**Introduction**

The Internet of Things (IoT) is an innovative concept of the Internet, which was initially introduced by Kelvin Ashton in 1999. It is defined as the possibility of connecting things using the internet to form a platform that is used to execute certain activities(Gamil et al., 2020).

The Internet of Things (IoT) describes the network of physical objects—“things”—that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the Internet. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025.

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things.

Using low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention. In this hyperconnected world, digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate. (Oracle, n.d.)

**Key Layers of IoT**

Theoretically, IOT comprises four different layers, which are the application layer, perception layer, network layer and physical layer.

Application Layer: Consists of the various applications and services that the IoT provides. Applications include smart cities, smart homes, transportation, utilities and healthcare

Perception Layer: This layer consists of various forms of sensory technologies, including temperature sensors, vibration sensors, pressure sensors, and RFID sensors that allow devices to sense other objects

Network Layer: This layer consists of network communications software as well as physical components such as topologies, servers, network nodes, and network components that allow the devices to communicate. Its main purpose is to transmit data between devices and from the devices to receivers

Physical Layer: The physical layer consists of the basic hardware such as physical components, smart appliances and power supplies that act as a backbone for networking the smart objects.

A diagram of a network layer

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(Kumar et al., 2016).

**History**

The precursor to IoT is the concept of connected devices that started in the early 1990s at the Auto-ID Centre at MIT. Reportedly, Kevin Ashton, director of the Centre, coined the term IoT in 1999 (Greengard 2015). In 1997, Ashton considered the possibility of using radio-frequency identification (RFID) tags to track products through Procter and Gamble’s supply chain. RFID tags were used to read and identify objects and then transmit the information wirelessly through a network. Before that, industry adoption of RFID tags started in 1980. Then a new concept of sensors and actuators through a wireless sensor network (WSN) appeared to sense, track and monitor objects with applications in healthcare and traffic management. Nowadays, these networks are enriched with GPS devices, smartphones, social networks, cloud computing and data analytics to support the modern concept of IoT. In Europe, and particularly Germany, IoT is one of the founding technologies of Industry 4.0 in the manufacturing sector. Industry 4.0 refers to the fourth industrial revolution where the three first industrial revolutions are related to mechanical power (Industry 1.0), mass production (Industry 2.0) and the digital revolution (Industry 3.0). Industry 4.0 is the integration of information and communications technologies with industrial technology. In addition to IoT technology, Industry 4.0 needs cyber–physical systems (CPS) and cloud manufacturing (CM). A CPS is composed of machines, storage systems and production facilities that can autonomously exchange information, trigger actions and monitor each other. A CPS links a manufacturing entity's virtual (computing) and physical (machines) elements by integrating analogue/digital hardware. IoT provides the needed platform to connect the CPS using a network of sensors, actuators and devices. IoT platforms generally use cloud-computing capabilities in external data centres, which led to the concept of cloud manufacturing (CM) in the Industry 4.0 context. (Ben-Daya et al., 2017)

**Real-Time observation**

From website observation to surveys, information from sensors enhances critical stages of a construction project, to avoid project delays, and delivers the catalyst for leaner ways of operation. Any downtime that takes place from an occasional provider of stock or performance failure by employees is pricey for construction firms. IoT solutions will alert your website supervisor once resources are amiss or are running out and employees would like help. (BIM Engineering, 2018)

**IoT BD works**

IoT has started automating the actuation of data-driven applications which are based on intelligent technologies. Data acquisition from the sensory devices and analyzing that data based on cloud services are the activities which are driven by the competent technologies on the connected objects. This revolutionary automation of systems has exhibited numerous benefits in real-life examples such as smart grids, smart transportation, smart inventory, smart healthcare and so forth. Nevertheless, recent state-of-the-art industrial surveys indicate that there are many data concerning issues which are accountable for the sluggish development of IoT in past years. Since a huge amount of data is produced through these sensory devices distributed over a larger area, the data-related challenges concern its acquisition process, integration, storage, and processing processes. Consequently, many researchers focus on managing heterogeneous data in a distributed environment having characteristics such as multiple source diverse data, dynamic data, semantically weak data, and inaccurate data.

Moreover, the authors have also developed an end-to-end solution for disentangling issues of knowledge graphs in IoT under a 5G environment. They have attempted to adopt techniques of blockchain management and have smartly produced a matching of the relevant concepts and their relations.

In addition, the emergence of IoT and 5G/6G has led to sophisticated communications with tera-hertz of high-speed data. The data communicated should be reliable but faces some intruder attacks. In this sensitive setting, the privacy and security of the data is a vexing issue. Many approaches for preserving the nature and confidentiality of the data are exercised to have secure data communication with seamless connectivity.

BDA has exponentially emerged as an important step in the IoT applications to create a better strategic decision-making process.22 “Connected things” is one of the key features of IoT that helps in efficient data acquisition. To avail fast real-time analytical information from unstructured data collected from internet-connected groups of devices, standard big data technology needs to be implemented and set up with proper infrastructure to handle high-volume storage and high-velocity processing of varied data. With readily available information quicker decisions and interaction can be facilitated which helps organizations in various ways. IoT and big data both have seen a compelling need in development and research to fuel the fields of business sector and IT.

Figure 3 shows that the relationship between big data and IoT systems can be divided into multiple steps for proper IoT data management. In the first step, the IoT data source nodes (sensors) interact with various applications. Complex data generated in the second step has high volume, high velocity and high variability of the data called big data. These huge data chunks are stored in distributed storage solutions and analytical systems draw meaningful insights from them through the four layers of analytics. Enterprises are assisted by big data technologies in better decision-making processes with the use of BDA in the IoT infrastructure by providing computation and data storage services. IoT applications such as smart grid systems, smart transportation systems, smart healthcare, and smart inventory systems are a major source of big data.23-25 Figure 4 summarizes the various applications of BDA in the IoT and their perceived benefits. For instance, intelligent transport system requires vehicular data to be processed in real time for better road management. Similarly, smart healthcare services demand quick response with carrying highly sensitive data where big-data analytics needs to be resilient for reliable operations to function correctly. (Mukherjee et al., 2022)

A diagram of a big data flow

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