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QoS Aware Scheduling Based Routing Protocol (QoS-SBRP) for Heterogeneous Mobile Ad hoc Networks

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Abstract— Ensuring QoS is the major research dimension in the area of MANET by which reliable transmission of data is ensured. This research focuses in proposing a routing mechanism which ensures QoS through packet scheduling. The proposed routing scheme has contributions three fold. At first, a QoS-aware neighbor node selection mechanism is incorporated in order to meet the transmission delay requirement among the mobile nodes. Next, a distributed packet scheduling mechanism for reducing the transmission delay of packets is presented. Finally in order to reduce transmission time, packet resizing mechanism is proposed that adjusts the segment size of the packet in adaptive manner. The proposed routing scheme has been tested on NS-2 using the performance metrics such as throughput, packet delivery ratio, overhead, packets drop and delay. The simulation has been carried out based on pausetime and mobility speed. Mobility speed is evaluated using NS-2 in order to ensure the protocol's performance on heterogeneous ad hoc networks. Simulation results prove that the proposed mechanism attains better QoS in terms of throughput, packet delivery ratio, overhead, packets drop and delay based on both pausetime and mobility speed.

1 INTRODUCTION

Mobile ad hoc network shortly termed as MANET is an ongoing research paradigm in the area of wireless communication. MANET comprises of nodes that are basically mobile in nature which demands higher bandwidth, higher energy usage, and strict quality of service (QoS) requirements. The applications of MANETs include surveillance, military battlefield, personal area networking and so on. In [1] the authors mentioned that a small transmission range is necessary to limit the interference and consequently leads to high throughput. Most of recent studies in WSNs presume a small transmission range for each sensor node. On the other hand, a smaller transmission range means that a packet needs to be transmitted through more hops, which inevitably leads to higher transmission delay. The authors of [2] demonstrate that the delay due to the multi-hop transmission is increased when the throughput scales. Hence, increasing the transmission radius is able to lessen the average number of hops and can reduce the transmission delay. However, the increased transmission range will inevitably cause higher interference which leads to the lower throughput. Thus, there is a trade-off between reducing the delay and improving the throughput.

2. Related Works

Despite the issue of QoS support in MANETs is a relatively novel subject; it has recently received much attention from researchers worldwide. In the literature it can be seen works that focus on QoS issues related to a single protocol layer (e.g., MAC layer, routing layer) along with works that propose a QoS framework that combines more than one layer. In terms of MAC layer protocols for ad hoc networks, the IEEE 802.11 Working Group E [3] has recently completed a new MAC standard, also denoted as IEEE 802.11e, to enhance Wi-Fi networks with QoS support. In [6] Romdhani et al. propose enhancements to the IEEE 802.11e technology to offer relative priorities by adjusting the size of the contention window (CW) of each traffic class, taking into account both applications requirements and network conditions. Sobrinho and Krishnakumar propose Blackburst [7], which is a novel distributed channel access scheme that is more efficient than the IEEE 802.11e technology. Other works such as [8]–[10] also propose alternate QoS MAC schemes designed specifically for ad hoc network environments. Concerning routing layer proposals

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offering QoS support in MANETs, Lin and Liu [11] propose a QoS routing protocol that includes end-to-end bandwidth calculation along with bandwidth allocation schemes. Shigang and Nahrstedt [12] define a distributed QoS routing scheme that selects a network path with sufficient resources to satisfy a certain delay (or bandwidth) requirement. In [13], Xue and Ganz propose a resource reservation-based routing and signalling algorithm (AQOR) that provides end-to-end QoS support in terms of bandwidth and delay. Also, Chen and Heinzelman [14] propose a QoS-aware routing protocol that incorporates admission control and feedback schemes to meet the QoS requirements of real-time applications by offering an estimate of available bandwidth.

Cluster-based certificate revocation with vindication capability for MANETs is proposed in [4] and recently a statistical traffic pattern discovery system for MANETs is also proposed in [5]. Concerning QoS frameworks for MANETs, Lee et al. propose INSIGNIA [15], an approach to integrated services support in MANETs through a flexible signaling system. Ahn et al. propose SWAN [16], an approach to differentiated services support in MANETs using plain IEEE 802.11 plus rate-control for best effort traffic; traffic acceptance is dependent on local bandwidth estimations and admission control probes.

3. Proposed Work

Scheduling feasibility is the ability of a node to guarantee a packet to arrive at its destination within QoS requirements. The QoS of the direct transmission between a source node and an access point cannot be guaranteed, the source node sends a request message to its neighbor nodes. While receiving a forward request from a source node, a neighbor node with space utility less than a threshold replies the source node. The reply message contains information about available resources for checking packet scheduling feasibility. The source node then prefers the replied neighbors that can guarantee the QoS of packet transmission to the access points. The selected neighbor nodes intermittently send their statuses to the source node. The individual packets are forwarded to the neighbor nodes that are scheduling feasible as described in section 2.2. that aims to reduce the entire packet transmission delay.

3.1. Neighbor Node Selection Mechanism (NNSM)

The proposed mechanism makes use of the earliest deadline first scheduling algorithm which is a deadline driven scheduling algorithm for data traffic scheduling in intermediate nodes. In this mechanism, an intermediate node assigns the highest priority to the packet with the closest deadline and forwards the packet with the highest priority first. The size of the packet is denoted as $S_P(i)$, bandwidth of the node i denoted as BW_i, packet arrival interval as $T_a(i)$, and the utilized space is denoted as $U_s(i)$.

$$U_s(i) = \frac{S_p(1)/BW_i}{T_a(1)} + \frac{S_p(2)/BW_i}{T_a(2)} + \ldots + \frac{S_p(m)/BW_i}{T_a(m)} \le 1 \qquad \ldots (1)$$

$$\frac{S_p(1)}{T_a(1)} + \frac{S_p(j)}{T_a(j)} + \ldots + \frac{S_p(m)}{T_a(m)} \le BW_i \qquad \ldots (2)$$

Once after receiving a forward request from a source node, an intermediate node with space utility less than threshold TH replies the source node. The replied node informs the source node about its available workload rate mentioned as (3) and the necessary information to calculate the queuing delay of the packets from the source node.

$$U_{as}(i) * W_i \ldots (3)$$

3.2. Packet Scheduling Mechanism (PSM)

The previous section solves the problem of how to select intermediate mobile nodes that can guarantee the QoS of the packet transmission and how a source node assigns traffic to the intermediate nodes to ensure their scheduling feasibility. In order to further reduce the stream transmission time, a packet scheduling mechanism is proposed for packet routing. This mechanism assigns earlier generated packets to forwarders with higher queuing delays and scheduling feasibility, while assigns more recently generated packets to forwarders with lower queuing delays and scheduling feasibility, so that the transmission delay of an entire packet stream can be reduced.

Time is represented as t when the packet is generated. T_{QoS} denotes delay QoS requirement. W_S denotes the bandwidth of the source mobile node and W_I denotes the bandwidth of the intermediate mobile node. Transmission delay between source mobile node and intermediate mobile node is denoted as $T_{S\to I} = \frac{S_P}{W_S}$. Transmission delay between intermediate mobile node and destination mobile node is denoted as $T_{S\to D} = \frac{S_P}{W_I}$. T_w denote the packet queuing time of n_i. The queuing delay requirement is calculated as

$$T_w < T_{QoS} - T_{S\to I} - T_{I\to D} \ldots (4)$$

T_w can be calculated as

$$T_w^{(x)} = \sum_{j=1}^{x-1} \left(T_{I\to D}^{(j)} \cdot \left[\frac{T_w^{(x)}}{T_a^{(j)}} \right] (0 < j < x) \right) \ldots (5)$$

Where x denotes a packet with with x_{th} priority in the queue, $T_{I\to D}^{(j)}$ represents transmission delay of a packet from the intermediate mobile node to the destination mobile node and $T_a^{(j)}$ represents arrival interval of the packet.

After receiving the reply messages from the neighbor mobile nodes, the source node calculates the T_w and chooses the intermediate node n_i for data transmission. Taking advantage of the different T_w in different neighbor nodes, the transmission time of the entire traffic stream can be decreased by making the queuing of previous generated packets and the generating of new packets be conducted in parallel.

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3.3. Packet Resizing Mechanism (PRM)

Reducing packet size can increase the scheduling feasibility of an intermediate node and reduces packet dropping probability. However, the size of the packet could not be made too small since it generates more packets to be transmitted, producing higher packet overhead. Based on this underlying principle and taking advantage of the benefits of node mobility, packet resizing algorithm is deployed.

The basic idea is that the larger size packets are assigned to lower mobility intermediate nodes and smaller size packets are assigned to higher mobility intermediate nodes, which increases the QoS-guaranteed packet transmissions. Also, when the mobility of the node increases, the size of the packet decreases.

$$S_p(new) = \frac{\gamma}{v_i} S_p(unit)$$

Where γ represents scaling parameter and v_i is the relative mobility speed of the node.

4. Simulation Settings and Performance Metrics

200 mobile nodes starting from IP address 192.168.1.1 to 192.168.1.200 move in a 1500 x 1500 meter rectangular region for 100 seconds (simulation time). The channel capacity of mobile nodes is set to 2 Mbps. Distributed Coordination Function (DCF) of IEEE 802.11 is used for wireless LANs. It has the functionality to notify the network layer about link breakage. It is assumed that each node moves independently with the variant mobility speed between 0.5 to 1.5 m/s. The transmission range is fixed to 250 meters. The simulated traffic is Constant Bit Rate (CBR). The simulation settings are also represented in tabular format as shown in Table 1.

Table 1. Simulation Settings

No. of Nodes	200
Terrain Size	1500 X 1500 m
MAC	802.11b
Radio Transmission Range	250 meters
Simulation Time	100 seconds
Traffic Source	CBR (Constant Bit Rate)
Packet Size	256 Kbits
Mobility Model	Random Waypoint Model
Speed	0.5 – 1.5 m/s

The following metrics are taken into account for evaluating the proposed routing mechanism with RAB.

- Throughput
- Packet Delivery Ratio
- Drop
- Overhead
- Delay

5. Simulation Results and Discussions

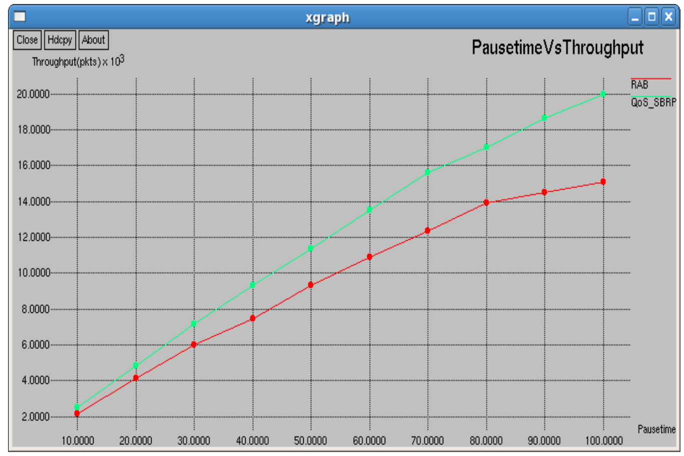

Figure 1. Pausetime Vs Throughput

Figure 1. shows the throughput performance of the existing RAB protocol and the proposed QoS-SBRP. It is evident that the proposed protocol QoS-SBRP achieves better throughput than that of RAB protocol. The numerical results are also given in Table 1.

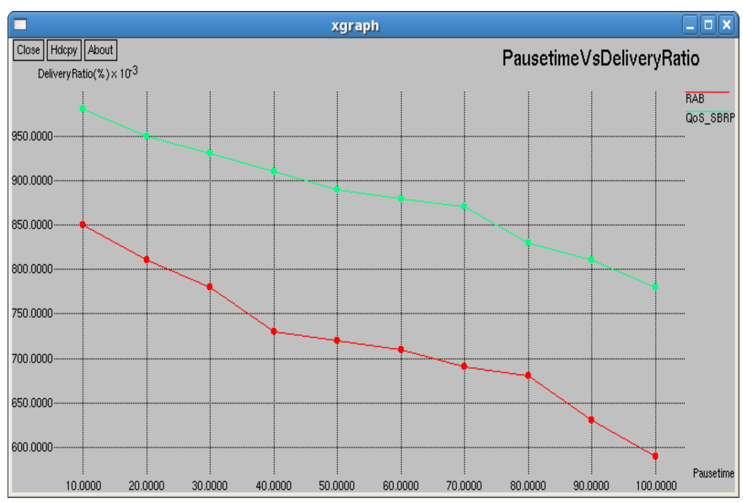

Figure 2. Pausetime Vs Packet Delivery Rati

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Figure 2. shows the packet delivery ratio performance of the existing RAB protocol and the proposed QoS-SBRP. It is clearly seen that the proposed protocol QoS-SBRP achieves better packet delivery ratio than that of RAB protocol. The numerical results are presented in Table 1.

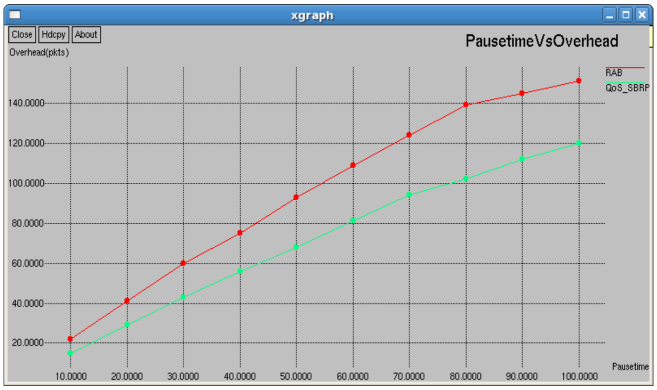

Figure 3. Pausetime Vs Packet Drop

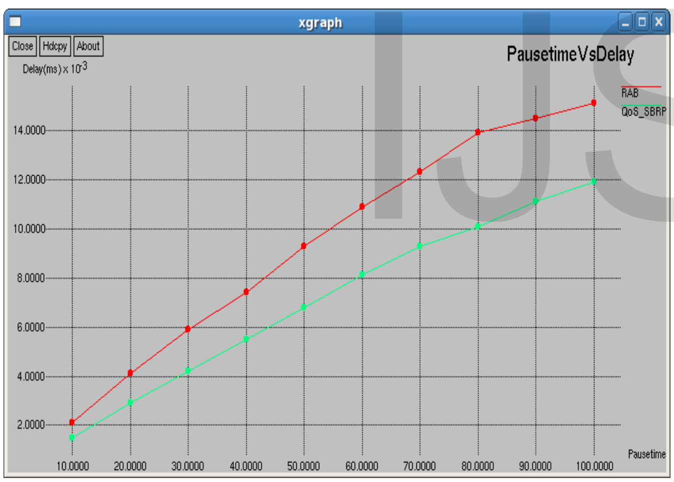

Figure 4. Pausetime Vs Overhead

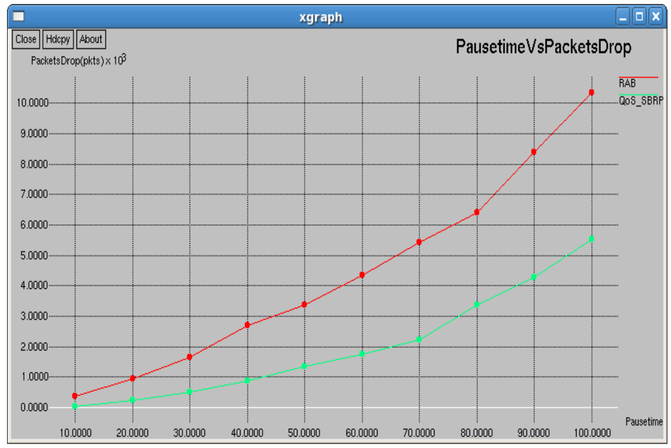

Figure 5. Pausetime Vs Delay

Figure 3. depicts the packets drop performance of the existing RAB protocol and the proposed QoS-SBRP. It is clear that the proposed protocol QoS-SBRP achieves lesser packet drop than that of RAB protocol. The numerical results are also given in Table 1.

Figure 4. shows the overhead performance of the existing RAB protocol and the proposed QoS-SBRP. It is proved that the proposed protocol QoS-SBRP achieves less overhead than that of RAB protocol. The numerical results are also given in Table 1.

Figure 5. shows the latency delay performance of the existing RAB protocol and the proposed QoS-SBRP. It is clear that that the proposed protocol QoS-SBRP procures lesser delay than that of RAB protocol. The numerical results are also given in Table 1.

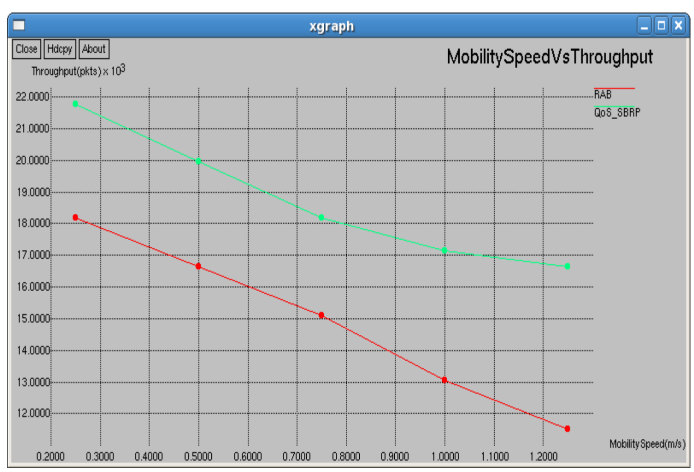

Figure 6. Mobility Speed Vs Throughput

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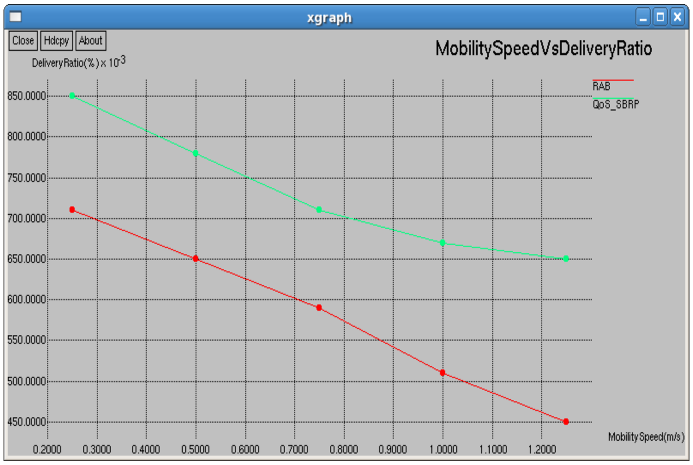

Figure 7. Mobility Speed Vs Packet Delivery Ratio

Figure 6. shows the mobility speed versus throughput performance of the existing RAB protocol and the proposed QoS-SBRP. It is evident that the proposed protocol QoS-SBRP achieves better throughput than that of RAB protocol. The numerical results are also given in Table 2.

Figure 7. shows the mobility speed versus packet delivery ratio performance of the existing RAB protocol and the proposed QoS-SBRP. It is clearly seen that the proposed protocol QoS-SBRP achieves better packet delivery ratio than that of RAB protocol. The numerical results are presented in Table 2.

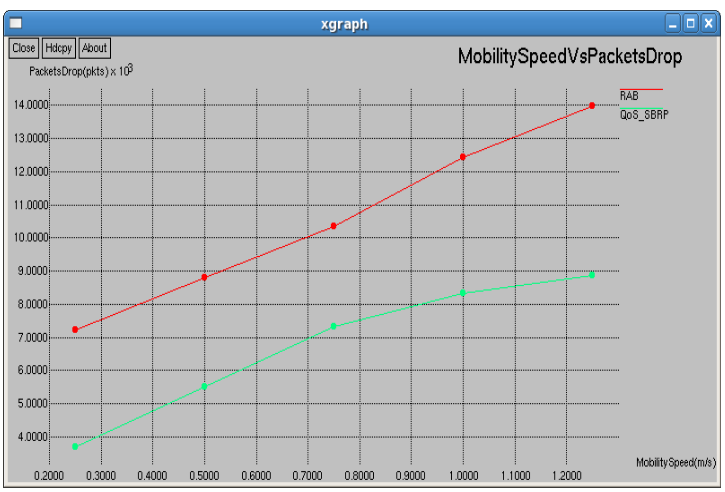

Figure 8. Mobility Speed Vs Packet Drop

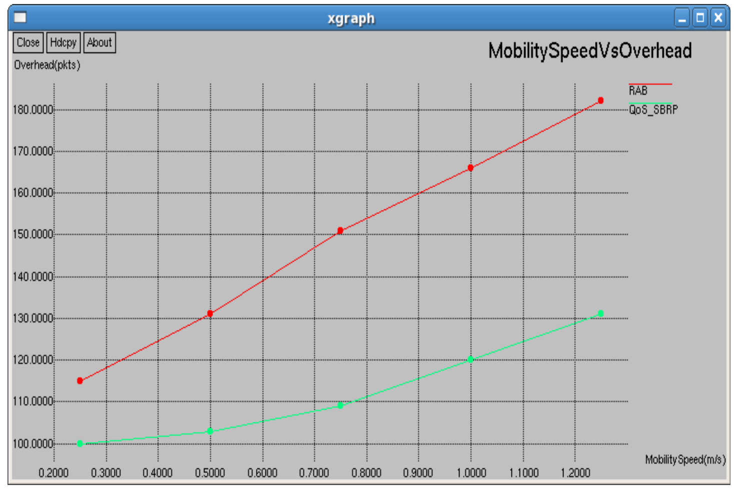

Figure 9. Mobility Speed Vs Overhead

Figure 8. depicts the mobility speed versus packets drop performance of the existing RAB protocol and the proposed QoS-SBRP. It is clear that the proposed protocol QoS-SBRP achieves lesser packet drop than that of RAB protocol. The numerical results are also given in Table 2.

Figure 9. shows the mobility speed versus overhead performance of the existing RAB protocol and the proposed QoS-SBRP. It is proved that the proposed protocol QoS-SBRP achieves less overhead than that of RAB protocol. The numerical results are also given in Table 2.

Figure 10. shows the mobility speed versus latency delay performance of the existing rab protocol and the proposed qos-sbrp. it is clear that that the proposed protocol qos-sbrp procures lesser delay than that of rab protocol. the numerical results are also given in table 2.

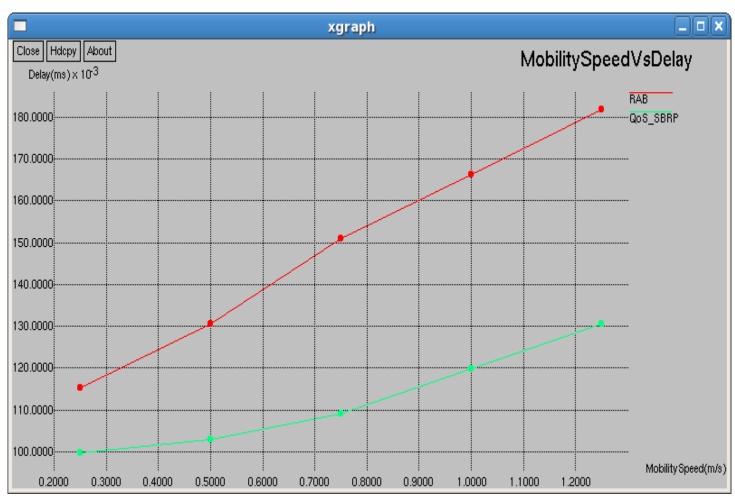

Figure 10. Mobility Speed Vs Delay

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Table 2. Pausetime Vs Throughput, Packet Delivery Ratio, Packets Drop, Overhead and Delay

	Throughput		Packet Delivery Ratio		Packets Drop		Overhead		Delay	
	RAB	QoS-SBRP	RAB	QoS-SBRP	RAB	QoS-SBRP	RAB	QoS-SBRP	RAB	QoS-SBRP
10	2176	2509	0.85	0.98	362	36	22	15	0.0021	0.0015
20	4147	4864	0.81	0.95	931	227	41	29	0.0041	0.0029
30	5990	7142	0.78	0.93	1630	495	60	43	0.0059	0.0042
40	7475	9318	0.73	0.91	2690	866	75	56	0.0074	0.0055
50	9344	11392	0.72	0.89	3363	1340	93	68	0.0093	0.0068
60	10906	13517	0.71	0.88	4345	1762	109	81	0.0109	0.0081
70	12365	15590	0.69	0.87	5432	2236	124	94	0.0123	0.0093
80	13926	16998	0.68	0.83	6414	3380	139	102	0.0139	0.0101
90	14515	18662	0.63	0.81	8380	4266	145	112	0.0145	0.0111
100	15104	19968	0.59	0.78	10345	5512	151	120	0.0151	0.0119

Table 3. Mobility Speed Vs Throughput

	Throughput		Packet Delivery Ratio		Packets Drop		Overhead		Delay	
	RAB	**QoS-SBRP**	**RAB**	**QoS-SBRP**	**RAB**	**QoS-SBRP**	**RAB**	**QoS-SBRP**	**RAB**	**QoS-SBRP**
0.25	18176	21760	0.71	0.85	7242	3709	115	100	0.1152	0.0998
0.50	16640	19968	0.65	0.78	8794	5512	131	103	0.1306	0.1029
0.75	15104	18176	0.59	0.71	10345	7315	151	109	0.1510	0.1091
1.00	13056	17152	0.51	0.67	12413	8345	166	120	0.1664	0.1198
1.25	11520	16640	0.45	0.65	13965	8860	182	131	0.1818	0.1306

6. Conclusion

This paper proposed a routing mechanism in order to ensure QoS through packet scheduling strategy. A QoS-aware neighbor node selection mechanism is used to meet the transmission delay requirement among the mobile nodes. A distributed packet scheduling mechanism for reducing the transmission delay of packets is also presented. Packet resizing mechanism is proposed which is capable to adjust the segment size of the packet in adaptive manner. The simulation is carried out based on pausetime and mobility speed. Mobility speed is taken for ensuring the protocol's performance on heterogeneous ad hoc networks. Simulation results prove that the proposed mechanism attains better QoS in terms of throughput, packet delivery ratio, overhead, packets drop and delay based on both pausetime and mobility speed.

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