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# INFLUENCES OF CLOUD AND WEB TECHNOLOGY ON IOT COMMUNICATION FOR EMBEDDED SYSTEMS

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**Abstract**

The Internet of Things (IoT) is the most common research subject. IoT is concerned with the creation of smart devices that assist people in performing a variety of tasks. Embedded systems are used to build smart devices. Embedded systems are miniature computers that allow sensor devices to collaborate to build an electronic system. In this paper, IoT in embedded systems in the various area are reviewed. Some of the major IoT technology and protocol (IoT Communication Protocols) are Bluetooth, Wifi, Radio Protocols, LTE-A, and WiFi-Direct. These IoT communication protocols cater to and meet the specific functional requirement of an IoT system. Opting for the wrong IoT communication technology will drain your connected devices of power, cause delays in data transfer, open security loopholes, and render the whole setup a failure. According to IoT Analytics, a market research company, there were 11.7 billion IoT connections in 2020 globally, and this number could swell to over 30 billion by 2025. As the Internet of Things adoption continues to grow, it's important to carefully consider how to connect cyber-physical systems in an optimal way and avoid signal interference. There are many IoT communication protocols out there, and it can be overwhelming to sift through their specifications and determine which technology is right for your application. This article clarifies the basic terminology around IoT connectivity and introduces the most popular IoT protocols. After reading it, you will have the knowledge you need to discuss your project with IoT software development service providers and select the protocol that will help you get the most out of your Internet of Things product.

**Keywords:** IoT, sensors, embedded system, smart devices, Cloud, Technology, IoT Communication

## 1. INTRODUCTION

The Internet of Things (IoT) is a network of interconnected computing devices, mechanical and digital machinery, things, animals, and people with unique identifiers and the ability to move data without human or computer contact [1, 2]. Many recent advances in the IoT have

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been concluded, and it involves many aspects such as wireless sensors, embedded computers, and microcontrollers that power the system, according to the assessment of time. Currently, the IoT is present in almost every sector and plays a significant role in almost every operation. Health, home automation, building structure management, transportation networks, and infrastructure management are all examples of where this is used [3]. Embedded IoT systems are used to transmit and receive data from one network to another. It is based on microcontrollers and applications that program them. It is focused on microcontrollers and software that program in response to commands. These embedded systems run on an Android or Linux operating system [4]. Embedded systems refer to the connection of electronic devices to computer-like systems to make it easier to perform specific tasks with electronic devices [5]. The goal of this study is to demonstrate the development and deployment of the Internet of Things in embedded systems across a variety of application domains.

## 2. GENERAL BACKGROUND THEORY

Over the course of the last several years, a considerable amount of time, effort, and financial resources have been allotted to, and spent on, research and development projects linked to the Internet of Things (IoT). This has been the case for an extensive period of time and may be attributed to a broad variety of historical events and conditions (IoT) [6]. The term "Internet of Things" refers to a world in which a large range of electronic gadgets of varied sizes are connected to one another and communicate with one another (IoT). This is a concept that outlines a world that will exist in the foreseeable future. These electronic devices are available in a wide range of configurations, but they may generally be categorized as follows: personal computers, laptops, cellphones, personal digital assistants (PDAs), tablets, and other electronic devices. Having said that, this list is not exhaustive [7]. In addition, these devices are able to link with one another and convey important information to the system that is centrally located. In addition to this, the wireless technology is used in the operation of these networks. Without the use of sensors, they would not have been able to accomplish their goal. In addition to this, the information gathered from the vast number of devices that are connected to the Internet of Things and stored inside the centralized system is being processed, evaluated, and sent in one form or another. The exponential growth of communication and Internet technology has led to a shift in the focus of our day-to-day activities away from the real world and toward a world that is more fictitious [8]. As a direct consequence of this transformation, the emphasis of our day-to-day activities has shifted away from the actual world and into a world that is more imagined. This change has occurred as a direct result of. This change is a direct result of the transformation that has taken place. As a direct consequence of this transformation, the focus of our day-to-day activities has switched from the real world to a world that is more imaginary in nature [9]. One of the primary objectives of the Internet of Things is the creation of a self-sufficient and intelligent environment, in addition to the fabrication of devices that are capable of both self-awareness and self-sufficiency (IoT) [10]. In addition to this, the number of different types of devices that are capable of being linked to the internet is constantly growing. In addition to this, the number of tangible devices that are connected to the internet is consistently growing at a rapid rate [11]. In addition to the qualities that it currently has, the

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purpose of this mission is to strive toward the achievement of this aim. Sadly, the most majority of these gadgets and applications are not constructed to withstand assaults on the users' privacy and the security of their personal information. This is a huge flaw in their design. The design of these devices has a serious defect that causes this issue. The problem exists at the most basic level that can be conceived of. As a direct consequence of the aforementioned fact, a sizeable number of people are worried about the degree of privacy and security offered by IoT networks [12]. The reason for this may be found in the internet of things. The outcomes of this investigation indicated that the proportion was 70%. [Citation needed] Because seventy percent of anything that is connected to the internet can be hacked with relatively little effort, it is even more important that these conditions be satisfied. An in-depth investigation of the past that led to the creation of fog computing has been carried out [13].

We say that the configuration of a system has "scattered components" when the various components of the system are stored on a number of different computers, and each of those computers is linked to the other components of the system through a network. In other words, the various components of the system are scattered across multiple computers. One possible interpretation of the term "dispersed" in reference to the setup of a system may be seen in this example [14]. They are able to link up with one another and have conversations with one another. They are able to do this by passing messages from the internal workings of their respective systems to those of one another. It may be necessary for the different computer systems to interact with one another in order to accomplish this goal by exchanging messages with one another [15]. Maintaining the concurrency of the system's components, compensating for the absence of a centralized clock, and handling the failure of certain system components on an individual basis are three of the most significant challenges that distributed systems face. Distributed systems face a number of challenges, the most significant of which include maintaining the concurrency of the system's components. Other difficulties might also arise while dealing with distributed system architectures [16]. This is the case in a few specific scenarios. This event might have been brought about by a variety of distinct factors, any one of which could have been responsible for its occurrence. This is not always the case, but it does happen on occasion. In other words, it is not always the case. Peer-to-peer applications, massively multiplayer online games, and SOA-based systems are some examples of the kinds of things that may be found in distributed systems (MMOGs) [17]. These options may be used to establish the system. On their various websites, you'll find information on how to access these alternatives. Message queues, connections that are analogous to RPC, and plain old HTTP are a few examples of the kinds of implementations that are believed to fall under this category, which is widely seen to include a fairly wide variety of such implementations [18]. When a problem is solved using distributed computing, it is first broken down into a number of distinct tasks, and then each of these jobs is given to either one computer or numerous computers to be carried out. This process continues until the issue has been solved [19]. When one is speaking about "computers" in everyday conversation, one may either refer to these nodes or to actual computers. Both options are available. Both of these are instances of what are often referred to as "computers." The animals are able to vocally speak with one another and understand what is being said to them if they want to do so. If they do not choose to do so, however, they are

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unable to understand verbal communication. Both the humans and the animals are able to converse with one another using their voices [20]. One possible interpretation of the term "dispersed" in reference to the setup of a system may be seen in this example. The configuration that we provide to a system that contains components that are distributed across the system is called having dispersed components [21]. Distributed computing is one of the subfields that may be researched within the wider subject of computer science. It is called one of the subfields that can be examined because it is one of the subfields that can be investigated [22]. It is not always the case that the failure of just one part of a system would result in the destruction of the system as a whole. In some cases, this is the case, but not always. This is the case in a few specific scenarios. This event might have been brought about by a variety of distinct factors, any one of which could have been responsible for its occurrence. This is not always the case, but it does happen on occasion [23]. Another requirement for a program to be considered distributed is that it must have the name distributed program. We refer to the kinds of computer programs that are written in such a way that they are able to fulfill the tasks for which they were designed while also complying with the constraints that are imposed by a distributed system as distributed programs. When computer programs are written in this manner, we call the kinds of programs that are written in this manner distributed programs [24]. This is another meaning of the term "distributed computing." One further interpretation of the term "distributed computing" is as follows: This objective may be accomplished in a number of ways, one of which is through making use of the phrase "distributed computing." The term "distributed computing" may be construed in a number of different ways, including the one that is shown in the following example: This clarification explains how the concept of distributed computing may be included into a procedure by offering an example of how it may be carried out, which emphasizes how the thought can be incorporated [25]. It is possible for these devices to communicate with one another via the exchange of messages with one another, which may occur between them in a form similar to a back and forth conversation. Because of this, the two separate pieces of technology are now able to interact with one another in whatever way that any one of them decides is appropriate for the situation [26]. There are other references made to these nodes and computers in a few different settings. This memory is unavailable to any processing units other than the one that is now under investigation. When talking about the collection of computers and nodes as a whole, people often use the phrase "system" as a collective noun to describe it. The word "server" is often used in the world of computing as a slang term for machines of this kind [27].

The efficiency of cloud computing has an immediate impact on the amount of shared resources that are made accessible to users of the service, which in turn raises the cloud's overall value. Cloud computing may be thought of as a virtuous cycle. This is by far the most significant contributor to the development of such a robust correlation between the two variables that are the focus of the present analysis [28]. In addition to this, it frequently makes use of a method that is known as the "pay as you go" approach, which may help in decreasing the initial rates but may also lead to customers being subjected to expenses that they had not expected in the long term. This is because the "pay as you go" approach is a method that allows customers to pay for services as they use them [29]. The notion that users should be able to make use of the

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advantages made accessible by a broad range of various technologies is at the core of the "computing in the cloud" concept, which is based on the premise that users should be able to take use of "cloud computing." The concept of cloud computing is based on the idea that end users should be able to take use of the benefits provided by a wide variety of different technologies. The concept of computing on the cloud is based on this basic principle [30]. As a consequence of this, the latter may be used to focus on strategic company objectives rather than on the resolution of technical challenges. One further advantage of using cloud computing is the reduction in costs that are connected with running a business [31]. This may be a significant savings for small and medium-sized businesses. Amazon Web Services (AWS) and Microsoft Azure, two of the first pioneers in the field of cloud computing, were the firms that originally pioneered cloud computing. Amazon Web Services (AWS) was the first company to provide cloud computing services (MS Azure). Virtualization is, by a significant margin, and by an enormous margin, the single most essential piece of technology that is related with cloud computing. Virtualization may be thought of as the backbone of the cloud computing model [32]. The fact that achieving this objective is not impossible to undertake thanks to the fact that doing so is not unrealistic. As a result of this, it is possible to make use of computer resources that could not have been exploited in any other way. This is made possible by using resources in a manner that is more effective despite the fact that, in other scenarios, they would be thrown away as waste. If all goes according to plan, the end result will be the building of a scalable system that is comprised of a number of different computing units [33]. If autonomous computing is utilized, then the process by which the user is able to give resources on demand may be mechanized into an automated process; this will make it feasible for the activity to be mechanized. If autonomous computing is used, then the activity may be mechanized. The pace at which a process may be finished improves when it is automated, the quantity of physical labor that is necessary to finish it lowers, and the chance of individuals making errors diminishes since they are required to engage in the process less frequently after it has been automated [34]. Cloud computing was developed in an effort to find a solution to these problems. Computing in the cloud was established as an attempt to find a solution to the problems that were being faced. The idea of computing on the cloud was conceived as part of an attempt to find a solution to these problems. Computing in the cloud was conceived of as a method for resolving issues in order to facilitate the process of finding solutions to the difficulties that were being experienced [35]. As part of an effort to identify and execute a solution to the problems that have come to light in recent times, the concept of doing computer operations over the "cloud" of the internet was created as part of that effort. In spite of the fact that they are not identical in any regard [36]. The term "grid computing" refers to a type of distributed and parallel computing in which the resources of a group of networked computers that are only loosely tied to one another in order to finish extremely large tasks are referred to. Grid computing is a type of distributed and parallel computing. Grid computing is a type of distributed and parallel computing. Computing on a grid is a kind of the distributed and parallel computing known as grid computing [37]. Computing on a grid is a kind of the distributed and parallel computing known as grid computing. The term "grid computing" refers to a kind of distributed and parallel computing that involves working with data on a grid. A reference to this idea may be seen in the term "grid computing." "Computing on a grid" refers to the practice

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of doing data processing on a computer by using a technique that mixes distributed computing with parallel processing [38].

Because of the Internet of Things, businesses who are involved in the manufacturing industry now have the capacity to create massive applications and infrastructure. A person who is in possession of a current license as well as an intelligent transportation system is able to monitor, in real time, the existence of automobiles as well as their movements within an intelligent transportation system that is connected to other nodes [39]. Other examples include the Internet of Things (IoT), which refers to the network of interconnected computing devices that will connect to each other over the Internet (GPS). In addition to that, the expression has been connected to a vast assortment of various sorts of one-of-a-kind things (GPS) [40]. The use of this information makes the achievement of this aim possible. Using the personally identifiable information that is obtained via the use of a mechanical process, this may become a reality provided the appropriate steps are taken. This is made possible with the help of the vital information as well as the personal data that is gathered via the use of an automated approach [41].

An estimate that is based on trends that are currently taking place all over the world predicts that the total value of the market for products of this kind will reach 17 billion dollars by the year 2019, which is the most recent year for which data is currently available. This prediction is based on the fact that data is currently available for the most recent year. After much consideration, it was decided that this projection would be developed. A wireless interface is used so that communication may be facilitated between the various devices and the base station. Because of this, the devices are able to communicate with the station in both ways, transmitting and receiving data [42]. In the context of medical care, the primary goal is to protect the integrity of the network in order to prevent dishonest parties from infringing upon the patients' constitutionally protected right to privacy. This right to privacy protects patients from having their medical information disclosed to third parties without their consent [43]. It is possible to achieve this goal by restricting access to the medical records of the patients by dishonest parties. This constitutionally mandated right to personal secrecy is protected under the Health Insurance Portability and Accountability Act (HIPAA). This is done to ensure that the patients' health will not be negatively affected in any way by the treatments that are being carried out, and it is done so as a precautionary measure [44].

Equipment essential for conducting preventative maintenance, which is required for every activity that requires the use of a battery and should be performed at regular intervals. The performance of maintenance of this sort is obligatory. When a sufficient number of networks are connected to the piece of equipment, there is a strong possibility that the availability, confidentiality, privacy, and safety of the piece of equipment might be compromised [45]. Portable electronic devices that are capable of being used with wireless networks do not come pre-configured with an authentication method when they are bought separately. This is because the default setup of these devices does not include an authentication mechanism. This is the case regardless of whether or not the devices themselves are able to function properly when connected to wireless networks. This is because the device does not need authentication in

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order for it to be utilized with wireless networks, which explains why this is the case[46]. Because the patient's right to privacy has been violated, the information about the patient is transmitted over a communication channel that leaves it open to the possibility that it will be changed by third parties who are not authorized to do so. Additionally, this places the information at risk of being misinterpreted by individuals who are not authorized to do so [47].

IoT Because to Internet Protocol (IP) addresses, a broad range of digital devices are now able to connect with one another in a way that is both efficient with regard to time and resources and also very adaptable. The Internet of Things is the driving force behind the realization of this vision. The advent of the Internet of Things has made it far more likely that this objective will be accomplished. As a direct result of this tendency, the demand for services that can be classed as "solutions for smart homes" has been gradually expanding, and it has been doing so for some time now [48]. The likelihood of this happening is significantly higher if the smart house is not maintained in an autonomous way. This is due to the fact that there is a lower likelihood that hostile actors would choose the home as their planned target for an assault. This is because there are fewer antagonistic actors in the picture now than there were before [49]. To the right of this sentence is a diagram that illustrates an example of the four key components that are accountable for the development of a smart home. These components are the internet, a computer, a mobile device, and an entertainment system. You may see this picture by clicking on this link. This statement will be followed by a graphic that will be positioned below this text, and it will show the four main components [50]. This piece of hardware acts as a go-between for the many exchanges that take place between the connected smart devices in your home and the wider internet. These connections are mediated by this piece of hardware, which acts as a go-between for these exchanges. This piece of hardware functions as a go-between for the various exchanges that take place between the connected smart gadgets in your house and the broader internet [51].

There is also the chance that legitimacy has been manufactured, which falls under this category as well. When it comes to the Internet of Things, there are specific security criteria that need to be achieved in order to protect the network from attacks that are carried out by hostile actors [52]. Specifically, these standards are designed to prevent unauthorized access to the network. It is very necessary for certain standards to be followed in order to ensure that the network will continue to function properly. These standards are meant to act as a barrier for users who are not allowed to access the network, hence preventing such users from gaining access to the network. The goal of this endeavor is to prevent unauthorized users from accessing the network [53]. In other words, the system should be able to withstand any potential issues. In other words, any effort to break into the server or listen in on it should be fruitless in the case that there is a problem with the server. In this specific circumstance, it will be lifted back up again, but the customers will not be informed that it was previously in a situation where it was lowered. However, it will be brought back up to its original level. Despite this, it will be discussed once again in the future. In the event that it does fall, they will be alerted that it has been raised back up to its original position [54]. There is a good chance that this same method of verification is still used in the present day. To be more specific, this authentication mechanism will be used for the whole of the procedure. Access control: the parts of the security system that restrict

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access are off-limits to anybody who does not have the explicit authority to use them [55]. The administrator is the one who is liable for carrying out this task as it has been allocated to him or her by the supervisor. Because of this, access to the database or program is limited for each individual user to only those features of the resource that are relevant to the unique requirements they have. This may be either a database or a software. This guarantees that each user has an experience that meets their expectations [56]. This is done to ensure that unauthorized parties are unable to get access to sensitive material and utilize it to further their own agendas. This may be achieved by always handling their data and information with the greatest discretion and ensuring that it is safeguarded from access by unauthorized parties [57]. The proliferation of the Internet of Things (IoT), which has resulted in a significant increase in the number of devices that are connected to the internet, has caused people's day-to-day activities to be forced to adapt to a number of previously unanticipated realities. This has caused people to be forced to adapt their day-to-day activities to a number of previously unanticipated realities [58]. In addition to this, one may be led to believe, as a consequence of this, that there is an inherent right to protect the personal information of users. This is because of the previous point. The facts may also lead one to the conclusion that there are a substantial number of possible vulnerabilities in the defenses, which is another conclusion that may be drawn. In addition to this, one is able to get the conclusion that there is a sizeable population of people who are concerned about this problem. This is a possibility [59]. By utilizing a network coverage that is comprehensive, it is possible to ensure that the data will not be altered in any way, beginning with the very first step of the process and continuing all the way through to the very last step of the process [60].

The conditions that are currently taking place include: A great number of electronic gadgets call this place their home. The following is a collection of situations that serve as examples of the many sorts of weather that may be seen in this region: Throughout the course of human history, this region has served as the fertile ground for the creation of a vast range of technical accomplishments of a wide variety of different kinds [61]. In order to protect an individual's physical safety in addition to their privacy, it is of the utmost need to come to a consensus on a set of guiding principles that can be mechanically implemented in the environment. This is a requirement of the highest order. This is one of the most essential tasks that has to be completed immediately. As a consequence of carrying out these steps, it will be possible to accomplish both of these goals [62]. The Confidentiality of the Data and the Protection of Individual Privacy Some companies that make smart TVs collect information about their customers in order to conduct research on the types of movies and television shows that those customers prefer to watch on their various electronic devices. This research can then be used to improve the products that those companies offer to their customers [63]. The absence of a standard that has been created and is recognized on a global basis as an industry standard because different manufacturers of Internet of Things devices adhere to a variety of different standards for their products, it may be quite difficult to differentiate between legal and unauthorized devices that are connected to the internet. This is because of the interconnected nature of the Internet of Things [64]. Security of the System: In order to determine a number of different security challenges, build a variety of different security frameworks, and provide adequate security

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suggestions for the purpose of achieving the goal of preserving network security, system security places a significant amount of emphasis on the Internet of Things (IoT) system [65].

## 3. EMBEDDED SYSTEM

An embedded system is a controller that carries out a particular function inside a larger mechanical or electrical system, often while adhering to time-sensitive computing limitations. Embedded systems are also known as on-board or in-system controllers. "Black boxes" is a term that's often used to refer to embedded systems. The vast majority of the time, it is either a mechanical part of a larger piece of hardware or a component of a larger device that it is attached to. In the modern world that we live in today, the use of embedded systems is often necessary for the proper operation of a broad range of pervasive electronic gadgets. [1, 66]. A broad range of settings may house an embedded system. Embedded systems are ubiquitous. The level of complexity is often considered to be modest when just a single microcontroller chip is used; nevertheless, it has the potential to reach an extremely high level when several modules, peripherals, and networks are employed inside of a large equipment rack [67, 68].


**Figure 1: An integrated device with a processor, memory, and external interfaces on a plug-in card [1]**

### 3.1. Embedded Systems Categorization

An embedded device can be thought of as a miniature computer with specific functions that are used in a real-time environment. The embedded device consists of several components [5], including: Processor: every embedded system's main component is the processor. It's often referred to as an IC microcontroller. In an embedded system, the IC is in charge of performing all of the tasks needed for the system to function.

### 3.2. Types of Embedded Systems

Embedded systems are classified into two classes, as seen below.

a. **Standalone Embedded Systems:** Stand-alone systems are those in which users simply provide an input and the device generates the desired output. These devices are now referred to as "systems on chips" and are considered intellectual property. SOCs include multimedia processors or digital signal processors (DSPs) for applications that need high performance

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and embedded functionality. Electronic customers are used in some stand-alone systems. CE is classified into three kinds: low-end devices, which are typically low-cost processors, and System on Chip devices, which have the smallest amount of memory, such as ROM (256 KB). Mid-range devices, such as digital cameras, have a memory of around 1 to 2 MB. It includes high-end consumer devices with memory up to 32 MB, such as smartphones [68].

b. **Networked Embedded Systems:** Network embedded system technology (NEST), network systems for embedded computers (EmNETS), and distributed real-time embedded systems are all examples of NESs (DRE). Wireless/wired communication is used to connect functionally distributed devices that can be embedded. Via the use of actuators and sensing instruments, it achieves the task of interacting with the environment [68].

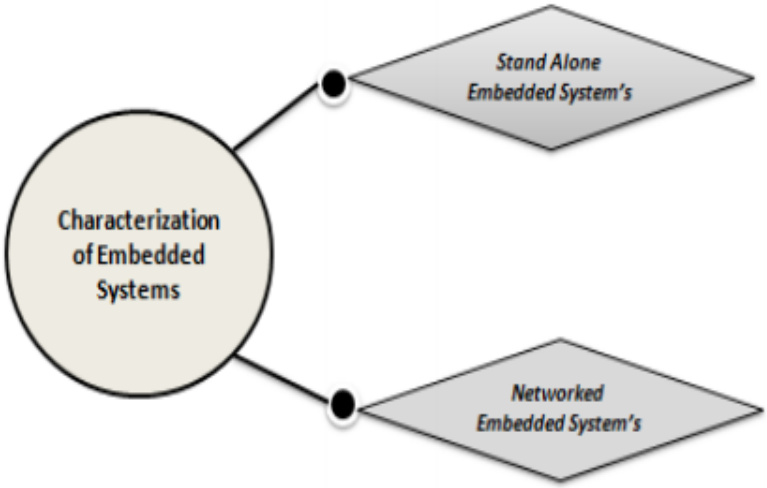


**Figure 2: Types of Embedded Systems [68]**

### 3.3. Hardware embedded system

There are several hardware embedded systems available for developers, but the Raspberry Pi and Arduino are the most common.

a. **Arduino:** Arduino is an open-source hardware platform that can be used to create customized electronic devices. Arduino is a chip made up of various components that can be used to create a variety of electronic systems, ranging from simple LED blinking to massive IoT-based smart systems that can be used to create smart homes and offices. Every part of an Arduino can perform a variety of functions, and we can connect a variety of sensors to it to expand the system's functionality. On behalf of digital signals, Arduino produces electronic devices. It accomplishes the task by writing code in the C and C++ programming languages. The coding is done with the Arduino IDE, which is the most commonly used. We may also use other IDEs that suit our needs. The Arduino chip is made up of a variety of parts. The "Arduino UNO" is the most commonly used Arduino [5].

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**Figure 3: Arduino UNO Structure [5]**

**b. RasberryPi:** the RasberryPi is a computer that can do any job that a computer can do. The key difference between a RasberryPi and a computer is that it runs slower and has less memory than a computer device, but it has more memory than an Arduino. Although an external memory card may be used to expand the memory size of the RasberryPi. RasberryPi, like any other computer system, requires the installation of an operating system to perform those tasks. The RasberryPi runs on Linux, and the code for this embedded framework is written in the Python programming language. Different components make up the RasberryPi chip. Char is the most commonly used RasberryPi [5, 69].

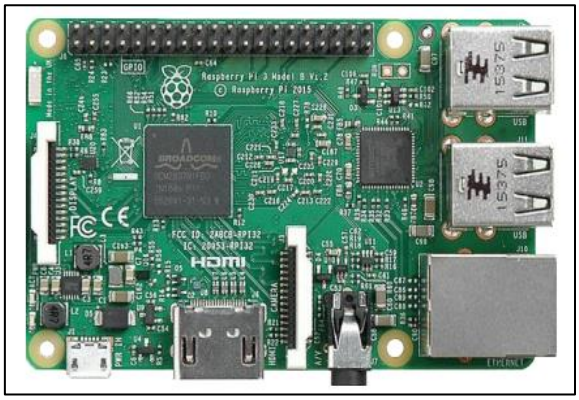

**Figure 4: RasberryPi 3[5]**

## 4. IOT OVERVIEW

Kevin Ashton, the inventor of the MIT auto-identification center, first presented the notion of the Internet of Things in 1999 [70] [71]. Ashton said, "The Internet of Things, like the internet, has the power to change the world or maybe even more" [70]. The International Telecommunication Union (ITU) formally introduced the IoT in 2005 (ITU, "The Internet of Things" (2005)). Many different meanings of IoT have been proposed by various organizations and scholars. IoT has been represented or characterized from a variety of viewpoints, and as a result, IoT is explained in a variety of ways. The two terms "Internet" and "Things" are the key

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explanation for the numerous meanings. The term "internet" refers to a set of networks and items that are mostly made up of generic objects [70]. Things in our daily environment can be a vehicle, an air conditioner, a house or a city, depending on the usage. The IoT uses a large number of embedded devices, such as actuators and sensors, to produce large amounts of data, which necessitates complex computations to extract information. As a result, the best option for storing and computing resources is to store and process the data [67].

### 4.1. Technologies of IoT

The main goal of the IoT is to link things and objects all over the world through the internet, wireless sensor networks (WSNs), and smart phones so that they can exchange information automatically, just like people do. Many innovations, such as sensing, radiofrequency identification (RFID), WSN, embedded systems, and nanotechnology, can help IoT become a reality by allowing objects to interact with one another [72, 73].

### 4.2. Applications of IoT

IoT developers have recently focused on a variety of real-time problems. IoT applications have been developed in smart buildings (school, hospital, and house), healthcare, supply chain management, retail, agriculture, transportation, infrastructure monitoring, industrial, and defense [74-76]. (Figure 5).

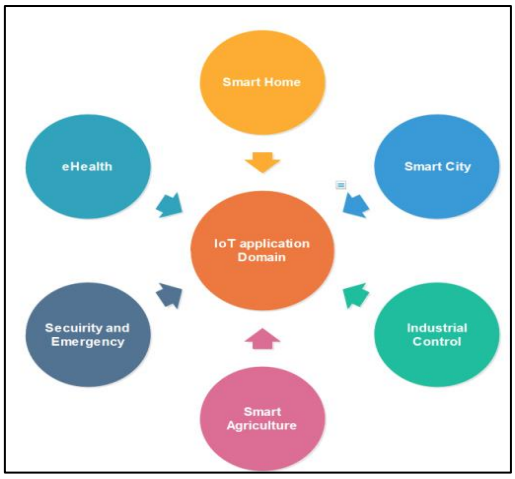


**Figure 5: Application domain of IoT**

### a. In Healthcare

There has been a recent uptick in the investigation of wearable sensors for the body as potential instruments in healthcare applications, and several devices are now widely available on the market for usage in domains such as individual healthcare, activity awareness, and physical activity [76]. The majority of the proposed remote health monitoring systems use a three-tier architecture, which consists of a body sensor network layer that includes wearable sensors that function as data acquisition units like heart rate, blood pressure, and body temperature, a communication and networking tier, and a service that collects and forwards data from sensors,

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and a third tier that includes communication and networking and a service that collects and forwards data from sensors, and a body sensor network layer that includes wearable sensors that function as data acquisition [77, 78].

### b. In Agriculture

The development of IoT technology can assist farmers in increasing crop yield. As the IoT in agriculture develops, farms will become more linked, automated, effective, and ultimately more profitable. The IoT will effectively address agricultural product quality and safety issues. Water quality control, soil constituent monitoring, water irrigation, and pest monitoring are all significant IoT applications in agriculture .[79]

### c. Industrial Applications

The advanced IoT technology can also be used in industrial applications to investigate the value of goods in real-time and improve marketing. With the use of smart technology, the record will be immediately updated on asset placement in industrial storage, saving both labor time and money in a short period of time [80].

### d. Building and Home Automation

The Internet of Things (IoT) allows users to connect everything in your home that can be monitored remotely, providing comfort, security, and minimal energy usage. The use of IoT to connect smart devices in the built environment has made life easier for everyone[80].

## 5. RELATED WORK

Gómez-Carrasquilla et al. [81] created a device that propels a small wheelchair in a forward direction while it is in motion. The device may be controlled by the involuntary blinking of the eye as well as by conscious blinking mixed with slow motion. A platform for the Internet of Things receives information about the location of a wheelchair as well as commands from the user with the intention of conserving the information that has been received. Information on the wheelchair, such as its current location and any directives that the user may be required to follow, is gathered by a platform that is linked to the Internet of Things (IoT).

It was proposed by Verma et al. [82] that fog computing may be used at the smart gateway in order to monitor the health of patients who are located farther away from the facility. The system that has been proposed makes use of forward-thinking strategies and infrastructure that is located on the network's perimeter. Among them are integrated data mining, notification services, and distributed storage, among other things. The live data that are being sent from the patient are being analyzed by the Fog Layer, which then delivers their data transmissions in response to an event-based trigger. In line with the notion of temporal mining, monitoring a patient's temporal health index may give researchers with an indicator of how often the patient is having a recurrence in their ailment (THI).

Deep neural networks were proposed as a method for attaining real-time automotive counting by Lücking et al. [83], and these networks were later tested and shown to be successful on an embedded computer. They employ a technique known as SSD-Mobilenet, which analyses

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information that is both publicly accessible and privately kept, in order to identify automobiles that are concealed within video feeds. This technology looks at data from both public and private sources. It was possible to effectively monitor the locations of the cars at all times thanks to the use of both a Kalman and a binary filter. According to the findings of their study, our neural network-based system for counting automobiles is very sensitive to variations over a broad spectrum of conditions.

In the procedure that Karthik and the other people who worked with him on the project [84] came up with, an alarm would go off, and a plate would be raised up to the location where the person's head had been. An ultrasonic sensor and a threshold value are used in conjunction with one another to determine whether or not a person has drowned or whether or not they are at the appropriate depth. The PIR sensor has the ability to distinguish between a human drowning, an animal drowning, and an inanimate object drowning. It is able to determine if the victim is a person, an animal, or anything that is inanimate. The decrease in the number of newborns who lose their lives as a direct consequence of this forward-thinking approach is one of the benefits of this method that is among the most beneficial.

Lata Sahu and her colleagues detailed the architecture of an Internet of Things healthcare system and emphasized the various layered components that make up the system in the book [85] that they wrote together. After conducting an investigation into the properties that the functions of the Smart Healthcare System (SHCS) have in common with one another, these functions have been segmented into the categories that are most appropriately suited to them.

Thermography, which employs a 3x3 array of embedded ultrasensitive microbio-heat sensors manufactured by Altium and used as part of an embedded device, has been suggested as a novel method for identifying breast cancer by Elouerght et al. [86]. This method of thermography was developed by Altium. This method incorporates thermography, a technique that measures heat using very sensitive microbio-heat sensors. Because it makes use of the Internet of Things, this system makes it feasible for the patient, their treating physician, and maybe a medical monitoring center to exchange information and undertake data analysis via the patient's smartphone.

The system that was proposed by Jeurkar et al. [87] maintains an accurate record of all of the parameters in real time, presents them on a mobile application, and enables remote monitoring and administration through the Internet of Things (IoT). Utilizing a capacitive level sensor makes it feasible to get an accurate measurement of the height of the water's depth. Because it is mounted to the plate, this sensor is able to detect motion because its capacitance varies in reaction to changes in the area of the plate. This allows the sensor to identify when there is motion. This is the primary mode in which the sensor can carry out the tasks that it was designed for.

A wireless sensor network (WSN) that is based on the Internet of Things (IoT) was presented by Chaturved et al. [88] as a possible method for monitoring the air quality. After the WSN-based air monitoring system has completed gathering data from the location where the sensors are placed, the system will next construct digital representations of the outcomes of the

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monitoring. After then, one may see and do research on these digital representations. Zigbee is used to create a connection between a personal computer and the DHT11 (Relative Humidity and Temperature) sensor.

Rao et al. [89] presented a programmable Smart Medicine Kit based on the IoT. It uses a specific warning system that includes smartphone notifications, buzzers, and LED signs on the package segments to guide nurses/patients in administering/taking the correct medication at the correct time schedules. When a patient fails to take his or her medication on time, a multilevel warning device alerts the caregiver. This kit can be utilized in a variety of situations, including hospitals and the homes of patients.

A method for determining whether or not a driver is suffering from tiredness was proposed by Ramya et al. [90] as a means of reducing the number of persons who are hurt or killed as a result of being involved in automobile accidents. This technique performs an analysis on the data that is obtained from a Raspberry Pi computer and a variety of sensors, such as a gas sensor and a vibration sensor, amongst others, in order to determine the causes of excessive daytime drowsiness. The goal of this analysis is to identify the factors that contribute to excessive daytime drowsiness.

An Internet of Things scenario that included sensors and actuators served as the source of inspiration for the prototype embedded system that was constructed by Gautam et al. [91] with the assistance of the Raspberry Pi board. The Internet of Things scenario included both passive and active components. The provision of a technological solution will assist to guarantee that the concentrations of gas are kept within the range of values that are regarded as being acceptable. This will be accomplished by ensuring that the acceptable range is adhered to. According to the findings, the system is acceptable for its intended application as a sensor-based embedded system for screening and monitoring air pollution and creating challans remotely via the usage of the internet of things.

Manshor et al. [92] offered a demonstration that demonstrated how to employ an Internet of Things (IoT) system to monitor the temperature, humidity, and power availability in a chicken coop at any time and from any place. They did this using a chicken coop as an example. It should be noted that the application of this device is not limited to its usage in aviaries; rather, it is capable of monitoring any environment in which the conditions are under control. One further use for this technology is to monitor the safety of one's home or place of business.

Nikolov et al. [93] presented the idea that communications might take place between the Internet of Things cloud, Android mobile devices, and IoT embedded equipment. This was a novel notion at the time. TCP connections are used by IoT clouds in order to facilitate the dissemination of the temperature and humidity data that has been gathered by such clouds. The procedure of moving data between the cloud and the numerous workstations is made easier by the use of a data format that is similar to JSON.

Tracking and filtering the migratory direction and motion of a light source was assigned to a smart heat vehicle that was created by Hu et al. [94] utilizing embedded control and IoT technologies. This vehicle was given the duty of tracking and filtering the motion of the light

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source. The intelligent heat vehicle was able to fulfill this task. The light-chasing automobile is able to gather the data from the light sources that are located to the back, front, left, and right of the vehicle by using embedded control technology from Ardiuno and four-azimuth light sensor components.

It has been suggested, based on the findings of the study conducted by Anand et al. [95], that an intelligent embedded system has been constructed with the intention of doing remote blood pressure monitoring on patients. It makes it much simpler for medical professionals to make accurate diagnoses in the here and now and to put preventative measures into action. The quick flow of data and the ease with which it can be accessed are both made possible by the Internet of Things (IoT), which contributes to an increase in both the efficiency and the practicability of the system that is being offered. In addition, the Internet of Things puts a premium on the safety of users' data while at the same time making an effort to reduce operational expenses to a minimum.

Shafi et al. [96] suggested utilizing a system that is based on the Internet of Things as a way to monitor the present condition of the quality of the water in real time. This was offered as a means to improve the accuracy of the monitoring process. This method was proposed as a means of determining the state of the water that is being tested. The proposed system makes use of a mobile application to perform remote control of the water flow as well as monitoring of the quality of the water in order to achieve these two goals.

Landge et al.[97] Demonstrated MD5 as a method of protecting embedded devices from attacks as they were connected to the internet and were part of the IoT. An introduction to embedded systems and the Internet of Things has been given. The different characteristics that a security algorithm must possess have been discussed. Using this as a foundation, the proposed system's reliability and compliance with the necessary features were assessed, and the decision to use MD5 in an embedded system for IoT security was reached.

In the parking lots of the Universidad Politecnica Salesiana, Carrión et al.[98] demonstrated how the Internet of Things, along with a collection of sensors and actuators, might be used to regulate the watering of an urban garden as well as the temperature of the environment around it. This was done in order to keep the garden at an optimal level of growth. This rally took place in the city of Salesiana, which is situated in the heart of Mexico's central region.

Pias et al. [99] presented a system that could determine the kind of car that a person was driving by utilizing data that was obtained from an implanted accelerometer and gyroscope sensor. This system could identify the type of vehicle that a person was driving. To restate: in order to detect automobiles, an artificial neural network–based machine learning model was developed and applied to sensor data. This model was utilized to analyze the data. The purpose of using this model was to ascertain whether or not there were any autos in the vicinity.

The idea of designing and deploying an Internet of Things (IoT)-based cargo monitoring system that makes use of a heterogeneous communication network that is made up of wireless and power-line networks to provide data to an unmanned monitoring center was proposed by Vijay et al. [100]. This system would make use of a heterogeneous communication network

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that would make use of wireless and power-line networks. This system would use a heterogeneous communication network, which would make use of both wireless and power-line networks to communicate with one another.

## 6. DISCUSSION

Given all that has been covered up to this point, it should not come as a surprise to learn that academics working in a broad number of fields have, via their work, made significant contributions to the Internet of Things sector. It was shown that it is essential to take into account the advantages that researchers predicted would arise as a result of their strategies. The results of the investigations discussed in Chapter 5 are summarized in Table 1, which may be seen below. You can buy it here.

Researchers such as Gómez-Carrasquilla et al. [81], Verma et al. [82], lata Sahu et al. [85], Elouerght et al. [86] , Anand et al. [95], and Rao et al. [89] Are just a few instances of those who have stressed the relevance of IoT in connection to applications that have to do with health. [81], [82], [85], and [89] In the case that drivers do suffer fatigue while they are operating a motor vehicle, there is a chance that the automobile industry will come up with a remedy for the problem. [90]. In addition, the technology that is described in [94]makes it feasible for a vehicle to always maintain a vigilant eye on the area that it is in regardless of where it is or what it is doing. This is made possible by the capability of the vehicle to detect light from from behind, in front of, to the right of, or to the left of the vehicle. Chaturved et al. [88] were able to monitor the air pollution that was created by industrial activities by making use of technology that was a part of the Internet of Things (IoT) and that was built specifically for the goal of monitoring the environment. With the assistance of Gautam et al.[91], we were successful in ensuring that the concentration of gases stayed safely within the boundaries that we had defined for them. Another area in which farmers have profited from these developments is agricultural productivity, which has increased as a result of the Internet of Things (IoT), which has also contributed to a rise in agricultural production. The stronger health of the ecosystem in the surrounding region is a direct result of the improved general quality of the crops [98]. The Internet of Things (IoT) has the potential to be used in agriculture in order to give aid to farmers in the form of problem-solving assistance for the challenges that they encounter. The Internet of Things has the ability to enhance agricultural productivity and ensure the safety of food by improving water quality, assessing the components of soil, maximizing the efficiency of water irrigation, keeping an eye on hen houses, and monitoring crop quality. We provide a method for the ongoing monitoring of water quality that is analogous to the work reported in [96] and is based on the Internet of Things. This methodology allows for continuous monitoring of water quality (IoT). The system that was examined in the research paper [87] has the capability of being controlled remotely via the use of mobile devices and the Internet of Things (IoT). A capacitive level sensor is used for the purpose of calculating the height of the water at the current moment. [Cause and effect] In the research that is described in [98], a variety of environmental characteristics were evaluated via the use of sensors. These environmental factors consisted of things like temperature, humidity, the amount of carbon monoxide present, and the amount of light. The device has a user interface that is built on the web, and it enables

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real-time monitoring of the garden. This, in turn, makes it possible to cultivate higher-quality crops. Researchers advise utilizing a smartphone in conjunction with an Internet of Things (IoT) device in order to monitor the temperature and humidity levels inside of a chicken coop. This suggestion is made in the study that is shown in reference number 36. In addition, Paper [100] presented a video analytics-based tamper detection technique that can be implemented as a low-cost enhancement to existing security camera systems. This strategy can identify tampering with footage.

**Table 1: Summary of the reviewed papers**

| #R | Applied Field | Use Case Scenario | Software | Major Hardware Components |
|---|---|---|---|---|
| [81] | Health care | Wheelchair control through eye blinking and IoT platform | Python | Raspberry Pi 3 controller, Servomotor controllers, Mecanum wheels |
| [82] | Health care | Fog Assisted- IoT Enabled Patient Health Monitoring in Smart Homes | Weka 3.7 | Bio-sensors, Smart wearables, Smart phone, Smart monitors |
| [83] | system of vehicle counting | design and implementation of a video-based vehicle counting system, using a resource constrained edge device | - | NVIDIA Jetson Nano, Raspberry Pi Camera V2.1 |
| [84] | saving human life | By activating the alarm and lifting the person upward using the plate, it prevents a person from drowning in a swimming pool. | Arduino IDE | Arduino Uno, Ultrasonic Sensor, PIR Sensor |
| [85] | Health Care | The exhaustive investigations on the classification of the IoT based SHCS have been carried out | - | Raspberry Pi, Pulse Sensor, Body Temperature, ECG, EEG, EMG, Blood Pressure, Respiration, Accelerometer |
| [86] | Health Care | A new approach based on a micro sensor thermal matrix card for early breast cancer detection has been developed | Python and Open CV | Raspberry Pi, Micro-BioHeat Ultrasensitive Sensors |
| [87] | Agriculture | measures water level using a capacitive level sensor | - | Temperature sensor, Water flow sensor, Level sensor, Microcontroller, Wi-Fi module |
| [88] | Air monitoring | Based on the IoT, a wireless sensor network for air pollution monitoring has been developed. | Arduino IDE | Arduino and Zigbee for wireless transmission, temperature sensor, humidity sensor, Gas sensor, Fire sensor |
| [89] | Health Care | The Smart Medicine Kit is designed and acts as a complete home healthcare system | Android | Tablet blister pack, raspberry pi camera, LED to indicate segments, LDR sensor, |
| [90] | Driver monitoring | EEG and ECG were used to detect the driver's drowsiness. | OpenCV | Raspberry Pi, GSM/GPRS, Piezo Buzzer, Gas Sensor, vibration Sensor |
| [91] | Pollution monitoring | The system can assist in keeping gas levels within predetermined limits. | Python | Raspberry Pi, MQ2 gas Sensor, LCD, buzzer, DC motor |

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| | | | | |
|---|---|---|---|---|
| [92] | Agriculture | monitor temperature and humidity levels from a smartphone for Poultry house monitoring | Python | Raspberry Pi, temperature and humidity sensor, Light bulb |
| [93] | mobile application | communication between IoT cloud, Android mobile application and IoT embedded systems | C ++ | STM32F429, esp8266, Wi-Fi module, temperature sensor, humidity sensor, LED diode |
| [94] | Vehicle system | Built a smart light-chasing vehicle that chases the light source from eight different directions and records the values and movement direction. | Ardi-uno | four-azimuth light sensing, play Robot IoT naker board, play Robot vehicle body, Ardiuno control board, dual-motor driven board |
| [95] | Health care | monitoring the blood pressure of patients | - | Raspberry Pi, Artificial pressure sensor, Smart controlling CPU, memory |
| [96] | Agriculture | monitor the water quality in real time | dashboard | pH sensor, turbidity sensor and temperature sensor, Arduino board, Arduino WiFi shield |
| [97] | security | MD5 is used to protect the embedded system from attacks. | Unix Timestamp. | Wireless Sensor Network, embedded IoT device |
| [98] | Agriculture | monitoring of climatic variables and irrigation of crops | MySQL, PHP | Humidity sensor, Temperature sensor, CO2 sensor, Moisture sensor, UPS, |
| [99] | Vehicle Recognition | Using the accelerometer and gyroscope sensor data, identify the vehicle that the subject is currently driving. | Python | Huawei smart watch, accelerometer sensor, Gyroscope sensor data |
| [100] | Air Cargo Monitoring | Air cargo monitoring and introduce the tamper detection and communication application. | - | smart camera, USRP PLC modem, USRP wireless modem, sensors |

## 7. CONCLUSION

Because it is responsible for making all of the embedded systems and applications that are now conceivable, the Internet of Things is the most recent technical advance. It also symbolizes the cutting edge of this sector because it is the most recent technological development. One has access to a broad range of high-tech gadgets, each of which is capable of transmitting and receiving copious quantities of data. One is free to choose any method they like from among these options at their own discretion. These gizmos are included as standard with the purchase. Over the course of the last few years, there has been a rise in the total amount of investigation carried out in connection with the Internet of Things (IoT). This may be ascribed to the adaptability of installations of the Internet of Things, which may take place in a broad variety of settings. Therefore, it is reasonable to assert that in order for the current technological environment to function, it is necessary to make use of technologies such as embedded systems and the internet of things. This is because such technologies are required in order for the current technological environment to function. This is due to the fact that technologies such as embedded systems and the internet of things are instances of this. This is as a result of the fact that such technologies are necessary for the current technological environment in order for it

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to function in the appropriate manner. As the number of connected devices continues to grow, it will be more vital than ever to make preparations for communication that is both trustworthy and secure across digital and physical systems. This will be the case more than ever before. This is owing to the fact that the number of connected devices will continue to increase in the foreseeable future. Given the wide variety of protocols that are currently on the market, finding the Internet of Things (IoT) communication standard that most closely corresponds to the specifications of the application that you are developing may prove to be a challenging task to accomplish.

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