

TECHNICAL NOTE

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VEHICULAR AD HOC NETWORKS

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Abstract: Vehicular ad hoc network is one of the most interesting research areas due to low cost, flexibility, fault tolerance, high sensing fidelity, creating many new and exciting application areas for remote sensing. So, it has emerged as a promising tool for monitoring the physical world with wireless sensor that can sense, process and communicate. Their applications range from safety and crash avoidance to Internet access and multimedia. VANETs are considered as one of the ad hoc network real-life application enabling communications among nearby vehicles as well as between vehicles and nearby fixed equipment, usually described as roadside equipment. In this paper, we are most concerned about the study of VANET applications as it is an evolving field which offers scope for research.

Keywords: VANET, Vehicles, Network, DSRC, ETC, RSU.

INTRODUCTION

VANET is a technology that uses moving cars as nodes in a network to create a mobile network. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 meters of each other to connect and, in turn, create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created. Fixed equipment can belong to the government or private network operators or service providers [1]. It is estimated that the first system that will integrate this technology are police and fire vehicles to communicate with each other for safety purposes. Advancing trends in ad hoc network scenarios allow a number of deployment architectures for nearby vehicles and between vehicles and nearby fixed roadside equipment. Vehicular Ad-hoc Networks are expected to implement a variety of wireless technologies such as Dedicated Short Range Communications (DSRC) which is a type of Wi-Fi. Other Wireless Technologies are Cellular, Satellite and WiMAX. Vehicular Ad-hoc Networks can be viewed as component of the [2] Intelligent Transportation Systems (ITS).

In Figure 1, it consists of vehicles and roadside base stations that exchange primarily safety messages to give the drivers the time to react to life-endangering events.

SPECIAL CHARACTERISTICS OF VANET

Though VANET could be treated as a subgroup of Mobile Ad Hoc Networks (MANETs) and it is still necessary to consider VANETs as a distinct research field, especially in the light of security provisioning. The unique characteristics of VANET include features:

High Dynamic Topology:

The speed and choice of path defines the dynamic topology of VANET. If we assume two vehicles moving away from each other with a speed of 60 km/h (25 m/s) and if the transmission range is about 250m, then the link between these two vehicles will last for only 5 seconds (250m). This defines its highly dynamic topology.

Frequent Disconnected Network:

The above feature necessitates that in about every 5 seconds or so, the nodes needed another link with nearby vehicle to maintain seamless connectivity. But in case of such failure, particularly in case of low vehicle density zone, frequent disruption of network connectivity will occur. Such problems are at times addressed by road-side deployment of relay nodes.

Mobility Modeling and Prediction [3]:

The above features for connectivity therefore needed the knowledge of node positions and their movements which is as such very difficult to predict keeping in view the nature and pattern of movement of each vehicle. Nonetheless, a mobility model and node prediction based on study of predefined roadways model and vehicle speed is of paramount importance for effective network design.

Communication Environment:

The mobility model highly varies from highways to that of city environment. The node prediction design and routing algorithm also therefore need to adapt for these changes. Highway mobility model is essentially a one-dimensional

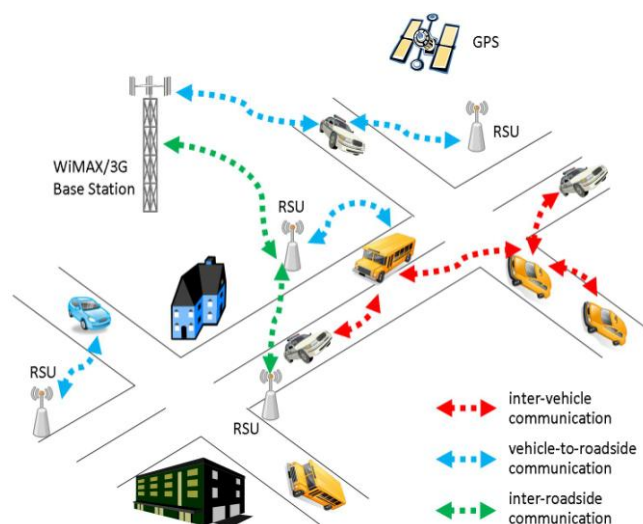


Figure 1. VANET

model which is rather simple and easy to predict. But for city mobility model, street structure, variable node density, presence of buildings and trees behave as obstacles to even small distance communication make the model application very complex and difficult.

Unlimited Transmission Power:

The node (vehicle) itself can provide continuous power to computing and communication devices.

Hard Delay Constraints:

The safety aspect (such as accidents, brake event) of VANET application warrants on time delivery of message to relevant nodes. It simply cannot compromise with any hard data delay in this regard. Therefore, high data rates are not as important as an issue for VANET as overcoming the issues of hard delay constraints.

Interaction with onboard Sensors:

These sensors help in providing node location and their movement nature that are used for effective communication link and routing purposes.

Higher Computational Capability:

Indeed, operating vehicles can afford significant computing, communication and sensing capabilities.

Rapidly Changing Network Topology:

Due to high node mobility, the network topology in VANET tends to change frequently.

Potentially Unbounded Network Size:

VANETs could involve the vehicles in one city, several cities or even a country. Thus, it is necessary to make any protocols for VANET is scalable in order to be practical.

Anonymous Addressee:

Most applications in VANETs require identification of the vehicles in a certain region, instead of the specific vehicles. This may help protect node privacy in VANETs.

Time-Sensitive Data Exchange:

Most safety related applications require data packet transmission in a timely manner. Thus, any security schemes cannot harm the network performance of VANETs.

Potential Support from Infrastructure:

Unlike common MANETs, VANETs can actually take advantage of infrastructure in the future. This property has to be considered to make any protocols and a scheme for VANET is better.

Abundant Resources:

VANET nodes have abundant energy and computation resources. This allows schemes involving usage of resource demanding techniques such as ECDSA, RSA etc.

Better Physical Protection:

VANET nodes are better protected than MANETs. Thus, Nodes are more difficult to compromise which is also good news for security provisioning in VANETs.

Partitioned Network:

Vehicular networks will be frequently partitioned. The dynamic nature of traffic may result in large inter vehicle

gaps in sparsely populated scenarios and hence in several isolated clusters of nodes.

APPLICATIONS OF VANET [7]

Vehicular ad-hoc network applications range from road safety applications oriented to the vehicle or to the driver, to entertainment and commercial applications for passengers, making use of a plethora of cooperating technologies. Thus, we have divided the applications into two major categories:

Safety-Related Applications:

These applications contain safety related applications such as collision avoidance and cooperative driving (e.g., for lane merging). The common characteristic of this category is the relevance to life-critical situations where the existence of a service may prevent life-endangering accidents. Hence, the security of this category is mandatory, since the proper operation of any of these applications should be guaranteed even in the presence of attackers.

Other Applications:

It includes traffic optimization, payment services (e.g. toll collection), location-based services (e.g. finding the closest fuel station) and entertainment information (e.g. Internet access). Obviously, security is also required in this application category especially in the case of payment services. But in this paper we focus on the security aspects of safety-related applications [5] because they are the most specific to the automotive domain because they raise the most challenging problems.

VANET would support life-critical safety applications, safety warning applications, electronic toll collections, Internet access, group communications, roadside service finder etc.

Life-Critical Safety Applications:

It provides Intersection Collision Warning/Avoidance, Cooperative Collision Warning etc. In the MAC Layer, the Life-Critical Safety Applications can access the DSRC (Dedicated Short-Range Communications) control channel and other channels with the highest priority. The messages can be broadcasted to all the nearby VANET nodes.

Safety Warning Applications:

Safety Warning Applications contain Work Zone Warning, Transit Vehicle Signal Priority etc. The differences between Life-Critical Safety Applications and Safety Warning Applications are the allowable latency requirements while the Life-Critical Safety Applications [5] usually require the messages to be delivered to the nearby nodes within 100 milliseconds, the Safety Warning Applications can afford up to 1000 milliseconds. In the MAC Layer, the Safety Warning Applications can access the DSRC (Dedicated Short-Range Communications) control channel and the other channels with the 2nd highest priority. The messages can be broadcasted to all the nearby VANET nodes.

Electronic Toll Collections (ETCs):

Each vehicle can pay the toll electronically when it passes through a Toll Collection Point (a special RSU) without stopping. The Toll Collection Point will scan the Electrical License Plate at the OBU (on-board unit) of the vehicle and issue a receipt message to the vehicle including the amount

of the toll, the time and the location of the Toll Collection Point. In the MAC layer, the Electronic Toll Collections priority. It should be a direct one-hop wireless link between the Toll Collection Point and the vehicle.

Internet Access:

Future vehicles will be equipped with the capability so that the passages on the vehicles can connect to the Internet. In the MAC layer, the Internet Access applications can use DSRC service channels except the control channel, with the lowest priority comparing with the previous applications. In the network layer, it is used to support VANET Internet access, a straight forward method is to provide a unicast connection between the OBU of the vehicle and a RSU, which has the link towards the Internet.

Group Communications:

Many drivers may share some common interests when they are on the same road to the same direction, so they can use the VANET Group Communication functions. In the MAC layer, the Group Communications can use DSRC service channels except the control channel with the lowest priority comparing with the safety related applications and ETCs. In the network layer, It is used to support such application scenario in which multicast is the key technology. In the past, Internet multicast has not been successful due to its complexity because Internet multicast requires global deployment, which is virtually impossible. In a VANET, however, since all nodes are located in a relatively local area, implementing such group communication becomes possible. There are many Roadside Service Finders. For example, find restaurants, gas stations etc., in the nearby area along the road. A Roadside Services Database will be installed in the local area that connected to the corresponding RSUs (Road Side Units). In the MAC layer, the Roadside Services Finder application can use DSRC service channels except the control channel, with the lowest priority comparing with the safety related applications and ETCs. Each vehicle can issue a Service Finder Request message that can be routed to the nearest RSU and a Service Finder Response message that can be routed back to the vehicle. In short, the application layer requirements must be addressed in the MAC layer and network layer design. In the next section, we provide a network design framework to satisfy the above applications while providing sufficient security.

DAHNI (Driver Ad Hoc Networking Infrastructure):

DAHNI provides numerous possibilities to revolutionize the automotive and transportation industry of the future. For example, data captured by DAHNI, when properly aggregated, can be fed into the traffic monitoring and flow control system for real-time traffic management. Alternatively, such information can be archived for off-line analysis to understand traffic bottlenecks and devise techniques to alleviate traffic congestion.

Dedicated Short-Range Communications (DSRC) [6]:

DSRC system has emerged in North America, where 75 MHz of spectrum was approved by the U.S. FCC (Federal Communication Commission) in 2003 for such type of communication that mainly targets vehicular networks. On the other hand, the Car-to-Car Communication Consortium[4] (C2C-CC) has been initiated in Europe by

car manufacturers and automotive OEMs (original equipment manufacturers), with the main objective of increasing road traffic safety and efficiency by means of inter vehicle communication. IEEE is also advancing within the IEEE 1609 family of standards for wireless access in vehicular environments (WAVE).

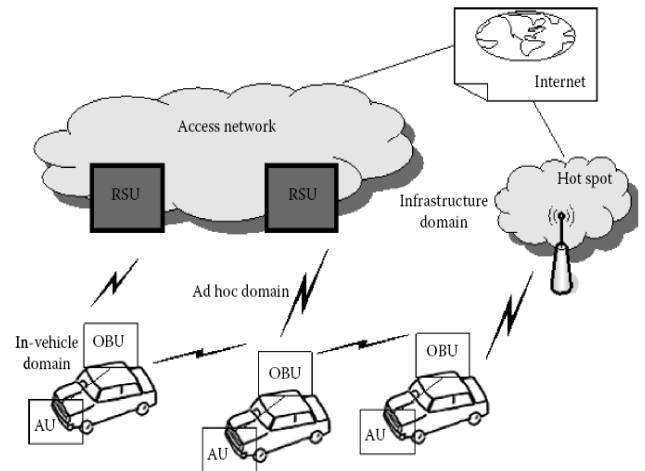


Figure 2. C2C-CC reference architecture [4]

FUTURE OF VANET

It's basically a network of cars that are in constant communication. Each car knows where it is, where it's going and basically any other quantity that it can measure. Not only has every car been made "self aware", it can also communicate with any other car on the road. Just take a minute to think of all the possibilities. The first one that comes to mind is road safety. If all cars know where all other cars are, cars headed for an imminent crash can warn their respective drivers and even apply autonomous control to avoid accidents.

Not only drivers can be informed about delays to their destination, but traffic lights can be connected to the communication network to most efficiently route traffic in real time. This creates a system where the road network always serves the current needs of the users on the network.

CONCLUSIONS


VANET is a promising wireless communication technology for improving highway safety and information services. In this paper, we propose a secure and application oriented network design framework in which the requirements of potential VANET applications are taken into account. We also study several applications as a promising tool for monitoring the physical world with wireless sensor that can sense, process and communicate. VANET applications range from safety and crash avoidance to Internet access and multimedia. We believe that our study can provide a guideline for more practical VANET.

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