

Trustworthiness Measure for e-Service

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Abstract

Traditionally, transactions were carried out face-to-face, now, they are carried out over the Internet. The infrastructure for the above business and information exchange could be client-server, peer-to-peer or mobile network environments, and very often users on the network carry out interactions in one of three forms:

- *Anonymous (No names are identified in the communication)*
- *Pseudo-anonymous (Nicknames are used in the communication)*
- *Non-anonymous (Real names are used in the communication)*

Incapability or a fraudulent practice could occur when the seller or business provider or buyer (the agents on the network) does not behave in the manner that is mutually agreed or understood, especially if published terms and conditions exist. This paper evaluates currently existing trustworthiness systems and points out that currently there is no existing standardized measurement system for Quality of Service and outlines the methodology that we have developed for this.

1. Introduction

In recent times, we find that people engage in a wide variety of activities over the Internet on a daily basis. The activities range from writing reports to looking at news, from selling a car to joining a club, from the purchase of goods (Amazon.com) to the purchase of services (priceline.com, travel arrangement), from entertainment to research and development (information surfing), from private resource utilization (Grid computing) to remote file sharing (peer to peer communications), from shopping at a

mall (BizRate.com) to bargains at virtual market (eBay), from e-bill to e-pay, from virtual community to virtual collaboration, from e-governance (e-administration) to mobile commerce (Stock Trading), from e-education (cyber-university) to e-learning, from e-Manufacturers (remote control production) to e-factory (e-products), from off-shore development (business expansion) to outsourcing, from e-warehouse to e-logistics, and numerous other possibilities. Since these transactions are carried out over the Internet, the users on the network can carry out interaction in one of three forms: a) Anonymous (No name is to be identified in the communication) b) Pseudo-anonymous (Nick name is used in the communication) and c) Non-anonymous (Real name is used in the communication). *Incapability or fraudulent practice* could occur and this could have several forms:

- (a) The *seller* or the *service provider* only delivers part of the service or partial promises, or is inconsistent in delivering good service i.e. sometimes delivering and sometimes not delivering or being incapable of delivering or never delivering what has promised or advertised.
- (b) The *customer* or user may always be negative and disrupt the business, or give false credit details.
- (c) The provider provides a *service* that is not up to the standard or not acceptable.
- (d) The seller's *product* is not of good quality.

Trust in virtual environment gives online user sensations such as 'squeeze the oranges before you buy' or 'get a first or second or third hand opinion before you make a decision' with respect to consumer confidence and business reputation. In other words, you feel confident about paying for a service or a product because you trust the seller's reputation or the quality of products (*goods*) or services. This is a better option than taking a risk and depending on your luck. On the other hand, *sellers* or

service providers can learn about their users and customers through trust relationships so that they can improve on-demand service that better meets customer needs.

There are some basic trustworthiness systems, or rating systems, or recommender systems already existing on the Web, such as e-Bay, Amazon, BizRate, CNet etc. These systems are getting more and more popular and providing a convenient technological tool to simulate the social trust and recommendation experience for all online users.

Trust is a crucial ingredient for honest interaction. Trustworthiness and quality of service are required in anonymous, pseudo-anonymous, non-anonymous distributed environment to ensure a trusted social and economical network, and mutual and natural environment which permits everybody to enjoy it and to benefit from it.

2. Service Oriented Environment

A Service Oriented Environment is defined as a collaborative, shared and open community in which agents utilise the infrastructure and technology to carry out business activities, such as product sales, services deliveries and information retrieval. It has at least 4 components: Agents, Business Activities, Infrastructure and Technology.

- Agents (Buyers, Sellers/Providers, Users, or Websites, Servers)
- Business Activities (product sells, or service deliveries, marketing, information sharing, etc)
- Infrastructures (networks communications)
- Technologies (service publishing, discovery, binding and composition)

It is a *collaborative environment*, because there are no closed wall individual operations in traditional business sense. On-line users are often anonymous, but help each other by posting questions on the web, answering questions on the web, and carrying out collaborative business or research or industrial processes etc.

It is a *sharing environment*, because agents share information all the time on the web, such as sharing information about unknown agents, unknown products, unknown service providers, or merchants etc.

It is an *open community environment* with emerging trusted technologies, the behaviours of sellers, producers, merchants, manufacturers, service providers, ratings by all kinds of on-line users, buyers, sellers, etc.

The following diagram depicts the service oriented environment and its major entities.

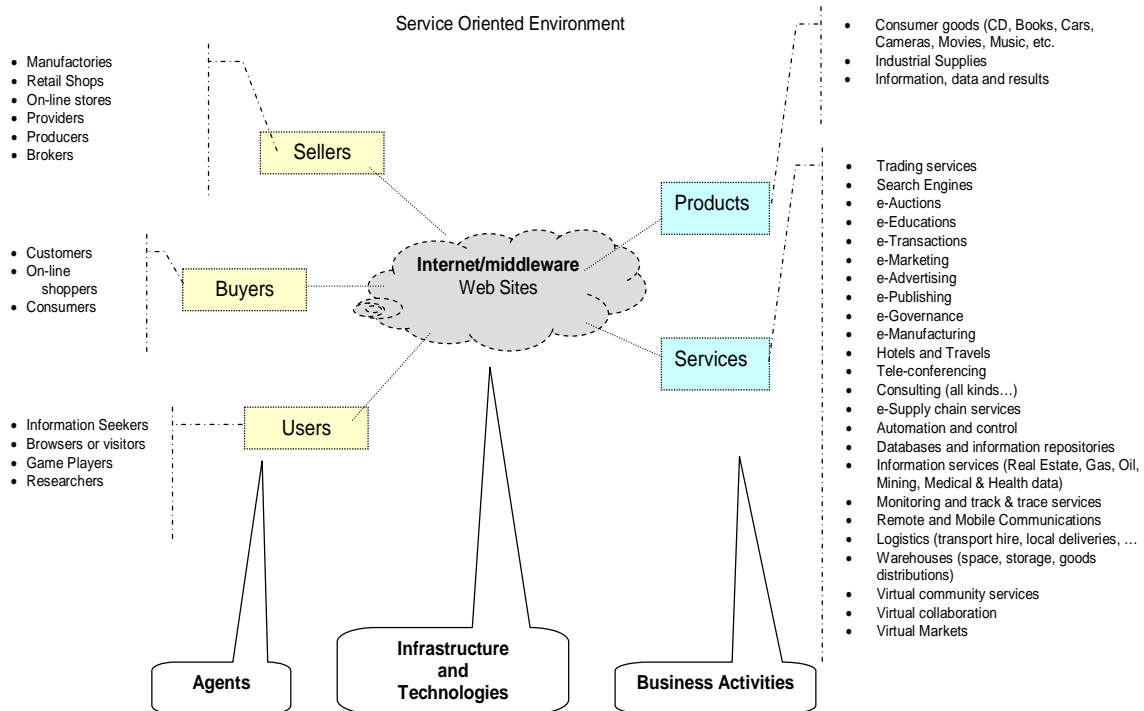


Figure 1. Service oriented environment and its major entities

An Agent in a service oriented environment is an intelligent autonomous entity. It can be a buyer, interacting peers over the network, or software that runs

through a website (software agents), or a server, server software that runs behind the scene, or even a website.

Sellers in service oriented environment are the one making sales. They are businessmen, brokers, dealers, merchants, retailers, auctioneers, on-line stores or shops, salesmen, tradesmen.

Buyers in service oriented environment are purchasers, clients, consumers, customers, or shoppers. Buyers can also be business entities, such as in B2B e-commerce. A Buyer is a very important entity in service oriented environment, because it raises all the issues that create business, infrastructure and technology that we are dealing today, such as security and trust and protecting consumer rights and fighting from vulnerability.

Users in service oriented environment are information seekers, browsers, information requesters, game players, researchers, patrons or shoppers; they could also be customers, buyers, sellers or providers. We separate users from buyers or sellers, because the population of on-line users is much larger than buyers or sellers.

Finally, we define *Web Sites* as agents. This is because *Web sites* in service oriented environments are intelligent information pages on the Internet with unique URLs and by incorporating and utilizing software technology and hardware infrastructure, it can carry out communication between agents and achieve business objectives such as enabling sales and service deliveries. They are normally

written in Hyper Text Markup Language (HTML) or Extended Markup Language (XML) with plug-in applications and linkage with databases. They are sometimes protected by firewalls. Example: www.google.com.

Products in service oriented environment are *goods* or *finished products* that are for sale to consumers. It could be any software or hardware, even information kits, results, data sets, documents, experimental output,, e.g., DVDs, Cars, Microsoft Windows OS, Bags, Whether Information, Drug Information, etc.

We also define any *information* retrieved from service oriented networks as products, regardless of whether it is free or not, because results, reports, documents or information are outcomes of research or development or products from information providers, e.g. IEEE, has the world's largest scientific article collection and they sell scientific papers as products.

Quality of Product can be valued or rated by consumers who used the product or customers who brought the product. They give the *quality of the product* rating based on their opinions.

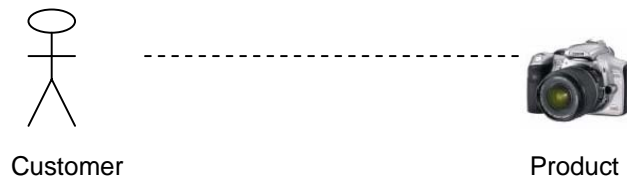


Figure 2. Customer gives an opinion on the quality of the product

Services in service-oriented environments are jobs, duties or works that a business or a provider offers to customers or consumers. Such as logistics services (they have trucks or train, and can delivery goods or products for you, however, they do not own or produce the goods), warehouses (such as space rental, freezers or air-conditioned space), information databases, etc. From Figure 1 we see the service include *not limited* to are:

- | | |
|--|---|
| <ol style="list-style-type: none"> 1) Trading services 2) Search Engines 3) e-Auctions 4) e-Educations 5) e-Transactions 6) e-Marketing 7) e-Advertising 8) e-Publishing 9) e-Governance 10) e-Manufacturing 11) Hotels and Travels | <ol style="list-style-type: none"> 12) Tele-conferencing 13) Consulting (all kinds...) 14) e-Supply chain services 15) Automation and control 16) Databases and information repositories 17) Information services (Real Estate, Gas, Oil, Mining, Medical & Health data) 18) Monitoring and track and trace services 19) Remote and Mobile Communications 20) Logistics (transport hire, local deliveries) 21) Warehouses (space, storage, goods distributions) 22) Virtual community services 23) Virtual collaboration 24) Virtual Markets |
|--|---|

From above list, you may notice the characteristics of services are:

- (1) None of above is a product.
- (2) The service may or may not be free.
- (3) Service items 16 and 17 are information services. They may or may not be free.

A Service always involves two parties, the service provider(s) and service customer(s). Therefore, it is always accompanied with a service agreement between the two parties. A service agreement may be very simple, or may

be very complex; this is depended on the size of job. A Service Agreement mainly contains terms and conditions. It contains the responsibilities of both parties, for example, the service customer should pay the right amount at right time and service provider should deliver the quality of service according to the mutually agreed terms and conditions.

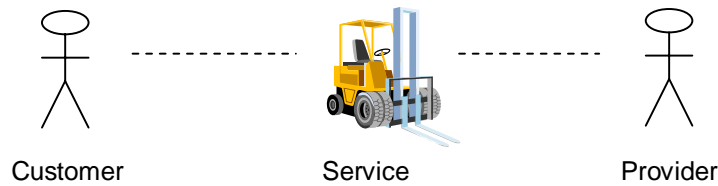


Figure 3. Quality of service is measure by consider the customer’s input as well as the input from the service provider

Quality of Service is determined by the fulfilment of service agreement. Normally, when a service contract is signed, it implies that both parties understand the service agreement and mutually agree with all the terms and conditions it contains. By default, the *service provider* should deliver the mutually agreed service to its *service customer*, and the measurement of the quality of service does not only take into account the service customer’s point of view, but also the service provider’s input, as the service agreement binds both parties together.

3. Existing Trustworthiness Systems

Amazon.com

Amazon.com is a very well-known on-line book store, which also sells many other consumer products. Amazon.com provides Product Quality Rating Systems on which a buyer can make a buying decision. The product review has a 5 star legend. The description of which is as follows:

- ‘Hated it’
- ‘don’t like it’
- ‘Its ok’
- ‘like it’
- ‘loved it’

Yahoo.com

Yahoo recommendation system rates the Merchants as well as the Products. Yahoo’s Merchant Rating System an integral part of Yahoo’s business strategy to boost consumer confidence with Yahoo. The rating system collects feedback from shoppers about merchants and then uses the feedback to determine an overall rating for that merchant. Users rate merchants on a five-star scale.

Epinion.com

Epinion.com’s Product Ratings ranks the products. All of the products in a category or subcategory are ranked based on their overall star rating. The overall star rating is

Excellent	☆☆☆☆☆
Very Good	☆☆☆☆☆
Good	☆☆☆☆☆
Fair	☆☆☆☆☆
Poor	☆☆☆☆☆
No rating submitted	N/A

calculated based on the following criteria:

- Overall product rating, with extra weight given to high quality reviews
- Number of reviews about the product
- Recency of reviews about the product



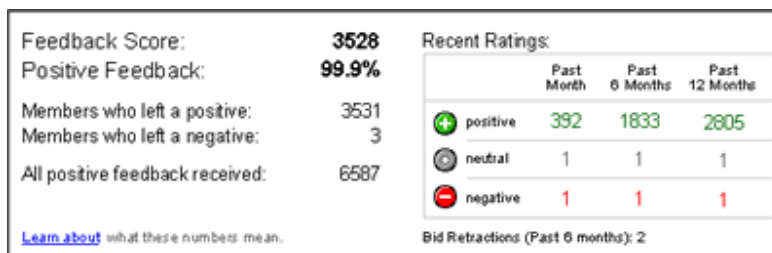
Example of the Digital Camera Ratings

Epinion.com's *Reviews Rating* is very unique. This adds to the quality of rating system. There are four criteria for rating reviews in Epinion and they are:

1. **Not Helpful:** The review is off-topic, inaccurate, offensive, or copied from another source.
2. **Somewhat Helpful:** The review is poorly presented or somewhat inaccurate.
3. **Helpful:** The review is accurate and well-presented.
4. **Very Helpful:** The review is exceptionally accurate, contains a significant amount of useful information about the subject, and is very well presented

e-Bay.com

In e-Bay, members only provide feedback about their interaction with another member. An e-Bay member or seller or buyer is scored by the number of members that are satisfied in doing business with this particular member. In order to make that feedback fair and safe, each e-Bay member can only affect another member's feedback score by +1, 0, or -1 with +1 point for a positive feedback and 0 points for neutral feedback and -1 for each negative feedback.



In the above figure, the total user *feedback* (points or score) in the last 12 months is 3528, the percentage of positive feedback is 99%, details of recent ratings from up to a year and a cumulative figure showing a positive and a negative feedback.

Based on the points scored the e-Bay member are assigned stars. As the number of positive feedback score increases, the higher the star level it gets.

Yellow Star (★) = 10 to 49 points

Blue Star (★) = 50 to 99 points

Turquoise Star (★) = 100 to 499 points

Purple Star (★) = 500 to 999 points

Red Star (★) = 1,000 to 4,999 points

Green Star (★) = 5,000 to 9,999 points

Yellow Shooting Star (★) = 10,000 to 24,999 points

Turquoise Shooting Star (★) = 25,000 to 49,999 points

Purple Shooting Star (★) = 50,000 to 99,999 points

Red Shooting Star (★) = 100,000 or higher

BizRate.com

The *Merchant or Stores* are rated on the four level scales, which is shown here



The Smiley Scale can quickly help you find stores with the level of quality you like for the price that you want. Example: Is it worth saving \$10 on a bouquet of flowers when the merchant has a 'Red Sad-face' for 'On-time delivery'?

CNet

CNet store rating is termed as CNET Certified Store and a store can get this certificate if the store participates in the CNET Certified Store Program. There are four categories that are involved in deciding the rating for a store.

- Site Functionality,
- Store Standards,
- Order Fulfilment,
- Customer Feedback.

Each above category is further decomposed into several criteria that the store has to satisfy.

Site Functionality category has seven criteria are:

1. Uses Shopping Cart technology and totalling of orders
2. Uses Secure Server transactions
3. Accepts multiple credit cards
4. Offers a published return policy
5. Offers a published FAQ/help policy
6. Offers a published policy on when credit cards are charged
7. Links user to product-specific 'buy' page

Corr_{service}

The correlation of *mutually agreed service* and the *actual delivered service*. In another words, the correlation between the original committed service and actual delivered service from the Trusted Agent.

Commit_{criteria c}

The commitment to the *mutually agreed service* from Trusted Agent.

Clear_{criteria c}

The clarity of the *mutually agreed service* that is understood by both parties.

Inf_{criteria c}

The influence of the *mutually agreed service* to the determination of the trustworthiness of Trusted Agent.

The Figure below shows the rating for stores.

Rating	Explanation
1-1.9	Abysmal
2-2.9	Terrible
3-3.9	Very Poor
4-4.9	Poor
5-5.9	Mediocre
6-6.9	Fair
7-7.9	Good
8-8.9	Very Good
9-9.9	Excellent
10	Perfect

Figure 4. CNet rating scales for store

User ratings on CNet are different from editors rating. Here the user simply ranks a product or service as 'Thumbs up' or 'Thumbs down'. And they have the option of leaving a leaving a comment with pros and cons. The overall user ratings are averaged into the categories of 'thumbs up' and 'thumbs down', e.g.,

Editors' rating:	8.6 Very good
User rating:	79% 21% from 292 users

We note that the above systems rate products not services and are also not standardized. We further note that there exists no standardized trustworthiness system for measuring quality of service. There are existing systems for measuring sellers, buyers, users, websites, and products, however, there has been no work done in measuring the quality of services. Below we propose a methodology for determining trustworthiness in service oriented networks.

4. Trustworthiness Measure with CCCI

We present the CCCI methodology for trustworthiness measure of quality of service, which can be used by the Trusting Agent to determine the trustworthiness value of the Trusted Agent after a business service interaction. The method contains four key metrics as follows:

Trustworthiness measure is defined as:










- The *measure of the trust level or the trustworthiness value* of Trusted Agent *after a service interaction.*;
- The trustworthiness measure is unidirectional from the Trusting Agent to the Trusted Agent;
- The measurement is made using a Correlation metric;
- We correlate the *actual service delivered* by the Trusted Agent against the *originally committed* service;
- *Terms and Conditions* serve as *criteria* or *benchmarks* when carrying out the correlation;
- The clarity of the *criteria* (or *terms and conditions*) is very important in avoiding disputes involving trustworthiness measure;

- The weight of each criterion influences the decision making and affects trustworthiness values.

5. CCCI Methodology










7 Levels of Commit_{crit} and Values

We define 7 levels of Commit_{crit}. We give semantic description of these levels for Commit_{crit}. Each of these seven levels corresponds to a different degree or extent to which the Trusted Agent fulfils its commitments.

7 Level Scale	Semantics	Description	Values of Commit _{crit}	Visual Representation (Star Rating System)
0	None or ignore	The criterion may be cancelled, or changed.	0	Not displayed
1	Nothing is Delivered	The Trusted Agent did not fulfil the criterion at all	$0 < x < 1$	Normally, not displayed
2	Barely Delivered any commitment	the Trusted Agent has not fulfilled the criterion	$1 \leq x < 2$	From  to 
3	Partially Delivered all the commitment	the Trusted Agent delivered part of the criterion	$2 \leq x < 3$	From  to 
4	Largely Delivered all the commitment	The delivery on the criterion is not bad	$3 \leq x < 4$	From  to 
5	Delivered all the commitment	The delivery is satisfactory	$4 \leq x < 5$	From  to 
6	Fully delivered all the commitment	the Trusted Agent has fully delivered on the commitment	5	










Levels of Clear_{crit} and Values

We propose seven different levels and values for Clear_{crit}, to represent how clear the criterion is defined. These seven levels lead to 7 value ranges of Clear_{crit} which are explained below.

7 Level Scale	Semantics	Description	Value of Clear _{crit}	Visual Representation (Star Rating System)
0	None or Ignore	A condition does not mean anything	0	Not displayed
1	Not clear	This criterion is not clearly defined	$0 < x < 1$	Normally, not displayed
2	Barely clear	Criteria is ambiguous	$1 \leq x < 2$	From  to 
3	Partially clear	The Trusted Agent knows this criteria at 50%	$2 \leq x < 3$	From  to 
4	Largely clear	The Trusted Agent knows this criteria generally	$3 \leq x < 4$	From  to 
5	Clear	The Trusted Agent knows the criteria	$4 \leq x < 5$	From  to 
6	Very clear	This criterion is explicitly terms	5	

7 Level of $Inf_{criterion}$ and Values

In order to express the influence of each criterion in the service interaction we propose seven levels that denote in increasing order the weight that can be assigned to a criterion in an interaction. The influence of each criterion in determining the outcome of the interaction will be taken into account when determining the trustworthiness of the Trusted Agent. The influence of each criterion as we mentioned before depends on the perception of the Trusting Agent and may vary from one agent to another.

7 Level Scale	Semantics	Description	Value of $Inf_{criterion c}$	Visual Representation (Star Rating System)
0	None or ignore	A condition doesn't mean anything	0	Not displayed
1	unimportant	If a criterion is assigned this weight it means that this is some additional information requested by the Trusting Agent and in case the Trusted Agent does not satisfy this criterion, it will not be assigned a low trustworthiness value.	$0 < x < 1$	Normally, not displayed
2	Barely important	This weight indicates that the criterion has minimum importance	$1 \leq x < 2$	From  to 
3	Partially important	This weight indicates that the criterion is 50% importance	$2 \leq x < 3$	From  to 
4	Largely important	This weight indicates that the criterion is not very important	$3 \leq x < 4$	From  to 
5	Important	This weight indicates that the criterion is important for the Trusting Agent and if the Trusted Agent does not satisfy this criterion, it may be assigned a low trustworthiness value.	$4 \leq x < 5$	From  to 
6	Very important	This weight indicates that the criterion is <i>crucial</i> for the Trusting Agent and if the Trusted Agent does not satisfy this criterion, it may be assigned a low trustworthiness value.	5	

6. Correlation of Mutually Agreed Service – $Corr_{service}$

$Corr_{service}$

The *correlation of mutually agreed service* is defined as a measure of how much the Trusted Agent deliver his commitment set out in the terms and conditions of the service agreement.

The *correlation of mutually agreed service* is represented by $Corr_{service}$

The Correlation Metric

$Corr_{service}$ can be expressed as the sum of the correlation values corresponding to all the **criteria** in the interaction. Here we assume that there are N criteria in an interaction and $Commit_{criterion c}$ denotes the fulfilment of the ' c^{th} ' criterion.

The contribution of the ' c^{th} ' criterion to the overall value of $Corr_{service}$ can be represented as:

$$f(Commit_{criterion c}, Clear_{criterion c}, Inf_{criterion c}) = Commit_{criterion c} * Clear_{criterion c} * Inf_{criterion c}$$

Therefore we can express $Corr_{service}$ as:

$$\begin{aligned}
 Corr_{service} &= \sum_{C=1}^N f(Commit_{criterion c}, Clear_{criterion c}, Inf_{criterion c}) \\
 &= \sum_{C=1}^N Commit_{criterion c} * Clear_{criterion c} * Inf_{criterion c}
 \end{aligned}$$

Corr_{service} for a given service as a sum of $f(\text{Commit}_{\text{criterion } c}, \text{Clear}_{\text{criterion } c}, \text{Inf}_{\text{criterion } c})$
 Substituting the expressions for Corr_{service} and Max Corr_{service} in the above equation we get the following:

$$\text{Trustworthiness} = 5 * \left(\frac{\sum_{C=1}^N \text{Commit}_{\text{criterion } c} * \text{Clear}_{\text{criterion } c} * \text{Inf}_{\text{criterion } c}}{\sum_{C=1}^N \text{Max Commit}_{\text{criterion } c} * \text{Clear}_{\text{criterion } c} * \text{Inf}_{\text{criterion } c}} \right)$$

Trustworthiness expressed in terms of Commit_{criterion c}, Clear_{criterion c}, Inf_{criterion c} and their corresponding maximum values

7. Example

An interaction between the two Logistics Companies (East Logistics and West Warehouse), we note that East Logistics as the Trusting Agent will assign a trustworthiness value to West Warehouse based on whether:

- West Warehouse allocated it with a warehouse space of 6000 sq feet.
- The warehouse space was provided to it for a duration of 2 months.

In other words, East Logistics will assign a trustworthiness value to West Warehouse based on the

above two criteria for the amount of space allocated and duration of time for which it is allocated.

- We denote the fulfilment of warehouse space against actually allocated space by West Warehouse to East Logistics and the warehouse space that was initially promised (6000 Sq Feet) as Commit_{space}.
- We denote the fulfilment of the duration of days for which the warehouse space was actually provided by West Warehouse and the duration of days that was initially promised (60 days or 2 months) is denoted as Commit_{days}.

Therefore the total fulfilment of the commitment can be represented as:

$$\text{Commit}_{\text{warehouse-booking}} = \text{Commit}_{\text{space}} + \text{Commit}_{\text{days}}$$

We can apply Equation 6 to the example in section 6.4.7 of the interaction between West Warehouse and East Logistics where:

$$\text{Corr}_{\text{service}} = (\text{Commit}_{\text{space}} * \text{Inf}_{\text{space}} * \text{Clear}_{\text{space}}) + (\text{Commit}_{\text{days}} * \text{Inf}_{\text{days}} * \text{Clear}_{\text{days}})$$

$$\text{Max Corr}_{\text{service}} = (\text{Max Commit}_{\text{space}} * \text{Inf}_{\text{space}} * \text{Clear}_{\text{space}}) + (\text{Max Commit}_{\text{days}} * \text{Inf}_{\text{days}} * \text{Clear}_{\text{days}})$$

Criterion c	Commit _{criterion c}		Inf _{criterion c}	Clear _{criterion c}	Corr _{service}	
	Actual	Max	Actual	Actual	Actual	Max
Space	4	5	5	5	100	125
Days	3	5	4	5	60	100
				Total	160	225

The table shows the actual values for Commit_{criterion c}, Inf_{criterion c} and Clear_{criterion c} for each criterion. The table

also shows the maximum possible scores for Commit_{criterion c} and Corr_{service c}.

From the table we conclude that in this case:

$$\text{Rel Corr}_{\text{service}} = \text{Corr}_{\text{service}} / \text{Max Corr}_{\text{service}} = 160/225$$

Therefore,

$$\text{Trustworthiness} = 5 * \text{Rel Corr}_{\text{service}} = 3.5 \text{ (approximately)}$$

Therefore the visual representation of this Trustworthiness Value using the ordinal scale of Trustworthiness introduced in Chapter 3 would be 3.5 stars (★★★★☆) and this corresponds to Trustworthiness Level 4. According to the semantics for this level, the Trusted Agent (in this case, West Warehouse) is largely trustworthy.

8. Conclusions

We have described a trustworthiness system for measuring quality of service over the distributed service oriented environment. There has been no work done in this area [7]. We also had initial patent for our approach and the implementation of the ideas. The trustworthiness system will be on-line in the very near future. This research is an outcome of the project funded by Australian Research Council.

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