A Web-based System for Supporting Structured Collaboration in the Public Sector

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Abstract. The development of effective public policies and programs concerning the big problems of modern societies is an increasingly complex task. The social problems today are multidimensional and their solution requires close collaboration among various Public Organizations from many regions or even countries. Each individual organization involved possesses pieces of information, experience, knowledge and competence about the problem. Their values, interests and expectations are often different, or even conflicting, and have to be taken into account. Similar hold for the 'high level functions' of the Public Administration, such as decision making towards the development of legislation. This paper presents a web-based system that supports collaborative activities in the above setting. Through a well-structured discourse graph, the system facilitates the wide participation and collaboration of the Public Organizations involved in the solution of social problem and provides a series of knowledge management and argumentative decision making features. The use of the system is described through a detailed example concerning a debate about state vs. non-state universities, which has recently started in Greece.

Keywords: e-Government, G2G, collaborative activities, IS framework, decision making, argumentation, knowledge management.

1 Introduction

Information and Communication Technologies (ICTs) have a huge potential for supporting and transforming the full range of contemporary Public Administration activities concerning the design, production and delivery of public services [4, 5, 9]. However, e-Government today is mainly focused on e-transactions, i.e. on offering citizens and enterprises the capability to perform electronically their transactions with the Public Administration (e.g., declarations, applications, etc.). The ICT-enabled innovation in this area is limited, mainly to the development of 'virtual public agencies' or 'one-stop e-Government', i.e. of single access points to many related electronic trans-

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actions and services, which are usually required in a particular life event or by a particular target group (of citizens or enterprises) and offered (or managed) by several different Public Organizations [9, 10, 17].

It is therefore necessary to exploit to a much larger extent the huge innovation potential of ICTs and enrich the concept of e-Government [10, 11, 12]. In particular, e-Government should be directed not only to e-transactions, but also to more critical 'high level functions' of Public Administration, such as: (i) the design, implementation, monitoring and evaluation of public policies, programs and services, (ii) the development of legislation, and (iii) the high level decision-making concerning difficult and complex social problems, granting licenses and permissions with high social impact, etc. These high level functions are of critical importance for the Public Administration and the society; at the same time, they are highly difficult and complex since they usually require close collaboration among many Public Organizations (POs), and very often the participation of citizens, enterprises and their associations as well.

In particular, the development of effective public policies, programs and services concerning the big and complex problems of modern societies is becoming more and more difficult. The social problems today are multidimensional and cross many regions or states. Also, the continuously growing international economic cooperation and interdependence gives rise to new complex problems of international nature. The forthcoming enlargement of the European Union with new member states will give rise to many complex international problems and issues. It is widely argued that the development of effective public policies and programs for such big and complex problems requires close collaboration among many POs from many regions or even countries (e.g. central governments, regions, prefectures, municipalities, local development organizations, employment organizations, social security organizations, education organizations, environment organizations, etc.). Each of these POs possesses small - but valuable - pieces of information, experience, knowledge and competence about the problem. In addition, there often exist differences among their values, interests and expectations. It is thus necessary to properly handle all these diverse but valuable pieces of information, experience, knowledge and competence, as well as their different values, interests and expectations. Effective and efficient collaboration may be a remedy to this problem. However, geographical distance and time/budget limitations do not allow this collaboration to be close enough, resulting in the design of suboptimal and ineffective public policies and programs, which are developed without the required wide participation of all competent and knowledgeable parties.

Similar hold for the development of legislation, for the decision making concerning difficult and complex social problems, and also for granting licenses and permissions with high social impact; a high level of participation and collaboration is required, but very often this cannot be achieved due to distance, time and budget limitations. Therefore, it is of critical importance to exploit the capabilities of modern ICTs for supporting and facilitating the required wide participation, argumentative discourse, interaction, synthesis and, in general, collaboration required for the abovementioned high level functions of Public Administration.

At the same time, one of the most important advantages of any organization in today's political, economic, social and technological environment is its ability to leverage and utilize its knowledge [14]. Such knowledge resides in an evolving set of assets including the employees, the structure, the culture and the processes of the organization. Of these, employee knowledge, and particularly tacit knowledge is identified as the dominant one, which is decisive at all mental levels and has to be fully exploited [13]. Such an exploitation refers to the transformation of tacit knowledge to codified information, which is considered as a core process for economic activity and development [1]. For the above reasons, we argue that it is necessary to adopt a knowledge-based decision-making view in the development of technologies for supporting collaboration [6]. According to this view, decisions should be considered as pieces of descriptive or procedural knowledge referring to an action commitment. In such a way, the decision making process is able to produce new knowledge, such as evidence justifying or challenging an alternative or practices to be followed or avoided after the evaluation of a decision, thus providing a refined understanding of the problem

This paper presents a web-based system that supports the structured collaboration required in the Public Sector and meets all the above requirements. Our approach allows for distributed and asynchronous collaboration and aims at aiding the involved POs by providing a series of argumentation, decision making and knowledge management features. The remainder of the article is structured as follows: Section 2 introduces the proposed e-Collaboration framework and discusses related work. Section 3 presents the features of the system and validates its use through an example concerning a discussion (electronic argumentation) about the type of universities (i.e., 'state' vs. 'non-state', 'non-profit' vs. 'profit-making') that should be allowed in the near future in Greece. Section 4 focuses on technical issues concerning the system's scoring and reasoning mechanisms. Finally, Section 5 concludes the paper by discussing the usability and applicability of the proposed system.

2 An e-Collaboration framework

The representation and facilitation of argumentative discourses in diverse collaborative settings have been the subject of interest for quite a long time. Many interesting systems have been developed so far, based on alternative models of argumentation structuring. Generally speaking, such systems aim at structuring group decision-making processes and helping group members in reaching a shared understanding of the issue by supporting knowledge elicitation, knowledge sharing and knowledge construction. Moreover, they exploit intranet or internet technologies to connect decision-makers in a way that encourages dialogue and stimulate the exchange of tacit knowledge. Representative systems falling in this category are Questmap [2], QOC [16], Sibyl [8], Zeno [3], Hermes [7] and Compendium [15].

The e-Collaboration framework proposed in this paper extends the one conceived in the Hermes system by providing additional knowledge management and decision-making features (see Figure 1). 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, we have developed a web-based system that provides POs engaged in such a discourse with the appropriate means to collaborate towards the solution of the underlying issues. In addition to providing a platform for group reflection and capturing of organizational memory, our approach augments teamwork in terms of knowledge elicitation, sharing and construction, thus enhancing the quality of the overall process. This is due to its structured language for conversation and its mechanism for evaluation of alternatives. Taking into account the input provided by the individual POs, the system constructs an illustrative discourse-based knowledge graph that is composed of the ideas expressed so far, as well as their supporting documents. Moreover, through the integrated decision support mechanisms, discussants are continuously informed about the status of each discourse item asserted so far and reflect further on them according to their beliefs and interests on the outcome of the discussion. In addition, our framework aids group sense-making and mutual understanding through the collaborative identification and evaluation of diverse opinions.

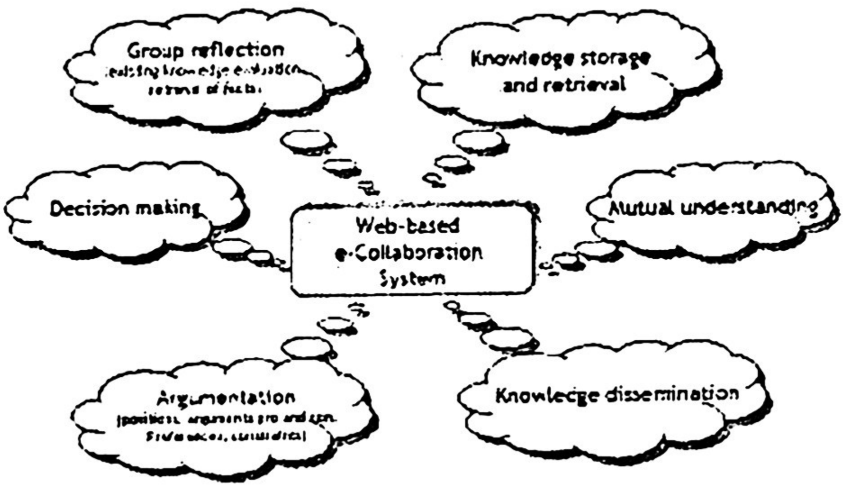

Fig. 1. Activities supported in our e-Collaboration framework.

Our web-based system provides a shared workspace for storing and retrieving the messages and documents of the participants, using a widely accepted document format (i.e. XML). The system's knowledge base maintains all these items, 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 the Public Sector community.

The basic discourse elements in our system are *issues*, *alternatives*, *positions*, and *preferences*. More specifically, issues correspond to problems to be solved, decisions to be made, or goals to be achieved. They are brought up by users representing a PO 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 favor 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 to the assignment of various levels of importance to the alternatives in hand. Like the other discourse elements, they are subject to further argumentative discussion.

3 An example case of use

This section presents the features and functionalities of the proposed system through an illustrative example. An intensive debate has recently started in Greece concerning the establishment (or not) of 'non-state universities'. So far in Greece, all universities are 'state' ones, which have been established and are being supervised by the Ministry of National Education. Also, according to the Greek Constitutional Law, the higher education should be provided only by the State, and not by any private-sector enterprises. In order to change the current situation, it has been recently proposed that initially new 'state universities' should be established, not by the Ministry of Education, but by other Public Sector Organizations, such as the big Municipalities, the Chamber of Commerce, the Church, etc. It has been also proposed that the Constitutional Law should be amended, so that it will allow higher education to be provided by private-sector enterprises as well. After such an amendment, new 'non-state universities', either 'non-profit' or even 'profit-making' ones, could be established.

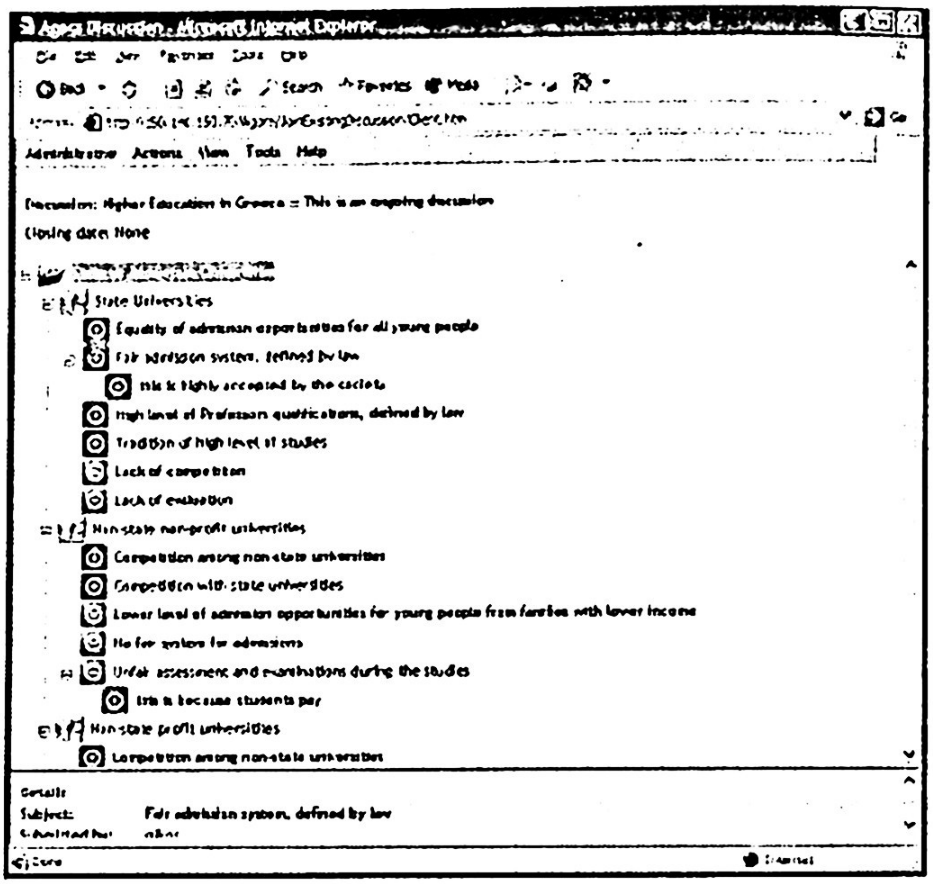

Fig. 2. An instance of the discourse-based knowledge graph.

In the instance depicted in Figure 2, six users (i.e., representatives from the Ministry of National Education and Religious Affairs, two state universities, the National Pedagogical Institute, and two secondary education schools) have been participating so far in the related discourse. Each of them possesses some information, experience and knowledge about the problem. As shown, our approach maps the overall collaborative process to a discourse-based knowledge graph with a hierarchical structure. Each entry in the graph corresponds to an argumentation element. Each such 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 (alternative forms in the appearance of each entry can be obtained through options provided under the *View* menu). The lower pane of the window provides more details about a selected entry of the discussion graph (users can select an entry by clicking on it).

In our case, the overall issue under discussion is "State vs. Non-state Universities", while three alternatives (namely "State Universities", "Non-state non-profit universities" and "Non-state profit universities") have been asserted so far. The users may argue about them by expressing positions speaking in favor or against them. For instance, "Equality of admission opportunities for all young people" is a position that argues in favor of the first alternative, while "Lower level of admission opportunities for young people from families with lower income" is a position that argues against the second one. All graph entries are subject to additional (multi-level) argumentation. For instance, "this is highly accepted by the society" has been asserted by a user to further validate the "Fair admission system, defined by law" position.

As noted in the previous section, users may also assert preferences about the already expressed positions. In the instance shown in Figure 3 (compared to the instance shown in Figure 2, all items asserted so far under the second and third alternatives are now folded), a user has expressed his opinion about the relative importance between the level of professors' qualifications (see position "High level of Professors qualifications, defined by law") and the equal opportunities in admission to universities (see position "Equality of admission opportunities for all young people") through the preference "High level of Professors qualifications, defined by law *is more important than* Equality of admission opportunities for all young people". Figure 3 also 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 argumentation element, its submission date, any comments that the user may had inserted, as well as links to related web pages and documents that the user may have uploaded to the system in order to justify 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 appropriate labeling for each entry of the discussion graph, the aim being to keep users aware of the discourse status. More specifically, alternatives, positions and preferences of a graph have an *activation label* indicating their current status. 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 (more technical details are discussed in the next section). At each discussion instance, the system informs users about what is the most prominent (according to the underlying argumentation) alternative solution. In the instances shown in Figures 2 and 3, "State Universities" is the better justified solution (it is shown in bold characters). 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.

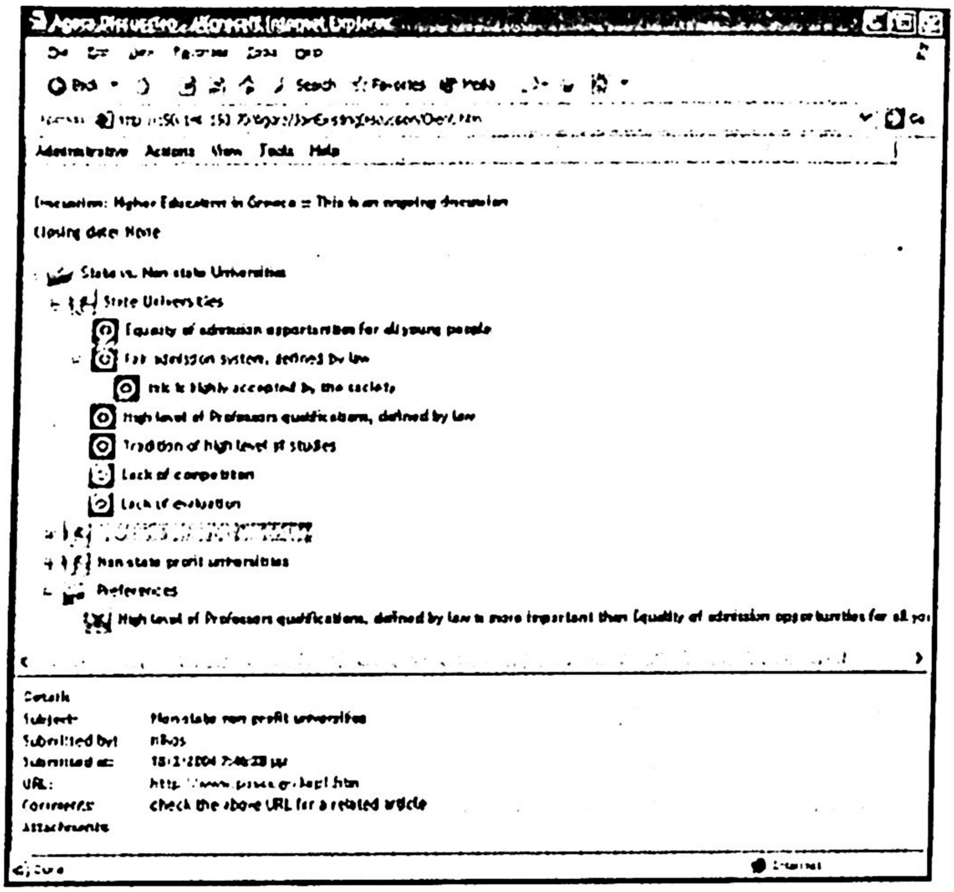

Fig. 3. A second graph instance.

The system also integrates e-mailing and electronic messaging features (options provided under the *Tools* menu) to further facilitate the 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 (these are deployed upon the user's selection under the *Actions* menu).

4 Scoring and reasoning mechanisms

This section describes the reasoning mechanisms integrated in the system. Without resorting to formal approaches (such as qualitative probabilistic knowledge and logic of argumentation), such mechanisms determine the appropriate labeling for each entry of the discussion graph, the aim being to keep users aware of the discourse status.

4.1 Proof Standards

As noted in the previous section, alternatives, positions and preferences have an activation label indicating their current status (they can be *active* or *inactive*). Generally speaking, different elements of the argumentation, even in the same debate, do not necessarily need the same type of evidence. Quoting the well-used legal domain example, the arguments required to indict someone need not be as convincing as those needed to convict him. Therefore, a generic argumentation system requires different proof standards (work on AI and Law uses the term *burdens of proof*). In the sequel, we describe the ones implemented in our system (see also [7]). In any case, we do not claim that the list of proof standards provided is exhaustive. However, additional ones (e.g. voting), which better match problem-specific needs, can be easily integrated.

? *Scintilla of Evidence (SoE):* according to this proof standard, a position p_i is active, if at least one active position argues in favor of it: $active(p_i) \Leftrightarrow \exists p_j\ (active(p_j) \wedge in\_favor(p_j, p_i))$.

? *Beyond Reasonable Doubt (BRD):* according to BRD, a position p_i is active if there are not any active positions that speak against it: $active(p_i) \Leftrightarrow \neg \exists p_j\ (active(p_j) \wedge against(p_j, p_i))$.

In the case of the third proof standard, each position has a *weight=(max_weight + min_weight)/2*, while an alternative with no positions linked underneath has a *weight=min_weight*. Both *max_weight* and *min_weight* are initialized to some predefined values, which may be changed upon the assertion of preferences. The score of an argumentation element e_i is used to compute its activation label. If an element does not have any arguments, its score is equal to its weight; otherwise, the score is calculated from the weights of the active positions that refer to it:

$$score(e_i) = \sum_{\substack{in\_favor(p_j, e_i) \wedge \\ active(p_j)}} weight(p_j) - \sum_{\substack{against(p_k, e_i) \wedge \\ active(p_k)}} weight(p_k)$$

? *Preponderance of Evidence (PoE):* According to this standard, a position is active when the active positions that support it outweigh those that speak against it: $active(p_i) \Leftrightarrow score(p_i) \geq 0$. Concerning alternatives, PoE will produce positive activation label for an alternative a_i when there are no alternatives with larger score in the same issue: $active(a_i) \Leftrightarrow \forall a_j\ in\_issue(a_i),\ score(a_j) \leq score(a_i)$.

In the discourse shown in Figures 2 and 3, the proof standard adopted is SoE for positions, while it is PoE for alternatives. Active positions are considered "accepted" due to discussion underneath (e.g., strong supporting arguments, no counter-arguments), while inactive positions are (temporarily) considered as "discarded" or "rejected". Similarly, active alternatives correspond to "recommended" choices, i.e., choices that are the strongest among the alternatives in their issue. Finally, the activation label of preferences is decided by two parameters: the discussion underneath (similarly to what happens with positions) and the activation label of their constituent positions. In Figure 3, the asserted preference has BRD as proof standard; thus, it is active since there is no argument speaking against it (also note that both its constituent positions are active). If during the evolution of the discussion, a new position inactivates one of its constituent positions, this will result in its inactivation (the same will happen if a new position speaks against this preference).

4.2 Detecting conflicts and inconsistencies

Apart from an activation label, each preference has a *consistency label* (it can be *consistent* or *inconsistent*). Every time a new preference is inserted in the discussion graph, the system checks if both constituent positions of the new preference exist in another, previously inserted, preference. If yes, the new preference is considered either redundant, if it also has the same preference relation, or conflicting, otherwise. A redundant preference is ignored, while a conflicting one is grouped together with the previously inserted preference in an issue automatically created by the system, the rationale being to gather together conflicting preferences and stimulate further argumentation on them until only one becomes active. It should be noted here that both constituent positions of a new preference have been already inserted in the discussion graph; thus, whenever a user is about to insert a new preference, the system provides him/her with a list of all possible combinations to select from.

If both positions of the new preference do not exist in a previously inserted preference, its consistency is checked against previous active and consistent preferences referring to the same element (or belonging to the same issue). Consider for instance the case, where there exist two preferences "*p_x is more important than p_y*" and "*p_y is more important than p_z*". A new preference "*p_z is more important than p_x*" would be inconsistent with respect to the first two ones, although it is not directly conflicting with either one. Inconsistency checking is performed through a polynomial ($O(N^3)$, N the number of the associated positions) path consistency algorithm (for more details, see [7]). Although path consistency, as most discourse acts described in the sequel, interacts with the database where the discussion graph is stored, the algorithm is efficient; even for preferences involving issues with numerous alternatives and positions linked to them, execution time is negligible compared to communication delay.

4.3 The weighting mechanism

Active and consistent preferences participate in the weighting mechanism. In order to demonstrate how the algorithm for altering weights works, we use the example of Figure 4. There exist five positions and four preferences that relate them, as illustrated in Figure 4a. The arrowed lines correspond to the "*more important than*" (>) relation (e.g., $p_1 > p_2$) and the dotted line to the "*equally important to*" (=) relation (e.g., $p_3 = p_4$). Initially (with no preferences inserted in the system), each position would have a *weight = (max_weight + min_weight)/2 = 5* (we have assumed that *max_weight=10* and *min_weight=0*). *Topological sort* is applied twice to compute the possible maximum and minimum weights for each position (Figure 4b). The new weight of each position (having taken all preferences into account) is the average of its new *max_weight* and *min_weight*. Thus, it is: $weight(p_1)=6$, $weight(p_2)=4.5$, $weight(p_3)=5$, $weight(p_4)=5$ and $weight(p_5)=4$.

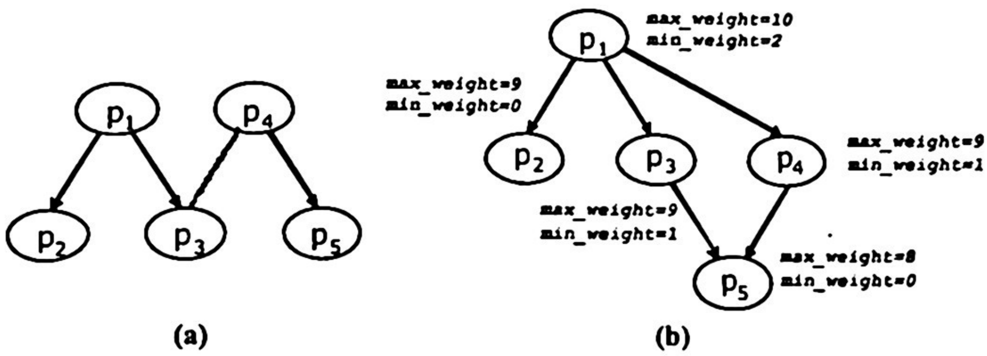

Fig. 4. The weighting mechanism.

The basic idea behind the above mechanism is that the weight of a position is increased every time the position is more important than another one (and decreased when it is less important), the aim being to extract a total order of alternatives. Since only partial information may be given, the choice of the initial maximum and minimum weights may affect the system's recommendation. Furthermore, this weighting scheme is not the only solution; alternative ones, based on different algorithms, can be easily integrated.

4.4 Discourse acts

Argumentation in our framework is performed through a variety of discourse acts. These acts may have different functions and roles in the argumentative discourse. We classify them in two major categories: user acts and system acts.

User acts concern user actions and correspond to functions directly supported by the user interface (these appear under the *Actions* menu – see Figures 2 and 3). Such functions include the opening of an issue, insertion of a new alternative to an issue, insertion of a new position in favor 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 top left part of Figure 5. When an alternative alt_i is added to another alt_j (and not directly to the issue iss_j where alt_j belongs), a new issue iss_i is automatically created inside iss_j. Both alt_i and alt_j are now put inside the new issue and compared through a function *update*(iss_i). *Update*(iss_i) will be called from *update*(iss_j) and the recommended choice between alt_i and alt_j will be compared against the other alternatives of the external (initial) issue. As shown, 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 multimedia documents to their discourse items.

The user interface for adding a new position is shown in the top right part of Figure 5. The father 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 favor* or *against*) and the proof standard they prefer (depending on the discussion context, this option may be inactivated; that is, the same proof standard is used for all positions). The bottom left part of Figure 5 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 editing a position is shown in the bottom right part of Figure 5. Users may there change any of the related information, as well as add new or remove previously inserted attachments.

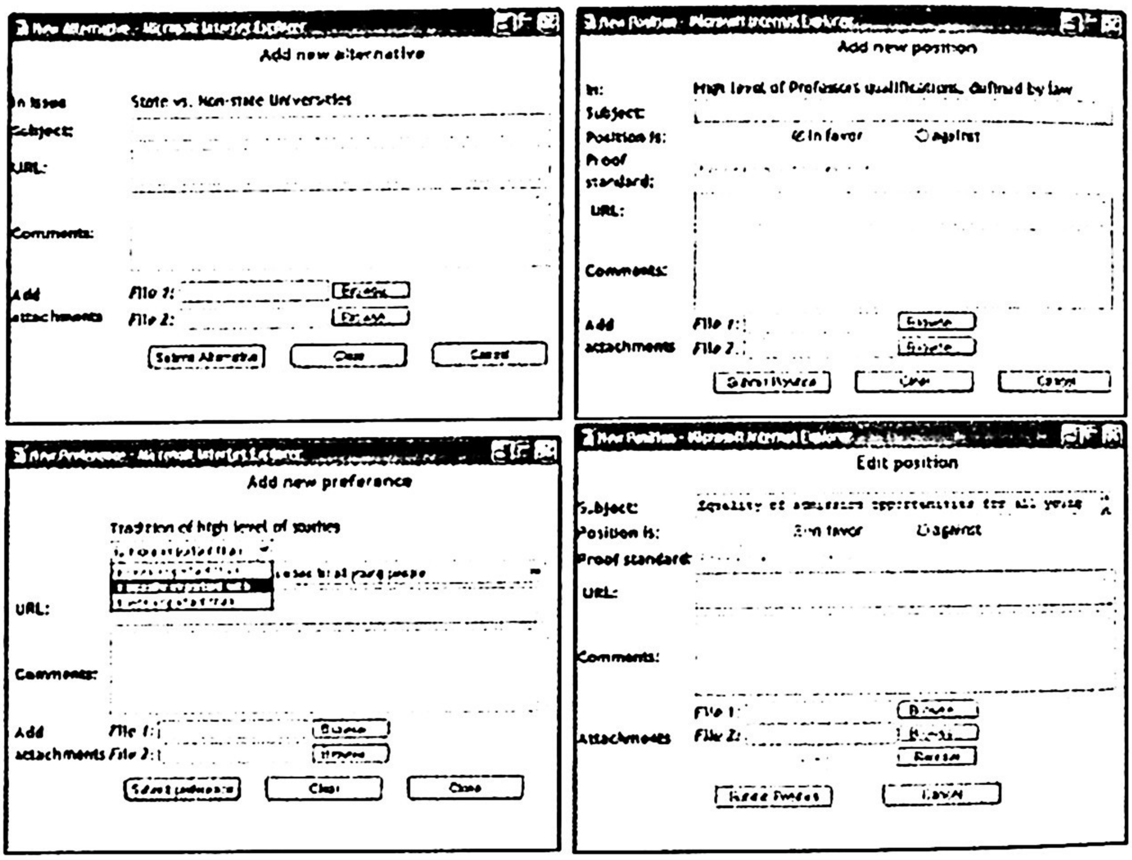

Fig. 5. User interfaces.

System acts are functions performed by the system in order to check consistency, update the discussion status and recommend solutions. These functions are automatically triggered by the user acts (that is, whenever a new item is added in the discourse graph) and are hidden from the end user (for more details, see [7]). Generally speaking, a single assertion in an ongoing discussion may update a large portion of the discourse graph. Every time there is a change, the status of the argumentation elements is recorded in the database that keeps track of the discourse.

5 Conclusions

A preliminary evaluation of the system described in this paper has already been made by the six users who participated in the argumentative discussion illustrated in the previous section. The results of this evaluation are positive and encouraging: the functionalities of the system were found to be complete, correct, user-friendly and well-integrated. These results advocate that the proposed system can offer an effective and user-friendly electronic space for G2G structured multi-participative argumentation on complex Public Sector problems and collaborative knowledge creation. In this sense, it can improve the quality and reduce the cost of the collaborative activities required for the critical 'high level functions' of Public Administration.

In particular, the system can effectively support the collaboration required for the design, implementation, monitoring and evaluation of public policies, programs and services, by first enabling all the involved POs to identify the basic problems and issues, propose alternatives and discover their advantages and disadvantages. A multi-criteria decision making approach can be then followed, in order to select the optimal alternative(s) based on the insight and understanding previously gained. The proposed system can also support the collaborative development of detailed action plans for the selected optimal alternative(s) (i.e. for each proposed action, positive or negative positions as well as preferences can be expressed by the participants, etc.). During the implementation of these actions, the proposed system can be used for the collaborative monitoring of them, the identification of implementation problems and issues, and the development of alternatives for managing them. Finally, the system can be used for the collaborative evaluation of these actions by all the involved POs, and the citizens and enterprises who are their recipients. In a similar way, it can support the collaborative development of legislation and the 'high level' decision-making concerning complex social problems, granting licenses and permissions with high social impact, etc.

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