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A Study on VANET Architecture and Routing Mechanisms

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Abstract: Vehicular Adhoc Network is gaining its scope in real time scenarios with the exploration of Smart City concepts. VANET suffers the challenges in terms of safety, robustness and real time environment. In this paper, these challenges are discussed in detail. Later on the VANET communication architecture is explained along with the exploration of different communication types and constraints. The architecture is also described with relative MAC protocols evolution and scope in VANET. The paper also discussed various routing protocols for VANET. The routing architecture, requirements and corresponding protocols are discussed in this section. The paper also discussed the multichannel communication in this dynamic architecture.

Keywords: VANET, MAC, WAVE, Architecture, Routing

I. INTRODUCTION

Till now the VANET is considered as the conceptual network form and having the lesser implementation level existence. But the smart city concept and increased problems in transportation system also increased the real implementation of this network. It is one of advanced technology which is having variety of usage including automatic traffic light management, auto driver system, optimized parking etc. As the VANET is real time scenario which implemented on roads and lack of accuracy results in life loss. The road safety is the primary challenge for this network because of which it can be applied after lot of testing and verification trails. Even then, the vehicular network cannot assure full safety in real scenario. Because of this, the each associated phenomenon to the VANET still requires monitoring and technological updation under different aspects. These aspects include the safety, optimization, scalability, heterogeneity and robustness. The safety here described earlier as its association with real life. The designed architecture must be accident free and avoid any kind of man or resource loss. The optimization is the basic need for any architecture, application or algorithm to improve the strengths from earlier system. The optimization can be in terms of throughput gain, minimize communication loss, minimization of communication delay etc.

Another requirement for any architecture is the scalability which actually describes the success ratio of implementation relative to network size. As the VANET itself represents a global region network which can be applied over a road, colony, city etc. As the size increases, the constraint with each aspect increases along with network criticality. Scalability also introduces some communication problems such as Handoff, route reconstruction, scenario change etc. Each time the architecture implied, the region and size specification is the major requirement to identify the traffic and communication level complexities. Another challenge to VANET network is the heterogeneity which resemble with each component, algorithm and aspect of this architecture. The network architecture itself combines the criticalities of mobile network and sensor network. The smart sensor nodes are installed with mobility. The vehicle type, speed and communication protocol also increases the heterogeneity in the network. The integration of multiple scenarios, mobility model and security aspects supported by different vehicles also required to handle. The robustness is the prior requirement for any architecture and in such complex wide network architecture this requirement is more challenging.

While setting up VANET network under any scheme, it is required to keep flexibility for defined challenges. The architectural specification, protocols and the routing methods are also described later in this paper.

1.1 VANET Architecture

Vehicle Adhoc network relies on fixed infrastructure setup with cellular gateways and controllers. These controllers are established on roadsides as access point and traffic information transition. The standard VANET architecture is shown in figure 1. This architecture includes the integrated components and the communication form between these components.

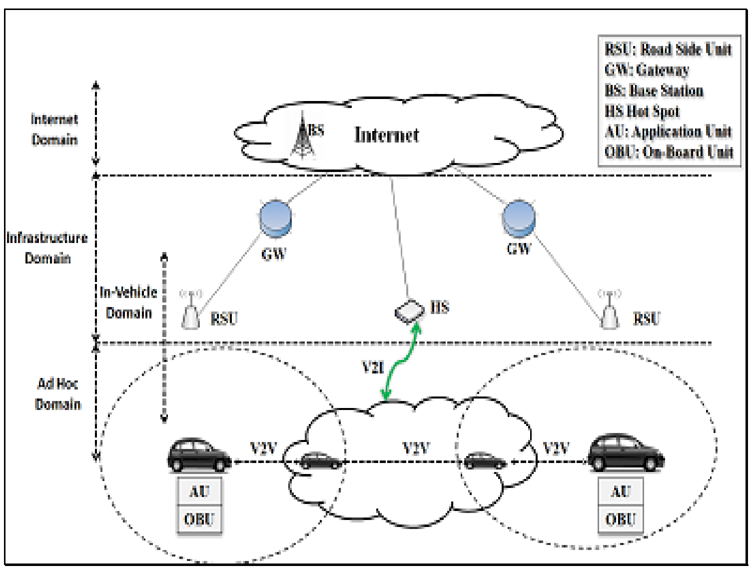

Figure 1 : Standard VANET Architecture

The infrastructure includes the smart sensors as vehicle nodes, RSU (Road Side Units) as controller coverage units and Infrastructure Domain (ID) as the WLAN gateway interface. RSU is responsible for the communication in coverage range including the route formation and aggregative information transfer. Each of the vehicle sensor device is having intelligent integrated module in the form of On Board Unit(OBU). This embedded unit is capable to capture the traffic information using GPS (Global Positioning System). Because of this, the vehicle nodes can identify the vehicles in its coverage. RSUs are having larger scope and coverage so that more traffic information can be tracked. The vehicle devices are also identified through the electronic license plate (ELP) with unique identity. This identity is verified to the central controller and the RSU through certification authority (CA). The secure communication is applied to achieve higher degree reliability.

1.2 VANET Communication

The communication in VANET among different components is termed as Intelligent Transportation System (ITS). Each of the component act individually or cooperatively based on situation. Each component is able to take the decision to act as sender, receiver or the router. Under ITS, three kind of communications can be performed as shown in figure 1 called V2V(Vehicle to Vehicle), V2I (Vehicle to Infrastructure) and I2I (Infrastructure to Infrastructure). V2V communication is performed between vehicles to perform cooperative multihop communication. As the information exchange is among the vehicles in specific range is performed, V2V communication is required. The information about the accident, group formation, effective neighbor identification, secure key exchange can be circulated or shared using V2V in ITS. V2I communication is taken place between the vehicle and RSU. This communication is either to broadcast some message by RSU relative to route change or congested road situation. I2I communication is large scope communication applied for inter-zone communication. The aggregative communication and information transfer to gateways is also done through I2I. This visual warning or alarm messages can be distributed over the region through this communication mode.

II. VANET STANDARDS

VANET system standard is required for real implementation in terms of architecture, service distribution, security aspects, communication form and the routing algorithm. These standards are able to set the rules and restrictions so that the seamless communication will be carried out. Some of these standards includes DSRC (Dedicated Short Range Communication), IEEE 802.11, Wireless Access in Vehicular Environment (WAVE), IEEE 1609 etc. In this section, some of these standards are shown in table 1 and discussed in this section.

Table 1 : VANET Standards

Standard	Purpose
1609.1	Resource Manager for Vehicle Components and Communication (WAVE)
1609.2	Facilitate Secure Communication along with Digital Signature Map, Secure Information Exchange
1609.3	For Information Management and Transportation. Routing and Transport Services Exploration
1609.4	Multi-Channel Communication support in relation with DSRC
802.11p	Low Level Control at MAC layer with PHY Enabled Communication for WAVE
802.16e	Broadband Access with Multiple Vendor Support System

2.1 DSRC

This standard work on different frequent ranges provided by CEN(European Committee for Standardization). This frequency standard is also regulated for telecommunication standard institute. This standard is allocated as the most effective frequency range for DSRC in the US. American society also defined the standard for PHY and MAC called ASTM E 2213 (American Society for Testing and Materials). The group tasks of the standard are under working group. The subsequent released standard is relative derived under standard IEEE 80.2.11a. Group p is defined under same working group to the working of DSRC standard. The VANET system assessment is also summarized under the same standard so that relation to the next layer telecommunication will be formed. Different spectrum allocations are allowed to achieve ITS safety for same standard. Some of these allocated frequency ranges for VANET are shown in figure 2. This standard also provides the integration of VANET with IEEE, ETSI, CEN and Society of Automotive Engineers.

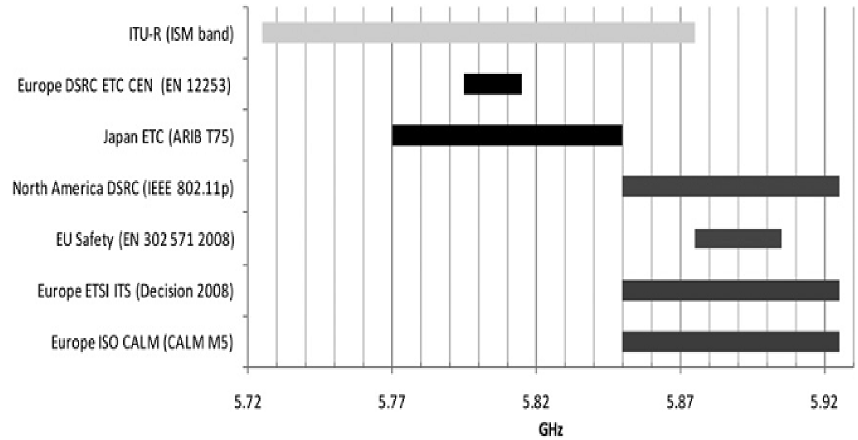

Figure 2 : DSRC Frequency Allocation for VANET

2.2 IEEE 802.11p

802.11 describe the basic MAC standard for wireless network under distribution coordinate function (DCF). VANET supports CSMA/CA employed MAC standard called 802.11p. The protocol analyzes the channel load and set the size of contention window. The handshake mechanism is applied by the protocol to avoid the collision. The protocol is also effective to improve the successful transmissions in case of hidden and exposed terminals. The structure architecture of this protocol is different from standard 802.11. 802.11p maintains the node allocation information as NAV (Network Allocation Vector). This information is captured as the combined information contents including RTS, CTS, ACK and data. Before transferring the contents, the channel sensing is performed to gain the reliable information transfer. The protocol does not support authentication as the vehicles in public domain change very frequently. The connected and infrastructure driven communication is provided by this improved protocol version. The integration of this protocol is also with WAVE. The functional channel access is provided in distributed form. Inter frame communication and contention window control methods are also provided by the protocol.

2.3 WAVE

802.11a having the limitation relation VANET architecture in terms of communication overhead. As in VANET, nodes moves at very high speed, there is requirement of some protocol that can coordinate with mobility and data transfer rate. WAVE is the improved protocol that provides the high speed data transition for highly mobile nodes. WAVE support the capabilities to handle the topological change and the hybrid nature of the network. It provide the capabilities to identify the congestion in network to provide collision free communication. The protocol also includes the security mechanism at the physical layer so that the system reliability is improved. The cross link layer based control management provided the coverage driven robustness so that the communication strength of network is improved.

III. VANET ROUTING

As the VANET communication is infrastructure driven and scenario specific so that the routing in the network is more challenging. The routing can be inter-zone or intra zone based on the information type. The broadcast or the specific are common types of communication. The routing in the network also required to handle node mobility, RSU coverage, topology, traffic, handoff and communication rate. One protocol or the routing method is not generalized to provide solution for all kind of communication. Because of this, routing in network is divided based on different aspects. Some of routing types with different constraints is discussed in this section.

3.1 Topology Based Routing

This routing model is applied for smaller geographical region where nodes act as simple mobile node with adhoc capabilities. It means, the communication requires managing the network, bandwidth and the radio transmission. Simple adhoc network protocols can be applied in such network for effective communication. The protocols included in this routing form are divided in two main categories called Proactive Routing Protocol and Reactive Routing Protocol. Proactive Routing Protocol generates a routing table to analyze the network connections. The route formulation is established for hop count relative to the destination. For generating the route, it sets the sequence number under stability parameters so that the effective packet transmission will be obtained. Proactive routing protocols include DSDV, OLS, FSR, WRP, STAR. The switched formed routing is obtained along with reverse path forwarding methods. But these routing methods suffer network load and bandwidth consumption. The optional routing protocol category is reactive routing protocol. In these protocols, the route formation is dynamic and on demand. As the route formation is done, the packet overhead analysis is applied and based on the route formation, the routing protocol is derived. Reactive protocols include DSR, AODV, TORA, PGB etc. As the VANET is complex network form, in some cases the hybrid protocol is also applied that combines the features of reactive and proactive routing protocol. The zone driven route formation is provided by the hybrid protocol. Zones are formed under coverage cluster analysis.

3.2 Position Based Routing

These routing methods and protocol uses the geographical information to identify the next communication hope and based on which the route formation and communication is formed. The routing tables are maintained based on the positional analysis and packet to node information is maintained. The positional information is captured through GPS services and maintained as detailed information. This information includes street map, road side locations and components, nearby places etc. The method also robust to the nodes movement and the topology change in the network. The performance information and the network load analysis is taken for route formation and effective communication. The routing effect algorithms are formed based on connectivity observation, mobility analysis, traffic analysis and position driven routing.

3.3 Cluster Based Routing

These routing methods are able to provide the communication in large scale network by forming the virtual clusters. The routing model in this method is divided in two main stages. In first stage, the cluster election and cluster head formation is done. The cluster node identification along with the aggregative and the many-to-one communication is formed. The clustered formed routing is a kind of hierarchical routing. Where the cluster nodes transfer the data to the cluster head and all the cluster heads over the network formed a communication route to the central controller.

3.4 Geo Cast Based Routing

The routing method defined in the network is relative to the multicast services. The region driven message communication is formed in the network. The region broadcast communication is performed for large scale communication. This method reduces the packet overhead and avoids the collision over the network. Inter-Vehicle communication along with directional observation so that the routing protocol formation is done. The dynamic route formation, time stable communication analysis and distribution robust communication route formation is done.

3.5 Broadcast Based Routing

As the collision is generated in some region, it is required to broadcast the message to other vehicles in same zone and other zone. In such case, the information distribution is done via broadcast routing. This routing method support high communication via V2I correspondence. The vector based routing with distribution model is applied to generate the communication trail. As the heavy communication is carried on it also suffers from the collision and the packet over heads. The high bandwidth consumption is the major factor of this routing model.

IV. VANET MULTI-CHANNEL COMMUNICATION

This protocol operations under time division model and structure in which the communication slots are divided with specification of virtual frames of specific length. The active nodes are defined for perform the packet transmission under period adaptive communication. This protocol is able to provide the frame division, frame synchronization, slot definition and the terminal driven communication formation. This protocol also provided the modification to basic channel so that the virtual frame will be applied to the communication slot. The RR-ALOHA adaptive communication is formed. The architecture adaptive communication is here formed under single hop communication so that the adaptation to the nearby terminals is done. The operational form of this protocol is able to provide the contention control under the channel access method and provided the use of same slot for providing the continuous communication. The transmitted packet adaptive communication is here performed under payload specification and the status information generation so that the adaptive use of slots is done[5][6][7].

This protocol is adaptive to the directional antenna and provided the multi channel communication in dense VANET. In this protocol, each vehicle maintains a Beam Table to provide the communication on all seven DSRC channels and provide the table entry for each possible communication in the network. The vehicle exchange adaptive RTS/CTS handshaking is provided by the vehicle to attain channel reservation. The vehicle adaptive transmission is here done under Channel selection and Request to Send model fo redirection adaptive communication formation. The signal transmission at certain time is formed by the beam[5][7][8][9]. The handshaking mechanism defined by the protocol is shown in figure 1.8

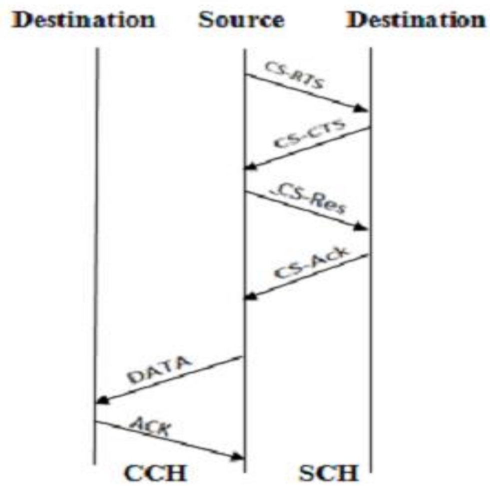

Figure 3 : Directional Handshaking

4.1 DMMAC

The multi channel MAC protocol is defined respective to adaptive broadcasting mechanism. The protocol provides the collision free and delay transmission adaptive communication for safety application in traffic environment. This architecture is similar to WAVE mac protocol. The channel time based partitioned division communication is performed in synchronized intervals. The slot adaptive communication control is performed under channel and service optimization. This model include the control interval based adaptive broadcast frame generation and contention based reservation period generation is provided by the protocol. This network form provides the transmission control adaptive safe message communication under collision analysis and uniform communication analysis. The CSMA/CA is been used to derive the channel collision estimation so that the safe communication will be form over the channel[8][9]

4.2 Congestion Controlled Communication

One of the major challenges in vehicular adhoc network and in any open network is the large packet communication. This kind of bulk communication in network is defined as congestion situation. Congestion problem degrades the network performance in the form of increased communication delay and communication loss. The congestion control is required to provide the effective network communication. To control the congestion, at first level the transmission parameters are adjusted. This kind of congestion control is called reactive congestion control mechanism and it uses explicit feed mechanism. In this method, the congestion channel status is analyzed under load vector identify the congestion situation. One the situation is identified, the parameter is setup to reduce the communication delay and to provide congestion control. The parameter adjustment can be done at application level, protocol level or the network level. The communication load or the channel load is required to identify to provide the communication under condition adaptive communication. The channel load is required to determine and to provide the maximum power transmission to achieve the maximum congestion limit. In vehicular network where the vast number of vehicle nodes is present and the node mobility also exist, there are higher chances of network congestion. The congestion can occur here using communication synchronization, self coordination, limited capacity communication and the channel adaptive communication. The congestion not only degrades the communication throughput but also increase the communication latency.

V. CONCLUSION

In this paper, an improved routing protocol GPSRV is presented. This protocol is designed to improve the communication strength and to provide the communication in fault driven network. The simulation result shows that the work has reduced the communication loss and communication delay.

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