On Instantiating Generalised Properties of Gradual Argumentation Frameworks

Antonio Rago, Pietro Baroni, and Francesca Toni

Imperial College London, UK, Brescia University, Italy, Imperial College London, UK
a.rago15@imperial.ac.uk, pietro.baroni@unibs.it,
ft@imperial.ac.uk

Abstract. Several gradual semantics for abstract and bipolar argumentation have been proposed in the literature, ascribing to each argument a value taken from a scale, i.e. from some ordered set. These values somewhat match the arguments' dialectical status and provide an indication of their dialectical strength, in the context of the given argumentation framework. These research efforts have been complemented by formulations of several properties that these gradual semantics may satisfy. More recently a synthesis of many literature properties into more general groupings based on parametric definitions has been proposed. In this paper we show how this generalised parametric formulation enables the identification of new properties not previously considered in the literature and discuss their usefulness to capture alternative requirements coming from different application contexts.

1 Introduction

Abstract Argumentation Frameworks (AFs) and their semantics [11] are a well-known formalism to represent at an abstract level conflicts between *arguments*, expressed as a binary relation of *attack*, and to evaluate the acceptance status of the arguments on the basis of the attack relation. Several extensions or modifications of AFs and their semantics have been proposed. Notably, a *support* relation between arguments may be used alongside or instead of the attack relation, as in Bipolar Argumentation Frameworks (BAFs) [5]/Quantitative Argumentation Debates (QuAD frameworks) [8] and as in Support Argumentation Frameworks (SAFs) [3], respectively. Moreover, several *gradual* (rather than *extension-based* [11]) semantics for AFs, BAFs and SAFs have been proposed in the literature, e.g. as in [5,14,13,12,8], ascribing to arguments values from one ordered set or another. These values somewhat match the arguments' dialectical status and provide an indication of their dialectical strength, in the context of the given argumentation framework. For example, the *Game-Theoretical* strengths of [14,6] assign values in $[0,1]$ to arguments in an AF or a BAF, by assessing the arguments' influence on players' rewards when included in strategies of suitable classes of games of argumentation. The *Social Models* of [13] also assign strengths from $[0,1]$ to arguments in an AF, aggregating attacks so as to reduce an argument's strength in proportion with its attackers' strength, while taking into account users' votes in a social context. The approach of [5] is similar in that it also aggregates attackers and supporters in a proportional manner, but for BAFs where arguments have an initial *intrinsic strength* (or

base score): attackers and supporters reduce and increase, respectively, an argument's strength, which in this case is a value in [-1,1].

These research efforts have been complemented by formulations of several properties that these gradual semantics may satisfy. For example, *Maximality* [2] states that any argument in an AF without any attackers should have a strength equal to its base score. Analogously, for SAFs, *Minimality* [3] states that any argument without any supporter should have a strength equal to its base score. For BAFs, *Equation 4* in [8] combines both of these concepts to state that an argument with no attackers and no supporters has a strength equal to its base score. These properties are defined for different types of argumentation frameworks but clearly share the same intuition.

Recently, the study of specific properties for specific types of frameworks has been extended by critical syntheses within more general groupings based on parametric formulations [7]. In particular, [7] introduces eleven *group properties*, generalising twenty-nine properties from the literature (including the three mentioned earlier), and four *principles*, generalising the group (and thus the literature) properties. The principles are *(strict) balance* and *(strict) monotonicity*, where balance states that a difference between strength and base score of an argument must correspond to some imbalance between the strengths of its attackers and supporters, while monotonicity requires that the strength of an argument depends monotonically on its base score and on the strengths of its attackers and supporters. Both group properties and principles are defined for a generalised version of argumentation frameworks, called *Quantitative Bipolar Argumentation Frameworks* (QBAFs), in terms of a number of parameters, that can be instantiated in several different ways. These parametric formulations, besides recovering existing literature properties as special instances, reveal the existence of a larger spectrum of possible properties and thus enable the identification of novel concrete properties, for AFs, SAFs, BAFs and QuAD frameworks alike.

In this paper we demonstrate the potential of this line of investigation by focusing on three of the group properties identified in [7], there called GP2, GP3 and GP9, and instantiate them to obtain a number of novel properties, not already considered in the literature. These group properties amount to the following:

- GP2 - In the absence of supporters, if there is at least one attacker then the strength of an argument is lower than its base score. This property is proven to generalise *Weakening* [2,4] and to be implied by balance [7].
- GP3 - In the absence of attackers, if there is at least one supporter then the strength of an argument is higher than its base score. This property is proven to generalise *Strengthening* [3] and to be implied by balance [7].
- GP9 - A higher base score gives a higher strength. This property is proven to generalise *Proportionality* [4] and to be implied by strict monotonicity [7].

Our new instantiations can be seen as "relatives" of the original literature properties and provide an illustration of how parametric group properties can be exploited to identify a comprehensive set of actual variants. We discuss the practical relevance of each variant by discussing examples of application contexts where its specific features turn out to be appropriate.

The paper is organised as follows. In Section 2 we give the necessary background from [7]. Section 3 describes the concept of instantiating the group properties before

Sections 4, 5 and 6 give the instantiations of GP2, GP3 and GP9, respectively. In Section 7 we conclude.

2 Background

This section is adapted from [7].

Let $\mathbb{I}$ be a set equipped with a preorder $\leq$ where, as usual, $a < b$ denotes $a \leq b$ and $b \not\leq a$. $\mathbb{I}$ may (but is not required to) contain top ($\top$) and bottom ($\bot$) values, such that if $\top \in \mathbb{I}$, then $i < \top$ for all $i \in \mathbb{I} \backslash \{\top\}$ and, if $\bot \in \mathbb{I}$, then $\bot < i$ for all $i \in \mathbb{I} \backslash \{\bot\}$. For example, $\mathbb{I} = [0,1]$ with $\top = 1$, $\bot = 0$, or $\mathbb{I} = \{low, medium, high\}$ with $low \leq medium \leq high$ and $\top = high$, $\bot = low$, or $\mathbb{I} = (0, \infty)$.

Given some $\mathbb{I}$, a QBAF assigns attackers, supporters and an initial evaluation (base score) in $\mathbb{I}$ to arguments.

Definition 1. *A Quantitative Bipolar Argumentation Framework (QBAF) is a quadruple $\langle \mathcal{X}, \mathcal{R}^-, \mathcal{R}^+, \tau \rangle$ consisting of a set $\mathcal{X}$ of arguments, a binary (*attack*) relation $\mathcal{R}^-$ on $\mathcal{X}$, a binary (*support*) relation $\mathcal{R}^+$ on $\mathcal{X}$ and a total function $\tau : \mathcal{X} \to \mathbb{I}$. For any $\alpha \in \mathcal{X}$:*
$\mathcal{R}^-(\alpha) = \{\beta \in \mathcal{X} | (\beta, \alpha) \in \mathcal{R}^-\}$ *is the set of attackers of α,*
$\mathcal{R}^+(\alpha) = \{\beta \in \mathcal{X} | (\beta, \alpha) \in \mathcal{R}^+\}$ *is the set of* supporters *of α, and*
$\tau(\alpha)$ *is the* base score *of α.*

QBAFs can be visualised as graphs, e.g. Figure 1 visualises $\langle \{a,b,c,d\}, \{(c,a),(c,b)\}, \{(d,b)\}, \tau \rangle$ (for any τ).

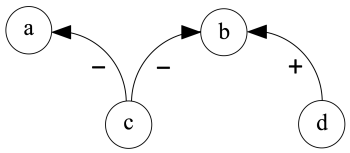


Fig. 1. Example QBAF visualised as a graph (ignoring τ).

In the remainder of the paper, unless specified otherwise, we will assume as given a generic QBAF $\mathcal{Q} = \langle \mathcal{X}, \mathcal{R}^-, \mathcal{R}^+, \tau \rangle$. We will also consider the following restricted instances of QBAFs:

aQBAFs	where	$\forall \alpha \in \mathcal{X}, \mathcal{R}^+(\alpha) = \emptyset$
sQBAFs	where	$\forall \alpha \in \mathcal{X}, \mathcal{R}^-(\alpha) = \emptyset$

aQBAFs correspond to AFs, as introduced in [11] and sQBAFs correspond to SAFs, as introduced in [3]. Whereas SAFs include a base score (called *basic strength* in [3]) for all arguments, AFs do not. In order to capture existing (non-gradual) semantics for AFs, such as the grounded extension semantics [11], specific choices of base scores

for arguments may be needed (e.g. $\forall \alpha \in \mathcal{X}$, $\tau(\alpha) = \top$, as in [8]). BAFs, as introduced in [5], do not include base scores either, but, analogously to the case of AFs, can be seen as special cases of QBAFs where the base score is the same for every argument. Finally, Social AFs [13] can be seen as QBAFs where base scores are determined by votes, whereas Weighted Argumentation Graphs [4] and Quantitative Argumentation Debate (QuAD) frameworks [8] are generic QBAFs.

Arguments in a QBAF have a final evaluation (strength):

Definition 2. *For any $\alpha \in \mathcal{X}$, the strength of α is given by $\sigma(\alpha)$ where $\sigma : \mathcal{X} \to \mathbb{I}$ is a total function. For any set of arguments $A \subseteq \mathcal{X}$, we refer to the multiset $\{\sigma(\beta) | \beta \in A\}$ as $\sigma(A)$.*[1]

If $\bot \in \mathbb{I}$, it may or not play a role in evaluating arguments. Thus, we consider two alternative notions of set equivalence:

Definition 3. *Let $*$ be either $\sigma\bot$ or $\sigma\not\bot$. For $Z \subseteq \mathcal{X}$, let Z^* denote $\sigma(Z)$ if $* = \sigma\bot$ and $\sigma(Z) \setminus \{\sigma(z) \in \sigma(Z) | \sigma(z) = \bot\}$ if $* = \sigma\not\bot$. Then, for $A, B \subseteq \mathcal{X}$, A is* $*$-strength equivalent to *B, denoted $A =_* B$, iff $A^* = B^*$; A is* at least as $*$-strong as *B, denoted $A \geq_* B$, iff there exists an injective mapping f from B^* to A^* such that $\forall \alpha \in B^*$, $\sigma(f(\alpha)) \geq \sigma(\alpha)$; A is* $*$-stronger than *B, denoted $A >_* B$, iff $A \geq_* B$ and $B \not\geq_* A$.*

Note that, directly from the definition, $B \not\geq_* A$ iff $|B^*| < |A^*|$ or $\exists \beta \in B^*$ such that $\sigma(f(\beta)) \not\leq \sigma(\beta))$. Note also that Definition 3 for $* = \sigma\bot$ reformulates the notion of *group comparison* in [1,9]. In the remainder $*$ is either $\sigma\bot$ or $\sigma\not\bot$.

Definition 4. *For any $\alpha \in \mathcal{X}$, the set of attackers of α is $\mathcal{R}^-(\alpha) = \{\beta \in \mathcal{X} | (\beta, \alpha) \in \mathcal{R}^-\}$ and the set of* supporters *of α is $\mathcal{R}^+(\alpha) = \{\beta \in \mathcal{X} | (\beta, \alpha) \in \mathcal{R}^+\}$. Also, $\mathcal{R}^-_*(\alpha) = \mathcal{R}^-(\alpha)$ if $* = \sigma\bot$ and $\mathcal{R}^-_*(\alpha) = \mathcal{R}^-(\alpha) \setminus \{\beta \in \mathcal{R}^-(\alpha) | \sigma(\beta) = \bot\}$ if $* = \sigma\not\bot$. Similarly, $\mathcal{R}^+_*(\alpha) = \mathcal{R}^+(\alpha)$ if $* = \sigma\bot$ and $\mathcal{R}^+_*(\alpha) = \mathcal{R}^+(\alpha) \setminus \{\beta \in \mathcal{R}^+(\alpha) | \sigma(\beta) = \bot\}$ if $* = \sigma\not\bot$.*

Thus, we use $\mathcal{R}^-_*(\alpha)$ and $\mathcal{R}^+_*(\alpha)$ to denote, respectively, the set of attackers and supporters of an argument α including or excluding, depending on the choice of $*$, those with bottom strength. Note that $\mathcal{R}^-_*(\alpha) = \mathcal{R}^-_*(\beta)$ implies $\mathcal{R}^-(\alpha) =_* \mathcal{R}^-(\beta)$ but not vice versa (similarly for support).

The definition of group properties (and principles) in [7] is also parametric w.r.t. an operator over $\mathbb{I}$, denoted $\ll$, expressing a form of strict comparison between values in $\mathbb{I}$. The basic requirement for this operator is that $< \subseteq \ll \subseteq \leq$ and, naturally, $m \gg n$ iff $n \ll m$. In this paper we consider the following instances of $\ll$:

- $\ll = <$,
- $\ll = \leq$,
- $\ll = <_\times$, where $m <_\times n$ iff $m < n$ or $m = n = \times$, where $\times$ is one of $\bot$ or $\top$.

In this paper we focus on the following group properties from [7]:

Definition 5. *Let $\alpha \in \mathcal{X}$.*
GP2: If $\mathcal{R}^-_*(\alpha) \neq \emptyset$ and $\mathcal{R}^+_*(\alpha) = \emptyset$ then $\sigma(\alpha) \ll \tau(\alpha)$.
GP3: If $\mathcal{R}^-_*(\alpha) = \emptyset$ and $\mathcal{R}^+_*(\alpha) \neq \emptyset$ then $\tau(\alpha) \ll \sigma(\alpha)$.
GP9: If $\mathcal{R}^-_*(\alpha) = \mathcal{R}^-_*(\beta)$, $\mathcal{R}^+_*(\alpha) = \mathcal{R}^+_*(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \ll \sigma(\beta)$.

[1] In this paper we use the same notation for sets and multisets.

Note that GP2 is not applicable to sQBAFs, where $\mathcal{R}_*^-(\alpha) \neq \emptyset$ is impossible, and similarly GP3 is not applicable to aQBAFs.

3 Instantiating Group Properties

The following instances of GP2, GP3, GP9, already present in the literature as indicated, are identified in [7]:

- GP2 for aQBAFs with $* = \sigma \not\perp$ and $\ll\!=\!<_\perp$ and for $\mathbb{I} = [0,1]$ implies the following:
  Weakening (Weak.) [2,4] - For any $\alpha \in \mathcal{X}$, if $\tau(\alpha) > \perp$ and $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ then $\sigma(\alpha) < \tau(\alpha)$.
- GP3 for sQBAFs with $* = \sigma \not\perp$ and $\ll\!=\!<_\top$ and for $\mathbb{I} = [0,1]$ implies the following:
  Strengthening (Str.) [3] - For any $\alpha \in \mathcal{X}$, if $\tau(\alpha) < \top$ and $\exists \beta \in \mathcal{R}^+(\alpha)$ such that $\sigma(\beta) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$.
- GP9 for aQBAFs with $* = \sigma\perp$ and $\ll\!=\!<_\perp$ and for $\mathbb{I} = [0,1]$ implies the following:
  Proportionality (Prop.) [4] - For any $\alpha, \beta \in \mathcal{X}$, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$, $\tau(\beta) > \tau(\alpha)$ and either $\sigma(\alpha) > \perp$ or $\sigma(\beta) > \perp$, then $\sigma(\beta) > \sigma(\alpha)$.

In this paper we consider the novel instances indicated as hyphens in Table 1, given in the remainder. Note that in the instantiations we do not make any commitment on τ nor on $\mathbb{I}$, thus ensuring that each novel property is still generic with respect to actual formalisms which may differ in the assignment of base scores and the scale adopted.

		$\sigma\perp$				$\sigma\not\perp$			
		$<$	$<_\perp$	$<_\top$	$\leq$	$<$	$<_\perp$	$<_\top$	$\leq$
GP2	aQBAF	-	-	-	-	-	Weak.	-	-
	QBAF	-	-	-	-	-	-	-	-
GP3	sQBAF	-	-	-	-	-	-	Str.	-
	QBAF	-	-	-	-	-	-	-	-
GP9	aQBAF	-	Prop.	-	-	-	-	-	-
	sQBAF	-	-	-	-	-	-	-	-
	QBAF	-	-	-	-	-	-	-	-

Table 1. The GPs that we consider and their implied instances in the literature.

4 Novel instances of GP2

GP2 expresses the general idea that, in absence of supporters and in presence of some attackers, the strength of an argument cannot be higher than its base score. As recalled in Section 3, in the literature this property has been explicitly considered, with the name *Weakening*, only for aQBAFs and for the choices $* = \sigma \not\perp$ and $\ll\!=\!<_\perp$

In this section we provide an explicit definition for the hyphens in Table 1 in the rows for GP2, thus identifying in a systematic way a set of novel properties, arising from the combinations of possible values of the parameters.

In this section and the two which follow, for each novel property we provide a short explanation and a comment on its possible relevance from the application point of view.

The first group of parameter choices which we assess are those with $* = \sigma\bot$, taking on the first notion for attackers or supporters with bottom strength stating that they may have an effect on their targeted argument. Generally, considering attackers or supporters with bottom strength may make sense in contexts where the presence itself of an argument, as weak as it may be, will always have some effect. This may make sense in trusted settings where malicious behaviour is not expected in the construction of the argumentation framework and so this choice of $*$ may be more appropriate when some inherent quality control is present. This is especially relevant in cases like GP2 where there are attackers but no supporters.

For GP2, GP3 and GP9, the selection of $\ll$ may allow a strength to *saturate* when the operator is relaxed, e.g. at $\bot$ when $\ll{=}<_\bot$. These properties are meaningful for semantics with fixed base scores.

GP2 for $\sigma\bot$ and $<$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ then $\sigma(\alpha) < \tau(\alpha)$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ and $\mathcal{R}^+(\alpha) = \emptyset$ then $\sigma(\alpha) < \tau(\alpha)$.

In the first property (for aQBAFs and QBAFs) the selection of $\ll{=}<$ gives the requirement of strict decrease and corresponds to the impossibility of ignoring the existence of any attack and implies that $\tau(\alpha) > \bot$, i.e. that no argument is completely discarded from the beginning and the bottom value is attainable only in presence of attacks. This property may be useful when argumentatively modelling a trial in the court of law (somewhat subjectively), where a person is assumed to be innocent (their argument holds and its base score is $\top$) until there is sufficient evidence proving them to be guilty (arguments attacking their argument of innocence). Then any attacker of their argument which is introduced may affect the jury's presumption of their innocence negatively and therefore reduce the strength of their argument claiming their innocence.

GP2 for $\sigma\bot$ and $<_\bot$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \bot$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ and $\mathcal{R}^+(\alpha) = \emptyset$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \bot$.

The second instances of GP2 use $\ll{=}<_\bot$. This property requires a strict decrease unless $\tau(\alpha) = \bot$, i.e. the argument is already as weak as it can possibly be. This may be useful in cases where an argument can have a base score equal to the minimum strength available, e.g. it is *rejected*, meaning that attackers may have no effect as they cannot reduce it further. An application of this may be in the modelling of an engineering discussion (e.g. see [16]) when a base score of $\bot$ may correspond to a critically dangerous solution to a problem, which would obtain the minimum base score and therefore attackers could not reduce it further.

GP2 for $\sigma\bot$ and $<_\top$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ and $\mathcal{R}^+(\alpha) = \emptyset$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

This property may seem somewhat counter-intuitive in that it allows arguments with top base score to have top strength even when they are attacked. However, this behaviour may be useful when arguments with a top base score need to have a special "tautological" status. Considering once again the engineering discussion setting with the base scores corresponding to some predefined level of importance to the project, an argument may be given a fixed strength of $\top$ if it is required by the stakeholders, such that there is no need to consider the dialectical reasoning against the argument and so the attackers of the argument may be ignored.

GP2 for $\sigma\perp$ and $\leq$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ then $\sigma(\alpha) \leq \tau(\alpha)$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) \neq \emptyset$ and $\mathcal{R}^+(\alpha) = \emptyset$ then $\sigma(\alpha) \leq \tau(\alpha)$.

When $\ll\!=\!\leq$ is selected for GP2 we have a less strict property which does not require an argument's strength to be reduced in the presence of attackers for any given base score. If the two previous properties' exceptions are both required in the engineering discussion setting as stated, this property would allow such a situation.

The next group of four sets of instantiations take on the second notion for attackers or supporters with bottom strength, i.e. $* = \sigma\not\perp$. This means that attackers and supporters with bottom strength will not have an effect on their targeted argument. Ignoring rejected attackers or supporters may be beneficial in less trusted environments, e.g. those containing malicious users. Considering the dialectical context of social media, the effect of so-called trolls' arguments may be negated by sufficiently strong attacks from other arguments or simply flagging from users, both of which may restrict the arguments to the bottom strength, which lead to them being ignored when $* = \sigma\not\perp$. This is again especially relevant for GP2 where there are attackers but no supporters.

GP2 for $\sigma\not\perp$ and $<$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ then $\sigma(\alpha) < \tau(\alpha)$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ and $\nexists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \perp$ then $\sigma(\alpha) < \tau(\alpha)$.

The selection of $* = \sigma\not\perp$ and $\ll\!=\!<$ gives a flexibility in how strict an attacker's effect is, since it allows possibility of ignoring rejected attackers but implies that $\tau(\alpha) > \perp$, i.e. that no non-rejected argument is completely discarded from the beginning and the bottom value is attainable only in presence of attacks In argumentation-based aggregation of user reviews (e.g. see [10]) in a context such as *Trip Advisor,* where the base score may correspond to the number of users voting for an argument, this affords a guarantee to users that any attacker or supporter they add will have an effect on a targeted argument's evaluation unless their argument is rejected, for example if it is flagged for a particular reason. This behaviour seems to be ideal for a setting such as this in which malicious arguments may be present (and flagged), but it is nonetheless important for non-flagged arguments to have an effect to entice users to participate.

GP2 for $\sigma\not\perp$ and $<_\perp$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \perp$.

- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \bot$ and $\nexists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \bot$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \bot$.

When $\ll\!=\!<_\bot$, this property requires a strict decrease unless $\tau(\alpha) = \bot$. Once again we have a situation where an argument may be rejected based on its base score. We now imagine a real world example in which the government is using argumentation-based e-polling (e.g. see [15]) for its policy planning. Here, the base score of an argument may correspond to the proportion of the public who agree with it, while an argument's strength depends its base score and the strengths of its attackers and supporters. For this property we assume that the default is for the government to continue with an already-implemented policy unless a certain threshold for amount of people who disagree with this argument is reached, i.e. all voters disagree with the argument and its base score is $\bot$. At this point the policy may be abandoned regardless of its attackers since the base score takes precedence. Note also that the former of the two instantiations implies the literature property Weakening.

GP2 for $\sigma \not\perp$ and $<_\top$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \bot$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \bot$ and $\nexists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \bot$ then $\sigma(\alpha) < \tau(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

This property states that a first non-rejected attacker will cause a strict decrease in strength is required unless $\tau(\alpha) = \top$, which at first seem counter-intuitive but can be justified in the case of the analogous example to that of the previous property. In this case, the government may be using e-polling to determine whether to implement an as of yet untested policy, the default for which is to decline to do so. In this case the votes causing the base score to reach the $\top$ threshold, i.e. all voters agreeing with the argument, may mean the policy is implemented, regardless of its attackers since the base score takes precedence.

GP2 for $\sigma \not\perp$ and $\leq$:

- For any $\alpha \in \mathcal{X}$ in an aQBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \bot$ then $\sigma(\alpha) \leq \tau(\alpha)$.

- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \bot$ and $\nexists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \bot$ then $\sigma(\alpha) \leq \tau(\alpha)$.

The final instantiations for GP2 cover the cases where $\ll\!=\!\leq$. The two exceptions in the two previous properties for $\bot$ and $\top$ may be required in an online debate setting where a group of people are to be convinced one way (in favour of an argument) or the other (in opposition an argument). Here, the base score may once again correspond to the proportion of the votes in favour of an argument and when the whole group agree (base score is $\top$) or disagree (base score is $\bot$) with an argument, this may obtain the maximum or minimum, respectively, strength, regardless of its attackers.

5 Novel instances of GP3

GP3 expresses the general idea that, in absence of attackers and in presence of some supporters, the strength of an argument cannot be lower than its base score. As recalled in Section 3, in the literature this property has been explicitly considered only for sQBAFs and for the choices $* = \sigma \not\perp$ and $\ll\!=\!<_\top$ with the name *Strengthening*.

In this section we provide an explicit definition for the hyphens in Table 1 in the rows for GP3 in the same manner as in the previous section.

For the choices of $*$, we use examples relating to the same two groupings as was done for GP2, i.e. $* = \sigma\perp$ corresponding to those in trusted settings and $* = \sigma\not\perp$ to those in untrusted settings where malicious users may be present.

GP3 for $\sigma\perp$ and $<$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) < \sigma(\alpha)$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) = \emptyset$ and $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) < \sigma(\alpha)$.

The selection of $\ll = <$ gives the requirement of strict increase and corresponds to the impossibility of ignoring the existence of any support, implying that $\tau(\alpha) < \top$, i.e. that no argument is completely accepted from the beginning and the top value is attainable only in presence of supports. This property may be useful when all non-rejected supports are taken into account, for example in game-theoretical contexts such as optimising debate strategy, as suggested in the games of argumentation strategy of [6], where the base score is some fixed midpoint.

GP3 for $\sigma\perp$ and $<_\perp$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \perp$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) = \emptyset$ and $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \perp$.

Here we have another property which seems counter-intuitive at first glance but it can be justified in the engineering discussion setting once again: arguments that are assigned the $\perp$ base score may take on the special status of being rejected outright, i.e. their strength is also $\perp$, for example if they cause a critically dangerous situation. Here this special base score takes precedence over the presence of supporters.

GP3 for $\sigma\perp$ and $<_\top$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) = \emptyset$ and $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

This property requires that supporters increase an argument's strength to a value higher than the base score except in the case of the base score being maximal. We once again look to the engineering discussion setting in which an argument having stakeholder approval gives it a special, 'indispensable' status, i.e. a base score, and therefore strength, of $\top$.

GP3 for $\sigma\perp$ and $\leq$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) \leq \sigma(\alpha)$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) = \emptyset$ and $\mathcal{R}^+(\alpha) \neq \emptyset$ then $\tau(\alpha) \leq \sigma(\alpha)$.

For the final property for GP3 with $* = \sigma\perp$, $\ll = \leq$ so we have a less strict property which does not require supporters to increase an argument's strength above any given base score. If the two exceptions from the previous two properties are both required in the engineering discussion setting as stated, this property may be suitable.

GP3 for $\sigma\not\perp$ and $<$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\exists \beta \in \mathcal{R}^+(\alpha)$ such that $\sigma(\beta) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$.
- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\nexists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ and $\exists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$.

The selection of $* = \sigma \not\perp$ and $\ll = <$ gives a flexibility in how strict a supporter's effect is, since it allows possibility of ignoring rejected supporters but implies that $\tau(\alpha) < \top$, i.e. that no argument is completely accepted from the beginning and the top value is attainable only in presence of supports. This behaviour once again seems to be ideal for the review aggregation/Trip Advisor setting in which supporting arguments (e.g. from an institution itself, attempting to increase its rating), may be malicious in the same way as attacking arguments. This property allows the malicious supports to be rejected and ignored, while still enticing users by guaranteeing that non-rejected supporters will have an effect on their targeted argument.

GP3 for $\sigma \not\perp$ and $<_\perp$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\exists \beta \in \mathcal{R}^+(\alpha)$ such that $\sigma(\beta) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \perp$.

- For any $\alpha \in \mathcal{X}$ in a QBAF,if $\nexists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ and $\exists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \perp$.

For this (seemingly unintuitive) property, we again turn to the setting of argumentation-based e-polling situation in which the default is for the government to continue with a policy unless the base score of the corresponding argument reaches the threshold $\perp$, in which case its supporters' effects are neglected.

GP3 for $\sigma \not\perp$ and $<_\top$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\exists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\nexists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ and $\exists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \perp$ then $\tau(\alpha) < \sigma(\alpha)$ or $\tau(\alpha) = \sigma(\alpha) = \top$.

This analogous property of the previous one uses the same e-polling setting but with the default position from the government of not implementing a policy unless the base score of the corresponding argument reaches the threshold $\top$, in which case its supporters' effects are neglected. Note also that the former of the two instantiations implies the literature property Strengthening.

GP3 for $\sigma \not\perp$ and $\leq$:

- For any $\alpha \in \mathcal{X}$ in an sQBAF, if $\exists \beta \in \mathcal{R}^+(\alpha)$ such that $\sigma(\beta) > \perp$ then $\tau(\alpha) \leq \sigma(\alpha)$.

- For any $\alpha \in \mathcal{X}$ in a QBAF, if $\nexists \beta \in \mathcal{R}^-(\alpha)$ such that $\sigma(\beta) > \perp$ and $\exists \gamma \in \mathcal{R}^+(\alpha)$ such that $\sigma(\gamma) > \perp$ then $\tau(\alpha) \leq \sigma(\alpha)$.

The final instantiations for GP3 may be applied to the online debate setting of the final instantiations of GP2, such that when all of the group agree (base score is $\top$) or disagree (base score is $\perp$) with an argument, it may obtain the maximum or minimum, respectively, strength, regardless of its supporters.

6 Novel instances of GP9

GP9 expresses the general idea that, when two otherwise equivalent (in terms of attackers and supporters) arguments have a difference in base score, that with the higher base score will have a higher strength. As recalled in in Section 3, in the literature this property has been explicitly considered only for aQBAFs and for the choices $* = \sigma \perp$ and $\ll = <_\perp$ with the name *Proportionality*.

In this section we provide an explicit definition for the hyphens in Table 1 in the rows for GP9 in the same manner as in the previous section.

For GP9, the choice of $*$ determines whether or not the equality between attackers and supporters includes those with the bottom strength or not. We therefore once again use examples relating to the same two groupings as were used for GP2 and GP3, i.e. trusted (when $* = \sigma\perp$) and malicious (when $* = \sigma\not\perp$) environments. It should be noted that GP9 is not a meaningful property for semantics with fixed base scores.

GP9 for $\sigma\perp$ and $<$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$.
- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$.
- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$, $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$.

In the first property for GP9 the selection of $\ll{=}<$ gives the requirement of a strict decrease in the strength when the base score is lowered, thereby giving the base score a high importance. We envisage this property's use when argumentation is used for conflict resolution in meeting support, for example the engineering discussion setting. If an argument's base score corresponds to the stakeholders' votes on the issues that arguments represent, in the case of equal reasoning (attackers and supporters) the votes would always be used to resolve the conflict, i.e. ranking one argument higher than another using their strengths, justifying the use of this property.

GP9 for $\sigma\perp$ and $<_\perp$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \perp$.
- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \perp$.
- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$, $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \perp$.

When $\ll{=}<_\perp$ for GP9, the strength of an argument is reduced when the base score is lowered unless it is already minimal. This may be required for situations where attacking arguments are able to reject their target arguments irrespective of their base score. This seems to be fairly important in the engineering discussion situation if an attacker states that its targeted argument is critically dangerous and therefore must take prevalence over their (unsupported) targeted argument's base score. Note also that the first of the three instantiations implies the literature property Proportionality.

GP9 for $\sigma\perp$ and $<_\top$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \top$.
- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \top$.
- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$, $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \top$.

As with the previous property (though this one may seem more counter-intuitive), the exception here for a base score of $\top$ could be justified in the engineering discussion

setting in which the stakeholder's opinions gives some supporters a special status, with base score and strength equal to $\top$, meaning their targeted (unattacked) arguments take on the $\top$ strength regardless of their base scores.

GP9 for $\sigma \perp$ and $\leq$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \leq \sigma(\beta)$.

- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \leq \sigma(\beta)$.

- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, $\mathcal{R}^-(\alpha) = \mathcal{R}^-(\beta)$, $\mathcal{R}^+(\alpha) = \mathcal{R}^+(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \leq \sigma(\beta)$.

The instantiation of GP9 for $\ll = \leq$ relaxes the inequality and therefore reduces the base score's importance. This could be used in a meeting support setting similar to the engineering discussion but one in which the voting on arguments is less crucial for the exercise than the reasoning. One example of this is classroom debating, where children can be taught to think critically, i.e. add attacking and supporting arguments to the framework, and the voting is less important.

GP9 for $\sigma \not\perp$ and $<$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-_{\sigma \not\perp}(\alpha) = \mathcal{R}^-_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$.

- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+_{\sigma \not\perp}(\alpha) = \mathcal{R}^+_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$.

- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, $\mathcal{R}^-_{\sigma \not\perp}(\alpha) = \mathcal{R}^-_{\sigma \not\perp}(\beta)$, $\mathcal{R}^+_{\sigma \not\perp}(\alpha) = \mathcal{R}^+_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$.

The first GP9 property for $* = \sigma \not\perp$ uses $\ll = <$ and therefore requires a strict reduction in strength if the base score is lowered but allows for rejected arguments to be ignored. This seems ideal for the Trip Advisor setting once again since it is desirable for users' votes, and therefore changes in arguments' base scores, to always have an effect on the arguments' strengths but malicious arguments can still be flagged, rejected and neglected.

GP9 for $\sigma \not\perp$ and $<_\perp$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-_{\sigma \not\perp}(\alpha) = \mathcal{R}^-_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \perp$.

- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+_{\sigma \not\perp}(\alpha) = \mathcal{R}^+_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \perp$.

- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-_{\sigma \not\perp}(\alpha) = \mathcal{R}^-_{\sigma \not\perp}(\beta)$, $\mathcal{R}^+_{\sigma \not\perp}(\alpha) = \mathcal{R}^+_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \perp$.

When GP9 is instantiated for $* = \sigma \not\perp$ and $\ll = <_\perp$ it requires the strict reduction in strength except when the strength is equal to $\perp$. In the setting of online debates on social media, this could correspond to a special status given to an attacker with which the whole group of users agrees, such that its base score and strength are $\top$ and therefore its (unsupported) target arguments are rejected irrespective of their base scores.

GP9 for $\sigma \not\perp$ and $<_\top$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-_{\sigma \not\perp}(\alpha) = \mathcal{R}^-_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \top$.

- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+_{\sigma \not\perp}(\alpha) = \mathcal{R}^+_{\sigma \not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then

$\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \top$.

- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-_{\sigma\not\perp}(\alpha) = \mathcal{R}^-_{\sigma\not\perp}(\beta)$, $\mathcal{R}^+_{\sigma\not\perp}(\alpha) = \mathcal{R}^+_{\sigma\not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) < \sigma(\beta)$ or $\sigma(\alpha) = \sigma(\beta) = \top$.

This (seemingly unintuitive) property requires the strict reduction in strength except when the strength is equal to $\top$. As with the previous property, this could be useful in the setting of online debates on social media. Here we may have the analogous case that a special status is given to a supporter with which the whole group of users agrees, such that its base score and strength are $\top$ and therefore its (unattacked) targeted arguments have $\top$ strength irrespective of their base scores.

GP9 for $\sigma \not\perp$ and $\leq$:

- For any $\alpha, \beta \in \mathcal{X}$ in an aQBAF, if $\mathcal{R}^-_{\sigma\not\perp}(\alpha) = \mathcal{R}^-_{\sigma\not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \leq \sigma(\beta)$.

- For any $\alpha, \beta \in \mathcal{X}$ in an sQBAF, if $\mathcal{R}^+_{\sigma\not\perp}(\alpha) = \mathcal{R}^+_{\sigma\not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \leq \sigma(\beta)$.

- For any $\alpha, \beta \in \mathcal{X}$ in a QBAF, if $\mathcal{R}^-_{\sigma\not\perp}(\alpha) = \mathcal{R}^-_{\sigma\not\perp}(\beta)$, $\mathcal{R}^+_{\sigma\not\perp}(\alpha) = \mathcal{R}^+_{\sigma\not\perp}(\beta)$ and $\tau(\alpha) < \tau(\beta)$ then $\sigma(\alpha) \leq \sigma(\beta)$.

This property could be useful in the same setting as the previous two properties when both of the exceptions to the strict decrease in strength are required.

7 Conclusions

This paper provides a contribution to the study of properties of (various types of) argumentation frameworks by instantiating, in several different ways, three *group properties* presented in [7]. As discussed in Sections 4-6, the parametric definition of the group properties turns out to support a systematic exploration of the spectrum of potential properties by allowing one to consider several actual variants of the same basic idea. In particular, for each of the three group properties considered in this paper only one instance had been previously considered in the literature while we have shown that a much larger set of alternatives (altogether 56 instances) can be considered. To illustrate the practical utility of this detailed investigation, examples of application contexts where each specific instance appears to be appropriate have been discussed. Altogether this line of investigation aims at building a comprehensive catalogue of fine-tuned properties where, in the phase of design of an argument-based system, one can identify those which are most appropriate for the considered application domain. In this line, a future work direction consists in extending this systematic analysis to the other group properties considered in [7].

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