iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** XI **Month of publication:** November 2026

DOI: https://doi.org/10.22214/ijraset.2026.85761

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue XI Nov 2026- Available at www.ijraset.com

Performance Analysis of Multi-Access Edge Computing (MEC) in Vehicular Ad-Hoc Networks (VANETs)

Avishkar Rathod[1], Ishika Bhad[2], Jeenali Shah[3], Mokshada Kharche[4], Dr. Ketki Kshirsagar[5]

Abstract: ***Reliable and coffee-latency communication between all motors, pedestrians, infrastructure, and networks (V2X) is arguably the main protection factor of the vehicle, independent operation. Specifically, time, vital functions such as collision avoidance or cooperative driving maneuvers may be significantly affected despite the slightest delay in communication. Processing based on the traditional cloud calls for an additional backhaul delay, which, consequently, makes the street environment much less responsive, the actual time. Multi Access Edge Computing (MEC) became the challenge of this paper and it was asked whether it can be powerful in reducing spherical, travel delay in the case of cars, to, whole lot (V2X) interactions supported through a VANET infrastructure. Python is used. An analytical delay version was hired to demonstrate the difference in latency between cloud, handiest, and aspect, assisted processing through an RSU. The vehicle experimental setup includes safety messages from 10 vehicles of different sizes. The overall performance of the system was measured through the average give up, to, stop latency, and the choice fulfillment rate. MEC implementation contributes greatly to the reduction of latency and therefore the reliability of time, sensitive car, oriented choice, making received progress. The results show that MEC will be the key technology enabling true, time autonomous automotive packages.***

Index terms: V2X conferencing, Multi-access edge computing, VANET, autonomous motors, ultra-low latency, URLLC, 5G NR-V2X

I. INTRODUCTION

Vehicle-to-X(V2X) communication allows vehicles to communicate wirelessly with their environment.

V2X contains 4 wonderful communication styles: Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Network (V2N), and Vehicle-to-Pedestrian (V2P). While V2Vlets cars share statistics, V2I lets vehicles in to talk to roadside infrastructure, V2N lets cars access records from the cloud and mobile network, and V2P connects cars with pedestrians and cyclists via smart gadget phones or wearable gadgets. This technology strengthens the backbone of cutting-edge related and autonomous vehicles.

V2X significantly complements road safety and visitor efficiency with the help of allowing collaborative driving. Vehicles can percentage information for platooning, collision avoidance, and lane-change assistance. Optimization of the road system is active for visitors to the site lighting fixtures and road use.

V2P makes pedestrians safer with real-time precautions. V2N also supports self-driving car technology, including visitor reporting, high-definition maps and cloud computing. Safety-critical applications for self-contained use will exhibit extremely low latency required for reliability of only about 99.999

MEC alleviates that problem using placing the compute and garage assets near cars (i.e. At the base stations or roadside). If we move all the way down to the community, there are many calculations, e.g. Sensor fusion, object detection, collaborative riding algorithms and so on can be done domestically. This app approach can significantly reduce call delay and satisfy URLLC necessities.

Neighborhood processing, redundancy, and handover while moving between community areas also ensure reliability. With the improvement of the latest 5G and destiny 6G networks, the edge-enabled V2X communication is further strengthened. 3GPP Release 16 and Release 17 include slicing mature net-paintings and MEC with advanced NR-V2X features to help collaboratively.

Through the 6G networks, latency is expected to be less than milliseconds, wireless area computing and AI-powered programs with feature-rich programs are brought through the use of mmWave and terahertz calls with excessive bandwidth. Inspired by these advances, in this paper, we simulate the evaluation between MEC-mainly based Vehicle to the whole thing (V2X) verbal exchange and conventional cloud-centric architecture approximately the delay according-to-formation. For the give up to end latency of a self-driving situation, this painting indicates the potential of aspect computing to satisfy the vital shutdown constraint of cooperative driving device and facilitate the deployment of a destination-intelligent transportation system.

©IJRASET: All Rights are Reserved

II. LITERATURE SURVEY

1) With the rapid development of self-driving technology and sensitive transportation structures, the desire for reliable vehicular communication with extremely low latency has become an increasingly crucial number. Vehicle-to-Everything (V2X) conversation generation enables many motors to communicate with various vehicles, infrastructure, pedestrians, and community servers, which can be used to improve road safety and site visitor efficiency. The m ission of ultra-low latency and excessive reliability of V2X calls is one of the major obstacles, which is dynamic in nature. Recent research has proposed the use of facet computing, artificial intelligence, 5G, and 6G wireless network generation to improve the overall performance of the V2X communication era.*Generative AI-Based Vehicular Networks* With the rapid development of self-taking costs and touching transport structures, the selection for reliable auto-verbal switching with extremely low latency has been confirmed as an increasing number of essential numbers. Vehicle-to-Everything (V2X) conversation era allows many vehicles to communicate with many motors, infrastructure, pedestrians, and community servers, which can be used to enhance traffic safety and the overall performance of vacationers on the site. Undertaking extraordinarily low latency and high reliability of V2X calls is one of the main constraints, that is dynamic in nature. Recent studies have proposed to use facet computing, artificial intelligence, 5G, and 6G wi-fi network technology to improve the overall performance of the era of V2X language exchange.*AI and Machine Learning in 6G V2X*
2) With the rapid improvement of computerized ticketing and touch transportation infrastructure, the choice for reliable vehicle-communique with unprecedented low latency has proven to be increasingly vital figures. Vehicle-to-Everything (V2X) conversational technology sends in many cars to talk to many vehicles, infrastructure, pedestrians, and community servants, which can be used to beautify passenger safety and the overall normal overall performance of recreationists on the floor. Undertaking particularly low latency and high reliability V2X calls is one of the major hurdles, which is dynamic in nature. Recent studies have proposed to use session counting, artificial intelligence, 5G, and the 6G wi-fi network time to beautify the general common overall performance of the generation of V2X language exchange.Adaptive Network Selection in V2X Systems Adaptive communication mechanisms are required to ensure that the reliability of the communication is achieved under different traffic conditions. The research in [5] has introduced a latency-aware network selection framework that can adaptively select the best communication channel between vehicles and infrastructure.
3) *Architectural Optimization for Dense Vehicular Networks* The vehicular communication networks have to function in an efficient manner even in dense traffic conditions. In a recent study in [12], an optimized V2X communication architecture is proposed for enhancing reliability in vehicular communication networks.

III. METHODOLOGY

1) The vehicular communication networks shall be symbolized in a green way even in dense area recreation areas. In a drift have a study in [12], an optimized V2X communication structure is proposed to enhance reliability in vehicular communication networks.The proposed framework evaluates two architectures for V2X communication:
   - Cloud-based architecture
   - Edge-assisted MEC architecture

In the cloud-based architecture, the vehicle sends the safety messages to the cloud server through cellular networks. The cloud server will perform the computation, and the decision re-sponse will be sent back to the vehicle. However, the presence of core network traversal as well as backhaul communication causes significant delays in the applications.

Edge computing helps to overcome this limitation by de-ploying computing resources closer to the edge of the network. In the MEC-assisted architecture, the vehicle communicates with nearby Roadside Units (RSUs) that have edge servers installed in them. The edge servers can process the safety messages locally, thus reducing the distance of communication and backhaul delay. Hence, the overall latency is reduced to a great extent.

Recent research on vehicular edge computing architectures shows that MEC-based processing significantly reduces com-munication delay and improves response time in safety-critical V2X applications [16], [17].

2) *Vehicular Mobility Simulation*

The movement of the vehicle is simulated by a Simulation of the Urban Mobility (SUMO) tool, which is an open source traffic simulator that can be employed in Intelligent Trans-portation Systems (ITS) research.

The SUMO tool can effectively simulate the movement of the vehicle by simulating realistic patterns of vehicle

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue XI Nov 2026- Available at www.ijraset.com

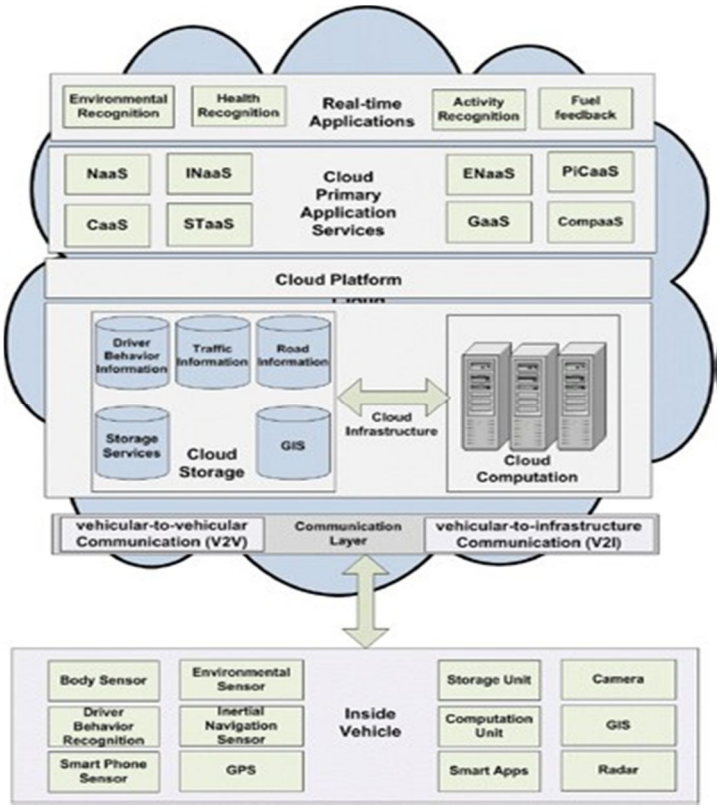


Fig. 1. Cloud-based architecture for vehicular data processing and centralized computation.

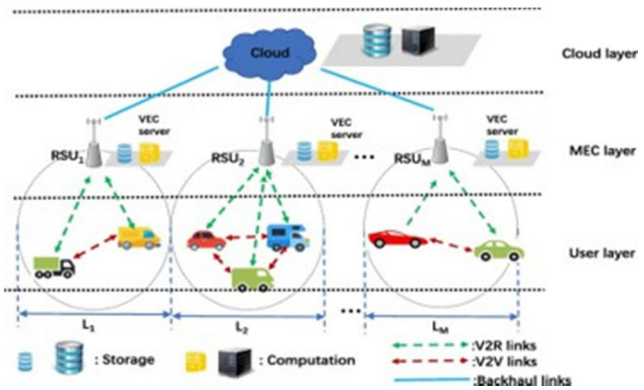


Fig. 2. Edge-assisted V2X architecture with RSU-based Multi-Access Edge Computing (MEC).

The movement of the vehicle is simulated with the help of Simulation of Urban Mobility (SUMO) tool, it is an open supply passenger simulation that can be rented in intelligent transportation system (ITS) studies.

The SUMO tool can effectively simulate the motion of the vehicle with the help of simulating intelligent patterns of car motion, which can be acceleration, braking, lane change, and intersection movement. The scenario where it is simulated is Speed

- Acceleration
- Route information
- Traffic condition updates

Each task generated has parameters such as packet size, computational requirement, priority level, and deadline con-straint. These tasks are sent either to the cloud server or the edge server of the nearby RSU, depending on the architecture being tested.

These parameters are extracted and used in the network simulation to model V2X communication behavior. SUMO-based traffic modeling is widely used for evaluating vehicular communication systems and intelligent transportation applica-tions [13].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

3) Task Generation Model

Vehicles periodically issue safety vital messages that must be processed within strict delay conditions. These warranties represent actual vehicle packages, Collision warning messages

- Cooperative driving alerts
- Emergency braking notifications
- Traffic condition updates

Each job generated has parameters along with package length, compute requirement, priority level, and close date constraint. These tasks are sent both to the cloud server or the edge server of the adjacent by the RSU, depending on the architecture being tested

In the MEC system, the computational resources acquired with the help of cars are offloaded to regional servers located on the RSU. The RSU has a task queue to schedule the received tasks for processing.

The edge servers perform calculations regionally and send return results directly to cars, lowering communication delays. Edge nodes can painting together with RSUs to enhance processing performance. Edge computing has been recognized as a green approach to offer vehicular verbal exchange and visitor intelligence with low latency [10], [17].

4) Latency Modeling

- A simplified analytical latency version is used to estimate the total communication delay in both architectures. General dormancy consists of three main components:
- Transmission delay
- Propagation delay
- Processing delay

Transmission Delay:

$$T_{tx} = \frac{Packet\ \ Size}{Data\ \ Rate} \qquad (1)$$

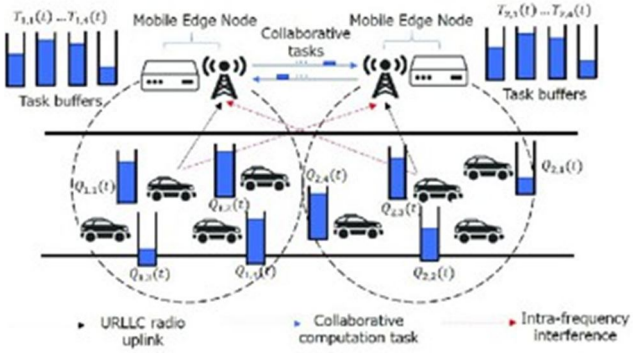


Fig. 3. Task offloading and collaborative processing among mobile edge nodes in a vehicular network.

$$T_{prop} = \frac{Distance}{Speed\ of\ Light} \qquad (2)$$

In the cloud-based architecture, the total latency is given by:

$$T_{cloud} = T_{uplink} + T_{backhaul} + T_{processing} + T_{downlink} \qquad (3)$$

In the MEC architecture, the latency is reduced because backhaul communication is eliminated:

$$T_{edge} = T_{V2I} + T_{edge\ processing} + T_{response} \qquad (4)$$

Since the edge server is located close to vehicles, the following relationship generally holds:

$$T_{edge} < T_{cloud} \qquad (5)$$

5) Simulation Workflow

The complete simulation methodology is shown in Figure 4. The whole workflow starts with vehicle mobility generation the use of SUMO, observed with task technology and communication with cloud or aspect servers.

6) Summary of Methodology

This method combines realistic vehicle mobility, or SUMO, and an analytical shared latency model created in Python. The method avoids the effects of backhaul and location variations, and offers a slight intrinsic evolution in latency achieved by means of deployment of MEC in independent V2X structures.

This structured approach ensures:

- Controlled comparison
- Reproducibility
- Clear isolation of architectural differences

IV. RESULTS AND DISCUSSION

In this section, the performance evaluation of the proposed MEC-based task offloading scheme in comparison to the baseline nearest RSU offloading scheme will be discussed. The simulation environment was developed using the SUMO traffic simulator, and Python was utilized to connect to the simulation

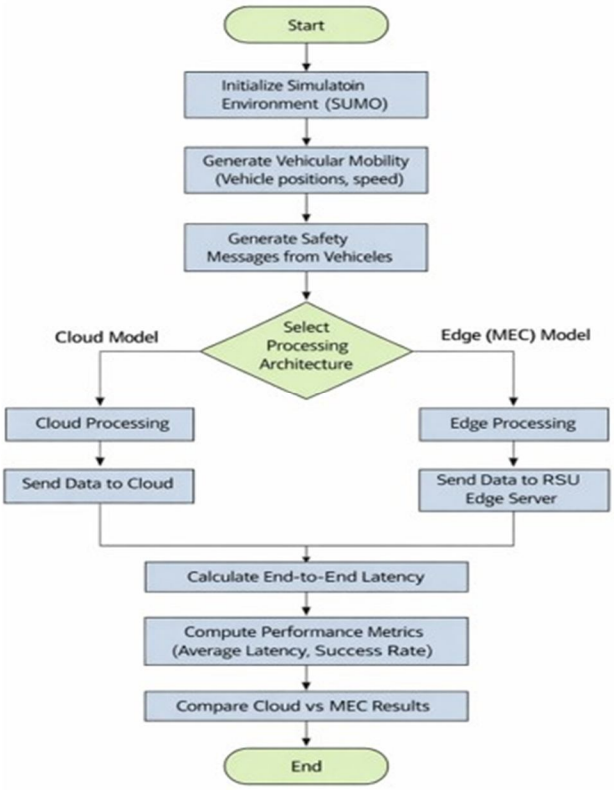


Fig. 4. Simulation workflow for latency evaluation in cloud-based and MEC-based V2X communication.

In this phase, the overall performance evaluation of the proposed MEC-based total mission offloading scheme in evaluation to the baseline closest RSU offloading scheme can be commented. The simulation environment became the overriding use of the SUMO page visitor simulation, and Python is used to connect to the simulation [10], [17].

A. Statistical Performance Analysis

The statistical performance evaluation between the baseline and the proposed MEC framework is provided in Fig. 5. The variety of vehicle tasks processed with the help of both architectures is the identical, but the latency metrics are significantly superior with the help of the proposed rule set.

The average quit-to-end delay changed to reduced from 1.38 seconds in the baseline device to 0.96 seconds inside the proposed architecture. This corresponds to an improvement of 30.2% in the reduction of stop-to-end procrastination

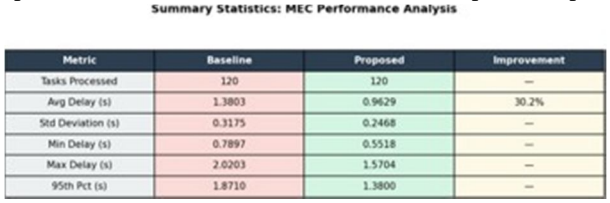


Fig. 5. Summary statistics comparing baseline and proposed MEC architec-tures.

TABLE I
SUMMARY STATISTICS: MEC PERFORMANCE ANALYSIS

Metric	Baseline	Proposed	Improvement
Tasks Processed	120	120	–
Avg Delay (s)	1.3803	0.9629	30.2%
Std Deviation (s)	0.3175	0.2468	–
Min Delay (s)	0.7897	0.5518	–
Max Delay (s)	2.0203	1.5704	–
95th Pct (s)	1.8710	1.3800	–

Deviations of stop-to-give-up postpone are additionally reduced from zero.3175 seconds to zero.2468 seconds. In the proposed device, the minimum and maximum quit-to-quit delays would have been additionally lower than the baseline system. These upgrades by reducing the braking delay using the proposed MEC-based vehicle computer architecture have also been mentioned in existing studies [17], [18].

B. Average Delay Comparison

Deviations of stop-to-give-up postpone are additionally reduced from zero.3175 seconds to zero.2468 seconds. In the proposed device, the minimum and maximum quit-to-quit delays would have been additionally lower than the baseline system. These upgrades by reducing the braking delay using the proposed MEC-based vehicle computer architecture have also been mentioned in existing studies.

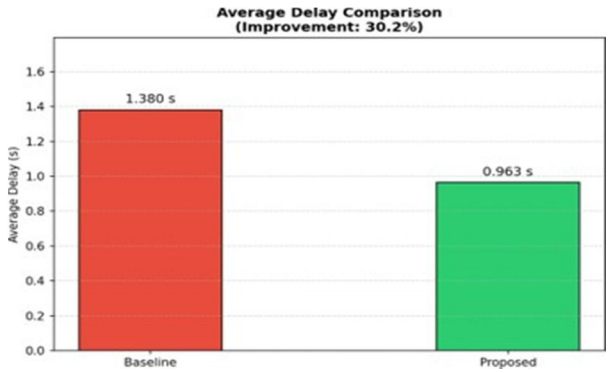


Fig. 6. Average end-to-end delay comparison between baseline and proposed MEC system.

The baseline system suffers from increased delays mainly due to congestion at heavily utilized RSUs, especially the RSUs that are positioned near the road intersection where different vehicular flows converge. However, the proposed Deviations of reserve-to-delivery-up delay are additionally reduced from 0.3175 seconds to zero.2468 seconds. In the proposed device, the minimum and maximum quit-to-end delays could be additionally lower than the base machine. These updates by lowering the brakes postpone the use of the proposed MEC-first based automotive laptop architecture have additionally been demonstrated in the current study . [19], [20].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

C. Task-Level Delay Analysis

To additionally look at the behavior of the device, the deployment of person commitments is given in Figure 7. This discern compares the quit-to-stop delay of the baseline and proposed algorithms for all processed commitments.

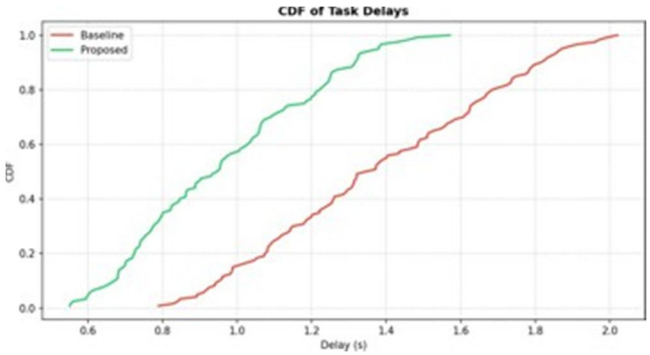


Fig. 7. End-to-end delay comparison for individual tasks under baseline and proposed MEC strategies

D. Delay Distribution Analysis

The cumulative distribution characteristic (CDF) of undergoing delays is proven in Figure eight. The CDF provides insight into the exposure distribution across all warranties addressed throughout the simulation.

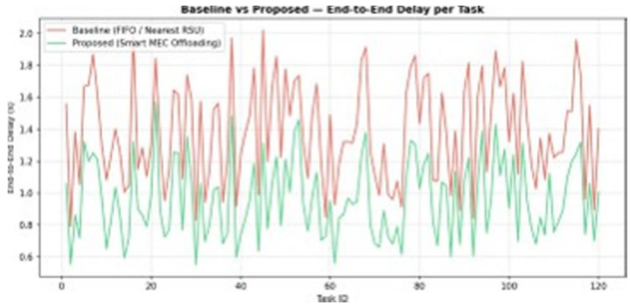


Fig. 8. Cumulative distribution function (CDF) of task delays for baseline and proposed MEC systems

As found, the CDF curve of the proposed scheme is shifted to the left compared to the baseline curve, indicating a reduced value of delay for all venture percentiles. It can also be determined that at the average cost or the fiftieth percentile, the proposed smart game plays faster compared to the baseline technique. Furthermore, a reduced charge for delay at the ninetieth percentile is found, indicating excessive reliability of proposed device for vehicular applications. Recent studies have proved that viable offloading strategies can be highly beneficial for latency and reliability in vehicular MEC [19], [20].

These results confirm that MEC-first based structure can effectively decorate the responsiveness and reliability of V2X communication systems, which is vital for protection applications in self-sufficient riding environments..

V. FUTURE SCOPE

A. Large-Scale Multi-RSU Deployment

For future work, it is necessary to validate and improve MEC-based V2X solutions by deploying a large number of RSUs in different cities and at various time of the day when traffic loads change and mobility patterns are different. The cooperation between different RSUs and balancing of their loads will make the system more scalable and able to handle more users and data traffice.

B. Integration with 5G and 6G

For destiny work, it is mile much essential to validate and beautify MEC-primarily based V2X solutions via implementing a huge variety of RSUs in specific cities and usually of the day while traveling loads of trade and mobility patterns are one in all a kind. The cooperation of distinctive RSUs and balancing their masses will make the system more scalable and able to manage higher customer and fact traffic..

VI. CONCLUSION

Self-driving motors need highly reliable and intermittent-latency communication for defense-essential applications such as emergency braking, hitting a pedestrian, and driving in a cooperative guy-ner. The traditional cloud-based totally Vehicle-to-Everything (V2X) structures are too latency heavy due to conversation through backhaul and middle networks. Therefore, they cannot help with real-time selection. This paper investigated the impact of Multi-Access Edge Computing (MEC) on latency in automotive oral exchange through automotive ad-hoc networks (VANETs). For vehicle motion modeling, SUMO changed to used, and Python changed to used for modeling latency, simulates the setup as compared to a cloud-primary based tool with an aspect computer gadget based on roadside gadgets (RSUs), where ten cars had been and sent to a protection fact.

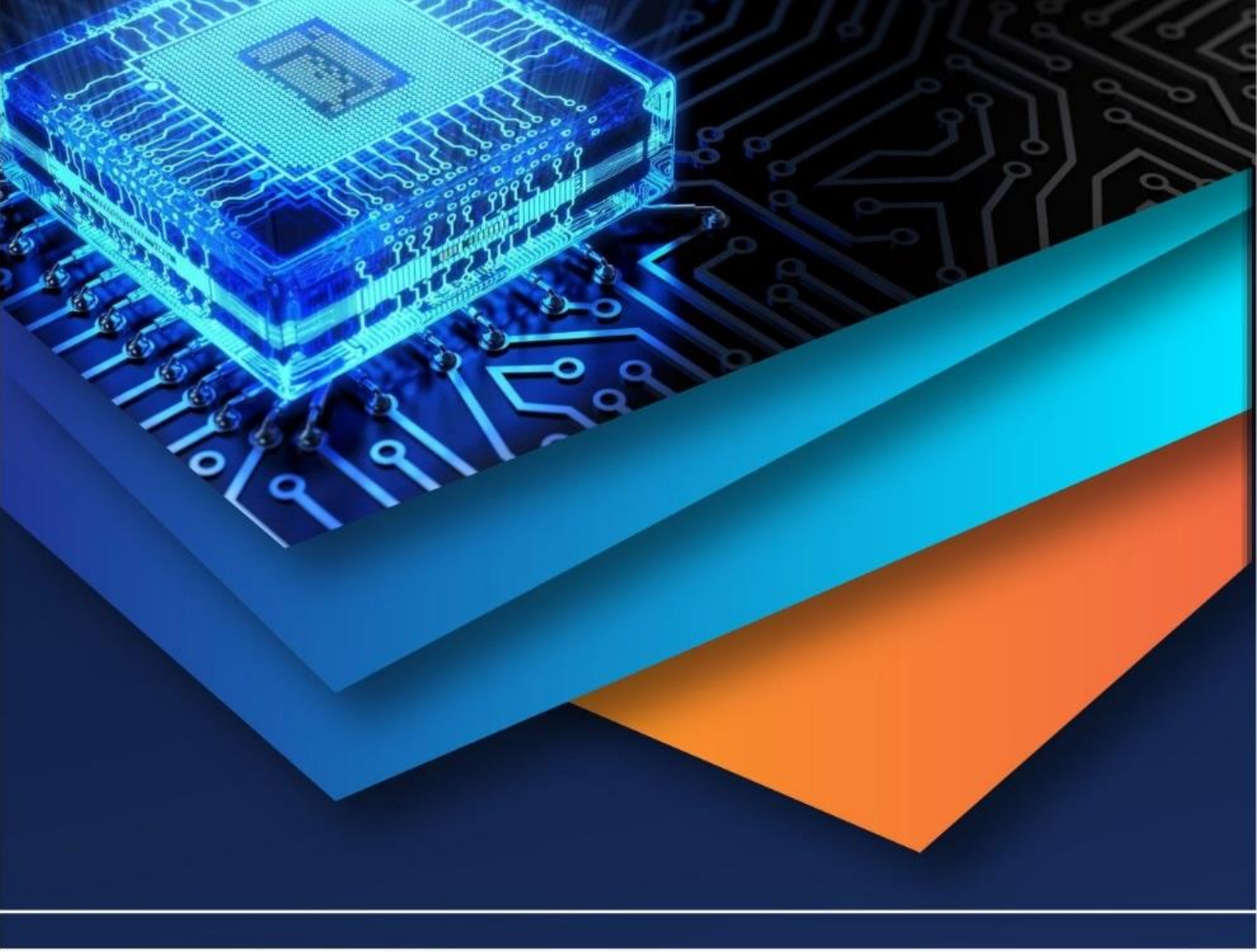
It appears deferred become greatly reduced through the target calculation-ing method due to fact records modified to be taken into the direction of the car. Because of this, the share of successful latency requirement pride went up These results screen that MEC is one of the main ingredients in the development of next-technology intelligent transportation systems with a view to relying on 5G NR-V2X and, in addition down the road, likely even 6G networks.

The transition from cloud processing that is fully centralized to V2X communication, this is supported by aspect nodes allocated, is the way forward, which in line with this study to real-time, reliable self-sufficiency using.

REFERENCES

[1] M. Kaur and P. Singh, "V2X communication systems: Architecture and applications," Springer Book Chapter, 2025.
[2] R. Zhang, K. Xiong, H. Du, D. Niyato, J. Kang, X. Shen, and H. V. Poor, "Generative AI-enabled vehicular networks: Fundamentals, framework, and case study," arXiv preprint arXiv:2304.11098, 2023.
[3] R. Hao et al., "Research challenges and progress in the end-to-end V2X cooperative autonomous driving competition," arXiv preprint arXiv:2507.21610, 2025.
[4] S. Zhang, H. Liu, and X. Shen, "Edge intelligence for autonomous vehicular networks: Architectures and applications," IEEE Internet of Things Journal, 2025.
[5] D. Wang, A. Qiu, Q. Zhou, and H. D. Schotten, "A survey on the role of artificial intelligence and machine learning in 6G-V2X applications," arXiv preprint arXiv:2506.09512, 2025.
[6] Y. Mao, C. You, J. Zhang, K. Huang, and K. B. Letaief, "Mobile Edge Computing: Survey and Research Outlook," IEEE Communications Surveys & Tutorials, vol. 19, no. 4, pp. 2322–2358, 2017.
[7] T. Taleb, K. Samdanis, B. Mada, H. Flinck, S. Dutta, and D. Sabella, "On Multi-Access Edge Computing: A Survey of the Emerging 5G Network Edge Architecture and Orchestration," IEEE Communications Surveys & Tutorials, vol. 19, no. 3, pp. 1657–1681, 2017.
[8] F. Marzuk, A. Vejar, and P. Chołda, "Deep reinforcement learning for energy-efficient 6G V2X networks," Electronics, vol. 14, no. 6, p. 1148, 2025.
[9] X. Hou, Y. Li, M. Chen, D. Wu, D. Jin, and S. Chen, "Vehicular Fog Computing: A Viewpoint of Vehicles as the Infrastructures," IEEE Transactions on Vehicular Technology, vol. 65, no. 6, pp. 3860–3873, 2016.
[10] Y. Li, Z. Chen, and M. Gerla, "Adaptive network selection for latency-aware V2X systems under varying network and vehicle densities," IEEE Transactions on Intelligent Transportation Systems, 2025.
[11] X. Liu, H. Zhang, and Y. Wang, "Sequential task assignment and resource allocation in V2X-enabled mobile edge computing," IEEE Internet of Things Journal, 2025.
[12] J. Park and S. Kim, "Architecture optimization for dense vehicular communication networks," Vehicular Networks, ScienceDirect, 2026.
[13] P. Krajzewicz, J. Erdmann, M. Behrisch, and L. Bieker, "Recent Devel-opment and Applications of SUMO – Simulation of Urban Mobility," International Journal on Advances in Systems and Measurements, vol. 5, no. 3–4, pp. 128–138, 2012.
[14] M. Chen, Y. Hao, L. Hu, K. Huang, and V. C. M. Leung, "Edge Artificial Intelligence for 6G: Vision, Enabling Technologies, and Applications," IEEE Communications Surveys & Tutorials, vol. 24, no. 1, pp. 144–180, 2022.
[15] K. Wang, Y. Wang, and X. Li, "Latency-aware task offloading for edge-based vehicular networks," IEEE Access, 2025.
[16] C. Zhao, X. Yue, M. Chen, G. Wang, and T. Wang, "Load-Aware Multi-Task Offloading Strategy Based on Optimal Stopping Theory in Mobile Edge Computing," Intelligent and Converged Networks, vol. 6, no. 3, pp. 234–246, 2025.
[17] J. Bo and X. Zhao, "Vehicle Edge Computing Task Offloading Strategy Based on Multi-Agent Deep Reinforcement Learning," Journal of Grid Computing, vol. 23, no. 1, 2025.
[18] W. Zhou, H. Li, and Z. Chen, "Deep Reinforcement Learning Based Task Offloading for Vehicular Edge Computing Networks," Vehicular Communications, 2025.
[19] F. Zeng, Y. Liu, and Z. Chen, "Task Offloading Delay Minimization in Vehicular Edge Computing Networks," Digital Communications and Networks, 2025.
[20] Y. Wu, H. Chen, and X. Shen, "Intelligent Offloading Balance for Vehicular Edge Computing Networks," IEEE Transactions on Intelligent Transportation Systems, 2025.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)