Advancing Knowledge Management and Exchange between Collaborative Environments: A Tool Integration Perspective

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Abstract. This paper focuses on supporting knowledge management and exchange between web-based and traditional collaborative environments. In particular we discuss the integration between a tool (*CoPe_it!*) supporting collaborative argumentation and learning in web-based Communities of Practices and a hypermedia and sense making tool (*Compendium*) acting as a personal and collective Knowledge Management (KM) system in traditional collaborative environments. We focus on the general applicability of this integration for supporting Communities of Practices and, more generally, collaborative works, and discuss the main objectives and challenges to be addressed.

Keywords: Knowledge Management, Knowledge Works, Collaborative Environments, Knowledge Exchange, CoP, VCoP.

1 Introduction

Communities of practices (CoPs) naturally generate and act in real world settings like work contexts, leisure and family or familiar places [1]. Contextual and contingent situations can bring people to discover common aims, desires, needs or problems and then trigger new unpredictable ways of collaboration towards shared objectives. Starting from these objectives people communicate and organize their actions towards a common goal. In this process of community definition, specific roles, tasks, and expertises start emerging within the group [2]. Eventually, the different roles are legitimated by social relationships of trust among the community members, forging the overall identity of the group as a whole [3].

This complex process of transition from a group towards a CoP is determined by the simultaneous occurrence of personal actions, choices and attributions of value. This transition is strictly related to the individual knowledge of the community members (often tacit knowledge) and to the contextualization of this knowledge to different environments, situations and times [1].

Defining the prototypical transition from a group towards a CoP is, therefore, highly challenging; it is particularly sensitive to the environment and highly dependent on the specificities of involved actors which can be only temporarily

involved. What happens to this complex dynamics when we look at web-based, i.e. virtual Community of Practices (VCoP)?

We could assume that acting in virtual environments, like web-based environments are, with fixed and predetermined protocols for information exchange, language and communication roles represent a significant help to analyse the VCoP dynamics. In VCoPs knowledge objects and communication rules are pre-structured and then we can monitor and control some of the social implications and influences that in traditional CoPs would make the problem more complex. Despite this we cannot consider VCoP members as isolated entities with no social (external to the VCoP) life, environment and relationship, separated from their personal histories which indeed affect their actions and positions within the VCoP.

Then the question is: In the global village does it make sense to distinguish traditional (real-world) CoPs and WCoPs? We should rather start thinking about a hybrid version of CoPs (HCoPs) whose community members act and communicate in both virtual and traditional modes in a way that is continuously shifting from one mode to the other one [4]?

When we think about virtual and traditional collaborative spaces we mainly refer to the web and to real-world environments; we mainly refer to activities performed on-line and off-line. In this sense we can consider computer supported works as real-world activities when they are performed off-line. The focus is on communication modalities rather than on the specificities of the communication space: traditional spaces are spaces in which humans communicate by real-world means, whereas in virtual spaces humans (or agents) communicate by artificial means.

Knowledge based works are increasingly looking for tools and environments able to manage and to integrate knowledge created and exchanged within and between virtual and traditional environments.

What integration method and tools should be envisioned and provided in order to take into account the influence and impact of hybrid knowledge in order to enlarge individuals and community networks?

Our aim is twofold: i. enhancing virtual interaction networks by exploiting social relationships in traditional spaces and, vice versa, ii. enlarging the social and real-world networks by exploiting links and knowledge from virtual communities.

Knowledge from virtual community networks is a key feature in the real-world environment for CoPs in order to make them able to leverage internal debates to a new way of communication: not only face-to-face but also remotely (i.e. distance and asynchronous interactions as they can be supported within virtual environments). At the same time knowledge from real-world communities is a key feature for VCoPs [5] to exploit social networks of members (in real-world settings) in order to enlarge participation and attract new individuals into the VCoP.

To cater for this we propose the integration between *CoPe_it!*, a tool to support collaborative argumentation in VCoPs, and *Compendium*, a hypermedia and sense making tool acting as a personal or collective KM system in physical CoPs.

CoPe_it! is the tool to gather knowledge from virtual communities. It helps VCoPs in discussing and making collaborative decisions about common issues. On the other hand Compendium is the tool to gather and manage knowledge from real world collaborative environment. It helps traditional CoPs: i. to gather and represent knowledge coming from face-to-face meetings taking trace of argumentative

discussions about common issues; ii. to manage and reuse this knowledge in diverse environments making sense of them in a personal way (using compendium as a personal KM tool); iii. to manage and reuse this knowledge in diverse environments making sense of them in a CoP perspective (Using Compendium as a collective KM tool). The integration of these tools allows to exchange knowledge and to enlarge the field of discussion between web-based and real world environments, several advantages and potentials of this integration will be discussed in the paper that is organized as follows. First we briefly present both *Cope_it!* and *Compendium*. Next, we show their functionality by outlining their complementarities and identifying potential mutual benefits of their integration. We then discuss the integration proposal focusing on possible technical solutions and finally define future steps for their integration focussing on the objectives and challenges to be addressed.

2   Compendium and CoPe_it!: a Brief Description

2.1   Compendium: a Hypermedia and Knowledge Management Tool for Individual and Collective Sense-making

Compendium is the result of over 15 years of research and development. It is difficult to give one comprehensive definition of the software because different uses are already carried out and new uses are continuously envisaged emerging from the practice and creativity of the users.

From the analysis of the recent state of the art [6] we can group the diverse Compendium uses in two main families : i. *in-real-time* and ii. *post-hoc* uses. This distinction mainly refers the work the user needs to do on-the-fly or post-hoc (during and after the meeting).

In the first family we count Dialogue Mapping (DM) and Conversational Modelling (CM) techniques. These techniques require high moderation skills either on-the-fly (for DM) or both on the fly and post-hoc (for CM techniques).

The first is mainly adopted in face-to-face meetings and Compendium is used for arguments' visualization and meeting moderation: the moderator (possibly assisted by an experienced *Compendium* user in charge of the mapping) maps the meeting (captures and displays discussion) in order to reach shared understanding about a problem. The process consists of both an incremental negotiation of meanings and the micro-agreements about problem representation [7].

Conversational Modelling (CM) has a balance between users' skills in mapping and modelling and the work in and behind the meeting room. In order to apply this technique a *Compendium* user needs to prepare templates, devoted to model the meeting evolution and to structure the discussions, in order to help and drive the group to decide about and define design variables (criteria, alternatives, priorities, list of actions, etc). In this phase the user applies process modeling skills and he works behind the meeting room. In order to manage such meetings the CM practitioner needs to be experienced in meeting moderation and mapping, nevertheless the

template driven moderation is a valuable support and makes the moderation work less dependent on the moderator skills.

Dialogue Mapping and Conversational Modeling are two techniques for collective sense making and these are 'real time techniques' for capturing meeting discussions and involving people in collective definitions and collaborative argumentation about problems.

In the second family, i.e. the post-hoc techniques, we count Knowledge Management oriented uses of Compendium. In these cases *Compendium* provides users with diverse features for managing knowledge, making sense of knowledge contents and using and reusing information in disparate knowledge works (hypermedia files and documents can be linked and enriched with comments, ideas, tags, etc).

KM oriented applications range from managing a PhD research [8] to political debates representation [9; 10]. In these latter cases *Compendium* has been used as a Computer Supported Argument Visualization tool oriented to represent a debate, making it easily exportable and eventually open for public discussion on the web. The main objective is to enlarge participation and deliberation about public policies. In these case studies *Compendium* has been used for post-hoc analysis and representation (mainly mapping) of political arguments. Contents are first gathered by interviews and/or public forums and then structured into argument maps (mainly following an IBIS model of argument representation). A different attempt has been carried out in the Participatory Planning domain and considers the use of Compendium as a multimedia project memory. In this application a post-hoc analysis of videos, interviews, documents, graphs, photos, and other material has been conducted to map the memory of a participatory urban planning project [11].

In all post-hoc applications the work on information structuring is committed to a Knowledge Manager who has to organize the contents according to specific objectives (i.e. how to trigger participation? What are the topics to focus on?, etc).

In the light of the examples reported above, *Compendium* can be defined as an hypermedia and knowledge management tool for individual and collective sense making. In the literature it is referred to not only as a software tool but as an approach to gather, structure, represent, and manage knowledge for individual or collaborative knowledge intensive works. In a Compendium approach knowledge objects (ideas, multimedia documents, artifacts, etc) are represented as nodes of a graph like structure; afterwards nodes are linked so as to organize contents and make-sense of individual and/or collective concepts and concerns.

2.2 Cope_it!: a Web-based Tool for Collaborative Argumentation and Learning

CoPe_it! is a young software developed in the context of a EU project, Palette (Pedagogically Sustained Adaptive Learning through the Exploitation of Tacit and Explicit Knowledge) started last year. Mainly it is a web-based tool supporting collaborative learning in VCoPs [12].

CoPe_it! has been designed according to what the research group describe as an incremental formalization approach (for references see [13]); it is based on the idea

that different levels of formalization of the argumentation contents need to be provided in order to support collaborative decision making.

CoPe_it! supplies members of VCoP with different features in order to deal with argumentative discussions. The software supports i. definition of alternative solutions and ii. analysis and evaluation of the discussion contents in order to drive groups throughout decision making processes. *CoPe_it!* is more than a web tool for collaborative argumentation, it is rather a tool supporting learning processes in VCoP. It supports i. the first step of problem setting, ii. the definition of alternative solutions, iii. the discussion and negotiation of meanings, pros and cons of each alternative, and finally iv. the analysis of content and the definition of solutions priorities.

CoPe_it! offers basically three levels of formalization corresponding to different representations of argumentative discussions, each of them associated to one of the following views:

1. *Desktop view*: it consists in the lower level of formalization; the community members can add contents in the most user friendly way (in a Compendium like approach). This is an intuitive way of gathering contents from the users without forcing them with pre-defined communication rules.
2. *Formal view*: this view consists in a machine readable version of the previous one. Predefined algorithms of conversion are applied to the desktop view contents in order to convert them in a IBIS-model like argumentative discussion.
3. *Forum view*: this view represents contents in a temporal sequence showing contents and node types (statement, argument, document type, etc).

Future developments include the support for simultaneous posting from all the tree views. Another important improvement to be implemented concerns the possibility to define and negotiate with the community members the specific algorithm of conversion between the desktop view and the formal one. This opportunity will couple a tool for collaborative argumentation with a valuable support for decision-making processes.

CoPe_it! provides members of communities with a common workspace where they can post and share ideas, resources, and arguments in a way that makes sense to them. Community members are registered and have specific names, roles and privileges within the community. Each user is assigned his personal workspace and he can make it private and organize his/her own ideas and contents to be eventually shared with the group in a second moment.

Knowledge items can change during the discussion (free interchange between node types: idea, comment, and note) and they can be linked with personalized links (of specific thickness, colors, and labels). Nodes can be arranged and moved freely in the workspace, and they can also be clustered using adornments (colored rectangles used to group together nodes). Other interesting features are i. the possibility to open a new browser for searching information by Google and Wikipedia, ii. the possibility to subscribe to RSS feeds, and define and manage a list of bookmarks.

This synthetic overview of CoPe_it! main features is not intended to be exhaustive and is the result of the testing of the most recent up-dating of the tool.

3 Why an Integration?: Discussing Similarities and Peculiarity of the Tools

Although addressing different tasks, *Compendium* and *CoPe_it!* show high integration potentials mainly because, they share similar communication principles and visualization means. Starting from the analysis of peculiar features of the software, (see the following table) we want to make visible the complementarities of the tools.

Table 1 shows in light-grey features which are similar (or will be similar referring to the future planned versions of *CoPe_it!*) like: export and import formats, source code distribution policy, administrator rights (registration and download), visualization and structure of contents (supported file types, IBIS model of argumentation, tagging etc).

Dark-grey rows identify the features in which both systems complement each other. The first feature refers to the communication mode (on-line/off-line use). Since we are interested in knowledge exchange between virtual/non-virtual spaces, candidate tools for the integration need to be complementary with regards to this feature.

Other key aspects where the two systems show complementarities are: at distance synchronous and asynchronous collaborations; users' roles, rules and privileges; hypertext features; personalization and revision of contents; Decision Making support.

Starting from the software analysis and focusing on the complementary aspects, we can identify the main mutual advantages of the envisaged integration.

In the following tables (Table 2 and 3) we analyze complementary features trying to link each of them to the relative additional feature it would provide both to *Compendium* and *CoPe_it!* users, in the case the integration is successfully implemented.

Table 1. *Compendium* and *CoPe_it!* main features.

Main Features	Compendium	CoPe_it!
Export formats	It supports 5 formats: XML, Jpeg, Html - web-maps and web-outline, power export.	It will support XML files and Jpeg format (not yet delivered)
Import formats	It supports XML imports, images and image folders, Quest Map files, Flash-Meeting files	It will support XML files and Jpeg format (not yet delivered)
Free download/access	YES	YES
Source Code Distribution Policy	Open source	Source code is intended to be released
WEB-BASED	NO	YES
Software download	YES (you need to download Compendium in order to access the full functionality)	NO (you don't need to download any software)

Registration	Needed the first time for the software download.	Needed the first time to get the User ID and Password and to get the administrator acceptance
Members attributes	There are no roles, rules and privileges imposer to the members not even any administration control on contents	There are roles, rules and privilege within a community
At distance asynchronous collaboration	YES - only on local networks	YES (through the web)
At distance synchronous collaboration	NO (yes - only slow performances)	NOT YET (it intends to be)
Structure of contents	No contents structure are pre-imposed	desktop view: flat; formal view: rules of communication and contents have a pre-defined structure
References: supported file types	drag+drop in any document, website, email, image	At the moment you can upload any kind of local file type, not yet any kind of file on the web
Support IBIS model of argumentation	YES	YES Partially (it doesn't support 'question' nodes, each question is supposed to be addressed in a separate workspace)
Tagging	You can choose between default tags and assign your own keyword 'tags'	NOT YET (it intends to offer some tagging features)
Personalization and customization of icons, backgrounds, colors, links, etc	You can create your own palettes of icons, links types, colors	At the moment no personalization features are present. Some features are under consideration for future versions: e.g. links color)
Hypertext features: Transclusion	You can place/edit a given knowledge object in many different views (supports transclusions)	Does not support transclusions, objects of different workspaces cannot be copied or linked
Contents revisions	Allows continuous changing and reviewing of contents and their organization	Does not support contents modification and revision (just erasing or adding new contents)
Information overload	It supports maps with large numbers of nodes	Not suitable for large number of nodes (very slow)
Support Decision making	NO (yes, only when paired with human assisted techniques)	YES (Support automatic generated view for different purposes)

Table 2. Additional features that the integration can provide to *CoPe_it!*

Compendium --------------------> CoPe_it!		
Additional features		*Complementarities*
1. Enlarges the advantages of real time capturing and integration with different materials, information, documents and hybrid files so that the face-to-face meeting memory can be shared in and out the meeting group		Compendium complements Cope_it! offering real time capture of meeting
2. Provides CoPs with a hypermedia environment in which community members can use, correlate and manage contents of different collaboration spaces (contents raised in different workspaces can be discussed and transcluded in new contexts)		Compendium complements Cope_it! offering transclusion features
3. Offers a KM tool in which community members can organize, structure and define information and resources also being off line on their machine, but always giving them the possibility at any time to publish content on the web and to share them with a list of community members or making it public for the whole VCoP		Compendium complements Cope_it! offering an off-line KM tools
4. Toward un Organizational Memory System	Exports Cope_it! discussions in an off line environment without no problem of information overload (Compendium support maps with thousands nodes)	Compendium complements Cope_it! supporting maps up to large number of nodes
	Allows to customize organization and archiving of knowledge objects in larger organizational databases (linking and referring discussion contents to any other off-line and private data sources)	Compendium complements Cope_it! offering customization of knowledge object and hyper textual environment running on your machine

Table 3. Additional features that the integration can provide to *Compendium.*

CoPe_it! --------------------> Compendium	
Additional features	*Complementarities*
1. Opens Compendium face to face meeting to a wider community on the www	CoPe_it! complements Compendium offering a web-based argumentation environment
2. Gives the possibility to trigger online discussions on specific topics (this is particularly useful in Public Policy cases)	CoPe_it! complements Compendium offering the possibility to modify and enrich Compendium maps directly on the web
3. Provides at distance Compendium users with an environment of asynchronous discussions that can easily be imported in their Compendium maps	CoPe_it! complements Compendium offering synchronous interaction for real time at distance discussions
4. Gives to Compendium based Project memory system the possibility to update results of at distance meeting and consultation forum on the web	CoPe_it! complements Compendium offering the possibility to import, in forms of Compendium maps, contents of at distance meeting and consultation forum
5. Offers support for Decision Making	CoPe_it! complements Compendium offering automatic analysis of Compendium maps, with customized algorithms

4 Integration Proposal

In the previous section we gave evidence of the mutual advantages when integrating *Compendium* and *CoPe_it!* In the following we'll discuss the integration proposal describing three possible scenarios:

First scenario: Importing *CoPe_it!* workspaces in Compendium maps (from virtual to real world settings – from VCoPs to CoPs).

Second scenario: Importing Compendium maps in *CoPe_it!* workspaces (from real to virtual world settings – from CoPs to VCoPs).

Third scenario: both side import.

In the first scenario the main goal is to enlarge to communities on the web discussions and collaborative knowledge works performed in real world communities. In order to make *on* and *off line* discussions completely complementary and to allow the on-line discussions to evolve together with the face-to-face process, we need to transfer into *Compendium* the contents gained in *CoPe_it!* workspaces. Contents can be imported in Compendium and then re-organized, linked and discussed within the same community or in different ones during ad-hoc face-to-face meetings.

The second scenario aims at:

- importing *Compendium* Dialogue maps in order to discuss within the virtual communities the results of face-to face meetings;
- importing single-user concept maps used as a reference for arguing something in the virtual discussion
- importing *Compendium* templates and models in order to trigger, organize or moderate the discussion in new workspaces.

The third scenario is the bi-directional integration between both tools, and it exhibits the benefits gained by performing the two scenarios already described. An additional advantage is envisaged: the results of virtual meetings can be submitted to the discussion in traditional communities (scenario 1) and the results of face-to-face discussions can go back to virtual environments (scenario 2) closing the cycle and allowing further contributions from the virtual community. This possibility provides means for continuously validating and revising contents from virtual to real world settings and vice-versa.

For the envisaged scenarios diverse technical solutions are possible. In figure 1 three options for implementing the three scenarios are synthesized: one manual and two automatic options.

In the first option a knowledge manager is in charge of the knowledge integration and exchange between both systems. This option offers three positive opportunities: i. to select specific knowledge contents according to specific needs, ii. to control and avoid knowledge redundancies, and iii. to locate imported and exported maps in their original position (spatial positions in the two-dimensional canvas) that is crucial for contents' interpretation. On the other hand, this option enhances external influence on knowledge interchange (knowledge manager interpretation) and the time and effort required to be implemented.
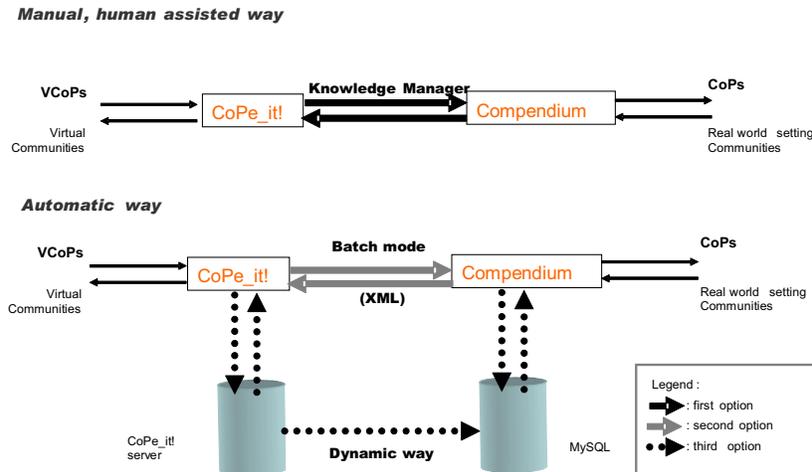
Fig. 1. Technical options for the proposed integration.

In the second option the knowledge exchange is performed in batch mode, allowing XML export/import. This option has the advantages to be transparent and fast but it presents several theoretical and technical criticalities in the definition of conversion rules. Therefore efforts have to be devoted to:

- defining conversion rules for contents export for *CoPe_it! – Compendium* objects: i.e. nodes types (each one with its features - title, descriptions, reference files, etc), links (with colors, thickness, texts labels, etc), adornments (with colors and titles), documents and reference objects (addressing compatibility and equivalence of document formats);
- building a XML export/import readable in both systems (compare and integrate XML schemas, detect information and decide how and which ones of them can or have to be converted, etc).

In the third option the integration is obtained connecting *Compendium* and *CoPe_it!* databases. This option offers additional capabilities by allowing synchronous update of both *Compendium* and *CoPe_it!* spaces. In this scenario, virtual and traditional communities can work together in synchronicity on the same project or collaborative knowledge work, with different means but in a unique hybrid environment. This is a suitable environment for HCoPs, hybrid communities of practices in which members can:

1. shift continuously between virtual and real world environments
2. simultaneously discuss, modify and produce knowledge objects in a whole hybrid space of collaboration.

This type of integration provides HCoPs' members with a new collaboration space in which they have the opportunity to perform argumentative collaboration at various level and in diverse (virtual/non-virtual) groups and contexts.

5 Conclusions

In this paper we focus on the integration of knowledge coming from different collaborative environments, virtual and traditional, thus leveraging CoPs to a truly collaborative environment with no communication boundaries. This is the environment in which HCoPs perform. HCoPs are an emerging kind of CoPs where users are no longer constrained to a particular communication environment may it be virtual or real. HCoP is a novel approach to CoP providing users with diverse environments for collaboration in knowledge works. In this perspective, we have proposed the integration of *Compendium* and *CoPe_it!* and we have explored three scenarios and possible technical solutions for this integration. . As a following step, we'll try to define feasibility and priorities of implementation, but some other considerations can be made.

Considering that knowledge generated in CoPs is highly context dependent, we argue that for knowledge exchange it is relevant to preserve knowledge from manipulation or mediate interpretation.

Regardless of the technical solution to be implemented, some operational goals need to be addressed:

- to keep trace of the social context: who made explicit this knowledge, during which discussion with whom;
- to maintain the conceptual relationships: why that knowledge emerged and in what context of discussion;
- to keep trace of the dynamics of cognitive events: when the knowledge emerged, is used, assessed, or shared during the discussion process;
- to represent knowledge with a similar visual language in both environments (virtual and traditional);
- to make knowledge easily reusable in both environments.

These points define some of the key constraints (requirements to fulfil) for the knowledge integration proposal for the knowledge exchange to be transparent, and ready for community validation. Further research effort will be devoted to implement a batch mode integration (bi-directional XML import/export), then moving to the point in which the two systems can be used and up-dated in a dynamic way.

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