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An efficient Joint of Bandwidth Reservation and Routing Protocol for Mobile Ad hoc Networks

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Abstract:
In Mobile Ad Hoc Networks (MANET), during routing, problems may arise due to the end-to-end delay, mobility, intra-flow contention and frame collision. In this paper, we propose to design the bandwidth reservation and routing technique in MANET. In this technique, the available bandwidth is estimated based on the interference from both background traffic and traffic along the path. Then the bandwidth reservation is performed using the admission control technique. When the sink node wants to forward the data packet, it uses the bandwidth aware proactive routing protocol. It selects the forwarding paths to distribute the load based on the end-to-end available bandwidth. By simulation results, we show that the proposed technique enhances the packet delivery ratio and reduces the delay.

Keywords: *Bandwidth Estimation, Joint Bandwidth Reservation, Routing Protocol, MANET*

I. INTRODUCTION
Mobile Ad hoc network is a collection of mobile nodes forming dynamic autonomous network anytime and anywhere without any existing network infrastructure. Nodes in MANET acts as a router to communicate among themselves without the involvement of centralized access points or base stations maintain connectivity decentralized [1]. These types of networks have many advantages, such as self- reconfiguration and adaptability to highly variable mobile features that the transfer conditions, propagation channel distribution properties and power level. There are many real-world applications using mobile ad hoc networks. Some of them include military battlefield circumstance, disaster relief and rescue in emergency, conferences, lectures, emergency search and Law Enforcement [2].

A. Issues
- Limited bandwidth provided by wireless channel is difficult to guarantee high traffic flows
- If traffic varies significantly, then resource allocated in MANET is inadequate.
- Due to mobility, happening of failures are frequent.
- QoS is more difficult to guarantee in mobile wireless networks due to node mobility, multi-hop communications, contention for channel access, and a lack of central coordination [3].

II. BANDWIDTH ESTIMATION IN AD HOC WIRELESS NETWORKS
Bandwidth is one of the essential resources of the network traffic. It refers to the data rate as part of the network or network route information carrying capacity of a node in the network. It is

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measured by bits per second, which refers to the speed of the piece transfer in a channel or link can transmit. Bandwidth is one of warranty attributes to measure the performance of the wireless network and to support QoS. Measurement of the available bandwidth is a promising resource management method improves network performance and quality of service in MANETs [3] [4]. To meet the QoS bandwidth requirements estimate is very important. When multimedia flows transfer in MANET a large amount of wireless network resources will be consumed for the sharing features in several hop MANET wireless medium, contention between neighbors and the source node occurred for the data frame and the control frame is sent frequently. So all existing network resources used to transmit data frames after successfully capture the wireless medium, which creates unfair channel access. Therefore, the exact estimate available bandwidth essential for network control mechanism, such as admission control, end to end path establishment, the relay node to select, channel scheduling, and others. Each host is imprecise knowledge of the network status and links change dynamically in ad hoc networks. So a single host has no knowledge of other neighboring hosts of the traffic status. Bandwidth is shared between neighboring hosts, as available bandwidth varies with the number of hosts contending for the channel. [6] [7]. The existing bandwidth calculation methods Listening bandwidth estimation (Active Approach) and Hello bandwidth estimation (passive strategy) [7], [8].
Factors affecting bandwidth estimation in MANET is Frame Collision, channel utilization, reversing Time, Frame retransmission Adaptive Transmission Rate, Channel Access Mode Service Type, Intra-flow statement, RTS / CTS overhead synchronization of the idle period, the transmitter and receiver [5], [9].

A. Drawbacks of bandwidth estimation methods

- Overhead caused by attaching neighbor’s bandwidth consumption information.
- Using higher power to propagate information consumes much more power.
- It destroys the frequency reuse pattern and causes much more interference.

III. PROBLEM IDENTIFICATION

A model has been developed [15] for calculating the path available bandwidth (AB) by considering interference from both the background traffic and traffic on the road to multi-rate and multihop networks where link adaptation is allowed through each stage of the independent sets and click to support the required data rates at different times. In order to solve common design problems heuristic algorithm is developed to choose the path with the largest ABW. To obtain information on the background traffic, carrier sensing mechanism used by observing the channel utilization.
But consider heuristic algorithm disorder of the links on the way to estimate AB by defining a local disturbance clicks of a path. It provides the computational complexity of finding all independent sets maximum increases dramatically with the number of links. It is not possible for the broadcast environment. The problem of finding all the maximal independent set is NP-hard problems. Moreover, the link scheduling part is not fully implemented in a distributed manner. And clique forcibly used to construct the upper and even lower limits on throughput, becomes invalid mulitrate network where links are allowed to transmit at different rates at different times. Channel idle time is not always effective to estimate nodes, "Links" and runway available

bandwidth. This document does not end to end delay of movement, intra-flow statement and frame collision.
To solve these problems, this document proposes a common bandwidth reservation and Routing (JBRR) Protocol for MANET.

IV. LITERATURE REVIEW

Qinghui Wang et al [10] have proposed an available bandwidth estimation in IEEE 802.11 ad hoc networks to give an accurate estimate of the available bandwidth. It evaluates the effect of the phenomenon that means assertion kanalstörningarsom affects the bandwidth available to it. Based on the impact of the phenomenon on the processing of medium access method that estimates the coupling of the available bandwidth for a wireless host to each of its neighbors. It appreciates the link AB by simply using the channel utilization. But do not think about the solution for factors that affect the available bandwidth such as collision, end to end delay, frame retransmission, mobility, etc., and not guarantee to provide QoS.

Muhammad Omer Farooq and Thomas Kunz [11] have proposed an available bandwidth based proactive routing protocol for IEEE 802.15.4-based single basin sink and several ad-hoc network. The available bandwidth based proactive routing protocol maintains the best transmission path in terms of end-to-end available bandwidth to each sink node present in a network. However, a node can have more than one data transmission path to the sink node. Selection of handling webs y only given end-to-end available bandwidth results in the length of the data transmission paths. Long data forwarding routes results in higher flux in the claim, thus PDR and end to end delay is affected.
Yang Peng and Zhang Yan [12] have proposed the available bandwidth estimation method in IEEE802.11e based mobile ad hoc network by considering channel monitoring, Collision Estimating, Time Estimation back. When the node density increases, there are more nodes within each other's transmission range, if a node transmits, the other nodes in the TX range to keep quiet, which reduces the use of channel resources and the number of hidden nodes also increases as the relative distance between the nodes is less because of the increasing transmission power of each node. But for the random appearance of frames collision and reversing procedure, monitoring results do not reflect the future status of the link, because the collision between the frames and the return of related information should be evaluated. When the link bandwidth is estimated, the node density increases the difference between the estimated and the measured value is affected and it applies to only medium density.
RedouaneBelbachir et al [13] have developed Accurate Bandwidth Reservation (ABR) mechanism to estimate the available bandwidth by considering each wireless 802.11 ad hoc criteria network overlap of the rest channel collisions and mobility. BR provides the data flow delivery without bandwidth degradation, while the currents of the current flows in the network and increases the accuracy of the available bandwidth estimation. But they do not have to be if the extra bandwidth caused by the back of the procedure and retransmission, in assessing the bandwidth of the data flow. Lannie et al [14] suggested Delay Minimized routing protocol based on Bandwidth Estimation (DMR BE) containing an admission control scheme and a decision tree to meet the QoS bandwidth requirements. In this approach delay taken into consideration as the factor path of least end to end delay among these roads are in route discovery process can be

selected. DMR-BE has waiting time into account when the access channels to estimate the bandwidth consumption of data flows. But just imagine if only delays in the way the recovery process to estimate the available bandwidth is not taken into account the QoS requirements, mobility, topology changes and channel relationship and route break causing performance degradation in mobile topologies has not been completed.

Feng Chen et al [15] have developed a model to estimate the available bandwidth by extending independent sets and click to mulirate and multi-hop wireless ad hoc networks where link adaptation is allowed. It has examined the effects of interference from both the background traffic and traffic on the road. The model has been extended to a common design for QoS routing and link scheduling, and a heuristic algorithm is proposed to solve the common design problems. In order to estimate AB of a road, must take into account the interference among links along the way by defining a local disturbance clicks a path. A local disturbance click is a click where all the links are in sequential order on the road. So it must consider all the links in the network is not small in the broadcast environment. The computational complexity of finding all independent sets maximum increases with the number of links. The problem of finding all the maximal independent set is NPhard problems. Although the link scheduling part cannot be fully implemented in a distributed manner.

V. JOINT BANDWIDTH RESERVATION AND ROUTING PROTOCOL

A. Overview

In this paper, we propose to design the bandwidth reservation and routing technique in MANET. In this technique, the available bandwidth is estimated based on the interference from both background traffic and traffic along the path. It considers the interference among links on the path to estimate AB by defining a local interference clique for a path. To obtain background traffic information, each node can observe the channel utilization which can be obtained as a byproduct when carrier sensing mechanism is used. Then the bandwidth reservation is performed using the admission control technique. When the sink node wants to forward the data packet, it uses the bandwidth aware proactive routing protocol. It selects the forwarding paths to distribute the load based on the end-to-end available bandwidth.

B. Estimation of Available Bandwidth

Each node monitors the channel utilization using the Carrier Sensing Mechanism. It estimates the channel idleness ratio $\square^{idl}$ ($^{\square 1}$) which is defined as the ratio of the sensed idle time to the total sensing time.

Consider that the link Qi can transmit new traffic for a time share $\square^{i}$ which is the minimum of $^{\square idl}$ value for the transmitter and receiver of the link Qi.

$$\sigma_I \le \min\{\sigma_{idl}, X_{itx}, \sigma_{idl}, X_{irx}\},\ \mathrm{BW} \le \sigma_I z_I \quad (1)$$

where xitx and xirx are the transmitter and receiver of the link, Qi, respectively
zi = effective data rate of the link Qi
BW = available bandwidth of the link Qi

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The available bandwidth of a path is estimated based on the local interference clique among the links on the path.

A local interference clique is defined as the clique in whom all the links are in sequential order on the path.

For a clique W = {Q1, Q2...., Q|W|} and for relevant idle time ratio for these links, σ= { σ |, σ2 1 ,......, σ W }, 1 | | 1 ≤ ∑ = W i i z BW (2)

time ratio for these links, $\vec{\vec{\sigma}} = \{\sigma_1, \sigma_2, \ldots\ldots, \sigma_{|W|}\}$,

$$\sum_{i=1}^{|W|} \frac{BW}{z_i} \leq 1 \tag{2}$$

$$BW \leq \min \left\{ \frac{1}{\sum_{i=1}^{|W|} \frac{1}{z_i}} \right\}, \sigma_i \times z_i \, (1 \leq i \leq |W|) \tag{3}$$

Eq. 3 gives an accurate path available bandwidth if any two links idle times are overlapped. Also it provides the upper bound of available end-to-end bandwidth of a path V given the rate vector $\vec{Z} = \{z_1, z_2, \ldots. z_{|V|}\}$ and link idleness vector $\vec{\vec{\sigma}}$

When the time share i σ of link Qi is shared by all the links in a clique with their individual time shares less than i σ that bounds the throughput for any g links in W by:

$$\sum_{i=1}^{g} \frac{BW}{z_i} \leq \max_{i \leq i \leq g} \sigma_i \tag{4}$$

If σ_i is ordered in increasing order, then

$$BW \leq \min_{i:1 \leq i \leq |W|} \frac{\sigma_i}{\sum_{j=1}^{i} \frac{1}{z_j}} \tag{5}$$

$$\text{Average end to end delay of the path V, Me} = \sum_{Q_i \in V} \frac{1}{\sigma_i z_i} \tag{6}$$

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Maximum average clique transmission delay, MW =

$$\max \sum_{Q_i \in W} \frac{1}{\sigma_i z_i} \tag{7}$$

For a given $\vec{Z}$ and $\vec{\vec{\sigma}}$, the available bandwidth is estimated based on the clique and background traffic as follows:

$$BW \leq \frac{1}{M_W} = \frac{1}{\max \sum_{Q_i \in W} \frac{1}{\sigma_i z_i}} \tag{8}$$

Thus Eq. (2), (3), (5), (6, 7) or (8) are used in estimating the path available bandwidth.

C. Bandwidth Reservation

Let S and D be the source and destination nodes respectively.
Let Ni be the neighbor nodes
After estimating the available bandwidth, bandwidth reservation is performed.
When the source has a data, it verifies the residual bandwidth in its route cache
If the check is positive, it sends RREQ to its Ni which indicates the bandwidth required for its flow.

$$S * \xrightarrow{RREQ} N_i \tag{9}$$

(9)

On receiving the RREQ packet, Ni performs the admission control by comparing the bandwidth required by source and the estimated available bandwidth.
The bandwidth required by S

$$BWav\ \{S,\ D\} = RD.\ \frac{(\lfloor T_S - \overline{bo_S} \rfloor)}{\Delta}.\varsigma\ .$$

$$\frac{\rho - T}{\Delta}$$

Where RD = Channel availability rate at the destination node

TS = channel availability time at the source node

boS = average back off time at the source node

ς = channel capacity

ρ = mobility

Δ = measurement duration

ρ is estimated using the mobility prediction technique as follows:

Let S travel at velocity λ_S with direction β

$$\rho = \begin{cases} \infty \text{ if } (\lambda_S = \lambda_D \text{ and } \beta = \delta) \\ \dfrac{-(ab + lm) + \sqrt{(a^2 + l^2).d^2 - (am - lb)^2}}{(a^2 + l^2)} \end{cases} \quad (10)$$

Where RD =

Knowing that (θ S, θ D) and (ψ_S, ψ_d) are the coordinates of the S and D respectively.

$$a = \lambda_S . \cos \delta - \lambda_D . \cos \beta$$

$$b = \theta_D - \theta_S$$

$$l = \lambda_S . \sin \delta - \lambda_D . \sin \beta$$

$$m = \psi_s - \psi_D$$

The above coordinates are obtained through GPS system.
Note: During exchange of request or data packets, each node indicates the starting coordinates of its movement and the coordinates of its destination as well as the speed.
If this check is negative, Ni discards the RREQ.
Also the node observes the distance evolution using the neighbors table.
If the prediction was after the flow admission and the predicted time is reached or approached, the node sends a RERR to the source.

$$Ni \xrightarrow{RRER} S$$

Note: Prediction of link failure caused by mobility reduces the bandwidth availability.

D. Route Discovery Process

For routing, bandwidth aware proactive routing protocol is used. It involves the following algorithm:
Let IDS and IDR be the sink node and receiving node ID respectively.
Let ZS and ZR be the sequence number of the sink and receiving end node respectively.
Let ABS and ABR be the end-to-end available bandwidth of the sink and receiving end node respectively.
Let ABmax be the maximum available bandwidth of the receiving end node.
Each sink node broadcast the hello message periodically. The format of Hello message is as follows

TABLE I. FORMAT OF HELLO MESSAGE

Sink Node ID	Sink Sequence Number	End to End Available Bandwidth

Note: Consider that each node within the network maintains a sink table.
Format of Sink Table

TABLE II. FORMAT OF SINK TABLE

Sink Node ID	Sink Sequence Number	Maximu M Available Bandwidth	Next Hop Address

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The sink table stores the sink node ID, sequence number, maximum available bandwidth on a selected data forwarding path towards the sink node and the next hop address.
When the immediate neighbor’s node of the sink receives the HELLO message, it extracts the information about the sink node from the sink table and performs the following process:
Compares IDR with IDS existing in its sink table.
If the record does no match
Then
The node creates a new record in the sink table.
Else
The node compares the ZS with ZR.
If ZR is greater
Then
The node updates the sink table with the received information.
Else
The node ignores the sink data existing in the HELLO message.
End if
End if
When the HELLO message is received from the non-sink node, the node extracts the information from the message and performs the following process similar to Step 2.
Compare the IDR with IDS existing in its sink table.
If the record does no match
Then
The node creates a new record in the sink table.
It stores the new sink ID, sequence number, maximum available bandwidth on the path towards the sink node and next hop address.
Else
The node compares the stored ZS with ZR
If ZR □ ZS
Then
The node ignores the sink data existing in the HELLO message.
Else
The node updates the sink table with the received information.
Else
End if
End if
Then the node matches the node ID of the HELLO message broadcasting node with the next hop address stored in the corresponding record of the sink table.
If Node ID matches,
Then
The node updates the corresponding record in the sink table with the received sink information.
Else
The node compares the ABR with ABSS in the corresponding record.
If ABR > ABSS
Then

The node updates the maximum available bandwidth and next hop fields of the corresponding record of the sink table with the ABmax and the HELLO message broadcasting nodes address respectively.
End if
End if
When a sink node wants to transmit a data, it is relayed to the next hop node whose address is stored in the sink table.
If the data forwarding path fails, then the node repairs the route locally by searching an alternate data forwarding path in its sink table.
If alternate data forwarding path is not found, then the node informs the upstream node about the route failure.
The upstream node repairs the route and if it is unsuccessful it informs its upstream node about the route failure.
Step 7 and 8 are repeated until a node on the data forwarding path finds an alternate route or the source node is informed about the route failure.
Note: There is a possibility that the sink table record may be removed during following scenario:
Next hop for the sink node is removed from the direct neighbor table.
If the node does not receive the data packet for the flow for a pre−defined interval of time.
A record in the sink table with the sink node and the next hop used by the flow times out.

VI. SIMULATION RESULTS

A. Simulation Model and Parameters

We use NS-2 [16] to simulate our proposed Joint Bandwidth Reservation and Routing Protocol (JBRRP). In simulation, mobile nodes move in a 1000-meter x 1000-meter region for 50 seconds simulation time. All nodes have the same transmission range of 250 meters. The Constant Bit Rate (CBR) traffic is used for data transmission. The simulation settings and parameters are summarized in TABLE III.

TABLE III. SIMULATION PARAMETERS

No. of Nodes	25,30,35,40,45 and 50
Area Size	1000 X 1000
MAC	802.11
Radio Range	250m
Simulation Time	50 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Flows	2,4,6 and 8
Traffic Rate	250Kb

B. Performance Metrics

We evaluate mainly the performance according to the following metrics.

Average Packet Delivery Ratio: It is the ratio of the number. of packets received successfully and the total number of packets transmitted.

End-to-End Delay: It is the time taken by the packet to reach the receiver.

Throughput: It is the average throughput received by each receiver and measured in Mbits/sec.

Fairness: It is the fraction of bandwidth utilized for each flow.

We compare the Path Available Bandwidth Estimation (PABE) technique [15] with the proposed JBRRP. The simulation results are presented in the next section

C. Varying the Number of Nodes

In order to show the scalability of the protocols, the number of nodes is varied as 25, 30,35,40,45 and 50.

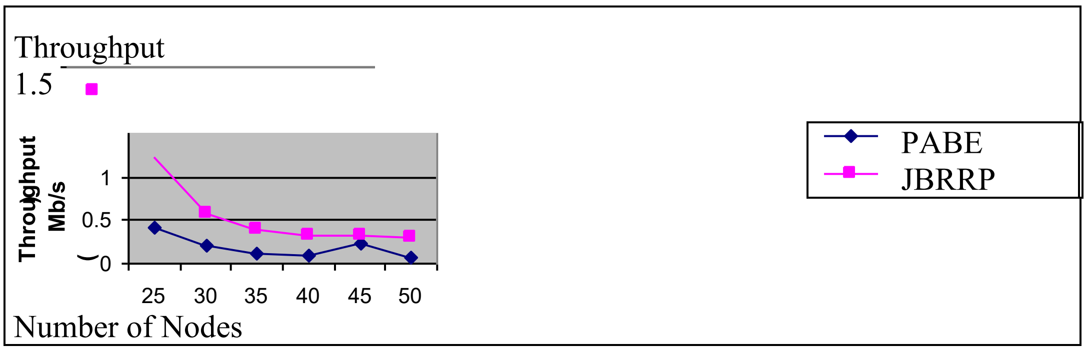

Fig. 1. Nodes Vs Throughput

The throughput obtained for both JBRRP and PBE are depicted in Fig. 1. It shows that increase in number of nodes decreases the throughput, since the number of hops increases. The figures clearly show that JBRRP obtains 63% higher throughput when compared to PABE.

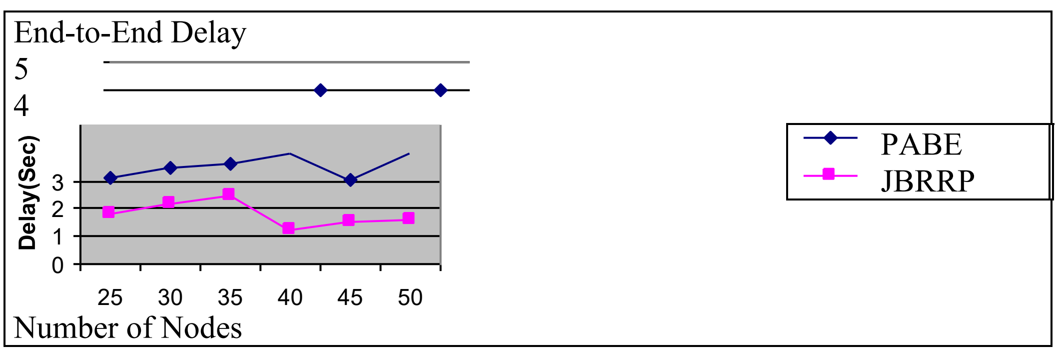

Fig. 2. Nodes Vs Delay

The end-to-end delay obtained for both the protocols are shown in Fig. 2. It shows that increase in number of nodes increases the delay, since the number of hops increases. The figures clearly show that JBRRP obtains 52% lesser delay than PABE.

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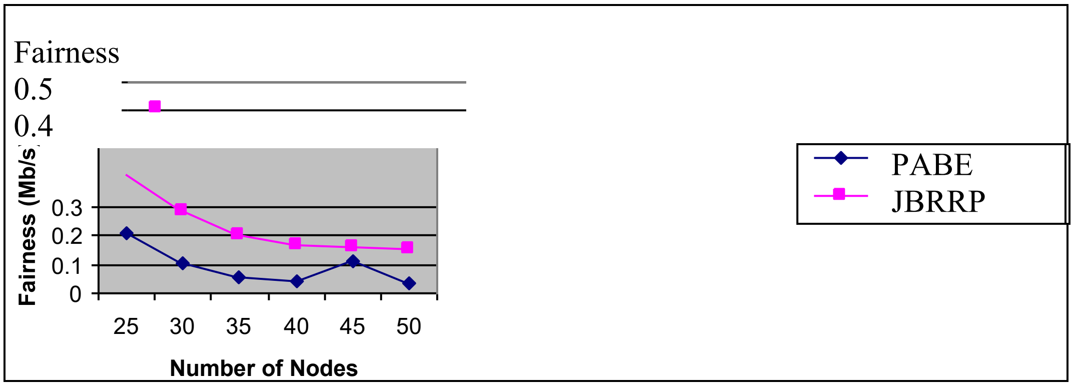

Fig. 3. Nodes Vs Fairness

The fairness obtained for JBRRP and PBE are depicted in Fig. 3. It shows that increase in number of nodes decreases the fairness, since the number of hops increases. The figure clearly shows that JBRRP obtains fairness 63% higher than PABE.

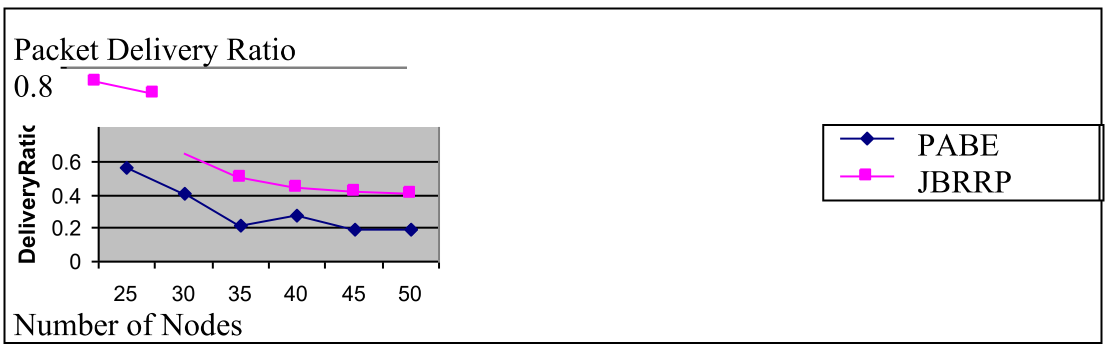

Fig. 4. Nodes Vs Delivery Ratio

The packet delivery ratio obtained for JBRRP and PBE are depicted in Fig. 4. It shows that increase in number of nodes, decreases the delivery ratio, since the number of hops increases. The figure clearly shows that JBRRP obtains 50% higher delivery ratio than PABE.

D. Varying the Traffic Flows

In order to analyze the effect of admission control, the number of traffic flows requesting for resources are increased from 2 to 8 for 50 nodes.

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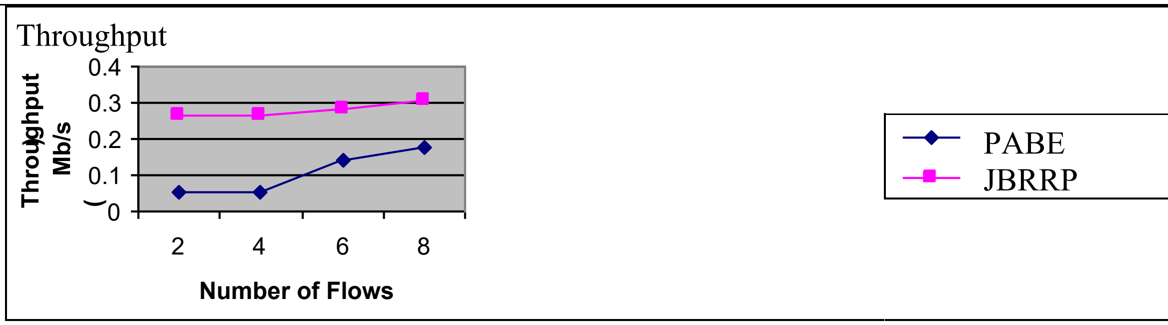

Fig. 5. Flows Vs Throughput

The throughput obtained for both JBRRP and PABE are depicted in Figure 5 for the increased traffic flow scenario. It shows that increase in number of flows increases the throughput, since a greater number of resources will be allocated. The fig. 5. clearly shows that JBRRP obtains 62% higher throughput than PABE.

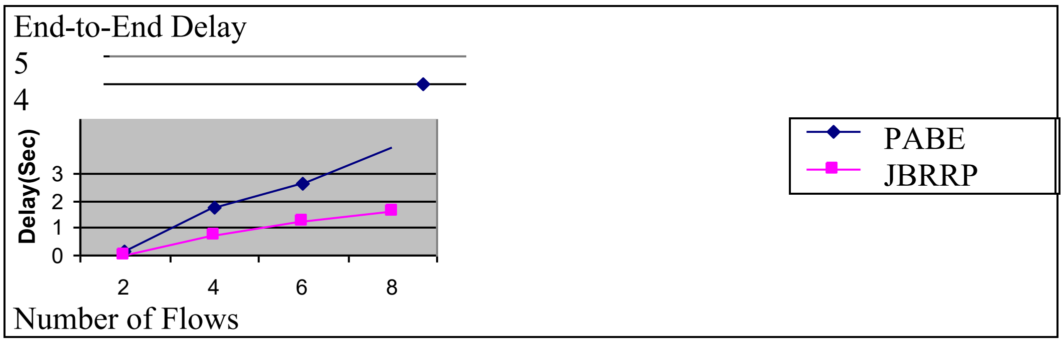

Fig. 6. Flows Vs Delay

The end-to-end delay obtained for both protocols are shown in Fig. 6. It shows that increase in number of traffic increases the delay, due to collision. The figure clearly shows that JBRRP obtains 60% lesser delay when compared to PABE.

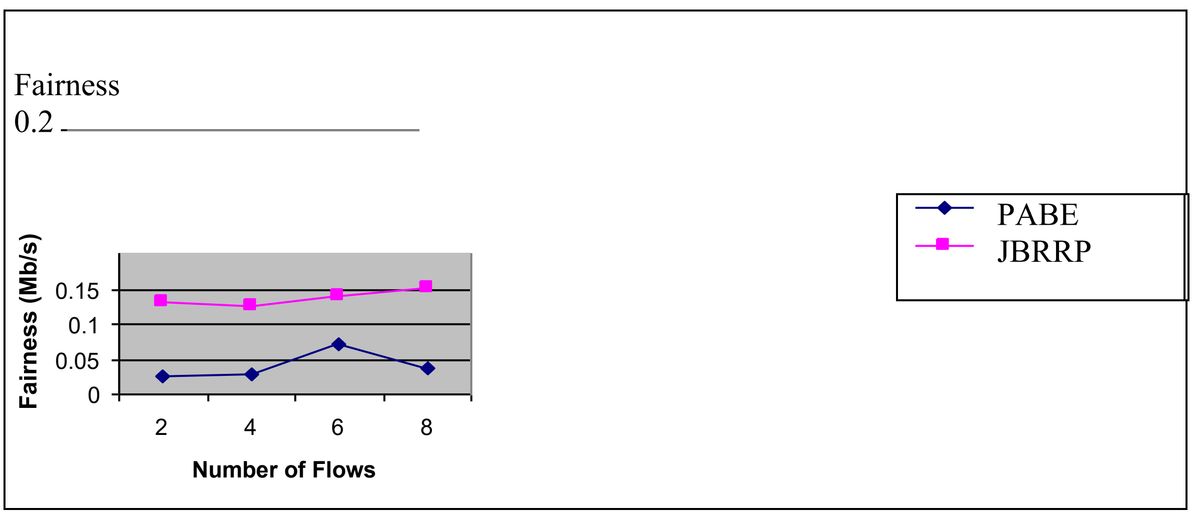

Fig. 7. Flows Vs Fairness

The fairness obtained for both JBRRRP and PABE are depicted in Fig. 7, for varying the flows. It shows that increase in number of flows, increases the fairness, since more resources are allocated. The figure clearly shows that JBRRP obtains 71% higher fairness than PABE.

Fig. 8. Flows Vs Delivery Ratio

The packet delivery ratio obtained for JBRRP and PBE for increasing the flows is depicted in Fig. 8. It shows that increase in number of nodes, decreases the delivery ratio, since there will be more packet drops due to collision and overload. The figure clearly shows that JBRRP obtains 51% higher delivery ratio than PABE.

VII. CONCLUSION

In this paper, we have proposed an efficient joint of bandwidth reservation and routing technique in MANET. In this paper, the available bandwidth is estimated based on the interference from both background traffic and traffic along the path. Then the bandwidth reservation is performed using the admission control technique. When the sink node wants to forward the data packet, it uses the bandwidth aware proactive routing protocol. It selects the forwarding paths to distribute the load based on the end-to-end available bandwidth. By simulation results, we have shown that the proposed technique enhances the packet delivery ratio and reduces the delay which positively impacts the network performance.

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