Tracing the Historical Progression and Analyzing the Broader Implications of IoT: Opportunities and Challenges with Two Case Studies

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***Abstract*—This paper provides a complete indication of the Internet of Things (IoT) by tracing its historical succession and analyzing its broad implications. We elucidate the progression of IoT, together with the improvements in wireless networking technologies and the miniaturization of sensors and processors that have made IoT a truth. It also highlights the impact of IoT on various industries, such as healthcare, transportation, agriculture, energy, and retail. Despite IoT's progression and potential, it has several technical complexities and challenges to deploy. Technical challenging includes hardware, software, application framework, and communication standards and protocols**

Moreover, other challenges include security, privacy, and safety. However, this paper focuses on the historical progression and implications of IoT. It presents the definition of IoT, the history of IoT, the working system of IoT, identify different levels, analysis of different sensors, and its applications. Moreover, it identifies the opportunities and challenges of IoT, IoT standards, furthermore frameworks. Finally, this paper presents a case study on smart homes and a case study on smart cities based on IoT technology.

Keywords—Internet of Things; IoT Levels; Sensors; IoT Applications; IoT Standards; IoT Frameworks

I. INTRODUCTION

The Internet of Things (IoT) is a rising inclination gaining popularity very rapidly [1]. IoT offers various benefits to the home, city, organization, industry, and so on. It is making a quality way of our living, increasing productivity in the organization, reducing time and cost in the supply chain, and creating better consumer experience, health care, and city life by deploying IoT in business, medical, and city. We are getting all these benefits in the favour of general to specific IoT technology such as the Industrial Internet of Things (IIoT), Internet of Medical Things (IoMT), V2X communications (Vehicle to Everything Communications), Internet of Vehicles (IoV) and Internet of Battlefield Things (IoBT) [2]. IoT is not any single thing, device, or technology. It is the combination of sensors, devices, communication technology, data analytics, software, and data technology (i.e., cloud computing).

II. NOMENCLATURE OF IOT

Kevin Ashton, a co-founder of the Auto-ID Lab at MIT first coined this term in 1999 [1-4]. The term IoT means "Internet of Things". That means things (e.g., devices, widgets, machines, humans, animals, plants) are connected to the Internet. Things are uniquely identifiable devices associated with networks, electronics, software, sensors, and actuators [4]. A network is used to connect things. Electronics are the wi-fi, Bluetooth, and ZigBee standard devices used to enable communication. Software is used to develop user interfaces and firmware, and it is responsible for data collection, processing, storing, communication, analysis, and visualization [5]. Sensors receive and transmit data over a network and actuators act upon things without human intervention [6]. It was 10 billion devices already connected by 2019 and expected to extend the 30 billion by 2025. It is also called the "Internet of Everything (IoE)". It is an emerging Information technology successfully applied by collaborating through additional technologies such as artificial intelligence, and big data, along with high-speed networks (e.g., 4G, 5G) [7- 8].

III. HISTORICAL PROGRESSION AND CURRENT STATUS OF IOT

A. History

1912- Monitoring data from the power plant using a telemetry system in Chicago [9].
1930- Monitoring weather conditions using radiosonde along with telemetry [9].
1957- The USSR embarked on Sputnik-1 plus marked the first space age and race [9].
1970- A concept used as the name of pervasive computing or embedded Internet [9].
1980- M2M technology began implemented by wired communication for controlling and acquiring data. It

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was used in factor, home, and business security systems.

1982- The Coca-Cola vending machine was first connected to the Internet at Carnegie Melon University by a group of students of computer science.

1990- M2M began with wireless communication. John Romkey made a toaster that could be controlled over the Internet.

1994- IEEE Spectrum magazine described the concept of integration and automation of everything using the Internet.

1995- Siemens brought the initial cellular module put up for M2M communication.

1999- Kevin Ashton first introduced the term “Internet of Things” during a presentation at Procter & Gamble (P&G) company [34].

2010- IoT began to popularity. Google’s Street View gained the attention of people and came into the mainstream.

2011- Gartner’s “hype-cycle for emerging technologies” included in their list “The Internet of Things”.

2012- Conference about the “Internet of Things” organized by LeWeb. Furthermore, various trendy magazines started using IoT to depict the event (for example, Forbes).

2013- IoT could exist as an $8.9 trillion souk in 2020 according to International Development Corporation (IDC).

2014- Its huge market gained popularity and became a real thing.

2015- Google bought Nest Labs for $3.2 billion. Consumer Electronic Show (CES) under the theme of IoT held in Las Vegas.

2016- AWS IoT core is launched [10].

2017- The number of IoT devices worldwide surpasses 8.4 billion. Many companies such as Amazon, Google, and Apple invested heavily in developing voice-activated smart home devices.

2018- The European Union’s General Data Protection Regulation (GDPR) went in effect, impacting IoT devices that process personal data. Blockchain technology explored as a potential solution for securing IoT devices and data. The IoT devices continued to grow and put the estimated number at around 11 billion.

2019- 5G networks began and raised IIoT.

2020- The number of IoT device connections increased by more than fifty percent of the activities connected to the device [10].

2021- More than thirteen billion active IoT devices [10].

2022- World economic forum names IoT as one of the three most impactful technological advancements [10].

2023- The number of IoT devices is expected to surpass 15 billion. The transportation and power sector is expected to gain momentum [10].

B. Current Status of IoT

According to the report of Statista the global market status of IoT devices and sensors is given below. The projection shows that smart city infrastructure is using more IoT technologies comparable to other applications [11-13].

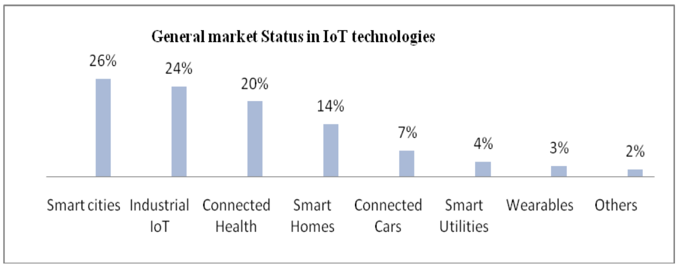

Fig.1. Global market status in IoT technologies [11]

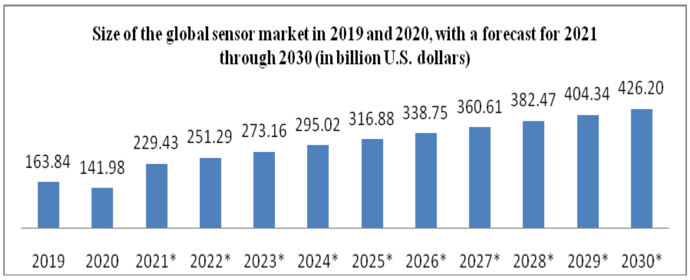

Fig.2. Current and forecast global IoT Sensor market [12]

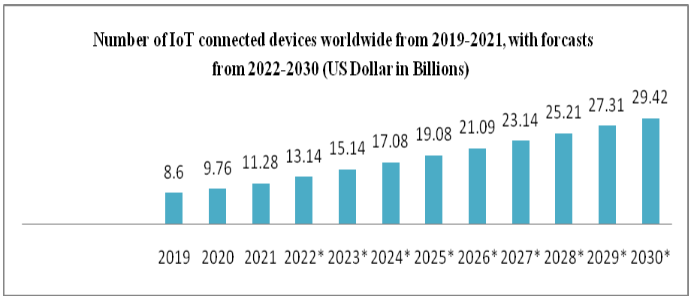

Fig.3. Current and forecast global IoT device market [13]

IV. HOW DOES IOT WORK?

IoT encompasses three layers: the physical layer, the transport layer, and the application layer. Some authors have shown the perception layer, the transport layer, and the application layer [14]. Other researchers have shown the perception, network, and application layers [15]. Some authors have proposed four layers: the objects layer, network layer, services layer, and application layer [16]. Another architecture of IoT has shown four layers and these layers are the device layer, network layer service support and application support layer, and the application layer but on the other hand, the same researcher has shown the generic five-layered architecture in the light of the OSI layer and these layers are: edge technology layer, access gateway layer, internet layer, middleware layer, and application layer [17]. Some other authors have shown three and five-layer architectures which imply the perception layer, network layer, and application layer, and the five layers are the perception layer, transport layer, processing layer, application layer, and business layer [18]. Other researchers have shown the perception layer, transmission layer, middleware layer, and application layer [19]. Cloud computing, fog computing, and edge computing is using recently as middleware services in

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IoT. Cloud computing is used in IoT to store, process, and analyze data in the cloud, and on the other hand fog computing process the data on-premises or locally [20]. Therefore clouds in the sky and fog on the ground as the name and its services. Fog computing helps to filter and analyze the data and it sends only the essential data to the cloud from edge computing or edge nodes. Processing of data occurs in edge devices which is why it is called edge computing. Fog and edge computing is introduced to process data quickly [21, 22]. In this paper, we have shown two architectures of entire IoT base systems. One is general architecture and the other one is extended architecture. The general architecture encompasses three layers based on IoT formation and working procedures. These three layers are the perception layer (we proposed this as the things layer), the network layer (we proposed this as the Internet layer), and the application layer, (fig. 4) [23]. On the other hand, the extended architecture comprises on perception layer, network layer, platform layer, and application layer, (fig. 5) [24]. However, IoT mainly works based on the combinations of its core components and technologies, which are described below.

A. *Key Components and Deployment Model*

- Things/Devices: Things are the real and physical devices or objects which will be associated with the Internet as a thing in the IoT. For example, television, light, fridge, etc [25, 26].
- Sensors: Sensors are used to receive data from the environment [27]. It is one of the foremost components of IoT. Different categories of sensors are used in IoT. It depends on the specific task that is carried out. For example, smoke sensors, water quality sensors, image sensors, etc.
- Internet/Connectivity/Infrastructure: Connectivity and infrastructures are all about internet
- connection. This is the Internet in the Internet of Things [27].
- Process/Analytics component: Data processing and analysis are done by this method. Fog computing can be used here for processing and analysis rapidly.
- Database: Data is collected, stored, and processed by IoT technology. The data storage can be local or cloud base. It is the soul of IoT [28].
- Resources: Resources of IoT are the software and hardware components that are used for accessing sensors and networks, storing, processing, and controlling the things connected to the Internet [28, 29].
- Controller service: It controls the entire systems of IoT devices by interacting with the web service and the user application or interface.
- Web service: Web service technology such as Hyper Text Transfer Protocol (HTTP), Representational State Transfer (REST) architecture, or WebSocket service is used to communicate among various components in the systems.
- Application: It is a UI and is used to monitor, control, and view all aspects of IoT base systems.

Fig.4. General IoT Systems Architecture

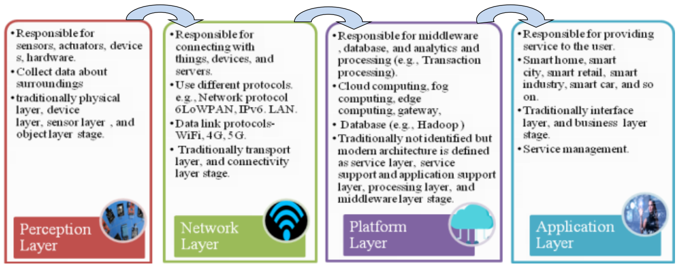

Fig.5. Extended IoT Systems Architecture

B. Working Procedure of IoT

- Things are connected by maintaining communication mediums, protocols, and standards.
- Things collect, transfer and perform acts on data received from the environment using specific sensors.
- Data collection, transfer, and analysis are carried out among the layers.
- Data is passed to the IoT gateway and fog computing or other edge devices for filtering and preprocessing and after that it goes to the cloud to store and further processing.
- Data is processed and analyzed to produce information in the back end and stored in the cloud or local data storage or the device itself.
- The Processed data is used by the physical device to act.
- All the activities and processing is done without human intervention but sometimes required human to adjust things.
- Lastly, the service is used by the user interface in the application layer to view and control the system.

V. IoT Levels in Smart Application

An IoT base system is developed based on several functional components. But it varies based on the application in the systems. Based on this reality, IoT systems are defined on various levels. These levels are described in the following table and various applications have been taken as examples to identify the multiple levels of IoT [29, 30].

TABLE I. IOT LEVEL, FEATURE AND APPLICATION

Level	Feature	Application
Level1	• Single node/Sensor • Local storage • Local analysis • Local application • Data volume is small • Suitable for a simple model • All activities are done locally • A mobile app or web app is used to	Smart home-room temperature, Lightings, appliances

	monitor and control Example: In a smart AC system, the temperature sensor is used and data gathering, analysis, controlling, and checking are done locally at this level.	
Level 2	• Single Node/Sensor • Local analysis • Introduced cloud storage • Cloud-based application • Data volume is comparatively bigger than L1 • A mobile app or web app is used to monitor and control Example: In a smart AC system, the temperature sensor is used and data gathering, analysis, controlling, and checking are done locally and the cloud is used to store at this level.	Smart agriculture
Level 3	• Single node/Sensor • Cloud storage • Cloud analysis • Big data • Cloud-based application • Suitable for a comprehensive solution Example: In a smart AC system, the temperature sensor is used and data gathering, analysis, controlling, and checking are done based on cloud computing, web app, or mobile app at this level.	Smart agriculture, smart transport
Level 4	• Multiple sensors • Multiple nodes • Cloud storage • Cloud analysis • Big data • Data Analytics • IoT intelligence • Cloud-based application • Suitable for multiple nodes or sensor-based solution	Smart noise monitoring
Level 5	• Multiple sensors • Multiple nodes • Cloud storage • Cloud analysis • Big data • Gateway and fog computing for filtering and analytics	Smart forest fire detection, Smart city
Level 6	• Multiple sensors • Multiple nodes • Cloud storage • Cloud analysis • Big data • Data Analytics • Real-time	Smart weather monitoring

VI. APPLICATIONS OF IOT

IoT is used in many different fields. The magnitude of users of the IoT global market is mounting every day. It is predicted that there would be 30 billion users by 2025. In this paper, we have only identified the applications of IoT due to the limited space of memory.

Home: Home automation, Home Improvement, Energy Efficiency, Smart Lighting, Smart Appliances, Intrusion Detection, Smoke Detectors, Smart Thermostats, and Smart Locks [31, 32].

City: Smart Road, Smart Parking, Smart Vehicles, Structural Health Monitoring, Surveillance, Emergency Response, Street Light, Trash Bins [33-36].

Environment: Weather Monitoring, Air Pollution Monitoring, Noise Pollution Monitoring, Forest Fire Detection, River Flood Detection.

Energy: Smart Grid, Renewable Energy System, Prognostics.

Retail: Stores, Shops, Supply Chain, Convenience, Payment systems, Sell machines.

Logistics: Route Generation and Scheduling, Warships Tracking, Delivery Monitoring, Remote Vehicle Diagnostics.

Agriculture: Smart Water Saving, Crop Growth Monitoring, Beast and Plant Life Information Monitoring, Green House Control, Intelligent Agro Machinery [37].

Public and Services: Schools, University, Government, Banking, Insurance, Administration, Commercial services.

Industry: Machine Analysis and Prediction, Internal Air Quality Monitoring, Safety & Security Control, Product & Process Innovation.

Manufacturing: Mining, Oil & Gas, Supply Chain.

Medical: Smart beds, Smart healthcare, Chronic Disease Management, Fall detection, Smart Medical Fridges, Home Care, Sleep Control, Patient Surveillance, Dental Health.

Health and Life Style: Fitness Monitoring, Entertainment, Wearable Computing, Pets.

VII. ANALYSIS OF SENSORS USED IN IOT APPLICATIONS

There are various types of sensors are identified for IoT-based systems development. These sensors are described in the following table and more details will be found about sensors type and applications in [38-43].

TABLE II. SENSOR NAME , FUNCTION AND USED IN SMART APPLICATIONS

Sensors Name	Function	Use
Temperature sensor	Measure temperature	Home, environment, agriculture, industries, city, health industry, water
Pressure sensor	Measure pressure, leaks	Residential, commercial areas, transport, city, wearable, health, retail, weather forecasting
Proximity sensor	Identify nearby objects.	Home, retails, cars, museums, parking, city, airport, malls
Accelerometer and Gyroscope sensor	Measure the rate of change of the velocity of an object or acceleration.	Mobile phones, drones, automobiles, retail, airplane
Gas sensor	Detect gas and leak in the gas area	Coal mines, oil and gas industries, chemical laboratory research, manufacturing- plastics, and paints, pharmaceutical, and petrochemical
Chemical sensor	Used to Identify the variations in liquid and atmosphere chemical alterations	Home, city, industry environment, transport, health, building, security, agriculture, retail, laboratory
Infrared (IR) sensor	Motion detection	Home (e.g., smart lamp, smart alarm), city, transport
Smoke sensor	Detect smoke	Industry, building

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Image sensor	Convert optical image into electrical signals	The driverless car, robotics, drones
Biometric/Bio sensor	Use for authentication and identification of a person	Industry (e.g., health care, manufacturing), organization
Motion sensor	Detect physical movement	Automatic doors, automatic parking, hand dryers, automated lighting, air-conditioner, fan, automated sinks, toilet flushers
Optical sensor	Convert light rays to electrical signals	Mobile phones, cameras, chemical factories, computers, copy machines, alarm systems
Light sensor	Convert light energy to electrical energy	Security, warehouse, agriculture, home, health, building, environment, city, retail
Magnetic/Magneto sensor	Detect magnetic field	Electronic compass, magnetic door, health, security, retail, home, building, position sensing, driverless car
Moisture sensor	Measure the moisture of the soil	Agriculture, farming
Humidity sensor	Detect steam in the air	Home, building, environment, industry, agriculture, city pharmaceuticals, structural health monitoring, weather, water
Nutrient/Nutrition sensor	Inclusive study of nutrition-related genetic material. Corroboration of the effects on general metabolic problems. Dependable experiment practice in the laboratory	Agriculture, health
Water quality sensor	Monitor water quality and Ion	Smart water, agriculture
Air quality sensor	Monitor air quality	Industry, city

VIII. OPPORTUNITIES OF IOT

IoT offers numerous benefits ranging from human beings to industry. IoT offers the following opportunities in our daily life:

A. Provide Quality Lifestyle

IoT is becoming a more useful technology in our everyday life to improve our quality of life. People are using IoT in homes, buildings, public infrastructure, and businesses to increase quality, competence, and productivity. It can improve better communication, security, and control of the home, organization, and city through the mobile phone. It reduces human endeavor and saves plenty of time by automation the systems. It enhances customer satisfaction by identifying their preferences and buying habits. Patient in hospitals uses smart appliance to get better health care [2].

B. Excellence in City-Infrastructure

The idea of making a smart city using IoT technology was first developed by IBM. IoT makes smart cities by enabling smart infrastructure for transport, road, buildings, and many more. Already more than two dozen smart cities developed around the world and by 2025 it is expecting 88 cities. A smart city uses smart lights, smart bins, smart traffic, and control systems to provide quality urban life for the citizens [44].

C. Greater Benefits in Business

IoT offers a mixture of benefits in a variety of ways in the business. It increases the effectiveness and productivity of the business organization. It improves safety and security in the organization. It does minimize operational and maintenance costs and maximizes profit. IoT captures huge data and it is used in business for making a suitable decision. Online Tracking system keeps information up to date that is very useful in the supply chain to maintain stock level as well as shipment information. IIOT offers superior decisions for lucrative direction in all aspects of the Industrial process.

D. Huge Impact in Medical Sector

IoT is offering cost-effective and quality of life for end users. IoMT platforms have improved the health care services for the whole community of the medical sector ranging from hospitals, general practitioners, care assistants, patients, and the pharmaceuticals industry. It has improved the digital systems, enhanced the user experience, and quality of service, and reduced the cost of treatment and response time. Patients' real-time monitoring and tracking have enabled them to take the right decisions for the proper treatment and safety [45].

E. Huge Device Connectivity

IoT relies on devices and Internet connection. It has a huge impact on device manufacturers that the connection of devices with the internet and making smart applications is increasing very rapidly. The market growth is expanding every day for IoT devices. Nevertheless, it is important that the reliability and the adoption should be maintained to be trusted for this device use.

IX. CHALLENGES OF IOT

Though IoT base systems have many opportunities, it has some set of pitfalls. Some of these pitfalls or challenges are given below:

A. User Adaptability

User adaptation towards IoT products and services is an important issue. It is a complex thing developed using many diverse systems. It is needed to be more flexible and simple to use and maintain. This technology must need to be made to feel free regardless of threats, security, and privacy. Another issue that must need to be considered is the economically feasible product service to widen the IoT technology and use.

B. Privacy

Patients' medical information requires privacy but it sometimes fails to keep privacy due to a huge amount of data being exchanged through different networks. As a result, malicious people may attack the entire network and hack sensitive information [45].

C. Security and Safety

IoT technology is connected with devices and makes an ecosystem. Due to a weak authentication process, it cannot make highly secured systems. Moreover, IoT uses different types of security and safety devices. It is mainly reliant on the Internet. If they fail to perform correctly due to software or other issues then can happen potential danger to the people and damage the control system [45, 46].

D. Designs for Compatibility and Integration

Currently, there is no available standard for IoT products and technology. It creates complexity and incompatibility for IoT. Common standards are needed for more interoperability demands. The development of IoT base systems through integrating devices from different manufacturers is quite hard. It takes more cost and time to develop and deploy. Therefore it requires a common platform, standard and available compatible products for quick IoT base systems development [45, 46].

E. Big Data

IoT technologies produce a huge amount of data. Due to data variety and volume, it is one kind of challenge to trace, analyze and overall maintain. Another challenge related to this issue is data hiding. It remains undetectable from where data is captured and stored.

X. IOT STANDARDS AND FRAMEWORKS

Widespread standards for IoT frameworks are required to avoid complexity and incompatibility. It is desired when interoperability with several deployments is wanted. Consumer IoT frameworks standards and Industrial IoT frameworks standards are formed by different foundations and consortiums. Open Connectivity Foundation (OCF) mostly uses consumer class use cases and Industrial Internet of Things Consortium (IIC), and OpenFog Consortium ponders on IIoT platforms. They use different frameworks that require diverse necessities and use cases. In some cases, they have similar requirements but do so in different ways. Consequently, arises incompatibility and common standards are needed. Some IoT standards that clinch:

- **Spectrum:** It is radio waves used in modern technology specifically in telecommunication systems. Its ranges from 0 Hz to 3000 Hz. It is regulated by the government and international regulatory bodies such as ITU. The mobile operator uses different bands in different countries. For instance, India uses 900 MHz and 1800 MHz but the USA uses 850 MHz and 1900 MHz. It needs to support various radio bands to use in IoT technology.
- **Wi-Fi:** Low power consumption wireless technology based on IEEE 802.11 standards. Used in WLAN, and WPAN to connect each other with wired and wireless networks. For instance, 802.11p is used in IoV communications, as a standard. Applications can be roadside communications from vehicle to vehicle such as toll collection.
- **Bluetooth / Bluetooth Smart (BLE):** Low power utilization is yet distinguished from Wi-Fi. Its battery charge can keep going for a long time even a month whereas Wi-Fi can few hours or days.
- **ZigBee:** IEEE's 802.15.4 standards Zigbee is a low-energy wireless technology used in smart home applications.
- **Z-Wave:** ITU included Z-Wave as new G.9959 standards good for home automation. The difference between Zigbee and Z-wave is frequency. They use different frequencies for communication.
- **NFC:** It is a short-range wireless technology. That's why it is called Near Field Communication (NFC) technology. It allows a broad array of use cases from keyless access to e-wallets in smartphones and smart tags for health applications. It can easily implement tags into different devices such as bank cards.
- **GPS:** It is a radio navigation system based on satellite. It is used in many applications such as autonomous vehicles, asset tracking, and fleet management. It can provide location information and time.
- **4G / 5G Cellular:** It is necessary for ubiquitous connectivity in IoT services.
- **LPWAN-Low Power Wide Area Network:** LoRaWAN and Sigfox are widely deployed LPWAN technology.
- **Weightless:** In the present day Cambridge-based weightless technology is used for M2M communication. Moreover, Data Distribution Service (DDS), OneM2M, Constrained Application Protocol (CoAP), Advanced Message Queuing Protocol (AMQP), and Universal Plug and Play (UPnP) are widely recognized IoT standards and protocols.
- **IoT frameworks:** There are many frameworks in the marketplace nowadays. The popular frameworks include IBM's Watson (framework), Microsoft Azure (Cloud), Amazon Web Services (framework), Google Cloud Platform, ThingWorx (Platform), Cisco IoT Cloud Connect, Oracle IoT Cloud, Salesforce (IoT Cloud), GE Predix (Software platform), Ayla Network (framework), IoTEclipse (Ecosystem), IoTContiki (OS). Recently the price of sensors was estimated headed for fall. As well as the necessitate for cloud computing is anticipated to quickly hit the highest point, IoT, cloud computing, and analytics as an overhaul are predicted to be the prospect trade contour of selection [47].

XI. CASE STUDY OF IOT

There are two case studies we have presented in this chapter. These are smart homes and smart cities. Both of the applications have used all the layers to implement IoT technology.

A. Smart Home

A smart home uses various types of applications such as smart lighting, smart locks, smart smoke detector, and so on. A smart thermostat is taken as an example. It is integrated with Wi-Fi and ZigBee. Lots of smart meters are now Wi-Fi competent and mobile phones are already rooted with Bluetooth and Wi-Fi. Gateway supports Wi-Fi and LAN is connected through Ethernet due to high bandwidth for audio and video applications. Based on PAN and Mesh networks Bluetooth and ZigBee are used in sensors and controllers for lighting, safety, and so on. The gateway uses cellular technology (such as 4G, and 5G) to send data to the cloud. Gateway provides analytics and intelligence service and the cloud provides different services such as IaaS, PaaS, SaaS, and so on. The thermostat uses a sensor to sense temperature then it stores and processes that data using local storage or the cloud. The home gateway (i.e., Rule engine and analytics) regulates temperature as a predefined value, and temperature readings are sent to energy providers through the wireless network.

B. Smart City

A smart city means is not about changing the city itself but is about deploying emerging technology such as IoT then it becomes a smart city. IoT improves safety, increases the efficiency of utilities, saves energy and the costing, produces available information for residents and city planners, and improves monitoring, managing, and controlling from a central point. And overall improves the quality of living for citizens. IoT technology already has been deployed in many developed cities around the world. Such as California, Chicago, London, Amsterdam, Uppsala-Sweden, Helsinki, Shanghai, Japan, Seoul, Singapore, Zurich, Fujisawa, and many countries that have initiated fully fledge smart cities projects designed to improve the value of life and economic escalation. (e.g., India).

In this paper, a smart city is taken as an example of a whole. Consider one day at 5 o'clock you are on the way to the office then you can see the smart light in the street which switched on autonomously when perceiving the presence of any objects or people or dusky. Smart traffic is giving you information in the morning about traffic congestion in the course of GPS and then you can use another route that is less traffic. It reduces the jam by alternative route selection. You might know the road accidents information by smart road and then you can change the route to the way of your office. After that, you may need a smart parking system to get parking spot information for parking the car that can save you time, and money and give a better experience. You might want to know the location of the garbage then you can get the right-way notification through smart bins. Smart grids and smart waste management increase efficiency and proper utilization of things through IoT technology those are all possible.

XII. CONCLUSION

The Internet of Things is regarded as one of the most significant fields in promising technology [48]. It is gaining more and more interest from a broad array of industries. IoT technology already has been implemented in various sectors ranging from consumer to industry such as medicine, agriculture, retail, education, public infrastructure, and so on. The number of users of IoT base systems is increasing very rapidly. This technology is indicating an immense result on society, the financial system, the infrastructure, and the milieu [48]. Therefore we have more opportunities to enrich this technology using big data, machine learning, and artificial intelligence and it can be made more efficient, reliable, and trustworthy to the user.

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