

Explanation for Case-Based Reasoning via Abstract Argumentation COMMA'16

Kristijonas Čyras¹ Ken Satoh² Francesca Toni¹

¹Imperial College London

²National Institute of Informatics, Tokyo

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What and Why

- ▶ CBR [Richter and Weber, 2013]
- ▶ Explanations [Sørmo et al., 2005]
 - ▶ hard to define formally
 - ▶ common: show most similar cases – need not suffice
 - ▶ transparency desirable (not hiding conflicting cases)
- ▶ AA-CBR [Čyras et al., 2016]
 - ▶ Abstract Argumentation [Dung, 1995] helps



Customer

Alice has bought a chair, wants to return it:

- ▶ doesn't like it (factor A);
- ▶ has used the chair (factor B);
- ▶ no signs of wear and tear (factor C);
- ▶ had it >30 days (factor D).



Seller

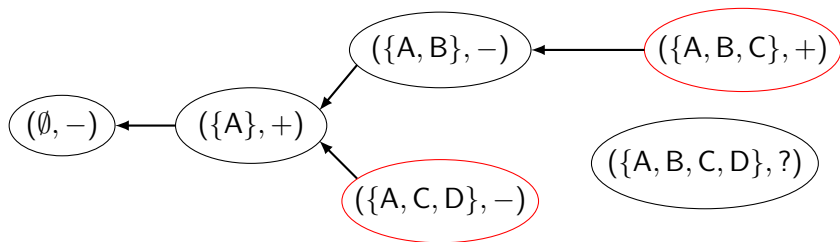
has a **default** $(\emptyset, -)$: no info, no refund $(-)$;
and a **case base** CB with:

- ▶ a case $(\{A\}, +)$: don't like, refund $(+)$;
- ▶ $(\{A, B\}, -)$: used, no refund;
- ▶ $(\{A, B, C\}, +)$: unless in good condition, refund;
- ▶ $(\{A, C, D\}, -)$: had it for too long, no refund.

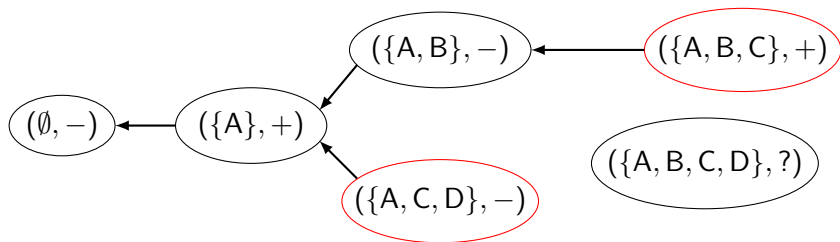
Alice's **new case** $(\{A, B, C, D\}, ?)$.



Argument Perspective



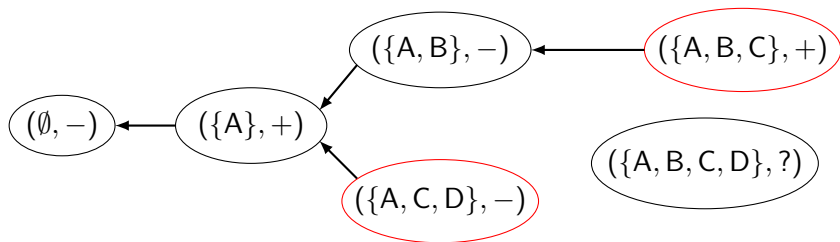
Argument Perspective



- ▶ Grounded extension $\mathbb{G} =$
 $\{(\{A, B, C, D\}, ?), (\{A, B, C\}, +), (\{A, C, D\}, -), (\emptyset, -)\}$



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- ▶ AA outcome of N is $-$



Case-Based Setting

- ▶ \mathbb{F} a set of factors
- ▶ $CB \subseteq \mathbb{F} \times \{-, +\}$ a case base
 - ▶ past cases (X, o) with $X \subseteq \mathbb{F}$ and $o \in \{-, +\}$
- ▶ Default case (\emptyset, d)
 - ▶ default outcome $d \in \{-, +\}$
 - ▶ its complement $\bar{d} \in \{-, +\} \setminus \{d\}$
- ▶ New case $N \subseteq \mathbb{F}$
- ▶ For cases $(X, o_X), (Y, o_Y) \in CB$, if $X = Y$, then $o_X = o_Y$



Corresponding AA Framework

Given CB , default d and new case N , define $(Args, \rightsquigarrow)$:



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Corresponding AA Framework

Given CB , default d and new case N , define $(Args, \rightsquigarrow)$:

- ▶ $Args = CB \cup \{(\emptyset, d)\} \cup \{(N, ?)\}$;
- ▶ For $(X, o_X), (Y, o_Y) \in CB \cup \{(\emptyset, d)\}$, it holds that $(X, o_X) \rightsquigarrow (Y, o_Y)$ iff
 - ▶ $o_X \neq o_Y$, and different outcomes
 - ▶ $Y \subsetneq X$, and specificity
 - ▶ $\nexists (Z, o_X) \in CB$ with $Y \subsetneq Z \subsetneq X$; concision



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- ▶ For $(Y, o_Y) \in CB$, it holds that $(N, ?) \rightsquigarrow (Y, o_Y)$ iff $Y \not\subseteq N$. irrelevant factors



AA Outcome

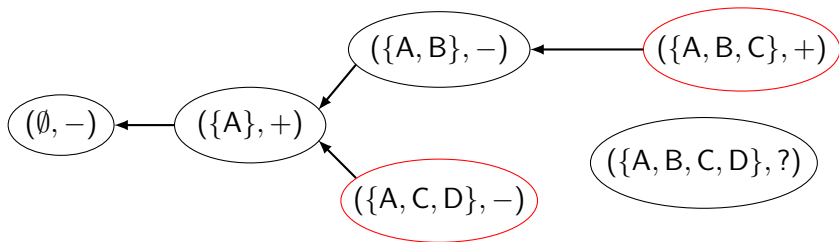
Given CB , $d \in \{+, -\}$, and N , assume the corresponding $(Args, \rightsquigarrow)$ and its grounded extension \mathbb{G} .

The **AA outcome** of the new case N is:

- ▶ the default outcome d , if $(\emptyset, d) \in \mathbb{G}$;
- ▶ the complement \bar{d} , if $(\emptyset, d) \notin \mathbb{G}$.



Illustration – As Before



- ▶ Grounded extension $\mathbb{G} =$
 $\{(\{A, B, C, D\}, ?), (\{A, B, C\}, +), (\{A, C, D\}, -), (\emptyset, -)\}$
- ▶ AA outcome of N is $-$



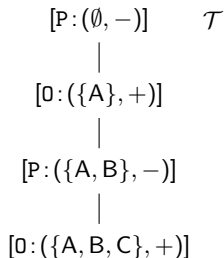
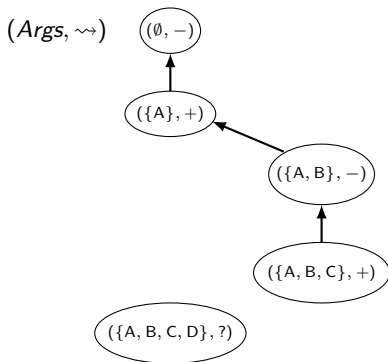
Explanations: Formally Defined

AA-CBR affords explanations of AA outcome as dispute trees:

- ▶ AA outcome of N is d — an explanation is any **admissible dispute tree** for (\emptyset, d)
 - ▶ every 0 node has a child
 - ▶ no argument labels both P and 0
- ▶ AA outcome of N is \bar{d} — an explanation is any **maximal dispute tree** for (\emptyset, d)
 - ▶ every 0 leaf is unattacked in $Args$



Explanation (for $\bar{d} = +$)

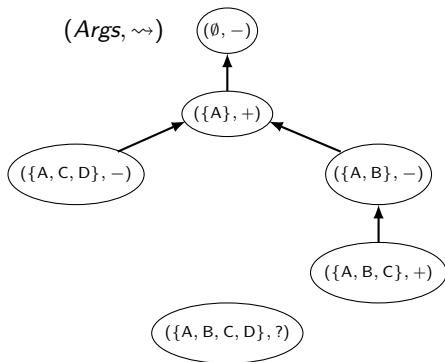


$$\mathbb{G} = \{(\{A, B, C, D\}, ?), (\{A, B, C\}, +), (\{A\}, +)\} \not\supseteq (\emptyset, -)$$

AA outcome of N is $+$



Explanation (for $d = -$)



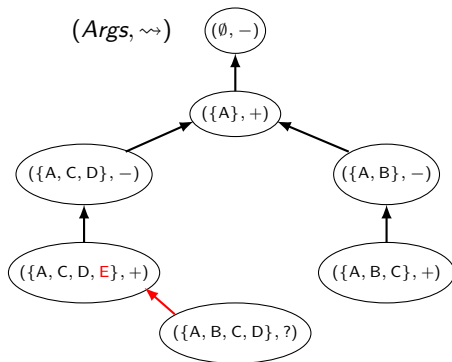
$$\begin{array}{c}
 [P: (\emptyset, -)] \quad \mathcal{T} \\
 | \\
 [0: (\{A\}, +)] \\
 | \\
 [P: (\{A, C, D\}, -)]
 \end{array}$$

$$\mathbb{G} = \{(\{A, B, C, D\}, ?), (\{A, B, C\}, +), (\{A, C, D\}, -), (\emptyset, -)\}$$

AA outcome of N is $-$



Explanation (for $d = -$)



$$\begin{array}{c}
 [P: (\emptyset, -)] \quad \mathcal{T}' \\
 | \\
 [0: (\{A\}, +)] \\
 | \\
 [P: (\{A, C, D\}, -)] \\
 | \\
 [0: (\{A, C, D, E\}, +)] \\
 | \\
 [P: (\{A, B, C, D\}, ?)]
 \end{array}$$

$\mathbb{G} = \{(\{A, B, C, D\}, ?), (\{A, B, C\}, +), (\{A, C, D\}, -), (\emptyset, -)\}$

AA outcome of N is $-$



Properties: Nearest Cases

(X, o_X) is **nearest** to N iff
 $X \subseteq N$, and $\nexists (Y, o_Y) \in CB$ with $X \subsetneq Y \subseteq N$.

- ▶ (X, o) unique nearest \Rightarrow AA outcome of N is o .
- ▶ **Transparency**: \mathbb{G} contains all the nearest cases.



Properties: Explanations

Given an explanation \mathcal{T} , the **defence set** $\mathcal{D}(\mathcal{T})$ is proponent's (P) arguments in \mathcal{T} .

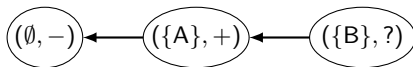
- ▶ AA outcome is $d \Rightarrow$ exists explanation \mathcal{T} for d
 - ▶ moreover, $\mathcal{D}(\mathcal{T})$ is admissible and $\mathcal{D}(\mathcal{T}) \subseteq \mathbb{G}$
- ▶ AA outcome is $\bar{d} \Rightarrow$ exists explanation \mathcal{T} for \bar{d}
 - ▶ moreover, $\mathcal{D}(\mathcal{T}) \not\subseteq \mathbb{G}$
- ▶ \forall nearest (X, o) , \exists explanation \mathcal{T} s.t.
 - ▶ $(X', o) \in \mathcal{D}(\mathcal{T})$ for some (X', o) with $X' \subseteq X$



Ir/Relevant Arguments, Lean Explanations

$(X, o) \in \text{Args} \setminus \{(\emptyset, d)\}$ is:

- ▶ **relevant** if $X \cap N \neq \emptyset$, $((\emptyset, d)$ is relevant.)
- ▶ **irrelevant**, if $X \cap N = \emptyset$.



Relevant dispute tree: only relevant arguments

- ▶ **Lean explanation** for d/\bar{d} : an admissible/maximal relevant dispute tree
 - ▶ preserves desirable properties of explanations



Burden of Proof

The burden of establishing as well as explaining the AA outcome falls onto the proponent

- ▶ A statement s is satisfied by a **proof standard** STD in $(Args, \rightsquigarrow)$ iff $STD(s, (Args, \rightsquigarrow)) = \text{TRUE}$
- ▶ s_d : given CB and d , the outcome of N is d
- ▶ **Scintilla of Evidence** proof standard SE:
 $SE(s_d, (Args, \rightsquigarrow)) = \text{TRUE}$ iff \exists adm. disp. tree for (\emptyset, d)
- ▶ $SE(s_d, (Args, \rightsquigarrow)) = \text{TRUE}$ iff $(\emptyset, d) \in \mathbb{G}$



Future work

- ▶ Legal CBR
 - ▶ proof standards, burdens of production/persuasion
- ▶ Explanations for (non-)acceptability of arguments e.g. [García et al., 2013, Fan and Toni, 2015, Schulz and Toni, 2016]
- ▶ Usefulness of explanation in argumentation e.g. [Cerutti et al., 2014]
- ▶ Complexity
 - ▶ explanations – low overhead
 - ▶ construction of $(Args, \rightsquigarrow)$ – ?



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