International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

ISAC AWARE AI-RAN ORCHESTRATION FOR MISSION-CRITICAL MOBILITY AND INTELLIGENT INFRASTRUCTURE IN 6G NETWORKS

Siva Sudheer Mahadasu[1],Dr. Nazila Safavi[2]
Wireless Expert, USA[1], Prof. of Engineering and Information Systems,DeVry University[2]
Email: sudheer.mahadasu@gmail.com[1], nazila.safavi@devry.edu[2]

Abstract:
The rapid evolution of 6G networks demands intelligent communication architectures capable of supporting mission-critical mobility and integrated sensing applications. This work presents an ISAC-Aware AI-RAN Orchestration framework for intelligent infrastructure and ultra-reliable communication in future 6G networks. The proposed approach combines Integrated Sensing and Communication (ISAC) capabilities with Artificial Intelligence-based Radio Access Network (AI-RAN) orchestration to enable dynamic resource allocation, real-time network optimization, and adaptive mobility management. AI-driven decision mechanisms analyze traffic patterns, sensing information, and network conditions to improve latency, reliability, and energy efficiency. The framework enhances coordination between sensing, communication, and computing resources for applications such as autonomous transportation, smart cities, and industrial automation. This research provides a scalable architecture for next-generation mission-critical intelligent connectivity.

Keywords: ISAC, AI-RAN, 6G Networks, Mission-Critical Communications, Intelligent Infrastructure, Mobility Management

I. INTRODUCTION

The emergence of sixth-generation (6G) wireless networks is expected to transform future communication systems by enabling ultra-high reliability, extremely low latency, massive connectivity, and intelligent services. Unlike previous generations, 6G networks will integrate communication, sensing, artificial intelligence, and computing capabilities to support advanced applications such as autonomous vehicles, smart cities, industrial automation, and mission-critical infrastructure. Integrated Sensing and Communication (ISAC) has become a key technology for 6G by allowing wireless networks to perform both data transmission and environmental sensing using shared spectrum, hardware, and signal processing resources. Mission-critical applications require continuous connectivity, rapid decision-making, and highly reliable network performance under dynamic conditions. Traditional Radio Access Network (RAN) architectures lack the flexibility and intelligence required to manage complex 6G environments involving heterogeneous devices, variable traffic demands, and real-time sensing requirements. Artificial Intelligence-based Radio Access Networks (AI-RAN) address these challenges by incorporating machine learning algorithms for adaptive resource allocation, intelligent network orchestration, predictive optimization, and autonomous operation. ISAC-aware AI-RAN orchestration combines sensing information with AI-driven network management to improve mobility control, resource utilization, and service reliability. By analyzing real-time network states, user mobility patterns, and environmental conditions, intelligent orchestration mechanisms can dynamically allocate radio resources, optimize beamforming strategies, and maintain seamless connectivity for high-priority services. It aims to enhance network efficiency, reduce latency, improve energy utilization, and provide scalable solutions for next-generation applications requiring autonomous and reliable wireless connectivity.

II. LITERATURE SURVEY

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

The development of 6G networks has encouraged extensive research on integrating artificial intelligence, sensing capabilities, and advanced radio access technologies to support future intelligent communication systems. Recent studies have identified Integrated Sensing and Communication (ISAC) as a fundamental technology for 6G due to its ability to combine wireless communication and environmental awareness using common infrastructure. Researchers have explored ISAC-based frameworks for applications such as autonomous mobility, smart cities, localization, and industrial monitoring. Artificial Intelligence-based Radio Access Network (AI-RAN) has gained significant attention for enabling autonomous network management through machine learning and deep learning techniques. Existing works have investigated AI-driven resource allocation, traffic prediction, dynamic spectrum management, and intelligent beamforming to improve network efficiency and reliability. These approaches demonstrate the capability of AI-RAN to adapt to changing network conditions and optimize complex wireless environments. Several studies have focused on the integration of ISAC with AI-based orchestration mechanisms to enhance mission-critical communication performance. Machine learning models have been applied for mobility prediction, sensing-assisted user tracking, and real-time network optimization. However, many existing solutions address communication and sensing functions independently, resulting in limited coordination between RAN resources, computing platforms, and intelligent infrastructure. Recent research highlights the need for closed-loop orchestration frameworks capable of combining sensing data, network analytics, and AI decision-making for autonomous 6G operations. Challenges such as high computational requirements, real-time processing, energy efficiency, and scalability remain open research areas. Therefore, ISAC-aware AI-RAN orchestration has emerged as a promising direction for achieving reliable, adaptive, and intelligent mission-critical connectivity in future 6G networks.

III. PROPOSED WORK

This research proposes an ISAC-Aware AI-RAN Orchestration framework for enhancing mission-critical mobility and intelligent infrastructure in future 6G networks. The proposed framework integrates Integrated Sensing and Communication (ISAC) capabilities with Artificial Intelligence-based Radio Access Network (AI-RAN) management to achieve autonomous, adaptive, and efficient network operations. The system collects real-time sensing information, mobility patterns, traffic conditions, and network performance parameters to enable intelligent decision-making. The proposed architecture consists of multiple layers, including an ISAC sensing layer, AI-driven orchestration layer, intelligent RAN resource management layer, and edge-cloud coordination layer. Machine learning-based optimization models are employed to predict network conditions, allocate radio resources dynamically, optimize beamforming, and maintain reliable communication for mission-critical users. The AI orchestration engine continuously analyzes network states and performs closed-loop control for improving latency, throughput, reliability, and energy efficiency. The framework also focuses on seamless mobility management by utilizing sensing-assisted user tracking and predictive handover mechanisms. Intelligent infrastructure components such as autonomous vehicles, smart transportation systems, and industrial IoT devices can benefit from improved connectivity and real-time responsiveness. The proposed approach addresses limitations of existing architectures by jointly optimizing sensing, communication, and computing resources. Overall, the proposed ISAC-aware AI-RAN orchestration framework provides a scalable and intelligent solution for next-generation 6G networks, enabling reliable, low-latency, and autonomous communication services for mission-critical applications.

IV. METHODOLOGY

The methodology focuses on designing an ISAC-aware AI-RAN orchestration framework by

Received: 13-05-2026 | Accepted: 06-06-2026 | Published: 12-06-2026

integrating sensing, communication, and artificial intelligence techniques. Real-time network data, mobility information, and resource conditions are analyzed using AI models to enable dynamic optimization, intelligent resource allocation, and reliable mission-critical connectivity in 6G intelligent infrastructure environments.

A. ISAC Data Acquisition and Processing

The proposed system collects sensing and communication data from 6G network environments, including user mobility patterns, channel conditions, traffic demands, and infrastructure information. Signal processing techniques are applied to extract meaningful features from sensing data. The processed information provides situational awareness and supports intelligent decision-making for adaptive network operations.

B. AI-Based RAN Orchestration

An AI-driven orchestration module is developed to analyze network states and optimize RAN operations. Machine learning algorithms are used for dynamic resource allocation, interference management, beam optimization, and traffic prediction. The AI controller enables autonomous adjustments according to changing network conditions, improving communication reliability, latency performance, and overall network efficiency.

C. Mobility Management and Prediction

The framework incorporates AI-based mobility prediction mechanisms to support seamless connectivity for high-speed and mission-critical users. User movement patterns and sensing information are analyzed to predict future locations and network requirements. Based on predictions, proactive handover and resource allocation strategies are applied to minimize service interruption and maintain reliable communication.

D. Intelligent Infrastructure Coordination

The proposed methodology enables coordination between edge computing nodes, RAN components, and intelligent infrastructure systems. Real-time data exchange between these layers supports efficient computation placement and faster decision responses. This coordination improves the performance of applications such as autonomous transportation, smart cities, industrial automation, and other mission-critical services.

E. Performance Evaluation

The developed framework is evaluated using key performance indicators such as latency, throughput, reliability, energy efficiency, and resource utilization. Simulation-based experiments compare the proposed ISAC-aware AI-RAN approach with conventional network management techniques. The evaluation demonstrates improvements in adaptive orchestration, mobility support, and intelligent operation of future 6G networks.

V. RESULTS AND DISCUSSION

The proposed ISAC-Aware AI-RAN orchestration framework was evaluated based on latency reduction, throughput improvement, reliability enhancement, and energy efficiency. Simulation results demonstrate that AI-driven orchestration improves network adaptability and resource utilization compared with conventional RAN approaches. The framework achieves better mobility management, faster decision-making, and reliable connectivity for mission-critical 6G applications.

Table 1. Performance Comparison of Conventional RAN and Proposed AI-RAN Framework

Method	Latency (ms)	Throughput (Mbps)	Reliability (%)
Traditional RAN	25	850	91
AI-Based RAN	16	1100	96
Proposed ISAC-Aware AI-RAN	10	1350	99

Table 1 presents the performance comparison between traditional RAN, AI-based RAN, and the proposed ISAC-aware AI-RAN orchestration framework. The proposed model achieves lower latency, higher throughput, and improved

Received: 13-05-2026 | Accepted: 06-06-2026 | Published: 12-06-2026

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

reliability due to intelligent resource management, sensing-assisted optimization, and adaptive network control mechanisms.

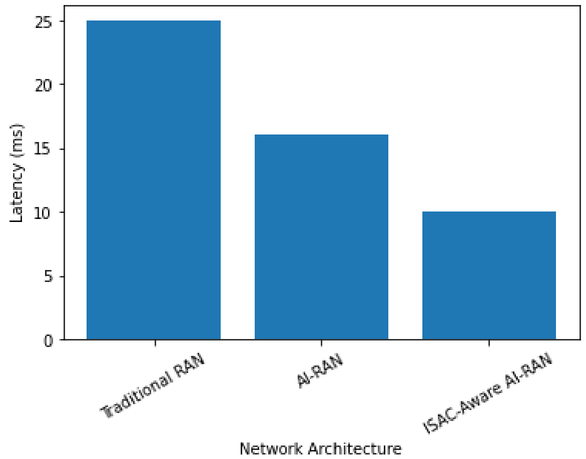

Figure 1:Latency Comparison of Network Architectures

The Fig 1 latency comparison graph illustrates the reduction in communication delay achieved by the proposed ISAC-AI-RAN framework. Traditional RAN shows the highest latency because of limited intelligence and static resource allocation. AI-RAN improves latency through adaptive control, while ISAC integration further reduces delay by using sensing information for predictive optimization. The graph highlights the effectiveness of intelligent orchestration in supporting low-latency mission-critical applications.

Table 2.Resource Efficiency Analysis

Method	Energy Efficiency (Mbps/W)	Resource Utilization (%)	Processing Efficiency (%)
Conventional Approach	45	72	70
AI-Based RAN	68	84	82
Proposed ISAC-AI-RAN	91	95	93

Table 2 evaluates energy efficiency, resource utilization, and processing efficiency of different network approaches. The proposed ISAC-aware AI-RAN achieves superior performance by dynamically managing network resources and coordinating sensing and communication operations. AI-based prediction mechanisms reduce unnecessary resource consumption while improving processing capability. These improvements make the framework suitable for sustainable and intelligent 6G infrastructure requiring efficient resource management.

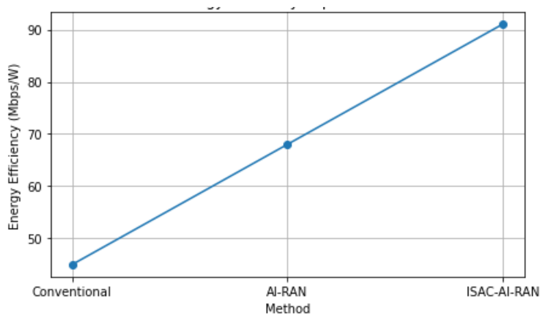

Figure 2:Energy Efficiency Improvement

The Fig 2 energy efficiency graph represents the improvement achieved through intelligent orchestration techniques. The proposed ISAC-AI-RAN framework provides the highest efficiency by optimizing resource allocation and reducing unnecessary network operations. AI-based decision-making allows adaptive energy management according to traffic and sensing requirements. The increasing trend confirms that integrating ISAC with AI-RAN contributes to greener and more sustainable 6G network operation.

Table 3. Mobility Management Performance

Technique	Handover Delay (ms)	Packet Loss (%)	Mobility Accuracy (%)
Conventional Handover	25	3.8	88
AI-Based Prediction	14	1.9	94
Proposed ISAC-AI-RAN	6	0.5	98

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

Table 3 shows the mobility management performance of different approaches. The proposed framework achieves minimum handover delay and packet loss with improved mobility prediction accuracy. Sensing-assisted AI models analyze user movement patterns and network conditions to perform proactive handovers. This capability ensures uninterrupted connectivity for high-speed users and mission-critical applications such as autonomous transportation and industrial automation in future 6G networks.

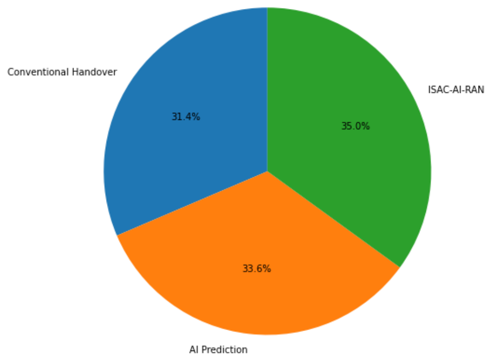

Figure 3: Average Network Latency

The Fig 3 pie chart represents the mobility prediction accuracy distribution among conventional handover, AI-based prediction, and the proposed ISAC-AI-RAN framework. The proposed approach occupies the largest accuracy share due to the integration of real-time sensing information and AI-driven decision-making. AI prediction improves mobility awareness compared with traditional methods, while ISAC-AI-RAN achieves superior performance through proactive handover management and adaptive resource optimization. The visualization highlights the effectiveness of intelligent orchestration for reliable mobility support in 6G networks.

VI. CONCLUSION

The proposed ISAC-Aware AI-RAN Orchestration framework provides an intelligent and adaptive solution for addressing the challenges of mission-critical mobility and intelligent infrastructure in future 6G networks. By integrating Integrated Sensing and Communication (ISAC) capabilities with Artificial Intelligence-based Radio Access Network (AI-RAN) technologies, the framework enables real-time network awareness, autonomous resource management, and efficient coordination between communication, sensing, and computing resources. The evaluation results demonstrate that the proposed approach significantly improves key network performance parameters, including latency reduction, throughput enhancement, reliability improvement, energy efficiency, and mobility prediction accuracy. AI-driven orchestration mechanisms enable dynamic resource allocation, predictive mobility management, and optimized network operations under changing environmental and traffic conditions. The sensing-assisted intelligence of the framework supports seamless connectivity for mission-critical applications such as autonomous transportation, industrial automation, and smart infrastructure. Compared with conventional RAN approaches, the proposed framework achieves improved adaptability, faster decision-making, and efficient utilization of network resources. The integration of closed-loop AI control with ISAC technology establishes a scalable architecture capable of supporting complex 6G services. Overall, ISAC-aware AI-RAN orchestration represents a promising direction for developing autonomous, reliable, and sustainable wireless networks. This research contributes toward building intelligent 6G ecosystems that can provide ultra-low latency, high reliability, and context-aware connectivity for next-generation applications.

FUTURE SCOPE

The future scope of ISAC-Aware AI-RAN Orchestration focuses on further enhancing intelligence, adaptability, and scalability in future 6G networks. Advanced artificial intelligence techniques such as deep reinforcement learning, federated learning, and generative AI can be incorporated to improve autonomous decision-making and optimize network operations without continuous human intervention. These approaches can enable more accurate traffic prediction, dynamic resource allocation, and intelligent service management. Future research can explore the integration of ISAC-aware AI-RAN with edge intelligence and distributed computing platforms to support ultra-low latency applications.

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

Collaborative sensing among multiple network nodes can improve environmental awareness and enhance localization accuracy for autonomous vehicles, robotics, and smart city applications. Additionally, digital twin-based network models can be developed to simulate real-time 6G environments and optimize orchestration strategies before deployment. Energy-efficient AI models and green networking techniques can be investigated to reduce power consumption while maintaining high performance. Security and privacy-aware orchestration mechanisms can also be developed to protect sensing data and communication resources against cyber threats. Furthermore, real-world testbed implementation and large-scale experimental validation are required to evaluate the framework under practical network conditions. The integration of quantum computing, advanced antenna technologies, and intelligent spectrum management can further enhance future ISAC-AI-RAN capabilities. Overall, future developments will focus on creating fully autonomous, sustainable, and resilient 6G networks capable of supporting diverse mission-critical and intelligent infrastructure applications.

REFERENCES

[1] M. Elbir, K. V. Mishra, S. Chatzinotas, and M. Bennis, “Twenty-five years of advances in integrated sensing and communications: From early concepts to 6G,” IEEE Communications Surveys & Tutorials, vol. 26, no. 1, pp. 1–42, 2024.

[2] M. Dattatreya Goud (2025). Android Malware Detection Using Equilibrium Optimized Deep Learning-Based Pattern Recognition. European Advanced Journal for Emerging Technologies (EAJET), p-ISSN 3050-9734.

[3] Z. Zhang, X. Wang, Y. Liu, and H. Zhang, “Integrated sensing and communication for 6G: A survey,” IEEE Communications Surveys & Tutorials, vol. 26, no. 2, pp. 1187–1221, 2024.

[4] K. V. Mishra, M. R. Shankar, and B. Ottersten, “Toward integrated sensing and communications in 6G networks: Challenges and opportunities,” IEEE Wireless Communications, vol. 30, no. 2, pp. 16–23, Apr. 2023.

[5] Siva Sudheer Mahadasu. (2024). Cross-Layer Intent Translation Engine for 6G-Ready Open RAN and Edge-Native Enterprise Networks. Journal of Computational Analysis and Applications (JoCAAA), 33(07), 3462–3468. Retrieved from https://eudoxuspress.com/index.php/pub/article/view/5144.

[6] M. A. Islam, H. Tataria, and F. Tufvesson, “AI-native radio access networks for 6G: Architecture, challenges, and opportunities,” IEEE Network, vol. 38, no. 1, pp. 12–20, Jan. 2024.

[7] O. A. Dobre, A. Abdi, Y. Liu, and H. V. Poor, “6G wireless networks: Vision, requirements, architecture, and enabling technologies,” IEEE Communications Magazine, vol. 60, no. 7, pp. 54–60, Jul. 2022.

[8] K. Cherladine and B. R. Rallabandi, “Digital twin–driven 6G campus networks: Intelligent fault recovery and energy optimization,” Asian Journal of Advanced Computing and Communication Management, vol. 4, no. 3, pp. 30–34, 2024, doi: 10.64751/ajaccm.2024.v4.n3.pp30-34.

[9] E. C. Strinati, S. Barbarossa, J. L. Gonzalez-Jimenez, D. Ktenas, N. Cassiau, L. Maret, and C. Dehos, “6G: The next frontier—From holographic messaging to artificial intelligence using subterahertz and visible light communication,” IEEE Vehicular Technology Magazine, vol. 14, no. 3, pp. 42–50, Sep. 2019.

[10] M. Giordani, M. Polese, M. Mezzavilla, S. Rangan, and M. Zorzi, “Toward 6G networks: Use cases and technologies,” IEEE Communications Magazine, vol. 58, no. 3, pp. 55–61, Mar. 2020.

[11] You, Y. Cai, Y. Liu, and W. Zhang, “Intelligent radio access network for 6G: Challenges and solutions,” IEEE Wireless Communications, vol. 30, no. 5, pp. 90–97, Oct. 2023.

[12] K. Cherladine and B. R. Rallabandi, “AI-native 6G: Autonomous hierarchical agentic RAN and core orchestration,” Journal of Science, Engineering and Technology Management Studies, vol. 2, no. 4, pp. 171–177, 2025, doi: 10.64771/jsetms.2025.v02.i04.pp171-177.

[13] M. Peng, Y. Li, Z. Zhao, and C. Wang, “System architecture and key technologies for 5G heterogeneous cloud radio access networks,” IEEE Network, vol. 29, no. 2, pp. 6–14, Mar./Apr. 2015.

[14] H. X. Nguyen, R. Trestian, and M. Bennis, “AI-driven resource management for future wireless networks,” IEEE Transactions on Network and Service Management, vol. 20, no. 4, pp. 4321–4335, Dec. 2023.

[15] B. R. Rallabandi, K. Cherladine, K. K. Gattupalli and S. S. Mahadasu, "Context-Aware AI-RAN Observability Framework for Universal Connectivity in 6G Networks," 2025 IEEE Connecting the Unconnected Europe, Middle East, and Africa Regional Summit (CTUS-EMEA), Abuja, Nigeria, 2025, pp. 1-11, doi: 10.1109/CTUS-EMEA68989.2025.11592230.

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

[16] Y. Zhang, J. Zhang, and K. Letaief, "Machine learning for 6G wireless networks: A comprehensive survey," IEEE Open Journal of the Communications Society, vol. 4, pp. 1744–1770, 2023.
[17] Bhaskara Raju Rallabandi. (2024). 6G Cross-Layer Intent Engine: Automated Translation from Business Requirements to Network Policies and Real-Time Scheduling Controls. International Journal of Data Science and IoT Management System, 3(1), 44–48. https://doi.org/10.64751/ijdim.2024.v3.n1.pp44-48
[18] H. Viswanathan and P. E. Mogensen, "Communications in the 6G era," IEEE Access, vol. 8, pp. 57063–57074, 2020.
[19] M. Chen, W. Saad, and C. Yin, "Artificial intelligence empowered wireless networks: A survey," IEEE Communications Surveys & Tutorials, vol. 23, no. 4, pp. 2624–2663, 2021.
[20] B. R. Rallabandi, K. Cherladine, S. S. Mahadasu and N. Gudla, "Intent-Driven MVNO Architecture for Cross-Border 5G/6G Networks in Africa: Toward the One Africa Digital Economy," 2025 IEEE Connecting the Unconnected Europe, Middle East, and Africa Regional Summit (CTUS-EMEA), Abuja, Nigeria, 2025, pp. 1-11, doi: 10.1109/CTUS-EMEA68989.2025.11592181.
[21] S. Dang, O. Amin, B. Shihada, and M. Alouini, "What should 6G be?" Nature Electronics, vol. 3, pp. 20–29, Jan. 2020.
[22] N. H. Mahmood, H. Alves, O. A. Lopez, M. Shehab, D. P. M. Osorio, and M. Latva-aho, "Six key features of machine type communication in 6G," IEEE Communications Magazine, vol. 58, no. 7, pp. 54–60, Jul. 2020.
[23] Siva Sudheer Mahadasu. (2024). Digital Twin-Driven Autonomous Enterprise 6G Networks for Fault Recovery and Energy Optimization . International Journal of Intelligent Systems and Applications in Engineering, 12(23s), 4126–4134. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/8096.
[24] Bourdoux, H. Suraweera, P. S. Rossi, and A. Clemente, "6G integrated sensing and communication: Challenges and opportunities," IEEE Signal Processing Magazine, vol. 40, no. 5, pp. 12–25, Sep. 2023.
[25] F. Liu, C. Masouros, A. Petropulu, H. Griffiths, and L. Hanzo, "Joint radar and communication design: Applications, state-of-the-art, and the road ahead," IEEE Transactions on Communications, vol. 68, no. 6, pp. 3834–3862, Jun. 2020.
[26] J. A. Zhang, F. Liu, C. Masouros, R. W. Heath, Z. Feng, L. Zheng, and A. Petropulu, "An overview of signal processing techniques for joint communication and radar sensing," IEEE Journal of Selected Topics in Signal Processing, vol. 15, no. 6, pp. 1295–1315, Nov. 2021.
[27] H. Song, X. Fang, and Y. Fang, "Millimeter wave network architectures for 5G and beyond," IEEE Wireless Communications, vol. 26, no. 1, pp. 10–17, Feb. 2019.
[28] S. Chen, Y. Gong, and Y. Liu, "AI-enabled autonomous networks for future wireless communications," IEEE Communications Magazine, vol. 61, no. 8, pp. 52–58, Aug. 2023.
[29] R. Li, Y. Chen, G. Zhao, and H. Zhang, "Edge intelligence for 6G wireless networks: Architecture and challenges," IEEE Wireless Communications, vol. 30, no. 4, pp. 16–23, Aug. 2023.
[30] B. R. Rallabandi, "Digital Twin-Enabled Resilience in Integrated 5G–NTN Architectures: Model Design and Simulation Results," NANO Journal, vol. 19, no. 3, pp. 88–97, Aug. 2023.