COLLA 2011

The First International Conference on Advanced Collaborative Networks, Systems and Applications

June 19-24, 2011

Luxembourg City, Luxembourg

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COLLA 2011

Foreword

The First International Conference on Advanced Collaborative Networks, Systems and Applications [COLLA 2011], held between June 19 and 24, 2011, in Luxembourg, initiated a series of events dedicated to advanced collaborative networks, systems and applications, focusing on new mechanisms, infrastructures, services, tools and benchmarks.

Collaborative systems became a norm due to the globalization of services and infrastructures and to multinational corporation branches. While organizations and individuals relied on collaboration for decades, the advent of new technologies (Web services, Cloud computing, Service-oriented architecture, Semantics and Ontology, etc.) for inter- and intra- organization collaboration created an enabling environment for advanced collaboration.

As a consequence, new developments are expected from current networking and interacting technologies (protocols, interfaces, services, tools) to support the design and deployment of a scalable collaborative environments. Innovative systems and applications design, including collaborative robots, autonomous systems, and consideration for dynamic user behavior is the trend.

We take here the opportunity to warmly thank all the members of the COLLA 2011 Technical Program Committee, as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to COLLA 2011. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the COLLA 2011 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that COLLA 2011 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of collaborative networks, systems and applications.

We are convinced that the participants found the event useful and communications very open. We also hope the attendees enjoyed the historic charm Luxembourg.

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Abstract—**This paper studies the problem of collaborative decision constructing in the context of services society. Starting by identifying the characteristics of services society and new challenges it should face, we present the problem of collaborative decision making and discuss creativity aspects of multi-domain collaboration. We analyze the main risks related to collaborative decision making and propose their initial classification. By having identified the related gaps in science and business practices, not addressed by classical techniques on collaboration modeling, we introduce our approach for supporting collaborative decision processes that replaces the traditional viewpoint of decision-making by a dynamic participative process of decision constructing. This approach is based on ontological modelling to represent the knowledge necessary for discussions, and on services to enable collaborative decision-making. We show how the proposed conceptual approach allows actors to achieve a richer understanding of discussed topics thanks to ontologies without changing their own working practices, and thanks to services that encourage actors' initiatives in decision constructing and facilitate their collaboration. Our approach is concretized by the development of the platform for collaborative decision constructing, Cross-Pollination Space, which conceptual architecture we briefly describe. A case study on possible implementation of this conceptual approach for service innovation in Long-life exploration is finally discussed.**

Keywords – decision constructing; service innovation; information kernel; collaborative environment; creative collaboration.

I. Introduction

During the last decades, the complex problem of decision making has been in the centre of interest of both academicians and business entrepreneurs. Its importance has been increased in the context of services society that allows creating services in trans-disciplinary domains, where people not only use their static bases of knowledge, but also turn out to be active participants in the process of services creation. Naturally, in services society, services constitute a major component of the enterprise development and they become much more efficient when they are supported by ICT. Besides, ICT, in particular Internet technologies, set off a huge field of new services to be immersed in any enterprise process and to become relevant conceptual instruments for production, development and management, especially when they result the decision-making processes based on collaboration of different experts from various domains and disciplines.

Indeed, it is one of the requirements of the services society when the actors of collaboration are both providers and consumers of different types of knowledge and services, even if they keep their own languages, ways of thinking and/or working and are not obliged to change their daily working practices. From a different point of view, the complexity of current business and academic processes also requires a more powerful approach for supporting its semantics – the multi-disciplinary knowledge used, retrieved and created as the result of decision-making processes should be modeled and maintained in a more expressive way that would allow not only its better representation, but also organization and reasoning, not only decision-making, but dynamic decision-constructing leading to the creation of new domain services.

We make here a distinction between domain services and information system services. Domain services are part of the business activities, such as, for example, electricity provision, medical consultation or car rental. On their side, information system services are autonomous coherent and interoperable components of an information system which we specify by a static, a dynamic, a rules and a responsibility space. Domain services are supported by one or more information system service(s).

It thus becomes crucial to offer an approach aiming to support the process of decision constructing by integrating the services-oriented approach and ontologies. Our research is in the middle of the complimentary domains of meta-modeling, economics of the enterprise, management sciences, knowledge engineering, collaborative decision-making, services science (SS) and artificial intelligence (AI). It reflects the new sustainability requirement for information systems and services: the ability to dynamically adapt to ever-changing environments; and offers an answer of an integrated approach, which is (i) generic enough to be implemented in different fields of business and research, and (ii) scalable and interoperable to be easily concretized for a applied use case (e.g., developing an enriched base of conformity construction rules).

By justifying the necessity of a new complex approach for collaborative decision constructing and by identifying missing meta-models, knowledge bases, tools supporting

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existing working practices throughout different collaborative environments and/or working groups, in this paper we introduce our approach and discuss the conceptual schema of the corresponding practical tool.

In the next section, we present the current state of the art related to collaborative decision making. In Section 3, we identify the main underlying risks and propose their first classification. Section 4 introduces our services-oriented approach for supporting decision-constructing processes and underlines the role of ontologies that enable to generalize a traditionally defined problem of decision-making by a semantically richer problem of decision constructing. A practical tool implementing this approach, the Cross-Pollination Space is introduced in Section 5 and its conceptual framework is presented. Finally, conclusions and perspectives of this research are argued in Section 6.

II. RESEARCH ON COLLABORATIVE DECISION-MAKING

The problem of the collaborative decision making has been in the centre of interest of both academicians and business entrepreneurs during the last decades. Its importance has only increased in the context of the knowledge- and services-oriented society and especially, thanks to the development of the information and communication technologies, social networks and thematic clouds, which facilitate decision making processes and remove their geographical boundaries.

While speaking about process modeling, in general, and modeling of the collaborative decision making, in particular, one should underline the growing role of services-oriented approaches [10]. Service orientation allows studying modeling principles that rely on the interactive exchange and functioning of interoperable services. In its complexity, such service orientation is introduced at different levels of services science [22]: services are incorporated into the core of all economic processes, and in addition to this, they are widely used in paradigms of conceptual modeling and technical implementation.

Indeed, the multitude and variety of complementary activities in an enterprise has recently proved to be an important challenge: the traditional approaches seem to be no longer appropriate (and/or corresponding) to the heterogeneous business environments. The level of complexity of enterprise ontologies and/or knowledge bases, the new working situations the enterprise should face, as well as the active participation of actors in decision making and creation processes require new ways for managing enterprise activities.

This trans-domain research primarily focuses on several aspects of science: the artificial intelligence, the intelligent automation, the idea management, the knowledge discovery and capitalization, the services science, the collaboration psychology and the process modeling, to mention but a few. The business aspects of it, especially those characterizing the collaboration in innovation, are also taken into consideration. Multiple works aiming various aspects of this situation [8], [16] were successfully conducted. However, the complexity of the domain offers greater opportunities for more profound studies.

Another aspect of the current economic and business development is the fact that services society is also based on the knowledge that becomes the main source for value creation. Such a knowledge society becomes rapidly self-sustaining [12], as it reflects the current needs and the corresponding ICT infrastructure, which can meet these needs, as well as the role of actionable knowledge [3] in its evolution for different contexts.

Among other challenges our society faces today, a particular importance should be given to diversity, since it concerns a large amount of human activities, the multitude of actors, both experts in specific domains and non-professionals that are involved in creating, consuming and transforming information and knowledge (in social networks, for example), the trans-disciplinarity of topics and situations of innovation, the cultural diversity and the independence of geographical boundaries, etc. Thus, it becomes a current practice to have a team of international experts, each of them a professional in her highly specified domain and has a very specific knowledge, that collaboratively work on a complex problem requiring processing and transforming of information and knowledge.

The general discussion on the possibility to support collaborative creation can thus be characterized as trans-disciplinary: from the management-oriented vision of [19], which perceives creation as a dynamic process in which an organization creates, maintains and exploits different kinds of knowledge, to models of collaboration discussed in [7]. The complexity of the phenomenon of creativity offers wide possibility for its modeling: from defining conflicts of interdisciplinary collaboration [20] to the development of creativity support tools [1].

As it is generally admitted, collaboration between different actors requires a certain level of collective intelligence, which working definition is described in [18] by the following aspects. It is viewed as the ability to learn, understand and reason and is exercised by a group of individuals doing things collectively that seem intelligent. In most cases, the collective intelligence is aimed to address new or trying situations and specifically applies knowledge to adapt to a changing environment.

Based on knowledge as a key value-added instrument lead to the increasing importance for knowledge modeling and management, the problem of supporting decision constructing can also benefit from applying the methods and technologies of the artificial intelligence (AI), particularly aimed to increase the semantics of the described knowledge. Indeed, in this case, knowledge provides a complex static-dynamic contribution to value creation: statically, by stocking the knowledge and managing information and knowledge flows [13], and dynamically, by capitalizing the practices of usage of this knowledge for the target applied task, as well as for complementary trans-disciplinary purposes.

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In the field of collaborative engineering, [6] identifies seven layers of collaboration which aim at supporting the designers: goals, products, activities, patterns, techniques, tools and scripts. They represent an organizing scheme for the collaboration science which may represent a theoretical ground for the next generation of collaboration support systems. In the patterns layer, the group activities are classified under: generate, reduce, clarify, organize, evaluate and build commitment.

Another area of investigation is thus semantics and context modeling in collaboration processes. Different ontology-based approaches [27] and context-oriented models [23] have recently proved the effectiveness of ontological modeling, which is also one of the key points of our approach.

III. Risks and Research Gaps

The analysis of the current state of the art highlights a number of risks of the currently used approaches for supporting collaborative decision making, which we schematically organized in nine groups.

A. Decision making as limited choice

Traditionally, decision making processes are seen as a choice between several already identified and (partially) formalized alternatives. In other words, collaborative discussions are focused around choosing a (partially) pre-defined solution, but not really constructing a new solution.

In this case, decision making risks being rather limited and not using advantages of multi-disciplinarity of the knowledge bases of involved actors. It is thus necessary to restructure decision making processes in the way that they would allow constructing a decision during – and not before – discussions.

B. Risks of group thinking

Generally speaking, groupthink can be seen as any type of thought within a deeply cohesive in-group whose members try to minimize conflict and reach consensus without critically testing, analyzing, and evaluating ideas. This kind of conformism might be the result of different reasons [14], [21]: (i) illusions of invulnerability encouraging risk taking and/or unquestioned belief in the morality of the group encouraging member to ignore the consequences of their decisions; (ii) direct pressure and excessive warning that might challenge the group's assumptions; (iii) stereotyping of the importance and roles of different members: from underestimating certain points of view to excessive presence of mind guards, as well as self censorship of ideas that deviate from the apparent group consensus; (iv) eliciting individual views; (v) conformism of participants due to their anonymity; and (vi) lack of motivation for participating in decision making when passiveness (or silence) is viewed as agreement. As the result, groupthink might lead to defective decision making and disables almost any types of decision constructing.

C. Influence of propaganda on collaborative decision

Another important source of influence on collaborative decision could be found in the phenomena of propaganda and spamming, which are typical for Web environments and online communities. Indeed, the practice of introducing additional information and its emotional evaluation by some actors of communities might lead to propagating the unreliable information and to increasing the general distrust in collaborative decision making processes, as well as to questioning the trustworthiness of the process in general, and its members in particular (as sources of unreliable information). Several successful researches [11], [26], [17] have been carried out recently that have demonstrated some techniques for preventing spamming in Web environments, and as such for increasing the quality of the exchanged information. However, the risks of semantic noise in collaborative decision constructing due to spamming, society (or environment) distrust or personal direct influence of certain actors are still among the main causes of its possible untrustworthiness.

D. Risks related to cognitive and professional security

It is also one of the particularities of processes of human collaboration that people prefer to keep their traditional ways of acting and are sometimes resistant and/or not willing to change them even for the reasons of efficiency and quality. This phenomenon might be explained by the fact that innovations are sometimes associated with the risk of losing the clear vision of the work to be implemented and even with the risk of losing (or not possessing) the necessary skills for this work. In this context, it becomes obvious that any approaches aiming to support multi-domain collaboration should take into account the established common practices and domain requirements [15] and is very likely to fail if for its implementation it requires important (or even partial) change of "know-how" knowledge of decision-making actors.

E. Conservation of traditional roles of providers and consumers of information

A different type of risk, which has emerged in the context of services society, concerns the conservation of traditional roles of providers and consumers and projecting these roles to actors of collaborative decision making. It should thus be taken into consideration that the new approaches for supporting decision constructing view all actors as both providers and consumers that could simultaneously exercise different types of information exchange, dissemination and integration.

F. Ontological modeling: formalization, maintenance and search for the unique solution

Current decision-making practices are characterized by the multitude and complexity of the involved knowledge, which in many cases is non-formalized, tacit and even non-identified. This requires implementing powerful approaches that are able to support the semantics of this knowledge and to make it (partially) formalized, for example, ontological modeling. It is important to underline, however, that ontological modeling is not aiming at giving the only unique and absolute approach for knowledge formalization, and neither could it provide a definite answer applicable in all domains and contexts. Ontology-enabled modeling could be effective only thanks to the constant dynamic integration of new knowledge related to specific domains, usage-based practices and feedback from implementation in different contexts [27]. Furthermore, there should always be found a compromise between the expressiveness of the modeled knowledge and the effectiveness of its maintenance and possibility to use for different tasks: e.g., reasoning.

G. Private and public data in the context of open environments

Open environments that motivate their members to create, link and share knowledge face the dilemma of public and private data, available for large communities or protected for the specified usage. In its ultimo form, this is characteristic for open governments that optimize the usual trade-off between the expense and difficulty of getting wide agreement, and the practicality of working in a smaller community [5]. The essential concern is the privacy of data which contains personally identifiable information. Despite an important research in this domain and a variety of proposed approaches – by defining for example so called platforms of liberation and platforms of control (depending on how they support or tend to limit creativity and innovation) [24], by introducing self-regulating mechanisms within environments where its members define themselves which information should be protected or public, by identifying the necessary balance levels between public and private knowledge [9], to mention but a few – the question of developing an open environment by guaranteeing the security of private data still remains open.

H. Limitations of a chosen collaboration model

The selection of different models supporting collaboration, in general, and collaborative decision-making, in particular, is rather wide. It is obvious that all of them have some limitations in application and usage, some are more efficient and some require more strict conditions to be implemented. The group of risks relating to a choice of one particular collaboration model combines thus a number of risks [21]: (i) low model acceptance by members of collaboration; (ii) necessity to verify a model – or prototyping with the vast interaction with participants; (iii) limited model comprehension when, from one hand, participants have problems in acting in the model's boundaries, and from the other hand, they feel misunderstood due to the bad translation of their perceptions into the model language; (iii) low technical model quality; (iv) low perceived model quality – when the model itself is developed by not taking in consideration the context of collaboration and/or without allowing integrating evolving changes of the environment; (v) difficulties in traceability and eventual storage of rejected ideas (in case some ideas are decided to be useless for a particular decision-making process, but are considered as important for further processes of decision constructing).

I. Paradoxes of innovation in collaboration

This group unites different risks that characterize the dualistic nature of innovation and reflect, to some extent, the controversial nature of collaborative creativity [25]. It is the point of finding a balance between polar aspects of collaborative decision making: from its innovative (or even creative) side to organizing and scheduling decision-making activities. In its complexity, the risk is to identify an approach that would (i) unite goal-oriented and exploratory idea constructing; (ii) establish a connection between universally accepted common sense and specific domain knowledge; (iii) allow a structured approach for a priori unstructured innovative ideas; and (iv) offer participants personal motivation to benefit from the results of collaborative decision constructing [2]. This schematic classification of risks was taken into consideration in our analysis for supporting collaborative decision constructing. In our approach, we envisage them as the main challenges to be addressed and to offer an approach that aims to reduce the corresponding research gaps in supportive collaborative decision processes, as well as to involve participants directly into constructing the process of collaboration.

IV. Our Services-Oriented Approach

Our services oriented approach for supporting collaborative decision constructing tends to answer the main challenges identified in the previous section

A. General presentation

Generally, the process of decision constructing can be schematized at Figure 1. It allows managing business and science knowledge (structured and non structured, formalized and non formalized, etc.), provides semantic techniques and tools for its representing and reasoning, and offers an approach for managing collaborative processes related to decision constructing.

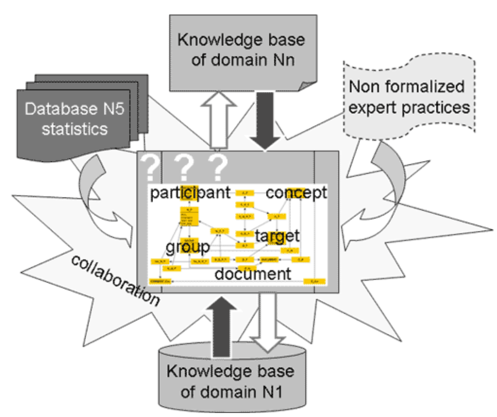

Figure 1. Collaborative information kernel .

The key elements of this approach are: Participants, Groups of participants, Concepts, Targets and Documents.

The participants are the individuals taking part in the decision constructing. In this collaborative process, the participants are directly involved. The groups of participants are unions of people which gather spontaneously around a target. A group arises after the initiative (or target) of one participant.

The targets are the objects of the decision constructing. They can take several forms: “request for discussion” (tacit need and not yet defined problem, such as an intuition), “request for solution” (defined problem without a proposed solution) or “direct proposition of action” (problem with a possible solution to be discussed and validated).

The concepts are general and abstract representations of an object (or group of objects). In our context, they originate either from the participants knowledge bases or from the participants collaborative knowledge co-construction. Interrelated to form ontologies, concepts are to be carefully handled. As a matter of fact, they carry a consensus (sometimes tacit, partial or yet to be assessed) on a knowledge serving a group’s target. The usage of knowledge bases serves multiple purposes: knowledge sharing among trans-disciplinary group members, linkage with necessary, permanent and unquestionable concepts (such as legal concepts), domain of expertise expression, positioning decisions and usage validation for the most important. Either internally or externally produced, documents are, for example, deliverable, memorial, white paper, report, proceedings or minutes. They serve the decision construction.

The participation in the decision constructing is characterized as follows: it is an outside-in and a bottom-up approach. Indeed, for the creation of domain services, we take our inspiration from open innovation experiences [4] where boundaries are blurred: the users/customers as well as the employees are empowered.

B. From risks and challenges to answers

In order to demonstrate how the proposed conceptual approach allows the actors to achieve a richer understanding of the discussed subject without changing their own working practices and domain terminologies, we analyse it from the point of view of the identified risks of collaborative decision making (cf. Section 3). We underline, however, that we do not claim the uniqueness of the proposed solution, but show its contributions to the complex problem of supporting collaborative decision constructing.

- Decision constructing aimed to overcome the limitations of decision making.

We have identified the limitations of the decision-making process that concludes with a choice of one of (partially) defined solutions (cf. Figure 2).

Thanks to the process of knowledge actionalizing and dynamic constructing of the information kernel, which are the key core of our approach, it is now possible to support the process of constructing the collective decision, while taking into consideration the environment of collaboration as well as the usage and practices. Thus the identification of possible choices of decision is done in parallel with discussions: predefined solutions are enriched with new ideas expressed during the discussions.

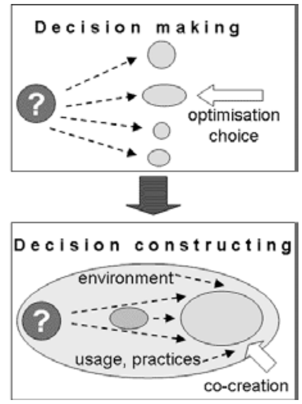

Figure 2. From decision making to decision constructing

- Risks of group thinking

The variety of risks caused by group thinking complicates the task of reducing them, especially by admitting the fact that the majority of them sources in social and psychological aspects of collaboration. In our approach, we do not particularly address these issues; however, we propose a number of solutions to be implemented in the corresponding framework, which combination will positively influence on group thinking.

First, supporting decision constructing with the help of information systems and services provides a certain level of anonymity of online societies, which weakens the direct pressure to certain members of real-time offline decision processes. Second, we offer a system of roles that encourages the participation in discussions and/or access to protected knowledge bases. Third, our approach is based on personal motivation to collaborate, which can be shown in results of decision constructing. For example, actors could be declared as authors in white papers, joint publications, new trans-disciplinary connections exceeding this current task are likely to be established, to mention but a few. Fourth, the ontological background of our approach provides the technical solutions necessary for actors to be understood without changing their terminology, and as such the knowledge is disseminated easier and can be used more effectively.

- Influence of propaganda and spam on collaborative decision

While having identified this risk, our ongoing work is currently not focused on it. Nevertheless, the task of reducing the influence of propaganda and spam in decision constructing within collaborative communities is one of the main perspectives of our future research.

- Risks of cognitive and professional security

Our previous work on capitalizing domain knowledge [27] has demonstrated the resistance of domain experts in changing their work routine: they could integrate new

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knowledge and ways of doing in their current work only if they were described in their own terminology and did not require an effort from their part. For this reason, one of the starting points for this research is to develop an approach allowing such a simplicity – that we have proposed with the help of ontological knowledge modeling, from one side, and services enabling collaboration, from the other side.

The process of decision constructing is naturally characterized by the risks of cognitive and professional security: new ideas proposed by some domain professionals can be hardly understood by experts from different domains and as such, the corresponding innovations might face some cognitive resistance of decision-making actors. However, by emphasizing the importance of allowing "domain" terminologies and by supporting them by ontologies, we allow jargon-free discussion around new ideas, which are constructed in multi-domain collaboration.

- Conservation of traditional roles of providers and consumers of information

Following the spirit of services society, it is crucial to allow the actors of collaboration to be both providers and consumers of different types of knowledge and services. By putting our prior attention to this requirement, our approach is designed as services-oriented. Indeed, we promote the initiator's role taking and, more generally, the stakeholders' empowerment by supporting the initiative taking. The main roles engaged in the collaborative decision constructing are: the initiator, the facilitator, the domain expert.

- Ontological modeling for the unique solution

In our general model, we do not particularly address the problems of formalization, maintenance and optimization of the related ontologies. Currently, this aspect is set to be issued in the implementation level, according to the concrete use case.

- Private and public data for open environments

The dilemma on the balance between private and public data in open environments (social networks, clouds, etc.) has recently been in the centre of research and practical interest. Without primarily focusing on this problem in the context of our model, we however offer a solution of balance between public and private data thanks to the roles of actors of decision constructing. It means that the access to data is defined in the scope of different roles, and the coherence and non-contradiction of the exchanged and created knowledge are maintained with the help of ontologies related to the process of decision constructing. A more profound study of this risk and its reducing are also one of our research perspectives.

- Limitations of a chosen collaboration model

It is obvious that it is not possible to completely overcome all the limitations of any collaboration models. In our research, we show that its level of acceptance could be increased thanks to the following reasons: (i) it is based on services aiming to dynamically take into consideration the changing environment; (ii) the knowledge bases are described by ontologies that allow integrating the results of the usage of the model; (iii) the model aims at supporting existing collaboration processes, but not to force new working practices and ways of collaboration. Improving the model also constitutes a perspective of this research, including implementing techniques for evaluating idea effectiveness and traceability of innovative ideas.

- Paradoxes of innovation in collaboration

The complexity of the paradoxes between innovation and collaboration leaves a vast field for research, which are our ongoing and future work. More precisely, we focus on the approach for self-motivation of actors taking part in collaboration, as well as developing a framework for organizing, disseminating and capitalizing repositories and knowledge bases related to decision constructing.

V. Cross-Pollination Space

The cross-pollination space (CPS) is a platform for enabling the creation of new domain services. CPS represents a collaborative space that brings together experts and non professional users from different domains working together on the co-creation process. As the result, it supports a group of participants in their collaborative decision-making and guides them in constructing the future, by conceptually creating innovative services.

CPS is thus an intermediate tool that allows a group of various participants to conceptualise, share and explicit ideas that will be used for creating new services, as well as to contribute to the development of the ontology-enabled knowledge base by capitalising the mutual understanding of the knowledge expressed and shared by participants in the process of CPS functioning.

A. CPS Boundary model

While developing the CPS framework [28], a particular attention is given to identifying roles of CPS participants and the main boundaries of CPS (cf. Figure 3). Schematically, CPS is based on three main components: (i) end-user services; (ii) data; and (iii) administration services.

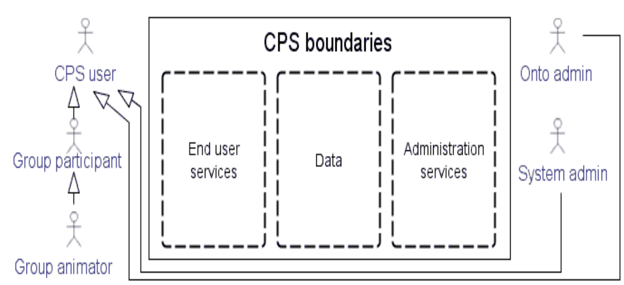

Figure 3. CPS boundary model

End-user services include but are not limited to account and group management, target launch, processing and management, social networking, CPS animation and documents management.

The main use cases identified in the boundary model allow us to identify services that the CPS has to provide to the end-users: (i) CPS user; (ii) group participant; (iii)

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group animator; (iv) ontology administrator; and (v) system administrator.

The *CPS user* (guest) is the most general type of a CPS actor, has access to discussed topics and public shared documents, and creates a new theme for discussion (group). The group participant is a CPS user, who is a member of one or many groups, takes part in CPS discussions, offers a target, joins a group, invites another participant to join the group, votes, etc. The *group animator* (self-declared or chosen by a group) is a CPS group participant who facilitates the process of CPS decision constructing within a group: s/he synthesizes the discussed problems/solutions, moderates the process of discussion, and initiates events: to vote, to sum up, to open deeper discussion, etc. The *ontology administrator* manages the ontologies, their concepts and relationships involved into CPS functioning. The *system administrator* manages different technical aspects of the CPS platform: accounts, CPS-produced documents, technical issues of the CPS platform, etc.

The data related to CPS consist of two main knowledge bases: (i) operations repository that comprises the data concerning the information on current CPS operations (e.g., user profiles, history of negotiation, group description, etc.); and (ii) ontologies repository that contains formally represented concepts and ontologies related to the discussed target(s). The knowledge bases and data are supported by administration services that allow the ontology administrator to maintain both the ontologies and operations repositories.

B. Usage scenario: constructing CPS for the system of Long-life exploration

In order to demonstrate how our approach can be applicable for practical issues, we chose an example of creating a CPS platform that enables the collaborative decision-constructing around Long-life exploration.

First, we note that the notion of Long-life exploration origins in traditional e-Learning. However, it will be a mistake to envisage it as only an extended e-Learning from a "provider-consumer" point of view. Long-life exploration represents a complex dynamic process which actors are involved in collaborative processes of discovering, sharing, acquiring new knowledge without any division on teachers and students, on knowledge producers and consumers. In this case, we de not divide the exploration process on units, but insist on the exploration environment that gives the necessary tools for knowledge discovery and motivates collaboration in decision constructing.

In this case, the CPS platform can largely facilitate the construction of a system, which supports Long-life exploration, but is not this system itself. CPS offers an environment for multiple actors that would like to participate in dynamic defining Long-life exploration scenarios, but is not limited for only this concrete purpose and context.

For example, a collaborative decision construction usage scenario can be drawn in the context of decision constructing around the idea to allow a university "student" (or an actor in terms of Long-life exploration) to gather on his/her own platform space a personalized toolset made of direct access to his/her exam results, to various news feeds, to the library catalog search tool, to his/her social network pages and to video lectures by example. For such a decision constructing, the stakeholders are: students, teachers, librarians, administrative staff, jurists, IT division staff. As knowledge bases, there are the university laws/regulations and platform exchange protocols among others.

However, by simply launching a collaborative platform and defining these roles, we often support the "producer-consumer" model: e.g., a student "consumes" the "know-what" knowledge "produced" by a teacher; a librarian "consumes" the "know-how" knowledge on disseminating academic literature, which was "produced" (i.e., formalized by internal rules) by a rector and other decision-makers. As a result, different users have the possibility only to make the decision, but not to take part in its constructing. A collaborative platform itself only supports the existing way of collaboration between stakeholders, but does not provide the environment for its dynamic development.

In contrast to this, our approach envisages the "knowledge creation and dissemination" vision. The actors are seen not as producers and consumers, but as partners who participate in exploring, discovering and creation of new knowledge, in exchange that leads to sharing and constructing new knowledge during the process of their collaboration. It means, for example, that students are participating in defining the scope of their courses, librarians are introducing their current practices to be capitalized as "know-how" knowledge of the establishment and the corresponding knowledge bases are updated as the result of such collaboration.

Obviously, a tradition notion of e-Learning is replaced by the approach for Long-life exploration for all actors of such a decision-constructing process. The CPS platform thus is designed not only for facilitating the exchange, but mostly as an environment that creates the necessary conditions for creativity in this exchange and assists the decision-constructing process.

Let us consider this example scenario from the point of view of practical implementation. In this scenario, a group of the IT division staff launches an initiative proposing a CPS platform building for Long-life exploration. It is a direct proposition for action. Then, different stakeholders join the initiative. They define the initiative objects, extract its main concepts and identify a set of shared concepts. It follows then with active debates with proposals/counter-proposals, questions/answers, arguments/counter-arguments which requires discussion and validation. When participants feel they are ready to vote, the initiative validation is put to vote. Once the decision is positively validated (and it is already updated by various knowledge from multiple stakeholders that was acquired during such decision constructing), the specification activities of a new system around Long-life exploration can start.

VI. CONCLUSION

In this paper, we discussed the issue of collaborative decision constructing in the context of the services society and defined some risks and challenges it faces today. In order to answer these challenges, we introduced our approach for supporting collaborative decision constructing and described the collaborative platform for facilitating this process: the cross-pollination space (CPS). We furthermore showed how CPS allowed overcoming certain risks and defined the axes for our future research.

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Towards a Collaborative Sessions' Management Tool for WSNs

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***Abstract* - In Wireless Sensor Networks (WSNs), the sensor nodes are typically resource limited. This fact forces nodes to collaborate in order to implement their tasks. In this paper, we propose and implement a model that represents the various types of collaboration relationships that can be established in a WSN. This involves identifying and analyzing the different types of collaboration that may occur in any WSN. As a result, we propose a hierarchy composed by different types and levels of collaboration, and we propose a collaborative session management tool, called WISE-MANager. This tool allows bringing these concepts into practice, more precisely to the establishment of collaborative sessions. WISE-MANager optimizes the WSN operation and increases the user control on the network monitoring.**

Keywords: Wireless Sensor Networks; Modeling; Collaboration Hierarch; CSCW; ZigBee.

I. INTRODUCTION

In WSNs, sensor nodes are resource restricted; i.e., they have limited memory and processing capabilities, short transmission range (thus, nodes can only communicate with local neighbors [1]. As a result, nodes need to collaborate to be able to accomplish their tasks: sensing, computing, routing, localization, etc. Therefore, WSNs are, inherently, collaborative networks [2].

In this paper, we provide an enhancement of the CWSN model by proposing a hierarchy of collaboration for WSNs. Another contribution is bringing the main CSCW (Computer Supported Cooperative Work) concepts into the area of WSNs, which includes identifying and describing the different types and levels of collaboration, as well as the collaborators that can exist within a WSN

By collaboration we refer to any interactions that may be established between two components of a WSN. These interactions can simply refer to: i) data transmission, or ii) collaboration between sensor nodes to carry out a specific task, or iii) the transmission of control information and commands necessary for essential procedures, such as configuration/reconfiguration of nodes, clusters, or the network itself.

Aiming to bring these concepts into practice, we have implemented a tool that allows creating and manipulating collaborative sessions in a real WSN.

This paper is organized as follows. Section 2 briefly describes the related work. In section 3, the different types of collaboration are identified and described, and a hierarchy of collaboration is proposed. Then, a definition of session and its classification is proposed. Section 4 describes the WISE-MANager tool and its implementation. Section 5 provides some conclusions and some perspectives of future work.

II. RELATED WORK

We have observed that the great majority of works on WSNs' modeling focus on modeling connectivity or mobility problems, or even both problems. Nevertheless, we have identified other modeling concerns, such as: communication, interference, data aggregation, coverage, and signal processing. On the contrary, the CWSN model intends to model a whole WSN, i.e., it tries to consider the most complete set possible of entities that can exist in a WSN, and their respective attributes.

Regarding the works focusing collaboration in WSNs, the great majority of them covers a specific type of collaboration, which is associated with the accomplishment of a certain task, such as: signal processing [4], sensing [5], computing [6], routing [7], localization [8], security [9], task scheduling [10], heuristics [11], calibration [12], resource allocation [13], time synchronization [14], transmission [15], etc., and also works concerning collaboration between wireless sensor nodes and other kind of devices (heterogeneous groupware collaboration) [16] to support some specific applications (for example, collaboration between sensor nodes and PDAs, in a fire fighting scenario).

According to the literature available, the only work that presents a model for collaborative work in sensor networks has been proposed by Liu et *al.* [18]. It is the SNSCW (Sensor Networks Supported Cooperative Work) model, a hierarchical model that essentially divides cooperation in sensor networks in two layers; the first one relates to cooperation between humans and sensor nodes; the second one relates to cooperation between the sensor nodes. This model was designed for sensor networks.

However, the SNSCW model only allows the modeling of collaboration itself. On the contrary, the CWSN model, which has been presented in [3], is a formal model that was created specifically to describe WSNs. However, the CWSN model allows not only the modeling of collaborative work (based in CSCW concepts), but also the modeling, formalization and graphical representation of the entities that can constitute a WSN (different types of nodes, clusters, relationships, sessions, obstacles, etc.), as

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well as its attributes. Moreover, it allows the representation of the WSN's hierarchy and the network evolution.

III. Collaboration Hierarchy in WSNs

In this paper, we present a new approach that brings some of the fundamental CSCW concepts into the world of WSNs. The CWSN model is, then, improved in order to represent not only the entities that can compose a WSN and its attributes, but also to represent collaboration in a WSN. So, on one hand, we enrich the CWSN model with the most important CSCW concepts, such as: participants, relationships, roles, tasks, sessions and groups. On the other hand, we identify several levels of collaboration, going beyond the two levels defined by the SNSCW model [17]. Thus, we extend the CWSN model with a hierarchical collaboration representation. As a result, the CWSN model evolves into a hierarchical model of collaboration.

By collaboration we denote any interactions that may be established between any two entities of a WSN. It may refer to collaboration involved in transmission of data between any two entities of the network, or to the collaboration required so that nodes can perform the majority of their tasks, which is a consequence of their severe resource limitations. However, the types of collaboration are determined by the types of nodes that exist in a WSN, since each type of node has its specific tasks. Consequently, the different types of collaboration that exist in a WSN are a natural result of its inherent hierarchy. For example, only the sink node can send data to the user; consequently, all the other nodes have to forward data towards the sink node; therefore, the sink node is naturally on the higher levels of the WSN hierarchy.

In a WSN, each participant in collaboration plays its own role. We define the possible roles that the participants can play in a WSN, as: user, sensor node, anchor node, cluster head, or sink node. A sensor node, for example, can simply play the role of a sensor node, or it can play the role of an anchor node or of a cluster head.

A. Tasks of the Participants

The tasks of each participant depend on its type, that is to say that it strongly depends on its role, and also on the characteristics of the intended application. Thus, most tasks are application-specific. However, in a WSN, tasks of the participants can be generally classified in two categories:

- Supporting tasks: these are tasks usually related to management, communication and maintenance functions (typically associated with the protocols in use).
- Information processing tasks: Data collected by sensor nodes can be processed depending on the application (data may have to be compressed, correlated, ciphered, etc.) and/or depending on the tasks of each node in the collaboration relationships established.

B. Sessions

In this work, we propose a definition of session as the essential unit of a collaborative activity in WSNs. Basically, this means that each time the user has a new objective (new type of phenomenon to monitor, new geographical area to monitor, new monitoring period, etc.) he can create a new session

In the context of WSNs and considering CSCW definitions, sessions are composed by participants, the collaboration relationships and data flows established among them, and the tasks of each participant. In a session, different types of collaboration relationships can exist; therefore, several different collaborative groups can be established inside a session.

Concerning the state of the nodes that constitute a session (regardless them being organized into groups or not), a session can be classified in one of four states:

- Created – The session has been created but not initiated; that is, the session is not in the open state yet. This is the first state of a session.
- Open – While the objective of the session is not fulfilled and some nodes are active, the session maintains its activity.
- Close – A session can become inactive due to one of two possible motives: 1) when all the nodes go into sleep mode; or 2) when all nodes are damaged or fail (for example, due to battery depletion); or 3) when there is a temporary interruption in the session (i.e., the session stops for a certain time interval that is settled by the user).
- End - A session ends due to one of three possible causes: 1) when the objective of the session is fulfilled; 2) when the predefined lifetime of a session comes to an end; or 3) when the session is aborted by the user (through the transmission of some command).
- Deleted – This state occurs when the user deletes the session and its respective data.

These session states and session evolution are represented in Fig. 1.

Depending on the WSN specific application, sessions can be classified according to their temporal characteristics: sessions can take place in parallel or in sequence; and they can be synchronous or asynchronous.

- Parallel sessions – Sessions that occur at the same time.
- Sequential sessions – A particular session starts only after the end of another session.
- Synchronous sessions – The occurrence of these sessions is planned by the network manager. Parallel and sequential sessions can also be classified as synchronous sessions.
- Asynchronous sessions – The occurrence of these sessions is not planned by the network manager. Rather, they can be started by some action (user

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initiated or node initiated), by the detection of an unexpected change in a particular phenomenon, etc.

Thus, in a certain moment, there may be several collaborative sessions in a WSN.

Defining a collaborative session with all its possible states, and different temporal relationships between collaborative sessions is important to allow users and managers to manipulate and control the operation of a WSN, in an optimized manner. These concepts can also help researchers to develop management tools that optimize the network management and that can make it more flexible, as will be demonstrated in section IV.

C. *Types of Collaboration*

Analyzing collaboration in WSNs from the point of view of relationships and interactions established among collaborators (or participants), we can identify essentially two main types of collaboration [17]: 1) collaboration between the user and the WSN, and 2) collaboration among nodes.

1) Collaboration between the user and the WSN: The user is the entity that interacts with the WSN, defining the application, querying the network, visualizing data, customizing the work of the sensor nodes, etc. However, depending on the application, nodes can also initiate collaboration. For instance, after analyzing some changes on the environment, nodes can notify and alert the user, and actively query the user about his needs.

So, this type of collaboration can be either initiated by the user or by the sensor nodes. From the user point of view, this collaboration can be carried out through a computer, a PDA, etc. From the WSN point of view, the collaboration is established via the sink node.

The sink node is the only node that can send data to the user; so, it controls the data transmission towards the user. Therefore, we can conclude that this collaboration established between the sink node and the user verifies the flow control property: it controls the flow of data. This CSCW property states that only one of the elements involved in a collaboration process can transmit data.

$$E_D = (S_{k,prod}, Da, User_{cons})$$

Where Da is the set of data that is shared by the S_k, the data producer, and the user, which is the consumer of data.

2) Collaboration among nodes: We consider that collaboration among nodes can be classified into several different subtypes:

- Collaboration among the same type of nodes (i.e., among sensor nodes, among anchor nodes, among cluster heads, etc.);
- Collaboration between sensor nodes and anchor nodes;
- Collaboration between sensor nodes and the sink node.
- Collaboration between sensor nodes and other type of wireless devices.
- Collaboration between other type of wireless devices and the sink node.

In relation to collaboration between sensor nodes and anchor nodes[1] it only makes sense in the case of an ad-hoc deployment, since in a manual deployment the localization of sensor nodes is known a priori. Since the application scenario that will be presented in section 4 involves manual deployment, this type of collaboration will not be covered in detail in this paper. The other types of collaboration will be described in detail further on.

In the case of heterogeneous WSNs, i.e., WSNs that are composed not only by sensor nodes, anchor nodes, cluster heads and sink nodes, but also by other types of wireless devices, like Bluetooth devices, Wi-Fi devices, PDAs, etc., more types of collaboration can occur:

- Collaboration between sensor nodes and other wireless devices.
- Collaboration between other wireless devices and the cluster heads.
- Collaboration between other wireless devices and the sink node.

In this case, wireless devices usually make use of these types of collaboration to ensure data transmission.

Fig. 2 proposes a collaboration hierarchy for WSNs that considers different collaboration levels and represents the different types of collaboration just described. The bidirectional arrows (horizontal and vertical) represent collaboration among the different participants that compose the WSN. This hierarchy can represent different types of collaboration; however, a type of collaboration that clearly verifies this hierarchy is data transmission, since it respects the hierarchy usually inherent to the participants of a WSN.

Analyzing this figure, it is rather intuitive to conclude that WSNs present a hierarchy of collaboration relationships. This hierarchy can be composed by different levels of collaboration, as represented in Fig. 2: the node level; the cluster level; the session level; the network level; and the user level. Besides, according to the types of collaboration presented above, collaboration can occur either within a certain level (horizontal collaboration) or between each two consecutive levels (vertical collaboration). However, this collaboration hierarchy intends to describe collaboration in a generic way. Therefore, this hierarchy needs to be modified and adapted in order to describe the collaboration relationships that occur in a WSN in particular.

[1] If localization of sensor nodes is unknown, it may be necessary to deploy some special nodes (anchor nodes) that will help the other nodes in the process of determining their own localization.

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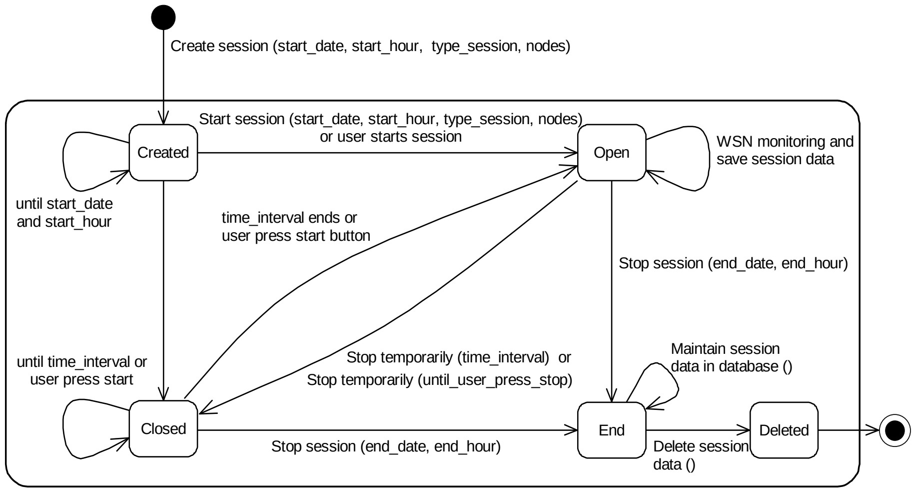

Figure 1. State transition diagram of a session.

For example, there might be the case of a WSN with heterogeneous devices, where these other wireless devices cannot communicate, and consequently, cannot collaborate with ordinary sensor nodes; they might be forced to collaborate only with the cluster heads or with the sink node. In this example, this other type of wireless devices is represented in the node level (they may even collect data like sensor nodes), but the horizontal arrows that represent collaboration between sensor nodes and these wireless devices will not exist; since they do not represent reality. Only the vertical collaboration arrows will be represented.

As mentioned before, the execution of most tasks in WSNs involves collaboration. Having a collaboration hierarchy as a framework that describes all the possible collaboration relationships that may occur in a WSN is a major advantage to researchers since they can use and adapt this framework to describe the collaboration activities of their own WSN.

a) Collaboration among the same type of nodes: As to cooperation among the same type of nodes, their relationships are uncertain, depending on the WSN's application. Nevertheless, it is possible to identify three fundamental collaboration subtypes:

- Peer collaboration [17] - The collaborators have the same roles and functions in collaboration. Peer collaboration can occur between nodes that are neighbors (so, it depends on the location of nodes), between a group of nodes in the active state, or between a group of nodes that is monitoring a common phenomenon. For example, this is the case of collaboration among ordinary wireless sensor nodes or among cluster heads.

- Master-slave collaboration [17] - In the process of collaboration, the "master" node mainly coordinates the work of the "slave" nodes, and maintains some sharing information relative to the collaboration. The slave nodes are responsible for executing specific operations. In the case of clustering being applied, master-slave collaboration is established between the cluster head and the sensor nodes that belong to the cluster.

b) Collaboration between sensor nodes and the sink node: All sensor nodes have to send collected data to the sink node. The sink node, in turn, can send queries or commands to the sensor nodes. Therefore, there is always collaboration between the sensor nodes and the sink node, unless a clustering algorithm has been implemented.

c) Collaboration between sensor nodes and the cluster head: If clustering is applied, one of the members of each cluster becomes the cluster head; the cluster head may be elected by the sensors in a cluster, or it may also be one of the nodes of the cluster that is richer is resources, or even pre-assigned by the network designer. Thereafter, all nodes in the cluster have to send collected data to the cluster head.

So, this type of collaboration involves:

- The sensor nodes send data to the cluster head.

- The cluster head receives queries and commands that the user poses to the WSN, and forwards them to the sensor nodes.

- The cluster heads can analyze received data to evaluate some parameters and take actions accordingly, sending commands to the sensor nodes; in this case, the cluster head acts as a sink node.

- Sensor nodes and cluster heads have to exchange information so that the cluster head is able to update which nodes belong to the cluster (nodes can run out of battery, or be damaged, mobile nodes can move to other clusters, etc.).

The cluster head also verifies the flow control property, since it is the only node that can transmit the set of data produced by all nodes that belong to the cluster towards the sink node. In this case, this property can be formally described as:

$$E_D = (CH_{prod}, Da, S_{k,cons}),$$

where Da is the set of data that is shared by the CH and the S_k (or other cluster head), which are the producer and the consumer of data, respectively.

d) Collaboration between the cluster head and the sink node: If clustering is applied, the cluster head is responsible for aggregating data collected by all the nodes in the cluster and sending it to the sink node. The sink node, in turn, can send user queries or commands to the cluster heads, or it can analyze received data to evaluate some parameters and take actions accordingly, sending commands to the cluster heads.

3) Collaboration between sessions: Collaboration between sessions occurs when some information has to be passed between sessions; it can happen, for example, in the case of sequential sessions, since in this particular case one session starts only after another session ends; this type of collaboration can also take place if, for example, a session is programmed to be initiated in the case a certain phenomenon is detected in another session, or in the case an unexpected change in a particular phenomenon occurs.

IV. WISE-MANAGER

In order to implement and validate the CWSN model, we have implemented a collaborative sessions' management tool, called WISE-MANager (WIreless SEnsor networks MANager for collaborative sessions). The WISE-MANager tool allows creating, monitoring and managing collaborative sessions. The purpose of using collaborative sessions is to provide a better interaction between the user and the WSN, since the user can customize the type of monitoring to be carried out (sensor node, phenomenon, or time interval of monitoring), and query the network and its components. This way, the WISE-MANager tool increases the flexibility of the WSN.

It is important to note that the proposed tool was developed in the context of the WISE-MUSE project [18]. The nodes used in this project implement the ZigBee protocol; therefore, the WISE-MANager was tested using these nodes. Nevertheless, the WISE-MANager is not ZigBee-oriented; this tool can be used to manage collaborative sessions in WSNs composed by nodes that use any other communication protocol.

Also note that the ZigBee protocol defines three types of devices: end devices, routers and coordinators. End devices correspond to sensor nodes with sensing capabilities, routers are sensor nodes can also sense data but they are essentially responsible for routing data collected by the end devices in the their WPAN to the coordinator, and, finally, the coordinator corresponds to the sink node.

The WISE-MANager tool was implemented in Java and it is ZigBee-compliant. It is composed of two main modules: (i) Collaborative Sessions' Management; and (ii) WSN Management.

The first module, collaborative sessions' management, allows creating and managing collaborative sessions inside a WSN. Users can configure the session's parameters (id, description, etc.), the sensor nodes that will make part of that session, the monitoring period, and the phenomena to be monitored (Fig. 3).

After creating the session, the user can visualize and change the session's parameters. Moreover, he can also start and stop the session's monitoring at any moment, monitor the sessions that are in an "open" state, and delete them. Thus, sessions can be opened manually by the user or automatically according to the session's monitoring schedule.

Moreover, the user can export the session's data to a MS Word document, choosing the session and the monitoring time interval. The document will contain the session's parameters as well as the data received during the session.

In the second module, named WSN Management, the user can choose a serial port where the WSN's coordinator is connected. Using this module, the user can see the WSN information, like the PAN ID, the network channel, and the network components (routers, end devices, coordinator, etc.) and its parameters. Moreover, the user can modify the device's identifier (Fig. 4).

A. Case Study

In order to validate the WISE-MANager tool, we have applied it to a heterogeneous network, which is composed of sensor nodes and other wireless devices that detect the state of the emergency doors at the Whale Museum situated in Madeira Island, Portugal.

Several experiments were carried out to validate the proposed tool. One experiment conducted at the museum was made to test the emergency door device inside the WSN. Thus, we created two sessions inside the WSN: (i) session 3 composed of node 3; and (ii) session 4 composed of node 2 and node 6. Fig. 5 illustrates physical location of the WSN inside the museum. In this figure, the whole WSN is represented using the CWSN model.

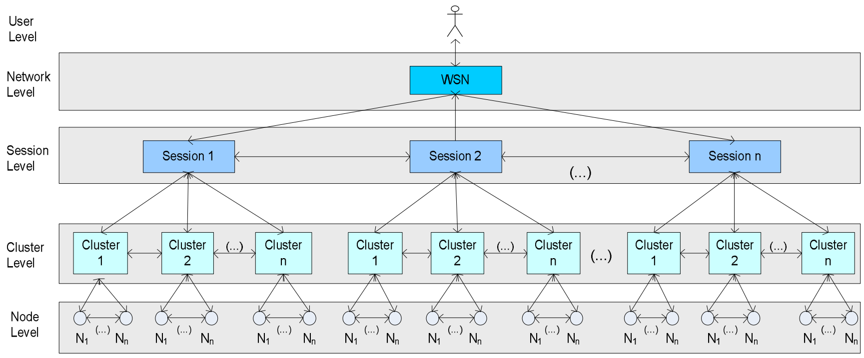

Figure 2. Multi-level collaboration hierarchy within a WSN.

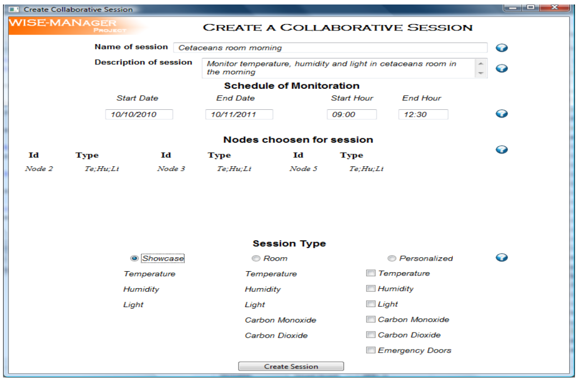

Figure 3. Creating collaborative sessions using the WISE-MANager tool.

In this experiment, both sessions were executed in parallel, monitoring two different exhibition rooms. Session 3 monitored temperature and humidity, while session 4 monitored temperature, humidity, light, and the emergency door state changes (emergency, open or close) from node 6, which was installed inside the emergency door's blocker. Data collected in this experiment is depicted in Fig. 6.

To evaluate the performance of the tool, a test was performed during 9 hours in order to check if the tool was receiving the correct packets for each session. This test was also used to analyze packet loss. It was verified that all data sent by the sessions was collected by the tool without any packet loss. After these experiments, we verified that the WISE-MANager tool was able to create, start, close, end and delete sessions.

B. Advantages and disadvantages

Analyzing Table 1, we can verify that in terms of querying the WSN, most of the tools are able to do it. On the other hand, none of these tools can create or use collaborative sessions to manage the WSN. The WISE-MANager tool allows customizing the monitoring activity and defining the session's parameters.

Moreover, the WISE-MANager tool, allows the user to control the network and inquire the WSN, getting information like communication channel, network ID, PAN ID, etc. It is also possible to detect the network's devices and change their identifiers.

Through collaborative sessions, the WISE-MANager tool enhances collaboration between the user and the network. Thus, the network is more flexible since the user can customize the collaboration, choosing different nodes to monitor different phenomena, and the monitoring time interval. Therefore, the network topology can be dynamic, since nodes can be active or inactive, according to the collaborative session's state. Additionally, this feature allows the energy saving of the network nodes.

V. CONCLUSIONS AND FUTURE WORK

In this paper, we have proposed a hierarchical model of collaboration that brings the CSCW concepts and properties to WSNs. We have described the roles and tasks of the collaboration participants in a WSN.

Another main contribution of this paper is the proposal of the concept of session as the main unit of a collaborative activity in a WSN. A classification of sessions regarding their timing characteristics was also presented. Moreover, we described the main requirements for creating collaboration groups in WSNs, as well as its advantages. Thus, we have enhanced the CWSN model [3] by proposing a hierarchy of collaboration that identifies the different types and levels of collaboration that might exist within a WSN.

This work allowed us to conclude that the collaboration hierarchy, which is composed by distinct collaboration levels, is a result of the distinct roles that the different entities play in a WSN. A major advantage of the hierarchical modelling of collaboration is that it can be used by other researchers as a framework to describe the collaboration relationships established in any WSN, despite its particular application.

Finally, we presented the WISE-MANager tool, which was created to manage collaborative sessions. This tool allows increasing collaboration between the user and the WSN. The user gains more flexibility in customizing, manipulating, and controlling the WSN. As for future work, we intend to implement an interface that facilitates the programming of the nodes and of the network from the user point of view.

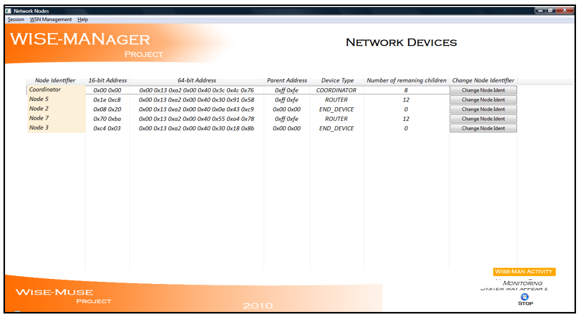

Figure 4. Detecting WSN devices.

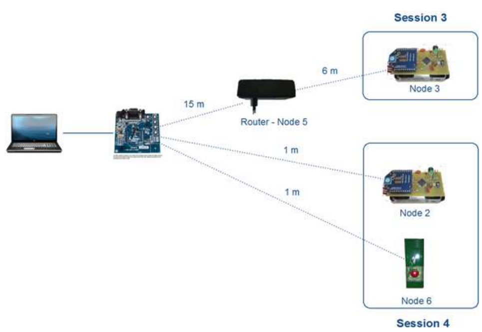

Figure 5. WSN devices for the second experiment conducted in the Madeira Whale Museum

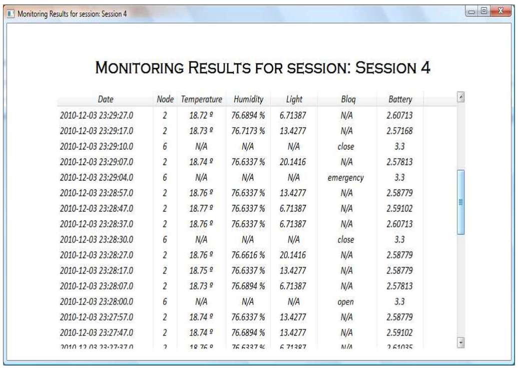

Figure 6. Data collected by Session 4.

Table 1. COMPARING WISE-MANAGER WITH RELATED SOLUTIONS

Tools	*Query WSN*	*WSN Managemen t*	*Create Sessions*	*View Session s*	*Monitor Sessions*
Tiny DB [19]	No	No	No	No	No
MonSense [20]	Yes	Yes	No	No	No
Mote-View [21]	Yes	Yes	No	No	No
MANNA [22]	Yes	Yes	No	No	No
BOSS [23]	Yes	Yes	No	No	No
WISE-MANager	Yes	Yes	Yes	Yes	Yes

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E-Collaboration Systems: How Collaborative They Really Are

Analysis of Collaboration Features of Electronic Collaboration Systems

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***Abstract*—Electronic Collaboration Systems support employees in communication, coordination and collaboration tasks to work together to a common purpose to achieve business benefit. However, the marketplace of E-Collaboration systems is multifaceted and is made up of various types of systems with differing emphasis. E-Collaboration systems may be well suited for communication tasks or coordination tasks (e.g., collaboration systems with focus on project management), but lack support of collaborative tasks – and vice versa. To identify the extent of the support of "real" collaboration of E-Collaboration systems, an analysis of collaboration features is applied to a number of E-Collaboration systems. Although we focus entirely on collaboration features and present results on a number of E-Collaboration systems with above-average collaboration emphasis, significant differences in extent and quality of collaboration support can be detected.**

Keywords-electronic collaboration; electronic collaboration systems; Enterprise 2.0; social software; social interaction

I. Introduction

Social software and social media, like Facebook, Xing, LinkedIn, Twitter, Flickr, Wikipedia and many more, are highly accepted in private use, and modern life became almost unthinkable without these tools – at least for the increasing communities of digital natives. The transfer of the highly accepted utilization of social software and social media from private use into companies is called *Enterprise 2.0*. Besides using weblogs, wikis and social networks to communicate with customers, these emergent social software platforms are used within enterprises, or between enterprises and their partners or customers [1]. Software solutions we used to call groupware and Computer Supported Cooperative Work (CSCW) software for decades incorporated these tools and got a significant development stimulus.

Team collaboration and willingness to share knowledge are increasingly claimed by companies as central requirements for their employees. Working in teams requires the ability to communicate, coordinate and cooperate. Employees have to share their individual knowledge and collectively manage the corporate knowledge. Team and community building activities and organizational measures affecting the social environment of the collaborating individuals can be supported by information systems supporting these collaborative tasks. Electronic collaboration systems (E-Collaboration systems) assist and support employees in different phases of social interaction within teams: communication, coordination, cooperation/ collaboration and networking.

Complete E-Collaboration systems have to provide high-quality support in all four phases of social interaction. The marketplace of E-Collaboration systems is multifaceted and is made up of various kinds of systems and tools with varying complexity. But do they really support all types of social interaction sufficiently? To be able to collaborate we have to be able to communicate and coordinate. Thus, communication and coordination features are actually preconditions of "real" collaboration.

In this paper we want to figure out whether and how well E-Collaboration systems really support core collaboration features. We will examine typical E-Collaboration systems for their ability to support collaborative activities among users. A feature-based evaluation approach is presented that identifies the degree of coverage of typical collaboration requirements. Therefore we will focus only on features that support the phase *collaboration* of social interaction. Features enabling communication, coordination and connection/networking will not be covered in this paper and are taken for granted.

In Section II we discuss the four types of social interaction and narrow down the term collaboration as the interaction type in focus. Section III briefly describes the marketplace of E-Collaboration systems we will analyze. The features of collaboration that are supported by E-Collaboration systems are introduced in Section IV. In Section V we present the results of evaluating a number of E-Collaboration systems whether they effectively support these features and discuss findings in Section VI. Section VII concludes this paper.

II. Types of Social Interaction in Electronic Collaboration

Riemer [2] describes E-Collaboration systems as "software for supporting communication, coordination and cooperation between people processes in groups". Riemer's definition is based on the basic types of social interaction that can be found in Computer Supported Cooperative Work (CSCW) systems and groupware: communication – coordination – cooperation [3]. In a similar way Cook [4]

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uses four primary functions to classify social software: communication – cooperation – collaboration – connection.

Communication allows people to converse with others and exchange information with the help of synchronous (e.g., chat, conferencing tools) and asynchronous (email, weblog, microblogging) communication tools [2][4].

Coordination allows a temporal or issue-related matching and agreement on tasks and resources. Typical operations of coordination support team members in coordinating appointments, processes and tasks in projects, plus surveys and workflow management.

Collaboration encourages people to work with each other on particular problems, with shared commitment and goals [4]. Collaborative activities involve working on some kind of content in a team. Creating and editing of the content can occur in an asynchronous or synchronous way. The content could, for example, comprise some kind of document or graphics, or collecting or creating information and ideas on a topic with the help of a wiki or a virtual whiteboard. Another kind of support for collaborative activities is provided by shared applications or shared desktops that offer synchronous working using the same applications simultaneously. Collaboration and cooperation use the services of communication and coordination.

Connection refers to networking technologies that enable people to make connections with and between both content and other people [4]. Social networking is the most prevailing technology for connection, but there are also a number of enabling technologies like people profiling and people search.

In terms of this work E-Collaboration systems are defined as *software for supporting and enabling communication, coordination and collaboration between people in shared projects, processes and teams within organizations and for cross-organizational use* (following Riemer [2]). Thus complete E-Collaboration systems have to support all four types of social interaction – the 4Cs:

- Communication
- Coordination
- Collaboration
- Connection

Even though complete E-Collaboration systems have to support all of these types of social interaction, the focus of this paper is on the provision of features for the core collaboration activities. The reason for this emphasis on collaboration is that the evaluation of a number of E-Collaboration systems according to these 4C categories showed, that some systems provide a variety of coordination or communication features, but fall short when it comes to supporting real collaboration [5].

In a narrow definition *to collaborate* means to work with others on a non-routine cognitive task – that is, working together [6]. Enterprise collaboration is a working practice whereby individuals work together to a common purpose to achieve business benefit [7]. Electronic collaboration (e-collaboration) is operationally defined in [8] as collaboration using electronic technologies among different individuals to accomplish a common task. Working together in a collaborative way is identified by cooperation, shared commitment and common goals. Examples of collaboration are working together on shared objects, or conjointly creating and modifying electronic documents (synchronous or asynchronous) [2]. Therefore we perceive collaboration as a special case of ICT-based cooperation where the main criteria are a collective goal-oriented behavior and collective responsibility for the result that are subjectively experienced by the participants. This definition presupposes types of personal work organization that assume high autonomy and intrinsic motivation of the participants (i.e., team members).

III. E-COLLABORATION MARKETPLACE

The marketplace of E-Collaboration systems consists of various heterogeneous system classes. There exists a large variety of open source and commercially available tools for team cooperation and collaboration. Some tools were developed out of former project management or content management systems, others put an emphasis on supporting communication with conferencing tools or originate from groupware solutions.

Several scientific and commercial market studies on E-Collaboration systems aim at structuring and organizing available software packages into system classes and categories and set up descriptive criteria, refer, e.g., to [2][9][10][11][12].

According to our definition of E-Collaboration systems, only those systems will be part of a detailed analysis that support all four basic types of social interaction (full support or partial support per interaction process, but all types have to be supported). Applying this limitation means that the vast number of single function tools, e.g., all those wikis, weblogs, chats, video conferencing tools, project management tools, content management tools, tagging or bookmarking solutions, etc., that offer only a limited number of features according to their system class, but do not cover the entire spectrum of functions for team collaboration, are excluded from the evaluation.

Based on a detailed market analysis in which we analyzed the functional range of candidates, we set up a list of about 50 tools to be included in our study. The entire evaluation process is described in [5].

IV. COLLABORATION FEATURES

Based on a literature study (e.g., [2][13]), an analysis of various studies and reports on the evaluation of E-Collaboration systems, CSCW software and groupware tools [9][12][14][15], as well as a number of interviews with experts in the field of CSCW and electronic collaboration, a set of typical functionalities of E-Collaboration systems that especially support collaborative activities was identified (Table I). These core functionalities or features of electronic collaboration are arranged in six subgroups. They provide the basis of a feature-based analysis of a representative number of E-Collaboration systems presented in the next section. They cover features regarding shared content and document creation (asynchronous and synchronous) as a core functionality including supportive content management features as well as social software and connection.

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TABLE I. FEATURES SUPPORTING COLLABORATION

Feature / functionality	Weight
Asynchronous content sharing	***20,00%***
Documents	9,00%
Multimedia content (audio, video, images)	4,00%
Document libraries	7,00%
Synchronous real-time editing	***11,00%***
Collaborative real-time editor	8,00%
Whiteboard	3,00%
Content management	***18,00%***
Versioning	4,00%
Check in/check out	4,00%
Access control	6,00%
Up- & download	4,00%
Creating and editing documents out of the shared workspace	***15,00%***
Text documents	5,00%
Spreadsheets	1,50%
Graphics and presentation	2,50%
MS Office integration	6,00%
Social software	***24,00%***
Wiki	5,00%
Weblog	5,00%
Social tagging	4,00%
Social bookmarking	3,00%
Social cataloguing	1,00%
Social presence	3,00%
Tracking	1,50%
Rating	1,50%
Connection	***12,00%***
People profiling	3,75%
People search	3,75%
People tagging	1,50%
Networking services	3,00%

Most of the activities in electronic collaboration involve creating or editing some kind of document jointly by several persons. E-Collaboration systems should thus offer features for asynchronous and even synchronous editing of documents. Concerning the asynchronous way of sharing documents or other kinds of files like multimedia content, the systems provide various kinds of libraries that support the collaborative editing of content by functionalities like check in/check out. The synchronous editing of documents allows for several team members to work on the same document at the same time. Thus, for synchronous collaboration the systems have to support functionalities for displaying who is editing which part of the document, highlighting the changes and locking parts of the document.

Brainstorming and creating ideas together is supported by virtual whiteboards that can be edited simultaneously and often are complemented by some kind of chat or instant messaging system to communicate while collaborating.

Versioning and access control are crucial for synchronous as well as asynchronous collaboration on documents or content.

Another important aspect concerning the collaboration on documents is, whether files can only be up- and downloaded to the platform or whether it is possible to create various kinds of documents directly out of the shared workspace. Our evaluation distinguishes between text documents, spreadsheets as well as graphics and presentation. Creating and editing documents out of the shared workspace explicitly focuses on documents and goes beyond just creating a webpage with the help of an online editor.

The possibility to create and edit Microsoft® Office documents within the workspace qualifies E-Collaboration systems for collaboration of standard teams as these are the prevailing document formats. Creating and editing documents within the shared workspace without having to up- and download the files, showed to be a significant feature for E-Collaboration systems to be integrated into daily work routines. Workspaces supporting this functionality have got higher chances to replace the desktop and to be used as the standard workplace that supports all daily collaborative working routines. Whereas E-Collaboration systems, that provide only up- and download of documents, risk being used as a repository for documents instead of supporting active collaboration. Such systems are often not used like a standard workplace, but the users enter the E-Collaboration system in order to get documents to be edited locally and afterwards the documents are stored within the platform again.

Among the social software tools, wikis have turned out to be a very flexible and suitable tool for collecting and structuring ideas and information on a topic together in a team. With the help of weblogs, news can be published and commented or discussed by other users. Social tagging, social bookmarking and social cataloguing refer to organizing content conjointly and to provide information for the other team members in a structured way. Thus, team members should get easy access to the collected information on selected topics.

Social presence provides information of the team members´ state and can reveal where people are, whether they are available for communication or concurrent content editing, and which is the best way to contact them. Thus, social presence serves as a basis for synchronous collaboration. Tracking refers to following the activities or tasks of other team members or the status of a document and thus provides transparency. Rating content is a very common feature for blog posts, but systems also provide rating for other kinds of content. The team can evaluate content together and thus gain a common understanding of the state of the art concerning a certain topic.

Finally, a very important aspect of E-Collaboration is connection. Features for connecting people, but also for establishing a connection between content and the team members who create the content, are a distinguishing characteristic for systems that really support collaboration. These features comprise people profiling, people search, people tagging and the support of social networking. Profiles provide information about the team members, their expertise and contact details as well as their organizational integration. Profile sites, that also provide space for personal details, support social networking activities. For example, the connection between content and the people creating the content is achieved by showing a picture of the author next to the documents, comments, blog posts etc. of this person. Clicking on or moving over this picture provides the basic profile information of the author and also the contact details. Some E-Collaboration systems combine the brief profile with instant messaging and presence information. These features support searching for experts and easy locating of the right contact person even if the users do not know each other in person.

In order to assess E-Collaboration products and to calculate an overall measurement of collaboration coverage we perform a value of benefit analysis. Each feature is assigned an individual weight (Table I) indicating dependencies and relevance in an overall weighted sum. Those weights refer to a standard scenario of team collaboration. In case of choosing an E-Collaboration system for a specific collaboration scenario these weights have to be adapted to the particular situation.

V. EVALUATION OF E-COLLABORATION SYSTEMS

The evaluation of E-Collaboration systems is based on the above described features (Table I) that were found to be relevant for providing an environment where electronic collaboration is supported at the best. Out of the list of 50 systems that support communication, coordination, collaboration and connection, 10 were chosen to be analyzed with a focus on how well they are suited for core collaboration activities:

- Alfresco Share, Community v3.4.0
- Collanos Workplace 1.4.0.2
- Jive SBS 4.5
- Microsoft® SharePoint Server 2010
- Socialtext 4.0
- Liferay Portal, Community Edition v6.0.5 CE
- PBWorks, Basic Edition
- Huddle
- EGroupware, v1.4
- Simple Groupware, v0.701

Table II presents the results of evaluating these E-Collaboration systems whether they implement the features introduced in Section IV. For the sake of simplicity each score in Table II is marked by ● if it is implemented and ○ if it is not available. Of course an assessment based on Boolean decisions is not sufficient for a detailed analysis and will be replaced by a graduation of the scale (e.g., on a scale from 0 to 4) for a more finely grained evaluation.

Alfresco provides very well supported and integrated document and content management features by offering all supporting functionalities that are needed in order to achieve efficient collaboration on documents in a team. With the help of activity feeds it is possible to track who added, edited or commented on which parts of the content. The social aspect is not the focus of Alfresco and thus there are no features for social networking activities.

TABLE II. EVALUATION OF COLLABORATION FEATURES

Collaboration feature	Alfresco Share	Collanos	Jive	MS SharePoint Server 2010	Socialtext	Liferay	PBWorks	Huddle	EGroupware	Simple Groupware
Asynchronous content sharing										
Documents	●	●	●	●	●	●	●	●	●	●
Multimedia content (audio,video,images)	●	●	●	●	●	●	●	●	●	●
Document libraries	●	●	●	●	●	●	○	●	●	●
Synchronous real-time editing										
Collaborative real-time editor	○	○	○	●	○	○	○	○	○	○
Whiteboard	○	○	○	○	○	○	●	○	○	○
Content management										
Versioning	●	●	●	●	●	●	●	●	●	●
Check in/check out	●	○	○	●	●	●	●	●	○	●
Access control	●	●	●	●	●	●	●	●	○	●
Up- & download	●	●	●	●	●	●	●	●	●	●
Creating and editing documents out of the shared workspace										
Text documents	○	●	●	●	○	●	○	●	●	●
Spreadsheets	○	○	○	●	●	●	○	●	○	●
Graphics and presentation	○	○	○	●	○	●	○	○	○	●
MS Office integration	○	○	○	●	○	●	○	●	○	○
Social software										
Wiki	●	○	○	●	●	●	●	●	●	●
Weblog	●	○	●	●	●	●	○	○	○	○
Social tagging	●	○	●	●	●	●	○	○	○	○
Social bookmarking	●	○	●	○	○	○	○	○	●	●
Social cataloguing	○	○	○	○	○	○	○	○	○	○
Social presence	●	●	●	●	●	●	●	●	●	○
Tracking	●	○	●	●	●	●	●	●	●	○
Rating	○	○	●	●	○	●	●	○	○	○
Connection										
People profiling	●	●	●	●	●	●	●	●	●	●
People search	●	●	●	●	●	●	●	○	●	●
People tagging	○	○	●	●	●	●	●	○	○	○
Networking services	○	●	●	●	●	●	●	○	○	○
Rating	67,00%	52,50%	69,00%	93,00%	70,00%	85,00%	57,00%	63,75%	53,00%	62,50%

Collanos offers a well integrated standard set of features for document management. The organization of not only documents, but all sorts of content in a folder structure, appears to be the dominating part of the system. However the synchronous editing of documents is not supported. In Collanos team members can be informed about changes or tasks via instant messages and the status of the team members is displayed in the workspace. Nevertheless, the support of social software features like wikis or blogs is somewhat limited. Looking at connection features, Collanos provides profiles of the team members, search for experts on certain topics and some social networking services.

Jive´s strength is connection. It offers many features for building employee communities using social networking

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concepts. Personal information about authors can be found throughout the entire collaborative content environment. Jive is a technologically mature platform rated by Gartner [12] as one of the market leaders.

Microsoft® SharePoint Server 2010 provides a wide range of features for content sharing and management. In combination with Microsoft® Office 2010 the editing of any office document by several users at the same time is possible. While editing the document together, one can see which user is editing which part of the content. If two users try to edit the same piece of text, the user who started editing later gets a warning that this part of the document is currently edited by another user. In combination with the social presence feature, an image as well as contact details of the other user are displayed and it is possible to contact this user via instant messaging. Thus, SharePoint 2010 is the only E-Collaboration system that offers real integration of synchronous collaborative working on content. Another feature of SharePoint 2010 is that Microsoft® Office documents can be created directly out of the shared workspace. While many platforms only support up- and download of documents but no editing on the platform, some, like Liferay, provide editing of Microsoft® Office documents, which were initially uploaded to the platform. As all analyzed E-Collaboration systems are web-based, creating some wiki like webpage out of the workspace is offered by all systems. However, we wanted to focus on creating and editing various kinds of documents and not only web pages using an editor. Even though SharePoint 2010 supports almost all features that were identified to be relevant for core collaboration, the effort to set up the system and integrate all functionalities must not be underestimated.

Socialtext offers an intuitive user interface combined with a lot of functionality that is highly integrated into the features offered by the system. The main focus of Socialtext is on the social aspect by transparently connecting people with the corresponding content. It offers new features like microblogging via so called Socialtext signals, which also allows for following the colleagues´ activities like using Twitter. With the help of an activity stream it is possible to see what the other team members are doing at the moment, like the status on Facebook. Groups can be created for projects, functional groups or communities of interest.

Liferay offers social tagging for web content, documents, messages, board topics etc. in order to organize and share content with other team members. Activities on, e.g., blogs, message boards, wikis can be tracked via a recent activity portlet on a Facebook-like activity wall.

PBWorks allows for sharing activities and tasks via the personal profiles of the team members and to follow users to see what they are doing. PBWorks offers a smooth integration of comments, microblogs, messages and information on the authors with the content. The synchronous editing of pages is provided by inviting the users who are allowed to contribute via chat. Thus, it is possible to edit the content of pages together and communicate about the changes via instant messages.

Huddle is a simple and easy to use E-Collaboration system that offers well supported content sharing and management with integration of Microsoft® Office. The set-up of Huddle is fast and easy, the user interface intuitive. Huddle can be recommended for small teams that want to start collaborating right away, having no special requirements. A shortcoming of Huddle are social aspects and features for connecting people and content.

EGroupware supports many project management features and also offers special functionalities for software development projects. However, when it comes to the support of core collaboration EGroupware offers only parts of the crucial collaboration features. The social aspect is not a strength of EGroupware and the connection between content and people is not as transparent as in Liferay for example. Even though EGroupware seems to have been developed for the collaboration in software development projects, it is easy to use and provides some other collaborative features apart from project management.

Simple Groupware is another open source groupware and content management software with distinct collaboration features. Simple Groupware provides many features for asynchronous content handling, including content creation and editing within the workspace. Content can be collaboratively managed in enterprise, project and personal spaces. However, Simple Groupware lacks some social software elements (especially tagging) and networking features and has shortcomings in usability.

VI. DISCUSSION

The presented results in Table II are derived from a number of E-Collaboration systems with above-average collaboration emphasis. However, significant differences in extent and quality of collaboration support can be detected.

As Table II shows, most E-Collaboration systems support collaboratively creating and managing content (especially documents or text, tags, bookmarks, people) in an asynchronous way. Asynchronous document handling for different kinds of documents – including versioning, check-in/check out, etc. – is well supported by all products (without going into details on the grade and quality of the implementation).

However, synchronous features, i.e. synchronous real-time editing, is provided only in rare cases, although nameable authors especially in the CSCW community regard synchronous functionality or concurrency as core aspects of electronic collaboration [13][16]. Only one system (Microsoft® SharePoint Server 2010) provides real-time synchronous editing facilities in certain setups. Another product offers a virtual whiteboard (PBWorks), but the others do not include synchronous editing at all.

E-Collaboration systems have benefited a lot due to the widespread use of social software and gained significant momentum throughout the last years. They introduce new options and functions to electronic collaboration and help to distinguish E-Collaboration systems from related CSCW systems and groupware. Modern E-Collaboration systems include typical elements of social software, like wiki, weblog, social tagging and social bookmarking, and these elements can be found in many E-Collaboration products. Nevertheless, significant differences can be identified in the utilization of social software elements. 8 out of 10 E-Collaboration systems implement a wiki, but only 5 systems include a weblog. Social tagging is provided by 5 E-Collaboration systems and social bookmarking is offered only by 4 out of 10 systems. Remark: These numbers are not representative for the entire group of E-Collaboration systems as defined in Section III and a percentage of social software utilization cannot be derived from these numbers.

Social presence and connectivity features have been included in the evaluation, although they actually make up a separate type of social interaction according to the 4Cs model (derived from the classical 3Cs of CSCW, extended by Connection), as they are highly important for modern E-Collaboration approaches. The reviewed systems provide sufficient support of connection features: 9 out of 10 systems possess social presence functionality and all offer personal profiles and people pages. Complex social networking services, as they are well-known from specialized social networking sites, are provided by 6 of 10 products. People tagging features are offered only by 4 products.

Substantial differences can be found in creating documents out of the shared workspace. Only a small number, 3 respectively 5 E-Collaboration systems offer this functionality for multiple kinds of documents (i.e., files) besides creating integrated, web page-based content.

VII. Conclusion and Future Work

We can identify quite differing degrees of collaboration support among the reviewed E-Collaboration systems. All reviewed products offer considerable support of core collaboration functionality. However, the focus of the systems is on asynchronous collaboration and the E-Collaboration systems marketplace lacks support of synchronous collaboration tasks in teams – notably synchronous real-time editing tools. To cover the entire spectrum of possible needs in E-Collaboration (i.e., core collaboration requirements) more options for synchronous cooperation should be provided. The evaluation of the reviewed systems educes that several systems might benefit by more complete offerings of social software technologies.

The presented features are used to compare E-Collaboration systems according to their true coverage of collaboration activities in a standard team collaboration scenario. These features and corresponding weights can be used as a basis of decision-making when selecting an E-Collaboration system but have to be refined for a specific collaboration situation. The results presented in Section V and VI can be broken down to provide more precise results. The evaluation in Table II included only ratings on a binary scale based on Boolean values (implemented ● or not ○). Future work will provide more detailed ratings on a scale of 0 to 4 and the accumulated criteria presented in Table II will be specified in more detail to be able to differentiate between products. Due to space restrictions we presented the evaluation of only 10 products of the 50 identified complete E-Collaboration systems.

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Modeling Collaboration for Crisis and Emergency Management

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Abstract— **Managing crisis and emergency requires a deep knowledge of the related scenario. Simulation and analysis tools are considered as a promising mean to reach such understanding. Precondition to these types of tools is the availability of a graphical modeling language allowing domain experts to build formally grounded models. To reach this goal, in this paper, we propose the CEML language and the related meta-model to describe structural aspects of crisis and emergency scenarios. The meta-model consists of a set of modeling constructs, a set of domain relationships, and a set of modeling rules. Finally, we propose a preliminary set of collaboration design patterns to model interaction and communication exchange arising among emergency services providers and citizens to solve the crisis.**

Keywords - Conceptual Modeling; Collaborative Networks; Critical Infrastructures; UML Profiles.

I. Introduction

Recent natural disasters (e.g., earthquakes, floods, fires) and technical faults (e.g., power outages) and their impact on critical infrastructures (CI)s and population have caused a growing attention on how to manage crisis and emergency. In this context, CI services may not work or could not guarantee an acceptable level of service. Since dependencies among CI services are often unpredictable, they could generate further unexpected faults in the CI network. Communications channels could be unavailable to teams needing to collaborate to solve the crisis. Furthermore, beneficiaries of CIs, not provided with the needed resources, can act in uncontrolled mode, hindering the work of operators who are trying to restore CI services.

To cope with such complexity and mitigate such effects, a promising approach is to simulate these scenarios. Simulation allows creating a portfolio of virtual *crisis and emergency management experiences* to be used, for instance, for training institutional operators with the responsibility of solving the crisis.

A precondition to build effective simulation tools is the availability of a modeling language and a modeling methodology allowing domain experts to build formally grounded models that can be converted into simulation models. The MDA (Model-Driven-Architecture) [1] approach can help us to this aim as it provides methods and tools that can be used by domain experts, i.e., institutional operators with a deep knowledge of crisis and emergency scenarios and with not necessarily high-level IT skills. The first required feature of such language is the *domain adequacy*, i.e., how the language is suitable to represent the addressed domain [2]. This is achieved by providing experts with modeling constructs and relationships better reflecting their knowledge about the domain. In the CI domain, it is required to allow modeling of collaboration and interaction among CI services, population, institutional operators and stakeholders operating in crisis and emergency scenarios. Then the language has to permit modeling of both structural and behavioral aspects. It has to be formally grounded to allow models to be processed as source code of appropriate simulation programs. It has to be based on widely accepted existing standards to support model interoperability. Finally, it has to be supported by a graphical notation to allow intuitive and user-friendly modeling.

In this paper we propose CEML (Crisis and Emergency Modeling Language), an abstract level language to model crisis and emergency management scenarios. In particular, we describe the related CEML meta-model, consisting of a set of modeling constructs, a set of relationships, a set of modeling rules, and its formalization using SysML [3] and OCL [4]. For sake of space, we focus mainly on presenting how CEML supports structural modeling of a crisis and emergency scenario. Modeling of behavioral aspects will be treated in a future paper.

Then we propose a modeling methodology tailored to model collaboration needed in crisis and emergency scenarios. This methodology is based on Collaboration Design Patterns (CDP)s. A design pattern is a reusable solution to a recurrent modeling problem [5]. In particular, collaboration design patterns model interaction and communication exchange arising during the crisis. Again for sake of space, here we propose just two CDPs: clustered service and heterogeneous networking.

The rest of the paper is organized as follows. Section 2 presents related work in the area. Section 3 describes the meta-model for crisis and emergency scenarios and its formalization. Section 4 proposes a preliminary set of collaboration design patterns for crisis scenarios. Section 5 describes an example concerning emergency management after earthquake events and showing the usability of the proposed modeling framework. Finally, Section 6 presents conclusions and future works.

II. Related Work

Nowadays there is an increasing interest on crisis and emergency management modeling and simulation. The aim is to propose effective modeling and simulation approaches

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to analyze crisis scenarios, and to test crisis and/or disaster management procedures.

The main concepts and definitions related to critical infrastructures (CI) are presented in [6]. An interesting approach to describe various aspects of CI is the ontological approach. In [7], for instance, five meta-models are proposed to characterize various aspects of an infrastructure network, such as managerial, structural and organizational aspects. These meta-models are defined as a UML profile with the aim to completely describe the critical infrastructures domain and their interdependencies. Instead, here we concentrate on the problem of graphically building structural models of crisis management scenarios, also involving humans for simulation purposes.

Ontologies to describe either emergency plans or disaster affecting critical infrastructures are presented in [8], [9], [10], and [11].

All these works, which we have considered as a starting point for our research, are complementary to our result, as they provide means to semantically enrich simulation models realized with our language.

Finally, in [12] and [13], SysML is proposed as "standard" meta-model for high level discrete event simulation models to be mapped to Arena and DEVS programs. Indeed, this is proposed to easy the access to simulation technology to non ICT experts and to allow exchange of simulation models between tools.

In addition to what presented by others in the same field, we propose a set of CDPs to support analysts and crisis management experts in modeling crisis scenarios.

III. A META-MODEL FOR CRISIS AND EMERGENCY SCENARIOS

In this section we present the CEML meta-model, to guide modeler in representing the structural aspects of a crisis and emergency scenario. A meta-model is a design framework describing the basic model elements, the relationships between them, and their semantics. Furthermore it defines rules for their use [14].

A. Modeling Constructs

Abstract Service. It represents the active entity processing either a *resource* entity or a *message* entity or a *connectivity* entity. It can be either a **service** (e.g., power house, information service, electrical power grid) or a **human service** (e.g., fire brigades) or a **communication service** (e.g., telecommunications provider).

Behavior. It represents an operational feature of either a *service* or a *human service* or a *communication service* or a *user* entity. This allows to complete the structural model with behavioral specifications.

External event. It represents the active entity (e.g., failure, earthquake) affecting the operational status of either a *service* entity or a *human service* entity or a *communication service* entity or affecting the wellness of a *user* entity.

User. It represents the entity using or consuming a *resource* entity (e.g., hospital). It is characterized by a wellness level.

Message. It represents information content exchanged in a communication.

Resource. It represents the passive entity processed by either a *service* entity or a *human service* entity. It can be input to either another *service* entity or a *communication service* entity or a *human service* entity or a *user* entity. It can contribute significantly to *user*'s wellness level.

Connectivity. It represents, from a physical perspective, the output of a *communication service* entity.

B. Relationships

Resource Flow. It represents resource passing through ports from a *service* or *human service* entity to either a *user* or a *service* or a *human service* or a *communication service* entity.

Connectivity Flow. It represents, from a physical perspective, the communication channel provision (through ports) from a *communication service* entity to either a *service* or a *human service* or a *user* or another *communication service* entity.

Message Flow. It represents, from a logical perspective, the exchange of information content through ports between two of the following entities: *service*, *human service*, and *user* (e.g., between two *services*, between a *service* and a *user*).

Abstract Port. It represents the abstract entity linking either an *abstract service* entity or an *user* entity to either one or more *connectivity flow* entities, or one or more *message flow* entities, or one or more *resource flow* entities. It can be either a *message port* or a a *communication port* or a *resource port*.

Communication Port. It represents the abstract entity linking either a *communication service* or *a human service* or *a service* or *a user* entity to one or more *connectivity flow* entities.

Message Port. It represents the abstract entity linking either a *service* or a *human service* or a *user* entity to one or more *message flow* entities.

Resource Port. It represents the abstract entity linking either a *service* or a *human service* or a *communication service* or a *user* entity to one or more *resource flow* entities.

Connection Port Group. It represents the abstract entity grouping one *communication port* entity and one or more *message port* entities and belonging to either a *service* or a *human service* or a *user* entity.

Impact. It represents how an *external event* entity affects one or more of the following entities: *service*, *communication service*, *human service*, and *user*.

C. Modeling Rules

C1. An element can be categorized only as a modeling construct or as a relationship.

C2. A **service** element has 0..n incoming **resource port** elements, 1...n outcoming **resource port** elements, and 0..n **connection port group** elements.

C3. A **human service** element has 0..n incoming **resource port** elements, 1...n outcoming **resource port** elements, and 0..n **connection port group** elements.

C4. A **communication service** element has 0..n incoming **resource port** elements and 1..n outcoming **communication port** elements.

C5. The **service** element, the **human service** element, and the **communication service** element are specializations of the **abstract service** element.

C6. The **message port** element, the **communication port** element, and the **resource port** element are specializations of the **abstract port** element.

C7. Every **abstract service** element is characterized by 0..n **behavior** elements.

C8. Every **abstract service** element is affected by 0..n **external event** elements by means of the **impact** element.

C9. A **user** element has 0..n incoming **resource port** elements and 0..n **connection port** group elements**.**

C10. A **user** element is affected by 0..n **external event** elements by means of the **impact** element.

C11. A **message flow** element is linked to 1..n **message** elements and holds between two **message port** elements belonging to two **connection port group** elements.

C12. A **resource flow** element is linked to 1..n **resource** elements and holds between 2 **resource port** elements. The **resource flow** element is directed from a **resource port** element belonging either to a **service** or **human service** element and to a **resource port** belonging either to an **abstract service** element or to an **user** element.

C13. A **connectivity** element is directed from a **communication port** element, belonging to a **communication service** element, to a **message port** element, belonging to a **connection port group**.

D. Meta-model formalization

In order to equip the language with a sort of formal grounding, so that smart editors could be defined with validation facilities, we identified SysML [3] a standard language sponsored by OMG (Object Management Group), as a good candidate. SysML comes as a *profile* of UML 2.0, that is, extends the UML meta-model with constructs to enable "system" other than "software" modeling and provides some new diagram types. Therefore, SysML inherits all the advantages of UML: the multi-views representation of a system model; the simplicity of the notation, which is addressed to stakeholders with different levels of technical knowledge; the xml schema for tools interoperability (XMI); and finally the "semi-formal" specification, which has been better clarified starting from version 2.0, that allows model-driven development to take place. Our meta-model is an application of SysML profile tailored to critical infrastructures modeling and, as such, it is a domain-specialization of a subset of SysML. We do this by creating a new profile following the stereotype extension mechanism specified by UML.

Specifically, we consider the components of the *Internal Block Diagram* of SysML, which is based on the *Block* entity. According to the OMG specification, blocks "are modular units of a system description, which define a collection of features to describe a system or other elements of interest. These may include both structural and behavioral features, such as properties and operations, to represent the state of the system and behavior that the system may exhibit".

Figure 1 shows the relationship of the *User* and *AbstractService* constructs of our meta-model with the *Block* entity of SysML. They can have a behavior specified and can be connected with other blocks through ports. However, differently from services, a *User* does not provide functions/resources to other model elements. Note that the *User* construct in our meta-model cannot be mapped to the UML (or SysML) Actor meta-class as we intend the *User* be inside the model (and not part of the environment).

Flow ports are introduced in SysML as a specialization of UML ports "to specify the input and output items that may flow between a block and its environment". *Flow ports* are generally typed with respect to the item that can flow (in, out, or inout). In our meta-model we decided to introduce three port types as shown in Figure 2.

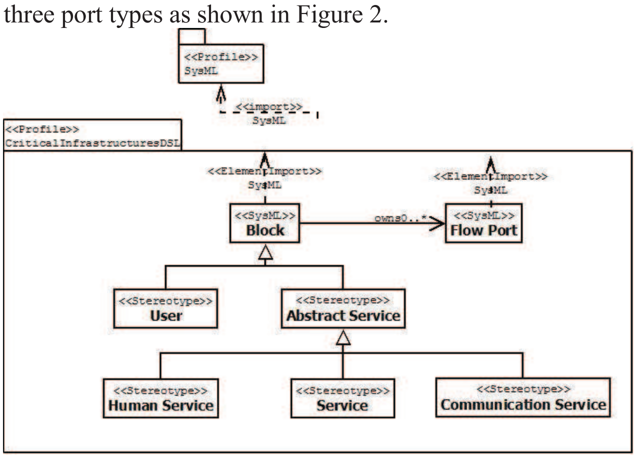

Figure 1: Abstract service hierarchy and user

In order to relate the message flow generating from a service/user with the transport mean that allows it (e.g., internet connection), we identified a particular type of (non-atomic) *Flow Port*, namely the *Connection Port Group*, with the aim of grouping together one or more message ports with one (in) communication port.

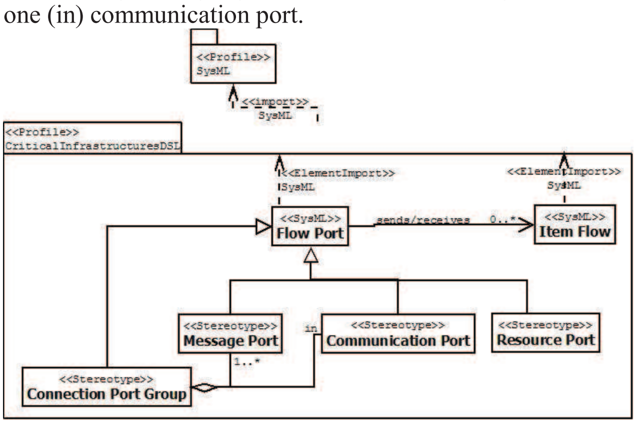

Figure 2: Ports

The specialization of *Flow Ports* in three types obviously requires that also *Item Flow* be specialized accordingly. We omit here the picture for space reasons. The type of the item that can flow through an atomic port (e.g., water, power) in SysML is specified by the *FlowProperty* stereotype, which can be simply a label. In our case, we want to distinguish between: *message*, *connectivity*, and *resource*, which we define as a specialization of *FlowProperty*. Instead, non-atomic *Flow Ports* in SysML are defined through a FlowSpecification object, which is a collection of FlowProperty objects, each referring to a single item. In SysML, items flow through *Connectors*, used to link blocks. For graphical convenience only, we defined a SysML connector specialization for *message flow* to represent it as a dashed arrow line (see Table II below).

As we want to design analysis scenarios for crisis management, we need to represent the events that may happen and what services/users they may affect. Here we want to represent just the type of the *external event*, such as earthquake, flood, and so on, and its "affecting" relationship to one or more scenario entities. Therefore, we intend the event being an abstract element outside the model (part of the environment) but influencing it, and so this definition specializes that of the *Actor* in UML.

Finally, each kind of service or user element, being a UML Class, might be modeled internally through a *Behavior* object, which is the link to one or more behavioral descriptions of the scenario that we will treat as future work.

The following tables include the list of all the constructs and relationships of the proposed meta-model, with the corresponding formal notation describing the extension from the SysML profile and UML references, and the graphical symbol we associated to them to be used in our diagrams.

TABLE I. MODELING CONSTRUCTS

Modeling Constructs	*SysML Specification*	*Graphical Notation*
Abstract Service	SysML::Blocks::Block:: AbstractService	NA
Service	SysML::Blocks::Block:: AbstractService::Service	Service Name
Human Service	SysML::Blocks::Block:: AbstractService::Human Service	Human Service Name
Communication Service	SysML::Blocks::Block:: AbstractService:: CommunicationService	Com. Service Name
Behavior	UML::CommonBehaviors ::BasicBehaviors:: Behavior	NA
External Event	SysML::Actor::External Event	External Event name
User	SysML::Blocks::Block:: User	User name
Message	SysML::Property::Flow Property::Message	Message name
Resource	SysML::Property:: FlowProperty::Resource	Resource name
Connectivity	SysML::Property:: FlowProperty:: Connectivity	NA

TABLE II. RELATIONSHIPS

Relationships	*Definition ….*	*Graphical Notation*
Resource Flow	SysML::Ports&Flows:: ItemFlow::ResourceFlow	Resource name
Connectivity Flow	SysML::Ports&Flows:: ItemFlow::Connectivity	Connectivity name
Message Flow	SysML::Ports&Flows:: ItemFlow::MessageFlow	Message name
Abstract Port	SysML::Ports&Flows:: FlowPort	NA
Connection Port Group	SysML::Blocks::Block:: ConnectionPortGroup	Connection Port Group Name
Message Port	SysML::Ports&Flows:: FlowPort::MessagePort	Message Port Name
Communication Port	SysML::Ports&Flows:: FlowPort::Communication Port	Communication Port Name
Resource Port	SysML::Ports&Flows:: FlowPort::ResourcePort	Resource Port Name
Impact	SysML::Association:: Impact	Affecting

In a UML profile, "well-formedness" rules, such as the constraint listed in sub-section C, can be encoded in OCL, which is a declarative formal language to express properties of UML models. An OCL rule is defined within a context, that is, the element to which some Boolean expression, specified by the rule, should apply. For sake of space, we give here only one example of OCL implementation of the constraints of our meta-model.

C4. A **communication service** element has 0..n incoming **resource port** elements and 1..n outcoming **communication port** elements.

```
Context SysML::Blocks::Block
self. oclIsTypeOf(CommunicationService) implies
(self.attributes->select(oclIsTypeOf(MessagePort))->size()=0) and
(self.attributes>
select(oclIsTypeOf(CommunicationPort).direction='out')->size()>0)
and (self.attributes->
select(oclIsTypeOf(CommunicationPort).direction='in')->size()=0)
and (self.attributes->
select(oclIsTypeOf(ResourcePort).direction='out')->size()=0)
and (self.attributes->
select(oclIsTypeOf(ResourcePort).direction='inout')->size()=0)
and (self.attributes->
select(oclIsTypeOf(CommunicationPort).direction='inout')-
>size()=0)
```

IV. CRITICAL INFRASTRUCTURES COLLABORATION DESIGN PATTERNS

Design patterns are proving to be one of the most promising methodological tools to support building of models and, more in general, ICT artifacts like software programs. Currently, there are several proposals of design patters in different fields, e.g., UML design patterns for software engineering [15], workflow patterns for business process management [16], and ontology design patterns for ontology building [17]. Here we propose to use a particular type of design pattern, the collaboration design pattern devoted to facilitate modeling of interaction and communication exchange arising among emergency services providers and citizens to solve the crisis. In particular, a CDP allows to represent a chunk of the reality where collaboration is performed. Using this approach, modelers can create a repository of CDPs to be reused to describe similar scenarios. As stated in the introduction, here we propose only two CDPs that are described in the following.

CDP1. Clustered Service

Figure 3 shows the clustered service CDP devoted to model collaboration arising among different services working together to either provide or produce or transport a resource. In particular, the objective of this CDP is to model exchange of resources and information. Furthermore, this CDP models the physical connection provided by a communication service and allowing information exchange.

CDP2. Heterogeneous Networking

Figure 4 presents the heterogeneous networking CDP modeling a network of different communication services, guaranteeing the physical connection between two services.

V. EMERGENCY SCENARIO EXAMPLE

The objective of this section is to demonstrate usability and flexibility of the proposed modeling framework by describing an actual emergency scenario after an earthquake [18]. In particular, we focus on the main services, resources and users related to the Italian Civil Protection (ICP) emergency management protocol. For the sake of brevity, we omit some details as our aim is to demonstrate the usability and flexibility of the proposed modeling framework. A detailed description of the scenario is available in [18]. After an earthquake event, the ICP is able to have a global picture of the impact of this event by using sensor networks, simulation tools, and specific expert team reports. The *Mixed Operative Center* (*COM* in Figure 5) is established near the areas mostly damaged by the earthquake. In this example, the *COM* plays the role of final user. Then there are the *Emergency Services*, the *Emergency Call Service*, and the *Lifeline networks*. The *Emergency Services* represent all actors involved in the emergency management protocol. We describe the details about this service using the clustered service CDP (Figure 6). The *Emergency Call Service* represents the network of emergency call centers devoted to receive feedbacks from user in order to assess how well ICP is facing the emergency. The *Lifeline Networks* element models the infrastructure networks (e.g., electrical distribution and telecommunication network, gas and water pipelines, water treatment systems) of the damaged area. Evaluation of the lifeline performances is one of the most important tasks during an emergency to allow rescue teams to properly and safely operate during an emergency. The networks and their dependencies can be further specified using an appropriate clustered service CDP. The *Telco Network* communication service models the connectivity services and resources operating in the area.

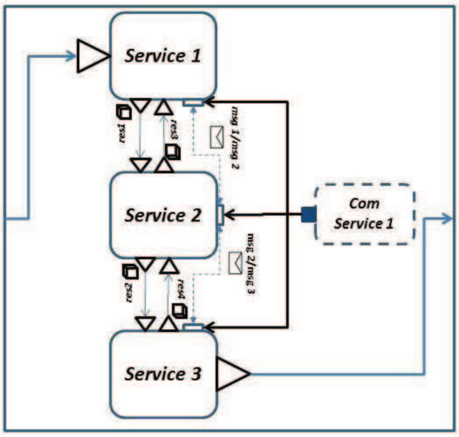

Figure 3 Clustered Service CDP

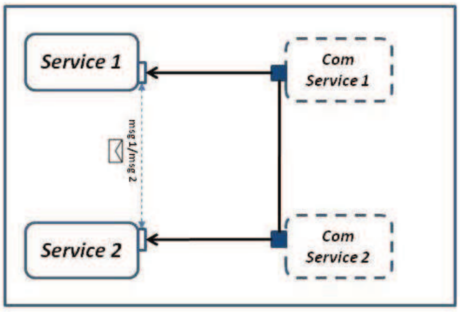

Figure 4 Heterogeneous Networking CDP

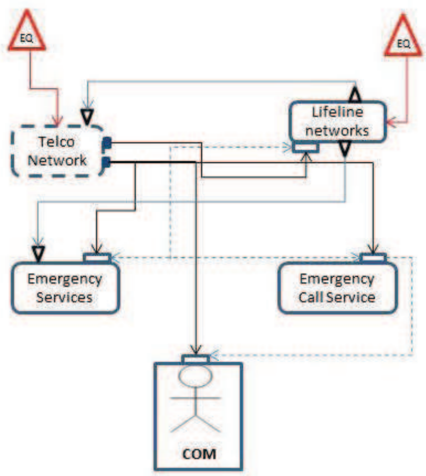

Figure 5 Emergency scenario example

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Using the clustered service CDP, it is possible to refine the definition of the *Emergency Services* to model the coordination messages that are exchanged among the major actors during emergency management (Figure 6). The decisional board is represented by the *National Civil Protection Service* (*SNPC*). The coordination messages aim to gather information about available resources at a national, regional, provincial, local level. The *Direction and Command on site* (*DiComaC*) service is in charge of resources distribution and operations management. All decisions rely on the information about the lifeline performance provided by the *Lifeline Owners* service. The Figure 6 shows also the output resources of the *Emergency Services* to the *COM.*

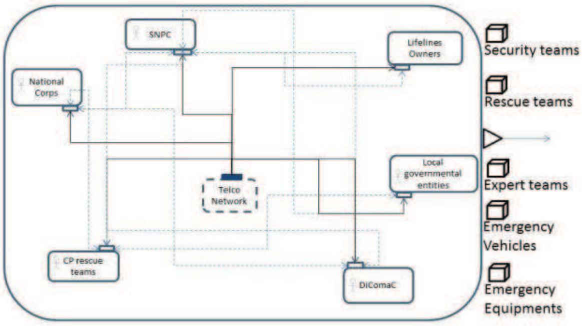

Figure 6 Clustered Service CDP example

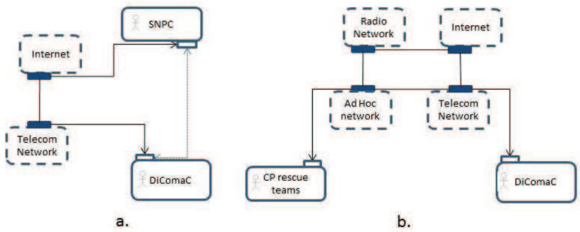

Figure 7 Heterogeneous networking CDP examples

Figure 7 shows how heterogeneous networking CDP can be used to represent different physical connections among services. The *SNPC* uses the public telecommunication network and the internet to exchange messages with the *DiComaC* (Figure 7 a.). On the other hand, for the communication between the *DiComaC* and the ICP rescue teams service it is possible to have several ICT emergency communication channels: telecommunication network, ad hoc network, radio network, and the internet (Figure 7 b.).

VI. CONCLUSIONS

In this paper we presented an approach to build models concerning crisis and emergency scenarios. Our approach is based, first of all, on the CEML language and the related meta model consisting of a set of modeling constructs, a set of relationships, and a set of modeling rules. Then it proposes a modeling methodology based on collaborative design patterns, i.e., reusable solutions to recurrent modeling problems, tailored to model interaction and communication exchange arising during the crisis.

Currently, CEML supports modeling structural aspects of a scenario. We are going to extend the language and the related meta-model to behavioral aspects in a future work. In particular, we intend to use ECA (Event Condition Action) rules [19] and the expressive power of a domain ontology to allow advanced reasoning. Finally, we are developing a simulation tool to permit these models to be simulated.

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Review on Living Labs

Their predecessors, their principles and the diversity of their applications.

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***Abstract*— In this paper, we are going to present the Living Lab concept. Through the last few years, many researchers have been arguing about this controversial term. Thus, there is a plethora of definitions been given to them and many case studies have been conducted, so as to conclude to a generally accepted explanation of this marketing phenomenon. The Living Lab (LL) theory is based on an Open Innovation ground and it co-exists with other marketing and production strategies such as Mass Customization, Open Source, Open Evaluation, Lean Production and so on, aiming to cover customers desires as much as possible. More and more organizations are confronted with highly dynamic external ecosystems. This notion is not an optional activity, but it stems from the fact that consumers seem to be more sophisticated and demanding about what fits their needs better. Colossal companies apply or even, are willing to adapt, these new ways of thinking. Moreover, European countries have already detected the emerging needs leading to the establishment the European Network of Living Labs (ENoLL). In periods of economic recession, innovation prevails and companies need to change their minds and be more "open" and conciliatory. The purpose of this shift is to utilize the majority of information deriving from all kinds of users. Till now, Marketing departments emphasize in approaching only the lead-users. Due to the fact that neither personalization nor customization was discerned, a vast amount of customers were unsatisfied. To conclude, users should have a dual action: they should be both innovators and developers. This will assist products and services to become more adaptive in real markets.**

Keywords-Living Labs; Open Innovation; openness; Mass Customization

I. INTRODUCTION

Innovation is a new way of accomplishing our visions. It may refer to the enrichment of the evolution of a new product or a service. Luecke & Katz (2009) presented one of the many definitions available concerning "Innovation": Innovation…is generally understood as the successful introduction of a new thing or method… Furthermore, it represents the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services. It typically involves creativity, but is not identical to it: innovation incorporates acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. For example, Amabile et al. (1996) propose: "All innovation begins with creative ideas... We define innovation as the successful implementation of creative ideas within an organization. In this view, creativity by individuals and teams is a starting point for innovation; the first is necessary but not sufficient condition for the second".

Innovation is a key-factor of business success [1], but in "many organizations, especially those with a traditional approach, innovation is often only seen as valid when it is completely 'homemade'. This conventional view of thinking, usually referred as "Closed Innovation", completely disregards the growth market of demand-driven innovation" [2] or Open Innovation (Fig. 1).

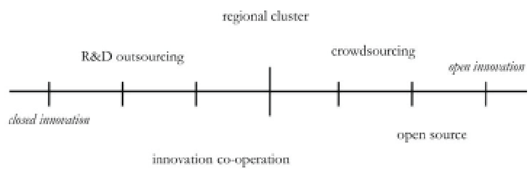

Figure 1. The Innovation Continuum [3]

For innovation to happen, we need something more than the generation of a new idea or an insight. There is a high need of tools, rules and disciplines. Towards this end, emphasis is put on a more general process of creation, progressive thought and action.

Innovation may represent:

- A totally new product, unknown to the customers, produced from scratch
- A new production method
- A new target group
- A new supplier
- The preserve in the field of commerce

As Werner Sombart said [4], Innovation and Entrepreneurship are the core of "creative destruction". Once you destroy something, something new is going to emerge. At the same time, innovation has a dual action. Its first stream is Closed Innovation and the second is Open

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Innovation, where the latter supersede the former, due to practical reasons.

The remainder of the paper is structured as follows: In subsection I.A we present Closed Innovation concept, whilst in subsection I.B we discuss the Democratized Open Innovation. In Section 2, we briefly discuss what LL represents, with a view to the reader's introduction to the field of innovation theory and the correlation between Mass Customization and Open Innovation. In section 3, we attempt to approximate the notion of a LL by presenting the tools needed. Furthermore, previous work, in all over the world and Greece, on LL and open environments is noted. When all is said and done, in the last section we recapitulate the facts and we gravitate to the contribution they have in new life circumstances.

A. Closed Innovation

The first form of innovation that appeared was Closed Innovation. Its key component is control. To begin with, every single industry has to manage the ideas, the production, the marketing, the distributions, the financing and generally every obligation needed. This type of innovation, dominated during the 20th century and it is attributed to the total absence of Universities and governmental interest in the field of exploiting science [5]. This, in turn, had a domino effect, while industries were organizing their R&D systems with the absence of any assistance. The lack of time and the imposition, in order to cooperate with external factors, caused to the companies autarky and unsociability. Company's boundaries were sealed and impenetrable (Fig. 2) [5].

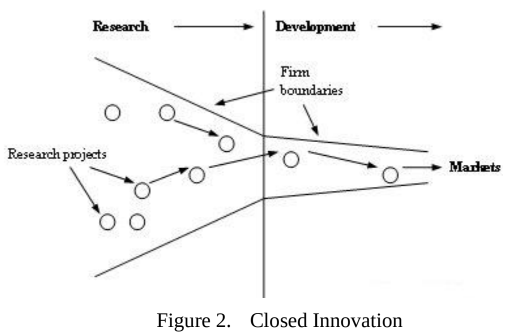

Figure 2. Closed Innovation

Gradually, a plethora of factors caused the erosion of Closed Innovation. Some of those factors are mentioned below:

- Workers' mobility
- Market extension
- Unused external ideas
- Capability for external suppliers

Those mentioned were the vital factors which contributed, in order to build a new knowledge market. Knowledge and information, is not any more company's monopoly, instead it belong to employees, suppliers, customers, competitor and universities. Thus, during these processes Closed Innovation changed into Open Innovation.

B. Open Innovation

More and more organizations are confronted with highly dynamic external organizational environments. MIT professor, Eric Von Hippel introduced the "Democratizing Innovation" concept [6]. In his book, he insists on innovation communities and their significant role towards the openness of innovation. In particular, it is clear that users have no more reservations in revealing their innovative thoughts and actions.

In a world where free speech and knowledge liberty take place, companies can no longer afford the financial weight of research and this is why they prefer to buy or even rent ideas and innovation from external stakeholders. This happens with the purpose of supplementing their internal innovative functions. Of course, it is apparent that Open Innovation is no longer a linear procedure, while innovation is distributed to more than one stakeholder. All in all, the conclusion is that, a company acting under the umbrella of Open Innovation has penetrable bounds, as illustrated in Fig. 3 [5], so as to serve external knowledge relations between innovation networks.

According to R. Freund [2], "Open innovation works from external ideas and knowledge in conjunction with the internal research and development activities. This bidirectional relationship offers new ways to create value. The existence of many "smart" people outside a company is not a regrettable problem for the prosperity of the company, it indicates also an opportunity for the company".

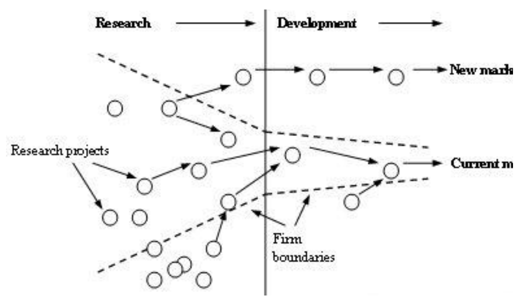

Figure 3. Open Innovation

II. WHAT'S UNDER THE UMBRELLA OF OPEN INNOVATION?

Before starting to elaborate on Open Innovation extensions, lets first focus on the themes found in the existing literature on Open Innovation [2], based on research activities. R. Freund [2] mentions that: "Research activities has been focused on the notion of Open Innovation, business models, organizational design and boundaries of the firm, leadership and culture, tools and technologies, IP, patenting and appropriation, industrial dynamics and manufacturing". Successful Open Innovation depends on the open character of the business model and on network-like interactions between multiple parties in the process of innovation. The foregoing themes and their inspirers are concisely presented in the following Table I, as been presented by R. Freund [2]:

TABLE I. THE THEMES FOUND IN THE EXISTING LITERATURE ON OPEN INNOVATION

Themes	References
The Notion of Open Innovation	Chesbrough, 2003, 2004, 2006; Chiaromonte, 2006; Gassmann & Reepmeyer, 2005; Gaule, 2006; Gruber & Henkel, 2006; Motzek, 2007; West & Gallagher, 2006; West, Vanhaverbeke, & Chesbrough, 2006
Business models	Chesbrough, 2003, 2007; Chesbrough & Schwartz, 2007; Van der Meer, 2007
Organizational design and boundaries of the firm	Brown and Hagel, 2006; Chesbrough, 2003; Dahlander & Wallin. 2006; Dittrich and Duysters, 2007; Fetterhoff & Voelkel, 2006; Jacobides & Billinger, 2006; Lichtentaler & Ernst, 2006; Lichtenthaler, 2007; Simard & West, 2006; Tao & Magnotta, 2006
Leadership and culture	Dodgson, Gann & Salter, 2006; Fleming & Waguespack, 2007; Witzeman et al., 2006
Tools and technologies	Dodgson, Gann & Salter, 2006; Enkel, Kausch & Gassmann, 2005; Gassmann, Sandmeier & Wecht, 2006; Henkel, 2006, Huston & Sakkab, 2006; 2007; Piller & Walcher, 2006; Tao & Magnotta, 2006
IP, patenting and appropriation	Chesbrough, 2003; Henkel, 2006; Hurmelinna, Kyläheiko & Jauhiainen, 2005
Industrial dynamics and manufacturing	Berkhout et al., 2006; Bromley, 2004; Christensen, Olesen & Kjaer, 2005; Cooke, 2005; Vanhaverbeke, 2006

A. *Mass Customization and Open Innovation*

As a consequence, after Open Innovation, new strategies emerged. One of them was Mass Customization. Concisely, Mass Customization meets two converse principles at once. On the one hand there is the price and on the other hand is the personalization of the product. Price, quality, flexibility and velocity must be taken into account.

The notion of Mass Customization was born by Stan Davis in 1987 [7], who supported that, the more you personalize a product, the more competitiveness you gain. Through years, Mass Customization has been described as the opposite of Mass Production and it uses agile processes, which aim to produce a variety of differentiated and personalized products or services.

Trying to integrate consumer in an Open Innovation environment, a new type of consumer, the "procumer" (producer + consumer) [8], emerges. By this we mean that consumers are also able to configure and shape their own products. According to Kondylis, under this contemporary philosophy, people are independent and equal beings, with separated roles and rights without facing any social discrimination. In fact, the acceptance of uniqueness boosted Mass Customization, from a social point of view. Kondylis referred to "Mass Democracy", but he was subconsciously referring to Mass Customization [9].

B. *Living Labs and Open Innovation*

A LL represents Open Innovation environments where real life conditions do exist. User-driven innovation is totally adapted to co-creation processes and Open Innovation Functional Region consists of SMEs Collaborative Networks and Virtual Professional Communities in a Public, Private, People Partnership.

In the previous sub-section, we discussed about Mass Customization phenomenon and this because it is the tie binding Open Innovation and LL. As we have already mentioned, their common characteristic is "openness" [10]. Another reason why we correlate these marketing strategies is the attention paid on the subjective and individual user needs [11].

III. ANALYZING THE LIVING LAB CONCEPT

In the next subsections we are going to present some key issues about LL, so as to make its meaning, function and use clearer.

A. *General Information about LL*

With the purpose of covering new needs in a meta-capitalist society, new practices are indispensable. In LL approach, users act as co-creators and constitute the core of the laboratory. Enterprises focus on user's deeper thoughts and needs. Furthermore, this is the biggest gain for an enterprise, while all the previous years, companies were struggling so as to have access to this fount of knowledge.

For one thing, historically the LL idea appeared during the 90's aiming to grasp new technologies in people's own habitat [12]. The sheer fact is that, LL was established in order to empower coordination in the European area and build a more anthropocentric profile. During the years, LL has been characterized as environments, methodologies or systems. Undoubtedly, they can be used as an anthropocentric research and development area, where everything is co-designed, controlled and evaluated under open and co-operative real world's circumstances.

In Europe, LL represents a very forceful tool in R&D processes. Thus, there is the ENoLL [13] which is a European User Driven Movement. At the moment there are 129 websites correlated with LL, with different scopes of interest. The 129 LL network represent an impressive partnership of:

- Public bodies
- Companies
- Final users

Figure 4. Some Commpanies that Use LL Concept

TABLE II. LIVING LABS IN GREECE

NAME	REGION	PURPOSE	CONTACT
Thessaly Living Lab	Thessaly - Volos	Quality of Life	[13][14]
Lever – Thessaloniki Lever for Open Innovation	Macedonia - Salonica	Innovative ICT Products and Services	[13][15]
LIFENET – UTH	Thessaly - Volos	e-Participation, Social Care, Emergency Network, SMEs Involvement, e-Transportation	[13][16][17]
Chania LL – TUC	Crete - Chania	Smart Cities	[18]
Xanthi LL – DUTH	Thrace - Xanthi	Connecting Industries to University	[19]

Another familiar strategy to LL is Open Evaluation. Selection and Evaluation of innovative ideas or concepts are typical activities of the company itself. “The benefit of Open Innovation is a much larger base of ideas and technologies” [26]. Open Innovation tools e.g., lead user method, toolkits, communities or innovation contests, allow external partners too to evaluate and select. Internal and external (IT-) evaluation of ideas is called Open Evaluation [27]. To handle the huge amount of ideas created by online communities isn’t that easy. A good example is Google’s Project 10^{100} where thousands of people from more than 170 countries submitted more than 150.000 ideas, from general investment suggestions to specific implementation proposals. These ideas were evaluated by 3.000 Google employees [28] and not by the crowd (community).

B. *Definition of LL*

What’s a living Lab? There is a great amount of definition about LL and that’s because it is a really new field of experimentation. Folstad presented three classes for a LL [10]:

- Those for experience and experimentation in software, bears resemblance to open source practices.
- Those witch function as Open Innovation platforms.
- Those where users interact with products and services in order to better develop and shape them.

Indeed, all three classes consider human to be the only source of innovation.

In addition, LL has been defined as “experimentation environments in which technology is given shape in real life contexts and in which (end) users are considered ‘co-producers” [23]. This definition differs slightly from the previous, but emphasizes in experimentation and not on research.

Needless to say, users are not “guinea pigs” but innovators. They aren’t also employees, but an interesting and interested group which contributes to productive processes. A Living Lab environment should include the following stakeholders: users, academia, emerging technology, firms and public.

The utmost partnership is the University-Enterprise-Government one. But here is the problem: “European private enterprises usually assume that their responsibility in the education process should start when the university system ends: once the (new) graduated engineers are recruited. Then, their responsibility is limited to (re)train new employees for specific job positions. Industry pressure to universities looks for including in university curricula the technical content capable of reducing cost and time to getting full usefulness of the recent graduates at the minimum time” [14].

Thus we conclude that there is no good collaboration between the components. And this explains why a LL approach is difficult to be applied, under the existing mentality.

C. *Three Tools to Exploit Living Labs*

We distinguish three kinds of “tools” to exploit a LL:

- Ethnographic research: it is hardly used any technology at all, but only ordinary human observation by other humans, while ‘living together’.
- Observation tools and technology: Such as cameras, microphones, etc.
- Cultural probes: Such as diaries, disposable cameras, voice recorders, etc. which make use of participants’ own observations and self-reporting. E.g., give people a camera and ask them to photograph each relevant occurrence or incident on the subject you are studying, have them return the camera, develop/print the pictures and interview the participant about what he/she has recorded.

The first two are synchronous observation (which could entail a lot of un-useful information), the third is asynchronous.

D. *Some Examples of Living Labs*

The Place Lab [25]: Stands for a consortium of the MIT House_n and TIAX, LLC. They have developed an

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apartment-scale shared research facility where new technologies and design concepts could be tested and evaluated in the context of everyday living. The Place Lab was constructed by TIAX and operated by both TIAX and MIT. It was completed in 2004 and this 1000 square-foot facility is located on the ground floor of a new full-service condominium building between Harvard and MIT buildings.

The home is rapidly becoming a center for proactive health care, distributed energy, learning, communication, commerce, entertainment, and work. This creates exciting opportunities and daunting challenges for companies developing related products and services. Consumers are reaching a limit to the number of stand-alone technologies that they will accept into their lives, and products and services developed and tested in laboratories often fail because designers often make erroneous assumptions about the effectiveness and use patterns in complex natural settings such as homes. The interaction of people with other human beings and with devices leads to unexpected behavior that is difficult to anticipate with focus groups, surveys, and other standard product development and marketing inquiry methods.

On the other hand, the Visible Living Lab [26] represents a Space Management and Real Time Occupancy Tool developed by Johnson Controls company. It is a unique web-based wireless application, which monitors and analyzes, in real time, the position and movement of occupants within a workplace – recording working behaviors, tracking movement and space utilization. The objective is to deliver, through active technology, an intelligent, analytical graphical assessment of the efficiency and effectiveness of the layout, occupancy and utilization of the workplace.

This technology was designed to help corporations identify space occupancy and utilization improvements to increase productivity and reduce the total cost of ownership (save 20-30% of occupancy cost).

The GALILEO project [27]: It is a Living Lab for location-based services that took place that took place in Holland having the assistance of the University of Leiden.

Location-Based Services (LBS) are based on the principle information be made available at any time and place. In the GALILEO project, the European Union is launching 30 new satellites in order to produce a very accurate signal as a basis for this. The current state of technology already offers multiple modular technologies, such as content management, maps, navigation systems like GPS and hardware like PDA’s However, with the coming of GALILEO and the advances of hardware, software and connectivity, a new dimension of location-based services will become possible.

The position signal alone, however, is not yet a location based service. Applications need to relate the position to data e.g., maps, traffic jams, weather forecasts, or even medical records. And in order to deliver this data to the devices, network connectivity is needed – for instance by glass-fiber for stable locations, or even more importantly, wireless networks for mobile devices.

“The living Lab Location-based services is a perfect opportunity for examining whether applications of Satellite-Navigation Technology might have a larger impact upon the region than the life sciences do” [28].

IV. Conclusions and Future Work

When all is said, not only are LL applicable, but they could have a great impact on our daily life. Emphasis should be placed on application domains such as culture and tourism, health and care, mobility and work. Incentives are necessary to enable this development, aimed at cluster-innovation management. We should also highlight LL extensions to Marketing. In this way customers’ interest could be easily captured by involving them directly in design and development processes.

Future work is going to focus on the different ways of networking that can be applied in a Living Lab, so as to serve its purpose in the best way. Some tools that suit the purpose are mathematical, algorithmical and technological. The challenge is to combine them.

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Challenges of Digital Era: Potential and Pitfalls of Social Media

Ethics and Trust in Collaborative Cross-Domains

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***Abstract* – The paper surveys the risks and benefits what a user faces in networked environment and how those challenges can be competed. The question is how to measure a potential or benefits of such complex phenomenon as the collaborative cross-domains in social media. We propose an innovative solution – to consider this in context of digital tools and the entities involved into cooperation-collaboration: core researchers, engineers developing information systems and tools, marketing technologists, users-consumers of services and products. The ways of collecting data and measures for protection privacy issues of data collected online as they were applied during the last two decades are overviewed in this paper. There is no universal law protecting online user's privacy in global world and hardly will it be ever. For a while only the awareness of the users, the Codes of Professional Ethics and a fairness of firms involved into collaboration could help them to avoid pitfalls hidden in social media. The summary table shows at a glance benefits and dangers met in social media by its explorers and users. An example included demonstrates how consumers' data can be analyzed and used by companies for behavioral targeting via clustering model and Bayesian approach in recommender systems.**

Keywords* – *social media; networking; digital footprint; data privacy; safety online; professional ethics; recommender systems.

I. Introduction

Today's Internet is an indispensable condition of normal life. Internet is a remarkable catalyst for creativity, collaboration and innovation providing opportunities that would have been impossible to imagine just two decades ago. Nowadays two contradictory Myths are popular, they stress: (i) unlimited opportunities to user in social media – a techno-enthusiastic vision; (ii) dangers and pitfalls for users of new technologies. Our aim is to investigate these Myths in context of individuals or other entities involved in order to identify WHEN and to WHOM benefits could become a real danger. We will consider how social media can entail both – potential and pitfalls. It is shown that legislation means were not helpful in several countries. The idea that the Codes of Professional Ethics can help users to avoid dangers hidden in social media is the main innovation of this paper and a possible solution.

The World Wide Web rapidly grew since the end of the 90s. An essential base for emerging social media came with Web 2.0. Social media are open, web-based and user-friendly applications that provide new possibilities when it comes to the co-creation of content (blogs, wiki, *Flickr*, *Twitter*), social networking (*Facebook*), the sharing of taste and relevance (*Amazon*, *Google Page Rank*). Besides of a great positive impact, several authors pointed at the disruptive potential of social media, when collecting and sharing consumers' information [1][2].

The entities involved into a cooperation-collaboration are: researchers in core principles and methods, informatics engineers developing systems, networks and applications, marketing technologists, users providing data and the users-consumers of services and products provided by firms involved into entire process of social media development.

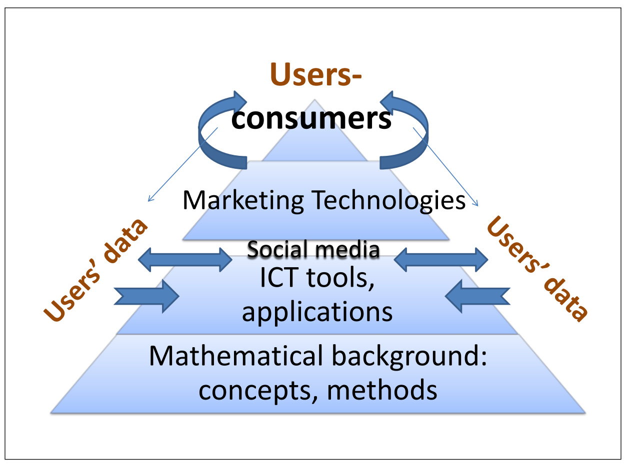

Figure 1. Collaborative cross-domains and users in a process

Fig.1 illustrates how these collaborative cross-domains, theoretical and applied, interact among each other and involve the users in a process. Users' data are the object of investigation, the main goal of a whole process is to focus on satisfaction of users' needs and to ensure profitable business. It is interesting to notice that the mathematical background and principles used in new technologies is almost the same as they were developed in previous centuries. Clustering and decision theory, classification rules for multidimensional data, Bayesian network models – to mention only a few of those methods and models what are widely used nowadays in creating modern information communication technologies (ICT) tools and applications for data mining and analysis.

Traditionally, data were gathered using surveys, public records and questionnaires in a very labor intensive way. As digital interaction has become the norm, the labor intensive gathering has become redundant. On line users now present all data via their digital footprint and social graph.

The definitions and explanations of concepts are given in Section 2. Section 3 is devoted to a short overview of extremely rapidly evolving ICT situation, the problems emerging there and the attempts to solve them. Section 4 contains an example – one selected algorithm to demonstrate how data are used to construct a proposal to user. Section 5 considers the Codes of Professional Ethics as one of possible solutions of emerging problems.

II. Definitions and Identification of Concepts

A. *Digital Footprint*

A digital footprint is a trail left by an entities interactions in a digital environment; including their usage of TV, mobile phone, internet and World Wide Web, mobile web and other devices and sensors [3]. Digital footprints provide data on what an entity has performed in the digital environment and are valuable in other *social media* services [2][3]. In social media a digital footprint is the size of an individual's online presence as it relates to the number of individuals they interact with.

A digital footprint is a collection of activities and behaviors recorded when an entity (such as a person) interacts in a digital environment. It may include the recording of activities such as system login and logouts, visits to a web-page, accessed or created files, or e-mails and chat messages. The digital footprint allows interested parties to access data for data mining or profiling purposes.

Early usage of the term focused on information left by web activity alone, but came to represent data created and consumed by all devices and sensors [2]. Footprints are about where we have been, for how long, how often, and the inter-relationships – for the most part they are memories and moments. But digital footprints are not about user' identity, passport, bank account or social security number.

B. *Web Browsing and Digital Shadow*

The digital footprint applicable specifically to the World Wide Web is the *internet footprint*; also known as *cyber shadow* or *digital shadow*, information is left behind as a result of a user's web-browsing activities, including through the use of cookies. The term usually applies to an individual person, but can also refer to a business, organization, and corporation or object [3], let us call them stakeholders.

Information may be intentionally or unintentionally left behind by the user; with it being either passively or actively collected by other interested parties. Depending on the amount of information left behind, it may be easy for other parties to gather large amounts of information on that individual using simple search engines. Internet footprints are used by interested parties for several reasons, including *cyber-vetting*, where interviewers could research applicants based on their online activities.

C. *Behavioral Targeting*

Behavioral targeting is a new marketing technique used by online publishers and advertisers to increase the effectiveness of their campaigns. Behavioral targeting uses information collected on an individual's web-browsing behavior, such as the pages they have visited or the searches they have made, to select which advertisements to display to that individual. Behavioral marketing can be used on its own or in conjunction with other forms of targeting based on factors like geography, demographics or the surrounding content. On line users now present, most often without their conscious awareness, all data via their *digital footprint* and *social graph*. Behavioral targeting is illustrated in Section 4.

D. *Social Graph and Social Network*

A graph is an abstract concept used in discrete mathematics; the *social graph* describes the relationships between individuals online, as opposed to the concept of a *social network*, which describes relationships in the real world [3] but nowadays these concepts are merged. The data what users provide include preferences, activities, social, economic and demographic facts. Consumers are now unconsciously offering, as a raw data feed, their entire *digital footprint* which includes new data about friends, linkages, location, influences, content created, games, attention and much more from web, mobile and TV. These data streams come in real time; this is an exceptional peculiarity of our modern time.

E. *Social Media as Consumer-Generated Media*

Social media are media for social interaction, using highly accessible and scalable publishing techniques. Social media use web-based technologies to turn communication into interactive dialogue. Social media is also defined as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, which allows the creation and exchange of user-generated content" [4]. A common thread running through all definitions of social media is a blending of technology and social interaction for the co-creation of value.

There are various statistics that account for social media ever growing usage and effectiveness for individuals and organizations worldwide. Such usage of social media allows digital tracing data to include individual interests, social groups, behaviors, and location. It is important to notice that data can be gathered from sensors within devices, collected and analyzed without user' awareness.

III. Challenges and Problems

A. *The Potential and Pitfalls of Social Media*

The diffusion and usage of social media applications have been growing so dramatically that these applications and services have become a mainstream. The research has revealed the explosive development of social computing & informatics activities, social networking sites attract the millions of new visitors, the millions of user-created videos are uploaded onto photo and video-sharing sites [5].

In spite of enormous growth the researchers need to be aware of: (a) different degrees of user participation: active users (contributors) versus passive users; (b) usage divides: young people are quicker to adopt social media. Both aspects force researchers to reflect critically on the potential and pitfalls of a social media. In addition to the aspects mentioned above, we may do not neglect other aspects of a 'dark side' of Web 2.0. More specifically, the active role of the user – as a contributor of so-called 'user-generated content on platforms such as *YouTube*, *MySpace* and *Facebook*' – seems to lead to new forms of exploitation and reorganization of labor in informational capitalism [6].

Users are becoming producers by actively contributing with content and interaction. Simultaneously, however, they constitute an audience commodity that is sold to advertisers. Other aspects that should be taken into account are the issue of trust in information found, privacy and surveillance [7]. The question is to what extent users are self-reflexive about and sufficiently aware of changes in privacy and personal data, i.e., how their digital activities are monitored, processed, analyzed and commoditized by third parties.

TABLE I. SUMMARY OF FINDINGS AT A GLANCE

Actors	**Results of Online Involvement in Social Media**		
	Activity	***Potentials***	***Pitfalls***
Users-consumers	Consuming	Wanted offers	Spammed
Users	Providing data (un)conciously	Targeted adds, self promotion	Privacy infringement
Firms	Profit seeking	Profit, products tailored to needs	Missing techno-knowledge
Marketing	Collecting digital footprints	Effective behavioral targeting, adds	Loss in general if only the economic goals focused
Media Developers	Data mining, strategy for monitoring	Using Internet as new currency in a digital world	Illegal massive data, forensic process
ICT Engineers	Creating soft and tools for networks, DB, applications	Interesting framework for new apps, increased competence	Work for third parties, to become involved into unfair game
Researchers	Developing new concepts, adapting the old one to new situation	Study of new power relation in computer mediated society, new science areas	Loss of IPR* when partners in applications earn a wealth

IPR* – Intellectual Property Rights

The outline of multifaceted investigation of social media and their potentials and/or pitfalls across the various actors-stakeholders of social media is given in Table I, where we summarize the main potentials and pitfalls possible to occur in whole process. It is not a surprise, that all of identified stakeholders have benefits as well as face various dangers in new media. We state that in many cases those dangers can be eliminated by fair role of researchers in the process of policymaking and applying ethics in science and profession. The role of ICT engineers is basic; they can stop malicious use of data by rejecting "dark deals". Now we will consider trials to regulate situation by legislation issues.

B. Trials to Regulate Online Privacy Issues

Many online users and advocacy groups are concerned about privacy issues around doing some type of targeting. Data privacy issues across the countries and trials to regulate behavioral advertising as well as governmental policies concerning social media during the last two decades will be dealt here shortly. The behavioral targeting industry is trying to keep all information non-personally identifiable or to obtain permission from end-users (so called a notice-based approach) [8]. But privacy experts and advocates widely agree that the notice-based model is outdated. Few consumers read privacy policies, and if they do, most consumers are not able to understand the complicated jargon used in such policies to describe increasingly complex data collection practices. Consumers have not complained about data collection online, mainly, because in most cases the collection is invisible to them.

The European Commission (EC) raised a number of concerns related to online data collection (of personal data), profiling and behavioral targeting, and is looking for "enforcing existing regulation" [9] mainly by fixing a time how long collected data have to be stored and how deleted by user. EC initiated the research envisioning a future of digital Europe; the four scenarios are described [10].

The Federal Trade Commission (FTC), an independent agency of the United States government for the promotion of consumer protection adopted a self-regulatory approach since 90^{th}. More recently, FTC has signaled intent to revisit its traditional notice-based framework and will recommend new policies on online privacy & behavioral targeting [11].

Social networking sites provide direct access to the public, but unchecked, these Web 2.0 tools sometimes can do more harm than good. Governments are finding out the hard way that social media is a double-edged sword [12].

C. Is it True that There is no Global Solution?

The potential and pitfalls of social media and several trials to regulate situation in various levels were mentioned here. We have dealt with only a few instances on persons' privacy problems in digital age of an active user of Internet – only one possibility of many others, available as modern world opportunities. Networked world is a world without limits; it is different from a previous world in principle when human beings were accustomed to live thousands of years, having own territory, country and the law system specific to that country. A global world has no separate territories and no common juridical law system applicable to a networked global world for a while. For example, the user is searching online when being in the country *A*, the server providing information of interest is located in the country *B*, the information was collected from other several countries, say *C*, *D*, *E*. Moreover, a company engaged in behavioral targeting is situated in the country *F*. If some illegal action is suspected in a whole chain of these activities, which country's law should be applied? Usually, the attempts to apply, say, intellectual property rights from offline case do fail in online situation. Not talking about much more complicated situations concerning so called *cyber attacks* or *cyber wars*, happening time to time and showing a tragic vulnerability of networks and systems as well as disabilities of security technologies currently available. Wiki Leaks' recent adventures, as well as the latest events in the North Africa, should lead to rethinking a lot of things. The mass political protests in Tunis and Egypt at early 2011 when *Facebook*, as it was said, helped to organize the meetings really demonstrated the power of social media even in such countries where one can't expect. The first reaction of the government there was to forbid a social media but soon it was converted into usage of it–for propagation of own aims.

IV. How it Works? – an Example of Recommendation Algorithm with Details

Two basic entities which appear in any Recommender system (RS) are the user (consumer, customer) and the item (also referred to as product, service). A user is a person who enters RS providing his opinion (often unconsciously) about various items and receives recommendations of new items from the system. The goal of RS is to generate suggestions of new items or to predict the utility of a specific item for a particular user – to apply a behavioral targeting.

Any RS consists of three parts: the input, the information filtering, and the output level. The input part is a workspace of Data Mining, as seen in the Fig. 2. In the second step – various information filtering algorithms are used. RS is producing recommendation or prediction in the output level.

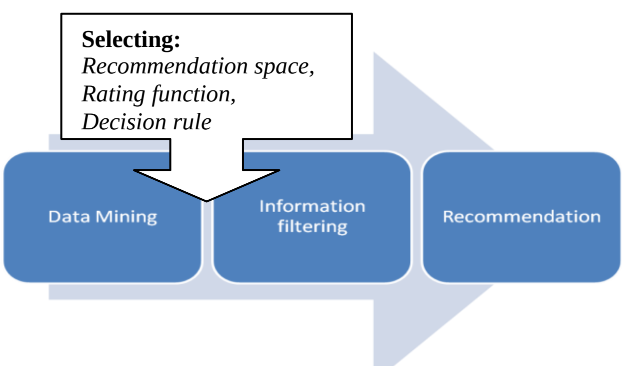

Figure 2. General processing in Recommender system

The input of RS depends on the type of information, filtering algorithms selected. Usually the input data can be divided into three main categories:

1. Rating (or vote) expresses opinion of user on the item in question; usually it has a numerical value (say, from 1 to 10 or often a binary format: 0 and 1 is used).

2. Demographic data providing information about the age, sex, education and etc. of users.

3. Content data, which are obtained from a textual analysis of the user' documents related to the items already rated and the digital footprints collected.

As a rule, RS is collecting information about users and often stores their private data. This is appropriate for RS with the input data belonging to the above-mentioned categories 2 and 3. Demographic data analyzed together with content data – private e-mails, chats, blogs allow identifying the user, and the question is only an acceptable scalability.

Let us formalize a bit the approach. Let m be the number of users u_k in the set $U = \{u_1, u_2,..., u_m\}$ and n – the number of items i_j in the set $I = \{i_1, i_2,...,i_n\}$. Let the opinion of the user u_k about the item i_j is denoted by r_{kj}. All these ratings are collected in the rating matrix of size m x n denoted by $\boldsymbol{R}$. Often a time dimension is added to the user-item space. The item i_j itself can be a vector as well, containing the features as components. In a general case $\boldsymbol{R}$ is a multidimensional space. Each user u_i where $i = 1, 2,..., m$, has rated only a part of items in I therefore he has a list of items I_i as a subset of I, for which he expressed his opinion about. The matrix $\boldsymbol{R}$ then has not rated values, often numerous. There are various techniques [13] for tackling the problems caused by those not available ratings.

An example of the rating matrix with the scale from 1 to 10, where not available ratings are marked as NA, is shown in the Fig. 3. The simplest problem to be solved here is to predict the rating r_{15} of the target user u_1 by joining the opinions of other users, what are most similar to u_1. Various similarity measures are helpful: from the classical Pearson correlation to the k-nearest neighbor rule.

	Item i_1	Item i_2	Item i_3	Item i_4	Item i_5
User u_1	5	7	5	7	**?**
User u_2	5	NA	5	7	9
User u_3	5	7	NA	7	9
User u_4	6	6	6	6	5
User u_5	NA	6	6	6	5

Selections	
	Target user
	Most similar to target users
	Ratings to be used in prediction
	Rating to be predicted

Figure 3. An example of user-item rating matrix $\boldsymbol{R}$

A large part of the information filtering algorithms capture user's opinions on different products and similarities between users. Working through the filtering results, RS generates a proposal for the consumer.

The output of RS can be a Recommendation or a Prediction of rating. The Prediction is a numerical value r^*_{aj} which means a predicted rating of the user u_a to item i_j. The Recommendation is expressed as a list of T items, which the user would like the most, according to the system.

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Recommendation approach can be content-based or based on the collaborative filtering but some authors indicate that results are better by combining collaborative filtering methods and content-based methods in RS. In this case the Bayesian method is used often.

Let us outline the Bayesian approach to RS in networking. Suppose that we have a number of features for products, by which we need to divide products into categories or classes C_j, j = 1, 2,…, p in order to make better recommendations to users who enjoy the products in their category. The probability of product, say D, being in class C_j is calculated, according Bayes theorem, as follows:

$$P\,(C_j\,|D) = P\,(C_j)\;P\,(D\,|C_j)\;/\;P\,(D),\ j = 1, 2,\dots, p, \quad (1)$$

where $P(C_j\,|D)$, $P(C_j)$, $P(D|C_j)$, and $P(D)$ are *posterior, prior* probabilities, *the likelihood*, and *the evidence*, respectively. Usual assumption is that the product D has a set of features (F_1,...,F_s) that are conditionally independent, then equation (1) can be expressed as follows:

$$P\,(C_j\,|D) = P\,(C_j)\prod_{i=1}^{s} P\,(F_i\,|C_j)\;/\;P\,(F_1,...,F_s). \qquad (2)$$

In order to apply this formula we need to know or evaluate a priori the probability of each class $P\,(C_j)$ and to know a distribution of features F_i which the most often is assumed to be the Gaussian. An estimate $P^*(C_j)$ for $P\,(C_j)$ can be derived from training samples.

The product D is assigned to that particular class for which the posterior probability $P\,(C_j\,|D)$ calculated by formulae (2) is the greatest one and will be recommended to other users belonging to that class.

What results can be expected by stakeholders in this example? Users are asked to rate products. If they do, they participate process consciously and will receive targeted adds. A negative aspect could be if a user is misclassified or the proposals become too interfering. Firms and marketing have an effective behavioural targeting if they do a fair business and do not sell the collected data to third parties.

V. Codes of Professional Ethics

Investigation of situation concerning privacy matters and a safety of an individual searching Internet or participating in other social media, described in the previous sections of this survey, shows that there are no universal means to overcome possible dangers and to enjoy only the potentials of social media. Self-regulation approach is not working, as interested parties and advocacy groups expected in early days of emerging ICT; the law system in a global level is not available and hardly will be available in real time.

Nevertheless, for a while there is a simple solution – each entity involved into networking, collecting data and marketing activities has to follow the own **Code of Ethics**. The Ethics of Science is applied already many years in all fields of a biomedical and biotechnological research and several others. Now it is a time to discover that the Code of Ethics in Engineering Science has become a pressing need in digital age and especially in the context of new media. In this section we will survey shortly the activities over the world on Science and Professional Ethics fostering.

A. Activities in the North America Continent

Probably the oldest source (issued as early as 1912) is the Code of Principles of Professional Conduct of the American Institute of Electrical Engineers [14], now it is accessible online via Library of the Center for the Study of Ethics in the Professions (CSEP). Very soon this Code will be celebrating a hundred years! General principles remain the same through centenary. CSEP Library [15] contains many other Codes of Professional Ethics.

The Online Ethics Center is maintained by the National Academy of Engineering and is a part of the Center for Engineering, Ethics, and Society at the Center for the Study of Ethics in the Professions at the Illinois Institute of Technology; they are working together [16]. It provides readily accessible literature and information, case studies and references, and discussion groups on ethics in engineering and science. Numerous sample scenarios on issues surrounding Internet privacy can be found in [16]. Many of the contemporary Code of Ethics with principles and guidelines are well applicable in situation of ethics and trust needed in the collaborative cross-domains.

B. European Activities in Fostering Science Ethics

The intense discussions in the research community on the appropriate approaches to maintain high standards in research practice were initiated by the European Science Foundation since 2000. The concerns were raised that the “self-regulation of science, based on traditional approaches was not sufficiently meeting heightened public and political expectations” [17]. This resulted in survey stating that the need has become more pressing today, as national research organizations encourage and support their research communities to engage in collaborative research efforts across borders. The report, where 18 countries covered in detail, provides a basis for an overview of mechanisms to promote good research practice and to handle cases of alleged research misconduct that exist in different European countries. The report contain recommendations to learned societies, research-funding agencies, research-performing organizations. The codes/guidelines analyzed in the report are different in two main aspects. On one hand there are documents which cover all research disciplines and on other hand those presenting the perspective of certain research fields. The situation connected to misconduct in the social media collaborative cross-domains could be improved in the light and recommendations of this report [17].

C. The Global Ethics Observatory

The Global Ethics Observatory (GEObs) – a free global repository of searchable information on ethics institutions, experts, legislation, codes of conduct and teaching programmes around the world [18]. The GEObs is a system of databases developed and maintained by UNESCO to provide information on ethics in science and technology, launched in December 2005. It consists of five independent databases: experts in ethics; key institutions active in areas of ethics; Ethics Teaching Programmes; Ethics-Related Legislation and Guidelines; Codes of Conduct. This database currently contains 151 codes of conduct of which over 30 are issued by Europe-based institutions.

VI. CONCLUSION AND FUTURE WORK

In the rapidly evolving digital age our theoretical frameworks at hand and used ICT tools, applications must be critically investigated. The concept of mass self-communication provides an interesting framework for studying new power relations in our computer-mediated society; however, it is not free of criticism. This survey summarized the positive and negative sides of social media.

Positive Aspects. Analyzing ever-changing situation during a couple of last decades the positive impact was identified: the users are becoming producers by actively contributing with content and interaction; the firms using personalization of user data are able to offer them innovative products and services and work more effectively. It could lead to new products tailored to the needs of Internet users. Targeted advertising allows customers to receive offers and information about goods and services in which they are actually interested.

Negative Aspects. The benefits mentioned above in real world too often are shadowed by malicious use of data and information. Additional risks to trust arise in the domain under investigation, mainly due to its potential pervasiveness, large scale and involvement of users. The Internet companies collect the massive volume of data. Users constitute an audience commodity that is sold to advertisers. Very often users are left ignorant or they are not informed properly how their digital activities are monitored, processed, analyzed and commoditized by third parties.

Future Tasks. The security technologies have to be developed to address the malicious use of data and information. The aspects that should be taken into account are the issue of privacy and surveillance and special means have to be developed for evaluating a safety of social media, similarly to the quality of digital repository evaluation [19][20]. “The digital community was failing to decently answer the challenge of how to measure or even make sense of the results and impacts of embracing this new world” [21]. The role of researchers in the process of policymaking, applying Codes of Professional Ethics is the most important. For a while only the means increasing awareness of the users, the professional Codes of Ethics and a fairness of firms involved into collaboration could help to avoid pitfalls menacing in social media. The guidelines of Codes of Professional Ethics could help at least partially to contest challenges of social media by all stakeholders involved, while security technologies and laws ensuring privacy in a global world without borders and limits are not developed.

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User Innovations Through Online Communities From the Perspective of Social Network Analysis

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***Abstract*—Organizations have begun to leverage both internal and external sources for innovation. Specifically, organizations are increasingly relying on end users that engage via user innovation communities to identify potentially valuable ideas for an organization to adopt. However, research has shown that organizational success in leveraging these communities relies on a thorough understanding of how users behave within the community. The purpose of this manuscript is to provide further analysis and develop a richer understanding of user behavior in the Dell IdeaStorm user innovation community. Findings illustrate different patterns of user behaviors when they comments or rate posted ideas.**

Keywords-user innovation; open innovation; online community; social network analysis.

I. INTRODUCTION

Organizations have widely acknowledged the role of innovation in economic growth. However, not all firms are successful when appropriating returns from innovations. Consequently, research is needed to understand the innovation process and how organizations can increase the likelihood of positive gains from innovation. According to [1], there are three building blocks which explain this phenomenon: 1) the appropriability regime, 2) the complementary assets, and 3) the dominant design paradigm. These building blocks are still central to the analysis of innovation in the 21st century.

Innovation can be divided into two primary types: product and process innovations. Both of them have traditionally taken place within the boundaries of a firm, and have been seen as the primary source of competitive advantage for organizations. This suggests the need for control of critical aspects of the innovation process in order to protect their competitive advantage. [2]. However, a new form of business innovation, called open innovation, has strongly emerged during the last years [3]. Open innovation means a firm opens up its boundaries to identify and capture innovative external ideas and knowledge to create value beyond the firm's limited resources and capabilities [4], [5].

Commercial firms, unlike individuals, face the additional problem that free revealing of its innovation process will benefit their competitors [6]. However, there are two conditions that explain why firms would expose themselves to such risk [7]. First, sharing may provide firms with valuable selective benefits, that are unavailable to free-riders [8], and which could be classified into economic (reduced production cost or enhanced value of complementary assets), social (improved reputation and image), and technological (increased network externalities and exploration of new technologies) [9]. Second, the potential negative impact of sharing may be quite low compared to the expected private gains. The act of revealing source code via the Internet is nearly costless, suggesting that even the prospect of minor benefits is sufficient to induce community participation [8]. Recent developments along the open innovation paradigm [4] suggest that firms need to reject the idea that control implies ownership and open themselves up to the broad array of resources available to the firm. To do this, managers must find new ways to conceptualize the 'post-Chandlerian firm, where innovation proceeds along less hierarchical lines [10] since "the network of relationships between the firm and its external environment can play an important role in shaping performance" [11].

Based on virtual world technology and using open innovation mechanisms, consumers and manufacturers jointly develop innovations in a media-rich and interactive environment. The idea of involving customers and end-users as co-innovators has become highly popular [12]. For example, Osram, a light manufacturer, started an idea contest and invited Second Life residents to contribute ideas on the topic of lightning; Toyota Scion launched a virtual car model and encouraged participants to modify and customize their cars. Before Aloft, a new hotel concept from Starwood Hotels was built, a virtual mockup was discussed, evaluated, modified, and further developed in Second Life, resulting in several changes to the overall design [13].

Prior research has focused on identifying the factors that influence an organization's adoption decision when innovations come from outside the organization's formal boundaries [14]. More specifically, [15] and [16] have examined how participation in open innovation communities influences the innovative and financial performance of the services sector and firms commercializing open source software, respectively, revealing that participation is more strongly related to performance for firms that also exhibit high levels of

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social participation, for firms of larger size, and for firms with high R&D intensities [15].

The aim of this paper is to increase our understanding of the social interactions that occur within a user innovation community. Using Social Network Analysis (SNA), we propose that insights into member roles and the nature of interactions among individuals and the organization can provide additional guidance to organizations that utilize these communities. Moreover, SNA can be considered an appropriate tool for identifying lead users that can help an organization identify promising ideas and/or users to adopt or follow.

This paper is structured as follows. First, the importance of user innovation communities is highlighted. Then, the methodology of our research is shown. Section 4 introduces to our case of study. Results are shown in section 5. And finally, Section 6 stands for our conclusions.

II. User Innovation Communities

Technology is enabling new forms of producer–consumer collaboration in an organization's innovation process. As opposed to the traditional models, the development work in the open innovation model is based on the needs and co-creation activities of a community of users that interact with one another and the organization [4]. User innovation communities can be defined as "distributed groups of individuals focused on solving a general problem and/or developing a new solution supported by computer mediated communication" [14]. It is a customer-centric innovation process, where new products and/or services are co-created together. Open innovation characterizes an innovation process where the customer is involved as a source for ideas, technical solutions, design or even first prototypes [17]. Instead of the firm creating innovations and exchanging it with their customers, during open innovation consumers take an active role and co-create these innovations together with the company [18]. For virtual co-creation the participation of engaged customers is crucial. Customers' actual experiences and their beliefs about the expected benefits significantly influence their actual continued participation in such forums.

This creates a context that is highly different from traditional Internet applications. To co-create value, the firm and its customers representing the open innovation community must reconcile their objectives and define both the role and effort required from each party and an equitable division of the returns [4]. In fact, changing the focus from ownership to the concept of openness in projects requires a reconsideration of the processes that underlie value creation [19]. The process of co-creation is mainly influenced by the user, and therefore also the experience largely depends on the users [17].

Firms participate in user communities because they feel that they can influence the direction of development, gain legitimacy to use the innovation, and benefit from the expertise of a large base of skilled users [2]. Strong ties to the developer communities allow firms to access important complementary assets [1] such as technological know-how and information on emerging user needs or interests that facilitate the appropriation of rents from internally developed innovations [2], [20]. Thus, the work developed in the user community can be used in conjunction with the firm's internal expertise to develop competitive products and/or services. Firms that engage in these communities, therefore, have a certain type of business model [21], [4], which works as a cognitive script and shapes the mindset of the firm towards looking for ideas in the community. Although this engagement in the community creates value for the firm, it is more difficult to appropriate because competitors may interfere. Firms with a strong knowledge base are in a better position to generate unique configurations of internal and external resources, which support their capacity to generate and appropriate returns from innovations [2], [22]. The presence of such "complementarities" [23] thus suggests that a firm's access to community resources is conditioned by its internal R&D activities. As firms with technological know-how can make more valuable contributions to the communities, they are also more likely to obtain valuable resources in return that contribute to higher performance. Firms with strong technical know-how have the absorptive capacity to recognize, assimilate, and apply the knowledge resources that are available in the community [24]. Similarly, community engagement stimulates the discovery of new opportunities that may redirect a firm's internal R&D towards more lucrative business activities [16].

III. Methodology

Social Network Analysis has been frequently used to analyze the behavior of online communities. The idea consists of representing communities as a graph $G = (N, E)$ where N denotes a finite set of nodes and E denotes a finite set of edges or arcs such that $E \subseteq V \times V$ [25]. In the case of online communities, nodes represent users, while arcs represent possible interactions among users. The number of vertices represents the number of community members and the arcs represent the interactions among them.

Density is defined as the number of lines in a simple network, expressed as a proportion of the maximum possible number of lines. However, this definition does not take into account valued lines higher than 1 and it depends on the network size. A different measure of density is based on the idea of the degree of a node, which is the number of lines incident with it [26]. A higher degree of nodes yields a denser network, because nodes entertain more ties, and the average degree is a non-size dependent measure of density.

IV. Case Study: DellIdeastorm

Dell IdeaStorm [27] is a user innovation community where end users freely reveal innovative ideas with community members and Dell [14]. This website represents a new way to listen to customers on how to build the best products and services. Through IdeaStorm, customers can post their ideas about existing or new Dell products, services and operations [28]. Moreover, users have the option of voting for the best or the worst ideas as well as discussing the ideas with other users. Using this information, Dell shares the ideas with top management, department managers, and key employees that work within relevant subject domains.

Users can comment on ideas by other (identified by an alias) as well as promote or demote ideas using the IdeaStorm vote feature. Promotion means adding ten points to the current rating of the idea while demotion means subtracting ten points. Dell takes part in the community commenting ideas through the user with alias *bill_b*.

Using the proposed methodology, the community can be modeled as a graph considering users as nodes and arcs as interactions among users. Using comments, promotions and demotions to set arcs among nodes, up to three graphs can be obtained for representing the community: 1) comment, 2) promotion, and 3) demotion. The analysis of obtained graphs can illustrate different pattern of user behavior when commenting or voting on ideas.

V. RESULTS

An automatic tool has been programmed for extracting reported ideas in IdeaStorm one year beginning January 2010. A total of 1482 ideas have been processed, obtaining the data for each idea detailed in Table I.

TABLE I. DATA EXTRACTED FROM IDEASTORM

• Idea name
• Author
• Date
• Comments o Number of comments o Authors who posted these comments
• Promotions o Number of received promotions o Authors who suggested promotions of the idea
• Demotions o Number of received demotions o Authors who suggested demotions of the idea

A. *Comment network*

The comment network is built as follows: nodes are users and arcs are set between users commenting an idea and the author who posted this idea. Thus, ideas represent the basic unit of analysis. This step is repeated through the 1482 extracted ideas. The obtained graph is a valued directed graph, where incoming links means comments received by a user. **Figure 1** shows the obtained network. The total number of users (nodes in the network) is 1361. These users can be categorized as:

- Users who have posted at least one idea (n = 1153)
- Users who have commented ideas but they have never posted an idea (n = 208)

In-degree means the number of arcs that a node receives. In our comment network, in-degree of a node represents those users whose ideas are most commented. Actually, nodes of **Figure 1** have been represented with an area proportional to their in-degree. 808 users exhibit an in-degree value of 0 (the 208 user who have never posted an idea plus those users who posted an idea but never received a comment). The number of users with an in-degree higher than 1 is 24. Obviously, user with alias “bill_b” shows an in-degree of 0, as the role of this employee from Dell is commenting ideas, not posting them. Table II details the in-degree partition, showing only those authors with low and high in-degree value.

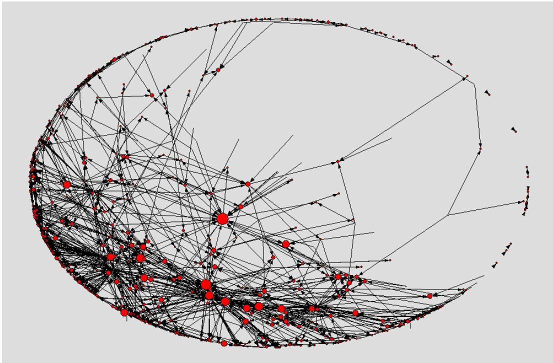

Figure 1. In-degree 2010 comments network.

TABLE II. IN-DEGREE PARTITION.

Partition	Freq	Representative Alias
0	808	bill_b
1	258	2tall
2	132	ARMADILLO
3	50	Allie
...	...	...
38	1	winoffice
50	1	Rebel333

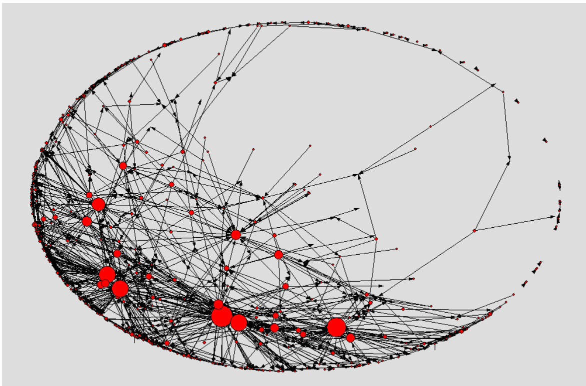

Figure 2. Out-degree 2010 comment network.

Figure 2 shows the out-degree network. Size of nodes is now proportional to the number of arcs a node sends (posted comments). As expected, 953 users of Figure 2 have an out-degree of 0 while just 408 users have posted at least one comment, following the typical participation inequality of online communities (the majority of contributions are posted by small fraction of the community) [29]. The number of users with an in-degree higher than 10 is 25 (nodes with a bigger area in **Figure 2**). The user in the second position of out-degree ranking is "bill_b" (from Dell), with an out-degree value of 111. Table III details the out-degree partition, showing only those authors with low and high out-degree value.

TABLE III. OUT-DEGREE PARTITION.

Cluster	Freq	Alias
0	953	000hmy
1	238	A..J..
2	70	BlinneOrlaith
3	33	Air2Ground
…	…	…
111	1	bill_b
131	1	jervis961

B. Promotion network

The promotion network is built considering users as nodes and arcs as the links between users promoting an idea and the author who posted this idea. In this case, the network size is 2151. Again, it can be distinguished among users who have posted at least one idea at IdeaStorm 1153, and users who have promoted ideas but they have never posted an idea, 998.

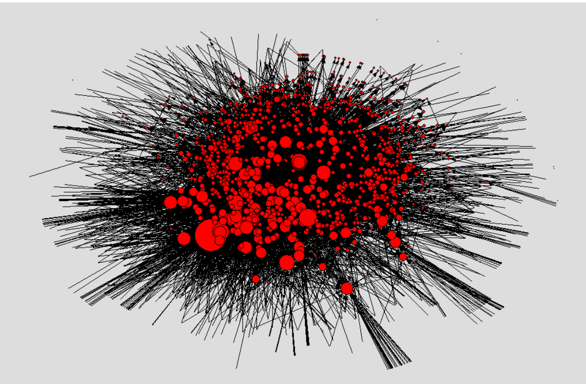

Figure 3. In-degree 2010 promotions network.

The in-degree network allows discovering those users who have posted ideas which have been most promoted (**Figure 3**). However, this network does not distinguish how many ideas have been posted by each author. Therefore, it is possible a node with a high in-degree due to posting a lot of ideas (for instance with a medium number of promotions). Regardless, it is clear that in general, ideas are receiving more promotions than comments if we compare this network with the in-degree comment network. The number of users with an in-degree higher than 1 is 1153, and the number of users with an in-degree higher than 10 is 341.

Figure 4 shows the out-degree promotion network. Nodes are overlapping, but we have maintained the same area scale for nodes' areas to highlight the high out-degree values of certain nodes as compared with the in-degree of **Figure 3**. There are five nodes with an out-degree higher than 500. It is also interesting to mention that there are just 6 nodes with an out-degree of 0, and 1281 nodes with an out-degree of 1. That means that the majority of users have at least promoted one idea. The high value of users with an out-degree of 1 could be explained if we assume that new users usually engage in exploratory behavior prior to full engagement. Therefore, they promote an idea to see how the site functions.

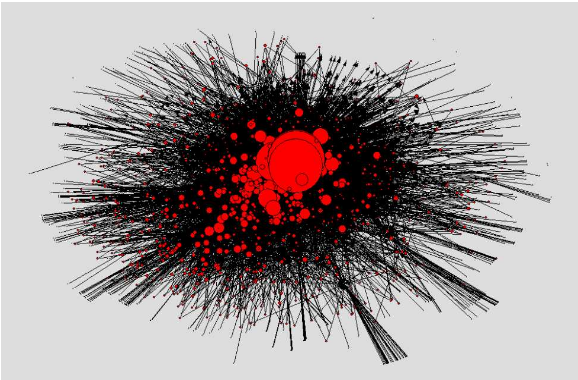

Figure 4. Out-degree 2010 promotions network.

C. Demotion network

Demotion network is built in a similar way to the previous network but using demotions instead of promotions. Network size is 1459 (users who have posted at least one idea at IdeaStorm 1153, and users who have demoted ideas but have never posted an idea, 306). The meaning of the demotion network is the same as the promotion network, but using the idea of demotion instead of promotion.

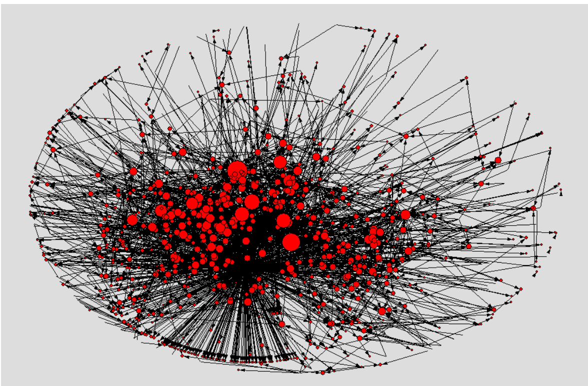

Figure 5. In-degree 2010 demotions network.

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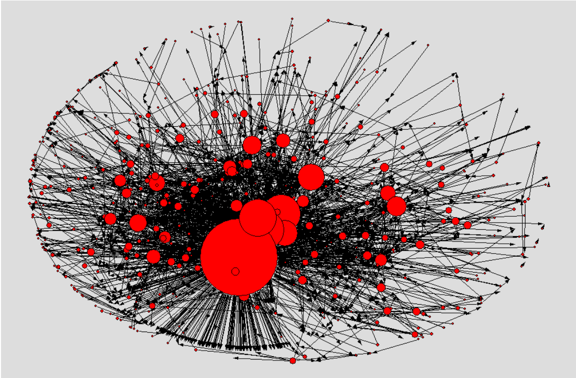

Figure 6. Out-degree 2010 demotion network.

Figure 5 illustrates the in-degree demotions network. 22 users exhibit an in-degree demotion value higher than 10. Figure 6 is the out-degree demotion network. In this case, it can be easily noticed the presence of a very active "demoter" user with an out-degree of 795!

D. User behavior

The obtained partitions of the three referred networks have been correlated to analyze to what extent the patterns of behavior in one network are similar to the rest of networks. Table IV details the obtained Spearman's rank-order correlations for the 1153 who have posted at least one idea. IN and OUT-COM refers to the in and out degree partition of the comment network, and a similar notation is used for the rest of rows and columns of Table IV. The Spearman's rank-order correlation is the nonparametric version of the Pearson product-moment correlation, and measures the strength of the association between ranked variables, that is, how closely several sets of rankings agree with each other [30].

TABLE IV. CORRELATION MATRIX.

	IN-COM	OUT-COM	IN-PROM	OUT-PROM	IN-DEM	OUT-DEM
IN-COM	1,000	,363**	,274**	,190**	,196**	,146**
OUT-COM	,363**	1,000	,315**	,461**	,144**	,434**
IN-PROM	,274**	,315**	1,000	,402**	-,079**	,276**
OUT-PROM	,190**	,461**	,402**	1,000	,170**	,588**
IN-DEM	,196**	,144**	-,079**	,170**	1,000	,134**
OUT-DEM	,146**	,434**	,276**	,588**	,134**	1,000

** Correlation is significant at the 0,01 level (2-tailed).

In-degree partition of the comment network is positively correlated with the in-degree partitions of promotion and demotion networks. However, the low value of correlation coefficients means that authors of most commented ideas are not always the ones who receive most promotions and demotions. Perhaps, a large number of comments signals controversy and disagreement among users making popularity of the idea ambiguous. The correlation coefficient of IN-PROM and IN-DEM is almost zero meaning there is no clear relationship among users receiving promotions and demotions.

In the case of out-degree partitions, correlation coefficients are also positive but higher meaning people frequently commenting on ideas are usually the same people who promote and demote most ideas. In fact, the correlation coefficient of OUT-PROM and OUT-DEM is the higher of Table IV.

In general, the participation inequality pattern can be distinguished in the three obtained networks, and most active users comment *and* vote on ideas.

VI. CONCLUSIONS AND FUTURE WORK

This paper deals with the concept of open innovation from a social network analysis perspective. For this purpose, the open innovation community from Dell has been modeled as a graph, considering three networks attending to the interaction possibilities offered through this web. More specifically, the in-degree and the out-degree distributions for these networks have been analyzed, obtaining several patterns of behavior of community members. A possible extension of this work would consists of identifying lead users, which represent the most important subset of the community from the organization perspective.

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Web-Based Community for Fire Response Actions

Scenario and Smart Framework

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Abstract—**The paper addresses organization of a Web-based community in a smart space, members of which aim at joint fire response actions. A smart framework for integrating concepts of smart space, Web-services and Web-based communities was developed. In the framework Web-services are proposed to represent the resources of the smart space and the members of the Web-based community. To coordinate Web-service interactions a service-oriented architecture was designed. An applicability of the smart framework was tested via a scenario-based organization of a Web-based community.**

Keywords—smart space; service-oriented architecture; Web-services; Web-based community; emergency response

I. Introduction

Recently, Web-based communities have received much attention due to offered advantages of instant information exchange that is not possible in real-life communities. Availability of operational information [1][2] as well as potentialities to instant information exchange [3][4][5] are of great importance to success in emergency response operations. Usually, in such operations joint efforts of independent parties are required. To involve the parties in the emergency response actions and to coordinate them, operational information about the parties' facilities, availabilities, locations, etc. is needed. In this connection, organization of a community of emergency response actors as a Web-based community, whose members can exchange operational information, seems to be a promising idea.

It is well known, that emergencies are rapidly changing situations characterized by context information. Context information is vastly available in a smart space [6]. Any smart space is comprised of a large number of various sensors, devices and other kinds of resources. It embeds a lot of services that are expected to be automatically provided according to the particular situation. The resources of the smart space can share information and services independently on their physical location.

The smart space technology has suggested an idea of exploiting its information sharing facilities and context aware service provision for the purpose of organization of Web-based communities. Research presented in this paper addresses the organization of such a community, members of which aim at joint fire response actions.

To achieve the research purpose a smart framework that serves to integrate concepts of smart space, Web-services and Web-based communities is proposed. This framework is based on the earlier developed hybrid technology supporting context aware operational decision support in pervasive environments [7]. Although some research has been done since the hybrid technology was published, this paper presents first extension of this technology with Web-based communities.

Due to Web-services enable seamless information exchange between distributed components of a smart space, the idea behind the framework is to use Web-services as mediators between resources of the smart space and members of the Web-based community. This idea is implemented via representation of the smart space's resources and the community's members by sets of Web-services. As a result of this representation, the Web-based community organized for fire response actions comprises Web-services representing units taking these actions.

To coordinate Web-service interactions service-oriented architecture is used. Service-oriented architecture facilitates the interaction of service components and the integration of new ones. The Web-services constituting this architecture implement resources' functionalities, produce model of the fire situation, provide fire response services, and represent participants of the fire response actions and other people somehow involved in the fire situation.

An applicability of the proposed framework is demonstrated via a scenario-based organization of a Web-based community.

The rest of the paper is structured as follows. Section II provides a comparative analysis of the presented research with related one. In Section III the scenario of fire response actions is described. The smart framework is discussed in Section IV. Results of scenario execution are given in Section V. Main findings are summarized in Conclusion.

II. Related Work

There is no extensive literature on the subject of organization of Web-based communities in smart spaces or involvement of members of such communities in joint actions. An example of coordination of different users doing collaborative activities from diverse locations through different devices is the use of a hypermedia model to describe and support group activities in intelligent environments [8]. Another on-going research tries to use social networks to form groups of individuals engaged in crises management efforts. These groups are suggested collaborating in crisis situations [9].

Ideas of an integration of emerging technology-driven paradigms belong to those aimed at organization of a collaborative environment for emergency response using potentialities of emerging technologies. Perspectives on the integration of paradigms of Web services, Web 2.0, pervasive, grids, cloud computing, situated computing, and crowd sourcing are considered to be the candidates that can support collective resource utilization and multi-parties cooperation with mutual interests [10]; integration of paradigms of virtual organizations and Semantic Web is offered to be used for organization of resources and services into a collaborative association to handle different kinds of emergency events [11].

Emergency response as search for emergency responders, their coordination, and calculation of time-efficient or cost-effective transportation routes for them taking into account road states and conditions is a goal of many studies (e.g., [12][13], and many others).

The above approaches address different aspects of emergency management. All these approaches integrate various emerging technologies to achieve their goals. But no one of them investigates both the problems of planning response actions and involvement of the participants of these actions into Web-based communities jointly.

The presented research shares the idea of the integration of emerging technology-driven paradigms. It integrates the paradigms of smart space, Web-based communities, and Web-services to organize a community of units to concur in fire response actions. Like the approaches considering the problem of searching for efficient transportation routes within the emergency response problem, the given research searches for such routes and uses them as the basis for joining independent units from diverse locations in a collaborative community. The community members are coordinated via Web-based interface. They are provided with the ability to exchange operational information and interact on-line using different Internet accessible devices.

III. SCENARIO

Suddenly, in some area inside a smart space a fire has started. Resources of the smart space as, e.g., fire sensors recognize it and send the appropriate signal to a smart space's service taking the role of the dispatcher. In the surroundings of this area available mobile fire brigades and emergency teams as well as hospitals with free capacities are found. Based on some criteria several of the brigades, teams, and hospitals are selected for the joint fire response actions. A plan for these actions is proposed to the selected units. It offers routes to the fire location for the fire brigades; and a transportation plan with routes to the fire place for first aid and to hospitals for transportation of the injured people for the emergency teams. The plan is displayed on Internet accessible devices of the hospital administrators and the leaders of the fire brigades and emergency teams. These persons are organized in a Web-based community to exchange information about their abilities, availabilities, surrounding conditions, etc. with the purpose of the joint actions coordination.

Potential victims are evacuated from the fire place using the ridesharing technology. A person who needs to be evacuated sets the location where he/she would like to be conveyed into an application installed in his / her mobile device. The application finds a driver able to transport the person. The found driver receives an appropriate signal. In the mobile devices of the driver and the person the ridesharing routes are displayed.

It is supposed that the scenario takes place in a smart space. The main requirement to fulfill the scenario is Internet accessibility for the persons involved in it. For the scenario implementation a smart framework has been developed.

IV. SMART FRAMEWORK

Smart Framework is defined here as a framework that is intended to coordinate operations of various resources of a smart space in context aware way to assist people in attaining their objectives. Sensors, databases, applications and other kinds of components of the smart space are regarded as resources.

Basically, the framework has been projected to assist in management of any emergency response actions. It is supported by an application ontology that represents non-instantiated domain & problem solving knowledge of the emergency management domain [14].

Whenever an emergency event occurs, knowledge and information relevant to the current emergency situation are extracted from the application ontology and integrated into an *abstract context*. This context is an ontology-based model of the current situation.

The abstract context is instantiated by resources of the smart space. An instantiated abstract context is *operational context*. The operational context is the base for organization of a community that unites members whose aim is taking joint actions on emergency response.

The framework relies upon the Web-service technology. In this framework the resources of the smart space as well as the organizations and people involved in an emergency situation in any way are represented by Web-services. Each of them is characterized by a profile describing its capabilities. Due to this representation a community purposed to emergency response actions comprises Web-services representing entities taking these actions. Figure 1 represents the generic scheme of the smart framework.

The community is organized by specially developed Web-services embedded in the smart space. Input data for the community organization are information characterizing the current situation, particularly the situation type, and types of services relevant to the response actions. The types of services are represented in the abstract context. The current situation is represented by the operational context.

The Web-services select possible community members and generate a set of feasible plans for actions. The set of plans is generated using the constraint satisfaction technology. Then, an efficient plan is selected from the set

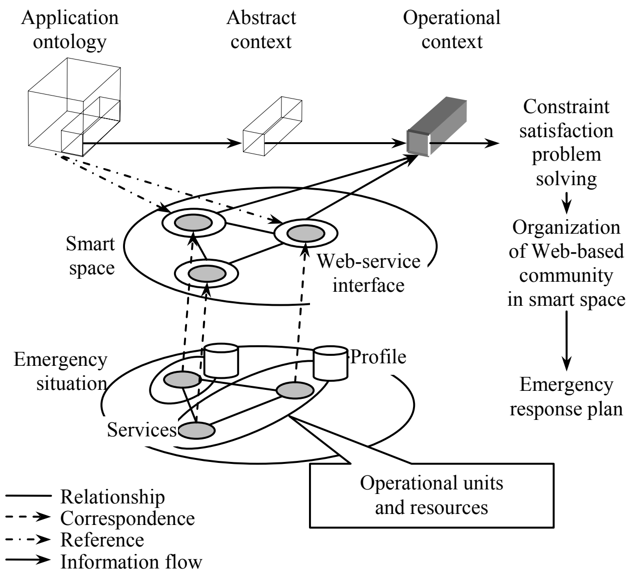

Figure 1. Generic scheme of the framework

and submitted to the possible community members to their approval. If the plan is approved by all the members the community is considered have been organized. Otherwise, another plan is taken up. The option of rejection is provided for due to the rapidly changing emergency situations – something may happen between the moment when a plan is selected and time when the possible community members receive this plan. The process of replanning is an iterative process repeated till a plan suited all the members is found. The approved plan is thought to be the guide to joint actions of the community members.

As practice has shown, emergency response actions, besides actions on emergency control and first aid, have to foresee opportunities to evacuate potential victims from the dangerous areas. In the smart framework this purpose is achieved applying the ridesharing technology.

A. Service-Oriented Architecture

Web-services comprising service-oriented architecture (Figure 2) of the smart framework are as follows:

- *registration service* registers the Web-services in the service register;
- *application ontology service* provides access to the application ontology;
- *abstract context service* creates, stores, maintains, and reuses the abstract contexts;
- *operational context service* produces operational contexts;
- *emergency response service* integrates information provided by different resources about the number of injured people, and the location, intensity and severity of an emergency event;
- *routing service* generates a set of feasible plans for emergency response actions;
- *smart logistics service* implements the ridesharing technology;

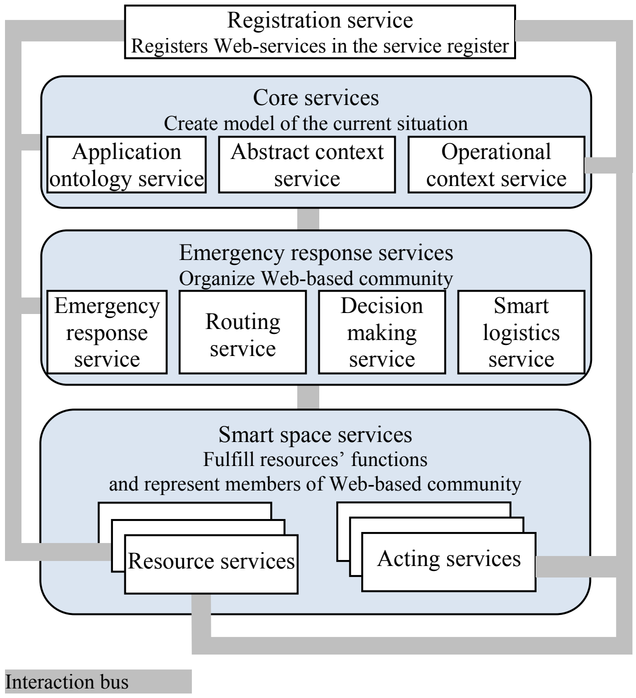

Figure 2. Service-oriented architecture

- *decision making service* selects an efficient plan for actions and concerts the actions among the participants of the response operation;
- *resource services* represent properties and implement functions of the resources (smart ones as well);
- *acting services* represent properties of organizations or people and roles played by them in an emergency situation.

To make the Web-services "active" components agent-based service model is used [15].

B. Organization of Web-based Community for Fire Response Actions

In the context of this paper a fire event is considered as an emergency. Therefore below, organization of a Web-based community aimed at fire response actions is described.

The starting point for community organization is receiving by *emergency response service* of the signal that a fire event takes place. Fire-prevention smart sensors had recognized some fire and sent this signal. Other kinds of smart information resources inform *emergency response service* of the number of injured people, and the location, intensity and severity of the fire.

Based on the information about the fire location, *emergency response service* requests the GeoInformation System (GIS) for a map of the fire area and the adjacent territory. The map contains some predetermined information as locations of the airports, buildings, roads, railway lines, water bodies, etc.

Using knowledge represented in the application ontology *abstract context service* determines what kinds of mobile

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teams and organizations providing response services are needed for the fire response actions and kinds of roles of the individuals involved in the fire situation. This service extracts knowledge related to the listed kinds of concepts from the application ontology and integrates it into an abstract context. In the case of fire, such kinds of teams are fire brigades and emergency teams; kinds of organizations are fire departments, emergency services organizations, and hospitals; kinds of roles are leader of a team, car driver, victim, etc. The referred kinds of concepts represent objects to be instantiated in the operational context. Thus, the abstract context is represented by the map above and knowledge about objects to be instantiated.

Operational context service instantiates the abstract context and produces in that way an operational context. For the instantiation *operational context service* uses information provided by the following resources of the smart space:

- GPS-based devices installed on the vehicles of mobile emergency teams and fire brigades to fix the positions of these teams and brigades and to determine what types of vehicles they use;
- databases to find addresses and contact information of the fire departments, emergency services organizations, and hospitals;
- smart sensors to receive information which routes are available (e.g., somewhere traffic jumps can be, or some roads can be closed for traffic for some reasons);
- hospital administration systems to find out free capacities of the hospitals.

Operational context service passes the operational context to *routing service*. *Routing service* analyses types of routes (roads, waterways, etc.) that the emergency teams and fire brigades can follow depending on the vehicles they use. Based on the information about the number of injured people, the intensity and severity of the fire *routing service* calculates number of emergency teams and fire brigades needed to succeed in the response actions. The information about the number of injured people, the intensity and severity of the fire is received from *emergency response service*.

Then, *routing service* selects possible fire brigades, emergency teams, and hospitals that can be involved in the response operation and generates a set of feasible plans for actions. The actions are scheduled taking into account the availabilities of fire brigades, emergency teams, and hospitals; the types of vehicles that teams and brigades use; the routes available for these types; and the hospitals' free capacities. The problem of transportation routes planning incorporates the shortest-path problem.

Decision making service using a set of criteria selects an efficient plan from the set of feasible plans. The selected plan and the operational context are submitted to the leaders of the emergency teams, fire brigades that have been included in the plan, and to the hospitals' administrators. They have access to the operational context through any Internet browsers (a browser supported by a notebook, PDA, mobile phone, etc.). These persons either approve the plan pressing "submit" button or decline it pressing "reject" button. In the latter case *decision making service* has to adjust the selected plan (so that the potential participant who refused to act according to the plan does not appear in the adjusted plan) and submit it to approval. As soon as representatives of all the emergency teams, fire brigades, and hospitals have approved the plan they are in, *decision making service* sends them an appropriate signal that the joint actions can be started.

Persons who need to be evacuated invoke *smart logistics service* that is responsible for the evacuation. Clients of this service are supposed to be installed on the mobile devices of car drivers and other people involved in the fire situation. The persons enter the locations they would like to be conveyed. *Smart logistics service* determines the persons' locations and searches for cars going to or by the same or close destinations that the persons would like to be. It searches the cars among the vehicles passing the persons' locations. This service reads information about the destinations that the car drivers are going to from the navigators that the drivers use or from the drivers' profiles. The profiles store periodic routes of the drivers.

Based on the information about locations and destinations of the person and the found cars, *routing service* generates a set of feasible routes for person transportations. *Decision making service* determines efficient ridesharing routes. The criteria of the efficiency are minimum evacuation time and maximum evacuation capacity.

Smart logistics service sends appropriate signals to the drivers included in the ridesharing routes and displays on the drivers' devices the routes each driver is selected for. The points where the driver is expected to pick up the passenger(s) is indicated in the routes. The ways the passengers have to walk to these points are routed for them as well. Besides the routes, the passengers are informed of the model, color, and license plate number of the car intended for their transportation.

The view of the routes displayed on the devices of the individuals involved in the fire situation depends on the roles of these individuals.

V. Scenario Use Case

The scenario (Section III) execution is demonstrated via organizing a Web-based community aimed at joint actions to response on a fire event happened in an urban area. It is simulated that from the scene of fire 9 injured people have to be transported to hospitals.

The application ontology used to create model of the fire situation had been created by experts via integration of parts of existing ontologies accessible through the Internet. To support the integration and necessary ontology modifications an ontology management tool – WebDESO [16] – was used. The application ontology has 7 taxonomy levels, contains more than 600 classes, 160 class attributes, and 120 relationships. The abstract context created to represent the situation at the abstract level has 3 taxonomy levels, contains 17 bottom-level classes, 38 class attributes, and around 30 relationships of different types.

7 available fire brigades, 8 emergency teams, 5 hospitals having free capacities for 4, 4, 2, 3, and 3 patients are found

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in the territory adjacent to the fire place; 6 fire trucks and 1 fire helicopter are allocated to the fire brigades, 7 ambulances and 1 rescue helicopter are allocated to the emergency teams. 1 fire brigade is calculated to be required to extinguish the fire. The plan for actions designed for the emergency teams supposes that one vehicle can house one injured person.

A set of feasible plans for actions was generated for criteria of minimal time and cost of transportation of all the victims to hospitals, and minimal number of mobile teams involved in the response actions. The set of feasible plans comprised 4 plans.

An efficient plan (Figure 3) was selected based on the key indicator of minimal time of victim transportations. In Figure 3 the big dot denotes the fire location; dotted lines depict routes to be used for transportations of the emergency teams and fire brigades selected for the response actions. The plan is approved by all the action participants. As it is seen from the figure, Web-based community comprises 1 fire brigade going by 1 fire helicopter, 7 emergency teams allocated to 1 rescue helicopter and 6 ambulances, and 3 hospitals having free capacities for 4, 2, and 3 patients. 1 ambulance (encircled in the figure) and the rescue helicopter go from the fire location to hospitals twice. The estimated time of the operation of transportations of all the victims to hospitals is 1 h. 25 min. Figure 4 shows part of the plan displayed on the smart phone of a member of an emergency team going by ambulance.

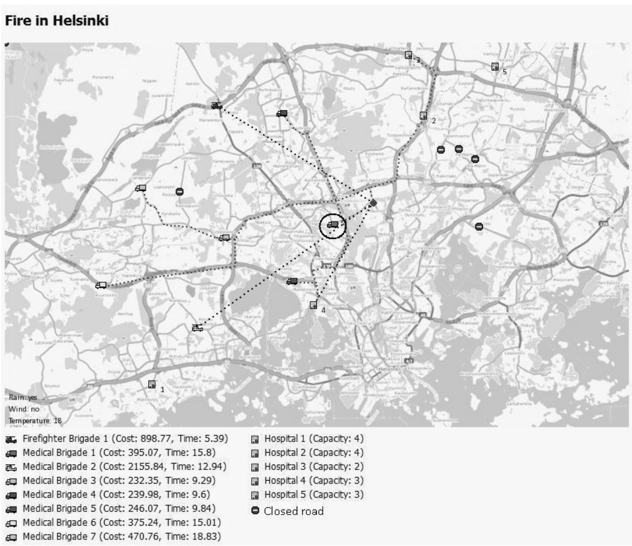

Figure 3. Plan for actions for fire brigades, emergency teams, and hospitals

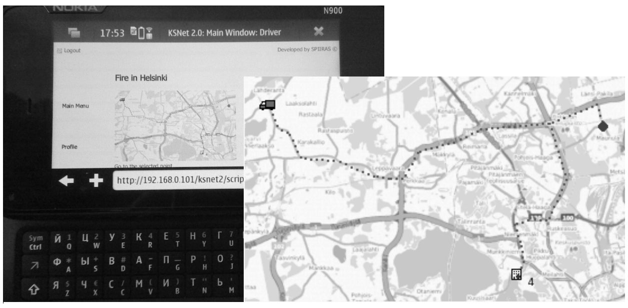

Figure 4. Plan for actions for an emergency team

Results of evacuation of safe people using the ridesharing technology are as follows: 26 persons desire to be evacuated from the scene of fire; 22 persons have been driven directly to the destinations by 16 cars whereas for 4 persons no cars have been found. Examples of ways routed for a driver and a passenger are given in Figure 5 and Figure 6. The encircled car in the figures shows the location where the driver is offered to pick up the passenger.

The Smart-M3 platform [17] has been used for the scenario implementation. Tablet PC Nokia N810 (Maemo4 OS) and smart phone N900 (Maemo5 OS) play role of user devices. Personal PCs based on Pentium IV processors and running under Ubuntu 10.04 and Windows XP are used for hosting other services.

VI. Conclusion

The problem of integration of the emerging technology-driven paradigms of smart spaces, Web-services, and Web-based communities for the fire response purposes was investigated. Most probably, judging from the literature, this is the first investigation on the integration of the mentioned technologies for emergency management aims.

A smart framework that serves to integrate concepts of smart space, Web-services and Web-based communities has been proposed. This framework is developed to operate with

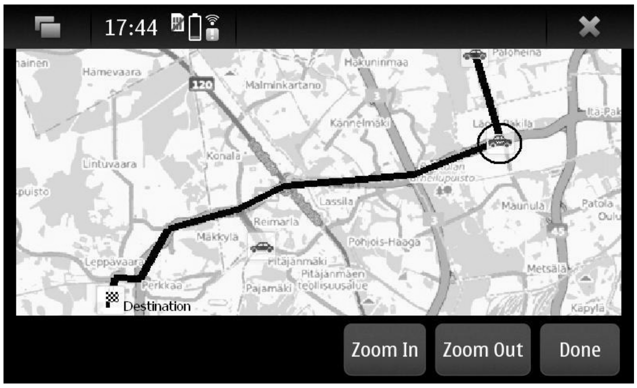

Figure 5. Ridesharing route: driver’s view

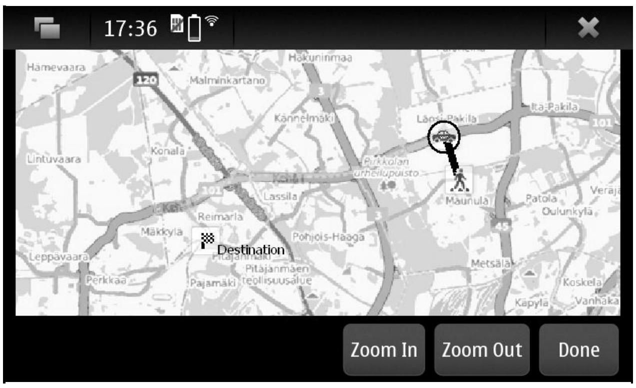

Figure 6. Ridesharing route: passenger’s view

Web-services representing the physical resources of a smart space and parties and individuals involved in a fire situation. The parties and individuals that are fire responders form a Web-based community. It is shown that they can communicate online independently on the devices they use, to exchange the operational information or make decisions on their readiness to participate in the joint response actions.

Due to the smart framework is built around the application ontology of the emergency management domain, this framework can be applied to organization of emergency management communities for response to different types of emergencies.

An original feature of the way the fire response actions are planned is in the involvement of ridesharing technology. Previously, the authors of this paper considered professional emergency responders to act on emergency response. In this paper, the community of professionals is extended with volunteers. Ridesharing serves as an example of the technology based on which volunteers can be involved in the emergency response actions.

To coordinate Web-service interactions within the smart framework the service-oriented architecture has been designed. The architecture contains a set of Web-services that is supposed to be sufficient to organize any fire response communities independently on types of operational units to be involved in response actions.

The applicability of the smart framework is tested by the scenario of planning fire response actions in an urban area. The scenario execution has shown that the paradigm of smart space provides efficient facilities to successful emergency response. Moreover, it can be concluded that ridesharing technology can be used for evacuation of potential victims from dangerous areas.

Some limitations of the developed framework are worth mentioning. The framework does not take into account cases when it is not found enough available acting resources or when some resources become disabled at time of the response actions. As well, the framework does not address the problem of lack of passing cars for evacuation of people from the fire area and the problem of searching for a route with changes if there are not any cars nearby the fire area going directly to the person destination. The listed limitations will be subjects for future research.

ACKNOWLEDGMENTS

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Design of Suitable Meeting Management Model for WebELS Meeting to Meet the Business Situations

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***Abstract*—This paper proposes a meeting management system for controlling member groups and contents in the WebELS Meeting system to meet suitable meeting controls at reasonable cost in business situations. The system is divided into two parts: the system management and the conference streaming management. This feature has been required for the system in implementing software as a service (SaaS) concept. The main concept of the system is group-based management of members and contents. We designed a new simple group-based structure for easier management. Each group holds two password types: manager password and guest password. The group manager can manage the contents on their group. The system can limit number of content and concurrent access in each group. Moreover, the system can control the behavior of logging-in members. We proposed the auto-reconnection network for booting up the performance of web-based online conference system to be used in the unreliable network environment. This system can help the administrator for managing and controlling the member groups and contents in the meeting system. Furthermore, our solution helps the participants who use the unreliable network by preserving the quality of online conference operation for the best distant meeting. This system increases efficiency and performance especially in operating WebELS Meeting as SaaS.**

Keywords- meeting management tool; simple group-based concept; business meeting; auto-reconnection; WebELS Meeting;

I. INTRODUCTION

As the Internet-based communication is rapidly growing, many kinds of online Internet applications have been developed to support new lifestyles, e.g., social networking, online businesses and so on. Online video meeting or conference technology becomes popular because it can help in organizing a meeting comfortably via the Internet. This technology is used to link members to join from any place to meet in a virtual room. Online video meeting usage is now wide-scale in many major areas, i.e., distant e-Learning [1], organizational business situation [2], tele-medical cares [3][4] and etc. This highly-technological change in business communication can reduce operational administrative costs and can make stronger business competition [2]. Currently, several video meeting systems and products are available in business sector. There are many well-known online conference systems, such as Skype [5], Polycom [6], Cisco WebEx meeting [7], Microsoft Live meeting [8], and Pc Video Conference [9]. Each system has different features and infrastructures. Most products have been integrated with useful services for supporting meeting processes, e.g., chat messaging, file sharing and so on.

Skype is the first to make Voice-over IP (VoIP) a massively popular tool [5][10]. It is a form of peer-to-peer network. A user who logged in can locate other users on the Skype and take part in audio or video call across the Internet. The benefit of Skype is the free connection to other Skype users. Furthermore, Skype's sound quality keeps the high and low tones of sound, whereas telephones and other VoIP software/hardware clip out those parts of speech. However, while it may be desirable to prevent telephone conversations being tapped, users and computer must be able to protect themselves. Polycom is a popular TV conference system that is used for real-time distant video communication [6]. It is a complete conference solution, however it requires special and expensive proprietary devices and technologies. It needs specially designed telecommunication infrastructures, cameras, and related devices. Cisco WebEx meeting, Microsoft Live meeting and Pc Video Conference are similar systems and technologies that propose for computer-based meeting via Internet [7][8][9]. Cisco WebEx meeting and Pc Video Conference support the cross platform environment. However, Microsoft Live meeting only supports cross platform in web access system. All of these systems can use the general computer with attached web camera and microphone units.

On the other side, there are some open-source web-based conference systems, e.g., OpenMeeting [11], BigBlueButton [12], which can be used for real-time meeting. The problem in the business point of view on these systems is the privacy of contents. In business meeting point of view, security and privacy of meeting contents and user information are very important. Furthermore, online meeting system should have an easy-to-use user interface and configuration that meets the technical abilities of non-IT users. Generally, most open-source web-based conference systems do not meet the necessary requirements in business meeting situations. In addition, most of the systems have limitation such that it requires high bandwidth network for providing better output quality in online meeting operations. Moreover, it also

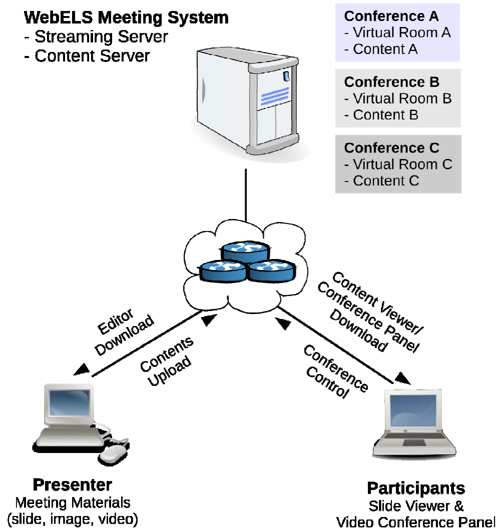

Figure 1. WebELS Meeting System Diagram

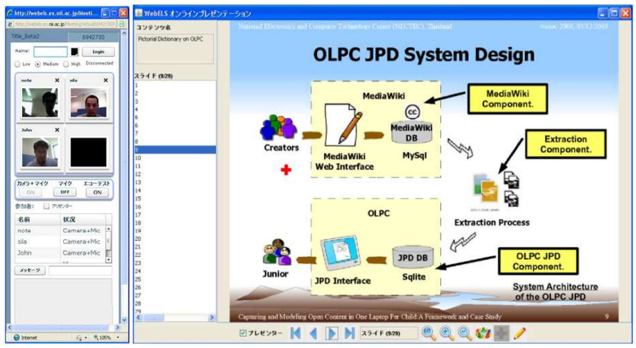

Figure 2. Example of using slide presentation and video conference

requires intricate proxy or firewall setting to access the system, so usability conditions are limited.

WebELS Meeting is one of the video conference applications that congregate several functions for supporting online meeting activities. The benefits of this system are: (1) online cursor synchronization that requires less bandwidth of network compared with the other online meeting systems, and (2) the online video conference of the system overcomes the network environment that defines strict firewall policy. The video stream can access through the firewall rules because it uses the general web protocols [13]. Since these features were appended in the WebELS Meeting, the usefulness and performance of the system has improved and its usage is now wide-scale that has eventually opened the opportunity for the business sector.

Several issues were discussed and considered in the business point of view to make an online video conference product that is credible and suitable for business companies [14] i.e., management functions, security issues, privacy of content, etc. Both privacy and security of content are important issues for business communication, since content is an asset of the person who has created the content. For content privacy, each member of the group can only access their own group's content. For content security, the system should have functions for protecting the content. i.e., data encryption, system firewall and etc [15]. The auto-reconnection is also required for improved system performance. The system should automatically connect the video meeting when disconnected from the network [16]. Several video conference systems do not have the function for managing this situation. Participants who lost the network connection manually re-connect the system by themselves. It makes uncomfortable usage for the members. Sometimes the unusual attendees occur during meeting. Therefore, the system should have some function to break the usage from the unusual attendee. i.e., pause any actions or eject that attendee out of the meeting.

To make more profit for the business companies, any cost of resources should be reduced. According to Gartner's survey [17], trend of business services moves to use Software as a Service (SaaS) model. SaaS is an emerging business model that delivers software applications to users through Web-based technology. Adopting SaaS applications allow companies to save their information technology cost, save time for deploying the system, addressing security concerns of customers and meeting service level agreements [18][19].

In this paper, we developed a suitable meeting management function for the WebELS Meeting system used in the business sector. We propose the management tools for controlling the member groups and contents. We also propose a method for using the video meeting in the unstable network environment. In addition, the system is developed based on the SaaS system for allowing small companies to minimize their operational cost.

II. WEBELS MEETING OVERVIEW

WebELS Meeting is designed based on online meeting via Internet-based technology for supporting a content-centered E-Learning Platform in Postgraduate Education [20][21]. To support the online meeting activities, several useful functions were integrated into the WebELS Meeting system such as content-authoring, online presentation, video conference and so on. This system involves fusion of synchronous features with powerful authoring tools for Internet meeting [22]. WebELS Meeting is designed as an administrator free system for authoring tool, slide presentation tool and video meeting window. Every logged-in user has the same right. By clicking the presenter button a user can obtain the presenter right who can change slides, point a cursor, annotate drawings, zoom and scroll slides and so on. It also has an easy-to-use interface for non-IT users. Users can edit their own meeting contents on their personal computer and share to the meeting participants. Some main features are listed as follows:

- Web-based usage: Easy to use and no need to install special programs. It can be used by any web browser application.
- Real-time meeting: Simulates the virtual meeting room. Anytime, anywhere and anybody concept to support a variety of usage.

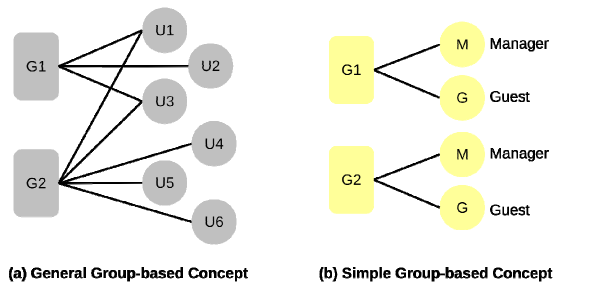

Figure 3. Comparison of general group-based and simple group-based concept

- Synchronous and Asynchronous: Supports slide synchronized with video and audio while used in online Internet.
- Cross platform solution: Operates on Windows, Macintosh and Linux at the same quality.

WebELS Meeting authoring and presentation tool are Java-based server systems. It functions even in a low-speed Internet environment [23], because the contents are pre-downloaded onto every participant computers and only control signals and data are synchronize to the server and updates by itself. Since WebELS Meeting uses HTTP protocol for online presentation and RTMP protocol over port number 443 for video conference, WebELS Meeting can be used under strong firewall setting rules. Fig. 1 shows the system diagram of the WebELS Meeting. The basic design of WebELS Meeting was proposed for content-based meeting. Each content has its own virtual room that can be used for meeting management. Any users who are accessing to the same content can share the online presentation and join the online video conference at the same time. Fig. 2 shows an example using that collaborate between live presentation function and live video meeting function.

III. Methodology And System Design

In this paper, we proposed an approach in designing the business WebELS Meeting system to support business applications. We added the management tools for controlling the user groups and contents to achieve suitable security management functions while keeping easy-to-use concepts onto a standard WebELS Meeting. Using shared single server system, small companies can share the system at lower costs with suitable security management safe guards. Each user group can manage separate secure online business meeting concurrently. We also invented a network connection handle function for the online video meeting to utilize in the unreliable network situation. The details are explained in the following sections.

A. Simple Group-based Concept

The group-based management concept is reasonable and popular for managing e-Meeting systems because it is easy to control multiple users in one time. One group consists of several users and one user can become a member of several groups too. Fig. 3 (a) shows a general group-based concept. From the business requirement, a disadvantage of this concept is very time-consuming while the administrator adds new members. It is better to use the same user name in each group for accessing contents. Therefore, we designed a new simple group-based concept that is easier to manage than a general group-based concept. Fig. 3 (b) shows a simple group-based concept to manage security of contents for the business sector. Each group consists of two members, i.e., manager member and guest member. Also members in each group cannot become a member of other groups.

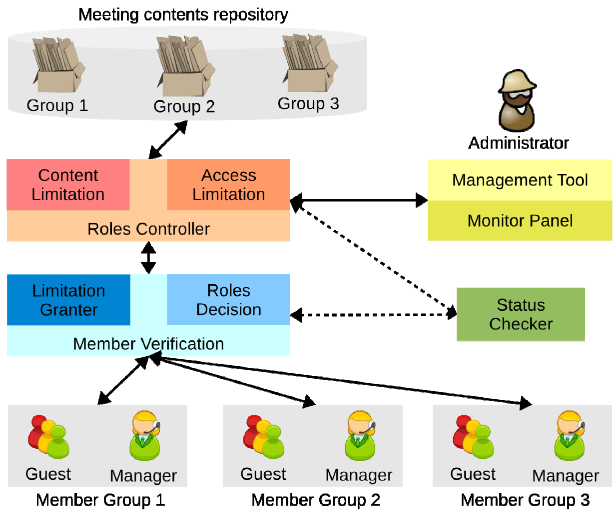

Figure 4. System architecture of system management for the business meeting

B. System Architecture

In response to the business meeting requirements, we have designed and implemented a new managing structure to override the existing structure while keeping the same technologies for future development, i.e., the old structure of the system is being preserved. We divided the system into two main parts, .e.g., system management and conference streaming management parts.

1) System Management Part

The concept of the system is based on our simple user-group control. The users in the system consist of member groups and administrator. The administrator can manage the member groups and system, but he/she cannot create and edit contents. For the member groups, each group hold two passwords i.e., (1) password for group manager, and (2) password for guest of the group. The group manager can manage the contents in own group and also monitor member group activities. Contents in each group cannot be accessed by members of other group which is an important policy in the business situation. Fig. 4 shows the system design of functional structure for supporting the business sector. In the design, we separated the system into 3 modules, i.e., (1) Member Verification, (2) Roles Controller and (3) Administrative modules. The details of modules are described as follows:

a) Member Verification Module

Member Verification module is used to identify the member and separate the member role. Since the system has two passwords for one group, we use the group name the

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Group data

ID	Name
10	nii
..	..

Member data

login	password	class
nii	xxxxx	manager
nii	yyyyy	guest
..	...	...

Figure 5. Example structure of user and group data

same as the user login name and use two records of user table to keep the user data and group role as shown in Fig. 5. To strengthen the security technique, every user password is encrypted into two steps. First, the plain text password is encoded by WebELS key-code. Second, the password is encrypted again by MD5 [24].

This module consists of two main sections for this module, i.e., Role Decision and Limitation Grantor sections.

Role Decision: Since the group role is dependent on the user login name and user password, this section matches both user login name and user password. The system uses the user class where the record is specific for the group role. This value is feed to the Role Controller module subsequently.

Limitation Grantor: This section is introduced for checking the special member properties. The block property is utilized to allow or deny the usage of members in the system. While a member group is blocked, every member cannot access the system even if the contents of this group have existed in the system. When a member group is unblocked, every member can use the system to carry on the existing contents of the group. Not only block property is available but also the expiry time is utilized for controlling the usage limitation time of the system for each group, in the case of free trial service for customers.

b) Roll Controller Module

Role Controller module consists of two main sections, i.e., Content Limitation and Access Limitation sections.

Content Limitation: This section is utilized for limiting the number of contents in each group. While the group manager creates a new content, the system checks the number of existing contents of their group and compared with the limitation value of that group. In case the number of existing contents equal or more than the limitation value, the permission for creating and any authoring tools will be denied.

Access Limitation: This section is generated for limiting the number of users who access to the system at the same time in each group (concurrent access). We defined the user status if login succeeds and the status will be cleared after the logout. The system uses that status for counting the number of accessing users. For the logout status, it is complicated for implementing because we could not control any users for logging-out from the system in a proper method, e.g., when someone who has logged-in to the system has accidentally shutdown their computer, or someone closes the browser without logging out from the system, etc. Therefore, the user status is not cleared, and the number of logging-in users is incorrect, too. We solved this problem by creating a system checker [25] that runs in the background mode for clearing the user status automatically.

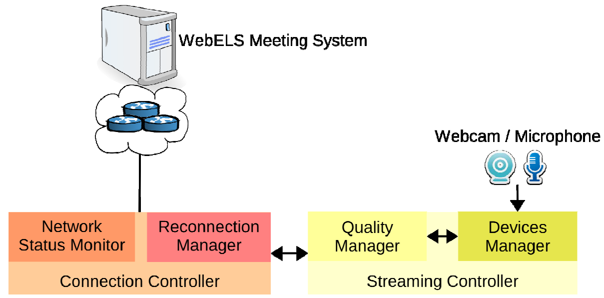

Figure 6. System architecture of streaming management for the business meeting.

c) Administrative Tool

The Administrative tool, a feature for the administrator user, is used to manage and control the system.

Management Tool: This tool is used for adding, editing and deleting group members and group roles information. For security reason, this tool cannot manage the contents in each group. When deleting a group member, this tool removes all contents of deleted group from the system, i.e., database, virtual room and data in physical storage.

Unusual Member Controller: This section is used to manage meeting participants while the meeting is running. There are two actions, i.e., break any actions and eject (kick-off) from the meeting. The participant who become an administrator of meeting can use those functions to control an unusual participant who has a behavior to disturbed other participants during meeting.

Monitoring Panels: We designed the monitoring panels for helping the administrator and group manager to monitor their system. This tool is important instrument for checking-up the system information. It is separated into two kinds, i.e., (1) System Monitor Panel is purposely for the administrator. This panel is used for monitoring the overall information of the system, such as, Number of contents, Number of users, Content size, etc, and (2) Group Monitor Panel is used by group managers. The group manager can track the activities of each user in their group, such as, Number of logged-in user, active and action content of each user, etc.

2) Meeting Streaming Management Part

This part is used in the client node for connecting to the virtual room of online meeting system. The system is automatically downloaded and run on the client computer via web browser when the members access to the conference web page. Fig. 4 shows the design structure on client side. The system consists of two modules as follows;

a) Connection Control Module

Connection Controller module is used to manage and control the network connection of the client nodes. There are two functions included in this module as follows;

Network Status Monitor: This section is used for monitoring the network connection status while the meeting session is ongoing. After the member logged-in to the system, this function is always check the network connection between server and client nodes. When losing connection, the reconnection manager function is triggered for handling the connection.

Reconnection Manager: This section is used to keep the network connection and waits for the new connection status. When the connection signal appears again, then login process is automatically done by using the latest meeting information.

b) Streaming Controller Modules

Streaming Controller module is used to control the streaming input of the client node including two functions.

Device Manager: This section is used to manage the basic input devices, such as microphone and web camera (or video camera). It is used for controlling the state of input devices such as setting the devices connect/disconnect or on/off. It also chooses proper features refer to the input devices of the client node.

Quality Controller: This section is used for controlling the quality of streaming data from the input devices. Several parameters are used for configuring the conference streaming data, i.e., video size, video scale, voice gain, voice silence level and etc.

IV. DISCUSSION

The new features in the business meeting system were designed based on functional standard WebELS Meeting version. Several features were developed to support the business roles to meet the requirements from the business sector while important features of standard version are preserved. The administrative tool was developed for managing and controlling the group members. The role controller was applied for group-based control. We have evaluated the system by comparing the new system with the standard system and other business conference systems. Table I shows the overview comparison of meeting systems. There are contrasts in the objective and usage of all systems. The standard WebELS Meeting was mainly designed for supporting the higher education while the other systems were mainly designed to be used in the business sector. Our new system has distinctiveness, by introducing the simple group-based for managing and controlling the contents and system.

Only our new system has special functions -- contents limitation, concurrent access limitation and system limitation is managed by simple group-based concept. We used the system checker for solving the incompletely logout problem and clearing the member status. The usage time limitation is one significant matter for restricting the free trial customers for the business approach. Furthermore, unusual member controller is integrated to be operated the logging-in participant who has a behavior to disturbed other participants during meeting operation. In the business sector, security of content is also important. Any content are protected and accessible by the group owner and members who have been granted permission only by the owner. Even an administrator of the system cannot manage the contents in member groups. Moreover, usage time limitation is one significant matter for restricting the free trial customers. That function meets the reasonable security in business situations. This is a benefit for merging the meeting system with SaaS in the business model.

TABLE I. SYSTEM OVERVIEW OF MEETING SYSTEMS

Criteria	A	B	C	D
Objective	Support the e-Learning	Support the business sector		
Target group	Higher education	Company / Organization		
Distribute	Open-source	Proprietary		
Concept	Content-base	Group-base		
Privacy of content	Open	By group	Depend on publisher	
System Limitation	Unlimited	By group	By product	

Note: A = Standard WebELS Meeting, B = Business WebELS Meeting, C = Cisco WebEx Meeting, D = Microsoft Live Meeting

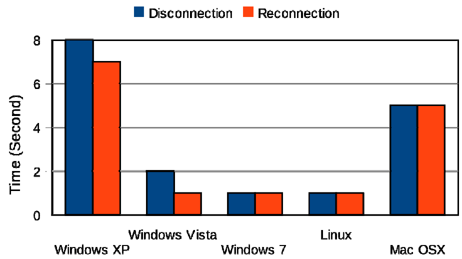

Figure 7. Comparison disconnection and reconnection time of each OS

Figure 8. Distant meeting of e-CC Seminar using the new WebELS meeting for business model system.

Not only the system management part but also conference streaming management was invented. The system has a feature to support meeting connection and quality while using the system in the unreliable network environment. Auto-reconnection is the convenient function for participant who lost the network connection during meeting operation. The system can keep the meeting session and automatic operation with the reconnection technique when network connection is restored. This feature is tested on many OS environments such as Windows, Linux and Mac OSX. In the evaluation, we focus on the effect in two events, such as (1) a disconnection time range after losing the network connection and (2) a reconnection time range while network status is appearing. Fig. 7 shows the approximate automatic reconnection time. This feature can work in all OS but the time range for automatic reconnection process differs and that it depends on the network connection probing of each OS.

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This system was proven by several usages from companies and communities, such as, Kyosei Systems Inc – Japan, etc. Every feature worked well within the business situations. The system can limit the number of contents and number of concurrent user access in case of content limitation or access limitation was defined. The system can provide as a TV conferencing system, like Polycom system, with high-quality video and audio streaming service. The system can be easily used anywhere and anytime without firewall and proxy settings. Participants can attend the meeting by using their personal computer or laptop that is connected to the Internet.

V. CONCLUSION

In this paper, we proposed the suitable meeting management tool for the WebELS Meeting module to meet the requirements of the business sector. The main function of the management tool is to be utilized for controlling user members and contents using simple group-based control concept. The administrator could manage the whole system. The group manager could manage the contents and also monitor activities of each user in their group. Member Verification and Role Controller methods were described using our techniques for controlling users and contents. Our management tool helps the administrator manage the system easily. We also developed network connection handler for online conference system when used in the unreliable network environment. To preserve the meeting operation, the system can keep the meeting session in operation with the reconnection technique when network disconnection occurs intermittently. Moreover, we implemented the WebELS Meeting system as a SaaS concept to minimize IT investment costs of business companies. The usefulness and performance of the system have been proven by practical uses of the business companies and community sectors. This system increases the efficiency and performance of the WebELS Meeting module in business sector.

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Static and Semantic Social Networks Analysis: Towards a Multidimensional Convergent Model.

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***Abstract*—Social networks of the Web 2.0 have become global (*e.g.*, FaceBook, etc). In 1977, FREEMAN published generic metrics for Social Networks Analysis (SNA), mainly based on graph-mining models. The objective of our work is to extend these static analysis models by taking the conceptual aspects of enterprises and institutions social graph into account. These conceptual aspects are embedded in trades-oriented ontologies extracted from the endogenous information, connate to the studied social networks. The originality of our multidisciplinary work is to define new multidimensional measures in SNA for new decision-making functions in Human Resource Management (HRM). This paper introduces three new contributions: (1) a metric of *tension* of a social network, (2), an extension of the FREEMAN's betweenness measure named *semantic betweenness* and (3) a notion of *reactance* of a social network used for the evaluation of the individual *stress*.**

***Keywords*-social, networks, analysis, ontologies, semantic, betweenness.**

I. INTRODUCTION

Current trends and needs of communication permanently require new functions and applications of social networking, as demonstrated by the constant eruption of new socialisation modes (*e.g.*, Twitter, Facebook Diigo). In comparison with the real spaces of exchange, these virtual spaces facilitate the static analysis and the emergence of metrics and methods dedicated to Social Networks Analysis (SNA). The measures of *centrality* introduced by FREEMAN are the basic foundation in SNA [1]. Naturally, SNA is gradually extended to enterprises, in order to provide new management tools dedicated to work organisation, workforce and human resource management tools. The culture of collaborative work is more and more paired to "Web 2.0" tools, characterising a form of enterprise "2.0", aware of human and social capital management. A social network can be formalised with a (not) directed, labelled and weighted graph. From such a structure, two kinds of SNA can be differentiated: *static SNA* and *semantic SNA*.

Static SNA studies the state S of social graphs at a time t. It is grounded on models and measures dedicated to structures - such as defined in [1], [2], [3] -, or flow-based models [4], [5]. The graphs can be random graphs [6], pseudo-random graphs [7], scale-free graphs [8] or hybrid graphs. *Static SNA* enables the classification of individuals groups or communities and the discovery of implicit relationships between individuals involved into the social graph, by computing *degrees*, *connectivities*, *distances* and *flows*. Basically, the count of edges connected to a vertex v is the *degree* of v. The count of other vertices accessible from v is the *connectivity* of v. The *distance* between two vertices is the minimal count of edges between them. An elemental *flow* is characterised by a count of units circulating between two vertices - *cf.*, electrical or hydraulic networks, road networks.

Semantic SNA studies the conceptual aspects of social graphs. It is based on the principles underlying conceptual graphs theory and semantic networks theory [9]. Semantic SNA refers to the Semantic Web standards (*i.e.*, W3C languages and micro-formats, such as RDF, OWL or FOAF), Ontology Engineering [10] and logical inferences, in correlation with cognitive sciences [11], [12]. With the exponential growth of social networks and information flows, semantic SNA becomes crucial for knowledge discovery and knowledge management, from the enterprise content to the large communities of the Web. Semantic SNA can notably bring real advantages in the areas related to social and human capital management or optimisation of work-groups and working methods, within professional organisations (societies, institutions).

Currently, not many works try to integrate the differentiated forms of analysis. The purpose of our work consists in filling this gap by defining a new convergent system based on both static and semantic analysis of Enterprises and Institutions Social Networks (EISN). Our approach is multidisciplinary, since it is based on physics and cognitive sciences. It leads to the definition of a multidimensional model enabling the development of new decisional tools for the optimisation of work and well-fare at work and for the social and human capital management. In its current version, this model includes three new contributions: (1) a metric of *tension* of a social network, (2) an extension of the L.C. FREEMAN's betweenness measure, named *semantic betweenness*, and (3) a notion of *reactance* used for the evaluation of the individual *stress* within a professional social networks.

Our work is funded by the French State Secretariat for prospective and development of the digital economy, in the context of the SOCIOPRISE project [13]. It is developed in collaboration with a French IT service and software engineering company which provides industry-leading software and implementation services dedicated to human capital management.

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The rest of this paper is structured as follows. Section 1 introduces, in a synthetic way, the principles and methods respectively used for static SNA and semantic SNA. Section 2 presents in details the approach we advocate to integrate static and semantic SNA. Our contributions are based on (1) a bridge-building between knowledge engineering and the measures of static analysis and (2) a bridge-building between the semantic SNA introduced in (1) and electric principles. Our work is dedicated to Enterprises and Institutions Social Networks Analysis - EISNA.

II. UNIDIMENSIONAL APPROACHES

A. Static Analysis

Static SNA studies the state *S* of a social graph at a time *t*, *S* being defined by the structures and/or the flows of the studied graphs. The first notions of SNA were focused on the leadership in communities [14]. These notions have been enriched with measures of centrality and betweenness [1], which characterise properties of social networks in terms of *power*, *prestige*, *proximity* and *confidence*.

The centrality measures are based on the comparison of a vertex degree or flows, to those of the graphs, neighbours or distant ones. A vertex connected to a large count of vertices in the graph (directly or not) holds an important *centrality of power* ratio. A vertex connected with the vertices of the social graphs bearing the strongest degrees holds an important *centrality of prestige* ratio. A vertex connected with a large count of close or neighbour vertices owns a high *centrality of proximity*. By induction, an important centrality of prestige and proximity can reveal a significant *trust* coefficient.

A measure of betweenness defines how an individual is important to interconnect his neighbourhood. According to [1] and [15], we formalise it as follows:

$$\forall i \neq u \neq j, \sigma(i,u,j) > 0, Iu = \sum_{(i,j)} \frac{\sigma(i,u,j)}{\sigma(i,j)} \qquad (1)$$

where $\sigma(i,j)$ is the count of shortest chains between *i* and *j*, $\sigma(i,u,j)$ is the count of shortest chains between the vertices *i* and *j* crossing *u*. The ratio $\sigma(i,u,j)$ by $\sigma(i,j)$ is cumulated for the (i,j) where $\sigma(i,u,j) > 0$. The sum can be restricted to the couples *(i, j)* for which $\sigma(i,u,j) > 0$, in order to define an approximative measure adapted to large social graphs analysis.

1) Structural Analysis: Classification (*graph-clustering*) and characterisation of graphs are the basic foundations of static SNA. Structural properties are defined for the main types of social graphs and they provide some elements of static SNA. In the context of random graphs [6], the degree of the n vertices of the graph is determined by a probability $p(n)$ with $p \mapsto [0;1]$. With pseudo-random graphs, the degree of n vertices is distributed according to an uniform distribution law (*e.g.*, law of Laplace-Gauss) where $G(V,E)$ owns a probability $p = \mid E \mid \div (\frac{|V|}{2})$, with V a set of vertices and E a set of edges. With scale-free graphs [8], the most connected nodes increase their connection degree following a power law (*"richers get richer"*). By defining specific behaviours for each type of networks and sub-graphs, these structural static properties also provide elements for dynamic analysis of social graphs.

2) Flows Analysis: Several works of graph theory (*e.g.*, the maximal flow problem) are applicable to static analysis of flows within social networks. It is particularly the case of the *small world* study in which V. LATORA et M. MARCHIORI have introduced the notion of *efficiency*, defined as a measure of communication weighted inversely proportional to the shortest path between two vertices *i* and *j* [4]. The work of J. LESKOVEC and E. HORVITZ about large social graphs (MSN - 179 millions of vertices), updates the "six degrees of separation" hypothesis, a *small world* characteristic. In [16], the MILGRAM hypothesis, advocating the ability to reach 100% of the vertices of a graph in 6 hops [17], is dropped down to only 48% of vertices reached. Following a *long-tail* curve, the distribution reaches 78% of vertices within 7 hops and for 90% of vertices, the measured mean is 7,8 hops, with a maximal shortest path of 19 hops between two vertices (measured on a sample set of 1000 vertices).

Some physics models are also treated with help of graphs for the understanding and discovery of theoretical principles. In the electricity area, the KIRCHHOFF's *law of nodes* and *law of meshes* are the most well-known illustration of this trend. The work of [5] about resistance and currents of finite networks, demonstrating the unity and continuity of flows within large graphs, brings a new hypothesis to be validated in SNA.

To sum up, static SNA provides a large set of mathematical, sociological and even physics models. These models are mainly based on the graph theory and and they can be used to discover explicit or implicit knowledge within social graphs. Some of these models are also extended to dynamic SNA [18], an aspect out of scope for this paper.

B. Semantic SNA

Semantic SNA studies the conceptual aspects of social graphs. It is founded on conceptual graphs and ontologies coupled with SNA principles [12]. Currently, to our knowledge, no significant work has been published in the domain, but the attractiveness of the subject is visible.

We define an ontology as *a formal and explicit specification of a shared conceptualisation* [10]. J. JUNG AND J. EUZENAT comment the description of a three-dimensional view of semantic SNA, putting together social graphs, annotations and ontologies *ERgraphs* - Entities/Relationships graphs, [19]. Their proposal overlays and makes the three dimensions coincide in order to build "consensual" ontologies, where annotations are linked to the social graph. ALEMAN-MEZA AND AL. introduce a semantic application for interest conflicts detection within social networks of scientific publications [20]. Based on the research of syntactico-semantic patterns, the application measures the semantic similarity between authors corpus, in order to detect possible redundancies or concurrencies within subjects shared or divided across teams. The work of [21] about semantic SNA paves the way of semantic and statistic analysis. It makes the outline of SNA operational, by integrating it to the models and languages of the Semantic Web (*i.e.*, OWL, RIF, FOAF, SIOC, MOAT, POWDER).

Rules and inferences systems, in correlation with cognitive sciences, bring a main line of SNA developments towards a semantic dimension. These developments are submitted to vertices and edges annotations, by automatic means such as statistic learning and natural language processing, or human treatments such as *social tagging*. *Reciprocal evaluation* between members of a social network shows how human interaction produces a valuation on which a reliable *degree of confidence* can be computed. We talk of *favours network* when the graph structure depends on peer-to-peer evaluations. Eventually, the integration of cognitive sciences such as linguistics, psychology or neurosciences, produces interesting results as demonstrated by ontology personalisation [11]. The hypothesis of derived methods specifically adapted to semantic SNA can be considered.

T. GRUBER cheers on initiatives which tend to integrate semantic web principles and languages, to social networks for the development of *Collective Intelligence* and *Collective Knowledge Systems* [12]. From the large Web communities to the enterprises social networks, semantic SNA can bring real progresses in different domains, such as global marketing linked to globalisation, social and human capital management or work-groups and work-methods optimisation within professional organisations, the domain in which we are interested.

III. MULTIDIMENSIONAL SYNERGIES IN EISNA

The main objective of our work is to exhibit multidimensional synergies between the static and semantic aspects in Enterprises and Institutions Social Networks Analysis - EISNA. The specificities of EISNA are: (1) social graphs composed of up to 100 000 nodes, (2) endogenous data restricted to a few specific and connate domains and (3) intensive collaborative work with trade-oriented information sharing.

The methodology we have adopted respects the segmentation of the problematics:

- Static SNA is integrated without any change. Our contribution mainly consists in providing relevant bridge-building of known methods and identified models, originally from physics or cognitive sciences. The results we provide concern new flows metrics of social graphs. Devoted to EISNA for the prevention of social risk, they consist in the definition of 2 metrics. The first metric is dedicated to evaluate a new notion named *tension of a social network* (*cf.* section III-A1). The second metric extends the L.C. FREEMAN's measure of *betweenness* (*cf.* section III-A2) which becomes semantic - *semantic betweenness*.
- Semantic SNA is developed by integrating social graphs, conceptual graph, ontologies and inferences rules. The contributions we provide can only be applied to EISNA and they are specially devoted to work organisation and social/human capital management. Currently, our third contribution consists in defining a new notion of *reactance*, which aims at the evaluation of individual stress (*cf.* section III-B).

The results we provide are jointly afforded to converge in a multidimensional model, leading to the development of decision-making tools for enterprises and institutions social networks.

A. Static EISNA, Physical Models and Cognition

Our model adopts FREEMAN's centrality and betweenness measures, starting with non-directed graphs. For instance with directed graphs, *Page-Rank* provides a score easily assimilated to a measure of *prestige* [22], and an extrapolation integrating an *authority coefficient* (author reputation), *Trust-Rank*, gives a *confidence/trust score*, also adaptable to non-directed graphs as a complement of other measures [23].

1) Static EISNA, Flows and Physical Models: To introduce some new flows measures, we test assimilation of the graph edges to conductors transporting electrical flows. Our method consists in quantifying and qualifying flows embedded in social networks with semantic ratios. These ratios are defined according to percentages of read, written or shared in common documents (*e.g.*, office, mails, instantaneous messages), exchanged data packets (ToIp, VoIp) and other numerical marks able to characterise conceptual links between individuals. Some electrical principles are adapted to static analysis of flows around a vertex, among which the KIRCHHOFF's *laws of nodes and meshes*. Figure 1 illustrates the *Law of nodes*, with *I* intensity of electrical charges for an output quantity *Q* by time unit *t*.

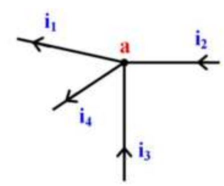

Fig. 1. Law of nodes, $\sum I_{input} = \sum I_{output}$, i2 + i3 = i1 + i4

The originality of our work consists in introducing the concept of *tension* in a social network related to the notions of *crossing flow intensity* and vertex *resistance*. A vertex *s* directly connected with two other vertices *r* and *t* can be likened to a dipole which resistance is noted *R*. We use OHM's laws:
$Urt = Rs.Irt$ and $Ps = Rs.Irt.Irt^2 = Urt.Irt^2/Rs = Urt.Irt$,
where Urt represents the electrical tension depending on Rs and Irt, and Ps represents the delivered power by a vertex of which maximal admissible power is noted $Pmax$, with $Umax = \sqrt{R.Pmax}$ and $Imax = \sqrt{Pmax/R}$.

By applying OHM's law upon a social graph, it is possible to compute a *charge-capacity* ratio of the enterprise social network, by analogy with $Ps, Pmax$. The purpose is to introduce a *stress* measure of individuals and communities. This measure uses the *Joule effect* to estimate the enterprise

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social network components *warm-up* and to prevent risks of performances degradation, instability or breakdown (socio-psychological trouble). The warm-up *T* depends on dissipated energy and material resistivity ρ. Since the value of ρ varies according to diversity of molecular structures, its computation gets out of the scope of this paper. So, it must be considered that the *social material* is *a priori* abstracted as a constant by initialising algorithms with ρ = 1, let $T.\rho = W = R.I^2.\Delta t$. Next, ρ should be refined by $\rho \mapsto [0; 1]$, according to a defined determinant used to induce recursive interaction between *T* and *R* encountered in physics, where ρ is varying according to *T*.

2) Static EISNA and cognition: Manual resources tagging requires cognitive processes. In the context of EISNA, this method can lead to psychological rejects mainly caused by political and ethical aspects. To be more ethically acceptable, manual tagging should be limited to non-human resources (documents, textual corpus, databases). The characterisation of individuals and groups must be based on criterias respecting persons and privacy.

By associating terms used to annotate trades-oriented resources with of concepts of an ontology, the semantisation of annotation process facilitates the discovery of *communities of practice* by the means of implicit relationships between annotated resources. According to this standpoint, we use trades-oriented ontologies to qualify numerical analysis of social graphs. Technically, this is done by correlating statistic results obtained on flows and structures to ontological conceptual graphs.

From the equation (1), we define a new measure of *semantic betweenness* weighted by endogenous resources (*i.e.*, mainly annotated documents with help of terms) where (1) each annotation is associated to at least one individual of the considered social network and where (2) the sum of annotation occurrences calibrates favourably the measure for the individuals who share resources associated to the majority annotations.

This new measure is defined in the following context. Explicit relationships between the set of human resources *Rh*, the set of resources *Rsi* extracted from the information system and the set of content annotations *Esi* are used to enrich EISNA and discover some implicit relationships.

We introduce the sets Rh, Rsi, Esi and the relationships R, R' and avoid to compute wastefulness reflexive relationships (*e.g.*, relationships in $RsiXRsi, EsiXEsi$).
We define a relationship $R(D, D')$ where:
$D = Rh$ or $D = Rsi$, $D' = Rh$ or $D' = Rsi$ or $D' = Esi$.
We define a new set of measures by introducing a weighting ratio C_p, based on the cardinality of R. When the SNA metric to which we apply our semantic extension method gives a result superior to 0, for a vertex u within a social graph, we modify the metric by integrating the C_p factor. The factor increases the value of the SNA measure for the vertices sharing the same knowledge. C_p uses the cardinality of the relationship R, relationship between the graph represented by pD, and the endogenous content or its indexation, represented by pD'. pD and pD' are respectively restricted by the arguments eD, eD', where eD represents an element of pD (*e.g.*, u) and eD' represents one or several elements of the content or the index, given by pD' (*e.g.*, some keywords). C_p is formalised as follows:

$$\textit{SNA metric} > 0 \land C_p = |R(pD, pD', eD, eD')| \quad (2)$$

We have simulated the behaviour of a betweenness centrality incorporating the C_p factor. The simulation is combining some one-decimal values ranged from $0,1$ to 1.0 for the centrality, and some values from 1 to 10 for the C_p factor. It aims at the estimation of three alternatives of the use of C_p. These alternatives are formalised as follows, with V the vertices of $G(V, E)$, $semindex$ a semantic index of the endogenous content, u a vertex in V and $knowledge$, a knowledge set related to seized keywords:

$$B_{Cp}(u) = \sum_{ij} \frac{\sigma(i,u,j)}{\sigma(i,j)} \times |R(V, semindex, u, knowledge)| \quad (3)$$

$$B_{Cp}(u) = \left(\sum_{ij} \frac{\sigma(i,u,j)}{\sigma(i,j)} \right)^2 \times |R(V, semindex, u, knowledge)| \quad (4)$$

$$B_{Cp}(u) = \sum_{ij} \frac{\sigma(i,u,j)}{\sigma(i,j)} \times \sqrt{|R(V, semindex, u, knowledge)|} \quad (5)$$

The figure 2 illustrates the behaviour of the equation (3) in green, of the equation (4) in blue and of the equation (5) in red (*i.e.*, the lowest curve). The output values are presented vertically and the samples used for the simulation are numbered horizontally.

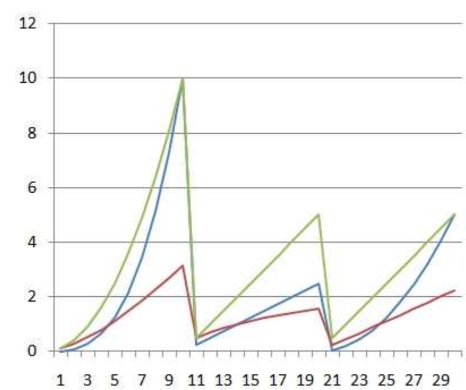

Fig. 2. Simulation of the C_p integration with the betweennes centrality.

C_p can reach a value superior to 1000 in the context of the *Socioprise* project. Therefore, we choose to weak its influence, using equation (5). When $C_p > 0$, the equation (1) is modified as follows:

$$B_{Cp}(u) = \sum_{ij} \frac{\sigma(i,u,j)}{\sigma(i,j)} \times \sqrt{|R(V, semindex, u, knowledge)|} \quad (6)$$

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Equation (6) introduces a new measure of *semantic betweenness*, based on [1]. This measure takes a qualitative dimension into account by integrating endogenous information contained in Rsi and Esi, to the calculus of betweenness centrality. C_p is quantified and qualified by eD, eD' through ontologies enabling semantic association of elements in Rsi and Esi. The discovered knowledge in these conceptual associations is the strong point of this new “smart” measure.

B. A use case of semantic EISNA

Sections III-A1 and III-A2 have introduced an analogy between flows and structures analysis within social networks, and some principles close to radio-electricity which seem to be relevant. We have put forward notions of *resistance, charge, capacity, warm-up* and *powers*. This context is used to characterise implicit or explicit relationships $R_s(i,j)$ between the vertices of a social graph. Our goal is to cross these relationships with semantic properties (object or data properties) represented by one or more domain ontologies to conceptualise interactions within the social graph.

The notion of *reactance* already exists in electrodynamic and social psychology. In electrodynamic, the reactance (in Ohms) describes the energy opposed to an alternative current. WANG uses reactance as a parameter of a neuron network, to control the defects of an electrical network, depending on the kind of element crossed [24]. In psychology, the reactance characterises ”*a state of negative motivation following a menace (supposed to be real) of individual freedom restriction that is translated into a influence resistance*“ [25].

In our work, we propose to use the *reactance* Ψ as a notion of individual stress. From the metric of *tension* defined in section III-A, we draw up the following assertions :
Let a graph $G(V,E)$ where vertices of V are connected by the edges of E, respecting the following properties:

- Each element v of V intrinsically holds coefficients resulting from classical measures of social networks (*cf.* Freeman) or possible refinements.
- $\forall(u,v) \in V$ connected by $e \in E, u, v$ intrinsically holds analogical values of *resistance, charge, capacity, warm-up, powers* depending on V, E.
- $\forall e \in E$ assimilated to an uncharacterised flow ϖ, owning a quantifiable value $\varphi_{\varpi} \neq 0$, e is intrinsically described by values of *resistance, charge, capacity, warm-up* and *powers*. For e, $\vec{\varpi}$ or φ_{ϖ} are measured as a pseudo-tension T_e or pseudo-intensity I_e.

From these assertions and the results of experiments managed in the context of the SOCIOPRISE project (*i.e.*, a project dedicated to human and social capital management) within trade-oriented organisations, we offer a first set of knowledge dedicated to the identification of individual stress. This set of knowledge can be represented by the following rules and axioms:

* **rule 1**:
If $CC_u = \frac{charge_u}{capacity_u}$ increases and $CC_u < 80\%$,
then Ψ_u increases.

By analogy with electronic power networks, we integrate the notions of minimal charge threshold under which the performance collapses.

* **rule 2**:
if $P_u = \frac{resistance_u.intensity_u^2}{Pmax_u}$ increases and $P_u \leqslant 1$,
then Ψ_u and $warm{-}up_u$ increases (P_u represents a used power).

* rule 2 *bis* (inference learning on rule 2):
if $warm - up_u$ increases,
then Ψ_u increases.

* **rule 3**:
if P_u increases and $P_u > 1$,
then Ψ_u decreases, $Pmax_u$ decreases and $warm - up_u$ quickly increases (P_u has exceeded $Pmax_u$).

* **rule 3 *bis*** (*inference learning on rule 3 and experts supervision*):
if Ψ_u decreases and $warm - up_u$ increases,
then quick decreasing of $Pmax_u$ and destruction risk.

* **axiom 1** (*inference supervised learning on rule 1*):
if $CC_u \leqslant 0.8$,
then risk to lose socio-professional performances.

* **axiom 2** (*inference learning on rule 3 and 3 bis*):
if $P_u > 1$,
then risk of socio-professional troubles.

* **axiom 3** (*inference supervised learning on axioms 1 + 2 and their premisses*):
performance optimisation is equivalent to $CC_u > 0.8$ and $P_u \leqslant 1$.

* **axiom 4** (*learning from symmetry on axiom 3 and his premisses*):
risk of socio-professional troubles is equivalent to risk of loss of socio-professional performances.

From the equations system underlying these rules and axioms, we are currently formalising an innovative scalar metric of *reactance* Ψ_u. From the multidisciplinary model we define, we plan to get an innovative tools-set for decisional applications dedicated to social capital management. These tools combining SNA metrics, knowledge engineering, ontologies and sociology, applied to enterprise content and to enterprise or institutions social networks (*e.g.*, LDAP Directories or other structures), will enable an innovative approach of human capital management and human risk management.

IV. CONCLUSION

The purpose of our work is to define a model of enterprises and institutions social networks analysis (EISNA). The main originality of this model is to integrate the static and the semantic dimension of EISNA. Our current proposal is based on 3 contributions, defined in the context of a multidisciplinary approach. These new contribution are respectively dedicated to the evaluation of *tension*, *semantic betweenness* and *reactance*, for professional social networks analysis.

Our introduction of semantics in the FREEMAN’s measures enables to qualify some collaborative and quantified exchanges, while establishing new centrality degrees for a semantic identification of knowledge communities within enterprises and institutions social networks. The possible new measures extended by our approach correlate statistic and conceptual dimensions through endogenous resources and scientific multidisciplinarity.

This work is a baseline for the development of new decision-making functions and tools applied in social and human capital management of enterprises and institutions. Compared to some usual methods of sociometry such as internal surveys, our model ought to significantly reduce the bias, while answering to the problems of socio-professional troubles risk prevention, performances loss risk prevention and social risk prevention.

From an applicative standpoint, our proposal is currently evaluated in the context of an experiment related to the SOCIOPRISE project. From a theoretical standpoint, this work is currently in progress towards the integration of dynamic aspects of EISNA. We plan to use AMPERE's laws and MAXWELL's laws of electrodynamic, in order to advocate a predictive analysis of social networks structural evolution.

The main applicative perspective of this approach is to assist the optimisation of work-groups and performance in an enlarged context, such as a pool of enterprises and institutions. The main theoretical perspective is to formalise *a complex and multidimensional model (static, dynamic and semantic) dedicated to professional social network analysis*.

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An Open Source Collaboration Framework with Inter-Desktop Movable Windows and Remote Multicursor Desktops

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***Abstract*—Many current tools for conferencing and synchronous collaborative work suffer from being limited to certain types of documents or to specific, often proprietary collaboration software. In this paper we introduce a system for assisting synchronous collaborative work with arbitrary software by enabling to move any window on a typical computer desktop to other desktops in the system, may it be another computer in the company or a virtual desktop being run on a shared desktop-server. We equip these desktop-servers with multiuser multicursor capabilities, such that groups of users can join to work concurrently on a shared desktop, both locally and from a distance. As any kind of window can be moved from desktop to desktop, the choice of software that can be used for collaborative tasks is unlimited. Our system is built from reliable open source components only and is freely available for everyone. In this paper we present the current version of our system that works for arbitrary Unix-based computers and demonstrate the feasibility of our approach. Thus we show how collaboration suites, terminal systems, desktop sharing and multicursor desktops can be generalized into a consistent system, where the window on the screen is the users essential movable item that is used for remote work and collaboration.**

Keywords*-*Real-time collaboration, technologies for collaborative work, open source, interface sharing.

I. Introduction

In [1], we augment seldom-used multiuser multicursor desktop technology [2] [3] [4] [5] by a remoteness-mechanism for allowing many users to connect to virtual remote multiuser desktops for accomplishing collaborative work. By combining well-tested open source components we achieve a system that supports small work groups in working together synchronously from afar. This appeares to be beneficial for e.g., an interactive meeting in a project design phase, but it can be useful in many other work and teaching situations as well. This approach models the natural “come together” on a shared conference table, where workers join for collaborative work on (paper) documents layed out on the table. However the data exchange with the shared desktop was limited to using shared data with some software that must be installed on the shared desktop server, thus having data sharing restricted to files or documents that must be somehow transferred to or accessed from the shared desktop.

With the current work we combine our remote shared desktop solution with a solution that allows to move arbitrary windows among different computer desktops without interrupting the running application. The target desktop can be just another desktop computer in the company, but can also be a (virtual) shared multiuser desktop where collaborative work can be carried out.

Such an approach substantially broadens the access to non-local information at a particular computer screen. We can make the freely movable window of a running application be the essential item of collaboration. And we can overcome the borders of the current desktop and create something like a “shared desktop space” on which project-wide or company-wide collaboration can take place, both locally and from afar.

In this paper we describe the architecture and the current version of our system. We start in Section II with comparing our work with existing collaboration software. In Section III we sketch various usage scenarios of our system. Section IV lists the components and describes the concepts of our systems architecture. In Section V we describe the functionality of our system from the users point of view with respect to the screenshots in Figure 4. Section VI and Section VII report on the hardware and network requirements and the availability of our software, followed by a conclusion and a proposal for future work in Section VIII.

II. State of the Art and Benefits

Most current systems for remote and (synchronous) collaborative work fall into the following categories or can be considered a combination of: ◦) e-Collaboration platforms like Alfresco [6], e-groupware [7], and Zimbra [8] basically allow for coordinated editing and sharing of documents and information. ◦) Software for collaborative editing of single documents like Gobby [9], Ace [10] [11], and Abiword [12] allow for synchronous collaborative editing, but only for limited types of documents. ◦) Terminal Systems like Citrix [13] and X2go [14] allow for accessing remote services (i.e., running software) that are run on a dedicated central server. ◦) Desktop sharing systems like the variants of VNC [15] [16] [17] or those based on RDP [18] allow to share the entire desktop with other remote users or to perform work on a distant computer. ◦) Web onferencing software like gotomeeting [19] and Openmeetings [20] usually combines some of these features, but still needs special (often proprietary) software to be installed, is bound to web interfaces or does not allow for the natural concurrent work of many users on the same desktop, like it is possible with the multicursor concept.

With our system we try to generalize these approaches to a consistent system of a shared desktop space among group members, that is tightly integrated into a standard user system, such that moving windows and concurrent and collaborative work of many users on multicursor group-work desktops (that can be accessed locally or from afar) gets a trivial part of everydays work routine.

For building blocks and communication between them we rely on open source components and on open protocols like SSH, X11, RDP, such that our system can be extended or integrated with other systems as needed. Our system is built for arbitary X11-based software and desktops (i.e., Unix-based systems). But with Cygwin [21] and X11 for MacOSX [22], it can be accessed from Windows or MacOSX powered computers too.

III. Usage Scenarios

Inter-desktop window movement has numerous applications by itself e.g., when visiting a colleague in another room and pulling over a window that is currently shown on the own computer screen for discussion, or when a teacher pulls a well-prepared presentation of some running software to a lecture hall's presentation computer, or when a system administrator delegates difficult problems to a specialist by pushing the application window of the running supervision software to the screen of the responsible specialist. Pulling windows may also be helpful for simply changing the workplace e.g., from company to home, or for letting an application do background work and reattach to it as soon as this is of interest again, independent from the location of the user.

Multiuser multicursor desktops could be installed in meeting rooms or at presentation computers. Meeting attendees could pull the relevant application windows to the shared desktop to work on it with the group collaboratively, like on a shared whiteboard. The same principle can be applied for student groups in a computer lab, which practice team work or get assistance from an instructor.

All these work situations can also be carried out from a distance by using remote shared multiuser desktops. Users could connect to the shared desktop from a remote computer, such that the view of the shared desktop is propagated to all participating users in real-time, thus being simultaneously visible to the participants.

All in all we give the application window on a computer desktop a new role, namely being the essential item that can be carried around, sent and received, like it was the "document" or the sheet of paper in pre-computer times.

Clearly, our system can freely be combined with any other collaboration solution, as this would most probably be just another software showing up in some window on the users' screens. In practice remote multicursor desktops will have to be accompanied by voice-chat systems to accomplish about the same group work as working locally.

IV. System Architecture

In this section we describe the main building blocks of our system and sketch how they are combined to a system that achieves the different functionalities we proposed.

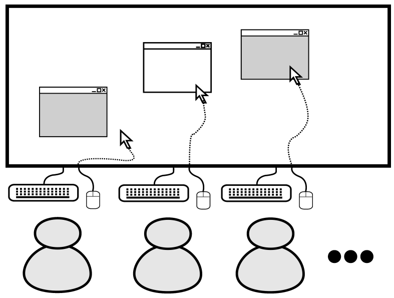

Figure 1: Multiuser multicursor desktops.

A. System Components

Our system is built from well-known open source components: SSH (Secure Shell) [23] [24] provides secure authentication mechanisms and secure encrypted data traffic and is nowadays the most widely used workhorse of secure communication.

VNC (Virtual Network Computing) [17] is used for graphical desktop sharing to communicate the contents of a remote computer screen to another computer. It is based on the platform-independent RFB protocol [25]. VNC viewers can connect to VNC servers running on different operating systems.

Our prototype system is implemented with Debian GNU/Linux [26] but can be used with any desktop system based on an implementation of the X windowing system [27] [28] like X.org [29], which is the central building block of most current Linux desktops.

Additionally we use xpra [30] as X11 proxy server. The xpra server can serve as a virtual X server for the application, while the xpra client can connect to it to fetch the interface of the application and make it visible on a computer screen (see Section IV-B). xpra can apply various degrees of compression to the traffic of user-interface information, making it possible to balance responsiveness and quality of the visible view according to the available network bandwidth.

Finally, the Multicursor Window Manager [2] [3] [4] [5] is an X11 window manager based on IceWM [31] that allows small groups of users to use a shared desktop concurrently by assigning a mouse cursor plus keyboard and a distinct input focus on the shared desktop to each participating user. By a simple click, a users can assign a window to his/her input focus to work on the window, while other users may utilize other windows on the desktop at the same time. This allows for simultaneous work of different users on different windows on the same desktop. Still, for the single window, no adaption of the application's user interface is required. Collaboration on a single window is achieved naturally by quickly switching input focus as necessary (see Figure 1).

A modified version of x2x [32] serves for sending mouse and keyboard events to the multi-cursor desktop from remote.

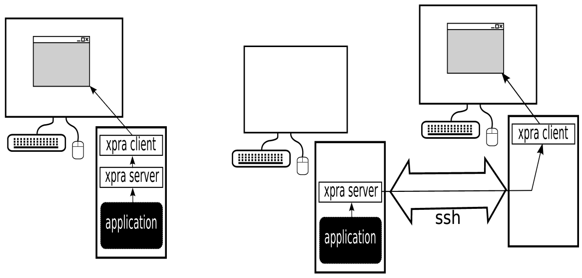

Figure 2: Pulling and pushing windows with xpra.

B. Pushing and Pulling Windows

For enabling inter-desktop window movement, we can make use of an ancient design principle of X11, namely the separation of applications from their user interfaces (i.e., the windows on the desktop), where the X11 protocol [27] [28] is the protocol for application-interface communication.

We add an xpra client-server pair to the line of X11-communication between application and interface (window) (see Figure 2, left), which is invisible for the user and has virtually no impact on the percepted performance. In case we want to push (or pull) the application window to another desktop, the local xpra client is terminated and another xpra client is started at the target machine, which then connects to the running xpra server to fetch the user interface and pass it on to its local X server, which takes care of displaying it on the local screen (see Figure 2, right). Meanwhile the xpra server serves as an X server for the application and as it is not interrupted by the switch of the xpra clients, the application can carry on undisturbed. Note that the window indeed is moved from one desktop to the other as it disappears from the original one (see Figure 4). Still, the target desktop itself can possibly be a (remote) shared desktop beeing equiped for group work, see Section IV-E.

C. Connection Tunneling

We tunnel all connections for running a remote desktop-session (the xpra connection, the mouse and keyboard events communicated via x2x, and the VNC connection that propagates the view of a remote desktop, see also Section IV-E) through a single SSH connection. As tunneling can be performed in both directions, it does not matter which computer was the originator of the SSH connection. Because of the reliable encryption of SSH, our system is capable to communicate safely, even behind firewalls and NATs. Note that as an alternative a VPN-solution like e.g., OpenVPN [33] could take the role of SSH accordingly.

D. Remote Multicursor Desktops

In the center of a remote multicursor desktop system we run a (virtual) X11 desktop with a multicursor window manager and with an attached VNC server on a server computer. Users can get a real-time view of the multicursor desktop by using an appropriate VNC client that connects to the VNC server (see the dashed lines in Figure 3). Thus, any action taken by one participant of the shared desktop is made visible to all participants simultaneously and synchronously. To allow participation on the work on the shared desktop, mouse and keyboard events are sent from the users to the remote multicursor desktop via x2x connections, where each mouse/keyboard is assigned to one of the mouse cursors and input focuses of the multicursor system (dotted lines in Figure 3). With a mouse click, users can assign their input focus to a window on the shared desktop to work on this window, while other work can be performed by other users on other windows independently, but visible to all participants.

E. Putting it together: Pushing Windows to Remote Multicursor Desktops

To being able to send local windows to a shared multicursor desktop for groupwork, we combine connection tunneling, desktop sharing and the pushing of windows via xpra as shown in Figure 3: For accessing the remote shared multicursor desktop, a user first establishes a single SSH connection to the shared desktop-server. Then a VNC-client is started locally to bring a real-time view of the remote desktop to the user, as described in Section IV-D. Subsequently, a locally run x2x-client is used to attach to one of the cursors of the multicursor desktop, enabling the user to do work on the remote shared desktop. Finally, for moving a window from the users local desktop to the remote desktop, a window pushing step with xpra as described in Section IV-B is performed.

By this combination we achieve the required functionality of a simultaneously visible remote shared multicursor desktop, to which each participant can push application windows.

Note that remote shared multicursor desktops are just the most complicated scenario that can be handled with our system. Simpler cases like window-movement to other ordinary desktops can be handled accordingly. In safe environments like computer labs, it is even possible to omit the SSH connection and to allow direct connections between the participating computers.

F. Security and Access Control

As mentioned in Section IV-C, all relevant connections (the VNC-connection, the x2x-connection, and the xpra-connection) are tunneled through a single SSH connection to guarantee encrypted safe communication. Via the well-tested SSH login-mechanism (password-protected or public-key-protected), security and access control can safely be handled by the SSH daemon. All the other daemons (xpra server, VNC server, X server) are restricted to local connections, which can only be accessed from the local SSH subsystem, thus there is no connection possible, before a proper SSH connection between the participating computers is established. This approach inhibits improper connections and enables various access control schemes that can be configured with the SSH configuration.

V. Screenshots

In Figure 4 (left) a locally running application (the spreadsheet) with a shared remote multicursor desktop in

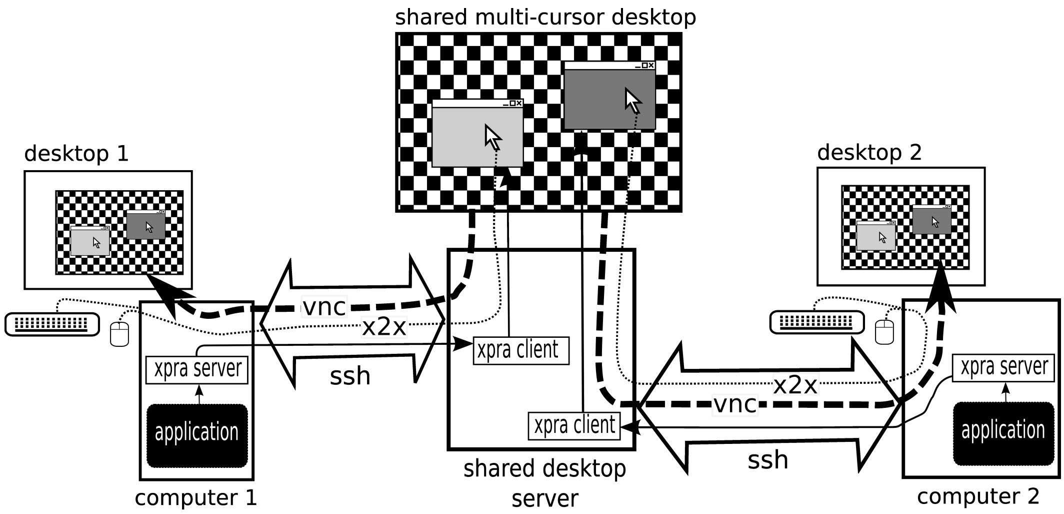

Figure 3: System architecture of a remote shared multiuser multicursor desktop with two participating users.

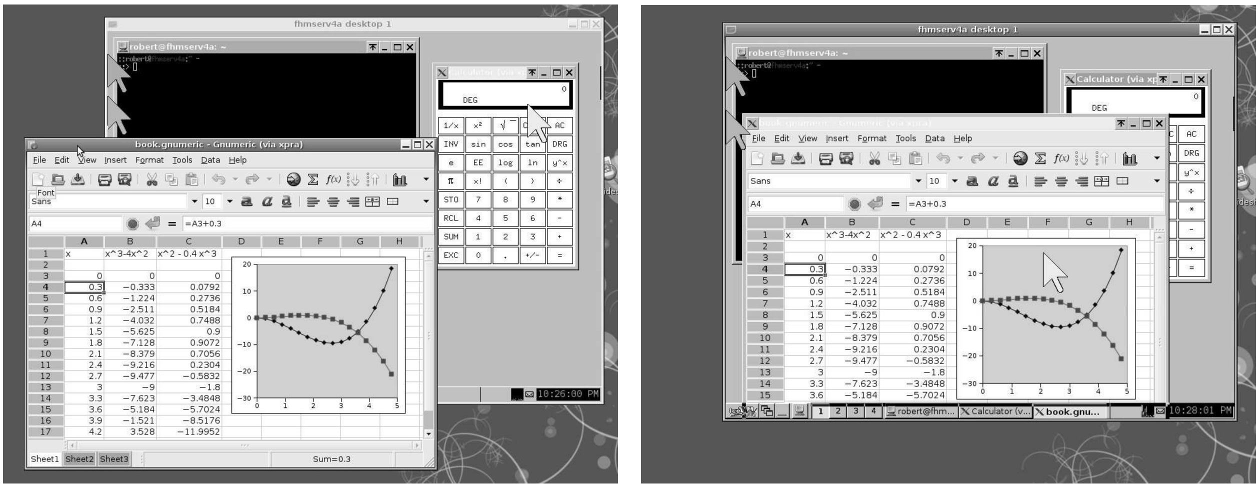

Figure 4: Screenshots of a remote multicursor desktop in use.

the background can be seen. On the remote desktop, 3 mouse pointers are visible, indicating 3 users currently attending the shared desktop. The different input focuses are indicated by different colors of the title-bars of the windows on the multicursor desktop. In Figure 4 (right) the spreadsheet application was pushed to the remote multicursor desktop to be worked upon by the participants collaboratively. At any time, the spreadsheet window can be pulled back to the local desktop without closing the application e.g., for completion steps. Note that in practice the shared desktop is configured to be substantially larger to provide enough screen space for collaborative work. It is even possible to add a dedicated monitor for groupwork on shared desktops to a workstation.

VI. Hardware and Network Requirements

As the xpra server and xpra client consume very little system ressources, the requirements for the client computer are essentially based on the software, that is planned to be used. For hosting a single shared desktop, a standard PC in the 1GHz/512MB/30GB-class is sufficient. A more powerful computer can consequently host more than one shared desktop.

As the xpra connections and the VNC connections can adapt to different network bandwidths the system can adapt itself to quite different network conditions by decreasing the image quality of the transmitted user interface, if necessary. Our system was tested to work with reasonable internet connections including ADSL, XDSL, modem and (with slightly degraded performance) even with mobile UMTS connections, thus we conclude that a bandwidth of 5-10 MBit/s per user of a multiuser desktop is sufficient for smooth operation. As mentioned in Section IV-C, firewalls and NATs pose no difficulty to the connectivity of our system.

VII. Availability

The current version of our system runs on a couple of Debian Linux-based demo computers, including a shared desktop server for remote multiuser multicursor desktops. Our system consists of the software and the system configuration necessary to combine the components as described

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in Section IV. It is currently packed into packages for easy installation on Debian Linux-based systems. We are also working on a proper GUI and on the close integration of our system into the user interface of desktop envirenments (e.g., GNOME [35]) as a supplement to the currently existing command line interface, and we are eager to make our system available to some production environment.

VIII. Conclusion

By combining multicursor desktops with VNC-based desktop sharing, we achieved a system for synchronous work of small work groups [1]. In this paper we enhance this system with an xpra-based feature for moving arbitrary desktop windows between different desktops, including the (virtual or real) shared desktops. This makes our solution applicable in many situations of everyday computer work, like e.g., team meetings, creative design phases, e-learning and system administration, both locally and from afar.

Generally, we declare the "window on the screen" to be the essential movable data unit, which can be taken along to other computers or workgroup sessions, enabling to collaboratively work with arbitrary software in a seamless manner. Thus our system meets the basic needs of coming together for collaborative work and of carrying the relevant information from one place to another.

By this design we could overcome limitations of being restricted to specific software, data formats or platforms and solve many problems at once, that are normally addressed by very different systems like e-collaboration platforms, collaborative editors, desktop sharing software and web conferencing tools.

Still our system can be freely combined with any other (collaboration) software suitable for a specific task, as this would be just another application with some GUI window on the desktop.

As we uniformly tunnel all data traffic through SSH connections, we can rely on the safe encryption and access control of SSH and can implement various access schemes with an appropriate SSH configuration. As SSH is so widely used and well developed, communication encryption and access control can be considered adequately safe even for critical operation. Additionally, the connection tunneling makes our system capable of working with a wide range of network configurations including NATs and firewalls.

Our system is designed to work with most Unix-based operating systems and is available as a running prototype to prove feasibility and usefulness of our approach. As we built our system from open source components only, it is freely available for everyone. In practice it has to be accompanied by a voice-chat system to support a wide range of collaborative work tasks even from a distance. A tight integration into the users desktop and a comfortable user interface is under active development.

Our system can be seen as a kind of virtualization of GUIs, which can be transferred freely among desktops, where we use X11 as an universal and flexible protocol for communication between an application and its GUI. Having achieved this, we could address the virtualization of the underlying application independently of its GUI. This is the starting point of our future plans to explore possibilities of application virtualization so that not only the application interface can be moved between computers, but also the running application itself, giving work groups a heterogeneous network of computers to flexibly assist location-independent collaborative work in many ways.

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