Profit Maximization in Cloud: Federation or Overlapping Coalition

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Abstract

Cloud computing is getting popular due to the freedom of consumers to use it. They can use it as pay-as-you-go manner whenever they like from anywhere. But this elastic demand is a great concern for the cloud providers and sometimes they are unable to meet this demand. So they form cloud federation among the providers to satisfy the consumers' demand. But traditional cloud federation allows a provider to participate in a coalition which can make some resources under-utilized. On the other hand, Overlapping Cloud Coalition (OCC) gives a provider to participate in multiple coalition with some resources. This gives providers flexible way to utilize their resources. In this paper, we analyze Cloud Federation (CF) and OCC approaches with some suitable workload and try to find out which approach is suitable for cloud providers in perspective of profit.

1.Intduction

Cloud computing is anticipating to make possible remote and on-demand access to shared and configurable computing resources whenever you like. Cloud computing is getting more popular due to its' freedom for the consumers to utilize. It offers enhanced capability and better services without investing heavily in new infrastructures [1]. At present, consumers are able to take advantages of cloud resources and services in a pay-as-you-go approach. The most common cloud services are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). IaaS allows cloud providers to trade resources in the form of Virtual Machine (VM) to the consumers. VMs are provided in the name of instances where instance types consists with varying combinations of CPU, memory, storage and networking capacity. Consumers can purchase the instances using one of the three models namely on-demand, reserved and spot. Amazon Web Services (AWS) charges consumers by rounding up the number of hours used with minimum use hour is one and Google Cloud Platform(GCP) charges for instances based on usage in minutes with a minimum of 10 minutes [2].

The demand for cloud resources are increasing day-by-day due to the introduction of lots of data-intensive applications. But this demand is elastic and sometimes it cannot be fulfilled by provider's limited resources. To handle such situations, they need to share resources from others. Rochwerger et al. discussed the primary requirements for forming federations or coalitions of CPs [3] to meet this kind of resilient demands. Cloud federation is the prime technique considered for cloud elasticity to surmount the dilemma of scarcity of resources. The most clear-cut solution is to form grand federation as it is simple and easy to implement. But there are situations when the grand coalition does not produce the optimal payoffs for the involved CPs and a more sophisticated coalition is necessary [4].

In the paper [5], authors provided a model to take easy decision for forming cloud federations among providers in order to maximize profit. But they did not consider the profits of other clouds when they provided resources and they also did not take into account different types of VMs and their heterogeneous resources. Mashayekhy et al. [6] proposed a profit-driven game theoretic approach for offering cloud IaaS services to the consumers by forming cloud federation. Such federation can offer cloud resources to the consumers at a lower costs. Their mechanism produces a stable cloud federation with high revenue. The major challenge of such federation is revenue sharing mechanism based on the effective resources of the cloud providers. Fairness of distribution of revenue and stability of cloud federation are two important issues. In the paper [7], Zant et al. proposed a novel pricing and revenue distribution model for the federated cloud environment. But they didn't take into account the resource allocation process with future demand and available capacity of the providers.

But most of the existing works focus on maximizing payoffs by allowing a provider to participate in a single federation. Sometimes, this federation may under-utilize the available resources of the coalition due to lake of demand in that coalition So it is necessary to permit cloud providers to take part in multiple coalitions, and consequently, provide more opportunity for the players to utilize their resources, which leads to higher payoffs.

In this paper, we analyze this two approaches to find out what is best for the CPs with some suitable experiment. The rest of the paper consists of problem formulation, experiment and conclusion.

2. Problem Formulation

To provide on-demand resources to the consumers and to increase the utilization of resources, CPs generally form cloud

federation and a CP can participate in a single coalition with all of its' resources which can make some resources under-utilized. A sample cloud federation is shown in the Fig. 1. On the other hand, overlapping coalition formation gives providers the opportunity to take part into multiple coalition with required resources, making coalition small and better utilize their resources. A sample overlapping cloud coalition is shown in the Fig. 2.

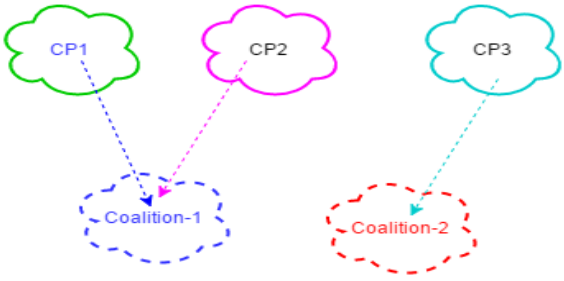

Fig. 1 A sample Cloud Federation

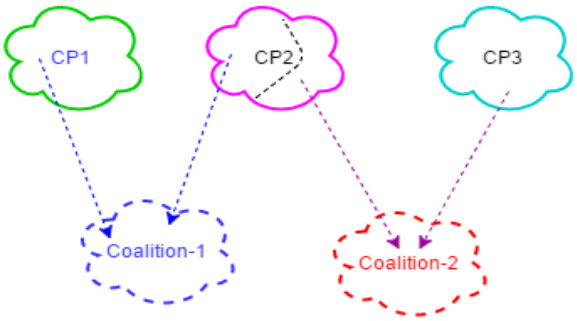

Fig. 2 A sample Overlapping Cloud Coalition

A coalition can be characterized by the resource vector $C = (R_1, R_2, ..., R_N)$ of the participating members of the coalitions where R_i is the resource contributed by CP_i. The payoffs generated by the coalition is $v = \sum_{i=1}^{N} R_i^g p - D_C c_d - |C| c_m$ where p is the price per unit VM, R_i^g is the granted resources to meet the demand in the coalition contributed by CP_i, D_C is the number of non-serving demand and c_d is the cost for that, $|C|$ is the number of resources in the coalition C and c_m is the VM management cost when they participate in coalition. Payoffs produced by the coalition should be fairly distributed among the CPs for the stability of the coalition. For ensuring the fairness in the distribution of payoffs, we consider the marginal contribution of the CPs in the coalition. Specifically, the payoff of CP_i from the coalition C is given by: $\phi_i(C) = \frac{R_i^g}{\sum_{j=1}^{N} R_j^g} v$

In case of overlapping coalition, a CP_i can participate into multiple coalition with some resources. Let $\prod$ be the set of all coalition where CP_i is a member. So CP_i will get a portion of payoffs from all the coalitions of $\prod$ and the amount of payoff is $P_i(\Pi) = \sum_{C \in \prod} \phi_i(C)$.

3. Simulation and Evaluation

In all scenarios, we consider 3 CPs, whose resources and 3 demand case are characterized as reported in Table I. We assume that all CPs use the same revenue rate policy for all VMs with the value $p = 2$, c_d =2 and c_m =0.25.

Table I
Resources of the CPs

Cloud Provider	VM	Demand		
CP_1	50	30	55	20
CP_2	30	35	10	20
CP_3	20	25	25	20

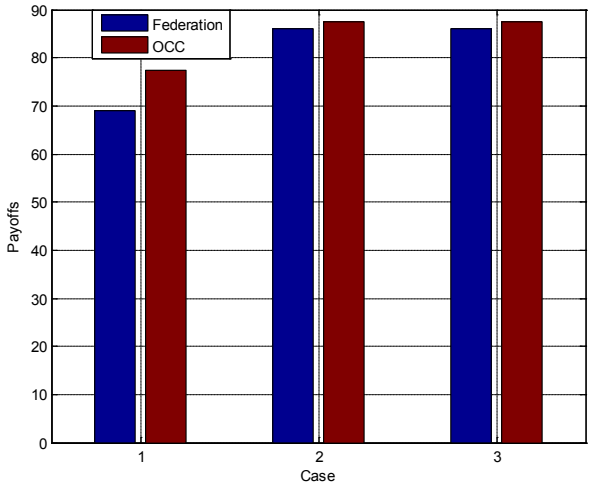

Fig. 3 Payoff of CP1

In Figure 3, we compare the performance in terms of payoff obtained by CP1 through OCC with respect to cloud federation with different level of workload. As can be seen from the figure, OCC provides better payoff than traditional federation in all

considered cases. This is because, OCC mechanism provides flexible way to utilize the resource by partitioning and giving opportunity to attain in multiple small coalition. Thus the approach reduces the VM management cost and in the same time reduce the un-satisfaction cost by better utilizing the resources. From Figure 4 and Figure 5, we also find that CP_2 and CP_3 get better payoff in case of OCC rather than cloud federation.

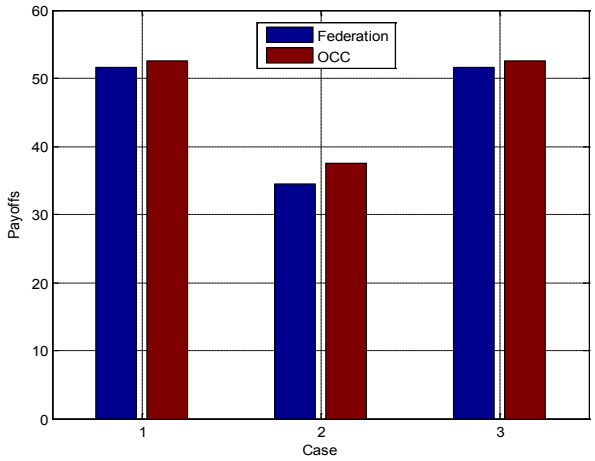

Fig. 4 Payoff of CP2

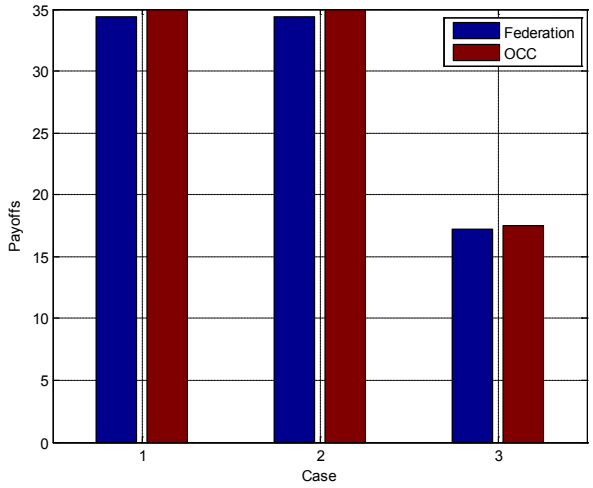

Fig. 5 Payoff of CP3

We compare the average payoffs of cloud federation and overlapping cloud coalition in Figure 6. From the figure, we find that OCC produce more payoffs for cloud providers on average than that of cloud federation.

4. Conclusion

In this paper, we analyzed the performance of CPs in term of payoffs in case of cloud federation and overlapping cloud coalition with some varying demands. We found that OCC process give better payoffs for all the cloud providers than that of the cloud federation. We found that cloud providers can increase their payoffs around 3.63% if they consider OCC instead of CF on average.

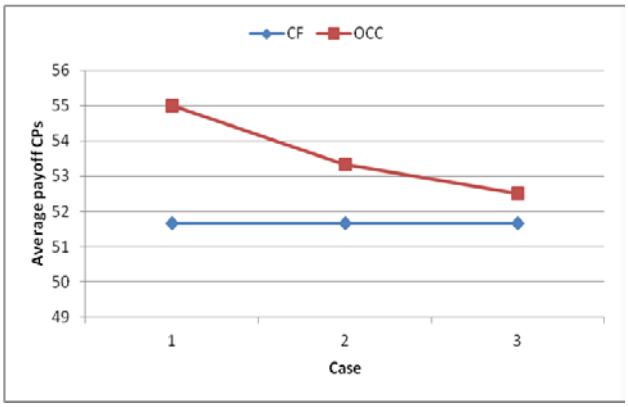

Fig. 6 Average payoff comparison between CF and OCC

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