International Journal of Electrical, Electronics and Computer Engineering **13**(1&2): 48-51(2024)

ISSN No. (Online): 2277-2626

A Study on Applications and Challenges of Internet of Things (IoT)

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(Received: 08 February 2024, Accepted: 18 April 2024)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Internet of Things (IoT) is basically a concept of interconnection of physical devices such as vehicles and appliances that are embedded with sensors, software, and connectivity that enables them to connect and exchange the data. The main goal of the IoT is to enable the efficiency, and connectivity in various aspects of daily life. The applications of IoT cover large areas including the industrial sector, manufacturing, health sector, agriculture, smart cities, security and soon. Thus, the potential application domains of IoT are diverse and span across various sectors. As we know if there are advantages of anything, then there are challenges too. Despite of the challenges, IoT still keeps growing and changing. To make the most from IoT, we need to work together, solve problems, and keep making it better. So we can say that, IoT is on its way of making the human's life as connected and the smarter one.

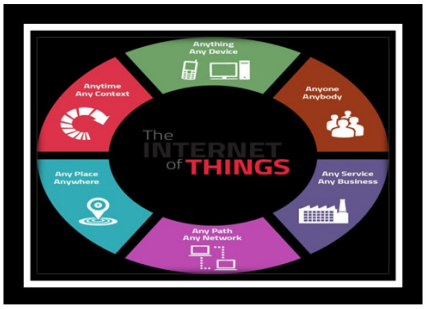
Keywords: Internet of Things (IoT), Smart Grid and Smart Energy.

INTRODUCTION

As we know that Internet is a network of network which connects billions of computers all over the world with each other and to the World Wide Web. The Internet helps the people all over the world to connect to the static information available but now it is helping to build connection from people to people, people to physical objects and physical objects to other physical objects which is termed as Internet of Things (IoT).

Definition of Internet of Things (IoT):

Internet of Things (IoT) is defined as the interconnection of physical devices such as vehicles and appliances that are embedded with sensors, software, and connectivity that enables them to connect and exchange the data. These physical devices can range from a very simple household appliances to any complex industrial machinery Therefore IoT allows for the collection and sharing of the data from a vast network of sources and creating different opportunities for more efficient and automated systems. Therefore, the main aim of the Internet of Things (IoT) is to make it possible for the physical devices to get connected with other physical devices, individuals, at anytime, anywhere by using any network, or service. The main goal of the IoT is to enable efficiency, automation, and connectivity in various aspects of daily life and business operations. [1] IoT is a system of interrelated things, computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers. We can also say that "IoT is a network of physical objects".



IoT.

For example: a user has a camera installed in his house he might want to check the video recordings and all the feeds through a web server.

IoT is network of interconnected computing devices which are embedded in everyday objects, enabling them to send and receive data.

Over 9 billion objects are currently connected to the Internet, as of now and in the near future, this number is expected to rise to a 20 billion or more.

Main Components of IoT (Internet of Things):

There are 5 main components of IoT (Internet of Things) which are as follow - Sensors, Gateway, Cloud, Analytics and User Interface:

— Sensors (Devices) are used to collect and transmit the data and also perform actions based on those data. E.g. sensors can be used for measuring temperature.

— Gateway acts as an interface between the sensors and the central cloud and it offers communication, management and processing of data.

— Cloud in IoT is basically the service which provides the management, storage, and processing of the data that is generated by IoT (Internet of Things) devices.

— In analytics, meaningful insights are analyzed which are generated by the IoT devices and sensors.

Some functions in Analytics are: data processing, machine learning, and statistical analysis.

— User Interface in IoT provides an interface by which a user can interact with system and applications.

Working of IoT devices: IoT devices work by utilizing sensors to gather data from the environment, and processing this data using onboard processors, and then transmitting the processed data over a network to other devices or to the cloud-based platforms. This process enables IoT devices to monitor, analyze, and respond to changes in their surroundings, facilitating various applications such as smart home automation, industrial monitoring, and environmental sensing.

APPLICATION DOMAINS OF IOT

The applications of the Internet of Things are not only large but also very diverse as they permeate into the virtually all aspects of daily life of individuals, and society. The applications of IoT cover large areas including the industrial sector, manufacturing , health sector, agriculture, smart cities, security and soon. Thus, The potential application domains of IoT are diverse and span across various sectors. Some of the key potential application domains of IoT are as follows:

1. Smart Cities. The IoT plays a vital role in enhancing general infrastructure and improving the smartness of cities . Some of IoT application areas in creating the smart cities include intelligent transportation systems, smart building, traffic congestion, smart parking, waste management, smart lighting, infrastructure optimization, enhancing urban sustainability, resilience, and livability and many mores. IoT-enabled traffic monitoring systems gather data on traffic flow, congestion, and accidents and then this information is used to optimize traffic signal timing, manage congestion, identify traffic patterns, etc. IoT sensors are deployed all over the cities to monitor and manage critical infrastructure such as transportation networks, water and energy systems, waste management, and public utilities and by collecting real-time data on usage, demand, and performance, cities can optimize resource allocation and reduce operational costs. IoT-powered surveillance cameras, and emergency response systems enhance public safety and security in smart cities. So, IoT plays a important role in development of smart cities by enabling data-driven decision-making, improving efficiency and enhancing the sustainability, and so enhancing the quality of life for resident.

2. Smart Agriculture. IoT has the capacity to strengthen and enhance the agriculture sector through examining soil moisture and in the case of vineyards, monitoring the trunk diameter. IoT would allow to control and preserve the quantity of vitamins found in agricultural products, and regulate microclimate conditions in order to make the most of the production of vegetables and fruits and their quality. The IoT-enabled drones and ground-based sensors monitor crop health, growth, and development throughout the growing season. Studying the weather conditions allows for forecasting of drought, wind changes, rain or snow, so controlling the humidity and temperature levels to prevent any microbial contaminants. IoT-enabled equipment automate various farming tasks such as harvesting, planting, irrigation, and pest control. These systems use real-time data and AI algorithms to optimize operations and increase efficiency. For example, automated irrigation systems adjust water flow based on soil moisture levels, while precision planting equipment ensures optimal seed placement for higher yields.

3. IoT for Smart Health. For the hospitalized patients whose physiological status should be monitored continuously, a constant attention is required towards and it can be continuously done by using IoT monitoring technologies. IoT devices enable the continuous tracking of vital signs and health metrics outside clinical settings, enhancing patient care and early detection of any type of abnormalities. IoT sensors collect and analyze the real-time health data, facilitating the predictive analytics for identifying health risks and preventing diseases before they effect the patient So, in this way, IoT improves the quality of care through continuous tracking of vital signs of patient's health.

4. IoT for Smart Home. In the present day, smart homes are becoming a need of fast life. Smart homes allows many household devices to be connected to the internet for the communication. IoT devices have automated various household tasks such as controlling lights, locks, and appliances remotely through the smart phone apps or voice commands, enhancing convenience and energy efficiency. IoT-enabled smart locks, cameras, and motion sensors provide real-time monitoring and alerts that improves home security by detecting the intruders and enabling homeowners to respond quickly to potential threats. Thus, IoT transforms traditional homes into smart and intelligent homes that enhances the convenience, safety, energy efficiency, and overall quality of life for residents.

5. IoT for Smart Grid and Smart Energy. IoT play a crucial role in smart grid and energy is pivotal for revolutionizing energy management and distribution. A smart grid basically combines the information and communications technologies (ICTs) to the electricity network which enables a real time, two way communication between suppliers and consumers. It creates more dynamic interaction on energy flow and that will help to deliver electricity more efficiently and sustainably. The significant elements of information and communications technologies will consist of sensing and monitoring technologies for power flows; digital communications infrastructure to transmit data across the grid; smart meters within home display to inform energy usage; coordination, control and automation systems to aggregate and process various information, and to create a highly interactive, responsive electricity. Many applications can be possible due to the internet of things for smart grids, such as industrial, solar power, nuclear power, vehicles, hospitals and cities power control (Z. Alansari *et al.*, 2021).

6. IoT for Smart Retails. Now a days, IoT applications in field of retail give shoppers a new experience. Now, customers do'nt have to wait in long queues, as the

checkout system can read the tags of the products and deduct the total amount from the customer's payment app with IoT applications' help. IoT devices, such as RFID and beacons tags, enable personalized marketing strategies by delivering the targeted messages to customers based on their location, preferences, and past purchases. Therefore, IoT technologies empower the retailers to create smarter and more connected stores that drive customer attention and engagement, increase sales, and streamline operations.

CHALLENGES IN IOT

Internet of Things (IoT) is perhaps the most smoking innovation in the period of computerized change, associating everything to the Internet. It is simply the center innovation behind brilliant homes, driving vehicles, savvy utility meters, and keen urban areas. For all the above potential applications of IoT, there has to be proper feasibility into the different domains to ascertain the success of some applications and their functionality. As with any other form of technology or innovation, IoT has many challenges and implications that must be sorted out to enable mass adoption. As we know that, the current IoT technologies have been greatly changed and improved in the recent years, but there are still many problems that require attention, in order to make IoT to be less challenging and more secure(GeeksforGeeks). So the challenges that are involved in IoT are as follows:

1. Security Challenges. Security is the first and foremost challenge on the list of challenges. As data storage and sharing being the backbone of IoT and the biggest question also arises about the security of data. The IoT devices often may have weak security measures, making them vulnerable to cyberattacks. As these IoT devices collect sensitive data and control critical systems, so ensuring robust security is crucial to prevent unauthorized access and protect user privacy.

2. Coverage. So, next challenge on list of challenges of IoT is coverage. IoT devices need a network connection for transmitting and receiving the data. If the connection is lost then you can also lose the device's capabilities. Ensuring adequate network coverage across the varied environments can be challenging, especially in hard-to-reach areas where network infrastructure is limited or is not available. The Signal can interference from other wireless devices, electromagnetic interference, physical obstacles, etc. that can disrupt wireless communication and reduce network coverage. Thus, Mitigating the signal interference is essential to maintain reliable connectivity for IoT devices. Thus, addressing coverage challenges in IoT requires infrastructure investments, technological innovations, and collaboration among industry stakeholders.

3. Insufficient Testing and Monitoring. Insufficient testing and monitoring in IoT environments leads to significant challenges primarily due to reliability concerns, security risks, performance issues and many more.

— Inadequate testing may cause unreliable IoT devices susceptible to errors, malfunctions, or security vulnerabilities.

— Without proper testing and monitoring, IoT devices can be susceptible to cyberattacks, potentially compromising the sensitive data or may cause physical harm.

— Insufficient Testing and Monitoring can result in poor performance, including slow response times, connectivity issues, or system crashes.

— Incomplete testing can result in non-compliance with the industry standards or regulations, exposing organizations to legal and financial risks.

Thus to address these challenges, rigorous testing should be done and continuous monitoring frameworks must be implemented all over the IoT system lifecycle, from the device development to deployment and maintenance (Abdel and Hussein 2019).

4. Processing, Analysis and Management of Data

The procedure for processing, analysis and data management is tremendously challenging because of the heterogeneous nature of IoT, and the large scale of data collected, particularly in this era of Big Data. So the processing, analyzing, and managing of data in IoT can be challenging due to the following factors:

— IoT generates huge amounts of data from various heterogeneous interconnected devices, leading to challenges in storing, processing, and analyzing such large volumes of data effectively and efficiently.

— IoT data may suffer from inaccuracies, noise due to factors like sensor errors, or network issues, posing challenges in ensuring data quality and reliability for meaningful analysis.

— IoT data also contains sensitive information, and ensuring its integrity, confidentiality, and availability throughout the data lifecycle is important. Managing access controls, encryption, and compliance with privacy regulations adds complexity or challenges to data management in IoT.

Thus to address these challenges, robust data management strategies such as data preprocessing, integration, storage, analysis, as well as the adoption of advanced technologies such as distributed systems, machine learning, and artificial intelligence, etc. to extract meaningful insights from IoT data efficiently is required (Sarika *et al.,* 2019).

5. Malware and Ransomware. The large diversity of IoT devices provide a vast attack surface for malware and ransomware. With billions of devices that are connected for use across the world, attackers have ample opportunities to target vulnerable devices. Generally many IoT devices have limited computing resources, such as processing power, memory, etc. which makes it challenging to implement robust security measures, thus leaving devices vulnerable to malware attacks that exploit these limitations. Many IoT devices are deployed in such environments where they cannot be easily updated. This results in a large number of devices running outdated software thus ,making them prime targets for malware and ransomware attacks. Malware and ransomware attacks can compromise the privacy of data such as sensitive

data, such as personal health information or location data, leading to regulatory violations and reputational damage for organizations. Thus to address these challenges security measures at the design stage of IoT devices, including encryption, secure boot, and regular security updates must be implemented

6. Outdated equipment and programming. Outdated equipment and programming leads to several challenges in IoT which are:

— Older equipments may lack essential security features and receive fewer updates, which makes them more susceptible to cyberattacks and malware.

— Older equipment may not meet the performance requirements of modern IoT applications which leads to slower response times and reduces the efficiency of devices.

— Aging sensors and components will get degraded over the time which affects the accuracy and reliability of data collected by IoT devices.

Thus, addressing these challenges must requires investment in upgrading or replacing the outdated equipment, and implementing robust security measures to protect against potential vulnerabilities (Afrah Salman Dawood, 2020).

CONCLUSION

In conclusion, this review has highlighted about the Internet of Things, and its diverse applications and significant challenges that associated with the Internet of Things (IoT). We have find out how the Internet of Things or IoT are being utilized across various sectors, from healthcare and transportation to agriculture and smart cities, showing their potential to enhance the efficiency, productivity, and quality of life. We've seen how IoT can make things more efficient and improve our lives. As we know if there are advantages of anything, then there are challenges too. The challenges involves in IoT includes privacy and security concerns, interoperability issues, difficulty in processing, analysis and management of data, outdated equipment and programming ,scalability limitations, and the need for robust infrastructure and standards. Despite of these obstacles, the continuous evolution of Internet of Things (IoT) continues to pave the way for the transformative innovations. To make the most from IoT, we need to work together, solve problems, and keep making it better.

Looking ahead toward addressing these challenges will be important for unlocking the full potential of IoT so it will continue to bring new possibilities and make our world even more connected and ensuring its sustainable integration into our increasingly interconnected world. As advancement in research and development in IoT will continue, collaboration among stakeholders, policymakers, and industry leaders will be crucial in navigating the complexities and harnessing the immense opportunities that lie ahead. As more and more research studies are conducted, new dimensions to the IoT processes, technologies involved and the objects that can be connected, continue to emerge, further paving way for much more application functionalities of IoT. So in present and in future also, IoT is on its way of making the human's life as a connected and smarter one.

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