# Brief Overview on Wireless Sensor Network Technologies in the Internet of Things (IoT)

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## ABSTRACT

Wireless systems based on IoT-based has evolved rapidly in various sectors. The IoT (Internet of Things) is the network in which physical devices, equipment, sensors and other objects can communicate among themselves without human involvement. The WSN (Wireless Sensor Network) is a central component of the IoT, which has expanded across several different applications in real-time. Various approaches and algorithms for energy-efficient data aggregation in IoT-WSN systems were presented. Wireless Sensor Network technologies play a vital role in enabling the IoT. In this analysis, we delve deep into the essential elements, functionalities, and applications of WSN technologies within the context of IoT. We explore the diverse sensor nodes, communication protocols, and network architectures that constitute WSNs, highlighting their crucial function in gathering, transmitting, and processing data from the physical environment.

The Internet of Things (IoT), which enables seamless connectivity among a variety of physical objects, has completely changed how we interact with the world around us. Wireless Sensor Network (WSN) technologies, which is the central nervous system of this interconnected ecosystem are a fundamental IoT enabler. This paper overview the essential elements, functionalities, and applications of WSN technologies in context of Internet of Things (IoT). We cover the various sensor nodes, communication protocols, and network architectures that make up WSNs in this thorough analysis, highlighting their functions in gathering, transmitting, and processing data from the physical environment. We explore the particular difficulties.

WSN technologies find applications across various domains within the IoT landscape. From smart cities and precision agriculture to healthcare and industrial automation, WSNs play a crucial role in transforming these sectors. We showcase real-world case studies that illustrate the practical implementation and impact of WSNs in these domains, providing concrete examples of their effectiveness. Our goal is to provide you with engaging and content that adds value to your understanding of the Internet of Things and Wireless Sensor Networks.

*Keywords--* Wireless Sensor Network (WSN), Internet of Things (IoT), Integration, Challenges, Applications, Aggregation Technique, Energy Efficiency

## I.    INTRODUCTION

The Internet of Things (IoT) has revolutionized the way we perceive and engage with the world around us. It connects numerous devices and objects to the internet, creating a vast and interconnected web of physical and digital entities. This transformative technology has reshaped industries, improved our daily lives, and holds the promise of even more profound changes to come.

At the heart of IoT-based systems are Wireless Sensor Networks (WSNs), which play a critical role in introducing significant energy-saving techniques. However, the rapid advancement of these devices has given rise to energy consumption issues in information exchange. The escalating communication and data exchange have led to unsustainable increases in energy consumption and carbon emissions. In various applications such as environmental control, agriculture, and border surveillance, sensor nodes must operate effectively for extended periods, ranging from months to years, depending on the requirements of the specific application.

In this paper, we embark on a journey to delve into the intricate interplay between Wireless Sensor Network technologies and the Internet of Things. Our goal is to uncover the core principles, challenges, and innovations that underlie the seamless integration of WSNs into the IoT landscape. We will explore the **architecture, protocols, and components** that make up WSNs, dissect the **hurdles** faced by these networks, and examine the **ingenious solution**s that have arisen to address these challenges.

In sum, the following pages will illuminate the indispensable role that Wireless Sensor Network technologies play in the uncovering narrative of the Internet of Things. These technologies serve as the critical bridge, connecting our physical world to the digital realm, promising to reshape technology, society, and industry on an unprecedented scale.

## II.    LITERATURE REVIEW

In IoT, real-time modules, such as sensors, are interconnected with one another to transmit valuable

data to centralized repositories. These repositories store and accumulate the data, making it easily accessible to authorized users. It's fascinating to compare IoT-based networking systems to traditional wired or wireless systems, as the sheer number of communication devices involved is significantly higher.

However, despite the high volume of IoT-generated traffic, it is generally not critically impacting the network's efficiency. This is because each IoT device senses and transmits data to its respective IoT Server. The data produced by a large number of objects does have some collective effect on the network's efficiency, but the impact is generally manageable. As a result, IoT networks can run seamlessly and sustainably for extended periods, even without human interference.

The beauty of the IoT lies in its ability to autonomously function, ensuring the safety and efficiency of interconnected systems without constant human oversight. This aspect is particularly beneficial for applications requiring continuous monitoring or control.

## III. REVOLUTIONIZING WIRELESS SENSOR NETWORK (WSN) TECHNOLOGY IN IOT

Wireless Sensor Network (WSN) technology plays a pivotal role in supporting the Internet of Things (IoT) by connecting the physical and digital realms. This technology enables the collection and transmission of vital data that forms the foundation for automated decision-making across various industries. Not only does it enhance the intelligence of our cities, bolster agricultural productivity, streamline healthcare operations, and boost industrial efficiency, but it also wields a profound influence on the overall IoT ecosystem. The ongoing evolution of WSN technology continues to drive our progress in this era of interconnected devices and data-driven decision-making, effectively shaping our increasingly interconnected environment.

The world of technology is rapidly evolving, and one of the most groundbreaking advancements is the wireless sensor network (WSN) technology within the realm of the Internet of Things (IoT). This revolution has brought about a paradigm shift, opening up a whole new era of interconnected capabilities and applications. In this article, we will explore the immense potential of WSN technology and its impact on various domains.

A key factor driving the widespread adoption of WSN technology is the miniaturization of sensor hardware and its enhanced functionality. These advancements have allowed WSN to seamlessly integrate into diverse IoT scenarios, offering unprecedented versatility. Now, sensors can be deployed in a wide range of environments, collecting valuable data that can be used to optimize various processes.

To ensure the effective deployment of WSNs, communication protocols have undergone significant evolution. The focus has shifted towards low-power consumption and mesh networking, enabling energy-efficient and scalable WSN deployments. This has greatly contributed to the sustainability of WSN nodes, thanks to innovations in energy harvesting and low-power electronics. As a result, WSNs can operate for longer periods without compromising their performance.

Thanks to the integration of 5G and edge computing, WSNs now have the ability to process data in real-time. This has significantly reduced latency, enhancing overall efficiency. With real-time data processing capabilities, WSNs can make quick and informed decisions, leading to improved operational outcomes. This integration has opened up new possibilities for leveraging the power of WSNs in various industries. While WSNs offer tremendous opportunities, it is crucial to address concerns around data security and integrity. To combat potential threats, robust security measures have been implemented. These measures include advanced encryption and intrusion detection systems, ensuring the confidentiality and integrity of data within the WSN. This instils trust and provides peace of mind to users who rely on WSN technology for critical operations.

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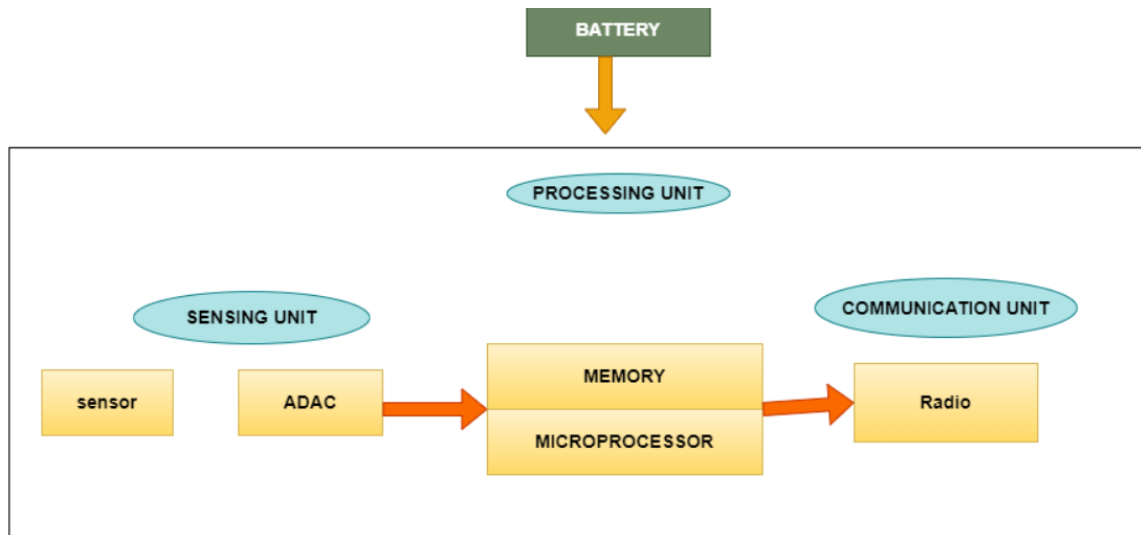
## IV.    ELEMENTS OF WSN

A basic wireless sensor network will have two components. They are:
- Sensor Node
- Network Architecture

### A) Sensor Node

A Sensor Node in   WSN consists of four basic elements. They are:
- Power Supply
- Sensor
- Processing Unit
- Communication System



When it comes to converting analog data from the physical environment into digital data, Analog-to-Digital Converters (ADCs) play a crucial role. These intelligent devices take the information collected by sensors and transform it into a format that can be processed and analysed by primary processing units like microprocessors or microcontrollers. To power the entire system, which comprises low-power components, such as sensors, processors, and communication modules, a tiny yet mighty battery is required. Consider the CR-2032, for example. Its diminutive size belies the important role it plays in keeping the system up and running efficiently. While the name may suggest otherwise, sensor nodes encompass more than just sensing elements. In addition to the core sensing component, a sensor node boasts processing, communication, and storage components as well. These multifaceted nodes are responsible for collecting data from the surrounding physical environment. However, their responsibilities don't stop there. Sensor nodes also perform network analysis, correlate data, and merge information from other sensors with their own findings.

### B) Network Architecture

**The Structural Design for Seamless Communication**

When we talk about WSN architecture, we're referring to the underlying framework that brings together all the components of a wireless sensor network. This framework includes both hardware and software elements, working in harmony to ensure the network's efficiency. Think of it as the backbone that supports the smooth flow of information between the sensors, gateways, and central systems. To paint a clearer picture, let's start with the hardware elements that make up WSN architecture. These components are like the gears in a well-oiled machine, working tirelessly to achieve seamless communication. Here are a few key players:

## V.    HARDWARE ELEMENTS

**1. Sensors:** These small, smart devices are the eyes and ears of the wireless sensor network. They collect data from the surrounding environment and transmit it to the gateways for further processing.

**2. Gateways**: Gateways act as intermediaries between the sensors and the central systems. They receive data from multiple sensors and ensure its smooth transmission to the intended destination.

**3. Central Systems**: This is where the magic happens! Central systems receive the data from the gateways, process it, and perform various tasks based on the specific application. These systems are responsible for making sense of the collected data and providing valuable insights.

## VI.    SOFTWARE ELEMENTS

**1. Network Protocol**: The language that allows devices within the wireless sensor network to communicate effectively. It determines how data is transmitted, received, and interpreted by the various components.

**2. Data Processing Algorithms:** Transforming Raw Data into Actionable Insights When it comes to data collected by sensors, it's often raw and unrefined. That's

where data processing algorithms come into play. They perform various tasks, such as filtering, aggregating, and analyzing data to extract meaningful information. These algorithms are like the magic wand that transforms raw data into actionable insights.

Here's an overview of the typical components and layers in a WSN architecture:
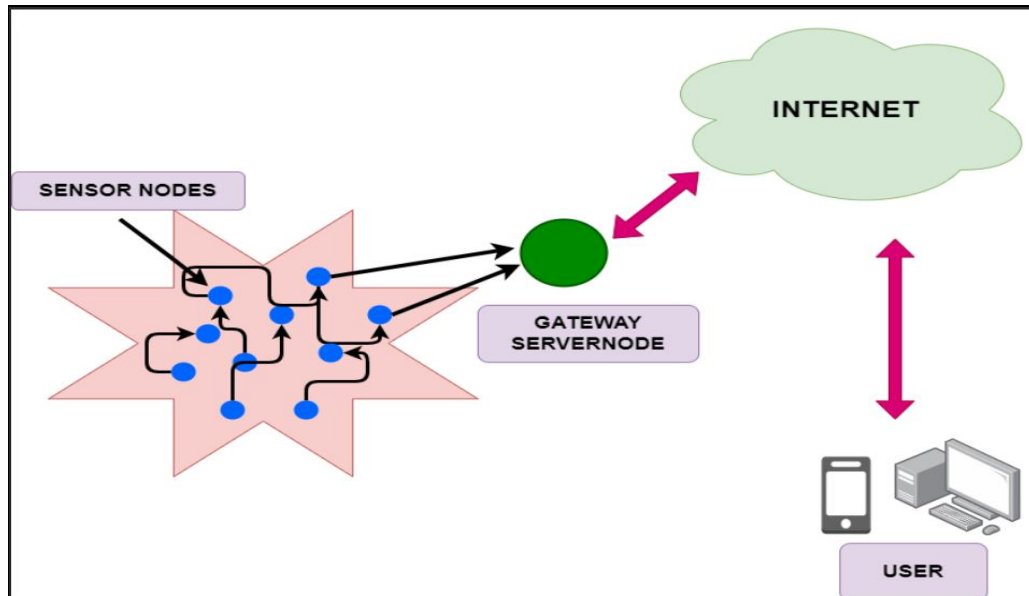


*Sensor Nodes*
- **Sensors:** These physical devices are responsible for collecting data from the surrounding environment. They can measure various parameters like temperature, humidity, pressure, light, motion, and other physical attributes.
- **Microcontroller:** To process the data gathered by the sensors, control the operations of the sensor node, and manage communication functions, a microcontroller is utilized.
- Transceiver: Facilitating wireless communication, the transceiver enables the sensor node to send and receive data within the network.

*Network Topology*
- **Node-to-Node Communication:** Sensor nodes communicate with neighboring nodes in a multi-hop manner, creating an ad-hoc network. Through this network, data is passed on to a sink node or gateway, which then transmits it to a central server or backend system.
- **Sink Node/Gateway:** The sink node or gateway plays a crucial role in this setup as it collects data from sensor nodes and relays it to the central infrastructure. Typically, this node possesses more processing power and a larger communication range than individual sensor nodes.

*Communication Protocols*
- **MAC Layer:** The Media Access Control (MAC) layer efficiently manages access to the wireless channel, ensuring unrestricted communication between nodes while avoiding interference. Commonly employed protocols include IEEE 802.15.4 and CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance).

- **Network Layer:** This layer is responsible for routing data from the source node to the destination nodes within the network. It incorporates routing protocols that determine the most appropriate path for data packets.
- **Transport Layer:** To facilitate end-to-end communication, ensure error correction, and maintain flow control, the transport layer of the network protocol stack comes into play.

*Gateway and Backend Systems*
- **Gateway:** Acting as the bridge between the wireless sensor network and the broader internet or intranet, the gateway aggregates data from sensor nodes and forwards it to backend systems.
- **Backend Systems:** The data collected from the sensor network undergoes processing, storage, and analysis on backend servers or in the cloud. These systems are responsible for making the data available to end-users through various applications and services.

*Power Management*
- **Energy Sources:** Sensor nodes are primarily battery-powered, making power management techniques crucial to extend the network's overall lifespan. Techniques like duty cycling, which involves putting nodes to sleep between data transmissions, and the use of energy-efficient hardware are commonly employed.
- **Energy Harvesting:** Some wireless sensor networks leverage energy harvesting methods like solar panels or vibration-based energy sources to recharge or prolong the lifespan of sensor node batteries.

*Security Layer*
- **Security Protocols:** To ensure the protection of data and maintain the integrity of the network, wireless sensor networks utilize security mechanisms such as

encryption, authentication, and intrusion detection systems.

### Application Layer

- **Application-Specific Software:** Custom software applications are developed to process and interpret the data collected by the sensor nodes. These applications can span various domains, including environmental monitoring, industrial automation, and healthcare.

Wireless sensor network (WSN) architectures can differ depending on the specific application and deployment requirements. Some systems may employ hierarchical structures with multiple layers of sensor nodes, while others may opt for flat topologies. The selection of architecture and components is influenced by factors such as the intended use, energy limitations, communication range, and scalability requirements. The architecture of a WSN involves a complex interplay of hardware, software, and communication protocols that collectively enable the efficient collection, transmission, and processing of data from sensor nodes within the network.

WSN architectures can vary depending on the specific application and deployment requirements. Some may use hierarchical structures with multiple layers of sensor nodes, while others may employ flat topologies. The choice of architecture and components depends on factors like the intended use, energy constraints, communication range, and scalability requirements. WSN architecture involves a complex interplay of hardware, software, and communication protocols, all designed to enable the efficient collection, transmission, and processing of data from sensor nodes within the network.

## VII. APPLICATIONS OF WIRELESS SENSOR NETWORK (WSNS)

Wireless Sensor Networks (WSNs) have found wide-ranging applications in various real-world scenarios, thanks to their cost-effective and efficient ability to monitor, collect, and transmit data. Let's explore some notable applications of WSNs across different industries and sectors:

### Environmental Monitoring

- **Air Quality Monitoring:** WSNs can be deployed to measure air pollution levels, offering vital information to authorities and researchers. This data helps in monitoring and managing environmental quality, particularly in urban areas.

- **Weather Monitoring:** Wireless sensors play a crucial role in collecting data on temperature, humidity, wind speed, and other meteorological parameters. Such data is pivotal for accurate weather forecasting and predictions.

### Industrial Automation

- **Condition Monitoring:** WSNs are extensively used in industrial settings to monitor the condition of machinery and equipment. By predicting potential failures and optimizing maintenance schedules, these networks help industries run smoothly and efficiently.

- **Asset Tracking:** Wireless sensors contribute to real-time tracking of assets. This capability enables enhanced logistics and inventory management in various industries.

### Smart Agriculture

- **Precision Farming:** WSNs are a valuable tool in monitoring soil conditions, humidity, and temperature. Farmers can leverage this information to optimize irrigation, fertilization, and crop management practices, resulting in increased yields and reduced resource wastage.

- **Livestock Monitoring:** With the help of wireless sensors, farmers can easily monitor the health and location of livestock. This facilitates better management and enables early detection of diseases, ensuring the well-being of farm animals.

### Healthcare

- **Patient Monitoring:** WSNs have revolutionized healthcare by enabling the tracking of vital signs and monitoring patient movements. The real-time transmission of this health data to healthcare professionals allows for remote patient monitoring, timely interventions, and improved patient outcomes.

- **Elderly Care:** Leveraging WSNs in elderly care ensures the well-being of older individuals. These networks provide assistance in emergencies and help create a safe living environment, thus promoting independent living for the elderly.

### Smart Cities

- **Traffic Management:** WSNs play a vital role in traffic management. By monitoring traffic flow and detecting congestion, these networks help optimize traffic signal timings. This results in efficient urban transportation, reducing travel time and improving overall traffic conditions.

- **Waste Management:** Wireless sensors are deployed to track fill levels in waste bins. This data allows for the optimization of waste collection routes, leading to cost savings and improved waste management practices.

### Structural Health Monitoring

- **Bridge and Building Monitoring:** WSNs provide valuable insights into the structural health of bridges and buildings. By measuring parameters such as vibrations, strain, and temperature, these networks aid in identifying potential structural issues and ensuring the safety of infrastructure.

### Wildlife Tracking and Conservation

- **Animal Behaviour Studies:** Wireless sensors attached to animals offer valuable data on their behaviour, migration patterns, and habitat use. This information contributes to wildlife conservation efforts and helps researchers understand and preserve biodiversity effectively.

- **Ecosystem Monitoring:** WSNs assist in monitoring environmental conditions in ecosystems. This data aids researchers in gaining insights into ecosystem dynamics

and plays a crucial role in preserving the delicate balance of different species.

### Home Automation

**- Smart Homes:** WSNs enable the automation and control of various household devices, including thermostats, lighting systems, and security systems. This integration leads to improved energy efficiency, convenience, and enhanced quality of life for homeowners.

### Military and Defence

**- Surveillance and Reconnaissance:** WSNs find extensive application in military and defence operations. These networks are deployed for border surveillance, monitoring military installations, and gathering intelligence in challenging terrains. They play a critical role in ensuring national security.

### Emergency Response

**- Disaster Management:** Wireless sensors play a crucial role in disaster-prone areas. By providing real-time data on environmental conditions, WSNs aid in establishing timely response strategies and facilitating effective evacuation plans. This technology is invaluable in mitigating the impact of disasters.

These various applications of Wireless Sensor Networks highlight their versatility and the substantial impact they have across different industries and sectors. By enhancing efficiency, safety, and resource management, WSNs continue to revolutionize the way we interact with our environment and infrastructure. These are just a few examples of the myriad applications for IoT-based wireless sensor networks. The versatility and adaptability of WSN technology make it a valuable tool in a wide range of sectors, helping to collect data, automate processes, and improve decision-making.

## VIII. THE FUTURE OF IOT-BASED WIRELESS SENSOR NETWORKS

The future of IoT-based wireless sensor networks (WSNs) is filled with exciting possibilities. Technological advancements and the widespread adoption of IoT in various industries have set the stage for significant trends and developments. In this article, we will explore some key factors that are likely to shape the future of IoT-based WSNs and transform the way we interact with the digital world.

- The deployment of 5G networks, and the upcoming 6G networks, will revolutionize data transmission in IoT-based WSNs. With faster speeds and enhanced reliability, these networks will significantly reduce latency and support a broader range of IoT applications.

- The high-speed connectivity provided by 5G and beyond will enable the seamless connection of numerous devices and sensors, making IoT even more pervasive in our daily lives.

- Edge computing is gaining prominence in the world of IoT and WSNs. This approach involves processing data closer to its source, enhancing real-time analytics and decision-making capabilities.

- With more computing power integrated into edge devices, data can be processed and analyzed at the network's edge, enabling quicker response times and reducing the burden on centralized servers.

- The integration of AI and ML algorithms into WSNs will empower these networks to process and analyse sensor data more intelligently.

- This advancement will pave the way for more accurate and effective predictive and prescriptive analytics, enhancing efficiency in various industries. For instance, in industrial settings, proactive maintenance can be achieved through smart data analysis.

- Energy harvesting is emerging as a sustainable solution for powering IoT-based WSNs. This innovative approach allows sensor nodes to recharge using renewable sources such as solar, vibration, or thermal energy.

- By harnessing these energy sources, the lifespan of sensor nodes can be extended, reducing the need for frequent battery replacements and facilitating long-term monitoring.

- Ensuring the security of IoT-based WSNs remains a top priority. To safeguard data and network integrity, robust encryption, authentication, and intrusion detection systems will be implemented.

- Blockchain technology, known for its immutability and decentralized nature, may be integrated into WSNs to enhance security and establish trustworthiness in data transactions.

- The integration of blockchain technology into IoT-based WSNs will have a profound impact on security and data integrity, particularly in applications like supply chain management and healthcare.

- By leveraging blockchain's decentralized and transparent nature, data immutability can be ensured, offering a reliable and trustworthy platform for sensitive information.

The future of IoT-based wireless sensor networks is filled with immense opportunities. From the deployment of advanced networks like 5G to the integration of AI, blockchain, and quantum computing, the possibilities are endless. As technology continues to advance, IoT-based WSNs will reshape industries, enhance human-machine interaction, and pave the way for a more connected and sustainable future. In future Wireless sensor networks powered by the Internet of Things will see improved connectivity, intelligence, and application diversity. The way in which we interact with our environments, businesses, and personal lives will be significantly shaped by these networks. We can expect even more ground-breaking solutions and paradigm-shifting changes in the IoT landscape as technology develops.

## IX. COMMON LOOPHOLES AND POSSIBLE SOLUTIONS FOR INTEGRATING WIRELESS SENSOR NETWORKS (WSNS) INTO THE INTERNET OF THINGS (IOT)

**- Security Concerns:** Inadequate data encryption and authentication may lead to unauthorized access and data breaches.
**Solution:** To ensure secure data transmission, it is crucial to implement strong encryption algorithms such as AES. Additionally, employing robust authentication mechanisms will help verify the identity of sensor nodes.

**- Limited Resources**: Limited power and processing capacity may hinder the operation and longevity of sensor nodes.
**Solution:** Optimizing power consumption through energy-efficient protocols and efficient sleep-wake strategies is essential. Furthermore, incorporating advanced low-power microcontrollers and implementing efficient algorithms will make the most of the limited resources.

**- Wireless Communication Challenges:** Interference and signal attenuation can disrupt wireless communication.
**Solution:** Wise selection of communication frequencies, along with the implementation of interference avoidance techniques, can help mitigate interference-related issues. Additionally, employing adaptive modulation and power control can help counteract signal attenuation.

**- Data Quality and Accuracy:** Issues such as sensor errors and calibration problems can lead to inaccuracies in data collection.
**Solution:** Implementing sensor calibration routines and incorporating redundant sensors for cross-verification will enhance data accuracy. Furthermore, the utilization of data fusion techniques can also contribute to improving data quality.

**- Network Management:** Dynamic changes in network topology due to node failures or external environmental factors can disrupt network functionality.
**Solution:** Implementing adaptive routing protocols that can dynamically adjust to changes within the network is crucial. Additionally, incorporating self-healing mechanisms to recover from node failures enhances the network's resilience.

**- Scalability Issues:** Managing large-scale deployments can be challenging and often leads to scalability issues.
**Solution:** Designing the network with scalability in mind is crucial. Hierarchical or clustering approaches can efficiently manage a large number of nodes. Implementing protocols that can handle increasing network size will help address scalability challenges.

**- Regulatory Compliance:** Adhering to spectrum regulations and standards can pose challenges.
**Solution:** Staying informed about regional regulations and relevant standards is important. Designing WSNs to operate within approved frequency bands and power limits ensures regulatory compliance.

**- Cost Constraints:** Implementing WSNs, especially in large-scale deployments, can be expensive.
**Solution:** Exploring cost-effective sensor node designs and leveraging economies of scale can help address cost constraints. Prioritizing essential functionalities that meet budget restrictions is also crucial.

Addressing these challenges requires a holistic approach that combines technological solutions, best network design practices, and adherence to security and privacy principles. By following these guidelines, the integration of WSNs into the IoT can be made robust, secure, and efficient.

## X. CONCLUSION

IoT-based Wireless Sensor Networks (WSNs) are an innovative technological paradigm that have the potential to fundamentally alter our world. As IoT and WSN technology continue to evolve, we can expect several trends to shape their future trajectory. These trends will further augment the transformative power of these networks and unlock even greater possibilities. To enable faster and more reliable data transfer, advanced communication networks such as 5G and the upcoming 6G are set to play a crucial role. These networks will provide enhanced connectivity, ensuring that the massive influx of data generated by IoT-based WSNs can be efficiently transmitted and processed.

By integrating artificial intelligence (AI) and machine learning (ML) into data analytics processes, IoT-based WSNs will gain the ability to derive valuable insights and patterns from the vast amount of collected data. This integration will significantly enhance the decision-making capabilities of these networks, leading to more efficient and intelligent systems. The expansion of edge computing capabilities will enable real-time processing of data collected by IoT-based WSNs. This decentralized approach to data processing reduces processing delays and enhances system responsiveness, making it ideal for applications that require instant decision-making and prompt actions.

As the value and volume of data transmitted through IoT-based WSNs continue to grow, ensuring robust security measures becomes paramount. Blockchain technology offers a promising solution by providing a decentralized and tamper-resistant platform for secure data transmission and storage. Its implementation will safeguard the integrity and privacy of sensitive information, instilling trust and confidence in these networks.

With the intersection of IoT and WSN technology poised for continued growth, the future holds boundless possibilities for innovation and transformation. By keeping a pulse on these emerging trends, we can anticipate the exciting developments that

will shape our world and revolutionize the way we interact with technology.

## REFERENCES

[1] Arat, F., & Demirci, S. (2020). Energy and QoS aware analysis and classification of routing protocols for iot and wsn. *7th International Conference on Electrical and Electronics Engineering (ICEEE), Antalya, Turkey*, pp. 221-225. Available at: https://doi.org/10.1109/ICEEE49618.2020.9102614. Amazo n services. (n.d.). What is _Local shops on Amazon? Retrieved from https://services.amazon.in/services/sell-onamazon/local-shops.html.

[2] Begum, K., & Dixit, S. (2016). Industrial wsn using iot: A survey. *International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai*, pp. 499-504. https://doi.org/10.1109/ICEEOT.2016.7755660.

[3] Fahmy, H. M. (2016). Wireless sensor networks: Concepts. applications, experimentation and analysis, signal and communication technology. *Springer*. https://doi.org/10.1007/978-981-10-0412-4.

[4] Healy, M., Newe, T. & Lewis, E. (2008). Wireless sensor node hardware: A review. *IEEE Sensors*, 621-624.

[5] Islam, M. S. & Dey, G. K. (2019). Precision agriculture: Renewable energy based smart crop field monitoring and management system using wsn via iot. *International Conference on Sustainable Technologies for Industry 4.0 (STI), Dhaka, Bangladesh*, pp. 1-6. https://doi.org/10.1109/STI47673.2019.9068017.

[6] Kaur, N. & Sood, S. K. (2017). An energy-efficient architecture for the internet of things (IoT). *IEEE Systems Journal, 11*(2), 796–805. https://doi.org/10.1109/JSYST.2015.2469676.

[7] Kim, K. I. (2016). Clustering scheme for (m, k)-firm streams in wireless sensor networks. *The Journal of Information and Communication Convergence Engineering, 14*(2), 84-88. https://doi.org/10.6109/jicce.2016.14.2.084.