A Performance Comparison of Information Sharing Protocols in VANET

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Abstract

With the advancement of VANET Different algorithms and architectures has been proposed for sharing information among each other in VANET environment. This paper presents the performance comparison study of information sharing in vehicular ad-hoc network using Hovering Information, Floating Content, AutoCast and Position Based Gossiping based on one performance matrix. The performance was analyzed based on memory usage, delivery cost, bandwidth usage and number of irrelevant packets received by each node. To achieve the best results all protocols have been simulated using the similar simulation settings. We have performed experiments on different traffic model in order to observe the behavior of protocols in different traffic situations.

Keywords: *VANET protocols; information sharing; protocol survey study; floating content; information hovering; position based routing*

1. Introduction

Traffic information systems (TIS) and traffic decision making systems are one of the important branches of information systems that deal with the traffic data and decisions [2]. As explained in [4] the traffic systems are generally divided into three levels that are collection and cleansing of data, inferring new data or information from existing data and distribution of data among other vehicles. In the data collection and cleansing phase all nodes collect row data using their local sensors, filtered and analyze data, and save it into local sensor repositories. In the second phase if there are some local decision making applications in the vehicles they take new data and apply rule or their decision making algorithm to make new decisions that are share with the other vehicles, Geographical information Systems (GIS) and external traffic information center (TIC). It is also not necessary that vehicles distributes data recorded by the sensors but they can also share other information like road maps, traffic jam information, address to some place etc.

The major issue in infrastructure less TIS or VANET is efficient distribution of information among vehicular nodes. There is alto of research in the area of information dissemination in VANET [1]. In this paper we have some of these information dissemination algorithms and perform a comparison among these. The algorithms we studied for information distribution in VANET in this paper are AutoCast [4], Position based grasping [9], Floating Content [8] and Hovering Information [7]. All of these algorithms have their own straight and weaknesses. Floating Content is a distributed optional of a short-lived content sharing service with a small dependency on the mobile devices in the locality. It uses opportunistic networking principles and allows users to create messages, define their

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geographical origin, geographical radius, and validity radius also called anchor zone in which message or information is useful along with time validity of the information. The protocol uses Euclidean Distance is the distance calculation function and epidemic routing as the routing algorithm. As a new message created it starts delivering algorithm unless the geographical boundary arrived.

Information Hovering is one of the new idea for sharing information in ad-hoc network. A few works has been done in this area also however it is not very popular yet. Hovering information can be consider as an innovation among the research being done in the area of ad-hoc networking especially in VANET. The main idea of Hovering Information is not information dissemination only but storing and preserving information within its anchor area. Information hovering encourage as much as replicas can of a message can be created with in anchor area. The anchor area is defined by a centralized point and a radius along that anchor point. It uses Attractor Point Replication Algorithm to create replicas of the messages within anchor area.

Position based grasping is a direction based information dissemination algorithm that is used only to disseminate information in a certain geographical area. Unlike Hovering Information and Floating Content it doesn't have many mechanism for information storing so to store information another application is required in case of this protocols. PbG do directional broadcasting and is specially design for vehicular ad-hoc network. Its dissemination mechanism is based on parent child relationship where parents are only allowed to disseminate new message and child receives these information only. This parent child relation is stored in the routing table that is updated periodically using beacon messages. Children can only forward the message to their children not their siblings to avoid the duplicate message forwarding. PbG is one of the best approaches to avoid duplicate dissemination of messages.

AutoCast is information dissemination mechanism that works with the Hovering Data Clouds in vehicular network and was designed as part of AutoNomos project. Hovering data clouds (HDC) can be explained as virtual structures for independent of particular carriers. HDCs is similar to a distributed structure of collective individual processors and considerable effort that is used to spent to ensure that everything has done it its way. HDCs can be considers as an enhancement of Hovering Information where the concept of hovering moves from information to clouds. Building virtual clouds in vehicular corresponds towards resource and information sharing within small networks as well where nodes with less resources can get benefits from the nodes having more resources.

The rest of the paper is organized as follows; Section 2 briefly explains above described four information dissemination algorithms. In section 3 we present our study and evaluation results in accompany with comparison study followed conclusion in section 4.

2. Information Dissemination Algorithms

2.1. Optimized Position Based Gossiping

Position Based Gossiping (PbG) [9] is based on message propagation and vehicle movement and it was specially designed for street movements. Hence the messages are only forwarded with respect to directing directions on the roads; the algorithm establishes a dependency graph using position data of nodes. Based on the dependency graph each node calculates its forwarding probability for each message before forwarding it to its neighboring nodes. Each node in the dependency graphs has three types of neighboring nodes, parents, siblings and children. For a node, parents are the nodes from where it receives new messages, siblings are neighbors that also receive new messages from the same node it receives – common parent node – and children are the nodes to whom it forward the message.

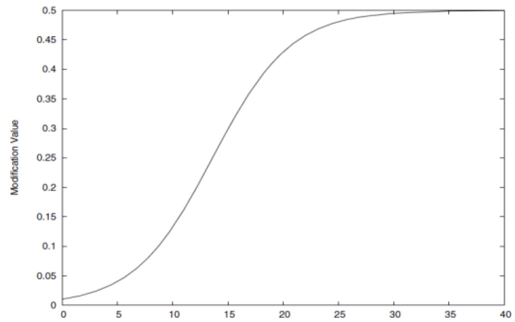

Figure 1. Relationship between a Number of Nodes and Reduction Value

Based on the neighboring table, forwarding probability is calculated using the parents' nodes and it also depends on the parents nodes as well. The probability remains low if there are few parents and it starts raising as the number of parents starts increasing. After computing the forwarding probability each node playback it's computed value that is used by the parents to set the routing path. As PbG disseminate information in once direction however VANET applications usually need to disseminate information in both directions, PbG requires two routing tables – one for each direction – to accomplish this goal. The protocol further has a reduce function that reduce the probability with respect to density to make the probability more realistic. If there is more probability it there will be more broadcasting as the probability depends on number of parents thus number of duplicate messages will increase and more bandwidth will also be used. Hence probability should be decreased by some factor. Figure 1 shows a relationship between a number of nodes and reduction value respective.

2.2 AutoCast

AutoCast [4] protocol in an enhancement of MIME – that was originally designed to share location information among vehicles – to make it workable for generic data sharing by making following improvements, 1) Reduce the amount of periodically needed data 2) Reach locally consistent states in the network

MILE stands for mobile information location exchange and it exchange information in round robin format. MILE [5] requests the updated information after a specific period of time. On each update the old information that is not confirmed in next update are deleted and new information is added. On this approach AutoCast was extended to share all kind of information. To overcome the issue of information updation and deletion it gives the information identification number to the messages that is used to determine ether the piece of information is alive or it has been obsoleted. However AutoCast does not take time base deletion into consideration. AutoCast was applied in Hovering Data Clouds where it was further extended for geographical based information sharing among the vehicles.

2.3 Floating Content

Floating content [7] is a technique for sharing information amount a MANET or VANET however it was designed especially to share information among mobile nodes in an urban area. Let I is piece of information or a message with a size $s(I)$ and certain lifetime (TTL) along with anchor zone already defined by sender. An anchor area can be defined using central point C and radius R as shown in Figure 2. R depicts the replication range where the nodes always try to replicas message on the other nodes. Availability range defines area where the message is used to keep in that defined area limited number and outside that area there will be no copies outside that area. When two nodes A and B meet in the anchor zone for a message I where A has the message and B doesn't have piece of message then A sends the message to B. Because the replication of messages depends on nodes' location thus each node must have copy of message however nodes anchor area can delete the message. *R(h)* represents probability of replication outside the replication area and it is between [0-1].

$$p_r(h) = \left\{ \begin{matrix} 1 & if\ h < r \\ R(h) & if\ h < r < a \\ 0 & other\ wise \end{matrix} \right\}$$

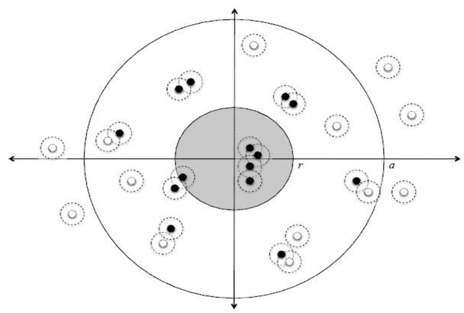

Figure 2. Anchor Zone of Floating Content

Each floating content message is identified using unique message deification number and contemns anchor space zone, anchor point in the headers where content and its size in message body. Floating point algorithm is a four point algorithm these points are as follow; In the first step, each node continually sends became messages for neighbor discovery. After receiving beach message in the second step nodes reply with the message containing list of messages available for replication on other nodes. If the summery accede from the maximum size of single message it can be limited to maximum size of a message the list of content is send using multiple summery messages using round robin fashion. As the device becomes aware about the messages its neighbors have, it requests for the subset of messages and receiver responded back with the all message not expired and in the anchor or replication area. This is the third step of the protocol. The order of messages can be change with respect to the priority that can be set using replication policy that determines the priority of replications among the messages. Finally in the last step the sender keep sending the requested items until it lost the contact and connection breaks.

2.4. Information Hovering

Hovering Information [9] enables sharing of information in a specific geographical area that is kept alive or stored for only that particular topographical content [1, 2]. A piece of hovering information is generated by some application running on a specific node and is valid for a specific geographical area called hovering area. Each node within hovering area stores and broadcasts the hovering information periodically within its own domain where nodes in hovering area may be connected to each other through ad-hoc connectivity. Part of hovering information is omitted when nodes leave out of hovering area.

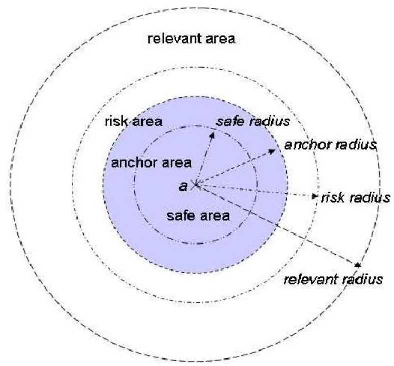

Figure 3. Information Hovering Safe, Risk and Irrelevant Areas

A hovering area can be divided into three different segments namely safe, risk and irrelevant areas as shown in Figure 3. Each piece of hovering information contains information about its safe, risk and irrelevant areas in its header. In the safe area information is consider safe at it doesn't need immediate replicas where in the risk area the information looks for the nodes towards the safe area to replica itself and in irrelevant area information can be deleted. Anchor Point algorithm is used for flooding of message. Followings are the steps of Anchor Point Algorithm.

In the first step the algorithm checks the position of the nod and position of neighboring nodes and finds the distance among itself and its neighboring nodes in the next step. In third step it checks if there exists any hovering message that can be disseminated to the nodes in the next step and finally it disseminate the information to the nodes present in the hovering area.

3. Performance Evaluation

We evaluate the performance and behavior of these four algorithms for vehicular environment, under various scenarios by varying number of vehicular nodes. Our performance matrix message complexity, message average arability, message replicas, irrelevant messages and average query response time to obtain a piece of information from other nodes. Furthermore we evaluated the mobility behavior for all four algorithm using different mobility models.

We perform simulation using NS2 network simulator [11]. All simulations were performed on Ubuntu 11.0 operating system using NS 2.35. We use the machine having 2.5 Core i5 with 2 GB of RAM for our experiments. For each simulation we chose the information provider nodes randomly that are 30% for the total nodes involves in the simulations. This is quite a reasonable amount of message provider to evaluate information dissemination algorithms in a vehicular network. The moving speed of vehicles was set to 40-60 km/h that is also a generic speed of vehicles on the road. In order to measure the message complexity, arability and replicas we uses the constant speed of the vehicles however for mobility evaluation we use speed set of 20-80 km/h at normal rode and 40-120 km/h at highway.

Figure 4 shows total number of messages exchanged during the time of 300 sec. Number of exchanged message imposes direct effect on the usage of bandwidth as many messages will be exchanged as much bandwidth and network resources will be used. More number of messages also effect the battery performance however in vehicular network we usually don't care about the battery usage as vehicles has long time batteries unlike sensor network where do have to really worry about the usage of power and battery. As we seen in the figure hovering information exchanged more messages because of its greediness for more and more message replicas. Floating Content is second greedy algorithm in this regards, however AutoCast and Position based Grasping send less messages then floating content and hovering information.

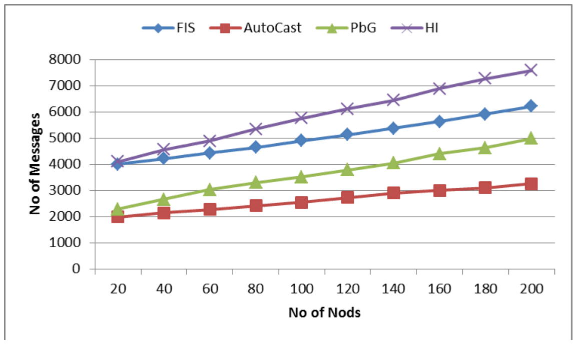

Figure 4. Number of Messages Exchanged

The second parameter we evaluated was average availability (see figure [5]) of the message with respect to time. A message in a network can disappear because of two major reasons, 1) the node carrying message went outside the anchor area of the message and is no more able to communicate with the nodes in the hovering area 2) life of the message expired and it needs to be deleted. Figure 5 shows the average arability of the message. Arability of the message is the time between receiving and deletion of the message. Figure shows the average value of 200 messages per node. Because Average availability has more concern with the geographical location thus all algorithms perform similarly that leads towards the the discussion of that can information dissemination algorithm effect the average availability of the message?. In our view it doesn't affect the availability because of its dependency on TTL and geographical location instead of information dissemination.

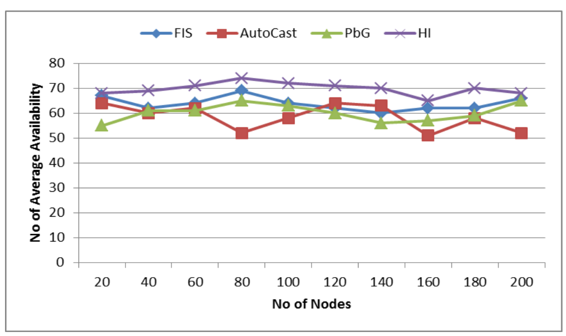

Figure 5. Average Availability of the messages

Figure 6 depicts the average message accessibility that is third parameter of our performance matrix. Availability of some message is ratio between total number of nodes in its anchor area and total number of nodes who can get the message. Similar to the message availability, message accessibility also have no dependency on the information dissemination algorithm however it depends on the mobility and speed of the vehicles. There will be high accessibility if vehicles are moving with slow speed however as vehicles start moving with the fast speed the accessibility of the information start decreasing. We identified the two reason for this rational during our study. 1) It is because of vehicles leaves the geographical area very quickly and 2) because of high speed vehicles cannot establish a connection with the source node. If the size of message is large the possibility of failure increase because of connation problem however when the message size is small it is more likely easy to transfer message over the network.

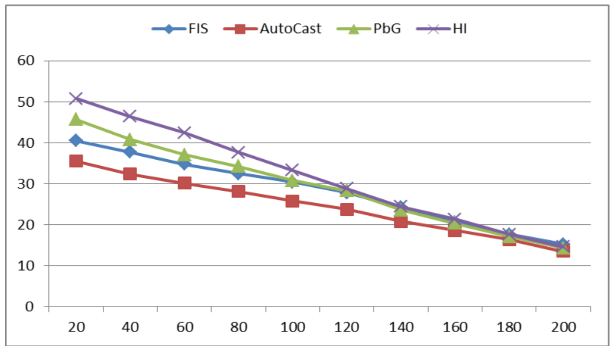

Figure 6. Average Availability of the Messages

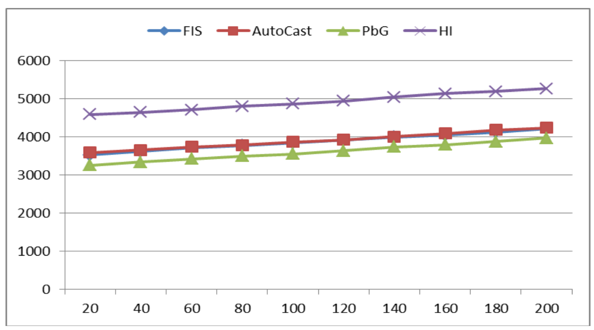

Figure 7. Number of Message Replicas

Message replica is one of the important concepts of information sharing that increase the accessibility of the information. Number of replicas directly depends upon the number of nodes in the anchor area. Figure 7 shows message replicas for 200 messages during the time period of 300 sec on varying number of vehicles. Similar to message exchanges shown in Figure 4, information hovering as greedy here in again following by floating contents. However instead of network bandwidth message replicas affect the storage and processing power of vehicles. Since vehicles do not have much space and much processing power this is a critical factor that we find in our study. Because AutoCast and Position based Grasping do not deal with storage and don not includes any such algorithm for storage of message, we apply a condition that each node receive a message forward the packet up to 3 hops and each node stores the message up to its geographical location and TTL. This was to ensure the similar behavior for all algorithms. For our experiment we distribute the vehicles uniformly in order to get more realistic. However we also find that if there will be some rush on some road there will be more replicas.

4. Conclusion

In this paper we studied the information sharing protocols for Vehicular ad-hoc network (VANET) using the simulation methodology and presented a comparison of four well know VANET information sharing protocols. For our evaluation we use message accessibility, message availability, number of exchange message as the performance matrix. Our study shows that these factors or important in VANET information sharing. Although different algorithms handle these issues differently thus the results become very from each other. However, overall all algorithms address these issues. Our experiments also show the need for improvement in message accessibility and availability in VANET information sharing.

Acknowledgements

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