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# PRACTICAL APPLICATIONS OF INTRNET OF THINGS (IOT)

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## 1.1 INTRODUCTION:

The concept of IoT dates back to 1982 when a modified coke machine was connected to the Internet which was able to report the drinks contained and that whether the drinks were cold [4]. Later, in 1991, a contemporary vision of IoT in the form of ubiquitous computing was first given by Mark Weiser . However in 1999, Bill Joy gave a clue about Device to Device communication in his taxonomy of internet [6]. In the very same year, Kevin Ashton proposed the term"Internet of Things" to describe a system of interconnected devices [7]. The basic idea of IoT is to allow autonomous exchange of useful information between invisibly embedded different uniquely identifiable real world devices around us, fueled by the leading technologies like Radio-Frequency Identification (RFID) and Wireless Sensor Networks (WSNs) [2] which are sensed by the sensor devices and further processed for decision making, on the basis of which an automated action is performed:[1]

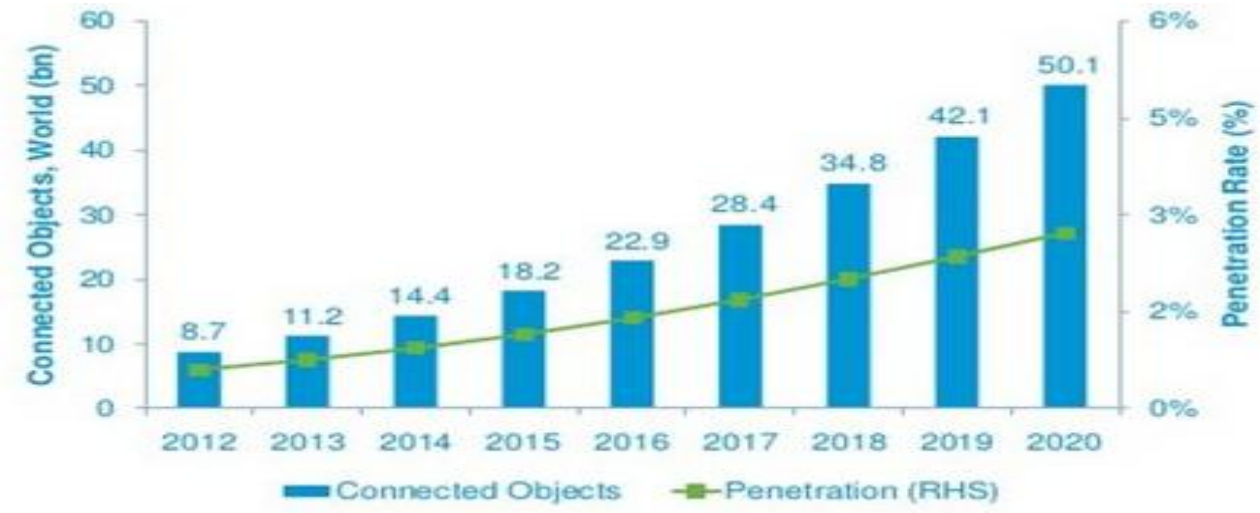


FIGURE 1:Expected penetration of connected objects by the year 2020, according to Cisco

## 1.2 ARCHITECTURE:

A number of multi-layered securityarchitectures are proposed. described a three key level architectureof IoT while described a four key level architecture. proposed a five layered architecture using the best features ofthe architectures of Internet and Telecommunication

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managementnetworks based on TCP/IP and TMN models respectively. Similarlya six-layered architecture was also proposed based on the networkhierarchical structure . So generally it's divided into sixlayers as shown in fig2.which is a huge number so the existing architecture of Internet with TCP/IP protocols, adopted in 1980, cannot handle a network as big as IoT which caused a need for a new open architecture that could address various security and Quality of Service (QoS) issues as well as it could support the existing network applications using open protocols.Without a proper privacy assurance, IoT is not likely to be adopted by many . Therefore protection of data and privacy of users are key challenges for IoT

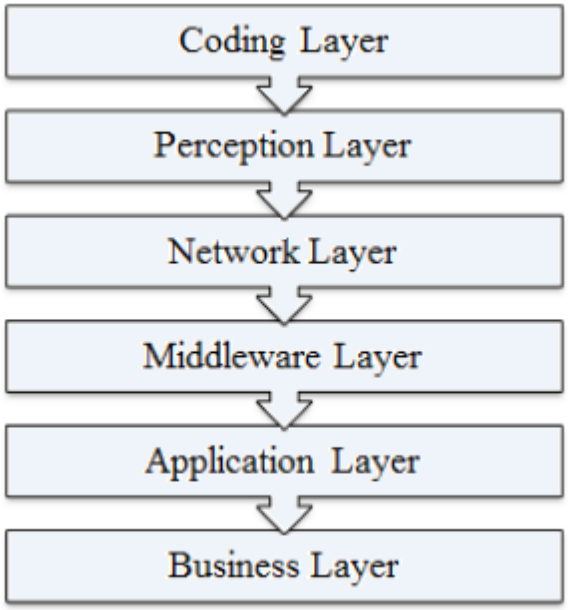


FIGURE-2: Six-Layered Architecture of IoT

### 1.2.1 Coding Layer

Coding layer is the foundation of IoT which provides identificationto the objects of interest. In this layer, each object is assigned aunique ID which makes it easy to discern the objects.

### 1.2.2Perception Layer

This is the device layer of IoT which gives a physical meaning toeach object. It consists of data sensors in different forms like RFIDtags, IR sensors or other sensor networks [23] which could sensethe temperature, humidity, speed and location etc of the objects.This layer gathers the useful information of the objects from thesensor devices linked with them and converts

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the information intodigital signals which is then passed onto the Network Layer forfurther action.

### 1.2.2 Network Layer

The purpose of this layer is receive the useful information in theform of digital signals from the Perception Layer and transmit it to the processing systems in the Middleware Layer through the transmissionmediums like WiFi, Bluetooth , WiFIMaX, Zigbee, GSM, 3Getc with protocols like IPv4, IPv6, MQTT, DDS etc.

### 1.2.3 Middleware layer

This layer processes the information received from the sensor devicesIt includes the technologies like Cloud computing, Ubiquitouscomputing which ensures a direct access to the database tostore all the necessary information in it. Using some Intelligent ProcessingEquipment, the information is processed and a fully automatedaction is taken based on the processed results of the information.

### 1.2.4 Application layer

This layer realizes the applications of IoT for all kinds of industry,based on the processed data. Because applications promote the developmentof IoT so this layer is very helpful in the large scale developmentof IoT network [21]. The IoT related applications couldbe smart homes, smart transportation, smart planet etc.

### 1.2.5 Business layer

This layer manages the applications and services of IoT and is responsiblefor all the research related to IoT. It generates differentbusiness models for effective business strategies

### Essential IoT technologies:

1. Radio frequency identification (RFID);
2. Wireless sensor networks (WSN);
3. Middleware;
4. Cloud computing;
5. IoT application software.

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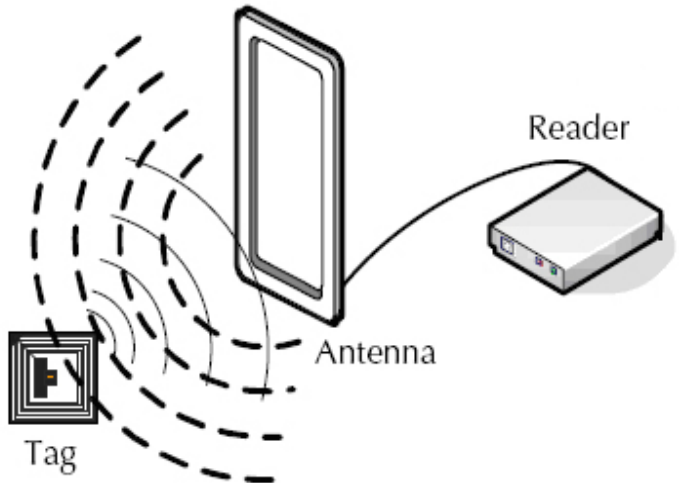
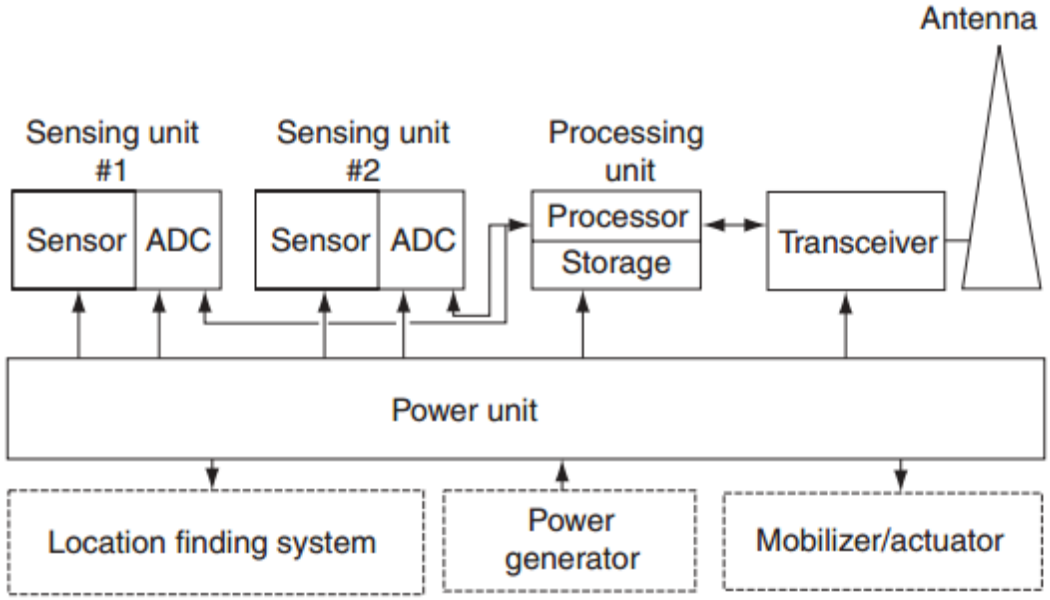



**RFID**




**WSN**

## 1.4 LITERATURE SURVEY

| S.NO | TITLE OF THE EXPERIMENT | DATE | REMARKS |
|---|---|---|---|
| 1. | A Review on Internet of Things(IoT) [1] | 2015 | This paper aims to provide a comprehensive overview of the IoT scenario and reviews its enabling technologies and |

| | | | |
|---|---|---|---|
| | | | the sensor networks |
| 2. | Use IoT Technology To Drive The Automotive Industry From Connected To Full Autonomous Vehicles [2] | 2016 | This paper examines the market and technical trends towards Autonomous Vehicles, evolution stages from early cars to fully autonomous |
| 3 | The Internet of Thing (IoT):Applications, investments, and challenges for enterprises [3] | 2017 | It discusses three IoT categories for enterprise applications used to enhance customer value. |
| 4 | Internet of Things: Trends , Challenges and Applications [4] | 2018 | This paper gives an overview of the trends, challenges and applications of the Internet of Things (IoT). It is paving the way towards a smart, interconnected world with infinite opportunities. |

| S:NO | TITLE OF THE PAPER | YEAR | REMARKS |
|---|---|---|---|
| 5 | Automatic Smart Receptacle Using IoT and Mobile Application [5] | 2021 | The main idea of this research work is to assemble a programmed dustbin, where it can automatically open and close the top layer to collect the trash from the person, |
| 6 | An IoT Based Smart Cubicle System for Effective Power Usage and Employee Monitoring in Offices [6] | 2018 | Our proposed system will eliminate the human errors such as leaving the buttons on due to negligence. The advent of such a system will conserve energy, enhance customer service and aid economic development. |
| 7 | Home IoT device certification through speaker recognition [7] | 2015 | This paper illustrates voice recognition technology and the trend of security that also proposes a system to control functions of daily living in the home environment |
| 8 | IoT based Electrical Device Surveillance and Control System [8] | 2019 | This paper talks about an energy saving electrical device Surveillance and Control system based on IOT. |

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## 2.1IoT applications to enhance customer value:

2.1.1 Monitoring and control

Monitoring and control systems collect data on equipment performance, energy usage, and environmental conditions, and allow managers and automated controllers to constantly track performance in real time anywhere, anytime. Advanced monitoring and control technologies such as smart grid and smart metering reveal operational patterns, spot areas of potential improvement, or predict future outcomes and optimize operations, leading to lower costs and higher productivity.

### 2.1.2 Big data and business analytics

IoT devices and machines with embedded sensors and actuators generate enormous amounts of data and transmit it to business intelligence and analytics tools for humans to make decisions. These data are used to discover and resolve business issuessuch as changes in customer behavior and market conditionsto increase customer satisfaction, and to provide value-added services to customers. Business analytics tools may be embedded into IoT devices, such as wearable health monitoring sensors, so that real-time decision making can take place at the source of data.

### 2.1.3 Information sharing and collaboration

Information sharing and collaboration in the IoT can occur between people, between people and things, and between things. Sensing a predefined event is usually the first step for information sharing and collaboration. In the supply chain area, information sharing and collaboration enhance situational awareness and avoid information delay and distortion. For example, if sensors are placed throughout a retail store where refrigeration is necessary, alerts can be sent to the store manager's mobile device whenever the refrigerators malfunction. The manager can then check the employee status report to see who is available and send task assignments to that employee via his or her IoT-enabled mobile device.

## 2.2 Evolution of the foundational IoT technologies:

the combination of increased revenues and lower costs will migrate among companies and industries from 2013 to 2022. From an industry perspective, four industries make up more than half of the $14.4

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trillion in value. These leading four industries in terms of value at stake include manufactuing at 27%; retail trade at 11%; information services at 9%; and finance and insurance, also at 9%. Other industries such as wholesale, healthcare, and education lag behind in terms of value generation, with a range between 1% and 7%. Much of the value for manufacturers comes from greater agility and flexibility in factories, and from the ability to make the most of workers' skills. Additionally, a large amount of the value for retailers comes from connected marketing and advertising. Geographic distributions of the value are heavily driven by each region's relative economic growth rate and by the relative size of industry sector in each region. In the United States, $4.6 trillion of value is most prevalent in the services area. However, in China, $1.8 trillion of value is derived from rapid economic growth, mainly in the manufacturing sector[2]

## 2.3 IOT MARKET FORECAST FOR CONNECTED VEHICLES:

As the main driver for Autonomous vehicle industry, the IoT market has seen a steady growth since 2014 and is projected to continue with this growth as shown in the figure below. Fig. 2. World market forecast for registered vehicles with IoT applications (Source: ABI Research) According to Gartner, a market research firm, IoT product and service suppliers will generate incremental revenue exceeding $300 billion in 2020. While IDC, another research firm, forecasts that the worldwide market for IoT solutions will grow to $7.1 trillion in 2020.

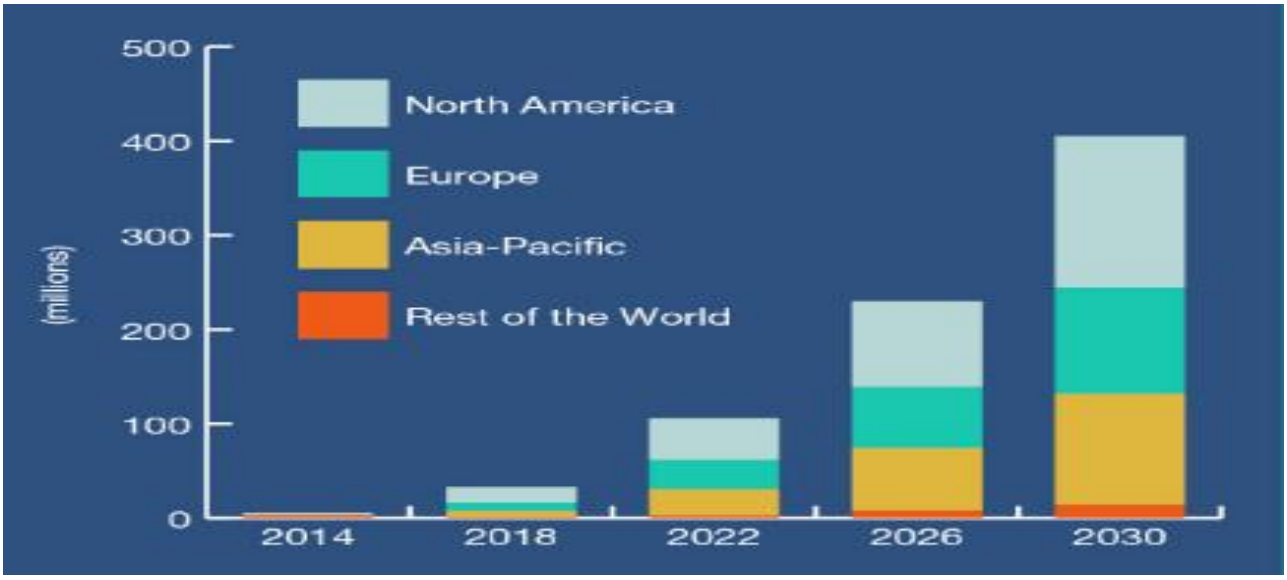


**FIGURE-3**: World market forecast for registered vehicles with IoT applications

### 3.1 IoT investment opportunities and evaluation (net present value vs. real option approach):

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Our survey shows the IoT is penetrating a wide range of industries including retailing, manufacturing, healthcare, insurance, home appliances, heavy equipment, airlines, and logistics. The benefits of IoT technologies such as RFID-based merchandise tracking and home networking are concrete and immediately measurable. Other IoT technologies such as intelligent automobiles and intelligent hospital robot systems are in the experimental stage and their benefits may be realized in the long term. While the IoT is relatively new, investment opportunities abound, along with the development of various foundational technologies summarized . Companies are expected to take advantage of the wave of IoT innovations in the coming years. In general, companies are going to take an immediate investment or a wait-and-see approach to investment based on the maturity level of the specific IoT technologies.[3]

Table 3. Real options variables

| Real Options | Variable | Financial Options |
|---|---|---|
| Present Value of Project | S | Current Stock Price |
| Investment Cost of a Project | X | Option Exercise Price |
| Riskiness/Uncertainty of the Project | $\sigma^2$ | Stock Price Uncertainty |
| Time Window of the Project | T | Time to Expiration |
| Time Value of Money | r | Risk-free Rate |

Source: Adapted from Li & Johnson (2002)

FIGURE-4:Real options

## 3.2 VISION OF AUTONOMOUS CARS:

**Definition for autonomous car**

A definition of a self-driving vehicle is any vehicle with features that allow it to accelerate, brake, and steer with limited or no driver interaction. Depending on who defines how and where the definition comes from, autonomous vehicles are divided into two different types: -

semi-autonomous

fully autonomous

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Semi-autonomous cars can accelerate, brake and steer, keep the distance from the car in front and also keep the lane at speeds up to 130 km/h, but the driver is still required and is still in full control. A fully autonomous vehicle can drive from point A to point B without needing any interaction from the driver. It is expected and believed that this type of car will debut in 2019/2020 timeframe.

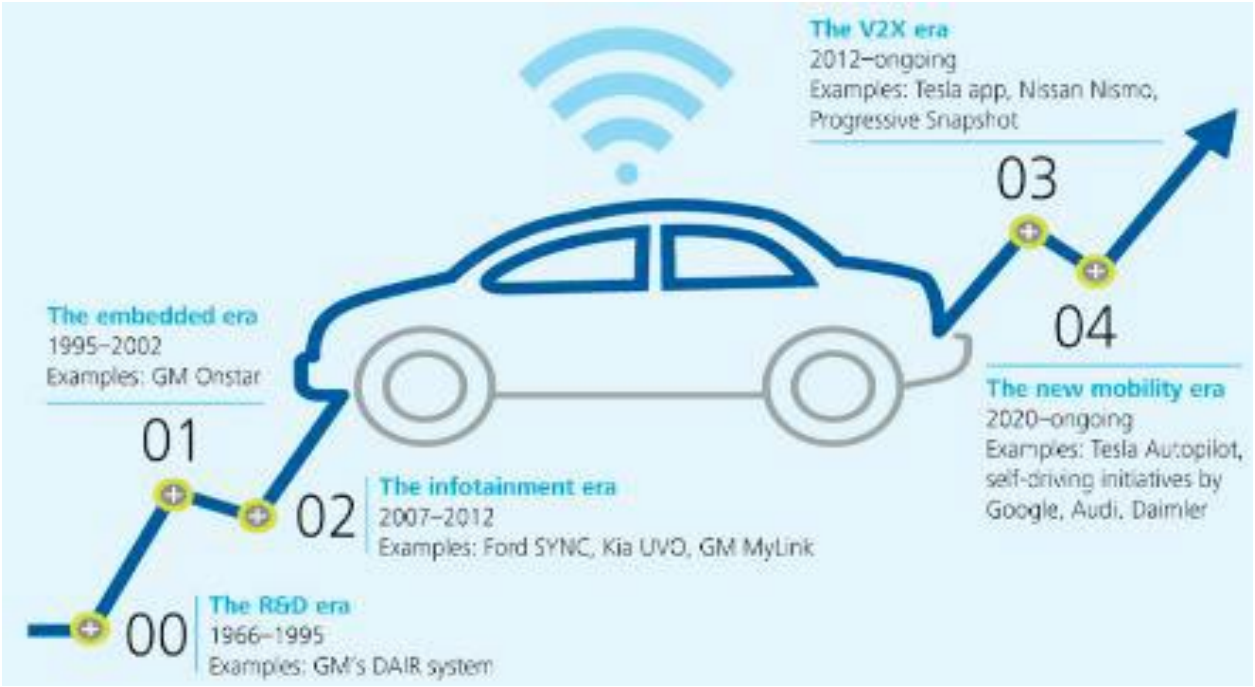


**FIGURE-5:**Car evolution path

## 3.3 FIVE PHASES BEHIND EVOLUTION OF CAR:

3.3.1 Research and development era :

This was the longest era, about 30 years long, during which great ideas were proposed but not implemented due to lack of technologies

3.3.2 Embedded era :

This is the era of embedded modules in the cars, e.g. mobile phones, used for communicating information wirelessly to a telematics service provided

3.3.3 Infotainment era :

This era marks the introduction of information and entertainment applications in the vehicle and starts a shift in the power equation in the industry where new players are added to the ecosystem, software providers and third-party content and app providers

3.3.4 V2X era:

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Communication of vehicle to any vehicle or infrastructure  This is the era that combines the embedded technology and services where the key elements are multiple sensors in the vehicle, in smart devices, smart home gadgets and infrastructure and which communicate and share data within an integration called V2X integration .

3.3.5 The new mobility era:This era of autonomous vehicles is expected to take off in 2020. Some prototype self-driving vehicles are already on the road ✓ This is also an era that carmakers and software providers compete for dominance and which may trigger a further shift away from vehicles as owned asset

## 4.1 MARKET TRENDS OF AUTOMATED CARS:

As indicated in other sections of this paper, the potential of self-driving vehicles market is huge with the direct impacts in many sectors. According to BI Intelligence, 10 million self-driving cars will be on the road by 2020, as shown in the figure below. Fig. 5. Global installed base of cars with self-driving features (Source: BI Intelligence) Different market research firms look at market and technical trends for self-driving vehicles from different angles and perspectives and their predictions and projections could be summarized as following (Bertoncello& Wee, 2015): Self-driving vehicles could deliver up to $507 billion in annual productivity gains Advanced Driver Assistance Systems market will increase to $23.6 billion by 2022, compared to approximately $15.0 billion at present More than 250 million vehicles will be connected globally by 2020, which will be an increase of 67% By the same period, 2020, it is estimated that consumer spending on in-vehicle connectivity will double It is anticipated that next generation drivers would like to have their cars act like smartphones on wheels, i.e. to have their cars connected while on the go and they are ready to spend quite a bit of money

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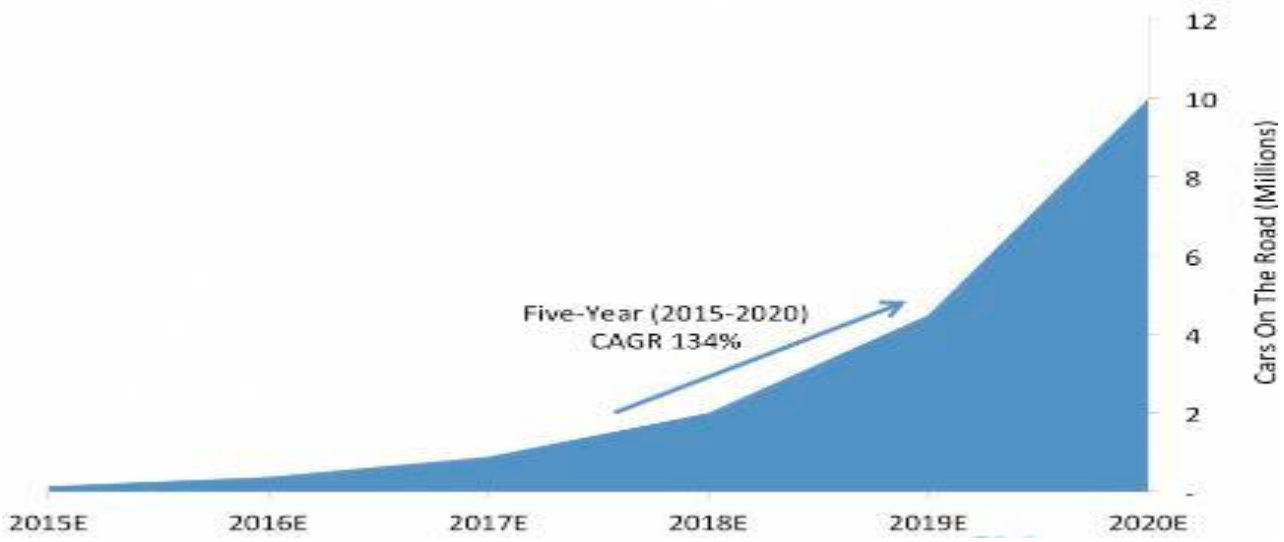


FIGURE-6: Global installed base of cars with self-driving features

## 4.2 THE ADVANTAGES OF AUTOMATED CARS (GREENOUGH, 2016) OUTWEIGH THE DISADVANTAGES

- Improvements of safety on the roads
- Without driver error there will be fewer vehicle crashes
- There were 1713 deaths in UK roads in 2013 where 80% of accidents were due to human error
- KPMG estimates that self-driving cars will lead to 2,500 fewer deaths between 2014 and 2030 in UK roads
- Better mobility for young, elderly, and disabled
- Provide independent mobility for non-drivers
- Reduces the need for non-drivers to have chauffeurs and other expensive transport
- Improvement of road congestions
- Traffic flow could be more efficient and congestion decreased
- Average UK motorist spends 30 hours a year in traffic jams and 82 hours in London
- Drivers can spend their time doing something else and more useful
- 7500 km of European motorways are blocked by traffic jams every day
- Improvement of fuel efficiency and parking spaces
- Less congestion means less fuel consumption and less pollution

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- Less urban parking will be needed
- Studies in the UK show that urban space released from the parking will increase for 15-20%, where in London alone, 16% of urban space is allocated to parking These advantages would be relevant to developing and poorer countries, in particular reduction of accidents that is a bigger issue in developing and poorer countries than in developed countries, but lack of road infrastructure in these countries will delay any early implementation.

DISADVANTAGES

- Potential impacts on businesses and economies based on public transit,
- automobile insurance and services
- Insurance Companies Association in US has warned that autonomous cars could disrupt their business model
- Cost reduction of driving may result in traffic congestion increase
- Increase of car costs for users
- Enhancements and maintenance cost and road infrastructure

## 4.3 KEY ISSUES OF SELF-DRIVING VEHICLES

Lack of good software

- Fail-proof software is needed to make sure no problems will happen
- Tesla accident in May 2016 where Tesla's car failed to distinguish a white tractor-trailer crossing the motorway against a bright sky
- Potential software problems as we have in today's systems could be fatal for car users

Lack of good maps

- Better maps with some additional details known as Street View on steroids that can recognize the surrounding objects and create some virtual-world maps of the streets
- This helps the self-driving cars to find the way and only look at dynamic obstacles, such as cars and pedestrians So far, only a fraction of roads in USA are covered by these enhanced maps
- When it comes to developing countries, this is even a bigger issue since it will take some time, probably years to have enhanced maps in those poorer countries

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Lack of good sensors

- Sensors to sense different unpredicted situations and to be able to differentiate between very dangerous situations from those less dangerous are needed
- Currently sensors are not capable of these features and can't process quickly these situations

## 5.1 HOW ENERGY SAVING HAPPENED IN ELECTRICAL DEVICES BASED ON IOT

This IOT based device surveillance and control system is exclusively used to keep surveillance on the electrical devices working condition and also to control the on/off functionality from a central remote location. The designed system works efficiently for both indoor and outdoor lighting. On the one hand it improves efficiency of the system by sending alert signal in case of any defect and on the other hand it drastically reduces the electric energy consumption by providing central control over the appliances. The graphical App based mobile controlling gives a user friendly and easily accessible platform to the user. This system can be installed as energy efficient system to control street lamp that requires a lot of energy and needs manual intervene

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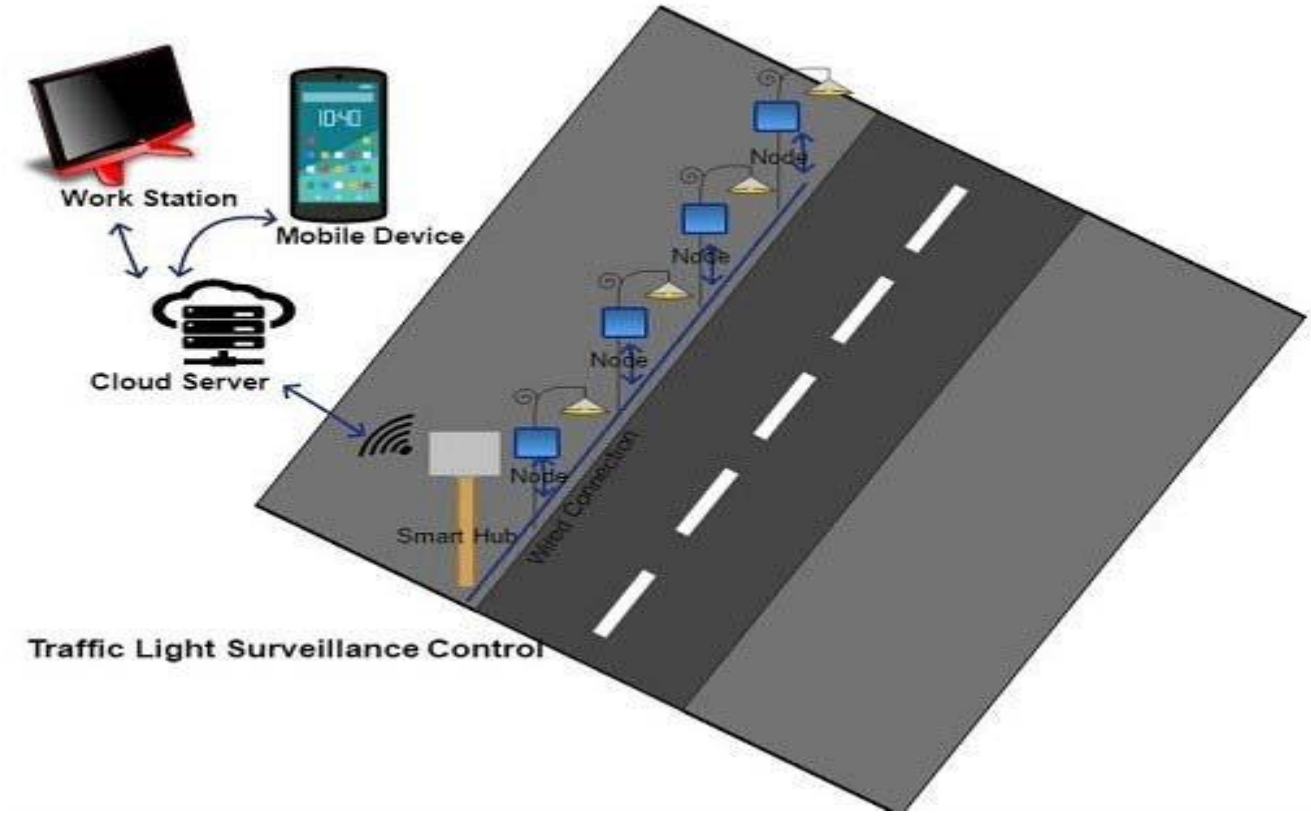


FIGURE-7:Block diagram of Wi-Fi based survilience and control system (One directional)

## 5.2 HOW IOT ELIMINATES HUMAN ERRORS

Sustainable development is the need of the hour. Hence, it is the main goal of a number of researches to conserve the resources by building or modifying the existing systems so as to use energy efficiently. In this paper we have proposed a new smart lighting system which has cheap and easy-to-install extensions to the current platform. The use of IOT has made it very easy to overcome the existing flaws thus reducing wastage due to human error. The implementation of IOT and use of raspberry Pi can is used for better monitoring of the employee actions as an added application and advantage of the system. The timestamp of the pin turning HIGH at entry of the employee in the range (his desk) of the PIR and the duration till it turns LOW (his working hours) can be analyzed to study the work-patterns of the employees. Thus, the enforcement of our proposed model will help reduce extravagant use of electricity as well as help in Employee monitoring.

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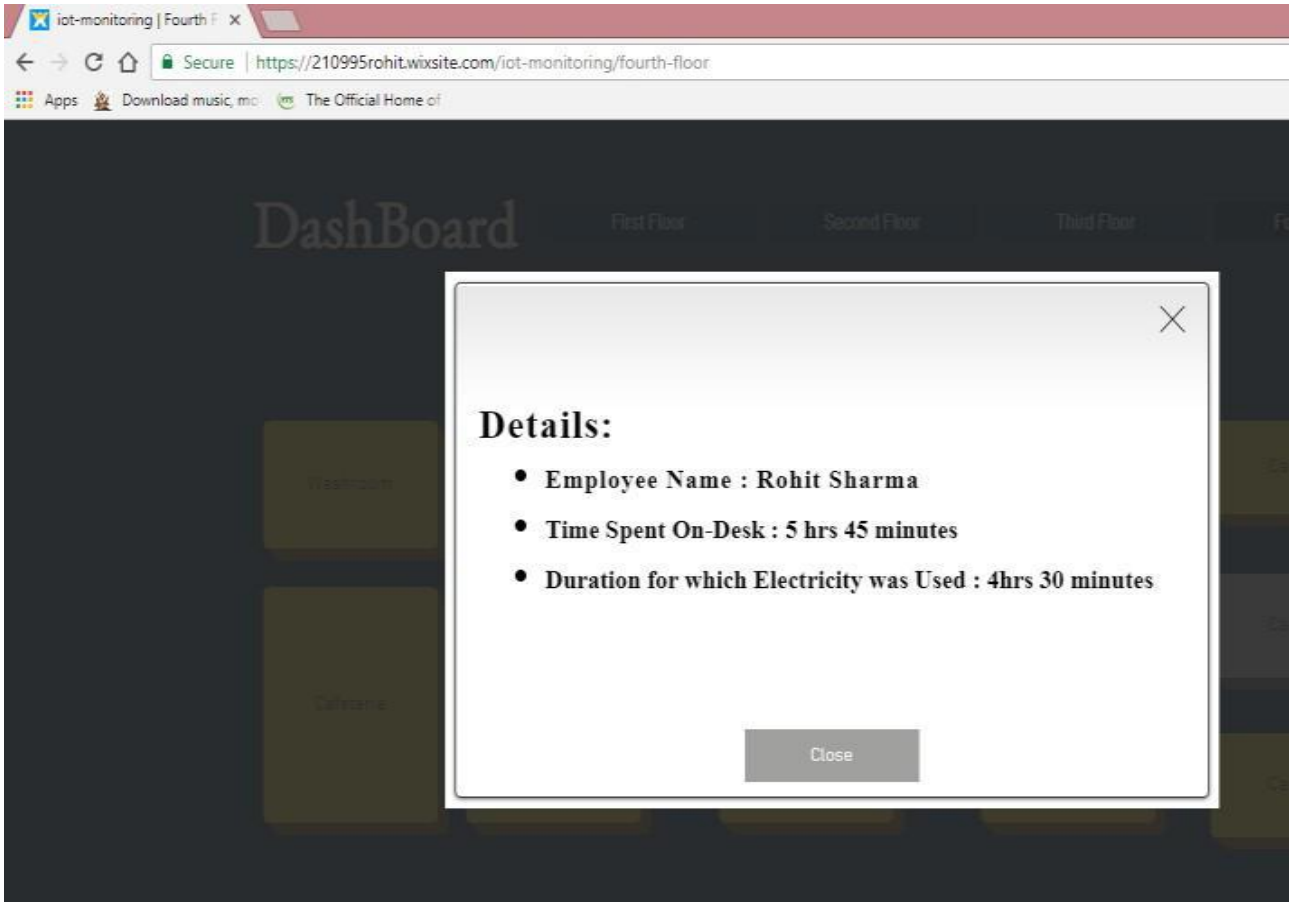


FIGURE-8:. Employee Monitoring

## 5.3 VOICE RECOGNITION TECHNOLOGY

To prevent control from unauthorized users of control devices in Home IoT, biometric security is being considered. Through voice recognition which is among one of them, the speaker can be recognized in advance and through analysis of corresponding commands only authorized users can control corresponding control devices at the same time with fast recognition rates high security can

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be expected

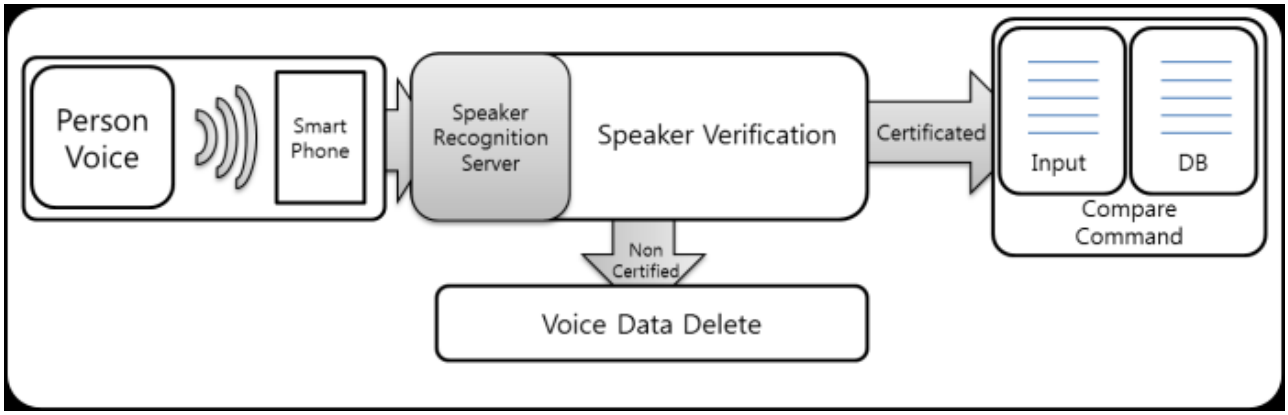


FIGURE-9:User recognition and command recognition through voice

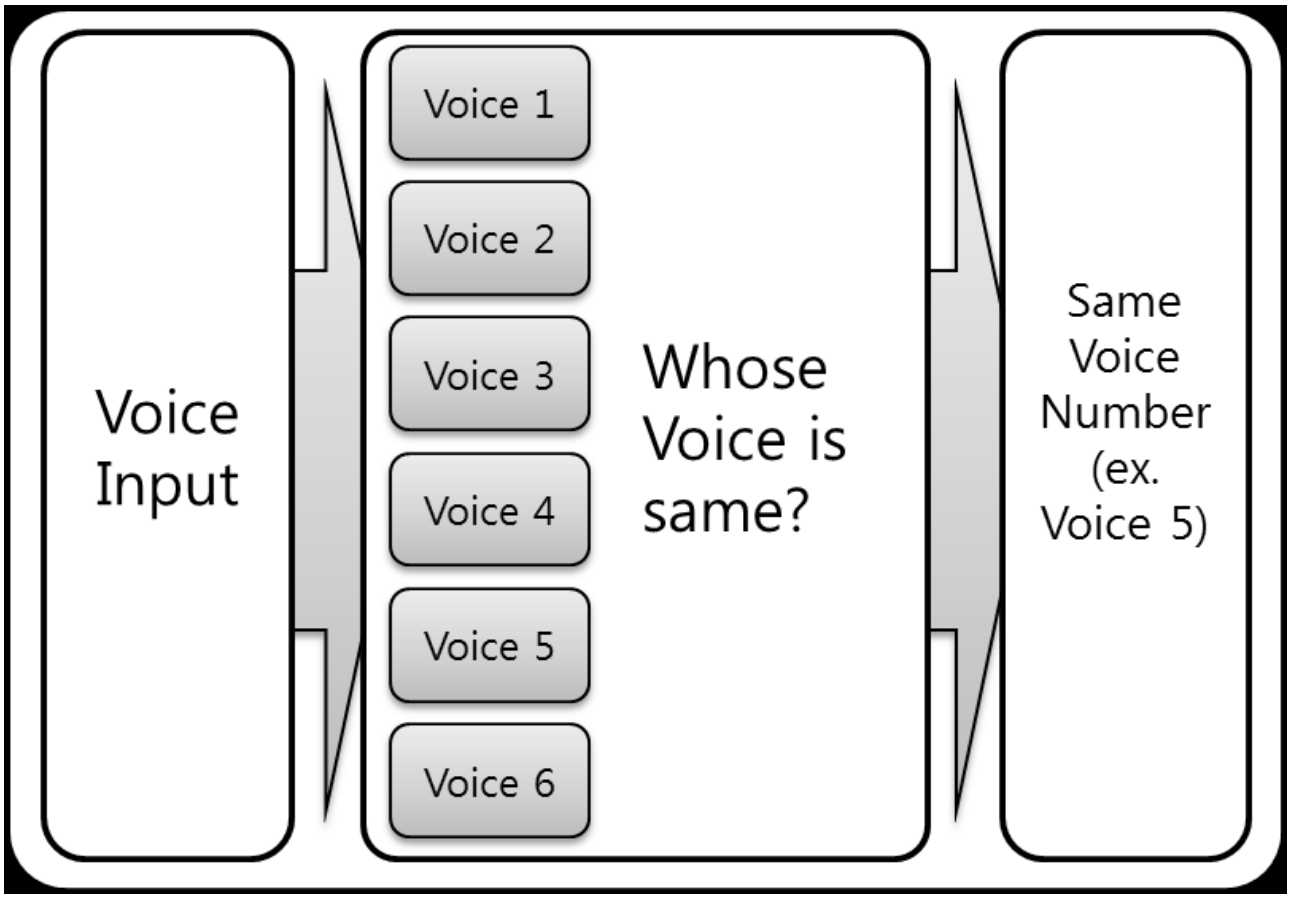


FIGURE-10:Speaker identification technology

## 6.1 CHALLENGES IN IOT DEVELOPMENT

6.1.1 Data management challenge

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IoT sensors and devices are generating massive amounts of data that need to be processed and stored. The current architecture of the data centre is not prepared to deal with the heterogeneous nature and sheer volume of personal and enterprise data (Gartner, 2014). Few enterprises would be able to invest in data storage sufficient to house all the IoT data collected from their networks. Consequently, they will prioritize data for operations or backup based on needs and value. Data centres will become more distributed to improve processing efficiency and response time as IoT devices become more widely used and consume more bandwidth.

6.1.2. Data mining challenge

As more data are available for processing and analy- sis, the use of data mining tools becomes a necessity. Data consist not only of traditional discrete data, but also of streaming data generated from digital sensors in industrial equipment, automobiles, electrical meters, and shipping crates. These streaming data are about location, movement, vibration, temperature, humidity, and even chemical changes in the air. Data mining tools can invoke corrective processes to ad- dress immediate operational issues or inform man- agers of discoveries regarding competitors' strategic moves and customers' preference changes that will impact their short-term and long-term business activities.

6.1.3. Privacy challenge

As is the case with smart health equipment and smart car emergency services, IoT devices can provide a vast amount of data on IoT users' location and movements, health conditions, and purchasing preferences all of which can spark significant privacy concerns. Protecting privacy is often counter- productive to service providers in this scenario, as data generated by the IoT is key to improving the quality of people's lives and decreasing service providers' costs by streamlining operations. The IoT is likely to improve the quality of people's lives. According to the 2014 TRUST e Internet of Things Privacy Index, only 22% of Internet users agreed that the benefits of smart devices outweighed any privacy concerns (TRUST e, 2014). While the IoT continues to gain momentum through smart home systems and wearable devices, confidence in and acceptance of the IoT will depend on the protection of users' privacy.

6.1.4. Security challenge

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As a growing number and variety of connected devices are introduced into IoT networks, the potential security threat escalates. Although the IoT improves the productivity of companies and enhances the quality of people's lives, the IoT will also increase the potential attack surfaces for hackers and other cyber criminals. A recent study by Hewlett Packard (2014) revealed that 70% of the most commonly used IoT devices contain serious vulnerabilities. IoT devices have vulnerabilities due to lack of transport encryption, insecure Web interfaces, inadequate software protection, and insufficient authorization. On average, each device contained 25 holes, or risks of compromising the home network. Devices on the IoT typically do not use data encryption techniques. Some IoT applicationssupport sensitive infra-structures and strategic services such as the smart grid and facility protection. Other IoT applications will increasingly generate enormous amounts of personal data about household, health, and financial status that enterprises will be able to leverage for their businesses.

6.1.5. Chaos challenge

The evolution of IoT technologies (e.g., chips, sensors, wireless technologies) is in a hyperaccelerated innovation cycle that is much faster than the typical consumer product innovation cycle. There are still competing standards, insufficient security, privacy issues, complex communications, and proliferating numbers of poorly tested devices. If not designed carefully, multi-purpose devices and collaborative applications can turn our lives into chaos. In an unconnected world, a small error or mistake does not bring down a system; however, in a hyper-connected world, an error in one part of a system can cause disorder throughout. Smart home applications and medical monitoring and control systems consist of interconnected sensors and communication devices and controllers.

## 6.2 SECURITY AND PRIVACY CHALLENGES

IoT makes everything and person locatable and addressable which will make our lives much easier than before; however without a lack of confidence about the security and privacy of the user's data, it's more unlikely to be adopted by many [47]. So for its ubiquitous adoption, IoT must have a strong security infrastructure. Some of the possible IoT related issues are as followed:

6.2.1 Unauthorized Access to RFID

An unauthorized access to tags that contains the identification data is a major issue of IoT which can expose any kind of confidential information about the user so it needs to be addressed. Not just the tag can be read by a miscreant reader but it can even be modified or possibly be damaged. In

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this context, [47] summarized some of the real life threats of RFID which includes RFID Virus, Side Channel Attack with a cell-phone and SpeedPass Hack.

6.2.2 Sensor-Nodes Security Breach

WSNs are vulnerable to several types of attacks because sensor nodes are the part of a bi-directional sensor network as discussed in Section 4.2, which means other than the transmission of data, acquisition of data is also possible. [48] described some of the possible attacks that includes Jamming, tampering, Sybil, Flooding and some other kinds of attacks, which are summarized as followed:

(1) Jamming obstructs the entire network by interfering with the frequencies of sensor nodes.

(2) Tampering is the form of attack in which the node data can be extracted or altered by the attacker to make a controllable node.

(3) Sybil attack claims multiple pseudonymous identities for a node which gives it a big influence.

(4) Flooding is a kind of a DOS attack caused by a large amount of traffic that results in memory exhaustion.

6.2.3 Cloud Computing Abuse

Cloud Computing is a big network of converged servers which allow sharing of resources between each other. These shared resources can face a lot of security threats like Man-in-the-middle attack (MITM), Phishing etc. Steps must be taken to ensure the complete security of the clouding platform [49]. Cloud Security Alliance (CSA) proposed some possible threats among which few are Malicious Insider, Data Loss, Accounts Hijacking and Monstrous use of Shared Computers etc

## 6.3 APPLICATION

### 6.3.1TRACKING AND MONITORING DEVICES

The IoT devices use for tracking and monitoring are smallchips with minimal processing capabilities. Typically GSM,GPRS, LTE, ZigBee, WiFi and Mesh Network are used forcommunication while RFID, NFC, GNSS and BLE areemployed for tracking. Sensors are utilized to detecttemperature, vibration, humidity, pressure and altitude. Thechips can be powered by solar, energy harvesting or short burst\ battery usage. In contrast to mobile devices, IoT nodes do notuse complex System-on-Chips (SoCs)! Specifically, ICs forIoT devices are small and have low level of design IPintegration. They do not need leading edge logic processtechnologies or

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integration of logic with MEMS and other special purpose semiconductor processing. As a result, IoTcreates new design opportunities for small and mediumenterprises and developing countries

### 6.3.2 SMART HOMES

IoT home automation is the **ability to control domestic appliances by electronically controlled, internet-connected systems**. It may include setting complex heating and lighting systems in advance and setting alarms and home security controls, all connected by a central hub and remote-controlled by a mobile app.


### 6.3.3 SMART GRIDS

IoT can be used in customer side in smart meters to **measure different types of parameters**, intelligent power consumption, interoperability between different networks, charging and discharging of electric vehicles, manage energy efficiency and power demand.

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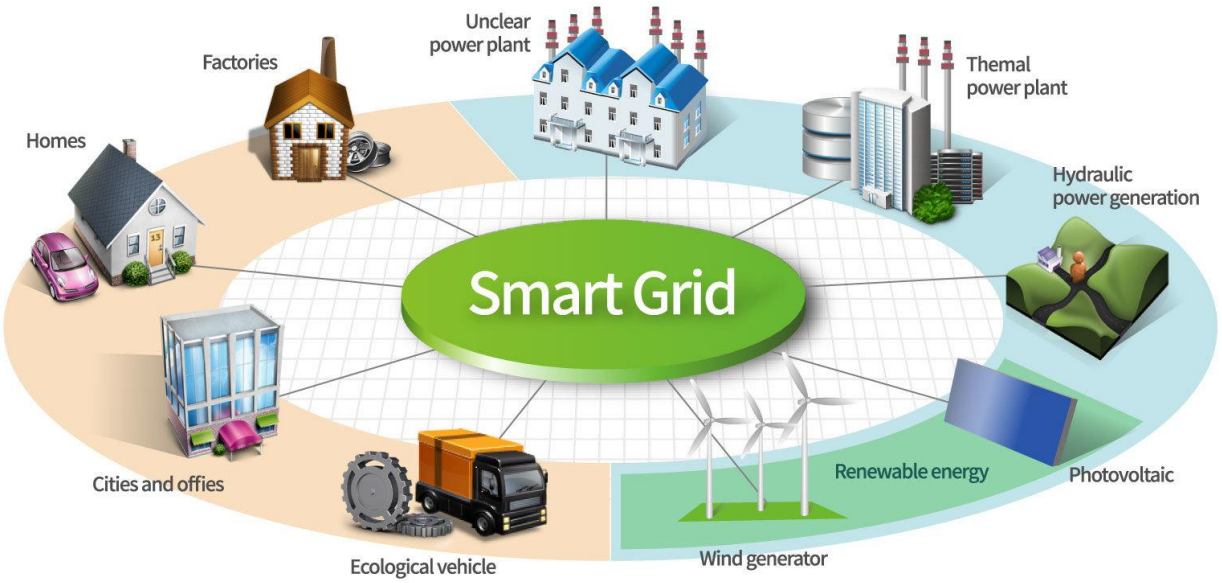


## 6.3.4 SMART FORMING

On farms, IOT **allows devices across a farm to measure all kinds of data remotely** and provide this information to the farmer in real time. IOT devices can gather information like soil moisture, chemical application, dam levels and livestock health - as well as monitor fences vehicles and weather

## 6.3.5 FULLY AUTONOMOUS CARS

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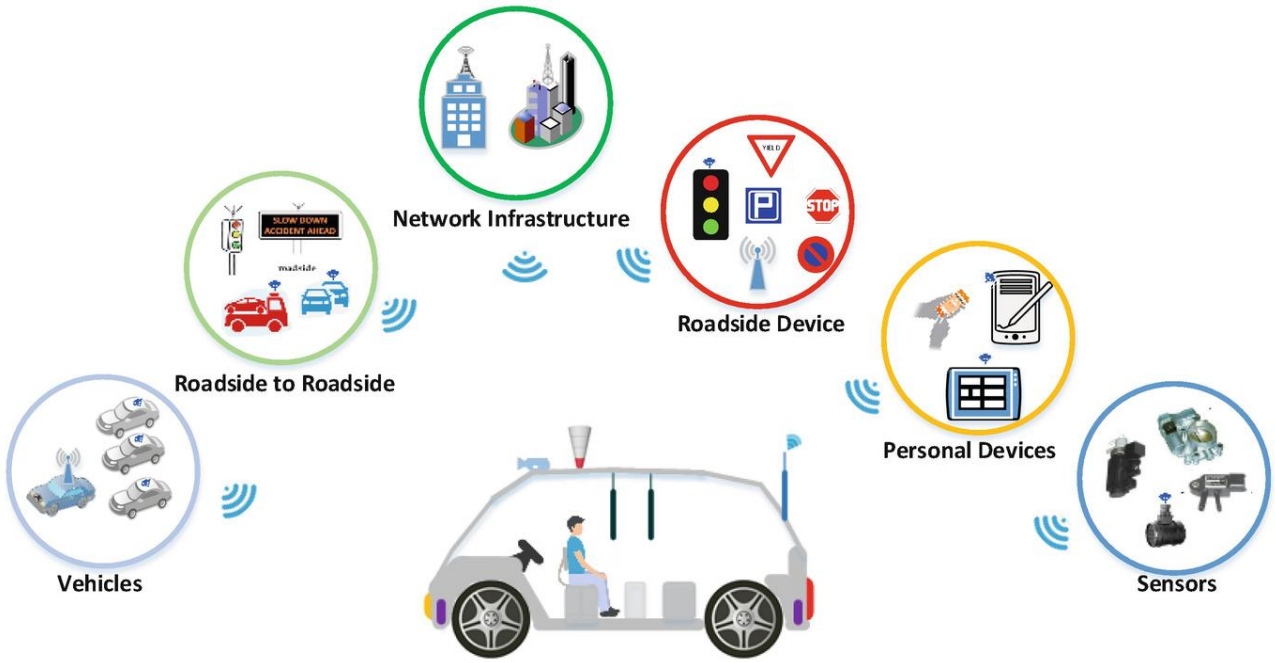
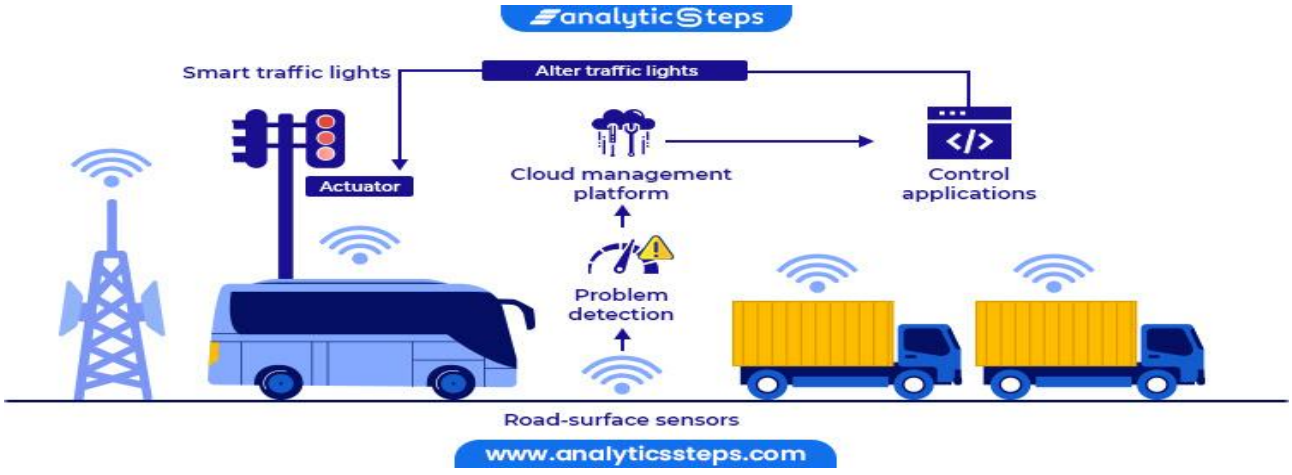
The Internet of Things (IoT) refers to the connectivity of multiple devices through the Internet. Driverless cars utilize this connectivity when updating their algorithms based on user data. These autonomous vehicles require an enormous quantity of data collecting and processing




## 6.3.6 SMART TRAFFIC SYSTEM

Smart Traffic Management Systems are **technology solutions that municipalities can integrate into their traffic cabinets and intersections** today for fast, cost-effective improvements in safety and traffic flow on their city streets




## 6.3.7 SMART HOSPITALS

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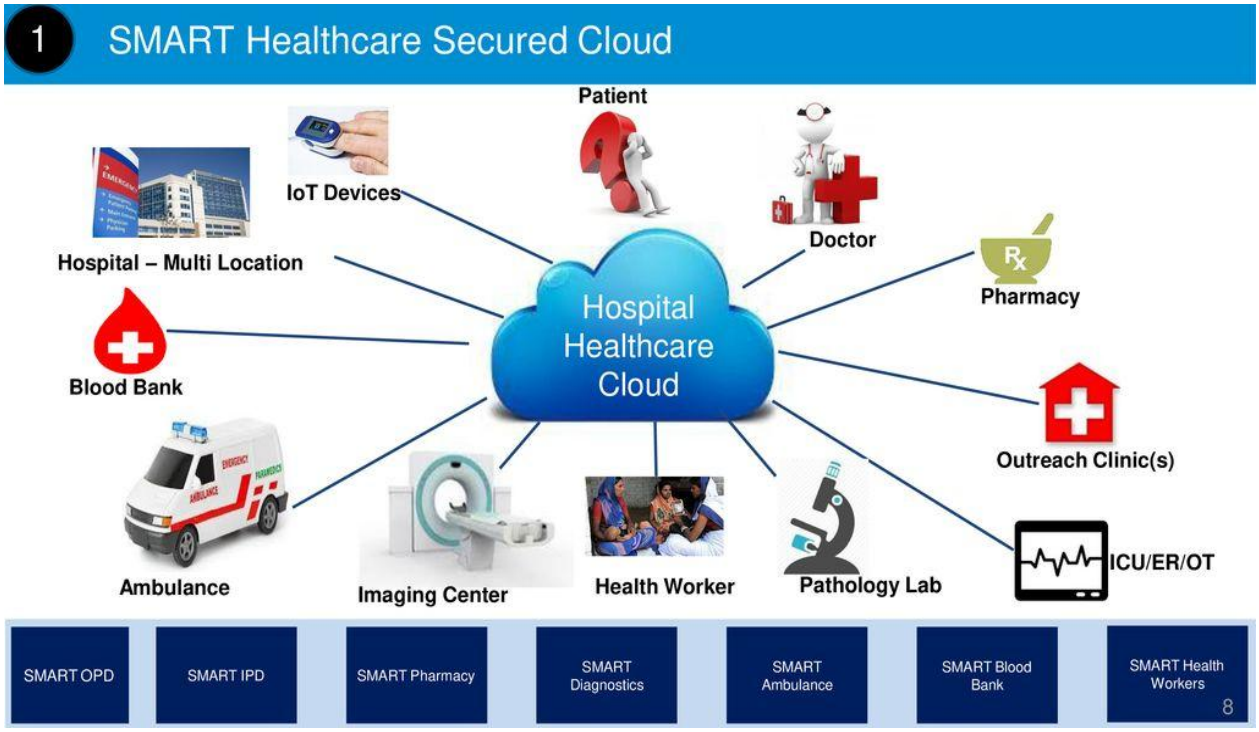
The health monitoring system using IoT consists of various modules like **pulse acquisition module, body temperature acquisition module, heart rate acquisition module, and blood pressure acquisition module**




## 6.3.8 SMART AGRICULTURE

IoT smart farming solutions is a **system that is built for monitoring the crop field with the help** of sensors (light, humidity, temperature, soil moisture, crop health, etc.) and automating the irrigation system. The farmers can monitor the field conditions from anywhere.

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## 7.1 OUTCOMES OF THE TERM PAPER

IoT has the capability to create public value and the intended public value dimensions have widened from the goal of improved efficiency. There has been a shift in value creation with other goals and outcomes such as effectiveness, transparency and collaboration gaining increased presence. Furthermore, the data suggest that the evaluation of IoT remains largely insufficient, and is mostly done abstractly or through financial metrics alone, which inhibits capturing the full potential of IoT. Public value derivation cannot rest on the implementation of IoT solutions alone, but must include improvements in management and policy according to the ample data generated by the devices.

Finally, there are limitations to be acknowledged. First, the research studied public value through the perspective of public organizations, however public values are rarely identical for stakeholders. Thus, additional research is required to study public value from the perspective of stakeholders like citizens and private organizations. Secondly, evaluating public value is never an easy task and more longitudinal studies could offer further in-depth understanding of public value created by IoT.

The rapid development and implementation of smart and IoT (Internet of Things) based technologies have allowed for various possibilities in technological advancements for different

aspects of life. The main goal of IoT technologies is to simplify processes in different fields, to ensure a better efficiency of systems (technologies or specific processes) and finally to improve life quality. Sustainability has become a key issue for population where the dynamic development of IoT technologies is bringing different useful benefits, but this fast development must be carefully monitored and evaluated from an environmental point of view to limit the presence of harmful impacts and ensure the smart utilization of limited global resources. Significant research efforts are needed in the previous sense to carefully investigate the pros and cons of IoT technologies

In the coming years, technology will impact the learning experience in many ways. Internet of Things (IoT) continues to confirm its important position in the context of Information and Communication Technologies and the development of society. With the support of IoT, institutions can enhance learning outcomes by providing more affluent learning experiences, improved operational efficiency, and by gaining real-time, actionable insight into student performance. The purpose of this study is to find out the potential of IoT in higher education and how to maximize its benefits and reducing the risks involved with it.

The reason why IoT is becoming popular day by day is that it's very cost-effective , it is easily available and the best part it cost absolutely Zero money for maintenance. Anybody can use IoT as IoT's main objective is to make a complex task easy for humans so you don't have to be super technical or learn advanced machine learning or artificial intelligence just to use the IoT.

## CONCLUSION AND FUTURE SCOPE

### 8.1 CONCLUSION

Internet of Things is the concept in which the virtual world of information technology connected to the real world of things. The technologies of Internet of things such as RFID and Sensor make our life become "better and more comfortable". The IoT has the potential to dramatically increase the availability
of information, and is likely to transform companies and organizations in virtually every industry around the world. The Internet of Things (IoT) is a system of interrelated devices connected to a network and/or to one another, exchanging data without necessarily requiring human-to- machine interaction. In other words (IoT) is a collection of electronic devices that can share information among themselves. Typical improvements that can result from (IoT)in the operations and maintenance of equipment include: Reduction in call centre time. Reduction in

unnecessary service call-outs. Reduction of the fleet of support vehicles we can say that IoT technology promises to put innovation in line with efficient management, analysis, and exploitation of the data; which is done by a strong, future-proof, scalable and secure IoTarchitecture.AnIoT architecture may offer diverse solutions for various industries but its fundamental feature is to create an IoT ecosystem that is functional, scalable, flexible, maintainable and cost-effective. Therefore, if you are looking to implement attractive and future-proof IoT projects, make sure you have a well defined and efficient IoT architecture.

**8.2**FUTURE SCOPE

**We are living in a digitalized world that is full of technological advancements. One of these technological advancements is Internet of Things (IoT). The future scope of IoT is paving its way to make the world a smarter place to live in.**

Internet of Things has emerged as a leading technology around the world. It has gained a lot of popularity in lesser time. Also, the advancements in Artificial Intelligence and Machine Learning have made the automation of IoT devices easy. Basically, AI and ML programs are combined with IoT devices to give them proper automation. Due to this, IoT has also expanded its area of application in various sector

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