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A CRITICAL REVIEW ON APPLICATIONS OF INTERNET OF THINGS

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ABSTRACT

One of the biggest technologies being used now is the Internet of Things (IoT). It is a widely applicable technology that is developing quickly. In the current study, IoT has been rigorously evaluated from the dawn of technology to the present. The results of the study indicate that the IoT has many uses in many different domains, such as the development of urban communities, the arrangement of required frameworks and resources, flexibility, transportation, and collaborations. This technique uses a variety of sensors to work. Because more sensors are being developed to sense a wider range of conditions, the IoT is expanding daily. The rise of IoT has shown that more structured data is being evaluated, protected, and shared in a variety of contexts.

Keywords: Internet of Things (IoT), Sensors, Smart Systems, Communication.

INTRODUCTION

Using the term IoT, it refers to the "Internet of Things." It makes reference to the entire system of physically linked devices. Different devices may now connect with the cloud, other physical devices, and each other thanks to technology. The advancement of computer chips and fast internet bandwidth has made it possible to connect billions of devices together. Everyday IoT-enabled equipment, such as cars, vacuum cleaners, and other machinery, employ sensors to gather data and intelligently reply to consumers on the internet. The IoT links frequently used items to the web. Since the 1990s, computer engineers have been integrating sensors and processors into commonplace objects to make them smarter. The original huge size of the chips meant that the development of intelligence was sluggish.

Eventually, expensive machinery was tracked using RFID chips, which are low power computer chips. Chips have gotten smaller, faster, and smarter throughout time, matching the size reduction of computing systems. As a result, product prices have dropped dramatically. This advancement enables anyone to provide Alexa speech services connectivity to MCUs with even less RAM than 1MB. An entire industry, including our homes, offices, and enterprises, has become intelligent thanks to IoT gadgets. These clever IoT-based devices are capable of independent data transmission and reception. The term "Internet of Things" describes

the aggregation of all these imperceptible computing devices along with the associated technologies. **(Potu *et al.*, 2016).**

Numerous studies present a range of viewpoints regarding potential applications of the Internet of Things in different domains. However, an individual's application of these ideas for progression tactics is unique to them. One of the better ideas for automating several sites is the Internet of Things. Collaboration between IoT and other disciplines is necessary to use this concept for enhancing many aspects of life. Many academics used IoT in a range of topics, including smart cities. A few noteworthy studies that were carried out in this field have been assessed.

REVIEW OF LITERATURE

Menon *et al.* (2013) worked on incorporating IoT into the bus system in Singapore. Finding out if integrating the IoT into Singapore's transportation system is feasible was the goal of this study. Even though Singapore is well known for its progressive movements, it was found that there is still space for improvement when it comes to how the development is applied to transportation. Consumers need to be able to comprehend and assess particular transit options with conviction, and here is where IoT architecture may come in handy.

Qiang *et al.* (2013) explored the uses of IoT and security issues associated with it. They found that there are many uses for IoT security in addition to a wide range of problems that require answers, including organized transmissions, remote connections, RFID label security, security insurance, and data preparation security. The foundation of this paper is an examination of the trends in system security innovation. In addition, by examining and minimizing IoT security in numerous ways, it provides a unique means of communication with specialists in certain IoT applications and designs.

Bhide (2014) provided extremely precise condition monitoring using a variety of sensors to analyze vital data and adjust the degree of comfort in homes by reducing energy use. As a result, he used estimation to identify and address any issues with the devices. For that, he's employing information mining in conjunction with the Naive Bayes Classifier. It will notify the owner as well as the required management specialist via email or SMS. The state-of-the-art home IoT systems are greatly enhanced by this.

Kaur & Singh (2014) carried out an IoT application survey and showed that the IoT is still playing a vital role in information and communication technology and the development of society. Improved correspondence standards, information transfer for sharp items, connected and remote sensor and actuator systems, and distinguishing evidence and following improvements are some of the most pertinent instances. As one might expect, any real dedication to the advancement of the Internet of Things should stem principally from cooperative learning activities carried out across multiple academic disciplines, including media communications, informatics, hardware, and sociology. This study is intended for those who, in such an unclear situation, must confront this confusing control and help to enhance it.

Shah *et al.* (2015) worked on enhancing the traffic monitoring system's density and flow control on the Indian Road System. Today, managing transportation remains a challenge because of the growing number and size of automobiles. The current activity regulatory framework functions within the framework of a planning element, which includes a comparable schedule. Every intersection has room for one opening. This is wasteful because of the sporadic influx of cars. This means that a flexible framework is required. Courses ought to be able to add more scheduling slots based on the requirements listed for each one. In order to avoid traffic bottlenecks, they proposed a flexible architecture that would enable each course to have a scheduled opening based on the level of activity.

Lee and Chong (2015) conducted research to investigate the connection between the impact of advertisements and appearing entomb animation. As a result, a dual-factor model was created to explain the implications of and future adoption of smart internet of things services. A commercial showcasing IoT innovations is utilized for this. An introduction to the IoT and related commercial advancements is provided to the individuals who are the subjects of this inquiry. An IoT advancements related advertisement is viewed, and then a review is done. They compare the clients with lower perceived entomb liveliness to those with higher perceived intuition, and they find that the clients with higher perceived intuition exhibit happier mental states.

Das and Tuna (2015) worked on machine-to-machine (M2M) communications for smart homes and found that M2M advancements may be defined as those that enable communication between wired and remote frameworks and other devices with similar capabilities. Because M2M may be utilized for a variety of monitoring and controlling applications, it provides business and industry with a few advantages. It is anticipated that PDAs and M2M innovations would both become incredibly important elements of contemporary dwellings. Likewise, this question presents an example of M2M technology use. The intelligent cooling and aeration system in the application is shown to adjust itself according to temperature information obtained from sensors. Even while the application on display is just a basic illustration of how M2M might be applied, it has the potential to improve various aspects of our daily life.

Nandyala and Kim (2016) worked on engineering for IoT-based medical services and real-time u-healthcare monitoring system for smart homes and hospitals observing under the supervision and advantageous circumstances of the Cloud to Fog (C2F) registering system, which enhances communication by offering closer to the edge (end focuses) at intelligent residences and medical facilities.

Kaur (2016) worked on IoT security and privacy concerns and presented security and protection challenges in the IoT along with an architectural diagram and an application zone diagram. An illustration of IoT would be a seven-layered design. Four groups—Business Value, Big Data, Cloud Computing, and Fog Computing—can be made out of the layers.

Gupta *et al.* (2016) collected funds for the World Water Development (UN) study that projects a severe water shortfall for half of the population and worked on the requirement for smart water systems in India. Water shortages are expected to worsen in emerging Asian and African nations like Bangladesh, China,

India, and Cambodia. By 2050, it was projected that 70% of people will leave India's cities. Given the size of the population, decreasing water reserves, little precipitation, and other issues, it is difficult to manage and supply resources like electricity and water. Sensors connected to information and communication technology (ICT) can be used to track and reserve water resources for later usage. Sensors offer automatic control and constant pressure-driven information checking, with the ability to interrupt situations such as water spills and other mishaps. Analyzing the data will help you take crucial actions. Water use in the horticulture sector is decreased and non-sustainable water losses are decreased through intelligent water management.

Deshpande and Deshpande (2017) highlighted the need for industry to protect all pertinent data, insights, and information regarding the many current processes, engines, machines, and devices employed in industry premises. The focus was on leveraging IoT to monitor and manage industrial environmental parameters. This is valid for limited access, enhanced efficacy, and superior results from the production of mechanical goods. This necessitates verifying and controlling contemporary natural characteristics. IoT is enabling rapid growth in innovation. A network of physical objects or objects that have been equipped with hardware, software, sensors, and organizational frameworks is known as the IoT. These objects are able to collect and share data thanks to this network. In this article, the IoT notion of remote devices, Android, and sensors are being used to construct a framework that would screen and manage cutting-edge characteristics. It is often the best and most valuable. So far, it has shown to offer excellent societal possibilities.

Ghute *et al.* (2017) worked on a smart garbage monitoring and air pollution control system that is based on the IoT. They called it an extremely creative framework that will keep cities clean. This system looks over the garbage cans and uses a web page to report on how much rubbish has accumulated inside of them. The trash canisters' depth and the rubbish level are compared by the system through the use of ultrasonic sensors that are positioned above the containers. This system also uses gas sensors to identify hazardous chemicals that are readily apparent everywhere. To show the status to the consumer who is checking it, a webpage is made. The site page shows the amount of waste accumulated and the quantity of harmful gasses present. On the LCD panel are the levels of hazardous gasses and rubbish. The framework initiates the notification when the amount of trash accumulated reaches its limit. As a result, this structure maintains the city clean by giving information about the trash levels in the containers and by using an internet page to provide a graphical picture of the containers.

Debauche *et al.* (2018) developed internet-based IoT bee health monitoring for apiculturists and researchers. They proposed an entirely new architecture for data storage designed with scientific research use in mind. A large variety of data, such as images, videos, time series data, punctual data, etc., can be ingested at a high frequency using the lambda architecture. One of this architecture's primary new features is its capacity to standardize, exchange, and interchange data throughout research teams. Furthermore, a wide range of data from several sources can be transported at a reasonable cost because to the expanding availability of IoT protocols. Deploying monitoring systems in difficult environments, such as cities, is made possible by the use of robust, interference-resistant protocols, especially in urban beekeeping.

Alexopoulos *et al.* (2018) worked on the design and development of an industrial Internet of things framework to implement services in industrial product service systems. This framework provides the architecture needed to build an Internet of Things framework that may be used to deploy services across various industries. A thorough prototype that effectively illustrates data collection, analysis, and reporting was made. It also provides a variety of services to fulfill the requirements of various roles. The primary benefits of this strategy are the methodical information collection, aggregation, analysis, and streamlining of user data. The output is presented to the users as a variety of graphs and figures. This architecture also allows users to use it for extended periods of time and in a multitude of scenarios.

Mourtzis *et al.* (2019) noted in their study that IoT has the power to turn industries into far more sophisticated systems with CPS, sensors, actuators, and machines that can exchange data and connect with one another to create a system that is adaptable and fully conscious. Work on mapping vulnerabilities in the context of the industrial internet of things led to this discovery. However, as wireless connectivity increases, so does the data's capacity to move from controlling actuators to machines. There are several risks since the growing IoT ecosystem makes it possible to misuse a network. That research assessed potential impacts on an industry's machine and human resources as well as vulnerabilities found in the IoT landscape. This framework was used in the shop floor to emphasize the need for cyber security at every level before providing users with a service because the equipment is usually designed with cost and security in mind rather than the other way around.

Bouras *et al.* (2019) conducted study on the IoT and found that a large number of devices are constantly being added to IoT enabled networks, with the goal of using the synergy of communication, processing, and caching for smart sensing. To resolve the sensing problems, computing, communication, and caching are needed. More IoT sensing-related issues need to be resolved in order to achieve anticipated benefits and enhance sensing for a smart world in the future. The authors of this research described the convergence of processing, caching, and communication for IoT smart sensing. They also enumerated additional requirements that must be fulfilled for IoT-related smart systems to be realized. The authors also mentioned the convergence of smart sensing and CCC. Future Internet of Things technologies like 5G networks, cloud, fog, and edge computing all depend on it.

Allah *et al.* (2020) claimed in their study that the IoT can be used to monitor water quality parameters and that they are developing a real-time IoT-based water quality management system to lower or completely eliminate the cost of doing water quality tests outside of a lab. Water quality parameters can be maintained with IoT. IoT is smartly used to preserve these qualities, which are validated at the input.

Zhu *et al.* (2020) developed an intelligent classroom management system for schools based on the Internet of Things. In this study, they developed an easy-to-use, low-cost, low-electricity smart classroom management system that is anticipated to be well-liked by students. It has been discovered that the storage model based on NoSQL and MySQL meets the appropriate system requirements. MySQL meets the requirements of small data volumes and is easy to use. H-Base provides fast and dependable data storage for

the massive volumes of data generated by the Internet of Things. Using that system, the user can quickly read data and take readings.

Aslam and Curry (2021) surveyed the approaches, challenges, and future possibilities of object identification for the internet of multimedia things (IOMT) using deep learning and event-based middleware. The characteristics and challenges of IOMT were investigated by the authors when using the Internet of Things' service-oriented architecture (SOA) to process multimedia events. After looking at event-based middleware possibilities and how the IOMT could use them, they concluded that middleware is essential to both addressing heterogeneity among structured events and providing general-purpose services. They also illustrated how the current multimedia event processing approaches' rigid user interface and lack of flexibility. The authors demonstrated the challenges of interpreting multimedia events using neural network-based algorithms through the use of object detection.

Tariqa *et al.* (2021) conducted a detailed analysis of the security requirements and difficulties for intelligent Internet of things applications and found that industry and research have focused on a number of security issues, such as device vulnerabilities and transit-related issues with IoT devices. When developing security measures, smart IoT applications present a lot of security challenges because of their constrained nature. The writers also discussed significant security concerns associated with IoT applications in smart cities, smart healthcare, and smart agriculture.

Hamdy *et al.* (2022) proposed a Node-RED-based IoT implementation plan for Warehouse 4.0. A Node-RED and MongoDB system has been proposed in this study for the implementation of the IoT approach for warehouse management. The research paper explains how implementing IoT in a warehouse can have positive effects and avoid problems with existing management methods. A dataset has been used to show the substantial impact that IoT has on operations warehouse, specifically on forecasting accuracy. By providing real-time sight of everything in the warehouse, this technology helps to increase speed and efficiency, decrease labor requirements, and minimize counterfeiting and inventory shortages. This study provided warehouses with a useful roadmap for implementing IoT to improve operations.

Long (2022) performed studies on the status information monitoring of power equipment and found that the IoT technology has significantly improved the degree of online grid monitoring. Online monitoring through the IoT is more intelligent, real-time, unlimited, and intelligent than traditional monitoring techniques. Its analysis of power equipment is also more automated and intelligent. This has the potential to improve monitoring's dependability and efficiency. Together, a multitude of sensors process and communicate data to build the network layer and perception layer.

Suryawanshi *et al.* (2022) worked on research, challenges and future applications of IoT and found out in their study that the IoT is rapidly developing as the next stage of the Internet's growth, thus it's important to understand the several fields in which it could be applied as well as the research problems that go along with them. IoT is anticipated to permeate almost every facet of daily life, including smart environments and living, health care, smart agriculture, logistics, and retail. Despite the recent significant advancements in IoT

enabling technology, a multitude of issues still need to be addressed. Since heterogeneous technologies constitute the foundation of the IoT, numerous research difficulties will inevitably emerge. IoT is an important research issue for studies in a variety of related topics, including computer science and information technology, because it is so broad and impacts almost every aspect of our life. IoT is thus opening up new study avenues for investigation. In addition to outlining the latest advancements in IoT technology, this paper addresses research problems and potential future uses.

Rafiq *et al.* (2023) worked IoT applications and challenges in smart cities and services, and concluded that it is a cutting-edge and innovative platform that allows a smart network to establish dependable, real-time connections with a vast array of electronic devices through existing communication systems. This allows for sensing that is, gathering data from sensors as well as computing and actuating devices. This article provides an overview of the state of IoT applications, architecture, communication infrastructure, and features as of right now. This overview covers the many applications of the IoT, the difficulties in creating smart cities, and the features and uses of communication protocols for this cutting-edge technological platform. Health applications, transportation applications, smart grid enhancements, and IoT-assisted smart city services are also covered. The difficulties and problems surrounding security, communication, applications, and system design are thoroughly discussed, as well as the potential paths that IoT technology may take in the future.

Sharma et al. (2023) worked on future research on IoT and it's applications and said that the emergence of the IoT has profoundly changed the global network that includes people, smart devices, intelligent things, information, and data. It's no secret that as the number of connected devices rises, it becomes more and harder to guarantee the security of sent data and initiated communications. There are two primary areas in which IoT devices have proliferated over time: the home and the office. In the former instance, Amazon's Echo devices and the Alexa Voice Service have given rise to a whole ecosystem. Giants in the technology industry including Apple, Microsoft, and Google have all embraced the idea. The platform providers are responsible for handling device security because of the constrained nature of these platforms. We emphasize the significance of cyber security as it relates to manufacturing in this study. Industries including manufacturing, oil and gas refining, pharmaceuticals, food and beverage processing, water purification, and many more are constantly looking for ways to increase their security as more and more devices and machinery are brought online. Plant managers and electronic device manufacturers are always facing pressure to protect their operations against intrusions. Furthermore, due to variations in the kinds of data collected, the organizational structures of IoT devices, and other aspects, the complexity of threat management and compliance varies substantially between enterprises.

Dallaev *et al.* (2023) worked on current applications and challenges of IoT and found out that the idea of the IoT has the potential to revolutionize several industries, including computer science, network technologies, microelectronics, and sensor technology. IoT has the potential to be a key player in the industrial revolution when combined with advancements in robotics and nanotechnology. By fostering economic relationships between machines and tying the human and machine economies together, IoT can help solve many of the

issues that humanity is now experiencing. The Internet of things is made up of all internet-controlled gadgets. All countries now have more opportunities to enhance life quality and implement technology innovations for productivity, efficiency, security, and profit thanks to the Internet of Things. Having an integrated security system is a major step in the right direction for the economy. The idea of the Internet of Things is essential to the industry's continued growth in information and communication. This is supported by the positions taken on the subject by the European Union and the International Telecommunication Union (ITU), as well as by the fact that the Internet of Things is listed among the cutting-edge technologies in use in China, the United States, and other nations. Therefore, this essay will discuss the IoT's current position and outline the gadgets and sectors that stand to gain from its benefits. Furthermore, statistical information is supplied regarding global IoT investments and trends.

Magara and Zhou (2024) performed research on IoT of smart homes: privacy and security and found out that the IoT is an advanced network that links objects to maximize functionality in a range of human endeavors. According to estimations from recent literature, there will be a substantial growth by 2025 estimates approach 50 billion connected devices. The IoT presents significant privacy and security challenges despite its transformative promise. These challenges include complex matters like data gathering, anonymization, retention, sharing policies, and behavioral profiling. The creation of new management techniques, flexible policy frameworks, and scalable solutions are necessary to effectively handle these difficulties. They perform a thorough analysis of the main IoT applications in this article, along with related privacy and security issues. We formally classify common privacy, security, and interoperability concerns in the framework of the IoTs' tiered architecture. The assessment outlines ongoing research projects aimed at creating energy-efficient gadgets, streamlining microprocessors, and encouraging interdisciplinary cooperation to tackle the problems in the IoT environment. In order to effectively mitigate risks within this ever-changing environment, stakeholders need to put in place all-encompassing policies that include strict data protection laws, broad user education campaigns, and the establishment of strong authorization and authentication protocols. The purpose of this article is to enable researchers, politicians, and industry leaders to efficiently traverse the intricacies of the IoT ecosystem by offering practical solutions rather than just insights. The development of user-centric privacy solutions, the standardization of interoperability protocols, and the reinforcement of security measures for extensive IoT deployments ought to be the top priorities for future research endeavors. This article aims to lead the conversation on IoT applications, privacy paradigms, and security frameworks by providing a strong fundamental framework, paving the way for a resilient and connected future.

CONCLUSION

The literature review has demonstrated that the IoT is a quickly evolving technology with a wide range of applications across multiple industries. It is based on sensors, which come in a variety of forms and are able to detect a broad spectrum of artificial, natural, and ambient factors. Many researchers employed sensors-based IoT technology to monitor multiple parameters that can be used to monitor different features. Data analysts must assess the information provided in addition to using technology to properly handle problems and implement changes. The public uses a lot of IoT-based systems in smart cities. The literature study

states that a number of researchers have used three or four sensors to monitor the weather or climate. More sensors must be added to the system in order to enhance it, for this reason.

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