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Integration of Cloud Computing, Big Data, Artificial Intelligence, and Internet of Things:
Review and Open Research Issues

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ABSTRACT

Cloud computing, internet of things (IoT), artificial intelligence, and big data are four very different technologies that are already discussed separately. The use of the four technologies is required to be more and more necessary in the present day in order to make them important components in today's world technology. In this paper, the authors center their attention on the integration of cloud, IoT, big data, and artificial intelligence. Several kinds of research papers have surveyed artificial intelligence, cloud, IoT, and big data separately and, more precisely, their main properties, characteristics, underlying technologies, and open issues. However, to the greatest of the authors' knowledge, these works require a detailed analysis of the new paradigm that combines the four technologies, which suggests completely new challenges and research issues. To bridge this gap, this paper presents a survey on the integration of cloud, IoT, artificial intelligence, and big data.

KEYWORDS

Artificial Intelligence, Big Data, Cloud Computing, Internet of Things

INTRODUCTION

Internet of Things (IoT) is a network of Smart devices which collect and transfer the data between them. The number of connected devices will be more than thirteen billion devices in 2020 and seventeen billion in 2025. It will create Trillions of Data every hour. For several years now, the internet has not been limited to computers and other smartphones. Now almost all objects are connectable to the internet. The Internet of Things has no limits. For this, businesses operate various communication networks. In order to control such enormous data, there is a need for Big Data.

Big Data is a term for data sets that are so large and huge. So, using Big Data can manage those huge data which the authors achieved from IoT devices and other sources.

The concept of big data is a concept generalized since 2012 to reflect the fact that companies are confronted with data capacities (data) to be processed more and more considerable and presenting great commercial and marketing issues. In order to cope up with scaling and rapidly increasing the volume, centralization, and infrastructure, here comes Cloud Computing.

Cloud Computing: Cloud Computing gives the centralized platform to access the data from anywhere in the world with the shared infrastructure. Now, everything works ideally. To treat all these data, there is a need for Artificial Intelligence.

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Artificial Intelligence: can use those data and learn from those data. It will predict or take decisions from those trillions of data. So, the usual information can get and predict our future from our past. There are a lot of AI offers. So, the real power comes with the use of all the technologies for our better future.

In this paper, the authors will discuss how these four technologies Internet of things, artificial intelligence, big data and cloud computing are related to each other.

FUNDAMENTAL CONCEPTS

In the modern world, the use of new technology is important for several IT operations and numerous industries such as big data, cloud computing, artificial intelligence and IoT (Internet of things) for many of their applications for efficient management of the company. Various concepts and definitions are discussed below.

Characteristics of Big Data

Big data is data whose scale, distribution, variety, and/or timeliness need the use of new technical architectures, analytics, and tools in order to allow insights that open new sources of business value. Three main features characterize big data: volume, variety, and velocity. The volume of the data is its size, and how enormous it is. Velocity concerns to the rate with which data is changing, or how often it is created. Finally, variety includes the different formats and representations of data, as well as the different kinds of methods and techniques of analyzing the data (EMC, 2012).

Characteristics of Cloud

Cloud computing is the realization of utility computing where resources are implemented by the service provider and the cloud costumer will pay as they use the resources. The user can access the cloud via a thin client. Cloud also provides memory for a large number of data to store and allows computation. Hence a lot of users can rely on a cloud as it reduces the infrastructure charge that the user needs to invest (Drissi et al., 2015), (Drissi et al., 2019).

Characteristics of IoT

Internet of Things: Future internet will be mainly based on IOT. As the title indicates the Internet of Things is nothing but an interconnected network of things which are embedded with sensors and actuators. The thing may be any real-world object. These objects have the ability to collect data from the environment with the help of sensors and therefore they are termed as smart objects. A large amount of data will be managed by such smart objects, which will be helpful in future analysis.

Characteristics of INTELLIGENCE Artificial

Artificial intelligence relates to science and technology that can simulate human sensing, thinking, reasoning and action, and demonstrates the capacity to solve problems with human intelligence. Artificial intelligence uses human input data to get knowledge and enhances problem-solving through machine learning mode (Maurício et al., 2018). Literature Review

In (Soldatos et al., 2012), the authors describe design principles for IOT cloud environment and also introduce a framework for converging computing models with developing IOT infrastructure. The paper has explained that future internet is mainly focused on IOT and therefore integrated easily with the services such as the Internet of Services (IOS) and their standards. Management of IOT based cloud environment is not simple and consequently, this paper introduces the main building block of a middle wear framework. With this framework service providers can efficiently handle end user requests by deploying cloud utility-based infrastructure. The paper also explains the design principles for the framework.

This paper (Tan & Wang, 2010) presents the notions of the Internet of things. Everything on the internet can be connected and it is called the Internet of Things. At present principal communication on the internet is between humans and in future things will be transferring information on behalf of the people. To develop IOT architecture some supporting technologies are needed. To connect the object to the internet they must be identified.

This paper (Gubbi et al., 2013) explains the visions as well as motivations for IOT, different application areas in IOT and a new process of defining them. It also sets on fire IOT realization, problems or difficulties associated and also future trends and scope in Cloud-centric Internet of things. The future generation of the Internet will be based on IOT and as all objects can be connected to the internet large data will be created. To manage a large amount of data, IOT investigates the help of Cloud computing.

Now, companies must be innovative and influenced the latest technologies simply to stay in business. Businesses that achieve online retail, investment, and other services aren't considering these channels as just another route to improve their revenue. They realize that online services are fast becoming their primary revenue channel. According to data analyzed over three months for Forrester's report(Forrester's Report on the Digital Business Imperative, n.d.), The Digital Business Imperative, 84% of US banking customers used online banking for their transactions, and 43% used a mobile phone for these activities.

This paper (Kyriazisa & Varvarigou, 2013) describes the management mechanism which is not centralized for IOT-based systems in order to use several devices and also explains an architecture in which things learn based on others experience. The paper presents the realization of IoT based applications based on the improvement of IoT technology. Humans interact with each other and sharing of information in turn results in development. By enabling IOT applications to collect a massive amount of data, which together form the information helps in development.

This paper (Kawsar et al., 2010) discusses a novel modeling method for pervasive systems based on high-level models of human activities. It presents a flow driven distributed software framework. A foundation for adaptation, discovery, and execution of flows in real time matching the dynamics of real-world activity is given by this framework. The paper illustrates the definition of IoT and the development of IOT in the preceding few years. It also addresses the two challenges given as loss of technology-independent and transferable models of human work activities and design of distributed and embedded interaction techniques and user interfaces to efficiently support people in demanding work environments such as industrial, hospitals and plants which assure temporal and spatial similarity.

This research paper (Fox et al., 2012) presents the architecture of IOT cloud framework and the various APIs available to the users. There are several technical difficulties involved in the IOT development and can be classified as deployment problem, interoperability problem, security, management problems etc. The paper illustrates the IOT architecture which has elements such as IOTCloud controller, a Message broker, Sensors and Clients. In (Wang et al., 2011), the authors discuss the concepts of cloud computing and IOT. Both cloud and IOT has its own advantages. Joining them will lead to higher performance

In (Taccari & Spalazzi, 2013), the authors present how the cloud of things can be used to tackle emergency situations. The emergency is any occasion which necessitates action to save lives and protect property, public health, and safety. Emergency management provides an important role. This paper aims at defining a framework by which the heterogeneous resources and data can be combined along with the capabilities provided by physical objects such as sensors and actuators.

In (Aazam et al., 2014), the authors discuss the IOT, Cloud Computing and the problems involved in integrating these two technologies. Now, there is a need for integration of IOT and the cloud. In IOT things refer to any object which is connected to the internet. The number of devices that are connecting to the internet is increasing and therefore it increases the data as well. Storing and handling the data in local storage devices is not possible anymore. More processing of data is not possible with the limited resources at the IOT end. These problems can be handled by Cloud Computing. The

author mentioned that IOT alone cannot manage the huge amount of data cloud is integrated. This is termed as Cloud of Things (COT).

In (Distefano et al., 2012), the authors discuss about the design of an architecture where new generation services collects the data from the outside environment and different management strategies are applied to them. It is precisely focuses on the implementation of the architecture based on COT. This paper explains ICT scenario in which number of devices connected to the network is growing which also includes sensors and actuator networks. To coordinate the interaction between computing, storage and sensing a proper methodology is needed.

In (Parwekar, 2011), the authors discuss the services proposed by IOT on Integration with Cloud Computing. IOT has little devices called sensors as well as actuators which are used to assemble the data. These sensors sense the changes in the environment and produce a very large number of data. These things are embedded in physical objects. Modern society has got several data constraints. This problem can be reduced by quick transfer and retrieval of data. With the help of cloud computing, things with less capacity can perform a high computation. But in current IoT providing security is a hard task and there is no communication between services and events. The paper gives information about the different services the IOT provides. The paper discusses the limitations of the deployment of IoT on the cloud. There might be connectivity problem, security, bandwidth availability, scalability problem, interoperability, etc.

In (Suciu et al., 2013), a new architecture has been proposed to transfer information through the internet. The main goal is to achieve customized services and nonintrusive behavior. The paper focuses mainly on explaining different frameworks surviving for IOT, cloud, and interoperability among them. Cloud Framework has several interoperable specifications and standards to provide a basis for a cloud. The main difficulty will be the management of SLAs for services as well as applications used in the cloud. The IOT FrameWork concept mainly came from Radio Frequency Identification technology. The need for standard protocols, architecture and APIs are defined to help interoperability between smart objects. The paper illustrates an architectural survey of the central elements of cloud computing. Different characters found in cloud computing such as service user, developer, and provider are also described.

In (Dores et al., 2014), the authors discuss the different technologies that can be adapted to develop future internet platforms. By combining different technologies such as Cloud Computing, IoT and Wireless Sensor Networks, different systems can be developed. The paper explains different technologies that can be used to make the future internet a reality. It describes Next Generation Networks which is a concept that makes network architecture more flexible and new services can be easily added to the network.

This paper (Ying & Hao, 2011) compares the brain with the internet and discusses designing a data center based on the IOT of the Smart Cloud Computing Data Center. The architectural part explains how data solution is given based on IOT concepts. The virtual brain is assumed as Cloud computing by changing virtual sensory organs into the IoT sensor and by changing the virtual internet nervous system into a ubiquitous network of IOT. Further, it explains the design of Smart Cloud computing and data center design.

This research paper (Hung et al., 2011) introduces a concept of smart travel design which intends to help the traveler capture the moment emotion memory and process the data. This paper also explores the possibility to develop tourism and introduces a new ubiquitous tourism system based on new concepts such as IOT, and other technologies. The paper explains the challenges faced in the tourism industry and how technology plays a major role to manage these challenges. Services provided to tourists can be improved by the advancement of technologies.

According (Xiao & Zhang, 2011) an open, secure, and flexible platform has been proposed which is based on the concept of IOT and Cloud Computing. To address interoperability short distance ambient communication protocols for a medical purpose are discussed. To solve different security issues Secure Socket Layer (SSL), authentication and auditing are taken into consideration.

This paper (Bo & Wang, 2011) discusses the use of IOT and cloud computing, how that can be employed to agriculture and forestry. Forest pest forecasting can be done based on the collected information of the pests which can be achieved by using the sensors. The data which will be collected is very large and this can be handled by the cloud.

According (Khan et al., 2013) ICT tools are discussed for a smart city deals with various application domains such as land use, transport, energy and provides integrated information. This information is helpful for smart cities but which requires software tools and several technologies to collect, store, process and analyze the data. This paper proposes a theoretical perspective which focuses on big data processing and analysis. This paper describes how urban management and better planning can be done with the help of ICT tool for smart cities. This paper gives an example use case of Smart town center and also proposes an architectural design for cloud-based big data analysis.

According to (Kumar, 2016), there has been an increase in the number of users of cloud technologies and AI and also the growth in branches. The industry has experienced various needs and preferences from various users. The demand for customized networks has increased and this has made it impossible for this industry to manage their operations without artificial intelligent (AI). Cloud robotics is a rapidly developing technology made possible by the current ubiquitous internet connectivity and the growing number of powerful cloud computing services available (Bogue, 2017). The technology has been applied favorably to industrial, mobile and other classes of robots, often through direct collaborations between robot manufacturers and major IT companies.

According to (Muhammad et al., 2017), the authors discuss the integration of the IoT and cloud technology in order to have a better solution for an uninterrupted, secure, seamless, and ubiquitous framework. The complementary nature of the IoT and the could in terms of storage, processing, accessibility, security, service sharing, and components make the convergence suitable for many applications. The advancement of mobile technologies adds a degree of flexibility to this solution. The health industry is one of the branches that can benefit from IoT-Cloud technology, because of the scarcity of specialized doctors and the physical movement restrictions of patients, among other factors.

According to (Liu et al., 2015), As cloud computing is being extensively adopted for big data processing, data security is becoming one of the major interests of data owners. Data integrity is an essential factor in about any data and computation related context. It is not only one of the qualities of service, but also an important part of data security and privacy. With the propagation of cloud computing and the growing needs in analytics for big data such as data generated by the Internet of Things, verification of data integrity becomes increasingly important, particularly on outsourced data. Therefore, research topics on external data integrity verification have attracted tremendous research interest in recent years.

According to (), Cloud Manufacturing twining with an Internet of Things (IoT) has been waked up to achieve final intelligent manufacturing. With IoT technologies such as radio frequency identification (RFID) implemented in manufacturing sites, huge data will be generated. Such data are so difficult, abstract, and variable so that it is challenging to make full use of the data which carry the great myriad of helpful information and knowledge. This paper gives a visualization approach for the RFID-enabled shopfloor logistics Big Data from Cloud Manufacturing.

ANALYSIS

Cloud and IoT complement each other; connected devices produce huge amounts of data and the cloud provides the infrastructure to store, process, and analyze the data. Cloud and AI complement each other; the cloud plays a significant role in enhancing the power of applications that incorporate AI. Almost all major players in the cloud business have developed AI services that use robust cognitive engines to treat structured data that get uploaded to the cloud. Cloud and Big Data complement each other; cloud-based systems give high bandwidth, immense amounts of memory, and scalable

processing power to help Big Data applications with enhanced real-time processing and analysis of streaming data. Because of this corresponding of the four technologies, the authors need to couple each one to others for our better technology's future.

CONCLUSION

To conclude, the concentration of the Internet of things, big data, AI, and cloud computing advantage a new horizon of decision support system. Further, the convergence of the IoT, big data, AI, and cloud computing can provide new opportunities, possibilities, and applications in all the areas.

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