e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:11/November-2023 Impact Factor- 7.868 www.irjmets.com

ADDRESSING INTEROPERABILITY OBSTACLES IN IOT: EFFECTIVE APPROACHES FOR CONNECTIVITY HARMONY

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DOI : https://www.doi.org/10.56726/IRJMETS46679

ABSTRACT

The ability to integrate various systems and devices utilised by applications is known as interoperability. Some terms or solutions for interoperability include integration, inter-operability, middleware, and standardisation. As a result, interoperability makes it easier to complete applications quickly, effectively, and efficiently as well as discover new, cleverer, and more adaptable services. Like many other settings and apps, smart cities experience a lack of interoperability, which makes processing very difficult. Ineffectiveness is another consequence of the absence of interoperability, which is very bad for applications that deal with emergencies or have special requirements. In particular, interoperability in heterogeneous systems is increasingly desired. This study provides a thorough analysis of the approaches and strategies that might be used to address the interoperability-related problems.

Keywords: Internet Of Things, Interoperability, Cross Domain, Framework, RFID. Interoperability, Smart City, Middleware, IOT, Internet Of Things, Services Integration.

I. INTRODUCTION

The Internet of Things (IOT) has emerged as a revolutionary force in our increasingly linked world, with the potential to change industries, urban settings, and our daily lives. Smart cities, faster logistics, and effective supply chains have all been made possible by IOT technology, but interoperability still stands as a strong barrier in this promising field. With an emphasis on cross-domain contexts, this research project sets out on a journey to investigate and answer the crucial topic of interoperability in IOT. Our goal is to identify practical strategies that can promote connection harmony and, as a result, maximise the potential of the IOT ecosystem.

The idea of interoperability in the IOT originates from the requirement for various systems and devices to connect with one another in an effortless manner. It entails the capacity for various IOT components, which range from sensors to RFID systems, to collaborate effectively while overcoming limitations imposed by proprietary technologies, communication protocols, and domain-specific requirements. Interoperability is therefore crucial in the context of smart cities, where several urban systems and services must come together to provide a comprehensive and effective urban experience.

IOT ecosystems cannot exist without Radio-Frequency Identification (RFID) technology, which provides unmatched capabilities for tracking and identifying items. But only when these technologies work well together will the whole potential of RFID—and the wider IOT landscape—be realised. Comprehensive frameworks and middleware solutions are needed for this collaboration in order to close interoperability gaps that frequently obstruct the seamless integration of RFID and other IOT components.

The pinnacle of urban innovation, smart cities, provide as an excellent testing ground for resolving IOT interoperability issues. These cities hold great promise if they can use IOT technology to optimise energy use, improve transportation, increase public safety, and raise citizens' standard of living in general. However, in order for the many systems and devices to cooperate, smart cities must overcome the barriers to interoperability.

In particular, the context of smart cities and cross-domain settings will be examined in this study to better understand the complexities of interoperability within the IOT ecosystem. A thorough analysis of current frameworks, middleware options, and service integration tactics is part of our methodology. We want to find and provide practical methods for creating connection harmony in IOT systems by critically analysing these methods.

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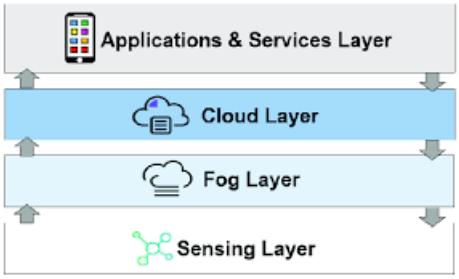
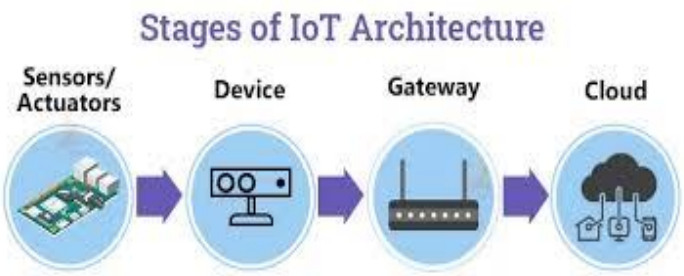
The ultimate objective of this project is to provide insightful knowledge and useful solutions that may assist IOT practitioners, municipal planners, and policymakers in solving interoperability problems successfully. Addressing interoperability challenges becomes crucial as we work to build smarter, more connected cities and a more effective Internet of Things ecosystem. We work to close the gap and advance the Internet of Things (IOT) into a time of continuous connectedness and peace, offering an infinite number of possibilities and previously unheard-of efficiency.





DEFINITION OF INTEROPERABILITY

The capacity of multiple IoT devices, systems, and technologies to easily connect, cooperate, and exchange data across numerous domains, standards, and protocols is referred to as interoperability in the context of the Internet of Things (IoT). It is the cornerstone of the IoT's transformational potential, acting as the vital link between dissimilar parts to facilitate the effective interchange of information and the accomplishment of shared goals.

Interoperability in the context of IoT fundamentally represents the idea that devices from various manufacturers, operating in various locations, and utilising various communication protocols may coexist peacefully to provide value-added services and functions. This harmony covers the capability to comprehend and use this data in a meaningful way, regardless of the origin of the device or the particular technology powering it, and goes beyond the simple ability to communicate data.

Technical interoperability: This aspect is concerned with how well software and hardware work together. To enable successful interoperability, devices, sensors, and systems must be built using standardised communication interfaces and protocols. Technical interoperability serves as the foundation for seamless connectivity.

Technical compatibility is only one aspect of semantic interoperability, which deals with the meaningful interchange of data. To guarantee that data transferred across devices is both understandable and useful, it entails the creation of standard data models, ontologies, and data formats. When using the gathered data to get insights and make decisions, this dimension is essential.

Functional interoperability is the capacity of IoT systems and devices to work together to carry out particular functions or provide services. It includes the coordination of operations among disparate components to accomplish a single objective. Realising the full potential of IoT applications, such as smart cities, industrial automation, and healthcare systems, depends on this dimension.

Cross-Domain Interoperability: In the context of the Internet of Things, where several businesses and sectors are converging, cross-domain interoperability becomes essential. To enable smooth data exchange and synergy between many application areas, such as healthcare, transportation, and agriculture, it entails tearing down silos between them. For the creation of comprehensive Internet of Things solutions, this component is particularly important.

Effective strategies for overcoming interoperability barriers in the IoT must take these factors into account in their whole. Interoperability across these dimensions is crucially supported by strong frameworks, middleware options, and standardised protocols. Additionally, an interoperable IoT ecosystem can unleash previously unheard of efficiency, spur innovation, and ultimately result in the development of smarter, more connected surroundings, such as smart cities and networked industrial systems.

In order to foster seamless connectivity and data exchange in the complex and dynamic Internet of Things landscape, the research on "Addressing Interoperability Obstacles in IoT: Effective Approaches for Connectivity

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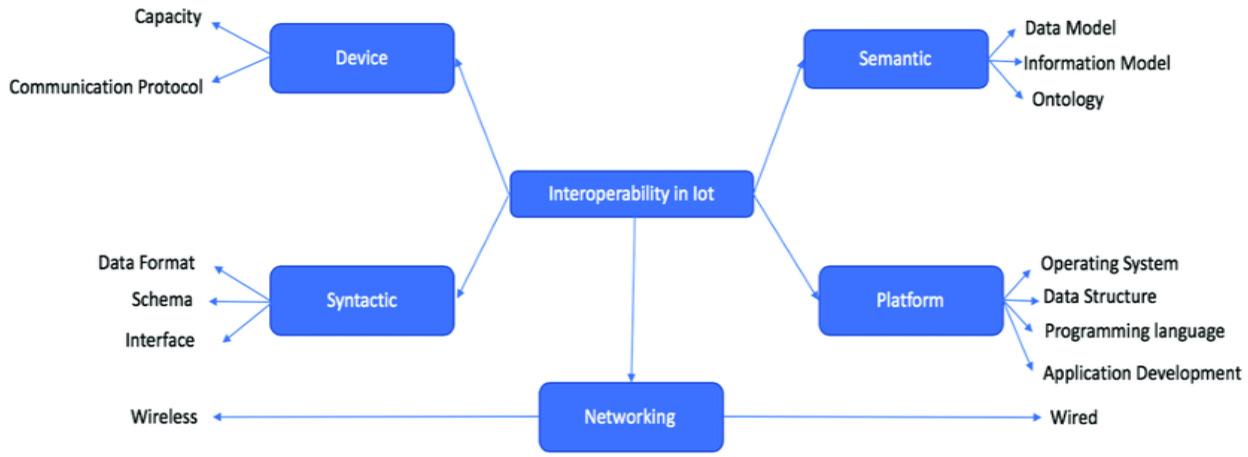
Harmony" aims to delve deeply into these interoperability dimensions, examine current difficulties, and propose creative strategies and solutions. We hope that our research will enable IoT practitioners, city planners, policymakers, and stakeholders to fully use IoT, bringing us one step closer to a time when connection harmony is the norm and providing access to a wide range of opportunities and efficiency.



ADVANCEMENT AND FORM OF THIS PAPER

IoT Interoperability Challenges: Practical Solutions for Connectivity Harmony.

The growth of the Internet of Things (IoT) has the potential to alter a number of sectors as well as our daily lives. A significant difficulty still exists in enabling seamless communication and interoperability among various IoT devices and systems. This study aims to analyse and remove the barriers preventing IoT interoperability while offering practical solutions to harmonise connections.

Introduction

We set the stage in the introduction section by exploring the context and driving forces behind our study. Despite being optimistic, the IoT's fast expansion has revealed severe interoperability challenges. We present our research goals, highlighting the relevance of our work and the necessity of filling in these gaps. We provide the main hypotheses that inform our work.

Research Review

An overview of IoT interoperability sets the stage for a thorough review of the available literature. We examine the interoperability frameworks and standards now in use, emphasising both their benefits and drawbacks. We examine the numerous difficulties and impediments to flawless IoT connection. We look at cutting-edge solutions and methods to contextualise our study. A gap analysis that identifies the need for our study finishes this section.

Methodology

A thorough explanation of our study process is given in this section. We outline our methods for gathering data from both primary and secondary sources. In order to fully address the study issues, our research design includes a varied range of methodologies, such as case studies, questionnaires, interviews, and experiments. The methods used for data analysis are in-depth and include qualitative, quantitative, and comparative studies.

Interoperability Guidelines and Standards

We begin with a survey of the current situation before delving into the area of interoperability standards and frameworks. We assess how well IoT systems and devices adhere to these requirements and suggest improving the current frameworks. Case examples showcasing effective framework applications highlight how practically applicable our research.

Getting Past Technical Obstacles

The technological difficulties that prevent IoT interoperability are examined in this section. We examine several protocols, examine IoT protocol compatibility, and propose protocol conversion methods. We also discuss data interchange and representation, placing a focus on semantic interoperability and data format standardisation.

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We look at methods for authentication, authorisation, and privacy protection since security and privacy issues are of the utmost importance.

Human-centered strategies

We acknowledge the value of human-centric strategies in promoting IoT interoperability outside of the technological sphere. We emphasise the importance of user experience and interface design in providing user-friendly interactions. We stress the value of end-user instruction and training while also suggesting user-centric interoperability solutions. The case studies in this section serve as illustrations of how these strategies actually work.

a case study

Successful IoT interoperability implementations in the real world are shown, and the difficulties they ran into are discussed. These case studies provide significant insights for future initiatives by distilling lessons learned and best practises.

Assessment and Validation

We provide a strong evaluation framework that includes metrics for assessment, experiments for validation, benchmarking against current solutions, and in-depth result analysis and discussion. This part offers a thorough evaluation of the performance of our suggested strategies.

upcoming directions

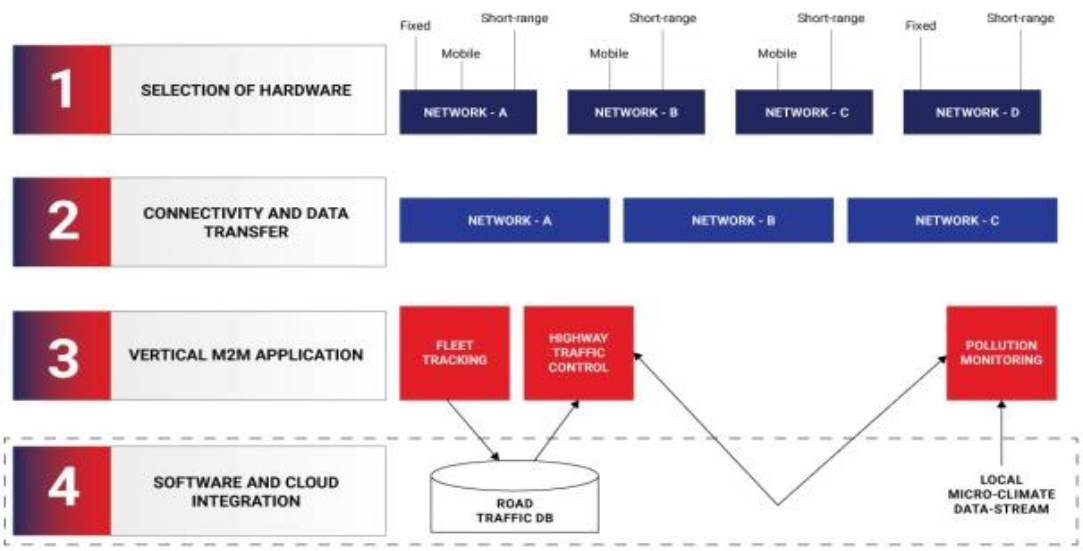
We examine future paths as the Internet of Things (IoT) develops, including new technologies, expanding standards and frameworks, resolving challenges, and guaranteeing scalability and sustainability in IoT ecosystems.

Conclusion

We briefly summarise our results and their importance in the final section. We emphasise the contributions of our study to the subject, both in terms of its theoretical and applied applications. We provide potential directions for further research and recognise the limits of our work.

Ultimately, our study aims to close the interoperability gaps in IoT by providing a systematic method for addressing both technical and human-centric issues while maximising current standards and frameworks. We hope to contribute to the full realisation of IoT's potential and its seamless integration into our everyday lives and industries by offering thorough insights and useful solutions

IOT PRODUCT DEVELOPMENT STAGES



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1. SELECTION OF HARWARE:

Making the right hardware choice is essential for IoT development.

It lays the groundwork for the operation and performance of an IoT system. Here is a succinct list of crucial factors:

1. Purpose and Application: To help with hardware selection, specify the IoT project's goals and use cases.

Device Types: 2. Select the appropriate IoT device types for your project (such as sensors, actuators, and gateways).

3. Sensors and Actuators: Evaluate the precision, range, and environment compatibility of the sensors.

4. Connectivity Choices Depending on the amount of data required, choose the connecting protocols and techniques (such as Wi-Fi and LoRaWAN).

5. Electricity Requirements: Establish if gadgets are powered by batteries or are plugged into a power source, and then manage power accordingly.

6. Match processing power to project needs, taking into account sophisticated computations or machine learning.

7. Cost Restraints: When choosing components, keep the project budget in mind.

8. Scalability: Ensure hardware selections for simple scalability as required.

9. Reliability and Durability : Pick hardware that is resistant to the elements.

10. Vendor Support: Take into account the support services, development resources, and ecosystem.

11. Security Features: Give security first priority by choosing devices with encryption and other security features.

12. Regulatory Compliance: Verify that the hardware complies with all applicable laws and standards.

13. Check component availability in the long term to prevent compatibility problems in the future.

For IoT projects to succeed, careful hardware selection is essential to match components with project requirements and goals.

2. CONNECTIVITY AND DATA TRANSFER

Connectivity and data transport are essential elements in IoT growth.

Wi-Fi, Bluetooth, and cellular networks are just a few of the protocols used in connectivity, which can be wireless or cable. While mesh networks and gateway devices improve connection, the quality of service (QoS) vary depending on the requirements of the application.

Data transfer begins with the gathering of data from sensors, which is then processed before being transmitted over a selected connection. Key factors to take into account include secure storage, visualisation, and batch or real-time processing. Due to the fast data buildup, effective data management is essential.

3. VERTICAL M2M CONNECTIONELECTION

IoT vertical M2M connections concentrate on industry-specific data sharing and communication. These connections uphold industry standards, prioritise pertinent data, and allow interoperability between devices. They require cross-domain integration, industrial platform integration, and application-specific data processing. In each vertical, such as agriculture or smart cities, vertical M2M connections handle particular issues, adapt to industry-specific demands, and adhere to rules.

4. SOFTWARE AND CLOUD INTEGRATION

In the Internet of Things, managing devices, processing data, enabling real-time control, and providing user interfaces are all part of software integration. Data transmission to scalable cloud platforms for processing, remote access, security, and economical infrastructure use are all included in cloud integration. For IoT solution optimisation, both are essential.

II. MOTIVATION AND IMPORTANCE

Motivation: With its promise to link the world through an extensive network of devices, sensors, and applications, the Internet of Things (IoT) has emerged as a technologically transformational force. IoT is

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changing daily life and many industries, from smart cities and homes to industrial automation and healthcare. However, interoperability remains a major barrier beneath the surface of this promising technology.

In the context of IoT, interoperability is the capacity of various platforms, systems, and devices to function harmoniously with one another. Several strong reasons underpin the drive for research on overcoming IoT interoperability barriers and devising workable solutions for connection harmony:

Enhanced Efficiency: Efficiency is directly impacted by efforts to remove interoperability barriers. In the context of industrial Internet of things, for example, where sensors and equipment must work together smoothly, solving interoperability issues lowers redundancy, improves resource efficiency, and simplifies procedures. Significant cost reductions and increased operational efficiency are the end results.

Data Utilisation: The Internet of Things' potential is rooted in its capacity to produce vast quantities of data. Nonetheless, smooth interoperability makes it possible to use this data effectively. To fully use IoT-generated data, interoperability must be addressed. This includes enabling improved decision-making, predictive analytics, and the creation of data-driven applications and services.

Security and privacy are critical in an era where the Internet of Things is permeating every aspect of our lives. Research on interoperability is necessary to guarantee strong security protocols and protect privacy. It is simpler to establish uniform security procedures, safeguard sensitive data, and reduce the dangers related to the Internet of Things when devices can interact with one other without any problems.

Sustainability: By maximising resource utilisation and cutting waste, IoT has the potential to improve sustainability. Interoperability is necessary, nevertheless, in order to realise this potential. Systems and gadgets that support sustainability initiatives, such waste management, smart grids, and environmental monitoring, must cooperate with one another. The key to realising the Internet of Things' full sustainability potential is doing research on interoperability barriers. industry Growth: Incompatibilities and inefficiencies might result from a lack of interoperability, which can split the IoT industry. This fragmentation might lead to lower customer acceptance and hinder market growth. Research on interoperability roadblocks is essential for expanding the market and encouraging healthy vendor competition, which is advantageous to customers and businesses alike.

In conclusion, research on overcoming IoT interoperability barriers and creating workable solutions for connection harmony is both extremely important and driven by the difficulties it aims to solve. The Internet of Things (IoT) is a rapidly expanding industry that benefits from seamless connectivity, innovation, development, enhanced user experience, standardisation, and, above all, increased efficiency, data utilisation, security, sustainability, and total market growth. By tackling these difficulties,

Historical solutions and approaches for interoperability-

Interoperability, or the smooth interaction of IoT devices and systems, is becoming more and more important as the Internet of Things (IoT) continues to transform businesses and everyday life. In the past, overcoming IoT interoperability barriers has been difficult, but creative fixes and methods have surfaced to promote harmony in connectivity. This article explores the ways that methods and solutions for IoT interoperability have historically evolved, showcasing the advancements in this area.

1. Proprietary Protocols and Closed Ecosystems: Many device makers and developers built closed ecosystems and proprietary protocols in the early days of the Internet of Things. They were able to guarantee compatibility across their product lines by taking full control of device communication. But it also led to the creation of silos, which hindered the efficient communication between devices made by various manufacturers. Although this strategy allowed for some interchange across product lines, it limited user freedom and wider networking.
2. Standardisation Efforts: As the IoT sector realised the shortcomings of proprietary solutions, it started to focus on standardisation. The Open Connectivity Foundation (OCF) is among the first and best-known IoT standardisation projects. The goal of OCF was to establish a standard framework for communication and device discovery. Through the definition of a collection of data formats and protocols, OCF aimed to facilitate communication between different IoT devices. The broad and dynamic nature of the IoT ecosystem made it difficult for these standardisation attempts to be widely adopted, even if they were a positive start in the right direction.

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3. IoT Middleware: One important step towards resolving interoperability issues was the development of IoT middleware. As go-betweens, middleware programmes fill the gap between various platforms and gadgets. By providing services like data translation, protocol conversion, and device discovery, they facilitate the interoperability of devices that use multiple communication protocols. Middleware may be implemented with flexibility because it can be hosted on edge devices or in the cloud. In the past, middleware has proven to be a useful tool for connecting various IoT systems and devices. These solutions frequently come with strong application programming interfaces (APIs) that programmers can use to build services and apps that communicate with Internet of Things devices in an easy-to-use manner. Google Cloud IoT, Microsoft Azure IoT Hub, and IBM Watson IoT are a few examples of IoT middleware.
4. IoT Gateways: IoT gateways are parts, either software or hardware, that act as a bridge between Internet of Things devices and a data centre or cloud. These gateways can execute edge analytics, preprocess data, and do data filtering. They are capable of handling a wide range of communication protocols. When integrating older devices with non-standard communication interfaces into an IoT ecosystem, IoT gateways come in very handy. By facilitating connectivity to a variety of devices and protocols, the gateway strategy efficiently expands the scope of the Internet of Things. It makes it simpler to manage and maintain connectivity by creating a layer of abstraction between the Internet of Things devices and the central infrastructure. IoT gateway technologies have advanced over time and are now able to handle intricate data conversions.
5. Edge Computing: This relatively new method solves interoperability problems by placing data processing and analysis closer to Internet of Things devices. Large-scale data transfers to centralised cloud servers are not as necessary with this approach, which can lead to improved security, faster response times, and reduced bandwidth use. Edge computing systems such as AWS IoT Greengrass and Azure IoT Edge, which may host IoT applications and services, enable interoperability at the edge. For applications where latency is crucial, such as industrial automation, autonomous automobiles, and smart healthcare, edge computing is particularly significant. Data processing at the edge makes interoperability less dependent on a centralised cloud infrastructure, increasing the solution's effectiveness and adaptability.
6. Semantic Interoperability: This method addresses the issue of ensuring that Internet of Things devices understand the data they are communicating. In order to create a common understanding of the data, this approach requires standardising ontologies and data models. By employing semantic frameworks like the Web of Things (WoT) and semantic data models like the Resource Description Framework (RDF), IoT devices may communicate such that they accurately interpret the data. Semantic interoperability is crucial for complex IoT systems that need the aggregation and analysis of data from several sources. Encouraging richer data flows lead to more advanced analytics and decision-making. The Internet of Things' semantic interoperability is being advanced through the creation of semantic standards like the oneM2M standard.
7. IoT Ecosystem Platforms: As IoT ecosystems become more sophisticated, all-inclusive platform solutions have become necessary. These systems offer comprehensive solutions for data management, device connection, and IoT application development. Top firms in the industry, such as Amazon, Microsoft, and IBM, provide IoT ecosystem platforms that include device security, analytics, administration, and development. IoT ecosystem systems offer a uniform environment for data integration and device management, which simplifies the process of creating and implementing IoT applications. They frequently have capabilities that facilitate interoperability in a complex IoT context, such as over-the-air upgrades, device provisioning, and real-time data analytics.
8. AI and Machine Learning: These two technologies are becoming more and more important in resolving interoperability issues in the Internet of Things. The dynamic nature of IoT networks may be accommodated with the help of these technologies. IoT devices can cooperate with ease because to machine learning algorithms' ability to evaluate device behaviour and modify communication protocols accordingly. Because AI-driven solutions can recognise and react to any threats instantly, they also improve the security of IoT networks. By identifying irregularities and highlighting security breaches, machine learning models help to make IoT systems more resilient overall.

In summary, significant progress has been made in overcoming interoperability challenges in the Internet of Things. The industry has changed dramatically from the early days of proprietary solutions and standardisation initiatives to the arrival of edge computing, gateways, and IoT middleware. Current frontrunners in the race for IoT connection harmony include semantic interoperability, IoT ecosystem platforms, and the incorporation of

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AI and machine intelligence. The emphasis on interoperability will remain crucial as IoT grows in order to realise its full potential and create a seamless, linked future.

III. PROPOSED COMPREHENSIVE FRAMEWORK FOR DEALING WITH INTEROPERABILITY

In the Internet of Things (IoT) space, interoperability is a major issue as many platforms, systems, and devices must interact with one another without any problems. In order to mitigate these interoperability challenges and promote harmony in connection, we put out a comprehensive architecture that spans several IoT ecosystem levels. This framework develops a comprehensive plan for resolving interoperability issues by fusing traditional methods with newly developed ones. The goal of the suggested framework is to guarantee scalable, secure, and effective interoperability, which will eventually improve users' and stakeholders' IoT experiences.

1. Hardware Layer:

We handle device interoperability at the core of the IoT platform. There are many different data formats and communication standards used by IoT devices. The following tactics are recommended by our framework to guarantee compatibility:

Standardised Protocols: To facilitate device-to-device communication, encourage the adoption of open, standardised communication protocols like MQTT, CoAP, and HTTP.

Device Management: To enable device provisioning, discovery, and over-the-air upgrades and guarantee a smooth device integration into the network, put in place reliable device management solutions.

Promote the use of semantic data models (such as RDF and JSON-LD) to provide users a consistent understanding of data across platforms and apps.

2. The Gateway Layer and Middleware:

Connecting devices and cloud services is made possible in large part by the middleware and gateway layer. It is a vital part of the framework since it makes data translation, protocol conversion, and preprocessing easier.

IoT Middleware: Use IoT middleware solutions to link and interact between devices and with cloud-based services by acting as middlemen. By functioning as integration points, these middleware elements hide the intricacies of communication protocols.

Edge Computing: To process data closer to the source, minimise latency, and boost efficiency, integrate edge computing capabilities into IoT gateways. In sectors with a lot of data and real-time applications, this strategy is very helpful.

3. Layer of Semantic Interoperability:

The semantic interoperability layer works to ensure that IoT systems and devices understand data consistently by creating a standard language for them to utilise.

Ontologies and Semantic Frameworks: To facilitate the interchange of data across devices, employ ontologies and semantic frameworks, such as the Web of Things (WoT), to provide a common vocabulary and a semantic understanding of data.

Semantic Data Mapping: Provide methods for converting and mapping data between semantic representations so that devices can interact with each other even if they are utilising different ontologies.

4. Layer of IoT Ecosystem Platforms:

Platforms for the Internet of Things ecosystem are essential for controlling and coordinating device and data interoperability across a variety of applications.

full IoT Platforms: To make device administration, security, and data integration easier, make use of the full IoT ecosystem platforms offered by top technology firms. These platforms provide complete solutions for developing Internet of Things applications. Security and privacy: Make sure that strong security protocols are in place to safeguard user privacy and safeguard data. To protect data while it's in transit and at rest, use encryption, authentication, and authorisation.

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5. Machine Learning and AI Layer:

At several IoT framework levels, apply AI and machine learning to tackle dynamic and developing interoperability difficulties.

Adaptive Device Behaviour: To ensure smooth device-to-device communication, use machine learning algorithms to analyse device behaviour and modify communication protocols as necessary.

Enhancement of Security: Use AI-driven solutions to instantly identify and address security issues. Models for machine learning are able to spot irregularities and stop possible security breaches.

This all-inclusive approach addresses interoperability issues at every tier of the Internet of Things ecosystem. With the help of middleware, standardising protocols, encouraging semantic interoperability, embracing edge computing, and incorporating AI and machine learning, the suggested architecture seeks to improve connection harmony in the IoT environment.

In conclusion, interoperability continues to be a major concern as the Internet of Things develops. The Internet of Things community has the potential to create a seamless and linked future through the implementation of a complete framework that blends traditional solutions with new technology. This framework offers a strong basis to enable the IoT ecosystem's ongoing expansion and development, in addition to addressing current interoperability challenges.

IV. CHALLENGES

After reviewing the proposed and previous works in the field of interoperability, a set of issues and challenges that are stillopen in the field of interoperability can be summarized as follows:

- There is no agreed-upon definition of smart cities.
- The occasional need for human intervention.
- Energy consumption and development cost issues.
- There is no standardization for standards.
- The problem of relying on fog computing to manage some intermediate tasks.
- The issue of fault tolerance and QoS support.
- The issue of scalability, complexity, and data redundancy.
- Privacy and security issue in the open data or with cooperation
- No ontology covers all areas of smart cities and therefore it is possible to work on creating a general ontology that includes many issues (administrative areas, city objects, events, services).
- Offering worldwide services. For instance, a person can utilise the same application to look for parking when visiting a different city
- An interest in contextual awareness and ubiquitous computing.
- Setting up and gathering services in a centralised setting to develop new applications.
- Preparing out dated data and converting it into a standardised, practical format so that it may communicate with contemporary systems

NEXT TRENDS

- Establishing a distributed unified database or open central data with standard protocols and formats for the entire smart city.
- Offer federated services for cross-border services, or services that are accessible from anywhere in smart cities or nations.
- Give developers a unified platform to apply service support interoperability by default.
- Use the ontology of ideas, NLP, and the semantic web to provide a greater degree of service integration.
- By offering a single language of understanding, create a unified worldwide ecosystem based on the Internet of Things.
- Including a unique programmable and dynamic cooperation layer in new apps or devices (similar to SDN's function in networks).Enhancing the standard of automatically produced services through the integration of

health domain services and assisting individuals with special needs in interacting with their surroundings while being mindful of their surroundings.

V. CONCLUSION

Many interoperability-related IoT challenges have been covered in this research. In fact, when it comes to smart cities, interoperability is linked to a number of difficult problems. Only by addressing this problem and offering a framework or model to facilitate collaboration amongst heterogeneous objects, devices, protocols, methodologies, services, and applications, will we be able to take advantage of many potential for more adaptable and intelligent services and applications .In order to develop thorough solutions that hold out a lot of potential, this research has evaluated the majority of previous attempts to solve this issue and summarised the current obstacles and outstanding issues. Lastly, a hybrid comprehensive design framework for interoperability is proposed. Our future study will concentrate on the specifics of the suggested method, including its implementation and validation in actual smart city application scenarios.

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