Cost-optimized Selection of CaaS Provider in Cloud Brokering Architecture for Cloud Based Healthcare Services

Md. Golam Rabiul Alam, Choong Seon Hong
Department of Computer Engineering, Kyung Hee University
robi@networking.khu.ac.kr, cshong@khu.ac.kr

Abstract

Cloud based healthcare services are the forthcoming patient-care amenities of autonomic and persuasive healthcare, where cloud broker acts as an intermediary between cloud service providers and healthcare service providers. Among the three type of cloud services i.e. infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS); the compute-as-a-service (CaaS) of IaaS services are more costly than other cloud services necessary for patient-care. This paper proposes an optimized solution of selection of CaaS providers based upon the online offered prices for their per hour CPU usage. The produced optimized solution is compared with the naïve certainty equivalent approach. The optimization formulation is horizontally scalable to select cost-effective IaaS and SaaS cloud services for healthcare provisioning.

1. Introduction

Advancements of cloud computing, body area networks, pervasive wireless broadband communication and wearable medical devices are empowering mobile healthcare services for the welfare being of patients as well as health professionals [1]. The cost of healthcare is growing progressively in all over the world [2]. Finding means of reduction of the healthcare cost is one of the major concerns of governments, health insurances companies, hospitals, healthcare professionals and patients. Several studies demonstrate that telehealth reduces the cost of healthcare [3]. The cloud based telehealth-care can be one of the cost effective solution for reducing per capita healthcare costs by deploying cloud brokerage for ensuring cloud services from cloud service providers to healthcare service providers. Consider a e-healthcare scenario of reference [4]. To analyze patients' data, cloud service providers' charges for their per second CPU utilization time. As for example, windows azure charges $0.12 for per hour CPU usages and amazon EC2 charges minimum $0.14 for per hour CPU usages. The goal of this research is to help cloud brokers to select CaaS providers' in a cost effective way, so that the broker can deliver cloud services to service consumers in optimized cost.

2. Related Works

The holistic approach, OPTIMIS, is proposed in reference [5] to optimize the service life cycle of cloud service provisioning. The optimized placement of virtual machines in cloud brokering architecture is proposed in reference [6].The broker infrastructure of e-healthcare services in cloud environment is presented in reference [7]. The authors' of this paper proposed a QoS based optimization algorithm for cloud brokers to deliver requested healthcare services.

3. System Model

In the cloud based healthcare model shown in figure 1, entails three principle entities, these are healthcare service consumer or enabler, cloud service broker and cloud service providers. The healthcare service consumers are the end users of patient-care system. The cloud service providers are the infrastructure, platform and/or software applications providers, who provide storage space, computation processors, network resources, and scalable software applications on demand via internet; and charges in different rates for their services. Finally, the cloud service brokers are the intermediary entity of healthcare service consumer and cloud service providers. The responsibilities of cloud service broker are to accept service request from healthcare service consumers, aggregate services of cloud service providers, create virtualized cloud resources, and ensures optimized cloud services through its scheduler and virtual infrastructure manager. The proposed optimization approach is deployed in scheduler module of cloud broker, which

selects cloud service providers optimally, based on dynamic offered prices by cloud providers and the availability of services of the cloud providers.

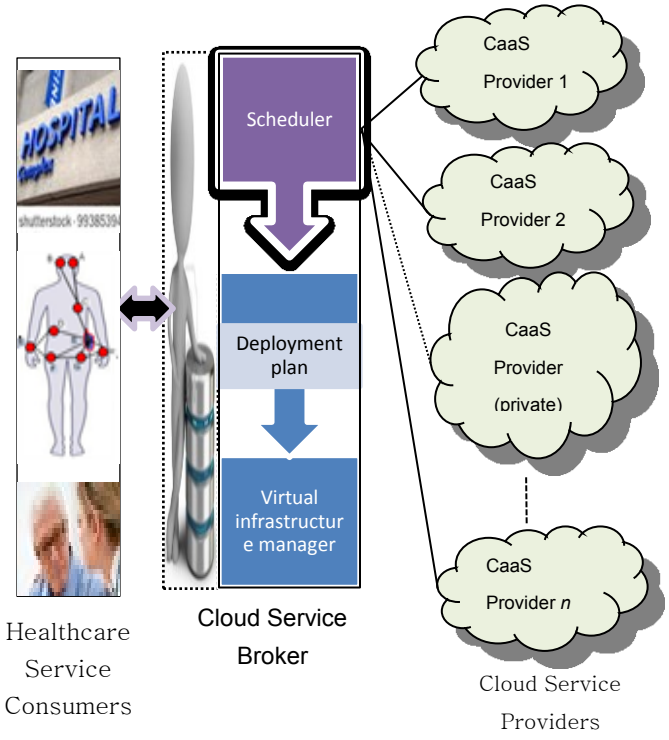

Figure 1. System model of cloud based healthcare service provisioning

4. Problem Formulation

The optimized selection of cloud service providers can ensure cost effective healthcare service provisioning in cloud based healthcare architecture through cloud brokers. Consider there are total n CaaS service providers. Assume that total submitted data volume from consumers is $v_{totl} \in R+$, for processing in n CaaS service providers. Now, the problem is to distribute volume v_{totl} data among n service providers in a cost effective manner, where CaaS provider i will process v_i volume of data.

Each CaaS service provider can process maximum v_i^{max} and minimum v_i^{min} volume of data, because of its processing capability and may also have the bindings to serve requests from other cloud broker. The processing charge of each individual CaaS provider is different and here considered as c_i for CaaS provider i. Thus the total charge of CaaS provider i to process v_i volume of data is $c^T v$.

Due to network failure or high traffic congestion some of the CaaS providers may not be reachable or accessible in each and every time. Thus the reachability factor is defined as a random variable r_i with values between 0 to 1. So, the CaaS provider i is accessible at time t with probability r_i. As the CaaS provider i has the processing capability of v_i volume of data and the probability of getting service from the CaaS provider i is r_i, then the service available from provider i is $v_i r_i$. And the total service available at time t from all accessible providers is $v^T r$. If the available service is less than the requested service v_{totl}, then cloud service broker will buy services from private CaaS provider with higher price p. The expected cost of buying services from private CaaS provider is $\boldsymbol{Ep}(v_{totl} - v^T r)$. Finally, the objective function of cost-optimized selection of CaaS providers is become minimizing the cost of the equation (1).

$$c^T v + Ep(v_{totl} - v^T r) \quad (1)$$

To solve the optimization problem, firstly the cost function (1) is minimized on the basis of sample average approximation equation (2), where $(v_{totl}^{(k)}, r^{(k)})$ are the set of samples from joint distribution of total demand and reachability and k=1,…,N;

$$c^T v + \frac{1}{N}\sum_{k=1}^{N} p(v_{totl}^{(k)} - v^T r^{(k)}) \quad (2)$$

Thus the designed solution of the optimization problem based on sample average approximation (SAA) is:

$$minimize\ (c^T v + \frac{1}{N}\sum_{k=1}^{N} p * \max(0, (v_{totl} - v^T r))) \quad (3)$$

Subject to

$$v \geq v_{min}$$
$$v \leq v_{max}$$

For checking the validity of the given solution, the larger validation set $(\check{v}_{totl}^{(k)}, \check{r}^{(k)})$ is used, where k=1 … N^{val} . The designed solution for checking the validity of the optimization problem based on sample average approximation (SAV) is:

$$minimize\ (c^T v + \frac{1}{N^{val}}\sum_{k=1}^{N^{val}} p * \max(0, (\check{v}_{totl} - v^T \check{r}))) \quad (4)$$

Subject to

$$v \geq v_{min}$$
$$v \leq v_{max}$$

5. Performance Analysis

For analyzing performance of the proposed optimization problem of selection of CaaS providers to get healthcare data processing service with optimized cost, the generated solution is compared with naïve certainty-equivalent CE-SAA and CE-SAV solutions.

To analyze the performance of proposed optimization approaches using CVX toolkit, the total number of CaaS provider (CP) is considered as 7, in which one of the CaaS provider is in a private cloud, which charges higher cost for processing data. The data processing charge of CP1 is considered as $0.14 per second and CPU speed is 1 GHz, and it can process maximum 35 Gigabits of data for a single processing request from any cloud broker. The data processing charge of CP2 to CP5 is considered as $0.12 per second and CPU speed of each of the processor is 1 GHz, and each of them can process maximum 12 Gigabits of data for a single processing request from any cloud broker. The data processing charge of CP6 is considered as $0.13 per second and CPU speed is 1 GHz, and it can process maximum 20 Gigabits of data for a single processing request from any cloud broker. Finally, the data processing charge of private CaaS service provider is considered as $0.20 per second and CPU speed is 1 GHz, and it can process any demanded amount of data. The pmf of the CaaS providers' accessibility or availability is assumed as uniform distribution between 0 and 1. The sample size of submitted processing request from broker to CaaS provider is 1000 for sample average approximation method, and 10000 for sample average validation. The different formulation of the optimization problem selects different CaaS providers and also determines processing data volume to provide cost effective solution for healthcare data processing in cloud, shown in figure 2.

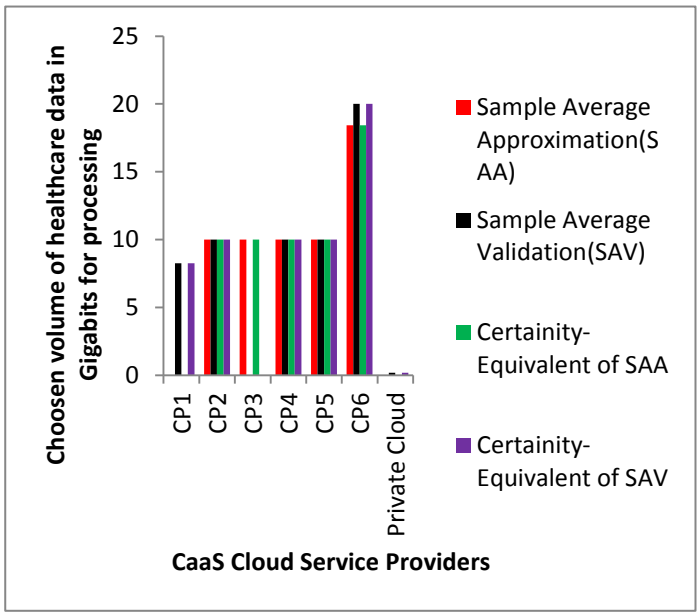

Figure 2: Selection of CaaS providers, and data volumes by different optimization approaches'

6. Conclusion

The cloud based healthcare services are promising and challenging research issue in ubiquitous healthcare industry. Cost-effective patient-care systems are the demand in need for sustainable healthcare solutions. The proposed optimization approach of cost-effective selection of CaaS providers' for analyzing bulk amount of healthcare data reduces the healthcare cost of cloud based e-health or m-health.

Acknowledgement

This research was supported by Next-Generation Information Computing Development Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (2010-0020728) Dr. CS Hong is corresponding author.

7. References

[1] Pandey, Suraj, et al. "An autonomic cloud environment for hosting ECG data analysis services." Future Generation Computer Systems 28.1 (2012): 147-154.

[2] Health expenditure per capita, "The World Bank", http://data.worldbank.org/indicator/SH.XPD.PCAP

[3] Noel, Helen C., et al. "Home telehealth reduces healthcare costs." Telemedicine Journal & e-Health 10.2 (2004): 170-183.

[4] Md.Golam Rabiul Alam, Choong Seon Hong, "A Cloud Based Autonomic Mental State Monitoring System Using Wearable Body Sensors", 2013 한국컴퓨터종합학술대회(KCC 2013), 2013.6.26~28(28)

[5] Ferrer, Ana Juan, et al. "OPTIMIS: A holistic approach to cloud service provisioning." Future Generation Computer Systems 28.1 (2012): 66-77.

[6] Tordsson, Johan, et al. "Cloud brokering mechanisms for optimized placement of virtual machines across multiple providers." Future Generation Computer Systems 28.2 (2012): 358-367.

[7] Wu, Ching-Seh, and Ibrahim Khoury. "E-Healthcare Web Service Broker Infrastructure in Cloud Environment." Services (SERVICES), 2012 IEEE Eighth World Congress on, IEEE, 2012.

[8] Moreno-Vozmediano, Rafael, Ruben S. Montero, and Ignacio M. Llorente. "Multicloud deployment of computing clusters for loosely coupled MTC applications." Parallel and Distributed Systems, IEEE Transactions on 22.6 (2011): 924-930.