Argument Theory Change Through Defeater Activation

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Abstract. Argument Theory Change (ATC) applies classic belief change concepts to the area of argumentation. This intersection of fields takes advantage of the definition of a Dynamic Abstract Argumentation Framework, in which an argument is either active or inactive, and only in the former case it is taken into consideration in the reasoning process. ATC identifies how the framework has to be modified in order to achieve warrant for a certain argument. The present article copes with this matter by defining a revision operator based on activation of arguments, *i.e.,* recognizing the knowledge that is missing.

1. Introduction and Background

This article presents a new approach to Argument Theory Change (ATC) [9,11], where belief change concepts [1,8] are translated to the field of argumentation. Here we use the Dynamic Abstract Argumentation Framework (DAF) [12], which extends Dung's framework [6] in order to consider (1) subarguments (internal, necessary parts of an argument that are arguments by themselves), and (2) a set of active arguments (those available to perform reasoning). The main contribution provided by ATC is a revision operator at argument level that revises a theory by an argument seeking for its warrant. That is, an argument is activated (begins to be considered by the argumentation machinery) and after its new status is analyzed, the revision theory proposes additional modifications to the set of active arguments in order to finally warrant the argument. The arguments to be activated will be defeaters of those somehow interfering with the warrant of the argument at issue. However, since defeaters might be unavailable to be activated, the activating revision is not always successful.

This article does not pursue a full formalization according to the classical theory of belief revision. Thus, no representation theorems nor characterization postulates are to be defined here. Instead, we look at the process of change from the argumentation standpoint. However, the usual principles of change from belief revision were taken into account, namely, minimal change and success.

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2. A Dynamic Abstract Framework

Arguments, in the usual sense, are interpreted as a reason for a certain claim from a set of premises. In abstract argumentation [5,10], these features are abstracted away; hence we will work with arguments as "black boxes of knowledge" which may be divided in several smaller arguments, referred to as *subarguments*. In the dynamic framework used here we assume a *universal set* of arguments holding every conceivable argument that could be used by the inference machinery, from which a subset of *active arguments* can be distinguished. These arguments represent the current state of the world and are the only ones to be considered to compute warrant. Activation and deactivation of arguments are thus assumed to be determined from an external mechanism. In some domains, an agent might have the capability of de/activating arguments, and therefore the challenge is to decide what kind of change has to be performed, *i.e.,* what to de/activate. This is the point in which ATC enters the scene, allowing to handle de/activation of arguments in a proper manner, seeking for a concrete objective. These changes are performed at a theoretical level, *i.e.,* any inactive argument could be eventually activated.

Definition 1 (DAF) *A* ***dynamic abstract argumentation framework*** *(DAF) is a tuple* $\langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}]$*, where* $\mathbb{U}$ *is a finite set of arguments called* ***universal****,* $\mathbb{A} \subseteq \mathbb{U}$ *is called the* ***set of active arguments****,* $\hookrightarrow \subseteq \mathbb{U} \times \mathbb{U}$ *denotes the* ***attack relation****, and* $\sqsubseteq \subseteq \mathbb{U} \times \mathbb{U}$ *denotes the* ***subargument relation****.*

The principle characterizing argument activation is:

(Activeness Propagation) $\mathcal{B} \in \mathbb{A}$ iff $\mathcal{B}' \in \mathbb{A}$ for any $\mathcal{B}' \sqsubseteq \mathcal{B}$.

In this article, we build and evaluate a *dialectical tree* rooted in the argument under study in order to determine whether it is warranted. A dialectical tree is conformed by a set of *argumentation lines*; each of which is a non-empty sequence λ of arguments from a DAF, where each argument in λ attacks its predecessor in the line. The first argument is called the *root*, and the last one, the *leaf* of λ. Different restrictions on the construction of argumentation lines can be defined under the name of *dialectical constraints* (DC) [7]. DCs are useful to determine whether an argumentation line is finally *acceptable*. We assume a DC to avoid constructing circular argumentation lines, keeping them finite.

We call *dynamic argumentation theory* (DAT) to a DAF closed under activeness propagation and enriched with DCs. An operator $\mathrm{C}_{\mathfrak{ap}} : \mathcal{P}(\mathbb{U}) \rightarrow \mathcal{P}(\mathbb{U})$ is assumed to implement the *closure under activeness propagation* required by a DAT $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}]$, where $\mathbb{A} = \mathrm{C}_{\mathfrak{ap}}(\mathbb{A})$. To represent change over the set of active arguments we assume an *activation operator* $\oplus : \mathcal{P}(\mathbb{U}) \times \mathcal{P}(\mathbb{U}) \rightarrow \mathcal{P}(\mathbb{U})$ such that $\Psi_1 \oplus \Psi_2 = \mathrm{C}_{\mathfrak{ap}}(\Psi_1 \cup \Psi_2)$, with $(\Psi_1 \cup \Psi_2) \subseteq \mathbb{U}$. The domain of all acceptable argumentation lines in a DAT T, is noted as $\mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$, while $\mathfrak{Lines}_{\mathsf{T}}^{\mathbb{A}} \subseteq \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$ will be the domain enclosing every acceptable line containing only active arguments. The root argument of a line λ from a DAT T will be identified through the function $\mathsf{root} : \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}} \rightarrow \mathbb{U}$. From now on, given a DAT T, to refer to an argument $\mathcal{A}$ belonging to a line $\lambda \in \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{A}}$, we will overload the membership symbol and write "$\mathcal{A} \in \lambda$", and will refer to λ simply as argumentation line (or just line) assuming it is acceptable. We identify the *set of pro (resp, con) arguments* containing all arguments placed on odd (resp, even) positions in a line λ, noted as λ^+ (resp, λ^-).

Definition 2 (Upper Segment) *Given a DAT* T *and a line* $\lambda \in \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$ *such that* $\lambda = [\mathcal{B}_1, \ldots, \mathcal{B}_n]$*, the* ***upper segment*** *of* λ *wrt.* $\mathcal{B}_i$ $(1 \leq i \leq n)$ *is defined as* $\lambda^{\uparrow}[\mathcal{B}_i] = [\mathcal{B}_1, \ldots, \mathcal{B}_i]$*. The* ***proper upper segment*** *of* λ *wrt.* $\mathcal{B}_i$ $(i \neq 1)$ *is* $\lambda^{\uparrow}(\mathcal{B}_i) = [\mathcal{B}_1, \ldots, \mathcal{B}_{i-1}]$*.*

We refer to both proper and non-proper upper segments simply as "upper segment" and either usage will be distinguishable through its notation (round or square brackets respectively).

Definition 3 (Dialectical Tree) *Given a DAT* T*, a* ***dialectical tree*** $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *rooted in* $\mathcal{A}$ *is built by a set* $X \subseteq \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$ *of lines rooted in* $\mathcal{A}$*, such that an argument* $\mathcal{C}$ *in* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *is: (1) a* ***node*** iff $\mathcal{C} \in \lambda$*, for any* $\lambda \in X$*; (2) a* ***child*** *of a node* $\mathcal{B}$ *in* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ iff $\mathcal{C} \in \lambda$*,* $\mathcal{B} \in \lambda'$*, for any* $\{\lambda, \lambda'\} \subseteq X$*, and* $\lambda'^{\uparrow}[\mathcal{B}] = \lambda^{\uparrow}(\mathcal{C})$*. A leaf of any line in* X *is a* ***leaf*** *in* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$*.*

However, the acceptability of a dialectical tree will depend on the set X of lines used to build such tree. Hence, an acceptable dialectical tree will be constructed from a *bundle set* $\mathcal{S}_{\mathsf{T}}(\mathcal{A})$ which –given a DAT T– contains all the acceptable and exhaustive argumentation lines from $\mathfrak{Lines}_{\mathsf{T}}^{\mathbb{A}}$ rooted in $\mathcal{A}$. (We refer to a line as exhaustive when no more arguments can be added to it.) Thus, following Def. 3, $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ is acceptable if it is built from a set $X = \mathcal{S}_{\mathsf{T}}(\mathcal{A})$. The domain of all acceptable dialectical trees from T is noted as $\mathfrak{Trees}_{\mathsf{T}}$. Besides, we will overload the membership symbol and write "$\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$" when the line λ belongs to the tree $\mathcal{T}_{\mathsf{T}}(\mathcal{A}) \in \mathfrak{Trees}_{\mathsf{T}}$.

Dialectical trees allow to determine whether the root node of the tree is warranted or not. This evaluation will weigh all the information present in the tree through a *marking criterion* to evaluate each argument in the tree –in particular the root– by assigning them a mark within the domain $\{D, U\}$, where U (resp., D) denotes an undefeated (resp., defeated) argument. We will adopt a skeptical marking criterion: (1) all leaves are marked U; and (2) every inner node $\mathcal{B}$ is marked U iff every child of $\mathcal{B}$ is marked D, otherwise, $\mathcal{B}$ is marked D. Finally, warrant is specified through a function $\mathsf{Mark} : \mathfrak{Trees}_{\mathsf{T}} \to \{D, U\}$ returning the mark of the root.

Definition 4 (Warrant) *Given a DAT* T*, an active argument* $\mathcal{A} \in \mathbb{A}$ *is* ***warranted*** iff $\mathsf{Mark}(\mathcal{T}_{\mathsf{T}}(\mathcal{A})) = U$*. Whenever* $\mathcal{A}$ *is warranted, the dialectical tree* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *is called* ***warranting tree****; otherwise, it is called* ***non-warranting tree****.*

3. An Activating Approach to ATC

The core of the change machinery involves the *alteration* of some lines in such dialectical tree when it happens to be non-warranting. Therefore, the objective of altering lines is to change the topology of the tree containing them in order to turn it to warranting. Alteration of lines comes from activation of arguments; that is, arguments cannot be simply added to the tree. Since an argument could appear in different positions in several lines in a tree, an alteration of a line could result in collateral alterations of other lines. This may end up extending the line and even incorporating new lines to the tree.

Definition 5 (Attacking Set) *Given a (not necessarily acceptable) tree* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *built from a set* $X \subseteq \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$ *of lines rooted in* $\mathcal{A}$*; the* ***attacking set*** $Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A}))$ *is the minimal subset of* X *if the tree built from the set* $(X \setminus Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A})))$ *warrants* $\mathcal{A}$*, otherwise* $Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A})) = X$*.*

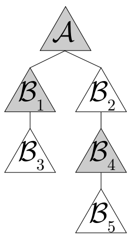
We refer to the lines included in the attacking set as *attacking lines*. The objective of Def. 5 is to identify attacking lines in a tree. This definition considers any set X, disregarding acceptability of lines and in/active arguments. (This generalization will be useful later.) In particular, when X is a bundle set $\mathcal{S}_{\mathsf{T}}(\mathcal{A})$, the tree $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ is acceptable, however, $(\mathcal{S}_{\mathsf{T}}(\mathcal{A}) \backslash Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A})))$ is not a bundle set, since it discards lines rooted in $\mathcal{A}$, and thus the tree built from it is not acceptable. That is, the removal of the attacking lines from the bundle set of a non-warranting tree is not intended to conform a change operation, but to pose a hypothetical scenario useful to isolate the causes for a non-warranting tree. Observe that a tree without attacking lines is warranting.

Lemma 1 *A tree* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *is warranting* iff $Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A})) = \emptyset$.

Proposition 1 *Given a line* $\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$*, if* $\lambda \in Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A}))$ *then every* $\mathcal{B} \in \lambda^{+}$ *(resp.,* $\mathcal{B} \in \lambda^{-}$*) is marked* D *(resp.,* U*).*

The following example (worked throughout the rest of the article) shows the importance of identifying the precise argument –in a line to be altered– for which a defeater needs to be activated. This is addressed by the *argument selection function* (Def. 6). Trees are drawn with gray/white triangles denoting defeated/undefeated arguments.

Example 1 *Consider a DAT* T *yielding the tree* $\mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *on the right with lines* $\lambda_1 = [\mathcal{A}, \mathcal{B}_1, \mathcal{B}_3]$ *and* $\lambda_2 = [\mathcal{A}, \mathcal{B}_2, \mathcal{B}_4, \mathcal{B}_5]$*. There is a single attacking line within the attacking set* $Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A})) = \{\lambda_2\}$*. If we activate a defeater for* $\mathcal{B}_2$ *in* T*, we would generate a new line within a new tree having no attacking lines. If we instead add a defeater for* $\mathcal{B}_5$*, the line that was attacking is "extended" and again, in the resulting tree, there would be no attacking lines. On the other hand, if we activate a defeater for* $\mathcal{B}_4$*, we would generate another attacking line.*



We call *effective alteration* to the alteration of an attacking line that turns it to non-attacking. The alteration of a given attacking line is done by activating a defeater $\mathcal{D}$ for a con argument $\mathcal{B}$ in the line. This would imply $\mathcal{B}$ to end up marked as defeated. Afterwards, from Prop. 1, the resulting altered line would not be attacking. However, a variety of situations may appear: if $\mathcal{D}$ does not exist, the alteration of the line over $\mathcal{B}$ turns out to be unachievable. Later it will be clear that, when this happens for every con argument in the same line, the revision operation cannot succeed. On the other hand, activating a defeater for a con argument may bring not only that argument to the resulting tree, but a whole new subtree. Hence, an effective alteration in the activating approach will require to ensure the new defeater to end up undefeated within the resulting tree.

Definition 6 (Argument Selection) *Given a DAT* $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}]$ *and a line* $\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$*; the* ***argument selection function*** $\gamma_{\mathsf{T}} : \mathfrak{Lines}^{\mathbb{A}}_{\mathsf{T}} \to \mathbb{A}$ *is such that* $\gamma_{\mathsf{T}}(\lambda) \in \lambda^{-}$.

When selecting a con argument from a line $\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$, a selection criterion could lead the mapping of $\gamma_{\mathsf{T}}(\lambda)$ to an argument $\mathcal{B} \in \lambda^{-}$ by setting an ordering among the con arguments in λ. In this article we abstract away from any specific selection criterion.

Definition 7 (Set of Inactive Defeaters) *Let* $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}]$ *be a DAT, the* ***set of inactive defeaters*** *of an argument* $\mathcal{B}$ *in a line* $\lambda \in \mathfrak{Lines}^{\mathbb{A}}_{\mathsf{T}}$*, is determined by the function*

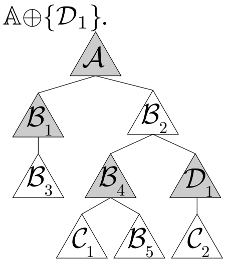
$\mathsf{idefs}_{\mathsf{T}} : \mathbb{A} \times \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{A}} \to \mathcal{P}(\mathbb{I})$ *such that:*
$\mathsf{idefs}_{\mathsf{T}}(\mathcal{B}, \lambda) = \{\mathcal{D} \in \mathbb{I} \mid$ *for every* $\lambda' \in \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$*, such that* $\mathcal{D} \in \lambda'$ *and* $\lambda^{\uparrow}[\mathcal{B}] = \lambda'^{\uparrow}(\mathcal{D})\}$

From Def. 7, every inactive defeater $\mathcal{D}$ of $\mathcal{B} \in \lambda$ belongs to a line λ' from $\mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}$ which means that λ' is acceptable but contains inactive arguments. Requiring $\lambda'^{\uparrow}(\mathcal{D})$ to coincide with $\lambda^{\uparrow}[\mathcal{B}]$ implies not only the segments from the root to $\mathcal{B}$ in both λ and λ' to be equal, but also $\mathcal{D} \hookrightarrow \mathcal{B}$.

The following notion allows to anticipate the effect of several changes over a DAT T by identifying a *hypothetical tree* $\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \Psi)$, as the tree rooted in $\mathcal{A}$ that would result from T by the hypothetical activation of the arguments in a set $\Psi \subseteq \mathbb{U}$. We refer to these trees as hypothetical given that they do not appear within the domain $\mathfrak{Trees}_{\mathsf{T}}$.

Definition 8 (Hypothetical Tree) *Given a DAT* $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle[\mathbb{A}]$*,* $\mathcal{A} \in \mathbb{A}$*, and* $\Psi \subseteq \mathbb{U}$*; the* ***hypothetical tree*** $\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \Psi)$ *is the tree built from the set of lines:*
$\{\lambda^{\uparrow}[\mathcal{B}] \mid \forall \lambda \in \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{U}}, \forall \mathcal{C} \in \lambda^{\uparrow}[\mathcal{B}] : \mathcal{C} \in (\mathbb{A} \oplus \Psi)$ *holds, where* $\mathsf{root}(\lambda) = \mathcal{A}$ *and either* ($\mathcal{B}$ *is the leaf of* λ) *or* $(\exists \mathcal{D} \in \lambda : \lambda^{\uparrow}(\mathcal{D}) = \lambda^{\uparrow}[\mathcal{B}]$ *and* $\mathcal{D} \notin (\mathbb{A} \oplus \Psi))\}$

Example 2 (Ex. 1 cont.) *Given the attacking line* $\lambda_2 = [\mathcal{A}, \mathcal{B}_2, \mathcal{B}_4, \mathcal{B}_5]$ *from Ex. 1, in order to warrant* $\mathcal{A}$ *a selection in* λ *should be performed. Assume that* $\mathcal{B}_2$ *is the most suitable argument according to the selection criterion:* $\gamma_{\mathsf{T}}(\lambda_2) = \mathcal{B}_2$*. Let consider* $\mathcal{D}_1 \in \mathsf{idefs}_{\mathsf{T}}(\mathcal{B}_2, \lambda_2)$ *as a* $\mathcal{B}_2$*'s defeater that could be activated, and assume the activation of* $\mathcal{D}_1$ *determines a new active set of arguments such that* $\{\mathcal{C}_1, \mathcal{C}_2\} \subset \mathbb{A} \oplus \{\mathcal{D}_1\}$*.*
Assume the collateral activation of $\mathcal{C}_1$ *as a consequence of the activation of* $\mathcal{D}_1$ *–for instance, we could have that* $\mathcal{C}' \sqsubseteq \mathcal{D}_1, \mathcal{C}' \sqsubseteq \mathcal{C}_1$ *and that the activation of* $\mathcal{C}'$ *activates* $\mathcal{C}_1$*. Additionally, suppose that* $\mathcal{C}_1 \hookrightarrow \mathcal{B}_4$*. Regarding* $\mathcal{C}_2$*, let assume it defeats* $\mathcal{D}_1$*, thus the activation of* $\mathcal{D}_1$ *would provoke* $\mathcal{C}_2$ *to be included in the resulting tree. Hence, from the hypothetical tree* $\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \{\mathcal{D}_1\})$ *on the right,* $\mathcal{A}$ *remains defeated, since the mark of* $\mathcal{B}_2$ *could not be turned to D.*



The addition of a defeater $\mathcal{D}$ for an argument in a line λ provokes a *line extension*: if $\mathcal{D}$ attacks the leaf of λ, the whole line ends up extended; but if $\mathcal{D}$ attacks an argument placed strictly above that leaf, a new argumentation line arises by extending an upper segment of λ. The activation of $\mathcal{D}$ not only attaches $\mathcal{D}$ to λ, but it also includes the addition of $\mathcal{D}$'s (active) defeaters, and these defeaters bring their (active) defeaters, and so on, and finally an entire subtree rooted in $\mathcal{D}$ sprouts from the activation of $\mathcal{D}$. This subtree could contain arguments that were already active, as well as arguments that ended up activated by virtue of activeness propagation. It is required to verify that the selected con argument (attacked by $\mathcal{D}$) finally ends up defeated, making the alteration of λ effective.

Definition 9 (Argument Defeating) *Given a DAT* $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle[\mathbb{A}]$ *and a line* $\lambda \in \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{A}}$*, where* $\gamma_{\mathsf{T}}(\lambda) = \mathcal{B}$ *is the selected argument over* $\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$ *and* $\mathcal{A} = \mathsf{root}(\lambda)$*; the* ***argument defeating function*** $\sigma_{\mathsf{T}} : \mathfrak{Lines}_{\mathsf{T}}^{\mathbb{A}} \to \mathbb{U}$ *is:*

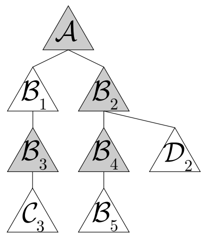
$$\sigma_{\mathsf{T}}(\lambda) = \begin{cases} \mathcal{D} \in \mathsf{idefs}_{\mathsf{T}}(\mathcal{B}, \lambda) & \textit{if } \mathcal{B} \in \lambda' \textit{ is marked } D. \\ \mathcal{A} & \textit{otherwise.} \end{cases}$$

where $\lambda' \in \mathcal{H}_{\mathsf{T}}(\mathcal{A}, \{\mathcal{D}\})$*, and* $\lambda'^{\uparrow}[\mathcal{B}] = \lambda^{\uparrow}[\mathcal{B}]$*.*

The defeating function returns the root argument when either it does not find a defeater, or every defeater found leads to a non-effective alteration. Thus, there would be no plausible inactive defeater for the selection at issue, situation that could be solved by a new selection in the same line. This is addressed by the following principle.

(Effective Alteration) $\sigma_{\mathsf{T}}(\lambda) \neq \mathcal{A}$, for any $\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$.

Example 3 (Ex. 2 cont.) *From $\gamma_{\mathsf{T}}(\lambda_2) = \mathcal{B}_2$ we have that introducing $\mathcal{D}_1$ as a defeater for $\mathcal{B}_2$ would not be an effective alteration. Assume there exists a second defeater $\mathcal{D}_2 \in \mathsf{idefs}_{\mathsf{T}}(\mathcal{B}_2, \lambda_2)$ whose activation would yield the hypothetical tree $\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \{\mathcal{D}_2\})$ on the right. Now the mark of $\mathcal{B}_2$ turns to D; nonetheless, by assuming $\mathcal{C}_3 \in \mathbb{A}{\oplus}\{\mathcal{D}_2\}$ and $\mathcal{C}_3 {\hookrightarrow} \mathcal{B}_3$, line $\lambda_1 = [\mathcal{A}, \mathcal{B}_1, \mathcal{B}_3]$ is collaterally altered, and even more, such collateral alteration turns the line to attacking. Since this alteration is independent from λ_2, λ_1 needs to be treated separately in a way that such collateral alteration does not affect it.*



Definition 10 (Collateral Alterations) *Let $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle[\mathbb{A}]$ be a DAT, the **set of collateral alterations** of a line $\lambda \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$, where $\mathcal{A} = \mathsf{root}(\lambda)$, is a function $\mathsf{coll}(\sigma_{\mathsf{T}}) : \mathfrak{Lines}^{\mathbb{A}}_{\mathsf{T}} \to \mathcal{P}(\mathbb{U} \times \mathfrak{Lines}^{\mathbb{A}}_{\mathsf{T}})$ such that:*
$\mathsf{coll}(\sigma_{\mathsf{T}})(\lambda) = \{\langle \mathcal{C}, \lambda' \rangle \mid$ *for any $\lambda' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$ and any $\mathcal{C} \in \lambda'$ such that for either $\lambda \neq \lambda'$ or $\mathcal{C} \neq \gamma_{\mathsf{T}}(\lambda)$, it follows* $\mathsf{idefs}_{\mathsf{T}}(\mathcal{C}, \lambda') \cap (\mathbb{A}{\oplus}\{\sigma_{\mathsf{T}}(\lambda)\}) \neq \emptyset\}$
A tuple $\langle \mathcal{C}, \lambda' \rangle$ identifies $\mathcal{C} \in \lambda'$ for which an inactive defeater is collaterally activated.

Example 4 *Collateral alterations occur in Ex. 2, where activating $\mathcal{D}_1$ implies the collateral activation of $\mathcal{C}_1$, and the collateral alteration of λ_2. A similar situation occurs in Ex. 3 with the activation of $\mathcal{D}_2$ and the collateral activation of $\mathcal{C}_3$. Finally, since $\sigma_{\mathsf{T}}(\lambda_2) = \mathcal{D}_2$ we have that $\langle \mathcal{B}_3, \lambda_1 \rangle \in \mathsf{coll}(\sigma_{\mathsf{T}})(\lambda_2)$.*

Collateral alterations should be controlled to avoid triggering new attacking lines. Since these changes have still not been made to the theory, the selection necessarily needs to map to arguments in the original tree. The selection function in a line that will be collaterally altered should be required to map to an argument in the upper segment of the collateral activation in that line. Thus we would *preserve* the effectivity of alterations achieved through a defeating function.

(Preservation) If $\langle \mathcal{C}, \lambda \rangle \in \mathsf{coll}(\sigma_{\mathsf{T}})(\lambda')$ then $\gamma_{\mathsf{T}}(\lambda) \in \lambda^{\uparrow}[\mathcal{C}]$ and $\mathcal{C} \neq \mathcal{A}$, $\forall \lambda' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$

Requiring to select in $\lambda^{\uparrow}[\mathcal{C}]$ ensures the mapping of the defeating function to provoke an effective alteration, since the new subtree would appear only below $\mathcal{C}$. This solves having this subtree defeating a pro argument in λ. Collateral alterations may extend the same line more than once. This threat is called *cumulative collateral alteration*.

(Non-Cumulativity) For any $\lambda \in \mathfrak{Lines}^{\mathbb{U}}_{\mathsf{T}}$ and $\lambda' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$ such that $\sigma_{\mathsf{T}}(\lambda') = \mathcal{D}$, if $\lambda^{\uparrow}(\mathcal{D}) = \lambda'^{\uparrow}[\mathcal{B}]$ then either $\mathcal{D}$ is a leaf of λ or there is some $\mathcal{C} \in \lambda$ such that $\mathcal{D} \in \lambda^{\uparrow}(\mathcal{C})$ and $\forall \mathcal{B}' \in \lambda^{\uparrow}(\mathcal{C})$ it holds that $\mathcal{B}' \in \mathbb{A}{\oplus}\{\mathcal{D}\}$ and $\mathcal{C} \notin \mathbb{A}{\oplus}\bigcup \sigma_{\mathsf{T}}(\lambda'')$, $\forall \lambda'' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$

To clarify, consider $\lambda = [\mathcal{A}, \ldots, \mathcal{B}, \mathcal{D}, \ldots, \mathcal{D}', \mathcal{C}, \ldots]$ where $\lambda' = [\mathcal{A}, \ldots, \mathcal{B}]$ is a line in the tree to be altered. Assume a defeating function mapping to $\mathcal{D}$, thus the activation of $\mathcal{D}$ leads to $[\mathcal{A}, \ldots, \mathcal{B}, \mathcal{D}, \ldots, \mathcal{D}']$ which ends up conforming the new altered line. (Recall that the defeating function ensures this alteration to be effective.) Afterwards, an argument activation from a different line in the tree triggers the collateral activation of $\mathcal{C}$, which ends up altering once more the same line, extending it. In this case, the activation of $\mathcal{D}$ cannot be ensured to be an effective alteration. Therefore, we need to protect the new subtree rooted in $\mathcal{D}$ (attached to $\mathcal{B}$) from collateral alterations like $\mathcal{C}$, which are "invisible" to the preservation principle.

Definition 11 (Warranting Defeating) *A defeating function "σ_{T}" is said to be* ***warranting*** *if it satisfies effective alteration, preservation, and non-cumulativity.*

The *alteration set* of a tree, contains the tree's attacking set along with those collaterally altered lines that end up turned into attacking in the resulting tree.

Definition 12 (Alteration Set) *Given a DAT* $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}]$*; the* ***alteration set*** $\Lambda_{\mathsf{T}}(\mathcal{A})$ *of the tree* $\mathcal{T}_{\mathsf{T}}(\mathcal{A}) \in \mathfrak{Trees}_{\mathsf{T}}$ *is the least fixed point of the operator* $\ell_{\mathsf{T}}(\mathcal{A})$*:*
$\ell_{\mathsf{T}}(\mathcal{A})^0 = Att(\mathcal{T}_{\mathsf{T}}(\mathcal{A}))$*, and*
$\ell_{\mathsf{T}}(\mathcal{A})^{k+1} = \ell_{\mathsf{T}}(\mathcal{A})^k \cup \{\lambda' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A}) |$ *for any* $\lambda \in Att(\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \Psi))$ *there is some* $\mathcal{B} \in \lambda$ *and* $\mathcal{D} \in \lambda$ *such that* $\mathcal{D} \notin \lambda'$ *and* $\lambda^{\uparrow}(\mathcal{D}) = \lambda'^{\uparrow}[\mathcal{B}]$ *where* $\Psi = \bigcup_{\lambda'' \in \ell_{\mathsf{T}}(\mathcal{A})^k} \sigma_{\mathsf{T}}(\lambda'')\}$

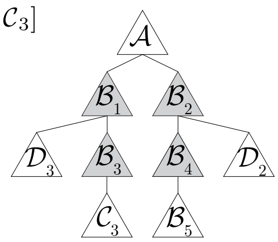
Within a step $\ell_{\mathsf{T}}(\mathcal{A})^{k+1}$ we include the lines in $\ell_{\mathsf{T}}(\mathcal{A})^k$ along with every $\lambda' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$ that would be collaterally altered (by activating an argument $\sigma_{\mathsf{T}}(\lambda'')$ where $\lambda'' \in \mathcal{T}_{\mathsf{T}}(\mathcal{A})$ and λ'' belongs to $\ell_{\mathsf{T}}(\mathcal{A})^k$) conforming a line λ which would end up being a new attacking line in the hypothetical tree. Finally, if "σ_{T}" is warranting then it cannot be the case that $\lambda' = \lambda''$ holds. This means that once the mapping $\sigma_{\mathsf{T}}(\lambda'')$ is considered in Ψ, no collateral alteration of λ'' will be included in $Att(\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \Psi))$ for any tree $\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \Psi)$.

Definition 13 (Argument Revision) *An* ***activating argument revision*** *operator "$*$" over* $\mathsf{T} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}]$ *by* $\mathcal{A} \in \mathbb{U}$ *is defined as:*

$$\mathsf{T}{*}\mathcal{A} = \begin{cases} \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}''] & \text{if "}\sigma_{\mathsf{T}}\text{" is warranting, or} \\ \mathsf{T} & \text{otherwise,} \end{cases}$$

where $\mathbb{A}'' = \mathbb{A}' \oplus \bigcup_{\lambda \in \Lambda_{\mathsf{T}'}(\mathcal{A})} \sigma_{\mathsf{T}}(\lambda)$ *,* $\mathbb{A}' = \mathbb{A} \oplus \{\mathcal{A}\}$*, and* $\mathsf{T}' = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A}']$

Example 5 (Ex. 3 cont.) *From* $\sigma_{\mathsf{T}}(\lambda_2) = \mathcal{D}_2$ *we have that* λ_1 *is collaterally altered by the collateral activation of* $\mathcal{C}_3$*. Moreover, since line* $[\mathcal{A}, \mathcal{B}_1, \mathcal{B}_3, \mathcal{C}_3]$ *is in the attacking set of* $\mathcal{H}_{\mathsf{T}}(\mathcal{A}, \{\mathcal{D}_1\})$*, the resulting alteration set ends up being* $\Lambda_{\mathsf{T}}(\mathcal{A}) = \{\lambda_1, \lambda_2\}$*. Note that having* $\langle \mathcal{B}_3, \lambda_1 \rangle \in \mathsf{coll}(\sigma_{\mathsf{T}})(\lambda_2)$*, from preservation* $\gamma_{\mathsf{T}}(\lambda_1) \in \lambda_1^{\uparrow}[\mathcal{B}_3]$ *must hold. Thus, assuming* $\gamma_{\mathsf{T}}(\lambda_1) = \mathcal{B}_1$ *and* $\sigma_{\mathsf{T}}(\lambda_1) = \mathcal{D}_3$*, preservation is guaranteed. Note that the defeating function ends up guaranteeing also both the effective alteration and the non-cumulativity principles. Finally, the warranting tree on the right appears from the revised framework* $\mathsf{T}{*}\mathcal{A} = \langle \mathbb{U}, \hookrightarrow, \sqsubseteq \rangle [\mathbb{A} \oplus \{\mathcal{A}, \mathcal{D}_2, \mathcal{D}_3\}]$.



The following results ensure that the revision of a theory through a warranting defeating function is successful and warrants $\mathcal{A}$, as stated by Theorem 1. Corollary 1 states that the revision does not change the original theory either when it already warranted $\mathcal{A}$ or the revision could not be successful.

Lemma 2 *If* $\mathsf{T}{*}\mathcal{A}$ *uses a warranting defeating function then* $Att(\mathcal{T}_{(\mathsf{T}*\mathcal{A})}(\mathcal{A})) = \emptyset$.

Theorem 1 $\mathsf{T}{*}\mathcal{A}$ *warrants* $\mathcal{A}$ iff $\mathsf{T}{*}\mathcal{A}$ *uses a warranting defeating function.*

Corollary 1 $\mathsf{T}{*}\mathcal{A} = \mathsf{T}$ iff *either* T *warrants* $\mathcal{A}$ *or* $\mathsf{T}{*}\mathcal{A}$ *does not warrant* $\mathcal{A}$.

4. Conclusions, Related and Future Work

We have presented a new approach for argument revision considering activation of arguments. This new approach is comprehended within Argument Theory Change [11] and provides another standpoint to change the status of warrant of an argument.

Regarding related work, in [4] change is studied over the set of extensions of a system after adding an argument. However, they pose a strong restriction: the newly added argument must have at most one interaction (via attack) with an argument in the system. This restriction (which we do not assume) greatly simplifies the revision problem, as multiple interactions with the original system are difficult to handle. Moreover, we consider the complexity added by subarguments.

Revision over an argumentation-based decision making system was defined in [2] through a generalization of the revision technique from [4], which evaluates the warrant status of a newly inserted argument supporting an option. A similar approach was presented in [3]. There, the *abstraction* of a framework (*i.e.,* removal of a set of arguments or attacks) is considered, and principles are proposed to establish conditions under which the semantics remains unchanged, in order to avoid its recomputation.

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