A Method for Improving Data Delivery Efficiency in Vehicular Adhoc Networks

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Abstract

*As vehicular networks become popular and many vehicles want to access data through a roadside unit. In this paper, there was a vehicle to roadside communication and we propose scheduling schemes for efficient delivery of data packets in vehicular adhoc network. On the basis of priority scheduling algorithm vehicles can download/upload the data from RSU. In this paper we can control the congestion and delay of data by assigning the priorities to the message. The process with highest priority is executed first and highest priority is assign to those processes which have the smallest data size and this scheme is the smallest data size first scheduling(SDF) . If the two processes having the same data size then we can assign the priority on the basis of first come first serve scheduling (FCFS). We can combine these two algorithms and the new algorithm D*A. is introduced. This algorithm is responsible for only sending the commercial messages and the safety messages will be send on the different channel. The emergency messages will be sending through control channel with help of EDF scheduling. This paper increases the efficiency and throughput of the process and decreases the turnaround time for the process.*

Keywords: *road side unit (RSU), priority, FCFS, SDF, algorithm, scheduling, download, upload*

1. Introduction

VANET is an emerging standard for data communication between moving vehicles and fixed equipments. It integrates components of WiFi, Bluetooth and other mobile connectivity protocols to facilitate data transfer between cars and between road side equipment and automobile traffic. The protocol needs of vehicular communication are unique the communication occurs32 in a constantly fluctuating environment. The signal must accommodate multiple signal and traffic densities and work in both urban and rural environments.

Car-to-roadside communication is based on a WLAN (IEEE 802.11p) platform developed especially for vehicles, while IEEE 1609 is a higher layer standard on which IEEE 802.11p is based. IEEE 802.11p is an approved amendment to IEEE 802.11 that adds WAVE. It therefore defines the enhancements to 802.11 required to support Intelligent Transportation Systems (ITS) applications, including data exchange between high-speed vehicles and between those vehicles and the roadside infrastructure in the licensed ITS band of 5.9GHz (5.85 - 5.925GHz). WAVE standards define architecture and a complementary, standardized set of services and interfaces that together enable secure vehicle to- vehicle (V2V) and vehicle-to-infrastructure.

Transportation benefits include greater vehicle safety, better navigation and traffic management, plus automated tolling. Vehicular networks are envision of the intelligent transportation system (ITS) vehicles communicate with each other via inter vehicle communication (IVC) as well as with roadside base station via roadside to vehicle communication (RVC). The optimal goal is that vehicular networks will contribute to safer and more efficient roads in the future by providing timely information to drivers and concerned authorities. Figure shows the Schematic Representation of a Vehicular Adhoc Network. Even though each vehicle can download data from RSU with in their communication range. There are many application of ITS but one of the important application of ITS is the emergency or event driven application.

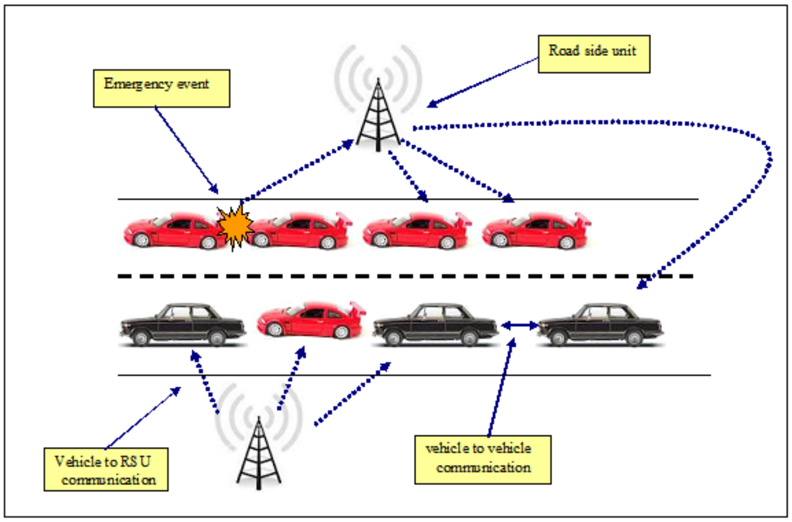

Figure 1. Vehicular Infrastructure Network

First, consider the opportunities. If vehicles can directly communicate with each other and with infrastructure [14], an entirely new paradigm for vehicle safety applications can be created. Even other non-safety applications can greatly enhance road and vehicle efficiency. Second, new challenges are created by high vehicle speeds and highly dynamic operating environments. Third, new requirements, necessitated by new safety of-life applications, include new expectations for high packet delivery rates and low packet latency. Typically this data is self-contained within a single vehicle. With a VANET, the ‘horizon of awareness’ for the vehicle or driver drastically increases. The VANET communication can be either done directly between vehicles as ‘one-hop’ communication, or vehicles can retransmit messages, thereby enabling ‘multi-hop’ communication. To increase coverage or robustness of communication, relays at the roadside can be deployed. Cooperation and path planning blocks fall under guidance. Localization and mapping blocks undertake navigation duties, while the safety and regulation blocks are issues dealt with under control. For safety applications, the navigation blocks determine the quality of the applications by building the knowledge of the vehicle’s own state, the surrounding environment, and the vehicle’s position within this environment. In this paper we discuss about the scheduling schemes. In message scheduling each node will schedule its message according to their priorities in the appropriate channel. There are two channels i.e. control channel (CCH) and the service channel (SCH). Control channel used to transmit the beacon and the emergency message. And the service channel use to transmit the message with medium and low priority. Different scheduling schemes are used to send the data efficiently. EDF is the earliest deadline first scheduling in which we send first the emergency data and then after the beacon data. Medium level of priority data are send with the help of shortest data size first scheduling (SDF). In this the data which have the smallest data size will be sent first. The data with smallest size gives higher priority and if the two messages having the same data size will arrive at the same time then sort it by the FCFS scheduling. In FCFS scheduling the data which request first will be serving first. With the help of scheduling scheme we can reduce the turnaround time of a process and increases the throughput.

And the rest of this paper is organized as follows: Section 2 describes the literature Work. Section 3 describes the data delivery in VANET. Section 4 gives the idea of new scheme that is used in this paper. Performance Evaluation is presented in section 5. Section 6 concludes this paper.

2. Literature Work

The different variety of services are provided by Vehicular Networks, ranges from safety and crash avoidance to Internet access and multimedia applications [8] .There is a lot of work and research is being conducted to study problems related to the vehicular communications. Different problems that can take place is network architecture, protocols for physical and link layers, routing algorithms, as well as security issues.

Vehicle-roadside data access is an important issue for data access in vehicular networks. The authors in [1] illustrated a basic picture of a radio architecture that offers two-way transmission services essential to Intelligent Vehicle Highway Systems (IVHS) using only a single (30 kHz) radio channel. This bandwidth can support the multiple communication services such as data casting, packet switched transmission to and from vehicles, collection of traffic data from probe vehicles and transmission of emergency messages. The emergency message are those message that are generated as a result of a dangerous situation or we can say that, when an abnormal condition is detected such as road accident. The emergency message is disseminated within a certain area with high priority [2]. Emergency and beacon messages will send through one single channel known as Control Channel (CCH). The Federal Communications Commissions (FCC) has allocated the frequency spectrum to Dedicated Short Range Communication (DSRC) in VANETs. The DSRC spectrum is divided into seven (7) 10MHz channels range from 3 to 27 Mbps and it contain the central channel (channel 178) that is the control channel (CCH) which is restricted to emergency communications only. The function of WAVE is to provide safety messages are delivered over a dedicated CCH communication channel, while non safety or commercial messages are delivered over a service channels (SCHs)

In vehicle to roadside communication, information is also available from roadside sources. The frequency range for car to roadside communication uses the 63 GHz band. The high range of frequency with roadside beacon provides a very high bandwidth link. The placement scheme of beacons are every kilometer or less, so that high data rates is maintained in heavy traffic and the different services it can provide on-demand or real-time video and high speed Internet access. The vehicle drivers and passengers are able to receive traffic information, browse the web while on the move; shop another application that takes advantage of vehicle-to-roadside communication technologies is Electronic Toll Collection (ETC) [3]. This is a fairly mature technology that allows for electronic payment of highway tolls. IEEE 802.11 PCF MAC protocol is used for reducing the contention probability and increasing the probability of uploading high-priority data to the RSU. According to the bandwidth requesting, a scheduling algorithm with linear programming scheme [4] is developed in RSU to maximize the bandwidth utilization and uploading ratio of high-priority data. With the help of simulation we can show that the proposed scheme has a good performance in term of bandwidth utilization and success data uploading ratio. Yang Zhang had proposed a basic scheduling scheme called D ∗ S [5] to consider both service deadline and data size when making scheduling decisions. An efficient search space pruning technique is also used to reduce the computation complexity for making the best scheduling decisions. With wireless broadcasting, Zhang proposed a new scheduling scheme called *D ∗ S/N* to serve multiple requests with a single broadcast. Two-Step scheduling scheme is used to provide a balance between serving download and update requests. Simulation results show that the Two-Step scheduling scheme outperforms other scheduling schemes. This is an important issue when multiple vehicles want to access the roadside infrastructure at the same time, how to schedule their service priorities. There are several scheduling algorithms used in the broadcasting environments such as first-come-first serve (FCFS), longest wait time (LWT), most requests first (MRF). In RSU scheduling the energy saving is our main problem. We divide this problem into two sub problems called the snapshot scheduling problem and the snapshot selection problem. [6] The snapshot scheduling problem decides the minimum number of active RSUs needed for a snapshot of the VANET at a given time point, while the snapshot selection problem decides a sequence of time points on which the snapshot must be updated.

Zhao and Zhang propose the data pouring and buffering paradigm to address the data dissemination problem in a VANET [10]. Stationary Access Points (APs) play a key role in route maintenance which can be deployed along the roadside to provide wireless coverage and network access for mobile vehicles. [7] We study reliable routing for Roadside to Vehicle (R2V) communications in rural areas and propose a novel routing protocol where the stationary APs play a key role in route maintenance. The protocol includes a prediction algorithm as well as routing algorithms, the former can predict the lifetimes of wireless links with consideration for terrain effects, and the later algorithm which can find stable paths for packet forwarding based on the prediction**.** Ming-Fong Jhang and Wanjiun Liao propose a new channel for access mechanism called Proxy-based Vehicle to Roadside (PVR) [8] access for IEEE 802.11-based vehicular networks. With the support of PVR, data from each vehicle are aggregated to proxies via multi-hop relaying during the long disconnection period between RSUs. Proxy vehicles can only access the channel within the coverage range of RSU. The set of proxies are organized to emulate non-overlapping transmissions within the coverage of RSU. As a result, PVR also reduces the contention among vehicles within the short period of time in the coverage of RSU.

3. Data Delivery in VANET

Communication in VANET take place over wireless link and VANET contains electronics embedded inside vehicles and installed on RSU. Data communication between the vehicles and RSU may be unidirectional or bidirectional. When the communication takes place then the vehicle/car will choose the nearest RSU to send its data or the request [11]. But if at that time RSU is too busy, the data will get lost and the bandwidth will be wasted. In this paper to overcome the problem of bandwidth wastage we use the scheduling schemes so that at proper time the data will send with delay control. In VANET multi-hop data delivery is complicated as we know that vehicular networks are highly mobile and frequently disconnected. Network density which is related to traffic density is affected by location and time. The traffic density is very high in urban areas during morning and evening when people go and come back from the office. And the traffic density is low in rural areas or during at the night time. Furthermore, a moving vehicle can carry the data and forward [9] it to the RSU. When vehicle communicate with RSU then we assume the request delivery information such as vehicle id, vehicle location, request generation time, RSU location, expiration time etc. A vehicle can detect its position with the help of GPS device which is popular in cars. Each vehicle and RSU will know its present location with the help of GPS. For efficiently deliver the data in VANET, VADD is based on idea of carry and forward [9]. In data delivery we have to take care of many parameters such as data packet size, data delivery ratio, data delivery delay etc.

As the larger packet size consumes the more bandwidth and the data packet with small bandwidth will be delivered efficiently. In scheduling schemes the highest priority is given to the data packet which have the small data size and the algorithm which work on this principle is the shortest data size first scheduling (SDF). Data delivery ratio is defined as the function of the data sending rate (DSR) per second. Data delivery ratio is poor when the vehicle density is low and when vehicle density is high then the data delivery ratio is high.

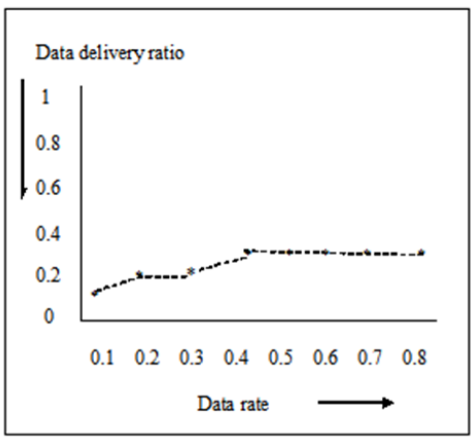

Figure 2. Plot of Data Delivery Ratio versus Data Rate

4. Proposed Scheme

4.1 System Model

As shown in the Figure 3 when the vehicles are in the communication range of RSU then they can upload the data from RSU. The RSU maintain the non-preemptive service cycle. In non-preemptive scheduling one service can not be interrupted until it finishes. The communication takes place with the help of wireless channel. If the vehicles want to access the data from RSU then the vehicle can send the request to RSU. Each request consists of three tuple: <v-no., d-id, opr> where v-no. is the number of the vehicle, d-id is the identifier of the requested data item and opr is the operation that vehicle can do i.e. upload or download. Based on the scheduling algorithm the RSU serves one request and remove it from the queue. The figure shows the architecture of vehicle roadside service scheduling.

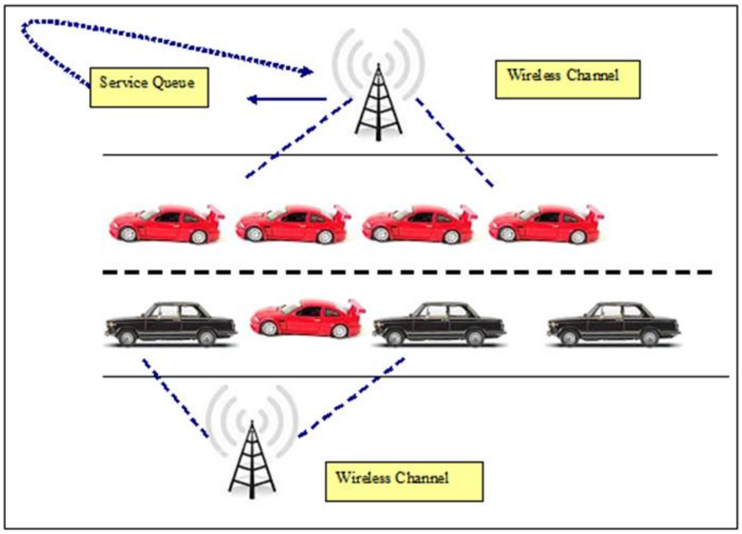

Figure 3. Architecture of Vehicle Roadside Service Scheduling

4.2 Message Prioritization

Message Prioritization means according to the priority the messages which are very urgent will be transmitted first and rest of the less urgent message will send later by contention for channel access. In the figure W is the small contention window. In order to calculate the message priority P, we divide our message into three levels of priorities i.e. PRI_{emg}, PRI_{high} and PRI_{mid} messages.

We calculate the Priority Index (PI) as

$$PI = \alpha e^{(-0.05*d)}$$

where α is the priority coefficient which represents how quickly the message priority dropped and the value of α are set to 13, 6 and 2 for emergency message, beacon message and commercial message. And d is the dissemination distance which is the distance between events and receiver's location. PI is exponential function of d. As the value of d is increasing the value of PI of all messages is dropping as shown in the Figure 5.

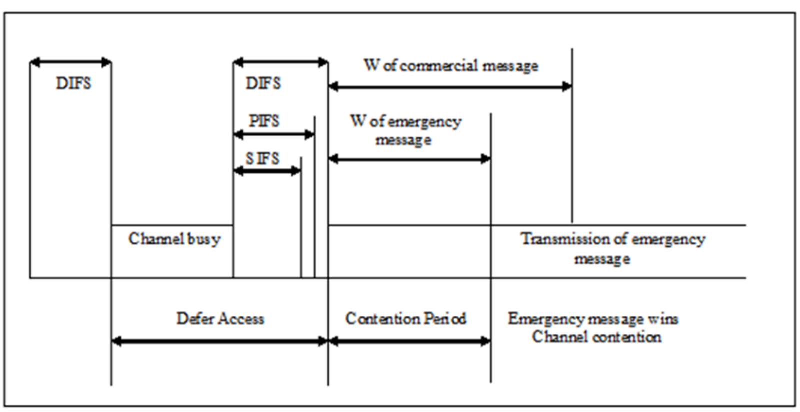

Figure 4. Contention Mechanism

The table 1 shows that if P = emg; the highest message priority is assigned to message if their indexes are greater than 6. If P=high is assigned to messages whose index is between 6 and 2 and P=mid to those messages which have indexes lower than 2.

Table 1. Assignment of Message Priority (P)

Message Priority (P)	Priority Index (PI)
Emg	PI>=6
High	6>PI>=2
Mid	PI<2

If the message is broadcasted with in the first 20 km then the message will have the highest priority (P=emg) and further from that point the priority will be decreased (P=high). When its distance is greater than 50 km then the message will assigned the lowest priority (P=mid). As we have define the three level of priority. In table 2 shows the three level of priority their message type and the example of this message prioritization.

Table 2. Default message priority

Priority	Type	Example
PRI_{emg}	Emergency message	Road Accident
PRI_{high}	Beacon message	Vehicle position, direction and speed
PRI_{mid}	Commercial message	Traffic congestion, weather conditioning Best path, hotels, pumps, road condition etc.

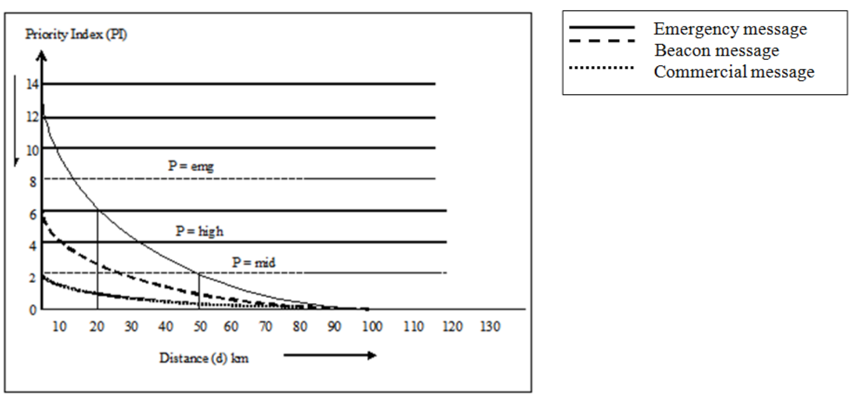

Figure 5. Characteristic of Piority Index (PI) and Message Priority (P)

4.3 Congestion Control Approach

Now, we would describe the channel coordination function [15], which is done mainly according to the MAC layer synchronizing operation. Based on the synchronization operation, packets could be sent from MAC layer into wireless channel. Shown in Figure 6 is the sync interval, it contains CCH interval and SCH interval components. A buffering time interval, called Guard Interval, is used to synchronize various devices (for example, synchronization of their time). For WAVE devices, Coordinated Universal Time (UTC) is used as the reference time. All WAVE devices shall monitor the CCH during the CCH interval. After assigning the priority to the messages now these messages are transmitted over the control channel (CCH) and the service channel (SCH). Control channel used to transmit the beacon and the emergency message [13]. And the service channel use to transmit the message with medium and low priority. Safety messages are transmitted over the control channel. Beacon message is that which is preventive in nature, means to avoid the occurrence of dangerous situation. Beacon message consist of information about the vehicle speed, position and direction. And emergency message is that when a dangerous situation is detected such as road accident.

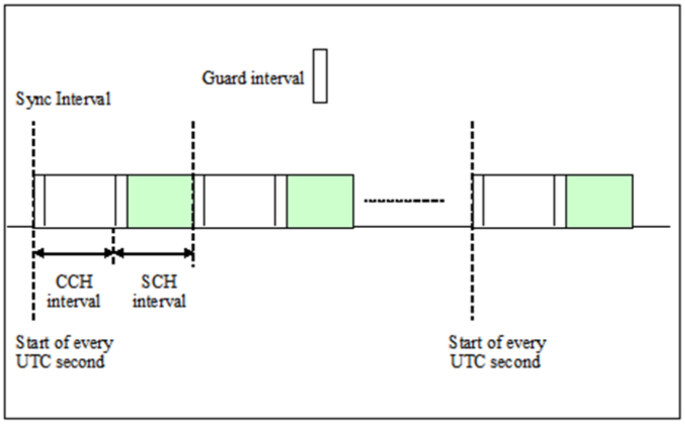

Figure 6. Sync Interval, Guard Interval, CCH Interval, SCH Interval [15]

At large traffic density area, there is a congestion of message which results in delay of the emergency message. Beacon and emergency message are send over the same channel i.e. control channel and if the control channel is congested with the packet queue of beacon message which will exceed the defined threshold value then we discard the control channel for beacon message . We will freeze all the data in queue except for the event driven emergency message. The event driven emergency message is based on the earliest deadline first (EDF) scheduling scheme. The pseudo code to send only emergency message is given and with the help of this code we can control the congestion in the channel.

4.4 Roadside Unit Scheduling Schemes

Three naive schemes for roadside unit scheduling are as follows:

1. Earliest Deadline First (EDF). In this scheme, the request which is most urgent will be served first.

2. Smallest Data Size First (SDF). In this scheme, the data with a small size will be served first.

3. First Come First Serve (FCFS). In this scheme, the request with the earliest arrival time will be served first.

4.4.1 Pseudo Code to Send Only Emergency Message: If (any emergency event is generated in a range) and (emergency event is detected)

{

Freeze all message in queue except for the emergency message

}

Else

```
{
If (packet queue > threshold value) {
Discard CCH channel for beacon safety messages
}
Else
{
If (event message detected>1)
{
Reject all messages in queue except for the emergency event message queue based on EDF scheduling
}
}
}
```

After sending the emergency message in the control channel, now we had to send the next higher priority message. The second highest priority is given to the beacon message (PRI_{high}). At this level of priority we will send only the beacon message. If the event driven beacon message is locally generated then we have to freeze all the data in queue except for the event driven beacon message. If the queue consists of commercial message which will exceed the defined threshold value then we discard the service channel for commercial messages and send only the beacon message based on the EDF scheduling scheme. Pseudo code to send only the Beacon message is given below.

4.4.2 Pseudo Code to Send Only Beacon Message: If (any event beacon message is generated in a range) and (event beacon message detected)

```
{
Freeze all message in queue except for the event beacon message
}
Else
{
If (packet queue > threshold value)
{
Discard SCH channel for commercial messages
}
Else
{
If (event beacon message detected>1)
{
```

Reject all messages in queue except for the event beacon message queue based on EDF scheduling

}

}

}

If the vehicle request's is send to the RSU for the commercial message such as Traffic congestion, weather conditioning, Best path, hotels, pumps, road condition, Parking space booking etc then the RSU send the requested data based on the SDF scheduling. SDF scheduling is the shortest data size first scheduling in which the request which have the small data size will be served first and the remaining data is stored in the buffer memory of RSU. If there is single request in RSU then there will be no comparison to be done and the processed data is send to the vehicle. In any case if the two or more request has the same data size then we can use the FCFS scheduling algorithm to send the requested data.

4.4.3 D*A Algorithm (basic algorithm of SDF and FCFS): This algorithm is explained as follows:

Notations:

Vi: the vehicle which sends the data to RSU

Di: the data which is transmitted between vehicle and RSU

T: the desired time period in which the Di will be fetched

Ds: it represents the size of data

Dp: it represents the processed data

BMrsu: it represents the buffer memory of RSU in which the data is saved. This is temporary memory buffer register.

Description:

Step1: for each vehicle Vi that reaches RSU

Step2: Transmitted data by vehicle will be received by the transceivers of RSU and data is saved in BMrsu.

Step 3: If there is a single request in RSU then

the requested Di is processed and sends to Vi

else

if there are more than one vehicle to send the request then

for the desired time period T the Di will be fetched from the BMrsu

end if

Step 4: Arrange the Di according to Ds in an increasing order in BMrsu.

if Ds are same for two or more request data arrange in the same order as fetched.

then

first request of queue will be processed and the Dp will be send to the Vi then the respective data will be scanned and Dp will be send to the Vi in the same order.

Step 5: For the same time period T the information will be fetched from the next address of the last instruction

Step 6: Go to step 4

Step 7: Go to step5

End if

End if

Our target is to schedule the maximum number of vehicles in the scheduling. With the help of scheduling schemes we can reduce the turn around time of a process and increases the throughput. We can also maintain the congestion control which helps in delay control of the request.

5. Performance Evaluation

5.1 Experimental Setup

For evaluation the performance of the proposed scheduling algorithm we developed an ns-2[12] based simulator. The experiment is based on a 500m*500m square street scenario. The position of one RSU server is at the center of the area. In this model there is a two way road which is the intersection of one horizontal road and one vertical road. To simulate the vehicle traffic we randomly deploy 25 vehicles in each lane total of 100 vehicles. When the vehicles are with in the range of RSU then they can easily communicate with them and if the vehicle reaches at the end of the road which means that that the vehicle will move away from RSU and its request is dropped due to the less range of RSU.

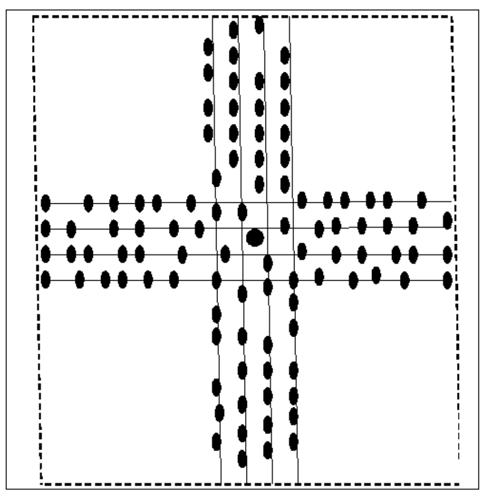

Figure 7. Simulation Scenario Layout Effect of Workload

Figure 8 compare the time delay without this new scheme (previous scheme). As our proposed method has reduced the congestion and delay control of the data. The CCH channel is congested if the packet queue of the beacon message exceed the define threshold value so that is why we assign the priority to the message and these message according to their priority. Highest priority is given to emergency message and after sending the emergency message we will send the beacon message and then after the commercial message. By sending these messages according to their priority we can control the congestion and delay of the data.

The message generation rate is the amount of message generated by the message manager in a given time interval. Here the messages are generated per second. If the message generation rate is 60 messages then the time delay is 15ms in our new scheme and previously takes the 40ms to generate the 60 messages. The new scheme helps in improving the performance of our system.

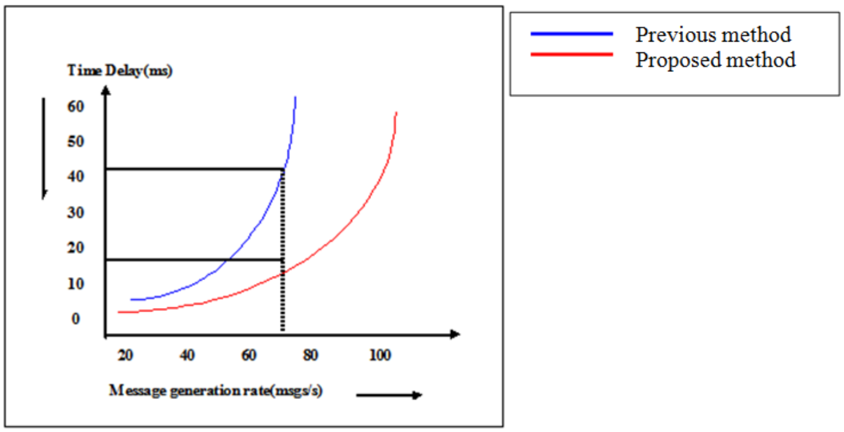

Figure 8. Improving the Performance by Controlling Delay and Congestion

Figure 9 show that the time complexity to send the message reduces. As the messages are send efficiently due to the message prioritization that is used in our proposed method. Also the congestion and delay control of data is reduced which is also help in reducing the time complexity. As shown in the graph in our new scheme if we are sending the 60 messages then it will take around 20ms and in previous scheme it will take the 55ms to send the same amount of data. As the time complexity reduces in new method.

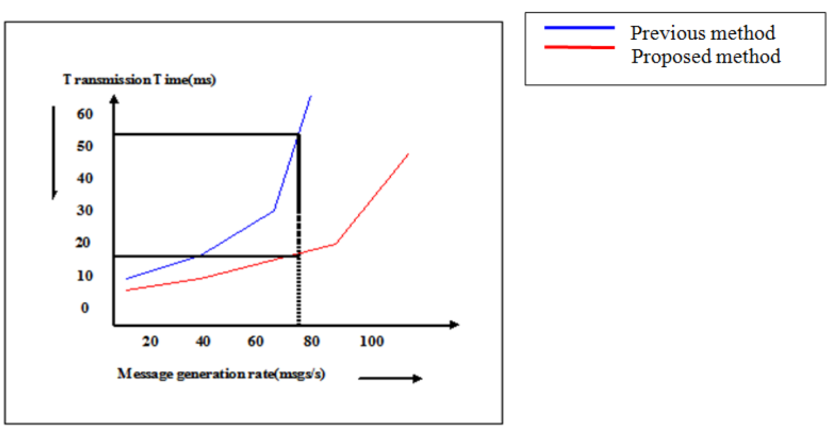

Figure 9. Transmission Time vs. Message Generation Rate to Reduce the Time Complexity

In Figure 10 the throughput of a process increases, as it is the process that completes their execution per time unit. In our proposed method as the message generation rate is 50 at the time interval of 40ms and the throughput is increases as compared with the previous method. As the time is the inversely proportional to the throughput, when the time decreases the throughput of a process always increases.

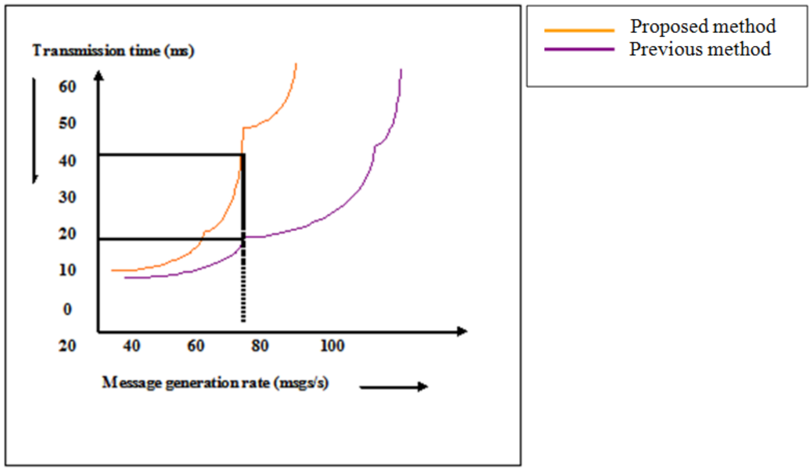

Figure 10. Throughput of a Process Increases

6. Conclusion and Future Work

In the paper, we addressed some challenges in vehicle roadside data access. We proposed the framework of the congestion control approach. With the help of congestion control we efficiently deliver the data in VANET and also the time complexity reduces. As in dense network, CCH channel is easily congested by the beacon message and also by the emergency message so, we proposed to adapt priority based EDF scheduling algorithm in our congestion control. After sending the safety message we will send the commercial message so we proposed a basic scheduling scheme called D*A which will consider both algorithm i.e. SDF and FCFS where D is the data size and A is the arrival time of request in the buffer memory of RSU. This will help in improving the reliability and scalability of a process.

This paper focuses on service scheduling issues in vehicle-roadside data access. With the help of congestion control approach we should reduce the channel load in order to meet the QoS requirements of the wireless network performance. This paper increases the efficiency and throughput of the process and decreases the turnaround time for the process. With the help of proposed algorithm the time complexity of a process reduces. Therefore, in the future we plan to improve reliability of D*A by implementing implicit acknowledgement. We also plan to inspect other improvements in terms of implementing security in the system.

Acknowledgements

The authors wish to thank the anonymous reviewers for their constructive comments and suggestions, which helped to improve the presentation of this paper.

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