

Ph.D. Research Proposal

Doctoral Program in “Department Name”

Emergency Message Dissemination through Secure

Communication under D2D VANET Environment



PHD PRIME

by

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I. INTRODUCTION / BACKGROUND

Device-to-device (D2D) communication is expected to play a significant role in upcoming cellular networks as it promises ultra-low latency for communication among users. This new mode may operate in licensed or unlicensed spectrum. It is a novel addition to the traditional cellular communication paradigm. Its benefits are, however, accompanied by many technical issues that must be resolved before integrating it into the cellular ecosystem. Cellular Vehicle to Everything (V2X) is emerging technology that incorporates Vehicle to Vehicle communication (V2V), Vehicle to Infrastructure (V2I) and Vehicle to Pedestrian (V2P) communication regarding to improve the road safety and traffic efficiency [1] [12] [15]. Routing is one of the significant processes in the V2X in order to provide effective communication between vehicles.

Emergency Message dissemination in vehicular communication is essential to provide safety precautions to the vehicle users who are present nearby accident or event occurred regions. Emergency Message dissemination schemes are proposed with two safety messages that are predict beacon message and event driven messages [1]. Zero Coordination Opportunistic Routing (ZCOR) protocol is used to deliver the safety messages with limited target regions where range of reliable users are selected using Circle of Trust (CoT) [2]. An adaptive link quality based emergency dissemination is exploited where physical channel connectivity methods are utilized. Scale based priority allocation mechanism is proposed for candidate forwarder [3]. Cluster based emergency message dissemination strategy is adopted for VANET using V2V communication. In this, data handling process is performed before disseminating the emergency message to the vehicular users. Emergency messages are optimized before transmitting it to the neighbours [4].

1.1 Research Outline & Scope

Emergency Message dissemination in vehicular communication is essential to provide safety precautions to the vehicle users or D2D users who are present nearby accident or event occurred regions.

1.2 Research Objectives

Our device discovery process uses subsequent metrics to discover device that are SINR, CSI and relative speed of the vehicle.

- To speed up emergency message dissemination
- To extend coverage for D2D users through 5G users
- To ensure connectivity to neighbor D2D and vehicular users

II. RESEARCH GAPS

2.1 Common Problem Statement

Device discovery is not effective since it discovers device with absence of mobility oriented information. Packet drop is high in V2X, since all vehicle selects high connectivity street to discover path that increases queue size of the vehicles. Number of hops is large in path discovery due to selection of street with absence of distance to the destination.

2.2 Problem Definition

This author proposes greedy traffic light and queue aware routing protocol [16] for urban VANETs. Proposed algorithm jointly considers street connectivity, channel quality, relative distance and queuing delay in regard to alleviate packet loss. Street connectivity metrics determines the number of vehicles present in the intersection area using duration of red signal in the traffic light. Channel quality metric is determined using Channel State Information (CSI). Distance prediction is performed using transformation of HELLO packet between neighbour vehicles. Street which has highest connectivity is selected for packet transmission and further relay is selected with CSI, distance and SNR metrics consideration.

Problems

- Packet drop is high in transmission, since all vehicle selects high connectivity street to discover path that increases queue size of the vehicles.
- Number of hops is large in path discovery due to selection of street with absence of distance to the destination.

Proposed Solutions

- Our proposed method selects next forwarder using stable matching algorithm with consideration of succeeding metrics that are distance to the destination, link stability, Expected Transmission Count and Jerk. This way of transmitting packet to the destination resultant in reduced packet drop and number of hops.

This paper proposes routing over VANETs [17] using bio inspired unicast routing protocol. Author proposes Unicast Routing protocol based on Attractor Selecting (URAS) that change adaptively to the complex and dynamic environment. Herein, Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) is proposed for reducing number of redundant candidates in relay selection. TOPSIS considers following metrics to determine the optimum sets that are relative speed between source and neighbour, relative speed between neighbour and destination, distance between the node and destination and congestion degree.

Problems

- Transmission delay is more, since TOPSIS algorithm run in each forwarder node to select the optimum candidate set.
- High complex nature of TOPSIS leads to imprecise results; hence forwarder selection is not effective.

Proposed Solutions

- Proposed routing performs through optimum forwarder selection where stable matching algorithm is used. Stable matching algorithm reduces delay through selecting best forwarder to transmit packets.

This work proposes mobility based routing protocol [18] for vehicular Adhoc network. Herein, Greedy Perimeter Stateless Routing protocol is proposed for route the packets to the destination. Next hop is selected based on the consideration of succeeding metrics that are distance, speed, direction and link expiration time. From these metrics, weight is computed for each neighbour vehicle. The vehicle with highest weight selected as forwarder for routing that improves the performance.

Problems

- Proposed GPSR algorithm induces more delay during packet transmission owing to increase in hop count metric.
- GPSR generates routing loops in the vehicular network that tends to circulation of transmitted data packet.

Proposed Solutions

- Proposed routing performs through optimum forwarder selection where stable matching algorithm is used. Stable matching algorithm reduces delay through selecting best forwarder to transmit packets that reduces the delay.

This author proposes clustering and D2D communication [19] in vehicles based on the dragonfly optimizer algorithm. This paper utilizes dragonfly optimizer to form the cluster with optimum cluster head selection and cluster member. Proposed clustering algorithm uses following metrics to forms best cluster those are distance of the neighbour ode from the cluster head, relative speed and direction. D2D communication is established between vehicular user devices.

Problems

- D2D communication is not effective due to absence of optimum device discovery that in turn reduces the transmission rate.

Proposed Solutions

- Our proposed D2D communication discovers device using Enhanced Sphere Decoder Like (ESDL) algorithm that forms sphere based on the present direction of vehicle that in turn increases the efficiency of the D2D communication. Herein, optimum device is discovered by consideration of subsequent metrics that are SINR, CSI and relative speed that increases the transmission rate.

This author proposes time barrier based emergency message dissemination [20] in vehicular Adhoc network. Herein, cluster is formed in order to reduce the congestion during the emergency message dissemination. If vehicle receives the emergency message, it first determines its status. The emergency message received vehicle is cluster head then it broadcasts it to the cluster member without any delay. Received cluster member sets time barrier to retransmit the emergency message. It sets time barrier based on the distance from the source vehicle. If time barrier exceeds then it broadcasts the emergency message to the neighbours.

Problems

- Herein, emergency message transmission increases number of broadcasts since there may exist same distance vehicle from the source vehicle.
- Performance of the proposed system is degraded when increase in the vehicular speed.

Proposed Solutions

- We proposed Chaotic Crow Search Algorithm (CCSA) based optimum disseminator selection that in turn reduces the number of broadcasts during emergency dissemination.

III. RESEARCH CONTRIBUTIONS

Our proposed work tackles problems that are present in existing cellular V2X and D2D network. Our network comprises of vehicles, vehicle user (D2D user), Cellular User (Pedestrian), and 5G base station. Research contributions are following.

Bernoulli Theorem based Routing

Our proposed work performs routing through best forwarder selection regarding to satisfy the Quality of Service (QoS) requirement. We propose **Bernoulli Theorem** algorithm for forwarder selection where reputation function is computed. Herein, reputation function is calculated using succeeding metrics fairness from the destination, Expected Transmission Count (ETC), link stability, Jerk and next moving direction. In this, next moving direction of the vehicle is gathered from the Traffic Light where each vehicle updates their next moving direction in regard to handle the intersections in the street while selecting next forwarder.

Matching Theory based D2D communication

Our work exploits D2D communication using matching theory by establishing Bipartite Matching algorithm. BM algorithm finds best pair to establish D2D communication using weighted matrix. Here, weight is computed using subsequent metrics such as Relative Mobility, Received Signal Strength (RSS) and Link Connectivity Duration.

Secure Communication

Device to device communication in 5G network is secured through **Advanced Encryption Standard (AES) algorithm**. AES encryption process consists of four steps which are Byte substitution, Shift rows, Mixcolumns and Addround key. In decryption process, reverse of the encryption process is performed. The decryption sub-processes are Addround key, Mixcolumn, Shift rows and Byte substitution. In performance evaluation process, following metrics are considered,

Optimization based Emergency Dissemination

Our work disseminates emergency message to the nearby vehicles through selecting optimum disseminator vehicle. Disseminator is selected using **Whale Optimization Algorithm**. The proposed WOA updates the position of the crow using sine chaotic map which performs better than other chaotic maps. Proposed WOA computes fitness function using subsequent metrics that are forwarding probability, Expected Transmission Time (ETT) and speed.

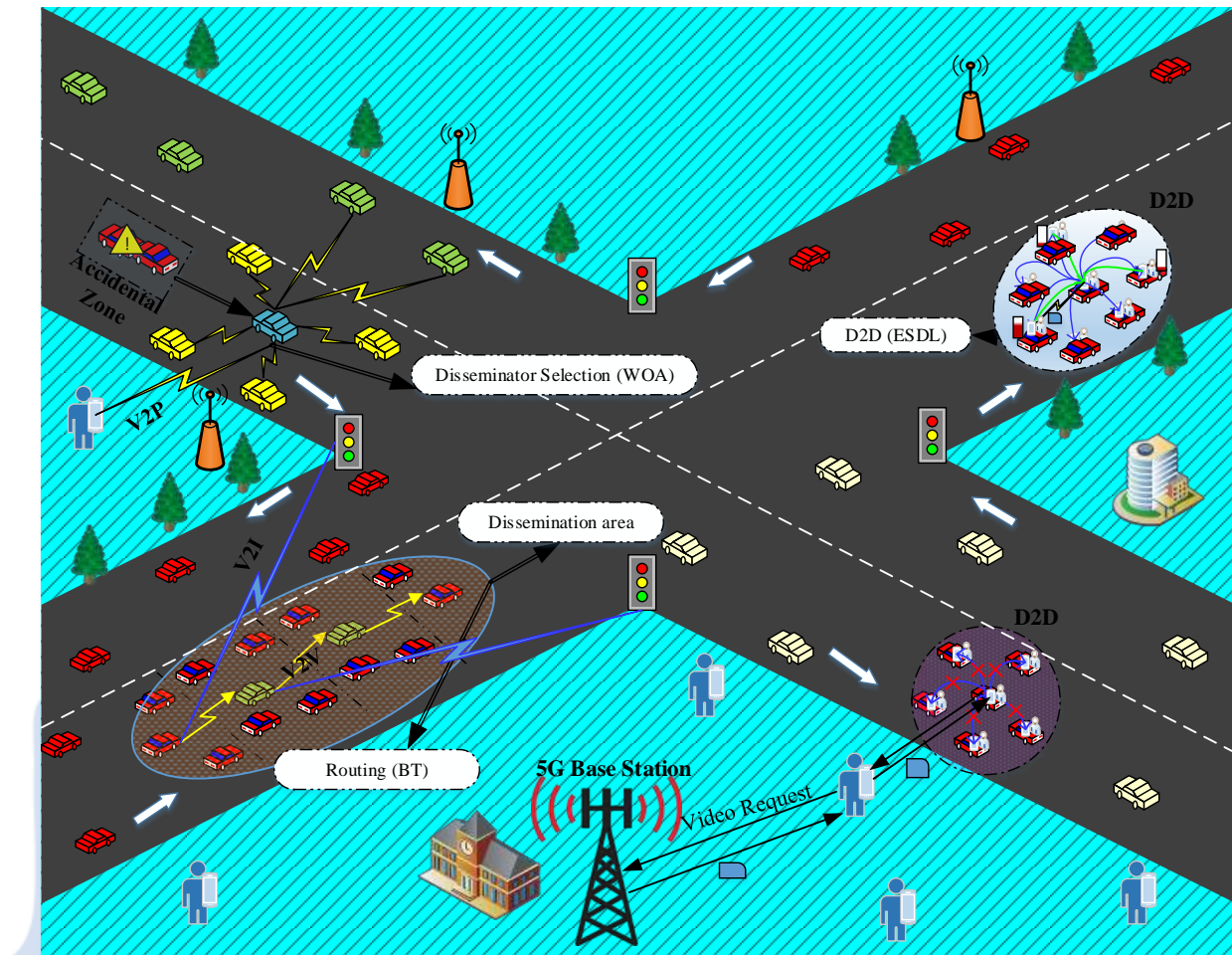
Performance Evaluation

Finally, we validate our proposed work performance with following metrics that are,

- Throughput
 - With respect to number of users.
 - With respect to distance.
- Signal to Interference Noise Ratio (SINR)
- Signal to Noise Ratio (SNR)
- Packet Delivery Ratio
 - With Respect to Number of Vehicles
 - With Respect to vehicle speed
- End to End Delay
 - With Respect to Number of Vehicles
- Emergency Information Coverage

SYSTEM ARCHITECTURE





IV. RESEARCH NOVELTIES

- Our method performs routing through forwarder selection with the aid of BT algorithm that reduces complexity during packet transmission. Stable matching algorithm computes reputation function for each user using following metrics distance to the destination, link stability, Expected Transmission Count and Jerk.
- Our proposed D2D communication discovers device using Enhanced Sphere Decoder Like (ESDL) algorithm that forms sphere based on the present direction of vehicle that in turn increases the efficiency of the D2D communication. Herein, optimum device is discovered by consideration of subsequent metrics that are SINR, CSI and relative speed that increases the transmission rate.

V. PREVIOUS WORKS & LIMITATIONS

Paper 1

Title - Cooperative Vehicular Content Distribution in Edge Computing Assisted 5G-VANET

Concept

This author proposes cooperative vehicular content distribution in edge computing assisted 5G-VANET. This paper investigates the content prefetching and distribution in 5G-VANET. Herein, graph theory based approach is utilized for content distribution in edge computing in vehicular network. In this Dedicated Short Range Communication (DSRC) is utilized for vehicular communication and cellular link is applied for gathering of context information.

Paper 2

Title - Chance-Constrained Optimization in D2D-Based Vehicular Communication Network

Concept

This author proposes Chance-Constrained Optimization in D2D-Based Vehicular Communication Network. Herein two types of model information is proposed that are channel model I and channel model II. Channel model I contains the cellular user with infrastructure link and channel model II contains the V2I link, D2D-V link and CU-V link. In this, optimization problem is utilized for power control problem with channel uncertainty in vehicular communication network.

Paper 3

Title - Energy-Efficient Multicast Service Delivery Exploiting Single Frequency Device-To-Device Communications in 5G New Radio Systems

Concept

This author proposes energy efficient single frequency device to device communication in 5G new radio systems. This paper designs the technique that efficiently delivers the service by

exploiting the benefits of the Device to Device (D2D) communication in order to improve the energy efficiency of the network. Herein, dimension of multicast area and D2D set of connection is established for maximization of the energy efficiency.

Paper 4

Title - Cellular-V2X Communications for Platooning: Design and Evaluation

Concept

This author proposes cellular V2X communication for platooning design and evaluation process. Herein, predecessor leader controller strategy is proposed to guarantee the better stability in vehicle platooning compared to the other strategies. This paper proposes two modes that are sequential and simultaneous. In order to disseminate Cooperative Awareness Message (CAM), proposed method derives the theoretical bounds along with time requirements.

Paper 5

Title - Privacy-Preserving Authentication and Key Agreement Protocols for D2D Group Communications

Concept

In this paper, two privacy preserving authentication and key agreement protocols are introduced to guarantee secure and anonyms D2D group communications. Device to device communications are significant for group based services. Using this protocol, group of D2D users mutually authenticate with each other without leaking their identity information while negotiate a common D2D group session key for secure communication in D2D session.

Paper 6

Title - Resource Allocation for Multi-cell Device-to-Device Communications Underlying 5G Networks: A Game-Theoretic Mechanism with Incomplete Information

Concept

In this paper, resource allocation problem where D2D links utilize common resources of multiple cells and each player's transmission parameters of other players is investigated. To overwhelm this problem, this paper presented the static game model and then extended it to a repeated one. Resource allocation protocol is proposed according to the interactions among base station and devices. This paper thoroughly analyzes the proposed mechanism by showing its optimally and by deriving a sufficient condition for its stability.

Paper 7

Title- D2D-U: Device-to-Device Communications in Unlicensed Bands for 5G System

Concept

In this paper, device to device communication is performed in the unlicensed bands for 5G systems. Device to device to communication enables direct communication between the nearby devices which improves the spectrum efficiency more. In this paper, device to device communication in unlicensed spectrum as underlay of uplink LTE network is proposed. To support unlicensed channel access for both LTE and D2D users, sensing base protocol is proposed. Iterative user sub-channel swap algorithm is introduced to allocate sub-channel to the users.

Problem

- In this paper, security is not considered while transmitting data between the devices which eavesdroppers to access the data and Unlicensed band communication increases the interference.

Paper 8

Title - VANET aided D2D Discovery: Delay Analysis and Performance

Concept

In this paper, VANET aided d2d discovery is proposed and analyzes the delay and performance of the proposed work. Initialization phase makes the entire surrounding node aware of its position and the transaction phase answers the user request. Herein, clustering is formed based transmission range, if the transmission range of the two node intersects then it forms cluster. Device discovery process is performed whenever OBU receives device discovery request. Carry and Forward strategy is used to deliver the message over the vehicle to the destination.

Problem

- Device discovery is not effective since it discovers device with absence of mobility oriented information.

Paper 9

Title - Asking neighbors a favor: Cooperative video retrieval using cellular networks in VANETs

Concept

This work proposes cooperative video retrieval using the cellular networks in vehicular environment. In this paper, COoperative video REtrieval scheme (CoRe) is proposed that allows the vehicles to download a good quality video. Neighbours are selecton based on their multiple on-road characteristics such as Euclidean distance, connection time, relative velocity, and the available cellular bandwidth.

Paper 10

Title - Device discovery for D2D communication in in-band cellular networks using sphere decoder like (SDL) algorithm

Concept

This paper proposes device discovery for D2D communication in in-band cellular networks using Sphere Decoder Like (SDL) algorithm. The centralized device discovery process

is chosen in regard to reduce the power consumption and signaling overhead. The proposed SDL algorithm forms hyper sphere around the discovered device. Proposed SDL uses QR factorization method to discover the devices within the generated hyper sphere. Device discovered based on the three metrics that are channel response, SINR and power constraints.

Problem

- QR factorization method is slow since it requires more steps to convergence in optimal result that tends to increase delay in D2D discovery.
- SDL based device discovery is not effective, since it forms sphere with random radius which may extend or shrink the communication range of discoverer device.

Paper 11

Title - Route discovery for vehicular ad hoc networks using modified lion algorithm

Concept

This author proposes route discovery for vehicular ad hoc network using the modified lion optimization algorithm. The proposed modified lion algorithm considers four metrics that are congestion cost, travel cost, QoS cost and collision cost. Herein, QoS cost is computed using the fuzzy membership function. QoS cost includes two metrics that are Received Signal Strength and congestion level and travel cost includes time, distance and fuel metric. Proposed method computes fitness function using discussed cost oriented metrics to determine the optimum path.

Problem

- Herein, path discovery process is complex due to usage of modified lion algorithm inbuilt with fuzzy in optimum path discovery. It takes more time to discover path, since Modified Lion algorithm has more processes to determine best path and also fuzzy is used to compute QoS cost.

Paper 12

Title - Coordination-free Safety Messages Dissemination Protocol for Vehicular Network

Concept

This author proposes Coordination-free Safety Messages Dissemination Protocol for Vehicular Network. Herein, Zero-Coordination Opportunistic Routing (ZCOR) algorithm is proposed to disseminate safety messages over constricted target geocast regions. Proposed ZCOR algorithm is scalable and robust over dynamic VANET conditions incorporating low rebroadcast overhead. The novel concept Circle of Trust (COT) is used to set the range of the neighbour.

Paper 13

Title - An Adaptive Link Quality Based Safety Message Dissemination Scheme for Urban VANETs

Concept

This paper proposes adaptive link quality oriented safety message dissemination scheme for urban VANETs. In this, physical channel connectivity calculation method is utilized to estimate the connectivity probability among vehicles. In addition to it, score-based priority allocation mechanism is used for candidate forwarders (CFs) to synchronize the contention among CFs. Minimum waiting time and contention window size is estimated for each vehicle in CFs to disseminate the safety message.

Problem

- Herein, optimum forwarder selection is required to reduce frequent broadcast of the Safety message.

Paper 14

Title - Cluster-based emergency message dissemination strategy for VANET using V2V communication

Concept

This paper proposes cluster oriented emergency message dissemination methodology for VANET using V2V communication. The proposed dissemination strategy performs data handling before establishing emergency message dissemination. If the event is detected by the vehicle then it immediately checks the neighbour vehicle determines this event. Message optimization process is performed before disseminating the emergency message.

Paper 15

Title – Multi-hop Routing for Data Delivery in V2X Networks

Concept

This author proposes multi-hop routing to deliver data in the Vehicle to Everything (V2X) network. Herein, multi-hop routing is performed through Carry and Forward (CF) strategy where V2V communication is established. To determine optimum vehicular pair, Karush Kuhn Tucker (KKT) conditions are used. Proposed KKT taken latency and data rate metrics into account in regard to compute weight. Highest weight vehicle is selected for V2V communication. If any optimum vehicle is not determined within the time, then it request Road Side Unit to discover vehicle for V2V communication.

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