Arguing with Preferences in EcoBioCap

Madalina Croitoru, Jérôme Fortin, Oren Nir

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Madalina CROITORU [a,1], Jerome FORTIN [b], Nir OREN [c]

[a] *University Montpellier 2, France*

[b] *University Montpellier 2, France*

[c] *Dept. of Computing Science, University of Aberdeen*

Abstract. In this paper we present the EcoBioCap project and the modelling needs of this project in terms of argumentation based preference aggregation. The aim of the paper is to well describe the problem encountered in this context and to propose a preference logic in line with the expressivity needed by the application. We then show how to embed this logic within the ASPIC+ system. Finally, we show how argument by expert opinion could be integrated within our framework where preference aggregation needs to take into consideration the different expertise of the project stakeholders.

Keywords. Applications, Argumentation, Preferences, ASPIC+

1. Introduction

A decision support system (DSS) can facilitate and enhance the group decision making process. Such a DSS must typically *aggregate* the preferences of multiple entities in the group in order to recommend a final decision. Argumentation forms a natural way of encoding reasons as to why some action should be taken (or avoided), and several researchers have recently focused on the problem of preference aggregation within an argumentation framework [1,6,7].

While assuming the existence of preferences, the logical semantics of these preferences is typically not fully described, and the modelling choices made are not explained. Since the chosen semantics need to satisfy the requirements of the application at hand, defining such preference logic semantics accordingly is an important task.

In this paper we instantiate an argumentation system designed to aggregate the preferences of multiple parties where preference information is defined in terms of an expert's knowledge on a topic. Our system recognises the need to make distinct the separation between "not preferred to" and "not the case to be preferred to". This difference is necessary given the different stakeholder expertise in the decision support system (and thus something "not preferred to" provides weaker preference information when contrasted with "known not to be preferred to").

Our system is instantiated on top of the popular ASPIC+ model [9]; the use of this model as one of our foundations allows us to ensure that it adheres to several desiderata, including the rationality postulates described in [4]. ASPIC+ provides an abstract model of argument (though far less abstract than the one described in [5]), and allows for

[1] Corresponding Author: E-mail: croitoru@lirmm.fr

different logics to be embedded within it. Part of our work is therefore to describe one such logic. Our contribution in this paper is to introduce a logic of preferences which we use within our argument framework, and describe how arguments and argument related concepts such as attacks can be obtained. We also discuss how to consider different viewpoints elicitation within our framework, and in particular, how the viewpoints of an expert can be represented.

The framework we describe below is aimed at a specific use-case, which has emerged from the EU funded EcoBioCap project. This project's goal is to provide the EU food industry with customisable, eco-efficient, and biodegradable packaging solutions, offering direct benefits to the environment, as well as to consumers in terms of food quality and safety. One aspect of this project requires a strategic analysis of stakeholder requirements to be carried out, allowing the project to identify an initial set of potential packaging materials on which further experiments can be carried out. The stakeholders in this domain includes consumers, manufacturers and food scientists, together with other experts on the properties of different packaging materials. Our aim is to identify candidate packagings that are consistent with each entity's expertise and preferences (as well as their justifications and arguments for these preferences).

This paper is structured as follows. We begin (in Section 2) by describing the EcobioCap project and the practical context of our work. Section 3 then describes the underlying logical language in which preferences are expressed, describing its syntax and semantics. This is followed, in Section 4 by a description of the ASPIC+ framework, and how our logical language can be embedded within it. We discuss the *argument from expert opinion* argument scheme, which is used to capture arguments by experts regarding preferences together with future work in Section 5.

2. The EcoBioCap project

The motivation for this paper comes from the argumentation based decision support system built for the European project EcoBioCap (ECOefficient BIOdegradable Composite Advanced Packaging) [2]. The aim of EcoBioCap is to provide customizable, ecoefficient, biodegradable packaging to EU consumers. Figure 1 illustrates the workflow of project.

The choice of food packaging depends on several physical factors that arise from interactions between the packaging and the food at the molecular, nanoscopic, microscopic and macroscopic levels. The project's industrial partners liase with research laboratories in order to ensure the feasibility of the research oriented packaging material produced. Finally, a decision support system is needed in order to choose between the feasible packaging based on several preferences of EcoBioCap stakeholders.

One of the project's core tasks involves carrying out a strategic analysis of stakeholder requirements in terms of food quality and safety but also cost, technical and environmental impact. The aim is to provide the right inputs to the further steps of the project with the development of modelling and decision support tools.

The EcoBioCap decision support system consists of several components, as shown in Figure 2. The fresh food database captures the gas exchange properties for each potential packaged foodstuff. The packaging database plays a similar role, identifying the oxygen and carbon dioxide permeability as well as other properties (e..g transparency) of

[2]http://www.ecobiocap.eu/

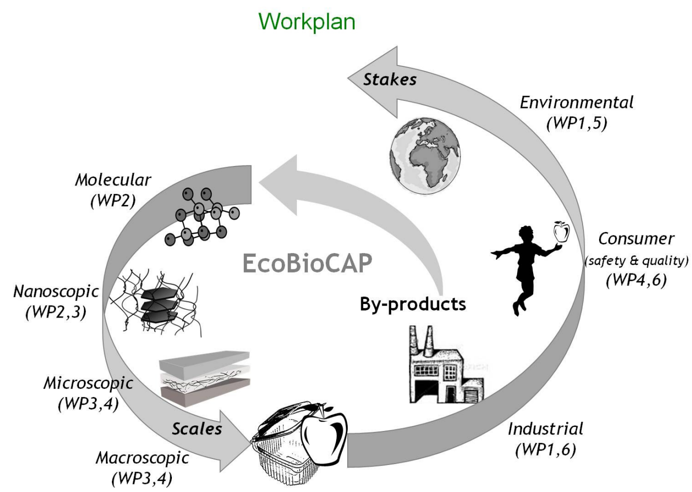

Figure 1. The EcoBioCap workpackage cycle

different packing materials. The third and final datastore tracks stake hold preferences, which are defined in terms of positive and negative preferences. Negative preferences correspond to constraints since they specify what values or objects have to be rejected (i.e. those which do not satisfy the constraints). Positive preferences correspond to wishes to specify which objects are more desirable to others.

The decision support workflow operates as follows:

1. Information from the stakeholder preferences and fresh food database is used as input to a simulator, which computes the ideal permeability properties of a packaging for a given food type.
2. The permeability data, together with information from the packaging database and stakeholder preferences, is used to run a multi criteria optimisation, from which a list of possible packagings, ranked from best to worst, can be identified.

Obviously, the aggregation of different stakeholder preferences into a consistent preference set must occur before the system begins running. In this paper we will show how to instantiate a preference logic for such stakeholder needs and how to integrate them in an argumentation system.

Note that for stakeholder preference elicitation and their corresponding arguments a series of questionnaires were sent to each EcoBioCap actor. The criteria on which the questions were focusing were transparency, price, nano particle presence, biodegradability etc. The objective was to collect information about the interest and needs of the stakeholders. As previously mentioned, the main results of this survey forms part of the initial specifications which are the basis of the experimental trials on the development of biodegradable packaging materials. In the next subsection we give an example of such preferences expressed by stakeholders.

2.1. EcoBioCap Stakeholder Preference Example

In the remainder of this paper we will use a running example originating from the EcoBioCap project regarding one aspect of the packaging of cheese, namely the transparency

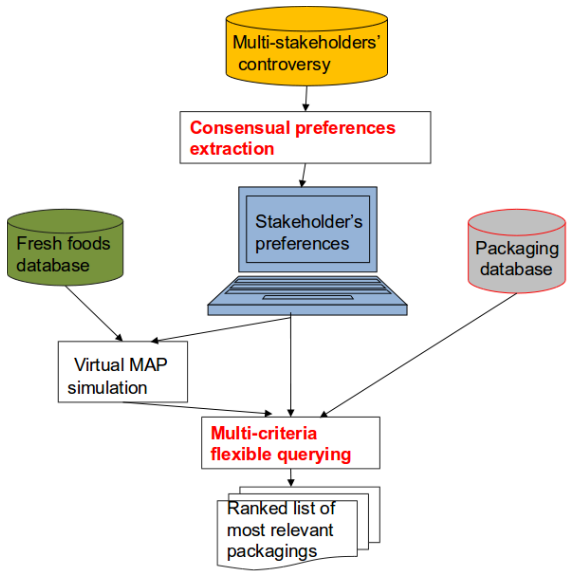

Figure 2. Decision Support System within EcoBioCap

of the packaging.

Let us consider the following three experts [3]:

- Expert 1 claims that "transparent packagings are preferred (by consumers) to opaque ones and that it is not the case that consumers prefer an expensive packaging to a cheap one".
- Experts 2 notes that "transparency adds cost to the packaging and cheap packagings are preferred to expensive packagings".
- Expert 3 claims that "cheap packaging is not preferred to transparent ones".

In this paper we propose a logic able to both (1) express and (2) reason with the above statements. Conflicts will then be integrated via a contrariness function into the ASPIC+ framework. Finally, in Section 5 we also look into the possibility of adding argument by expert opinion into this framework and how it will change the inferences which could be obtained.

3. Preference Logic

In this section we define a simple logical language that allows us to express and refer to preferences. We begin by describing the language's syntax, before examining its semantics and associated inference rules.

The language we described is based on [3,2], which describes the semantics of preferences between propositions. We introduce two types of negation when talking about preferences: first, we consider the negation of a preference: "it is not the case that: a is

[3] Please note, that due confidentiality requirements, the statements used by the experts in Section 2.1 have been slightly modified.

preferred to b". This means that in all possible models "a is preferred to b" does not hold. On the other hand saying "a is not preferred to b" is interpreted in our language as the existence of at least two models in which "a is preferred to b" does not hold.

The above two features are motivated by EcoBioCap's needs of expressing preference information that is known never to hold, and preference information that sometimes holds (for example customer preferences that vary from one group of customers to the other).

3.1. The Syntax of $\mathcal{L}$

In the following we inductively define the syntax of the language $\mathcal{L}$ we consider as the basis of our argumentation framework.

Let $\mathcal{L}$ be the language generated from a set of propositional symbols $\mathcal{PS}$ together with the connectives $\wedge, \neg, \succeq$ and $\not\succeq$ as follows:

- $Prop(\mathcal{PS})$ is the set of formulae classically defined in propositional logic over connectors $\wedge, \neg$.
- If $A \in Prop(\mathcal{PS})$ then $A \in \mathcal{L}$.
- If $A, B \in Prop(\mathcal{PS})$ then $A \succeq B \in \mathcal{L}$ and $A \not\succeq B \in \mathcal{L}$.
- If $A, B \in \mathcal{L}$ then $A \wedge B \in \mathcal{L}$.
- If $A, B \in Prop(\mathcal{PS})$ then $\neg(A \succeq B) \in \mathcal{L}$ and $\neg(A \not\succeq B) \in \mathcal{L}$.

We also make use of the classical abbreviations :

- $A \vee B = \neg(\neg A \wedge \neg B)$
- $A \to P = \neg A \vee B$
- $A \leftrightarrow B = (A \to B) \wedge (B \to A)$.

Given these definitions, consider as an example the set of propositional symbols $\mathcal{PS} = \{a, b, c\}$. Then the following are all formulae in $\mathcal{L}$:

- $a \wedge b$;
- $a \wedge \neg b$;
- $a \wedge (a \succeq b)$
- $\neg(a \wedge b \wedge \neg c) \succeq (a \wedge b)$;
- $\neg(a \wedge b) \succeq \neg(b \wedge c)$.

If we reconsider the example in Section 2.1 all of the following are syntactically valid formulae in $\mathcal{L}$, where "t" stands for "transparency"; "o" stands for "opaque"; "e" for "expensive" and "c" for "cheap".

- Expert 1: "$t \succeq o; \neg(e \succeq c)$"
- Expert 2: "$t \to e; \neg e \succeq e$"
- Expert 3: "$c \not\succeq t$"

Note that in the remainder of this paper we assume the existence of a knowledge base containing agreed universal knowledge (ontology), namely $\mathcal{KB}_E = \{e \leftrightarrow \neg c; c \leftrightarrow \neg e; t \leftrightarrow \neg o; o \leftrightarrow \neg t\}$.

3.2. The Semantics of $\mathcal{L}$

Having defined the syntax of $\mathcal{L}$, we now describe its semantics. We define a model as $M \subseteq 2^{\mathcal{PS}}$. Let $\mathcal{M}$ be a set of models. An interpretation is defined with the help of a set of models $\mathcal{M}$ and a given total order $\geq$ over $\mathcal{M}$: $\geq \subseteq M \times M$. We write $M_1 \geq M_2$ iff $(M_1, M_2) \in \geq$ and $M_1 \not\geq M_2$ iff $(M_1, M_2) \notin \geq$. We associate the total order with a utility function over the propositions within a model: $\mu : 2^{\mathcal{PS}} \mapsto \mathbb{R}$. Given such a function, $\geq$ is defined as follows : $M_1 \geq M_2$ if and only if $\mu(M_1) \geq \mu(M_2)$.

Given a model M, we define the satisfaction relation $\models$ according to a model as follows:

- $\forall A \in \mathcal{PS}$, $M \models A$ iff $a \in M$.
- $\forall A \in \mathcal{PS}$, $M \models \neg A$ iff $a \notin M$.
- $\forall A, B \in \mathcal{PS}$, $M \models A \wedge B$ iff $M \models A$ and $M \models B$.

Now, let $(\mathcal{M}, \geq)$ be an interpretation. The satisfaction relation $\models$ is defined on $(\mathcal{M}, \geq)$ as follows :

- $\forall a \in \mathcal{PS}$, $(\mathcal{M}, \geq) \models a$ iff $\forall M \in \mathcal{M}$, $a \in M$.
- $\forall A, B \in Prop(\mathcal{PS})$ $(\mathcal{M}, \geq) \models A \succeq B$ iff $\forall M_1, M_2 \in \mathcal{M}$ satisfying:
  - $M_1 \models A \wedge \neg B$
  - $M_2 \models B \wedge \neg A$
  - M_1, M_2 coincide for all other elements of $\mathcal{PS}$

  then $M_1 \geq M_2$.
- $\forall A, B \in Prop(\mathcal{PS})$ $(\mathcal{M}, \geq) \models A \not\succeq B$ iff $\exists M_1, M_2 \in \mathcal{M}$ satisfying:
  - $M_1 \models A \wedge \neg B$
  - $M_2 \models B \wedge \neg A$
  - M_1, M_2 coincide for all other elements of $\mathcal{PS}$

  then $M_2 \geq M_1$.
- $\forall A, B \in Prop(\mathcal{PS})$ $(\mathcal{M}, \geq) \models \neg(A \succeq B)$ iff $\forall M_1, M_2 \in \mathcal{M}$ satisfying:
  - $M_1 \models A \wedge \neg B$
  - $M_2 \models B \wedge \neg A$
  - M_1, M_2 coincide for all other elements of $\mathcal{PS}$

  then $M_2 \geq M_1$.
- $\forall A, B \in \mathcal{L}$, $(\mathcal{M}, \geq) \models A \wedge B$ iff $\forall M \in \mathcal{M}$, $M \models A$ and $M \models B$.

Note that the difference between $\neg(A \succeq B)$ and $(A \not\succeq B)$ revolves around the universal quantification in the former, and an existential quantification in the latter.

Let us now analyse the expert statements from Section 2.1:

- Expert 1: "$t \succeq o$; $\neg(e \succeq c)$". The first statement means that in all worlds transparent packagings are preferred to opaque ones. The second statement says that we can never find two worlds in which the world in which we have expensive and not cheap has a greater utility than a world in which we do not have expensive and we have cheap (if all the other things are the same).

- Expert 2: "$t \rightarrow e; \neg e \succeq e$". The first statement means that every time we will find a model in which transparent takes place expensive will also take place. The second statement means that for two worlds in which in one not expensive holds and the other expensive holds, if all things equal, the utility of the first world is greater than the utility of the second.
- Expert 3: "$c \not\succeq t$". This statement means that we can find at least two worlds in which, if all things the same, the utility of the world in which we find transparent and not cheap it is greater than the utility of the world in which we find cheap and not transparent.

3.3. Inference Rules

ASPIC+ encodes a logic within an argumentation framework by utilising its proof theory represented as a set of inference rules. We must therefore identify the set of inference rules that are valid in $\mathcal{L}$.

Given a set $\mathcal{F}$ of formulae on $\mathcal{L}$, we say that $C \in \mathcal{L}$ is the consequence of $\mathcal{F}$ (denoted $\mathcal{F} \vdash C$) if and only if for all interpretations $(\mathcal{M}, \geq)$ such that for every $F \in \mathcal{F}$, $(\mathcal{M}, \geq) \models F$ it is the case that $(\mathcal{M}, \geq) \models C$.

We assume the standard properties of associativity and distributivity over $\wedge$ and $\neg$, as in classical propositional logic, and again include the standard abbreviations for implication ($\supset$), and disjunction ($\vee$). We then denote by $RS^{\mathcal{PS}}$ the set of classical inference rules in propositional logic. Apart from these, our language $\mathcal{L}$ admits the following valid rules.

$$RS_1 : \neg(\phi \succeq \psi) \vdash (\phi \not\succeq \psi)$$

$$RS_2 : \neg(\phi \not\succeq \psi) \vdash (\psi \succeq \phi)$$

$$RS_3 : (\phi \succeq \psi) \wedge (\psi \succeq \sigma) \vdash (\phi \succeq \sigma)$$

$$RS_4 : (\neg\phi \succeq \phi) \wedge (\psi \rightarrow \phi) \vdash (\neg\psi \succeq \psi)$$

$$RS_5 : (\phi \succeq \neg\phi) \wedge (\psi \rightarrow \phi) \vdash (\psi \succeq \neg\psi)$$

RS_1 can be shown true by noting that the left hand side can only be true if either $M_1 < M_2$, or $(M_1, M_2) \notin \geq$ (i.e. they are incomparable). Both of these situations satisfy the requirement imposed by the right hand side of the rule. The proof for RS_2 is analogous to this. RS_3 follows directly from the transitivity of the model preference relation $\geq$. The last two rules can be trivially proven from the definition of the set of models satisfying the preference operator.

3.4. Contrariness function on $\mathcal{L}$

We are now in the position to define a contrariness function $cf : \mathcal{L} \rightarrow 2^{\mathcal{L}}$. Intuitively this function denotes the mutual exclusivity between two formulae within a given $\mathcal{M}$. This function will be used in the next section to define the attack between two arguments in our argumentation system.

For all "classical" propositional formulae ϕ:

- $cf(\phi) = \{\neg\phi\}$
- $cf(\neg\phi) = \{\phi\}$.

For all others formulae in $\mathcal{L}$:

- $cf(\neg(a \succeq b)) = \{(a \succeq b)\}$,
- $cf((a \succeq b)) = \{(b \succeq a), \neg(a \succeq b), (a \not\succeq b)\}$
- $cf((a \not\succeq b)) = \emptyset$
- $cf(\neg(a \not\succeq b)) = \{(a \succeq b), \neg(b \succeq a), (b \not\succeq a)\}$

Let us reconsider the example in Section 2.1.

Concerning Expert 1, from the fact that $o \leftrightarrow \neg t$ and that $t \succeq o$ we can deduce that $t \succeq \neg t$. Concerning Expert 2, from $t \rightarrow e$ and $\neg e \succeq e$ we can deduce that $\neg t \succeq t$. Please note that $t \succeq \neg t$ and $\neg t \succeq t$ belong to each other image of the cf function (thus the two arguments will attack each other according to ASPIC+ framework definitions). Similarly, since $\neg(e \succeq c)$ according to Expert 1, we can deduce that $e \not\succeq \neg e$. We can see that $e \not\succeq \neg e$ and $\neg e \succeq e$ belong to each other's cf function. Such reasoning will be made possible within the an ASPIC+ instantiation with the language $\mathcal{L}$ (where the cf function will be then used to compute attacks between arguments).

3.5. Defeasible Logic

In order to fully instantiate ASPIC+ this section provides a very simple definition of an instantiation of defeasable inference. We will only consider one kind of defeasible inference: $RD_1 : (\phi \succeq \psi) \rightsquigarrow (\phi \not\succeq \psi)$. The semantics of this defeasible logic is defined as the usual semantics of defeasible logics (see [8]). We thus consider defeasible modus ponens, which we label:

$$DMP : \{\phi, \phi \rightsquigarrow \psi \Rightarrow \psi\}$$

This section is only used for a very basic defeasable power of the language we defined. In Section 5 we further discuss the need for such logic and how to integrate argument by expert opinion in our framework.

4. Argumentation Framework

Following [9], we define an argumentation system as the tuple
$\mathcal{AS} = (\mathcal{L}, cf, \mathcal{R}, \geq)$, where:

- $\mathcal{L}$ is the logical language explained in Section 3;

- cf is the *contrariness function* from $\mathcal{L}$ to $2^{\mathcal{L}}$ as defined in Section 3;

- $\mathcal{R} = \mathcal{R}_s \cup \mathcal{R}_d$ the set of inference rules within $\mathcal{L}$ defined cf. Section 3 as follows:

  * $\mathcal{R}_s = \{RS_1, ..., RS_5\} \cup RS^{\mathcal{PS}}$;
  * $\mathcal{R}_d = \{DMP\}$;

- $\geq$ a preference ordering over defeasible rules, which we ignore for now ($\geq = \emptyset$).

Given a knowledge base $\mathcal{K} \subseteq \mathcal{L}$, we define an argument A as per Defn 3.6 of [9], requiring that $\phi, \neg\phi$ cannot be inferred from either $\texttt{Conc}(A)$ or $\texttt{Prem}(A)$.

An argument A on the basis of a knowledge base $\mathcal{K}$ is:

1. ϕ if $\phi \in \mathcal{K}$ with $\texttt{Prem}(A) = \{\phi\}$; $\texttt{Conc}(A) = \phi$; $\texttt{Sub}(A) = \{\phi\}$; $\texttt{Rules}(A) = \emptyset$; $\texttt{TopRule}(A) =$ undefined.
2. $A_1, \ldots a_n \rightarrow / \Rightarrow \psi$ if $A_1, \ldots, A_n$ are arguments such that there is a strict or defeasible rule $\texttt{Conc}(A_1), \ldots, \texttt{Conc}(A_n) \rightarrow / \Rightarrow \psi$ in $\mathcal{R}_s/\mathcal{R}_d$.

   - $\texttt{Prem}(A) = \texttt{Prem}(A_1) \cup \ldots \cup \texttt{Prem}(A_n)$
   - $\texttt{Conc}(A) = \psi$,
   - $\texttt{Sub}(A) = \texttt{Sub}(A_1) \cup \ldots \cup \texttt{Sub}(A_n) \cup \{A\}$
   - $\texttt{Rules}(A) = \texttt{Rules}(A_1) \cup \ldots \cup \texttt{Rules}(A_n) \cup \{\texttt{Conc}(A_1), \ldots, \texttt{Conc}(A_n) \rightarrow / \Rightarrow \psi\}$
   - $\texttt{DefRules}(A) = \{r | r \in \texttt{Rules}(A)$ and $r \in \mathcal{R}_d\}$
   - $\texttt{TopRule}(A) = \texttt{Conc}(A_1), \ldots, \texttt{Conc}(A_n) \rightarrow / \Rightarrow \psi$

ASPIC+ defines three types of attacks:

1. An *undercutting attack* from argument A to argument B occurs if there is some $B' \in \texttt{Sub}(B)$ iff $\texttt{Conc}(A) \in cf(B')$ and B' is of the form $B''_1, \ldots, B''_n \rightarrow \phi$.
2. A *rebutting attack* from A on argument B occurs iff $\texttt{Conc}(A) \in cf(\phi)$ for some $B' \in \texttt{Sub}(B)$ of the form $B''_1, \ldots, B''_n \rightarrow \phi$. if $\texttt{Conc}(A)$ is a contrary of ϕ then A contrary-rebuts B.
3. A *undermining attack* occurs from argument A to B iff $\texttt{Conc}(A) \in cf(\phi)$ for some $\phi \in \texttt{Prem}(B) \backslash \mathcal{K}_{\backslash}$. If $\texttt{Conc}(A)$ is a contrary of ϕ or $\phi \in K_a$ then A contrary-undermines B.

The notion of an attack is then extended to the notion of a defeat via two concepts:

1. Argument A successfully rebuts argument B if A rebuts B on B' and A contrary-rebuts B'.
2. A successfully undermines B if A undermines B on ϕ and A contrary-undermines B.

Then argument A defeats B iff no premise of A is an issue and A undercuts or successfully rebuts or successfully undermines B. If A defeats B and B does not defeat A, then A strictly defeats B.

We can now map from ASPIC to a Dung argument framework$\langle Arg, Def\rangle$ by defining the set of arguments Arg from the definition of arguments above, and defining Def according to the defeat notion defined above.

5. Discussion and Future Work

This paper explained the EcoBioCap project's need for obtaining consensual preferences by the means of an argumentation framework. We proposed a simple preference logic and used the ASPIC+ system to instantiate it for our application.

Currently, the above approach is being implemented and tested within the consortium. Finalising this implementation and reporting on its practical results is an immediate line of current and future work in the context of practical applications of argumentation systems. Another important line of work we are currently pursuing is the investigation of extension and inference properties under the semantics given by the language $\mathcal{L}$.

However, one major feature of the EcoBioCap project that was not exploited was the existence of different experts within the system. It is thus natural to include argument by expert opinion. While current work did not develop the defeasable logic aspect within $\mathcal{L}$, this is an important aspect to consider for implementing argument by expert opinion. We conclude the paper by a description of how the above aspects can be integrated within EcoBioCap.

5.1. Argument by expert Opinion

Let $\mathcal{A}$ be the different stakeholder agents involved in the project (customers and different kinds of experts). In the same spirit as [10] we introduce the notion of perspective (called here viewpoint). We consider a given set of viewpoints $\mathcal{V}$ and a given mapping function μ from the set of viewpoints $\mathcal{V}$ to the elements of $2^{\mathcal{PS}}$. This function associates to each viewpoint $v \in \mathcal{V}$ a subset of propositions $\mu(v) = \{a | a \in \mathcal{PS}\}$.

Example:

- $\mathcal{V} = \{aesthetic, cost, ecology\}$
- $\mathcal{PS} = \{transparent, opaque, expensive, biodegradable\}$
- $\mu : V \to P$ is defined as:
  - $\mu(aesthetic) = \{transparent, opaque\}$;
  - $\mu(cost) = \{expensive\}$;
  - $\mu(ecology) = \{biodegradable\}$

Each agents has an expertise according to a given function $expert : \mathcal{A} \to 2^{\mathcal{V}}$ which is associating to each agent a, the subset of viewpoints in which s/he is an expert: $expert(a) \subseteq \mathcal{V}$.

We then define the truth values of the following propositions:

$$\mathcal{L}_1 = \{expert_{e,d}, domain_d, assert_{e,p}, within_{p,d}\}$$

as follows:

- $expert_{e,d} = \top$ iff $e \in \mathcal{A}$, $d \in \mathcal{V}$ and $d \in expert(e)$
- $domain_d = \top$ iff $d \in \mathcal{V}$
- $assert_{e,p} = \top$ iff $p \in \mathcal{L}$ and agent $e \in \mathcal{A}$ stated p
- $within_{p,d} = \top$ iff $p \in \mathcal{L}$, $d \in \mathcal{V}$ and there is at least one propositional symbol s in p such that $s \in \mu(d)$.

Example. Considering the above functions μ and $expert$ the following propositions are true:

- $domain_{cost}$,
- $domain_{ecology}$, $within_{transparent \succeq \neg transparent, aesthetic}$,
- $within_{expensive, cost}$

Finally, for each agent $a \in \mathcal{A}$ we consider two new propositions $\mathcal{L}_2 = \{reliable_a, credible_a\}$ which will be instantiated to $\top$ if the information of reliability / credibility is manually encoded in the knowledge base (or manually added).

5.2. Argument from Expert Opinion

In $\mathcal{L} \cup \mathcal{L}_1 \cup \mathcal{L}_2$ we can now represent the argument from expert opinion scheme as follows ($P \in \mathcal{L}$):

$$AEO : expert_{E,D} \wedge domain_D \wedge assert_{E,P} \wedge within_{P,D} \rightsquigarrow P$$

$$\neg reliable_E \rightarrow \neg AEO$$

$$\neg credible_E \rightarrow \neg AEO$$

Here, AEO is shorthand for the scheme. The latter two rules form undercutting attacks on AEO.

As an example, consider a knowledge base containing the following, which we refer to as $PREM$:

$$\begin{array}{ll} expert_{e_1, materials} & domain_{materials} \\ assert_{e_1, plastic \succeq paper} & within_{plastic \succeq paper, materials} \\ (plastic \succeq paper) & \end{array}$$

Then this knowledge base, combined with AEO (which is also assumed in the knowledge base) allows us to apply the defeasible modus ponens rule DMP, leading to the following argument A_1:

$$\texttt{Prem}(A_1) = \{PREM, AEO\}$$

$$\texttt{Conc}(A_1) = \{plastic \succeq paper\}$$

$$\texttt{Sub}(A_1) = \texttt{Prem}(A_1) \cup \{DMP\}$$

$$\texttt{DefRules}(A_1) = \texttt{TopRule}(A_1) = \texttt{Rules}(A_1) = \\ \texttt{Prem}(A) \Rightarrow plastic \succeq paper$$

Now the addition of the fact $\neg credible_{e_1}$ would add the new argument $A_2 = \neg credible_{e_1}$ where $\texttt{Prem}(A) = \{\neg credible_{e_1}\}$; $\texttt{Conc}(A) = \neg credible_{e_1}$; $\texttt{Sub}(A) = \{\neg credible_{e_1}\}$; $\texttt{Rules}(A) = \emptyset$; $\texttt{TopRule}(A) =$ undefined, and A_2 would perform an undercutting attack on A_1.

6. Conclusions

In this paper we outlined the requirements of the EcoBioCap decision support system. Argumentation plays a critical role in this system; rather than using an (opaque) social choice function to combine expert preferences, arguments are advanced by these experts as to why some packaging should/should not be used. This increases the transparency of the process, allowing for explanations to be generated as to why some decision was taken.

The argumentation process within EcoBioCap is with regards to — rather than using — preferences, which required us to define a logic of preferences which we then instantiated within ASPIC+. We briefly discussed how the most important argument scheme for our purposes, namely argument from expert opinion, is implemented in our system. Having laid the groundwork for EcoBioCap, we are now in the process of implementing and evaluating the tool using arguments obtained from domain experts.

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