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Bandwidth Estimation to Provide QoS Routing in MANET

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Abstract—In mobile ad hoc networks (MANETs), the provision of quality of service (QoS) guarantees is much more challenging than in wire line networks, mainly due to node mobility, multi-hop communications, contention for channel access, and a lack of central coordination. QoS guarantees are required by most multimedia and other time- or error-sensitive applications. The difficulties in the provision of such guarantees have limited the usefulness of MANETs. However, in the last decade, much research attention has focused on providing QoS assurances in MANET protocols. The QoS routing protocol is an integral part of any QoS solution. We propose a QoS routing protocol is the use of the approximate bandwidth estimation to react to network traffic. Our approach implements Admission control and feedback scheme by using two bandwidth estimation methods (Hello and Listen). We simulate our QoS- routing protocol for nodes running the IEEE 802.11 medium access control. Results of our experiments show those Comparisons among Hello and Listen Methods with the Qos metrics.

Index Terms— Bandwidth estimation, mobile ad hoc routing networks (MANETs), Quality-of-service (QoS

I. INTRODUCTION

QoS is usually defined as a set of service requirement's that needs to be met by the network while transporting a packet stream from a source to its destination. The network is expected to guarantee a set of measurable pre-specified service attributes to users in terms of end-to-end performance, such as delay, bandwidth, probability of packet loss, and delay variance (jitter). Most applications that attract interest for use in current wired networks (e.g.,video Conferencing, on- line live movies, and instant messenger with Camera enabled) would attract interest for MANETs. QoS metrics can be concave or additive. Bandwidth is concave in the sense that end-to-end bandwidth is the minimum of all the links along the path. Some applications require minimum bandwidth support. If the minimum bandwidth cannot be met, all data will be useless. Thus, it is better not to transmit data in this case, because it will just waste network bandwidth and energy. Therefore, an admission control scheme is also embedded into our QoS-aware routing protocol to address this issue..Delay and delay jitter are additive. The end-to-end delay (jitter) is the accumulation of all delays (jitters) of the links along the path. Furthermore, QoS metrics could be defined in terms of one of the parameters or a set of parameters in varied.

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Another challenge of QoS is medium access control (MAC) layer design. We argue that the IEEE 802.11MAC is not the best MAC for supporting QoS. However, it is widely adopted in the wireless local area network (WLAN) community, and many devices have been commercialized with IEEE 802.11. Therefore, in our design, we choose the IEEE 802.11 standard as the underlying MAC layer. IEEE 802.11 has no support for constant bit rate streams, guaranteed delay, etc.

II. MOTIVATION

AODV is one of the most widely used table-based and reactive routing protocols. In AODV, a source host broadcasts a route request (RREQ) packet when it needs a route to a specific host. Each host that receives the RREQ packet checks whether it is the destination; if it is, it sends a route reply (RREP) packet; otherwise it rebroadcasts the RREQ packet. Intermediate hosts between the source and the destination create an entry in their routing tables and record the neighbor ID of the host from which the RREQ packet was received. The destination host responds to the first RREQ packet it receives by uni casting a RREP to the neighbor from which it intermediate hosts forward the RREP packet to the source according to their own routing tables.

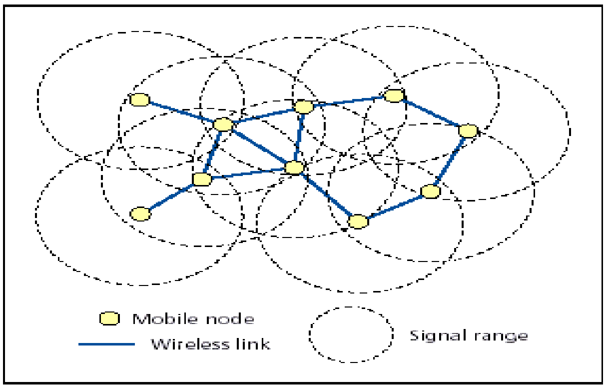

Fig.1 Mobile Ad-hoc Network

One unique feature in AODV is that hosts use "Hello" messages to probe their neighbors in order to validate routes. Hosts broadcast "Hello" messages in a reasonable interval. If a host does not receive a "Hello" message from a particular neighbor for a certain period, it will delete this neighbor from its neighbor cache and mark the corresponding routes as invalid.

We propose a QoS routing protocol, which is based on residual bandwidth estimation during route set up.

Our QoS routing protocol is built off AODV, in which the routing table is used to forward packets, "Hello" messages are used to detect broken routes and "Error" messages are used to inform upstream hosts about a broken route. We explore two ways to perform bandwidth estimation, and we incorporate both an adaptive feedback-based scheme, an admission control scheme.

III. QOS-AWARE ROUTING

QoS is an agreement to provide guaranteed services, such as bandwidth, delay, delay jitter, and packet delivery rate to users. Supporting more than one QoS constraint makes the QoS routing problem NP-comple te. Therefore, we only consider the bandwidth constraint when studying QoS-aware routing for supporting real-time video or audio transmission. We propose a QoS-aware routing protocol that either provides feedback about the available bandwidth to the application (feedback scheme), or admits a flow with the requested bandwidth (admission scheme). Both the feedback scheme and the admission scheme require knowledge of the end-to- end bandwidth available along the route from the source to the destination. Thus, bandwidth estimation is the key to supporting QoS. Our work focuses on exploring different ways to estimate the available bandwidth, incorporating a QoS-aware scheme into the route discovery procedure and providing feedback to the application through a cross- layer design.

A. Bandwidth Estimation

To offer bandwidth-guaranteed QoS, the available end-to-end bandwidth along a route from the source to the destination must be known. The end-to-end throughput is a concave parameter which is determined by the bottleneck bandwidth of the intermediate hosts in the route. Therefore, estimating the end-to-end throughput can be simplified into finding the minimal residual bandwidth available among the hosts in that route. One is for hosts to listen to the channel and estimate the available bandwidth based on the ratio of free and busy times ("Listen" bandwidth estimation). The other is for every host to disseminate information about the bandwidth it is currently using in the "Hello" messages, and for a host to estimate its available bandwidth based on the bandwidth consumption indicated in the "Hello" messages from its two-hop neighbors ("Hello" bandwidth estimation).We directly use the relation of the end-to-end throughput with the number of hops and the bottleneck bandwidth in the route as follows

1) "Listen" Bandwidth Estimation:

To estimate the available bandwidth, intuitively, each host can listen to the channel to track the traffic state and determine how much free bandwidth it has available every second. Using the "Listen" method to estimate residual bandwidth is straightforward. "Listen" only counts the used bandwidth, at does not distinguish the corresponding bandwidth cost for each flow. This greatly affects the accuracy of bandwidth estimation n when a route is broken. Therefore, introduce another approach—"hello" bandwidth estimation that is better able to reallocate available bandwidth when routes break. The MAC detects that the channel is free when the following requirement is met:

- **NAV's value is less than the current time;**
- **receive state is idle;**
- **Send state is idle.**

The MAC claims that the channel is busy when one of following occurs:

- **NAV sets a new value;**
- **receive state changes from idle to any other state;**
- **Send state changes from idle to any other state.**

2) "Hello" Bandwidth Estimation:

In the "Hello" bandwidth estimations method, the sender's current bandwidth usage s well as the sender's one-hop neighbors' current bandwidth sage is piggybacked onto the standard "Hello" me ssages. Each host estimates its available bandwidth based on the information provided in the "Hello" messages and knowledge of the frequency reuse pattern. This approach avoids creating extra control messages by using the "Hello" messages to disseminate the bandwidth information.

ID	Consumed Bandwidth	Timestamp
Neighbor ID 1	Consumed Bandwidth	Timestamp
. . . .	. . . .	. . . .
Neighbor ID n	Consumed Bandwidth	Timestamp

Fig.2 Hello Structure

AODV uses the "hello" messages to update the neighbor caches. The "Hello" message used in AODV only keeps the address of the host who initiates this message. We modify the "Hello" message to include two fields. The first field includes host address, consumed bandwidth, timestamp, and the second field includes neighbors' addresses, consumed bandwidth, timestamp each host determines its consumed bandwidth by monitoring the packets it feeds into the network. This value is recorded in a bandwidth-consumption register at the host and is updated periodically.

B. Incorporating QoS in Route Discovery

QoS-aware routing discovery, the source host sends a RREQ packet whose header is changed to model- flag, bandwidth request, min-bandwidth, AODV RREQ header. The model- flag indicates whether the source is using the admission scheme or the adaptive feedback scheme. When an intermediate host receives the RREQ packet, it first calculates its residual bandwidth. If the model- flag is the admission scheme, the host compares its residual bandwidth with the requested bandwidth. If its residual bandwidth is greater than the requested bandwidth, it forwards this RREQ. Otherwise, it discards this RREQ. If the model- flag is adaptive, the host compares its residual bandwidth with the min-bandwidth field in the RREQ. If its residual bandwidth is greater than the min-bandwidth, it forwards the RREQ. Otherwise, it updates the min-bandwidth value using its residual bandwidth.

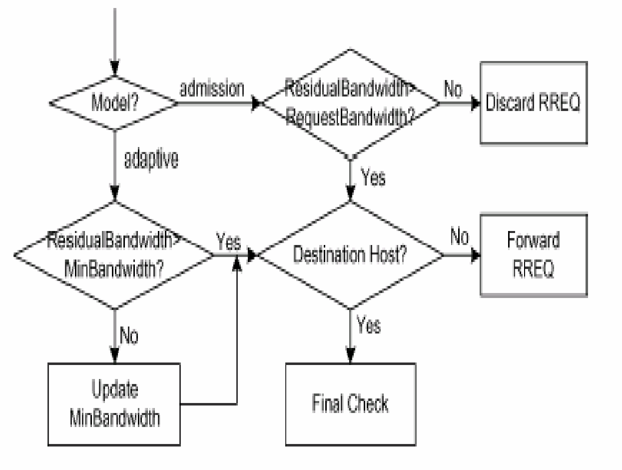

Fig.3 Host working Procedure

C. Route Maintenance

Listen Method:

QoS-aware routing with "Listen" bandwidth estimation, AODV's route maintenance scheme is used, because releasing bandwidth from the bandwidth consumption registers is impossible without knowing how much bandwidth is consumed by each host in the route. Therefore, no change in AODV's route maintenance scheme is needed to address the bandwidth releasing issue.

Hello method:

We cannot directly use AODV's route maintenance scheme in the QoS-aware routing protocol with "Hello" bandwidth estimation. We should incorporate a forced cache update in the route maintenance scheme. The QoS-aware routing with "Hello" bandwidth estimation uses the first neighbors' relay to get the second neighbors' information. Therefore, once the neighbors get the forced updates, they should disseminate the update information immediately to their neighbors. We use an "Immediate Hello" message to address this concern. This special message's content is exactly the same as the "Hello" message, except the packet type is marked as "Immediate Hello" in order to differentiate with the regular "Hello" message. When a host receives an "Immediate Hello" message, it sends its regular "Hello" message immediately. The "Error" message is also adopted to trigger.

IV. SIMULATIONS AND RESULTS

To test the performance of our QoS-aware routing protocol, we ran simulations using ns-2.1b9a. We use the IEEE 802.11 MAC protocol in RTS/CTS/Data/ACK mode with a channel data rate of 2Mb/s. The topologies vary according to the different Simulation purposes.

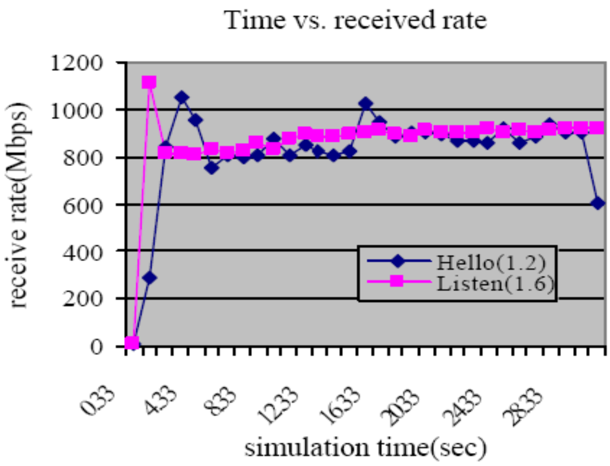

Fig.4 Time Vs Receive Rate

"Hello versus Listen Bandwidth estimation when Routes break

A. broken route can be caused by two reasons:

1) *Route break caused by losing "hello" messages:*

"Hello" packets are dropped often when traffic becomes heavy. The packets are still successfully transmitted to the destination host during the time between the first "Hello" message being dropped and another "Hello" message being dropped. The route discovery procedure is initiated right after the source host receives the "Error" message. A small time interval, it is almost impossible for the hosts to automatically and correctly update their bandwidth registers in the "Listen" bandwidth estimation method. The "Hello"-based bandwidth estimation approach can easily solve this problem by using the forced update scheme.

2) *Route break caused by Moving out of a Neighbors Transmission range:*

The "Listen" technique cannot react well to a broken route due to the fact that the MAC's NAV cannot truly reflect the traffic status, and the bandwidth consumption registers cannot be updated in time. Thus, when routes break, "Hello" bandwidth estimation performs better than "Listen" bandwidth estimation.

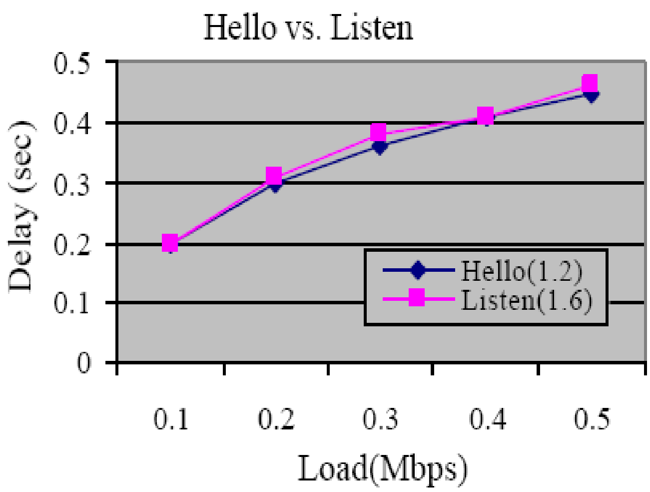

Fig.5 Load Vs Delay

The input parameters Specify Mac type 802.11, protocol is used for AODV, number of nodes and number of packets in this paper specify 50 and 60.packet size max 1500 min 60.Bandwidth size 11 Mb.

here slot time used as 50 micro second. Basic rate and data rate with specified as 1.0 and 0.1. Packet interval with specification of 0.020 that is equal to send rate of 8000 bytes.

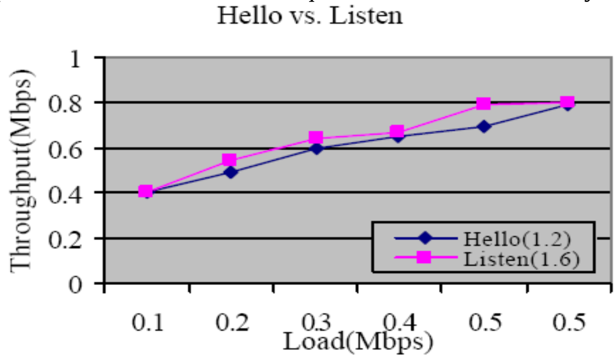

Fig.6 Load Vs Throughput

Changing of Data rate value and Basic rate value, make the corresponding changes in metrics.

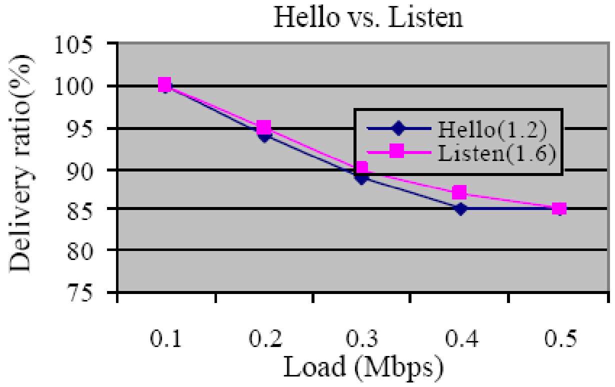

Fig.7 Load Vs Delivery Ratio

Topology using Admission scheme and Feedback scheme:

Both the feedback scheme and the admission scheme require knowledge of the end-to- end bandwidth Available along the route from the source to the destination. In the admission scheme, flows are denied if there is not enough bandwidth available to support their request. This result in the total capacity of the admitted flows being less than that of the feedback scheme, so packet collisions occur less frequently. Correspondingly, the packet delay should be decreased significantly due to fewer collisions.We compare QoS-aware routing with "Hello" bandwidth estimation, QoS-aware routing with "Listen" bandwidth estimation, and conventional AODV, which has no QoS support. The metrics used in measuring the protocols' performance are delay, packet delivery ratio, and overall end-to end throughput.

Weight Factor Comparison:

We cannot compare the performance of "Hello" bandwidth estimation and "Listen" bandwidth estimation using the same weight factor, because these two methods define the consumed bandwidth differently.

- **"Listen" mode**—accounts for RTS, CTS, ACK, retransmission, routing packets, and transmitted packets.
- **"Hello" mode**—counts the transmitted packets only.

Therefore, the "Hello" weight factor should be Smeller than the "Listen" weight factor if we want to get the same performance. We find that the performance of choosing weight factor 1.9 in "Hello" mode matches well with the performance of choosing weight factor 2.3 in "Listen" mode. The RTS, CTS, and ACK overheads affect differently small size packets and large size packets. Therefore, different weight factors should be used for different packet sizes.

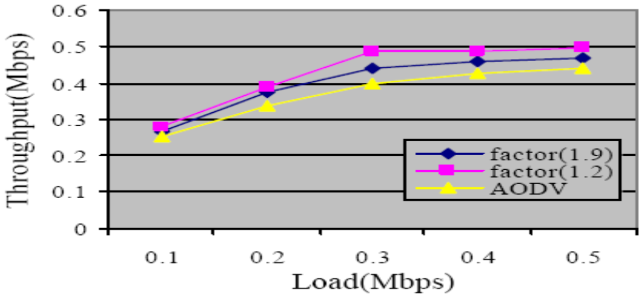

Fig.8 Load Vs Throughput (Listen Method)

The performance when the QoS-aware routing protocol with "Listen" bandwidth estimation is used compared with AODV and Weight factor. Fig. 9 shows great improvement in packet delivery ratio. However, Fig.8 the end-to-end throughput is decreased. In Listen, Data rate and weight rate is greater than the Hello method. While the "Listen" scheme's performance is better than the "Hello" scheme's performance in term of packet delivery ratio.

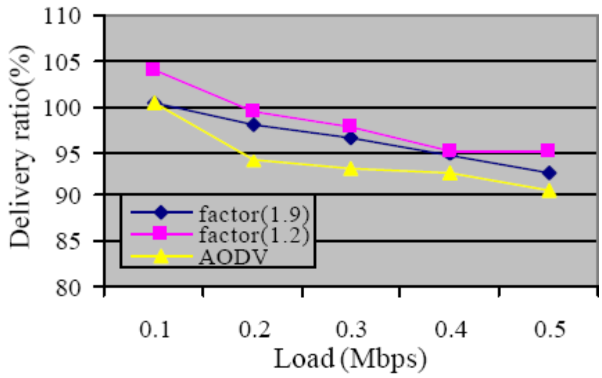

Fig.9 Load Vs Delivery Ratio (Listen Method)

The performance when the QoS-aware routing protocol with "Hello" bandwidth estimation is used compared with AODV and Weight factor. Fig.13 shows great improvement in Throughput. However, Fig.10 the Delay is decreased.Fig.11 Delivery ratio improved when the route is not break. Suppose the route is break that leads to affect the performance of delivery ratio. Data rate and weight rate is small, compare than Listen method.

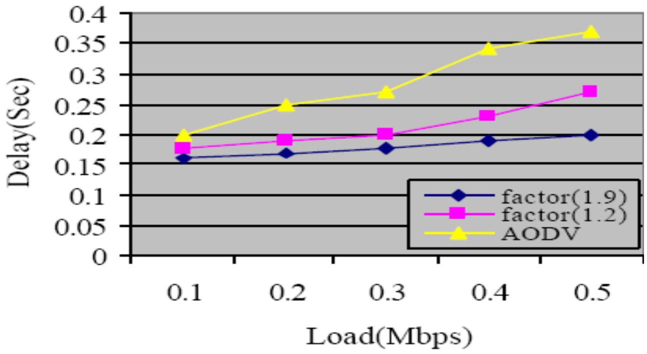

Fig.10 Load Vs Delay (Listen Method)

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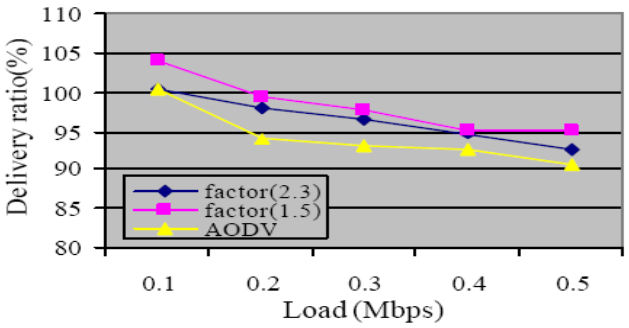

Fig.11 Load Vs Delivery Ratio (Hello Method)

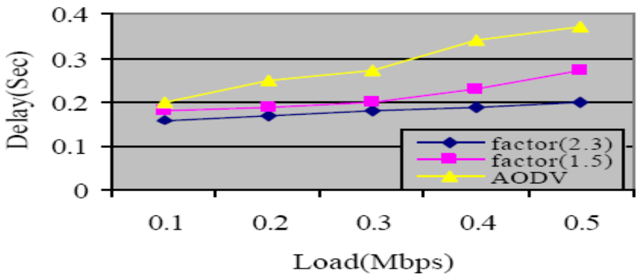

Fig.12 Load Vs Delay (Hello Method)

The "Hello" scheme's performance is better than the "Listen" scheme's performance in term of end-to-end throughput, while the "Listen" scheme's performance is better than the "Hello" scheme's performance in term of packet delivery ratio.

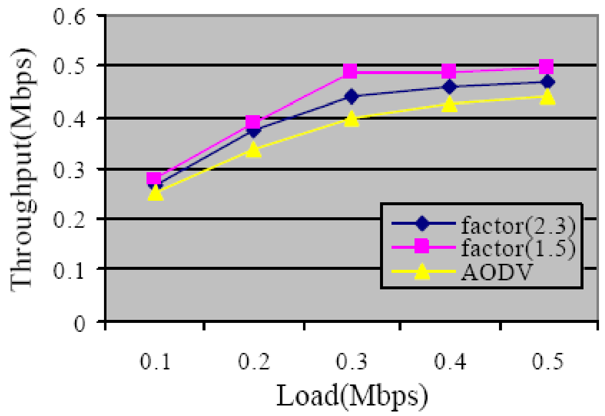

Fig.13 Load Vs Throughput (Hello Method)

V. CONCLUSION AND FUTURE WORK

This paper proposes incorporating QoS into routing, and introduces bandwidth estimation by disseminating the bandwidth information through "Hello" messages. We have compared two different methods of estimating bandwidth. The "Hello" bandwidth estimation method performs better than the "Listen" bandwidth estimation method when releasing bandwidth immediately is important. The accurate measurement of the capacity of a multi hop mobile network is an open issue right now. Further study of the802.11 MAC layer's behavior could be helpful to understand this capacity issue. Also, in a real scenario, shadowing will cause a node's transmission range to vary, and it will not be the ideal circle that is assumed here. How to incorporate these non idealities into our protocol is the subject of our future research. Furthermore, incorporating different transmission ranges among all the hosts and analyzing fairness among the hosts will be explored in our future work. Our ultimate goal is to provide a model from the application layer to the MAC layer for supporting service differentiation. A transport layer protocol to support different data streams, queue management and a QoS-supported MAC will be addressed in our future work.

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