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CoPe_it! - Supporting collaboration, enhancing learning

Nikos Karacapilidis
University of Patras, nikos@mech.upatras.gr

Manolis Tzagarakis
2Research Academic Computer Technology Institute, tzagara@cti.gr

Nikos Karousos
2Research Academic Computer Technology Institute, karousos@cti.gr

George Gkotsis
2Research Academic Computer Technology Institute, gkotsis@cti.gr

Vassilis Kallistros
2Research Academic Computer Technology Institute, vkallist@cti.gr

See next page for additional authors

Authors
Nikos Karacapilidis, Manolis Tzagarakis, Nikos Karousos, George Gkotsis, Vassilis Kallistros, Spyros Christodoulou, Dora Nousia, Christos Mettouris, and Panagiotis Kyriakou

11.COPE_IT! - SUPPORTING COLLABORATION, ENHANCING LEARNING

Nikos Karacapilidis[1,2], Manolis Tzagarakis[2], Nikos Karousos[2], George Gkotsis[2], Vassilis Kallistros[2], Spyros Christodoulou[2], Dora Nousia[2], Christos Mettouris[2], Panagiotis Kyriakou[2]

[1]IMIS Lab, MEAD, University of Patras, Greece
nikos@mech.upatras.gr

[2]Research Academic Computer Technology Institute, Greece
{tzagara, karousos, gkotsis, vkallist, shristod, nousia, mettour, kyriakou}@cti.gr

Abstract

CoPe_it! is an innovative web-based tool that complies with collaborative practices to provide members of communities with the appropriate means to manage individual and collective knowledge, and collaborate towards the solution of diverse issues. In this article, we demonstrate its applicability in tackling data-intensive collaboration settings, which are characterized by big volumes of complex and interrelated data obtained from diverse sources, and knowledge expressed by diverse participants. We focus on issues related to the representation of such settings and the proposed approach towards making it easier for participants to follow the evolution of a collaboration, comprehend it in its entirety, and meaningfully aggregate data in order to resolve the issue under consideration.

Keywords

Argumentative collaboration, incremental formalization, data-intensive collaboration, visualization of collaboration.

1. Introduction

Data-intensiveness, a term used to characterize settings that exhibit high volumes of complex and interrelated data, may have a vague interpretation. It is not only the size of data to be handled that counts in a particular setting; the cognitive abilities of the person or organization that has to deal with them, as well as the overall working context, are also critical factors. While for large organizations, such as space agencies and search engines providers, data-intensive refers to dealing with data that fall in the terabyte and petabyte ranges on a daily basis, when considering individuals or communities that are committed to some collaborative work, a relatively small number of files of few megabytes is enough to also consider this setting as a data-intensive one.

Recent advances in computing and Internet technologies, together with the advent of the Web 2.0 era, resulted to the development of a plethora of online, publicly available environments such as blogs, discussion forums, wikis, and social networking applications. These offer people an unprecedented level of flexibility and convenience to participate in complex collaborative activities, such as long online debates of public interest about the greening of our planet through renewable energy sources or the design of a new product in a multinational company.

Information found in these environments is considered as a valuable resource for individuals and organizations to solve problems they encounter or get advice towards making a decision. In any case, people have to go through some type of sorting, filtering, ranking and aggregation of the existing resources in order to facilitate sense-making. Yet, these activities are far from being easy. This is because these collaboration settings are associated with huge, ever-increasing amounts of multiple types of data, obtained from diverse sources that often have a low signal-to-noise ratio for addressing the problem at hand. In turn, these data may vary in terms of subjectivity, ranging from individual opinions and estimations to broadly accepted practices and indisputable measurements and scientific results. Their types can be of diverse level as far as human understanding and machine interpretation are concerned. They can be put forward by people having diverse or even conflicting interests. At the same time, the associated data are in most cases interconnected, in a vague or explicit way. Data and their interconnections often reveal social networks and social interactions of different patterns.

The above bring up the need for innovative software tools that can appropriately capture, represent and process the associated data and knowledge. Such tools should shift in focus from the collection and representation of information to its meaningful assessment and utilization. They should facilitate argumentation (i.e. discussion in which reasoning and disagreements exist, not only discourse for persuasion, logical proof and evidence-based belief (Kunz & Rittel 1970), the ultimate aim being to augment collaborative sense-making. This can be seen as a special type of social computing where various computations concerning the associated context and group's behavior need to be supported.

Designing software systems that can adequately address users' needs to express, share, interpret and reason about knowledge during an argumentative collaboration session has been a major research and development activity for more than twenty years. Technologies supporting argumentative collaboration usually provide the means for discussion structuring and visualization, sharing of documents, and user administration. They support argumentative collaboration at various levels and have been tested through diverse user groups and contexts. Furthermore, they aim at exploring argumentation as a means to establish a common ground between diverse stakeholders, to understand positions on issues, to surface assumptions and criteria, and to collectively construct consensus.

While helpful in particular settings, the above solutions prove to be inadequate in data-intensive situations. In this context, our work focuses on the development of a web-based tool, namely CoPe_it! (http://copeit.cti.gr), which is capable to tackle the diversity and complexity of the above issues, the ultimate goals being to make it easier for users to follow the evolution of an ongoing collaboration, comprehend it in its entirety, and meaningfully aggregate data in order to resolve the issue under consideration.

2. Existing approaches

Existing approaches to support argumentative collaboration vary in terms of the problem dimension they principally address and the context they particularly target. One category, focusing on a meaningful representation of the related items and their interconnections, builds on the concepts of IBIS (Issue Based Information System), introduced back in 1970 (Kunz & Rittel

1970). For instance, gIBIS (Conklin & Begeman 1989) is a pioneer argumentation structuring tool, initially developed for the capturing of a design process rationale. It is a hypertext groupware tool that allows users to create issues, assert positions on these issues, and make arguments in favor or against them. Sibyl (MacLean et al. 1991), an extension of gIBIS, is a tool for managing group decision rationale that also provides services for the management of dependency, uncertainty, viewpoints and precedents. QuestMap (Conklin et al. 2001) resembles to a 'whiteboard' where all messages, documents and reference material for a project, together with their relationships, are graphically displayed, the aim being to capture the key issues and ideas during meetings and create a shared understanding in a knowledge team. Hermes (Karacapilidis & Papadias 2001) builds on concepts from the areas of Decision Theory, Non-Monotonic Reasoning, Constraint Satisfaction and Truth Maintenance, and offers an integrated consideration of classical decision making and argumentation principles. Compendium (http://www.compendiuminstitute.org) is a tool that supports dialogue mapping and conceptual modeling in a meeting scenario, and can be used to gather a semantic group memory. In the same context, Belvedere (Gelder, 2002) is used for constructing and reflecting on diagrams of one's ideas, such as evidence maps and concept maps. It represents various logical and rhetorical relations within a debate and supports problem-based collaborative learning scenarios through the use of a graphical language.

Other approaches focus on the representation of knowledge. These include Euclid (Smolensky et al. 1987), a tool that provides a graphical representation language for generic argumentation, Sepia (Streitz et al. 1989), a knowledge-based authoring and idea-processing tool that supports the creation and revision of hyper-documents, Janus (Fischer et al. 1989), which is based on acts of critiquing existing knowledge in order to foster the understanding of knowledge design, and QOC - Questions, Options and Criteria (MacLean et al. 1991), which is a model to represent the rationale of reasoning in a decision making process and provides the means to represent and integrate rationale of varying degrees of stability at the different stages of a design process.

In the context of argumentation theory, systems supporting the visualization of argumentation have played a considerable educational role by supporting the teaching of critical thinking and reasoning skills. For instance, Araucaria (Reed & Rowe 2004) supports the contextual analysis of a written text and provides a tree view of the premises and conclusions. This software has been designed to handle advanced argumentation and theoretical concepts, which reflect stereotypical patterns of reasoning. In the same line, ArguMed (Verheij, 2003) builds on a formal argumentation approach to addresses the issues of argument mapping. The Reason!Able argumentation tool (Gelder, 2002) provides a well structured and user-friendly environment for reasoning. Through the use of an argumentation tree, a problem can be analyzed or decomposed to its logically related parts, whereas missing elements can also be identified. MindDraw (http://info.cwru.edu/minddraw/index.html) is another educational software providing assistance in the creation and sharing of visual images of ideas; it enables users to produce maps of causal relationships, and has been proven to be useful for students and learners of all ages, from primary school through graduate training and professional practice. Athena Standard and Athena Negotiator (http://www.athenasoft.org) are two more examples of argument mapping software. Athena Standard is designed to support reasoning and argumentation, while Athena Negotiator is designed to facilitate analysis of decisions and two-party negotiations. It is directed at tertiary education, ranging from first year to postgraduate students or for elementary use by professionals. The above two systems are efficient argumentation structuring tools, but do not employ knowledge management features.

As derives from the above, the majority of existing argumentative collaboration support systems mainly focus on the expression and visualization of arguments. Generally speaking, existing approaches provide a cognitive argumentation environment that stimulates reflection and discussion among participants. However, their features and functionalities are limited, they pay no or limited attention to data and knowledge management issues, they are mostly tested in academic environments, they are not interconnected with other tools, and they do not efficiently tackle the technological and social dimensions of data-intensive collaboration. They receive criticism related to their adequacy to clearly display each collaboration instance to all parties involved (usability and ease-of-use issues), as well as to the formal structure used for the representation of collaboration. In most cases, they merely provide a sort of threaded discussion forums, where messages are linked passively. This usually leads to an unsorted collection of vaguely associated positions, which is extremely difficult to be exploited in future collaboration settings. Also important, they do not integrate, in most cases, any reasoning mechanisms to (semi)automate the underlying decision making processes required in a collaboration setting. Thus, there is a lack of alternative formalization, consensus seeking and decision-making support abilities. It has been also admitted that these solutions often require that users carry out activities that do not naturally belong to their work, or they support activities which are infrequent in normal work; thus, such activities are often considered artificial or insignificant by users. As a result, traditional argumentation software approaches are no longer sufficient to support contemporary communication and collaboration needs (Moor & Aakhus 2006). There is a need to provide alternative representational features in order to demonstrate a significant effect on the users' collaborative knowledge building process.

3. Requirements and challenges

Design of a smart solution to improve a community's understanding and productivity during a data-intensive argumentative collaborative session is certainly a big challenge. Towards meeting it, we have first performed a series of interviews with members of diverse communities in order to identify the major issues they face during their ordinary practices. These were:

Cognitive overhead and management of information overload: This is primarily due to the extensive and uncontrolled exchange of diverse types of data and knowledge resources. For instance, such a situation may appear during the exchange of numerous ideas about the solution of a public issue, which is accompanied by the exchange of big volumes of positions and arguments in favor or against each solution. In such cases, individuals usually have to spend much effort to conceptualize the current state of the collaboration and grasp its contents. The need to consider an overwhelming amount of resources may ultimately harm a community's objectives. To avoid that, functionalities for scalable filtering and timely processing of the associated big amounts of data need to be offered.

Social behavior: The representation and visualization of social structures, relationships and interactions taking place in a collaborative environment with multiple stakeholders are also of major importance. This is associated to the perception and modeling of actors, groups and organizations in the diversity of collaborative contexts. A problem to be addressed is to provide the means to appropriately represent and manage user and group profiles, as well as social relationships. However, neither relationships nor contexts are static; they are emerging and change over time, which necessitates the development of adaptive services. Furthermore, social relationships are diverse and of different intensity. What is required is development and utilization of appropriate mechanisms that perceive given structures in order to extract useful information.

Situational differences: Interviews indicated that the evolution of the collaboration proceeds incrementally; ideas, comments, or any other type of collaboration objects are exchanged and elaborated, and new knowledge emerges slowly. When members of a community participate in a collaborative session, enforced formality may require them to specify their knowledge before it is fully formed. Such emergence cannot be attained when the collaborative environment enforces a formal model from the beginning. On the other hand, formalization is required in order to ensure the environment's capability to support and aid the collaboration efforts. In particular, the abilities to support decision making or estimation of the present state benefit greatly from formal representations of the information units and relationships. Generally speaking, solutions to the problem under consideration should be generic enough to address diverse collaboration modes and paradigms.

Expression of tacit knowledge: A community of people is actually an environment where tacit knowledge (i.e. knowledge that the members do not know they possess or knowledge that members cannot express with the means provided) predominantly exists and dynamically evolves. Such knowledge must be efficiently and effectively represented in order to be further exploited in a collaborative environment.

Integration of legacy resources: Many resources required during a collaborative session have either been used in previous sessions or reside outside the members' working environment (e.g. in e-mailing lists or web forums). Moreover, outcomes of past collaboration activities should be able to be reused as input in subsequent collaborative sessions. The inherent issues of liability and preservation of intellectual rights need particular attention in such cases.

Data processing and decision making support: In the settings under consideration, timely processing of data related to both the social context and social behavior is required. Such processing will significantly aid the members of a community to conclude the issue at hand, extract meaningful knowledge and reach a decision. This means that their environment (i.e. the tool used) needs to interpret the knowledge item types and their interrelationships in order to proactively suggest trends or even aggregate data and calculate the outcome of a collaborative session.

The above issues delineated some categories of crucial (problem-specific) requirements to be met during the development of CoPe_it!. At the same time, it was made obvious that argumentative collaboration, as a particular social computing type, is also knowledge-intensive, in that access to and manipulation of large quantities of knowledge is required.

4. The proposed solution

CoPe_it! allows for distributed, synchronous or asynchronous, collaboration over the Web. Our overall approach is the result of action research studies (Checkland & Holwell 1998) concerning the improvement of practices, strategies and knowledge in diverse data-intensive collaborative environments. The research method adopted for the development of CoPe_it! follows the design science paradigm (Hevner et al. 2004). To appropriately tackle the issues identified in the previous section, CoPe_it! builds on an integrated consideration and exploitation of the concepts listed below.

4.1 Incremental formalization

When engaged in the use of existing technologies and systems supporting argumentative collaboration, users have to follow a specific formalism. More specifically, their interaction is regulated by procedures that prescribe and - at the same time - constrain their work. This may refer to both the system-supported actions a user may perform (e.g. types of discourse or collaboration acts), and the system-supported types of argumentative collaboration objects (e.g. one has to strictly characterize a collaboration object as an idea or a position). In many cases, users have also to fine-tune, align, amend or even fully change their usual way of collaborating in order to be able to exploit the system's features and functionalities. Such formalisms are necessary towards making the system interpret and reason about human actions (and the associated resources), thus offering advanced computational services. However, there is much evidence that sophisticated approaches and techniques often resulted in failures (Shipman & Marshall 1994, Shipman & McCall 1994). This is often due to the extra time and effort that users need to spend in order to get acquainted with the system, the associated disruption of the users' usual workflow (Fischer et al. 1989), as well as to the "error prone and difficult to correct when done wrong" character of formal approaches (Halasz, 1988).

Data-intensive situations imply additional disadvantages when using formal approaches. Such approaches impose a structure which is not mature enough to accommodate the management of huge amounts of data coming from diverse sources. They do not allow users to elaborate and digest these data at their own pace, according to the evolution of the collaboration. Instead, a varying level of formality should be considered. This variation may either be imposed by the nature of the task at hand (e.g. decision making, deliberation, persuasion, negotiation, conflict resolution), the particular context of the collaboration (e.g. medical decision making, public policy making), or the group of people who collaborate each time (i.e. how comfortable people feel with the use of a certain technology or formalism).

The above advocate an incremental formalization approach, which has been adopted in the development of CoPe_it!. In our approach, formality and the level of knowledge structuring is not considered as a predefined and rigid property, but rather as an adaptable aspect that can be modified to meet the needs of the tasks at hand. By the term formality, we refer to the rules enforced by the system, with which all user actions must comply. Allowing formality to vary within the collaboration space, incremental formalization, i.e. a stepwise and controlled evolution from a mere collection of individual ideas and resources to the production of highly contextualized and interrelated knowledge artifacts, can be achieved. As shown in Figure 1 (bottom part), this evolution is associated with a set of functionalities that are ordered in terms of formality level.

4.2 Visualization and reasoning

It has been widely argued that visualization of argumentation conducted by a group of experts working collaboratively towards solving a problem can facilitate the overall process in many ways, such as in explicating and sharing individual representations of the problem, in maintaining focus on the overall process, as well as in maintaining consistency and in increasing plausibility and accuracy (Kirschner et al. 2003). Moreover, it leads to the enhancement of the group's collective knowledge. For the above reasons, visualization issues received much attention while shaping the proposed solution.

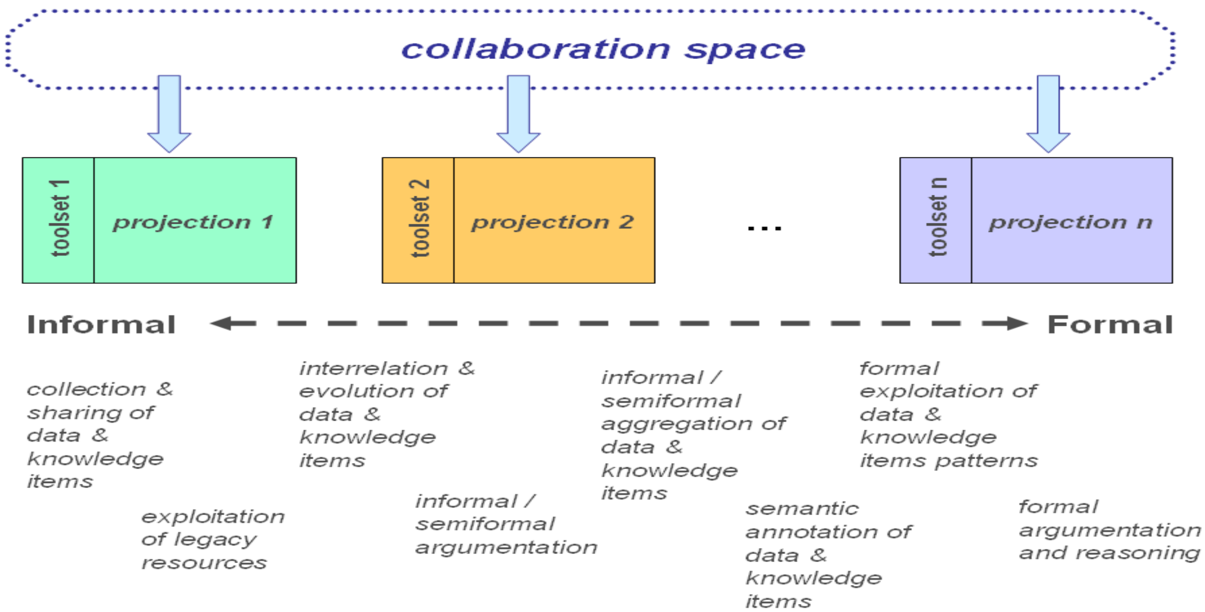

Figure 1. The proposed incremental formalization approach.

In CoPe_it!, *projections* constitute the 'vehicle' that permits incremental formalization of argumentative collaboration (see Figure 1). A projection can be defined as a particular representation of the collaboration space, in which a consistent set of abstractions able to solve a particular organizational problem during argumentative collaboration is available. With the term abstraction, we refer to the particular data and knowledge items, relationships and actions that are supported through a particular projection, and with which a particular problem can be represented, elaborated and be solved. CoPe_it! enables switching from a projection to another, during which abstractions of a certain formality level are transformed to the appropriate abstractions of another formality level. This transformation is rule-based; such rules can be defined by users and/or the facilitator of the collaboration and reflect the evolution of a community's collaboration needs. It is up to the community to exploit one or more projections of a collaboration space (upon users' needs and expertise, as well as the overall collaboration context).

Each projection of the collaboration space provides the necessary mechanisms to support a particular level of formality (e.g. *projection_1* may cover only needs concerning collection of knowledge items and exploitation of legacy resources, whereas *projection_n* may cover the full spectrum of the functionalities shown at the bottom part of Figure 1). The more informal a projection is, the more easiness-of-use is implied; at the same time, the actions that users may perform are intuitive and not time consuming (e.g. drag-and-drop a document to a shared collaboration space). Informality is associated with generic types of actions and resources, as well as implicit relationships between them. However, the overall context is more human (and less system) interpretable. As derives from the above, the aim of an informal projection of the collaboration space is to provide users the means to structure and organize data and knowledge items easily, and in a way that conveys semantics to them. Generally speaking, informal projections may support an unbound number of data and knowledge item types. Moreover, users may create any relationship among these items; hence, relationship types may express agreement, disagreement, support, request for refinement, contradiction etc.

While such a way of dealing with data and knowledge resources is conceptually close to practices that humans use in their everyday environment, it is inconvenient in situations where support for advanced decision making processes must be provided. Such capabilities require resources and structuring facilities with fixed semantics, which should be understandable and interpretable not only by the users but also by the tool. Hence, decision making processes can be better supported in environments that exhibit a high level of formality. The more formal projections of a collaboration space come to serve such needs. The more formal a projection is, easiness-of-use is reduced; actions permitted are less intuitive and more time consuming. Formality is associated with fixed types of actions, as well as explicit relationships between them. However, a switch to a more formal projection is highly desirable when (some members of) a community need to further elaborate the data and knowledge items considered so far. Such functionalities are provided by projections that may enable the formal exploitation of collaboration items patterns and the deployment of appropriate formal argumentation and reasoning mechanisms. A switch to a projection of a higher level of formality disregards less meaningful data and knowledge items, resulting to a more compact and tangible representation of the collaboration space. This effect is highly desirable in data-intensive situations.

4.3 Information triage

Our solution builds extensively on the information triage process (Marshall & Shipman 1997), i.e. the process of sorting and organizing through numerous relevant materials and organizing them to meet the task at hand. During such a process, users must effortlessly scan, locate, browse, update and structure knowledge resources that may be incomplete, while the resulting structures may be subject to rapid and numerous changes. Information triage related functionalities enable users to meaningfully organize the big volumes of data and knowledge items in a collaborative setting.

The informal projection of a data-intensive collaborative workspace in CoPe_it! is fully in line with the above. Drawing upon successful technologies coming from the area of spatial hypertext (Marshall & Shipman 1997), the informal projection of CoPe_it! adopts a spatial metaphor to depict collaboration in a 2.5-dimensional space (the space is considered 2.5-dimensional, and not 2-dimensional, because it permits overlap of the items; the tool is aware of which items overlap, as well as of various spatial proximity issues). Spatial hypertext is admittedly a promising approach to address issues in argumentative environments, as it introduces a visual language in an attempt to take advantage of the humans' visual memory and their ability to recognize patterns. Exploiting these human capabilities can greatly reduce the negative impacts of data-intensive environments. Spatial hypertext removes the barrier between reading and writing processes enabling articulation of tacit knowledge and ambiguity, as well as establishment of emerged problem-solving strategies. Thus, users are incrementally processing information and are not forced to predefined structural commitments. The related features and functionalities of CoPe_it! enable users to create and organize information by making use of spatial relationships and structures, giving them the freedom to express relationships among information items through spatial proximity and visual cues. Such cues are related to the linking of collaboration items (e.g. coloring and thickness of the respective links) and the drawing of colored rectangles to cluster related items.

As highlighted above, the informal projection of a collaborative workspace in CoPe_it! permits an ordinary and unconditioned evolution of data and knowledge structures. This projection also provides abstraction mechanisms that allow the creation of new abstractions out of existing ones. Abstraction mechanisms include: (i) annotation and metadata (i.e. the ability to annotate instances of various knowledge items and add or modify metadata); (ii) aggregation (i.e. the ability to group a set of data and knowledge items so as to be handled as a single conceptual entity); (iii) generalization/specialization (i.e. the ability to create semantically coarse or more detailed knowledge items in order to help users manage information pollution of the collaboration space); (iv) patterns (i.e. the ability to specify instances of interconnections between knowledge items of the same or a different type, and accordingly define collaboration templates).

Information triage related activities can be conducted in CoPe_it! either collaboratively (a moderator may be required in some cases) or individually. The tool permits individuals to copy a collaborative workspace, paste all of its items in a private one and work on it at their pace. In such a way, individual reflections and experimentations can be conducted and evaluated before being made public. By doing so, individuals may also ask for filtered views of a workspace. Such filters may involve the actors participating in a collaborative setting, the types of items shared (together with the corresponding links), keywords in their title and body, annotations made on them, etc.

4.4 Exploitation of legacy resources

CoPe_it! reduces the overhead of entering information by allowing the reuse of existing resources. Generally speaking, when legacy resources have to be reused during a collaborative session, data-intensiveness is increased. This is not only due to the additional amount of data involved, but also to the conceptual overhead and distractions imposed to the user from switching among applications and environments. One way of dealing with this situation is to enable the ubiquitous access of legacy resources from within the collaboration environment by seamlessly integrating the systems involved. Towards this direction, we have achieved interoperability between CoPe_it! and a number of applications that include Web-based forums, search engines and existing argumentative collaboration tools (e.g. Compendium).

4.5 Social networking

Management of social structures, interactions and relationships is also critical in a data-intensive e-collaboration framework. Applications and projects dealing with social relationships mainly support explicit and abstract structures. However, social structures may gain from the expertise of structure domain research, including various structure abstractions or ways for implicit structuring. Another issue to be addressed concerns the elaboration of social relationships in their contexts, that is, how they relate to assets, locations, or change over time. Social network analysis (Castells 2004) has to be extensively used to find who is depending on whom in a network. Such an analysis will also help to detect hidden hierarchy of social networks. Other requirements of this category concern the (semi)automatic role-specific cognitive mapping for each participant, based on his/her overall behavior, and the development of artifacts-related collaboration metrics.

CoPe_it! integrates a sophisticated user and role modeling module to tackle the above issues. The module builds on an explicit representation of the notion of user/group, which is based on a predefined attribute hierarchy. The associated attributes can be domain-specific. They are categorized, depending on how they are populated and who may modify them, as explicit (their values are provided by users themselves and include personal data such as name, address, birth date, preferences, competencies, skills etc.) or implicit (their values are not provided by users explicitly, but implicitly, by observing their behavior within the system). User/group modeling is also associated with mechanisms for the acquisition of the abovementioned implicit information of users/groups. These mechanisms observe and log the operations and discourse moves of users within the system and record them in the user's profile. Finally, the user and role modeling module of CoPe_it! offers inference engines. The role of these engines is to analyze all data present in the profile, together with data from the collaborative workspaces, to extract meaningful information about social structures, interactions and relationships. Contrary to most user modeling approaches, our approach pays much attention to community-related aspects (i.e. relationships between individual users and relationships between users and artifacts).

5. Using CoPe_it!

This section demonstrates the applicability of CoPe_it! in a real, data-intensive debate that took place at the 5663rd Meeting of the United Nations Security Council (UNSC). An accurate representation of this debate has been incrementally built in CoPe_it! by using its minutes (the official press release is available at: http://www.un.org/News/Press/docs/2007/sc9000.doc.htm). Additional data sources, corresponding to previous debates and information that is strongly related to the issue at hand, have been uploaded and appropriately linked in the corresponding workspace.

The context of this debate is as follows: United Kingdom, holding the presidency of the UNSC for April 2007, raised the issue of whether climate change has an impact on peace and security. Over fifty delegates from the UN Member States collaborated by expressing their points of view through various statements and arguments of legal, environmental, scientific and political content. Some delegates welcomed the initiative, while others expressed their doubts on the mandate of the UNSC to discuss such issues. Some arguments were in favor or against an idea or a previously asserted argument. In some cases, delegates were speaking on behalf of more than one member states (cases of geographically, politically or economically related states). Last but not least, delegates often referred to diverse sources of massive and complicated data such as data on territorial changes and maps, meteorological data, facts and figures related to energy resources, data concerning international agreements and protocols, financial data of different nature and complexity, records of similar debates conducted inside and outside UNSC, etc.

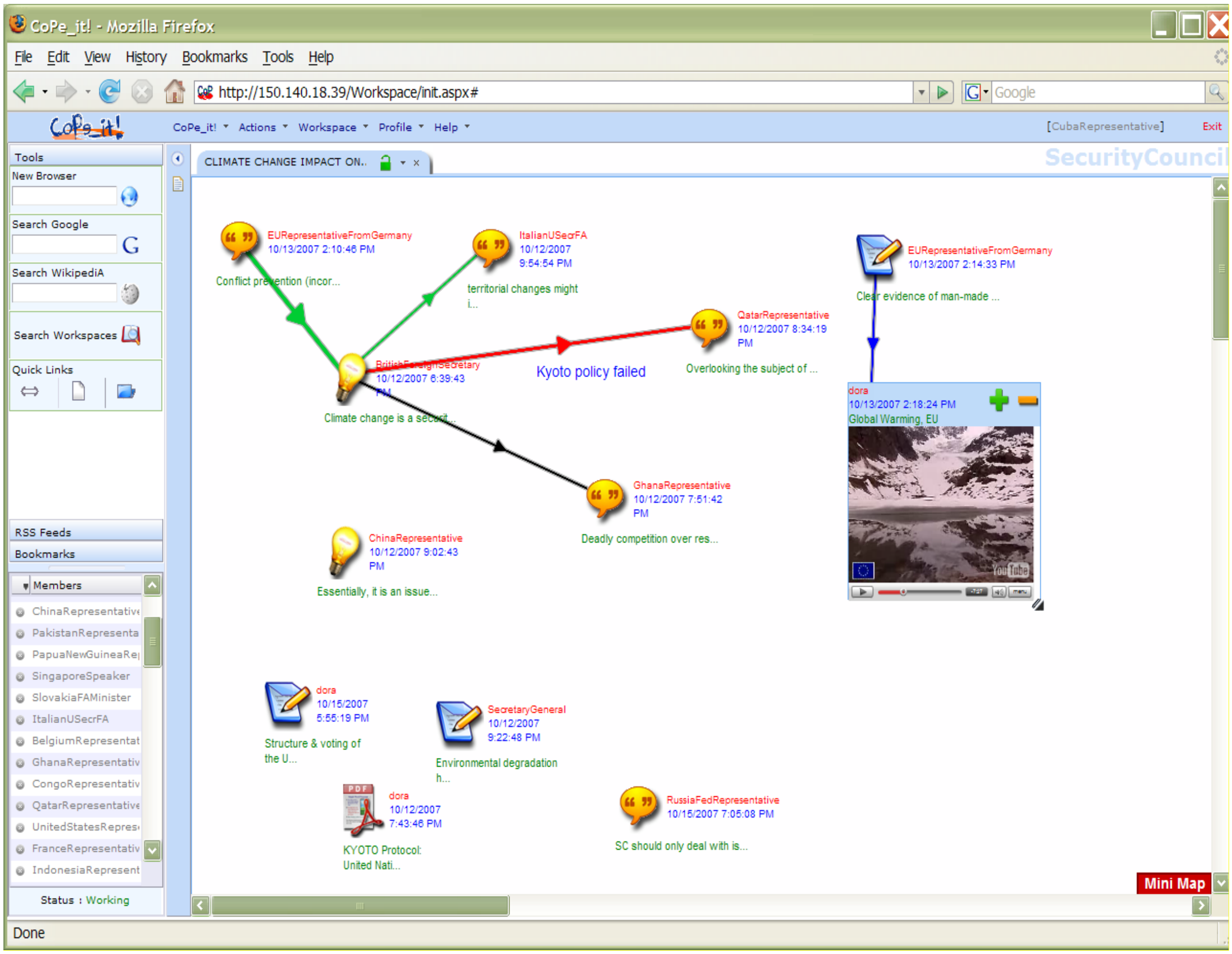

Figure 2. An early instance of the collaboration.

In the following, we sketch an emulation of the above debate through CoPe_it! to show the tool's capabilities in tackling such data-intensive collaboration settings. The particular emulation was conducted in an asynchronous way, among geographically dispersed participants (taking the roles and using the wording of the real delegates). The layout of the tool's informal projection is shown in Figure 2. The left hand side bar enables participants to open a new browser, search for related information, and be aware of other online members of their community. Participants may easily create and upload various types of data and knowledge items (a predefined set of item types is given; participants may enrich this set by defining additional ones). These can be either dedicated item types such as ideas (depicted as light bulbs), notes and comments, or existing multimedia resources. Ideas stand for items that deserve further exploitation; they may correspond to an alternative solution to the issue under consideration and they usually trigger the evolution of the collaboration. Notes are generally considered as items expressing one's knowledge about the overall issue, an already asserted idea or note. Finally, comments are items that usually express less strong statements; they are uploaded to express some explanatory text or point to some potentially useful information. Knowledge item types may change upon the evolution of the collaboration (e.g. a user that has asserted a particular comment may elaborate it further and change its type to an idea). All the above items can be interrelated. When interrelating items, participants may select the color of the connecting arrow and provide a legend describing the interrelationship they conceive. These legends are intentionally arbitrary. CoPe_it! enables participants to spatially arrange the uploaded items and organize them in a meaningful way.

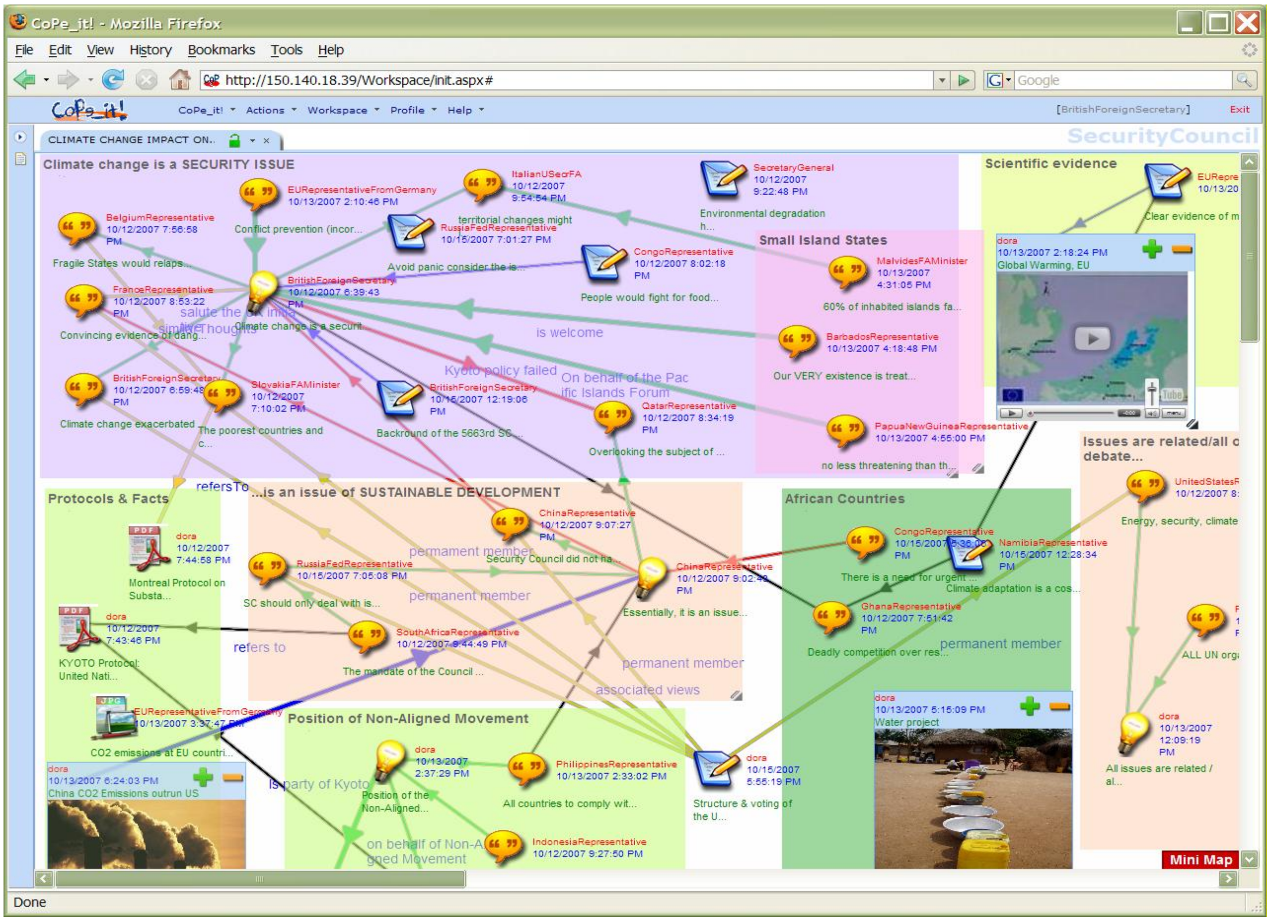

Figure 3. A data-intensive instance of the collaboration.

Figure 2 corresponds to an early instance of the collaborative workspace created for the needs of our example. As shown, some stakeholders have contributed so far by uploading on the workspace some useful resources (including a video), proposing two concrete ideas, and interrelating one idea with four additional items. Figure 3 illustrates a second instance of the collaborative workspace under consideration (the left-hand side bar is closed for visualization purposes). As shown, this is a highly data-intensive instance where many delegates have been contributed their ideas and positions. Four ideas are now expressed, which are highly interconnected with multiple data and knowledge artifacts. More multimedia resources, particularly relevant to some items, have been also uploaded. Beyond coloring of the arrows that interrelate knowledge items (in the example given, green arrows declare support, red ones declare opposition, whereas the other colors just denote an unjustified relation), another visual cue that appears in Figure 3 concerns the colored rectangles that have been created by participants to cluster related items. Other visual cues bear additional semantics (e.g. the thickness of an edge may express how strongly an item objects another one). The spatial arrangement of the collaboration artifacts aid users have a neat and quick view of the alternative ideas considered so far as well as the underlying argumentation. Since the process of gathering and sharing resources about the particular debate is unstructured, highly dynamic and thus rapidly evolving, this projection provides an appropriate environment to support collaboration at this stage. The aim is to bring the session to a point where main trends crystallize. Filtered views may be of additional help towards this direction. Figure 4 illustrates a view that has been produced after a participant's request to visualize the workspace shown in Figure 3 according to some filtering. In the particular instance, a participant requested to visualize only the ideas expressed so far together with all the related argumentation in favor and against them (the filtering process invokes an algorithm for the better spatial arrangement of a workspace's items).

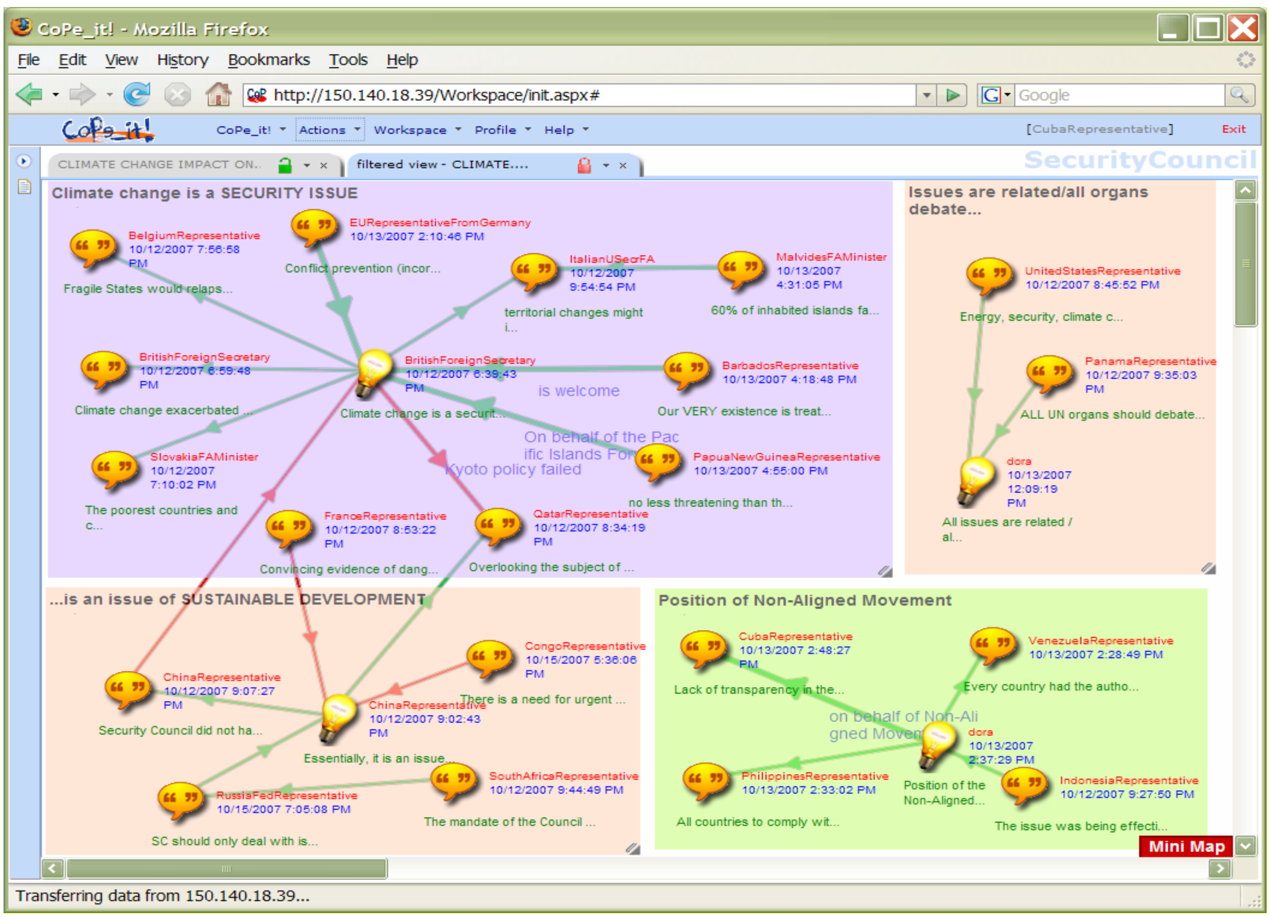

Figure 4. A filtered view.

Some contexts necessitate a further elaboration of the knowledge items considered so far, and exploitation of additional functionalities such as formal argumentation and reasoning mechanisms. A formal projection in CoPe_it! is able to cover such needs by providing a fixed set of discourse element and relationship types, with predetermined, system-interpretable semantics. Further elaborating our example, let us assume that the collaboration has reached a point where a switch to a more formal projection is needed. This implies that selected knowledge items' and relationships' types have to be transformed. The above are determined by the underlying visualization and reasoning model of the formal projection (this process can be semi- or fully automated).

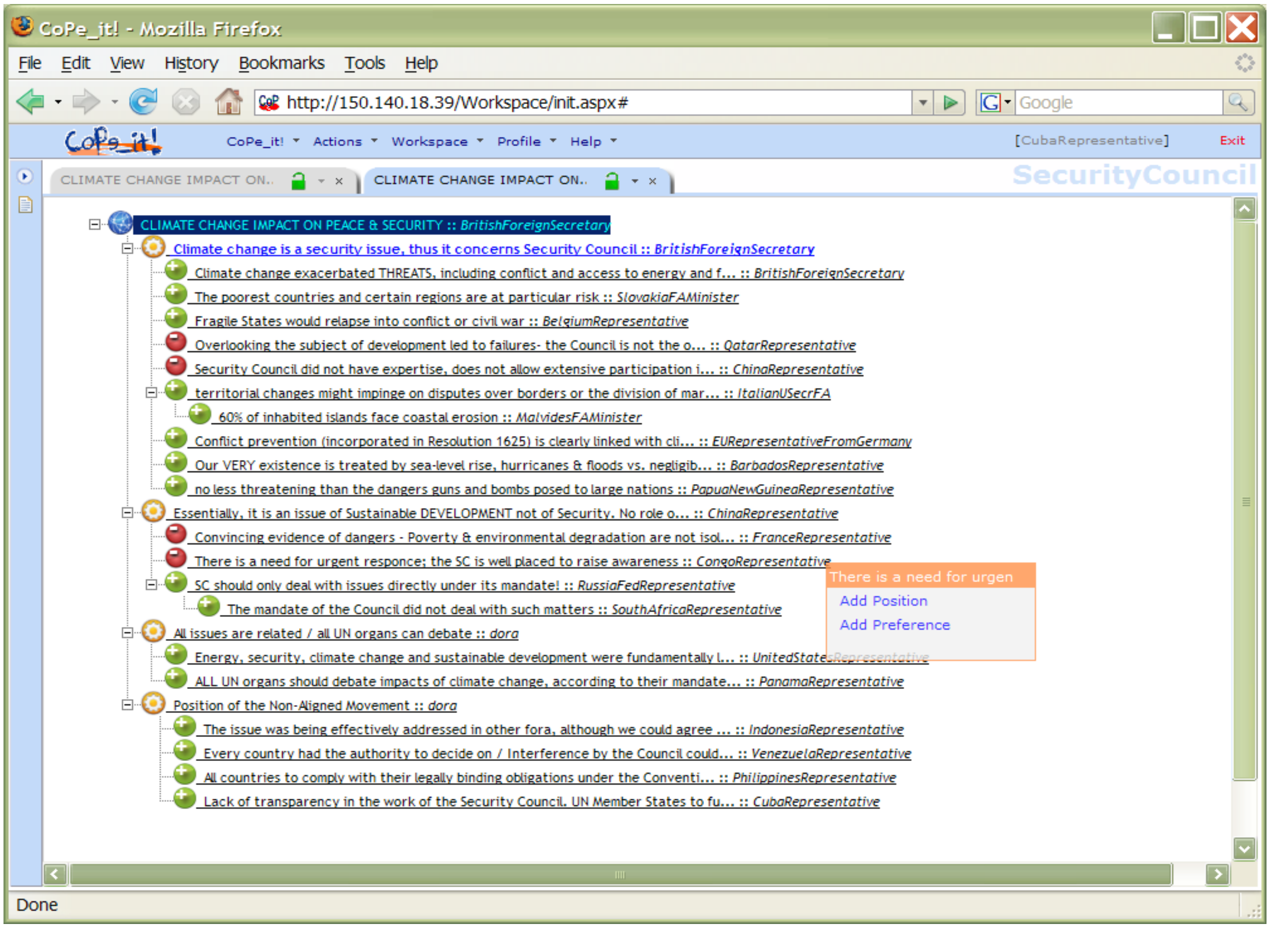

Figure 5. An instance of the formal projection of the collaboration.

An instance of the workspace's formal projection (corresponding to both the data-intensive view of Figure 3 and the filtered view of Figure 4) is shown in Figure 5. This projection adopts an IBIS-like formalism (item types supported are issues, alternatives and positions) and provides a structured language for argumentative discourse together with a mechanism for the evaluation of alternatives. More specifically, the ideas appearing in the informal projection have been transformed to alternatives (alternatives correspond to solutions to the issue under consideration). Other knowledge items have been transformed to positions in favor or against exploiting the coloring and the legends of the interrelating arrows. Additional reasoning can be performed through the expression of preferences, which provide participants with a qualitative way to weigh reasons for and against the selection of an alternative. Further to the argumentation-based structuring of a collaborative session, this projection integrates a reasoning and scoring mechanism that determines the status of each discourse entry (according to broadly accepted argumentation rules), the ultimate aim being to keep users aware of the most prominent alternative (Karacapilidis & Papadias 2001) (in the instance of Figure 5, the alternative “Climate change is a security issue, thus it concerns Security Council” wins; this can be changed in another instance of the collaboration, depending on the underlying argumentation).

Collaboration through CoPe_it! may continue at the informal projection, where users are able to exploit a richer set of features and functionalities. Alternative projections of a collaboration workspace should be considered jointly, in that a switch from one to the other can further facilitate the argumentative collaboration process. Moreover, a particular collaboration context may be better handled through a less or more formal projection. One may also consider the case where decrease of formality is desirable. For instance, while collaboration proceeds through a formal projection, some discourse elements need to be further justified, refined and elucidated. It is at this point that the collaboration session could switch to a more informal view in order to provide participants with the appropriate environment to better shape their minds.

6. Concluding remarks

CoPe_it! has been already introduced in diverse collaborative settings for a series of pilot applications. Preliminary results show that it fully covers the user requirements analyzed earlier in this article. Furthermore, users have admitted that it stimulates interaction, makes them more accountable for their contributions, while it aids them to conceive, document and analyze the overall collaboration context in a holistic manner, by facilitating a shift from divergence to convergence. We argue that the proposed approach, due to its inherent scalability, is able to fully support the evolution of a data-intensive collaboration, while it provides the means for addressing the issues related to the formality needed in collaborative knowledge building systems. It aims at contributing to the field of social software, by supporting argumentative interaction between people and groups, enabling social feedback, and facilitating the building and maintenance of social networks.

Future work directions include the extensive evaluation of CoPe_it! in diverse collaboration paradigms, which is expected to shape our mind towards the development of additional projections, as well as the experimentation with and integration of additional visualization cues, aiming at further facilitating and augmenting the information triage process.

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References

Castells, M. The Network Society: A Cross-cultural Perspective, Edward Elgar, 2004.

Checkland, P. and Holwell, S. “Action Research: Its Nature and Validity”, Systemic Practice and Action Research, vol. 11, no 1, 1998, pp. 9-21.

Conklin, J. and Begeman, M. “gIBIS: A tool for all reasons”, Journal of the American Society for Information Science, vol. 40, no 3, 1989, pp. 200-213.

Conklin, J., Selvin, A.M., Buckingham Shum, S. and Sierhuis, M. “Facilitated hypertext for collective sense-making: 15 years on from gIBIS”, Proc. 12th ACM Conference on Hypertext and Hypermedia, ACM Press, 2001, pp. 123-124.

de Moor, A. and Aakhus, M. “Argumentation support: from technologies to tools”, Communications of ACM, vol. 49, no 3, 2006, pp. 93-98.

Fischer, G., Lemke, A.C., McCall, R. and Morch, A. “Making Argumentation Serve Design”, Human Computer Interaction, vol. 6, no 3-4, 1991, pp. 393-419.

Fischer, G., McCall, R. and Morch, A. “JANUS: Integrating hypertext with a knowledge-based design environment”, Proc. Hypertext ’89 Conference, ACM Press, 1989, pp. 105-117.

Halasz, F. “Reflections on NoteCards: Seven Issues for the Next Generation of Hypermedia Systems”, Communications of the ACM, vol. 31, no 7, 1988, pp. 836-852.

Hevner, A.R., March, S.T., Park, J. and Ram, S. “Design Science in Information Systems Research”, MIS Quarterly, vol. 28, no 1, 2004, pp. 75-105.

Karacapilidis, N. and Papadias, D. “Computer supported argumentation and collaborative decision making: The HERMES System”, Information Systems, vol. 26, no 4, 2001, pp. 259-277.

Kirschner, P., Buckingham Shum, S. and Carr, C. Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-Making, Springer, 2003.

Kunz, W. and Rittel, H. “Issues as Elements of Information Systems”, Technical Report 0131, Universität Stuttgart, Institut für Grundlagen der Planning, 1970.

Lee, J. “SIBYL: A tool for managing group decision rationale”, Proc. CSCW’90 Conference, ACM Press, 1990, pp. 79-92.

MacLean, A., Young, R.M., Bellotti, V. and Moran, T. “Questions, options and criteria: Elements of design space analysis”, Human Computer Interaction, vol. 6, no 3-4, 1991, pp. 210-250.

Marshall, C. and Shipman, F.M. “Spatial Hypertext and the Practice of Information Triage”, Proc. 8th ACM Conference on Hypertext, 1997, pp. 124-133.

Reed, C.A. and Rowe, G.W.A. “Araucaria: Software for Argument Analysis, Diagramming and Representation”, International Journal of AI Tools, vol. 14, no 3-4, 2004, pp. 961-980.

Shipman, F.M. and Marshall, C.C. “Formality Considered Harmful: Issues, Experiences, Emerging Themes, and Directions”, Tech. Rep. ISTL-CSA-94-08-02, Xerox Palo Alto Research Center, 1994.

Shipman, F.M. and McCall, R. “Supporting knowledge-base evolution with incremental formalization”, Proc. CHI ’94 Conference, 1994, pp. 285-291.

Smolensky, P., Fox, B., King, R. and Lewis, C. “Computer-aided reasoned discourse, or how to argue with a computer”, in Guindon, R. (Ed.): Cognitive Science and its Applications for Human-Computer Interaction, Erlbaum, Hillsdale, 1987, pp. 109-162.

Streitz, N., Hannemann, J. and Thuring, M. “From ideas and arguments to hyper-documents: Travelling through activity spaces”, Proc. Hypertext ’89 Conference, ACM Press, 1989, pp. 343-364.

Suthers, D., Weiner, A., Connelly, J.and Paolucci, M. “Belvedere: Engaging students in critical discussion of science and public policy issues”, Proc. 7th World Conference on Artificial Intelligence in Education, 1995, pp. 266-273.

van Gelder, T.J. “Argument mapping with Reason!Able”, The American Philosophical Association Newsletter on Philosophy and Computers, 2002, pp. 85-90.

Verheij, B. “Artificial argument assistants for defeasible argumentation”, Artificial Intelligence, vol. 150, no 1-2, 2003, pp. 291-324.