Ph.D. Research Proposal

Doctoral Program in "Department Name"

EventSafe: Reliable Safety Message Dissemination & Sense Event Classification in Cluster based Vehicular Adhoc Network

by

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I. INTRODUCTION / BACKGROUND

Vehicular Adhoc Networks (VANET) has increased the interest of researches for providing safety for human lives while moving over high speed vehicles. In VANET vehicles requests RSU either with an Emergency Message (EM) or normal data transmission. EM from vehicle is more urgent and so it needs to be disseminated throughout the network. Many previously research works in VANET have undergone, by concentrating either data dissemination or routing protocol, but both the process is required to be performed based on the type of data packets received from vehicles. In order to enhance the communication in vehicular environment, clustering is a resulting technique which divides the vehicles into set of clusters. Clusters are formed with each cluster head and the EM is unicasted to other vehicles. Clustering consumes higher time in case of dynamic vehicles and also cluster head has to be elected repeatedly when head leaves the cluster. Each cluster is managed through specific vehicle named as CH which collects data from its CM. Cluster based emergency message dissemination approach is proposed in vehicular networks. Cluster forwarder node is selected based on the position within the cluster. If any accident occurs in cluster, source node sends emergency message to the cluster forwarder. Cluster forwarder node transmit emergency packet after receiving clear to broadcast message from the cluster head

Data collision avoidance is significant process while collecting data from CM. Safety message broadcasting is significant in vehicular based network in order to preserve safety among vehicles in road areas. Since, there exist several unforeseen incidents that are occurred frequently on the roads which threaten the people lives. If an accident happened in the environment, a message must be transmitted to all vehicles present in the surroundings. Different broadcasting algorithms are utilized to transmit safety message to the vehicles whenever accident occurs in the vehicular sensor environment. However, blind broadcasting of safety message results in broadcast storm and also induces loss in safety message. In VANET distance and position are considered as significant metrics for route selection.

1.1 Research Outline & Scope

Achieve reliable safety message delivery to all neighbor vehicles and also classifies events accurately under any environment i.e. Urban and Highway.

1.2 Research Objectives

The key objective of this research is to mitigate the broadcast storm and data collision in the design of vehicular network. The following objectives set to acquire the aforementioned goals that are follows.

- To propose the effective clustering scheme to form the stable vehicular environment.
- To achieve high throughput in data transmission using the effective collision avoidance technique.
- To propose new safety message broadcast mechanism to reduce the broadcast storm in the network.
- To propose new machine learning based event classification approach which provides better performance under critical situations.

II. RESEARCH GAPS

2.1 Common Problem Statement

In this field, there are some crucial problems include frequent topology changes induce instability in clustering which tends to concurrent cluster formation. Data collisions occurred during transmission due to multiple vehicles sending their data in same period of time. Broadcast storm is high in safety message broadcasting due to pursuing of blind procedure. Most of studies don't consider event classification that leads to false identification of events exist in vehicular surroundings.

2.2 Problem Definition

In this work author [1] intends novel store-carry-forward (SCF) scheme for message dissemination in vehicular ad-hoc network. The proposed method tackles broadcast storm problem which is major issue in VANET. Herein, source vehicle sends warning message to the

SCF vehicles that are its communication range. SCF vehicle broadcast warning message to its neighbours and carries this information until it new neighbour is arrived. SCF vehicle broadcast warning message to the new neighbour.

Problem

- Source vehicle sends warning message to the SCF vehicle at a time, there may be more than one SCF vehicle in one region that leads to collision in warning message.
- Vehicles nearby SCF vehicles receives more duplicate warning message, since two nearby SCF vehicle broadcast warning message to the new neighbour that leads to the broadcast storm.

Proposed

- This work avoids broadcast storm via best forwarder selection by slicing source node communication range into square and find best forwarder using Deep Reinforcement Learning method.
- Proposed work reduces data collision through Adaptive CSMA & TDMA protocol that provides unique timeslot to each node based on the queue length. In addition to it, we also adaptively change contention window size based on the number of users.

In [2] author advises air quality monitoring using VSN and also executes Efficient Data Gathering and Estimation (EDGE) mechanism on VSN. EDGE proposes dynamic partition procedures using region quad tree algorithm. This paper proposes three phases that are adjustment phase, gathering phase and estimating phase. In adjusting phase, grids are merged, split according to the sensed data from the one grid. Gathering phase, vehicular nodes receives beacon signal to sense respective grid. Each vehicular node sends two reports to the base stations that are standard report and differential report. In estimation phase, remote server computes Air Quality Index for each grid.

Problems

- Grid partitioning based on region quad tree leads to depend on minimum and maximum size. If selected size is not optimal size, then it tends to partitioning not effective. Grid size is dynamically changed according to the sensed data; it is unnecessary to frequent splitting of grid in vehicular network.
- Region Quad tree based partitioning is applicable only to the unobstructed road scenario. Generally road contains many blocks besides its structure, hence this method not suitable for VSN.

Proposed

- Proposed clustering using HCTCW where sensing and sensed data transmission is performed that can be applicable to any road scenario.
- The proposed HCTCW based cluster formation doesn't depend on initial size of the cluster.
- Then formed clusters based on the mobility, connectivity, distance and link stability that tends to maintains stable cluster and reduces loss in transmitted packets

In [3] author advises hybrid sensor and vehicular network for efficient message delivery using mathematical linear programming. Herein, sensor nodes are deployed between two RSU nodes. Sensed data from the sensors are provided to the RSU node, if there is no vehicle passing in its sensing range. RSU sends sensed data to the sink node via vehicular nodes which is selected using mathematical linear programming. The proposed mathematical linear programming considers distance metric to select vehicular node.

Problem

- Mathematical Linear programming is produces optimum result, if only linear variable is given as input, otherwise it won't provide optimum result and mathematically more complex technique find solution.
- Relay vehicle is selected based on distance metric only that leads to more packet loss in transmitted information, since doesn't considers metrics related to distance, direction, speed which are plays vital role in vehicular network communication.

Proposed

- Our work forms clusters based on the high link stability that tends to reduce the packet loss in data packet transmission.
- Proposed HCTCW selects optimum cluster head through chaotic variant update which provides fast convergence rate.
- We transmit classified data information to the RSU through cluster head which is optimally selected using HCTCW that improves efficiency in data packet transmission between cluster head and RSU or Sink nodes.

A Integrity oriented Content Offloading (ICO) with variable modulation schemes are proposed in [4] VSN. This work proposes two offloading procedures that are direct link and relay assisted path respectively. In direct link offloading, vehicular nodes are directly offload data into the RSU. Relay vehicles are selected by computing distance to the sink node in its communication range. In relay assisted path based offloading; vehicular nodes send data to the RSU via two hop relay nodes. Finally, minimum distance node is selected as relay vehicle to offload data to the RSU.

Problem

- Relay vehicles are selected only based on the distance metric that leads to loss in transmission, since there may be less link connectivity that tends to easy breakable of communication between relay vehicle and RSU.
- The proposed method is only applicable to the highway scenario not to urban scenario, since if number of users increase, this ICO direct link and relay assisted based offloading is not effective.

Proposed

- The proposed scheme can be applicable to both highway and urban scenario through optimum clustering and safety broadcasting using HCTCW and Deep Reinforcement Learning methods respectively.

- Then, transmit classified data information to the RSU or Sink nodes through cluster head which is optimally selected using HCTCW that improves efficiency in data packet transmission between cluster head and RSU or Sink nodes.

Author proposes two phase event monitoring and data gathering in [5] Vehicular Sensor Networks (VSN). This paper has two phases that are monitoring and event checking phases. In monitoring phase, node senses environment in low cost sensing mode and generates the sensed data. Sensed data exceeds the some threshold, and then nodes are transferred into high sensing mode. In the meantime, threshold for event decision making is changed adaptively based on the previous event decisions.

Problem

- In regard to monitor event, machine learning algorithm is executed in each vehicular node and RSUs that leads to more complexity in event decision making and also consumes more time.
- Event decision making process consumes more bandwidth, since it broadcast many messages to vehicular and RSU node.

Proposed

- The proposed work classify event in cluster head node only that tends to reduce complexity in event detection and also reduces bandwidth consumption.
- Then classify the event using DR2N2 which performs fast and simplicity in execution.

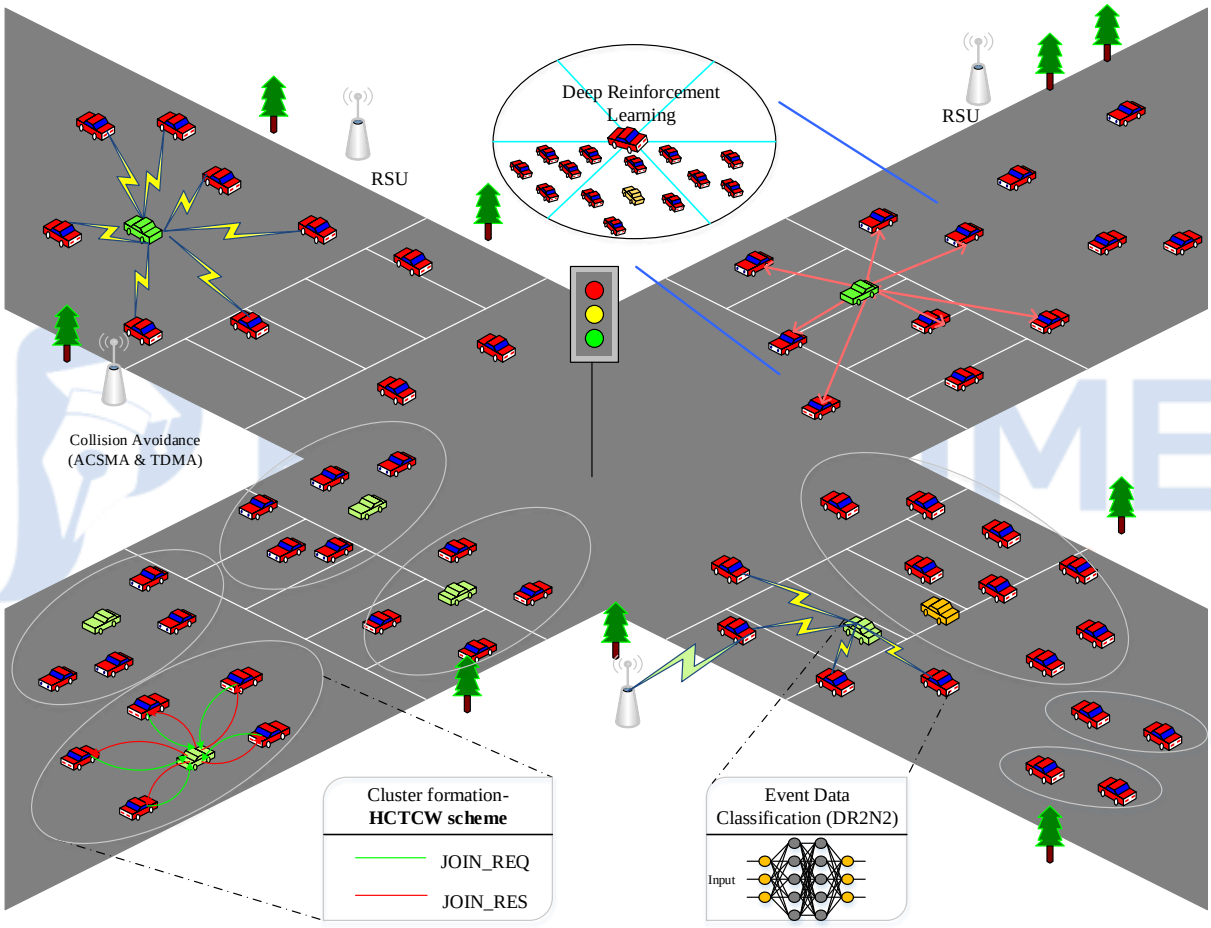
III. RESEARCH CONTRIBUTIONS

The proposed work overwhelms the glitches that are occurs in the existing emergency broadcast schemes in VANET. Proposed vehicular environment includes of subsequent entities that are *Road Side Unit (RSU), and Vehicles.* A primary aim of this work is to reduce broadcast storm in Safety data broadcasting and also reduce data collisions. The proposed work composed of the four major phases that are follows,

- **Cluster formation and Cluster Head Selection**

- **Collision Avoidance**
- **Safety Message Dissemination**
- **Sensing Event Classification**

SYSTEM ARCHITECTURE



1) Cluster formation and Cluster Head Selection

Cluster formation is the first process in the work which is performed through Irregular Scheme. The proposed scheme contains two processes that are cluster head selection and cluster formation. I) Cluster head (CH) selection procedure is performed through Hybrid Chaotic and Crow Search algorithm. Here, updates position of crow through two irregular variants such as

circle and gauss. This is one of the fast convergence rate algorithms. For CH selection, we consider three metrics that are mobility, vehicle connectivity and distance. Mobility metric is computed by Relative Position, Speed and Maximum Acceleration. Vehicle connectivity metric composed of node connectedness, node stability and packet transmission and reception ratio. Vehicle node which has highest fitness function for both mobility and connectivity metric is selected as CH. After CH election, cluster formation process will be initiated for neighbour nodes. After that, neighbor node sends join request to the CH. From the received request, highest link stability node only selected as cluster member by CH. This way of forming cluster reduces data packet loss while transmitting sensed data packet from cluster member to CH node and also maintains stable cluster.

2) Collision Avoidance

In this process, **Adaptive CSMA and TDMA scheme** is executed in CH. Herein, CH adaptively change timer of its cluster member based on the queue length. This way of selecting timeslots for each cluster member tends to reduce the collision while sending packets in each cluster in VANET. In addition to it, we also adaptively change contention window based on the number of vehicles.

3) Safety Message Dissemination

Safety message dissemination is attained through **Slice based Forwarder Selection** method. If any vehicle supposed to accident in road, then the source vehicle performs forwarder selection via SFS method. SFS method first segments transmission range into square region. After that, region is split into front and back regions and further split into left and right diagonal region. Here, we focus on back region of source vehicle hence safety message is must send to the vehicles that are coming towards the source vehicle. In back region, we provide first priority to the center portion. From center portion, we select optimum forwarder using **Deep Reinforcement Learning** method by considering succeeding metrics that are node degree, position, forwarding probability and delivery delay.

4) Sensing Event Classification

Event classification is final process in this work which is executed by CH. CH receives sensed data from both cluster member and passive sensor deployed in road side. We deploy passive sensor node alternatively in both sides of roads and also maintains particular distance between passive sensor nodes; passive sensor nodes send their sensed data to the nearby CH. CH executes Dynamic Running Recurrent Neural Network (DR2N2) to classify the event. Passive sensor node and cluster member node sends sensed data to the CH node at each time interval and CH classifies which type of event occur in environment like fire accident, etc… Here, CH adaptively change the parameters related to event detection, since climate is changing day by day. By means of changing parameters adaptively, we can identify event accurately. Event detected data packet is send to the RSU based on the accessible transmission range. If the CH node within RSU transmission range, then it transmits event data packet to RSU. The proposed work is implemented for urban and highway scenarios.

Performance Evaluation

Finally, we evaluate performance of our proposed work through succeeding metrics that are,

- Latency vs. No of vehicles
- Reachability (%) vs. No of vehicles
- Average number of collisions vs. No of vehicles
- Packet Delivery Ratio (%) vs. No of vehicles
- Throughput (%) vs. No of vehicles
- No Duplicate Data Packets vs. Total packets sent
- Reliability vs. Total packets sent

IV. RESEARCH NOVELTIES

- This work avoids broadcast storm via best forwarder selection by slicing source node communication range into square and find best forwarder using Deep Reinforcement Learning method.

- Proposed work reduces data collision through Adaptive CSMA & TDMA protocol that provides unique timeslot to each node based on the queue length. In addition to it, we also adaptively change contention window size based on the number of users.
- The proposed scheme can be applicable to both highway and urban scenario through optimum clustering and safety broadcasting using HCTCW and Deep Reinforcement Learning methods respectively.

V. PREVIOUS WORKS & LIMITATIONS

Paper 1

Title - CESense: Cost-Effective Urban Environment Sensing in Vehicular Sensor Networks

Concept

This work proposes the cost effective urban environment sensing in the vehicular sensor network. Cost effective sensing model uses the probabilistic matrix model to reveal the status of the environment. The matrix factorization method reduces the amount of uncertainty in the unsensed data. With spatial temporal correlation of the sensed data, sensing task is only allocated to the small subset of sensing area.

Paper 2

Title – ReIDD: reliability-aware intelligent data dissemination protocol for broadcast storm problem in vehicular ad hoc networks

Concept –

In this paper broadcast storm problem is solved by using game theory in which vehicles are considered as players. Reliable route is selected by ReIDD scheme, initially clustering is constructed with estimation of payoff values. Payoff values are computed with three parameters such as maximum communication range, storage resources and computation power. These pay-off values are hashed and sorted in distributed hash table. Next weight value is determined with distance, relative speed, relative acceleration and angle. With this estimated weight, reliability of link is predicted.

Limitations –

- Clustering is high speed moving vehicles is difficult and also collision may occur due to larger number of hello packets exchanges
- The vehicle's sending EM is not verified, since vehicles are not genuine at all times.

Proposed –

- To avoid collision during data dissemination, in our proposed work we select a single vehicle as best data dissemination and make it to broadcast the EM. Here only the selected vehicle's will broadcast EM.
- Clustering is constructed with less complexity
- Vehicle's identity is verified and also trusted authority is involved to check certificates of the vehicle.

Paper 3

Title – A Routing Protocol for Urban Vehicular Multi-hop Data Delivery

Concept –

Multi-hop broadcasting scheme is presented in this paper, which proposes improved distance based VANET routing protocol. This scheme was designed for reliable packet dissemination in the network. Using distance-based broadcast method, the packet is broadcasted. Next the packets received by vehicles wait until its waiting time becomes zero for rebroadcasting. In this scheme the vehicle present at far distance will have larger waiting time.

Limitations –

- Distance is the only metric considered
- Distant vehicle receive EM with some delay

Proposed Solutions –

- More than one metric is considered

Paper4

Title – A survey and comparative study of QoS aware broadcasting techniques in VANET

Concept –

This paper gives a detailed idea on VANET and its application along with VANET architecture and their characteristics. Broadcasting protocols are explained brief with a figure including its classifications. This paper is considered only to get introduction knowledge about VANET.

Paper 5

Title – An Adaptive Multipath Geographic Routing for Video Transmission in Urban VANETs

Concept –

For guarantee Quality of Service in video transmission, the authors have proposed a scheme named as adaptive geographic routing scheme. Multiple routes are selected between source and destination for single transmission. Using this scheme multiple shortest routes are discovered by Dijkstra algorithm with the support of digital map. After route discovery the connectivity probability is determined by source. The videos are separated into parts and transmitted over selected routes (i.e.) a part of video in a route. On the whole the proposed scheme is executed in two phases, 1. Estimate with the number of required routes for particular video size and 2. Discover connectivity probability.

Limitations –

- Video regeneration at destination was complex since video are separated and received in different routes
- Loss of video was also difficult to identify

Proposed Solutions –

- Single perfect route is selected with two reliable channels

Paper 6

Title – Position Based Seamless Connectivity for Vehicular Ad Hoc Networks

Concept –

Position based Seamless Connectivity Routing is proposed in this paper for performing routing between source and destination vehicles. As per this routing algorithm, if the destination is within the transmission range of source vehicle, then they directly communicate. In case if the destination is present far away from the transmission range of source, then source node transmits the packet to base station. The base station forwards the packets to Wi-MAX tower which in turn broadcasts the packets to base stations that are present in the coverage of Wi-MAX. Bases station on receiving the packets checks with Home Location Register and Visitor Location Register, for identifying the location of destination vehicle. This paper shows improvements in experimental result with the following parameters listed as packet delivery ratio, reliability and end-to-end delay.

Limitations –

- This algorithm is a lengthier process
- Specified route is not selected, data packets are transmitted via base station

Proposed Solutions –

- Route selection based on multiple criterions

Paper 7

Title - MERVS: A Novel Multi-channel Error Recovery Video Streaming Protocol for Vehicle Ad-hoc Networks

Concept –

This paper focuses on video streaming process for minimizing error during video transmission, here I-frames are considered as most important frames. For higher quality and error recovery, a Multi-channel Error Recovery Video Streaming (MERVS) is proposed. This work of MERVS selects two different channels such as reliable channel and unreliable channel for video frames transmission. Reliable channel is preferred for I-frames and unreliable channel is preferred by P and B frames. The reliable channel uses TCP protocol and unreliable channel uses UDP protocol. Loss of I-frames is only concentrated in MERVS, which causes loss of P and B frames due to their transmission in unreliable channel.

Paper 8

Title – Analysis of Angle Based Opportunistic Routing Protocol for Vehicular Ad-Hoc Networks

Concept –

Angle based Opportunistic Routing Protocol is proposed in this paper, this protocol determines suitable next-hop node for the purpose of selecting stable links between intermediate nodes. The working of this protocol is as follows; (1) Region division, (2) selection of one-hop node and (3) Prioritizing the selected nodes. Based on the angle changes each one-hop node is selected.

Paper 9

Title - Novel Technique in Multi-hop Environment for Efficient Emergency Message Dissemination and Lossless Video Transmission in VANETS

Concept

This work proposes the novel multi-hop environment for emergency message dissemination in VANET. Best data disseminator for emergency message dissemination is selected through the computation of weight value. Herein, weight factor is computed using following metric that is average speed. The vehicle with good score is selected as the best disseminator for emergency messages.

Paper 10

Title – Time Barrier-Based Emergency Message Dissemination in Vehicular Ad-hoc Networks

Concept

This paper proposes time barrier based emergency message dissemination in vehicular networks. Herein, data dissemination is executed through time barrier mechanism which reduces message overhead. This method works based on the super node, in order to timely disseminate the messages. Using this approach farthest node rebroadcast the message which can more distance.

Paper 11

Title - Cluster based emergency message broadcasting technique for vehicular ad hoc network

Concept

In this work, cluster based emergency message dissemination framework is proposed for vehicular ad-hoc network. Proposed work contributes three fold that are cluster formation, clustering and emergency message dissemination. Cluster size is formed based on the average speed of the vehicle within the cluster. Herein, each cluster contains three types of nodes that are unique node, sub-unique node and normal node. Unique node sustains in the cluster act as cluster head. Emergency message is broadcasted via cluster forwarder which selected in each cluster.

Problem

- Emergency message dissemination is not effective, since it select forwarder based on the position metric only that increases delay and loss in emergency data.

Proposed

- Proposed work finds best forwarder using fuzzy-VIKOR where following metrics are considered that are position, node degree, forwarding probability and delivery delay.

Paper 12

Title - Vehicle location service scheme based on road map in Vehicular Sensor Networks

Concept

This work proposes the vehicle location services based on the sensors deployed in the road sides. In this quorum based location service schemes to provides sensor nodes with location information of the vehicles in the VSN. Location information of the vehicles are provided by using the cross point between the quorum of location update and quorum of location query. Herein road map information is used for quorum of location update and quorum of location query.

Paper 13

Title - A robust distance-based relay selection for message dissemination in vehicular network

Concept

This work proposes distance based relay selection for message dissemination in vehicular network. In this, two adverse scenario is proposed for distance based relay selection in message dissemination. Herewith, best relay is selected using exponent based partitioning broadcast protocol. It also incorporates the mini-black burst assisted mechanism. In this analytical model is proposed for robust performances in terms of contention latency and packet delivery ratio.

Paper 14

Title - Cooperative vehicle positioning with multi-sensor data fusion and vehicular communications

Concept

This work proposes cooperative vehicle positioning with fusion of sensor data and vehicular communications. Availability of the information from multiple sources exchange of sensor information and multi sensor data fusion can be applied to discover the position of the vehicle. Herein, one host vehicle and three neighbour vehicles are considered to find the position of the vehicle. In this host vehicle obtains position information via two resources that are on board GPS receiver in host vehicle and relative position information from neighbour.

Reference 15

Title - Accident Management System Based on Vehicular Network for an Intelligent Transportation System in Urban Environments

Concept

This work proposes accident management system through intelligent transport systems in urban environments. Accident management system consists of three modules that are sensor module, speed monitor module and message and alert module. Herein, sensor module is used to monitor and control the sensors deployed in the network. Message and alert module is used to maintain the communication between RSU unit, ambulance and central server. Speed monitor module is used to measure the speed of each vehicle.

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