Integration of Artificial Intelligence, Big Data, and Cloud Computing with Internet of Things

Jaydip Kumar

Department of Computer Science, Babasaheb Bhimrao Ambedkar University, Lucknow (UP), India

Abstract

The Internet of Things (IoT) provides to the client an effective technique for communicating with the Web world through ubiquitary object enabled networks. The rapid progress in IoT connected devices creates a huge amount of data in a second from personal and industrial devices. This information should be utilized to help business and functional objectives. Thus, there is an urgent requirement for adopting cloud computing, big data, and artificial intelligence techniques to enable storage, analytics, and decision making. In this article, we focused our consideration to integrate Cloud Computing, Big data and Artificial Intelligence technique with the Internet of Things devices. Cloud computing, Big Data, Artificial Intelligence, and IoT are different techniques that are already part of our life. Their adoption and uses are expected to make them more comprehensive and make them essential components of the future Internet. The Internet of Things (IoT) is a system of interconnected gadgets, digital or mechanical machines that are given exceptional identifiers and the capacity to move information over an organization without expecting human-to-human or human-to-pc collaboration.

Keywords: Artificial intelligence, big data, cloud computing, Internet of Things

Email: jaydipkumar2001@gmail.com

1.1   Introduction

With the wide-spread discovery of techniques in the current digital era, increasing physical entities are interconnected to the Internet of Things (IoT) devices. In recent years IoT technologies are applied with different techniques such as Artificial Intelligence, Big Data, and Cloud Computing. Artificial Intelligence (AI) is a technique which has the ability to compute a huge amount of task that is usually done by a human. Artificial Intelligence uses different learning techniques to facilitate automatic rules and regulations for decision making. Artificial intelligence is divided into two different modules such as learning module and predicate module [1]. The learning module is used for effective data collection, training, and data modeling. And the predicate module is used to take action on the current situation. The flow and storage of exponentially increasing data are easily managed by Artificial Intelligence (AI). The integration of cloud computing and IoT are also two different technologies that assume a vital part in our daily life. Cloud computing and the Internet of Things are merged together is expected to break both current and future internet which we called as new paradigm CloudIoT [2]. In the era of the internet which plays a fundamental role in cloud computing, it seems to be represented as a medium or the platform through which many different cloud computing services are accessible or delivered its services. If you are thinking that the internet as a virtual "space" for connecting users from over the globe, it is like a cloud, sharing information by using the internet. Cloud computing is the trending technology in the daily life of everyone which provides on-demand web services such as networking devices, data storage, servers, and applications. It provides higher flexibility and cost efficiency while users try to use cloud computing resources and applications. The different number of connected devices has already exceeded the number of users on the earth. This is due to exponential increase of connected devices rapidly increasing huge amount of data as well. The storage of data locally and temporarily will not be possible to access different devices which are connected to each other. There is a need to be centrally storage space which is provided by cloud storage [3]. And the intense invention in the Internet of Things (IoT) technologies, the Big Data technique has critical data analytics tools which bring the knowledge within the IoT devices to make the better purpose of IoT systems and support critical decision making. Big Data has been divided into five fundamental bases such as volume, variety, velocity, veracity, and value. The volume indicates the size of the data. And the different types of data from different sources are known as variety. The real-time data collection is known as velocity, and veracity is the uncertainty of data and the value which shows the benefits
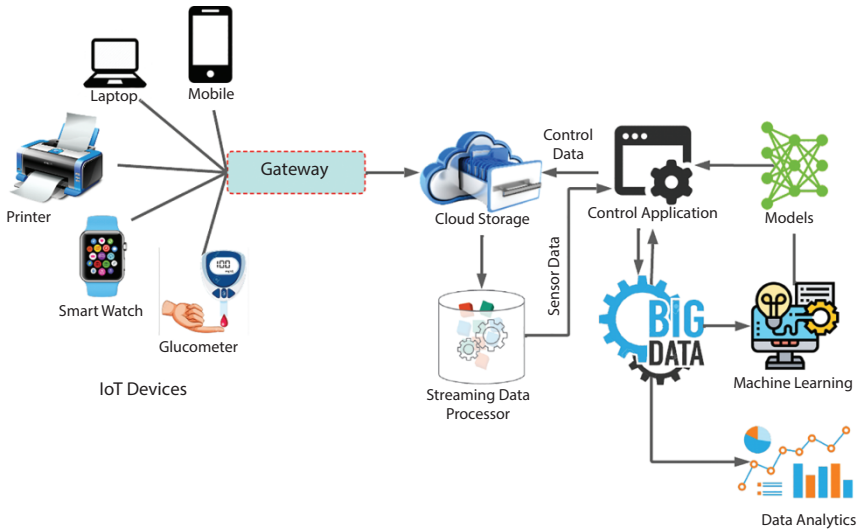
Figure 1.1 Flow diagram of AI, big data, and cloud computing integrated with Internet of Things.

of different industrial and academic fields [4]. The combination of IoT and Big Data has created opportunities to develop complex systems for different industries such as healthcare, smart city, military and agriculture, education, etc. The flow diagram of AI, Big data, and cloud computing integrated with the Internet of Things is given below in Figure 1.1.

1.2   Roll of Artificial Intelligence, Big Data and Cloud Computing in IoT

Internet of Things (IoT) is an interconnection of various devices which are connected to each other through the internet and exchange information. These IoT devices generate a huge amount of information [5]. Artificial Intelligence (AI) uses the decision-making support system to provide data flow and storage in IoT networks. The integration of artificial intelligence (AI) with the Internet of Things (IoT) techniques will generate extraordinary value-creation opportunities. The IoT devices with AI enabled the rise of a "factory of the future" [6]. This increases the efficiency, turnaround, and waiting time and reduces the cost. The IoT with AI is used in different fields such as 3D printing, Robotics, the food industry, manufacturing, logistics, and supply chain management. These fields create lots of information in a regular mode which is centrally stored in cloud computing.

It can be said that the cloud with IoT will be the future of the next generation of the internet. However, the cloud computing services are fully dependent on cloud service providers but IoT technologies are based on diversity [7]. Cloud computing reduces the cost of the use of applications and their services for users. It also simplifies the flow of Internet of Things data capturing and processing and also provides fast and cheapest cost integration, installation, and deployment. And without Big Data analytic applications, the huge amount of data generated by the IoT devices creates an overhead for any business. Due to this any organization must know how to handle this massive amount of data that is collected by the IoT devices. Fetching accurate data is not a problem for any organization; the challenge is to get the necessary skills in the analytical analysis field to deal with big data [8].

1.3 Integration of Artificial Intelligence with the Internet of Things Devices

For addressing any problem AI needs to two-step process which is shown in Figure 1.2. A set of AI models has been created in the first stage. The models are created by the machine learning algorithm with a set of training data. These trained data are processed by the natural language documents or by the encoding of human expertise [14]. The models are invented in different categories like neural networks, decision trees, and inference rules. The models use the inferences from the Internet of Things sensor's input data and guide the operations of the system [9, 18]. There are lots of work have been completed with the integration of Artificial intelligence and Internet of Things. We have mainly surveyed previous works on the personal and industrial applications such as attendance monitoring system, human activity and presence in hospitality, agricultural applications, hospital, human stress monitoring [15, 21]. The short review of IoT applications domains are given below Table 1.1 and the difference between the AI and IoT are given below in Table 1.2.
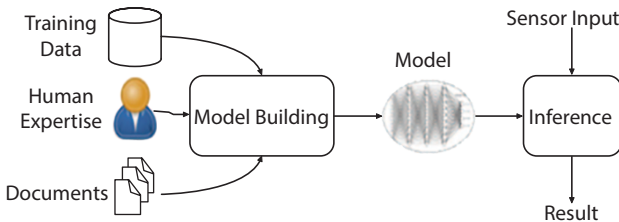
Figure 1.2 Integration architecture of AI in IoT.

Table 1.1 Recent Artificial Intelligence based Internet of Things applications.

Problem	Techniques	Data
Wearable devices	Decision tree, logistic regression	Health data
Human attendance system	Random forest, decision tree etc.	Images
Smart meter operation	Bayesian network, naïve Bayes, decision tree, random forest	Meter reading data
Parking space detection	Clustering algorithms	Camera data
Human stress detection	SVM, logistic regression	Pulse waveform

**Table 1.2** Table of differences between the internet of things and artificial intelligence.

Based on	Internet of things	Artificial intelligence
Connection type	A set of interconnecting devices over the network	Interconnection and machine independent is not needed
Capability	Capabilities of the devices are known prior	The capabilities never be predicted of machine
Interaction	Interaction of human between the devices is needed	Interaction of human between the devices is not needed
Future scope	Interaction of human between the devices is needed	Machine can learn and start reacting more than human
Instruction need	Instruction needed to IoT devices	Machines can learn from experiences
Dependency	IoT devices cannot work without artificial intelligence	Artificial intelligence is not dependent on IoT devices
Applications	Smart home, smart city, medical, water monitoring etc.	Fraud prevention, voice assistant, personalized shopping, AI-powered assistants etc.

1.4   Integration of Big Data with the Internet of Things

The generations of the huge amount of data are collected from the Internet of Things devices and its sensors leads to an exponential incremental in data. This data needs to manage, processed, and analyzed by the organization [10] which is shown in Figure 1.3. IoT technology is a major source of Big Data which motivates the organization to deploy Big Data technology and its applications to acquire the needs of IoT technologies. The collected data from the IoT devices is managed, processed, and analyzed by the big data. Big Data provides a framework for data transmission and processing which support IoT data and virtualization. The provided data become deep and more complicated to be stored and analyzed by conventional technology. So the broad consensus is that the big data and Internet of Things techniques are highly interconnected [11]. The architecture of Big Data integrated with the Internet of Things is given below in Figure 1.3 and the comparative study of big data applications is given below [17] in Table 1.3.

1.5   Integration of Cloud Computing with the Internet of Things

The combination of cloud computing and IoT are efficient for every business or user. This enhanced the efficiency of every task and reduced the setup cost for applications, servers, storage spaces, etc. The different cloud provider provides cloud services pay as requirements model, where cloud
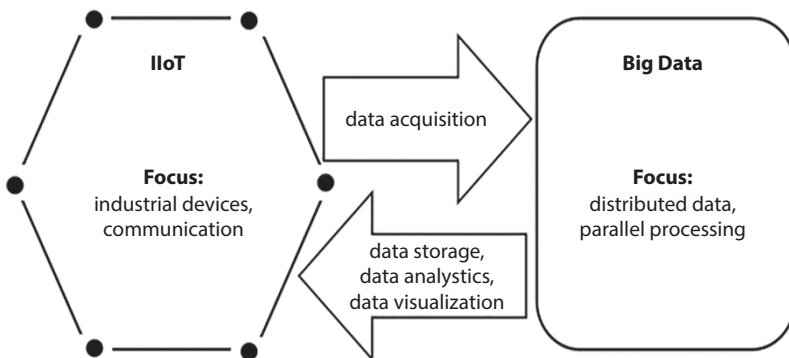
Figure 1.3 Integration architecture of big data with internet of things devices.

Table 1.3 Comparisons of big data applications.

Applications	Sources	Characteristics
Healthcare	Patient and laboratory data, gene expression data, risks and emotions of user's data.	Text, structured, images, videos, hypertext
Government Sectors	Governmental defense data, scientific and technological data, education data, treasury, power and energy records, employment records.	Text, images, videos, audios
Retails and customer products	Sales and purchasing records, marketing, accounting, inventory and feedback data.	Text, audio, videos, hyperlinks, emotional symbols
Agriculture	Weather information, agricultural drones and videos and images, soil's map and fertilities data, global positioning system (GPS) records.	Text, number, images videos
Banking sectors	Transactional information, customer's information, policies, loans, accounts, financial information.	Text, numbers, images
Transportation	Transport information, tracking devices information, GPS information, accidental information, vehicles and products information.	Text, numbers, images, videos, hyperlinks, audios

user can pay for the particular services used [22]. When an organization needs to collect a huge amount of data from the IoT device sensors, each sensor needs a large amount of computation power and storage space. This problem is solved by the combination of Cloud computing and Internet of Things techniques, in which the IoT sensors uses the cloud resources and store the collected information in a centralized manner [12]. The architecture of cloud computing with the Internet of Things is given below in Figure 1.4. Cloud computing and the Internet of Things contain different characteristics which are compulsory for each other which is shown in Table 1.4. Due to these characteristics, the integration of Cloud computing and IoT gives an excellent solution to real-world problems [13].
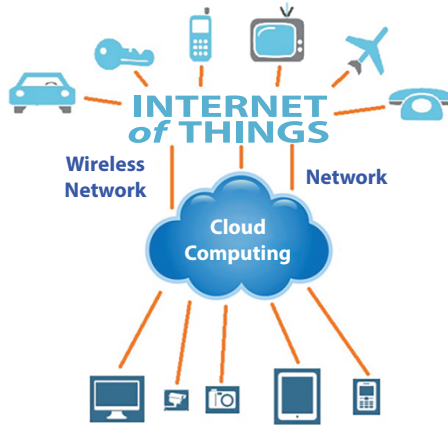
Figure 1.4 Architecture of cloud computing with internet of things.

Table 1.4 Characteristics of the internet of things and cloud computing.

Cloud computing	Internet of things	Characteristics
Give procedure to manage	Producer	Big Data
Provide virtually unlimited	Limited	Storage
Provide virtually unlimited	Limited	Computational services
Centralized services	Widespread	Displacement
Comprehensive	Limited	Reachability
Mode of service providing	Point of convergence	Internet role

The integration of Cloud computing and Internet of Things can be divides in three categories such as cloud platform, infrastructure and IoT middleware. Cloud computing removes the IoT limitations and provided opportunities for the business and it is managed by the cloud infrastructure. The IoT provides interconnection between the IoT devices and Cloud platform for data exchange.

1.6   Security of Internet of Things

The security challenges of IoT technologies are directly related to their applications. The aim of the IoT technique is to provide the combination

of both physical and digital world in a single ecosystem which created the new intelligent era of web world [16, 23]. IoT provides huge business and opportunities for organizations such as energy, healthcare, government and other sectors. Due to this enhancement of IoT techniques, it suffers from different security issues which are more challenging to secure its data and applications [19]. The IoT devices faced different security issues such as privacy of data, authorization, verification, access control, data storage management, etc. The few security challenges are given below in Table 1.5. In IoT, the wireless communication channel involves radio communications,

Table 1.5 Internet of Things security requirements.

Security requirements	Description	IoT security properties
Availability	The resources of the IoT devices are readily available.	IoT resources must be attack free from the denial of service (DoS) attacks.
Integrity	It is accuracy, consistency of data and its services, trustworthiness of IoT life cycle.	The security algorithms must be capable of detecting modification and manipulation of data breaches on IoT devices.
Confidentially	The protection from the unauthorized users and access.	
Authentication	It authenticate that the user is genuine user.	The security technique must be capable of verification and authentication of user.
Authorization	Prevented the illegal uses of IoT devices or resources.	Only authorized or legal user can access the network
Access Control	Provided management and prevent unauthorized user and access to IoT resources and data.	Ensured that the IoT devices are verified and authorized to access the IoT data.

transmitters, and receivers for the information exchange between two IoT devices. So this communication channel suffers from different security threats and attacks such as man-in-middle attacks, communication signal loss, hacking of data, Denial of service attacks, protocol tunneling [20].

1.7   Conclusion

The Internet of Things is a wide field and contains incredible and different variety of applications. The main aim of IoT is to provide a facility of exchange information and synergic performance between devices and peoples via global machine-to-machine (M2M) networks. Due to M2M network, exchange of information between the devices creates an exponential amount of data. It is impossible to manage or keep secure these generated personal or organizational data in local devices. The IoT techniques need centrally storage space for personal or industrial data. To avoid these problems, in this paper we have introduced the integration of Cloud Computing, Big Data and Artificial Intelligence techniques with the Internet of Things devices. The integration of cloud computing with IoT techniques stores the information centrally generated by the IoT devices. And the collected data which is centrally stored in cloud computing is managed, processed, and analyzed by the Big Data Techniques. To extract the high volume of IoT data in real-time, processing needs machine learning and AI algorithms.

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