A framework to report and to analyse a debate

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Abstract

The paper introduces a framework whereby arguments put forward in a discussion concerning a specific decision can be graphically represented as a directed graph and analysed according to different decision procedures. The intended benefits of the proposed framework are to support a decision manager in the light of the experts' arguments and to record the motivations for the decisions in a corporate memory.

1. Introduction

In an organization, such as a company, decision making is often supported by input from a collective of experts who exchange views on the matter at hand during meetings held under the authority of a manager. During these meetings, experts exchange arguments to reach a solution, to come to a final choice. These meetings may occur face-to-face or virtually with collaborative tools, during a few days or over a long period of time. In such a case the manager is responsible for taking the final decision. But, as the manager is not necessarily an expert, he needs to be helped in order to analyse and understand the final decision of the group. We propose to provide him with a framework that captures the arguments of the experts during the debate as well as the relationships between the arguments. By using this framework, the manager could analyse the arguments that led to the decision. He could then check if the arguments are evidence-based, if the decision is sufficiently well supported by the arguments, and if some of the expert's opinion had changed their during the debate, etc.

It should be noted that having a framework to keep a record of meetings can be very interesting for the constitution of a corporate memory. As highlighted by Kalawsky [Kal09] in the research grand challenge "Through life information and knowledge management", during the project's lifetime, there is a danger that explanation of decisions are forgotten. The experts are likely to have moved to another job or even to have retired. This is why a framework to report meetings should record evidence given by the experts to motivate their choices. Furthermore, very often, when a project is over, no one remembers why certain choices have been made, mainly because people have left or have forgotten and because the reasons for decisions have not been recorded. In this case, the same discussions may be organized again and valuable time may be lost. Keeping records of the arguments would avoid having the same discussion all over again, with the same arguments. In addition, recording the debate would allow the discussions to be resumed and experts could introduce new arguments if they feel the need of.

Consider this example: a discussion has been organized between five experts on the selection of the right numerical model to simulate the noise generated by a jet engine in the airplane cabin. The conclusion was that *noise should be modelled as a non-uniform flow using the Euler equations*. During the debate:

- expert 1 gave several examples in which noise has been modelled as a non-uniform flow using Euler equations, and argued that this was a good choice in each case;
- expert 4 agreed with expert 1;

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- expert 2 gave academic references on the Euler equations applied to this kind of problem;
- expert 5 was not convinced by the references;
- expert 3 replied to 1 and 2 that the problem was not confined only to the noise generated inside the cabin, but also to the jet noise outside since both are heard inside the cabin, he gave scientific results;
- based on scientific results, expert 2 argued that using a non-uniform flow model is a good representation of the noise both inside and outside the cabin;
- in agreement with the expert 2, the expert 5 reports a former project of the company where this approach has been used;
- expert 4 replied that, for this project (business reason), modelling non uniform flow was too time consuming.

A discussion report like the previous one is difficult to understand and not recoverable as part of the evolution of a project. The ins and outs are not necessarily clear. And here, we have a very simple example with only a few arguments and a few links between them.

This paper aims at defining a framework as formal as possible in order to provide well-founded analyses of a debate. It is organized as follows. Section 2 lists the main concepts appearing in a debate and presents a brief state of the art of argumentation formal models. The model we propose is presented in Section 3. The analysis that can be performed on this model are presented in section 4. Section 5 focuses on graphical representations of argumentations and describes our prototype. Finally, section 6 is devoted to a discussion.

2. Report a debate: a simple argumentation?

2.1. The concepts we need

Firstly, the debate ends because a decision is taken by the group of experts. We call it the *conclusion*. In the example given in section I, the conclusion is: "noise should be modelled as a non-uniform flow using the Euler equations".

Secondly, *arguments* have been exchanged between experts. More precisely, at each stage of the discussion, an *agent* (who is one of the experts) utters an *assertion* and sometimes provides *evidence* to support it.

The scientific community who studies the notion of arguments and dialogue is the community of argumentation theory. If we refer at the work of Toulmin[Tou03], he defines the notion of *claim*, a "conclusion whose merits we are seeking to establish". This definition is close to our *assertion*. In the same idea, what we call evidence corresponds to notion of data and backing. Furthermore, the notion of *evidence* corresponds to Toulmin's notion of *data* and *backing*. Indeed, for Toulmin, *data* are "the facts we appeal to as a foundation for the claim" and *backing* is a kind of justification like a law or a statistical result. References to scientific articles, business practices, examples, physical contingencies are evidence as well. In the example, expert 2 provides bibliographic references as evidence for his assertion.

Another point is the relation between arguments. Argumentation theory studies in detail the notions of *corroborate* and *attack*. To be simple, and a little bit naïve, in a discussion, any argument *corroborates* or *attacks* one or several previously presented arguments. For instance, when expert 4 says that he agrees with expert 1, he corroborates expert 1's view, but then expert 1's view is attacked by expert 3's assertion.

Of course, to define all relations between arguments with these two relations is restrictive, but our aim is to define a framework as simple as possible. An argumentation structuring technique like [KR70] propose a more complex model with more arguments objects and relations. In [PSG11], the authors add the relation *specifies*. An argument specifies another when it gives precision or when it answers an open point. They need this relation just to capture the debate, but it disappears in the debate report.

Finally, a key point is that, in a debate there are several *agents* that shows that we are clearly in the context of dialogical argumentation.

It should be noted that here all the arguments are relevant to the discussion since they corroborate or attack a previous argument. However, in general, an expert could assert something that is not related to the debate. This will be excluded in this present work.

2.2. Argumentation: a brief state of the art

Many formal models of argumentation have been defined, mainly in Artificial Intelligence field.

In some approaches, logic is used to model the notion of argument. More specifically, the notion of argument is defined from the notion of logical implication. Besnard and Hunter [BH01] consider a given set of formulas Δ and define an argument as a pair of formulas in Δ, $\langle A, B\rangle$ such that the support , A, is a non contradictory formula which logically implies the conclusion B, and this, in a minimal way. An argument undercuts another one when conclusion of the first one contradicts the support of the other. The main notion is the notion of argument tree. An argument tree describes the various ways an argument can be challenged, as well as how the counter-arguments to the initial argument can themselves be challenged, and so on recursively. This work has been extended in several ways. Hunter [Hun04a][Hun04b] introduces the notion of "resonance" of arguments which depends on a given audience.

Some other formal approaches to argumentation are based on Dung's work [Dun95] Dung's argumentation framework defines an argument system as a pair $\langle A, R\rangle$ in which A is a finite set of arguments and $R \in A \times A$ is the attack relationship between arguments. Dung gives several formal semantics to an argument system so that an argument x in A can be accepted. Dung's work has been the basis of many researches. For instance, [CLS05] Cayrol and Lagasquié-Chiex introduce "graduality" in the selection of the best arguments. In [BCDD07], Bench-Capon et al. propose the notion of "value-based argumentation system" by adding values to arguments in an argument system in order to take into account the public to whom the argumentation is addressed.

Recently, [ADDSC08], Amgoud and Dupin de Saint Cyr aim at studying the quality of a dialog. In this work, arguments are composed by a support and a conclusion and are linked, like in Dung's formalism, by an attack relation. A dialog is a sequence of "moves", a move being defined by the agent that utters the move, the set of agents to which the move is addressed and the argument which is uttered. In a dialog, arguments are weighted. From these, the authors analyse the quality of the exchanged arguments during a dialog, the agent's behaviour and the properties of the dialog itself.

This last work is particularly interesting because it is based more or less on the same assumptions than our own work: it considers a dialog between agents which utter arguments. However, it does not consider the corroborative relation we need.

3. A formal framework to report a debate

This section presents the formal framework we define in order to report a debate.

3.1. Debate structure

We consider a language L (for instance the natural language) the sentences of which are called propositions and are used to model arguments. We also consider a set A of agents used to model the experts.

An argument is defined as triple in which the first item is an expert assertion represented by a proposition, the second item is an agent (the one who came up with the argument), and the third item is a list of the evidence given by the agent to support the assertion.

Definition 1 (Argument)
An argument as a triplet $\langle \Psi, a, e\rangle$ where

- Ψ *is a proposition ;*
- $a \in A$ *is an agent ;*

- *e is set of proposition, possibly empty (denoted ∅).*

Example 1 *In our introduction example, an argument could be ⟨ "modelling uniform flow was too time consuming", Expert1, {business reason} ⟩.*

A conclusion is a particular argument defined as follows:

Definition 2 (Conclusion)
A conclusion is an argument $\langle \Psi, A, \emptyset \rangle$

Example 2 *The conclusion of our debate is ⟨ "noise should be modelled as a non-uniform flow using the Euler equations", {Expert1, ... Expert5}, ∅⟩.*

As seen previously, we consider that in the debate, arguments are linked by two types of binary relations. The relation is a corroborating relation when an argument is given to reinforce another one. The relation is an attacking relation when an argument is given to attack another argument.

A debate is modelled by the notion of argumentation defined as follows.

Definition 3 (Argumentation)
An argumentation is a connected directed acyclic graph[1]
$Arg = (V, E)$ *with:*

- *vertex in V are arguments ;*
- *there is one and only one sink*[2] *which is a conclusion ;*
- *each edge in E between* $v1$ *and* $v2$ *is labelled with* $+$ *if* $v1$ *corroborates* $v2$*;*
- *each edge in E between* $v1$ *and* $v2$ *is labelled with* $-$ *if* $v1$ *attacks* $v2$*;*
- *Two vertices are connected by at most one edge.*

We define two relations between arguments, $\xrightarrow{+}$ and $\xrightarrow{-}$. These two relations aim to represent a corroborating and an attacking relation.

Definition 4
Consider an argumentation $Arg = (V, E)$. *Let* $v1 \in V$ *and* $v2 \in V$.

- $v1 \xrightarrow{+} v2$ *iff the edge between* $v1$ *and* $v2$ *is labelled* $+$.
- $v1 \xrightarrow{-} v2$ *iff the edge between* $v1$ *and* $v2$ *is labelled* $-$.

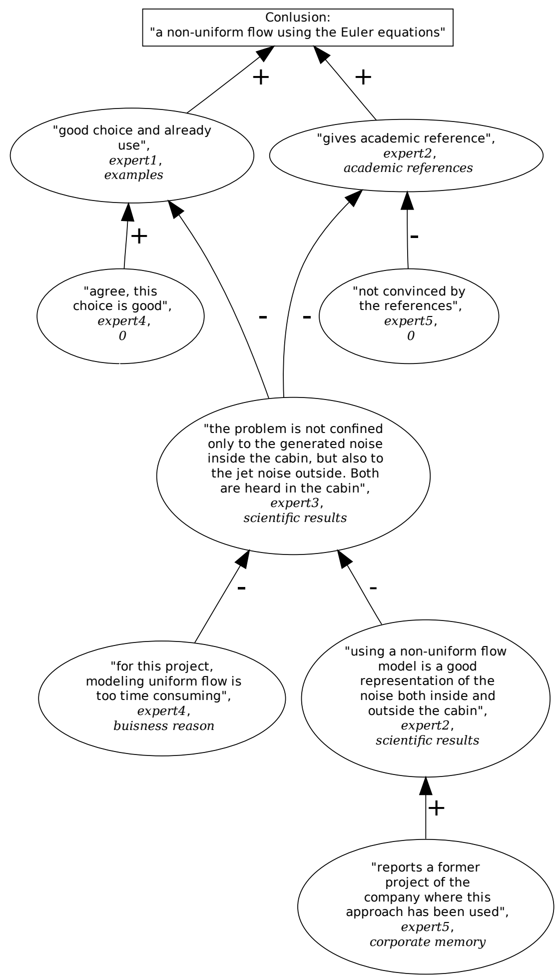

Figure 1: *Argumentation structure example*

Figure3 is the graphical representation of the argumentation corresponding to our example.

[1] A *DAG* (directed acyclic graph) is a graph $G = (V, E)$ where V is a set of vertices, or nodes, and E set of directed edges, each edge connecting one vertex to another, such that there is no cycle.

[2] A *sink* is a particular node with only incoming edges.

Note that the graph is connected. There is no vertex without any connection (edge) with another vertex. If it did, it would mean that an agent said something completely unrelated to anything that was said during the debate, in other words we would have an argument irrelevant. In this work, by hypothesis, we consider that all arguments are relevant to the debate.

3.2. Properties of relations between arguments

We would like however to consider as valid some deductions like: if argument a corroborates argument b and if b corroborates argument c, then is a corroborating c. Or, if argument a attacks argument b and if b attacks argument c, then is a corroborating c. This notion is what Dung[Dun95] called *acceptability*. We capture it in a naive way. Of course, having three arguments defending the conclusion is not the same as having one argument defending the conclusion and other two arguments corroborating it. However, our aim is to support the debate report in a way as simple as possible that is why we handle this two situations in the same way.

In some cases, our deduction rules may lead to problems. It would be possible that an edge is labelled both $+$ and $-$. Consider the three arguments a, b, and c. b attacks a and c attacks both a and b (see fig.2). The problem is, with the deduction rules, c attacks a but also supports a. Besnard et al.[BH08] name an argument like c a controversial argument. In our framework, we define controversial as follow:

Definition 5 (Controversial argument)
v is a controversial argument if there exists two arguments $v1$ and $v2$ such that one of the following is true:

- $v1 \xrightarrow{-} v2$ *and* $v \xrightarrow{-} v1$ *and* $v \xrightarrow{-} v2$
- $v1 \xrightarrow{+} v2$ *and* $v \xrightarrow{-} v1$ *and* $v \xrightarrow{+} v2$
- $v1 \xrightarrow{-} v2$ *and* $v \xrightarrow{+} v1$ *and* $v \xrightarrow{+} v2$
- $v1 \xrightarrow{+} v2$ *and* $v \xrightarrow{+} v1$ *and* $v \xrightarrow{-} v2$

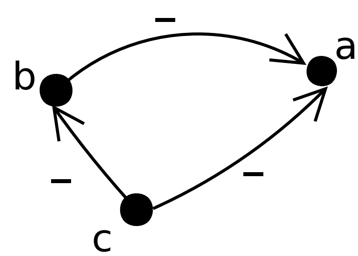

Figure 2: *Controversial example*

To better understand what is a controversial argument [BH08] gives this example:

(a) Allyson: She locked the door on purpose because she hates me.

(b) Beverly: She likes you; she volunteered to help you move in.

(c) Christin: She didn't volunteer; she had to because of Dad, who also told her to lock the door.

First of all, it seems possible to split it in two arguments:

(c1) Christin: She didn't volunteer; she had to because of Dad

(c2) Christin: Dad told her to lock the door.

Now, $c1$ and $c2$ are not controversial. $c1$ attacks b and $c2$ attacks a. Secondly, as Besnard et al. say "It is not trivial to demonstrate that controversial arguments make sense." In the context of this article, agents can be considered as collaborative and it seems acceptable to assume that there is no controversial argument. With this hypothesis, we can show that deduction rules do not introduce inconsistencies.

Definition 6 (Deductions)
Consider an argumentation. Let $v1$, $v2$ and $v3$ three arguments

- *If* $v1 \xrightarrow{+} v2$ *and* $v2 \xrightarrow{+} v3$ *then* $v1 \xrightarrow{+} v3$
- *If* $v1 \xrightarrow{+} v2$ *and* $v2 \xrightarrow{-} v3$ *then* $v1 \xrightarrow{-} v3$
- *If* $v1 \xrightarrow{-} v2$ *and* $v2 \xrightarrow{+} v3$ *then* $v1 \xrightarrow{-} v3$
- *If* $v1 \xrightarrow{-} v2$ *and* $v2 \xrightarrow{-} v3$ *then* $v1 \xrightarrow{+} v3$

Proposition 1
If there is no controversial argument in the argumentation, then there exists no two arguments $v1$ *and* $v2$ *such that* $v1 \overset{+}{\to} v2$ *and* $v1 \overset{-}{\to} v2$.

Finally, we define two relations *pro* and *con* by:

Definition 7 (pro and con)
Consider an argumentation. Let us denote $v0$ *its conclusion. Let* v *be an argument.* $pro(v)$ *iff* $v \overset{+}{\to} v0$ *and* $cons(v)$ *iff* $v \overset{-}{\to} v0$

If there is no controversial argument, any argument in the argumentation is related by $\overset{+}{\to}$ or by $\overset{-}{\to}$ with the conclusion. This means that there are two types of arguments; arguments that are pros the conclusion and arguments that are cons. This result is not surprising. Indeed, in our context, any agent utters arguments accordingly to her position in regard to the conclusion. He does not utter arguments without a goal, but, in fine, for validating or invalidating the conclusion. Therefore, any argument has an attitude that can be classified as either for or opposite to the conclusion.

Proposition 2
Consider an argumentation. For any argument v: $pro(v)$ *is true or* $cons(v)$ *is true but not both.*

4. Argumentation analysis

We propose an automatic analysis of an argumentation in order to understand the underlying debate and its conclusion as well. For that, we define a set of questions that can be automatically answered to understand a group decision. Notice that here, we focus on the dialog properties, not on the expert validity like Godden and Walton [GW06a] do.

In this paper, we focus on the three following questions:

1. Are there weak arguments? (i.e. not supported by evidence)?
2. Are there assertions from the same expert both in favour of the conclusion and against it ?
3. How valid is the conclusion?

4.1. Weak argument

In our example, the expertise of the experts are obviously relevant, otherwise we could assume they were not invited in the debate. But experts they are not infallible. In such debate, there is a risk of *argumentum ad verecundiam* (appeal to authority), which means considering an argument is correct because argument is made by a person that is commonly regarded as authoritative. We therefore propose to identify which of the arguments are not supported by evidence. The aim here is not to refute such argument, but just to identify it in the debate report.

An argument is weak if it is not supported by any evidence. This idea is close to one of the Walton [Wal07] Backup Evidence Critical Questions: "Is expert's assertion based on evidence?", but here this is only a structural test. We do not look the quality or the credibility of the evidence, just if the argument is supported by evidence or not.

Definition 8 (Weakness)
An argument arg is weak if and only if $arg = \langle \Psi, a, \emptyset \rangle$ *where a is an agent.*

Example 3 *For instance, argument* $\langle$*"not convinced by the references"*$, 5, \emptyset\rangle$ *is weak because expert 5's assertion has no evidence to support it.*

4.2. Consistency of expert's assertions

During a debate, an agent could hold two arguments that relate differently to the conclusion. There are two possible explanations for this. First, an agent may attack the conclusion of the debate, but it may disagree with an attacking argument. As a common example, one may disagree with the decisions of a politician, but may attack some arguments against the politician, e.g. because they refer to strictly personal habits. Second, during the debate, an agent was convinced by other agents. In this case, even if he had uttered cons arguments in the beginning, he can utter pro arguments in the end. Note that in order to reach a consensus, a group argumentation framework must accept that agents change their mind during the debate. Otherwise, it would mean that every agent stays on his position and, if experts do not agree that no consensus is possible.

Definition 9 (Assertions consistency) *We define the predicate positionchange so that for an agent a, positionchange(a) iff there are two arguments $arg_1 = \langle \Psi_1, a, e_1 \rangle$ and $arg_2 = \langle \Psi_2, a, e_2 \rangle$ such that $pro(arg_1)$ and $cons(arg_2)$.*

Example 4 *After having heard expert 2, expert 5, who is against to model noise as a uniform flow, gives an argument pro: a former project of the company had already used this method. Expert 5 changed his position in regard with the conclusion.*

4.3. Degree of validity of the conclusion

Here, we would like to offer the manager means that can check if the conclusion of the debate agrees with some decision procedure he had in mind or implicitly accepted by the organization he belongs to.

There are different decision procedures that may be accepted:

- a procedure according to which a conclusion is valid if the number of pros arguments that are not attacked nor supported are greater that the number of cons that are not attacked nor supported;
- a procedure according to which a conclusion is valid if all cons arguments are attacked;
- a procedure according to which a conclusion is valid if in which most cons arguments are attacked;
- etc. . .

Each decision procedure defines what is the valid conclusion and each decision procedure could lead to a question the manager could ask.

We define, for instance, a validity degree of a conclusion as the number of sources[3] against the conclusion over the number of sources. We subtract the result of the operation to 1 to conform to the intuition: the higher the degree validity, the lesser the conclusion it attacks.

Definition 10 (Conclusion degree of validity)

Consider an argumentation, its conclusion degree of validity is defined by:

$$d = 1 - \frac{\mid \{source(v) \wedge cons(v)\} \mid}{\mid \{source(v)\} \mid}$$

Example 5 *The argument corresponding to experts 5's utterance is the only leave which is a cons argument. Thus the validity degree of the conclusion is:* $3/4$.

5. Graphical representation of argumentation: visualisation tools

A visual representation of a debate can improve its understanding. [Twa04] shows how the use of graphical tools helps students to better understand the links between the arguments and the reasoning steps. In the same idea, Verheij, in [Ver03], examines the undeniable contributions that visualization tools could have in legal argumentation field. We can also cite Bob Horn's work [Hor03] on information mapping and how a visual representation clarify a debate. He has proposed, for example, a clear graphical representation which summarizes the positions of 380 philosophers, and computer, cognitive and mathematical scientists on the question “Can computers think?”. He proposes an "Arguments Map" which explains how 700 arguments are related to one another.

Graphical representations of argumentation have been introduced a long time ago. According to Reed et al.[RWM07] the first example of diagrams used to illustrate an argumentation is provided by Richard Watley in his book “Elements of Logic” (1836, pp. 420-430). As an example a figure is given in a page footnote[4] (p. 422) with the following: “Many students

[3] A source is a vertex with no incoming edge. $source(v)$ is true iff the vertex v is a source of the argumentation DAG.

[4] In the version we have, of 1836, the footnote is on page 342.

probably will find it a very clear and convenient mode of exhibiting the logical analysis of a course of argument, to draw it out in the form of a Tree". Whately said here that the diagram aspect is not useful per se for logical demonstrations but helps students to understand them. This is precisely what motivates our approach: giving a representation that helps non-experts, here the students, to understand the outcome of a debate.

In 1917, Wigmore defined a visual representation for structuring hypothesis to evidence in the legal framework as presented in [GF01]. He provided a formalism to represent the various entities that compose a legal argument (e.g. Affirmative Prosecution Evidence probandum...). He presented them as a diagram in which entities were linked by arrows. He defined different links such as an arrow for *Strong Probative Force* or an arrow for *Provisinal Probative Force*. One aim was "to include all the evidential data presentable in a given case." [RWM07] gives more information about the history of argument diagramming.

While the first diagrams were drawn with a pencil, graphical diagramming tools appeared with computers and advances in human computer interfaces. Nowadays, a lot of tools try to represent argumentation. In most of these tools, the argument map is a diagram, with boxes and arrows representing the structure of an argument.

For instance, Carneades[5][GW06b] is software based on a formal mathematical model for argumentation. Carneades provide argument evaluation in respect of various argumentation schemes. In the field of legal argumentation[Ver07] describes a nonmonotonic logic, DefLog, and an associated tool Argumed. The software Araucaria[6][RRK03] was tested in 2004[RR08] by the Magistrate Court of Justice in Ontario, Canada. The results of this study were two-fold. In simple cases with few arguments involved, the software allowed the magistrate to quickly see what critical questions to answer. In complex cases, some judges found the software useful for clarifying all the aspects of the case and links between them. Araucaria support text analysing and supports the user in constructing an argumentation diagram. The diagram is a tree structure and it is possible to translating them in Toulmin diagram or Wigmore diagram. All these tools are designed to evaluate an argumentation based argumentation schemes. If they provide support in the context of understanding an argumentation, they are not really adapted to our problem. Our goal here is not modelize the structure of arguments, as the case in legal argumentation, but reporting a debate. Moreover, none of these software has the notion of agents as we have with the experts.

There are a lot of software for visual representation of the structure of an argument. Tools like Argunet[7], Compedium[8] (a graphical IBIS-type tool [KR70]) or commercial software bCisive[9] provide a visual environment for creating collaboration diagrams such as the map argument. They have a lot of fancy features and they clearly address problems like collaborative work, argumentation report and corporate memory.

Unfortunately, these software are mostly graphic and they do not provide a formal structural analysis. This is why we have developed a prototype of a graphical tool based on our framework.

This tool provides a graphical representation of the debate. Each box represents an argument with the assertion, the name of the agent and a small icon if the assertion is supported by evidence (see fig.3). Our tool can perform analysis of the graph as defined in section 4 and some statistics analysis. In option, it is possible to draw automatically all arguments in the same color or use different colors for pros and cons arguments.

[5]http://carneades.berlios.de
[6]http://araucaria.computing.dundee.ac.uk/doku.php
[7]http://www.argunet.org
[8]http://compendium.open.ac.uk/institute
[9]http://www.bcisiveonline.com

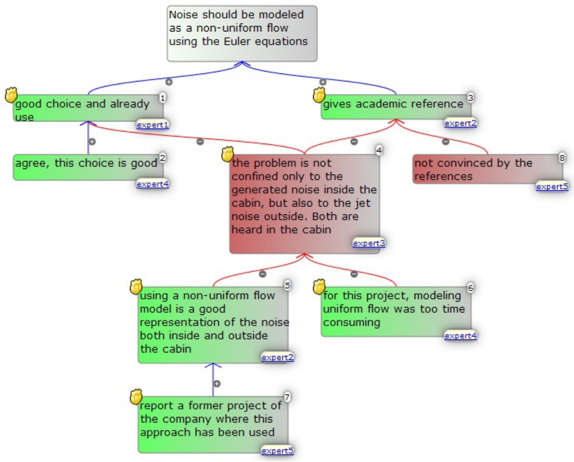

Figure 3: *Snapshot of our prototype*

6. Conclusion and Perspectives

In this paper, we have presented a framework to report and analyse a debate. Several hypotheses have been made and could be relaxed.

First, we have assumed that all arguments are relevant to the debate by attacking or supporting another argument. However, it is frequent that in a debate, agents utter non relevant arguments. Taking non relevant arguments would lead to model the debate as a non connected graph. Analysis presented here could be easily extended to this case and new analysis could also be made. For instance, knowing who utters non relevant arguments or knowing how frequent or in which situation an agent utters a non relevant argument can be informative.

For the moment, our framework does not manage time. Indeed, arguments are not indexed by time so we cannot know in which order the arguments have been given. Knowing this order could help to understand more precisely the debate and the agents attitude as well. This extension is quite obvious: a fourth item, representing the time of the utterance, can be added to arguments. We could then make more analysis of the debate.

We could also add weights to arguments, representing their force in the debate. Any analysis could then be extended to take these weights into account.

We could also consider different analyses. For example, we could perform a measure of aggressiveness as the number of attacks performed by an agent over the number of her utterances.

As for the decision procedure, more work remains to be done. We have seen that there are many procedures, each of them leading to a validity degree of the debate conclusion.

Finally, let us mention an interesting extension, which would consist in using logic as language L. We could then reason on assertions and evidences provided by the agents. For instance, like [GW06a], we could ask if a given assertion is consistent with some others assertions. We could also check if it is subsumed by some others and take benefit of the power of logic.

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