Chimærarg: Configuring Static Portfolios for Solving Argumentation Problems

Mauro Vallati[1], Federico Cerutti[2], and Massimiliano Giacomin[3]

[1] School of Computing and Engineering,
University of Huddersfield, m.vallati@hud.ac.uk

[2] School of Computer Science & Informatics,
Cardiff University,
CeruttiF@cardiff.ac.uk

[3] Department of Information engineering,
University of Brescia, massimiliano.giacomin@unibs.it

Abstract. In this paper we describe Chimærarg, an approach for combining algorithms into efficient portfolios for addressing enumeration problems — associated to preferred and stable semantics — in abstract argumentation.

1 Introduction

An abstract argumentation framework (*AF*) consists of a set of arguments and a binary *attack* relation between them. In [7] four semantics were introduced, namely *grounded*, *preferred*, *complete*, and *stable* semantics: each of them lead to a single or to multiple *extensions*, where an *extension* is intuitively a set of arguments which can "survive the conflict together." We refer the reader to [2] for a detailed analysis. Moreover, for each semantics, several *decision* and *enumeration* problems have been identified.

While there is a growing number of solvers which are able to deal with (some of) the mentioned argumentation problems, there is no solver that is able to outperform all the others on any set of benchmark. However, a fruitful way for exploiting the strengths of multiple solvers, is to combine them into portfolios.

In this paper, we present Chimærarg,[4] an approach for combining solvers into static sequential portfolios for solving the problems of enumerating preferred and stable extensions.

2 Dung's Argumentation Framework

An argumentation framework [7] consists of a set of arguments and a binary attack relation between them.[5]

[4] https://github.com/federicocerutti/Chimaerarg

[5] In this paper we consider only *finite* sets of arguments: see [3] for a discussion on infinite sets of arguments.

Definition 1. *An* argumentation framework *(AF) is a pair $\Gamma = \langle \mathscr{A}, \mathscr{R} \rangle$ where $\mathscr{A}$ is a set of arguments and $\mathscr{R} \subseteq \mathscr{A} \times \mathscr{A}$. We say that $\boldsymbol{b}$* attacks *$\boldsymbol{a}$ iff $\langle \boldsymbol{b}, \boldsymbol{a} \rangle \in \mathscr{R}$, also denoted as $\boldsymbol{b} \rightarrow \boldsymbol{a}$.*

The basic properties of conflict–freeness, acceptability, and admissibility of a set of arguments are fundamental for the definition of argumentation semantics.

Definition 2. *Given an AF $\Gamma = \langle \mathscr{A}, \mathscr{R} \rangle$:*

- *a set $S \subseteq \mathscr{A}$ is a* conflict–free *set of Γ if $\nexists\, \boldsymbol{a}, \boldsymbol{b} \in S$ s.t. $\boldsymbol{a} \rightarrow \boldsymbol{b}$;*
- *an argument $\boldsymbol{a} \in \mathscr{A}$ is* acceptable *with respect to a set $S \subseteq \mathscr{A}$ of Γ if $\forall \boldsymbol{b} \in \mathscr{A}$ s.t. $\boldsymbol{b} \rightarrow \boldsymbol{a}$, $\exists\, \boldsymbol{c} \in S$ s.t. $\boldsymbol{c} \rightarrow \boldsymbol{b}$;*
- *a set $S \subseteq \mathscr{A}$ is an* admissible set *of Γ if S is a conflict–free set of Γ and every element of S is acceptable with respect to S of Γ.*

An argumentation semantics σ prescribes for any *AF* Γ a set of *extensions*, namely a set of sets of arguments satisfying the conditions dictated by σ.

Definition 3. *Given an AF $\Gamma = \langle \mathscr{A}, \mathscr{R} \rangle$: a set $S \subseteq \mathscr{A}$ is a:*

- preferred extension *of Γ iff S is a maximal (w.r.t. set inclusion) admissible set of Γ;*
- stable extension *of Γ iff S is a conflict–free set of Γ and $\mathscr{A} \setminus S = \{\boldsymbol{a} \in \mathscr{A} \mid \boldsymbol{b} \rightarrow \boldsymbol{a} \text{ and } \boldsymbol{b} \in S\}$.*

3 Generation of Static Portfolios

In this section we describe the technique we used for combining solvers into sequential portfolios. The approach requires as input a set of solvers, a set of training *AF*s, and measures of performance of solvers on the training set. Solvers' performance are measured in terms of Penalised Average Runtime (PAR) score. This metric trades off coverage and runtime for successfully analysed *AF*s: runs that do not solve the given problem get ten times the cutoff time (PAR10), other runs get the actual runtime. The PAR10 score of a solver on a set of *AF*s is the average of the relevant scores.

Static portfolios—as the name suggests—are generated once, according to the performance of the considered solvers on training instances, and never adjusted. Static portfolios are defined by: (i) the selected solvers; (ii) the order in which solvers will be run, and (iii) the runtime allocated to each solver.

Our approach is inspired by the Fast Downward Stone Soup technique [12]. We start from an empty portfolio, and iteratively we either add a new solver component, or extend the allocated CPU-time[6] of a solver already added to the portfolio, depending on what maximise the increment of the PAR10 score of the portfolio. We continue until the time limit of the portfolio has been reached, or it is not possible to further improve the PAR10 score of the portfolio on the training instances.

[6] A granularity of 1 CPU-time second is considered.

4 Chimærarg Configuration

We randomly generated 2,000 *AF*s based on four different graph models: Barabasi-Albert [1], Erdös-Rényi [9], Watts-Strogatz [16] and graphs featuring a large number of stable extensions (hereinafter StableM).

*AF*s have been generated by using `AFBenchGen2` [5], while the StableM set has been generated using the code provided in `Probo` [6] by the organisers of ICCMA-15.[7]

In order to identify challenging frameworks—i.e., neither trivial nor too complex to be successfully analysed in the given CPU-time—*AF*s for each set have been selected using the protocol introduced in the 2014 edition of the International Planning Competition [15]. This protocol lead to the selection of *AF*s with a number of arguments between 250 and 650, and number of attacks between (approximately) 400 and 180,000.

The set of *AF*s has been divided into training and validation sets. For each graph model, we randomly selected 200 *AF*s for training, and the remaining 300 for testing. Therefore, out of the 2,000 *AF*s generated, 800 have been used for training purposes, while the remaining 1,200 have been used for validating the generated portfolios.

We considered all the solvers that took part in the EE-PR and EE-ST tracks of ICCMA-15 [14], respectively 15 and 11 systems. For the sake of clarity and conciseness, we removed from the analysis single solvers that did not successfully analyse at least one *AF* or which were always outperformed by another solver. The interested reader is referred to [13] for detailed descriptions of the solvers.

Experiments have been run on a cluster with computing nodes equipped with 2.5 Ghz Intel Core 2 Quad Processors, 4 GB of RAM and Linux operating system. A cutoff of 600 seconds was imposed to compute the extensions—either preferred or stable—for each *AF*. For each solver we recorded the overall result: success (if it solved the considered problem), crashed, timed-out or ran out of memory.

4.1 Generated Portfolios

The portfolio generated for solving the EE-PR problem includes Cegartix [8]—run for 450 CPU-time seconds—and GRIS [11], which is allocated the remaining 150 CPU-time seconds. The portfolio configured for dealing with the EE-ST problem is composed by LabSATSolver [4], that starts first and has 300 CPU-time seconds allocated, and ArgTools [10].

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[7] http://argumentationcompetition.org/2015/results.html

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