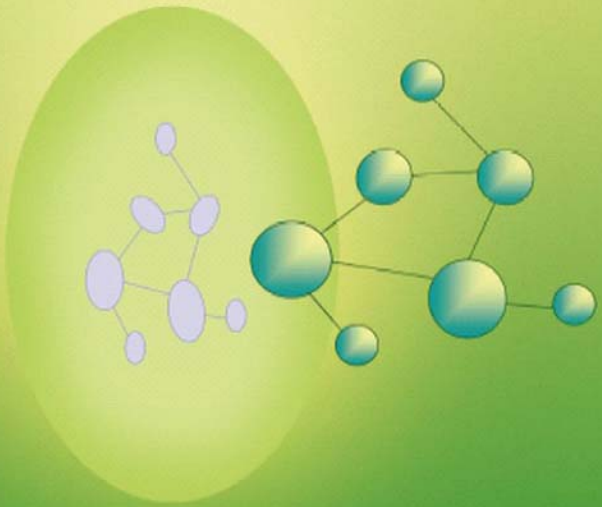
Collaborative Networks: Reference Modeling

Edited by Luis M. Camarinha-Matos
and Hamideh Afsarmanesh



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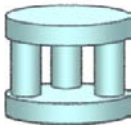

ECOLEAD
European Collaborative Networked Organizations Leadership Initiative
IST IP 506958 project
www.ecolead.org

Foreword

The field of Collaborative Networks has seen a remarkable progress during the last 10 – 15 years in terms of research and practical applications. Nevertheless the ongoing consolidation of the area as a new discipline requires more efforts on establishing its theoretical foundation. This book is a contribution in this direction.

Particular emphasis is put on modeling multiple facets of collaborative networks and establishing a comprehensive modeling framework that captures and structures diverse perspectives of these complex entities. Further, a contribution to the definition of reference models for Collaborative Networks is introduced.

This work was mostly developed in the context of the ECOLEAD project, a large 4-year European initiative including 28 academic, research, and industrial organizations from 14 countries in Europe and Latin America, within which the authors had major leading responsibilities. In addition to the contribution from the authors, some other colleagues have also contributed to some chapters, namely with provision of some modeling examples, as indicated in the corresponding sections.

We would like to also thank those colleagues who acted as referees reviewing earlier versions of this manuscript and making valuable contribution to its improvement.

Finally we expect this work to effectively contribute to the establishment of comprehensive reference models for Collaborative Networks, and thus to offer a basis for researchers and practitioners interested in the field.

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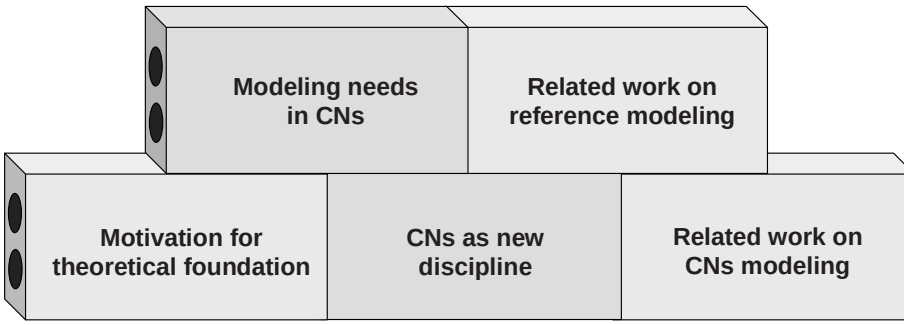
PART 1

INTRODUCTION

1.1 Overview



The area of collaborative networks is already extended over two decades of research and development since the first results on virtual enterprises were published. A large number of research projects and pilot applications contributed to the worldwide establishment of the area since then, generating a vast amount of concepts, mechanisms, models, systems, approaches, etc. In order to facilitate its smooth progress, it is necessary to invest on a theoretical foundation that gives a solid basis for further developments.

The motivation for this foundation and the need for recognition of collaborative networks as a new discipline are introduced in this section.

Main modeling needs and an overview of related work on modeling CNs are also discussed, giving the baseline for the technical propositions appearing in the following sections of the book.

1.2
Motivation for a theoretical foundation for collaborative networks

A growing number of collaborative networks can be observed in many domain areas. However, the developments and even the understanding of these cases have suffered from ad-hoc approaches, being urgent to establish a proper theoretical foundation for the area. Furthermore, the fast developments in the area and the nature of the paradigm configure the emergence of a new discipline, which needs to be built on a sounder theoretical basis.

1. INTRODUCTION

The rapid progress on computer networks and pervasive computing has offered the base conditions for the establishment of a networked society where new forms of collaboration are being explored. In fact a large variety of collaborative networks have emerged during the last years as a result of the challenges faced by the business, social, and scientific worlds and enabled by the fast progress in the information and communication technologies. Advanced and highly integrated supply chains, virtual enterprises / virtual organizations, virtual (professional) communities, virtual laboratories / e-science, are illustrations of a major trend in which entities seek complementarities and join efforts that allow them to better participate in challenging and competitive opportunities (Fig. 1) (Camarinha-Matos, Afsarmanesh, 2007). In particular for industrial societies composed mostly of small and medium enterprises (SMEs), as is the European case, the involvement in a collaborative network represents not only a survival factor but also a competitive advantage in face of turbulent market scenarios. Market turbulence in this context is characterized by complexity as well as the speed of change in interactions and inter-dependencies in the socio-economic environment.

In addition to industry, many similar cases can be found in other domains, namely in the service sector. For instance, the concepts of virtual organization and virtual community are entering the elderly care sector (Camarinha-Matos, Afsarmanesh, 2004b) as a way to facilitate a smooth interaction and collaboration among all actors involved in an integrated elderly personal wellness system. The logistics and transportation sector is another example where new synergies are being created through collaborative processes among a diversity of actors (Osorio et al., 2005).

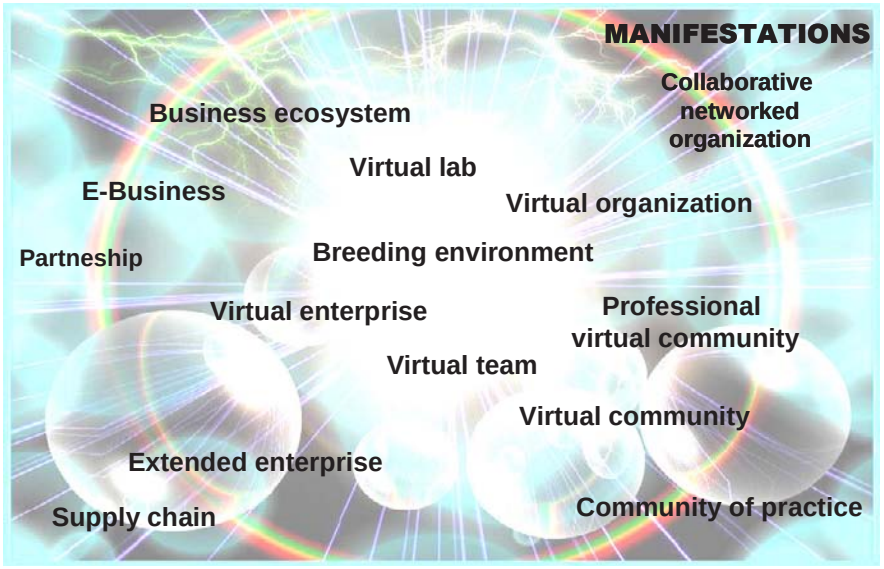


Figure 1 – Some "manifestations" of collaborative networks

A large number of research projects have been carried out worldwide in the last decades and a growing number of practical implementations showing different forms of collaborative networks are being reported. This trend has so far led to an extensive amount of empirical base knowledge that now needs to be organized and leveraged.

The initial investments on Virtual Organizations led, in most cases, to highly fragmented and case-based approaches. For many years, one of the main weaknesses in the area has been the lack of appropriate theories, consistent paradigms definition, and adoption of formal modeling tools. Often the project of a new case of collaborative network is conducted from scratch, without benefiting from previous experiences because knowledge from past cases is not properly organized and made widely accessible. Dramatically enough, there is not yet a common definition of basic concepts such as virtual organization, collaborative networks, or virtual enterprise. This situation constitutes a major obstacle for interaction among experts from multiple disciplines, involved in this area, and creates an obstacle for the recognition of collaborative networks as a new scientific paradigm. Based on the acquired experiences, it is now urgent to consolidate and synthesize the existing knowledge, setting a sounder basis for the future.

As in any other scientific discipline or engineering branch, collaborative networks (CNs) require the development of formal theories and models, not only as a help to better understand the area, but also as the basis for the development of methods and tools for better decision-making. In fact decision-making in all phases of the future CNs life cycle needs to be based on well argued and verified models and methodologies. These models and methodologies constitute the basis for the ICT-based support for business and organizational development and operation, as well as the base for education, training, and effective management and operation of CNs.

After an initial phase in which, mostly biased by traditional business practices, the very first infrastructures and pilot cases were developed, there is at present a vital need to focus more on fundamental research in order to understand both the architectures and the emerging behavior as well as to support the design of new collaborative organizational forms. The establishment of a theoretical foundation for collaborative networks needs to proceed in two directions:

1 - Consolidation / structuring of the large body of existing empirical knowledge.
2 - Adoption / extension of theories and modeling tools developed elsewhere, in order to understand and explore emerging forms of collaborative networks and their behavioral patterns.

Existing knowledge on diverse manifestations of "traditional" collaborative networks is in fact quite fragmented, being urgent to proceed with an integration and formalization effort. Nevertheless, purely formal methods in addition to being hard to apply are also difficult to follow by those not familiar with such methods. This might suggest, in some cases, the appropriateness of semi-formal methods.

On the other hand, new forms of collaborative networks and new patterns of behavior are being invented and explored. As illustrated in Fig. 2, it is typical that emerging CNs are first perceived and explained through informal descriptions. Only when more cases become available and sufficient experience is accumulated an effort to consolidate the acquired knowledge through formal modeling methods starts.

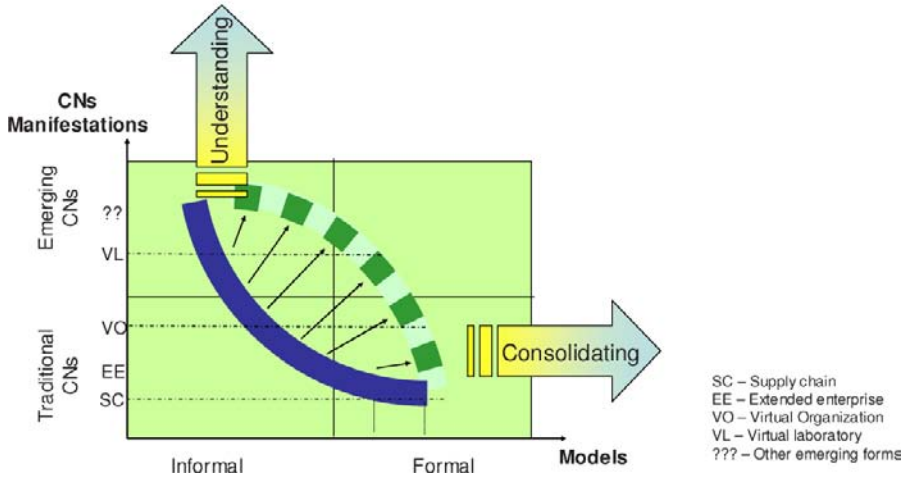


Figure 2 – Evolution of modeling approaches

Furthermore, new CN forms correspond to complex phenomena that require new ways of analysis and proper modeling tools. These phenomena show characteristics such as complexity, emergence[1], self-organization, dynamics, interaction of social

[1] A property studied in the Theories of Complexity

networks with organization networks, etc. As new collaboration-support infrastructures and tools become available, new behavioral patterns emerge, even in traditional collaborative networked organizations. In this context, new ways of collaboration, new forms of organizing the collaborative networks, even new institutions, and new roles for participants are being rapidly developed while not being yet well understood. Therefore, a theoretical foundation is necessary, not only to consolidate the existing empirical knowledge, but also as a basis for perceiving and understanding emerging collaborative forms.

In order to establish a theoretical foundation for CNs inspiration and help can be sought in other areas. Some theories and paradigms defined elsewhere (see part 3 of this book) have been suggested by several research groups as promising tools to help understand and characterize emerging collaborative organizational forms. Nevertheless, it is unlikely that any of these theories and modeling methods will cover all modeling needs of CNs; they can be used as a starting point but extensions or adaptations are needed. In fact, there is no single (formal) modeling tool / approach that adequately covers all perspectives – i.e. no "universal language" for all modeling problems in this area. For instance, typical works on networking and social networks consider, for sake of simplicity, just one kind of links among network members, while practical methods for CNs need to consider a diversity of link types (and different strengths for each link). Furthermore, interoperability of different modeling tools and approaches is needed for a comprehensive definition and modeling of this paradigm.

2. TOWARDS A NEW DISCIPLINE

CNs are complex systems and consist of many facets whose proper understanding requires the contribution from multiple disciplines. In fact the various manifestations of this paradigm have been studied by different branches of science, including the computer science, computer engineering, management, economy, sociology, industrial engineering, law, etc., to name a few. The 1990s and early 2000s correspond to the stage that Kuhn would call a pre-paradigmatic phase (Kuhn, 1975), in which the collaborative networks phenomenon has been described and interpreted in many different ways, depending on the background of the researcher.

The acceptance of a new paradigm is not a pacific process (Kuhn, 1975), as the established sciences and paradigms tend to resist the introduction of another "competitor", and rather prefer to extend the existing sciences or fields and their associated rules to explain the new phenomena. For instance, virtual enterprises have been studied, in a quasi independent way, by the engineering and management communities with almost no mutual recognition. This tension situation is further increased by the multi-disciplinary nature of the phenomena, namely in the case where multiple traditional disciplines / branches of organized knowledge and professionals compete to claim and master the new area. This is the clear case we have observed for collaborative networks.

As a good example of this strained behavior, so far several of the established branches of science have tried to use / extend their definition and behavioral model of the single enterprise paradigm to explain the collaborative networks; e.g. the attempts in the direction of "enterprise engineering" and "enterprise architecture",

among others. Considering a virtual enterprise as just another form of an enterprise naturally leads to consider that extending the existing models of a single enterprise would be a promising approach. However, *anomalies* appear when the existing enterprise-centric models and their extensions fall short of capturing the key facets and specificities intrinsic in networked organizations, as well as when realizing that the base facilities of the applied discipline are not sufficient to properly represent and model all aspects of the behavior of collaborative networks. Instead of focusing on the internal specificities and tight interconnections among the internal components of an enterprise, *the focus* in collaborative networks must be directed to the external interactions among autonomous (and heterogeneous) entities (e.g. interoperability mechanisms and tools), the roles of those entities (e.g. coordinator, member, cluster-manager, broker), the main components that define the proper interaction among entities (e.g. common ontologies, contracts, distributed business processes, distributed multi-tasking, collaborative language), the value systems that regulate the evolution of the collaborative association (e.g. collaborative performance records), and the emerging collective behavior (e.g. trust, teamwork), among others.

In the history of science, the recognition and acknowledgement of *anomalies* has resulted in "crises", that are the necessary preconditions for the emergence of novel theories and for a paradigm change or even the rise of a new discipline. As in other past paradigm changes, considerable research efforts have been focused on identification of "anomaly" aspects for CNs, i.e. the identification of what is new in the collaborative networks in reference to the established body of knowledge, that has itself lead to the induction and progressive characterization of a new scientific paradigm. CNs cannot be seen as proprietary to any one of the single contributing disciplines, rather representing a new emerging discipline of its own (Camarinha-Matos, Afsarmanesh, 2005). A **new discipline** emerges once: (i) the new paradigm is adjusted to cover the various manifestations of the emerging collaborative forms, (ii) the consolidated set of basic knowledge is organized, and (iii) the various multi-disciplinary researchers involved in this work start to identify themselves as members of this new community, rather than experts doing research on collaborative networks while staying as members of their original communities and disciplines. Fig. 3 illustrates the foundation for the CNs discipline.

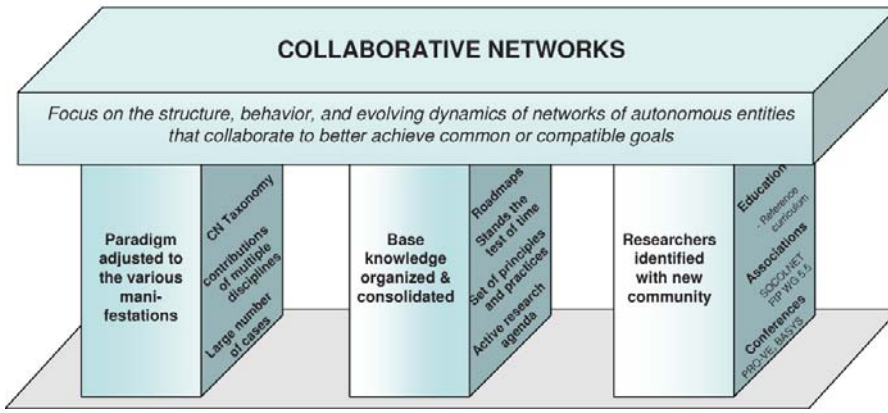


Figure 3 – The foundation of a new discipline

Adjustment to manifestations.
An ordered set of principles and practices form the foundation of a discipline (Liles et al., 1995). In the case of Collaborative Networks and their manifestations, a large number of R&D projects and practical implementations have been developed during last years. Particularly in Europe, more than 100 projects have been supported by the European Commission, in addition to various national initiatives. However, each one of these efforts has only addressed particular facets of the CNs, leading to some fragmentation of research. Furthermore most of the early initiatives were of an ad-hoc nature, not relying on sound theories and principles. In spite of this ad-hoc and fragmented research situation, a growing set of principles and practices has been collected in many projects and pilot applications. In this way, the paradigm is progressively better characterized.

At present, the main phases of the life cycle of a CN are intuitively understood and the primary required support functionalities have been identified. It is also nowadays a widely accepted principle that the effective establishment of dynamic VOs requires an underlying breeding environment (or cluster network). A variety of such breeding environments or clusters can already be identified for instance in Europe (Plüss, Huber, 2005), Japan (Kaihara, 2004), Brazil (Vargas, Wolf, 2006), and Mexico (Flores, Molina, 2000). CNs is therefore seen as the paradigm that gives the base framework for all such manifestations.

On the other hand, disciplines, like the proposed one, are frequently based upon other disciplines that can be called the reference disciplines or adjacent disciplines (Liles et al., 1995). Developments in CNs have benefited from contributions of multiple disciplines, namely computer science, computer engineering, communications and networking, management, economy, social sciences, law and ethics, etc. Furthermore some, theories and paradigms defined elsewhere have been suggested by several research groups as promising tools to help define and characterize emerging collaborative organizational forms.

Base knowledge organized and consolidated.
A scientific discipline for Collaborative Networks is characterized by the existence of an active research agenda where many fundamental questions are being tackled and studied. In principle, the existence of an active research agenda is revealed if the following three main characteristics exist (Liles et al. 1995): (1) It stands the test of time, (2) It is complex and substantial enough to be subdivided into different research directions, and (3) Multiple fundamental questions / approaches are raised and formulated to guide the research in the area. In the case of collaborative networks the following situation holds:

1. *It stands the test of time.* CNs represent an active research area for more than 15 years. During this time a growing number of research projects have been launched world-wide and many pilot application cases are being developed in different regions for a variety of application domains. Definition of challenges and the research questions are becoming more precise and detailed, and their dimension more evident as the knowledge about the area accumulates. The application domains are also growing. In addition to industry, forms of collaborative networks can now be found in services, governmental

organizations, elderly care, energy management, etc. It is therefore becoming clear that this is not a temporary *fashion* but rather a major area of research that continuously grows.

2. *It is complex, and substantial enough to be subdivided into different research directions.* CNs represent a vast area of research that requires a subdivision into a number of research areas in order to be studied and handled. This subdivision can be based for instance, on the type of manifestation (VE/VO, Professional Virtual Communities, Collaborative Virtual Laboratories, etc), or on different technical perspectives (e.g. socio-economic focus, management focus, ICT infrastructure focus, ICT support services focus, theoretical foundation focus).
3. *Multiple fundamental questions/approaches are raised and formulated to guide the research in the area.* A large and growing number of open issues and research challenges are being identified in the various manifestations of the CNs and their focus areas. These questions are illustrated by a number of research roadmaps related to collaborative networks, that are elaborated, namely in Europe (Camarinha-Matos, Afsarmanesh, 2004a).

An example of a comprehensive research agenda for CNs is given by the VOmap roadmap for advanced virtual organizations (Camarinha-Matos, Afsarmanesh, 2003), (Camarinha-Matos et al, 2005). VOmap aimed at identifying and characterizing the key research challenges needed to fulfill the vision, required constituency, and the implementation model for a comprehensive European initiative on dynamic collaborative virtual organizations (VO). The VOmap vision is that of an effective transformation of the landscape of European industry into a society of collaborative relationships. In order to be efficient and competitive in their operation, VOs of the future have to rely on solid bases and strong methodological approaches. This roadmap, which includes contributions from about 100 experts from industry and academy, identifies a large number of the main challenges for research and development in this area, and suggests a time frame for the proposed research actions.

Other roadmaps have also been proposed, addressing some of the related research challenges to collaborative networks. For instance, the COCONET roadmap (Schaffers et al., 2003) is focused on virtual communities and their cooperation environments, the IDEAS roadmap (Chen, Doumeingts, 2003) addresses needs for supporting interoperability of ICT infrastructures, the Semantic Grid roadmap (Roure et al., 2001) focuses on e-Science and GRID infrastructure needs, and the Assembly-net roadmap (Onori et al., 2003) discusses research challenges in advanced collaborative manufacturing systems.

A new research community.

Community development through education and professional associativism is essential to the widespread recognition of a discipline. Several activities that have taken place during last years have contributed to the establishment of a significant community of professionals involved in collaborative networks. Examples are:

- *Education activities*. Some universities already offer courses on virtual organizations / virtual enterprises (Klen et al., 2005). For instance, the New University of Lisbon (Portugal) offers a 1-semester course on Virtual Enterprises to the 5th year students of Electrical and Computer Engineering since 2002

(Camarinha-Matos, Cardoso, 2004). Similarly the Federal University of Santa Catarina (Brazil) and the Costa Rican Institute of Technology (Garita, 2004) started offering VE/VO courses to their students. Other universities are designing similar courses or including CN-related modules in their existing curricula (Klen et al., 2005). Other similar example courses are being developed in Europe at the Master program level. A proposal for a reference curriculum for CN education at the university level was developed by the ECOLEAD project (Camarinha-Matos et al., 2008).

- *Scientific associations*. Scientific associations play an important role as facilitators and promoters of collaboration among professionals involved in a specific discipline. Some initiatives in this area have been launched in recent years. For instance, at IFIP (International Federation for Information Processing) level, a Working Group on Infrastructures for Virtual Enterprises and e-Business (COVE - CO-operation infrastructure for Virtual Enterprises and electronic business) was established under its Technical Committee 5. The SOCOLNET Society of Collaborative Networks started in 2006 and aims at promoting and stimulating the scientific research, teaching, technological development, technical and scientific interchange between researchers in the Collaborative Networks area, including virtual organizations, virtual enterprises, virtual laboratories and related areas. Another example is the ESoCEnet (European Society of Concurrent Enterprising Network) established in Italy.
- *Conferences*. Professional and scientific conferences provide a forum to discuss current thoughts and experiences, as well as a channel to publish emerging ideas. The IFIP/SOCOLNET Working Conference series PRO-VE [www.pro-ve.org], the first yearly conference focused on Virtual Enterprises started in 1999, and since then has established itself as the reference conference and most focused scientific event on collaborative networks, attracting a good number of professionals from academia and industry. CTS is an American annual conference devoted to Collaborative Technologies and Systems. BASYS is an IFIP conference series focused on Information Technology for Balanced Automation Systems that devotes a track to collaborative networks. Another related event, more focused on the Concurrent / Collaborative Engineering aspects is the ICE conference.

These elements are evidence of the establishment of Collaborative Networks as a new discipline. As such, CN require a sound theoretical basis to support its continued development.

3. CONCLUSIONS

The large diversity of existing and emerging collaborative forms and related experiences and empirical knowledge require a consolidation effort in order to:

- better understand the paradigm and its manifestations, and
- facilitate new developments.

A theoretical foundation supported by adequate modeling tools is also important to help understanding the new collaboration forms and thus support a more rational design, analysis and management.

Furthermore, as the CNs phenomenon is not "property" of any single established discipline, it clearly requires a multi-disciplinary approach. Progressively, the area of CNs has been turning itself into a distinct discipline. Further developments of the discipline require a sounder holistic modeling effort.

The following chapters of this book represent a contribution to this modeling effort. Complementarily, in (Camarinha-Matos et al., 2008) a comprehensive collection of methods and tools for collaborative networks also developed in the ECOLEAD project are presented.

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4. REFERENCES

1. Camarinha-Matos, L.M.; Afsarmanesh, H. (2003). A roadmap for strategic research on virtual organizations. In *Processes and Foundations for Virtual Organizations*, Kluwer Academic Publishers, Boston.
2. Camarinha-Matos, L.M.; Afsarmanesh, H. (Ed.s) (2004a). *Collaborative networked organizations – A research agenda for emerging business models*, Kluwer Academic Publishers, Boston.
3. Camarinha-Matos, L.M.; Afsarmanesh, H. (2004b). TeleCARE: Collaborative virtual elderly care support communities, *The Journal on Information Technology in Healthcare*, Vol. 2, Issue 2, pp 73-86, ISSN 1479-649X, London, Apr 2004.
4. Camarinha-Matos, L.M.; Afsarmanesh, H. (2005). Collaborative networks: A new scientific discipline, *J. Intelligent Manufacturing*, vol. 16, N° 4-5, pp439-452.
5. Camarinha-Matos, L.M.; Afsarmanesh, H. (2007). Classes of Collaborative Networks. In Encyclopedia of Networked and Virtual Organizations (G. Putnik, M. M. Cunha, Ed.s), Idea Group, Dec 2007.
6. Camarinha-Matos, L.M.; Afsarmanesh, H., Cardoso, T., Klen, E. (2008). A reference curriculum for education in CNOs. In *Methods and Tools for Collaborative Networked Organizations*, Springer, 2008.
7. Camarinha-Matos, L.M.; Afsarmanesh, H., Ollus, M., (Ed.s)(2008). Methods and tools for collaborative networked organizations. Springer.
8. Camarinha-Matos, L.M.; Cardoso, T. (2004). Education on Virtual Organizations: An experience at UNL. In *Virtual Enterprises and Collaborative Networks*, Kluwer Academic Publishers, Boston.
9. Chen, D.; Doumeingts, G. (2003). Basic Concepts and Approaches to develop interoperability of enterprise applications. In *Processes and Foundations For Virtual Organisations*, Kluwer Academic Publishers, Boston.
10. Flores M., Molina A., "Virtual Industry Clusters: Foundation to create Virtual Enterprises", in *Advanced in Networked Enterprises - Virtual Organizations, Balanced Automation and Systems Integration*, L.M. Camarinha-Matos, H. Afsarmanesh, Heinz-H. Erbe (Eds.), Kluwer Academic Publishers, 2000, pp. 111-120.
11. Garita, C. (2004). A case study of VO education in Costa Rica. In *Virtual Enterprises and Collaborative Networks*, Kluwer Academic Publishers, Boston.
12. Kaihara, T. (2004). A challenge towards the Japanese industry: Industrial cluster. In Collaborative Networked organizations – A research agenda for new business models, Springer 2004.

13. Klen, E., Cardoso, T., Camarinha-Matos, L. M. (2005). Teaching Initiatives on Collaborative Networked Organizations, in *Proceedings of 38th CIRP - International Seminar on Manufacturing Systems*, May 16-18, Florianópolis-SC, Brazil.
14. Kuhn, T. S. (1975). *The structure of scientific revolutions*. Univ. of Chicago Press, 2nd edition.
15. Liles, D.; Johnson, M.; Meade, L.; Underdown, D. (1995). Enterprise Engineering: A discipline?, Society for Enterprise Engineering (SEE) Conference, Orlando, FL, http://www.webs.twsu.edu/enteng/ENTENG1.html.
16. Onori, M.; Barata Oliveira, J.; Lastra, J.; Tichem, M. (2003). European Precision Assembly – Roadmap 2010, Assembly-Net, ISBN 91-7283-637-7.
17. Osorio, A.L., Camarinha-Matos, L.M., Gomes, J.S. (2005) – A collaborative network case study: The extended "Via Verde" toll payment system. In Collaborative Networks and their Breeding Environments, Springer.
18. Plüss, A., Huber, C. (2005). "VirutelleFabrik.ch – A Source Network for VE in Mechatronics. In *Virtual Organizations Systems and Practices.* Edited by L.M. Camarinha-Matos, H. Afsarmanesh and M. Ollus. Springer, pp. 255 – 264.
19. Roure, D.; Jennings, N.; Shadbolt, N. (2001). Research Agenda for the Semantic Grid: A future e-Science infrastructure, EPSRC/DTI Core e-Science Programme.
20. Schaffers, H.; Ribak, A.; Tschammer, V. (2003). COCONET: A roadmap for context-aware cooperation environments. In *Processes and Foundations for Virtual Organizations*, Kluwer Academic Publishers, Boston.
21. Vargas, R., Wolf, P. (2006). "Virtual Collaboration in the Brazilian Mould and Die Making Industry" in *Real-Life Knowledge Management: Lessons from the Field*, KnowledgeBoard. Abdul Samad Kazi & Patricia Wolf (Eds.), ISBN: 9525004724. April 2006, pp. 323 – 333.

1.3 Related work on reference modeling for collaborative networks*

Several international research and development initiatives have led to development of models for organizations and organization interactions. These models and their approaches constitute a background for development of reference models for collaborative networks. A brief survey of work on modeling the enterprises, enterprise architectures, and early contributions to reference models of virtual enterprises is provided. Finally an identification of the main modeling requirements for collaborative networks is made.

1. INTRODUCTION

Some authors see the roots of the Virtual Organization / Virtual Enterprise paradigm, which constitutes one of the first manifestations of the Collaborative Networks, in the early works of economists such as Oliver Williamson in the 1970s. Along his very prolific work, and in particular in the "Markets and Hierarchies" (Williamson, 1975), Williamson established the study of Transaction Cost Economics as one of the first and most influential attempts to develop an economic theory of organizations. He defends that manufacturing firms should make much greater use of externally purchased goods and services, rather than those internally supplied. Williamson also discusses the business transaction costs at the same level as the production costs. While production costs are considered as being analogous to the costs of building and running an "ideal" machine, transaction costs cover those that incur by deviation from perfection. For instance, he argues that the lack of information about the alternative suppliers might lead to paying too high a price for a good or service. Through identifying the important variables that determine the transaction costs, the work of Williamson contributed to the better understanding of business interactions among enterprises.

These ideas had a more evident impact with the booming of the "outsourcing" wave in the 1980s. Outsourcing became very attractive when managers had to reduce the organization overheads and eliminate the internal inefficient services, the so called lean manufacturing, as it transfers the problem to the outside, namely other efficient service providers. For many enterprises, outsourcing some services allows them to concentrate on their core competencies. For others, outside contractors simply provide complementary services for which the company lacks adequate internal resources or skills. In the same line but with a focus on the management

* *By H. Afsarmanesh, L. M. Camarinha-Matos*