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Trustworthiness measurement methodology (TMM) for assessment purposes

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Abstract— Quality assessment process is a very complex process. At the same time quality assessment is very vital and crucial for many business processes. In this paper we propose and explain trustworthiness measurement methodology, which is a generic method which can be used to determine the quality of service (QoS) of a given service provider and the quality of product (QoP) of a given product.

I. INTRODUCTION

In this paper, we propose a generic methodology which can be used to determine (a) the quality of service (QoS) of a given service provider and (b) the quality of a given product (QoP). We term the methodology as 'trustworthiness measurement methodology'.

The steps involved in the trustworthiness measurement methodology are as follows:

1. Determine the context of interaction between the trusting agent and the trusted entity.
2. Determine the criteria involved in the interaction between the trusting agent and the trusted entity.
3. Develop a criterion assessment policy for each criterion involved in the interaction.
4. Determine the trustworthiness value of the trusted entity in the given context and time slot corresponding to the time spot of interaction by making use of CCCI metrics.

It is important to note here that the above proposed methodology can be used to

1. determine the quality of service of service (QoS) when the trusted entity is a service provider; (and)
2. determine the quality of service of product (QoP) when the trusted entity is a product.

The proposed methodology for determining the Quality of Service (QoS) is exactly similar to the above methodology with the exception that the terms are changed to reflect the service domain. The specialized methodology that determines the Quality of Service provided by a given

service provider in an interaction comprises of four steps as follows:

1. Determine the context of interaction between the service requestor and the service provider.

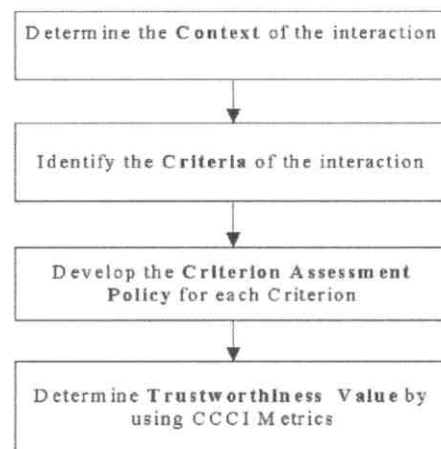


Figure 1: Flow Chart of the Trustworthiness Measurement Methodology

2. Determine the criteria involved in the interaction between the service requestor and the service provider.
3. Develop a criterion assessment policy for each criterion involved in the interaction.
4. Determine the Quality of Service of the service provider in the provided service and time slot corresponding to the time spot of interaction by making use of CCCI Metrics.

The proposed methodology for determining the Quality of Product (QoP) is exactly similar to the above generic methodology with the exception that the terms are changed to reflect the product domain. The specialized methodology that determines the Quality of Product of a given product comprises of four steps as follows:

1. Determine the context of use by the buyer of the product. In this thesis we make use of the

phrase 'interaction between the buyer and the product' to denote the use of the product by the buyer.

2. Determine the criteria involved in the use of the product by the buyer.
3. Develop a criterion assessment policy for each criterion involved in the use of the product by the buyer.
4. Determine the Quality of Product of the product in the given context and time slot corresponding to the time spot of the use of the product by the buyer by making use of CCCI Metrics.

In Section 2, we define and explain the term 'context of the interaction'. In Section 3 and Section 4, we explain how the context of interaction can be determined when the trusted entity in an interaction is a service provider and a product, respectively. In Section 5 we explain how the criteria involved in an interaction can be determined and derived once the context of interaction has been determined. Section 6 details how the criterion assessment policies can be developed by the trusting agent. In Section 7 we give an overview of carrying the quality assessment. Due to space constraints we are unable to give detailed description of the assessment process. Finally, Section 8 concludes the paper.

II. DETERMINING THE CONTEXT OF INTERACTION

We define the *context of an interaction* as a means of representing broadly the set of all the coherently related functionality(ies) or activity(ies) that the trusting agent is looking for in an interaction with the trusted entity. The context of an interaction can be additionally described as a high level summarized description of all activity(ies) or functionality(ies) that the trusting agent is looking for in its interaction with the trusted entity. Since the context of interaction broadly reflects what the trusting agent is looking for in its interaction, it has to be derived from the mutually agreed behaviour between the trusting agent and the trusted entity. The mutually agreed behaviour specifies the outcome of each functionality(ies) or activity(ies) in an interaction, numerically in commonly understood terminology. Conversely, the context of the interaction summarizes broadly the functionality(ies) or activity(ies) involved in an interaction without specifying their desired individual outcome (from the perspective of the trusting agent). The context of the interaction can be represented by different terms, as long as they all mean the same. In order to express the context of interaction, one has to make use of those terms (or synonymous terms) that are present in the mutually agreed behaviour and which manifest the involved activity(ies) or functionality(ies) in the interaction.

The process of determining the mutually agreed behaviour varies depending on whether the trusted entity is

a service provider or a product. However, the process of determining the context of interaction from the mutually agreed behaviour is the same irrespective of the trusted entity involved in the interaction. Since determining the mutually agreed behaviour is pivotal in determining the context of interaction, in this section, we propose how the mutually agreed behaviour can be determined if the trusted entity is a product or service. We then subsequently explain the process of determining the context of interaction from the mutually agreed behaviour.

Trusted Entity	Forms of Mutually Agreed Behaviour
Service Provider	Mutually Agreed Service (or) Service Level Agreement (or) Advertisements(or) Contract(or) Agreement
Product	Advertisements (or) Product Catalogue(or) Product Manual(or) Specification of Product(or) Purchase Agreement(or) Product Disclosure Statement(or) Warranty Agreement

Table 1: Different possible forms of mutually agreed behaviour for different types of trusted entities in service-oriented environment

Table 1, above shows the different possible forms for documenting the mutually agreed behaviour, depending on the different trusted entities.

In Section 3 and Section 4 we present the process for determining the context of interaction in the scenario when the trusted entity is a service provider and product respectively.

III. PROCEDURE FOR DETERMINING CONTEXT OF INTERACTION WITH TRUSTED ENTITY IS A SERVICE PROVIDER

As was discussed previously, the first step in determining the context of the interaction, is to determine the mutually agreed behaviour. If the trusted entity is a service provider, then the service requestor and the service provider need to enter into a Negotiation Phase. During the Negotiation Phase, the service requestor and the service provider negotiate and agree upon the mutually agreed service. The steps involved in the negotiation phase are as follows:

Step 1: Initial Service Proposal from the Service Requestor: As was pointed out in the previous chapter, the service requestor interacts with a given service provider in order to achieve certain objective(s). The initial service proposal from the service requestor contains a finite set of clearly and precisely specified activity(ies) that it expects the service provider to perform in the interaction, in order to achieve its objective(s). By a clear specification of all the activities, we mean that each activity that the service requestor expects the service provider to perform in the interaction should be spelled out in easily comprehensible and unambiguous terminology during the negotiation phase. By precise specification of the activities, we mean that the output of each activity that the service requestor desires the service provider to perform should be quantified and expressed in terminology that is mutually understandable to both the interacting parties.

Step 2: Revision of Initial Service Proposal by the Service Provider: Based on the initial service proposal, the service provider should revise the initial service proposal into a service proposal that comprises of a set of clearly and precisely specified set of activities, which it feels that it is willing and capable of delivering. In order to do so, the service provider determines the set of activities specified in the initial service proposal that it feels it is not capable of, or unwilling to carry out. It would then revise the initial service proposal and produce a new service proposal that comprises of a set of clearly and precisely specified set of activities, which it is capable of and willing to carry out in its interaction with the service requestor. The service provider should in practice try its best to ensure that the set of proposed activities in the modified service proposal achieves the objective(s) of the service requestor in the interaction. The service provider would then communicate the modified service proposal to the service requestor.

Step 3: Considering the Revised Service Proposal: Once the service requestor receives the revised service proposal, it would consider whether the revised service proposal would help it to achieve its objective(s). If it feels that the objectives that it aims for in the interaction would be achieved by the revised service proposal, then it has the option of changing the revised service proposal into the mutually agreed service.

Conversely, if it feels that the revised service proposal from the service provider would not help it achieve its objectives in the interaction, then it has two options as explained below.

Step 3(a): Engage in Further Negotiations with the Service Provider by proposing an alternative service proposal: If the service requestor likes to further negotiate with the service provider, then it has to put forward an alternative service proposal. The alternative service proposal can be derived by the service requestor from the

revised service proposal communicated to it in Step 2. Alternatively, the alternative service proposal may comprise of a new set of clearly and precisely specified set of activities that the service requestor feels would help it in achieving its objective(s) in the interaction. Irrespective of whether or not the new service proposal is derived by modifying the revised service proposal, or comprises of a new set of coherently related activities, the service requestor and the service provider would need to go through step 1, step 2 and step 3 in the same order to arrive at the mutually agreed service. We term each iteration through Steps 1, 2 and 3 as a *Negotiation Cycle*. We term this stage or phase in the interaction, where the interacting partners agree or negotiate on the mutually agreed service the '*Negotiation Phase*'.

Step 3(b): Consider negotiating with an alternative service provider: Based on the revised initial service proposal from the service provider, if the service requestor feels that the revised initial service proposal would not help it to achieve its objective(s) in the interaction and would not like to negotiate with the service provider any further, then it may choose to consider negotiating with an alternative service provider who is willing to engage in an interaction with the service requestor.

The outcome of the Negotiation Phase, which is the mutually agreed service (in case the trusted entity is a service provider), may be documented in one of the following ways:

- (a) Contract (and)
- (b) Agreement (and)
- (c) Mutually Agreed Service (and)
- (d) Service Level Agreement (and)
- (e) Advertisements by the Service Providers: Usually service providers advertise their services. The advertisement of a given service specifies that the service provider is committed to providing a particular level of service. If the service requestor feels that the Quality of Service advertised by the service provider in the advertised service could help it in achieving its objective(s) in the interaction, then the service requestor can go ahead and interact with the service provider on the terms, conditions and the Quality of Service as specified in the advertisement. It should be noted here that mostly in the case of an advertisement, there is no room for negotiation.

Once the mutually agreed service has been determined, the service requestor can determine the context of interaction. The procedure for determining the context of interaction from the mutually agreed service is as follows:

1. The context of interaction should encapsulate all the activities that were mutually agreed upon between the interacting partners.

2. The context of interaction does not quantify the expected output of the activities that were mutually agreed upon between the interacting partners.

The context of the interaction should be a high level summarization of all the mutually agreed activities between the interacting partners. As mentioned before, the terminology used by the service requestor to represent the context of interaction is not important as long as the terminology is synonymous with the terminology used in the mutually agreed service.

IV. PROCEDURE FOR DETERMINING CONTEXT OF INTERACTION WITH TRUSTED ENTITY IS A PRODUCT

Unlike the situation where a trusting agent is engaging in an interaction with a service provider, there is no negotiation phase in case the trusted entity is a product. The reason for this is that, unlike a service provider, a product is not intelligent and hence cannot determine whether or not it can deliver on a given functionality. As a result, it cannot engage in a Negotiation Cycle with another entity.

In order to determine the mutually agreed functionality, the trusting agent needs to make use of the product manual or product disclosure statement or product catalogue or purchase warranty or specification or purchase agreement produced by the manufacturer for the product. These documents specify the functionality of the product. The functionality of the product should be clearly and precisely specified or clearly and precisely disclosed by the product manufacturer to the user by using one of the forms of documents listed in Table 1. These documents specify that the product manufacturer assures or vouches that the product will accomplish certain functionality(ies) to a specified extent. The extent to which a given functionality would be accomplished is specified by making use of standard terminology.

If the trusting agent feels that the extent to which a given functionality would be satisfied or accomplished by the product (as specified or disclosed by the manufacturer using one of the forms of documents listed in Table 1) could help it in achieving its objectives in its interaction then the trusting agent can go ahead and interact with the product on the terms and conditions specified in one of the forms of documents listed in Table 1. Those quantitatively expressed functionalities, based on which the trusting agent is making a trust-based decision of interaction with a product and which have been agreed to by the product manufacturer, constitute the *mutually agreed functionality*.

The mutually agreed functionality can be additionally derived from the advertisements about the product. The advertisement of a product quantitatively (in commonly used terminology) specifies the functionality of the product.

The mutually agreed functionality of the product specifies the set of all functionality(ies), corresponding to the use of the product by the user and that have been disclosed to the buyer.

Once the mutually agreed functionality has been determined, the context of the interaction can be determined in the same way as outlined in the previous section.

V. IDENTIFY THE CRITERIA FOR MUTUALLY AGREED BEHAVIOUR

We define *criterion* as a decisive factor, the performance or the output of which has been mutually agreed upon by both the trusting agent and the trusted entity, and the trusting agent would evaluate the performance of the trusted entity in that decisive factor in its interaction with the trusted entity. In the case where the trusted entity is a service provider, the criteria in an interaction would be the set of all the activities involved in the interaction, the output of which has been mutually agreed upon by the interacting partners. In the case where the trusted entity is a product, the criteria in an interaction would then be the set of all the functionalities in the mutually agreed functionality. The different forms of documenting the mutually agreed functionality between the trusting agent and the product are depicted in Table 1.

In order to determine the criteria involved in an interaction, the trusting agent needs to go through the mutually agreed behaviour and individually pick out all those activities or functionalities that have been mutually agreed upon by the interacting partners.

VI. DEVELOP THE CRITERION ASSESSMENT POLICY

We define *criterion assessment policy* as the rules or regulations or policies based on which the trusting agent would assess whether or not a given criterion in its interaction with the trusted entity has been met. For each given criterion in the interaction (determined as outlined in the previous section), the trusting agent would need to develop its corresponding criterion assessment policy. A criterion assessment policy for a given criterion would quantitatively compare the actual behaviour and the mutually agreed behaviour of the trusted entity in that particular criterion to determine whether or not that particular criterion has been met by the trusted entity (or the extent to which the given criterion has been met).

Developing a criteria assessment policy for a given criterion is a subjective process and depends on the trusting agent. As an example, let us assume that Alice purchased Apple iPod Nano, only because she read in the product advertisement that it can hold up to 7500 songs. Based on

the above guidelines for determining mutually agreed functionality and the context of use of the product, the mutually agreed functionality in this case is 'storing 7500 songs' and the context of use of the product is 'storing songs'. There is just one functionality involved in the interaction which motivated Alice to purchase the product namely, 'storage capacity of 7500 songs'.

In order to assess whether or not the actual behaviour of the product Apple iPod Nano in the criterion involved in the use of the product, was in consonance with the mutually agreed behaviour, Alice needs to develop the criterion assessment policy for the given criterion. However, this process is very subjective since Alice may regard:

- That Apple iPod Nano delivered on the mutually agreed functionality, for the given criterion, 'fully' if it can store 7500 songs and did not deliver on the mutually agreed functionality, for the given criterion, 'at all' if the number of songs it can store is less than 7500.
- That Apple iPod Nano delivered on the mutually agreed functionality, for the given criterion, 'fully' if it can store 7500 songs and delivers on the mutually agreed functionality, for the given criterion, 'partially' if the number of songs it can store is less than 7500.
- That Apple iPod Nano delivered on the mutually agreed functionality, for the given criterion, 'fully' if it can store 7500+-100 songs and delivers on the mutually agreed functionality, for the given criterion, 'partially' if the number of songs it can store is less than 7400.

Each of the above constitutes a valid criterion assessment policy, for the given criterion, from Alice. As can be seen, the criterion assessment policy for a given criterion compares the actual behaviour with the mutually agreed behaviour and gives as output the extent of correlation between them [1,2]. The extent of correlation between the two factors specifies the extent to which the actual behaviour complies with the mutually agreed behaviour. The extent of correlation should be specified by the trusting agent itself, since different agents may have different interpretations when determining the degree of parallelism between them [1,2].

We propose a metric that would enable the trusting agent to numerically represent the criterion assessment policy of each criterion in the interaction. Due to space constraints we are unable to describe in detail and explain the assessment metric in this paper. Interested readers are requested to refer to [1] for a detailed explanation. Based on this metric, the trusting agent would then determine the trustworthiness value.

VII. DETERMINE THE TRUSTWORTHINESS VALUE

The final step is measuring the trustworthiness value of the trusted entity and quantifying it numerically is by determining the correlation between

- The actual behaviour of the trusted entity in the interaction (and)
- The mutually agreed behaviour of the trusted entity in the interaction.

In order to measure the correlation between these two factors, we need to quantify them. In the next section, we propose a metric to quantify both the actual behaviour and the mutually agreed behaviour of the trusted entity in the interaction. Additionally in the next section, we will propose the CCCI Metrics that leverage the criterion assessment policy of each criterion in the interaction to determine a weighted value of the actual behaviour and the mutually agreed behaviour of the trusted entity. The weights applied in determining the weighted values of the actual behaviour and the mutually agreed behaviour are the clarity of the criteria and the importance of the criteria that compose the interaction. Finally, the CCCI Metrics determine the correlation between the weighted values of the actual behaviour and the mutually agreed behaviour to determine the trustworthiness value of the trusted entity, numerically.

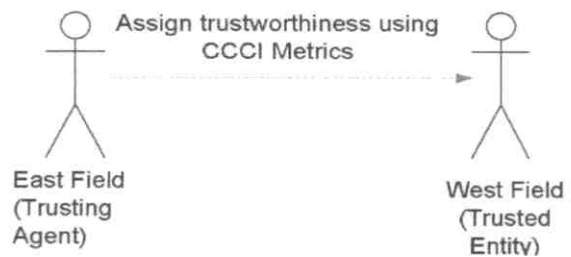


Figure 2: The trusting agent would assign a trustworthiness value for the trusted entity by making use of CCCI Metrics

When the trusted entity is a service provider, then in order to quantitatively and semantically express the Quality of Service (QoS) provided by a given service provider, the service requestor needs to determine the correlation between

- The actual service delivered by the service provider (and)
- The mutually agreed service between the service requestor and the service provider.

When the trusted entity is a product, then in order to quantitatively and semantically express the Quality of Product (QoP) in a given context, the trusting agent needs to determine the correlation between

- The actual functionality delivered by the product (and)

- (b) The mutually agreed functionality between the trusting agent and the product.

VIII. CONCLUSION

In this paper we proposed and described the trustworthiness measurement methodology for quality assessment purposes. The trustworthiness measurement methodology can be used to determine the quality of service (QoS) when the trusted entity is a service provider and can be used to determine the quality of product when the trusted entity is a product.

The proposed trustworthiness measurement methodology comprises of 4 steps. Each of these steps were described and discussed in this paper. Due to space constraints the description was not in depth and extensive. Interested readers are requested to refer to [1,2] for an extensive and in depth discussion and description of the trustworthiness measurement methodology.

REFERENCES

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