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The Rise of Internet of Things and Big Data on the Cloud: Challenges and Future Trends

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Abstract

Huge growth in the scale of data generated through cloud computing has been led to Internet of Things (IoT). Fog computing has been recently adopted to improve some features of cloud computing and makes cloud computing more attractive to users. Furthermore, it comes to improve some parameters such as latency, security and load network. The combination of cloud and fog computing is seen a new progress in distributed computing and the appropriate platform for the data. Fog computing is defined as a new paradigm that works at the edge of the network to improve the quality of the network. In this paper, the use of fog computing in cloud computing is reviewed in this work. The characteristics, architectures and discussions and the relationship is further elaborated. Additionality, recommendation for further research is discussed.

Keywords: *Fog Computing, Internet of Things, Cloud Computing, Big Data, Edge Computing, CloudSim*

1. Introduction

The rise of scale of data by the dramatic use of Internet has led to Big data which is used as Internet of Things (IoT). This significant size of data is processed in the cloud. To illustrate, sensors which users generate from their respective network items, social network, data generated from the use of social media. Cloud computing with its keys values namely innovation, opportunities, efficiency, saving, accessibility and flexibility [10] is used for processing with low cost. Then, cloud computing has been adopted to cope with the increasing data with low computational cost and a minimized cost [1]. Further, as the data size increases, the communication bandwidth increases as well while processing in the cloud. Thus, a new platform called fog computing is developed to perform at the edge of the network to lower the network traffic as well minimizing the bandwidth used. Fog computing gives a promising future for the use of cloud computing and it increases the potential of using cloud computing.

IoT is a new concept that gathers in network all connected objects around us as part of internet [2]. IoT gives the ability to interrelate all connected objects and computing devices we live with like smart phones, digital cameras, sensors and to get their updates through the use of Internet without human to human interaction. Then, all connected devices make a network where they support each other to facilitate the needs in terms of health, environment, economies, and so on. Therefore, the accumulated data form a part of big data we face nowadays.

Fog computing [3] is made of a virtualized platform, which offers computation, storage, and networking services between the end nodes generated in the IoT and respective clouds. Cloud computing being a distributed computing, fog computing gives more a widely-

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distributed environment. Some of highly applications of fog computing are delivering high-quality of real-time applications, also in the healthcare applications it gives low latency requirements especially in emergency services. The basic idea of fog computing is to provide an extension of the cloud for processing data at the edge and reducing the path to the cloud when it is not required. When some resources are distributed, this will reduce the network to be highly-saturated. This will result to the reduction of the latency which is highly demanded when processing large-scale data. However, while fog computing presents many advantages, cloud computing remains the appropriate platform for many applications that require complex processing methods.

The contribution of this paper is summarized as follow:

- A summary of fog computing, IoT, and big data along with their characteristics;
- A view of difference between fog and cloud and their relations;
- A proposed task scheduling algorithm between the cloud and a traditional for provider at the end nodes.

The proposed task scheduler is an extension of our previous work where users submitted their tasks directly to the cloud. The execution time and cost were minimized by using a scheduling algorithm that tasks follow. However, in this work, the proposed fog computing is used a broker where users send their tasks before sending it to the cloud. Thus, the proposed task scheduling algorithm has role of minimizing execution time and the cost for the use of cloud resources.

The remainder of the paper is organized as follows. In Section 2, we introduce some related work to the task scheduling problem in heterogeneous environments. Big data and IoT technologies and an architecture of the cloud-fog computing system are elaborated in Section 3. In Section 4, difference between fog computing and cloud computing is discussed. Then we conclude and give further recommendation in Section 5.

2. Technology and Related Work

2.1. Fog Computing

Fog computing is an extension of cloud computing by being an intermediate layer between mobile devices and cloud. The intermediate layer called for layer contains many geo-distributed Fog servers based on mobile users. the main purpose of Fog computing is to perform the task of a cloud provider such as storage and communication resources in the closest mobile users. It eliminates for the users to request from the cloud for processing.

The role of Fog servers is to serve as a bridge between mobile users and cloud. In one case, Fog servers relate to mobile users through single-hop wireless connections using wireless interfaces, such as Wi-Fi, cellular or Bluetooth1. since those servers use cloud resources, a Fog server has the flexibility to provide services without the connection with neighbor Fog servers or cloud. On another case, the Fog servers can be connected to the cloud through the use of Internet and content resources of cloud [4].

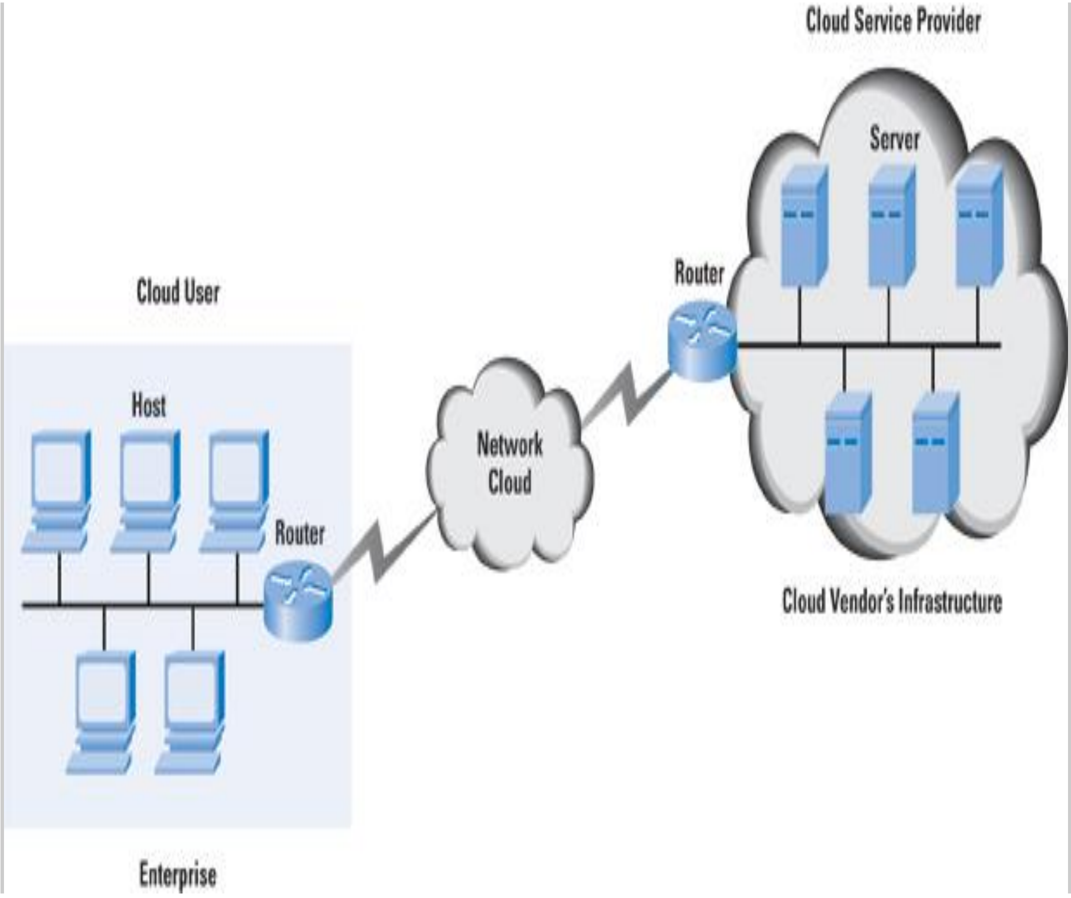

Figure 1. Architecture of Cloud Computing

Fog Computing in the field of healthcare

Fog computing has a great contribution in healthcare, in the sense of improving telehealth and telemedicine infrastructure. It shows an important feature in healthcare especially for the elderly people suffering from chronic diseases. Fog computing is used as well to reduce the cost as those patients can be monitored outdoor hospitals and their status are updated remotely [5]. This also helps to decrease the risk of errors and data corruption as the path to the cloud maybe more costly and inefficient in this case. Therefore, fog computing presents an efficient way to deal with medical big data.

2.2. Fog Computing and the Internet of Things

In this section, we demonstrate how fog computing is an appropriate platform for IoT.

Currently there are billions of devices connected to Internet such as tablets, laptops, phones and so on [7]. This amount is expected to increase dramatically in the next few years. This trend needs new technologies to cope with their requirements. Latency being an important parameter to monitor, developers look about applications could be used to reduce the latency. IoT brings the necessity to make communication tools near to users in order to be more reliable and efficient.

As data sources in IoT are distributed geographically, platforms that process data in a distributed manner will be suitable. Therefore, fog computing has been developed to process data locally near to the sources. This decreases the latency, the cost and the energy efficiency used.

Big Data Analytics in Fog System

Big data can be defined as succession of datasets coming from diverse sources, in different formats and nature that need new technologies for analyzing storing and processing.

Data generated from the sources are in form of structured, semi-structured and unstructured. Figure 2 gives a summary of the structure with their different sources of data.

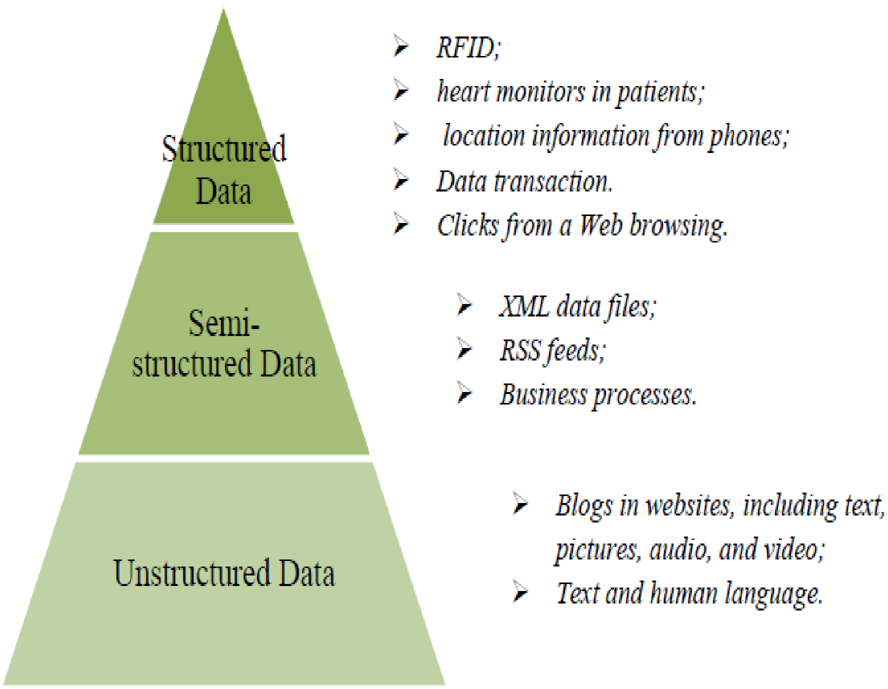

Figure 2. Structure of Big Data

3. Relation between Cloud and Fog Computing

Both cloud and fog computing deliver services to users. However, fog computing is a sub-part of cloud computing where it reduces the load that the cloud is carrying.

Fog nodes provide localization, thus enabling low latency, the Cloud provides global centralization. Therefore, both play its role in processing applications particularly for large scale-data and Big Data. Some applications require real-time (in arrange of milliseconds up to sub seconds) and they can be processing at the edge nodes also called fog [6].

Fog node can be referred as a smart Gateway that manages various aspects of IoT. It takes care of collecting, pre-processing, storing temporary data and sending only data that require complex processing to the cloud.

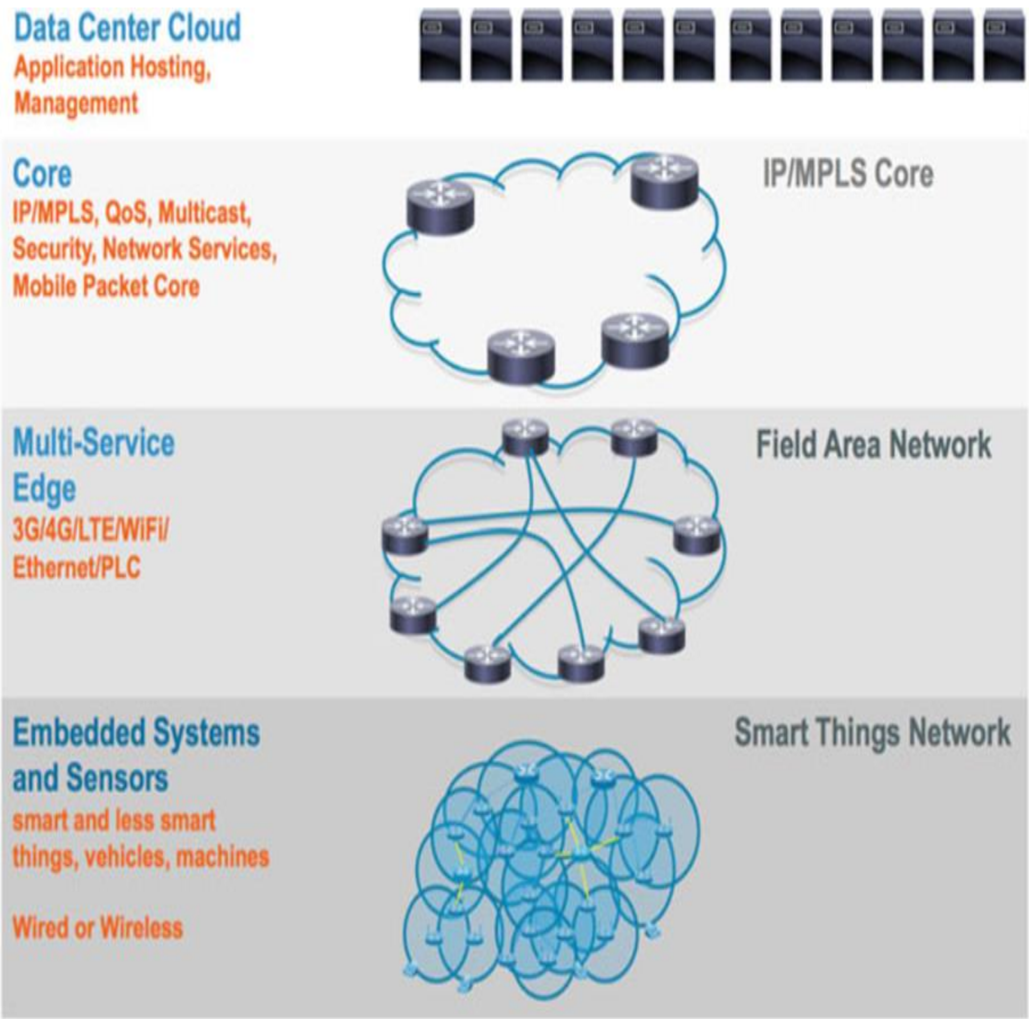

Figure 3. A Fog Computing Architecture with Network Layers

3.1. Task Scheduling in Cloud Fog-based

Many scheduling algorithms are proposed over the years for cloud computing to cope with some challenges such as latency, high consumption of energy efficiency, cost and execution time. Recently, fog computing has been adopted widely to work beside the cloud for the same challenges.

4. An Example of Simulation

In this section, we elaborate an example of simulating tasks in a CloudSim environment. This is to show that many parameters are put together to process data in the data. In addition, this could increase the bandwidth, energy efficiency and as consequent the cost. Even though, some optimization algorithms [9] are used sometimes in order to minimize the resources, it can still fail to find the optimum solution.

In 4.1, the scenario in CloudSim is illustrated and 4.2 shows the tasks are transferred from one node to another without being sending to the cloud for processing.

4.1 Simulation Scenario in Scenario

CloudSim [8] enables modelling and simulating cloud computing environments. It also allows creation of tasks, VMs and how the tasks are allocated to the VMs through the use of the Broker. The scenario for sending tasks to the simulator and getting an output with their mapping to specific is shown is the Figure 4 Before that, below are the terms used in CloudSim simulation process.

Cloudlet: cloudlet is represented in CloudSim as task to be schedule;

Broker or Data center Broker: it is a component that acts on behalf of the users. It receives tasks and maps them into a suitable VMs;

Host: is the physical machine where VMs are located;

Data center: where resources are located and it holds at least a host or more;

*Cloud Information Service (CIS):*it is where all resources are registered. It has also the information of which service available to be used.

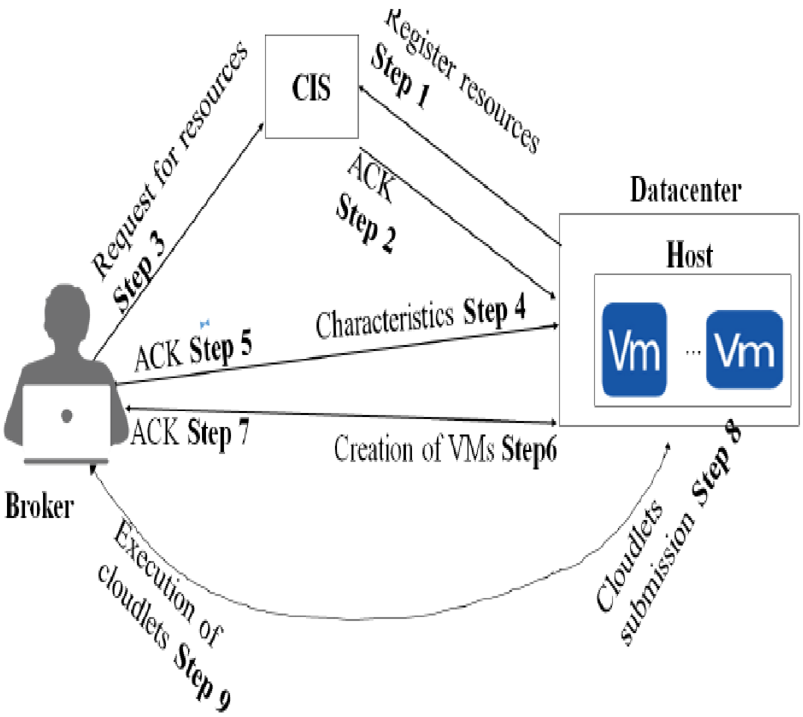

Figure 4. CloudSim Simulation Data Flow

The mechanism works as follow: all resources in data center are registered in CIS. Then, when a broker needs resources then it refers to CIS to get the resources needed for scheduling. The broker gets the specific resources based on the cloudlets size and other parameters. Further, the broker sends the characteristic of the simulation of number of VMs needed. Then, in return the cloudlets are executed in data center VMs and results are sent back to the broker.

4.2. Fog Computing Platform

As the example illustrated in [11]. The fog computing system is composed of the front-end layer which is hosting IoT devices, and also a medium for sending requests from users. The fog layer, which is the combination of the nodes join as a network and also communicate with each other and transfer data. Further, it also the main layer than process data received from users' requests. Computing resources available from fog nodes are used to process users' requests.

In the fog computing system, it is shown that the bandwidth used to transfer data are minimized as nodes get closer to users. In addition, energy efficiency is reduced as well. Consequently, this can reduce the execution cost as the path to access the resources has been made very short.

5. Discussion of and Challenges

In Figure 2, an architecture of a network layers in fog computing has been pointed out. Three main parts need to be addressed when elaborating a fog architecture which are the computing, network and storage areas. Those parts are the cloud services as well.

As in fog is divided into nodes. Each node requires its own configuration or sometimes they can share the same topology architecture [13] [14].

Cloud is one of the distributed computing in computing systems. Therefore, each node or component of fog need to be configured to support this technology. For this, some points are illustrated:

- For the computing: virtualization of resources of fog nodes is required to connect to the cloud;
- Defining the reliable network for fog nodes;
- A virtualized storing system for keeping data safe.

Similar to cloud, fog architecture allows elasticity and distribution of resources. This means many applications from different users run simultaneously on fog nodes. In return, resources are allocated to each task or application and a new topology is proposed. Below are some requirements for fog nodes when their architectures are designed.

- The architecture for fog computing a heterogeneous environment since applications are added randomly and continuously;
- The architecture should allow multiple platforms to be run;
- Each layer of the network is connected by a gateway to other nodes of the fog network;
- Applications process in fog nodes are from Internet sources mainly. Drawing a connection between the Internet layers and the cloud is highly needed for for computing.

An architecture for processing big data applications is proposed by our previous work in [12]. It is based on lambda concept for tackling big data challenges. It reduces considerably the cost and the latency in the process. Therefore, this architecture will be tested in our future work to compare if the latency can be decreased inside nodes or between nodes.

5.1. Fog Computing Architectures

In fog computing, many architectures have been proposed to have a reliable connection with the cloud. In this section, architectures are discussed and a new design of an architecture is proposed for fog.

6. Conclusion

The use of internet has been increasing dramatically and more mobile devices are connected to Internet than ever. In addition, cloud computing is widely adopted for processing large applications with lower cost. However, still few technologies are needed to work beside the cloud computing to make it more efficient. In that direction, fog computing is a new technology that remove the heavy load from cloud computing. In this paper, we have analyzed the use of fog computing to reliably process data. Further, a comparison of these two computing systems have been shown to clarify the need of fog computing in cloud processing.

As future work, we would like to explore in detail the use of fog computing and explore some new scheduling algorithms that may needed for an efficient use of fog computing.

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