

# INTERNET OF THINGS

## Abstract

The paper contains information about different aspects of Internet of Things (IoT) mainly concentrating on Embedded systems, sensors, Privacy and Security, Virtual reality and Augmented reality and applications of it. The part-I discusses about embedded systems, sensors and their main applications and brief description of them. The part-II discusses about privacy and security. The part-III contains information about virtual reality and augmented reality and the latest products. At the end we also discuss about the different applications of IoT in everyday life.

**Keywords:** Things in IoT, RFID tags, Embedded Systems, Privacy, Security, Blockchain, Sensors, Actuators, Augmented Reality, Virtual, Reality, metaverse, cryptocurrency, IoT Trackers

## Authors

### **K. Padmapriya**

Assistant Professor  
Department of Computer Science  
Bhavan's Vivekananda College  
Secunderabad, Telangana, India.  
padmapriya1bvc@gmail.com

### **B Harshagna Reddy**

Department of Computer Science  
Bhavan's Vivekananda College,  
Secunderabad, Telangana, India,  
harshagnareddy64@gmail.com

### **S. Siddharth**

Department of Computer Science  
Bhavan's Vivekananda College,  
Secunderabad, Telangana, India  
sidhu.sindhu39@gmail.com

### **Adep Ajay**

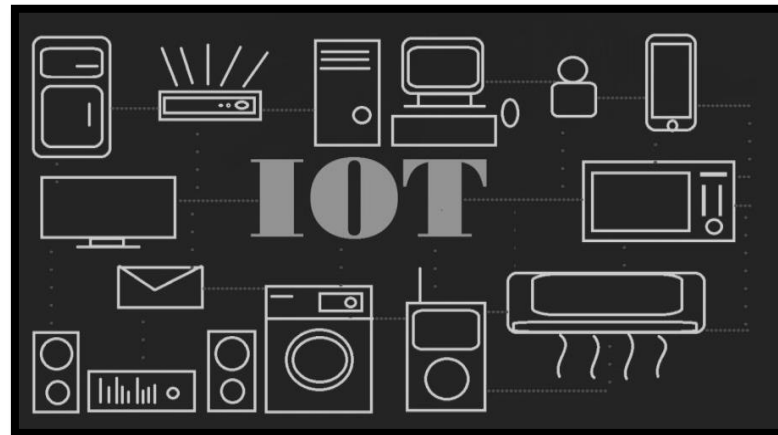
Department of Computer Science  
Bhavan's Vivekananda College,  
Secunderabad, Telangana, India,  
adepajay03@gmail.com

### **D. Abhinav Vardhan**

Department of Computer Science  
Bhavan's Vivekananda College,  
Secunderabad, Telangana, India  
vardhanabhi22@gmail.com

## I. INTRODUCTION

1. **What is Iot:** IoT or Internet of things, is a system of interrelated computing devices, machines, objects, animals or humans provided with unique identifiers and have ability to transfer data over network. In simple words “Computation + Communication = IoT.”



2. **Things in Iot:** In terms of IoT, any physical device can be called as a thing. For example, it can be smart phone, washing machine, smart watch, headphones, smart vehicle, etc. A person with a heart monitor is considered as a thing, animals with biochips are considered as things, vehicles, homes, devices with sensors can be considered as things in IoT. IoT is a giant network of connected “things”.

Technically things are embedded with software and sensors and other components which help them to send and receive data. Three kinds of relationships in IoT network are

- Things-things
- People-things
- People-people

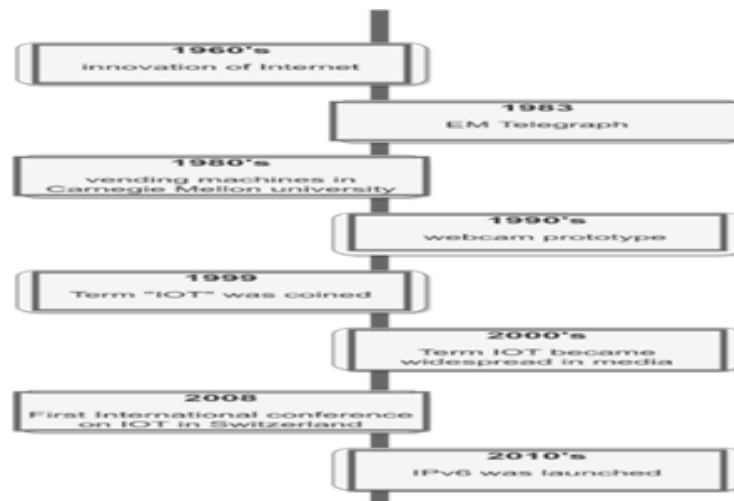
Some of the most common benefits of IoT include:

- Better safety
- Management of devices is more efficient
- Reduced human labor (Automation)
- Cost-effective

3. **Brief history of iot:** IoT as a field has evolved due to many innovations and developments on the innovation. In this part we will see what are the major innovations /discoveries which popularized IoT and led many others to work on its development.

The true history of IoT started by the innovation of the Internet in late 1960's interconnection of the devices in IoT today is possible due to the Internet and this discovery of the Internet in the 1960's was revolutionary.

The concept of connected devices was first explored in the year 1983 and an Electromagnet telegraph was designed which led to direct communication between two devices possible by the transfer of electrical signals. After this, many scientists and university students started to work on the concept of connected devices.



Carnegie Mellon University in 1980's had coco-cola vending machines which were operated by local programmers. The vending machines were integrated with microchips and micro-switches which help them to find out if the vending machine had coco-cola in them and microchips were installed to check if the cooling systems were working correctly. This was one of the initial steps of integrating microchips and micro switches with the connected devices and program some functionality into them.

- Scientists in Cambridge University in 1990's came up with one of the first webcam prototype and put it in their computer to monitor the amount of coffee available in their coffee pot. The scientists programmed the camera to click three pictures per minute and send them to the available computers so that everyone could check if the coffee was available in the pot.
- The year 1999 was very significant for the IoT historians as the term "Internet of Things" was coined by Kevin Ashton. Ashton during a presentation described IoT as "Technology that connected devices together using RFID tags for supply chain management". While the current definition of IoT is different from the Ashton's idea of RFID tags the term IoT was a breakthrough.
- In 2000's the term IoT became very widespread and was used by the media very often. In the year 2008 the very first international conference on IoT was organized in Switzerland. 23 Countries participated in this conference. Some of the topics discussed in the conference were about RFID, short-range and wireless communications.
- IPv6 a popular network protocol that was launched in 2010's and was a very important development for the IoT industry in that decade. Since then, interconnected devices became widespread. Tech giants like Apple, Samsung, Google focused and

paid more efforts on producing sensors and also R&D in producing sensors and microchips were paid more attention.

**4. Future of iot:** The number of connected devices in the network is rapidly growing as the population is increasing. Currently the human population is about 7.9 billion and the number of connected devices is almost over 50 billion. At this rate the IoT industry will play major role in changing the graphs of some of the current industries. IoT will conquer the automobile and the enterprise industry. Some of the automobile companies like Tesla has already started to integrate IoT with automobile in a very huge scale. We can see a very steep growth in the IoT in the coming years.

The reason for the same would be:

- Decrease in the manufacturing cost of the sensors due to large scale production.
- Decrease in the cost of data connections due to cloud storage solutions.
- Wide internet connection.
- Increase in the smart phone / tablet usage.

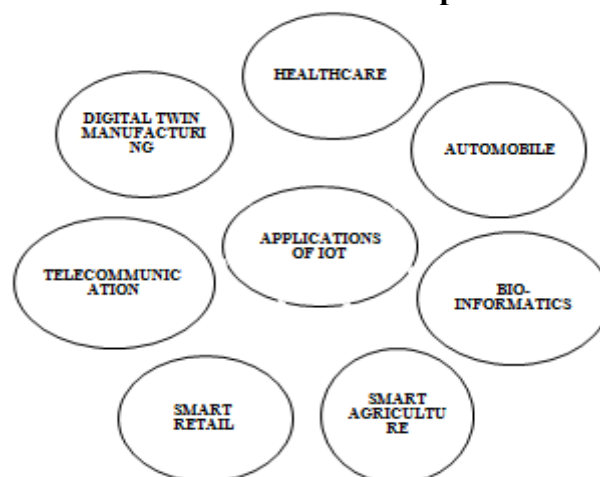
This rapid growth of the IoT Industry will change the world we live in. e.g., there will be smart vehicles developed which will automatically send messages to the concerned person if we are late to the destination.

IoT will become industry specific.

- Separate solutions will be designed for particular industries.
- There will be an increase in demand for specific usage.

**5. IoT networks:** IoT network defines how the IoT devices are connected and the way in which they share data with other devices. The main part is choosing the correct protocols and layers to facilitate data sharing. There are many types of IoT networks available. Few of the wireless network types are: RFID, Cellular, Bluetooth, Wi-Fi, etc. Each of these networks communicate at different speed with each other depending on the type and network strength. With so many network options, to ease the process there is a reference model referred as 'Decision tree' to help us find out the correct IoT network.

**6. The new areas in which IoT solutions will be developed are:**



## II. EMBEDDED SYSTEMS

- 1. What is an embedded system:** Embedded systems can be found everywhere. Almost every electrical device you engage with that is more sophisticated than a basic light switch has a digital processor that reads input data from its surroundings, runs a computational algorithm, and provides some type of output that interacts with the environment.

Embedded systems and IoT are two interconnected technologies that are trending in the IT industry. The application of embedded systems is there in every technology, including IoT.

A desktop computer, even though it is capable of performing a wide range of activities and may be upgraded by the addition of a large range of accessories, is just a computer. A vehicle, on the other hand, is designed primarily for passenger transportation. It relies on several subsystems with embedded processing to carry out its role. Automobiles are examples of embedded systems. Personal computers, however, are not.

An Embedded system is a small system that has a specific function in the larger system. That larger system works because it can do smaller functions. Embedded systems, whether they are basic devices or extremely complicated systems, are often made up of many components.

The components include Power source, time base, digital processing, memory, software and firmware, specialized circuitry, etc. Embedded systems enable IoT to perform better. Without an Embedded system, IoT can face so many issues while operating.

- 2. Role of embedded system in IoT:** In the Internet of Things, embedded devices can fulfil a variety of functions. It can be adapted to meet your specific requirements. IoT devices without an embedded system might be expensive and energy-intensive. It makes cloud connection and mesh networking possible. Embedded system technology is in charge of IoT real-time operations. The usage of embedded technology coupled with IoT is opening the doors of innovation.

To capitalize on the growing IoT business, prominent embedded system hardware and software development companies are attempting to include these transitions into their products. Among the industries that will transform are real-time operating systems (RTOS), microprocessors and microcontrollers, memory footprints and networking, open-source communities, and developers.

The interconnected embedded systems have the potential to change the way we interact with our environment, communities, and homes.

As a result, while developing embedded IoT systems, we must consider factors such as low power consumption, secure design, and so on. As a result of the heavy

reliance on Embedded systems. Embedded system technology serves a greater purpose in IoT.

### III.PRIVACY AND SECURITY

1. **Security will remain a blind spot in the future:** Despite all the methods to improve and strengthen the protection mechanism, cybercriminals find out more & more sophisticated tactics to find out a loophole and tap into the connected devices, getting access to sensitive information.
2. **Privacy and Security in IoT:** Concern over privacy and security increased as people realized the true potential of IoT. IoT devices collect information about the user which might be sensitive and private, when leaked might land the user into trouble as it might contain information like the user's email, passwords to many other accounts, and other bank related information which will be hacked by the cybercriminal. In future millions of new IoT devices will be used by millions of new users, as the usage of the connected devices increase, the security and privacy concerns related to it will also increase.
3. **Why is security and privacy important in IoT?:** By the year 2025 almost more than 65 billion new devices will be used by billions of new users. Using smart devices have their own advantages like using smart lights will help in decreasing electricity bills of the user and using smart devices in healthcare industry will be beneficial for both the patient and the doctor. As the number of devices connected to the network increases, it increases the privacy and security concerns as it provides more entry points for the hackers and cybercriminals to get into the connected network.
4. **Concept of security in IoT**
  - IoT has become more diverse with the introduction of legacy computing systems and modern computing devices and is vulnerable to wide range of security risks.
  - Many devices like sensors and micro switches are used in a huge scale in current IoT industry and all the chips and sensors are connected to each other.
  - In this case if a poorly secure device is used in such a large scale, it affects the security and resilience of IoT.
  - Due to the development of the devices in a large scale, IoT developers must make sure that they should not put the user into risk.
5. **Authentication**
  - The currently available authentication models in IoT only provide limited safeguard against DOS (denial of service) and reply attacks.
  - Security is very important in man-in-the-middle attacks where the 3<sup>rd</sup> party agents intercept the communication channels and impersonate one of the users to attain sensitive information from others.
6. **Privacy in IoT:** User privacy and rights are the basic requirements to improve trust between user and the connected device. Connection of the devices through internet also

amplifies the privacy issue as it lets the hacker remotely access the data from anywhere. IoT devices are connected with various hardware and software and there is a threat of the sensitive information being leaked through unauthorized sites. There are a few cases recorded where the IoT devices transmit users' personal information like DOB, email, bank details and other details without proper encryption methods through the internet.

The potential harm which comes with implementation of IoT might play an important role in stopping the full-fledged usage of these devices by the consumers.

#### 7. Factors which compromise the efforts to secure IoT are:

- **Occasional updates:** Regular updates are released by the manufacturer for the security patches or software updates which improves the user interface experience. These updates give plenty of time to the hacker to crack the security protocols.
- **Embedded passwords:** Devices have embedded passwords to support technicians to solve problems in the device. Hackers use this embedded password to tap into the device.
- **Automation:** This property is used in many business activities like information collection. If the automated AI is not specified with the threat sites, then it can access this source and download malicious files in the device.
- **Remote access:** There are several network protocols which can establish remote access between the devices. protocols like wi-fi and zig-bee help to establish remote access. When specific measures are not taken while establishing the network then it can be dangerous.

#### 8. Security threats in different layers of IoT: The IoT architecture is divided into a few layers which are:

- Sensing layer
- Network layer
- Middleware layer
- Application layer

There are various threats in all the different layers mentioned above. In this section let us talk about different threats in the different layers and the possible solutions to overcome the threats.

##### • Sensing layer threats

- **Booting attacks:** The node devices are vulnerable to various attacks during the boot process as the security systems of the device are turned off during the booting process. The hackers might take advantage of this and attack this device when they are being restarted.
- **False Data Injection Attack:** Once the node is captured the cybercriminal injects false/unauthorized data into the system which will lead to false results being generated by the system which eventually lead to the malfunction of the IoT application.

- **Network layer threats**

- **Phishing site attack:** In this attack several devices are targeted by the hacker by minimal efforts. The user might encounter phishing sites during browsing by which the hacker obtains the user’s email and password and by this the whole network is conquered by the hacker.

- **Middleware layer threats**

- **SQL injection attack (SQLi):** In this attack, the hacker injects malicious SQL statements into the program by this the attacker can access private data of the user and also can disrupt the database.

- **Application layer threats**

- **Access control attacks:** Access control mechanism allows only legitimate user to get the access of the network. once this access control is compromised by the attacker the whole network is vulnerable to threat.

LAYERS	THREATS	SECURITY MEASURES
Sensing Layer	SQL injection attack	Privacy protection, key agreement
Network Layer	RFID spoofing	Identity authentication
Middleware	Data breach and virus	Anti-virus software
Application Layer	DOS/DDOS attacks	Block chain technology

**9. Solutions to the IoT threats and attacks:** As the number of attacks are increasing by the increasing devices in the Network, many technologies were developed to overcome the threats, some of the important technologies and what threats are suppressed by them are discussed in this section:

- **Blockchain:** Blockchain is a shared, decentralized digital ledger that stores the information in the form of blocks. This is used to store information transparently due to its property of immutability and access allowed only to the members. There are many beneficial key features of blockchain technology which overcomes the attacks faced in the different layers, some of the features of the blockchain technology are Immutable records, cryptographic key pairs, traceability during transactions and smart contracts. The data in transit is protected by unauthorized access by using encryption. Blockchain based storage solutions help in decentralized storage and protect the sensitive data from attacks. The main feature of blockchain is DNS security (domain name system security) as a result of the features of immutability and decentralized storage DNS has been proved to be very crucial to the connected networks.
- **Machine learning:** Machine learning is a type of AI which makes software applications accurate in predicting the outcomes without programming to do so. With the help of machine learning algorithms cyber security systems can predict and learn about different attacks and be more active to overcome the threats and attacks in real



time. In simple words machine learning can make cyber security more active less expensive and more secure.

- **Deep learning:** Deep learning is a type of machine learning and AI which imitates how humans gain certain type of knowledge. Deep learning algorithms are capable to detect advanced threats and learn the system and can recognize suspicious activities that might indicate the presence of a malware.

## IV SENSORS

1. **Sensors:** IoT sensors are pieces of hardware that detect changes in an environment and collect data. They're the pieces of an IoT ecosystem that bridge the digital world to the physical world. IoT sensors may detect things like temperature, pressure, and motion, and if they are connected to a network, they share data with the network.



### Types of IoT Sensors

- **Motion sensors:** Motion sensors detect physical movement in an area. of course, these sensors play a significant role in the security industry, but they are used in nearly every industry. Applications include automated sinks and toilet flushers, automatic door controls, energy management systems, and automated parking systems. Standard motion sensors include ultrasonic, microwave, and passive infrared (PIR). Example: Hue Motion Sensor (an adaptive lighting system), Fibaro, or Onvis Motion Sensor are some of the most popular motion detector tools homeowners use to have remote control over their living space and integrate automation into everyday activities.



- **Image sensors:** These sensors convert optical images into signals and are generally used to display or store files electronically. They are found in radar and sonar, biometric devices, night vision equipment, medical imaging, digital cameras, and even some cars. Charge-coupled devices (CCD) and complementary metal-oxide semiconductors (CMOS) are most commonly used.



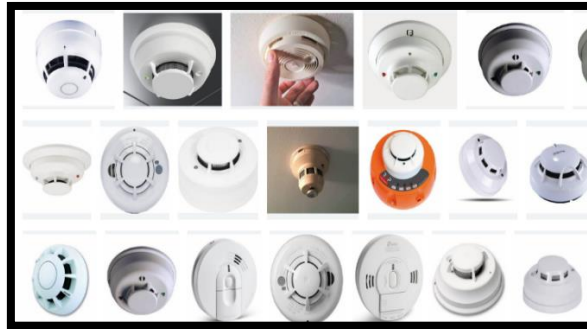
- **Optical sensors:** Optical sensors measure light and convert it into electrical signals. Many industries make use of optical sensors, including auto, energy, healthcare, and aerospace. Sensors include fiber optics, photodetector, and pyrometer.



- **Water quality sensors:** The importance of water to human beings on earth not only for drinking but as a key ingredient needed in many production processes dictates the need to be able to sense and measure parameters around water quality. Some examples of what is sensed and monitored include:
  - chemical presence (such as chlorine levels or fluoride levels)
  - oxygen levels (which may impact the growth of algae and bacteria)
  - electrical conductivity (which can indicate the level of ions present in water)
  - pH level (a reflection of the relative acidity or alkalinity of the water)
  - turbidity levels (a measurement of the number of suspended solids in water)



- **Smoke sensors:** Most people are familiar with smoke detectors, as they have protected our homes and businesses for a long time. However, with improvements based on IoT, smoke detectors are now more user-friendly, convenient, and wire-free.



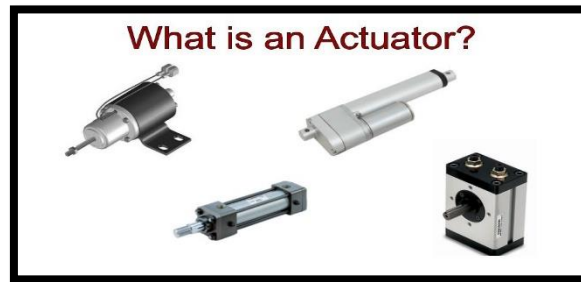
- **Pressure Sensors:** A pressure sensor is a device that senses pressure and converts it into an electric signal. Here, the amount depends upon the level of pressure applied. There are plenty of devices that rely on liquid or other forms of pressure. These sensors make it possible to create IoT systems that monitor systems and devices that are pressure propelled. With any deviation from standard pressure range, the device notifies the system administrator about any problems that should be fixed.

Deployment of these sensors is not only very useful in manufacturing, but also in the maintenance of whole water systems and heating systems, as it is easy to detect any fluctuation or drops in pressure.



IoT is a thing that we can use for many different purposes and for everything new you can get a sensor and if you aren't that much lucky to get one for your purpose then there's always a way to modify one that is lying previously or to create one sensor of your own J. In contrast with the rapidly developing world in which all are getting busier and busier it will be very common to see IoT coming into play with different sensors used. So, tighten your seatbelts from now onwards and keep taking knowledge about the futuristic gadgets, sensors and the most important IoT.

2. **Actuators:** An actuator is a part of a device or machine that helps it to achieve physical movements by converting energy, often electrical, air, or hydraulic, into mechanical force. Simply put, it is the component in any machine that enables movement.

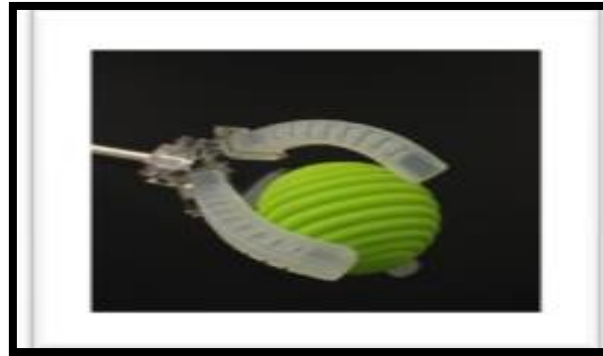


Actuators are present in almost every machine around us, from simple electronic access control systems, the vibrator on your mobile phone and household appliances to vehicles, industrial devices, and robots. Common examples of actuators include electric motors, stepper motors, jackscrews, electric muscular stimulators in robots, etc.

**Types of Actuators:** Soft Actuators: A soft actuator is one that changes its shape in response to stimuli including mechanical, thermal, magnetic, and electrical. Soft actuators mainly deal with the robotics of humans rather than industry which is what most of the actuators are used for. For most actuators they are mechanically durable yet do not have an ability to adapt compared to soft actuators. The soft actuators apply to mainly safety and healthcare for humans which is why they are able to adapt to environments by disassembling their parts. This is why the driven energy behind soft actuators deal with flexible materials like certain polymers and liquids that are harmless to humans.



- **3D printed soft actuators:** The majority of the existing soft actuators are fabricated using multistep low yield processes such as micro-moulding, solid free form fabrication,



and mask lithography. However, these methods require manual fabrication of devices, post processing/assembly, and lengthy iterations until maturity in the fabrication is achieved. To avoid the tedious and time-consuming aspects of the current fabrication processes, researchers are exploring an appropriate manufacturing approach for effective fabrication of soft actuators. Therefore, special soft systems that can be fabricated in a single step by rapid prototyping methods, such as 3D printing, are utilized to narrow the gap between the design and implementation of soft actuators, making the process faster, less expensive, and simpler. They also enable incorporation of all actuator components into a single structure eliminating the need to use external joints, adhesives, and fasteners.

#### IV. AUGMENTED REALITY AND VIRTUAL REALITY IN IOT

1. **Augmented (AR) and virtual realities (VR)** are simulations that are closely comparable to real-world experience. The definition given by Google is quite simple and can be understood by any person with or without any experience in AR, VR or technology. But if you want to know the working of VR and AR brace yourself because this will turn out to be the most interesting topic for you this year.

Starting with Augmented reality (AR), in today's world we use a lot of apps which use Artificial intelligence to add digital elements to the world which can be seen through a programmed screen like smart phone,





famous apps like LensKart uses the AR tech to show the customer how the glasses would look on them , it just asks the user to select the glasses and give camera permission to the app through which it can access the camera of your device after which it asks the user to place their face in the particular position at this point the Artificial Intelligence used by the app scans your face( features like ears , eyes , nose , mouth) , after the scan the Ai now understands the facial features of the person on which the app adds the 3D image of the glasses onto the user eyes at this point even when the user turns around , moves his/her head won't have an effect the user can still see the glasses on their face with great precision.



You might be wondering how this simple application can have so much going in the background but to be honest this is just the tip of the mountain. To perform the above tasks properly it takes a lot of efforts and planning, explaining this to a fellow person might seem easy but to make things work properly the dedicated company hires multiple programmers for each sector of the app to function seamlessly, there are hundreds thousand lines of codes running the background to make the app work perfectly. The above mentioned is a simple example of AR but if we look closely, we can notice almost all the apps using Ai or AR or even both to give the user/ customer more flexibility, Apps like Instagram, Facebook, snapchat allows the user to add elements on to their face from their application.



**2. Virtual reality:** Virtual Reality industry has seen great heights in the past years, companies like Facebook turned their main business into virtual reality using Ai.



How would it feel if you had a chance to travel the world just by sitting at your desk and feeling them as it was real, seems impossible right? Not any more virtual reality can replicate the whole world and would allow any user to feel the place just by sitting on their desk, I believe that there is a lot to come in the industry of virtual reality and once the huge companies like Facebook (now called as meta) succeed on creating a virtual world referred to as metaverse that would be the start of new world, things which you could only dream about would come into reality , work requiring in-person assistance would be easier than ever . If we get into practicality or how useful would virtual reality actually be? There is no definite answer for that because even the thought of virtual reality has opened many doors in the tech industry and there is much more to come.



We are at an early stage where there are virtual reality games, applications and movies which are out and available for the people to use and access. Today we do get VR

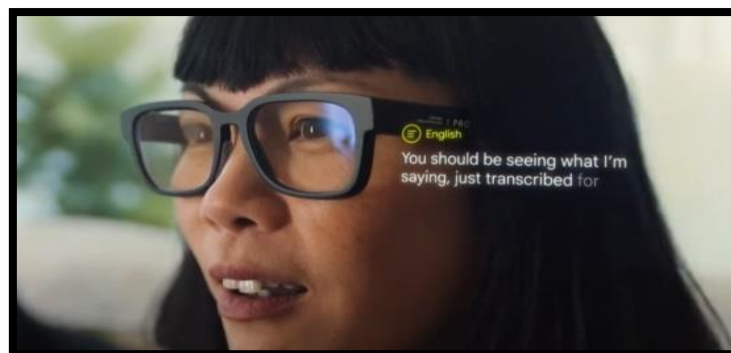
glasses in Amazon for 500 rupees which is really easy to use, it just requires the smart phone to be inserted into the VR glasses. There are very few games and a lot of videos available on YouTube, the VR glasses use 2 wide angle lenses on the inside when we watch a video or play a game which supports VR the game or video shrinks and replicates the screen contents into 2 same parts so when we watch them on the VR glasses it feels like we are in the game/video giving a very real immersive experience.



## V. RECENT UPDATES ON PHYSICAL GADGETS OF AR AND VR

With the previously introduced technology of air gestures and new AR and VR tech combining them to make a superior application and programming that into a physical device, this seems like something straight from a sci-fi movie but Companies like Apple, Google, Amazon, Microsoft and Facebook are working to make something similar to put that into real use.

1. Google is testing their AR glasses (prototype) which are expected to have a very advanced features like translating languages on the go, new age navigation features, advanced voice command accessibility and many more.



2. Amazon as we all know is company which is known for their great technology in almost all categories, some of their famous gadgets are echo dot, fire tv, smart bulbs etc. Amazon is also known for its voice assistant referred to as Alexa, what if I tell you that Amazon will launch their smart glasses similar to amazon echo frames with the support of Alexa. The specification might even shock you this pair of glasses looks just as any normal glasses but it has speakers, microphone for voice commands, speaker on both sides, a mini projector to display the contents and many outstanding technologies attached to a simple pair of glasses.





3. Xiaomi smart glasses: Xiaomi announced their smart glasses on 3<sup>rd</sup> of august, which look exactly like sun glasses and has 0.13-inch micro led display which is said to be smaller than a grain of rice, through reflection and diffusion of their waveguide lens a much larger display is offered to the eye, it allows you to attend and reject calls, navigate directions, translation in real-time and many more.



4. Meta Oculus quest 2: oculus quest 2 is the second generation first wireless and most affordable VR headset it is also the most popular VR headset out in the market. This VR headset allows you to play the most realistic games and make you experience the things you could only dream of



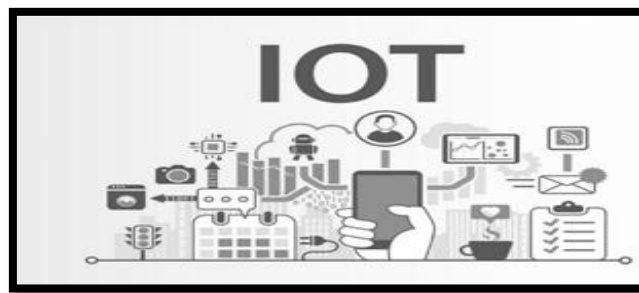
All the top-tier companies are working on VR and AR technologies as almost all the tech geeks and companies believe that the coming decade is all about meta-verse. The global cryptocurrency market size was 1.49 billion dollars in 2020 and is estimated to reach 4.94 billion dollars by 2030, growing at a CAGR of about 12.8% from 2021-2030 and the cryptocurrency is a perfect fit for the virtual world, seeing a positive response from the global users we see a lot of universities and governments taking interests in virtual reality, Augmented reality and digital money(currency). Recently the Indian

government has also imposed a tax on the profits made from cryptocurrency as many Indians have recently started investing in crypto and making their living out of it.

This is the perfect time to start learning a thing or two from the internet about AR and VR technologies or even make this a career as it is expected that most of the companies will require a huge number of programmers to work on their upcoming applications or projects.

## VI. PRACTICAL AND INNOVATIVE APPLICATIONS OF IoT

With the rapid increase in the field of automation and artificial intelligence, research and inventions around IoT are becoming. There are many devices which are created based of IoT like RFID tags, robots, smart appliances, fitness wearables, etc. There are also generic devices developed like the Raspberry Pi and Arduino which let us build and code and create our own projects. The combination of Internet of Things (IoT) and sensors with the help of machine learning and Artificial intelligence to collect data lead in the creation of many innovative devices which are going to be a boon for the society and for the coming generations. They also act as an integral part in creating smart cities.



**1. Smart cities:** Smart cities are the future. Modern urban areas that use different IoT methods like sensors and transmitters to collect data and use it to manage the area and assets and resources are known as smart cities. The main aim of a smart city is to optimize the functioning of cities and increase the economic growth with simultaneously also increasing the quality of life of people living there. Some of the main features of smart city are:

- City infrastructure based on technology
- Easier and effective public transportation facilities for people
- Better healthcare facilities
- Confident, efficient and progressive city plans, etc.



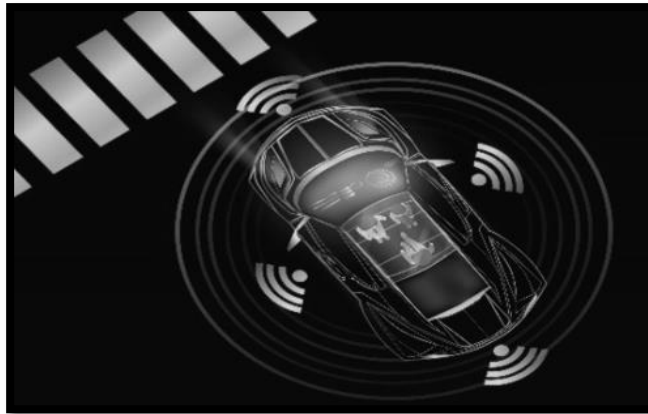
2. **Smart mobility:** Smart mobility refers to the use of IoT to help us ease the problem of transportation. Its main agenda is to provide people with multiple modes of transportation which are also cheap, affordable and time efficient. It also aims on efficient and fast navigation using different IoT devices.

Some of the best practical applications are as follows:

- **Traffic management:** One of the hardest task in this fast generation of increasing vehicle usage is to optimizing the traffic. To ease this, we can attach sensors to the traffic lights. They can help us in measuring the volume of the traffic and then the data is analyzed with the help of machine learning using which we can set the time in the traffic lights. For example, if the volume of traffic is more, then the time for the green light automatically adapts and increase its duration and in the wee hours when there is almost no traffic the lights should automatically switch to yellow light to make the travelling easier.

Also, while coming to pedestrians, IoT can be used by place few sensors near the footpath to recognize the whenever they are waiting to cross the road. Then it automatically stops the traffic on the road and help them cross it. Due to this it is a lot easier and safer for them to cross the road. Risk of accidents is reduced.

- **Route navigator:** We can use IoT sensors to help the people find their best route to reach their destination. This includes placing sensors at different places around the city and connecting them to a mobile app. The sensors collect the data about the present traffic, shortest distance and would send it to an Artificial Intelligence to analyze the traffic and provide the user with the best route which is shorter and also time saving.
- **Public transport tracker:** One of the most common mode of transportation for most population is still public transport. It is very crucial for the development of a city to have an efficient public transportation system. But the transportation is still not optimized with its arrival timings. Sometimes the bus comes early and sometimes really late. We can use IoT to help us by attaching sensors to the vehicles and tracking its speed and distance from the bus stop. Then the user can access this through the app and plan their movement and time accurately so that they can't miss the transport or can plan for other mode of transport if the vehicle is delayed. This would help a lot of citizens to reach their destination on time.
- **Auto Pilot in vehicles:** Everybody has heard about Tesla and one of the main reason for its popularity is the auto pilot feature it provides. In this there are different cameras and sensors attached around the car and using them the car can calculate its area around it and drive itself without any accidents. The primary data collected through sensors is analyzed and then combined with other factors like speed and traffic and drives itself safely. It is still under process for optimization but is still considered one of the best applications of IoT.



**3. Smart home:** In this smart generation people want everything to happen with a touch of a button. This is fulfilled by attaching different sensors, cameras, transmitters, receivers, etc. with the help of IoT. Some of the most common devices which use IoT are smart air conditioners, lights, fans, windows, doors, etc. Few IoT applications are

- **Virtual assistant:** Virtual Assistant are like a part of your home these days. They help us perform many basic tasks by just speaking it aloud. Some of the most common works are like switching on/off the lights, controlling other electronic devices, making call, playing music, etc. They are usually connected to the internet where they are able to communicate with the main server. They use a microphone to take in our commands, analyze it and then perform the specific action.

One of the most common everyday examples is Amazon Alexa, Google nest, etc. They have in-built sensors and microphone which are used to take in voice commands from users and are send to a cloud server over the internet and the command is analyzed to find the correct response and it is executed.



- **Smart Infrastructure:** Within the cities there is a lot of buildings and urban infrastructure. We can build smart buildings with IoT where we add different sensors to do different things. Some of the best uses is in the air conditioners and heaters. We can create them using IoT in such a way that they can measure the outside temperature and automatically adapt to it by increasing or decreasing the internal room temperature. Also, we can add sensors to different devices like lights which can be programmed to on when a person is present and turned off when no one is present. This helps in saving a lot of electricity.

- **Security:** One of the most important aspects of a house is its security. We cannot always be at home guarding it. Here comes the place of sensors which are placed at different places in the house. They are programmed in such a way that they can detect even the slightest movement in the house and alert the owner about the breach in. In addition to this we can even program it in such a way that they can directly alert the nearest police station in case of break in.
- **Automatic doors:** The most common applications of IoT which we can see every day is automatic opening and closing of doors. This is most common in places like shopping malls, movie theaters, etc. There are sensors attached at the front of the doors which recognize the presence of people and open itself. This can be more upgraded to only give access to specific people by either face recognition or unique identity of the person which can be either fingerprint or Bluetooth or security cards.



**4. Smart Health:** There are a lot of IoT applications in the field of healthcare for both the healthcare professionals as well as to the patients. IoT have enabled remote monitoring of health which help to keep the patients safe and healthy and warn in case of any trouble.

- **Remote monitoring of patients:** It is one of the most commonly used IoT application. The data of the patient's heart rate, glucose, temperature and other vital signs are directly sent to the doctor's office where he can monitor it remotely. This would be very useful when either the patient or the doctor cannot be physically present at a time. The IoT trackers track the data and send it to the respective destination which can be also accessed with an app.

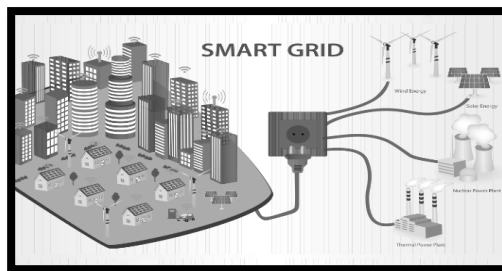
One of the real time application of this can be seen in patients pacemaker. The new gen pacemakers are coming with embedded IoT through which the doctors can control and stimulate the patients heart beat.

- **Smart bands:** The most popular and one of the best applications of IoT is in smart watches/bands. They contain sensors at the back which help to continuously track few vitals of a person. The main advantage is its compactness and cost-efficient way of tracking without the help of heavy machinery. They can track different vitals like heart rate (bpm), breathing, oxygen levels, etc. Now a days they also come with equipped alarm which is used to intimate few chosen people in case of sudden spike in their vitals and they are not in a situation to do anything. This was proven very useful and was successful in saving many lives.

Some of the most common smart bands are Apple watch, Mi fit, Fastrack reflex, etc.



- **Staff and equipment tracking:** IoT is also used to keep a track of equipment being used like wheelchairs, stretchers, etc. and the medicines being sold at every movement of time. Also, they can be used to keep a track of the hospital staff which would help them in efficient assignment of doctors to the patients. The equipment tracking is really useful cause in case of any emergency they can immediately locate the medicines (like blood, oxygen cylinders, etc.) and help the patients.
5. **Smart Grid:** The term “Grid” means nothing but the network of the electrical wires which serve the purpose of providing electricity to every household. Smart grid uses different sensors, gateways, routers, etc. to wirelessly communicate and to make better energy usage decisions. In these days the government as well as the municipalities are switching to smart grid as it is easier to use and more efficient.



- **Smart grid sensors and meters:** The role of sensors in IoT is really useful. They can be used for tracking energy consumption on the consumer side. Then the data is analyzed and reports on consumption are generated through which consumers can monitor their usage including loads and estimated cost.

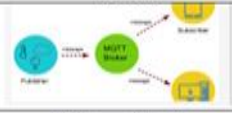
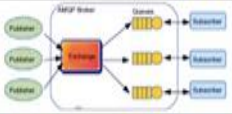

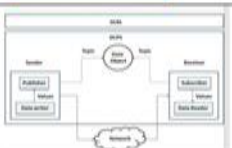


- **Automated distributions:** They use IoT to estimate real-time data and respond to the fluctuations in load, detect overload and correct power distribution to enable both safety and cost effectiveness.

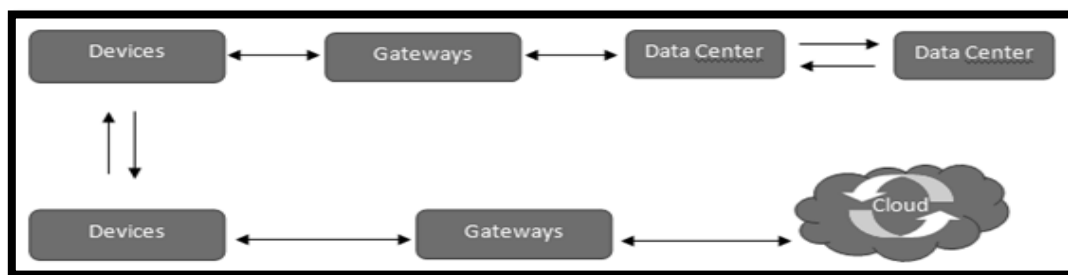
- **Smart street lights:** One small application of a IoT is installing street lights with built in sunlight detecting sensors. They automatically turn on in the evening and turn off in the morning. They help in energy saving a lot. It is widely used these days and has proved to be more efficient.

## VII. IOT PROTOCOLS

1. The IoT grew up to an entirely different Internet. Four major IoT communication protocols.

Protocol Name	Advantages	Structure
Message Queue Telemetry Transport Protocol	It is suitable for M2M, WSN or IoT applications. Data transfer MQTT is reliable, user friendly and easy to build. It utilizes less network resources.	
Advanced Message Queuing Protocol	More reliable and secure, flexible routing, durable, continuous and high availability queues. In case of network down, the consumer need not connect to broker every time.	
Constrained Application Protocol	It is a light-weight fast HTTP for use with constrained nodes in the IoT. COAP makes use of the UDP protocol. Message reliability is handled at the application layer. Asynchronous message exchanges.	
Data Distribution Service Protocol	DDS supports private key infrastructure protocol. DDS is a peer to peer, low-latency and high-performance communication protocol.	

2. **IoT architecture:** An IoT system comprises of devices, gateways and data systems.



Four types of Transmission Channels

The above IoT architecture where the sensors/devices send data to a gateway and then takes all that consolidated data and retransmit the data to the cloud and Data centres.

Arduino UNO Microcontroller and ESP 8266 Wi-fi Module are employed for implementing the IoT server, and an IoT framework which is used for communication between the IoT server and cloud.

3. **Steps to upload sensors data to cloud**

- **Step1:** (Sign-up) & Configuration

Create an account into Thingspeak (Initially it requests for details and mail verification).

- **Step2:** Only 4 projects are allowed to upload onto the free cloud. If payment is accepted you can upload for more projects.
- **Step3:** Click on New channel and then it requests for data. Enter some sample data such as weather data. In weather data it prompts for project description. Eight sensors related data can be upload in one project. (Examples: Temperature sensor, Humidity sensor etc.) Go to the private view and save it. (Considered private view)
- **Step4:** The code merges with the cloud using the API key. Click on the API key (which is a 12-digit API) interface between cloud and code. API key play an important role. Define thingspeak.com function. Enable ESP8266wifi module. Import DHT11 library. Go to sketch folder--Add DHT11 ZIP file. Use WIFI server code 80 to upload data to api.thingspeak.com (URL).

- 4. Retrieving data from thingspeak server:** ThingSpeak is an IoT analytics cloud platform service that permits you to blend, visualize and analyze live knowledge streams within the cloud. ThingSpeak provides immediate visualizations of data by ESP8266 (ESP8266 Wi-Fi silicon micro controller chip). We can download the collected data by navigating to "Data Import/Export" -Export" à "Download". This will generate in a CSV formatted spreadsheet file. We can use that file data for analysis and make predictions.

## VIII. CONCLUSION

The IOT has developed in many ways and has proved to be beneficial for the consumers and at the same time increasing number of connected devices increases the privacy and security concerns of the developers of the devices. The manufacturing of these sensors is done in a huge quantity and producing devices with poor security systems might prove risky. There are many security measures developed by using machine learning and deep learning algorithms to overcome these threats and to develop threat free devices for the better future. There is industry growth in Virtual reality & Augmented reality and how government and companies are implementing them. Also, there are many IoT projects which are working at real time to help us and makes our life easier. Also, research is still going on in this field to invent more innovative applications and to try to increase the efficiency of the existing ones.

## REFERENCES

- [1] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, "A survey on internet of things: Architecture, enabling technologies, security and privacy, and applications," IEEE Internet of Things Journal, vol. 4, no. 5, pp. 1125–1142, Oct 2017.
- [2] S. B. Baker, W. Xiang, and I. Atkinson, "Internet of things for smart healthcare: Technologies, challenges, and opportunities," IEEE Access, vol. 5, pp. 26 521–26 544, 2017.



- [3] O. Elijah, T. A. Rahman, I. Orikumhi, C. Y. Leow, and M. N. Hindia, "An overview of internet of things (iot) and data analytics in agriculture: Benefits and challenges," *IEEE Internet of Things Journal*, vol. 5, no. 5, pp. 3758–3773, Oct 2018.
- [4] H. Xu, W. Yu, D. Griffith, and N. Golmie, "A survey on industrial internet of things: A cyber-physical systems perspective," *IEEE Access*, vol. 6, pp. 78 238–78 259, 2018.
- [5] Z. Ling, J. Luo, Y. Xu, C. Gao, K. Wu, and X. Fu, "Security vulnerabilities of internet of things: A case study of the smart plug system," *IEEE Internet of Things Journal*, vol. 4, no. 6, pp. 1899–1909, Dec 2017.
- [6] Gupta, A. K., & Johari, R. (2019). IOT based Electrical Device Surveillance and Control System. 2019 4th International Conference
- [7] on Internet of Things: Smart Innovation and Usages (IoT-SIU). doi:10.1109/iot-siu.2019.8777342.
- [8] Fox, J., Donnellan, A., & Doumen, L. (2019). The deployment of an IoT network infrastructure, as a localised regional service. 2019 IEEE 5th World Forum on Internet of Things (WF-IoT). doi:10.1109/wf-iot.2019.8767188.
- [9] MQTT.org, "MQTT." [Online]. Available: <http://mqtt.org/>.
- [10] Vishwakarma, S. K., Upadhyaya, P., Kumari, B., & Mishra, A. K. (2019). Smart Energy Efficient Home Automation System Using IoT. 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU). doi:10.1109/iot-siu.2019.8777607.