Internet of Things (IoT)

An Emerging Technology

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ABSTRACT

In this paper, we will discuss the Internet of Things (IoT) in general, as well as the main issues of the IoT environment, with an emphasis on the most recent developments in this area. IoT has recently emerged as a new technology used to express a modern wireless telecommunication network. It can be defined as an intelligent and interoperability node interconnected in a dynamic global infrastructure network, and it aims to implement the connectivity concept of anything from anywhere at any time. Indeed, the IoT environment presents a wide variety of obstacles that have a significant impact on their performance. We also briefly explore the merits, drawbacks, and future technologies related to the Internet of Things here. In addition, the main applications of the Internet of Things are highlighted.

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INTRODUCTION

The Internet of Things, abbreviated as IoT, is a concept that emerged as a result of the convergence of the fields of electronics and computer science. The Internet of Things (IoT) is a term that describes how regular household items will connect and communicate with other household items over the internet. Objects in an IoT are enabled to communicate with one another through the use of microcontrollers, sensor devices, as well as a variety of software applications and a protocol stack that is tailored to their needs. The Internet of Things refers to any "thing" that may be connected to the internet, including people, devices, animals, buildings, vehicles, and anything else that is a part of our regular lives. The Internet of Things enables communication between seemingly unrelated devices. In a broad sense, the Internet of Things (IoT) can be conceptualized as a combination of sensors, connectivity, and people and processes. IoT is able to construct compound applications by combining smart devices with smart services, such as intelligent transportation, smart cities, smart healthcare, smart homes, smart buildings, digital farms, smart agriculture, and so on. The Internet of Things helps save time, money, and even labor by providing on-demand services that are updated in real time. This in-depth literature analysis investigates the influence that the Internet of Things (IoT) technology has had in a variety of industries.[1]

A BRIEF HISTORY OF IoT

Mark Weiser wrote a book called "Ubiquitous Computing" in 1991 about what he thought the Internet would be like in the future. With this vision, he was thinking about how to make a smart living environment with mobile phone technology. This would make a powerful multimedia system. One of the first people to talk about IoT was Kevin Ashton [2]. Atzori A.lera et al. put the Internet of Things into three categories: 1) Internet-oriented (Middleware), 2) Things-oriented (Sensors), and 3) Semantic-oriented (Knowledge). In his book "When Things Start to Think," published in 1999, Neil Gershenfeld talked about similar things from the Massachusetts Institute of Technology, MIT Media Lab. In 1999, Auto-ID labs and MIT tried to make EPC (Electronic Product Code) and RFID (Radio Frequency Identification) to identify things on the network. In 2003 and 2004, projects like Cooltown, Internet0, and the Disappearing Computer initiative started to support the idea of IoT. IoT also started to show up in book titles for the first time. The US department

of Defense put out a lot of information about how RFID is being used. IoT moved to a new level when the International Telecommunication Union ITU published its first report on it in 2005. In 2008, Cisco, Intel, SAP, and more than 50 other companies got together to form IPSO Alliance. Their goal was to promote the use of Internet protocol (IP) and get the IoT concept going. Cisco's Internet Business Solutions Group (IBSG) "gave birth" to IoT in 2008-2009. From what has been said so far, IoT can be thought of as a group of smart things like home devices, mobile phones, laptops, etc. that are given a unique address and connected to the Internet through a single framework. This framework could be cloud computing.[2]

ARCHITECTURE OF IoT

Internet of Things (IoT) technology can be used for many different things, and the number of people who use it is growing quickly. The Internet of Things works the way it was made to work based on the different ways it can be used. But it doesn't have a standard way of working that is followed by everyone everywhere. IoT's architecture depends on how it works and how it is used in different fields. Still, the Internet of Things is built on a basic process flow.

So, in this section, we'll talk about the basics of IoT architecture, which is called 4 Stage IoT architecture.

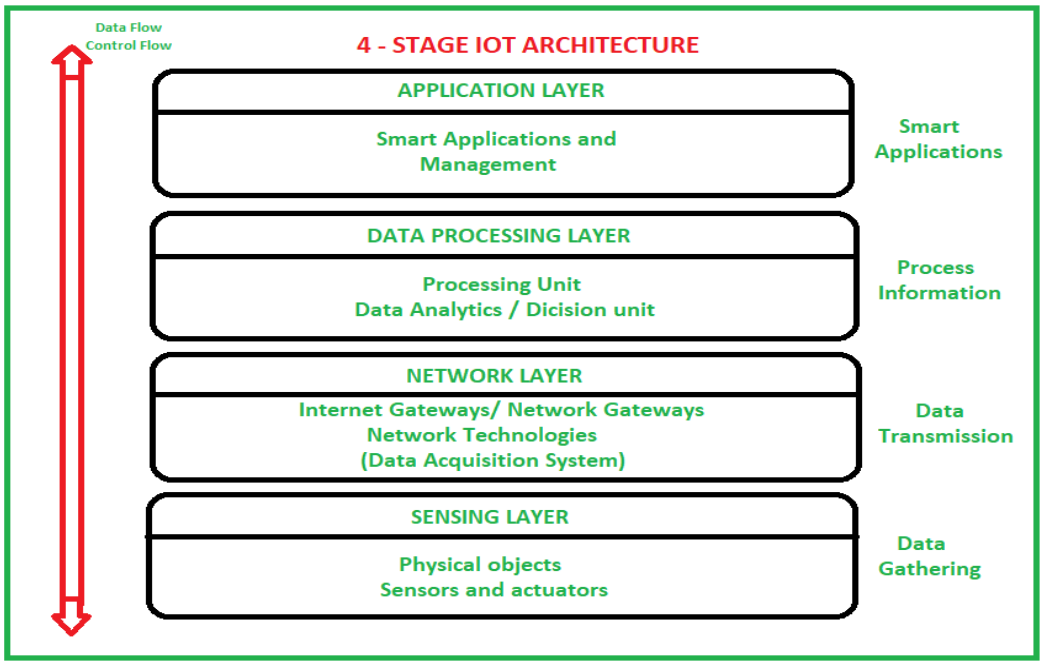

Figure.1. Architecture of IoT

So, it's clear from the picture above that there are 4 layers, which can be broken down into the Sensing Layer, the Network Layer, the Data Processing Layer, and the Application Layer.

Here's how to understand each of these.

Sensing Layer: This layer has sensors, actuators, and other devices. These sensors or actuators take in data (physical or environmental parameters), process the data, and send the data over a network.

Network layer: This layer has gateways to the Internet and other networks, as well as the Data Acquisition System (DAS). DAS is in charge of gathering and converting data (Collecting data and aggregating data then converting analog data of sensors to digital data etc). Advanced gateways mostly connect Sensor networks to the Internet, but they also do a lot of basic gateway tasks like blocking malware and filtering, and sometimes making decisions based on the data they receive and providing data management services, etc.

Data processing layer: This is the part of the IoT ecosystem that does the processing. Here, data is analyzed and pre-processed before being sent to a data center. From the data center, software applications, which are often called "business applications," access the data and use it to monitor and manage it, as well as plan what to do next. So, this is where edge IT or analytics come into play.[3]

Application layer: This is the last layer of the four stages of IoT architecture. Data centers or the cloud are the stage of data management where data is managed and used by end-user applications like agriculture, health care, aerospace, farming, defense, etc.

RECENT DEVELOPMENTS

The Internet of Things has a multidisciplinary vision to deliver its benefits to a variety of fields, including the environment, industry, public and private sectors, medicine, and transportation, amongst others. Various researchers have offered a variety of explanations of the IoT, each catering to their own particular areas of interest and concerns. There are many different application fields where one can observe the potential and power of the Internet of Things.

In the recent past, a number of significant Internet of Things projects have emerged to dominate the industry. Figure 2 presents a number of the more significant Internet of Things initiatives that have successfully cornered the majority of the industry. A global distribution of these Internet of Things initiatives is illustrated in Figure 3, broken down into the regions of the Americas, Europe, and Asia/Pacific. It is clear that the American continent is contributing more to the smart supply chain and smart healthcare initiatives, whilst the European continent is contributing more to the smart city projects.[4]

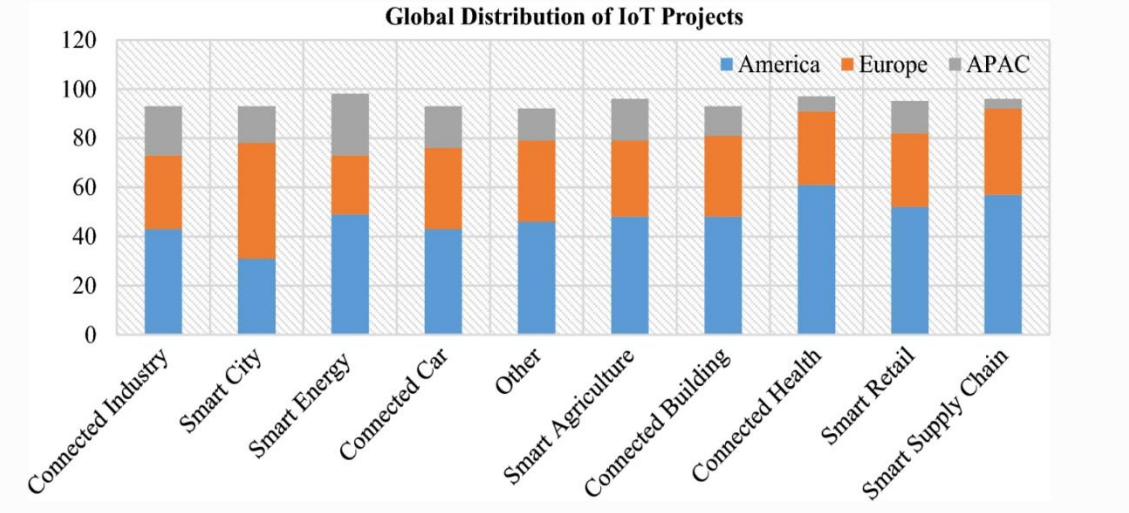

Figure.2. Global distributions of IoT projects

The global market share of IoT projects is illustrated in figure 3, which can be found here. When compared to other types of Internet of Things projects, those centered on industries such as smart cities, smart energy, and smart vehicles clearly have a larger market share.

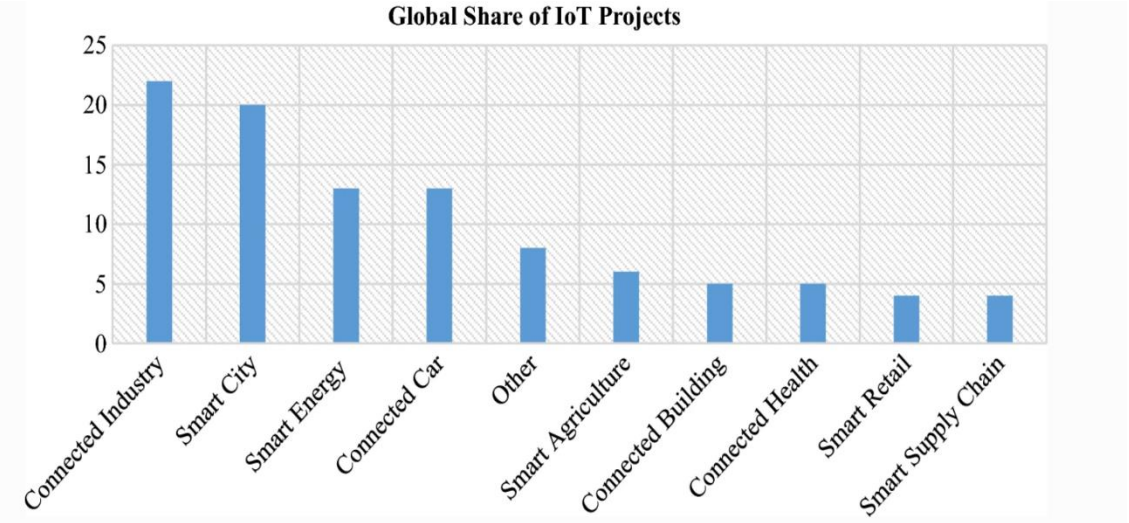

Figure.3. Global share of IoT projects

APPLICATIONS

IoT has numerous useful applications for humans. Experts use these technologies to meet societal needs. IoT apps create real-time wonders. Transportation, Smart Home, Smart City, Lifestyle, Retail, Agriculture, Smart Factory, Supply chain, Emergency, Health care, User interface, Culture and tourism, Environment, and Energy are IoT application domains. Following are some IoT applications.

Smart homes: The Internet of Things has some of the best and most practical applications, and one of those applications is smart homes, which really take the concepts of convenience and home security to a whole new level. The Internet of Things can be used in smart homes on a number of different levels; however, the most effective implementation is the one that combines intelligent utility systems with entertainment options. Automatic Illumination Systems, Advanced Locking Systems, and Connected Surveillance Systems are all examples of technologies that are compatible with the concept of smart homes. Other examples include your electricity meter, which is equipped with an Internet of Things (IoT) device that provides you with insights into your everyday water usage; your set-top box, which enables you to record shows from a remote location; and so on. As the Internet of Things develops, we can be certain that the majority of the gadgets will become more intelligent, which will make it possible to have increased levels of home protection.

Smart city: Smart cities are supposed to have devices that can connect to the internet, not just the people who live there. And we're happy to say that we're making progress toward making this dream come true. Infrastructure needs and important things like traffic management, waste management, water distribution, electricity management, and more are being worked on to include connected technology. All of these help people get rid of some of the problems they face every day and make their lives easier.

Self-driven car: We've seen a lot about cars that can drive themselves. Google and Tesla both tried it out, and Uber came up with a version of self-driving cars that it later put away. Since we're talking about people's lives on the roads, we need to make sure that the technology has everything it needs to make the roads and passengers safer.The cars have a number of sensors and built-in systems that are connected to the Cloud and the internet. These systems keep sending data to the Cloud so that Machine Learning can use the data to make decisions. Even though it will take a few more years for the technology to fully

develop and for countries to change their laws and policies, what we're seeing now is one of the best uses of the Internet of Things.

Iot retail shop: If you haven't seen the video of Amazon Go, the eCommerce giant's concept store, you should do so right away. Maybe this is the best way to use technology to connect an online store to a physical store. You can pay without cash at the store by taking money out of your Amazon wallet. It also adds things to your shopping cart as you take them off the shelves.[5]

If you change your mind and add another item to your cart, the first one gets deleted and the new one takes its place. The best thing about the concept store is that it doesn't have a cashier. You don't have to wait in line. Once you pick up your items from the shelves, you can just walk out. If this technology works well enough to bring in more customers, it will become the norm in the years to come.

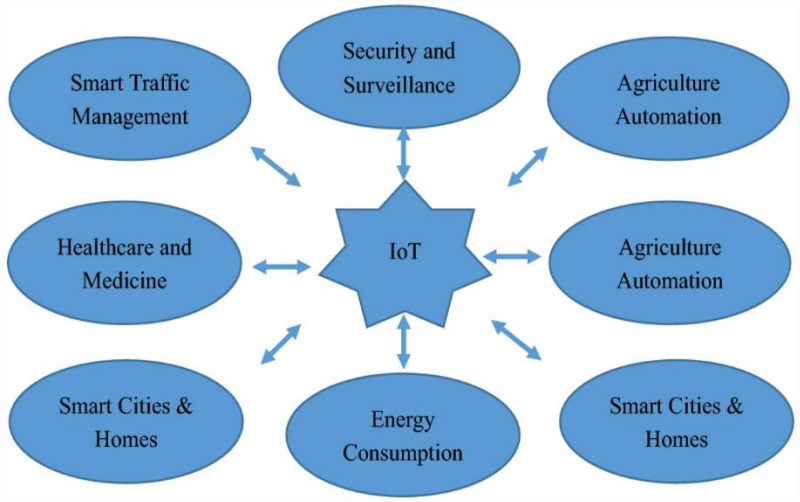

Figure.4. Some applications of IoT

Farming: One area that will gain the most from the Internet of Things is farming. With so many improvements being made to tools that farmers can use, the future looks bright. Tools are being made for drip irrigation, figuring out crop patterns, distributing water, using drones to keep an eye on farms, and more. These things will help farmers make more money and take better care of their animals.

Wearables: Even now, wearables are still a big deal in the market. These devices are used for a wide range of things, from health and fitness to medicine and wellness. Jawbone, a company that makes wearables, has the most money of all the IoT startups.

Smart Grids: A smart grid is one of the many useful IoT examples. It is an all-in-one solution that uses a wide range of IT resources to help both old and new gridlines use less electricity and save money. A smart grid of the future will make electricity cheaper, more reliable, and more efficient.

Industrial Internet: The Industrial Internet of Things is made up of sensors, instruments, and other devices that are linked to industrial applications on computers, such as manufacturing, energy management, and so on. Market researchers like Gartner, Cisco, etc. think that the industrial internet has the most potential in the long run, even though it isn't as popular as IoT wearables and other uses.

Telehealth: Telehealth, also called telemedicine, hasn't really taken off yet. Still, it has a lot of promise for the future. IoT Telemedicine includes digital communication of medical imaging, remote medical diagnosis and evaluations, video consultations with specialists, etc.

Smart supply-chain Management: Smart supply-chain Management Solution for keeping track of goods on the road is a common example. With IoT technology behind them, they are sure to be around for a long time.

Traffic management: With the help of the Internet of Things, traffic management in big cities can be made much better (IoT). The Internet of Things helps us stay informed and improves traffic monitoring by letting us use our cell phones as sensors to collect and share data from our cars through apps like Waze or Google Maps. This adds to and improves the information about the different ways to get to the same place, how far they are, and when they are expected to arrive.IoT can also be used to look at traffic patterns over a long period of time. It gives you an idea of what could happen during busy times. By knowing about possible alternatives, commuters will be better prepared to avoid traffic and delays.

Water/ Waste Management: Water treatment units are being used in many cities to recycle water. With an IoT app, you can see how much wastewater is being made, how much is being used in a certain area, and how the amount of wastewater being made changes over time.Using Internet of Things apps and smart sensor technology, we can solve this problem in a good way. With a smart waste management system, authorities will be able to predict, among other things, how much trash will be made in a certain area,

how to process it properly, when to clean it up, and how to analyze data for future planning.[6]

Analytics solutions make it easy to get an overview of how much trash is made in each neighborhood and how much trash is made over time. This information will be used to plan the city's projects to grow and improve. Smart analytics solutions can be used to manage waste collection and treatment fleets and to predict future trends.

IoT AND RELATER FUTURE INTERNET TECHNOLOGIES

Cloud Computing: "Applications as a Service" and "Platforms as a Service" are examples of new ways of thinking about how technology can be used. They are two of the most important parts of the Internet's future. In [54], it is said that Internet of Things (IoT) applications (sensor-based services) will only be available through the cloud. If we wanted to use Internet of Things (IoT) systems on a large scale, security would be a big problem. Even if we used the same IT security architecture for IoT as we do for IT, that wouldn't be enough. If you want to keep these smart objects (or smart things) safe for a long time, you will need cloud-based security services with powerful resources. People have noticed that, with the rapid growth of the Internet of Things (IoT), we are moving towards a cyber-physical paradigm, where we generally combine computing and communication technology with connected smart objects (or smart things) to control how they work.

In addition to location awareness and low latency (the amount of time it takes for a message to travel through a system), many Internet of Things applications need support for mobility (or potency) and geo-distribution. This is because the data needs to be processed in "real time" in micro clouds or fog. Micro cloud and fog computing and services use a different data management system that extends the Cloud Computing paradigm (a certain pattern) to the edge of the network. This makes it possible for many new applications to work. Micro Cloud/Fog is similar to the Cloud in that it gives end users data, computing, storage, and application services.

The micro cloud or fog needs to have some features, such as low latency and location awareness, wide geographical distribution, mobility/potency, and a large number of nodes. Wireless access plays the most important role, Strong presence of streaming and real-time applications, heterogeneity) in order to make IoT applications work well. Also,

if we broaden the "serving scope" of an Internet-connected object or things beyond the "sensing service," it's not hard to imagine virtual objects (or things) that will be built into future IoT services and used in many different ways.

IoT and Semantic Technologies: The IERC SRIAs have already found that semantic technologies are important for both finding devices and getting to the goal of semantic interoperability. Linked Open Data is likely to be used in IoT research in the future. This could build on the way sensor technologies have already been used in IoT infrastructures and apps. Semantic technologies will also be a key part of making it possible to share and reuse virtual objects as a service through the cloud, or validating that this is possible. With semantic enrichment of virtual object descriptions, the Internet of Things will be able to do what the Semantic Web has been able to do with semantic interpretation of web pages. Semantic-based reasoning will help users of the Internet of Things (IoT) find relevant virtual objects that have been proven to improve performance more quickly and on their own.

Networking Technology: Today The traffic on mobile devices has been driven by activities that are quite predictable, such as making phone calls, reading email, and viewing videos. In the next five to ten years, billions of Internet of Things (IoT) devices that have less traffic patterns will join the network. These devices will include automobiles, machine-to-machine (M2M) modules, which require bandwidth all the time, and various types of sensors that send out tiny bits of data each day. It has been recognized that the proliferation of cloud computing necessitates the development of new network strategies for the growth of fifth generation mobile cellular networks (also known as 5G), and that a good convergence of network access technologies has been very clearly illustrated. The infrastructure of such a network must be designed to accommodate the requirements of Internet of Things applications. A network that is both quick and has a high capacity is required in order to make IoT and M2M communication practicable.[7]

CHALLENGES OF IoT

IoT-based systems are involved in every part of people's lives, and the different technologies used to transfer data between embedded devices made it hard and led to a number of problems and issues. In a society with a lot of smart tech, these problems are also a challenge for IoT developers. As technology gets better, so do the problems and

the need for more advanced IoT systems. So, IoT developers need to think about new problems that might come up and come up with solutions for them.

Security and privacy issues

Due to several threats, cyber attacks, risks, and vulnerabilities, security and privacy are two of the most important and difficult issues in the Internet of Things (IoT). Device-level privacy problems include not enough authorization and authentication, insecure software, firmware, web interfaces, and transport layer encryption. Concerns about security and privacy are very important for building trust in IoT systems in many different ways. To stop security threats and attacks, security mechanisms must be built into each layer of the IoT architecture. To make sure that IoT-based systems are safe and private, many protocols have been made and are being used effectively on every layer of communication channel. Secure Socket Layer (SSL) and Datagram Transport Layer Security (DTLS) are two cryptographic protocols that are used in IoT systems to provide security between the transport layer and the application layer. But some IoT applications need different ways to make sure IoT devices can talk to each other securely. Aside from this, the IoT system is more likely to have security problems if it uses wireless technologies for communication. So, there should be some ways to find malicious actions and for the system to self-heal or recover. On the other hand, privacy is an important concern that lets users feel safe and at ease when using IoT solutions. So, it's important to keep authorization and authentication going over a secure network so that trusted parties can talk to each other. Another problem is that different IoT objects have different rules about how they handle privacy when they talk to each other. Because of this, each object in the IoT system should be able to check the privacy policies of other objects before sending the data.

Issues with interoperability and standards

Interoperability means that different IoT devices and systems can share information with each other. This exchange of information doesn't depend on the software and hardware that have been set up. Interoperability is a problem because the different technologies and solutions used to build the Internet of Things are not the same. Technical, semantic, syntactic, and organizational are the four levels of interoperability. IoT systems offer many different functions to improve the interoperability that makes it possible for

different objects in a heterogeneous environment to talk to each other. Also, it is possible to combine different IoT platforms based on how they work to give IoT users more options. Interoperability is a big problem, so researchers came up with a number of solutions, which are also called "interoperability handling approaches". These solutions could be based on adapters and gateways, virtual networks and overlays, service-oriented architecture, etc. Even though there are ways to handle interoperability that make IoT systems less stressed, there are still some problems with interoperability that could be studied in the future.

Ethics, Law and regulatory rights

Developers of IoT also have to think about ethics, the law, and regulatory rights. There are rules and regulations in place to keep moral standards high and keep people from breaking them. The only difference between ethics and law is that ethics are the standards that people believe in, while laws are the rules that the government makes. But both ethics and laws are made to keep standards high and stop people from using drugs illegally. With the development of IoT, many real-world problems have been solved, but it has also brought up important ethical and legal issues. Some of these challenges are data security, privacy protection, trust and safety, and being able to use data. Because people don't trust IoT devices, it has also been seen that most IoT users agree with government rules and regulations about data protection, privacy, and safety. So, this issue needs to be taken into account if people are to keep and increase their trust in IoT devices and systems.

Scalability, availability and reliability

A system is scalable if you can add new services, equipment, and devices to it without affecting how well it works. The biggest problem with IoT is that it has to work with a lot of different devices that have different amounts of memory, processing power, storage space, and bandwidth. The availability of the item is another important thing to think about. Scalability and availability should be put in place at the same time in the IoT's layered framework. IoT systems that run in the cloud are a great example of scalability because they allow the IoT network to grow by adding new devices, storage, and processing power as needed.[8]

But this global distributed IoT network gives rise to a new research paradigm to make an IoT framework that works well and meets the needs of people all over the world. Another big problem is that it can be hard to find resources for authentic objects, no matter where they are or when they are needed. Several small IoT networks are connected to global IoT platforms at the same time so that they can use their resources and services. So, availability is an important thing to think about. Because of the use of different data transmission channels, like satellite communication, some services and resources may not be available at the same time. For resources and services to be available all the time, there needs to be an independent and reliable way to send and receive data.

Quality of Service (QoS)

Quality of Service (QoS) is also an important part of the Internet of Things. QoS is a way to measure how good, efficient, and effective IoT devices, systems, and architecture are. IoT applications need to have QoS metrics for reliability, cost, energy use, security, availability, service time, and service time. QoS standards must be met by an IoT ecosystem that is smarter. Also, the QoS metrics of any IoT service or device must be set up first in order to make sure they are reliable. In addition, users may be able to specify their needs and requirements. Several methods can be used to measure QoS, but as White et al. There is a trade-off between factors of quality and ways of doing things. So, to get around this trade-off, good quality models must be used. There are some good models in the literature, like ISO/IEC25010 and OASIS-WSQM, that can be used to compare the methods used for QoS assessment. These models offer a wide range of quality factors that are more than enough for judging the QoS of IoT services.

ADVANTAGES

The Internet of things offers a number of practical benefits that make our lives easier. The following is a list of some of its advantages:

Minimize human effort: As Internet of Things (IoT) devices interact and communicate with one another, they are able to automate tasks, which helps to improve the overall quality of a company's offerings while also minimizing the amount of work that needs to be done by humans.

Save time: this helps us save a lot of time by lowering the amount of human effort that is required. One of the most significant benefits that comes from utilizing the IoT platform is the reduction of wasted time.

Enhanced data collection: Information is easily available, even if we are far away from our actual position, and it is updated often in real-time. Additionally, the information is collected in a more efficient manner. Because of this, these devices are able to access information at any time and from any location on any other device.[9]

Increased safety: If we have a system that is networked, it will be easier to exercise more intelligent control over our homes and communities using our mobile devices. It gives personal safety in addition to enhancing overall security.

Efficient resource utilization: By understanding the functionality of each item and how it operates, we can increase the amount of resources that are used and monitor the natural resources that are available.Electric devices are directly connected to one another and are able to communicate with a controller computer, such as a mobile phone. This results in an efficient use of electricity and reduces the need for extra electronic equipment. As a result, there won't be any pointless utilization of the electrical apparatus.

Use in traffic systems: Asset tracking, delivery, surveillance, traffic or transportation tracking, inventory control, individual order tracking, and customer management can all be performed more efficiently and at a lower cost with the appropriate tracking system that makes use of internet of things technology.

Useful for safety concerns: It is good for safety concerns because it can detect any potential hazard and advise users of it. This makes it useful for safety concerns. One example of an integrated safety system is GM OnStar, which may detect when a vehicle has been involved in a collision or accident while driving. If it detects a collision or an accident, it will immediately place a phone call.[10]

Useful in the healthcare industry: Real-time patient care can be carried out in a more efficient manner than care that requires a doctor's visit to be completed. They will also be able to deliver care that is based on facts as well as the ability to make choices.

DRAWBACKS

As the Internet of things makes some things easier, it also makes a lot of problems. Here are some of the bad things about IoT:

Security issues: IoT systems are linked together and talk to each other over networks. So, even with security measures, the system is hard to control, and it can lead to different types of network attacks.

Privacy concern: The IoT system gives out important personal information in full detail without the user's help.

Increased unemployment: Both unskilled and skilled workers have a high chance of losing their jobs, which makes unemployment rates high. People who used to do these jobs are being replaced by smart security cameras, robots, ironing systems, washing machines, and other tools.

The complexity of the system: It's hard to design, build, maintain, and enable a system that uses a lot of technology like IoT.

High changes of the entire systems getting corrupted: Chances are high that the whole system will get messed up. If there is a bug in the system, it is possible that every device connected to it will also get messed up.

Lack of international standards: Because there isn't an international standard for IoT compatibility, it's hard for devices made by different companies to talk to each other.

High reliance on the internet: They use the internet a lot and can't do their jobs well without it.

Reduced mental and physical activity: People who use the internet and technology too much become lazy and inactive because they rely on smart devices instead of doing physical work.[11]

CONCLUSIONS

IoT technology is a relatively new revolution that is quickly receiving widespread adoption. We are moving toward a future when each individual will have a significant number of connected objects. Even though the Internet of Things technology is still in its developing phase, it will soon revolutionize the future and the way we live. It is a technology that will be used in the future. In the same way that cellphones have brought about a significant shift in the manner in which we communicate and disseminate information, thanks to the abundance of applications that are now at our disposal, Soon, the technology of the internet of things will also bring about significant changes in the way we live and interact with the world in ways that we have never even considered. The Internet of Things provides a large scope for research in a variety of domains. This literature review will assist academics better grasp the concept and implementation of the Internet of Things (IoT), which will in turn help them continue their research efforts in this area. Massive Scaling, Architecture and Dependencies, Creating Knowledge and Big Data, Robustness, Openness, Security and Privacy, Humans in the Loop, Software and Algorithms, Network and Communication Technologies, Hardware Technology, Power and Energy Storage Technologies, Data Signal and Processing Technology, Discovery and Search Engine Technology, and Standardization are some of the research directions in Internet of Things (IoT).[12]

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