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Internet of Things Based On GoC

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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.**

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

I. INTRODUCTION

INTERNET OF THINGS (IoT) is expected to be a worldwide network of interconnected objects. 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.

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 [2], [11].

Compared with other models, cloud services are easier to access and use, cost-efficient, and environmentally sustainable. As they eliminate 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. 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 [7].

In bilateral negotiation, negotiation strategies are critical. To create a proposal, a negotiation agent can adopt two strategies—concession and tradeoff. Our previous studies show that a tradeoff negotiation approach can outperform a concession one in terms of utility [13], [14]. However, if information is incomplete, it may cause miscalculations, and so underperform the concession one in terms of success rate. To balance utility and success rate, we, in this paper, present a mixed approach for cloud service negotiation, which is based on the "game of chicken."In other words, if a party's counterpart uses a concession strategy, it is best to adopt a tradeoff one; if a party's counterpart uses a tradeoff strategy, it is best to adopt a concession one; and if a party is uncertain about the strategy of its counterpart, it is best to mix concession and tradeoff. In fact, those are the three Nash equilibria of a negotiation game with two pure strategies.

The paper's main contributions are as follows.

1) A multi-attribute bilateral negotiation mechanism involving five qualities attributes. To accommodate these attributes, we adopt nonlinear utility functions and redesign the concession and tradeoff strategies.

2) A mixed negotiation approach based on the "game of chicken," which can balance utility and success rate. In particular, if a party has no knowledge of which strategy that its counterpart will play, it is best to mix concession and tradeoff in negotiation.

The rest of the paper is structured as follows. Section II describes multi-attribute bilateral negotiations where concession and tradeoff strategies are detailed. Section III proposes a mixed approach for cloud service negotiation, which is based on the "game of chicken". Section IV summarizes the paper and mentions potential limitations

II. 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 [12]. 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 [4], [5], [7].

A. Negotiation Protocol:

A negotiation protocol specifies the "rules of encounter" among agents [7]. In this paper, we adopt an alternating-offers protocol for cloud service negotiation [10]. In multi-attribute bilateral negotiations, two agents alternately exchange their 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. Three points should be mentioned here. First, a failure could happen if one cannot suggest a valid proposal [12], because of incomplete information. Second, instead of time, a predefined maximum negotiation round is used to model the deadline. In fact, automated negotiation can complete in seconds, which makes time unsuitable to model the deadline in our case. Third, in each negotiation round, multiple attributes are negotiated simultaneously, which would be tedious, if not impossible, for a human negotiator to do so.

B. Negotiation Strategies:

Once the negotiation protocol is chosen, negotiation strategies become critical. Two negotiation strategies, concession and tradeoff [9], 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. Indeed, the party who adopts the concession strategy can move toward the preferences of its counterpart, even under incomplete information. If no miscalculations happen, its proposal has a higher chance of being accepted. As the concession strategy decreases the party's utility, it is considered when no alternatives exist. However, if two parties have different preferences, conflicts could be resolved without concession. With a tradeoff strategy, a party yields on its less important attributes, but demands more on its more important attributes. As a result, a proposal more attractive to its counterpart is created, but no utility is reduced. In particular, if it succeeds, the tradeoff strategy can generate more utility than the concession one [13]. However, if information is incomplete, the party who adopts the tradeoff strategy could move away from the preferences of its counterpart, or in the worst case, move in the opposite direction. So, its proposal becomes less attractive, and it is very likely that a failure happens.

III. MIXED NEGOTIATION APPROACH

We outline above two negotiation strategies—concession and tradeoff. With a concession strategy, 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 [3]. 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 I, where a number only has a relative significance, namely, the greater the number, the higher the payoff. 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" [3]. 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 (payoff −10). So, those are the two pure strategy Nash equilibria. Below, we give a formal description for Nash equilibrium [6].

TABLE I GAME OF CHICKEN

		Bob	
		Swerve	Stay
Alan	Swerve	0, 0	-1, 1
	Stay	1, -1	-10, -10

TABLE II 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

Theorem 1 (Negotiation with Complete Information): Let G be a two-player negotiation game, whose payoff matrix is shown in Table II. 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 counter- part. 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 [12]. Below, we give a formal description for the mixed strategy, the payoff function, and the expected payoff concepts.

Theorem 2 (Negotiation with Incomplete Information): Let G be a two-player negotiation game, whose payoff matrix is shown in Table II. 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 $\sigma_1^*= [((a_1-b_2)/(a_1+c_2-b_2-d_2)),((c_2-d_2)/(a_1+c_2-b_2-d_2))]$ and $\sigma_2^*= [((a_2-b_1)/(a_2+c_1-b_1-d_1)),((c_1-d_1)/(a_2+c_1-b_1-d_1))]$.

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 [3]. 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 [8].

C. Algorithmic Description:

Algorithm [1] implements a mixed negotiation approach. It works as follows: First, in line 1, agent i sends V—its initial proposal—to agent j, and waits for a response. If j does not accept V and j's counter proposal is not acceptable to i , then i 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. Next, in line 4, i uses the function random to generate a random number between 0 and 1 for variable r. In lines 5–10, if r < 1 -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, k1 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 [12] for its algorithmic description. If r≥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, k2 is increased by 1, each time the condition is triggered.

Algorithm: 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<p<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 counter proposal is not
3. acceptable to agent i
4. r <- random (0, 1)
5. if r < 1-p then
6. k_1 <- k_1+1
7. V <- concession (V, W, F, $k_1\lambda_1$)
8. else
9. k_2 <- k_2+1
10. V <- tradeoff (V, W, F, $k_2\lambda_2$)
11. K <- k_1+k_2
12. if V is out of bounds then
13. return FLASE
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 send 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 or be reduced. It can be proved that Algorithm converges and terminates in a finite number of rounds.

IV. 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. It should be noted that the mixed approach works under incomplete information, and so is applicable for real negotiations, where information is generally not complete. This work, however, has one potential limitation. However, it is not realistic to have an accurate utility function at this time, since we do not know how and at what cost to engineer QoS requirements. Even with the limitation, the main results and conclusions of the paper are not affected. In conclusion, when one is uncertain about the strategy of its counterpart, a mixed negotiation approach, which exhibits a certain degree of intelligence, can achieve a higher utility than a concession one, while incurring fewer failures than a tradeoff one. It thus becomes a promising approach for cloud service negotiation.

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