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A Study of the Architectures, Protocols, and Applications of the Internet of Things (IoT)

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ABSTRACT: The Internet of Things (IoT) is a new technology that uses billions of embedded sensors from many suppliers to continually detect data based on context and transmit that data to a central database through the internet. The necessary context is provided by data analytics. This leads to a pleasant existence with little to no human interference. Understanding the basic components necessary to develop IoT and also the combination of various communication technologies is the most significant aspect of IoT. This study presents a comprehensive overview of the most recent advancements in this exciting new field, including the most cutting-edge methodologies, protocols, and applications. This study suggests a new classification scheme for Internet of Things (IoT) technologies and provides examples of some of the most significant IoT technologies, and characteristics of some applications that could significantly improve the quality of life, particularly for the elderly and people with disabilities. This study is also far broader in scope, including a variety of different technologies, from sensors to software.

KEYWORDS: Internet of Things (IoT), IoT Architectures, Sensors, Smart cities.

1. INTRODUCTION

The Internet of Things (IoT) refers to a network of devices, both fixed and mobile, that are connected and a central database via wired or wireless networks like Bluetooth, Wireless Fidelity (WI-Fi), 3G, and 4G. The advent of cheap sensors, better technology, cheaper storage, and powerful analytic tools have all contributed to IoT's recent surge in popularity. By the year 2020, the Cisco Internet Business Solutions Group (IBSG) predicts that there will be 7.6 billion people on the planet and roughly 50 billion devices linked to the internet [1].

The term "Internet of Things" is used to describe the concept of everyday objects that can be read, recognized, located, addressed via an information sensing device, and controlled over the Internet. This is true regardless of the communication method employed (Radio-Frequency Identification (RFID), wireless LAN, wide area networks, etc.). Things that we encounter daily include not only the electronic devices we encounter or the products of higher technological development such as vehicles and equipment, but also food, clothing, chairs, animals, trees, water, and other things that we do not typically think of as electronic at all.

Despite the immense potential of a smart gadget equipped with smart materials, sensors, and an online connection, today's most popular Internet of Things apps provide surprisingly simple user interfaces. Human-technology interaction is mostly centered on graphical mobile or web interfaces, and in some instances integrated interaction devices like touch screen panels, when

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considering the most successful real IoT applications. Typical "smart house" equipment includes things like thermostats, ovens, and light fixtures. Due to the widespread belief that IoT devices can function independently of human intervention, most of the controls are designed for one-time configuration or setup purposes alone [2].

Visualize a world where billions of things are linked over IP networks, allowing them to perceive, communicate, and exchange data with one another. With the constant collection, analysis, and instigation of data from these networked things, a plethora of insight is made available for the plan, administration, and decision-making [3]. Instruments for influencing one's surroundings, sensors, and actuators are crucial in shaping one's experience of the world around them. Useful conclusions can only be drawn from the sensor data after it has been securely stored and analyzed. Keep in mind that we use a very wide definition of the word "sensor," considering everything that offers inputs about its present state (internal state + surroundings) to be a sensor. The thermostat on your air conditioner is an example of an actuator since it causes a change in the surrounding environment.

2. DISCUSSION

Data may be stored and processed locally, at the network's edge, or off-site on a server. Data preprocessing, if practicable, is often performed at the sensor or a nearby device. After the data has been processed, it is often sent to an off-site server. Because of size, energy, power, and computing capacity constraints, the processing and storage capacities of an IoT item are frequently severely limited. Therefore, obtaining the proper type of data with the required degree of precision is the primary issue of research. Challenges in communication exist alongside those in data collecting and management. Because IoT devices are often deployed in distant areas, wireless technology is used for the majority of their inter-device communication. High levels of distortion and unreliability in wireless channels are commonplace. Communication technologies are fundamental to the study of IoT devices because they solve the crucial challenge of successfully transmitting data without excessive retransmissions in this situation [4].

2.1.IoT Architecture:

There is not one design for the internet of things that are widely accepted as the consensus. Researchers have come up with a wide variety of innovative architectural concepts.

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Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 6, June 2022

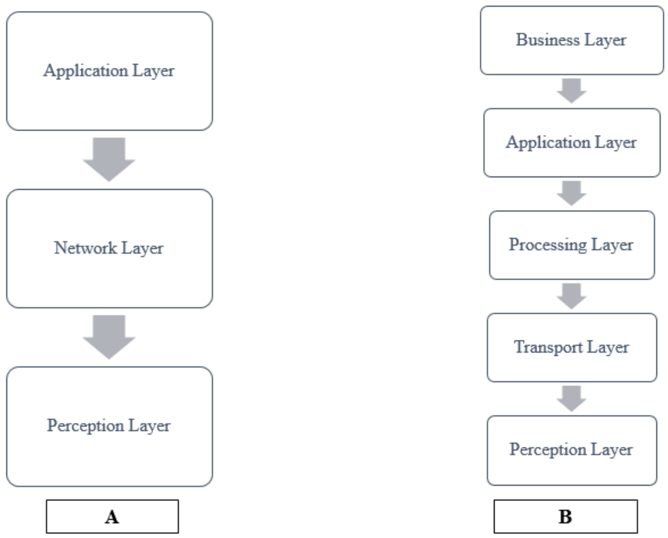

Figure 1: Displays the Internet of Things Architecture (A: Three Layers) (B: five layers).

2.1.1. Architectures of three and five layers:

A three-layer design, like the one represented in Figure 1, is the most fundamental kind of architecture. It was first used back when the study into this field was in its infancy. It is composed of three layers: the perception layer, the network layer, and also the application layer [5].

- The physical layer known as the perception layer is the one that contains the sensors used for perceiving and acquiring data about the surrounding environment. It can either detect certain physical qualities or locate other intelligent items in its surrounding surroundings.
- Communicating with other smart objects, network equipment, and servers falls within the purview of the network layer. In addition to that, its characteristics are used in the transmission and processing of sensor data.
- The application layer is in charge of providing user-facing application-specific services and is accountable for doing so. It outlines a variety of applications that may be carried out with the help of the Internet of Things, including "smart homes," "smart cities," and "smart health".

Although the three-layer design explains the Internet of Things in its entirety, it is not adequate for research on IoT, which often concentrates on the finer details of the Internet of Things. Because of this, there have been several proposals for multilayered structures in the scientific literature. The five-layer design incorporates an extra data-access layer in addition to the presentation, transport, application, and business levels. In this model, there are five distinct levels: perception, transportation, processing, application, and business see Figure 1. The perception and application levels provide the same purpose as in a three-layer design. What the other three levels are for is explained in detail.

ISSN PRINT 2319 1775 Online 2320 7876

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- Through mediums including Wireless Fidelity (Wi-Fi), 3G, Local area network (LAN), Bluetooth, Radio-Frequency Identification (RFID), and Near-field communication (NFC), sensor data travels from the perception layer to the processing layer and back again.

- Processing may also be referred to as the middleware layer in other contexts. Massive volumes of data that are received from the transport layer are saved, analyzed, and processed by this layer. It can control the lower levels and deliver a wide variety of services to those layers. It makes use of a wide range of technologies, including database management systems, cloud computing, as well as big data processing modules.

- Everything in the Internet of Things, from apps to business and profit models to user privacy, is controlled by the business layer. This study does not cover the business layer. For this reason, the author refrains from expanding on the issue.

Ning and Wang [6] offer an alternate design that takes its cues from the brain's decomposable functional modules. It was motivated by the capacity of humans to reason, feel, remember, make choices, and respond to their physical surroundings. There are three constituent elements. One example is the brain, which may be compared to a computer server farm or a large storage facility. The second structure is the spinal cord, which represents a smart gateway or centralized data processing node. The third component is the system of nerves, which represents the detectors and other networking parts.

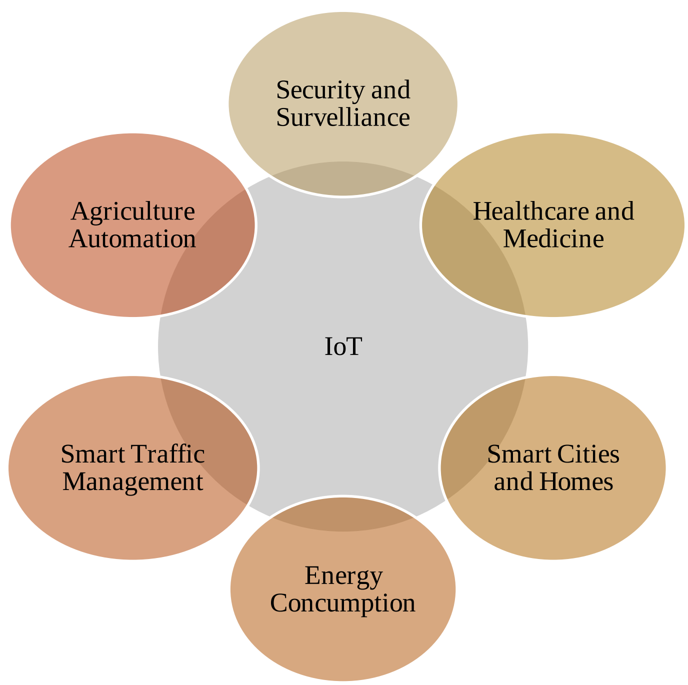

Figure 2: Some of the Possible Application Areas for the Internet of Things (IoT).

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 scholars have offered a variety of explanations of the IoT, each catering to their particular areas of interest and concerns. There are many different application fields where one may observe the potential and power of the Internet of Things. Figure 2 depicts a selection of the many possible applications for the Internet of Things.

A study on the Internet of Things (IoT) solutions for smart energy regulation was conducted by Khajenasiri et al. for the advantage of smart city application development. They added that at this time, IoT has only been used in a very small number of different application domains to serve both the people and also the technology. The Internet of Things has a very broad reach, and it has the potential to include almost all application domains shortly. They claimed that conserving energy is one of the vital parts of society, and they also mentioned that IoT may help in the development of a smart energy management system that would conserve both money and energy. They presented an architecture for the Internet of Things concerning the notion of smart cities. The authors also mentioned the immaturity of IoT hardware and software as another one of the arduous tasks that must be accomplished to achieve this goal. They hypothesized that these problems needed to be addressed to make the IoT system dependable, effective, and user-pleasant [7].

2.2.IoT's major difficulties and challenges:

Due to the pervasiveness of IoT-based systems and the heterogeneity of the technologies required to facilitate data flow amongst embedded devices, several complications have arisen. When applied to the Internet of Things developers in today's high-tech, data-driven culture, these problems become much more complex. Challenges and the demand for sophisticated IoT systems are increasing in tandem with the development of new technologies. In light of this, it is incumbent upon IoT developers to anticipate future problems and provide workarounds.

2.2.1. Security and privacy concerns:

Several dangers, cyber assaults, hazards, and vulnerabilities make security and privacy one of the most critical and complex challenges in the Internet of Things. Inadequate authorization and identification, vulnerable programming, firmware, web interface, or inadequate transport layer encryption are also the root causes of privacy concerns at the device layer[8]. Not all IoT use cases call for the same approaches to ensuring secure IoT device-to-device connectivity. Additionally, the security of an IoT system is compromised if it relies on wireless technology for internal communication. As a result, it's important to put in place mechanisms for spotting attacks and for performing repairs or recoveries automatically. However, privacy is another major issue that has to be addressed so that people may adopt IoT solutions with confidence. As a result, trustworthy communication between parties requires the maintenance of authorization and authentication through a private network. Another challenge is the varying privacy rules for different items interacting inside the IoT system. For this reason, before sharing information, every IoT device should first check the security and privacy settings of all other devices in the network [9].

2.2.2. Interoperability And Standardization Concerns:

To be interoperable means that data from various IoT devices and systems may be shared. This data sharing is independent of the currently running applications and infrastructure. The disparate nature of the technologies and approaches used in IoT creation gives rise to the problem of incompatibility. Technical, semantic, syntactic, and organizational interoperability are the four

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 UGC CARE Listed (Group -I) Journal Volume 11, Iss 6, June 2022

tiers of compatibility. IoT systems are providing some features to enhance interoperability, which is essential for ensuring that disparate items can communicate with one another in a variety of settings. In addition, multiple solutions may be made available to users of the IoT by combining different IoT platforms depending on their capabilities [10].

2.2.3. Values, Rules, And Legal Protections:

Concerns about legality, privacy, and ethics are a further challenge for IoT creators. There are laws in place to keep individuals from going against the grain of society's accepted norms and morals. The only real distinction between ethics and law is that the latter refers to societal norms while the former refers to governmental prohibitions. However, the goals of ethics and law are the same: to keep things as they should be and to prevent individuals from abusing them. Though the Internet of Things (IoT) has enabled the solution of many practical problems, it has also given rise to serious ethical and legal issues [11].

2.3.Application of Internet of things (IoT):

2.3.1. Emerging economies, the environment, and healthcare services:

The Internet of Things is an initiative solely focused on delivering forthcoming public and monetary advantages and progress to society and its citizens. This encompasses a vast array of public amenities, such as those geared toward economic growth, water quality upkeep, well-being, industrialization, and so on. As a whole, IoT is actively contributing to the realization of the United Nations' development objectives in the areas of social welfare, health, and the economy. The preservation of the natural environment is also a major issue. To mitigate the potentially disastrous effects of the Internet of Things (IoT) systems and devices on the environment, developers of these systems and devices must give serious consideration to this issue.

2.3.2. Smart cities, transportation, and automobiles:

With the idea of a "smart city," "smart house," and "smart cars and transit," the Internet of Things is converting the conventional civic organization of society into a high-tech framework. Helping technologies like machine learning and natural language processing are being rapidly implemented to better comprehend the need and usage of technology in the home, allowing for rapid development. Vehicle health monitoring is another area where IoT shines. Through the use of sophisticated sensors, autonomous vehicles may be able to exchange data with one another. As a result, the flow of traffic would be more continuous than when automobiles were driven by humans. Adopting this practice on a global scale will take some time. Up until then, IoT gadgets may assist by foreseeing traffic jams and taking corrective measures. As a result, a transportation manufacturer needs to include Internet of Things (IoT) devices in their products [12].

2.3.3. Automation In Agriculture and Industry:

The world's population is expected to exceed 10 billion people by 2050. Agriculture is very vital in our life. To feed such a large population, we must improve present agricultural practices. As a result, there is a need to integrate agriculture and technology to boost output effectively. One viable method in this way is greenhouse technology. It enables the adjustment of environmental conditions to enhance output. Human control of this technology, on the other hand, is less effective, necessitates manual efforts and costs, and results in energy waste and decreased output [13]. Smart gadgets and sensors made it easy to adjust the environment within the chamber and monitor the operation, resulting in energy savings and enhanced productivity. Another benefit of IoT is the automation of industries. IoT has revolutionized industrial digitization, inventory control, quality assurance, logistics, and optimization of supply chains and management [14].

3. CONCLUSION

Recent innovations in IoT have piqued the interest of scientists and programmers all around the globe. Researchers and developers of the Internet of Things are collaborating to maximize the technology's societal benefits and its potential for widespread deployment. To make progress, however, researchers must first take into account the many problems and limitations of the current technological method. The development of this area is only beginning. There is is no limit to what may be accomplished with the advent of the Internet of Things. The degree of interoperability and integration, as well as the attention paid to issues of safety, will rely greatly on the programmatic directions taken by manufacturers on the worldwide market to ensure maximum compatibility across all linked devices. These are indications of technological maturity in the foundational levels of the system. Still, more development is required in the fields of communication technology and Internet of Things applications. Over the next decade, these areas will develop and have unfathomable consequences for people's daily lives.

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