On the Analysis of Joining Communities of Agent-based Web Services

(Extended Abstract)

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ABSTRACT

Communities of agent-based web services are virtual groups gathering functionally equivalent web services having different non-functional attributes. Building reputable communities hosting reliable web services is still an open challenge. In this paper, we propose a mechanism that web services through associated agents can use to join existing communities. Key components of this mechanism are agents providing information about potential members of communities. Analyzing incentives for these agents to reveal accurate information is the main contribution of this paper.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent Systems; J.4 [**Computer Applications**]: Social and Behavioral Sciences - Economics

Keywords

Communities of web services; game theory

1. INTRODUCTION

Recently, some research proposals have demonstrated the importance of grouping functionally equivalent web services within *communities* providing these web services with high visibility and many security and management advantages [2, 3]. In this context, selecting reliable web services to be part of a given community is a challenging issue that still needs further consideration. We abstract web services as autonomous intelligent entities, which are benefit maximizers in the sense that their objective is to get a maximum number of requests.

The contribution of this paper is a game-theoretic model analyzing the communities of agent-based web services from the perspective of hosting different web services. Web services initially act alone and analyze the benefits of joining a community. A game is set between the *master web service* acting as the manager of the community and services acting as information providers within a group called *information service group*. Agents in this group, called *information services*, provide the necessary information regarding the web service that is attempting to join a community. The involved information services can either lie or tell the truth about the requested information. It is worth mentioning that web services themselves could be malicious and collusion between web services aiming to join a community and information service agents should be considered. In this paper, we analyze this important issue because information services can be incentivized from web services to exaggerate about their qualities or even provide bad recommendations about other competitive services [4]. In [1], the authors addressed the problem of extracting truthful opinions from large groups of agents that could be service agents in online feedback systems by 1) designing various incentive-compatible payments and rewards; and 2) addressing the problem of collusion. However, this model addresses the reputation in environments where web services and agents function alone with no plan of cooperation.

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2. PAYMENT FUNCTION

The utility $u_k(x)$ an information service agent k aims to maximize by choosing the strategy $x \in \mathcal{X}$ is a function having 3 incentive components where the service agent obtains rewards or penalties according to the chosen strategy and considering the truthful probability of the master agent which provides the payment. The master's truthful probability is modeled here using Beta-mixture distribution because data on the service's behavior is not fully available. The truthful probability of the master is computed using a combination of L parameters:

$$p(D) = \sum_{l=1}^{L} \pi_l p_l(D|\theta_l) \quad (1)$$

where $D = [O_1, \ldots, O_N]$ is an N dimensional vector of observations on the master agent's behavior, p_l is the l^{th} parameter distribution and θ_l and π_l are the two distribution parameters, which are usually estimated using the maximum-likelihood. Particularly, $\pi_l(l \in L)$ is the mixing coefficient that controls the contribution of each trust parameter in the overall trust value.

The problem the information service agent should solve is:

$$x^* = \operatorname*{argmax}_{x \in \mathcal{X}} u_k(x)$$

where $u_k(x)$ is defined as follows:

$$u_k(x) = p(D)(f_k(x) + g_k(x) + c.h_k(x)) \quad (2)$$

The first component $f_k(x)$ is a positive reward that a customer gives to the information service agent k that is willing to provide the asked information. The second incentive component $g_k(x)$ corresponds to a value that will be granted to the information service agent depending on the similarity between the information he gives and the average information revealed by the other information service agents. Finally, after having used the service being evaluated, the customer can tell whether the provided QoS fits the information service agents' predictions. The difference between what was expected and what was actually experienced is used to calculate the third component incentive $h_k(x)$. Of course, the latter can only be considered if the customer decides to have a transaction with the provider. In this case, c will be set to 1 in the utility function, otherwise, c will be equal to 0.

In the set up game, there are a number of involving entities: (1) a typical community of agent-based web services that is supervised by the master agent (M_i); (2) a typical single agent-based web service (S_j); and (3) a typical information service agent (I_k). When M_i asks I_k for information about the quality of S_j, a reputation value is produced. This value, representing what I_k reports to be the reputation of S_j, is assigned to the triplet (M_i, S_j, I_k).

We define strategies of truth telling and lying within strategy profile $st = \{0, 1\}$, where 0 and 1 respectively reflect lying and telling the truth. An information service agent would choose his strategy based on the gained utility.

The payments that information service agents receive can come from M_i and from the service being evaluated. For simplicity reasons and to avoid notation confusion, we use three simple variables α, β, and γ that refer to the previously described incentives $f_k(x)$, $g_k(x)$, and $h_k(x)$ in Equation 2. β is calculated in Equation 3 where $Tr_{M_i}^{I_x}$ represents the value of trust (confidence) M_i has towards I_x, and $Rr_{I_x}^{S_j}$ represents the value of the reputation of S_j reported by I_x. β is then a decreasing logarithmic function ($0 < b < 1$) on the difference between the average reported value by all the information services and the value reported by I_k.

$$\beta = \log_b(|\frac{\sum_{x=0}^{n} Tr_{M_i}^{I_x} Rr_{I_x}^{S_j}}{\sum_{x=0}^{n} Tr_{M_i}^{I_x}} - Rr_{I_k}^{S_j}|) \quad (3)$$

The value γ is the payment M_i gives to I_k if M_i has registered S_j in C_i and evaluated his reputation. After this evaluation, M_i can compare $Rr_{I_x}^{S_j}$ to $Ro_{M_i}^{S_j}$ and pay I_k with a value of γ, which is computed in Equation 4, where $Rr_{I_x}^{S_j}$ represents the value of the reputation of S_j reported by I_x, and $Ro_{M_i}^{S_j}$ represents the value of the actual reputation of S_j observed by M_i.

$$\gamma = \log_b(|Rr_{I_x}^{S_j} - Ro_{M_i}^{S_j}|) \quad (4)$$

3. GAME-THEORETIC ANALYSIS

In this section, we analyze some cases using a game involving two players ($I.S$ for a typical information service agent and $O.I.S$ for the other information service agents). The game is represented as a table where the rows show the strategies of $I.S$ and the columns indicate the strategies of $O.I.S$. Each cell of the table represents the action profile, i.e. the outcome that each player has according to the adopted strategy. The first outcome is for $I.S$ and the second one for $O.I.S$. If the received payment is negative, we use the superscript $-$. We only consider the case where S_j is honest (with good and bad QoS). In that cases, S_j does not try to corrupt $I.S$ and $O.I.S$ by rewarding them.

3.1 S_j has Good QoS

The assigned payoff regarding each strategy is set up in Table 1. If every information service tells the truth, i.e. informing M_i that S_j is good, everyone will receive a maximum payment of $\alpha + \beta + \gamma$. If $I.S$ decides to lie while $O.I.S$ continue to tell the truth,

		O.I.S	
		Truth	Lie
I.S	Truth	$(\alpha + \beta + \gamma), (\alpha + \beta + \gamma)$	$(\alpha + \beta^-), (\alpha + \beta_-)$
	Lie	$(\alpha + \beta^- + \gamma^-), (\alpha + \beta_- + \gamma)$	$(\alpha + \beta), (\alpha + \beta)$

Table 1: Honest single web services - S_j has good QoS

$I.S$ will degrade his total payment to $\alpha + \beta^- + \gamma^-$. If $O.I.S$ decide to change their strategies and lie, they will only get α and β_- as payment. The fact that the majority of information services announce that S_j is bad implies that the community will not accept him, and therefore the third payment γ will not be granted.

We can see that there is an incentive to tell the truth for everyone because it corresponds to the situation that guarantees the maximum payment $\alpha + \beta + \gamma$.

3.2 S_j has Bad QoS

		O.I.S.	
		Truth	Lie
I.S.	Truth	$(\alpha+\beta), (\alpha+\beta)$	$(\alpha+\beta^-+\gamma), (\alpha+\beta_-+\gamma^-)$
	Lie	$(\alpha+\beta^-), (\alpha+\beta_-)$	$(\alpha+\beta+\gamma^-), (\alpha+\beta+\gamma^-)$

Table 2: Honest single web services - S_j has bad QoS

If every player tends to tell the truth and reveals that S_j has bad QoS, they will all get a payment of $\alpha + \beta$ (see Table 2). They will received α for processing the request and β because each information service will report a very close value to the actual one. If $I.S$ decides to modifies his strategy and lies by announcing that S_j has good QoS, he will degrade his total payment. He will still receive α but a negative β due to the fact that the reputation he announced is far from the average. However, $O.I.S$ will get the two first payments but the second one will be slightly decreased in comparison to the previous situation. In the next situation, assume that $O.I.S$ change their strategies and start to lie. Because the majority of information services will declare S_j as good, the web service will join the community. Soon, M_i will realize that S_j has actually bad QoS. Therefore, the group of $O.I.S$ will receive $\alpha + \beta_- + \gamma^-$. On the other hand, $I.S$ who kept his strategy of telling the truth will get $\alpha + \beta^- + \gamma$. Indeed, the information service will receive a negative β but will be rewarded by γ as he reported correctly that S_j has bad QoS. If everyone decides to lie, all the information services will get $\alpha + \beta + \gamma^-$. γ will be negative because S_j will join the community, so M_i will discover his bad QoS.

4. REFERENCES

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