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### On inter-organizational trust engineering in networked collaborations : modeling and management of rational trust

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**Publication date**  
2009

[Link to publication](#)

#### **Citation for published version (APA):**

Msanjila, S. S. (2009). *On inter-organizational trust engineering in networked collaborations : modeling and management of rational trust*. [Thesis, fully internal, Universiteit van Amsterdam].

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## Annex B

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### TrustMan validation with standard indicators and against related systems

A key aspect for the research is related to evaluating the quality and the innovation of the achieved results. This annex provides the descriptions of standard indicators applied to the evaluation of the TrustMan system.

#### B.1 Applied standard indicators

Although indicators (measurable attributes) frequently used in the field of computer science, it is still possible to systematically evaluate the level of quality and innovation of developed models and systems [Pressman, 2005]. The evaluation is based on a set of clearly defined rules, which characterize the possible qualitative indicators. In this thesis to evaluate the quality and innovation of the TrustMan system we apply standard indicators inspired by the ISO 9126 quality factors of software [Pfleeger, 2001] as addressed below.

##### 1. Functionality

Functionality refers to the state of being functional and especially focusing on a particular set of functions or capabilities associated with computer software, computer hardware or an electronic device. The key aspects related to functionality that are considered for the evaluation of the TrustMan system are *interoperability and security*.

1.1 **Interoperability:** With respect to software, the term interoperability is used to describe the capability of different programs to exchange data via a common set of exchange formats, to read and write the same file formats, and to use the same protocols. Interoperability is the ability of a provider system to work with recipient systems without special effort on the part of the client system. To realize interoperability among systems a set of standards must be defined and followed during the development of those systems.

*Interoperability of the TrustMan system: The TrustMan system is developed using the java programming language. It provides services that can be accessed through a web interface by human users and through invocation by system users. Web service technology standards are applied to the development of TrustMan system. Thus as described in Section 6.5.2, the remote invocation of services provided by the TrustMan system applies the SOAP protocol. This support the interoperability of the TrustMan system with other systems developed applying these standards.*

1.2 **Security:** Security of a system refers to protecting the information managed by that system and the system itself from unauthorized access, use, disclosure, disruption,

modification, or destruction. It is also concerned with the confidentiality, integrity and availability of data stored and managed by the system.

**Security of the TrustMan system:** *The TrustMan system manipulates performance data of organizations, expressed in terms of their trust criteria, to assess their trust level. The performance data can be too strategic for the owner organization to disclose to other organizations. To enhance the security of the trust related data stored in the TrustMan system, we have classified the access to the system depending on roles of users. This security aspect is further addressed in Section 6.4.2.*

## 2. Efficiency

Efficiency refers to a system's ability to perform (support performing) a process with optimal use of time and resources. As such, it refers to increasing productivity of a system while minimizing the amount of consumed resources and time taken to meet a set of requirements for the output, such as the quality. We address the efficiency of the TrustMan system by considering two quantitative indicators, namely, **resources and time** as addressed in detail in Section 6.6.2 and Chapter 7.

## 3. Maintainability

Maintainability refers to the ease with which a software system or a component of a system can be modified to correct faults. It also refers to the possibility to improve performance or other attributes of the system and to adapt the system to a changed environment. In other words, maintainability measures the ease and speed with which a system can be restored to an operational status after a failure had occurred. We have evaluated the maintainability of the TrustMan system with two indicators, namely: **analyzability and changeability**.

**3.1 Analyzability:** Refers to the ease/possibility to in detail examine a system in order to identify causes of problems/faults that are experienced in operations of the system.

**Analyzability of the TrustMan system:** *As stated earlier, the TrustMan system is developed using the java programming language. Modules developed to support the operations of the TrustMan system are grouped into sets of integrated services. Each module is developed to provide one complete service such as computing a score for a single trust perspective. These modules operate independent of each other while executed to provide the required services. Thus each module can be analyzed and modified independent of others.*

**3.2 Changeability:** Refers to the quality of a system to allow replacement of some of its modules without major modification of others modules. This quality is related to the independent nature of modules in the system.

**Changeability of the TrustMan system:** *As explained earlier, the modules of the TrustMan system operate independent of each other. Thus they can be replaced with new modules which meet the format and type of input and out data.*

## 4. Usability

Usability is a qualitative attribute of a system that assesses how easy user interfaces are to use. It includes aspects such as: (1) Who are the users, what do they know, and what can they learn? (2) What do users want or need to do? (3) What is the general background of the users? (4) What is the context in which users are working? (5) How much training do users need? (6) What documentation or other supporting materials are available to help the users and can those users find the solutions they seek in those materials?

Usability can be indicated by the quality of the system related to **learnability, operability, and understandability**.

**4.1 Learnability:** Refers to the easy for which users can accomplish basic tasks the first time they encounter the system. According to ISO 9126, in software testing the learnability of the system is defined as the capability of a software product to enable the user to easily learn how to use it.

***Learnability of the TrustMan system:** Human interfaces designed to support each group of users to access the TrustMan system are developed as web based interfaces. The interface is designed to support a particular user to access only specific functionalities which makes it possible to develop simple but efficient interfaces that facilitate users with basic knowledge of accessing website to easily use the TrustMan system.*

**4.2 Operability:** Operability refers to the ability of a system to let users access its functionality without an appeal of high level of technical knowledge.

***Operability of the TrustMan system:** Mechanisms developed to support the computation of the trust level of an organization are based on a set of mathematical equations. Understanding such equations is quite difficult for users who have little knowledge of both mathematics and computer science. As implemented in the TrustMan system, these equations are hidden and their related services are developed to the level at which they can be easily executed by users through the web interface.*

**4.3 Understandability:** Refers to the degree to which the purpose of the system is clear to evaluators or users. To achieve understandability the system should be comprehensible for users and not only for developers. There are many aspects addressing the understandability of a system including: application structure, navigation, procedures, terminology, etc. Understandability may also be achieved when users are supported to know the state of their task, what to do next, how the application reacts to certain inputs, and so on.

***Understandability of the TrustMan system:** As described in Section 6.4.2, user interfaces of the TrustMan system are classified per user category. Furthermore, user interfaces for each user category are classified per main functionality (integrated service). Example interfaces are those supporting the access of functionalities for: managing trust related data, assessing and viewing trust level, tuning and for viewing trust criteria, etc. The classification of interfaces per user group enhances the understandability of the TrustMan system.*

## 5. Reliability

Reliability refers to the ability of a system or its components to perform the required functions without a failure under stated conditions for a specified period of time. Reliability can be indicated by *maturity and recoverability* of the system.

**5.1 Maturity:** In engineering discipline the maturity of a product is measured in terms of the time which has elapsed since the product was introduced in the market. Considering the fast evolution of software, the time elapsed is not sufficient indicator to measure maturity of software. One methodology applied to analyze the maturity of software is examining aspects related to the development approach, programming language, applied standards, etc.

***Maturity of the TrustMan system:** As stated earlier, the TrustMan system is developed using the java programming language. Java is a proven programming language which implies a system developed in java shall have a high reliability in relation to maturity indicator. However, the TrustMan system itself is not mature since it is still new to the market.*

**5.2 Recoverability:** Refers to the ability to restore a system deployment from a point at which a failure has occurred to a normal operation state without any loss of data. The ability to recover quickly from a system failure or disaster depends not only on having current backups

of data, but also on having a predefined plan for recovering that data on new hardware. Recoverability is enhanced when software is developed on the basis of a well defined set of standards and the reconfiguration is well thought during the development stage.

**TrustMan system:** *TrustMan system is developed on the basis of well established standards as inspired by web service technology. These standards enforce that the components of the system must be developed as simple and independent to each other as possible. Thus the components can be recovered and even replaced without affecting the operability of other components. Furthermore, the developed components of the TrustMan system are logically separated with the storage and management of trust related data. Thus failure of the system can hardly have any effect on the stored data and therefore, its backup can be made independent of the state of the system, such as using the functionalities provided by the database management system.*

## 6. Portability

Portability refers to the ease with which the software can be transposed from one environment to another, such as from one (e.g. operating system) to another platform. The pre-requirement for portability is the generalized abstraction between the application logic and system interfaces. When developers are targeting several platforms with the same application, portability is the key issue for achieving cost reduction. Among others portability of a system can be evaluated in relation to **adaptability, installability and replaceability**.

**6.1 Adaptability:** The construction of software in modern computing contexts is increasingly concerned with volatile and unpredictable nature of both user requirements and business environments. A number of research fields have thus emerged, which seek to increase the adaptability of systems, both before, but even after software has been built and deployed. One key aspect of adaptability is that the software should be capable of running on any platform.

**Adaptability of the TrustMan system:** *TrustMan system is developed using the java programming language. Java is a platform independent programming language and thus the developed systems can run on any platform. Therefore, the TrustMan system can be stated as an adaptable system. Furthermore, the perceptions of trust differ among users of the TrustMan system. To enhance adaptability of the TrustMan system to different VBE environments, we have developed a supporting module based on logical operations. The logical operations support users to enable or disable some trust criteria to meet their preferences and perceptions on trust. The TrustMan system was successfully tested by different VBE networks as described in Section 6.6.2 which indicate its adaptability.*

**6.2 Installability:** The installability is a characteristic which allows easy configuration of a system at a designated environment. It correlates with metrics which measure the effort and time needed to install the software in a specified environment.

**Installability of the TrustMan system:** *Installing the TrustMan system can be done by simply copying the class files into the publishing directory of the web server. Thus the installation does not need any special technical knowledge and therefore, the installability of TrustMan system can be stated as easy.*

**6.3 Replaceability:** Refers to the characteristics that relate to the ease with which a system can be replaced with another system without using much technical knowledge, resources or time.

**Replaceability of the TrustMan system:** *The replacement of TrustMan system can be done either for the entire system or some specific modules. If it is needed to replace the entire TrustMan system then the new system must match the schema of the database which is designed to manage the trust related data. If it is needed to replace some modules of the*

*TrustMan system then the new modules must at least match the input and output data. There will be no need to reconfigure classes in other modules of the system.*

## B.2 Related trust management systems

A number of systems supporting some tasks related to the management of trust among actors were analyzed and their functionalities compared to those provided by the TrustMan system. Below we provide a brief description of five example trust management systems.

### 1. Dynamic Responsibility Authorization for Collaborative Organizations – DRACO (COMARCH, Poland)

This is a commercial system developed by COMARCH Company, first as a prototype during the ECOLEAD project period, and then later enhanced for business purposes. The system is applied to analyze trust among collaborating partners based on security of the collaboration infrastructure. The main assumption is that security and trust are fundamentally related. Without properly defining these concepts, the configured collaborations will hardly show their full potential. When the number of participants (members) in a VBE is large, the organizations involved may have no initial trust relationship on forehand. The security of the infrastructure plays an important role in supporting the establishment of trust between participants by dynamically facilitating authorization, sharing, exchanging and assigning roles among partners while working together to achieve a joint goal. To achieve this facilitation, all applied local systems must be configurable to meet the security indicators as defined in the DRACO system, such as reliability, availability, access control, identifications, etc.

### 2. okCupid.com ([www.okcupid.com](http://www.okcupid.com))

This is a freeware system accessed online and is developed to support individuals to create their communities of friends. Trust among partners in these communities is assessed based on matching profiles of membership applicants to the profiles of the owner of the online community. Profiles are characterized with a number of common elements. Each element is assigned with some optional values that a user can select while creating his/her profile. If a specific user wants to join a certain community then his/her profile is matched with the profile of the owner and the result is provided in terms of percentage. If the matching percentage is equal or greater than the threshold set by the owner of the community then the owner is notified about the potential new member in order to make a decision.

### 3. Trusted Advisor Associates (<http://trustedadvisor.com/>)

This is a freeware system accessed online that supports individuals to assess their own trust level by answering dynamic questionnaires. Based on the answer that the actor provides in response to the current question, the system dynamically decides about the next question selecting it from the large pool of questions. Once all required questions are answered the system computes the trust level based on a pre-defined formula. Each answered question is related to one of four trust criteria applied in this system, namely: Credibility (C), Reliability (R), Intimacy (I) and Self-orientation (S). The trustworthiness (trust quotient TQ) of an actor is calculated using the following equation:

$$TQ = \frac{C + R + I}{S}$$

### 4. Trust assessment wheel (<http://www.darden.virginia.edu/faculty/james.htm> )

This is an interactive guidance supporting students to analyze the trust of others for potential collaboration at school. It is designed to support students to trust each other and facilitate co-working in a group work. The guidance provides a number of trust criteria organized in a wheel. Based on the answers that a student provides on some specific questions the guidance

suggests some possible trust criteria. The student will then decide about the final preferred set of trust criteria to apply in assessing trustworthiness of others.

### **5. Truster (<http://www.truster.org/>)**

Truster.org is a free central online reputation system. It utilizes the latest OpenID identification technology (such as yahoo ID, Microsoft messenger ID, etc.) to uniquely identify an online user and allows all users of the system to see his rating and feedbacks. Each user has his/her own-personal profile page. Users can then inform the Truster about what forums and sites they are members in (example: ebay, forums, blogs and so on) and customize their profiles (picture, emails etc). When an online transaction is made, the user authorizes the other site to submit their feedback to Truster.org. Feedback will include the deal URL, overall experience with the person and other trust related information. Finally, the user will get a Truster.org trustworthiness rating (ranging between 0-5) and rating symbol (thumbs up is the best and thumbs down the worse and other symbols denote ratings in between).

## **B.3 Evaluation of TrustMan system with standard indicators**

Figure 7.4 shows the results of the evaluation of TrustMan system with standard indicators and against other related systems. As it can be seen from that figure the TrustMan system performs better than other related trust management systems for supporting the management of inter-organizational trust in VBEs. Based on the evaluation results as shown in Figure 7.4 the following are example fundamental conclusions in relation to evaluation of the TrustMan system against other systems:

- TrustMan system performs better than other systems in relation to the analyzability indicator. The other systems are difficult to analyze due to a number of reasons for example: (1) the mechanisms applied to match the profiles in the okCupid.com system are not clear and missing detailed description, and (2) the relation between the four criteria applied in the “Trusted Advisor Associates” and the large set of questions asked to the user is difficult to analyze and not detailed in the system.
- Considering changeability indicator, the modules of TrustMan system are easier to change than those implemented in other systems except the Trust Assessment Wheel because the later is system providing guidelines on how trust can be analyzed. Thus those guidelines can easily be changed with other guidelines than changing java classes in modules of the TrustMan.
- DRACO system performs better than the TrustMan system in the aspects of security. A number of security services needed to support collaboration among organizations in distributed environments are implemented in DRACO system. However, in the TrustMan system the needed security services are remotely invoked from the ECOLEAD ICT infrastructure as addressed in Chapter 6. The invocation process might have some difficulties, such as network failure, and in such cases the TrustMan system might fail to assure the required security level.
- TrustMan system provides services that can be accessed by other VMS subsystems through invocation methods (see in Chapter 6) which results to a high interoperability with other VMS subsystems. However, the five compared system does not support service invocation and thus they have limited interoperability.
- The maturity of TrustMan system is lower than all other compared system considering the popular indicator used in the market, namely, the time since it was developed and deployed at different environments.