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INNOVATIVE SUSTAINABLE APPLICATION IN CLOUD OF THING

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ABSTRACT
The increase in the number of connected devices and the popularity of cloud computing has resulted in the generation of a large amount of data. These data need to be stored, transmitted, processed and analyzed. It can be applied to a variety of forward-thinking activities that foster wisdom and understanding. IoT and Cloud computing has become so popular that there is a need to integrate them. This integration is referred to as Cloud of Thing in this paper. This paper reviews the work in the sustainable practices of the cloud of things and gives direction for future research.

Keywords: *IoT, Cloud Computing, Green IoT, Sustainability, Cloud of Things (CoT)*

INTRODUCTION

People these days are familiar with Cloud computing and IoT devices. Easy availability of the internet and a rapid increase in sensor technologies like WSN and Cloud computing resulted in the demands for integration of IoT and Cloud. Looking at the current trend in coming years the number of connected devices would be more than the number of people. Cloud provides services like storage, application, and platform from anywhere at any time using devices connected through the internet. The popularity and the amount of data generated by IoT devices make the cloud an ideal option for data storage. With the increase in the number of devices and extensive use of cloud technologies thinking about sustainability becomes the need of time. Sustainability should be considered in terms of environmental and economic effects. The major carbon footprints generated using these technologies are by sensors and cloud data centers. How much sustainability can be achieved depends on how green our sensors and data centers are.

A. Cloud Computing

The global definition of cloud computing announced by NIST (Mell, 2009.) is as follows: d "cloud computing" is a model that makes it possible to quickly create and deploy a shared pool of reconfigurable computing resources (such as networks, servers, storage, applications, and services) via a network while requiring little management labor or service provider interaction.

Cloud computing is a model where computing is moved from personal computers or application servers to a “cloud” of computers that is present at a remote location providing service through public or private networks. It is a technological innovation of clustering, grid computing, and virtualization. It is based on service-on-demand and a pay-as-you-use model. It consists of four actors cloud user, cloud provider, cloud broker, and cloud carrier. (Khalifeh, February 2012).

Cloud provides virtual servers, storage, virtual network, and computing which can lead to a digital data revolution if accordingly designed for IoTs and integrated with advanced technologies on data processing, transmission, and storage(CloudOfThing, n.d.). It has a layered architecture where the lowest layer comprises hardware. The layer on top of it is the software platform layer and the last layer is the application software layer. Each of these layers uses services of other layers through APIs. Depending on these layers cloud provides three types of service models.

(i) Infrastructure as a Service (Iaas)

This model provides computing and storage service on demand using the pay-as-you-use model. It is very economic as clients need not have to purchase expensive machines, servers, or storage.

(ii)Platform as a Service (PaaS)

Under this model, the service provider provides the necessary operating system platform required to build applications and services.

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(iii) Software as a Service(SaaS)

It refers to the service where the service provider provides applications working over the internet as a service. The user need not have to install or maintain the application. The user only needs an internet connection to access the service rented by the SaaS service provider. (Y. Jadeja, 2012)

Figure 1. Cloud Service Models (Khalifeh, February 2012)

B. Internet of Things.

Any device that can communicate using the internet is termed an IoT device. In IoT, the word "thing" refers to any object on the face of the earth, which can be a communicating device or a non-communicating device. This device communicates using RFID (Radio Frequency Identification) tags, Bluetooth, or IEEE ZigBee [6]. IoT is a network of interconnected things that can connect to the internet. They gather data using sensors and send them to servers or exchange them with similar devices which make decisions to trigger an action, Power consumption of IoT devices is very less. A single IoT device will connect itself to a home router or a nearby tower but if the number of devices is more, one needs to use an aggregation point that will collect the data from all the devices and send it to the server. An example of an aggregation point is the monitoring of oil pipelines or sewage lines in smart cities. IoT also enables heterogeneous devices

to communicate with each other and send the data to a centralized server. An example of this application is the "Intelligent Transportation System (ITS)" with IoT.

The architecture of IoT is usually 5-layer, This five-layer architecture is described in figure 2

1. Perception Layer

It is the lowest layer where all the data collection happens. Sensors, RFID tags, cameras, GPS, etc are part of this layer. It gathers data and sends it to the above layer.

2. Network Layer

It works to send the data collected by the lower layer over the internet. It consists of various interfaces including a network management center and information processing center which are connected to both sensors and the internet. (CloudOfThing, n.d.)

3. Middleware Layer

It receives data from the network layer, stores it, processes it, and takes decisions based on the results automatically.

4. Application Layer

This layer is responsible for presenting data to the user in the form of applications like smart health applications, vehicle tracking, smart home, etc.

5. Business Layer

This layer as the name suggests takes care of the business part. i.e. how much money each of the services provides. It also takes care of how more money can be generated by molding data into meaningful services. Reuse of existing services are also done to generate more business.

IoT works on the basis of Machine-to-Machine (M2M) where two machines communicate without human intervention, but not limited to it. In IoT, even non-connected entities can become part of IoT, with a data communicating device, like a bar-code or an RFID tag, sensed through a device (may even be a smartphone sensing it)(CloudOfThing, n.d.)

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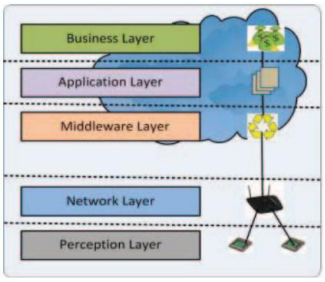

Figure 2. Internet of Things Layers [5]

C. Cloud of Things

IoT devices are light weight, small and low-cost. Storage and processing of data are not possible by these devices and hence data needs to be stored on the server. With the increase in the number of connected devices, the amount of data being generated will be huge. Storing such a large amount of data on a local server temporarily would be difficult. Moreover, storing, managing, and processing such huge data would be very expensive also. Cloud provides storage and computing services on a rental basis. Hence the huge data generated by IoT devices can be stored and processed on the cloud. This processed data can be converted to meaningful information which can be a source of knowledge to provide wisdom to the user through further processing using cloud services. IoT and cloud computing working in integration makes a new paradigm, which is termed as Cloud of Things (CoT). (CloudOfThing, n.d.). The Cloud of Things will provide more business opportunities. There are certain concerns regarding the security and privacy of data if taken care of, CoT has huge potential.

Figure 3. IoT and Cloud (CloudOfThing, n.d.)

D. Sustainability in the Cloud of Things

Sustainability in the Cloud of Things will result in a sustainable smart world. Sustainability cannot be achieved without reducing the greenhouse effect and carbon emissions by IoT devices and Cloud resources such as sensors, applications, devices, and networks. Emphasis should be made on Reusing, refurbishing, and recycling unwanted hardware causing minimal impact on the environment. (San Murugesan, 2012)

Achieving sustainability requires an innovative approach. As technology advances in the coming years, the number of smart devices equipped with additional sensors and communication add-ons will increase. The energy consumption by these devices will also increase forcing us to think of green IoT and green Cloud. This will result in reduce energy consumption and create a smart world with sustainability.

An Innovative Approach for Sustainable Cloud of Things

Green RFID

RFID includes tags and tag reader. The RFID tag are linked to objects to store small information about them. These tags are of two types active and passive, where active tags have batteries for continuous signal transmission and passive tags do not have batteries. RFID tags are made of non-degradable material. For green RFID we need to reduce the size of these tags so we will automatically minimize the usage of non-degradable material. Printable RFID is also proposed by some researchers. In addition, we also need to focus on energy-efficient algorithms and protocols to improve tag estimation, reduce tag collision and overhearing, and dynamically adjust power transmission.

Green WSN

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WSN consist of a base station and number of sensor nodes connected to it. Sensor nodes are responsible for collecting data and passing it on to the base station for processing. For Green WSN we need to make sure that 1)Sensors should be in sleep mode when idle and becomes active only when needed to conserve energy. 2) Renewable sources of energy like solar energy should be used for power generation 3) Data and context-awareness algorithms should be used for data and storage reduction. 4) Energy-efficient routing techniques should be used to reduce power consumption. (CHUNSHENG ZHU, 2015)

Green Cloud Computing

The most energy-efficient technology used in cloud computing is power-saving virtualization. Cloud also reduces carbon emissions by reducing the IT infrastructure through multi-tenancy. Dynamic provisioning of energy-efficient resources is another key feature. Auto-scaling helps companies avoid over-provisioning and thus saves energy as the company need not have to run unutilized resources provisioned for the future. Cloud shares a large pool of managed resources with its users through virtualization and saves energy as the user need not have to own and manage its own resources. Green cloud should have an application that uses energy-efficient algorithms which consume less energy and resources.

Green M2M

Machine-to-machine communication involves a large number of massive machines which consumes a large amount of energy. Green M2M requires a reduction in transmission power to the minimum necessary level. Moreover, communication protocols need to be optimized. Emphases should be made on energy savings

Green Data Centers

Data centers are intricate ecosystems that link various ICT components. It has three components storage, servers, and local area network. A large amount of energy is consumed for running these servers, coolers, lighting, LAN routers, and switches. Server virtualization and turning servers into sleep mode are measures taken to reduce energy consumption. Data centers use disk arrays for data storage. The total number of hard discs used is reduced by consolidation and centralized coordination, significantly improving storage's overall energy efficiency. Use of green buildings and renewable sources of energy like wind, solar, etc to run data centers. The design of hardware and software used in data centers should be energy efficient. Storage of only the data that is required also helps in energy conservation. The use of computational fluid dynamics (CFD) and computer room air conditioning (CRAC) units can be used to optimize air conditioning. Thermal storage and thermal management is other approaches to energy conservation. Renewable sources of energy can be used for lighting.

Green ICT Principles

To achieve sustainability ICT principles can be followed

1) Turn off any unnecessary amenities.2) Only necessary data should be transmitted3)Implementing change in routing scheme to reduce data path4)Data from multiple sources should be fused before transmission5)Use of MIMO communication technique 6)Use of renewable green power sources to reduce carbon footprint.

Sensor Cloud

Sensor Cloud is a cutting-edge platform for storing, visualizing, and managing sensor data over the internet that makes use of strong cloud computing technologies to deliver high data scalability, quick visualization, and user-programmable analysis. It gathers various sensory data about the surrounding environment, such as temperature, humidity, traffic, house surveillance, etc., using ubiquitous sensors (such as static sensors, mobile sensors, video sensors, etc.) provided by the sensor network provider. The sensory data is then transferred once more to the cloud service provider's cloud for storage and additional processing. (CHUNSHENG ZHU, 2015)

Challenges and Future scope

Although there is tremendous research going on in the field of green IoT and green Cloud, still they are in their infant stage. Switching from the current system to green infrastructure is challenging when various parameters like hardware-based, and software-based. There are a few challenges that need to be overcome in order to achieve sustainability

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1. It is necessary to have a better understanding of the characteristics of various IoT applications and the services they demand.
2. Realistic models of IoT systems with respect to energy consumption are needed.
3. Emphasis on Quality of service or quality of experience is required.
4. Deployment of Sensors as a Service can be envisioned.
5. Creation of energy-efficient routing algorithms

CONCLUSION

This paper has covered a range of green IoT and green Cloud technologies and problems, which plays an important role in achieving sustainability. It reviewed various application areas of cloud of thing especially green WSN, green CC, green DC, and green RFID future research directions and future scope have been presented.

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