

# AI-Driven Enhancement of 5G Signal Strength for Improved Network Services

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**Abstract:** The aim of this work was to study how AI techniques can be used to improve the performance of 5G network. In addition, the work also investigated some of the challenges facing the integration of AI in 5G network systems. The research work was carried out using the review research method. This method provided the authors the opportunity to critically study the research works in this area, mostly the recent ones. From the research work, it was observed that some of the methods of improving 5G network performance using artificial intelligence technologies are network optimisation, interference management, beamforming, predictive maintenance, resource allocation, and self-healing networks. The results also showed that some of the impediments to the integration of AI with 5G network services are data security and privacy, infrastructure complexity, energy constraints, interoperability, ethical and regulatory issues, and data quality and volume. It was concluded that despite some challenges facing the integration of AI with the 5G network, AI technologies have the capacity to improve the signal strength of the 5G network. This result will be important to telecommunication service providers as well as stakeholders in communication sectors for the improvement of the services as well as the formulation of proper policy aimed at providing a quality service in telecommunication. The findings will be important in the areas of optimizing 5G network efficiency, predicting and mitigating signal degradation, and enhancing overall network reliability, and supporting widespread adoption of 5G technologies.

**Keywords:** AI, Beamforming, Interference Management, Data quality, signal strength.

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## 1.0 Introduction

Artificial intelligence is defined as the ability of computer systems or other machines to perform actions or tasks thought to require intelligence such as learning, problem-solving and decision-making. Digitilisation has transformed our current world through the introduction of disruptive technologies such as IoT, artificial intelligence, and 5G just to mention a few (Shafique, 2020).

Presently, the telecommunications industry is undergoing a profound transformation driven by the integration of Artificial Intelligence (AI) and Machine Learning (ML), significantly influencing both customer satisfaction and operational efficiency. However, the adoption of AI and ML is not without its challenges such as infrastructure investment and complex system upgrades, significant workforce training and concerns for data privacy and cybersecurity (Santhosh, 2025). AI offers potential benefits for mobile communication, such as enhancing communication accessibility and efficiency, improving personalization, and providing valuable insights through data analysis (Nguyen, et al., 2021). AI and its subcategories like machine learning and deep learning have been evolving as a discipline, to the point that nowadays this mechanism allows fifth-Generation (5G) wireless networks to be predictive and proactive which is essential in making the 5G vision conceivable (Gizealew and Sisay, 2021). Also, the categorization of the network layers and AI techniques systematically addresses the implementation of energy-efficient technologies within 5G networks, thus, utilization of AI techniques can also help improve energy efficiency and enhance KPIs across the 5G network.

## 2.0 Research method

This study made use of the review research method to examine how artificial intelligence (AI) can be applied to enhance 5G signal strength and improve overall network service quality. It enabled the authors to take a critical look at some related works that were recently conducted, with a view to bringing some important points out which were aimed at achieving the aim of the research work. The data used in this research were secondary data obtained from credible sources such as peer-reviewed journals, conference papers, textbooks, technical reports, and reputable online publications related to artificial intelligence and 5G networks. Special attention was given to recent research works in order to capture current trends, innovations, and challenges in AI-driven 5G network enhancement. These materials were carefully selected to ensure relevance to key areas such as network optimization, beamforming, interference management, predictive maintenance, resource allocation, and self-healing networks. The findings of the study are evidence-based, practical, and useful to telecommunication service providers, researchers, and policymakers interested in improving network performance and service delivery through artificial intelligence.

## 3.0 Results and discussion

### 3.1 Methods of improving 5G Network Performance using Artificial Intelligence Technologies

Below are some methods of improving 5G network performance through the integration of AI with 5G network.

#### 3.1.1 Network Optimisation

5G Network Optimization is defined as the processes and techniques employed to enhance the performance, efficiency, and capacity of 5G networks. This involves various strategies, such as **dynamic resource allocation**, **network slicing**, and **advanced antenna technologies**. AI-driven network optimization makes use of the data from base stations, user equipment, and core network elements, such as signal-to-noise ratio reference signal received power, user mobility, and environmental conditions such as atmospheric components. Machine learning models such as artificial neural networks (ANNs), or other models analyse this data to identify patterns and predict signal degradation caused by various factors such as multipath fading, network congestion, environmental conditions, etc. Accurate prediction of 5G network allows proactive optimisation, which includes adjusting transmission power, antenna parameters, or handover triggers before the deterioration of

service quality. AI-based network optimization in 5G network improves its spectral efficiency, reduces coverage gaps, and ensures consistent Quality of Service.

According to Thati et al, (2025), AI can help in optimizing network resources, enhancing the user experience, thus, enabling new capabilities that may not be possible with traditional methods. This can be achieved by focusing on optimizing beam direction in real-time by leveraging spatial data and environmental characteristics, aiming to enhance signal strength and system efficiency (Qing et al., 2024). The 5G network optimization using real-time edge intelligence has resulted to the provision a scalable and intelligent framework for real-time, self-optimizing wireless networks like 5G. When ML and AI are integrated within 5G, it will help to Forecast the peak traffic, resource utilization and application types; and optimize and fine tune network parameters for capacity expansion. In addition, network optimization must assist in network management in order to keep the quality of service when necessary, through various systems upgrades to cope with the changes in the operating environment (Abdelfatteh et al, 2021). Another key role is that planning and deploying 5G networks also face issues like high infrastructure costs, spectrum allocation, and urban–rural disparities, but machine learning techniques applications helps to optimize base station placement and improve coverage accuracy (Kumar et al., 2025).

### **3.1.2. Beamforming**

Beamforming, is defined as the signal processing technique that directs the transmission and reception of the signal in a specific or desired direction, rather than sending the signal uniformly in all directions It is a type of radio frequency (RF) management in which a wireless signal is directed toward a specific receiving device. Beamforming is a core 5G technology that directs signals toward specific users rather than broadcasting omnidirectionally, thus, maximising signal strength, efficiency, increases throughput, and reduces interference.

AI maps channel state information (CSI) to optimal beam configurations, and allowing accurate alignment where attenuation is high. AI-driven beamforming is extremely effective in multi-user scenarios, where beams are directed to multiple users simultaneously, reducing interference and maximizing network capacity. Furthermore, AI facilitates proactive beam management for mobile users, predicting trajectories and adjusting beam directions to maintain connectivity and minimize handover delays. To facilitate adaptive, real-time decision-making in complex and dynamic situations, beamforming systems are increasingly incorporating AI and machine learning. AI-based beamforming is capable of assuming mobility conditions and forecasting the best beam directions [Qiao et al, 2024]. Andras et al., (2025), state that beamforming facilitates improved synchronization accuracy, accelerates beam sweeping, and enhances the reliability of initial access—capabilities that are particularly crucial in 5G NR deployments. This highlights the importance of precisely configuring beamforming and synchronization parameters to optimize network performance based on the specific deployment environment and service requirements.

### **3.1.3. Predictive Maintenance**

Predictive maintenance is defined as the proactive strategy that uses AI, and real-time data analysis as well as IoT sensors, to monitor equipment condition and predict failures before they occur. In the case of 5G, the predictive maintenance is an advanced industrial strategy that uses high-speed, low-latency 5G networks to connect, monitor, and analyze machine data in real-time, which helps for identification of potential equipment failures before they occur. Simply put, predictive maintenance leverages AI to anticipate network faults before they impact service quality, ensuring smooth and reliable 5G connectivity. AI introduces a proactive approach by analyzing historical and real-time network data to forecast potential issues. This is done through the monitoring of key network parameters such as base station

performance, traffic load, and hardware status by AI tools, and by identifying early warning signs of equipment failure, congestion, or signal degradation, AI systems can trigger preventive actions, such as adjusting network configurations, rerouting traffic, or scheduling maintenance activities.

In addition to the prevention of fault, AI-driven predictive maintenance helps to reduce unplanned downtime, optimizing maintenance schedules, improving resource utilization, and enhances network reliability and operational efficiency. AI-powered predictive models can examine past data to foresee possible network failures before they happen, enabling the implementation of preventive measures. In addition to decreasing downtime, this proactive method to fault management helps to improve network performance and its dependability generally [Huang, Y., & Zhang, 2012 & Perumallapalli, 2015]. The seamless integration of AI with 5G network facilitates the predictive maintenance, automatic fault detection and intelligent network reconfiguration (Bhargavi, and Siva 2025) which is helpful in network reliability.

#### **3.1.4. Resource Allocation**

5G resource allocation defined as the intelligent process of distributing and managing limited network resources such as **spectrum, power, time, and computational capacity** among various applications, devices, and network slices. Resource Allocation in 5G network using AI helps 5G network to satisfy diverse Quality of Service (QoS) requirements for various applications. Resource allocation in 5G networks involves distributing network bandwidth, power, and spectrum among multiple users and services to optimize performance. AI technologies enable intelligent allocation of resources, ensuring efficient utilization and improved user experience. AI models when integrated with 5G network, analyze user density, device mobility, traffic fluctuations, and application requirements to allocate resources where they are most needed. Furthermore, AI facilitates load balancing across multiple base stations and network slices which allows operators to dedicate virtualized resources to specific services or user groups. This is why Sushma, et al, (2025) reported that the broad use of 5G technology, which offers increased data rates, reduced latency, and huge connection, is a result of the telecommunication networks' rapid evolution such as AI integration which helps to provide a flexible and scalable solution that maximises performance as well as effective network resource allocation. Additionally, ITU-T Recommendation [ITU-T, 2019] emphasises the potential of AI and ML to enhance 5G network performance, thus, in order to improve coverage maps and optimise the network resource allocation, the ITU report's architectural framework recommends integrating deep learning models or AI with network infrastructure.

#### **3.1.5. Interference Management**

5G network signal interference management is defined as the specialized techniques applied to mitigate signal degradation which are caused by high-density deployments, shared spectrum, and complex multi-tier network architectures. Network interference is a critical factor affecting the performance and reliability of wireless communication systems, as it is experienced when multiple transmissions overlap in frequency, time, or space, causing degradation in throughput, increased delays, and higher energy consumption. Interference occurs in dense 5G networks area like in urban environments with closely spaced cells, overlapping frequency bands, as well as high device density. Interference causes increase in latency, reduction in signal quality, and limits network capacity. The integration of AI with 5G helps in detecting, and predicting interference, as well as mitigating it dynamically, thus ensuring optimal 5G network performance. AI Machine learning algorithms analyze network data such as signal-to-interference-plus-noise ratio, traffic patterns, and channel conditions to identify interference sources. AI Reinforcement learning can dynamically

adjust transmission power, beamforming angles, frequency assignments, and scheduling to reduce interference effects while maintaining high throughput. AI technique like deep learning-based models have the ability to overcome interferences and increase the accuracy of network rollout plans. These algorithms use neural networks to analyse large datasets, identify trends, and forecast the best places to put 5G infrastructure (Sushma, et al, 2025).

### **3.1.6. Network Signal Coverage Prediction**

5G network signal coverage prediction is defined as the process of using mathematical modeling, simulation tools and AI algorithms to estimate the strength, quality, and reach of radio signals from 5G base stations. Effective network prediction allows operators to optimize base station placement, antenna configuration, and network topology before deployment, which will reduce trial-and-error adjustments and improving service quality. Artificial intelligence performs network signal coverage prediction by analyzing historical network performance, geographic information, user distribution, and environmental data. It predicts coverage maps with high accuracy, thus, enabling network planners to identify weak signal areas and optimize resource allocation accordingly. In an effort to improve service quality, some telecom companies have also implemented AI-based coverage prediction models [Nokia Corporation, 2025]. Machine learning can be used in coverage prediction in 5G, in which the cellular network is managed proactively and in real-time (Varsha, 2025). From various studies, it can be observed that 5G coverage estimation is seeing an increase in the use of deep learning methods like recurrent neural networks (RNNs) and convolutional neural networks (CNNs) (Sushma et al., 2025), and this is as a result of the effective and desired results obtained through improved signal quality. In the work by Butt et al. [2021], it was stated that location-based coverage evaluations of network signals are improved by AI-driven prediction models, implying that a data-driven approach for network coverage prediction using machine learning techniques is very paramount.

### **3.1.7. Anomaly Detection**

5G network signal anomaly detection is defined as the process of continuously monitoring key performance indicators (KPIs) and radio frequency (RF) measurements within a 5G network to identify, in real-time, data points or patterns that deviate significantly from the established normal behaviour or pattern. In other words, anomaly detection involves identifying unusual patterns in network behavior that may indicate faults, attacks, or performance degradation. These network anomalies, such as latency spikes, unexpected signal drops, interference, often indicate that there are some underlying issues such as hardware failures, network misconfigurations, or malicious security threats like network jamming. AI provides advanced tools for detecting anomalies in real time, ensuring both network security and operational reliability. AI models can analyze traffic patterns, signaling data, and device behaviour to detect deviations from normal conditions, thus allowing network operators to respond proactively to anomalies, mitigating service disruptions and enhancing security.

To find and diagnose network issues, a variety of AI technology approaches are investigated, such as supervised learning algorithms (like decision trees and support vector machines) and unsupervised learning techniques (like clustering algorithms and anomaly detection methods). These are used to analyse the data in order to fix the errors being experienced (Perumallapalli, 2015). Wireless Sensor Networks Anomaly Detection Using Machine Learning provide a way of de-noising and change-point techniques that can stabilize training for AI channel predictors in interference-prone settings (Amithesh et al., 2025). In dynamic environments where new, unnoticed fault types may be experienced, anomaly detection mechanism is crucial because the system has the capacity to identify invisible flaws further improve the system (Zhang & Wang, 2014). Anomaly detection is a

method commonly used in the diagnosis of network faults or misbehaviours, as it is designed to identify and flag abnormal behavior within the network using AI methods (Jaleh, 2023). In the same way, the detection of doubtful activities becomes possible through anomaly detection algorithms using AI machine learning tools. (Santhosh and Gary, 2023). Aside these, anomaly detection is very important as it provides valuable insights into network performance, enabling proactive responses that minimize disruptions, ensure high availability, and support self-healing (Babak et al, 2025).

### **3.1.8. Self-Healing Networks**

**Self-Healing Network** is defined as an advanced infrastructure powered by AI, capable of autonomously monitoring, diagnosing, and repairing network problems, performance degradations in real-time without human intervention. Self-healing networks represent a critical advancement in the automation of 5G operations as it makes use of AI technologies by combining predictive analytics, anomaly detection, and reinforcement learning, to detect, diagnose, and resolve issues autonomously without human intervention, thereby reducing network downtime and operational costs. One of the benefits of self-healing networks is that, by minimizing manual intervention, AI reduces operational expenditure and human error. In addition, the continuous adaptation enhances Quality of Experience for end users, providing consistent throughput, low latency, and reliable connectivity. According to Santhosh and Gary, (2023), the combination of AI and ML in self-healing networks enables automated repairs from machines that detect problems without significant human involvement when maintenance occurs. These networks perform pre-failure predictions and real time anomaly detection which enables them to execute self-maintenance duties to recover network performance at maximum levels. The capacity of AI-based self-healing networks to continuously learn and adjust to shifting network conditions is an important feature. New network data is added to the AI models following each cycle of problem identification and recovery, which allows the system to develop its issue detection and diagnosis skills over time, and in the process, enhancing accuracy and responsiveness (Perumallapalli, 2015). Jaleh and Amirreza, (2023) stated that Self-healing is a promising approach to network management, which aims to detect and compensate for cell outages in an autonomous way. It was reported further in the work that this technology aims to decrease the expenses associated with the installation and maintenance of existing 4G and 5G, and emerging 6G networks by simplifying operational tasks through its ability to heal itself.

## **3.2 Challenges of AI Integration with 5G Networks**

Bringing Artificial Intelligence (AI) into 5G networks promises smarter, faster, and more efficient communication systems. However, this integration is not without challenges, some of which are as follows.

### **3.2.1 Data Security and Privacy**

One of the biggest concerns with AI-driven 5G networks is data security and user privacy. Unlike earlier mobile networks, 5G is highly distributed and relies heavily on virtualization, which increases the number of potential entry points for cyberattacks. The global adoption of AI in financial services presents immense opportunities, but it also introduces complex ethical and regulatory challenges (Arunkumar, 2023). Despite this clear potential, the application of AI in Nigeria's telecommunications sector remains nascent and fragmented, as studies show barriers to adoption of AI such as concerns regarding data privacy (Geku and Okafor, 2025). In other words, AI systems require constant access to large volumes of network and user data in order to make real-time decisions. But if this data is not properly protected, it can be exposed to breaches, or misuse. As a result, there is a need for a strong security measure such as encryption, secure data handling policies, and privacy-aware AI

techniques to protect sensitive information while still allowing AI systems to function effectively.

### 3.2.2 Infrastructure Complexity

5G networks are far more complex than previous generations, as it combines cloud platforms, edge computing, software-defined networking, and virtualized network functions. Integrating AI into such an environment is challenging, especially when many operators still rely on older legacy systems. These older systems may not easily support AI-based automation, leading to integration difficulties and increased complexity. In addition, ensuring that AI tools can work smoothly across equipment and software from different vendors further complicates deployment and maintenance. That is why (Geku and Okafor, 2025) stated that Nigerian telecom providers, in collaboration with government and private stakeholders, should prioritise investments in reliable broadband, data centres, and energy infrastructure to create a supportive foundation for AI deployment. Also, the rollout of 5G networks marks a foundational shift in wireless communication, designed specifically to support massive IoT connectivity and ultra-low latency applications, but this requires critical infrastructure (Himanshu, 2025). It is therefore necessary to state that revolutionizing Telecom with AI and ML is extremely important, but the initial investment required for AI and ML infrastructure can be substantial, especially for small to mid-sized telecom providers (Santhosh, 2025).

### 3.2.3 Data Quality and Volume

It is good to note that AI systems depend heavily on accurate and timely data to perform well. Also, even though 5G networks generate massive amounts of data, not all of this data is useful or reliable. Collecting the right data, cleaning it, and processing it in real time can be difficult without introducing delays. Thus, poor-quality or incomplete data can lead to incorrect AI decisions, which may negatively affect network performance. In this case, efficient data management is crucial to ensure that AI-driven network optimisation is both accurate and efficient. It is also important to state that there should be investment in Data Quality and Openness such that there will be open standards and open data portals for third-party use (Himanshu, 2025). To build an extensive dataset for AI model training, historical network performance data is also sourced. Furthermore, preprocessing procedures are used to handle missing data, eliminate noise, and have the data normalised because data quality is very important. These processes make that the dataset reliable and prepared for use [Lee, S., & Park, 2013].

### 3.2.4 Energy Constraints

AI processing increases energy consumption, which can raise operational costs and will in a way affect the sustainability goals. This is because, the running AI algorithms requires significant computing power, which can be a major challenge in 5G environments, particularly at edge nodes with limited resources. Network operators must find a balance between achieving high AI performance and minimizing energy use, especially as 5G networks continue to expand. As stated by Geku and Okafor, (2025), from a technical standpoint, wireless communication systems sector suffers from limited infrastructure, as well as heavy dependence on unstable energy sources, which reduce the reliability of AI-driven solutions. In today's world, the significance of reducing energy consumption globally is increasing, making it imperative to prioritize energy efficiency in 5th-generation (5G) networks. But it is crucial to ensure that these energy-saving measures do not compromise the Key Performance Indicators (KPIs), such as user experience, quality of service (QoS), or other important aspects of the 5G network (Ezzeddine et al, 2024). Energy efficiency is a critical consideration in modern networks, including 5G. As the demand for data and connectivity continues to grow exponentially, reducing energy consumption has

grown in significance (Bohli, and Bouallegue, 2021). This makes energy one of the major challenges in the intergration of AI with 5G network systems.

### **3.2.5 Skill Shortages**

Another major challenge is the lack of skilled professionals who understand both AI technologies and telecommunications systems. AI–5G integration requires knowledge of AI techniques like machine learning, data analytics, network architecture, and cybersecurity. However, studies have shown that individuals with expertise across some of these areas are limited. This skills gap can slow down deployment, as well as reduce the effectiveness of AI-driven solutions. However, for widespread adoption, several challenges must be addressed., and this includes shortages in skilled personnel, high implementation costs, and ethical considerations surrounding AI deployment (Santhosh, 2025)

### **3.2.6 Interoperability**

5G networks involve multiple vendors, hardware platforms, and communication standards. For AI solutions to be effective, they must be able to operate across these diverse systems without compatibility issues. The absence of common standards for AI integration in 5G can lead to fragmented deployments, reduced scalability, and vendor lock-in. Establishing clear standards is important to ensure smooth integration and long-term flexibility. It is sometimes challenging to define an integrated reference architecture for multi-cloud IoT based microservices, enabling intelligent data acquisition and analysis through integrated protocols and standards with uniform access while supporting different interactions between various IoT services deployed on federated cloud systems at the 5G networks (Krylovskiy et al., 2015). Also, diverse IoT vendors, protocols, and device generations create fragmented urban data ecosystems, which sometimes lead to deployment failures and long-term inefficiencies. A lack of interoperability standards meant devices from different vendors could not communicate within the same region (Himanshu, 2025), making it a big problem.

### **3.2.7 Ethical and Regulatory Issues**

The use of AI to make autonomous decisions in 5G networks raises ethical and regulatory concerns. When AI systems control network operations, questions arise especially in terms of accountability. There are also concerns about bias, transparency, and fairness in AI decision-making. In addition, regulations governing AI and telecommunications differ across countries, thus, Network operators must ensure that their AI-driven systems comply with these regulations while still delivering reliable and efficient services to the public. As opined by Santhosh, (2025), AI-driven decision-making in 5G networks can raise ethical issues, including fairness in resource allocation, transparency of AI operations, and accountability for automated actions. Additionally, regulatory compliance for data use, network security, and AI deployment varies across regions, which makes global implementation very complicated. Therefore, to responsibly develop and integrate AI into mobile communication, collaborative efforts are needed among industry, academia, and government. This includes developing and implementing regulations and standards for the use of AI in mobile communication (Shaifali and Sandeep, 2023).

## **4.0 Conclusion**

This work investigated the roles or applications of AI technologies in the improvement of the performance of 5G networks. Using the review research method, the research work studied some challenges facing the integration of AI in 5G network systems. From the results, it was found out that some of the methods of improving 5G network performance using artificial intelligence technologies are network optimisation, interference management, beamforming, predictive maintenance, resource allocation, and self-healing networks. The results also showed that some of the impediments to the integration of AI with 5G network

services are data security and privacy, infrastructure complexity, energy constraints, interoperability, ethical and regulatory issues, and data quality and volume. From the results, we can conclude that despite some challenges facing the integration of AI with the 5G network, AI technologies have the capacity to improve the signal strength of the 5G network. This result will be important to telecommunication service providers and communications experts, as well as stakeholders in communication sectors, for the improvement of the services as well as the formulation of proper policy aimed at providing a quality service in telecommunication. The findings will be important in the areas of optimizing 5G network efficiency, predicting and mitigating signal degradation, and enhancing overall network reliability, supporting widespread adoption of 5G technologies.

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