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A Hybrid Model for Performance Evaluation of Fixed VANETs using Novel 1C3N and Topology-Based Ad-Hoc Routing Protocols with Packet Loss Control Methods

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Abstract: Vehicular ad-hoc Networks (VANETs) play a significant role in Intelligent Transportation Systems (ITS) Design. Intelligent Transportation Systems are the first mandatory requirements for any smart city. Researchers are vigorously working on ITSs for smart cities and so VANETs have received a lot of attention. In VANETs, Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) message transmissions are carried out using wireless access technologies like IEEE 802.11p and IEEE 1609 WAVE family of standards. The crucial challenge in the implementation of VANETs involves the task of deciding the routing protocol because unlike MANETs, handover in VANETs is extremely high. In this paper, a novel routing technique, One Caption for 3 Nodes (1C3N) algorithm is proposed. This algorithm is implemented along with other topology-based existing routing protocols for the implementation of VANETs in the Coimbatore-Urban Area (Indian Smart City). The performance evaluation is carried out by comparing metrics like goodput, Overhead, Packet delivery ratio (PDR), Packet loss ratio (PLR) and end-to-end delay for four existing VANET routing protocols. The results show that a proper combination of packet loss model with routing protocol enhances the goodput and reduces the overhead for a fixed VANET. It is observed that the proposed 1C3N routing technique provides 60-65% better goodput than the other four algorithms.

Keywords: VANETs, Ad-hoc Routing Protocol, 1C3N Algorithm, Smart City, Performance Evaluation.

1. Introduction

India is the first densely populated country in the world with a stretch of 1, 15,435 km roadways. The maintenance of roads is very difficult when the major population of the country uses roadways. Moreover, controlling the mushrooming vehicular population on roads in not an easy task. When the majority of population prefer roadways to reach their destination, it is found that burgeoning cities like Mumbai, Delhi, Chennai and Kolkata could not bungle in providing reliable transportation. This results in various difficulties like traffic jams, violation of traffic rules and some serious and fatal road accidents. It is officially reported that nearly 1.77 lakh deaths per year occur on Indian roads which are far higher than the deaths of Indians in wars. This can be rectified with the implementation of VANETs in all smart cities of India.

Vehicular ad-hoc network is currently the most vibrant research domain, due to developing technologies like driverless vehicles, lane detection, collision detection and various driver safety systems. This paper aims at suggesting the implementation of VANET in Coimbatore city, one of the smart cities in South India. VANETs support V2V and V2I communication with the help of 5.850-5.925 GHz frequency band allocated by the federal communication commission for dedicated short range communication. It uses IEEE 809.11p and IEEE 1609 family of standards.

Wheeb *et al* [1] UAV adhoc networks performance were analyzed with difference protocols. VANET is enhanced with the help of 5G networks to increase the efficiency and stability Naeem *et al* [2].

The article is designed as follows: section II explains about related work; section III explains about simulation setup, concerned with the loss models, routing and interfacing protocols; section IV dwells on proposed 1C3N Algorithm.; section V focuses on the results analysis; section VI sums up the conclusion; section VII is acknowledgement and section VIII is references.

2. Related Work

There are various advanced routing protocols such as TLRC and GLSR-L posited by Xia *et al* [3].

AQRV is specially designed for ant colony optimization in VANETs by Guangyu *et al* [4]. There are other routing algorithms that are specially designed for VANETs such as short video distribution in simplex format and 5G assisted content distribution according to Leo *et al* [5]. Intelligent OLSR and situation-aware routing models have been proposed by Toutouh *et al* and Hasham *et al* [6, 7]. But these routing models have not considered the importance of loss models that improvise the performance of VANETs. In this paper the proposed method is designed to use Friis and ITU. 1411 loss model by which VANET performance can be observed and improved. GPSR protocol uses greedy forwarding techniques in numerous vehicular nodes. It is mostly restricted and designed to operate in the city environment. VADD, recommended by Zaho *et al,* is the Vehicle Assisted Data Delivery system that works by means of direction probe D-VADD and Location probe L-VADD [8]. Yet the edge selection for transmitting a packet has been found to be difficult in this method.

A-STAR algorithm scheduled by Raissi *et al* has been initially developed to work in wireless sensor networks [9]. Based on its performance, it is currently positioned in VANETs for its ability to find the optimal path for the packet delivery. It uses packet forwarding technique and it is more applicable for city environment. Most packet forwarding techniques are suitable for city environments as their packet delivery ratio will be higher compared to the rural areas. CAR proffered by Neumuo *et al*., is a connectivity aware routing protocol which is designed for communication between vehicles in highway environment where the mobility is high [10]. In this case, a technique 'Guards' is used to track the mobility and applied for real road maps in Switzerland. Jarupan *et al* put in place PROMPT which is a position-based or geo-location-based routing convention that uses source routing mechanism [11].

It helps in finding the shortest paths by relying on independent vehicle positions. It is a cross-layer and delay aware protocol. This protocol performs better than GPSR, A-STAR and CAR, since the priority flag in the packet overtakes all these algorithms. The results of GPSR, A-STAR and CAR algorithm is also discussed with OLSR, DSDV, DSR and AODV algorithms [12-17].

3. Materials and Methods

3.1 Simulation set up

Simulation of Urban Mobility (SUMO) is used in our model to generate the realistic urban environment of Coimbatore city. It uses discrete time and continuous space traffic mobility modeling simulator which helps to stimulate different vehicles like cars, buses, trucks, motorcycles and even pedestrians. Traces and routes are carried out with the help of NS-3.29 simulator [18]. SUMO helps with the direct import from Open Street Map (OSM). The authors of this paper have used OSM to generate the mobility created by SUMO for a fixed VANET with the help of wireless vehicles and 10 fixed RSU's which are equally distributed. Figure 1a shows mobility model created and Figure 1b shows the traffic congestion.

3.2 Friis Loss Model

This model works only in vacuum or free space. The model is defined by

$$\frac{P_r}{P_t} = \frac{A_r.A_t}{d^2.\lambda^2} \tag{1}$$

$$\Rightarrow \frac{P_r}{P_t} = \frac{\lambda^2}{(4\Pi d)^2} \text{ (incase of isotropic)} \tag{2}$$

Figure 1a. Coimbatore-urban area

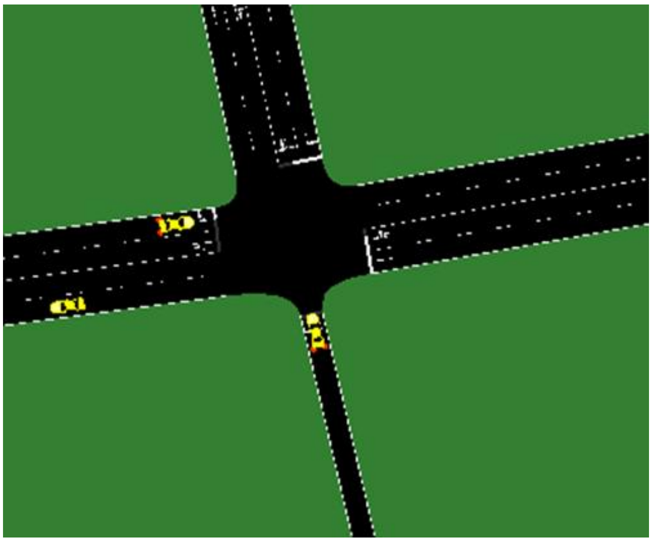

Figure 1b. Traffic Congestion

Where $A_{isotrop} = \frac{\lambda^2}{4\Pi}$ and equation 2 can be written as

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\Pi d)^2 L} \quad (3)$$

where $\lambda = \frac{C}{f}$, C=299792458 m/s and f=5.9 Ghz in our model.

L is system loss, for which in many cases it is very less and negligible.

3.3 ITU-RP.1411

An International Telecommunication Unit (ITU) has been designed for the protocol for 300 MHz to 100 GHz. This model works with upper and lower bound using the break point distance to decide the bounds. The breakpoint distance is given by

$R_{bp} = \frac{4H_b H_m}{\lambda}$ (H is height and ƛ is wavelength)

3.4 AODV

Ad-hoc On-Demand Distance Vector (AODV) is a routing convention specially designed for MANETs and now it is currently used for VANETs. In fact, AODV supports all ad-hoc networks. For any routing protocol, route discovery and route maintenance are the two major responsibilities. In route discovery, source code does not take full responsibility for identifying the destination because each node has to maintain route cache which contains the information of previous and next hops. Here, the routes are created on-demand and a route discovery packet RREQ (Route Request) is sent from the sender that consists of SID, DID, Recent Sequence number, Broadcast ID, Hop count and Time to live (TTL) [19, 20]. TTL is also used to keep the control of traffic and security in the network. Once the route is discovered, RREP (Route Reply) is used to establish the path. Since AODV uses frequent update messages to maintain route cache, the memory used is very less and thus it can be implemented in Zigbee protocol and any other low rate protocols. AODV has various implementations such as AODV-UU, AODV-UIUC and Kernal-AODV.

3.5 OLSR

Optimized link state routing protocol is a convention that is along with optimization in number and size in the control packets. Less number of control packets results in less traffic and congestion. This is carried out by using multipoint relays (MPR's) which shows a huge difference between OLSR and LSR protocols. MPR is a node which is selected by one-hop neighbor to the source node mentioned in Figure 2. Usually flooding of routing information to the neighbours is used in LSR [21]. Instead of this, OLSR uses flooding from one-hop neighbor which reduces the route search time by N^x to N^{x-1} times. Routing information is maintained withperiodic updating of routing table at MPR. MPR will be selected only if the willingness of the node is 1.

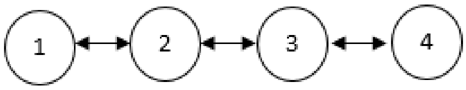

Figure 2. Hop Routing

Here for node 1, node 3 is one-hop neighbor and vice versa. Similarly for node 2, node 4 is one-hop neighbor and vice versa.

3.6 DSR

DSR is a routing convention that is reactive. The proactive routing protocol updates the routing table by flooding up routing information, whereas reactive routing protocol always attempts to identify a new path from the source. Since the routing information is not shared, there is no need for route maintenance as routes are discovered dynamically. A re-request packet sent from the destination node ensures the dedicated route to the source node so that the packet gets ensured delivery. Destination computes the shortest path upon receiving the packets from different routes based on broadcasting done in each node [22-26]. Then, a re-request packet is sent through the shortest path to start packet transmission. Generally, the physical layer overhead of DSR will be higher when compared to any other protocols especially with less number of nodes. So, this protocol needs to be handled carefully.

3.7 DSDV

Destination Sequenced Distance Vector (DSDV) uses Bellman-Ford routing. For every 5 seconds, a routing table is broadcast from every node to every other node [27]. It is usually called as periodic updates. Sequence numbers are used to avoid loopings in the network. The route used for broadcasting is decided based on the latest sequence number. When mobility of the route is high, route fluctuation increases which further increases the congestion and decreases the PDR in the network.

4. Proposed Model

In the proposed VANET model, the realistic Coimbatore city traffic scenario, involving traffic signals, road segments, highways and other building blocks, is taken into account. This model considers equally distributed vehicles and 10 RSU's in the network. MAC layer interfacing protocols IEEE 1609 WAVE STD and IEEE 802.11p standard are used in this work.

Table 1. Assumptions and Simulation Parameters

Parameters	Values	Parameters	Values
Simulation tool	NS-3.29	Vehicle communication range	1 Km
Mobility model	SUMO	Network interface protocols	IEEE 1609 IEEE 802.11p
Simulation area	Coimbatore-urban area	Routing protocols	AODV, DSDV, DSR, OLSR & 1C3N
Number of vehicles	20,40,60	Frequency band	5.9 Ghz
Total nodes created in mobility model	103 for 20V 136 for 40V 203 for 60V	Packet size	1200 Bytes
Sinks/Base stations/RSU's	10	Message type	Broadcast and Unicast
Simulation time	300 Sec	Performance Metrics	Avg Goodput, Overhead, PDR, PLR and End to End Delay
Channel characteristics	Pathloss	Link mode	Half duplex
Pathloss model	Friis and ITU-RP.1411	Bit rate	2 Mbps
Vehicle Speed	20 m/s	Transmission time	7.5 dBm

As mentioned earlier, network layer protocols AODV, OLSR, DSDV and DSR along with 13CN are applied to the proposed fixed VANET model. Therefore the performance can be improved by means of identifying the best loss, fading and shadowing models for the channel in the implementation of routing protocols. The assumptions and simulation parameters used in the work are given in Table 1.

4.1 Why 1C3N upon other algorithms?

One Caption in Three Node (1C3N Algorithm) is designed in such a way that it provokes the routing design of all the four algorithms. Algorithms like AODV, OLSR, DSDV and DSR work efficiently under the foreign conditions, for example, Wi-Fi enabled road structures, well equipped road side units, driver sides, etc. But when implementing this algorithm for the Indian road systems, it gradually reduces the packet delivery rate at very high level (i. e. out of 100 packets, only 10-19 get delivered based on algorithms. It varies in this range and the remaining packets are lost). This heavy packet loss results in some difficulty during implementation, such that each router in the road side unit fails to deliver nearly 80% of its packets and also helps to reduce/avoid accidents by considering the driver's careless mistakes [28-29]. It causes network congestion, overload in CRC check at the receiver side and a lot of security and implementation problems.

4.2 Design and Working of 1C3N

The 1C3N algorithm enables dynamic to send instant information, Auto-execute when the vehicle is switched on and connected vehicles provides an easy hop routing between the mobile nodes wishing to establish a VANET. 1C3N allows every node to obtain routes as quickly as possible for the newest destinations. 1C3N allows nodes to respond to links. It also allows the dynamic change in network topology to be updated in a timely manner. There is no separate node is needed to maintain the routes in the table for each and every cluster linked to the network for both active and passive communication. The operation of 1C3N is loop-free. This algorithm is designed in such a way that it avoids the Bellman-Ford, "counting to infinity" problem. An Easy convergence technique is used in this algorithm to adapt itself to the current topology changes (at times when a node moves in the network from one cluster to another). When any node breaks the link and moves out of the network, it notifies every other node in the network so that it can modify the routing table by deleting its entry. For the 2 nodes in the network, there is one captain and this captain node takes responsibility for routing all of its associated nodes (2 nodes). It takes all the computation process of its associated node that is required for routing the packet and reduces the complexity of the network by $2^{n-3}/2^{n}$.

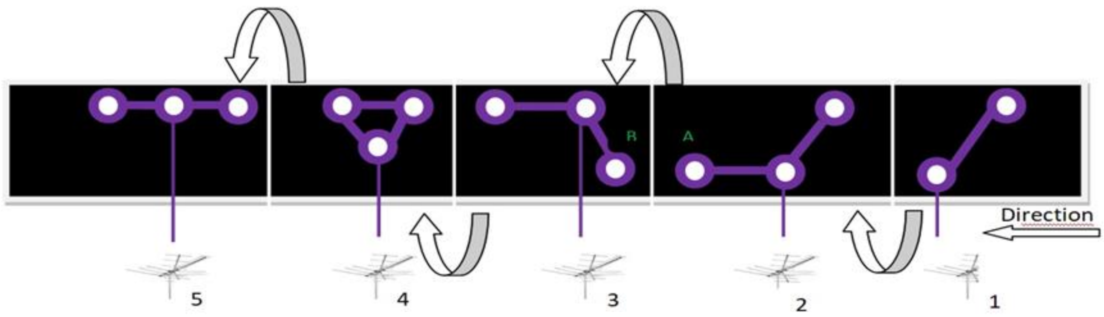

Figure 3. 1C3N Working structure

The overall packet structure like packet design, type, size, routing table parameters, encoding and decoding methods and various other important designs of 1C3N are decided dynamically by the sumo tool in Figure 3.

5. Results and Analysis

The intention of most researchers focuses on the performance evaluation of the network in two categories: 1) How does the information propagate? 2) How much time is taken to spread information to all vehicles in the network? It is also equally important to know about the performance of communication protocols used in the network. In this approach, observational areas are considered separately and implementing new model for improving propagation in VANET and New way of transportation systems were proposed to improve the health systems with the help of drones [30, 31]. This work evaluates the routing protocols combined with loss models.

5.1 Average Goodput (GP)

GP is total end user meaningful bits that are captured by the vehicles in the designed network at the given amount of time. It plays a pivotal role in deciding the network performance.

Avg. Goodput (Kbps) = Total useful bits received *1000 / Simulation time (sec).

5.2 Average Phy / MAC layer Overhead (OH)

The saturation point of the network is decided by this value. A lower OH indicates that the network has a higher performance. It is given by Avg. Overhead (Bytes) = Total Overhead messages / Total transmitted packets.

5.3 Average Packet Delivery Ratio (PDR)

Ratio of total number of packets sent by the start node and the number of packets received by final node.

For a higher PDR, a higher network performance is required.

Avg. PDR (%) = Total packets received successfully / Total transmitted packets

5.4 Average Packet Loss Ratio (PLR)

The percentage of packet loss is, ratio of difference between the total packets sent and received packets to total transmitted packets.

Avg. PLR (%) = (Total packets sent – Total packets received) / Total packets transmitted.

Sometimes, PLR is also called as collision ratio because collision of packets leads to packet loss. In other form, PLR is given by using PDR, PLR (in %) = 100 - PDR.

5.5 Average End to End Delay (EED)

The data packets that are successfully transmitted and received are counted and the time taken for every packet to pass through the destination vehicle is recorded. The average EED is given by

Avg. EED (ms) = Average time taken of delivered packets / Total number of packets delivered.

5.6 Goodput Analysis

For the present scenario, it is found that when the number of vehicle increases, ITU model performs better than the Friis model. It is clearly seen in the graph in Figure 4 a, b, c, d, e, f. For 20-Vehicle input network, OLSR with Friis model performs better than any other combination of routing protocol with loss model used this study. Similarly, for 40-vehicle OLSR with ITU model and 60-vehicle, DSR with ITU model performs better. But deciding the algorithm and loss model for the VANET depends not only on goodput but also on various other parameters. 1C3N performs much better than any other algorithms as shown in the graph in Figure 4.1 g and h.

For any loss model, DSR has shown considerable performance in terms of goodput for our VANET and New way of transportation were proposed during the COVID based diseases with safety travel using deep Learning algorithms [32]. So, for a static VANET, DSR can be implemented without considering overhead. But for the random structured VANET, dynamic selection of routing algorithm, depending upon the road structures, is preferred.

5.7 Overhead Analysis

For our scenario, DSR working with source routing, which has the highest overhead compared to any other routing protocols in any type of loss model, increases the load to the physical layer. It is always important to compare the overhead and goodput to analyze the best suitable routes. So based on overhead, DSR can be totally omitted as observed from Table 2. OLSR performs better comparatively than the other protocols for all 20, 40 and 60 vehicle scenario. It is also found that 1C3N performs very well with ITU when the number of vehicles increases.

5.8 PDR, PLR and End to End Analysis

PDR and PLR are related to each other and here in terms of PDR, FIIS model gives good results for upto 40 vehicles and for more than 40 vehicles ITU will be implemented. It gives better results especially when OLSR is implemented with ITU as shown in Figure 5 a, b, c, d. For more vehicles, end to end delivery in Friis model is better when compared to ITU. ITU can be implemented for less than 40 vehicles by considering only the end to end delivery time in 1C3N.

Table 2. Comparative Analysis for Avg Goodput and Avg Overhead

Vehicles	Algorithm	Friis Loss model		ITU – RP. 1411 Loss model	
		Avg Goodput (Kbps)	Avg Overhead (Bytes)	Avg Goodput (Kbps)	Avg Overhead (Bytes)
20 V	OLSR	**16.363**	**0.0786**	10.0315	0.0794
	AODV	15.4073	0.1189	**12.7347**	**0.1388**
	DSDV	13.5146	0.0986	9.2856	0.1315
	DSR	18.4229	522.144	10.3574	123.658
	GPSR	15.3698	0.6356	8.5360	0.4578
	A-STAR	17.5264	0.2467	9.1243	24.5689
	CAR	13.2573	0.7961	6.5438	0.0156
	1C3N	**42.2569**	**32.1548**	**38.2561**	**26.312**
40 V	OLSR	**8.4392**	**0.0662**	**11.023**	**0.0786**
	AODV	2.6555	8.8034	8.1268	0.1173
	DSDV	5.0498	0.0938	6.9186	0.1457
	DSR	18.6191	258.942	11.9702	99.2945
	GPSR	14.3694	0.7467	9.6471	0.4578
	A-STAR	15.6375	0.3578	9.2354	24.5689
	CAR	11.3684	0.8072	7.5638	0.0653
	1C3N	**43.5689**	**56.498**	**41.8972**	**43.1563**
60 V	OLSR	0.3533	0.0568	**4.9321**	**0.0725**
	AODV	0.1587	0.0155	2.5189	0.0015
	DSDV	0.0273	0.1102	0.6758	0.1399
	DSR	17.6481	153.849	9.9307	71.4024
	GPSR	17.3705	0.8578	9.7582	0.5689
	A-STAR	17.7486	0.4689	9.3465	24.1173
	CAR	13.4795	0.9183	7.6749	0.0786
	1C3N	**34.6892**	**31.6981**	**31.689**	**18.9632**

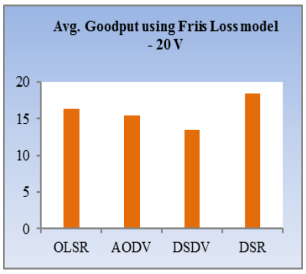

Figure. 4 (a)

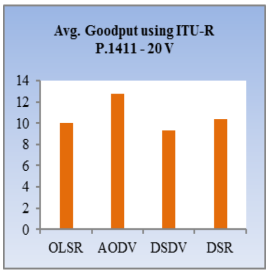

Figure 4 (b)

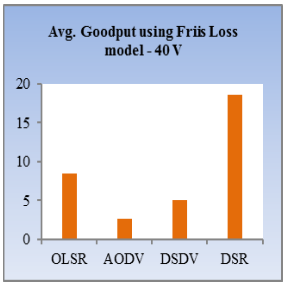

Figure. 4 (c)

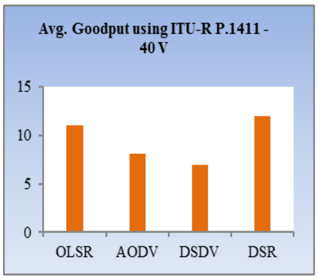

Figure 4 (d)

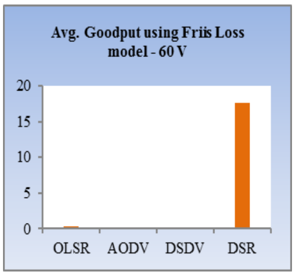

Figure 4 (e)

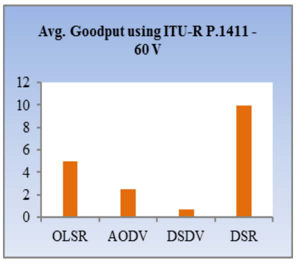

Figure 4 (f)

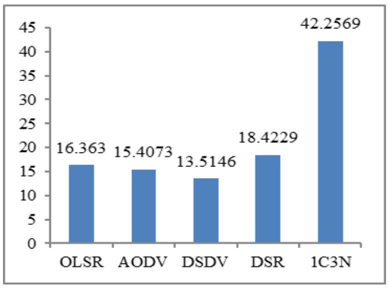

Figure 4 g

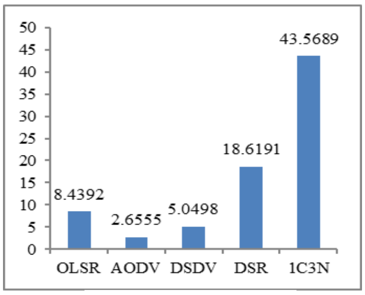

Figure. 4 h

Figure 4 (a-h) Avg Throughput of 20V in Friis and Avg Throughput of 40V in friis

Table 3. Analysis of PDR, PLR and E2E delay of traditional and proposed 1C3N

Performance Parameter	No. of Vehicles	Loss model	OLSR	AODV	DSDV	DSR	1C3N
Avg. PDR (%)	20V	Friis	**16.30916**	**15.3566**	13.47019	**18.36056**	**44.45327**
		ITU-R P.1411	9.998458	12.69284	9.255123	10.32335	**41.55354**
	40V	Friis	8.409728	2.646751	5.033249	**18.55787**	**42.54287**
		ITU-R P.1411	10.98674	8.100146	6.895841	11.93079	**39.26194**
	60V	Friis	0.352106	0.156492	0.027216	**17.59001**	**39.58001**
		ITU-R P.1411	4.91588	2.510671	0.673595	9.8981	**32.89564**
Avg. PLR (%)	20V	Friis	**83.69084**	**84.6434**	86.52981	**81.63944**	**55.54673**
		ITU-R P.1411	90.00154	87.30716	90.74488	89.67665	**58.44646**
	40V	Friis	91.59027	97.35325	94.96675	**81.44213**	**57.45713**
		ITU-R P.1411	89.01326	91.89985	93.10416	88.06921	**60.73806**

	60V	Friis	99.64789	99.84351	99.97278	**82.40999**	**60.41999**
		ITU-R P.1411	95.08412	97.48933	99.32641	90.1019	**67.10436**
Avg. E2E Delay (ms)	20V	Friis	1.16	1.2	1.14	1.02	**2.04**
		ITU-R P.1411	0.86	0.86	0.85	0.78	**1.72**
	40V	Friis	1.3	1.15	0.97	0.98	**2.38**
		ITU-R P.1411	1.31	1.13	1.18	1.07	**1.89**
	60V	Friis	1.11	0.97	**0.66**	**0.78**	**2.69**
		ITU-R P.1411	1.53	1.29	0.92	0.88	**2.10**

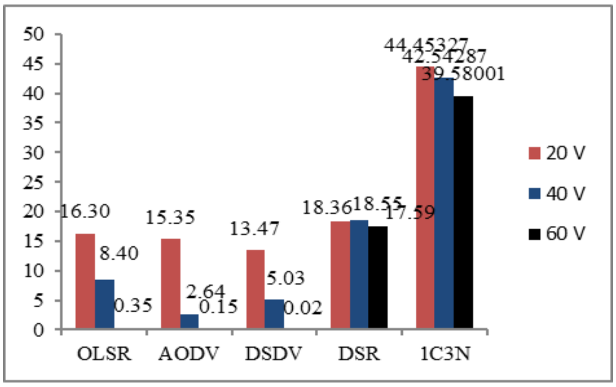

Figure 5 (a) Avg. PDR or receive rate using Friis

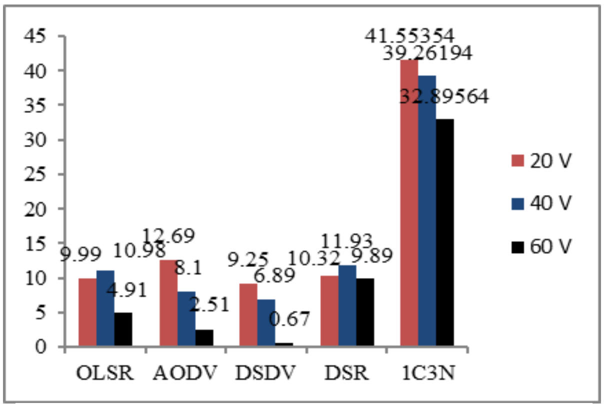

Figure 5 (b) Avg. PDR or receive rate using ITU-RP.1411

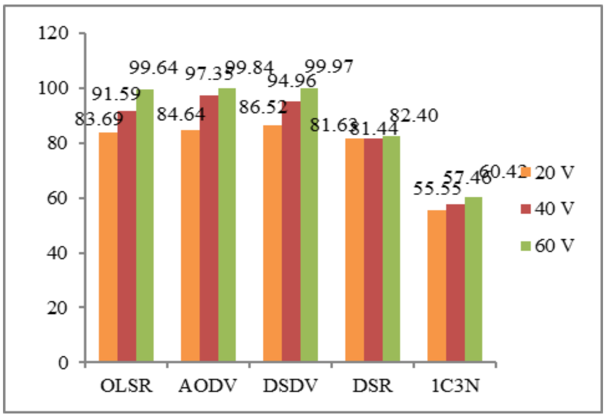

Figure 5 (c) Avg. PLR or Collision Ratio using Friis

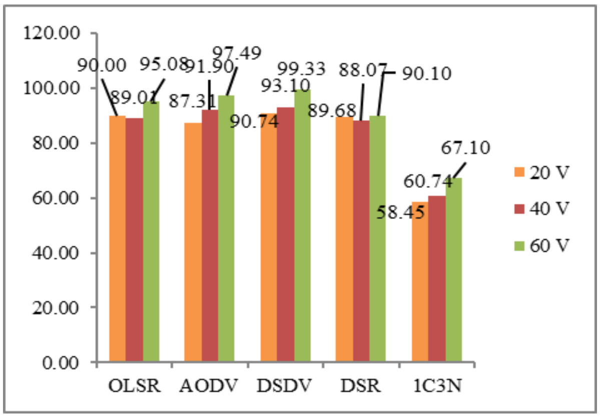

Figure 5 (d) Avg. PLR or Collision Ratio using ITU-RP.1411

6. Conclusion

The analysis discussed so far is based on the simulation results of the fixed VANET system in using different network sizes and different RPs. In this paper, the authors have presented the performance of the ad-hoc routing protocols of AODV, OLSR, DSDV, DSR and the proposed 1C3N. The model offers significant insights on how to enhance the VANET performance and how to implement it in intelligent transportation systems. As a result, OLSR with Friis loss model performs very well for the designed scenario of up to 40 vehicles and 1C3N with ITU outperforms with 60+ vehicles. The results corroborate and strengthen the importance of 1C3N and offer instructive guidelines to implement the modern traffic system, followed by safety applications and connection problems in VANETs.

References

[1] A.H. Wheeb, R. Nordin, A.A. Samah, D. Kanellopoulos, Performance Evaluation of Standard and Modified OLSR Protocols for Uncoordinated UAV Ad-Hoc Networks in Search and Rescue Environments, Electronics, 12(6),

(2023) 1334. https://doi.org/10.3390/electronics12061334

[2] A. Naeem, M. Rizwan, S. Alsubai, A. Almadhor, M. Akhtaruzzaman, S. Islam, H. Rahman, Enhanced clustering based routing protocol in vehicular ad-hoc networks, IET Electrical Systems in Transportation, 13(1), (2023) e12069. https://doi.org/10.1049/els2.12069

[3] Y. Xia, X. Qin, B. Liu, P. Zhang, a Greedy Traffic Light and Queue Aware Routing Protocol for Urban VANETs, China Communications, 15 (2018) 77-87. https://doi.org/10.1109/CC.2018.8424605

[4] G. Li, L. Boukhatem, J. Wu, Adaptive Quality-of-Service-Based Routing for Vehicular Ad Hoc Networks With Ant Colony Optimization, IEEE Transactions on Vehicular Technology, 66 (2017) 3249-3264. https://doi.org/10.1109/TVT.2016.2586382

[5] G. Luo, Q. Yuan, H. Zhou, N. Cheng, Z. Liu, F. Yang, X.S. Shen, Cooperative vehicular content distribution in edge computing assisted 5G-VANET. China Communications, 15 (2018) 1-17. https://doi.org/10.1109/CC.2018.8424578

[6] J. Toutouh, J. Garcia-Nieto, E. Alba, Intelligent OLSR Routing Protocol Optimization for VANETs. IEEE Transactions on Vehicular Technology, 61 (2012) 1884-1894. https://doi.org/10.1109/TVT.2012.2188552

[7] M. Hashem Eiza, T. Owens, Qiang Ni, Qi Shi, Situation-Aware QoS Routing Algorithm for Vehicular Ad Hoc Networks. IEEE Transactions on Vehicular Technology, 64 (2015) 5520-5535. https://doi.org/10.1109/TVT.2015.2485305

[8] J. Zhao, G. Cao VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks. IEEE Transactions on Vehicular Technology, 57 (2008) 1910-1922. https://doi.org/10.1109/TVT.2007.901869

[9] K. Rana, M. Zaveri, (2011) A-star algorithm for energy efficient routing in wireless sensor network. In International Conference on Web and Semantic Technology, Springer Berlin.

[10] V. Naumov, T.R. Gross, (2007) Connectivity-Aware Routing (CAR) in Vehicular Ad-hoc Networks. IEEE INFOCOM 2007 - 26th IEEE International Conference on Computer Communications, USA. https://doi.org/10.1109/INFCOM.2007.223

[11] B. Jarupan, E. Ekici, PROMPT: A cross-layer position-based communication protocol for delay-aware vehicular access networks. Ad Hoc Networks, 8 (2010) 489-505. https://doi.org/10.1016/j.adhoc.2009.12.006

[12] M. Asgharpoor Salkuyeh, B. Abolhassani, An Adaptive Multipath Geographic Routing for Video Transmission in Urban VANETs. IEEE Transactions on Intelligent Transportation Systems, 17 (2016) 2822-2831. https://doi.org/10.1109/TITS.2016.2529178

[13] A.S. Chhonkar, An Efficient Intersection Based VANET Routing Strategy on Smart City Roads Using Real-Time Vehicular Traffic, International Journal on Recent and Innovation Trends in Computing and Communication, 5(5), 1203-1207.

[14] F. Cunha, L. Villas, A. Boukerche, G. Maia, A. Viana, R.A.F. Mini, A.A.F. Loureiro, Data communication in VANETs: Protocols, applications and challenges. Ad hoc networks, 44 (2016) 90-103. https://doi.org/10.1016/j.adhoc.2016.02.017

[15] G.S. Khekare, A.V. Sakhare, A smart city framework for intelligent traffic system using VANET, IEEE 2013 International Mutli-Conference on Automation, Computing, Communication, Control and Compressed Sensing (iMac4s), India. https://doi.org/10.1109/iMac4s.2013.6526427

[16] N. Lin, Y. Shi, T. Zhang, X. Wang, An Effective Order-Aware Hybrid Genetic Algorithm for Capacitated Vehicle Routing Problems in Internet of Things, IEEE Access, 7 (2019) 86102-86114. https://doi.org/10.1109/ACCESS.2019.2925831

[17] S. Malik, P.K. Sahu, A comparative study on routing protocols for VANETs, Heliyon, 5 (2019) e02340. https://doi.org/10.1016/j.heliyon.2019.e02340

[18] K. Raissi, B.B. Gouissem, Comparative Study of Ad Hoc Routing Protocols in Vehicular Ad-Hoc Networks for Smart City, International Journal of Information and Communication Engineering, 12 (2018) 176-181. https://doi.org/10.5281/zenodo.1316093

[19] H. Saleet, R. Langar, K. Naik, R. Boutaba, A. Nayak, N. Goel, Intersection-Based Geographical Routing Protocol for VANETs: A Proposal and Analysis, IEEE Transactions on Vehicular Technology, 60 (2011) 4560-4574. https://doi.org/10.1109/TVT.2011.2173510

[20] S.A.A. Shah, E. Ahmed, J.J.P.C. Rodrigues, I. Ali, R. Md Noor, Shapely Value Perspective on Adapting Transmit Power for Periodic Vehicular Communications, IEEE Transactions on Intelligent Transportation Systems, 19 (2018) 977-986. https://doi.org/10.1109/TITS.2017.2775965

[21] S. Xingjun, X. Huibin, An effective scheme for location privacy in VANETs, Journal of Networks, 9(8), 2239. https://doi.org/10.4304/jnw.9.8.2239-2244

[22] R. Shrestha, R. Bajracharya, S.Y. Nam, Challenges of Future VANET and Cloud-Based Approaches, Wireless Communications and Mobile Computing (2018) 1-15. https://doi.org/10.1155/2018/5603518

[23] R. Shringar Raw, M. Kumar, N. Singh, Security Challenges, Issues and Their Solutions for Vanet, International Journal of Network Security & Its Applications (IJNSA), 5 (2013) 95-105. https://doi.org/10.5121/ijnsa.2013.5508

[24] K.L.K. Sudheera, M. Ma, P.H.J. Chong, Link Stability Based Optimized Routing Framework for Software Defined Vehicular Networks, IEEE Transactions on Vehicular Technology, 68 (2019) 2934-2945. https://doi.org/10.1109/TVT.2019.2895274

[25] G. Sun, L. Song, H. Yu, V. Chang, X. Du, M. Guizani, V2V Routing in a VANET Based on the Autoregressive Integrated Moving Average Model, IEEE Transactions on Vehicular Technology, 68 (2019) 908-922. https://doi.org/10.1109/TVT.2018.2884525

[26] N. Taherkhani, S. Pierre, Centralized and Localized Data Congestion Control Strategy for Vehicular Ad Hoc Networks Using a Machine Learning Clustering Algorithm, IEEE Transactions on Intelligent Transportation Systems, 17 (2016) 3275-3285. https://doi.org/10.1109/TITS.2016.2546555

[27] M.T.A. de Oliveira Barros, R.C. de Morais Gomes, A.F.B.F. da Costa, A top-down multi-layer routing architecture for vehicular ad-hoc networks, IEEE Latin America Transactions, 11(6), (2013) 1344-1352. https://doi.org/10.1109/TLA.2013.6710382

[28] M.T. Barros, R.C. de Morais Gomes, A.F.B.F. da Costa, Routing architecture for vehicular ad-hoc networks, IEEE Latin America Transactions, 10(1), (2012) 1411-1419. https://doi.org/10.1109/TLA.2012.6142494

[29] D. Selvakarthi, D. Sivabalaselvamani, V. Nivetha, M.S. Pratheep, M.S. Pravin, M.S. Thiyaneshwaran, A Novel Approach Using Sensor Technologies for Enhancing Accident Safety Assistance System in Different Environments, International Journal of Scientific & Technology Research, 9(2), (2020) 2130-2134.

[30] A. Tamilarasi, D. Sivabalaselvamani, L. Rahunathan, N. Adhithyaa, An Active Broadcast System for Safety-Oriented Facilities in Decentralized TDMA Assisted VANETs, Advances in Science and Technology Research Journal, 16(1), (2022) 122-128. https://doi.org/10.12913/22998624/143677

[31] D. Sivabalaselvamani, D. Selvakarthi, L. Rahunathan, G. Gayathri, M.M. Baskar, (2021) Survey on improving health care system by implementing an air ambulance system with the support of drones, In 2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA), IEEE, 878-883. https://doi.org/10.1109/ICECA52323.2021.9675859

[32] D. Selvakarthi, D. Sivabalaselvamani, S. Ashwath, A.A. Kalaivanan, K. Manikandan, C. Pradeep, (2021) Experimental analysis using deep learning techniques for safety and riskless transport-a sustainable mobility environment for post covid-19. In 2021 6th International Conference on Inventive Computation Technologies (ICICT), IEEE, 980-984. https://doi.org/10.1109/ICICT50816.2021.9358749

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Yes

Authors Contribution Statement

A. Tamilarasi: Conceptualization, Supervision, Writing Draft, Review and Editing; D. Sivabalaselvamani: Formal analysis, Methodology, Writing – original draft, Writing – review and editing; L. Rahunathan: Writing Draft, Review and Editing; N. Adhithyaa: Writing Draft, Methodology and Implementation, Review and Editing. All the authors read and approved the final version of the manuscript.

Conflict of Interest

The Authors have no conflicts of interest on this article to declare.