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CloudNeg: An Autonomous Multi-Issue Negotiation System, with Preference Elicitation Component, for Trading Cloud Services

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Abstract. Cloud services provide its users with flexible resource provisioning. But in the current market, a user has to choose from a limited set of configurations at a fixed price. This paper presents an autonomous negotiation system termed CloudNeg for negotiating cloud services. CloudNeg provides buyers and sellers of cloud services with autonomous agents to negotiate on the specifications of a cloud instance, including price, on their behalf. These agents elicit their buyers' time preferences and use them in negotiations. Further, this paper presents two artifacts: a negotiation algorithm and a prototype which together form CloudNeg.

Keywords: cloud computing, time preference, autonomous negotiation, design science.

1 Introduction

Cloud computing is a computing paradigm in which users buy IT resources as a service. It offers several advantages to buyers like reduced operating costs, scalability and flexibility but at the same time poses challenges like data lock-in, confidentiality and service availability[1]. US National Institute of Standards and Technology (NIST) classifies cloud computing service models into Infrastructure as a Service (IaaS) e.g. Amazon EC2, Platform as a Service (PaaS) e.g. Microsoft Azure and Software as a Service (SaaS) e.g. Salesforce.com. These cloud services can be availed either directly through vendors or through e-marketplaces. We draw motivation for this research from the increasing focus on adoption of electronic negotiations (e-negotiations) for cloud computing services [2], [3].

A negotiation can be manual or automated. Research has shown that automated negotiations are faster and provide higher utilities and better agreement rates as compared to human negotiators [4]. Thus agent based automated negotiation is adopted. Furthermore, e-agents represent buyers and sellers and therefore, it becomes imperative for the negotiating agents to acquire their user's trade-off preferences to be able to negotiate better [5].

Some researchers have tried integrating preference elicitation with agent technology in the past [6]. While representing those preferences, it is assumed that preferences of issues (like price, bandwidth and time) are independent of each other. But, from the literature on behavioral sciences (intertemporal choice) [7], [8] one can infer that the preferences among delivery time and other issues (such as bandwidth and storage speeds) are not independent.

Frederick et al. [7] define time preference as "preference for immediate utility over delayed utility". To capture this time preference, Samuelson [8] gave the discounted utility model which discounts the future payoffs exponentially. Though the model is simple and convenient it fails to explain various intertemporal anomalies, one of them being the common difference effect [9]. The common difference effect essentially means that preferences might switch when incremented by constant delay, a property known as non- stationarity. To explain this anomaly, Lowenstein and Prelec [9] proposed a generalized hyperbolic discounting. Extending this effect in the context of procuring cloud services, the trade-off between delivery time and other parameters can change with time. A person who might pay higher to get a delivery of a cloud instance in 5 hours over 10 hours may not pay a higher price for the delivery of a cloud instance in 30 hours over 35 hours. Even though the difference between the choices offered is same but the choices have been delayed by 25 hours [9]. Such kind of behavior can give real insights on how a buyer perceives different offers and can help negotiating agent get a deal which might maximize buyer's utility. Krishnaswamy & Sundarraj [10] have explored this by analyzing the effect of time discounting on offer concessions in e-negotiations. They have suggested incorporation of intertemporal preferences in e-negotiations. Pahuja et al. [11] have used Time Tradeoff (TTO) sequence to elicit time preference in the context of movie ticket negotiations but they have dealt with only price and time negotiations. Also they did not elaborate on the details of offer evaluation and generation during a negotiation. This research attempts to improve extant system by developing a multi-issue negotiation system (CloudNeg) incorporating time preferences using a design science approach. CloudNeg provides a platform for automated negotiations between buyers and sellers on the following cloud service specifications: price, time, bandwidth, storage read and write speeds. CloudNeg also provides a preference elicitation subsystem to gather buyer preferences. The system is elaborated on in subsequent sections.

2 Design Science Research Methodology

CloudNeg is developed using a design science research approach. Our research is aimed at developing artifacts which together constitute an e-negotiation system for cloud services. The research approach follows the set of guidelines prescribed by Peffers et al. [12] for the design and implementation of the artifacts.

Identify problem and motivation.

Even though there exist quite a few E-commerce negotiation platforms like the MAGNET and Genius, time preference elicitation has not been given due importance

in the autonomous negotiation literature . Alsrheed et al. [3] present a cloud negotiation system, but their work primarily focusses on algorithms for automated negotiation and not on preference elicitation and its incorporation. Experiments conducted by Krishnaswamy & Sundarraj [10] established the need for efficient representation of time preferences in the context of cloud negotiations. Works of Son & Sim [2] do consider time slot negotiations but their algorithm relies on the preferential ordering of the time slot as stated by the buyer. In their work, they have interpolated the utility of intermediate time slot which fall between the ordered time slot preferences. The streams on intertemporal choice and e-negotiations have been disjoint. We propose a different approach to time slot (delivery time) negotiations in an attempt to emulate user behavior. This is achieved by modelling the time discounting behavior of buyers and then using it to discount the utility of other issues with respect to delivery time of the offer.

Define objectives of a solution.

To this end, we define the objectives leading to the development of proposed negation system. The first objective is to design a system that is capable of modelling and user's devaluation of utility with time. This is achieved by implementing a time preference elicitation subsystem, using the concept of discounting function[1]. Discounting function governs the trade-offs between time and other issues (price, bandwidth, storage speeds). The second objective is to develop a modular negotiation system that exposes the APIs necessary for offer generation and evaluation, thus enabling an option to test different strategies.

Design and development.

At the design stage, we look into the literature on intertemporal choice to estimate the time discounting function from the time preference. We adapt a tool called as Time Trade-off Sequence proposed by Attema et al. [13]. TTO sequence is favoured because it does not assume linear utility and focusses on single outcome. The only drawback of this method is that it assumes that the discounting function doesn't change over time. The design of the system is based on negotiation systems proposed by Lin et al. [14]. The interaction of preferences with offer generation and evaluation is adopted from the mechanism proposed by Venkataraghavan & Sundarraj [10].

Demonstration.

Based on the objectives, we have developed two artifacts: an algorithm to approximate preferences and a prototype instantiation exhibiting modular design. The proof of concept, which dealt with price and time negotiations only, was demonstrated at GDN 2014 [11]. The artifact was extensively modified to accommodate multi-issue negotiation, since in real life negotiations include several issues other than price and time.

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[1] A mathematical function to capture a person's impatience. E.g. Samuelson's Discounted Utility Model [8]

Evaluation.

We will use a case study approach, based on guidelines given by Yin [15], to evaluate CloudNeg. Case studies will primarily consist of semi-structured interviews with buyers of cloud services to understand their perceptions of such a system.

3 Research outputs:

3.1 Artifact 1 : An Algorithm to capture buyer's preferences and use them in negotiations

Given that an offer is received, the algorithm calculates the utility of the received offer, and then based on the utility for that round it either accepts the offer or proposes a counter. Accordingly, we divide the algorithm into three parts: the first part deals with calculation of utility of the received offer, the second part elaborates on round-on-round utility concessions and the third part describes the steps involved in proposing a counter offer.

Part 1: Calculating the utility of a received offer.

In this part of the algorithm, buyer's preferences about price, delivery time, bandwidth, storage read and write speeds are captured into a multi-attribute utility model, which is then discounted using buyer's time preference. This part can be further divided into three segments: the first segment deals with multi-attribute utility model, the second with time discounting of utility and the final with cumulative utility model.

Segment 1: Multi-attribute utility model.

1. The agent asks the buyers about maximum and minimum acceptable values of the issues other than delivery time (price, bandwidth and storage read and write speeds). It also asks about the weights of the issues, which signify their relative importance.
2. The utility of these issues is calculated using the multi-attribute utility model

$$U(X) = \sum_{1 \le j \le n} w_j \, U_j(x_j) \tag{1}$$

where $U_j(x_j)$ is the utility of issue j at value x_j, from the received offer. Further, buyers value a lower price and higher bandwidth, storage read and write speeds. Therefore utility function for price is

$$U_{price}(p) = \frac{p_{max} - p}{p_{max} - p_{min}} \tag{2}$$

where p is the price and p_{max} and p_{min} are maximum and minimum acceptable values of price.
Utility function for bandwidth, storage read and write speeds is

$$U_j(x_j) = \frac{x_j - x_{min}}{x_{max} - x_{min}} \tag{3}$$

where x_j is the value of the issue (bandwidth, storage read and write speeds) and x_{max} and x_{min} are maximum and minimum acceptable values of that issue.

Segment 2: Time discounting of utility.

1. To capture buyer's time preference, electronic agent then administers TTO sequence [13] to get the parameters of discounting function CRDI 2 [16]

$$\phi(t)=ke^{-a\ t^{1-\delta}} \tag{4}$$

where a > 0, δ < 1, k > 0
Given a delivery time t, equation 5 gives the corresponding discount factor

Segment 3: Cumulative utility function.

Incorporating time preference into the multi-attribute utility model, the proposed discounted utility model is

$$U(X,t)=U(X)\phi(t) \tag{5}$$

where $U(X)$ is the utility of all the issues except delivery time; $\phi(t)$ is the discount factor at delivery time t.

Part 2: Round-on Round Utility Concessions.

The negotiating agents employ tactics, a set of functions derived from buyer's preferences, to calculate utility for a particular time. Tactics can belong to one or more of the following types: time dependent, resource dependent and behavior dependent [17], [18]. In this research, agents use the time dependent tactic to vary the utility with negotiation round.

$$U_r=U_{min}+(1-\alpha^r)(U_{max}-U_{min}) \tag{6}$$

where $\alpha^r=\left(\frac{r}{r_{max}}\right)^{\frac{1}{\beta}}$; $U_r \in (0,1]$;
r is the current round and r_{max} is the maximum number of rounds
$U_{min}=0$ & $U_{max}=1$ are maximum and minimum utility

Based on the value β, time dependent tactic can be classified into two sets of families: boulware and conceder. If β < 1, the agent does not concede significantly on utility until the deadline almost expires, and then it makes large concession upto u_{min}. This type of behavior is termed as boulware. If β > 1, the agents concedes substantially in the initial rounds and not so much till the deadline is reached their behavior is termed as conceder. (See figure 1).Based on their TDTs, agents decide on the utility for a particular round (u_r), which they use to accept an offer or propose a counter.

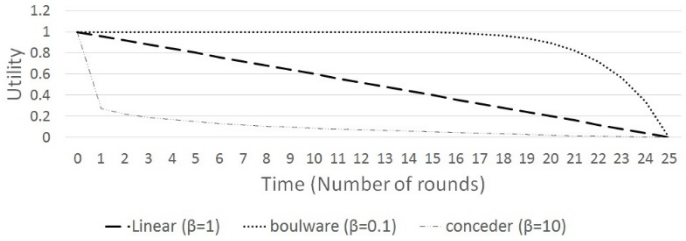


Fig. 1. Round on round utility concession using time dependent tactic

Part 3: Offer Generation.

1. The utility of the current round is calculated as per the second part of the algorithm.
2. An offer is accepted if the utility of that offer is more than or equal to expected current round utility, else multiple concurrent counteroffers are proposed by trading-off the distribution of utility between discount factor $\phi(t)$ and utility of issues other than time $U(X)$.
3. Delivery time is calculated using inverse of CRDI 2 function (equation 4) and values of other issues are calculated using the utility functions (equations 2 and 3) described in part 2.

3.2 Artifact 2 : System Instantiation

CloudNeg sports a modular design, which enables testing different negotiation strategies. There have been many negotiation systems proposed in the past, but, to the best of our knowledge, none of them focus on eliciting time preference and using them in multi-issue negotiations. Work of Luo et al. [6] is somewhat closer to our work. They employ a default-then-adjust method to elicit buyer's trade-off preferences. But neither do they consider non-linear preferences like time preference nor they provide a mechanism to use the trade-off preferences in negotiations.

It is assumed that buyers and sellers are negotiating on pre-agreed set of issues. The negotiation system is targeted at the post discovery phase. The negotiations are time bound and the negotiating agents are self-interested and utility maximizing. An alternating offers protocol is followed, where e-agents take turns to propose offers.

Logical Description.

CloudNeg can be logically divided into two main subsystems: preference elicitation and negotiation. Preference elicitation subsystem deals with eliciting buyer's preferences and converting them to actionable reasoning model which will be used during negotiation. The negotiation subsystem takes over once preference elicitation is done. It loads the seller preferences and buyer preferences into their respective automated negotiating agents and establishes a communication channel between them. Negotiations begin by buyer proposing an offer. Negotiation ends once an agreement is reached or the deadline is expires.

Technical Description.

CloudNeg follows a Model View Controller (MVC) architecture (see figure 2) by implementing Struts2 framework. The web application is hosted on Apache Tomcat Web server. GUI comprises of a set of JSPs, which are used to record buyer preferences and display negotiation outcome. Code for negotiation subsystem is linked to the controller. The negotiation subsystem communicates with database (MySQL) to retrieve seller profiles and system properties, and store the results of negotiation. Hibernate framework is used to map the model to MySQL tables.

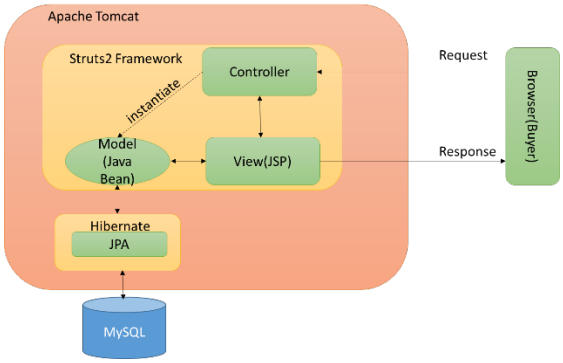


Fig. 2. Overview of technical implementation of CloudNeg

4 Conclusion, limitations and future work.

In this paper, CloudNeg is presented as an artifact for negotiating cloud services. It was developed using DSR approach. The system was described in general and a prototype was developed. The novelty of the system is in its approach to integrate time preferences with negotiation systems. There have been attempts to apply behavioral economics to understand the individual decision making process in the context of Information Systems and our work is a step forward towards understanding those decision making behaviors and making the system imitate part of it in a negotiation setting. We limited the time preference elicitation to TTO sequence [13] due to practicality issues. Other preference elicitation techniques need to be explored in order to adapt them to current context. Effects of loss aversion and reference dependence on negotiation behavior need to be studied and incorporated with the system. Current implementation of CloudNeg features only preference elicitation and negotiation subsystems. Other supporting subsystems such as service discovery and negotiation ontologies need to be implemented. We leave this for future work.

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