

# Cost-aware Optimized Virtual Machine Placement through Cloud Broker in Multi-cloud Architecture

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## Abstract

Cloud services through cloud brokers are upcoming services acquisition approach for cloud service consumers, where cloud broker acts as an intermediary between cloud service providers and service consumers. From the viewpoint of service charge, the IaaS cloud service providers impose higher services charges for their services. As the service charge varies dynamically in respect to cloud service providers, in respect to requested cloud resources and timestamp. In this paper, we propose a cost-aware selection of cloud providers and their virtual machines (VMs) as well from the broker perspective to provide cost effective services to consumers. We consider multi-cloud environment for cloud service provisioning and apply portfolio optimization technique to purchase services from cloud service providers.

## 1. Introduction

The charges of various IaaS provider [1], which provides a multi-tenant on-demand multi-cloud computing environment [2], are varies upon user demands, contracts, contract periods, location, service availability and requested virtual machine instances etc. 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 objective of this paper is proposing a method of cost effective service selection i.e. cost effective VM placement from brokers' perspective.

## 2. Related Works

The optimized placement of virtual machines in cloud brokering architecture is proposed in reference [3]. The paper presented very detail architecture of cloud service broker. The optimized selection of virtual resources of cloud brokers through cloud scheduler was one of the primary objectives of the paper. The authors' of the paper didn't consider dynamic cloud scheduling and dynamic pricings to place virtual machines dynamically.

The cost-effective deployment of computing clusters in multi-cloud infrastructure is presented in reference [8]. They provide analysis on the viewpoint of performance and cost. The proposal is only for loosely coupled many task computing (MTC) applications. The

proposal may not perform well for tightly coupled MTC applications, where facts are highly interdependent and synchronization among the computational units are necessary.

To maximize the revenue of cloud data center, a joint or coordinated VM resource provisioning and maintenance scheduling method is proposed by the authors of reference [4]. They formulate the problem as an Integer Linear Programming problem and then transformed it to equivalent problem to obtain linear programming relaxation solution, then they apply LIST rounding algorithm towards final approximate solution.

## 3. System Model

The considered system model of cloud based service provisioning is presented in figure 1. The system model consists three stuffs, these are service consumers, cloud service broker and cloud service providers. The service consumers are the end users. The cloud service providers are the infrastructure and compute service vendors, who sales IaaS services with dynamic charges. The cloud service brokers are the intermediary entity, who acts as an agent of cloud service providers. The responsibilities of cloud service broker are to accept service request from service consumers, aggregate services of cloud service providers, create virtualized cloud resources, and ensures optimized cloud services through its optimizer and virtual resource manager. The proposed

optimization approach is deployed in optimizer module of cloud broker, which optimally selects the virtual machines (VMs) as well as cloud service providers based on dynamic offered prices by cloud providers and the availability of services of the cloud providers. The goal of dynamic selection of VMs is optimizing the service cost of cloud based services acquisition.

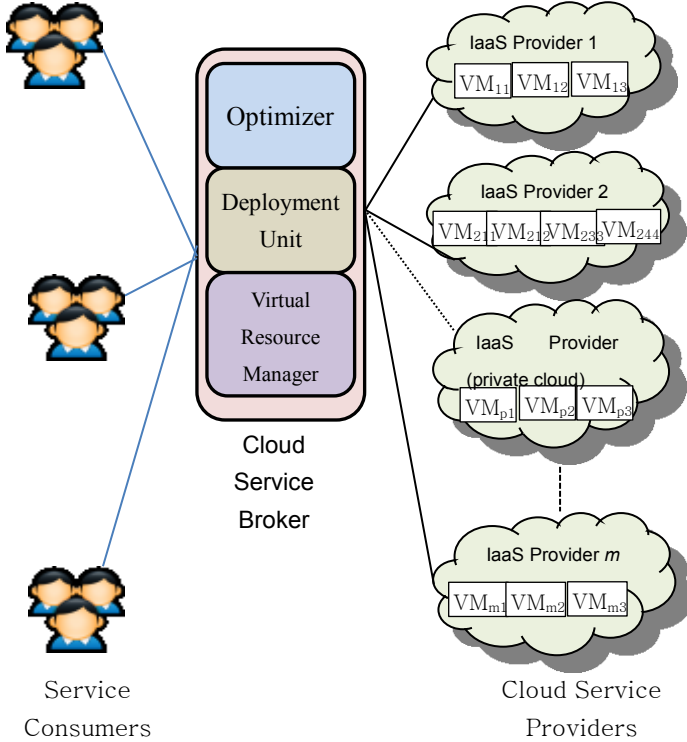


Figure 1. System model of cloud based service provisioning

4. Problem Formulation

The problem of cost effective selection of cloud providers or cost-aware placement of VMs can be formulated as portfolio optimization problem, where consumers' volume of works  $v_k$  can be considered as the consumer demands and VMs with different processing capabilities are considered as the infrastructure portfolio sources. The symbols used in this optimization problem formulation are presented in table 1.

Table 1. Symbols and there meanings in optimization problem formulation

$n$	Number of virtual machines
$m$	Number of cloud providers
$u$	Number of users or consumers
$V_i$	Volume of work (data to be processed) of consumer $i$
$V_{totl}$	Total volume of work received by broker at time $t$ from some users of $u$
$v_{sj}$	Volume of data processed by provider $s$ in VM $j$

$c_{sj}$	Charge to process $v_{sj}$ volume of data
$c$	Total charge to process $v$ volume of data in public cloud
$\rho$	Charge to process a unit volume of data in private cloud, where $p > c_{sj}$
$b$	Charge of broker for the deployment service of a unit volume of work
$r_{sj}$	Availability of virtual machines $j$ of provider $s$ , where $r \in \{0,1\}$
$v_{sj}^{max}$	Maximum processing capability of VM $j$ of cloud provider $s$
$v_{sj}^{min}$	Minimum processing capability of VM $j$ of cloud provider $s$

The total charge to process total  $v$  volume of data in public cloud including brokers fees is  $(c^T v + b * v)$ . The rest volume of the data will be processed in private cloud because due to higher queuing delay some of the consumer jobs need to place at private cloud to meet customer demands.

Total service available at time  $t$  from all accessible VMs of all 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 IaaS providers VMs with higher price  $p$ . The expected cost of buying services from private IaaS provider is  $E[p * (v_{totl} - v^T r) + b * (v_{totl} - v^T r)]$ . The objective function of cost-optimized selection of VMs of IaaS provider is becoming the minimization of the cost of equation (1).

$$c^T v + b * v + E[p(v_{totl} - v^T r) + b(v_{totl} - v^T r)] \tag{1}$$

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  $k=1, \dots, N$ :

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

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

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

Subject to  $v \geq v_{min}; v \leq v_{max}; v^T r \geq v_{totl}$   
 For checking the validity of the given solution, a larger validation set  $(\check{v}_{totl}^{(k)}, \check{r}^{(k)})$  is used, where  $k=1 \dots N^{val}$ .

The designed solution for checking the validity of the optimization problem based on sample average approximation (SAV) is:

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

Subject to  $v \geq v_{min}; v \leq v_{max}; v^T \check{r} \geq \check{v}_{totl}$

The generated solution is compared with naïve certainty-equivalent solutions.

The certainty-equivalent solution of the optimization problem based on sample average approximation (CE-SAA) is:

$$\text{minimize } (c^T v + b * v + (p + b) * \max(0, (average(v_{totl}) - v^T * average(r)))) \quad (5)$$

Subject to  $v \geq v_{min}; v \leq v_{max}; v^T r \geq v_{totl}$

And the certainty-equivalent solution for checking the validity of the optimization problem based on sample average approximation (CE-SAV) is:

$$\text{minimize } (c^T v + b * v + (p + b) * \max(0, (average(\check{v}_{totl}) - v^T * average(\check{r})))) \quad (6)$$

Subject to  $v \geq v_{min}; v \leq v_{max}; v^T \check{r} \geq \check{v}_{totl}$

### 5. Performance Analysis

To analyze the performance of proposed optimization approaches using CVX toolkit, the total number of VMs of 3 different IaaS provider (CP) is considered as 7, in which one of the VM is considered as from private IaaS provider of a private cloud, which charges higher cost for processing data. The pmf of the IaaS providers' accessibility or availability is assumed as uniform distribution between 0 and 1. The optimal cost of processing 58.4311 Gigabits of data is shown in table 2.

Table 2. Optimal costs of requested service (data) processing in cloud using cost effective IaaS provider selection.

Optimization Approaches	Chosen Volume of Data for Processing							Private Cloud	Optimal value Cost in dollar
	VM11	VM21	VM13	VM34	VM15	VM26			
SAA	0	10	10	10	10	18.43	0	7.1960	
SAV	8.25	10	0	10	10	20	0.1775	7.3555	
CE-SAA	0	10	10	10	10	18.43	0	7.1960	
CE-SAV	8.25	10	0	10	10	20	0.1775	7.3555	

Figure 2 shows that the proposed optimization formulation i.e sample average approximation returns optimal cost, which is always optimum than the optimal value produced from its validation set, and

also in all form of availability of IaaS providers.

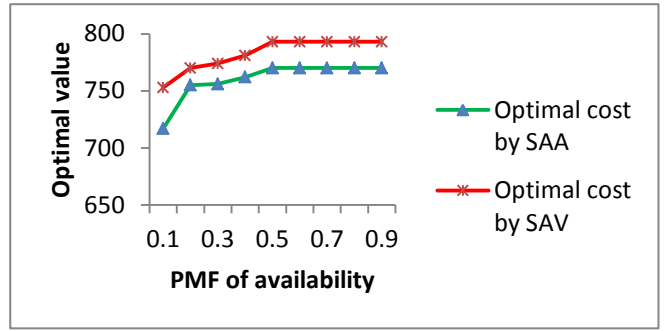


Figure 2: Performance of SAA and SAV in the PMF of IaaS providers' availability

### 6. Conclusion

The cost effective cloud service provisioning is the one of the promising and challenging research issues in cloud computing. The proposed optimization approach of cost-effective selection of IaaS providers' for analyzing bulk amount of data through cloud broker will help reduce the cost of cloud based service providers. This paper focused on the optimization of data processing cost to minimize the overall service provisioning cost in cloud environment.

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