IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 1, March, 2013
**ISSN: 2320 - 8791**
**www.ijreat.org**

# Secure Data Delivery Mechanism in Vehicular Ad Hoc Networks

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**Abstract**

Vehicular Ad-hoc Networks (VANETs) are special Mobile Ad-hoc Networks (MANETs) in which networked nodes are vehicles equipped with wireless communication capability. The challenges in designing a robust message dissemination technique are due to the diversity of VANET applications. Reliable broadcasting is one of the keys to success for services and applications on intelligent transportation system. Many reliable broadcasting protocols have been proposed. Broadcast protocols of VANETs must cope with the dynamics of wireless signals to guarantee fast and reliable delivery of information to all the vehicles. The proposed Robust, Dependable and Secure Data Delivery Mechanism (RDSM) Protocol specifically designed for satisfying requirements for safety applications with respect to delay, packet delivery and overhead. The superiority of this proposed protocol over existing protocols is highlighted conceptually and with simulations.

*Keywords - Vehicular Networks, Data Dissemination, Broadcasting, Security, Performance Evaluation.*

## 1. Introduction

VANET is an emerging technology to achieve inter-vehicular communication resulting in improved road safety and essential alerts. The technology integrates WLAN/cellular and Ad hoc networks to achieve the continuous connectivity between the nodes. Each node in an Ad hoc network acts as both a data terminal and a router. The nodes in the network then use the wireless medium to communicate with other nodes in their range. A VANET is effectively a subset of MANETs. Vehicular Ad hoc Networks (VANETs) consist of collections of vehicles equipped with wireless communication capabilities. Vehicles cooperate to deliver data messages through multihop paths, without the need of centralized administration. In VANETs (Vehicular Ad hoc Networks) RSUs (Road Side Units) and vehicles disseminate safety and non safety messages. The aim of VANETs is to enable dissemination of traffic information and it is important to disseminate data from an information source vehicle to many destination vehicles on the road. The main goal is to solve technical challenges related to robustness, performance, scalability and security for inter-vehicle communications. The key hindrance in operation of VANETs comes from the high speed and uncertain mobility of the mobile nodes (vehicles).The design of efficient routing protocol should cope with the key characteristics of VANET.

## 2. Vechicular Ad-Hoc Network - Characteristics

Broadcasting is the task of sending a message from a source node to all other nodes in the network which is referred as data dissemination. Nodes are equipped with one or many wireless transceivers. Network that contains these nodes is called a Vehicular Ad-hoc Network (VANET) with characteristics that can be summarized under the following Characteristics:

**Packet Loss:** As received transmission power levels, co-channel interference levels and wireless connectivity vary highly depending upon time and nodes relative position in different environments, packet loss varies significantly.

**Capacity:** Wireless link capacity differs due to effects such as multiple nodes accessing the same channel simultaneously, fading, noise and interference.

**Energy:** Nodes do not consider energy conservation as vehicles and RSUs act as a constant supply.

**Mobility:** The mobility pattern is predictable due to road layout, however it can involve nodes being static as well as nodes moving at very high speeds.
**Dynamic Topologies:** The speed and choice of route defines the dynamic topology of VANET. The topology changes with

time and consist of both bidirectional and unidirectional links that lost only a few seconds and can be frequently disconnected.

**Security:** This is a crucial aspect in vehicular networks and requires robust security protocols to secure private data transfer over the network.

**Application Distribution:** The range of applications running over a VANET can vary from low priority traffic such as email or web traffic to high priority data like emergency warnings.

**Interaction with Onboard Sensors:** This sensors helps in providing node location and their movement nature that are used for effective communication link and routing purposes.

## 2.1 Broadcast Protocols - Characteristics

Broadcast protocols of VANETs must cope with the dynamics of wireless signals to guarantee fast and reliable delivery of information to all vehicles in the neighborhood. Broadcast protocols for safety application dissemination must satisfy the following requirements:

**1) High Packet Delivery (Reliability):** The probability of reception for message dissemination must be very high. This is a measure that depends on the vehicle density and network topography. The protocol must disseminate warnings over the vehicles in a defined geographical area giving drivers sufficient time to react.

**2) Low End-to-End Delay:** The time delay between the initial transmission of a safety message and its reception by vehicles within the area of interest must be as low as possible and should be a fragment of the driver reaction time giving drivers sufficient time to react. This delay must also satisfy the safety application requirements.

**3) Minimal Overhead:** the packet overhead associated with safety applications should be minimal while maintaining acceptable delivery ratios and delay values. Repetitions of broadcasts must be incorporated within broadcast protocols to increase reliability but must not saturate the medium. The number of nodes that act as forwarders in the dissemination process must be considered as this effects the persistence of broadcast process and the load in the network.

## 2.2 Technology - WiMAX

WiMAX stands for Worldwide Interoperability for Microwave Access. It is a standard based technology. The purpose of WiMAX promotes deployment of broadband wireless access networks by using a global standard and certifying interoperability of products and technologies. It focuses on interoperability. There is Flexible and dynamic per user resource allocation & Support for advanced antenna techniques & Quality-of-service support is also available. IP-based architecture, Support for mobility, robust security is the features of WiMAX. WiMAX is a long range wireless metropolitan area network technology providing up to 30 miles (50 km) for fixed stations, and 3 - 10 miles for mobile stations. It is based on the IEEE 802.16 standard currently covering spectrum ranges from 2 GHz range through 66 GHz range, with non-line-of-sight offered on lower frequencies, 2 – 11 GHz, and line-of-sight offered on frequencies up to 66GHz. WiMAX is further categorized in fixed WiMAX (IEEE 802.16d-2004) and mobile WiMAX (IEEE 802.16e-2005).

# 3. Literature Review

Plethora of existing VANET broadcasting protocols is described in several surveys. Here only protocols most relevant to the proposal are described.

*The Parameterless Broadcast in Static to Highly Mobile (PBSM)* The main idea of PBSM [3] is two nodes do not transmit every time they discover each other as new neighbors. It is a parameter less protocol which does not consider vehicle position, direction and velocity. To overcome this problem ACKPBSM was proposed which tries to reduce the control packet overhead in data forwarding. It uses GPS to retrieve position information and acknowledgements are piggybacked in periodic beacon messages. It employs 1-hop position information obtained by periodic beacons to construct CDS.

*Acknowledged Parameterless Broadcast in Static to Highly Mobile (AckPBSM)* AckPBSM [2] is a modified version of PBSM, which is a parameterless broadcast in static to highly mobile ad-hoc network. It is an extension of PBSM which tries to reduce the protocol redundancy under the aforementioned vehicular situations. The main novelty is the modification of the algorithm to handle acknowledgements of broadcast messages. Such acknowledgements are piggybacked in periodic beacons. Hence, the protocol is called Acknowledged PBSM (AckPBSM). As PBSM AND ACKPBSM uses store and forward method to deliver the message in whole network which employs high end to end delay this is not acceptable in safety application for VANET.

*Acknowledged Broadcast from Static to highly Mobile (ABSM) protocol* [1] ABSM automatically adjusts its behavior without keeping track of the degree of mobility sensed by the vehicle. Each node independently decides whether or not to forward a received broadcast message. Such decision is solely based on the local information that vehicles acquire from their neighborhood by means of periodic beacon messages. This guarantees ultimate scalability regardless the size of the VANET. The set of parameters in ABSM [1] is minimal and consists only of few natural choices. In ABSM, a car that receives a broadcast message does not retransmit it immediately. Instead, the vehicle waits to check if retransmissions from other neighbors already cover its whole neighborhood, making its transmission then redundant. To acquire one-hop neighborhood position information, periodic beacons contain the position of the sender. Such information suffices to compute a connected dominating set (CDS). Nodes in the CDS select a shorter waiting time-out than regular nodes. This allows them to retransmit first if their neighborhood has not been already covered. That is, combines two different techniques, CDS and neighbor elimination scheme (NES). Beacons also include identifiers of the recently received broadcast messages, which serve as acknowledgments of reception. This way, nodes can check whether all their neighbors successfully received a message. If this is not the case, a retransmission is scheduled (upon the expiry of time-out duration). Otherwise, retransmission would be redundant. In both cases, when a new neighbor emerges, nodes restart their evaluation time-out if the message being disseminated is not acknowledged. If the message identifier is actually included within the beacon, the neighbor already got the message and no retransmission is scheduled. Hence, the use of acknowledgments makes the protocol more robust to transmission failures while, at the same time, saves redundant retransmissions. Although the described protocol inherently uses the store-carry-forward paradigm, ABSM does not incur large delivery latencies. Nodes connected to the source will receive the message with small delay, due to propagation via CDS. Vehicles' movements are generated with a microscopic road traffic simulation package, in order to mimic common scenarios of real vehicular networks. Different mobility conditions are simulated. Under realistic IEEE 802.11p models, ABSM is shown to outperform remaining approaches. This situation is common when vehicular mobility patterns are considered, and also occurs in other similar settings. There are many factors which influence the reception of a wireless signal (attenuation, multi-path fading, interference, etc.). ABSM's overhead is slightly higher, because it also needs to include an identifier for each received broadcast message.

## 4.The Rdsm Protocol

To design a reliable and efficient broadcast protocol, one should take the following metrics into considerations. The first metric is reliability: that is a broadcast message should be delivered to as many vehicles as possible in an area of interest. The second metric is overhead: that is, delivery of a broadcast message to all vehicles should generate as few redundant messages as possible. The last metric is speed of data dissemination; that is, a broadcast message should be delivered to all vehicles as fast as possible. Although a broadcast message can reach all vehicles, it can be meaningless if it arrives too late. This metric is very critical for emergency services.

### 4.1 Protocol Details

The main objective is to guarantee fast and reliable delivery of information to all vehicles in the neighborhood, where the wireless communication medium is shared and highly unreliable with limited bandwidth. The proposed Robust, Dependable and Secure Data Delivery Mechanism (RDSM) Broadcasting Protocol specifically designed for Vehicular Ad-hoc Networks (VANET), where the emphasis is on satisfying requirements for safety applications with respect to delay, packet delivery and overhead. The proposed protocol gives the vehicle in the most dangerous situation the highest priority to transmit the acknowledgement signal. It uses adaptive beacon to get neighbors' position and velocity.

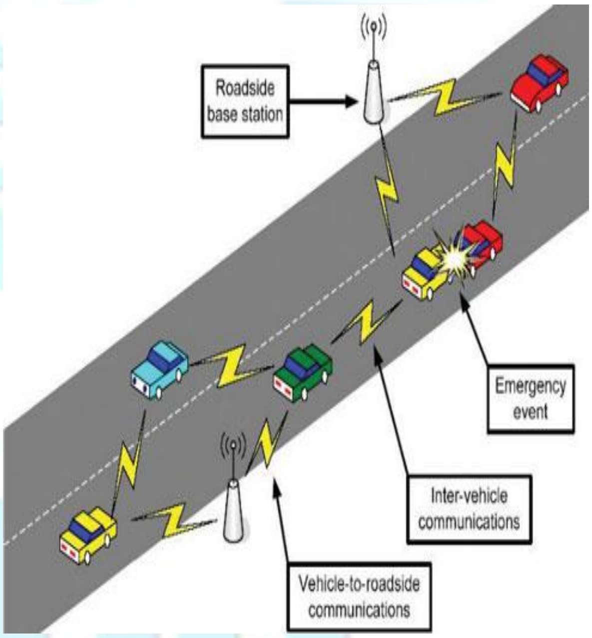


Fig.1. Inter-vehicle Communications

When nodes want to broadcast messages, nodes will select the neighbors in preferred distance to rebroadcast the message. The preferred distance is based on the distance between nodes and selector nodes. The selected node will rebroadcast the message immediately. In case the selected nodes do not rebroadcast the message, other nodes which have set waiting timeout since they received message will do this task instead. The waiting timeout is calculated depend on the distance between node and precursor node. So a node that is closest to selected node will rebroadcast the messages. Nodes can know if the neighbors miss some messages and rebroadcast the message to them by set waiting timeout. So a node in the same road section will rebroadcast the messages to neighbors.

## 5.PERFORMANCE EVALUATION

### Simulation Environment

The simulation work has been done with The Network Simulator NS-2. The NS instructions can be used to define the topology structure of the network and the motion mode of the nodes, to configure the service source and the receiver, to create the statistical data track file. The traces files have been simulated. The following metrics are considered for performance evaluation.

Reliability is measured as a percentage of number of nodes that received the message at the end of simulation.

Overhead is measured from bandwidth consumption which is from messages transmission and beaconing transmission. Beacon size includes node's local information (e.g. identifier, position and velocity) and list of received messages identifiers as acknowledgement.

Speed of Data Dissemination is measured as on protocol's preferred node selection algorithm and waiting timeout calculation.

### Simulation Results

Speed of Data Dissemination: Speed of data dissemination results can be seen in Fig.2. The speed of data dissemination depends on protocol's preferred node selection algorithm and waiting timeout calculation. ABSM has the slower speed than RDSM.

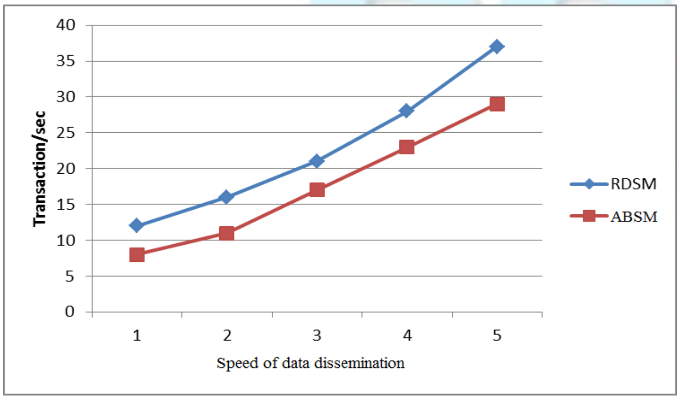


Fig.2. Speed of Data Dissemination

Reliability: Reliability results can be seen in Fig.3.for highway and urban scenarios respectively.

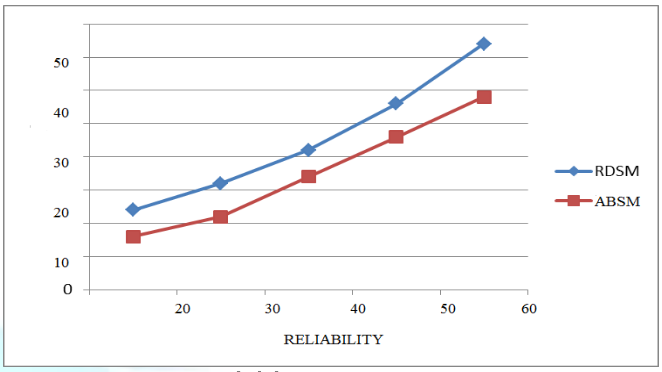


Fig.3. Reliability

## 6.Conclusion And Future Work

The research on vehicular networks has been growing rapidly in recent years. The security issue is very important for VANETs. A comparative study has to be done with the previously existing protocols and the improvements can be made to efficiently disseminate information in vehicular ad hoc networks. There are several directions that could be investigated in order to make protocol more secure. Proposed protocol need to be analyzed mainly in the following aspects: authentication and key management, privacy, and secure positioning. Proposed protocols need to be analyzed in real test bed in order to assess its performance in real scenarios. Such test bed experiments will enhance the protocol.

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