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A Hybrid Routing Protocol for VANET Using Ontology

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Abstract

Vehicular Ad-hoc NETwork (VANET) is a wireless communication technology applied to transportation, its main objective is to improve road safety, logistics and information services. However, the efficiency and performance of VANET applications depends primarily on the way in which messages is transmitted between the vehicles, but the major challenge is to find a routing protocol adapted to a highly dynamic environment such as VANET. So the proposed solutions must take into account the specific characteristics and constraints of VANET, such as speed, acceleration, geographical position, the transmission radius, management, etc. In this paper, we propose an approach using ontologies and vehicle traffic information to ensure the transmission of packets as soon as possible and in the most reliable way.

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Keywords: Ontology, Vehicular Ad-hoc Networks, Routing Protocol;

1. Introduction

The rapid development of wireless communication technologies, allow now the implementation of this technology in vehicles as VANET (Vehicular Ad-hoc NETwork), in order to improve intelligent transport systems by the great benefits that can be derived from this technology with the aim of improve the fluidity of traffic and enhance road safety, this type of network allows communication between vehicles or between vehicles and infrastructure by roadside access points. Thus, a driver on the road could have a reliable and fast access to practical information with a wide range of applications, these applications are designed to enhance road safety, comfort, driving assistance and entertainment.

VANET is a form of Mobile Ad-hoc NETwork (MANET), where nodes are represented by the vehicles, which are characterized by a high mobility, and this causes a highly dynamic topology that changes continuously and very

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rapidly. Most traditional MANET routing protocols are unsuitable for VANET. Thus, a protocol must necessarily supports high mobility. Although many properties must be taken into account when deploying a protocol, such as the location, scope, speed, security, and the amount of information disseminated in order to optimize the flow of packets.

Unlike the MANET nodes, the movement of vehicles is dependent on several parameters such as infrastructure, the laws of traffic and even other vehicles. So based on these road traffic information the wireless transmitter can define the most optimal path to take, to ensure that the packet reaching its destination in the most reliable way. In this context, we propose in this paper an approach of structuring road traffic data based on ontologies to provide useful information in order to route packets as quickly as possible and in the most reliable as possible.

The rest of the paper is organized as follows, the next section presents an overview of routing protocols in VANET. In section 3, we present the proposed approach. Finally, in section 4 we conclude our work.

2. Related Work

VANET is a promising technology for the next generation of vehicles. It offers a wide range of applications, but the major challenge[1] is to find a routing protocol adapted to a highly dynamic environment such as VANET, which causing frequent links disconnections. For this, various protocols were proposed for routing with different strategies and they have been classified into five categories:

2.1. Topology Based Routing Protocols

The topology based routing protocols use the information about the links between nodes for routing packets. This family of protocols can be divided into three categories:

Proactive protocols is a protocol that builds the routing tables before the application is made. It receives information on the topology, which is constantly updated by the regular exchange of packets in the network topology between nodes the same network. Each node remembers an absolute image of the network until it receives a new one. This recent information network allows a minimum waiting period to determine which route to take, which is especially important for time-critical traffic. The various types of proactive routing protocols are: FSR[2], DSDV[3], OLSR[4], CGSR[5], WRP[6], and TBRPF[7].

Reactive protocols is based on the principle that there is no information about the topology of the entire network, since the latter is constantly changing. So each time a node requires information on a road for a given target, it initiates the route discovery process. So it tries to establish a protocol when a node route request to initiate communication with a node for which there is no road. This type of protocol is usually based on flooding the network with the Route Request messages and Route Reply messages. The various types of reactive routing protocols are AODV[8], PGB[9], DSR[10], TORA[11], and JARR[12].

Hybrid protocols are introduced to reduce the control overhead of proactive routing protocols and decrease the initial route discovery delay in reactive routing protocols. The various types of hybrid protocols are ZRP[13] and HARP[14].

2.2. Position Based Routing Protocols

In the routing based on the position, the decision of transmission by a node is essentially based on the position of the destination of packets and on the position of the neighbor node one hop. The data of the target position is stored in the header of the packet by the source. As for the position of the neighboring node to a jump, it is obtained by the sent tags, it implies that each node knows its own position and that the sending node knows the position of the receiving node. An example of this type of ad hoc routing is the unity of the global positioning system (GPS), whose popularity is not to demonstrate, which is the basis of several embedded navigation systems. The various types of Position based routing Protocols are: GPSR[15], CAR16, GSR[17], STBR[18], GyTAR[19], LOUVRE[20], DIR[21], ROMSGP[22], AMAR[23], TO-GO[24], CBF[25], VADD[26], GeOpps[27].

2.3. Broadcast Based Routing Protocols

This protocol is characterized by its simplicity, but still unable to solve the problem of storm generated by divergent step by step diffusion mechanisms. The spread for this type of ad hoc routing is based on the hierarchical structure of the road network. The route is then divided into virtual cells that move like vehicles. There are two levels of hierarchy in the organization of the nodes of a road: the first level of the hierarchy which includes all the nodes in a cell, whereas the second level of the hierarchy is represented by the reflector cells, which are a few nodes located very near the centre of the cell. Some reflectors cells temporarily act as group leaders and manage emergency messages from the same cell members or a close neighbour. This protocol is based on flooding to the spread. The various Broadcast routing protocols are UMB[28], V-TRADE[29], DV-CAST[30], and EAEP[31].

2.4. Cluster Based Routing Protocols

In this type of routing protocol, vehicles or mobile that are close to the other form a group or cluster, and each group has a cluster head. Group formation and selection of cluster head are determining process. Each group leader will play the role of bridge between the group and the other groups. Moreover, in the VANET, known for their dynamic mobility, training groups is a dominant process.

This type of protocol has a very important advantage: lower costs and delays in delivery of data packets during transportation due mainly to its management. Indeed, each group leader is responsible for management of nodes within the same group, but also the management between the other groups. However, the communication differs in these two cases. Communication between nodes in the same group is by direct links between them, while communication between groups is done through group leaders. . The various Clusters based routing protocols are CBLR[32], LORA-DCBF[33], TIBCRPH[34] and HCB[35].

2.5. Geo-Cast Routing Protocol

Geo-Cast Routing protocol is basically a position based multicast routing. Geographic routing is a routing that each node knows its own and neighbour node geographic position by position determining services like GPS. Its objective is to deliver the packet from source node to all other nodes within a specified geographical region. It doesn't maintain any routing table or exchange any link state information with neighbour nodes. The various Geo cast routing protocols are ROVER[36], DG-CASTOR[37] and DRG[38].

The problem of routing in VANET is the ability to use the following metrics in all environments:

• The discovery of neighbouring vehicles;
• Identifying the destination;
• The data transmission;
• Network partition;
• The prediction of movements.

Each one of the categories presented routing uses these metrics to route packets, further performance of these categories varied from environment to another, which leaves that each category unable to perform in any environment. For that we propose in our approach a total recognition of the environment, in order to offer the most adapted protocol to this environment.

3. Proposed routing protocol

VANET inherits the same characteristics of MANET, but with some differences, such as the high mobility of nodes, which makes frequent topological changes. Therefore, a vehicle can quickly join or leave a group of vehicles in a short time, and this makes low connectivity or even impossible. Furthermore, VANET provides broadband connectivity, and in addition a number of location and technical solutions with great precision, whatsoever relative or global.

In our approach, we propose that the network is divided into clusters as Fig. 1, and each cluster has only one node Clusterhead and member nodes, the Clusterhead is elected by its path, the longest path in a road, and member nodes belonging to the cluster also built routing paths for the retransmission of packets to other clusters.

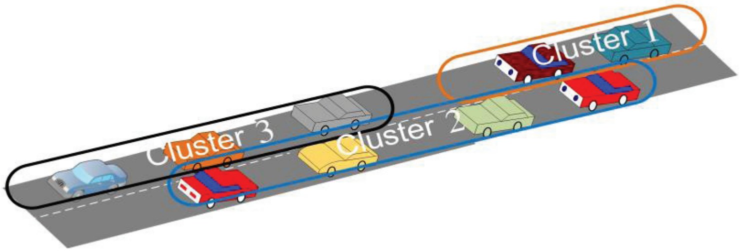

Fig. 1. The formation of vehicle clusters in the road.

3.1. Cluster creation

The high mobility of vehicles involves topology changes frequently and limited lifetime of connections between vehicles. However, as the vehicles move according to traffic laws and according to the already predefined ways by road infrastructure. Thus, by using the information on traffic can improve and optimize the communication management.

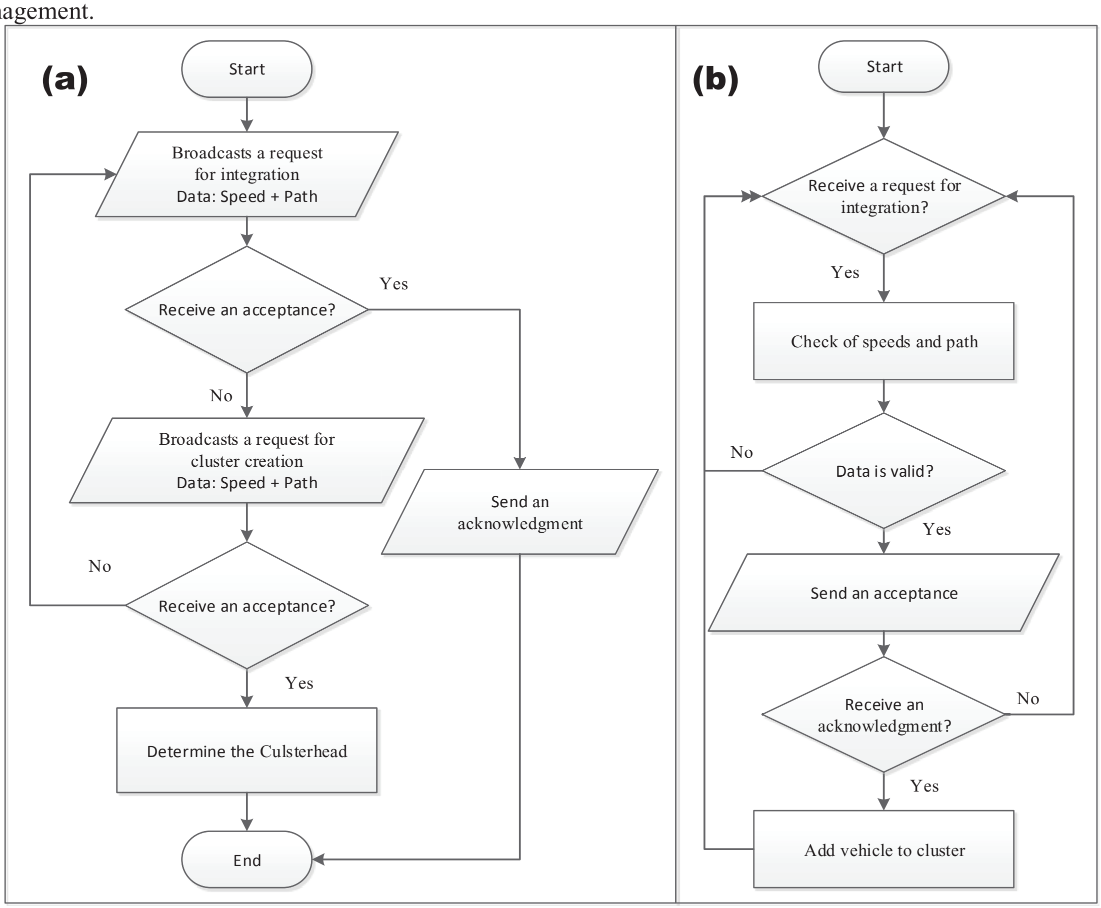

Fig. 2. (a) Steps for a vehicle established a connection. (b) Steps for Clusterhead added a new vehicle.

A vehicle may be able to communicate various information with neighboring vehicles effectively for a period of time, this period depends on the average speed and trajectory of the vehicles that are in connection. So in our approach, we will mainly base on these two criteria for identifying the nodes to build a cluster of nodes. If the cluster is not yet formally established, and there are at least two vehicles. First, these vehicles will be a check of their speeds and path Fig. 2 (a), the path is the common route segment between vehicles that should be sufficiently long to establish a connection and exchange information, the speed should be around average speed of the other so that the vehicle remainder within the scope of another vehicle, and thereafter the election of the Clusterhead, which is on a longer route segment of the vehicle.

On the other hand if the cluster is already created, the vehicle broadcasts a request for integration with its speed and path subsequently the Clusterheads receives the request Fig. 2 (b), and then they check the speed and around average speed of the cluster and the road segment in common between the vehicle and the Culsterhead is long enough, whether the Clusterhead sending an acceptance and waits an acknowledgment. Clusterhead and shall not accept a vehicles more than two levels as Fig. 3, namely that between the Clusterhead and the vehicle there are at most one vehicle to establish the communication.

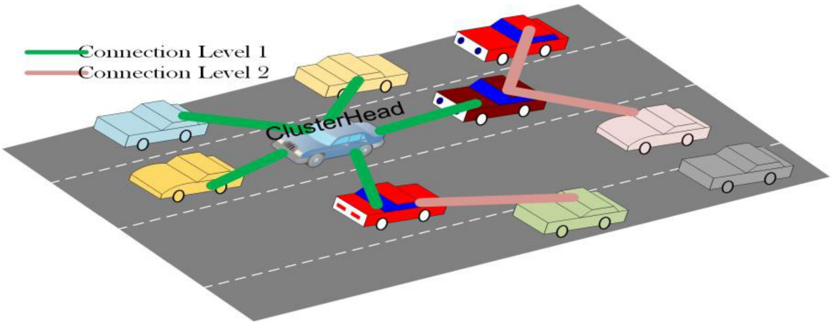

Fig. 3. Levels of connection between the Clusterhead and the vehicles.

3.2. Cluster change for a Simple node

The migration of a cluster to another for a vehicle is carried when the speed or route changes. So the vehicle is integrated to a new cluster that will be suitable with the new changes, the search for a new cluster is through the Clusterhead if the vehicle in question approximates to the end of the common segment with the cluster. But cons, in the case of a sudden change in the speed or the path of a vehicle, the vehicle itself looking for a new cluster, then return a warning message to the old Clusterhead.

3.3. Cluster change for the Clusterhead

When the Clusterhead needs to change its path or speed he must choose his successor before quite the cluster, for that it must compare the paths of all vehicles and select one that has the longest path on the road, then returns the update for all vehicles in the cluster.

3.4. Knowledge Representation

As we have already mentioned, our approach is based on the traffic information to facilitate communication between vehicles, for this we propose an ontology to represent knowledge and the information's of vehicles and traffic. Ontologies can be used to build and reuse common knowledge, they can ensure interoperability between various systems, allowing assembling, sharing and exchanging of knowledge. So the used ontology in our approach is integrated directly into each vehicle, and it also receives information update on the traffic in real time from the infrastructure. Therefore a learning phase is essential for each vehicle in order to collect information on the infrastructure, and replenish the map and connections between routes. And subsequently knowledge representation that will be used for cluster creation and communication between vehicles.

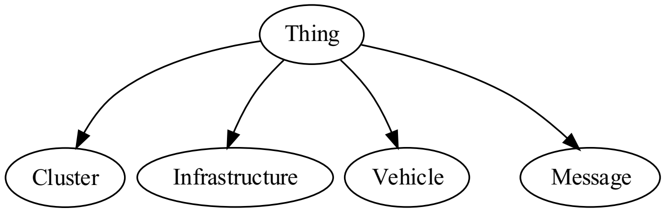

Fig. 4. The components of the ontology.

The ontology that we work with shown in Fig. 4, it begins with a super class named Thing, which all other classes are subclasses. This brings us directly to the concept of inheritance, therefore inherited classes are: Cluster, Message, Infrastructure and Vehicle. These concepts that relate to each other.

The first class is Cluster shown in Fig. 5, which include the properties of cluster, such as IDCluster, IDHead, AvgSpeed and Members. Members are the vehicles of the same cluster except the Clasterhead, and each member has an IDVehicle, Path and Level. Level describes the level of connection between the Clusterhead and the members.

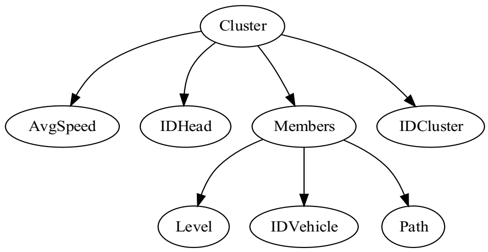

Fig. 5. Description of Cluster class.

The class Infrastructure shown in Fig. 6, which is composed of Road, Parking and BusStop for bus station, and each Road shown in Fig. 7 (a), has a number of lanes for the rolling of the vehicle, and a maximum speed not to exceed by vehicles, and her type which include the properties of road. The TrafficControl shown in Fig. 7 (b), which include the Panel of Traffic Control and Traffic Light to provide important information as a message to help drivers to respect traffic law.

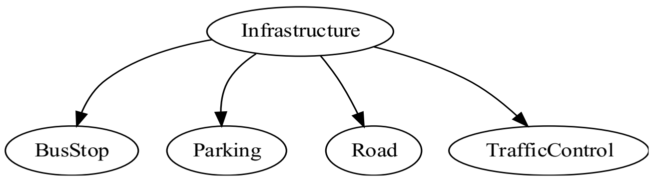

Fig. 6. Description of Infrastructure class.

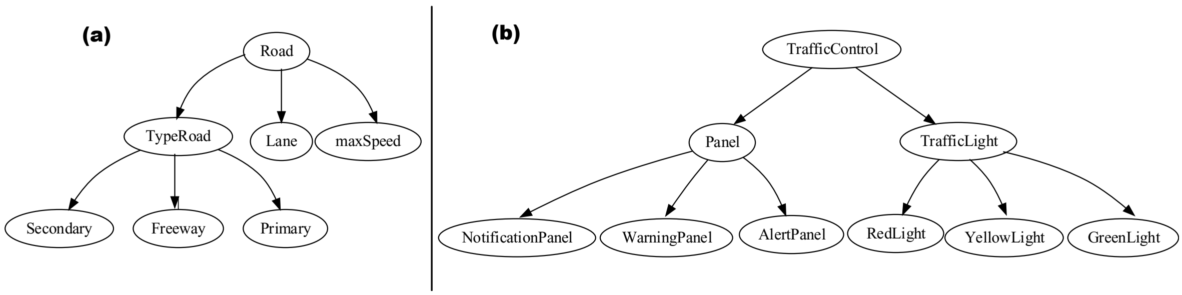

Fig. 7. (a) Description of Road; (b) Description of the TrafficControl.

The Message class shown in Fig. 8 (a), which include the type of Message, it can be an AlertMsg for emergency situations, Warning for unpredictable situations or NotificationMsg for the information. These messages are sent by the other driver in the event of a request or change of situation.

The Vehicle class shown in Fig. 8 (b), which include the properties of Vehicle, such as Priority, Position and Speed. Vehicle comes in three types: ClasterHead, Level_1 and Level_2. TypeVehicle describes the vehicle role in the cluster.

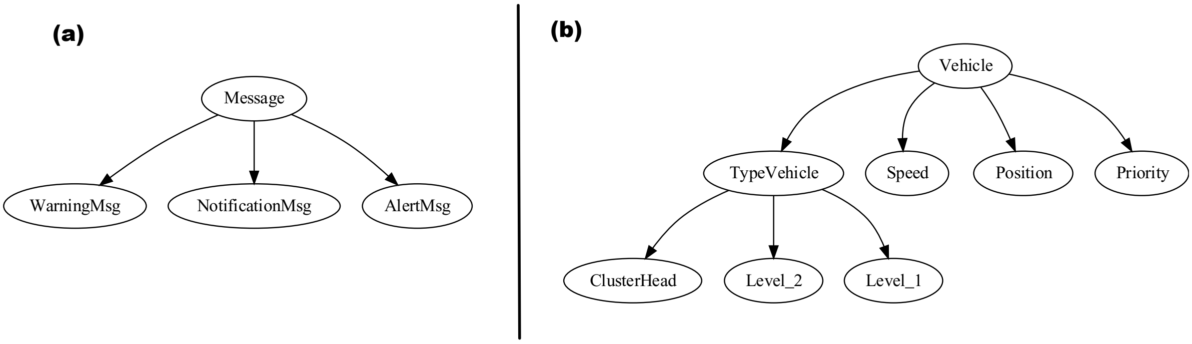

Fig. 8. (a) Description of Message; (b) Description of the Vehicle.

4. Conclusion

VANET networks are characterized by high mobility vehicle, and therefore, a vehicle can join or leave the network in a very short time, which makes them very frequent topology changes. Which requires routing protocols that must react quickly to these changes in order to allow the proper routing of packets to their final destinations. In this article, a new approach based on ontologies and traffic information to allow the proper routing of packets to their final destinations is presented. The use of ontology in vehicles, facilitates the interpretation of the information collected on traffic, and the cluster to reduce the overhead of the delay of the communication in vehicles. Our approach can reduces significantly the delivery time and optimize routing and improve road service performance at the same time. Currently our ontology does not contain sufficient concepts for complex scenarios. In the future, this approach will be enhanced to include several concepts. Subsequently, we propose to build a platform for validation, which could show the effectiveness of our approach.

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