QoS Constrained Multicast Routing For Mobile Ad Hoc Networks

P.Latha[1] and R.Ramachandran[2]

Research Scholar	Professor
Sathyabama University	Sri Venkateswara College of Engineering
Chennai	Chennai
India	India

Abstract:
QoS is essential in MANET to satisfy the communication constraints. Due to the fully mobile infrastructure and limited resources provided by the MANETs, qos techniques need to optimize the scarce resource. To meet the qos requirements of the applications, multicast routing protocols are required to construct the routes, with the qos being guaranteed. Previous qos routing/multicast routing protocols adopted some algorithms, but it does not guarantee that an admitted application receives the resources that were available from the network. So we propose a new protocol QoS-MAODV that extends MAODV with the qos support using the architecture of two–layered qos model (2Lqos). QoS-MAODV makes use of network layer metrics for the path discovery to balance the routing load and the consumption of resources. The application layer metrics is then used for the selection of the path based on the qos state of the path and the application requirements. Also the network resources is reserved and guaranteed for an admitted application using the diffserv architecture proposed for Internet. Simulation results show that the performance has been enhanced and the qos constraints have been satisfied when compared with MAODV.

Key words:
Quality of service, MAODV, Multicast routing, MANET, qos model.

I Introduction

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 MANET is to optimize the network resource utilization while satisfying specific application requirements. The difficulties for supporting qos in MANET environments are node mobility, routing overhead and limited battery life. Our protocol 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 protocol 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 protocol also emulates both the end-to-end service management of intserv while maintaining the scalability and per–hop service differentiation of diffserv.

II Related work

QoS in adhoc networks can be introduced in several independent levels [6], MAC level [7] and the routing protocols level [1-5]. Existing qos solutions enable the execution of multimedia applications such as video conference, Visio phony etc. However the consumption of significant amount of resources and the dynamic nature of adhoc network makes it difficult for an application to obtain accurate knowledge of the network state. Moreover existing algorithms or approaches try to establish a path subject to delay, bandwidth or cost constraint. Considering the qos models, the throughput of SWAN [10] is much lower and also varies with mobility. FQMM [11] model is suitable for medium sized MANETs less than 50 nodes only. INSIGNIA [12] does not scale well but effectively deliver adaptive real time flows. Our protocol considers multiple constraints the cost, bandwidth and delay in the selection of the path to satisfy the qos requirements .It also optimize the path establishment in consideration with the MANET features such as mobility, power inefficiency and routing overhead.

III Architecture of 2LQoS model

The QoS metrics of 2Lqos model are network and application layer metrics. The objective of network layer

Manuscript received July 5, 2009
Manuscript revised July 20, 2009

metrics is to enforce the balanced network utilization and to restrict the network resources. The network layer metrics are used by the path discovery procedure to determine the qos state which is utilized in the generation of paths. Among the generated paths, the destination node selects the most suitable path using the qos state and the qos class according to application requirements.

A. Network layer metrics:

The network layer metrics employed by the path discovery procedure are hop count, power level, buffer level and stability level. This extracts the qos state of the path.

Hop count: It is defined as the number of intermediate nodes between the source and destination. This metric is related to resource conservation, since the path with smaller number of hops consumes fewer network resources. It is also used to generate the shortest path.

Power level: Power level of a node indicates the availability of current amount of battery. It is also an indication of the load of the node.

Buffer level: Buffer level is used to represent the available unallocated buffer. This metric is also related to routing load.

Stability level: Stability level is defined as the connectivity variance of a node with respect to its neighboring nodes over time. This metric is used to avoid unstable nodes to relay the packets.
For all the network layer metrics, if qos state = high (75-100 %), code = 11, state = medium (50-75 %), code = 10, state = low (25-50 %), code = 01, state = selfish (0-25 %), code = 00.

B. Application layer metrics

The application layer metrics used by the path selection procedure are delay, throughput and cost. Qos class = 1 (code = 01) is associated with the metric delay, class = 2 (code=10) is associated with throughput, and class = 3 (code=11) is associated with the hop count. So if qos class of the incoming traffic is 1 then it is delay sensitive application and if its class =2 then it is throughput sensitive and if class = 3 mean that no constraint. The destination node employs the qos state together with the qos class to select the path to satisfy the application requirements

IV QoS-MAODV

MAODV [8] is an on demand multicast routing protocol which selects routes on demand. QoS-MAODV extends MAODV with the qos support using the architecture of 2Lqos model. The operation of the QoS-MAODV protocol is described as follows.

A. 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. Source-id, 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 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 umber of packets is queued up for 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 MANET 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.

B. 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.

C. 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.

V Implementation

The qos state of a path message consists of power, buffer and stability level.

A. 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 t_1 and t_0 .

B .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).

C. Service Differentiation

Diffserv architecture proposed for Internet is used in QoS-MAODV 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.

VI Simulation Results

Simulation of QoS-MAODV is performed and compared with MAODV using NS-2 [9] to evaluate the protocol. A total of 60 nodes were simulated for duration of 700s in an area of 1000m × 1000m.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 packets are transmitted in the network.

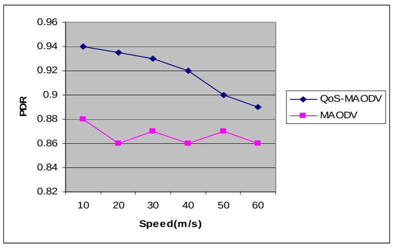

Fig.1.PDR vs speed

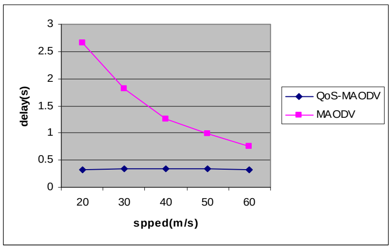

Fig.2.Average end-to-end delay vs speed

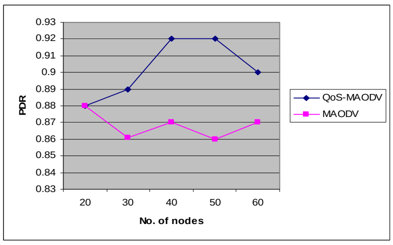

Fig.3.PDR vs no. of nodes

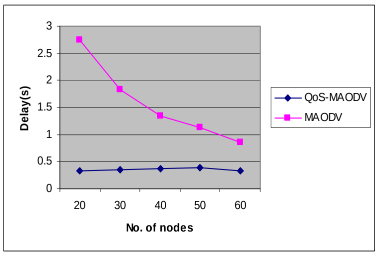

Fig.4.Average end-to-end delay vs no. of nodes

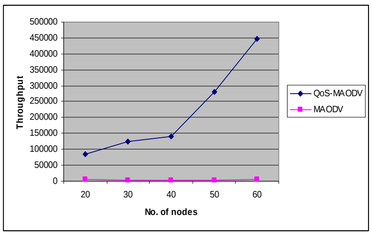

Fig.5.Throughput vs no. of nodes.

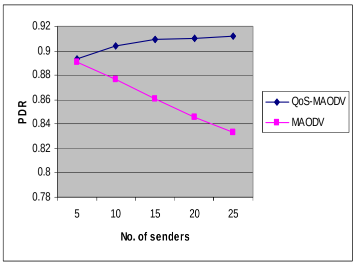

Fig.6.PDR vs no. of senders

A. Speed

The packet delivery ratio (PDR) of MAODV and QoS-MAODV is compared with respect to speed in Fig.1. The PDR of QoS-MAODV 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.2. shows that delay of QoS-MAODV 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.

B. 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.3.reveals that the packets delivered is slightly higher in QoS-MAODV 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.4. shows the delay comparison of QoS-MAODV with respect to MAODV. There is no significant change in the delay of QoS-MAODV 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 QoS-MAODV 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.

C. 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 QoS-MAODV 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 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	55784	-	53,591
Delay of hp flow	.327	.351 .367	.363 .358
Delay of lp flow	.535	-	.584

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.

VII. Conclusion and Future work

QoS-MAODV, the multicast routing protocol is the extension of MAODV with the qos support .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.

References

[1]R.Sivakumar, P.Sinha and V.Bhaghavan,"CEDAR:A Core Extraction distributed Ad Hoc Routing Algorithm," IEEE J. Selected Areas in Comm., vol.17,pp.1454-1465,1999.

[2] S.Chen and K.Nahestedt,"Distributed quality-of-Service Routing in Ad Hoc Networks", IEEE J. Selected Areas in Comm., vol.41,pp.120-124,1999.

[3] Q.Xue and A.Ganz,'Ad Hos QoS on-demand Routing(AQOR) in Mobile Ad Hoc Networks", J. Parallel and Distributed Computing, vol.41,pp.120-124,2003.

[4].E.Pagani and G.P.Rossi,"A framework for the Admission Control QoS Multicast Traffic in Mobile Ad Hoc Networks,"Proc.Ninth ACM Int'l Workshop Wireless Mobile Multimedia (Multimedia '01), pp.3-12,2001.

[5] P.Sinha ,R.Sivakumar, and V.Bhaghavan,"MCEDAR:Multicast Core Extraction distributed Ad Hoc Routing,"Proc.IEEE Wireless Comm. And Networking Conf. (WCNC'99),PP.1313-1317,1999

[6] Kui Wu and Janelle Harms,"QoS support in Mobile Adhoc Networks'Computing science Department,University of Alberta,2001.

[7] A.Veres,Campbell,A.T.Barry.M and L-H.Sun,"Supporting service differentiation in wireless packet using distributed control",IEEE journal of selected areas in Communication.(JSAC)vol.19,No.10,pp.2094-2104,October 2001

[8] Yufang Zhu and Thomas Kunz, "MAODV Implementation for NS-2.26",Systems and computer Engineering ,Carleton University, Technical Report SCE-04-01,Jan 2004.

[9] The network simulator—NS-2 Notes and documentation and source code. . Available at: http://www.isi.edu/nsnam/ns/

[10] G.Ahn,A.Campbell,A.Veres, and L.Sun,'SWAN ; Service differentiation in Stateless Wireless Ad Hoc Networks," Proceeding of IEEE INFOCOM 2002,Jun 2002.

[11]H.Xiao,K.G.Seah,A.Lo and K.C.Chua,"A flexible quality of service model for mobile adhoc networks',IEEE Vehicular technology conference (VTC spring2000),Tokyo,Japan,May 2000,PP. 445-449.

[12] S.Lee,G.Ahn,X.Zhang and D.Campbell,'INSIGNIA ; An IP-based quality of service framework for Mobile Ad hoc Networks,"J of Parallel and Distributed Computing (JDDC), vol.60,No.4,April 2000.

P.Latha is a faculty in a self-financing Engineering College in Chennai. She is currently doing her PhD (Computer Science & Engineering) in Sathyabama University. Her area of interest is Computer Network, Mobile Computing and Genetic Algorithm.