Research Design and Research Plan for Using Fog Computing to Optimize the Autonomous Car

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1. Introduction

In 2012, the number of Internet of Things (IoT) devices has increased remarkably. The increase of data stream leads to the demand for fast computing and low latency. In order to solve this problem, a new paradigm called Fog Computing came into being. Typically, Fog computing is an extension of Cloud Computing in data storage, computing and network facilities and it resides closer to IoT devices/sensors. Fog Computing provide resources in the distributed edge networks which is closer to the user level (Amendola, Cordeschi & Baccarelli, pp.21-26). Therefore, 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). This article mainly designs and proposes a research plan on how to save energy using fog computing.

This paper is structured as follows. Section 2 explains the motivation of the research question and identifies the research question. Section 3 introduces the previous algorithm researchers use to save energy using fog computing and proposes an investigation method based on previous work and section 4 describes a new idea for improving the result. Section 5 analyzes the expected result. Finally, section 6 concludes with a description of the likely contribution in the fogging sphere.

2. Motivation & Identification

In this section, 2.1 introduces the incentive of the research problem, 2.2 identifies the research question.

2.1. Incentive

As the development of the Internet of Things (IoT) became rapid, people are increasingly relying on cloud computing. What' more, the autonomous car also develops fast, e.g. Google Driverless Car. A smart car requires low-latency as well as low-energy consumption. However, data transmission between cloud servers and users and cars would cost a lot of energy consumption and also a waste of time. In order to minimize the expenses of communication traffic in data centers, we need to create a middle layer between cloud servers and user devices which is called fog layer. The layer should be close to end-users so that the data transmission delay would be small as well as the energy consumes.

2.2. Identification

An autonomous car needs to update various data from cloud servers. According to the CNBC website Beijing time on 28th April, Morgan Stanley's analyst Adam Jonas claims that a Tesla autonomous car can generate 40TB data per hour. However, transmit data from/to cloud data centers may lead to large energy consumption as well as a high latency. Computing and training data by fog might also cause enormous energy discharge. Therefore, the best way to solve this problem is to use fog layers to storage data which need to be transmitted in real-time, combined with cloud computing for computing and train large data, finally optimize the energy utilization rate and reduce the latency.

3. Traditional algorithm

In previous works, researchers used a model called *Time-Based Energy Consumption Model* and *Flow-Based Energy Consumption Model* (Jalali et al., 2016). The Flow-based model is based on the proportional allocation of the power

consumption of the device on the entire device flow. When data traverses the network from source to destination, data usually passes through multiple network nodes. Through Flow-based model, we can get energy consumption of cloud services in the access network, in centralized Data centers, per edge network and per core network. Then using the Time-based model to calculate the energy consumption of the customer premises equipment. Finally, compare the number of bits exchanged between clients and servers (Nano Data Centers) to evaluate the energy consumption. The application previous researchers used is WordPress[1]. By operations such as uploading and downloading files to/from the WordPress application on data centers and Raspberry Pi (a micro Nano Data server near to the user-end) computes the number of exchanged bits and power consumption.

However, using this method on current research question may not be the best choice. The following section explained the reason why changing the algorithm may improve the performance in this research question.

4. Improved algorithm

The assumption of how to improve the algorithm is, download a part of the data using the fog layer instead of downloading all of them. When the autonomous car is moving in a high speed, downloading all of the data from the cloud server is a very dangerous thing due to the high latency. On the contrary, when a car is stopping at a crossroad, downloading data from cloud server is a safer and wiser choice. So, the improved algorithm is to download data with priority from the cloud server rather than all of them when the car is moving

such as traffic conditions. And every time the car passes a crossroad, the fog device will send the updated data to the car.

Due to the constraints of the equipment, the method I chose for simulating the energy consumption is MATLAB [2] and SIMULINK. The application for proofing my assumption is building a fog layer on traffic lights. First, add Nano devices on traffic lights. A smart car needs to update the map information and traffic condition in real-time in order to have a better performance in auto-driving. So, the first step is to compare the energy consumption by downloading the same map information from the cloud server using the time-based model. Then, figure out the energy utilization using the fog layer. Nano Data Centers settled on the traffic lights can build up a fog network, which can store map information and other traffic condition information computed by the cloud servers. When cars pass by the traffic lights, it will receive a part of updated data from the traffic-light-network, thus reduce the burden of downloading all data from the cloud server. Next, use the flow-based model to calculate each energy usage in the two methods mentioned above.

5. Analyze

The expected result for this experiment is that, when moving cars download a large proportion of data from fog layer instead of all of the data, the energy consumption is the lowest. When stopping cars update data from the cloud servers, the energy utilization has the highest rate.

If the consumption is established, the field of driverless car would take a huge progress. Fog computing may help the automobile industry breakthrough a large restriction and make driverless car emerge

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[1] https://wordpress.com

[2] https://www.mathworks.com

into people's vision.

6. Conclusion

In conclusion, the research I designed is based on a previous algorithm, but using a different application and considered about the simulation methods. Further experiment could focus on how to do the mathematical modeling and adjust the threshold of how many data should been downloaded by the cloud server and how many data should been storage in the fog layer.

References

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