2. A Critical Analysis of Distributed Systems with a focus on the Distributed Data Management in Edge Computing Environment

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ABSTRACT

The emerging of distributed systems such as Distributed Computing, Grid, Jungle, Fog, Edge, Cloud computing systems, and the future of Inter-Cloud Computing helps to the decreasing of the communication cost in terms of delay and band width consumption while increasing the advances in communications, networking complexity and the advent of big data technology such as proficient knowledge and smart decisions. Edge computing aims to alleviate the load on cloud data centers and minimize delay by making compute and other resources and services available closer to the users.

Therefore, in this work, a critical analysis on distributed systems was conducted with a focus on the Distributed Data Management in Edge Computing Environment and it drew its recommendations for future applications such as the Internet of Things.

Keywords- Distributed systems cloud; computing; internet of things; edge computing

I. INTRODUCTION

Recently, one of the catchwords in the field of Information Communication Technology is Internet of Things (IoT), where real world objects are transformed into smart virtual objects. IoT aims to keep us informed of the state of the things at anytime, anywhere by anyone without constant human intervention, it allows the exchange of information between things-to-things, human-to-things and human-to-human [1]. IoT continues to be most hyped; many startups, government agencies and high potential companies are injecting lots of resources to further its research and advancement.

IoT has been applied to bring practical solutions in various domains such as Education, Agriculture, Healthcare, Energy, Environmental Monitoring, Transportation and more so. Therefore, with increasing emerging of Internet of Things (IoT) applications, it is clear that huge amounts of data are being generated every second on daily basis. A number of connected devices is increasing growing bigger as more devices are being connected to the internet on a daily basis. It is expected that over 41.6 billion IoT devices will be connected by 2025 generating 79.4 zettabytes of data [2]. In this case, wireless sensors have become the common component in the IoT environment, when connected, sensors which automatically collect lots of big data.

A typical IoT architecture consists of the three main key elements for computing; (a) hardware which comprises actuators, sensors, actuators, and any embedded hardware. (b) middleware which consists of on-demand storage and data analytics computing tools and (c) Presentation and visualization tools [3].

Therefore, in this work a critical analysis is based on the middleware where the data analytics take place, focusing closely on distributed data management in edge computing environment.

An IoT sensor network can consists various sensor nodes in a network and all these nodes are collecting data. Sensor nodes collect and exchange various kinds of data from the real-world environment after which relevant information can be extracted based on the intelligent algorithms in the nodes and later can be used to improve the daily life of the user concerning the related situation [4].

Big Data in IoT applications

According to [5] Big data consists of velocity, variety and volume where velocity refers to the speed at which data is generated that is to say that sensor nodes generate data at a very high speed compared to the old traditional systems, Variety refers to the various forms in which data is collected in the sensor node network and Volume indicates that data generated is of a very huge volume compared to the past years.

With accumulation of huge chucks of data gathered by the sensors, there is a challenge of how to cope up with the big volumes of data [6] because huge data requires efficient data storage and manipulation mechanisms.

IoT devices require lots of resources such as processing, storage and power but with the emergence big data at the center IoT, these resources have become limited rendering them inefficient [7].

More to say there are transmission issues where all the gathered data requires real time transmission which is sometimes difficult because the required bandwidth to transmit the data might not be available at the required time, also there are issues related with storage because large volumes of data require large storage and backup as over 35 zetta bytes of data are stored daily [8].

What we see these days is that huge chucks of data are being stored but less being processed because processing such big datasets in real time requires special mechanisms and resources which is very difficult therefore leaving us with a big percentage of unprocessed data on rise [9].

Cloud computing in IoT applications

Centralized cloud computing paradigm have been used as traditional technique to handle some of the issues such as processing and storage however, it is also limited because cloud computing is still faced with unresolved challenges of lack of mobility support, high latency, location-awareness and network failure especially in the IoT applications that are time-critical [10]. The cloud infrastructure model provides access to a network with computer resources however it does not provide resource mobility support, low latency and location awareness that critically required by the IoT applications.

Fog computing in IoT applications

In order to resolve issues of cloud computing paradigm, fog and jungle computing were introduced which are extensions of the cloud computing that provides storage, computation and networking resources at the edge of the network instead of sending them to the cloud.

Jungle computing includes a combination of clouds, clusters, grids so as to gain extreme potential computing power [11].

In fog computing architecture model, the fog nodes which are devices with storage, network connectivity and computing capabilities can be anywhere within a network connection.

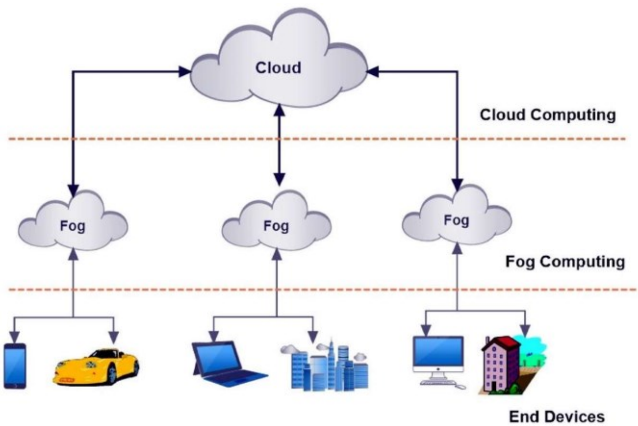

Figure 1. *Fog computing is an extension of the cloud that brings resources nearer to end devices [14].*

Fog computing is a key technique to big data analytical issues on the IoT applications that require real time computing; fog computing has the ability to support real-time computing [12].

Fog computing offers elastic resources; wide geographical spread distribution of resources; in which fog nodes can be deployed in different locations and services at the edge of network to end users [13].

As shown in Figure 1 above, fog computing brings storage, processing and networking services near the end devices compared to the cloud computing that provides all the resources at the cloud.

Fog computing Vs cloud computing in IoT applications

In [15] a Remote Patient Monitoring system was designed to provide convenient and easy to access healthcare service. The system was designed based on an architecture that uses fog computing and IoT to mitigate the challenge of high latency. The designed system enables the health care providers to verify any of their data through a local server before it is sent to the main server.

To test latency under both cloud and fog computing paradigm, feasibility of a scalable fog architecture against a standard cloud-device setup was carried out, results indicated that the fog set up yielded low latency compared to the cloud computing set up.

In [16] Complex Event Processing engine-based Fog architecture was analyzed for real-time IoT applications that uses a publish-subscribe protocol; To assess performance, the authors analyzed the effectiveness and cost of the designed solution in terms of latency and resource usage; Results showed that the fog computing architecture reduces event-detection latencies up to 35%, while the available computing resources were used more efficiently, when compared to a Cloud deployment

Edge-based IoT Applications

Therefore, there is a clear need to process data close to the IoT device or on the device itself and that's where to edge computing comes into place; edge computing helps IoT devices process some of that data locally. This distributed, edge computing paradigm frees IoT devices from latency and connectivity issues because the resources are embedded at devices themselves [17].

In edge computing devices analyze data at the devices themselves therefore, this creates zero latency, unlike in the cloud computing where data has to first be sent to the cloud for analysis.

This makes edge computing a good deal for IoT applications that require real-time and very low-latency in decision making especially in environment where there is no cloud connectivity or very scarce.

Future Recommendations for IoT Applications

Although the computational nodes have been moved closer to the devices in edge computing to improve the energy efficiency, latency and scalability and IoT applications, there are still challenges with edge computing such as unreliability of batteries since most computational at the edge happens in the battery-operated devices. The future studies need also to look into the security issues with fog/edge computing specially on the data that has been stored at the edge.

Conclusion

In conclusion, there is a need to efficiently provide computing resources to the IoT applications with low latency and better battery reliability options and integrate them in edge/ fog computing with cloud computing to enable IoT applications with sufficient and scalable resources especially in the systems that require real time processing to make decisions.

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