FFHBR: Flooding and Forwarding History Based Routing Algorithm for Vehicular Delay Tolerant Network

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Abstract—In a vehicular delay-tolerant network (VDTN) which is actually one of the type of delay-tolerant network (DTN) [1] in which message is passed by vehicle to vehicle and finally reached to the destination. Some times it may be possible that the path between the two nodes never exists and it can be possible due to high mobility of the nodes. So we can disseminate the packet directly to the destination, therefore, delivering the message to the destination reduces drastically and we can observe that in these type of scenario routing is the challenging task in VDTN. So, in this paper, we put forward flooding and forwarding history-based routing algorithm. In the proposed history-based algorithm we will try to find out the best relay node for taking the decision whether to flood the message or forward the message to the destination. In the proposed algorithm we will create the history based on the nodes encounters.

Keywords— DTN,VDTN,MANET,FFHBR

I. INTRODUCTION

In MANET [11], delay-tolerant networks are one of its types, throughout the life cycle lacking is the basic problem of this network. It is possible because of some reason like: maybe transmission range is very low, maybe in some constraints in the power of wireless devices or partitioning of the network. We can divide these networks by their delays and by their high error rates. Some of the examples of these networks are UAN [22] (Underwater Acoustic Network), VDTN [14] (Vehicular Delay Tolerant Network), PSN (Packet Switched Network) [3], MSN (Mobile Sensor Network) [2], etc. VDTN is a special type of DTN in which vehicle itself carrying a wireless device to transmit the message into the network. In VDTN these vehicles are considered as a mobile node. Because of the high vehicle mobility, these nodes are having very high mobility. Because of high mobility of the nodes, the frequent disconnection between the nodes is possible during message transmission when the traffic network will be sparse. In VDTN mainly two types of wireless devices are used for communication purpose. One of the wireless devices is OBU (On-Board Unit) which is placed inside the vehicle and the second one is RSU (Road-Side Unit) which is planted at the intersection of the roads. RSU is also called relay nodes. Because of the placement of these devices, we can conclude that OBU is a movable wireless device while RSU is a fixed wireless device. Relay nodes are used for communication of mobile nodes to each other while they navigate from one end to another end. For storing the messages, Buffer capacity of relay nodes are very high for storing the messages.

Some MANET routing protocols are DSDV [9], DSR [7] and AODV [13]. These protocols are used for routing the packets. These protocols are transmitted the packets after constituting end to end path between source to destination. These protocols are basically used for finding the shortest path between source to destination in the network before transmitting the packets. If we use all these protocols directly to DTN then they dont succeed due to lack of end to end path between the nodes. So this is the challenging task in DTN routing. Rather than to focus for determining the shortest path between the nodes in the network, first make sure that the message reach to the destination successfully.

There are two kind of routing protocols in DTN i.e. Forwarding and Flooding [18]. Detailing of these routing protocols are discussed in the next section. Some other important DTN routing protocols are DSCF [10], SERVUS [4], UV-CAST [19], DV-CAST [17] and ROD. And one of the very important routing protocol which is also the part of this paper is history-based algorithms. Based on the past history of a node, this algorithm will decide for routing packets. In this algorithm past history includes: inter contact time between the nodes, number of an encounter of the nodes, etc. Few history-based routing protocols are CAR, ZEBRANET [20], PRoPHET [6], etc.

In this paper we present Flooding and Forwarding History Based Routing (FFHBR) algorithm. In this paper we will compare the performance of FFHBR with other existing history based routing algorithms in terms of delivery ratio and latency.FFHBR performance is better than other history based routing protocols. Some history based routing protocols are PRoPHET [6], CONHIS [12] and Spray-and-Wait [21].

This paper is organized as the following. First we elaborates the work done in this area. Secondly describes the proposed FFHBR algorithm. And the last portions of this paper is conclusion and future work.

II. RELATED WORK

DTNs are having two types of algorithms one is forwarding based algorithm and other one flooding based algorithms [8]. We categories these algorithms based on the number of replicas of messages that are roaming across the network at any point of time. Forwarding based algorithms are having only one replica for any message that has to be maintained by any node in the network during its life cycle. Because of only one replica or very less replica of any message, this technique does waste the network resources like bandwidth, buffer, and energy. While in flooding type of algorithm or technique number of replica of any message exist. Message replicas are flooded among the nodes in the network so this technique ensures the maximum delivery at the cost of replicate messages. Flooding techniques waste the network resources as high as replication will be there.

A. Forwarding

Some algorithms are First Contact, Spray-and-Focus [15], etc. First Contact said that node send a message randomly through any available node. But if no one path is available to transmit the message then it wait until the path is available and then to the first available contact node. The main dis-advantage of this technique is opportunity of successful message delivery is very less but in the other hand the main advantage of this mechanism is it utilizes very less network resources like buffer space, bandwidth and energy.

B. Flooding

Some of the DTN routing protocols belong to this category such as Epidemic [16] routing algorithm. In this algorithm, messages are transmitted from one node to all the other encountered nodes. This algorithm ensures the maximum successful delivery of the message to the destination but exploiting a huge amount of resources like "energy" , "buffer capacity" , and "bandwidth" etc.

C. Control Flooding and forwarding

To heighten and control the overhead ratio and the resource utilization cost respectively caused by flooding algorithm, use control flooding based technique. In controlled flooding, scheme node can flood the rigid number of messages copies to encountered nodes depending upon the protocol decided. So the algorithm which belongs to this type of scenario is Spray-and-Wait algorithm. The spray-and-wait algorithm is a two-phase algorithm i.e. spray phase and wait phase. Spray phase is for spraying K (value of K is decided by an algorithm) number of message copies by a source node. Source node forwards the copy of the message to first K distinct relay nodes and one of the nodes will be a destination node. In wait phase relay node directly forward the message to the destination node. It means the relay node find out the destination node first rather than blindly forward the message to the intermediate node. So this technique is known as control forwarding.

D. History Based Routing Algorithms

It is another type of algorithm in which nodes preserve the history of other encountered nodes with itself while roaming through the network area. Very few algorithms are belongs to this category and some of them are PRoPHET, CAR, ZebraNet and MaxProp.
In ProPHET each node measure the probabilistic metric at every node for some well-known destination. Probabilistic metric in PRoPHET defines the delivery predictability. Delivery predictability measure the chance of delivering a message to the destination node. ZebraNet is also a history-based algorithm in which wireless sensor nodes are attached with the zebras neck and this device is known as a collar. The collar is a device that operates through a battery. ZebraNet is used for the study of animal behavior. Location of data and history about the nodes are collected by sensor nodes when they go through with any radio range of a base server.

And the third history-based routing algorithm is Context-Aware Routing (CAR). In this algorithm delivery of the message based on the combination of two-mode that is asynchronous and synchronous mode. In synchronous mode, the end-to-end path is pre-decided before the delivery but in asynchronous it is not pre-decided during message delivery. In a synchronous mode, any message delivery node gets disconnected from the existing network then synchronized way of delivery cannot possible. In this scenario, CAR does not flood the message to all the connected node instead of to send the message to the node which is having a high probability of reaching the destination node.

III. FFHBR:THE HISTORY-BASED ALGORITHM

A. Background of the work

Some VDTN issues are:
1) We are considered a vehicle as a mobile node. Because of the high speed of vehicles, they meet each other for a very short duration of time. Due to this type of activity they can transfer a very few messages to each other.
2) Nodes may meet to each other very frequently if they follow some predefined routes. It is also possible that node can visit the same location again and again as like college student or office employee. So, the history that is created by an encountered of mobile nodes with some other relay nodes may have a remarkable impact to take the forwarding decision for a certain destination.

Based on the above two characteristics of VDTN, we propose FFHBR (Flooding and Forwarding History-Based Routing) algorithm. In this algorithm, history is maintained by a source node and mobile nodes and history contain the past encountered information with various relay nodes in the network.

B. Assumptions are to be taken:

We are taking some assumptions for the algorithm FFHBR
1) Generic Assumptions: Some generic assumptions are following as
   a) Within the network, each node having the unique characteristics which are transparent to all the other nodes in the same network.
   b)) In FFHBR, two types of terminal nodes assume: one is source node (S) and another one destination node (S). Again we assume that both nodes are stationary nodes and placed at two different ends of the network.
   c) All the vehicles who are carrying network devices acts like mobile nodes that carry the message among themselves
   d) Any mobile node follow any routes i.e. fixed or random routes.
   e) Assume relay nodes as stationary nodes, called Road Side Unit (RSU) is placed in the network at the different intersection. These relay nodes are used for Store and Forward mechanism. Due to the placements of RSU, delivery ratio could also be improved.

2) strategy for message creation:: Messages are only created by a source node.
3) Message replication strategy: Source node, Mobile node and relay nodes apply selective flooding and forwarding.
4) Dropping and scheduling strategy::
   a) Random Scheduling strategy will be applied for the selection of any random message form the queue.
   b) Dropping strategy based on TTL. Message will be dropped from the queue at TTL=0.

5) Flooding and Forwarding policy:: We will use selective flooding and selective forwarding mechanism as described in the next section.

C. The Algorithm

Our algorithm is a two phase algorithm. First phase is for history creation of relay node node counts.And message dissemination is a second phase.
1) Phase-I (History Creation or updating): Table-I Describe the stored history at various nodes. Initially we take history of source node and mobile nodes Null.

Node Type	Stored History
Mobile node and Source node	Mobile Node id (MOid), Relay Count (RC)
Destination and Relay Nodes	NA

TABLE I

HISTORY STORED AT VARIOUS NODES

The first scenario is, when the various relay nodes are encountered with the mobile node at the very first time then mobile node set their RC value in its history table. When any mobile node MO passes by the source node S, source node snatch all the history from mobile node MO about their encounter with any relay node and creates the history by storing the information from the mobile node as MOid and RC.

And the second scenario is, when mobile nodes are encountered to each other in a very starting moment then they also create the history as a like source node and interchange the history with each other. Source node updates their history table all the time when they encountered with any mobile node more than once. The mobile node also does the same as like source nodes for updating their history table.
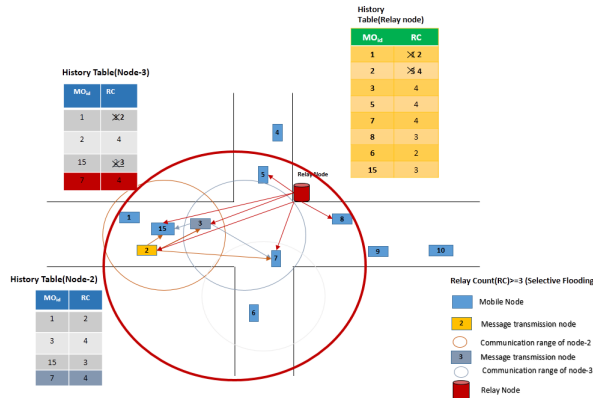

Fig. 1. Message transmission(Selective Flooding)

2) Phase-II (Message Transmission): It is based on two scenario-

In the first scenario, whenever a mobile node (MO1) interacted with some other mobile node (MO2), it checks the history about that node on their history table. Node MO1 find the best candidates for flooding the message as finding those candidates whose RC value greater than d. This mechanism is known as control flooding. If all the candidates having RC value less than d then choose the maximum RC value from them and forward the message to that corresponding node. This mechanism is known as control forwarding.

In the second scenario, whenever a source node(S) find the mobile node in its neighbor or in their area, S checks their history table for that mobile node whether the history of that mobile node is present in its history table or not. If S found the history for all the mobile nodes which are currently in their range then flood the message to those mobile nodes whose RC value is greater than d. If all the node present in the history table having RC value less than d then forward the message to that node who is having the highest RC count.

In both scenario, if mobile node having the same RC value or none of them having the RC value greater than zero then select one of them randomly and forward the message. This technique is also known as random forwarding technique.

D. Working of FFHBR

Above table represents the history stored by various nodes. Initially, the history stored by the source node and mobile nodes is null. But when the mobile nodes encountered with various relay nodes in the very beginning stage then they set their relay count field in the history table. We are running FFHBR algorithm in two phases- rest is the same

Phase-1 is history creation phase in which history is created by relay nodes and source node and Phase-2 is message transmission phase. In both Figure.1 and Figure.2, history is created by the relay nodes and source node but these two phases differ in message dissemination. In Figure.1 selective flooding is used for message transmission and in Figure.2 selective forwarding mechanism is used for message transmission. The deciding factor of choosing one of the mechanism is based on relay count (RC) value. In FFHBR we are using d as a threshold value that will be changed map to map. If the relay count (RC) will be greater than or equal to d then selective flooding mechanism (Figure.1) will be applied for message transmission and if relay count will be less than d then selective forwarding mechanism (Figure.2) will be applied for message transmission. In Figure.1 and Figure.2, mobile node 2, mobile node 3 and the relay node create the history just for example. History is created when the mobile nodes come to contact. We also tried to show the contact area or we can say that the communication range of node-2 and node-3. when they encounter they exchange their information and update their history table continuously after some period of time. When mobile node encountered by source node or relay node then the relay node fetches the information from the mobile node. In both the figures, message transmission has to be described earlier, how they forward the message by using measuring factor relay count (RC) value and the threshold value d.

In both the scenario, if the relay count value of the mobile nodes is either same or less than zero then select any of them randomly and forward the message.
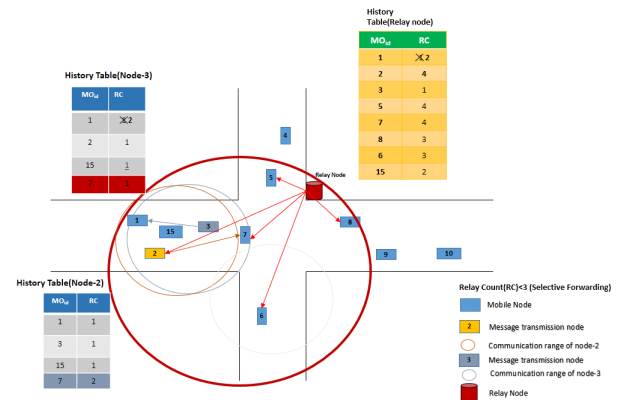

Fig. 2. Message transmission(Selective Forwarding)

IV. EXPERIMENT AND RESULTS

Opportunistic Network Environment (ONE) [5] simulator is used for this algorithm. Some assumptions are to be taken for the execution of this algorithm. We have considered the simulation area of 3500m * 3500m. All the nodes (i.e. source node, destination node, mobile nodes, and relay nodes) should be in the network. We set node transmission speed 2.5 Mbps and transmission range we take 12m. In our algorithm, we have assumed that there are two types of stationary node i.e. terminal and relay nodes. We have also assumed that there

are a single source and single destination node in the network. And they both put the extreme end of the network. Source node creates a message and destination node receive the message. We are taking 10 relay nodes and mobile nodes are varied from 40 to 240. We are taking fixed buffer size i.e. 80Mb for all the types of nodes. Random waypoint model is the reference for mobile nodes. Size of messages is chosen randomly from 512KB to 1.5MB. We initialize the TTL value as 350 minutes. Total simulation time has been set to 22500 seconds.

Some performance measures have been considered-

a) Delivery ratio: It is defined as the total number of messages are reached to the destination over the number of all messages are created.

b) Average delivery latency: Average Delivery Latency: it is defined as time taken by the messages to reach to the destination over total number of messages delivered.

c) Overhead ratio: Over Head Ratio: It is described as the ratio of the difference between number of relayed message and delayed message to the number of delayed messages.

Now we have compared our algorithm that is FFHBR with some popular existing algorithms like CONHIS, Spray-and-Wait and PRoPHET. We have set number of copies to 4 for spray-and-wait algorithm.
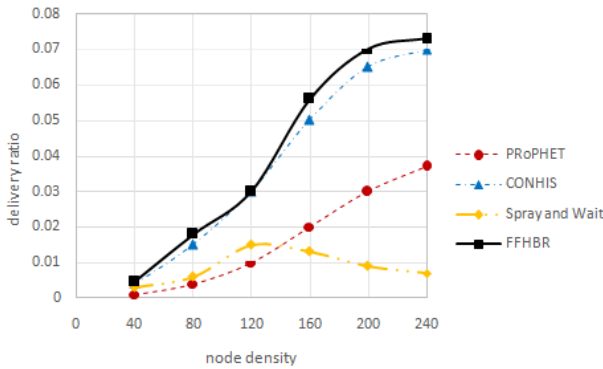

Fig. 3.   Delivery Ratio vs. Node Density

Working Scheme: we can see the effect of changing of mobile node density on three parameters like delivery ratio, overhead ratio and average delivery latency of all the mentioned history based algorithms with variation in the number of mobile nodes.
Figure 3 describes the number of mobile nodes which are varied from 40 to 240. All the given algorithms delivery ratio has increased. We can clearly observe that FFHBR algorithm has a tremendous delivery ratio. This is possible because node density is directly proportional to the number of contacts made by the nodes with the other relay nodes. As we increase the density of the nodes, a number of contacts also increases, therefore, relay count (RC) value also increases. Without any doubt, we can say that the heart of FFHBR algorithm is their relay count value.
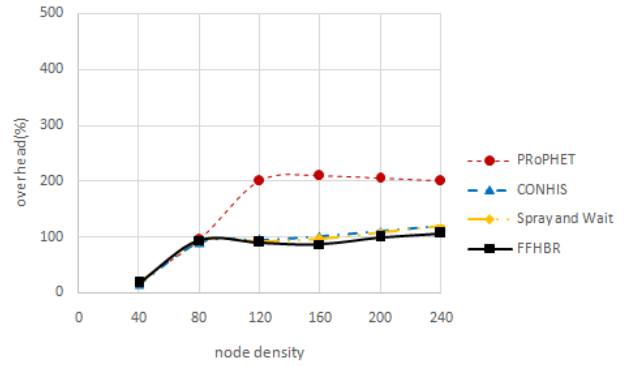

Fig. 4.   Overhead vs. Node Density

Figure.5 describe the relation between average delivery latency with respect to the node density. FFHBR again perform excellently in this criteria as compared with the other mentioned algorithms. When the number of nodes is increased from 40 to 120 in figure 5 then delivery latency has increased drastically. But between 120 to 160 delivery latency decreases. This is possible because as we increase the mobile nodes then selective flooding and selective forwarding play their own task very efficiently.

Figure.4 describes the overhead with respect to node density. FFHBR perform better in terms of overhead with respect to CONHIS, PRoPHET, and SPRAY-AND-WAIT algorithms. This is possible because when the number of mobile nodes increases then relayed messages develop very faster rather than the delivered messages.
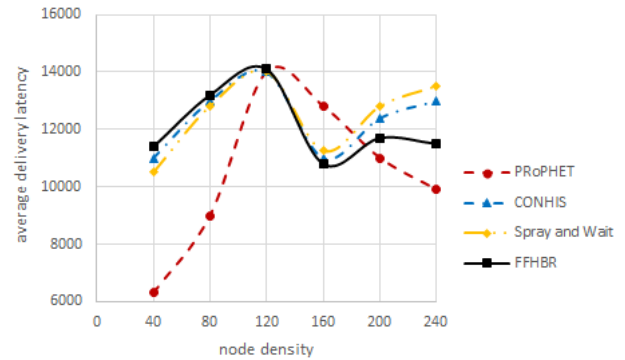

Fig. 5.   Average Delivery Latency vs. Node Density

V. CONCLUSION

We have developed the algorithm based on contact history called FFHBR. Working of FFHBR algorithm based on two mechanisms called forwarding and flooding mechanism. Decisions are taken whether the mechanism should be flooding or forwarding based on values called relay count values (RC).

VI. FUTURE WORK

In FFHBR, we are using only one parameter to take the decision called relay count (RC) value but in future, we can use some other

parameter like destination meeting count (DMC) and contact duration (CD)

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