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

(Extended Abstract)

Jamal Bentahar
Concordia University, Canada
bentahar@ciise.concordia.ca

Babak Khosravifar
McGill University, Canada
babak.khosravifar@gmail.com

Kathleen Clacens,
Christophe Goffart,
Philippe Thiran
University of Namur, Belgium
kclacens,cgoffart,pthiran@fundp.ac.be

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
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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.

2. PAYMENT FUNCTION

The utility \( u_k(x) \) an information service agent \( k \) aims to maximize by choosing the strategy \( x \in X \) 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:

\[
p(D) = \sum_{i=1}^{L} \pi_i p_i(D|\theta_i) \quad (1)
\]

where \( D = [O_1, \ldots, O_N] \) is an \( N \) dimensional vector of observations on the master agent’s behavior, \( p_i \) is the \( l^{th} \) parameter distribution and \( \theta_i \) and \( \pi_i \) are the two distribution parameters, which are usually estimated using the maximum-likelihood. Particularly, \( \pi_i (l \in L) \) 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:

\[
x^* = \arg\max_{x \in X} u_k(x)
\]

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 $\alpha$, $\beta$, and $\gamma$ that refer to the previously described incentives $f_k(x)$, $g_n(x)$, and $h_k(x)$ in Equation 2. $\beta$ is calculated in Equation 3 where $TR_{M_i}$ represents the trust (confidence) $M_i$ has towards $I_k$, and $Rr_{S_j}$ represents the value of the reputation of $S_j$ reported by $I_k$. $\beta$ 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 $I_k$.

\[
\beta = \log_b(\frac{\sum_{n=0}^{\infty} TR_{M_i} Rr_{S_j} - Rr_{I_k}}{\sum_{n=0}^{\infty} TR_{M_i} Rr_{S_j}}) \tag{3}
\]

The value $\gamma$ 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 $Rr_{S_j}$ to $Rr_{M_i}$ and pay $I_k$ with a value of $\gamma$, which is computed in Equation 4, where $Rr_{S_j}$ represents the value of the reputation of $S_j$ reported by $I_k$, and $Ro_{M_i}$ represents the value of the actual reputation of $S_j$ observed by $M_i$.

\[
\gamma = \log_b(\frac{Rr_{S_j} - Ro_{M_i}}{\sum_{n=0}^{\infty} TR_{M_i} Rr_{S_j}}) \tag{4}
\]

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 case, $S_j$ 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 $O.I.S$ continues to tell the truth, $I.S$ will degrade his total payment to $\alpha + \beta^- + \gamma^-$. If $O.I.S$ decide to change their strategies and lie, they will only get $\alpha$ and $\beta$ 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 $\gamma$ 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

If every player tells the truth and reveals that $S_j$ has bad QoS, they will all get a payment of $\alpha + \beta$ (see Table 2). They will receive $\alpha$ for processing the request and $\beta$ because each information service will report a very close value to the actual one. If $I.S$ decides to modify his strategy and lie by announcing that $S_j$ has good QoS, he will degrade his total payment. He will still receive $\alpha$ but a negative $\beta$ 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 $\beta$ but will be rewarded by $\gamma$ as he reported correctly that $S_j$ has bad QoS. If everyone decides to lie, all the information services will get $\alpha + \beta + \gamma^-$. $\gamma$ will be negative because $S_j$ will join the community, so $M_i$ will discover his bad QoS.

4. REFERENCES


