

**REVIEW OF AI-BASED ENERGY EFFICIENT COMMUNICATION IN IOT SYSTEM***Shital Chavan**UG Student, Department of Electronics and Telecommunication Engineering
SKN Sinhgad College of Engineering, Pandharpur, India
chavanshital3108@gmail.com**Anam Bedrekar**UG Student, Department of Electronics and Telecommunication Engineering
SKN Sinhgad College of Engineering, Pandharpur, India
anambedrekar09@gmail.com**Sanika Babar**UG Student, Department of Electronics and Telecommunication Engineering
SKN Sinhgad College of Engineering, Pandharpur, India
sanikagbabar33@gmail.com**Prof. M. N. Naiknavare**Assistant Professor, Department of Electronics and Telecommunication Engineering
SKN Sinhgad College of Engineering, Pandharpur, India
madhav.naiknavare@sknscoe.ac.in***Abstract:**

The rapid growth of the Internet of Things (IoT) has led to a massive increase in the number of connected devices across various domains such as smart homes, healthcare, agriculture, and industrial automation. As these devices are often battery-powered and deployed in remote or large-scale environments, energy efficiency has become a critical concern in IoT communication systems. Traditional IoT networks typically operate using fixed transmission power levels, which do not adapt to changing environmental or network conditions, resulting in unnecessary energy consumption and reduced battery life. To address these limitations, there is a growing need for intelligent and adaptive communication mechanisms that can dynamically optimize power usage without compromising reliability. In this context, Artificial Intelligence (AI)-based adaptive transmission power control has emerged as a promising solution. This review paper presents an analysis of AI-driven techniques that enable IoT devices to adjust their transmission power based on real-time conditions and network requirements. The study explores approaches such as machine learning-based prediction models, which utilize parameters like Received Signal Strength Indicator (RSSI), distance, interference levels, and packet loss rates to determine optimal transmission power. Additionally, the role of edge computing is examined, enabling faster decision-making with reduced latency. The integration of Low Power Wide Area Network (LPWAN) technologies is also discussed for supporting long-range and energy-efficient communication. Furthermore, the paper highlights how adaptive power control improves network performance by reducing energy wastage, minimizing interference, and extending device lifetime.



These benefits are especially useful in applications like smart cities, precision agriculture, and industrial automation. Despite these advantages, challenges such as implementation complexity, resource constraints, and data privacy concerns remain. The paper also outlines future research directions, including the development of lightweight AI models and improved integration with emerging technologies. In conclusion, AI-based adaptive transmission power control significantly enhances energy efficiency and communication reliability, making it essential for the sustainable development of next generation IoT systems. It also supports scalable and cost-effective deployment of IoT networks in diverse realworld environments.

Keywords: IoT, Artificial Intelligence, Energy Efficiency, Transmission Power Control, Machine Learning,.

LPWAN

Introduction:

With the rapid expansion of IoT networks, energy efficiency has become a critical challenge in modern communication systems and plays a key role in ensuring sustainable and reliable network operation. IoT devices are typically battery-powered and deployed in large numbers across wide and often remote areas.

Efficient energy utilization is therefore essential for long-term operation, reduced maintenance, and costeffectiveness. Traditional communication systems use fixed transmission power, which does not adapt to changing network conditions and often results in unnecessary energy consumption.

This issue becomes more significant when devices are located close to each other or when lower transmission power levels are sufficient for communication. As a result, energy resources are wasted, and the overall lifetime of IoT devices is reduced.

To overcome this limitation, intelligent systems based on Artificial Intelligence (AI) and Machine Learning (ML) are being developed to enable smarter, more adaptive, and efficient communication. These systems dynamically adjust transmission power according to real-time network conditions.

Parameters such as signal strength, distance between devices, interference levels, and packet loss are continuously analyzed to make accurate decisions. This helps in optimizing power usage, reducing energy wastage, and maintaining reliable and stable communication.

AI-based adaptive communication systems represent a significant advancement in IoT technology. They improve energy efficiency, enhance system reliability and scalability, and support applications such as smart agriculture, environmental monitoring, industrial IoT, smart cities, and wireless sensor networks.



In addition, these systems contribute to better network management by reducing congestion and improving data transmission efficiency. They ensure that communication remains stable even in dynamic and changing environments.

Furthermore, the integration of AI and ML enables IoT systems to learn from past data and continuously improve their performance. This makes the communication process more intelligent, adaptive, and responsive to real-world conditions.

Overall, AI-based adaptive transmission power control provides a practical and effective solution for modern IoT challenges. It supports sustainable development by optimizing energy usage and enhancing the performance of next-generation IoT networks.

Literature Survey:

Recent research in IoT communication has increasingly focused on improving energy efficiency through intelligent and adaptive techniques. Traditional IoT systems often use fixed transmission power, which leads to unnecessary energy consumption and reduced battery life. To overcome this limitation, several researchers have explored Artificial Intelligence, edge processing, and advanced wireless communication models for optimizing IoT performance.

Pan and Wu (2020) proposed an AI-assisted communication framework integrated with Intelligent Reflecting Surface technology for 6G IoT environments. Their work aimed to improve signal quality and energy efficiency by intelligently managing wireless communication conditions. The study showed that AI can play an important role in reducing energy usage while maintaining better communication performance. However, the major limitation of this approach is its high implementation and deployment cost, which may reduce its practicality for low-cost IoT systems. **hakur and Sarkar (2024)** presented an AI-driven energy-efficient routing approach for IoT-based wireless sensor networks. Their work focused on selecting optimized communication paths so that network lifetime could be extended and unnecessary energy loss could be minimized. This approach is useful for sensor-based IoT systems where nodes are battery-powered and network sustainability is important. Although the proposed model improves energy utilization, it involves algorithmic complexity and requires proper training data to achieve effective results.

Mirani and Awasthi (2025) introduced an industrial IoT-based energy monitoring system using edge data processing. Their research emphasized processing data near the source instead of relying completely on cloud systems. This reduced latency and enabled faster system response, which is valuable in real-time IoT monitoring applications. The study highlighted that edge computing can contribute to efficient energy management and quick decision-making. However, the main drawback is the limited processing capability of edge devices, which may restrict the complexity of the deployed intelligence.

Chen and Miao (2025) proposed an intelligent LPWAN-based IoT communication model for hybrid lowpower wide-area networks. Their work combined AI techniques with LPWAN

technology to support longrange communication while reducing power consumption. The system was found to be suitable for largescale IoT deployment because of its scalability and low-energy operation. However, the integration of multiple advanced technologies makes the system more complex to design and implement.

Proposed Methodology:

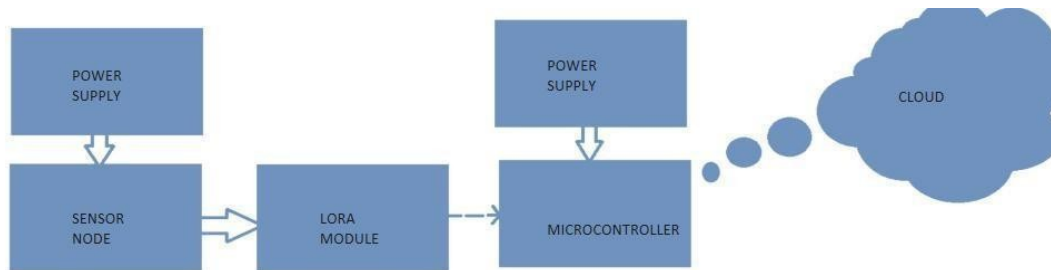


Figure 1 Block Diagram of Proposed System

The diagram represents the architecture of an IoT-based communication system designed for efficient data transmission and monitoring. The system begins with a power supply unit that provides energy to the sensor node, ensuring continuous operation. The sensor node collects real-time data such as communication parameters or environmental conditions and acts as the primary data source. This collected data is then transmitted to the LoRa module, which is responsible for long-range, low-power wireless communication between devices.

The LoRa module forwards the data to the microcontroller, which serves as the central processing unit of the system. The microcontroller receives and processes the incoming data, performs necessary computations, and prepares it for further transmission. It is also powered by a separate power supply to maintain stable and efficient operation. After processing, the data is sent to the cloud platform, where it is stored, analyzed, and visualized.

The cloud enables remote access to the data through mobile or web applications, allowing users to monitor system performance in real time. Overall, the system ensures reliable communication, efficient data handling, and supports applications such as adaptive transmission control and smart IoT monitoring.

In addition, the use of LoRa communication technology allows the system to operate over long distances while consuming very low power, making it suitable for large-scale IoT deployments. This helps in reducing energy consumption and extending the battery life of devices, which is essential for remote and distributed environments.

Furthermore, the integration of cloud technology enhances the scalability and flexibility of the system. It allows data to be accessed, analyzed, and managed from anywhere, supporting better decision-making and system optimization. This architecture can also be extended by integrating



AI-based techniques for intelligent control and improved communication efficiency in future IoT applications.

Discussion:

In the proposed AI-based adaptive transmission power control system for IoT communication, the performance of the system will be evaluated based on its ability to optimize energy consumption while maintaining reliable data transmission. The system is expected to continuously monitor communication parameters such as RSSI (signal strength), distance between devices, packet loss, and power usage in real time.

The collected parameters will play a crucial role in understanding the network conditions under which communication occurs. For instance, RSSI values will indicate signal strength, while packet loss and distance will help in identifying communication quality. These factors are expected to assist the system in determining the most suitable transmission power required for efficient communication.

The data gathered from IoT devices will be processed and analyzed using machine learning techniques. Based on this analysis, the system will predict the optimal transmission power for different network conditions. It is expected that the system will provide accurate and adaptive decisions, ensuring efficient communication with minimal energy consumption.

The predicted transmission power will be applied dynamically to the IoT devices. The system is expected to continuously adjust power levels in real time instead of using fixed transmission power. This adaptive mechanism will help in reducing unnecessary energy usage, minimizing interference, and extending the battery life of IoT devices.

However, the system may face certain limitations such as dependency on the accuracy of the machine learning model and variations in network conditions. Additionally, implementing AI algorithms on resource-constrained IoT devices may introduce computational challenges. Despite these limitations, the system is expected to provide a practical and efficient solution for energy optimization.

Overall, the integration of AI and IoT in adaptive transmission power control is expected to significantly improve communication efficiency, reduce energy consumption, and support the development of sustainable and scalable IoT networks.

Conclusion:

This review paper highlights the significance of AI-based adaptive transmission power control in improving energy efficiency in IoT systems. By dynamically adjusting transmission power based on real-time network conditions, the system reduces energy consumption while maintaining reliable communication. The study concludes that AI-driven approaches are essential for the future of IoT networks and can significantly enhance performance in various smart applications.



In addition, the paper emphasizes that such adaptive systems help in extending the battery life of IoT devices and reducing overall operational costs. It also highlights the ability of AI models to learn from network patterns and improve decision-making over time. Overall, AI-based energy-efficient communication plays a crucial role in developing sustainable and intelligent IoT ecosystems.

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