

A Brief Survey on Performance Analysis and Routing Strategies on Vanets

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Abstract

Background/Objectives: To analyze the performance and find the challenges of routing in VANET. **Findings:** VANET protocols should be designed in such a way that a link should be established between the nodules in a nexus for efficient communication. Routing protocols are developed usually based on the two types of communication (i.e.) Vehicle to Vehicle (V2V) communication and Vehicle to Infrastructures (V2I) irrespective of their environment. This paper gives a survey of about the various routing protocols in VANETs, their main characteristics and their pros and cons which help for the further enrichment of the same. **Applications/Improvements:** The results observed from this work will motivate to improve the issues in VANET and to enhance the routing protocols.

Keywords: Greedy Forwarding, Issues in VANET, Routing Protocols, VANET

1. Introduction

Vehicular Ad hoc Nexus is an increasing area of interest for research in the Intelligent Transportation System (ITS). In the ITS each of the vehicular nodules act as the router, transceiver or the receiver broadcasts various safety or non-safety information to the other nodules in the same nexus. VANETs use cars as the mobile nodules which allow each of it to communicate to each other to a distance of approximately 100 to 300 meters. The application of VANET is that it broadcasts the safety measures along with the vehicle's velocity and location without embedding the infrastructure. The VANETs make use of the wireless technologies (IEEE 802.11) such as the Wi-Fi, Bluetooth, etc. But all these do not support the highly dynamic nature of the vehicular nodules. The IEEE 802.11p was specially designed for the vehicular environment and was derived from IEEE 802.11. These plexus are found to be highly dynamic such that if a car falls out of the nexus other cars can tie up together to form a new nexus. Hence a special standard has been developed for the VANETs which are IEEE 802.11p which

supports a highly dynamic nature of the nodules in the vehicular plexus. The two basic components that are involved in the VANETs are the Roadside Units (RSU) and the Onboard Units (OBU). The OBU is an in-built vehicle radio and it consists of a transponder which is a wireless communication or a monitoring device that picks up and automatically responds to the incoming signal. The RSUs are the antennas, transmitters and the receivers which are used to receive and to transmit the signals. Nowadays, the number of vehicles is increasing at a very high rate and the rate of accidents has been proportionally increasing. Hence the VANETs have been developed in order to provide safety information, interruptions and crashes on the roads and also provide various other information's such as alternate paths of travel, etc.

1.1 Architecture

The VANET architecture is of three types (i.e.) pure Adhoc, pure cellular and hybrid architecture. The pure Adhoc architecture represents that the communication takes places directly between the vehicles in the nexus. The pure cellular architecture depicts that the communication takes

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place between the vehicular nodes and the Roadside Units (RSU). The hybrid architecture is a combination of both the architectures and is most commonly used for all the research developments.

2. Computational Models

The architecture of VANETs depends on the communication types. Two types of communication takes place that is classified as Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I) and Vehicle to Roadside. Hybrid architectures are also constructed where the communication takes place between Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I).

2.1 Vehicle to Vehicle Communication

Vehicle to Vehicle communication also known as the inter-vehicular communication refers to the communication that takes place between the drivers and the vehicles in the ITS. It takes place among vehicles within a short range and provides fast and reliable passing of information to enhance road safety that is effective in a speed of about 80 km/hr and a range of 80 km. Communication does not get affected depending on the size or the type of the vehicle that is Vehicle to Vehicle communication does not get affected by the Vehicle Shadowing. Communication takes place by means of the On-Board units and provides the service of exchange and distribution of data. Very High Frequency (VHF) and microwave frequencies are used that it broadcasts the messages. Communication also takes place between the vehicles by means of Bluetooth which operates at 2.4 GHz. The disadvantages of the Vehicle to Vehicle (V2V) communication are that there may not be a continuous connection between the vehicles due to the high maneuverability of the plexus and the address of the vehicles are most often not known to each other in the case of a highway scenario. The messages about the location can be broadcast periodically, but the address positions keep changing due to the dynamic nexus.

2.2 Vehicle to Roadside Communication

In Vehicle to Roadside communication the interaction takes place between the Onboard Units and the Roadside Units. The Onboard Unit is inbuilt in the vehicles. It itself is a transponder where the exchange of data take place automatically. The transponder refers to a wireless device used in communication to monitor and to control the devices by picking up the incoming signal and responding

back to it. The Roadside Unit refers to the antennas, the transceivers and the receivers. Sensors are placed on various locations on the roadways. The Vehicle to the Roadside communication takes place at a frequency of 63 GHz. This frequency provides a very high bandwidth such that the communication takes place efficiently between the vehicles and the roadside traffic units. Using the bandwidth and the wavelength the drivers will be able to obtain the traffic information, access the internet, share media, etc. The major application of this type of communication is the Electronic Toll Collection (ETC.).

3. Issues in VANET

Though VANET is an increasing area of research and various methodologies have introduced there are also problems related to each methodology. The various issues addressed in VANETs are

3.1 Flooding in the Initial Phase of Route Discovery

Flooding refers to the process where the packets are broadcast from one node to all the other nodes excluding the source node. This causes a problem in route discovery where all the nodes broadcast its routes which cause flooding.

3.2 Delay

Delay refers to the transmission of the packets late or out of time. The importance of VANET is to transmit the information in order to avoid collision or transmit information about the traffic or the weather conditions. If the packets are delayed it could demolish the importance of VANETs.

3.3 Increasing Nexus Congestion

Nexus congestion occurs when a node carries a large amount of data such that the quality of service depreciates. In urban areas when the traffic density increases the nexus congestion also increases depreciating the QoS of VANET.

3.4 Bad Performance due to the Distance

When the distance increases between the vehicles the V2V communication becomes ineffective. Hence, the roadside units have to be implemented which increases the cost of installation.

3.5 Duplicate Packets

Duplicate packets may also get transmitted in the plexus. If packets are delayed and transmitted at very much later rate then it can also be indicated as the duplicate packet.

3.6 Link Breakages

Vehicles always form a link with another vehicle in order to transmit the data. If the links between the vehicles break then the messages could not be transmitted which leads to the nexus congestion.

In order to transmit the information in an efficient way the routing protocols play an important role. As a preliminary process before the beginning of the communication, the link has to be established between the nodes in the nexus which occurs with the help of the vehicular routing protocols. The protocols should be designed in such a way that it should be able to choose the best path and also operate efficiently even in case of failure of any nodes. The evaluation of the protocols is mainly based on the parameters such as bandwidth, jitter, delay and the overhead ratio.

4. Routing Protocols

4.1 Position based Routing

4.1.1 Forwarding Strategies

There are various forwarding strategies that are used in the position based routing protocol. Each node usually consists of the routing table which periodically broadcast its information to the neighboring nodes. Hence the next hop is chosen based on the implementation of the various routing strategies¹.

4.1.1.1 Greedy Forwarding

In this type, the packets are forwarded in such a way that the source consigns the packet to the node that is closest to the terminus.

4.1.1.2 Improved Greedy Forwarding

In this type, the source node first gathers the information from the routing table based on the velocity and the direction and then it propels the packets closest to the destination.

4.1.1.3 Directional Greedy Forwarding

In this type, the source sends the packets to only those nodes that travel in the direction of the destination and also that is closest to the destination.

4.1.1.4 Predictive Directional Greedy Forwarding

In this type, the sender consists of the information about the next two hops and then forwards the packets in such a way that it selects the nodes depending on the information in the table and the node that travels in the same direction and closest to the destination.

5. Protocols

The position based routing protocols can be applied to both architectures (i.e.) Vehicle to Vehicle (V2V) and vehicle to Infrastructure (V2I). There are various position based routing protocols available, which is used to find the location of the node and also its neighbor node using the GPS. It does not maintain a routing table which forms a major drawback while forwarding the packets. It is classified into three types as Delay Tolerant Plexus (DTN), Non Delay Tolerant Plexus (N-DTN) and Beacon Plexus². The DTN uses the store and forward technique where when no nodes are found nearby it stores the packet in the corresponding node and when the neighbor node becomes available it starts forwarding the packets. The N-DTN are highly used where the vehicle density is high and does not consider the connectivity that happens at irregular intervals. Beacon nexus sends small hello packets to check for the route or link information and if any link fails the entry is deleted from the routing table.

5.1 Geographic Source Routing (GSR)

This type of routing chooses the path of travel in such a way that it consists of a number of junctions through which the packet containing the information has to journey to reach the destination but, it does not take into consideration of the traffic in the plexus. This makes use of the greedy forwarding technique to traverse the packet and the path with the minimum cost is found using the Dijkstra's shortest path algorithm. The GSR³ can be implemented only in the city environment. Using the GSR high rate of packet delivery can be achieved, but the limitations are that it rejects the situation where the nexus density is

high and it also has a high routing overhead. For example, Source sends route request to the destination. Since it does not know the route it initiates the route discovery. While forwarding the request it appends its own address in the packet header. Below this is the following diagram for DSR. Using greedy technique, it forwards the packets. Thus it provides two routes as S-A-B-D and S-E-F-D. It treats the shortest path as the best path therefore S-E-F-D is the path where source node S sends its route request to its destined node. The reply requests have been sent in the reverse order.

5.2 Anchor based Street Traffic Aware Routing (A-STAR)

A-STAR is used to calculate the junctions available to reach the destined location. This type of routing uses traffic information and street awareness in path finding. If any of the paths has a high traffic density (Local Maximum Problem)⁴ then it has been marked as 'Out of Service' temporarily and the information has been propagated throughout the nodes in the nexus.

5.3 Connectivity Aware Routing (CAR)

This routing is used to identify the route to the terminus. It maintains a routing table that consists of effective beeline between the start and the end pairs and can also periodically depict the change in position of the nodes in the case of mobility nodes⁵. The nodes in the nexus continuously send the hello packets in order to find the position and the velocity of the other nodes in the nexus. A node determines itself as the anchor node if the celerity vector of the node is not equidistant to the celerity vector of the previous node in the packet. No digital map is required. When the traffic environment changes, it cannot adjust with sub paths.

5.4 Greedy Perimeter Stateless Routing (GPSR)

In GPSR, the node expedites the information to the corresponding node that is geographically adjacent to the destination. Each node periodically sends the message with their identification number and position. If the message is not received by the node, then GPSR assumes that the node is not valid at certain instances and hence removes it from the table.

The recovery strategy may also be applied in the case when the nodes encounter a local maximum where

the packets are propelled to the next node that is very much closer to the destination. GPSR⁶ applies the greedy forwarding technique while the recovery strategy uses the perimeter forwarding technique. For example, source node S reaches the destined location by choosing the closest path. Traversal is given as S-G-H-I-D. In case of perimeter forwarding, it traverses through the circumference of the node.

5.4.1 Street Topology based Routing

This routing is used to calculate the connectivity at junction nodes. Master node is responsible for this connectivity. Every master contains two level junction neighbors⁷. In the first level, information is sent directly to junction nodes through neighboring nodes. In the second level, information is sent through their neighboring nodes and then to their own junction. Packets are forwarded to their correct destination. Their routes are formulated using Dijkstra shortest path algorithm.

5.4.2 Spatial and Traffic Aware Routing (STAR)

The source node which wants to forward a packet constructs a weighted graph employing the street map and the traffic information. The packets are forwarded in such a way that from the anchor nodes the packets are sent to the other anchor nodes until it ambits the final anchor node that is responsible to forward the data to the target node. The edge with less traffic is given high weights and the one with high traffic is given less weights. It suffers collision. The Dijkstra algorithm is implemented to identify the shortest path⁸.

5.4.3 Greedy Traffic Aware Routing Protocol (GTAR)

Greedy Traffic Aware Routing Protocol uses carry and forward technique to restore from local maximum. It selects the junction effectively to find the possible routes. GyTAR assumes the information that number of cars is given for each road in the nexus and also contains information about the connectivity between the nodes which are obtained from the Roadside unit⁹. To transmit the packet, Greedy strategy is used. Thus, it makes the packet to move closer to the destination. Since it has high mobility, topology changes rapidly and often may have the occurrence of nexus fragmentation. It reduces the control message overhead and end to end delay.

5.4.4 Contention based Forwarding (CBF)

Contention Based forwarding routing is used to transmit the packet to all neighbors that are directly connected to it. The actual data that has been sent to the node that is identified by distributed timer contention based process. It does not send beacon messages periodically and this reduces the amount of bandwidth. It reduces the packet collision probability¹⁰.

5.5 Topology based Routing

The topology routing protocol, consists of link information that is used to forward the packets from one node to the other. It is classified into two types based on how the information is stored as proactive and reactive.

5.5.1 Proactive Routing

Proactive routing contains the distinct information in the form of the table and it is said to be table driven. The next forwarding hop is maintained in the table in order to forward the packets. This information is also shared with their acquaintance. Whenever any change occurs in nexus topology, every node updates its routing table.

5.5.2 Fisheye State Routing (FSR)

FSR is an adept link state routing protocol that broadcast the link information to all the nodes in the nexus that is stored in the routing table. The information is broadcast based on the hopping distance. It reduces the amount of bandwidth used because it exchanges only partial information about the update of the changes in the link state. Storage complexity and processing overhead increases when nexus size increases¹¹. It has less knowledge about distant nodes.

5.5.3 Reactive Routing

Reactive routing is otherwise known demand routing¹² as it discovers the path only when the source node has to forward the packet to the destination node. The path is discovered in such a way that a quick query packet is forwarded along the path.

5.5.4 Temporally Ordered Routing Algorithm (TORA)

TORA routing protocol finds multiple way to reach the

target from the source. All nodes construct Directed Acyclic Graph (DAG) by trolling dubiety packet¹³. While obtaining the packet back, if it reaches the destination by downstream link then, it sends response to information or else the packet will be discarded. It offers route to all the nodes in the nexus and hence the maintenance of the nexus is too burdensome. This protocol cannot be applied to the system where nexus is highly mobile and does not have large scalability¹⁵.

5.5.5 Adhoc on Demand Distance Vector Routing (AODV)

In this, source node initiates the routing mechanism by transmitting hello messages to the neighbor. Source node broadcast the route request to all its neighbor and neighbor further transmit it to the other neighbors until it reaches its destination. The address of the node that sends the query information to next node is recorded in the routing table. This type of learning is called Backward Learning after the query information reaches the destination, the reply packet is sent through the path obtained by backward learning¹⁴. If single route request packet has multiple route reply then, heavy control overhead occurs. For example, Source node S broadcasts packet to all its neighbor by means of route request. Until it reaches the destination the neighboring nodes transmit the packet. The request message contains IP address of the source and destination and also it has current and last sequence number. Similar to that of DSR, the reply has been transmitted in reverse order. It uses the principle of multi-hop strategy^{15,16}.

5.5.6 Dynamic Source Routing (DSR)

In this routing source finds the shortest path to the destination using simple graph algorithm. It uses reactive location servers to find the physical location for the node. In this routing broadcast, position request to the required node. If it receives the position request it replies with a position reply. It uses a greedy technique along the preselected shortest path and this path can be calculated using Dijkstra's algorithm¹². It does not suite for the node with high mobility and flooding occurs more frequently. Table 1 and Table 2 shows the routing protocol

6. Conclusion

This paper presents a detailed survey about the various routing protocols in VANETs. Among the various forwarding strategies that are described above the greedy forwarding is found to work better in the delivery of the packets. The routing protocols are classified into a major of two types as position and topology based routing. The position based routing protocols can be applied to both the V2V and V2I architectures. The disadvantage is that nexus disconnection occurs more often in the V2V communication and the implementation of the infrastructure in the V2I communication is also more expensive. This is not much applicable to the urban environment. Hence, a protocol should be developed in such a way that it is suitable for both the communication architectures and also in all compatible environments. The topology based protocol is classified as proactive and reactive routing. The proactive routing protocol, maintains the information of the routes in the form of the table whereas the reactive routing protocols do not contain any predefined information. Each has their own advantages and disadvantages as mentioned earlier. Our future enhancement is to design a protocol in a way that the major disadvantages are brought to minimal in reference to the most important performance metrics.

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