ISSN 2278-3091
Volume 9, No.3, May - June 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse220932020.pdf
https://doi.org/10.30534/ijatcse/2020/220932020

A Framework of Heterogeneous Cloud Service and Multi Attributes Negotiation using Double Auction

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ABSTRACT

Many double auction frameworks have been proposed for cloud service negotiations [1]. However, the frameworks are not able to accommodate both the heterogeneous cloud services and multi-attributes negotiation simultaneously. Therefore, this paper proposed a double-auction framework to accommodate heterogeneous cloud services and multi-attributes negotiation. The study postulated four activities namely literature review, cloud service marketplace investigation, data formulation and double auction-based negotiation framework development. The market requirements, auction requirements and two new mechanisms of a double auction framework have been proposed.

Key words : auction mechanism, automated negotiation, cloud services, double auction.

1. INTRODUCTION

Many double auction frameworks have been proposed for cloud service negotiations [1]. But, the frameworks are not able to accommodate both the heterogeneous cloud services and multi-attributes negotiation simultaneously. The auctioneer was designed to auction only a single type of cloud service. For heterogeneous cloud services, the auction coordinator needs to create multiple auctioneers based on the number of cloud services. The size of the solution space and the execution time will increase and this could lead to sub-optimal results. Similarly, the utility function and the matching function were designed for a single-attribute negotiation. The consequences could be sub-optimal as negotiations are more difficult for heterogeneous cloud services with multi-attributes [2-4]. Hence, a double-auction framework to accommodate heterogeneous cloud services and multi-attributes negotiation is proposed in this paper.

The paper is organized as follows. In Section 2, related works of double auctions used for cloud service negotiations are presented. Section 3 presents the methodology used in this study. Section 4 and Section 5 present the proposed framework and conclusion.

2. RELATED WORK

Negotiation can be used by a cloud service provisioning framework to manage resources [5]. Negotiations protocol is a set of rules that defines interaction boundaries between participants, and it covers participant types, negotiation states, the event that triggers a change of negotiation state and permissible action by agents in each state [6]. In the current literature, the double auctions are the preferred M-N negotiation protocols used for cloud service negotiation, however, it requires efficient coordination and consistency [1].

CDA and combinatorial double auction are examples of cloud service negotiation's double auction that able to solve several types of real-time negotiations and cloud services combinations [1,6]. The combinatorial double auction enables participants to bid on compounds of discrete items preferably than just single items [7]. Some argue that cloud services are a type of combinatory items such as the VMs, CPUs, and storage [7]. On the other hand, the CDA protocol allows multiple buyers and sellers to send bids and sell service respectively and matches them in real-time [8, 9].

There are three categories that have been categorized from the double auction protocols namely the double auction, continuous double auction (CDA) and combinatorial double auction.

2.1 Double Auction

To cater to the issues of maximizing the time-average profit in dynamic VM trading and scheduling, [10] has proposed the double auction-based mechanism. This double auction-based mechanism is a benefit for cloud organization ultimately and to fulfill the resource and SLA requirements of each job.

Meanwhile, for cloud resource allocation, a Double Multi-Attribute Auction (DMAA) was proposed by [11]. DMAA is a double auction-based mechanism that used to predict the price, and it implements the Support Vector Machine (SVM) for price prognostication and Neural Network (NN) to determine the Quality Index (QI).

2.2 Continuous Double Auction

The combinatorial double auction indicates a proper protocol for cloud services intervention, which broadly used to resolve several sorts of cloud services combinations [7, 12-15]. To allocate service combinations (bundling), [16] proposed a double auction-based mechanism that used to hold future services from a forward business and the current services from the spot business. Besides, for IaaS resource allocation, Intelligent Economic Approach for Dynamic Resource Allocation (IEDA) was proposed by [12]. It based on a double auction-based mechanism and able to applies enhanced combinatorial double auction protocol by implement two mechanism agents that is Paddy Field Algorithm (PFA) and Backpropagation Neural Network (BPNN) algorithm.

2.3 Combinatorial Double Auction

The CDA protocol enables various buyers to send bids, while sellers are allowed to tender asks (offering) in the auction market [8, 9, 17-19]. MANDI is a double auction-based mechanism used for market exchange infrastructure and proposed by [20]. MANDI selected as an integration of the double auction that consists of the first bid sealed auction and commodity market. In MANDI mechanism, the first bid sealed auction is a typical auction protocol where every bidder tenders contemporaneous unrevealed bids. In different circumstances, [21] proposed a Nash Equilibrium Continuous Double Auction (NECDA) for cloud resource allocation and performance optimization. This double auction-based mechanism is also known for its benchmark with the CDA, Min-min algorithm, and Max-min algorithm to present promising outcomes.

Besides, a cloud service agreement for the prospective market and spot market uses a double auction-based mechanism and the implementation of a knowledge-based CDA as proposed by [22]. Meanwhile, an auction-based mechanism for cloud resource allocation and strategic pricing was introduced by [23] to engage a multi-unit CDA. Likewise, [24] proposed a double auction mechanism established from the Parallel CDA (PDCA) for cloud service allocation where PCM and PREZ algorithm used to allocate the resource. Contrarily, to improve profit known as Belief based Hybrid Strategy (BH-strategy), a double auction-based mechanism is introduced by [25]. The approach used here is based on CDA protocol for homogeneous market and utilizes a new bidding strategy and decentralize resource allocation in cloud markets. The CDA has been identified as the preferable double auction protocols in the literature compared to the combinatorial double auction and double auction.

Figure 1 illustrates the double auction framework for cloud service negotiations [10-16]. The combinatorial double auction indicates a proper protocol for cloud services negotiation that broadly used to solve various problems.

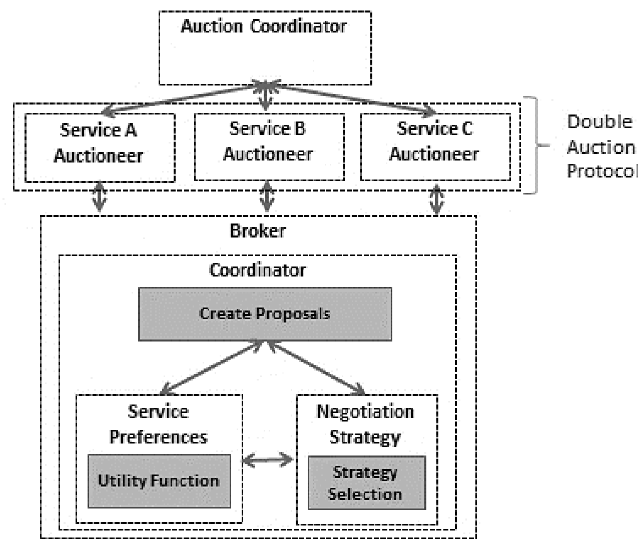

Figure 1: A general example of the double auction framework for cloud service negotiations

A. Auctioneer

The auctioneer is an individual agent that starts, manages, end cloud service auctions. The auctioneer used double auction protocols. The auctioneer sorted the bids and cloud services from service customers and service providers to determine the winner [17].

B. Broker

The broker is an autonomous agent that represents the service customer. The broker received service requests from a customer, formulated bids and submitted bids to the auctioneer. The broker has its coordinator that creates a proposal (bids). The broker's coordinator relies on mechanisms, namely, the service preference mechanism and negotiation strategy mechanism to create a proposal. The service preference mechanism accepts service requirements from the customer and formulates the price utility. Meanwhile, the negotiation strategy mechanism is responsible for selecting the best negotiation strategy for the broker to use during the auction, e.g. truthful, concession making, BH-strategy, or Efficient Bidding Strategy (EBS) [18-22].

3. METHODOLOGY

This research postulated four activities that are depicted in Figure 2. The listed four activities are literature review, cloud service marketplace investigation, data formulation and double auction-based negotiation framework development.

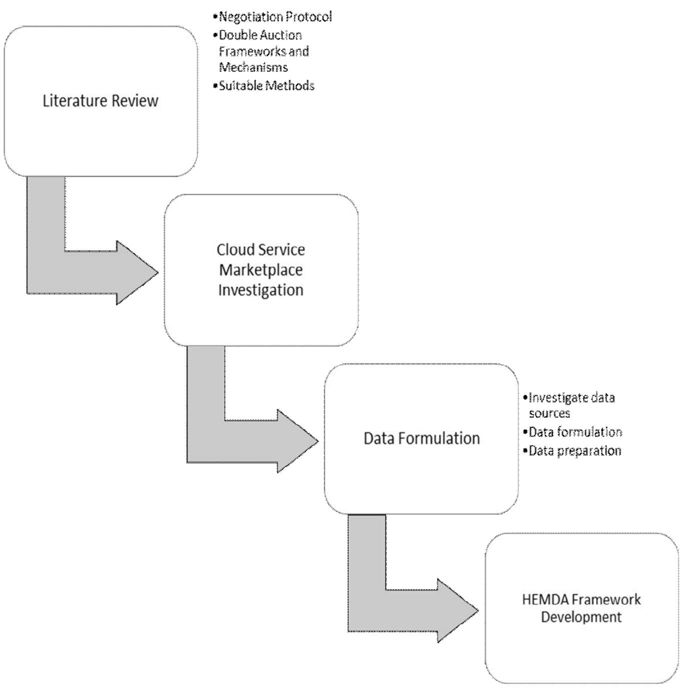

Figure 2: The research activities.

The framework is proposed after completing the first three activities: literature review, cloud service marketplace investigation, and data formulation. The literature review was conducted to investigate the problem domain, identify gaps, analyse related works, and find applicable methods for the research. The sources of the study are books, journals, conference proceedings and papers, and online articles. The cloud service marketplaces, namely, Amazon EC2, Google IaaS, Microsoft Azure, Zimory and CloudSurfing were investigated after the literature review was conducted. The goal of the review is to gain an understanding of how the marketplaces were developed and current tools available in the marketplaces. Another goal of the review is to identify the types of required datasets.

4. PROPOSED FRAMEWORK

The double auction framework illustrated in Figure 1 has limitations. Firstly, the auctioneer was designed to auction only a single type of cloud service. The problem lies in heterogeneous cloud services, where the auction coordinator must create multiple auctioneers based on the number of cloud services. The size of the solution space will increase as well as the execution time. It could lead to sub-optimal results in service discovery and matchmaking. Therefore, the frameworks would be inefficient if applied for heterogeneous cloud services, especially in real-time auctioning using the CDA.

Secondly, the service preferences mechanism illustrated in Figure 1 calculated the utility based on a single attribute which is the price [14]. It was designed for a single-attribute negotiation. It is perhaps crucial for the cloud service negotiation mechanism to consult various properties of various options to meet bidder`s decisions [3, 4]. For the heterogeneous cloud services, the mechanism must compute the utilities for multi-attributes. The results could be sub-optimal as negotiations are more difficult for heterogeneous cloud services and multi-attributes [2-4]. Consequently, the results can increase service adoption costs, resource wastage, negotiation delay, and risks [23-29].

Thirdly, the matching function used by the auctioneer was designed to sort and match bids and cloud services only for a single attribute. The matching function, which was used to determine the winner, should be designed for sorting and matching multi-attributes services. Also, the execution time of the double auction frameworks and mechanisms must be considered. Several mechanisms have been reported to have longer execution time due to the utilization of various algorithms [30]. It was also suggested that the speed of negotiation should be increased [22]. Therefore, it is important to test the double auction frameworks and mechanisms for execution time and ensure it can be implemented efficiently within an acceptable time. The researcher believes the term ‘acceptable time’ means the framework and its mechanism can work in real-world scenarios such as in the cloud-based marketplace.

The proposed framework was instigated with the investigation of cloud service negotiation frameworks from the literature [6, 31-35]. The aim was to understand how the existing cloud service negotiation frameworks were proposed and developed. Subsequently, the double auction protocols and frameworks were investigated to understand the current design of M-N double auction frameworks for cloud service negotiations. Then, the market requirements and auction requirements were identified from related works.

4.1 Market Requirements

Market requirements are necessary for an exchange marketplace [36]. The market requirements are shown in Table 1.

Table 1: Market requirements that a cloud service negotiation framework should fulfill.

Market requirements	Descriptions	Proposed Framework
Multiple application models and compute services	The framework must support various customer resource requirements and the provider's services. In other words, the framework should be able to accommodate multi-attributes resources requirements and heterogeneous cloud services [36].	The proposed framework can accommodate multiple application models and compute services. However, the current framework limits the number of negotiation attributes to five (price, VCPU, RAM, storage size, and time slot.
Multiple user objectives	The framework should be able to satisfy different customers' objectives such as cost reduction and benefit maximization [33, 36, 37]. It should have matching strategies to meet different objectives.	The framework can support different customers` objectives using the multi-attribute utility function. Meanwhile, the different objectives have been matched to heterogeneous cloud services using the multi-attribute matching function. However, to support the different business level objectives simultaneously such as client satisfaction and cost reduction, the framework must be further expanded.
Resource discovery	The framework should allow customers to access and discover heterogeneous resources on-demand [36].	The framework can discover heterogeneous cloud services as a result of the proposed automatic clustering mechanism. On the other hand, the proposed multi-attribute negotiation mechanisms can allow service customer to prioritize their needs based on the attributes.
Support for multiple market models	The framework should be generic enough to support many market models [36].	The framework is flexible in adapting the negotiation protocol for its auctioneers (either double auction or CDA). Besides, the proposed multi-attribute negotiation mechanism can support combinatory cloud services [7]. The proposed framework negotiation protocol is suitable to be extended into the combinatorial double auction.
Coexistence/isolation of market models	The framework should support different negotiation protocols concurrently [36].	The framework is flexible in choosing the negotiation protocol for the auctioneers (either double auction, CDA, or any other forms of auction). The auctioneers can run concurrently. However, the coordination of different protocols will be challenging.
Support for holding, joining. and discovering auctions	The service customers may have their bids lose or unmatched in the current auction. Also, they can discover, wait, or join other auctions if necessary [36]	The framework's broker agents can hold, join, and discover auctions according to the negotiation strategy.

4.2 Auction Requirements

Auction requirements defined the parameters of the auction design space [38]. The auction requirements are shown in Table 2.

Table 2: Auction requirements that an auction-based framework should consider [38].

Auction requirements	Descriptions	Proposed Framework
Bidding rule	i) A bid refers to a message that states an agent is willing to make an exchange (money for service or vice versa) [38]. ii) The bid dominance rule determined the relationship of an agent's new offer to the current bid. iii) The Beat-the-Quote rule set the conditions for a new bid compared to bids by other bidders and often complimentary with the bid dominance rule.	i) The proposed framework express bids for multi-attributes namely, the VCPU, RAM, storage size, cost per hour, and time slot attributes. ii) The service customers and providers have been allowed to compete in M-N auctions. The broker agents generate and place bids autonomously on behalf of the service customers. iii) The framework`s bid dominance rule was set to increase. iv) A prior bid can only be replaced by a superior bid. This is to ensure bid progression. v) The framework's beat-the-quote rule has been set where a new bid must be superior to the currently unmatched bid in the auction. It is to ensure bid progression. vi) Bids have been allowed to be withdrawn if it is not matched. vii) The framework only allowed broker agents to replace their current bids in each round. The agent must progressively make bids to stay in the auction.
Clearing policy	i) The clearing policy determines the allocation of resources [38]. ii) The clear timing policy determines when a clear should occur in the auction, namely, scheduled, random, bidder activity, or bidder inactivity. iii) The closing conditions determine when a clear should be a final clear. It is known as the end of a trading day, a period when service customers and providers are allowed to submit offers and bids [20]. iv) Tie-breaking is when two brokers bid for the same resources at the same price.	i) The proposed framework matching function has been conditioned to maximize total surplus, p^1-p^2. The p^1 refers to the service buying price and p^2 is service selling price [38]. The auctioneer sorted bids in descending order and cloud services in ascending order. ii) The framework clear timing policy is bidder activity (common for CDA) where clear occurs when a new bid is received. The policy can be triggered when a certain number of bids are received (5,10,20…) for handling a larger number of transactions. iii) The framework closing conditions have been determined according to the experimental setting. iv) The framework preferred bid that was placed

		earlier or bid with the larger quantities.
Information revelation policy	i) The information is revealed as a quote function that represents the summary of current bid state. ii) Quote timing iii) Order book refers to the set of active bids. iv) Transaction history is information about past exchanges.	i) The proposed framework has shown the minimum and maximum values for each cluster. It is anonymous where the same quote is reported to every broker agent. The price has been determined by the average of the matched bid and service. ii) The framework has generated the price quote with new bidder activity. iii) The framework has close book policy where active bids are not shown. Only the highest service utilities for each cluster are shown to the broker agents. iv) The framework has not publicized any historical information to the broker agents as it is not necessary for this study.

The framework is designed according to market requirements and auctions requirements that fulfilled and considered multiple application models and compute services, multiple user objectives, resource discovery, support for multiple market models, coexistence/isolation of market models, support for holding, joining and discovering auctions, auctions' bidding rule, clearing policy, and information revelation policy.

The framework is designed to have similar functionalities to the CloudSim, i.e. for modeling and simulation of cloud computing infrastructures and services [39]. However, the proposed framework was made specific to cloud service negotiation. The architecture of the proposed framework is illustrated in Figure 3.

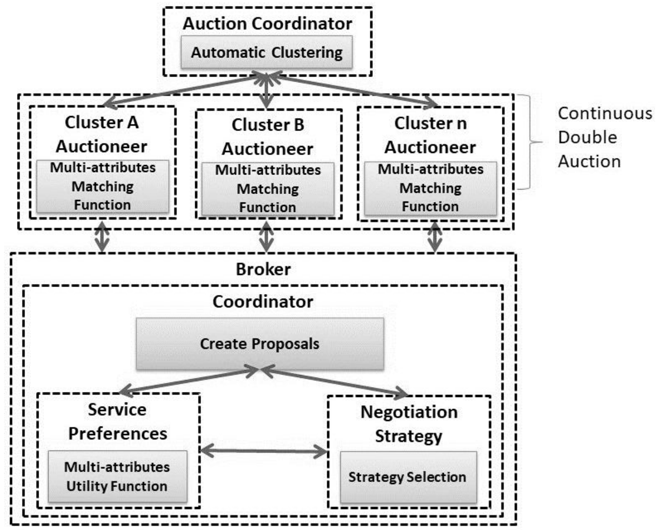

Figure 0: The proposed framework.

The proposed framework was constructed with:

A. Automatic Clustering Mechanism

The auction coordinator uses the proposed automatic clustering mechanism to cluster heterogeneous cloud services into several clusters, namely, cluster A, cluster B, …n as shown in Figure 3.

The auctioneer agents manage concurrent double auctions for each cluster (cluster A, cluster B, and cluster C). The aim of using clustered cloud service concurrent negotiations is to reduce the number of individual cloud service concurrent negotiations.

B. Multi-attribute Negotiation Mechanism

The proposed multi-attribute negotiation mechanism of the proposed framework consists of two main functions which are multi-attribute utility function and multi-attribute matching function (as shown in Figure 3).

The broker agent negotiates on behalf of the customer. The broker agent consists of a coordinator. The coordinator creates a proposal using the service preference mechanism and negotiation strategy mechanism. The service preference mechanism consists of the proposed multi-attribute utility function while the strategy mechanism selects suitable a strategy during negotiation.

5. CONCLUSION

The investigations of current literature have identified that the current double auction frameworks would be inefficient if applied for heterogeneous cloud services, especially in real-time auctioning using the CDA. Furthermore, the current frameworks only focused on single attribute negotiations. Therefore, this paper presented a double auction framework that able to accommodate both heterogeneous and multi-attributes cloud service negotiation.

ACKNOWLEDGEMENT

The author would like to thank Universiti Pendidikan Sultan Idris, Universiti Teknologi PETRONAS and Dhofar University for supporting this study.

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