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A NOVEL DE ROUTING SCHEME FOR VEHICULAR AD-HOC NETWORK

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Abstract- *Vehicular Ad hoc Networks (VANET) became one of the most challenging research areas in the field of Mobile Ad hoc Networks (MANET). In VANET vehicles send emergency and safety messages from one control channel having a restricted bandwidth, which results in increasing collision to the channel. In this paper Differential Evolution (DE) optimization algorithm is used in vehicular ad hoc network. DE algorithm is used to choose which vehicle is the most suitable to act as cluster manager by minimizing the fitness function. Using various key metrics of interest including data packet delivery ratio, throughput, time complexity, a modified scheme based on Differential Evolution (DE) algorithm is proposed which is compared to the PSO based routing in VANET.*

Keywords **–VANET, PSO, Velocity, Best Search**

I. Introduction

The main aim of Intelligent Transport System is to provide security and safety for drivers. It is very essential and serious concern to create capable safety system on the road for humans today. Traffic congestion wastes time and fuel, thus, there is a serious need to develop efficient safety systems. VANET enables the intelligent vehicles to communicate with each other. Implementation of such systems is possible in vehicles with devices enhancing safety, such as small range radars, night vision, light sensors, rain sensors, navigation systems, and the Event Data Record (EDR) resembling the Black-Box [1]. However, VANET is still at the early stages of deployment, and real and intensive research pertaining to essential safety solutions is still limited. This research gap prevents VANET from achieving its main goal of creating an efficient safety system on the road [2].

Wirelesses access in vehicular environment (WAVE) is a multi-channel approach, planned by the Federal Communications Commission (FCC), kept for one control channel from 5.855 to 5865 GHz, for high availability, low latency vehicle safety communications. WAVE represents the first VANET standard published in 2006. Enhancement was required on IEEE 802.11 standard to support applications from the Intelligent Transportation Systems (ITS). The 802.11p standard is used in VANET communication and uses dedicated short range communications (DSRC) spectrum; it is divided into eight 10 MHz channels with only one control channel for safety application communication. VANET that depends on the exchange of safety information among vehicles (V2V communication) or between vehicle to infrastructure (V2I Communication) using the control channel. VANET safety communication is implemented in two ways, namely, periodic safety message called beacon and event-driven message known as emergency message, both sharing only one control channel. The beacon messages contain status information about the sender vehicle, such as position, speed, heading, and others. Beacons provide new information about the sender vehicle to the surrounding vehicles in the network, which updates the status of the current network and predict the movement of vehicles. Beacons are sent aggressively to nearby vehicles at 10 messages each second. This results a raise in channel collision that the control channel cannot bear, especially when extreme traffic occurs in small geographic areas. So channel load should be controlled and limited channel resources should be efficiently used. In this paper Differential Evolution optimization algorithm is implemented in VANET to minimize the fitness function which results to choose best suitable vehicle as cluster head.

II. Related Work

In VANET network is divided into clusters which assures fast delivery of data packets from one vehicle to another vehicle which result to increase data packet delivery ratio and reduce collision.

In [3] authors have proposed an “energy aware” adaptive algorithm, which uses only local information to alter power [4, 5 and 6] and fixed on the minimum transmission power does not always maximize throughput. In VANET energy efficiency is not a matter where nodes have a nearly unlimited power supply for communication.

Dynamic alteration of transmission power based on estimates of local vehicle density is proposed in [7]. Traffic density does not specify channel load; thus, if the channel load is high and the traffic density is low, the sender chooses high power for sending the message, that further increasing channel load and causing message reception failure [8].

A comparison is done between single- hop transmission at high transmission power and multi-hop transmission at low transmission power. This resolves whether the multi-hop beaconing can reduce channel load or not [9]. The author found that single hop is best for beaconing and multi hop is suitable for full coverage. Sending in high power enables beacons to arrive at long distances in single-hop and may increase channel load. Broadcasting at full power results in broadcast storm problem [10] and increases the channel load. In [11] a power control algorithm is developed to determine best possible transmission power for beacon message transmission by adding a power tuning feedback beacon during each beacon message exchange. On each message exchange, the sender computes the distance to the receiver and sets a predicted transmission power. On the receiver side, the distance is computed to determine if the transmission power achieved a greater distance or not. However message exchanges results in delay that makes the information gathered outdated as network status is variable.

An analytical model is planned to find a transmission power, which maximizes single-hop broadcast coverage [12]. An adaptive algorithm that adjusts to a given fixed transmission power is proposed [13]. Both studies paying attention on a unpolluted broadcast environment, their assumptions made their approach infeasible for vehicular networks, because their nodes were static and had the same priority, i.e., there was no differentiation among the transmission power of beacon and emergency messages.

In [14] authors proposed a Delay-Bounded Dynamic Interactive Power Control (DB-DIPC), in which the transmission powers of VANET nodes are verified by neighboring vehicles at run-time. The idea is to send beacons to neighbor vehicles at very low power, and if the sender receives an acknowledgment, then that specific power is sufficient for close neighbors. This mechanism sends beacons to very close vehicles and limits the information gain for vehicles in the network. It also produces a very long delay as the sender needs to send the message many times to its neighbors and wait for a reply to decide the suitable transmission power.

Various routing metrics such as throughput, end-to-end delay, packet delivery ratio, path duration, and so many have been used to calculate the performance of routing protocols in VANETs [15]. Path duration is one of the most influential metrics among these routing metrics. Highly movable vehicles results in regular topology transformation in vehicular network environment that ultimately affects the path duration. Author derived a mathematical model to calculate approximately path duration using border node-based most forward progress within radius (B-MFR), a position based routing protocol. The mathematical model for estimation of path duration consists of probability of finding next-hop node in forwarding region, evaluation of expected number of hops, probability distribution of velocity of nodes, and link duration among each in-between pair of nodes.

Vehicular Ad hoc Network (VANET) studies have focused on the communication methods based on IEEE 802.11p, which forms the standard for Wireless Access for Vehicular Environments (WAVE) [16]. VANET network which uses the IEEE 802.11p only, the broadcast storm and disconnected network problems at high and low vehicle densities respectively degrade the delay and delivery ratio of safety message dissemination. Recently, as an alternative to the IEEE 802.11p based VANET, the usage of cellular technologies has been investigated due to their low latency and broad range communication.

An efficient clustering algorithm for Vehicular Ad Hoc Networks (VANETs) is provoked by the recent research in cluster-based MAC and routing schemes [17]. VANETs are highly dynamic and have extreme channel conditions, thus a suitable clustering algorithm must be robust to channel error and must consider node mobility during cluster formation. This work presents a narrative, mobility-based clustering scheme for Vehicular Ad hoc Networks, which forms clusters using the Affinity Propagation algorithm in a distributed manner. This proposed algorithm considers node mobility during cluster formation and generates clusters with high stability. It is also robust to channel error and exhibits reasonable overhead.

Ever-present integration of high-speed WLANs with wide-range 3GPP systems results in the service extension of the backbone cellular network. In such heterogeneous wireless network architecture which combines IEEE 802.11p VANETs with 3GPP LTE to get flawless data connectivity for continuous multimedia sessions amongst spatially-apart vehicular clusters. Issues based on cluster head-based multicasting and QoS are explored. An adaptive multi-metric Cluster Head (CH) election mechanism is proposed to manage the VANET sub-clusters. Building of a 2-hop virtual superimpose mesh-based shared multicast tree for lower level multicasting within VANETs is discussed.

A vehicular ad hoc network (VANETs) involve vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication and has established a better attention in the recent years. Though safety is the primary motive for the growth of vehicular ad-hoc network, they also make possible applications like supervision of traffic flow [18], monitoring the road conditions, broadcasting of data and many more. Efficiency of all these applications depends on density estimation. A clustering approach for traffic monitoring and routing is proposed where the Cluster Head (CH) election is done based on distance and direction information. As clusters are created all along the road, CH's will take the liability of routing the packet to destination. The simulation results show better stability, accurate density estimation in the cluster, better End-to-End delay and good delivery ratio.

sAuthor presents huge applications introduced by Vehicular Ad-Hoc Networks (VANETs), such as intelligent transportation, roadside advertisement, make VANETs become an important part of metropolitan area networks [19]. In VANETs, mobile nodes are vehicles which are prepared with wireless antennas; and they can communicate with each other's by wireless communication on ad-hoc mode or infrastructure mode. Compared with Mobile Ad-Hoc Networks, VANETs have some intrinsic characteristic, such as high speed, sufficient energy, etc. According to previous research, clustering vehicles into diverse groups can introduce many advantages for VANETs.

Clustering in vehicular ad hoc networks (VANET) is one of the organized schemes used to make VANET global topology less dynamic. Many of the VANET clustering algorithms are derived from mobile ad hoc networks (MANET) [20]. However, VANET nodes are characterized by their high mobility, and the existence of VANET nodes in the same geographic proximity does not mean that they exhibit the same mobility patterns [21]. Therefore, VANET clustering schemes should take into consideration the degree of the speed difference among neighboring nodes to produce relatively stable clustering structure

III. Optimal Clustering Method

Clustering in VANET is the most important issue of concern because the selection of optimal cluster head is essential. In VANET every vehicle is able to learn its neighboring environment and take a judgment autonomously. In VANET every vehicle behaves as an agent [22]. Therefore Differential Evolution Algorithm is applied to choose an optimal cluster head. Hence three features is to be considered in the selection of cluster head. Firstly, the cluster head should be at a least average distance to its cluster members. Secondly, the velocity value should be nearby to the average speed. Finally, the vehicle that acts as cluster head must have utmost neighbors. A fitness function f is defined:

$$f = \min \left(\sum_{it=1}^{Nit} [w1.d + w2.\left| avg - s \right| + w3.n] \right)$$

s is the speed of vehicle V; n is the number of the neighbors of vehicle V; Nit is the maximum number of iterations; *it* is the iteration that ranges from 1 to *Nit*; w1, w2 and w3 are random constants and d is the Euclidean distance between two vehicles communicating with each other at any instant of time which is defined as:

$$d = \sqrt{(x_{vi}-x_{vj})^2 + (y_{vi}-y_{vj})^2}$$

avg is the average speed of vehicle V calculated as

$$avg = 1/n \sum_{k=1}^{n} s;\ V \in [1,n]$$

IV. Proposed Work

Differential Evolution is a method that optimizes a problem by iteratively trying to improve a candidate solution. In this paper **DE** is applied to VANET that generate better results as compared to **PSO** used in VANET [23].

- Initialize all **'a'** with random positions in the search-space.
- Unless an ending criterion is met (e.g. number of iterations performed, or sufficient fitness reached), repeat the following:
  - For every agent '**a**' in the population do:
  - Choose three agents **s, t and u** from the population at random, they must be different from each other as well as from agent
  - Choose a random index $R \in \{1, \ldots, n\}$ (***n*** being the dimensionality of the problem to be optimized).
  - Calculate the agent's potentially new position $b = [b_1, \ldots, b_n]$ as follows:
    - For every $i \in \{1, \ldots, n\}$, choose a uniformly distributed number $r_i \equiv U(0,1)$
    - If $r_i < CR$ or $i = R$ then set $b_i = s_i + F \times (t_i - u_i)$ otherwise set $b_i = a_i$
    - The new position is the outcome of the binary crossover of agent **a** with the intermediate agent z= s+ F ×(t-u).
- Choose the agent from the population with the highest fitness or lowest cost and return it as the best found candidate solution.

V. Performance Evaluation and Results

Simulation of the VANET based cluster algorithm that was carried out using MATLAB language (matrix laboratory) which is a numerical computing environment. MATLAB allows matrix multiplication, showing graphs of functions and data, implementation of algorithms. Here a comparative analysis is performed between **PSO** applied to VANET and with **DE** applied to VANET.

i) Comparison of fitness: Using Differential Evolution algorithm (proposed) the Fitness value with respect to iterations is minimized as compared to PSO (base) as shown in Fig.1

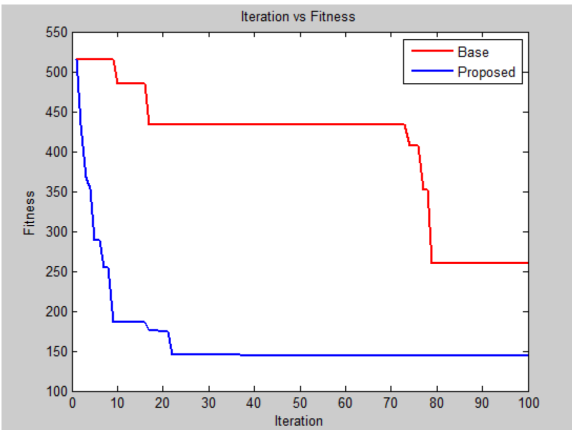

Fig.1. Fitness vs. Iteration

ii) Comparison of fitness score: Fitness score is minimized using differential evolution which helps to select suitable cluster head in VANET as shown in Fig.2

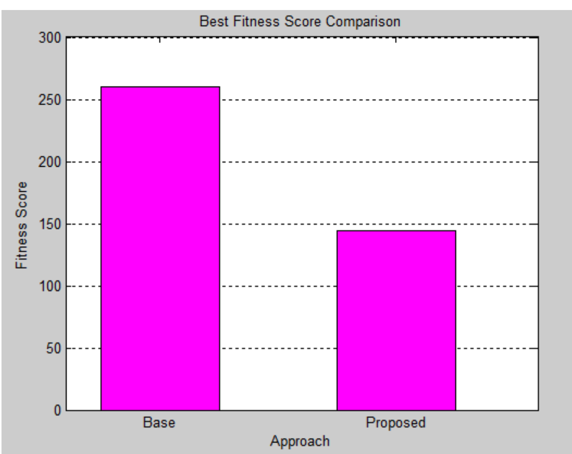

Fig.2.Fitness score

iii) Comparison of data packet reception: According to Fig.3, it can be seen that data packet reception with respect to time using DE is enhanced as compared to the previous work of VANET using PSO. More number of data packets between vehicles is exchanged which enhance the performance of network.

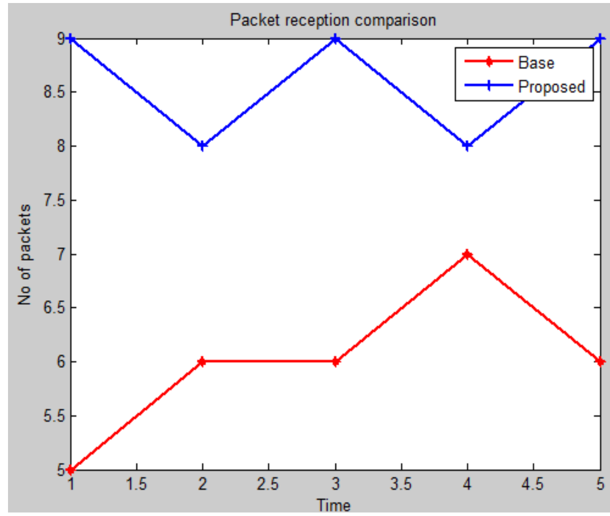

Fig.3. Packet reception vs. Time

iv) Comparison of packet delivery ratio: Packet delivery ratio using DE is increased as shown in Fig.4

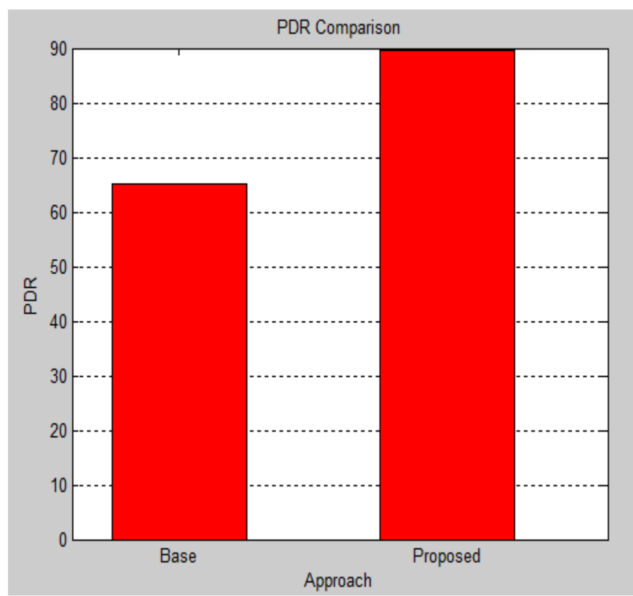

Fig.4. PDR

v) Comparison of throughput: Number of packets in proposed solution is increased as shown in Fig.5

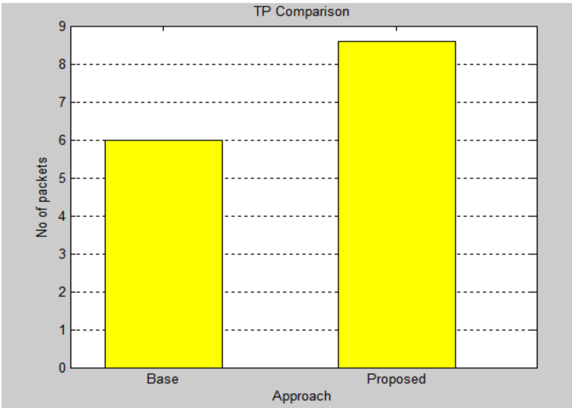

Fig.5. Throughput

vi) Comparison of time complexity: The proposed algorithm DE reduced the time as shown in fig.

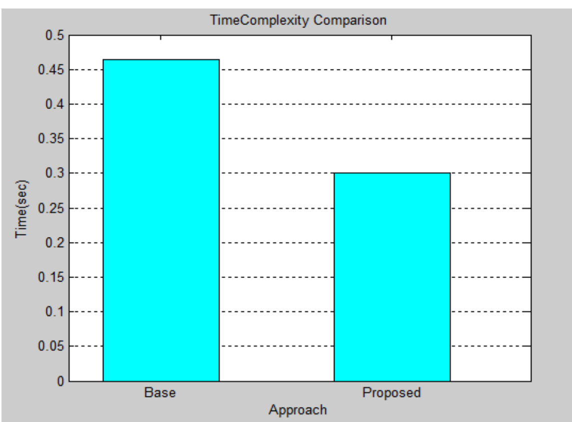

Fig.6. Time Complexity

The main problem of old scheme [24] is the number of data packet delivery from source to destination is less and time taken in vehicle to vehicle communication is more. This paper tries to overcome these drawbacks. The modified scheme based on DE proposes novel criteria to choose the best cluster head by reducing the fitness function value and computationally reduces the time. The following table shows the comparative analysis:-

Table1. Comparison of PSO and DE applied to VANET

Approach	PDR	TP	Avg Fitness Score	Time(sec)
Base	65.1111	6	322.3552	0.4509
Proposed	89.5556	8.6	238.5075	0.3

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VI. Conclusion

In this paper, a novel forwarding approach to improve performance of vehicles in VANETs is proposed. The data is forwarded over a set of groups with an optimal Cluster Head which is selected using PSO optimization algorithm. Fitness value is minimized which results an increase in packet reception, increase in throughput and reduces the time complexity. As a future work, hybrid optimization techniques with the combination of PSO and DE algorithm can be used for better results.

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