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QoS Routing Based on Available Bandwidth for Mobile Ad hoc Network

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Abstract: Mobile Ad-hoc network is a self configuring wireless network. It does not have any fixed infrastructure. Mobile node can leave and join the network. Therefore network topology changes any time. In Manet hosts can work as a router and forwards data from initiator to receiver. Since wireless channel is shared and topology is dynamic, providing quality of service (QoS) is a challenging task. QoS routing can find optimal routes that supports QoS requirement based on the received information during route discovery process. If QoS requirement cannot be supported, the admission control mechanism reject incoming request. Bandwidth estimation is a technique to determine available data rate on a route in the network. The term bandwidth means data rate not the physical bandwidth in hertz. QoS routing is required because most of the real time applications depend on the network's condition. QoS in terms of bandwidth ensures transmission of real time data. In this paper a new bandwidth estimation method EAB (enhanced available bandwidth) is proposed. The performance of EAB-AODV is compared with AODV. The performance of EAB-AODV is better than AODV in terms of bandwidth.

Index Terms: QoS Routing, Active Technique, Passive Technique, Bandwidth Estimation, Admission control, Manet.

I. INTRODUCTION

Mobile Ad hoc network has gained a lot of attention due to its attractive infrastructure-less nature. Now a day most of the applications generate multimedia data and requires QoS routing. Therefore QoS solutions are proposed for mobile ad hoc network. Bandwidth estimation technique has generated several contributions Manet. This type of network is used in many applications because it does not need any fixed infrastructure support. Communication in small area and collaborative computing can be built up using Manet[2]. Bandwidth is defined as the maximum transmission rate that can be supported in absence of competing flows. Available bandwidth is the maximum data rate that can be supported for the current competing flow. In network layer QoS can be provided in terms of delay, data rate and jitter. Transmission of real time media can supported by providing QoS in terms of bandwidth and delay [3]. If data rate is not enough for transmission of real time data only part of the traffic will be sent on time. There will not have importance to receive the remaining data after some time because real time data is sensitive to delay. Data that does not arrive at right time will be useless. As a result, it is important to consider QoS enabled routing protocol to support real time data transmission.

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Bandwidth estimation technique can be classified as active (intrusive) or probe based technique and passive (non-intrusive) technique or sensing based technique.

II. ACTIVE (INTRUSIVE) APPROACH

Active technique also called probe based technique. Node sends probe packet to estimate the available bandwidth along a route. Most of the active techniques estimate the available bandwidth from one end to another end by sending packet of equal size from initiator to a receiver. This technique can be divided into four categories.

A. Variable Packet Size (VPS) Probing Technique

This technique measures the throughput of each hop along a route. This technique aims at the measurement of time taken for sending a packet and receiving ACK. VPS utilizes TTL (time to live) information of the IP header to keep an expiration time for probing packet to expire at a hope[4]. If packet expires, the node at that hop discard probe packet and return a exceeded time error message (ICMP) to the initiator than initiator uses the error message to measure the RTT to that hop. Capacity of each hop is measured with respect to size of the probe packet

B. Packet Pair/Train Dispersion (PPTD)

Packet pair technique calculates the capacity of a path from one end-to-another. The multiple packet pair is sent by the source to the receiver [5]. Two packets of same size are included in each packet pair and sent back-to-back. At a particular link of the path, "dispersion of a packet pair" is the distance in time between the last bit of each packet [6]. When a packet pair passes through each hop along an empty route than dispersion D_P is measured by the receiver using equation (1).

$$D_P = \max_{i=0,1\ldots h}\left(\frac{L}{C_i}\right) = \frac{L}{C} \qquad (1)$$

Where, C is the channel capacity from one end to another end. Size of the packet is L. Receiver measures the capacity of the path using equation.

$$C = \frac{L}{D_p} \qquad (2)$$

PPTD measurements can be done without access at the receiver, by enabling the receiver to send some error message for each probe packet [7]. But capacity of reverse route and cross traffic may effect on the result.

C. Self Loading Periodic Stream (SLoPS)

SLoPS estimates available bandwidth from one end to another end. The source sends multiple equal size packets to the receiver at a rate R.

SLoPS observes variations in the one way delay of the probe packet [8]. If the rate of sending probe packet is greater than available bandwidth of the path, a short period overload on the link will occur due to long queue. If the stream rate R is less than the available bandwidth, probe packet will be transmitted without increasing queue length at the tight link and will not increase one way delay. Also sender keeps an interval between successive probe packets to keep the traffic below 10% of the path's available bandwidth. During the measurement, the available bandwidth may vary. SLoPS identify such variation when it observes that the one way delay of probe packet does not show any increment or decrement. In this situation, the SLoPS indicates the variation range of variable bandwidth during the measurement.

D. Trains of Packet Pair (TOPP)

TOPP uses dispersion mechanism to estimate the path's available bandwidth. TOPP sends multiple packets pair by increasing rates from source to destination. Suppose that packet pairs are sent with an interval Δ and each packet size is L bytes, than offered rate of the packet pair is $R_s = L/\Delta$. If $R_s > A$ (available bandwidth) the second probe packet will be in the queue behind the first probe packet and rate at the receiver will be $R_r < R_s$. If $R_r < A$, this technique assumes that the packet pair arrival rate will be same at the receiver. The basic idea of TOPP is similar to SLoPS. The difference between TOPP and SLoPS is in the statistical processing of the measurement [9]. SLoPS adjust the offered rate using binary search. In TOPP offered load increases linearly. TOOP can measure the tight link's capacity of the path.

III. PASSIVE (NON INTRUSIVE) APPROACH

Passive bandwidth estimation technique measures the used bandwidth (i.e., channel usage by sensing the radio channel) based on the predefined interval of time. This method may exchange this information using broadcasting, broadcast is performed using hello message. This message is used by many routing protocols.

A. Retransmission based ABW Estimation (RABE)

RABE provides a mechanism to estimate ABW per link. RABE includes average number of attempts for retrains-mission in the bandwidth estimation [10]. The bandwidth estimation depends on the following factors: the ABW per node, average number of retransmission, collision probability and ratio of packet loss. Statistical information shows that RABE achieves a "mean error ratio" of 17% in comparison with real measured value. RABE is more accurate than IAB (Improved available bandwidth) estimation technique.

B. Contention Aware Admission Control Protocol

In this protocol IEEE 802.11 based single channel MAC layer is used. This protocol performs tasks like route discovery, admission control, forming C-neighbor sets. Admission control is performed based on the available bandwidth at a node and the new flow on neighboring nodes. CACP uses source routing with on demand route discovery [11]. Source routing allows CACP to decide which path will be used by the flow, that path will be accepted by admission control and will have sufficient bandwidth for the flow.

Local Available Bandwidth:

CACP uses the idle period of channel to estimate the available local bandwidth. The busy period of channel is sensed by a node with "signal strength larger than a threshold called carrier sense threshold". For every period of time T_p the available bandwidth B_{local} at a node can be measured by weighted moving average.

$$B_{local} = \alpha B_{local} + (1-\alpha) \times \frac{T_{idle}}{T_P} B_{channel} \qquad (3)$$

Where, $B_{channel}$ is the channel capacity.

Weight $\alpha \epsilon \quad [0, 1]$

C – Neighborhood Available Bandwidth:

C-neighborhood available bandwidth $B_{neighbor}$ can be calculated as:

$$B_{neighbor} = \alpha B_{neighbor} + (1-\alpha) \times \frac{T^{neighbor}_{idle}}{T_P} \qquad (4)$$

Route Discovery:

CACP utilizes "partial admission control" to minimize the overhead caused during route discovery process. The route request includes information about required bandwidth for application, initiator's address, destination address, sequence of hops. Bandwidth requirement B_W of a flow can be estimated as:

$$B_w = R \times T_{data} + B_{channel} \qquad (5)$$

$$T_{data} = T_{Data} + T_{rts} + T_{cts} + \frac{L_S + H_d}{B_{channel}} + T_{ack} + 3\, T_{sifs}$$

Where L_S indicates packet size and H_d indicates "IP and MAC header length". T_{rts} is the time required to transmit RTS, T_{cts} is the time needed to transmit CTS, T_{ack} is time taken for sending ACK. The sequence of hops is used to determine the minimum number of contention count of the complete route.

Admission Control:

In CACP-CS, a passive method is used to obtain available bandwidth of c-neighborhood, where no admission "request/rejection messages" are needed. The node which receives a RREP estimates available bandwidth of its c-neighborhood by (4) and compares it with bandwidth consumption of flow for admission decision. CACP-CS has less packet delay compared to DSR and SWAN.

C. Quality of Service Enabled AODV

In this protocol a new mechanism for the occupancy rate of the radio medium is used. This protocol is based on MAC layer bandwidth estimation. It uses admission control and resource reservation for QoS routing. Admission control is used to accept or reject the request based on the available bandwidth at a node.

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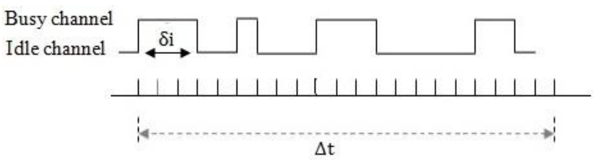
Any node with QoS routing protocol can reserve resources. The medium occupation is the part of used channel capacity by the traffic [12]. To determine the medium occupation rate, mobile node keeps the temporal period of occupation during an observation period Δ_t seconds. Factor of occupation:

$$f_{occup\_bp} = \frac{\text{Busy\_channel\_period}}{\Delta t} \quad (6)$$



$$\text{Busy channel period} = \sum_i \delta i \quad (7)$$

It is necessary to consider types of traffic that exist on the medium:

Traffic (I): Traffic relating to the node's own emission.

$\text{Traffic}_{one\_hop\_neighborhood}$ (I): Traffic of the direct neighborhood of node (I).

$\text{Traffic}_{two\_hop\_neighborhood}$ (I) : Neighbors traffic that are in the inference zone of node (I).

Why AODV?

In Manet radio medium is shared by all mobiles. AODV is a "reactive routing protocol". It reduces the overhead of the network, because route is established only on demand.

Time required for transmission of data packet:

$$t_{forwading} = DIFS + t_{backoff} + t_{rts} + t_{cts} + t_{DATA} + t_{ack} + 3 \times SIFS \quad (8)$$

Applicative available bandwidth at a node is given by the equation:

$$Applicative_{Available_{Bandwidth}} = \frac{1 - f_{occup\_bp}}{t_{forwarding}} \times packet\_size \quad (9)$$

First request of bandwidth takes place at = 0 Second therefore f_{occup_bp} is null. This protocol provides more accurate estimation of available bandwidth in ad hoc configuration. Result shows that it performs better than AODV in terms of bandwidth.

IV. QOS ROUTING

In mobile ad hoc network providing QoS is difficult due to highly dynamic topology and limited sources. To support QoS routing, information such as the link state, bandwidth, jitter, delay and cost must be available and manageable. But obtaining and managing link state information is challenging task because topology with the movement of node. Many routing protocols have been proposed but they do not provide QoS routing for real time application. Indeed QoS can be provided in the form of bandwidth and delay in the network layer, QoS in the form of bandwidth and delay ensure quality of transmission of real time data [9]. For multimedia application if enough bandwidth is not available few parts of the data will be transmitted and there is no use of receiving left part because real time data is delay sensitive.

A. *Comparative Evaluation*

The objective of this section is to evaluate and compare the performance of best effort AODV protocol with proposed EAB (enhanced available bandwidth) estimation. A node estimates the available bandwidth by (10). Where T_i is the free time period, T_B is the busy time period, T_S is the time of sensing busy state and T is the observation period and C is capacity of the medium.

$$AB = \frac{T_I}{T} \times C = \frac{T - T_B - T_S}{T} \times C \quad (10)$$

To avoid this inaccuracy, we use a coefficient K.

$$K = \frac{DIFS + \overline{backoff}}{T}$$

Where K is the "bandwidth consumed by the waiting and back-off process". Therefore available bandwidth can be expressed as:

$$AB = (1 - K) \times \frac{T_i}{T} \times C \quad (11)$$

The back-off slots decrements until the last attempts for a single frame and it can be written as.

$$\overline{backoff} = \sum_{K=0}^{M} P(X = K) \times \frac{\min(CW_{max}, 2^K CW_{min}) - 1}{2}$$

Where CW_{min} is the minimum value of the "contention window".

$CW_{max} = 2^N CW_{min}$ is maximum window size of retransmission attempts $(M \geq N)$; and X indicates the number of retransmission of the same frame.

$$P(X = K) = \begin{cases} P^K(1 - P) & 0 \leq K \leq M - 1 \\ P^M & K = M \\ 0 & K > M \end{cases}$$

Where p is the conditional collision probability that a packet transmitted shall collide.

Probability of idle Period Overlap:

Let P_1 is the probability of sense busy state of sender and P_2 is the probability of sense busy state of receiver and s is the IDLE state.

$$AB_s = (1 - K) \times \left[\frac{T_i^s \times (1 - P_2 \times T_s^r / T)}{T} - \mu \right] \times C \quad (12)$$

Where T_s^r is the sense busy period sensed by receiver during the measurement period T.

$$AB_r = (1 - K) \times \left[\frac{T_i^r \times (1 - P_1 \times T_s^s / T)}{T} - \mu \right] \times C \quad (13)$$

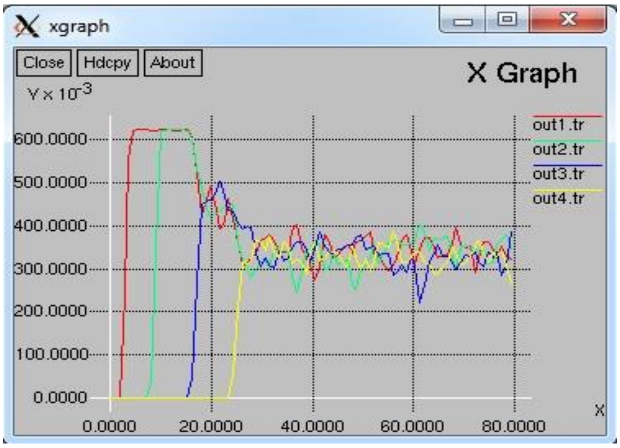
Where T_s^s is the sense busy period sensed by the sender in the observation period T. Where $\mu = 1 - C_u \times (1 - p)$ is a parameter to stop the node to reuse bandwidth. C_u is the usage of channel and p is rate of collision.

Where C_u = 95% for a node while using RTS/CTS, when rate of average collision is around 0.06, therefore $\mu \approx 0.1$, if μ is large than estimated available bandwidth is small.

V. SIMULATION RESULT

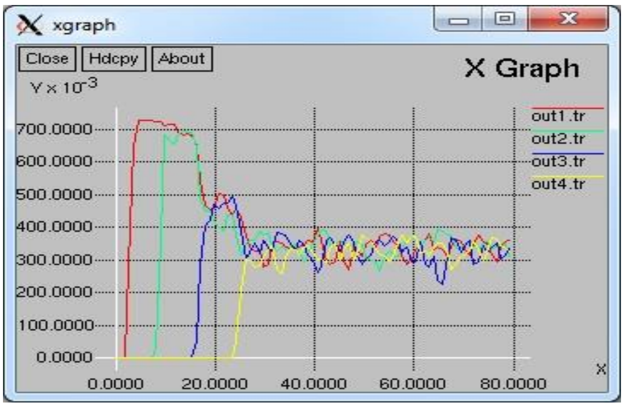
Table 1. Simulation Parameters.

Parameters	Value
Number of nodes	25
Simulation time	80 Seconds
Simulation Area	500×500 m^2
Traffic source	CBR
Agent	UDP
No of Flows	4
Routing Protocol	AODV, EAB-AODV
Packet Size	512 Bytes
Basic rate	1 Mbps
Data rate	2 Mbps



. Figure 1. Throughput of each flow using AODV.

In figure 1, every data flow contains of 512 bytes packet with a data rate of 600 kbps using a data rate capacity of 2 Mbps. Flow 1 start at time 2 seconds, flow2 at 8 seconds, flow 3 at 16 seconds and flow 4 at 24 seconds. First we observe that all 4 flows have been accepted. Flow 1 reached a throughput more than 600 kbps, when flow 2 is admitted it also reached a throughput more than 600 kbps. When flow 3 admitted it also



achieved a throughput of 500 kbps, when fourth flow is admitted, it has achieved a throughput of 350 kbps and all the flows throughput decreased and reached to a lower throughput between 300 and 400 kbps.

Figure 2. Throughput of each flow using EAB-AODV.

In figure 2, first flow has reached a throughput of more than 700 kbps, flow 2 has achieved 700 kbps, flow 3 has achieved a throughput 500 kbps and flow 4 has achieved more than 300 kbps. When all the flows admitted, all flows achieved a minimum throughput between 300 kbps and 400 kbps.

VI. CONCLUSION AND FUTURE WORK

In this paper an EAB method has been implemented. As we can observe that the throughput using EAB-AODV is much better than best effort AODV because AODV does not incorporate any bandwidth estimation technique and admission control. In future our plan is to incorporate bandwidth estimation techniques into NS-2.35 simulator. In this embedded NS-2.35 We will be able to see the improvement in throughput using routing protocols in different network topology. The aim of implementing bandwidth estimation mechanism is to improve resource utilization in a proper way in mobile ad hoc network. The bandwidth estimation method will be integrated with admission control and reservation mechanism. Thus we can improve QoS in highly dynamic network.

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Rajeev Kumar *received* Bachelor of Engineering and Master of technology from VTU, Belagavi, India. He is currently pursuing Ph.D in Computer Science and Engineering. He has published 3 research papers in reputed international journals and conferences including IEEE and it's also available online. His main research work focuses on QoS routing in ad hoc network and Cross layer design for QoS support for real time application.

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