THOMSON REUTERS ENDNOTE
[Bailkur., 3(5): May, 2016] ISSN 2349-4506
Impact Factor: 2.265
Global Journal of Engineering Science and Research Management

A NOVEL ARCHITECTURE FOR COMPETITION AND PARTICIPATION AMONG CLOUD PROVIDER

Mounesh Bailkur E*, Raghunandan R
*PG Student Department Of Computer Science Shridevi Institute Of Engineering and Technology Tumakuru, Karnataka, India
Asst Professor Department Of Computer Science Shridevi Institute Of Engineering and Technology Tumakuru, Karnataka, India

DOI: 10.5281/zenodo.51256

KEYWORDS: Cloud computing, dynamic pricing, cooperation, Markov Decision Process, Markov Perfect Equilibrium, game theory.

ABSTRACT
The cloud market is nowadays fiercely competitive with many cloud providers. On one hand, cloud providers compete against each other for both existing and new cloud users. To keep existing users and attract newcomers, it is crucial for each provider to offer an optimal price policy which maximizes the final revenue and improves the competitive advantage. The competition among providers leads to the evolution of the market and dynamic resource prices overtime. On the other hand, cloud providers may cooperate with each other to improve their final revenue. Based on a Service Level Agreement, a provider can outsource its users' resource requests to its partner to reduce the operation cost and thereby improve the final revenue. This leads to the problem of determining the cooperating parties in a cooperative environment. This paper tackles two issues of the current cloud market. First, try to solve the problem of competition among providers and propose a dynamic price policy. Here a discrete choice model is employed to describe the user's choice behavior based on his obtained benefit value. The choice model is used to derive the probability of a user choosing to be served by a certain provider. The competition among providers is formulated as a non-cooperative stochastic game where the players are providers who act by proposing the price policy simultaneously. The game is modelled as a Markov Decision Process whose solution is a Markov Perfect Equilibrium. Then, Address the cooperation among providers by presenting a novel algorithm for determining a cooperation strategy that tells providers whether to satisfy users' resource requests locally or outsource them to a certain provider. The algorithm yields the optimal cooperation structure from which no provider unilaterally deviates to gain more revenue. Numerical simulations are carried out to evaluate the performance of the proposed models.

INTRODUCTION
During the past few years, cloud computing has received significant investments in the industry. Many cloud providers are participating in the market, forming a competitive environment which is referred to as multiuser and multi-provider cloud market. Hereafter, terms referred as "providers" and "users" to refer to the cloud actors. Since the amount of resources in a user's request is much smaller than the capacity of a provider, the user's request can be satisfied by any provider. A rational user will choose the provider whose resources best satisfy his computational needs, and the resource usage cost does not exceed his budgetary constraint. The user's satisfaction can be evaluated through a utility measure which depends not only on the resource properties but also on the user's preference to choose certain providers, i.e., two providers with the same resource capacities and usage price may be considered different for a user due to the user's choice behaviour and loyalty. Furthermore, the task of optimally pricing cloud resources to attract users and improve revenue is very challenging [1].They need to take into account a wide range of factors including the preferences of users, resource capacities and potential competition from other providers. A provider naturally wishes to set a higher price to get a higher revenue; however, in doing so, it also bears the risk of discouraging demand in the future. On the other hand, they also look for the means to cooperate with other providers to reduce the operation cost and therefore improve their final revenue. In this paper, there are two main problems in cloud market: competition and cooperation among providers.

The competition among providers leads to the dynamics of cloud resource pricing. Modelling this competition involves the description of the user's choice behaviour and the formulation of the dynamic pricing strategies of

ISSN 2349-4506
Impact Factor: 2.265

Global Journal of Engineering Science and Research Management

providers to adapt to the market state. To describe the user's choice behavior,Here try to employ a widely used discrete choice model,the multi-nomial logit model [2], which is defined as a utility function whose value is obtained by using resources requested from providers. From the utility function, derive the probability of a user choosing to be served by a certain provider. The choice probability is then used by providers to determine the optimal price policy. The fundamental question is how to determine the optimal price policy. When a provider joins the market, it implicitly participates in a competitive game established by existing providers. Thus, optimally playing this game helps providers to not only survive in the market, but also improve their revenues. To give providers a means to solve this problem, in this paper first formulate the competition as a non-cooperative stochastic game [3]. The game is modelled as a Markov Decision Process (MDP) [4] whose state space is finite and computed by the distribution of users among providers. At each step of the game, providers simultaneously propose new price policies with respect to the current policies of other competitors such that their revenues are maximized. Based on those price policies, users will decide which provider they will select to request resources. This also determines whether the market will move to a new state or not. The solution of the game is a Markov Perfect Equilibrium (MPE) such that none of providers can improve their revenues by unilaterally deviating from the equilibrium in the long run.

On the second problem, the cooperation based on afinancial option allows providers to enhance revenue and acquire the needed resources at any given time [5]. The revenue depends on the total operation cost which includes a cost to satisfy users' resource requests (i.e., cost for active resources) and another cost for maintaining data center services (i.e., cost for idle resources). Here try to address the problem of cooperation among providers by first employing the learning curve [6] to model the operation cost of providers and then introducing a novel algorithm that determines the cooperation structure. The cooperation decision algorithm uses the operation cost computed based on the learning curve model and price policies obtained from the competition part as parameters to calculate the final revenue when outsourcing orlocally satisfying users' resource requests. The cooperation among providers makes the cloud market become a united cloud environment, called Cloud-of-Clouds environment. In this architecture, the Cloud-of-Clouds Broker is responsible for coordinating the cooperation among providers, receiving users' resource requests and also doing accounting management.

RELATED WORK

A. ***Dynamic pricing and competition***

Dynamic pricing in the cloud has gained considerable attention from both industry and academia. Amazon EC2 has introduced a "spot pricing" feature for its resource instances where the spot price is dynamically adjusted to reflect the equilibrium prices that arises from resource demand and supply. Analogously, a statistical model of spot instance prices in public cloud environments has been presented in [7], which fits Amazons spot instances prices well with a good degree of accuracy. To capture the realistic value of the cloud resources, the authors of [8] employ a financial option theory and treat the cloud resources as real assets. The cloud resources are then priced by solving the finance model. Also based on financial option theory, in [5], a cloud resource pricing model has been proposed to address the resource trading among members of a federated cloud environment. The model allows providers to avoid the resource over-provisioning and under-provisioning problems. But there is an underlying assumption is that there are always providers willing to sell call options.

In [9] and [10], the authors presented their research results on dynamic pricing for cloud resources. While [9] studied the case of a single provider operating an IaaS cloud with a fixed capacity, [10] focussed on the case of an oligopoly market with multiple providers. However, both [9] and [10] make the assumption that the user's resource request is a concave function with respect to resource prices. The amount of resources requested will decrease when prices increase. This assumption is not practical when users have a processing deadline or architectural requirements for their execution platform. Users therefore have to request the required amount of resources no matter what the prices are. In [11] and [12], the authors presented auction-based mechanisms to determine optimal resource prices, taking into account the user's budgetary and deadline constraints. However, they considered the pricing model of only one provider. In contrast, we consider the realistic case of the current cloud market with multiple providers. In addition, users may have their preferences in choosing to be served by particular providers.

THOMSON REUTERS ENDNOTE

[Bailkur., 3(5): May, 2016] ISSN 2349-4506

Impact Factor: 2.265

Global Journal of Engineering Science and Research Management

B. ***Game theory in utility computing***

Game theory has been widely applied in economic studies for dynamic pricing competition [13], [14], [15]. In utility computing, game theory has been applied study different issues: scheduling and resource allocation 16], [17], dynamic pricing [18] and revenue optimization [19]. In [16], a game-theoretic resource allocation algorithm has been proposed to minimize the energy consumption while guaranteeing the processing deadline and architectural requirement. In [17], a user oriented job allocation scheme has been formulated as a non-cooperative game to minimize the expected cost of executing users' tasks. The solution is a Nash equilibrium which is obtained using a distributed algorithm. However, none of these works considered the user's choice behavior, although some of them assume that resources are owned by different resource owners.

C. ***Cooperation among providers***

Cooperation among providers in cloud computing has been extensively studied with two research approaches: cloud federation and coalitional formation based on coalitional game theory.

The idea of federating systems was originally presented for grid computing. For instance, in [20] and [21], the authors used the federation approach to get more computing resources to execute large scale applications in a distributed grid environment. The application of the federation approach in the cloud was initially proposed within the RESERVOIR project [22]. Nevertheless, the aforementioned works focused only on aggregating as much resources as possible to satisfy users' resource requests. They did not consider the economic issue which one of the intrinsic characteristics of cloud is computing. In [23], the authors presented an economic model along with a federated scheduler which allow a provider, operating in a federated cloud, to increase the final revenue by saving capital and operation costs.

PROPOSED SYSTEMS

In the Proposed System,There is a concept of dynamic pricing strategy, here the price will be set dynamically based on the user's resource request. Due to this we can satisfies both the cloud provider as well as user. In this the Broker will acts as an interface between the cloud provider and the cloud user, Broker should play the crucial role. The realistic case of the current cloud market where providers may have different operation costs. Cooperation among providers may reduce the operation cost and therefore improve the final revenue.

PROPOSED ALGORITHM

Algorithm 1 Finding optimal price policies $\hat{\mathbf{p}}$

Input: Users' resource requests and budgetary constraints: r_k and b_k, $k = 1, \ldots, K$. Information about all providers: $\varphi_i, \psi_{ij}, \lambda_{ij}, c_{ij}^{o}$ and c_{ij}^{0}, $i = 1, \ldots, N, j = 1, \ldots, M$. Discount factor: γ.

Output: Optimal price policies: $\hat{\mathbf{p}}$

Make initial guesses for the value function $\hat{V}_i^0(\omega) \in \mathbb{R}$ and the price policy $\mathbf{p}_i^0(\omega) \in \mathbb{R}_+^M$ for each provider $i = 1, \ldots, N$ in each state $\omega \in \Omega$. Pick a random state to be the initial state of the market;

$stop \leftarrow 0$; /*stop condition*/; $t \leftarrow 0$ /*iteration*/

while $stop \neq 1$ **do**

  Update the value function $\hat{V}_i^t(\omega)$ and the price policy $\mathbf{p}_i^t(\omega)$ for all providers according to Eqs. (18) and (19), respectively. In (18) and (19), $\mathbf{p}_{-i}^{t-1}$ refers to the price policies of providers other than provider i at iteration $t-1$;

  $cc \leftarrow \max_{\omega \in \Omega} \left| \left(\hat{V}^t(\omega) - \hat{V}^{t-1}(\omega)\right) / \left(1 + \hat{V}^t(\omega)\right) \right|$;

  if $cc < \epsilon$ **then** /*satisfied by all providers*/

    $stop \leftarrow 1$;

  else

    Compute the next state of the market;

    $t \leftarrow t + 1$;

  end if

end while

ISSN 2349-4506
Impact Factor: 2.265
Global Journal of Engineering Science and Research Management

Algorithm 2 Determination of the cooperation structure

Input: Users' resource requests: $r_k, k = 1, \ldots, K$. Information about all providers: φ_i, ψ_{ij}, c_{ij}^o and c_{ij}^∂, $i = 1, \ldots, N, j = 1, \ldots, M$. Price policies of all providers $\hat{\mathbf{p}}$.

Output: Cooperation structure.

$\mathbb{P} \leftarrow \{1, 2, \ldots, N\}$; /*set of all providers*/
for $i = 1 \rightarrow N$ **do**
    for $i' = 1 \rightarrow N$ **do**
        if $i \neq i'$ **then**
            Compute $R_{ii'}^{\text{outsource}}(\boldsymbol{\beta}_i, \mathbf{p}_i, i')$ based on (22);
        end if
    end for
end for
$\mathbb{P}_1 \leftarrow \emptyset; \mathbb{P}_2 \leftarrow \emptyset; stop \leftarrow$ FALSE;
while $stop \neq$ TRUE **do**
    $stop \leftarrow$ TRUE;
    for $i' \in \mathbb{P} \setminus \{\mathbb{P}_1 \cup \mathbb{P}_2\}$ **do**
        Find $\mathbb{L}_{i'}$; /*set of providers outsourcing to i'*/
        if $\mathbb{L}_{i'} \neq \emptyset$ **then**
            $stop \leftarrow$ FALSE;
        end if
    end for
    $i^* \leftarrow 0; i^{*'} \leftarrow 0; maxval \leftarrow -realmax;$
    for $i' \in \mathbb{P} \setminus \{\mathbb{P}_1 \cup \mathbb{P}_2\}$ and $\mathbb{L}_{i'} \neq \emptyset$ **do**
        Compute $R_{i'}^{\text{hosting}}(\boldsymbol{\beta}_{i'}, \mathbf{p}_{i'}, \mathbb{L}_{i'})$ defined in (24);
        Determine the best provider i'' for provider i' to outsource to by evaluating $R_{i',i''}^{\text{outsource}}$;
        if $i'' \neq 0$ **then**
            $R_{i'}^{\text{diff}} \leftarrow R_{i'}^{\text{hosting}} - R_{i',i''}^{\text{outsource}}$;
        else
            $R_{i'}^{\text{diff}} \leftarrow R_{i'}^{\text{hosting}}$;
        end if
        if $maxval < R_{i'}^{\text{diff}}$ **then**
            $maxval \leftarrow R_{i'}^{\text{diff}}; i^* \leftarrow i'; i^{*'} \leftarrow i''$;
        end if
    end for
    if $i^* \neq 0$ **then**
        if $maxval \geqslant 0$ or $i^{*'} \notin \mathbb{P}_1$ **then**
            $\mathbb{P}_1 \leftarrow \mathbb{P}_1 \cup \{i^*\}$; /*hosting provider*/
        else
            $\mathbb{P}_2 \leftarrow \mathbb{P}_2 \cup \{i^*\}$; /*outsourcing provider*/
        end if
    end if
end while
if $\mathbb{P} \setminus \{\mathbb{P}_1 \cup \mathbb{P}_2\} \neq \emptyset$ **then**
    for $i \in \mathbb{P} \setminus \{\mathbb{P}_1 \cup \mathbb{P}_2\}$ **do**
        Determine the best provider i' for provider i to outsource to;
        if $i' \neq 0$ and $i' \in \mathbb{P}_1$ **then**
            $\mathbb{P}_2 \leftarrow \mathbb{P}_2 \cup \{i\}$; /*outsourcing provider*/
        else
            $\mathbb{P}_1 \leftarrow \mathbb{P}_1 \cup \{i\}$; /*stay local*/
        end if
    end for
end if

TABLE 1: Mathematical notations

Notation	Description
N	Number of providers on the cloud market
M	Number of resource types of each provider
K	Number of users on the cloud market
i	Index of cloud providers
j	Index of resource types
k	Index of cloud users
b_k	Budgetary constraint of user k
φ_i	Learning factor of provider i
ψ_{ij}	Maximum number of instances of resource type j offered by provider i
λ_{ij}	Per unit benefit of resource type j offered by provider i
p_{ij}	Per unit price of resource type j charged by provider i
c_{ij}^{o}	Operation cost of the first active instance of resource type j owned by provider i
$c_{ij}^{\bar{o}}$	Operation cost of the first idle instance of resource type j owned by provider i
Ω	State space of stochastic game/the cloud market
ω	State of the market ($\omega \in \Omega$)
β_i	Individual state of provider i
γ	Discount factor of money
η_{ki}	Preference of user k to provider i
r_{kj}	Number of instances of resource type j requested by user k
c_{ki}	Cost that user k needs to pay when requesting resources from provider i
U_{ki}	Utility of user k being served by provider i
P_{ki}	Probability of user k choosing provider i
C_i^{o}	Operation cost of provider i for active resources
$C_i^{\bar{o}}$	Operation cost of provider i for idle resources
C_i	Total operation cost of provider i
$C_{ii'}^{\text{outsource}}$	Outsourcing cost of provider i when outsourcing to provider i'
R_i^{local}	Revenue of provider i when satisfying all users' resource requests locally
$R_{ii'}^{\text{outsource}}$	Revenue of provider i when outsourcing all users' resource requests to provider i'
R_i^{hosting}	Revenue of provider i when hosting users' resource requests from other providers
V_i	Discounted sum of future revenue of provider i

SYSTEM ARCHITECTURE

Increasing resource demands with different requirements from users raise new challenges which a single provider may not be able to satisfy, given that the resilience of cloud services and the availability of data stored in the cloud are the most important issues. Scaling up the infrastructure might be a solution for each provider, but it costs a lot to do so, and the infrastructure may be under-utilized when demand is low. A multiple cloud approach, which is referred to as Cloud-of-Clouds, is a promising solution in which several providers cooperate to build up a Cloud-of-Clouds system for allocating resources to users. The Cloud-of-Clouds system can facilitate expense reduction (i.e., savings on the operation cost), avoiding adverse business impacts and offering cooperative or portable cloud services to users [34]. The architecture of a Cloud-of-Clouds system is depicted in Fig. 1 in which a dedicated broker is responsible for coordinating the cooperation among providers. The broker has all information about the resource capacities and price policies of all providers. Based on the users' resource requests, the broker will run a cooperation decision algorithm to decide with whom a particular provider should cooperate. The broker can be cloned on each provider's infrastructure and the cooperation decision algorithm will be executed when required

THOMSON REUTERS ENDNOTE
[Bailkur., 3(5): May, 2016] ISSN 2349-4506
Impact Factor: 2.265
Global Journal of Engineering Science and Research Management

by its owner. However, since price policies and resource capacities of providers change over time [8], keeping the consistency of this information for each version of the broker may not be easy. Therefore, we consider the case of a centralized algorithm run on the centralized Cloud of- Clouds Broker to yield a global optimal solution.

The focused cooperation problem is the agreement among providers for outsourcing user's resource requests. Although providers are competing to attract users and improve their revenues, between any two providers, an outsourcing agreement may be established such that one provider can outsource its users resource requests to its cooperator (or helper), i.e., satisfying users resource requests by using the cooperator's infrastructure. However, how is the outsourcing cost calculated? Since providers are rational, the cooperation should result in a win-win situation where the provider who outsources its users' resource requests may pay a lower cost than satisfying them locally, and the provider who hosts outsourcing requests will receive the final revenue at least as much as that without cooperation.

It is to be noted that under the Cloud-of-Clouds model, many intertwined issues need to be considered before the system can operate efficiently. First, interoperability is one of the major issues. Every provider has its own way on how users or applications interact with the cloud infrastructure, leading to cloud API propagation [35]. This prevents the growth of the cloud ecosystem and limits cloud choice because of provider lock-in, lack of portability and the inability to use the services offered by multiple providers. An interoperability standard is therefore needed to enable user's applications on the Cloud-of-Clouds to be interoperable. Second, cooperation among providers requires a common Service Level Agreement (SLA) governing expected quality of service, resource usage and operation cost. Defining a "good faith" SLA allows the Cloud-of-Clouds to minimize conflicts which may occur during the negotiation among providers. One reason for the occurrence of these conflicts is that each provider must agree with the resources contributed by other providers against a set of its own policies. Another reason is the incurrence of high cooperation costs (e.g., network establishment, information transmission, capital flow) by the providers as they do not know with whom they should cooperate [34]. Last but not least, the network latency among providers' infrastructures also needs to be taken into account. It can be added as a constraint in the cooperation model to guarantee the service availability and satisfy the special requirements of users, and thus, may affect the optimal cooperation structure. In this paper, Focus is on the cooperation agreement among providers, and leave the stud of the other issues mentioned above for future work. Hereafter, the term "hosting" provider is used to refer to the provider who satisfies its own users' requests (i.e., "stays local") and accepts outsourcing requests from other providers, and the term "outsourcing" provider is used to refer to the provider who outsources its users' resource requests to another provider and becomes idle.

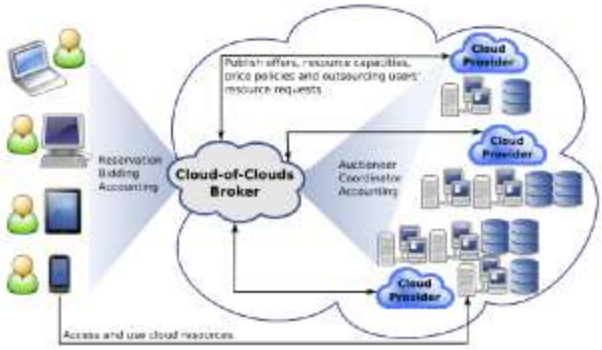

Fig 1: Architecture of a Clouds of Clouds system

CONCLUSION

Finally the conclusion is to maximizing the final revenue of the cloud providers and to satisfy the customers with the dynamic and reasonable pricing rates based on the user's resource requests. Here the main thing is to establish the competition along with the cooperation among the cloud providers. The current fiercely competitive cloud market, many providers are facing two major challenges: finding the optimal prices for resources to attract a common pool of potential users while maximizing their revenue in the presence of other competitors, and deciding whether to cooperate with their competitors to gain higher revenue after receiving their own users' resource requests.

REFERENCES

[1] H. Xu and B. Li, "Dynamic Cloud Pricing for Revenue Maximization,"IEEE Trans. Cloud Comput., vol. 1, no. 2, pp. 158–171, 2013.
[2] K. E. Train, "Discrete Choice Methods with Simulation," Identity,vol. 18, no. 3, pp. 273–383, 2003.
[3] M. J. Osborne, An Introduction to Game Theory. Oxford UniversityPress, 2004.
[4] R. Bellman, "A Markovian Decision Process," Indiana Univ. Math.J., vol. 6, no. 4, pp. 679–684, 1957.
[5] A. N. Toosi, R. K. Thulasiram, and R. Buyya, "Financial Option Market Model for Federated Cloud Environments," in UCC 2012,Chicago, Illinois, USA, Dec. 2012, pp. 3–12.
[6] A. Gera and C. H. Xia, "Learning Curves and Stochastic Models for Pricing and Provisioning Cloud Computing Services," Service Science, vol. 3, no. 1, pp. 99–109, Mar. 2011.
[7] B. Javadi, R. K. Thulasiram, and R. Buyya, "Characterizing spot price dynamics in public cloud environments," Future Generation Computer Systems, vol. 29, no. 4, pp. 988–999, Jun. 2013.
[8] B. Sharma, R. K. Thulasiram, P. Thulasiraman, S. K. Garg, and R. Buyya, "Pricing Cloud Compute Commodities: A Novel Financial Economic Model," in CCGrid 2012, Ottawa, Canada, May 2012, pp. 451–457.
[9] D. Niu, C. Feng, and B. Li, "Pricing Cloud Bandwidth Reservations under Demand Uncertainty," in SIGMETRICS'12, London, UK, June 2012, pp. 151–162.
[10] H. Xu and B. Li, "Maximizing Revenue with Dynamic Cloud Pricing: The Infinite Horizon Case," in IEEE ICC 2012, Ottawa, Canada, June 2012, pp. 2929–2933.
[11] F. Teng and F. Magoul`es, "Resource Pricing and Equilibrium Allocation Policy in Cloud Computing," in CIT 2010, Bradford, UK, June 2010, pp. 195–202.
[12] M. Mihailescu and Y. M. Teo, "On Economic and Computational- Efficient Resource Pricing in Large Distributed Systems," in CCGrid 2010, Melbourne, Australia, May 2010, pp. 838–843.
[13] G. Allon and I. Gurvich, "Pricing and Dimensioning Competing Large-Scale Service Providers," Manufacturing Service Operations Management, vol. 12, no. 3, pp. 449–469, 2010.
[14] D. Bergemann and J. V¨alim¨aki, "Dynamic price competition," Journal of Economic Theory, vol. 127, no. 1, pp. 232–263, 2006.
[15] K. Y. Lin and S. Y. Sibdari, "Dynamic price competition with discrete customer choices," European Journal Of Operational Research, vol. 197, no. 3, pp. 969–980, 2009.