AUTOPOIETIC SOCIETIES: A HERMENEUTIC APPROACH TO SOCIO-COGNITIVE ENGINEERING

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After having presented an epistemological overview of state-of-art knowledge management practices, this paper proposes the adoption of the "Socio-Cognitive Engineering" paradigm in order to both understand the nature of cognition and provide a new framework for knowledge management implementation. Socio-Cognitive Engineering is defined as a multi-disciplinary research field which aims at engineering the social conditions from which knowledge can emerge among the agents (biological or virtual) of an *autopoietic* society. In this perceptive, knowledge and intelligence are presented as dependent on the existence of a society, and, reciprocally, the notion of society is directly linked to the occurrence of semiotic enactions (mutually constitutive semantic interactions). Four socio-cognitive approaches, which allow the engineering of conditions for knowledge emergence, are then presented and illustrated with examples. The issue of protecting knowledge is also addressed in a socio-cognitive perspective, and some ethical considerations are proposed, in the context of knowledge ecology.

Keywords: Knowledge Management, Socio-Cognitive Engineering, Autopoiesis, Phenomenology, Epistemology, Hermeneutics.

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A Hermeneutic Approach to Socio-Cognitive Engineering

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1 Introduction

"Know your adversary and know yourself as well, and if you have a hundred battles to engage, you will be a hundred time victorious. If you ignore your adversary and know yourself, your chances of winning or being defeated will be identical. If you ignore yourself as well as your adversary, you will count all your battles with defeats."(Sun Tzu in Barros Cassal, 2002: 43). More than two thousand and five hundred years ago, the well-known Chinese military strategist and philosopher Sun Tzu was already claiming that managing knowledge was a critical factor for businesses' (battles') success. Thus, it seems clear that this idea is not new. What has changes then? Why does the so-called "knowledge management" seem to be the great executive revolution of the new

century? Why have such diverse successful companies, like, for instance, Siemens (Davenport and Probst, 2002), Nortel Networks or Xerox (Terra and Gordon, 2003) invested during the last five years a huge amount of time and resources for implementing a bench of so-called “Knowledge Management Practices”? After several years of academic and practitioners focus on knowledge management issues, the answer became quite clear: what has really changed during the last twenty years **is the business context**. Doing business in the XXIst century means doing business in worldwide electronically connected network of networks, where all the information, which needs be accessed in order to know yourself better, as well as your partners and competitors, is virtually available. How to transform this potential omniscience in actual competitive advantage is a first concrete way to look at knowledge management. Moreover, the businesses of the XXIst century have to be conducted in a pos-industrial economy, where intangible assets are much more valuable than tangible assets (Sveiby, 1997). As pointed out by modern strategies’ tracking methodologies, such as Norton & Kaplan’s Balanced Scorecards (Norton and Kaplan, 1996), in nowadays’ context, an exclusive financial perspective on businesses is insufficient: it is also needed to take into account, for instance, external and internal image perspectives, or process and innovation’s capabilities visions. In a world where real-time innovation is required to maintain market’s leadership, it has became a pre-requirement to be able to access systematically to the right information at the right moment, to acquire efficiently this information in order to turn it part of the “corporate knowledge”, and to put finally the learned ideas into action as quickly as possible.

However, it is not because the context where they are being asked is new that the questions behind the idea of managing knowledge are original. Effectively what is really at stake, with knowledge management, continues to be the understanding of the nature of cognition: **a recurrent and recursive search on the nature of consciousness**. Pragmatically speaking, before starting to manage knowledge, a company always have to make (consciously or not) some epistemological decisions on the nature of what will be managed (is it information, documents, people, communication between people, something else?). Even if this epistemological prolegomena is often considered useless, as it seems to be purely theoretical, we believe on the contrary that it is essential, as it will be the starting point, which will fully orient both technologies and methodologies that will be implemented to achieve the objective of managing knowledge. Therefore this paper will propose an analysis of state-of-art knowledge management practices based on an epistemological investigation on the nature of knowledge, before proposing the Socio-Cognitive Engineering research program as a

new paradigm for both understanding the nature of cognition and implementing adequately knowledge management practices inside organizations. In order to be more didactic, several examples will be used as empirical support to the epistemological concepts presented.

2 On the Nature of Knowledge

The second section of this paper do not intend to provide an exhaustive and in-depth analysis of thousands of years of epistemological interrogations on the nature of knowledge, but rather to propose a quick overview of the main approaches to cognition, from antic philosophy to modern phenomenology and biological constructivism, in order to understand better some of the classical choices which are made in organizations, when they decide to "manage knowledge". This quick investigation will allow us to propose the *Autpoiesis* (the theory of biological autonomy) as a paradigmatic choice for describing what will be described as the "Socio-Cognitive Engineering" research program.

2.1 Knowledge in the Antic Philosophy

Let us start pragmatically this investigation with the following question: how may I know that my client is satisfied? Probably because he told it to me, or maybe because he sent me a mail expressing his satisfaction. I may also have heard it from a third part, or even read it in a report. Actually, I can be quite convinced that my client liked my job, but I will never be fully sure of it. Let us then say that the knowledge of my client's satisfaction is a belief that has been sufficiently justified by facts to be assumed true. Plato (427 – 347 B.C.) would agree with us and tell that **knowledge is a "Justified true belief"** (Nonaka & Takeuchi, 1995). He would even go further by adding that there is only an "idea" of my client being happy, which is beyond the sensible world I am living in. This same vision of cognition can be recognized in Nonaka and Takeuchi's definition of "*tacit knowledge*" (tacit meaning personally linked to my own beliefs and lived experiences), and in the proposition of knowledge transfer through "*socialization*". For Nonaka & Takeuchi, sharing knowledge trough socialization means creating personal, durable and emotionally rich links between people. For instance, to solve the problem of automating the process of dough's preparation in the "Home Bakery" product development, the company Matsushita sent several engineers to work with

artisans in traditional bakeries, so that the tacit understanding of the preparation process could be socialized. This is a Platonic epistemological choice!

Of course, with a given decision always come drawbacks. Two of them should be mentioned here. Firstly, if knowledge is tacit, it can surely be shared, but it cannot be properly managed, since it cannot be measured. Effectively, in order to know if my client is satisfied, I can transfer this knowledge to me by socialization (by organizing a dinner with him, for instance), but I will not be able to say objectively *how much* he is satisfied. We will come back several times in this paper on this main shortcoming of what will be technically referred as "*phenomenological knowledge*". A second drawback of the Platonic approach is the fact that it is not very intuitive: Plato says that real knowledge is inside the "ideas" of things, from which my embodied nature takes me away. However, we have the opposite intuitive conviction that what we perceive is the truth. In other words: if I see that my client is happy, it is because he is *really* happy. That is exactly where Aristotle decides to oppose his philosophy to the one of his master Plato.

For Aristotle (384 – 322 B.C.), true knowledge can be found in the sensible world, and not in any transcendental "world of ideas". However, even if the Aristotelian approach appears to be more "pragmatic", it remains a phenomenological proposal. Effectively, **to *know*, for Aristotle, means to say with adequate words what my senses perceive**. Hence, the Aristotelian "syllogism" (the famous "*All men are mortal, and Socrates is a man, then Socrates is mortal*") is the correct form not only of expressing, but also of creating knowledge. This very intuitive proposal of "to know is to be able to express correctly the real nature of things" is the main way we naturally relate to each other. Snowden, for instance, when proposing his "story telling" technique (Snowden, 2001) takes this same epistemological decision of a "linguistically articulated qualitative knowledge". Applying in a simple way this particular form of "socialization", one can imagine how, during the milestones of a project, stakeholders should be encouraged to gather and tell the stories of what is going right or wrong. These "stories" can then be collected and transferred ether orally or through a given media. This typically Aristotelian choice has also its drawbacks. The first one, more philosophic, would consist on arguing that nothing can ensure that my perception allows me to access to the world "*the way it is*", and that my natural language was surely not *designed* to describe a world that may even not be accessible. The second one, more pragmatic, would consist on asking how different people, with different cultures, and using different natural languages could then be able to share knowledge. The answer to this second question could be the creation of a common "neutral field"

between these different people: a neutral field where knowledge could be more "objective". This is exactly what the Cartesian philosophy will propose to us.

2.2 Knowledge and the Cartesian Revolution

Behind the well-known Cartesian proposal *Cogito ergo Sum* (I think, thus I am), lays a sophisticated approach to knowledge which has innumerous consequences on present "knowledge management" perspectives. Let us start by looking at the "My-client-is-satisfied" story-told with doubtfully Cartesian eyes. What if my perception betrayed me? What if I am wrongly convinced that my client is satisfied? What if, sending another person to listen to him, he or she would reach antagonist conclusions? Descartes (1596 – 1650) would have called our posture a "methodological doubt", and would have guaranteed us that our qualitative perception of the world was so confused, that it would not be a good idea to trust our *feelings*. How can then a trustfully method be built in order to ensure that what I believe is the truth? This is the central question of the Cartesian meditations of the "Discours de la Méthode" (Descartes, 1637). After having proposed that my body and my soul are made of antagonist substances (my body, as well as the physical world, being made of pure *extension*, and my soul being made of pure *thinking*), Descartes concludes that, on the contrary of what the Aristotelian approach proposes, **knowledge should proceed from *thinking to being***. This pragmatically means that, in order to know something, I should firstly construct *a priori* (without having any empiric experience of it) a clear idea of what I want to see, in order to observe secondly this something, not with my natural naïve perception, but with a pre-constructed clear *model* of it. As the world is pure *extension*, Descartes finally adds that a clear pre-constructed model should be built mathematically.

In the scientific context of the XVIIth century, this implies that Galileo, for instance, do not look at the stars with his own eyes, but with a mathematical object, reflecting a measurable perspective on the world: the Galilean astronomic telescope! As for our client-satisfaction problem, this means that a satisfaction's measurement model has to be introduced, which, if applied by a hundred different people, will give a hundred times the same result. Such a Cartesian knowledge of my client's satisfaction could be, for instance, the result of the statistical application of a pre-designed questionnaire. It could also be a systematic measurement of trouble-shooting page *hits* at my homepage, or of the number of phone calls to my pos-selling service hotline… These are Cartesian epistemological choices.

In the Cartesian perspective, knowledge is quite easy to share and to manage, as it only needs to be quantified to do so (which, by the way, does not make any sense for Descartes, since ideas cannot be measured, as they have no *extension*). The challenge of sharing knowledge, in a Cartesian approach, consists then on having a common understanding of models, and good methodologies of documents indexation and retrieval. Effectively, as knowledge can be objectively and commonly understood through pre-designed mathematical views (models), the real knowledge sharing should simply consist on "capitalizing" this knowledge in documents, which should be easy to find when needed. This approach to Knowledge Management is a real "engineers' heaven", where everything can be harmoniously stored in databases and taxonomies, according to common rules. Even Nonaka and Takeuchi do not resist to the strong temptation of adding an "explicit knowledge" to their model, so that knowledge can not only be "socialized", but also "externalized" (transformed into explicit knowledge), "combined" (confronted explicitly with other models) , and then "internalized" (assimilated back as new tacit knowledge). The Cartesian approach is also perfect for resolving the problem of a real *management* of knowledge, since, in this perspective, knowledge is an object that can be measured. As an example, it is quite easy to say, in a Cartesian perspective, if a given client is more satisfied than another is, or if I know more about a client than about another, since I am precisely using mathematically constructed models to access to knowledge.

Of course, it can be argued that knowledge cannot be properly "externalized", as it is subjective and phenomenological. It is exactly what is often claimed against document-management-based knowledge management: I can surely read a technical book on how to drive a bicycle, but I will never be successful in this task before having *experienced* it. As announced in beginning of this paper, knowledge management is strongly epistemological-choice driven.

2.3 Knowledge for Classic Cognitive Science

As already mentioned, Descartes would have found absurd the idea of "quantifying thoughts", as the soul has, for him, no extension. For other reasons, the German philosopher Kant (1724 – 1804) would have agreed. Kant also believed that true knowledge should be objective. However, instead of thinking that scientific objectivity comes from my *Understanding*, he argued that it comes, on the contrary, **from the phenomena that I can only observe in the dimensions of space and time**. As my mental activities can only be given in the unique dimension of time (the succession of

my ideas), there cannot be a quantitative (i.e. scientific) approach to my toughs (Rivelaygue, 1992: 313), for Kant. If asked how the knowledge of my client satisfaction should be managed, Kant would have answer that this question just makes no sense: it can simply not be managed.

It is quite clear to us that the will of funding a “scientific psychology”, the more recent idea of an “artificial intelligence”, and the very proposal of “managing knowledge” are direct consequences of the Cartesian and Kantian philosophies. Effectively, both philosophers have taken the nature of knowledge out of the field of science. In that sense, we understand that the proposal of managing knowledge reflects the pragmatic tentative of putting back knowledge into a scientific, manageable world.

Both Descartes and Kant actually gave us the central clue on how to solve the problem of scientifically understanding the nature of knowledge, when posing the impossibility of such project. Effectively, if the true (scientific) understanding of the nature of things requires their mathematical physicalization, then knowledge and consciousness should simply be mathematized, in order to be managed and scientifically understood. This assumption not only leads us back to the document-management perspective: it also allows the proposition of managing knowledge with Artificial Intelligence tools.

Thus, the main proposal of classic Cognitive Science, which leads technically to Symbolic Artificial Intelligence Systems (SAIS), consists on thinking that “to know” means “to compute”, that is, **to manipulate formally semantic-free symbols**. This is the main idea of Fodor’s functionalist approach: the “language of thoughts” (Fodor, 1975). It is important to recognize that, for Fodor, the digital computer (the Turing Machine) is not only a model of a mind: it is a mind! Ask then 1975-Fodor how to solve our client-satisfaction problem, and he will answer you that an expert system can be designed to automatically interview your clients, and then decide if they are satisfied or not. The design of such system would simply require to extract (or to externalize, in Nonaka’s semantic) the knowledge of your “client-evaluation specialists” through semantic logical rules like: “*if, when asked if he would use again your services, your client answers yes, then add 10 to satisfaction-probability and go to rule 5*”. In order to solve the same problem, followers of Fodor, like Schank and Riesbeck, would advise you, for instance, to construct a “Case-based-reasoning” (CBR) system (Schank and Riesbeck, 1989). The main idea behind these systems is also that to know means to compute, but CBRs specifically operate on cases automatic retrieval, using symbolic

matching rules. With these systems, I know that this client B is satisfied, because the patterns of the B-client case are similar to the patterns of the A-client case. Of course, we can ask how it is possible to know whether client A was satisfied or not. To that, we can answer, in a Cartesian vision, that we have an objective model of clients' satisfaction, or, in an Aristotelian vision, that we are sure of it because we *saw* it. It is just a matter of epistemological choice…

2.4 Biological Constructivism and Embodied Meaning

As always, all choices have their intrinsic drawbacks. In the case of classical cognitivism (the functionalist proposal of Fodor), we can list two of them. The first, more conceptual, is commonly referred as the "symbol-grounding-problem". Its more classic expression is the *Gedankenexperiment* (experience of thought) of Searle known as "the Chinese room" (Searle, 1980). Without entering in too much detail, the argument of Searle consists on saying that the simulation of cognition cannot be assimilated to cognition itself: it is not because a system manipulates symbols *as if* it was intelligent, that it is *effectively* intelligent. In order to be actually intelligent, the system has to *understand* the symbols it manipulates; therefore, the idea of intelligence as a *semantic-free* symbol manipulation just does not make any sense at all for Searle. The second argument that we can propose is much more pragmatic: symbolic systems only work for a short period on very narrow and specific cognitive problems. For the case of expert systems, for instance, these pragmatic symptoms consists on the constant need of adding new "expert rules", until reaching the conclusion that "externalizing" the knowledge of the specialist was quite interesting in theory, but not realizable in practice.

As argued by Dupuy (Dupuy, 1994), the research program of classic cognitive science, as well as of classic Artificial Intelligence, have missed their point when forgetting the notion of *autonomy*. Effectively, if the "knowledge" that is inputted inside of Fodorian "mechanical thinking machines" consists on "semantic-free symbols' manipulation rules", then someone, at a given moment, has to lend his or her semantic views on these rules, so that "knowledge" can effectively exist. In other words, SAISs are intrinsically heteronomous, in the sense that they do not have their own understanding of themselves: someone, who is actually cognitive, always has to interpret them. Therefore, Dupuy reaches the conclusion that cognition is the fact of autonomy, and thus, that a cognitive system should firstly be an autonomous system.

The same proposal of cognition as autonomy can be found in Maturana and Varella's proposition of "*Autopoiesis*". This paradigm of cognition is based on a modern phenomenological analysis of knowledge: the Husserlian Phenomenology. The German philosopher Husserl (1859 - 1938) modernized the antic approach to phenomenological knowledge, by recognizing, as Kant did, that the only true knowledge I can have is **the knowledge of a perceived phenomenon**, which cannot, by definition, be objective. Therefore, Husserl proposed to focus epistemological researches no more on the construction of objects' representation, but on the subject of knowledge as well as his relationships with the phenomenon (Husserl, 1901). From this philosophical perspective on knowledge, the Chilean neuroscientists and philosophers Maturana and Varella defined cognitive beings as "*Autopoietic*" (Maturana & Varella: 1980). Without entering in too much detail, the *Autopoiesis* paradigm (form the Greek *autos* and *poiein*, meaning "auto-production") is based on two main ideas. The first consists on recognizing that cognitive beings are autonomous and the second that their autonomy is enabled by their capacity of *enaction*. The autonomy of an autopoietic system is its capability of being determined by own internal rules, instead of "inputs" received from environment. The *enaction* is the circular causality of the system and its environment. In such context, the coupling between the system and its surrounding is no more given by any "input-output" scheme, but by a "perturbation-dissipation" effect, which is the direct consequence of the self-maintenance of the *autopoietic* system. In other words, to be cognitive, for Marurana and Varella, means to be able to maintain a physical autonomous stability, despite of environment constant perturbations. Therefore, cognitive systems are embodied, operationally closed, and have their own personal enactive relationships with the world. Maturana and Varella add that the autopoiteic machines' autonomous properties are the consequence of their organization and not their structure. This allows broadening the notion of "living" and "cognitive" to any autonomous enactive organization. The nature of autopoietic machines' organization is described by the authors as fractal, in the sense that an autopoietic being can be constituted by other lower-order autopoietic systems. For instance, a society, which is an autopoietic system, is constituted of biological beings (also autopoietic), which are, themselves, constituted by cells (which are also autopoietic). Finally, knowledge itself is described, in the autopoietic perspective, as a stable coupling emergence of the autopoietic machine and its environment. Therefore, knowledge, in such paradigm, is not an object, which can be turned into an explicit version of itself, but an emerging phenomenon, which results from the stable coupling relationships of a cognitive being with its environment.

The consequences of such epistemological choice for Knowledge Management, as well as for our client-satisfaction problem, will be described in the rest of this paper, with the proposition of the “Socio-Cognitive Engineering” paradigm.

3 Socio-Cognitive Engineering

The third section of this paper will provide the reader with an introduction to the idea of “Socio-Cognitive Engineering”, based on the Husserlian philosophical approach to knowledge, and the pragmatic description of autopoietic machines of Maturana and Varella. Therefore, the socio-cognitive engineering research program will be formally defined. Then, a general vision on how this program intends to “engineer” the social conditions for Knowledge emergence will be proposed, and illustrated with some examples. After that, the topic of knowledge protection will be contemplated in a socio-cognitive perspective. Finally, the notion of knowledge ecology will be contextualized inside the proposed paradigm.

3.1 The Socio-Cognitive Engineering Research Program

In order to propose the paradigmatic basis of what will be defined as “Socio-Cognitive Engineering”, we need to emphasize the two main epistemological choices, which support them. The first one concerns the nature of knowledge. The orientation followed by the paradigm we want to propose is the Husserlian phenomenology, where knowledge does not consists on an objective access to the world, through sensation or mathematical construction, but on a **subjective coupling emergence of an autonomous organization with its environment**. In other words, it is not because I see a white table that there actually is a white table. What can be affirmed, is that I have the stable perception of a white table, and that I am equally responsible for this stable emergence, than the proper “table” of the world is: knowledge is a mutually constituted emergence constructed by both the subject and the object of knowledge. The second choice concerns the nature of cognitive beings. The orientation we will follow here consists on thinking that cognitive beings are autopoietic and fractal. To be cognitive, will mean **to be autonomous**, that is, to possess internal autopoietic rules, which allow maintaining identity and integrity, by resisting to environment’s perturbations. Autopoietic beings will be seen as made recursively of other autopietic

beings, until reaching the most elementary autopoietic machines, constituted by alopoietic (not autonomous) parts.

We are now ready to define socio-cognitive engineering. Socio-Cognitive Engineering refers to a multi-disciplinary research field, involving biology, psychology, sociology, artificial intelligence, linguistics, management and ethics, aiming at studying and reproducing the conditions from which knowledge can emerge among the agents (biological or not) of an autopoietic society. In a socio-cognitive perspective, knowledge cannot emerge without the existence of a society, and a society cannot be stable without the emergence of knowledge fluxes. Knowledge emergence is then seen as the fundamental glue, which allows the stability of a society. Therefore, if, in a given society, cognitive coupling links disappear between individuals, the society will not be autopoietic anymore (it will not be able to continue producing itself in a stable way), and then, it will disappear. As detailed by Luhmann: “Social systems are auto-referenced systems based on meaningful communication. They use communication in order to constitute and interconnect the events, which construct themselves as a system. In that sense, they are autopoietic. They exist only for reproducing the events which serve as components for themselves.” (Luhmann in Provost, 2000: 23). The “meaningful communications” described by Luhmann, are what we will technically call “semiotic enactions”. These “semiotic encations” are, for instance, natural language communication, body language interactions, or chemical exchanges between autonomous beings. It is important to emphasize that, in such perspective, natural language can no more be seen as a tool designed for accessing to the world “the way it is” (as in the Aristotelian philosophy): it has to be contemplated as a particular coupling device, whose only purpose is to provide a stable auto-maintenance of a system’s unity.

In order to engineer the conditions from which specific knowledge will be able to emerge, socio-cognitive engineering will follow four approaches:

1. The direct approach will consist on creating direct face-to-face-related ad-hoc societies;
2. The alopoietic-artifact-mediated approach will consist on mediating the relationships between the cognitive agents of a society with heteronomous semantic-carrier artifacts like, for instance, books or intranets;

3. The autopoietic-artifact-mediated approach will consist on mediating relationships with autopoietic artificial artifacts, like cognitive artificial agents;
4. The mixed approach will consist on creating a complex socio-cognitive environment by combining the three previous approaches.

The next section will provide the reader with a more detailed view and some examples of each approach.

3.2 Engineering Social Conditions for Knowledge Emergence

As knowledge, in a socio-cognitive perspective, is not something that can be stored in order to be retrieved latter on (as it is the case in a Cartesian or classic cognitive vision), it has actually to be produced by emergence anytime it is needed. As already mentioned, this emergence will only be able to occur inside an autopoietic society, meaning that if this society does not exist anymore, knowledge will no more be able to appear. The notion of society has, in the socio-cognitive perspective, to be understood in the sense of Maturana and Varella's proposition of Autopoietic systems. A bench of cells continuously auto-producing and maintaining themselves in a given configuration, allowing the continuous maintenance of a tissue, despite of environment's perturbation, is a society. The brain of a biological being is also a society: the society of mind, in the intuitive modular vision of Minsky (Minksy, 1987), which is being empirically confirmed by brain-activity mapping with functional Magnetic Resonance Imaging (Carter, 2002: 14-62). Finally, a bench of software engineers relating themselves in the context of a project is also an autopoietic society.

The first, and the most intuitive method, which socio-cognitive engineering shall investigate in order to describe how social conditions can be produced to let knowledge emerge, is **the direct approach**. The direct approach consists on creating the conditions which will allow cognitive beings (mainly, for knowledge management, people) to meet directly, and share ideas via natural dialog, which is the most social and trivial way to do so. The direct approach can be compared to Nonaka and Takeuchi's *socialization*. By organizing, for instance, meetings, brain-stormings, or simulation games, people can be gathered to form an ad-hoc community, from which ideas will emerge. The unmediated story-telling technique falls, for instance, in the direct-approach socio-cognitive category. Concerning our client-satisfaction problem, the direct approach would then consist on meeting directly the client, in order to create

trustful relationships, and let the knowledge of client's satisfaction emerge from these social interactions. As far as management is concerned, the direct approach can be measured with "interacting-time" metrics. Such measurements should remain non-financial, and should be added in a balanced-scorecard vision of strategic objective achievements, in order to sustain the results of a given business.

The second and classic approach, for companies that have successfully implemented some computer-based Knowledge Management practices, is the **alopoietic-artifact-mediated approach**. As it is not always possible, for several reasons, to gather directly people, it is interesting to try to mediate the relationships of a given society's individuals with some "alopoietic" (non-cognitive) artifacts. The most trivial one would simply be a document. It is completely heteronomous, as it needs someone to lend a semantic in order to make sense. However, it still represents a semantic connection between an author and a reader, from which a society can be created, and knowledge can emerge. More evolved artifacts can be used to create alopoietic connections between people. It is of course the case of all CSCW (Computer Supported Collaborative Work) Systems, like the famous Communities of Practice, Chats, Groupware, Workflow Systems, Audio and Video-Conferences devices, and the general Information Portals. To this list can be added more elaborated social-connection-supporting systems like Yellow-Pages, Recommenders, Reputation Systems, and Voting and Group Decision Systems. All these mediators possess the common property of being heteronomous semantic-carriers: a cognitive being has to access and interpret them to let knowledge emerge. As Bachimond points out, computers, used in that way, are not "machines that think", but "machines that give food to thoughts" (Bachimond, 1996). The alopoietic-artifact-mediated approach of socio-cognitive engineering is exactly what Havelange also describes as "the technological genesis of meaning" (Havelange, 1999). In her research work on Technological Anthropology, Havelange proposes the notion technological object's hermeneutics to describe the fact that physical artifact, which can carry a semantic, are granted with meaning in a society's context. In Havelange own words: "Anthropologically constitutive, the technology mediates a representation through an external memory, which is registered in material objects. In a phenomenological perspective, this gives birth to a technological genesis of intentionality, which modifies the traditional separation between the empirical and the transcendental" (Havelange, Lenay and Stewart, 2003: 5).

As for our client-satisfaction problem, the alopoietic-artifact-mediated approach would consist on socializing the client's knowledge through synchronous and asynchronous computer-supported collaboration tools, like, for, instance, communities of practice. As far as management is concerned, the alopoietic-mediated approach can be measured through non-financial tendency indicators like *hits*, or *collaboration-time*. As already described for the direct approach, a balanced-scorecard strategic vision tracking should be used together with these indicators, in order to justify the impact of such social practices on business' results.

The third, and very promising branch of knowledge emergence engineering, is the **autopoietic-artifact-mediated approach**. Its most trivial proposition would consist on gathering only biological autopietic beings to let knowledge emerge, but this would lead us back to the direct approach. Therefore, we define the autopoietic-artifact-mediated approach as the introduction inside biological societies of non-biological autopoietic artifacts, like, for instance, *artificial cognitive agents*. Artificial autopoietic artifacts, mainly called, in the literature, "artificial agents", represent by-now in computer science a classic research field. A good introduction to artificial agents' concept can be found in Bradshaw's "Introduction to software agents" (Bradshaw, 1997). The main characteristics of a software agent, which are generally referenced, are (Franklin and Graesser, 1996): (i) its autonomy, social-skills, pro-activity and persistence, (ii) the fact of possessing sensors, executors, personal objectives, a proper agenda and knowledge on its environment, (iii) the fact of being able to plan, dialog, negotiate, coordinate and collaborate. Reducing all these characteristics to the essential elements implied by their autopoietic nature, we can more simply say that an agent exhibits: (i) a self-regulated autonomy, (ii) an emergent intentionality, and (iii) an emergent embodied identity. As a consequence, virtual autopoietic artifacts do not need anyone to beneficiate form any kind of ad-hoc semantic: they have their own objectives, they can guide and anticipate users' need, introduce themselves thoughtfully inside social networks and provide active supports to social processes (like, for instance, communication or negotiation). Some richer conceptual and experimental considerations can be found in (Cassapo and Scalabrin, 2003), where the nature of both software agents and software agents' societies are detailed trough concepts, and agent-based socio-cognitive empirical experimentations.

As for our client-satisfaction problem, the autopoietic-artifact-mediated approach would consist on creating an autonomous software agent, whose self-regulated autonomy would result on the emergent intentionality of:

- Introducing itself inside societies where knowledge on my client can emerge (such societies should then be alopoietic-artifact mediated);
- Introducing itself inside a society I participate to, and where knowledge on my client is required (like a Client Relationship Management Network, for instance).

As the artifact responsible for triggering knowledge emergence is autopoietic, the management issue should be handled, here, as described in the direct approach. Non-financial tendency indicators, like time of interaction, hits inside specific communities, should be collected to measure agents' efficiency. In order to evaluate the autopoietic-artifact-mediated approach's impact on business, a balanced-scorecard vision of strategic objective achievements should also be used.

The fourth and final proposal of socio-cognitive engineering, is **the mixed approach**. This mainly consists on applying rationally (taking into consideration risks, complexity, costs, and time issues) the three previous approaches, in order to create a socially integrated human-and-agents environment, where knowledge emergence's probability can be maximized. In such context, managing knowledge, that is, being able to say if, for instance, if I know more about a given client's satisfaction than about the satisfaction of another one, remains a complex challenge. In order to address this issue, the only epistemological alternative available is the Cartesian mathematical modeling *a priori*. As knowledge is an emergent property of social networks, the agents' connectivity inside societies should then be measured, with the number and duration of social contacts, in order to evaluate the socio-cognitive approaches' efficiency. Giving a few examples, community's *hits* per person is a socio-cognitive metric of the alopoietic-artifact-mediated approach; artificial agent's dialoging time per person per day is another metric, which can be used for the autopoietic-artifact-mediated approach. As already pointed out, all these measurements should be strategically followed, together with other business indicators, in order to allow strategic objectives' tracking.

3.3 On Knowledge Protection, in a Socio-Cognitive Perspective

When knowledge is seen as an object that can be *stored*, knowledge protection consists mainly on impeding unwanted retrievals of this object. In such context, knowledge can be protected with passwords and firewalls, and "stealing knowledge" requires, basically, discovering how to access to documents.

When projecting the same problem in a socio-cognitive perspective, protecting knowledge with passwords and firewalls actually continues to make sense, since the proposition of a knowledge emergence through an alopoietic-artifact-mediated approach (through documents and CSCW Systems). However, the reason why socio-cognitive engineering can recommend the use of classic information security guidelines is quite different from what is generally understood. Effectively, if knowledge can only emerge from the operationally-closed relationships of a given society's individuals, **then knowledge protection can only mean preventing this society from being formed**. Preventing undesired persons from accessing semantic-carriers (like books, reports, communities of practice, chats, portals, etc.) can surely be a way of doing so, but it is not the only one. Impeding the introduction of a virtual autopoietic artifact, like a *Computer Virus*, inside an electronic collaborative environment, or searching and destroying such unwanted artifact, is another way of stopping the creation of undesired autopoiteic societies. We shall here add that computer viruses are typical autopoietic artifacts: they are autonomous, they have their own agendas and objectives, and their main autopoietic rules tell them how to maintain themselves by resisting to environmental perturbations. In order to fulfill an integrated proposition of socio-cognitive-oriented knowledge protection, the direct-approach-based knowledge emergence has also to be addressed. Protecting corporate knowledge, in a direct-approach perspective, means minimizing the emergence of certain critical knowledge via unwanted direct human interactions. This signifies, firstly, being able to retain people as employees of the company. Many crucial elements, like working quality, life quality, respect, ethics, opportunities of growth, are essential to attract and retain highly knowledgeable people. In a company where employees do not feel well, the probability of knowledge escape through people resignation is much higher. Of course, guaranteeing a high motivation inside a company is necessary, but not sufficient, for impeding knowledge escape. Protecting knowledge from being inadequately socialized also means informing and sensitizing people about social aspects of knowledge. For instance, a key-knowledge, which needs to be kept confidential, can easily be transmitted through a simple journalistic interview. This kind of risk has to be addressed with adequate communication of direct knowledge security guidelines.

Coming back to our client-satisfaction example, knowledge protection in that context would consist on preventing my concurrent from knowing that a given client of mine is actually not too satisfied. In order to do so, four measures have to be adopted:

- The people of my company, who knows that my client is not really satisfied, should avoid commenting so in external social networks (in dinners, interviews, or chat-rooms, for instance);
- The access to artifacts (documents) which carry such idea should be restricted;
- Employees should be informed on the nature of spying-viruses (like, for instance, Trojan-Horses), and on how such kind of program can be involuntary introduced in a computers' network. All kind of suspect autopoietic artifact running free on the corporate Intranet should be destroyed immediately.

Concerning the management of knowledge protection, many indicators can be used in the three perspective of socio-cognitive engineering: for instance, climate and satisfaction questionnaire for people retention, and results of intrusion's test for information and network security.

3.4 Socio-Cognitive Engineering, Ethics, and Knowledge Ecology

When knowledge is considered as an emergent phenomenon allowing the autopoietic coherence of a society, the concepts of *knowledge ecology* and *ideas' natural selection* (Pór, 1998; Davenport and Prusak, 1997) become particularly meaningful. Effectively, since the fractal nature of autopoietic organizations, a society is actually perceived, by socio-cognitive engineers, as a living system, immerged inside an environment. As it is autopoietic, such living organism possesses its own intrinsic rules allowing its survival by dissipation of the pressures suffered from surrounding. These internal auto-producing processes consists on "meaningful communications" (Luhmann in Provost, 2000: 23), which we also called technically "semiotic enactions". Metaphorically speaking, we could say that knowledge is the fundamental glue, which sticks the parts of a social network. As a consequence, if all, or part of the "semiotic enactions" of a given autopoietic society disappears (due to, for instance, unsupportable pressure from surrounding), such autopoietic society explodes, at least in part, and can then disappear. As explained by natural selection theory, the social networks, which are the most *adapted* in the global surrounding, are the one that will survive, and then transmit their inner autopoietic material to further societies. Such direct application of Darwin's paradigm is possible since the extension of the idea of "*living*" propitiated by Maturana and Varella's work.

Another important fact, which fully supports the notion of knowledge ecology, is the *hermeneutic dimension of socio-cognitive engineering*. Effectively, as socio-cognition recognizes that there cannot be knowledge without society, or society without knowledge, the study of ideas' evolution (in the Darwinian sense of the term) becomes an anthropology. Therefore, a bench of ideas, as well as the autopoietic society where they emerge, always have, according to the socio-cognitive paradigm, to be studied in a given socio-historical context.

As a general consequence of the hermeneutic dimension of socio-cognitive engineering, **ethic considerations have to be taken into account, when dealing with social networks as living organism**. As it is today clear that some biological species are under the menace of definitive extinction, due to uncontrolled and chaotic transformation of surrounding, it has also to be recognized that some varieties of autopoietic societies are under the same kind of threat. Thus, a profound respect for ideas, beliefs, or natural languages, which do not belong to the most globally spread-out cultures, is essential to preserve a **healthy knowledge surrounding**. Therefore, all previous considerations on knowledge protection have to be taken in a very responsible and carefully way, as they can very easily be misunderstood and applied anti-ethically.

4 Conclusions

This article aimed at providing an epistemology-based high-level analysis of knowledge management practices, in order to allow the proposition of the Socio-Cognitive Engineering paradigm for both understanding the nature of cognition, and proposing a new framework for managing knowledge.

The Socio-Cognitive research program, based on a Husserlian phenomenological approach to knowledge, and on the pragmatic proposition of a Biological Constructivism known as "Autopoeisis", aims at engineering the social conditions from which knowledge can emerge among the agents (biological or virtual) of an autopoietic society. In this perceptive, knowledge and intelligence cannot be without the existence of a society, and reciprocally, there cannot be a society without semiotic enactions. Consequently we recognized in this paper that knowledge management beneficiates more from social networks than from any kind of *ad-hoc* explicitation.

In order to engineer the social conditions from which knowledge can emerge, four approaches have been presented: the direct approach consists on creating direct face-to-face-related *ad-hoc* societies; the alopoietic-artifact-mediated approach consists on mediating the relationships between cognitive agents with heteronomous semantic-carrying artifacts; the autopoietic-artifact-mediated approach consists on mediating these relationships with autopoietic artificial artifacts; the mixed approach consists on creating complex socio-cognitive environments by combining the three previous approaches.

This article also presented some views on knowledge protection in a socio-cognitive perspective. These can be summarized with the following idea: if knowledge can only emerge from the operationally-closed relationships of a given society's individuals, then knowledge protection can only mean preventing an undesired society from being formed. This proposition has also been moderated with some ethical considerations. The study of the *hermeneutic dimension of socio-cognitive engineering* allows recognizing that uncontrolled and chaotic transformations of the global knowledge environment can lead to the extinction of some varieties of autopoietic societies. Thus, a profound respect for ideas, which do not belong to globally spread-out cultures, is essential to preserve a healthy knowledge surrounding.

Far from being a purely theoretical concept, socio-cognitive engineering has already experimentally putted into practice, and one of its main promising research-line concerns the engineering of artificial autonomous agents (Cassapo and Scalabrin 2003).

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