Toward Integrating Social Trust into Web Service Compositions

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Abstract

Web 2.0 helped bring about the development of social communities, Web services and a host of applications. Web service compositions traditionally utilize the functional and quality-of-service parameters of candidate services to decide which services to include in the composition. However, users of services often form an opinion of a service. User-driven composition techniques will form compositions that likely behave as stated in practice, and which are better received by the users. We develop a preliminary framework for integrating social trust in Web service compositions and experimentally validate the utility of our trust framework.

Introduction

Web 2.0 helped bring about the development of social communities, a host of applications and, more importantly, e-commerce and other web services. Web service compositions traditionally utilize functional and quality-of-service (QoS) parameters of candidate services to decide which services to include in the composition (Zhao and Doshi 2007). This is a straightforward way of selecting services, which allows the composition to theoretically meet its goal and satisfy non-functional requirements. However, users of services often form an opinion, somewhat subjective, of a service (analogous to other Web 2.0 applications). This opinion may be based on prior interactions with the service, and may include judgments such as whether the perceived behavior of the service conforms to its stated behavior and intangibles such as the overall experience of the user with the service.

We present a simple method by which trust values are progressively updated over time based on interactions with multiple users. We show how trust may be aggregated into a single value for different types of compositions having sequential, concurrent, and other types of flows. Finally, we empirically validate our approach.

Formulation of Trust in Web Services

Trust of a requester, B, on a Web service, w, is the confidence of B on w's competency, reliability and honesty, which will make B depend on w to perform the actions on which B's welfare depends, even though negative consequences are possible.

We may objectively measure honesty of a service as the difference between the advertised or agreed upon values of QoS parameters appearing in the service level agreements and the actual observed values of the QoS parameters. As cost is not observed, we limit our focus to the parameters, response time $\bar{R}$ and availability (A). The response times are normalized, as shown below, to make them comparable with availability. Let A_a and $\bar{R}_a$ be the advertised values while A_m and $\bar{R}_m$ be the observed values of the QoS parameters. Then, we define an objective measure of honesty as: $h = 1 - \frac{|A_m - A_a| + \left|\bar{R}_m - \bar{R}_a\right|}{2}$ where $\bar{R} = \frac{R - R_{min}}{R_{max} - R_{min}}$ if $R_{max} - R_{min} \neq 0$, otherwise 1; and R_{max}, R_{min} are the maximum and minimum values of response times respectively.

Reliability, r, is measured as one minus the fraction of times the service fails or does not behave as per its function. Finally, we formalize competency, c, as a binary valued concept indicating whether the service is able to satisfy the goals. If it does, we assign $c = 1$, otherwise 0. Thus, the objective component of trust is averaged as: $t_w^o = \frac{h + r + c}{3}$

We now define our model of trust, t_w, as a convex combination of the subjective feedback and objective measures.

Trusted Compositions of Web Services

We describe how trust values of services may be utilized while forming compositions, and subsequently updated. Our initial trust framework is shown below in Fig. 1.

In order to compute the composite trust, we consider *four* types of basic flows of services that are often encountered in compositions. We point out that the methods for computing the composite trust are somewhat analogous to the computations in (Cardoso et al. 2004).

• *Sequential, Concurrent flows and Loop:* As each of the services is executed, we construct the composite trust, t_{cw} using the honesty, reliability and competency of the individual component services. The composite honesty is the average of the honesty of all the services: $h_{cw} = \frac{\sum_{i=1}^{n} h_{wi}}{n}$ The composite reliability aggregates the reliability of all individual services: $r_{cw} = \prod_{i=1}^{n} r_{wi}$ Finally, the composition is competent if all component services are competent, otherwise it is not.

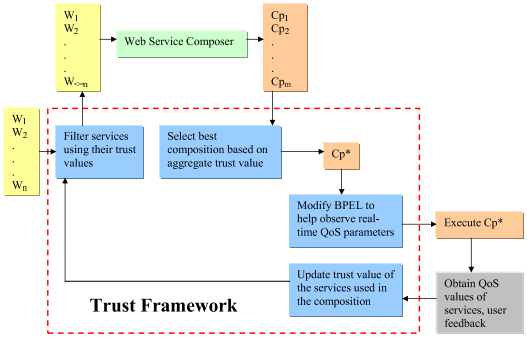

Figure 1: Our framework for considering trust while composing Web services.

The composite objective trust is, $t^o_{cw} = \frac{h_{cw}+r_{cw}+c_{cw}}{3}$. Subsequently, the aggregate trust of the composition is a combination of the objective and subjective trusts, $t_{cw} = \frac{t^o_{cw}+t^s_{cw}}{2}$.

• *Conditional flow:* Any one of the branches is executed in a conditional flow. The composite trust value is the expected sum of the individual trust values, $t_{cw} = \sum_{i=1}^{n} p_i \times t_{wi}$

We seek to update the trust values of the component services within a composition after it has executed. We utilize the new mean value to update the trust. This approach is Bayesian, and integrates the new trust with the previous trust value for the service, thereby remembering the history.

We point out that trust values associated with a service are not private to a user and are updated by all users interacting with compositions containing the service. This has the advantage that a service deemed untrustworthy by some user (t_w is below her threshold) could have its trust value improve over time because of interactions with other users, until it meets the threshold of the user. This is what makes trust in our framework social - the ability for a community of users to influence the trust of a web service.

Experimental Validation

The objective of our experiments is to validate the utility of our trust framework. We empirically demonstrate that a consideration of trust in the selection of compositions results in compositions that progressively exhibit less deviations from their advertised or agreed upon QoS values.

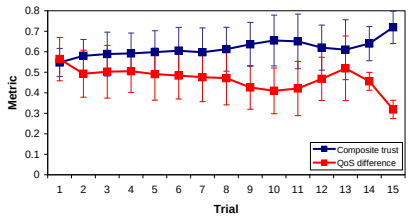

Figure 2: Composite QoS differences and trust across trials.

In Fig. 2, we show a plot of the difference between the composite empirically measured QoS of the deployed compositions and the composite advertised QoS of the composition. We executed 15 trials, averaged over 80 iterations, during which each composition was executed 4 times. The empirically observed QoS parameters were averaged over these 4 runs. Notice that the difference gradually reduces over the 15 compositions. This is because compositions with larger trust values are gradually being selected and deployed. An increasing number of these compositions are behaving as advertised. The better trust values are a result of the previous good performances of the participating services in the compositions.

Related Work

(McKnight and Chervany 1996) characterize a trusting intention as the extent to which one party is willing to depend on the other party in a given situation with a feeling of relative security, even though negative consequences are possible. While the above definition is vague about the characteristic of the trusted entity, which makes the trusting entity trust it, we project trust to lie along three axes, namely, competency, reliability and honesty.

Our trust model is somewhat similar to the approach mentioned in (Liu, Ngu, and Zeng 2004) but we also introduce the notion of using objective measures. Solely relying on user feedback has a two-fold disadvantage: First, different users may have different opinions and a service preferable to one consumer might not appear so for another. Also, some users might give a deceptively negative or positive feedback on purpose.

Discussion

We have developed a novel, but preliminary, framework for integrating trust considerations in Web service compositions. Specifically, we focused on the behavioral (social) aspect of trust in the context of Web services and its role in improving the pragmatics of service compositions. We are investigating the scalability of our framework, in particular, when there are a large number of candidate compositions and users. Another avenue of research is the inclusion of recommender trust into the computation of the trust value of a Web service.

In conclusion, with the growing number of mashups and websites delivering Web services (contributing to the emergence of Web 3.0), we believe that this work will be relevant in pulling together the threads needed to deliver trustworthy services to users.

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