On the Development of Knowledge Management Services for Collaborative Decision Making

Christina E. Evangelou[(1)], Nikos Karacapilidis[(1, 2)], Manolis Tzagarakis[(1)]

(1) Research Academic Computer Technology Institute, E Learning Sector, Patras, Greece
Email: {chriseva, karacap, tzagara}@cti.gr

,

(2) Industrial Management and Information Systems Lab, MEAD, University of Patras, Greece
{nikos}@mech.upatras.gr

***Abstract*— Admitting that the quality of a decision depends on the quality of the knowledge used to make it, it is argued that the enhancement of the decision making efficiency and effectiveness is strongly related to the appropriate exploitation of all possible organizational knowledge resources. On the other hand, software is perceived as an encapsulation of knowledge. Especially software tools offering Knowledge Management can become substantial organizational artifacts. Developing such tools should be in absolute compliance with the organizational practices so as to be easily integrated with and augment every day activities. Towards this end, this paper presents a multidisciplinary approach for developing knowledge management services for the capturing the organizational knowledge in order to augment teamwork in terms of knowledge elicitation, sharing and construction, thus enhancing decision making quality. Based on a properly defined ontology model, our approach is supported by a web-based tool that serves as a forum of reciprocal knowledge exchange, conveyed through structured argumentative discourses, the ultimate aim being to support the related decision making process.**

***Index Terms*—Knowledge Management, Decision Making, Software Development**

I. Introduction

According to Moffett *et al.* [1], among factors relating to the contribution of technology for business improvement and competitive advantage, focus is placed on technology for effective collaboration and decision making. On the other hand, experiences reported by an increasing number of companies show that their long-term survival and competitive success is determined not so much by their financial muscles and size, but by the manner in which they consciously attempt to learn, create, codify, and utilise knowledge [2]. In a similar vein, Curley [3] states that the main challenges towards organizational change and development are threefold: first, knowledge discovery; second, corporate collaboration; and third, rapid decision making.

Software is an encapsulation of knowledge [4]. Perceiving Knowledge Management (KM) tools as knowledge artifacts themselves, lack of reusing parts of the system that might be needed by other KM systems has severe impact on leveraging and augmenting organizational knowledge. It is widely argued that organizations should capitalize the existing human resources and assist them in using online tools to increase the effectiveness of their work, by providing a unique space for knowledge generation and exchange [5], [6].

Remarks drawn from our experience in developing knowledge-based collaboration tools for diverse collaborative settings identify the following issues: a) knowledge *per se* is intensively *domain dependent* whereas Knowledge Based Systems are context specific applications; thus, reusability is certainly a ubiquitous and complex issue. b) the lack of sophisticated methodologies or theories for the extraction of reusable knowledge and reusable knowledge management patterns has proven to be extremely costly, time consuming and error prone. c) supporting knowledge sharing processes in a virtual community needs more technical support to deal with the asynchronous addition of knowledge objects and the maintenance of a consistent knowledge structure.

Taking the above remarks into account, this paper presents an integrated, multidisciplinary approach for supporting knowledge-based collaborative decision making, aiming at "bringing together" decision makers holding complementary knowledge. Furthermore, our goal is to provide the necessary means for this knowledge to be unified, revised and improved while it is being used for decision making processes. Acknowledging the significance of software tools as contributors and enablers in performing collaborative tasks within an organizational context, this paper also proposes an innovative

Based on "Handling knowledge-based decision making issues in collaborative settings: An integrated approach", by Christina E. Evangelou and Nikos Karacapilidis which appeared in the Proceedings of the 4th Hellenic Conference on Artificial Intelligence (SETN'06), Herakleion, Greece, May 2006. © 2006 IEEE.

development approach for the design and implementation of software providing integrated collaboration, decision support and knowledge management services.

The remainder of the paper is structured as follows: Section II presents related work and summarizes a series of issues regarding the development of Knowledge Management tools that motivate our work. Section III gives an overview of our approach. Section IV presents the conceptual design and comments on the domain-independent and domain-specific processes that shape our approach. Section V presents the services required for supporting knowledge based decision making. Sections VI and VII present the building of the ontology model and service oriented components employed by our approach, respectively. Section VIII presents an implemented web-based tool that fully supports the proposed approach, and demonstrates its features and functionalities through an example case. Section IX discusses a set of issues regarding our work. Section X concludes our work by outlining final remarks.

II. Motivation

Davenport and Prusak define knowledge as "a combination of information and context in a way that enables action" [7]. In order to obtain a body of existing knowledge, which is as complete, consistent and correct as possible, the knowledge acquisition field deals with the transfer and transformation of knowledge from the forms in which it is available into forms that can be used by a Knowledge Management System (KMS) [8]. KMSs are the tools and techniques that support KM practices in organizations [9]. From the above it is clear that the processing of knowledge is integrally tied to the specific needs and preferences of a specific organization.

Technology has been both a key contributor to and enabler of the field of Knowledge Management [5]. KM is considered as a managerial, computer-based approach aiming at collecting, processing, and organizing organization-specific knowledge assets for organizational activities such as decision making [10]. In the past three decades, a variety of knowledge processing tools and techniques have emerged, mainly based on algorithmic learning, artificial intelligence, cognitive technologies, computational intelligence, data mining, intelligent information processing and natural language processing (for a detailed description see: [11], [12], [13]).

The effectiveness of technology investment in KMSs depends on how work is organized around that investment [14]. KM tools do not exist in isolation, but rather in an environment where other tools already work and with which users are accustomed. Stand-alone KM tools enforce users to leave their favourable everyday working environment, requiring the learning of a new tool [15]. If knowledge management tools are not pervasively available in their everyday working environment, users' productivity may decrease and their problem solving capabilities may be harmed. This finally impacts their popularity and applicability. It is not enough to simply introduce new KM tools in an organization. Rather, they should be introduced in a way which will not lead to technological obstacles ensuring that their building, maintenance and use can be easily achieved. This requires that KM tools need to explicitly address integration issues.

From a more technical point of view, most KM tools are currently developed based on stand-alone and monolithic architectures [16]. In speaking of stand-alone tools we refer to tools that are unable to interoperate with other tools, while the term monolithic is used to describe system architectures where a single process provides all necessary functionalities without clear conceptual boundaries among the systems' functional modules. This kind of architectures exhibits a number of shortcomings, such as lack of integration with the users' every day practices and working environment.

Furthermore, issues such as the inconsistency, imprecision, uncertainty and fuzziness impose additional complexity to the knowledge management process. As a result, KM tools exhibit great complexity (due to their application dependent nature) and their maintenance and evolution proves a sophisticated and time consuming task [17]**Error! Reference source not found.**. These setbacks also reflect on the storage of the acquired and processed knowledge in Knowledge Bases (KB). Moreover, issues regarding the construction and maintenance of KBs, such as the lack of clear, neutral, expressive and concise modelling, in addition to their low reusability, make the distinction between content and structure more essential than ever.

Another issue to be addressed is the lack of extending and reusing tools. While monolithic tools are tightly bound to a domain tailored to solve knowledge management problems for a particular domain (i.e. they are domain specific), they do not evolve smoothly when (even minor) changes in the system are necessary. Due to their tightly bound nature, even small changes result to time consuming tasks and in many cases require the building of a new tool from scratch.

Taking the above remarks into account, we argue that implementation of KMSs should follow the culture, norms and especially the practices of organizations. Furthermore we emphasize that simply admitting knowledge management systems into organizations is not panacea. KMSs should conveniently and naturally leverage organizational practices. From a technological viewpoint, this means that KMSs should fit easily into existing technological infrastructures thus raising important issues with regards to reusability and integration. Our approach attempts to address those issues by explicitly adopting service oriented architecture (SOA) in delivering KM services. Answering this twofold goal is what motivates our approach.

III. Our Approach

Decision making, being one of the most critical collaborative processes within an organization, consists one of the most prominent organizational practices that can be exploited and supported by knowledge management services. On the other hand, as clearly stated in [18], the efficiency and effectiveness of decision making is strongly related to the appropriate exploitation of all possible organizational knowledge resources. In our perspective, developing KM services that facilitate collaboration is about supporting and enhancing the organizational processes of knowledge creation, storage, sharing, retrieval, transfer, processing and application. Towards this aim, we develop a set of services and associated scenarios of use, whose design and implementation are based on real life decision making activities.

The proposed development process is iterative, comprising five core tasks (see Figure 1). In the beginning, we identify the services required from a particular organization in order to address its specific needs as far as collaboration and communication are considered. After the formal definition of an organization's requirements in terms of services, we formalize the organizational practices, as well as their knowledge domain using a set of ontology models. We then implement the service-oriented components of the system. Finally, we proceed to the synthesis and specialization of the integrated services according to the particular organization. In the following, we present the abovementioned processes in more detail, putting emphasis on the technical solutions to be employed.

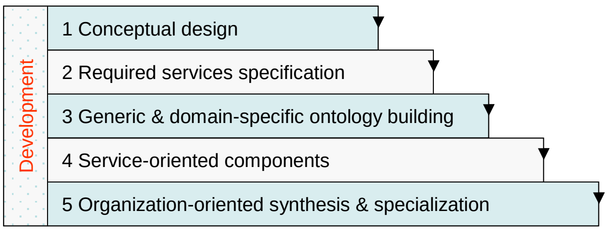

Figure 1. The proposed development process.

IV. Conceptual Design

Conceptual design is about offering an abstract view of data and conveying the real-world view and meaning of the domain of interest. In our approach, the conceptual design necessary for the shaping of knowledge management and decision making services is analyzed in terms of concepts, properties and relations among concepts.

A. Domain independent processes

Decision making is widely considered as a fundamental organizational activity that comprises a series of knowledge representation and processing tasks, the final aim being to resolve a problem, attain a goal or seize an opportunity [19], [20]. The majority of organizational decisions require the collaboration of a group of managers, who are experts in a specific knowledge domain and often represent diverse functions or departments of an organization.

In most cases decision making is a collaborative process that takes place through a series of argumentative discourses carried out among members of a workgroup formed to solve a particular issue. Such discourses are based on the exchange of the involved individuals' knowledge in the form of linguistic statements. These statements express the experience, values, contextual information and experts' insights that enable stakeholders (i.e. decision makers, domain experts, knowledge workers) evaluate and incorporate new experiences and information).

As argumentative discourses evolve, the stakeholders' knowledge is usually clustered around specific ideas, solutions and views, while the whole collaboration process can result in knowledge exchange and reconstruction [21]. The final outcome of such discourses is usually a set of decisions, resulted out of appropriate reasoning and evaluation mechanisms, which may then constitute new knowledge. If this new knowledge is made explicit properly (e.g. in the form of a structured argument), it can be reused in a future (context-related) decision making process.

What derives from the above rationale is that, in a collaborative setting -irregardless the domain of the issue under consideration- there is a clear interrelation between the processes of knowledge management, argumentation and decision making. Consequently, there is a strong interplay between the concepts of knowledge, argument, and decision. It is this very interrelation, as sketched in Figure 2, which characterizes the conceptual modelling of our overall approach and forms the domain-independent part of the ontology model used.

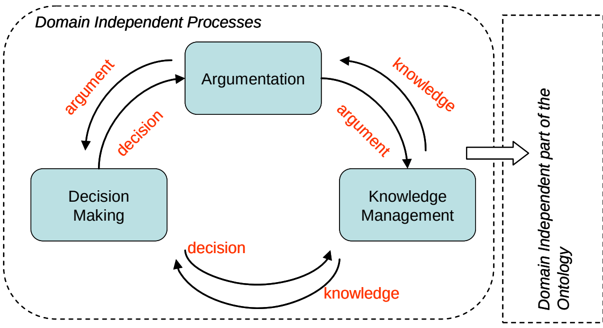

Figure 2. Domain independent processes.

B. Domain specific processes

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, maintaining focus on the overall process, as well as in maintaining consistency and increasing plausibility and accuracy [22]. 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 approach.

More specifically, in order to visualize knowledge-driven collaborative decision making processes, our approach takes into account how an argumentative (decision making related) discourse is structured and evaluated. Our approach comprises a set of Decision Making Frameworks (DMFs) in order to provide the necessary procedures for the structuring of complex organizational problems. Actually, DMFs can be considered as models that enable the formalization of the above discourses. Being employed as a "backbone" of a particular discourse, a DMF does not limit participants in the expression of their diverse views, but it provides the guidelines for the evolvement of the underlying argumentation.

At the same time, in order to evaluate the alternative courses of action, our approach employs a set of Scoring Mechanisms (SMs), which are actually models based on methods and techniques coming from the Multiple Criteria Decision Aid discipline [23]. These facilitate the selection of the most acceptable alternative solution by measuring the extent to which the alternative solutions meet the objectives set by the stakeholders (and accordingly sort the proposed courses of action). Furthermore, they provide the means for integrating multiple views of a problem and support both quantitative and qualitative criteria.

Both DMFs and SMs are strongly dependent on the knowledge domain of the issue under consideration and delineate the domain-specific part of the ontology model to be used in a particular collaborative decision making setting (see Figure3).

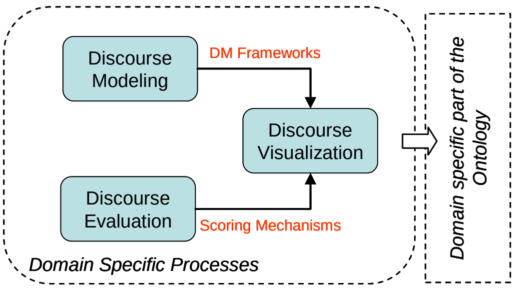

Figure 3. Domain independent processes.

V. REQUIRED SERVICES

Based on the above, we claim that Knowledge Management service is required for the gathering and sharing of knowledge. More specifically, the related module should handle the extraction and collection of the pieces of knowledge that are embedded in the discourse participants' statements (these are submitted to the tool via the GUI), as well as the uploading of them to the tool's KB. Moreover, it should provide users with the necessary functionalities for knowledge extraction and sharing, thus aiding decision making activities. It should also facilitate the generation and maintenance of the users' profiles. The conceptual modelling of the KM service should also define the structure of the related ontology model part.

Moreover, an appropriate Decision Support service is required for the appropriate handling of the argumentative discourses conducted by users, the ultimate aim being to support them in the underlying decision making processes. Our approach proposes the use of well-established decision making models and techniques, with respect to the problem domain, in order to evaluate the proposed alternatives and establish an acceptable solution. Towards this aim, we employ a set of broadly accepted and commonly used theories and models from the Strategic Management [23], [24], [25], [26] and the Multicriteria Decision Aids domains of research [27], [28], [29], [30]. Moreover, due to the fact that characteristics of information needs and problem solving models differ with respect to the specific decision support environment [31], our approach can easily integrate concepts and models from the particular knowledge domain considered each time. This service is closely related to the development of the tool's Model Base, where the DMFs and SMs models are maintained.

VI. ONTOLOGY BUILDING

In general, ontologies are employed as a means to provide exhaustive and rigorous conceptual schemata for the specification of semantics within a certain knowledge domain, thus establishing a shared language and common terms of reference [32]. Furthermore, ontology building also addresses another important issue to be resolved in decision making, the fact that it is often impeded by the use of different terminology and means of expression of the stakeholders' positions, mainly due to the diversity of their professional backgrounds.

Our overall work is based on an ontology model that appropriately serves the capturing of the organizational knowledge and augments teamwork in terms of knowledge elicitation, representation, sharing and storage [33]. This ontology model has derived after a comprehensive literature and practice survey of the related disciplines (i.e. Knowledge Management, Argumentation, Collaborative Decision Making and Multicriteria Decision Aid), aiming at the identification of the prevailing concepts and parameters. Furthermore, we exploited a set of associated scenarios of use based on real life collaborative decision making activities, in order to extract the domain semantics. From the knowledge acquired, and after the consideration of the domain-independent and the domain-specific processes described in Sections IV.A and IV.B we defined the overall structure of the ontology. Then, its physical model was implemented with the use of the Web Ontology Language (OWL).

VII. SERVICE-ORIENTED COMPONENTS

The design of service-oriented components facilitates the abstract and graphical representation of system modules independently of the technology options and implementation choices. To support an open and extensible system, a layered and component-based architecture has been adopted (see Figure 4). Each layer consists of components, responsible for a particular aspect of the system. In the following, we present the responsibilities of each layer and describe briefly the components they provide. Moreover, all services should be available through a single interface, which all applications use to request services.

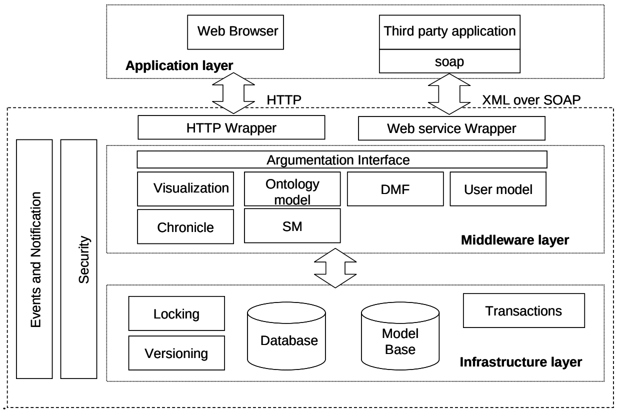

Figure 4. The conceptual architecture of our approach.

The *application layer* handles the interaction with users and communicates with the argumentation system in order to pass requests and receive responses that will be displayed to the user. Clients to the argumentation services can be either Web browsers communicating using the HTTP protocol, of third party applications (i.e. applications that were created prior to the argumentation system and thus are unaware of its existence) that may communicate using web services.

The *middleware layer* constitutes the core of the system and contains all services that reify domain specific parts. In our approach, this layer comprises the following set of components:

- The *Visualization component* handles the discourses graphical representation
- The *DMFs component* formalizes the content of the argumentation by providing a set of related criteria according to which the alternatives are evaluated
- The *SMs component* provides the mathematical models employed for the evaluation of the overall discourse and the selection of a specific alternative,
- The *User Model component* maintains the user profiles that can be taken into consideration when evaluating argumentation graphs and allows the explicit modelling of users and their preferences
- The *Chronicle* that acts as a logbook, logging all decision makers' actions, and
- The *ontology model* facilitates the checking and constraining of discourse alterations in order to avoid inconsistent argumentation graphs. Furthermore, it renders with the possible inconsistency issues of statements expressed in the Argumentation Graph.

The *infrastructure layer*, responsible for providing generic services such as persistent storage for data, the ontology model and the scoring mechanism along with versioning of the argumentation graph, locking and transaction management. Locking is in particular crucial since it avoids inconsistent data due to insert, delete and update anomalies.

Finally, the set of services depicted as orthogonal to the proposed conceptual architecture are the services available at all the abovementioned layers. More specifically, the *Security* service performs the checking of clearance as regards all requested operations, while the *Events and Notification* service informs other components of the system as well as the end-users (when appropriate) about particular events (e.g. New item insertion in the Argumentation Graph).

VIII. THE SUPPORTING TOOL

Our approach, as described above, is supported by a software tool based on service oriented and component-based architecture (SOA) which seem particularly well suited for the KM context. Exploiting features and functionalities from diverse Artificial Intelligence and Operational Research fields, we have developed a component-based tool that can be employed as a forum of reciprocal knowledge exchange, conveyed through structured argumentative discourses, the ultimate aim being to support the related decision making process. In order to provide users with the necessary means to communicate in a distant and asynchronous mode, the proposed tool is a web-based application. Much attention was paid to openness and extensibility issues; we have thoroughly exploited the .NET and XML technologies in order to establish a high level of interoperability, as well as to assure generic, neutral and extensible information modelling.

A. Features and functionalities

According to our approach, a discourse can be initiated after a registered user's request. The mandatory registration of the users' personal and professional information serves their assignment to certain roles (i.e. discourse moderator, decision maker, domain expert, knowledge manager, external participant). With respect to the role assigned, each user has a specific access level; accordingly, each of them is associated to a specific set of permitted actions (for a particular discourse).

After the definition of the issue under consideration (and the identification of the related knowledge domain), a set of rules is triggered in order to define the structuring of the Discourse Graph, which serves the visualization of a discourse. Actually, these rules associate the knowledge domain with the available DMFs and SMs. The Argumentation Interface is actually the core component of our approach, since it reflects the tool's decision support and knowledge management features and provides users with integrated services. Although our tool is able to propose the appropriate structure of the Discourse Graph (by exploiting meta-data), the final selection of the DMF and SM to be adopted is up to the discourse moderator. The following XSLT defines the structure of the graph.

```
<?xml version="1.0" encoding="UTF-8" ?>
<!--This XSL defines the treeview visualization on the Graph-->
<xsl:stylesheet version="2.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  ...
  xmlns:xdt="http://www.w3.org/2004/07/xpath-datatypes">
        <xsl:strip-space elements="*" />
        <xsl:output method="text" indent="yes" />
        <xsl:template match="/">
        <xsl:apply-templates />
        </xsl:template>
        <xsl:output method="xml" />
<!--goal creation-->
        <xsl:template match="goal">
                <xsl:element name="goal">
                <xsl:attribute name="subject">
                        <xsl:value-of select="@subject" />
```

```
                </xsl:attribute>
        <xsl:apply-templates />
                </xsl:element>
        </xsl:template>
<!--alternative creation -->
        ...
<!-- argumentInFavor creation-->
        ...
<!--argumentAgainst creation-->
 <xsl:template match="argument[@signPlus='false']">
        ...
        </xsl:template>
        <!--supportingEvidence creation-->
 <xsl:template match="supportingEvidence">
        ...
        </xsl:template>
        <!-- suppression of content and criteria elements-->
        <xsl:template match="content" />
        <xsl:template match="criteria" />
</xsl:stylesheet>
```

Discourse participants may then contribute their positions through the above graph. In order to assure a high level of expressiveness, the proposed tool enables stakeholders to contribute their individual positions in the form of linguistic statements. The creation of a statement comprises an insertion request and the definition of its *type*, *content*, *related criterion* (if applicable), and *placement* on the Discourse Graph. Individual positions inserted in the graph, called hereafter discourse items, are considered and treated as knowledge items, and are associated with a specific semantic value according to their placement in the graph and their creator.

The supported types of discourse items (i.e. “goal”, “alternative”, “argument in favour” or “argument against”, “criterion” and “supporting evidence”) comply with semantics explicitly defined in our approach’s ontology model, while they are also associated with the set of parameters used in DMFs and SMs. More specifically, a goal corresponds to the discourse item that briefly describes the overall aim of a conducted discourse. This is always defined by the discourse moderator. Alternatives are the items representing the proposed courses of action. In order to state their personal beliefs about the proposed alternatives, discourse participants may attach arguments to them (speaking in favour or against them). Furthermore, discourse participants may relate their arguments to one or more criteria.

A list of criteria is always provided to the users whenever a new argument is inserted in the Discourse Graph. In order not to limit participants in expressing their views, new criteria may be also asserted. In this case, such criteria are registered in the tool’s Knowledge Base (KB) and added to the above list. Finally, users can upload supporting evidence items (e.g. multimedia documents, URLs), thus providing additional information for their statements. Discourse items of past discourses, containing related bodies of knowledge, can also be retrieved and reused in an ongoing discourse as supporting evidence.

A key functionality of the proposed tool concerns the exploration of the decision makers’ statements, as these are expressed during argumentative discourses, in order to elicit knowledge related to the decision making process, the decision makers and the decision *per se*. In order to efficiently and effectively exploit the decision makers’ knowledge, the proposed approach maintains a set of *user profiles*. These provide information about the decision makers’ expertise, as well as their behaviour during their participation in the argumentative discourses and knowledge sharing activities. Besides the recording of the users’ personal and professional information (discussed above), this is accomplished by extracting a *behaviour pattern* (mental model), which is built by taking into account the users’ involvement in the overall process (e.g. number and type of discourse items inserted, frequency of their appearance, intervention on items inserted by others, etc.). Towards this aim, our approach exploits the decision makers’ actions to maintain a set of metadata reflecting their attitude in the specific knowledge domain. In speaking about metadata [34], we refer to the structured information that describes, explains, locates, or makes it easier to retrieve, use or manage an information resource (e.g., information about how often the “cost” criterion becomes the decisive factor for the resolution of a discourse, and which decision makers are always contributing to this issue).

Another functionality enhancing knowledge elicitation builds around the construction of a chronicle that provides a summary of the decision makers’ actions during the evolution of a discourse. Pieces of these chronicles can be easily retrieved from the KB through a search engine (in order, for instance, to be reused in future discourses). The information acquired through chronicles can be further analysed through cluster analysis or causal maps in order to enrich the users’ profiles and amend their mental models. Furthermore, it can be used for the analysis and validation of the related decision making process.

B. An example case

In this section, we demonstrate the features and functionalities of the proposed tool through a strategy development case concerning the choice of the location where a new plant should be placed. For this particular case, the DMF employed for the structuring (modelling) of the discourse derived from the “Resource Based View-RBV” conceptual framework [25]. This particular DMF involves two basic criteria, i.e. supporting activities and supporting resources, which actually consist the core concepts of the RBV approach. Each of these criteria is associated with a list of sub-criteria (activities with the set {*history*, *cost*, *dependability*, *flexibility*, *speed*, *quality*} and resources with the set {*level*, *cost*, *dependability*, *flexibility*, *speed*, *quality*}). As far as the SM is concerned, a generic algorithm, based on the principles of the Analytic Hierarchy Process [27], was employed for the evaluation of the overall discourse. The following XML document presents the method utilized for the opening of a new discourse.

```
/// <summary>
   /// method that creates a new XML discourse documents and demands its insertion
in the DB
   /// </summary>
   /// <param name="subject"> discourse subject </param>
   /// <param name="content">discourse content</param>
   /// <param name="Domain">discourse domain</param>
   /// <returns>returns the new discourse id</returns>
   public string newDiscourse(string subject, string content, string Domain)
   {
      //discourse creation
      crtDiscourseXML = new XmlDocument();
      XmlElement rootEl = crtDiscourseXML.CreateElement("goal");
```

```
rootEl.SetAttribute("subject", subject);
XmlElement contentEl = crtDiscourseXML.CreateElement("content");
contentEl.InnerText = content;
rootEl.AppendChild(contentEl);
rootEl.SetAttribute("lastId", "0");
crtDiscourseXML.AppendChild(rootEl);

//store in DB
db.storeDiscourse(crtDiscourseXML, Domain, crtUserId);
    return "";
```

Figure 5 illustrates an instance of the Discourse Graph structured for this case. As shown, the overall issue was “New plant location” (appearing on the top of the window), while the goal to be met was “Increase capacity” (top of the Discourse Graph). Discourse participants have proposed (so far) three alternative solutions, namely “Thessaloniki”, “Patras” and “Tirana”. These solutions are supported by in favour and challenged by against arguments. For instance, a decision maker placed the in favour argument “Transport goods to our nearby distribution center” for the alternative “Thessaloniki”. This argument was associated to the “supporting activities” criterion and the “speed” sub-criterion, in particular. Discourse items are preceded by an identification label which is associated to their type (e.g. [SuAc02] refers to a supporting activity). Different colours and images are used in order for the users to better visualize the different types of discourse items. Furthermore, by right clicking on them, users may see the list of permitted actions and act accordingly.

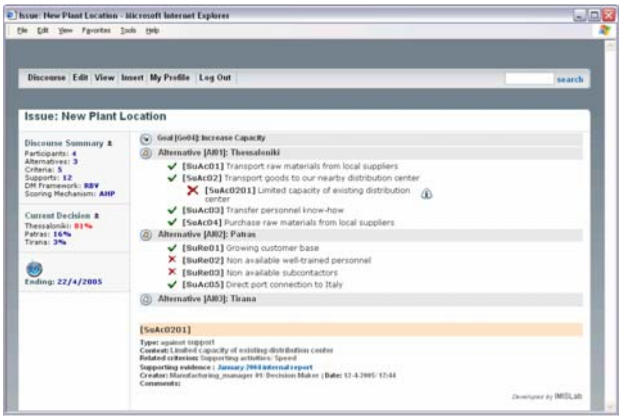

Figure 5. An instance of the Discourse Graph.

Argumentation in our approach can be performed in multiple levels. As shown in Figure 5, another user has attached the item “Limited capacity of existing distribution center”, which is an argument against the above in favour argument. In the instance shown, this particular item has been selected (by clicking on it). Details concerning a selected item appear at the bottom right part of the window. This comprises information about the item’s type, content, related criteria, supporting evidence, creator, date/time of insertion, as well as related comments.

In general, whenever a new discourse item is inserted in the graph, a set of procedures is executed by the tool to update the discourse status and evaluate the alternative solutions. At the same time, the chronicle functionality records the corresponding user’s action. These procedures are automatically triggered and are hidden from the discourse participants. For instance, a users request for the creation of a new alternative invokes the following procedure:

```
/// <summary>
///method that creates alternatives in discourse XML and asks for discourse
modification in DB
/// </summary>
/// <param name="subject">alternative subject</param>
/// <param name="content">alternative content</param>
public void addAlternative(string subject, string content)
{
//find previous alternative id
int alternativeId = Convert.ToInt32
(crtDiscourseXML.DocumentElement.Attributes["lastId"].InnerText) + 1;
 crtDiscourseXML.DocumentElement.SetAttribute("lastId", alternativeId.ToString());
//insert alternative
XmlElement alt = crtDiscourseXML.CreateElement("alternative");
alt.SetAttribute("id", alternativeId.ToString());
alt.SetAttribute("userId", crtUserId);
alt.SetAttribute("creationTime", DateTime.Now.ToShortDateString());
alt.SetAttribute("lastUpdate", DateTime.Now.ToShortDateString());
alt.SetAttribute("subject", subject);
alt.SetAttribute("activate", "1");
XmlElement contentEl = crtDiscourseXML.CreateElement("content");
contentEl.InnerText = content;
alt.AppendChild(contentEl);
crtDiscourseXML.DocumentElement.AppendChild(alt);
//TODO : execute algorithm
db.modifyDiscourse(crtDiscourseXML, crtdiscourseID);
}
```

After a user’s discourse item insertion request, the Discourse Graph gets automatically refreshed in order to graphically display the new entry and update the Discourse Summary and Current Decision results (appearing at the left part of the window). The Discourse Summary provides information about the number of participants that have contributed to the overall discourse, the number of alternative solutions that have been proposed, the number of in favour and against arguments inserted in the graph, as well as the number of criteria considered (i.e. the number of criteria associated with the discourse items).

Furthermore, users can see the DMF and SM employed for the structure and evaluation, respectively, of the discourse. The Current Decision part of the window provides a sorting of the proposed alternatives, according to the score they get each time (this score is calculated by the SM). At the instance shown in Figure 6, the alternative “Patras” appears to be winning (its priority is 44%). The date set for the closure of the discourse can be also indicated.

Figure 6. Another instance of the Discourse Graph.

Obtaining knowledge from human resources is integrally tied to how the mind organizes and represents information [35], [36]. One of our aims being to assist the elicitation of knowledge from stakeholders participating in collaborative decision making argumentative discourses (in order to share it with their peers), the web-based tool that supports our approach is furnished with a set of knowledge gathering and sharing functionalities. These are based on the exploitation of the stakeholders' statements and their interrelations during such discourses.

Towards this aim, after the closure of a discourse, all statements expressed are stored in the tool's KB, classified according to their type and placement on the Discourse Graph. More specifically, a sample output XML document summarizing a discourse is as follows:


```
<?xml version="1.0" encoding="UTF-8"?>
<!--Sample XML file generated by XMLSPY v2004 rel. 4 U
(http://www.xmlspy.com)-->
<discourse discourseID="0" subject="establishment">
    <user userId="0">
        <firstName>chriseva</firstName>
        <lastName/>
    </user>
    <domain id="0" name="increase capacity"/>
    <openingDate>2001-12-17T09:30:47-05:00</openingDate>
    <closingDate>2001-12-17T09:30:47-05:00</closingDate>
    <scoringMechanism scoringMechanismTypeId="1"
scoringMechanismTypeName="Pytho Scoring Mechanism"/>
    <decisionFramework decisionFrameworkTypeId="1"
decisionFrameworkTypeName="RBV Framework"/>
    <content>selection of place to build new facilities </content>
```


In general, the storage of the overall discourse to the KB conforms to the XML Schema employed for the structuring of the discourse. For the strategy development issue under consideration, the discourse's structure was delineated by the XML Schema appearing in Figure 7 (the figure also illustrates some instantiations of the Schema's elements according to the discourse instance considered above). This particular Schema has derived after the joint consideration of the RBV DMF and the SM that is based on the principles of the Analytic Hierarchy Process. The overall discourse was stored as an XML document that complies with this Schema.

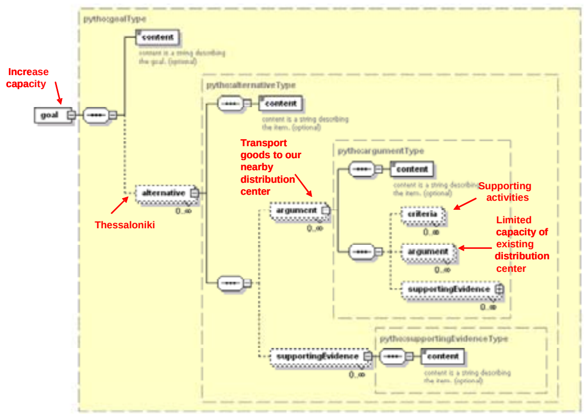

Figure 7. The XML Schema for the structure of the Discourse Graph.

IX. FURTHER IMPLICATIONS

A very significant aspect of human-computer interaction concerns the structure and presentation of the provided services to the end user. User interfaces should strive for consistency, enable frequent users to use shortcuts, offer informative feedback, offer error prevention and simple error handling, permit easy reversal of actions, and support internal locus of control [37].The proposed tool could also be properly enhanced according to the aforementioned "good practices". Furthermore, appropriate navigation and help tools could be also provided for users with diverse expertise. In this direction, taxonomies and classification schemes could also be employed wherever possible, as a means for "guiding" users' cognition. In any case, it should be noted here that there is no panacea for the design of user-friendly interfaces. The abovementioned practices could be interpreted, refined, and exploited according to the needs of the different types of knowledge workers involved in the particular environment.

Knowledge dissemination via the proposed tool can be further enhanced through the deployment of tools that enhance human-computer interaction and stimulate the user's perception, imagination, and creative thinking. Towards this end, a series of features formulated dynamically, according to the user's profile, should be incorporated in the system. More specifically, a knowledge worker's profile may comprise a set of predefined attributes related to issues such as participation in knowledge sharing activities and domain of expertise. Such profiles may evolve to accommodate an individual's changing needs. They may also evolve according to the attitude the user demonstrates while interacting with the system.

Deliberately built on an open architecture, the proposed tool can also cooperate with other tools (e.g. intelligent agents) that can better monitor the "moves" of a knowledge worker and accordingly offer him/her advanced help. Moreover, through maintenance of these profiles, users could be assigned with fluctuating weight factors that reflect their degree of participation in knowledge sharing activities. The users' willingness to participate in such activities can be also stimulated by the proper externalization of the knowledge sharing outcomes. Finally, benefits in terms of innovation and creativity can also be attained by communicating the potential of the work being carried out and the accomplishments made so far.

X. CONCLUSIONS

We have argued that a proper design of tools offering Knowledge Management services can be regarded as a very promising solution for contemporary organizations to resolve every day practices. Towards this aim, we presented a multidisciplinary approach that provides the means for capturing the organizational knowledge in order to augment teamwork in terms of knowledge elicitation, sharing and construction, thus enhancing decision making quality. The proposed web-based tool can serve as a forum of knowledge exchange in natural language. This is through the tools integrated Discourse Graph, which is structured according to the knowledge domain of the problem under consideration and is based on a properly defined ontology model for providing and accessing knowledge sources. The proposed approach elaborates a set of metadata to make explicit the relations occurring between the decision makers and their statements. In such a way, argumentative discourses carried out in collaborative decision making settings can be exploited for the elicitation of the decision makers' knowledge. We envisage it not just as another groupware solution, but as a highly active tool that provides a structured way for modelling and solving complex organizational problems.

ACKNOWLEDGEMENTS

This work has been partially funded by the Palette IST FP6-2004.

REFERENCES

[1] S. Moffett, R. McAdam and S. Parkinson, "Technological Utilization for Knowledge Management", *Knowledge and Process Management,* vol. 11, no 3 pp 175–184 (2004)
[2] M. Shukla, "Building corporate culture for transformation", *Productivity*, Vol. 35, no 3, pp. 419-428, 1994.
[3] K. Curley, "The role of technology. knowledge management: a real business guide", Caspian, London, pp. 48–52, 1998.
[4] J. Martin, "Knowledge is money", *IT Week*, vol. 7 September, 1998.
[5] E.Y., Li and H. Lai, "Collaborative work and knowledge management in electronic business", *Decision Support Systems,* vol. 39, pp. 545-547, 2005.
[6] H. J.Ahn, H.J. Lee, K. Chob and S. J. Park, "Utilizing knowledge context in virtual collaborative work", *Decision Support Systems*, vol. 39, pp. 563–582, 2005.
[7] T. Davenport and L., Prusak, "Working knowledge: managing what your organization knows", Harvard Business School Press, Boston, MA, 1998.
[8] B.G. Buchanan, D.K. Barstow, R. Bechtel, J. Bennett, W. Clancey, C. Kulikowski, T. Mitchell and D.A. Waterman, "Constructing an expert system", in F. Hayes-Roth, D. Waterman, and D.B. Lenat (Eds.), "Building expert systems", Addison-Wesley, Reading, MA, pp.127-168, 1983.
[9] B. Gallupe, "Knowledge management systems: surveying the landscape" [Electronic Version]. *International Journal of Management Reviews*, vol. 3(1), pp. 61-77, 2001.
[10] L. Prusak, "Where did knowledge management come from?", *IBM Systems Journal*, vol. 40, no 4, pp. 1002-1007, 2001.
[11] S. Liao, "Knowledge management technologies and applications literature review from 1995 to 2002", *Expert Systems with Applications*, vol. 25, pp. 155–164, 2003.
[12] K. Mertins, P. Heisig, and J. Vorbeck, "Knowledge management: best practices in europe", Springer-Verlag, Berlin, 2001.
[13] R. Maier, "State-of-Practice of Knowledge Management Systems: Results of an Empirical Study", *Upgrade*, vol. 3, No. 1, pp. 15-23, 2002.
[14] K. Balasubramanian, J. Nochur, C. Henderson and M. Millie, "Managing process knowledge for decision support", *P. Kwan Support Systems*, vol. 27, pp. 145–162, 1999.
[15] Y. Malhotra, "Integrating knowledge management technologies in organizational business processes: getting real time enterprises to deliver real business performance", *Journal of Knowledge Management*, Vol. 9, No 1, pp. 7-28, 2005.
[16] R. Akscyn, D. McCracken, and E. Yoder, "KMS a distributed hypermedia system for managing knowledge in organizations", Communications of the ACM, vol. 31, no 7, 1988.
[17] F. Ulrich, "Knowledge management systems: essential requirements and generic design patterns", in Proceedings of the International Symposium on Information Systems and Engineering, ISE'2001, Las Vegas: CSREA Press 2001, pp. 114-121E
[18] E.Y. Li and H. Lai, "Collaborative work and knowledge management in electronic business", *Decision Support Systems*, vol. 39, No 4, pp. 545-547, 2005.
[19] E.F. Harrison and M.A. Pelletier, "The essence of management decision", *Management Decision*, vol. 38, pp. 462-469, 2000.
[20] N. Karacapilidis, E. Adamides and C.E. Evangelou, "A computerized knowledge management system for the manufacturing strategy process", *Computers in Industry*, vol. 57, no 2, pp. 178-188, 2006.
[21] C.E. Evangelou and N. Karacapilidis, "Knowledge-based strategy development: an integrated approach", in Proceedings of the I-KNOW'05, Conference, Graz, Austria, ,pp. 4-11, 2005.
[22] P. Kirschner, S. Buckingham Shum and C. Carr, "Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-Making", Springer-Verlag, London, UK, 2003.
[23] A.D. Jr. Chandler, "Strategy and structure: concepts in the history of the industrial enterprise", MIT Press, Casender, MA, 1962.
[24] M.E. Porter, "Competitive strategy", The Free Press, New York, 1980.
[25] B. Wernerfelt, "A resource-based view of the firm", *Strategic Management Journal*, vol. 5, pp. 171-180, 1984.
[26] M.E. Porter, "How competitive forces shape strategy", *Harvard Business Review*, vol. 57, pp. 86-93, 1979.
[27] T.L. Saaty "The Analytic Hierarchy Process" McGraw-Hill, New York, 1980.
[28] W. Edwards, "SMARTS and SMARTER: Improved simple methods for multi-attribute utility measurement", *Organizational Behaviour and Human Decision Processes*, vol. 60, pp. 306-325, 1994
[29] B. Roy, "the outranking approach and the foundations of ELECTRE methods", *Theory and Decision*, vol. 31, pp. 49-73, 1991.
[30] C. Zopounidis and M. Doumpos, "Multicriteria classification and sorting methods: A literature review", *European Journal of Operational Research*, vol. 138, pp. 229-246, 2002.
[31] Gorry, G.A. and Scott Morton, M.S. "A framework for management information systems", *Sloan Management Review*, vol. 13, pp. 55-70, 1971.
[32] T.R. Gruber, "A translation approach to portable ontology specifications", *Knowledge Acquisition*, vol. 5, no 2, pp.199–220, 1993.
[33] C.E. Evangelou, N. Karacapilidis and O. Abou Khaled, "interweaving knowledge management, argumentation and decision making in a collaborative setting: the KAD ontology model", *International Journal of Knowledge and Learning*, vol. 1, pp. 130-145, 2005.
[34] P. Widener, G. Eisenhauer and K. Schwan, "Open metadata formats: efficient XML-based communication for high performance computing", in Proceedings of the 10th IEEE International Symposium on High Performance Distributed Computing, pp. 371–380, 2001.
[35] J.H. Boose, "A survey of knowledge acquisition techniques and tools", *Knowledge Acquisition*, vol. 1, pp.3-37, 1989.

[36] E.S. Cordingley, "Knowledge elicitation techniques for knowledge-based systems", in D. Diaper (Ed.), Knowledge Elicitation: Principles, *Techniques and Applications*, John Wiley & Sons, NY, 1989.
[37] J. Liebowitz and I. Megbolugbe, "A set of frameworks to aid the project manager in conceptualizing and implementing knowledge management initiatives". *International Journal of Project Management*, vol. 21, pp. 189–198, 2003.

Christina E. Evangelou was born in Kastoria, Greece in 1977. She received her Diploma from the Mechanical Engineering and Aeronautics Department, Patras University, Greece in 2001, and since 2005 she holds PhD from the same Department. Her thesis work builds around the integration of collaborative decision making and knowledge management in contemporary organizations.

She is currently a post-doctoral research collaborator in the E-Learning Sector of the Research Academic Computer Technology Institute, Patras, Greece. Her research work focuses on collaborative and computer mediated decision support systems, knowledge management, multicriteria decision aid, ontologies and XML technologies.

Nikos Karacapilidis, born in 1967 made his undergraduate and graduate studies at the University of Patras (B.Sc. in Computer Engineering, 1989, and Ph.D. in Engineering, 1993).

He holds an Associate Professor position at the Industrial Management and Information Systems Lab, Department of Mechanical Engineering and Aeronautics, University of Patras, Greece since 2000. His current research interests are on the areas of intelligent information systems, decision making, knowledge management, e-collaboration and semantic web.

Information about his professional activities and publication list can be found at: http://www.mech.upatras.gr/_nikos/.

Manolis Tzagarakis was born in 1971. He received his Diploma from the Dept. of Computer Engineering and Informatics University of Patras, Greece in 1995, and since 2003 he holds a PhD from the same Department. His thesis work builds around hypertext and hypermedia.

He is currently working in the E-Learning Sector of the Research Academic Computer Technology Institute, Patras, Greece. His research work interests include hypertext/hypermedia, structural computing, WWW technologies, knowledge management, software engineering and digital libraries.