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Inter-regional Performance Analysis of Data Center Networks in Public Cloud Systems

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Abstract

Recently, due to the development of the service using the network, it has become possible to provide services not only to the country where the service was developed but also to other countries. Building a system in a service area can result in poor quality of service due to a large amount of capital and personnel spent on costs, operations, and maintenance. Therefore, many service providers construct and operate a system using a public cloud system. Public cloud systems allow users to borrow hardware and software resources from cloud providers to build the systems they need. The public cloud system has a data center in each region, and it is possible for a user to create a virtual machine in the area and configure the desired type of system. There are various types of performance metrics that evaluate the system such as hardware performance, disk performance and network performance. However, if the service is provided at various locations, the user of the service should show the least level of satisfactory for system performance, and it is necessary to evaluate the performance of the network, which is a measure for evaluating the fast response speed and the amount of transmission to the user. In this paper, we compare and analyze network performance among data centers in public cloud systems. RTT and SCP throughput were measured to compare and analyze the network performance between data centers in a public cloud system. In order to measure network performance between data centers in a public cloud system, a virtual machine was created for each region. RTT test and throughput test were performed as virtual machines in the data centers of other regions in the created virtual machines.

Keywords: Public Cloud System, Cloud Computing, Cloud Network, Datacenter

INTRODUCTION

With the recent diversification of network-based services, it has become possible to provide services not only to the countries that developed the services but also to other countries. In the case of providing services overseas, the server is constructed to facilitate the provision and operation of services in the corresponding countries. However, it is difficult for small to medium sized service providers to build the system by purchasing the equipment directly due to the initial construction cost and maintenance cost of the system. When the system is constructed in the service area, the quality of service may be deteriorated because a large amount of capital and personnel are input into the initial construction cost, operation and maintenance. Thus, many service providers use public cloud systems to build and operate systems in various locations.

A public cloud system is a service that rents system resources from a data center through the Internet and builds a system that meets the needs of users. Users can borrow system components at a low cost without having to purchase expensive hardware and software resources each time the system is built. Also, since the system can be configured according to the user's demand within the leased resources, the system construction using the public cloud system is a system configuration method suitable for a small and medium sized service provider. It is very cost-effective to build various types of systems at low prices, and the data center of public cloud system is located in various places, so there is a great advantage in providing services [1][2][3].

The user of the service wants to use the system faster and faster. As the position of the service providing system moves away from the user's position, the speed of the system decreases and the satisfaction of the user decreases. In this paper, we evaluated the performance of public cloud system based on the location of data center. We created a virtual machine by designating one data center for each continent using Google's GCP (Google Cloud Platform). We measured RTT (Round Trip Time) and SCP (Secure Copy Protocol) throughput between data centers through network

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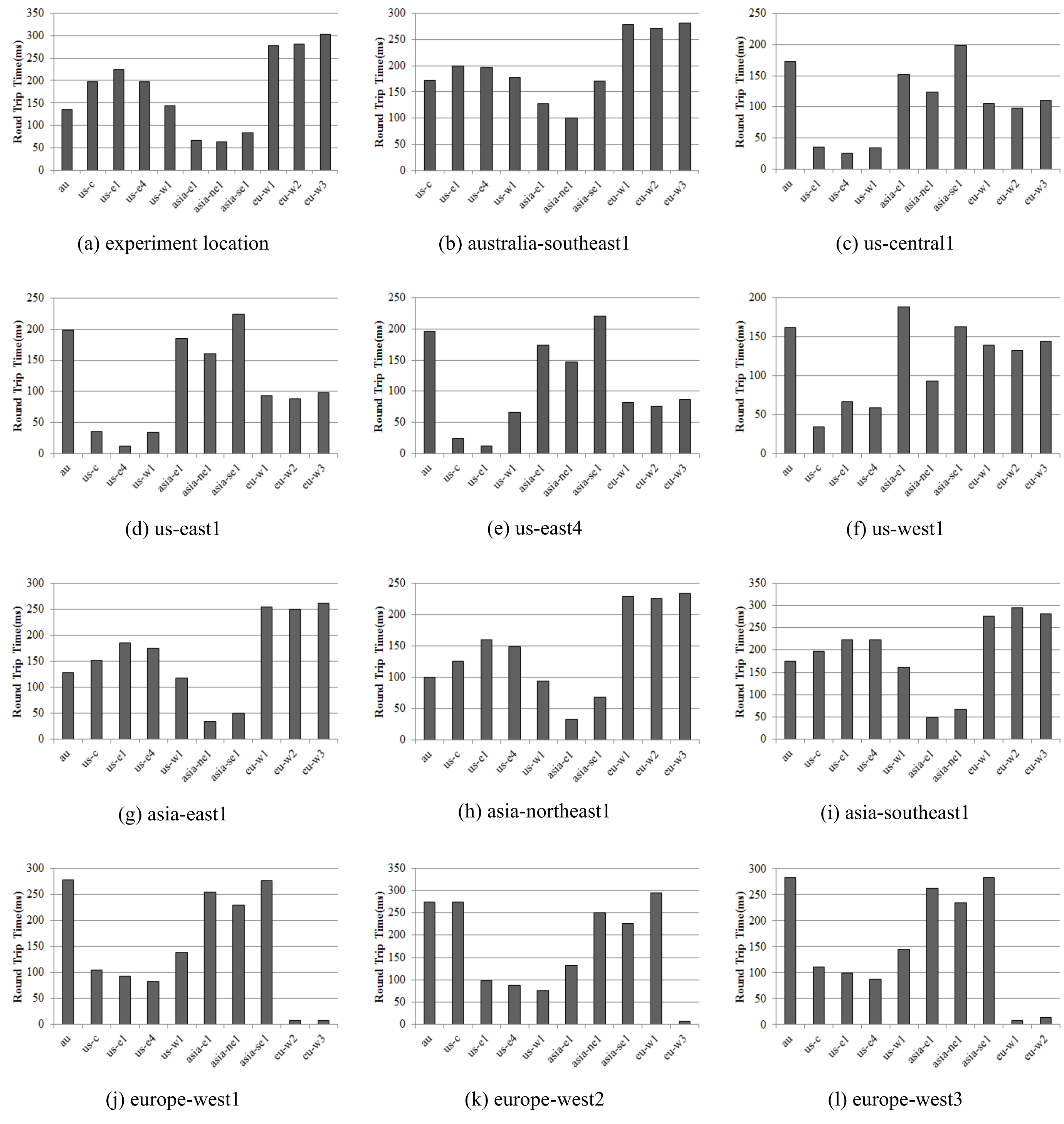
performance measurement modeling in the created virtual machine. RTT is the time to send a packet to the receiving host and return to the receiving host. In the case of a host serving as a server relaying a plurality of clients, the shorter the RTT, the faster and smooth the service can be provided to the user. SCP throughput is the amount of data transmitted to the receiving host every second using SCP. High SCP throughput is required when a user uses a host for storage or when sending a lot of data for a particular application. High performance RTT and SCP throughput play a big role in improving user's system usage satisfaction. Therefore, in this paper, RTT and SCP throughput are selected as factors to measure network performance between data centers.

The rest of this paper is organized as follows. In the background, we describe the necessity and advantages of cloud computing and discuss the relationship between host



(a) experiment location (b) australia-southeast1 (c) us-central1

(d) us-east1 (e) us-east4 (f) us-west1

(g) asia-east1 (h) asia-northeast1 (i) asia-southeast1

(j) europe-west1 (k) europe-west2 (l) europe-west3

Figure 1: Round Trip Time of all data centers in GCP

location and network performance. In the related work, a case study on the public cloud system is reviewed. In the methodology, the method of establishing the network performance measurement model is proposed and the performance measurement method is also described. In the performance evaluation, network performance evaluation is performed between each data center using the network performance measurement model, and finally we conclude our work.

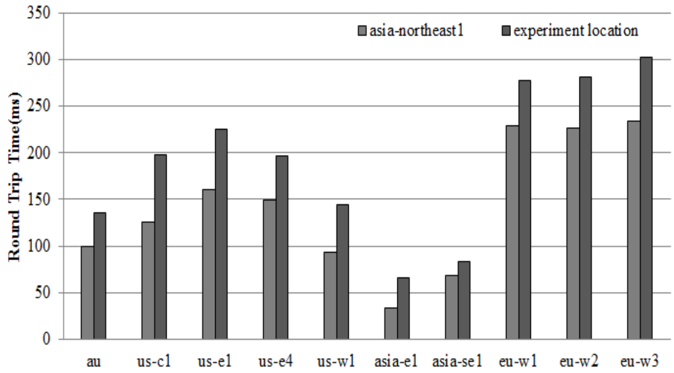


Figure 2: Roud Trip Time measured by asia-northeast1

BACKGROUND

Cloud Computing

Cloud computing means borrowing expensive hardware or software from the data center over the Internet at a low cost. Individuals or developers who want to provide Web services rent software or virtualized hardware resources that they need through the data center. At this time, the user pays the price of the resource used by the user, which is inexpensive as compared with actually purchasing and operating the high-performance resource directly.

Cloud computing is classified as IaaS, Paas, and SaaS depending on the service model provided. IaaS (Infrastructure as a Service) is a service to rent virtualized CPU, main memory, storage and network environment in the data center. It provides the highest level of service and users can design and use the system according to their needs. Paas (Platform as a Service) is a service that provides a platform for developers to develop software. It is often used when there is not enough space to obtain development tools or when testing the results in various environments. Finally, SaaS (Software as a Service) is a service that provides general users with the usage environment of the software. For example, if a user wants to work on a document and does not install a word processor directly on one's PC, It is a service to rent environment [4][5][6].

With cloud computing, users can freely use the systems they want to build as much as the resources they lease from the data center. Through this, users can utilize various forms from simple document work to construction and operation of web server.

Network Performance by Datacenter Location

Figure 1 shows the results of a survey of RTTs between 11 data centers as well as experimental environments provided by Google to determine the correlation between host-to-host and network performance. RTT is an important measure for determining network congestion and distance by sending data to the other host and returning the response back to it.

Google has 11 data centers on four continents around the world, each of which manages resources such as virtual machines and disks created by users. Before measuring the network performance between GCP's data centers, the RTT of each data center including the experimental area (Korea) was examined and the result is shown in Figure 1. As can be seen in Figure 1, when the distance is close, it shows a very fast RTT. Especially, in case of three data centers in Europe, RTT is the shortest because the distance is very short compared to other areas. It can be seen from this that among the factors affecting the performance of the network, the distance between the hosts greatly affects the network performance.

In this paper, we select one data center for each continent among 11 data centers provided by Google, and measure, compare and analyze the network performance among each data center. The RTT of 11 data centers in Google were surveyed based on asia-northeast1, the closest data center in the experimental environment. Figure 2 shows the results. In Australia, we selected australia-southeast1, us-west1 in the US and europe-west2 in Europe.

RELATED WORKS

The public cloud system can be configured in various forms according to the user's purpose. When a user collects, analyzes, and processes data using a public cloud system, a system with a high computing power is required. Also, a system that needs to accommodate a large number of clients is required to have a public cloud system with high computing power and excellent network performance. Therefore, in this section, we will examine the comparative analysis of public cloud systems.

Wang et al. analyzed network performance of public cloud system. They selected small instance and medium instance among several virtual machines provided by Amazon to measure packet delay and TCP/UDP throughput of the instance. There is a difference in that the performance of the network is measured using Amazon's virtual machine. However, public cloud providers have a distributed data center in many locations, meaning that performance measurement and evaluation between each data centers is required necessarily [7].

Unlike previous studies, Persico et al. measured the network performance of Amazon and Azure, and they selected the medium instance and extra-large instance for each public cloud provider. Their research not only measured the network performance according to the size of the virtual machine but

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also measured the TCP/UDP throughput according to location of the data center [8].

CloudCmp is a tool for comparing public cloud systems, comparing four common cloud systems that many users use. They compare and analyze each cloud system supplier in terms of CPU, Memory, and Disk I/O. They compare not only the hardware performance but also the range and price of the service provided to the users [9].

METHODOLOGY

Comparison of Network Performance in the Datacenter

Public cloud systems are typically used to store and process data. In addition, if relays are needed between local and remote sites, it will cost a lot to build a system directly, but a public cloud system can be used to replace the corresponding roles. Since the users of the system want to use the system with the fast response rate and the high throughput, in this paper, we measured the RTT and the SCP throughput by transmitting the user 's data to the host of each data center.

The GCP has data centers in four continents (US, Europe, Asia, Australia), with a total of 11 data centers. We selected Australia-southeast1, us-west1, and Europe-west2, which are the fastest data centers in the region, with similar straight-line distances, based on asia-northeast1, the nearest data center in our experimental environment.

Modeling for Network Performance Measurement of Datacenter

In this paper, we measured RTT and SCP throughput to measure network performance between data centers. RTT refers to the time it takes for a packet to travel from the network to the destination host, and is a measure of the congestion and distance of the network [10]. SCP throughput is the time taken to transmit data from the network to the peer host, divided by the size of the data, and indicates how much data is transmitted to the peer host every second. Both the RTT and the SCP throughput are the requirements of users who want to use a system with high network performance.

In this paper, modeling for performance measurement between data centers is defined. Figure 3 and Figure 4 show our experimental the structure. After creating a virtual machine with the same performance in each data center, the network performance measurement module used in this paper is created and installed in each virtual machine. The network measurement module installed in the virtual machine plays a role of measuring RTT and SCP throughput between host sender and host receiver. In this paper, we define a host sender to send input data needed to execute workload. After receiving data from host sender and executing actual workload, host receiver sends download completion message to host sender and receives download completion message from host receiver. Figure 3 shows the scope of the proposed modeling and how to measure the network performance.

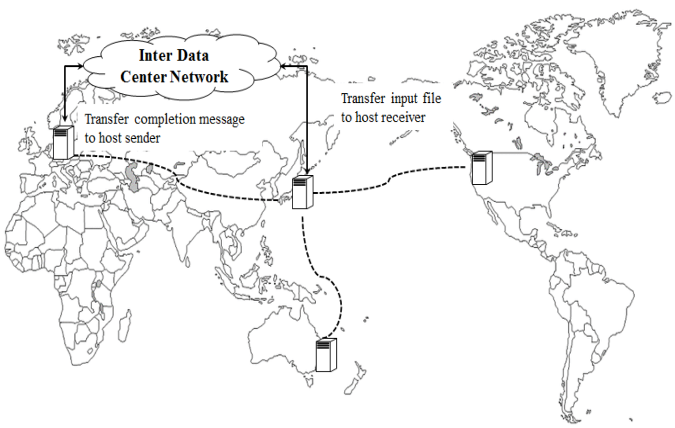


Figure 3: The scope of proposed modeling of network performance mearsurement

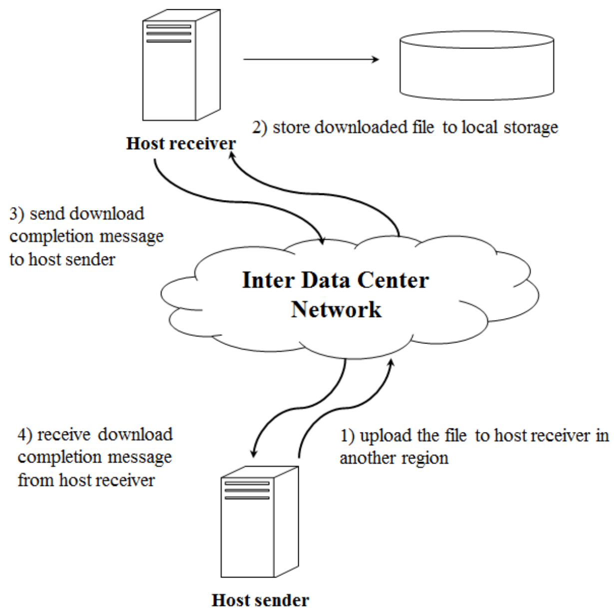
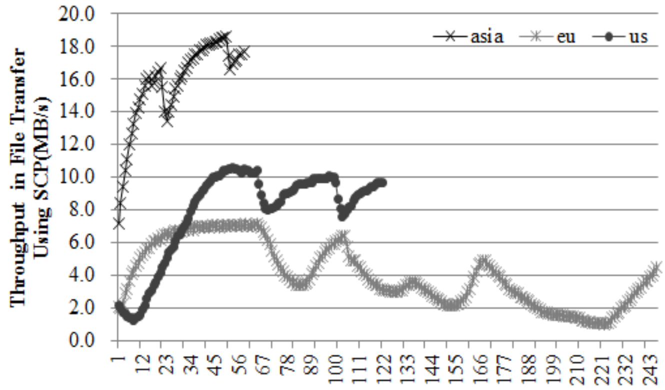
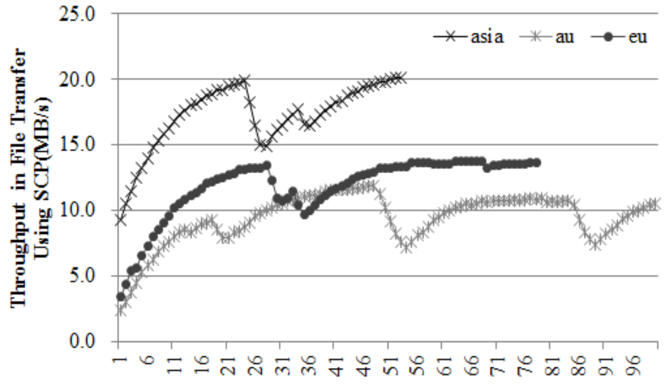


Figure 4: The structure of proposed modeling of network performance measurement

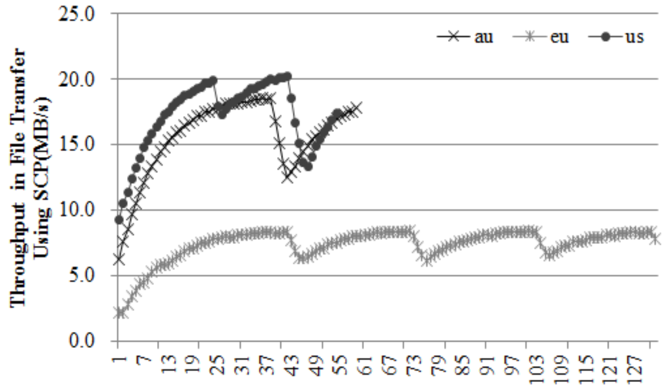
Figure 4 shows the structure of network performance measurement between two hosts by applying the network performance measurement modeling proposed in this paper. In the network performance measurement module of the host sender, a message confirming the status of network communication is transmitted to the host receiver. The host receiver transmits the response to the received message to the host sender. The time that occurs at this time is the RTT in the network performance measurement module. The host sender, which receives the message from the host receiver, sends the file and input data needed for the execution of the workload to the host receiver. At this time, the host sender measures the amount of data transmitted per second at the same time as transmitting the data. The host receiver executes the workload using the received data. After the workload is complete its execution, the host receiver completes the process by sending a completion message to the host sender.



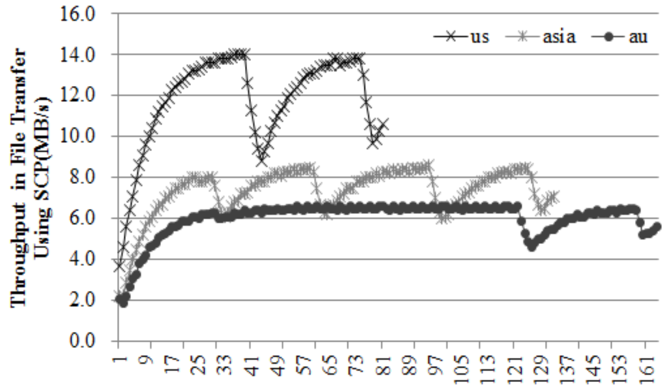
(a) australia-southeast1



(b) us-west1



(c) asia-northeast1



(d) europe-west2

Figure 5: The SCP throughput of each data center

Performance Evaluation

Experiment Environment

In this paper, we choose the workload to be used in the network performance measurement model from the workload provided in PARSEC (Princeton Application Repository for Shared-Memory Computers) benchmark suits 2.1 [11][12].

PARSEC benchmark suits 2.1 includes various types of workloads, which are useful for measuring the performance of virtual machines according to each different the situation. However, in this paper, we aim to measure network performance between data centers. A large workload, blackscholes, was selected for the experiment. In order to transfer input data, SCP (Secure Copy Protocol), which is a file transfer protocol generally used in Linux, was adopted for our experiment.

Figure 5 shows the result of tracking the throughput when the input file is transmitted to each host from four data centers specified in this experiment. The network performance between two hosts is closely related to the distance, and the above results also show higher SCP throughput as the distance between data centers becomes closer. The SCP throughput changes over time, which is affected by the period of receiving ACK messages in each system and the size of the buffer of the host receiver.

Table 1 shows the average of the SCP throughput that occurs when input data is transmitted to each host in four data centers selected in this experiment. As a result of comparing the average of the SCP throughput measured in each data center, normalized by US, the SCP throughput is 102.89%, 66.9% and 85.98% in Asia, Europe and Australia, respectively. In Asia, despite the fact that the specifications of the hardware provided by the data center are lower than those of other data centers, a high level of network performance was provided in comparison with the US. High SCP throughput with low hardware performance indicates that the network congestion of the data center is lower than other data centers. Therefore, data centers in Asia have lower network congestion rates than the US, Europe and Australia.

Table 1: The average SCP throughput of each data center

Host sender	Host receiver	Average throughput (MB/s)
au	us	11.5
	asia	17.4
	eu	6.7
us	au	9.9
	asia	19
	eu	12.5
asia	au	16
	us	18.3
	eu	8.3
eu	au	6.9
	us	12.5
	asia	8.3

CONCLUSION

Recently, due to the development of various services using a network, it has become possible to provide services to various parts of the world. Small- and medium-sized service providers have a difficulty in expecting high-quality services because they are costly to build systems directly in the service area. As a result, many small and medium-sized service providers can deploy and operate their own services using public cloud systems. Although it is possible to operate high-quality services, users who use the services want to use high-level services with a low cost. Therefore, in order to construct a system with high reaction rate and throughput, it is necessary to select a data center near the user.

In this paper, the experiment was to define the network performance measurement model to evaluate the network performance between the data center of the public cloud system. It was the experiment by specifying one of the data centers for each constitutional of 11 regions supported by the Google to evaluate the network performance of the public cloud system, and RTT for the network response time is the best when the distance between the data center is short, and SCP throughput in Asia was 102.89% compared to the results of United States, 66.9% to Europe and 85.98% to Australia. Asia had lower hardware performance compared to other data centers, but higher than average SCP throughput between the US and other data centers. Therefore, there is a congestion in the network data center in the region of United States, Europe and Australia and Asia can be judged lower congestion than in the US, Europe, and Australia.

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