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*To smooth the cooperation within a VBE, and to facilitate the partner selection for VOs configured in VBEs, the VBE member organizations need to trust each other. Among others, lack of trust relationships among organizations, negatively affects their information exchange and resources sharing. In small-size VBEs, organizations have the chance to get to know each, and thus can individually make their judgment on trustworthiness level of others. For large-size VBEs however, new approaches and mechanisms are required to be designed for measuring/assessing the trustworthiness level of other organizations. This paper first addresses this problem area and its challenges and then classifies it into three focus areas. It then introduces an approach for measuring the trustworthiness level of other organizations, based on both the trust criteria defined by the trustor and the past performance of the trustee. Three trust perspectives pentagon, square, and triangle, are then defined addressing the three problem focus areas.*

## 1. INTRODUCTION

Stability and success of a strategic alliance among organizations, such as the Virtual organizations Breeding Environment (VBE), require the right balance of trust among its members. Thus, once in a network or alliance such as a VBE, organizations need suitable approaches and mechanisms to identify and measure trustworthiness of other organizations for the purpose of information exchange, resources sharing, and fruitful collaboration in VOs [Dillon, T. S. et al 2004].

A VBE refers to an association of organizations and their related supporting institutions, adhering to a base long term cooperation agreement, and adoption of common operating principles, and infrastructures, with the main goal of increasing both their chances and their preparedness towards collaboration in potential Virtual Organizations (VO) [Afsarmanesh, 2005]. In larger VBEs, members meet and need to cooperate or collaborate with little known or even unknown other members. Members collaborate in order to achieve common goals. Entering in collaboration requires a member to make decision about the trustworthiness of others.

Trust is a key concept addressed by research in many disciplines and it is gaining more importance in the new emerging information societies. In sociology, trust is related to reputation and previous interactions among individuals. The ways in which reputation for trustworthiness is established or destroyed are important in social trust relationships. According to Good [Good, D., 1988], not only will the perceivers of reputation have access to information which the reputation holder does not control, but also the manner in which both types of information are interpreted is not straightforward. Therefore, individuals wish to have complete information about the people they wish to deal with, before they deal with them [Dasgupta, P., 1988].

In economics, decisions about trust are similar to decisions about taking risky choices. Individuals are presumed to be motivated to establish trust relationship with others in order to either maximize the expected gains, or minimize expected losses from their transactions [Williamson, O. E., 1985, Josang, A. et al 2004]. The critical factor in economic studies about trust is the risk management in trust relationships.

Trust in psychology is related to beliefs [Marsh, S. P. 1994]. A trusting behaviour occurs when an individual believe that there is an ambiguous path; the result of which could be good or bad [Deutsch, M. 1962, Morgan, R. M, et al 1994]. The occurrence of the good or bad result is contingent on the actions of another person. If the individual chooses to go down that path, he makes a trusting choice.

In politics and digital governments, trust is related to truth-telling. It is important for digital government, to maintain high standards of truth-telling, to avoid being associated with the poor reputation and losing trust [Sztompka, P. 1999]. Trust in governments and politics is very important to keep governments and related political parties continuing in power. However, several factors are identified to be influencing the trustworthiness level of governments towards citizens, such as reputation, performance, accountability, commitment, etc. [Sztompka, P. 1999].

In computer science, trust is related to security, reputation, and privacy. Generally, when an environment is secure it is easier to establish trust relationships among systems users, and equally, if a users respect the privacy of others personal data and sensible information, he can be seen as trustworthy [Seigneur, J.M. 2004].

Trust studies as addressed in the above disciplines shows that trustworthiness has been perceived as a probability and thus, measured as a unit less probability value. Moreover, in some studies, trust is mainly related to reputation. Trust in most disciplines also has been studied at the level of individuals and not at the level of organizations. In our approach, we address trust among “organizations” being involved in collaborative environments and specifically, within VBE environments. We have observed and pointed out that trust is multi-criteria and thus trustworthiness cannot be measured with a single value. As presented later in section 3, trustworthiness is measured for different objectives, from different perspectives, and in terms of the values of a set of trust criteria. Thus we address trust as a multi-objective and multi-actor subject, considering all necessary factors that can influence the changes of trustworthiness. More challenges will rise due to the fact that VBEs are new scientific discipline and are characterized with heterogeneity among the interests, goals, disciplines, autonomies, cultures, etc., of their members [Camarinha-matos, 2005, Shao, J. et al 2004]. Trust assessment and creation is among the important subjects that need innovative approach and mechanisms. This paper addresses the assessment and creation of trust in VBEs.

## **2. TRUST IN VBEs**

In this section we address the question of who needs trust and the challenges that must be addressed to realize trust in VBEs. We first start with the base definitions.

### **2.1 Base definitions**

In this section we provide definition for the following terms: trust actors, trust criteria, trustworthiness, and trust relationship.

*Trust actors:* refer to the two organization parties involved in a specific trust relationship. The first party is the organization that needs to assess the trustworthiness of another party and is referred to as the *trustor*. The second party is the one that needs to be trusted, and thus it will need its trustworthiness to be assessed. This party is referred to as the *trustee*.

*Trust criteria:* refer to the measurable elements that can establish a judgment about a given trust requirement. For example for the requirement of ICT infrastructure, the measurable trust criteria can include the storage capacity, the computing capacity, frequency of the system's security violation, network speed, etc. Every trust criteria have two attributes for its values, namely: *Trust value metrics*, which refer to the scales that identify the meaning of the measured values for the criterion, (e.g. for computing capacity can be megabyte MB/s), and *Trust value constraints*, which refer to the limits for values that separate the acceptable from unacceptable range of values (e.g. for computing capacity can be >300GB/s).

*Trustworthiness:* Is the trait of deserving trust and confidence. In this paper, we use the term trustworthiness to refer to the level (intensity) of trust for a trustee in a trust relationship, based on the assessment of the necessary criteria. Clearly enough, the criteria for organizations' trust assessment are varied and wide in spectrum. In our research we focus on those criteria that can be measured, and we have systematically categorized and identified these measurable items as described in section 3.2 and table 1. Trustworthiness cannot be measured directly (by a single value) rather it needs to be measured indirectly through values for a set of criteria. Namely, the level that the constraints for a given set of criteria are met determines the level of trustworthiness.

*Trust relationship:* A relationship is a state of connectedness among people or organizations or is a state involving mutual dealing among people or parties. The trust relationship refers to the state of connectedness between a trustor and a trustee whose intensity is characterized and based on the trustworthiness level.

## 2.2 Who needs trust in VBEs?

Three kinds of focus areas (FA) were identified for trust needs in VBE:

*FA1- Trust among VBE members:* The main aim of establishing and maintaining trust relationships among VBE members is to enhance the efficiency and success of both their cooperation within the VBE as well as their potential collaboration in VOs that will be configured within the VBE. Further to the individual member's achievements, the main criteria that influence the trustworthiness among VBE members include their roles, reputations, and membership level at the VBE as well as their past performance on activities related to the VBE. FA1 is further addressed in **section 3**.

*FA2- Trust of a VBE member to the VBE and to the VBE administration:* Trust of VBE members to the VBE and VBE's administration enhances the chance of members remaining loyal to the VBE, increases their willingness for active involvement in VBE, and encourages VBE members to invite and bring other valuable organizations into VBE. Among the main issues that influence the trustworthiness of the VBE and the VBE's administration, we can mention: successes in managing the VBE environments, VBE's successes in external markets and recognitions achieved through VBE's marketing and branding.,

transparency of the administration procedures and rules, transparency and efficiency of members performance measurement, frequency of opportunities brokerage, and fair possibility for all VBE members to get involved in potential VOs. FA2 is further addressed in **section 4**.

*FA3- Trust of a customer to the VBE:* VBEs must be trusted by its customers. Customers that create opportunities in the market (to which VBE can respond by creation of VOs) must recognize and trust the VBE to accept its proposed bid. Consumers (end users of VBE results) also need to trust a VBE in order to decide positively on purchasing or accepting VBE's products and services. FA3 is further addressed in **section 5**.

### 2.3 Trust challenges in VBEs

In relation to trust studies in VBEs, we identified three challenges that must be well addressed in order for the identified trust needs (section 2.2) to be realized.

*Challenge 1:- Causality:* A main challenge in trust study is its causality. The future trustworthiness of a VBE member is "causally" related to its role and behavior at present, and actions it has performed and events it has caused in the past. Therefore, a part of trust engineering in VBEs is intended to support the decision-making about future trustworthiness of a member, while the information needed for this estimation mostly belongs to the past.

*Challenge 2:- Transparency and fairness:* One more challenge in assessment of trustworthiness of VBE members is its transparency and fairness to its stakeholders. Each step taken for entire trust assessment process must be clear and transparent to all involved VBE members. For fairness, the steps taken and the approach used for trust assessment must accompany some (formal) reasoning, and also the information used for the assessment must be accredited/certified to avoid personal (subjective) judgment and biases.

*Challenge 3:- Complexity:* Another challenge in trust study is to handle the complexity of multi-objective, multi-perspective, and multi-criteria nature of trust and trustworthiness in VBEs. Trust is not a single concept [Castelfranchi, 2000] that can be applied to all cases, for trust-based decision making, and its measurements are subjected to both the purpose of the trust relationship, and the specific actors involved. Every case is different and consists of its own specific set of criteria to be considered for estimating trustworthiness.

## 3. ASSESSING AND CREATING TRUST AMONG MEMBERS

In this section we address the question on how VBE members can trust each other and how their trustworthiness can be assessed. Thus, as described in section 2.2, FA1 is further addressed here.

### 3.1 Trust perspective pentagon for FA1

There are five possible trust perspectives [[Ratnasingam, 2005]] that a trustor can assume as primary aspects when assessing trustworthiness of the trustee. In addition to providing mechanisms for assessing the trustworthiness, information about every perspective based on generated/specified criteria must also be provided. When a

VBE member needs to trust another VBE member, support for acquiring the needed information and mechanisms to acquire the information in every preferred element must be provided as indicated in trust perspective pentagon (Figure 1).

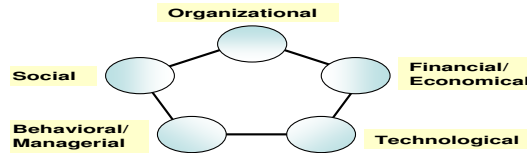


Figure 1: Trust perspective pentagon for FA1.

### 3.2 “BASE” and “SPECIFIC” trust criteria for FA1

A VBE member will need to be trusted in two different cases: when applying to become a VBE member (base), and when it has to apply (or to be selected) to take a specific task in cooperation in VBE (e.g. to become an administrator) or in collaboration in VO (e.g. to become a VO partner or VO planner). In each case, there might be different trust criteria for assessing the trustworthiness (Table 1).

Perspective	Requirements	BASE Criteria
1. Organizational	Organizational strength	Size of an organization
		Organization coverage
		Competences
		Personnel expertise
2. Social	Community participation	Activities participated
	Community compliance	Community service contribution Community standards complied
3. Financial / Economical	Capital	Cash
		Physical capital
		Operational capital
	Financial stability	Cash in
		Cash out
		Profit/Loss
		Operational costs
	VO -Collaboration based financial stability	Cash in
		Cash out
		Profit/Loss
Financial standards	Auditing standards Auditing frequency	
4. Technological	ICT- Infrastructure	Network speed (Broadband)
		Interoperability
	Technology standards	Availability
		Protocol supported
		Software standards
		Hardware standards
	Platforms	Security standards
		Operating systems
	Platform experience	Programming languages
		Applied in VOs
External project applied		
5. Managerial / Behavioural	Stable management	Duration held
		Years in power
		Management structure
	VO-Collaborative behaviour	Frequency of power change
		VO opportunistic behaviour occurred
		VO successful collaborations
		VO participation as organizer/leader
	Reliability	Quality
Adherence to delivery dates		

Table 1: Examples of base trust criteria.

BASE trust criteria refer to those criteria that must be complied (at least at the minimum acceptable level) by all members in the VBE. These criteria are identified by trust experts, a-prior to the establishment of the VBE, but can be updated when needed. The trustworthiness assessment is done when the organization is applying for VBE membership based on the data filled on base trust (application forms) questionnaires. The collected data will also be stored in the VBE management system and will be updated periodically. Table 1 shows some base trust criteria identified with this study and validated by experts in ECOLEAD project and existing VBEs (VF in Germany, Virfebras in Brazil, and IECOS in Mexico). SPECIFIC trust criteria refer to those criteria that are generated and applied for a specific trust objective. Section 3.2 describes how to generated specific trust criteria.

### 3.3 Generating SPECIFIC trust criteria

Generating specific trust criteria needs to be achieved by trust experts knowledgeable about the VBE. At the highest level the process of establishing trust relationship is characterized by a set of trust objectives. Each of these trust objectives is characterized by a set of trust perspectives. Trust perspectives for FA1 are shown in Fig 1. Based on the trust objective and preferred trust perspective, trust requirements are then identified (Fig. 2). Also, for each requirement, the specific criteria are identified. Metrics and constraints for each criterion are then specified.

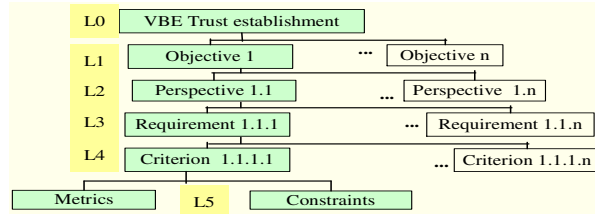


Figure 2: Abstraction hierarchy for the trust establishment in VBEs.

To further describe our approach, consider the case where the *partner selection process* at the VBE has made a list of suggestive VBE members that can fulfill VO requirements. Then, the planner of that VO needs to measure the trustworthiness of the suggested VBE members for invitation decision. Suppose that VO is focused on online selling of movies and therefore, trusting the capacity of the ICT infrastructure for each VBE member that may be invited to VO is important requirements and specifically, its download supporting capacity must be totally trusted. Figure 3 shows an example on how trust criteria are generated.

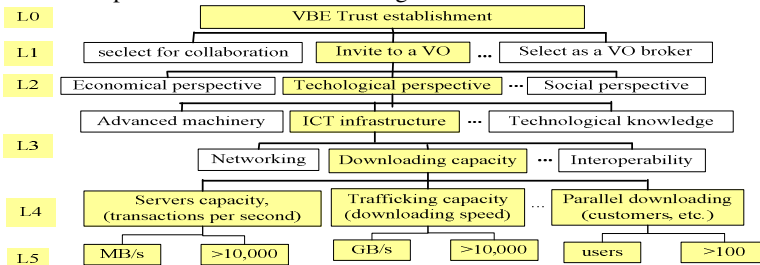


Figure 3: Generating specific trust criteria for assessing ICT-I based trustworthiness.

### 3.4 Analysis of relations among criteria

In order to perform the trustworthiness assessment efficiently, inter-relations among the criteria must be studied and well understood. While the inter-relations among the pre-defined “base” trust criteria can be developed a-prior to the VBE establishment, and suggested to the trustor in the VBE, the trustor may also require to dynamically defining “specific” criteria for which their inter-relations with other criteria must be dynamically defined. In our approach we use causal relations among the criteria to represent their inter-relations. To present this approach, consider the example in figure 3. Figure 4 shows a causal diagram including both the “specific criteria and selected base criteria”. Factors that also influence the behavior of criteria must be identified and represented in the causal diagram. Factors (e.g. request rate, queuing time, etc.) must also be measurable, but they cannot stand alone or become criteria themselves. In the causal diagram, the plus sign (+) indicate that the increase or decrease of the first factor/criteria causes the increase or decrease of the second factor/criteria, and the minus sign (-) indicate that the increase or decrease of the first factor/criterion causes the decrease or increase of the second factor/criterion.

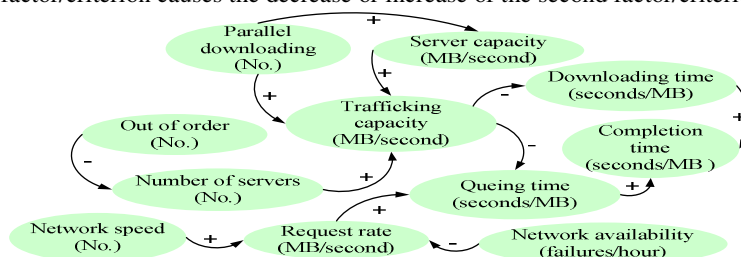


Figure 4: Qualitative analysis of relations among criteria using causal diagram.

### 3.5 Formal representation of relations among criteria/factors

We use the causal effect as in figure 5 to represent the relations among criteria in form of mathematical equations. Using the reasoning (approach as addressed in section 3.4), the plus sign (+) in the causal diagram represents either addition or multiplication, and the minus sign (-) represents subtraction or division depending on the metrics that scale the criteria. The selection of the correct arithmetic operator depends on the balance of dimensions (when complex relations are involved, dimension analysis<sup>1</sup> can be applied). In developing equations, arrows that are directed to the respective factor/criterion are considered for the equation. For illustration purposes (short forms in table 1), we provide three examples.

*Example 1: Formulating equation for trafficking capacity (TC)*

We refer to TC as the number of movies (expressed in Megabyte MB or Gigabyte GB) that can be downloaded in a specified amount of time. Three factors influence the TC: number of server (NS), server capacity (SC), and parallel downloading (PD). Assuming that each server can support a certain number of requests, and each request has certain size, the product of these factors balances the dimensions of the equation as shown in equation 1. The derivative of equation (1)

<sup>1</sup> Checking the correctness of an equation which you have derived after some algebraic manipulation:  
<http://www.physics.uoguelph.ca/tutorials/dimanaly/>

represents the rate of change of each of the factor with respect to time and the relations among the changes (equation 2). The integration of equation 2 provides the accumulation of TC, which represents the total number of movies that can be downloaded for a period of time t1 to t2 (equation 3).

$$TC = NS * PD * SC \quad (1)$$

$$\frac{d}{dt}TC = (PD * SC) \frac{d}{dt}NS + (PD * NS) \frac{d}{dt}SC + (SC * NS) \frac{d}{dt}PD \quad (2)$$

$$\int_{t_1}^{t_2} \left( \frac{d}{dt}TC \right) = \int_{t_1}^{t_2} \left( (PD * SC) \frac{d}{dt}NS \right) + \int_{t_1}^{t_2} \left( (PD * NS) \frac{d}{dt}SC \right) + \int_{t_1}^{t_2} \left( (SC * NS) \frac{d}{dt}PD \right) \quad (3)$$

*Example 2: Formulating equation for completion time (CT)*

Similar to example one, the respective three equations for CT are as below:

$$CT = QT + DT \quad (4), \quad \frac{d}{dt}CT = \frac{d}{dt}QT + \frac{d}{dt}DT \quad (5), \quad \text{and} \quad \int_{t_1}^{t_2} \left( \frac{d}{dt}CT \right) = \int_{t_1}^{t_2} \left( \frac{d}{dt}QT \right) + \int_{t_1}^{t_2} \left( \frac{d}{dt}DT \right) \quad (6)$$

Where **QT** is queuing time and **DT** is downloading time,

*Example 3: Formulating equation for queuing time and processing time*

For these criteria we applied queuing theory<sup>2</sup> to formulate their respective equations. However, it is also possible to formulate the equation using the approach applied earlier as it will be shown at the end of this example. We refer to DT as the time (can be average) needed to download a specified number of movies. We refer to QT as the period that a request will wait in queue from its arrival to when its download starts. Using queuing theory, the three factors: DT, QT, and TC are statistically related. Comparing to queuing theory terms, DT is similar to the service time, QT is the same as the queuing time in queuing theory, and TC is similar to the service rate. Requests arriving for download are distinct. Also, the downloading for movies is distinct in respect to movies. From probability distribution, both the RR and TC follow Poisson distribution<sup>3</sup>. The DT follows exponential distribution<sup>4</sup> since it measures the time required to process a single job. Based on queuing theory definitions, the equations for DT and QT are as shown in equations (7) and (8). For this case, request rate (**RR**) is similar to the arrival rate in queuing theory.

$$DT = \frac{1}{TC} \quad (7) \quad \text{and} \quad QT = \frac{RR}{(TC - RR)TC} \quad (8)$$

Consider the relations among these factors in the causal diagram (figure 3). TC is negatively related to DT and thus, proves the fact that a minus sign can be represented as a division in the mathematical equation as in equation (7). The same reason applies for TC to QT in equation (8). RR is positively related to QT but in the equation its representation is a special case. Although it is in the quotient part of equation (8), the RR in the quotient is negated to indicate that it is positively related to QT. Completion time (**CT**) in principle is the sum of DT and QT, which match the relations as indicated in the causal diagram and also from queuing theory. Therefore, equation (9) shows the CT. Thus CT equation is also written as follows:

$$CT = \frac{1}{PC - RR} \quad (9)$$

The rates of change and as well the accumulations equation for CT, QT and DT can be generated in same way as in equations (2), (3), (5) and (6).

<sup>2</sup> [http://www.eventhelix.com/RealtimeMantra/CongestionControl/m\\_m\\_1\\_queue.htm](http://www.eventhelix.com/RealtimeMantra/CongestionControl/m_m_1_queue.htm)

<sup>3</sup> <http://www.itl.nist.gov/div898/handbook/eda/section3/eda366j.htm>

<sup>4</sup> <http://www.itl.nist.gov/div898/handbook/eda/section3/eda3667.htm>



**3.6 Quantitative trustworthiness assessment**

Based on the selected *base trust criteria*, *specific trust criteria*, and the *collected data*, trustworthiness of an organization can be assessed. When, trustworthiness needs to be forecasted to enable long-term assessment, simulation can be applied, using the developed equations. Also, when a large amount of data must be analyzed fast and efficiently, simulation is suggested. For the purpose of this paper, a simulation model was developed in Powersim to study the behavior of CT, TC, and QT. Here, we assumed that we have data for a number of past years. In this example, we assume that the trustworthiness of this VBE member can be assessed (and forecasted) based on its capability to support short time downloading. For this experiment (figure 6), the following parameters were applied: RR follows Poisson distribution with mean 1000MB and seed 0GB, number of PD as 10 per server for the 5 servers each supporting 10MB/s.

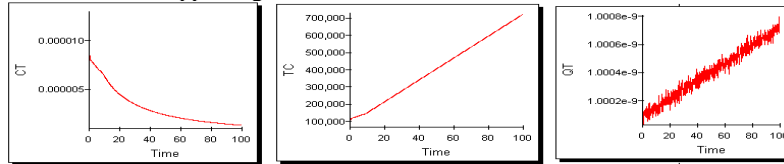


Figure 6: Simulation results for trustworthiness assessment based on TC, CT and QT

From the results presented in Figure 6, trustworthiness can be assessed and decisions can be made about when in future an organization reaches a level of time for downloading, in order to be technically trusted. Nevertheless, in real cases clearly this aspect provides only one among several criteria that are considered for useful trustworthiness assessment.

**4. CREATING TRUST FOR VBE MEMBERS TO THE VBE**

In this section we address the question on how VBE members can trust the VBE and the VBE administration. Thus, FA2, as described in section 2.2, is further addressed in this section.

**4.1 Trust perspective square for FA2**

There are four trust perspectives that a VBE member can assume as primary aspects when assessing trustworthiness of the VBE and the VBE administration (Fig 7). The VBE member must be supported by being provided the mechanisms to access the needed information on the preferred trust perspective stored in the VBE.

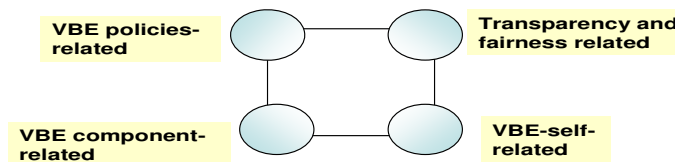


Figure 7: Trust perspective square for FA2

**4.2 Trust criteria for assessing trustworthiness of VBE and its administration**

A VBE member, in different cases, will need to be convinced to trust the VBE and

the VBE administration. For example, the VBE member will compete to win a chance for participation in VOs within the VBEs. For any decision made, VBE members must be convinced on why the selected members qualify than others. We suggest providing information about the following basic criteria in each perspective: *VBE policy related perspective*: Policy is plan of action to guide decisions and actions. Policies in short can be understood as political, management, financial, and administrative mechanisms arranged to reach explicit goals. In VBE aspects and related to trust, policies that must be accessible to members include the following:

- Cooperation rules
- Governance principles
- Bylaws

*Transparency and fairness related perspective*: The VBE administration must be transparent and fair to all VBE members. For this purpose the following information must therefore be accessible by all VBE members:

- Trustworthiness measures
- Performance measures
- Partner selection processes
- Incentives and rewards

*VBE component related perspective*: Refers the components that constitute the VBE. The main component of a VBE is its members. VOs in some cases, when existing, become components of the respective VBE. Another, component is the supporting institutions. A member that wants to assess trustworthiness of a VBE and its administration might possibly prefer information related to VBE structure and its components. We suggest that a member can be provided with information about:

- VBE members restricted profiles
- VBE supporting institution restricted profiles
- VO restricted profiles, etc.

*VBE-self related perspective*: When it comes to trusting a VBE as whole, VBE members must also be supported with information that can build a positive picture about the VBE. We suggest providing information about the following:

- Member restricted performance history
- VBE self restricted profile
- VBE performance history
- VO performance history

## 5. CREATING TRUST FOR CUSTOMER TO THE VBE

In this section we address the question on how an external organization can trust the VBE. Thus, FA3, as described in section 2.2, is further addressed in this section.

### 5.1 Trust perspective triangle for FA3

There are three trust perspectives that a customer can assume as primary aspects when assessing trustworthiness of the VBE (Fig 8). Customers (section 2.2) must be provided with relevant information based on their preferred trust perspectives.

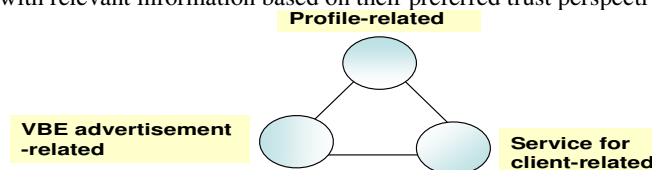


Figure 8: Trust perspective triangle for FA3

### 5.2 Trust criteria for assessing trustworthiness of a VBE

A customer, when selecting a VBE, (e.g. when a customer wants to provide a tender or need to recommend a VBE for an opportunity), will need to trust the VBE. In this paper, we recommend providing the customer with the following information:

*Profile related perspective:* This information will enable the customer to understand the constituents of the VBE and its related competences. This includes:

- VBE public profile including list of members and list of VOs,
- VO public profile including partners' information and VO performances,
- VBE members public profiles,
- Previous product/service recognitions or acknowledgements,
- Specific previous achievements.

*VBE advertisement related perspective:* As in normal business world, VBEs will also advertise their products and services (offered through VOs) to the market. Information on advertisements that are usually made can indicate the capability of the VBE to reach customers. Such information can include the following:

- News letters,
- Copy of advertisements in the media,
- Link of advertisements in various websites.

*Service for client related perspective:* A customer can be convinced to trust the VBE based on how it will be supported when acquiring the services. This includes:

- Customer portal,
- Customer registration functions.

## 6. REFLECTION ON THE TRUST CHALLENGES IN VBEs

In section 2.3, three trust challenges were identified namely: *causality, transparency and fairness, and complexity*. In this work causality was addressed with the use of causal analysis about past behavior of the member based on the causal relations among the criteria. The use of past performance of members, the VBE and its administration indicates how causally their today and future trust is influenced by the past. Transparency and fairness is addressed by enabling trustors, and trust experts to formally reason (based mathematical formulas) for the trustworthiness assessment (section 3). The use of transparency and fairness measure, governance rules, cooperation rules and bylaws, also enhance the transparency and fairness (section 4). The suggested approach also, addresses the trust complexity by use of multi- objective, perspective, and criteria in the trustworthiness assessment.

## 7. CONCLUSION AND FURTHER WORKS

VBEs have proved promising for enhancing survivability of organizations, especially SMEs, in the current market with highly volatile opportunities and requirements. VBE is a strategic alliance, providing a cooperative environment that aims at enhancing organizations' preparedness for getting involved in potential virtual organizations. Among the important preparedness aspects to be supported within the VBEs, are the creating, assessing, and managing trust [Camarinha-Matos, L. M.\*, et al 2005].

In this paper, three main focus areas for trust in VBEs were identified. Approaches for assessing and creating trust, considering the identified challenges

were introduced. The kinds of information that a trustor needs to use in order to assess the trustworthiness level of a trustee were also addressed. Thus, this paper has contributed to the subject of assessing and creating trust in VBEs, which can also be applicable to the VO environments.

The paper has addressed the challenging tasks of assessing and creating trust in VBEs. Other important areas of trust (trust management) studies such as trust relationship establishment and trust modeling are not addressed in this paper, but it is an important subject in our trust studies in the ECOLEAD project, and the topics of forthcoming papers. Furthermore, some other collaborative environments that their memberships involve individuals, such as the Professional Virtual Community (PVC) and Virtual team (VT), are not addressed in this paper. The trust assessment and creation approaches are in fact very different for organizations than for individuals.

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## 8. REFERENCES

1. Afsarmanesh H., Camarinha-Matos L., A framework for management of virtual organization breeding environments, in *Collaborative Networks and their Breeding Environments*, Springer, 2005, pp. 35-49.
2. Camarinha-Matos, L. M\*, Silveri, I., Afsarmanesh, H., & Oliveira, A. I., Towards a Framework for Creation of Dynamic Virtual Organizations, in *Collaborative Networks and their Breeding Environments*, Springer, 2005, pp. 69-81.
3. Camarinha-Matos, L., Afsarmanesh, H. Collaborative networks: A new scientific discipline. In the international journal of *Intelligent Manufacturing*. Springer, Volume 16, 2005
4. Castelfranchi, C., Falcone, R. Trust Is Much More than Subjective Probability: Mental Components and Sources of Trust. In proceedings of the 33rd Hawaii International Conference on System Sciences – 2000
5. Dasgupta, P. Trust as a Commodity. In *Trust: Making and Breaking Cooperative Relations*, 1988.
6. Deutsch, M. Cooperation and Trust: Some Theoretical Notes. In proceedings of Nebraska Symposium on Motivation. Nebraska University Press, 1962.
7. Dillon, T. S., Chang, E., Hussain, F. Framework for a trusted Environment for virtual collaboration. In Proceedings of the 5<sup>th</sup> International Conference on Advances in Web-Age Information Management, Dalian, China, 2004.
8. Good, D. Individuals, Interpersonal Relations, and Trust. In *Trust: Making and Breaking Cooperative Relations*, 1988.
9. Josang, A., Lo Presti, S. Analysing the relationship between risk and trust. In the proceedings of trust management second international conference. Oxford, UK, 2004.
10. Marsh, S. "Formalising Trust as a Computational Concept", 1994.
11. Morgan, R. M, Hunt, A. D. The commitment-trust theory of relationship marketing. In the journal of marketing, Vol 58, No. 3, 1994.
12. Ratnasingam, P. Trust in inter-organizational exchanges: a case study in business to business electronic commerce. In the journal of *Decision Support System*, Vol. 39, 2005.
13. Seigneur, J.M. & Jensen, C.D. (2004). Trading Privacy for Trust. In proceedings of second Trust Management International Conference, UK, 2004.
14. Shao, J., Gray, W. A., Fiddian, N. J., Deora, V., Shercliff, V., Stockreisser, P. J. Supporting Formation and Operation of Virtual Organizations in a Grid Environment. In proceedings of the UK e-Science All Hands Meeting 2004, Nottingham UK.
15. Sztompka, P. *Trust: A Sociological Theory*. Cambridge, UK: Cambridge University Press, 1999.
16. Williamson, O. E. *The Economic Institutions of Capitalism*. The Free Press. New York, 1985.