Chapter 13
Managing Argumentative Discourses in Multi-Actor Environments

Nikos Karacapilidis

13.1 Introduction

Argumentative collaboration is critical for the creation, leveraging and utilisation of knowledge in various public administration issues. One of the most important advantages of modern organisations in today's complex political, economic, social and technological environment is their ability to leverage and utilise their knowledge (Prahalad & Hamel, 1990). Such knowledge resides in an evolving set of organisational assets, such as the employees, the structure, the culture and the processes of the organisation. Employee knowledge, and particularly tacit knowledge, has been identified to be the dominant asset, as it is decisive at all levels and has to be fully exploited (Nonaka, 1994). Such exploitation refers to the transformation of tacit knowledge to codified information, a process considered to be critical for organisational performance and success (Cohendet & Steinmueller, 2000).

For the above reasons, we argue that it is necessary to adopt a knowledge-based public policy and decision-making view in the development of the supporting technologies (Holsapple & Whinston, 1996). According to this view, public policies and decisions should be considered as pieces of descriptive or procedural knowledge referring to an action commitment. Moreover, any public policy and decision-making process should be viewed as a collaborative production of new knowledge, for example, evidence justifying or challenging an alternative, or practices to be followed (or avoided) thus providing a refined understanding of the problem.

Taking into account the above requirements, this chapter investigates whether and how argumentative collaboration for policy and decision-making can be effectively supported by an appropriately developed information system. The research method adopted for this purpose follows the 'Design Science Paradigm', which has been extensively used in information systems research (Hevner, March, Park, & Ram, 2004). We used this paradigm to develop a Web-based system for supporting:

N. Karacapilidis (✉)
Industrial Management and Information Systems Lab, University of Patras,
Patras 26 504 Rio, Greece
e-mail: nikos@mech.upatras.gr

M. Cerreta et al. (eds.), *Making Strategies in Spatial Planning*,
Urban and Landscape Perspectives 9, DOI 10.1007/978-90-481-3106-8_13,

(a) the collaboration required for public policy and decision-making; as well as (b) the creation, leveraging and utilisation of relevant knowledge. The proposed system allows for distributed (synchronous or asynchronous) collaboration and aims at aiding the involved parties by providing them with a series of argumentation, decision-making and knowledge management features.

The remainder of this chapter is structured as follows: Section 13.2 comments on literature related to the issue of argumentative collaboration; Section 13.3 presents the features and functionalities of the proposed system; while Section 13.4 describes its application in a real public policy problem. Finally, Section 13.5 discusses set of critical issues related to the proposed solution and draws conclusions.

13.2 Related Work

Designing software systems that can adequately address users' needs to express, share, interpret and reason about knowledge during an argumentative discourse has been a major research and development activity for more than 20 years (de Moor & Aakhus, 2006). Designing, building and experimenting with Information Systems for the development of specialised argumentation and decision rationale support systems has resulted in a series of computer-supported argument visualisation approaches (Kirschner, Buckingham Shum, & Carr, 2003). Technologies supporting argumentative collaboration include, among others, mailing lists, forums, group decision-support systems, as well as co-authoring, and negotiation support systems. There is also increasing interest in implementing Web-based tools supporting argumentative collaboration. These usually provide means for discussion structuring and user administration, while the more sophisticated ones allow for sharing of documents, online calendars, embedded e-mail, chat tools and so on.

The above approaches support argumentative collaboration at various levels, and have been tested through diverse user groups and contexts. Furthermore, all aim at exploring argumentation as a means of establishing a common ground between diverse stakeholders, to understand positions on issues, to bring to the surface assumptions and criteria and to collectively construct consensus (Jonassen & Carr, 2000). In the rest of this section, we present an overview of the existing software supporting argumentation that has been applied in different organisational and educational contexts. The primary aim of this overview is to highlight the features and functionalities of the existing argumentation tools, as well as to comment on their strengths and weaknesses in aiding argumentative collaboration.

Argumentation based on the exchange and evaluation of interacting arguments, which support opinions and assertions, has been extensively applied for collaborative decision support systems or for negotiation support in diverse organisational contexts.

gIbis (Conklin & Begeman, 1987), for instance, a pioneer argumentation structuring tool that has exhibited major impact on a series of other tools, was developed for the capturing of a design process rationale. This is a hypertext groupware tool that allows its users to create issues, assert positions on these issues, and make arguments in favour or against them. Sibyl (Lee, 1990), an extension of gIbis, is a tool for managing group decision rationale. This tool also provides services for the management of dependency, uncertainty, viewpoints and precedents, and can be viewed as a knowledge-based system. QuestMap (Conklin, 1996) is another approach based on gIbis's main principles that resembles a 'whiteboard', where all messages, documents and reference material for a project and their relationships are graphically displayed during meetings. QuestMap captures the key issues and ideas during meetings and creates shared understanding in a knowledge team. All messages, documents and reference material for a project are placed on the 'whiteboard', where the relationships between them are graphically displayed. Users end up with a 'map' that shows the history of an online conversation that led to key decisions and plans. Compendium (Selvin & Sierhuis, 1999) is a graphical hypertext system which can be used to gather a semantic group memory, when used in a meeting scenario. Compendium provides a participatory user interface for conceptual modelling frameworks and other diverse applications required by the community of users.

Other approaches, focusing on the representation of knowledge, include Euclid (Smolensky, Fox, King, & Lewis, 1987), a tool that provides a graphical representation language for generic argumentation, Sepia (Streitz, Hannemann, & Thuring, 1989), a knowledge-based authoring and idea-processing tool that supports the creation and revision of hyper-documents, Janus (Fischer, McCall, & Morch, 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) which is another model to represent the rationale of reasoning in a decision-making process (MacLean, Young, Bellotti, & Moran, 1991).[1]

In the same context, Belvedere (Suthers, Weiner, Connelly, & Paolucci, 1995) is used for constructing and reflecting on diagrams of one's ideas, such as evidence maps and concept maps. It represents different logical and rhetorical relations within a debate and supports problem-based collaborative learning scenarios through the use of a graphical language. Finally, Hermes (Karacapilidis & Papadias, 2001), a tool supporting distributed, asynchronous collaboration by integrating features based on concepts from well-established areas such as Decision Theory, Non-Monotonic Reasoning, Constraint Satisfaction and Truth Maintenance, aims at augmenting classical decision-making approaches by supporting argumentative discourse among decision-makers.

In the context of argumentation theory, systems supporting the visualisation of argumentation have played a considerable educational role as they support teaching of critical thinking and reasoning skills. For instance, Araucaria (Reed & Rowe, 2001) provides an interface for the decomposition of text into argumentation premises and conclusions. It 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. These features, combined with its platform independence and ease of use, make Araucaria an interesting argumentation tool. The Reason!Able argumentation tool (van Gelder, 2002) also provides a well structured and user-friendly environment for reasoning. Through the use of an argumentation tree, a problem can be analysed or decomposed to its logically related parts, whereas missing elements can also be identified. Furthermore, Reason!Able provides the means for an elegant structuring of the tree diagram. Another educational software providing assistance in the creation and sharing of visual images of ideas is MindDraw,[2] a descendant of Spidermap. This software tool enables users to produce ‘cause maps’ (maps of causal relationships), thus supporting and encouraging self-reflection, inquiry and critical thinking. It is a special purpose, simple, point-and-click drawing tool that allows the creation, analysis and pictorial representation of ideas. MindDraw is a thinker’s tool that is useful for students and learners of all ages, from primary school through graduate training and professional practice. Athena Standard and Athena Negotiator (Rolf & Magnusson, 2002) 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.

The above approaches have been thoroughly considered during the development of our approach and aided the conceptualisation, shaping and implementation of its currently integrated features and functionalities. For instance, the discourse graph of our tool is gIbis-like, while its reasoning mechanisms have exploited features of the above-mentioned argumentation tools. As noted earlier, majority of the existing argumentative collaboration systems focus mainly on the expression and visualisation of arguments. In this way, they assist participants to organise their thoughts and present them to their peers. However, their features and functionalities are limited (e.g., they pay almost no attention to knowledge management issues), they are tested, almost exclusively, in academic environments (i.e., not broadly used), they are not inter-connected with other tools, and they do not efficiently integrate the technological, social and pedagogical dimensions of collaboration. As acknowledged in de Moor and Aakhus (2006), traditional argumentation software approaches are no longer sufficient to support contemporary communication and collaboration needs. Our approach aims at filling this gap, by providing a list of features and functionalities described in the next section.

13.3 The Proposed Solution

Having followed an argumentative reasoning approach, we have developed a Web-based system that supports the multi-actor collaboration required for public policy decision-making, by facilitating the creation, leveraging and utilisation of the relevant knowledge. The overall framework of our approach extends the one conceived in the development of the Hermes system (Karacapilidis & Papadias, 2001), by providing additional knowledge management and decision-making features.

Discourses about complex problems in the public sector are considered as social processes and, as such, they result in the formation of groups whose knowledge is clustered around specific views of the problem. Following an integrated approach, our system provides public organisations, engaged in such a discourse, with the appropriate means to collaborate towards the solution of diverse issues. In addition to providing a platform for group reflection and capturing of organisational memory, our approach augments teamwork in terms of knowledge elicitation, sharing and construction, thus enhancing the quality of the overall process. This is achieved through its structured language for conversation and a mechanism for evaluation of alternatives. Taking into account the input provided by the individual public organisations, the system constructs an illustrative discourse-based knowledge graph that is composed of the ideas expressed so far, as well as their supporting documents. Through the integrated decision-support mechanisms, discussants are continuously informed about the status of each discourse item asserted so far, and reflect further on those items according to their beliefs and interests regarding the outcome of the discussion. In addition, our approach aids group sense-making and mutual understanding through the collaborative identification and evaluation of diverse opinions. Such an evaluation can be performed through either argumentative discussion or voting.

Furthermore, our system provides a shared Web-based workspace for storing and retrieving the messages and documents of the participants, using the widely accepted XML document format. Exploitation of the Web platform renders, among others, low operational cost and easy access to the system. The knowledge base of the system maintains all the above items (messages and documents), which may be considered, appropriately processed and transformed, or even re-used in future discussions. Storage of documents and messages being asserted in an ongoing discussion takes place in an automatic way, that is, upon their insertion in the knowledge graph. On the other hand, retrieval of knowledge is performed through appropriate interfaces, which aid users explore the contents of the knowledge base and exploit previously stored or generated knowledge for their current needs. In such a way, our approach builds a 'collective memory' of a public sector community.

The basic discourse elements in our system are issues, alternatives, positions and preferences. In particular, issues correspond to problems to be solved, decisions to be made or goals to be achieved. They are brought up by users representing a public organisation and are open to dispute (the root entity of a discourse-based knowledge graph has to be an issue). For each issue, the users may propose alternatives (i.e., solutions to the problem under consideration) that correspond to potential choices. Nested issues, in cases where some alternatives need to be grouped together, are also allowed. Positions are asserted in order to support the selection of a specific course of action (alternative), or avert the users' interest from it by expressing some objection. A position may also refer to another (previously asserted) position, thus arguing in favour or against it. Finally, preferences provide individuals with a qualitative way to weigh reasons for and against the selection of a certain course of action. A preference is a 'tuple' of the form (position, relation, position), where the relation can be 'more important than', or 'of equal importance to' or 'less important than'.

The use of preferences results in the assignment of various levels of importance to the alternatives in hand. Like the other discourse elements, they are subject to further argumentative discussion.

The above four types of elements enable the users of the system, who typically represent public organisations or other parties involved in a public policy or decision-making discourse, to contribute their knowledge on the particular social problem or need (by entering issues, alternatives and positions), and also to express their relevant values, interests and expectations (by entering positions and preferences). In such a way, the system supports both the rationality-related dimension and the socio-political dimension of the public policy and decision-making process. Moreover, the system continuously processes the elements entered by the users (by triggering its reasoning mechanisms each time a new element is entered in the graph), thus facilitating users to become aware of the elements for which there is (or there is not) sufficient (positive or negative) evidence, and accordingly, conduct the discussion in order to reach consensus.

The features and functionalities of the proposed system, as well as its applicability in supporting multi-actor collaboration for public policy and decision-making, are presented in more detail in the following section.

13.4 A Case Study

A real-life application of the system, for one of the most important, difficult and widely discussed public policy issues in Greece, was organised. The case concerned the establishment (or not) of non-state universities. Today in Greece, all universities are ‘state’ ones, established and supervised by the Ministry of National Education. According to the Greek Constitutional Law, higher education should be provided only by the State, and not by any private-sector enterprises. However, it has been proposed by some politicians and private companies that this status should be changed; initially, new ‘state universities’ should be established, not by the Ministry of Education, but by other public sector organisations, such as big municipalities, chambers of industry and commerce, the Church and so on. It has been also proposed that, as a next step, the Constitutional Law should be amended, so that it will allow higher education to be provided by private-sector companies as well. However, there are many parties and citizens who strongly object to the establishment of private universities. In this public policy issue many public organisations are involved (the Ministry of National Education, the Universities, the big Municipalities, the Chambers of Industry and Commerce, the Church, etc.), therefore extensive multi-actor consultation and collaboration is required among them, concerning this issue. In addition, there are private-sector stakeholders involved, namely, the owners of various existing private non-university level educational institutions. They are interested in establishing private universities (mainly in cooperation with foreign universities), providing the related Constitutional Law amendment are made. From the above, one can easily conclude that the public policy issue under consideration is quite complex, and diverse arguments both in favour and against all the proposed alternatives should be expected. Needless to say, the issue is of critical importance for many young people in Greece and their families.

Four groups of users participated in this application, each one representing a significant stakeholder in the issue: the Ministry of National Educational (three persons), university professors (four persons), the Chambers of Industry and Commerce interested in establishing non-for-profit universities (three persons), and owners of the existing private educational institutions (four persons). Participants were geographically dispersed and had access to the system via an Internet connection and a Web browser. They were all familiar with using computers and the Internet; all had previously participated (at least once) in an unstructured electronic forum on the Internet. They were trained by postgraduate students, who visited them in their own locations and introduced them to the basic functionality of the system. This training took on average less than an hour.

An instance of the argumentative discourse that developed during their collaboration appears in Fig. 13.1.[3] As shown, our approach maps the overall collaboration process to a discourse-based knowledge graph with a hierarchical structure. Each entry in the graph corresponds to an argumentation element (i.e., issue, alternative,

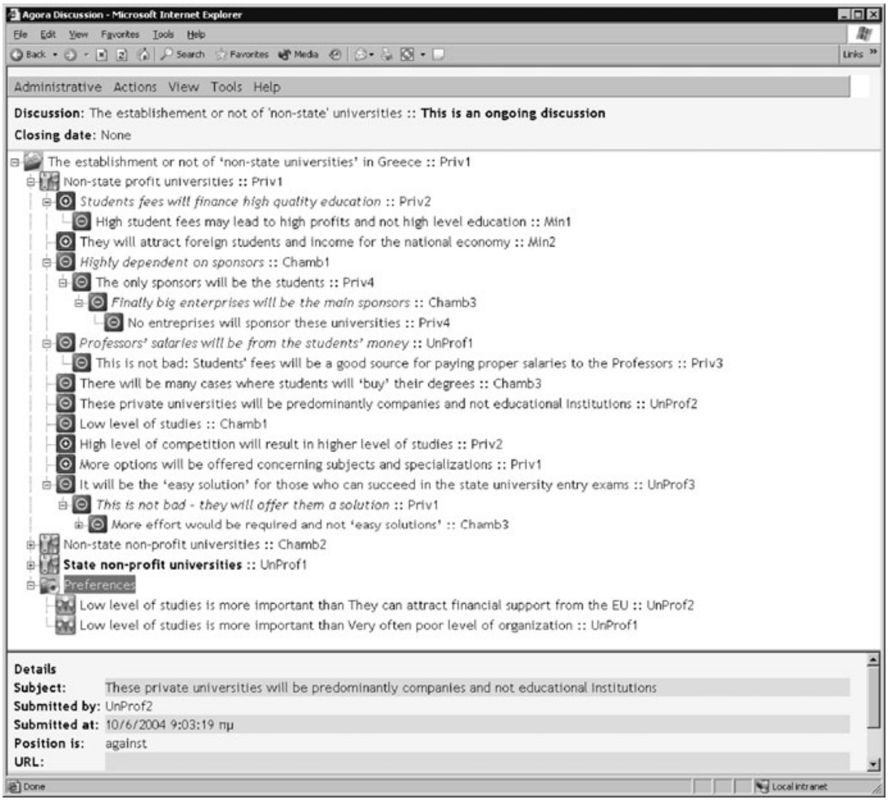

Fig. 13.1 An instance of the argumentative discourse

position or preference). Each element is accompanied by an icon that indicates the element type. There are also icons for folding/unfolding purposes, thus enabling users to concentrate on a specific graph's part; this is particularly useful in graphs of considerable length and complexity. Each entry in the graph may contain the username of the user who submitted it and the date of submission.[4]

In the application discussed in this chapter, the usernames used declare the type of the group the participant belongs to; for instance, the usernames Min1, Min2 and Min3 correspond to users representing the Ministry of National Education, the ones starting with UnProf correspond to university professors. The system may also support 'anonymous discourse', by not revealing the name of the user who entered an element.

According to literature (Beaudouin-Lafon, 1999; Lococo & Yen, 1998), such an approach may be useful in cases where more freedom in ideas generation is sought; also, it often allows users to evaluate each entry more impartially, without taking into account the hierarchical position, the social status and the other characteristics of the user who contributed it. The lower pane of the window shown in Fig. 13.1 provides more details about a selected entry of the discussion graph.[5]

In our case (Fig. 13.1), the overall issue under discussion is 'the establishment (or not), of non-state Universities in Greece'. Three alternatives, namely 'non-state-for-profit universities', 'non-state not-for-profit universities' and 'state non-for-profit universities', have been asserted so far by the users Priv1, Chamb2 and UnProf1, respectively.

The users (discussants) have argued about them extensively, by expressing positions speaking in favour or against them. For instance, 'They will attract foreign students and income for the national economy' is a position (asserted by Min2) that argues in favour of the first alternative, while 'Highly dependent on sponsors' is a position (asserted by Chamb1) that argues against it. All graph entries are subject to multi-level argumentation. For instance, 'Easy solutions are disastrous' has been asserted by UnProf4 to further validate the 'More effort would be required and not easy solutions' position (asserted by Chamb3), while 'No enterprises will sponsor these universities' to challenge the 'Finally big enterprises will be the main sponsors'.

As noted in the previous section, users may also assert preferences about the already expressed positions. As shown in the bottom of the main pane of Fig. 13.1, users UnProf2 and UnProf1 have expressed two preferences concerning the relative importance between the position 'Low level of studies' and two others (namely, 'They can attract financial support from the EU', and 'Very often [there is a] poor level of organisation'), arguing that the first position is (for them) of bigger importance. Users may also express their arguments in favour or against a preference.

Figure 13.1 shows the full information provided in the lower pane of the basic interface of the system. This comprises details about the user who submitted the selected discussion element, its submission date, any comments that the user may had inserted, as well as links (URLs) to related Web pages and documents that the user may have uploaded to the system in order to explain this element and aid his/her peers in their contemplation.

Further to the argumentation-based structuring of a discourse, the system integrates a reasoning mechanism that determines the status of each discussion entry, the ultimate aim being to keep users aware of the discourse outcome. More specifically, alternatives, positions and preferences of a graph have an activation label (it can be ‘active’ or ‘inactive’), indicating their current status (inactive entries appear in red italics font). This label is calculated according to the argumentation underneath and the type of evidence specified for them. Activation in our system is a recursive procedure; a change of the activation label of an element is propagated upwards in the discussion graph. Depending on the status of positions and preferences, the mechanism goes through a scoring procedure for the alternatives of the issue (for a detailed description of the system’s reasoning mechanisms, see Karacapilidis & Papadias, 2001).

At each discussion instance, the system informs users about the most prominent (according to the underlying argumentation), alternative solution (shown in bold font). In the instances shown in Figs. 13.1 and 13.2 (all items asserted under the first alternative are folded in Fig. 13.2, while items under the second and third

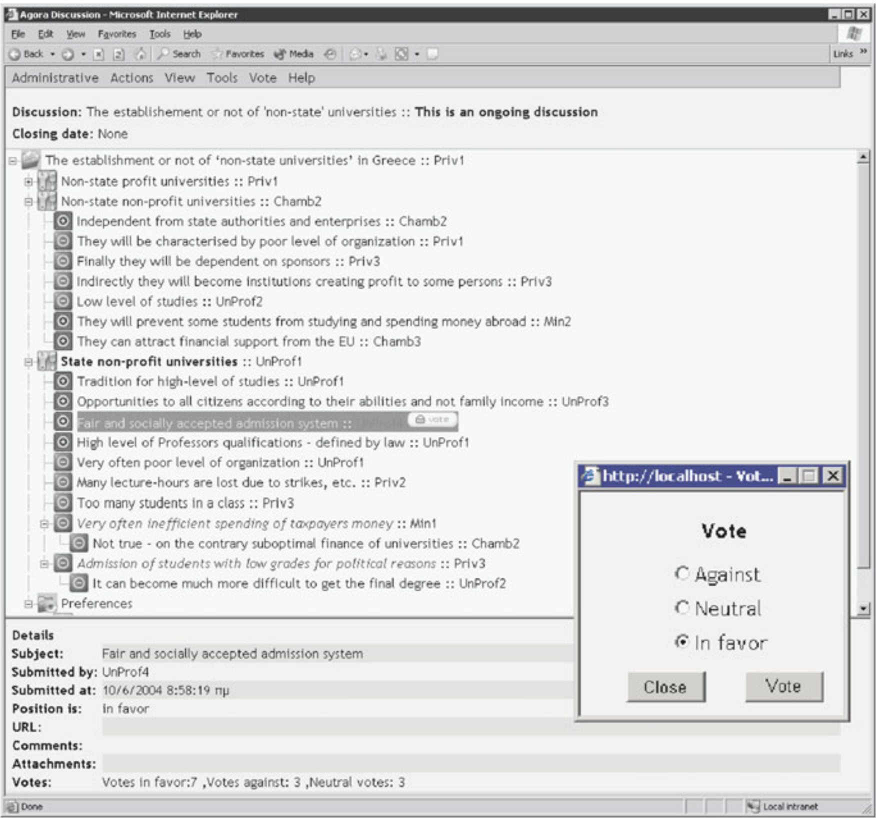

Fig. 13.2 Another instance of the argumentative discourse and the voting option

alternatives are unfolded – the opposite holds for Fig. 13.1), ‘State non-for-profit universities’ is the better justified solution so far. However, this may change upon the type of the future argumentation. In other words, each time an alternative is affected during the discussion, the issue it belongs to is updated, since another alternative solution may be indicated by the system.

Positions, preferences and alternatives may be evaluated also by voting. In such a case, the ‘majority rule’ is used in order to decide whether the item is active or inactive (i.e., whether it should be taken into account in the overall evaluation of the issue under consideration).

In order for an item to become subject to voting, the user who has asserted should take the appropriate action (the related option appears under the Vote menu). When an item is subject to voting, an indicative icon appears at the end of it. Any user may then vote about the validity of the item, having the options ‘in favour’, ‘neutral’ and ‘against’ (the related option also appears under the Vote menu, and the small window of Fig. 13.2 pops up). Such a case is shown in the discussion instance in Fig. 13.2, for the position ‘Fair and socially accepted admission system’, asserted by UnProf4. As one can see in the lower pane of the figure, 13 (out of 14) users have voted so far, while the results are 7 votes in favour, 3 votes against and 3 neutral votes.

The system also integrates e-mailing and electronic messaging features (options provided under the Tools menu) to further facilitate communication among users, before one asserts an argumentation element in the graph. The insertion of all types of entries in the graph is performed through appropriately designed interfaces deployed upon the user’s selection under the Actions menu. Such functions include the opening of an issue, insertion of a new alternative (to an issue), insertion of a new position (in favour or against an existing position, preference or alternative) and insertion of a new preference (to an existing issue). Editing features are also provided.

The user interface for adding a new alternative to an existing issue is shown in the bottom left part of Fig. 13.3. As illustrated, users can give a subject (title), of the new alternative, but also provide more details about their assertion through the URL (related Web addresses), and comments (free text), panes.

Moreover, they can attach multi-media documents to their discourse items. The user interface for adding a new position is shown in the top left part of Fig. 13.3. The further element can be an alternative, another position, or a preference. In addition to the ‘Add a new alternative’ interface, users have to specify here the type of link (in favour or against), and the proof standard they prefer (depending on the discussion, context, this option may be inactivated; i.e., the same proof standard is used for all positions). The top right part of Fig. 13.3 illustrates the user interface for adding a new preference to an issue. The interface provides users with the means to consider all valid combinations of positions, thus preventing them from making errors in expressing a preference. The relation type menu includes the preference relations ‘more (less) important than’ and ‘equally important to’. Finally, the user interface for adding a new issue is shown in the bottom right part of Fig. 13.3.

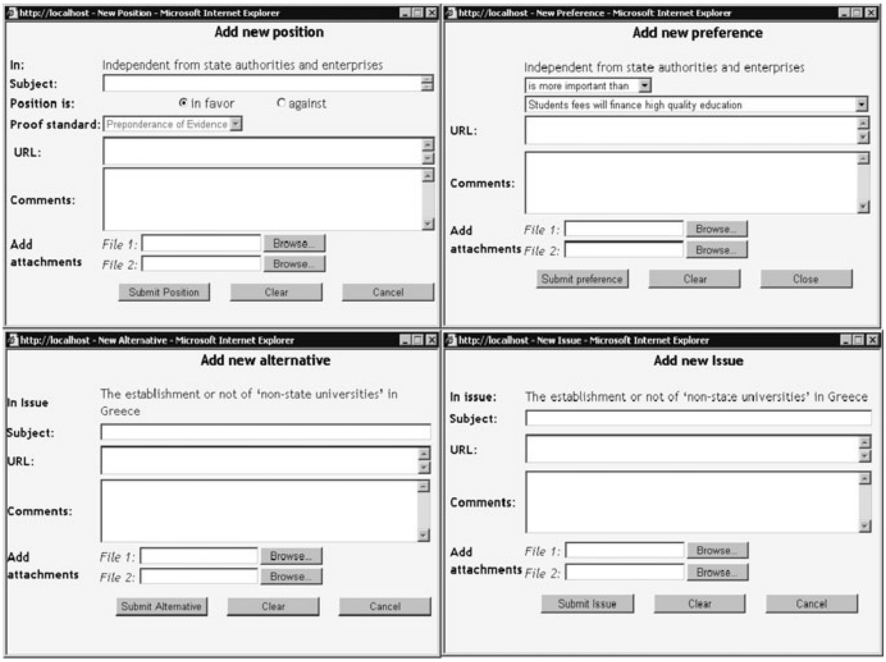

Fig. 13.3 User interfaces

13.5 Discussion and Conclusions

The proposed solution is a Web-based tool that attempts to assist and augment argumentative collaboration being held among multiple actors with diverse interests and backgrounds, by facilitating the creation, sharing, leveraging and utilising the relevant knowledge. The system follows an argumentative reasoning approach, which complies with collaborative principles and practices. As noted by many influential thinkers, argumentation is central to learning (Paul, 1989; Perkins, 1986; Resnick, 1987).

In a variety of contexts, argumentation is an essential element for effective learning, in that it enables people to develop their points of view and refine their knowledge. In an effective collaborative argumentation environment, participants focus on the same issues, and learn to negotiate conflicting opinions, until they accept or share the answer, solution and so on. (Veerman, Andriessen, & Kanselaar, 1998). Sharing information and creating common knowledge in argumentative discourse also contributes to trust development and enhances collaborative behaviour (Chesñevar, Maguitman, & Loui, 2000). Moreover, argumentation facilitates learning as it increases the coherence of organisational mental models by assuring their rationality, logical consistency, and by eliminating any internal contradictions (Rescher, 1970). Similarly, as it operationalises trust and power relations, argumentation has been proved to be an efficient coordination mechanism (Malone & Crowston, 1990).

For the above reasons, the employment of Information and Communication Technology that supports argumentation-based collaboration and knowledge management, 'argumentation as explanation' (van Eemeren et al., 1996) in the context under consideration, is crucial.

In summary, our approach enables easy expression and sharing of a community's knowledge, structured visualisation of the above knowledge expressed during argumentative discourses, organisation of a community's knowledge through an illustrative discourse-based knowledge graph, augmentation of group reflection and leveraging of knowledge creation through argumentation, efficient building of organisational memory, which can be reused in future collaboration, and integration of argumentation-based reasoning mechanisms for the evaluation of the proposed courses of action. Moreover, our approach supports multi-level user management and it can be accessed through major Web browsers.

Future research directions concern an extensive evaluation of the system through diverse real application settings. This input will be further considered towards improving the functionality of the system, as well as towards the potential integration of additional features. In any case, we foresee the need of multiple collaboration spaces, each one having different characteristics, to cover diverse needs, such as: recording of sparse thoughts and arguments of participants, hosting of original free-text dialogs, collection of original resources needed in the context of a specific session of collaboration, creation of new knowledge by elaborating original resources and so on. Such collaboration spaces should be tightly inter-connected, while the transition from one to another should be both transparent and user-friendly.

Notes

1. QOC provides the means to represent and integrate rationale of varying degrees of stability at the different stages of a design process.
2. See http://info.cwru.edu/minddraw/index.html
3. We asked participants to carry out this experiment in English.
4. Alternative forms in the appearance of each entry can be obtained through options provided under the View menu.
5. Users can select an entry by clicking on it.

References

Beaudouin-Lafon, M. (1999). *Computer supported collaborative work*. New York: Wiley.

Chesñevar, C., Maguitman, A., & Loui, R. (2000). Logical models of argument. *ACM Computing Surveys*, *32*(4), 337–383.

Cohendet, P., & Steinmueller, W. E. (2000). The codification of knowledge: A conceptual and empirical exploration. *Industrial and Corporate Change*, *9*(2), 195–209.

Conklin, E. J. (1996) *Designing organisational memory: Preserving intellectual assets in a knowledge economy*. Group Decision Support Systems Working Paper [http://www.gdss.com/wp/DOM.htm; accessed 22/01/2007].

Conklin, E. J., & Begeman, M. L. (1987) *gIBIS: A hypertext tool for team design deliberation*. In: Proceedings of the Hypertext'89 Conference. ACM Press, New York, pp. 247–252.

de Moor, A., & Aakhus, M. (2006). Argumentation support: From technologies to tools. *Communication of ACM*, *49*(3), 93–98.

Fischer, G., McCall, R., & Morch, A. (1989) *JANUS: Integrating hypertext with a knowledge-based design environment*. In: Proceedings of the Hypertext'89 Conference. ACM Press, New York, pp. 105–117.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75–105.

Holsapple, C. W., & Whinston, A. B. (1996). *Decision support systems: A knowledge-based approach*. St. Paul, MN: West Publishing Company.

Jonassen, D. H., & Carr, C. S. (2000). Mindtools: Affording multiple representations for learning. In S. P. Lajoiem (Ed.), *Computers as cognitive tools II. No more walls: Theory change, paradigm shifts and their influence on the use of computers for instructional purposes* (pp. 165–196). Mawah, NJ: Erlbaum.

Karacapilidis, N., & Papadias, D. (2001). Computer supported argumentation and collaborative decision making: The HERMES system. *Information Systems*, *26*(4), 259–277.

Kirschner, P., Buckingham Shum, S., & Carr, C. (2003). *Visualizing argumentation: Software tools for collaborative and educational sense-making*. London: Springer.

Lee, J. (1990) *SIBYL: A tool for managing group decision rationale*. In: Proceedings of the CSCW'90 Conference. ACM Press, New York, pp. 79–92.

Lococo, A., & Yen, D. (1998). Groupware: Computer supported collaboration. *Telematics and Informatics*, *15*(1–2), 85–101.

MacLean, A., Young, R. M., Bellotti, V., & Moran, T. (1991). Questions, options and criteria: Elements of design space analysis. *HCI*, *6*(3–4), 210–250.

Malone, T. W., & Crowston, K. (1990) *What is coordination theory and how can it help design cooperative work systems?* In: Proceedings of CSCW 90 Conference. ACM Press, New York, pp. 357–370.

Nonaka, I. (1994). A dynamic theory of organisational knowledge creation. *organisation Science*, *5*(1), 14–37.

Paul, R. W. (1989). Critical thinking in North America: A new theory of knowledge learning and literacy. *Argumentation*, *3*(2), 197–235.

Perkins, D. N. (1986). *Knowledge as design*. Hillsdale, NJ: Lawrence Erlbaum Associations.

Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review*, *68*(3), 79–91.

Reed, C., & Rowe, G. (2001). *Araucaria: Software for puzzles in argument diagramming and XML.* Technical Report. Dundee: Department of Applied Computing, University of Dundee.

Rescher, N. (1970). *The coherence theory of truth*. Oxford: Oxford University Press.

Resnick, L. B. (1987). *Education and learning to think*. Washington, DC: National Academy Press.

Rolf, B., & Magnusson, C. (2002) *Developing the art of argumentation: A software approach*. In: Proceedings of ISSA 2002 [http://www.athenasoft.org/; accessed 22/01/2007].

Selvin, A. M., & Sierhuis, M. (1999) *Case studies of project compendium in different organisations*. In: Proceedings of Computer-Supported Collaborative Argumentation for Learning Communities. Workshop held at Computer-Supported Collaborative Learning'99, Stanford.

Smolensky, P., Fox, B., King, R., & Lewis, C. (1987). Computer-aided reasoned discourse, or how to argue with a computer. In R. Guindon (Ed.), *Cognitive science and its applications for human-computer interaction* (pp. 109–162). Hillsdale, NJ: Erlbaum.

Streitz, N., Hannemann, J., & Thuring, M. (1989) *From ideas and arguments to hyperdocuments: Travelling through activity spaces*. In: Proceedings of the Hypertext'89 Conference. ACM Press, New York, pp. 343–364.

Suthers, D., Weiner, A., Connelly, J., & Paolucci, M. (1995) *Belvedere: Engaging students in critical discussion of science and public policy issues*. In: Proceedings of the 7th World Conference on Artificial Intelligence in Education (AI-ED '95), Washington, DC, pp. 266–273.

van Eemeren, F. H., Grootendorst, R., Henkemans, F. S., Blair, J. A., Johnson, R. H., Krabbe, E. C. W., et al. (1996). *Fundamentals of argumentation theory*. Mahwah, NJ: Lawrence Erlbaum Associates.

van Gelder, T. J. (2002). Argument mapping with Reason!Able. *The American Philosophical Association Newsletter on Philosophy and Computers*, *2*(1), 85–90.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (1998) *Learning through computer-mediated collaborative argumentation* [http://eduweb.fsw.ruu.nl/ar-ja/PhD2.html; accessed 22/01/2007].