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Review Article

IoT and Its State of Art Applications: A Survey

Kiran Maraiya[1*], Dr. Monika Tripathi[2]

[1]Research Scholar Department of Computer Science and Engineering, Shri Krishna University Chhatarpur, (M.P.) India
[2]Professor Department of Computer Science and Engineering, Shri Krishna University Chhatarpur, (M.P.) India

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***Corresponding author:** Kiran Maraiya
Research Scholar Department of Computer Science and Engineering, Shri Krishna University Chhatarpur, (M.P.) India

Abstract

In today's information technology world, the Internet of Things is a popular notion. In the future, the Internet of Things will turn everyday things into intelligent virtual objects. The Internet of Things (IoT) aims to integrate everything in our environment together under a unified infrastructure, allowing us to not only control but also keep track of our surroundings. According to an analysis of IoT history, the number of IoT devices has increased in recent years and is expected to grow dramatically in the coming years, indicating that IoT will interact in every aspect of our lives. The applications of IoT vary from a small network like home automation to large networks like cloud-based industry applications. This paper revisits the some important historical events of Internet of Things from the beginning. Furthermore, Many State of Art applications of IoT are presented in this article. This research will be useful and helpful for future research in the field of IoT.

Keywords: IoT, Sensor, Smart City, Energy Management, Scalability, Applications.

1. INTRODUCTION

The Internet of Things (IoT) has sparked a technological revolution with its fast growth. It is a system that incorporates various computing devices, actuators, wireless sensors, routing protocols, and applications that can independently share data and commands across networks in order to provide intelligent services. The Internet of Things (IoT), refers to billions of physical devices connected to the internet and storing and exchanging data around the world. It's possible to transform anything, from a pill to an aero plane, into an IoT device thanks to low-cost processors and wireless networks [1]. The definition of the Internet of Things (IoT) is not recent. Kevin Ashton was the first person to use it and thus claim credit for its invention. According to Ashton, the title was first used for a presentation he gave at Procter & Gamble in 1999. It's difficult to define the definition of the "Internet of Things" since it differs from one research field to the next. In the publication "Towards a description of the Internet of Things," the IEEE Internet of Things community gathered definitions from different Internet organizations and study groups. The following are the most relevant definitions for IoTs:

"The basic idea is that IoT will connect objects around us (electronic, electrical, non-electrical) to provide seamless communication and contextual services provided by them. Development of RFID tags, sensors, actuators, mobile phones make it possible to materialize IoT which interact and co-operate each other to make the service better and accessible anytime, from anywhere."–Internet Engineering Task Force (IETF), 2010.

"A network of items—each embedded with sensors—which are connected to the Internet."
–Institute of Electrical and Electronics Engineers (IEEE), 2014

The Internet of Things (IoT) is a fast expanding area of research that affects almost each aspect of modern life [2]. The goal of the IoT is to allow anything to be connected to anything and anywhere at any time via any network or service [4]. The Internet of Things (IoT) is a piece of planned network that can also be seen as a part of an overall system base with self-organizing capacities based on common and interoperable communication protocols. Figure.1 portrays the Internet of Things, which involves networking, computation, data processing (collection), and convergence of all elements in the area. Object can be found both in real and virtual "things," and virtual identities and physical characteristics use intuitive interfaces and are reliably organized through the knowledge system.

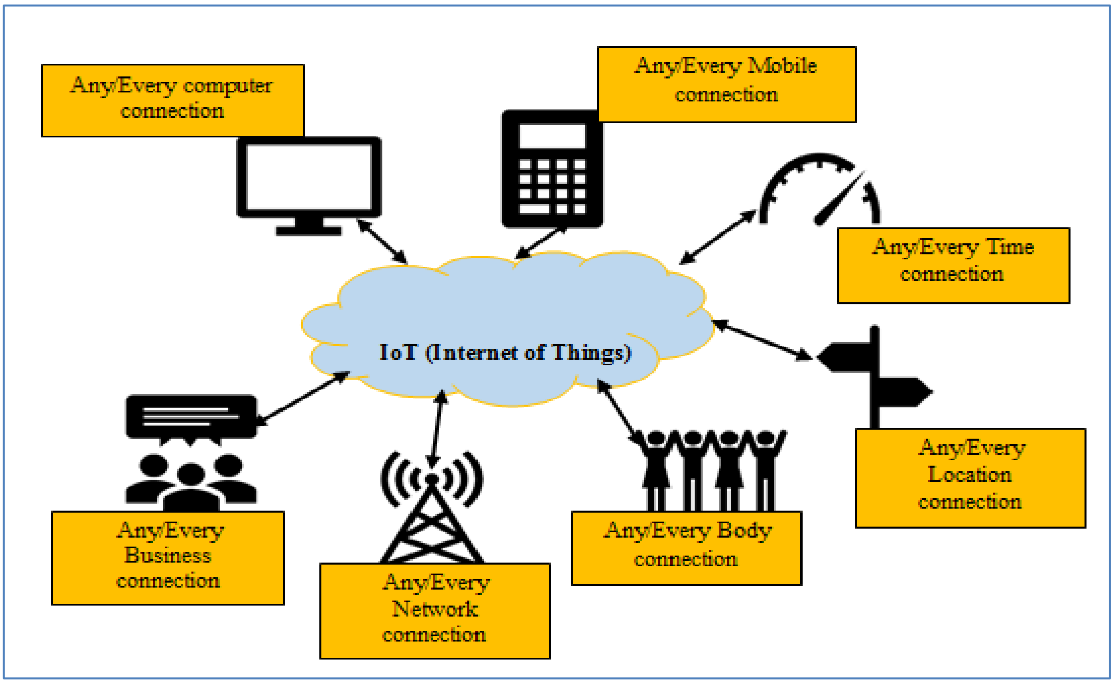

Fig-1: Internet of Things (IoT) Converging to any thing

2. BRIEF BACKGROUND OF IoT

The Internet of Things (IoT) was invented between 2008 and 2009. IoT refers to a growing number of things or devices connected to the internet. Since the 1980s, the phrase "embedded computing" has been used to describe how gadgets interact with the web. In 2010, China identified IoT as a significant business and announced plans to spend heavily on it. Furthermore, IPv6 was introduced in 2011 and has a capacity of addresses, which is enough to address every atom in the world [7]. In IoT, the IPv6 protocol can be applied. Mobile computing technology became popular and widely utilized in IoT development in 2012. As the number of linked IoT devices grew, new problems occurred, and new solutions, such as IoT platforms, were offered. The majority of well-known IoT systems emerged in 2013 [8].

To speed up IoT development, many proprietary and open-source platforms have been established. In the same year, Intel established an IoT group, while Google developed Brillo, an IoT operating system, in 2015 [9]. As a result of the enormous evolution of technologies, such as embedded systems, people's perceptions of promising technology have changed dramatically. As a result, the Internet is connected to billions of IoT devices. In this regard, Statista (the statistics portal) predicted that the number of linked IoT devices will reach 75.44 billion by 2025, based on data from more than 22,500 sources [10, 11].

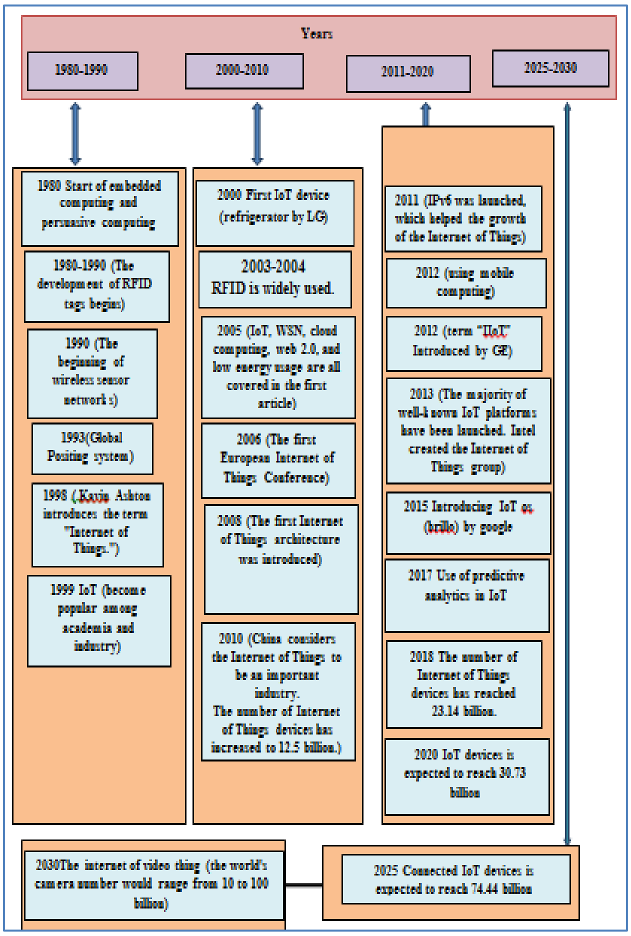

Fig-2: Brief History of IoT

According to [14], the number of internet-connected cameras will reach 100 billion by 2030 (Internet of video things).The history and evolution of the IoT are depicted in Figure 2. IoT has been progressively evolving due to the development of numerous technologies, including RFID, wireless sensor networks, global positioning systems, cloud computing, web 2.0, low energy communication, IPv6, mobile computing, analytics systems, and other new technologies, as shown in Figure 2. According to an analysis of IoT history, the number of IoT devices has increased in recent years and is expected to grow dramatically in the coming years, indicating that IoT will interact in every aspect of our lives.

3. FEATURES OF IoT APPLICATIONS

The fundamental features of the Internet of Things are as follows [15, 16, 29]:

3.1. Connectivity

The IoT infrastructure relies heavily on connectivity. Regardless of their location, IoT devices should be connected. Nothing makes sense without a link. Network accessibility and compatibility are made possible via connectivity. Accessibility is the way of connecting to a network, while compatibility is the capacity to consume and output data in a common way.

3.2. Dynamic changes and Self-Adapting

Device states fluctuate dynamically, such as waking and sleeping up, being connected and/or disconnected, and the context of devices, such as location and speed. Furthermore, the number of devices can fluctuate. IoT devices should dynamically adapt to changing circumstances. A camera, for example, can gather data based on lighting conditions. It automatically switches between night and day modes. It is an adaptable technique.

3.3. Enormous scale

The number of IoT devices is steadily expanding. As a result, the IoT's scalability must be sufficient to handle the large volume. The number of devices that must be controlled and communicate with one another will be at least an order of magnitude greater than the number of devices currently linked to the Internet. The management of the data collected and its interpretation for application purposes will be even more crucial. This has to do with data interpretation as well as efficient data management.

3.4. Embedded Intelligence

The information extraction from the sensor devices is critical. This information is only useful if it is properly analyzed. The Internet of Things (IoT) performs operations on sensed data in such a way that the outcomes are helpful to us. It is an IoT intelligence property.

3.5. Heterogeneity

Connected devices are heterogeneous because they are built on several hardware platforms and networks. Through different networks, they can connect devices or service platforms.

3.6. Safety

The primary priority should be safety. However, because various devices are connected over the internet in the case of IoT, safety is a major concern. And maintaining security at each node is a difficult undertaking. We must not forget about safety as we receive the benefits of the Internet of Things. We must plan for safety as both developers and recipients of the Internet of Things. This encompasses the security of our personal information as well as our physical safety. Securing endpoints, networks, and the data that moves between them all requires the development of a scalable security paradigm.

3.7. Things-specific services

Within the restrictions of things, the IoT is capable of providing thing-related services, such as privacy protection and semantic consistency between real and virtual things. Both information and cyber world technologies will alter in order to provide thing-related services within the constraints of things.

3.8. Identity

Every IoT device has a distinct identity. Its identifying characteristics are very useful if it needs to retrieve data from a certain device. IP addresses are unique identifiers of internet-connected devices that allow them to be identified throughout the network. The Smart interface on IoT devices enables communication with users. It adjusts to the surrounding surroundings. In conjunction with the control, configuration, and administration infrastructure, it also allows the user to query the devices, observe their status, and control them remotely.

3.9. Data gathering and processing by things

IoT devices receive and pre-process data from the actual world. The consumer is then given with IoT services, which are delivered either directly via IoT devices or through a service provider.

10. Collaborative data processing

IoT devices can work together to address difficult sensing issues like item categorization and tracking in the real world. Data from an IoT device can be pre-processed and enhanced on the device that collected it or on another IoT device. This pre-findings processing's might be shared among IoT devices.

3.10. Maintenances free operation

IoT devices may be required to function without maintenance or technical help for extended periods of time in order to fix issues. It may be necessary to provide remote diagnostics and resolution.

3.11. Self-adaptation

Self-adapting IoT devices can handle changing operational circumstances, increase resilience and dependability, and improve resource management and functionality.

3.12. Energy efficiency and operating lifetime

In many IoT devices, energy management is critical since the device is battery-powered and it is ideal for the device to run for as long as feasible. Energy harvesting technology might aid in energy management and gadget longevity.

3.13. Location considerations

The specific geographic position of an item, as well as its precise geometrical dimensions, will be crucial (for example, certain IoT objects will serve as sensor nodes in wireless sensor network. For many applications, the position of the sensor node is essential.) To optimize the IoT, it is important to offer spatial context to items and, if necessary, IoT applications.

3.14. Observation and/or actuation vs. data exchanges

Things with integrated sensors often examine physical settings and collect data about their surroundings. Some devices (actuators) are actuated and the physical environment can be regulated based on this information. Data transfers between items are used in some applications, such as RFID applications. To deliver IoT services in this form of application, data that the item obtains from the outside and/or keeps on its own is required.

4. BENEFITS OF IoT

The benefits of the Internet of Things are listed below [20].

1. IoT increases accuracy in manufacturing plants, and new products can be produced easily with the benefit of its applications.
2. Data can be easily transferred from one user to another using Internet of Things applications.
3. It can be used to keep track of patients in hospitals.
4. It can be used as a home surveillance system in smart homes. To gain control over all of the items in one's home.
5. The use of IoT can help to eliminate traffic jams and crashes in transportation.
6. The consumption of electricity will be decreased, and the quality of life will be increased, thanks to the Internet of Things.
7. When we shop for something on a website and want to check the status of our order, we can use IoT applications.

5. Application of Internet of Things

The applications of IoT vary from a small network like home automation to large networks like cloud-based industry applications. The primary goal of the IOT will always be to improve the essence of human life by incorporating smart cities, intelligent construction, smart agriculture, clever automobiles, smart health care services, smart environmental monitoring and control, smart grids, smart transportation and logistics, smart water supply management, smart parking and so on into lifespan [21, 22]. Real-time hospital laundry management, bus transportation, agriculture and greenhouse monitoring system, classroom access control, middleware, medical, railways, vegetation traceability system, and so on are other examples of IOT applications. Table 1. gives the brief description of different IoT application along with their related field. Some of the Common requirements for IoT applications are like Unique identification of the thing to communicate is required before communication. Interoperability is required to be ensured among heterogeneous and distributed systems for provision and consumption of information and services. Autonomic networking may be supported in networking control functions of the IoT in order to adapt to different application domains. Privacy protection is required to strike a balance and not impose an undue a barrier to data source authentication provided by the authentication requirement. Plug and play capability is an important feature to be supported in the IoT in order to enable on-the-fly generation of interconnected things with applications. IoT devices can be either mobile or static. When an IoT device moves from place to place, it is necessary to support mobility at the application level (such as service mobility between different service providers). The scale of the network of IoT devices may be huge and applications are recommended to support scalability [29]. IoT applications may be divided with respect to their main requirem nts into three main categories [26].

1. Real-time - applications which contain time restrictions. For example, the Connected Health and Smart Farming require real-time monitoring of vital signs, and the Smart Supply Chain needs real-time for an efficient trading.
2. Data analysis - Applications that concentrate on data processing For example, data analysis is used in Smart Retail, Smart City, and Smart Grid to optimise industry, towns, and electrical grids, respectively.
3. Device interaction-Applications focus on devices relations. In Smart Home, Wearables, and Industrial Internet, device interaction is a key aim.

Table-1: Applications of IoT [23][24]

No.	Field	Application
1.	Smart Cities	Parking Areas Monitoring, Bridges, Monitoring In Buildings, Android Devices, iPhone Detection, Energy Radiated Measure.
2.	Smart Environment Smart Earth	Forest fire detection, Air pollution, Catastrophic early detection [27]
3.	Security & Emergencies	Revolution and Hazardous Gas Detection, Radiation Level Detection, Liquid Monitor Data Centers, People Detection and Control in Non-Authorized and Restricted Areas
4.	Industrial Control	Oxygen Levels and Toxic Gases are Monitored Within Chemical Plants Monitoring, Ozone Tracking, Temperature Monitoring, Monitoring of the water level.
5.	Medical field	Patient monitoring, real-time health status, tracking of a person's body temperature, heart rate, and blood pressure, and hospital management are all available.
6.	Home Automation	Appliances with remote control.
7.	Smart Agriculture	Soil Moisture Monitoring, Greenhouse Monitoring, Controlling Humidity and Temperature Levels, And Studying Weather Conditions
8.	Smart Water Quality Monitoring	Detect context such as water quality, water flow, speed, temperature, water pollution
9.	Supply-chains	Monitors the entire supply chain, from raw material purchases to production, distribution, storage, retail sales, and after-sales services.
10.	Traffic Management	Real-time traffic and path optimization are used in smart transportation.
11.	Energy management	The Internet-connected combination of sensing and actuation systems is likely to maximize energy consumption. IoT systems will be able to connect with power generators and will be integrated into all types of energy-consuming devices. [25]
12.	Consumer electronics	children tracking and safety devices, entertainment and fitness applications, professional development, wearable electronic wallets and personal IDs, etc.[28]
13.	Connected Vehicles	Smart telematics, Route navigation, Driverless car, Accident Prevention.
14.	Smart Workplace	Sociometric badges : Sociometric sensors are wearable IoT devices that use social signals generated from speech qualities, body motion, and relative location to assess the amount of face-to-face interaction, conversational time, physical closeness to other people, and physical activity levels.
15.	Home Intrusion Detection Systems	Smart locks and security cameras that detect motion and transmit alerts to users' cellphones are examples of IoT-based home security applications. Users can use their mobile phone or smart home to check the safety conditions of their home from anywhere in the world.
16	Smart Metering	Smart Grid: Utilities are focusing on reducing energy consumption as the public's awareness of climate change and carbon emissions grows. IoT allows remote data management and monitoring capabilities for utility companies, allowing them to better regulate power flows into and out of their grids and providing users with the information they need to understand their energy infrastructure investments.
17.	Near Field Communication (NFC) Payment	NFC allows for contactless transactions. Customers are adopting contactless payments via their cellphones, and POS(Point of a Point of Sale) providers are including NFC capability in their systems.
18.	IoT in Education Applications	Smart Classrooms, Assists Special Children, Task-Based IoT Learning, Foreign Language Guidance
19.	IoT-Connected Factories	The Industrial Internet of Things (IoT) can assist industries in lowering energy use, improving asset tracking, and detecting equipment problems early. It can also help to protect revenue and enhance supply chain efficiency. IoT technology is used in smart factories to collect data on industrial processes and equipment in order to create strategic plans.
20.	IoT in Government Applications	City Planning and Management, National Defense,
21.	IoT in Law Enforcement Applications	IoT supports the judicial system by enhancing law enforcement agencies and techniques. The technology improves transparency, disseminates essential data, and eliminates unnecessary human interference. ex- Policing, Court System
22.	Logistics	Quality of Shipment Conditions, Item Location, Storage Incompatibility Detection, Fleet Tracking
23.	Smart Animal Farming	Animal Tracking, Toxic Gas Levels, Toxic Gas Levels
24.	IoT- consumer application	IoT optimization and data analysis benefit consumers both personally and professionally.The Internet of Things functions as a team of personal assistants, counsellors, and security. It improves our quality of life, work, and pleasure.ex- 1. Home (Butler, Chef, Gardner, Repairman, Security Guard). 2. Work. 3. Play (Culture and Night Life, Vacations, Products and Services).
25.	IoT −Manufacturing Applications	Current manufacturing technology makes use of standard technologies as well as modern distribution and analytics. Deeper integration and more powerful analytics are introduced by the Internet of Things (IoT). According to Boston Consulting Group researchers, this opens up the world of manufacturing in a level that has never been seen before. Ex.- Intelligent Product Enhancements, Dynamic Response to Market Demands, Lower Costs, Optimized Resource Use, and Waste Reduction, Improved Facility Safety, Product Safety.

6. CHALLENGES AND OPEN ISSUES

Some of the IoT's Major Key Challenges and Open Issues are mentioned below:

6.1. Scalability

One more main challenge is the scalability of the internet of things, as new devices and objects are getting connected with the network. So IoT should be capable of solving issues such as naming and addressing conventions, service management and information management, etc and also should support both small-scale and large-scale environments. etc[17].

6.2. Self-configuration

Self-configuring IoT objects can be configured to fit a specific environment without the need for manual configuration by the user [18].

6.3. Complexity of software

Since software systems in smart objects operate with limited resources, software infrastructure is required to support the network, which necessitates the use of a server in the background to control and support the network's smart objects [18].

6.4. Interoperability

Many smart objects are linked in the Internet of Things, and each smart object has its own data collection, processing, and communication capabilities. They should have a popular communication standard for communication and collaboration between smart objects of various types [18].

6.5. Security and Privacy

Since the Internet of Things (IoT) is a network created by smart objects connected through the internet, maintaining security and privacy is a major challenge. In the Internet of Things, users can prevent other users from accessing certain information at a specific time, or from communicating or transacting, in order to protect sensitive information from competitors. As a result, dealing with all of this is a major challenge [18].

6.6. Fault tolerance

Smart objects or devices in the Internet of Things are dynamic, and their meaning can change quickly. However, the network must continue to run properly automatically in order to respond to dynamic environment. As a result, IoT must be designed to be fault tolerant and stable [19].

6.7. Energy-optimized solutions

A network is made up of many interconnected devices that take a lot of energy to keep running. As a result, energy optimization is a crucial feature of IoT [17]. With billions of devices connected to the internet, power management is critical. Although some devices, such as gateways and home appliances, are powered by an AC line, the majority of IoT devices have self-powered or battery-powered sensors. The various gateway features, including the various sensor interfaces, Internet connection, and embedded processing, require that devices be plugged into main power or otherwise recharged on a regular basis. Many devices are expected to be recharged using solar energy or self-charged batteries in the near future, resulting in a substantial reduction in total energy usage in IoT applications.

7. CONCLUSION

The Internet of Things (IoT) has progressively introduced a sea of technological advancements into our daily lives, contributing to making our lives simpler and more pleasant through various technologies and applications. IoT applications benefit medical, manufacturing, industrial, transportation, education, government, mining, habitat, and other industries. According to various studies, the number of linked IoT devices will increase in the upcoming years. Although the Internet of Things offers numerous benefits, it also has a number of challenges in terms of governance and implementation. To help in understanding how IoT applications connect to one another, in this survey we present definitions of essential concepts and background information on the different types of State of Art IoT applications in this article. This research is useful and helpful for future research in the field of IoT.

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