Pricing Mechanisms for Fair Bills and Profitable Revenue Share in Cloud Federation

Sameera Dhuria, Anu Gupta, and R. K. Singla

Abstract Cloud Federation is the coalition of multiple Cloud Providers (CPs) to surmount the constraint of finite physical resources of individual CPs. The collaboration enables them to share resources with each other at a certain price based on Federation Level Agreement (FLA). The pricing mechanism used for the resources requested by customer's acts as an important factor in the calculation of their bills and in the generation of revenues for CPs, in such an environment. Consequently, it performs a key role in the selection of a CP by customers and in incentivizing the CPs to remain in Federation. Considering this, the present paper aims to propose mechanisms of pricing to charge internal users and peer CPs. The proposed mechanisms are evaluated in a simulated environment. The simulation results illustrate that the proposed pricing mechanisms ensure fair bills for customers and profitable share of revenues for the collaborating CPs.

Keywords Cloud computing · Federation · Pricing mechanisms · Revenue · Bill

1 Introduction

Cloud computing technology represents a logically inexhaustible pool of ubiquitous infrastructure that can be accessed by different organizations and individuals from anywhere in the world through Internet [1]. The infrastructure is offered to customers in the form of Virtual Machines (VMs) by the Cloud Providers (CPs). Though customers are given an illusion of infinite resources, the market potential of CPs is hindered due to their finite and limited capacity. This reduces the number of service requests accepted and served by them. To offer Cloud services without any constraint on the number of accepted service requests, the CPs must be able to

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scale up their resources [2]. This can be done by the interconnection of infrastructure of different CPs to form Cloud Federation so as to enable resource sharing among them [3]. Cloud Federation allows collaborating CPs to share and allocate resources requested by customers, consisting of internal users of a CP and peer CPs, based on the Federation policies that are described in a Federation Level Agreement (FLA) [4]. By collaborating in a Federation, CPs intend to earn profitable revenue either by renting their underutilized infrastructural resources or by outsourcing resources to peer CPs. Generally, when a collaborating CP receives resource request from internal users, it tries to serve the request locally. But in case of peak load, the resource constraint of local infrastructure is overcome through outsourcing of resources to other members of the Federation to fulfill user's request with a guaranteed Quality of Service (QoS).

Pricing is an important factor in such an environment to incentivize sharing of resources among CPs. Bills of customers and revenues of participating CPs are calculated based on the pricing mechanisms used. A user prefers to request resources from a CP that guarantees computation of fair bills based on the resource usage. Similarly, a CP outsources request to a peer CP if it is assured that the amount charged by outsourcing CP for the requested resources does not cause financial loss to it, and it is able to earn profitable revenue through outsourcing. An outsourcing CP also prefers to contribute resources for the service request of peer CP if the revenue obtained from leased resources is profitable. Such a scenario necessitates the selection and usage of an appropriate mechanism for pricing.

Selection of a suitable mechanism for resource pricing in Cloud Federation is a non-trivial and complex task and has been an area of focus of several studies [4–8]. Various pricing mechanisms have been proposed in the literature for single provider and Federated Cloud environment. But none of the existing studies has proposed pricing mechanisms to charge both internal users and peer CPs for the requested resources in a Federation of Clouds. The present work is focused on proposing pricing mechanisms for the on-demand VMs requested by internal users and peer CPs. Equations to calculate bills of customers and revenue earned by collaborating CPs are also formalized based on the proposed pricing mechanisms. The proposed mechanisms ensure the generation of fair bills for customers requesting resources and fair and profitable distribution of revenue for participating CPs. Usage of the proposed mechanisms shall persuade more customers to use the services of Clouds. It will also encourage resource contribution and participation of CPs in Federation. The paper is organized as follows: Related work is reviewed in Sect. 2. Section 3 discusses the issue of pricing in Federated Cloud scenario. Section 4 describes proposed pricing mechanisms and the equations to calculate bills and revenues based on the proposed mechanism. Evaluation of proposed mechanisms is presented in Sect. 5. Discussion is given in Sect. 6. Section 7 concludes the paper.

2 Related Work

The inability of CPs to handle the sudden spikes in resource demands of various users without compromising the QoS offered necessitates the creation of Federation of Clouds. Though a number of platforms have been proposed for Cloud Federation [9–11] with diverse motivations, various issues associated with it have yet not obtained substantial attention and need to be addressed. One of these issues is the pricing of resources that are offered to customers in this environment. Pricing is one of the most important metrics that motivate customers to use the services of a CP [12]. Numerous pricing mechanisms have been proposed in various studies [13–16]. But the existing literature on pricing in Cloud environment is largely inclined toward single provider Clouds that work alone without collaboration. Pricing problem in Cloud Federation is discussed in very few studies.

Jin and Tang [17] proposed pricing policies for a Cloud Federation scenario where one CP supplies resources and multiple CPs demand resources. The demanding CPs do not share their resource utility functions with the supplying CP due to privacy concerns. Therefore, a pricing scheme is proposed based on the predictions of the utility functions of the demanding CPs to maximize the social welfare and utilization of supplying CP's idle resources.

The broker defines a price for each VM type in the mechanism proposed by Hassan et al. [18]. The price is set strategically to encourage CPs to contribute resources to earn profit from Federation. The CPs cooperatively try to maximize the social welfare of the Federation by collectively deciding the amount of VM resources to supply based on the price of the broker. Double auction-based pricing mechanism has been used by Li et al. [7]. CPs acting as buyer and seller present buy-bid and sell bid. A broker in Cloud Federation collects entire buy and sell bids and executes a double auction to decide the set of successful buy and sell bids and their clearing prices. A strategy-proof dynamic pricing mechanism is proposed by Mihailescu and Teo [19]. It is suitable for requests of rational users containing multiple resource types. The proposed mechanism is incentive compatible and budget balanced. It is designed to cater to the requirements of large distributed systems.

Equations for revenue generation, resource utilization, and the calculation of cost incurred in the allocation of resources have been proposed by Goiri et al. [6]. These equations enable collaborating CPs to take decisions regarding resource outsourcing, insourcing, or shutting down of unused nodes in a Cloud Federation scenario. The limitation of their work is that the resource prices of all CPs are assumed to be the same, which is unrealistic in an actual Federation scenario. Peer CPs are charged by applying a factor α to the cost of VMs. The value of α is chosen in a random manner for various experiments. Similar kind of work has been performed by Toosi et al. [4] but with an option of termination of spot VMs to consider incoming on-demand VMs. The price of each CP for its contributed resources (VMs) is calculated dynamically based on the idling capacity of its data center. It results in lesser price for CPs having higher resource capacity. But at the same time, this approach may

also result in very high price for CPs having lower resource capacity. The adverse effect of this approach on bills of CPs and their revenue is overlooked.

Apart from these limitations, there are many other problems associated with the above-discussed approaches. In all the studies, mechanisms to charge only peer CPs are proposed. The mechanisms to charge internal users are not discussed. Moreover, proposed mechanisms are biased toward CPs. Main focus is on maximizing revenues of CPs without considering the benefits of customers. The present work intends to overcome these limitations. It proposes pricing mechanisms for both CPs and internal users. The aim is to ensure fair bills for all the entities requesting resources; along with fair and profitable share of revenue for all the participating CPs through the proposed mechanisms.

3 Pricing Issue in Cloud Federation

In a Federation scenario, when CPs receive service requests from customers for instantiation of VMs; resources are either allocated locally or are outsourced depending upon resource availability. The CP which originally receives resource requests from internal users is termed as host CP, and the CPs where requests are outsourced are called outsourcing CPs. To foster resource sharing in this environment and increase the utilization of idle resources, they must be allocated to customers at a suitable price. When resources are allocated locally, an appropriate pricing mechanism is required to charge only internal users. But when resources are outsourced, pricing mechanisms are required to charge both internal users and host CPs.

An outsourcing CP may charge host CP at the same or different price as compared to the price offered to internal users. Ideally, resources must be allocated to host CPs at a cheaper price. This ensures host CPs economic interest to participate in Federation by enabling it to earn profitable revenue from outsourced resources. On the contrary, if the expenditure to acquire outsourced resources is high, host CP may prefer to reject the request of its internal user instead of outsourcing resources. Alternatively, it may even charge its internal users at a higher price depending on the acquisition cost of resources from peer CPs. As a whole, pricing mechanism used to charge one entity affects the profitability of other, i.e., pricing mechanisms of both entities are correlated. Therefore, selection must be done in such a way so that any kind of financial loss to internal users or collaborating CP due to inflated bills can be avoided.

Broadly, customers may be charged using two pricing approaches: fixed and dynamic. Various fixed and dynamic pricing-based mechanisms are proposed in the literature. It is important to decide between these two approaches for resource pricing of both the entities: internal users and peer CPs. In fixed pricing approach, fixed prices are charged from customers irrespective of their characteristics and real-time market conditions [20]. A common example of this approach is 'pay-per-use' pricing, which is presently used by most of the commercial CPs. Using dynamic pricing, customers are charged at different prices based on various attributes like workload, Cloud market fluctuations, CP's resource capacity [12]. Though dynamic

pricing reflects current market price of resources, it is difficult to be implemented in a multi-Cloud scenario. The unpredictability and uncertainty associated with values of different attributes of multiple CPs may cause the outsourced resources to be charged at a very high price, thus creating problem for both CPs and the end users. To address this problem, complex SLAs and FLAs need to be established that can define and fix the upper limits of resource prices under different situations. But as Cloud Federation is itself in early stages of development, defining and managing such complex rules for pricing in SLAs and FLAs are a difficult task. Apart from these limitations, reluctance of adoption of new pricing mechanisms by commercial CPs and lack of proper experimentation are some of the other factors due to which dynamic pricing has not yet been used at a large scale even by commercial single provider Clouds. Considering all these limitations, the present paper focuses on usage of fixed pricing-based approach to address the area of pricing in Cloud Federation.

4 Proposed Mechanisms for Pricing

Pricing mechanisms are proposed for internal users and peer CPs requesting resources in Cloud Federation keeping in view the interrelationship and dependency among them discussed in Sect. 3. The proposed mechanisms focus on the benefits of both entities. The motive is to increase user's satisfaction, CP's profit and resource contribution of CPs in Federation. This can be done through fair billing of both entities and ensuring profitable share of revenue to all the participating CPs. In this direction, equations to calculate bills and revenues using these mechanisms are also formalized. Various acronyms used in the equations are:

VM_{total}	Total number of VMs requested by internal users
VM_{own}	Number of VMs allocated from host CP's own resources
VM_{out}	Number of VMs outsourced to peer CP
VM_{ins}	Number of VMs insourced
t	Time for which VM is allocated
$Price\_VM_{own}$	Price of VM per unit time offered by host CP
$Price\_VM_{out}$	Price of VM per unit time of outsourcing CP
$Price\_VM_{req}$	Price of VM per unit time of requesting CP
$Cost_{out}$	Amount paid for borrowing resources from insourcing CP
$Total\_R_{out}$	Total revenue earned from outsourced resources
R_{total}	Revenue earned by a CP participating in Federation
R_{own}	Revenue earned from own resources allocated to internal users
R_{out}	Revenue earned from resources outsourced to peer CPs
R_{ins}	Revenue earned from resources leased to peer CPs

4.1 Internal Users

Internal users of CPs may be charged in the following ways:

Based on Price of Host CP (PHCP). In this mechanism, internal users are charged for all the requested VMs based on fixed uniform price of host CP which is offered to them at the time of service request, irrespective of the actual location of execution of requested VMs. Factors that affect users' bill in this mechanism are the number of VMs requested, price of host CP, and the time for which VMs execute. Thus, user's bills are calculated using the following equation:

$$\text{User Bills} = \text{Price\_VM}_{\text{own}} * \text{VM}_{\text{total}} * t \tag{1}$$

Based on Price of Outsourcing CP (POCP) In this mechanism, internal users are charged for the requested service based on fixed prices of both host and outsourcing CPs, depending upon the location of execution of requested VMs. Factors that affect users' bill in this mechanism are the number of VMs requested, price of host CP, number of VMs outsourced, price of CP where VMs request is outsourced and the time for which VMs execute. Thus, user's bills are calculated using the following equation:

$$\text{User Bills} = ((\text{Price\_VM}_{\text{own}} * \text{VM}_{\text{own}}) + (\text{Price\_VM}_{\text{out}} * \text{VM}_{\text{out}}) * \text{t} \tag{2}$$

4.2 Peer CPs

Peer CPs are charged at a reduced price in comparison to the amount charged from internal users. For this, a *reduction factor r* ($0 < r < 1$) is used either with the price of host CP or outsourcing CP in the following ways:

Reduced Price of Host CP (RPHCP) In this mechanism, a reduction factor r is applied to the price of host CP. The host CP obtains resources from outsourcing CPs based on this reduced price. Factors that affect CP's bill and revenue in this mechanism are the price of host CP, number of VMs outsourced and the time for which VMs execute. Bills of peer CP for outsourced resources are calculated using the following equation:

$$\text{Peer CP Bills} = r * \text{Price\_VM}_{\text{own}} * \text{VM}_{\text{out}} * t \tag{3}$$

Revenue (R_{total}) earned by a CP participating in Federation is the sum of revenue earned from its own resources allocated to internal users (R_{own}), resources outsourced to peer CPs (R_{out}), and resources leased to peer CPs (R_{ins}).

$$R_{total} = R_{own} + R_{out} + R_{ins} \tag{4}$$

This revenue is calculated as follows using proposed mechanism:

- Revenue from own resources (R_{own})

$$R_{own} = Price\_VM_{own} * VM_{own} * t \tag{5}$$

- Revenue from outsourced resources (R_{out})

$$Total\_R_{out} = Price\_VM_{own} * VM_{out} * t \tag{6}$$

Host CP has to pay some amount to outsourcing CP to obtain resources from it, which is given by Eq. (3)

$$\text{i.e. } Cost_{out} = \text{Peer CP Bills}$$

Net revenue (R_{out}) is calculated by subtracting cost of obtaining outsourced resources from the total revenue generated from outsourced resources.

$$R_{out} = Total\_R_{out} - Cost_{out} \tag{7}$$

- Revenue from insourced resources (R_{ins})

$$R_{ins} = r * Price\_VM_{req} * VM_{ins} * t \tag{8}$$

Reduced price of Outsourcing CP (RPOCP) In this mechanism, a reduction factor r is applied to the price offered by outsourcing CP. Host CP is charged for outsourced resources based on this reduced price. Factors that affect CP's bills and revenues in this mechanism are the price of outsourcing CP, number of VMs outsourced and the time for which VMs execute. Bills of peer CP for outsourced resources are calculated using the following equation:

$$\text{Peer CP Bills} = r * Price\_VM_{out} * VM_{out} * t \tag{9}$$

Revenue of a collaborating CP is calculated as follows using this mechanism:

- Revenue from own resources (R_{own}): It is calculated using Eq. (5).
- Revenue from Outsourced Resources: Total revenue earned from outsourced resources is calculated using Eq. (6).
  Amount paid to outsourcing CP to obtain resources from it is same as given by Eq. (9)

$$\text{i.e. } Cost_{out} = \text{Peer CP Bills}$$

Net revenue earned is calculated using Eq. (7).

- Revenue from insourced resources

$$R_{ins} = r * Price\_VM_{own} * VM_{ins} * t \tag{10}$$

5 Evaluation

The pricing mechanisms proposed in Sect. 4 are evaluated through experiments conducted using CloudSim simulation tool [21]. For this, a peer-to-peer simulated Cloud Federation is created in which Clouds commune directly with each other without the involvement of any mediator [22].

5.1 Simulation Settings

Federation scenario is created with the collaboration of three IaaS providers (CP_1, CP_2, and CP_3). Collaborating CPs receive service requests from own internal users (User_1, User_2, and User_3 are the internal users of CP_1, CP_2, and CP_3, respectively) and peer CPs. It is assumed that only 1 type of VM is offered by all CPs though different VM types may be used as an extension to this work. A 24 h long workload is generated. Prices of VMs offered by each CP are fixed to 1.0, 2.0, and 3.0 ($/hour), respectively. Different resource prices have been used by CPs to study the impact of proposed mechanisms on bills and revenues when resources are outsourced.

The metrics considered for determining the effect of proposed mechanisms on CPs and customers are: Bills of internal users, Bills of host CPs, Revenues of host CPs, and Revenues of outsourcing CPs. The parameter used to study the behavior of pricing mechanisms proposed for internal users is 'workload,' while the parameters used to study the behavior of pricing mechanisms proposed for peer CPs are 'workload' and 'reduction factor *r*.' The proposed mechanisms differ in their way of calculation of bills and revenues based on whether the requested resources are allocated by local or remote CPs. Therefore, in various experiments, workload is varied to simulate the provisioning of requested VMs through resources of host and outsourcing CPs. As value of *r* determines the share of revenue of each CP obtained from outsourced resources. So, experiments are also conducted using different values of *r* varying from 0.1 to 1.0.

5.2 Results

Results of various experiments are shown in Figs. 1, 2, 3, 4, and 5. In Figs. 1, 3, 4, and 5, (a) represents the scenario when VMs are outsourced to CPs having higher

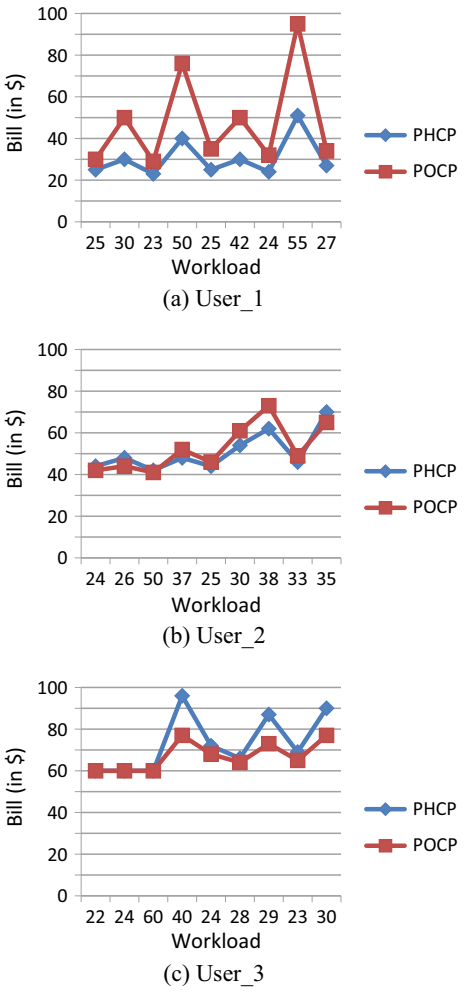

Fig. 1 User bills using PHCP and POCP mechanisms

price, (b) represents the scenario when some of the VMs are outsourced to CPs having higher price and others are outsourced to CPs having lower price, and (c) represents the scenario when VMs are outsourced to CPs having lower price. The entries corresponding to x-axis are different as the collaborating CPs receive different number of VM requests, i.e., their workload is different.

The first experiment is aimed at evaluating the impact of pricing mechanisms proposed for internal users on their bills. Bills of users are calculated using Eqs. 1 and 2 given in Sect. 4. It can be observed from Fig. 1a–c that in all the scenarios of outsourcing using *PHCP* mechanism, variation in the price of outsourcing CP does not adversely affect bills of users. As shown in Fig. 1a, even when the VMs are outsourced to a CP with higher price than that of host CP, fair bills are generated for internal users. On the contrary, in case of *POCP* mechanism, if the outsourcing CP has

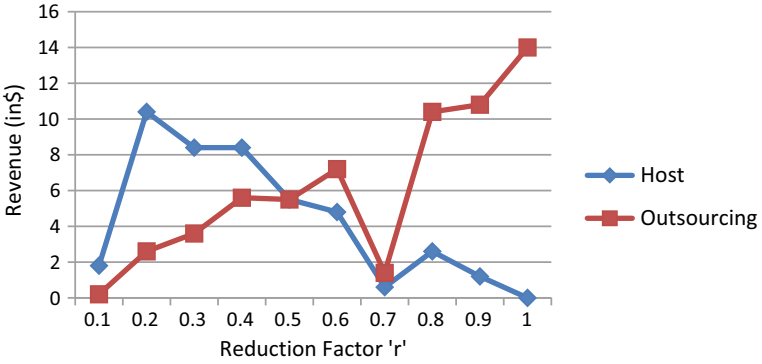

Fig. 2 Revenue of host and outsourcing CP with different values of r

higher price, unexpectedly high bills may be generated depending upon the number of VMs outsourced and the price of CP where they are outsourced as shown in Fig. 1a, b. *POCP* mechanism is appropriate for use only if the outsourcing CP is selected based on its price, i.e., CP with lesser price is selectively used for outsourcing. Such a scenario may help in avoiding financial loss to users, but at the same time it will prevent CPs having high prices from participating in Federation. Considering this, *PHCP* is found to be a suitable pricing mechanism to charge internal users.

The second experiment is aimed at selecting an appropriate value of r to be used for the pricing mechanisms proposed for peer CPs. It demonstrates and analyzes the effect of usage of different values of r on the revenues of host and outsourcing CPs. For this experiment, price of all CPs is assumed to be same (fixed to $1.0/h) so that the results are generated based on the value of r only irrespective of the price of CPs. Value of r is varied from 0.1 to 1.0. For each value of r, various experiments are performed with different number of VMs contributed by outsourcing CPs. This is done to study the effect of increase or decrease of number of VMs on revenue (with same value of r). To present the results and analysis in a simplified manner, Fig. 2 shows the revenue obtained by a CP with each value of r in a single experiment. It is clear from the results that using value of 0.1 for r, outsourcing CP obtains very less revenue. As value of r is increased, the revenue share of outsourcing CP improves. But, for very high values of r (e.g., 0.9 or 1.0), the increase in revenue share of outsourcing CP causes loss to host CP. It earns less revenue despite being the original receiver of the resource request of users. Therefore, to generate genuine share of revenue for both host CP and outsourcing CP, the value of r should be neither very high nor very low. A fair revenue share for both is generated using $r = 0.5$. Though 0.5 is considered to be an ideal value to be used for r, its value can be varied from the range of 0.4–0.6 depending upon factors like QoS, resource availability of the outsourcing CP.

The third experiment evaluates the mechanisms proposed to charge peer CPs. Their impact on bills generated for host CP and revenues earned by host and

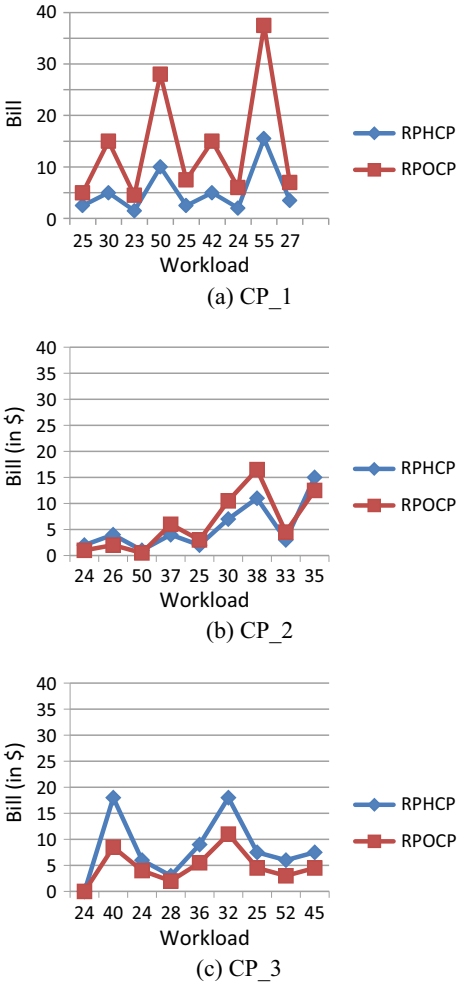

Fig. 3 Bills of host CPs using RPHCP and RPOCP mechanisms

outsourcing CPs is analyzed. Experiments are performed by varying the workload and using 0.5 value for r.

Impact on bills of host CP: It can be observed from Fig. 3a–c that in all the scenarios of outsourcing, the bills generated for host CPs are genuine and predictable using *RPHCP* mechanism, i.e., fair bills are generated for host CPs irrespective of the price of CPs where VMs are outsourced. On the contrary, in *RPOCP* mechanism, if resources are outsourced to a CP with higher price, then despite using $r = 0.5$, host CP has to pay a high amount as bill as shown in Fig. 3a, b.

Impact on revenues of host and outsourcing CPs: The profitability of host CP is evaluated by comparing the cost of host CP to acquire resources from peer CPs and the revenue earned by it. It is observed from Fig. 4a–c that using RPHCP mechanism, the cost of host CP to acquire resources from peer CPs is lesser than the revenue

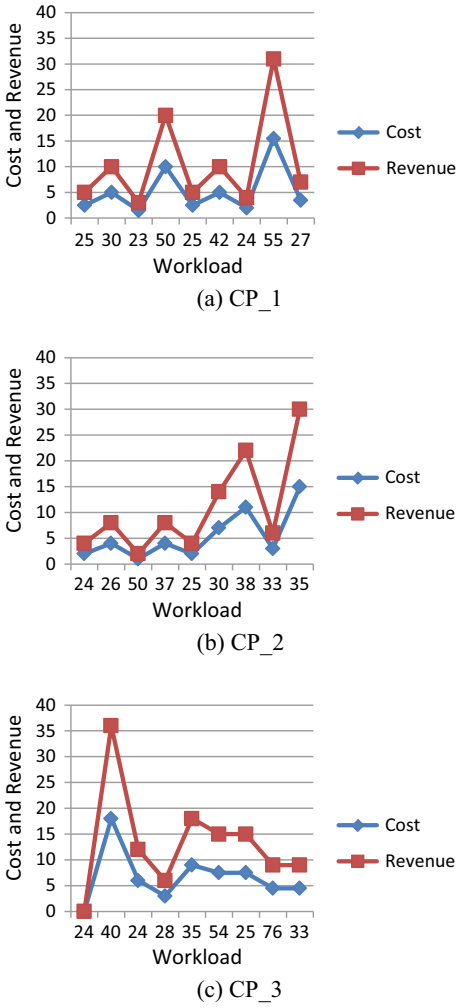

Fig. 4 Cost and revenue of host CP using RPHCP

earned in all the scenarios of outsourcing. Therefore, a host CP always obtains a profitable share of revenue using RPHCP mechanism. The price of CPs where VMs are outsourced becomes inconsiderable. In all the scenarios, outsourcing CPs would also earn 50% of the total revenue earned from users for the VMs allocated to host CP as the price of reduction factor r is set to 0.5.

As shown in Fig. 5a, using *RPOCP* mechanism, when VMs are outsourced to a CP with higher price, then host CP pays a high amount to acquire resources. As the cost incurred is higher than the revenue earned, therefore, host CP does not obtain profitable revenue and thus suffers financial loss. It is observed from Fig. 5b that even when some of the VMs are outsourced to CPs with lower price while others are outsourced to CPs with higher price, the earned revenue may not ensure profit. Only

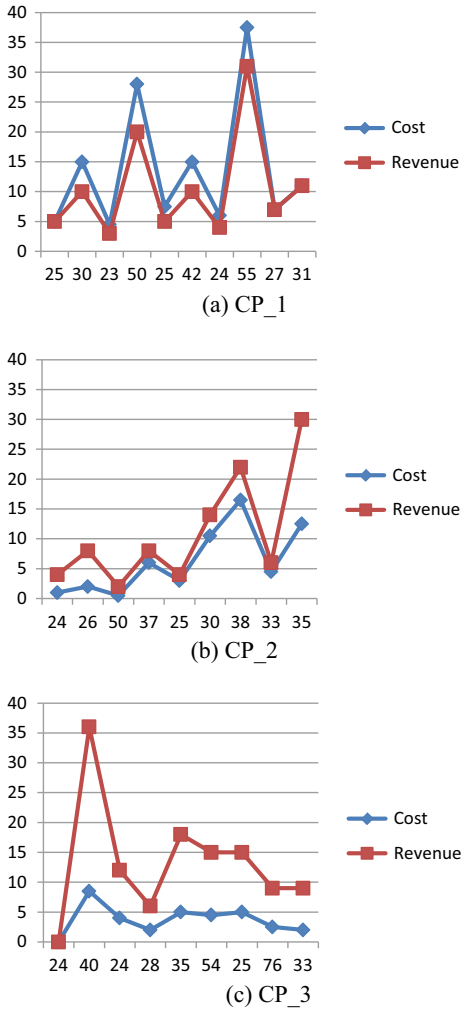

Fig. 5 Cost and revenue of host CP using RPOCP

when VMs are outsourced to CPs with cheaper price, profitable revenue is obtained, as shown in Fig. 5c. As a whole, *RPOCP* mechanism offers profitable revenue to host CP when price of outsourcing CP is less than or equal to the price of host CP. But outsourcing CP always obtains 50% of its own price for leased resources irrespective of the price of requesting CP.

Due to the benefits offered by *RPHCP* and limitations of *RPOCP*, *RPHCP* is found to be more suitable to be used for pricing of peer CPs requesting resources and revenue sharing of all collaborating CPs.

6 Discussion

Based upon the evaluation of various mechanisms in Sect. 5, '*Price of Host CP*'—and *'Reduced Price of Host CP'*—based mechanisms are found to be more suitable for user and CP pricing, respectively. These mechanisms offer many advantages. In *PHCP* mechanism, users know the values of all the attributes affecting their bills, i.e., host CP price, number of VMs requested, and time for which they execute. It helps users in predicting the tentative cost to acquire requested resources and enables them to select a CP based on the prices offered by it. It also offers transparency, prevents any unnecessary charges levied by CPs on users, and generates fair bills for them. This further attracts more customers to use the services of Cloud infrastructure.

RPHCP mechanism generates predictable and fair bills for host CP and profitable revenue for all the participating CPs. It guarantees cheaper price for outsourced resources. It is not biased toward host or outsourcing CP. It helps host CPs to outsource requests based on resource availability without any consideration of prices. The price to be paid for outsourced resources is predictable in this mechanism. Therefore, financial losses to host CP due to outsourcing are minimized. It further enables host CP to charge internal users in an impartial manner. As this method encourages outsourcing, therefore, host CP is able to accommodate more user requests which help in increasing its profit and building reputation. Outsourcing CP also finds it profitable to contribute its idle resources to Federation as it is assured that it will get at least 50% of the revenue of the VMs provided by it to host CP.

These mechanisms also overcome limitations of existing mechanisms. They are based on the fixed pricing approach. It helps in minimizing the increase in price due to various attributes related to dynamic pricing. This further prevents rejection of resource request, financial loss to CP, or any kind of wrong imposition of charges on customers by CPs. Pricing mechanisms are proposed considering different prices for participating CPs, to represent real Federation scenario. Rather than choosing random values of reduction factor to calculate bills and revenues, a suitable value is selected for it keeping in view of the benefits of users and CPs, which guarantees fair bills and profitable revenues. Apart from this, bill and revenue calculation are done on the basis of amount of work performed by each CP, i.e., on the basis of number of VMs contributed. All these factors assure that the selected pricing mechanisms are suitable to be used for the purpose of billing and revenue sharing.

7 Conclusion

In a Cloud Federation, resources are traded among various collaborating CPs through FLA. Pricing is considered to be an important factor in this environment to help users in selecting an appropriate CP for the fulfillment of their resource requirements. It is also a vital element in determining the benefit of CPs participating in Federation. Therefore, in the present work, pricing mechanisms are proposed for the resources

requested by internal users and peer CPs. For this, the relationship among pricing requirements of both entities is established. Based on it, pricing mechanisms are proposed with focus on minimal loss to internal users in terms of fairness in their bills, along with profitable and fair distribution of revenue among individual participating CPs. Experiments are conducted in a simulated Federation scenario to evaluate the proposed mechanisms. From the analysis of results of experiments, '*Price of Host CP*'—and '*Reduced Price of Host CP*'—based mechanisms are found to be suitable to charge internal users and peer CPs, respectively. These mechanisms attract more customers to use the services of Cloud. They also encourage the participation of CPs in Federation as collaborating CPs are able to completely keep their standalone revenue and obtain profitable share of revenue from the Federation.

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