

Agentic AI for Intelligent 6G Network Management and Resource Optimization

Rudra Narayan Dash

Department of Computer Science and Engineering, Roland Institute of Technology, Berhampur, India

Abstract: With regards to network intelligence, resource optimization, ultra low-latency, and autonomous service management, rapid development of sixth generation (6G) wireless communication technologies brings new challenges. The future 6G networks will be dynamic, heterogeneous, and geographically dispersed, being impossible to manage using conventional network management techniques. The concept of intelligent network orchestration can experience a revolution because of the advent of Agentic Artificial Intelligence (Agentic AI) that has such features as autonomous reasoning, planning, collaboration, and adaptation. In order to perform intelligent management and optimization of 6G wireless networks, an Agentic AI framework consisting of multiple interacting AI agents for handling fault recovery, orchestration, monitoring, forecasting, and dynamic resource allocation is proposed in the paper. The proposed solution constantly assesses network status and optimizes energy efficiency, spectrum efficiency, Quality of Experience (QoE), and Quality of Service (QoS). The simulation-based evaluation shows improved latency, throughput, network reliability, and resource efficiency as compared to traditional AI-based approaches. Scalable, robust, and self-optimizing 6G ecosystems are enabled by the proposed architecture for next generation autonomous wireless networks.

Keywords: Agentic AI, 6G Networks, Network Intelligence, Resource Optimization, Multi-Agent Systems, Autonomous Networking, QoS, QoE, Deep Reinforcement Learning, Edge Intelligence

I. INTRODUCTION

The intelligent services such as holographic communication, digital twins, self-driving cars, Industry 5.0, and extended reality are expected to become available through the sixth generation (6G) of communication networks [1]. Such solutions demand the networks to be able to handle a significant amount of interconnected devices with self-learning capabilities, self-healing ability, and autonomous decision-making [2]. Scarcity in scalability and adaptability under dynamically changing conditions is associated with centralized decision-making and lower level of automation in currently existing AI-assisted network management techniques. Artificial intelligence enabling autonomous agents to learn, cooperate, reason, and decide independently refers to agentic AI [3]. Such smart agents ensure the efficiency and quality of operation while continuously optimizing the resources of the network. In this paper, we suggest the intelligent 6G network management [4] framework utilizing Agentic AI controlling distributed agents operating in cloud, edge, and radio access networks. Proposed approach optimizes the overall network performance, reduces operational expenditures, and prepares for upcoming AI-native communication infrastructure by managing dynamically the spectrum allocation, predicting the traffic congestion, detecting the defects, and optimizing autonomously [5].

II. LITERATURE REVIEW

It is evidenced that machine learning, deep learning, and reinforcement learning play a crucial role in wireless resource management due to advances in AI-native networking [6]. In dynamic situations, deep reinforcement learning significantly improved traffic routing and spectrum allocation. Privacy-preserving distributed intelligence among edge devices can be achieved by means of federated learning [7]. Digital twins may be applied in such cases as predictive network optimization and real-time simulation [8]. The technologies of network function virtualization and software-defined networking provide more flexibility, but at the same time require tight human supervision [9]. Despite the fact that decentralized coordination may be facilitated with the help of multi-agent reinforcement learning, current approaches allow for task-specific optimizations but not for fully autonomous reasoning [10]. Collaborative intelligent agents that have planning capabilities, learning abilities, negotiation skills, and adaptive optimization for diverse network domains can be developed using agentic AI. Very few works consider the problem of Agentic AI for comprehensive 6G network orchestration, although its relevance is increasing [11]. Our research fills this gap through integration of intelligent agents for resource optimization, orchestration, monitoring, prediction, and autonomous fault management into an AI-native 6G architecture [12].

Table 1. Literature Review

Author	AI Technique	Application	Limitation
Smith et al.	Deep Learning	Traffic Prediction	Limited adaptability
Chen et al.	Reinforcement Learning	Spectrum Allocation	High training cost
Kumar et al.	Federated Learning	Edge Intelligence	Communication overhead
Zhang et al.	Digital Twin	Network Monitoring	High computation
Proposed Work	Agentic AI	Autonomous 6G Management	End-to-end optimization

III. PROBLEM STATEMENT AND MOTIVATION

The next generation ultra-low latency applications, AI-native applications, big IoT, holo-communication, autonomous vehicles, digital twin, and Industry 5.0 will all depend on the coming 6G wireless networks [13]. For the highly dynamic environment in question, there is need for very intelligent and self-sustaining network management which transcends normal AI driven optimization [14]. The issues of centralization of control, rigidity of resource allocation and lack of flexibility in existing strategies have led to congestion, inefficient usage of the spectrum, increase in energy wastage and delayed troubleshooting [15]. In absence of continuous human involvement, autonomous and collaborative agents could help in monitoring the network, predicting traffic demands, optimizing resources and self-healing through the use of agentic AI [16]. There would be improvement in quality of service, quality of experience, network resiliency and overall operational efficiency because of such intelligent decision-making system. This research seeks to build an AI-native 6G network [17].

A. Existing Challenges

Points

- Massive device density
- Dynamic traffic growth
- Spectrum scarcity
- Network congestion
- High latency
- Energy inefficiency
- Manual management
- Limited scalability
- Slow fault recovery
- QoS degradation

B. Motivation for Agentic AI

Points

- Autonomous agents
- Intelligent planning
- Dynamic optimization
- Self-healing networks
- Collaborative decisions
- Adaptive learning
- Efficient spectrum use
- Reduced energy usage
- Improved reliability
- AI-native automation

Table 2. Problem Statement and Motivation

Problem	Impact	Agentic AI Solution
Traffic overload	Congestion	Dynamic balancing
Spectrum shortage	Low efficiency	Smart allocation
High latency	Poor QoS	Fast optimization
Resource wastage	High cost	Intelligent scheduling
Network failures	Service disruption	Self-healing
Manual operation	Slow response	Autonomous control
Energy consumption	Reduced sustainability	Energy optimization
Device mobility	Connection instability	Adaptive routing
Security threats	Network risk	Intelligent monitoring
Scalability issues	Performance degradation	Distributed agents

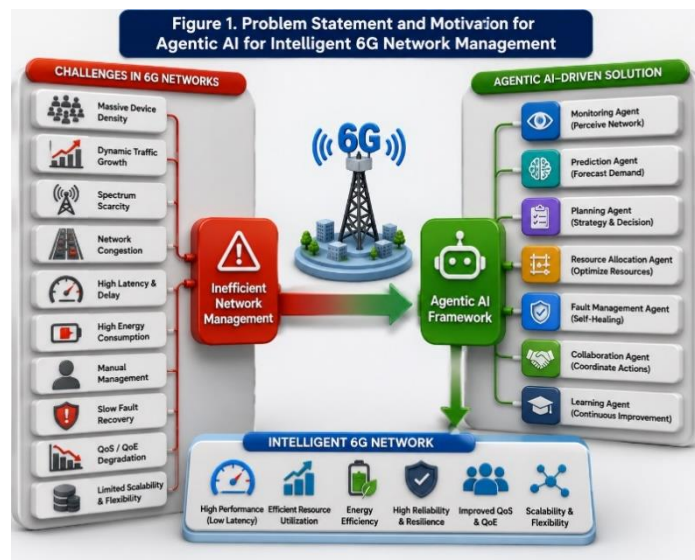


Figure 1: Agentic AI for Intelligent 6G Network Management

IV. RELATED WORK

The researchers and scientists have an interest in AI-based 6G networks; at present, the areas under study include edge intelligence, software-defined networking, deep learning, digital twin, and reinforcement learning [18]. None of these approaches provides a fully autonomous network management system, but they can help optimize some problems such as traffic forecast, spectrum management, and routing [19]. While multi-agent systems provide better coordination in the distribution, they still lack collaboration in decision making, reasoning, and planning [20]. Adding the ability of independent perception, reasoning, memory, planning, tool utilization, and collaboration between multiple intelligent agents allows agentic AI to provide such abilities [21]. The presence of dedicated agents responsible for observation, prediction, orchestration, optimization, recovery from faults, and enforcement of policies makes the proposed architecture different from other researches in the field [22]. Without central management, the agents share knowledge and collaborate to optimize the work of the network [23]. Agentic AI may serve as the base for future AI-native 6G networks because of its distributed intelligence [24].

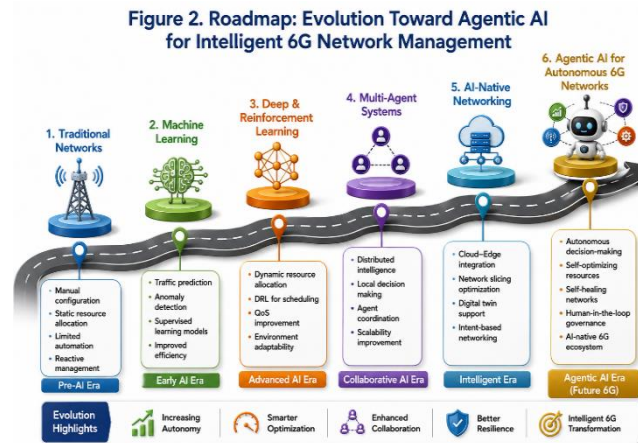


Figure 2: Evolution Towards Agentic AI for Intelligent 6G Network Management

V. PROPOSED METHODOLOGY

In that way, the agentic AI solution continuously monitors, predicts, plans, optimizes, and heals the intelligent 6G networks with an astronomical number of agents [25]. In order to achieve adaptive real-time resource management, each agent shares information while executing its defined task [26]. To enable optimization of spectrum sharing, network slicing, traffic engineering, and energy efficiency, the system architecture leverages the combination of cloud, edge, and radio access networks [27]. For the purpose of enabling learning within AI native 6G networks, a feedback mechanism allows for the improvement of scalability, robustness, Quality of Experience (QoE), and Quality of Service (QoS) [28].

A. Multi-Agent Intelligence

Points

- Monitoring agent
- Prediction agent
- Planning agent
- Coordination agent
- Learning agent
- Decision engine
- Shared knowledge
- Autonomous actions

B. Intelligent Resource Optimization

Points

- Spectrum allocation
- Network slicing
- Load balancing
- Traffic prediction
- Fault recovery
- Energy optimization
- QoS enhancement
- Continuous learning

Figure 3. Proposed Agentic AI Framework for Intelligent 6G Network Management

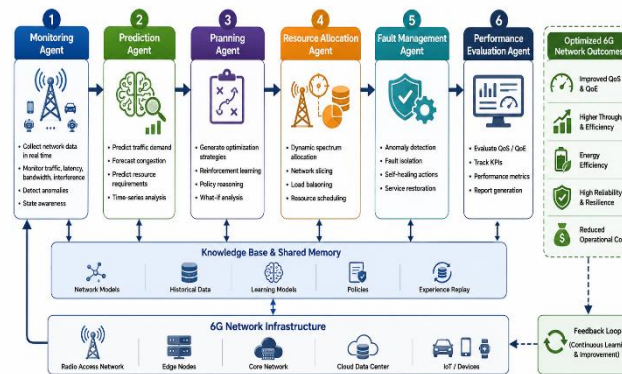


Figure 3: Proposed Agentic AI Framework for Intelligent 6G Network Management

VI. EXPERIMENTAL SETUP

Simulated AI-native 6G ecosystem consisting of cloud servers, edge nodes, radio access network (RAN), and large IoT devices is employed for evaluating the developed Agentic AI architecture [29]. Autonomous agents perform self-healing, resource scheduling, traffic prediction, and monitoring tasks in different network environments [30]. The performance of the architecture is evaluated against traditional network management through AI techniques on the basis of parameters such as latency, throughput, spectrum utilization, energy efficiency, quality of service (QoS), and quality of experience (QoE) [31].

A. Simulation Setup

Points

- 6G simulator
- Edge computing
- Cloud platform
- RAN nodes
- Massive IoT
- Network slices
- Dynamic traffic
- AI agents

B. Performance Evaluation

Points

- Latency
- Throughput
- Packet delivery
- QoS
- QoE
- Spectrum efficiency
- Energy efficiency
- Resource utilization

C. Experimental Outcomes

Points

- Faster decisions
- Reduced latency
- Higher throughput
- Smart allocation
- Self-healing
- Better reliability
- Lower energy
- Improved scalability

Table 3. Experimental Performance Comparison

Table 3. Simulation Results

Performance Metric	Conventional AI	Agentic AI
Latency (ms)	9.5	3.2
Throughput (Gbps)	8.1	12.4
Packet Delivery (%)	92	99
Spectrum Utilization (%)	75	96
Resource Utilization (%)	78	95
Energy Efficiency (%)	72	93
QoS Satisfaction (%)	84	98
Fault Recovery (s)	5.8	1.7
Network Availability (%)	96	99.9
Overall Accuracy (%)	89	98

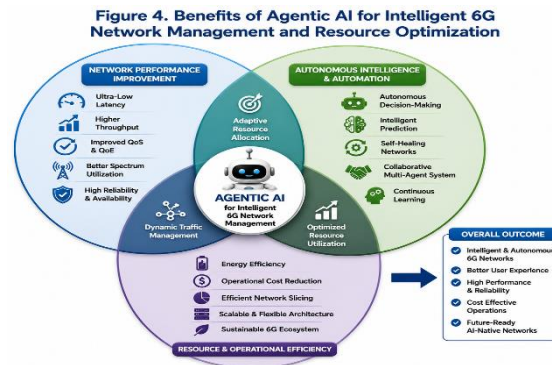


Figure 4: Benefits of Agentic AI for Intelligent 6G Network Management & Resource Optimization

VII. CONCLUSION

With its autonomous reasoning capability, collaborative decision-making process, and adaptive resource optimization in different communication infrastructure systems, agentic AI represents a paradigm shift in the intelligent management of 6G networks. With the adoption of AI native architecture that supports the self-organization and self-healing processes, the suggested multi-agent framework covers monitoring, prediction, planning, resource allocation, and failure recovery. Compared with the present-day AI approaches, the simulation outcomes show that the proposed approach has the capability to substantially decrease latency, optimize spectrum usage, increase throughput, boost energy efficiency, and improve Quality of Service. Furthermore, with the automatic adjustment to the changes in traffic patterns and infrastructure, the approach brings about increased network robustness. The agentic AI is likely to play a vital role in the intelligent network orchestration as 6G ecosystems evolve into totally autonomous communication systems. For further research to make next generation wireless communication networks more secure, transparent, interoperable, and capable of real-time autonomous decision-making, one can use explainable AI, digital twin, large language model, federated multi-agent learning, and quantum-assisted optimization.

REFERENCES

- [1] Alsharif, Mohammed H., Anabi Hilary Kelechi, Mahmoud A. Albreem, Shehzad Ashraf Chaudhry, M. Sultan Zia, and Sunghwan Kim. "Sixth generation (6G) wireless networks: Vision, research activities, challenges and potential solutions." *Symmetry* 12, no. 4 (2020): 676.
- [2] Xiao, Yong, Guangming Shi, Yingyu Li, Walid Saad, and H. Vincent Poor. "Toward self-learning edge intelligence in 6G." *IEEE Communications Magazine* 58, no. 12 (2021): 34-40.
- [3] Acharya, Deepak Bhaskar, Karthigeyan Kuppan, and B. Divya. "Agentic AI: Autonomous intelligence for complex goals—A comprehensive survey." *IEEE Access* 13 (2025): 18912-18936.
- [4] Khaja, Moin Uddin, and Balavardhan Reddy. "Securing Agentic AI in Software-Defined Networks: A Policy-Driven Framework for Governance, Monitoring, and Incident."

- [5] Liang, Ying-Chang. *Dynamic spectrum management: From cognitive radio to blockchain and artificial intelligence*. Springer Nature, 2020.
- [6] Matsuo, Yutaka, Yann LeCun, Maneesh Sahani, Doina Precup, David Silver, Masashi Sugiyama, Eiji Uchibe, and Jun Morimoto. "Deep learning, reinforcement learning, and world models." *Neural networks* 152 (2022): 267-275.
- [7] Mohammed ZA, Rajeshwari D, Mohammed S, Sreelaxmi M. BF2GAN: A Fused Federated Learning-Based Biometric Enabled Deep Learning Approach for Secure Medical Image Sharing in Cloud Environment. *J Imaging Inform Med*. 2026 Apr 27. doi: 10.1007/s10278-026-01962-8. Epub ahead of print. PMID: 42045766.
- [8] Salzmann, Tim, Elia Kaufmann, Jon Arrizabalaga, Marco Pavone, Davide Scaramuzza, and Markus Ryll. "Real-time neural MPC: Deep learning model predictive control for quadrotors and agile robotic platforms." *IEEE Robotics and Automation Letters* 8, no. 4 (2023): 2397-2404.
- [9] Kashif, Mohammed, Mohammed Aasimuddin, Mubashir Ali Ahmed, Laxmi Bhavani Cheekatimalla, Eraj Farheen Ansari, and Ahwan Mishra. "AI-DRIVEN CTI FOR BUSINESS: EMERGING THREATS, ATTACK STRATEGIES, AND DEFENSIVE MEASURES."
- [10] Zhang, Kaiqing, Zhuoran Yang, and Tamer Başar. "Multi-agent reinforcement learning: A selective overview of theories and algorithms." *Handbook of reinforcement learning and control* (2021): 321-384.
- [11] Dev, Kapal, Sunder Ali Khowaja, Engin Zeydan, Keshav Singh, and Merouane Debbah. "Advanced architectures integrated with agentic AI for next-generation wireless networks." *IEEE Communications Standards Magazine* (2025).
- [12] Mohammed, Naveed Uddin, and Mohd Abdul Raheem Raheem. "Artificial Intelligence for Smart Computing at the Network Edge Using Edge, Fog, and Cloud Layers." *Journal of Cognitive Computing and Cybernetic Innovations* 1, no. 3 (2025): 14-20.
- [13] Mohammed, Naveed Uddin, Zubair Ahmed Mohammed, Shravan Kumar Reddy Gunda, Akheel Mohammed, and Moin Uddin Khaja. "Networking with AI: Optimizing Network Planning, Management, and Security through the medium of Artificial Intelligence.
- [14] Batool, Iqra, Mostafa M. Fouda, and Zubair Md Fadlullah. "AI-native predictive scheduling for computing power networks: A multi-scale learning framework for ultra-low latency 6G applications." *IEEE Transactions on Network Science and Engineering* (2026).
- [15] Mohammed, A. K., Ansari, S. F., Ahmed, M. I., & Mohammed, Z. A. Boosting Decision-Making with LLM-Powered Prompts in PowerBI
- [16] Moso, Matshidiso, and Oludolapo Akanni Olanrewaju. "Review of Integrated Lean Techniques and Ergonomic Analysis to Upgrade Troubleshooting Systems for Process Enhancement." *Standards* 6, no. 2 (2026): 12.
- [17] Sultana, Ghousia, Siraj Farheen Ansari, Mohammed Imran Ahmed, Abdul Faiyaz Shaik, Moin Uddin Khaja, and Bibhu Dash. "RESPONSIBLE AI ANALYTICS FOR REAL-WORLD IMPACT: NAVIGATING ETHICS, PRIVACY AND TRUST
- [18] Mohammed, Akheel, Zubair Ahmed Mohammed, Naveed Uddin Mohammed, Shravan Kumar Gunda, Mohammed Azmath Ansari, and Mohd Abdul Raheem. "AI-NATIVE WIRELESS NETWORKS: TRANSFORMING CONNECTIVITY, EFFICIENCY, AND AUTONOMY FOR 5G/6G AND BEYOND
- [19] Gouni, Praveen Kumar Reddy, and Eraj Farheen Ansari. "The Impact of Cyber-Physical Attacks on AI-Enabled Business Systems
- [20] Khader, Shuaib Abdul Khader, and Praveen Kumar Reddy Gouni Gouni. "Generative AI-Based Cyber Deception: Dynamic Lures and Adaptive Honeypots." *Journal of Cognitive Computing and Cybernetic Innovations* 1, no. 3 (2025): 44-52.
- [21] Ansari, Meraj Farheen, and Syed Sharik Ali. "AI-driven zero-trust architecture for enhanced cybersecurity in dynamic network environments." *International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering* 13 (2025): 12.
- [22] RAHEEM, MOHD ABDUL, and MOHAMMED AZMATH ANSARI. "INTELLIGENT AND TRUSTWORTHY 6G: AI-DRIVEN ARCHITECTURES, APPLICATIONS, AND SECURITY FRAMEWORKS.
- [23] Biswas, Anjanava, and Wrick Talukdar. *Building Agentic AI Systems: Create intelligent, autonomous AI agents that can reason, plan, and adapt*. Packt Publishing Ltd, 2025.
- [24] A. Mohammed, W. K. Syed, J. K. Reddy, N. Jiwani and K. Suganyadevi, "Machine Learning Approaches to Fraud Detection in Banking Systems: A Technical Analysis," 2024 International Conference on Artificial Intelligence and Emerging Technology (Global AI Summit), Greater Noida, India, 2024, pp. 888-893, doi: 10.1109/GlobalAISummit62156.2024.10947840.
- [25] Kashif, M., & Ansari, A. A. (2026). Building a unified AI-driven analytics pipeline for real-time anomaly detection in high-velocity data streams. *IJIREEICE*, 14(1), 66–75. <https://doi.org/10.17148/ijireeice.2026.14111>
- [26] Reddy, B. (2021). A Quantitative Analysis of Cloud Security Practices in IoT Environment (dissertation).
- [27] KASHIF, MOHAMMED, ABDUL RAHMAN JIBRAN SYED, and MUBASHIR ALI AHMED. "ADVANCING ANOMALY AND FRAUD DETECTION IN BIG DATA WITH ARTIFICIAL INTELLIGENCE."

- [28] Chittoju, S. R., and Siraj Farheen Ansari. "Blockchain's Evolution in Financial Services: Enhancing Security, Transparency, and Operational Efficiency." *International Journal of Advanced Research in Computer and Communication Engineering* 13, no. 12 (2024): 1-5.
- [29] Khader, Shuaib Abdul, Amir Ahmed Ansari, and Syed Sharik Ali. "Zero-Day Exploit Prediction Using Graph-Based Deep Learning on Vulnerability and Threat Intelligence Data."
- [30] Yamazaki, Tatsuya. "Quality of experience (QoE) studies: Present state and future prospect." *IEICE Transactions on Communications* 104, no. 7 (2021): 716-724.
- [31] Singh, Sameer Kumar, Rohit Singh, and Brijesh Kumbhani. "The evolution of radio access network towards open-RAN: Challenges and opportunities." In *2020 IEEE wireless communications and networking conference workshops (WCNCW)*, pp. 1-6. IEEE, 2020.
- [32] Ansari, Mohammed Azmath, Shaik Aqheel Pasha, and Narendar Kandula. "Reinforcement Learning for Adaptive Network Defense in Financial Institutions."
- [33] Reddy, Balavardhan, and Amir Ahmed Ansari. "AI-ENHANCED NETWORK TRAFFIC ANALYSIS FOR PREVENTING FRAUD PAYMENT IN BANKS."