

COLLABORATIVE NETWORK STUDY, FUNDAMENTALS, APPLICATIONS AND DISCIPLINE FORMATION: AN EXPERIENCE AT CEFET/RJ

Antonio José Caulliraux Pithon, caulliraux@gmail.com

Marina Rodrigues Brochado, marinabrochado@gmail.com

Federal Center of Technological Education – CEFET/RJ, Av. Maracanã 229 bloco E sala E506

Abstract. Collaborative networks composed by organizations and/or people can nowadays be found in a wide variety of forms, including virtual organizations, virtual enterprise, extended enterprises, dynamic supply chains, social network, etc. A large body of empiric knowledge related to collaborative networks is already available, but there is an urgent need to consolidate this knowledge and build the foundations for a more sustainable development of this area. The establishment of a scientific discipline for collaborative networks is a strong instrument for achieving this purpose. In this context, the article presents the experience developed by the Federal Center of Technological Education – CEFET/RJ Brazil that began, in the first semester of 2007, a pilot course on Collaborative Network for students in Master Program in Technology.

Keywords: collaborative network, social network.

1. INTRODUCTION

The “term” network is nowadays a central issue in many fields, such as social sciences, communications, physics, computer science, virtual organization, virtual enterprise, etc. Among various types of network, collaborative networks have special relevance. A collaborative network (CN) is constituted by a variety of entities (e.g., organizations and people) that are largely autonomous in terms of operating environment, culture, social capital and goals. Nevertheless, these entities collaborate to achieve better objectives and goals, and those interactions are supported by computer networks (Camarinha-Matos and Afsarmanesh, 2005).

The implementation of collaborative process has recently accelerated throughout the years as a consequence of the new challenges posed to companies and organizations by the fast-changing socio-economical conditions, as well as new developments in ICT sector.

In fact, during the last three decades, information and communication technologies have been playing an improving role in organizations, namely as an instrument to support integration and flexibility. As a result of these developments, a new scientific discipline emerged or consolidated, as in the case of collaborative Network (Camarinha-Matos et al., 2004).

Nowadays, several courses in the Collaborative Network area are already being taken or organized at different universities worldwide. For instance, the University of Lisbon (Portugal) offers a 1-semester course on Virtual enterprise to 5th year students of electrical and Computer engineering since 2002 (Garita, 2004).

Similarly, the Federal University of Santa Catarina (Brazil) offers course of Automation and Systems Engineering and the Costa Rica Institute of technology [4] started offering Virtual Organization courses to their students, as well as, on February 2007, Federal Center of Technological Education – CEFET/RJ in Brazil, started a pilot course.

In the context, the objective of this paper is to describe the experience with a pilot initiative of teaching a complete course on Collaborative Network (EDA 3022) at the Federal Center of Technological Education – CEFET/RJ in the Master Technological program in first trimester of 2007 academic year.

The proposal of this course is presented later on.

2. COLLABORATIVE NETWORK

The word “net” is very old and it comes from the latin “retis”, meaning *interlacement of threads with regular openings that form a type of cloth*. Starting from the interlacement notion, mesh and reticular structures, the word net gained new meanings with time, thus being used in different situations.

From defined concept to (Cândido, et al., 2000.), “nets are organizational systems capable to gather individuals and institutions, by democratic form and share, around similar causes. Having flexible structures and established horizon, its work dynamics has supposedly a collaborative performance and is sustained by the will and likeness of their members, being characterized as a significant organizational resource for the social structuring”.

In agreement, enterprise networks are formed initially with the objective of reducing uncertainties and risks and organizing economical activities, starting from the coordination and cooperation among companies.

Most of the authors study the nets’ perspective and its use as a way to study organizations, referring to the organizations as social nets, and they must be analyzed as such. A social net must contain a group of people, organizations, etc., linked through a social relationships’ group of a specific type. In this perspective, the structure of

any organization should be understood and analyzed in terms of multiple nets of internal and external relationships. In that sense, the organizations are nets and the organizational form depends on the characteristics, interests and needs of participant companies.

In order to properly understand and model collaborative works, it is necessary to first focus on the very notion of collaboration (Camarinha-Matos and Afsarmanesh, 2006, 2007). Although everybody has an intuitive notion of what collaboration is, this concept is often confused with cooperation. For many people, the two terms are indistinguishable. Even when a distinction is made, there are many different uses to term *collaboration* in current literature.

The ambiguities reach a higher level when other related terms are considered such as networking, communication, and coordination (Himmelman, 2001), (Pollard, 2005), (Denise, 1999). Although each one of these concepts is an important component of collaboration, they are neither of equal values nor equivalent.

In an attempt to clarify the various concepts, the following working definitions can be proposed:

Networking: involves communication and information exchange for mutual benefit. It shall be noted that this term is used in multiple contexts and often has different meanings. For instance, when people refer to “enterprise network” or “enterprise networking” the intended meaning is probably “collaborative network of enterprises”.

Coordinated Networking: in addition to communication and exchanging information, it involves aligning/altering activities, so more efficient results are achieved. Coordination, that is, the act of working together harmoniously, is one of the main components of collaboration.

Cooperation: involves not only information exchange and adjustments of activities, but also sharing resources for achieving compatible goals. Cooperation is achieved by division of some labour (not extensive) among participants.

Collaboration: a process in which entities share information, resources and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal. This concept is derived from the Latin *collaborare* meaning “to work together” and can be seen as a process of sharing creation; thus a process through which a group of entities enhance the capabilities of each other. It implies sharing risk, resources, responsibilities, and rewards, which if desired by group can also give to an outside observer the image of a joint identity. Collaboration involves mutual engagement of participants to solve a problem together, which implies mutual trust and thus takes time, effort, and dedication.

As presented in the given definitions and depicted in Figure 1, each of above concepts constitutes a “building block” for the next definition. In other works, coordination extends networking; cooperation extends coordination; and collaboration extends cooperation.

Table 1 – Notion of Collaboration (Camarinha-Matos, L. M. & Afsarmanesh, H., 2008)

Integration level					
Complete integration					Joint goals Joint identities Joint responsibility Working together (creating together)
High adjustment/alignment			Complementarity of goals Individual entities working apart (with some coordination)		Complementarities of goals Individual entities working apart
low adjustment/alignment		Complementarity of goals Aligning activities for mutual benefit	Complementarity of Goals Aligning activities		Complementarity of goals Aligning activities
No integration	Communication and information exchange	Communication and Information exchange	Communication and Information exchange	Communication and Information exchange	Communication and Information exchange
		Network	Coordinated Network	Cooperative Network	Collaborative Network
		Coalition's type			

The organizational nets can be considered as a consequence of concepts and beginnings of social nets and they can be divided in intra and inter-organization.

We started to detail the several types of formations of nets below:

- **Social Network:** focus on relationship among social entities, is used widely in the social and behavioural sciences, as well as in economics, marketing, and industrial engineering;
- **Virtual Organization:** comprising a set of (legally) independent organizations that share resources and skills to achieve its mission/goal, but that is not limited to an alliance of for profit enterprises. A Virtual Enterprise is therefore, a particular case of Virtual Organization;
- **Virtual Enterprise:** a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks;
- **Extended Enterprise:** a concept typically applied to an organization in which a dominant enterprise “extended” its boundaries to all or some of its suppliers. An Extended Enterprise can be seen as a particular case of Virtual enterprise;
- **Agile Enterprise:** is the ability of an organization to adapt proficiently in continuously changing, unpredictable business environment;
- **Joint Venture:** is an entity formed between two or more parties to undertake economic activity together. The parties agree to create a new entity by both contributing equity, and they share revenues, expenses, and control of the enterprise;
- **Cluster:** geographical concentrations of acting interlinked enterprises as a same section of specialized suppliers, providers’ services and associated institutions, having in common, besides its location, the contribution for developing regional products. They are oriented by beginnings as cooperation, complementarities, community’s sense and competition.

In that sense, Collaborative Network course is being implanted, trying to give an approach of concepts mentioned above.

3. DISCIPLINE STRUCTURE

Collaborative network was included in 2007 as an optical discipline in the Master Technological Program at CEFET/RJ and it is a part of the curricular structure and the academic regime. These structure curricula are divided in a cast of obligatory and elective disciplines.

The distribution of those disciplines in the curriculum of the course can be seen in Table 2.

Table 2 – Distribution of disciplines in Master’s degree course

Obligatory Disciplines		
Code	Denomination	Credit
MAD 3007	Statistical Methods I	3
EDA 3024	Organization	3
EDA 3025	Technology	3
EDA 3300	Seminar for Master dissertation	0
EDA 3301	Research for Master dissertation	0
Elective Disciplines		
EDA 3029	Integrated Analysis of Life Cycle	3
EDA 3302	Study Activity Integrated	0
EDA 3033	Evaluation Projects	3
EDA 3030	Evaluation Technological Projects	3
EDA 3012	Systems Reliability	3
EDA 3013	Structural Reliability	3
EDA 3014	Human Reliability	3
EDA 3022	Corporate Finances	3
EDA 3021	Integration of Administration Systems	3
EDA 3008	Intelligence Computational	3
EDA 3010	Statistical Methods II	3
EDA 3011	Statistical Methods III	3
EDA 3026	Modelling of Phenomena	3
EDA 3022	Collaborative Network	3

The minimum duration for accomplishment of the course is 18 (eighteen) months and the maximum is 24 (twenty for) months. The course is divided in 3 (three) main steps, for instance: obtaining the credits, development of research and defence of the dissertation.

During a period of 12 weeks, each week includes 4h of theory, whose lectures comprise a presentation of main concepts, state of the art and supporting technologies, and discussion of major trends and challenges. Although being an optional discipline, this attracted 10 students in summer 2007, which is a significant number considering that was the first time that discipline was offered.

Offering this discipline, the Master's degree in Technology of CEFET/RJ answers directly to the student's longings, i.e., offers possibility the same ones know and learn on the emerging organizational concepts that will face in his professional life. The next sections describe in general terms the structure of Collaborative network discipline.

4. STRUCTURE

The specific contents of the course are described bellow. For each subject the main bibliographic references that may be used.

Generally, some adjustments may be done, depending on interest and skills of each student's group.

1. Network
 - a) Introduction and concepts (Yoguel and Hantis, 1990; Noria, 1992; Loiola, 2007).
2. Network Models
 - a) Social network: definitions, application and examples (Yoguel and Hantis, 1990; Burt, 1983; Martelo, 2001);
 - b) Intra-organization Network: definition, application and examples (Grandori and Soda, 1995);
 - c) Inter-organization Network: definition, application and examples (Grandori and Soda, 1995);
 - d) Interpersonal Network: definition, application and examples (Grandori and Soda, 1995);
3. Virtual Organization (Jägers and Jansen, 1998; Camarinha-Matos and Afsarmanesh, 1999);
 - a) Agile Enterprise (Lee, 1998; Pithon, 2004);
 - b) Virtual Enterprise (Camarinha-Matos and Afsarmanesh, 1999; Osório and Barata, 1999; Pithon, 2004);
 - c) Extended Enterprise (Browne, 1995);
 - d) Fractal Enterprise (Rajan, 1996);
 - e) Life cycle (Fuchs, 1999; Zimmermman, 1996);
 - f) Contracts in Virtual Organization (legal form) (Teixeira, 2007);
 - g) Broker in Virtual Enterprise Formation: (Pithon, 2004; Ávila and Putnik, 2002);
 - h) Teams in Virtual Enterprise: (Pithon, 2004).
4. Cooperative Network
 - a) Joint Ventures (Pimenta, 2005);
 - b) Cluster (Porter, 1998);
 - c) Scientific Collaborative Network (Dias dos Santos, 2008).
- 5) Awareness in Network
 - a) Introduction e definitions (Gutwin and Greenberg, 2004).

5. OBJECTIVES

Collaborative network discipline has many objectives as the students are capable of:

- In-depth study of CN paradigm focusing on related information technologies and concrete applications;
- Identify and develop possible subjects for pos-graduation theses/projects;
- Explore the application of CN concepts within a national context;
- Develop in the students basic skills to carry out applied research and publish the corresponding scientific results;
- Aim at the establishment of a research group on CN at the Collaborative Work Nucleus.

6. PRACTICAL ACTIVITIES

The activity developed at classroom is based in games as tool that makes possible business existence simulation in their several activities, from planning to execution. This technique is very used, mainly in the administration courses, masters degree and MBA's and it portrays, in an informal and entertaining way, strategies adopted by managers in the execution of the tasks, mainly those that involves team work, which is the focus of our experiment.

The accomplished experience tried to show the importance of concepts learned at classroom, concerning the structure of a Collaborative Network and all their interfaces concerning the obtainment of results. It fits to detach that the exercise happened in real time and attendance, because it is not a very common occurrence once the nets operate in a virtual way.

The team, composed for team students, a consultant (invited teacher) and the director of enterprise (teacher of the discipline), was under the consultant's orientation, positioned with the hands given in circle form, halfway some of other ones, in the classroom.

The circle disposition is due to the fact that communication must flow in many directions, without being controlled, but administered, that is, without hierarchy relationship. The consultant distributed numbers written in a piece of paper

(from 1 to 10), so that it was put in the ground ahead of the feet of each team member, passing to be this identification numbering of each one. To proceed, the consultant distributed string pieces with approximately 2,5 meters in length, that crossing in diagonal, it tied for the tips each member the other, tends these to tie one of the tips of string in right pulse (Figure 1). In this dispositions and already connected, the consultant explained the game rule that consisted beforehand, in the choice manager on the part of team. Tends the manager been chosen, the consultant request to the same as does the annotations related with what will happen.

At this time, the consultant begins the change of positions of each one in the circle, and in the end of those changes, he grew up a true knot in the string, as seen in the Figure 1. That knots the events that happen the any net type acts, since for beginning, the social nets are not static. The manager's paper was driving the actions that they would be developed by group, in the sense of untying the knot. It was not allowed that in any hypothesis, the string that tied each member of the group was cut and the knot that tied him to the undone pulse. The established time so that the manager drove his task was 5 minutes.

Therefore, in the beginning, it was noticed that manager didn't stop the control task or command of the team, letting his insecurity to appear for the group. With the control loss on the part of manager, the group began showing in a disordered way, random and empiric with objective of undoing knot. Visibly amazed, the team unchained a series of disconnected manifestations that disrupt the search of solution for the problem. The time of five minutes became exhausted and the result was not reached.

Before this problem, the consultant undid the net and it replaced the manager with other group member. Starting from this substitution, the group, through a disassembling process, managed to complete the exercise in the stipulated period of five minutes.

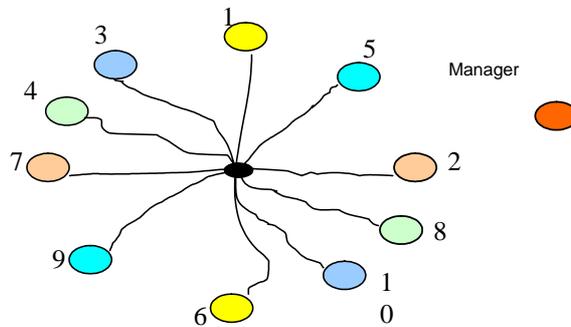


Figure 1 – Teams formation

7. CONCLUSION

Introduction of Collaborative network discipline in master technological Program at CEFET/RJ, although an optional discipline, is being successful and contributing to preparation of a new generation of engineers and research able to play a major role in the deployment of Collaborative Network concept in a brazilian university.

The assertiveness of result this experience is in the number of students that intend to include concepts of collaborative network as theoretical establish (or regarding analysis) in their theme of dissertation research.

As a result, the course is planned to be given again in coming semesters in this program.

Regarding future horizon, the possibility of offering a Virtual Course on Collaborative Network in Spanish (using e-learning techniques) aiming at integration Universities and Institutes of Technology of Latin America and Caribbean countries, can be evaluated.

Finally, it is clear more textbooks in this area are necessary in order to facilitate education tasks.

6. REFERENCES

- Ávila, P., Putnik G., et al., 2002. In: Brokerage function in Agile Virtual Enterprise Integration – A Literature Review. Collaborative Business Ecosystems and Virtual Enterprise. L. M. Camarinha-Matos (Ed.). Kluwer Academic Publisher.
- Burt, R.S., Minor, M.J., 1983. Applied Networks Analysis. Berverly Hills, Sage.
- Browne, J., 1995. The Extended Enterprise – Manufacturing and the Value chain. In: Balanced Automation Systems – Architectures and design Methodologies, H. Afsarmanesh (Ed.).
- Camarinha-Matos, L. M., Cardoso, 2004, T. Education on Virtual Organizations: An experience at UNL, In Virtual Enterprise and Collaborative Networks, Kluwer Academic Publisher, Boston.
- Camarinha-Matos, L. M., Afsarmanesh, 2005, H. Journal of Intelligent Manufacturing, Vol 1, N° 16, pp.439-452.

- Camarinha-Matos, L. M. & Afsarmanesh, H., 2006, A modeling framework for collaborative networked organizations. In L. M. Camarinha-Matos, H. Afsarmanesh, & M. Olus (Eds.): *Network-centric collaboration and Supporting Frameworks*. Boston, USA: Springer.
- Camarinha-Matos, L. M. & Afsarmanesh, H., 2007, Concept of Collaboration. In: Encyclopedia of Networked and Virtual Organizations (Eds.): G. Putnik, M. Cunha. Idea Group.
- Camarinha-Matos, L. M. & Afsarmanesh, H., 2008, Collaborative Network: Reference Modeling, Springer.
- Cândido, G.A., Abreu, A. F., 2000, Os conceitos de redes e as relações inter-organizacionais: um estudo exploratório. In ENANPAD, Florianópolis, Brasil.
- Cheng, K., 2005. E-Manufacturing: Fundamentals and Applications (Ed.) WIT Press London.
- Dias dos Santos, P., 2008. Redes de Colaboração Científica Interdisciplinares: estudo de caso na Rede Brasileira de Universidades Federais. XXXI Congresso Brasileiro de Ciências da Comunicação – Natal.
- Denise, L. collaboration vs. C-Three (Cooperation, Coordination and Communication), 1999. In: *INNOVATING*, 7(3), Spring.
- Fuchs, M., 1999. Design and Implementation of value Systems: The Lifecycle Perspective. Institute for Technology Management, University of St. Gallen, Switzerland.
- Garita, C., 2004, A case study of VO education in Costa Rica, In Virtual enterprise and Collaborative Network, Kluwer Academic Publisher, Boston.
- Grandori, A. & Soda, G., 1995. Inter Firm Networks: Antecedentes, Mechanism and Forms.
- Gutwin, C. Greenberg, S., 2004. The Importance of Awareness for team Cognition in Distributed Collaboration. In: E. Salas and S.M. Fiore (Ed.) Team Cognition: Understanding the factors that drive Process and Performance. Pp. 177-201.
- Himmelman, A. T., 2001, On Coalitions and the Transformation of Power Relations: Collaborative Betterment and Collaborative Empowerment. In American Journal of Community Psychology, 29(2).
- Jägers, H., Jansen, W., 1998. Characteristics of Virtual organization, In: Organization Virtualness, Pascal Sieber and Joachin Griese (Ed.), Simowa Verlag Bern. Pp. 65-76.
- Lee, G.H., 1998. Designs of Components and manufacturing Systems for Agile Manufacturing. International Journal of Production Research. Pp. 1023-1044.
- Leon, M.E., 1998, Uma Análise de Redes de Cooperação das Pequenas e Médias Empresas do Setor de Telecomunicações. Dissertação de Mestrado, Engenharia de Produção da Escola Politécnica da Universidade de São Paulo.
- Lipnak, J., Stamps, J., 2000. Virtual Teams: People Working Across Boundaries with Technology, John Wiley & Sons, Ins.
- Loiola, E. Moura, S., 2007. Análise de Redes: Uma contribuição aos Estudos Organizacionais. In: Fischer, T. (Org). Gestão Contemporânea: cidades estratégicas e organizações locais. Rio de Janeiro, pp. 53-68.
- Martelo, R. M., 2001. Análise das Redes Sociais – aplicação nos estudos de transferência da informação. Revista Ciência e Informação. Vol 30, nº1, pp.71-81.
- Noria, N., 1992. Is a network perspective a useful way of studying organizations? In: Nohria, Nitin & Eccles, Robert G. (ed.) Network and Organizations: structure, form and action. Boston, Massachusetts: Harvard Business School Press, pp. 1-22.
- Osório, L. Barata, M., Gibon, P., 1999. Communication Infrastructures Requirements in a Virtual Enterprise. In: Infrastructure for Virtual Enterprises – Networking Industrial Enterprises, L.M. Camarinha-Matos and H. Afsarmanesh (Ed.). Kluwer Academic. Pp. 65-76.
- Pithon, A.J.C., 2004. Projeto Organizacional para a Engenharia Concorrente no Âmbito das Empresas Virtuais. Ph.D. Thesis, University of Minho, Guimarães, Portugal.
- Porter, M., 1998. Clusters and the new economics of competition. Harvard Business Review.
- Pollard, D., 2005, Will That Be Coordination, Cooperation or Collaboration? Bolg, 25 Mar 2005. <http://blogs.salon.com/0002007/2005/03/25.html#a1090>.
- Rajan, V. N., 1996. An Agent-Based Fractal model of Agile manufacturing Enterprises: Modeling and Decision-Making Issues. Proceedings of the AI and Manufacturing Research Planning Workshop.
- Teixeira, B. M., 2007. Proposta de um Modelo Contratual para as Empresas Virtuais no Âmbito da Legislação Brasileira. M.Sc Thesis, CEFET/RJ, Rio de Janeiro.
- Yoguel, G. & Kantis, H., 1990. Reestructuración Industrial y Eslabonamientos Productivos: El rol de las pequeñas y Medianas Firms Subcontratistas. Buenos Aires, CEPAL.
- Zimmerman, F., 1996. Structural and Managerial Aspects of Virtual Enterprise. University of Bamberg, Business Information Systems.

5. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.