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Experimentation of Rational Trust Evolution and Sustainability in Dynamic VOs

Morice Daudi and Simon Samwel Msanjila

Faculty of Science and Technology, Mzumbe University, Mzumbe, Tanzania
{dmorice, smsanjila}@mzumbe.ac.tz

Abstract. Piloted semi-automated mechanisms for monitoring and managing Virtual Organizations (VO) on the bases of established trust for collaboration that has already started need to be developed. Various researches in dynamic VOs have not established a semi-automated solution to manage the changing trustworthiness of the partners in the collaboration. The experimentation on semi-automated analysis of dynamic trustworthiness of VO indicates that a statistical standard deviation model promises more to be used to assess partners who sustained trust or failed to sustain trust in a period of time. This paper proposes a semi-automated TrustSEv (Trust Sustainability and Evolution) system for assessing partner's trust sustainability in the VO during evolution phase. Further, the paper establishes a linear relationship between objective trust level of the individual partner constituting the VO, and the strength of the VO itself.

Keywords: trust evolution, trust sustainability, VO, trust experimentation

1 Introduction

Smooth operation of the VO needs to be supported with properly established trust relationships among partners as a bonding factor for enhancing co-working. Although there are a number of forms of trust that can be established, rational trust which is established on the basis of factual performance has been mentioned to be the sustainable bonding factor for business collaboration [5]. Established rational trust among organizations using mechanisms that are formulated based on measurable factor can enhance partner's confidence on a specific partner of the VO to execute its assigned roles appropriately and thus contribute in achieving the common goal(s). Despite the different and opposing perceptions of trust to different actors, in this paper we perceive rational trust in VO as the objective-specific confidence of a trustor in a trustee, based on the results of rational (fact-based) assessment of trust level of the trustee [4]. For our developed mathematical base mechanisms, the main input into trust analysis is measurable organization's performance data [1]. The factual performance data obtained from the analysis of objective trust plays a significant management role towards various reasons driving the collaboration.

Organizations collaborate and cooperate for a number of reasons including enhancing preparedness, saving time and decreasing development process, sharing

costs and risks with partners, improving resource utilization, and gain access to new markets through partnership [6]. For these advantages of collaboration to be gained it has been stated in research and observed in practice that participating organizations must rationally trust each other throughout the collaboration period. However, although can be established at the VO creation, trust of the VO partner does not remain static, but evolve depending on many influencing factors including actual partner's performance in the VO. The dynamic trust can result in either rise or fall of the trust level of a specific partner with respect to time.

It is therefore important to note that trust of an organization is dynamic and evolves over time. The dynamicity nature of trust needs comprehensive analysis and measurement approaches, particularly for the collaboration which is already in progress. The dynamic nature of trust cannot be assessed conventionally, especially for short-term collaborations, because conventional approach to build trust among business partners has proven to be inefficient [7]. Such conventional approach in building trust, is what we refer to as subjective trust. Therefore, when subjective trust is inefficient, then objective trust assessment provides a promising solution for measuring dynamic trust.

This paper describes classification of trust (section 2) and background of Trust Management (TrustMan) system (section 3). The specification and architectural design of Trust Sustainability and Evolution (TrustSEv) system are discussed in sections 4 and 5, respectively. The pilot setup of the TrustSEv system (section 6), experimentation and discussion (section 7) are presented, and we finally provide conclusion of our paper in section 8.

2 Classification of Trust

Trust can be classified in two aspects, namely; Subjective trust, and Objective trust. In the past, trust used to be perceived as subjective (opinion-based); posing difficulties in its evaluation and formal reasoning on analysis of its results, due to the use of opinion-based data, thus being risky as it is biased [5]. In subjective trust aspect, a trustee is evaluated based on opinions, suggestions, recommendations, and sometimes polling. It is a biased trust due to the difficulty in reasoning about correctness and rationality of the assessed trustworthiness. Objective trust is the results of the rational (fact-based) assessment of the trust level [2]. It is trust based on organizational performance data (fact-based), and provides results which an individual can reason about using the formal evidence.

Trust in the past was measured statically and did not consider the variation of trustworthiness with time as the collaboration continues. Such dynamic behavior of trustworthiness accounts for existence of Trust Evolution which needs to have proper sustainability mechanisms. We thus refer to Trust sustainability as the process whereby a VO partner maintains their trustworthiness to the specific trust level to enable it remains acceptable in the VO during execution of the activities that lead into achieving the common goal of their collaboration [1]. Each VO partner maintains its trust level at or above the acceptable value, namely the required specific trust level for the VO. If the trust level falls below the specific trust level of the VO then the VO

partner is not trustable on capacity to execute its roles. When such an organization fails to sustain its level of trust, the VO can undergo evolution for which new partners are selected from pool to fill the gap of departing partner with poor trust. When new partners are added in the VO the trust level of others will change because of the comparative analysis and measurement which is applied in our developed mechanisms. This process is referred to as trust evolution.

3 The TrustMan System

The objective trust presented in section 2, require proper conceptualization and modeling in order to address its measurement factually. The varying perception of trust accounts for a complex modeling of trust measurement. When the objective trust is a concern, then formal approaches are important so that trust can be processed and executed by computer systems. The rational results from such kind of measurement can be used to objectively configure a new consortium, by selecting members from Virtual organizations Breeding Environment (VBE). In a study conducted by [3], a HICI (Hierarchical, Impact and Causal Influence) was used to model trust measurement. The assessment of trust employed data from organization's performance for every VBE member. The automation of assessment mechanisms were presented through TrustMan system. The TrustMan system is prototypical software that was used to configure the new VO, for a new business opportunity realized. The VO is formed based on specific objectives, by selecting partners from VBE members, whose trustworthiness are objectively assessed to be satisfactory. The TrustMan system was used as source of data for TrustSEv system.

4 Specification and Analysis of TrustSEv system

In designing our system we have adopted Service Oriented Architecture (SOA). The SOA is an architectural style employing the principles of loose coupled interacting components, for the purpose of providing the intended service to the consumer. While designing the TrustSEv system, integration and interoperability was our forethought, in order to improve information flow for service provision. The SOA architecture used, allows new applications which are capable of interacting with the existing components through the defined interfaces. Therefore, the TrustSEv system provides five (5) integrated services as described in Table 1, to support management of dynamic trust in VOs. The services offered by TrustSEv system are coded as "S".

Table 1: Specified Services of the TrustSEv System

Code	Service Name and Description
S1	<i>For input of basic information related to VO:</i> This service supports VO coordinator to enter basic information related to partners of the said collaboration. The coordinator is appointed among partners who can solely be a prime partner.

Code	Service Name and Description
S2	<i>For input trust values and trust level:</i> This service supports requesting trust values and related data from <i>TrustMan</i> system after activation by the participant observer into <i>TrustSEv</i> system. A participant observer is a human user (say, VO coordinator). This is an administrative service and it is accessed by the VO coordinator.
S3	<i>For forecasting target goals for the next period of assessment:</i> This service provides target agreements customizable to every participating VO partner. Since trust is dynamic, the target is a range defined by lower limit and upper limit trust values, in which a healthier partner's trust level is optimally allowed to oscillate.
S4	<i>For assessment of sustainable trust value and trust level:</i> This service provides a mechanism for assessing trust level of VO partners. This is a limited administrative service and is thus accessed by the VO coordinator and the VO partner.
S5	<i>Defining, authorizing and assigning rights to other users:</i> The service supports defining user access levels for VO partners and guests with different privileges. It is a highly administrative service and thus only VO coordinator can access it.

5 Architectural Design for the TrustSEv system

The TrustSEv system provides services specified in Table 1, through employment of two architectural styles, namely: (1) the Interoperability Architecture, and (2) the Four-layer Componential Architecture. In order to provide the promised services systematically, accurately and comprehensively, the TrustSEv system interacts with other systems as illustrated in Interoperability Architecture (Figure 1).

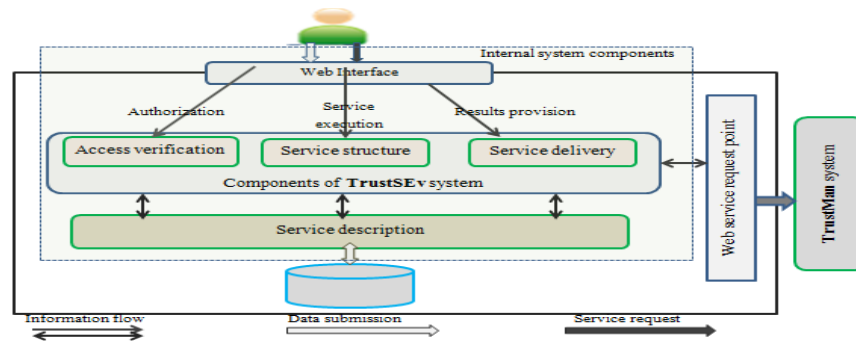


Figure 1: Interoperability Architecture of TrustSEv System

Such interaction is mainly for two purposes, namely; (1) acquiring trust values and trust levels data from TrustMan system and (2) supporting human user access to deliver the requested services. The further purpose behind this TrustSEv interoperability architecture is to guide developers during the implementation of modules supporting the required external interactions. External interactions into TrustSEv system are supported by internal components classified into three groups, namely: (1) access verification, (2) service structure, and (3) service delivery. The components for access verification provide administrative functionalities to both human and system users interacting with TrustSEv system. They also classify the

services that can be requested based on privileges for each specific user in the system. The components for service structure provide the internal mechanisms, namely the choreography related to business logic functionalities based on service request. The components for service delivery provide requested response to users, or when failure a feedback and cause of failure.

The componential architecture of TrustSEv system (Figure 2) comprises of four layers, namely: (1) the presentation layer, (2) the process layer, (3) the description layer and (4) the message layer. Presentation layer links process layer and human user. It is a platform where data/information from human user/TrustSEv system is exchanged in human readable form. Consequently, it deals with transformation of data from process layer into human readable text. Further, in order to protect sensitive information from exposure to the third party, the web services are designed to support user access rights in three levels, namely, public, restricted and protected interfaces.

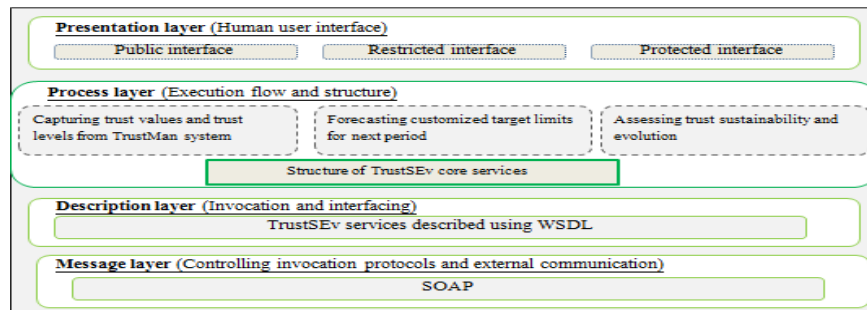


Figure 2: Four-layer Componential Architecture of the TrustSEv system

Process layer is the core heart of the business logic processing in which various modules and components are executed, for services provision. The process layer is constituted of process scheduling referred to as orchestration and choreography. The description layer provides grammatical and dictionary-like specifications of services in order to create supportive invocation by external and remote components, and employs Web Services Description Language (WSDL). The message layer is responsible for specifying communication protocols among both, the internal and external components. The layer controls invocation protocols internally, and communicates externally by using Simple Oriented Access Protocol (SOAP) standard protocol for web services.

6 The Pilot Setup of the TrustSEv System

The experiments were conducted in four specific defined periods, with the assumption that every VO coordinator had collected required performance data for each partner. The experimental method was meant to the statistical based mechanisms which are implemented in the TrustSEv system [1]. The model predicts acceptable range in which trust values of an individual VO partner is optimally allowed to oscillate. The

experiment used organization's trust values that were computed by TrustMan system using the performance data at the highest level of granularity, termed as trust criteria. Trust criteria are well described in the wheel of general trust elements [2].

The TrustMan system is capable of measuring partner's trustworthiness through organization's performance data at a specific point in time [4]. However, the TrustMan system does not have services that can track the variation of the trustworthiness and thus assess the sustainability of trust in a range of period [1]. Therefore, the time-point computed trustworthiness are captured and stored in the TrustSEv system in form of textual description and numeric scores. For each specified period of time the TrustSEv computes the evolution of trustworthiness based on the captured data from TrustMan system. The operations, design and development of TrustMan system are published in [2] and [4]. Furthermore, in the experimental setup using TrustSEv system, the assumptions for applied terms, namely: (1) *Base period*, (2) *Target goal*, (3) *Assessment Period*, and (4) *Trust Value Standard Deviation*, are defined in [1].

7 Experimentation of TrustSEv System

To conduct assessment of trust sustainability and evolution, a VO coordinator specifies a base period. Then, the coordinator executes a forecasting service which determines target goal of each individual VO partner. The target goals are custom-set based on individual partner's capacity expressed as organization performance. The individual planned target goal results are expressed in a range, as defined in [1]. For this experiment, two six month periods was assumed to be between 2012 and 2013 as assessment period. Therefore the settings established in 2012 were used to assess the trust sustainability in the next two periods, which is the year 2013.

7.1 Forecasting Trust Target Goals

This service supports the VO coordinator to set target goal on trust values that VO partners must sustain in order to remain trustworthy in collaboration. For example, in Figure 3 the coordinator was forecasting target goals for year 2013 using organization's performance data of the year 2012.

The screenshot shows the TrustSEv web application interface. The header includes the logo 'TrustSEv' and the subtitle 'Automated Management of Trust Sustainability and Evolution Support'. Below the header is a navigation menu with options: Home, Partner's Info Entry, Capturing Trust Values, Trust Forecasting, Trust Assessment, Compare Trust Trend, Display Trust Trend, and Logout. The main content area is titled 'ASSESSMENT RESULTS: TRUST SUSTAINABILITY or EVOLUTION?' and contains two tables.

PRESET TARGET GOALS			SCORE AFTER ASSESSMENT IN 2013	
S/N	ORG ID	TARGETS SET IN YEAR 2012	SCORED VALUE	REMARK
1	51	2.063 to 2.641	2.271	Strong partner
2	54	1.896 to 2.474	1.854	Replace partner
3	58	1.867 to 2.445	2.212	Strong partner
4	60	2.317 to 2.895	2.459	Strong partner
5	72	1.434 to 2.012	2.028	Prime partner

Figure 3: Assessment on trust sustainability and evolution from TrustSEv system.

For instance, the organization with Identity (ID 51) had its target goal in terms of trust value set to lie between 2.063 and 2.641 inclusive for the year 2013. Then after a lapse of a two six month period, organization’s performance data for each partner is submitted to the VO coordinator. Then the values are fed into TrustSEv system for assessment, by diagnosing to whether the current trust value lies within preset custom target goals. After assessment, the partner with ID number 51 had its performance score in 2013 found to be 2.271, which implies that such partner maintained its trust level within the acceptable limits. Contrary, a partner with ID number 54 had its target goal preset to lie between 1.896 and 2.474 inclusive, but managed only to score a trust value of 1.854. The partner had failed to maintain its trust level.

Such failure implies partner’s low ability to collaborate, because it cannot be trusted in execution of her duties. Since the partner has starved, then it is recommended for replacement. Such replacement of the failed partner accounts for overall change in trust level set by the VO. The change brings new reconfiguration in trust value, termed as *trust evolution*.

7.2 Discussion of Pilot Results

A strong collaboration will always comprise of partners whose trustworthiness strengths bear slight differences. Where the collaboration may result in risk, such risk is likely to be shared among the VO partners, thus increasing accountability towards full execution of the assigned roles. Such facts are evidenced in Figure 4 to depict the trend of *trust value lower limits*. The trust value lower limits used in Figure 4, were drawn from Figure 3 for a consecutive experimentation, in a period of four years.

The trust value lower limits are dependent on *trust value standard deviation (Vsd)* variables as presented in [1]. It is observed that where the standard deviation in trust value is set small, the difference in lower limits of the trust value become small values and vice is also true. Scattering of lower limits trust value is determined by the size of trust value standard deviation. In standard deviation statistical model [1], the closeness in terms of partners’ strength is observed through the size population standard deviation. High size standard deviation implies low precision and large deviation among data sets and vice versa is also true. The graphical presentation of lower limits trust value trend is depicted in Figure 4.

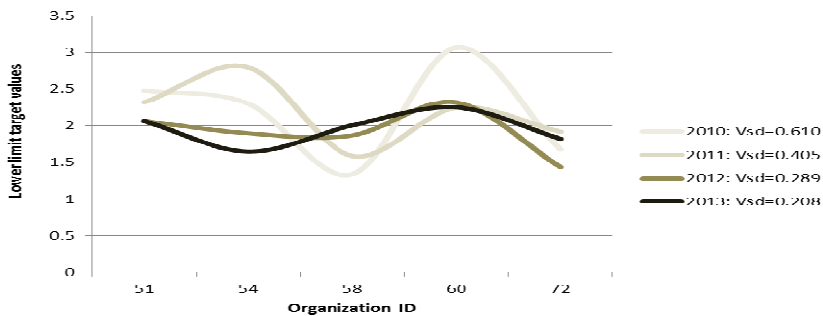


Figure 4: Impact of trust value standard deviation size on strength of collaboration

For example, for the target goals settings for years 2010 and 2013, the trust value standard deviation is 0.208 and 0.610 respectively. The graphical line for 2013 is closely scattered than that of 2011. These statistical implications reveal an important knowledge on management of dynamic VO. That, the operating VO with partners, whose strengths in terms of trust value differ significantly, is likely harder to achieve its goals. Because, the collaboration contains both, stable and weak partners such that the weak partners are doubted on their ability to fulfill their roles. On the other hand, the operating VO whose partners' trust values have low differences becomes very stable as similar strengths encourage team spirit and objective confidence trust among the partners.

8 Conclusion

The management of trust sustainability and evolution in dynamic VOs, whose collaboration is live, represents an important factor and enabler of VO success. We have shown that trust acquired during VO formation is not static and it changes with time, due to internal and external factors that may influence the partner's performance. Since the overall trust level of the VO partners is subject to change, such situation requires management of dynamic trust in terms of trust sustainability and evolution. We have presented the specification, designing and piloting of the TrustSEv system as statistical based semi-automated system for assessment of dynamic trust in partners in VO.

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