

Reverse Auction to Trade Unused Cloud Computing Resources

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Abstract

Objectives: This paper solves the resource underutilization issues by trading the unused cloud computing resources and also obtains an optimal profit with the help of reverse auction mechanism. **Methods/Statistical Analysis:** Cloud market uses direct selling model to allocate resources for fixed price. Cloud service providers are not considering marketing principles such as supply-demand rate. In existing works, several market-based resource allocation models and algorithms have been projected to show that dynamic pricing models might be more suitable for both the providers and the customers of cloud resources. The proposed work uses reverse auction mechanism to trade the unused resources along with the resource overbooking and pooling facilities. **Findings:** Cloud services are offered by more service providers. It is a complicated task to calculate the right cost for the usage by the cloud service providers. Reverse auction mechanism is used to trade the unused cloud computing resources, which is unable to be allocated through direct-selling. An adaptive bidding strategy is used to suggest the provider to take the right actions in auctions. This mechanism solves the issue of resource underutilization with the help of resource overbooking and resource pooling. Though overbooking is generally used to reduce penalty for the service providers, resource pooling facility is highly effective in accessing the resources from resource pool which can be utilized by service providers instead of paying penalty and also increases the datacenter utilization. **Applications/Improvements:** Resource pooling assisted reverse auction mechanism helps to improve the datacenter utilization and also reduces penalty for cloud service providers in both English Reverse (ER) and Second Price Sealed Bid (SPSB) auctions.

Keywords: Adaptive Strategy, Cloud Marketplace, Overbooking, Reverse Auction, Resource Pooling

1. Introduction

Cloud computing is an approach to deliver computing IT services through internet and experience a direct cost benefits where large pool of systems are connected in private or public networks to offer dynamically scalable infrastructure. Cloud computing provides anything as a service with high benefits and offer pay-as-you-go model. The providers aim is to maximize the revenue and the customers goal is to attain highest level of QoS with reasonable cost. To avoid the wastage, the cloud providers lease part of their unused resources to the other providers or customers who are in need to finish their tasks. Providers need efficient resource management strategy to

attain the goal of revenue maximization. The cloud service providers determine the rate for the services or resources they offer through different pricing strategies. To remain high in business and achieve high profit the service providers must know the marketing rate of the same service or resource offered by the other providers. Auction¹ can be referred as a market mechanism with set of rules that determine prices and resource provision from different participants. Participants submit their bids against each other and in every round the bid increases subsequently.

An Auctioneer is the one who displays the bid prices and announces the auction winner. Every demand request from the customers are handled by an auctioneer. In this paper, the reverse auction is proposed to trade the unused

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resources and solve resource underutilization. The customer demands are handled by the auction broker. The winner who offered the lowest price will have the right to serve the customers demand. Multiple service providers register their details and the available resources to the auction broker to participate in auction. The auction broker will select the auction type (whether ER auction or SPSB auction). Once the user demands of the customer are known, the service providers should reserve the resources. Even though the resource is not available the provider can participate in an auction with overbooking facility. If the customer demands match with the data center capacity of service provider, the provider can reserve the resources and participate in an auction. If the demand is less than the capacity the provider can make use of overbooking pool to reserve the resources. The group of service providers will load their auction type and participate. The least bidder will be selected as auction winner. If the winner fails to serve the customer demands, then that service provider is 'defaulter'. The defaulting providers must pay their penalty. Re-assignment is used where the next least bidder is selected as winner to serve the customer demand. If no provider is available to serve the demand, once again call for proposal is issued for auction. Resource pooling mechanism is added to avoid penalty for the defaulters and make use of the resources that are in resource pool. Customer's unused resources are collected from datacenters and stored in resource pool to solve resource underutilization issue and it is less cost when compared to penalty which is high benefit for the providers.

Cloud services are offered by the more service providers, it's a complicated task to calculate the right cost for the usage by the cloud service providers. Amazon started to lease the unused capacity by adopting different pricing strategy to maximize the revenue and crack resource underutilization issue. On-demand pricing scheme charged the customers for an hour to access the cloud computing capacity. Customers can get discounts only through reservation or with flat rates for a long term commitment. Through pay-as-you-go basis the cloud user access the resource or service for the desired time and pay only for the time they used the resource or service.

Amazon's spot instance price model sells the unused cloud computing resources through bid and offers with market pricing. In spot instance the users can only bid for single instance of resource instead of multiple instances at a time.

A market exchange framework² is proposed and also the authors discussed about the resource allocation strategies which helps both the consumers and providers to trade the needed resources. The various resource management pricing techniques³ and made a classification analysis on each techniques. A drive system⁴ is proposed to increase the occupancy rate and the system utilization but it is not effective in different workload scenarios. Amazon's spot price^{5,6} is not that effective in preventing malicious behavior of the users and the model is proved to be unclear. With the help of direct-sell/fixed price model, the providers are unable to allocate their computing capacity fully. Also there is some portion of resources that remains unsold and do not produce any income to the service providers. Several computing markets⁷ namely Popcorn, Spawn, GRACE and tycoon have been analyzed where every approach have some lack of flexibility in evaluating new market designs and measure the performance in market environment. To overcome the issues faced by these approaches GridEcon project created the GridEcon platform to evaluate new market designs and use value added services in cloud computing. In the market exchange, both the providers and consumers communicate their ask and bid prices respectively where the matching's are found with the proposed allocation mechanism. To defeat the issue of resource underutilization optimal dynamic pricing strategy⁸ is proposed where the user demands can be controlled. CaaS (Cache as a Service) model⁹ is introduced to maximize the cloud profit and performance. The main difference between other works is that the author has used joint adoption of different pricing plans¹⁰ to maximize the revenue and used benchmark algorithm to compare the performance among the joint adoption of different pricing plans.

The Combinatorial Double Auction (CDA)¹¹ model groups the auction and adjust the price between the users and providers to gain revenue. Price adjustment algorithm is used to select the winner of auction. The different algorithms for cost-optimal cloud service¹² has been analyzed in dynamic pricing schemes. The authors proposed a two-phase gaming model¹³ to optimize the resource benefits and balance the users cost with provider benefits and also introduced virtual resource broker to analyze the available resources and configure it in cloud environment. The authors addressed about the participation of different cloud vendors for multiple resource procurement¹⁴ at a time. The Combinatorial Auction Branch on Bids (CABOB) model is proposed to determine the winner of

auction. The CA PROVISION¹⁵ mechanism is proposed for dynamic provisioning of resources depending on the users request and to maximize the profit. The real group auction system¹⁶ is evaluated in terms of performance, complexity, stability and optimality which prove its effectiveness and benefits the auction participants.

Applying MDT-Auction¹⁷ will help the user to select the best cloud service provider based on their requirements. Online reverse auction¹⁸ is the traditional bid but have reverse action where the buyer will offer contract who have lowest bidding rate in suppliers instead of supplier offering a product for sale. The procurement auction market^{19,20} is proposed by the authors to maximize the utilization of datacenters and also addressed about the issues of bidding strategies taken by the providers in auction. The two challenges²¹ are faced by cloud storage providers in online procurement auction. The cloud storage services depend on the datacenters in cloud and providers face significant cost in purchasing resources are the challenges faced by cloud service providers.

2. Materials and Methods

Basically, a marketplace is used by the providers and consumers to trade the cloud resources securely. On provider's point of view, services are provided by the providers according to the customer demand with discount offers and solve the underutilization issues with the help of overbooking and resource pooling facilities. The customers can acquire the needed resources with lowest price and can find all the service providers in one single marketplace. The marketplace provides the chance to increase the datacenter utilization. Every customer demands are sent to the marketplace which will be handled by the auction broker. The public auction is run by the auction broker to decide which providers can participate in an auction. Multiple service providers can participate since the auction is open and each service providers must register themselves with an auction broker. The winning service provider will ultimately have to serve the customer demand. The cloud broker will load two auction types namely ER auction and SPSB auction. ER auction is multi round auction and every round duration is fixed. The number of rounds depends on the tough competition in an auction. In every rounds, the providers will post their bid price offers and at the end of the round everyone will be notified with the winner bid price. But

the auction ends only when no more discount offers are posted by the providers. Contrary to ER auction, SPSB auction is a single round auction where the providers can bid just once before the auction is cleared. To participate in an auction, the providers must reserve their available resources with the auction broker.

During resource reservation, even if the resource is not available the cloud service provider can participate in an auction with overbooking facility. If the resource is available in overbooking pool, the resource can be reserved. If not, resource pooling mechanism can be preferred. During winner determination, the winner should be ready to serve the customer demand. If the resource is not available at the time of serving the customer demand then the provider is called as Defaulter. The defaulters will be asked to pay the penalty for not serving the customer demand.

In order to serve the customer demand the next winner must be selected. The Reassignment policy is used to select the next possible winners to serve the demand. If no providers are available to serve the demand the call for auction is made again. If the winner is unable to serve the demand with the help of overbooking, resource pooling facility can be selected to avoid defaulting and penalty. In resource pooling, utilization rate of datacenter is calculated to find the unused resources of customers. The unused computing capacity is collected to create a new host in order to serve the customer demand which relieve the service provider from defaulting.

The main aim of resource pooling assisted reverse auction mechanism which is portrayed in Figure 1 is to utilize the datacenter resources efficiently without wastage. In direct-sell/fixed-price, the providers are unable to allocate their computing capacity fully. There is some portion of computing resources which do not produce income and remain unsold which are referred to as spare or unused resources. If the providers are unable to allocate the total computing resources through direct-sell pricing model, there is an alternative supply-demand based pricing model to be chosen to allocate the unused resources. Providers wish to sell the unused resources at low prices, which include the cost of running, spare machines are also covered, instead of getting loss. The auction mechanism is proposed, where resource allocation is carried out through auctions that run among the customers. If virtual machine is not sold during a particular time period, it means a loss to the providers who need to spend money to maintain the physical machines.

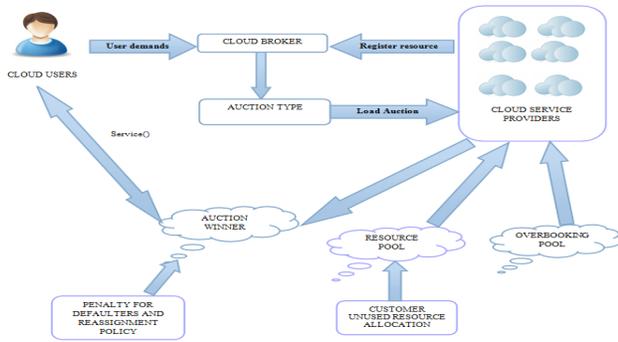


Figure 1. System Architecture.

2.1 Reverse Auction Mechanism

The reverse auction mechanism helps both the customers and providers. The customers post their demands to the cloud broker to take part in auction and to acquire the resources with less cost and the providers can boost their datacenter utilization by providing right to use to the unused capacity.

To maximize the business objective and to gain an optimal profit, providers can make use of this reverse auction mechanism.

The reverse auction mechanism is implemented as follows,

Step 1: Create a database to store details of datacenter, user demands, provider registration and reserved resources to view the information about an auction process.

Step 2: Generate a user demand by requesting the resource with Mips, processing element count, bandwidth range, RAM size and the virtual machine count details to obtain the resource with less profit by selecting the least bidder.

Step 3: The user demand is sent to the cloud broker who handles every demand from the customer.

Step 4: An auction type includes ER auction and SPSB auction to serve the needs of a customer through an auction process. An auction type is selected and loaded by the cloud broker based on the customer demand.

Step 5: The cloud service providers register their details with the cloud broker to participate in an auction. Every service provider must register themselves with unique id and name.

Step 6: Initially to join in an auction, the cloud service provider must reserve their available resources with the cloud broker.

Step 7: Different data centers are created with varying capacities as needed.

Step 8: The cloud service provider logs in with their unique name and id to check the user demand and participate in an auction.

Step 9: Check the resource availability by comparing the user demand request with the cloud service provider capacity for every element of the resource.

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If (service provider capacity >= user demand)
    Reserve the resources
Else
    Check overbooking pool
    Overbooking ()
        Service provider capacity/2 + service
        provider capacity = capacity in overbooking pool
    End if
    If (overbooking pool resources >=user demand)
        Reserve the resources
    Else
        Check in resource pool
        Resource pool = customer unused
resources
        If (provider = ready to serve demand)
            Service to user ()
        Else
            Calculate utilization rate ()
            Integrate customer unused resources
            with new host ()
            Serve demand ()
        End if
    End if

```

9.1: check the resource availability to participate in an auction. If the resources are available the resources will be reserved for participation.

9.2: The resources are reserved and locked to participate in an auction if available. If the resources are not available, then the overbooking facility can be selected to reserve the resources for participation.

Step 10: In overbooking mechanism, check every demand of the user with the service provider capacity. The service providers cannot enter into an auction without any resources.

When the user demand is compared with service provider capacity, the service provider capacity must exceed the user demand to reserve the resources.

10.1: The service provider capacity is divided into half and added with the service provider capacity to generate overbooking pool resources. If the overbooking pool

resources match with user demand then that resources are reserved for participation.

10.2: If the user demand does not match or exceeds the limit of overbooking pool resources, the resources cannot be reserved. Without reservation of resources the service providers cannot take part in an auction. The service provider can make use of resource pooling facility.

Step 11: Resource pool collects the unused resources of customer and integrate that to new host.

Step 12: The provider who is defaulter can access the resources from resource pool to avoid defaulting and penalty which in turn raise the datacenter utilization.

2.1.1 An Adaptive Strategy

An adaptive strategy put forward the right actions to be taken in auction market and helps to decide whether to participate in a given auction, to bid in a given round or not to bid, or which price to offer. If the task is longer and the resources are committed for long time there is a possibility that the provider can miss the chance of short profitable tasks. In auction, providers may be more or less violent while bidding a price. Providers should not accept the price which is lower than the running cost of machine. This random strategy is helpful in selecting the actions to be taken in an auction market.

2.1.2 Resource Overbooking

The overbooking facility lets providers try to win for more customer demands than they are able to ultimately supply. Providers may participate in a given auction even though if they do not have any resource at the time of joining that auction. The Providers who overuse the overbooking mechanism in order to make profit are penalized.

2.1.3 Resource Pooling

Instead of wasting idle resources, customers contribute their idle resources to the resource pool storage. This contribution reduces the network traffic and also storage trouble of servers in datacenters. Cloud storage users give their local resources to the storage pool. If the resource is not available in overbooking pool too, the provider can make use of resource pool. The service provider who is unable to serve the demand can avoid defaulting and penalty by reserving the unused resources from the resource pool. Cloud storage users are motivated to submit selling bids to the cloud storage provider with the details of amount of resources the user is planning to contribute

along with desired payment information. Hence resource pooling mechanism helps to stay away from defaulting and penalty.

3. Results and Discussions

The reverse auction mechanism is simulated with the help of CloudSim 3.0.3. The customers request for the resources by posting their demands to the cloud broker. Database is created to store and retrieve the details of service provider resources, datacenter details, reserved resources and the user demand details. Once the customer demands are sent to the cloud broker, different cloud service providers register their details and available resources with the cloud broker to join in an auction. CloudSim 3.0 starts all entities and the virtual machines are created in the data centers.

If the resources are available, the service provider must reserve those resources with an auction broker to participate in auction which is shown in Figure 2. Auction broker conducts an auction among several service providers. Each service providers post their bid and the winner will be notified at the end of the auction process.

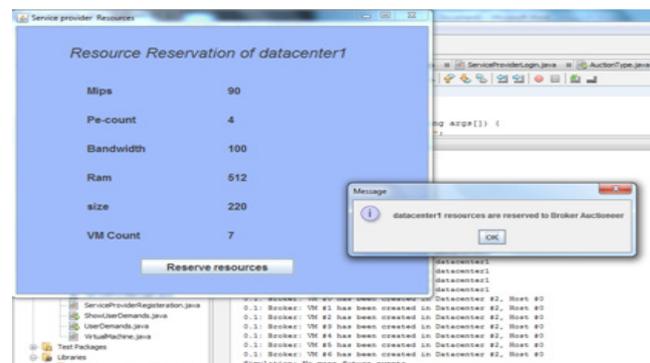


Figure 2. Resource reservation.

The auction scenario is shown in the Figure 3. If the winner is unable to serve the demand at the time they are announced as auction winner, that service provider is named as defaulter and has to pay penalty.

Through resource pooling facility, the service provider can avoid penalty and increase the datacenter utilization. The utilization rate of datacenter is calculated. A new host can be created which in turn also integrate with the customers unused resources to serve the demand. Resource pooling helps the service providers to stay away from penalty and also increase the datacenter utilization.

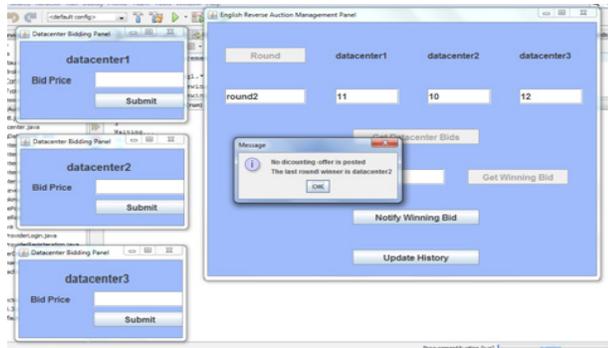


Figure 3. Auction scenario.

In existing works, datacenter utilization is measured with the help of overbooking mechanism. Even though overbooking facility reduces penalty but it is not that effective in single round auctions. In proposed work, resource pooling helps in avoiding penalty and increases the datacenter utilization. In both Figures 4 and 5, datacenter utilization increases with resource pooling in ER Auction and SPSB Auction.

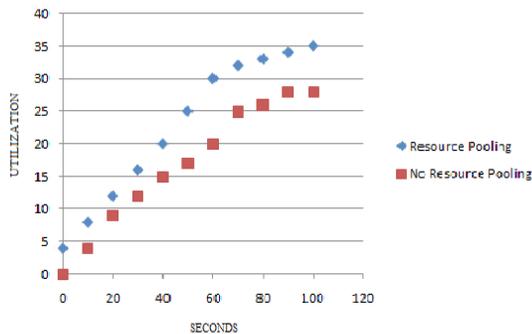


Figure 4. ER Auction.

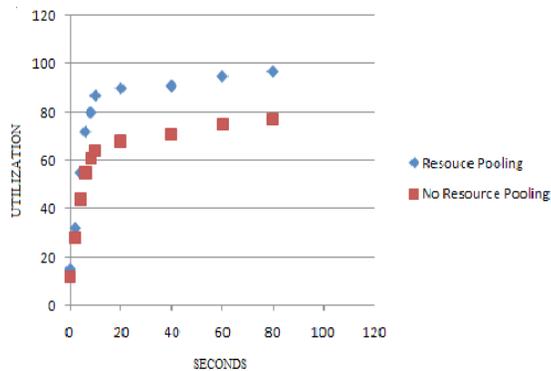


Figure 5. SPSB Auction.

4. Conclusion

The main contribution of the work is to trade the unused cloud computing capacity to the customers who demand for the resource through the reverse auction mechanism. The overbooking facility allows the cloud service providers to take part in an auction, even when the resource is not available at the time of joining an auction. The cloud service providers who overuse the overbooking mechanism to enlarge their profit will be penalized. The more penalty problems faced by the cloud service providers can be resolved with the resource pooling. The customers contribute their unused resources to the resource pool. The provider who is penalized can access resources from the resource pool which is less cost when compared to penalty. The reverse auction mechanism can be further extended with service level agreements.

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