Collaborative Networks: A Mechanism for Enterprise Agility and Resilience

Luis M. Camarinha-Matos

Abstract The collaborative networks paradigm, particularly when focusing the rapid formation of consortia, represents an important mechanism to support enterprises' agility and resilience in turbulent business environments. 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 seeking to take advantage of new business opportunities. In this context, this paper provides a brief survey of the area, summarizing the main classes of collaborative networks, current state of developments, and challenges ahead.

Keywords Collaborative networks · Agility · Resilience · Business sustainability

1 Introduction

There seems to be a wide consensus that enterprises are nowadays under a big pressure, having to cope with rapidly and continuously changing market conditions and related business environments [1, 2]. 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, economical crisis in some regions, demographic shifts, and fast technological evolution, 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

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frequency and in their effects [3]. In this environment, generally accepted rules and business norms become uncertain and volatile, thus inherently unstable [4].

As such, agility and resilience appear as relevant qualities for enterprises' survival and business sustainability. The notion of agility represents the ability to quickly and effectively cope with unexpected changes in the environment [2, 5]. Some authors also add the capability to take advantage of the changes [1]. Resilience, although also related to changes, has a more specific focus, representing the ability of a system to cope with severe disturbances or disruptions and return to its original or desired state [1, 6, 7]. In other words, the ability to repair or reconstitute lost capability or performance after damaging perturbations in the environment. In both cases, there is the underlying desire of a fast and effective reaction to unexpected and even disruptive changes.

Collaboration has been pointed out as a mechanism to facilitate agility and resilience, and thus a way to mitigate the effects of disruptions [6, 8, 9]. For instance, in supply chains, an increased level of visibility along the chain, which is achieved through collaboration, can help enterprises to quickly adjust to demand fluctuations and disruptions [6, 8]. On the other hand, advances in ICT, and particularly the progress 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. Associated to these organizational forms, and also led, to some extent, by a technology push, new business models emerged. In this way, technology represents an important enabler for the implementation of agility and resilience [9].

However, global interconnectivity and effective and transparent information flows, although facilitating interactions and timely feedback, also bring increased complexity and dynamics, which contribute to more uncertainty, emergent and not well-understood behaviours, new risks, including cyber risks, and increased time pressure [2]. Furthermore, in globally interconnected environments, problems that used to remain confined, have now far-reaching impacts [10].

In this context, this brief *position paper* discusses the role of collaborative networks as a facilitator for agility and resilience, pointing out the main achievements in this domain, but also identifying critical research challenges ahead.

2 Motivation for Collaborative Networks

Collaborative networks (CNs) have long been associated with agility and business sustainability in turbulent markets [9, 11]. The reason being the flexibility of the corresponding organizational structures. Instead of pursuing an effort to increase in-house competencies and resources to address each new challenge, what takes time even when feasible and tends to create rigid structures, the idea is to focus on

a small number of core competencies and then seek complementarities by dynamically joining efforts with other enterprises according to the needs of each business opportunity. In this way, different collaborative networks, with different "shapes", can be formed more quickly, according to the needs. At least in theory, rapid reconfiguration of consortia allows to rapidly adjust to market demand and environment constraints.

This idea has led to many works on (optimal) consortia formation, including requirements analysis and consortia planning, partners' search and selection, negotiation, and consortia launching [12–14], which is perhaps one of the most addressed topics in CNs. Nevertheless, practical implementation of the idea faces some challenges, as discussed Sect. 3.

There are two main perspectives of collaboration—the enterprise-centric view and the network-centric view. The first one focuses on management of the relationships with clients and suppliers, as reflected in the areas of Client Relationships Management (CRM) and Multiple Relationships Management (XRM). This perspective puts the enterprise in the center ("egocentric view") and, as such, is more easily assimilated by the traditional enterprise culture. However, it is biased by the client-supplier and subcontracting notions, focusing on one-to-one relationships, not really capturing the potential of agile collaborative structures.

The second perspective, represented by the area of Collaborative Networks (CNs), focuses on the network as a whole ("holistic view"), emphasizing global performance, group governance, collective/emerging behaviors, etc., thus embedding the notion of "business community" or "business ecosystem". Agility and resilience can more effectively be supported under this perspective, which pursues global (community) optimization and not only individual benefits.

It shall be noted that collaboration implies opening or diluting organizational borders, which by itself brings new risks, especially when dealing with non-trustable parties. There is, therefore, an issue of finding the right balance between competition and collaboration, which goes hand-in-hand with trust building.

3 Classes of Collaborative Networks

As mentioned above, velocity, i.e. rapid adaptation to unexpected changes or disruptions is a key pillar of agility and resilience. The dynamic formation of a consortium, combining the most adequate set of competencies and resources to satisfy the needs of each new situation sounds indeed as a very appealing approach. However, reaching a rapid "alignment" among a diverse group of heterogeneous entities is not that simple and may require considerable time to achieve. Besides technical issues such as interoperability, establishment of proper sharing mechanisms, and setting up a collaboration platform, a number of other difficult issues including trust building, establishment of proper business agreements and intellectual property management rules, governance structures and principles, alignment of value systems and business cultures, among others, require considerable time,

especially if involved participants do not have experience of working with each other. Rapid formation of an effective consortium in fact requires that the involved entities are prepared to work together.

On the other hand, reaching some "universal preparedness" for collaboration is currently not realistic. This situation led to the emergence of the concept of virtual organizations breeding environment (VBE) [15], aimed at the creation of long-term communities whose members invested in being prepared to collaborate with each other and thus be in conditions, after the initial preparation effort, to rapidly respond to new business opportunities or drastic changes in the business environment. Dynamic virtual enterprises or virtual organizations can then rapidly emerge in a VBE context, seeking to find the best consortium configuration for each situation. This concept emerged in the sequence of other more primitive organizational structures such as industry clusters, or industry districts [16]. Another variant of this concept is the business ecosystem, which is inspired in the biological ecosystems and represents an alliance of stakeholders, often from the same geographical region, that aims to preserve and leverage local specificities, tradition, and business culture. Besides the aim of preparedness for collaboration, this organizational structure more clearly embeds the idea of community and the objectives of collective optimization and sustainability.

Therefore, two main classes of CNs can be identified: the mentioned breeding environments or strategic alliances focused on preparedness for collaboration, and goal-oriented networks, comprising well-focused consortia which combine competencies and resources in order to achieve a common goal or a set of compatible goals [16]. Among the goal-oriented networks, we can find dynamic and often short-term organizations such as virtual enterprises and virtual organizations, which are formed within the context of a VBE, and dissolve once the triggering business opportunity is achieved. But under this category, we can also find long-term networks, reflecting some form of continuity in production or servicing, such as supply chains, collaborative transportation networks, distributed manufacturing systems, collaborative smart grids, etc. In these cases, given the long life cycle, it is affordable to invest some time in the initial preparation phase and thus the existence of a VBE is not a pre-requisite for them.

Similarly to networks of organizations, two classes of networks of professional individuals have emerged - the Professional Virtual Community (PVC), a kind of breeding environment for dynamic goal-oriented Virtual Teams formation.

4 Trends and Further Research Challenges

The area of collaborative networks has shown considerable progress along the last decades. Figure 1 briefly illustrates the main milestones of this evolution.

In the last few decades, substantial efforts have been put at various levels, as illustrated in Fig. 2. Some overviews of achievements in these areas can be found in [17–19]. An aspect that is less studied is the dissolution phase of the CN's life

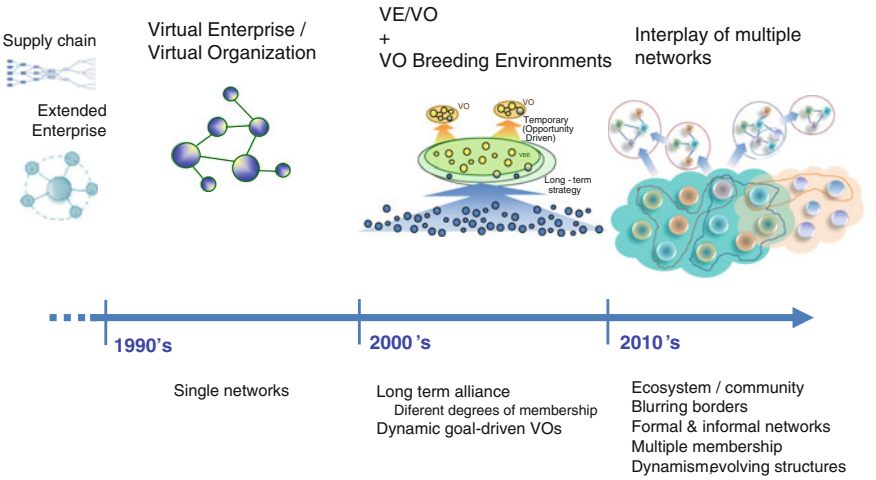

Fig. 1 Brief historic perspective of collaborative networks evolution

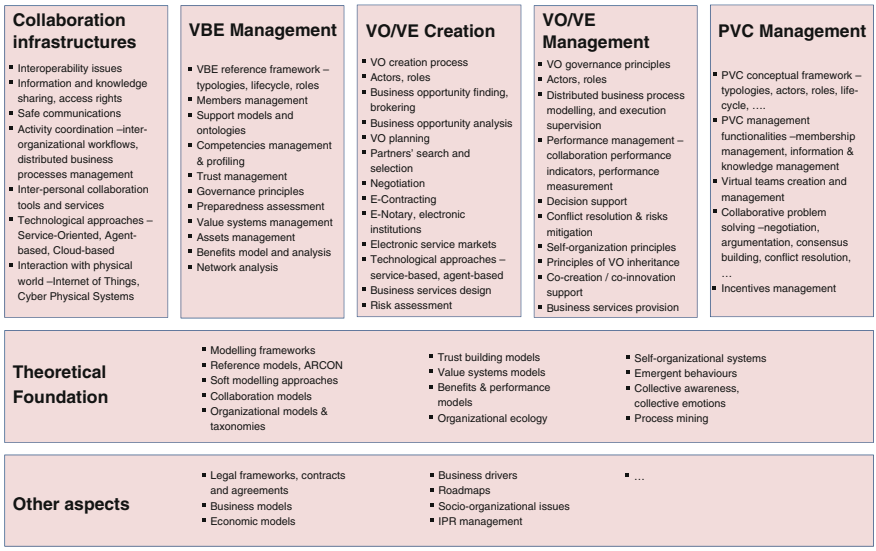

Fig. 2 Examples of key research areas in CNs in recent decades

cycle, which is becoming more relevant as dynamism and interplay among multiple networks increase.

In addition to manufacturing and supply chains, diverse forms of collaborative networks are being established in different application domains, although sometimes using different terminologies. Examples include: collaborative logistics networks, intelligent transportation systems, product-service systems, elderly care

networks, collaborative sensor networks, smart environments, collaborative learning networks, etc. This growing scope of applications, 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 dynamic interconnectivity, which in turn raises new research challenges. Examples of current challenging areas 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. Examples of relevant research questions include [20]: How to cope with the evolution of business ecosystems (or VBEs) and emerging endogenous behavioural patterns? Can self-organizing and emergence (including co-evolution, bounded instability, recombination, etc.) play a role in changing behaviours? How to support and promote collective emotional health at the ecosystem level? Which mechanisms are adequate to induce collaborative behaviour? Which negotiation and mediation mechanisms can support conflict resolution? How can trust be promoted? How to facilitate alignment in case of disruptions? etc. In order to properly address these questions, a multi-disciplinary approach is needed (socio-technical systems).
- *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 are 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. [21]. Additional challenges come from the fact that enterprises can be involved in multiple business communities, with different degrees of membership. Furthermore, it is also necessary to consider the co-existence of formal and informal networks.
- *Risks and complexity*—Although expected, risks in collaborative networks are, surprisingly, one of the least developed areas [6, 22]. Particularly in turbulent environments, it is necessary to deal not only with endogenous risks (due to misalignments), but also with exogenous ones (terrorism, natural disasters and occurrences, acceleration of globalization, demographic shift, etc.). Cyberspace risks are becoming an increasingly relevant subject of concern. As complexity of business environments increase, namely with the multiplicity and volatility of the involved organizational structures, also the risks and vulnerabilities increase, calling for urgent research actions.
- *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. This trend is reflected in a number of contemporary terms that focus on partial perspectives of the larger notion of "interconnected worlds" where collaboration can play a significant role: Internet of Things, Internet of Objects, Cyber-Physical Systems, Ambient Intelligence, Smart Environments, Collective Awareness Systems, Sensor Networks and Big data, and Sensing Enterprise.

In addition to these areas, which are only given as examples, further developments will be needed in the various sections shown in Fig. 2. A transversal challenge in all these areas is the validation issue. Since most of the effects of any change on the organizational structures and business models can only be observed much later than the normal duration of a research project, the validation process becomes a challenge on its own. A substantial part of the literature in the area remains at the "position paper" level with only minimal validation. Nevertheless, in recent years, the community is more aware of the need to find adequate validation methods for this new discipline. Attempts to combine quantitative and qualitative strategies are resorting to a mix of experimental research (when data can be available), simulation, ethnographic approaches, case studies, etc., but this will remain as a critical issue for the next years.

5 Concluding Remarks

The collaborative networks paradigm can facilitate enterprises' agility and resilience in turbulent business environments. The potential benefits of collaboration are not limited to providing a survival capability, but can also facilitate the identification and exploitation of new opportunities in such contexts.

In line with an increased set of possibilities offered by ICT and especially the so-called Future Internet, collaborative networks are "spreading" over many application domains. As a result, also new research challenges and even new research and validation approaches are emerging. In fact, the nature and wide scope of issues addressed in CNs require a multi-disciplinary approach and the involvement of different communities with distinct research cultures.

In terms of practical implementations, it shall be noted that the addressed challenges are not only a matter of technology. The introduction of this paradigm in existing business environments often requires a cultural change and a new mindset (e.g. going from a sub-contracting/outsourcing model to a collaborative culture), which is not a trivial task.

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