COMP90044 - Assignment A
Student Name: Xu Wang
Student ID: 979895
Email: xuwang2@student.unimelb.edu.au

Significance of fog computing in energy efficiency

1. Introduction

The concept of "Cloud Computing" first came from Google's CEO Eric Schmidt on 9th August, 2006 (Dingyu 2018, p. 062192): distributing the computing and data to a large number of distributed computers.

However, as the data stream increase and the demand of fast computing, "in 2012, the need to extend cloud computing with fog computing emerged, in order to cope with huge number of IoT devices and big data volumes for real-time low-latency applications" (Wikipedia 2018). For example, mobile phones using the 5G technique combined with fog computing can download a blue ray video in seconds and actualize direct device-to-device wireless communication theoretically. That being said, fog computing can improve the network performance in spectrum and energy efficiency (Kitanov & Janevski 2017).

The difference between fog computing and cloud computing is that cloud computing is more likely focusing on providing resources in core networks while fog computing is closer to the user level, or is said to provide resources in the distributed edge networks (Amendola, Cordeschi & Baccarelli, pp.21-26). This paper is mainly used for analyzing the significance of fog computing in energy efficiency.

This paper is structured as follows. Section 2 reviews literatures about the fog computing model, recent works and the ways of fog computing achieving energy-efficient. Section 3 lists some remaining problems and future studies in fogging. Finally, Section 4 summarizes the conclusions of this work.

2. Literature Review

2.1 Basic attributes of Fog Computing model

As the development of Internet of Things (IoT) and mobile Internet (e.g. 5G) became rapid, people are increasingly relying on cloud computing. The increasing number of networking devices, intelligent devices and mobile applications become the main way for people to deal with transactions on the internet. The amount of data and the number of data nodes increase with accompany, therefore, a large number of network bandwidth will be occupied, thus increase the burden of data centers and the load of data transmission.

Fog computing can be understood as a distributed cloud computing which is nearer to the end of users. In order to minimize the expenses of communication traffic in data centers, fog computing concentrates data, data processing and application on devices at the edge of the network, complements cloud computing by computing from remote data centers to edge devices and distributing network resources (Baccarelli et al. 2017, pp.9882-9910). Unlike cloud computing, fog computing is a distributed model that lies between the cloud computing and personal computing. Since fog computing emphasizes the number of

nodes instead of the quality, it computes data with every possible device no matter how weak the single device is.

With the combination of distributed fog computing, techniques such as intelligent routers can form up a data transmission belt between different devices to reduce network traffic while the computing load of data centers is also decreased.

Moreover, fog computing has other attributes such as programmability, scalability, security and real-time features (Baccarelli et al. 2017, pp.9882-9910) that cloud computing doesn't have or exist defects. With the assistance of distributed fog nodes, data are separated in a large range of distributed servers, so that hackers wouldn't be able to hack a specific server meanwhile data won't be lost if the operator had a mistake in coding, for example, Amazon S3 service disruption on 28th February, 2018.

2.2 Ways to increase energy utilization

In 5G technology, the ideal capacity of 5G is 1000 times that of 4G and the speed is also faster. That means if we want to increase the capacity and speed in the same time, we need to increase the bandwidth, the spectrum efficiency and the area capacity. First comes to the bandwidth, the high frequency band is richer in frequency resources. At present, the low frequency band which is less than 3GHz is basically occupied by 2G/3G/4G, so 5G has to be extended to the high frequency band of 3.5GHz-30GHz (or even higher). However, the higher frequency, the stronger the reflectivity leads to the lower penetration ability and the coverage. So, we need a large number of distributed fog nodes to support the requirement.

By using fog nodes and edge computing, energy costs in signaling overhead can be reduced. For example, the main energy consumption in 5G technique is the energy for signals transferring from densely network edge base station to the base station. Unlike cloud computing, data, data processing and applications are concentrated in devices at the edge of the network, data storage and processing rely more on local devices. These features make mobile devices more convenient and satisfy wider node access.

Fog nodes are close to the end of users, transmission between fog layer and internet backbone need less energy. Users can get the data they need from the fog node instead of requesting from the cloud server every time in order to reduce the network transmission overhead, so energy utilization can be improved by putting the computing on the network layer instead of cloud servers. At the same time, the delay between communications can be reduced, such as vehicle-to-vehicle communication needs a low latency below a few tens of milliseconds (Baccarelli et al. 2017, pp.9882-9910), otherwise it may cause severe traffic accidents. These kinds of computing need to be computed at the edge of the fog layer near to the user end, so the low latency fog computing is also called as "edge computing" (Amendola, Cordeschi & Baccarelli, pp.21-26).

2.3 Recent related works

Fog computing can be applied in Internet of Things (IoT) since it is a distributed model. The conception of Smart Grid is a good application of using fog computing to save energy. The Smart Grid model incudes irregular dispersed "consumers" and "producers". Wireless sensors in buildings that need electricity such as smart homes and intelligent buildings are the consumers. Devices that can produce electrical energy such as wind farm, solar plant and central power plant are the producers. These devices require to support device-to-device communication through Wi-Fi, Bluetooth or other methods. As soon as the energy-producing plant produced electrical energy, the fog layer computes the raw data and manages the energy flow in real-time, in order to ensure power-need devices can get enough electricity from the nearest producer while the producers near low-demand consumers can have a rest. By reducing the energy-loss during energy transmission can improve energy-efficient.

(Baccarelli et al. 2017, pp.9882-9910).

There is another application which uses tiny and distributed computers located in the end-user premises such as Raspberry Pi which been called as nano data centers. (Jalali et al. 2106, pp. 1728-1739). Experiments have been made to compare the power consumption rate and the file size downloading from a data center (DC) and from a nano data center (nDC). The results shown that exchanged bytes during downloading files from a DC is greater than that of a nDC, and the energy consumption of uploading files to a nDC is much smaller than to a DC. More data shows that the best way to save energy is to use distributed small devices that are not frequently accessed, such as video surveillances in users' house. (Jalali et al. 2016, pp. 1728-1739).

3. Future studies

Nowadays, Amazon Web Service Elastic Compute Cloud (EC2) and Simple Storage Service (S3), one of the most popular and advanced cloud server and storage service in the world, do not supply energy-efficient resource or models (Beloglazov, Buyya & Abawajy 2011, pp. 1397-1420). Future studies can focus on how to build a middleware fogging platform based on the remote cloud servers to save data transmission energy resources.

Furthermore, equipping heterogeneous wireless interface cards on IoE devices and then design a platform using the inter-networking of local computing devices (can be a mobile phone, a smart vehicle or any wearable devices), proximate computing entities (e.g. distributed fog nodes) and remote (cloud) servers to allocate all kinds of resources is another considerable issue (Baccarelli et al. 2017, pp.9882-9910).

4. Conclusion

We have outlined the model of fog computing and the applications with a combine of fogging and cloud computing. All the experiment data and results test by previous researchers are in multiple attempts and simulation. It is clear that by adding a fog layer between the cloud nodes and the end-users can reduce the energy consumption during data transmission. Fog nodes at the edge of the fog layer can compute data and share it between IoT devices, in order to allocate energy resources evenly by figuring out the energy demand of users.

References

[1] Dingyu, Z. (2018). Cloud Computing Technology and Its Application in Robot Control. IOP Conference Series: Materials Science and Engineering, 392(6), p.062192.

[2] En.wikipedia.org. (2018). Fog computing. [online] Available at: https://en.wikipedia.org/wiki/Fog_computing [Accessed 17 Aug. 2018].

[3] Kitanov, S. and Janevski, T. (2017). Energy efficiency of Fog Computing and Networking services in 5G networks. IEEE EUROCON 2017 - 17th International Conference on Smart Technologies.

[4] Amendola, D., Cordeschi, N. and Baccarelli, E. (2016). Bandwidth Management VMs Live Migration in Wireless Fog Computing for 5G Networks. 2016 5th IEEE International Conference on Cloud Networking (Cloudnet), pp.21-26.

[5] Baccarelli, E., Naranjo, P., Scarpiniti, M., Shojafar, M. and Abawajy, J. (2017). Fog of Everything: Energy-Efficient Networked Computing Architectures, Research Challenges, and a Case Study. IEEE Access, 5, pp.9882-9910.

[6] Jalali, F., Hinton, K., Ayre, R., Alpcan, T. and Tucker, R. (2016). Fog Computing May Help to Save Energy in Cloud Computing. IEEE Journal on Selected Areas in Communications, 34(5), pp.1728-1739.

[7] Beloglazov, A., Buyya, R. and Abawajy, J. (2011). Optimal online deterministic algorithms and adaptive heuristics for energy and performance efficient dynamic consolidation of virtual machines

in Cloud data centers. Concurrency and Computation: Practice and Experience, 24(13), pp.1397-1420.