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The Collaborative Future

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Abstract

Collaboration has become an important goal in modern ventures, across the spectrum of commercial, social, and intellectual activities, sometimes as a mediating factor, and sometimes as a driving, foundational principle. Research, development, social programs, and ongoing ventures of all sorts benefit from interactions between teams, groups, and organizations, across intellectual disciplines and across facets and features of the inquiry, product, entity, or activity under consideration. We present a survey of the state of collaboration and collaborative enterprise, in the context of papers and presentations at the International Symposium on Collaborative Enterprises 2011 (CENT 2011), and the extended papers appearing in this special issue.

Keywords: Collaboration, interoperability, collaborative enterprise, knowledge management.

1 Introduction

Collaboration has become an important goal in modern ventures, across the spectrum of commercial, social, and intellectual activities, sometimes as a mediating factor, and often as an underlying philosophy, driving practices and mechanisms. Research, development, social programs, and ongoing ventures of every kind benefit from interactions between teams, groups, and organizations, across intellectual disciplines and across facets and features of the inquiry, product, entity, or activity under consideration.

Achieving successful, sustainable, repeatable collaboration, however, requires far more than simply a decision by the collaborating organizations or entities. Rather, it needs a milie and environment in which collaboration feels natural, in which collaborative ventures can easily be imagined, created, developed, and maintained. That environment will rely on a number of interrelated changes—to social and corporate culture; to business plans, policies, practices and processes; to our understanding of the nature and management of knowledge, risk, and intellectual property; and to the technology base itself.

Technology has in turn been an important mediating factor and enabler for collaboration, supporting realistic and fine-grained communication across nations and cultures, as well as organizations, and for the first time allowing large, often distributed communities to work easily together on a common effort. Successful collaboration will clearly involve use of common technology and tools, or at least of technology and tools with mutually comprehensible interfaces and supporting a common view of processes, projects and products—the most basic definition of interoperability. Shared data, product artifacts (typically code), or even process information, often stored and sometimes executed in the cloud, not only intensifies these needs but can also address many of them.

As discussed below, real interoperability will call for far more integration and for mutual intelligibility and controlled mutual transparency for selected business and technical processes, as well as other common elements. It must, however, also be complemented by integration of intellectual resources, while however safeguarding the privacy, security and intellectual property interests of the individual participants and groups.

Interdisciplinarity is a key component of collaboration and collaborative enterprise, providing a motivator through an availability of complementary and specialized expertise, a synergy through the interaction of resources, ideas and perspectives, and a challenge in the need to provide translations, common views, and compatible objectives. This will clearly thus require a higher level of transparency and interoperability than simply a well-functioning common platform.

(It is important to distinguish transparency and intelligibility, which are largely orthogonal. The former lies in determining what must be shared and creating mechanisms for sharing, and the latter in agreeing on and guaranteeing common context, notations, glossary, and structures to make what is revealed understandable and usable by all parties involved.)

In addition, consideration must be given to human factors, and the challenges, changes and incentives entailed in collaboration between established entities with their individual goals and their own established practices and viewpoints. Resistance to collaboration and partial integration is (perhaps inherently) further compromised by differences in culture, the need to establish trust, the need to reward collaboration, the sense of membership in an individual group or organization, and resistance—often partially justified—from subgroups, such as the IT and legal departments and some upper-level managers in large corporations.

Finally, successful use of collaboration will entail understanding collaboration itself and its success factors. Again, there are several facets: the importance of cultural understanding, good communication, and trust (as documented in the organizational behavior and other literature [14, 18, 21]), and the establishment of good collaborative relationships. Collaborations will unsurprisingly also need a solid product vision and business plan, and will require support and advocacy from corporate leadership and from technical managers and staff. (For community development, this translates into support from government or foundations, staff and community.) Business processes will also have to be modified to value and reward collaborative activities, including support activities with no apparent business function within the organization, in order to establish good relationships and solid communication.

The remainder of this paper looks at a conceptual framework and environment for collaboration, including the knowledge base and knowledge management for collaboration; collaborative infrastructure and interoperability; and evaluation of collaboration, and places the papers in this issue, some of which also appeared in CENT 2011 [1], in the context of this overview.

2 Providing a framework for collaboration

2.1 The collaborative environment

The first conceptual step in establishing a framework for collaboration—if one that is difficult and often very much delayed—lies in creating a social, educational and business environment that encourages, values, and rewards cooperative behavior, rather than competition alone, while still striving for excellence and creativity. Since contrary attitudes are established early, at least part of the solution lies in restructuring education.

Rodriguez and Nuño [p. 48] present an approach currently in use in selected kindergartens in the Mexican state of Puebla, aimed at fostering and rewarding group formation, individual and group responsibility, cooperation, creativity and synthesis of ideas. Part of the effort lies, of course, in sensitizing the instructors, parents and administrators. The approach has been quite successful, appreciated by students, parents, and teachers, and will be replicated in more kindergartens and eventually up the educational scale.

At the other end, Ripley [p. 18] documents a successful academic collaboration, offering an interdisciplinary course integrating philosophy and marketing, aimed at both liberal arts and business students. The course was extremely rewarding if demanding for the faculty. It also made the problems of philosophy and business ethics more real for students, and encouraged them to think interdisciplinarily, and gave them a positive model for collaboration. However, Ripley also documents the costs and difficulties in creating and teaching such a course, from both the faculty and the administrative perspective, providing an excellent example of the changes and adjustments needed to realize the benefits of collaboration.

On the other side of the ledger, we [7, 12, 14] and others have discussed the changes needed in business practices and processes. First, the resistance from key personnel, mentioned above, will need to be addressed by education, training, positive examples, and customer/market demands. It will also most likely require selection of managerial personnel and demonstrated support, including top-level contacts for collaborative projects. Second, practices and processes will need to change to support and value work on collaborative projects and the development of good collaborative relationships. Third [9], the goals and strategies of individual partners, and to some extent their internal processes, practices, artifacts and conventions, need to be aligned. Finally, all involved need to recognize that some artifacts, processes and knowledge will be inherently collaborative, requiring development of policies for sharing, agreements and/or metrics for credit and use, and procedures for negotiation or arbitration and for risk management.

Nousala *et al* [p. 65] discuss in passing similar changes in perspective and approaches that need to occur for successful community efforts, both in the community and among the practitioners.

2.2 The knowledge base

Collaboration, whether in academia, business, or community action, entails sharing and integration of knowledge from many sources. Sharing of publicly available knowledge poses little difficulty, and sharing of information about component interfaces and constraints is obviously needed and will usually pose little difficulty. But sharing of component internals, or of internal processes, practices and approaches, and in particular of organizational memory, confidential information or intellectual property, will evoke more (and often justified) resistance, but may to some extent be necessary for interoperability, for process optimization and project efficiency, for product maintenance and evolution, for risk analysis and management, or for evaluation of global constraints and metrics [p. 41, 12, 13, 14].

It is a well-understood fact that knowledge is often not objective and often context-dependent. It is also clear that knowledge will be encoded in many ways, using languages, glossaries and notations reflecting local conditions and cultural understandings, both social and corporate, but also in many cases simply an accident of history or chance (such as the choice of a particular database design methodology and product).

Finally, it is known that while some knowledge is explicit—documented and available—and even managed—with tools or approaches for access, modification, cross-reference and access control—much knowledge is implicit—documentable but not yet captured or not available—or even tacit. We distinguish two sorts of tacit knowledge—on the one hand, processes and practices "known to the senses but not to the mind", such as how to make fine adjustments to a machine; on the other, knowledge that affects individual, societal and corporate behavior without being fully understood or articulated, and certainly not communicable, such as "how do I decide which stock to invest in?" or even "who do people really listen to on this issue?". (See [Zouaghi, p. 77] for further discussion and references on tacit knowledge.)

Because intellectual property and the level of contribution is so important in collaboration, we have also distinguished the orthogonal category of "collaborative" or "community" knowledge from shared knowledge on the one hand, and individual or corporate knowledge on the other [13]. This is knowledge that results from integration of knowledge from multiple partners, or from the action or analysis of the products of collaboration or of the collaborative process. Almost all collaborative knowledge is emergent—that is, it is not known, and often cannot be known, by a single partner at the start of the project.

There are at least three dimensions to the role of knowledge covered in this issue: the nature, representation and relationships of knowledge, the identification and integration of knowledge for collaborative activities, and the role of knowledge in collaborative ventures, especially as connected to interoperability.

2.3 Nature, representation and relationships of knowledge

van Lier [p. 91] looks at the distinction between knowledge and information, in the context of general systems theory, and argues that a (conceptual) knowledge base must account for not only information about entities and objects, but the objects themselves, their environments, and the subjects who observe them, and that this need is made both more pressing and more valuable with increasing technology and possibilities for communication, resulting in an "Internet of Things". A theory of collaboration will need to consider and address this, since in this perception successful collaboration will entail integration of abstractions and translations of multiple views of this Internet of Things.

Karbe [p. 98] considers the representation of knowledge artifacts using Mahr's Model of Conception together with context. Considering this model and considering both the role of context and the uses of knowledge, he explores requirements for communication, abstraction and use of knowledge that apply in single-entity ventures, but will have an even more powerful impact on sharing and management of knowledge for collaboration.

Nousala *et al* [p. 65] also discusses in context issues of cultural differences, communication, notations and representations, and steps needed to ensure that meaningful communication occurs.

2.4 Identification and integration of knowledge for collaboration

Zouaghi [p. 77] addresses primarily the identification and encoding of tacit knowledge (of "the senses know" kind), and its capture as organizational knowledge, and eventually inter-organizational knowledge. As he suggests, tacit knowledge is often preserved by a succession of apprenticeships or hands-on workshops within a single organization, and by identification of key personnel within the organization for solving particular kinds of problems. One of the challenges in collaboration is how to share this knowledge among organizations, and for that matter in deciding the extent to which such knowledge must or should be shared for collaborative success.

Fortunato *et al* [p. 12] discuss an approach and initial results in identifying engineering competencies in the aerospace industry, focusing not just on explicit knowledge, but on "hands-on" tacit knowledge and on implicit or tacit behavioral knowledge. Each competency is structured as an Activity (goal, process or problem), a Competency (solution or approach) consisting of Method, Technology and Product, and an Output. This approach, extended to also apply to Business and other aspects, is likely to prove valuable in identifying both process and product knowledge to be shared, and obstacles in achieving interoperability.

2.5 The role of knowledge in collaborative ventures

Jastroch *et al* [p. 30] explore how the nature of the collaboration and in particular the nature of its product or goal affect the level and types of knowledge needed, difficulties arising due to intellectual property and confidentiality, and the likely consequences of catastrophic events affecting one partner. The kinds of goals they distinguish are resource sharing, creating a service, creating a material product, or creating an intellectual property artifact, such as a piece of software.

In another paper in this issue, Jastroch, Kirova, Marlowe and Mohtashami [p. 36] discuss the interaction of partner and collaborative knowledge across the phases of a collaborative venture aimed at developing a complex, long-lived, and evolvable software artifact or system. The demonstrated need for steady information and knowledge flows in and out of collaborative activities, and forward and especially backward between software development and knowledge management phases and/or iterations, imposes particular constraints on the sharing of product, process, and business knowledge which must be considered in entering and pursuing such projects.

Nousala *et al* [p. 65] discuss the required knowledge base and social and technical infrastructure needed for community action, governance and repositories of community knowledge. There are intriguing connections to the theoretical discussions mentioned above, and to issues of culture, trust and communication. It will be important to understand the similarities and differences between this kind of venture/project and collaborative business enterprises, especially for ventures, such as those based on virtual reality or social media, that will increasingly combine elements of both.

3 Creating collaborative infrastructure and collaborative ventures

Much of the discussion of collaboration elsewhere has focused on support services and tools, such as repositories, software and communication support for live meetings and group editing, and on the business aspects of collaboration. However, satisfactory collaboration will also entail interoperability, as well as use of collaborative structures and processes for arbitration or mediation of differences.

3.1 The technology base

3.1.1 Interoperability

In two papers from the symposium (but not appearing in this special issue), Koussouris *et al* [9, 10] explore the dimensions of interoperability. The first proposes an initial classification of the different facets of interoperability and the relationships between those facets, identifying directions for future research as well as providing a valuable checklist and roadmap for complex collaborative technology-based ventures. In its view, interoperability involves not only creating common (or at least mutually intelligible and inter-translatable) frameworks for the platform and the knowledge base, as well as its referents, but also requiring cross-cultural intelligibility and aligned and consistent technical and business processes and practices. The second outlines a research program for exploring the facets, with the eventual goal of developing an Enterprise Interoperability Science Base [EISB], in response to a research program proposed by the European Commission [2].

Popplewell [p. 6], likewise in the context of the EISB, and very much sharing notations with the two previous papers, considers a structure for interoperability, less in terms of the features and domains of investigation, and more from a semantic and knowledge-generation perspective. The two main contributions are consideration of the sources and use of knowledge, and structuring the knowledge base of results.

3.1.2 The collaborative platform

While the collaborative platform was not a major focus of the symposium, there were significant contributions in two areas: a cloud-based platform for collaboration, and interactions of collaboration and virtual reality.

Teichmann, Schwartz and Dittes [p. 57] propose a cloud-based platform and design methodology for collaborative creation of business applications, based on material flow diagrams. The structure allows quick design and deployment of systems with well-specified interfaces, more or less via plug-and-play with consistency checking. The paper also presents compatible approaches to a design methodology.

Lemus-Martinez *et al* [p. 86] propose a layered approach for video conference platforms with the specific goal of increasing communication and collaboration during disaster simulations (and eventually, during disaster management). The paper points to the need to specialize platforms if one wants to improve collaboration, particularly in situations in which communication is a priority, and in which some participants may be reluctant to fully collaborate.

Kopecki [p. 24] deals with an orthogonal, almost dual problem—how to smoothly integrate existing applications into virtual reality applications, or for that matter, meshing existing applications into any "meta-applications" that combine and extend application functionality. Thus, the approach can both be a collaborative tool, and a technique for developing collaborative applications.

3.2 Collaboration structures and resources

A common theme, both in our earlier papers [7, 12, 14] and in papers presented here [p.36, p.98, p.57], is the need for structures belonging not to the individual partners but to the collaboration, including knowledge bases, component repositories and configuration managers, risk management plans, and integration wrappers, although partners may retain certain rights to parts thereof.

There are a number of interesting questions involved, partially addressed, but open to a great deal of further research. What knowledge or artifacts does the resource own or have the right to use? What rights does each partner have, and are they global to the resource, or local to particular items? What credit does each partner receive, for providing knowledge, artifacts, hosting, financing, or analysis? And what charges, if relevant, does each partner accrue for the use of the resource and its contents?

Further, each of those questions, as well as conflicting interpretations of requirements and specifications, and other issues, will require clear and mutually agreed policies for resolution of differences, well-defined channels of business-level communication, and in extreme cases, even an provision for third-party arbitration or mediation.

4 Evaluating collaboration

One of the themes of modern business and technical processes is evaluation and quality control. It will prove important to evaluate the collaborative process, both qualitatively and quantitatively. There are three major goals: better understanding to promote further research (compare [9, 15]), optimizing the collaborative process, and evaluating a particular collaborative venture. If there are quality indicators and metrics for such evaluation, they can be used in deciding whether to pursue collaboration, in evaluating the current state of a collaborative venture, and in evaluating the success of the collaboration.

Focusing on one domain, [15] considers a number of attributes of collaboration for a complex software development project and product that would need to be measured, discussing a small number in detail. As with many of these papers, the focus is in creating a roadmap for future research. Several other papers [9, p.6, p.18, p.48] also touch on collaborative success as a measure in a specific context.

5 Conclusions

Collaboration is the future, in several dimensions. Collaborative, inter-organizational and often cross-national, cross-lingual and cross-cultural ventures are of increasing importance. Collaborative and interdisciplinary research allows synthesis of knowledge and models, and supports to economic and scientific activity. And interdisciplinary meetings focused on collaboration provide researchers and practitioners with context, information, and ideas, and opportunities for interactions.

Conferences such as CENT offer a setting for consideration of collaboration-written-large, complementing specialized conferences focused more narrowly on infrastructure, tools, and platform, on management and coordination of collaborative projects, or on analysis of collaboration from the perspective of management science.

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Towards the definition of a Science Base for Enterprise Interoperability: A European Perspective

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ABSTRACT

Research on Enterprise Interoperability (EI) has evolved to meet real pragmatic needs to support the ever more collaborative nature of, for example, enterprise supply chains, and virtual enterprises. Research outputs have therefore focused on generating solutions to current problems, rather than to developing a body of knowledge which is structured for ease of re-use.

In Europe there is move to define just such a structure: an Enterprise Interoperability Science Base (EISB). We explore here the current state of this ongoing research, reviewing the understanding gained so far, and looking to the likely future outcomes. However this is clearly not just a European research domain. The main purpose of presenting the European perspective is to stimulate interaction with researchers in all regions who have an interest in the domain.

We therefore address three issues. We review the development of neighbouring sciences, identifying science base structures, and methodologies for their development. The definition and objectives of a science base are analysed, leading to an outline structure for an EISB to include formalised problem and solution spaces as well as structured EI domain knowledge. Twelve Scientific Themes of EI are identified and the current state of research in each is briefly discussed.

Keywords: Enterprise Interoperability; Science base..

1. INTRODUCTION

The need for definition of an Enterprise Interoperability Science Base (EISB)was first documented in the Enterprise Interoperability Research Roadmap version 4 [1] published in 2006 by the European Commission. Here the definition of an EISB was specified as one of 4 main Grand Challenges to be addressed by researchers in the domain. This challenge was recognised by the Enterprise Interoperability Cluster promoted by the European Commission, and in 2008 the Cluster formed a small task force to work on the EISB. This reported back to Cluster meetings through 2008 and 2009, and compiled much of the source material which is summarised in the chapters below. This work was published in [2] in 2010.

During 2009 the European Commission sponsored an "Enterprise Interoperability Science Base Meeting" to which members of the Future Internet Enterprise Systems (FInES) Cluster (previously the Enterprise Interoperability Cluster mentioned above) as well as international scientific experts were invited. This discussed the possible purpose and structure of the EISB, and led to the EC call for a Coordinating and Support Action under Framework Programme 7 in October 2009. The ENSEMBLE project was proposed and subsequently funded as a result of this call.

Any scientific domain exists in an ecosystem of neighbouring scientific domains, and must therefore recognise its relationship with these domains and with formal definitions of science bases already established for these domains. This relationship will include at least:

1. Boundaries between application fields, which may be fuzzy in the sense that there are some applications which could be addressed from the perspective of either domain. Formally, it may be appropriate to define membership functions to applications to recognise and resolve this overlap.
2. Shared methodologies, techniques and tools which may be applicable to problems in more than one domain. Recognition of such sharing provides opportunity for domains to advance by absorbing methodological and technical advances from related disciplines.
3. Conflicts in approach may also exist, and present possible barriers to interdisciplinary research or application. Formal documentation of such conflict areas will reduce risk of failure in projects arising out of the application of incompatible approaches.

For this reason we review below the definitions and structures of science bases in neighbouring sciences reveals that there is no common structure or content to such science bases. However a methodology emerges which might be applied in defining a science base, based on application of generally accepted scientific principles. Specifically we examine the lessons to be learned from not only applied sciences, where perhaps enterprise interoperability science may be based, but also social sciences, in recognition that enterprises are also social organisations and their interactions are societal in nature. Lessons from formal sciences are also relevant to support the formalisation and structuring of the EISB. There are clear interoperability issues identified in each of these three domains.

There is no generally accepted definition of a "Science Base", which can describe comparable constructs in a range of scientific domains. We therefore propose below a definition of the scope, purpose and content of an EISB. This definition will guide initial research on the EISB, but the authors would be unsurprised to see development of the definition during the course of that research. This seems both inevitable and desirable in the absence of any pre-existing definition of the term.

Finally we review the established Scientific Areas in the Enterprise Interoperability domain identifying 12 major Scientific Themes of Enterprise Interoperability (see below). Since domain research has continued for than a decade, there is a significant body of reported research and application, which contributes to the EISB. This is a first review of this content and will in future support the classification of methodologies, techniques and tools within the EISB.

2. NEIGHBOURING SCIENCES

The concept of science is generally related with observable knowledge, described in the form of testable laws and theories [3], [4]. Nevertheless, there is a plurality of sciences that differ very much from each other. Physics is accepted as a well defined science, but there are others that are not universally accepted, e.g., history and linguistics. Therefore, the definition of science is difficult and ambiguous, but it can be agreed that formalisms like logic and mathematics are an integral part of every science, i.e., they are essential for physics, less important for chemistry and biology, and their significance continues to decrease towards the more social and humanistic sciences [5].

Modern sciences introduce a paradigm shift since, unlike the traditional philosophy of science, they usually do not apply to a single domain, being interdisciplinary and eclectic. Modern sciences search for their methods and raise research questions in broad areas, crossing borders and engineering different scientific fields. For example, the modern computer science embraces formalisms and algorithms created to support particular desired behaviour using concepts from physics, chemistry, biology [5], [6]. Thus, being also a multi-disciplinary domain by nature, the establishment of an EISB should be developed comprising concepts and theories from related neighbouring sciences and scientific domains [2].

Based on the previous work from Charalabidis et al. [2], an initial analysis of the sciences that could contribute to EI is depicted in Figure 1. Due to its characteristics where interoperability issues can be identified, the general classification of scientific domains recognizes the social sciences, the applied sciences and the formal sciences [10] as promising contributors for the EISB formulation, and categorise the work developed so far within four levels of scientific elements of interoperability (semantics, models, tools, orchestration) [2]:

- At the level of semantics, the mathematical domains of logic, set theory, graph theory and information theory seem to have practical applications for describing interoperability problems in a formal way. A mention to patterns has also to be made in this area, both in the form of design patterns [2] and also in the more mathematical form of general pattern theory.
- At the level of models and tools, one should look for existing knowledge in the neighboring domains of systems theory, systems engineering, computer algorithms or operational research. Service science [7] should also not be overlooked in the needed definitions of models and tools for interoperability, at this level. Systemic simulation approaches, such as the System Dynamics approach [8].
- At the orchestration level, where more generic formulations are needed, the social sciences provide a sound scientific corpus, in the face of economics, legal science or even public administration and management.

In addition to the above directions towards the EISB formulation, some literature draws special attention on approaches and propositions for a formal framework to describe interoperability such as the category theory application to semantic interoperability [9], combined category theory and calculus approaches [10], or knowledge discovery metamodel application to interoperability of legacy systems [11].

For the higher levels of interoperability, that is the organisational and enterprise interoperability facets, the scientific domains of systems complexity, network science and information science seem to have a high degree of relevance and applicability [12]. As well, relevance for the establishment of the scientific foundations has been identified with domains such as distributed systems, evolving applications, dynamics and adaptation of networked organizations on a global scale.

All these domains possess strong theoretical background, based on domains tagged as "neighbours" of EI, and serve as an input to the work presented on section 2.3 "EI Neighbouring scientific domains reference taxonomy".

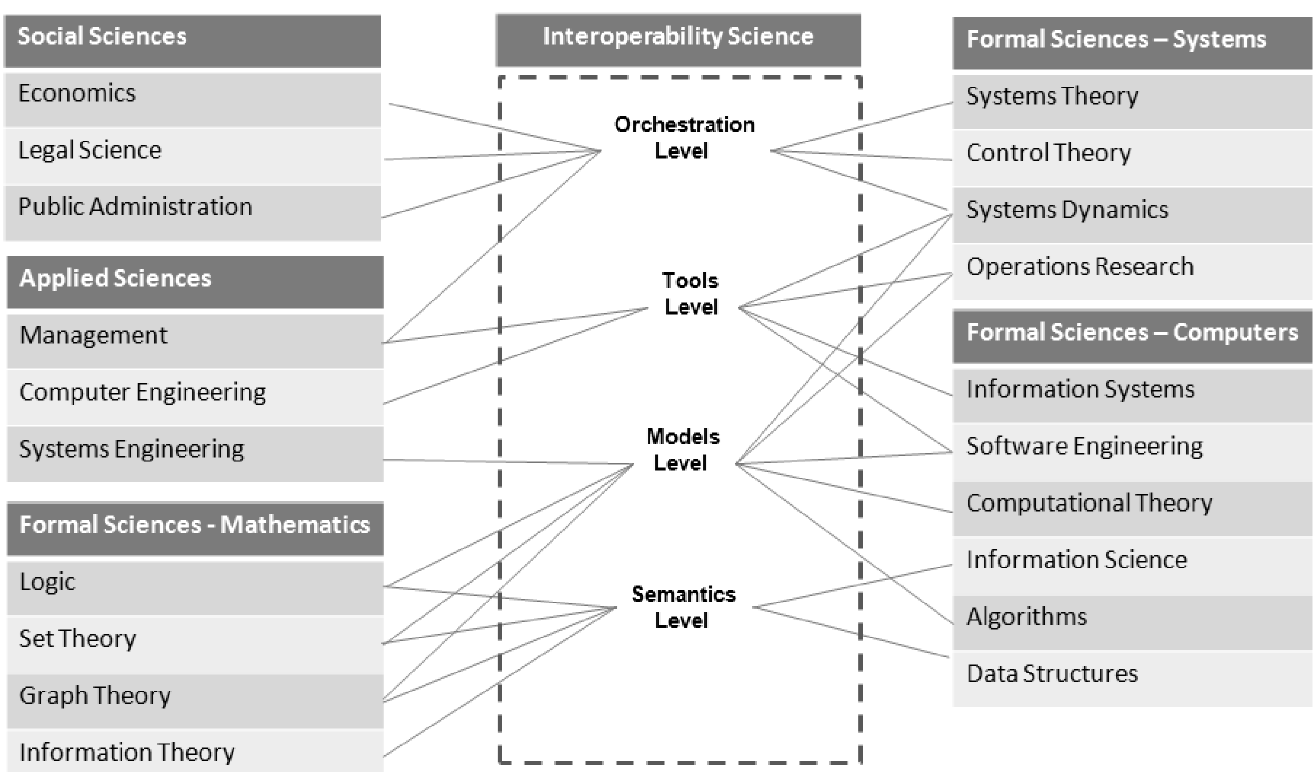

Figure 1: Interoperability Science and Neighbouring Domains

3. DEFINITION AND CONTENT OF A SCIENCE BASE FOR ENTERPRISE INTEROPERABILITY

There is no view of the definition of a science base common to all, or even a related set of, scientific domains, although good examples exist, including for example that for software engineering science [13]. We therefore submit that the definition of a science base is to a degree dependent on the nature of the domain and the purpose for which it is designed and maintained, and indeed the definition for a particular domain will evolve as the needs of the domain evolve with its maturity.

Scope and Content

The content of a science base for an applied science may therefore consist of the following categories of knowledge:

- Formalisation of the Problem space: a taxonomy of the range of application and theoretical problems addressed by the domain, organised so as to be used to characterise real applications and to link these to elements of the solution space.
- Formalisation of the Solution space: the converse of the problem space, this provides a taxonomy of knowledge available for the solution of domain application problems. In turn this links to methodologies and tools in the domain knowledge base.

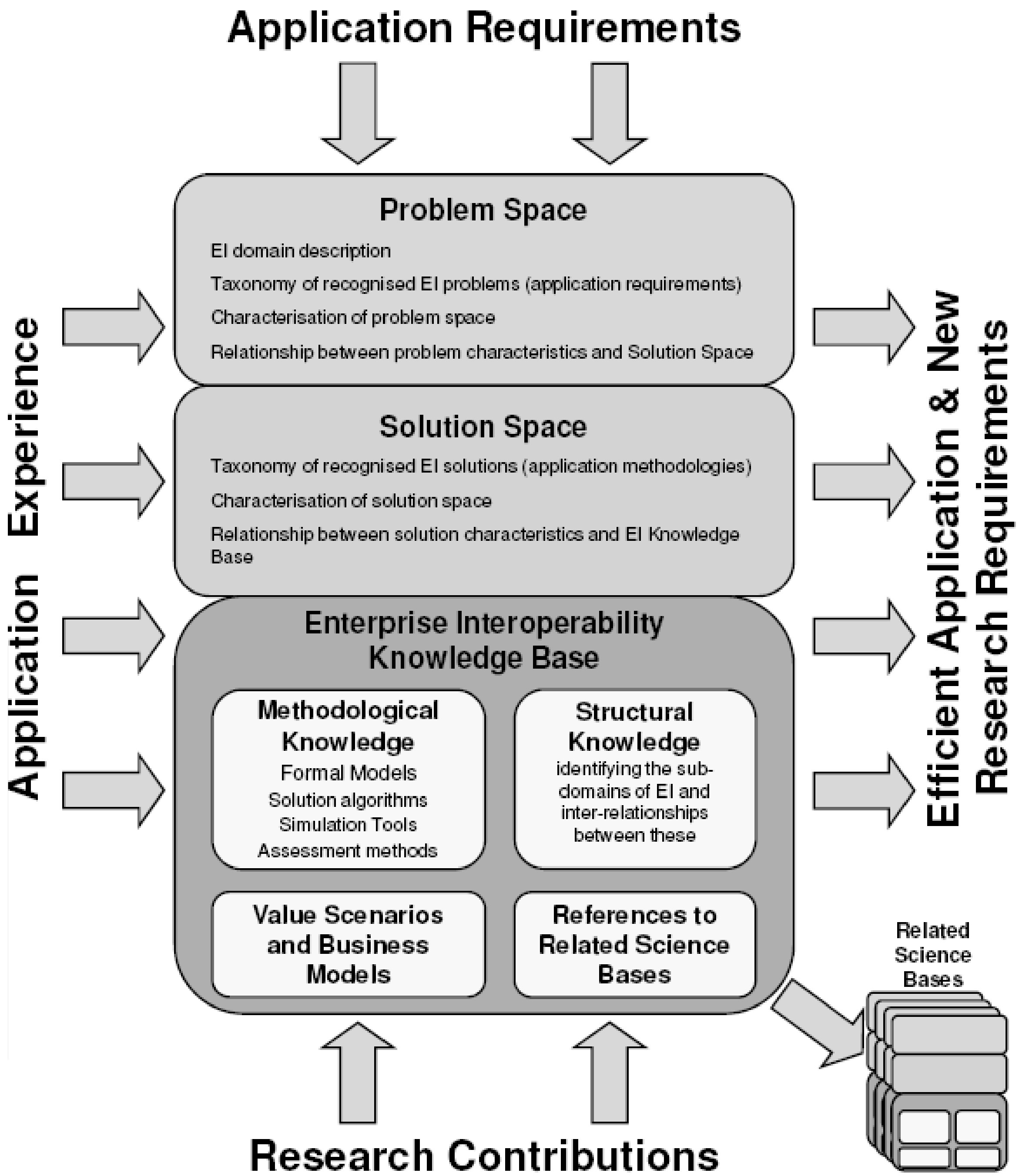

Figure 2: A view of EISB content

- Domain Knowledge Base: the domain knowledge base contains both structuring and methodological knowledge. The former defines the structure of the domain as perceived by its participant stakeholders:
  - a taxonomy of topics within the domain knowledge;
  - the scientific principles which provide the foundation of knowledge in the domain, and of both future research and application;
  - relationships between these topics, the problem space and the solution space;
  - relationships between domain knowledge and knowledge embedded in related scientific domains.

This is further illustrated in Figure 2.

4. SCIENTIFIC THEMES OF ENTERPRISE INTEROPERABILITY

Review of the state of the art (SoTA) of EI related research suggests analysis of published results along 3 dimensions:

- An Enterprise Interoperability Dimension that indicates the interoperability aspect it concerns.
- A Science Base Dimension that classifies the type of the approach, i.e. is it a method developed or a proof-of-concept or a survey?
- A SoTA Dimension capturing the type publication (eg. journal publication, conference proceedings, etc.).

These are illustrated in Figure 3.

Literature on EI research can also be categorised under a set of 12 main Scientific Themes:

1. Process Interoperability
2. Rules Interoperability
3. Ecosystems Interoperability
4. Knowledge Interoperability
5. Data Interoperability
6. Cultural Interoperability
7. Services Interoperability
8. Social Networks Interoperability
9. Cloud Interoperability
10. Electronic Identity Interoperability
11. Objects Interoperability
12. Enterprise Software Interoperability

Study of the state of the art of research on interoperability in general identifies distinct layering of political, organisational, semantic and technical interoperability, and EI is represented in all of these layers. The 12 Scientific Themes can be mapped on to the interoperability layers as shown in Figure 4.

It is significant to note the scale of research activity across these Scientific Themes. Figure 5 shows, in addition to the number of research publications identified, number of research projects relevant to the domain, the number of related events (conferences, workshops, etc.) and the number of initiatives (working groups, clusters, independent entities, standards bodies, etc.) which are current or recent. It is important to note the research project figure is for European activity only. This is not to suggest in any way that activity is limited to Europe: indeed it certainly is not, but the scope of this paper is to report the European perspective. The clear conclusion is that this is a highly active domain, and that efforts to formalise a science base, thus providing a theoretical base for future research as well as the links between the application problem space and the scientific solution space that are essential foundations for an applied science.

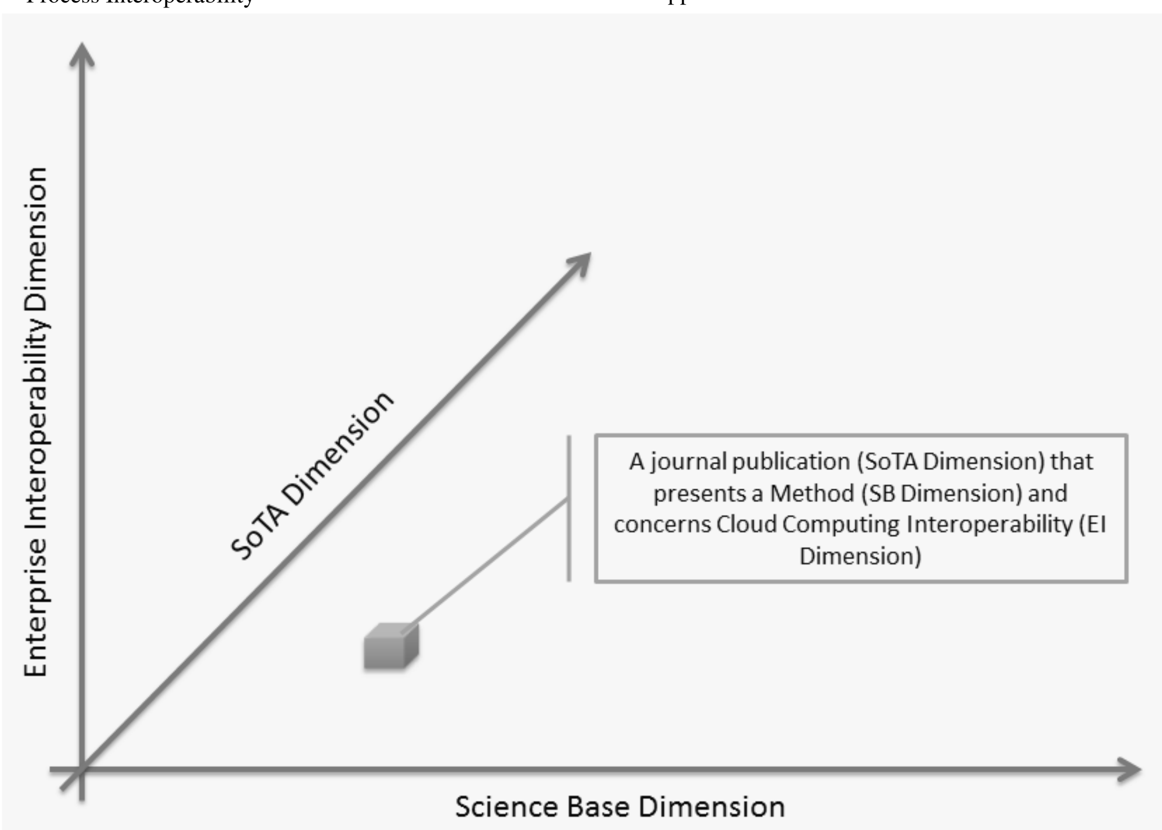

Figure 3: State of the Art Analysis Dimensions

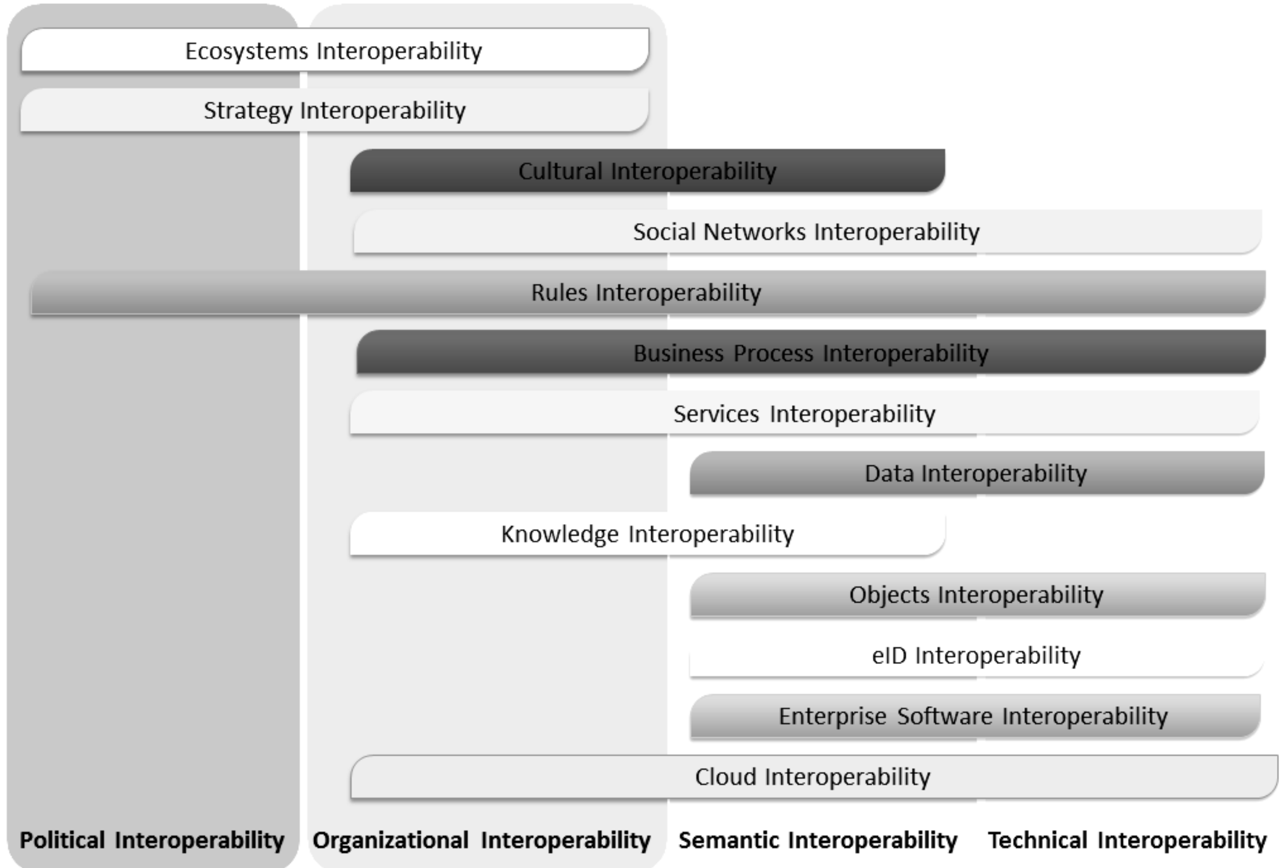

Figure 4: EI Scientific Areas Mapping to Interoperability Layers

5. CONCLUSION

The Enterprise Interoperability domain has clear links with a number of neighbouring scientific domains. Through drawing on these relationships, and identifying the unique contributions of EI research, it has been possible to draft a structure for an EISB which recognises the pragmatic, problem-solving purposes of EI as an applied science, whilst providing structure and content to domain knowledge. This latter must make domain knowledge accessible for application, as well as defining the underlying principle, axioms and theorems that are the foundation of EI.
However it is clear that the definition of an Enterprise Interoperability Science Base is not a parochial, European, interest. Initiatives are in place to develop a worldwide dialogue on the domain, of which this workshop is a part.

Total research contributions reviewed	544
European research projects relevant to EI	34
Relevant events worldwide	66
Relevant initiatives	13

Figure 5: Statistics indicative of level of EI research activity

6. ACKNOWLEDGEMENT

This work is supported by the European Commission Framework Programme 7 through the ENSEMBLE Co-ordinating and Support Action.

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A Methodology for Engineering Competencies Definition in the Aerospace Industry

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ABSTRACT

The need to cut off lead times, to increase the products innovation, to respond to changing customer requirements and to integrate new technologies into business process pushes companies to increase the collaboration.
In particular, collaboration, knowledge sharing and information exchange in the Aerospace Value Network, need to a clear definition and identification of competencies of several actors. Main contractors, stakeholders, customers, suppliers, partners, have different expertise and backgrounds and in this collaborative working environment are called to work together in projects, programs and process.
To improve collaboration and support the knowledge sharing, a competencies definition methodology and the related dictionary result useful tools among actors within an extended supply chain. They can use the same terminology and be informed on the competencies available. It becomes easy to specify who knows to do required activities stimulating collaboration and improving communication.
Based on an action research developed in the context of the iDesign Foundation project, the paper outlines a competency definition methodology and it presents examples from the implementation in Alenia Aeronautica company.
A new definition of competency is suggested supporting by a new method to specify the structural relationship between competencies and activities of aeronautical processes.

Keywords: Aerospace industry, Technical activities, Human competencies, Competency management, Competency dictionary.

1. INTRODUCTION

In a value network [1], many actors are called to work together in projects, programs and processes sharing resources, knowledge and expertise.
This interaction requires to several actors with different expertise and backgrounds to discuss about the requirements of products and decide about technologies, innovation, time, budget by which develop the product that best satisfy the potential customers.
The organizational activities aimed to continuous monitoring of resources and their expertise, become fundamental to identify the gaps in the skills and to define the actions to fill them [2] improving the creation of value for the whole network of companies.
In business environments, characterized by extended structural dimensions and by organizational complexity, often it is very difficult to objectively define and identify competencies of people involved in business activities. Also, it is complex to express these competencies with a common language shared by all the companies belonging to the network.
Each competency must be associable and linkable to specific activities performed into a company and to individuals, who are the owners of these competencies. Having a skills portfolio, companies can define a competency development plan consistent with future objectives and strategic positioning of the company.
In fact, the competency management has an important impact on improving the overall quality of the final product, and then on customer satisfaction.
These effects are clearly visible in a very complex enterprise network, like Aerospace Value Network, where the design and manufacture of complex products such as aircraft are based on the integration of specialized management and engineering competencies [3, 4, 5] available in different companies.
In aerospace industry, often the effort of improving the performance of engineering activities is translated into an enhanced knowledge management of people about sophisticated technology, innovative materials and knowledge-intensive processes and into an appropriate allocation of human resources in complex engineering processes, such as the design and manufacturing of aircrafts.
Therefore, competencies sharing between these companies necessitates of a clear definition and identification of competencies within the aeronautical network. However, studies explore the competencies management topic in aerospace industry [6, 7] but none is focalized on the description of a methodology that allows competencies definition in one company and in the whole network.
In this industrial context, the scientific research has the role to define general reference models, to indentify the basic pillars and the future troubles. The research project Innovative Design Foundation (iDF) is being carried out by a partnership among the Center for Business Innovation, a laboratory of University of Salento (Lecce, Italy), and two Italian firm: Avio, an aero-engine company, and Alenia Aeronautica, an airframe one. It aims to define an innovative model of a collaborative New Product Development, NPD, into the aeronautical value network, building a framework able to permit an intra-firm

collaboration, with high levels of standards of security and protection of knowledge assets.

The development of a complete competencies definition methodology and of a system supporting it is one of main objectives of the iDF project. A competencies definition methodology means a set of rules to specify and, thus, define all the available competencies creating a dictionary. The proposed iDF methodology is based on a competencies dictionary that contains and structures all the competencies available in the network in order to homogenize and generalize similar competencies and to define and identify critical competencies into a specific area. The system is actually under development and it will be able to evaluate the competencies set existing into each aeronautical company areas and to measure the impact of different allocation of individual and their competencies in other areas or firms in order to support collaboration and creation of relationships for NPD. This paper aims to describe the developed methodology and the related dictionary focused on a competencies identification process based on technical activities of design and development of complex products such aircrafts that is characterized by many competencies that need to be analyzed.

The paper is structured as follows. In the next section some theoretical definitions and previous studies are briefly reviewed in order to outline the background of the proposed methodology. Section 3 contains the description of the research approach highlighting the followed phases. In section 4, the paper results are treated: firstly the definition of a competency dictionary methodology is done and secondly there is a practical case study of the methodology application. Finally, section 5 draws conclusions, limitations, and future research.

2. BACKGROUND

In literature, several definitions of competency are available. The term competency has became popular with the study of McClelland and his collaborators, especially Richard Boyatzis [8, 9]. In its book "The Competent Manager", Boyatzis defines a competency as an intrinsic characteristic of an individual casually related to an effective or high level performance (e.g. motivations, skills, own image, knowledge) in executing one or more defined task [10]. Klein [11] has, instead, provided a definition that looks the competency as a set of observable behaviours or behavioural indicators that can be grouped around a central topic and became a competency.

From the definitions available in literature, it is possible to conclude that competencies are the knowledge, ability and behavior to execute an effective work task. These features are observable and measureable and looking to them is possible to improve and differentiate the results of the related activities [12, 13].

Several studies are focused on the classification of competencies. In competency model of Harzallah [14] the competencies are shared in three categories:

a) *Knowledge*. It concerns to everything that can be learned from educational/formative system, training course and everything which involves cognitive processes (i.e. perception, learning, communication, association and reasoning). It represents the theoretical understanding of something such as a new method or procedure, an updating of them, etc.…
b) *Know-how*. It is related to personal experiences and working conditions. It is learned by doing, by practice, by experience. It is the practical knowledge consisting in "how to get something done".
c) *Behavior*. It is referred to individual characters, talents, human traits, or qualities that 'drive, direct or select' someone to act or react in a certain way under certain circumstances.

Furthermore, an individual has several competencies impacting on the organizational activities and on patterns of organizational evolution and change [15]. An activity needs specific competencies to be executed and to optimize its performance. The application of the same competencies in two different activities can lead to different level of results. In this perspective, competencies are defined in literature as "effective performance within a domain/context at different levels of proficiency" [16]. In addition, the level of specialization in a given competency, based on the qualification, experience and focalization of the actor in executing an activity is also an important aspect. A more specialized competency allows to execute an activity, in which it is required, in a faster and more effective way [15].

Competency management involves several processes that can be categorized in four classes [17]:

- *competency identification*. Starting from an analysis of business processes, business areas, operating procedures, values and corporate culture, and using the definition of competency on the business context, for each business area/process, the competencies of the human resources are identified. These are the skills that must have employees to make (in the short and medium term) the expected performance and business objectives. This phase brings to a competency dictionary creation. In order to be an effective tool, this catalogue of competencies should be regularly updated and adapted to any changing needs of business and corporate strategy.
- *competency assessment*. In this process, a valid method to measure the effective knowledge of human resources that performs a specific activity, is identified. To calculate a competency gap, the real competency level of each employee is compared with the level of competency considered optimal.
- *competency acquisition*. In this phase, a company have to plan and decide about how and when to acquire some competencies. There are different acquisition competency tools that allow several types of analysis.
- *competency utilization*. This process uses information about the competencies produced and transformed by the identification and assessment processes.

The assessments obtained allow to perform analysis such as [6]:

- identifying the gap between the competencies needed by activities and competencies possessed by personnel and corporate entities;
- placing all available resources in the right roles with positive organizational effects;
- identifying critical resources that need training and/or improvement actions to develop their potential;
- assessing the change impact of movements of certain individuals in other companies or areas.

Looking to the literature, it is perhaps missed a definition of competency able to collect all the evidences needed to represent the complexity of high technological sectors such as the aerospace one.

3. RESEARCH DESIGN

Based on an action research, the paper outlines a competency definition methodology and it presents findings from the implementation in Alenia Aeronautica company. An action research [18] has been realized moving from the objectives of the iDF project and from the needs of the members companies.
In Corallo [6] is described a methodology used by Alenia Aeronautica to improve and monitor the own competencies looking to the internal company activities. This methodology needs more customization and theoretical justification that have lead the company to explore a new methodology able to catch all the available competencies and structured them in a sounder way. Furthermore, technological systems are available inside the company to support the employees allocation in the work activities based on their competencies [6] and new technological solution more powerful are actually under development [19].
The aim of the study is to suggest a new competency definition methodology representing the complexity of the aerospace industry that can be diffused in networks of companies in order to share common definitions about the competencies needed to perform an activity favoring the allocation of employees and the scouting among companies. The methodology is, thus, created and used to define a competencies dictionary for the aerospace sector. To develop the methodology four main phases have been followed:

- literature analysis;
- companies exploration;
- methodology definition;
- methodology test.

The literature analysis has investigated competency definitions and methodologies available in scientific papers in order to highlight and compare different scholars and specify existing gap. The second phase has, instead, explored how companies manage their competencies and which methodology they apply. In this phase, the methodology used in the iDF partner companies and in other companies have been explored in order to find best practices and criticalities. The first two phases have been useful to design the "as is" in the competencies field and to guide the development of a new methodology. In the third phase, a new methodology has been proposed to reflect the complexity of the aerospace sector and the network perspective. In the final phase, the methodology has been tested in the Alenia Aeronautica by a set of interviews to company key persons in order to validate the findings.
In the following section, the methodology is described and some practical examples are reported.

4. COMPETENCY DICTIONARY

The research activities in the Research Project I-Design Foundation have allowed to develop a methodology for drafting a competency dictionary for aeronautical network.
The competency concept definition is focused on the structural relationship between technical activities of an aeronautical process and its required skills .
Starting from the competency subdivision in *knowledge, know-how* and *behavior* ([14]; see section 2), this study leaves out the behavior category. Because for its multifaceted feature it's difficult to define and classify. Only the concept of knowledge and know-how related to a competency have been considered. The introduction of behavior in the competency dictionary methodology will be evaluated in a future extension.

Concepts and proposed methodology

The analysis of Alenia Aeronautica's technical activities and the study of competencies classification (knowledge, know-how, behavior) reported in the literature have been necessary to obtain a competency definition valid in a technical context. This definition provides guidelines for the creation of a competency dictionary.
In order to get the competency/ies necessary to realize/implement a technical activity it is necessary to ask: *"What is it need to know?", "What are the main aspects of the tasks you need to know to perform them?"*. By analyzing the activities and how they are described, it is possible to identify three main features that characterize them: method, technology and product.
Method represents procedures, company policies, methodological standards, implementing rules and calculation methods. Method's knowledge allows the human resource to operate and carry out activities in accordance with default procedures.
Technology is the tool or technological knowledge used for the activity. It may be broadly defined as everything, both material and immaterial, created by a mental and physical effort to solve real world problems. In this sense, technology can refer to both simple and complex tools/machines and technological knowledge necessary to carry out the activities. The virtual technology as a software falls under this definition of technology [20].
Product refers to the good or service (with all its components and sub-components) that the company produces. For manufacturing activities, it could coincide with the output of an activity. In general, the product is defined on the basis of its physical characteristics (size, shape, etc..) and its complexity (detail or assembly).
Given a task, a human resource has the competency to carry out this task if he knows these three aspects.
In conclusion, the competency to perform a given activity is defined as the knowledge that the human resource must have about the three main features characterizing the activity: method, technology and product.
The activities description will be the starting point of this study: only after understanding in detail their content it is possible to identify the related three competencies features.
To correctly identify the competencies all the activities must be described with the same level of detail.
However, the list of activities considered often presents both macro activities described in a very general way and simple activities described in great detail.
In these cases, to obtain an homogeneous and detailed definition of competencies of each activity, it could take into consideration the output of the activity.
A macro activity produces several outputs while a simple activity produces a single output.
Starting from the analysis of the information about the output, the competencies features about method, technology and product required to perform an activity, can be specified. Usually, an activity generates an output that typically can be a document, a design model, a single product or assembly, etc. The output description contains all the information about the three aspects of competencies that people must have to execute the task. (Fig. 1)
Considering a simple activity that produces a single output, the three aspects of competency required by activity can easily be deduced from the analysis of the only output.

Considering a macro activity that produces several output, the list of competencies required is given by the set of competencies needed to get every output.
The output of the activities can also be considered in the competency assessment phase within the competency management model.
Indeed, an objective competency evaluation of human resources is focused on the assessment of the output produced by the resources in their activities.
Therefore, the output is a fundamental element both to identify and to evaluate business competencies.

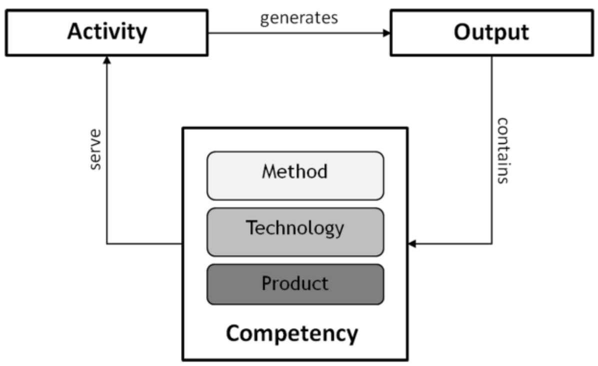

Fig. 1: Competency identification.

Competencies indentified in this phase are used to populate the competency dictionary. This dictionary will be composed by three chapters: the first containing the competencies related to the products made in the activity, the second comprising those related to the methods, practices and procedures adopted and the last including those related to technological tools and technologies that the activity uses.
In this study the term "competency" is intended only as *knowledge*, i.e. the theoretical knowledge about the three features but not as *know-how* or practical knowledge.
The dictionary should be used to understand which competency of a person must be assessed. In the competency assessment phase, only the knowledge aspects that find expression in tasks and become know-how, are evaluated. To allocate its resources on the business activities, a company needs to evaluate what a person can effectively do, that is the "know-how" derived by his experience in present or past programs or projects useful to perform the activities. When the available knowledge is not converted in know-how, improvement initiatives, such as training courses, must be provided to the resources in order to fill the identified gaps.

Practical Examples

The case study presented aims to be an example of the application and, consequently, validation of the methodology illustrated in the paper. It is focused in the Alenia's Interiors Area, specialized in the development of all aircraft's inside arrangement.
The competency dictionary methodology is applied to all the activities of the Interiors Area in order to obtain a complete competency dictionary related to this area.
In this section, it is reported a part of this competency dictionary obtained from the application of the methodology to the technical activity "Drawings and production detail models issue" belonging to Alenia's Interiors Area. This is a generic task which produces different types of outputs, related to different products.

Consequently, a detailed definition of competencies of method, technology and product of this activity, cannot occur without the analysis of its outputs. As an example, two of the several activities outputs are treated ("Design model of Lining of the passengers cabin"; "Design model of aircraft's secondary structure") and some competencies of method, technology and product are identified.
The realization of the output "Design model of Lining of the passengers cabin" requires the competencies listed in figure 2. In order to carry out the activity "Drawings and production detail models issue" that produces such design models is necessary to know:

- the products Lining;
- the materials forming the product (such as Aluminum);
- the manufacturing technologies (such as folding process) related to the product material;
- the software tools as the CATIA V5 modeling tool and the product lifecycle management (PLM) software, Engineering Team Center;
- some company procedures (Drafting Manual, Practice and Procedure Design, Civil Regulations).

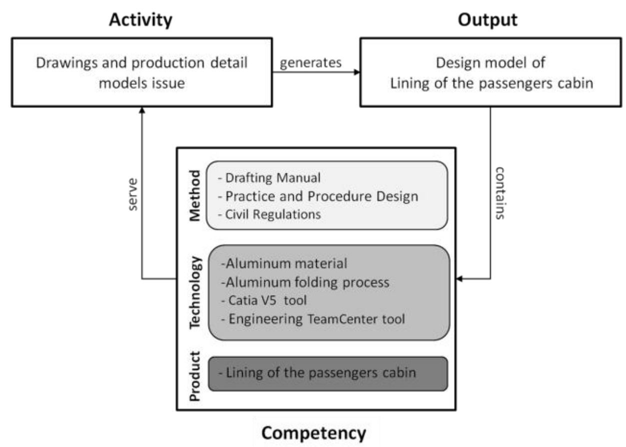

Fig. 2: Competency identification starting from the output "Design model of Lining of the passengers cabin".

Different competencies will be associated with the same activity for each output it produces. The activity taken in example, "Drawings and production detail models issue", realizes the output "Design model of Lining of the passengers cabin" described before and the output "Design model of aircraft's secondary structure". For this last one, a competency characterized by a specific combination of Method, Technology and Product is required (Fig. 3) and it differs from the previous one described (Fig. 2). In fact, the realization of this output, requires the knowledge of:

- the aircraft's Secondary Structure;
- the materials which form the product (such as Steel);
- the manufacturing technologies (such as forming process) related to the product material;
- the software tools as the CATIA V5 modeling tool and the product lifecycle management (PLM) software, Engineering Team Center;
- some company procedures (Drafting Manual, Practice and Procedure Design, Civil Regulations).

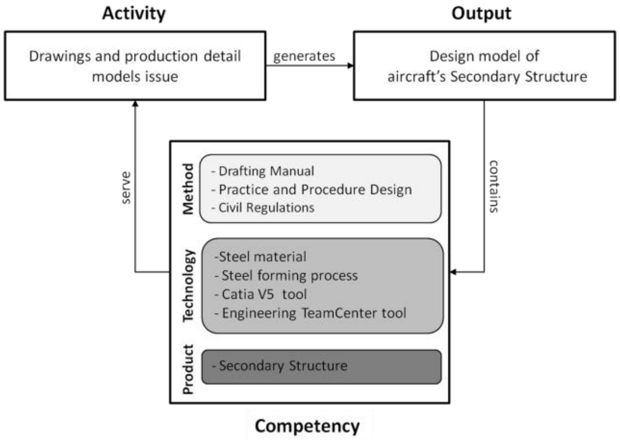

Fig. 3: Competency identification starting from the output "Design model of aircraft's Secondary Structure".

The similarity of the competencies of methods and of technologies (related to the tools) between the previous examples was expected since both competencies are related to different outputs which belong to the same activity. Therefore, among competencies of the same activities there could be some similarities.

Looking to a whole activity it is possible to summarize all the related competencies and thus, to present the activity as a set of competencies. Looking to the analyzed activity "Drawings and production detail models issue", the identified competencies respect to the two outputs, are summarized in the following table.

Activity	**Competency aspect**	**Competency: Knowledge of…**
Drawings and production detail models issue	**Method**	Drafting Manuals
		Practice and Procedure Design
		Civil Regulations
	Technology	Aluminum material
		Steel material
		Aluminum folding process
		Steel forming process
		Catia V5 tool
		Engineering TeamCenter tool
	Product	Lining of the passengers cabin
		Aircraft's Secondary Structure

Tab. 1: Example of Competencies dictionary related to the activity "Drawings and production detail models issue".

Continuing the analysis of all the different outputs, the complete competencies dictionary associated with this activity can be obtained.

The same method has been applied to all the activities belonging to Alenia's Interiors Area in order to achieve a complete competency dictionary.

5. CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH

Starting from the definition of the "competency" concept reported in literature and by the analysis of competency definition methodology in literature and in the firms practices, a new methodology to define the engineering competencies has been defined and tested on a real process of Alenia Aeronautica using a set of interviews to company key persons. The main goal of this approach is to obtain a competency dictionary common to the actors working into a collaborative environment. The competencies available in each company will be defined with the same criteria and using the same terminology that will support the collaboration, the search and exchange of resources.

A competency related to an activity, it is characterized by three main aspects: method, technology and product. Consequently, the competency dictionary mapping the knowledge required for the activities is divided in three sections, the competencies related to the methods, the competencies related to the technologies and the competencies related to the product. The methodology has been tested on the activities of a specific technical area of Alenia Aeronautica but the study will be enlarged with the implementation of the proposed methodology to the whole enterprise including also other areas and activities (such as logistics activities, manufacturing activities, administrative activities, etc…).

The approach described and validated in this study may be and should be extended also in other companies of the aeronautical sector in order to obtain a common and sharable competency dictionary.

Furthermore, in a future research the methodology could be tested and verified into company of others complex sectors (such as naval, medical, ecc…)

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Plato, Socrates, Hunt, and Rotfeld: Eigenforms of Academic Collaboration

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ABSTRACT

A number of academic institutions profess to offer Interdisciplinary Studies but few truly achieve it, and not without a great deal of effort over and above the normal workload of a professor and a level of patience and perseverance not found in many university students. This paper will report on a successful academic collaboration between two very different disciplines: philosophy and business. It will examine a course taught jointly by the two disciplines in a strategy of imbrication attempted by a college of York University in Toronto, Atkinson College, housing both liberal arts and professional school.

Keywords: advertising, collaboration, cybernetics, education, imbrication, marketing, Plato

1. INTRODUCTION

In the York University academic year of 2003-2004, Professor Claudio Durán and I set out to teach Atkinson College's first and only imbricated course. But we had been talking about it for many years prior to this.

Atkinson College – Atkinson College no longer exists at York University, having merged with the Faculty of Arts to form the Faculty of Liberal Arts and Professional Studies, but for more than a quarter century it was a special place where full-time professors taught their full course load in the evening and summers. The college specialized in offering university study to part-time and mature students, with more than two thirds of our students being full-time working adults returning to university. Another large number were university-age students who could not afford to go to school full-time without working. The college consisted of a large liberal arts component, teaching all the subjects taught during the day at the York Faculty of Arts, and a professional studies side consisting largely of the Department of Administrative Studies, offering a business degree called the Bachelor of Administrative Studies. Both programmes were available only on a part-time basis, although students could conceivably take four evening courses and a Saturday course in a week and proceed as full-time students. We had functioned since 1962 as two separate entities: the liberal arts side of the college and the business side. York University, like other universities in Canada, is government funded.

When I first started teaching at Atkinson College, my department on the fifth floor did not have enough room for me there, so I landed on the sixth floor among the Philosophers. This changed the direction of my research in ways that have been rewarding to me personally and professionally. The move suited me well. While my terminal degree was in business (major in marketing), I had always, since studying at a fine small liberal arts college in Illinois, Shimer College, possessed a strong interest in philosophical discussion and in the roots of our Western education system in Plato and Socrates. On the sixth floor of Atkinson College, among the Philosophers, I met Professor Claudio Durán whose terminal degree was in philosophy and who had always possessed a strong interest in mass media, advertising and ethics. Business and liberal arts are not natural companions, but while our respective departments often battled, Professor Durán and I often met to discuss our mutual research interests, often over lunch or dinner at Atkinson before classes. One of our favourite topics of conversation was the idea of teaching a course together, combining our mutual interest in philosophy, ethics, and advertising.

Professor Durán had often guest lectured in my courses, addressing logic and introducing us to the work of fellow York professor Michael

Gilbert, who originated the theory of multi-modal argumentation. We both now used this theory in our research and in our classrooms. I became a frequent guest lecturer in Professor Durán's course titled Philosophical and Ethical Issues in the Mass Media, where I brought the application of logic and multi-modal argumentation to advertising.

Imbrication – The dictionary definition of the word *imbrication* tells us that it derives from the Latin *imbricare*, to cover with gutter tiles, to form like a roof or gutter tile from the Latin *imbrix*, a gutter tile, from *imber*, rain. The word imbricate means "lying over each other in regular order, like tiles on a roof, as the scales on the cup of some acorns; overlapping each other at the margins, without any involution" [13]. A shorter definition gets to the point of the use of the word at Atkinson College, "to place so as to overlap". I describe the definition in fine detail because at the time that we were asked, as university professors, to develop "imbricated courses", none of us knew what that meant. Dean Ron Bordessa and the Working Group responsible for this strategy had in mind to take the two diverse parts of Atkinson College and put them together in a collaborative way so they were each part of the integrated whole and overlapped.

To understand imbrication, one also needs to understand the difference between multidisciplinary and interdisciplinary studies. Multidisciplinary studies bring together the separate expertise of two or more scholars from different fields of study; they each approach the problem from the viewpoint of their respective fields. Interdisciplinary studies also bring together two or more scholars but they approach the problem together, as a team, each building on the knowledge and expertise of the other. Most universities offer multidisciplinary programmes but they cannot be called interdisciplinary work. We might observe, for example, a course on Long Term Space Travel taught by a professor of physics during the fall term, and then by a professor of sociology in the winter term, each teaching and testing separately. Most undergraduate students are required to take several courses outside their major discipline, one hopes as different as possible from their major discipline. Thus a student might be majoring in marketing but take electives in the Music Department in music of the Middle Ages. A school might offer a joint programme between two disciplines, where each discipline would contribute its own offering to the student's learning. The proposed imbrication would see courses designed and taught together by faculty from the liberal arts and the business sides, with a vision of both professors in the classroom at the same time, teaching together students from different disciplines.

2. THE FIXED POINTS

Plato – Plato lived from 428 or 427 to 348 or 347 B.C. in Ancient Greece where he taught students using the Socratic Method. He was a pupil of Socrates. It has been said that our current education methods in Western society have their direct roots in Plato's teaching and writing. Plato also is known for his theory of Forms, wherein we evaluate what we can or cannot truly know.

Socrates – From Socrates we have no writing at all, only what Plato wrote about him. He lived in Greece from 470 to 399 B.C. before being condemned to death by drinking hemlock for his unusual teaching methods. His unusual method is what we know today as the Socratic Method. In this way of teaching, the teacher asks carefully chosen questions and encourages the student to learn the truth through logically questioning his assumptions.

Hunt – Shelby D. Hunt serves as one of marketing's cornerstones of academic theory, bringing to the discipline a thorough understanding of the field, and of its links to other fields going as far back as Plato and Socrates. He teaches marketing as the Jerry S. Rawls and P.W. Horn Professor of Marketing at Texas Tech University. He has served as editor of the *Journal of Marketing*, and his work has recently been selected to be published in Sage Publications' "Legends in Marketing" series.

Rotfeld – Herbert Jack Rotfeld is a self-labelled iconoclast, Professor of Marketing at the Auburn University College of Business, but with a watchful eye always on the world of misplaced marketing. He edits the *Journal of Consumer Affairs*, serves as President-Elect of the American Academy of Advertising, and writes a regular column on how marketing can be misused, especially advertising.

Durán and Ripley – Professors Claudio Durán and Louise Ripley (author) are both professors in the Faculty of Liberal Arts and Professional Studies at York University in Toronto. Professor Durán teaches philosophy and Professor Ripley teaches business and women's studies. Both have been winners of the Atkinson College Alumni/ae Award for Teaching Excellence and consider teaching their life's work.

3. TEACHING THE COURSE

Professor Durán's terminal degree was in philosophy, with its links to logic, argumentation, and classical studies, but he also held an abiding interest in advertising and ethics. My terminal degree was in business with its links to advertising and ethics but I also held an abiding interest in logic, argumentation, and classical studies. We both were interested in the role of philosophy in helping us understand questions of ethics, whether in advertising or elsewhere.

While our respective departments fought grand battles on the floors of Council and Senate, Professor Durán and I frequently ate together in a quiet corner of the Faculty Club and tallied all the advantages of working in a college that combined both liberal arts and business. Knowing I was interested in finding ways of analyzing the ethics of advertisements, Professor Durán introduced me to Professor Michael Gilbert, also in philosophy at York, in the Faculty of Arts. We actually met on the picket lines during York faculty's 1997 fifty-five day strike. It was from Professor Gilbert that I learned multi-modal argumentation theory and invited Professor Durán to my courses a number of times to teach my students the basics of logic and argumentation. As my research progressed in the area, Professor Durán invited me a number of times to give a guest lecture in his classes. Particularly suited to this arrangement was his course entitled, "Philosophical and Ethical Issues in the Mass Media". We began to speak regularly and excitedly about the idea of teaching the course together. When the strategy of imbrication was introduced, we recognized our chance.

We planned the course together, creating a new (and online) course syllabus that laid out in detail how the course would be organized, combining readings and instruction in both logic and advertising. We started the course with Plato writing in the *Gorgias* [8] about the teaching method of Socrates and the concepts of argument and persuasion and the good of society. We then moved through Formal and Informal Logic, using the work of Morris Engel [3]. In the second half of the course, we moved to the work of Shelby Hunt, a modern-day marketing scholar who bases his study of marketing theory in philosophy as it came down to us through Plato, Socrates, and Aristotle. Hunt himself says, "…we shall see that many of the current debates in marketing and the social sciences were argued (perhaps better) in Plato's time" [7]. Shelby Hunt introduces his book, *Modern Marketing Theory*, with a quote from Epictetus, a Greek born Roman slave of the second century.

> *Question: Prove to me I should study logic!*
> *Answer: How would you know it was a good proof? [7]*

Plato, Hunt claims, defined knowledge as "justified true belief". For Plato true philosophical wisdom must pass the test of critical discussion, the Socratic Method of today. This fits not only with Hunt's view on how we should view marketing theory but also with the enlightened system of education which encourages more student participation. It also provides a method to examine the logic in advertisements as we look at advertising as in pragma-dialectics, as a dialogue between advertiser and consumer, where we will examine the exchange to understand what tactics are being used in order to sell [9]. Hunt also reminds us of Plato's theory of Forms, which is most useful in examining pictures as verbal arguments [6]. Coming out of the school of thinking of Pythagoras, and enamoured of the concept of abstract terms in mathematics, Plato set forth a theory that abstract ideas or essences had an ultimate reality outside of how we saw them. What we perceived through senses, Plato said, was only an imperfect copy of the ideal thing, and we could therefore only know things as we perceived them. This links directly to Hunt's chart on the differences between positivist/empiricist science and relativistic/constructionist science whereby we find many realities in a science that s a "social process" as opposed to a science where it is possible to discover the "true nature of reality" [7].

We used a paper by Ripley [10] to study the use of Gilbert's multi-modal argumentation theory [4,5] in examining advertising as it is seen by advertisers. We used articles by Professor Durán on the Chilean newspaper *El Mercurio* [1,2], which provided another link to the use of logic and multi-modal argumentation theory in analyzing arguments.

We wrapped up the course with chapters from Herbert Jack Rotfeld's book, *Adventures in Misplaced Marketing* [12]. This book**,** in its argument that marketing when abused often results in outcomes not in the best interests of society, brought us full-circle back to Plato's work in examining the ethics of persuading the masses, where we had started in the fall. Rotfeld maintains that it is not right to criticize marketing in the way that many people do, citing the number of people who approach him as total strangers and demand, "…how dare you advertise cigarettes to children!" as if, because he studies marketing, he were personally responsible for what is instead a reflection of society's wants. Research consistently shows, says Rotfeld, that "people are very resistant to the persuasive efforts of marketing tools". Marketers wish they possessed the power that critics accuse them of having [12]. There is the further issue of whether an advertiser of a consumer good, such as perfume or body wash, is the one totally responsible for the public's attitudes toward casual sex or violence against women. Rotfeld maintains that they are not, as does Ripley [9,10,11]. Marketers are generally reflecting what a large part of our society already believes. Rotfeld describes two types of misplaced marketing, the first where the seller did not consider the consumer in the proposed campaign, a lack of the marketing concept. The second occurs when marketing is used properly but it may not have been done in the best interests of society, such as the marketing of cigarettes, liquor distillers, gun companies, or pornographers to the wrong people. He cites the example of a new beer appealing to low-income black consumers. All of this is helpful as we contemplate the arguments made in the advertisements that sell these products.

Following from Plato and returning to him through works in logic, argumentation, and advertising, both Professor Durán and I taught together in the classroom for every class for the full year. We tried to avoid both of us standing at the front of the room, lest we intimidate students. We like to think of ourselves as anything but intimidating but two professors at the front of a classroom is an oddity for students. In a college that held evening classes from 7:00 to 10:00 p.m., after years of budget cuts, class sizes grew too large for good discussion, so we arranged the three hour class differently. Half the students came for a tutorial with both professors from 6:00 to 7:00 p.m. There followed a lecture and full class discussion from 7:00 to 9:00 p.m., and then a tutorial with both professors from 9:00 to 10:00 p.m. for the second half of the students. Assignment to tutorials was not rigidly enforced, and students could move between early and late tutorial as it suited their schedules. Formal lectures were rare; we strongly encouraged full class participation and utilized a variety of pair and share, small group work, and other pedagogical exercises that kept students engaged.

The course was well received. Students loved the chance to interact with others from different disciplines and the course produced one award-winning paper by two students, one from philosophy and one from marketing. The Dean at that time, Dean Rhonda Lenton (who succeeded Dean Bordessa) heard about our course and asked if she might visit. We invited her to show up at any time. The Dean arrived during a period when the whole class was together for the two-hour lecture and discussion. Professor Durán was on one side of the room and I on the other, and a lively discussion was proceeding, bouncing from student to student with occasional input from us. Our dean was highly impressed. At that time we were teaching the course experimentally with each of us receiving only half the full-course teaching credit, something we did not want to continue in a unionized Faculty. The Dean arranged the next time we taught the course together, for us each to get full teaching credit for teaching a full-year course. This is not sustainable, however, especially in a college and university facing continual budget cuts.

4. CONCLUSION

There is no satisfactory answer to the budgetary problems that inhibit fair payment for two professors of an imbricated course. Professor Durán although retired, still teaches at York University and University of Chilé, and I am teaching mostly online. But we still count as some of the best years of our combined eighty-plus years of teaching experience our imbricated course that brought together students of philosophy and business to study with a professor of philosophy and a professor of business, reading the works of men who can serve as tokens for stability in academic work that has come down to us, in many changing ways in a rapidly changing world. What does change, for the good, is our continued ability, while applying the old classics to our teaching, to apply new classics in research to what we already know and are teaching. This is particularly appropriate to a collaborative imbricated course.

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Collaborative Integration of Classic Applications in Virtual Reality Environments

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Abstract

When working collaboratively with others, it is often difficult to bring existing applications into the collaboration process. In this paper, an approach is shown how to enable different applications to work collaboratively. It enables a user to do three things: First, the ability to work collaboratively with the application of choice, selecting those applications that fit the need of the scenario best, and the user is comfortable to employ. Second, the user can work in the environment he chooses, even if the application is not specifically designed for this environment like Virtual Reality Environments or mobile devices. Third, the technology presented makes it possible to mesh applications to gain new functionalities not found in the original applications by connecting those applications and making them interoperable. Taking a Virtual Reality Environment and a standard office application, the use and fitness of this approach is shown. It should be specifically noted that the work underlying this paper is not specifically on multimodal usage of Virtual Environments, although it is used that way here, but rather showing a concept of meshing application capabilities to implement "Meta-Applications" that offer functionality beyond their original design.

Keywords: Collaborative Engineering, Collaborative Work, Virtual Reality, Scientific Visualisation

1 Introduction

Traditional collaborative work that is state-of-the-art today focusses on screen sharing and video conferencing. Although this method works, as it is simple and does not imply a lot of demand on the systems used, it is awkward and uncomfortable. Modern collaboration demands more than just screen sharing. Especially in research and development the data is much more interesting than just the visual representation that you can capture using screen sharing alone.

The design of a new prototype in R&D often requires the consideration of a multitude of parameters that influence the final product. The product design impacts on the process in manufacturing and on the physical properties and vice versa, costs have to be calculated and reduced as much as possible and physical prototypes have to be somehow correlated to the initial virtual design. This often requires a multitude of data and views on that data, each usually bringing along its own application for display.

Thus, a design process involves several documents that contain different data that is somehow interrelated. An Excel sheet could contain the specifications for a virtual prototype that is visualised in a Virtual Environment, and a simple text file may specify the log and parameters for a simulation run whose results are displayed on top of the displayed prototype. Also, different views using the same application are often required to assess a development. This does not just include different viewpoints to a data set, but also different representations and different aspects. Sometimes, different tasks require different media for display or kinds of interaction, like making it necessary to relocate a discussion from a meeting table to a Virtual Environment for a closer discussion of an issue that has arisen.

Especially in aforementioned Virtual Reality Environments – but also on emerging every-day technologies like multi-touch screens – it is difficult to work with "classic" applications, as the interaction paradigms there are quite different from those used on the desktop. Here, the traditional screen sharing approach definitively fails, as it is impossible to translate the unique input restraints in those environments directly to the shared screen, thus limiting the collaboration to the same kind of the original device.

In this paper, an approach is introduced to make applications accessible in a collaboration, even beyond the boundaries of a single application. This technology will be used to access data from Microsoft Excel in the collaborative Virtual Reality Environment OpenCOVER for COVISE. COVISE is a modular and collaborative post-processing, simulation and visualisation framework enabling the analysis of complex data sets in engineering and science [1]. OpenCOVER, the COvise Virtual Environment Renderer first described in [2], supports Virtual Environments ranging from workbenches over Power Walls, curved screens up to full domes or CAVEs and head mounted displays. Using OpenCOVER, users can analyse their datasets intuitively in a fully immersive environment through state of the art visualisation techniques, including Volume Rendering and fast sphere rendering. Physical prototypes or experiments can be included into the analysis process through Augmented Reality techniques. OpenCOVER features an extensible plug-in framework that allows to add further functionality to the environment. OpenCOVER already supports collaboration at every level. Users can connect from different locations, analyse data sets, include audio and video conferencing in their session, mark and document collaboratively features of the data set, and other. Using COVISE and OpenCOVER, it is even possible to join a collaboration just using a plain web browser without any specialised plug-ins, enabling collaboration from everywhere [3].

2 Related Work

It is generally accepted that applications especially created with collaborative use in mind are less functional and used than the single user applications that are commonly used by the end users (e.g. [4] [5]).

A few methods exist that enable different users to share their applications with each other. There are the rare kind of applications especially designed for sharing. They incorporate concepts for collaborative work and inherent sharing. The advantage of that approach is that, as the sharing is done at the application level, it is usually much more sophisticated, efficient and powerful compared to all other approaches. Drawbacks here are that the shared application is usually developed primarily as a research vehicle for sharing concepts and often lacks the functionality typically found in state-of-the-art single user applications [5]. This is still true, though recent efforts of e.g. Microsoft [6] and others show that the once single user applications start to be extended to further support collaboration, integrating more and more into collaboration enabling Groupware systems. When looking at application design, collaboration features form usually a very small part of a complete application [7]. Thus the common collaboration research applications are doomed to fail comparing to state of the art applications. Collaboration design is nevertheless important, but it seems more straightforward – if the original software creator refuses to add internal collaboration facilities – not to replicate the application just for adding collaborative features, but rather to extend the existing application for collaborative functionality.

Different methods of transparent application sharing have been deployed. The first efforts undertaken were focused on image based sharing of the application. Here, the desktop screen or parts thereof is captured and transmitted to the partners in the session. This is currently the most accepted form of application sharing, used in various state-of-the-art commercial collaboration software like WebEx [8], TeamViewer [9], and others. The reason behind the wide adoptance is the ease to share arbitrary applications, nowadays usually without a dedicated application framework but through the web browser with appropriate standard plug-ins. The main drawback is generally a comparatively high bandwidth needed while sharing the application and that the application shared is not really collaborative, but rather just one user can work with a single application instance at a time, the others are viewers only. This limits the usability and flexibility of this approach, leading to other ways of transparently sharing an application.

In research, more semantic approaches are common nowadays. Those approaches use transparent sharing that enables to share applications without them explicitly knowing that they are being shared. In contrast to the screen sharing approach, they usually only capture raw input events like key presses or mouse clicks rather than pixel data and transform those into more abstract events using knowledge about the application. The clicks and inputs are then replayed in all the participants' locally running applications and thus keep the application state consistent on all connected hosts. Systems using this approach are described e.g. in [5] and [4].

The main advantage of this approach is that it is feasible for all current applications. But it requires the applications to be visually equivalent to capture the right button at the right coordinates. If one user reconfigures his user interface, this method may fail completely. It is also usually limited to a single operating system type as it accesses low level operating system features not found on other systems. Furthermore, only the surface of collaboration is touched this way. Capturing the application state and the content currently processed in the application cannot be included in the synchronisation process, although it is typically the most important part in the collaborative work.

A more sophisticated system will try to access the internals of an application and use the loaded documents and application states to improve the collaborative experience [7]. Almost all state-of-the-art commercial applications, especially on Microsoft Windows, nowadays support some kind of API a programmer can connect to and issue commands to the application or retrieve information about the document loaded or the state the application is in. This kind of API makes it often very easy to implement a collaborative layer, quickly enabling an application to be used in a collaborative way.

In the last decade, several such solutions emerged that did not simply broadcast screen contents and capture keyboard input, but rather analyse the input events and the application semantically and replicate the events and synchronise the application contents on remote machines. This approach is surprisingly successful, as several examples show, extending off-the-shelf software like Word [7], Visual Studio [10], or Maya [11]. Xia e.al. [7] for example use Operational Transformation to map events from an application to simple insert and delete operations on a linear object space. As those operations are quite simple, it is also relatively easy to assert the consistency of the two documents when edits change cursor positions in the document. Thus, no direct data is exchanged, but the events occurring in one application are analysed, packaged into an abstract, simpler representation and replayed in the target application. This is currently done between the same applications though, forfeiting much of the power of this approach, but this is maybe owned to the linear operational space and the simple operations.

3 OBJECTIVES

Many sophisticated applications are available that offer a plethora of functionality. Usually, this functionality is limited to a certain environment – usually the desktop – and is available to a single user only. Users should be enabled to choose the application and the environment they desire and collaborate freely with others nonetheless, even if the other partners prefer other applications or environments. Thus participants should be enabled to work in Virtual Environment if desired or at their local desktop, or on mobile devices. It is also desirable to switch between those environments and let others participate in what they are working on.

In Section 2 several examples for coupling two running instances of an application or two applications of the same type were introduced. But while enabling collaboration between different partners, a goal is also to bring together different applications to offer a unique functionality not available out of the box, harnessing the power of a specialised application and connecting it to offer an advanced functionality via a common interface. This separates this approach from others available that allow the collaborative, real-time working on documents like Microsoft Office Live, Google Docs and is even more powerful than the simple screen sharing approach used by WebEx or TeamViewer.

Both, the sharing and coupling of those applications, should be done transparently without the need of explicitly informing the application that it is used in a way thus. Also, the set-up of the functionality should be both flexible and easy to learn, using state-of-the-art technologies available on most platforms.

4 DESIGN

The implementation of the collaborative and inter-application capabilities is designed around a central component – the Application Controller – that is running on every participants' computer. It can be used for starting and stopping the applications as well as – more important – to steer the application and distribute and transform events originating from the controlled applications to other participating applications.

Application Controller

For transparently sharing applications, a component is needed that captures application events, analyses their contents, transforms them appropriately and distributes them to all applications interested in this kind of event. Thus, an Application Controller was developed that is capable of taking control of an application and steer it with a small subset of commands. Using the Application Controller it is also possible to save the application state of the controlled application to storage and to resume the operation later on with the same application state as before.

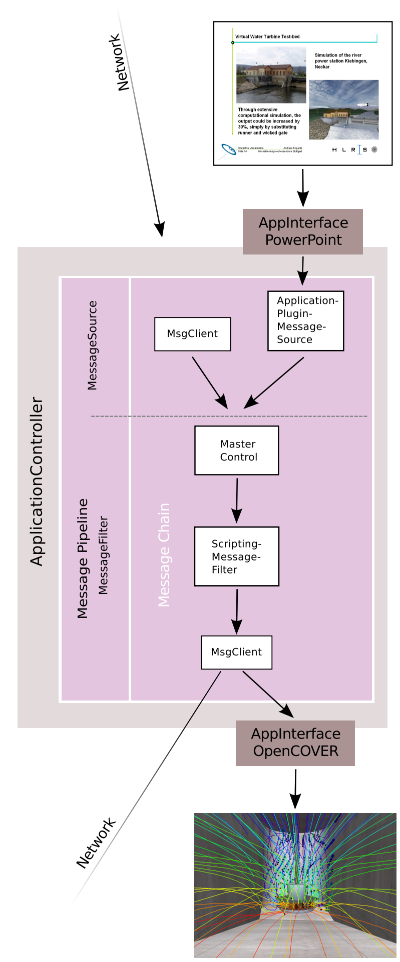

Figure 1: The message pipeline of the Application Controller

The Application Controller is a small networked service application that is running at every host participating in a session. Every application that is integrated into a session will require a specialised application interface for communicating with the Application Controller. These interfaces are realised as plug-ins, linking them at run-time directly to the Application Controller. The application interface is responsible for translating the commands originating from other applications to mechanisms native to the application, like COM, CORBA, WebServices, signals, and others. It also gathers the feedback and events from the application and sends them back to the Application Controller. Thus the network of the Application Controllers creates a hub that connects all applications in a session, relieving them of the necessity to directly communicate with a common protocol.

The Application Controller itself is listening at a SOAP interface [12], waiting for commands to execute or sending messages to other running instances. Applications are instantiated using this interface and taken control of by the Application Controller. It creates the new application instance by loading the appropriate application plug-in and starting the application process. A communication link is established to the native API of the application.

The capabilities – i.e. the commands an application accepts – are published using a simple XML document. This descriptive document also contains other information about the application like what documents it is able to process, if it can load directly from a certain source (e.g. via the http protocol), and more. Clients to the Application Controller can use this information to create generic user interfaces to steer every application supported by the application controller out of the box. All Application Controllers are connected via a network bus for collaboration beyond host boundaries.

Messages

Generally, the design is based on a message passing, message transformation and state preservation mechanism. Messages are usually coming in from the network or generated by the applications with the help of their application plug-ins connecting them to the Application Controller. Thus, whenever e.g. a PowerPoint slide set is loaded, an event is generated in PowerPoint that is captured by the Application Controller plug-in for PowerPoint. It generates a message, indicating that a file was loaded. This message is sent to all other components that are subscribed to these events. In Fig. 1 the message is transformed and passed on to a Virtual Reality Environment, loading a data set corresponding to the slide displayed in PowerPoint. Messages are realised as strings encoding the message body. Arbitrary strings can be sent in the message body, but per convention, an XML format is used for easy parsing and structuring of the message content. But of course, other formats can also be used that are understood by the message destination, like JSON for ECMA-Scripts or Base64 encoded binary data for other destinations. Choosing a string representation has several advantages, like human-readability, non-endianess, same bit representation, and ease of use, but of course limits the amount of data sent between applications. While it still may be feasible to distribute a text document, the overhead for large data like in numeric simulations is just too much and has to be done using different communication channels.

Message Filters

Applications could react directly to those events, but that would be quite inflexible, only allowing a pre-defined behaviour that also would be hard to switch off if not desired. Thus, a more flexible approach is used. All messages are sent down a message pipeline that consists of several filters that process the message on its way to the receivers. Filters can be arranged sequentially in the pipeline, as well as in parallel, allowing the aggregation of results from several independent filters. This aggregation allows the flexible combination of functionality, for example to prevent Master/Slave control from having an impact on network communications. The filters are able to modify messages, add new messages, replace the message with one or more, or discard the message entirely. As messages sent from and to applications are basically strings containing information possibly interesting for others, it is very simple to parse and react on them even from different frameworks like scripting languages or other runtime environments using their own byte-code like Microsoft CLR or Oracle JVM. Messages also contain some extra fields providing information like who generated the messages and a topic describing a message group. Other applications or message filters can subscribe to a topic or subscribe to all topics and filter messages themselves for topics of interest.

Message filters are realised as plug-ins and dynamically loaded by the Application Controller. Message filters can have arbitrary functionality, but are usually used to modify or block messages or send them to other Application Controllers or components partaking in a collaboration. Filters exist for communication, transformation, master/slave floor control, collecting user data, and others. Currently, the most used filters in the Application Controller framework are a network component sending all messages to a message bus for other Application Controllers to react on them, thus enabling collaboration between different users or allow application meshing between applications running on different hosts, and a scripted transformation filter that reacts on events using a scripting language. The advantage of a scripting language for filtering is its flexibility and fitness for quick rapid prototyping cycles. For scripting, QtScript was chosen. QtScript is a subset of the ECMA standard that is also the base for more common languages like JavaScript and should be easy enough to learn by anyone who is already familiar with languages like C++, C# or Java. Scripts can also access all Application Controller functionality by calling its native methods. Thus, scripts can send arbitrary commands to application plug-ins to retrieve further data to be processed.

A script can be easily loaded by directly distributing it amongst the Application Controllers issuing a command or by passing a file name to all Application Controllers to load the script from. This creates what we call a workspace, connecting different applications together, enabling meshed functionality and collaborative features.

5 Application of the Concept

The concept of collaboratively using off the shelf applications in different environments was used in several scenarios ranging from contextual support to complete workspaces for meeting support. To exemplify this technique, a small evaluation scenario was chosen for this paper to demonstrate the possibilities of collaboratively using applications and meshing two applications within a Virtual Reality environment. It consists of a small real life problem in turbo machinery development. Here,

Figure 2: Using Excel data in a Virtual Environment

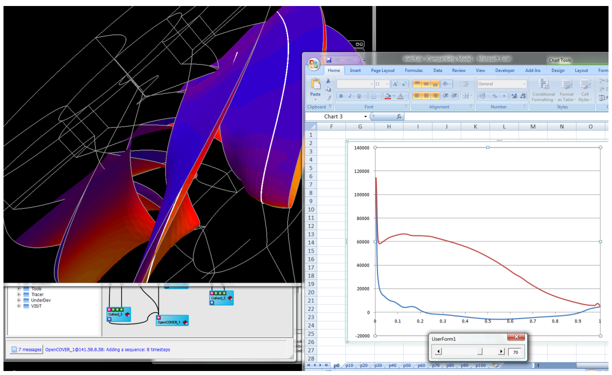

Figure 3: Using the same set-up as in Fig. 2 collaboratively at the desktop

while designing turbines for water power stations, the performance data is usually assessed using two tools: A 3D visualisation of the turbine with various parameters mapped on the turbine blades in the Virtual Reality Environment OpenCOVER and a two-dimensional curve of the pressure profile in Microsoft Excel. Those two views are difficult to merge: The pressure profiles are selected using a percentage of the boundaries of the turbine that is not easily mapped to the real turbine in 3D.

Thus it is difficult to correlate these views that reside in two different applications. Therefore, a method was needed that was able to show the location of the pressure profile in the Virtual Reality Environment to make it possible to establish this correlation. Admittedly, it is possible to somehow display those curves by exporting them from Excel and writing a reader module for the Virtual Reality Environment for visualisation. But it is obviously more desirable to have the data within its original application and share it with others in a transparent way – and to do this using the applications as they are without adding direct functionality. If changes are made, they can be directly applied to the Excel table and will be immediately visible in the Virtual Environment for further analysis without any explicit conversion steps. Using the Application Controller, this also allows to collaboratively share and discuss the data from within several environments.

The applications were connected using the Application Controller and a small script reacting on changes within Excel and sending the data to the Virtual Reality Environment. In the set-up described here, three computers are involved. One head node driving the cluster for the Virtual Environment running OpenCOVER in Linux (Fig. 2), one Windows Workstation running Microsoft Excel and a TightVNC server [13], and one Notebook of a remote partner running a desktop version of OpenCOVER and another instance of Excel (Fig. 3). When the script for the workspace is loaded, it automatically loads the Excel file corresponding to the turbine currently displayed in the Virtual Reality Environment. It also causes OpenCOVER to connect to the workstation running Excel using VNC, displaying Excel directly within the Virtual Environment and allowing a limited interaction with Excel and the data loaded. On the remote notebook, both, Excel and OpenCOVER are started, the appropriate data loaded and displayed. Both users – the one in the Virtual Environment and the other one at the remote notebook – can now analyse and discuss the data, select different pressure profiles via a slider in Excel and compare the pressure profiles to the three-dimensional visualisation of the turbine blade.

When the slider is moved, the chart displaying the pressure profile changes and an event is sent to all participants. The event arrives at the script that consecutively queries Excel for the location of the pressure profile on the blade. The coordinates are stored within the Excel sheet and thus can be accessed by the Application Controller script. The coordinates are transformed to the correct format and sent to OpenCOVER that can use the x-/y-/z-coordinates to display a poly-line on top of the turbine. The user in the Virtual Environment can now compare the pressure profile with the data mapped on the 3D visualisation with ease. The other user sitting at his desktop can also compare the same results concurrently.

A small evaluation was done with engineers doing turbine assessment in their daily work. They were impressed by the ease they could now compare the pressure profiles and the three-dimensional visualisation. All used both views for assessment while working in the virtual environment. None of the users neglected one view in favour of the other. This shows that meshing applications allows for a wider range of functionality than that available from a single application that is unable to cover everything, but is usually focused at one field it excels. Using the internal API of an application while meshing them gives a lot more possibilities in combining views, data and control. The shown example is very basic in its nature, but shows that just using the off-the-shelf applications it is possible to get results that were not able to be achieved before.

6 Conclusions

In this paper, a technique was demonstrated that not only allows to make applications collaborative in a way transparent for them, but also allows to mesh those applications to add functionality to other applications in use. It was not necessary to change those applications for the functionality implemented. In the given example, we chose an Virtual Environment application and a standard Office application for showing the application meshing concept. The approach is not directly targeted or limited to this example though, but rather a generic coupling method of two or more distinct applications. The coupling is done by generic or specialised filters that transform application events into new behaviours and commands. The flexible approach chosen using a directed message filtering graph allows to combine different filter functionality with ease.

This example is still not "feature complete" of what you may have in mind what can be achieved by coupling of data sources and applications. Of course, when adding further functionality to the applications in question, a more seamless interaction concept is possible. E.g. the Virtual Reality Environment OpenCOVER could be extended by a plug-in that better visualises the location of the pressure profile and even maps the profile directly onto the turbine blade. Also, the slider to steer the Excel table could be integrated as an interaction concept into the virtual environment rather than using the original Excel slider. This would have required a dedicated component in one of the applications, a thing that to do was avoided in this paper to show the possibilities of the method without extending the original application and with relatively minimal effort in scenario programming.

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Inter-organizational Collaboration: Product, Knowledge and Risk

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ABSTRACT

Inter-organizational collaboration is no longer entirely a free choice, but is close to a necessity imposed by economic, technical, and knowledge-related concerns. A deep understanding of collaboration will assist in making intelligent decisions on entering, operating, and evaluating collaborative ventures. The nature of the partners—industrial corporations, consultants, academic institutions and others—and the collaborative structure are important, but so too is the nature of the product. We consider its effects in the collaborative domain on knowledge, intellectual property, and catastrophic risk.

Keywords: Collaboration, knowledge management, ICSD, risk management,

1. INTRODUCTION

Inter-organizational collaboration entails multiple organizations working together to provide a product (perhaps in a very general sense), with value for the partners, and perhaps for a wider community, in the success of the product. Such collaboration is no longer entirely a free choice, but is close to a necessity imposed by economic, technical, and knowledge-related concerns. A deep understanding of collaboration will assist in making intelligent decisions on entering, operating, and evaluating collaborative ventures. Important factors include the structure of the collaboration [6,23], the nature and experience of the partners [20,24], collaboration-aware handling of policies and risk [10,14,21,22,27], knowledge [3,7,9,12,18], mental models [4], and information flow [13,14,16,17], and the goal of the collaboration, which we consider in this paper.

In [23], we reviewed four modes for multi-organizational collaboration, three of them collaborative, largely in the context of software development:

- Contractual development using subcontractors and vendors.
- Supply-chain structures.
- *Ad hoc*, short-lived virtual organizations.
- Long-term collaborations.

While we explicitly excluded development of open software in that earlier paper, we should here add federation as a fifth mode, whether a federation of individuals and organizations developing open software, a collection of libraries centralizing cataloging, or a group of franchisees who need to maintain the reputation and consistency of services provided.

In [23], we argued that software development in particular tends to encourage long-term collaborations, resulting either from long or iterated development cycles for novel applications, maintenance of a long-lived system, or the desire to preserve technical and knowledge-intensive relationships in a setting of increased trust and cultural familiarity [1,19,28].

As we considered risk and collaboration further, it became apparent that the nature of the product was also significant. As an initial classification, we consider (1) sharing of resources, (2) provision of services, (3) development or manufacture of material artifacts, and (4) creation or modification of intellectual property.

- Resources: In such ventures, partners tend either to be collocated, sharing support services, or more-or-less peers in the same field, sharing production resources. We consider two simple examples—a consortium of Brazilian tool-and-die manufacturers sharing excess plant capacity and staff [29], and a group of small companies or organizations centralizing coordinated business support services.
- Services: We consider three classes of examples: first, franchised or coordinated professional services, such as large tax accounting firms or independent insurance agents and adjusters; second, services meeting daily needs, such as fast-food franchises; and third, a virtual organization—an ad hoc or permanent confederation of concerns—bidding

(for example) to host social events or conferences, each providing a different aspect of support.

- Material artifacts: Most collaborative supply-chain operations fit here. We consider the manufacture of automobiles and of electronic devices. (While there is a contractual side here, the relationship often becomes obligate on both sides—there are at most a few suppliers of a specified part, and at most a few large customers for that part. Thus planning for future production inevitably takes on a significant collaborative dimension.)
- Intellectual property: Notable examples include collaborative software development [2,14,30], multi-author development of on-line courses, collaborative works of art or knowledge (although these often involve individuals and not organizations), and collaborative knowledge bases. One further example of interest is collaborative design and engineering of a novel structure [15]—while the building or other structure itself is clearly a material artifact, the difficulties often emerge in or from the design, which is clearly an intellectual product.

Individual collaborative ventures may of course comprise a mix of these characteristics, in both dimensions. A fast-food franchise operation, for example, comprises both a supply-chain operation to provide materials, and a federation to provide service, and its product is both a service and a material good, if not exactly a novel one. Likewise, structure building can be seen throughout as a mix of intellectual property and material artifact.

(While some consider most instances of resource or service sharing as coordination or cooperation rather than full collaboration, it is clear that there is a spectrum, based in part on the degree to which the partners share goals and a joint business plan, or contribute to a common venture, and in part on the complexity of collaborative arrangements and shared policies. In this paper, we will not further explore such distinctions.)

It is tempting to think that there can be central control over knowledge and risk in a collaborative project. But this is unlikely to be true even in the contractual mode, and of limited validity even for large, complex, long-lived single-organization projects.

Extended discussion of several papers at CENT 2011 (where an earlier version of this paper was presented) suggested that the overall project manager should have this knowledge. But the lifetime of a collaborative venture begins prior to the appointment of a project manager, in evaluating the proposed venture and forming the collaboration, and often outlasts him/her. Moreover, the project manager will rarely know the internals of business plans, processes, or components of other collaborators, and may not be privy to corporate management issues even at his/her own institution, and will typically not have the expertise to understand the issues of knowledge integration or collaborative risk in all relevant disciplines and domains.

These arguments apply, *mutatis mutandis,* for senior corporate executives or heads of requirements or risk management teams, as well. Nor would some sort of central clearinghouse or arbitrator be suitable, since a general principle (related to information hiding) would be to expose as little information as needed to such a party, both for protection and to avoid overcomplicating its role. This is an interesting question for further exploration.

In the balance of the paper, we consider the relationship between the nature of the product and the collaborative structure, product implications for the role of knowledge and the nature of knowledge objects, and implications for risk—in particular, motivated by current news, legal issues on the one hand, and the consequences of catastrophic failure for one partner on the other.

2. PRODUCT AND KNOWLEDGE

The different classes of product require different types of knowledge object [9,11,12].

Resources: A consortium of Brazilian tool-and-die manufacturers [29] organized in the last decade to share idle capacity, and possibly also portable tools and manpower. Since the partners work in a common domain, and processes were for the most part well-established, the role of knowledge is minimal—at most the specifications of parts made for a largely-shared client base. Likewise, establishing a common venture to share bookkeeping services such as payroll would expose some personnel and perhaps corporate information, but largely information already known to a good approximation by the other partners. Knowledge objects thus comprise primarily specifications and data sets, with minimal surprise, minimal required integration, and minimal interpretation.

Material artifacts: Two good examples are parts for automobile manufacture or electronic devices. Such ventures tend to fit into supply-chain collaboration. The relationship, even if legally contractual, is often collaborative in practice, obligate if not exclusive. Collaborators typically undertake differing parts or process steps. Relevant knowledge typically involves the physical interfaces (e.g., mechanical) and interactions (e.g., chemical) between components, and process and internal product knowledge must be revealed only insofar as necessary to satisfy specification. While constraints on factors such as safety and precision must be exposed, much of this is again largely shared if approximate knowledge. Knowledge objects are part/component specifications and descriptions plus external constraints. There will tend to be some surprise, a moderate amount of integration and collaborative knowledge [18], and varying but perhaps high amounts of encoding and interpretation needed. The most important dimension of knowledge sharing and integration lies in planning, requiring coordinated analysis, design, and implementation of changes.

Services: While knowledge for resource-sharing and production of material artifacts is largely product knowledge (plus common domain knowledge), service-oriented ventures inherently also and perhaps primarily need to share the knowledge needed to promote consistency and non-interference. While marketing and product knowledge are important for the fast-food example, sharing of process knowledge is important in the other two cases. For the independent agents, processes are common and shared, and consistency of process is typically what characterizes successful collaborative and franchise professional service ventures. With the catering service venture, on the other hand, processes are heterogeneous, and interactions are more frequent and less predictable, requiring that awareness of other partners' internal processes sufficient to minimize interference. For many such organizations, sharing will also include customer and/or supplier information and management guidelines. We would expect varying levels of surprise, a level of integration depending on the level and form of partner interactions, and moderate-to-high levels of encoding and interpretation.

Intellectual property: There is a spectrum here between loosely coupled components—as in the chapters of a book taking different points of view, or in software components that have little interaction except to share a user- and file-interface—and a single tightly-woven seamless product—such as a building design or a complex computer application. At the high end of the spectrum, the complications are significant—as we have discussed in our other papers. In the software example, partners have to have access to some knowledge of the internal technical and perhaps business processes at other partners, a view (not necessarily complete) of their domain knowledge bases, and some understanding of aspects of the internal structure of their components. The set of knowledge objects is diverse, and needs to encompass business and technical process knowledge, domain knowledge [5], and development knowledge. Knowledge is both a critical input and a critical output of the development process. Some knowledge (both input and output) may emerge from the collaboration, and be joint rather than individual property [18]. The levels of integration and of encoding/interpretation will tend to be very high, and the level of surprise likewise, especially since some knowledge objects will not initially exist, but come into existence only by integrating partner knowledge, or in the process of development and use of the product, and others will be dynamic, changing over the lifetime of the project.

Thus, resource-sharing collaborations tend to have minimal knowledge requirements; service and material artifact ventures have varying demands, generally with high needs for interpretation and encoding; and intellectual property efforts are characterized by diverse, dynamic and heterogeneous knowledge objects, with high levels of integration and dynamism, and a very high need for interpretation.

There are of course ventures that mix modes. In the building design example—with two or more architectural and/or engineering partners, the knowledge-sharing requirements are defined by a combination of those for intellectual property, material artifacts, and perhaps shared resources.

3. MORE ON KNOWLEDGE OBJECTS

We can distinguish three categories of knowledge objects entailed in the collaborative development of a product:

- Hard-coded: The physical structure of the product and its concomitant artifacts, its input data sets, and its output (if different from the product itself), and specifications and testing support for interfaces and component interactions.

- Soft-coded: Knowledge of processes, practices, and team/partner interactions.

- Meta-coded [11]: Views and understandings, related to cultural co-variances and to intellectual property protections.

When we consider the collaborative knowledge base itself, these become, respectively, the data in the knowledge base; its inference rules, forms, queries and reports, and its patterns of use; and the views available to each partner and collectively, and the informal guidelines for interpretation of that information.

In general, a product – whether of resource, service, material artifact, or intellectual property – bears a blend of hard-coded, soft-coded, and meta-coded knowledge in varying shares. Figure 1 provides an initial picture. Collaborative efforts require the sharing of product knowledge between partners, either by making common use of a set of knowledge objects, or by employing interfaces which act as links between knowledge objects [11,12]. At the same time, there is the tension at each collaborating partner between the benefits of sharing one's own knowledge with others and the risk of giving away competitive advantage and market share, and compromising intellectual property or reputation.

Balancing this tension is critical to the success of a collaboration. The balance must be envisaged prior to the start of a collaboration, maintained while collaborating, and reflected at the end of a collaborative venture–all of this making it, for each partner, subject to knowledge management: the assessment of and the decision on which knowledge objects to share, and whether to share in whole or in part.

In [9,12] we have suggested the knowledge objects approach for knowledge management in the context of collaborative software development. The broader horizon of collaborative engineering, or collaboration in general, leads to an extended definition of knowledge objects, with the distinction of hard-coded, soft-coded, and meta-coded knowledge. It results in different ways of knowledge sharing or protection depending on the category of a knowledge object. And it may even make the case for designing new knowledge objects that are specific for, or adapted to, a given collaborative setting.

Figure 1. Sharing of knowledge in collaboration

Nature of product	Hard-coded	Soft-coded	Meta-coded
Resource Sharing	Moderate	Moderate	Minimal
Service (homogeneous)	Moderate	Substantial	Minimal
Service (heterogeneous)	Moderate	Substantial	Moderate
Material Artifact	Substantial	Moderate	Moderate
Intellectual Property	Substantial	Substantial	Substantial

In addition, the management of knowledge objects in a collaborative context will have to be hierarchical [10,13,17]. Sharing will require agreed-on but flexible boundaries, hiding information via abstractions, filters, views and translations, and will need to handle "collaborative knowledge"—knowledge that results from integration of partner (and common) knowledge, and knowledge acquired through use of the product. Credit assignment will be a difficult problem where substantial collaborative knowledge is generated and used.

This hierarchical approach will have to extend not only to the knowledge base itself, but to risk management (RMMM) activities and configuration management as well [21].

4. PRODUCT AND LEGAL RISKS

Every venture of course may encounter a wide spectrum of risk. The discussion here treats only risks that arise because of collaboration, not those to which a single organization providing the same product would be subject to a comparable degree.

Resources: The individual data sets are of course proprietary, and in a case such as the tool-and-die example, there needs to be protection against theft of clients or jobs. But such risks are usually well-understood at the time a venture is begun, and standard safeguards exist. In the presence of goodwill, property issues can often be resolved with minimal trouble.

Services: In cases where the partners are peers supplying a common service, the main goals are consistency and reputation/reliability. Problems are well-understood, and structures exist to try to prevent them or recover from them. There are three refinements. First, if business information from the individual partners needs to be shared, difficulties are introduced as in the previous case. Second, in the heterogeneous case, there are two complications. To the extent that the partners are providing different services, as in the catering example, there is a risk that one partner will use the process or business information provided by the other to compete. Also, some (usually limited) internal product or process information may need to be revealed to other partners to support proper interaction or contingency planning. Nonetheless, the process and business information required to be shared will not usually reveal trade secrets or endanger privacy and security of the partners or third parties.

Material artifacts: Legal concerns focus on scheduling (and/or cost) and non-compliance plus those interfaces and interactions. Since internal process information typically needs to be revealed only to the extent that it affects safety or other extra-functional requirements, there is generally no need to share process knowledge. Two exceptions exist, though: first, whenever incremental innovations from either side are to be included in the product, at least partial knowledge about business or market strategies must be exchanged; second, when an artifact as a whole (an end product, like a new type of car – or a part, like a new drive control device) is being innovated, also technical and manufacturing processes have to be aligned and therefore revealed to a certain extent. Customer and supplier information, to the extent shared, is also a concern.

Intellectual property: Typically, almost all of the concerns raised above apply. Further, intellectual property, privacy and security issues are inherent in development, not only of software development, but of most production of intellectual property. These issues affect the necessary sharing of internal technical and business processes, knowledge bases, the internal structure of the components, and knowledge produced directly by the product, or indirectly by analysis thereof.

Intensifying product factors in all cases—to some extent mentioned above (but particularly for intellectual property) include: the complexity, novelty and innovation entailed; the degree of dynamicity and evolution expected; the extent, intricacy and robustness of component interaction; direct involvement of protected or confidential information in the product or in interactions with users. Process factors include process novelty and a lack of collaborative history, either in general or with these particular partners.

Nonetheless, the first three forms of product have moderately well-understood intellectual property risks and protections, while development of intellectual property, particularly software development, introduces a wide variety of risks pertaining to privacy, security, trade secrets, and other concerns.

5. PRODUCT AND CATASTROPHIC RISK

Recent news events, particularly the Japanese earthquake, tsunami and nuclear disaster, but also volcanoes, hurricanes, tornados, wildfires, have exposed serious problems in supply-chain manufacturing. Comparable problems will affect most collaborative ventures, and are more substantially affected by the nature of the product and its decomposition into components than by the nature of the collaboration.

Resources: A catastrophic failure to one of the partners, unless it damages a central processing or distribution facility, will generally not impede the collaboration, but at worst reduces the benefit of collaboration, either by limiting the resources available to the other partners, if they are overloaded, or by reducing the work available to the central facility, raising the amortized cost to all other partners. The immediate impact will typically be small.

Services: In the homogeneous case, one partner's failure, unless accompanied by serious damage to the venture's reputation, will have almost no short-term effect on the other partners, or in some cases even a small positive effect, as that partner's business is allocated among the remaining collaborators. In the heterogeneous case, or when the service is to be provided in a single venue, there may be a delay or loss of capacity until that partner is replaced. But this will not usually introduce substantial delays or losses, unless the partner is essentially irreplaceable, or the event occurs at a particularly critical time, since the collaborative knowledge demands are minimal.

Material artifacts: The Japanese disaster illustrates difficulties with supply-chain ventures, when all facilities making a critical part fail catastrophically. Since modern manufacturing processes typically require specialized facilities, and material artifacts often require bottom-up integration, the lack of such a part imposes a bottleneck, as can currently be seen with the automobile industry or the manufacture of laptops. In the meantime, other partners will have either to curtail operations, or to allow large inventories of parts to accumulate. If it is possible to replace the failing partner, there are still likely to be delays resulting from start-up instrumentation and activities, as well as the need to acquire and understand needed information. The risk is greatest when integration is highly structured and sequential, with interaction between physical device components.

Intellectual property: Failure of a generalist partner (one who is simply "sharing the load") will result in more-or-less proportional delays until the partner is replaced, although the other partners can pick up the slack to some extent. The loss of a specialist partner or its key personnel is also problematic for an intellectual property venture, but not usually as severely as in the material artifact case, and some of the other partners may be able to assume some of the responsibility, often at a lesser level of performance. Alternatively, since interaction typically entails exchange of information, rather than interaction of physical parts, there is often significant non-determinism in activities and development. The other partners may be able switch temporarily to parts of the product that do not interact with those being developed by the missing partner, or otherwise adjust to its absence, mitigating the cost and schedule hits. The time to recover full capacity is generally less. On the one hand, the start-up instrumentation will be at most acquisition and training on some development tools; on the other, the high level and dynamism of collaborative knowledge, and the need for specialized learning and training, is likely to continue to have some effect well after the replacement occurs.

Overall, catastrophic failure of one partner is likely to have minimal effects on most resource-sharing and service collaborations, versus great effects on material artifact ventures; intellectual property ventures are between these two extremes.

6. A CASE HISTORY

The nature of the product can, (as previously discussed in the introduction) significantly impact the collaborative structure with some manufacturing processes benefiting. Recent case study work [8,25,26] discusses a small-to-medium enterprise (SME) manufacturing company's interaction with its much larger customer. The key application is a knowledge-sharing network, with implications for collaborative business structure and policy. The final product is thus intellectual property with aspects of service.

The knowledge sharing networks operated on many levels, within the SME and beyond the SME to interact with small teams within the larger customer company. These interactions were developed longitudinally to satisfy a variety of products with success reflecting the SME's earlier experiences of a "whole team flat structure" approach, translating into various team-based projects. This approach provided flexibility needed to produce a variety of products, and the required rapid change in production methods.

The SME capability directly reflected the wide and in-depth knowledge of staff, gained over time (and documented longitudinally), through flexible "working team practices". These practices included working beyond SME teams to incorporate the customer and its supply chain network. These capabilities have resulted in company members acquiring the ability to balance company and project vertical structures with horizontal knowledge experiential exchanges. This is not something that is easily achieved within project-based manufacturing organizations. The various "layers" of experience were developed over time and formed the basis for the application of quick and timely in-depth expertise. The horizontal knowledge exchanges of staff members built over time formed the basis of new individual and company knowledge (from various sources) utilizing internal and external networks to update or advance specific or general knowledge. It is interesting to note that capability supported by various combinations of team or co-workers, were fundamentally initiated by individuals. This more flat structured approach at times resulted in knowledge networks developing and moving between the SME and its customers' supply chains regardless of formal boundaries, blurring product, services and supply chain structures.

Organizations are essentially knowledge-based network systems that are complex, and emerge, evolve and mature through various stages throughout their life cycles, displaying specific features and capabilities. Understanding these capabilities and features are fundamental to building sustainable economic, social and leaning network organizational structures. Long-range strategies require the understanding of emergent behavior within and beyond the organization, including its sociological impact, and its relationships to the explicit formal/physical structures. Looking deeper into the development of informal networks across boundaries highlights the geographic structures, their importance and how knowledge flows influence them.

But the networks are also influenced by the nature, structure and content of the intellectual property developed and the service(s) to be provided—the results would be very different for a regional network aimed at oral history or at coordinating distributed community assistance efforts.

7. CONCLUSION

Collaboration is affected by the organizational, geographical and cultural dispersion of the participants, and by the form of the collaboration [23]. But it is also affected by the goal of the collaboration, that is, the nature of its intended product. In this paper, we have considered three factors—the role of knowledge, the extent and nature of legal—especially intellectual property—risks, and the consequences of catastrophic failure of a single partner, and argued that there are significant differences based on the nature of the product—whether sharing resources, providing a service, making an artifact, or developing intellectual property. While there are further distinctions within each category, and collaborations that produce multiple or hybrid kinds of product, this classification appears to provide some insight into preparing for and evaluating collaboration.

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Dams, Flows and Views: Cross-Aspect Use of Knowledge in Collaborative Software Development

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Abstract

Collaboration between organizations raises significant knowledge management issues, especially in software development of complex projects, in which both product and process are themselves knowledge. While research has examined direct, explicit flows of knowledge within project aspects, or forward between aspects, there is less investigation of the need and support for backward, implicit or emergent flows.

Keywords: Collaborative software development, collaboration, software engineering, knowledge management, ICSD.

1 Introduction

The share and impact of inter-organizational collaborative software development (ICSD), in various modes [19] and with multiple motivations have increased. Concurrent trends of growing complexity, feature space and size of software packages, which are also increasingly knowledge intensive, are characteristic of the majority of projects. Many of these applications can be expected to be long-lived, evolvable, and used in diverse contexts and environments. This combination of factors entails use of sophisticated and specialized organizational, software engineering, and knowledge management (KM) approaches. We consider a software development project *hard* if it is large, complex, and knowledge-intensive, and intended to be long-lived, evolvable, portable, and useful in diverse settings or for diverse user populations or clients.

Collaboration in general, and collaborative software development for hard projects in particular, requires cooperation, information sharing, and interaction at multiple levels. Working more-or-less from the governance business aspects toward the technical and deployment ones, and forward in project time, we identify in Section 2 a number of critical, knowledge-intensive aspects of collaborative software development, particularly crossing organizational boundaries.

In past papers , we and others have investigated the impact of collaboration in hard projects, and recommended changes in policies, processes and artifacts. These papers have addressed both general concerns [4,9,19,22,24,25] and specific areas such as business policies and processes [10,15], risk management [16,17], and technical processes and artifacts [11,12,13,23].

These recommendations affect corporate policy and procedures, software development, risk management, and knowledge management. Major themes are (1) a layered approach, comprising single-organization structures, a collaborative structure, and a method of resolving priorities and conflicts; and (2) methods and/or artifacts to extract, communicate and display appropriate knowledge, possibly including new kinds and forms of information, as well as filters, abstractions and views.

In the KM literature [2.6,7,8,14], knowledge is frequently classified as explicit, implicit or tacit; it may also be useful to distinguish emergent knowledge—knowledge that arises from synthesis of existing knowledge, or is a result, possibly in combination with such knowledge, of the project or product under investigation. Collaborative knowledge (see [5,7,14]), particularly the more difficult to control tacit and/or emergent, poses its own problems, most particularly those of intellectual property, security, privacy, and confidentiality, on the one hand, and credit (cost-benefit) assignment on the other [14]. With care, it is not that difficult to create a structure for the sharing and use of such knowledge, especially if used within an aspect, or when the flow is forward, that is, used as a driver of tasks more immediately focused on the current project, process, or product. It is more difficult when the flow itself is implicit/tacit or emergent, and especially if the flow is backward, that is, from a more product focused back to a more process or policy focused context.

In Section 3 we review and extend a list of drivers, benefits, impediments and risks in collaborative software development for hard projects, thus identifying the dams. Section 4 presents some examples of emergent and backward flows and related views.

The final Section 5 briefly presents recommendations and conclusions.

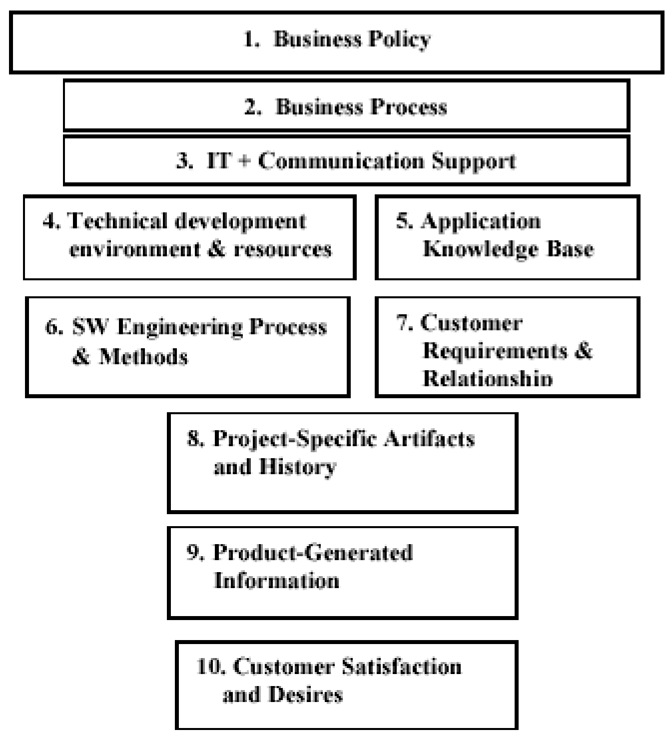
2 Aspects of software development

Collaboration in general, and collaborative software development for hard projects in particular, requires cooperation, information sharing, and interaction at multiple levels. Working more-or-less from outside in (governance and business drivers to development and domain platform to specific project and product), and forward in time, we can identify a number of critical, knowledge-intensive aspects of collaborative software development, particularly crossing organizational boundaries.

1. Business policy: Includes business vision and plans, risk tolerance, legal (intellectual property, proprietary information, privacy, confidentiality, and related issues), collaboration readiness and advocacy, marketing and management strategies, and issues related to reputation, business culture, and openness to employees, collaborators and customers.
2. Business process: Includes security, risk management and knowledge management, personnel management (including attitude toward collaborative work), culture and trust, marketing, and support for extramural activities.
3. IT and related support: Communication infrastructure and restrictions, establishment of shared representations and glossaries (see [15]).
4. Application knowledge base: Domain (e.g., banking) and product discipline and functions (e.g., auditing) knowledge. Heterogeneous contributions of partners; integration and inclusion of external knowledge, including new developments; supporting extramural use; credit and debit assignment; support of domain expert/discipline specialist consultation and collaboration [3].
5. Technical development environment and resources: Development platforms: computing resources; software tools including change management and dependency tracking.
6. Software engineering process and methods: Includes technical management processes including requirements analysis and quality assurance; people issues such as training and team management; nature of artifacts to be developed in SW process, and patterns of use, dependence and sequencing of these artifacts. Requirements for documentation and views.
7. Customer requirements and intimacy. Initial and ongoing interaction with customer (and possibly other stakeholders), prior to release, or explicit requests for modifications.
8. Project and product artifacts and history: Includes definition and design time software artifacts and change history. The actual artifacts associated with the current project and/or product: Requirements, specification, architecture, design, code, documentation, dependence analysis and traceability, testing and debugging. Interacts with Customer Requirements.
9. Product-generated information: Information resulting from use and/or analysis of product: input-output patterns, including unexpected exceptions or errors, patterns of use and performance based on information from profilers, history, logs, and similar tools, results of static and dynamic compiler analyses and transformations,
10. Customer satisfaction and desires: customer satisfaction survey results, modification requests and theirs severity and scope, ongoing feedback, new feature requests and long-term partnering proposals

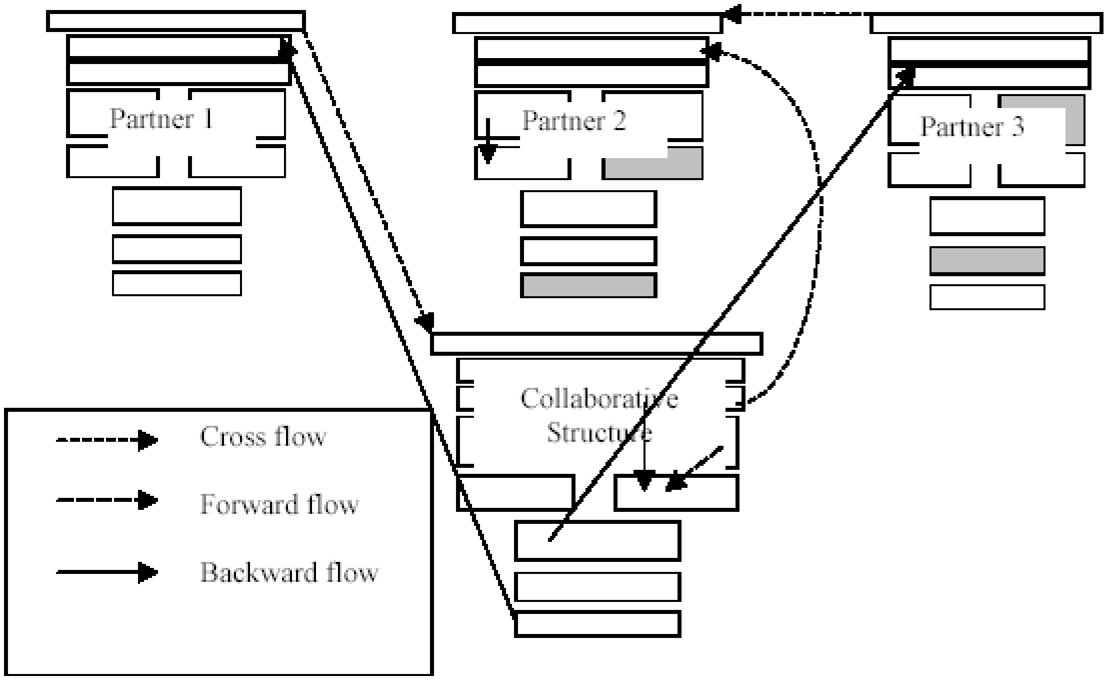
Each aspect generates and ideally consumes its own information, and must manage that information for efficient use. Each aspect may but need not exist for each partner and for the collaboration, and some, such as (7) and (10), will necessarily be limited to one or two collaborators as discussed in [18]. Figure 1 shows the aspect structure, and Figure 2 shows its replication in a collaborative structure/engagement. Figure 2 shows some example flows: *cross-flows* are those between identical aspects; *forward flows* are those downward in the diagram; and *backward flows* include all the others.

Figure 1. Aspects of Software Engineering



Flows out of the collaborative structure are especially likely to involve collaborative knowledge, as are those (not illustrated for reasons of simplicity) with multiple sources in multiple partners. Emergent flows are most likely to include some backward flow, and emergent knowledge is most likely to be (at least in part) carried along such flows.

Figure 2. Aspects in Collaboration



In our previous papers,we have considered modifications in both the structure in each aspect [10,11,12,13,19] and in its knowledge management to support collaboration [7,8], including supporting flows forward/downward in the process, and some of the more evident feedback flows. Here, we indicate the need for a more careful investigation of the need for additional, emergent or backward flows, to improve the collaboration, to optimize the process and product, to improve partner corporate and technical decision processes, or to improve the acquisition, organization, management, and protection of knowledge.

3 Drivers, benefits, impediments and risks in ICSD

In order to motivate the investigation of knowledge flows, we briefly review the tradeoffs in collaboration and in ICSD. These are based on existing literature and project observations, some of which have been discussed in our previous work and that of others. The identified impediments, and to a lesser extent the risks, become the dams obstructing the flow of needed information.

Drivers

1. Increase product feasibility, market, and profitability by leveraging expertise, knowledge, intellectual property, and reputation and connections of the partners.
2. Improve time to market by resource and expertise sharing, by reducing cost and time for knowledge acquisition, and training, and by parallel development.
3. Establish good working relationships with trustworthy partners.
4. Foster innovation by exploiting collaborative knowledge and collaborative process optimization.

Other Benefits

1. Increased knowledge and expertise from collaborating with specialists at other partners [3].
2. Improved tool, process and development environment, and improved component repository.
3. Better resilience due to extended personnel resource pool.
4. Improved reputation resulting from quality product and association with quality partners.
5. Innovation and insights resulting from development of knowledge and data filters, abstractions, representations and views.

Impediments

1. Corporate inertia and resistance from corporate and technical management, IT departments, and legal counsel [16].
2. Intellectual property, proprietary information, privacy, confidentiality and security.
3. Corporate policies and procedures for sharing information, firewalls, access restrictions, …
4. Difficulty in establishing trust and understanding of differences in social and corporate cultures [1,16,17,21].
5. Inconsistencies in tool suites, software development processes, and so on.

Other risks—business

1. Management contingency policies need to be collaboration-aware [18].
2. Risk management process needs to be collaboration-aware.
3. Customer and vendor contact needs to be centralized.
4. Indirect communication (e.g., via agents).

Other risks—technical

1. Specification needs to be collaboration- and decomposition-sensitive.
2. Software development process not amenable to cooperation and collaboration.
3. Inappropriate definition of component interfaces, in particular with respect to supporting evolution, both before and after release.

4 Dams, flows and views

Definitions and concerns:

- A *knowledge object* is a representation, often an abstraction, of a set of information and analysis results together with a context. The denotation, and especially the connotation, of a knowledge object is in large part defined by the domain, the discipline, the organization, and the social and organizational culture and history/memory and learning capability of an institution. One problem in collaboration lies in assuring communication not just of the object, but of enough context so that common denotations and connotations of knowledge objects can be established. Another lies in assuring that there is minimal leakage of protected information that is not needed by the recipient or the collaboration, or conversely underestimation of the cost associated with achieving minimal leakage.
- A *view* is a picture of a product, process, project, or knowledge object, arising from an angle of analyzing an object as to perceive/identify some of its aspects under given/specific interest – employs filtering, results in extraction, generates a knowledge object.
- A *flow* is a communication, with appropriate extraction, translation, filtering and abstraction, of a knowledge object available in one aspect or subaspect of a collaboration, to another aspect or subaspect in which it will be needed, or in which it will be integrated with other knowledge objects, or in which it will be further manipulated for use in a third aspect.
- A *dam* is a rule, guideline or standard related to management or technical procedures and policies, tool suites, and interfaces which, intentionally or not, regulates flows. A set of such dams works as the regulative framework for all flows in a collaboration.

The key issue in ICSD for hard projects is the tension between evolvability on the one hand, and intellectual property and related issues on the other. We have already considered modifications of management and software processes and artifacts, but largely to support later project aspects and phases, or to support change and optimization of the aspect or phase under consideration. Much of our attention has been separately focused on business structure (1)-(3), knowledge management (5), or software development (6)-(8).

A typical way to address the impediments and risks is to figure out which of these are considered controllable, establish limits/levels of acceptability for them, and implement guidelines in order to ensure that those limits be kept without unduly inhibiting progress on the project. Intellectual property issues thus can be (and frequently are) made subject to an explicit corporate policy. Customer and vendor contacts can be restricted to specified personnel, with necessary communication then being channeled through fixed reporting lines and procedures. Tool suite and process inconsistencies often get treated by general ruling in (respectively, out) of what is allowed.

In effect, once ICSD becomes a frequently used practice or even a sort of a business concept of an organization, the management of impediments and control of risks soon drive toward the introduction of guidelines or even standards for a variety of processes and technical facilities. This is normal for intra-organizational software engineering, and in this context it is usually considered to deliver a sound balance of evolvability and risk management.

However, there are clear examples of the potential utility of collaborative, emergent or backward flows, as well as the protections that may need to be applied.

New information in, or new inferences from, a partner knowledge base (5) can help in meeting customer requirements (7) or desires (10), or in improving product design (8). However, credit assignment for this information, and its use by the collaboration and by other partners remains an issue, especially when the knowledge must be integrated with knowledge available to other partners or developed by the collaboration to be useful.

Inadequacy in collaborative software engineering structures (6) may require changes in technical infrastructure (4), either for the collaboration or for individual partners, or in IT and communication support (3), or even in intellectual property policies and processes (1-2). Alternatively, the problem may be traced back to problems in sharing knowledge (5)—and perhaps again indirectly to intellectual property and security (1-3), or to inadequate development of abstractions, filters or views—a combination of (2, 3, 6).

Finally, as is well-known, information resulting from the design process (8) or the analysis or execution history of the application (9) can reveal flaws in security or confidentiality policies and processes, or be needed to tune or change risk management plans, affecting the business phases (1)-(3) and perhaps the technical infrastructure (4)-(5). But both the information and its analysis may require divulging the internals of software components or proprietary tools.

5 Conclusions

ICSD, to a far greater extent than collaboration in general, will always be driven by the tension between the overwhelming need for shared knowledge in all phases and aspects of the corporate and technical process, and the need to protect legitimate security, intellectual property, confidentiality, and privacy interests, including those of third parties not involved in the collaboration. Although the risks are real, the benefits are substantial enough to encourage greater use of this fully collaborative mode of development.

However, sharing must be guarded, by filtering and abstracting transmitted knowledge, and by providing constraint views, while still communicating the necessary information. The ubiquity of integrated and emergent knowledge, and the utility of emergent and backward flows, argue that the harder the development project, and in particular, the greater the reliance on dynamic knowledge and product evolution, the greater the anticipation of and the need for filters, abstractions and views, an agreed-on scheme for credit allocation, and an approach for mediation and conflict resolution.

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Metrics Are Needed for Collaborative Software Development

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Abstract

There is a need for metrics for inter-organizational collaborative software development projects, encompassing management and technical concerns. In particular, metrics are needed that are aimed at the collaborative aspect itself, such as readiness for collaboration, the quality and/or the costs and benefits of collaboration in a specific ongoing project. We suggest questions and directions for such metrics, spanning the full lifespan of a collaborative project, from considering the suitability of collaboration through evaluating ongoing projects to final evaluation of the collaboration.

Keywords: Collaboration, metrics, software engineering, ICSD, management contingency policies, risk management, intellectual property.

1 INTRODUCTION

Software engineering is essentially collaborative for any but the smallest and simplest projects. But the extent of collaboration has increased from multiple teams at a single site, to distributed teams in a single organization, to collaborating teams in multiple organizations. Yet not all collaborations are successes. As collaboration broadens, and as projects become more complex and long-lived, it becomes ever more important to have management oversight, technical coordination and supervision, and quality control. But once the projects become too large for day-to-day personal contact, these command, control, coordination and communication (4-C) factors need to rely more and more on reports and metrics [1,8,9,21,24]—and, indeed, metrics have been created for every phase of software engineering and its management, for project, process and product, for the single-team, multi-team, and distributed models of development [2]. There are also metrics for knowledge management [22,23,24] and for communication [16], which assume far greater importance in a complex, long-lived and evolvable software development project [4,5,6,15]. However, there is little in the literature on metrics specifically devoted to collaboration.

Inter-organizational Collaborative Software Development (ICSD) [6,19,20,21] is here understood as: multiple institutions working together on complex, long-lived, evolving software. Each institution is responsible for one or more product components, product aspects, process activities, or business tasks, and neither institutional nor product roles and responsibilities are completely constrained by initial agreement. Collaboration affects every software development phase and activity [11]. The obvious complications occur not only in the usual product and process incompatibilities, but also with intellectual property, privacy and security, on the one hand, and knowledge management and risk analysis, on the other.

ICSD has multiple implications, some of which are fairly subtle. All aspects of development and its context need to become even more modular and hierarchical, typically entailing parallel partner and collaboration structures paired with conflict resolution mechanisms. New risks are introduced at the same time that risk management becomes more complex [17.18]. Interfaces need to be more highly specified yet retain flexibility. Moreover, granularity of knowledge becomes an inherent issue, not just a convenience for efficiency or abstraction, but isolation of the internals of one partner's components and processes to address intellectual property, privacy and security concerns.

As ICSD becomes more common, metrics need to be revised or created to support this mode of development. There are two major dimensions. First, as we discussed in [12], creating or modifying metrics for the standard criteria for software project, process and product: for example, measures of effort and time, of software quality, of process compliance, and of test coverage. Second, metrics aimed at the collaborative aspect itself, such as readiness for collaboration, the quality and or the costs and benefits of collaboration in a specific ongoing project.

Example metrics of the first type include product metrics focused on structural complexity (at specification time, during design, or on release) or test coverage; process metrics aimed at process compliance or quality assurance; and project metrics for schedule, budget, staffing and/or training; metrics on the effectiveness of risk management.

Such metrics typically comprise a selection of a set of key performance indicators, and a weighted combination to a balanced scorecard. The identification of suitable factors, and the weights to be used, relies on results from knowledge management, statistical factor analysis, and domain processes and practices from management science, software engineering, risk management, and requirements analysis.

In this submission, we concentrate on the second facet. We consider what metrics are needed, some difficulties, and some issues. We divide our metrics in two dimensions—staging (when are the metrics useful) and focus (corporate, infrastructure, people, project, process, product). It will of course also be useful to adjust the metrics to the type of collaboration anticipated—whether, for example, largely separate design of components for later integration or coordinated or complementary use (strategic collaboration), or coordinated development of a single product or product suite, interacting in every software engineering activity (tactical collaboration), or an intermediate form. We intend to address this issue, as well as propose metrics, in future work.

2 PRE-COLLABORATION METRICS

These divide into generic (ready for collaboration?) and specific (ready for this collaboration?) metrics. Generic metrics should consider the following issues [16].

- Corporate: Are we willing and ready to participate in a collaborative software development venture? A reasonable metric will combine survey data with a checklist of criteria. A survey of key personnel can establish support among management, IT department heads, technical managers, and so on, as well as attitudes toward crediting employees for success in collaborative ventures. The checklist should include the degree to which policies, procedures and practices favor collaboration: in particular, intellectual property and information sharing, risk management, and knowledge management. To the extent possible, a similar checklist should be applied for evaluation of (proposed) partners.
- Infrastructure and technical: Is there a robust, multi-mode communication infrastructure in place? Are processes, practices and tools amenable to collaboration? Which CMMI maturity level [3] is in-place in the organization, and has this been adapted for collaboration?

  What is the state of (proposed) partner infrastructure and policies? Do (proposed) partners have the requisite expertise at the required level? Do we have a common (or interconvertible) set of processes, conventions and notations, and a common glossary?
- People (human resources): Is there appropriate support for training and cultural sensitivity? Are there corporate and technical managers who will be willing and able to work with counterparts in other organizations? Are there obstacles to collaboration in the people or policies in corporate management, or in the legal or IT departments [17,18]?

Metrics aimed at specific projects and products should attempt to determine the appropriateness of the project and product for collaborative development, and (if possible) the appropriateness and quality of the proposed collaborators. The latter will definitely include evaluation of past relationships with other collaborators or their key personnel. It is also of course important that the project and product have clear and viable objectives, be a good strategic and tactical fit with institutional vision and mission, and have good agreement with partner experience and expertise.

Technical considerations include the following.

- How natural is the decomposition of this project into components? Are the boundaries relatively clear? Does the component decomposition fit with the expertise of the proposed partners?
- To the extent that components or interfaces are fuzzy, does the software process allow for any flexibility in interfaces?
- To the extent that innovation, novel interfaces, or use of scientific or technical information is part of the product, is there a provision for conferencing and meetings of domain or discipline experts?

In addition, we must be able to measure the willingness of the partners to establish required structures.

- Are the partners, and the collaboration as a whole, willing to create, maintain and support a shared technical infrastructure, including communication media and protocols, electronic and in-person meetings and consultations, shared tools and views, knowledge management, and risk management?
- Are the partners, and the collaboration as a whole, willing to create, maintain and support a management superstructure, both in the individual partners and collaboratively, to provide direction, support and championship?
- Will the collaborative agreement provide for reflection and evolution in collaborative structures and processes, and do such processes exist for individual partner structures, policies and processes?
- Are the partners, and the collaboration as a whole, willing to create, maintain and support methods for resolving ambiguities, conflicts and difficulties, whether technical, corporate, or legal?
- Is there a clear strategy and allocation of responsibility for marketing (or using) the product? Is there a clear allocation of responsibilities for maintenance and evolution (or a process for determining these)?

The following are templates for two useful pre-collaboration metrics. The values and weightings, and the method for assigning those are subjects of future work.

2.1 BUSINESS INFRASTRUCTURE READINESS

Business infrastructure readiness must consider the suitability of the communication and development platforms, and the existence of shared/sharable artifacts. The evaluation needs to be carried out by each partner, for themselves, their prospective partners, and the collaboration as a whole.

A robust communication platform should support both synchronous and asynchronous modes, formal and informal electronic communication and interpersonal communication; and support, repositories, and configuration management for documents, messages, and artifacts, with virtual meeting and multi-user editing facilities. Virtual meetings and other synchronous communication must adapt to geographical and particularly temporal dispersion of participants.

All policies and practices should be collaboration-aware (C-A), and in particular IT policies and procedures, including firewalls, should support and not interfere with collaboration. Likewise, software engineering, risk management, and knowledge management policies, practices and tools should be amenable to collaboration. Finally, the appropriate domain-specific certifications and practices should have been achieved—or should be possessed by potential partners.

In addition, in evaluation of the collaboration, the existence of shared glossaries, notations and conventions—for risk and knowledge management as well as for software engineering, and familiarity with them, or with artifacts that can be transformed into them, should be established.

2.2 PROJECT SOFTWARE STRUCTURE

Once the partnership is formed, the decomposition into partner responsibilities is of primary importance. Evaluation of the quality of this decomposition is crucial to determining whether to proceed with the venture. There are at least three major issues.

First, is the decomposition into components clear and natural, and a good fit with partner expertise and capabilities? Second, are the boundaries and interface specifications clear, or if fuzzy, is there flexibility in interface definition, and does this flexibility correspond to and address the perceived lack of precision?

Finally, and particularly if the project or product requires innovation, novel interfaces, of heavy use of scientific or technical information, are the project and process flexible enough to accommodate resulting pressures? In particular, does the project budget and schedule allow for flexibility in goals and in partner responsibilities? And is there provision for conferencing and/or meetings of domain or discipline experts?

Table 1. Overview of Pre-Collaboration Metrics

	Corporate/ Infrastructure	**Technical/ Development**	**Knowledge/ Risk**
Collaboration	Advocacy C-A policies	Communication C-A processes	Maturity C-A processes
This project	Partners Shared artifacts	Decomposition Interfaces	Intell. Property
Infrastructure	IT support	Tools Training	KBs Security policy

3 METRICS FOR ONGOING COLLABORATION

In addition to the standard (if modified) metrics, it will be important to have several other classes of metrics.

The first would measure the quality of the ongoing collaboration, complementing schedule and cost tracking with evaluation of the success, use and usefulness, and problems of the collaborative structures. These include measurements of the clarity of interface specification (have problems arisen? Are they due to differences in language or culture?), risk management (have unanticipated collaborative risks emerged?), management cooperation, or problems with infrastructure? This would be itself complemented by ongoing measurements, assuring that the project and product continued to fit with strategic and mission objectives, and that collaborative and partner support structures were continuing to act and to function as required.

The second, interacting with risk management and knowledge management, aims at early detection of problems—which of course interacts with the first. These may arise from corporate, legal, or people issues in the collaboration, or from stresses and changes in the development process resulting from collaboration. In [7,10,13,14,17,18], we have identified a number of these stresses, and proposed a number of changes to project and process artifacts to support collaboration, good software engineering, and evolvable systems. It should be noted that significant stresses include the quality of both structures and processes for partner and collaborative risk management and knowledge management.

Third, in long-lived and knowledge-intensive projects, it will be necessary during the current project, and for the development and maintenance of trust in ongoing relationships, to be able to assign credit for knowledge and services provided by one partner to another, or to the collaboration as a whole, and costs for the use of others' knowledge and services. This is important in particular where long-lived projects need to maintain organizational partners in the face of a turnover of most or all of the original team members. This assignment is complicated by cases in which the product, the integration of components, the collaborative process itself, or the analysis of any of these, generates knowledge, but needs to accommodate that possibility. Even approximate measures of value will allow such metrics to be maintained.

Finally, it would be helpful, both during the collaboration and in post-project evaluation, to have a metric of the costs and benefits of collaboration, ideally a fine-grained metric so that different areas and forms of collaboration could be evaluated. During the collaborative process, such metrics could focus attention on problem areas, and perhaps indicate areas in which the task decomposition could be revisited. This would also have substantial benefits for future collaborations on similar projects, perhaps suggesting facets or attributes that might be best left in control of a single partner, or as an input on the decision to collaborate or use single-developer mode.

Also note that the quality and utility of these metrics depends both on their timeliness and the quality of data collected. Thus, in addition, a process and accompanying metrics will be needed to assure timely, consistent, and accurate data from each organization, and where relevant, from collaborative structures.

As usual, this process will benefit from common or compatible approaches and tools for data gathering, storage and communication, data quality assessment, and so on.

3.1 COLLABORATIVE COST-BENEFIT ANALYSIS

Ongoing evaluation of the utility of collaboration entails the standard examination of risks, costs, benefits and opportunities. The obvious benefit is the time and money saved vis-à-vis a hypothetical single-organization or contractual development; less obvious benefits include the risks, errors, and flaws avoided, plus unexpected enhancements, optimizations, and preferred implementations, as well as the knowledge and expertise acquired, generated, obtained and maintained—although this must be balanced against lost opportunities to obtain such expertise by developing the other components. The standard examination approach can also be seen as embedded within normal procedures, reducing the risk of resistance within the ranks of processweary personnel.

Costs including the start-up costs in preparing for and initiating the collaboration—although these are amortized over the history of collaboration and interaction with the same partners. Ongoing costs arise from difficulties encountered in working with unsatisfactory partners, handling interface errors and incompatibilities, as well as addressing other collaborative risks, and the overhead of maintaining collaborative structures and infrastructure, including collaborative risk management and knowledge management.

Finally, risks include loss of relationships with customers and users, and with partners, as a result of a failed collaboration, an unsatisfactory partner, or poor handling of interorganizational interactions.

Conducting such an evaluation on an ongoing basis has impacts on both the current and future projects. For the current project, it presents opportunities to quickly identify and focus on problem areas, to identify problems with decomposition, interfaces or responsibilities, to evaluate collaborative structures and relationships, and to provide feedback for risk management and possibly for knowledge management as well.

Impacts on future projects include tuning the collaborative readiness metric and collaborative structures, improving the "Collaborate-Contract-Work Alone" decision, optimizing project decomposition and responsibilities, and assisting in identifying good and unsatisfactory partners for future collaborations.

4 POST-COLLABORATION METRICS

One class of post-project metrics will mirror pre-collaboration and/or mid-collaboration metrics. How well did a particular corporate facet or collaborative function perform (communication support, intellectual property control, risk management, etc.)? How well did the collaboration function, and what problems need to be addressed? Did project management and software process function as expected, or what should be changed?

A second class deals with the overall success of the project and the collaboration itself. The real questions that need to be answered are: Was the project a success? Did the product meet its functional and non-functional requirements? Did the project, process and product meet quality targets? Did collaboration help or hinder in meeting schedule and budget? And did the project and the product fulfill partner and collaborative business objectives?

If it was not a success, was the project worth trying? Was the collaboration a success? How did collaboration affect the success of the project? One tricky point is that some projects would never have been undertaken by any of the partners acting alone. (Since many if not most software development projects do not succeed fully, it is not clear that partial failure of a collaborative venture is in and of itself evidence that collaboration is not viable.)

Finally, what have we learned? What changes are needed—in structures, artifacts, staging, or management? Are revisions needed in collaborative configuration and change management, risk management, knowledge management, or metrics and quality assurance themselves? We consider one post-collaboration metric below.

4.1 EFFECTIVENESS OF COLLABORATIVE KNOWLEDGE MANAGEMENT

How many queries to the collaborative knowledge base required access to information from multiple partners (both as an absolute measure and as a percentage of total queries)? From the collaborative knowledge base? From analysis of multiple components of the product?

What proportion of the information in the collaborative knowledge base resulted from integration? From analysis? Required both?

How much credit would be assigned to the collaboration as a whole if it were considered a partner? How much collaborative information is needed to analyze, test, maintain, or modify individual partner components? To modify interfaces or collaborative structures and practices?

On the cost side: How often did inference or representation of information fail because the abstraction or filtering hid required information? That is, in principle, when it would have succeeded if this had been a single-organization project?

How much effort, time and money were used in determining representations for the collaborative knowledge base, or encoding/decoding its information? How often was human intervention required for the encoding?

These questions also assume that there is an awareness of such issues, with the experience to understand the value and deliver crucial information from collaborative knowledge embedded within organizational frameworks. Thus, the cost of training and sensitization, and of development of algorithms and approaches for identifying integrative and collaborative knowledge [15] must also be taken into account, although it may be possible to amortize it across a set of collaborative projects..

5 CONCLUSIONS

We have argued a need for metrics for collaborative software development, and in particular metrics aimed at the collaboration itself, and have considered many of the important questions that will have to be addressed by such metrics. See Figure 1 for an overview. Many but not all of these issues apply to collaboration in general. Future work will entail

- Developing metrics, via interviews, surveys, and case histories, and applying these to collaborative software development projects.
- Applying our approach to a broader range of inter-organizational collaboration on other technical projects, particularly intellectual property ventures and those with complex collaborative structure, or a complex, long-lived and evolvable product.
- Integrating these metrics with new or revised versions of traditional metrics into a metric suite.
- Investigating interactions of these metrics, and their interaction with ongoing technical and business processes, with the aim of determining correlations as well as co-regulative negative and positive synergistic feedback/feedforward loops.

One difficulty is that corporate management may resist some forms of metrics, so that obtaining data may be a serious problem. Collaboration is likely to intensify this.

The same factors that resist collaboration are likely to resist sharing internal data that is apparently not needed for the functioning of the collaboration or the development of its product. Resistance will be intensified where there is little trust of the quality or validity of data supplied by the partners—both to providing the data, and to believing the results.

While increasing trust between partners addresses this question in part, trust alone is not sufficient. Thus future work—ours or others'—will also be needed to develop structures and processes to assure consistency of interpretation of measures, together with quality and timeliness of data.

In sum, development of metrics to measure collaboration, and adaptation of traditional metrics to a collaborative context, is a key step in developing a viable framework for successful collaboration.

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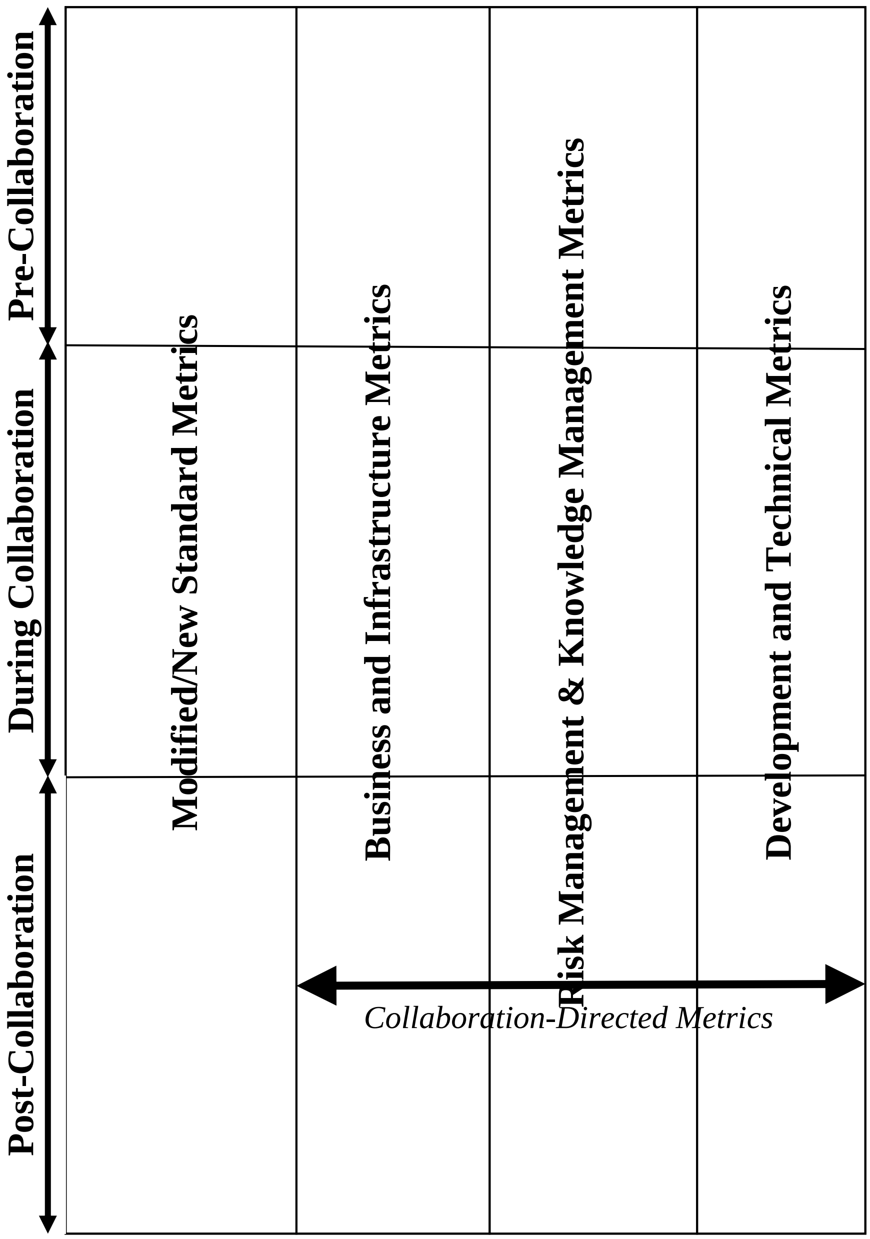
Figure 2. Overview of Metrics for Inter-Organizational Collaboration



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A Cooperation Model Applied in a Kindergarten

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ABSTRACT

The need for collaboration in a global world has become a key factor for success for many organizations and individuals. However in several regions and organizations in the world, it has not happened yet. One of the settings where major obstacles occur for collaboration is in the business arena, mainly because of competitive beliefs that cooperation could hurt profitability. We have found such behavior in a wide variety of countries, in advanced and developing economies. Such cultural behaviors or traits characterized entrepreneurs by working in isolation, avoiding the possibilities of building clusters to promote regional development.

The needs to improve the essential abilities that conforms cooperation are evident. It is also very difficult to change such conduct with adults. So we decided to work with children to prepare future generations to live in a cooperative world, so badly hit by greed and individualism nowadays.

We have validated that working with children at an early age improves such behavior. This paper develops a model to enhance the essential abilities in order to improve cooperation. The model has been validated by applying it at a kindergarten school.

Keywords: cooperation, model, collaboration, essential abilities, interactions.

1. INTRODUCTION

The state of Puebla is a region where some industries have flourished in the past like the textile and rustic furniture. However due to globalization and world competition many textile mills and furniture factories have closed leaving many people unemployed and the regional economy has come down.

The creation of clusters in a region has been extensively validated [1] as a strategy to successfully transcend globally. However this implies for many organizations to compete but at the same time working together, sharing objectives, knowledge, information, and resources, collaborating intensively with related and supporting organizations, which have to do with cooperation.

We have been working with different clusters trying to promote collaboration as a natural tendency on adults. However it is been very difficult to infuse such virtue in their DNA. It is not difficult to conceive that children could have an easier tendency to collaborate with their peers. This could be achieved if they are motivated appropriately to respond more naturally to the virtue of cooperation.

2. DIAGNOSIS

We found that a cooperative behavior is absent in the majority of the firms in the region of Puebla, México. One of the consequences has been the foreclosure of most textile and furniture firms and also because of the lack of innovation and creation of clusters.

Based on questionnaires applied to business consultants we found that even though there is some evidence of improvement in the entrepreneur’s cooperative behavior, they tend to work individually and in isolation. Entrepreneurs need to learn to cooperate in a global world, where a national and international cultural competence is necessary for survival.

3. STRATEGY

We usually understand and comprehend the world and the people around us through education. Based on the theory of constructivism which states that knowledge is built on previous experiences, it is very difficult to change the way of thinking and behavior of an adult.

That is why it was decided to evaluate a strategic shift in the way most adults were educated, by developing the abilities of cooperation in children where mental structures are under development. These essential abilities are described next within the context of a cooperative model developed as a framework for this research work.

4. MODEL FOUNDATION

To search for the essential abilities for cooperation, a simple definition of cooperation is proposed here as working together having the same objective, measuring its performance as a collective achievement rather than the traditional individual performance evaluation criteria.

4.1 The essence of the human being

Studies of the human brain for practical purposes have been typically divided in two parts, the emotional and the rational hemispheres. The emotional part deals with sensations and feelings and responds to stimulus instantaneously.

People with the ability to control and handle emotions, but at the same time understanding the emotions of others have more possibilities to live a plain full life. The physiologist Savory considers that emotional intelligence consists of five domains: “knowing your emotions (self awareness), managing your own emotions (self-mastery), motivating yourself (motivation), recognizing and understanding other people’s emotions (empathy), and managing relationships (social abilities)” [2].

The rational or cognitive side of the brain analyzes the stimulus to comprehend the events giving them meaning and finding conclusions. It is intriguing that many organizations do not relate with other institutions because they don’t trust them mainly because they do not want competitors to know their strategy and the way they manage their business.

This comes from a deformation of the concept of competition. Competition in Latin literally means consensus, not beating others as understood nowadays. There is even a common saying in some Latin-American economies, “if you do not cheat you do not progress”. Cheating could provide a short term success in some cases, but not a long term one. This entrepreneurial reasoning must change.

When economic transactions are performed with truth, meaning transparency, responsibility, honesty and justice, an environment of confidence, communication and dialog is created. As a result, love and affection arises, creating a sense of community, where transactions become distributive instead of commutative where reciprocity and solidarity are present to create a reinforcing environment.

Pope Benedictus XVI [3] states that “The essence of a human being is the perception of an interior impulse to love in a truth way. Love and truth never abandon us completely because they are the calling that God has put in our hearts”

4.2 Relationship with others

Some conditions in organizations that foster cooperation are presented next. In regions or countries where clusters of organizations are present, there are continuous and direct interactions amongst members, building strong linkages. The more frequent the communication and information sharing the better for the advancement of the cluster, which translates into better understanding of each other´s culture, technical language, and face to face contacts, building knowledge which is the basis for innovation [4].

The direct observation of processes and products enrich the creation of knowledge [5]. There must be trust between the parts because of the important information that flows in transactions. For instance, a superior example of cooperation is in place at the Mondragon Cooperative System in the north of Spain [6].

The root of their success is based on the idea of sharing, cooperation, caring for others having “love” as the center of the society. They started with an education program based on trust, collaboration and moral values. The philosophy of the economic activity is based in the concept of “equilibrium”, which translates as equilibrium, having the purpose of promoting unity in the diversity in a society. It has three characteristics:

1. Identify the importance of the person and the group.
2. Allowing the existence of different responsibility levels according to capabilities.
3. Considering what it is called “opportunity”, meaning placing the events in the present. There is a limit in the size of the organization for the benefits of personal relationships, intimacy, confidence and better communication.

4.3 Education

Communication is the condition which makes education possible. Education presents two complementary aspects, one related with the transmission of information and knowledge, and the other with the interactions of the actors of the process. The foundation of Constructivism is based on the social interactions and the intelligence built around it [7].

According with this perspective the particular worth of a human being is not the capacity to understand the world, but by the constant interpretation of the minds of others manifested by different forms, such as in words, actions, and developments among others. Such capacity let us learn from others and understand our own mind. Constructivism is the predecessor of the cooperative learning [8].

Five elements are required for cooperative learning [9]:

1. Positive interdependence. That means the need to work together.
2. Individual and group responsibility. The group members have common objectives and each member assumes its responsibility.
3. Stimulate interactions.
4. The members of the group have the personal and team abilities required.
5. Group evaluation rather than individual.

5. MODEL DEFINITION

The framework for this research is represented by a model that consists of seven modules. The first module of the model is called “Vocation”, meaning the natural tendency, the reason for the existence of something, the inspiration to follow. The natural tendency is to orient ourselves by instinct and reasoning based on our being, believes, qualities, preferences, developing skills to face our lives. The reason of existence is the purpose and in the organization is the common purpose that gives cohesion. The vision must be clear, and specify the purpose of our efforts and everyday work.

The authors believe that there is an intrinsic and continuous search of our vocation. We could say that in a supportive environment, a vocation is supported by the creator's need to work together.

The second module is defined as the "Values" component. Values represent the foundation and the base of behavior of individuals and groups. They are the guidance and orientation of any process activity, describing the behavior of each person and the relationship with others. Ethical contributions are values that go beyond particular benefits [10]. Benefit values of an organization should be selected by all their members, such as truth, justice, solidarity, generosity, love, and others. The collaboration that each member of the organization perceives of others determines the confidence created in the organization.

The "Organization" element is the third module of the framework for cooperation. It represents the setting where the actors perform, where the vocation and values of the people take action. It is the environment that influences the interactions and their performance. It is desirable to promote collaboration across the entire organization in order to achieve better results.

The fourth module reflects "The Success Factors" of the cooperative model. They represent the key elements that guarantee the cooperation across individuals and organizations. The main success factors have been grouped in two different levels for the purpose of this research.

The first level includes seven factors:

1. Common objectives
2. Principles and rules
3. Common language.
4. Frequent interactions
5. Trust environment
6. Well defined roles
7. Innovativeness

1. Common objectives have to be created because of the need to work together. The common objective has to be something significant, interesting or important.

2. Principles and rules are the signs to indicate the road to follow for personal relations to flow smoothly with minimum conflicts. Frequent interactions create conflicts inevitably. The principles and rules are flexible and apply according with the situations.

3. Common language refers to the communication vehicle used to exchange ideas, thoughts, knowledge, and initiatives in order to have the same meaning for all the participants, going in the same direction as the common objective.

4. Frequent interactions provide the opportunity to know, share, change, implement, create and innovate.

5. Trust environment refers to the sensation of freedom. It is created by the acceptance of each person just as he or she is, having virtues and weaknesses.

6. Well defined roles help to achieve their performance, speeding up decision taking and reducing conflicts.

7. Innovativeness is an ingredient to increase and maintain the interest in the common objective. It implies diversity and a variety of ideas, analysis and flexible implementation.

The second level of success factors of importance has to do with the operationalization of the model and include:

1. Balance of interests and needs
2. Common technology
3. Limited group size
4. Training
5. Change adaptation

1. The balance of interests and needs refers to justice and equity among the members of the group.

2. Common technology helps to build knowledge and to align processes. It is a tool to think, criticize, deduct, discuss and infer.

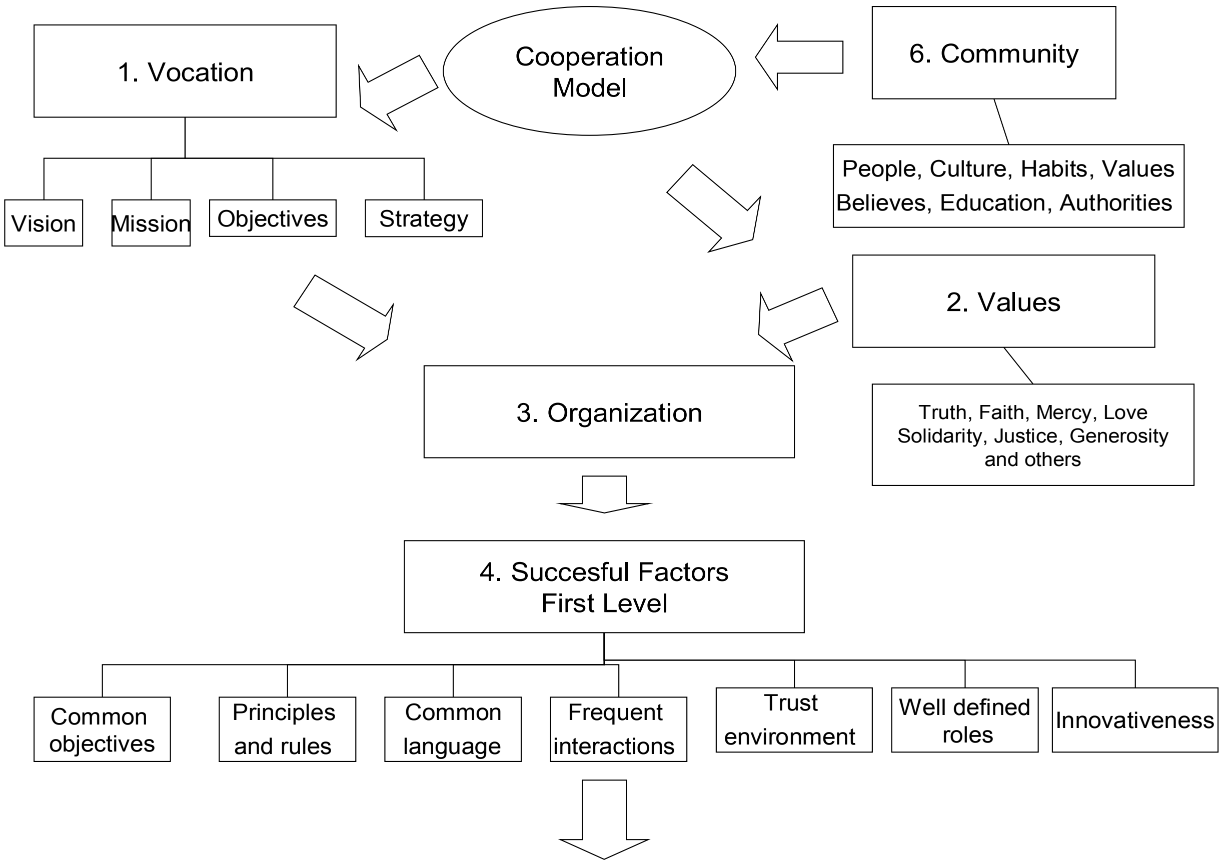
3. A limited group size usually creates a feeling of belonging, identification and integration, which makes it easier and is more effective.

4. Training gives the opportunity to support the achievement of the objective.

5. Change adaptation implies a continuous adjustment to a changing world of scenarios and the capacity to be a leader or follower as needed. In a few words, be ready to change.

The fifth module of the model is comprised of "Performance Indices" with respect to a) human capital, b) profitability and return on investment, c) Innovation and d) growth. The framework can be adapted to any environment to enhance collaboration. For the specific application of the framework to the kindergarten case, the only indexes used pertain to human capital, as one would expect.

The Community module the sixth module and represents the surrounding environment of the organization. It has to do with people and their culture, believes, values, habits, education, and authorities. For the kindergarten case, the community relates to the families of the school children.


1. Vocation
Cooperation Model
6. Community
Vision
Mission
Objectives
Strategy
People, Culture, Habits, Values
Believes, Education, Authorities
2. Values
3. Organization
Truth, Faith, Mercy, Love
Solidarity, Justice, Generosity
and others
4. Succesful Factors
First Level
Common objectives
Principles and rules
Common language
Frequent interactions
Trust environment
Well defined roles
Innovativeness

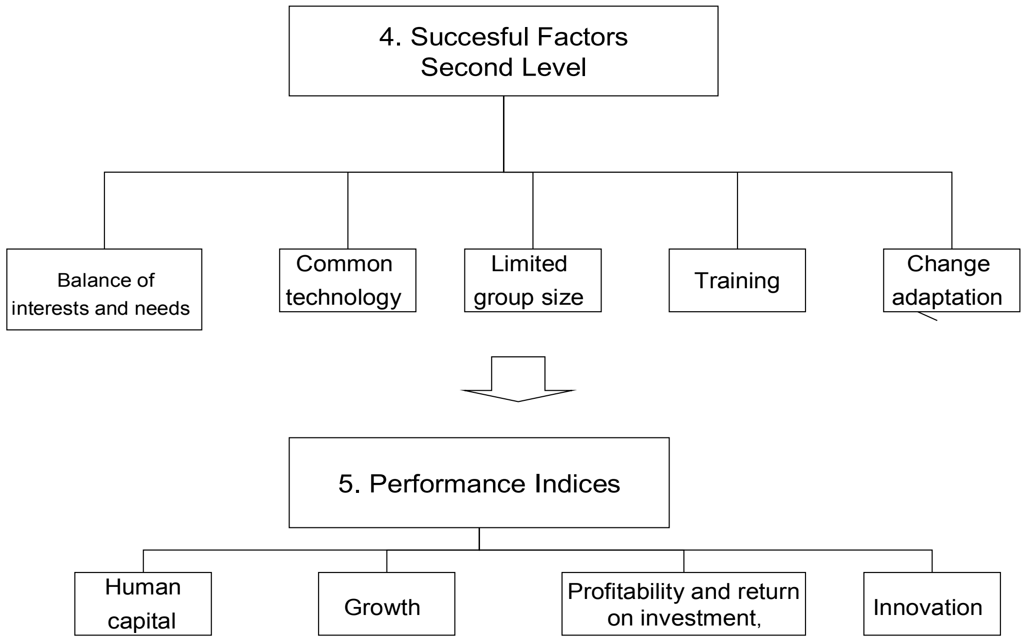


Figure 1. General Model for Cooperation

6. ESSENTIAL ABILITIES

One of the key elements required for cooperative learning according to Johnson and Johnson [9], refers to a disposition of the group members to cooperate. That means, that they have the personal and team abilities required for collaboration. These could be intrinsic to the individual due to cultural heritage or developed by each person as part of the evolution in the pursuit for cooperation to accomplish any vocation.

These abilities has to do with getting along, solving differences, taking decisions, respecting and serving others as we would like ourselves to be treated. With respect to an individual and from the emotional intelligence perspective, we focus in four domains: self awareness, self-mastery, empathy and social abilities.

The cognitive ability is another important one related with the capacity to understand and to learn the need to cooperate, as well as its advantages. The last ability is comprehensive, and is called the ability of cooperation and has to do with generosity, the ability to give unconditionally, as Mother Theresa used to call it.

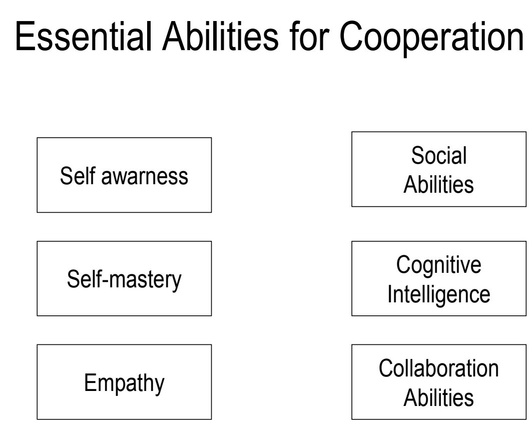


Figure 2. Essential Abilities

7. APPLICATION OF THE MODEL

The cooperation model was applied in a kindergarten mainly because their vocation and values are in line with our definition of cooperation. So we decided to work with children to prepare future generations to live in a cooperative world.

The Public Secretary of Education in México (SEP) created the Educational Program for Kindergartens in 2004, which is based on competences, such as knowledge, skills, attitudes, social abilities, and values that children acquire through the learning process, evaluating the performance under different circumstances.

Even though collaboration is mentioned in the fundamental purposes of the SEP program which are the essence for the development of competencies list, collaboration itself as a competence is not in the list. We propose to include specifically learning to work in collaboration, as one of the competences in the field of Personal and Social Growing in the aspect of interpersonal relationships.

7.1 Development fields

According to SEP [11], there are six development fields where these capacities need to grow:

1. Personal and social growing.
2. Language and communication.
3. Mathematical thinking.
4. Knowledge and exploration of the world.
5. Artistic expression and appreciation.
6. Physical development and health. [11].

The same way medical doctors use a treatment to cure a patient; we decided to carry out a comprehensive treatment to improve the essential abilities to enhance cooperation. The treatment consists of applying didactic situations in the six development fields just mentioned.

For each didactic situation a standard format was used to facilitate processing of the information. The format included the name of the didactic situation, its purpose, the capacities to develop, the development field, the didactic sequence, aspects to evaluate, aspects to think about and materials to use.

7.2 Didactic Situations

The prior knowledge of the children has to be known in order to develop the didactic situations, since we learn building over past experiences. One desired quality of the didactic situations is to be a real one or a problem that the children have at the moment.

The history of the community, values, believes, customs, sayings, myths, authorities, food, and culture could be topics included in the didactic situations. They should be developed for the following areas: social development, affective, willingness, intellectual, physical and sexual health, moral and spiritual. The didactic situations have to be designed and organized in a way that cooperation is highly required. An effective way to instill cooperation is to implement it in common situations at home or at school.

When the didactic situation is complex and is related to several activities, it is recommended to classify it as a project. As an example, we develop a project starting with a didactic situation of "the lost dog". We began with a history of the dog, and then different teams were organized. The next day the search for the dog took place and a report was presented. A homework that included the parents was assigned to keep looking for the dog. The teacher showed a picture of the dog with the news that it had been found. Letters to thank the people involved in the search were dictated by the children. The project gave them the opportunity to organize themselves, take decisions and cooperate.

Another way to organize the didactic activities is by having a workshop. Here a space is conditioned and an activity like painting could be planned. In our case, we selected to work with a farm. The animals of the farm have to be painted. The children organize themselves to paint a different animal. Then the children are free to work. They children are encouraged to work things in cooperation with the guidance of the teacher.

We have developed the concept of "Needs Detector". Every person has a detector and has to be used every day. We practiced with them at school and at home. They have to say what needs are detected in the exercise. The idea is to sensitize the children of the needs around them. They must be aware of the existence and problems of their young fellows and fellow citizens.

Another concept is the "Union Vehicle". At the start a didactic activity or a new day, we can ask the students who is going with you in the vehicle to work together this new adventure.

The didactic activities have to be designed and applied taking into consideration the four pillars of "Education Learning: the Treasure Within, The report to UNESCO of the International Commission of Education for the XXI Century2, presided by Jacques Delors [12]. The four pillars are: Learning to know, by creating the interest and curiosity to learn and how to ask; learning to do, by practicing cooperation; learning to live together, by organizing teams listening and interacting frequently; and learning to be, developing all the students potentials.

7.3 Teachers Participation

The teacher´s roll in kindergarten is of vital importance. He or she has to know the previous knowledge that the students have before entering school. Based on previous knowledge and the improvements that each student has on the six development fields, the teacher plans the work in weekly biweekly classes.

The type of activities, their complexity, their sequence, the materials to use, and the scenarios, are part of the responsibility of the professor. The organization of the class, rules, discipline, an environment of trust, and spaces is also part of the job. That is why the teacher´s compromise with the concept of cooperation is crucial. The benefits of developing the contents of the activities, the materials and contexts to perform are important for the success of this idea.

7.4 Information and communication technology

The advancement of information and communication technologies has opened the doors for new ways of learning. The internet has changed our society having information and knowledge at hand. The Public Secretary of Education in

Mexico (SEP) [13] has developed a web page as a platform for the schools to get in touch and exchange experiences. It also provides material to be used in classes.

The challenge here is to use the videogames, movies and digital materials in a way that cooperation is needed to reach common objectives. The time and frequency used of these technologies have to be limited, since they have repercussions in the oral language and non verbal communication skills. In the long run, it could diminish the abilities to relate with others, having less empathy and social abilities. Supervision of the context of the materials is a must.

7.5 Guidance of the application of the didactic situation

The following section provides guidance for the application of each didactic activity.

Name of the didactic situation. The teacher asks students how much idea they have about the subject. The objective is to create an environment of trust and a common language.

Purpose. The teacher explains the main purpose of the activity, with common objectives and instructions.

Didactic Sequence.

1st Step. Definition of teams and roles (states the rules, establish the responsibilities, balance of interests, size of the teams).
To define the teams we used the Puzzle Aronson Technique [7].

2nd Step. Preparation of material (creativity and innovation).

3rd Step. Doing the activity (confident environment, frequent interactions, adjustment to change, and innovation).

4th Step. The teacher asks questions about the points to think about.

5th Step. Knowledge building (Create a drawing representing the activity just developed. Put it in a wall of the classroom together with the other didactic activities).

8. EXAMPLES OF DIDACTIC ACTIVITIES

The main purpose of the activities is to promote the spirit of collaboration. Some of the activities designed for this research are:

- Knowing my team
- Let´s go buying
- The hospital of collaboration
- Using wastes
- Travel to the universe
- Play fair
- The great firemen team

Each activity is evaluated in general terms using a standard format represented in Figure 3. Each student is evaluated using the format shown in Figure 4. The activities have been validated with experts in childhood education and pedagogy, as well as by the principal and teachers of the school.

- Date :
- NAME DIDACTIC ACTIVITY: ____________________
- TEACHER:____________________
- SUCCESFULL FACTORS:
- THEY WERE PRESENT
- COMMON OBJECTIVES: YES___ NO___ SOME (explain)________
- PRINCIPLES AND RULES: YES___ NO___ SOME (explain)________
- COMMON LANGUAJE: YES___ NO___ SOME (explain)________
- FREQUENT INTERACTIONS: YES___ NO___ SOME (explain)________
- CONFIDENT ENVIRONMENT: YES___ NO___ SOME (explain)________
- WELL DEFINED ROLLS: YES___ NO___ SOME (explain)________
- INNOVATION YES___ NO___ SOME (explain)________
- BALANCE OF INTERESTS AND
- NEEDS YES___ NO___ SOME (explain)________
- LIMITED SIZE YES___ NO___ SOME (explain)________
- TRAINNING YES___ NO___ SOME (explain)________
- COMMON TECHNOLOGY YES___ NO___ SOME (explain)________
- KNOWLEDGE FORUM YES___ NO___ SOME (explain)________
- CHANGE ADJUSTMENT YES___ NO___ SOME (explain)________

Figure 3. General Didactic Activity Evaluation Form

- DATE:____________
- STUDENT NAME:____________________
- DIDACTIC ACTIVITY ____________________
- Scale technique:
- Scale of Likert:
- 1=I Totally disagree
- 2= I disagree
- 3=I am Indifferent
- 4=I agree
- 5=I Totally agree
- SELF AWARNESS: :___:___:___:___:___:
- 1 2 3 4 5
- SELF-MASTERY: :___:___:___:___:___:
- 1 2 3 4 5
- EMPHATY: :___:___:___:___:___:
- 1 2 3 4 5
- SOCIAL ABILITIES: :___:___:___:___:___:
- 1 2 3 4 5
- COGNITIVE INTELLIGENCE: :___:___:___:___:___:
- 1 2 3 4 5
- COLLABORATION ABILITY: :___:___:___:___:___:
- 1 2 3 4 5

Figure 4. Student Activity Evaluation form

9. PRELIMINARY RESULTS

A small kindergarten was selected as our research laboratory. Teachers follow a closed companionship with their students. The successful factors of the cooperation model mentioned in the Section 5 are present in general in all the activities developed during the school day. The teacher was trained in the application of the didactic activities and in the use of the evaluation forms. A group of seven children between four and five years old was chosen to implement the research. At such age, children already have self awareness.

A social map was created with the teacher before applying the model, relating each student with the rest of the group. The social map will be revised at the end of the year to evaluate the performance of the group and of each student.

Student	Self mastery	Self awarness	Empathy	Social abilities	Cognitive intelligence	Cooperation abilities
1	=	=	+	=	=	+
2	+	+	+	+	+	+
3	+	=	=	+	+	+
4	+	+	+	+	+	+
5	=	=	=	=	=	=
6	=	+	=	+	+	=
7	+	+	+	+	+	=
TREND	+	+	+	+	+	+

Figure 5. Preliminary Results

Eight didactic activities were applied having most of the successful factors present. The students had the opportunity to develop their cooperation abilities. The results of well planned and familiar situations are notorious; where they could identify real life situations, which made them understand better their reactions, learn about themselves, making a simpler effort to work together with their peers, improving their abilities.

To analyze the results, we applied a nonparametric statistical method known as "The Sign Test". Nonparametric tests are used in the social sciences when values are difficult to quantify. "They are particularly useful in making inferences in situations where doubts exist about the assumptions that underlie standard methodologies" [14].

The Sign Test is a particular Hypothesis Testing based in the binomial distribution where the answer could be success (+) or failure (-). The sign test is just the binomial test with p=1/2.

We defined the Null Hypothesis as follows:

Ho: The essential abilities of the children in the kindergarten after applying the model decreased and worsened (failure).

The alternative Hypothesis:

H1: The essential abilities of the children in the kindergarten after applying the model increased and improved. (Success).

The number of students is seven.

The number of abilities is six.

The total essential abilities measured were 7 x 6 = 42.

Since we need to check if the abilities improve, we used a one-tailed test. The null hypothesis that we wish to reject will be:

Ho: $P(+) \leq P(-)$ (1)

The alternative Hypothesis is: H1: $P(+) > P(-)$ (2)

The decision rule. First, we disregarded all tied pairs meaning results that neither improved nor got worse. And let n equal the number of results that are not ties.

n= total number of +´s and -´s (3)
\+ Abilities improved = 28
\- Abilities worsened = 0

n = 28 + 0 = 28

Let α represent the approximate level of significance desired.

$\alpha = .025$

The Test Statistic T equals the number of + "plus"

T = 28

The value of y corresponding to α, is called t

The rejection region of size α corresponds to values of T greater or equal to n-t.

For n larger than 20 the following approximation is used.

$t=1/2(n+w\alpha.\sqrt{n})$ (4)

$w\alpha = -1.96$

$t=1/2(28-(1.96x\sqrt{28}))$ (5)

t= 8.814

n-t = 28 - 8.814 = 19.185

T = 28 > 19.185

So the null Hypothesis Ho is rejected and the Alternative Hypothesis H1 is accepted.

H1: The essential abilities of the children in the kindergarten after applying the model increased and improved. (Success).

The results of the sign test proved and confirmed that in general the cooperation abilities improved. In some cases some abilities did not improve, but in any case the abilities got worse.

We revised the social map at this point of the research and found that through the activities, the children started to know each other better and adjusted to the group. There has been more integration in the class even though the compatibilities among them remain the same.

The topic of cooperation opens many possibilities for different ways of working with the students, having different projects, research, workshops, games, and any other activity that reinforces cooperation.

.
We need to start working at home with their families, so that we know the values being taught to their children. Their support in homework, and to receive training and guidance in order to develop at home the key successful factors such as a trust environment built with acceptance and love. This is the main purpose behind this work. To do so, we have sent a questionnaire asking for this possibility. A more ambitious plan

in the future is the school for parents, to learn from other parents, from experts, to learn basic teaching skills, all with the purpose of helping their children to transcend in true happiness.

10 CONCLUSIONS

We firmly believe that cooperation, collaboration and sharing are basic values that need to be present in society if we wish for this world to change for the well being of humanity. The efforts of several organizations to reverse the trend of individualism and selfishness are promising. We are excited about the preliminary results with children and we are in the process of establishing a similar construct for higher levels of education.

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Collaborative Engineering of Inter-Enterprise Business Processes

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ABSTRACT

Enterprise 2.0 and cloud computing are two of the last years most popular topics. Researchers and Business Analysts see great opportunities and potential for a kind of business application revolution. Unfortunately the revolution has not started yet due to different reasons – for example the lack of concepts for integrating new ideas into the already known principles. We are convinced that combining the power of cloud computing with principles of social networking and methodology of business engineering will open new horizons for the global value creation. This paper describes a concept how cloud computing technology can be used to support new ways of inter-enterprise collaboration using the example of logistics.

KEYWORDS: Collaborative Business Engineering, Cloud Computing, Enterprise 2.0, Distributed Modeling, Model Driven Architecture

1. INTRODUCTION

What exactly is "cloud computing"? Unfortunately the term is not clearly defined. All software and web services which are distributed throughout the World Wide Web are referred to as cloud computing.

Following this definition of cloud computing a lot of telematics solutions are included. Internet-based fleet management systems have been controlling thousands of vehicles for years. Millions of parcels are tracked and traced by the use of internet technologies. Seen from this point of view logistics industry has been an early adopter of cloud computing. It seems to be no coincidence, that internet based technology is highly interesting especially for this industry.

What is the reason for this? Logistics is particularly strong driven by globalization related changes. Outsourcing, insourcing and global relocations are growing business topics beyond the classical transportation, handling and warehousing. These topics in conjunction with the increasing cost pressure require more powerful and flexible IT systems. On the other hand term contracts are shortened year by year and cycles change extremely fast, which challenges traditional IT solutions. Relief can be brought by means of cloud computing.

There are some additional factors which have been neglected in the discussion so far. Cloud computing could be the basis for new innovative business solutions not only within the field of logistics. The vision behind cloud computing is the availability of infinite internet resources which can be completely and freely adapted to the actual demand without any delay. Considering the huge investments in the area of dynamic cloud infrastructure, this vision is slowly becoming reality.

Cloud computing creates a new, fast growing field for innovative business solutions, just waiting to be cultivated.

However, the currently discussed approaches are limited to just a fraction of possible ways, since the opportunities and risks of cloud computing are usually considered for pure software services and in the context of a single company only.

With cloud computing, it is secondarily a matter of providing and consuming "everything" as a usable dynamic service, whether it is computing power, accounting, simplest work done by human labor, a ready-made software solution or any other service. This extreme form is known as "Everything as a Service". Logistics represents the interface between the real world and IT solutions. Therefore, it seems to be an obvious idea to transfer the logical representation of logistics services from the real world as web services into the cloud. And who other than innovative logistics service providers could be more qualified to do this?

Right now several promising research projects are processing the scope of this issue in Germany. The goal is to define a standardized model of the logistics domain, to be used as a basis for intercompany definition of services in IT and real world. But this makes sense only if these services can be offered, searched, consumed and billed across companies.

If we succeed in bringing "everything as a service" into the cloud, whilst better supporting inter-enterprise collaboration, totally new business development opportunities will become reality. Business development within the field of logistics would no longer be driven by the customer only. Chances especially for small enterprises can rise.

Our vision is to design businesses simply by “Drag&Drop” in combination with the automatic generation of appropriate cloud software services in real time. Our approach starts from three basic ideas.

- First idea: New Business solutions should be developed model based. These models should be derived from a business idea and must include three parts: A business object/data model, a business process model and an organizational model. These 3 parts describe the enterprise architecture and are organized in business repositories.
- Second idea – an innovative method how to create the models: All specific models within the costumer business repositories are not developed in the green field. They are derived from a shared Business repository that contains proven reference models which are ready for use as pre-supplied model templates and can be adapted to the specific needs of customers.
- Third idea: The use of model driven software engineering concepts in order to generate suitable software services from the model, which can be deployed in „the cloud“ in real time.

2. STATE OF THE ART

The development of services within a dynamic environment featuring high uncertainties, and in collaboration with other companies, is an object of research. Early tools support a model-driven approach and different stakeholders. Most of these approaches for service engineering in digital ecosystems use the “Zachman Matrix”, a framework for enterprise software in combination with UML diagrams.
However, an interactive platform similar to Wikipedia (as a web site easily available for everyone, usable without any technical knowledge) for collaborative business engineering in heterogeneous and virtual teams is still lacking. A platform supporting the whole process of implementing an idea combined with a measurable success does not exist due to the poor understanding of the combination of open innovation and business engineering. In the past the need to open business engineering processes did not exist. Quite the opposite: opening was seen as a risk.

Open Innovation starts with the independent single player. It puts the interactive sharing of work between individuals in the center of attention. Open Innovation promotes the dissolution of rigid organizational boundaries within the inner circle and at the outer edge of the enterprise.

3. A COLLABORATIVE BUSINESS ENGINEERING PLATFORM

A synthesis of both approaches requires switching the "modus operandi" of the participating companies from reactive transmissions to active acts.

There is a scientific discipline that delivers methods for such an active creation of new businesses. Business engineering deals with the development of new business solutions arising from the transformation of the industrial to the information society. Business engineering represents the method-oriented and model-based engineering design for companies of the information age.

In order to take a business advantage from the tremendous technological possibilities of cloud computing, suitable cloud-computing solutions, tailored to the business developer and decision-makers of the companies are required. This clientele expects easily applicable solutions offering immediate benefits. So how would such a solution look like? Modern distributed modeling tools, providing suitable software engineering models, could represent the basis for a solution – provided they contain suitable models not only for software engineering but for business engineering, as well.

After three years of research we developed a platform, delivering the fundamentals to fit these demands. Figure 1 shows the architecture of the platform.

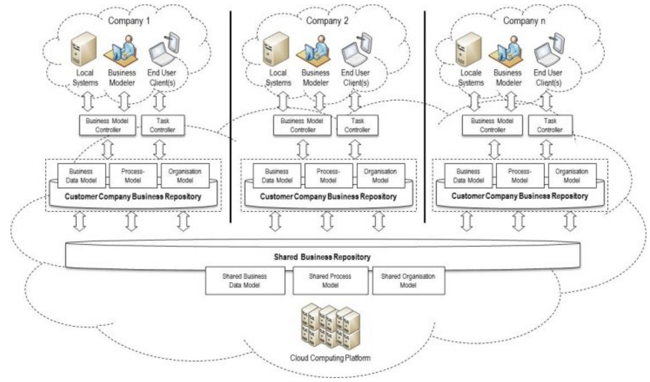

Figure 1: A cloud computing platform architecture for collaborative business engineering

The intended use:
Business users can apply a business modeling tool to create their own business models and to design businesses by "Drag&Drop”. The platform generates an executable prototype of the new business solution without any delay. After the successful completion of testing, the prototype can be transformed into a software solution, and automatically deployed into the cloud.

The process:
Distributed modeling and model-driven architecture are nothing new, neither is the creation of business applications by service compositions. But a closer examination of the most known examples shows that these are rather trivial.

In our opinion the road to success lies in the combination of three key factors:

1) Providing the “right” models,
2) Providing the right way of adopting/adapting the models,
3) Defining simple and complexity-restricting transformation rules.

The design of a suitable model:
UML diagrams are far too abstract and sophisticated to be understood in an intuitive way. Instead, we use a map, inspired by material flow diagrams, providing a synoptical view upon three aspects of value creation: resource flow, data flow and financial flow.

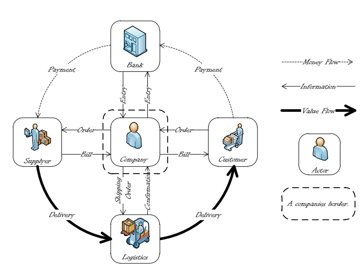

Figure 2: A synoptical cycle model of a companies business

In figure 2 a basic software map for a company is shown. It consists of essential business patterns, especially the relationship between a buyer and a supplier.

Additional three general restrictions exist:

1) All models are based on cycles.
2) All data structures are constructed on self-similar hierarchies of master-detail or parent-child structures.
3) All flows of money, information and material/value are modeled coherently.

These restrictions enable a formal definition of integrity rules which assure the consistency of a model even if it is changed. The fact that all models are based on cycles creates a great benefit: We are able to define implicit consistency rules and constraints, for example between Revenues and Expenses or between required and existing stocks. This has been the basic idea of enterprise resource planning systems and also (in our opinion) their main purpose.

The result features a form, identical to a map, which has been intented, and it inspires other ideas. Maps can be specialized in order to serve different purposes: There are geographical maps, political maps, maps for climate or time zones etc. Our map can be applied for different business modeling aspects: Imagine the physical structure of an enterprise in form of a political map, while the application or IT-Infrastructure can be imagined in form of a geographical map.

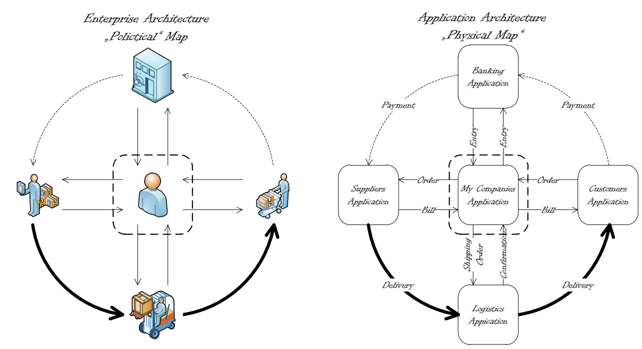

Figure 3: Similar maps for different aspects

The map can contain different types of boundaries:

- Boundaries of organizational responsibility,
- Boundaries of ownership in logistics and supply chains, as well as geographic boundaries of the real world,
- And last but not least boundaries of software systems and applications.

This is very important later when we automatically derive software services and components from our models. If more than one client has to be supported by a service oriented architecture, it is always a challenge to find the right functional cut.

The next step enables the decomposition of our model into a deeper level of detail. The decomposition is tool-supported. Our maps feature "zooming in", similar to Google Earth.

Let‘s start again with the initial software map of a company and let us interpret it as a context diagram. At the next decomposition level we integrate the company's organizational chart.

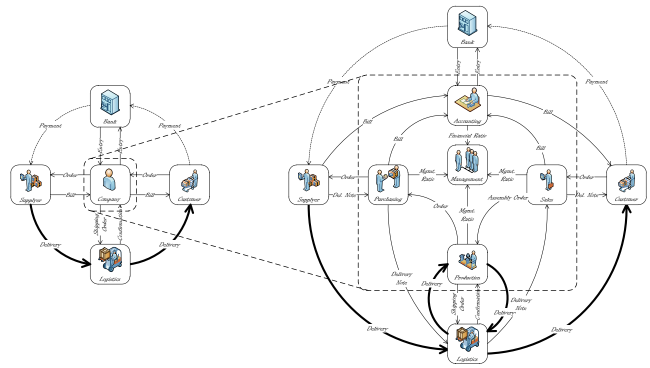

Figure 4: Organizational decomposition

Our platform provides a set of best practice templates for organizational decompositions. Additionally every company can adjust the charts by assembling and disassembling nodes or icons in the map.

So far the enterprise architecture and the organizational model have been discussed. Finally, a suitable process- and a business data model need to be integrated. A thesis states that a business process model implicitly defines its object model and vice versa.

Back to our minimal business pattern: There are three Business Objects: Order, Delivery Note and Bill. Obviously there must be a process step "write order" at the Buyers side, and the suppliers side has to feature process steps "accept order", "prepare delivery" and "write bill".

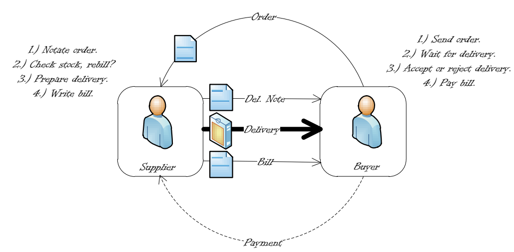

Figure 5: Objects and processes implicitly define each other

Our platform also features a built-in, predefined set of common Business objects and matching process steps which are adaptable and can be modified by adding new attributes as well as new process steps. A new process step always leads to a new state transition within one or more Business Objects. All state values and state transitions are modeled by State Transition Diagrams. Since all transitions are controlled at runtime by the built-in Task Controller modifications are possible without any programming.

The right way of adopting and adapting these models

Our models can be created by choosing and enriching a template with more detailed information. We apply the decomposition pattern in order to create holarchic[1] structures. All processes are derived from enterprise architecture templates. An apparent disadvantage is that processes cannot be created in a green-field-approach. However, this is not really a disadvantage! It enables us to define a set of straightforward patterns for transformation rules.

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[1] A **holarchy**, in the terminology of Arthur Koestler, is a hierarchy of holons – where a *holon* is both a part and a whole. The expression was coined in Koestler's 1967 book *The Ghost in the Machine*.

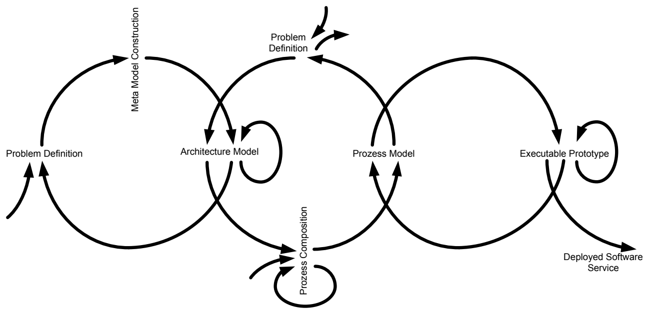

Figure 6: Three iteration cycles of model transformation

How do all the parts work together and how does the platform work? There are three main cycles of model transformation: The left one represents the reference model creation, the center cycle is about model adaption and the right one represents the transformation and execution of the model.

The left cycle is hidden to the user. It provides all the templates for business engineering. The user starts on top of the middle cycle. He answers an interactive questionnaire about his business. In the background, an initial software map of his enterprise architecture is created. The user can modify this map by assembling or disassembling icons and improve it by decomposition. Then the user can start to design a new business case by putting map icons into a process chain. A process model is generated. Data objects can be modified, data sources can be connected. This process model can automatically be transformed into an executable prototype, used for immediate simulation. If the simulation had been successful, the modeled software can be deployed on a cloud computing platform.

The models are always executable and are used to simulate the generated software enabling the testing of real situations.

Each company can create its own enterprise architecture model and the according processes. Since all model artifacts are derived from the same shared business repository they are compatible with the models of other companies. Therefore, one more step ahead can be done and model driven ad hoc projects in form of virtual organizations can be created. So the transformation of executable models to the appropriate project software becomes much easier.

The mission of the task controller component is to transform inter-enterprise process steps into service calls and to provide appropriate end-user interfaces. This transformation is strictly task-based within the context of the specific collaboration business. The trusted access to data, stored in the cloud can be assured, solving one of the major issues in conjunction with cloud computing.

This way, inter-enterprise collaboration is supported much easier. Business collaboration of a new dimension can come into existence.

4. SOLUTION TO THE PROBLEM OF ACCEPTANCE

How can the supposed risk of opening business engineering processes be transformed into a chance? A win-win situation for all potential stakeholders has to be created.

The basic idea is to consider Business Engineering processes no longer as pure technical processes but rather as innovation processes. Using this point of view, methods of innovation research and innovation management can be incorporated.

Two main challenges have to be solved in the context of Business Engineering. The first challenge is to track down ideas and inventions as the nucleus for innovations in all three dimensions of the integration process (see Fig. 12, below), evaluating positive and possibly negative effects on other dimensions. The second challenge represents the action of different people within all three dimensions on behalf of different individual experiences, goals and knowledge.

According to Everett M. Rogers, five factors play an important role for the successful implementation of innovations [1]:

1) The relative advantage of an innovation,
2) The compatibility with an existing value system,
3) The complexity and the perceived simplicity at initial contact with the innovation,
4) The trialability or the possibility of experimentation with the innovation,
5) The observability of the innovation.

All these factors contain strong social components completely hidden in classical business-engineering approaches. This gap is closed by the explicit consideration of the so-called "soft facts" and "soft skills". The soft factors (soft facts) include images, moods, but also knowledge and their subsequent behavior and practices (support / resistance). Soft skills are defined as personal attributes enhancing individual interactions, job performances and career prospects.

We selected several current approaches of other disciplines and combined them in an appropriate manner.

Approach 1: Business Model Canvas
The first approach is the “Business Model Canvas” developed by Osterwalder and Pigneur. [2]

This pragmatic but holistic approach focuses on the business idea as the originating cell of all business, driven by customer needs and represented by a value proposition.

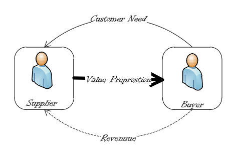

Figure 7: A business idea in software map notation

The Business Model Canvas structures a business idea into nine categories.

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
Who are our Key partners? Who are our Key Suppliers? Which Key Resources are we acquiring from partners? Which Key Activities do partners perform?	What Key Activities do our Value Propositions require? Our Distribution Channels? Customer Relationships? Revenue Streams?	What value do we deliver to the customer? Which one of our customer's problems are we helping to solve? What bundles of products and services are we offering to each customer segment? Which customer needs are we satisfying?	What type of relationship does each of our Customer Segments expect us to establish and maintain with them? Which ones have we established? How are they integrated with the rest of our business model? How costly are they?	For whom are we creating value? Who are our most important customers?
	Key Resources What Key Resources do our Value Propositions require? Our Distribution Channels? Customer Relationships? Revenue Streams?		**Channels** Through which Channels do our Customer segments want to be reached? How are we reaching them now? How are our Channels integrated? Which ones work best? Which ones are most cost-efficient? How are we integrating them with customers routines?	
Cost Structure What are the most important costs inherent in our business model? Which Key Resources are most expensive? Which key Activities are most expensive?		**Revenue Streams** For what value are our customers really willing to pay? For what do they currently pay? How are they currently paying? How would they prefer to pay? How much does each Revenue Stream contribute to overall revenues?		

Figure 8: Business Model Canvas

For all nine parts of the model questions exist – which is quite compatible with our enterprise architecture questionnaire. We integrated these questions as a starting point for a new business engineering project.

Transforming the business model canvas into a software map notation will result in an initial collaboration model as shown in figure 9.

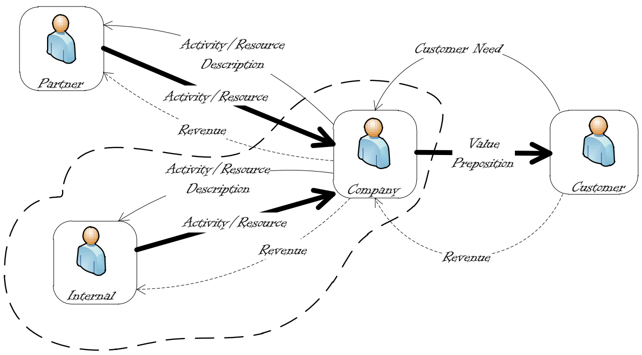

Figure 9: Business Model Canvas in software map notation

Various partners are now able to build a shared model for a virtual organization. All partners are represented by a software map icon which capsules the internal structure. The partners themself can develop their own enterprise architecture to fulfill the business needs of the collaboration.

This enables the building of value or supply chains and networks. The components of all models are derived from the same base and are compatible. In combination with the usage of special graphical visualizations for enterprise architecture, business processes and business models we address the factor "Observability". Software maps are special graphical representations of information, value, and cash flow. In contrast to existing visualization technologies they should be understood by "non-techies" without any prior technical or modeling knowledge.

Approach 2: Collective Mind Method

The second approach has been adopted from the "Collective Mind Method" developed by Köhler and Oswald for usage in software development projects. [3]

It points out that the key for success or failure of a project in software development is the formation of a common sense, the "Collective Mind". For this, the project design represents a key component – a joint assessment of project settings, project environment and project momentum formulated by all stakeholders together. The goal is the creation of such a joint project understanding – the collective mind – as a condition for the conscious control of the "soft" criteria for success.

The success factors in software development projects are the same as in business engineering projects because both define creative processes. Team effectiveness in creative processes depends on many factors. While the "hard" factors such as project planning, budgeting and quality management in recent decades were largely standardized and supported by tools, the consideration of "soft factors" (soft skills) such as communication, knowledge sharing, individual experience and skills is still largely unexplored and often ignored. It just seems to be a major key. Köhler and Oswald proof the increased project success in case a common project understanding, a "Collective Mind" is developed. The project design represents an essential component leading to a common project understanding as a prerequisite for the conscious control of the "soft" criteria for success. Project design consists out of a joint assessment of project settings, the project environment and the project momentum by all stakeholders.

When classifying types of people Köhler and Oswald use the typology of Myers-Briggs. This typology is often used in human resources management, due to the characteristic correlations between MBTI (Myers-Briggs Type Indicator) and vocational aptitude.

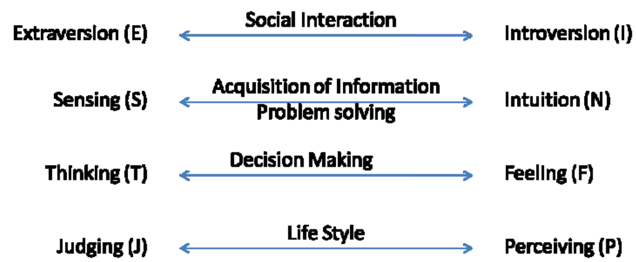

Figure 10: Dimensions of Myers-Briggs Type Indicator

Applying the MBTI classification not only to individuals, but also to organizations and companies in which they operate, a methodology for the formation of the Collective Mind and its implementation in targeted marketing is created.

To classify organizations Köhler and Oswald use an instrument called the Organizational Character Index (OCI) which was developed by William Bridges as an extension of the Myers-Briggs Type Indicator. OCI applies to organizations the same categories of extraverted, introverted, intuitive, etc. as the MBTI applies to individuals. It was developed in order to understand why a particular organization behaves as it does and what kind of "development" it needs. [4]

Köhler and Oswald developed an analogue classification for tasks and projects by the degree of innovation, mission, abstraction and management, distinguishing between four different types of projects:

- Inventor project (high level of innovation and abstraction),
- Missionary project (high level of mission and innovation),
- Master builder project (high level of mission, abstraction and management),
- Carpenter project (high-level of management).

As the names of the project types suggest, they require very different methods, different skill types and therefore different staffing. This seems logical and obvious, however appropriate tools for the support of these themes cannot be found on the market. Project management software focuses exclusively on economic aspects; most of the common tools for the change and process management feature a strict focus on rigid processes.

We recommend the use of an appropriate questionnaire to typify the task, the involved people and organizations. This will create the basis for building a data base of "soft facts", which can be used to generate proposals for the optimal staffing of a project. We can provide appropriate forms of communication and best practice process models patterns.

As a result of this project design tool, an optimally adapted template for the project implementation is generated. Considering the specific project conditions a suitably adapted process model will be provided.

We have generalized and expanded the Collective Mind Method and applied Business Engineering specific methods. The Collective Mind method provides the control and methods kit, which forms the methodological pillar representing the Collective Business Engineering and integrates the important soft factors into the framework.

Our approach to "Collaborative Business Engineering" is (by its structured nature) perfectly suited to develop special software tools for its implementation. Such tools must support the collection, processing, evaluation and development of all relevant informations and ideas as well as their relationships and interactions – representing a new class of business software.

The main advantage is the ability of permanent “Triability”, which is enabled by a completely model driven approach in conjunction with the automated transformation of all the models into prototypical software services in the cloud.

Besides modeling components for business models and business process models, components for modeling and controlling the project’s Collective Mind cover the whole life cycle of the innovation.

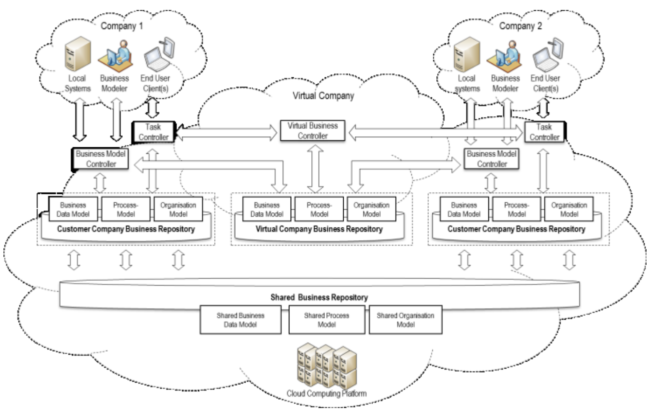

Figure 11: Collaboration at the platform using a virtual organization

How does the platform support this multiply interwaved process of collaboration? First, the initial business idea is transformed into a description of the target state, the necessary steps of the implementation and the resulting values. The model therefore describes the shared vision and mission and the desired organizational culture and provides the framework for policies, objectives and operational actions.

Each potential stakeholder or organization can define its own mission statement, used as an assessment criteria according to the Collective Mind Method within the following phases of the collaborative project.

In addition, all requirements derived from the initial idea have been formulated in form of user stories well known from agile software development. [5]

These user stories can be viewed and continuously evaluated by potentially involved stakeholders. They can be reevaluated if necessary – as soon as new knowledge is present. The open assessment allows the horizontal and vertical integration of all stakeholders by means of a transparent information exchange.

The possibilities for the assessment of user stories go significantly beyond established standards (namely assessing the costs and benefits). The stories can be evaluated by any number of criteria, as a function of different contexts, according to the corresponding mission statements. Its values can be weighted differently. This multi-criteria evaluation allows an active participation of all stakeholders, including those from different "cultures", because the symptoms of failures (different opinions) in large projects are visible early. In addition to the evaluation, all stakeholders can deploy new user stories or add links to the stories, enabling the early recognition of conflicting demands and the discussion of ideas. This approach succeeds by "preventing rather than curing". It supports a proactive handling of changing conditions and suppresses the delayed identification of problems or ideas.

The multi-objective evaluation mechanism also represents the basis for decisions and for the vertical integration dimension.

Managers receive unprecedented (because mathematically underpinned) support in uncertain (because complex) decision-making situations.

Figure 11 shows how this approach is implemented in the platform view. The Business Repository of a cooperative Business is build up by “Copy&Paste” of relevant parts of participant’s repositories. A special virtual business controller coordinates tasks between the participants and ensures the consistency of the virtual system. Note that the decisions of the virtual business controller are by no means arbitrary, but strictly based on the mathematical algorithm underlying the evaluation.

The model and software integration is necessary, but not sufficient to implement a successful collaborative business in reality. Engineering processes should be considered as innovation processes instead of pure technical processes. This way, methods of innovation research and management could be incorporated.

The result is a conceptual model of the integration process featuring three dimensions of integration and a life cycle consisting of four phases.

These phases reflect the regular lifecycle of a virtual organization. The horizontal dimension of the integration represents different organizational units or individuals, while the vertical integration dimension represents hierarchical structures within an organizational unit.

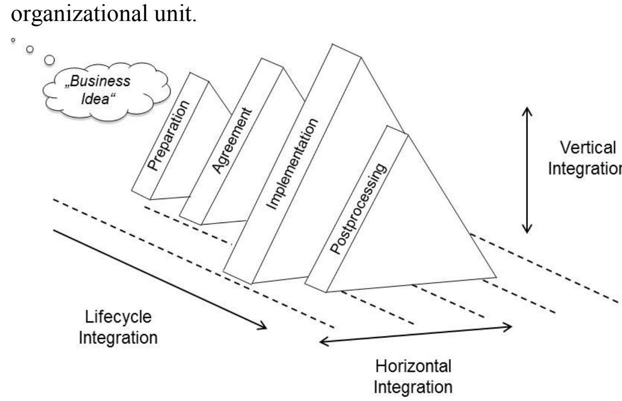

Figure 12: Lifecycle and integration model

As seen in Figure 12, collaborations are characterized by three integration dimensions. Decisions have to be permanently made within and between these three dimensions.

The project life cycle is the first (time-based) dimension. The choice of partners in the preparation phase is a very important decision, since it defines the cooperation of various companies and institutions which form the second horizontal dimension. Hierarchies within companies and institutions represent the third, vertical dimension.

All three dimensions build the frame for the synchronization and escalation mechanism. User stories form the basis of every decision making process.

All decisions are made by collective assessments. These decisions have to be reviewed permanently, since the success of the project is based on the summated, most essential decisions. A holistic view upon these decisions is required, since our approach will comprehensively document them for the first time.

Classically, decisions within businesses, companies and institutions are made on the basis of cost estimations only. We want to introduce additional evaluation dimensions, which are not only of financial but also, e. g. political, ethical or environmental nature. This requires the introduction of multidimensional and multi-criteria decision-making networks which can be treated by computer-assisted methods of numerical mathematics.

5. METHODOLOGY

The mathematical basis is the modeling of networks i. e. systems of nodes (such as individual actors or actions) and their connections (the inter-connection of nodes). In classical graph theory, the existence or absence of a connection between two nodes is relevant only. However, in real networks these connections are multidimensional: Between two actions or two actors there exist not only physical and monetary relations, but an action can produce marketing-related, confidence building, etc., i. e. "soft" effects.

Moreover, every action (and ultimately a project as a whole) features often not only one, but several objectives. In addition to direct economic considerations (profit concerns, achieving new customers), it focuses on strategic and political considerations (strengthen locations, initiate start-ups) environmentally-oriented ones (spare resources) etc.

All of these objectives have to be taken into account. Each COBE project has to consider multiple criteria. The underlying structure is, therefore, a multidimensional and multi-criteria decision network.

The analytical treatment of such networks is impossible. Instead, the net must be simulated, i. e. the impact of any action on the project objectives has to be pursued by computer-based methods of numerical mathematics. This includes

1) The calculation of effects,
2) The visualization of causal chains and
3) The optimization of procedures.

All three components together build the foundation of the Collaborative Business Engineering tool.

The calculation of effects enables the conduction of a cost / benefit analysis of various possible options in order to fulfill a customer request (e. g. choosing the stakeholders, taking into account interests and experiences of customers).

Visualization is a key component in our approach in order to integrate the "human factor" into the project implementation: it permits the illustration of the consequences of an action, would it be the change of a parameter (e. g. cost increase), or a subjective decision within the network, and thus contributes significantly to the increasing transparency of the project implementation.

Finally, optimization is the (automatic) search for the best solution or – more realistically – the automatic suggestion of a number of suitable solutions and the description of their respective advantages and disadvantages, so that the manager can select and implement one of them. A service to be provided can now be interpreted as a path within the network. Its cost is given, in the simplest case, by the sum of the costs of the nodes on this path.

To find the optimal solution for a given task is then the search for the best path which can be carried out by applying standard methods of global optimization.

To bring the described approach into function two things are necessary:

1) The comprehensive coverage of both the targets and the data of all involved stakeholders, i. e. the correct implementation of the preparatory phase as the base of the whole approach,
2) The realistic and up to date assessment of the various actions and their interrelationships. This requires a constant maintenance of data and a voting procedure on the assessment of the effects of an action – different stakeholders can have quite different points of view!

Moreover, the impact of real decisions is often not predictable. Rather, probabilities have to be provided by the decision makers, which in turn could be influenced by later decisions or by changes in the environment. The modeling of the network also takes this (probabilistic) aspect into account.

6. LEARNING FROM THE COLLECTIVE

Another new and important approach within this idea is the representation of best practice patterns via a recommender system. It means that we use and analyze information about projects, problems and solutions. We provide important information and solution drafts for new projects and situations, which are based on the experience of already existing users.

Recommender systems have been developed as a computer-based intelligent technique to solve the problem of information and product overload. Recommender systems are tools for the creation and dissemination of recommendations. The purpose of these systems is to filter information and to provide valuable recommendations for the user. At present, recommender systems are mainly used within the field of e-commerce, to introduce more products to the user.

The goal of the recommender system in this context is to work like a human brain. It should store the entire amount of existing data and the according results – especially the rating of the results of the project.

The stored data can also be analyzed for new projects featuring similar combinations and cases, enabling a provision of recommendations.

This recommender system can provide help and support based on the experience of other companies, as well.

7. SUMMARY AND OUTLOOK

This paper presents an integrated framework for the structured and tool-supported transfer of new ideas into products and services based on a multidimensional and multi-criteria decision network with special reference to the so-called "soft" factors.

The framework integrates market and business strategies, allowing a "hybrid innovation." Pure technology skills are accompanied by agile business models and attractive, emotional marketing activities.

The basis of the approach is the mathematical formulation of the underlying decision network. Particular challenges lie – in addition to the expected high number of information (requests, offers and services) – in the control of the network dynamics, i.e. the fast change of its structure.

The management of such dynamic, with probabilities weighted networks is very complex and places high demands on the supply of network data. In particular, it requires novel forms of visualization and user interaction.

The development of appropriate simulation, evaluation and optimization algorithms require further research. Research activities in this direction will be continued.

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Do I know where I am going and why?
Connecting Social Knowledge for Governance and Urban Action

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ABSTRACT

This paper seeks to expand our focus to understand how communities can assemble and manage knowledge to support more rational decisions regarding government services and actions in the community environment. We focus on the knowledge transfer interface between communities and urban councils, with a view to extending theoretical understanding of such transfers, and the socio-technical knowledge support systems interfacing between action groups and councils.

Utilizing theory from several previous domains we discuss how science does not exist in a vacuum. It is surrounded by philosophy, theology (although not always popular to recognise today) and art as a beginning. These diverse areas have undergone parallel developments and as they do so the tools and techniques to investigate and explore these areas have also progressed in parallel. Following the movement of the modern western world this paper utilizes a broad comparison using science, branches of mathematics, philosophy and art, with additional comparisons with theology.

Knowledge management - an often abused expression - is more than just data collection, in- formation presentation, or simple pathways beyond this. Rather it involves the efficient juxtaposition of background information and the value adding of presentation to enhance explicit understanding in a dynamic manner.

This paper goes one step further than normally considered, by investigating approaches to cognition in the data management areas and human cognition requirements and advantages. As society evolves, the requirements for successful presentation of data evolve, and yet the raw data amounts can also be effectively presented in new and more compressed manners. So the total information presented can actually increase exponentially and may become easier to understand.

Finally explicit modern examples are utilised to demonstrate the effect of the *altered approaches through the distinct time periods and a simple juxtaposition of the technological tools available in each period are utilised to enhance the data presentations. The end results are considered and the effect that the technology may have made to the recording and use of the data and it's transmission as data, information or knowledge evaluated, and a suggested model for overall efficiency of knowledge management presented in conclusion.*

1. Introduction

In a world facing global warming and growing scarcities of water, power, mineral and food resources, there is reason to be concerned with the design and practicality of socio-technical systems for multi-level governance. These systems form the interface between people's urban systems and their physical environment. These are complex systems that are co-manage with constrained activities typical of urban and regional administrative juggernauts. The work is informed by several years' experience researching theory, technology and practice of building and managing tacit and explicit knowledge in hierarchically complex organizational systems. This paper discusses the trialing of Google Apps as knowledge management tools for community action groups creating links within, between and beyond groups and their networks with a view to understanding practical connectivity, crucial for sustainable social networked structures.

2. Background

Humanity's growing population makes ever increasing demands on limited resources of our planet that we need for survival, more and more people are moving into urban environments where their impacts on the world environment are greatest. Folke (2006) emphasizes that human societies with their interconnected economies rely on what are called ecosystem services and support for survival. According to Folke "a major challenge is to develop governance systems that make it possible to relate to environmental assets in a fashion that secures their capacity to support societal development.... It will require adaptive forms of governance". Brondizio (et al. 2009) makes the case that such adaptive governance needs to be multilevel to build and maintain capital assets necessary to manage and sustain environmental affordances over time. Such capital assets are physical (i.e., built infrastructure), human (i.e., acquired knowledge and skills), and social ("value of institutions as a form of social capital formed through diverse processes involving the development of trust, norms of reciprocity, and networks of civic engagement, including the rules and laws within and between levels of organizations"). In the framework summarized by Brondizio et al's "social capital" is adaptive knowledge embodied in the connections and capabilities of multiple levels of organizational structure, i.e., what Nelson & Winter (1982) called "organizational tacit knowledge". Berkes (2009) makes many of the same points and stresses that multiple levels of social organization need a knowledge sharing framework that allows all levels to be rationally involved in "co-managing" the resources. The research discussed in this paper has been concerned with the analyzing and designing of knowledge sharing frameworks that would make co-management possible and effective.

3. The Framework - Theoretical and the Practical

3.1 Framework Background

The theoretical and practical framework has emerged from an "invisible college" (Kuhn 1970) interested in the Theory, Ontology and Management of Organizational Knowledge (TOMOK). TOMOK's theory combines evolutionary epistemology and autopoiesis to understand knowledge in hierarchically complex (i.e., multilevel) systems. The project and case study frameworks, have to date, combined three major threads of TOMOK's work approach:

- *Theory*: e.g., Hall (2005; 2006) Hall (et al., 2005; Hall et al. 2007) Nousala and Hall (2008) Hall and Nousala (2010; 2010a) Nousala (2010) Vines (et al 2010).
- *Case study and practice*: (Nousala 2006; Nousala (et al. 2005; 2005a), Hall (2006a), Hall and Nousala (2007), Nousala & Tersiovski (2007), Nousala and Hall (2008), Nousala (et al., 2009), Hall (et al. 2009), Hall and Nousala (2010), Nousala (2010), Nousala (et al. 2010), Vines (et al. 2007;2010)
- *Technology implementation and practice*: Hall (2001; 2001a; 2003a 2006b, 2010a,), Hall (et al. 2002), Hall (et al. 2002a), Hall and Brouwers (2004), Hall (et al. 2010), Hall and Best (2010).

The research and projects focused on what interfaces were required between urban and regional governing bodies and community groups (where local community knowledge may be transferred and used by decision makers to produce better results). The work also focused on emergence and the roles of communities in generating and sharing tacit knowledge, and making it explicit within larger organizational structures. Finally, the research focused on the pragmatic design and implementation of collaborative authoring systems in hierarchically complex organizational environments.

3.2 Theoretical Framework Discussion

The Nobel laureate Herbert Simon (1947; 1979) argued administrators can never make perfectly rational decisions. Rationality is bounded by cognitive limits on how much knowledge/information a mind can acquire, hold and process in the limited time available to make decisions. The best that can be done is to maximize the availability and quality of information to produce the knowledge needed and minimize overloading decisions with irrelevant information. However, it is the nature of administrative systems that decision makers are often hierarchically and geographically far removed from problem situations they manage. In other words, committees or individual administrators making decisions about local issues affecting people often have too little appropriate knowledge, and what they have is probably out of date and/or irrelevant. On the other hand, local inhabitants encounter problems directly and probably either have or can easily acquire the kind of detailed local knowledge for proposing solutions, which need to be incorporated to be effective. Unfortunately, existing bureaucratic systems provide few effective links between decision makers and sources of real-world knowledge they need to maximize the rationality and effectiveness of their decisions. Similar arguments can be made regarding the implementation of administrative decisions in the environment. With appropriate administrative support, local individuals could apply solutions, or at the very least be apart of the process.

3.3 The origin of things - digging deeper

In English the word "orient" originally meant, "to face east". The original meaning is recalled in now older use such as "Orientals" to mean Asians, or even the original full description of P&O, "Pacific and Orient" In fact some early maps started off with east being "up", rather than the "north" of current standard practice. Others, primarily from Moslem cultures saw south as up, and some had Jerusalem as the centre of the world, primarily for theological reasons.

But this is not the only change that has occurred with maps, the initial combining of disparate maps into Atlases, and their "more modern" offspring, street directories. In fact we are suggesting that the changes that have occurred in the map world are explicit demonstrations of information packaging in both past, present, and future, and they hold promise to demonstrate how to effectively present information to humans for easy absorption and use.

Homer is often presented as a blind minstrel. Yet centuries later his epic song is still "known," of sorts. While knowledge of the original (which was not actually ever directly recorded, even on paper,) is sketchy, Greek, Latin and English, amongst other versions exist. What Homer does is present, as entertainment, a (questionable) history and allows us to travel with the tale without moving.

Humans have a limited number of inputs, often called senses. The 5 classics are Sight, Feel, Taste, Smell, and Hear. Sometimes "developed" additions are included, such as intuition. Intuition is probably an evolutionary survival adaption allowing the formation of conclusions from an incomplete data set by triggering "memories" with a bypass of signals through the amygdala (Damasio, 1994)

3.4 Oral Travel and it successor, travel books

Most of us are familiar with instructions like "travel down beyond the house with the white picket fence and then turn down the 2nd street on the left." This is the basis of oral travel or instructions, and the precursor to visual maps and travel instructions like maps We mean precursor in two distinct ways, one is prior to actual maps as a scientific guide, and the other is prior to specific maps as the recordings of travelers have been used to develop specific guides and maps. Homer's stories allowed travel through the recipients imagination, as well as presenting details of a world picture and possible routes to specific places – real or imagined.

Benjamin of Todelo (Adler 1907, Benjamin of Tudela 1840) was a major 12th century traveler who was on the road from around 1159 to 1173 C.E. (Benjamin of Tudela 1840) and so approximately 100 years prior to Marco Polo. He was the first European traveler to write about China although there is some doubt if he actually traveled to China or just reported on the travels of others there.

Benjamin's work gives us clear demographic detail such as key personalities, community sizes, and skills and economic status of persons and communities he met, as well as secondary reporting of others information (in such a form as to distinguish between original and hearsay information!) (Benjamin of Tudela 1840)

Marco Polo spent approximately 24 years traveling to and in Asia and China, and following his return to Venice in 1295, he was captured by Genoan forces and imprisoned. At that time he dictated his story of travels to Rustichello da Pisa, an author of romantic fictions, and Fra Mauro picked up, these details amongst other sources in his significant map of the known world in 1540.

3.5 The significance of maps and communities

The history of cartography probably is well founded in pre-history as sand/dirt drawings and also cave drawings placing location of objects and places in perspective. (4,5) Harley and Woodward notes "Maps are not natural, self-evident 'statements of geographical fact produced by neutral technologies'. The hand of the mapmaker is guided by a mind located in a certain time and place and sharing inevitably the prejudices of his or her surroundings." (6) Edney goes further and suggests that maps not only “...just show the world. They show our conception of what the world ought to be."(5) Maps are depictions of the earth's surface scaled and un-scaled with or without a defined projection, limited in content to the extent of technology and the knowledge, wish and, or wants of the cartographer or person or the purpose for which the maps were produced.

Maps are used as tools to convey all sorts of information, the list is endless: political, historical, topographic, ethnic, religious, economic and military to name but a few. Today we often think of maps only as tools for navigating from one point on the world's surface to another. If we stop and look at all the maps that we are bombarded with every day we can see that maps are much more than navigational tools. Advertisers, governments, journalists, academics and everyday people, use them for a myriad of reasons. Maps have a great visual power capable of conveying information with incredible authority whether real or illusionary.

"The medieval world map (Mappae Mundi) conveyed little useful information for the traveler, it wished to convey the beauty and clarity of God's world, as described in the psalms "Nach Zahl, Gewicht und Maß hast Du alles geschaffen." For this reason Jerusalem is placed in the centre with the rest of the world divided in the continents Asia, Europe and Africa, showing the settling of the world through Noah's sons; Sem, Japhet and Cham. The map emphasises the reach of God's work by showing that the graves of the apostles can be found in the farthest corners of the World,” (Einführung 2002)

Of course maps up to and into the late 15th century were sometimes, like Homer’s records, a record of real and imagined countries and facts. But sometimes the discrepancy between accurate and imagined is not arranged chronologically. The Fra Mauro map was made around 1450 by the Venetian monk Fra Mauro and his assistant Andrea Bianco, a sailor-cartographer, under a commission by king Afonso V of Portugal. At least significant sections such as Africa and parts of Asia and Japan are recognizable to the modern eye.

Compare this with Vopel’s Terrestrial Globe with Armillary Sphere, of 1543, produced in Cologne Germany. It illustrates terrestrial and celestial globes and armillary spheres were important educational tools for illustrating the Ptolemaic, or earth-centered, cosmic system. The series of eleven interlocking and overlapping brass rings or armilla, some of which are movable, that make up the armillary sphere are adjustable for the seasons and illustrate the circles of the sun, moon, known planets, and important stars (http://www.1worldglobes.com/History/historyofmaps.htm) .

Ironically this was the same year that Copernicus's theory of a heliocentric universe was published, a theory that greatly changed the design of armillary spheres. (http://www.1worldglobes.com/History/historyofmaps.htm). Other forms of information such as perspective and colour were also developing, although with only a few exceptions, maps were not printed in color until the end of the nineteenth century. The “lines” are those that form the image and are normally black or black-brown. (http://www.phil.unipassau.de/histhw/tutcarto/english/index-hiwi-karto-en.html Last accessed: 10 June 2011).

And perspective and projections were developments from a renaissance world coupled with developments in both geometry and philosophy.

A popular start date for the renaissance involves the competition in 1401 between Lorenzo Ghiberti and Filippo Brunelleschi for the contract to make the Florence

Baptistery doors won by Ghiberti. Of note in this art piece is the development of perspective and elements of implied distance, prerequisites for maps that are trying to impart data about distance and relationships on a single page.

3.6 Discussion on practical frameworks

Past studies of various knowledge-based groups have been known as “communities of interest” or “communities of practice” and are found within larger organizations. In the urban or governmental domains such emergent communities are often known as “action groups”. People in action groups have or can easily acquire significant amounts of personal knowledge and documentation relating to their areas of concern (Smith 2010; Smith and Nair 2010; Hocking and Wyatt 2010; Kuruppu 2010). Organizational knowledge managers need to work towards implementing social and technological systems that help collect, transform and make such knowledge available in usable forms for decision makers. The literature survey suggests that most research into relationships between government and community groups have had a top-down focus, i.e., where governments seek to push information (e.g., on health issues) into the community.

Another example of the nature of usability of pooled personal knowledge comes in the form of communities or action groups. In the field of cultural heritage, actions in the 80s and 90s utilized digitalization of artifacts as a method for preservation and transferring cultural information to the public and a multitude of interested groups. A decade later, and with the benefit of hindsight, more is understood, and its local knowledge and interaction that enhances these cultural collections that act as a focus for virtual communities of practice.

4. Field Work

The field work involved working with community action groups to identify the kinds of knowledge they were actually holding (Nousala and Jamsai Whyte 2010 Smith 2010, Smith and Nair 2010, Vines et al. 2010) and tested for utility of social technologies such as Google’s cloud applications for community knowledge building and sharing (Hall 2010, Hall and Best 2010, Hall et al. 2010). This work followed experiences from 2007-2008 in building a knowledge base to support reference literature and working drafts for the TOMOK group, using a collaboration platform known as BSCW (OrbiTeam’s Basic System for Collaborative Working). The BSCW platform was abandoned due to hosting and server issues. In January 2010, following the announcement that Google Docs could manage all kinds of document file formats, TOMOK was subsequently successfully transferred. TOMOK’s extensive knowledge base as a wiki using Google Apps, proved so successful that a subsequent trial (also successful) used the tools as a support system for a knowledge intensive community action group (Hall et al., 2010). The demonstration template (Hall and Best 2010) offered a range of capabilities to support community action: e.g., data collection with the capacity for imaging and geo-tagging, data aggregation, building knowledge bases from specific literature, collaborative authoring with document tracking capabilities, presentation development, social networking, membership management, financial tracking and the like.

5. What has been learned so far…

Urban councils and their delegates are responsible for providing services necessary for civil life, maintaining peoples’ health and amenities. To do this functionaries need to know who, what, where, when, why and how-to relate to problem areas. Hall, Nousala and Best (2010) discuss epicyclic knowledge acquisition through building and acting in urban environments. Figure 1 shows the epicyclic knowledge concept built on from ideas from Hall (2003; 2005), Nousala (2006), Vines (et al 2007;2010) and Hall and Nousala (2010a). Figure 1 illustrates the theoretical application of the epicyclic knowledge framework to illustrate the acquisition, of building and acting in the urban environment. The knowledge related concepts in this paper have been informed by knowledge-based autopoietic systems at least three nested levels, highlighted by the discussion in the accompanying text of figure 1:

- *Individual people ("**I**").* When concerned about a problem individuals are motivated to collect explicit knowledge eg; documents, images, maps, records, etc building personal knowledge in the process. . This knowledge building may involve cycles of **O**bserving, **O**rienting, constructing **T**entative **T**heories, and acting to **E**liminate **E**rrors (Hall et al. 2010).

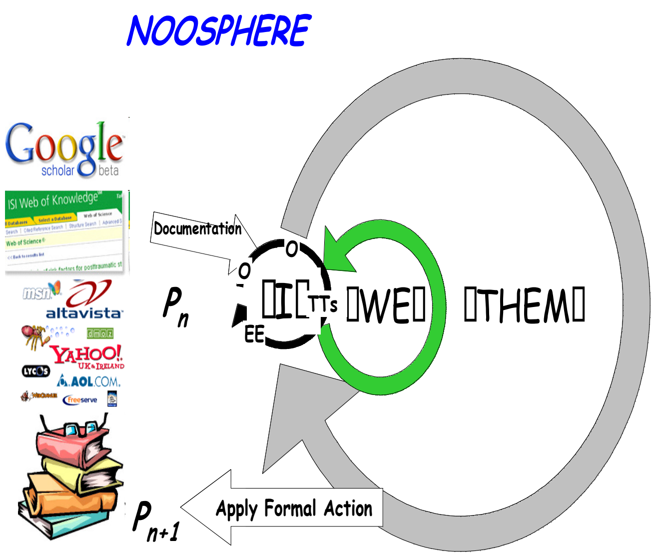

Figure 1. Knowledge cycles in urban governance (derived from Vines et al. 2010). Noosphere is the sum of human knowledge. Individuals, groups and councils all draw from and add to this store of knowledge as consequences of their activities.

- *Community action groups ("**WE**").* Where individuals in the community face similar problems, they may share concerns and knowledge to stimulate the emergence of a community group (Nousala and Hall 2008) to resolve the problem. Group knowledge building may involve sharing personal knowledge and building a group repository of documentation and observations. The success and sustainability of the group will depend to a considerable degree on the success of the personal interactions in assembling useful knowledge and action plans (Hall et al 2010).
- *Councils ("**THEM**").* Councils are complex bureaucracies, organized into departments responsible for problem areas. Decisions to formalize actions tend to be centralized, where the bounds to rational decision making are likely to be the greatest (Hall et al. 2009). Committees or officers making decisions often have little or no personal knowledge of specific problems. Groups close to the problems can play important roles by collecting, organizing and presenting their collective knowledge in formats easily used by functionaries (Hall et al. 2010).

Noosphere described by Krippendorff (1986) as the space occupied by the totality of information and human knowledge collectively available to man. As discussed by Hall (et al 2010) the concept of Noosphere initially emerged from discussions between Valadimir Vernadsky (who also coined the term "biosphere"), Teilhard de Chardin, and Edouard Le Roy. Hall (et al 2010) goes on to discuss how Turner (2005) reviewed to enhance the concept in such a way so as to make it possible to employ it in figure 1, meaning "..the noosphere is the net product of the global diversity of knowledge ecologies…" (Hall et al 2010).

6. The impact of interaction between human cognition and the physical world

6.1 Atlases and Street Directories

In 1570 the Antwerp cartographer Abraham Ortelius published the Theatrum Orbis Terrarum, often considered the first modern atlas.

The key elements of this first atlas were the publication of diverse location maps in one publication.

The addition of multiple maps allows comparisons and the building up of detail in layers. It is also important to recognize that Ortelius also included a vast southern continent, 'Terra Australis Incognita,' supposedly to counterbalance the known northern hemisphere world. (Notes from the State Library of Victoria, Australia associated with the Theatrum Orbis Terrarum by Abraham Ortel published in 1574 Street Directories were not far away. The earliest reference we have found was to a 1650 publication for the City of Albany, New York, USA, utilizing the research of Prof. Jonathan Pearson, of Union College and including the dates of patents and transfers of city lots (http://books.google.com/books?id=ydgRAAAAIAAJ&pg=PR3&sig=b81fhST4ILavF0VDu5YNoR2MKbQ&hl=en Last accessed: 13 June 2011).

In the same year, Henry Robinson produced a directory in London, in this case, a list of names kept in an "office of addresses" available for viewing, presumably on paid subscription. Whilst not a map, it provided detailed background data that in time would become part of the overall street directory (http://en.wikipedia.org/wiki/Henry_Robinson_(writer) Last accessed: 14 June 2011).

Over time, although exactly which year and where is questionable, the data was provided graphically – nominally in line drawings using black ink.

6.2. Layers

In this paper we have made reference to layers several times. Layers are both actual and also conceptual.

Layers allow explicit details to be published having a combined impression and context. We can see geographical information such as streets together with land use information, specialist services, traffic flow and/or direction (such as one way streets or time limited parking zones) and even economic spheres of influence such as "natural shopping zones" for demographic differentiation.

Originally layers were produced using a transparent or semi transparent material such as acetate sheets or tracing paper over a fully opaque back sheet.

Today layers are usually electronic in form, and are seen easily in places such as GPS software or versions such as Google Maps where feature sets can be turned on or off.

It should be noted that layer information can be detailed but often requires context to be easily or fully understandable.

6.3 The Psychology of cognition

In this paper the term cognition is not used just to mean thinking but rather the process that includes an ontological examination of terms and processes.

Because cognitive science often tries to understand minds in the same way a computer processes inputs through processing and then to specific outputs we utilize a simplistic but usable model.

The authors also have come into knowledge management from a Engineering and Human Engineering / Ergonomics background and so the when understanding human cognition try and utilize a holistic view drawing on the work of application oriented modeling both within the individual and also within the layered environment between work space and outside world (Leamon 1980, Wilson and Corlett 1991).

So cognition requires sensors to "read" displays – be they visual, tactile or audible, a processor stage, and an effector stage with potential feedback loops to fine-tune processing and ability to effect specific control.

6.4 Memory

In humans, different types of memory have different roles. Short-term memory is involved with processing and comparison.

Miller's (Miler 1956) approaches to 7 +/-2 numbers is an example of short term memory. Long-term memory is sometimes structured into declarative and implicit classes. Declarative memory is that which is recognized and consciously remembered. Implicit memory is used for priming and is also sometimes called procedural memory as actions and activities cause it recall.

Norman (1988) specifically considers human mapping and activities and concludes that where the design of control systems correlate with the human's mental model our ease and accuracy of using equipment is enhanced and made more effective.

6.5 Concrete – abstract continuum

The more concrete a symbol or instruction is the easier to understand and act on. The more abstract the greater the local processing that must be done by the individual. Symbols may be concrete or abstract. Language too is worthy of consideration here as if the language and connotations of language are understood, then we may fast track to understanding context and means of tacking in information, and also of acting upon such information.

6.6 Knowledge Skills Rules

Rasmussen (1983, Rasmussen & Vicente 1989) introduces the ideas of Knowledge, Skills and Rules, and that repetition of acts, activities, or even thinking may make a process evolve from requiring active thought to becoming an automatic activity. This may be demonstrated by rote learning of a route to travel or by rote learning of multiplication tables till they become automatic responses.

The familiarity and use of standard technologies, be they maps or computer programs leads to a repetitive speed and enhanced ability to take in information. It must be highlighted that this is not the same as understanding – the repetition increases speed to do not to understand what is going on as sometimes the data intake is more superficial.

6.7 "Knowledge tools"

Tools are hereby considered as items that enhance our ability to intake information, ensure it is in context, and then potentially ease our ability to act upon such information. They may also minimize repetition without adding significant knowledge or context, and so automate or partially automate our responses to the information.

The use of modern computer programs to place information in a graphical form, and in context of geographical or major numerical factors, such as traffic patterns and activity, alternative route recommendations, and facilities within reach, as well as means of minimizing the need for instruction books (Norman 1988) and allow "the information in the world" to be understood in correct context, is to be desired.

The use of colour and audible tones in a manner consistent with human facilities (be they physical or cultural,) and the use of controls that match human attributes (eg. size of fingers, response times,) increase the usability of knowledge tools, ensuring interaction with the tool is likely to enhance the total experience.

7. Conclusion

Surveying of the literature shows that social technology has most frequently been used to push information from higher-level governance into the community. Very few works were found that demonstrated the social technologies gathering and communication information to higher levels of governance. This included the lack of involvement of community groups in areas of governance that affect them directly. Based on experience to date, the freely available Google Apps have offered a platform for directly interfacing community action into the processes of urban governance.

Well designed knowledge tools should enhance the total knowledge experience. They need to build upon human attributes, be they physical, cultural or psychological, and they need to ensure knowledge presented is in a context to enhance absorption and to enhance the utilisation of this knowledge.

Whilst these ideas seem simple the lack of application is regularly experienced and the use of older tools can be reviewed in light of modern understandings of human interaction in a broader world.

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Tacit Knowledge Generation and Inter-Organizational Memory Development in a Supply Chain Context

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ABSTRACT

In recent years, particular attention has been paid to knowledge management and organizational learning in general and tacit knowledge management and organizational memory in particular. This interest is driven by saturation of various markets, innovation speed and increasingly uncertain environments that have led companies to organize and structure themselves as parts of supply chains, by focusing on their core competencies and outsourcing non value-added and less strategic activities. Developing distinctive competencies under such circumstances comes from tacit knowledge learning, creation and memorization. In this paper, we first analyze tacit knowledge from different perspectives; we show how individuals and organizations can learn from tacit knowledge and how they also create new relational and collaborative tacit knowledge from individual, organizational and inter-organizational learning. We then explore how this knowledge can be capitalized into inter-organizational memory which is independent of individuals and organizations within the supply chain.

Keywords: Tacit knowledge, supply chain management, inter-organizational memory, learning.

1. INTRODUCTION

Most organizations evolve today in a complex environment in which competition is becoming increasingly intense, pushing companies to develop distinctive competencies by mastering knowledge and technology, and outsourcing non value-added and non strategic activities. Hence, they form reticular organizational configurations characterized mainly by supply chains. The critical and distinctive knowledge developed by a company does not particularly rely on structured information, or on explicit business rules. In fact, over time it becomes increasingly tacit. Keeping and developing this knowledge is not an easy task, however, owing to loss of skills and capabilities due to impending retirement or accelerated specialist and expert turnover.

Neglected for years by academics and professionals, tacit knowledge development and use is emerging as a source of value for most businesses. Many authors have raised this issue in terms of organizational knowledge transfer, proposing complex information management systems relying on information technology and communications. However, given the proliferation of knowledge in today's environment, it is not a question of managing all knowledge, but rather, of knowing how to locate and identify key knowledge related to strategic objectives of an organization. This work focuses on this key knowledge, and especially on how to enable its development and exchange through more open and collective working practices, as well as teaching methods and scalable and responsive training.

Analysis of organizations from a systemic point of view requires adopting complex thinking, allowing us to address the supply chain as a whole, whereby individual learning leads to organizational, and then to inter-organizational learning. Inter-organizational learning results in supply chain knowledge, which is different from organizational or individual knowledge. Therefore, in this paper, the fundamental question being addressed concerns acquisition by learning, the creation and development, and capture of inter-organizational tacit knowledge so that it can be disseminated throughout companies and to individuals.

To address this issue, our paper is divided into four sections. In the first section we present a critical overview and classification of the tacit knowledge concept. In the second section, we highlight the relationship between supply chain management, inter-organizational collaboration and learning organizations to better understand the role of collaboration in this approach. Then, in the third section we show how a company generates tacit knowledge from individual and inter-organizational learning. The last section focuses on inter-organizational memory formation via organizational tacit knowledge, to show that an organization is made up of embedded organizational knowledge which belongs not to individuals or the organizations, but to the supply chain.

2. TAWARD TACIT KNOWLEDGE DEFINITION AND CLASSIFICATIONS: A CRITICAL APPROACH

Polanyi [41] says that we can know more than we can tell. His works have significantly influenced a set of contemporary works on the nature of organizational knowledge. The idea of tacit knowledge is very important for those trying to understand sources of competitive advantage. This advantage comes partially from knowledge that cannot be expressed and also from the organization's experiences that provide specific skills and capabilities that cannot be imitated by competitors [9].

While tacit knowledge can generate a unique competitive advantage for the company, it cannot easily be capitalized upon and disseminated in different parts of the same organization [50].

The notion of tacit knowledge was introduced by Polanyi [41], a philosopher who has become well known because he was cited in the writings of Kuhn [28] and since then has had a renaissance with the writings of Nonaka and Takeuchi [36]. As noted by Polanyi [41], "we can know more than they say" means that ineffable knowledge exists in individuals and organizations but they cannot easily identify it. Nonaka and Takeuchi [36] used the notion somewhat differently from how Polanyi himself used it. Because of the influence of Nonaka and Takeuchi's [36] works in the knowledge management field, however, the idea of something being "relatively ambiguous" has been widely adopted. While Polanyi [41] speaks about tacit knowledge as a backdrop from which all actions are understood Nonaka and Takeuchi [36] use the term to denote particular knowledge that is difficult to express.

Thus, in contemporary literature, the meaning of tacit knowledge has little in common with Polanyi's [40] conception. More oriented towards the vision proposed by Nonaka and Takeuchi [36], tacit knowledge is defined as knowledge that is not yet articulated. That is to say, it represents a set of rules embodied in the activity in which the individual is involved, that can later, (and it's just a matter of time) be transmitted in a certain learning process. Today, Nonaka and Krogh [37] stipulate that ""tacit knowledge" is a cornerstone in organizational knowledge creation theory and covers knowledge that is unarticulated and tied to the senses, movement skills, physical experiences, intuition, or implicit rules of thumb".

In his critique of rationalism, Oakeshott [38], in the same vein as Polanyi [40], distinguishes between two types of knowledge, namely technical knowledge and practical knowledge. Technical knowledge is the knowledge of rules, while practical knowledge represents skills and capabilities. For this author, it is clear that skills and the know-how, or in other words, competency cannot be transmitted from one person to another, nor acquired easily by simply following rules. The knowledge can be acquired only through "learning by doing" under the watchful eye of the master (teacher). The value of this analysis lies in its usefulness when applied toward understanding scientific knowledge (which is often confused with explicit knowledge).

Scientific knowledge is neither mechanistic nor explicit. It is developed by people who are deeply involved and have learned their profession over many years by teaching others. Scientific knowledge is often seen as purely representative of technical knowledge or a set of facts. However, the work behind this knowledge and these facts, intuitions, beliefs, and multitude of hours of interaction with other scientists is the real driving force behind progress in science. Thus, the metaphor of a "pipe line" that underpins many discussions on communication (argues Tsoukas [57]) emphasizes that Nonaka and Takeuchi [36] consider ideas as objects that can be transmitted between individuals via their behaviors, thus reducing practical knowledge to technical knowledge [15]. Process practical knowledge, which is tacit in nature, and therefore initially cognitive, has content that can be easily set and then translated into explicit knowledge [36]. It is the reduction of "what is known" into "what can be articulated", hence the concept of tacit or "practical" knowledge is impoverished [55].

Weick [60] explains practical knowledge by highlighting the fact that it redefines the specific differences in all activities to attract the attention of those who are involved, to distinguish certain hitherto unnoticed aspects, and also to see the connections between various items previously imagined as disconnected. This systems approach to practical (tacit) knowledge formation is supported by Katz and Shotter [24]. Guzman [22] also reported from Thompson and Walsham [53] that practical knowledge is located, given that it focuses on current actions developing in a precise framework that can be temporal, emergent and social. In that, tacit knowledge is acquired by engaging in practical activity through participation in social practices, under the supervision of people who are generally more experienced [52], who, by paying attention to certain actions or operations, can see the interconnections [61].

Table1. Tacit knowledge definitions

Authors	Definitions
Polanyi [41]	***Ineffable*** knowledge that exists in individuals and organizations but which cannot easily be identified
Nonaka and Takeuchi [36]	Knowledge ***not yet articulated*** or knowledge ***waiting to be translated*** or converted into explicit knowledge.
Weick [60]	Knowledge that redefines the ***specific differences***… in order to distinguish certain aspects hitherto unnoticed, and also to see the ***connections*** between the various items imagined disconnected before.
Tsoukas [56]	A ***set of particulars*** of which we are subsidiarily aware as we focus on something else.
Nonaka and Krogh [37]	Knowledge that is ***unarticulated*** and tied to the senses, movement skills, physical experiences, intuition, or implicit rules of thumb.

To recapitulate, we can say that tacit knowledge has a multitude of definitions and interpretations. Nonaka and Takeuchi [36] consider tacit knowledge as knowledge not yet articulated or knowledge waiting to be translated or converted into explicit knowledge. This interpretation has been widely adopted in management, yet is flawed in that it ignores the ineffable nature of tacit knowledge [55]. But if we refer to Nonaka and Krogh's [37] definition, we find that instead of being *knowledge that is not yet articulated*, tacit knowledge becomes *knowledge that is unarticulated*. Its ineffable nature does not mean that we cannot discuss the possibilities of learning. However, insistence on the fact that tacit knowledge must be converted into explicit knowledge should be limited, and instead attention should focus on the creation of tacit knowledge, taking into consideration that it cannot be captured, translated or converted, but only displayed and manifested in activities [54]. So for a learning organization, the goal is not to transform knowledge from tacit to explicit, but rather to promote the emergence of new knowledge from the interaction between the tacit and explicit knowledge of all those individuals involved in the performance of its activities. The ultimate objective of the organization that is learning for the creation of a specific "intangible capital" is to generate by this act, a sustainable, competitive advantage.

Collins [13], based on Polanyi's [41] approach, came up with new classifications of tacit knowledge, namely "Relational tacit knowledge", "Somatic tacit knowledge" and "Collective tacit knowledge". For Collins [13], relational tacit knowledge is knowledge that can easily be turned into explicit knowledge by social interaction with the knower. This is the type of knowledge which was studied by Nonaka and Takeuchi [36]. Somatic tacit knowledge is knowledge that is emblazoned in the substance of body and brain. Collective or strong tacit knowledge, as discussed by Collins [13], is knowledge that can be attained by individuals only if they are embedded in a group or society. For this type of knowledge, Collins [11] stipulates that the unique capacities of body and brain allow one to acquire this knowledge from the collectivity, or what he called in his previous work [12] the "social collectivity".

In our paper, we principally make reference to relational tacit knowledge generated by dyadic interactions between individuals, groups or organizations within the supply chain. We also refer to the third type of tacit knowledge, collective knowledge, that is generated by supply chain system dynamics and that is acquired by individuals, groups and organizations only if they are embedded in the supply chain.

3. SUPPLY CHAIN MANAGEMENT, INTER-ORGANISATIONAL COLLABORATION AND LEARNING ORGANIZATIONS

Supply chains can be presented as inevitable phenomena that arise from a need for coordination between companies whether they are managed or not [33]. They can be defined as a process oriented set of autonomous companies (from the first supplier to the end customer), linked by upstream and downstream flows (physical, informational, financial and knowledge), established to satisfy the customers through better coordination and integration, but also possessing great flexibility and responsiveness.

Managing a supply chain requires coordination and synchronization of material and financial end information flows by developing cooperation and collaboration from the first supplier to the end customer. As reported by Lambert [29, p.2], the *Supply Chain Forum* defines supply chain management as "the integration of key business processes from end-user through original suppliers that provide products, services, and information that add value for customers and other stakeholders".

For Mentzer et al. [33, p.18], "Supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole". Cooper et al. [14] define it as an integrative philosophy to manage the total flow of a distribution channel from supplier to end user. The main purpose of SCM is to make the most of the value created, for both the company and the total supply chain. Also worthy of mention are the bipolar strategies of supply chain partners that can simultaneously include cooperation and competition [62]. In this work, however, the game aspect is not included to permit focusing on collaborative aspect of relationships.

Inter-organizational collaboration is a key element of SCM. In fact, Horvath [30] insists on the fact that collaboration represents the driving force of SCM. SCM promotes inter-organizational collaboration because it facilitates process integration, information and knowledge transfer and exchange, organizational coordination and strategic cooperation. When analyzing collaboration between supply chain partners, whether cross-functional or inter-organizational, it is striking the extent to which SCM effectiveness depends on individuals. When interacting with one another, individuals develop knowledge networks that allow producing, sharing, disseminating and applying strategic knowledge to improve operational and strategic performance [59].

Inter-organizational knowledge transfer and learning are more efficient when enacted between learning organizations. Skule [44] states that lack of knowledge transfer can be associated with a lack of development in the various models that govern all practices. As learning organizations encourage knowledge transfer, they necessarily help achieve the processes and structures for double-loop learning. As a result, organizational routines will suggest what the organization needs, and will automatically determine the solutions to problems [43].

The concept of a learning organization recently appeared in the literature. Although Garvin [19] stipulates that a clear definition of this concept has not yet been established, there are several propositions. Senge [42, p.1], one of the first to study this concept, defined a learning organization as an "organization where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together". For Pedler et al. [39, p.3], "The Learning Company is a vision of what might be possible. It is not brought about simply by training individuals; it can only happen as a result of learning at the whole organization level. A Learning Company is an organization that facilitates the learning of all its members and continuously transforms itself."

Kim [25] observed in her studies that organizations learn only if they consciously choose to do so. She concluded that, in strategic terms, the most important thing for a company is not the speed of learning, the things learned or the people who learn, but how the information is used, processed and transferred as knowledge within the company. Furthermore, the fact that some companies continue to advance even in times of economic uncertainty, while others decline, is proof that businesses depend on their ability to learn and adapt [45].

Senge [42] believes that in rapidly changing situations, only organizations that are flexible, adaptive and productive will succeed. To this end, these organizations need to discover how to harness the commitment and learning capabilities of all their employees. For Senge [42], even if all individuals have an ability to learn, the structures in which they operate may not provide adequate incentive for thought and commitment, especially if tools and ideas to enable them to make sense of the situations they face are lacking. Organizations that consistently invest in creating their future require a fundamental change in the attitudes of their members. He adds that real learning delves into what it means to be human and it is from this place that individuals and organizations somehow become able to recreate and rebuild themselves. Thus, for a learning organization, learning is not just about survival. “Learning to survive” or what is commonly called “adaptive learning” is certainly important, but needs to be supported by “generative learning”, learning that enhances the ability of individuals to create new things.

In his work on the fifth discipline, Senge [42] states that Systems Thinking is presented as the cornerstone of all the other disciplines because it integrates them into a coherent set of theories and practices. Systems thinking helps one understand an organization as a whole and the interrelations between all its parts. It allows individuals to see beyond the immediate context and incorporate the impact of their actions on others, and the effect others have on them. Additionally, since the construction component of systems thinking is relatively simple, it allows people to develop models that are comparatively complex and sophisticated, which runs contrary to what organizations typically do today. Senge [42] states that for complex systems, use of simplistic models may blur analysis of the real situation. Finally, systems thinking can make sense of action and reaction mechanisms within an organization, and thus enhance learning how to identify tacit knowledge and allowing its transfer and capitalization.

In the same vein as Spender and Grinyer [46], we can say that the firm is conceptualized as a whole, as a community of practice with institutional dimensions that gives meaning to these practices, rather than as a system of market resources under explicit control of managers. The resulting model is an organization designed as a dynamic system, autonomous from its elements and which is partially responsive to managerial influences.

This systemic vision leads us to an interesting observation. Since:

- The environment in which organizations evolve is complex, and thus requires a complex vision,
- All parts within a system are necessarily interdependent,
- The interactions between these parts are as important as the parts themselves,
- The organization is more than the sum of its parts,
- There is a very close relationship between what emerges and those who make it emerge,
- Tacit knowledge is the strategic knowledge in an organization,
- Tacit knowledge results from an individual’s emerging internal mental schema.

Consequently, we can say that an organization can have tacit knowledge that emerges from the interaction between the tacit and explicit knowledge of individuals. These outcomes are not necessarily formalized or known in an overt way. Consequently, we cannot talk about a concept of capitalization because, in our opinion, to capitalize on knowledge it needs to be articulated and simplified. Based on the above, the goal of a learning organization is not that of knowledge articulation nor of simplification, it is, rather, of processing knowledge in its complexity. As a result, the best suited concept is that of memorization, which unlike capitalization is dynamic, in the sense that it allows intelligence and complexity. It also allows introducing the concept of intelligence, toward the end of creating tacit organizational knowledge by using organizational memory. Before exploring how organizational memory is constituted, however, let us try to understand how tacit knowledge is generated through individual, organizational and inter-organizational learning.

4. TACIT KNOWLEDGE GENERATION: FROM INDIVIDUAL TO INTER-ORGANIZATIONAL LEARNING

Organizations can only learn via the individuals who constitute them. However, not all organizations promote individual learning and occasionally, seeking to understand has been considered an act of disobedience. Additionally, few organizations really try to capitalize upon knowledge developed by their members. It must also be noted that not all forms of learning are necessarily geared towards formulation, oral verbalization or codification. Overall, researchers have tended to focus on learning that manifests in simple forms with clear and apparent processes.

Historically, companies have felt relatively little pressure to learn. Over time, however, knowledge capitalization has become a more or less pressing preoccupation, depending upon the company’s context. Today, it appears that new approaches to learning are different from traditional professional approaches (how do we learn?) or theoretical/academic approaches (why do we learn?). These two approaches respond to particular goals and are the outgrowth of limited worldviews that are gradually changing. Current market realities require companies quickly mobilize distinctive or specific knowledge in environments that are increasingly volatile.

Additionally, tacit knowledge is mainly personal, stemming from each individual’s experience. The fact that knowledge is inseparable from its owner also implies that an employee’s departure causes loss of this individual tacit knowledge. A consequence of high turnover within the company is knowledge loss. Conversely, hiring workers with previous experience in the industry, from a competitor, a supplier or customer, contributes to knowledge within an organization [18].

Organizational learning can be defined as an organization’s ability to organize and enhance the effectiveness of its collective action over time. Nevis et al. [35] defines it as the capacity or processes within the organization that can improve performance based on experience. It should be emphasized again that there is no organizational learning without individual learning, yet the organizational learning process is much more complex because it must be understood from a systems approach. In this sense, individuals' mental models play a central role because, according to Argyris and Schön [6], organizational learning is based on "shared mental models".

The work of Argyris and Schön [6] on organizational learning that distinguishes between single loop and double loop learning has gained general acceptance. Single loop learning is a process of behavioral adaptation/response or correction of errors in established organizational patterns that are not challenged. Double-loop learning is a cognitive process of challenging mental models which leads to adoption and production of new patterns of knowledge, thoughts and actions.

For Argyris [3], tacit knowledge is the basis for efficient and effective management, but can also be the cause of its undoing. The main objective of effective management is the definition and transformation of required behavior into action-based routines to achieve organizational objectives [3, 5, 34]. These routines are implemented through skillful actions that are necessarily based on tacit knowledge. To better understand this, Argyris and Schön [5] focus on action strategies, which leads them to develop two action theories: Espoused theory (what we say) and Theory-in-use (what we do). Although they detect many different behaviors, the authors have noticed that there are really only two theories-in-use, Model I and Model II.

For nearly two decades Argyris and Schön have pursued analysis of conscious and unconscious individual reasoning processes within organizations [17]. They assume that people are designers of their actions, who perform actions to achieve their goals and learn when they perform actions that seem effective. In other words, Argyris and Schön [6] argue that all individuals have within themselves cognitive maps with which they plan, implement and correct their actions.

These authors also assert that few individuals are aware that the cognitive maps on which they rely intellectually are not the same as those they use when they take action [7]. Argyris and Schön [5] suggest that there is a theory that corresponds to what people say and another one that corresponds with what they do. Thus, the distinction is not made between theory and action, but between two different "theories of action" [8], hence the concept of "espoused theory" and of "theory-in-use".

Espoused theory represents values and commonly held views upon which people believe their behaviors are based. Theory-in-use, on the other hand, is theory in which individual behaviors, or maps they use, involve their views and values. In other words, we can say that people are unaware that theories-in-use are not the same thing as espoused theories, and they are even unaware of their use of theories, implying that much of their knowledge is tacit.

Argyris and Schön [5] argue that these theories of action determine the totality of purposeful behavior of individuals. Argyris [2] suggests that one of the reasons that led him to insist that the actions of individuals are the result of a theory, is the claim that what is done by these individuals is not fortuitous. People design their actions and are therefore responsible for this design. Argyris [2] also states that in designing their actions, people are generally unaware of this design and its divergence with what they say. This raises a question: if individuals are unaware of the theories that guide their actions (theories-in-use), how can they effectively manage their behavior? Argyris [7] suggests that effectiveness results from an individual developing congruence or fit between their espoused theory and their theory-in-use.

Models developed by Argyris and Schön [5] are designed to help people become aware of the tacit aspect of their knowledge and then to chose actions they design and implement. In this context, they develop models (namely single and double loop learning models) that attempt to explain processes that create and maintain the theory-in-use of individuals. Thus, interaction between these theories-in-use stimulates organizational learning.

Organizational learning thus represents an emerging interaction between all cognitive maps of all individuals. According to a systems approach, the organization is not the sum of its parts, but represents a whole with a specific behavior. It is a system of norms and meanings shared by actors, or cognitive maps, called by Argyris [2], theories-in-use [51].

Beesley [31] believes that individual learning, group learning, organizational learning and inter-organizational learning are closely interrelated and interdependent (see Figure1). He stipulates that the individual learning level is embedded in the group level, which is embedded in the organizational level which is ultimately embedded in the inter-organizational level. He adds that this dynamic is not linear but symbiotic in nature. Therefore, it is interesting to see how this knowledge is memorized through the accumulation of tacit organizational knowledge.

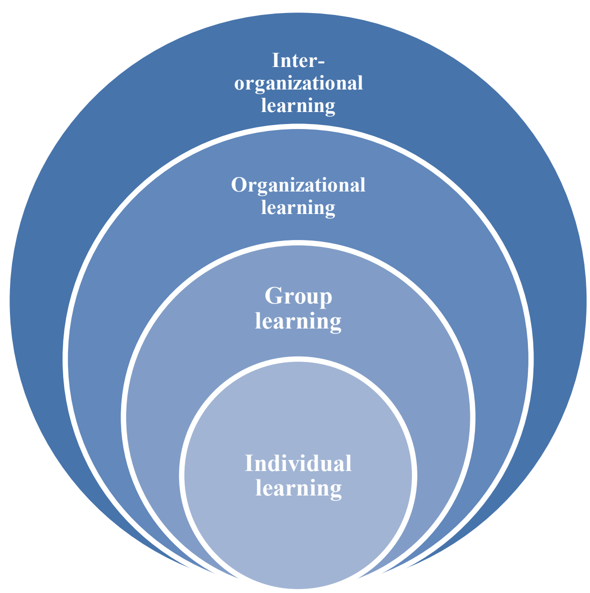

Figure1. The interrelated levels of learning [31]

5. INTER-ORGANIZATIONAL MEMORY FORMATION VIA TACIT ORGANIZATIONAL KNOWLEDGE

Organizational knowledge is a concept that has become widely used in the literature because it is a significant and very expressive instrument for explaining the nature of organizations and their behavior [27]. The company can be described as a “knowledge warehouse” that is embedded in assets, rules, routines, standard operating procedures and dominant logics [32]. In addition, several studies claim that to have a sustainable competitive advantage, a company must have fundamentally organizational knowledge, and at the same time, be able to create new knowledge suited to its context [26].

Grant [21] goes further by saying that the primary role of companies, and the essence of their capabilities, is the integration of knowledge. He adds that companies exist because they can integrate and coordinate specific knowledge held by individuals in a more efficient manner than do markets, and because they can transform individual knowledge into collective knowledge, otherwise known as organizational knowledge. This knowledge is difficult to reproduce and enables companies to be autonomous from their competitors and partners, and to maintain a sustainable competitive advantage, provided of course, that they are able to produce more knowledge, and depending upon the speed of change in their particular competitive environment.

It is recognized in the literature that organizational knowledge is embedded in a kind of organizational memory that does not disappear with the loss of an individual [32]. Organizational knowledge does not belong to individuals, but is rather a separate property from the organization, a social actor [20]. Thus, organizational memory is presented as a fundamental organizational system that requires storage; or rather a memorization of knowledge produced by the organizational learning process. In simpler terms, learning can be seen as the development of organizational memory [16]. For Stein [48], all current conceptualizations of organizational memory are mainly based on the work of Walsh and Ungson [58] and define organizational memory as the set of information stored from the history of the organization so that it can be used in ongoing decisions. Organizational memory consists of decision stimulus series kept in a kind of “memory box” and has behavioral consequences when used [58].

In general, studies on organizational memory have tended to theorize on a large scale, yet they are not based on empirical works, making it difficult to identify measuring variables [1]. Huber [23] states that the support of a corporate memory analysis is certainly useful, but all works do not clearly distinguish what constitutes corporate memory. Stein and Zwass [48] recognize the need for empirical studies in this field.

For Ackerman and Halverson [1], most studies on organizational memory have largely focused on a set of technological systems designed to replace physical and human factors. These studies were very limited due to overly reductionist definitions of memory and organizational tasks, mirroring the current trend toward standardization. It would be interesting to examine the human side of this issue by studying how to transform standardized knowledge into personal knowledge and then into idiosyncratic (specific) memory.

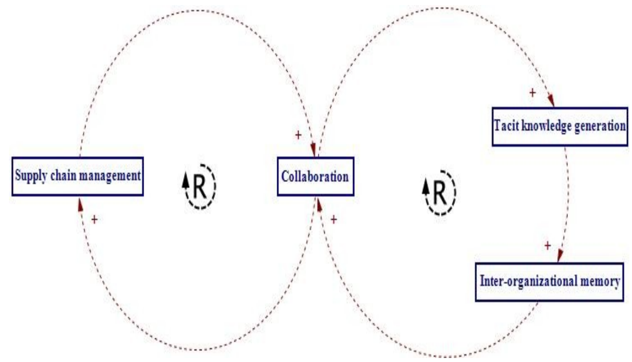

Figure2. A CLD representation of the dynamics of tacit knowledge generation and inter-organizational memory constitution in a supply chain context

We can consolidate our analysis by a CLD (Closed Loop Diagram) representation (Figure2) to show the mutually reinforcing systemic dynamics between tacit knowledge generation, inter-organizational memory development, collaboration and supply chain management. From this perspective, supply chain management adoption reinforces inter-organizational collaboration that tends to reinforce and stimulate tacit knowledge generation. This develops inter-organizational memory, also translating into organizational and individual memory. This inter-organizational memory reinforces collaboration between organizations that further reinforces the supply chain management approach.

6. CONCLUSION

In conclusion, we can say that there is growing interest in the concepts discussed in this paper, namely tacit knowledge, learning organizations and inter-organizational memory. To better apprehend this, we presented a critical overview of the tacit knowledge concept and we classified it according to Collins [13] to illustrate the types of tacit knowledge we need to mobilize. We then highlighted the link between inter-organizational collaboration, supply chain management and learning organizations to better identify the important role of inter-organizational collaboration. We showed how a company generates tacit knowledge from individual, organizational and inter-organizational learning, and then explored how inter-organizational memory is formed from relational and collaborative tacit knowledge. This allowed us to state that an organization is made up of embedded organizational knowledge belonging not to individuals or organizations, but to the supply chain.

In other words, we show that an organization as an entity interacts with its environment, its partners, its competitors, and with the individuals that constitute it. These interactions permit individuals and organizations to develop relational and collaborative tacit knowledge and to generate inter-organizational tacit knowledge that can be capitalized in inter-organizational memory.

This inter-organizational memory allows organizations to develop distinctive competencies that are the outgrowth of or reaction to market saturation, increasing innovation frequency, increasingly demanding customers and highly uncertain environments. These circumstances compel companies to organize themselves into supply chains, reticular organizations that reinforce collaboration and in turn tend to improve organizational and inter-organizational learning. This leads to increased collaborative and relational tacit knowledge that further develops inter-organizational memory. We thus enter a virtuous circle leading to a process of continuous improvement.

But, as with all research, our work has limitations. One of these limitations is that we do not integrate learning barriers, which could enrich our approach. As pointed out by Barson et al. [10], multiple types of barriers can exist between supply chain partners. We can briefly mention technology barriers (available technology and legacy system), organizational barriers (poor targeting of knowledge, cost of managing knowledge transfer, protection of proprietary knowledge and geographical distance), people or human resource barriers (internal resistance, self interest, lack of trust, risk, fear of exploitation, fear of contamination) or cross-category barriers (existing resources, the need for reward and culture). However, McLaughlin et al. [49] find that barrier impact cannot be assumed to be uniform across the core processes of an organization. Thus, barrier identification and management have to take place at a process, rather than at an organizational level.

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Video conference platforms: A tool to foster collaboration during inter-organizational *in vivo* simulations

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ABSTRACT

Inter-organizational problem solving of emergencies and extreme events are complex research fields where scarce experimental data is available. To address this problem, the *Inter-GAP In Vivo System*, was developed to run behavioural experiments of complex crisis. The system design and testing included three categories of participants: for pilot testing, first year university students; for theoretical validity, college students engaged in emergency management programs; and for field validity, expert decision makers who managed major crises. A comparative assessment was performed to select the most suitable video conferencing software commercially available, since it was more cost-efficient to acquire a tool already developed and customized it to the experiment needs than it was to design a new one. Software features analyzed were: ease of use, recording capabilities, format delivery options and security. The *Inter-GAP In Vivo System* setup was implemented on the video conference platform selected. The system performance was evaluated at three levels: technical setup, task design and work flow processes. The actual experimentation showed that the conferencing software is a versatile tool to enhance collaboration between stakeholders from different organizations, due to the audiovisual contact participants can establish, where non verbal cues can be interchanged along the problem solving processes. Potential future system applications include: collaborative and cross – functional training between organizations.

Keywords: Collaboration, simulation, video conference, inter-organizational problem solving.

INTRODUCTION

The study of emergency management is a complex research arena that involves the intersection of many different disciplines. One of its main challenges is the low likelihood of occurrence of emergencies and disasters, plus different uncertainty factors surrounding each one of these events. For this reason, historical retrospective studies involving qualitative approaches such as ethnography (Latiers and Jacques, 2009), phenomenology (Klein et al, 1989), open ended interviews (Hart, 1997), and case studies based on documental evidence (Lemyre, 2009) have been used to understand the many variables involved in the development of an emergency response. These approaches have the advantage of providing a general view of the events. However *aposteri* reports have a lower reliability level, since they lack the precision of an experimental design. Another problem of retrospective approaches, is the challenge to overcome the social desirability bias (Fisher, 1993), where participants tend to portray an enhanced positive image of themselves while accounting their narration. A second approach employed to study emergency management, are field studies. Field studies or field simulations have the advantage to provide data collection *in situ* and in real time. Field simulations also facilitate transitions from planning to practice, to test different organizational capacities (Hart, 1997). However simulations can be extremely complex and costly (Nja & Rake 2009;Latiers & Jacques, 2009). Oftentimes, field simulations are bounded by specific contexts and can easily become very technical (Hart, 1997).

An alternative approach to research emergencies has been the use of laboratory exercises based on computer games and simulations. The challenge, as Rolo and Diaz-Cabrera (2005) explained, is for computer simulations to allow participants to experience *complex and dynamic environments*, under controlled conditions that aim to capture the realistic settings of a field study. Brehmer and Dorner (1993) called these computer simulations "*microworlds"* since they can emulate the realistic conditions needed for research. Three main characteristics of microworlds are described: 1) *opaque*, which means that a micro world must allow researchers to hide from participants as much features and attributes of the simulation as needed. 2) *Complex* to enable participants with novel, uncertain and overlapping activities that challenge their regular professional roles and workloads. And the last characteristic is that micro worlds should be 3) *dynamic*, allowing participants to experience the accelerated step of real emergencies. These features aim participants can have lively experiences and therefore the reactions and behaviours observed resemble real ones. Computer simulation games have also be named as *role playing games* (Woltjer et al, 2006), where several stake holders participate and problems must be solved in a collaborative manner.

However, one main shortcoming of computer simulations is that participants have been university students (Pearsall et al, 2010)(Homan et al, 2007) who lack the level of professional background and knowledge needed to manage real emergencies. Another limitation according to Nja and Rake (2009), is that laboratory based approaches under controlled conditions will not encompass as much characteristics of a real emergency, nor of field simulations. Despite these shortcomings, interesting results have been found under laboratory controlled conditions (Pearsall et al, 2010;Homan et al, 2007), which can potentially inform field simulation studies based on the laboratory settings.

One of these computer simulations was a training system developed by Alison and Crego (2008) called HYDRA. This system was created to train the police in England. However the design of the system was aimed to target only the security forces. For this reason in 2010 Lemyre et al, developed the *Inter-GAP In Vivo System*, which purpose was to run behavioural computer simulations that look at inter organizational problem solving, expanding from previous work (Alison and Crego, 2008) that had focused on the intra organizational level only.

During an *Inter-GAP simulation system* session, participants are assigned to groups of participants, called "*pods*". Each pod is equipped with a computer and communication equipment. Teams work along a simulated emergency event while all their interactions are recorded to be further analysed. The simulation stream is delivered from a separate control room using video conferencing software, with the simulation, tasks and injects rendered following a set script. Each session is initiated with a briefing session where participants are oriented on the materials to be used and the technology available for the experiment, as well as to acquire an informed consent from each participant.

Rationale to use video conferencing software

The experimental design had two main requirements: First, simulated data should be delivered simultaneously to each pod; and second, text, audio and video outcomes should be recorded. This last feature was of vital importance for the experiment given the large amount of data that was needed to be collected in order to perform later analyses.

The commercial video conferencing software was able to provide a suitable solution to meet the experimental requirements. Many advantages were found in commercially available software, such as offering a robust study environment, given that simulation sessions have to be delivered not only locally but also to remote locations. The commercial software also provided the seek feature of storing data outcomes in different formats such as text, audio and video, which was essential for the experiment data collection. Another related significant feature is that video streaming itself, allowed participants to hold fluid "*face to face"* interactions and communications with each other. Therefore non verbal communications through visual cues were possible.

Another relevant feature of commercially available conferencing software is that it represents a readily available cost-efficient alternative. Due to the fact that the experiment was run over a limited budget, and holding strict delivery timelines, it was not possible to develop a full system to then run the experiment based on it. On the other hand, an available feature of the software, not yet fully exploited is the capability of deploying simulations to remote geographical locations. The following sections explain how the software selection was developed, the system tested, then results are discussed pointing out implications for future research.

METHODS

Software selection process

Different video conferencing software providers were considered to be used in the experiment: Nefsis™, GoToMeeting™, NetMeeting™, Adobe Connect™, DimDim™ and WebEx™. Overlaps in the features offered by the suppliers were found. However after the assessment, Nefsis™ was the software that best fitted the experimental requirements. Features assessed were:

- Ease of use for participants
- Recording of meeting sessions
- Recording of chat messaging
- Security
- Delivery of information in multiple formats
- Smooth delivery of audio/video files

In terms of easiness of use, most of the applications assessed have a friendly environment that allows users to intuitively navigate along the different software's tools.

Although many platforms offered to record the video conference sessions, Nefsis™ allowed recording them in a commercial video format (.avi). While many of the other providers offer to record sessions in their own proprietary formats, which could only be played afterwards using also proprietary applications.

In terms of chat availability, most firms offered this feature. When assessed, GoToMeeting™ and Nefsis™, offered simple solutions. Nefsis™ allows users to save each chat enabled as a text (.rtf) file which was considered as a powerful solution for research analysis.

In terms of security, the experiment required each session to be kept securely. For this reason software were evaluated on this feature. Nefsis™ offered user access control through virtual private networks deployed for each session to be held. Additionally the software allowed researchers to control the "*opacity"* of the simulation by enabling control of the simulation injects, by individual pod.

Most of the video conferencing software evaluated, allowed the delivery of simulation injects in multiple formats, such as documents, power point presentations, audio and video files, hand writing and drawing; as well as desktop, applications and, web browsers sharing.

For the purpose of the deployment of the experiment simulation we aimed for good management of long pauses and poor transitions. The challenge was to avoid these kinds of distractions while rendering good media files to the participants. Nefsis™ allowed smooth data streaming; at the time of the system design, it was the only software that worked with cloud computing to deploy the video conference simulation. Box 1 summarizes the software features assessed:

Box 1. Features assessed

- Ease of use for participants
- Recording of meeting sessions
- Text recording
- Security
- Delivery of information in multiple formats
- Smooth delivery of audio/video files

Equipment and facilities requirements and set-up

The basic equipment and facilities needed to operate the video conference software for the experimental design are shown in Table 1. Each POD room was equipped with a desktop computer and a dedicated broadband internet connection, a duet microphone / speaker, and a webcam placed at an angle that would capture the image from all the pods participants. The control of the simulation was delivered from a different room equipped with a desktop computer, a broadband internet connection, and a microphone / headset headphone. Nefsis™ licenses allowed up to 16 different computers to be connected to each session.

Table 1. Video conference equipment

Quantity	Item	Features
3	POD rooms	Rooms in close proximity to each other to assist in troubleshooting
1	Control room	
3	Web camera	Logitech™ Web cam C260
3	USB Conferencing mics/speakers	Phoenix™ PCS duet conference phone
10	Computers	Any brand of PC
1	Microphone/ headphone headset	Logitech™ USB Headset H360
16	Licences internet web conferencing	NEFSIS™ web conferencing

System performance evaluation

Technical evaluations were performed over the system, and its experimental set-up. The goal of these tests was to guarantee the appropriate functioning and system layout. System resilience was tested by rehearsing under "real" simulation conditions. These tests also included simulation deployment and reception from remote locations. The system design and testing included three different categories of participants: for pilot testing, first year university students; for theoretical validity, college students engaged in emergency management programs; and for field validity expert, decision makers who had managed major crises in their career.

Pilot testing with participants allowed researchers to update system settings to improve the overall simulation content, workflow, processes, and system performance. The original system set up was designed for 18 laptops, one per participant, and for each researcher involved in the experiment run-through, participating either as technical staff or as experiment observers. This first system set up was intended to run remotely. However, at this stage of the system performance evaluation, it was noticed that technical staff should also need to be deployed to each remote location to comply with all the experiment requirements, and data collection. Additionally it was noticed that the deployment of the simulation was dependant on the infrastructure available at the delivery point. For this reason, it was decided to run the experiment at the University of Ottawa facilities only.

During the pilot testing with university student volunteers, simultaneous visualization of nine webcams on each monitor saturated the screen, and it took participant's attention away from the core experimental tasks. Moreover, the only way to connect simultaneously 18 laptops to the internet was through a wireless connection. Given the local wireless infrastructure, the deployment of the simulation presented delays, interference, glitches and echo between computers. For these reasons it was decided to group three participants per computer, to ensure a broadband internet connection and accurate system performance.

In terms of audio and video quality during pilot testing, the webcams proved to be a reliable source for video. However the sound transmitted from the integrated web camera microphone was poor. For this reason usb conferencing speaker / microphones were integrated into the system. These devices have the advantage of cancelling echoes and background noise, while allowing a clear audio transmission.

Participants for system evaluation

University volunteer students were required for the pilot testing sessions. At this level, participants provided valuable feedback in terms of simulation content, workflow processes, as well as perceived easiness of use, technical set-up, and overall system layout. The next level of assessment included junior level career professionals and students related with emergency management programs, military and non governmental organizations. During these sessions the objective was to refine the experiment instruments, simulation materials and provided cues for further analysis. The third evaluation level included senior managers, feedback from this session help to refine simulation's task design, to test work flow processes and overall technical system setup. At all levels, participation in the study was voluntary and consent was obtained from each participant as per ethics requirements.

RESULTS

A total of fourteen *in vivo* sessions have been deployed. They have included participation of senior decision makers, early career professionals and university student participants (to pilot). In terms of system performance, workflow process and task design, the number of challenges to be overcome decreased notably from one session to the next one. Technical and process improvements were immediately incorporated as opportunities arose. The end product was an appealing, efficiently delivered simulation exercise that reflected high professional standards (according to feedback received from senior officers participating).

The experience of using video conferencing software for research purposes brought forth valuable learning insights. On the minus side, one has to mention that the deployment and reception of the study simulation was dependant of the local physical infrastructure. And if not appropriate, the quality of the simulation was not at its full extend. Specifically, an important element of the technical infrastructure is the networking bandwidth available for the deployment of the simulation. Another limitation is the number of participants with individual webcams per session, limited to no more than eight for proper visualization. The loading of the video conferencing software at each computer implied the installation of additional plug-ins and login access requirements, which were not intuitive for end users who are not familiar with the video conferencing software.

Another important constraint while controlling the workflow for the experiment simulation was to control the individual audio settings for both experiment participants and research observers. This posed a challenge, given that these kind of software are design to broadcast simultaneously the same information to all video conference participants. However, the experiment required to hide and control simulation elements for participants at given periods, which pose an enormous challenge to provide a flawless and smooth flow of the experiment simulation.

A last limitation experienced, is the time available to use the video conferencing software, bound to the license period purchased. Box 2 summarizes the limitations experienced using video conferencing software for research purposes.

Box 2. Experienced video conferencing software limitations

- Dependent on local physical infrastructure
- Bandwidth dependent
- Limited number of participants per meeting
- Limited to license duration to use software
- Technical challenges for end users to install the application
- Challenging to control audio settings to follow experiment requirements

On the other hand, the benefits offered by the video conferencing software surpassed the limitations to be overcome. One of these benefits was the accurate work flow control offered by the many video and audio controls, which allow group and individual adjustments. Another relevant feature is the users' access control, which is managed by granting administrative session permissions to each participant. These permissions are not only for access, but also extended to resource sharing of the multiple data formats available to be shared: audio injects, video streaming, whiteboard sharing, power point presentations, desktop sharing, and internet browser sharing.

Another benefit provided by the video conferencing software was the smooth delivery of video and audio streaming. The modularity of the software allowed controlling the video and audio quality which had a direct impact on the simulation delivery performance. In order to provide participants a high quality immersive experience, all the video conference software settings were setup to the maximum. An additional benefit the video conference software offered, were the multiple options for data collection. For experimental purposes, video and text were the formats chosen to be kept for further analysis. The formats chosen to store the data were .avi for video, and .rtf for text.

In terms of experimental results, the preliminary observational outcomes pointed out the fact that there was an increased group interaction when the video conference option was open for senior managers, enabling them with "face to face" communication. However text was the preferred option for university students. Meanwhile, the junior level career professional used both options, text and video-conference, to interact with each other.

Nevertheless, when the video conference option was used by participants, behavioural cues others than explicit verbal communications were used, and visual contact facilitated these interactions. Box 3 summarizes the benefits of using conferencing software for research purposes.

Box 3. Experienced benefits offered by video conference software for behavioural research purposes

- Simulation work flow control
- User access control
- Control of resource sharing
- Smooth video / audio streaming
- Data collection: Audio + video + text
- Facilitates communication between pods
  - Visual contact
  - Behavioral cues
- More group interaction between pods when video conference option was available, for senior managers and junior level professionals
- Text option was poorly used by senior managers and junior level professionals

DISCUSSION

After assessing the benefits and limitations offered by the video conferencing software to run *in vivo* simulations, we found it is a very useful tool for behavioral research purposes. In these terms, it proved to be a cost efficient tool. given tat the research benefits obtained by using commercial software surpassed the investment made to acquire the software license, and the technical limitations of the system. Potentially, video conference software may offer solutions to overcome geographical and environmental challenges. Additionally video conference platforms may assist in fostering collaboration by enabling resources and information sharing. And the most salient feature, in our experience, was that it enabled a virtual “face to face” communication. In terms of future research, video conference software is a potential platform to develop training programs. Given that they provide the necessary conditions to layout modular and flexible training and research designs.

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Connections, Information and Reality

'*thinking about the internet of things'*

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ABSTRACT

The number of connections between people, organizations and technology is proliferating rapidly, and the amount of information they produce, exchange and share is increasing accordingly. These connections and the information they produce are defining and shaping our daily life and work and our perception of reality. Computers in all forms are becoming smaller and less visible, but they are omnipresent. This development of information technology 'everyware', as Greenfield calls it, is also referred to as ubiquitous computing. With the development of ubiquitous computing, computers not only disappear from our perception, but also from our experience. When these new and almost invisible technological devices are tied together, for instance in the Internet of Things, the information resulting from that connection will be more than the sum of its parts. The Internet is the place where subjects are connected and where they exchange and share information. With the development of the 'Internet of things', the Internet will also connect objects and enable them to exchange and share information. In this Internet of the future, subjects and objects are more and more connected in random coalitions and networks on the basis of information. These new connections and their seamless exchanging and sharing of information will challenge traditional organizational structures. The information produced in networks will be used for changes to our existing reality and will help create a new reality. Will this development of subjects and objects connected in networks raise new questions and challenges for science and for the development of knowledge within a changing reality?

Keywords: *Postphenomenology, ubiquitous computing, networks, interpenetration, enactment*

1. POSTPHENOMENOLOGY

The connections that arise within and between combinations of man, organization and technology define, as observed by philosopher Martin Heidegger (1927), the way in which reality as created by the joint efforts of man and technology is approached. This specific combination also determines the eventual possibilities of what products or services can be produced (as in the combination of weaver and loom, and blacksmith and anvil). Heidegger attempts to unearth new and as yet non-existent phenomena in the relationship between man, organization and technology. Heidegger discourages us from considering technology as something mythical or unreal, urging us to look for the essence of applied technology, the relation with that technology, and the underlying objective of technology usage. He found that technology and technological applications are increasingly becoming a framework around the actions of individual people or the collective of people. Following on from Heidegger, philosopher Don Ihde (2003:2009) posited that modern man should start devising an interrelational ontology of entities that applies to new and hybrid combinations of man, organization and technology. Interrelational ontology refers to the inextricable link between human experience and the environment or world in which humans live. In this world, man and organization are subject to continuous changes to their perception and experience of reality. This process is affected by the fast development and uptake of technology and technological applications that play a fundamental role in man's environment. Ihde argues for research into and analysis of the new embodiment of these relations, and to analyze them as relations of man, technology and world (IT, digimedia). Embodiment is Ihde's concept signifying the way in which man approaches his environment or world, connects with it, and the role of artifacts or technology in that. Within that very framework we can, for example, consider the reciprocal relations of man-IT-man and organization-IT-organization in any possible manifestation as a kind of embodiment of relations between hybrid systems as defined by Ihde. The mutual relation that thus arises between subjects and objects, and between the physical and the digital world, requires a new and different approach to these relations. Continuing Ihde's train of thought, Verbeek (2005) goes on to designate that new approach using the term 'post'phenomenology: "*From the postphenomenological perspective, reality cannot be reduced to interpretation, language games or contexts. To do so would amount to affirming the dichotomy between subject and object, with the weight merely being shoved to the side of the subject. Reality arises in relations as do the human beings who encounter it*". (2005:113). During the ninety years that separate the ideas of Heidegger and those of Ihde and Verbeek, technology not only saw sweeping changes, but also became a more integral and indiscernible part of our daily existence. This has not only changed our relationship with this technology and these technological applications and made it more self-evident, it is also increasingly changing what we produce using this technology. Technology and technological applications are increasingly turning into the framework within which we live and work. They encase our everyday reality. In this context, I concur with Berger & Luckmann's definition of reality: *"It will be enough for our purposes, to define 'reality' as a quality appertaining to phenomena that we recognize as having a being independent of our own volition, and define 'knowledge' as the certainty that phenomena are real and that they possess specific* *characteristics."* (1966:13). Berger & Luckmann argue that everyday reality is experienced as something we take for granted and does not require additional verification in its everyday appearance and perception. Everyday reality is just there, Berger and Luckmann point out, as an undeniable axiom. Man's biological development therefore always feeds off his surroundings, *"in other words, the process of becoming man takes place in an interrelationship to its environment*". (1966:66). The increasing number of interconnections between man, organization and technology are causing them to be ever more intertwined. They are basically casually drawing on that relation in creating a new everyday reality as an everyday environment made up of reciprocally interacting elements. The Internet is one example of relations and the possibilities these offer for the exchange and sharing of information. The relation between man, organization, technological application and the Internet, and the information exchanged and shared within that realm, drives our perception of everyday reality.

2. UBIQUITOUS COMPUTING AND THE 'INTERNET OF THINGS'

At the end of the twentieth century, Mark Weiser (1991) concludes that a new way of thinking and working is needed in relation to the physical fashion in which computers present themselves in the world. The basic underlying principle for Weiser's new way of thinking is that computers in a new manifestation will eventually fade into the background of the human environment, both physically and in terms of perception, and will at the same time disappear from man's perception altogether. Computers will, in his view, become smaller, increasingly indiscernible and more autonomous over time. Weiser (1991) comes up with the concept of ubiquitous computing to refer to that new reality of computers. The real challenge Weiser (1993) sees in the development and shaping of ubiquitous computing is that it will involve reinventing and reshaping the relationship between man and computers *"one in which the computer would have to take the lead in becoming vastly better at getting out of the way so people could just go about their lives".* (1993:2). The advent of the Internet adds, in Weiser's theory, a new dimension to the concept of ubiquitous computing. Weiser considers the Internet as a form of distributed computing (1996) connecting millions of people and computers through a network (i.e. the Internet) to exchange and share information. The evolution of the Internet will eventually not only make it a network of distributed computers, but also contain ubiquitous computers. These ubiquitous computers are small, indiscernible and, as the concept suggests, ubiquitous. When discussing the development of ever smaller and ubiquitous computers, Weiser says: "*tie them, to the Internet, and now you have connected together millions of information sources with hundreds of information delivery systems in your house*". (1996:5). The evolutionary development towards a combination of distributed computing and ubiquitous computing will, in Weiser's opinion, peak in the period between 2005 and 2020. According to Greenfield (2006), ubiquitous computing forebodes a development that will see everyday objects enabled to observe their own environment and record information about, for example, their environment, location, status and history. And the possibility of exchanging and sharing that information with other objects and subjects will inevitably lead to a changing relation with these objects. "*We'll find our daily experience of the world altered in innumerable ways, some obvious and some harder to discern*". (2006:23). Looking upon all available technological possibilities as components of a network of mutual connections leads to a whole that is more than the sum of its parts. The (im)possibilities and applications of this new whole are as yet uncharted. Greenfield therefore goes on to state: "*But when things like sensors and databases are networked and interoperable, agnostic and freely available, it is a straightforward matter to combine them to produce effects unforeseen by their creators*". 2006:143. Greenfield foresees the birth of this network of sensors and databases and the ensuing behavior throwing up some new and major challenges for us as individuals and as a society in the coming years. However, Bell and Dourish (2006) point out that Weiser's prophecy has basically already been fulfilled in that the network he foresaw has already taken root in our society: "*in the form of densely available computational and communication resources, is sometimes met with an objection that these technologies remain less than ubiquitous in the sense that Weiser suggested*". (2006:140). Bell and Dourish base their finding on the unstoppable development of mobile applications and the possibilities these offer to exchange and share information anytime and anywhere. Although mobile telephony is a form of ubiquitous computing that is still visible and tangible for subjects, that visibility and tangibility is a whole lot less in the case of a technological application such as the RFID chip. Wu et al. (2006) describe a radio frequency identification (RFID) chip as a: "*small tag containing an integrated circuit and an antenna, which has the ability to respond to radio waves transmitted from the RFID reader*" (2006:1317). One of the manifestations of the concept of ubiquitous computing is the development and shaping of the 'Internet of Things'. In a report published by the cluster of European research projects on the development and shaping of this 'Internet of Things' (CERP-IoT - 2010) the effect of this concept is considered an addition to existing interactions between man and their applications. Within the context of the 'Internet of Things', a 'thing' is defined as a real/physical or digital/virtual entity that exists and moves in time and space and that can be identified. The 'Internet of Things' is an integral part of the development towards and the future usage and application of the Internet. The 'Internet of Things' will slowly but surely create a dynamic network of numerous and wirelessly connected 'things' that are capable of intercommunication. The 'Internet of Things' arises and is developed based on, among other things, ideas stemming from the concept of ubiquitous computing. The 'Internet of Things' enables interconnections between people and things anytime and anywhere. Mark Weiser's vision is set to become reality in the coming years as the 'Internet of Things' evolves. The evolution of the 'Internet of Things' will, according to Clarke (2003) inevitably lead to changes in our private and work lives both on an individual and a collective level. On an individual level, new technological applications will further blur already diffuse boundaries between man and technology. On a collective level, this new form of distributed and activity-sensitive software will enable us to accrue new knowledge based on the electronic traces left behind through the use and application of that knowledge. Clarke formulates the latter as follows: "*These shiny new* *tools will not simply redistribute old knowledge; they will transform the ways we think, work and act, generating new knowledge and new opportunities in ways we can only dimly imagine. Our smart worlds will automatically become smarter and more closely tailored to our individual needs in direct response to our own activities. The challenge, as we are about to see, is to make sure that these smarter worlds are our friends, and that our tracks, tools and trails enrich rather than betray us*". (2003:165). In order to be able to develop and shape this new and smart world, we need better understanding of ourselves as humans, Clarke states. The first step en route to this greater understanding of the concept of the human being is the recognition that man is de facto already a hybrid being. Man as a hybrid being is a combined product of our biological origin and the cultural, linguistic and technological networks man is part of. Only based on that recognition of man as a hybrid being will we be able to make an active contribution to the development and shaping of a new and smart world, as well as the corresponding technology and culture, while also developing into the human beings we want to be in such a world.

3. ORGANIZATIONS AND NETWORKS

Biologist Ludwig von Bertalanffy (1966) claimed that the combination of technology and society (nuclear bombs, the space program) had become too complex for traditional scientific approaches and interpretative systems to grasp. He identified a need for more holistic or 'system-oriented' and more generic and interdisciplinary approaches, and therefore formulated a general systems theory; a doctrine or a collection of accepted and well-founded general principles and methods, which can be applied to all kinds of systems that are the object of scientific research in different fields. He defines a system as a complex of mutually interacting elements, with interaction meaning that these elements are in a mutual relationship and that they all have an effect on each other. The approach that ensues from general systems theory is, in the eyes of Von Bertalanffy, not limited to material entities, but rather intended for entities that are partly immaterial and largely heterogeneous in their make-up. This latter point is, in my view, fully applicable to the development of ubiquitous computing and the ensuing 'Internet of Things'. The development towards networked subjects and objects gives rise to new questions about the way in which organizations can handle that, and the consequences it will have for the process of organizing. After all, in that new reality, organizations and their environments will be hybrid systems (combinations of man, organization and technology) that will increasingly depend on information from networked systems and entities. However, modern organizations are generally still structured and shaped based on vertical principles, with information organized from the top down. This vertical principle is increasingly eroded by the process of hybridization, the use and application of ever more connections and the exchange and sharing of information across these connections. These developments are creating organizations that are increasingly connected horizontally on the level of their activities. There are, in the opinion of Baecker (2001), hardly any phenomena, events or activities in today's world that are not in some way interconnected or that do not co-produce as part of networks. In many situations it will be unclear or imperceptible whether communication and interaction actually takes place between two or more persons, two or more machines, or a random combination of both. This complex of networked, interacting and intercommunicating systems is perpetuated based on information from random combinations of hybrid systems. In this context, organizations are increasingly showing a metaphorical resemblance to the human brain, as suggested by Morgan (1986). He based this metaphor on the idea that every aspect of an organization's functioning depends on some kind of information processing. That makes an organization a more or less closed system of information processing, where information is interlinked and converted into new links back to the organization's environment, based on the exchange and sharing of information and corresponding actions. However, organizations' thinking and operations within information-based networks requires new insight. Barabasi (2003) claimed that real networks are made up of *communities*, which, in turn, are made up of nodes with tight mutual links, stronger than their links with nodes outside the network. "*Thus a web of acquaintances – a graph – emerges, a bunch of nodes connected by links. Computers linked by phone lines, molecules in our body linked by chemical reactions, companies and consumers linked by trade, nerve cells connected by axons, islands connected by bridges are all examples of graphs. Whatever the identity and the nature of the nodes and links, for a mathematician they form the same animal: a graph or a network.*" (2003:16). The network is then the result of the sum of all interaction and communication between the different hubs or nodes in the network. A relatively limited number of nodes, which Barabasi calls hubs, dominate most of these networks. These hubs are special and dominate the structure of the network they are part of, and make it come across as an independent small universe. Their central position amid a large number of nodes means that many connections between those nodes run through them, and they therefore enable quick links between any two nodes in the network or system. Barabasi claims that hubs make networks *scale-free* in the sense that some hubs seem to be able to maintain an infinite number of links with nodes, regardless of whether the nodes in question are similar or not. He goes on to distinguish between *scale-free* networks and what are known as *random* networks, with the large majority of nodes in the latter having a similar number of connections with other nodes. Barabasi's assumptions lead to the conclusion that the development of organizations as hybrid systems will, in the future, strongly depend on connections and communication. On the other hand, there is a dependency on the process of organizing this complex of connections and communication. That makes the extent to which organizations are capable of functioning as a hub in their section of the network, organizing their (information) links with other nodes and exchanging and sharing information within this process of organizing a decisive factor in the development and success of organizations in their environment. Baecker (2001) claims that our thinking on organizing and structuring organizations is changing, leading to drastic changes in both existing organizations and their management. The shift in our thinking is one from a hierarchical and functional approach to a more horizontal and connection-driven approach. This new and more horizontal approach mainly involves developing and maintaining relations between the hybrid system's interior and its exterior world. As a hybrid system, an organization will increasingly be incorporated into the networks in its environment on a social, technological and economic level. The ability and willingness to operate in these networks will pose a growing challenge for the existing organizational structures as they are today. But the organization as a social system, which is based on traditional principles such as hierarchy, will not quickly or easily accept a different form or allow itself to transform, or be transformed, as a matter of fact. New theoretical insights are needed to channel such developments and support organizations in developing a new basis for themselves. New insights are also needed to be able to further develop new connections between organizations as systems and hubs in the network for the exchange and sharing of information with their environment. In the eyes of Baecker, this will not add up to hierarchical or organizational layers being wiped out altogether by these developments and the exchange and sharing of information, but rather to new functions being added to them to absorb the insecurities that are part and parcel of operating in networks. In this changing environment, information is a crucial raw material for organizations. However, with an increasingly horizontal instead of vertical flow of information, organizations will have to start developing and implementing new and more ecological forms of management and control. These new forms of control and management must veer away from exclusively focusing on direct management of the execution or controlling of available information, and move towards self-organization and self-management of and by small hybrid systems. Organizing thus becomes focused on creating smaller sub-systems that, within the greater whole, independently organize their connections, and exchange and share information with their environment within the boundaries of predefined frameworks. That will not only contribute to the development and growth of each sub-system, but also to the development of the system as a whole. Organizations organize themselves as networks, and can therefore be included in networks around them without any problem, which is increasingly creating a likeness between organizations and living organisms sharing a living body with other organisms.

4. INFORMATION AND REALITY

Information generated by connections between man, organization and technology is increasingly making a mark on our reality. Bateson (1972) already observed that a complex network of interconnected entities is shaping our world. This connection is, in his view, formed by the exchange of messages, or in other words "*the relationship is immanent in these messages"* (1972:275). Bateson considers the connection the intrinsic result of the exchange and sharing of messages and "*a difference which makes a difference is an idea or unit of information*" (1972:318). In his view, information is a new and externally-created difference or change that installs new differences or changes in a new recipient environment. The message should, in Bateson's theory, end up in a structure that is capable of processing these new differences or changes. But, Bateson warns, structure alone is not enough. The recipient structure must be willing to accept and process the incoming difference or change, or in Bateson's own words: "*This readiness is uncommitted potentiality for change, and we note here that this uncommitted potentiality is not only always finite in quantity but must be appropriately located in a structural matrix, which also must be quantitatively finite at any given time*" (1972:401). In order to be able to understand and interpret the behavior and experience of people, Bateson claims we will, in principle, always need to depart from the complex of connections that systems are part of. Bateson considers these connections a simple unit of thought. Systems with higher levels of development and complexity should, in his view, be looked upon as systems of units of thought. The possibility and ability to exchange and share information between random systems and entities can also be referred to as information interoperability. Van Lier & Hardjono define information interoperability as: "*the realization of mutual connections between two or more systems or entities to enable systems and entities to exchange and share information in order to further act, function or produce on the principles of that information"* (2011:69). The information exchanged and shared between random people, organizations and technological applications in the form of communicative units can be either accepted or rejected by the recipient system. Luhmann's (1995) concept of interpenetration from his social systems theory starts with the possibility of receiving or rejecting an incoming communicative unit. When systems possess a reciprocal willingness and ability to accept the communicative unit, and grant communicative acts from other systems access to their system, a form of interpenetration comes about. "*Interpenetrating systems converge in individual elements – that is they use the same ones – but they give each of them a different selectivity and connectivity, different past and futures*". (1995:215). Luhmann (1995) uses the concept of 'interpenetration' to pinpoint the special way in which systems contribute to the shaping of other systems within the environment of the system. Interpenetration is more than just a general relation between system and environment, but rather an inter-system relation between two systems that make up an environment for each other, and through which a system makes its own complexity available to build other systems. Interpenetration therefore only really occurs when these processes are evenly matched. That is the case when both systems enable each other to introduce their own existing complexity to the other side. The concept of interpenetration presupposes therefore, according to Luhmann, the ability to connect different forms of autopoiesis, such as life, consciousness and communication. The concept of interpenetration is equally Luhmann's answer to the question of how double contingency between different systems is enabled, and a new system based on communication comes into being with sufficient frequency and density. Making connections between two or more systems leads to the evolutionary creation of a new and higher form of system formation, which only manifests itself as it occurs, i.e. in the process of entering into and maintaining a communicative commitment. In Luhmann's view, system evolution is only facilitated by the concept of interpenetration, i.e. in the form of reciprocity. In the systems theoretical approach, reciprocity turns evolution into a self-perpetuating circular process: "*Therefore evolution is possible only by interpenetration, that is only by reciprocity. From the systems theoretical viewpoint, evolution is a circular process that constitutes itself in reality*" (1995:216). Every system that participates in the concept of interpenetration must be willing and able to allow a difference created by another system access to itself without that leading to the erasing of its own difference between system and environment. The concept of interpenetration does not connect execution, but shapes connections every system uses to stabilize its own internal complexity. The difference adopted by the system is shaped by the communicative unit consisting of a combination of information, utterance and understanding. Systems, such as organizations, want to quickly obtain new and relevant information from their environment, and be able to adequately apply this information within their own complexity. New information must therefore be acceptable for the system, and enable the system to assign meaning to the information. Luhmann (1996) borrows the neologism 'sensemaking' coined by US scientists to refer to this process of assigning meaning. By assigning meaning to information, i.e. sensemaking, a system is enabled to perpetuate existing executions, and to pass the ambivalence between knowing and not knowing on to a subsequent situation. A system benefits internally from new information based on what a system can or wants to do with this new information.

Changes based on new information stemming from connections between the organization as a system and its environment create what Weick (1979) calls a meaningful environment. After all, incoming information requires the organization to act in the form of assigning meaning (enactment) to that new information. Intruding information is subsequently the raw material for a process of sensemaking in organizations. The concept of enacted environment, where changes from the environment interpenetrate into the organization as a system, is, in Weick's view, not the same as the concept of a perceived environment. If a perceived environment were to be the core, this phenomenon would have been called 'enthinkment' and not 'enactment' (the act of assigning meaning). Weick considers reality a product resulting from an active process of social construction, and sees the concept of 'enactment' as the starting point of that process. Weick joins Berger and Luckmann (1966) in stating that observing our environment from different viewpoints does not lead to everyone observing a common world in the same way. Similarities in our perception of this common world are based on, among other things, the fact that we use language as a common system. Berger and Luckmann point out that man uses language to construe his social reality. The concept of an ecological environment and the ensuing process of construction of social reality is based on the fact that knowledge is developed through connections between subjects and between subjects and objects. The subject observes the object, and subsequently processes that observation cognitively, labels it in different ways and links it to various other isolated or external events. Weick states that there is too little focus on the possibility that the development of knowledge can also move into another, seemingly opposite, direction, namely the potential effect of the subject on the object. This effect turns knowledge development into an activity where the subject, partly through his own interaction, establishes the object both within his environment and within existing relations in that environment. In Weick's view, that vindicates the principle of a mutual relation between subject and object. That reciprocal influencing is what Weick sees as the model for the relation between enactment and ecological change, which he mainly sees in organizations that greatly depend on technology and technological applications in their operations. Such organizations have to shape enactment around and while taking account of the (im)possibilities of the technology. The high level of entanglement with technology and technological applications causes the process of enactment at organizations to change. But arguing that enactment reduces when the intensity of technology usage increases goes too far, in Weick's view. According to Weick, that argument loses sight of the fact that it is not the technology in itself that is leading to these changes. It is the information this technology generates and the information that is edited and processed using and through the intervention of technological applications that breed change. Technology generates ever greater volumes of raw data, which is a development that is also making ever greater demands on organizations to assimilate this raw data into their own context, in such a way that this data can be turned into usable and manageable information. Weick compares the term enactment, when used in the context of organizing, to the relation that evolution theory established between the term variation (the existence of differences within a kind) and natural selection. He prefers the concept of enactment over variation as enactment has a more active connotation. That reflects the active role participants at organizations play in the creation of their environment and the readiness to impose the environment they created upon themselves. The act of assigning meaning is closely linked to the principle of ecological change. Weick, like Luhmann, follows Bateson's (1972) epistemology, which states as follows: "*Ecology, in the widest sense, turns out to be the study of the interaction and survival of ideas and programs (i.e., differences, complexes of differences etc.) in circuits*" (1972:491). Especially where new differences arise within existing knowledge and experience in the organization, such as through the arrival of new information from the environment, this requires action from one or several actors to isolate and further scrutinize this new difference in order to eventually assign meaning to it. This kind of bracketing of new differences is merely one manifestation of enactment. Another manifestation of enactment can, for example, come about when an actor does something that leads to a new ecological change, i.e. a change that subsequently leads to a limitation in the environment, which, in turn, reproduces a next ecological change, making this an endless sequence. The process of assigning meaning is the only process through which the organism or the organization approaches its external environment. The perspective of being able to assign meaning gives people in organizations greater self-confidence. They become willing to reflect on their own day-to-day actions to a greater degree, as well as on the influence they exert on their environment and the influence their environment has on them. The organization needs to be more committed to and aware of its environment and the influence it has on the reality the organization constructs. If man and organization are more aware of the fact that they construct their own environment and hence their own reality, they can influence that process more. When organizations approach environments from the perspective of active meaning assignation, the focus shifts from the question of what's true and what's not, to the question whether the presented or conceived version of reality is more reasonable or less reasonable. That would prevent endless discussions and questions aimed at showing whether things are perceived and judged correctly and whether they are true or not. From the perspective of assigning meaning, such discussions can, in Weick's view, be replaced by questions along the lines of: what have we done? what meaning can we, and do we want to, assign to certain actions and information? and which actions did we refrain from? This way, people are, on an individual level, challenged to analyze whether the meaning they assigned to changes in their environment has led to the right form of common meaning or sensemaking for that change.

5. CONCLUSIONS

The new, reciprocal relations that arise between subjects and objects, and between the physical and digital world, demand new and different approaches to the connections between the different phenomena. Postphenomenology offers an ontological basis for further research into and the development of these new connections between man, organization and technology. Postphenomenology also offers a basis for further research into a changing reality, as developed and shaped based on these new relations between man, organization and technology. New, emerging forms of technology, such as ubiquitous computing, are breeding technological applications that are becoming ever smaller and less discernible, are all around us and drive our human behavior, but are also leading to new connections between objects amongst themselves and between objects and subjects. These connections facilitate an ever greater stream of information exchange and sharing. This information influences the development and shaping of our perception of reality. Everyday reality is hence the product of the connections between man, organization and technology. The increasing volume of exchanged and shared information will slowly but surely erode the vertically-oriented structure and shape of organizations. A more horizontally-oriented approach, based on random combinations of people, organizations and technological applications with a capability to exchange and share information between them, therefore becomes a necessity. This approach to organizations has yet to be developed. A more ecological management and control set-up must lie at the root of that approach, as well as the creation of smaller sub-systems that independently organize connections and exchange and share information with their environment within predefined frameworks. Such a horizontal and ecological approach would have organizations organize themselves as networks. Organizations can then be incorporated into networks around them without any problem, conjuring up a likeness to a living organism co-habiting with other organisms in a living body. Systems theory offers an epistemological framework for further research into and development and shaping of hybrid networks made up of man, organization and technology. Reality comes into being and gains shape as people, organizations and technology exchange and share information. Information that is received leads to active sensemaking by the recipient system. Assigned meaning, in turn, triggers ecological changes to reality as perceived and experienced by humans and organizations. If people had greater awareness of the fact that they create their own environment, which is made up of new combinations of man, organization and technology, they would be able to exert greater influence on the creation of this new and self-constructed reality. Social constructivism can be a methodological framework for further research into the development of a new reality springing from connections between man, organization and technology.

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Conceptions and Context as a Fundament for the Representation of Knowledge Artifacts

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ABSTRACT

It is a well-known fact that knowledge is often not objective and not context-independent. However, in many application systems knowledge is treated as objective and independent. In this paper it is argued that subject and context dependencies of knowledge need to be reflected in knowledge representation. Bernd Mahr's Model of Conception offers a fundament for new knowledge representation technologies which takes these properties of knowledge into account. Nevertheless, it is still possible to represent objectivity and context-independence in the model.

Davis, Shrobe and Szolovits [2] outlined five roles of knowledge representations. In this paper we will examine Bernd Mahr's Model of Conception in these five roles and argue for its usefulness in modelling information systems.

Keywords: subject-dependency, objectivity, context, conception, knowledge representation, modelling

1. INTRODUCTION

The need for interoperability and semantic integration in information systems shows that subject- and context-dependent actions and processing are almost everywhere present.

Bernd Mahr argues with the Model of Conception, that everything which is conceived of by some subject is conceived of as something influenced by a context. The context is not only influencing the conception, it even is the only source of meaning for the conceived object.

Context is not naturally existing but originates from subject's conceptions and actions of interpretation. It supports the subject in recognizing relevant information and using it in the process of reasoning.

In the following sections, we will first discuss how the notion of context was analyzed and used in literature. Then we introduce Bernd Mahr's Model of Conception, along with its views on subject– and context-dependency. Later we explain the five roles of knowledge representation according to Davis, Shrobe and Szolovits [2] and examine the Model of Conception in these roles. The envisaged scope of knowledge representation based on the Model of Conception includes agent systems, telecommunication, distributed AI-systems, context-aware systems, ambient intelligence systems and others. It also could be a step into the direction of generality in AI.

2. CONTEXT IN LITERATURE

There is lots of work related to context, e.g. in the fields of context-aware computing, ubiquitous computing, linguistics, artificial intelligence and many others, but there is only a small line of work, which particularly focuses on the concept of context itself.

The need for representing context was probably first stated by John McCarthy in [13]. He argued, that in order to reach the goal of generality in AI, the notion of context needs to be formalized. Then, in [14] and [15] he made a first approach, by adding abstract contexts to logical formulas.

Following the ideas of McCarthy, Ramanathan V. Guha developed a logic, based on first order predicate calculus, which handles contexts [5].

Based on the work of McCarthy and Guha, Doug Lenat built his common sense knowledge base *CYC* (see [1], [10]). The knowledge base is build as a lattice of contexts. Each context then consists of a set of assumptions and a set of content assertions, which hold under the assumptions.

Dourish analyzed in [4] how the notion of context is used in ubiquitous computing and on which principles it is based. He describes these principles as a *representational model* and argues for a new set of principles, which he calls an *interactional model*. One important change he introduces is that context is dynamic and not static.

Kokinov in [8] analyzed the notion of context from a cognitive point of view and found several properties that characterize the term. He also built a cognitive architecture called *DUAL*, which offers an implicit model of context. We'll come back to this model later.

Anind K. Dey [3] even offers a definition for context:

> Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.

The definition focuses on interactions between users and applications, but nevertheless, it captures a point that was also seen by Kokinov: Context is any information that is considered *relevant*.

Based on these insights into context, we provide a more detailed analysis of context-dependency in [6].

3. BERND MAHR'S MODEL OF CONCEPTION

The term *conception* is used in a wide variety: We say that *something is conceived of by somebody* and mean situations where somebody perceives something with his senses in a certain way; where somebody thinks of something somehow; where somebody wishes something to be; or where somebody understands that certain things are related to each other in a certain way.

Based on his work on "Object and Context"[1] [11] and on following studies on the notion of *context* Bernd Mahr developed his *Model of Conception*, which was published in [12]. It models conception by relating the term to the three other terms *subject*, *object*, *context*, and it derives from it the notion of the *content* of a conception.

None of these terms can be seen as being "more basic" than the others and each of the terms can only be understood in relation to the others. Thus, the Model of Conception can also be seen as a model of "object", of "context", or of "content".

Following the model, a subject conceives of an object in some context. The context is a complex which consists of relationships into which the conceived object is embedded. These relationships determine the content of the conception.

Clauses of the Model of Conception

Bernd Mahr's Model of Conception is given by thirteen clauses in natural language:

Entity

1. An entity is something that is. Anything that is, is an entity.
2. An entity is the content of some conception.
3. Any two entities are different.

Both, the concepts of conception and content are explained in later clauses. However, they are entities themselves and so this clause results in a circular relation, which states that both, conceptions and contents are themselves a content of some conception.

Relationship

4. A relationship is an entity by which entities are related.
5. An entity belongs to a relationship, if it is one of the entities which are related by this relationship.

Complex

6. A complex is an entity by which entities belong to relationships.
7. A relationship belongs to a complex, if the entities which belong to this relationship belong to this relationship by this complex.
8. An entity belongs to a complex, if it belongs to a relationship which belongs to this comxplex.

Conception

As the name states it, conceptions are central in the model of conception. They are, together with the content of a conception, described by the following two clauses:

9. A conception is a relationship by which an entity, identifiable as the subject of this conception, an entity, identifiable as the object (or subject matter) of this conception, and a complex, identifiable as the context of this conception, are related.
10. The content of a conception is a complex, to which exactly those relationships belong, which belong to the context of this conception, and to which the subject matter of this conception belongs.

[1] translated from German "Gegenstand und Kontext"

Situation

11. A situation is a complex in which all entities which belong to this complex are conceptions.

Universe

12. A universe is a complex to which with every entity which belongs to it, also belongs a conception, whose content is this entity.

13. A universe is called reflexive, if it belongs to itself.

Example

The following example demonstrates an application of the Model of Conception:

A man and a woman are sitting in a restaurant and the man gives his credit card to the waiter to pay.

The whole event can be described as a *situation*, a *complex* which consists of many *conceptions*. In this case, there are conceptions where either the man, the woman, or the waiter are the *subject* of the conception.

One of these conceptions would describe that the man uses his credit card to pay. He would be the *subject* and the credit card would be the *object* of this particular conception.

The *context* of the conception would contain *relationships* that describe information about credit cards in general, about the role of a waiter in a restaurant, and that the waiter needs the card to process the payment.

The *content* of this conception would consist of all information in the context that relates to the credit card. This content would describe the actual meaning of the credit card in this particular context.

Viewing this situation as an entity in the Model of Conception shows how complex this seemingly simple example is.

Subjectivity vs Objectivity

By introducing the term "subject", the model, among other things, allows explicit description of communication situations between persons, between machines and between a person and a machine. Furthermore, subjects are not restricted to persons and computers. Every entity that can have a conception of something can be seen as a subject. Thus, also a whole nation, a book on art, or a scientific community could be the subject of a conception.

The first clause of the Model of Conception states that "Anything that is, is an entity" and thus, the model simply takes *everything* into account. One may assume, that therefore the Model of Conception itself is an ontology of everything, but in fact, it takes an opposite role.

Entities in ontologies are supposed to be objective in the sense that they are independent of a conceiving mind. By the second clause any entity is the content of some conception and therefore depending on a subject and a context. Consequently, the model itself and each ontology are entities and as such subject-dependent. According to [17] "the ontological status of objectivity can only be given within an ontology".

Because of the subject-dependency of Bernd Mahr's Model of Conception, it was originally coined *A* Model of Conception and not *The* Model of Conception. In this paper we often use the article *the*, referring to the model made by Bernd Mahr. We do not intend to see it as the only possible model. It is in the very nature of the model, that there are other models in other conceptions.

Context-Dependency

According to the second clause of the Model of Conception, every entity is the content of some conception. Therefore every entity must be a complex, which consists of relationships from the context of the conception. The content of the conception is the whole meaning of the entity and it is completely derived from the context of the conception. In other words, the content is a part of the context of a conception.

Following this idea, an entity alone has no meaning. The whole meaning of an entity is given by its relationships to other entities.

Consistency of the Model of Conception

For using the Model of Conception in calculations, it needs to be formalized somehow. This seems to be problematic because of the circular nature of the model: A conception is a relationship and thus an entity. Each entity is the content of some conception and thus each conception is the content of a conception.

In [17] Tina Wieczorek formalized the model by writing the logical reading of its clauses in first order logic notation, using appropriate function and predicate symbols. She gave two axiom systems for universes, and constructed for each of these systems a Tarski-style model.

Her model constructions do not only prove consistency of the Model of Conception, also in the case of reflexive universes, but they also show that the conventional set-theoretic universe and the ϵ-theoretical universe of ϵ-sets are both universes in the sense of the Model of Conception. In ϵ-theory it is possible to consistently represent reflexive and circular structures up to self-reference.

4. FIVE ROLES OF KNOWLEDGE REPRESENTATION

In [2] it is argued, that knowledge representation is best described in five roles: It states that a knowledge representation is

a surrogate Every reasoning process takes place in the mind of some reasoning entity. Thus, there must be a representation of everything the entity is reasoning about in its mind.

a set of ontological commitments The ontological commitments are "a strong pair of glasses that determine what we can see, bringing some part of the world into sharp focus at the expense of blurring other parts." [2]

a fragmentary theory of intelligent reasoning This theory usually describes three components of reasoning: a fundamental conception of intelligent inference, a set of inferences that the representation sanctions, and a set of inferences that the representation recommends.

a medium for efficient computation The knowledge representation must not only represent knowledge, but it must also allow for efficient usage of the knowledge in inference processes.

a medium of human expression A knowledge representation should allow humans to describe their knowledge in a natural way.

In [16] John F. Sowa argues that these five roles "can be used as a framework for discussing the issues of knowledge representation". Following this idea, we will examine the Model of Conception with respect to the five roles, to motivate its potential usefulness as a fundament for knowledge representation.

The Model of Conception as a Surrogate

The Model of Conception was largely inspired by cognitive science and thus, is based on the idea, that everything in our mind is a conceived thing. We can only think, talk and act on things which we have conceived before. The idea of conceptions is expressed by the sentence "There is nothing for us, which is not through us.[2]"

According to [2] everything that an intelligent entity is reasoning about is an internal representation of a real thing in the external world. As a result from this thought, the authors come up with two questions about surrogates: "What is it a surrogate for?" and "How close is the surrogate to the real thing?".

The Model of Conception does not deal explicitly with the external world. It does not represent the "real thing" directly, but the conception of a thing, which is already internal. Still, such a conception is a real thing too, and so we have two levels of surrogates here: first, the conception and the content as a surrogate for the real thing and second, the Model of Conception as a surrogate for the conception.

For the first level, in the example given above, there is an entity which is a surrogate for the credit card and the content of the described conception is a surrogate for what the man considers relevant to the credit card in the context of a restaurant.

For the second level, the question "How close is the surrogate to the 'real' thing?" translates then to "How close is the Model of Conception to the 'real' conceptions?". Although the thirteen clauses of the model are carefully formulated, they are very abstract and thus, they leave room for interpretation. So the answer to this question depends on the way in which the Model of Conception is formalized.

Ontological Commitments in the Model of Conception

As we have argued before, the Model of Conception is not an ontology in the sense that it does not claim objectivity. Still, there is an ontological commitment to concepts like *entity*, *relationship*, *conception*, *subject*, and *context* and to the way they are related to each other. This kind of commitment is fairly minimal, like it is in the case of logic. Every model based on the Model of Conception would use these few concepts to represent others.

The amount of ontological commitment for a knowledge representation should depend on its purpose. For a tool that is specialized on a certain area the corresponding knowledge representation does only need to cover that area.

The Model of Conception was not designed for a specialized application, but for applications in many different fields. A human is not restricted to understand a limited set of concepts, and thus the Model of Conception should not be restricted in the same way. Every restriction in this sense would prevent realizing McCarthy's goal of generality in AI.

A Fragmentary Theory of Intelligent Reasoning based on the Model of Conception

The Model of Conception does not include a theory of reasoning and therefore it is no knowledge representation by itself. Nevertheless it can be seen as a fundament for a theory of reasoning and thus for a knowledge representation. Ideas for such a theory can

[2] This statement was made by the German philosopher Günther Figal.

be found in the models of cognitive science. One concept that is particularly interesting is described by Kokinov in his *DUAL*-architecture [7]. The architecture is a net of DUAL-agents, called nodes. Kokinov introduces the notion of *activation* which is a property of a node and which practically denotes how relevant this node is in a particular situation.

Interpreted in the Model of Conception it means, that the object of a conception serves as a source node which has a constant level of activation. It spreads a percentage of its activation to the entities which are related to it. These entities again spread a part of their activation and so the activation propagates through relationships. All entities have a certain threshold and when their activation is below the threshold, they are inactive and will not spread any activation.

By the concept of activation the concept of *relevancy* is modeled, which was seen as a important part of context by Kokinov and Dey.

Efficient Computation in the Model of Conception

In the Model of Conception, calculations would manipulate conceptions and contexts. Doug Lenat describes context in [9] as follows:

> We understand the potential usefulness and power of contexts, of being in and reasoning within a context:
>
> - Enabling us to ignore 99.999% of our knowledge so we can focus on the task at hand
> - Enabling us to be terse and sloppy in our communications and yet expect our readers/listeners to understand our intent
> - Enabling us to accommodate apparently contradictory information, by partitioning it out to different contexts

The first item in his list explains, why computations on contexts would be efficient. Sorting out irrelevant information provides a means to reason about things as it reduces the amount of information to a proper size which can be handled.

In the given example, only relationships are considered relevant, which on the one hand are related to the credit card, and which on the other hand are part of the restaurant context.

The Model of Conception as a Medium of Human Expression

There is no formal language defined for the Model of Conception. However, as we mentioned before, it is inspired by cognitive science and therefore by the human mind. Thus, a language based on the Model of Conception would allow for a very natural way of expressing knowledge in terms of relationships and complexes.

5. CONCLUSION

We discovered that the Model of Conception by itself is no knowledge representation, but that it is possible to create one on its basis. A first step towards it is to formalize the Model of Conception, which we are currently working on. The next step would be to develop a theory of reasoning on top of the model. The theory should formally define the notion of relevance and thereby allow for efficient computation. Further, we need to define a formal language that allows for a natural way of expressing knowledge.

Our examination of Bernd Mahr's Model of Conception with respect to the five roles of knowledge representation argues that it can serve as a fundament for knowledge representation. The model introduces the two central concepts of subject– and context-dependency, which offer a new perspective into representing knowledge. The idea to include these concepts into the model is inspired by cognitive science, and its goal is to improve the way that computers handle knowledge artifacts and make it more similar to the way humans do.

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Editorial Purpose, Strategy and Methodology

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As it was emphasized in the editorial of the first issue, the main purpose of the Journal is to collaborate in the **systemization** of knowledge and experience generated in the areas of Systemics, Cybernetics (communication and control) and Informatics. This systemization process necessarily implies a progressive increase and enlargement of the **relatedness** among the associated areas, as well as among their respective disciplines. So, improvement in **interdisciplinary communication** would provide a very good support for the sought systemization process. This is one of the main objectives of the Journal we are launching with this first issue, and our editorial policy will be directed by it.

We are trying to support the process of interdisciplinary communication among and in the areas included in Systemics, Cybernetics and Informatics, by means of 1) providing a **multidisciplinary forum** in the related areas, 2) fostering **interdisciplinary research** in them, 3) publishing papers related to transdisciplinary concepts, allowing different disciplinary perspectives on the same concept, and 4) encouraging communication among disciplines by means of **interdisciplinary tutorials**, and among the academic, the public and the private sectors by means of publishing information related **multi- and inter-disciplinary** projects which involve at least two of them.

In the context of this main purpose, a basic immediate objective of the Journal is to provide a multidisciplinary vehicle for disseminating information about diverse but highly interrelated areas through a single medium. It covers a wide range of areas, sub-areas and topics related to Systems Science, Engineering and Philosophy (Systemics), Communications and Control of Mechanisms and Organisms (Cybernetics) and Computer Science and Engineering, along with Information Technologies (Informatics).

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Therefore, the basic aims of this Journal are

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