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Data scheduling in VANET:A survey

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ABSTRACT

Wireless technology equipped in *ad-hoc* network to ease the devices to communicate with each other. If it is about high mobility of devices then seamless connectivity to the devices must concern into the network. VANET technology implies to such network. It is the subversion of MANET where self-organizing feature provides the communication between vehicles or between vehicles and Road Side Units (RSU's) within a range. Safety of public, Transport Traffic-control, infotainment and enhance driving are some of the major applications of VANET environment. In VANET environment, each vehicle can go for access to data from RSU or can communicate to any other vehicle. In heavy order here, service scheduling becomes an important challenge to provide equal distribution of data access. "Data Scheduling" measured a very important issue in VANET to successful delivery of data item to the vehicle in proper and accurate way. The purpose of the literature is to present a survey on various available scheduling policies to manage the data accessibility from the RSU's to the vehicles. Data scheduling schemes minimizes the network overhead issues from the VANET and ensures the stability between the vehicles.

Keywords:- VANET; Data Transmission; Data Scheduling; Deadline; Data size; RSU; Hotspot.

I. INTRODUCTION

From the last decade, the use of mobile communication systems in vehicles is now one of the expected research environment to advance the transportation systems. Communications using mobile devices have changed human lifestyles by allowing them to exchange information; at any time in anywhere. This new era of communication in vehicular network allows sharing information among vehicles and infrastructure (RSU's, Hotspot etc.) which avoids hazardous road conditions, traffic jams, accidents, possible detours. Communication shares information such as emergency services, weather conditions and location of facilities *e.g.* Gas stations, Restaurants [1], safety, driver assistance, infotainment, traffic efficiency applications to the vehicle transportation environment. Vehicular Ad-hoc Network comprises all these research work into a practical theory to provide Intelligent Transportation System *(ITS)*.

Apart from the applications and facilities provided by VANET it is necessary to focus on the distribution of services to the vehicles using scheduling techniques. Data scheduling can be applied using three basic transmission methods *i.e., Unicast, Multicast*, and *Broadcast*. These transmission methods considered as the main epoch to the distribution of data over the VANET. Unicast fulfills only one request at a time which directly increases the network overhead. Such methods are more applicable to exchange small data in network to achieve one to one transmission of data. In order to serve multiple requests to a specific group, *Multicast* technique is used to download data from RSU [3]. RSU generally stores the data related to the specified region.

It allows vehicles to communicate using 802.11 access points. Moreover, RSU act as a router, buffer point and server for vehicles to offer various type of information to on-roads vehicles and the vehicles moving in that region. When a vehicle sends a request to the RSU it is the responsibility of RSU to fulfill its request by sending data item to each vehicle in an appropriate and efficient way. Literature [2] worked with data scheduling in a vehicle to hotspot communication instead of vehicle to RSU communication. The hotspots are kept far apart as compared to roadside units this is the only difference between a hotspot and a roadside unit. Paper [4] elaborates an asymmetric communication environment. Such environment performs the broadcasting of available information to a large number of users in an effective way. Asymmetric communication environment uses a satellite or base stations to provide the communication to the wireless hosts. Considering asymmetric communication the upstream communication capacity from clients to a server is less than the downstream communication capacity from a server to clients [5]. Author(s) of [6] introduces the design of an on-demand broadcast to provide good, average and worst-case performance and scales well in terms of increasing request arrival rates, database sizes, and bandwidth. Paper [6] overcomes the issues of [7]. Literature [8] designed a timely delivery of data to mobile clients using Aggregated Critical Requests *(ACR)* scheduling algorithm. Algorithm ensures requests meet their deadlines. The author(s) of [6, 9] have performed extensive research on a pull-based approach which allows data on demand request to the server and broadcasts the data to a mobile user.

This paper highlights the various proposed and available data scheduling techniques in Vehicular Ad-hoc Network. Paper reviewed all scheduling techniques and presents the comparisons between each by explaining their features and working result into the network. For the quick review paper briefly describes the components and basic requirements to establish a VANET. Fig.1 shows the working structure of VANET components (vehicle, road side units, sensors, on-board systems, *etc.*) and communication between them. Communication between vehicles or between vehicles to infrastructure is most concerned features of VANET that allows accessibility of data within the component of the Vehicular Ad-hoc Network.

II. VANET

A. VANET Environment

To establish a vehicular network environment we necessarily need advanced automobile vehicles with an On-board sensor or Bluetooth facilities. . Vehicles which are high-mobility nodes frequently requests for the data using wireless network. A new generation wireless networks Dedicated Short Range Communications *(DSRC)* allows data communication between vehicles. Vehicle nodes can communicate with each other *(V2V)* or with other infrastructure nodes *(V2I)*.Infrastructure such as, Road Side Units, Hotspot act as a base-station, server, router, buffer-point and data-storage. They allow vehicles to access the data from the RSU and re-allocate the information to the vehicles to provide safety applications like accident warning, emergency message call, *etc.* Next is a Communication channel, to send the data in communication channel an electromagnetic radiation takes with the high wavelength such as Radio Waves frequencies 190 GHz to 3 KHz. Other radiations like Infrared have fewer wavelengths than the radio wave. For V2V and V2I (RSUs) communication, 5.850 to 5.925 GHz frequency band set by the Federal Communications Commission (*FCC*).Dedicated Short Range Communications (*DSRC*) provides the comfort applications to the users.

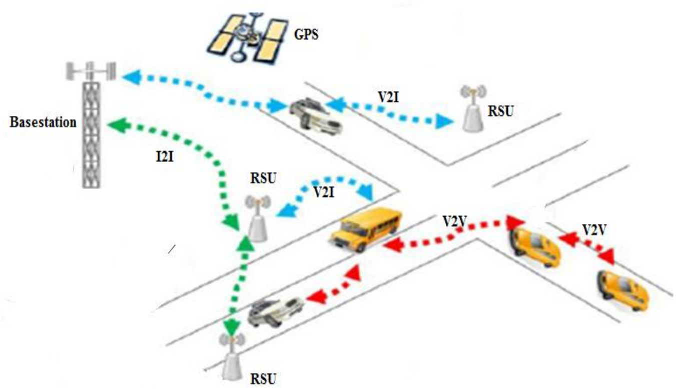

Fig.1. VANET Components and their communication

B. Data Transmission in VANET

In Data communication and networking, data transmission can be of various types. In Vanet selecting a data transmission is one of the major constraints. It allows equal distribution of data access from RSU to the mobile nodes in *Unicast*, *Multicast*, and *Broadcast* method. In *Unicast* only one request can be fulfilled at a time by the infrastructure (RSU). It is a one to one transmission of data. This data transmission is not so useful in heavy networks. *Multicast* is the group of a request can be fulfilled at a time by the infrastructure devices (RSU, Hotspot) also termed as one to many transmissions of data [10]. *Broadcast* can also be termed as many to many transmissions of data and can be categorized into PUSH and PULL based technique. In Push based broadcast, a static broadcast program is used by the roadside unit (RSU) to broadcasts the whole or part of the database periodically. Pull based broadcast is commonly known as demand broadcast. In this broadcast technique, RSU simply accepts the request from vehicles and sends data items to the client. All request fulfilled by the infrastructure using broadcast scheme. A Pull based broadcast technique defined in [8] consider a time constraint and ensures requests meet before their deadlines. Different types of data transmission techniques for vehicle and infrastructure communication shown in the Table1.

Data Transmission for VANET Communication			
	For vehicles	*For Infrastructure*	*Feature*
Unicast	Vehicle to Vehicle	Vehicle to Infrastructure	Increases load to the server

Multicast	Vehicle to other Vehicles	Infrastructure to Infrastructures	Single transmission sends the service to specific group
Broadcast	Many to Many vehicles	Many to Many Infrastructure	Single transmission broadcast the service

Table1. Data Transmission methods

C. *Data Scheduling in VANET*

Transmission of data always raises the issue when the data item is not properly acknowledged within a time bound. Scheduling of data must be done in such a way that each vehicle can get its requested item. Scheduling of data differently outperforms in *Unicast*, *Multicast* and *Broadcast* transmission techniques. As Vanet comprises of high mobility vehicles, infrastructure devices such as RSU, Hotspot, GPS and Cloud where each infrastructure devices can act as a server, storage and router to provide the data to the client (vehicles) and maintains region bound. Schedule applies the scheduling technique to request data *R* item which stored in the form of queue considering a time bound given to each request. Fig.2. simply shows the scheduling of data in terms of time interval for each *R* and broadcast the data according to the time *t*. The different scheduling schemes are introduced concerning different parameters like Data size *(S)* of the request, Deadline *(D)* of the request, Arrival time *(A)* of the request *etc*.

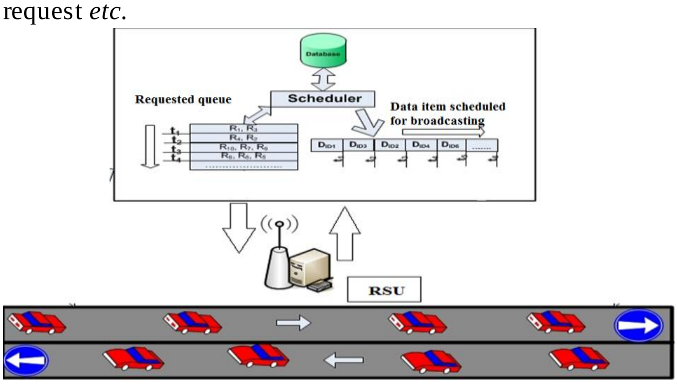

Fig.2. Data Scheduling architecture

III. SCHEDULING TECHNIQUES

A. *First Come First Served (FCFS):*

Initially, FCFS was developed as a schedular for computer operating system to schedule the different processes later on it use for scfeduling of data in vehicular network .A concept of broadcasting of pages to the clients first introduces by [12] and inlitalizes the scheduling concept in VANET. Same paper uses concept of data items that are broadcast as per the request and redundant broadcasts are ignored for the pages that already have entries in the maintained queue.In *FCFS* agorithm, a request which will arrive first will be served first. Vehicles who get successfully registered in the network can request for service.When many vehicles request to services from a server, the server looks at their time stamps of arrival and serves services on first come first serve manner [10].

B. *Most Requests First (MRF):*

Most Request First algorithm involves pending request in the queue. These pending request with the maximum number of page (hot data items) broadcast first, while cold data items has less chance to fulfilled first. *MRF* maintains the lowest waiting time for hot pages which improves the performance but it is not the starvation free algorithm [11].

C. *Most Requests First Lowest (MRFL):*

The function of *MRFL* much similar to *MRF* only difference is it sever ties in favor of the page with the lowest access probability whereas with no ties, MRFL drop to MRF[11].The performance of *MRFL* for large systems is not remarkable[37].

D. *Longest Wait First (LWF):*

It selects the page which has the highest total waiting time of pending requests (i.e., sum of all request's waiting time). In *LWF*, waiting time is calculated for all pending requests of data items and data item having the largest waiting time is selected to broadcast next. Though it is expensive to implement but is applicable in non-real-time broadcast system. *LWF* is designed to minimize the mean wait time and provides more bandwidth to hot pages. Algorithm avoids starvation of cold pages [12].

E. *Shortest Service Time First (SSTF):*

In *SSTF*, item is chosen by the server to broadcast. The aim of the scheme is to take data item with the smallest size to broadcasts first.

F. Preemptive Earliest Deadline First (PEDF):

PEDF is the preemptive version of Early Deadline First algorithm. The only difference between *PEDF* and *EDF* is *EDF* need to be applied after a page broadcast to decide the next page to broadcast.*PEDF* Algorithm is infeasible, impractical and computationally expensive because of its preemptive nature.

G. Log-time algorithms for scheduling data broadcast:

The informational server has much more bandwidth available as compared to the clients such environment comes under the consideration of asymmetric environment [4] and periodically broadcast the information. This algorithm based on "packet fair queue-ing" and removes the broadcast scheduling problem of fair queuing using multiple channels. Algorithm also works over the minimization of access time [5].

H. RXW scheduling algorithm:

Author(s) of [6] have developed a parameterized scheduling algorithm called *R X W*, a scheduling low-overhead scalable approach for large-scale on-demand data broadcast. Algorithm works on the pull-based broadcast technique where the transmission of data depends on client requests rather than profiles or subscriptions. In order to achieve good performance algorithm combines the benefits of *FCFS* and *MRF* as ensures scalability by having low overhead. The maximal *R X W* value must single out to broadcast the page where *R* refers to the number of request for that page and *W* is the time that the oldest request for that page has been waiting.

$$W = clock - 1^{st} ARV$$

Where *clock* is the current time and 1^{st} *ARV* is the arrival time of the first request for the page [6].

I. Earlier Deadline First (EDF):

EDF determines the service to be broadcast with the earliest deadline. This means that the server broadcasts the most urgent request first having earliest deadline. If there are several requests for different services with each earliest deadline, then the service with the largest number of request selected [13]. Algorithm is best suited in real-time database systems and non-mobile environments.

J. Aggregated Critical Requests (ACR):

ACR is a pull-based real-time broadcast system. It is used to identify scheduling algorithms for broadcast systems that ensure requests meet their deadlines. This algorithm is used to minimize the deadline missed. Therefore, data is timely delivered. Algorithm is compared with pull-based algorithms *EDF*, *LS*, *FCFS* and *LWF* and results *wasted broadcasts* does not suffers the performance of ACR [8].

K. Preemptive Request Deadline Size (PRDS):

It is an online preemptive scheduling algorithm with data size, deadline constraints of data requests .It schedules real-time on-demand heterogeneous broadcast. The pyramid preemption mechanism is used to optimize the performance and reduce computation overhead. Paper [14] use different performance matrices in the algorithm *i.e.*, deadline miss rate, response time, stretch and computational overhead. Algorithm reduces computation overhead compared with pure preemptive scheduling algorithm.

L. Smallest Data Size First (SDF):

In *SDF*, scheduling decision data size of the requested data is considered. The requests with smallest data size will be served first. The scheduling algorithm there leads to the problem of starvation because it may possible that request with higher data size will not be served during the deadline. It ignores the request urgency and takes the data size into account.

M. First Deadline First (FDF):

In *FDF*, the most urgency request will be served first. In this scheduling algorithm, parameter deadline of the requested data is considered for scheduling decision. It neglects the service time taken by those data items who gives the highest priority to the most urgent request. The service ratio of *FDF* drops quickly if request arrival rate increases; the deadline factor has more impact on the performance when there is less workload.

*N. D*S scheduling algorithm:*

In *D*S*, Data Size *(S)* and Deadline *(D)* to schedule data access on vehicle-roadside communication is considered. Algorithm serves one request at one time and increases overhead into the network. Each request consist a service value based on its deadline and data size, called *DS value* and can be calculated as [15].

$$DS\ value = (Deadline - CurrentClock) * DataSize$$

Algorithm does not use a broadcast technique to serve the request. Hence, it increases the load on the server as the request for the data item increases.

*O. D*S/N scheduling algorithm:*

Algorithm *D*S/N* is the extension of *D*S* and improves the broadcast efficiency; in which the data with more pending requests should be served first. For this, author of [15] have added one more parameter to the *D*S* scheme *i.e.*, the number of pending requests for the same data *(N)*. The service value, *DSN_value* calculated as,

$$DSN\_value = (Deadline - CurrentClock) * S/N$$

They used three parameters deadline *(D)*, data size *(S)* and pending requests *(N)* .The value of S and N are combined to form a single S/N list so that when a new request comes, the S/N value of the corresponding data item updated. This change does not bring much maintenance overhead in comparison of *D*S* algorithm [15].

P. Proposed Priority Based NDS Algorithm:

The algorithm performs over the vehicle to hotspot communication. Hotspot act as buffer storage and kept far apart as compared to roadside units. Limited numbers of services are stored in the Hotspot and data can be downloading and upload from it. Services stored in Hotspot are categorized into emergency and non-emergency where each service assigned a priority. An emergency service has greater priority than the non-emergency services. For each service, a weight must be calculated using,

$$Wi = (Ni * Pi) / (Di * Si)$$

Where, *N* is the number of requests for each service *i*, *P* refers to the priority of any service *i*, *D* is the deadline of service request *i* and *S* is the data size of service *i*. Algorithm provides broadcast transmissions using weight value as many vehicles requests of similar data [2].

Q. Two-step Scheduling:

Scheduling allows the vehicle to presume a download from a new RSU. Two–step scheduling first performs over the requests. It simply departs the requested data item on the basis of presumed data or first time requested by the vehicle. This scheme maintains two queues one for an emergency request and other for the data request. Requests are inserted in two queues according to the type of request in *FCFS* scheduling scheme. The second step selects one of two queues for the transmission with *D*S* [15] scheduling scheme. Queue head with the less *DS_value* is served first [16].

R. D*A scheduling algorithm:

In *D*A*, *D* is the data size and *A* is the arrival time. Highest priority is assign to processes with the smallest data size and known as Smallest Data size First scheduling. If the two processes with the same size of data then the priority assigned on the basis of First Come First Serve to schedule. *D*A* applicable only for the commercial messages. In this algorithm the emergency messages will be sending through control a channel with the help of *EDF* scheduling [21].

S. Motion Prediction based scheduling scheme:

MMPS scheme is the extended part of a cooperative scheduling scheme called Motion Prediction Optimization *(MPO)*. Scheme enables the cooperative work between a set of RSU [17]. *MPO* allows multi-RSU cooperative data broadcasting. This cooperation among RSU leads to better utilization of bandwidth and balances workload into the network. Author(s) [17] uses *D*S/N* scheme [15] to serve multiple request in a single broadcast. When the value of theta is large for the same few data items vehicles can tend to request and achieves a higher service ratio. *MPO* achieve better scheduling performance in effect of request valid time, request inter-arrival time, and data access pattern then the *FCFS*, *EDF* and *SDF*.

T. Two-step Scheduling:

Two-step scheduling algorithm is the combination *FCFS* and *D*S/W* (Deadline, Size of Data and Waiting time). Algorithm performs multicast technique in order to serve multiple requests. Priority set to requests having short deadline. Algorithm performs two steps. In first step data divided into normal or emergency category and on the basis of category, requests are separated. In next step two queues (Data and Emergency) are maintained to insert the request in *FCFS* scheme. Selection of queue is done by *D*S/W* scheduling scheme. Queue with min *DSW-value* is to be served first. A comparative result in [10] between *FCFS*, *SJF*, *D*S/W* concludes that *D*S/W* policy leads to serving more normal requests than the other two policies.

U. Scheduling of Periodic Messages:

Periodic messages like traffic control information, road condition, weather information, etc. need to be scheduled by the RSU. Real time traffic, vehicle density and deadline are the main concern parameters to the scheduling of periodic message. Literature [36] overcomes the problem of static periodic broadcast and focuses on to set optimal time interval to broadcast message periodically. Priority to the services not known to any messages hence no concept of emergency messages needed.

V. Bandwidth Scheduling:

To improve the data delivery rate and delay, algorithm uses the concept of replica management and reduces the infrastructure requirement. Replica allocation and bandwidth scheduling are divided into five module [35] *i.e.*, bandwidth scheduling, replica management, vehicle infrastructure management, pattern analysis and content delivery process.

W. Priority based selection algorithm:

Algorithm schedules data for those vehicles which are in the coverage area. The author(s) of [24] have done research to those vehicles that request for services to RSU and leaves the range after forwarding the request. In this pull based messages scheduling, queue are scheduled in such a way that they are sorted according to the request selection priority with popularity of each request. Algorithm provides the priority to vehicles before completion of its deadline and performs over bandwidth utilization and fairness.

IV. CONCLUSION

Compromising with the accessibility of data from RSU may lead to the improper and inefficient distribution of data items. Research on the broadcast of data access in VANET has introduced the scope of work. Different data scheduling schemes have been surveyed in this literature. The aim of the paper is to give an overview of presently available scheduling schemes (algorithms). FCFS is the first scheduling technique introduced by Wong in the year of 1988. The illustrated scheduling techniques assure that the vehicle receives the desired data service in the desired time. To reduce the issues of scheduling many pieces of literatures has introduced the broadcast technique with priority preset to the data-item. This improves facilities to a client and subsequently outperforms good result in Bandwidth utilization, Energy consume and total time taken by the RSU to fulfill request. Different metrics can be used to measure the performance of scheduling schemes such as *service ratio*, *data access*, *priority factor*, *reliability*, *fairness*, *responsiveness*, *time constraint*, and *data quality*. A good scheduling scheme serves many requests at a time considering the each performance metrics. Service ratio is one of the so-called major performances metric which calculates the ratio of number of served requests before the service deadline to the total number of arrived requests. This survey concludes that to schedule data in an efficient and reliable manner data scheduling is very much essential in high mobility device network (VANET).

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