A Survey of QoS Routing Protocols for Ad Hoc Networks

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Abstract

The aim of this paper is to give a big survey in enhancing the balance of the routing load and the consumption of resources using network layer metrics for the path discovery in the MAODV protocol. A ad hoc network (AD HOC NETWORKS) consists of a collection of wireless mobile nodes, which form a temporary network without relying on any existing infrastructure or centralized administration. The bandwidth of the ad hoc networks architecture is limited and shared between the participating nodes in the network, therefore an efficient utilization of the network bandwidth is very important. Multicasting technology can minimize the consumption of the link bandwidth and reduce the communication cost too. As multimedia and group-oriented computing gains more popularity for users of ad hoc networks, the effective Quality of Service (QoS) of the multicasting protocol plays a significant role in ad hoc networks. In this paper we propose a reconstruction of the MAODV protocol by extending some featuring QoS in MAODV. All simulations are prepared with the NS2 simulator and compare the performance of this algorithm with the MAODV algorithm. The achieved results illustrate faster path discovery and more performing routing balance in the use of MAODV-Extension.This paper would give relatively a modest support in Mobile Technology according to QoS communication.

Key words: QoS, MAODV, Multicast routing, AD HOC NETWORKS, MAODV-Extension.

1. Introduction

Ad hoc Networks are collections of mobile nodes that communicate with each other over wireless links in the absence of any infrastructure or centralized administration. Each mobile node acts as a host generating flow, being the receiver of a flows from other mobile nodes, or as a router and responsible for forwarding flows to other mobile nodes [1]. Mobile nodes in Ad hoc networks have a limited transmission range, nodes that relies with the transmission range can communicate directly with each other, while intermediate nodes is needed to forward flow between nodes that are unable to communicate directly. The function of a routing protocol in Ad hoc network is to establish routes between different nodes. Mobile nodes are free-to-move without predefined mobility pattern which makes classical routing protocols used in wired networks are not suitable for ad hoc networks. The routing protocols are classified according to the way of route information collection into proactive and reactive protocols.

Group communication becomes increasingly important in ad hoc networks because a lot of applications relay on cooperation between a team (one-to-many and many-to-many). Video conferencing or class room settings, interactive television, temporary offices and multi-uses gaming are common examples of these application [2], [3].

As a consequence, multicast routing has received significant attention over the recent days.

Multicast communication is emerged to support applications that facilitate effective and collaborative communication among groups of users with the same interest. Multicast is a scheme for sending the same data from a source to a group of destinations. This is efficient in saving the bandwidth and improving the scalability, which is essential in ad hoc networks [2],[4].

Multicast routing protocol can be classified into four categories based on how routes are created to the members of the group [5].

The first is known as tree-based approaches, there is only one path between a source receiver pair and the union of the paths from the source to the receivers forms the multicast tree. This is done using either source-base trees or shared trees. In source-based trees, single multicast tree is maintained per source, while in shared trees a single tree is shared by all the sources in the multicast group. Tree-based protocols provide high data forwarding efficiency and low overhead but it is not robust in high mobile environments [6],[7].

The second approach is mesh-based, where may be multiple paths between senders and receivers. This redundancy provides robustness against topological changes better than tree-based protocols [5],[6].

The third one is the hybrid approaches which try to achieve better performance by combining the robustness of mesh-based approaches and low overhead of tree-based approaches [1],[5].

The fourth approach is Stateless multicasting, tree and mesh based approaches have an overhead of creating and maintaining the delivery packet in tree. In ad hoc networks environment, frequently movement of mobile nodes considerably increases the overhead in maintaining the delivery. To minimize this overhead stateless approach is proposed where a source explicitly mention the list of destinations in the packet header. This approach focuses on small and medium multicast groups. Assuming that the protocol takes care of forwarding the packet to represent destinations based on the address in the packet header [5],[8].

The increasing popularity of using multimedia and real time in different potential commercial applications in ad hoc networks makes it a logical step to support Quality of Service (QoS) over wireless network. QoS means a set of service requirements to be met by the network while transporting a flow from the source to destination. The objective of QoS routing in ad hoc networks is to optimize the network resource utilization while satisfying specific application requirements. The difficulties for supporting QoS in ad hoc networks environments are node mobility, routing overhead and limited battery life.

Our algorithm MAODV-Extension (support to QoS – MAODV) take steps in the estimation of node mobility by adopting the metric stability of the node, limited battery life by the power level of the node and the avoidance of routing overhead by coding method. Coding method associates a code to the available network resources which is initially set at the source node for each of the metrics and is updated at each intermediate node. Destination node then selects the most suitable and stable

path based on the application layer metric (delay, cost and throughput) to satisfy the application requirements.

Applications may be either delay sensitive or throughput or with no constraints. So our algorithm also considers the type of application in the path selection so as to satisfy the QoS constraints. Hence if the QoS state corresponds to the application requirements, data transmission occur without any delay else source node shape or dismiss its traffic. The algorithm also emulates both the end-to-end service management of intserv while maintaining the scalability and per–hop service differentiation of diffserv.

2. QoS Routing Protocols

We are presenting some multicasting protocols proposed specifically for supporting QoS over the ad hoc networks.

The Lantern-Tree-based QoS On-Demand Multicast Protocol (LTM) in [12] first searches for lantern paths from a source to a set of destination nodes and then merges them together to construct the lantern tree. The QoS path is a path which satisfies end-to-end bandwidth requirement under CDMA-over-TDMA channel model at the MAC layer based on [13],[14]. Available bandwidth in this model is measured in terms of the number of free time Slots

2.1 Providing Quality of Service to Ad hoc Multicast Enabled Networks

In [16] the idea is to extends existing approaches of mesh based multicasting like ODMRP [17] and unicast provisioning like SWAN [18] by introducing service differentiation (real-time (RT) and best-effort (BE) traffic class), distributed resource probing and admission control mechanisms as well as adaptive control of nonreal-time traffic based on MAC layer feedback. When a node has real-time traffic to send for multicast group, it floods the network with the first data packet (*Join-Probe*) piggybacked with bottleneck bandwidth (BB) and required bandwidth (RB). When the intermediate node receives the request, it sets a pointer toward their upstream nodes and updates the BB field if its local available bandwidth is less than BB in the request. Bandwidth availability at the local node is calculated similar to SWAN [18]. When the request arrives to a multicast receiver, it waits to collect all the requests and it evaluates the available bandwidth. If the largest value of BB is greater than RB, it creates Join- Reply packet piggybacked with the largest BB and RB. Also, it sets RTF-Flag and becomes multicast forwarder for the group to construct the mesh similar to ODMRP.

Intermediate forwarder node updates BB field with the maximum of all received replies and sets RTF-Flag if BB is larger than RB for the given multicast group and rebroadcast the reply[15].

2.2 Qos routing protocol

A Qos routing protocol is presented in [11],[19]. It's a mesh-based on demanded protocol to connect a group of members and provide QoS paths to the multicast group. Bandwidth estimation is done at MAC layer using CDMA/TDMA channel model using passive listening method [20]. The estimation of the bandwidth at each node is based on the status of the radio channel, they rely on the physical carrier sense to determine the idle and busy state of the channel. Each node monitors the channel and start counting the channel state from idle to busy states. They uses forward group as a subset of the network topology that provides at least one path from each source to each destination in the multicast group like On-demand Multicast Routing Protocol (ODMRP) [17].

The session is initiated by the node that has data to send by broadcasting a QREQ packet with the required bandwidth and maximum hop (MH) greater than zero. Intermediate nodes calculate its available bandwidth, update its available bandwidth with current QoS condition and if the node satisfies the requested bandwidth it rebroadcast the packet until MH equal zero or QREQ arriving at a destination.

Otherwise, the packet is dropped. The bandwidth is computed at intermediate nodes independently without the need to share information with all neighbors. The destination receive QREQ from several paths, it choose the route with best QoS conditions and send a reply back to the source to start data transfer. In replay phase, the intermediate node compares the ID with the ID from the reply if it is match then it set the *ack* flag to indicate that its part of the forwarding group. Also, it reserves the bandwidth to be used in forwarding data packets.

QMR provides a load balancing and contention prevention scheme by updating the forwarding nodes and use intermediate nodes with enough bandwidth to forward the data. This scheme is used when multiple sources sending to the multicast group simultaneously which causes nodes in a single path to be overloaded and the probability of packet discarding increase[9].

Another metod is a mesh based protocol which offers bandwidth guarantee for applications in ad hoc networks. The multicast mesh is created by broadcasting a RouteRequest packet from the source.

The intermediate node rebroadcasts the packet after it updates its cache and increases the hop count. When the receiver, receives the request, it caches the route and broadcast a RouteReply packet. If the upstream node is the node that sends the request to the receiver, it will set the Forwarding Flag and Forwarding Timeout fields and rebroadcast the reply packet. Otherwise, it will set the Neighbor Flag and Neighbor Timeout and does not rebroadcast the request packet. The receiver uses the first request without waiting for other requests. It responds for the request after waiting for a period of time and choose the best route based on the Forwarding count and non- Forwarding count and gives preference for the route with the highest value of Forwarding count. In both cases the RouteRequest is rebroadcasted because the receiver node may be a forwarding node for other receivers [10].

Another survey is protocol for Quality of Service in Ad hoc Routing Protocol [3] tracks resource availability within a node neighborhood based on previous reservation, and announce the QoS conditions at session initiation. Any node can start the session by broadcast a message (SIS-INIT) with QoS requirement, number of users and the application type. Its predecessors (MCN_PRED) propagate the packet upstream as long as QoS can be satisfied and within the number of hops limit. The node that receive SIS-INIT message updates QoS information field with the current QoS conditions. New nodes can join the session by sending JOIN-REQ toward any member of the session, only nodes that aware of the session consider this request. Downstream nodes aggregate the replies from the session members and forward the reply within the QoS conditions, to enable the requester to choose the best of them. And then, a reservation message is sent to the node which is the forwarder of the reply. If the intermediate node among the intended forwarder on the path, they change their state to be forward nodes, reserve resources and update membership table, until the reserve message reaches the reply originator. The replier may be a forwarder or server initiator, it have already reserved resources and it added the new joining node to its member table and continue send multicast data.

3. MAODV-Extension with QoS

MAODV is an on demand multicast routing protocol which selects routes on demand. MAODV-Extension extends MAODV with the QoS support using the architecture of 2Lqos model). The operation of the MAODV-Extension algorithm is described as follows:

3.1 Route discovery

Source node initiates the path discovery by broadcasting a RREQ with the QoS extension (i.e qos state, class) to destination D. RREQ contains the following fields: Sourceid, seq. no, dest-id, hop count, qos state (stability level, power level, buffer level), and class.

Hop count: Hop count is the number of intermediate nodes between the source and the destination. The hop count is related to resource conservation.

Power level: Power level is used as a designation of routing load of each node. This represents the QoS state of a node in terms of available battery. Power level or available battery of a node is coded as high = 11, medium = 10, low = 01, selfish = 00. This metric is used to determine how long the node can be able to communicate.

Buffer level: Buffer level is used to find out the availability of unallocated buffer. It is also used to find out the load of each node on the path. If a large number of packets is queued up for the forwarding, then the buffer level of a node is low. Buffer level or the nodes internal state is coded as high = 11, medium = 10, low = 01 selfish = 00.

Stability level: Since the nodes in the AD HOC NETWORKS are mobile, this metric is used to find out whether the nodes are stable or unstable. If the changes in the neighbors of a node are frequent, then the node is unstable otherwise it is stable. If any node is found as unstable then the packets will not be delivered to that node. The stability level of a node is coded as high – 11, medium – 10, low-01 selfish-00.

Cost: Cost is also estimated during the path discovery procedure. The cost metric is additive and so as the RREQ is forwarded it is incremented by the intermediate nodes. Cost metric is updated based on the credit to forward in that link.

Class: Source node assigns the class to a packet by assigning a two bit code to the IP header of each packet of the application. The delay sensitive application is mapped to class = 1, code = 01.The application which requires a high throughput is class =2, code = 10 and class = 3, code = 11 with no constraints.

3.2 Path Selection

As the QoS path request message reaches the destination node, it executes the path selection procedure. The destination node selects the path based on qos class and the qos state. If class=1, the path with the minimum end to-end delay is selected. If class=2 the path with the maximum available bandwidth is selected. If class=3 the shortest path is selected. RREP is then propagated by the destination to the source.

RREP indicates the QoS state of the path from the source to the destination. If more than one path is available for the class, then the metric stability is first used to select and again if more than one path is available then the path with the highest power level is selected and data is forwarded through this path to the destination.

3.3 Service differentiation

To guarantee the network resources of an admitted application, diffserv architecture are implemented in MAODV which make use of class based weighted fair queuing (CB-WFQ) scheduling. A queue is reserved for each class and is implemented at each node. Source node classify the incoming packet in to the appropriate queue and the traffic belonging to the class is forwarded to that queue. The packets in the queue belong to different applications of the same class. The queue will receive prioritized service based on the weight of the queue and hence even the low priority application will also get serviced.

4. Implementation

The QoS state of a path message consists of *power level*, *buffer level* and *stability level* for Network Layer and *throughput* for Application Layer.

4.1 Network layer metrics

Power: The power level is a concave function and therefore the power level of each node is computed by path:

power = min (path. power, power)

It is implemented by modifying the code in mac/wireless-phy.cc and get the link in aodv/aodv.cc. This metric is related to routing load and is used to estimate the efficiency of the node and the duration with which the node can able to communicate in the network.

Buffer: The buffer level is also a concave function and the average buffer level of each node of the path is computed using the formula:

*path. buffer=hop * path.buffer+buffer/hop+1*

If its value =00, then it is in selfish mode and the RREQ message is not forwarded to this node. The buffer level is implemented in queue/priqueue.cc and the declaration of buffer level in aodv/aodv.cc.

Stability: The stability level of each node in the path is a concave function and its value is computed using the formula:

path.stab=min (path.stab, stab)

The RREQ message is not forwarded to unstable nodes. A node is unstable if the neighbors of a node change frequently. A node is highly stable if none of its neighbors change at the two times t1 and t0.

4.2 Application layer metrics:

Throughput: Throughput is the rate at which the packets are transmitted in the network. Throughput is computed using the following formula:

Throughput = total no. of bytes 8/ (Start time – end time).*

4.3 Service Differentiation

Diffserv architecture proposed for Internet is used in MAODV-Extension to guarantee the network resources based on Class based weighted fair Queuing (CB-WFQ) scheduling.

A queue is reserved for each class and the incoming flow (flow = high or low priority) is forwarded to the appropriate queue based on the class of the packet. The packets from different queues are serviced based on the priority of the queue. The priority of each queue is set by assigning a weight to the queue. The weight of each queue at the node is assigned such that class 1 queue occupies 60% of CPU times, class 2 occupies 30% and class 3 gets 10%.

CB-WFQ is implemented in ns-2.29/queue/wfq.cc & wfqclassifier.cc & wfqsamplec.cc. The weight for the queue and the packet length is assigned using tcl script.

The queue reservation of each class is implemented in Wfq.cc and it also verifies that the traffic belongs to which queue. The assignment of weight for each queue is implemented in wfqclassifier.cc.

5. Simulation Results

Simulation of MAODV-Extension is performed and compared with MAODV using NS-2 [24] to evaluate the protocol. A total of 60 nodes were simulated for duration of 700s in an area of 2000m × 2000m.The mobility model is the random way point to model the mobility of the nodes in the network. The MAC layer protocol used was IEEE 802.11.

The transmission range for each node was 250m and the channel capacity was 2 Mbps. The size of the packet was 1000 bytes. The maximum queue length is 500 packets.

The performance metrics used for comparison are packet delivery ratio, receiving ratio, end-to-end delay and throughput.

Packet delivery ratio: Data packet delivery ratio is defined as the number of packets delivered to the destination to number of packets to be received.

End-to-end delay: The end-to-end delay is the total delay the packet experiences when it travels across the network.

Throughput: Throughput is the rate at which the pa ckets are transmitted in the network.

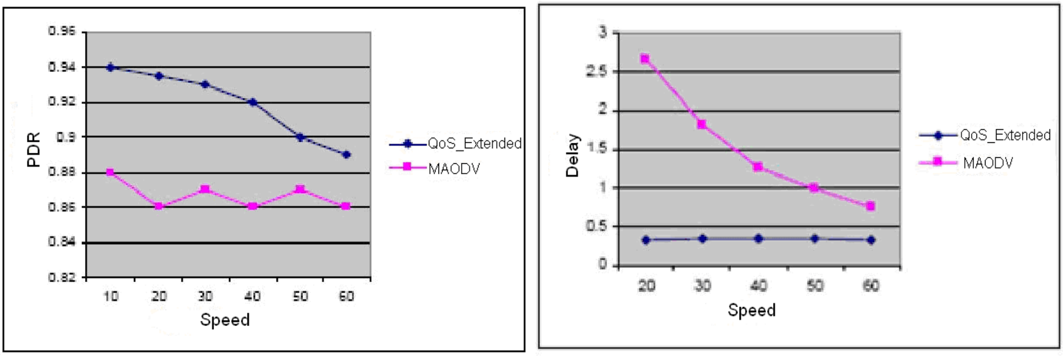

Fig. 1-2. Comparison of the packet delivery ratio and delays in MAODV and MAODV-Extension

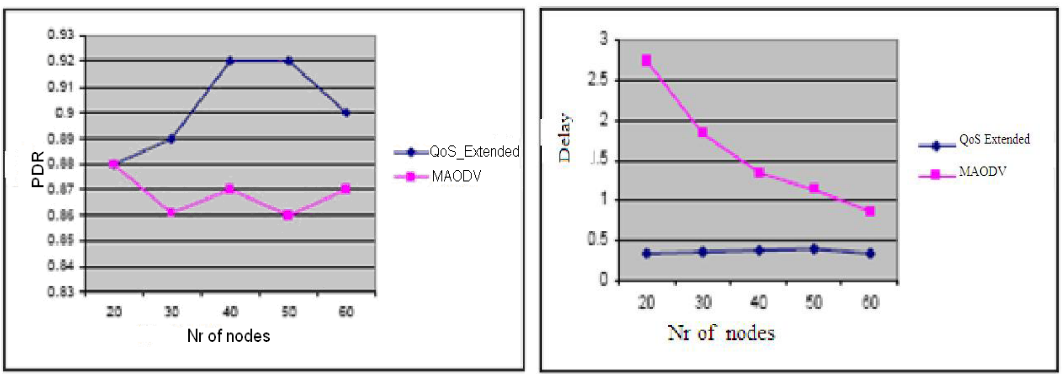

Fig. 3-4. Comparison of the packet delivery and Delay in MAODV and MAODV-Extension

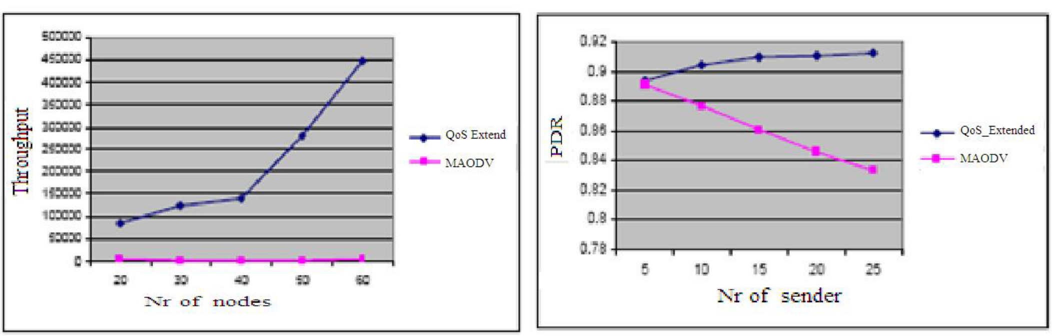

Fig. 5-6. Comparison of Throughput between MAODV and MAODV-EXTENSION

5.1 Speed

The packet delivery ratio (PDR) of MAODV and MAODV-Extension is compared with respect to speed in Fig.1. The PDR of MAODV-Extension is significantly high when compared to MAODV, but there is a decrease in PDR as the speed increases from 10 to 60 m/s. The usage of network layer metrics in the routing process such as buffer level and power level balanced the routing load and hence there is an increase in PDR.

Fig.b1. shows that delay of MAODV-Extension is comparatively less than MAODV. The fact is that destination selects the path based on the QoS state and the application metric which consider the delay, bandwidth and cost in the path selection. This in turn reduces delay in the establishment of the path.

5.2 Network Size

The scalability of the protocol is tested with respect to the group size by varying the number of members in the group. Fig.2.reveals that the packets delivered is slightly higher in MAODV-Extension when compared to MAODV. The control overhead is reduced by means of using the coding method and this in turn increases the packet delivery ratio. The coding method is implemented to check the buffer, power and stability level. Packet delivery is also increased due to the transmission of the RREQ packets to those nodes which is having a high stability i.e. the nodes which are of less mobility. Hence there is a decrease in the packet drop and the control overhead.

Fig.3. shows the delay comparison of MAODV-Extension with respect to MAODV. There is no significant change in the delay of MAODV-Extension as the number of node increases. But the delay of MAODV is significantly high when compared to the proposed protocol. The delay is less due to the inclusion of network layer metrics in the procedure of path discovery and the selection of the path based on the QoS state of each path received by the source node.

Throughput of MAODV-Extension is measured and compared in Fig.5.with respect to the number of nodes. Throughput of the proposed protocol is increased which is due to the application of application layer metrics namely the throughput delay and cost in the selection of the path.

5.3 Sender

The number of senders is varied to evaluate the protocol scalability based on the number of multicast source nodes.Fig.6.shows that as the number of senders is increased from 5 to 25 the number of packets delivered in MAODV-Extension is significantly higher when compared to MAODV. The traffic sources are chosen to be CBR with traffic of 3 high priority flows and 3 low priority flows. The throughput, delay of high priority (hp) and low priority (lp) flows is analyzed. The results given in the table reveals that if the number of high priority flows is increased the delay is increased. Also the delay of high priority flow is less compared to low priority flow. The throughput is considerably reduced if the number of flows is increased. The results are given in the table 1:

Table 1. Simulation results of the flow of traffic generated.

No. of flow	2	2	3
No. of hp flow	1	2	2
No. of lp flow	1	-	1
Throughput of hp flow	58,263	57,263 56,682	56,852 55,312
Throughput of lp flow	55,784	-	53,591
Delay of hp flow	,327	,351	,363
Delay of lp flow	,535	-	,584

6. Conclusion and Future Work

MAODV-Extension is the extension of MAODV with the QoS support in the multicast routing protocol. The network layer metrics is involved in the path discovery to find a QoS path to the destination. The application metric is employed at the destination to select the path based on the QoS state, the class of the application and the application requirements.

The path with the highest stability is the preferred path and if more than one path is found the destination node selected the path with the highest power level. Regarding the application requirements, if the application is delay sensitive then the path with the minimum delay is chosen and for the application with throughput constrained the path with maximum bandwidth is selected and with no constraint any path is chosen by the destination. Hence this criterion is adopted in the enhancement of the proposed protocol to satisfy the QoS issues. The protocol balanced the routing load and also minimized the consumption of resources.

As a future work different number of flows can be analyzed with different network scenarios.

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