Resource Reservation using PRTMAC Protocol in MANET

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Abstract: **Most of the real-time applications require guaranteed QoS during transmission. Mobile Ad hoc network is an infrastructure less network in which the parameters like mobility, limited resource, lack of central coordination which affects Quality of service (QoS). Therefore it is essential to maintain QoS in real-time traffic. This paper presents PRTMAC (Proactive Real Time Medium Access control) protocol to achieve guaranteed QoS in terms of delay, throughput. It supports QoS by the resource reservation mechanism. Once the resources are reserved, nodes get exclusive access on the resource. The performance metrics are analyzed using NS2 simulation and it shows better improvement in terms of throughput and delay.**

Keywords: QoS, MANET, PRTMAC, Resource reservation, End-to-End path.

I. INTRODUCTION

Mobile Ad hoc Network is an autonomous system of mobile nodes that self-configure to form a network without the aid of any established infrastructure. It uses multi hop connections, whereby intermediate nodes send the packets towards their final destination. Each node can act as a host or router with necessary controls and networking tasks using distributed architecture.

An ad hoc network is an infrastructure-less network which allows all wireless devices within range of each other. In case of a large network, it is necessary to consider the performance of routing protocols and MAC protocols while designing.

Quality of Service (QoS) is to measure the performance level of a network. To achieve a more deterministic network behavior is the goal of QoS provisioning. So that better delivery of information carried by the network and better utilization of network resources are the challenges in an ad hoc network. The QoS parameters such as bandwidth, jitter, delay, packet loss rate etc. are differed applications to applications. For example, bandwidth, delay and jitter are service requirements in multimedia applications. Military applications require strong security. Search and rescue operations require availability of the network whereas little energy is the requirement in conference applications.

It is a hot research area to support QoS for ad hoc networks. The issues and challenges in ad hoc networks are dynamic topology, imprecise state information, lack of central coordination, hidden terminal problem and limited resource availability. To support QoS for real-time applications, the solution is classified as several ways based on layers in network protocol stack. This paper deals with how effectively the resources like bandwidth are utilized. Here the QoS is supported by resource reservation concept [4, 11]. Once the bandwidth is reserved the nodes get exclusive access on the bandwidth.

II. RELATED WORK

Cross layer design is one of the solutions for providing QOS in wireless networks. It means that to share network information between different layers. In OSI architecture, each layer has some relationship with QOS. Application layer aims at frequent disconnection & reconnection, transport layer focus on delay & packet loss error due to transmission, network layer deals with change in bandwidth and delay, data link layer handles variable bit error rate and physical layer takes care of transmission Quality. The shared information’s are classified as physical information MAC information, network information. By combining network layer and MAC layer with transport layer mechanisms, J.Premalatha and P.Balasubramanie [1, 5] proposes the concept which improves QoS metrics such as throughput by 35-40%, bandwidth delay product by 25-30%, packet delivery ratio by 15-20% and packet loss rate is reduced by 20-25%. So cross layer design is used to satisfy multiple QOS constraints.

Dr.R. Asokan proposes [2] “Review of quality of service routing protocols for QOS routing”. The QOS is implemented at the network layer which provides QoS provisioning. This paper presents both single and multiple metric QOS routing protocols. In single metric QOS routing protocols, INSIGNIA, QOS-TORA and INORA are the solutions which uses bandwidth as an important metric. In multiple metric QOS routing protocols, extension of AODV and OLSR are the solutions which uses bandwidth and delay as metrics.

“TDMA–based multi-hop resource reservation protocol for real-time applications in tactical mobile ad hoc networks” [3, 12] uses time division multiple access for resource reservation. Here, the time of a channel is divided into super frames. Each super frame has three major parts that are beacon period, data transmission period and resource reservation period. At first node get access on beacon slots. After successfully allocated a beacon slot, the node which has data to send first tries to perform multi-hop channel resource reservation process by carrier sense multiple accesses (CSMA) in the non-reserved slots in both beacon period and data transmission period. When the multi hop channel reservation process is completed, the node starts data transmission on data transfer period.

M.Sulleman Memon, Niaz A.Memon and Manzoor Hashmani [7, 8] propose an algorithm for routing and resource reservation for prioritized traffic to satisfy QOS requirements. Using this algorithm, only three best paths are selected among the multiple paths on certain criteria. These paths are called as primary, secondary, ternary paths. Criteria used to select those three paths are maximum bandwidth, minimum delay (number of hops), path must be loop free and node disjoint. The primary path is initially used for transmission. If any path break occurs, the source uses the secondary path that reduces the route computation delay. The traffic is categorized into four according to their priorities. They are very high priority in an Emergency environment, high priority in a military environment, medium priority in academic and business environments and low priority in Data, voice and Entertainment environments. Very high priority transmission requires resource reservation on the primary path for full duration of transmission. Similar to that, the secondary path also reserves the resources but it is not in the ternary path. For high priority transmission, resources are reserved on the primary path for the complete duration of transmission. But in secondary path, only 25% of the duration of transmission is used for reservation. If the primary path breaks within 25% duration of time, the secondary path becomes a primary path. Then ternary path becomes secondary path but resources are not reserved for it. Resources are reserved for the primary path in medium priority transmission and there is no reservation in secondary and ternary paths. For lower priority transmission, primary and secondary paths are found without reservation. Ternary path is not applicable for low priority transmission.

The QoS routing using optimized link state routing protocol (OLSR) by enhancing the MPR selection criteria is proposed by Suman Banik, [9]. The main path constraint is to obtain the best bandwidth and minimum delay. This table-driven routing protocol uses multipoint relaying concept which is an efficient link state packet forwarding mechanism. Two ways used to achieve optimization in QoS OLSR are by reducing the control packets size and by reducing the number of links that are used for forwarding the link state packets. The key concept of OLSR protocol is to select multipoint relays (MPR) among the one-hop neighbors. MPRs are responsible for forwarding control traffic into the entire network. Each node selects a set of MPR Selectors and is also noted in the routing table which covers maximum bandwidth, minimum delay and two hop neighbors to destination node.

III. PRTMAC PROTOCOL

To support QoS in real-time traffic for mobile ad hoc networks, Proactive Real Time Medium Access Control protocol (PRTMAC) [6] is used. It is on-demand, decoupled and MAC & network layer dependent protocol. It supports resource reservation for real-time traffic. This protocol will operate in asynchronous mode. Free slot may occur between reservation slots. Some of the free slots are used to accommodate data and ACK packets and the remaining free slots may be used to transmit ResvRTS, ResvCTS and ResvACK. Hence the bandwidth is effectively utilized in the PRTMAC protocol. It also solves hidden terminal problem.

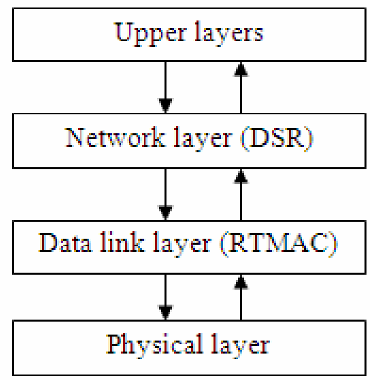

Figure 1. Architecture of PRTMAC

Figure 1 shows the architecture of PRTMAC protocol. This paper focuses on only middle two layers such as MAC part of the Data link layer and network layer. To achieve QoS routing, it uses DSR (Dynamic Source Routing) routing protocol and the real-time medium access control (RTMAC) protocol is used in the MAC layer to support real time traffic with high mobility. PRTMAC is combination of DSR and RTMAC protocol. The overall functionality of the PRTMAC protocol can be subdivided into End-to-end path finding and Resource reservation.

A. End-to-End Path Finding

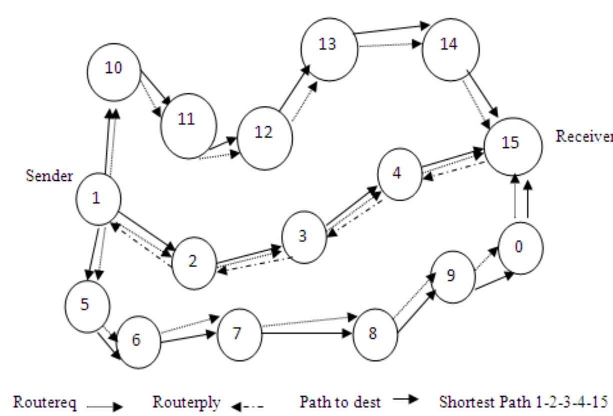

Figure 2. End-to-End path

The end-to-end routing is achieved by on demand reactive protocol called DSR [10]. When a source node wants to send data, it should establish path from source to destination. Figure 2 represents how the route is established between one end and other end using DSR protocol which uses source routing technique. When there is a path break, the route error message is forwarded to sender and the sender node finds another path based on the requirements.

B. Reservation Mechanism

RTMAC is responsible for bandwidth reservation. The reservation process of RTMAC protocol is as shown in figure 3.Time slots are used to reserve the resource which are divided into super frames. Reserve variable length time slots in super frames. For that, bandwidth reservation can be done which is sufficient enough to carry the traffic generated by the node. When a node wants to send data, first it should reserve set of reservation-slots. Each node maintains a reservation table that has sender id, receiver id, starting and ending times of reservations.

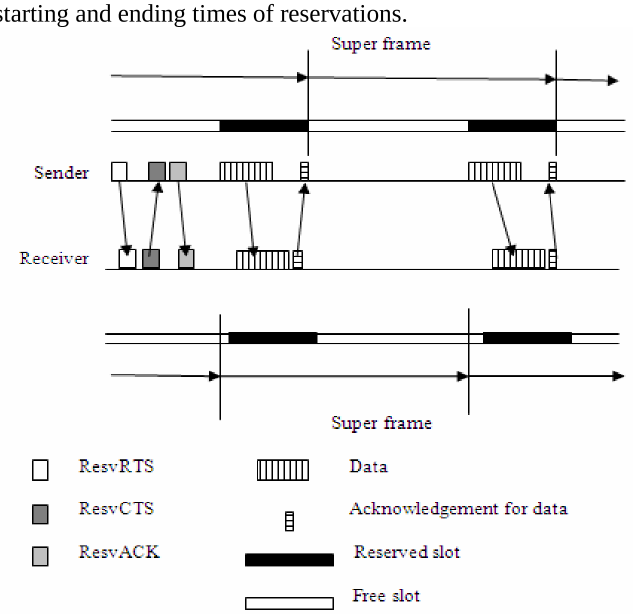

Figure 3. Reservation mechanisms in RTMAC

For reserving bandwidth each node needs three control messages are ResvRTS, ResvCTS, ResvACK [13, 14, 15]. The node which wants to reserve sends ResvRTS to the destination node. ResvRTS packet has starting and ending relative time information to be reserved. After receiving ResvRTS packet, the destination node checks its reservation table. It receives any reservation on those slots. Once slot is free, destination node replies with ResvCTS packet. It also contains relative time information of the same reservation-slot. On receiving ResvCTS, sender node responds with ResvACK.

If the receiver node receives the ResvRTS packet on a slot, it does not respond with a ResvCTS packet and it discards the received ResvRTS packet since the ResvRTS packet has already been reserved by one of its neighbor nodes. Hence the collision is avoided, if the node responds with a negative or positive ACK. The ACK packet may cause collisions with the reservations made by its neighbor. The sender node times out and retries later. In case the requested connection-slot is not free at the receiver node, but the control message ResvRTS is received on a free slot. Then, the receiver sends negative CTS (ResvNCTS) back to the sender. On receiving this, the sender reattempts following the same procedure but with another free connection-slot.

Once the reservation process gets finished, the node releases the resources reserved by sending reservation release RTS (ResvRelRTS) packet. The Route break is detected by the intermediate node, the route reconfigured locally as shown in figure 4 or Route error message is sent to the sender and the sender reconfigures the route from end-to-end as shown in figure 5.

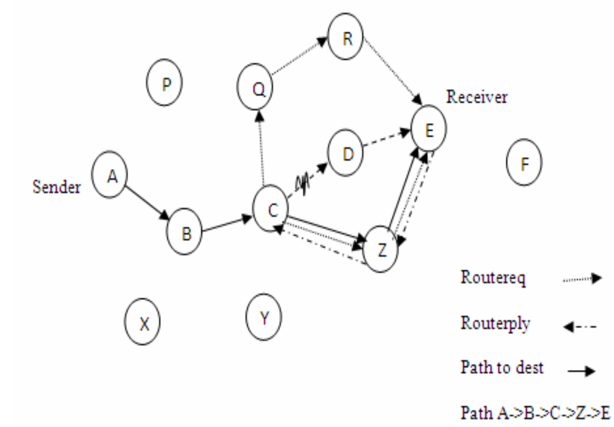

Figure 4. Local reconfiguration

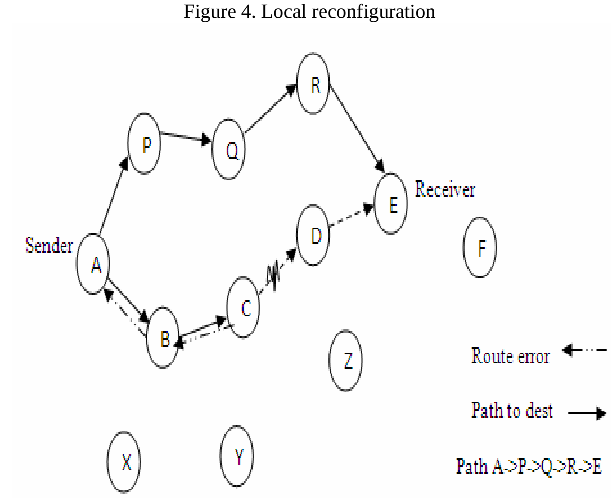

Figure 5. End-to-end reconfiguration

When a node receives data packet for a new connection, it reserves bandwidth for particular duration in the forward link and forwards the packet to the next node towards destination. The figure 6 shows how reservation and data transfer has been taken place in end-to-end path.

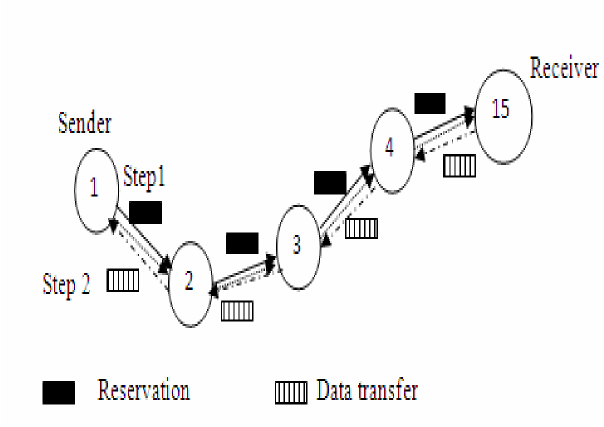

Figure 6. Reservation and data transfer from end-to-end

IV. RESULTS AND DISCUSSION

The performance level is analyzed using NS2 simulator with the parameters delay and throughput. To achieve QoS, it requires minimum delay, maximum throughput. The following results show the better improvement in QoS parameters.

A. Simulation Setup

Table I shows the simulation parameter to implement the PRTMAC QoS protocol in ns2.

TABLE I. SIMULATION PARAMETERS

Parameter	**Value**
Number of Mobile Nodes	3,10 and 25
Simulation Time	156s
Traffic Model	TCP
Packet Size	512 bytes
Routing Protocol	DSR
Mac Protocol	RTMAC
Topography	500 x 400
Coverage Area	250m

B. Reservation Process in Ns2

The following tables II.A and II.B describes how the reservation process is initiated and also describes the data transmission process. These values are extracted from the trace file during 3 nodes simulation process.

TABLE II.A. RESERVATION BETWEEN NODE_0 TO NODE_2

Event	Time	Node_id	Layer	Seq.No	Packet_type	Packet_size
s	40.126832281	_0_	MAC	0	ResvRTS	44
r	40.127184912	_2_	MAC	0	ResvRTS	44
s	40.127194912	_2_	MAC	0	ResvCTS	38
r	40.127499543	_0_	MAC	0	ResvCTS	38
s	40.127509543	_0_	MAC	0	ARP	86
r	40.128198174	_2_	MAC	0	ARP	28
s	40.128208174	_0_	MAC	0	ResvACK	38
r	40.128512805	_2_	MAC	0	ResvACK	38
s	40.131801329	_0_	MAC	68	tcp	138
r	40.132905961	_2_	MAC	68	tcp	80

C. Throughput

Throughput is defined as the rate over a wireless communication channel of successful message delivery and is measured in terms of bits per second. Figures 7, 8, and 9 shows the comparison of throughput with reservation and non-reservation based process by varying the number of nodes in Ns2 simulation. In the simulation, the throughput of reservation process is initially little bit less compared to non-reservation process since it takes some time for initial reservation process.

D. Average End-to-end Delay

It is defined as the time taken from source to destination across a network for a packet to be transmitted and it is calculated for both reservation and non-reservation by varying the number of nodes in the simulation is show in table III. In all the three cases, the reservation based process gets minimum delay. This delay comparison is represented as a graph shown in figure 10.

TABLE II.B. RESERVATION BETWEEN NODE_2 TO NODE_1

Event	Time	Node_id	Layer	Seq.No	Packet_type	Packet_size
s	40.133289961	_2_	MAC	0	ResvRTS	44
r	40.133642691	_1_	MAC	0	ResvRTS	44
s	40.133652691	_1_	MAC	0	ResvCTS	38
r	40.133957421	_2_	MAC	0	ResvCTS	38
s	40.133967421	_2_	MAC	68	tcp	138
r	40.135072151	_1_	MAC	68	tcp	80
s	40.135082151	_2_	MAC	0	ResvACK	38
r	40.135097151	_1_	RTR	68	tcp	80
r	40.135097151	_1_	AGT	68	tcp	40
s	40.135097151	_1_	AGT	1973	ack	40
r	40.135097151	_1_	RTR	1973	ack	40
s	40.135097151	_1_	RTR	1973	ack	80
r	40.135386881	_1_	MAC	0	ResvACK	38
s	40.151531586	_2_	MAC	1974	tcp	1118
r	40.160476316	_1_	MAC	1974	tcp	1060

TABLE III. DELAY COMPARISON FOR RESERVATION AND NON-RESERVATION

No of Nodes	With Reservation	Without Reservation
3	122.424ms	141.095ms
10	176.778ms	200.522ms
25	217.747ms	239.71ms

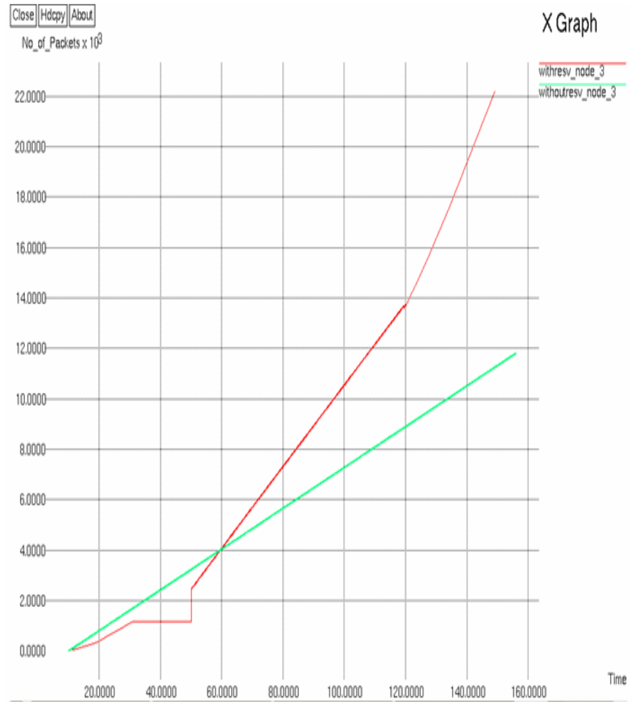

Figure 7. Throughput comparison for 3_nodes

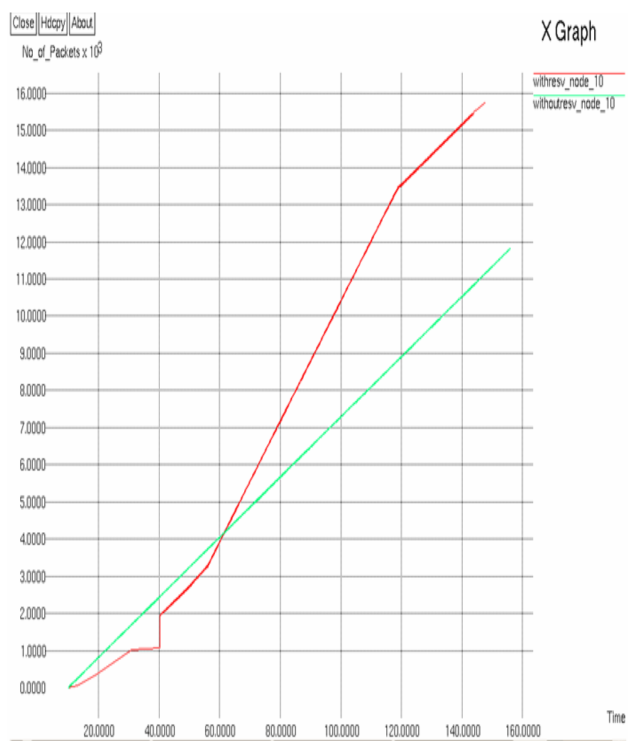

Figure 8. Throughput comparison for 10_nodes

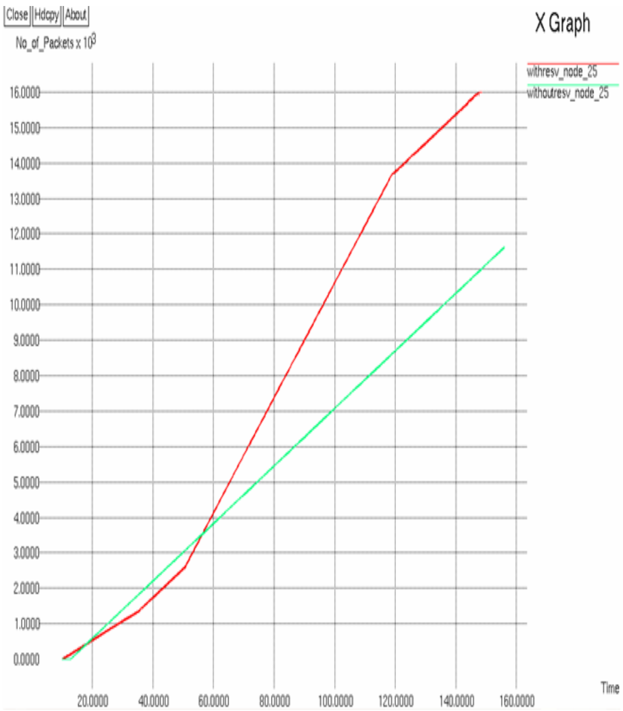

Figure 9. Throughput comparison for 25_nodes

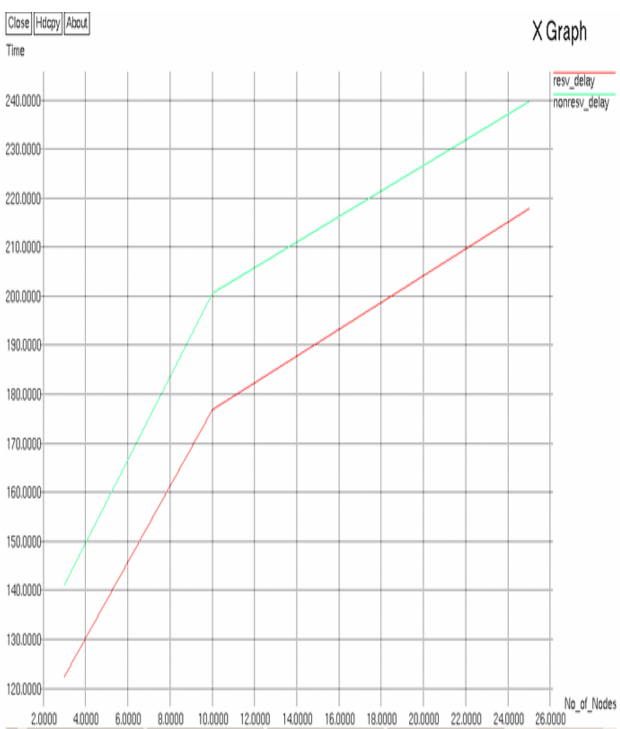

Figure 10. Average end-to-end delay comparison

V. CONCLUSION

This paper uses the PRTMAC protocol for reservation process. It is observed that the throughput is high in reservation compared to non-reservation process. While varying the number of nodes in the simulation, it retains the same level. In the reservation process, average end-to-end delay is less and also there is substantial change in the delay while varying the number of nodes. Therefore, the PRTMAC protocol gives better performance in the reservation process. In future, it would be interesting to observe the behavior of PRTMAC protocol by varying other network parameters.

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