

ORIGINAL RESEARCH

Achieving Efficient and Reliable Communication in 6g Wireless Communications Network Using Intelligent Based Advanced Modulation Technique

[Udeagbala, Remigius Ndidika¹, Ezema, D. C.¹, Egbonwonu, Emmanuel Livinus¹, Ogbodo, Ikechukwu Ogbodo¹, Okika, Stephen S.¹, Nwaogaidu, Simeon Obinna¹]

¹ Department of Electrical/Electronic Engineering, State University of Medical and Applied Sciences, Igbo-Eno, Enugu State, Nigeria

Volume	Issue	Year	Pages
7	2	2026	1-18
Type	Published	DOI	Journal
Original Research	2026-05-31	10.5281/zenodo.20479357	AJASE

Abstract

The persistent communication network failure in some parts of the world at different occasions, has continuously jeopardized economic, social and security activities. The major cause of this ugly trend is the inability of the system performance metrics such as Data Rate (Throughput), Latency, Signal-to-Noise Ratio (SNR), Spectral Efficiency, Packet Loss Rate, Bit Error Rate (BER), Network Reliability, Device Density, Energy Efficiency, Coverage Efficiency, Mobility Support and Channel Capacity, to attain threshold value. This was overcome by the introduction of efficient and reliable communication in 6G wireless communications network using intelligent based advanced modulation technique. In order to achieve this perfectly, the following procedure was adopted; Communication network in 6G wireless communications network was characterized and causes of poor communication network was established and SIMULINK model for 6G communications network was designed. Then an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G wireless communications network was developed and ANN was trained in it to boost the effectiveness and minimize the causes of poor communication network in 6G wireless communications network. Then an algorithm that would implement the process was developed, SIMULINK model for enhancing 6G communications network using intelligent based advanced modulation technique was designed and the results obtained were evaluated and justified. The results obtained shows that the conventional Data Rate (Throughput), that Latency causes of poor communication network in 6G wireless communications network was 98Gbps. On the other hand, when an intelligent based advanced modulation technique was incorporated into the system, it automatically increased by 131.3Gbps and the conventional technique Latency, that Latency causes of poor communication network in 6G wireless communications network was 6ms. Meanwhile, when an intelligent based advanced modulation technique was input into the system, it drastically reduced to 5ms. Finally, the percentage enhancement in 6G wireless communications network when an intelligent based advanced modulation technique was incorporated into the system was 16.7%.

Keywords: 6G Communications Network, Intelligent Based Advanced Modulation Technique, Data Rate, Latency

1. Introduction

The rapid evolution of wireless communication technologies has continued to reshape global connectivity, enabling high-speed data transfer, intelligent networking, and seamless integration of digital services. From the early generations of wireless communication systems to the current fifth-generation (5G) networks, the demand for higher data rates, ultra-low latency, massive connectivity, and reliable communication has significantly increased. However, the exponential growth of data traffic driven by emerging technologies such as the Internet of Things (IoT), autonomous systems, smart cities, and immersive

multimedia applications has exposed the limitations of existing wireless communication infrastructures. As a result, research attention has shifted toward the development of the sixth-generation (6G) communication network, which is expected to deliver extremely high data rates, improved spectrum efficiency, and intelligent network management (Saad et al., 2020; Zhang et al., 2021). The envisioned 6G communication network aims to support advanced applications such as holographic communications, intelligent transportation systems, remote healthcare, and fully autonomous industrial operations. These applications require data transmission speeds beyond those provided by current 5G systems, along with ultra-reliable and low-latency communication. Consequently, researchers and engineers are exploring innovative techniques that can significantly improve the performance and efficiency of wireless communication systems. Among these techniques, advanced modulation schemes have become an important area of study because modulation plays a crucial role in determining spectral efficiency, signal robustness, and overall system performance (Dang et al., 2020). Advanced modulation techniques are designed to enhance the transmission of information by improving bandwidth utilization and minimizing signal distortion during transmission. In conventional wireless communication systems, modulation schemes such as Quadrature Amplitude Modulation (QAM) and Orthogonal Frequency Division Multiplexing (OFDM) have been widely used due to their ability to support high data rates and reliable communication. However, with the increasing complexity of modern communication networks, these traditional approaches may not adequately meet the stringent requirements of 6G networks. Therefore, researchers are exploring intelligent and adaptive modulation techniques that can dynamically adjust transmission parameters based on network conditions and channel characteristics (Giordani et al., 2020). The integration of intelligent-based techniques such as Artificial Intelligence (AI), Machine Learning (ML), and Artificial Neural Networks (ANN) into communication systems has opened new possibilities for optimizing modulation strategies and improving network performance. Intelligent algorithms can analyze large volumes of communication data, predict channel conditions, and automatically select the most suitable modulation scheme for a given transmission scenario. This capability enhances signal quality, reduces transmission errors, and improves overall system efficiency. In addition, intelligent-based advanced modulation techniques enable adaptive resource allocation, improved interference management, and efficient spectrum utilization, which are critical requirements for the successful implementation of 6G communication networks (Saad et al., 2020). Furthermore, intelligent modulation techniques can support the development of self-organizing and autonomous communication networks capable of learning from environmental conditions and adapting to dynamic network demands. Such networks are expected to play significant role in future digital ecosystems where billions of devices will be interconnected through wireless communication infrastructures. The combination of intelligent algorithms with advanced modulation methods therefore provides a promising approach for addressing the technical challenges associated with next-generation wireless communication systems (Zhang et al., 2021). Despite the promising capabilities of intelligent-based advanced modulation techniques, several challenges remain in their practical implementation. These include computational complexity, energy efficiency constraints, hardware limitations, and the need for robust algorithms capable of operating under varying network conditions. Therefore, continuous research is required to develop optimized intelligent modulation techniques that can enhance the performance of 6G communication networks while ensuring reliability, scalability, and cost-effectiveness. Based on these considerations, this study focuses on enhancing 6G communication networks using intelligent-based advanced modulation techniques. The research aims to explore how intelligent algorithms can be integrated with advanced modulation strategies to improve data transmission efficiency, signal reliability, and overall communication performance in next-generation wireless networks.

1.1 Problem Statement

The evolution toward sixth-generation (6G) communication networks is driven by the need for ultra-high data rates (in the order of Tbps), ultra-low latency ($\leq 1\text{ms}$), massive connectivity, and highly reliable communication. However, existing modulation techniques used in current wireless systems are increasingly inadequate to meet these stringent performance requirements. Conventional modulation schemes such as Orthogonal Frequency Division Multiplexing (OFDM) and Quadrature Amplitude Modulation (QAM) suffer from limitations including high peak-to-average power ratio (PAPR), spectral inefficiency, susceptibility to interference, and poor adaptability to dynamic and complex channel conditions. Furthermore, the increasing demand for emerging applications such as smart cities, autonomous systems, virtual reality, and massive Internet of Things (IoT) introduces additional challenges in terms of energy efficiency, bandwidth utilization, and system reliability. These challenges are further compounded by the use of high-frequency bands such as millimeter wave (mmWave) and terahertz (THz) communications, which are highly sensitive to signal attenuation, noise, and environmental variations. Despite recent advancements, current communication systems lack sufficient intelligence to dynamically adapt modulation parameters in real-time based on changing network conditions. This results in suboptimal performance characterized by higher bit error rates (BER), increased latency, inefficient energy consumption (bits/Joule), and reduced spectral efficiency (bits/s/Hz).

Therefore, there is a critical need to develop intelligent-based advanced modulation techniques that can leverage Artificial Intelligence (AI) and Machine Learning (ML) to enable adaptive, efficient, and robust communication in 6G networks. Such techniques should be capable of optimizing modulation schemes in real-time, improving system performance, and overcoming the inherent limitations of conventional methods.

This study aims to address these challenges by achieving efficient and reliable communication in 6G communication networks through the integration of intelligent-based advanced modulation techniques, thereby improving spectral efficiency, reducing latency, increasing reliability, and optimizing energy utilization in next-generation wireless systems.

1.2 Aim and Objectives of the Study

The aim of this research work is to achieve efficient and reliable communication in 6G wireless communications network using intelligent-based advanced modulation technique.

The objectives include the following:

1. To characterize and establish the causes of poor communication network in 6G communications network
2. To design a conventional SIMULINK model for 6G communications network
3. To develop an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G communications network
4. To train ANN in an advanced modulation technique rule base for effective minimization the causes of poor communication network in 6G communications network
5. To design a SIMULINK model for advanced modulation technique
6. To develop an algorithm that would implement the process
7. To design a SIMULINK model for achieving efficient and reliable communication in 6G communications network using intelligent based advanced modulation technique
8. To validate and justify the percentage improvement in the reduction of the causes of poor communication network in 6G communications network with and without an intelligent based advanced modulation technique.

1.3 Research Hypotheses

Null Hypothesis (H_0): Intelligent-based advanced modulation techniques do not significantly enhance the performance of 6G communication networks in terms of spectral efficiency, latency, reliability, and energy efficiency.

Alternative Hypothesis (H_1): Intelligent-based advanced modulation techniques significantly enhance the performance of 6G communication networks by improving spectral efficiency, reducing latency, increasing reliability, and optimizing energy efficiency.

Breaking down into more measurable sub-hypotheses for deeper analysis:

1. H_{01} : Intelligent-based advanced modulation does not significantly improve spectral efficiency in 6G networks. H_{11} : Intelligent-based advanced modulation significantly improves spectral efficiency in 6G networks. H_{02} : Intelligent-based advanced modulation does not significantly reduce latency in 6G networks. H_{12} : Intelligent-based advanced modulation significantly reduces latency in 6G networks. H_{03} : Intelligent-based advanced modulation does not significantly improve reliability (e.g., bit error rate performance). H_{13} : Intelligent-based advanced modulation significantly improves reliability in 6G networks. H_{04} : Intelligent-based advanced modulation does not significantly enhance energy efficiency. H_{14} : Intelligent-based advanced modulation significantly enhances energy efficiency in 6G networks. These hypotheses align well with performance metrics in S.I. units such as: Spectral efficiency (bits/s/Hz) Latency (milliseconds, ms) Bit Error Rate (dimensionless) Energy efficiency (bits/Joule)
2. Literature Review

2.1 Theoretical Background

The evolution of Wireless Communications has progressed rapidly from earlier generations of mobile networks to the emerging paradigm of 6G communications, which aims to deliver ultra-high data rates, extremely low latency, and massive connectivity. According to recent studies, 6G networks are expected to support data rates in the terahertz (THz) spectrum and enable advanced applications such as holographic communication, smart cities, and autonomous systems (Zhang et al., 2022). However, achieving these ambitious goals requires significant improvements in modulation techniques and network intelligence. Traditional modulation schemes, such as Quadrature Amplitude Modulation (QAM) and Orthogonal Frequency Division Multiplexing (OFDM), have been widely adopted in 4G and 5G systems due to their spectral efficiency and robustness. Nonetheless, these techniques face limitations in highly dynamic and dense network environments, particularly in terms of interference management, energy efficiency, and scalability (Li & Wang, 2023). As a result, researchers have proposed advanced modulation techniques, including non-orthogonal multiple access (NOMA), filter bank multicarrier (FBMC), and generalized frequency division multiplexing (GFDM), to enhance performance in next-generation networks (Rahman et al., 2021). In recent years, the integration of Artificial Intelligence into wireless communication systems has gained significant attention. AI-driven approaches, particularly those based on Machine Learning and deep learning, have demonstrated the ability to

optimize network parameters, predict channel conditions, and enable adaptive decision-making in real time (Kim et al., 2023). These intelligent techniques can be applied to dynamically select or design modulation schemes based on varying channel characteristics, thereby improving spectral efficiency and reducing error rates. Several studies have explored intelligent-based modulation strategies for beyond-5G and 6G systems. For instance, deep learning-based adaptive modulation has been shown to outperform traditional methods by learning complex channel behaviors and adjusting modulation parameters accordingly (Huang et al., 2022). Similarly, reinforcement learning approaches have been used to optimize modulation and coding schemes in dynamic environments, enabling more efficient resource allocation and improved quality of service (Qin et al., 2023). Despite these advancements, the integration of intelligent algorithms with advanced modulation techniques remains at an early stage, with limited real-world implementation. Moreover, challenges such as computational complexity, training data requirements, and latency associated with AI models present significant barriers to their practical deployment in 6G networks. The need for lightweight, scalable, and energy-efficient intelligent modulation frameworks is increasingly emphasized in the literature (Zhang et al., 2022). Additionally, there is a lack of standardized architectures that seamlessly integrate intelligent decision-making processes with advanced modulation techniques across heterogeneous network environments. In summary, existing literature highlights the potential of combining intelligent-based approaches with advanced modulation techniques to enhance 6G communication networks. However, further research is needed to develop efficient, adaptive, and scalable solutions that can be practically implemented. This study aims to contribute to this growing body of knowledge by addressing the identified gaps and proposing an intelligent-based advanced modulation framework tailored for 6G systems.== 2.2 Research Gap

Despite significant advancements in Wireless Communications and the deployment of 6G communications as a successor to 5G networks, several limitations persist in achieving ultra-reliable, high-capacity, and low-latency communication. Existing studies have largely focused on conventional and adaptive modulation schemes; however, these techniques often fail to fully optimize spectral efficiency and energy consumption in highly dynamic network environments (Zhang et al., 2022; Li & Wang, 2023). Furthermore, while intelligent approaches such as Artificial Intelligence and machine learning have been introduced into network optimization, their integration with advanced modulation techniques remains underexplored. Current literature reveals a lack of comprehensive frameworks that combine intelligent-based decision systems with advanced modulation strategies tailored specifically for 6G architectures. In particular, there is insufficient research addressing real-time adaptability of modulation schemes using intelligent algorithms to cope with varying channel conditions, interference, and massive device connectivity (Kim et al., 2023). Additionally, challenges related to computational complexity, scalability, and implementation feasibility in practical 6G scenarios are not adequately addressed. Therefore, the key research gap lies in the development of an intelligent-based advanced modulation technique that can dynamically enhance 6G communication networks by improving spectral efficiency, reducing latency, and ensuring robust performance under diverse operating conditions. Addressing this gap will contribute to more efficient and adaptive next-generation wireless systems.== 3. Methodology

Efficient and reliable communication in 6G wireless communications network using Intelligent based advanced modulation technique was achieved using the following procedure;To characterize and establish the causes of poor communication network in 6G communications networkTable 1, characterized and established causes of poor communication network in 6G communications network.== S/N

Network Parameter

Metric Threshold (S.I Units)

Typical Acceptable Value for Efficient 6G

Condition Indicating Poor Network

Conventional Causes of Poor Communication Network in 6G Systems

Possible Causes

1Data Rate (Throughput)bits per second (bps) ≥ 1 Tbps (10^{12} bps) ≥ 5 ms6 msNetwork congestion, inefficient routing, processing delays in edge devices3Signal-to-Noise Ratio (SNR)decibel (dB) ≥ 30 dB 10^{-3} 0.001Congestion, unstable links, hardware failures6Bit Error Rate (BER)dimensionless ratio $\leq 10^{-9}$ $> 10^{-6}$ 0.000009Noise interference, fading channels, poor modulation7Network Reliabilitypercentage (%) ≥ 99.9999 % 10^{-9} J/bit0.0000009 J/bitInefficient hardware design, poor power management10Coverage Efficiency ≥ 100 m (THz small cell coverage) < 10 m effective coverage9 m effective coverageHigh path loss at THz frequency, poor antenna design11Mobility Supportkm/h ≥ 500 km/h < 200 km/h198 km/hWeak handover mechanism, poor mobility algorithms12Channel Capacitybits/s $\geq 10^{12}$ bits/s $< 10^{11}$ bits/s10000000009 bits/sLimited spectrum availability, channel fading== Table 1: Causes of poor communication network in 6G communications networkTo design a conventional SIMULINK model for 6G communications networkFigure 1: Designed conventional SIMULINK model

for 6G communications network. The results obtained were as shown in figures 9 and 10. To develop an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G wireless communications network. Figure 2: developed advanced modulation technique fuzzy inference system that would minimize the causes of poor communication network in 6G wireless communications network. This has two inputs - causes of poor communication network in 6G wireless communications network and monitoring sensor. It also has output of the results. Figure 3: Developed an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G wireless communications network. The rules were fully written in table 2.1. if causes of poor communication network in 6g communications network is high; reduce and monitoring sensor is not functioning; replace then result is unenhanced 6g communications network. 2. if causes of poor communication network in 6g communications network is partly high; reduce and monitoring sensor is partly not functioning replace then result is unenhanced 6g communications network. 3. if causes of poor communication network in 6g communications network is high; reduce and monitoring sensor is partly not functioning; replace then result is unenhanced 6g communications network. 4. if causes of poor communication network in 6g communications network is partly high; reduce and monitoring sensor is not functioning; replace then result is unenhanced 6g communications network. 5. if causes of poor communication network in 6g communications network is very low; maintain and monitoring sensor is functioning; maintain then result is enhanced 6g communications network. Table 2: detailed developed, advanced modulation technique rule base that would minimize the causes of poor communication network in 6G wireless communications network. Figure 4: the operational mechanism of developed an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G communications network. To train ANN in an advanced modulation technique rule base for effective minimization the causes of poor communication network in 6G wireless communications network. Figure 5: trained ANN in an advanced modulation technique rule base for effective minimization the causes of poor communication network in 6G wireless communications network. ANN was trained twenty times in the five rules $20 \times 5 = 100$ to give 100 neurons that looked similar to human brain. Figure 6: result obtained during the training of ANN in an advanced modulation technique rule base for effective minimization of the causes of poor communication network in 6G wireless communications network. To design a SIMULINK model for advanced modulation technique. Figure 7: designed SIMULINK model for advanced modulation technique. This was integrated into the designed conventional SIMULINK model for 6G communications network to give the results obtained in figures 9 and 10. To develop an algorithm that would implement the process. 1. Characterize and establish the causes of poor communication network in 6G communications network. 2. Identify Data Rate (Throughput) that could not attain threshold. 3. Identify Latency that could not attain threshold. 4. Identify Signal-to-Noise Ratio (SNR) that could not attain threshold. 5. Identify Spectral Efficiency that could not attain threshold. 6. Identify Packet Loss Rate that could not attain threshold. 7. Identify Bit Error Rate (BER) that could not attain threshold. 8. Identify Network Reliability that could not attain threshold. 9. Identify Device Density that could not attain threshold. 10. Identify Energy Efficiency that could not attain threshold. 11. Identify Coverage Efficiency that could not attain threshold. 12. Identify Mobility Support that could not attain threshold. 13. Identify Channel Capacity that could not attain threshold. 14. Design a conventional SIMULINK model for 6G communications network and integrate 2 through 13. 15. Develop an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G communications network. 16. Train ANN in an advanced modulation technique rule base for effective minimization the causes of poor communication network in 6G communications network. 17. Design a SIMULINK model for advanced modulation technique. 18. Integrate 15 through 17. 19. Integrate 18 into 14. 20. Did the causes of poor communication network in 6G communications network reduce and attain threshold? 21. IF NO go to 19. 22. IF YES go to 23. 23. Enhanced 6G communications network. 24. Stop. 25. End. Figure 8: Flowchart for Conventional SIMULINK model for 6G communications network. Figure 9: designed SIMULINK model for enhancing 6G communications network using intelligent based advanced modulation technique. Validation of the Proposed Intelligent-Based Advanced Modulation Technique

The results obtained from the simulation experiments are presented in Figures 9 and 10. To validate the effectiveness of the proposed intelligent-based advanced modulation technique in minimizing the causes of poor communication network performance in a 6G wireless communication network, a percentage improvement analysis was conducted by comparing the performance of the conventional model with that of the proposed intelligent-based advanced modulation model. == Percentage Improvement in Data Rate (Throughput)

The throughput values obtained from the simulation are as follows: Conventional Data Rate (Throughput) = 98 Gbps. Intelligent-Based Advanced Modulation Technique Throughput = 131.3 Gbps. The percentage improvement in throughput was calculated using Equation (1): Percentage Improvement = $\frac{\text{Proposed Throughput} - \text{Conventional Throughput}}{\text{Conventional Throughput}} \times 100$. Substituting the obtained values: Percentage Improvement = $\frac{131.3 - 98}{98} \times 100 = 33.3\% \approx 34\%$. Therefore, the intelligent-based advanced modulation technique achieved a 34% improvement in data rate (throughput)* compared to the conventional 6G communication network model. This improvement indicates a significant enhancement in network transmission capacity and communication efficiency. == Percentage Reduction in Latency

The latency values obtained from the simulation are as follows: Conventional Latency = 6 ms

2. Intelligent-Based Advanced Modulation Technique Latency = 5 ms

Since latency is a parameter that should be minimized, the percentage reduction was calculated using Equation (2):

Percentage Reduction = $\frac{\text{Conventional Latency} - \text{Proposed Latency}}{\text{Conventional Latency}} \times 100$

Substituting the obtained values:

Percentage Reduction = $\frac{6 - 5}{6} \times 100$

1 X 100 6

16.67%

$\approx 16.7\%$

Therefore, the intelligent-based advanced modulation technique achieved a 16.7% reduction in latency when compared with the conventional 6G communication network model. The reduction in latency demonstrates the capability of the proposed model to improve response time and support real-time communication services more effectively.

The results indicate that the proposed intelligent-based advanced modulation technique substantially improves network performance by increasing throughput by 34% and reducing latency by 16.7%, thereby mitigating key causes of poor communication performance in 6G wireless communication networks.

4. Results and Discussions

Time (days)	Conventional Data Rate (Throughput) that Latency causes of poor communication network in 6G communications network(Gbps)	Intelligent based advanced modulation technique Data Rate (Throughput that Latency causes of poor communication network in 6G communications network(Gbps)
1	98	131.3
2	98	131.3
3	98	131.3
4	98	131.3

Table 2: Comparison of conventional and intelligent based advanced modulation technique Data Rate (Throughput) that Latency causes of poor communication network in 6G communications network
Figure 10: Comparison of conventional and intelligent based advanced modulation technique Data Rate (Throughput) that Latency causes of poor hand, when an intelligent based advanced modulation technique was incorporated into the system, it automatically increased by131.3 Gbps.
Time (days)
Conventional Latency that Latency causes of poor communication network in 6G communications network(ms)
Intelligent based advanced modulation technique Latency that Latency causes of poor communication network in 6G communications network(ms)
165265365465
Table 3: comparison of conventional and intelligent based advanced modulation technique Latency that Latency causes of poor communication network in 6G communications network.
Figure 11: comparison of conventional and intelligent based advanced modulation technique Latency that Latency causes of poor communication network in 6G wiles communications network.
The conventional technique Latency that Latency causes of poor communication network in 6G wireless communications network was 6ms. Meanwhile, when an intelligent based advanced modulation technique was input into the system, it drastically reduced to5ms. Finally, the percentage enhancement in 6G wireless communications network when an intelligent based advanced modulation technique was incorporated into the system was16.7%.5. Conclusion

The consistent poor communication network that had crippled business and social activities and also jeopardized security architectures across the globe was subdued by the introduction of enhancing 6G communications network using intelligent based advanced modulation technique. To perfectly achieve this, it was done in this approach, communication network in 6G wireless communications network was characterized and causes of poor communication network was established and SIMULINK model for 6G communications network was designed. Then an advanced modulation technique rule base that would minimize the causes of poor communication network in 6G wireless communications network was developed and ANN was trained in it to boost the effectiveness in minimizing the causes of poor communication network in 6G wireless communications network. Then an algorithm that would implement the process was developed, SIMULINK model for enhancing 6G communications network using intelligent based advanced modulation technique was designed and the results obtained were evaluated and justified. The results obtained were the conventional Data Rate (Throughput) that Latency causes of poor communication network in 6G wireless communications network was 98Gbps. On the other hand, when an intelligent based advanced modulation technique was incorporated into the system, it automatically increased by131.3 Gbps and the conventional technique Latency that Latency causes of poor communication network in 6G wireless communications network was 6ms. Meanwhile, when an intelligent based advanced modulation technique was input into the system, it drastically reduced to 5ms. Finally, the percentage enhancement in 6G communications network when an intelligent based advanced modulation technique was incorporated into the system was16.7%.

Recommendations

1. Adoption of AI Driven Modulation Schemes

Researchers and network designers should integrate Artificial Intelligence (AI) and Machine Learning (ML) algorithms into modulation design to enable adaptive and self optimizing communication systems that can respond effectively to dynamic channel conditions.

2. Development of Hybrid Modulation Techniques

Future studies should focus on developing hybrid advanced modulation schemes, such as combinations of OFDM, NOMA, and Index Modulation, to improve spectral efficiency and support the ultra high data rates required in 6G networks.

3. Implementation of Real Time Channel Intelligence

Communication systems should incorporate intelligent channel estimation and prediction models that dynamically adjust modulation parameters, thereby reducing error rates and improving transmission reliability.

4. Optimization for Energy Efficiency

Intelligent based modulation techniques should be designed with energy aware algorithms to minimize power consumption, particularly for Internet of Things (IoT) devices and edge computing environments.

5. Integration with Reconfigurable Intelligent Surfaces (RIS)

Future 6G communication systems should leverage RIS technology to enhance signal propagation and improve modulation performance in complex environments, including urban and indoor settings.

6. Standardization and Policy Development

Regulatory agencies and standardization bodies should establish comprehensive frameworks and standards for the implementation of intelligent modulation techniques to ensure interoperability, scalability, and global adoption.

7. Investment in High Frequency Spectrum Utilization

Greater research attention should be directed toward modulation techniques suitable for Terahertz (THz) frequency bands, which are expected to play a significant role in achieving ultra high speed 6G communications.

8. Robust Security Enhancement

Intelligent modulation schemes should incorporate built in security mechanisms, including AI driven encryption and anomaly detection systems, to mitigate cyber threats and enhance communication security.

9. Hardware and Infrastructure Upgrade

Telecommunication industries should invest in advanced hardware platforms, high speed processors, and smart antenna technologies capable of supporting intelligent modulation processing requirements.

10. Simulation and Real World Testing

Extensive simulation studies and practical experimental validations should be conducted using realistic 6G deployment scenarios to assess the effectiveness and reliability of intelligent modulation techniques before commercial implementation.

11. Interdisciplinary Research Collaboration

Collaboration among experts in wireless communications, artificial intelligence, computer science, and data analytics should be encouraged to accelerate innovation in intelligent modulation technologies.

12. Capacity Building and Training

Academic institutions, research centers, and industries should establish specialized training programs to equip engineers and researchers with competencies in AI based communication system design and optimization.

13. Support for Edge Intelligence Deployment

The deployment of intelligent modulation techniques at network edge locations should be encouraged to reduce latency and improve real time communication performance.

14. Scalability and Flexibility Consideration

Future intelligent modulation designs should be scalable and adaptable across diverse applications, including smart cities, autonomous transportation systems, industrial automation, and immersive technologies.

15. Continuous Performance Monitoring

Intelligent monitoring mechanisms should be implemented to continuously evaluate key performance indicators such as spectral efficiency, latency, bit error rate, and energy consumption, thereby supporting ongoing system optimization.

References

- Akyildiz, I. F., Kak, A., & Nie, S. (2020). 6G and beyond: The future of wireless communications systems. *IEEE Access*, 8, 133995–134030. <https://doi.org/10.1109/ACCESS.2020.3010896>
- Dang, S., Amin, O., Shihada, B., & Alouini, M. S. (2020). What should 6G be? *Nature Electronics*, 3(1), 20–29. <https://doi.org/10.1038/s41928-019-0355-6>
- Saad, W., Bennis, M., & Chen, M. (2019). A vision of 6G wireless systems: Applications, trends, technologies, and open research problems. *IEEE Network*, 34(3), 134–142.
- Letaief, K. B., Chen, W., Shi, Y., Zhang, J., & Zhang, Y. J. A. (2019). The roadmap to 6G: AI empowered wireless networks. *IEEE Communications Magazine*, 57(8), 84–90.
- Gui, G., Liu, M., Tang, F., Kato, N., & Adachi, F. (2020). 6G: Opening new horizons for integration of comfort, security, and intelligence. *IEEE Wireless Communications*, 27(5), 126–132.
- Jiang, W., Han, B., Habibi, M. A., & Schotten, H. D. (2021). The road towards 6G: A comprehensive survey. *IEEE Open Journal of the Communications Society*, 2, 334–366.
- Huang, C., Zappone, A., Alexandropoulos, G. C., Debbah, M., & Yuen, C. (2019). Reconfigurable intelligent surfaces for energy efficiency in wireless communication. *IEEE Transactions on Wireless Communications*, 18(8), 4157–4170.
- Basar, E. (2019). Reconfigurable intelligent surface-based index modulation: A new beyond MIMO paradigm for 6G. *IEEE Transactions on Communications*, 68(5), 3187–3196.
- Hanzo, L., Hui, S. Y., & Keller, T. (2021). *OFDM and MC-CDMA for broadband multi-user communications*. Wiley.
- Wang, J., Chen, C., & Li, Y. (2021). Intelligent modulation recognition for 6G communication systems using deep learning. *IEEE Transactions on Cognitive Communications and Networking*, 7(3), 978–990.
- Zhang, Z., Xiao, Y., Ma, Z., Xiao, M., Ding, Z., Lei, X., ... Fan, P. (2019). 6G wireless networks: Vision, requirements, architecture, and key technologies. *IEEE Vehicular Technology Magazine*, 14(3), 28–41.
- Lin, X., Andrews, J. G., Ghosh, A., & Ratasuk, R. (2014). An overview of 3GPP device-to-device proximity services. *IEEE Communications Magazine*, 52(4), 40–48.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.
- Giordani, M., Polese, M., Mezzavilla, M., Rangan, S., & Zorzi, M. (2020). Toward 6G networks: Use cases and technologies. *IEEE Communications Magazine*, 58(3), 55–61.
- O'Shea, T. J., & Hoydis, J. (2017). An introduction to deep learning for the physical layer. *IEEE Transactions on Cognitive Communications and Networking*, 3(4), 563–575.
- Ye, H., Li, G. Y., & Juang, B. H. F. (2018). Power of deep learning for channel estimation and signal detection in OFDM systems. *IEEE Wireless Communications Letters*, 7(1), 114–117.
- Mao, Q., Hu, F., & Hao, Q. (2018). Deep learning for intelligent wireless networks: A comprehensive survey. *IEEE Communications Surveys & Tutorials*, 20(4), 2595–2621.
- Qin, Z., Ye, H., Li, G. Y., & Juang, B. H. F. (2019). Deep learning in physical layer communications. *IEEE Wireless Communications*, 26(2), 93–99.
- Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies. *IEEE Communications Surveys & Tutorials*, 17(4), 2347–2376.
- Shafi, M., Molisch, A. F., Smith, P. J., Haustein, T., Zhu, P., De Silva, P., ... Wunder, G. (2017). 5G: A tutorial overview. *IEEE Communications Magazine*, 55(5), 162–169.
- Rappaport, T. S., Xing, Y., Kanhere, O., Ju, S., Madanayake, A., Mandal, S., ... Trichopoulos, G. C. (2019). Wireless communications and applications above 100 GHz. *IEEE Access*, 7, 78729–78757.
- Tataria, H., Shafi, M., Molisch, A. F., Dohler, M., Sjöland, H., & Tufvesson, F. (2021). 6G wireless systems: Vision, requirements, challenges, insights, and opportunities. *Proceedings of the IEEE*, 109(7), 1166–1199.
- Chen, M., Saad, W., Yin, C., Debbah, M., & Hong, C. S. (2020). Artificial intelligence for wireless networks: Applications, challenges, and opportunities. *IEEE Communications Magazine*, 58(6), 36–42.
- Park, J., Samarakoon, S., Bennis, M., & Debbah, M. (2020). Wireless network intelligence at the edge. *Proceedings of the IEEE*, 107(11), 2204–2239.

- Huang, H., Yang, Y., Ding, Z., Adachi, F., & Poor, H. V. (2020). Deep learning for super-resolution channel estimation. *IEEE Wireless Communications Letters*, 9(12), 2057–2061.
- Wang, S., Liang, Y. C., Chen, S., & Zhang, X. (2020). Machine learning for wireless communications in the Internet of Things. *IEEE Wireless Communications*, 27(1), 106–113.
- Li, X., Zhao, H., & Zhang, Y. (2022). Intelligent modulation classification using convolutional neural networks for beyond 5G systems. *IEEE Access*, 10, 45678–45690.
- Yang, P., Xiao, Y., Xiao, M., & Li, S. (2015). 6G wireless communications: Vision and potential techniques. *IEEE Network*, 33(4), 70–75.
- Jiang, C., Zhang, H., Ren, Y., Han, Z., Chen, K. C., & Hanzo, L. (2017). Machine learning paradigms for next-generation wireless networks. *IEEE Wireless Communications*, 24(2), 98–105.
- Zhou, Z., Chen, X., Li, E., Zeng, L., Luo, K., & Zhang, J. (2019). Edge intelligence: Paving the last mile of artificial intelligence with edge computing. *Proceedings of the IEEE*, 107(8), 1738–1762.
- You, X., Wang, C. X., Huang, J., Gao, X., Zhang, Z., Wang, M., & Fettweis, G. (2021). Towards 6G wireless communication networks: Vision, enabling technologies, and new paradigm shifts. *Science China Information Sciences*, 64(1), 1–74.

How to Cite: Udeagbala, Remigius Ndidika, Ezema, D. C., Egbonwonu, Emmanuel Livinus, Ogbodo, Ikechukwu Ogbodo, Okika, Stephen S., Nwaogaidu, Simeon Obinna (2026). Achieving Efficient and Reliable Communication in 6g Wireless Communications Network Using Intelligent Based Advanced Modulation Technique. **American Journal of Applied Sciences and Engineering**, 7(2), 1-18. <https://doi.org/10.5281/zenodo.20479357>

Open Access. Published under CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>).

Article URL: <https://airjournal.org/article/achieving-efficient-and-reliable-communication-in-6g-wireless-communications-network-using-intelligent-based-advanced-modulation-technique>