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Research paper

Cost Efficient Resource Scheduling in Cloud Computing: a Survey

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Abstract

Resource scheduling is a tricky task in cloud environment. QoS is the main parameter from user's perspective for Resource scheduling, while in parallel with this task, profit is very important parameter from point of view of cloud provider. The cloud service platform controls the revenue under particular market needs. The consumer get puzzled with many cloud suppliers for storing their data because various suppliers' varying pricing scheme. In particular, recently many studies have paying attention on shaping the bond between server-side system facts and performance experience for dropping resource wastage.
The main aim of cloud supplier is to provide utmost resource usage and profit, while also decreasing the energy and cost. The user wants higher throughput and less response time. Allocating proper resources with least overhead and full resource utilization is the objective of cloud. The service requests are generated by various users in cloud. Hence proper scheduling of resources is required for better performance of system and less operative cost.

Keywords: *Cloud computing; Cloud resource scheduling; Cloud workload;, Profit maximization; Resource scheduling.*

1. Introduction

Cloud computing is a viability which has unbounded capacity, quick versatility. The client needs to pay for resources that he uses and for a particular time period.

1.1. Cloud Computing Features:

Service on Demand: Resources are given automatically to user as and when needed with no human interaction.
Broad Network Access: The cloud environment provides great network capabilities
Rapid Elasticity: The client can scale in and scale out the resources quickly as on demand.

1.1.1. Service Models in Cloud:

The service models are categorized as follows:
1. Software as a Service (SaaS): The users want on demand software to run their application from any location. So cloud provider issues a license to user on subscription basis.
2. Platform as a Service (PaaS): The cloud provides a platform, which allows developing, running, and managing the applications without maintaining infrastructure.
3. Infrastructure as a Service (Iaas): The virtualized resources are given over the internet by service provider. The user can deploy any software by these resources.

1.1.2. Cloud Deployment Models

Cloud deployment models are categorized as: private, community, public and hybrid cloud. In case of a Private Cloud, a single entity works with the private infrastructure. Here entity can be a organization or a user. In Community Cloud, the cloud infrastructure is shared among multiple entities and they provide their support to a particular community. In case of Public Cloud, the public uses the services, which are owned an organization on cloud infrastructure. And in case of Hybrid Cloud, uses private and public cloud combination.

1.2. Cloud Computing Structure

A cloud computing structure explained in detailed in subsequent section.

1.2.1. A Cloud System Model

In this model, there are three entities, i.e., customers, service providers and infrastructure service providers. The three-tier structure is used usually.

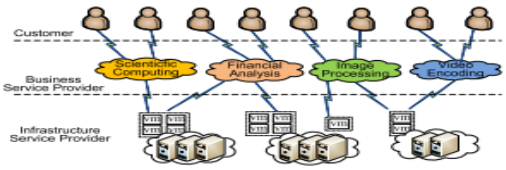

Fig. 1: structure of cloud

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An infrastructure service provider provides the essential software and hardware services. A service provider leases the resources from infrastructure service providers and also prepares virtual machine (VM) as a set of services. The service provider provides services on demand. The customer pays to service provider for providing the service. The service provider pays to infrastructure providers to rent their physical resources, for whatever cost is generated. And also charges the customers for dealing their service requests, so revenue is generated. Correspondingly the profit is the difference between cost and revenue.

1.2.2 A Multi Server Model

A multi-server system has a service request queue as shown in fig. 2**Error! Reference source not found.**.

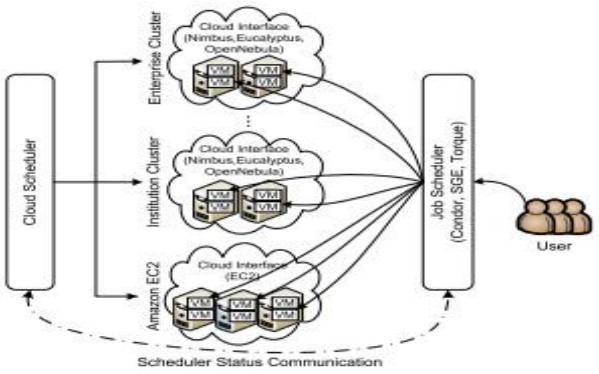

Fig. 2: cloud computing structure

The cloud provides virtual machines (VMs) as resources for jobs. As shown in fig.3, the user submits their jobs to a service request queue, which is queued in a job queuing system. Here a job scheduler works like multi-server system, which schedules all the jobs in centralized manner and then these jobs are allocated to various VMs. Therefore a job scheduler works like a dedicated workload manager. It performs management of job queue, priority scheme, scheduling, monitoring and management of resources in efficient manner **Error! Reference source not found.**.
In this structure, a cloud service provider uses a multi-server model to process customer's service requests.

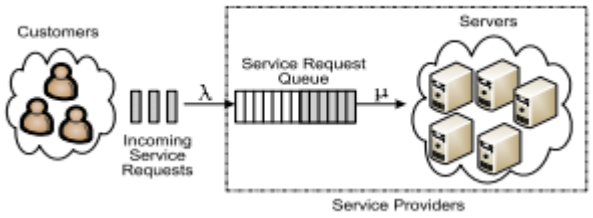

Fig. 3: Multi-server model

2. Resource Scheduling

Due to physicaldiversion of resources, shifting load, dissimilar user needs and different pricing strategy, resource scheduling is a difficult job in cloud [89]. Resource scheduling is the term which does mapping and execution of workloads based on certain resources using resource provisioning [87].
A lot of research work dealing withresource scheduling in cloud has been done already. This paper presents review on cost efficient and profit maximization related work in detail. Section 2 contains cost aware resource scheduling related work. Section 3 contains profit maximization related work. Section 4 explains detailed procedure for cost analysis and pricing strategy used in cloud. Section 5 is conclusion.

2.1 Cost Aware Resource Scheduling

Cloud provides hardware typically a virtual server, as a service and create employing servers more convenient and cost efficient, as the definition of cloud computing given by NIST is "a pay-per-use model for enabling available, convenient and on demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." Here we reviewed some papers related to cost effectiveness in cloud.
Fei Tao et al. proposed the issue of active transmigration of Virtual Machines [3]. The proposed DM-VM considers vitality intake, VMs communication, and takes transmigration charges under the conditions.
David Candeia et al. reported that using reservation market's instances, the cloud providers can decrease their operative cost, where the instances can be purchased. But they also need to forecast the quantity of instances needed in the long term[4]. Their work investigates the importance of capacity planning. In addition, the impact of business driven heuristics is presented.
Xuanjia Qiuet et al. investigate that in hybrid cloud, the content distribution service can be an optimally migrated [5]. The author has proposed a framework, which is based on Lyapunov optimization theory. To reduce the operative cost and guaranteed QoS, a combined algorithm for dynamic, joint content placement and request distribution is proposed.
Shuangcheng Niu et al. proposed a computing model for organizations named as Semi-Elastic Cluster (SEC) for reserving and dynamically resizing a virtual cluster in cloud [6]. The author has presented batch scheduling set and an algorithm for reserved instance provisioning, which uses job history is also presented.
Philipp Hoenisch et al. presented a unique way for business processes scheduling and optimizes the operational cost of resources [7]. For that, they point out the problem of efficient scheduling of service instances among resources.
Yi Zhang et al. proposed a heuristic method that contains ordering and task planning of task [8]. It utilizes Longest Task First (LTF) scheme to produce a task order. A method for Task Assignment is fixed for mapping tasks in required order one at a time. The experimental result shows that the proposed EH method has shown better results than the baseline (Round Robin) considerably.
Renan Delvalle et al. proposed that the data centers undergo a considerable cost for power and energy consumption, while running these workloads and managing high utilization of their components [9]. To deal with this cost they have invented a new structure, called Electron. The proposed new structure is intended to high performance, efficient power and scheduling strategies.
Eya Dhib et al. proposed a structure to deal with resource provisioning in cloud[10]. Their proposed structure is intended to manage the tradeoff between cost involved in resource allocation and processing delay and also allocates necessary virtual resources.
Mohammad Jassas et al. presented a framework for embedded systems, to increase the usage of restricted local [11]. The framework provides scalability and throughput. The scheduling algorithm reduces the execution time and estimated cost.
Gursleen Kaur et al. suggested a hybrid genetic algorithm to reduce the operational cost and execution time under the given deadline [12].
Ryan Marcus et al. proposed that, a demonstration, which provides the interaction between conference attendees and knowledge based service [13]. At the same time, User is capable to see the performance of provisioning and decision for query scheduling in real time.
Xuezhi Zeng et al. proposed a scheduling algorithm (MASA) which is based on greedy approach. The approach compliments the user's to lessen the renting cost of resources and considering user's budget and deadline constraints [13]. The result shows considerable reduced cost as compared with other current methods.

Lei Jiao et al. examined the issue of price optimization in case of dynamic OSN over sequential interval of time [15]. They form the cost, the QoS, and the data availability of OSN.
Yichao Jin et al. investigated the cost optimal content placement issue. Particularly, it is designed to reduce the entire cost, with respect to the resource capacity [16].
Song Li et al. focused on improving the functional price of hybrid cloud model by tentatively evaluating the difficulty [17]. Their technique can deal with the issues where renting costs and user's upcoming probability distribution are unknown.
Yongyi Ran et al. created a method to reduce the entire computing cost considering QoS by using number of the purchased instances dynamically [18]. By mapping QoS, the author has proposed a scheme for dynamic instance provisioning to calculate the minimum instances for the upcoming demands.
Peng Zhao et al. investigated to reduce the long term energy charge of dynamic Internet-scale systems [19]. They designed a dynamic approach of request mapping to resolve problem, while balancing the tradeoff in energy cost and delay performance. Based on present queue backlogs and system states, the algorithm takes real-time decisions.
Jianguo Yao et al. proposed a framework COMIC, i.e. Cost Optimization for Internet Content Multi-homing [20]. The author has designed a centralized optimization approach for content Multi-homing environment, to balance end user's loads dynamically and to reduce the content service charges.
Lena Mashayekhy et al. addresses the difficulty of autonomic VM provisioning and distribution [21]. In addition, this mechanism calculates the amount to pay by user for using the resources.
Soumen Moulik et al. reported that they strive to eliminate such business from the pricing agreements, and predict this challenge [22]. To achieve it they use bargaining concept involved in game theory.
Yusen Li et al. reported that new version of DBP issue, named as MinTotal DBP problem whose objective is to minimize total bin cost [23]. It is determined by the problem of request sending generated from gaming systems in cloud.
Wenhua Xiao et al. reported optimization problem and designed an online algorithm [24]. Maintaining the user's QoE their method is able to reduce the cost to rent resources on cloud.
Shiqiang Wang et al. presented a scheme to determine the ideal placement of instances to minimize the average cost over time, in presence of many users and instances [25].
Abhishek Gupta et al. suggested the approach for selection of cloud for HPC and the HPC applications that run on cloud. They demonstrated by running a group of HPC applications and analyzed their cost and performance [26].
Danilo Ardagna et al. proposed a game method for managing the resources dynamically. The method shows a cost model showing their revenue as well as penalties due to failures of requests [27].
Zhicheng Caietal et al. proposed a method for mapping of job mode [28]. Based on the consequence of job mode mapping, a tabular list is prepared showing processing cost and slot matching of task.
Tamir Hegazy et al. reported that the cost and time can be saved mostly due to the virtualization of controllers and the minimization of hardware charge [29].
Ioan Petri et al. used Comet Cloud to derive the framework to address the issue of a cost based cloud federation [30].
Boyang Yu et al. reported the isolated memory cache's problems associated with request dispatching. To maintain queue stability, minimum energy cost and high cache hit, an online method is proposed [31].
Balaji Palanisamy et al. presented Cura, to provide cost effective MapReduce services in cloud. Cura is more efficient as compared to existing cloud services [32].
Hamed Shah Mansouri et al. proposed task scheduler to achieve the pricing scheme for mobile devices. In addition, they designed a solution to consider energy cost, service cost, delay and scheduling [33].
Shivaswamy Rashmi and Anirban Basu proposed a scheduler to optimize the cost of VM, bandwidth and energy, and for job execution under the deadline [34].
Arvind Mohan et al. proposed a high performance BARENT workflow scheduler. The scheduler aims to reduce the workflow make span and works in different cloud environment[35].
Jinlai Xu et al. implemented a framework for resource sharing to maintain contract of resource sharing with the data centers for geo-distributed clouds for defined time intervals [36].
Viviane T. Nascimento et al. proposed a model to show customer's contract data, least energy costs, and allocating the services based on search items for better usage of energy [37].
Qiushi Wang et al. developed a speedy and efficient strategy to calculate instances for each pricing option on hourly distribution basis [38]. The author also designed a scheme for proper arrangement of scheduled instances.

Table 1: Comparison of different algorithms used for cost efficiency in cloud

Sr.	Authors	Algorithm/Tech./Method	Result
1	Fei Tao et al. [3]	DM-VM's triple-objective optimization model	Energy consumption, message between VMs, and migration charge get reduced.
2	Xuanjia Qiu et al. [5]	Lyapunov optimization theory,	Operative cost minimization
3	Renan Delvalle et al.[9]	Electron	Reduces power usage of CPU and DRAM, total energy usage, average power usage and max peak power usage.
4	Gursleen Kaur et al. [12]	Hybrid genetic algorithm	Minimizes the cost and also managing execution time lessen the given deadline
5	Xuezhi Zenget et al. [14]	Greedy scheduling algorithm	Minimizes the price for renting the resources on Cloud, while taking into account user's budget and deadline constraints
6	Lei Jiaoet et al. [15]	Cosplay	Form the cost and QoS, as well as the data availability in an OSN
7	Song Liet et al. [17]	Lyapunov optimization framework, dynamic provision algorithm	Optimizes the operative cost for the hybrid cloud

2.2. Profit Maximization in Cloud

K.Sutha et al. discussed a profit maximization scheme to understand importance of job scheduling for efficient utilization of services. [42].
Qiufen Xia et al. aim to optimize the operational cost, with capacity of resources and user fairness constraints to get better system throughput [47]
Subarna Chatterjee et al. presented a model, which deals with profit maximization and dynamic pricing strategy for hardware [48].
Xiaoxi Zhang et al. designed a proficient online VM auction based scheme with varying intervals and location preferences, and aiming to welfare and profit maximization of cloud [49].
Laiping Zhao et al. presented an online VM placement algorithm to maximize the revenue of cloud provider by dropping SLA violation cost [50].
Jianxiong Wan et al. considered a problem of pricing of dynamic server based on resource needs [51].

Mahyar Movahed Nejad et al. formulated greedy and optimal solution for provisioning of VM dynamically and allocating the resources in an auction based model to winning user and accordingly calculates their payments [52].

Guoxin Liu et al. proposed a mechanism for cost minimization and SLO guarantee [53].

Mingxi Cheng et al. presented the DRL-Cloud, to decrease energy cost for CSP with data centers and user requests in huge amount [54].

Table 2: Comparison of different algorithms used for profit Maximization in cloud

Sr.	Authors	Algorithms	Results
1	Fatemeh Ebadifard et al. [45]	Black hole Optimization (BHO), Pareto optimizer method	Method considers user needs and also the interest of service providers
2	Subarna Chatterjee et al. [48]	dynamic pricing model	Model maximizes the profit of various owners involved in transmission of data
3	Xiaoxi Zhang et al. [49]	online VM placement algorithms	Profit maximization of cloud provider
4	Laiping Zhao et al. [50]	online VM placement method	Cloud provider's revenue is maximized and SLA violation cost is reduced
5	Guoxin Liu et al. [53]	multi-cloud Economical and SLO-guaranteed cloud Storage Service (ES3)	Cost minimization
6	Mingxi Cheng et al. [54]	DRL-Cloud	Helps in reducing energy cost for huge data centers and user requests

3. Cost Analysis and Pricing in Cloud

Fee demanded by provider in exchange of providing services or resources is the part of Pricing. Cloud providers may choose any of many pricing models for their services [57]. To run a successful business it is must to choose a right pricing model. Lounge of company provides a tool for server selection [58]. For exact and correct pricing a Provider must know right prices of every service and resource. In cloud computing the pricing should be calculated using factors that takes into account both economical strategies and appropriate computer strategies.

There are 3 main factors which should be used to be considered while determining the price.

3.1. Cost of Services

A provider first calculates the cost of services and then adds a percentage of that cost for their profits. As of now we there are no pricing systems that are completely explained by any company and everything about how pricing is done is confidential. But there has already been some work done in this area of cost computation.

3.2. Market Competition

As of now this market is dominated by companies like amazon, google and Microsoft etc. So any new company should compare and fix the prices of their services with that of their competitors.

3.3. Value to Consumer

Cloud service providers should know how much price customer is willing to pay for services and then use those services as a basis to decide the pricing model. Researchers have done some detailed study into how the cost should be calculated keeping in mind customers point of view for minimizing the cost. These efforts help service providers to determine whether the model is upto customer's satisfaction. The cost of providing and maintaining cloud services can be measured broadly in two ways [55].

1. Amortized model

We cannot keep the cost of various factors together directly due to various purchase prices and intervals [57]. It is necessary to calculate the cost of each factor for monthly lease. Hence from early purchase expense the amortized cost is planned for each factor based on their interval.

2. Cost model

The considerable factors constituting the cost in cloud have been collected, and these factors are server, facilities, software, support and maintenance, power, network, cooling, etc. The cloud provider charges the customer for these factors and expects the profit also.

Hence, two most important costs of Cloud are Total Cost of Ownership (TCO)[57] and Resource Consumption Cost.

4. Conclusion

Cloud computing has become to be an increasingly prominent area for research and development. From cloud expert perspective, it is necessary to optimize the cost and maximize the profit, while from user point of view the performance and throughput should be high, keeping in mind the least pricing strategy offered by the cloud provider. In this review work, we have studied total 90 research papers, related to cost optimization and profit maximization. Managing cost and better allocation of resources can be achieved by in depth analysis of cloud and its workload. We summarized this literature by systematic evolution of resource scheduling with cost optimization and profit maximization parameter. Also the cost analysis procedure i.e., how the cost analysis is done in cloud is also presented along with the cost models given in literature.

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