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INTERNET OF THINGS FOR SMART ENVIRONMENT APPLICATIONS

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Abstract

Internet of Things (IOT) is becoming an emerging technology due to the rapid use of internet.IOT is a kind of "universal global network" that combines different things such as mobile, laptop, notepad etc. IOT is a smartly integrated system that interacts with other machines, environments, objects and infrastructure that comprises intelligent machines including radio frequency identification (RFID) and sensor network technologies. In every company, the people send email and access websites, or other online means, but in most countries, the internet is available to transmit data across mobile devices and the Internet through easier, faster, and less costly systems. The main purpose of this article is to provide the detailed study about IOT along with its applications in different field such as health, urban city, industry, transportation and smart building. This document also helps researchers who want to do research on the Internet of Things.

I. Introduction

The Internet of Things (IOT) was initially presented in 1998, which is relating to objects and things. In recent years, the term IOT has become popular by using in different fields such as greenhouse monitoring, traffic control, in healthcare system, smart homes/cities and many more [1]. The IOT is comprises of two words such as internet and things. The Internet is a

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large-scale network of billions of interconnected computer networks that use the standard Internet Protocol Package (TCP or IP), which serves billions of users globally. Presently there are over 100 countries around the world that are linked to each other and exchange information, news and ideas through the wireless or wired connection [2]. The IOT technology is mainly comprises of three layers as shown in Table 1.

Table 1. IOT-product-services [3].

Things	+ IT	=IOT based Function	+ IOT based Services
	IOT stack	Light	Save electricity
	IOT stack	Vehicle Tracking	Safety
	IOT stack	Captured and display data	Security

Communication in IOT applications will normally form the following links, as shown in Figure 1.

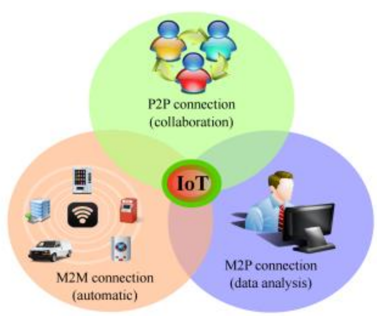

Figure 1. Internet of Things (IOT) elements [4].

• People to People (P2P) connection: using this link, the information is transferred from one person to other person. The connection is made through audio/video call as well as via social media and also known as collaboration connection.

• Machine to People (M2P) connection: In this process, the data transmission/communication is possible between machine such as mobile phone, personal computer, sensors and many other means that can analyze the data. The example may includes weather forecasting in which machine (smart device) is used to collect information related to the environment condition and the forwarded the information to the control unit for further analysis.

• Machine to Machine (M2M) connection: This is the process in which the data transfer takes place between machines without human interactions. For an example, a car communicates to another car to know traffic related information such as its speed, lane alteration or braking intent, etc [5].

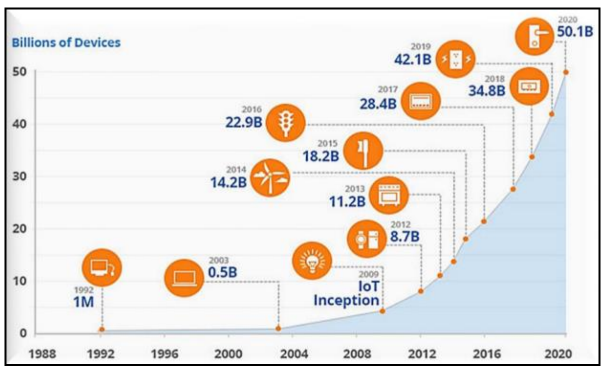

Figure 2. The growth rate of IOT devices [6].

The growth rate of IOT devices from 1988 to 2020 is shown in Figure 1. As the time passed the use of IOT devices also increases. The rate of IOT devices attached to the internet is predicted to be increases above 50 to 100 billion.

II. Architecture of IOT System

The IOT structure mainly comprises of four distinct units such as sensors, connecting device, data processing and a user interface. The detail description of each component is provided in the subsequent section.

i. Sensors: These devices are used for the collection of data from the outside environment. The mobile phone is an example of sensor device as it consists of number of sensors such as camera, GPS and many more [7].

ii. Interconnecting unit: It might be wireless connection such as Bluetooth, LAN, WAN, Wi-Fi, which is used to connect sensor devices to the cloud environment.

iii. Data processing: The received data is processed in such a way so that I could be interpreted by the user.

iv. User interface: To provides data to the user in a presentable forms [8].

III. IoT-Based Smart Environments

IOT based smart system depends upon the type of application domain such as used in smart cities, smart homes, smart building, smart transportation, smart health and smart industry [9]. Each application along with its state-of-art is explained in the following section.

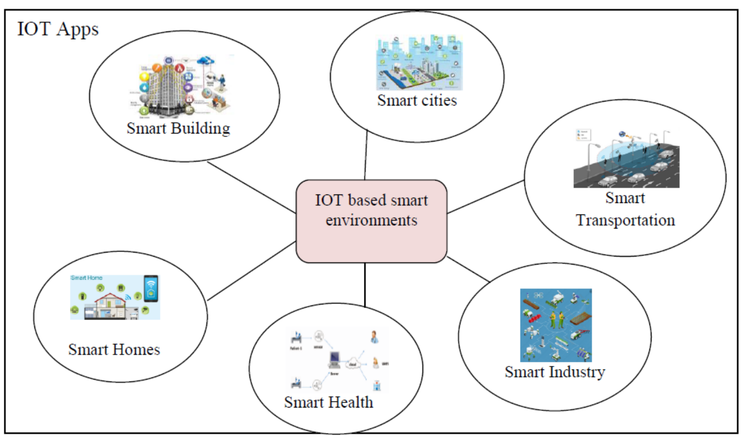

Figure 2. IoT Applications.

3.1. Smart Cities

Due to the increase in the population rate of urban areas, infrastructure as well as services is required to meet the needs of urban residents. Depending upon this factor, there is a significant increase in digital devices, for example. Sensors like cameras and smart phones that lead to great business potential for IOT so that all devices can communicate with each other through the internet. The IOT prototype is the system, which provides smart and self-regulated objects, interconnected through a global network infrastructure. The IOT is generally regarded as realistic, widely dispersed, low storage and processing facilities to enhance the reliability, operation and security of smart cities and infrastructure. As per the survey conducted by Pike research on smart city, the market of smart city is predicted at hundreds of billion dollars upto the year of 2020. According to Pike Research on Smart Cities, the Smart City market is estimated at hundreds of billion dollars by 2020, with an annual spending reaching nearly 16 billion. This market stems from synergistic interactions of key industries and services sectors such as Smart Management, Smart Mobility, Smart Utilities, Smart Buildings and Smart Environment. https://smartcitiescouncil.com/tags/pike-research. In smart cities, IOT helps in different ways such as:

i. Detecting the leakage of water and hence save the water

ii. Used to monitor road traffic by getting information from the driver phone through mobile phone so that the destination as well as the speed of vehicle can be determined.

iii. Helps to park vehicles in smart way. The free ground space is analyzed through GPS data and hence a real time parking map solution is created.

iv. Helps to manage street light system. The sensors installed on the streetlight gather data related to the movement of vehicle as well as people and hence accordingly control the streetlight system such as (Dim, Brighten and switch On /OFF).

v. Helps to manage waste materials by deploying sensors in the waste container. A threshold has been defined, if the material goes above the defined level then there is a message sent to the waste management, which send collecting truck to empty the waste container.

Zanella et al. [10, 2014] have discussed an inclusive survey regarding to the recent techniques, protocols and its architecture for urban cities. The data has been collected from “Padova smart city” in Italy. The data such as temperature, humidity, light and benzene reading has been analyzed for a span of seven days. The street light has been localized geographically on a city map, which is later on linked to a unique IOT node that integrates IOT data with the related information. The operation of bulb has been monitored using photometer sensors. These sensors measure the intensity of light. The IOT sensor nodes have also been attached with the temperature and humidity sensing nodes and the node which is attached to benzene has been used to monitor the air velocity. These sensors are covered with plastic material so that the electronic part can be protected from different atmosphere conditions such as rain, snow etc.

Ahmed and Rani [11, 2018] have designed an IOT framework specifically for the data link layer and the route is determined using AODV with SPEED protocol. The test results have been analyzed in terms of delay, energy consumption, packet delivery rate (PDR) and miss ratio of the packet transmission. The remaining energy analyzed using AODV routing protocol is varies from 0.8 to 11 J whereas the variation of about 0.6 to 1.6 J has been obtained using AODV with SPEED algorithm. Also, the Packet delivery Ratio (PDR) analyzed using hybrid approach has been obtained upto 0.9 to 1. Also the delay upto 2-11ms has been achieved.

Roy et al. [12, 2016] have proposed solution to the problems faced by the modern transport system. The problems such as (i) traffic jam that leads to delay in office as well on home, (ii) fuel wastage, (iii) wear and tears of vehicles and many more. Also the authors have concentrated on reducing waiting time at toll tax station. The problem of parking vehicles has also been resolved by using IOT system, which makes cities more smart and intelligent. Shortest path algorithm has been developed to control traffic congestion along with the parking system.

Thakur et al. [13, 2016] have designed an algorithm to manage traffic in real time environment. In this the threshold range has been decided according the vehicles tracked in the active road lane. LOW, High and Medium are the three classes in which the traffic has been categorized. Below 60 % of lane traffic, it comes under Low traffic category; therefore extra time has to be provided to the busy lane. Above 60 % traffic comes under high traffic, therefore a fix time span has been provided to that particular lane. In case of any emergency vehicle, 40 % of time slot has been provided to that lane.

Shyam et al. [14, 2017] have proposed a Smart Waste Management Algorithm which works on the basis of wastes present in the waste container. The data has been gathered using sensors and passes through the internet connection to the server for storage and processing purpose. The data has been analyzed on daily basis and based on the data an optimized route has been find out. The route information has been sent to the worker's phone through navigation means. Other factors such as where the waste bin has to be placed depending upon the traffic congestion has been considered.The performance in terms of cot, time taken and the distance covered with respect to number of location has been determined.

3.2. Smart Building

For the last few years the development of Smart buildings (IBs) hasgain increasing interest. An intelligent/smart building means that human being can easily control various building operations such as security, ventilation, lights and many more [15]. The sensors are deployed to gather data and process that data as per the needs. This helps to enhance the asset reliability as well as performance by minimizing the energy consumption. A number of researchers have contributed for creating smart building using IOT technique. A few of them is described in the following section.

Nesa and Banerjee, [16, 2014] have used Dempster-Shafer Evidence Theory to collect data from heterogeneous environment. The designed system is shown in Figure below.

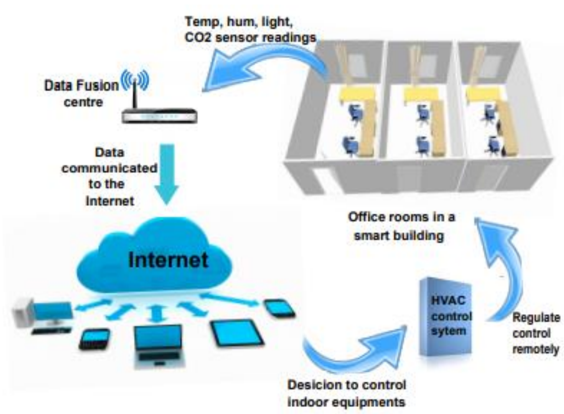

Figure 3. Smart Building structure proposed by Nesa and Banerjee [16].

The Demspter and Shafer theorem is used to represent uncertainties in a hypothesis. Hypothesis is the assumption related to the all possible input output of the designed system. Demspter and Shafer finds applications in medical imaging, traffic congestion monitoring, or to monitor air quality etc. The performance of the designed system has been analyzed using Linear Discriminant Analysis (LDA) and Demspter and Shafer approach in terms of precision and accuracy and the values such as 86.42 % and 89.11%, 92.24 % and 92.23% has been achieved. Here, LDA has been used to detect the occupancy of the room.

Yu et al. [17, 2016] have presented an intelligent building using IOT technology which is based on cloud environment. This paper has mainly focused on the energy saving of large building spread in1.2 million square areas. The real time data from HCAV has been used which is collected in distinct weather and other environment conditions. The data includes information related to temperature, humidity, air velocity and solar irradiation index along with cooling energy used by the building. The presented system mainly comprises of four different modules such as building with IOT elements, data base, building energy forecasting along with the cloud dependent building monitoring. The building agent collect real time data related to the energy and stores into the data center. The data has been analyzed based on machine learning and data mining approach schemes. The purpose of the building energy forecasting module is to decide the energy forecasting. The training has been performed by randomly generating data and hence obtained an enhanced system. The forecasted results which have been obtained using machine learning approach are forecasted to the cloud based server. After receiving the forecasting results, the cloud server forward those results to the building manager, which control the system accordingly and hence, save the energy. The performance of the system has been measured in terms of precision, recall, accuracy and energy level. Four different machine learning approaches have been used such as (ANN, C 4.5, SVM and Baysian). From the experiment has been observed that the accuracy level of multiclass SVM (94%) is higher compared to ANN and other two approaches.

3.3. Smart Industry

Shrouf et al. [18, 2014] proposed a system for an IOT based intelligent factory and defines the important features like as flexibility, best decision making, and distant monitoring with respect to energy management. The presented approach enhances energy consumption in an intelligent factory by integrating energy data into construction management.

Li et al. [19, 2018] have developed a new system by using fog computing technique. By utilizing the concept of offloading in which the load from the overloaded server has been transfer to the fog nodes and the systems has attain the ability to deal with extremely large amount of available data. The designed system has mainly two benefits such as (i) The concept of Convolutional neural network (CNN) approach enhances the computing efficiency of the fog computing model and (ii) and the failure in the system has been detected by using an inspection model. The experimental results have shown that the designed system is robust and provide better results. The designed system has been illustrated in figure 3.

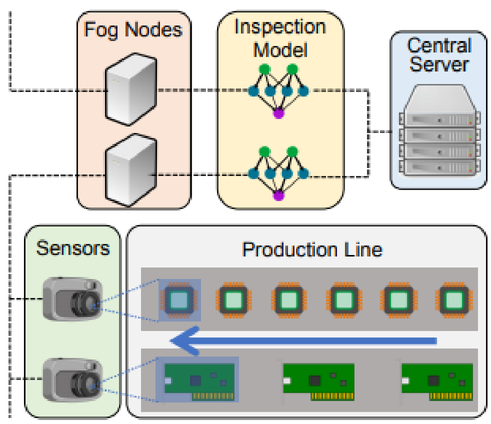

Figure 3. Designed smart industry model by Li et al. (2018).

The applications of IOT are represented in figure 3. The sensor units in the form of cameras are deployed to monitor the production line of a manufacturing company. The collected information through cameras is send to the fog nodes for further processing. The inspection unit is used to determine the failure in the production line and then the output is provided to the central server. The central unit provides feedback to the production unit along with some recommendation. In this way the production quality as well as quantity has been increased. The performance of the designed system has been measured in terms of True Positive Rate (TPR) and False Positive Rate (FPR), which represents the accuracy of the system. The average accuracy of the system about 87 % has been obtained.

3.4. Smart Transportation

The transportation is one of the essential field in which IOT can be applied to collect information related to count number of passengers, provide ticket through internet and to communicate with passenger from remote places. With the development of the national economy of our country (India), urbanization is accelerating which increases the growth of vehicle without any delay due to which there is imbalance between the urban traffic and its control is came into existence. Therefore, the traffic problem becomes a major issue specifically in urban areas. To overcome this problem, Wang and Qi have presented an intelligence transport system in 2012. The general framework for the smart transport system is shown in Figure 4.

The system mainly comprises of three modules such as server, moving terminal and medium. The moving terminal divided into two sub modules (i) vehicle terminal and (ii) station terminal that includes PXA 310, GPS and GPRS sub-module. The data from the moving vehicles has been collected from the embedded devices and stored into the database using GPRS and GPS module. The data is extracted from the database using internet or satellite connection. GPS unit is used to gather real time data of vehicle such as vehicle speed, longitude, latitude and time. The collected data is being uploaded using GPRS module. PXA 310 terminal is used to perform administrative operation along with sequence monitoring role. This helps to reduce the development time as well as the expensive to manage server [20].

Eurotech [21] have offered IT solutions to the public transport unit and improves the technical tools in order to interlinked sensors and other transport units to the IT infrastructure. In the same field, Kapsch Group [22] has also investigated how the Internet set up has been used to improve transportation conditions in cities.

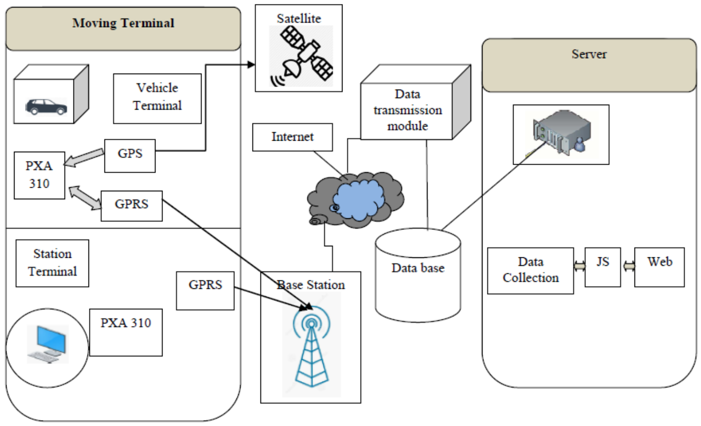

Figure 4. General Structure of Smart Transportation System.

3.5. Smart Health

There are many people in the world whose health is suffered due to inadequate access to hospitals. This problem can be resolved by installing the small wireless units to the IOT devices so that the condition of patient can be monitored from remote places instead of visiting hospital physically. A number of sensor units known as electrodes are attached to the human body to get information related to their physical characteristics such as blood level, temperature, sugar level, heart reading and many more. The collected data is then transmitted to the server through various communication means such as 3G or 4G and Wi-Fi. This data is then transmitted to the doctor so that they can analyze the data and then provide services to the patient accordingly. The entire process is depicted in Figure 5.

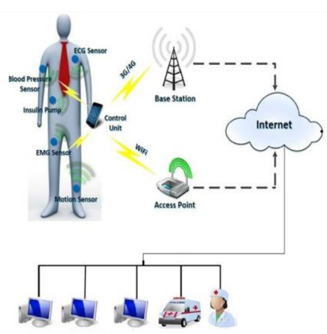

Figure 5. General Structure of IOT based healthcare system [23].

M. Chen et al. [24] have explored a 2G Radio frequency identification technology (RFID) based electronic healthcare architecture, which is capable of being providing emergency services to the public. The designed architecture comprises of number of units such as RFID reading unit, camera unit, processing module, rule database, Wireless Body Area Network (WBAN). Using WBAN technology, the information related to patient health such as temperature, blood pressure etc are obtained by attaching small sensor units to the human's arms, legs etc. Also the technology such as IEEE 802.15.4 and Zig Bee might be utilized to connect these sensor units to the internet.

Jara et al. [25] has proposed a framework to monitor data from distant places by using IOT technique. The designed system has integrated multiple systems such as hospital data, service provider, management of data unit, database system along with environment integrated platform. RFID approach along with 6LoWPAN has been used to handle the emergency situation.

Wang et al. [26] have presented e-healthcare system to display as well as to record the health data of hospital. To provide the interface between the hospital and the outer environment wireless techniques such as 3G, WLAN and UAAP has been used. But this model is not capable to provide emergency services to the patient.

3.6. Smart Agriculture

Traceability regulations for agricultural animals and their activities need the utilization of techniques such as IOT to detect animals in real time scenario, for example, infectious disease outbreaks. In addition, in many cases, the government provides subsidizes while the farmer create a small business with cattle, sheep and goats based on the number of animals in the herd and other requirements. Since it is difficult to determine the number, there is always the possibility of fraud. Therefore, a high-quality identification system is required that can help to minimize this type of fraud. Using proper identification system, the animal diseases can be monitored and hence prior measure can be taken to save their lives. The official identification of animals in national, domestic and international trade already exists, while identifying the animals that have been vaccinated or tested can be controlled. Blood and tissue properties can be accurately identified and the health status of flocks, regions and countries can be confirmed using IOT. With the IOT, single farmers can deliver their products to consumers in a wider area than in direct marketing or stores. This will change the entire supply chain, which is mainly in the hands of big companies, now, but a more direct, shorter chain between manufacturers can change consumers [27].

3.7. Smart energy and smart grid

Smart grids are related to information and control and also have evolved to smart energy management. A smart grid that integrates information and communication technology (ICT) into the grid to enable real-time, two-way communication between suppliers and consumers, resulting in more dynamic interactions in the energy flow that will help to provide energy with more efficiency and with sustained Power generation. The main factors of ICT will comprises of sensing as well as monitoring units for power flows; transfer data throughput the grid using digital communication technique, energy usages is directly displayed on home electric meter, monitor and control different automation as well as process multiple data so that a highly interactive electricity can be created. Smart energy and smart grid finds applications in different fields such as: industrial, solar power, nuclear power, vehicles, hospitals and cities power control as depicted in Figure 6.

Figure 6. Smart Grid Applications [30].

3.8. Smart Environment

The environment plays an important role in human life. In an unhealthy environment, not human being but other living beings such as animals, birds, fish and plants are also been affected. In order to solve the problem of environmental pollution and waste of resources, many studies have been conducted. Creating a healthy environment is not easy due to industrial and transportation waste, and irresponsible human activities are everyday factors that cause environmental damage [28].

The environment requires an intelligent approach and novel technologies for monitoring & management. The environment monitoring is essential to assess the present state of the environment in order to make the correct life decisions based on the data gathered from the monitoring system, and in addition to reducing plant and vehicle waste, management also requires effective resource consumption and use. Both monitoring and waste management provide large amounts of data to force governments or health environmental organizations to develop health standards to protect people and the environment and to mitigate or avoid possible natural disasters.

An intelligent environment is an important technology in our daily lives, providing many facilities and solutions for many environmental applications, such as water & air pollution, weather & radiation monitoring, waste management, natural disasters and many other environmental indicators, as shown in Figure 7 in which an individual is connected to everyone via home LAN. Developed an intelligent environment device integrated with IOT technology to track sense and monitor environmental objects that provide potential benefits for a green world and sustainable living [29].

The IOT has many applications in the environment and can be categorized into two types: environmental resource management, environmental quality management. Resource management involves all natural resources, including animals, planets and forests, birds and fish, coal, oil, land, fresh water, air and heavy metals, including gold, copper and iron. All of these resources may be significantly degraded or affected by multiple factors such as pollution, waste and abuse.

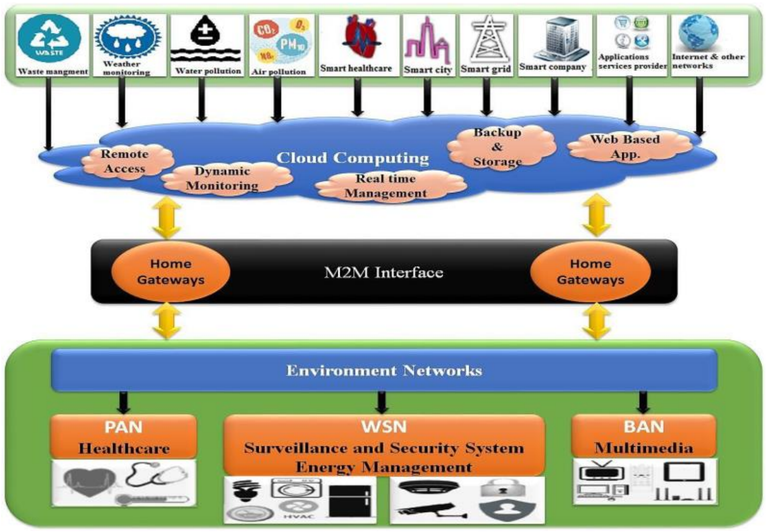

Figure 7. Smart Environment based IOT [30].

3.9. Insurance Industry

Often the application of IOT technology is conscious about a heavy incursion on privacy of individuals. Sometimes, unauthorized people are willing to trade in secrecy for better service or money. An example is car insurance. If the car insurance person is willing to accept the terms of car insurance companies like install the electronic recorder in their car (to record: acceleration, speed, fuel and other parameters) and transfer these information to the car insurer, then he/she must get a cheaper rate/ premium.

The insurer can save money by participating in a very early stage it can trigger an impending crash and the most economical actions. One part Deposit insurance can be provided to customers through discounts awards. The same thing buildings, cars, etc., equipped with IOT technology. In these cases, technology mainly helps or prevents large-scale repairs cheaper prediction service before an incident occurs [31].

Conclusion

Instant advances in wireless technology have covered the way for understanding the vision of installing IOT sensors in smart environment. This paper has provided a detailed study of IOT applications in smart environment. Also, the efforts made by research experts in IOT specifically in health, urban city, industry, transportation and smart building have been discussed. A smart discussion related to the existing work based on the intelligent/ modern environment is presented that helps readers to understand the latest efforts in this regard. In addition, we have provided information and discuss unique events opportunities created by integration of IOT with intelligent environment. In the end, we come to this conclusion that deploying IOT may be one of the future platforms for ensuring that the physical devices communicate with each other and provide high functionality, power efficient, prosperous interactivity and better response in a dynamic way.

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