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A Survey of Quality of Service Routing Protocols in MANETs

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***Abstract*-Mobile Ad-hoc networks are collection of mobile nodes, which communicate over wireless links. These networks inherit the traditional problems of wireless and mobile communications. In addition, the multi-hop nature and self routing. As mantes are gaining popularity because of its self organizing nature, easy to deployment, adaptation to highly variable characteristics and frequent network topology changes without requiring any fixed infrastructure these networks are becoming useful for Quality of Service (QoS) sensitive applications too such as multi-media and VoIP. So there is a requirement to support QoS for real time traffic. Traditional routing protocol in mantes have not done much focus on QoS issues, But recently many QoS routing protocol has been proposed to solve these issues. Traditional routing protocols have been modified as well as new routing protocols have been introduced. This paper presents a survey of QoS routing protocols which support various QoS metrics, first the brief description of protocols is given and then their key features and comparison is summarized.**

INTRODUCTION

Routing is the inherent problem in mobile adhoc networks because of lack of any fixed base stations and unpredictable mobility of nodes, based on best effort delivery services many algorithms has been designed, some widely accepted algorithms are DSDV,AODV,OLSR,DSR these algorithm find paths from source to destination based on minimum number of hop count but do not give much focus on the quality of services issues, the absence of base stations and unpredictable nodes movement makes the QoS a required features rather than an extra service provided by the networks.

While attempting to enhance these networks to support applications with quality-of-service (QoS) requirements, there are many challenges. At the physical layer there are interference problems by the other neighbor nodes. At the MAC layer, since these networks use distributed channel access mechanism which causes the hidden and exposed node problems. Such problems make bandwidth reservation very complicated process. At the network layer, routing protocols have to deal with two things path construction and, path maintenance because the topology of such type of networks change very frequently, so network layer should be adaptive to deal with frequent path break and repair it or find new path immediately without violating QoS constraint. For QoS support, network layer should select path which meets the QoS constraint required by the traffic flows among the various available paths. A QoS enabled routing protocol is expected to support several metrics in terms of end-to-end delay, throughput, bandwidth and jitter as well packet delivery ratio. These metrics are described below.

A. Delay

Delay is the total time elapsed between a sender node sends the packet and the receiver receives the packet, this includes the transmission delay by the sender and intermediate nodes, propagation delay and the waiting time in queue at routers, for a highly congested network delay increase dramatically.

B. Bandwidth

For QoS sensitive application there exist a lower bound of required bandwidth, which is the payloads receive by the receiver during some specified amount of time, since the available bandwidth from source to destination is not fully used by a single traffic flow because of the shared medium, but routing protocol should ensure to meet the minimum required data rate experienced by the application layer of the receiver.

C. Jitter

The waiting time of packet for its transmission at the queue of the router is the jitter, as jitter increases the delay also increases. Which degrade live video quality nearly as much as packet loss rate.

D. Packet delivery ratio

The effective delivery ratio is the ratio of total packets received by the receiver and the total number of packets transmitted by the sender. In a congested network the packets is dropped by the intermediate nodes because of the queue overflow these loss packets need to be re-transmitted which degrades the network performance A high packet delivery ratio is desirable.

Theoretically an QoS routing protocol needs to be satisfied all these QoS matrices, But To design a single protocol with guaranteed two or more QoS constraints is a NP-complete problem [1] [2] [3] and the time to solve a NP-complete problem using algorithms available currently increases as the size of the problem increases because An NP-complete problem can only be solved via an brute force search of the solution space which takes a long time. In term of QoS, routing algorithm need to check all the paths from source to destination which satisfies the QoS constraints.

But it has been observed that real world traffics usually don't have more than two QoS constraints simultaneously[4],so there is no need to design a single protocol which is satisfying all QoS parameter simultaneously. The effectiveness of a protocol can be judge based on the application requirement. A protocol can be very effective for an application but not that much in another application. Because the importance of QoS constraint vary from application to application, some may require energy constraint an important issue but cannot tolerate the delay or some soft QoS application can tolerate the delay up to some extinct but require to utilize network resource efficiently. Since QoS constraints are application dependent so researchers give focus on the requirement of an application during design of QoS model. Almost all the protocols try to enable the delay and bandwidth provision which are very important QoS parameters.

RELATED WORK

Many QoS routing protocol for mobile ad-hoc network has been proposed based on various parameter and design approach.

In 2001 Chakrabarti and Mishra [5] gave a comprehensive overview of QoS related issues which needs to be solved by the protocols for QoS provisioning in mantes. In 2004, Kamal [6] classified the QoS routing protocol based on various categories such as network topology, power aware security, unicast and multicast. Reddy et al. in [7] highlighted various significant challenges for QoS supporting technique in Manets and also proposed their solution. In [8] author summarized various QoS routing protocol with their functions and suggested various parameter which needs to be taking account during design of routing protocol which includes delay, bandwidth, throughput, jitter and packet loss constraint since optimizing routing technique is the very effective way to support QoS constraint, so significant attention should be given at the network layer.

DESCRIPTION OF SURVEYED PROTOCOL

A**.** *Q-AOMDV*

C. Wu et al. [12] presented an ad hoc on-demand multipath routing (Q-AOMDV) and compared its performance with AOMDV Simulation result shows that performance of Q-AOMDV is far better than AOMDV in term of delay and packet delivery ratio.

Q-AOMDV support quality of service, for a flow, by selecting the path based on delays, bandwidth, and hop-count constraint. The route request and route reply packets includes these field also to check the path which can provide threshold level of service requirement.

In route discovery phase, the source node floods the RREQ message. Travelling through the different paths which provide required QoS many RREQ packets reach to the destination. The destination node selects multiple disjoint routes and sends RREP packets back to the source via the chosen routes .Q-AOMDV also has the route maintenance phase, when primary path breaks due to node mobility or some other reason, the first node which become unable to send data packets to its downstream node send a ROUTE ERROR (RERR) to the source. Route error packets contains the information of the broken link, upon receiving the RERR packet the source node deletes all the entries for any route which uses the broken path. Since Q-AOMDV maintain multiple path source uses the remaining valid route to deliver data packets.

Other than Q-AOMDV there are some other protocols which are based on AODV these are described below.

1) *AQOR:* In AQOR [9] to explore path which satisfies delay and bandwidth constraint, AQOR flood the route request packet. These packets contain the acceptable delay and required bandwidth constraint. When an intermediate node receives the route request (RREQ) packets it will broadcast the packet only if it satisfies the bandwidth constraint itself. In this way protocol minimize the route request flooding, intermediate nodes which forward the packet make an entry for the route and wait for route reply (RREP) for some duration of time. This duration is double of the acceptable delay, if it does not receive RREP within this duration; it deletes the route entry because it violates the delay constraint of QoS. Because this packet is flooded, several duplicates request packets that traversed through different routes reach the destination node destination will send back a reply packet along each of these routes. Route with the least delay is chosen by the source but, the bandwidth reservation is done by the arrival of the first data packet from the source node.

2) *QAODV or (QoS AODV):* This is developed by Shayesteh *et al* [10] is a modification of the traditional AODV routing protocol. QAODV protocol use a weighted function to select the best route, the weighted function is the composition of various QoS metrics. So here the quality of link and node through the path are also being taken as a parameter in addition to the minimum number of hop count from source to destination. For this purpose the route request process of AODV is modified. Because of checking these constraints, route discovery processes introduce extra overhead to the network, but the throughput is increased significantly at the cost of this overhead.

3) *AOMDV:* This protocol [11] was designed as an extension of AODV protocol that modifies the route discovery procedure of AODV to find multiple paths. All these paths are link and node disjoint, in AODV which find a single path once the path breaks then source need to initiates route discovery procedure again and establish another path. During this time a lot of packet loss occurs. But in AOMDV protocol maintains multiple paths in advance so once if the primary path breaks packet transmission can be continue by using another path without initiating path discovery process again. This protocol is robust and reduces packet loss significantly.

B. *QAMR*

In [13] author proposed the protocol QAMR. It is based on Ant Colony Optimization (ACO). The basic idea behind ACO algorithms for routing is the use of ants like agents, called forward agents (FANTs) and backward agents (BANTs). FANTs ants are generated by the source nodes and BANTs are generated by the destination node, with the task to sample a path between the source and an assigned destination. An Fant going from source node to destination collects information about the quality of the path (e.g., number of hops, hop delay, available bandwidth, node energy etc.). BANTs return its way back to setup the path, the paths are represented in a pheromone tables which represents the quality of path, and a path with high pheromone value means high quality of path.

For the route discovery FANTs and BANTs are used. FANTs are broadcasted to the neighboring nodes which have next hop availability (NHA) greater than threshold availability, (NHA>NHAthr). FANTs have the address of all the nodes through which it passes. When FANT reaches the destination, it waits for some duration of time for receiving all the FANTs Then receiver calculates

The path preference probabilities for each path P (i) which satisfies Dc<Dt, Bc>Bt, Hc<Ht using formula:

P(i)= (dgbghg)i/ Σj€pi(dgbghg)j.

Where Dc, Bc, Hc are the delay, bandwidth, hop count read by the FANTs and Dt, Bt, Ht is the threshold delay, bandwidth and hop count required.dg, bg, hg are the percentage of goodness of QoS parameters: delay, bandwidth, hop count respectively.

Then BANTs are generated and unicast to all these paths, when an intermediate or source node receive BANTs it updates pheromone value in its pheromone table. The BANTs with highest pheromone concentration is selected as path.

The performance of QAMR was compared with AODV and QAMR and it was found that QAMR performed better for the metrics packet delivery ratio, QoS path success ratio, routing overhead.

C. *RTLB-DSR*

RTB-DSR [14] is an extension of DSR protocol, DSR protocol which select the paths based only on the minimum hop count suffers with unbalanced traffic load at the selected nodes. A highly loaded node degrades the network performance and increase the end-to-end delay due to the congestion and delay at the bottleneck node. Sang-Woon describe in [15] to achieve minimum delay in a network with many path and various traffic load, there should be some upper bound between the maximum and minimum link load, independent of the number of the traffic in the network. The RTLB-DSR routing protocol minimizes the end-to end delay and utilizes the network bandwidth efficiently by balancing the traffic in the network. In RTLB-DSR algorithm the DSR algorithm is modified to balance the traffic in the network and to select the path based on minimum links cost, author has taken the link cost based on the degree of the nodes which is the number of nodes which are within communication range of a node. For instance the cost between node A and B will be x if x is the degree of node B. then in RTLB-DSR protocol the objective is to minimize,

$\frac{1}{\mathrm{N}} \sum_{k=0}^{n}$ size of Neighbour count(k),

during selection of any path, where K is the node which is a part of any path.

During the path discovery phase the DSR route request packet contains the link cost in addition to the nodes which encounter during the path discovery. when the route request reach to destination the destination select the paths which have minimum delay. To provide different treatment to different kinds of flow (real time and best effort), the packets are marked and the deadline is set at the transport layer. If packets are real time packet, then when the packets are received at MAC layer, a full buffer MAC layer drop the best effort packets ahead of real time packets, or gets higher priority for transmission if deadline is not expired

Simulation result shows that RTLB-DSR method outperforms than DSR in term of packet delivery ratio and end-to-end delay.

D. *MP-QMRB*

It utilizes the network resources efficiently by balancing the load in the network. It is the combination of QMRB-AODV and AOMDV. It inherits the routing backbone concept of QMRB-AODV and multipath capability of AOMDV. So MP-QMRB setup multipath on demand link disjoint and QoS enabled path. The set of nodes which are selected for path setup are called mobile routing backbone (MRB). To decide the nodes that can be part of MRB QoS matrices are used which are same as used in QMRB-AODV.QoS metrics are size of packet queue of a node, load of a node, number of neighbor node and link stability. Protocol ensures that each explored path will satisfies the requirement of MRB. The path with highest QoS matrices is selected as the primary path for data transmission and rest is secondary path which will be used if the primary path breaks. Thus it reduced the overhead of path discovery process again .MP-QMRB performs better in dense network. Simulation result shows that MP-QMRB perform better than both QMRB-AODV and AOMDV, in term of end to end delay, throughput, and packet delivery ratio and also utilize the network bandwidth efficiently.

E. *CBC-OLSR*

CBC-OLSR [17] is proactive protocol which is based on OLSR it is a cross layer design approach which takes into consideration, weighted connectivity index of network layer parameter and Bit error rate of physical layer parameter, bit error rate is the average error rate of communication links and weighted connectivity index is the function of nodes degree and link capacity (Bandwidth). Aim of the protocol is to select path with low bit error rate and high weighted connectivity index, path with low bit error rate ensures that packet retransmission will be reduced and high weighted connectivity index indicates that path with high link capacity and low degree of nodes are selected. Because if the intermediate nodes through the path has less degree then there will be less inference at MAC layer for packet transmission, and high link capacity ensure the bandwidth of the link is high.

COMPARISON OF QOS ROUTING PROTOCOLS

	Q-AOMDV	MP-QMRB	QAMR	RTLB-DSR	CBC-OLSR
QOS-METRIC	BW, Hop Count, End to End delay	BW, hop count, node stability	Delay ,BW, hop count, node stability	Delay, Bandwidth	Bandwidth and bit error rate
BASE PROTOCOL	AOMDV	AOMDV and QMRB-AODV	-	DSR	OLSR
MULTIPLE ROUTE	yes	yes	Yes	yes	NO
ROUTING OVERHEAD	Lower than AOMDV at high speed.	Less than AOMDV	Higher than AODV	Higher than AODV but lower than AOMDV.	Higher than OLSR
LOOP FREE	yes	yes	Yes	yes	yes
CROSS LAYER	no	no	NO	no	Yes
STABILITY	-	yes	Yes	-	-
BAND-WIDTH RESERVATION	no	yes	No	No	No
LOAD BALANCING	yes	yes	No	yes	yes
POWER EFFICIENCY	no	no	NO	no	No
BW\DELAY ESTIMATION	BW and Delayestimation	BW estimation	BW, delay estimation	Delay estimation	BW estimation

CONCLUSIONS

In this paper survey of various routing protocols has been done. This protocol uses different techniques to satisfy QoS constraints. First the brief explanation of protocols has been given and then there comparison based on different metrics such as routing overhead, QoS metrics, load balancing etc has been provided. It shows that still there many challenges need to solve to provide QoS requirements to the users. These includes improving security and reducing power consumption in QoS routing protocols, without degrading routing performance and giving extra overhead to the network.

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