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Bipolarity in temporal argumentation frameworks ☆

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ABSTRACT

A *Timed Argumentation Framework* (*TAF*) is a formalism where arguments are only valid for consideration during specific intervals of time, called availability intervals, which are defined for every individual argument. The original proposal is based on a single abstract notion of attack between arguments that remains static and permanent in time. Thus, in general, when identifying the set of acceptable arguments, the outcome associated with a *TAF* will vary over time.

Here, we are introducing an extension of *TAF* adding the capability of modeling a support relation between arguments. In this sense, the resulting framework provides a suitable model for different time-dependent issues; thus, the main contribution of this work is to provide an enhanced framework for modeling a positive (support) and negative (attack) interaction which varies over time, features that are highly relevant in many real-world situations. This addition leads to a *Timed Bipolar Argumentation Framework* (*T-BAF*), where classical argument extensions can be defined, aiming at advancing in the integration of temporal argumentation in different application domains.

1. Introduction

Commonsense reasoning presents many characteristics that have been explored by philosophers first and by Artificial Intelligence research community more recently. Argumentation is one of these aspects which models a human mechanism for decision making that explores reasons in favor and against different pieces of potential beliefs, or claims, supported by some form of reasoning from a set of premises; the final purpose of this process is to ascertain if a particular claim is acceptable [1–3]. Research in the area of argumentation has introduced several argument-based formalisms for dealing with applications in many practical areas, i.e., legal reasoning, autonomous agents, and multi-agent systems. In such environments, an agent may use argumentation to perform individual reasoning to reach a resolution over contradictory evidence or to decide between conflicting goals, while multiple agents may use dialectical argumentation to identify and settle differences interacting via diverse processes such as negotiation, persuasion, or joint deliberation. Many of such accounts of

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argumentation are based on Dung's foundational work characterizing *Abstract Argumentation Frameworks* (*AF*) [4,5] where arguments are considered as atomic entities and their interaction is represented solely through an attack relation.

A salient feature of commonsense reasoning is that in many cases the use of temporal information is important, requiring the representation of time because the notion of "change" is relevant in the modeling of the argumentation capabilities of intelligent agents [6,7]. In particular, in [8–10] a novel framework called *Timed Abstract Framework* (*TAF*) was proposed combining arguments and temporal notions, where arguments are relevant only during a period of time, which is called its availability interval. This framework maintains a high level of abstraction in an effort to capture intuitions related with the dynamic interplay of arguments as they become available and cease to be so. The notion of *availability interval* conceptualizes an interval of time in which the argument can be legally used for the particular purpose of an argumentation process; thus, a timed-argument has a limited influence in the system that will be given by the temporal context in which this argument can be taken into account. Using an expanded concept of admissibility that considers time, a skeptical timed interval-based semantics will be introduced for *TAFs*. As arguments may get attacked during a certain period of time, the notion of defense is also time-dependent, requiring a proper adaptation of classical acceptability; furthermore, algorithms for the characterization of defenses between timed-arguments are presented, and used to specify the acceptability status of an argument varying over time [10,9].

In the original abstract argumentation frameworks [5], only a conflict interaction between arguments is considered; however, in recent years, studies on argumentation have shown that a support interaction may also exist between arguments, and this intuitions represents relations in real world situations. Several formal approaches have been considered such as deductive support, necessary support, and evidential support [11–14], where an abstract argumentative framework is enhanced with the capability to model not only the negative interaction of attacks between arguments, but also a positive relation of support is considered. In particular, a simple abstract formalization of argument support was provided in the framework proposed by Cayrol and Lagasquie-Schiex in [11], called *Bipolar Argumentation Framework* (*BAF*), where they extend Dung's notion of acceptability by distinguishing two independent forms of interaction between arguments: support and attack. Besides the classical semantic consequences of attack, new semantic considerations are introduced that relies on the support to an attack and the attack to a support.

Here, we provide a timed argumentation framework seeking to analyze the effect of attacks and supports in a dynamic situation, obtaining a specialized form of *BAF* where the resulting framework provides a suitable model for different time-dependent issues. The main contribution of this move is to provide an enhanced framework for modeling a positive (support) and negative (attack) interaction varying over time, both of which are relevant in many real-world situations, advancing in the integration of temporal argumentation in different, time-related application domains and contributing to the successful integration of argumentation in different artificial intelligence applications, such as Knowledge Representation, Autonomous Agents in Decision Support Systems, and others of similar importance. Next, in order to state the relevance of our formalization, we examine a classical example of bipolar argumentation case introduced in [15] about editorial publishing. Our formalism helps to represent a model that analyzes the temporal effects, as follows:

Let us consider the following scenario where an Editor is evaluating the presentation of an important note related to a public person P. *For that, the Chief Editorial Writer considers the following arguments which contemplate the importance and legality of the note.*

$\mathcal{I}$: *Information* I *concerning person* P *should be published.*
$\mathcal{P}$: *Information* I *is private so,* P *denies publication.*
$\mathcal{S}$: I *is an important information concerning* P*'s son.*
$\mathcal{M}$: P *is the prime minister so, everything related to* P *is public.*

Some of these arguments are controversial, as is the case of the conflict between arguments $\mathcal{P}$ *and* $\mathcal{I}$*, and between arguments* $\mathcal{M}$ *and* $\mathcal{P}$*. On the other hand, there is a relation between arguments* $\mathcal{P}$ *and* $\mathcal{S}$*, which clearly is not of conflict. Moreover,* $\mathcal{S}$ *provides a new piece of information enforcing argument* $\mathcal{P}$*.*

This is an appropriate example to introduce positive and negative argument relations; nevertheless, it does not *explicitly* consider the evolution of time. By its own nature, argumentation is a *process* in which arguments are issued as time progresses, thus it is interesting to evaluate the arguments and conflicts at different stages of such a process. Also, as the context where argumentation occurs evolves in time, some arguments may become useless, invalid, or even irrelevant. In the example above, argument $\mathcal{M}$ results valid only in the period when P holds the Prime Minister office, i.e., such an argument is irrelevant to a dialectical analysis taking place after P has left the PM office. If P is Prime Minister from 2010 to 2014, then argument $\mathcal{M}$ is pertinent only in the interval of time $[2010, 2014]$. To get a more accurate description of the situation, we improve the argument representation with temporal information about the periods of time in which this argument is relevant. Consider now the following, time-enriched scenario about the publishing problem above:

Arguments $\mathcal{I}$ *and* $\mathcal{P}$ *can be both considered as general information applicable at any moment, a sort of editorial rules; however, argument* $\mathcal{M}$ *is available only during the period of time when* P *is prime minister. Before that time span, argument* $\mathcal{M}$ *does not apply, and after* P *leaves the Primer Minister Office, the information could be less relevant for publication. Then, a new prime minister* P_2