ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

A Mixed Approach of Negotiation in Internet of Things for Cloud Environment

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ABSTRACT:

Internet of Things (IoT) allows connected objects to communicate via the Internet. IoT can benefit from the unlimited capabilities and resources of cloud computing. Also, when coupled with IoT, cloud computing can in turn deal with real world things in a more distributed and dynamic manner. As the cloud market becomes more open and competitive, Quality of Service (QoS) will be more important.

However, cloud providers and cloud consumers have different, and sometimes opposite, preferences. If such a conflict occurs, a Service Level Agreement (SLA) cannot be reached without negotiation. A tradeoff negotiation approach can outperform a concession approach in terms of utility, but may incur more failures if information is incomplete.

To balance utility and success rate, we propose a mixed approach for cloud service negotiation, which is based on the "game of chicken." In particular, if one is uncertain about the strategy of its counterpart, it is best to mix concession and tradeoff strategies in negotiation.

To evaluate the effectiveness of this approach, we conduct extensive simulations. Results show that a mixed negotiation approach can achieve a higher utility than a concession approach, while incurring fewer failures than a trade off approach.

Index Terms:

Cloud computing, Internet of Things (IoT), mixed negotiation approach, Quality of Service (QoS).

INTRODUCTION:

I NTERNET OF THINGS (IoT) is expected to be a worldwide network of interconnected objects [7].

IoT allows objects like computers, sensors, mobile phones, etc. to communicate via the Internet. It is characterized by limited capacities and constrained devices, and its development depends on new technologies including cloud computing. IoT can benefit from the unlimited capabilities and resources of cloud computing.

Also, when coupled with IoT, cloud computing can in turn deal with real world things in a more distributed and dynamic manner. In this sense, IoT and cloud computing can complement each other.

Cloud services are Internet-based IT services. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are three representative examples.Compared with other models, cloud services are easier to access and use, cost-efficient, and environmentally sustainable.

As theyeliminate large upfront expenses in hardware and expensive labor costs for maintenance, cloud services are beneficial to small- and medium-sized enterprises. Moreover, large-sized enterprises with computationally intensive tasks can obtain results quickly, since their applications can scale up promptly.

As the cloud market becomes more open and competitive, Quality of Service (QoS) will be more important. However, cloud providers and cloud consumers have different and sometimes opposite preferences.

For example, a cloud consumer usually prefers a high reliability, whereas a cloud provider may only guarantee a less than maximum reliability in order to reduce costs and maximize profits.

If such a conflict occurs, a Service Level Agreement (SLA) cannot be reached without negotiation. Automated negotiation occurs, when software agents negotiate on behalf of their human counterparts.

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It has been studied in electronic commerce and artificial intelligence for many years and is considered as the most flexible approach to procure products and services.

Existing System:

IoT allows connected objects to communicate via the Internet, whereas cloud computing promises unlimited resources delivered over the Internet . Zhou et al. review the state of the art of integrating IoT and cloud computing and propose a cloud-based IoT platform to facilitate things application development. In conducting service research, many ideas and methods have been proposed . QoS is important in discovering, selecting, and composing Web services , grid services and cloud services. Li et al. report that commercial cloud services are not yet stable and ask for more attention to the performance, reliability, scalability, and security issues of cloud services. Wang et al. argue that QoS and SLAs are increasingly emphasized in enterprise cloud services, and automated SLA and adaptive resource management are needed. Automated negotiation occurs when software agents negotiate on behalf of their human counterparts. It has been studied in artificial intelligence and electronic commerce for many years .Jennings et al. argue that negotiation is the most fundamental mechanism to manage runtime dependencies among agents, and thus underpins cooperation and coordination.Lomuscio et al. argue that automated negotiation underpins the next generation of electronic commerce systems, and develop a classification scheme for negotiation in electronic commerce. It offers a systematic basis on which different negotiation mechanisms can be compared and contrasted.

Proposed System:

Internet startups are able to reside on a cloud to build their services even without their own infrastructure. A storage cloud allows users to store their data in data centers without worrying about backup, such that they can focus on their core businesses Amazon Simple Storage Service (Amazon S3), Microsoft Windows Azure Blob Storage (Azure Blob), and Aliyun Open Storage Service (Aliyun OSS) are three well-known storage clouds . Here, we present a motivating example, where a StorageConsumer (SC) negotiates over QoS with a Storage Provider (SP). It contains conflicts that cannot be resolved without negotiation. Suppose that, five attributes, i.e., Availability (AVAL), Reliability (REL), Responsiveness (RESP), Security (SECY), and Elasticity (ELAS), are used to describe a storage cloud, as shown in Table I. The numbers are built upon our experiences with real-world storage clouds . Refer to for the definitions and the metrics of the five attributes. It is also shown in Table I that for the SC, availability is a higher-is-better attribute, for which a symbol is assigned beside its preferred values.

By contrast, for the SP, availability is a lower-is-better one, for which a symbol is assigned beside its preferred values. However, the two parties differ in their preferences over availability. The SP puts a weight of 0.20 on availability,whereas the SC places a weight of 0.10 on it. For conciseness, we list corresponding numbers for other attributes in Table I, without going into details.

MULTI-ATTRIBUTE BILATERAL NEGOTIATION:

Here, we introduce multi-attribute bilateral negotiations, with a focus on their negotiation protocol and negotiation strategies. In bilateral negotiations, two agents have a common interest in cooperation, but have conflicting interests regarding the particular way of doing so . In multi-attribute negotiations, multiple issues are negotiated among agents, where a win–win solution is possible.

However, a multi-attribute negotiation is more complex and challenging than a single-attribute one, because of complex preferences over multiple issues and the multiple-dimensional solution space. For multi-attribute bilateral negotiations, which we deal with in the paper, their negotiation protocol and negotiation strategies merit special attention .

Negotiation Protocol:

A negotiation protocol specifies the “rules of encounter” among agents . In this paper, we adopt an alternating-offers protocol for cloud service negotiation . In multi attribute bilateral negotiations, two agents alternately exchangetheir proposals and counter proposals, until one of them accepts a proposal, a failure to reach an agreement happens, or the deadline is reached. If the first case occurs, the negotiation ends successfully with an agreement established; otherwise, it fails and terminates with no deal made.

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Once the negotiation protocol is chosen, negotiation strategies become critical. Two negotiation strategies, concession and tradeoff , can be used to make a proposal. When the deadline approaches or something undesirable happens, a party has to concede in order to make a deal. With a concession strategy, the party gradually reduces its utility until all conflicts are resolved.

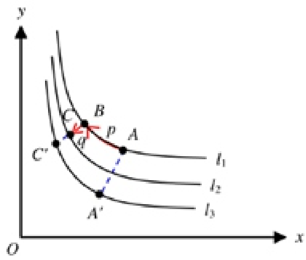

Fig. 1. Mixed negotiation approach.

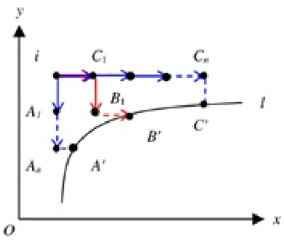

Fig. 2. Agent i's mixed behavior.

Mixed Negotiation Approach:

An agent may receive less utility, but has a higher chance to reach an agreement. With a tradeoff strategy, the agent may get more utility, but incurs more failures, if information is incomplete. To balance utility and success rate, we propose a mixed negotiation approach for cloud service negotiation, which is based on the "game of chicken."

A.Two-Player Negotiation Game:

In a negotiation game, a selfish agent's utility remains the same with a tradeoff strategy, whereas its utility is decreased with a concession one. As the agent attempts to maximize its utility, it seems that it should stick to the tradeoff strategy instead of the concession one. . If the agent and its counterpart both adopt the tradeoff strategy, unfortunately, it is very likely that a failure happens, whereupon both receive the worst utility. It thus becomes a dilemma. This indicates that how to play concession and tradeoff strategies is of utmost importance. However, to the best of our knowledge, no previous work deals with this problem.

In fact, we first identify the problem and model it with the "game of chicken," which goes as follows [2]. Two boys, say Alan and Bob, want to prove their manhood. They drive toward each other at breakneck speed. The one who swerves loses face and becomes a "chicken," whereas the other who stays, of course, proves his manhood and becomes a hero to his friends. If both swerve, nothing is proved. If neither swerves, they crash into each other with potentially disastrous results. A possible payoff matrix of the game of chicken is shown in Table II, where a number only has a relative significance, namely, the greater the number, the higher the payoff. A Nash equilibrium is "a situation in which each player in a game chooses the strategy that yields the highest payoff,given the strategies chosen by the other players" [2]. The "game of chicken" has two pure strategy Nash equilibria. One is for Alan to swerve and for Bob to stay, whereas the other is for Alan to stay and for Bob to swerve. In fact, if Alan swerves, Bob is better off staying (payoff 1) than swerving (payoff 0). Conversely, if Alan stays, Bob is better off swerving (payoff −1) than staying.

TABLE II
GAME OF CHICKEN

		Bob	
		Swerve	**Stay**
Alan	**Swerve**	0, 0	−1, 1
	Stay	1, −1	−10, −10

TABLE III
TWO-PLAYER NEGOTIATION GAME

		Player 2	
		Concession	**Tradeoff**
Player 1	**Concession**	b_1, b_2	c_1, a_1
	Tradeoff	a_2, c_2	d_1, d_2

(Payoff −10). So, those are the two pure strategy Nash equilibria. Below, we give a formal description for Nash equilibrium [6].

Definition 1 (Nash Equilibrium): A Nash equilibrium is a strategy profile $s^* = (s_i^*, s_{-i}^*)$, such that each player, $i\ (i = 1, 2, \ldots, n)$, has no incentive to deviate from its current strategy, s_i^* given the strategy profile, s_{-i}^* of the other players, where $s_{-i}^* = \{s_1^*, s_2^*, \ldots, s_{i-1}^*, s_{i+1}^*, \ldots, s_n^*\}$.

A general payoff matrix of a two-player negotiation game with concession and tradeoff strategies is shown in Table III, where $a_1, a_2, b_1, b_2, c_1, c_2, d_1, d_2 \in R$ and $a_1 \geq a_2 > b_1 \geq b_2 > c_1 \geq c_2 > d_1 \geq d_2$. It should be noted that, here, the game is asymmetric, in that the two players are distinguishable from each other, and is more applicable, in that it generalizes the "game of chicken." We establish Theorem 1 to determine its pure strategy

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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Nash equilibria. Refer to [30] for the proof.

Theorem 1 (Negotiation With Complete Information): Let G be a two-player negotiation game, whose payoff matrix is shown in Table III. There exist two pure strategy Nash equilibria for G. One is for Player 1 to make a concession and for Player 2 to make a tradeoff, whereas the other is for Player 1 to make a tradeoff and for Player 2 to make a concession.

In the above negotiation game, the best move of a player is to do the opposite of what its counterpart decides. So, it is important for the player not to have its behavior anticipated by its counterpart. In other words, its behavior should be unpredictable. A good way to achieve this is to let chance decide. In contrast to the case with pure strategies, where a player attempts to maximize its payoff, a player, here, employs a *mixed strategy* to maximize its *expected payoff* [30]. Below, we give a formal description for the mixed strategy, the payoff function, and the expected payoff concepts.

Definition 2 (Mixed Strategy): For a player i, its mixed strategy $\sigma = (p_1, p_2, \ldots, p_m)$ is a probability distribution over a set of pure strategies, $S = \{s_1, s_2, \ldots, s_m\}$, where i plays s_j $(j = 1, 2, \ldots, m)$ with probability p_j $(p_j \geq 0$ and $\sum_{j=1}^{m} p_j = 1)$.

Definition 3 (Payoff Function): For a player, i, its payoff function, π, is a real-valued function $\pi : S \rightarrow R$, such that $\pi(s)$ is the payoff to i when strategy $s \in S$ is chosen, where S is a set of pure strategies.

Definition 4 (Expected Payoff): For a player i, its mixed strategy $\sigma = (p_1, p_2, \ldots, p_m)$ and its payoff function, i's expected payoff of σ, is $\pi(\sigma) = \sum_{j=1}^{m} p_j \times \pi(s_j)$, where s_j $(j = 1, 2, \ldots, m)$ is a pure strategy of i.

We establish Theorem 2 to determine the mixed strategy Nash equilibrium of a two-player negotiation game with concession and tradeoff strategies. Refer to [30] for the proof, and [6] for *incomplete information game*.

Theorem 2 (Negotiation With Incomplete Information): Let G be a two-player negotiation game, whose payoff matrix is shown in Table III. There exists a mixed strategy Nash equilibrium $\sigma^* = (\sigma_1^*, \sigma_2^*)$ for G, where Players 1 and 2 play σ_1^* and σ_2^*, respectively, and $\sigma_1^* = \left(\frac{a_1 - b_2}{a_1 + c_2 - b_2 - d_2}, \frac{c_2 - d_2}{a_1 + c_2 - b_2 - d_2}\right)$, and $\sigma_2^* - \left(\frac{a_2 - b_1}{a_2 + c_1 - b_1 - d_1}, \frac{c_1 - d_1}{a_2 + c_1 - b_1 - d_1}\right)$.

B.Game-Theoretic Description:

A mixed strategy is "a choice among two or more pure strategies according to prespecified probabilities," where a pure strategy is a specific choice of possible strategies [2]. A mixed negotiation approach works as follows. In preparing a proposal, a party plays a concession strategy with a certain probability and a tradeoff strategy with another probability. In the case that a concession strategy is played, the utility of its reference proposal, on which a counter proposal is based, is reduced; in the case that a tradeoff strategy is played, the utility of its reference proposal remains the same .Similarly, the values of its attributes are adjusted, accordingly, in favor of its counterpart. So, the party can encourage its counterpart to accept the proposal with a higher probability, but at a reasonable price. In fact, the idea of mixed strategies can be traced back to Nash's 1950 seminal paper on Equilibrium Points in n-Person Games, where a mixed strategy is defined as probability distributions over a finite set of pure strategies [11].

A graphical representation of a mixed negotiation approach is depicted in Fig. 1. Without loss of generality, a two-dimensional space xy is assumed here. Also, utility functions are assumed to be nonlinear and additive (i.e., Assumptions 3 and 4). Let l_1, l_2, and l_3 be the indifference curves of a party's preferred proposal, its counter proposal, and the preferred proposal of its counterpart, respectively. In economics, an indifference curve connects a set of consumption baskets that yield the same level of utility to a consumer [2]. Again, let point A correspond to the party's initial proposal, and point B its counter proposal. Especially, when the party randomizes its choices of strategies, it moves along l from point A to point B, with probability p, where a tradeoff strategy is played, and so no utility is reduced from l_1. It then moves from point B to point C, with probability $q(p \quad q = 1)$, where a concession strategy is played, and thus a certain amount of utility is reduced from l_1, but is closer to l_3, since $|CC'| < |AA'|$ Similarly, the party moves toward the preferences of its counterpart, but only a reasonable amount of utility is reduced from its preferred proposal by doing so.

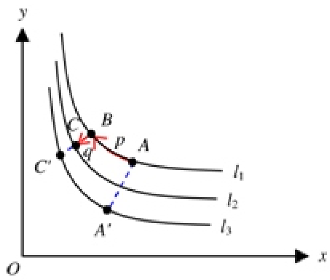

Fig. 1. Mixed negotiation approach.

C.Algorithmic Description:

Algorithm 1 implements a mixed negotiation approach. It works as follows. First, in line 1, agent sends —its initial proposal—to agent , and waits for a response. If does not accept and 's counter proposal is not acceptable to , then adopts a mixed approach in the while loop of lines 2–15 to create a new proposal; otherwise, true is returned in line 16. Here, a party's acceptance criterion is that the utility received from a proposal is no less than that of its reserved proposal, and the values received from the proposal do not go beyond its reserved values.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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In Section VII, we relax the criterion a little bit.

Next, in line 4, i uses function *random* to generate a random number between 0 and 1 for variable r. In lines 5–10, if $r < p$, which implies that a concession strategy is triggered, i uses function *concession* to create a new proposal, where $\Pr\{r < 1 - p\} = 1 - p$. In line 6, k_1 is increased by one, each time the condition is triggered. It should be mentioned that *concession* is a function that implements a concession strategy of a multi-attribute negotiation. Refer to [30] for its algorithmic description. If $r \geq 1 - p$, which implies that a tradeoff strategy is triggered, i uses function *tradeoff* to create a new proposal, where $\Pr\{r > 1 - p\} = p$. In line 9, k_2 is increased by 1, each time the condition is triggered.

Algorithm 1: Mixed Approach $(V, W, F, \lambda_1, \lambda_2, p)$

Input: *array* V with raw values of n attributes;
array W with weights of n attributes;
array F with flags of n attributes; a flag indicates whether an attribute is higher-is-better;
parameters λ_1 and λ_2 $(0 < \lambda_1, \lambda_2 < 1)$ which indicate the rate of concession and the rate of tradeoff at a time, respectively;
parameter p $(0 \leq p \leq 1)$ which indicates the probability of playing tradeoff, or p – mix for short

Output: true if succeed and false otherwise

```
1  agent i sends V to agent j and waits for a response
2  while agent j does not accept V and j's counterproposal is not
3    acceptable to agent i
4      r ← random(0, 1)
5      if r < 1 − p then
6          k1 ← k1 + 1
7          V ← concession(V, W, F, k1λ1)
8      else
9          k2 ← k2 − 1
10         V ← tradeoff(V, W, F, k2λ2)
11     k ← k1 + k2
12     if V is out of bounds then
13         return FALSE
14     else
15         agent i sends V to agent j and waits for a
           response
16 return TRUE
```

It should also be mentioned that *tradeoff* is a function that implements a tradeoff strategy of a multi-attribute negotiation. Refer to [30] for its algorithmic description. In line 11, k counts the total number of negotiation rounds.

Finally, in lines 12–15, if V is out of bounds, *false* is returned; otherwise, agent i sends V, whose values are adjusted, to agent j as a new proposal, and waits for a response again. The process repeats until either success or failure occurs. In this process, i's utility of the current proposal can remain the same (i moves along its current indifference curve) or be reduced (i moves down to its next indifference curve). It can be proved that Algorithm 1 converges and terminates in a finite number of rounds. Refer to [30] for the proof.

Agent i's mixed behavior is illustrated in Fig. 2. Suppose that i now sits at the top-left point, where it can choose C or T. If T is chosen, it moves, horizontally, to point C_1 (utility remains the same), where it can choose C or T again. If C is chosen, it moves, vertically, to point B_1 (utility is reduced), where it can choose C or T again. The process repeats until it moves to point B', where it reaches l—the indifference curve of the preferred proposal of its counterpart. As a result, i moves toward the preferences of its counterpart with a higher success rate, but only a moderate decrease in the amount of utility. While Algorithm 1 is not always guaranteed to find a solution, even if one exists, any solution it finds is always guaranteed to be correct, in terms of the acceptance criterion specified earlier. In this sense, Algorithm 1 is a *Las Vegas algorithm*—a randomized algorithm that always gives a correct result, i.e., it always produces correct results or it informs of a failure [26].

It should be noted that the mixed approach we adopt in negotiation exhibits a certain degree of intelligence. Just as Turing [22] pointed out in *Computing Machinery and Intelligence*, "Intelligent behavior presumably consists in a departure from the completely disciplined behavior involved in computation, but a rather slight one, which does not give rise to random behavior, or to pointless repetitive loops."

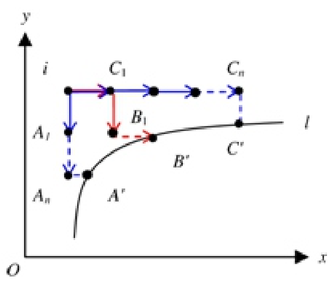

Fig. 2. Agent i's mixed behavior.

EVALUATION AND ANALYSIS:

We conduct extensive simulations to evaluate the mixed approach for cloud service negotiation. First, we describe the experimental setup. Next, we describe the parameter setup. Finally, we report and analyze simulation results.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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A. Experimental Setup:

All simulations are conducted on a Lenovo Think Centre desktop with a 2.80-GHz Intel Pentium Dual-Core CPU and a 2.96-GB RAM, running Microsoft Windows 7 Professional Operating System. The simulations are implemented with Java under Net Beans IDE 7.2.1 with JDK 7u13. An alternating-offers protocol is adopted as the negotiation protocol, and a mixed negotiation strategy is compared with concession and tradeoff strategies. The negotiation process works as follows. First, without loss of generality, a SP sends its initial proposal to a SC. Next, if the proposal is accepted by the SC, negotiation ends successfully; otherwise, the SC uses either mixed, tradeoff, or concession negotiation approach to create a counter proposal.After that, the SC sends back the counter proposal to the SP, and the negotiation process repeats. The process ends once a proposal or a counter proposal is accepted, and it fails if no proposal is acceptable to both parties.Java multithreading, which allows multiple tasks in a program to be executed concurrently, is the ideal technique to simulate the negotiation process.A thread is the flow of execution, from beginning to end, of a task. We model the behaviors of the SP and the SC as two threads. In particular, we use thread synchronization techniques to coordinate their behaviors, and a shared object to exchange their proposals and counter proposals.

CONCLUSION:

IoT and cloud computing complement each other. IoT can benefit from the unlimited capabilities and resources of cloud computing. Also, when coupled with IoT, cloud computing can in turn deal with real world things in a more distributed and dynamic manner. To succeed in a competitive market, cloud providers need to offer superior services that meet customers' expectations. However, cloud providers and cloud consumers have different and sometimes opposite QoS preferences. If such a conflict occurs, an agreement cannot be reached, without negotiation. A tradeoff approach can outperform a concession one in terms of utility, but may incur more failures if information is incomplete. To balance utility and success rate, we propose a mixed approach for cloud service negotiation, which is based on the"game of chicken." In particular, if a party is uncertain about the strategy of its counterpart, it is best to mix concession and tradeoff strategies. In fact, it is a mixed strategy Nash equilibrium of a negotiation game with two pure strategies, which provides the theoretical basis for our approach.

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