Formalizing Balancing Arguments

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Balancing Arguments (Application Scenarios)

- Practical reasoning. Balancing pros and cons of alternative actions
- Theoretical argumentation. Constructing and comparing alternative theories. Balancing multiple criteria to choose the most coherent theory.
- Factual argumentation. Balancing conflicting evidence (e.g. testimony). Constructing and comparing alternative narratives (“stories”). Balancing multiple criteria to choose the most coherent narrative.
- Arguing about open-textured concepts (subsumption). Balancing different methods of interpretation (e.g. literal, historical, teleological). Balancing interests to preserve “proportionality”.

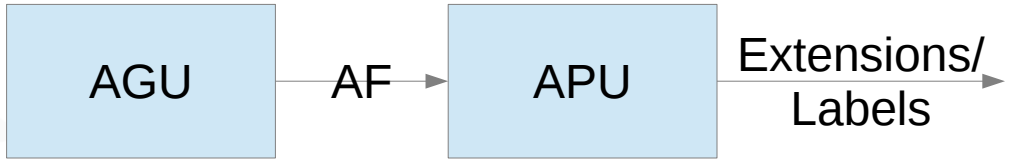
Limitations of Dung Abstract Argumentation Frameworks (1995)

AF = (Arguments, Attacks)

Designed not to handle balancing, but rather only to resolve (cyclic) attack relations among arguments:

“The goal of this paper is to give a scientific account of the basic principal 'The one who has the last word laughs best' of argumentation …”

Dung's Argumentation System Pipeline



Labeling Statements

Balancing Arguments are Cumulative

- In a cumulative argument, the failure of a premise can affect the **weight** of the argument, without causing it to fail entirely.
- Balancing arguments weigh factors pro an con alternative options (also called “positions”)
- Example: When choosing a car to buy, if a car is safer than claimed, the argument for that car is strengthened (a fortiori), not defeated.

Problem with Dung's Pipeline When Balancing Arguments

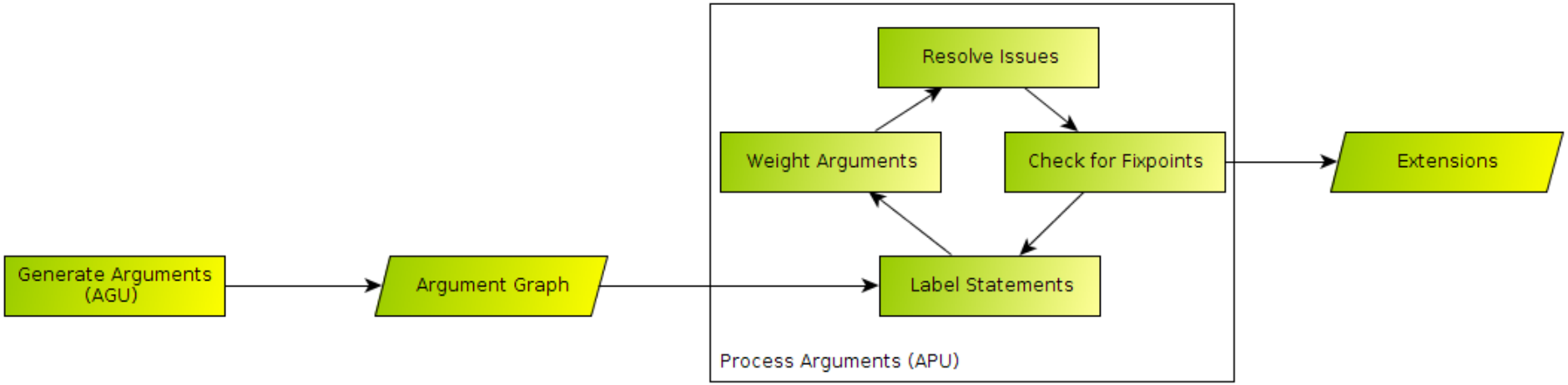
- Because balancing arguments are cumulative:
  - The label of an argument can depend on the label of the statements which are its premises, and **recursively**
  - The label of a statement can depend on the labels of the arguments pro and con this statement.
- Thus, the labels of arguments cannot always be computed before the labels of statements, as required by the pipeline model.

Possible to Model Balancing Using Dung AFs?

- It might be possible to model balancing using Dung AFs, since no restrictions are placed on the structure of arguments or the definition of the attack relation.
- But it seems doubtful that this would be the simplest or most direct approach
- Here we try to model balancing in requirements-driven, straightforward way, without worrying now about how to map balancing arguments to Dung AFs.

Sketch of the Formalization

Recursive Process Model



Arguments

Definition 2 (Argument) *An* argument *is a tuple* (s, P, c, u)*, where:*

- *s is the scheme instantiated by the argument*
- *P, the* premises *of the argument, is a finite subset of* $\mathscr{L}$
- *c, a member of* $\mathscr{L}$*, is the* conclusion *of the argument, and*
- *u, a member of* $\mathscr{L}$*, is the* undercutter *of the argument.*

Example Argument

Let $a_1 = (s, P, c, u)$ be an argument for buying a Porsche, where:

- *s is the car buying scheme,*
- *P, the premises, are:*

  1. *type(porsche,sports)*
  2. *price(porsche,high)*
  3. *safety(porsche,medium)*
  4. *speed(porsche,fast)*

- *c, the conclusion, is buy(porsche), and*
- *u, the undercutter, is $\neg applicable(a_1)$*

Argument Weighing Functions

- The model is a framework, instantiated by
  - Language
  - Argumentation schemes with weighing functions
  - Proof standards
- Weighing functions of argumentation schemes are new

Example Weighing Functions

- Linked Argument
  - 1.0 if all premises are in
  - 0.0 otherwise
- Convergent Argument
  - 1.0 if some premise is in
  - 0.0 otherwise
- Cumulative Argument
  - number of in premises / total number of premises
- MCDA
  - weighted sum of the normalized **proven** (in) values of the properties of each option

Issues

Issues generalize the concept of a contrary, to allow more than two options

Definition 3 (Issue) *An* issue *is a tuple* (O, f)*, where:*

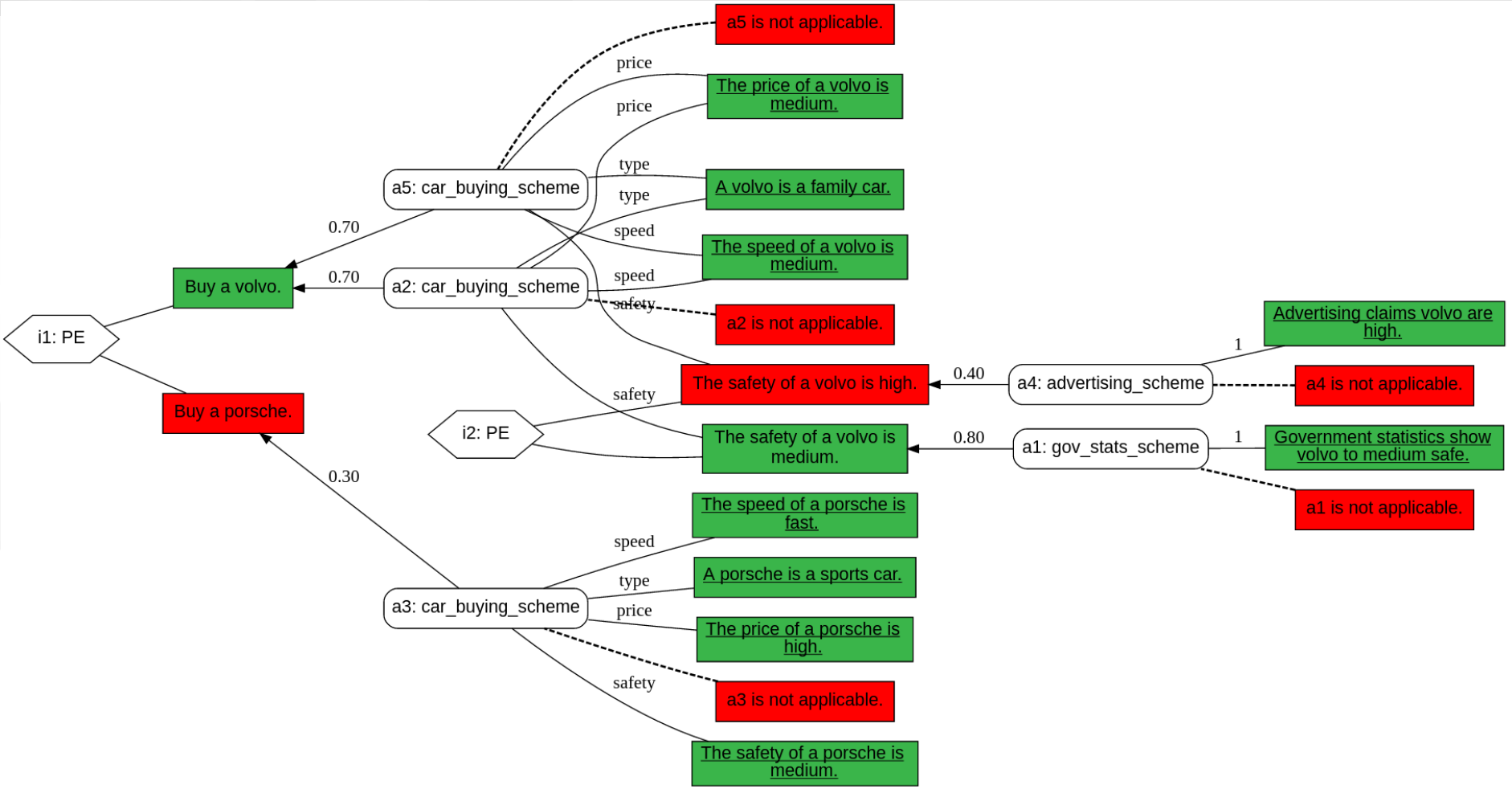
- O*, the* options *(also called* positions*) of the issue, is a finite subset of* $\mathscr{L}$.
- f*, the* proof standard *of the issue, is a function which tests whether an option satisfies the standard.*

Argument Graphs

Definition 4 (Argument Graph) *An* argument graph *is a tuple* (S, A, I, R)*, where:*

- *S, the* statements *of the argument graph, is a finite subset of* $\mathscr{L}$.
- *A, the* assumptions*, is a subset of S assumed to be provable.*
- *I, the* issues *of the argument graph, is a finite set of issues, where every position of every issue is a member of S and no* $s \in S$ *is a position of more than one* $i \in I$*, and*
- *R, the* arguments *of the argument graph, is a finite set of arguments, where all conclusions, premises and undercutters are members of S.*

Example Argument Graph



Semantics

- Labeling
- Weighing functions
- Proof standards
- Applicability of arguments
- Supported statements
- Unsupported statements
- Resolvable Issues
- Conflict-free labeling
- Characteristic Function
- Extensions

Errata

- Definition 7 (Applicable Argument) An argument $r \in R$ is applicable in a labelling *l* iff:
  - *The undercutter of r is **In** in l, or*
  - The undercutter of r is **Out** and every premise of *r* is not **Undecided** in *l*

Note: Somewhat unintuitively, **undercut arguments are applicable but have 0.0 weight**. Similarly, an applicable argument can have Out premises, decreasing (or increasing!) the weight of the argument.

Conjectures

- Monotonicity of the characteristic function
- Satisfies Caminada's rationality postulates
- As in Dung AFs, every argument graph has exactly one grounded extension
- Computing the grounded extension is a tractable problem
- Generalizes the 2007 version of Carneades
- Generalizes and simplifies ASPIC+
- Can simulate any Dung AF

Some Related Work

- ASPIC+
- Abstract Dialectical Frameworks (ADF)

ASPIC+

- Prakken, Henry (2010). An abstract framework for argumentation with structured arguments. Argument & Computation, 1, 93-124.
- All three kinds of attack supported by ASPIC+ (undercutters, rebuttals, premise defeaters) are also supported here.
- Many ASPIC+ examples have been successfully reconstructed
- ASPIC+ can handle cumulative arguments (accrual) only by creating additional arguments for each subset of the premises. Causes exponential blow-up in the number of arguments.
- Conjecture: our model is both simpler and more expressive
- Future work: proving this conjecture

ADFs

- Brewka, Gerhard and Woltran, Stefan (2010). Abstract Dialectical Frameworks. Proceedings of the Twelfth International Conference on the Principles of Knowledge Representation and Reasoning (pp. 102-111), AAAI Press.
- Convenient generalization of Dung AFs for defining a wide-variety of graph-based formalisms.
- But labels of nodes can depend only on their parent nodes.
- This is not general to handle balancing, where the labels of nodes can depend on properties of nodes further away, as in the example.

Conclusions

- Original formal model of structured argument with support for
  - Attack relations (undercutters, rebuttals, premise defeaters)
  - Balancing arguments, cumulative arguments, argument accrual, without blowing up the number of arguments
- Extends argumentation schemes with weighing functions
- Can simulate multiple-criteria decision analysis
- Defined with a fix-point semantics, similar to and generalizing Dung AFs
- Fully implemented, in Carneades 4
- Future work: proving the conjectures and further properties, as well as relations to other formal models

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Policy Compass

Open data-driven analysis and impact evaluation