Network Coding Assisted Reliable Message Broadcasting In VANET

Darshna Dalvadi[1] and Dr. Dhaval Vyas[2]
[1] Research Scholar, [2] Dean, Master of Philosophy
C. U. Shah University, Wadhwan City, Surendra Nagar, Gujarat, India.

Abstract : A Vehicular Ad-Hoc Network which is well familiar as VANET, is a delay tolerant network in which no frequently disconnectivity is experienced more often than not between source and destination. Routing protocols for VANET follow 'store-carry-forward' strategy where two nodes commute messages with each other just when they meet with each other. Broadcast can be used to perform to deliver infotainment as well as safety related messages but in turn it needs high efficiency, low network overhead. NC with Multi-Generation-Mixing (MGM) is a peculiar in-network data-processing technique which can drastically increases throughput in wireless environments. In this work, a network coding(NC) with MGM based message broadcasting strategy is proposed. The offered algorithm decreases the average block delivery delay. We propose a framework which leverages the safety and transmission efficiency simultaneously. We designed multi-copy routing protocol which incorporates MGM technique. Simulation results demonstrate that offered protocol outperforms the conventional network coding based protocol in terms of reduction in latency.

IndexTems : Multi Generation Mixing, Network Coding, Reliable Message Broadcasting, Vehicular Ad-hoc Network

I. INTRODUCTION TO VANET

Vehicles have become a daily necessity for most of the people in the world today. As vehicles usage increasing the technology used in it is becoming more advance day by day, which opens the doors for the researchers in both the fields of automotive industry and education. To receive or to transfer safety or non-safety information the vehicles need to communicate which is done using networks called Vehicular Ad-hoc Networks (VANETs). VANETs can be defined as a combination of node-to-node and node-to-roadside units' communication. VANETs are having characteristics of MANETs like changing topology, high mobility and large scale which makes it a subset of MANETs as well as differentiates it from other networks [1].

II. VANET ARCHITECTURE

In 2014, Wenshuang Liang et al.[1] presented the VANET architecture from three different perspectives: 1. Domain View 2. Communication Architecture and 3. Layered Architecture. For domain view architecture of VANETs[2] divides VANET into three different domains like the mobile domain, the infrastructure domain, and the generic domain; while [3] divides it into domains like in-vehicle, ad-hoc and infrastructure domain. According to [4] VANETs communication architecture represents the communication between components it supports and based on which it is categorized as, vehicle-to-vehicle, Vehicle-to-road infrastructure, in-vehicle and vehicle-to-broadband cloud communication. For the VANETs layered architecture [5] have presented layered architecture of OSI(Open System Interconnection) including its sub-layers which are presented in figure-1.

<table>
<tr><td colspan="2">Application Layer</td></tr>
<tr><td colspan="2">Transport Layer</td></tr>
<tr><td colspan="2">Network Layer</td></tr>
<tr><td rowspan="2">Link Layer</td><td>LLC Sub layer</td></tr>
<tr><td>MAC Sub layer</td></tr>
<tr><td rowspan="2">Physical Layer</td><td>PLCP Sub layer</td></tr>
<tr><td>PMD Sub layer</td></tr>
</table>

Figure -1 Layered Architecture [5]

Hartenstein et al. in [6] represented DSRC (Dedicated Short-Range Communication) layered architecture for both safety and non-safety applications with its sub-layers which is presented in figure-2.

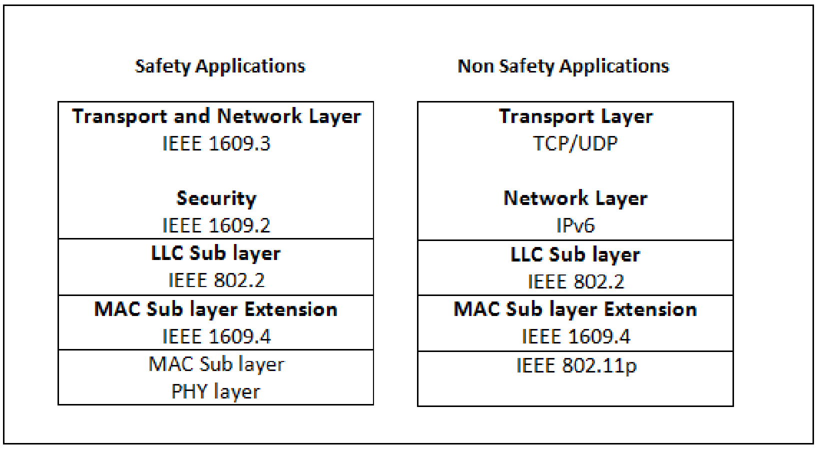

Figure-2 DSRC layered architecture for Safety and Non Safety Applications [6]

III. INTRODUCTION TO NETWORK CODING

The available network resources can be used optimally and efficiently using network coding which uses computational power for encoding and decoding [7]. The linear combinations of previously received information which are utilized by linear algebra are sent by the relay nodes using network coding which do good to achieve high possible throughput and an eminent robustness [8]. Figure-3 represents the concept of linear network coding replacing XOR operation by a linear combination of data.

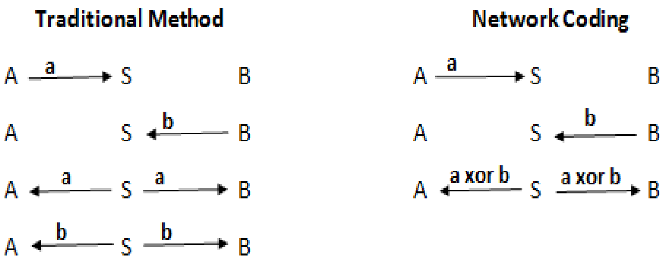

Figure -3 An example of basic XOR based Network Coding [8]

Figure reveals that nodes A and B commutes data packets using the mediate node S, where A sends a packet a to B and B sends a packet b to A, and S propagates a xor b rather than a and b in sequence from which packets of interest can be recovered by both A and B which ultimately reduces the number of transmissions [8]. Linear network coding can be well understood by the same concept replacing xoring with linear combinations of the data packets. As a passable number of linearly independent combinations of packets (encode packets) are received at receiving side, the original information can be reconstructed (decoding of packets). Decoding matrix stores its original packets and received encoded packets row by row and using linear algebra the received packets are decoded. The success of receiving a message relies upon receiving an sufficient number of independent packets not on receiving a specific packet content, which ultimately improves end-to-end delay in receiving message [8].

IV. MULTI GENERATION MIXING SET

The chances of raising bandwidth utilization and broadcasting nature of Network Coding do well to wireless network. Network Coding’s practical deployment requires chunks having grouped sender packets, which is known as generations having fixed number of packets and on the generation level encoding and decoding is performed on the packets of the same generation[9, 10] which is better explained in figure-4.

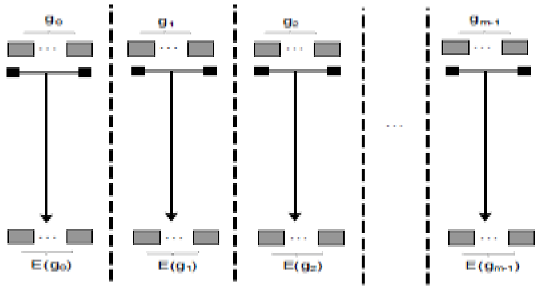

Figure-4 Generation by Generation based NC [9, 10]

Multi Generation Mixing(MGM) allowing encoding among generations which helps to recover the generations using encoded data of other generations which significantly minimizes the loss of data and enhances the recovery of data. In MGM mixing sets are generated by grouping generations on which encoding/decoding is performed in a way allowing multiple decoding options at receiver side [9]. The mixing set's each generation is having a position index pointing to its relative position within the mixing set. Figure-5 shows MGM encoding of packets within a mixing set of size m, where packets of the generation having position index l, $o \leq l < m$ are encoded with packets of all generations having lower position indices in the same mixing set[9].

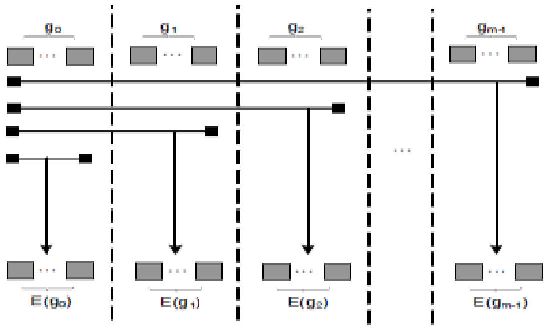

Figure -5 MGM, each generations encoded with previous generations in mixing set [9, 10]

At receiving side extra independent packets are received and to decode it two scenarios Incremental Decoding and Collective Decoding are possible, where for recovering generations of position index I, k independent packets are sufficient and for recovering generations of lower position indices the packets of generation of higher position index of the mixing set are used, respectively. Receiving side receives additional independent packets having generations of higher position indices which help in decoding generations of lower position indices in the mixing set which reveals one of the MGM's advantages [9].

This work is dedicated to the reliability of message broadcasting in a V2V environment. We consider emergency messages which are delay sensitive. Major contributions of this paper are as follows:

- We present NC enabled network coding based data broadcasting framework, in which data is encoded and decoded at node itself.
- We present simulation model for the said scenario and evaluated the protocol.

The rest of the paper is organized as follows; Section II assesses various network coding techniques and related works in VANETs. Section IV focuses on basics of network coding with multi generation mixing. Section
V focuses on problem formulation. Section VI presents our proposed NC enabled architecture for message broadcasting using MGM technique. Section VII precisely describes proposed algorithm for reliable data dissemination. Section VIII describes simulation model and discusses the simulation results. Finally, we conclude with open issues.

V. PRELIMINARIES

In this section, we present basics of random linear network coding as well as MGM based NC technique in order to motivate the concerned message broadcasting scenario. This work considered V2V communications based on DSRC, where vehicles are NC enabled. Interior network nodes independently opt random linear mappings from inputs to outputs. Coefficients of aggregate effect is conveyed to receivers as shown in figure.

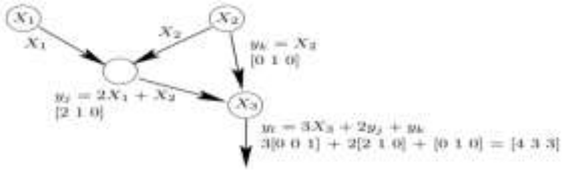

Figure 6-Communication of coefficients

Receiver nodes can decode if they get the same number of independent linear combinations as the number of source processes.

VI. SYSTEM ARCHITECTURE

Architecture comprises data plane i.e. where vehicle generates their own information like coordinates, speed related information can be further processed through high performance compute engine which projects towards future work.
We focused basically on message broadcasting where nodes i.e. vehicles itself perform encoding and decoding and forward the data to concern through V2V communication.

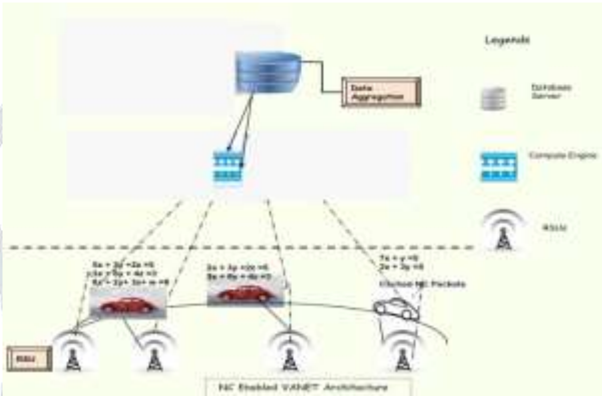

Figure 7: Proposed system architecture

VII. PROPOSED ALGORITHM

Author proposed network coding enable routing protocol in which node i.e. vehicle performs encoding and decoding as mentioned in algorithm-1

Pseudocode: MGM Based Network Coding

Procedure_Sender

Divide Message set into N groups

For each group of m packets
  Generate Random Co-efficient Coeff i.e. m * m , where m = n
  For m packets //Apply Network Coding
   sum = sum + ($q_i * m_i$) //where q = q1,q2,q3….qn] represents global coding vector
End For

 // Send All the mixing set network coded packets
  Send(Packets, DestId)
End Procedure

Procedure _Relay-node
 Caches the Coded Generation Packets
  Forward the Original packets
End Procedure

Procedure_Destination
If id == dest_id
then
 Buffer m Packets of same group

Discard duplicate packets
Apply decoding by using Random co-efficient from packet header
Receive (Packets)
End Procedure

In algorithm, Firstly messages is to be divided in to N packets then each number of packets randomly coefficient over galois field are generated. Further, using these coefficients, packets are encoded and their header is filled with respective coefficient. These packets are then forwarded using V2V mechanism. Intermediate nodes will relay the message and buffer the packets. Destination node will buffer the message until and unless all the packets of that particular mixing set are received or in other words, rank of the matrix is sufficed.

VIII. SIMULATION SETUP

The proposed protocol is simulated in NS2 simulator. The network holds 20-170 wireless nodes which move according to mobility models generated by MOVE simulator. The base speed of a node is 15 m/s. The commute range of a node is 150 mt. Meeting rate (M_r) is changed by varying field area of the network. There is source in the network and there are different numbers of destinations.

For network coding, randomly chosen coefficients and various operations for encoding and decoding are performed over the Galois field.

SIMULATION PARAMETERS :

Table 1: Simulation Parameter

Parameter	**Value**
Simulator	NS-2.35/SUMO/MOVE
Types of messages	Infotainment
Speed of vehicle	15 – 25 m/s
No. of nodes	20-170
Simulation Time	1000 sec
Message Size	40Bytes
Bandwidth	2Mbps
Routing Protocol	WFRP
RSU range	150 m

IX. RESULT ANALYSIS

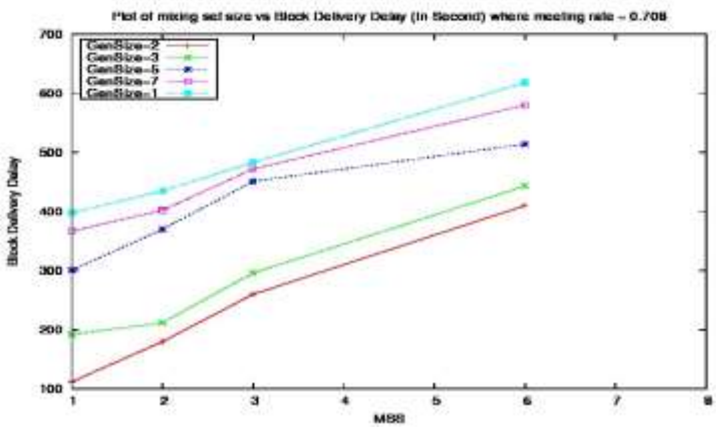

Figure 8: Mixing Set Size vs Block Delivery Delay

Figure 8 highlights the effect of different mixing set size on block delivery delay. It is clearly depicted that increasing the mixing set size results in increase in delay but for mixing set with generation size =2 outperforms over other combinations. Mixing set size=1 and Generation size =1 indicates that there is no network coding.

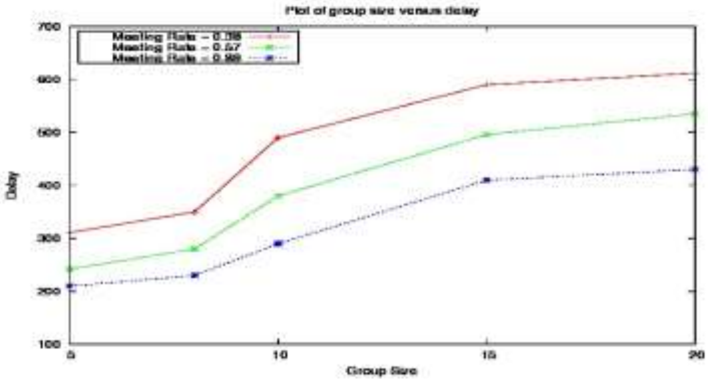

Figure 9 : Group Size vs Delay

Figure 9 demonstrate the impact of various group size i.e., generation size on block delivery delay for different meeting rate. As the meeting rate increases, probability of delivery also increases so for meeting rate=0.89, block delivery delay drastically reduced while it increases in the dense Topolgy i.e., meeting rate=0.38.

X. CONCLUSION

Delay Tolerant Networks require different routing approach due to frequently dis-connectivity than traditional approaches. In order to increase the chances of delivery, single or multicopy schemes can be used as per meeting rate of the entire topology i.e. scenario. By incorporating NC with MGM, significant improvement is observed in case of block delivery delay compared to traditional broadcasting approach. Furthermore, we can combine the packets at intermediate nodes to do buffer management. Also, we will observe the impact of different mixing set and generation size on performance parameters. Centralized view for deciding optimal generation size and mixing set size will be a motivational direction.

References

1. Liang W, Li Z, Zhang H, Wang S, Bie R. Vehicular ad hoc networks: architectures, research issues, methodologies, challenges, and trends. International Journal of Distributed Sensor Networks. 2015 Aug 31;11(8):745303.
2. Kosch T, Schroth C, Strassberger M, Bechler M. Automotive inter-networking. John Wiley & Sons; 2012 Feb 14.
3. Moustafa H, Zhang Y. Vehicular networks: techniques, standards, and applications. Auerbach publications; 2009 Apr 9.
4. Faezipour M, Nourani M, Saeed A, Addepalli S. Progress and challenges in intelligent vehicle area networks. Communications of the ACM. 2012 Feb 1;55(2):90-100.
5. http://en.wikipedia.org/wiki/OSI model
6. Hartenstein H, Laberteaux K, editors. VANET: vehicular applications and inter-networking technologies. John Wiley & Sons; 2009 Nov 4.
7. Khushbu M. Network Coding Based Multi-copy Protocol to Anycast Information in VANET.
8. Fragouli C, Le Boudec JY, Widmer J. Network coding: an instant primer. ACM SIGCOMM Computer Communication Review. 2006 Jan 10;36(1):63-8.
9. Halloush M, Radha H. Network coding with multi-generation mixing: A generalized framework for practical network coding. IEEE Transactions on wireless communications. 2011 Feb;10(2):466-73.
10. Halloush M, Radha H. Network coding with multi-generation mixing for scalable and non-scalable video communication. InInnovations in Information Technology (IIT), 2011 International Conference on 2011 Apr 25 (pp. 398-403). IEEE.