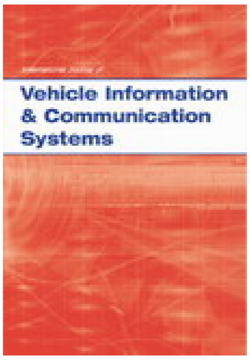


International Journal of Vehicle Information and Communication Systems

ISSN online: 1741-8208 - ISSN print: 1471-0242
https://www.inderscience.com/ijvics

Route forecasting-based authentication scheme using A* algorithm in vehicular communication network

Vartika Agarwal, Sachin Sharma, Gagan Bansal

DOI: 10.1504/IJVICS.2023.10055779

Article History:

Received:	22 November 2022
Last revised:	13 December 2022
Accepted:	06 January 2023
Published online:	20 June 2023

Route forecasting-based authentication scheme using A* algorithm in vehicular communication network

Vartika Agarwal* and Sachin Sharma

Department of Computer Science and Engineering,
Graphic Era Deemed to be University,
Dehradun, Uttarakhand, India
Email: vartikaagarwal2015@gmail.com
Email: sachin.cse@geu.ac.in
*Corresponding author

Gagan Bansal

Department of Mechanical Engineering,
Indian Institute of Technology (BHU),
Varanasi, Uttar Pradesh, India
Email: gaganbansal.rs.mec21@itbhu.ac.in

Abstract: Researchers have developed several authentication techniques for route predictions based on user requirements. These techniques estimate the shortest path and available resources in vehicular communication networks. In the current research, the existing authentication techniques for vehicular communication are compared and their inadequacies are identified. Then, new authentication technique based on route forecasting are presented for vehicular communication networks, with the service provider anticipating alternate routes for customers if the current routes have more network traffic congestion. By presenting the most efficient route, the suggested model allows users to maximise their time efficiency. Using A* algorithm, VCN agent seeks path with less network traffic congestion. This algorithm determines the shortest path between a source and a destination. Users are provided with several options by the service provider. User accepts the finest option that meets their needs. This method allows the service provider to deliver at least 15 routes within three seconds. This strategy is beneficial when a significant number of vehicles are stuck in traffic and consumers require network resources to utilise their time effectively.

Keywords: vehicular communication network; route prediction-based authentication scheme; network traffic congestion; network traffic index.

Reference to this paper should be made as follows: Agarwal, V., Sharma, S. and Bansal, G. (2023) 'Route forecasting-based authentication scheme using A* algorithm in vehicular communication network', *Int. J. Vehicle Information and Communication Systems*, Vol. 8, Nos. 1/2, pp.16–32.

Biographical notes: Vartika Agarwal received Master of Computer Application degree from Shree Ram Murti Smarak College of Engineering and Technology (SRMS), Bareilly, India. Currently, she is pursuing PhD degree in Computer Science and Engineering Department from Graphic Era Deemed to be University, Dehradun, Uttarakhand, India. Her research interests include internet of things, image processing, etc.

Sachin Sharma is an Associate Dean, International Affairs and Professor in the Department of Computer Science and Engineering at Graphic Era Deemed to be University, Dehradun, Uttarakhand, India. He is also a Co-founder and Chief Technology Officer (CTO) of IntelliNexus LLC, Arkansas, USA-based company. He also worked as a Senior Systems Engineer at Belkin International, Inc., Irvine, California, USA for two years. He received his Philosophy of Doctorate (PhD) degree in Engineering Science and Systems specialisation in Systems Engineering from University of Arkansas at Little Rock, USA with 4.0 out 4.0 GPA and MS degree in Systems Engineering from University of Arkansas at Little Rock with 4.0 out 4.0 GPA. His research interests include wireless communication networks, IoT, Vehicular ad hoc networking and network security.

Gagan Bansal is currently working as a Research Scholar in Indian Institute of Technology (BHU) and is Assistant Professor, ME, GEU, Dehradun. He has 50+ research publications and awarded Best Student Award, 2016 at GBPUAT, Pant Nagar, Best Researcher Award, 2018 Uttarakhand Educator Excellence Award, 2019 Uttarakhand Icon Award 2020. His research fields: biocomposites, nanocomposites, characterisation, fabrication and computational analysis of advance material, tribology, solar energy applications and bioimplants.

1 Introduction

As the growing demand for traffic efficiency, it is crucial for user to obtain route which has less network traffic congestion. To meet the goal, various authentication schemes have been raised. Such schemes are helpful for confidentiality, integrity, security and forecasting purpose. Without such authentication schemes, communication between vehicles can't be possible. Authentication schemes verify the authenticity of vehicles and users. These schemes reduce duplicacy and loss of message, and verify the sender's and receiver's identity. Authentication schemes are responsible for route planning. It validates messages and protects information from different kind of security attacks. Such techniques enhance security feature in VCN through digital signature and cryptography. Network resource aware route planning authentication schemes based on route planning. Such schemes are responsible for establishing communication between those vehicles which are on the same route. Efficient message cooperative authentication schemes are responsible for protecting information from free riding attacks. Conditional privacy preserving authentication schemes are basically used to solve privacy issue. Anonymous authentication schemes works for message failure. Scalable privacy preserving authentication schemes are based on cryptography. Cryptography means to attach public and private key with message for encryption and decryption. Senders have to send message with public key and receiver have to decrypt message with private key. Main reason behind this scheme is to verify the sender's and receiver's identity. Edge computing-based privacy preserving authentication schemes works on device-to-device communication. It consists of whole process from vehicle registration to vehicle verification. Such schemes verify the authenticity of vehicle. It checks that vehicle is licensed or not.

Beta distribution-based update and revocation schemes are based on monitoring behaviour of vehicle. It checks that nodes have suffered from different kind of security attacks or not. Signature-based authentication schemes are basically used for verify the authenticity of message. Identity-based batch verification schemes enhance the security features of vehicular communication. Token-based authentication schemes enable user to enter their credential and start vehicular communication process. Such scheme maintains security of information so that unauthorised user cannot access it.

All authentication schemes have their own importance. These schemes make VCN more smart and reliable.

Owing to the specific features and advantage of different authentication schemes, user expects that any authentication scheme should work for user. Which help them to utilise their time by getting the best route which has less network traffic congestion. For fulfil user requirement, we propose route forecasting-based authentication scheme which offer best route to user to avoid network traffic congestion. In this scheme, there is a service provider who works for suggesting multiple routes to user through A* algorithm. User can choose one of them according to their need.

Route forecasting-based authentication scheme has shown many outstanding advantages, it saves time of user and increases user satisfaction rate. VCN provides an effective way of communication between vehicles. Authentication schemes make it more secured and reliable. Route forecasting-based authentication schemes save time of user by offering best possible optimal routes. Such schemes help user for identifying the multiple routes which have less network traffic congestion and user can choose one of them. Such schemes work well in case of network throughput, processing time and execution time.

Main contributions of this paper are as follows:

1) Analyse different authentication schemes which are used in vehicular communication.
2) Propose route forecasting-based authentication schemes.
3) Use A* algorithm for finding the route which has less network traffic congestion.

2 Literature review

Several research works have been proposed by different researchers during the decade. Wu et al. (2012) proposed distributed algorithm for packet forwarding. It helps communication between vehicles. Simulation results show that this scheme works well for large number of vehicles in a network. Yu et al. (2013) used the concept of cloud computing into vehicular communication network so that vehicle can share bandwidth resource, storage resource as well as computational resource. Zheng et al. (2015) used vehicular cloud network to make vehicular communication more effective. They use Semi Markov decision process for validating the performance of vehicular cloud network. Ren et al. (2015) used concept of device to device communication in vehicular communication networks. Simulation results verify the feasibility of this scheme and make communication more secure and reliable. Siding et al. (2020) proposed scheme of allocation of resources in a vehicular cloud network. This scheme fulfils the latency requirement of V2V links. Simulation results show that it has great performance over half duplex scheme. Yang et al. (2017) use resource allocation policy for enhancing security in vehicular communication networks. They propose max-min secrecy rate problem and this problem has been mathematically formulated. Numerical results validate the optimality of this problem. Guo and Zhou (2019) proposed cascade Hungarian channel assignment algorithm for solving resource allocation problem. Simulation results validate the efficiency and effectiveness of this algorithm over traditional scheme. To enhance the efficiency of video streaming, Zhou et al. (2018) investigated scalable video coding. Simulation results verify the accuracy of this system and reduce computational complexity. Liang et al. (2019) reviewed about wireless resource allocation in vehicular cloud network. They highlight reinforcement learning approach for solving resource optimisation problem. Li at al. (2019) proposed resource allocation scheme based on vehicular communication networks. They present an immune algorithm. Simulation results validate the efficiency of proposed system. We can apply this algorithm in optimisation of vehicular user equipment communication networks. Noor-A-Rahim et al. (2020) reviewed about vehicular network technologies namely dedicated short range communication and cellular-based vehicular networks. This paper provides a quick review about different resource allocation strategy in vehicular cloud network. Yang et al. (2020) proposed semi-persistent scheduling algorithm for information exchange between vehicles. Simulation results validate the efficiency and great performance of this system. Zhang et al. (2021) investigate about usage of radio resource allocation in vehicular networks. This scheme reduces transmission delay and offers an effective communication between different vehicles. Ibrar et al. (2020) proposed AI-based vehicle to everything network using software defined vehicular-based fog computing. Simulation result shows that this scheme utilise maximum resource at fog layer and reduce delay time. Agarwal et al. (2021) used the concept of secured scheduling and assign task to the resources. Such techniques fill the gap between vehicular communication. These techniques help for proper vehicular communication in a specific network. Agarwal and Sharma (2022) proposed a multitype vehicle identification scheme from a real-time traffic database in 2021. Once the multitype has been identified, the service provider can offer the user a subscription plan based on their needs. Agarwal et al. (2020) reviewed various vehicular communication systems in 2022. Such programs are crucial to the vehicle communication system. Azam et al. (2021) proposed various authentication schemes for vehicular ad hoc network. Such authentication schemes have to deal with privacy, security and reliability. For vehicular communication, Elahi et al. (2022) proposed PKI-based authentication techniques. Such strategies are created to guarantee a just and effective transportation system. Ryu et al. (2022) proposed Chebyshev chaotic map for efficient authentication. This scheme works 44 times faster in comparison of other scheme. Bal et al. (2022) proposed resource allocation security scheme by using a hybrid machine learning technique. This technique works well in case of efficient resource utilisation and less-energy consumption. Huang et al. (2022) proposed temporal computing resource allocation scheme. This scheme can improve efficiency of computing resource allocation. Magsino and Ho (2022) proposed a roadside unit allocation scheme and compare its performance with traditional scheme. Rathee and Chaba (2022) execute spectrum sharing and power allocation approach for vehicular network. Here, D2D-based communications between vehicles are proposed. Kambalimath and Kakkasageri (2020) proposed resource allocation scheme for vehicular cloud network. They use a generic algorithm for the implementation of this scheme.

Bhanja et al. (2018) proposed short term traffic flow prediction method. Experimental results validate the effectiveness and efficiency of this method. Song and Wu (2022) proposed traffic analysing scheme for reducing accidents. The experimental results validate the throughput and accuracy of this method.

From Table I, we can see that this scheme has better accuracy and has less network traffic congestion which is far better than in comparison of other algorithm. Several authentication schemes are introduced for validating and fulfil the requirement of users. Most authentication schemes are based on security as well as utilisation of resources. These schemes authenticate and validate users. There are different authentication schemes which are used for validating the authenticity of resources.

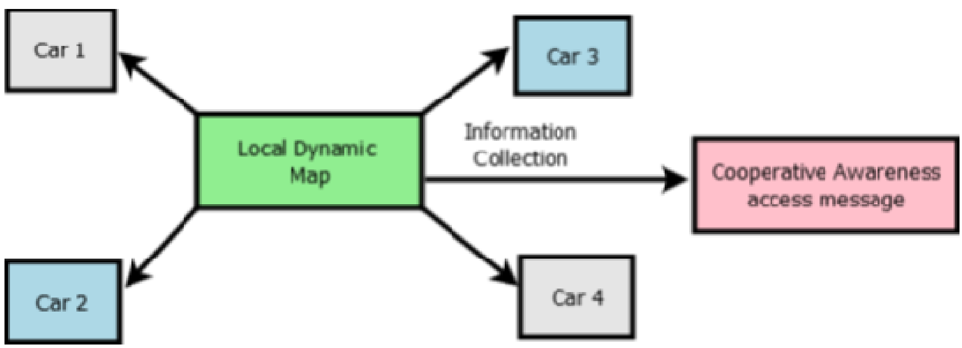
Table 1 Comparative study

Scheme	*Accuracy*	*Advantage*	*Future scope*
Distributed algorithm (Wu et al., 2012)	70%	Solve the problem of packet forwarding and buffer allocation.	Modify the algorithm for improving data delivery packet in a network
Game theoretical approach (Yu et al., 2013)	75%	Sharing of bandwidth, Storage and computing resources across vehicles.	We can improve this scheme for reduction of service dropping rate.
Optimal computation resource allocation scheme (Zheng et al., 2015)	80%	Improve performance in terms of resource allocation.	Modify this scheme for making more robust, reliable and secure.
D2D communication to support V2V communication (Ren et al., 2015)	80%	Optimal performance of D2D system.	Reduce computational complexity for improving this scheme
Resource allocation scheme (Siddig et al., 2020)	85%	Low-transmission rate high performance.	Modify the scheme for better performance
Max-min secrecy rate scheme (Yang et al., 2017)	90%	Improve communication between vehicles.	Use deep learning approach for better performance
Cascade Hungarian Channel Assignment Algorithm (Guo and Zhou, 2019)	80%	Improve throughput and reliability of vehicular networks.	Improve vehicular communication through dynamic user scheduling
Tabu search based metaheuristic algorithm (Zhou et al., 2018)	85%	Improve performance and reduce computational complexity.	Modify this scheme for more accurate result
Deep reinforcement learning approach (Liang et al., 2019)	90%	Improving network efficiency.	Use mathematical approach for better performance
Route Forecasting Based Authentication Schemes [Proposed scheme]	98%	Less network traffic congestion.	Modify this approach for better result

2.1 *Network resource aware route planning authentication scheme*

Route planning is an important function for vehicular communication network. Without route planning communication between vehicles can't be possible. Suppose two vehicles are connected through sensors in a route but one vehicle stay out of route. Instead of those vehicles, other vehicles come to the path. Communication should automatically start between those vehicles which are on the route. Local dynamic map is a component which is used for collecting static and dynamic information around vehicle and passes the information from one vehicle to another. We can combine it with network access object and take this information as input and design better authentication scheme. LDM with NC object is not only used for path selection but also for network selection (see Figure 1).

Figure 1 Network resource aware route planning authentication scheme



2.2 *Efficient message cooperative authentication schemes*

This scheme reduces duplicity of message. Sometimes different vehicles work on the same messages. This scheme remove redundant message and secure information from free-riding attacks. Free-riding attacks are those attacks in which an attacker generates token and breaks the whole vehicular authentication process. This scheme tries to identify token and remove it from the vehicular communication process.

2.3 *Anonymous authentication schemes*

This scheme reduces message loss when density of vehicle is about 200/km^2. It improves authentication process between vehicles. It uses cooperative authentication method and categorise it into two parts. First one is failure report based and second one is success report based. Failure report-based approach report invalid beacon messages whereas success report based approach report about valid beacon messages.

2.4 *Cryptography-based authentication schemes*

This scheme is based on public key and private key. Public key is used by those vehicles which sends message. Whereas private key is used by those vehicles which receive message. Such keys are used for encryption and decryption. It maintains the confidentiality of an information.

2.5 Signature-based authentication schemes

With this scheme, digital signature is attached with messages. Such signatures are used for validating the authenticity of an information. Sender send message with this signature. Receiver receive message and send digital signature to sender which is the confirmation for the sender that receiver has receive the message.

2.6 Verification-based authentication schemes

With this scheme, RSU works as a mediator between vehicles. When sender send message, RSU verify the message and check priority of message. If message is regarding any emergency or accident, RSU send this message first and ensure that message has been delivered to the destination promptly.

2.7 Conditional privacy preserving authentication schemes

This technique is basically able to solve privacy as well as a security requirement of whole vehicular communication network. It is based on message authentication code. Here vehicle can generate the authenticity of messages using different keys.

2.8 Edge computing-based privacy authentication schemes

In this scheme, various vehicles exchange data with each other through device-to-device communication. It consists of 5 phases from vehicle registration to vehicle verification. This scheme is highly useful for obtaining information from another vehicle. In case of any accident or emergency, this system can deliver the appropriate information to the appropriate user at the appropriate time. This scheme is able to prevent accident or other mishappening which can occur at any time due to the unavailability of an information.

2.9 Scalable privacy preserving authentication schemes

This scheme is based on hybrid cryptography. It is more secured and scalable in comparison of other authentication schemes. This scheme works for those vehicles which are equipped with sensor unit and on-board unit, sensor unit and on board units are smart devices who is responsible for verification and validation of message as well as user.

2.10 Identity-based batch verification schemes

This scheme enhances the security and efficiency of automatic dependent surveillance broadcast. It reduces computational costs as well as transmission overhead. This scheme is responsible for verifying the identity of sender and receiver who is responsible for vehicle-to-vehicle communication. This scheme checks that from which route message has been delivered to one vehicle from another vehicle. This scheme analyse modification done by attackers for destroy the confidentiality of an information.

2.11 Beta distribution-based reputation update and revocation schemes

This scheme is able to detect various types of security assaults which disrupt the confidentiality and security of an information. This scheme works well for recognising different kind of cyber security attacks. If any unauthorised user or attacker try to destroy or change the information. This scheme can easily detect it. This scheme protect whole vehicular communication network from attackers or hackers. This is safe and secure and able to maintain the integrity of an information.

2.12 Route forecasting-based authentication scheme (proposed scheme)

Owing to network traffic congestion, a lot of time has been wasted. Major research gap we found in the study to utilise user's time in case of network traffic congestion. So, we propose route forecasting-based authentication scheme in vehicular communication network. By selecting the route with the least amount of network traffic congestion, this system enables users to make the most of their time. Service providers offer multiple options to the user and user can choose one of them. This scheme offers excellent processing time, execution time as well as bandwidth availability.

3 Proposed methodology

Consider there are *n* number of routes available to reach destination. Destination is denoted as *y*. VCN agent collect user's data from real time traffic database and generate network traffic index. Network traffic index measures level of traffic congestion. Range of network traffic index lies between (0, ∞). User enters path and agent authenticates user is licensed or not. If user is licensed and demand for network traffic, VCN agent forecasts alternate route which have less traffic congestion. It depends on user choice whether he will accept that route or not. For route forecasting agent choose A* algorithm (see Figure 2).

A* is a searching algorithm for finding the shortest path between source and destination. This algorithm will find the least cost outcome for a problem. In our research, this algorithm helps us to find the best route which has less network traffic congestion.

Equations used in A* algorithm

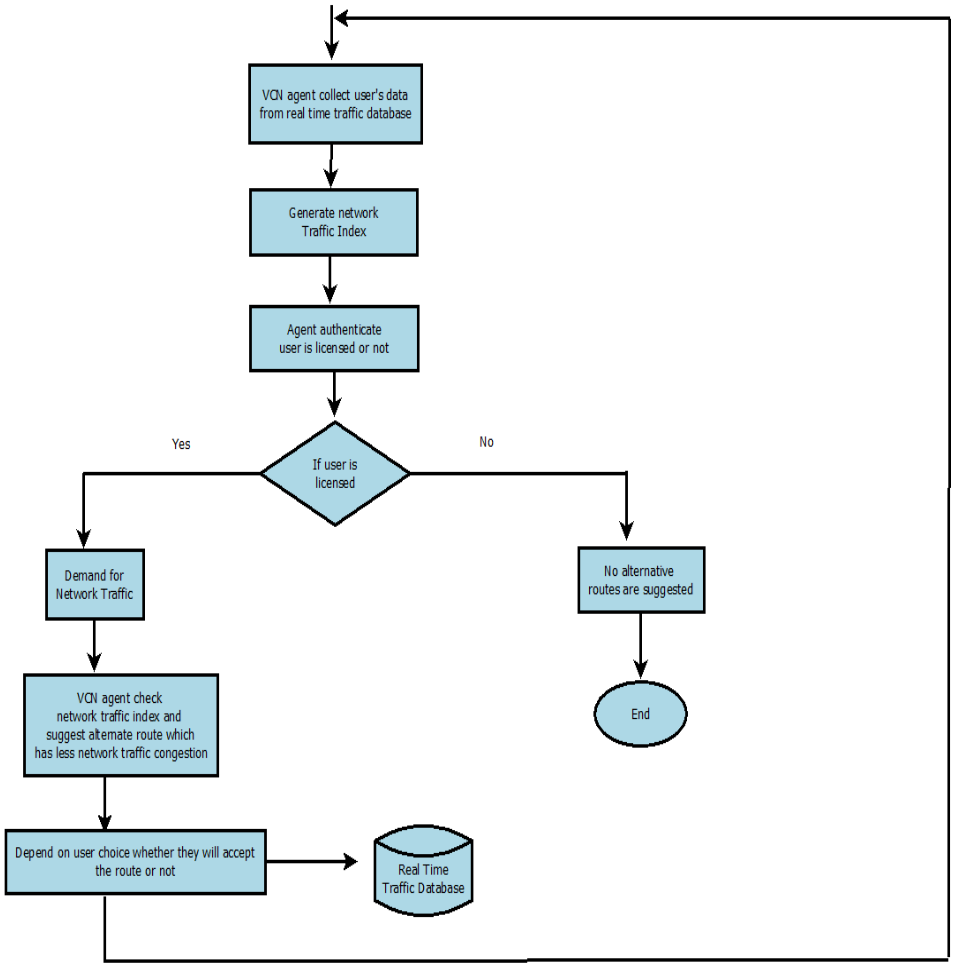
$$f(n) = g(n) + h(n) \tag{1}$$

$g(n)$ = distance from current route to goal. $h(n)$ = heuristic function

$f(d, c)$ where *d* stands for destination route and *c* stands for current route. Total route means user pass the number of routes from source to destination.

$$Tp \text{ (Total Path)} = c \tag{2}$$

Figure 2 Network traffic congestion and validation process



Here, users have to start from the current route and reach the goal node. Total cost is calculated by the heuristic function. g_{score} means the cost incurred from passing route to a goal node.

start = s goal = g

A*(s, g, h) where s = start, g = goal, h = heuristic function

$$g_{score} := \text{infinity} \tag{3}$$

$g_{score}[s] = o$

f_{score} means the cost of cheapest route

$$f_{score} := \text{infinity} \tag{4}$$

$$f_{\text{score}}[s] := h(s) \tag{5}$$

c = lowest f_{score} c = g

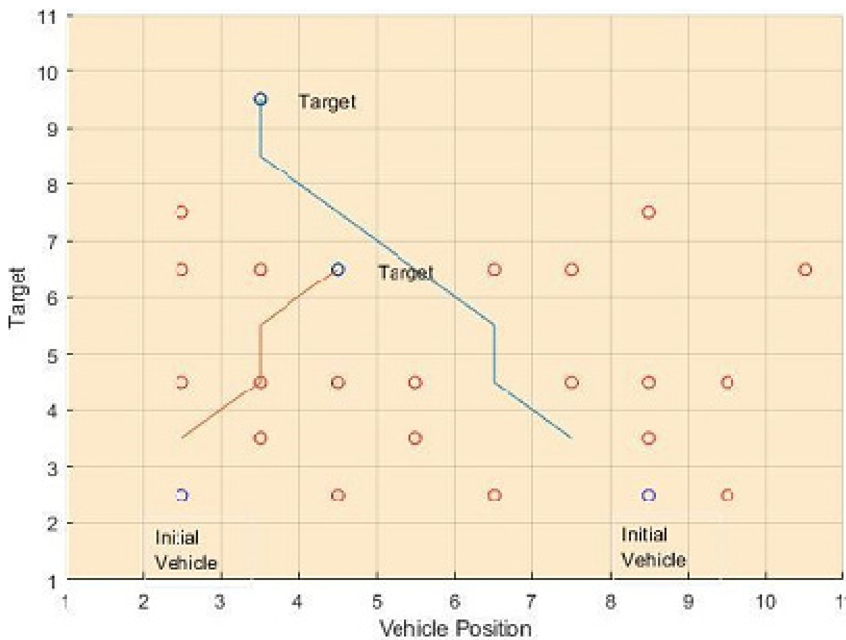
s. remove(c)

for each neighbour of current

$$g_{\text{score}} := g_{\text{score}}[c] + h(n) \tag{6}$$

From Figure 3, we can see that VCN agent searches for those routes which have less traffic congestion. Target means the destination of user. Initial vehicle means source from where vehicle have to start its journey. VCN agent offers shortest path to every user which has less congestion.

Figure 3 Path searching using A* algorithm



A* algorithm

1) Make an open list containing starting node, starting node means position of user on the path.
   a) **If** user is already in the path which have less no of traffic congestion
   b) Make a closed empty list

2) Put the current path in the list and check its neighbours **For** each neighbour of the current path:

   a) **If** neighbour has a less network traffic congestion in comparison of current node. Then replace neighbour with this node as the neighbour's parent.

   b) **Else if** check all the neighbour of the current route and replace neighbour with the node which have less traffic congestion.

From Figure 4, we can see the working of VCN agent. Here, VCN agent checks user's position. If user is already in the route which has less network traffic congestion, then VCN agent checks all its neighbours and finds the route which has less congestion. From Figures 5 and 6, we can see that no shortest path exists from source to destination.

Figure 4 Working of VCN agent

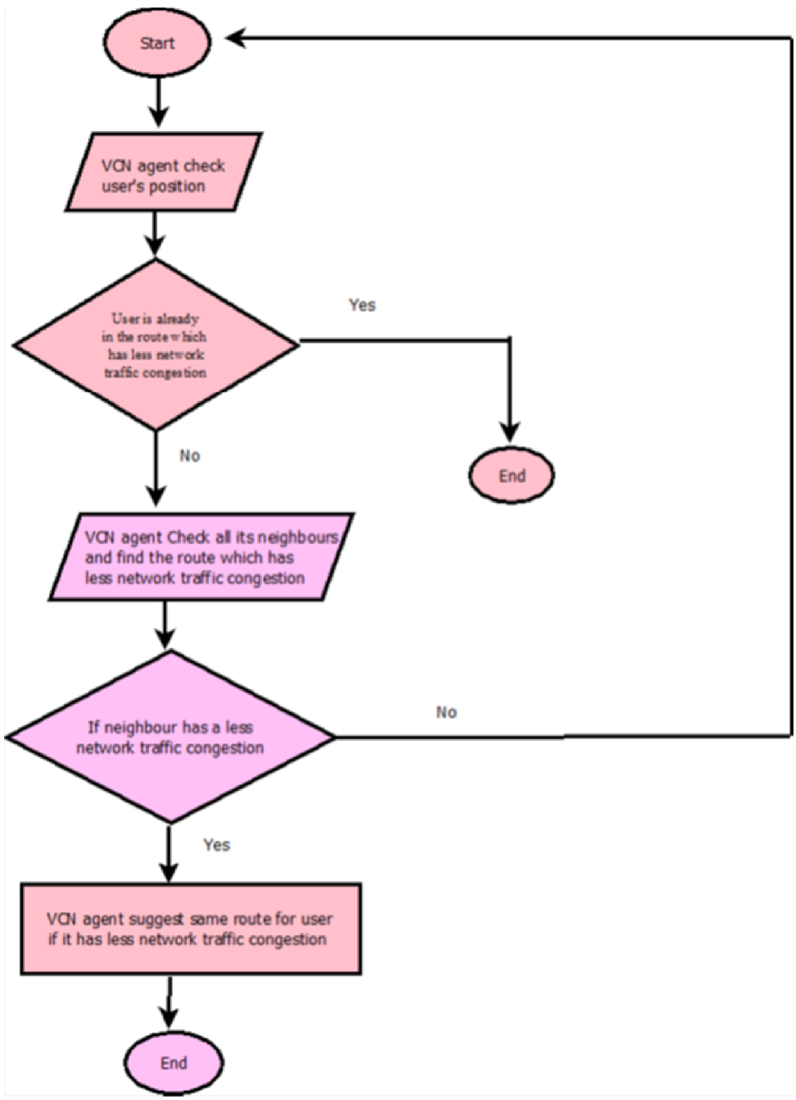
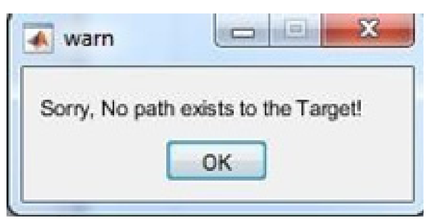


Figure 5 Path searching using A* algorithm

Figure 6 No path found by VCN agent



4 Performance metrics

For performance evaluation (see Table 2), we use following parameters processing time, network throughput, Execution time, Bandwidth Availability and Delivery of Network Services. These parameters are basically used for validating the performance of the system.

- *Forecasting accuracy*: This scheme can predict all the possible routes for user which has less network traffic congestion. But user can choose only one of the routes. So, service provider needs to exclude the redundant routes as much as possible to provide user the best route. The evaluation criteria of forecasting accuracy is shown as

$$\text{Forecasting} = (Nr * 100)/Tr \tag{7}$$

where *Nr* represents the number of redundant routes and *Tr* represents the total number of routes offered by service provider.

(5*100)/10 = 50

- *Forecasting integrity*: Forecasting integrity is used to evaluate integrity of those routes chosen by user from list of routes suggested by service provider.

$$\begin{aligned} \text{Integrity} &= (Cr\ {*}100)/Tr \\ &= (2{*}100)/10 \\ &= 20 \end{aligned} \tag{8}$$

where *Cr* represents the route which is chosen by user from list of routes suggested by service provider and *Tr* represents the total number of routes offered by service provider.

- *Processing time*: Time required to detect suitable path for vehicle.
- From Figure 7, we can see that service provider allocates 15 routes to users within 3 seconds. Within 4 seconds, service provider allocates 5 routes. Within 5 seconds, service provides allocates 5 routes. Number of routes may vary, and it depends on network traffic congestion.

Figure 7 Service provider response time vs. total no. of VCN resources allocated

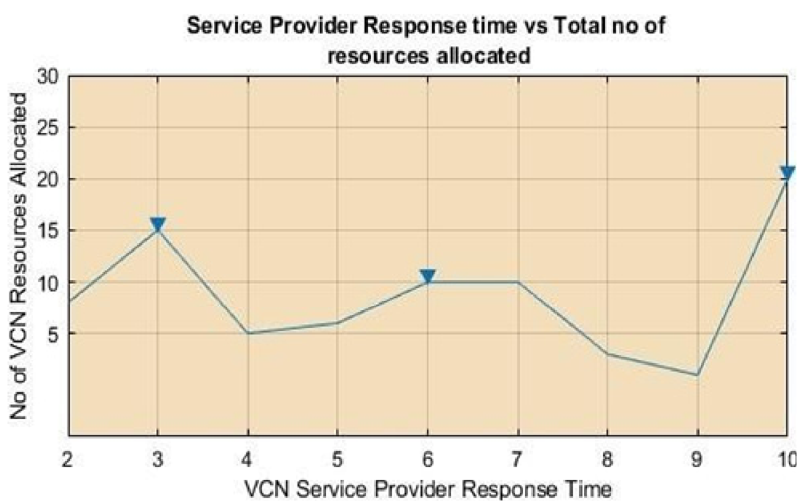


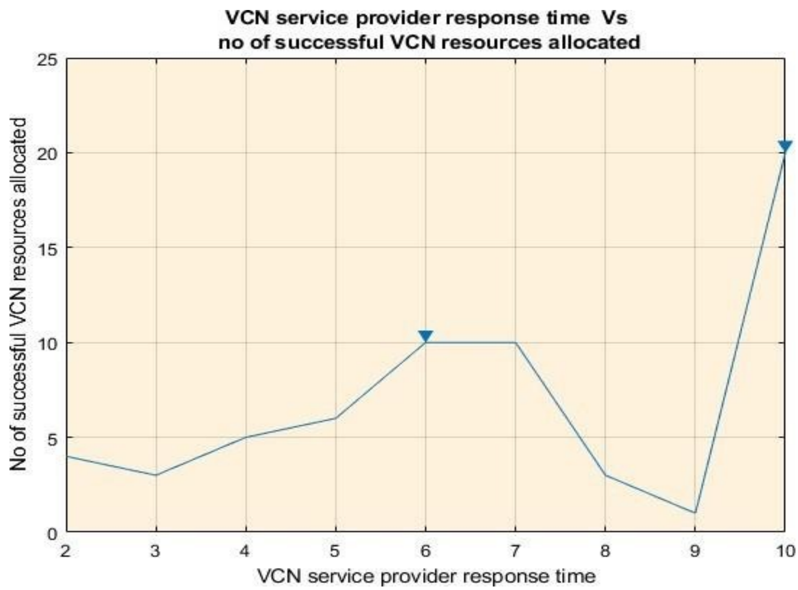
Table 2 Performance metrics

Parameters	*Value*
Forecasting accuracy	50
Forecasting integrity	20
Processing time	3 Sec
Network throughput	3 Sec
Execution time	10 Sec
Bandwidth availability	15 routes
Delivery of network services	4 routes

- *Network throughput*: Number of paths allocated within limited time.

From Figure 8, we can see that within 3 seconds there are four users who accept the route suggested by VCN service provider and there are 5 users who accept the route suggested by service provider within 4 seconds. Number of users may vary and it depends on the route suggested by VCN service provider.

Figure 8 VCN service provider response time vs. no. of successful VCN resources allocated



- *Execution time*: Time taken by the service provider to execute the task. From Figure 8, service provider takes 2 to 10 seconds for route allocation.
- *Bandwidth availability*: Network resources demand by user and the availability of resources within a time. It means allocation of network resources according to user demand by the VCN service provider. We can see service provider allocates 15 routes within 3 seconds. These routes are according to user need.
- *Delivery of network services*: Quality of service provided by VCN agent. It means user satisfaction rate after taking service of VCN service provider. Figure 8 illustrates that service providers allocate 15 routes within 3 seconds but according to user, there are 4 best routes which fulfil their need.

From Table 3, we can see that proposed scheme works well for suggesting route which has less network traffic congestion with 98% accuracy. FRCNN technique detects 85–95% accuracy and takes 3–40 seconds for identifying type of vehicle. The delivery of network services rate is 95%. Hybrid algorithm approach has 80% accuracy and result of genetic algorithm depend upon density of vehicles.

Table 3 Performance comparison of route prediction based existing methodologies

Technique	*Execution time*	*Throughput/ Accuracy*	*Delivery of network services*
FRCNN (Agarwal and Sharma, 2022)	3–40 sec	85–95%	95%
Hybrid algorithm approach (Rathee and Chaba, 2022)	80–90 sec	80%	80%
Generic algorithm (Kambalimath and Kakkasageri, 2020)	40 sec	20 sec	40%
A* algorithm [Proposed scheme]	2–10 sec	3 sec	98%

5 Conclusions

After reviewing various authentication schemes, we propose route forecasting-based authentication scheme. In this scheme, when user needs a path which has less network traffic congestion, the VCN service provider helps them to utilise the path according to their need. A* algorithm is used by VCN service provider for finding the suitable path which has less network traffic congestion. The suggested work is simulated in terms of processing time, resource allocation success, total number of resources allocated, service provider quality, etc. Tables 1 and 3 show that the proposed scheme offers 98% accurate result which is far better than other schemes.

References

Agarwal, V. and Sharma, S. (2022) 'EMVD: efficient multitype vehicle detection algorithm using deep learning approach in vehicular communication network for radio resource management', *International Journal of Image, Graphics and Signal Processing (IJIGSP)*, Vol. 14, No. 2, pp.25–37. Doi: 10.5815/ijigsp.2022.

Agarwal, V., Sharma, S. and Bansal, G. (2021) 'Secured scheduling techniques of network resource management in vehicular communication networks', *Proceedings of the 5th International Conference on Intelligent Computing and Control Systems (ICICCS)*, pp.198–202. Doi: 10.1109/ICICCS51141.2021.9432278.

Agarwal, V., Sharma, S. and Bansal, G. (2022) 'Network resource allocation security techniques and challenges for vehicular communication network management', *Proceedings of the New Trends and Applications in Internet of Things (IoT) and Big Data Analytics*, Springer, Cham, pp.123–137.

Azam, F., Yadav, S.K., Priyadarshi, N., Padmanaban, S. and Bansal, R.C. (2021) 'A comprehensive review of authentication schemes in vehicular ad-hoc network', *IEEE Access*, Vol. 9, pp.31309–31321.

Bal, P.K., Mohapatra, S.K., Das, T.K., Srinivasan, K. and Hu, Y.C. (2022) 'A joint resource allocation, security with efficient task scheduling in cloud computing using hybrid machine learning techniques', *Sensors*, Vol. 22, Vol. 3. Doi: 103390/s22031242.

Bhanja, U., Mohanty, A. and Das, B. (2018) 'Embedded based real time traffic congestion detection', *International Journal of Vehicle Information and Communication Systems*, Vol. 3, No. 4, pp.267–280.

Elahi, M.M., Rahman, M.M. and Islam, M.M. (2022) 'An efficient authentication scheme for secured service provisioning in edge-enabled vehicular cloud networks towards sustainable smart cities', *Sustainable Cities and Society*, Vol. 76. Doi: 10.1016/j.scs.2021.103384.

Guo, S. and Zhou, X. (2019) 'Robust resource allocation with imperfect channel estimation in NOMA- based heterogeneous vehicular networks', *IEEE Transactions on Communications*, Vol. 67, No. 3, pp.2321–2332. Doi: 10.1109/TCOMM.2018.2885999.

Huang, H., Xue, Y., Wu, J., Tao, Y. and Hu, M. (2022) 'Temporal computing resource allocation scheme with end device assistance', *IEEE Internet of Things Journal*, Vol. 9, pp.16884–16896.

Ibrar, M., Akbar, A., Jan, R., Jan, M.A., Wang, L., Song, H. and Shah, N. (2020) 'ARTNet: AI-based resource allocation and task offloading in a reconfigurable internet of vehicular networks', *IEEE Transactions on Network Science and Engineering*, Vol. 9, No. 1, pp.67–77.

Kambalimath, M.G. and Kakkasageri, M.S. (2020) 'Cost optimization based resource allocation scheme for vehicular cloud networks', *International Journal of Computer Network and Information Security*, Vol. 12, No. 2, pp.22–31.

Li, X., Sun, Y., Zhou, L., Qi, A. and Zhou, S. (2019) 'A resource allocation scheme based on immune algorithm for D2D-based vehicular communication networks', *IEEE Access*, Vol. 7, pp.122536–122543.

Liang, L., Ye, H., Yu, G. and Li, G.Y. (2019) 'Deep-learning-based wireless resource allocation with application to vehicular networks', *Proceedings of the IEEE*, Vol. 108, No. 2, pp.341–356.

Magsino, E.R. and Ho, I.W.H. (2022) 'An enhanced information sharing roadside unit allocation scheme for vehicular networks', *IEEE Transactions on Intelligent Transportation Systems*, Vol. 23, No. 9, pp.15462–15475.

Noor-A-Rahim, M., Liu, Z., Lee, H., Ali, G.M.N., Pesch, D. and Xiao, P. (2020) 'A survey on resource allocation in vehicular networks', *IEEE Transactions on Intelligent Transportation Systems*, Vol. 23, No. 2, pp.701–721.

Rathee, A. and Chaba, Y. (2022) 'Efficient resource allocation scheme for D2D enabled vehicular networks in secured 5G communication', *Journal of Discrete Mathematical Sciences and Cryptography*, Vol. 25, No. 4, pp.931–942.

Ren, Y., Liu, F., Liu, Z., Wang, C. and Ji, Y. (2015) 'Power control in D2D-based vehicular communication networks', *IEEE Transactions on Vehicular Technology*, Vol. 64, No. 12, pp.5547–5562.

Ryu, J., Kang, D. and Won, D. (2022) 'Improved secure and efficient chebyshev chaotic map-based user authentication scheme', *IEEE Access*, Vol. 10, pp.15891–15910.

Siddig, A.A., Ibrahim, A.S. and Ismail, M.H. (2020) 'Optimum resource allocation for full-duplex vehicular communication networks', *IEEE Access*, Vol. 8, pp.146683–146696.

Song, M. and Wu, B. (2022) 'Effectiveness evaluation method for traffic data acquisition based on vehicle-borne network', *International Journal of Vehicle Information and Communication Systems*, Vol. 7, No. 3, pp.211–227.

Wu, Y., Zhu, Y. and Li, B. (2012) 'Infrastructure-assisted routing in vehicular networks', *Proceedings IEEE INFOCOM*, IEEE, pp.1485–1493.

Yang, H., Zhang, K., Zheng, K. and Qian, Y. (2020) 'Joint frame design and resource allocation for ultra-reliable and low-latency vehicular networks', *IEEE Transactions on Wireless Communications*, Vol. 19, No. 5, pp.3607–3622.

Yang, W., Zhang, R., Chen, C. and Cheng, X. (2017) 'Secrecy-based resource allocation for vehicular communication networks with outdated CSI', *Proceedings of the IEEE 86th Vehicular Technology Conference (VTC-Fall)*, IEEE, pp.1–5.

Yu, R., Zhang, Y., Gjessing, S., Xia, W. and Yang, K. (2013) 'Toward cloud-based vehicular networks with efficient resource management', *IEEE Network*, Vol. 27, No. 5, pp.48–55.

Zhang, K., Peng, M. and Sun, Y. (2021) 'Delay-optimized resource allocation in fog-based vehicular networks', *IEEE Internet of Things Journal*, Vol. 8, No. 3, pp.1347–1357. Doi: 10.1109/JIOT.2020.3010861.

Zheng, K., Meng, H., Chatzimisios, P., Lei, L. and Shen, X. (2015) 'An SMDP-based resource allocation in vehicular cloud computing systems', *IEEE Transactions on Industrial Electronics*, Vol. 62, No. 12, pp.7920–7928.

Zhou, H., Wang, X., Liu, Z., Ji, Y. and Yamada, S. (2018) 'Resource allocation for SVC streaming over cooperative vehicular networks', *IEEE Transactions on Vehicular Technology*, Vol. 67, No. 9, pp.7924–7936.