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Prioritized Markov Chain Model in VANET

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Abstract

The design of robust congestion control mechanism that guarantees reliable and timely dissemination of safety related messages in VANET can be achieved by reducing the transmission rate of beacon messages reactively. Due to reactive congestion control mechanisms, the actions are taken only after the congestion is detected. To cope with this problem, existing proposes four stages based solution in which existing first assign different priorities to messages according to their contents. Secondly, we monitor the nodes' buffers during a predefined interval T. Thirdly, apply a congestion detection mechanism based on a Markov chain to predict congestion in VANETs. Finally, a vehicle adjusts its beacon transmission rate, according to the result obtained from the previous step, to assist the propagation of the emergency messages. This process leads to delivery of the normal message effectively but the high priority message i.e. accidental message delivery gets late. This work introduces phenomena that check the message type to deliver the normal and the high priority message effectively.

Keywords: *Vanet, Markov Chain, Congestion Control*

I. Introduction

VANETs are composed of vehicles equipped with advanced wireless communication devices and self-organized networks built up from moving vehicles. The VANETs tends to operate without any infrastructure or legacy client and server communication. Each vehicle equipped with communication devices will be a node in the VANETs and allow to receive and send other messages through the wireless communication channels. This network will provide wide variety of services such as Intelligent Transportation System (ITS). The safety application is one of the most crucial application in ITS. For example, if a vehicle detects road accident, it will inform other neighboring vehicles about this road accident. The safety messages must to be delivered to each neighboring node with almost no delays. The safety messages can be categorized into two categories; beacon and event-driven messages. Beacon messages end periodically by vehicles to inform their condition such as position, direction and speed to their neighbor vehicles [1].

II. Wireless Ad Hoc Network Congestion

Wireless ad hoc network is a decentralized wireless network. The wireless ad hoc network does not rely on a pre-existing infrastructure, such as routers in wired networks or access points in managed wireless networks. Instead, each node participates in routing by forwarding data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity. Every node in wireless ad hoc network can become aware of the presence of other nodes within its range. The wireless ad hoc networks can be further classified by their application such as Mobile Ad Hoc Networks (MANET), Wireless Mesh Networks (WMN), Wireless Sensor Networks (WSN) and Vehicular Networks (VANETs) [2]. Wireless ad hoc is prone to network congestion due to the mobility of nodes, synchronization difficulties in self-coordination, and the limited capacity of the wireless channels [3,4]. Therefore, node in wireless ad hoc may experience low throughput and long latency under the circumstance of network congestion. One of the important aspects in wireless ad hoc networks is to maintain the efficiency network operation while preventing degradation of wireless channels communication [5,6]. They were proposed the congestion control algorithm as solution. The major goal of congestion control mechanism is simply to use the network as efficiently as possible by attaining the highest possible throughput while maintaining a low loss ratio and small delay [7].Vehicular networks are one of the most important technologies in this field. VANETs (Vehicular Ad hoc Networks) can be defined as an Ad hoc-type network without a predefined infrastructure where different types of vehicles, equipped with a number of specified equipment on board, can communicate and exchange information related to their positions, speeds, etc., and if any problem occurs (e.g., accident), vehicles that are on the same road will be informed well before they arrives on its location. The purpose of existing proposal is to design a robust congestion control mechanism that guarantees reliable and timely dissemination of safety related messages. Currently, most of the existing works propose to reduce the transmission rate of beacon messages reactively. Because of their nature, reactive congestion control mechanisms take actions only after the congestion is detected. To cope with this problem, existing proposes four stages based solution in which existing first assign different priorities to messages according to their contents. Secondly, we monitor the nodes' buffers during a predefined interval T. Thirdly, apply a congestion detection mechanism based on a Markov chain to predict congestion in VANETs. Finally, a vehicle adjusts its beacon transmission rate, according to the result obtained from the previous step, to assist the propagation of the emergency messages [41]. Congestion control methods for VANETs could be classified according to several criteria. The main classification criterion is how a congestion control mechanism takes decisions to adjust the transmission parameters (e.g. rate adaptation, power adjustment). The first class, called reactive congestion control, uses first-order information about the channel congestion status to decide whether and how an action should be undertaken. Reactive congestion control approaches can be defined as an instance of *feedback* control mechanisms. Due to their nature, decision actions to control the congestion are undertaken only after a congested situation is detected. The second class, called proactive congestion control uses models which, based on information such as number of nodes in the neighborhood and data generation patterns, estimate the transmission parameters that do not lead to congestion conditions, meanwhile providing the desired application-level performance. In particular, such mechanisms use models to estimate the channel load under a given set of transmission parameters. Using control theory terminology, proactive congestion control approaches can be defined as an instance of *feedforward* control mechanisms. The third class, called hybrid congestion control mechanisms, combines the two previous classes to control the congestion (e.g., by adapting the messages rate reactively and the transmission power proactively). Existing solutions can further be classified with reference to the means through which congestion is controlled, which is typically achieved by adjusting the transmission power, the packet generation rate, the carrier sense threshold or a combination of a subset of the transmission parameters. Given their capacity to prevent congestion, proactive methods are very attractive for vehicular environments, where radio communications are mainly used for safety applications, whose performances would be seriously menaced by congested channel conditions. However, proactive approaches come with two major disadvantages. First, in order to estimate the expected load generated by neighboring vehicles, such approaches need a communication model that maps individual transmission power levels to deterministic carrier sense ranges. However, this mapping is reasonable only as long as it reflects the average propagation conditions of the wireless channel. Thus, propagation conditions should be either dynamically estimated as the vehicle moves, which is very difficult to do in a practical scenario, or they should be statistically estimated to build specific profiles for different environments, e.g., urban and highway. The second disadvantage is the need to carefully estimate the quantity of generated application-layer traffic in a certain period of time. Although in some cases this is certainly possible (e.g., in the case of applications built on top of periodic beacon exchange), accurate application-layer traffic estimation is a challenging task in general.Even reactive methods do not suffer of the previous shortcomings; they have the significant disadvantage of undertaking control actions only after a congestion condition is detected. Considering that some time is needed to recover from a congested condition, this means that reactive approaches expose safety-related applications to the risk of not being able to perform their design objective, due to the poor performance of the underlying radio channel. Another drawback of reactive approaches is that some important design objectives, such as packet prioritization and fairness, are more difficult to implement than in a proactive approach.

III. Markov Chain Model

The network is further assumed to operate under acknowledged, unsaturated traffic conditions. The system is fully described by three stochastic processes, namely, the backoff stage at time t (s(t)), the state of the backoff counter at time t (c(t)), and the state of the retransmission counter at time t (r(t)). For the Markov chain to be applicable, it is assumed that nodes start sensing the medium independently. With these assumptions in mind, a 3-dimentional Markov chain results. It can be described by the tuple (s(t), c(t), r(t)). Assuming the stationary distribution of the Markov chain to be

$b_{i,k,j} = \log_{t\to\infty} P(s(t) = i, c(t) = k, r(t) = j,$

where , i∊(-2,m) $k \in (-1, \max(W_i - 1, L_s - 1, L_c - 1))$ and j∊ (0,n), a closed form formulae can be derived for this distribution chain. These derivations are tedious and the interested reader is referred to [42] for full derivations. It is worth mentioning that to reduce the complexity of the resulting formulae, Park applied some approximations such that the final mathematical system becomes implementable on sensor nodes. Now list the approximated formulae of Park's model that are of interest to us, and then we explain their significance: where, The parameters L_s, L_{ACK} andL_s are the duration of successful transmission, the ACK packet, and the duration of packet collision, respectively. Furthermore, W_0 is the smallest backoff window defined in the standard to be$2^{macMinBE}$, m is set to *macMaxCSMABackoffs* and n is set to *macMaxFrameRetrie*. Finally, the probabilities α, β and P_C represent the probability of finding $CCA1^1$ busy, the probability of finding CCA2 busy, and the probability of collision, respectively [9].

$\sum_{i=0}^{m}\sum_{k=0}^{w_i-1}\sum_{j=0}^{n} b_{i,k,j} + \sum_{i=0}^{m}\sum_{j=0}^{m} b_{i,-1,j} +$
j=0nk=0Ls−1b−1,k,j+k=0Lc−1b−2,k,j+l=0L0 −1Ql=1

(1)

$\sum_{i=0}^{m}\sum_{k=0}^{w_i-1}\sum_{j=0}^{n} b_{i,k,j} \approx \frac{b_{0,0,0}}{2}[(1+2x)W_0 + 1 +$ *x(1+y)* (2)

$\sum_{i=0}^{m}\sum_{k=0}^{w_i-1}\sum_{j=0}^{n} b_{i,k,j} \approx b_{0,0,0}(1-\alpha)(1+x)(1+y)$ (3)

$\sum_{j=0}^{n}\left(\sum_{k=0}^{L_s-1} b_{-1,k,j} + \sum_{k=0}^{L_c-1} b_{-2,k,j}\right) \approx b_{0,0,0}L_s(1-$ *xm+1(1+y)* (4)

$\sum_{l=0}^{L_0-1} Q_l \approx b_{0,0,0}\frac{1-\lambda}{\lambda}L_0[1 + y + P_c(1 - x^{m+1})(y^n - y - 1)]$ (5)

$\tau \approx (1+x)(1+y)b_{0,0,0}$ (6)

Where

$x = \alpha + (1-\alpha)\beta$ (7)

$y = P_c(1 - x^{m+1})$ (8)

$\alpha = LP_c(1-\alpha)(1-\beta) + L_{ack}\frac{N\tau(1-\tau)^{N-1}}{1-(1-\tau)^N}P_c(1-$ *α(1−β)* (9)

$\beta = \frac{P_c + N\tau(1-\tau)^{N-1}}{2-(1-\tau)^N + N\tau(1-\tau)^{N-1}}$ (10)

$P_c = 1 - (1-\tau)^{N-1}$ (11)

The state Q is the idle state during which no packets are available for transmission. This state is modeled as $Q_i(where\ i = 0,1, \dots \dots L_0 - 1$ to show that it has a duration specified by L_0. Q_i models the unsaturated traffic condition. Equation (1) is the normalization condition. The first term in this equation represents the probability of being in a backoff state. The second term refers to the probability of initiating CCA2. The third and fourth terms refer to the packet transmission state and packet collision state, respectively. Finally, the fifth term refers to the probability of being in the idle state when no packets are available. Equations (2)-(5) provide the mathematical expressions for all of these terms. Equations (2)-(5) can be directly used to find an expression for $b_{0,0,0}$.[8]

IV. Modified Markov Chain Model

This work introduces phenomena that check the message type to deliver the normal and the high priority message effectively. In this work the normal message is transferred using existing technique while the high priority message is delivered immediately. The working steps can be understood by the flowchart of figure 1.

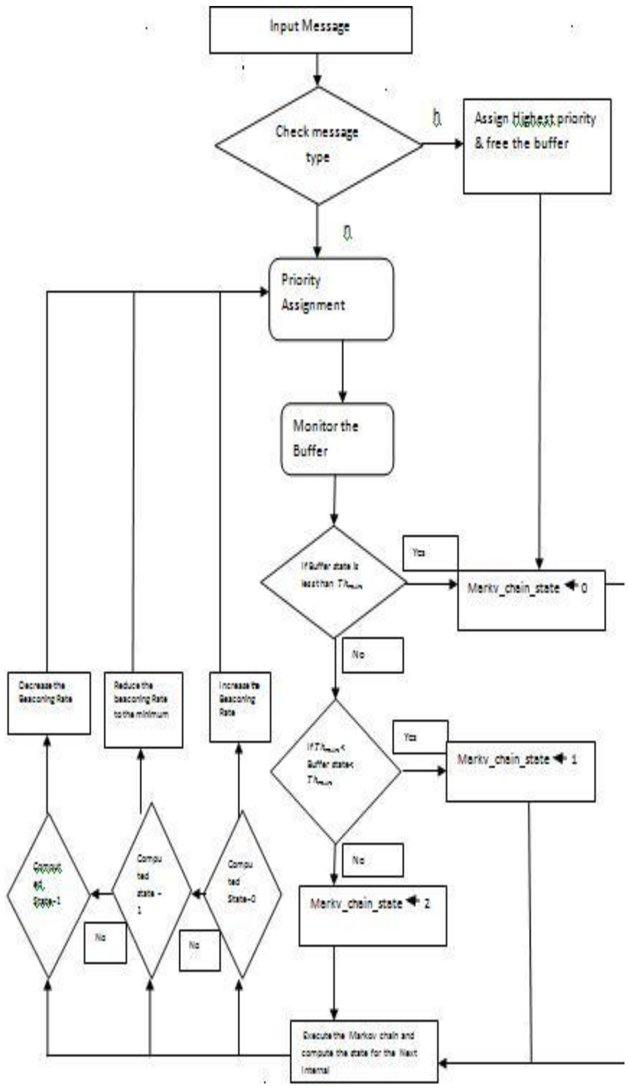

Figure 1: Modified Markov Chain Model

The work is implemented using the NS2. The figure 2 shows the network animation file generated by executing the TCL file. The NAM file is shown at the starting of the simulation time. The small circles show the nodes and the large circle shows the broadcasting. While the small lines show the packet transmission.

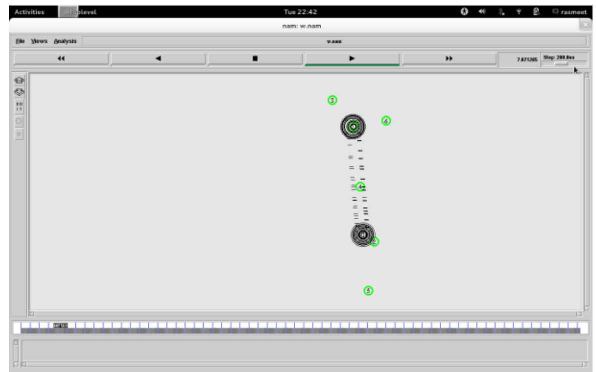

Figure 2: NAM Results

The PDR(Packet Density Ratio), Loss ratio and the throughput is analyzed. These results are also shown in the table 1, 2, 3. The table shows the better performance of the proposed protocol as compared to the existing protocol.

Table 1: Performance Comparison of PDR between Existing and Proposed

S.No.	Number of nodes	PDR	
		Existing Protocol	Proposed Protocol
1.	7	94.5593	99.7225
2.	17	94.5639	99.2495
3.	27	94.5608	99.4057
4.	37	94.5599	99.1672

The results can also be compared graphically. The fig. 3 to fig. 5 shows the graphical comparison of the results.

The figure 3 shows the comparison of PDR, 4 of loss ratio and the 5 of E2Edelay.

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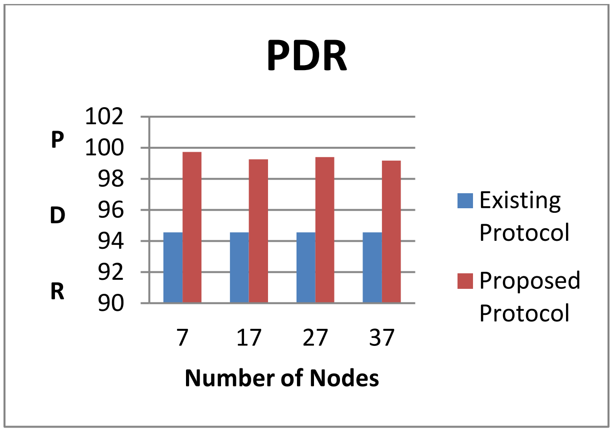

Figure 3: Comparison of PDR between Existing And Proposed

Table 2: Loss Ratio Comparison between Existing And Proposed

S.No.	Number of nodes	Loss Ratio	
		Existing Protocol	Proposed Protocol
1.	7	0.0544059	0.00185185
2.	17	0.0543594	0.00703895
3.	27	0.0543908	0.00561427
4.	37	0.0543996	0.00812162

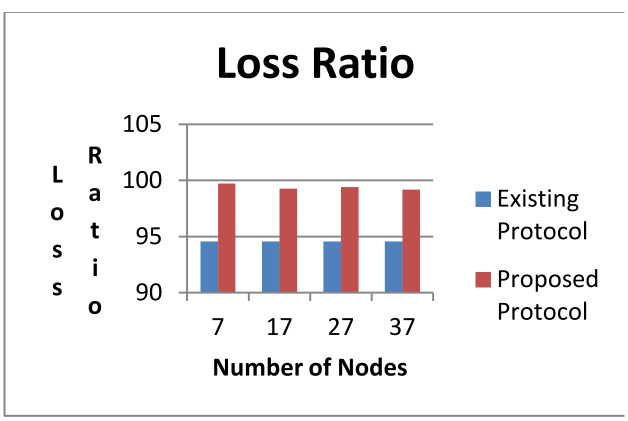

Figure 4: Comparison of Loss Ratio between Existing and Proposed

Table 3: E2E Delay between Existing And Proposed

S.No.	Number of nodes	E2E Delay(ms)	
		Existing Protocol	Proposed Protocol
1.	7	0.15011	0.183289
2.	17	0.15011	0.184089
3.	27	0.15011	0.184089
4.	37	0.15011	0.184089

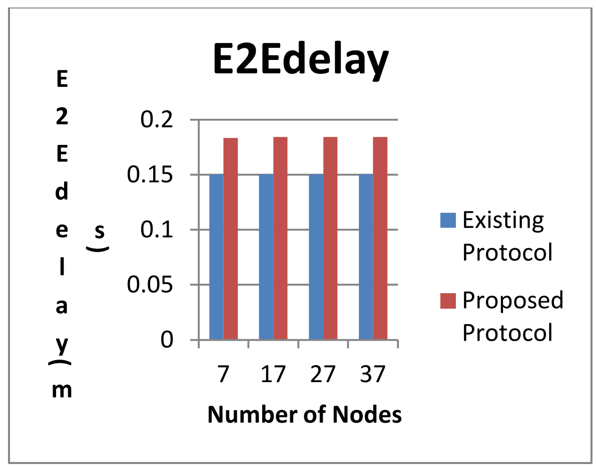

Figure 5: Comparison of E2E Delay between Existing and Proposed

The graphical comparison confirms the better performance of the proposed protocol is better than the existing protocol. The packet delivery ratio is increased and the delay gets reduced and the loss ratio also gets increased. It means overall performance get enhanced.

V. Conclusion

This paper discusses a process that leads to delivery of the normal message effectively but the high priority message i.e. accidental message delivery gets late. This work introduces phenomena that check the message type to deliver the normal and the high priority message effectively. In this work the normal message is transferred using existing technique while the high priority message is delivered immediately. The simulation results show the effectiveness of the technique. The delay gets reduced as well as the loss ratio. This results in enhanced performance. In future, the work can be extended to use the artificial intelligence for adaptive speed vehicle.

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