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DATA DELIVERY THROUGH VEHICULAR AD-HOC DELAY TOLERANT NETWORKS (VANETS)

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Abstract— **This paper presents the application of Vehicular Ad-Hoc Delay Tolerant Networks (VANETs) in data delivery on highway from one place to another by accomplishing vehicle to vehicle communication (V2V) without any fixed infrastructure. Every moving vehicle on road is equipped with wireless devices of identical Wi-Fi facility and acts as a mobile node which can simultaneously receive and forward data packets. A prediction has been made on vehicle mobility limited by traffic patterns, speed, road length and layout. Three different schemes are proposed for data delivery which are: One Way One Direction, Multi-hop One Direction and Multi-hop Multi Direction. The mechanism "store, carry and forward" is adopted here. In this mechanism, if a moving vehicle receives a data packet from a data source, it may carry the data packet throughout the whole path by itself (One Way One Direction) or forward the data packet to the vehicle of same direction (Multi-hop One Direction) within its vicinity or to the vehicle of both directions (Multi-hop Multi Direction). Simulations are performed by the software NETLOGO and the results demonstrate that the proposed Multi-hop Multi Direction scheme has the best performance in terms of Data Delivery Rate among the three proposed data delivery schemes.**

Keywords— **Store, carry and forward, data delivery rate, VANETs**

I. INTRODUCTION

Vehicular Ad-Hoc Network (VANET) is one of the applications of mobile ad-hoc network where vehicle are used as nodes to create the network. It is an emerging technology which uses ad hoc networks to create vehicle to vehicle (V2V) communications and delivers data from one place to another without any fixed infrastructure. VANETs are the key components of Intelligent Transportation Systems (ITS) because they have been used in road safety and many commercial applications [1], [2]. For example, VANET is used to avoid traffic jams and accidents by transmitting warning signals to drivers behind a vehicle. To accomplish this, inter vehicle communications are applied. Several researches have been done to improve inter-vehicle communications. Slot-reservation, MAC scheme and congestion control policies for emergency warning are studied in [3], [4] and [1]. Inter-vehicle communications with the static network nodes such as traffic lights, bus shelters, and traffic cameras have been addressed in [2] and [5]. Schemes [6], [7] have been posited to circulate information about traffic, obstacles and hazards on the roads. Some other applications, for example, real-time video streaming between vehicles have also been studied in [8].

However, the aforementioned applications are applicable only if the wireless technology (e.g. GSM or 3G) is available. Also, it costs high and may be impossible if such conventional infrastructures are absent or get damaged due to disasters. For example, data transmission is impossible from a remote area where there are no TCP/IP infrastructures. Also, in case of battle field no TCP/IP is available. To handle these situations, VANETs are applicable for the communication which is more economical and independent. Without conventional infrastructural network, data can be delivered to a place several miles away through VANETs.

In this work, a highway is considered where vehicles are moving continuously. It is desired to deliver data from one end to another but there is no fixed infrastructure (e.g. 3G towers). Now, VANET is created where every vehicle is considered as a mobile node equipped with wireless devices (e.g. smart phones) with a common Wi-Fi facility. In this process, a vehicle receives a data packet from the source (one end of the highway) and stores it. The vehicle may carry that data packet throughout the whole path until it reaches the destination or forward the data packet to another vehicle which comes into its Wi-Fi range. Thus, ad hoc networks are created and eventually the data packets are delivered to the destination. To accomplish this, three different schemes are proposed for data delivery from source to destination. These are- One Way One Direction, Multi-hop One Direction and Multi-hop Multi Direction.

The proposed mechanism is different from the existing carry and forward approaches presented in [9]–[11]. Proposed schemes makes use of the predictable mobility in a VANET, which is limited by traffic pattern, vehicles velocity and road layout. Extensive simulations are performed by the software NETLOGO to evaluate the performance of the proposed data-delivery schemes.

The rest of this paper is organized as follows. Section II describes the assumptions considered for the proposed schemes. Proposed Schemes are presented in Section III. Section IV demonstrates the theoretical approach. Section V evaluates the performance of the proposed schemes and Section VI concludes this paper with works

II. ASSUMPTIONS FOR PROPOSED SCHEMES

The model for the proposed schemes, shown in Figure 1, consists of two sinks (A and B), a road of two lanes and different types of vehicles on the road. Both of the sinks may be source or destination. If A is source, B is the destination, or vice versa. Now, the assumptions considered for the proposed model are described in the following paragraphs.

***Road*:** A road is considered consisting of two lanes. It has a length of 5 km. The lanes are ideal where there is no bending, obstacles and there is no section or sub-section.

***Sink*:** There are two sinks at two ends, Sink A and Sink B. Each sink can generate and receive data simultaneously and the generated data is delivered by the vehicles.

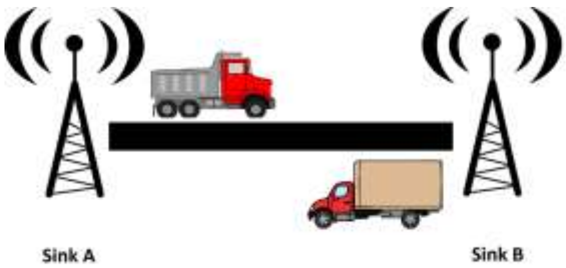

Fig. 1. Proposed Model

***Vehicle*:** Car, truck and bus are taken as vehicles. They move straightforward in either same direction or opposite direction through the lanes. It is assumed that every vehicle has a data storage system with identical Wi-Fi facility. Vehicles will always try to connect with each other within their Wi-Fi range. If a vehicle finds any other vehicle within its Wi-Fi range, they will remain in touch for at least one second and then deliver the data. The new vehicle then carries the data until it finds another vehicle within its vicinity. Thus data is stored, carried and forwarded from one sink to another. Also, itis assumed that the vehicles do not change their direction and route.

***Data storage system*:** Every vehicle is equipped with devices called *transceiver* which can not only store the data packet but also receive and pass to another vehicle either in forward direction or backward direction. The maintenance and reliability of this system are out of this work.

***Data Characteristics*:** Proposed schemes work at a data rate of 1 packet per second. No data loss and data conflicts occur throughout travelling from Sink A to Sink B or vice versa. Each data packet contains the information of direction at which it is travelling.

***Wi-Fi range*:** Wi-Fi range of each vehicle's transceiver is 250 meter. Within this range a vehicle can connect with other vehicles and transfer data.

***Speed of the vehicles*:** The vehicles are considered with the speedsof70 km/h, 80 km/h and100 km/h. Each speed is considered to be constant for the whole simulation period for a particular scheme.

III. PROPOSED SCHEMES

A. *One Way One Direction*:

One Way One Direction shown in Fig. 2 is the simplest one among the proposed schemes. In this scheme, when a vehicle starts its journey from one end of the highway, it receives a data packet from the sink(Sink A or Sink B).

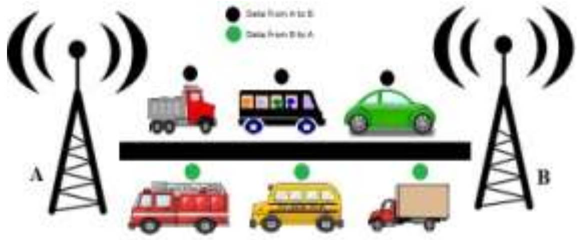

Fig. 2. Data delivery in One Way One Direction Scheme

Then, it continues carrying the data packet until it reaches the destination (another sink). On its journey from one sink to another, it does not forward the data packet to any other vehicle and eventually forward the data packet to the destination sink. This is like a postman travelling from one place to another. The algorithm is shown by flowchart in Fig.3.

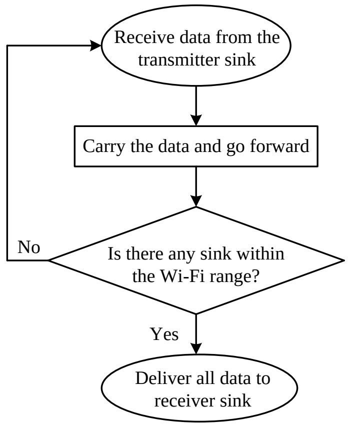

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Fig. 3. Data delivery algorithm for One Way One Direction Scheme

B. Multi-hop One Direction:

In Multi-hop One Direction scheme shown in Fig. 4, a vehicle collects data from one sink (A or B). This vehicle will keep carrying the data packet until it finds another vehicle moving in the same direction within its Wi-Fi range and then forwards. Data packets are forwarded by hop-by-hop manner and it continues until the data packet reaches the destination (another sink). Data packet may flow from both of the sinks, A and B, without changing the direction, e.g. hopping will not occur between vehicles of opposite direction. The algorithm for data delivery is depicted in Fig. 5.

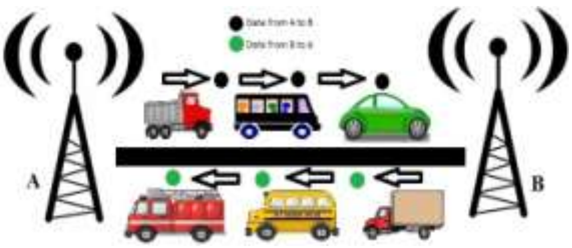


Fig. 4. Data delivery in Multi-hop One Direction Scheme

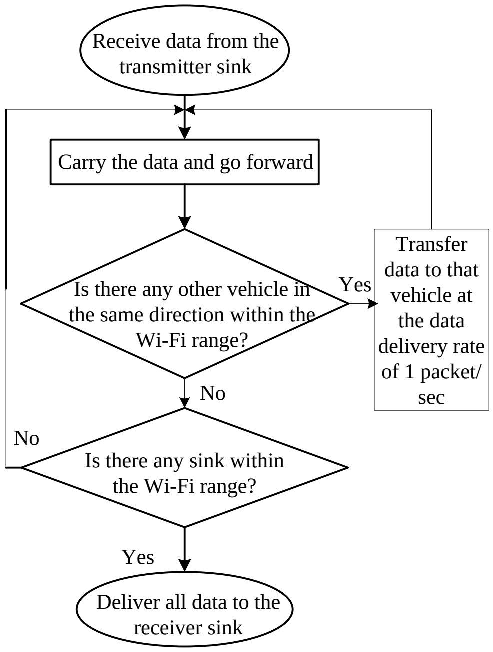


Fig. 5. Data delivery algorithm for Multi-hop One Direction Scheme

C. *Multi-hop Multi Direction*:

Though in Multi-hop One Direction there is no hopping of data packet to the vehicles of the opposite direction but in multi- hop multi-direction in Fig. 6, hopping of data packet occurs within the vehicles of the same direction as well as the vehicles of the opposite direction. Thu, a s*ubnet* indicated by the blue circle in Fig. 6 is created. Each vehicle will try to find out the shortest possible path and create a subnet to send the data packet towards the destination through multi hops in both (multi) directions. This scheme reflects the real life situation and the algorithm for data delivery is demonstrated by flowchart in Fig. 7.

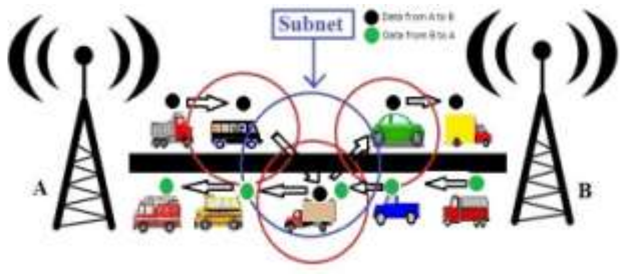


Fig. 6.Data delivery in Multi-hop Multi Direction Scheme

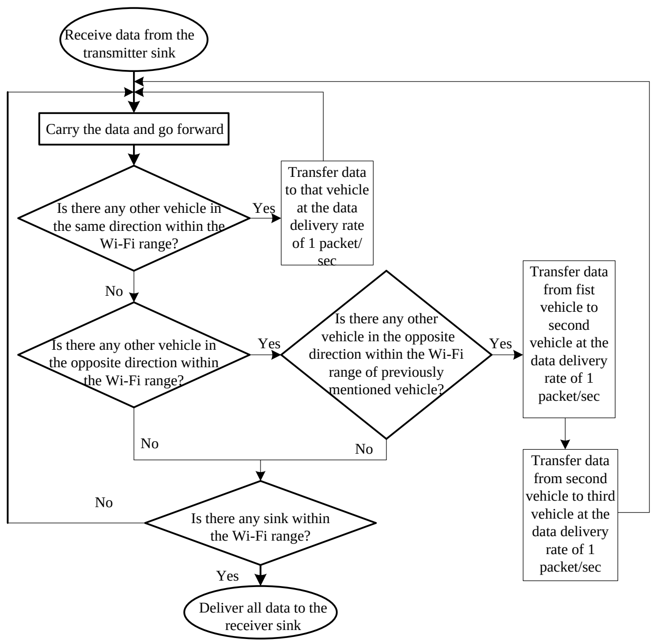


Fig. 7. Data delivery algorithm for Multi-hop Multi Direction Scheme

IV. THEORETICAL APPROACH OF THE PROPOSED SCHEMES

The proposed schemes are theoretically evaluated and it is depicted in Fig. 8.

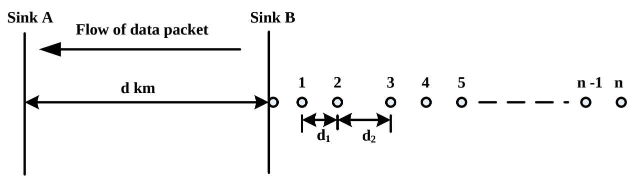


Fig. 8. Theoretical Model for One Way One Direction and Multi-hop One Direction schemes

Let,

s = Wi-Fi range of each vehicle in meter

v = speed of each vehicle in km/h

d = distance between Sink A and Sink B

d_1 = distance between any two vehicles where $d_1<s$

d_2= distance between any two vehicles where $d_2>s$

p = no. of total data packet

n_1 = no. of vehicles apart from each other by d_1

n_2 = no. of vehicles apart from each other by d_2

n = total no. of vehicles

And $n_1 + n_2 = n-1$

Time to pass the Wi-Fi range s by any vehicle, $t_1 = \frac{s \times 3600}{v}$ seconds

So, each vehicle remains connected to other vehicle or to any sink for t_1.

If we assume that the data delivery rate from vehicle to sink or vice versa is 1 packet per second, the number of data packets transferred just after passing the Wi-Fi range from vehicle to vehicle or vehicle to sink = $\frac{s \times 3600}{v}$

So, the total number of vehicles to deliver total p number of packets from Sink B to Sink A, $n = \frac{p}{\frac{s \times 3600}{v}} = \frac{pv}{3600 \times s}$

In case of One Way One Direction:

Total distance between Sink B and the n^{th} vehicle = $n_1d_1 + n_2d_2$

Total distance passed by the n^{th} vehicle to deliver total data packet, $D = d + n_1d_1 + n_2d_2 - s$

[When the n^{th} vehicle is ahead of Sink A by s meter, it connects with it and delivers the data packet before crossing the distance s. That's why s meter is subtracted]

So, the total time to deliver total data packet p from Sink B to Sink A = $\frac{D \times 3600}{v}$ seconds

In case of Multi-hop One Direction:

In this scheme, n_1 number of vehicles is apart by $d_1 < s$. That means, they are connected with each other and the distance n_1d_1 should be subtracted from the total distance to be covered by the vehicles. So, the total distance covered by the vehicles to deliver p number of data packets from Sink B to Sink A = $D - n_1d_1$

So, the total time to deliver total data packet p from Sink B to Sink A = $\frac{(D - n_1 d_1) \times 3600}{v}$ sec

V. EVALUATION OF PERFORMANCES

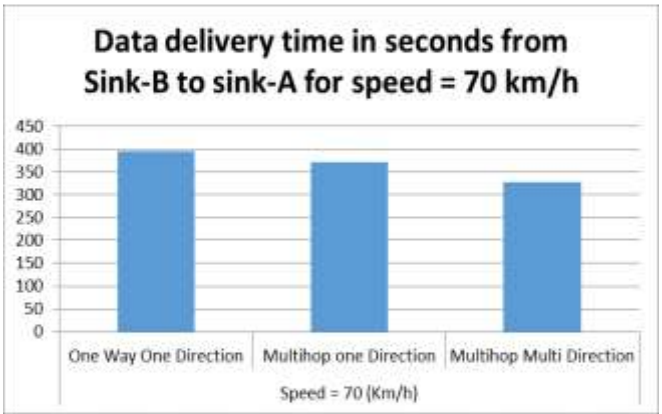
This section represents the data delivery rates of the proposed schemes for different speeds of the vehicles. The *NETLOGO* software is used for the simulation, but every time the simulation is performed with an identical speed for all the proposed schemes. It is performed only for the road length of 5 km, the number of vehicle of 20 on the road, Wi-Fi range of 250 m. The following table depicts the whole simulation setup and results.

Table 1: Data Transmission Rate of Different Schemes

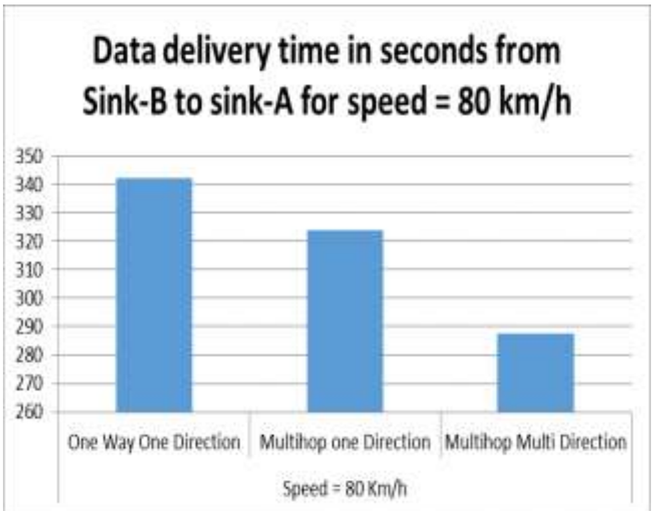
Road Length in kilometer (km)	Speed in km/h	Proposed schemes	Sink- B to sink – A data delivery time in seconds (s)	Sink- A to sink- B data delivery time in seconds (s)
5	70	One Way One Direction	394.689	391.074
		Multi-hop one Direction	370.863	350.096
		Multi-hop Multi Direction	326.843	319.124
	80	One Way One Direction	342.157	351.735
		Multi-hop one Direction	323.91	351.593
		Multi-hop Multi Direction	287.612	282.617
	100	One Way One Direction	310.318	309.6
		Multi-hop one Direction	295.366	282.663

		Multi-hop Multi Direction	276.758	261.753

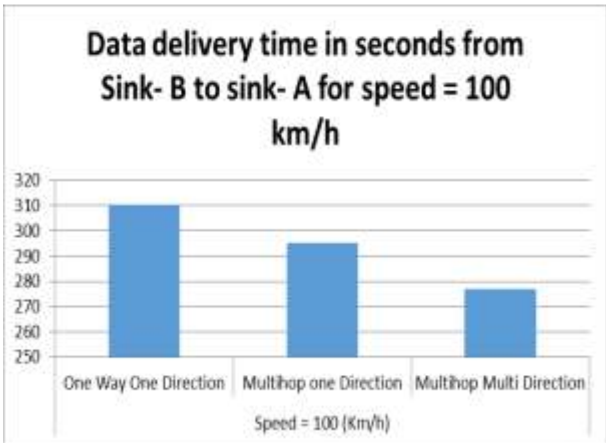
The comparison between the proposed data delivery schemes are also demonstrated by the following bar charts.



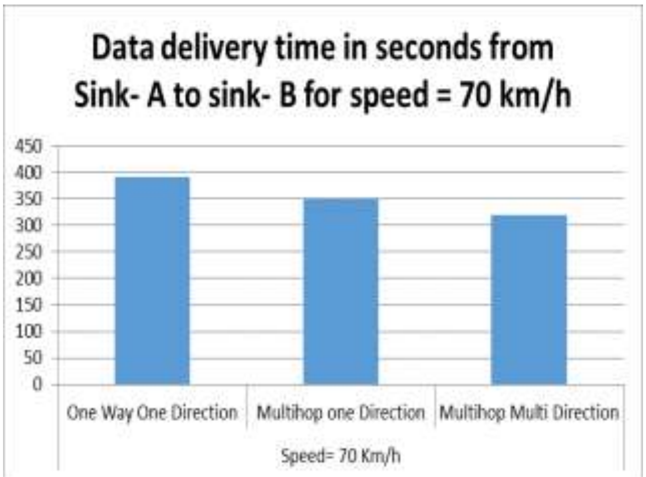
(a)



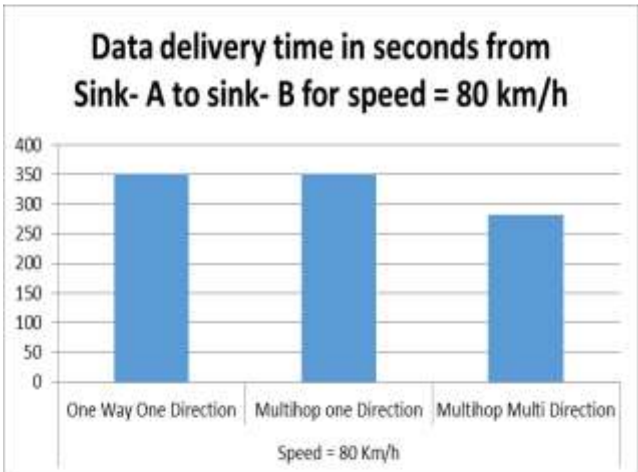
(b)



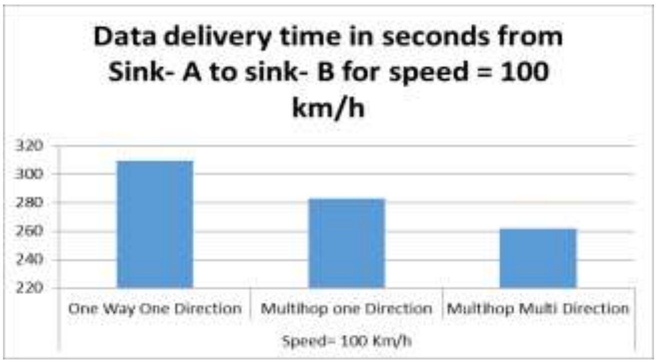
(c)



(d)



(e)



(f)

Fig.9. Data delivery rate from sink-B to sink-A for the speeds of (a) 70 km/h (b) 80 km/h (c) 100 km/h, and from sink-A to sink-B for the speeds of (d) 70 km/h (e) 80 km/h (f) 100 km/h

The above bar charts demonstrate the performances of different proposed schemes on the basis of data delivery rate and vehicle speed. It is seen that the data delivery rates in all the proposed schemes increase with the increase of vehicle speed. Among all three schemes the multi-hop multi-direction outperforms the rest of the schemes in terms of data delivery rate.

VI. CONCLUSION AND FUTURE WORKS

Proposed schemes are employed where there is no infrastructural communication protocols. Ideally, all three proposed schemes, One Way One Direction, Multi-hop One Direction and Multi-hop Multi Direction, have no data loss. Though the One Way One Direction scheme has no data loss in both ideal and practical cases, the other two have a good possibility of data loss in practical case. This is due to the uncertainty of the vehicle's mutual connection as they can lose connection as soon as they go beyond the Wi-Fi range. That's why though the data delivery rate in One Way One Direction is the lowest, it is the most secured one. However, among the proposed schemes, Multi-hop Multi Direction shows the best performance by simulation in terms of data delivery rate. Another thing is that since the proposed schemes work on infrastructure less structure, justification of cost is nicely accomplished.

In future, the mathematical derivation of data delivery rate for Multi-hop Multi Direction would be done. Also, research will be progressed focusing on designing the network with the consideration of different road layouts, different traffic patterns and traffic with variable speeds. Research may also be on data transmission from vehicle to road side infrastructure under these proposed schemes.

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