

## Collaborative Networks in Industry and the role of PRO-VE

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### Editorial

Most industrial enterprises are going under a big pressure, having to cope with continuously and rapidly changing market conditions and related business environments (Alberts, 2011; WEF, 2013). The accumulated effects of a number of factors such as the acceleration of the globalization, changes in regulations for environmental protection and working conditions, more demanding quality standards, economic crisis in some regions, demographic shifts, and fast technological evolution, among others, led to what is often called market turbulence. Under these conditions, the threats to business sustainability lead to higher levels of risk; furthermore, trends show that unexpected disruptive events are increasing in frequency and in their effects (Camarinha-Matos, 2014).

Collaboration is often pointed out as a mechanism to facilitate agility and resilience, and thus a way to mitigate the effects of disruptions (Camarinha-Matos *et al.*, 2009; Peters, 2010). By dynamically combining the best fitting set of competencies and resources, *communities* of enterprises can be reshaped in different organizational forms, in order to cope with unexpected changes and disruptions, while also pursuing new business opportunities. For instance, in supply chains, an increased level of visibility along the chain, which is inherent to collaboration, can help enterprises to quickly adjust to demand fluctuations and disruptions (Peters, 2010). On the other hand, advances in ICT, and more specifically on Internet-related technologies, have induced or enabled new organizational forms such as the extended enterprise, virtual enterprise, virtual organization, business ecosystem, and many others, materializing different

cases of collaborative networks and constituting highly interconnected and dynamic value chains. In connection with these organizational forms, and also led, to some extent, by a technology push, new business models emerged.

In this context, the PRO-VE ([www.pro-ve.org](http://www.pro-ve.org)) series of working conferences on virtual enterprises have been playing a major role along the last 15 years in terms of knowledge sharing, identification of research and development needs, and setting the trends.

*Knowledge sharing and multi-disciplinary convergence.* Although topics related to collaborative networks appear in many recent conferences, PRO-VE established its long-term position as a well-focused conference in the area. One of its most relevant characteristics, since the beginning, has been the effort to welcome contributions from a multi-disciplinary nature and promote fruitful interactions among researchers and practitioners from different backgrounds. As such, PRO-VE is designed and organized to offer an effective opportunity to synergistically combine contributions from computer science, manufacturing, engineering, economics, management, and socio-human communities. Such approach contributes to the creation of a more holistic understanding of the challenges, as a basis to reach more comprehensive solutions.

*Identifying needs and setting the trends.* An analysis of the focus of each annual edition of the conference (Figure 1) and corresponding proceedings shows the role of PRO-VE in promoting the identification of gaps, trends, and research challenges in this scientific area. In fact, several relevant international research roadmaps have been published and discussed in



**Figure 1.** Setting the trends on collaborative networks

these events. As such, the conference has been contributing to help the research community defining and promoting its research agenda.

As briefly illustrated in Figure 1, various phases can be identified along the time line:

- Virtual enterprise support infrastructures. In the early phases of PRO-VE, most emphasis was put on ICT infrastructures to support single networks such as virtual enterprises / virtual organizations. Information sharing and federation, secure communications, and distributed business processes management / inter-organizational workflows were among the most addressed topics.
- Business ecosystem and virtual organizations breeding environments (VBE). The need to support rapid formation of agile virtual enterprises in response to business opportunities, coping with the challenges of trust building and achieving preparedness for collaboration, led to the emergence of long-term strategic networks. These organizational forms constitute proper

breeding environments for the creation of dynamic goal-oriented networks. Understanding the organizational and business models, supporting the various stages of the life cycle of different types of networks, and developing models and systems for the management of VBEs and dynamic consortia formation in such context, became relevant research topics.

- Emergence of collaborative networks as a discipline. As the number and variety of forms of networked organizations increased, and empiric knowledge on those networks accumulated, the research community started to feel the need to better organize related knowledge and activities as a new scientific discipline (Camarinha-Matos and Afsarmanesh, 2005; Kühnle and Dekkers, 2012). The first *manifesto* for launching the discipline of Collaborative Networks was presented in the 2004 edition.
- Theoretical foundation and science base. As part of the consolidation of the area, and boosted by the aim of establishing the new discipline, the following years encompassed several dedicated efforts to create a sounder scientific and engineering basis for collaborative networks. Attention was directed to modelling the various aspects of collaborative networks, with particular relevance to the establishment of reference models such as ARCON. A closer look at other relevant disciplines and an effort to integrate and synthesize contributions from those disciplines was carried out and discussed in various PRO-VE editions, with more emphasis since 2007. A particularly relevant stream of research started by looking into the “soft computing” area in order to find suitable approaches for modelling aspects related to human behaviour in collaborative organizations and to handle the issues of decision making and behaviour management in the contexts of incomplete and imprecise knowledge.
- Pervasiveness of collaborative networks. The consolidation of the area and the fast progress on ICT support led to an expansion of the collaborative networks paradigm to multiple application areas. Besides the “traditional” sectors represented in advanced supply chains, virtual enterprises, virtual organizations, virtual teams, and their breeding environments, new forms of collaborative structures started to emerge in all sectors of the society. Examples can be found in e-government, intelligent transportation systems, collaborative virtual laboratories, agribusiness, elderly care, health care, education, collaborative

logistics networks, etc. By promoting the sharing of experiences from all these sectors, PRO-VE has been contributing not only to enlarge the scope of the area, but also to consolidate concepts and terminology, which is fundamental to facilitate cross-sector and open innovation.

- Sustainability and societal challenges. More recently, and in line with major worldwide trends and challenges raised by the economic crisis, PRO-VE editions have been motivating the research community to more pro-actively apply the collaborative networks paradigm to critical societal challenges. Aiming to reach a sustainable world calls for a wider collaboration among multiple stakeholders from different origins, as the changes needed for sustainability exceed the capacity and capability of any individual entity. Collaboration thus plays an important role. Examples of addressed issues include carbon-efficient value networks, active ageing, rescue and humanitarian organizations, collaborative health networks, and environment monitoring and management. Another relevant discussion focus is re-industrialization, which appears as the economic, social, and political process of organizing resources for the purpose of re-establishing / revitalizing industries in order to reinvigorate the economy. Collaboration is essential here, especially to small and medium enterprises in order to acquire critical mass, reach new markets, and leverage skills. But the re-industrialization cannot simply follow the steps of past century. New perspectives of industry are needed, as exemplified by issues widely discussed in recent editions of PRO-VE: (i) Focusing on service-enhanced products; (ii) Addressing the full life cycle of products, including refurbishing / retrofitting and recycling; (iii) Taking on board the concerns of energy saving and reduction of ecological footprint; and (iv) Having a *glocal* perspective, while relying on co-innovation and co-evolution.
- Extended networked environments. Fast progress in pervasive computing and areas such as Internet of Services, Internet of Things, Cyber-Physical Systems, and Smart Environments, create new business opportunities and open new possibilities for expanding collaborative networks. Collaborative systems provide a promising basis for smart networked environments wherein humans, organizations, intelligent agents, and devices collaborate. Modelling, design, and development of collaborative systems of

systems is likely to support a large number of novel applications in areas including security, transportation, construction, sustainability and energy management, education, government, and manufacturing.

*Building a community.* An important outcome of the PRO-VE series of conferences was the gradual building of a research community on collaborative networks. The focused scope of the events facilitates the interactions among participants, even if they are coming from different backgrounds. Complemented with a deliberate effort to promote mutual respect among the contributing disciplines, the focus and aims of the conference facilitated the creation of collaborative bonds among many participants. This is reflected in the fact that a good percentage of attendants participate in consecutive editions and that many collaborative projects started among them. In 2007 the informal community gathered around PRO-VE launched a more formal organizational structure – SOCOLNET, the International Society of Collaborative Networks ([www.socolnet.org](http://www.socolnet.org)). This society, which currently counts members in 48 countries, is a not for profit research association, that aims at promoting and stimulating scientific research, education, technological development, and scientific and technical interactions among researchers in the area of Collaborative Networks.

Complementarily, PRO-VE has been contributing to education. A number of curricula proposals and teaching experiences on collaborative networks have been discussed in its various editions. The conference proceedings, published by Springer under the titles of the main themes shown in Figure 1, and included in the IFIP Advances in Information and Communication Technologies series, provide important background material for the area. Being indexed in major databases such as Web of Science, SCOPUS, and DBLP, increased the visibility of the knowledge generated in this area. Its impact is also reflected in the fact that many PRO-VE papers have reached a very good number of citations.

The increasing range of applications of collaborative networks, combined with the possibilities offered by new technologies (e.g. cloud computing, smart mobile devices, natural user interfaces, etc.), induce new organizational forms and new business models, all pointing to a strong and more dynamic interconnectivity, which in turn raises new research challenges. Some examples include:

- *Behavioural aspects* – the success and sustainability of collaboration requires better

understanding of the involved behavioural aspects, which will provide a basis for the development of sounder governance principles and support tools.

- *Multiplex networks* – more and more, complex applications require the involvement and interplay of multiple networks. For instance, in the area of service-enhanced products (or product-service systems), various collaborative networks need to be involved, namely for product manufacturing, creation or co-creation of business services that enhance the product, service provision along the life cycle of the product, involvement of the customer and other local stakeholders close to the customer in the process of co-creation / co-innovation, etc. Furthermore, enterprises can be involved in multiple business communities, with different degrees of membership. It is also necessary to consider the co-existence of formal and informal networks.

- *Risks and complexity* – particularly in turbulent environments, it is necessary to deal not only with endogenous risks (due to misalignments of values and strategies of network members), but also with exogenous ones (terrorism, natural disasters and occurrences, acceleration of globalization, demographic shift, cyber risks, etc.).

- *Interconnected worlds* - fast progress towards smart environments, i.e. context sensitive systems in which the physical and the cyber worlds are interwoven through seamless integration of sensors, actuators and other everyday objects, progressively enriched with computational and decision making power, and interconnected through networks.

A challenge for the PRO-VE / SOCOLNET community is to keep up with these new requirements and work together to devise adequate solutions in the near future.

## References

- Alberts, D. S. (2011). *The Agility Advantage – A Survival Guide for Complex Enterprises and Endeavors*. DoD, ISBN 978-1-893723-23-8, [http://www.dodccrp.org/files/agility\\_advantage/Agility\\_Advantage\\_Book.pdf](http://www.dodccrp.org/files/agility_advantage/Agility_Advantage_Book.pdf) (access 28 May 2014).
- Camarinha-Matos, L. M. (2014). Collaborative Networks: A Mechanism for Enterprise Agility and Resilience. In *Enterprise Interoperability VI* (K. Maertins *et al.* Eds.). Springer, pp. 3-11. doi:10.1007/978-3-319-04948-9\_1
- Camarinha-Matos, L. M., Afsarmanesh, H. (2005). Collaborative networks: A new scientific discipline. *J. Intelligent Manufacturing*, 16(4-5): 439-452. doi:10.1007/s10845-005-1656-3
- Camarinha-Matos, L. M., Afsarmanesh, H., Galeano, N., Molina, A. (2009). Collaborative Networked Organizations - Concepts and practice in Manufacturing Enterprises. *Computers & Industrial Engineering*, 57(1); 46-60. doi:10.1016/j.cie.2008.11.024
- Kühnle, H., Dekkers, R. (2012). Some thoughts on interdisciplinarity in collaborative networks' research and manufacturing sciences. *J. Manufacturing Technology Management*, 23(8): 961-975. doi:10.1108/17410381211276826
- Peters, C. (2010). Improving Supply Chain Resilience with Network Centric Manufacturing, DSN Innovations White paper. [http://thelucrumgroup.com/documents/ImprovingSupplyChainResiliencewithNCM\\_FINAL\\_cpeters.pdf](http://thelucrumgroup.com/documents/ImprovingSupplyChainResiliencewithNCM_FINAL_cpeters.pdf) (access 25 Nov 2013)
- WEF. (2013). Building Resilience in Supply Chains. *World Economic Forum*, Jan 2013. [http://www3.weforum.org/docs/WEF\\_RRN\\_MO\\_BuildingResilienceSupplyChains\\_Report\\_2013.pdf](http://www3.weforum.org/docs/WEF_RRN_MO_BuildingResilienceSupplyChains_Report_2013.pdf) (access 28 May 2014)