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### Collaboration behavior enhancement in co-development networks

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**Publication date**

2017

**Document Version**

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

Shadi, M. (2017). *Collaboration behavior enhancement in co-development networks*.

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### 1.1 Motivation and Problem Definition

Organizations can hardly gain from available business opportunities in the market due to the increasingly change and challenges that are outside of their control. They often face demands that are beyond their own capabilities and resources. Numerous technological developments and breakthroughs are among the main causes for vast dynamism in production and services industry, both on the supply side of the products and services, and the customer demands and general expected standards of living. Encountered with constant fluctuations, Small and Medium Enterprises (SMEs) find their survival at risk, and reconsider the way in which they structure, coordinate, and manage their businesses and related processes. Furthermore, advances in ICT (Information and Communication Technologies) has enhanced mobility and flexibility of organizations and has facilitated collaboration among them regardless of their geographic location. New forms of co-working are emerging that bundles a number of organizations' interests and abilities together to better address market demands. These new forms link organizations not only at the local, regional, and national level, but also at the global level. Therefore, the traditional organization structures are gradually shifting to the networked organizations.

An effective networked organization structure, benefiting from advanced ICT, constitutes the so-called Collaborative Network (CN). The CN is defined in [22] as follows:

*"A collaborative network (CN) consists of a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in their operating environment, culture, social capital and goals, but that collaborate together to better achieve common or compatible goals, and whose interactions are supported by computer network."*

One emerging form of CN, applied to organizations in business and science

areas, is the Virtual Organization (VO). The VOs involve heterogeneous, autonomous, and geographically distributed partners, mostly consisting of SMEs. VO is typically short-term and goal-oriented, and needs to form dynamically and fluently, in order to address specific emerged opportunity. VOs usually compete against large organizations in attracting customers. The definition of a virtual organization, adopted in our research, is as follows [19]:

*"Virtual Organization (VO) is a dynamic and temporary form of collaborative networks, comprising a number of independent organizations that wish to share their resources and skills to achieve its common mission/goal."*

Research and practice have shown that effective support of the VO's requirements necessitate the pre-existence of a strategic alliance among organizations in the sector. The role of this alliance would be to provide the common base infrastructure and conditions needed to prepare organizations for their effective involvement in dynamic creation and successful operation of potential future VOs. This alliance – the so-called Virtual organizations Breeding Environments (VBEs) is a long-term CN, and is already manifested in practice in many industry sectors. The definition of a VBE, adopted in our research follows [2]:

*"VO Breeding environment (VBE) represents 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 their preparedness towards rapid configuration of temporary alliances for collaboration in potential Virtual Organizations."*

To acquire more business opportunities and qualify themselves to participate in larger projects, organizations get involved in VBE networks. Co-working among the members of the VBE and the partners of the VO are very different, and consequently so is the role of the VBE's administrator and the VO's coordinator, as described below.

In VBEs cooperation is practiced among its members [3]. As a base task, VBE increases the preparedness of organizations for collaboration in potential future VOs. Achieving this, primarily concerns exchanging some information about their competencies and resources, adjusting some of their activities, and adopting some new infrastructure and standards, all in order to enhance their compatibility with each other and increase their chance of effective future collaboration. Therefore, division of some minor tasks among the VBE members requires their cooperation. In most cases, the adjustment plans for VBE members is specified individually for each organization, rather than jointly for all VBE members, and organizations compliance with the suggested adjustments are coordinated by the VBE administrator. Furthermore, VBE administration provides to its members the needed information and a set of ICT tools to support them with: identifying market opportunities, planning the formation of a VO in response to an emerged opportunity in the market, selecting the most suitable set of partners to configure the planned VO, reaching agreements and negotiating among the selected VO partners that is required for formation of an effective VO, as well as assisting the

VO coordinator (once the VO is established) for monitoring and observation of the VO partners' performance on one hand, and for any required reconfiguration of the VO's consortium during its life time [2] and [3].

Some of the main roles played by the VBE administration for the benefit of its members include: creating common infrastructure for information sharing and exchange, common taxonomy and an ontology for the shared concepts among members [4], providing information about competencies of each member in order to enhance their acquaintance with other members [41], as well as defining a set of measurable criteria for assessment of organizations' trust level and periodically performing the measurement of base trust level for each organization at the VBE, thus serving as the means for trust establishment among the VBE members a main determinant for effective collaboration in potential future VOs [69].

However, in **VOs** collaboration is practiced, which requires that partners effectively share their information and resources, and fully comply to the VO plans and schedules, thus performing well, both in their individual responsibilities as well as in tasks that are assigned to them jointly [2] and [20]. All partners' activities are necessary to be fulfilled to achieve the VO's common goal. In other words in VOs, activities of a group of partners are tightly-coupled with each other. Partners must work and co-develop products closely together, which in turn completely boost each of their individual capabilities. Furthermore, partners share any possible risks or losses facing the VO, as well as the profits and rewards among themselves, following their agreement achieved at the time of VO creation and reflected in their internal negotiations. As such, the VO collaboration provides both a competitive advantage for the involved SMEs as well as increasing their survival factor. It is therefore of extreme importance that VO partnerships are carefully planned and all measure are taken to increase the possibility of their success. While achieving success for such level of closed collaboration among independent organizations needs strong effort and devotion spent by all VO partners, some innovative assisting mechanism and systems, in automated or semi-automated format, can be designed to enhance partners' collaboration, as addressed in our research.

Based on the literature, in spite of the fact that the number of created networked organizations are gradually increasing, the rate of overall success in alliances of organizations is nearly 50% [42], and according to [96] the great number of VOs either end up in failure or operate under very high risks! Various reasons are stated in the literature for such high numbers of failures in VOs [8]. These can be categorized into three classes:

- Internal risks at organization level including: strikes, machine failure, management failure, etc.
- External risks at market level including: competition, change in demand, political situation, social atmosphere, etc.

- Network-related risks at collaboration level including: lack of trust, insufficient information sharing, clash of work culture, work overload, etc.

Our research primarily narrows down on addressing the last category of risks and how to improve the success rate of networked collaborations.

Several research works have been performed aiming to shed light on the causes that lead to success or failure of partnerships. The result of research performed in [80], takes into account and analyzes large number of available documents on the web that report on organization's cooperation. It extracts a number of factors concerning cooperation's success and failure status, as presented in Figure 1.1. The findings of this research, resulted through analyses of web reports and documents, reveal that a large number of failures in partnerships among organizations are caused by their behavior. The identified factors were partly related to the individual organizations and partly to the collaboration as a whole. Our research approach mainly focuses on addressing virtual organizations' success and failure in terms of their observed and monitored behavior in the network.

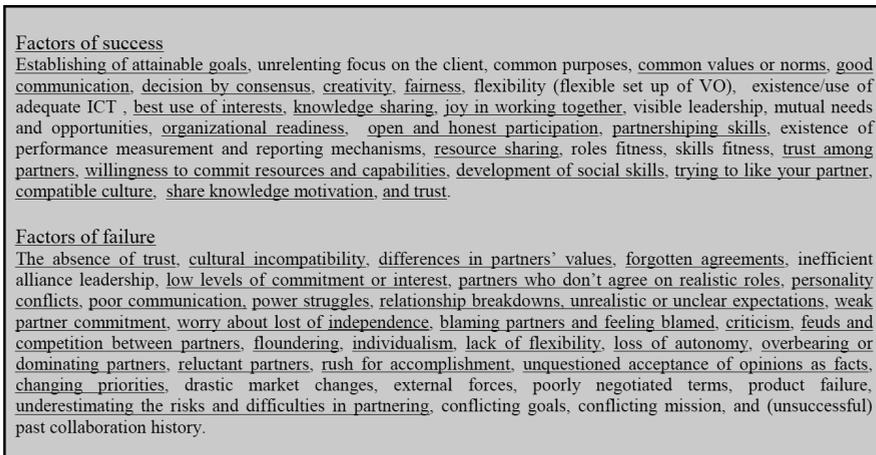


Figure 1.1: Factors of success and failure of partnerships obtained in partnership-related web documents [80].

A main literature review on this topic goes beyond the above. It attributes for instance some of the VO's risks and failures to the general lack of common existing infrastructure and collaboration procedure, which are also identified in research that characterizes the role of VBEs, e.g. by establishing a common base for sharing among them, or better VO configuration/creation [2] and [3]. But also identifies other causes related to deficiencies in partner organizations' performance in the VO. Thirteen specific sources of risks and flaws in VOs are specified in [9] that can lead to failure for instance in delivery time, or customer satisfaction

in relation to the cost and quality of the aimed product. These thirteen sources of problems include: **lack of trust among partners**, inadequacy of collaboration agreement, heterogeneity of involved partners, ontology/taxonomy differences, structure and configuration of the VO, **inefficiency in communication between partners**, cultural differences, **work overload of partners** (e.g. bidding for several Virtual Organizations at the same time), inadequacy in information sharing, lack of top management's commitment, deficiency in partners selection, geographical distance among partners and their location, and **unawareness of potential failures and their severity in the VO**.

Several of the above risks are already addressed in other research, for instance exemplified above in [4], [41], and [69]. However, four of the above mentioned risk factors in this literature review (illustrated as bold) are related to the behavioral factors of partners, and addressed in our research. We also address supporting the last key challenge above on the need to identify and when possible to predict the risks in the VO. Addressing this last source of risk and failure requires monitoring and analyzing VO's detailed activities during its operational stage, in order to diagnose and forecast potential failures in running its plans and schedules. Making such failure transparent in the VO, alarms its decision makers to potentially intervene and take remedial actions. In turn this will enter the VO into its evolution phase, where, the original plan and schedule of activities may need to be replaced with some new plans and schedules to be negotiated and agreed with other partner. Due to their shorter life span and being goal-oriented, it is very important to identify the weak or weakest points in the planning and scheduling of VO activities, and to measure potential risks of VO failures due to the monitored behavioral perspective of the partners and the VO as a whole, as addressed in our research.

We briefly mentioned above about two specific stages of the life cycle of the VOs, the operation and the evolution stage, which are addressed further below. The VO's complete life cycle consists of four stages: creation, operation, evolution and dissolution [20]. While there are challenges in all stages of the life cycle of VOs, our research focuses on parts of its operation and evolution stages' challenges. If VO is mimicking the operation of one large organization in real market, then its partners need to collaborate closely and effectively, as if they represent different departments within a large organization. However, it shall be noted that the VO partners are heterogeneous, autonomous and geographically dispersed organizations, who agree to temporarily contribute a part of their resources and skills into the VO, as required for achieving their common VO goal. Also note that while these independent organizations themselves individually evolve in time, the VO is also dynamic in nature and shall evolve its goals as well as its activity plans and schedules, etc., in order to adapt itself with changes that occur either internal or external to its environment.

In other words, VO evolves in time to cope with changes in the market and society, and as such, even some of its goals may need to evolve. Additionally, due

to the fact that VOs depend on a number of independent entities, constituting the VO partners, it is possible that even its configuration of partners may need to evolve in time. The customer is however typically not concerned with the needed VO dynamism. Usually from the customer's point of view, the contract commits to deliver some final products with all the specificities of those products, including delivery date, location, quality, etc., and in that sense, there is no difference between a VO producing these required products, or a single company. Please note that the contract between a customer and a large company does neither address the names of its internal departments which will perform different tasks and sub-tasks, nor the planning and scheduling of their activities. Similarly, in some VOs, the VO partners are not even distinguished within the contract. This is the usually case when one representative organization signs the contract with the customer, on behalf of the entire VO consortium. As such even the name of the VO partners may not be mentioned in the contract signed during the VO's creation stage. Later on during its operation stage, similar to any large organization that has a contract with a customer, the virtual organization acts as a dynamic entity. In other words, its daily activities are decided internal to the VO, specifying each partner's responsibilities and monitored by the VO coordinator.

Considering the dynamic complexities of VOs, in some other forms of VOs, besides the product specificities, the customer may wish to also know about the VO partners during its creation phase. Usually in such VO contracts, the main goals and sub-goals as well as the high level planning and scheduling of its work packages (sub-projects) together with a number of their coarse-grained tasks, can be predefined in the contract that the VO signs during its creation stage with the customer. It is however known to all parties that VO is dynamic and as long as it delivers its final agreed product, its daily activities are internal and the customer will not interfere. Therefore, similar to the case above, daily activities and other details of the VO are only gradually, systematically, and dynamically extended and defined during its operation phase, under the supervision and decision making of the VO coordinator. However, VO is a federation of independent organizations. So, daily activities are always advised by the coordinator and agreed by the partners that are suggested by the VO coordinator to take those tasks.

Capturing and supporting the required dynamism during the VO operation stage can benefit from a VO supervisory framework to assist on one hand with continuously formalizing and reflecting the detailed agreement on tasks to be executed by partners, as well as the evolved situations at the VO, and on the other hand to record partners compliance, successful completion and performance of their assigned, planned, and scheduled tasks. In other words, while the customer of the final product of the VO is not at all interested in knowing details of which organization did what, when, and how within the VO consortium, these information are quite critical to the VO's coordinator and VO partners. As such this information shall be carefully recorded, logged and preserved internal to the VO.

On the one hand, it shall provide a reference point on assigned/agreed responsibilities for the VO consortium partners. On the other hand, it shall be used as a main tool in the hand of the VO coordinator for monitoring, supervision, alignment, potential intervention and even decision making on needed evolution of the VO during its operation stage. Furthermore, the collection of past logs of each partner's activities in the VO, combined with that partner's past records stored within the VBE provides a good source for assessment of each organization and can be used for their accountability, measuring their trustworthiness, selecting suitable partners for task reassignment, and even for potential fair distribution of some profits and losses in the VOs, etc.

As a building block for establishing such a supervisory framework and using it to measure potential risks of VO failure due to the monitored behavioral perspectives of the partners and the VO as a whole, the regulatory role of the VO coordinator must be concisely specified. In this role, a set of working principles and regulations must be defined for partners' behavior regarding both their responsibilities and rights by the VO coordinator, which will then be used to supervise the VO. The principles limit and lead both the collective and individual behavior of partners. There is a need for formation of well-founded behavioral models in VOs, which can then also be applied to mechanisms for effective selection of VO partners, aiming to prevent future failures in VOs. Moreover, such a framework facilitates introducing new mechanisms, e.g. a reward system for good performance, where many studies show it encourages behavior enhancement in collaborative networks. Motivation and rewarding models and mechanisms increase sustainability of the networks, through fair and transparent distribution of some benefits, and tap on the expectation of partners offering to contribute more, and collaborate more effectively.

## 1.2 Research Questions

The VO coordinator can play a vital role in supporting successful collaboration of the VO. We investigate the above addressed supervisory framework and aim to develop a supervisory assisting tool to support VO coordinators with increasing the resilience and success of their VOs, through monitoring and analysis of partners' behavior and diagnosing and alarming about the potential points of failure in the VO.

The main related research on this topic is addressed in [69], [96], [8], [55] and [25]. However, joint responsibilities, and VO's dynamism that are of great importance to building our targeted supervisory assisting tool have not been sufficiently addressed. Moreover, while the related research in the area mainly focuses on the VO creation phase, the main focus of our research is to support the operation and evolution stages of the VOs, with slightly addressing how some of our introduced functionality can also be applied to the creation stage, as exemplified in

the service oriented VOs. To build our proposed system, we need to answer the following fundamental questions.

**RQ1: How to model and assess the work-related collaborative behavior of VO partners?**

This research question is primarily related to two specific measurements at each VO partner: (i) individual collaborative-behavior of the VO partner, as incrementally measured for it and recorded in the VBE, and (ii) current collaborative-behavior of the organization in the VO. It should be noticed that, based on the definition of VOs and VBEs, adopted from [19] and [2], the VO partners refer to organizations. This research question is addressed in Chapters 2, 3, 4 and 5 of the thesis, and it includes the following two sub-questions:

*S1-RQ1: How to characterize and model **past collaborative-behavior** of members in the VBE?*

We present a mechanism for identifying and comparing the individual collaborative-behavior of organizations based on the causal relationships that we have defined among organizations' **behavior traits**, and some **known factors** in the VBE. Chapter 2 explains that information related to organization's behavior traits as collected from their involvement in the past VOs. This information is used for measuring and comparing the organization's behavior against other organizations.

*S2-RQ1: How to monitor and measure **current collaborative-behavior** of partners in a VO?*

We introduce four specific kinds of behavioral norms, including: (i) **Socio-regulatory norms**, (ii) **Co-working norms**, (iii) **Committing norms**, and (iv) **Controlling norms**, as addressed in Chapter 3. We formalize these norms in order to both deal with the VO's dynamism and its evolution, as well as dealing with the relationship among partners that are involved in a joint-responsibility. Moreover, we develop new mechanisms for monitoring the organizations' behaviors against these norms, to measure their degrees of norm obedience, as discussed in Chapter 4. A mechanism is proposed in Chapter 5 to evaluate the trust level of each VO partner during the VO operation phase, which has two advantages: (i) measuring the lack of trustworthiness for each VO partner, to predict the risk of failure in VO goals, and (ii) more effective service selection, as exemplified for service selection in a Service Oriented Architecture (SOA)-based VOs.

**RQ2: How does the partner's work-related behavior influence the achievement of the VO goals?**

This research question is related to the specification of behavior-related risk factors aiming at the risk prediction in VOs. This question is mainly addressed in Chapter 6, and includes the following two sub-questions:

*S1-RQ2: What are the **main behavior-related risk factors** in VOs?*

We introduce three risk factors related to the VO partners, i.e. **lack of trustworthiness**, **work overload**, and **failing in communication**. The lack of trustworthiness of the partner is measured based on the results of modeling and monitoring the partners' behavior, which are discussed in Chapters 4 and 5 of

the thesis. Other factors are mostly addressed in Chapter 6.

*S2-RQ2: How to predict risk of failure in achieving VO goals, considering behavior-related risk factors?*

We introduce a new mechanism to predict the risk of failure in the VO goals and the VO tasks. This mechanism uses the probabilities of the three risk factors mentioned above under S1-RQ2, addressed in Chapter 6, as well as information related to the inter-dependencies among different partner's responsibilities, while these responsibilities are themselves dynamically and gradually specified during the VO operation phase.

*RQ3: How to enhance collaboration success in VOs, in relation to partners' work-related collaborative behavior?*

This main question is primarily related to the prevention of failure risk, as well as promotion and enhancement of collaboration, which results in improving the success rate in VOs. It is mainly addressed in Chapter 6. This research question includes the following two sub-questions:

*S1-RQ3: How to prevent potential work-related VO failure, through task reassignment?*

Task reassignment is one of the solutions that the VO coordinators can consider to prevent a potential failure in fulfilling of the VO goals. We introduce a new approach for selecting the best-fit member to which the risky task is re-assigned, as addressed in Chapter 6. The proposed approach aims to bring new insights on how to increase the chances of partnership success.

*S2-RQ3: How to promote work-related collaboration behavior among VO partners?*

We introduce the concept of indirect rewards, which can be distributed among organizations based on their collaborative work-related behavior during the VO operation phase. It can encourage partners to perform better and more collaboratively, and it is aimed to enhance and affect their future behaviors. This is also discussed in Chapter 6.

Obtaining satisfactory answers to these questions have resulted in developing our VO supervisory assisting tool (VOSAT) for monitoring and controlling organizations' behavior that enables the VO coordinator to both predict and prevent failures, and to promote collaborative behavior among the partners.

## 1.3 Research method

Our research method consists of the following phases:

**(1) Establish the motivation.** This phase aims at indicating the importance of modeling and monitoring the behavior of VO partners in increasing the resilience and success of VOs. Two specific measurements for each VO partner are identified: (a) established past collaborative-behavior of the VO partner, measured in the VBE, and (b) current collaborative-behavior of the VO partner in

the VO.

**(2) Review the related works.** This phase aims at providing enough information for the approach pursued in this thesis to monitor the VO partners during its operation phase, diagnose and prevent the potential causes of failures, related to partners collaborative behavior, in fulfilling the VO goals.

**(3) Establish the research assumptions.** The first assumption of this research is that the collaborative behavior of organizations involved in a VBE can be measured and compared with each other, based on a number of organizations' traits. The reason behind this assumption is that when organizations collaborate with each other to achieve common and compatible objectives, they may show different behaviors, which are usually repeated over time. As a result of the repetition of these behaviors, some behavioral patterns are formed, that are in turn related to a number of certain traits [79]. In other words, certain actions by an organization in collaboration situations are the evidence of certain behavioral patterns. Therefore, we define the personality of an organization being composed of a series of traits that highlight the organization's behavior. Applying the organization's personality, the organization's behavior can therefore be predicted, thorough our suggested mappings between the traits and behavior.

The second assumption is that similar as humans the behaviors of organizations involved in VOs, are also constrained by some norms. Considering the VO's dynamism and its evolution during its operation stage, there are certain *obligations*, *prohibitions* and *constraints* that limit the behavior of involved organizations in VOs, so it is assumed that we can monitor the organizations' behavior through checking the state of these norms.

The third assumption is that the failure risks of the VO goals, and the planned collective responsibilities in VOs depend primarily on the *trust levels*, *communication rates* and *work overloads*, which are measured in our approach for the involved partners, although there are some other risk sources also identified in the literature [8]. The main reason behind this assumption is that collaboration risk assessment in our approach is performed using the concept of organization's behavior. For example, the trust level of organizations, as a main factor of risk, is evaluated from a *behavioral perspective*. It means that for instance if an organization's behavior is considered positive regarding the collaboration's norms, and its individual collaborative behavior is also high in contrast to other organizations, then its level of trust increases, and from this aspect, this organization is not predicted to put the VO at risk.

**(4) Design the assisting supervision framework.** This phase aims at developing the assisting supervision framework to support VO coordinators with increasing the resilience and success of the VOs. In this framework, to measure the organizations behavior within the VBE, four specific quality-behavioral dimensions are considered, and modeled through a set of traits. A quantitative causal approach is then defined to inter-relate some known factors from the environment with the traits of these four behavioral dimensions. The results are then used to

measure each organizations level of Individual Collaborative Behavior (ICB) in the VBE, in comparison to all others. Formulas are derived from the causal relationships, for computing the collaborative behavior degree for each organization. This measure constitutes one criterion in our proposed approach for evaluating collaborative trustworthiness of the organization, as needed to be known during the VO operation phase. To address the collaborative-behavior of the VO partner in current VO, four specific kinds of behavioral norms are introduced, i.e. (i) *Socio-regulatory norms*, (ii) *Co-working norms*, (iii) *Committing norms*, and (iv) *Controlling norms*; our proposed model is therefore called the S3C model. This model characterizes each of the four norms for organizations' behavior in the VO. Our approach to this model introduces new formalization and mechanisms for organizations to make promises (for performing individual sub-tasks) and/or joint-promises (for performing joint-tasks), thus the VO partners committing themselves in a bottom-up manner to perform tasks, as opposed to the VO coordinator assigning tasks to them in a top-down manner. The bottom-up manner is more in line with the collaboration nature in the VOs that resembles a federated partnership among organizations. Furthermore, based on the results of monitoring the socio-regulatory norms, co-working norms, and committing norms as well as the value of partner's ICB, the trust level of the partner is specified. Using the controlling norms, as well as responsibility inter-dependencies, applying Bayesian network, the probability of failure in each of the planned sub-task, task, sub-goal, as well as the general VO goal can be concisely measured. Moreover, some decision making suggestions are provided for intervention toward failure prevention and collaboration promotion in VOs, and thus enhancing the success rate of VOs. A summary of our contributions in this thesis are presented in Table 1.1.

**(5) Tool Development.** This phase aims at addressing the development of the VO assisting tool, the VOSAT. The development of this tool applied the behavior models and mechanisms for behavior monitoring, diagnosing the risks, reassignment of risky tasks, and support some rewards distribution, which were designed in phase 4. Our VOSAT tool is developed using the 2OPL (Organization Oriented Programming Language) [1], while also extending its environment with the formalization of the notion of promises, joint-promises and fuzzy norms.

**(6) Model validation.** Since applying the model to the sufficient number of cases needs more time, and also there is no similar competitive system introduced for VOs, statistical validation approaches cannot be applied here. Therefore, other approaches are introduced and used for this purpose. The proposed behavior model of organizations in VBEs, addressed in Chapter 2, is validated by more than fifty members of the SOCOLNET community of experts in collaborative networks <sup>1</sup>. The mechanism of monitoring VO partners' behavior and their trust evaluation is applied to a Service Oriented Architecture (SOA)-based VO,

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<sup>1</sup><https://sites.google.com/a/uninova.pt/socolnet/>

Chapter	Contribution	Rank
2. Partners' Behavior in VBEs	Hierarchical model of Individual Collaborative Behavior (ICB)	**
	ICB causal analysis	**
3. Norm Specification in VOs	S3C model of VO as a normative multi-agent system (addressing: Socio-regulatory, Co-working, Committing, and Controlling norms)	**
4. Normative VO Supervisory Assisting Tool (VOSAT)	Formalizing promises, joint-promises and partners' trustworthiness as one form of fuzzy behavior norm	**
	2opl-based norm monitoring approach	*
	Committing Norm Obedience Degree (CNOD)	**
5. Behavior-based Trust Evaluation of VO partners	VO partners trust characterization	**
	4C-based C3Q model of competencies for service selection, considering the trustworthiness of service providers (addressing: Capability, Cost, Conspicuity, and quality of services)	*
6. Behavior-based VO Supervision and Intervention	VO partner behavioral risk analysis (addressing: lack of trust, lack of communication, heavy workload)	**
	Bayesian network-based VO failure risk prediction mechanism	*
	behavior-based task reassignment characterization	**
	performance-based reward distribution characterization	**

Table 1.1: Summary of thesis Contributions and their ranks (\*\* novel in the area, \* enhancing the state of the art).

as addressed in Chapter 5. Furthermore, we have applied our developed tool to some examples, such as a project aims at producing the canned tomato paste, briefly addressed in Chapter 4, a designed case study within the framework of an EU-funded project, and the project aiming at investigating the impact of certain Scientific Research on the Agriculture (SRA), as briefly addressed in Chapter 6.

## 1.4 Thesis Structure

This thesis addresses mechanisms that are used to support the supervision of VOs. The structure of the thesis is as follows.

In Chapter 2, we discuss the causal relationships among the organizations' personality, behavioral dimensions, and traits. We adopt some applicable ideas from existing personality models, such as [75] to evaluate the organizations' behavior. Several new measurable traits are then introduced, and their causal relationships with behavioral dimensions are defined. Furthermore, the system dynamics method is applied to formulate measurable organizations' behavior.

Chapter 3 introduces four specific behavioral norms, including: Socio-regulatory norms, Co-working norms, Committing norms, and Controlling norms. Then the formalizations of the related concepts are discussed based on which a new approach is proposed to monitor organizations' behavior against these norms. Our

developed supervisory tool, called VOSAT (VO Supervisory Assisting Tool), is briefly introduced in this Chapter. It consists of the following five components:

- Norm Monitoring Component (NMC)
- Norm Abidance Component (NAC)
- Trust Evaluating Component (TEC)
- Risk Predicting Component (RPC)
- Partner Selecting Component (PSC)

Chapter 4 focuses on addressing the first two components. In other words, Chapter 4 addresses how to monitor the partners' behavior against the four specific norms defined in Chapter 3. Moreover, the obedience degrees for socio-regulatory norms, co-working norms and committing norms are measured in Chapter 4.

Chapter 5 presents a mechanism for evaluating the trust level of VO partners, using the measures discussed in Chapter 2, and Chapter 4. A case study is introduced for partners' behavior monitoring and trust evaluation, which applies our approach for most-fit partner selection to the software service industry, and a specific case of a Service Oriented Architecture (SOA)-based VO. We have also extended our approach here by introducing a new competency-model used for most-fit service selection in this environment. This model leads to an effective service discovery and consequently assists with integrated service composition in VOs. New meta-data to describe and model the services is introduced.

The main focus of Chapter 6 is on enhancing resilience of the VO, for which a set of mechanisms are proposed. At first, the risk of failure in fulfillment of assigned tasks is predicted. When risky tasks are specified then it may be needed to reassign them; therefore, the best potential partners to which the risky tasks can be delegated are selected, based on findings of our proposed approach. These task reassignments can prevent risk of failure in fulfilling the VO goals. Another important issue addressed in this chapter is how to promote stronger collaboration, which is proposed to be guided through transparent and fair rewards distribution.

Finally, in Chapter 7, we conclude the thesis, address how we have answered to the defined research questions, and our assessment and validation of our approach and the developed system. Some on going and future works are also mentioned in this chapter.

The material represented in Chapter 2 to Chapter 6 of this thesis have been published, as indicated below. Co-authorship and roles:

- Addressing behavior in collaborative networks [89],
  - Presented in Chapter 2,

- Awarded as the best paper in *Adaptation and Value Creating Collaborative Networks*, 12<sup>th</sup> IFIP WG 5.5 Working Conference on Virtual Enterprises, 2011,
- Mahdiah Shadi: All aspects of the paper,
- Hamideh Afsarmanesh: Guidance and technical advice
- Behavioral norms in virtual organizations [91],
  - Presented in Chapter 3 ,
  - Published in *Collaborative Systems for Smart Networked Environments*, 15<sup>th</sup> IFIP WG 5.5 Working Conference on Virtual Enterprises, 2014,
  - Mahdiah Shadi: All aspects of the paper,
  - Hamideh Afsarmanesh: Guidance and technical advice
- Behavior modeling in virtual organizations [90],
  - Presented in Chapter 3,
  - Published in *Proc. Advanced Information Networking and Applications Workshops (WAINA)*, 2013,
  - Mahdiah Shadi: All aspects of the paper,
  - Hamideh Afsarmanesh: Guidance and technical advice
- Agent behavior monitoring in virtual organization [92],
  - Presented in Chapter 4,
  - Published in *Proc. Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE)*, 2013,
  - Mahdiah Shadi: All aspects of the paper,
  - Hamideh Afsarmanesh: Guidance and technical advice,
  - Mehdi Dastani: Guidance and technical advice
- VO Supervisory Assisting Tool (VOSAT),
  - Presented in Chapters 4,
  - Submitted to *International Journal of Networking and Virtual Organisations*,
  - Mahdiah Shadi: All aspects of the paper,
  - Hamideh Afsarmanesh: Guidance and technical advice,
  - Mehdi Dastani: Guidance and technical advice

- Semi-automated software service integration in virtual organisations [6],
  - Presented in Chapter 5,
  - Published in *Enterprise Information Systems*, 2015,
  - Mahdiah Shadi: The proposed competency model and the approach for service selection (non-functional service discovery),
  - Mahdi Sargolzaei: The functional service discovery and service integration
  - Hamideh Afsarmanesh: Guidance and technical advice
- A framework for automated service composition in collaborative networks [5],
  - Presented in Chapter 5,
  - Published in *Collaborative Networks in the Internet of Services*, 13<sup>th</sup> IFIP WG 5.5 Working Conference on Virtual Enterprises, 2012,
  - Mahdiah Shadi: The proposed competency model and the approach for service selection (non-functional service discovery),
  - Mahdi Sargolzaei: The functional service discovery and service integration
  - Hamideh Afsarmanesh: Guidance and technical advice
- Bayesian Network-Based Risk Prediction in Virtual Organizations [7],
  - Presented in Chapter 6,
  - Published in *Risks and Resilience of Collaborative Networks*, 16<sup>th</sup> IFIP WG 5.5 Working Conference on Virtual Enterprises, 2013,
  - Mahdiah Shadi: All aspects of the paper,
  - Hamideh Afsarmanesh: Guidance and technical advice
- Task Failure and Risk Analysis in Virtual Organizations,
  - Presented in Chapter 6,
  - Submitted to *International Journal of Cooperative Information Systems*,
  - Mahdiah Shadi: All aspects of the paper
  - Hamideh Afsarmanesh: Guidance and technical advice