set as ∞), Demanding Bandwidth (DB)). The Sequence number is assigned by the multicast source to uniquely identify the JQ_ANT. The TTL field defines the number of hops JQ_ANT can traverse inside the network. The Hop Count field defines number of hops traveled so far by this JQ_ANT.

Any node receiving JQ_ANT will store Source IP address, Multicast group IP address, Sequence number in its message cache. This helps for the avoidance of processing JQ_ANT duplicates in future. Suppose the received JQ_ANT is not a duplicate, before rebroadcast the JQ_ANT to others, each intermediate node say 'j' update its QoS fields with current conditions experienced by that node. That is

Case 1: If available bandwidth of link (i, j), B_{ij}< DB, node ‘j’ drops the JQ_ANT.

Case 2: If the available bandwidth of the link (i, j), B_{ij} ≥DB (Demanding Bandwidth), JQ_ANT deposits the pheromone value, τ_{ij}=0.01. Also at ‘j’, the information “Multicast group Id, Multicast Source node, previous node ‘i’ that propagated JQ_ANT to ‘j’” are maintained in the Multicast Routing table for remembering the reverse path towards the multicast source.

Additionally, following updates are done to JQ_ANT and then ‘j’ rebroadcast it to j’s neighbors.

- Decrementing TTL by1. If it is greater than 0, then the current node’s IP address is set as Previous Hop IP address field in the received JQ_ANT.
- Incrementing Hop Count field by 1.
- Updating Minimum available bandwidth as

$$MAB=\min \{\text{received MAB, current } B_{ij}\} \quad (1)$$

If the current node is already a member node of the multicast group (its mesh code is 1) or it wants to become a member of the multicast group, it invokes Join Reply

Phase. In addition to that, the existence of multicast group is realized. This increases the multicast group lifetime. For example, in Fig. 1, a multicast group of mobile nodes S1, S2, R1, and R2 is considered. Here S1 & S2 act as multicast sources and R1& R2 act as multicast receivers of that same group. In Fig. 2 JQ_ANT from the multicast sources S1 and S2 deposits pheromone amount towards the multicast receivers R1 and R2 only on the bandwidth satisfied paths. This offers the additional advantage that propagation of JQ_ANT is restricted from flowing in all the paths which does not satisfy the bandwidth constraints. This leads to a reduction of unnecessary and excessive bandwidth consumption due to heavy control overhead.

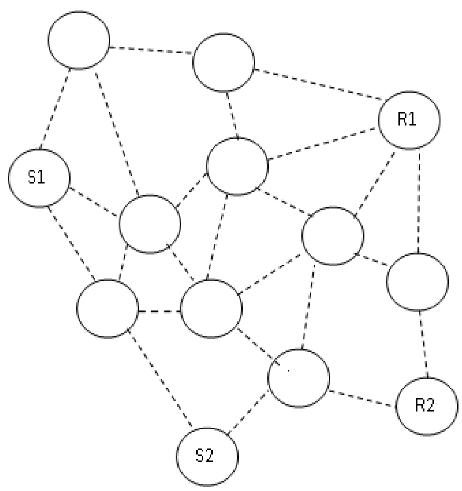

Fig.1: Sample MANET scenario

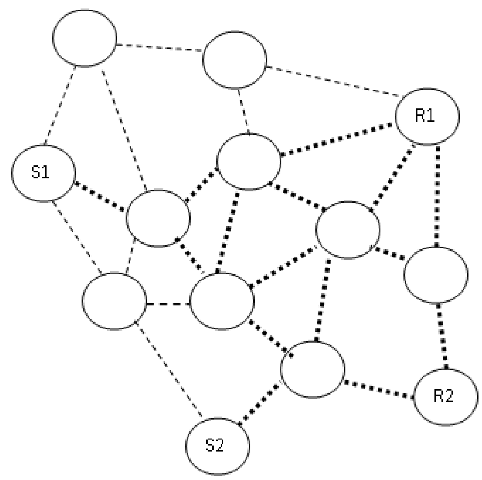

Fig.2: Propagation effect of JQ_ANT

3.2.2 Join Reply Phase

Once a JQ_ANT reaches a multicast receiver R from multicast source S, received MAB(S, R) indicates the minimum available bandwidth (MAB) found along the path which is greater than demanding bandwidth (DB). The receiver waits for a small time period MAX_JOIN_WAIT_TIME to aggregate all JQ_ANT it has received. If multiple such paths exist from multicast source to receiver R of the multicast group, the path with largest Minimum Available Bandwidth MAB(S, R) should be selected first. Not only depending upon the bandwidth, but also the path selected by the multicast receiver R is based on the delay bound and the pheromone amount deposited by the JQ_ANT on its bandwidth satisfied path. The minimum end to end delay taken by the JQ_ANT is found by first calculating end-to-end delay of each path traveled by JQ_ANT from multicast source S to Receiver R of the multicast group where, end-to-end delay of JQ_ANT on the path P(S, R) is the difference between received time at multicast receiver R and starting time at multicast source S. After calculating the end to end delay of JQ_ANT on each path, multicast receiver R selects the path whose end-to-end delay is lower than the Demanding Delay which is piggybacked along with Demanding Bandwidth on JQ_ANT. Any non-member which wants to become as a member of the multicast group for which it has received the JQ_ANT will send the reply message called as JR_ANT. The JR_ANT selects the multicast route among several routes to reach the multicast source S from the receiver R with the Route Preference Probability P_{SjR} ,

$$P_{SjR} = \frac{[\tau_{jR}][B_{SjR}][D_{SjR}][\eta_{SjR}]}{\sum_{l \in N_R} [\tau_{lR}][B_{SlR}][D_{SlR}][\eta_{SlR}]} \tag{2}$$

where

N_j- Set of neighbor nodes in the MANET

τ_{jR} - pheromone deposition from neighbor j to receiver R o the multicast group

B_{SjR} - max {received MAB, B_{jR}}

D_{SjR} – relative metric of end-to-end delay of P(S, R) through the neighbor j.

η_{SjR} – relative metric of hop count from source to receiver

$$\eta_{SjR} = \frac{1}{hopcount \quad of \quad P(S,R)} \tag{3}$$

By probabilistically forwarding JR_ANT, good reliability is achieved since redundant routes are exploited. The sequence of operation in this phase starts with multicast receiver 'R' creating JR_ANT <Forwarding Node Count, Multicast group IP Address, Multicast receiver (R) IP Address, Previous Hop IP address, Sequence number, Array of [Source IP addresses, Next Hop IP addresses]). Sometimes multicast receiver 'R' can also be a forwarder of the multicast group. Therefore the Previous Hop IP address field defines the IP address of the last node that has processed the JR_ANT. The sequence number assigned by the Previous Hop node is to uniquely identify the JR_ANT. Now receiver node 'R' transmits JR_ANT after selecting the multicast route with highest Route Preference Probability.

When JR_ANT is received at node 'i', it looks up Next Hop IP address field of JR_ANT entries. If no entries match with the neighbor node's IP address, simply the node 'i' kills JR_ANT. Every node which forwards JQ_ANT to multicast receiver R expects to receive JR_ANT for a certain time period. Pheromone amount on the link (i, j) ∈ □E is reduced periodically if it is not receiving any JR_ANT through that link as follows,

$$\tau_{ij} = \begin{cases} 1 & \text{if } (1-\rho)\tau_{ij} \geq 1 \\ (1-\rho)\tau_{ij} & \text{if } 0 < (1-\rho)\tau_{ij} < 1 \\ 0.01 & \text{otherwise} \end{cases} \tag{4}$$

where ρ is the pheromone evaporation rate. If one or more entries coincide with the node's IP address, node 'i' considers itself as forwarding node and builds its own JR_ANT. The next hop IP address can be obtained from the probabilistic multicast routing table maintained at each node. Then node 'i' updates the pheromone amount on the link (i, j) by

$$\tau_{ij} = \tau_{ij} + \Delta\tau \tag{5}$$

where $\Delta\tau = 0.1$. This updating pheromone shows that the JR_ANT is received on the corresponding link (i, j). Now, mesh code for this forwarding node on the selected multicast route is set as 2 and that node maintains the group information, "Multicast Group IP address, Time when the node was refreshed" in the Forwarding Group Table. The Forwarding Group Table is always sorted based on descending Route Preference Probability of respective intermediate non-member nodes. If any forwarding node wants to become the member of the multicast group, it creates JR_ANT with the Route Preference Probability and forwards to the multicast source 'S'. So such a node acts as both forwarding and multicast group member node, and hence mesh code for this node is set as 3 and JR_ANT is broadcasted to the other neighbors. Once a JR_ANT reaches a multicast source S from the multicast receiver 'R', 'S' waits for a small time period called MAX_RPP_WAIT TIME to aggregate all JR_ANT with Route Preference Probability (P_{SjR}) in descending order. If multiple paths exist from the multicast receiver R to multicast source S, the path with highest Route Preference Probability should be selected first.

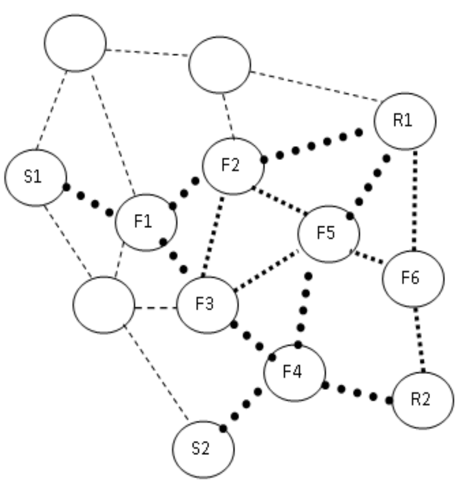

Fig.3:Effect of JR_ANT on selected routes

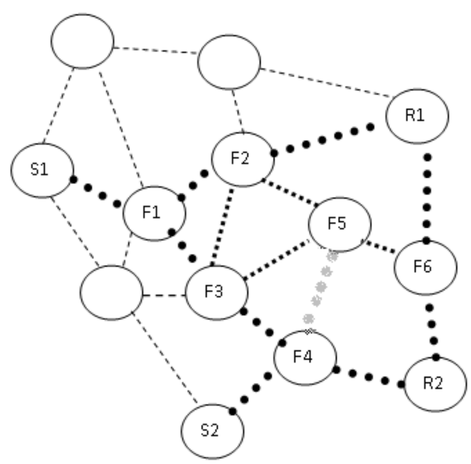

Fig.4:Mesh after (F5, R1) link failure

For example in Fig.3, after waiting MAX_JOIN_WAIT_TIME period, multicast receiver R1 creates JR_ANT after receiving JQ_ANT from its neighbors. Then it chooses the node F2 to forward JR_ANT to reach multicast source S1 by using the Route Preference Probability according to (2). Similarly it forwards JR_ANT to F5 to reach the multicast source S2. The multicast receiver R2 creates JR_ANT after receiving JQ_ANT from its neighbors. It forwards JR_ANT to its neighbor F4 by using Route Preference Probability according to reach multicast sources S1 and S2.

Here, the MAB (Minimum Available Bandwidth) and DB (demanding Bandwidth) does not introduce additional control packet overhead compared to ODMRP as it is piggybacked on JQ_ANT message, which is flooded throughout the network. Hence JQ_ANT with MAB and DB are disseminated periodically throughout the network gathering information on resource availability of individual nodes at the same periodicity as the messages that are responsible for mesh creation and maintenance by JQ_ANT and JR_ANT without creating additional signaling packets.

3.3. Multicast Mesh Maintenance

Link failure can happen when the intermediate forwarding node moves out of range from neighbor nodes in the selected route. Multicast source S retransmits JQ_ANT if it does not receive JR_ANT after 3 seconds.

Case 1**:** If multicast receiver R is connected to the mesh through more than one path, link failure will not affect the data transmission. Based on the next highest Route Preference Probability, the other intermediate node j (i.e., the node from which JQ_ANT is received through the other branch of the multicast mesh) is selected to forward the JR_ANT. The following steps are done when the intermediate forwarding node j on the selected route is lost,

1. The pheromone deposited on link (i, j) is made as 0.
2. All information about the lost forwarding node will be removed from Forwarding group table, Probabilistic multicast routing table and also from subsequently generated JR_ANT.
3. If multicast receiver R is lost, because it can also act as forwarder for the multicast group, then all information about the receiver R of the multicast group is removed.

Case 2**:** If the multicast receiver R is connected only through the failed link for a multicast group, source node S will reinvoke a multicast mesh creation procedure.

For example in Fig.4, the multicast receiver R1 is connected to multicast source S2 through the forwarding nodes F5 and F4 in the mesh. Suppose the link failure occurs between F5 and R1, the multicast receiver R1 forwards the JR_ANT with the next highest Route Preference Probability through the forwarding node F6 and the multicast receiver R2. JR_ANT from the multicast receiver R1 updates pheromone amount on links (R1, F6) and (F6, R2) according to (5). So mesh code for F6 and R2 is set as 2 and 3 respectively. Now, forwarding node, F5 is not receiving JR_ANT from multicast receiver R1 because of link failure between F5 and R1. Hence F5 made the pheromone amount on its link to R1 as 0. Also, the forwarding node F4 is not receiving JR_ANT from F5 for certain time period. Therefore the pheromone amount on the link between F4 and F5 is reduced periodically according to (4) by F4.

4 SIMULATION, RESULTS AND DISCUSSION

4.1. Simulation Scenario

To analyze the performance of proposed algorithm and to compare its effectiveness and efficiency to the state of the art protocol ODMRP, we have selected NS-2 for proposed protocol implementation. We have considered a mobile ad hoc network with 50 nodes supporting 802.11b DCF Mac layer in a terrain of size 1000m * 1000m. The transmission range of all nodes are fixed as 250m and nodes were allowed to move within the terrain randomly as in random waypoint mobility model with a speed of [0..20] meters per second. The channel capacity is assumed as 2Mbps. In the created MANET with 50 nodes, one multicast group is considered with 20 nodes and varying number of senders. Also for each set of experiments we have considered two kinds of packets size as 256bytes and 512 bytes. To analyze the QoS support by proposed protocol, the bandwidth and delay are demanded as 1Mbps and 500 ms respectively. The source nodes of multicast group forward a total number of 20 packets per second to remaining multicast group members. To analyze the performance of proposed protocol with non-QoS-ODMRP version, we have considered packet delivery ratio, end-to-end delay, average data loss burst and control overhead as metrics.

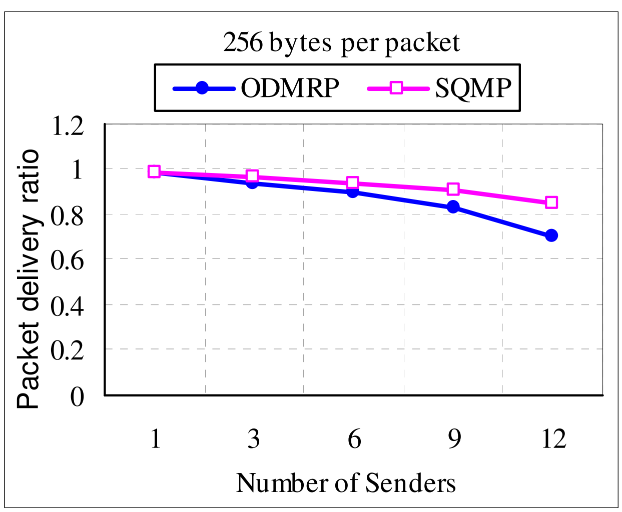

Fig.5: Effect of PDR for 256-bytes packet size

In Fig.5 and Fig.6, we have compared packet delivery ratio for increasing number of senders with 256 bytes and 512 bytes as packet size. In case of 256 bytes as packet size, each source has a data transmission rate of almost 41Kbps and the same will be 82Kbps in case of 512 bytes as packet size. Since our proposed algorithm constructs the mesh using links which can only satisfy demanding delay and demanding bandwidth, SQMP is able to achieve higher packet delivery ratio than ODMRP which mainly constructs the mesh using shortest hop distance. Also it can be seen from Fig. 5 that packet delivery ratio of both ODMRP and SQMP is above 0.7 for sending 256 bytes per packet. Where as from Fig.2 it can be observed that packet delivery ratio for both protocols is slightly decreased towards 0.4 for sending 512 bytes per packet. In both cases, PDR decreases when increasing number of senders goes above 6. In general, source initiated algorithms perform well when number of sources is less compared to multicast group size. As the number of senders increase, propagation of join requests and join replies will occupy network bandwidth and this to leads to less space for data transmission. So as senders increase, the packet delivery starts decreasing for both protocols. In spite of that, proposed algorithm ‘SQMP” has better packet delivery ratio because of the adaptation of QoS satisfied paths to construct multicast mesh.

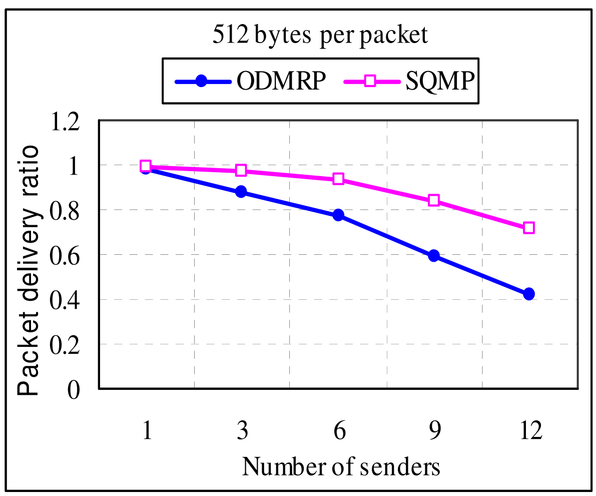

Fig.6: Effect of PDR for 512-bytes packet size

When nodes use any non-QoS routing protocols to determine the paths to destinations, no admission control is followed. Without admission control, more packets are injected into the network despite the fact that they can not reach destinations. These packets sometimes waste a lot of channel bandwidth also. Where as, if the admission control scheme is adopted, inefficient usage of channel bandwidth can be limited. Since SQMP has limited propagation of Join queries than ODMRP, there is less chance of data packet loss due to congestion and collision caused by control packets. The data delivery ratio of ODMRP and SQMP decreases as number of sources increases under high mobility conditions as shown in Fig.7. SQMP still maintains good packet delivery ratio than ODMRP because of reduction of propagation of join query overhead. Since SQMP transmits multicast data through the paths which can satisfy a demanding delay of 500 ms, it is able to keep end-to-end delay with in 500 ms as shown in Fig. 8. But for ODMRP, average end-to-end delay is with in 500ms only when the mobility is short. When node mobility increases to more than 6 m/s, end-to-end delay increases almost linearly as shown in Fig.8.

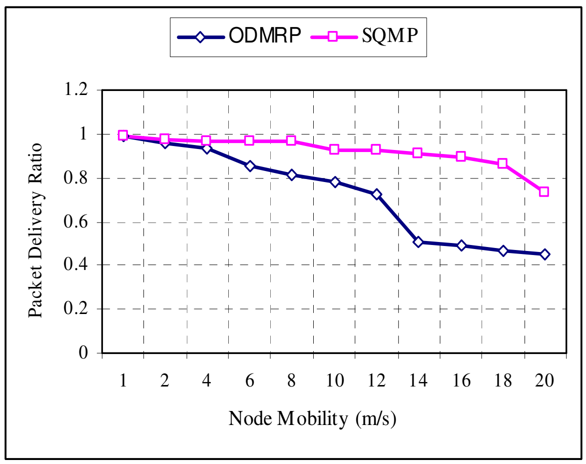

Fig.7: Effect of PDR for 512-bytes packet size

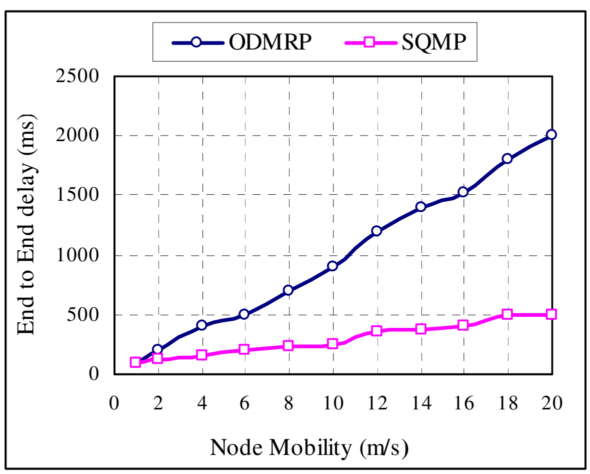

Fig.8: Effect of delay for 512-bytes packet size

In a source based multicast approach, sources periodically initiate a mechanism for the multicast mesh creation as well as maintenance through Join Queries. However it is possible that between two Join Queries, a link connecting receiver to a source goes down because of node mobility. In such a situation, it is possible that an unfortunate receiver misses all the packets until the multicast backbone is re-built. Normally, for high data rates, a large number of packets can be missed by receivers and recovering from such a loss can impose a huge overhead on the bandwidth-constrained ad hoc network. Besides, large data bursts mean a delay in detecting a gap in sequence number spacing. By the time, the receiver initiates a mechanism to recover lost packet, those packets may no longer be cached by other nodes. Such a situation is very likely in ad hoc networks, where the nodes have restricted storage capacity, and a large number of data packets cannot be cached. Recovering from such large packet loss burst in ODMRP may impose a huge overhead in ad hoc network. It is easy to show that to maintain ordering of data packets, out of order packets have to be held in a buffer, and only when the expected sequence number arrives, it is passed on to the application. Large data loss in burst could mean a delay in loss detection (through gap in sequence number space), and also delay in packet delivery to the application.

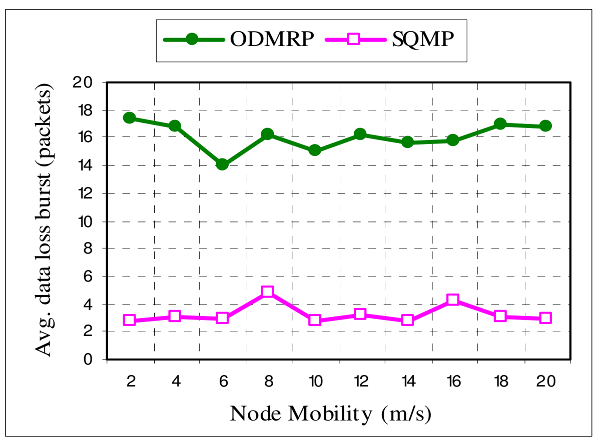

Fig.9: Average data loss burst

If a node detects data loss too late, it is possible that the packets it has missed may no longer be available in network for retransmission. If a receiver finds that it is not receiving data from its source for a while, it must itself try to probe the network, and look for an alternative path, through which it starts receiving data again. This is what we have tried to accomplish through the Route Preference Probability feature. The Route Preference Probability requires both the Forwarding Group (FG) nodes and the receivers to keep an estimate of the data rate. If the period elapsed since the reception of last data item is more than MAX_RPP_WAIT_TIME, the receiver node can assume that there is a packet loss. The use of Route Preference Probability in SQMP keeps the data loss bursts at a lesser value compared to ODMRP as indicated in Fig.9. Route preference probability allows a node to detect link breaks, and reconnect the multicast receivers to the multicast mesh through the alternative path based on next highest order Route Preference Probability, through which data can be delivered to it. If there are more than one feasible path between multicast source and multicast receivers, the multicast receiver no longer waits for the next JQ_ANT to create new paths. Therefore data loss bursts are kept at a smaller value irrespective of node mobility and pause time in case of SQMP

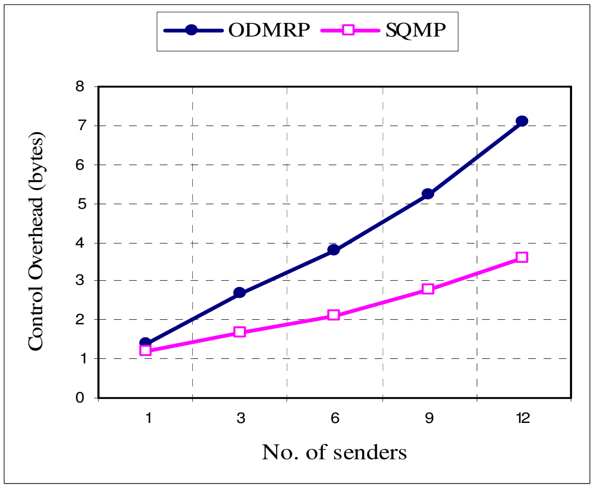

Fig.10: Control overhead for increasing senders

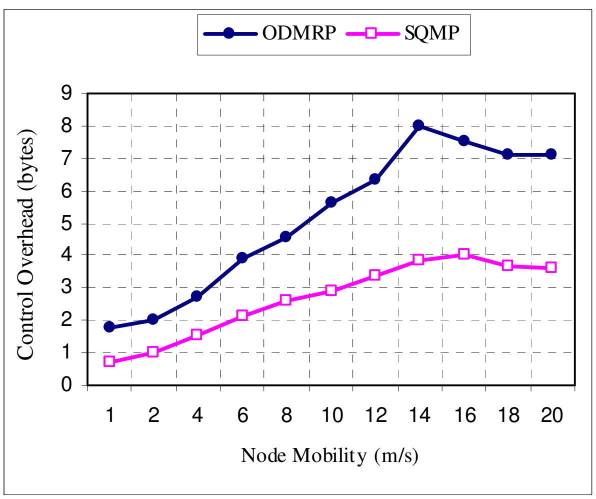

Fig.11:Control overhead for increasing mobility

Fig.10 and Fig.11 demonstrates that efficiency of the proposed protocol SQMP provide considerably better performance than non-QoS ODMRP in terms of control overhead. The reason is that every multicast sender floods Join Query packets periodically in non-QoS ODMRP while in SQMP the multicast sender who has data to send forwards the packet to its neighbor based only on the Route Preference Probability. Furthermore, non-QoS ODMRP entails each member to send a Join Reply toward each sender via the reverse path on which the Join Query was received, ensuing in a somewhat large forwarding group, especially with the higher number of senders. SQMP discriminates that each multicast group member set up the connectivity towards the sender only based on the satisfying parameters such as low hop count traveled by the JQ_ANT and end-to-end-delay experienced by JQ_ANT as well as the bandwidth consumption by JQ_ANT at each node.

5 Conclusion

In this paper we have proposed an ant based QOS multicast routing protocol, SQMP for mobile adhoc networks from given source to set of multiple destinations. Multiple paths have been found with first-rate route preference probability. The data is sent over the paths with higher route preference probability which can satisfy the required bandwidth and required delay by the applications. The proposed algorithm has been compared with ODMRP in terms of packet delivery ratio, end-to-end packet delay, average data burst loss rate and average number of forwarding nodes in the mesh. Since data transmission is more important, in subsequent research we have planned to investigate the feasibility of making the proposed scheme to be adaptive when the QoS requirements can not be completely satisfied.

References

[1]. Wang., Z. and Crowcroft, J. "Quality of Service routing for supporting multimedia applications", *IEEE Journal on Selected Areas in Communications*, Vol. 14, No.7 (1996), pp.1288-1294.

[2]. Chen, T.W., Ttsai, J. and Gerla, M. "QoS routing in multihop, multimedia, wireless networks". *Proceedings of IEEE 6th International Conference on Universal Personal Communications Record.* (1997). San Deigo,USA.

[3]. Chakrabarti,.S. and Mishra, S. "QoS issues in ad hoc wireless networks", *IEEE Communications Magazine*, Vol. 39, No. 2 (2001), pp.142-148.

[4]. Chen, L. and Heinzelman, W.B. "QoS-aware routing based on bandwidth estimation for mobile ad hoc networks", *IEEE Journal on Selected Areas in communications*, Vol. 23, No. 3 (2005), pp.561-572.

[5]. Chao, H. C., JunHua Gu and Qijun Gu, "A Heuristic ant algorithm for solving QoS Multicast Routing (QMR) problem". *Proceedings of Congress on Evolutionary computation*. May 12-17, 2002. Honolulu, HI.

[6]. Sun, L. and Li, L.Y. "A QoS-based multicast routing protocol in ad hoc networks", *Chinese Journal of Computers*, Vol. 27, No. 10, pp.1402-1407.

[7]. De, M.C.C., Gossain, H. and Agarwal, P. "Multicast over wireless mobile ad hoc networks: present and future directions", *IEEE Network*, Vol. 17, No. 1, pp.52-59.

[8]. Osamah, S.B. and Michel, K. "Multicast Routing Protocols in Mobile Ad Hoc Networks: A Comparative Survey and Taxonomy", *EURASIP Journal on Wireless Communications and Networking*, Vol. 2009, Article ID 764047, doi:10.1155/2009/ 764047.

[9]. Dorigo, M., Birattari, M. and Stutzle, T. "Ant colony optimization: Artificial ants as a computational intelligence technique" *IEEE Computational Intelligenc*e, Vol. 1, No.4 (2006), pp.28-39.

[10]. Liu, Y.P., Wu, M.G. and Qian J.X. "The distributed multicast routing scheme with delay constraint using ant colony optimization". *Proceedings of Sixth world congress on intelligent control and automation*. (2006). Dalian, China.

[11]. Wang, Y. and Xie, J.Y. "Algorithm for multimedia multicast routing based on ant colony optimization" *Journal of Shanghai Jiaotong University*, Vol. 36, No. 4 (2002), pp 526–528.

[12]. Mina, M. "A review and performance comparison of QoS multicast routing protocols for MANETs" *Ad Hoc Networks*, Vol. 7, No. 6 (2009), pp.1150-1155.

[13]. Viet, T.M.D., Lars, L. and Oivind, K. "A Survey of QoS Multicast in Ad Hoc Networks" *Future Internet*, Vol. 1, No. 2 (2010), pp.388-416.

[14]. Aisha, A.H., Mohammad, M.Q. and Othman, K.L.Q. "Review of Multicast QoS Routing Protocols for Mobile Ad Hoc Networks" *International Journal of Computer Science and Network Security*, Vol. 8, No. 12 (2008), pp.108-117.

[15]. Darehshoorzadeh, A., Mehdi, D. and Jahed, M.R. "Quality of Service support for ODMRP Multicast Routing in Ad Hoc Networks". *Proceedings of the 6th international conference on Ad-hoc, mobile and wireless networks*. (2007). Morelia, Mexico.

[16]. Yunjung, Y., Lee, S.J., Su, W. and Gerla, M. "On-Demand Multicast Routing Protocol (ODMRP) for Ad Hoc Networks" Internet-Draft, draft-ietf-manetodmrp- 04.txt, November. (2002).

[17]. Sam, J., Maryam, S. and Amir, D. "IQoS-ODMRP: A Novel Routing Protocol Considering QoS parameter in MANET". *Proceedings of IEEE Symposium on Industrial Electronics & Applications*. October 3-6, (2010). Penang, Malaysia.

[18]. Li, L. and Li, C. "A QoS multicast routing protocol for mobile ad hoc networks", *Computer Communications*, Vol. 30, No. 7 (2007), pp.1641-1654.

[19]. Dayin, P. and Sornil, O. "A mesh based QoS aware Multicast Routing Protocol". *Proceedings of Eighth ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel Distributed Computing.* July 30 -August 1, (2007), Qingdao, China.

[20]. Kaan, B. and Cem, E. "Adhoc quality of service multicast routing", *Computer Communications*, Vol. 29, No. 1 (2005), pp. 136-148.

[21]. Wang, H., Shi, Z. and Li, S. "Multicast Routing for delay variation bound using a modified ant colony algorithm", *Journal of computer Network and Computer Applications*, Vol. 32, No. 1 (2009), pp.258-272.

[22]. Tebbe, H., Kassler, A.J. and Ruiz, P.M. "QoS-Aware mesh construction to enhance multicast routing in mobile ad hoc networks". *Proceedings of First International Conference in Integrated Internet Ad Hoc and Sensor Networks*, May 30-31, (2006). Nice, France.

[23]. Sagir, M., Wan, T. and Budiarto, R. "Load Balancing QoS Multicast Routing Protocol in Mobile Ad Hoc Networks". *Proceedings of Asian internet engineering conference.* December 13-15, (2005). Bangkok, Thailand.

[24]. Ng, J.M., Low, C.P. and Teo, H.S. "On-demand QoS multicast routing and reservation protocol for MANETs". *Proceedings of 15th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*. September 8th, 2004. Barcelona, Spain.

[25]. Royer, E.M. and Perkins, E. "Multicast ad hoc on-demand distance vector (MAODV) routing", IETF Manet, draft-ietf-manet-maodv-00.txt, (2001).