An argumentation framework based on contextual preferences

Leila AMGOUD[1] Simon PARSONS[1] Laurent PERRUSSEL[2]

[1] Department of Computer Science, University of Liverpool
Chadwick Building. Liverpool L69 7ZF
E-mail: {amgoud, s.d.parsons}@csc.liv.ac.uk

[2] CERISS – Université Toulouse I. 21, Allées de Brienne, Manufacture des tabacs,
F-31042 Toulouse Cedex FRANCE
E-mail: perussel@univ-tlse1.fr

Abstract.
Argumentation is one of the promising approaches to handle inconsistency in knowledge bases. It consists of constructing arguments and counter-arguments (defeaters) and then selecting the most acceptable of them. In [1], a preference-based argumentation framework has been proposed. In that framework, the knowledge base is supposed to be equipped with a preordering between the beliefs. However there are limits to what can be achieved with this framework since it does not take into account the case where several preorderings on the beliefs (contextual preferences) are available. The aim of this paper is to extend the framework defined in [1] in order to reason from multiple points of view on an inconsistent knowledge base.

Keywords: Defeasible argumentation, Contextual preferences.

1. Introduction

An important problem in the management of knowledge-based systems is the handling of inconsistency. One of the solutions that have been proposed to handle inconsistency is the use of argumentation frameworks [8], [10], [11], [13], [14] particularly preference-based argumentation frameworks [1], [2]. In these frameworks, arguments are constructed for and against a given belief and the acceptable ones are selected. To determine the acceptable arguments, these last are ordered using a preference relation. This preference relation between the arguments is induced from a preordering between the beliefs.

One of the limits of these frameworks is that they are not able to take into account different preorderings on the beliefs. These different preorderings can be considered to be contextual preferences, that is preferences which depend upon a particular context. According to McCarthy [9], a context represents the set of conditions determining if a belief is true or false. There are various conditions: space, time, environment etc...

Contextual preferences are given in terms of preorderings between beliefs. For example, in a multi-agent system where the agents share the same knowledge base, each agent expresses his preferences on the beliefs. In this case, the agents represent the different contexts and a preference is true only in the context in which it is defined. A context may also be a point of view or criteria. In multicriteria decision making, each solution of the problem under consideration is described with a number of criteria. The different solutions are comparable according to each of these criteria. Let's consider the following example:

Example 1. *A person X wants to buy a second-hand car with a low mileage, not very expensive and which is comfortable. He has the choice between a Megane and a Twingo. The characteristics of the two cars are resumed in the table below.*

	Comfort	*Kms*	*Price*
Megane	*Yes*	*82000*	*37000FF*
Twingo	*No*	*60000*	*45000FF*

The three criteria (comfort, mileage and price) correspond to contexts. In the two contexts Comfort and price Megane is preferred to Twingo and in the context mileage, the Twingo is preferred to the Megane.

The aim of this paper is to extend the argumentation framework developed in [1] by taking into account contextual preferences.

This paper is organized as follows: section 2 introduces the preference-based argumentation framework developed in [1]. Section 3 presents the contextual preferences and their characteristics. In section 4 we present the argumentation framework based on contextual preferences. We present three solutions to compute the set of acceptable arguments in such frameworks. Section 5 presents three consequence relations allowing deductions from a knowledge base with contextual preferences. Section 6 is devoted to some concluding remarks and perspectives.

2. Preference-based argumentation framework (PAF)

In this section we present the argumentation framework defined in [1], [2]. A preference-based argumentation framework is defined as a triplet of a set of arguments, a binary relation representing the defeat relationship between arguments and a preference relation between the arguments. Here, an argument is an abstract entity whose role is only determined by its relation to other arguments. Then its structure and its origin are not known. Formally:

Definition 1. A *preference-based argumentation framework* (PAF) is a triplet <A, R, Pref>. A is a set of arguments, R is a binary relation representing a defeat relationship between arguments, i.e. $R \subseteq A \times A$. (A, B) $\in$ R or equivalently "A R B" means that the argument A defeats the argument B. Pref is a (partial or complete) preordering on $A \times A$. $>>^{Pref}$ denotes the strict ordering associated with Pref.

As we are interested by handling inconsistency in knowledge bases, let's illustrate the concepts of argument, defeat relation (R) and preference relation (Pref) in that context. Hence, the arguments are built from a knowledge base Σ, which may be inconsistent. Formulas of Σ are expressed in a propositional language L.

An *argument* of Σ is a pair (H, h), where h is a formula of the language L and H a subbase of Σ satisfying: i) H is consistent, ii) $H \vdash h$, iii) H is minimal (no strict subset of H satisfies i and ii). H is called the *support* and h the *conclusion* of the argument.

As example of defeat relation let's consider the two famous ones: Rebut and Undercut defined in [7] as follow. Let (H, h) and (H', h') be two arguments of A.

(H, h) *rebuts* (H', h') iff $h \equiv \neg h'$. This means that an argument is rebutted if there exists an argument for the negated conclusion.

(H, h) *undercuts* (H', h') iff for some $k \in H'$, $h \equiv \neg k$. An argument is undercut if there

exists an argument against one element of its support.

In [3], several preference relations between arguments of $\mathcal{A}$ have were discussed. These preference relations are induced by a preference relation defined on the supports of arguments. The preference relation on the supports is itself defined from a (total or partial) preordering on the knowledge base Σ.

An example of such preference relations is the one based on the elitism principle (ELI-preference [4]). Let $\geq$ be a total preordering on Σ and $>$ be the associated strict ordering. In that case, the knowledge base Σ is supposed to be stratified into $(\Sigma_1, \ldots, \Sigma_n)$ such that Σ_1 is the set of $\geq$-maximal elements in Σ and Σ_{i+1} the set of $\geq$-maximal elements in $\Sigma \setminus (\Sigma_1 \cup \ldots \cup \Sigma_i)$.

Let H and H' be two subbases of Σ. H is *preferred* to H' according to ELI-preference iff $\forall k \in H \setminus H', \exists k' \in H' \setminus H$ such that $k > k'$.

Let (H_1, h_1), (H_2, h_2) be two arguments of $\mathcal{A}$. $(H_1, h_1) >>^{ELI} (H_2, h_2)$ iff H_1 is preferred to H_2 according to ELI-preference.

Example 1. *$\Sigma = \Sigma_1 \cup \Sigma_2 \cup \Sigma_3$ such that $\Sigma_1 = \{a, \neg a\}$, $\Sigma_2 = \{a \rightarrow b\}$ and $\Sigma_3 = \{\neg b\}$. $(\{a, a \rightarrow b\}, b) >>^{ELI} (\{\neg b\}, \neg b)$.*

Using the defeat and the preference relations between the arguments, the set $\mathcal{A}$ of arguments may be partitioned into three subsets: the subset of *acceptable arguments* S_a, the subset of *rejected arguments* and the subset of *arguments in abeyance*. The rejected arguments are the ones defeated by acceptable arguments and the arguments in abeyance are those which are neither accepted nor rejected.

Definition 2. Let $\langle \mathcal{A}, \mathcal{R}, Pref \rangle$ be a PAF. Let A, B be two arguments of $\mathcal{A}$ such that B $\mathcal{R}$ A. A *defends itself against* B iff A $>>^{Pref}$ B. In other words, an argument *defends itself* iff it is preferred w.r.t Pref to each counter-argument. $\mathcal{C}_{\mathcal{R}, Pref}$ denotes the set of arguments defending themselves against their defeaters.

This set also contains the arguments that are not defeated (in the sense of the relation $\mathcal{R}$). However, $\mathcal{C}_{\mathcal{R}, Pref}$ is too restricted since it discards arguments which appear acceptable. Intuitively, if an argument A is less preferred than its defeater B then it is weakened. But the defeater B itself may be weakened by another argument C which defeats B and is preferred to B. In this latter case we would like to accept A because it is defended by C. This notion of defence was introduced by Dung [6] in the case without preference relations and has been used in legal reasoning [12].

Definition 3. Let $\langle \mathcal{A}, \mathcal{R}, Pref \rangle$ be a PAF and $S \subseteq \mathcal{A}$. An argument A is *defended* by S iff $\forall$ B $\in \mathcal{A}$, if B $\mathcal{R}$ A and not(A $>>^{Pref}$ B) then $\exists$ C $\in$ S such that C $\mathcal{R}$ B and not(B $>>^{Pref}$ C).

The set of acceptable arguments S_a of a PAF $\langle \mathcal{A}, \mathcal{R}, Pref \rangle$ is obtained as the least fixpoint of the function $\mathcal{F}$ defined as follows:

$$\mathcal{F}: 2^{\mathcal{A}} \rightarrow 2^{\mathcal{A}}$$
$$S \rightarrow \mathcal{F}(S) = \{A \in \mathcal{A} \,/\, A \text{ is defended by } S\}.$$

Definition 4. Let $\langle \mathcal{A}, \mathcal{R}, Pref \rangle$ be a finite PAF (each argument is defeated by a finite number of arguments). The least fixpoint of $\mathcal{F}$ is: $S_a = \cup \mathcal{F}^{i \geq 0}(\emptyset) = \mathcal{C}_{\mathcal{R}, Pref} \cup [\cup \mathcal{F}^{i \geq 1}(\mathcal{C}_{\mathcal{R}, Pref})]$.

Note that the PAFs <A, Rebut, Pref> and <A, Undercut, Pref> are finitary. The above result shows that the acceptable arguments are the ones which defend themselves against their

defeaters ($C_{R, Pref}$) and also the arguments which are defended (directly or indirectly) by the arguments of $C_{R, Pref}$.

Example 2. *Let* $<A, R, Pref>$ *be a PAF such that* $A = \{A, B, C, D, E\}$, $R = \{(C, D), (D, C), (A, E)\}$ *and* $C >>^{Pref} D$, *then* $C_{R, Pref} = \{A, B, C\}$.

3. Contextual preferences

Conflicts between preferences may appear when these preferences are expressed in different contexts. For example, an argument A may be preferred to another argument B in a context c_1 and the argument B may be preferred to A in a context c_2. To resolve this kind of conflicts meta-preferences are needed. A first natural solution is to order the contexts. This is useful for conflict resolution. In legal domain, for example, the rules defined by the European community take precedence over those defined in any country in Europe. So the European context takes precedence over the national context. In a company, the preferences of the agents respect the hierarchical level of the agent who expresses them. For example, the preferences of the managing director take precedence over those of the Marketing director. This solution has also been used in [5] to merge several knowledge bases. The author supposes that the knowledge bases are ordered.

The second solution involves defining different orders between the preferences of the contexts. Let's consider the following example about a police inspector investigation.

Example 3. *According to the first witness, say Jane, the murder was wearing a dress and had a car of model Megane. According to Joe, the murder was a woman wearing a skirt and having a car of model Laguna. In this example, the two contexts are Jane and Joe. In the first context, dress is preferred to skirt and Megane is preferred to Laguna. In the context Joe, we have exactly the opposite preferences.*
The police inspector knows that women are more reliable concerning clothes and men are more reliable concerning mechanics. So he concludes that the murder was wearing a dress and she had a Laguna car.

In this example, two new incomparable contexts are generated: the context "clothes" and the context "mechanics" and separate consequences drawn from both of them. Since the contexts are not comparable there is no conflict between the preferences expressed in each of them. We can suppose then that the set of new contexts is equipped with a total preordering and that all the contexts have the same preference. It is easy to see then that this second possibility of meta-preference is a particular case of the first one. In the following, we suppose that we have a set of contexts equipped with a total preordering.

4. Argumentation framework based on contextual preferences (CPAF)

Let's consider a set of arguments A equipped with several preference relations $Pref_1$, …, $Pref_n$. Each preference $Pref_i$ is induced from a preordering $\geq_i$ expressed in the context i on the knowledge base. In the following we just focus on the preference relations between arguments and not on the different preorderings $\geq_i$.
We denote by C the set of contexts and by $\succ$ a total ordering between the elements of C. Let $c_1, c_2 \in C$, $c_1 \succ c_2$ means that the context c_1 is privileged to the context c_2.

Definition 5. An *argumentation framework based on contextual preferences* (CPAF) is a

tuple <A, R, C, $\succ$, $Pref_1$, …, $Pref_n$> where A is a set of arguments, R is a binary relation representing a defeat relationship between arguments, C = {c_1, …, c_n} is a set of contexts, $\succ$ is a complete preordering on C × C, $Pref_i$ is a (partial or complete) preordering on A × A issued from the context c_i.

After constructing the arguments and counter-arguments, the second step in an argumentation process is the selection of the most acceptable ones. To find the acceptable arguments in an argumentation framework based on contextual preferences, we suggest three solutions:

- *Aggregating the different preference relations*. The idea here is to define from $Pref_1$, …, $Pref_n$ a single preference relation Pref, then to apply definition 4 of acceptable arguments of the PAF <A, R, Pref>.
- *Changing the definitions of individual and joint defence*. This solution consists of taking into account the different preorderings between the arguments and the preordering between the contexts in the definition of the two key concepts of acceptability: individual defence and joint defence.
- *Aggregating the sets of acceptable arguments*. This solution consists of first defining the different acceptable arguments in the frameworks <A, R, $Pref_1$>, …, < A, R, $Pref_n$>, then aggregating them to one set. The resulted set represents the acceptable arguments of < A, R, C, $\succ$, $Pref_1$, …, $Pref_n$>.

Solution 1. Aggregating preference relations

From the different preorderings between arguments $Pref_1$, …, $Pref_n$ a unique preference relation will be defined, let's denote it by Pref. The idea behind the construction of Pref is to start by keeping all the preferences expressed in the best context (most privileged context) and among the remaining contexts, we select the best one (in the sense of the relation $\succ$). Among the preferences of the selected context, we keep only those which do not contradict the ones already kept. A preference contradicts another if it is its opposite. For example the preference (A, B) contradicts (B, A). The same process is repeated until there is no remaining context. Formally:

Definition 6. Let C = {c_1, …, c_n} be the set of contexts. The result of the aggregation is Pref = $\prod_n$ such that:

$T_1 = C$

$\prod_1 = \{(A, B) \in Pref_i$ such that $\forall c_j \in T_1 \backslash \{c_i\}, c_i \succ c_j\}$

$T_{k+1} = T_k \backslash \{c_i\}$

$\prod_{k+1} = \prod_k \cup \{(A, B) \in Pref_i, c_i \in T_{k+1}$, such that $(B, A) \notin \prod_k$ and $\forall c_j \in T_{k+1} \backslash \{c_i\}, c_i \succ c_j\}$

Example 4. *Let Σ be a knowledge base such that Σ = {a, a$\rightarrow$b, $\neg$b, c, $\neg$c}. Let's consider the following arguments: A = ({a, a$\rightarrow$b }, b), B = ({$\neg$b}, $\neg$b), C = ({c}, c) and D = ({$\neg$c}, $\neg$c). Let's suppose C = {c_1, c_2, c_3} such that $c_1 \succ c_2 \succ c_3$ and $Pref_1$ = {(A, B)}, $Pref_2$ = {(B, A), (C, D)}, $Pref_3$ = {(D, C)}. According to definition 6, Pref = {(A, B), (C, D)}.*

Note that the relation generated is not transitive. Let's take the following example.

Example 5. *Let <A, R, C, ≻, $Pref_1$, $Pref_2$, $Pref_3$> be a CPAF. A = {A, B, C}, C = {c_1, c_2, c_3} such that $c_1 \succ c_2 \succ c_3$, $Pref_1$ = {(A, B)}, $Pref_2$ = {(B, C)}, $Pref_3$ = {(C, A)}. According to definition 6, Pref = {(A, B), (B, C), (C, A)}.*

Once the aggregation done, it is easy to find the acceptable arguments of <A, R, C, ≻, $Pref_1$, …, $Pref_n$>. We have just to compute the set S_a of the argumentation framework (PAF) <A, R, Pref>.

Definition 7. The set of acceptable arguments of the framework <A, R, C, ≻, $Pref_1$, …, $Pref_n$> is exactly the set of acceptable arguments of the framework <A, R, Pref>, let's denote it by S_{a1}.

$S_{a1} = \cup F^{i\geq 0}(\emptyset) = C_{R, Pref} \cup [\cup F^{i\geq 1}(C_{R, Pref})]$.

Example 4. (continued) *Let's consider the framework <A, Rebut, C, ≻, $Pref_1$, $Pref_2$, $Pref_3$>. The argument C is acceptable.*

The advantage of this solution is that we don't modify the framework presented in section 2. We just add a step of aggregating preferences before constructing the acceptable arguments. However doing this means that we only know the acceptable arguments from the combined contexts, we don't know the acceptable arguments from each context on its own.

Solution 2. Computing the new set of acceptable arguments

Another solution is to change the definition of both individual and joint defence so that all the preferences are taken into account. The idea behind the new definition of self defence is that the defeated argument must be preferred to its defeaters in a context which takes precedence over all the contexts where the opposite preference is available.

Formally:

Definition 8. Let A and B be two arguments of A such that A R B. B *defends itself* against A iff $\exists c_i \in C$ such that B $>>^{Prefi}$ A and $\forall c_j$ such that A $>>^{Prefj}$ B then $c_i \succ c_j$. B *does not defends itself* against A iff $\exists c_i \in C$ such that A $>>^{Prefi}$ B and $\forall c_j$ such that B $>>^{Prefj}$ A then $c_i \succ c_j$.

We denote by $C_{R, \succ}$ the set arguments defending themselves against their defeaters.

Example 4. (continued) *Let consider the framework <A, Rebut, C, ≻, $Pref_1$, $Pref_2$, $Pref_3$>. The argument A defends itself against B whereas B does not defend itself against A since the context in which B is preferred to A (c_2) is less privileged to the context (c_1) in which A is preferred to B.*

Definition 9. Let $S \subseteq A$ and $A \in A$. S *defends* A iff $\forall B$ R A and A does not defend itself against B then $\exists C \in S$ such that C R B and B does not defend itself against C.

The set of acceptable arguments is the least fixpoint of the function F defined above but by replacing the definition of defence by the new one.

Definition 10. The set of acceptable arguments of the framework <A, R, C, ≻, $Pref_1$, …, $Pref_n$> denoted by S_{a2} is: $S_{a2} = \cup F^{i\geq 0}(\emptyset) = C_{R, \succ} \cup [\cup F^{i\geq 1}(C_{R, \succ})]$.

As for solution 1, this doesn't calculate the acceptable arguments in every context on its own. Since in some applications it is useful to know the conclusions from each context, the following solution resolves this problem.

Solution 3. Aggregating the sets of acceptable arguments

In this case we first compute the acceptable arguments of the frameworks $< A, R, Pref_1>$, …, $<A, R, Pref_n>$ as shown in section 2, let's denote them by S_1, …, S_n. These are, of course, the acceptable arguments from each context as required. Then we aggregate these sets to one set S_{a3}. S_{a3} will represent the acceptable arguments of the framework $< A, R, C, \succ, Pref_1, …, Pref_n>$. The idea of the aggregation is similar to the one presented in solution 1. We start by keeping all the arguments of a set S_i such that the context c_i is the most privileged one. Then we select the best context (in the sense of the relation $\succ$), c_j, among the remaining ones. Among the arguments of S_j we keep only those which are not defeated by an argument already kept.

Formally:

Definition 11. The set of acceptable arguments of the framework $<A, R, C, \succ, Pref_1, …, Pref_n>$ is $S_{a3} = \prod_n$ such that:

$T_1 = C$

$\prod_1 = \{A \in S_i$ such that $\forall c_j \neq c_i, c_i \succ c_j\}$

$T_{k+1} = T_k \setminus \{c_i\}$

$\prod_{k+1} = \prod_k \cup \{A \in S_i, c_i \in T_{k+1}$ such that $\forall c_j \in T_{k+1} \setminus \{c_i\}, c_i \succ c_j$ and $\nexists$ B $\in \prod_k$ such that B R A and B $>>^{Prefl}$ A with $c_l \notin T_{k+1}\}$.

Example 4. (continued) *Let consider the framework $<A, Rebut, C, \succ, Pref_1, Pref_2, Pref_3>$. $\{A\} \subseteq S_1$, $\{B, C\} \subseteq S_2$ and $\{D\} \subseteq S_3$. Then $\{A, C\} \subseteq S_{a3}$.*

Irrespective of whether we compute all the arguments from each context and then aggregate them, or combine the contexts and then compute the arguments we get the same set of acceptable arguments (as one would hope). This property is formalised as:

Proposition 1. Let $<A, R, C, \succ, Pref_1, …, Pref_n>$ be an argumentation framework based on contextual preferences. $S_{a1} = S_{a2} = S_{a3}$.

5. Acceptable deductions

The last step of the argumentation process is to conclude or to infer from an inconsistent knowledge base. Selecting the most acceptable arguments will enable us to find the most plausible inferences. So from the sets S_1, …S_n and S_{a3} we define the three following consequence relations.

Definition 12. Let $\sigma = <A, R, C, \succ, Pref_1, …, Pref_n>$ be a CPAF.

- h is a *contextual consequence* or a consequence from $c_i \in C$ iff $\exists$ (H, h) $\in S_i$. This relation is denoted as follows: $\sigma \mid\sim c_i : h$
- h is a *plausible consequence* iff $\exists$ $c_i \in C$ such that $\exists$ (H, h) $\in S_i$. This relation is denoted as follows: $\sigma \mid\sim \Diamond h$
- h is an *acceptable consequence* iff $\exists$ (H, h) $\in S_{a3}$. This relation is denoted as follows: $\sigma \mid\sim h$

The first consequence relation is the same as the one defined in the case of mono-context. It determines the conclusions that can be made from the knowledge base given a particular context. The second relation gives the conclusions that can be made from the knowledge base

given any context; the set of all conclusions that can be drawn from all contexts. Finally, acceptable consequence delivers the safe conclusions of an inconsistent knowledge base, those which take into account all the preference orders and the relationship between them.

Let Σ be a knowledge base and let's denote by respectively Δ_c, Δ_p, Δ_a the set of conclusions inferred with contextual consequence, plausible consequence and acceptable consequence from Σ. Formally:

$$\Delta = \{h / \Sigma \mid\!\!- h\}$$
$$\Delta_c = \{h / \sigma \mid\!\!\sim c_i : h\}$$
$$\Delta_p = \{h / \sigma \mid\!\!\sim \Diamond h\}$$
$$\Delta_a = \{h / \sigma \mid\!\!\sim h\}$$

Property 1. When the knowledge base Σ is consistent then $\Delta = \Delta_c = \Delta_p = \Delta_a$ for each context c_i.

Property 2. Let Σ be an inconsistent knowledge base. The following inclusions hold:

$$\Delta_c \subseteq \Delta_p$$
$$\Delta_a \subseteq \Delta_p$$

6. Conclusion

The work reported here concerns handling inconsistency using preference-based argumentation frameworks. The existing frameworks suppose that the knowledge base is equipped with only one preordering between the beliefs. Our principle contribution is to take into account contextual preferences which means that several preorderings on the knowledge base may be taken into account together.

In preference-based argumentation frameworks, the preferences are used to select the most acceptable arguments. Our aim is not to give a new definition of acceptability but to extend the framework developed in [1] to take into account contextual preferences. We have proposed three solutions to compute the acceptable arguments and we have shown that they give the same result. We have also proposed three consequence relations allowing the deduction from inconsistent knowledge bases.

An immediate extension of this work would be to study the logical properties of the consequence relations associated with the different sets of acceptable arguments we have defined in this paper. Another extension would be to take into account several knowledge bases instead of one, a very natural step since it is easy to imagine the separate contexts being different views of the same information in different knowledge bases (as in Example 3). In this way we can develop a distributed argumentation framework. This looks likely to be very useful in multi-agent systems where each agent is supposed to have its own knowledge base.

7. References

[1] L. Amgoud, C. Cayrol 2000. *A model of reasoning based on the production of acceptable arguments*. Accepted for publication in the proceedings of the 8th International Workshop on Non-Monotonic Reasoning NMR'2000 (Collocated with KR'2000), session Uncertainty frameworks in NMR. Colorado 2000.

[2] L. Amgoud, C. Cayrol 1998. *On the acceptability of arguments in preference-based argumentation frameworks. In: Proc. of the 14th Conference on Uncertainty in Artificial*

Intelligence, UAI'98. pp. 1-7.

[3] L. Amgoud, C. Cayrol, D. Le Berre 1996. Comparing Arguments using Preference Orderings for Argument-based Reasoning. *In: Proc. of the 8th International Conference on Tools with Artificial Intelligence, ICTAI'96*. pp. 400-403.

[4] C. Cayrol, V. Royer, C. Saurel 1993. Management of preferences in Assumption-Based Reasoning. *Lecture Notes in Computer Science (B. Bouchon-Meunier, L. Valverde, R.Y. Yager Eds.)*, Vol. 682. pp. 13 - 22.

[5] L. Cholvy 1998. A general framework for reasoning about contradictory information and some of its applications. *In: Proc. of ECAI workshop "Conflicts among Agents", ECAI'98.*

[6] P. M. Dung. 1993. On the acceptability of arguments and its fundamental role in non-monotonic reasoning and logic programming. *In: Proc. of the 13th International Joint Conference on -Artificial Intelligence, IJCAI'93*. pp. 852-857.

[7] M. Elvang-Goransson, A. Hunter. 1995. Argumentative logics: Reasoning with classically inconsistent information. *Data & Knowledge Engineering.* Vol. 16, pp. 125-145.

[8] F. Lin, Y. Shoham. 1989. Argument systems - A uniform basis for non-monotonic reasoning. *In: Proc. of the first International Conference on Principles of Knowledge Representation and Reasoning, KR'89*. pp. 245-255.

[9] J. McCarthy. First-order theories of individual concepts and propositions. *Expert Systems in the Micro Electronic Age*, 1979.

[10] G. Pinkas, R. P. Loui 1992. Reasoning from inconsistency : a taxonomy of principles for resolving conflicts. *In: Proc. of the 3rd International Conference on Principles of Knowledge representation and Reasoning, KR'92*. pp. 709-719.

[11] J. L. Pollock. 1992. How to reason defeasibly. *Artificial Intelligence*. Vol. 57, pp. 1-42.

[12] H. Prakken, G. Sartor. 1996. A Dialectical Model of Assessing Conflicting Arguments in Legal Reasoning. *Artificial Intelligence and Law*. pp. 331-368.

[13] G. R. Simari, R. P. Loui. 1992. A mathematical treatment of defeasible reasoning and its implementation. *Artificial Intelligence*. Vol. 53, pp. 125-157.

[14] G. Vreeswijk. 1991. The feasibility of defeat in defeasible reasoning. *In: Proc. of the 2nd International Conference on Principles of Knowledge Representation and Reasoning, KR'91.* pp. 526-534.