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The Internet of Things (IOT): A Review of Concepts, Technologies, and Applications

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Abstract: The Internet of Things (IoT) is a system in which everyday objects such as gadgets, cars, and appliances are equipped with electronics, software, sensors, and network connectivity that allow them to connect to one another and share information and perform tasks. In this study, we examine the fundamentals of the IoT, including its sensors, actuators, and communication protocols. There are still a number of issues and challenges that must be fixed before IoT can live up to its full potential. Many angles on the Internet of Things, such as applications, challenges, enabling technologies, social and environmental repercussions, etc., need to be considered while tackling these issues. The primary purpose of this article is to provide a comprehensive explanation from a technical and societal perspective. The numerous challenges, important issues, architecture, and significant application domains associated with the IoT are all discussed in this article. Many IoT applications are covered, from healthcare to agriculture to transportation, and beyond.

Keywords: IOT, QOS, Scalability, Automation.

1. INTRODUCTION

There is a developing network of physical items that can share data and communicate with one another thanks to built-in sensors, software, and connection; this network is known as the Internet of Things (IoT). The Internet of Things (IoT) has the potential to revolutionise numerous sectors by making existing processes more streamlined and opening up entirely new markets. The purpose of this study is to survey the IoT and its supporting technologies, frameworks, and software. The Internet of Things (IoT) is becoming increasingly significant and omnipresent in all aspects of modern life. The Internet of Things (IoT) is an umbrella term for a collection of interconnected technology innovations, such as sensor networks,

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smart systems, and frameworks (Fig. 1). Storage, sensing, and processing speed are all improved in ways that were previously impossible thanks to quantum and nanotechnology [2]. Extensive studies have been undertaken to show the potential efficacy and applicability of IoT changes, and the results have been published in academic journals and press articles that can be found online and in print. It could serve as a foundation upon which to build novel, imaginative business strategies while keeping in mind the importance of security, assurance, and interoperability.

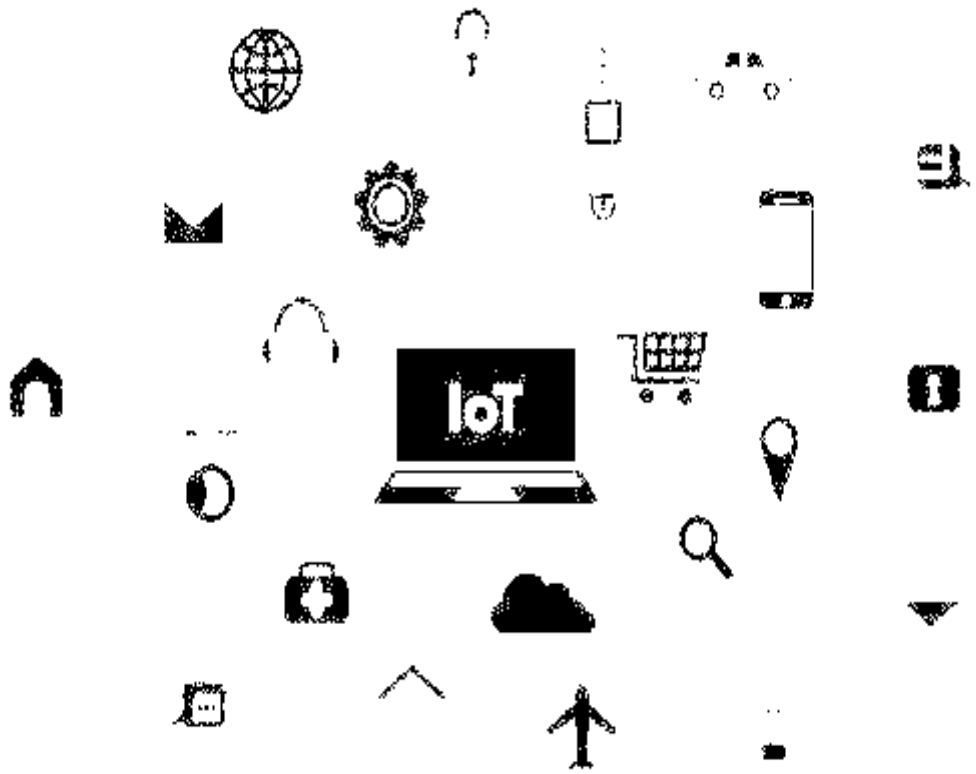


Figure 1 shows IOT devices.

The widespread adoption of IoT tools and infrastructure has brought about profound changes to our daily lives. One example of an IoT development is the concept of smart home systems (SHS), which entails internet-connected appliances, home automation systems, and trustworthy energy management systems [3, 4]. Another major success of the Internet of Things is the Smart Health Sensing system (SHSS). Only a small amount of high-tech tools and appliances designed to improve people's health are incorporated into SHSS. The health conditions, fitness level, number of calories burned in the gym, etc. can be examined and monitored both indoors and outdoors with the help of these devices. It's also used to monitor critical conditions in healthcare facilities like hospitals and trauma centers. Hence, by

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empowering it with cutting-edge technology and sophisticated tools, it has fundamentally revolutionized the field of medicine [4, 5]. Researchers and entrepreneurs in the Internet of Things are also making strides towards making daily life better for the elderly and those with physical impairments. The Internet of Things has made tremendous strides in this area, providing individuals who live in it with new purpose and meaning in their daily lives. Because of their low initial investment requirements and high return on investment, most people have adopted the use of these products and equipment [6]. Thanks to the Internet of Things, they can lead a normal life. Our ability to get from place to place is also crucial. The Internet of Things has spawned a number of novel advancements that boost its efficiency, convenience, and dependability. Intelligent sensors and drone devices are now in charge of controlling traffic flow at many signalised intersections in major cities. Vehicles are currently being launched to markets with pre-installed sensing devices that can identify upcoming heavy traffic congestions on a map and may propose another route with minimal congestion, demonstrating the value that IoT may provide to many other areas of life and technology [7]. The Internet of Things, we may conclude, holds great promise for advancing technology and bettering human life.

The Internet of Things has also proven its worth and potential in a developing region's thriving industrial and economic development. It's a game-changer for business and the stock market alike. Despite the importance and desirability of data and information security, it is a notoriously challenging subject to resolve [5]. Due to the Internet's role as the primary vector for security threats and cyberattacks, the latter have multiple vectors of entry, putting sensitive information at greater danger. In spite of this, IoT is committed to delivering top-tier responses to data and information security issues. This means that security is the primary concern for businesses and the economy when it comes to the IoT. Developers in the IoT space are putting in extra time and effort to provide a secure channel for cooperation across social networks in light of the prevalence of concerns over personal data.

Features of the Internet of Things:
Sensors, actuators, communication protocols, and cloud computing are just some of the parts that make up the Internet of Things. Sensors are devices that pick up on alterations in the environment, such as shifts in temperature, brightness, motion, or sound. However, actuators are different in that they are able to conduct actual actions, such as opening and closing a valve or starting a motor. Bluetooth, Wi-Fi, and ZigBee are all examples of communication protocols since they allow devices to talk to one another in standardized ways. The ability to store and interpret data from IoT devices is made possible by cloud computing, allowing for massive data sets to be analyzed and insights to be drawn.

Internet of Things Technologies and Architectures:
Edge computing, fog computing, and blockchain are just a few of the technologies and architectures employed in IoT systems. The term "edge computing" refers to a type of distributed computing model in which data processing occurs at the network's periphery, in proximity to IoT devices. Fog computing is an extension of edge computing in which a

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network of edge devices collaborates to do data processing. The distributed ledger technology known as blockchain facilitates trustworthy record-keeping and transaction verification.

Examples of the Internet of Things in Action

There are many potential uses for the Internet of Things, including the medical and health industries, the agricultural sector, the transportation sector, and others. Internet of Things devices have several potential applications in healthcare, including remote patient monitoring, device tracking, and medication administration. Internet of Things devices have several applications in agriculture, including precision farming, animal monitoring, and crop management. Traffic control, vehicle tracking, and preventative maintenance are just some of the ways that the Internet of Things may improve transportation.

Review of literature

The Internet of Things (IoT) is designed to benefit many different sectors, including the public and private sectors, industries like healthcare and transportation, and the environment. Academics have offered conflicting descriptions of the IoT, each focusing on particular areas of study and concerns. Some industries believe in the power and promise of the Internet of Things. Figure 2 depicts a handful of the many potential IoT application domains.

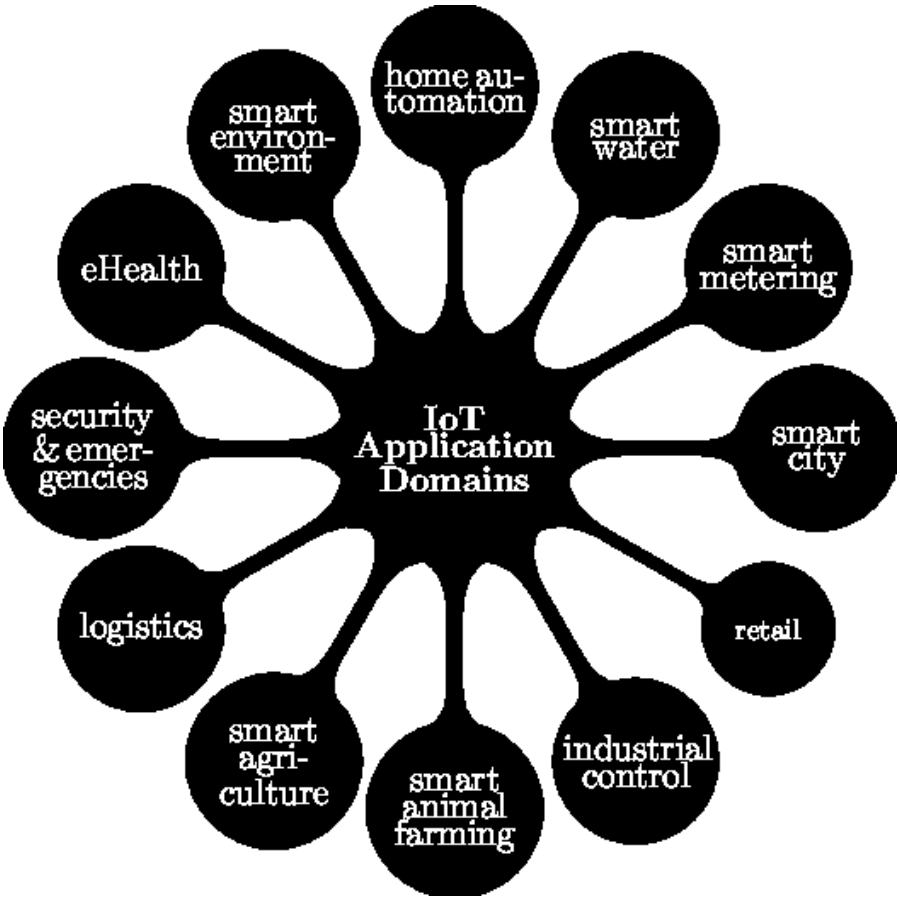


Figure 2 shows IoT application areas that might be used.

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Several major IoT initiatives have emerged in recent years and seized the initiative. Several of the most influential IoT initiatives are shown in Fig. 3. Figure 3 demonstrates how these IoT initiatives are distributed globally throughout the American, European, and Asia/Pacific regions. The American continent is more active in smart supply chain and healthcare projects, whereas the European continent is more active in smart city projects [8].

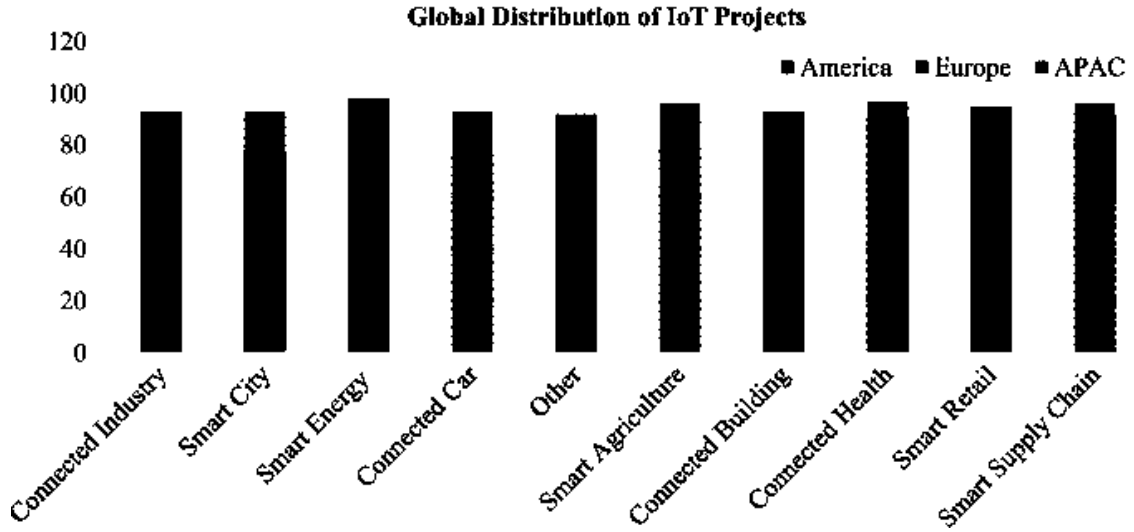


Figure 3: Worldwide distribution of IoT projects among Europe, APAC, and America (USA, South America, and Canada) (Asia and Pacific region)

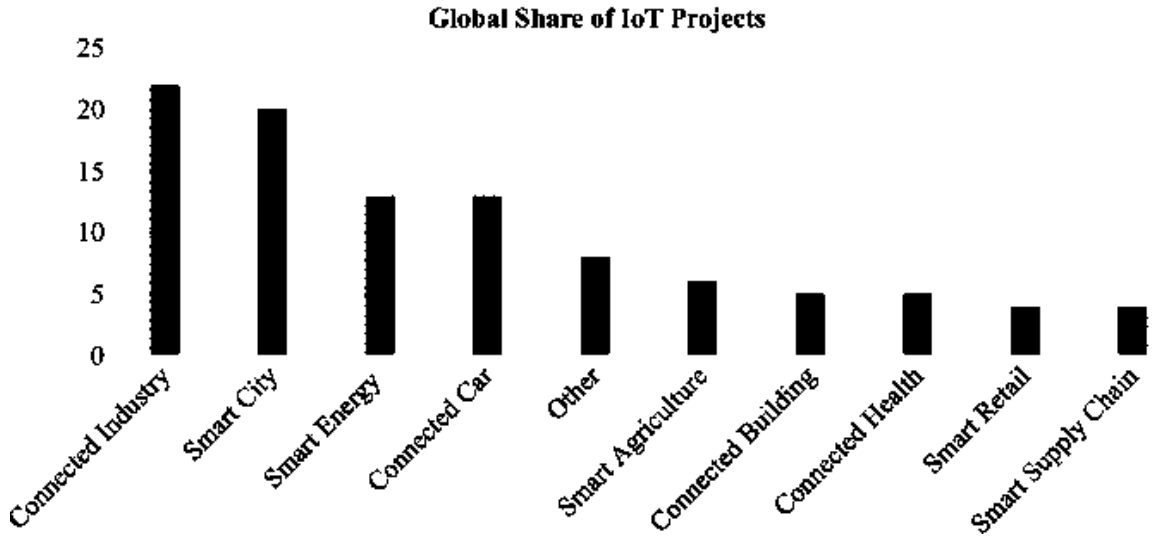


Figure 4: Total number of IoT projects worldwide

The smart city is a common Internet of Things use case since it incorporates smart houses. Comfort, safety, and efficiency are maximized in a smart home because of the interoperability of its Internet of Things (IoT)-enabled appliances, HVAC system, television, audio/video streaming devices, and security systems. All of this interaction takes place through the Internet of Things' centralized control system. The concept of a "smart city" has

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gained popularity and attracted significant academic interest in the past decade [9]. Smart home companies are expected to generate $100 billion in revenue by 2022 [10]. A smart home's owner can save money in multiple ways, including through reduced energy use and the associated decrease in the monthly power bill. Aside from smart homes and smart transportation, smart cities also incorporate smart vehicles. Almost every part of a contemporary car, from the headlights to the engine, is operated by electronics and sensors [11]. The Internet of Things (IoT) is committed to developing new smart vehicle systems that combine wireless connectivity between vehicles and between vehicles and drivers in order to provide predictive maintenance and an enjoyable and safe driving experience [12].

Khajenasiri et al. [10] looked into IoT systems for smart energy control to see how they could be used to improve existing smart city applications. According to them, IoT has only been put to use in a select few scenarios where it can benefit both machines and people. Eventually, IoT will be able to dominate virtually every industry. Their argument was that a smart energy management system that conserves both money and energy might be developed with the help of the Internet of Things, which is one of the most important parts of modern civilization. Smart cities were addressed in the context of an IoT architecture. The authors acknowledged that this is a challenging goal to achieve because of the slow pace of development in IoT hardware and software. The authors argued that addressing these issues was necessary to ensure an efficient, trustworthy, and user-friendly IoT system.

The issue of rapid urbanization was examined by Alavi et al. [13]. Urban populations are growing as a result of people leaving rural areas. Hence, we need smart answers for things like transportation, healthcare, and energy. The smart city is an important application area for IoT designers. It covers a wide range of issues like traffic, air quality, and public safety management, as well as smart parking, smart lighting, and smart garbage collection.
They went on to say that IoT is putting in a lot of work to solve these complex issues. Enhanced smart city infrastructure is in high demand, and this has opened up new markets for companies specializing in smart city technologies. The authors argue that Internet of Things (IoT) enabled technology is essential to the development of long-term smart cities.

Principal challenges and issues with the Internet of Things
Because of the proliferation of IoT-based systems and the proliferation of technologies used to transport data between embedded devices, the situation has become increasingly complex and has given rise to a number of new challenges. These issues are problematic for IoT developers even in today's high-tech, smart world. Complex Internet of Things (IoT) systems are becoming increasingly necessary as the industry grows, yet new problems arise at the same time. This means that those working on IoT projects need to anticipate issues and address them as they come up.

Worries about confidentiality and safety
There are a lot of potential dangers, hazards, and vulnerabilities in the Internet of Things (IoT), making security and privacy two of the most important and challenging obstacles to overcome [21]. Problems at the device level include insufficient authorization and

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authentication; insecure software and firmware; unstable web interfaces; and insufficient transport layer encryption [22]. From a number of perspectives [23], trust in IoT systems relies heavily on assurances of security and privacy. Security measures should be integrated into the IoT architecture at each level [23] to prevent security breaches and attacks. Several protocols have been developed and successfully applied on all levels of communication channels to ensure the security and privacy of IoT-based systems [44, 45]. Secure Sockets Layer (SSL) and Datagram Transport Layer Security (DTLS) are two cryptographic protocols used between the transport and application layers to provide security solutions in various IoT systems [24]. Yet, different IoT use cases necessitate varying approaches to ensuring secure inter-IoT device connection. It's important to note that when wireless technology is used for communication, the IoT system is more open to security risks. Therefore, it is important to adopt specific methods for recognizing problematic conduct and encouraging recovery. On the other hand, customers also need to think about privacy concerns to ensure their security and comfort when utilizing IoT devices. Authorization and authentication must be kept up over a safe network in order for reliable parties to communicate [16]. Another issue is the fact that there are different privacy standards for the different things that interact within the IoT system. As a result, devices in an IoT network need to verify their privacy settings before exchanging any information with one another.

Discordant standards and incompatible systems

Interoperability refers to the capacity of different IoT systems and devices to exchange data with one another. This data transfer operates independently of the operating system and hardware in use. The interoperability issue is a result of the wide variety of technologies and approaches used in IoT development. Organizational, technological, semantic, syntactic, and [47] are the four tiers of interoperability. Interoperability is a key component of the Internet of Things, and IoT systems include a number of capabilities to improve it. Furthermore, it is possible to integrate multiple IoT systems based on their functionality to provide IoT consumers with a wide range of options [8]. Although researchers recognized interoperability as a significant issue, they approved of a variety of approaches, sometimes known as interoperability management techniques [19]. Adapters, gateways, virtual networks, overlays, service-oriented architecture, and similar technologies could form the foundations of such solutions. Although interoperability management strategies lessen the load on IoT systems, there are still some interoperability challenges that could be the focus of future study [25].

Regulation, ethics, and the rule of law

IoT developers must also examine questions of ethics, regulation, and regulatory rights. There are laws and regulations in place to ensure that people adhere to these moral standards and prevent them from being broken. The only difference between ethics and law is that the latter relates to constraints created by the government, while the former refers to norms maintained by individuals. Nonetheless, the goals of ethics and regulations are similar: to maintain high quality standards and to prevent unauthorized use. The advancement of the Internet of Things has helped to resolve numerous practical challenges, but it has also raised serious ethical and legal concerns [20]. Usability of data, security of data, and protection of personal privacy are all examples of such issues. It has also been observed that most IoT

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users prefer government rules and laws on data security, privacy, and safety because they do not have faith in IoT devices. This issue needs to be considered in order to maintain and grow public trust in IoT systems and devices.

Capacity for growth, ease of use, and reliability

A system is considered scalable if its capabilities can be increased without any noticeable drop in efficiency. The core problem of IoT is supporting a vast number of devices with widely variable specifications for memory, processing, storage, and bandwidth [23]. Availability is another crucial aspect to think about. Scalability and availability must be achieved concurrently in the layered IoT architecture. As an excellent example of scalability, cloud-based IoT solutions enable the addition of new devices, data storage, and processing capacity to the existing IoT network as needed.

This geographically distributed IoT network has, however, prompted the creation of a unified IoT architecture that meets the needs of everyone [11]. Further complicating matters is the fact that people can't rely on the location or timing of their needs to affect the accessibility of resources for actual things. Dispersed, real-time connections between numerous tiny IoT networks allow access to the global IoT platforms' combined resources and services. And hence, ease of access is a major concern [22]. Inconsistent use of data transmission techniques, such as satellite communication, can cause disruptions in the provision of essential services and materials. A reliable and unaffiliated data transfer method is essential to ensure the continued availability of resources and services.

Service Quality (QoS)

Quality of service is another important aspect of the Internet of Things (QoS). Quality of Service (QoS) is a statistic for gauging the efficiency, usefulness, and effectiveness of an Internet of Things (IoT) system, architecture, or device [24]. Quality of Service requirements for IoT systems include reliability, cost, energy usage, security, availability, and service time [23]. A smarter Internet of Things setting is required to meet the QoS requirements. Dependability in the IoT relies on the upfront definition of Quality of Service metrics for each service and device. Users may also be able to provide detailed descriptions of their needs and preferences. White et al. [14] note that there is a compromise to be made between techniques and quality standards when evaluating QoS. Because of this, it is imperative to employ high-quality models in order to avoid making this concession. ISO/IEC25010 [15] and OASIS-WSQM [25] are two examples of high-quality models that can be used to investigate QoS evaluation techniques. These models supply an abundance of quality criteria for measuring the QoS of IoT services. In this article, we present a synthesis of the research literature on the most pressing issues and obstacles connected to the Internet of Things.

The Internet of Things' Primary Applications

Healthcare, ecology, and the new economy

The main purpose of the Internet of Things is to provide societal and individual benefits in the form of additional financial and public resources. This encompasses a wide range of public benefits, such as increased industrialization, better water quality management, robust economic expansion, and improved quality of life. Much progress is being made in the realm

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of IoT to advance the social, health, and economic goals of the United Nations. Environmental sustainability is another important consideration. The negative effects of IoT systems and devices on the environment can be reduced if developers keep this in mind [18]. The negative impact on the environment from the use of energy by IoT devices is a problem. Energy consumption is on the rise as a direct result of the proliferation of internet-enabled services and advanced technological innovations. Research is needed to create high-quality materials for use in the construction of new Internet of Things devices that consume less energy. Also, eco-friendly technology can be employed to create high-performance, long-term energy-saving devices. Both people and the planet benefit from it. Researchers and engineers are creating highly efficient IoT devices to track a wide range of health issues, such as diabetes, obesity, and depression [20]. Studies often account for several environmental, energy, and health issues.

Transportation, electric cars, and high-tech urban areas

The Internet of Things is transforming the traditional civic organization of society into a high-tech framework with the concept of a smart city, smart house, and smart automobiles and transit. Rapid progress is being achieved with the help of enabling technologies like machine learning and natural language processing in order to interpret the demand for the usage of technology in the home. For a smart city to function properly, it is necessary to combine Internet of Things (IoT) servers with other technologies, such as cloud computing and wireless sensor networks. The smart city's impact on the surrounding environment must also be taken into account. Hence, energy-saving and environmentally friendly technology must be considered throughout the planning and construction of smart city infrastructure. Newer cars are being equipped with high-tech features that may detect traffic congestion and direct the driver to a more direct path. This could help alleviate traffic problems in major cities. Developing and installing low-cost smart devices in all vehicles is essential for monitoring engine performance. The Internet of Things is also useful for maintaining vehicle health. Vehicles that drive themselves can communicate with one another via sophisticated sensors. If this were implemented, traffic would flow more smoothly than when cars were operated by humans and would constantly come to a halt. It will take time for this therapy to be widely used around the world. For now, Internet-of-Things gadgets could be helpful if they could anticipate traffic jams and take corrective measures. Incorporating Internet of Things (IoT) devices into mass-produced automobiles is a socially beneficial move for transportation manufacturers.

Industrial and agricultural automation

Experts estimate that by 2050, the global population would have risen to about 10 billion. Agriculture plays a crucial role in our society. If we are to successfully feed such a massive population, we will need to upgrade our farming practices. As a result, combining farming with modern technologies is essential for achieving sustainable yield increases. An option that could be pursued is the implementation of greenhouse technology. It provides a method for manipulating external factors to increase productivity. Nevertheless, when operated by humans, this technology wastes resources and slows down. In addition to mental effort and financial investment, physical labor is required. The Internet of Things has made it easier to

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control the chamber's temperature and humidity and keep tabs on production status, resulting in decreased energy consumption and more output. The automation of numerous industries is another another gain brought about by IoT. Logistics, supply chain management, inventory management, quality control, and the digitalization of industry have all benefited greatly from the innovations brought about by the Internet of Things.

The significance of big data analytics in the Internet of Things

Large numbers of sensors and other devices are linked together to form an IoT system. As the IoT network grows and develops, the number of sensors and devices connected to it increases at a rapid rate. These devices communicate with one another and transmit huge amounts of data via the web. Data like this is considered "big data" because of its sheer volume and constant flow. The exponential expansion of IoT-based networks presents formidable challenges in the areas of network management, data collection, storage, processing, and analytics. Monitoring oxygen levels, detecting smoke and harmful gases, and gauging lighting levels are just a few examples of the many problems that may be effectively tackled with the help of the IoT big data framework for smart buildings. A system like this would be able to collect data from sensors inside of buildings and apply data analytics to determine what actions should be taken. In addition, a cyber physical system built on the Internet of Things and equipped with information analysis and knowledge acquisition tools may improve manufacturing output. Yet, transportation congestion is a major issue in smart cities. An Internet of Things (IoT) based traffic management system might collect real-time traffic data from sensors and devices installed at traffic lights. Patients' IoT-connected devices generate reams of real-time data on their health conditions, which can then be analyzed by the medical community. Big data technology is ideal for this since it can collect and organize vast amounts of data into a single repository for rapid, precise analysis. Big data analytics and the Internet of Things may also help update antiquated production techniques. The data collected by the sensors might be analyzed with big data techniques and put to use in a variety of choices. Analytics and the cloud have the potential to enhance customer happiness while also reducing the cost of energy development and conservation. IoT devices generate a massive amount of streaming data, which must be efficiently stored and analyzed to enable real-time decision making. When dealing with such a large data set, deep learning can be an effective technique that has the potential to produce precise findings. A high-tech society cannot advance without the Internet of Things, big data analytics, and deep learning.

2. CONCLUSION

There is a developing network of physical items that can share data and communicate with one another thanks to built-in sensors, software, and connection; this network is known as the Internet of Things (IoT). The Internet of Things (IoT) has the potential to revolutionize numerous sectors by making existing processes more streamlined and opening up entirely new markets. Sensors, actuators, communication protocols, and cloud computing are only some of the IoT's many building blocks, and the numerous technologies and architectures employed in IoT systems have many potential uses. To maintain the safety and reliability of IoT systems, it is crucial to tackle the issues of security, privacy, and standardization as the

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IoT continues to expand. New innovations in the IoT are of interest to researchers and developers everywhere. Academics and IoT developers are working together to scale up the technology and increase its positive impact on society. But, improvements are possible only if we take into account the various issues and gaps in the current technical methods. In this roundup post, we spoke about some of the issues and challenges that IoT developers face while trying to improve the current model. There is also discussion of key areas of IoT application development and the research that is being done in those areas. So, the IoT generates not just services but also copious amounts of data. Hence, the need of big data analytics is also emphasized, as this might yield accurate judgements that could be used to improve the IoT system.

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