IJIRSE) International Journal of Innovative Research in Science & Engineering
ISSN (Online) 2347-3207

An Adaptive Slot Reservation Frame for Efficient Contention Access in VeMAC-VANET

[1]K.Selvakumaran, [2]K.Saravanakumar
[1]M.E-CSE, [2]AP-CSE
V.S.B. Engineering College,
Karur, Tamilnadu, India.
[1]selvakumaranrk@gmail.com, [2]saravanakumar.mtech@gmail.com

***Abstract*— Vehicular ad hoc networks (VANETs) arehigh priority safety applications that need medium access control (MAC) protocol for efficient broadcast service. The existing work presented VeMAC, a novel multi channel TDMA MAC protocol for VANET supports efficient one-hop and multi-hop broadcast services on control channel using implicit acknowledgments and eliminating hidden terminal.The drawbacks of existing work allow a node to reserve only one slot in an information frame. Once a node has reserved a slot it ceases contending for other slots.**

The proposed work presented an Adaptive Slot Reservation Frame Scheme for improved contention access on control channel in VeMAC. Nodes are allowed to contend for more than one slot in a reservation frame according to priority criteria. The advantages of proposed work allow nodes to reserve a slot adaptively in the information frame as per priority. Simulation methodology is adopted to eliminate the artificial boundary effect of VeMAC.

Keywords—Ad hoc network, Five-Phase Reservation Protocol (FPRP), Contention Slot, Media Access Control (MAC)protocol.

I. INTRODUCTION

A mobile ad hoc network (MANET) consists of a number of mobile terminals connected with wireless links and is independent from any fixed infrastructure. MANETs can be established quickly and moved flexibly and therefore have wide applications in various types of communication, such as military and emergency. The media access control (MAC) protocol, which provides channel access control mechanisms to coordinate multiple nodes in a network, is an important part of ad hoc networks.

To date, many time division multiple access (TDMA)-based MAC protocols have been proposed. There are reservation-based protocols, such as the five-phase reservation protocol (FPRP) and the hop reservation multiple access (HRMA) protocol.

The reservation-based TDMA protocols can be classified into two categories: fixed allocation and dynamic allocation. Fixed allocation protocols make slot assignments at the scale of the whole network. They do not have the conflict problem but are not suitable for networks with dynamically changing topologies. In contrast, dynamic allocation protocols, such as FPRP, HRMA, evolutionary-TDMA (E-TDMA), and DRAND, use distributed algorithms to assign slots by coordinating nearby nodes. FPRP is a fully-distributed protocol with a low probability of conflict. Using dynamic slot assignments, FPRP has many advantages, such as being scalable with the network size, suitable for changing topology, and insensitive to node mobility. These merits make FPRP a very promising MAC layer protocol for MANETs.

In this algorithm, nodes compete for different time slots in a reservation cycle, making the number of transmission nodes in each slot nearly equal. In the authors modified the reservation mechanism to take into account different levels of urgency of the traffic. After the slot reservation cycle is completed, every node will maintain a table of slot assignments, which specifies which slots have been acquired by neighbor nodes. When the next reservation cycle starts, all nodes will contend for slots based on the prior information in the table, thereby improving the spatial channel utilization.

An improved FPRP algorithm was proposed, in which nodes use different initial probabilities for contention, according to different traffic loads. In this improved FPRP, the node that receives the collision report will check the report to decide whether it should continue to contend or stop immediately.

An improved FPRP (I-FPRP) protocol applying the pseudo-Bayesian broadcast algorithm is subsequently proposed and theoretically analyzed in section III. In section IV, we investigate various performance metrics in detail and critically study the pros and cons of FPRP and I-FPRP via simulation results.

ISSN (Online) 2347-3207

II. RELATED WORK

The VeMAC framework is developed by Hassan Aboubakr Omar et al., (2011) [1] supports efficient one-hop and multi-hop broadcast services on the control channel by using implicit acknowledgments and eliminating the hidden terminal problem. The protocol reduces transmission collisions due to node mobility on the control channel by assigning disjoint sets of time slots to vehicles moving in opposite directions and to road side units. Analysis and simulation results in highway and city scenarios are presented to evaluate the performance of VeMAC and compare it with ADHOC MAC, an existing TDMA MAC protocol for VANETs. It is due to its ability to decrease the rate of transmission collisions, the VeMAC protocol can provide significantly higher throughput on the control channel than ADHOC MAC.

Location Division Multiple Access (LDMA) scheme is designed by R.Mangharam et al., (2007) [2] to suppress the broadcast storm problem and ensure bounded end-to-end delay across multiple hops. This scheme requires participating vehicles to time synchronize with the GPS time and receive the regional map definitions consisting of spatial cell resolutions and temporal slot schedules via an out-of-band FM/RDBS control channel. We use the Groove Net vehicular network virtualization platform with realistic mobility, car-following and congestion models to evaluate the performance of LDMA in simulation and on the road.

This paper is developed by J.W. Wang et al., (1999) [3] probability that m out of n boxes each have exactly one ball resulting from distributing k balls into n boxes. The solution to this problem is given by a set of recursive expressions. By translating these formulae into computer program, one can easily obtain the numerical results.

Our model is designed by M.I. Hassan et al., (2004) [4] validated using extensive simulations and we show that our model yields better predictive accuracy than other existing models. The model is then used to investigate the performance of a modified DCF that uses a fixed number of sequential retransmissions to improve the reliability of packet delivery. We find that with sequential retransmissions, the PDR improves at low vehicle density (i.e. low traffic load), but degrades at heavy loads where higher collisions induced by the retransmissions outweighs the benefit of repeated attempts.

III. AN ADAPTIVE SLOT RESERVATION FRAME FOR EFFICIENT CONTENTION ACCESS IN VEMAC-VANET

The protocol reduces transmission collisions due to node mobility on the control channel by assigning disjoint sets of time slots to vehicles moving in opposite directions and to road side units.

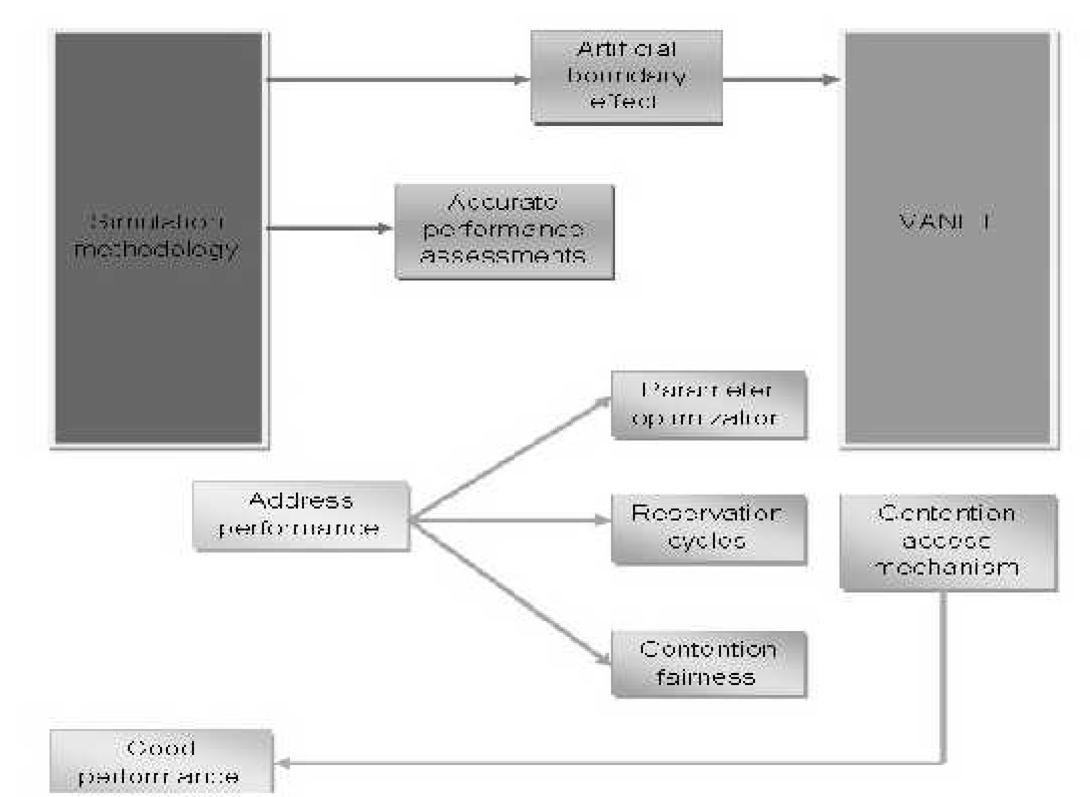

Fig.1Architecture Diagram of An Adaptive Reservation Frame for Efficient Contention Access in VeMAC-VANET

Analysis and simulation results in highway and city scenarios are presented to evaluate the performance of VeMAC and compare it with ADHOC MAC, an existing TDMA MAC protocol for VANETs. It is shown that, due to its ability to decrease the rate of transmission collisions, the VeMAC protocol can provide significantly higher throughput on the control channel than ADHOC MAC.

FPRP is proposed, in which nodes are allowed to contend for more than one slot in a reservation frame according to a certain probability/priority. Simulation results indicate that the proposed mechanism performs better than FPRP in time slot utilization and hence the network throughput under various scenarios.

Analysis and simulation results in highway and city scenarios are presented to evaluate the performance of VeMAC and compare it with ADHOC MAC, an existing TDMA MAC protocol for VANETs. It is shown that, due to its ability to decrease the rate of transmission collisions, the VeMAC protocol can provide significantly higher throughput on the control channel than ADHOC MAC.

FPRP is proposed, in which nodes are allowed to contend for more than one slot in a reservation frame according to a certain probability/priority. Simulation results indicate that the proposed mechanism performs better than FPRP in time slot utilization and hence the network throughput under various scenarios.

- Contention Access for VeMAC-VANET
- Adaptive Slot Reservation Frame
- Bayes Timeslot Probability
- VeMAC VANET Model
- Accessing Slots on Control and Service Channel
- Multi-hop Broadcast Services

A. Contention Access for VeMAC-VANET

Contention Mechanism, because nodes are allowed to contend for two slots, a node that has reserved a slot will continue to contend at the next slot with a reasonable probability until it gets two slots. Therefore, it will still update the number of contending nodes by detecting if there is an "idle," "success," or "collision" event. Clearly, the estimated number of contention nodes in the next slot will be different from that in FPRP due to the influence of second-round contention nodes. In what follows, we will first present the new contention algorithm in I-FPRP and then describe its reasonableness.

The Multi-hop pseudo-Bayesian algorithm used in FPRP is modified from the (single-hop) pseudo-Bayesian broadcast algorithm. The original pseudo-Bayesian algorithm only performs well in single-hop ALOHA networks, whereas the multi-hop pseudo-Bayesian extends itself to multi-hop networks to obtain efficient estimation on
the number of contention nodes within two hops. Following a similar procedure, we will first analyze the improved mechanism in single-hop networks and further extend it to multi-hop networks.

Each node has two transceivers: transceiver1 is always tuned to the cch, while transceiver2 can be tuned to any of the M schs. For a certain node x, the sch to which transceiver2 is currently tuned is denoted by sch(x). It is assumed that the transmission power levels on the cch and schs are fixed and known to all nodes. All channels are symmetric, in the sense that node x is in the communication range of node y if and only if node y is in the communication range of node x.

For a certain node x, the following two sets are defined:

1. Ncch(x): the set of one hop neighbors of node x on the cch, from/to which node x can receive/transmit packets on the cch;
2. Nm(x): the set of 'expected' one hop neighbors of node x on schm, m = 1; : : : ; M.

B. Adaptive Slot Reservation Frame

An RS is composed of *M* RCs, each of which consists of a five-phase dialogue. If a node wants to reserve an IS, it contends in the RS. A slot is reserved in the RF and used in each IF until the next RF arrives to initiate the next round of reservation. In FPRP, a node that wants to make a reservation will first send a reservation request (RR) packet with probability *p* to its neighbors.

Two types of packets are used in the packing packet (PP) is sent by the nodes two hops away from the reservation node to inform nodes that are three hops away, and the elimination packet (EP) is sent with a probability of 0.5 to resolve a non isolated deadlock (when there are two transmission nodes within one hop, and they cannot detect each other until one EP is received from one to the other). Further, nodes can always detect that they receive zero, one (success), or more (collision) packets, so they are aware of the success or failure events in each phase of FPRP.

Time is partitioned to frames. A frame consists of a fixed number S of constant-duration time slots. Each frame is partitioned into three sets of time slots: L, R, and F. The F set is associated with RSUs, while the L and R sets are associated with nodes moving in left and right directions respectively. Every node (i.e. vehicle or RSU) is equipped with a GPS receiver. Each vehicle can determine its direction using GPS, and synchronization among nodes can be performed using the 1PPS signal provided by any GPS receiver. The rising edge of this 1PPS is aligned with the start of every GPS second with accuracy within 100ns even for inexpensive GPS receivers. Consequently, this accurate 1PPS signal can be used as a common time reference among all nodes.

Each second contains an integer number of frames. Hence, at any instant, each node can determine whether the current time slot belongs to the L, R, or F set. The VANET has one control channel (cch), and M service channels (schs), denoted by sch1; sch2; : : : ; schM. The cch is mainly used for transmission of two kinds of information: high priority short applications (such as periodic or event driven safety messages), and control information required for the nodes to determine which time slots they should access on the cch and schs. The M schs are used for transmission of safety or non-safety related application messages.

C. Bayes Timeslot Probability

The pseudo-Bayesian algorithm assumes that the number of contention nodes during a slot can be approximated by a Poisson distribution with mean v. Moreover, each node keeps v as the best estimation for the number of contention nodes and broadcasts with probability $p=1/v$. To improve time slot utilization, we propose animproved contention mechanism for FPRP to allow the nodes to acquire two slots. The new mechanism keeps estimation about the number of nodes (within two hops) that contend for the second slot. Since every node can hear any successful reservation within two hops, nodes can know the number of slots reserved by other nodes within two hops.

Bayesian Algorithm:

1. A modified pseudo-Bayesian algorithm is chosen to compute the contention probability p in the RR phase.

2. In a multi-hop pseudo-Bayesian algorithm, a node needs to keep two estimated values: one is the number of nodes n_c that contend within two hops; the other is the number of nodes n_b within two hops that need reservations but cannot contend in the current slot due to a nearby successful reservation.
3. Some heuristic constants are used to capture the effect of a reservation success on the behavior of the nearby contenders.
4. Specifically, for nodes that are one hop away from the success node, a portion (R_1) of its neighboring contenders ceases to contend in the current slot.
5. Similarly, for nodes that are two and three hops away from the success node, this portion is R_2 and R_3, respectively.

D. VEMAC VANET MODEL

VANET consists is set of RSUs and set of vehicles moving in opposite directions on two-way vehicle traffic roads. If two vehicles are moving in opposite directions on a two-way road guaranteed that one vehicle is moving in a left direction, while the other vehicle is moving in a right one. VANET has one control channel and M service channels is used for transmission of two kinds of information and high priority short applications (such as periodic or event driven safety messages). Control information required for nodes to determine which time slots they should access on channel. Service channels are used for transmission of safety or non-safety related application messages.

Service provider is a node announces on channel for service offered on a specific service channel. User is a node receives the announcement for a service decides to make use of this service. Each node has two transceivers; transceiver1 is tuned to channel c. Transceiver2 is tuned to any service channel c. Transmission power levels on all channels are fixed and known to all nodes. All channels are symmetric node x and node y in the communication range between themselves. Each node is identified by a MAC address and a short identifier. ID is chosen by each node at random included in the header of each packet transmitted on channel.

Each node transmits a packet during its time slot even if the node has no data to include in high priority short applications field. Information in the header, AnS and AcSfields, is necessary for other nodes to decide which time slots they can access on the control channel and service channels. Two types of transmission collision on time slots on the channel are access collision is happen when two or more nodes within two hops of each other attempt to acquire same available time slot. Merging collision happens when two or more nodes acquiring same time slot become members of the same two-hop set (THS) due to node activation or node mobility.

In VANETs merging collisions happen among vehicles moving in same direction due to acceleration or deceleration, more likely to occur among vehicles moving in opposite directions or between a vehicle and a stationary RSU.

Let K denote the number of contending nodes, each of which needs to acquire a time slot on channel c0. We want to determine the average number of nodes which acquire a time slot within n frames, the probability that a specific node acquires a time slot within n frames, and the probability that all the nodes acquire a time slot within n frames. To simplify the analysis, the following assumptions are made:

1. All the contending nodes belong to the same set of THSs, with the same T0 and A sets, e.g. node w and node x in its final position.
2. The set of THSs to which the contending nodes belong does not change.
3. The set A is not augmented when a node fails to acquire a time slot after τ frames.
4. At the end of each frame, each node is aware of all acquired time slots during the frame, and updates the sets T0 and A accordingly, i.e. all nodes are within the communication range of each other.
5. At the end of each frame, all contending nodes are informed whether or not their attempts to access a time slot during this frame were successful. Based on this information, each colliding node randomly chooses an available time slot from the updated a set, and attempts to access this slot during the coming frame.

The delay that a high priority safety packet experiences on channel c0 depends on the value of s 0 as well as the duration of a time slot. Considering a maximum VeMAC packet size of 450 byte and a transmission rate of 12 Mbps, the packet requires a transmission time of 0.3ms. By adding guard periods and taking account of the physical layer overhead, such as the preamble and the physical layer header, a 0.35ms slot duration can be assumed. In terms of synchronization, this slot duration is suitable as it is much larger than the jitter of the 1PPS of GPS receivers which is usually in the order of nanoseconds.

E. ACCESSING SLOTS ON CONTROL AND SERVICECHANNEL

Access time slot assignment on channel in the header of each packet transmitted. Transmitting node includes set N(y) and time slot used by each node. Short IDs in set N(y) serve to decrease the overhead compared to including MAC address of each one-hop neighbor in the header of each transmitted packet.

Suppose node is just powered on and needs to acquire a time slot, starts listening to channel successive time slots. At the end of the slots node x can determine N(x) and the time slot used by each node. Since each node announces N (i) and time slot used by each node x determine the time slot used by each of its two-hop neighbors.

Consider node x has a MAC layer service data unit (MSDU) to be delivered to a certain destination on service channel. Service refers to the delivery of an MSDU on a certain service channel.

Node x announces information in the AnS field of its next packet transmitted on channel,

1. Reliability of service (i.e. acknowledged or not),
2. MAC address of intended destination y
3. Number of service channel
4. Priority of service

Once the provider announces for the serviceno further action is needed unless destination accepts service.

The assignment of time slots to nodes on the schs is performed by the providers in a centralized way. For the slot assignment without a hidden terminal problem, each node x should determine Um(x) defined as the set of time slots used on schm by all nodes which are expected to be within the two-hop neighborhood of node x on schm. This set represents the time slots that node x cannot use on schm, and will be used by the provider to assign time slots to nodes without causing any hidden terminal problem.When node x receives a packet on the cch from another node y indicating that sch(y) = m, if y2 Nm(x), node x adds to Um(x) the time slots used by each node j2 Nm(y); otherwise, node x does not update Um(x).

When a provider (R) has a service to offer on ansch, it announces the following information in the AnS field of the next packet transmitted on the cch: priority of the service, address (es) of the intended user(s), provider's main slot, and the sch on which the service will be offered. Based on the information announced by provider R on the cch, each node x2 Ncch(R) determines whether or not to make use of the announced service.

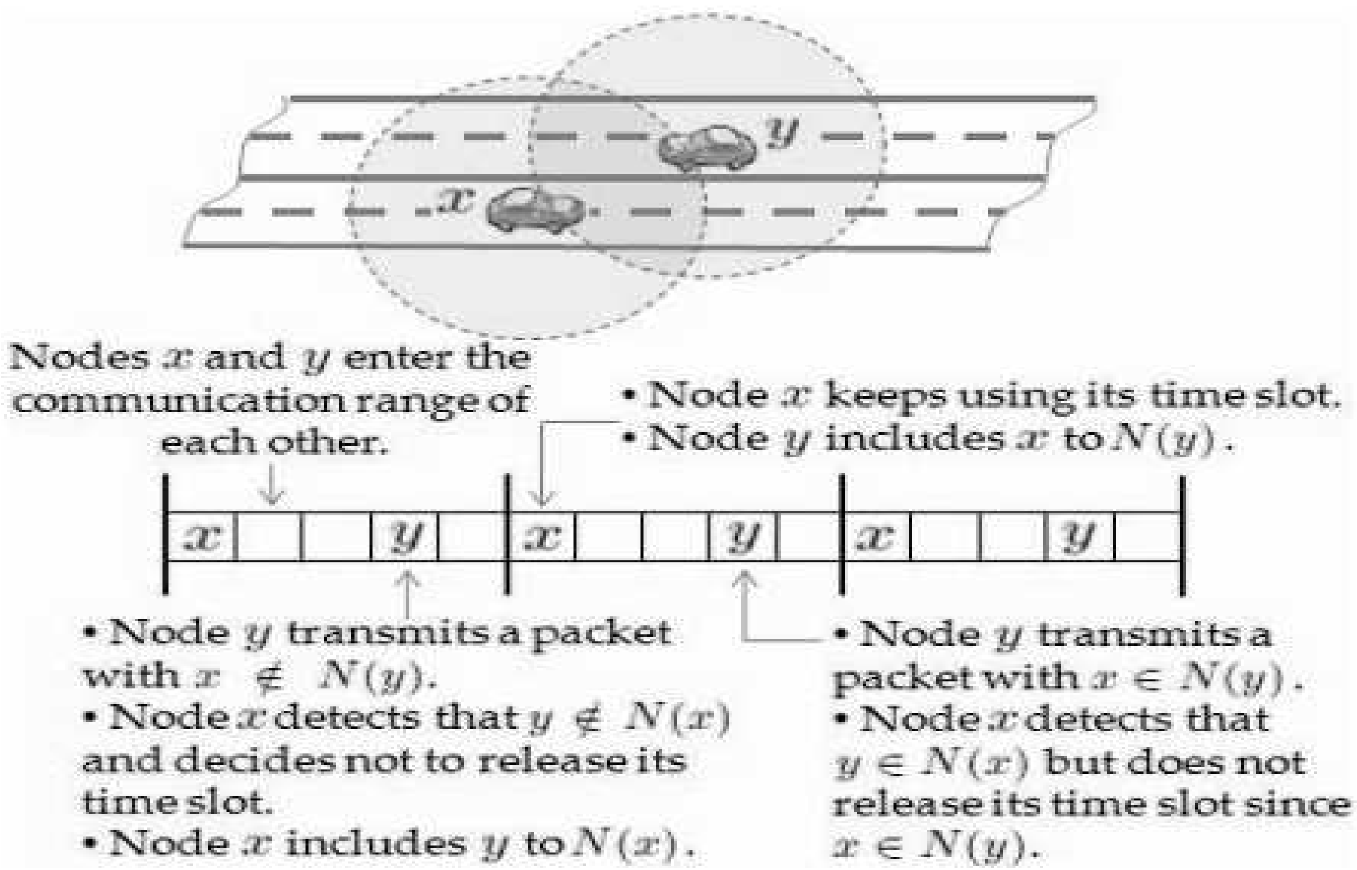

Fig.2 Slot Release Prevention Condition---Prevent Node x Unnecessary Time Slot Release

If node x decides to use the service by provider R on schm, it transmits the following information in the ACS field of the next packet transmitted on the cch: Um(x), address of provider R, and the number of time slots that node x needs. Once node x indicates its acceptance of the service, it tunes transceiver2 to schm and waits for the time slot assignment transmitted on the provider's main slot.

F. MULTI-HOP BROADCAST SERVICES

Efficient multi-hop broad- cast service presented for ADHOC MAC directly supported by VeMAC on channel. Node x transmits a broadcast packet on channel c; this packet needs to propagate throughout whole network. For each node which receives the broadcast packet as the set of one-hop neighbors of node i which did not receive the packet broadcast by node x.

Suppose node x is just powered on and needs to acquire a time slot on the cch. Node x starts listening to the cch for one complete frame. At the end of this frame, node x can determine Ncch(x) and the time slot used by each node i 2 Ncch(x). In addition, since each i 2 Ncch(x) announces Ncch(i) and the time slot used by each j 2 Ncch(i), node x can determine the time slot used by each of its two hop neighbors, j 2 Ncch(i); j =2 Ncch(x), 8i 2 Ncch(x). Hence, by listening to one complete frame, node x can determine the set of time slots used by all nodes within its two-hop neighborhood, denoted by Ucch(x). This set represents the time slots that node x cannot use on the cch, in order to avoid any hidden terminal problem. Given Ucch(x), node x determines the set of accessible time slots Vcch(x) (to be discussed) and then attempts to acquire a time slot by randomly accessing any time slot in Vcch(x), say time slot k. If no other node in the two-hop neighborhood of node x attempts to acquire time slot k, then no access collision happens. In this case, the attempt of node x is successful and all nodes i 2 Ncch(x) add node x to the sets Ncch(i) and record that node x is using time slot k.

When node I receives the broadcast packet from node x listens to channel for successive time slots. At the end of this duration node I determine the sets N (j). Node i relays the packet if none of the previous three conditions is satisfied. By using this relaying procedure in most cases minimum set of relaying nodes needed to cover the whole network is selected.

IV. PERFORMANCE RESULTS AND DISCUSSION

The performances of FPRP and the proposed I-FPRP are simulated and compared. A new simulation methodology is adopted to eliminate the artificial “boundary effect” that occurs in simulations of finite-sized networks.

The performance of the protocols will be investigated from various aspects by changing the network parameters and protocol parameters. The performance measurement metrics are listed below,

- ✓ Protocol Overhead
- ✓ Packet Delay
- ✓ Gain Factor
- ✓ Reservation Cycles
- ✓ Number of nodes

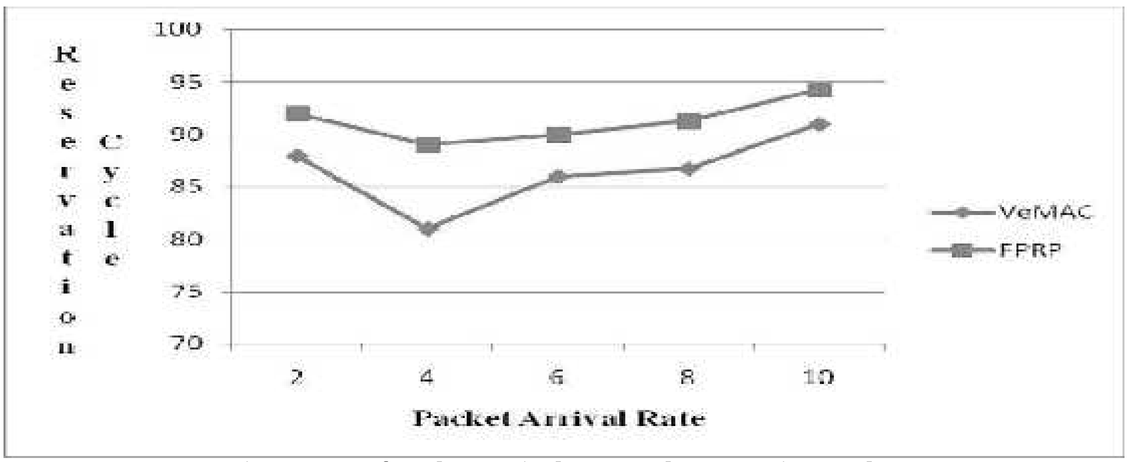

Fig.3 FPRP of Packet Arrival Rate and Reservation Cycle

Fig.3 shows I-FPRP adds extra reserved cycles in the remaining slots. Because nodes can contend for the second slot, with the increase of R_4, the reservation cycleswill increase as a logarithm function. Although extra reserved cycles do not lead to increased time delay because the RF frame includes a constant RC number in each slot, they do result in more power consumption.

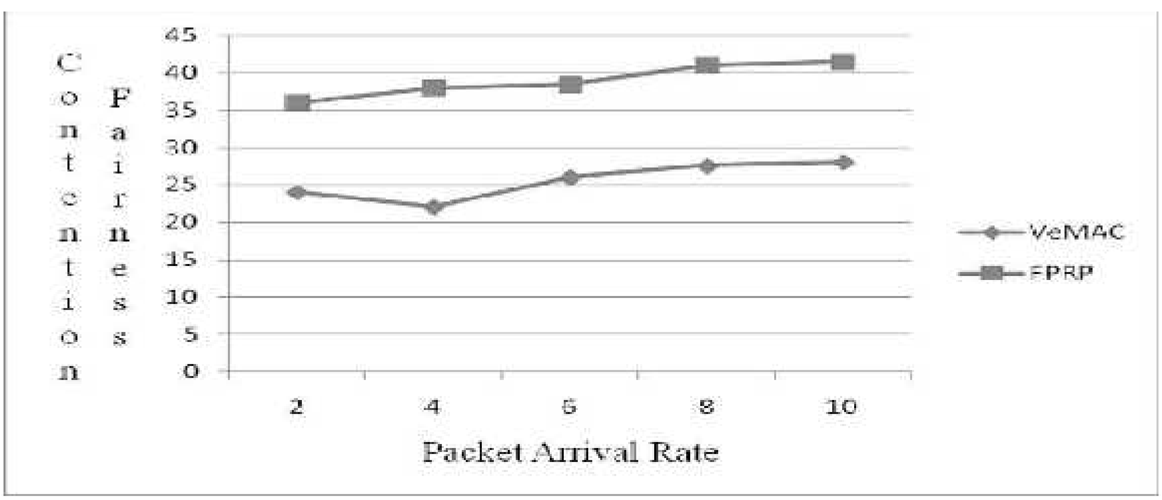

Fig.4 FPRP of Packet Arrival Rate and Contention Fairness

Fig.4 indicates that the failure ratio increases when either the traffic load, second contention probability R_4, or transmission range R increases.

V. CONCLUSION

The contention-based reservation mechanism in FPRP and showed that slots are not fully utilized because nodes can only contend for one slot in an information frame. An improved contention access mechanism based on a pseudo-Bayesian broadcast algorithm was subsequently proposed to allow nodes to contend for more slots with certain probabilities related to their traffic demands. Theoretical and simulation results show that the proposed mechanism can significantly improve the overall slot utilization and hence the throughput of MANETs, especially for networks with low spatial node densities. More importantly, such an improvement is achieved with an acceptable increase in the signaling overhead and a marginal and manageable deterioration to the overall user fairness. We conclude that the proposed I-FPRP makes a promising improvement to FPRP for high-throughput applications.

REFERENCES

[1] H.A. Omar, W. Zhuang, Li Li "*VeMAC: A TDMA-based MACProtocol for Reliable Broadcast in VANETs*", Mobile Hoc, 2011,pp. 190-201.

[2] R.Mangharam, R. Rajkumar, M. Hamilton "*Bounded-LatencyAlerts in Vehicular Networks*", University of Pennsylvania, 2007.

[3] J.H. Wen, J.W. Wang "*A recursive solution to an occupancyproblem resulting from TDM radio communication application*",Applied Mathematics and Computation 101(1-3), 1999.

[4] I. Hassan, L. Vu, T. Sakurai "*Performance Analysis of theIEEE 802.11 MAC Protocol for DSRC with and without Retransmissions*", the University of Melbourne, 2010.

[5] L. Kleinrock and F. Tobagi, "*Packet Switching in RadioChannels: Part I – Carrier Sense Multiple-Access Modes and Their Throughput-Delay Characteristics*," IEEE Trans.Communication, vol. 23, no. 12, Dec. 1975, pp. 1400-1416.

[6] IEEE Std 802.11, "*Wireless LAN Medium Access Control(MAC) and Physical Layer (PHY) Specifications*," IEEE, NewYork, 1999.

[7] B. Sharp, E. Grindrod, and D. Camm, "*Hybrid TDMA/CSMAProtocol for Self Managing Packet Radio Networks*," 4th IEEE Int.Conf. Universal Personal Communication, 1995, pp. 929-933.