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An Appraisal of Various Network Coding Schemes in Vehicular Ad-hoc Networks

K. Lakshmi[1], Dr.M.Soranamageswari[2]

Research Scholar[1], Assistant Professor[2]

lakhsk2012@gmail.com[1],swarnakannappan@rediff.com[2]

[1,2]PG and Research Department of Computer Science, Government Arts College, Coimbatore, Tamil Nadu, India

***Abstract*: Network Coding is an optimized technique in which the message content dissemination is a combination of n number of messages to make the network more efficient. It is used in all forms of network in order to tackle the related communication problems in those networks. Network coding plays a vital role in Vanets to satisfy all the communication issues like rapid structural changes, fast moving vehicles, neighborhood connectivity for message passing etc. In Vanets, vehicles communicate with each other for providing entertainment services, to deliver traffic details and to pass life safety alert information. This is one of the most favored areas of researchers for the well-being of humans. This survey paper provides different Network Coding schemes used under Vanets. It has been classified based on Vanets applications such as Content Distribution, Routing, Medium Access Control (MAC), Multimedia Audio and Video streaming, Multihop Wireless and Broadcasting. We presented a detailed exploration and collation of current state-of-the-art protocols and algorithms for Network Coding in Vanets.**

***Keywords*: Dissemination, Network Coding, Relay, Transmission, Streaming, Transformation.**

1. INTRODUCTION

The major limitation of Vanets is as the vehicle moves faster it is very difficult for the vehicle to download the file and causes two main problems namely duplication which lead to improper utilization of bandwidth channel and increasing the protocol overhead. Basically the traffic scenario is categorized based upon busy timing in traffic into four types namely late night time, rush hour, dense and sparse [1]. So according to the scenario the movement of vehicle varies from time to time. The message content is of two types namely *Commercial* and *Non-Commercial*. The Commercial messages hold advertisement from Ad Company and Non-Commercial messages hold real time traffic and accident information from traffic authority. The main goal of content dissemination must have short downloading delay or high downloading rate. Generally the emergency messages will be in the form of text, images, audio or video files. The size of the safety message is less than 200 bytes and the lifetime of each messages are less than 200 ms.

One of the problems in dissemination of safety messages is packet loss. The reason of packet loss is when any packet collision happens or when the packet arrives too late. The packet loss has two solutions namely *Retransmission* but this increases end-to-end delay and *Multipath Routing* which increases message overhead. The two types of errors occurs namely *Random* and *Bursty errors*. Redundant packets are controlled by redundancy controller. Redundant broadcast must be reduced to obtain high packet dissemination ratio and low end-to-end delay. Protocols are of two types namely *Receiver-oriented or Deterministic* which determine whether to forward messages or not and *Sender-oriented or Non-Deterministic* which perform selection of relay nodes. Most probably all the recent protocol uses Fuzzy Logic Algorithm for selection of next relay node.

The drawback of Flooding is Broadcast Storm Problem which is overcome by using Network Coding which provide more flexibility in content sharing, maintain system stability and scalability. Before introducing Network Coding, the information is secured using Public key Cryptography and Symmetric key algorithm. The main objective of Network

Coding will reduce duplicate transmission and simplifies transmission scheduling. It deals the message on packet level and is mainly suitable for dynamic networks. The traditional one is named as Linear Network Coding behave like Linear Algebra which performs single communication per session [2]. Advanced coding technique will reduce delivery delay whereas Simple coding technique reduces repetition.

The pollution attack in content is prevented using Network Coding. The main property of it is to identify the corrupted blocks before the transmission begin and all files must be available before transmission. *All-or-nothing* transformation is applied to maintain protocol overhead. Small waiting time will reduce collision otherwise causes *Terminal Problem*. UDP is used to transfer packets to its neighbours. There are two types of Network Coding namely *Packet Level Network Coding* to improve network performance and *Symbol Level Network Coding* for effective bandwidth utilization. The three requirements of Live Multimedia Services (LMS) are large LMS content, achieve stable and high streaming rate. Video quality is determined using packet loss and packet delay.

2. RELATED WORK

Ming [3] et al proposed a Cooperative popular content distribution for Vanets using Symbol Level Network Coding. This approach is a novel push-based Popular Content Distribution (PCD) which reduces transmission errors and encourages concurrent transmission. The CodeOn protocol consists of 3 steps namely exchange of neighbor information to reduce overhead, node utility calculation to enhance downloading rate and protocol efficiency and transmission coordination among potential relays for better error tolerance. Finally this achieves high downloading rate, robust and high protocol efficiency.

Joon Sang [4] et al suggested a Delay analysis of car-to-car reliable data delivery strategies based on Data Mulling with Network Coding. Data mules represent the movement of vehicle in opposite direction. This approach consists of three strategies namely *Network Coding, Erasure Coding and Repetition Coding*. The idea behind this protocol is the vehicle will pick up the message, carry and forward to other lane vehicles which is moving in forward direction. In summary this increases the delivery of data but cause *Coupon Collector Problem* where the opposite vehicle catch only limited number of packets at each pass.

Kusumine [5] et al recommended Abiding regional data distribution using relay and Random Network Coding (RNC) on Vanets. The proposed algorithm RNC based Regional Data Distribution on Vanets (R2D2V) achieve high data delivery ratio with low traffic and short delivery delay. This algorithm uses Random Linear Network Coding to broadcast data item on certain probability even after arriving in data effective area. Future work will be to concentrate on scalability of the proposed scheme.

Gerlay [6] et al designed an Efficient Weak Secrecy scheme for Network Coding data dissemination in Vanets. The proposed algorithm Weak Secrecy used to secure information for bounded time and then released. The main objective of this approach is to encode the information and uses secure random checksum to identify polluted blocks and prevent attack in dissemination content. This applies "*all-or-nothing*" transformation to maintain message overhead by controlling its increase. It makes use of mixing and obfuscation to distribute more files than encryption.

Tai-Xing [7] et al developed a Rank based Network Coding for content distribution in Vanets. The Rank based Network Coding is based on content reception status of their neighbours. Overall it minimizes end-to-end delay, maximizes throughput and high packet innovation rate for both sparse and dense traffic in highway. For future work no assumption will be made and include different traffic types for evaluation.

Vichin Lee [8] et al designed CodeTorrent content distribution using Network Coding in Vanets. This approach is Network Coding based on File Swarming Protocol where each file is divided into many pieces. Each node exchanges file pieces with small waiting time that reduces collision otherwise can cause Terminal Problem. It uses UDP to transfer packets to its neighbours. This approach achieves shorter file downloading time.

Wu [9] et al proposed a Loss-Tolerant scheme for unicast routing in Vanets using Network Coding. This approach uses multiple forwarder nodes to improve Packet Reception Ratio (PRR). There are two types of nodes namely *Master node* and *Slave node*. The Master node selects the most stable and nearest neighbor as Slave node. On the whole this improves the packet delivery ratio without increasing message overhead.

Behnam Hassanabadi [10] et al suggested Reliable network coded MAC in Vanets. The proposed algorithm is *Opportunistic Network Coding* which minimizes the average delay and message loss probability. The main aim of this protocol is to combine the entire previously received message using XOR operation and send it in single transmission. In short, this provides a reliable and low delay delivery output.

Antonopoulos [11] et al recommended a Network Coding based Cooperative ARQ (NCCARG) scheme for Vanets. This is a network coding based Medium Access Control (MAC) protocol which makes use of *Automatic Repeat request* (ARQ) technique for simplicity and higher reliability and *One-hop to multi-hop* transmission to minimize the number of transmission. It has been named as NCCARQ-MAC protocol which is a combination of Cooperative and Network Coding techniques. Finally this protocol maximizes the throughput and minimizes packet delay. Future work will concentrate on relay selection and include application of game theoretical techniques.

Alberto Gonzalez [12] et al developed a Fuzzy redundancy adaptation and joint source network coding for Vanets video streaming. This approach makes use of Network Coding and Multiple Description Coding for robust streaming of video. The Redundancy Controller is used to adjust the redundant packets based on Fuzzy Inference System. The proposed protocol is named as *Reliable Joint Coding* approach which improves video quality, protect packet loss and maximize application layer throughput.

Zhenya Yang [13] et al designed a CodePlay of Live Multimedia Streaming (LMS) in Vanets using Symbol Level Network Coding (SLNC). The proposed algorithm CodePlay is a new LMS based on SLNC which utilizes the bandwidth efficiently. The main aim is to divide the original stream content into many Generations each with T seconds playback. Again each Generation is divided into K pieces which hold M Symbols and Network Coding. The receiver will store these into Playback Buffer. It achieves short buffering delay, smooth playback and high source rate. But it need additional infrastructure to disseminate LMS to end user.

Abdul Razzaq [14] et al proposed a Video transport over Vanets with multi-stream coding and multipath accompany Network Coding. The Robust Scalable Video Coding provides less error-prone channels which divide the video into different layers. It contains one *Base Layer* to encode lowest temporal, spatial and quality representative having highest priority which holds high quality path. There are many *Enhancement Layer* which holds additional information considered as lowest priority will low quality path. The Grey Relational Analysis used to identify the quality paths by analyzing the relationship grade from discrete sequence and finally selecting the best one. The result shows less in delivery delay, less jitter effect, less loss rate and high throughput.

We [15] et al recommended a Joint Fuzzy relays and Network Coding based forwarding for multihop broadcasting in Vanets. The proposed protocol *FUZZy logic based BRoadcast with Network Coding* (FUZZBR-NC) is a multihop broadcast protocol uses joint fuzzy relay selection and Network Coding based forwarding schemes. The next relay node selection is performed by using Fuzzy Logic Algorithm which take inter vehicle distance, velocity and link quality as its parameters. If any packet loss is obtained it either retransmits or applies different encoding and then retransmits. Finally this improves packet dissemination ratio and reduce end-to-end delay with low message overhead.

Wu [16] et al designed a Multi-hop broadcasting in Vanets integrating Intra-flow and Inter-flow Network Coding. The proposed protocol employs Intraflow Network Coding to reduce the number of transmission and Interflow Network Coding for light weight transmission. It makes use of two packets one to forward message in same direction and another message in opposite direction. In connection to that each node has two buffers one is Forward Direction Buffer and another is Backward Direction Buffer. This approach uses Backbone Selection Algorithm for reliable vehicle connection. In short, this achieves high packet dissemination ratio and low end-to-end delay. On the whole it ultimately reduces the channel busy time.

Ndih [17] et al developed a Reliable broadcasting in Vanets using Physical Layer Network Coding. The proposed protocol *Vehicular Physical Layer Network Coding Medium Access Control* (VPNC-MAC) has two phases namely *Setup* and *Heart beat packet exchange* phase. The Setup phase uses OFDMA signaling technique for quick and non bandwidth consumption. The Packet Exchange phase has two periods of adjustable length namely VPNC-MAC session and Contention Period. This approach achieves better reliability with appreciable time and frequency synchronization.

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3. SURVEY OF VARIOUS NETWORK CODING SCHEMES IN VANET

S. No.	Vanet Applications	Topic Name	Description	Mechanism / Algorithm	Methodology	QoS / Performance
1.	Content Distribution	CodeOn: Cooperative popular content distribution (PCD) for Vanets using Symbol Level Network Coding [3]	A novel push based PCD using Access point	CodeOn	Piece Division Run Length Symbol Level Network Coding	High downloading rate, high protocol efficiency and robust
2.	Content Distribution	Delay analysis of car-to-car reliable data delivery strategies based on data mulling with network coding [4]	Pickup, carry and forward message to other lane in opposite direction	Data Mulling	Relay with Network Coding	Reduce data delivery relay
3.	Content Distribution	Abiding regional data distribution using relay and Random Network Coding (RNC) on Vanets [5]	Broadcast data item on certain probability only arrive in data effective area	RNC based regional data distribution on Vanets (R2D2V)	Random Linear Network Coding	High data delivery ratio, short delivery delay
4.	Content Distribution	An efficient Weak Secrecy scheme for network coding data dissemination in Vanets [6]	Secure information for bounded time then released	Weak Data Secrecy	All-or-Nothing Transformation with Winnow and Chaffing mechanism	High downloading rate, guaranteed protection, reduce download time
5.	Content Distribution	Rank based Network coding for content distribution in Vanets [7]	Injecting packets into network to reduce congestion	Rank based content propagation scheme	Content reception status of neighbours	High throughput, low end-to-end delay and low protocol overhead
6.	Content Distribution	CodeTorrent: Content distribution using network coding in Vanets [8]	Node exchange coded frames than file pieces	CodeTorrent	File Swarming Protocol	Shorter file downloading time
7.	Routing	A Loss-Tolerant scheme for unicast routing in Vanets using network coding [9]	Make use of Multiple Forwarder nodes to improve packet reception ratio	Loss Tolerant	Cooperative scheme with Multiple Forwarder Selection	High packet delivery ratio, low end-to-end delay and normalized control overhead
8.	MAC	Reliable network coded MAC in Vanets [10]	Each node find the best message combining strategy which maximizes in decoding an uncoded packets	Opportunistic Network Coding	Network coding in repetition based MAC schemes	Low message loss probability and low average delay
9.	MAC	Network coding based cooperative Automatic Repeat request (ARQ) scheme for Vanets [11]	Coordinate a set of relays by minimizing the number of transmission and enhance network performance	NCCARQ-MAC	ARQ in terms of Signal to Noise Ratio (SNR).	High throughput, low packet delay and highly reduce number of transmission

10.	Multimedia Audio Video	Fuzzy redundancy adaptation and joint source network coding for Vanets video streaming [12]	Increases the robustness of video streaming in vehicular networks.	Reliable joint coding approach	Multiple Description Coding and Random Linear Network Coding Approach	Gain video quality, high throughput and protect packet loss.
11.	Multimedia Audio Video	CodePlay: Live Multimedia Streaming (LMS) in Vanets using Symbol Level Network Coding [13]	New LMS based on Symbol Level Network Coding for effective bandwidth utilization	CodePlay	Opportunistic Transmission Scheduling algorithm	Short buffering delay, smooth playback and high source rate
12.	Multimedia Audio Video	Video transport over Vanets: Multi-stream coding with multi-path and network coding [14]	Effective video transmission without any packet loss	Scalable Video Coding	Uses Grey Relational Analysis to identify quality paths.	Low packet delay, low jitter, loss packet loss rate and high throughput
13.	Multihop Wireless	Joint Fuzzy relays and network coding based forwarding for multihop broadcasting in Vanets [15]	Multicast broadcast protocol for choosing best relay node to reduce packet loss	Fuzzy logic based Broadcasting with Network Coding (FUZZBR-NC)	Uses Joint Fuzzy for relay selection and network coding based forwarding schemes	Improve packet dissemination ratio, reduce end-to-end delay and low overhead
14.	Multihop Wireless	Multi-hop broadcasting in Vanets integrating Intra-flow and Inter-flow Network Coding [16]	Proposed protocol reduces channel busy time.	Intraflow and Interflow Network Coding	Uses Backbone Selection Algorithm for reliable vehicle connection	Reduce number of message transmission, high packet dissemination ratio and low end-to-end delay
15.	Broadcasting	Reliable broadcasting in Vanets using Physical Layer Network [17]	For efficiency and better reliability of beacon transmission	Vehicular Physical Layer Network Coding based MAC protocol (VPNC-MAC)	Uses Orthogonal Frequency division Multiple Access (OFDMA) scheme for quick and non bandwidth consumption	Minimize number of transmission and maximize Packet Reception Rate (PRR)

4. CONCLUSION

In this article, we furnish a compendious appraisal of Network Coding in Vanets. Various Network Coding schemes are categorized based on the applications of Vanets. We confer various Network Coding approach executed in Vanets with their purpose, Algorithm used, Methodology applied and its Performance Metrics. From this paper, we have come to an interpretation that Network Coding is an efficient way for message content dissemination in terms of high delivery ratio, low end-to-end delay and highly reduce number of transmission. On the whole Network Coding is an effective technique to perform vehicular communication in a safe and secure manner.

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