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Business Service Composability on the Basis of Trust

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Abstract— *In the real world a service in a business is usually composed of many component services. These component services join together to form a composite of components. The trustworthiness of component services determines the trustworthiness of this composite. This trustworthiness of composite service has a large impact on the successful delivery of a service. In this paper we study that how we can determine the trustworthiness of this composite. Since the components in the composite form parallel or series and/or combination of parallel/series arrangements we use probability theory to determine the trustworthiness of the composite service. We use a case study to demonstrate the concepts.*

Index Terms—Trust, Service Composability, QoS, probability theory.

I. INTRODUCTION

Trust in business environment plays a vital role and determines the success or failure of a business in the real world. However it involves many functional and non-functional aspects that need to be considered while determining the trust of a service [1], [2]. On the basis of functional and non-functional aspects, metrics have been defined to determine the trustworthiness of a service. These factors are helpful in daily life business interactions as well as in virtual world of computing.

In recent years there is an increasing trend of businesses to offer their services online. Service-oriented environment has made it possible through the use of modern web technologies. The Service-oriented environment enable businesses to manage processes and workflows for successful delivery of services through the use of new web technologies. One important technology that enables heterogeneous applications talk to each other is the Web Services technology that uses Service Oriented Architecture (SOA). There are Web Services standards available for implementation of e-Businesses therefore Web Services seems a natural solution for it. Details of Web Services technology can be found on W3C website [3]. Web Services represents one implementation of SOA and several others are possible. In this paper, however, we are concerned about a business service that is delivered on time [1].

A service in the real world may consist of component services. In logistics, for example, a moving service may consist of pick up, transportation, warehouse and delivery services. These components form a composite of components, trustworthiness of which determined by the trustworthiness of each component of the composite. A method is

needed to compose services on the basis of trustworthiness of component services.

Composition of Web Services is a complex task involving many issues as discussed by [4]. One of these issues is Quality of Services (QoS) which has different parameters. These parameters include trust, reliability, availability, security and performance etc. Composition of Web Services model should embed all these parameters of QoS. In some service applications all of these parameters have equal importance. In other applications, one of these parameters has more importance than another. For example, in business applications trust has paramount importance for delivery of service.

The concepts of trust and security are not same as it is often misunderstood. Trust has been defined clearly in the Service-oriented environment by Chang et al [1]. They defined trust as “the belief that the trusting agent has in the trusted agent’s willingness and capability to deliver a mutually agreed service in a given context and in a given time slot”. Security on the other hand provides a safe computing environment for successful service delivery. In other words, security supports trust by providing a secure computing environment for trusted business activities.

Similarly the concepts of trust and reliability are not the same. Reliability is a fault in a component leading to the component not meeting its specification. Trust depends on the factors like capability, intent, knowledge, skills etc. The reliability depends upon the availability, Mean Time To Failure (MTTF), Mean Time To Repair (MTTR) etc. We use a very simple example to demonstrate the difference between trust and reliability.

Consider a Track & Trace service. For this service there is an agreement (SLA) between service requester and service provider. In SLA it is agreed that service will be provided within 30s (seconds). Whereas in the service provider’s specification the availability of the service is 0.95 and time in which service is to be delivered is from 30s to 90s. In this case if the service is not delivered by service provider within 30s the derated service is still provided. If the service requester is still happy with the derated service then this service delivery will not affect trust in the service provider. However, if service provider promised to provide service within 30s and this service is defined in the service specification to be delivered in 90s, the service provider is misleading the service requester at the time of agreement. In this case with derated service the trust of service provider may also be affected because of the behaviour of service provider. It may also be possible for a service provider to deliver service within 30s but the service is delayed de-

liberately. This will not affect the reliability of the service as according to service specification service can be delivered in 30s rather this will affect the trust of the service provider. We observe from the given example that trust depends upon reliability of the service but reliability does not necessarily depend upon trust.

In this paper we focus on service composition on the basis of trust in the service-oriented environment. Hence methodology we introduce is for the services in general.

This paper has been divided into four sections. Section II presents a literature review. In section III the proposed methodology is explained. Section IV gives the conclusion and future work.

II. BACKGROUND

We discussed earlier that trust is an important parameter for QoS. We also discussed that a service, such as a removal service, may be composed of a composite of components and trustworthiness of these components determines the trustworthiness of this composite. In this section we look at literature in two important streams: trust calculation and Service Composition on the basis of QoS.

Enormous work has been done for trust and reputation calculation in Service-oriented environment. However, they do not cover the trust calculation for real world service, for example, logistics service except [1] and [2]. Most of the literature in this stream describes trust as probabilistic the nature and calculations are based on that.

A 'Bayesian network' or 'Bayesian belief network' has been studied by researchers for trust/reliability modelling. It is a probabilistic model that can be represented by directed acyclic graph where nodes represent events and arcs represent probabilistic dependency relations among the events. Using Bayesian network posterior trustworthiness of a trusted agent can be determined using Bayes rule.

Wang et al [5] used Bayesian network based approach in peer-to-peer networks for trust calculations. Their method is context dependent and they assume 3 pre-defined contexts. Each peer, after interaction, updates the Bayesian network of the trusted peer corresponding to context of interaction. Then the weighted aggregate of the outcome of each criterion in the interaction is determined. Posterior probability can be determined in the given context or in any combination of the three contexts by making use of Bayes rule. Third party recommendations can be solicited if the peers interacting with each other don't have previous experience. Reputation value we calculated in the given interval [0, 1].

As discussed in section I that service composition is a complex task and therefore, addressed by many researchers. Service composition consists of functional as well as non-functional parameters. Protocols for service composition have been developed and supported by vendors like Oracle, Microsoft, IBM, BEA etc. Dynamic services composition is directly related to the semantic web. Use of ontologies introduced a new generation of web services called semantic web services [6].

Non-functional parameters are quality related issues and discussed in the literature as Quality of Service (QoS) parameters [4]. This list includes, but is not limited to, the following parameters: scalability, capacity, performance, reliability, availability, trust and security [7].

Hussain [2] has introduced metrics for trustworthiness measurement that takes into account the dynamic nature of context and time. There is usually a service level agreement between the service provider and the service requester. How much this agreement is obeyed determines the quality of service. For this assessment CCCI metrics introduced by Hussain plays an important role. Based on this work Chang et al [1] has presented a comprehensive method of trust calculation. A chapter in their book is devoted for trustworthiness measurement using CCCI metrics. The metrics used in the book are refined beyond the metrics defined by Hussain. Although all this discussion in this chapter is for trustworthiness measurement in Service-oriented environment, the methodology can be used in general to determine trustworthiness value of any physical service. There are four key metrics as defined by Chang et al [1]:

- $Corr_{qualities}$ – Correlation of defined quality against the actual delivered quality
- $Commit_{criterion\ c}$ – Commitment to the criterion which is how much the delivered quality by the trusted agent committed to the defined Quality Assessment Criteria.
- $Clear_{criterion\ c}$ – The Clarity of criterion c gives the level of common understanding of Quality Assessment Criteria by trusted agent and trusting agent.
- $Inf_{criterion\ c}$ – The Influence of criterion determines the impact of different Quality Assessment Criteria on overall quality

These metrics lead to successful calculation of trustworthiness.

We discussed the methods for trust calculations especially methods that use the probabilistic approach. As we mentioned in section I the important challenge is to determine the trustworthiness of composite service if the trustworthiness of component services is given. We noticed none of the methodologies discussed above are able to address this problem. We also mentioned in section I that composition of web services on the basis of trust values is a complex problem and one way to address this problem is to look at service composition of physical services on the basis of trust values. In our literature review, the methodology used by Chang et al [1] can be utilised to determine the trustworthiness of the physical service provider and to the best of our knowledge this methodology is the most comprehensive methodology. How services can be composed on the basis of trust values of component services need to be explored. We use probability theory to address this problem as given in the next section.

III. PROPOSED METHODOLOGY

We discussed in section II that composition of services on the basis of trust has not been addressed before. Although component services may have trust value, the trust value of composite service may not known. For services like removals it is interesting to know their trustworthiness when they deliver their door-to-door service.

Since the component services in real world have trust value, probability theory can be used to calculate trust value of a composite service. Component services are logically or physically dependent or independent of each other to deliver a complete (composite) service. Hence components form series or parallel or combination of series and parallel patterns. Probability theory simply combines the trust values of components that are in series or parallel or in series and parallel. To demonstrate our methodology we discuss series composition, parallel composition and then with the help of a case study we demonstrate service composition on the basis of trust.

I. Series Composition

Consider three services: S1 transportation service at origin, S2 warehouse service and S3 transportation service at destination with associated trust values of 0.8, 0.75 and 0.85 respectively as depicted in Fig. 1. These services are in series and independent of each other. However they are logically dependent on each other.

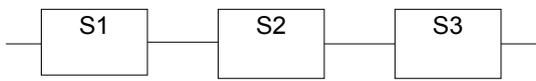


Fig. 1 Composition of Services in Series

Let service S is the composite service. Then

$$S = S1 \wedge S2 \wedge S3$$

Or more precisely

$$P(S) = P(S1).P(S2).P(S3) = \prod_{i=1}^3 P(Si)$$

$$P(S) = (0.8).(0.75).(0.85) = 0.51$$

The probability of service S on the basis of given trust values of component services S1, S2 and S3 is 0.51.

II. Parallel Composition

Consider three warehouse services S1, S2 and S3 with associated trust values 0.7, 0.9 and 0.8 respectively. These services are in parallel and independent of each other. Block diagram to for these services is given in Fig. 2.

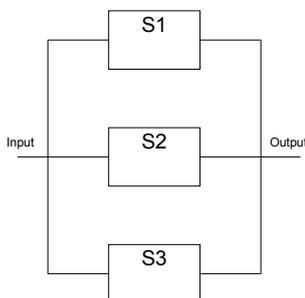


Fig. 2 Composition of Services in Parallel

Let S be the composite service, then

$$S = S1 \vee S2 \vee S3$$

Or more precisely

$$P(S) = \max(P(S1), P(S2), P(S3))$$

$$P(S) = \max(0.7, 0.9, 0.8) = 0.9$$

This means that P(S) is the probability that service S will be delivered given trust values of S1 or S2 or S3.

Now we discuss a real world scenario where services are joined together to deliver a composite service. The trust value of each component is given and we want to calculate the trust value of composite service. The trust value, for example 0.9, of a component is calculated considering clarity of criterion of criterion, influence of criterion, commitment of criterion and correlation between parameters as given by Chang et al [1]. Therefore, it is clear that trust values that we use in our examples represents the trustworthiness of a service not the reliability or security of a service as these parameters need separate discussion.

III. Case Study

Mr. X is moving from Melbourne to Perth due to his new job in Perth. He finds a removal service offering door-to-door service. Services included in this door-to-door service are: packing service, road transport, warehouse service, sea transport, sets of road transport and warehouse services and unpacking service at destination. Fig. 4 depicts delivery of this removal service where each component service has its trust value. It is important to note that the components in Fig. 4 must execute in order as it is often the case with physical services. That is, the services are physically dependent on each other.

To calculate the trust value of delivery of Door-to-Door service, we first calculate the service delivery of the node that consists of sets of road transport and warehouse services. This node is in between Sea Transport and Unpacking Services in Fig. 4. Expansion of this node is given in Fig. 3. Its explanation is as follows: Consider following set of similar services:

$$\text{Set1} = \{S_{\text{transport1}}, S_{\text{warehouse1}}\}$$

$$\text{Set2} = \{S_{\text{transport2}}, S_{\text{warehouse2}}\}$$

Associated trust values with these services are shown in Fig.3. The storage capacity of both warehouse in Set1 and Set2 is equal to 1200 tons. Mr. X has requirement of moving and storing 1000 tons of goods. Since Set1 and Set2 are similar they can provide the service. The service composition depends upon the storage capacity available at each warehouse and the trust value associated with each set of service. Block diagram depicts our case.

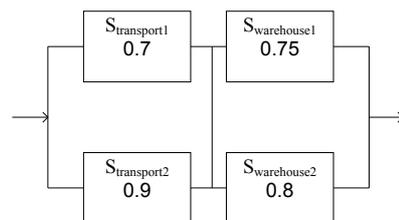


Fig. 3 Set of Services in Parallel

Now we calculate the probability based on trust and availability of required storage space.

$$P(S_{trust}) = \max((P(S_{transport1}) \cdot P(S_{warehouse1})), (P(S_{transport2}) \cdot P(S_{warehouse2})))$$

$$P(S_{trust}) = \max(((0.7) \cdot (0.75)), ((0.9) \cdot (0.8))) = \max(0.52, 0.72) = 0.72$$

$$P(S_{capacity}) = \max(P(S_{warehouse1} = 1000), P(S_{warehouse2} = 1100))$$

$$P(S_{capacity}) = P(S_{warehouse2} = 1100)$$

Based on the trust and storage capacity available, services in Set2 are choice. Since the storage capacity offered by warehouses varies (≥ 1000 tons) the choice of services to compose Service S changes. Here we suppose that trust value does not change.

If we combine the trust value of composite service (door-to-door service), the trust value of delivery of Door-to-Door service can be calculated as:

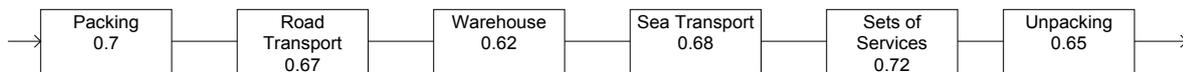


Fig. 4 Block Diagram for Delivery of Door-to-Door Service

The components shown in Fig. 5 are logically dependent on each other as this is often the case in Web Services.

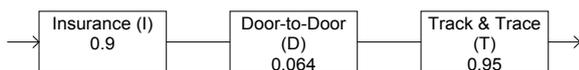


Fig. 5 Services in combination

If removal service consists of components services as described above, the trust value of service provided by Removal Company is 0.079. This calculation takes into consideration of trust values of all components and whether the component services are in series or parallel. This overall trust value of composite service has not been calculated before using the probability theory. This is our contribution to the literature.

IV. CONCLUSION

Composition of web services has many aspects that have been explored in recent years. Composition of web services on the basis of trust has not been discussed much. This issue is a part of Quality of services which leads to successful delivery of services. In this paper we addressed this issue by using probability theory. Since composition of services is a complex issue, we started looking at composition of services on the basis of trust in real world businesses. A case study of a removal company has been used to demonstrate our proposed methodology.

We distinguish trust from reliability and security which are often misunderstood as trust. We solely focused on trust of composite service on the basis of trust of component services. Services in real world are either physically dependent on each other (series composition) or physically independent of each other (parallel composition) or logically dependent on each other. We therefore, used probability theory to calculate the trust of a composite services. How

$$P(D) = (0.7) \cdot (0.67) \cdot (0.62) \cdot (0.68) \cdot (0.72) \cdot (0.65) = 0.092$$

In addition to door-to-door service Mr. X needs insurance service and track & trace service for his goods. These services, if combined with delivery of the door-to-door service, forms a composite of components as shown in the Fig. 5 whereas the description of door-to-door service have been given in Fig. 4. The trust value of this composite service can be calculated as:

$$P(D + I + T) = (0.092) \cdot (0.9) \cdot (0.95) = 0.079$$

ever, this is initial work towards trust calculation of composite service.

The case study we presented is a real world scenario. We see from our case study that a removal service consists of number of component services each with its own trust value. However, it is clear that determining the trust value of a removal service (composite) is a complex task. We observed that delivery of component services is either logically or physically dependent on each other. Hence probability theory can be applied as given by our example.

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