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Big Data in Internet of Things

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Abstract Big data and the Internet of things (IoT) are the two most-talked-about technologies in the last few years. While big data is about data, IoT is about data, devices, and connectivity. The two technologies are poised to transform every aspect of business and life. The aim of this paper is to discuss the positive and negative impacts of big data and IoT in our daily lives. It also covers big data IoT, its applications and challenges.

Keywords big data, Internet of things (IoT), big data IoT

Introduction

Internet of Things (IoT) and big data are closely intertwined and interconnected. While big data is about data, IoT is about data, devices, and connectivity. IoT interconnects heterogeneous physical devices, such as sensors, actuators, embedded sensors, and RFID through the Internet and enables them to communicate with each other. It is driven by smart sensors, powerful embedded microelectronics, high-speed connectivity. IoT is an important big data source, which is rendered useless without data analytics. Big data analytics has been identified as a key enabler for the IoT.

Although big data and IoT go hand in hand, the two technologies come from different backgrounds. IoT is driven by sensor technology. Big Data has deep roots in software paradigms developed by the Internet and social media enterprises like Google, Facebook or Yahoo [1]. Before we analyze their connection, let us take a brief overview of the two technologies.

Internet of Things

The Internet of Things (IoT) is a worldwide network of physical, daily life objects that can be accessed via the Internet. These objects are everyday items like wristwatches, smart phones, cars, dishwashers, vehicles, home appliances, refrigerators, microwave ovens, air conditioners, water heaters, animals or people, which contain embedded technology that can interact with the environment [2]. All surrounding electronic equipment can be connected to an IoT network and can be controlled remotely. Sensors such as video cameras, audio sensors, environment sensors, and motion sensors are becoming ubiquitous in IoT.

The concept of Internet of things (IoT) is converting things into smart objects. The devices that will make up the IoT will vary by nature. The main objective of IoT is to bridge together the small islands of networks of smart devices. A typical IoT application framework consists of three layers: perception layer, network layer, and application layer. IoT has been deployed in many domains such as smart city, smart energy, smart transportation, healthcare, food and agriculture, logistics and retail. In almost all IoT applications, huge amount of data is dumped into storage for the purpose of data analysis. IoT is on a fast accelerating path with evolving standards, technologies, and platforms.

Big Data

Unlike traditional data, the term big data refers to large growing data sets with heterogeneous formats (structured, unstructured and semi-structured data) from heterogeneous sources (e.g. laboratory and clinical data, hospitals operations, pharmaceutical data, government, social networks, marketing, banking) [3]. Big data is characterized by the five "Vs" which are volume, variety, velocity, veracity and value. Volume relates to the data's size (terabytes, petabytes, or zettabytes). Variety refers to different types of data and their sources (sensors, devices, social networks, the Web, mobile phones, and so on). Velocity refers to the speed with which the data is generated from sources (for hourly, daily, weekly, monthly, or yearly). Veracity implies truthfulness and credibility of the data thus collected. Value refers to the actual use of the data collected [4]. Other researchers like to introduce additional characteristics beyond the 5V's model such as: validity (correct processing of the data), variability (context of data), viscosity (latency data transmission between the source and destination), virality (speed of the data sent).

With big data comes big responsibility. The collection, storage, and analysis of data are far outpacing individual privacy protections. This problem is further complicated by the evolution of IoT. Great opportunities are presented by the capability to analyze huge amounts of IoT data, big data analytics is the process of examining huge data to reveal hidden patterns, market trends, and ultimately help in making decisions. Big data analytics can transform a large amount of structured, unstructured, and semi-structured data into a more understandable data [5,6].

Big IoT Data Analytics

The phenomenon of daily life objects that are interconnected through a worldwide network is known as the Internet of Things (IoT) or Internet of Objects. The sensors from a large number of IoT devices continuingly generate a huge amount of data, often referred to as big data. The data can be environmental, geographical, or logistics.

IoT is one of the largest sources of big data. IoT interacts with big data when voluminous amounts of data are needed to be processed, transformed, and analyzed in high frequency. The big data enabling technologies in the IoT context are related to ubiquitous wireless communication, real-time analytics, machine learning, and data capturing elements [7].

With the rapid development of IoT, big data technologies have emerged as a critical data analytics tool to bring the knowledge within IoT and support critical decision making. Big data analytics (BDA) refers to the process of collecting data, transferring them in centralized cloud data centers, preprocessing, analyzing, and visualization. BDA tools have the capacity to handle large volumes of data generated from IoT devices. The IoT promises to take big data to a new level.

Applications

There are several applications of big data and IoT working well together. A typical application is shown in Figure 1 [8]. Applications of big IoT data analytics include smart homes, healthcare, energy, transportation, building automation, agriculture, industry, military, banking, human resources, monitoring of public health, and smart metering. We will discuss some of these in detail.

- *Smart Cities:* The smart city improves the standard of living of the citizens. It consists of various types of IoT-based smart systems including smart home, vehicular networking, weather and smart water system, smart parking, and surveillance objects. The convergence of big data with IoT brings new challenges and opportunities to build a smart city. A smart city is essentially an integration of all smart systems (such as smart home, smart parking, smart transportation, smart energy, etc.) and the IoT devices (such as sensors, actuators, and smartphones). From smart energy to smart buildings, IoT is transforming the way cities manage services, systems, and infrastructure [9].
- *Manufacturing:* Manufacturing plays a crucial role in economic development. IoT-based sensors can be considered a solution to provide efficient monitoring of the manufacturing process. Big data from the production line and environmental data, need to be analyzed to help managers with decision making [10]. Industrial IoT empowers the manufacturing companies to adopt new data-driven strategies and compete globally.
- *Healthcare:* The application of data and IoT in healthcare provides a better solution for health management and analyze real-time medical information in order to minimize medical errors. Big data

in healthcare and data analytics can help transform a huge volume of sensor-collected data into valuable insights. Data analytics can help healthcare professionals analyze a large patient data and learn the history of a disease.

- *Agriculture:* This is a vital domain of our society. Smart agriculture can benefit from the use case of big IoT data analytics. It takes advantage of the benefits from IoT technologies to assure the quality of the products and customer satisfaction.

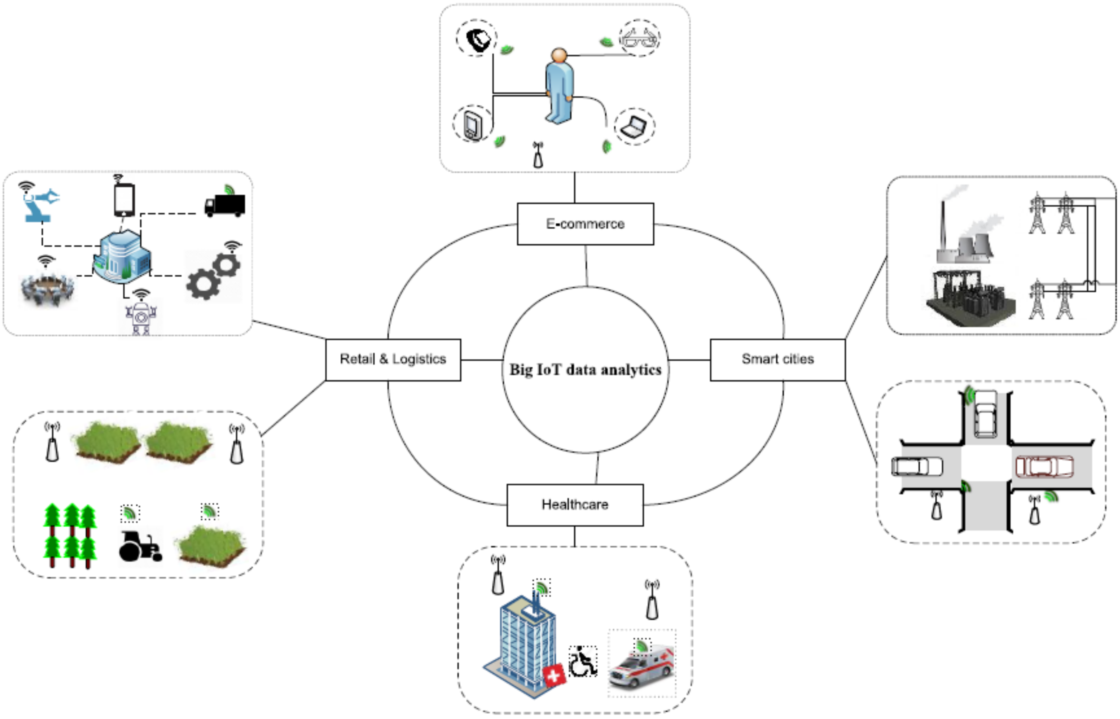

Figure 1: A typical big IoT data analytics architecture [8]

Challenges

As the IoT continues to grow, we will witness major safety concerns and cybersecurity issues. The IoT is vulnerable to privacy violations. IoT devices also raise security challenges. Increased data needs increased security. IoT data security will be a challenge to big data security professionals. Interoperability is an issue with interacting IoT devices developed by different manufacturers. Another challenge of IoT is standardization problem because the objects may employ different communication technologies.

Conclusion

Big data and the Internet of things (IoT) are the most promising technologies in the current epoch. IoT will allow billions of objects to exchange data. It represents one of the main markets of big data applications. With the rapid development of IoT, big data technologies have emerged as a critical data analytics tool to bring the knowledge within IoT infrastructures. Big data and IoT open up considerable opportunities. They are transforming existing businesses processes, creating new business opportunities, and enabling new business models. Big Data IoT is slowly redefining our lives. It will have profound technological, social, and economic impacts.

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