An Efficient Directional Broadcast Protocol with Adaptive Range for VANETs

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Abstract

Routing in vehicular ad-hoc networks (VANETs) is a major challenge. The unique characteristics of VANETs such as high mobility of nodes, dynamically changing topology and high partitioned network makes it difficult to ensure reliable, continuous and seamless communication among the vehicles in motion. In this paper, we propose a position and probability based broadcast protocol called Directional Broadcast Protocol with Adaptive Range (DBAR). This protocol focuses on safety application in urban environment in order to disseminate data during emergency situations efficiently. This protocol combines different concepts such as directional broadcast, dynamic transmission range selection and probability based rebroadcasting. It works both at normal roads and at intersection of roads. It disseminates the emergency message to its immediate neighbors only in one direction within a given range. If the vehicle density is high then the range is reduced dynamically by adjusting the transmission power which avoids the broadcast storm problem. The performance of DBAR is evaluated using NS2 simulator and the results are presented and compared with existing routing algorithms.We have achieved better packet delivery ratio and low latency which are essential requirements for the safety applications demanding real-time response.

1. Introduction

VANETs are emerging area of MANET's in which vehicles act as the mobile nodes within the network. The major objective of VANETs is to increase safety of road users and comfort of passengers. Routing is a major challenge in Vehicular Ad-hoc Networks (VANETs). The high mobility of nodes and dynamically varying vehicle density result in rapid changing topology, which inturn leads to frequent disruptions. The routing protocols for VANETs should be capable ofmaintaining the routes during the communication process and should be capable of discovering alternate routes quickly on the fly in the event of losing the path. It becomes quite challenging to maintain a stable path for broadcasting Emergency and Warning (E/W) messages from a risk zone. Reducing network overhead, avoiding network congestion, traffic congestion and increasing packet delivery ratio are the major issues of routing in VANETs [1, 2].

It is essential to broadcast the risk notification (RN) messages such as accident and injury prevention messages, congestion control messages, road condition and emergency/warning messages in time to the nearby vehicles. Broadcast protocols are commonly employed for disseminating data for safety applications. Flooding is a prominent technique used in broadcast routing protocols. However, blind flooding results in broadcast storm problem [3]. A broadcast storm can overload the limited channel capacity, causing channel congestion that reduces communication reliability.

In this paper, we propose an efficient Directional Broadcast protocol with Adaptive Range (DBAR), for real-time safety emergency response system for urban environment. This is a hybrid protocol which combines three different concepts viz. *directional broadcast, dynamic transmission range adaptation and probabilitybased rebroadcasting*. It is capable of providing priority based message dissemination. The DBAR protocol is composed of two parts viz. *directional broadcast on road* and *directional broadcast on intersections.* In the event of anyemergency situation on road, we adopt directional broadcast focusing on the rear vehicles in order to disseminate warning messages toavoid accidents. In addition, we select farthest vehicle within a range to rebroadcast the message. The emergency vehicle also detects the opposite direction vehicle in the other lane and sends information so that it reaches the intersections faster.

The rest of the paper is organised as follows: Section 2 discusses the related work. Section 3 describes the proposed protocol. Section 4 presents the simulation results with discussion and finally Section 5 provides the conclusion.

2. Background

Broadcast technique is the prominent method for routing in VANETs, especially in safety related applications. In broadcast mode, a packet is sent to all (even unknown or unspecified) vehicles in the network. Broadcast techniques in VANETs are basically classified into four categories viz. *Traffic based broadcast, Position based broadcast, Probability based methods and Cluster based methods*. Refer [4] for a taxonomy of VANETs for routing and an in-depth review of various routing protocol for VANETs.

In *traffic based broadcast methods*, a source node broadcasts a packet blindly to all its neighbours and each of these neighbours, in turn, re-broadcast the packet exactly one time[5]. This process continues until all the reachable network nodes have received the packet. As the vehicle density increases, this type of blind broadcast results in Broadcast Storm Problem (BSP) [3] such as congestion, contention, excessive collisions and redundant re-broadcast. In *position based methods*, the routing decisions are based on geographic position of the vehicles. These methods require location services to determine the position of the destination node. With the proliferation of GPS based devices, position based protocols are gaining importance [6]. In *probability based methods*, nodes retransmit the message with a predetermined probability [7]. The aim is to avoid the redundant broadcast messages and collision. However, the selection of the probability value, by itself is a challenging task. Researchers explore fixed probability schemes [8] as well as dynamic probability schemes [9]. In *Cluster based broadcastmethods*, the network is divided into several clusters and each cluster has one head node. These methods try to provide scalability and stability of the route, since only the cluster-heads participate in routing [10]. We do not discuss cluster based approaches in this paper.

The following position based routing protocols explore the concept of directional and intersection broadcast - Ad-Hoc Multi-hop Broadcast protocol (AMB) [11] and Efficient Directional Broadcast (EDB) [12]. AMB [11] is designed for multi-hop broadcast in urban scenarios. It does not depend on infrastructure. AMB uses handshake signals between nodes for directional broadcast, which mitigates hidden-node problem. This protocol incorporates an efficient intersection broadcast mechanism using *Hunter Vehicle* concept. EDB [12] assumes that two fixed directional antenna are fit on every vehicle as well as availability of directional repeaters at the intersection for its operation. It forwards packets only in the opposite direction. It waits for the acknowledgment from the receivers before making the forwarding decision. This protocol achieves long transmission range, low redundancy and less collision due to the use of directional antenna. Position based Adaptive Broadcast (PAB) [13] protocol is developed for cooperative collision avoidance applications in two-way multilane highway. It aims to reduce the latency and number of re-transmissions during message delivery. This protocol selects an appropriate candidate for retransmission by exploiting the position, direction and velocity information of vehicles to reduce latency.

DV-CAST and ABS protocols exploit the use of probability for rebroadcasting. DV-CAST [14], istraffic based distributed multi-hop broadcast protocol, which uses the local one-hop topology for routing decisions and uses fixed probability approach for rebroadcast. It does not depend on infrastructure. It computes connectivity in forward and opposite directions with periodic heart beat messages. In dense environment, it applies probability based suppression schemes, whereas in sparse environment it uses store-and-forward technique [14]. However, this protocol is attributed with high overhead and end-to-end delay during data transfer. Adaptive Broadcasting Scheme (ABS) [15] tries to improve the route discovery process of AODV protocol [16]. It applies dynamic probability for forwarding based on local and global neighbourhood information instead of blind flooding.

The dynamic range adaptation concept is explored by [17], in which both range and contention window are dynamically varied based on the vehicle density and network traffic condition. This scheme enhances the overall performance with high throughput and less delay for high priority messages

3. Directional Broadcast Protocol with Adaptive Range

As discussed earlier, simple broadcast protocols are suitable for only small number of nodes in the network. As the density of nodes increases, there is an exponential increase in message transmission, which results in higher bandwidth consumption and more number of collisions. Efficient broadcast routing protocol is required for dissemination time-critical warning messages. We propose a directional broadcast routing protocol in the context of our research work, to build a *generic layered architecture* for VANET applications. It consists of three layers addressing *safety, convenience and comfort* applications. The heart of the generic architecture is the *routing protocol stack* integrating appropriate VANET protocol in each layer. The major requirement of the architecture is the integration of suitable protocol meeting the quality of service requirements in each layer [18]. The inner layer of the architecture addresses time-critical safety applications for which as efficient broadcast protocol are needed.

The proposed directional broadcast routing protocol with adaptive range (DBAR) is an event-driven method. The aim of the DBAR protocol is to deliver the emergency to immediate neighbour vehicles in the rear side as soon as possible once an emergency occurred to avoid pile-up accidents. DBAR is a combination of position and probability based methods for emergency message delivery. Our algorithm assumes that vehicles are equipped with positioning devices, such as GPS and wireless devices and also each vehicle can sense the intersection/junction.

DBAR combines the concept of directional broadcast, dynamic range selection and dynamic probability based rebroadcasting. It is composed of two parts such as directional broadcast on road and directional broadcast on intersections. In directional broadcast on the road, any event occurred as emergency situation the messages are disseminated only to its one-hop neighbours in the rear side vehicles for avoiding the pile-up accidents. Only the farthest away vehicle is responsible for rebroadcasting emergency message to its rear vehicles based on the probability. This avoids the possibility of more than one node transmitting at the same time and reduces collision. The emergency vehicle also detects the opposite direction vehicle in the other lane and sends information to reach the intersections. The opposite vehicle rebroadcasts the message in its forward direction till it reaches an intersection. If the vehicles are present in the intersections, those vehicles are responsible for re-broadcasting emergency message to its rear vehicles; otherwise the message is lost.

A count value is used for multi-hop routing; it is set by the source vehicle with a value greater than zero and every rebroadcasting, it is decremented by one. The count value becomes zero then packet will be discarded. Rebroadcasting is carried out based on the probability by exploiting the vehicle density, position, direction and speed information of vehicles to reduce the latency.

We adopt the dynamic range selection by varying the transmission power based on the vehicle density. Hello messages are exchanged between vehicles based on which the vehicle density is computed. The dynamic range selection combined with directional broadcast conserves bandwidth during transmission by limiting the number of vehicles.

Fig.1 shows the directional broadcast on the road without intersection. Consider the three vehicles; vehicle A generates the emergency message and sends to its neighbours to B and C. The counter value C, which is the farthest vehicle, is set to greater than zero and B is set zero. Hence only C re-broadcasts emergency message to its rear vehicles. The neighbour vehicle B will not re-broadcast emergency message. The Vehicle C also verifies its neighbour vehicles are at same distance as well as same speed then applies the probability value to one of the vehicle to avoid broadcast storm problem. The probability value is estimated in real-time based on the vehicle density over a transmission range algorithm is described in section-3.

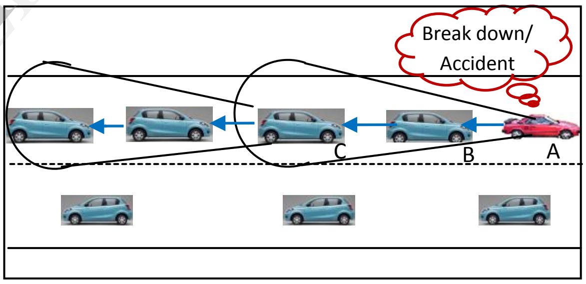


Figure1. Directional Broadcast on the road

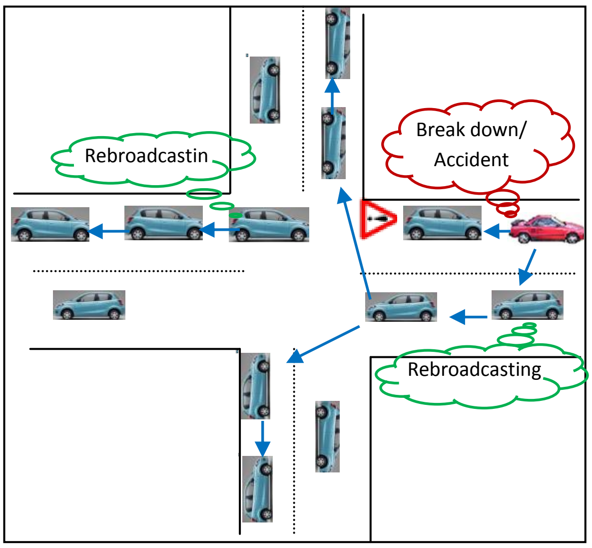


Figure2. Intersection re-broadcasting

Figure 2 shows the directional broadcast routingprotocol at intersection. During emergency, vehicledetects the opposite direction vehicle in the other lane and sends information to intersections.This enables faster delivery of the message to the intersection. Once the emergency message isreached to intersection, it rebroadcasts the data toits neighbours based on the direction of the vehicles.

3.1 Hello Messages

This message is sent to the one-hop neighbours for discovering presence of vehicles within a range. It helps to measure the vehicle density of the local network. All the vehicles send the hello packet information at an interval of one second. The information offered from GPS including time, current position and speed of the vehicles are embedded in the hello message[19]. The format for the hello packet is shown in Figure 3.

Vehicle ID	Road Lane	Position X, Y	Time	Speed	Flag	Sequence Number	Type of Node

Where,

Vehicle ID - Unique identification of the vehicles
Road lane - Road lane number where vehicle is travelling
Position X,Y- Location information from GPS
Time - Current local time
Speed - Speed of the vehicle
Flag -Emergency Message: Tansmit-1, received-2
Sequence Number- Number of hello messages
Type of Node-Vehicle - 0, Intersection – 1;

Figure3.Format of HELLO Packet

While vehicle receives a hello message from neighbours, it records as a new neighbour or updates an existing record. If the node does not receive a sequence of five hello packets then the node will assume that it has lost its neighbours connectivity. There is a provision in the hello message for confirming the sending and received emergency messages. Vehicle adds piggybacked acknowledgment to the source node through the ‘Emergency Message Received Flag’. Upon seeing the acknowledgement packet source vehicle avoids retransmission of the emergency message once again, which avoids redundant rebroadcasting. Source vehicle takes responsibility of rebroadcasting to the vehicles which have not received the emergency messages. This ensures guaranteed delivery of message. Vehicle sending hello messages increments the sequence number, this helps the identification of the new hello message at the receiving end. Vehicle on the road gives identification of node as ‘0’ whereas vehicles near intersection give ‘1’.

3.2Dynamic Range

In this section, we describe that how transmission range is dynamically calculated by adjusting the transmission power. Based on the traffic flow theory [20], the transmission range is a function of local density of vehicles, which is determined by the speed of the vehicles. The transmission range is calculated using

$$TR = min(L(1-K),sqrt((L\ ln(L)/K) + a\ L \text{ ----} \quad (1)$$

Where
L-Length of road segment over which the vehicle estimates its initial local vehicle density
K - Local vehicle density
a - Traffic flow constant from traffic flow theory.

The local traffic density – K, is calculated by counting every new hello messages from the neighbours. Equation (1) calculates the transmission range based on K.

3.3Transmission Range

The transmission power is calculated using the following equations [21, 22]

$$Path\ Loss = \left(\frac{4\pi R}{\lambda}\right)^2 \quad (2)$$

Where

R - Transmission range
λ - Operating wave length;
$\lambda = \left(\frac{V}{F}\right)$

Where
Velocity (V) = $3x10^8$
Frequency (F) = $5.9x10^9$

The signal on the receiver is calculated using following formula

$$Signal_{RX} = (Power_{TX} + Antenna\ gain_{TX} - Path\ Loss + Antenna\ gain_{RX}) \text{--}(3)$$

Assuming the receiver threshold is -100dbm and the Transmit power is calculated using the equation

$$Power_{TX} = (threshold\ Sensitivity_{RX}) - (Antenna\ gain_{TX}) + (Path\ Loss) - (Antenna\ gain_{RX}) \text{ ------ } (4)$$

Equations (2), (3) and (4) are used for estimating power for adapting the transmission range. The power values are adjusted based on the local vehicle density results varying transmission range. For example, initially power is set to *-28 db*with transmission range of 500 m is capable of handling approximately 100 vehicles. If the vehicles increases to more than 100 then transmit power will be reduced for maintaining 100 vehicles within the range. The typical values of transmission power, path loss, range and its vehicle density value are shown in the table 1.

Transmit Power(MW)	Path Loss(db)	Range (meters)	Vehicle Density
-10db	*120*	*4000*	*864*
-16db	*114*	*2000*	*432*
-22db	*108*	*1000*	*216*
-28db	*102*	*500*	*108*
-34db	*96*	*250*	*54*
-40db	*90*	*125*	*27*
-46db	*84*	*62.5*	*14*
-52db	*78*	*31.25*	*7*
-58db	*72*	*15.625*	*4*

Table1: Transmission Power and Range along with vehicle density

3.4 Distance and Direction of the Vehicle

The inter-vehicle distance is calculated using the position information from GPS. The distance is computed using the formula

$$Distance = sqrt((X_2 - X_1)^2 + (Y_2 - Y_1)^2 \text{----} \quad (5)$$

Where X_1, X_2 – Coordinates of Source vehicle
Y_1,Y_2–Coordinates of Destination vehicle

From the source node, vehicle direction is used to decide whether the vehicles are in the rear side or in the forward side .Angle between the moving direction of current vehicle and the position of the neighbor vehicle [23]. If vehicle A is in front of B

if |Angle (M_B, $Position_{AB}$)|<= 90^0 ---------- (6)
Otherwise A is behind B

Where

M_B – Moving direction of B vehicle

3.5 Priority Messages

The 802.11e provides the possibility to assign different priorities to the data packets, which implies different listening/sending periods. IEEE 802.11e Enhanced Distributed Channel Access (EDCA) has the different services for providing Quality of Service (QoS) messages in different types such as *voice traffic, video traffic, best effort and background traffic* [24]. EDCA mechanism in VANET categorized into different messages according to their urgency and delay requirements as shown in the table 2.

Priority(EDCA)	Message Type for VANET
Priority -1(Voice traffic –AC(3))	Accident message, message from emergency vehicle
Priority –II(Video Traffic-AC(2))	Accident indication messages, sensing vehicle tyres etc.
Priority –III(Best Effort Traffic-AC(1))	Warning related messages e.g. work ahead, school ahead, etc.
Priority-IV(Background Traffic-AC(0))	General messages e.g. periodic broadcast messages

Table2: Priority Messages

3.6 Directional Broadcast Protocol with Adaptive Range

We assume the maximum range of 400 meters and maintain a threshold of vehicles (typically 33) within the range. If the vehicle density increases then the transmission range is adjusted as discussed in section 3.2.

3.6.1 Compute Vehicle density

As discussed in section 3.1, the vehicle density is computed based on exchange of hello message packets among neighbours. The algorithm to identify neighbours are given in the Fig. 4.

Algorithm-1 Compute vehicle density

Setp1: Set R as the Maximum transmission range.

Step2: Send/Receive Hello messages to/from the neighbours and maintain neighbours information

Step3: Estimate local vehicle density, K

Step4: If (K < threshold0)

Assign the transmission Range (TR) equal to Maximum value of R

else

Compute the transmission range using equation *(1).*

Setp5: end

Figure4. Identification of neighbours

3.6.2Calculate Dynamic Probability

We adopt a dynamic probability scheme based on the vehicle density. Since we use directional broadcast of safety information only to the vehicle in the rear direction, the probability is calculated as a ratio of the local vehicle density in the rear portion to the local vehicle density within the range. The algorithm is given in the Fig 5

Algorithm-2 Calculate Dynamic Probability

Step 1: Send/Receive Hello messages to/from the neighbours and maintains neighbours information
Step 2: Estimate local vehicle density, K
Step 3: Calculate the direction of the vehicle using equation (6)
Step 4: Estimate Vehicle density in rear direction, K1
Step 5: Set the value of rebroadcast probability according to the local and rear vehicle density
PROB Value (P) = K1/K
Step 6: Generate a random uniform Number R over the time interval between [0, 1]
if (R > P)
Rebroadcast the received Message Packet
else
Delete (Received Message Packet);
Step 7: end

Figure5. Probability Algorithm

3.6.3Directional Broadcast – Source vehicle

Directional broadcast during emergency situations, the source vehicle is responsible forgenerating message and sending to its neighbours in the reardirection on the road. The source node is also a responsible for forwarding message to intersection vehicles by selecting opposite side vehicle. The directional broadcast protocol algorithm is shown in the Fig. 6.

Algorithm-3 Directional Broadcast protocol with Adaptive Range Algorithm – Source vehicle

Step1: Call Function (Computing Vehicle density)
// Handle Events
Step2: Events with multiple priorities then choose the highest priority event for serving
Step3: {
Generate the emergency message,
Set the rebroadcast count value
}
// Broadcast to Rear vehicle
Step4: Broadcast message to the neighbours in rear direction
// Broadcast to Intersection
Step5: If (Vehicle is present in Opposite direction)
{
broadcast message to opposite vehicle
}
Step6: end

Figure6.Directional Broadcast from source vehicle

3.6.4Directional Broadcast protocol for Road – Neighbor Vehicle

Once the emergency message is received by the rear neighbour, it checks the count value is greater than the zero. If the count value is greaterthan it computes distance with respect to its neighbour and checks the distance and speed of the vehicles are different then it rebroadcast to its neighbours in the rear direction. Otherwise its forwards emergency message with probability. This algorithm is represented in the Fig. 7.

Algorithm-4a Directional Broadcast protocol with Adaptive Range Algorithm – Receiver vehicle Rear

Step1: Call Function (Computing Vehicle density)
Step2: Receive the message from source vehicle
Step3: Check for the count value
if (Count > 0)
{
Compare own distance and speed information with neighbours
if (Different)
Rebroadcast message
else
{
Calculate Dynamic probability
Rebroadcast message with Probability
}
}
Step4: end

Figure7.Directional Broadcast on road with Rear Receiver vehicle

3.6.5 Directional Broadcast protocol for Intersection – Opposite Neighbor Vehicle

The Opposite vehicle is selected for reaching emergency message very fast. If opposite vehicle is not present on other lane then it follows the normal directional broadcast for road algorithm with delay in reaching the emergency message to intersection. The algorithm is given in the Fig. 8.

Algorithm-4b Directional Broadcast protocol for Intersection – Receiver vehicle opposite direction

Step1: Call Function (Computing Vehicle density)

Step2: Check for the Rebroadcast Count value
    If (Count > 0)
    {
    If (Check for the Intersection Vehicle)
        Rebroadcast Message
    else
        Forward the Received Message to front vehicle
    }

Step3: If (intersection reached)
    Stop forwarding

Step4: end

Figure8.Directional Broadcast on Intersection with Front vehicle

4. Simulation Results

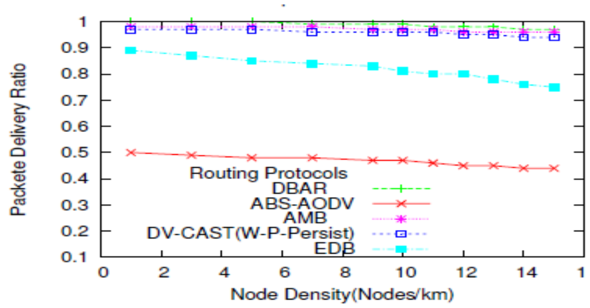
This section evaluates the performance of our new protocol, DBAR in comparison with similar VANET Broadcast routing protocols such as AMB, EDB, DV-CAST and ABS-AODV.

4.1 Simulation Scenario

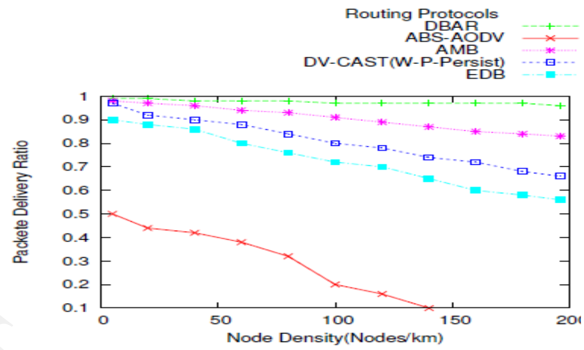
The simulations are carried out using Network Simulator tool NS-2[25] Version 2.33. We have considered simulation area of 2000 m x2000 m, with bi-directional with intersection road scenario. The MAC 802.11e protocol is used in the MAC layer with *random way point* mobility model. A maximum of 800 nodes are considered with simulation time of 600 seconds and its transmission range varied from 250 m to 400 m. We have carried out simulations with different vehicle density; sparse scenario with 16 vehicles, nominal scenario with 200 vehicles and dense scenario with 500 and 800 vehicles. The data packet size considered is 1024 bytes.

4.2 Performance Analysis and Discussion

Initially we studied the performance of DBAR with four more protocols viz. AMB, EDB, DV-CAST and ABS-AODV. The study focused on two parameters i.e. packet delivery ratio and overhead.[Refer Fig. 9 and Fig.10]. The performance of the first four protocols is comparable and it is better than ABS-AODV. As the node density increases the performance of ABS-AODV drops further [Fig. 9.b and Fig.10.b]. This is due to the fact that it is atopology based protocol which has high overhead for route discovery and maintenance, whereas DBAR, AMB and EDB position based protocols. Among the position based protocols DBAR, AMB

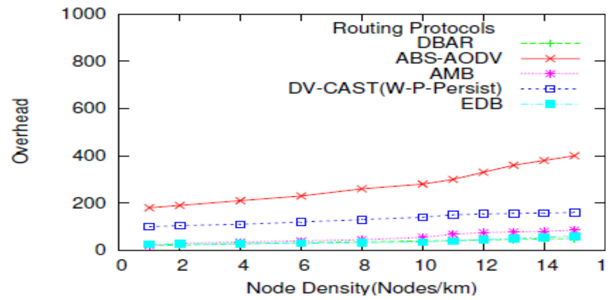


a) Sparse Scenario

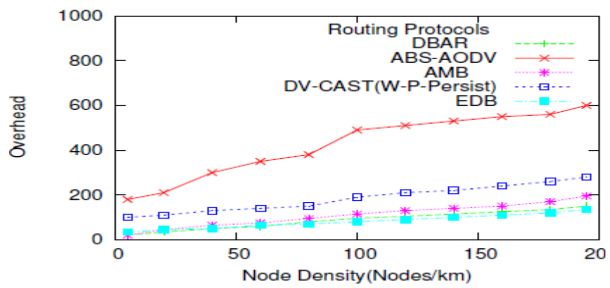


b) Normal Scenario

Figure9. Packet Delivery Ratio vs. Node Density



a) Sparse Scenario



b) Normal Scenario

Figure10. Overhead vs. Node Density

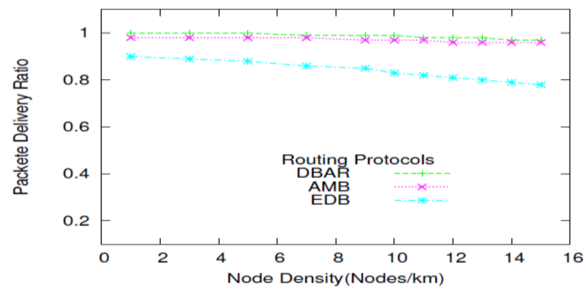
perform better than EDB. Even though DV-CAST is also traffic based protocol performance improvement is achieved due to the directional broadcast. It may be noted that DV-CAST protocol is designed for highway road structure and it does not support city scenario with several roads join at an intersection.

In further simulations, we have studied our new protocol DBAR in comparison with AMB and EDB, which are position based directional broadcast protocols and considers urban road with intersection. This simulation focused on three parameters viz. packet delivery ratio, latency and overhead. The simulations are carried out for four different scenarios as shown in Fig 11, 12 and 13.

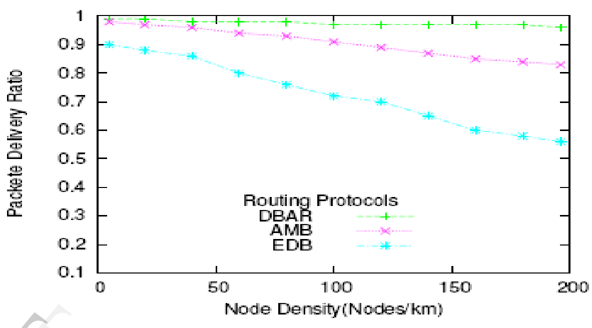
The packet delivery ratio of all the three protocols is comparable in sparse condition as shown in the Fig. 11.a. It is interesting to note that with increase in vehicle density, the packet delivery ratio of DBAR remains steady, whereas for AMB and EDB, it drops [Fig. 11.b, 11.c & 11.d]. In our design, the improved packet delivery ratio is achieved by introducing dynamic range selection concept and directional broadcast mechanism. DBAR dynamically adjust the transmission range, which maintains the vehicle density always within the threshold value in a specified range. Moreover, by using the directional concept, the protocol disseminates messages only to the rear direction addressing only those nodes for which the message is useful. Even though AMB protocol also uses directional broadcast feature the detection of neighbours and the RTB/CTB handshake signal introduces overhead and in turn impacts packet delivery ratio, whereas, in DBAR the local neighbour information is available via Hello messages. Another advantage of DBAR protocol over AMB is the guaranteed delivery of message using the transmit/receive flag in HELLO packet. The drop in packet delivery ratio for EDB is due to the fact that as the density of vehicles increases, contention and collision increases which impacts packet delivery ratio.

With respect to overhead, the performance of all the three protocols is comparable; with increase in vehicle density the overhead increases linearly [Fig.12].

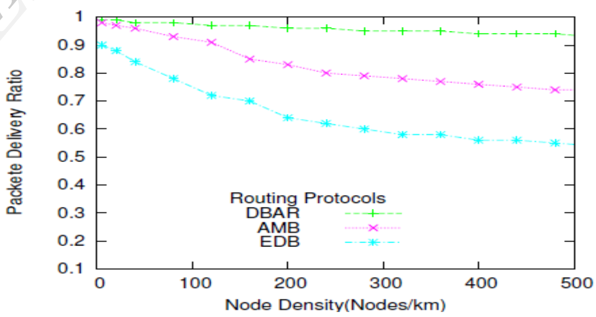
Fig. 13 shows the latency of DBAR, AMB and EDB protocol. DBAR achieves a very low latency since it sends the packet to its neighbours immediately based on the available neighbour information as well as applying the novel idea of using the opposite vehicle to communicate with the intersection. In sparse scenario the latency of DBAR and AMB are comparable, however as the vehicle density increases latency of EDB increases. The latency of EDB protocol is high since the



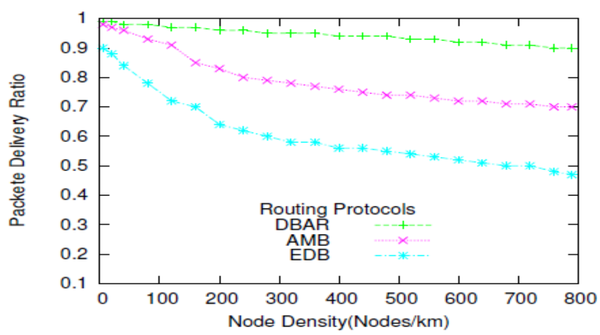
a) Number of nodes 16



b) Number of nodes 200

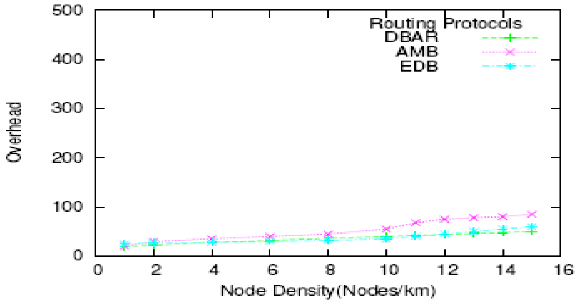


c) Number of nodes 500

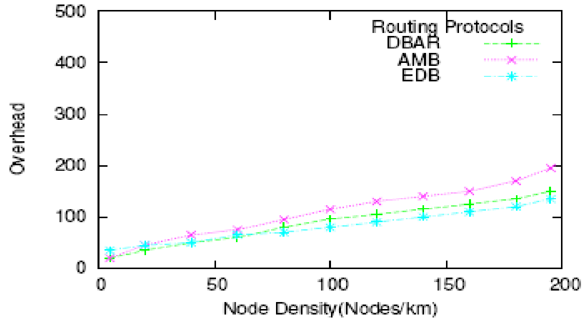


d) Number of nodes 800

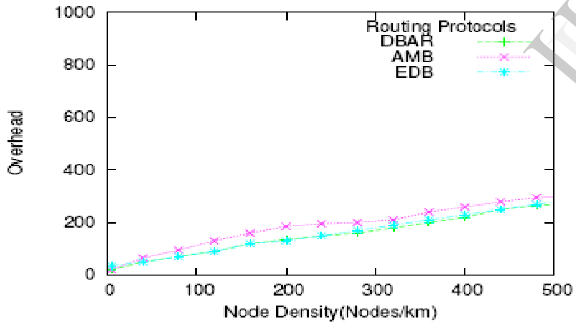
Figure11. Packet Delivery ratio vs. Node Density



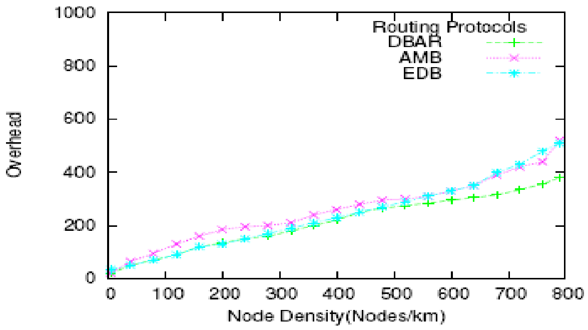
a) Number of nodes 16



b) Number of nodes200

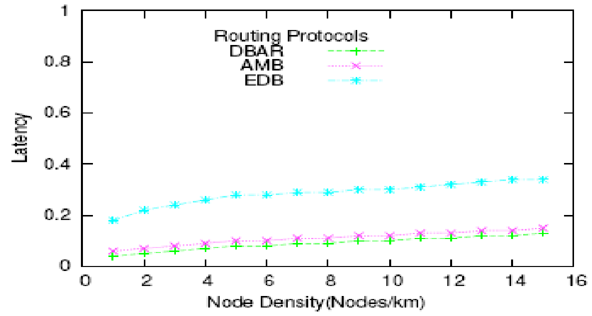


c) Number of nodes 500

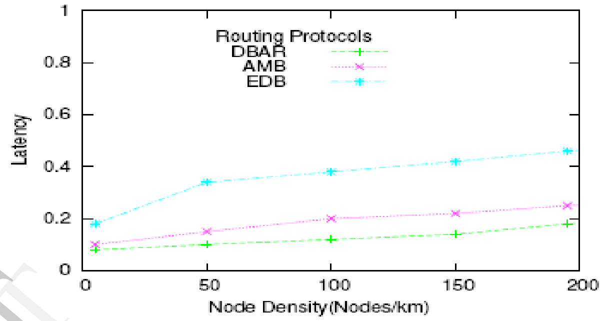


d) Number of nodes 800

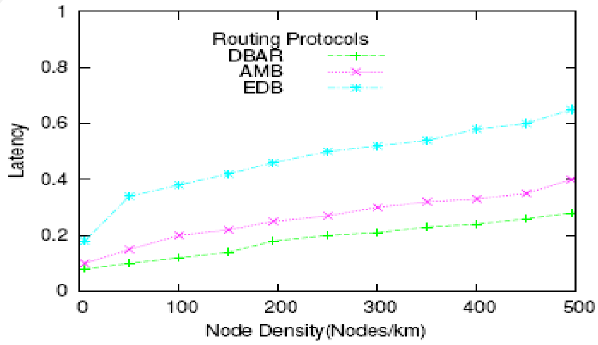
Figure12. Overhead vs. Node Density



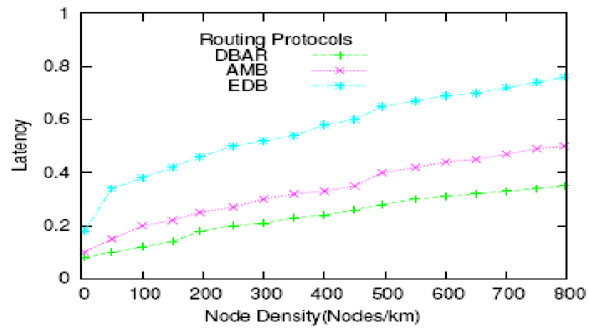
a) Number of nodes 16



b) Number of nodes 200



c) Number of nodes 500



d) Number of nodes 800

Figure13. Latency vs. Node Density

neighbour selection process uses multiple MaxWT delay are continued until a next hop neighbour acknowledges[12].

5. Conclusion

We have proposed DBAR, a directional broadcast protocol with adaptive range to improve the efficiency of emergency message dissemination of real time response system in urban environment. We have achieved better packet delivery ratio and low latency which are essential requirements for the safety applications demanding real-time response. These improvementsare due to the innovative combination of directional broadcast with dynamic range adaptation and dynamic probability for re-broadcast. This protocol will be integrated into the innermost layer of our generic architecture to support safety applications.

6. References

[1] S SManvi and M S Kakkasageri, "Issues in Mobile Ad hoc Networks for Vehicular Communication"**,** IETE Technical Review, Vol 25, No 2 March-April 2008.

[2] Venkatesh, Indra. A and Murali. R, "Vehicular ad hoc Networks (VANETs): Issues and Applications", Journal of Analysis and computation, Vol. 8, No. 1, 2012.

[3] S. Ni, Y. Tseg, Y. Chen and J Sheu, "The Broadcast Strom Problem in a Mobile Ad hoc Network", IEEE/ACM Proc. MOBICOM '99, pp. 151-162, August 1999.

[4] Venkatesh, Indra. A and Murali. R, "Routing Protocols for vehicular ad-hoc networks (VANETs): A Review", submitted to CIS Journal

[5] B. Williams and T. Camp, "Comparison of Broadcasting Techniques for Mobile Ad Hoc Networks," *Proceedings of the 3rd ACM MobiHoc'02*, Switzerland, pp.194-205, 2002.

[6] James Bernsen and D. Manivannan, "Greedy Routing Protocols for Vehicular Ad Hoc Networks",IEEEWireless Communications and Mobile Computing Conference, 2008.IWCMC '08.International, August 2012, pp. 632- 637.

[7]Q. Yang, L. Shen, and W. Xia, "Distributed Probabilistic Broadcasting for Safety Applications in Vehicular Ad Hoc Networks," Wireless Communications & Signal Processing, 2009. WCSP 2009.International Conference, 2009, pp. 0-4.

[8] N. Wisitpongphan, O. Tonguz, J. Parikh, P. Mudalige, F. Bai, and V. Sadekar,"Broadcast storm mitigation techniques in vehicular ad hoc networks,"IEEEWireless Communications, vol. 14, no. 6, pp. 84–94, December 2007

[9]Bae, Ihn-Han*et al*, "Design and evaluation of Hi-CAST and its variants for safety message dissemination in VANET", International Conference onControl, Automation and Systems (ICCAS), Oct. 2013, pp.800 – 806.

[10] L. Bononi, "A Cross Layered MAC and Clustering Scheme for Efficient Broadcast in VANETs" Mobile Ad hoc and Sensor Systems, 2007.MASS 2007.IEEE Internatonal Conference, 2007.

[11] G. Korkmaz, *et al.*, "An efficient fully ad-hoc multi-hop broadcast protocol for inter-vehicular communication systems," in Proc. *IEEE Int. Conf. Communication.*, 2006, pp. 423-428.

[12] Hongyu Huang *et al*, "A Distance-based Directional Broadcast Protocol for Urban Vehicular AD Hoc Network", IEEE International conference on wireless communications, sept.2007,pp.1520 – 1523.

[13] Yao-Tsung Yang *et al*, "Position based Adaptive broadcast for inter-vehicle communications", IEEE 2008.

[14] O. K. Tonguz*et al*, "DV-CAST: A distributed Vehicular broadcast protocol for vehicular ad-hoc networks", IEEE wireless communication, vol. 17, April 2010, pp. 47-57.

[15]MustsfaBaniKhalaf et al, "A New Adaptive Broadcasting Approach for Mobile Ad hoc Networks" IEEE 2010

[16] C. Perkins, E. Royer, and S. Das,"Ad hoc On-Demand DistanceVector (AODV) Routing," IETF, RFC 3561, 2003

[17]Danda B Rawat*et al*, "Dynamic Adaptation of Joint Transmission Power and Contention Window in VANET", IEEE Vehicular Technology Conference Fall (VTC 2009-Fall), sept. 2009 pp. 1– 5.

[18] Venkatesh, Indra A, and Murali R,"GPS Based Routing Protocol Stack for Intelligent Transportation System (ITS)", A National Conference on Applications and Challenges in Space Based Navigation, April 2013

[19]http://en.wikipedia.org/wiki/Global_Positioning_System.

[20]M.M. Artimy, "Assignment of DynamicTransmission RangeBased on Estimation of Vehicle Density," IEEE Trans. IntelligentTransportation Systems, vol. 8, no. 3, pp. 400-412, Sept. 2007.

[21] M L Christieson,- Radio frequency link budgets

[22]David M Pozar, "Microwave Engineering", john-wiley, 2011.

[23] Lung-chin Tung *et al*, "An Efficient Road-Based Directional Broadcast protocol for Urban VANETs", IEEE Vehicular Networking Conference, December 2010. pp. 9-16

[24] C Suthaputchakun and S Ganz, "Priority based inter - vehicle communication in Vehicular ad-hoc Networks using IEEE 802.11e", VTC2007-sring, IEEE 65th, pp. 2595-2599, April 2007.

[25] Network Simulator (NS2) - http://www.isi.edu/nsnam/ns/