Evaluation the robustness of VM assignment with truncated normal distribution in multi-cloud system

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Abstract. In this paper, we present our view on a cloud broker model for multi-cloud environments. The model deals with a Virtual Machine (VM) mapping problem via a meta-heuristic algorithm and considers the uncertainty of the VM demands, hence allowing to obtain robust assignment solutions.
keywords: cloud broker, meta-heuristic optimization, multi-cloud computing, uncertainty

1 Introduction

The development of cloud computing is a great trend nowadays. The cloud computing with virtualization technology brings the resources of the cloud to the end users in an "all-as-a-service" form. The service deployments offered by the cloud computing can be categorized as [1]: Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS). Standing between the cloud user and the cloud service provider, the cloud broker plays an important role in connecting both of them.

A cloud broker, with respect to the scope of our study, needs to deal with an assignment problem for virtual machine requests from cloud users. In cloud computing, the Service Providers (SPs) can offer their services to the cloud users under Service Level Agreement (SLA) and Quality of Service (QoS) specifications. The characteristics of the services can be defined in terms of (a) pricing model e.g average monthly price, (b) resource planning and SLA/QoS. The SPs can also be categorized based on their characteristics with respect to the service model: SaaS, PaaS and IaaS, or the QoS and SLA for the services they implement. Our concept for the cloud broker is to use a meta-heuristic mechanism to deal with the VM assignment optimization problem.

The Virtual Machine Assignment Problem (VMMP) raises important challenges in the domain of cloud computing. In this paper, we propose different meta-heuristic methods for VMMP, namely for cloud brokerage in a multi-cloud system. In our model, the VMMP optimization algorithm is designed to deal with uncertainties in the VM demand, for our case specifically looking at execution time modeled by a truncated normal distribution.

We propose to use several meta-heuristic methods including: Evolutionary Algorithm (EA), Particle Swarm Optimization (PSO), Differential Evolution (DE), and Covariance Matrix Adaptation – Evolutionary Strategy (CMA–ES).

2 Proposed Model

In this section, we present a cloud broker model that deals with VMs assignment in a multi-cloud system. The service level of the VMs mapping problem can be viewed as:

- vector of service providers (SP): $\mathrm{SP}_i, i \in \overline{1, N}$;
- vector of VM requests: $\mathrm{VM}_j, j \in \overline{1, M}$;
- vector of consolidated profiles: $\mathrm{P}_i = \{\beta_i^1, \beta_i^2, ..., \beta_i^K\}, \forall i \in \overline{1, N},\ \mathrm{P}_i \in \{0,1\}^K$;

- variables:

$$x_{ij} = \begin{cases} 1, \textbf{if } \mathrm{VM}_j \textbf{ is assigned to } \mathrm{SP}_i; \\ 0, \textbf{otherwise}. \end{cases}$$

$$\alpha_{ij}^l = \begin{cases} 1, \textbf{if } \mathrm{VM}_j \textbf{ is assigned to the profile } l \textbf{ on } \mathrm{SP}_i; \\ 0, \textbf{otherwise}. \end{cases}$$

- model input data: $\beta_i^l = \begin{cases} 1, \textbf{if the profile } l \textbf{ is available on } \mathrm{SP}_i; \\ 0, \textbf{otherwise}. \end{cases}$
- resource: $r \in \overline{1,R} = \{memory, bandwidth, CPU, ...\}$
  - σ_{ij}^l: the amount of a resource r (e.g memory) the VM_j needs when assigned to the profile l of the SP_i;
  - ϵ_i^l: the maximum amount of a resource r available at the profile l of the SP_i.

Our objective is to minimize the cost:

$$\sum_{i=1}^{N}\sum_{j=1}^{M}\sum_{l=1}^{K} x_{ij}\alpha_{ij}^l\rho_i^l(y_j)$$

where $\rho_i^l(y_j)$ is a cost function for a given profile l of the service provider SP_i; y_j is the demanded execution time of VM_j, subject to the following constraints:

1. $\sum_{i=1}^{N} x_{ij} = 1, \forall j \in \overline{1,M}$: a VM can be assigned to a single SP only;
2. $x_{ij}(1 - \sum_{l=1}^{K} \alpha_{ij}^l) = 0, \forall i \in \overline{1,N}, \forall j \in \overline{1,M}$: if we have an assignment of the VM_j to the SP_i then only one profile l is used;
3. $x_{ij}(1 - \sum_{l=1}^{K} \alpha_{ij}^l\beta_i^l) = 0, \forall i \in \overline{1,N}, \forall j \in \overline{1,M}$: the assignment is made to an available profile l on the SP_i;
4. $x_{ij}\alpha_{ij}^l\sigma_{ij}^l(r) \le \epsilon_i^l(r), \forall i \in \overline{1,N}, \forall j \in \overline{1,M}, \forall l \in \overline{1,K}, \forall r \in \overline{1,R}$.

For the uncertainty factor in the execution time of the VM request, there are two cases that we considered in our paper:

- generate input data scenarios (execution time of VM request) with model of uncertainty – stochastic model with truncated normal distribution;
- implement stochastic model directly into the VMMP algorithm.

The truncated normal distribution of a VM's execution time $X \sim N(\mu, \sigma^2)$ has a normal distribution conditioned to $X \in (a, b)$. The execution time y_j is modeled as $y_j = \overline{y_j} + \mathbb{E}(X|a < X < b)$ where $\mathbb{E}$ is the expected value of the execution time X.

As a last part of our paper we compare and analyze the results of the two independent cases.

3 Results

The first results that we obtained from experiments run on Grid5000 (`http://www.grid5000.fr`) show that the methods we propose are promising. For example, we ran benchmark with 20 VM requests, 15 SPs and 3 profiles over 30 runs: for the first case we get an average result of 81.71 as the best solution of the cost objective and in the second case we get a result of 83.77, so the difference between two cases is approximated 2.5%, which is quite close.

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References

1. Zhang, Q., Cheng, L., Boutaba, R.: Cloud computing: state-of-the-art and research challenges. J. Internet Services and Applications (2010) 7–18