A Beacon-less Relay-node Selection Method for 3-D Scenarios in Internet of Vehicle

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Abstract

Internet of Vehicles (IoV) presents a multilevel feature when vehicles move in multilevel scenarios, such as interchange. Wireless channels and node distribution in 3-D scenarios is more complex compared to that in 2-D scenarios, which leads to a smaller range of communication when sender and receiver are located on the different levels compared to the communication range when they are on the same level. It leads to the issues that hop count increases and delivery ratio decreases in the process of relay-node selection, and then makes the relay-node selection more challenging in the multilevel environment. Moreover, the flood beacon for location information exchange of nodes can occupy too much spectrum resources and lack of the real-time. To address the issues, we propose a Relay Selection method based on black-burst for Bi-layer Straight road scenarios (RSBS). The simulation results demonstrate that RSBS not only reduces the possibility of hop increases of average 30% but also reduces the possibility of delivery ratio decreases over average 30% compared to EPBP method.

Keywords: Internet of Vehicles, 3-D scenarios, Relay node selection, Hop, Delivery ratio

1 Introduction

Internet of Vehicles (IoV) [1-7] is a new generation of communication technology that achieves intelligent connection between vehicles, people and facilities on the roadside in Intelligent Transportation System (ITS) [8-9]. It strengthens the connection between various elements in the Intelligent Transportation System through acquisition and sharing of sensory information. In addition, it achieves the goal of providing strong support for the safety assistant driving in the near term and the ultimately complete automatic driving in the long term. The relay-node selection in the Internet of Vehicles is one of the basic technologies of Internet of Things (IoT) [10-13] and ITS, which has attracted extensive attention of researchers in recent years. Its fundamental idea is selecting the optimal node within the communication range of the transmitter as Relay node with the goal of minimum delay and maximum coverage through optimal algorithm. Thus, it promises that the messages are transmitted at a fast speed so that we can improve efficiency for the traffic flow and reduce accidents and so on.

As the number of vehicles constantly increases, three-dimensional road structures, such as viaducts, tunnels, and ramps, are vigorously constructed in order to reduce congestion in the traffic and save resources of land, especially in the big cities. However, the existence of multi-layer structures in 3-D scenarios makes the node distribution and the wireless communication environment more complicated, which brings new problems for relay-node selection.

The quality of the wireless channel between levels is poorer than that in the same level due to the existence of obstacles between the transmitter and receiver. Therefore, the communication radius R' between the levels will be less than the communication radius R within the level, further brings the problem of hop count increases and delivery ratio decreases [14]. The transmitter gets the information of neighbors by constructing a routing table with periodic flood beacons, and then select relay with the rule of Greedy Forwarding (GF) [15]. However, the position information of neighbors in these methods inevitably has deviation due to the period of beacon. The black-burst-based methods can find the neighbors with the priority location of the sender by the neighbors' broadcasting black-burst, and the black-burst-based methods benefits the performance in term of real-time. So, we propose some methods to deal with the problems mentioned above, and the main contributions of this paper are as follows:

(1) We propose a Relay Selection method based on black-burst for Bi-layer Straight road scenarios (RSBS), which is used to solve the problem that the number of hop increases and delivery ratio decreases and beacon-less. Compared with the GOF [14] method that obtains the position of neighbors on the road through periodic beacon, the performance in terms of real-time is better.

(2) The extensive simulation are conducted to evaluate the proposed RSBS, and the results demonstrate the effectiveness of RSBS in terms of the possibility of hop increases and the delivery ratio decreases.

The rest of this paper is organized as follows: Section 2 briefly describes the existing works related to the relay-node selection methods. Section 3 analyzes the problems of relay-node selection in 3-D scenarios. RSBS method is proposed in Section 4. Section 5 demonstrates the relatively excellent performance of this method. Finally, Section 6 concludes this paper.

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2 Related Work

Existing relay-node selection methods can be divided into two classes of methods based on beacon or black-burst. And the most representative method among the former is Greedy Perimeter Stateless Routing (GPSR) [15]. This method utilizes the periodic flood beacons to gain the location information of neighbor and adopts the Greedy Forwarding (GF) algorithm to select the relay-node as the next transmitter. In the environment where the topology changes frequently, the non-real-time of beacon period will lead to the positional information deviation of the neighbor. Then in a worse situation that the selected Relay node might moves out of the communication range of the sender when the message is transformed, and it brings about the relay-node selection failure. The improved method Greedy Opportunity Forwarding (GOF) algorithm based on GF is also can not get rid of this problem.

In the black-burst-based relay-node selection methods [16], each node determines when to send black-burst according to its own location to block the channel so that the relatively optimal node can be selected as the Relay node. A robust distance-based relay selection for message dissemination in vehicular network [17], proposed by our team earlier. It achieves maximum message dissemination speed in general scenarios and an accepted dissemination speed in the adverse scenario. Mobile relay communication system is used for Unmanned Aerial Vehicle (UAV) [18-20], it aims to maximize the number of tasks completed on the UAV and AP by optimizing the local computing frequency, offloading ratio, offloading power, computing frequency of the AP. Quality of Service-Optimized Link State Routing (QoS-OLSR) is used to find routing paths using the Multi-Point Relays (MPRs) in [21], It tackles the problem of the propagation of charging information in Vehicular Ad-hoc Networks (VANETs) [22] and the decentralized allocation of Vehicle-to-Vehicle (V2V) charging pairs.

All the relay-node selection methods mentioned above adapt to the 2-D scenarios, but a few work about the relay-node selection in 3-D scenarios is proposed. A 3-D-based position detection scheme for beam alignment/selection purpose is proposed [23], then a group-based routing algorithm is performed to select a secure path for achieving trustworthy data transmissions. It achieves relatively excellent performance in terms of data rate and delivery rate in urban and highway scenarios. [24] presents a hybrid improved 3-D scenario oriented routing (ITSR), and the intra-layer transmission priority forwarding rule is introduced to alleviate the hop and delivery rate problem caused by the inter-layer transmission. Simple ITSR (S-ITSR) and Complex ITSR (C-ITSR) of complex 3-D scenarios are explored for the simple overpasses and the complex exchange 3-D scenarios respectively. Based on ITSR, [25] introduces a packet-reception-probability-based reliable routing protocol for 3-D VANET, and selects the optimal routing based on packet reception probability. It gains the higher packet delivery ratio and lower end-to-end delay compared to ITSR. [26] proposes a Link Reliability-based Adaptive Routing algorithm (LRAR) in 3-D scenarios. Different from [24], it amends GPS original data for more preciser location of vehicles and establishes a Multilevel Dynamic Link Model (MDLM) to evaluate the wireless link performance. It selects the link with highest reliability as transmission path which improves the performance in terms of delivery ratio and end-to-end delay compared to ITSR. [14] proposes a Multilevel-scenario-oriented Greedy Opportunity routing Protocol (M-GOR). In this protocol, inter-level transmission is not avoided, but the neighbor who locates in the different level with the transmitter is stricter to be chosen as Relay node. However, while these GOF-based methods mentioned above reduces the probability of hop increases and possibility of delivery ratio decreases, the performance in term of real-time is relatively poor compared to black-burst-based method.

3 Problems Description

In this section, we discuss the characteristics of wireless communication channel [27] in 3-D scenarios and its influence on the selection of Relay node, and describe the problems in 3-D scenarios.

Problem 1: The wireless communication channel is more complex compared with 2-D scenarios, which leads to a smaller communication range. Experiment in [14] verifies that the inter-level communication range is less than that of intra-level, and analyzes that the differences of the communication range in 3-D scenarios can cause hop count increases and delivery ratio decreases. As is shown in Sence 1 of Figure 1, Sender S_1 transmitter the packet to the destination A_3 along path S_1-A_4-A_5-A_2-A_3 obeying the GF rule with four hops. However, it is found that there exists a route with only three hops of S_1-A_1-A_2-A_3. So a new rule is need to be explored to deal with the problem that the number of hop increases.

Problem 2: As is shown in Sence 2 of Figure 1, Sender S_2 will select B_3 as the next Relay node with the GF rule. But because of no node located in the coverage of B_3, the transmission will be broken. However, along the path S_2-B_1-B_2 can the message be delivered successfully. So the difference between the inter-level communication range and the intra-level communication range of Sender can causes the problem that the delivery ratio decreases.

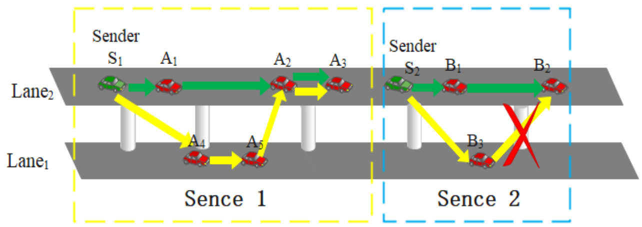

Figure 1. Problems in 3-D scenarios

4 Algorithm for Problems

To deal with the non-real-time problem of the interactive beacons as well as the increased hop count and reduced delivery ratio described in Problem 1, we put forward a Relay Selection method based on black-burst for Bi-layer Straight road scenarios (RSBS), shown in Algorithm 1. Problems usually appear in the scenarios that the density of node is relatively small, we give the higher priority to the nodes locate on the same level with sender. Considering on this idea, only the horizontal distance between the farthest inter-level neighbor and Sender is greater than that between the farthest intra-level neighbor and Sender, and when the value of difference of this two distances is greater than σ, the farthest inter-level neighbor will be chosen as Relay node, otherwise, the farthest intra-level neighbor will be selected as Relay node. σ is expressed as:

$$\sigma = \begin{cases} \frac{\lambda_2 - \lambda_1}{\lambda_2} \times (R - R'), \lambda_2 > \lambda_1 \\ 0 \qquad\qquad\qquad\quad , \lambda_2 \le \lambda_1 \end{cases} \quad (1)$$

where σ related to the difference in node density between the layers and the difference in communication ranges between inter-level layer and intra-level layer. λ_1 and λ_2 are the density of vehicles on $Lane_1$ and $Lane_2$ respectively. R and R' are the intra-level communication range and inter-level communication range respectively.

We mark all the locations of the segment boundary obtained from the partition on $Lane_1$ as $Label\_y_i$ and that on $Lane_2$ where Sender located as $Label\_x_i$, respectively. The width of segment through iterative partitions are decided by the position of sender, P_{opt}, the number of iteration N_{iter}, the number of segment in each iteration N_{part}, and compression coefficient A.

The optimal position P_{opt} is the junction of the communication range circle of Sender and the road. In the process of relay-node selection, we want to select the farthest neighbor node from Sender to improve the performance in terms of one hop distance. However, because vehicles are generated randomly, it might exists the condition that there is no node locates on the junction of the communication range circle of Sender and the road in the process of relay-node selection. So, we should take the position P_{opt} on the road as the assisted point to select the Relay node. P_{opt} is the same point with $Label\_x_0$.

In the process of iterations and partitions, the bigger is A, the faster the width of segments decreases in the messages broadcasting direction corresponding to an exponential curve. Commonly, we assume A = 2.3. In this case, the widths of the 1st, 2nd and 3rd segments in each partition are about 1/4, 1/4 and 1/2 of their partition range, respectively. Because of the road in our simulation is straight road, we could use x-axis to replace the $Lane_2$. We set the value of $Label\_x_0$ and P_{opt} on x-axis to 0, the values on x-axis decrease in the messages broadcasting direction, the value of $Label\_y_0$ is $-\sigma$ which is calculated through $Label\_x_0$ according to the rule of RSBS.

Algorithm 1. The algorithm of RSBS

1.Input: locations information of Sender and neighbors in the coverage of Sender, N_{iter}, N_{part}, A, σ, P_{opt}, R, R'.

2.Output: Relay node

3.Origin: Position of $P_{opt} = 0$, Position of $Label\_x_0 = 0$, Position of $Label\_y_0 = -\sigma$.

4.Begin: Sender broadcasts a RTB package which includes the location and coverage R of the sender.

5.Nodes who receive the RTB start exponential iterative partition.

6.for $j = 1 : N_{iter}$

7.for $i = 1 : N_{part}$

8. $\Delta x_i = \frac{1}{A}(1+A)^{\frac{i-1}{N_{part}}}\left[(1+A)^{\frac{1}{N_{part}}} - 1\right]$

9. $Label\_x_i = \left[\sum_{1}^{i} \Delta x_i\right] \times R$

10. $Label\_y_i = Label\_x_i - \sigma$

11.end

12.The segment number that nodes on $Lane_2$ is i if these nodes locate between $Label\_x_{i-1}$ and $Label\_x_i$, and the same to the segment number on $Lane_1$.

13. Nodes in Segment i broadcast a black-burst in the i_{th} time-slot, and nodes closest to the P_{opt} sends the black-burst firstly.

14. The nodes, having broadcast the black-burst, get into the next iteration.

15. $R = \Delta x_i$.

16.end

17. Nodes who broadcast black-burst in the last partition compete for the Relay node by selecting a random back-off time.

5 Simulation Results and Discussion

In this section, we first calculate the possibility of hop count increases and delivery ratio decreases in 5.1, then, we prove the effectiveness of our proposed method through analyzing and summarizing the simulation results in 5.2.

5.1 Simulation Setup

To prove the effectiveness of our proposed algorithm, we construct a 3-D bi-layer straight road scenarios, as is shown in Figure 1, Where $Lane_2$ is the upper level and $Lane_1$ is the lower level. Let the inter-vehicle space follows exponential distribution with the parameter λ_1 on $Lane_1$ and λ_2 on $Lane_2$, respectively. We consider the intra-level communication as R and the inter-level communication range as R'. In the real environment of IoV, the communication range of vehicle is unknown due to the time-varying characteristic of wireless signal, so, the communication range should be estimated for the partition. The transmission of wireless signal in the inter-level communication belongs to non-line-of-sight transmission, Rayleigh fading is only applicable the condition when there is no direct signal between sender and receiver. So, the estimated communication range in our experiment follows the Rayleigh distribution whose mean is R. α is the transmission degradation and its value is the ratio of R' to R. We set the first vehicle generated on $Lane_2$ as Sender. The unit of the node density is vehicle/meter.

We denote the m_{th} one-hop progress by a random variable X_m for the hop on $Lane_2$, whereas Y_n depicts the n_{th} one-hop progress for the route on $Lane_1$, where m and n are positive integers. We first need X_1, Y_1, and X_2, Y_2, for analyzing the EPBP algorithm and RSBS algorithm.

RSBS method is an improved method based on EPBP, the difference between RSBS method and EPBP method is σ, they are the same in the process of iteration and partition if σ =0. So, we calculate the probability of hop count increases (pgh_1) and delivery ratio decreases (pgt_1) to portray the variation of EPBP performance, we calculate the probability of hop count increases (pgh_2) and delivery ratio decreases (pgt_2) to portray the variation of RSBS performance, the same to [14]. We express them as follows.

$$pgh_1 = \frac{\Pr\{X_2 > Y_2, Y_1 > X_1\}}{\Pr\{Y_1 > X_1\}} \quad \textbf{(2)}$$

$$pgt_1 = \frac{\Pr\{X_2 \neq 0, Y_2 = 0, Y_1 > X_1\}}{\Pr\{Y_1 > X_1\}} \quad \textbf{(3)}$$

$$pgh_2 = \frac{\Pr\{X_2 > Y_2, Y_1 > X_1 + \sigma\}}{\Pr\{Y_1 > X_1 + \sigma\}} \quad \textbf{(4)}$$

$$pgt_2 = \frac{\Pr\{X_2 \neq 0, Y_2 = 0, Y_1 > X_1 + \sigma\}}{\Pr\{Y_1 > X_1 + \sigma\}} \quad \textbf{(5)}$$

5.2 Effectiveness

In this part, we will evaluate the positive effect on the possibility of hop count increases and delivery ratio decreases in RSBS method compared to EPBP method.

The results of possibility of hop increases versus λ_1 and α for the proposed RSBS and the benchmark EPBP are shown in Figure 2 and Figure 3 respectively. As is shown in Figure 2, when λ_2 = 0.06, RSBS method has the same value of the probability with EPBP when λ_1 increases, the reason is that λ_1 varies from 0.06 to 0.1, which is always bigger than λ_2, so the value of σ is 0 and the mechanism is not working. Then the RSBS method selects the farthest neighbor as Relay node as the same way as EPBP. The value of possibility for RSBS is smaller than that for EPBP when $\lambda_1 < \lambda_2 = 0.1$. It reveals that the RSBS has the improved performance in terms of the possibility of hop count increases. The result curve of $\lambda_2 = 0.07$ shows that when $\lambda_1 > \lambda_2$ the results for the two algorithms are the same, and the value of RSBS is always smaller than the EPBP algorithm when $\lambda_1 < \lambda_2$. It also proves that RSBS has solved the problems that the possibility of hop count increases in 3-D scenarios if only density of nodes on $Lane_2$ is bigger than that on $Lane_1$.

Figure 3 shows the relation between α and the possibility of hop count increases in EPBP and RSBS. The value of α varies from 0 to 1 under the normal condition. However, in this simulation we conduct, if the value of α is too small, it will bring the problem that the Sender can not find an available inter-level neighbor node in its communication range. In this way, we can not get the data that the hop count increases and delivery ratio decreases. So, we set the value of α from 0.65 to 0.95. The value of possibility in EPBP and RSBS raise first and then decrease when α is continuous increased. The reason is that σ has a suitable value, and the performance will be best. When the value of α is 0.95, we can find that the value of possibility of hop count increases is almost the same in RSBS method and EPBP method. The reason is that the inter-level communication range R' is almost the same with the intra-level communication range R, so that the value of σ is 0, and RSBS method works as the same way as EPBP method. The solid lines of different color show that the possibility of hop count increases will decrease when the intra-level communication range R increases under the same value of α in EPBP method. The same phenomenon is also existed in RSBS method. The reason is that when the intra-level communication rang R is increased, the distance between the Sender and the selected Relay node will increase, the possibility of hop count increases will decline. As we can see from the solid and dashed lines of the same color, we can conclude that the performance in terms of hop count increases has been improved in RSBS compared to EPBP under the same transmission degradation α.

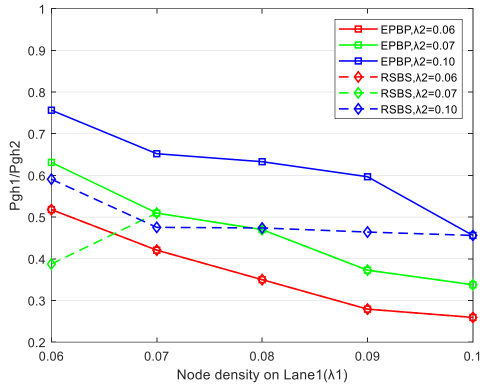

Figure 2. Hop increase probability versus λ_1

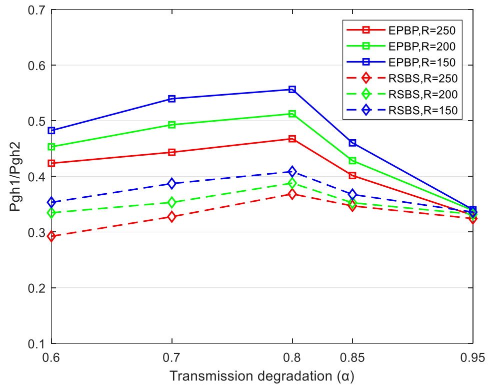

Figure 3. Hop increase probability versus α

The results of the probability of delivery ratio decreases for EPBP and RSBS are given in Figure 4 and Figure 5. As is shown in Figure 4, when λ_2=0.04, the possibility of delivery ratio decreases is declined as the value of λ_1 increases. The reason is that the density of vehicles on $Lane_2$ is always bigger than that on $Lane_1$, the messages will be transferred on $Lane_2$ for multi hops. It will reduce the possibility of hop count increases and delivery ratio decreases. The same phenomenon appears when λ_2=0.015, since the sender might select the node on $Lane_2$ as Relay node in the first hop when λ_1=0.01, and the messages will be transferred on $Lane_1$ as the value of λ_1 increases. It also reduces the possibility of hop count increases and delivery ratio decreases. The value of probability in RSBS method is always smaller than that in EPBP when $\lambda_2 = 0.04$ which is bigger than λ_1. It proves that the performance is improved when we adapt the RSBS method. When $\lambda_2 = 0.015$, the value of possibility in RSBS is the same with that in EPBP when $\lambda_2 \leq \lambda_1$ and the value of RSBS is smaller than that of EPBP when $\lambda_2 > \lambda_1$.We can conclude that RSBS has alleviated the problems that the possibility of delivery ratio decreases in 3-D scenarios when density of vehicles on the upper level is bigger than that on the lower level.

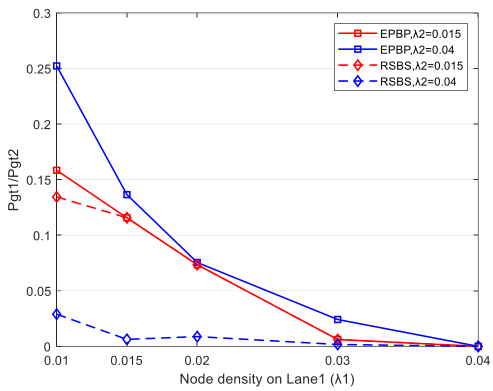

Figure 4. Delivery decrease probability versus λ_1

The relation between α and the possibility of delivery ratio decreases is shown in Figure 5.

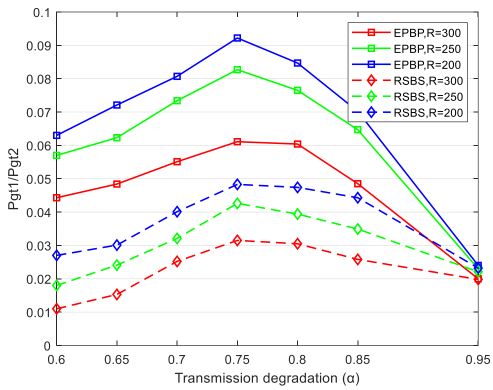

Figure 5. Delivery decrease probability versus α

Through the information shown in the solid and dashed lines of the same color, we can find that the performance in terms of possibility of delivery ratio decreases in RSBS method is better than that in EPBP method under the same value of α. The solid lines of different color show that the possibility of delivery ratio decreases will decrease when the intra-level communication range R increases under the same value of α in EPBP method, and the same phenomenon is also existed in RSBS method. The reason is that when the intra-level communication rang R is increased, the possibility that the Sender can not find an available neighbor as the Relay node will be reduced, so the possibility of delivery ratio decreases will be smaller.

We calculate the average value through the data in the four pictures mentioned above. The simulation results demonstrate that RSBS not only reduces the possibility of hop count increases of average 30% but also reduces the possibility of delivery ratio decreases over average 30% compared to EPBP method.

6 Conclusion

This paper has investigated the problems of relay-node selection for the 3-D scenarios in VANET. We propose RSBS method to deal with these problem. we have proved that the RSBS could reduce the possibility of hop increases and delivery ratio decreases compared to EPBP. Finally, we have conducted simulations and analyzed the results.

In the future, we will consider the issue of relay-node selection in more complex 3-D scenarios [28-30] of Internet of Vehicles instead of only the bi-layer straight road.

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References

[1] C. Chen, L. Liu, T. Qiu, J. Jiang, Q. Q. Pei, H. B. Song, Routing with traffic awareness and link preference in Internet of vehicles, *IEEE Transactions on Intelligent Transportation Systems*, Vol. 23, No. 1, pp. 200-214, January, 2022.

[2] H. Abualola, H. Otrok, H. Barada, M. Al-Qutayri, Y. Al-Hammadi, Matching game theoretical model for stable relay selection in a UAV-assisted internet of vehicles, *Vehicular Communications*, Vol. 27, Article No. 100290, January, 2021.

[3] M. A. Hamza, H. M. Alshahrani, F. N. Al-Wesabi, M. Al Duhayyim, A. M. Hilal, H. Mahgoub, Artificial Intelligence Based Clustering with Routing Protocol for Internet of Vehicles, *CMC-Computer Materials& Continua*, Vol. 70, No. 3, pp. 5835-5853, 2021.

[4] W. T. Cho, Y. W. Ma, Y. M. Huang, A smart socket-based multiple home appliance recognition approach over IoT architecture, *Journal of Internet Technology*, Vol. 16, No. 7, pp. 1227-1238, December, 2015.

[5] Z. S. Xu, W. Liang, K. C. Li, J. B. Xu, H. Jin, A blockchain-based Roadside Unit-assisted authentication and key agreement protocol for Internet of Vehicles, *Journal of Parallel and Distributed Computing*, Vol. 149, pp. 29-39, March, 2021.

[6] T. Zhang, D. G. Zhang, H. R. Yan, J. N. Qiu, J. X. Gao, A New Method of Data Missing Estimation with FNN-Based Tensor Heterogeneous Ensemble Learning for Internet of Vehicle, *Neurocomputing*, Vol. 420, pp. 98-110, January, 2021.

[7] S. H. Wan, R. H. Gu, T. Umer, K. Salah, X. L. Xu, Toward Offloading Internet of Vehicles Applications in 5G Networks, *IEEE Transactions on Intelligent Transportation Systems*, Vol. 22, No. 7, pp. 4151-4159, July, 2021.

[8] D. Cao, K. Zeng, J. Wang, P. K. Sharma, X. M. Ma, Y. H. Liu, S. Y. Zhou, BERT-Based Deep Spatial-Temporal Network for Taxi Demand Prediction, *IEEE Transactions on Intelligent Transportation Systems*, pp. 1-13, November, 2021.

[9] J. Wang, H. Han, H. Li, S. M. He, P. K. Sharma, L. Chen, Multiple Strategies Differential Privacy on Sparse

Tensor Factorization for Network Traffic Analysis in 5G, *IEEE Transactions on Industrial Informatics*, Vol. 18, No. 3, pp. 1939-1948, March, 2022.

[10] S. J. Yang, T. C. Wei, Design Issues for Communication Protocols Conversion Scheme of IoT Devices, *Journal of Internet Technology*, Vol. 22, No. 3, pp. 657-667, May, 2021.

[11] J. Wang, J. X. Gu, W. Liu, K. A. Sangaiah, H. J. Kim, An Empower Hamilton Loop based Data Collection Algorithm with Mobile Agent for WSNs, *Human-centric Computing and Information Sciences*, Vol. 9, Article No. 18, May, 2019.

[12] J. Y. Zhang, S. Q. Zhong, T. Wang, H. C. Chao, J Wang, Blockchain-Based Systems and Applications: A Survey, *Journal of Internet Technology*, Vol. 21, No.1, pp. 1-14, January, 2020.

[13] J. Wang, Y. Q. Yang, T. Wang, R. S. Sherratt, J. Y. Zhang, Big Data Service Architecture: A Survey, *Journal of Internet Technology*, Vol. 21, No. 2, pp. 393-405, March, 2020.

[14] L. N. Zhu, C. L. Li, B. B. Li, X. B. Wang, G. Q. Mao, Geographic Routing in Multilevel Scenarios of Vehicular Ad Hoc Networks, *IEEE Transactions on Vehicular Technology*, Vol. 65, No. 9, pp. 7740-7753, September, 2016.

[15] B. Karp, GPSR: Greedy Perimeter Stateless Routing for Wireless Networks, *MobiCom00: The 6th Annual International Conference on Mobile Computing and Networking*, Boston, Massachusetts, USA, 2000, pp. 243-254.

[16] Y. G. Bi, H. G. Shan, X. M. Shen, N. Wang, H. Zhao, A Multi-Hop Broadcast Protocol for Emergency Message Dissemination in Urban Vehicular Ad Hoc Networks, *IEEE Transactions on Intelligent Transportation Systems*, Vol. 17, No. 3, pp. 736-750, March, 2016.

[17] D. Cao, B. Zheng, B. F. Ji, Z. B. Lei, C. H. Feng, A robust distance-based relay selection for message dissemination in vehicular network, *Wireless Networks*, Vol. 26, No. 3, pp. 1755-1771, April, 2020.

[18] Q. Tang, Z. Q. Yu, C. Y. Jin, J. Wang, Z. F. Liao, Y. S. Luo, Completed tasks number Maximization in UAV-assisted mobile relay communication system, *Computer Communications*, Vol. 187, pp. 20-34, April, 2022.

[19] J. M. Zhang, K. Wang, Y. Q. He, L. D. Kuang, Visual Object Tracking via Cascaded RPN Fusion and Coordinate Attention, *Computer Modeling in Engineering & Sciences*, April, 2022. DOI: 10.32604/cmes.2022.020471.

[20] X. Y. Fan, D. Liu, B. Fu, S. J. Wen, Optimal relay selection for UAV-assisted V2V communications, *Wireless Networks*, Vol. 27, No. 5, pp. 3233-3249, July, 2021.

[21] H. Abualola, H. Otrok, R. Mizouni, S. Singh, A V2V charging allocation protocol for electric vehicles in VANET, *Vehicular Communications*, Vol. 33, Article No. 100427, January, 2022.

[22] M. Afrashteh, S. Babaie, A Route Segmented Broadcast Protocol Based on RFID for Emergency Message Dissemination in Vehicular Ad-Hoc Networks, *IEEE Transactions on Vehicular Technology*, Vol. 69, No. 12, pp. 16017-16026, December, 2020.

[23] I. Rasheed, F. Hu, Y. K. Hong, B. Balasubramanian, Intelligent Vehicle Network Routing With Adaptive 3D Beam Alignment for mmWave 5G-Based V2X Communications, *IEEE Transactions on Intelligent Transportation Systems*, Vol. 22, No. 5, pp. 2706-2718, May, 2021.

[24] L. N. Zhu, C. L. Li, B. Xia, Y. He, Q. Lin, A Hybrid Routing Protocol for 3-D Vehicular Ad Hoc Networks, *IEEE Systems Journal*, Vol. 11, No. 3, pp. 1239-1248, September, 2017.

[25] C. Xu, Z. Y. Xiong, X. H. Kong, G. F. Zhao, S. Yu, A Packet Reception Probability-Based Reliable Routing Protocol for 3D VANET, *IEEE Wireless Communications Letters*, Vol. 9, No. 4, pp. 495-498, April, 2020.

[26] C. Xu, Z. Y. Xiong, Z. Z. Han, G. F. Zhao, S. Yu, Link Reliability-Based Adaptive Routing for Multilevel Vehicular Networks, *IEEE Transactions on Vehicular Technology*, Vol. 69, No. 10, pp. 11771-11785, October, 2020.

[27] F. Yu, A Low-Voltage and Low-Power 3-GHz CMOS LC VCO for S-Band Wireless Applications, *Wireless Personal Communications*, Vol. 78, No. 2, pp. 905-914, September, 2014.

[28] Q. W. Wang, J. H. Li, Q. Qi, P. Zhou, D. O. Wu, A Game-Theoretic Routing Protocol for 3-D Underwater Acoustic Sensor Networks, *IEEE Internet of Things Journal*, Vol. 7, No. 10, pp. 9846-9857, October, 2020.

[29] J. M. Zhang, B. B. Huang, Z. Ye, L. D. Kuang, X. Ning, Siamese anchor-free object tracking with multiscale spatial attentions, *Scientific Reports*, Vol. 11, Article No. 22908, November, 2021.

[30] B. Yin, J. Z. Lu, A Cost-Efficient Framework for Crowdsourced Data Collection in Vehicular Networks, *IEEE Internet of Things Journal*, Vol. 8, No. 17, pp. 13567-13581, September, 2021.

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