# An Adaptive Clustering Mechanism for Data Dissemination in Urban Scenario

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## Abstract

For the past few decades, there is a lot of advancement especially in communication technologies which provide an implementation of various networks in different environments. Vehicular Ad-hoc Network (VANET) is one of the end products of that evolution leading to have a greater scope in the near future. There is a lot of research that is going on VANETS in countries like US, Japan, and European Nations. The main reason for this is due to the standardization of VANETS in combination with infrastructure based communication contributes a new era in Intelligent Transportation Systems (ITS). This ITS enabled vehicles can be used for high level of transportation from conventional controlled car to an autonomous vehicle. ITS deals with road safety, faster transport, Collision avoidance and many other transportation problems that are faced in real time scenarios. A lot of researches have focused on VANET algorithms, routing protocols, broadcasting techniques and security related issues. Broadcasting in VANETS is highly unreliable due to the Broadcast storm problem. This can be minimized with the help of modified broadcasting technique by splitting the region based on density and followed by clustering mechanism. Such type of context aware mechanisms leads to increase in efficiency and Quality of service (QoS) of the system.

Keywords: Broadcast Protocol, Context-Aware Broadcasting, Cluster, Information Dissemination, ITS, VANET

## 1. Introduction

VANET a special type of Mobile Ad hoc NETworks (MANETs), encompass vehicular communication. Differently to cellular networks, VANETs conduct communication with no help from traditional infrastructure. VANETs are categorized into two basic types; Vehicle-To-Roadside-Infrastructure (V2X) and Vehicle-To-Vehicle (V2V). A V2X network provides the vehicles, which are connected to roadside infrastructure, e.g. traffic lights and road lights, with access to the Internet, while in V2V operation the vehicles organize the network and share information with no central control.

According to the type of information provided<sup>1,2</sup>, VANET applications are divided into two types: safety and infotainment. Safety applications include information on traffic conditions, e.g. traffic collisions, congestion, emer-

lane changing assistance or pre-accident warnings. Safety applications of VANETs inform drivers of any change in traffic conditions and take corresponding actions. Infotainment, the portmanteau word of information and entertainment, provides drivers with locale-based services, e.g. points of interest notification, and media downloading, information sharing among vehicles and Internet access.

gency vehicle warnings, overtaking vehicle warnings,

The US Federal Communications Commission (FCC) allocates the 75 MHz spectrum in the 5.9 GHz band exclusively to vehicular applications and research in the Dedicated Short Range Communication (DSRC) was launched in 1992<sup>3</sup>. Since 2004, the focus of research on vehicular network has migrated to the auspices of the IEEE standard group. IEEE 802.11p is the amendment to the 802.11 standard on data links and physical layers for

vehicular environments, the latest version of which was released in 2010<sup>4</sup>. IEEE Task group 1609 undertook the work of developing specifications for vehicular networks at the application and network layers, and establishing the IEEE 1609 standards set<sup>5</sup>.

### **1.1 Features of VANETs**

VANETs are a subset of MANETs. They differ from MANETs as the nodes are vehicles, subject to current traffic conditions. They exhibit the following features<sup>6.7</sup>:

#### 1.1.1 High Dynamic and Frequent Disconnection

Due to the high-speed movement of nodes (vehicles) in VANETs, compared with nodes in MANETs, the duration time of connection could be shorter than that in MANETs, which leads to more frequent breakage of links than in MANETs. Typically, the radio range is assumed to be 240m, which is the configuration in this paper, and the gap in speed between two vehicles moving in the same direction is 10 kph, e.g., 50 kph and 60 kph, so the maximum connection time is approximately 107 s if the faster vehicle is catching up the other one from the very beginning. If they are moving in the opposite direction, the maximum connection time is less than 10 s. While for a relatively low-speed MANET, e.g. 1 m/s between two nodes, the connection duration could be as long as 480 s, approximately 4 times 109 s. Frequent disconnections of links in VANETs also leads to the frequent change of network topology. Frequent disconnection is an important factor in the design of protocols for VANETs.

#### 1.1.2 Density Variation

Due to the mobility of VANETs, the density of vehicles varies with road condition and time. Traffic jams and accidents, especially in rush hours on weekdays, make the road congested to varying degrees. Vehicles may accumulate near traffic lights even in sparse traffic conditions. Usually in an urban scenario, vehicle density is higher than on a highway or rural scenario. Congestion in rush hours reduces highway efficiency, yet drivers can experience a relatively comfortable driving experience at other times of the day, especially at night when vehicles are sparse on the road. The vehicle density is related to the network connectivity of VANETs and may make an impact on the performance of communication schemes dedicate for VANETs.

#### 1.1.3 Regular Trace

In MANETs, nodes can move in any direction along an irregular trace. While in VANETs due to the confines of the roads, buildings and bridges, the traces of the node are regular, i.e., along the road. In addition, it is observed that the speed of a vehicle may be influenced by other vehicles on the road, especially in dense traffic. Therefore, the traces of nodes in VANETs are not completely independent. The traces of nodes may be predictable from the road maps and traffic conditions.

#### 1.1.4 Power Consumption of VANETs

In MANETs, power consumption is a crucial problem, since the carrier is usually a small device and the battery capacity for the sensor is limited. While in VANETs, network power is supplied by an on-board source, i.e. the vehicle battery which provides enough energy for the VANETs sensors, and power consumption is not an important problem.

#### 1.1.5 Varying Environment for Communication

The impact of environment on the VANET system changes with the type of environment. Typically, two types of environment are considered in the application of VANETs, i.e., an urban scenario and a highway one. In the urban scenario, the vehicles move slower with more complicated traffic patterns, due to traffic lights and congestion. The buildings and traffic lights provide the potential for VANETs to form a Vehicle-To-Infrastructure (V2I) network, as well as block radio propagation. In the highway scenario however, conditions are simpler, i.e., faster speed, mainly straight paths, less interference from roadside units. Due to the lack of roadside infrastructure, the communication between vehicles is mainly in the form of vehicle-to-vehicle.

#### 1.2 IEEE 802.11p

IEEE 802.11p, a.k.a. Wireless Access for the Vehicular Environment (WAVE), is the communication protocol dedicated to ITS. The application of WAVE in ITS includes the data exchange between vehicles on the move (V2V) and between vehicles and roadside units (V2X) in the frequency band 5.9 GHz, licensed by the US FCC and European Telecommunications Standards Institute (ETSI). As an enhancement to IEEE 802.11 protocols, 802.11p has been standardised and the latest amendment version was released in 2010<sup>6</sup>. The US FCC and ETSI allocated 75 MHz and 30 MHz of spectrum in the 5.9 GHz for DSRC, respectively. The channel for DSRC consists of seven sub-channels with one control channel and six service channels. V2V and V2I applications adopting DSRC can potentially reduce the possibility of traffic accidents by informing drivers of the real-time traffic conditions. In addition, non-safety applications can also be provided via DSRC technology. Safety applications have higher priority than non-safety applications, and therefore they are the focus of vehicle technologies, aimed at saving lives by preventing accidents.



Figure 1. IEEE 802.11p layers.

This paper is organized as follows: introduction of some existing broadcast schemes is in Section II, the proposed network architecture and methodology is explained in Section III, detailed design of broadcast scheme is written in Section IV, simulation and result are recorded in Section V, Section VI conclude this paper.

# 2. Broadcast Protocols

Flooding broadcast is a simple and straightforward method of message dissemination. In a flooding scheme, every node receiving the message forwards the message. Yet, the problems caused by flooding, e.g. waste of bandwidth and frequent collisions, make it an inefficient method especially in the case of a dense network. Broadcast storm in VANETs is quantified<sup>8</sup>, which indicates that in the flooding scheme, with the increase of vehicle density, the transmission performance is significantly affected, in terms of the number of hops, total delay and packet loss ratio.

Selective forwarding schemes are used to improve the performance of the flooding scheme<sup>8</sup>. In weighted p-persistence broadcasting, if a message is received for the first time, the receiver forwards the message with a specific probability p, which is the ratio of the distance between the transmitter and the receiver to the transmission range. That is, the farther receivers to the transmitter forward the message with higher probability. In addition, slotted 1-Persistence broadcasting permits the receiver to forward the message with probability 1 in the preassigned time slot. The assigned time slot relates to the one-hop delay, total number of time slots and the distance from the transmitter to the receiver.

In slotted p-persistence broadcast, the hybrid scheme, the receivers forward the message in a pre-assigned time slot with a specific probability. Both the assigned time slot and the probability relate to the distance from the transmitter to the receiver. Broadcast redundancy and packet loss ratio are reduced by up to 70% compared to flooding and the propagation latency is still at acceptable levels. The properties of urban traffic are analysed and compared with the highway scenario [916], and Urban Vehicular Broadcast protocol (UV-Cast) is proposed. Store-Carry-Forward (SCF) scheme is adopted in UV-Cast. Region Of Interest (ROI) in the highway scenario is usually unidirectional along the road while in an urban scenario ROI is multi-directional. Therefore, the broadcast scheme for the highway needs to be modified from the one applied in the urban case. More than one vehicle is selected as the relay for SCF in the urban case, since one relay may fail to propagate the messages in all directions considering the direction of movement of the relay. A relay for SCF forwards the message more than once to inform all the possible vehicles in the ROI. Experiments in an urban scenario show excellent performance of UV-Case in terms of reachability and network overhead.

A Border Node-Based Routing (BBR) protocol is proposed for a partially connected network, e.g. VANETs in a rural area. The border node is defined as the node with minimum common neighbour nodes with the transmitter, which is the furthest node from the transmitter within the transmission range. As is shown in Figure 2, the common neighbours between vehicle Tx and 1 are vehicle 4 and 5. While for vehicle 2, 3, 4 and 5, the number of common vehicles with vehicle Tx is 3 or more. Therefore, vehicle 1 is the border node. In BBR, the beacon message is sent out by the network layer of the nodes to claim their existence and one-hop neighbour information is collected, since it is assumed that the location information is unavailable for the vehicles. As the transmitter broadcasts a message, the border node of the transmitter forwards the message in a flooding way. Simulation indicates that a high packet delivery ratio can be achieved in a highly partitioned network, e.g. a rural network, by using a limited flooding scheme, e.g. BBR, although flooding schemes cause problems resulting in low delivery ratio in dense networks.



Figure 2. Illustration of border node.

Broadcasting protocols are a simple and straightforward method of message propagation in vehicular environments but the issues, e.g. broadcast storm, can lead to low efficiency of message propagation in dense traffic.

#### **2.1 Cluster-Based Protocols**

In cluster-based protocols, a virtual chain of networks is created for message propagation, unlike the flooding scheme adopted in IEEE 802.11, in which every node is involved in forwarding messages. The vehicles are grouped geographically as clusters. The size of the cluster depends on the radio range of wireless devices adopted in the network. The Cluster Head (CH) is selected in each cluster and it takes charge of inter-cluster communication. Cluster members communicate directly with members in the same cluster and via CHs with vehicles in other clusters. The stable and reliable communication between CHs affects the system performance. In a cross layer protocol for alert message propagation in VANETs, predefined Backbone Members (BM) are selected to forward messages prior to the propagation, which is named as DBA-MAC, Dynamic Backbone Assistance MAC. Once a vehicle has not received any messages from nearby BMs for a specific period, it upgrades itself as a BM and broadcasts a beacon to create a BM network. The vehicles receiving a beacon, which then become BM candidates, start a contention to be the next BM. The suitability as a BM is measured by the relative distance between the BM candidates and the BM at the end of the predefined period, the one with the longest distance winning contention with the highest probability.

During message propagation, only BMs forward messages from the preceding BM. Once a BM fails to forward a message, all the other vehicles start contention to forward the message. A scheme of on-line game message propagation is similar to DBA-MAC. Each time a message is to be transmitted, a beacon is broadcast to start a contention. The suitability of the vehicles is determined by the relative distance, similar to the BM selection scheme. The propagation scheme for online game messages is the basis for the on-demand part and the BM selection part of DBA-MAC. The difference between on-line game message propagation and DBA-MAC lies in the fact that in DBA-MAC it is assumed that every vehicle has a constant radio range and this assumption in the former scheme has been relaxed. And the ratio of relative distance to Tx and the unique radio range of Tx is used to calculate the suitability of candidates.

The Affinity Propagation algorithm is adopted to select CH in a distributed manner periodically. Considering node location and mobility, similarity function between nodes within mutual radio range is built, which is related to the sum of negative Euclidean distance between two nodes now and in the future. In order to achieve a stable CH link, the proposed protocol is able to group vehicles into clusters which minimize relative mobility between CHs and the distance between CHs and cluster members. To deal with the situation where CHs lose connection, a scheme whereby more than one CH is used to forward messages is proposed. The network formation procedure is divided into two phases, a setup phase and a maintenance phase. In the setup phase a normal node claims to be a CH if it does not receive any messages from nearby CHs. CHs broadcast beacons to create a CH network. In the maintenance phase, a secondary CH (SCH) is selected. A weighted sum of speed difference and location distance between CH and any cluster member can be acquired and the member with the minimum sum is selected as the SCH. If the CH leaves the cluster network, the SCH undertakes message propagation and upgrades itself to the CH of the cluster.

The cluster-based protocols disseminate messages through a CH, which reduces the contention, collision and thus energy consumption of vehicles in message propagation.

## 2.2 Factors Related to the Network Connectivity

Current research shows that the network connectivity in vehicular networks is mainly determined by the following factors: 1) vehicle density; 2) transmission power, or the Maximum Transmission Range (MTR); 3) network mobility; 4) whether roadside units (RS)/infrastructures are involved in the communication; and 5) impact from environments on signal propagation.

## 3. Problem Statement

In VANETS, information is conceded in the form of broadcasting. Each node having its own probability for rebroadcasting, i.e., if a node having same broadcast probability and distance from another node then there occurs a packet drop this is explained due to the broadcast problem.

The main problem in the existing mechanism is message cannot be delivered correctly due to continuous broadcasting. This may be due to the mobility nature of the node, lack of infrastructure, data size and in some cases failure of node coordination. In addition, lack of infrastructure for high data rate transmission is another problem that arises in Vehicular Ad-hoc Networks. This can be minimized with the help of modified broadcasting technique by splitting the region based on density and followed by clustering mechanism. Broadcast storm problem mainly occurs due to the increase in node density i.e., in Urban areas. So the main aim is to reduce this broadcast problem, a new hybrid broadcasting mechanism may solve this issue.

## **4. SYSTEM ANALYSIS**

For designing a new mechanism, it should have same throughput as that of the simple broadcasting and increase

in QoS should be considered. For these two approaches, should be done 1) Classify the regions on the basis on Density. 2) Apply clustering or any other BSP reduction mechanism. For classifying the regions based on density VWPP scheme is applied.

## 4.1 Versatile Weighted Probabilistic Persistence Scheme (VWPP)

The main aim is to reduce the number of retransmissions as possible. In a conventional mechanism, a packet rebroadcasts with a probability of  $p_{ji}$  and can be given by

$$p_{ji} = \frac{D_{ij}}{R} \tag{4.1}$$

Where  $D_{ij}$  represents the relative distance between nodes i and j, and R is the average transmission range. But every node has to wait sometime it is given by  $T_{wait}$ before it has to broadcast again so it will make the probability as low as possible and reduce the message that has been received from multiple sources.

This is done by using the distance calculation Euclidean Distance is

$$d_{ij} = \sqrt{\left[\left(x\right]_j - x_i\right)^2 + \left[\left(y\right]_j - y_i\right)^2} \quad \forall i, j \ge \mathbf{0}$$

$$(4.2)$$

Root Mean square distance is

$$d_{ij} = \sqrt{x_i^2 + y_i^2} + \sqrt{x_j^2 + y_j^2} \quad \forall i, j \ge$$
(4.3)

Vehicles with the same distance from the source have same probability leads to BSP. So a forwarding broadcasting mechanism is needed.



Figure 3. Shortcomings of WPP scheme.

From Figure 3. assume vehicle s broadcasts within the range of 250m whereas C, E, F, G and H are 5 m, 100m, 100m, 125m and 125m respectively. Let's say the rebroadcasting probability is 0.02, 0.4, 0.4, 0.5, and 0.5 respectively. it can be observed that rebroadcast process from C will lapse and in the same way rebroadcasting from vehicles E, F, G and H will result in duplicated messages.

```
Begin
        Step1: Upon reception of a broadcast message
        msg at a Vehicle V_r for the first time.
        Step2: Get the distance d between sender Vs and
        receiver V<sub>r</sub>.
        Step3: Get Number of neighbours N_n at V_r.
        Step4: Get the network average number of
        neighbours Navg.
        Step5: IF d< r/2 and N_n > N_{avg} THEN
```

{

Vr is located at a dense area

 $V_r$  is near to  $V_s$  and small broadcast coverage  $V_r$  rebroadcasts with a low Probability  $\mathbf{P} = P_{low}$ 

Go to step 7 Step6: IF d> r/2 and  $N_n < N_{avg}$  THEN

V<sub>n</sub> is located at a sparse area

 $V_r$  is far from  $V_s$  and large broadcast coverage

 $V_r$  rebroadcasts with a high Probability P =  $P_{high}$ 

Go to step 7

```
Step7: IF ((Random :: uniform (0.0, 1.0) <= P)
        Forward(msg)
```

Else Free(msg)

}

End

Figure 4. VWPP scheme flowchart.

So, in order to avoid this inefficient broadcasting a generic probability method that dynamically adjusts the re-forwarding probability per vehicle and the local density should be considered.

Now for reducing BSP clustering is applied and various clustering algorithms that are available can be given as

## 4.2 Forming of Clusters

For making the cluster and CH the following algorithm is implemented. Here threshold value is considered to be optimum for the broadcasting. The threshold value gives the number of vehicles that can be present in that cluster. For our scenario, 50 vehicles are considered to equally divide the clusters we make our threshold value as 17. For selecting the cluster head, we take the retained energy into consideration i.e., the node having the maximum energy is considered as cluster head. For the entire simulation, the energy considered for a node is 10 watts and for rebroadcasting it spends 0.5 watts. The Figure 5. is given as





This clustering is done above the AODV protocol whereas the selection of CH is based upon the mobility of that particular node along with the energy it retained. Whenever a node is moving from one cluster to another that region is said to be mixed zone. The communication between cluster nodes is done by using a different protocol known as XFX VANETS.

In the case of mixed zones, the hop distance is taken into consideration for the assigning of the CH to that particular node. So the active node region can be reduced so as the number of packets that can be lost along with the rebroadcasting packets.

If a node fails to participate in the rebroadcasting it is set to be inactive and it should be eliminated from the network.

In stochastic broadcast, the following assumptions are taken

$$\lambda_s = P \rho \pi r^2 \tag{4.4}$$

where P denotes the broadcast probability in order to maintain  $\lambda_s$ , it is necessary to adjust P dynamically while the network topology changes. Thus, every node needs to maintain a neighbour node list using either beacons or location services.

# 5. Performance and Analysis

The simulation of a VANET is a problem by itself and out of scope of this work. We used a common simulation framework which is given by the following software tools: Simulation of Urban Mobility (SUMO) [16], Network Simulator 2 and the network simulator whereas NS2 is the central application to concatenate the other ones.

#### Table 1. Simulation metrics

Simulation area	1000*1000 square meters
Transmission range	250m,1000m
No of connections	3
Connection type	UDP, TCP, RTR
MAC Protocol	IEEE 802_11p
Routing Protocol	XFX, AODV
Channel rate	10Mbps, 100Mbps
Traffic type	Ping
Packet Size	1000 bytes
Simulation Time	500sec
No of nodes	10-100
Simulation Tool	Ns2, SUMO, VANET Simulator



Figure 6. Forming of cluster heads in the NS2.

The above simulation takes place in Network Simulator (NS2) on Ubuntu OS 14.04 LTS. Here for the number of

nodes is taken up to 50 and number of clusters as 3 with an optimum cluster weight of 17 i.e., each CH can have up to 17 nodes as a cluster.

Here CH0, CH1, and CH3 are the cluster heads for the respective clusters and M0, M1, M2. etc, are the mobile nodes respectively.

The results of this simulation are given as

## 5.1 End to End Delay

It is the time taken by Propagation Delay, Packetization delay, and Queueing delay. Where the propagation delay and packetization delay are fixed in a network the only delay that is variable is queueing delay i.e., buffering delay. Since the concept of clustering is being applied the buffering delay can be reduced at a rapid rate. It is given as









From the above result, it can be easily explained as the number of nodes are increasing existing approach has much more end to end delay compared to that of the proposed clustering model. So from this, it is clearly explained that as the number of nodes is increasing the proposed model efficiently works comparable to that of existing model.

### 5.2 Overhead

Network overhead is often defined as the total number of routing packets, counted once per hop. For the normal network as the number of nodes increases so as that of the packets that are required for the routing. But in the case of proposed model due to the clustering algorithm, the number of packets that are required for routing can be minimized.

## 5.3 Packet Delivery Ratio (PDR)

It is defined as the ratio between the received packets by the destination and the generated packets at the source.



Figure 8. Packet delivery ratio.

From the Figure 8., it can be clearly shown that the proposed model has more packet delivery ratio than the existing approach since as the broadcasting of packets are confined to a limited number of hops due to clustering there is less number of packet drops so there is an increase of packet delivery ratio.

## 5.4 Throughput

Throughput is explained by taking an example

let  $t_1$  be the send time of first packet by source

let  $t_2$  be the send time of last packet by source

let n by the number of packets sent

let s be the size of a packet

Now, Throughput = 
$$\frac{(t_1 - t_2) * 1000}{(t_1 - t_2) * 1000}$$
 (in Kb/s) (5)





Throughput can also be increased by reducing the packet loss. Since in the case of the clustering algorithm, the packet loss is less so an observation of high throughput is seen.

## 5.6 SUMO Implementation

The Sumo version used for the simulation is 0.19.0.



Figure 11. SUMO implementation.

# 6. CONCLUSION

This paper introduces the challenges in VANET emergency message broadcast and its contribution of protecting human lives and properties. It also summarized our objectives to contribute to emergency message broadcast in VANET research. This paper also categorized different broadcast schemes, analyzed their strength and weakness. On top of that, this paper introduced two broadcast schemes that related to the study.

In order to boost performance and mitigate network fragmentation in high density regions, we proposed the concept of context aware broadcasting process, explained the scheme to work actively and individually in the broadcast using VWPP scheme. By applying contextaware mechanism especially in urban scenario leads to high efficiency and less overheard.

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