Indian Journal of Science and Technology *Vol 9(16), 10.17485/ijst/2016/v9i16/78650, April 2016*

ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

An Intelligent Authentication Based Vehicle Initiated Broadcast-Dynamic Path Data Collection Scheme in VANET

Arun Malik[1]* and Babita Pandey[2]

[1]Department of Computer Science and Engineering, Lovely Professional University, Jalandhar - 144411, Punjab, India; arunmalikhisar@gmail.com

[2]Department of Computer Applications, Lovely Professional University, Jalandhar - 144411, Punjab, India; shukla_babita@yahoo.co.in

Abstract

Objectives: The major focus of this research paper is to propose an Intelligent Authentication based Vehicle Initiated Broadcast-Dynamic Path (IAVIB-DP) data collection scheme with the aim of increasing the effectiveness of existing Vehicle Initiated Broadcast-Complete Path (VIB-CP) data collection scheme which is considered to be the best and most commonly used way that is opted for data collection in VANET and is evaluated in terms of packet delivery ratio, average latency and communication overhead. **Methods/Analysis**: Simulation is conducted by using OMNet++ to compare the performance of IAVIB-DP with one of the best data collection scheme working on single RSU, VIB-CP. Performance Index (PI) is measured by evaluating the Packet Delivery Ratio (PDR), average latency and Communication Overhead (CO) for proposed and existing scheme of collecting data. Best scheme will be decided on the basis of calculated PI. Other parameters for simulation such as the minimum speed, space dimensions and the maximum speed of moving vehicles remain fixed. **Findings:** VIB-CP and IAVIB-DP Data Collection Schemes (DCSs) are compared and analysis is done on the calculated value of Performance Index. PI decides whether a data collection scheme is effective or not. PI is calculated on different factors like PDR, Latency and CO. The simulation results show that PI of proposed IAVIB-DP data collection scheme is more as compared to PI of VIB-CP, as it has high PDR, low latency and less CO. Application/Improvements: VIB-CP and IAVIB-DP are compared on same factors and are used for PI calculation. On the basis of the simulation results it is evaluated that IAVIB-DP performs better**.**

Keywords: Communication Overhead (CO), Data Collection Schemes (DCSs), Packet Delivery Ratio (PDR), Performance Index (PI), Road Side Unit (RSU)

1. Introduction

VANET is a promising automation and an explicit Mobile Ad-Hoc Networks (MANET). In[1] it is described that there are two categories of wireless units in VANET- Road Side Units (RSU) and mobile units. The mobile units in VANET act as most active moving vehicles that operate with a mechanism embedded for sensing like a Global Positioning System (GPS) and transceivers like antennas are incorporated for receiving and transfusing information, usually referred as On Board Unit (OBU) which is present for achieving statement with the other moving vehicles or can also be used with the pre established component in the available network. Whereas, Road Side based Units act as the pre established wireless units present on the road sides which make use of Internet Service Providers (ISP) to assure internet connectivity to the moving vehicles.

As described in[2], communication is possible in two ways in VANET - Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). V2V do not require any infrastructure where only the vehicles that are present in VANET can map out position of each other and establish communication among them. When the communication is established among the vehicles, using OBU messages

**Author for correspondence*

are transmitted among them. V2I depends on the infrastructure as it enables communication between vehicles with the pre established units like traffic lights or Road Side based Units.

In[3] it is mentioned that VANET continuously changes in topology that varies frequently and is susceptible to other environmental issues like buildings, trees or other moving vehicles on road. Instead of these critical challenges VANET plays vital role in other application areas as specified in[4]. VANET offers Safety and Traffic related Applications[5] refraining accidents on road, improving conditions of road, initiating warning alerts, tracking vehicles position and traffic violation checking, generating path map for vehicle. VANET is used for Providing Information like news, Internet access, videos, music, video conferencing, parking availability discussed in[6]. In[7] different threats are discussed in VANET such as Sybil attack, node impersonation or vehicle tracking. Therefore, trust and authentication maintenance is significant for the moving vehicles. In[8] it is presented that VANETs are characterized by fast moving vehicles going on the road. In[9] it is stated that topology of VANET keep on changing very dynamically due to this fast mobility of the vehicles that may lead to high communication overhead to provide new information after variation to the vehicles.

The best path map chosen by a discrete vehicle comprise of all the road segments traversed by it to arrive its destination within stipulated time, with least chance of accident or any traffic related problems. Therefore, data is collected from the vehicles those are opting diverse segments or paths to reach a common destination in tough conditions of road or due to any other unusual collision to identify the best way path map that can be used for a specific vehicle. RSUs always retain the information collected from the DCSs through the moving vehicles that are in the close proximity of a discrete RSU available (Figure 1). Methodology of the work is presented with the help of flow chart (Figure 2).

This research paper is organized as follows. Section 1 put some light on background and introduction to VANET. Section 2 reviews the existing diverse DCSs used in literature in VANET. In Section 3 VIB-CP data collection scheme in VANET is illustrated. Section 4 describes the IAVIB-DP, the proposed data collection scheme in VANET. Section 5 elaborates the implementation of IAVIB-DP and VIB-CP DCSs using OMNeT++ and presents the results that will evaluate the PI of both the scheme. In Section 6, work done is concluded.

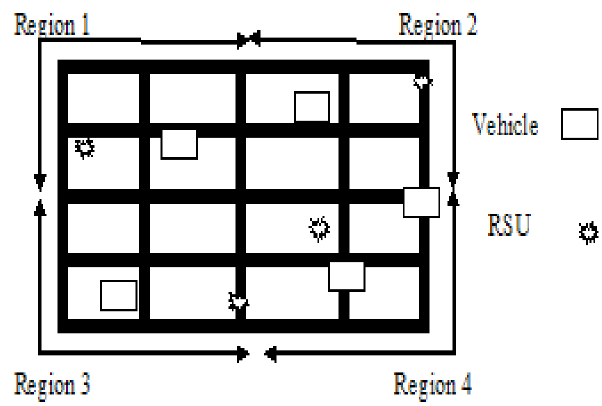

Figure 1. Area consisting of RSUs and moving vehicles.

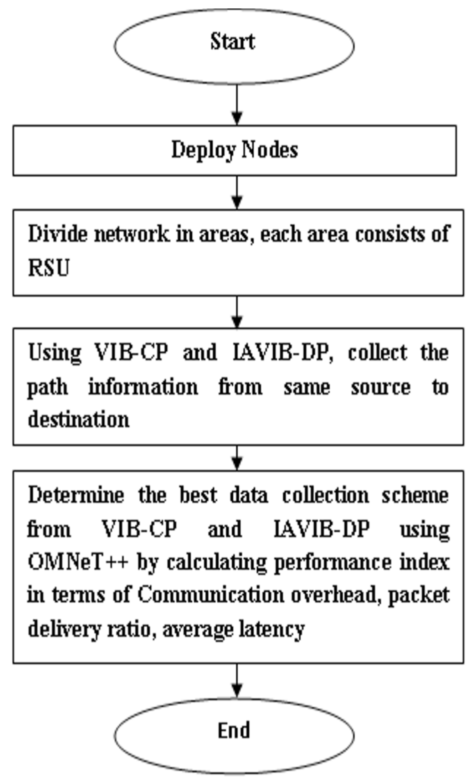

Figure 2. Flow chart showing methodology.

2. Existing DCSs in VANET

Vehicle path information collection is projected by different authors using diverse DCSs. Static and Dynamic are the two groups into which schemes can be categorized. Information related to path remain static in static schemes and such schemes are not able to collect the information about the path if some amendment is made by the vehicles whereas dynamic operating schemes are proficient of collecting such type of dynamic information about the path.

Department of defense of US have presented Global Positioning System (GPS)[10] in 1973. GPS consist of 24 satellites that operate in orbit which rotates about the earth. Out of 24 satellites, each satellite revolves twice in a day over the height of 20,200 km about the earth. In[11] an eye on the various actions that used to happen by variety of actions like humidity, fire, temperature, etc. sensed using the technique of GPS is maintained. To position the fast moving vehicles in the network correctly, GPS is used in order to track the vehicles easily. Trilateration technique is used to find the Time of Arrival (TOA) that will help in locating the exact position of the vehicles moving on road. Due to different problems in line of sight like various path obstacles such as trees, buildings, etc. exact information location of vehicle may not be obtained. In[12] it is described that VANET should not fit well with GPS, as vehicles are moving and GPS may not be present everywhere and is not even dynamic enough due to which it results in numerous issues in VANET. A protocol is projected[13] which is used to identify the right position of the fast moving vehicle devoid of the work of GPS because of above stated disadvantages. Map matching[14] was reviewed that can be used as GPS but it is not a location tracking technique. In[15] different map matching techniques that are described to map the GPS points to deem the petite time intervals for polling. Therefore to work for long interval polling a new algorithm was proposed. Dead reckoning[16] technique is projected that is used to identify the position of neighbor nodes. Cellular design in[17] is suggested. Hence this area is alienated as various cells and correct position of the vehicle is identified by using the received signals generated by vehicles. In[18] hand off based traffic model is presented that uses variance and mean, instead of traditional poisson method due to its longer times invalidity. The main focus of this model is to determine the traffic pattern during the hand off process. In[19] proposed a measure, CDT (Cell Dwell Time), that identified road traffic congestion. Various modernize techniques[20] are described to get the location of moving vehicles. The above described are static DCS and such types of schemes can only obtain the basic vehicle information.

Cluster based communication technique[21] is discussed for VANET. In this technique, designated Cluster Head is used for the communication under their surveillance. In[22] a hybrid geo reactive routing protocol is used that is combination of geographical and reactive routing that makes use of stable links for better performance. Collision detection scheme[23] is used to maintain security my minimizing the delay time. Moreover, neighbor discovery can also be done. In[24] existing routing methods performance is analyzed in VANET by varying the different parameters for performance like vehicles speed, traffic pattern and no. of vehicles travelling on the segment of road. In[25] an inventive scheme is used to collect traffic, environmental and information regarding accidents using probing on road sides where RSU initiate the process of probing for enquiring every vehicle that traverses the road. In Vehicle Initiated mode of Broadcast scheme, vehicle will transmit the packets to all the RSUs in its vicinity by using broadcast mode. Two methods[26] are proposed that are used to collect data through confined two-hop broadcast mechanism, broadcast mode and probabilistic confined two-hop broadcast. On the other hand, dynamic schemes work in a very efficient manner and evaluated on basis of PDR, Latency and CO as compared to the aforementioned schemes. Broadcast based schemes[27] are evaluated using various parameters like performance, reliability, congestion, contention and collision. DCSs are divided into two sections[28] Vehicle or RSU initiated that depends on the way of data collection scheme. Vehicle Initiated mode of Broadcast scheme (VIB) is again categorized into two further schemes. First is VIB New Segment (VIB-NS) where packet will be transmitted whenever the vehicle will receive a new segment while traversing in its path. Second, VIB Complete Path (VIB-CP) where only information about Complete Path will be transmitted by the vehicle, this will happen when the vehicle has fully crossed the segments of road occurring in the path and finally it stopped moving after arriving at its final destination. In Vehicle Initiated RSU find mode (VIR) scheme**,** unicast message is used for transmitting packets from the vehicle, for this vehicle has to first broadcast a message for finding RSU. Vehicle will get response and address of the RSU that is available in its vicinity. VIR scheme is again categorized into two schemes. First, VIR New Segment (VIR-NS) where only new segment information collected by the vehicle will be transmitted as packet to a specific RSU. Second, VIR Complete Path (VIR-CP) where only information collected about Complete Path will be transmitted to the RSU.

In[29] it is concluded that from the existing DCSs VIB-CP outperforms due high PI as compared to other DCSs. Effectiveness of VIB-CP can further be improved. As VIB-CP does not provide any security to the data exchange between vehicles and RSU due to which there should be a possibility that any malicious vehicle will enter into the network and a bulk of malicious data will be collected at the RSU and the same malicious data is exchanged with the vehicles that are within the range of that RSU. To overcome this problem a new DCS is proposed that provide security to the exchange of data between vehicles and RSU and hence increasing the PI.

3. VIB-CP Data Collection Scheme in VANET

In[28] it is described that in VIB-CP, vehicles are exclusively accountable in making decision of sending information to the RSU. In this DCS, the vehicle (Vi) maintain roadway of the Road Segments (RS_i) as it move in the VANET so as to reach the specific RS_i. On the other hand, vehicles broadcast their Complete Path data CP_i only to the surroundings RSUs at the time they have reached their final target. Algorithm 1 represents the action of every vehicle using VIB-CP.

Algorithm 1 for Vehicle (V_i,CP_i[])

- For (;i = true;).
- While Vi is proceeding repeat.
- Fetch road segment RS_i;
- While new RS_i is fetched repeat.
- Insert RS_i to Complete Path CP_i[] at the end.
- End while.
- End while.
- While Vi has reached the its destination then.
- Broadcast (Vi,CPi[]) to neighbouring RSUs.
- End while.
- End for.

The RSU will insert information collected as a Complete Path into the database, as soon as data is obtained from different vehicles by the RSU. To send the data there is no need to sporadically trigger of vehicles by the RSU and thus beacon timer is not at all mandatory for VIB-CP. Algorithm 2 represents the action taken by every RSU using VIB-CP.

Algorithm 2 for RSU (LT[][], RSUAddr)

- For (;i = true;).
- While (Vi, CPi[]) is obtained repeat.
- Make a new valid entry for Vi in lane table LT[][];
- Append CPi[] to LT[Vi][];
- End while.
- End for.

All the Complete Paths CP_i obtained by the RSUs from the vehicles within the range of transmission of the RSU and insert this to its Lane Table (LT) whenever they reach. However, VIB-CP is considered to be the best and most likely used DCS among all existing DCS but still VIB-CP does not concern about the security issues in VANET. As VIB-CP does not provide any security to the data exchange between vehicles and RSU due to which there should be a possibility that any malicious vehicle will enter into the network and a bulk of malicious data will be collected at the RSU and the same malicious data is exchanged with the vehicles that are within the range of that RSU. To overcome this problem we introduce a new DCS that provide security to the exchange of data between vehicles and RSU and hence increasing the PI.

4. IAVIB-DP Data Collection Scheme in VANET

In this section, we introduce an Intelligent Authentication based Vehicle Initiated Broadcast Dynamic Path (IAVIB-DP) data collection scheme in VANET. In this scheme the vehicle authentication will be done at the RSU i.e. the vehicle will confirm to the RSU that it is an authorized one. An advance security will need the RSU to confirm it is an authorized one as well, so to have reciprocal authentication. During authentication, a furtive session key will be established between vehicle and RSU for the communication afterwards. The session key could be time-honored in such a manner that synchronizes the update at both the vehicles and the RSU so to permit location confidentiality countermeasures. Once the mutual authentication between vehicle and RSU is completed, vehicle starts communication with the RSU. While moving from a source to destination after a set value of threshold, say ThS_o, vehicle will transmit the message to RSU. Threshold is set to 3 to get optimal message length, otherwise in case of lengthy message retransmission of lost message will be cumbersome and will eventually decrease the throughput of the network. Algorithm 3 shows the action of every vehicle in IAVIB-DP and Algorithm 4 represents the action of every RSU in IAVIB-DP. All notations used to write pseudo code of Algorithm 3 and 4 (Table 1).

Table 1. Notation used in Algorithm 3 and 4

NOTATION	DESCRIPTION
PBFP	Public Key of Facility Provider
PBKV	Public Key of Vehicle
PRKV	Private Key of Vehicle
PBKR	Public Key of RSU
PRKR	Private Key of RSU
SSk	Session Key
REk	Re-encryption Key
FP	Facility Provider
Vi	ith Vehicle
RSUi	ith Road Side Unit
DPL	Dynamic Path table
X1	Arbitrary number
X2	Arbitrary number
NS	New Segment
DT	Destination
ThSo	Threshold value

Algorithm 3

Input: $PB_{Kv,}$ $PR_{kv,}$ $RE_{k,}SS_{k}$, $PB_{KR}PR_{kR}$,$PB_{FP.}$

- Initiating Authentication (V_i, RSU_i).
- FP->V_i:({PB_{kv},$PR_{kv,}$$RE_{kv,}$$SS_k$},$t_i$).
- FP->$RSU_{i:}$({PB_{kR},$PR_{kR,}$$RE_{kR,}$$SS_K$},$t_i$).
- V_i->RSU_i:PB_{kR}{t1,X1, SS_K}.
- RSU_i->V_i:PB_{FP} {SS_k ,X1,X2,t2}.
- V_i:RE_{kv}{ PB_{FP} {SS_k ,X1,X2,t2}}.
- V_i->RSU_i: PB_{FP} {SS_k ,X2,t3}.
- RSU_i: RE_{kR}{PB_{FP}{SS_k ,X1,X2,t2}}.
- end Authentication.
- Initialize Communication (V_i).
- For (;i = true;).
- While ($V_{i,}NS_i$[]) is received repeat.
- Insert New entry for V_i in DP_L[][].
- Set ThS_o = 3.
- If Size(DP_L[][])<$ThS_{o.}$
- Update(DP_L[][]).
- Else.
- Broadcast DP_L[][] to neighboring RSU_i and reset DP_L ==Null.
- End if.
- Repeat step from 12-18 till.
- Reached to $D_{T.}$
- End While.
- if D_T Reached.
- Broadcast DP_L[][] to neighboring RSU_i and reset DP_L ==Null.
- end if.
- End For.

Algorithm 4

- Initialize Communication (RSU_i).
- For (;i = true;).
- Get DP_L[][] from $V_{i.}$
- While(V_i,DP_L[][]) is obtained then.
- Make a new valid entry in PL list.
- If DP_L[][] is received from the same $V_{i.}$
- Update PL list by appending DP_L [][].
- End if.
- End while.
- End for.

Based on the algorithms the key features of VIB-CP and IAVIB-DP are compared (Table 2)

Table 2. Key features comparison of VIB-CP and IAVIB-DP

Key Features	VIB-CP	IAVIB-DP
Vehicle initiated	Yes	Yes
Broadcast Based	Yes	Yes
Path Collection Type	Complete Path	Dynamic Path-Threshold Based
Authentication	No	Yes

5. Results and Discussion

OMNet++ is used for simulation at single RSU scenario for implementing VIB-CP and IAVIB data collection schemes (Figure 3). For simulation some constant parameters are used (Table 3).

Table 3. Parameters for simulation

Parameters	Value
Dimension of Space	1000 m ×1000 m
Minimum Velocity	0 m/s
Maximum Velocity	120 m/s
Radio Range	200 m
Data Payload size	512 bytes/packet
Physical Link Bandwidth	2 Mbps
Traffic Type	Constant Bit Rate
Scenario	Random mobility

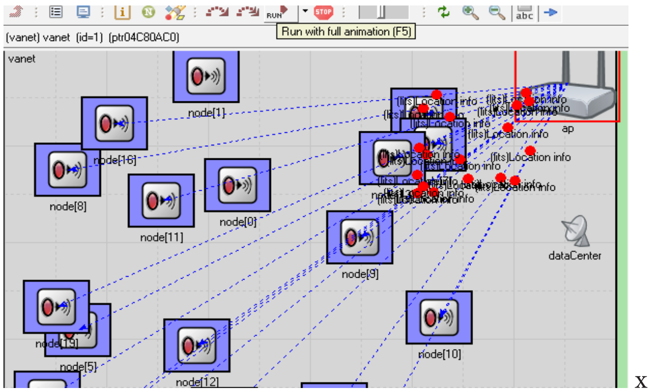

Figure 3. OMNeT++ scenario.

Evaluation of PDR, Latency and CO is performed by taking various readings from OMNeT++ scenario (Figure 4).

CO is calculated by identifying the no. of transmitted messages and the no. of communicating vehicles over the identified messages. Rule employed for calculating CO is mentioned in Equation 1.

$$CO = \frac{\sum \text{Total messages}}{\sum \text{No of communicating vehicles}} \quad \ldots\ldots\ldots (1)$$

VIB-CP and IAVIBDP are compared by considering CO as one of the factors. (Figure 5)

Latency is calculated by measuring time required by a data packet to arrive at destination. End to End delay is also referred as latency. Rule employed for calculating latency is mentioned in Equation 2.

$$\text{Latency} = \frac{\sum (\text{arrive time} - \text{send time})}{\sum \text{Number of links}} \quad \ldots\ldots\ldots (2)$$

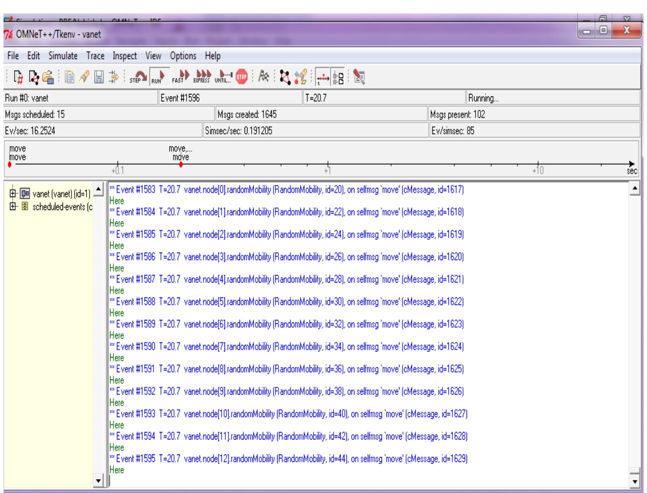

Figure 4. Data collection scenario in OMNeT++.

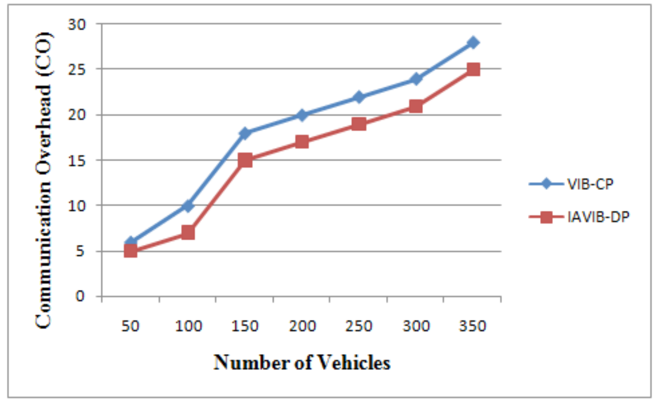

Figure 5. Communication overhead with number of vehicles for VIB-CP and IAVIB-DP.

VIB-CP and IAVIBDP are compared by considering latency as one of the factors. (Figure 6)

PDR is calculated as the fraction of received data packets by final destination and produced data packets by original source. Rule employed for calculating PDR is mentioned in Equation 3.

$$PDR = \frac{\sum \text{No of received packets}}{\sum \text{No of sent packets}} \quad \ldots\ldots\ldots (3)$$

VIB-CP and IAVIBDP are compared by considering PDR as one of the factors (Figure 7)

In[29] it is mentioned that Performance Index (PI) decides whether DCS is effective or not. PI is calculated based on different factors like PDR, Latency and CO. If received data packets by a destination are more that will make PDR more and will ultimately enhance the value of PI. Therefore, increase in PDR will also increase the PI of DCS. If time taken by packets to arrive at destination is more or more delay will extend the latency and that will

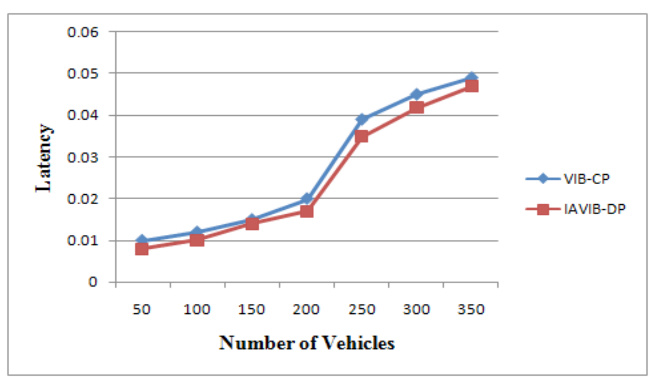

Figure 6. Latency with number of vehicles for VIB-CP and IAVIB-DP.

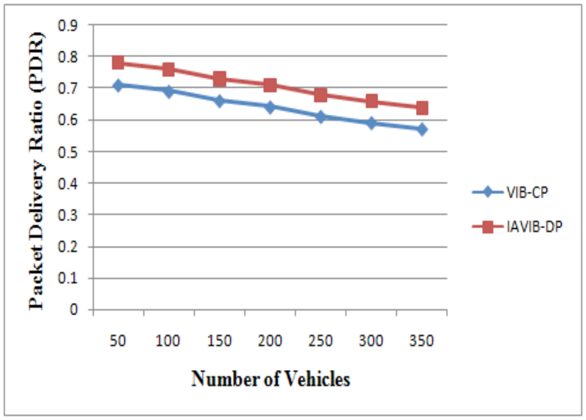

Figure 7. Packet delivery ratio with number of vehicles for VIB-CP and IAVIB-DP.

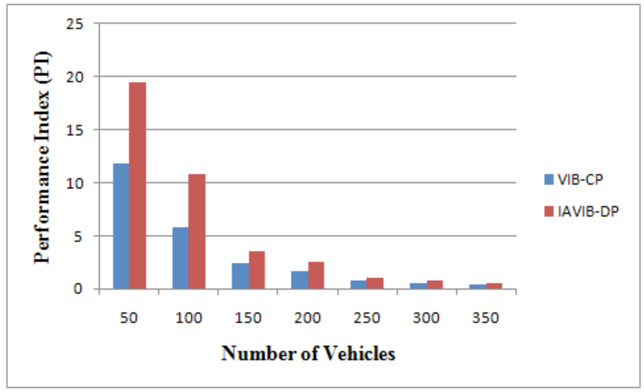

Figure 8. Performance Index with number of vehicles for VIB-CP and IAVIB-DP.

ultimately diminish the value of PI. Therefore, increase in latency will diminish the PI of scheme. If messages communicated among the vehicles will enhance that will enhance the CO and that will ultimately diminish the value of PI. Therefore, increase in CO will decrease the PI of DCS. The rule employed for calculating PI is mentioned in Equation 4.

$$PI = \frac{k * PDR}{(CO * L)} \quad (4)$$

Here the constant k depends on the count of traversed segments by the vehicles.

VIB-CP and IAVIBDP are compared by calculating PI (Figure 8).

The results calculated above reveal that IAVIB-DP has high PDR, less latency and less CO as compared to VIB-CP. Hence it has high PI as compared to VIB-CP. Comparison of IAVIB-DP and VIB-CP based on implementation is made (Table 4).

6. Conclusion

In this work an Intelligent Authentication based Vehicle Initiated Broadcast Dynamic Path Scheme is proposed which provides authentication between vehicles and RSU. In this, after a set threshold on DP size say ThS_o, vehicle will broadcast the TP list to all the neighboring RSUs and reset its TP list to NULL. Both IAVIB-DP and VIB-CP are evaluated and comparison is made on the basis of PDR, Latency and CO. PI is calculated for both DCS by using the Equation (4). From the calculated PI value, it can be deduced that PI of IAVIB-DP is high as compared to VIB-CP as it has high PDR, low latency and less CO.

This research work motivates the beginner to select the best scheme for data collection in VANET. IAVIB-DP can be extended in future to embed security services like confidentiality and integrity of data being transmitted from vehicle to RSU or vice versa.

Table 4. Comparison of VIB-CP and IAVIB-DP in VANET

	Performance Factors			Performance Index (PI)
DCS	Communication Overhead (CO)	Latency	Packet Delivery Ratio (PDR)	$PI = \frac{PDR}{CO*L}$
VIB-CP	HIGH	HIGH	LOW	LOW
IAVIB-DP	LOW	LOW	HIGH	HIGH

7. References

1. Zeadally S, Hunt R, Chen YS, Irwin A, Hassan A. Vehicular Ad Hoc Networks (VANETS): Status, results and challenges. Telecommunation System, EURASIP Journal on Wireless Communications and Networking. 2012 Aug; 50(4):217–41.
2. Boukerche A. Vehicular Ad Hoc Networks: A new challenge for localization-based system. Computer Communication. 2008 Jul; 31(12):2838–49.
3. Balasubramanian R, Mahajan A, Venkataramani BN, Levine BN, Zahorjan J. Interactive WiFi connectivity for moving vehicles. SIGCOMM Computer Communication. 2008; 38(4):427–38.
4. Eriksson J, Balakrishnan H, Madden S. Cabernet: Vehicular content delivery using WiFi. Proceedings of the 14th ACM International Conference on Mobile Computing and Networking (MobiCom'08); San Francisco, California, USA. 2008. p. 199–210.
5. Lee S, Lee U, Lee K, Gerla M. Content distribution in VANETs using network coding: The effect of disk I/O and processing O/H. Proceedings of the 5th annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON'08); San Francisco, California, USA. 2008 Jun 16-20. p. 117–25.
6. Yang Q, Lim A, Li S, Fang J, Agrawal P. ACAR: Adaptive Connectivity Aware Routing for Vehicular Ad Hoc Networks in city scenarios. Mobile Network Application. 2010 Feb; 15(1):36–60.
7. Suresh J, Jongkun L. A TPM-based Architecture to Secure VANET. Indian Journal of Science and Technology. 2015 Jul; 8(15):1–6. Doi no: 10.17485/ijst/2015/v8i15/73099.
8. Kabir H. Research issues on Vehicular Ad hoc Network. IJETT. 2013 Dec; 6(4):174–9.
9. Samara G, Salihy W, Sures R. Security analysis of Vehicular Ad Hoc Networks. Second International Conference on Network Applications, Protocols and Services. IEEE Computer Society; Washington, DC, USA. 2010. p. 55–60.
10. Kaplan E, Hegarty C. Understanding GPS: Principles and applications. Artech House; 1996.
11. Boukerche A, Oliveira H, Nakamura EF, Loureiro A. Localization systems for Wireless Sensor Networks. IEEE Wireless Communications – Special Issue on Wireless Sensor Networks. 2007 Dec; 14(6):6–12.
12. Boukerche A, Oliveira H, Nakamura EF, Loureiro A. Vehicular Ad Hoc Networks: A new challenge for localization-based systems. Computer Communications. 2008 Jul; 31(12):2838–49.
13. Lagraa N, Yagoubi B, Benkouider S. Localization technique in VANETs using Clustering (LVC). International Journal of Computer Science Issues. 2010 Jul; 7(4):10–6.
14. Jagadeesh G, Srikanthan T, Zhang X. A map matching method for GPS based real-time vehicle location. Journal of Navigation. 2005; 57(3):429–40.
15. Yang J, Kang S, Chon K. The map matching algorithm of GPS data with relatively long polling time intervals. Journal of the Eastern Asia Society for Transportation Studies. 2005; 6:2561–73.
16. King T, Fubbler H, Transier M, Effelsberg W. On the application of dead-reckoning to position-based routing for vehicular highway scenarios. Proceedings of ACM Conference on Emerging Network Experiment and Technology; New York, NY, USA. 2005. p. 258–9.
17. Hac A. Cellular network model with hand off delays. IEEE Communications Magazine; Seattle, WA. 1995 Jun 18-22; p. 1834–8.
18. Rajaratnam M, Takawira F. Hand-off traffic modelling in cellular networks. IEEE Communications Magazine; Phoenix, AZ. 1997 Nov 3-8. p. 131–7.
19. Pattara-atikom W, Peachavanish R. Estimating road traffic congestion from cell dwell time using neural network. Communications Magazine; Sophia Antipolis. 2007 Jun 6-8. p. 1–6.
20. Civilis A, Jensen C, Nenortaite J, Pakalnis S. Efficient tracking of moving objects with precision guarantees. Proceedings of the First Annual International Conference on Mobile and Ubiquitous Systems: Networking and Services. IEEE, Mobiquitous; 2004 Aug 22-26. p. 164–73.
21. Sakthipriya N, Sathyanarayanan P. A reliable communication scheme for VANET communication environments. Indian Journal of Science and Technology. 2014 Jun; 7(S5):31–6.
22. Darisini PS, Kumari NS. Geo-Reactive: An efficient and reliable hybrid routing protocol for VANETs. Indian Journal of Science and Technology. 2015 Oct; 8(27):1–6. Doi no: 10.17485/ijst/2015/v8i27/79306.
23. Chandramohan K, Kamalakkannan P. An efficient neighbor discovery and Aloha based collision detection and correction in VANET. Indian Journal of Science and Technology. 2015 Dec; 8(35): 1–9. Doi no: 10.17485/ijst/2015/v8i35/79955.
24. Gamess E, Chachati M. Analyzing routing protocol performance with NCTUns for vehicular networks. Indian Journal of Science and Technology. 2014 Sep; 7(9):1391–402.
25. Yang L, Xu J, Wu G, Guo J. Road probing: RSU assisted data collection in vehicular networks. IEEE Communications; Beijing. 2009 Sep 24-26. p. 1–4.

26. Xu Y, Wu Y, Wu G, Xu J, Liu B, Sun L. Data collection for the detection of urban traffic congestion by VANETs. IEEE Asia-Pacific Services Computing Conference; Hangzhou. 2010 Dec 6-10. p. 405–10.
27. Rahim A, Muhaya FB, Sher M, Khan ZS, Ahmad I. Performance evaluation of broadcast techniques in VANETs. Indian Journal of Science and Technology. 2009 Oct; 2(10):52–5. Doi no: 10.17485/ijst/2009/v2i10/30721.
28. Merah AF, Samarah S, Boukerche A, Mammeri A. A sequential patterns data mining approach towards vehicular route prediction in VANETs. Mobile Networks and Applications. 2013 Dec; 18(6):788–802.
29. Malik A, Pandey B. Performance analysis of various data collection schemes used in VANET. Indian Journal of Science and Technology. 2015 Jul; 8(15):1–8.