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Emotions-Oriented Monitoring System of Collaborative Networks

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Chapter 1

Introduction

The aim of this chapter is to present the background and motivation for the research work to be developed. The main research questions which will guide this work as well as the corresponding hypothesis are described.

1.1. Background and Motivation

In recent years the emergence of a large variety of collaborative networks has become a reality. This is due to the advent and rapid evolution of information and communication technologies along with the rapidly evolving challenges faced by business entities and the society in general (Camarinha-Matos & Afsarmanesh, 2005).

A collaborative network (CN) is a network consisting of a variety of entities (such as organizations, people, and even intelligent machines) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are supported by computer networks (Camarinha-Matos & Afsarmanesh, 2006).

Through collaboration the involved entities achieve their common goals and increase their own stability and sustainability, within the context of today's global economy, by sharing resources, sharing and exchanging information, reducing risks, costs, time-to-market, and delivery-time, and increasing the market share, asset utilization, skills and knowledge, and customer services (Abreu & Camarinha-Matos, 2008; Bititci, et al., 2007; Camarinha-Matos & Afsarmanesh, 2005, 2006; Parung & Bititci, 2008).

Despite the fact that collaboration has significant benefits especially in creating value and boosting innovation, some empirical studies indicate that although the number of CNs is increasing, 70% fail (Bititci, et al., 2007, p. 456). Conducted research has identified several reasons for this high failure rate namely due to lack of commitment and sharing goals among participants, lack of mutual trust, lack of agreed practices and values, difficulties in participants' relationships, participants' dissatisfaction with the collaboration outcome, or internal conflicts (Bititci, et al., 2007; Camarinha-Matos, Macedo, & Abreu,

2008; Msanjila & Afsarmanesh, 2007c; Parung & Bititci, 2008; Pouly, Monnier, & Bertschi, 2005).

Based on these facts, it becomes necessary to develop/apply new approaches and methods for the next generation of collaboration networks, providing support through better understanding of the nature of the network and inherent tasks and reducing a variety of risks involved in business collaboration among involved participants. This can be achieved not only by resorting to the provision of more advanced ICT functionalities but also taking into consideration other innovative ways for value co-creation within different cultural collaborative networks, including:

- a clear identification of the amount of the "added value" contributed by each partner (Abreu & Camarinha-Matos, 2008; Camarinha-Matos & Afsarmanesh, 2006);
- the collaborative network value system, in order to properly align the partner's value systems (Camarinha-Matos & Macedo, 2010);
- trust building (Msanjila & Afsarmanesh, 2007c);
- the establishment of a system for contract and agreement negotiation as well as systems for incentives and rewards (Oliveira, Camarinha-Matos, & Pouly, 2010);
- the involvement of customers in business processes (Shuman & Twombly, 2008).

Furthermore, the efficiency and effectiveness of the decisions and activities within the network will depend on how good the interaction among partners is.

Emotions constitute a central element for human beings, especially in human interactions. Likewise, they can influence the experience of partners in collaboration environments by increasing the achievement and performance level, motivation, excitement in interaction with each other and the whole perception among individuals. Moreover, emotions can control the motivation for achieving goals as well as improving an individual's problem solving ability (Damasio, 1994). In this way, the study of their functioning is a prerequisite for the understanding of individual and collective behaviors (Frijda, 1986; Johnson-Laird & Oatley, 1992; Mackie, Devos, & Smith, 2000).

In the context of collaborative networks, individual participants experience emotions not only as a result of directly experiencing events (that involve/evoke their own particular emotions) but also through collaborative interactions and by identifying themselves with the network as a whole. As a consequence, and viewing the collaborative network as a living body, it is dependent of the intricate interactions between the various participants, so it develops a (collective) emotion which is influenced by each individual participant's dominant emotions representing, in this way, the emotional state or the emotional climate of the network (Camarinha-Matos, Afsarmanesh, & Ferrada, 2010).

In humans if the emotional system fails the body suffers the consequences. Likewise, if the CN emotional system fails, the CN might not achieve its goals, even if from the socio-organizational competencies point of view it is excellent. In this context, a challenge will be to apprehend the emotional symptoms or emotional signs that may arise during the different types of interactions within partners of a CN (e.g. during negotiations or when some technical details are being planned during a project operation). Furthermore, these

symptoms or signs might help understanding the internal malfunctioning or the potential conflicts associated to the interactions among CN participants.

In this context, the introduction of a proper supervision system to manage and monitor the emotional climate/state – or the "collective virtual emotions" – of collaborative networks with the intention of maintaining the emotional equilibrium of the community, forecasting and attempting to heal potential conflicts among participants and external communities are important elements for the success of the network. As Parung & Bititci (2008) claim, the healthier collaboration will have a longer life than less healthy ones.

Affective computing, also known as emotion-oriented computing, is a relatively young discipline first established in 1997 by Picard and her team at MIT (R. W. Picard, 1997). This discipline is concerned with emotional interactions performed with and through computers as well as mechanisms for better interaction, so it is related to advanced human computer interaction (HCI).

This thesis work will focus on the emotional interactions within the collaborative network rather than in the affective interactions with computers as in the affective computing area. In this way, forms to understand the emotions in groups and in different environments, will also assist in the identification and creation of collaborative network's and participant's emotional models facilitating the formulation of new approaches for conflict resolution as well as the definition of advanced governance strategies that promote emotional health at the network level, and constitute a basis for the design of mechanisms for self-regulation of emotions.

1.2. Research Question and General Approach

As mentioned above, a new challenge emerges when dealing with "collective virtual emotions" within collaborative networks. In addition, several studies reveal that emotions are very often the cause for misunderstandings and conflicts which, in some cases might lead to the failure of collaborative networks. If we take for instance, the business negotiation example where different participants get together to negotiate the business propositions including delicate issues such as the risk sharing or profit distribution, it is likely that some tension and conflicts might arise. If a proper system could monitor the negotiation process, negative emotions found in the negotiation interaction among partners could be perceived and some assistance could be launched for the sake of the business and the network success. In this way, monitoring the interactions within the network might provide multi-modal emotional input (such as specific interfaces or special sensors borrowed from the Human-Computer Interaction research areas) for achieving awareness of each participant itself as well as the collective emotional state.

Having these challenges been taken into consideration, the main research question chosen for this work is the following:

Research Question:

What could be a suitable set of models, methods and tools to promote emotional health in collaborative networks, namely allowing the diagnosis of the networks' emotional state and assisting in conflicts resolution?

The proposed hypothesis to address this research question is:

Hypothesis:

Collaborative networks' emotional health can be identified, modeled and promoted if a combination of contributions from human related sciences such as psychology, physiology and sociology along with human-computer interaction techniques and intelligent supervision systems, is used to develop models and methods which will serve as a basis for the design and development of an emotions-oriented supervision system focused on monitoring the emotional state of the network and providing emotions' self-regulation mechanisms.

An illustration of the contributing research areas mentioned in the hypothesis is presented in Figure 1.

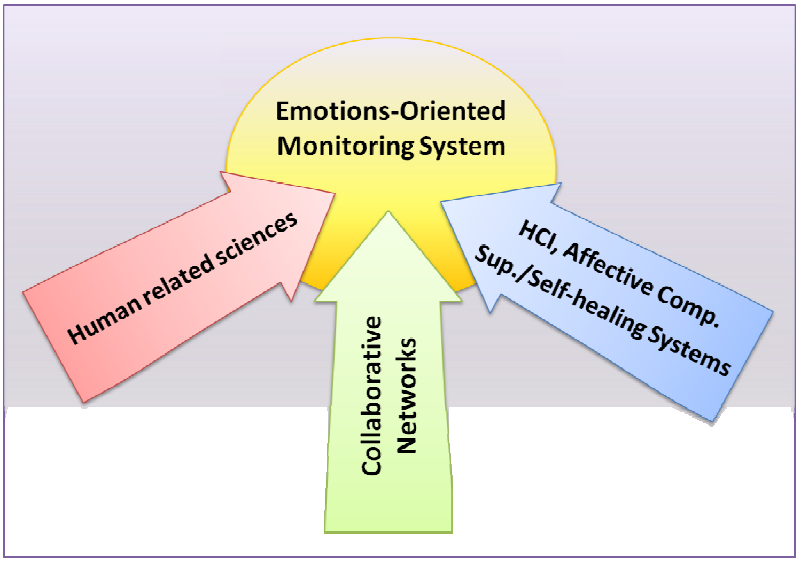

Figure 1 – Emotions-Oriented Monitoring System contributing Research Areas

In addition, three more detailed research questions are proposed with the aim to better understand and solidify the main research question:

Research Question a):

How biological and social interaction emotions can contribute to the design and modeling of emotions in collaborative networks?

Research Question b):

How virtual collective emotions can be perceived and modeled on network interactions?

Research Question c):

How can intelligent supervision mechanisms and methods contribute to the design and development of a suitable emotions-oriented supervision system architecture?

Research Question d):

How can self-healing mechanisms contribute to the emotions' self-regulation process?

In order to find answers to the above mentioned research questions, the following steps should be taken into consideration:

- Identification and characterization of emotions according to disciplinary approaches of biological sciences, psychological sciences, social sciences and computer sciences.
- Clarification of the concepts of emotional healthy collaborative network and virtual collective emotions.
- Building a conceptual framework aimed at developing a working definition of the involved concepts and their relationships.
- Building formal models of emotions and emotional interactions within the context of collaborative networks.
- Elaboration of methods for perceiving and classifying collective emotions.
- Designing and developing methodologies to model an emotions-oriented supervision system including self-regulation of the collaborative network's emotions.
- Developing a software tool to support the emotions-oriented supervision system.
- Propose a validation strategy.

As a result, the main expected outcomes of this thesis include:

- Contribution to a healthier exchange of information and communication among partners, with the introduction of the emotions assessment.
- Avoidance of potential complicated conflicts, that sometimes is difficult to solve, at the partners negotiation and socialization levels.
- A contribution to the conceptual basis of collaborative networks, with the design of emotional models applied to CNs.
- A contribution to the theoretical foundation of collaborative networks in respect to the behavioral dimension, through the development of methods and methodologies to understand emotions.
- Contribution to the collaboration technology, through the development of a health monitoring tool including a set of mediation functionalities.

Chapter 2

Literature Review

Having identified the inherent challenges of this thesis proposal, a new generation of collaboration environments designed to benefit from the emotions assessment requires a combination of multiple contributions from three different areas namely: collaborative networks, emotions and self-healing systems.

The following sections briefly describe each of these contributing areas for this thesis work.

2.1. Collaborative Networks

2.1.1. Introduction

The concept of *Collaborative Network* (CN) has become stronger in recent years within the academic and industrial areas. It constitutes an effort to concretize and modernize the traditional concept of cooperation networks among companies referring essentially to shared work, which implies shared capabilities and resources, and the use of a 'network' to communicate and exchange information.

Although several definitions can be found in the literature (Alves, et al., 2007; Chituc & Azevedo, 2005; Parung & Bititci, 2008), in this research work, the adopted definition is: *"A CN is a network consisting of a variety of entities (e.g. organizations, people, even intelligent machines) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but which decide to collaborate to better achieve common or compatible goals (e.g. problem solving, production, or innovation), and whose interactions are supported by computer networks*" (Camarinha-Matos & Afsarmanesh, 2006).

CNs manifest in a large variety of forms, moving from the classical supply chains format to more dynamic structures that are nowadays emerging in industry, science, and services. Among these CNs, long-term "strategic" alliances and goal-oriented networks

can be distinguishable. *Long-term strategic networks/alliances* are established to act as the *breeding environments for goal oriented networks*, namely with the purpose of getting their participants prepared for participation in response to collaboration opportunities. In other words, they are alliances aimed at offering the conditions and environment to support the rapid and fluid configuration of goal oriented collaboration networks, when opportunities arise. *Goal-oriented networks* are CNs in which intense collaboration, either towards a common goal or a set of compatible goals, is practiced among their partners and for a limited time period (Figure 2).

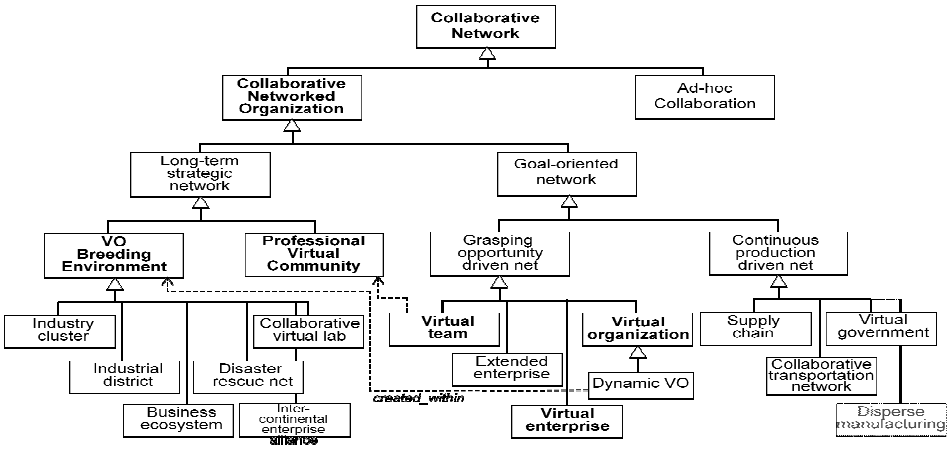

Figure 2 – Collaborative Networks Taxonomy (Camarinha-Matos & Afsarmanesh, 2005; Camarinha-Matos, Afsarmanesh, & Ollus, 2008)

In context of this thesis two specific forms of CNs are addressed, namely the short-term type – Virtual Organizations (VOs) – and the long-term type - Virtual organizations Breeding Environments (VBEs). VOs represent short-term goal-oriented collaborations between partners, while VBEs represent long-term cooperation. Although their main actors involve organizations, the base concepts have the potential to be adopted, tuned and applied in network settings involving individuals such as communities of professional individuals.

In the CN context, organizations interoperate and collaborate within VO and VBE networks while being facilitated by computer networks, in order to achieve certain common or compatible goals, such as the acquisition of and response to larger, better, and more business opportunities. As a basic rule, supporting the dynamic/fluent formation of collaborative networks, such as in a short term consortium, requires its potential partners to be *ready and prepared to jointly participate* in such a collaboration environment. The foundation of this readiness should include reaching commonality agreements on aspects such as the interoperable infrastructure, operating rules, and cooperation. Any collaboration also requires that involved actors meet the required level of competency performance, and emotional equilibrium to be considered trustworthy by other partners. Therefore, the concepts of long-term strategic alliances have emerged as the necessary context for the effective creation of dynamic short term consortia.

Moreover, with the development of new collaborative tools supported by Internet and better understanding of the mechanisms of collaborative networks, new organizational forms are naturally emerging in different sectors, e.g. networks of healthcare institutions together with relatives involved in elderly care, networks of governmental institutions, networks of academic institutions forming virtual institutes, networks of entities involved in disaster rescue, etc. With the consolidation of Collaborative Networks as a new

discipline in the last 4 or 5 years, more emphasis is being put on the elaboration of the theoretical foundation for the area and reference models that form the basis for further sustainable developments. The IP ECOLEAD project designed the ARCON reference modeling framework for collaborative networks as illustrated in Figure 3 (Camarinha-Matos & Afsarmanesh, 2008).

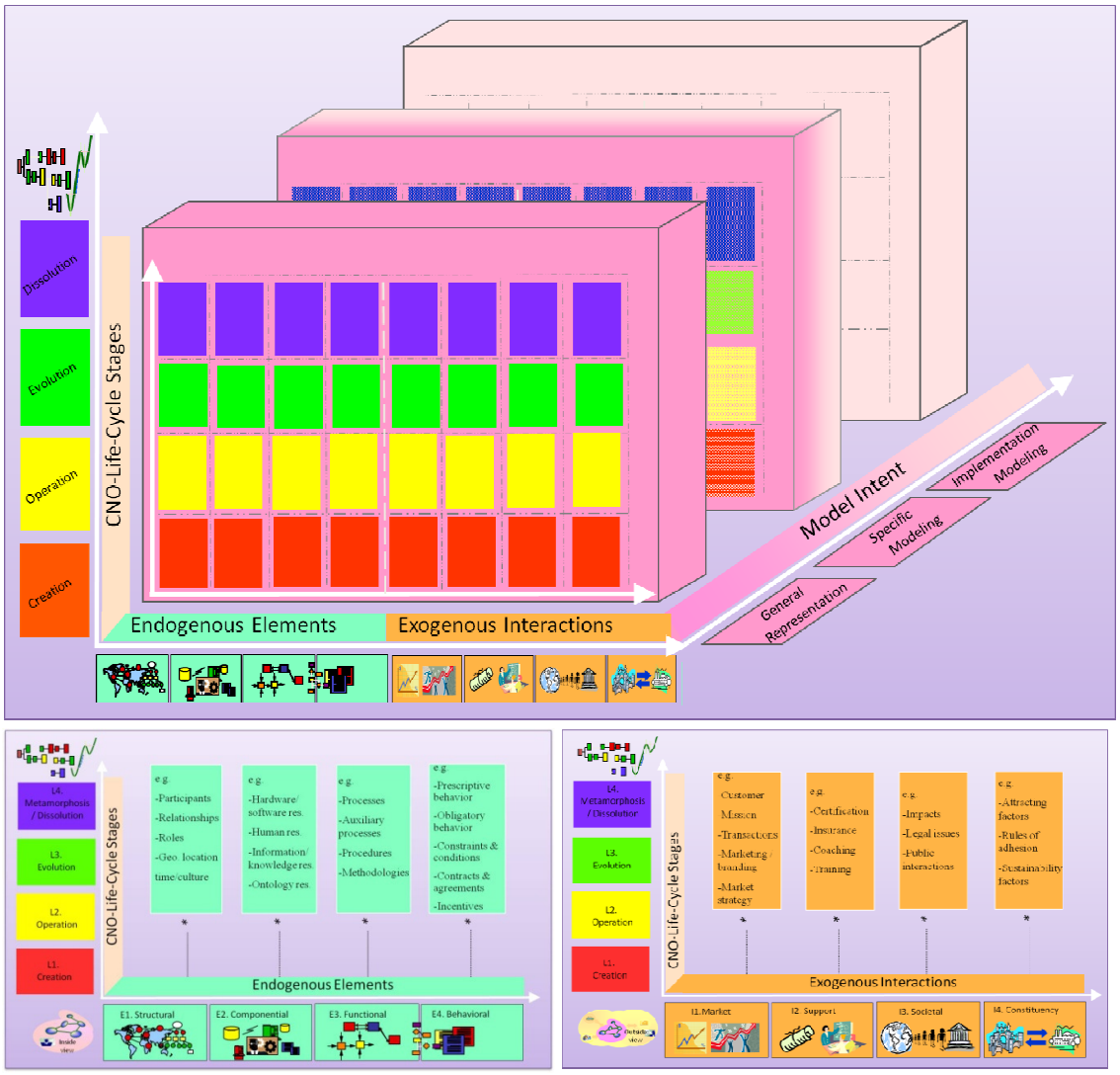

Figure 3 – The ARCON Reference Modeling Framework for Collaborative Networks

ARCON comprises three modeling axes – (1) the life cycle of CN (i.e. creation, operation, evolution, metamorphosis, and dissolution), (2) the environment characteristics including both the CN endogenous elements (i.e. the structural, componential, functional, and behavioral dimensions) and the CN exogenous interactions (i.e. with market, support, societal, and constituency dimensions), and (3) the model intent (i.e. general representation, specific modeling, and implementation modeling). Some attempts to identify the key modeling elements for each dimension were also performed, and a textual description of each of these key elements is provided in (Camarinha-Matos & Afsarmanesh, 2008).

The results from the ARCON reference modeling framework that are relevant for this thesis work are mainly the *behavioral endogenous elements* or *behavioral dimension*. The

behavioral dimension provides the context for integration and generalization of the various behavioral aspects of CNs. The principles of collaboration and rules of conduct (CN governance), where issues such as business process modeling, principles of trust, value systems, contracts negotiation and conflicts resolution, collaboration readiness, reward and incentives, among others can be found, are addressed with special focus in this dimension. It is also within this dimension that the emotions' modeling aspect proposed in this work fits.

2.1.2. Collaborative Networks Governance Rules

Governance of a CN plays a regulatory role, through the use of some structures, authorities, and institutions, the setting of some principles and rules for allocation of resources and assignment of rights, as well as the management and supervision of both actors and activities within the CN. There is therefore a dual relationship identified between the governance and the behavioral aspects of the CNs: on one hand the CN governance constrains or guides collective and individual behavior of the network members, while on the other hand the driving forces behind the actors' behavior (e.g. their value systems, character, etc.) influence the nature of the CN governance.

When collaboration processes are less structured as addressed in this thesis work proposal, more dynamic modeling formalisms are needed. This is why well-founded emotional and social models along with other behavioral models are the basis to move from the currently applied set of ad-hoc rules to the new principle-based governance of CNs. In this line, this research work will establish emotional behavior-based improvements in different CN organizational structures. Rules for more effective partner selection, negotiation, definition of incentives and conflict resolution, are examples of governance-related mechanisms foreseen to be derived on the basis of this emotions-oriented modeling approach. A further ambitious goal is to design an information system that can provide proactive assistance for supervision of the CN emotional health, including monitoring, diagnosis, and generation of recommendations and healing mechanisms in pursuit of the governance principles.

In the following sub-sections, a brief description of some of the influencing factors of the CN governance is presented.

Social Protocols

Interactions have been defined as the basis for social relations. Social relations are regulated by social norms between two or more people, with each having a social position and performing a social role. The concept of social norm is a key concept to cope with modeling of interactions among collaborators, as social norms may be considered as a set of rules to structure interactions among collaborators.

The importance of emotions in social interaction has been studied by several sociologists as described in section 2.2. Although many theories have been proposed to define the concepts mentioned above and their relations, none of them is directly applied to develop computer support to interactions among collaborators.

In computer science, the focus has been on *i)* interactions among software entities, e.g. research on distributed systems, workflow systems and in the recent years on service-oriented architecture (SOA); *ii)* interactions among humans sharing information, e.g. virtual workplace and electronic communication means; and *iii)* collaborative management tools facilitating and managing group activities, e.g. project management systems. Works on interactions among software entities provide models for structured collaboration, such as Petri Nets, BPEL (Business Process Execution Language), BPMN (Business Process Modeling Notation) or XPDL (XML Process Definition Language) (Danylevych, Karastoyanova, & Leymann, 2010; Grefen, Eshuis, Mehandjiev, Kouvas, & Weichhart, 2009; W. Picard, 2008; Wang, Zhang, & Shi, 2007). Nevertheless, these works do not encompass the social dimension of human interactions as such a dimension does not exist among software entities. Works on interactions among humans sharing information focus on problems such as awareness and concurrency but they do not address the social dimension formerly mentioned (Gross, 1999a, 1999b; He & Han, 2006; Kekwaletswe, 2007). Finally, works on collaborative management tools resulted in tools which, while occasionally providing some basic support for social aspects with the concept of roles, impose some rules of interactions to the collaborators, these rules being defined by the software provider (P. M. Jones, 2001; Ollus, Karvonen, Uoti, & Riikonen, 2009). The dynamic nature of interactions within a group, i.e. evolution of social norms in time, is an important obstacle to the adoption of these tools.

The concept of social protocols has been proposed by (W. Picard, 2007) as a model for structuring interactions among a group of collaborators. Additionally, adaptation of social protocols has been proposed as a mean to support dynamics of interactions, allowing collaborators to modify the social protocol ruling the group they belong to. However, the support for the social dimension of interactions is still insufficient: the concept of social role is reduced to its simplest expression, i.e. role, emotions and other social aspects of collaboration are not supported by social protocols.

Rational Trust

Establishing trust relationships among members, organizations or individuals, of a network is a pre-condition for smooth collaboration. With widely divergent goals of members and characteristics of networks, and geographically separated parties, building and maintaining trust relationships are fundamental and even more challenging when dealing with large networks and temporary partnerships (Msanjila & Afsarmanesh, 2008).

While selecting reputable partners provide a basis, building up trust will heavily depend on a large number of factors, e.g. openness, good communication, executing tasks as agreed, etc. A partnership strategy based on a step-by-step strengthening of the tangible and measurable characteristics will allow a gradual building-up of the trust level. While informal contacts can play an important role in trust building, care should be taken to avoid the formation of cliques and emotional conflicts, which may interfere with the business.

Research on management and establishment of trust is conducted in a variety of disciplines, each focused on different perceptions of trust, e.g. modeling, assessing, creating, and maintaining trust and trust relationships (Povey, 1999). Various works have attempted to characterize trust and its related aspects. Most of these works focus on subjective (opinion-based) trust elements, e.g. by recommendation, ranking, reputation,

and polling (S. Jones, Wilkens, Morris, & Masera, 2000; Kini & Choobineh, 1998). Only a few research approaches focus on objective/rational (fact-based) trust elements, e.g. measuring the past performance and current standing of organizations/individuals as the main input for assessing their trustworthiness (Msanjila, 2009; Msanjila & Afsarmanesh, 2007a, 2007b).

Value systems

Decision making as well as the individual and joint behavior in a collaborative network depend on the underlying value system. Therefore, identification and characterization of the value system of the networks and their members are fundamental when attempting to improve and sustain a collaborative process. Value systems and their effects on the networks have been preliminary studied in the past in diverse areas such as education, organizational management, and information system design. Many research initiatives have also referenced the value system concept in their collaborative networks studies. However, the concept of value system is not yet formally defined and there is not even an agreement within the research community about its intuitive definition (Camarinha-Matos & Macedo, 2010).

Value Systems and their effects on networks have been preliminary studied in a number of different scientific areas. Social sciences consider a Value System as the ordering and prioritization of the ethical and ideological values that an individual or society holds, while economical sciences defend that a Value System describes the activity links among the firm and its suppliers, other businesses within the firm's corporate family, distribution channels and the firm's end-user customers (Porter, 1985). Goguen and Linde have developed, since 1978 several works on studies about value and Value System in organizations (Goguen, 1994, 1997, 2004), which proposed a method for using discourse analysis to determine a Value System for an organization from a collection of stories told by members of the organization among themselves on informal occasions. Another contribution comes from the Distributed Artificial Intelligence discipline, which has developed some Value Systems theories using agents (Antunes, Coelho, & Faria, 2000; Filipe, 2003; Rodrigues, Costa, & Bordini, 2003). During the last years some works on Value Systems in networked environments have been developed by groups of researchers, Katzy (1998), Gordijn (2000), Tan (2004) and Kartseva (2004). In Organizational Sociology Alle (2000), Hall (1995) and Hebel (1998) studied the corporate-identity in organizations. These studies show how relevant it is to specify the corporate-identity of an organization in order to manage organizations. In the last decade, several studies inside the knowledge management discipline led to the development of frameworks to classify the value's elements inside an organization according to their nature. Sullivan (2000), and Alle (2000) demonstrated the importance of managing intangible issues for the sustainability of organizations. A research work conducted by Camarinha-Matos and Macedo (2010) proposes the adoption of a set-theoretical approach to model value systems, and some elements from the graph theory and causal reasoning to model the causal relationships among organization's core values, in order to analyze their interrelationships.

The CN decision-making process is naturally influenced both by the common value system of the network and the individual value systems of each partner. Therefore the identification and characterization of these value systems is an important issue when attempting to improve collaborative processes. As partners have different value systems,

they might have different perceptions of the outcomes of the collaboration processes, which might lead to non-collaborative behavior, such as hindering knowledge sharing, and inter-organizational conflicts. Therefore, the development of a common value system is a significant element for the sustainability of collaboration.

A critical issue in collaborative knowledge creation is the intellectual property and how to determine the individual added value of each actor. Although some IPR principles are well known, there is not yet a sound approach to handle this issue in a networked environment although a basic model for benefits identification was first developed in the ECOLEAD project (Abreu & Camarinha-Matos, 2008) and a credit assignment model was suggested in the PRODNET project (Camarinha-Matos & Afsarmanesh, 2000).

Collaboration Readiness

Collaboration readiness can be intuitively established as how well, and to which extent, an organization is ready, competent, prepared and willing to participate in a partnership. The rationality of the concept is that "higher collaboration readiness should increase the likelihood of partnership success".

Previous research works related to partnership performance in collaborative networks were mostly focused on "hard" factors such as competency matching or technological preparedness, which do not consider behavioral, or soft, issues. For such, it is necessary to adopt a behavioral perspective of collaboration readiness. According to a recent research work (Rosas & Camarinha-Matos, 2009), collaboration readiness involves assessing an organization's preparedness, competencies fitness, and collaboration willingness.

The main focus of *collaboration preparedness* is to assess whether an organization is likely to display reliable behavior inside partnerships. The rationality of this concept lies on the idea that an organization's behavior can be to some extent predicted. When in partnerships, entities develop behaviors that typically tend to show some repetition through time, this repetition usually leads to the formation, or identification, of behavioral patterns. These patterns can in turn be associated to a set of identifiable traits. These traits together, form what is referred to as character. The underlying mapping between character traits and behavior could be used to perform behavior prediction. Specific behavioral patterns may cause positive or negative effects on collaboration. Basically, if the predictability of an organization to develop beneficial behavioral patterns is high, then its preparedness to collaborate is also higher, and the other way around. As such, current developments try to assess collaboration preparedness using the concept of organization's character (Rosas, 2010).

In a partnership, partners are typically selected considering functional competencies, or hard competencies, which allow achieving partnership goals. But collaboration has its specific requirements, of a more behavioral nature, for which it is necessary to exercise other type of competencies influencing organizational performance and the partnership success. The concept of *competencies fitness* is introduced as a way to assess whether a partner is able to adequately use its hard competencies in a collaboration context, in which it is also required some specific soft competencies, like the ability to share knowledge. To adequately handle this type of issues, a "hard versus soft" competencies dichotomy is considered (Rosas & Camarinha-Matos, 2009). The idea is to identify the

performance effects of the soft competencies on the hard ones, within a given collaboration context.

The success of a partnership depends on the partners' active participation and commitment to achieve the shared goals, which fundamentally depends on the attitudes and intentions a partner assumes towards the partnership. If a partner shows relatively positive, but marginal, interest to engage in a partnership, its performance might not be very high. The aim of *willingness to collaborate* is precisely to assess these partners' attitudes, which may influence its willingness to commit to the partnership activities.

Negotiation

Reaching agreements and contracting are important elements in the process of creating dynamic collaborative networks. To improve the effectiveness of the contracting process and to dynamically form goal-oriented teams, the need to develop forms of e-contracting has been identified (Angelov, 2006; Camarinha-Matos & Oliveira, 2007). Several significant characteristics for e-contracting process have been proposed and initial progress on electronic institutions such as e-notary has been introduced (Cardoso & Oliveira, 2008; García-Camino, Rodríguez-Aguilar, Sierra, & Vasconcelos, 2006). Works on electronic negotiations may be split into two main areas: automated agent-based negotiations and negotiation support systems. In automated agent-based negotiations, negotiating tasks, such as offer exchange or evaluation, are performed by software agents behaving on behalf of the users. Developments include negotiation protocols, auction mechanisms, learning, multi-attribute constraint negotiation, etc. Elaboration of contract templates and repositories of clauses has been another line of development (Shelbourn, Hassan, & Carter, 2005). On a more theoretical basis, deontic logic is used to describe contract models specifying obligations, permissions, and forbiddances for specific business processes but still in extremely ideal cases (Xu, 2004) . Models of negotiating agents are usually based on the game theory, focusing on the maximization of the users' gain. A rare exception is the EDBI model proposed by Hong Jiang in his Ph.D thesis, which includes support for emotions in negotiation strategies. While the vision of automated negotiations is attractive, the removal of the human factor is also the Achilles' ankle of automated agent-based negotiations, as social and affective relationships existing among negotiators, which highly influence the negotiations, are overlooked in the automated agent-based negotiations. Negotiation support systems (NSS) aim at supporting negotiators by providing necessary negotiation means and tools.

One may distinguish two kinds of NSS: 1) preparation and evaluation systems, 2) process support systems. Preparation and evaluation systems provide tools to organize information, develop negotiation strategies, and evaluate negotiation offers. Preparation and evaluation systems are to a large extent inspired by (group) decision support systems, based on multi-attribute utility representation. An example of such a system is the INSPIRE system. Process support systems focus on collaboration during the negotiation process providing communication and authoring tools for negotiators.

As these functionalities shall not be based only on rationality, this thesis work aims to contribute with the affecting aspects of negotiations providing means to assess each stakeholder emotional state during the discussions. Although interesting research has been done in the field of electronic negotiations to model such negotiations with the help of the adequate protocols, none of the works concerning negotiation protocols provides

mechanisms for protocol adaptation supporting the needed advanced social and emotional elements. Moreover, these past efforts are, by nature, limited to the field of electronic negotiations, which is only a subset of the field of human collaboration.

Conflicts Resolution

Another relevant aspect that must be considered in collaborative environments is that collaboration and conflicts are inseparable. Thus collaborative structures require a conflict mediation mechanism if successful collaborations are sought because conflicts may affect the organizational performance. Resolution of conflicts necessitates substantial efforts and time, which have an adverse impact on development costs and time. In addition, the outcomes of conflict resolutions affect the quality of products or services as well as the collaborative relationship.

Conflict has been a hot topic studied by researchers in the discipline of psychology, sociology and business (Rahim, 2001). Conflicts may appear due to many different natures, for example in client-supplier collaboration. Lam and Chin (2005) conducted a survey to explore conflict in client–supplier collaborative new product development. Nevertheless, it is also of great interest to explore conflicts among collaboration partners, that is, intra-collaboration. So, in this context, conflict mediation mechanisms should consider three distinct levels: conflict avoidance, conflict identification and conflict solution.

So in order to avoid conflicts, solid models for: relationship and emotions management, commitment to the collaboration, trust and mutual understanding of organizational objectives must be considered. Another subject matter that must also be considered is that in collaborative networks there may be different groups' structures and dimensions, so prediction of conflicts must also reason on this matter.

2.1.3. Research Work in the Area of Collaborative Networks

A growing number of EU funded research projects have emerged during the last years in the area of CNs as a result of the challenges faced by both the business and scientific worlds.

The following table illustrates some of these research projects.

Focus Area	Project Name
Business Networking	ECOLEAD (www.ecolead.org) European Collaborative Networked Organizations Leadership Initiative CROSSWORK (www.crosswork.info) Developing Cross-Organizational Workflow Formation and Enactment MYCAREVENT (www.mycarevent.com) Supporting Mobility and Collaborative Work in European Vehicle Emergency Networks VE-Forum (www.ve-forum.org) The European Forum for the Virtual Organization Domain

	THINKcreative (www.thinkcreative.org) Thinking network of experts on emerging smart organizations MASSYVE (www.gsigma-grucon.ufsc.br/massyve/) Multi-Agent Manufacturing Agile Scheduling Systems for Virtual Enterprises COVE (www.uninova.pt/~cove) CO-operation Infrastructure for Virtual Enterprises and Electronic Business
Enterprise Interoperability	ATHENA (www.athena-ip.org) Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Application INTEROP (www.interop-noe.org) Interoperability Research for Networked Enterprises Applications and Software COIN (www.coin-ip.eu) Enterprise Collaboration and Interoperability
Ambient Intelligent Technologies for the Product Life-Cycle	CO-DESNET (www.codesnet.polito.it) Collaborative Demand & Supply Networks VERITAS (www.veritas-eu.com) Virtual Enterprises for Integrated Industrial Solutions SPIDER-WIN (www.spider-win.de) Supply Information Dynamic Exchange and Control by Web-based Interaction Network
Digital Ecosystems	SATINE (www.srdc.metu.edu.tr/webpage/projects/satine/index.html) Semantic-based Interoperability Infrastructure for Integrating Web Service Platforms to Peer-to-Peer Networks DBE (www.digital-ecosystem.org) Digital Business Ecosystem
Roadmapping	VOmap (www.uninova.pt/~vomap/index.htm) Roadmap design for collaborative virtual organizations in dynamic business ecosystems

Table 1 – Example of CNs Research Projects

2.2. Emotions

2.2.1. What are Emotions?

"All that emotion is, in many circumstances, is a particular form of communication"
(Parkinson 1995:170)

The meaning of emotion (*animi motus* in the Latin) is expressed in the term itself, that is, the idea of 'motion' in one's inward feelings and self-consciousness. These inward motions of the 'soul' (*psyche*) signal and give rise to 'moods,' inner *feelings* and *dispositions*.

The concept of 'emotion' presents a particularly difficult problem. Even though the term is used very frequently, the question "What is an emotion?" rarely generates the same answer from different individuals and scientific researchers. This is due to the fact that emotions concern what is most intimate and important to human life and because some of their effects demand understanding.

Therefore, in spite of being a common word and apparently understandable by everybody, the definition of emotion has been a matter of discussion over the past 100 years and the number of scientific definitions proposed has grown to the point where counting seems quite hopeless (de Sousa, 2003; Fehr & Russell, 1984; Forsyth, 2004; Frijda, 2000). Only in 1981 Kleinginna and Kleinginna reviewed more than one hundred definitions (Kleinginna & Kleinginna, 1981). As a consequence, no complete list can be assured but it is possible to provide a sense of the way psychologists and others have thought about the topic by examining a few of the more influential definitions (see Table 2).

My theory… is that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion… *(James, 1884)*
Ideas are cathexes – ultimately of memory traces – while affects and emotions correspond with process of discharge, the final expression of which is perceived as feeling. *(Freud, 1915)*
An emotion is an hereditary "pattern reaction" involving profound changes of the bodily mechanism as a whole, but particularly of the visceral and glandular systems. *(Watson, 1924)*
The peculiar quality of the emotion is added to simple sensation when the thalamic processes are roused. *(Cannon, 1929)*
Emotion is an acute disturbance of the individual as a whole, psychological in origin involving behavior, conscious experience, and visceral functioning. *(Paul T. Young, 1943)*

Emotion can be both organizing (making adaptation to the environment more effective) and disorganizing, both energizing and debilitating, both sought after and avoided.

(Donald O. Hebb, 1958)

Emotion is felt tendency toward anything intuitively appraised as good (beneficial) or away from anything intuitively appraised as bad (harmful). This attraction or aversion is accompanied by a pattern of physiological changes, organized toward approach or withdrawal. The patterns differ for different emotions.

(Arnold, 1960)

An emotion may be defined as a patterned bodily reaction to either destruction, reproduction, incorporation, orientation, protection, reintegration, rejection or exploration or some combination of these, which is brought about by a stimulus.

(Robert Plutchik, 1962)

Emotional feelings guide our behavior with respect to the two basic life principle of self-preservation and preservation of species.

(Paul McLean, 1963)

Emotions are phases of an individual's intuitive appraisals ether of his own organismic states and urges to act or to the succession of environmental situations in which he finds himself…. At the same time, because they are usually accompanied by distinctive facial expressions, bodily postures, and incipient movements, they usually provide valuable information to his companions.

(Bowlby, 1969)

Emotion is a complex process that has neurophysiological, motor-expressive, and phenomenological aspects.

(Carroll Izard, 1972)

An affect is a sensation of pleasure, unpleasure, or both, plus the ideas, both conscious and unconscious, associated with that sensation.

(Charles Brenner, 1974)

Emotions are complex organized states consisting of cognitive appraisals, action impulses, and patterned somatic reactions.

(Lazarus, Kanner, & Folkman, 1980)

Emotion is a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labeling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behavior that is often, but not always, expressive, goal-directed, and adaptive.

(Kleinginna & Kleinginna, 1981)

Emotions are tendencies to establish, maintain, or disrupt a relationship with the environment…. Emotion might be defined as actions readiness change in response to emergencies or interruptions.

(Frijda, 1986)

Emotions are a primary idiom for defining and negotiating social relations of the self in a moral order.

(Lutz & White, 1986)

Emotions are valenced reactions to events, agents or objects, with their particular nature being determined by the way in which the eliciting situation is construed.

(Andrew Ortony, C. L. Clore, and A. Coffins, 1988)

Emotion (is) a complex disturbance that includes three main components: subjective affect, physiological changes related to species-specific forms of mobilization for adapted action, and action impulses having both instrumental and expressive qualities.

(Lazarus, 1991)

Emotions are processes that establish, maintain, change, or terminate the relation between the person and the environment o0n matters of significance to the person.

(J. Campos, D. L. Mumme, R. Kermoian, and R. G. Campos, 1994)

Affects are the experiential representation of a non-symbolic information-processing system that can serve as the central control mechanisms for all aspects of human behavior.

(Joseph M. Jones, 1995)

Emotions are crude predispositions to react to life events, shaped by an evolutionary heritage, but not always adaptive in the modern context.

(Denys A. de Cantanzaro, 1999)

An emotion is a superordinate program whose function is to direct the activities and interactions of the subprograms governing perception; attention; inferences; learning; memory; goal choice; motivational priorities; and physiological reactions, etc.

(Leda Cosmides and John Tooby, 2000)

An emotion is a phylogenetically evolved, adaptive mechanisms that facilitates an organism's attempt to cope with important events affecting its well-being.
(Torn Johnston and Klaus Scherer, 2000)
Emotions direct and color our attention by selecting what attracts and holds our attention. They regulate priorities and communicate intentions. Emotions are concerned with issues of survival and social status.
(Aaron Ben-Ze'ev, 2000)

Table 2 – Some Definitions of Emotion

After analyzing all these definitions, it can be said that most theories hold that emotion is a complex entity with many components: physiological, cognition, sensory input, behavior correlates (e.g. expressions of emotion). In addition and common to all definitions is the undeniable value of emotion for people and the society. Emotions determine personal viability; prepare people for action; shape people's behavior; regulate social interactions; facilitate nonverbally communication; make life worth living by adding value to experience; allow people to respond flexibly to the environment (approaching good, avoiding bad) and have a central place in moral education and moral life through conscience, empathy, and many specific moral emotions such as shame, guilt, and remorse; inextricability linked to moral virtues.

Furthermore, the definition of emotion changes according to the point of view taken by the researcher, i.e., in accordance with several different disciplinary perspectives: biology, psychoanalysis, psychology (cognitive psychology, social psychology), sociology, organizational theory, and management, community and humanities studies. Biological researchers' focus on emotion is via observation of physiological responses to particular situations or stimuli (Ashkanasy, Härtel, & Zerbe, 2000; Stanley & Burrows, 2001), emotion is also studied in non-human animals in ethology[1], a branch of zoology that focuses on the scientific study of animal behavior in their normal environment. Psychoanalysts explore the deeply embedded nature of human emotions such as anxiety within the context of the individual's life experience (Meyerson, 2000; Weiss & Brief, 2001). Psychology for over a century has differentiated three areas: thinking (or cognition), feeling (or affect or emotion) and acting (or behavior), but until recently has focused much more on cognition and behavior than on emotion (Fineman, 2001; Zerbe & Härtel, 2000). Cognitive psychologists such as Lazarus (1982) typically subordinate emotion to cognition, whilst social psychologists consider emotion from a behavioral perspective, within the context of interpersonal interaction and social relationships (Stanley & Burrows, 2001; Weiss & Brief, 2001). Sociology, organizational theory and management and community studies also tend towards the relational view of emotion (Tanner, 2005). Humanities studies are made at the level of how emotions influence authors when writing a book or what could be the sensory-emotional values found in historical or philosophical texts. Finally, the most recent area focusing on the importance of human–computer emotions, affective computing is a branch of the study and development or artificial intelligence that deals with the design of systems and devices that can recognize, interpret, and process human emotions (see Figure 4).

[1] Ethology is a combination of laboratory and field science, with strong ties to ecology and evolution. Among the early ethologists were Herbert Spencer, Charles Darwin, G. J. Romanes, and William James. Zoologists Konrad Lorenz and Nikolaas Tinbergen are widely considered to be the founders of modern ethology. In 1973 they and zoologist Karl von Frisch were awarded the Nobel Prize in Physiology or Medicine for their work in shaping the science of comparative animal behavior (Allaby, 1999; "ethology"," 2008).

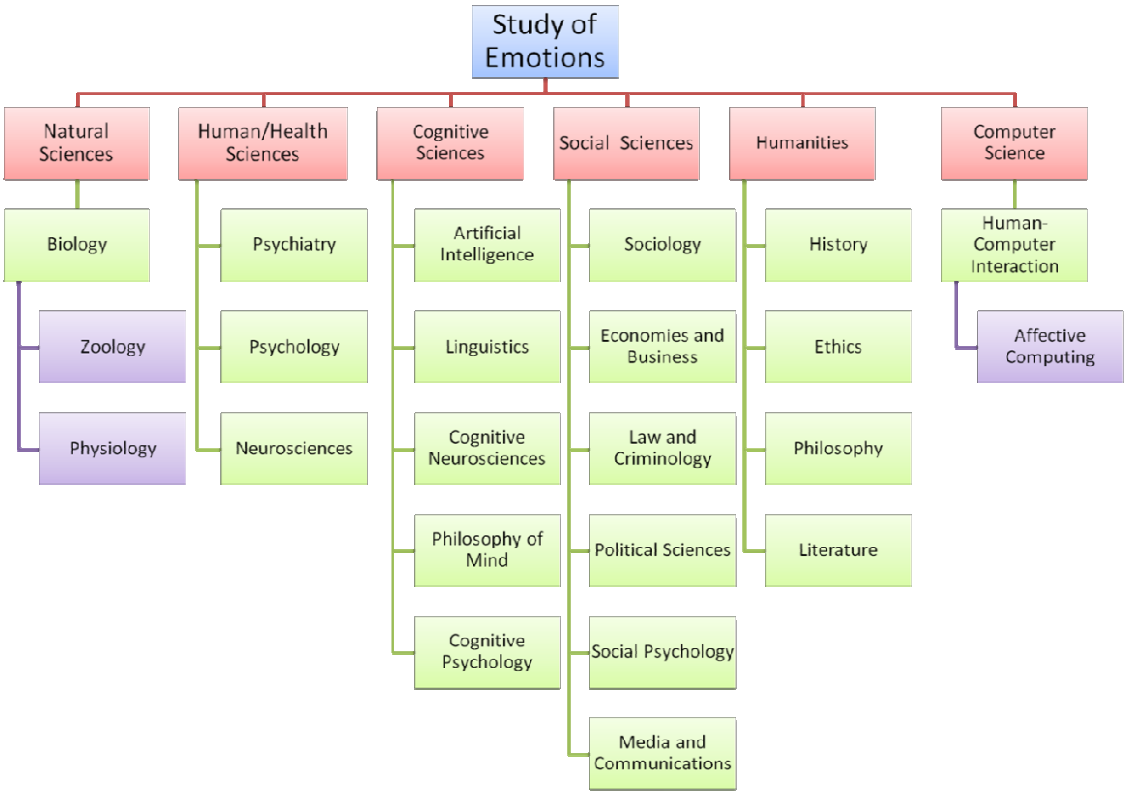

Figure 4 – Disciplinary Perspectives of Emotions' Research

In this thesis, the focus will be essentially on the engineering perspective of the sociology, social psychology, and affective computing areas. Nevertheless, the studies conducted at the biological, and psychological domains will give the basis for the better understanding of what emotions are and what can be borrowed from these sciences to apply in the context of the collaborative networks paradigm.

Therefore, the reminder of this chapter is divided into a section that will make an overview the physiological aspects of emotion; followed by a study of emotions in psychology, where some of the most important theories of emotion are presented as well as the psychological cognitive and social aspects; and finally the sociological point of view is discussed.

2.2.2. Physiology of Emotion

"Emotions are not merely cerebral; they are embodied".
(Larsen, Berntson, Poehlmann, Ito, & Cacioppo, 2006)

Emotions are unique to each human being and deviations from person to person are the result of each person's genes and the involved environment in conjunction. The end result is a complex network of mental processes that, when triggered by stimuli, sets of a chain of psychological and physiological reactions that are expressed internally and externally by emotions.

The natural processes by which emotions operate are concentrated in the nervous system (Figure 5). The *nervous system* is divided into two broad components: the central nervous system and the peripheral nervous system. The *central nervous system* comprises de brain and the spinal cord while the *peripheral nervous system* comprises the autonomic and somatic nervous systems. The *autonomic nervous* system innervates smooth muscles (e.g. the heart) and glands and is divided into the sympathetic and parasympathetic branches. Whereas the sympathetic branch generally prepares the body for action (e.g. by stimulating heart rate), the parasympathetic branch aids restorative functions (e.g. by stimulating digestion). Finally, the *somatic nervous system* innervates skeletal muscles, including those of the face.

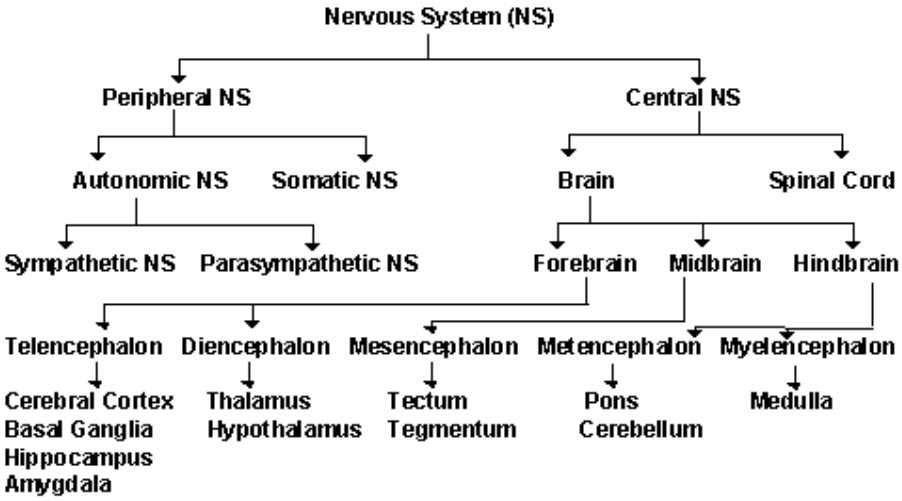

Figure 5 – The Nervous System Components (from: http://www.dls.ym.edu.tw/chudler/nsdivide.html)

According to Brave and Nass (2002) the 'seat' of emotion is the brain. The vast network of brain cells or neurons, responsible for the development and realization of emotion, communicate through a series of chemical signals. They utilize neurotransmitters to relay their signals to other parts of the brain or body, thus generating other emotions or causing some of the physical side effects associated to certain feelings. In this way, certain brain structures are associated to emotions and when interconnected comprise the limbic system, which is responsible for the regulation of emotions and memory.

The limbic system, named after the Latin word *limbus* for edge, is the innermost part of the brain, wrapped around the core ventricles. It is also called the "old mammalian system" or the "mammalian brain" in the popular McLean's "triune" or "three-in-one" brain model (Figure 6). According to this model, the brain has gone through three stages of evolution over time: the reptilian (also known as "R-complex"), the limbic system (or mammalian) and the neocortex (or neomammalian or cerebral cortex) (MacLean, 1970).

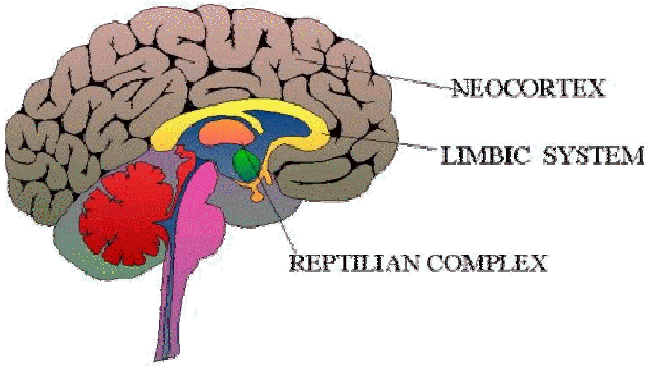

Figure 6 – McLean's triune brain model (MacLean, 1970)

In human beings and higher mammals, these three brains all coexist. The most primitive mammals have only the limbic system and the reptilian brain, while birds, reptiles, amphibians and fish have only the reptilian brain.

The limbic system's components are the amygdala, the hippocampus, the cingulate gyrus, fornicate gyrus, hypothalamus, mammillary body, epithalamus, nucleus accumbens (the brain's famed "pleasure center"), orbitofrontal cortex, parahippocampal gyrus, and the thalamus.

The limbic system is the home of emotions, motivation, the regulation of memories, the interface between emotional states and memories of physical stimuli, physiological autonomic regulators, hormones, "fight or flight" responses, sexual arousal, circadian rhythms, and some decision systems. The limbic system is what gets "duped" when people get addicted to hard drugs.

2.2.3. Psychology of Emotions

Most psychologists agree that emotions consist of three components: physiological processes, expressive behavior, and cognitive appraisal as shown in Figure 7 (Barlow & Durand, 2008; Kassin, 2004). Nevertheless there exists a controversy in relation to what comes first: does physiological arousal precede or follow emotional experience? or does cognition (thinking) precede emotion (feeling)?

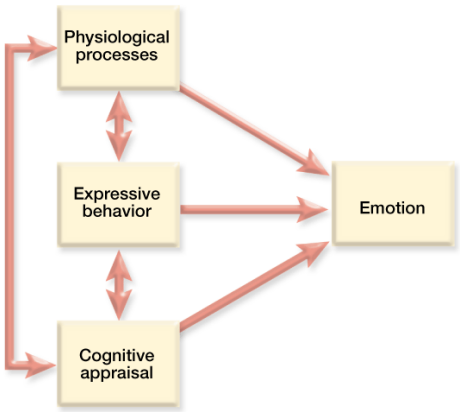

Figure 7 – Components of Emotion

The observations of physiological changes are the foundations of a theory known as James-Lange theory. The James-Lange theory brought forward the importance of the body in the phenomena called emotions. Supporters of this theory are Ekman (1992), Tomkins (1980), and Izard (1993) suggesting that facial expressions generate, amplify, and/or regulate emotional experiences (Tanguy, 2006).

The behavioral aspect of emotion involves the actions people take when they are experiencing an emotion (how they behave). For example, if you are feeling very happy you might hug the person next to you. Or if you are feeling afraid of something, you might run away from it.

The cognitive aspect of emotion involves the thoughts a person has when he/she is experiencing a particular emotion. For example, you may be feeling happy and then say to yourself "what a wonderful day". Emotion can also be described as states resulting from, or processes involving cognitive or non-cognitive evaluation of internal and external events in relation to one's well being. This evaluation is known as *appraisal* (Frijda, 1986; Izard, 1993; Lazarus, 1991; Plutchik, 1980). Within this theory, many points of view exist, mainly depending on the definition adopted for cognition, but also on the dimensions used to evaluate events (Tanguy, 2006).

Where James-Lange theory focuses on the relation between body changes and emotions, researchers such as Darwin (1979), Plutchik (1980), Izard (1977), Tomkins (1980) and Ekman (1999) studied behavioral changes. They defined a set of emotions having a special status called *Basic*, *Primary* or *Fundamental* Emotions, based on behavioral observations. This type of emotion is generally assumed to be innate and to have several *survival* functions (Tanguy, 2006).

2.2.3.1. Theories of Emotion

As above mentioned, and in the same way as the definitions of emotions, numerous theories involving the origins, mechanisms and nature of emotions have been generated over the years. All of the classic theories of emotion have fallen under criticism at various times, though many modern theorists still use them as a basis to work from. Chronologically, the progression began with James-Lange Theory, which was opposed by Cannon-Bard. The James-Lange Theory was later modified by Schachter-Singer. Some more recent theories are the Affective Events Theory (Basch & Fisher, 2000; Weiss & Cropanzano, 1996), which explores time as it is related to the influence on behavior of emotional reaction to events, and the modern Cognitive Appraisal Theories (Arnold, 1960; Lazarus, 1991; Ortony & Turner, 1990; Scherer, Schorr, & Johnstone, 2001), many of which connect interpretation to emotional response.

James-Lange Theory

William James (1884) published the first widely accepted theory, known as the James-Lange theory (the same theory was devised independently by James and Lange). James argued that the body reacts to certain situations (like danger) with bodily responses (increase breathing, heart rate, etc.). According to James, different emotions are the result of our body reacting in different ways, so our emotions are just our perception of a bodily response.

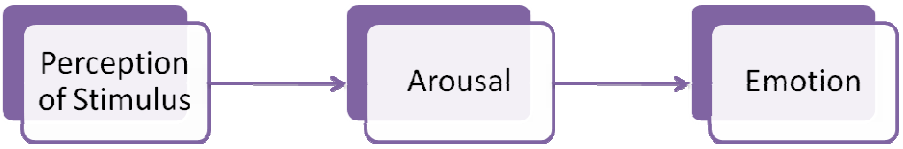

Figure 8 - James-Lange Theory of Emotion

Thus, James did not think that emotions could be generated in the brain alone, and he disputed the idea of structures in the brain that could produce emotions single-handedly. Several later concepts seemed to dispute the James-Lange Theory, such as the discovery that patients with spinal cord injuries were able to experience a full range of emotions. However, a sound basis to doubt the James-Lange Theory is given when considering how animals experience emotions when all the nerves to and from their body have been cut. In this way, scientists have been able to prove that it is possible to elicit and inhibit certain emotions by stimulating specific areas of the brain, subsequently refuting the James-Lange Theory.

EXAMPLE: You are walking down a dark alley late at night. You hear footsteps behind you and you begin to tremble, your heart beats faster, and your breathing deepens. You notice these physiological changes and interpret them as your body's preparation for a fearful situation. You then experience fear.

Cannon-Bard Theory

In 1929, Walter Cannon refuted James's theory and advanced another one, which was soon modified by Philip Bardand and became known as the Cannon-Bard Theory (Cannon, 1929) which states that, when a person faces an event that somehow affects him or her, the nervous impulse travels straight to the thalamus where the message divides. One part goes to the cortex to originate subjective experiences like fear, rage, sadness, joy, etc. The other part goes to the hypothalamus to determine the peripheral physical changes (symptoms). According to this theory emotion can be produced in the brain alone and physiological reactions and emotional experience occur simultaneously.

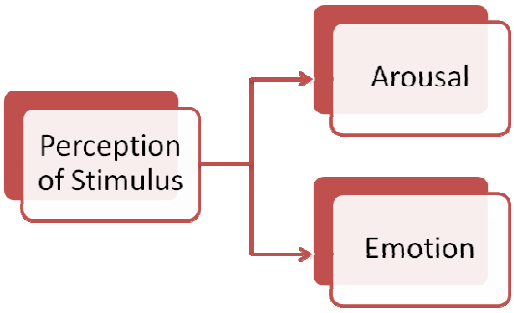

Figure 9 – Cannon-Bard Theory of Emotion

EXAMPLE: You are walking down a dark alley late at night. You hear footsteps behind you and you begin to tremble, your heart beats faster, and your breathing deepens. At the same time as these physiological changes occur you also experience the emotion of fear.

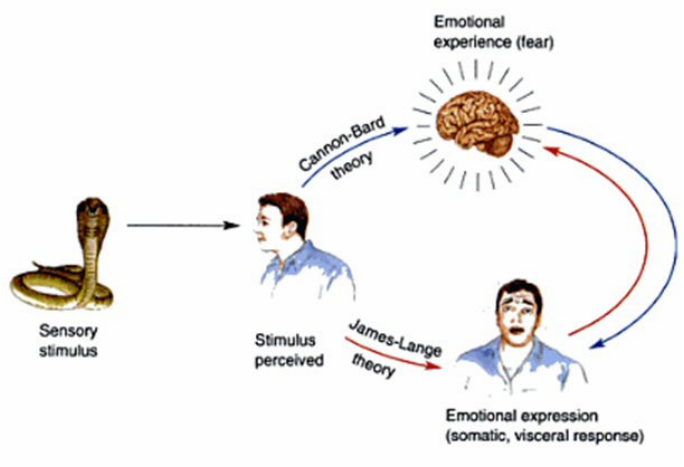

Figure 10 – Comparison of the James-Lange and Cannon-Bard Theories of Emotion.

According to James-Lange theory (red arrows), the man perceives the frightening animal and reacts with physical manifestations. As a consequence of such unpleasant physical reaction, he develops fear. In the Cannon-Bard theory (blue arrows), the frightening stimulus leads, first, to the feeling of fear which, then, brings about the physical response (Bear, Connors, & Paradiso, 2007).

The essential error of the Cannon-Bard Theory was to consider the existence of an initial "center" for emotions (the thalamus). Later on, Paul McLean discovered the limbic system where the hypothalamus and other brain components are involved (see section 2.2.2).

Two-factor Theory or Schachter-Singer Theory

Stanley Schachter and Jerome Singer (1962) proposed another theory which suggests that for an emotion to occur there must be a physiological arousal, and second there must be an explanation for the arousal. So there must be some kind of attention-getter and the reason why it got that specific person's attention.

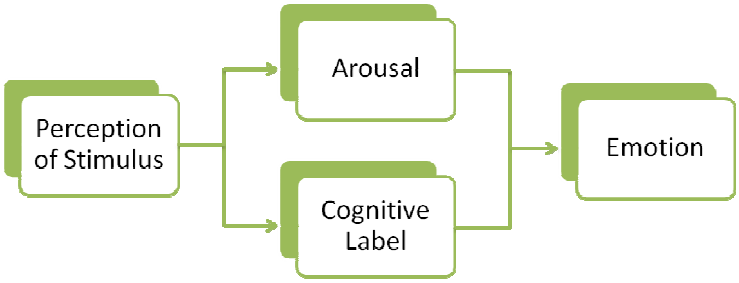

Figure 11 – Schachter-Singer Theory of Emotion

Therefore, to really understand what emotions people are having at a particular time, they use the cues in environment at the same time to help them determine the current emotion. This labeling process depends on two factors: *(i)* some element in the situation must trigger a general, nonspecific arousal marked by increased heart rate, tightening of the stomach, and rapid breathing; *(ii)* people search the situation/environment for cues that tell them what has caused the emotion.

EXAMPLE: You are walking down a dark alley late at night. You hear footsteps behind you and you begin to tremble, your heart beats faster, and you breathing deepen. Upon noticing this arousal you realize that this comes from the fact that you are walking down a dark alley yourself. This behavior is dangerous and therefore you feel the emotion of fear.

Cognitive Appraisal Theory

The Cognitive Appraisal Theory builds on the Schachter-Singer Theory, taking it to another level. It proposes that when an event occurs, a cognitive appraisal is made (either consciously or subconsciously), and based on the result of that appraisal, an emotion and physiological response follow.

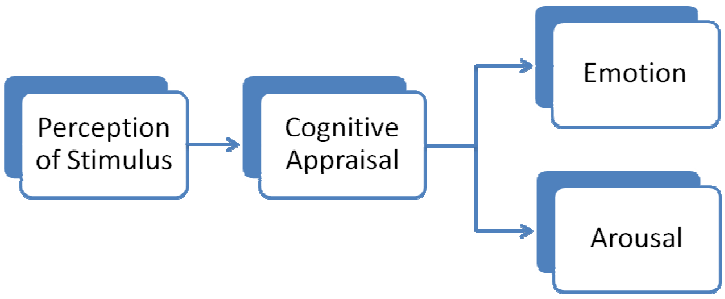

Figure 12 – Cognitive Appraisal Theory

Different versions of this assumption can be found in various cognitive appraisal theories of emotion (Arnold, 1960; Lazarus, 1991; Ortony & Turner, 1990; Scherer, et al., 2001).

According to Lazarus (1991) there are three aspects of appraisal: *(i)* primary (relevance); *(ii)* secondary (options); and *(iii)* reappraisal (anything changed).

EXAMPLE: You are walking down a dark alley late at night. You hear footsteps behind you and you think it may be a mugger so you begin to tremble, your heart beats faster, and your breathing deepens and at the same time you experience fear.

Two Routes or Paths to Emotional Responses

None of these theories are solely accepted in isolation, but it is generally acknowledged that the mechanics of emotions encompass different aspects of the theories discussed above. The figure below illustrates the two routes or paths to emotional responses.

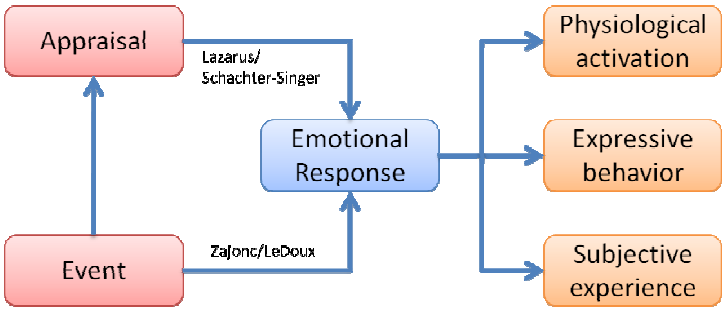

Figure 13 – Two Routes to Emotional Responses

Basically, what is discussed in the paths to emotional responses is the connection of how people *think* (cognition) and how people *feel* (emotion). On one hand, cognition defines emotion (Lazarus / Schachter, and Singer (1998)); on the other hand cognition does not

necessarily precede emotion (Zajonc and LeDoux – 1984), emphasizing that some emotions, such as simple likes, dislikes, and fears, are immediate, needing little if any conscious appraisal. In addition, Lazarus recognizes that, in fact, some emotions do not require conscious thought. However, there must be a minimum of unconscious thought.

As a consequence, many current theories of emotion now place the appraisal component of emotion at the forefront in defining and studying emotional experience. However, most contemporary psychologists who study emotion accept a working definition acknowledging that emotion is not just appraisal but a complex multifaceted experience with the following components:

1. Cognitive Appraisal. Only events are judged or appraised to have significance for people's goals, concerns, values, needs, preferences, or well-being elicit emotion.

2. Subjective feelings. The appraisal is accompanied by feelings that are good or bad, pleasant or unpleasant, calm or aroused.

3. Physiological arousal. Emotions are accompanied by autonomic nervous system activity.

4. Expressive behaviors. Emotion is communicated through facial and bodily expressions, postural and voice changes.

5. Action tendencies. Emotions carry behavioral intentions, and the readiness to act in certain ways.

2.2.3.2. Taxonomy of Emotions

There is no single definitive taxonomy of human emotions and considerable debate concerning the *number* and *kinds* of distinct human emotions, and whether some emotions are more *basic* than others (Stanley & Burrows, 2001). Some classifications isolate two or three main continuums of emotion such as positive-negative affect/valence; activation/arousal (Russell & Feldman-Barret, 1999) or pleasantness-unpleasantness/hedonic (Russell, 2003); whilst others identify a varying number of specific emotions. Duration of emotion state is another differentiator, with emotion, short-term and situation specific; mood, longer-term and more unfocused; and temperament, an enduring personality trait (Gray & Watson, 2001).

Emotions, Feelings, Moods, Affect and Sentiments

Emotions can be distinguished from feelings, affects, moods, and sentiments. The first two are less specific terms, the latter two, more specific. The general term *feelings* includes the experience of physical drive states (e.g. hunger, pain, fatigue) as well as emotional states. *Affects* refer to positive and negative evaluations (liking/disliking) of an object, behavior, or idea; affects also have intensity and activity dimensions (Heise, 1979). Thus, emotions can be viewed as culturally delineated types of feelings or affects. Compared to emotions, *moods* are more chronic, usually less intense, and less tightly

tied to an eliciting situation. (Moods rarely are examined by sociologists.) *Sentiments* are "socially constructed pattern[s] of sensations, expressive gestures, and cultural meanings organized around a relationship to a social object, usually another person .... or group such as a family" (Gordon 1981, pp. 566,567); examples of sentiments include romantic love, parental love, loyalty, friendship, and patriotism, as well as more transient, acute emotional responses to social losses (sorrow, envy) and gains (pride, gratitude). As defined by Gordon, the term "sentiment" emphasizes relatively enduring social relationships as affect elicitors. The social emphasis in Gordon's definition helps focusing attention on what is important to sociologists about emotions, namely their social antecedents and their social acquisition and/or shaping.

In sum, e*motions* are more dynamic and episodic processes than *moods*, which are generally less intense (Mandler, 1983), longer lasting (Ekman, 1984) and not directed at specific stimuli (Parrott, 2001), although this distinction is more often made theoretically than empirically (Fredrickson, 2001). *Affect* is a broader term and can be defined as a valence evaluation in reference to the self (Baumeister, Vohs, DeWall, & Zhang, 2007). Put simply, affect indicates if something is good or bad for oneself. While this demarcation of the emotion concept provides no more than a working definition, it is adequate for the present purposes.

Basic Emotions

In emotions theory, there is a great debate on whether there is a set of basic emotion states i.e., if there is a set of primitives from which other emotions can be derived and how this set of basic emotions is defined, and if there is any functional difference between the basic and derived emotions. The notion of basic emotions is probably most known due to its association to universally recognized facial expressions, but this is only one side of the story. The debate within the framework of basic emotions is concerned with questions such as: How many emotions are basic? Which emotions are basic? No general consensus has been reached to answer these questions. The number of basic emotions suggested in the literature varies from 2 to 11 and the overlaps between the different sets of basic emotions are small (Edwards, 1999; Ortony & Turner, 1990).

One of the most accepted basic sets is the one defined by (Plutchik, 1980) who distinguished among eight basic emotions (Figure 14).

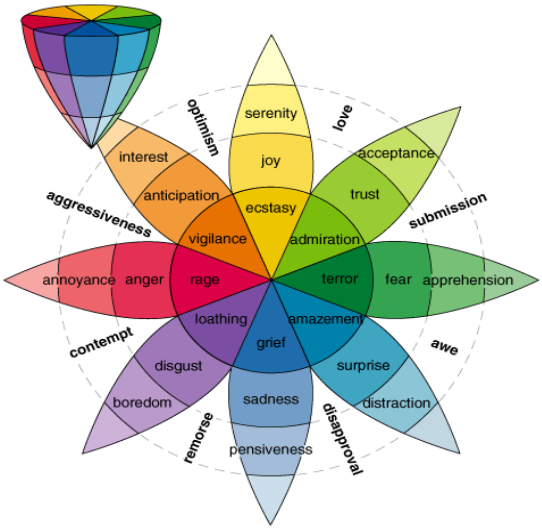

Figure 14 – Plutchick's Wheel of Emotions

Three-dimensional model describing the relations among emotion concepts which are analogous to the colors on the color wheel. The cone's vertical dimension represents intensity, and the circle represents degrees of similarity among the emotions. The eight sectors are designed to indicate that there are eight primary/basic emotion dimensions defined by the theory arranged as four pairs of opposites. In the exploded model the emotions in the blank spaces are the primary dyads-emotions that are mixtures of two of the primary emotions (Plutchik, 1980).

According to Ortony and Turner (1990), there are two main definitions of basic emotions. The first definition views the basic emotions as "biologically primitives" and the second definition views them as "psychologically primitives". These two views can be compatible (Ortony & Turner, 1990).

Biologically Primitives

Biologically, basic emotions are innate and serve survival functions developed through evolution. One consequence of this argument is that basic emotions should be found across human cultures and across species of higher animals. The most common method to study basic emotions is the observation of facial expressions (Darwin, 1979; Ekman, 1999; Izard, 1977; Plutchik, 1980; Tomkins, 1980). The main arguments in favor of the existence of basic emotions are studies carried out by Ekman (1992) and Izard (1971), showing that facial expressions of basic emotions are universally recognized. Ekman (1999) insists that the only existing emotions are the basic ones. A second consequence to view basic emotions as biologically primitives is that "one would except to find neurophysiological or anatomical evidence of them in all (normal) members of the species" but at the moment this evidence has not yet been found (Ortony & Turner, 1990, p. 320).

Psychologically Primitives

The psychological point of view of basic emotions aims to build a set of "psychologically irreducible" emotions, which means that these emotions would be building blocks for other emotions, and that they could not be composed of other emotions (Ortony & Turner, 1990). Within this view, basic emotions can be differentiated by appraisal conditions (Arnold, 1960) or by action readiness (Frijda, 1986).

2.2.3.3. Social Nature of Emotions

Averill (1980) in his social-constructivist perspective of emotion first argues that emotions are syndromes that occupy the entire person. With this he means that appraisals, physiological changes, expressions and action tendencies may all be typical of emotions (see 2.2.3) but none of these characteristics, either single or combined, is a necessary or sufficient condition for an emotion to occur, nor can emotion be reduced to them. Subsequently, he claims that the composition of such syndromes has to be derived primarily from the social context, because it is in this social context that emotions have functioning and meaning. Thus, Averill claims not just that emotions are best regarded as social phenomena, but even that the meaning of emotions cannot be properly understood by studying only their constituent elements.

Modern work on emotion is to some extent congruent with Averill's argument on the social nature of emotions, though it should be stated explicitly that this does not mean that intrapersonal (individual) functions of emotions should or have been ignored (Frijda, 1986) (Levenson, 1994, 1999; Oatley & Johnson-Laird, 1987; Tooby & Cosmides, 1990). Indeed, in the example of an individual that is walking down a dark alley and hear footsteps behind him, fear is clearly functional without being social.

Emotion theory also began to increasingly recognize the social nature of emotion. Manstead and Fischer (2001) introduced social appraisals in the appraisal theory by noting that other people's reactions to an emotional event are often also instrumental to

one's own appraisal process and subsequent emotion experience. For instance, the boss admiration may make a worker feel proud of an achievement him/her would otherwise regard as not worth mentioning. When emotions are expressed in face-to-face settings, 'primitive emotional recognition' may occur, caused by people's tendency to "automatically mimic and synchronize expressions, vocalizations, postures, and movements with those of another person and, consequently, to converge emotionally". But when it comes to computer-mediated interaction (and it can be also applied to collaborative networks), where mimicry is impossible, emotional contagion seems to occur (Friedman, et al., 2004; Thompson & Nadler, 2002; Van Kleef, De Dreu, & Manstead, 2004) suggesting that, to some extent, the emotional connotation of typewritten language is sufficient for people to unintentionally catch each other people's emotions (Derks, Fischer, & Bos, 2008). Nevertheless it should be taken into consideration if the emotional connotation in these cases is perceived correctly and will not lead to misunderstandings.

In this context, emotions are a social need because they give more information to the interactions and represent an important channel of communication with one-self and others. Thus, they play an important role in social interaction and rational thinking (Damasio, 1994). Emotion researchers have begun to document how interpersonal problems provoke specific emotions (e.g. (Averill, 1980; Miller & Leary, 1992)) and how the behavioral manifestations of these emotions trigger interpersonal interactions that can resolve the origination problem (Johnson-Laird & Oatley, 1992; Lutz & White, 1986).

While the emotion literature became more social, researchers also started to speculate more about how specific emotions were socially functional. There is now considerable consensus about these social functions (Frijda & Mesquita, 1994; Keltner & Gross, 1999). According to Keltner & Haidt (1999), emotions can be socially functional at four levels of analysis: *(i)* the individual (or intrapersonal); *(ii)* dyadic (or interpersonal – between two individuals); *(iii)* group (set of individuals that directly interact and has some temporal continuity); and *(iv)* cultural level (within a large group that shares beliefs, norms and cultural models).

At the individual level, emotional responses within the individual serve two broad social functions (Oatley & Jenkins, 1996). First, emotions *inform the individual* about social events and conditions that require attention or action (Campus, Campus, & Barret, 1989) and, second, emotion-related physiological (Levenson, 1992) and cognitive processes (Clore, 1994; Schwarz, 1991) *prepare the individual* to respond to those social interactions, even in the absence of any awareness of an eliciting event (Oatley & Jenkins, 1996).

At the dyadic level, the focus is on how emotions organize the interactions of individuals in meaningful relationships: *(i)* Emotional expression *helps individuals know other emotions, beliefs, and intentions* (Fridlund, 1992), thus rapidly coordinating social interactions, as when children rely on parents' facial emotion to assess whether ambiguous situations, stimuli, and people are safe or dangerous (Klinnert, Campos, Sorce, Emde, & Svejda, 1983); *(ii)* Emotional communication *evokes complementary and reciprocal emotions in others* that help individuals respond to significant social events, as when an embarrassed individual evokes amusement in others (Keltner, Young, & Buswell, 1997); and *(iii)* Emotions *serve as incentives or deterrents for other individual's social behavior* (Klinnert, et al., 1983).

At the group level of analysis, emotions help collections of interacting individuals who share common identities and goals meet their shared goals, or the super-ordinate goals of the group. Groups, such as families, work groups, or social clubs, are the systems with respect to which the functions of emotion are interpreted. Emotions *help individuals to define group boundaries and identify group members* (Durkheim, 1965), as is apparent when supporters cheer for their favorite team (Keltner & Haidt, 1999). In addition, within groups, the differential experience and display of emotion may *help individuals define and negotiate group-related roles and statuses* (e.g. (Clark, 1990; Collins, 1990)), for instance, higher status is typically attributed to angry than to sad man (Brescoll & Uhlmann, 2008; Tiedens, 2001). Furthermore, emotions may resolve certain group challenges, such as resource allocation, for example by solidifying the group bonds and thereby preventing discord or conflicts.

At the cultural level, finally, emotions allow people to shape their cultural identity, to teach cultural norms and values to their children and to preserve their cultural inheritance. Some of the social functions attributed to this level overlap with those at the group level of analysis.

Although all levels of analysis are to some extent relevant for this thesis purpose, the group level of analysis is of primary importance. Furthermore, the focus in this thesis is not what emotions *are*, but what emotions *do*, in particular in the context of collaborative networks. It therefore seems wise to provide a pragmatic definition of emotions in the virtual context, the "virtual emotions" concept. Thus, future research will rely on the contributions from the group level of analysis with the aim to create proper emotional interaction models based on phenomena such as:

- The differential distribution of emotion across group members (Collins, 1990; Kemper, 1993);
- Collective emotion (de Waal, 1996; Durkheim, 1965);
- Emotion directed at other groups (Frijda & Mesquita, 1994); and
- Role-related implications of emotional experience in group contexts (Clark, 1990).

2.2.4. Sociology of Emotions

"*Emotions are an important part of most societal dynamics*".
(Bar-Tal, Halperin, & de Rivera, 2007)

Over the past fifteen years there has been a great resurgence in interest in the nature and role of emotion in community and work contexts, and a growing recognition of the centrality of emotion, and on particular emotions like trust, in making connections between people. Increasingly theorists are attempting to integrate insights from divergent perspectives, and are using the *emotion lens* to re-examine many aspects of organizational and community life (Stanley & Burrows, 2001).

The understanding of the central role of emotions within social, organizational and political lens, with the acknowledgement of their potential to become a societal phenomenon, leads almost naturally to their examination as part of the intragroup and intergroup processes described before.

In this way, this section will examine those sociological approaches to understanding emotions and their application in interpersonal relationships and work and how some of these aspects could contribute to this thesis purposes.

2.2.4.1. Sociology

Emotion is a relatively new substantive topic in sociology. The growing interest on emotion is evident since the establishment of the Sociology of Emotions Section within the American Sociological Association in 1986. According to Thoits (1989), considerable gaps exist in social knowledge about emotions; in particular, little is known about distribution of different emotional experiences in the population, the content of emotion culture, emotional socialization processes, emotional interactions, and relationships between social structure and emotion norms.

Collective and Group-Based Emotions

Collective emotions have been defined in a relatively general way as emotions that are shared by large numbers of individuals in a certain society (Stephan & Stephan, 2000) while g*roup-based emotions* are defined as emotions that are felt by individuals as a result of their membership in a certain group or society (Smith, 1993).

According to Bar-Tal, et al. (2007), both concepts suggest that individuals may experience emotions, not necessarily in response to their personal life events, but also in reaction to collective or societal experiences in which only a part of the group members have taken part. But while the former concept suggests that group members may share the same emotions for a number of different reasons, the latter refers only to emotions that individuals experience as a result of identifying themselves with their fellow group members part (Bar-Tal, et al., 2007).

The initial work by de Riviera (1992) focused on the context in which collective emotions are evoked. He suggested that it is important to differentiate emotional atmosphere from emotional culture and emotional climate: *emotional atmosphere* or *collective mood* refers to the collective behavior that a group or society may manifest when it is focused on a common event, rather than to the emotional relationships between members of the society. Such an atmosphere appears when those who identify with a group celebrate a collective success, lament a tragedy, or suffer a common threat.

Emotional culture refers to the emotional relations that are socialized in a particular culture while e*motional climate* refers to the collective emotions experienced as a result of a society's response to its sociopolitical conditions. Thus, in times of political repression, people are afraid of expressing their ideas in public; in times of ethnic tension, there is hate and/or fear toward other groups, and so on. Emotional climate is more stable than emotional atmosphere (de Rivera, 1992) and may be a useful construct for analyzing social dynamics in contexts of political violence (Conejero & Etxebarria, 2007).

A number of scholars have also pointed to the important behavioral implications of collective or group-based emotions when there are conflicts between groups and societies (Bar-Tal, 2007; Petersen, 2002; Volkan, 1997). Moreover, Bar-Tal, et al. (2007)

argue that the emotional element of context has great potential to influence emotional reactions and subsequent behavior. Furthermore, they proposed that, in contrast to individual emotions which are sometimes related to a dispositional system or physiological mechanism, collective or group-based emotions are solely formed as a consequence of experiences in a particular societal context. Society members experience collective emotions not only as a result of directly experiencing events that evoke particular emotion but also by identifications with the society as a collective.

To this thesis purposes, collective emotions will be further researched in order to find mechanisms to apply all the related aspects to the collaborative emotions that are felt within collaborative networks. Nevertheless, one important challenge for this thesis development is finding models and methods to measure, or identifying these emotions within CNs.

2.2.4.2. Social Work

Emotions at Work

Until recently, emotions at work have not gained the attention of the researchers working in the field of organizational life (Ashforth & Humphrey, 1995; Ashkanasy, et al., 2000; Fineman, 2000, 2003; Payne & Cooper, 2001). In what concerns single organizations, several researchers have conducted studies on how emotions influence people and the organization as a whole. Some have argued that the everyday emotions people feel at work have been surprisingly neglected (Ashforth & Humphrey, 1995), given the fact that they are part of the organizational routine. Others noted that the research around workplace emotions has focused on affective states like satisfaction or boredom, commitment, mood, and work stress or simply on positive and negative emotions (Fineman, 2000).

Rafaeli, Semmer, & Tschan (2010) also wrote that the study of emotion in organizations concentrated on the antecedents and consequences of individual effort. Truly, several studies have chosen a narrow angle, usually being the investigation of a particular emotion, especially employee's anger (Domagalski & Steelman, 2005), the consequences of emotions (Diefendorff & Richard, 2003; Fisher, 2002), the concept of emotional labor (Grandey, 2000; Wharton, 1993) or they point to the multiple organizational processes and organizational power relations such as decision making, motivation, leadership, and genders (Domagalski & Steelman, 2005; Pirola-Merlo, Hartel, Mann, & Hirst, 2002).

While in the past decades people were told to leave their emotions at home, now more and more researchers stress the importance of emotions in organizational life (Fineman, 1993). Ostell, Baverstock, & Wright (1999) discuss this variety of emotions supporting that employees could be thrilled at gaining a promotion, show fear for a job loss, be excited by a new project, be furious about their managers' behavior and even become jealous of a colleagues' success.

Interestingly, work conditions and stressful events can emotionally affect workgroups (Brief & Weiss, 2002), while multiple role juggling – that is when people are simultaneously involved in different roles – has a negative effects on task enjoyment and daily mood (Williams, Suls, Alliger, Learner, & Wan, 1991).

The literature also informs that employees' emotions do not necessarily stay restricted to one employee. Instead emotions seem to be contagious (Hatfield et at., 1994), as people have the tendency to influence the emotions of others during their encounters and synchronize themselves emotionally by feeling what the other is feeling, or by experiencing a complementary emotion. Just watching the emotions of someone else is often enough to share these emotions to some degree, giving support to authors (e.g. Harré, 1986) who have written about the social consequences of emotion on others.

Emotion Labor or Emotion Work

In *The Managed Heart: Commercialization of Human Feeling (1983)*, Arlie Hochschild defined the concept of emotion work or emotion labor in terms of requirements or expectations at work to pretend emotions that were not genuinely felt (e.g. the forced niceness and inauthentic smile in a customer service interaction). She argued that emotion work alienates people from their emotions and creates a state of emotional dissonance between displayed emotions and actual feelings that over time, if not resolved, can have profound negative health impacts (Tanner, 2005). As Lazarus and other researchers have demonstrated, personal emotional control is a significant element of psychological and physiological wellbeing. While more recent research has supported the broadly negative connotations of emotion labor, there is currently less of an 'all-or-nothing' view of it (Ollilainen, 2000). Mumby & Putnam (1992) define emotional labor as "the way individuals change or manage emotions to make them appropriate or consistent with a situation, a role, or an expected organizational behavior." Most professions have unwritten emotion display rules, e.g. nurses being empathetic and caring; police or debt collectors showing anger and impatience (Rafaeli & Sutton, 1991). At times, emotional detachment may be a functional way of coping with a very stressful or difficult job, e.g. medical personnel dealing with death.

Emotional Intelligence and Emotional Competence

According to Goleman (1998), *emotional intelligence* refers to "the capacity for recognizing our own feelings and those of others, for motivating ourselves, and for managing emotion in ourselves as well as in our relationships". It describes abilities distinct from, but complementary to, academic intelligence, the purely cognitive capacities measured by IQ. Many people who are 'book smart' but lack emotional intelligence end up working for people who have lower IQs than them but who excel in emotional intelligence skills. These two different kinds of intelligence – intellectual and emotional – express the activity of different parts of the brain.

Among the most influential theorists of intelligence to point out the distinction between intellectual and emotional capacities was Howard Gardner, a Harvard psychologist, who proposed in 1983 a widely regarded model of "multiple intelligence"[2] (Gardner, 1983). His list of seven kinds of intelligence included not just the familiar verbal and math

[2] In addition to the standard cognitive abilities like mathematical reasoning and verbal fluency (as well as intelligences in domains like movement and music), Gardner proposed that there are "personal intelligences": one for managing oneself and another for handling relationships. But in Gardner's descriptions of the personal intelligences, he emphasized the cognitive elements of these personal intelligences, little exploring the crucial role of emotions in these areas.

abilities, but also two "personal" varieties: knowing one's inner world and social adapteness.

A comprehensive theory of emotional intelligence was proposed in 1990 by two psychologists, Peter Salovey, at Yale, and John Mayer (Salovey & Mayer, 1990). They proposed a model of emotional intelligence as: "a set of skills hypothesized to contribute to the accurate appraisal and expression of emotion in oneself and in others, the effective regulation of emotion in self and others, and the use of feelings to motivate, plan and achieve in one's life." Another pioneering model of emotional intelligence was proposed in the 1980s by Reuven Bar-On, an Israeli psychologist (Bar-On, 1988). And in recent years several other theorists have proposed variations on the same idea.

Salovey and Mayer defined emotional intelligence as: "a form of social intelligence that involves the ability to monitor one's own and others feelings and emotions, to discriminate among them, and to use this information to guide one's thinking and action" (Salovey & Mayer, 1990). While they (Salovey and Mayer) have continued fine-tune the theory, Goleman has adapted their model into a version he found most useful for understanding how these talents mater in work life. Goleman's adaptation includes the following five basic emotional and social competencies:

- *Self-Awareness*: Knowing what we are feeling at the moment, and using those preferences to guide our decision making; having a realistic assessment of our own abilities and well-grounded sense of self-confidence.

- *Self-Regulation*: Handling our emotions so that they facilitate rather than interfere with the task at hand; being conscientious and delaying gratification to pursue goals; recovering well from emotional distress.

- *Motivation*: Using our deepest preferences to move and guide us toward our goals, to help us take initiative and strive to improve, and to persevere in the face of setbacks and frustrations.

- *Empathy*: Sensing what people are feeling, being able to take their perspective, and cultivating rapport and attunement with a broad diversity of people.

- *Social Skills*: Handling emotions in relationships well and accurately reading social situations and networks; interacting smoothly; using these skills to persuade and lead, negotiate and settle disputes, for cooperation and team work.

Goleman's model (2002) has since been simplified still further, into four 'competency clusters':

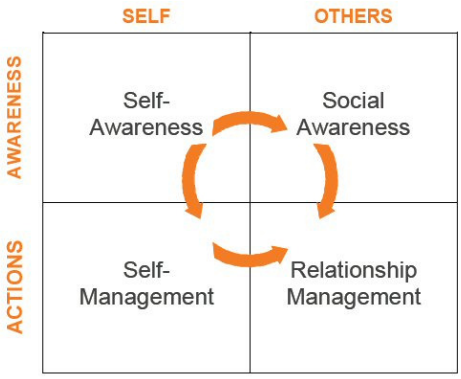

Figure 15 – A Model of Emotional Intelligence (Goleman, et al., 2002)

Thus far it has been described that "emotional intelligence" is important for the success either of people's work and life and organizations. Nevertheless, this notion might be to some extent simplistic and misleading. Some researchers (Goleman, 1998; Mayer, Salovey, & Caruso, 2008) have argued that by itself emotional intelligence probably is not a good predictor of job performance. Rather, it provides the bedrock for competencies that are. Goleman has tried to represent this idea by making a distinction between emotional intelligence and emotional competency. Emotional competence refers to the personal and social skills that lead to superior performance in the world of work. "The emotional competencies are linked to and based on emotional intelligence. A certain level of emotional intelligence is necessary to learn the emotional competencies" (Gowing, 2001). For instance, the ability to recognize accurately what another person is feeling enables one to develop a specific competency such as *influence*. Similarly, people who are better able to regulate their emotions will find it easier to develop a competency such as *initiative* or *achievement drive* (Goleman, 1998). Ultimately it is these social and emotional competencies that are needed to identify and measure if the prediction of performance will be possible.

In the context of the planned thesis, all of these concepts are a starting point to better understand the emotions in groups and in different contexts/environments, which will assist in the identification and creation of collaborative network's and participant's emotional models. This will also facilitate the formulation of new approaches to conflict resolution as well as the definition of advanced governance strategies that promote emotional health at the network level, and constitute a basis for the design of self-healing mechanisms.

Monitoring the interactions within the business ecosystem will provide multi-modal emotional input for achieving awareness of the individual as well as the collective emotional state. Emotional intelligence in appraising and evaluating the interaction with respect to the overall benefits for the CN will open the way for devising effective pro-active mediation mechanisms. Affective interaction protocols will be specified, extending the notion of social interaction protocol, and will take into account the wider spectrum of emotion, mood and behavior, of both the individuals and the CN as a whole. Effective mediation is only possible through proper communication with partners. Therefore, both affective approaches and social protocols play major roles in effective mediation in collaborative networks.

2.2.5. Affective Computing

In computer science, affective computing is a branch of the study and development of artificial intelligence that deals with the design of systems and devices that can recognize, interpret, and process human emotions. It is an interdisciplinary field spanning computer sciences, psychology, and cognitive sciences. While the origins of the field may be traced as far back as to early philosophical enquiries into emotion, the more modern branch of computer science originated with Rosalind Picard's (1995) paper on affective computing.

It is then a young filed of research dealing with issues regarding emotions and computers that has as aim to give answers to questions such as what is the foundation of recognizing, understanding and expressing emotions (in and through computers)? And how can we build a computer able to *feel*?

A motivation for the research is the ability to simulate empathy. The machine should interpret the emotional state of humans and adapt its behavior to them, giving an appropriate response for those emotions. Recent scientific findings indicate that emotions play an essential role in decision making, perception, learning, memory and more (R. W. Picard, et al., 2004; Vesterinen, 2001). They influence the very mechanisms of rational thinking.

Emotions and Computers

According to Vesterinen (2001), affective computing consists of four related areas: *(i)* recognizing emotions; *(ii)* expressing emotions; *(iii)* having emotions; and *(iv)* emotional intelligence. The first two are essential for communication, the third deals with the question of if it is possible computers to feel and the last one relates emotional intelligence (see 2.2.4.2) with computers, i.e. if they are able to have emotional intelligence.

1. Recognizing Emotions

   The foundation of affective computing will be the ability to recognize emotions, to infer an emotional state from observation of emotional expressions and through reasoning about an emotion-generating situation.

   For recognizing ordinary human emotions computer needs human senses like audio and video, gathering facial expressions and vocal intonations. Additionally, it can sense inputs that may not have analogs in human senses – reading infrared temperature, measuring electro thermal conductivity, and so forth. Once emotional expressions are sensed and recognized, the system can use its knowledge about emotion generation and situation to infer the underlying emotional state that most probably gave rise to the expressions.

   In this context, detecting emotional information might begin with passive sensors which capture data about the user's physical state or behavior without interpreting the input. The data gathered is analogous to the cues humans use to perceive emotions in others.

2. Expressing Emotions

   A computer can express emotion without actually having emotions, just as actors can express emotions that they do not have. The basic requirement for a computer to express emotions is to have channels of communication such as voice, image, and an ability to communicate affection over those channels. The ways of expressing emotion could be human, like showing a face, to easily communicate the emotion to human users. It could be also something totally different and new, as computers are not humans and don't genuinely have the same ways of expression.

3. Having Emotions

   Can computers *feel?* Certainly this is the most profound question in the field of affective computing. Feelings are usually considered to be the division between a human and a machine. The question is closely related to the issue of computers having consciousness, which is an even more debated issue. Consciousness is also a prerequisite for many human emotions, like shame and guilt – if you don't have consciousness, there's no reason to be ashamed of anything.

   Picard (1997) proposes a model of five components that all should be present in a system if it is to have emotions, which are: emergent emotions, primary emotions, cognitive emotions, emotional experience and body-mind interactions.

4. Emotional Intelligence

   A computer with emotional intelligence will be one that is skilled at understanding and expressing its own emotions, recognizing emotion in others, regulating affect, and using moods and emotions to motivate adaptive behaviors. These components of emotional intelligence rely on the three abilities of affective computing presented above: recognizing and expressing emotions, and "having" emotions. Computers that have emotions have to be aware of them, and will need to be able to regulate and utilize them.

Conducted Research

According to MIT (2010), affective computing research has contributed to: (1) Designing new ways for people to communicate affective-cognitive states, especially through creation of novel wearable sensors and new machine learning algorithms that jointly analyze multimodal channels of information; (2) Creating new techniques to assess frustration, stress, and mood indirectly, through natural interaction and conversation; (3) Showing how computers can be more emotionally intelligent, especially responding to a person's frustration in a way that reduces negative feelings; (4) Inventing personal technologies for improving self-awareness of affective state and its selective communication to others; (5) Increasing understanding of how affect influences personal health; and (6) Pioneering studies examining ethical issues in affective computing. Figure 16 gives an illustration of these research areas.

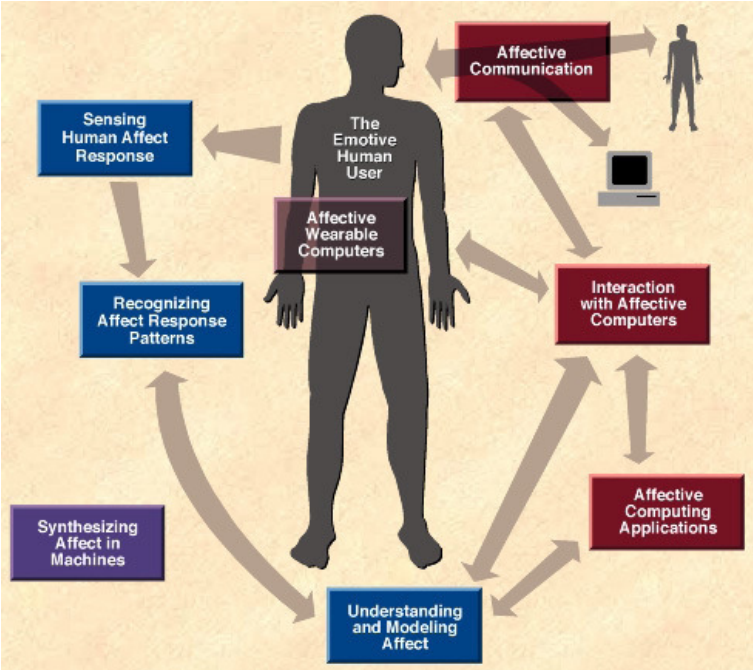

Figure 16 – The research areas of affective computing as visualized by MIT (2001)

In addition, several EC projects made substantial contributions to research in affective computing area such as NECA[3], ERMIS[4], ICEA[5], etc. The EC Network of Excellence HUMAINE[6] brings together many of the most active teams with the goal of structuring the research area.

Summing up, affective computing deals with computers that can recognize express and even *feel* emotions like humans do. It has to do with the human-machine interaction and with building up computing devices that would be able to understand and communicate emotions between computers and humans. Wearable computers represent one natural application field but, as seen above, much more applications are under research.

For this thesis purposes, the issue of emotional interactions (within a community) through computer networks is of more importance than the affective interactions with the computer. Nevertheless, the area of affective computing would contribute as an input to this work.

Specifically for collaborative networks further research is needed to enhance the development of a conceptual base for behavioral modeling, data-mining / machine learning approaches for behavioral patterns discovery, forecasts and simulation methods and tools for behavioral analysis. Furthermore, models and tools need to be designed and developed for supporting management of emotional health of collaborative networks.

[3] NECA Project - http://www.ai.univie.ac.at/NECA

[4] ERMIS Project - http://www.image.ntua.gr/ermis/

[5] ICEA Project – http://www2.his.se/icea/

[6] HUMAINE - http://emotion-research.net/

2.3. Supervision and Self-Healing Systems

Inspired by biology, self-healing has evolved as a property of IT systems that enables such systems to diagnose themselves and react to faults such that a satisfactory mode of operation is restored after the occurrence of a fault or a failure (Rodosek, Geihs, Schmeck, & Stiller, 2009). Self-healing is not confined to a certain class of IT systems but covers the broad span of computing from applications over system software to networking, from small embedded devices over personal computers to power grids.

Self-healing is also commonly used in psychological and social domains to resolve societal conflicts. It is defined as a process by which a party repairs the damage incurred over the course of (social) conflict, independent of the other party in the conflict (Nets, 2005). In this perspective, healing aims at least partly, to reduce the negative aspects caused by the conflict (Frankel, 1998). According to Nets-Zehngut & Bar-Tal (2007) "self-healing refers to healing on the level of the society considered as an entity, and implies that the healing takes place by the party itself, without collaborating with the other party in the conflict".

In this context, the adoption of these social concepts together with the self-healing systems of the IT software engineering domain will contribute to the advanced emotional self-regulation mechanisms that need to be developed and established in CNs in order to give dynamic responses to emotional changes maintaining in this way a healthy emotional network.

2.3.1. Terminology

The term self-healing can be found in numerous research works from different research areas (Jonas & A.Chez, 2004; Nets, 2005). Nevertheless, it is on the IT systems area that it is mostly explored and applied.

Self-healing is commonly associated to the IBM's autonomic computing concept (Horn, 2001; Kephart & Chess, 2003) and "self" systems introducing a very large research area that involves different aspects and several facets of Information Technology.

According to IBM, the essence of autonomic computing systems is self-management, the intent of which is to free system administrators from the details of system operation and maintenance, limiting in this way, hands-on intervention in case of exceptional situations. Like their biological namesakes (ANS – Autonomic Nervous System), autonomic systems will maintain and adjust their operation in the face of failure, changing components, workloads, demands, and external conditions and in the face of hardware or software failures, both innocent and malicious. In this context, the autonomic system continually monitors its own use.

IBM frequently cites four aspects of self-management that are: self-configuring, self-optimization, and self-protecting, which Figure 17 summarizes.

Concept	Current computing	Autonomic computing
Self-configuration	Corporate data centers have multiple vendors and platforms. Installing, configuring, and integrating systems is time consuming and error prone.	Automated configuration of components and systems follows high-level policies. Rest of system adjusts automatically and seamlessly.
Self-optimization	Systems have hundreds of manually set, nonlinear tuning parameters, and their number increases with each release.	Components and systems continually seek opportunities to improve their own performance and efficiency.
Self-healing	Problem determination in large, complex systems can take a team of programmers weeks.	System automatically detects, diagnoses, and repairs localized software and hardware problems.
Self-protection	Detection of and recovery from attacks and cascading failures is manual.	System automatically defends against malicious attacks or cascading failures. It uses early warning to anticipate and prevent systemwide failures.

Figure 17 – Four aspects of self-management (current vs. autonomic computing) (Kephart & Chess, 2003)

In 2004, David Tosi claims that the classification provided by IBM does not explain the interactions, overlap and similarities among the four aspects. Furthermore, Tosi even highlights that, in other contexts, self-managed solutions have been proposed to address environment changes and component upgrade, and have been identified as self-adaptive and self-organizing. Figure 18 shows a possible schematization of these concepts.

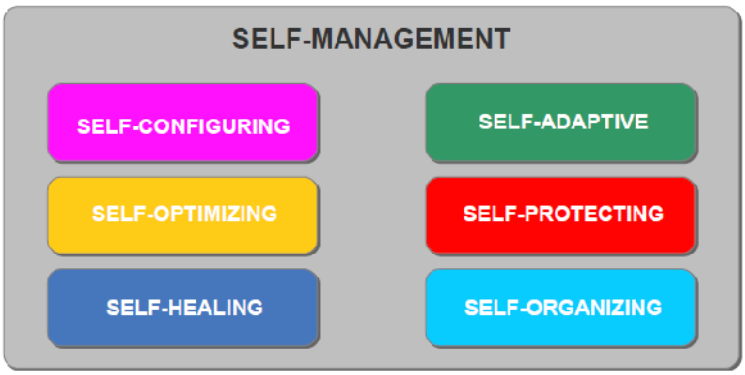

Figure 18 – Self Categories (Tosi, 2004)

More recently, Rodosek, et al. (2009) also developed the taxonomy presented in Table 3. The authors claim that from a practical point of view it does not pay off to differentiate those terms that appear in the same cell, which refutes the Tosi's classification. In addition they argue that self-healing is (almost 100%) synonymous to self-repairing, self-regeneration and self-immunity. These terms describe a system that can make by itself all necessary recovery steps to restore its distributed behavior to a specified mode of operations. Furthermore, terms such as self-optimizing related with self-tuning, self-protecting and self-managing are circulating. They provide a definition of a self-stabilizing system in terms of that a self-stabilizing system arrives at a legitimate state in a finite number of steps regardless of its initial state.

Self-Managing *Self-organizing* *Self-adapting*	A system continuously perceives its own state of its environment and reacts to certain events in order to maintain a high degree of usefulness without a human in the loop.	
	Self-Healing *Self-repairing* *Self-regenerating* *Self-immunity*	A system can make by itself all necessary recovery steps to restore its disturbed behavior to a specified mode of operation.
	Self-Optimizing *Self-tuning*	A system optimizes its use of resources; it may decide to initiate a change in an attempt to improve its performance or quality of service. This optimization action may seem proactive from the perspective of a self-healing system design, but nevertheless it is reactive because it monitors the performance and decides to act when some specified condition is reached.
	Self-Protection	A system protects itself form malicious attacks as well as potential erroneous states but also from end users who inadvertently make software changes, for example, by deleting an important file.
	Self-Stabilizing	A system is self-stabilized when, regardless its initial state, it is guaranteed to arrive at a legitimate state in a finite number of steps.

Table 3 - Taxonomy of Self-* Systems (Rodosek, et al., 2009)

Other taxonomies/terminologies of self-management systems as well as other self-* terms have been proposed in the last years (Tianfield & Unland, 2004), nevertheless almost all of them have the IBM's classification as basis.

A very interesting classification that helps understanding the differences and similarities among various autonomic computing research areas, including self-healing systems, and their dimensions is the one suggested by David Tosi and illustrated in Figure 19.

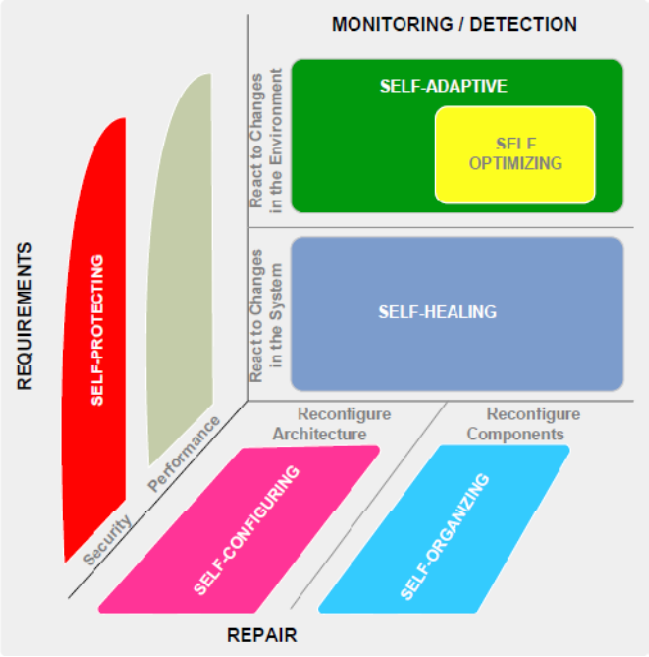

Figure 19 – A detailed Self-Management Classification (Tosi, 2004)

2.3.2. Self-Healing Mechanisms

Self-healing can be defined as the property that enables a system to perceive that it is not operating correctly and, without (or with) human intervention, makes the necessary adjustments to restore itself to normalcy. Healing systems that require human intervention or intervention of an agent external to the system can be categorized as assisted-healing systems (Ghosh, Sharman, Rao, & Upadhyaya, 2007). In this context, healing systems are more concerned about post-fault or post-attack states; they are focused to a greater degree upon the healing process and upon bringing the system back to "normal".

Self-healing systems can support decision making in a large way for managerial and organizational situations. As these systems are typically recovery oriented, they can take their own decision on how to come back to normalcy from a broken state. Many of the decision support systems (DSS) offer passive forms of decision support, where the decision-making process depends upon the user's initiative. But self-healing systems can offer an active form of decision support, without human intervention they can detect the fault, diagnose and recover from the fault. Also, with intelligent architectural models, a self-healing system can select the proper repair plan to deploy the broken component, if there is more than one component that needs to be healed; they can prioritize a faulty component over the others, etc. Such active involvement is especially needed in complex decision-making environments (Ghosh, et al., 2007).

Design for self-healing introduces features that enable detecting run-time failures and identifying and isolating faulty behaviors of components and services and support the following main phases:

- Detecting failures (Failure Detection) or monitoring
- Diagnosing (Fault Diagnosis)
- Healing faults (Fault Healing)
- Verify the changes (Validation)

Examples of application of self-healing systems:

1. Grid Computing (Cheng, Garlan, Schmerl, Steenkiste, & Hu, 2002);
2. Software agent-based self-healing architecture (Huhns, Holderfield, & Gutierrez, 2003);
3. Service discovery systems (Dabrowski & Mills, 2002);
4. Reflective middleware (Blair, et al., 2002; Kon, et al., 2000; Narasimhan, Moser, & Melliar-Smith, 2002);
5. GRACE approach (Adve, et al., 2002);
6. Clustering (Corsava & Getov, 2002).

2.3.3. Healthy vs. Unhealthy Systems

Before a system can make adjustments necessary to restore itself to normalcy, it needs to be cognizant of what constitutes "normalcy" in its operations and be attentive to

deviations there from. Therefore, it is important to define the criteria for a "healthy" system and identify thresholds indicative of the need to initiate a healing process (Ghosh, et al., 2007).

The distinction between "healthy" and "broken" is often indistinct and fuzzy, and often there is a gradual transition between these two states; a system often does not break down recognizably but deteriorates over time. Thus we can say there is a fuzzy zone, a degraded state, separating acceptable and unacceptable behavior of a system, which again depends on user preferences and environmental changes.

In summary, it is difficult to draw a discrete separation between "healthy" and "unhealthy" states of a system as the transition in between the two states is not abrupt. What is generally obtained is a gradual transition from one state to another, this deterioration forming a "fuzzy zone" of behavior. It is important that a self-healing system discerns this progressive decline, and also identifies a definite threshold to initiate rectification at, and thereby maintain its health. In the context of this thesis, it will also be extremely difficult to differentiate between the emotional "healthy" and "unhealthy" states. This, along with the question whether the healing is achieved with or without human intervention constitutes an important research challenge.

2.3.4. Conclusion

The goal of self-healing systems is to design and develop survivable systems that are reliable, highly available and dependable. Self-healing systems are an integral part of most biological systems, which exhibit properties such as adaptation, mutation, self-preservation, etc. These mechanisms provide good inspiration and a rich source of ideas.

The structure of self-healing systems can be quite modular (for example, failure detection, diagnosis, system recovery and maintenance of health). This provides possibilities to improve and generate various types of architectures for the different modules. Typically self-healing systems are based on different paradigms of computational models (such as, architectural models, repair plans, agent-based models) or by imitating natural (biological) models, so the opportunity to develop systems based on new sources of inspiration is substantial.

Much of the literature focuses on repair plans for single process systems. However there is a great lacunae of work that relates to distributed architectures which are increasingly becoming commonplace. Undoubtedly recovery issues relating to distributed systems are more complex for a variety of reasons. This is therefore a new area for research as it relates to self-healing systems.

New research directions also include the creation of systems and architectures that have system-behavior prediction models appended to the system maintenance schema in self-healing systems. An intelligent adaptation of machine learning algorithm can automatically classify and predict the system behavior based on execution data. The analysis can also lead to learning about behaviors before the occurrence of certain states of the system and this can then be used for predictive purposes (perhaps with the help of learning in multi-agent systems).

Self-healing systems are interactive, flexible and adaptive computer-based information system. Such systems can be developed for supporting the solution of a non-structured management problem for improved decision making. Self-healing systems are relatively new both for the academia and the industry points of view. However, there are a large number of systems, software and architectures that borrow ideas and concepts from nature. Biological systems have exhibited characteristics such as evolution, adaptation, self and assisted healing including social networking. These are good models to emulate and recreate to provide the necessary functionality for the emotions-regulation supervision system that is envisioned in this thesis hypothesis.

Chapter 3

Research Methodology

3.1. Aimed Contribution

In order to give answers to the proposed research questions, the adopted approach will develop a collaborative network emotions-oriented supervision system that will comprise the following main blocks:

1. Modeling Design

    a. Building a conceptual framework aimed at developing a working definition of the involved concepts and their relationships.
    b. Building formal models of emotions and emotional interactions within the context of collaborative networks.

2. Self-Healing Methods and Mechanisms

    a. Elaboration of methods for perceiving and classifying collective emotions.
    b. Identification of the main emotions-related functionalities within CNs.
    c. Elaboration of emotional proactive mediation mechanisms.
    d. Creation of an emotions-regulation architecture based on the software models for self-healing.

3. Prototype Tool

    a. Development of a software tool that supports the emotions-oriented supervision system integrating the identified emotions-related functionalities and focusing on supporting the monitoring of collaborative emotions.

3.2. Detailed Work Plan and Scheduling

The work plan and scheduling of this thesis is following the phases of the classical research method as illustrated in the following figure:

Figure 20 – Classical Research Method

First Year [2008/2009]

1. Courses component of the PhD program.
2. Research on the SoA and the definition of the research question. (preliminary version is detailed in the Literature Review Chapter)

Second Year [2009/2010]

1. Definition of base/working concepts along with updates of the research on the SoA.
2. Development of the modeling design of emotions in collaborative networks.
3. Starting the elaboration of methods and mechanisms for self-regulation of emotions.

Third Year [2010/2011]

1. Finalization of the development of the modeling design of emotions in collaborative networks.
2. Elaboration of methods and mechanisms for self-regulation of emotions.
3. Specification of the emotion-oriented architecture.
4. Development of the software tool.

Fourth Year [2011/2012]

1. Finalization of the software tool.
2. Validation and analysis of the results.
3. Refinements and thesis writing.

3.3. Validation Methodology

The validation will be comprised into three fundamental aspects:

- Through acceptation of this thesis work in International Journals and Conferences indexed in the Web of Science.
- Through the integration of part of this work within European projects having in this way, access to some networks that are expected to be interested in giving the opportunity of testing the developments.
- Through scientific research peers.
- Through interactions with collaborative networks managers.

3.4. Dissemination Plan

This work dissemination will rely on submitting/publishing in International Journals and Conferences indexed in the Web of Science. In this context, the following table illustrates a tentative dissemination plan.

Dissemination Channel	Name	Date
Conferences	INES - IEEE International Conference on Intelligent Engineering Systems	June 2011
	PRO-VE - IFIP Working Conference on VIRTUAL ENTERPRISES	October 2011
	DoCEIS - Doctoral Conference on Computing, Electrical and Industrial Systems	February 2012
	ICEIS - International Conference on Enterprise Information Systems **or** CTS – International Symposium on Collaborative Technologies and Systems **or** DEST - IEEE International Conference on Digital Ecosystems and Technologies	June 2012 May 2012
Journals	IEEE Transactions on Systems, Man, and Cybernetics	2012
	Computers in Industry **or** Computers & Industrial Engineering	2012
	FGCS - Journal of Future Generation Computer Systems **or** Information Systems Frontiers **or** Engineering Applications of Artificial Intelligence	2012

Table 4 – Dissemination Intentions Plan

3.5. Integration with other Research Activities

This thesis work is building upon the results of previous projects in the area of collaborative networks (ECOLEAD FP6 2004-2008; ePAL FP7 2008-2010; BRAID FP7 2010-2012), and aims to integrate new proposals for the future within the CoDIS group from the UNINOVA institute.

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