**Ph.D. Research Proposal**

**Doctoral Program in "Department Name"**

# Stable Cluster Formation and D2D Communication to Enable Cellular-V2X Communication

**by**

<Name of the Candidate>

<Reg. No of the Candidate>

**<Supervisor Name>**

**<Date of Submission (DD MM 20YY>**

# 1. Introduction

Vehicle to Everything (V2X) communication becomes emerging in recent days with advancement in 5G technology [1], [2]. Link level comparison also confirms that LTE and growing cellular technologies provide better performance than traditional IEEE 802.11p [3]. Furthermore, device to device (D2D) communication brings many advantages in vehicular communication [4]. In 5G-V2X communication, route selection is performed based social relationships instead of network parameters [5]. In hidden Markov model based V2X routing, route selection is performed by considering delivery probability and delivery delay [6]. Cellular V2C (C-V2X) routing is assisted by UAVs which are equipped with flying base stations [7]. Multi-hop cluster formation supports vehicle to internet communication [8]. To improve data forwarding in VANET-LTE-A integrated architecture, optimal mobile gateway selection is performed by cluster formation [9]. Amplify and forward based relay selection and power allocation is introduced to enable green communication [10]. In order to improve connectivity among vehicles with heterogeneous traffic flow dual ring connectivity model is designed [11]. AODV based routing in VANET selects optimal route based on speed and direction [12]. For routing planning, heterogeneous vehicular clustering scheme is presented in VANET-LTE [13]. In VANET-LTE network, vehicle to vehicle (V2V) communication is established by D2D communication [14]. Typically, emergency and safety message dissemination is performed in flooding manner which consumes large bandwidth [15].

# 2. Problem Definition

## 2.1 Overall Problem Statement

To enable V2X communication in cellular VANET following challenges are to be considered,

- Stable cluster formation which minimizes frequent clustering. Stable cluster formation improves data aggregation which results in minimized data loss

- Optimal V2V and D2D communication establishment which can handle congestion as well as improve data transmissions
- Optimal mobile gateway selection to enable V2X communication with minimum delay and reliable data transmission
- Emergency message dissemination method to minimize broadcasting storm and dissemination delay

## 2.2 Specific Problem Definition

In 5G based VANET, V2X communication was enabled by two-level cluster based routing scheme [16]. Here first level cluster head (CH) was selected by fuzzy logic and second level CH (gateway) was selected by improved Q-learning scheme. First level CH selection increases time consumption since each vehicle computes leadership value for itself and other neighbors using fuzzy rules (27 rules). In addition, IQL based gateway selection is not suitable for dense network since number of requests and number of agents increases rapidly. This will results in ineffectual selection of gateway and also increases time consumption. Multi-hop moving zone (MMZ) clustering scheme was proposed for cellular V2X communication using 5G technology [17]. Cluster formation based on hopcount alone affects the stability of cluster formation which results in frequent re-clustering. In addition, multi-hop data transmission through non-optimal vehicle increases packet loss. In greedy traffic light and queue aware routing protocol (GTLQR), route selection was performed based on street connectivity, channel quality, relative distance, and queuing delay [18]. However, street with high connectivity is not ensures presence of optimum relay always. In addition, when same street is selected by multiple vehicles then large congestion is introduced in that street. To enable D2D communication in 5G VANET, dragonfly optimization based cluster formation algorithm was proposed [19]. This paper doesn't provide brief discussion on D2D communication. CH selection without considering relative speed and mobility minimizes stability of the clusters in the network. In addition, dynamic change in transmission range requires huge beacon changes between vehicles. For emergency data dissemination, optimal mobile gateway selection was performed based on midpoint of the road in cellular VANET [20]. Mobile gateway selection method increases

number of gateways for emergency data dissemination and also the emergency message is not distributed uniformly. This method is not able to minimize broadcasting storm and redundant message transmission in the network.

**2.3 Problem Explanation**

**Reference 16**

**Title:** Two-Level Cluster Based Routing Scheme for 5G V2X Communication

**Concept**

In this paper, a two-level clustering scheme is proposed to enable efficient data dissemination in 5G VANET. Here initially level-1 cluster head (L1CH) is selected by fuzzy logic based on relative velocity factor, k-connectivity factor, and link reliability factor. Then level-2 CH (L2CH) which is also denoted as gateway is selected by Improved Q-learning (IQL) algorithm. The L2CH is selected based on distance with base station.

**Problems**

- This method is not suitable for dense network since IQL performs large number of iteration when number of agents and requests are increased. In addition, Q value determination is performed only based on distance metric which is not effectual.
- In cluster formation, each vehicle computes leadership value (using 27-fuzzy rules) for itself and other vehicles which increases computational complexity.

**Proposed solution**

- Optimal gateway selection is performed by MF-SMO algorithm which minimizes time consumption. Further, gateway selection considers multiple metrics which improves the data transmissions.
- CH selection is performed based on majority voting method which mitigates complexity on each vehicle.

**Reference 17**

**Title**: A Multi-Hop Moving Zone (MMZ) clustering scheme based on cellular V2X

**Concept**

This paper introduces a clustering scheme for VANET in which IEEE 802.11p standard is combined with 5G cellular technology. In this scheme, vehicles are clustered upto multi-hops (i.e. three hops) through V2V communication upon IEEE 802.11p. Further, cluster head (CH) or zonal head (ZH) is selected through cellular-V2X based on relative speed, distance, and link life time. Cluster formation is performed based on neighbor set that includes vehicle's ID, position, speed, and direction. Then the data is forwarded through multi-hops in the network

**Problems**

- Here N-hop clustering is adapted and clusters are formed only based on hopcount metric which minimizes the stability of clusters
- Multi-hop communication is performed through non-optimal vehicles which increases packet loss

**Proposed solutions**

- Cluster formation by SMCF scheme is performed based on speed difference and path similarity which increases stability of the clusters
- In each hop optimal relay is selected by NEIA algorithm to improve data transmission

**Reference 18**

**Title:** A Greedy Traffic Light and Queue Aware Routing Protocol for Urban VANETs

**Concept**

In this paper a greedy traffic light and queue aware routing protocol (GTLQR) is proposed in which street connectivity, channel quality, relative distance, and queuing delay were jointly considered for route selection. Here firstly, street with highest connectivity was detected and then relay nodes in that street were selected. The major objective of this work is to enable data transmission in urban scenario.

**Problems**

- The node with high connectivity is not always ensure that optimum relay vehicles always presented in that street
- When same street is selected by multiple vehicles then congestion is introduced in that street

**Proposed solution**

- We perform optimum relay selection in each cluster by NEIA algorithm
- Cluster based data transmission minimizes the congestion in the network

**Reference 19**

**Title:** Clustering algorithm for internet of vehicles (IoV) based on dragonfly optimizer (CAVDO)

**Concept**

In this paper 5G interface and deice to device (D2D) communication is established. In order to support D2D communication, cluster formation is proposed. For clustering process, CAVDO algorithm is proposed in which CH selection is performed by dragonfly optimization algorithm. To achieve stable clusters, the transmission range of cluster members is dynamically changed with respect to mobility. In CH selection, speed, distance, and direction metrics are considered.

**Problems**

- Here further analysis is needed on D2D communication since no discussion is provided
- CH selection without considering relative speed and mobility metrics is not able to form stable clusters.
- Dynamic change in transmission rage of vehicle needs huge beacon changes which leads to high congestion

**Proposed solution**

- For D2D communication, device discovery process is enabled by NEIA algorithm
- CH selection considers significant metrics which increases the stability of the clusters
- Stable clusters are formed by exchanging path pattern which can be done along with CH election broadcast message which minimizes the congestion

**Reference 20**

**Title:** Cloud-Assisted Safety Message Dissemination in VANET–Cellular Heterogeneous Wireless Network

**Concept**

This paper presents a cloud assisted safety message dissemination mechanism in which emergency data dissemination is performed through optimal mobile gateway nodes. Here DSRC and LTE-A network is used for communication. Gateway selection is initiated with selection of midpoint of the segment. Then the vehicle very close to midpoint is selected as optimal gateway. Then the optimal gateway is considered as midpoint and vehicles nearer to forwarder are selected as optimal forwarder. This optimal gateway selects forward delegator and backward delegator based on relative mobility



**Problems**

- Here mobile gateway selection based on midpoint increases number of gateways. If no vehicle is found nearer to midpoint then the safety message is not distributed uniformly.
- Selection of forward and backward delegator increases redundancy since same vehicle may be forwarder for one vehicle whereas same vehicle be a backward delegator to other vehicle

**Proposed**

- Emergency data is broadcasted through SA-HTD which minimizes redundant messages
- In each level of tree optimal forwarder is selected based on emergency level of data

## 3. Proposed Work

In order to overwhelm major problems in VNAET cellular networks, we proposed a ***novel Cellular 5G-VANET architecture*** to support V2X communication. Our network comprises vehicles, pedestrians with mobile device, 5G base station (BS), road side units (RSUs), and vehicular mobile users (such as drivers and passengers within vehicle with mobile device). We perform following processes to achieve better data delivery in VANET,

### *3.1 Cluster formation*

Initially the vehicles are segregated into small groups of clusters to support data aggregation. For cluster formation, novel **Stable Mobility-aware Cluster Formation (SMCF)** scheme is proposed. Here optimal CH selection is performed based on *Adaptive Mobility factor and Centrality factor*. Subsequently, stable cluster formation is performed based on future path similarity and speed difference between CH and other vehicle. Considering path similarity extend the lifetime of forms clusters which results in reduced number of re-clustering processes.

### *3.2 V2V and D2D communication*

Our proposed work supports both V2V communication and D2D communication in 5G-VANET. V2V communication is performed between on board units (OBUs) of vehicles whereas D2D communication is performed between mobile devices presented in different vehicles. We proposed **Neutrosophic Intelligence Algorithm (NEIA)** to support V2V and D2D communication. In V2V communication, NEIA selects optimal relay vehicle between source and destination while in D2D communication NEIA assists in device discovery process. In NEIA, link quality, signal strength, mobility, and distance are considered.

### *3.3 V2X communication*

To establish V2X communication we select optimal mobile gateway nodes between CH and infrastructure. The mobile gateway is selected from the pedestrians on the road which has lower mobility than vehicles. For optimal mobile gateway selection, new **Multi-Fitted Spider Monkey Optimization (MF-SMO) algorithm** is proposed. MF-SMO selects optimal mobile gateway without increase in time consumption as well as overcome the problem of local optima.

Fitness value is formulated based on residual energy level, channel quality, distance with vehicle, and distance with infrastructure.

### *3.4 Emergency data dissemination*

To support emergency data broadcasting, we include code value in the data packet as follows,

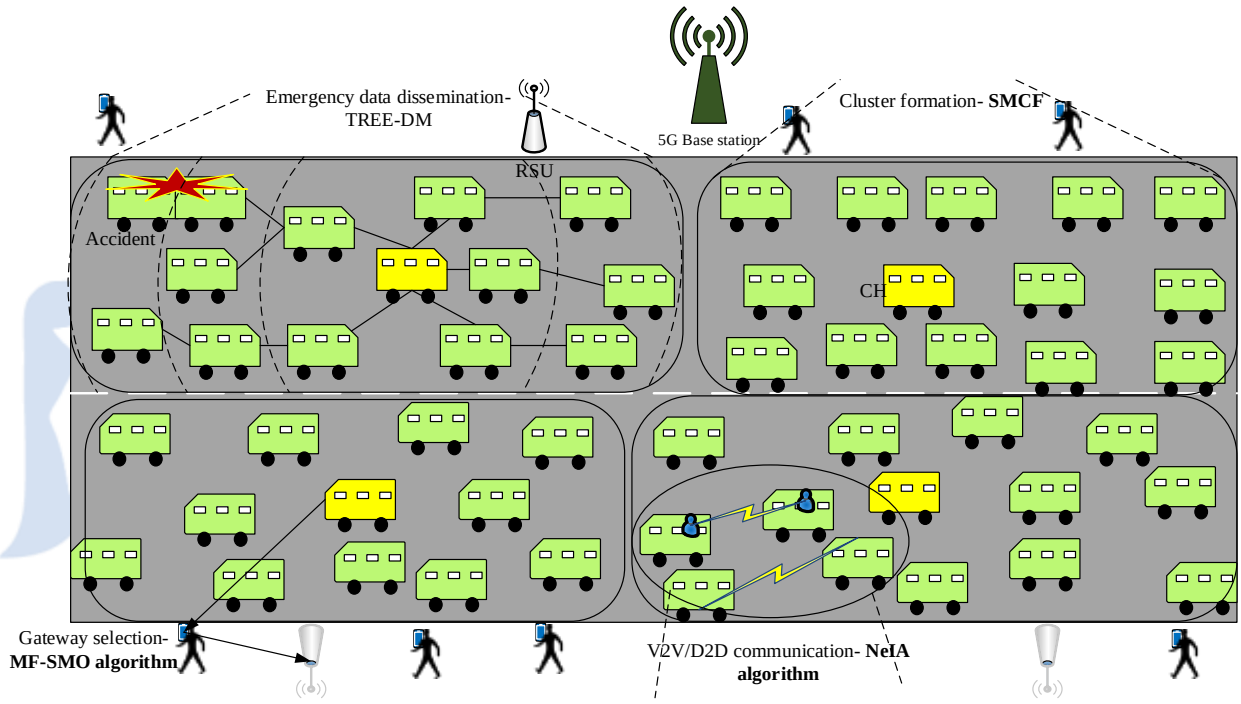
- **00**-Type1-*Accident and road breakage*
- **01**-Type2-*Traffic congestion*

Both level1 an dlevel2 data are transmitted to CH by source vehicle and the CH broadcast the data to all vehicles in the cluster to minimize broadcasting congestion. For emergency data dissemination, we proposed a **Tree based Dissemination (TREE-DM)** mechanism. CH constructs a hierarchical tree based on hopcount between CH and other vehicles. Then optimal forwarder is selected in each level of the tree based on safety message type. For type1 message, CH selects optimal forwarder based on fo*rwarding probability, delay, and link duration.* For type2 message, CH selects optimal forwarder based on forwarding probability.

Finally, our proposed work is evaluated based on following performance metrics,

- Packet delivery ratio for V2X communication
  - With respect to number of vehicles
  - With respect to mobility of vehicles
- Throughput for V2X communication
  - With respect to number of vehicles
  - With respect to mobility of vehicles
- Packet delivery ratio for D2D communication
- Throughput for D2D communication
- Transmission and Dissemination Delay

## Overall Architecture




## Research Highlights

- We proposed a novel Cellular 5G-VANET network to support V2X communication which includes V2V communication, V2I communication, and V2P communication particularly designed for urban scenario.
- Network is segregated into multiple clusters to support data aggregation. Cluster formation adapts a novel method in which path similarity and adaptive mobility metrics are formulated

- Optimal V2V and D2D communication is supported by optimal relay selection and optimal device discovery respectively. V2I communication is enabled through V2P communication in which optimal mobile gateway is selected based on significant metrics
- Emergency data broadcasting is performed within each cluster which suppresses duplicate packets and broadcast storm effectually.

**Reference Explanation**

**Reference 1**

**Title:** A 5G V2X Ecosystem Providing Internet of Vehicles

**Concept**

This paper presents a new 5G V2X ecosystem for internet of vehicle (IoV). This system utilizes software defined networking (SDN) concept to enable V2X communication. The major objective of this IoV is to provide multimedia services to the mobile users. Here SDN controller is deployed in the core network which is also called as 5G core network. Here the vehicles are considered as entertainment consumer points and the network infrastructure is guaranteed to provide delivery quality.

**Reference 2**

**Title:** A Novel WLAN Vehicle-To-Anything (V2X) Channel Access Scheme for IEEE 802.11p-Based Next-Generation Connected Car Networks

**Concept**

In this paper, IEEE 802.11ax standard based orthogonal frequency division multiple access (OFDMA) scheme is used to establish V2X communication in the network. Further, dedicated V2X channel is assigned to support massive V2X communication and to ensure high

channel capacity without increase in latency. The authors have highlighted that the existing IEEE 802.11p based V2X communication is not able to support massive V2X vehicles.

**Reference 3**

**Title:** Link level performance comparison between LTE V2X and DSRC

**Concept**

This paper analyzes the performance of IEEE 802.11p and LTE standards in V2X communication. The authors highlighted that cellular networks provides better connectivity than IEEE 802.11p for V2X communication. The cellular LTE communication improves bit error rate, SNR, and power-BLER. The authors also highlight that further analysis is needed to handle V2X communication in cellular based VANET.

**Reference 5**

**Title:** A Reference Framework for Social-enhanced Vehicle-to-Everything Communications in 5G Scenarios



**Concept**

In this paper, SDN and mobile edge computing (MEC) are combined with VANET in order to design a social-enhanced 5G-V2X routing framework. Here the process is performed in twofold: (i) facilitating the management such as establishment, storage, and maintenance, (ii) improving data distribution among them. In this framework, social relationship among vehicles is established in order to improve data forwarding. The social relationship includes parental object relationship (POR), ownership object relationship (OOR), social object relationship (SOR), and co-work object relationship (CWOR). Further, the data forwarding is carried out based on social relationships among vehicles.

**Problem**

- Perhaps, this framework establishes social relationship this method is not able to select optimal data forwarding path which leads to performance degradation

**Proposed solution**

- Data is forwarded through optimal relay vehicles selected by NEIA algorithm which minimizes packet loss.
- **Reference 4**
    - **Title:** VANET aided D2D Discovery: Delay Analysis and Performance
- **Concept**
- This paper discusses the D2D communication among vehicular drivers and passengers in VANET. Here the peer discovery process for vehicular user is performed by on board unit (OBU) of vehicles. At first, the user equipment which needs to establish D2D communication sends request the OBU of corresponding vehicle. Then OBU discovers user equipment by communicating with other vehicles in its proximity. In this manner, D2D communication is performed using VANET.

**Reference 6**

**Title:** V2X Routing in VANET based on Hidden Markov Model

**Concept**

V2X routing includes both V2V communication and V2I communication. In this paper V2X routing is performed through predictive routing based on the hidden Markov model (PRHMM). This method estimate future destination of a vehicle by analyzing regularity of vehicle moving strategy and past behaviors of the vehicle. After prediction of destination, the next process is to select optimal route for data transmission. In this work, delivery probability and delivery delay are considered as for route selection process.

**Problems**

- Relay node selection based on delivery probability and delivery delay without consideration of direction of vehicle leads to large amount of packet loss

**Proposed solution**

- Relay vehicle selection by NEIA considers multiple significant metrics which improve packet transmission

**Reference 7**

**Title:** Trajectories and Resource Management of Flying Base Stations for C-V2X

**Concept**

This paper presents a cellular V2X communication in the integrated network. Here aerial and terrestrial components are integrated in the network. Unmanned aerial vehicles (UAVs) based trajectory design is proposed for resource assignment and to enable V2X communication. Here the UAVs are equipped with base stations and other vehicles transmit their data to moving UAVs. UAVs are responsible to allocate radio resources to other vehicles and V2X routing is performed based on moving trajectory of UAV vehicles.

**Problems**

- The route selection by considering only UAV trajectory is not effectual

**Proposed solution**

- Optimal relay selection is performed by NEIA algorithm

**Reference 8**

**Title:** MCA-V2I: A Multi-hop Clustering Approach over Vehicle-to-Internet communication for improving VANETs performances

**Concept**

This paper presents multi-hop clustering approach for vehicle to internet communication in VANETs. The vehicle to internet communication is enabled through special infrastructure called as roadside unit gateway. After connected with internet, each vehicle obtains information about the multi-hop neighbors to initiate the clustering process. Cluster formation is performed

by using breath first search algorithm (BFS) for graph traversing based on mobility rate. The stability of the formed clusters is improved via selection of slave CH in each cluster.

**Problem**

- BFS algorithm based cluster formation increases clustering time which is not suitable for large scale networks

**Proposed solution**

- Cluster formation by SMCF scheme improves stability of the clusters with minimum time consumption

**Reference 9**

**Title:** A New Integrated VANET-LTE-A Architecture for Enhanced Mobility in Small Cells HetNet using Dynamic Gateway and Traffic Forwarding

**Concept**

This paper designs a heterogeneous network (HetNet) using LTE-A network to support both V2V and V2I communication. First a network based mobile gateway selection algorithm is proposed based on one-hop cluster formation. Formation of one-hop clusters supports the effectual data aggregation which improves the network performance. For seamless mobility of connected vehicles, local k-hops anchor based mobility scheme with intra-domain procedure, inter-domain procedure, and k-hops inter domain is proposed.

**Problem**

- Gateway selection is performed based on predicted average RSRP which increases data loss
- Cluster formation is not stable which requires frequent re-clustering process

**Proposed solution**

- Mobile gateway is selected by MF-SMO algorithm based on significant metrics

- Stability of cluster formation is improved by SMCF scheme by considering path similarity

**Reference 10**

**Title:** Joint power allocation and relay selection strategy for 5Gnetwork: a step towards green communication

**Concept**

This paper is focused on relay selection in 5G heterogeneous network towards green communication. For optimal relay selection, amplify and forward relay selection mechanism is used. To resolve relay selection and power allocation problem jointly, hidden markov model is maintained in base station. The source, destination, and relays may be cellular users or vehicles. Thus from multiple mobile relays, optimal relay is selected by signal to noise ratio.

**Problem**

- Amplify and forward based relay selection is not effectual

**Proposed solution**

- NEIA based relay selection improves the data transmission

**Reference 11**

**Title:** A Dual Ring Connectivity Model for VANET under Heterogeneous Traffic Flow

**Concept**

A dual ring based connectivity model is proposed to enable effectual data transmission and connectivity among vehicles in the network. Here the network is designed with dual rings such as primary ring and secondary ring. During data transmission and safety message dissemination, the slow speed vehicles (buses) presented on secondary ring provide the backup path of communication for high speed vehicles (cars). Here the slow speed vehicles are responsible to maintain connectivity in the network.

**Problems**

- The road structure is not considered which affects the dual-ring structure.
- Data dissemination through all slow speed vehicles introduces broadcast storm and congestion in the network.

**Proposed solution**

- Connectivity among vehicles is preserved by stable cluster formation
- Broadcast storm is reduced by SA-HDT mechanism

**Reference 12**

**Title:** Mobility Aware and Dual Phase AODV Protocol with Adaptive Hello Messages over Vehicular Adhoc Networks

**Concept**

This paper improves the traditional AODV routing protocol to enable routing in VANET. The proposed protocol is named as mobility and dual phase AODV with adaptive hello messages (MA-AODV-AHM) protocol. This proposed protocol aims to build route between source and destination vehicles based on vehicle speed, and direction of motion with respect to source vehicle. In addition, an adaptive control packet announcement mechanism is also proposed which minimizes the control packet overhead in the network.

**Problems**

- Route selection based on speed and direction is insufficient to improve data transmission since VANET is high dynamic network

**Proposed solution**

- Optimal relay selection and gateway selection considers multiple metrics which improves data tarnsmission

**Reference 13**

**Title:** VANET–LTE based Heterogeneous Vehicular Clustering for Driving Assistance and Route Planning Applications

**Concept**

To enable cooperative data transmission in LTE based VANET, this paper proposed a destination and interest aware clustering (DIAC) mechanism. Here a strategic game theoretic algorithm is employed for self-location calculation. DIAC approach maintains cooperativeness among cluster members using fair-use policy and game theory approach is used to determine the location of each vehicle. Vehicle mobility and LTE link quality are considered as major constraints in cluster formation. To increase the stability of the clusters, interest among vehicles is also considered for clustering.

**Problem**

- Involvement of fair use policy in cluster formation limits the CH selection efficiency

**Proposed solution**

- Optimal CH selection is performed based on adaptive mobility factor which prolongs the CH lifetime

**Reference 14**

**Title:** Analyzing Performance and QoS Parameter Estimation for VANET Using D2D

**Concept**

This paper attempts to improve V2V communication using D2D communication in LTE-assisted VANET. Here D2D communication is adapted to overcome the problems involved in traditional V2V routing. The D2D based communication includes two main components such as direct discovery and direct communication. This paper analyses QoS in D2D communication in different scenarios as follows: In-coverage, out of coverage, and partial coverage.

**Problems**

- Further analysis is required on V2I communication and the authors concluded that LTE-advanced will be better solution than LTE.

**Proposed solution**

- We have used cellular 5G technology to enable V2I communication which improves data rate and transmission delay

**Reference 15**

**Title:** Reliability and energy-efficiency analysis of safety message broadcast in VANETs

**Concept**

The authors have considered multi-hop VANET and aims to ensure end-to-end reliability in safety message broadcasting. Firstly, the channel error and collision is modeled in the network. Based on channel error and traffic congestion, optimal route is selected between source and destination from multiple paths. The safety message is broadcasted to all vehicles through optima forwarders.



**Problems**

- Here flooding is finalized as significant way for safety message broadcasting. However, flooding of emergency data will consume large bandwidth
- Broadcasting through non-optimal forwarder increases redundant data in the network

**Proposed solution**

- Emergency data dissemination by TREE-DM minimizes broadcasting storm as well as data redundancy

phdprimehelp@gmail.com
+91-97 91 62 64 69



**References**

Carlos Renato Storck, and Fátima Duarte-Figueiredo, “A 5G V2X Ecosystem Providing Internet of Vehicles”, Sensors, 19, 2019.

Jinsoo Ahn, Young Yong Kim and Ronny Yongho Kim, “A Novel WLAN Vehicle-To-Anything (V2X) Channel Access Scheme for IEEE 802.11p-Based Next-Generation Connected Car Networks”, Applied Sciences, Vol. 8, 2018.

Jinling Hu, Shanzhi Chen, Li Zhao, Yuanyuan Li, Jiayi Fang, Baozhu Li, Yan Shi, "Link level performance comparison between LTE V2X and DSRC", Journal of Communications and Information Networks, Vol.2, No.2, pp. 101-112, 2017.

Hussein Chour, Youssef Nasser, Hassan Artail, Alaa Kachouh, Ahmed Al-Dubai, "VANET aided D2D Discovery: Delay Analysis and Performance", IEEE Transactions on Vehicular Technology, Vol. 66, No. 9, pp. 8059-8071, 2017.

Claudia Campolo, Antonella Molinaro, Antonio Iera, "A Reference Frame-work for Social-enhanced Vehicle-to-Everything Communications in 5G Scenarios", Computer Networks, 2018.

Lin Yao, Jie Wang, Xin Wang, Ailun Chen, Yuqi Wang, "V2X Routing in VANET based on Hidden Markov Model", IEEE Transactions on Intelligent Transportation Systems, Vol. 19, No. 3, pp. 889-899, 2018.

Silvia Mignardi, Chiara Buratti, Alessandro Bazzi, and Roberto Verdone, "Trajectories and Resource Management of Flying Base Stations for C-V2X", Vol. 19, 2019.

O. Senouci, Z. Aliouat and S. Harous, "MCA-V2I: A Multi-hop Clustering Approach over Vehicle-to-Internet communication for improving VANETs performances", Future Generation Computer Systems, 2019.

Ahmed Salim Chekkouri, Abdellatif Ezzouhairi, Samuel Pierre, "A New Integrated VANET-LTE-A Architecture for Enhanced Mobility in Small Cells HetNet using Dynamic Gateway and Traffic Forwarding", Computer Networks, Vol. 140, No. 20, pp. 15-27, 2018.

Akshita Abrol, Rakesh Kumar Jha, Sanjeev Jain, Preetam Kumar, "Joint power allocation and relay selection strategy for 5G network: a step towards green communication", Telecommunication Systems, Vol. 68, No. 2, pp. 201-215, 2018.

Tariq Umer, Muhammad Khalil Afzal, Ehsan Ullah Munir, Muhammad Alam, "A Dual Ring Connectivity Model for VANET Under Heterogeneous Traffic Flow", Wireless Personal Communication, Vol. 98, No. 1, pp. 105-118, 2018.

K.A. Darabkh, M.S.E. Judeh, H. Bany Salameh, S. Althunibat, "Mobility Aware and Dual Phase AODV Protocol with Adaptive Hello Messages over Vehicular Adhoc Networks", International Journal of Electronics and Communications, Vol. 94, pp. 277-292, 2018.

Iftikhar Ahmad , Rafidah Md Noor , Ismail Ahmedy , Syed Adeel Ali Shah , Ibrar Yaqoob , Ejaz Ahmed , Muhammad Imran, "VANET-LTE based Heterogeneous Vehicular Clustering for Driving Assistance and Route Planning Applications", Computer Networks, Vol. 145, pp. 128-140, 2018.

K. P. Sharmila and C. Ramesh, "Analyzing Performance and QoS Parameter Estimation for VANET Using D2D", Innovations in Electronics and Communication Engineering, Springer, pp. 249-259.

Saira Sattar, Hassaan Khaliq Qureshi, Muhammad Saleem, Shahid Mumtaz, Jonathan Rodriguez, "Reliability and energy-efficiency analysis of safety message broadcast in VANETs", Computer Communications, Vol. 119, pp. 118-126, 2018.

Zahid Khan, Pingzhi Fan, Fakhar Abbas, Hongyang Chen, and Sangsha Fang, "Two-Level Cluster Based Routing Scheme for 5G V2X Communication", IEEE Access, Vol. 7, pp. 16194- 16205, 2019.

Zahid Khan, Pingzhi Fan, "A Multi-Hop Moving Zone (MMZ) clustering scheme based on cellular V2X", China communications, Vol 15, No 7, pp 55-66, 2018.

Yangyang Xia, Xiaoqi Qin, Baoling Liu, Ping Zhang, "A Greedy Traffic Light and Queue Aware Routing Protocol for Urban VANETs", China Communications, Vol 15, No 7, pp 77-87, 2018.

Farhan Aadil, Waleed Ahsan, Zahoor Ur Rehman, Peer Azmat Shah, Seungmin Rho, Irfan Mehmood, "Clustering algorithm for internet of vehicles (IoV) based on dragonfly

optimizer (CAVDO)", The Journal of Supercomputing, Vol. 74, No. 9, pp. 4542-4567, 2018.

Bingyi Liu, Dongyao Jia, Jianping Wang, Kejie Lu, and Libing Wu, "Cloud-Assisted Safety Message Dissemination in VANET–Cellular Heterogeneous Wireless Network", IEEE Systems Journal, Vol. 11, No. 1, pp. 128-139, 2017.