Scheduling policies in VANET

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***Abstract*— Due to recent advancements in vehicular technologies vehicular communication has emerged. A Vehicular Ad-Hoc Network (VANET) is a subset of Mobile ad-hoc network (MANET), which provide communications among vehicles within the range and between vehicles and nearby fixed infrastructure known as Road Side Unit (RSU). VANET are self-organizing networks established among vehicles equipped with communication facilities. Some of very important application areas of VANET are public safety, infotainment and enhance driving. Large numbers of messages are to be exchanged between Vehicles (OBU) and Fixed infrastructure (RSU). When many vehicles want to access data from RSU or from other vehicles, service scheduling becomes an important issue. In this paper we have done survey on comparison of different available scheduling policies. We have also listed some challenges in OBU-RSU communication and OBU-OBU communication. Since all the vehicles involve in communication are mobile so deadline is the main concern for scheduling. Real time traffic is also considered for taking scheduling decision.**

***Keywords*— VANET; Deadline; OBU; RSU; Real time traffic**

I. INTRODUCTION

Vehicular Ad-hoc NETwork (VANET) is a subset of the Mobile Ad-hoc Network (MANET) which provides wireless communication capabilities between devices in a certain range. VANET enable vehicles to communicate among them (V2V) and with roadside infrastructure (V2I). VANET have been a very active research topic in the last years due to the very positive impact of their implementation in vehicular safety, traffic management and infotainment applications. The Federal Communications Commission (FCC), realizing the problem of traffic fatalities, in US dedicated 75 MHz of the frequency spectrum in the range 5.850 to 5.925 GHz to be used for vehicle to vehicle and vehicle to roadside communication, known as Dedicated Short Range Communications (DSRC). Although the primary purpose of DSRC is to enable automotive safety applications, the standard allows for a range of comfort applications like internet access from vehicles, office-on-wheels, multimedia applications, mobile internet games, mobile shopping, downloading files, reading e-mail while on the move, chatting within social networks, etc. Figure: 1 shows the different applications of VANET. Due to the vast span of VANET, number of messages to be handled by vehicle and Road Side Unit (RSU) are more.

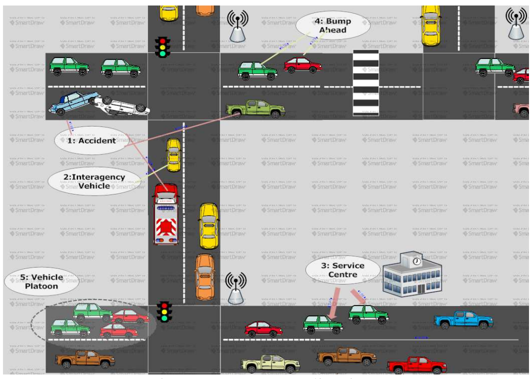

Fig.1 VANET Applications

In this scenario which message should be processed first is the biggest issue. To handle this issue, different scheduling policies are implemented depending upon different scheduling parameters. The aim here is to study about different scheduling policies available in VANET and to improve service ratio in terms of packet delivery ratio with reduction in network traffic. Mostly the mobility pattern of the vehicles in day to day life for city scenario is fixed. This factor gives the motivation to work in this field.

II. Communication Pattern in VANET

Most important elements of Vehicular Adhoc Network (VANET) are Vehicles (OBUs) and Roadside fixed infrastructure (RSUs). Numerous amounts of messages are exchanged for communication between OBU and RSU. Some examples of messages are listed here.

Table 1 List of messages broadcasted by Vehicle

Application	**Type of application**	**Broadcast type**
Crash Warning	Safety	Event based
Danger of collision	Safety	Periodic
Response to VIP / Emergency vehicles	Non safety	Event based
Dangerous road Condition	Safety	Periodic
Abnormal traffic and road conditions	Safety	Periodic
Entertainment data	Infotainment	Event based
Advertisement	Business	Periodic / Event based
News	Infotainment	Periodic / Event based
Vehicle Maintenance	Maintenance	Event based
Vehicle Tracking	Non safety	Event based
Notification services	Non safety	Periodic / Event based
Map location	Non safety	Event based
Automatic Parking	Non safety	Periodic / Event based

As listed in above table there are good number of safety, business, maintenance and infotainment applications available for VANET which requires large number of messages to be exchanged between either one vehicle and other vehicle or vehicle and infrastructure. In VANET, infrastructure means Road Side Unit (RSU) which is situated at fixed location and having capability to broadcast the messages. Each vehicle is having On Board Unit (OBU) which is also having capability to broadcast the messages. In all the applications of VANET, either RSU or OBU needs to broadcast the message. In this scenario, many messages can be queued at RSU / OBU side. Now the question is that from those queued messages which message should be broadcasted first? To answer this question different scheduling policies came into existence.

III. Related Work

To improve the communication between vehicle (OBU) and Fixed infrastructure (RSU) different scheduling policies are implemented on RSU side. Some of the scheduling policies are discussed here.

A. *First Come First Serve (FCFS)*

In this policy [5], arrival time of the message (request) is considered for scheduling. No other parameter is considered for scheduling decision.

B. *Earliest Deadline First*

In this policy [5], deadline (time for which a vehicle is within the range of RSU) is considered for scheduling decision. All the vehicles can know the range of RSU and its own speed so it can calculate service deadline. This deadline is to be send along with the message to RSU.

C. *Smallest Data First (SDF)*

In this policy [5], data size of the requested data is considered for scheduling decision. The message with smallest data size will be served first. In this scheduling algorithm it may possible that request with higher data size will not be served during deadline. This is known as starvation. Probability of sending the message is inversely proportional to data size. If the request arrival rate increases, the service ratio of FDF drops quickly while SDF performs relatively better.

*D. D*S scheduling*

EDF and SDF focus on deadline and data size respectively. To overcome the problem of both authors in [5] have introduced a new policy called D*S. For each request two queues are maintained one for deadline other for data size. RSU serves the requests with the minimum DS_value.

$$\text{DS\_value} = (\text{Deadline} - \text{CurrentClock}) \times \text{Data Size}$$

*E. D*S/N scheduling / Multicasting*

Policy mentioned in [5, 7] is just the enhancement of D*S suggested for optimization of broadcast. Basically used for periodic messages or messages which are frequently requested. If we can delay some requested data and broadcast it just before the deadlines, several requests may be served through a single broadcast. Suspension of the requested data should be time bound (Tsuspend). The data with more pending requests should be served first.

$$\text{DSN\_value} = (\text{Deadline} - \text{CurrentClock}) * \text{DataSize} / \text{Number}$$
$$\text{Tsuspend} = \text{Tdeadline} - \text{Tcurrent} - \text{Tresponse}$$

F. ROADCAST: Popularity Aware Content Sharing

This scheduling policy in [11] tries to reduce service response time in vehicle–to–vehicle communication. Roadcast ensures more popular data is more likely to be shared with other vehicles. Roadcast consists of two components: popularity aware content retrieval and popularity aware data replacement. The popularity aware content retrieval scheme makes use of information retrieval techniques to find the most relevant data towards user's query, but significantly different from information retrieval techniques by taking the data popularity factor into consideration. To deal with the long delays of accessing the less popular data, we rely on the popularity aware data replacement algorithm.

G. Two Step Scheduling

In this scheme data quality is also considered as a scheduling parameter [5] along with service ratio. So to implement that two priority queues are used, one for the update requests and the other for the download requests. The scheduling goes through two steps: the first step chooses the service queue and the second step chooses the most suitable service request.

Step I: Update queue or download queue

Service_Profit, as the sum of the profit gained from update and download requests which is considered to find out that by serving which queue performance will be improved.

$$\text{Service\_Profit} = \text{Update\_Profit} + \text{FreshDownload\_Profit} + \text{StaleDownload\_Profit}$$

Step II: Selecting the service request

For selection of service request in download queue D*S/N is used and in update queue D*S/R is used. Given two update requests with the same DS_value, the request that updates hot data should have a higher service priority since when the data item is updated, more download requests can get the fresh data thus improving the system profit. Therefore, we add the service rate, denoted by R, as a weight factor to the priority calculation, that is:

$$\text{DSR\_value} = (\text{Deadline} - \text{CurrentClock}) \square \text{DataSize}/R$$

H. Two Step Scheduling

As per author in [7], Quality of Service (QoS) is defined as serving of urgent and critical requests with lowest delay. By considering this fact in account, it was suggested to have data queue and emergency queue separately for distinguish between normal data request and emergency request. Weight (W) is to be allocated to each request according to the nature. Finally DSW_value will be calculated and the request which is having lowest DSW_value will be served first.

DSW_value = (Deadline – CurrentClock)*DataSize/Weight

I. Multi item request scheduling

In [6], vehicle can request for more than one item in a single request and if all the items are successfully handled by RSU then only request is considered as successfully served. For each data item d which belongs to the unserved set of a request, the data item with the highest data priority should be served first to allow more broadcast optimization since it is requested by the biggest number of requests. Given two requests with the same deadline, the request with the smaller unserved size should be served first. Given two requests with the same unserved size, the request with smaller slack time should be served first since it is more urgent. If one request is not likely to be served successfully by the RSU where it is currently queuing, say the scheduled finish time of the request is bigger than its deadline, then this request can be considered for transferring to a nearby RSU with lighter workload.

J. SCORE (SCheduling of users cOnnections at RoadsidE units)

The scheduling scheme in [15] exploits the presence of roadside units to reduce the load on vehicles and to hide the complexity of getting the required data in a secure way for them. In this, RSUs to make use of their free timeslots (TSs) to obtain users' data and cache them until the users connect to the VANET. Users register with the default RSU using RSU network online (via Internet). When registering, the user specifies his frequent interests (such as web sites, email, news, etc…) so that the RSUs will prepare his interests ahead of time before he connects to the VANET. User specifies the time slots in which it connects to RSU (Activity profile). According to activity profile, RSU schedule is going to be prepared. SCORE reduces end-to-end delay and percentage of false estimation.

K. Dynamic Periodic Broadcast

This scheduling algorithm [4] is mainly focusing on periodic messages, no concept of emergency messages is being considered in this. The objective here is to set optimal time interval (broadcast time interval) for periodic message broadcast. For this authors have considered deadline and real time traffic.

This scheduling algorithm is working in two phase: Learning and Running. In learning mode RSU will set optimal broadcast time interval for each time slot (24 slots per day – one hour for one slot) and running mode. If due to some reason if traffic increases i.e. speed of the vehicle decreases for long time, RSU will switch to learning phase and again find out the optimal broadcast time interval.

L. Bandwidth Scheduling

This scheduling algorithm [1] is basically used for both safety and non safety messages. The scheduling decision is being taken by considering density, request level, request frequency and load level. This scheduling algorithm also uses the concept of replica management to improve data delivery rate and data delivery delay. This scheduling algorithm also reduces the infrastructure requirement.

M. Beacon Safety Message Dissemination

This scheduling algorithm [3] is focusing on the dissemination of beacon safety message. The road block is divided into sections. Vehicles are forming cluster and there will be one cluster head which is responsible for broadcasting the message. Since this is focusing on safety messages, service ratio must be as higher as possible so to maximize service ratio concept of relay vehicle is introduced. Relay node is the farthest node from the cluster head so it will also broadcast the safety message. We can achieve good service ratio and collision rate is also very low because only cluster head and relay vehicle broadcast the safety message in place of all the vehicles.

N. Cluster based Emergency Message Dissemination

This scheduling algorithm [3] is focusing on dissemination of risk notification messages. To minimize network congestion the concept of cluster is being introduced. All the vehicles will be a part of one cluster. When any unwanted situation occur (accident, traffic congestion, etc.) in any cluster, that cluster head will generate risk notification message. Since here highway scenario is considered, vehicles are moving so fast. So to minimize message congestion, cluster head will broadcast risk notification message after a specific amount of time so rare clusters can know about the unwanted situation and taka appropriate step. By this scheduling algorithm, good packet delivery ratio can be achieved with less message traffic.

O. Priority based Scheduling

In this scheduling algorithm [3] authors have focused on the problem of starvation. This is basically to disseminate both emergency and infotainment messages. In implement scheduling, all the requests have one priority value associate with it. If the message is emergency message then it is having highest priority. Other messages are having less priority. But here if the infotainment message's deadline is less than emergency message then priority value of infotainment message will be increased. By implementing this scheduling algorithm the problem of starvation is solved up to some level.

IV. PROBLEM SCENARIO

A. Request starvation Problem / Fairness Problem

Problem: Request with the lower priority may not be served within deadline

During the study of above discussed scheduling algorithms, it was found that scheduling decision is being taken on the basis of deadline, data size and number of user requested for the particular data item. Since all the scheduling algorithms are non preemptive in nature, in this situation it may happen that a request with higher data size or lesser number of user may not be served within deadline which situation can be considered as starvation problem. Due to this situation service ratio can be reduced.

B. Traffic light based deadline

Problem: Deadline calculation at traffic signal

In all scheduling policies service deadline plays very vital role but in all, deadline is calculated depending upon the speed of the vehicle and the range of the RSU, now consider that one of the vehicle is moving towards the cross road having traffic signal and sent the request to RSU with deadline = 1 sec. immediately after sending the request vehicle will get red light in its lane. So vehicle has to stop and its previous deadline will not be correct now. During this, RSU also gets requests from other vehicles (from active lane – having green light) with deadline more than the previous request (more than 1 sec). RSU will reply (broadcast) according to the deadline, means reply to the vehicle waiting for the green light is given first. Due to this type of situation it may possible that service ratio can be reduced.

V. PROBLEM SCENARIO

A. Challenges and Assumption

In VANET to serve safety and non safety message with lower delay and fairly due to starvation situation is challenging task. Also in V2V communication, both vehicles are moving so finding service deadline is difficult. We assuming here All the vehicles have OBU, The road under consideration is equipped with road side communication units (RSU), All the RSUs are connected with each other by wired connection, OBU can upload only traffic and safety messages, Each OBU is capable of detecting event and generates event driven messages.

B. Proposed Algorithm

Step-1: RSU broadcast Hello Packet

Step-2: OBU receives Hello Packet and send request (upload / download) message to RSU

Step-3: RSU checks for the request_type.
If request_type = upload then
Put request into upload queue.
Else
RSU allocates priority to OBU's request message and put it in Download Queue.
(Incident message – 0, Dangerous road feature – 1, Traffic message – 2, Maintenance message – 3, Infotainment message – 4)

Step-4: If upload queue is not empty then

Serve upload queue first according to deadline.
Else If download queue of other RSU is not empty then Serve request from other RSU's queue according to D*S/N
Else
Serve request from download queue according to D*S//N

Step-5: If deadline completed and request not served then
Transfer request to next RSU Make the entry of that request in to download queue.

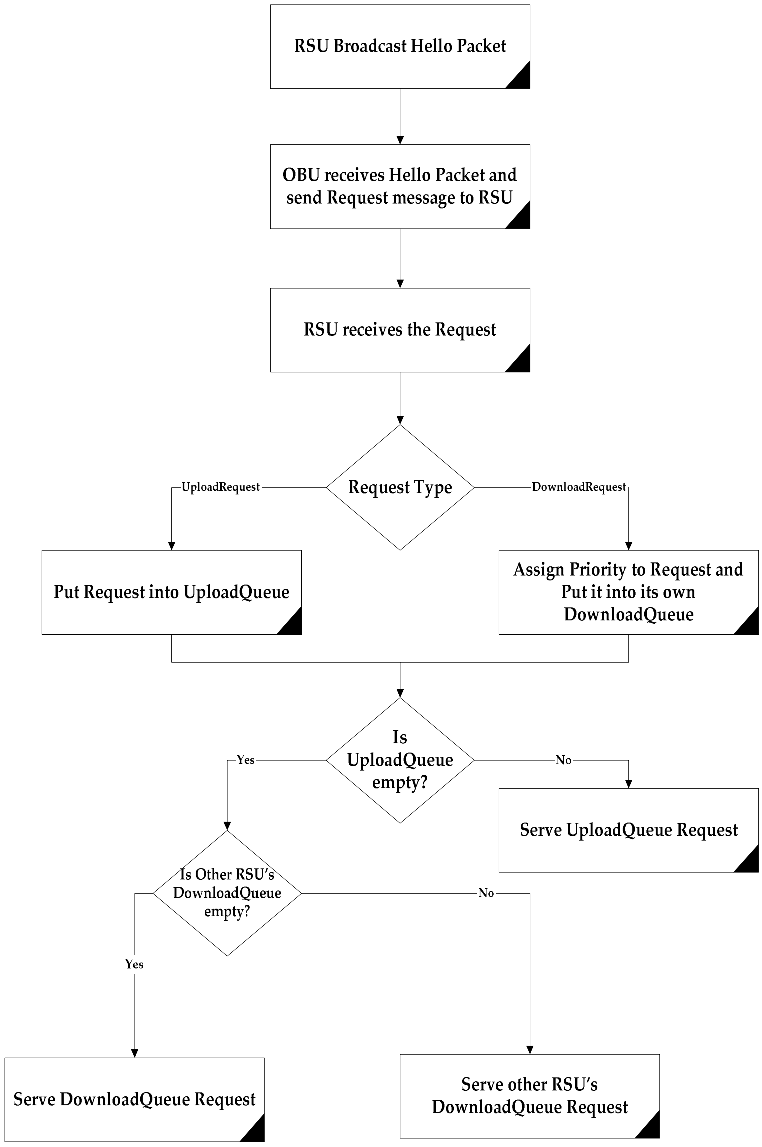

Fig. 2: Flowchart of Proposed Algorithm

In proposed scheduling algorithm, there will be three queues. First queue contains all update requests. In this scheduling algorithm OBU can upload only traffic and safety messages to RSU, non safety messages cannot be uploaded to RSU. Second queue contains all the requests received by RSU and third queue contains all the requests received by previous RSU and not served. Priority will be assigned to all the requests received by RSU. Request will be served according to the priority. By this scheduling algorithm we will try to improve service ratio for both safety and non safety messages without affecting fairness.

VI. IMPLEMENTATION

A. Simulation Environment

We have used NS 2.34 [15] to simulate the proposed approach and SUMO [16] and MOVE [17] have been used as traffic simulator. In total 200 wireless nodes (vehicles) moves according to mobility generated by SUMO and MOVE. Since this is one way highway scenario, speed of vehicles ranges between 16.67 m/s (60 kmph) to 25 m/s (90 kmph). Arrival rate of the vehicle is 10 per second. The communication range of RSU is 150 m and bandwidth of channel is 1000 kbps. Summary of simulation parameters is given in table 2. In this proposed approach OBU and RSU both can send and receive the messages. If any OBU wants to update traffic information or incident information then it can send data to RSU.

Table 2. Simulation Parameters

Vehicle Velocity	16.67 m/s to 25 m/s
Wireless Range	150 m
Datasize	200 kb to 1500kb
No. of Vehicles	200
Transmission Rate	1000 kbps
Antenna Model	Omni antenna
Inter vehicle space	5 m

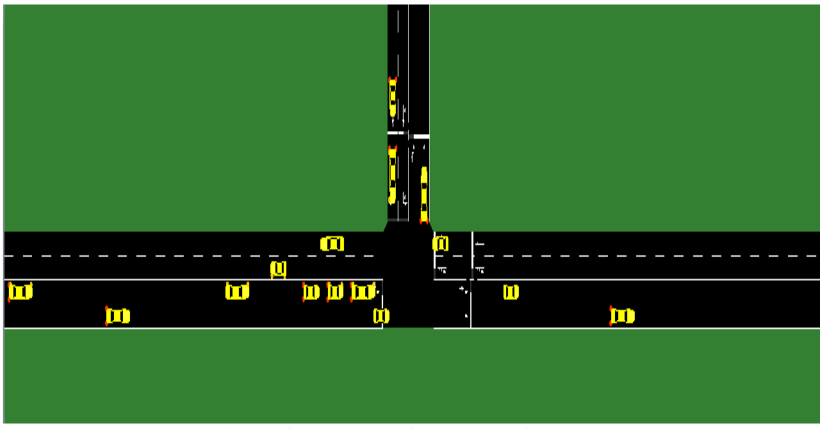

Fig.3: Highway scenario developed in SUMO

B. *Simulation Result*

Our performance parameters of interest are service ratio in terms of packet delivery ratio and Fresh data rate. Service ratio is defined as number of vehicle, which have received the proper response from RSU out of total number of vehicles which have requested for data to RSU. Fresh data rate is percentage of correct / updated data received by requesting node. The protocol parameter is priority depending upon that a vehicle request is being served by RSU.

(a). The effect of Workload

Figure 4, shows the effect of request arrival rate to the scheduling performance of four schemes which are: Priority Based Scheduling, Two Queue Scheduling, Multicasting and our proposed scheduling. As shown in Figure 4, number of request served by RSU decreases as the request arrival rate (workload) increases. Since Priority Based Scheduling serve each request individually, there service ratio decreases very quickly with the increasing in service request arrival rate (workload).

Multicasting and our proposed scheduling algorithm use delayed broadcast scheme to optimize the service so in both the schemes service ratio is higher along with increase in request arrival rate. In our proposed scheduling scheme, all the requests which are not being served by current RSU will be transferred to next RSU and the priority of that request is higher so service ratio will nearly about 100%.

As shown in Figure 5, Fresh data rate decreases as workload increases for Multicasting and Priority based scheduling scheme because when workload increases, number of download request increases and due to that the chance of serving update request decrease. Due to this, the data served by RSU is not up-to-date. In Two queue scheduling and in our proposed scheduling scheme, fresh data rate persist. In our proposed scheduling, high priority is given to update request considering that vehicles only updates safety and traffic information

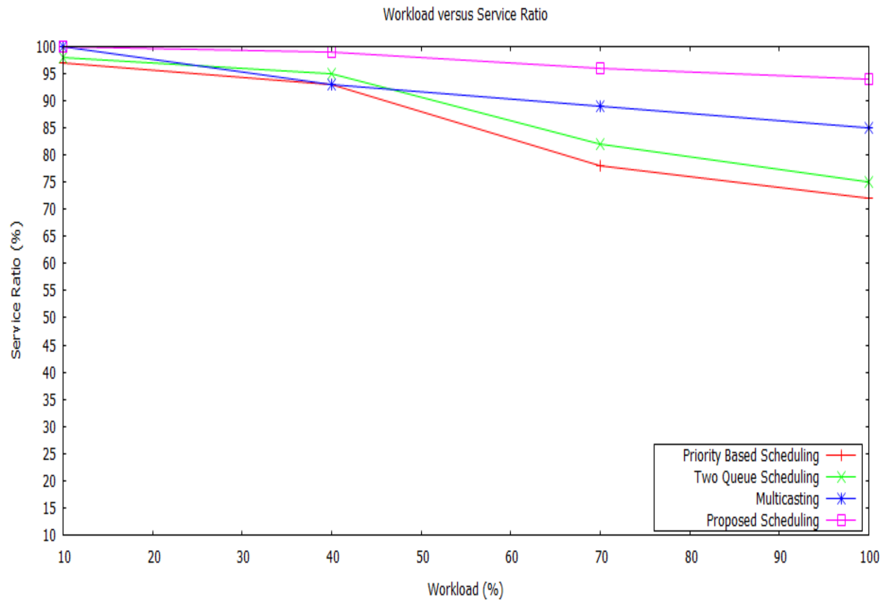

Fig.4: Service ratio

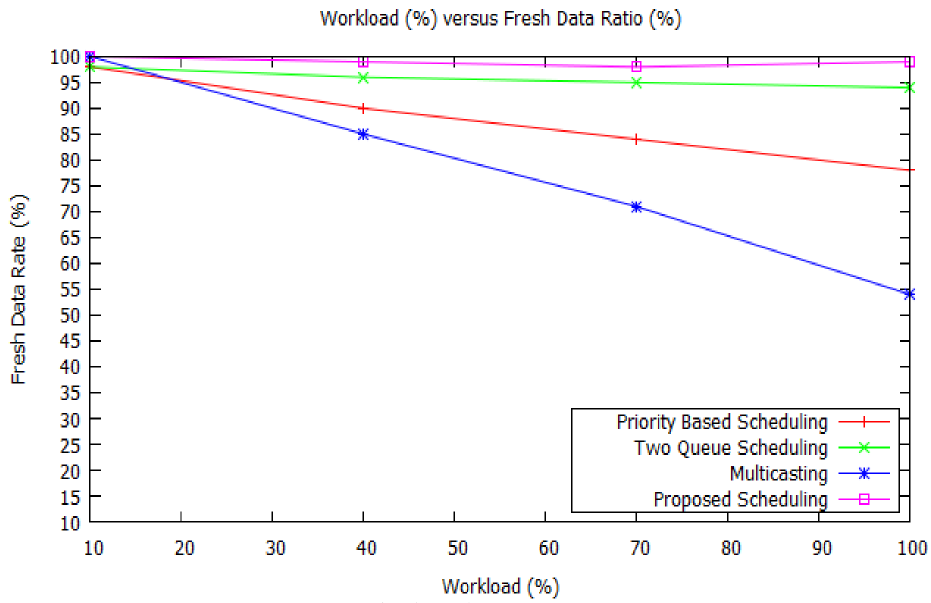

Fig. 5: Fresh Data Rate

(b). The effect of Download / Update ratio

From Fig. 6, we can conclude that service ratio increases with increase in rate of download request for all four scheduling schemes. When rate of download request increase, the proposed scheduling scheme is more likely to be act as multicasting in which a single broadcast may serve more number of request and thus service ratio increases.

From Figure 7, we can state that with increase in rate of download request, Fresh Data Rate decreases in all scheduling schemes except the proposed scheduling scheme. The main reason of decrease in Fresh data rate is rate of download request.

When download request increases, update request decreases and it directly affects on data quality. Since priority is given to the upload request first in our proposed scheduling algorithm, it maintains data quality at its maximum.

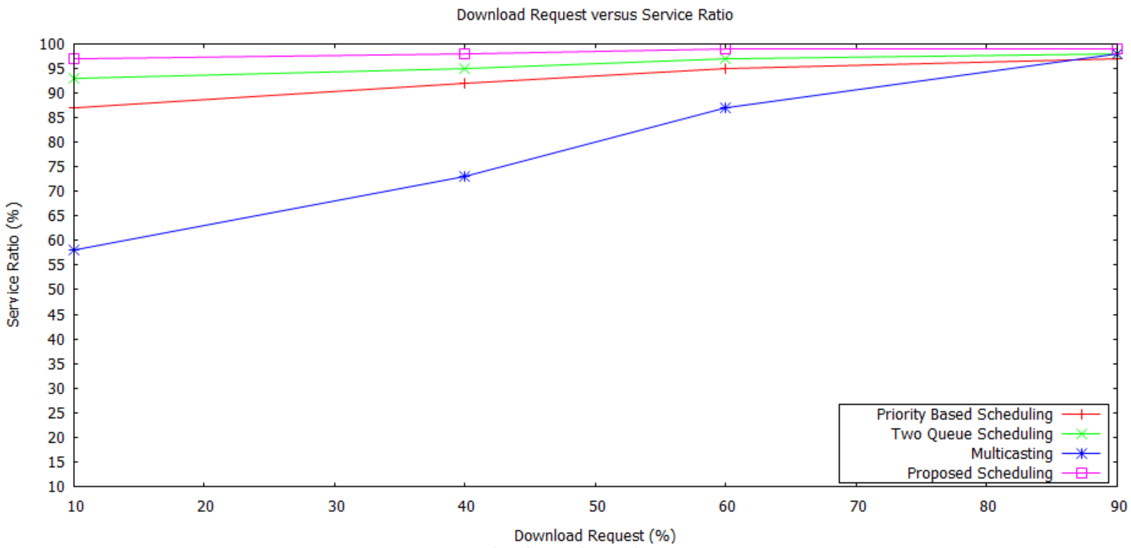

Fig. 6: Service ratio

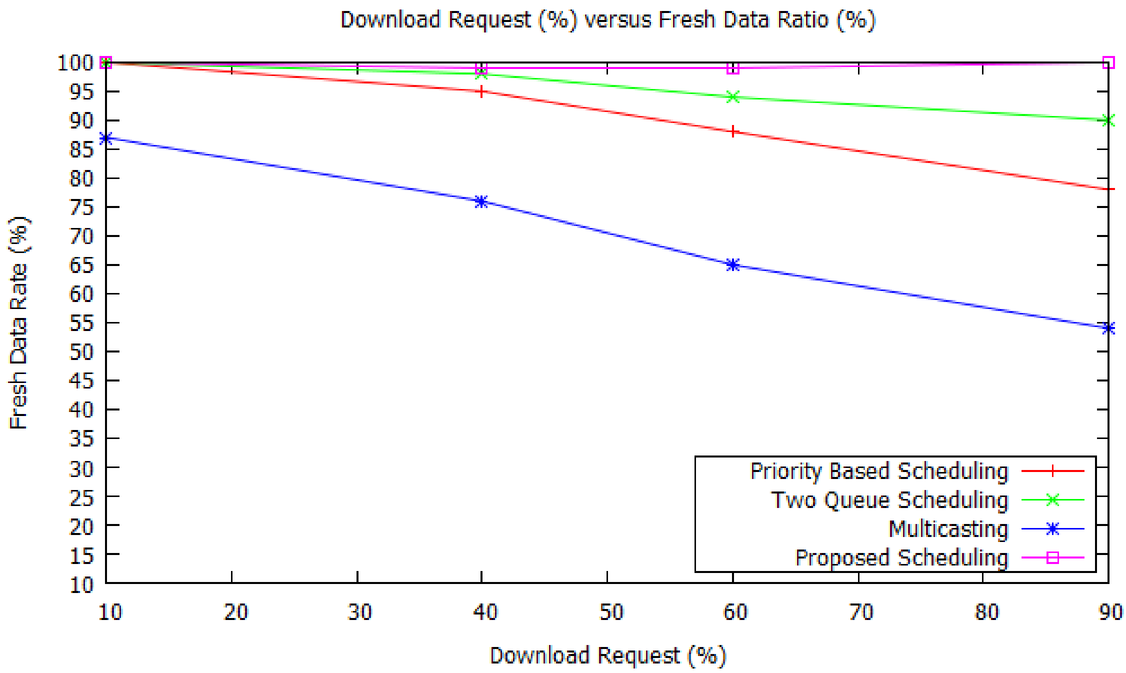

Fig. 7: Fresh Data Rate (%)

VII. CONCLUSION

Scheduling policies discussed in this paper are applicable at RSU side, from which, many of them cannot implement at OBU (for V2V) due to the constraints like service deadline. All the scheduling policies except Two-step scheduling policy consider only downloading of data (I2V) which leads to problem of data quality. Some of the algorithms [5, 7] focus on optimizing broadcast by delaying popular non safety message up to some threshold value (Tsuspend) but not considered any real time traffic scenario (No. of vehicles, Speed of the vehicle, etc). In most of the scheduling policies service deadline plays very vital role but in all, deadline is calculated depending upon the speed of the vehicle and the range of the RSU, What will be the deadline of the vehicle at traffic signal? All the algorithms discussed above are mainly focuses either on emergence / warning messages or on non safety message (infotainment, comfort, etc.). In this scenario if emergency messages are considered then starvation problem may happen to non safety message and if non safety messages are considered then probability of broadcasting emergency message (safety message) may be reduced. The proposed scheduling scheme outperforms the Two queue scheduling, Multicasting and priority scheduling in service ratio by 20% - 25% and this scheme also maintain the data quality up to greater extent.

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