Explainable Answer-Set Programming

Research Project

Cape-KR 2024

Tobias Geibinger

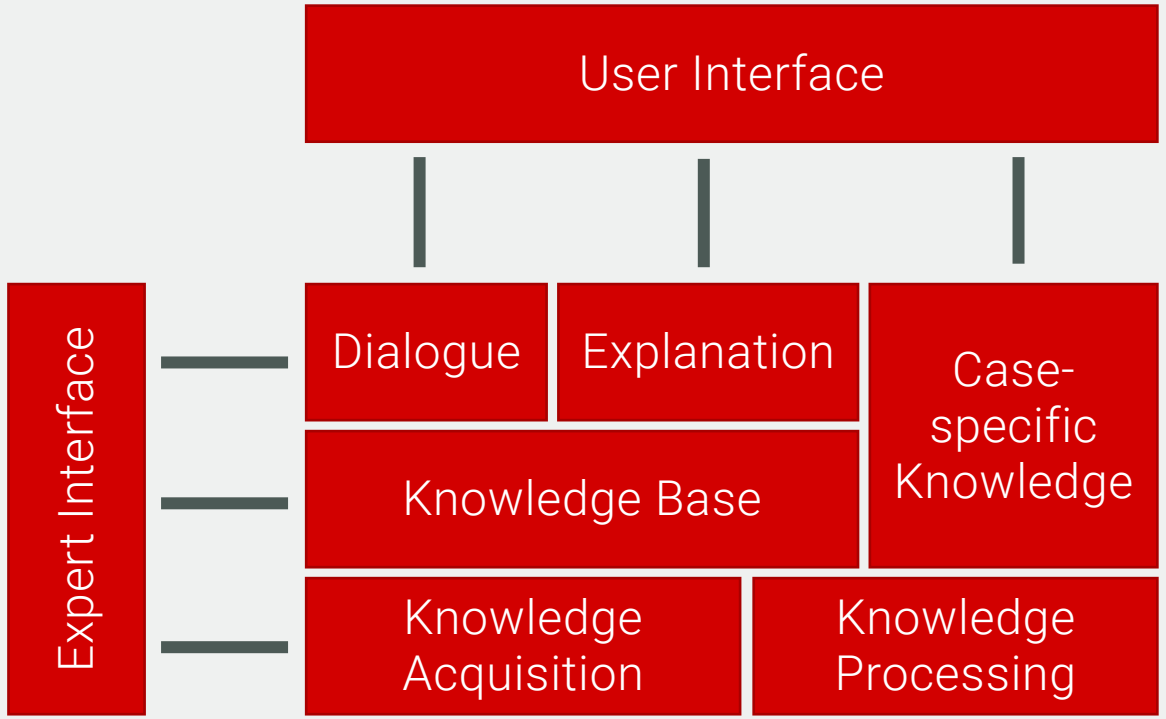
TU WIEN Informatics

kbs Knowledge-Based Systems Group

logics

Introduction

Historical Architecture of Symbolic AI Systems



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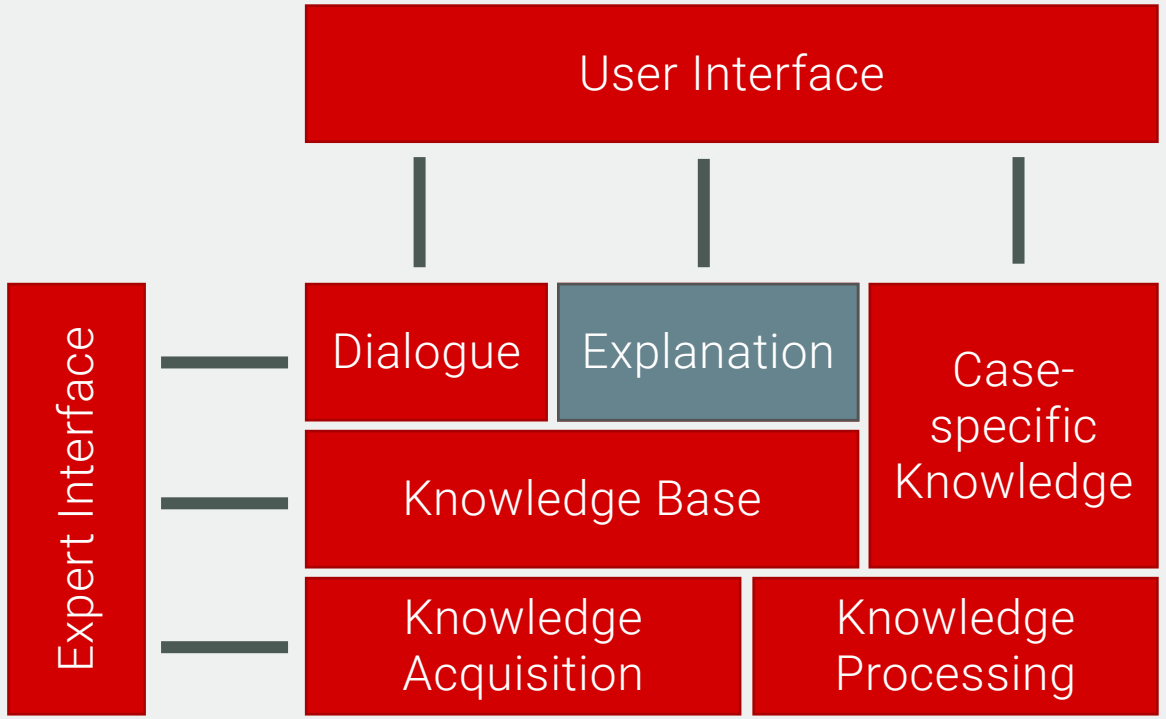

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Provided solutions still need to be **explained**

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instantiated during **grounding**

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whenever $b_{k+1}, \ldots, b_m \in I$ and $b_{m+1}, \ldots, b_n \notin I$, then $a_i \in I$ for some $(1 \leq i \leq k)$

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$I_1 = \{ republican(\mathsf{nixon}), quaker(\mathsf{nixon}), warhawk(\mathsf{nixon}) \}$

$I_2 = \{ republican(\mathsf{nixon}), quaker(\mathsf{nixon}), pacifist(\mathsf{nixon}) \}$

Answer-set Programming (ASP)

Methodology

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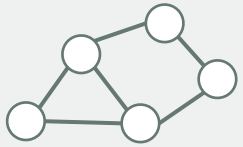
Methodology

Combinatorial Problem



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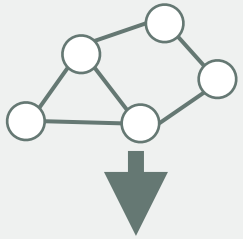

Facts

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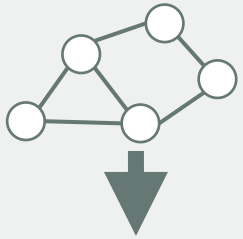

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ASP Encoding

$$r(X) \vee g(X) \vee b(X) \leftarrow node(X)$$
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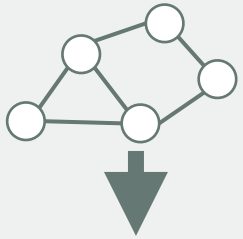

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ASP Solver

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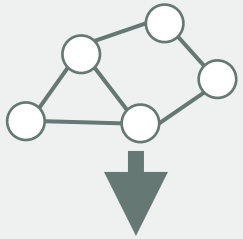

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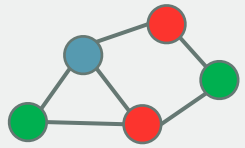
ASP Solver

Answer set

$g(1), b(2), r(3), r(4), g(5)$

Solution



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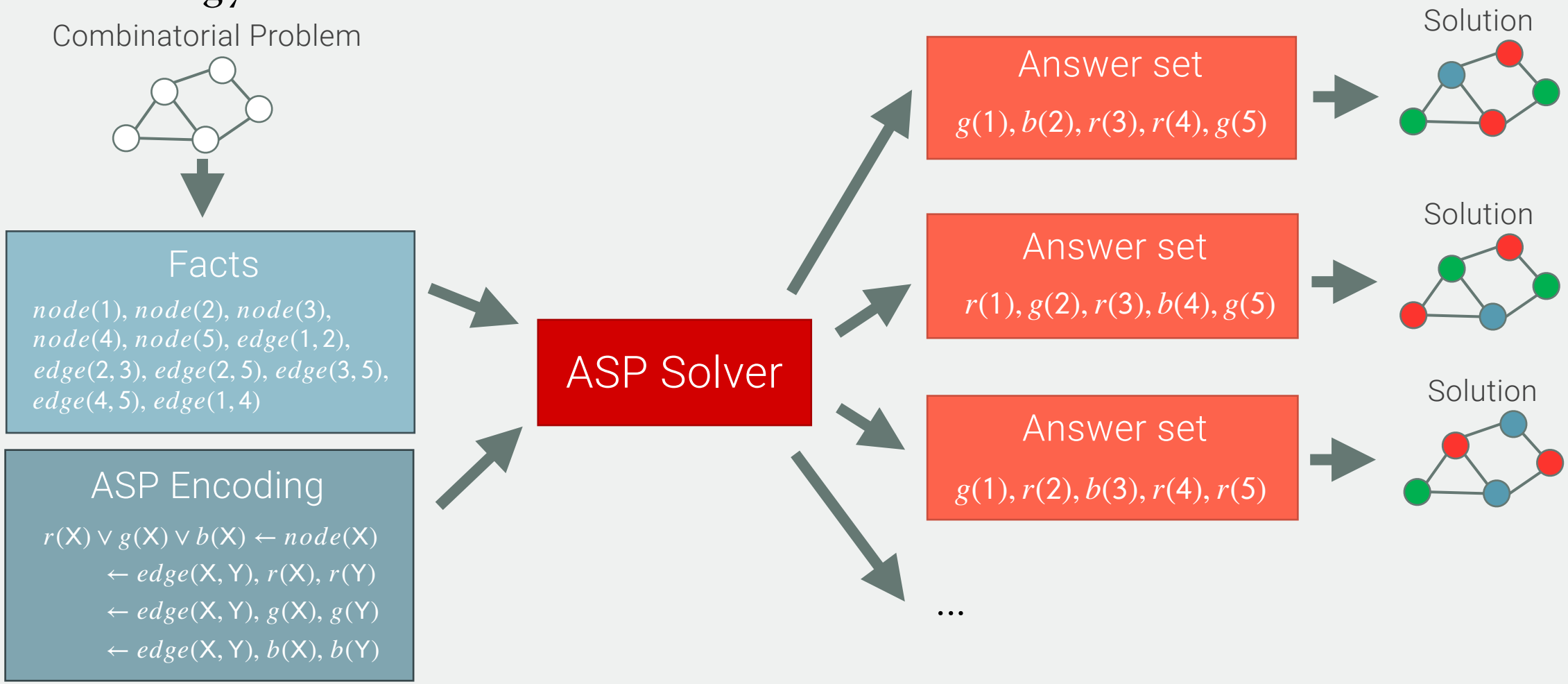

Answer-set Programming

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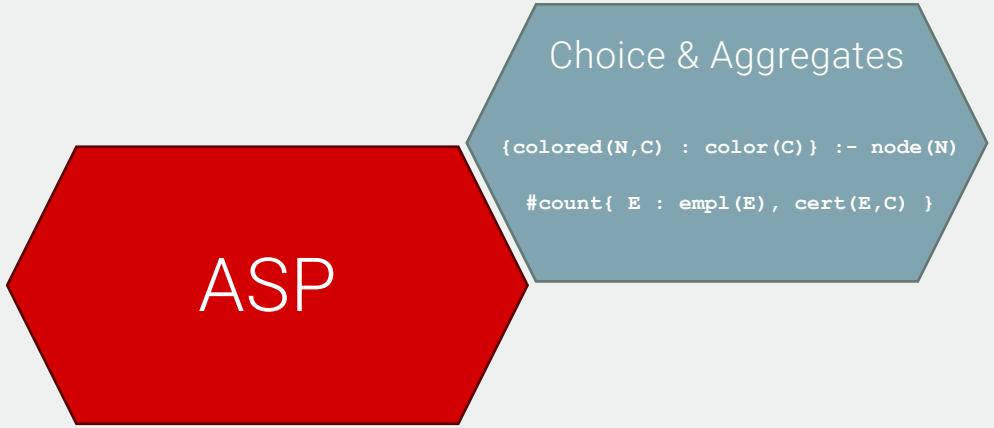

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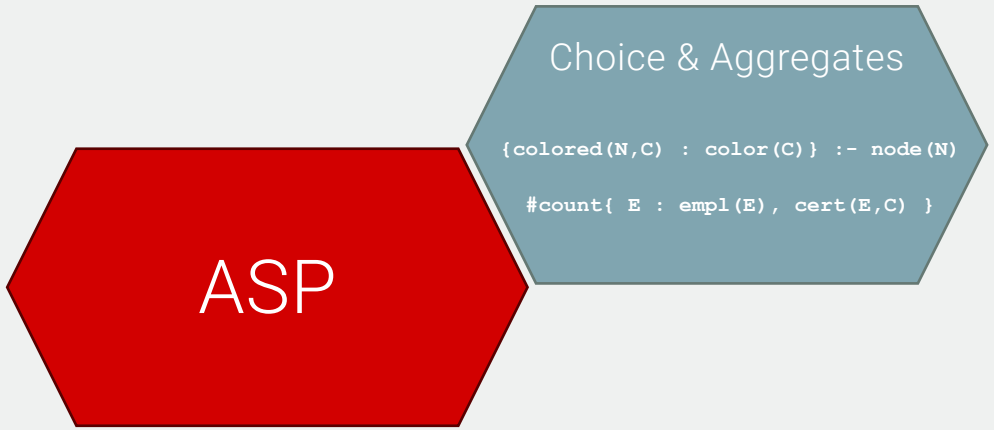

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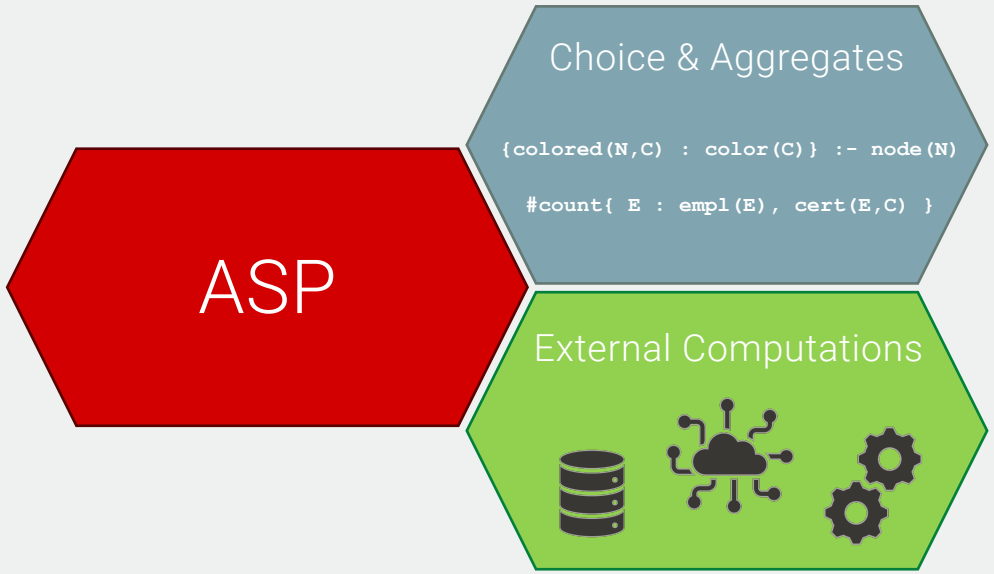

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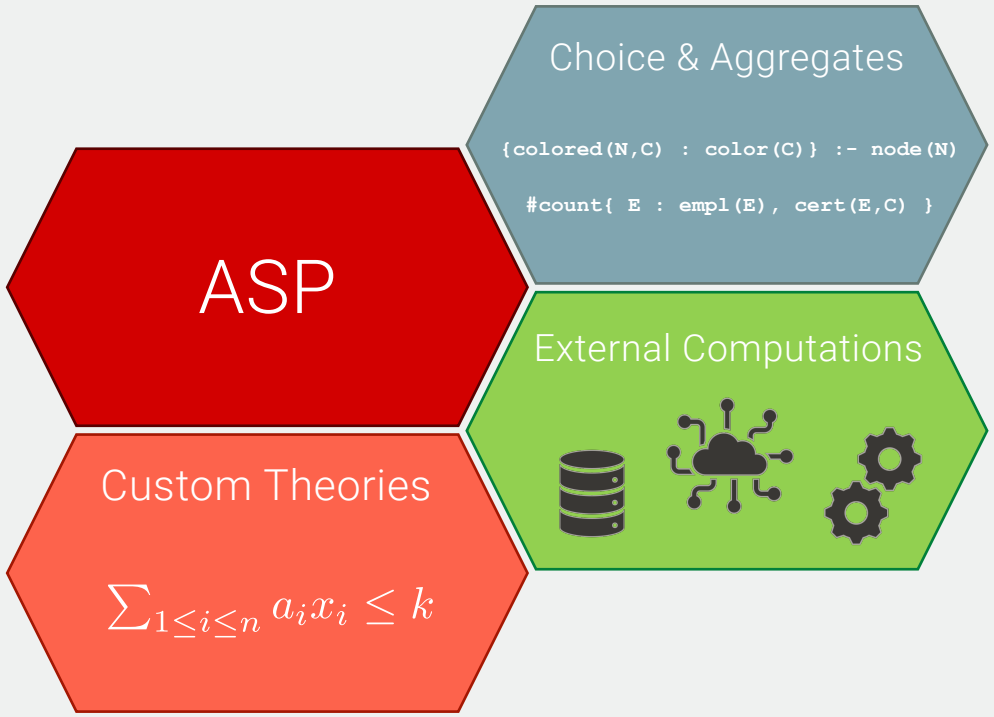

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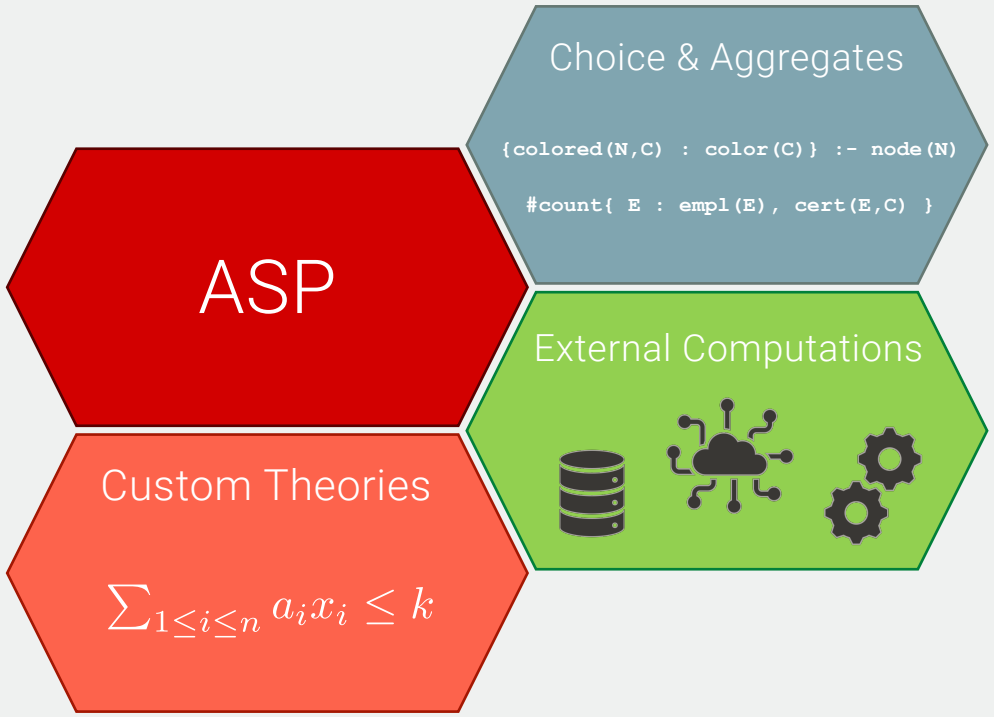

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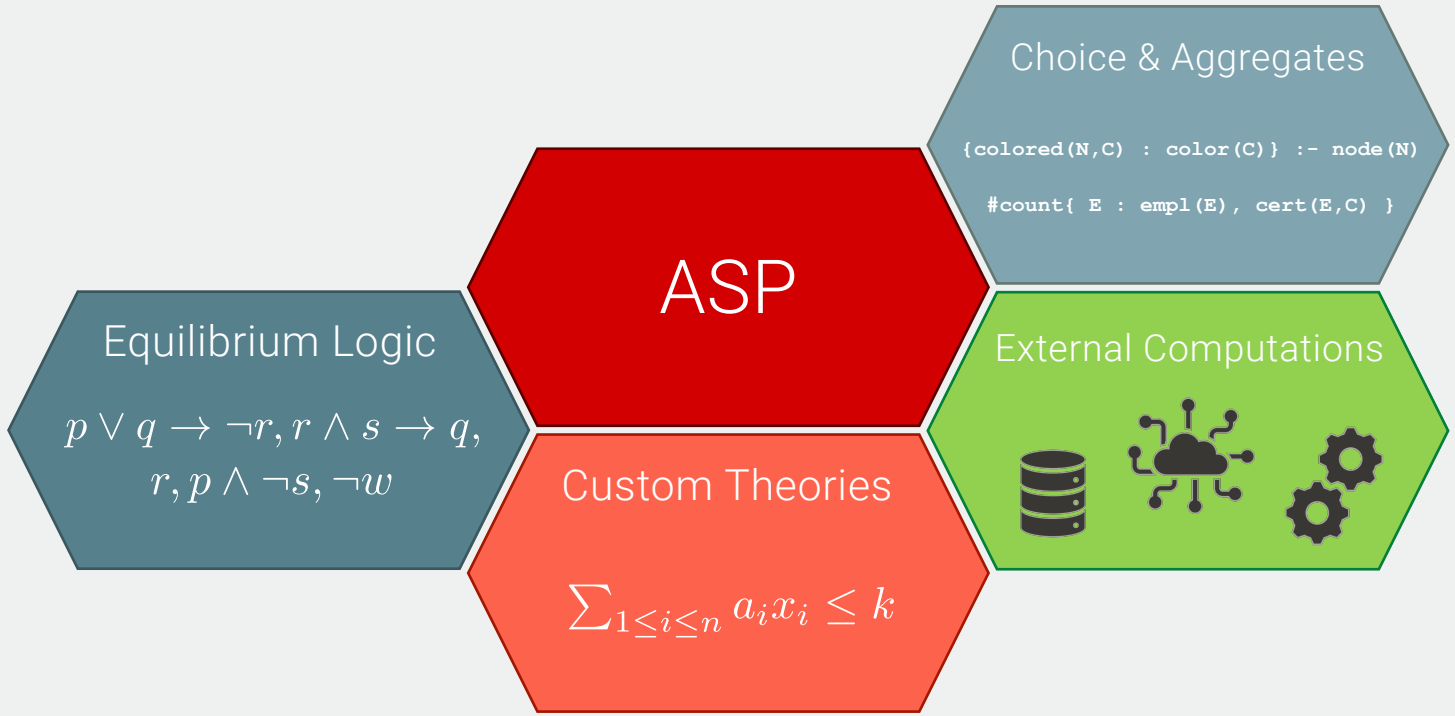

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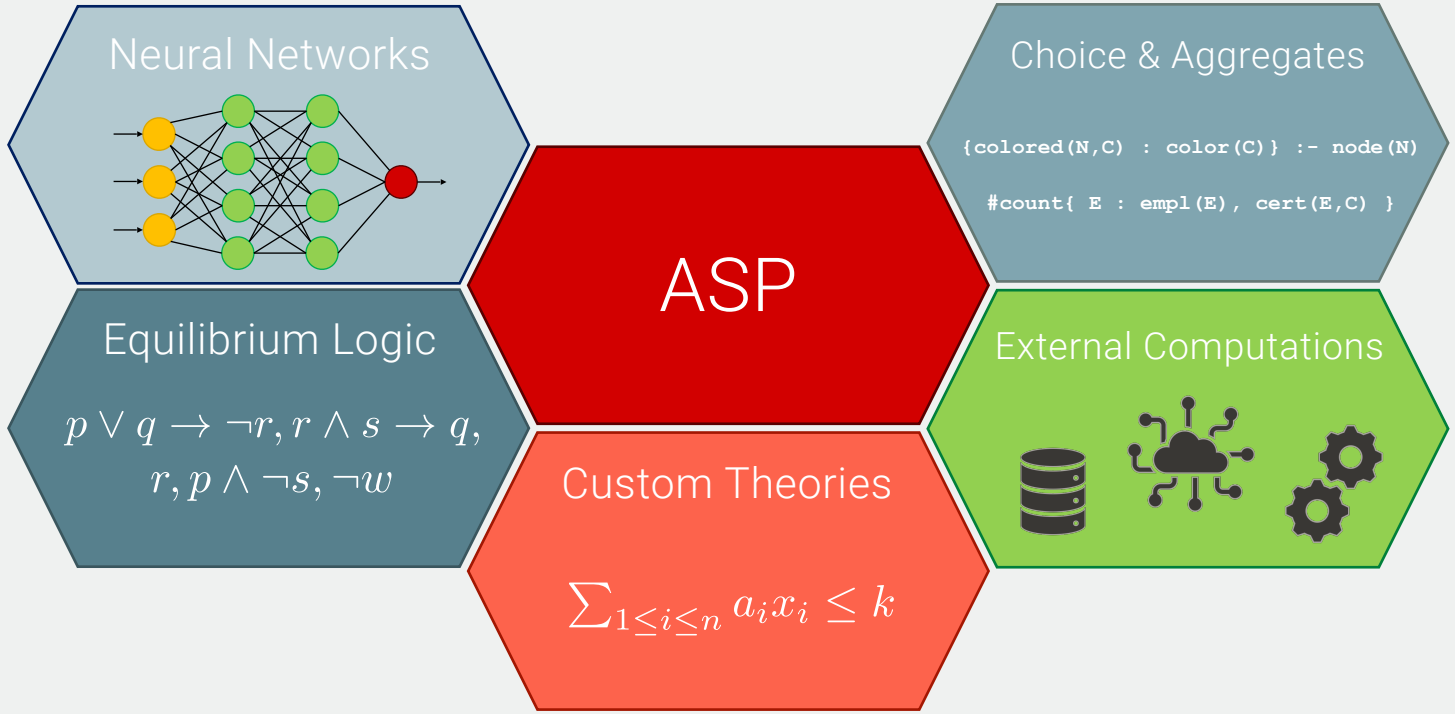

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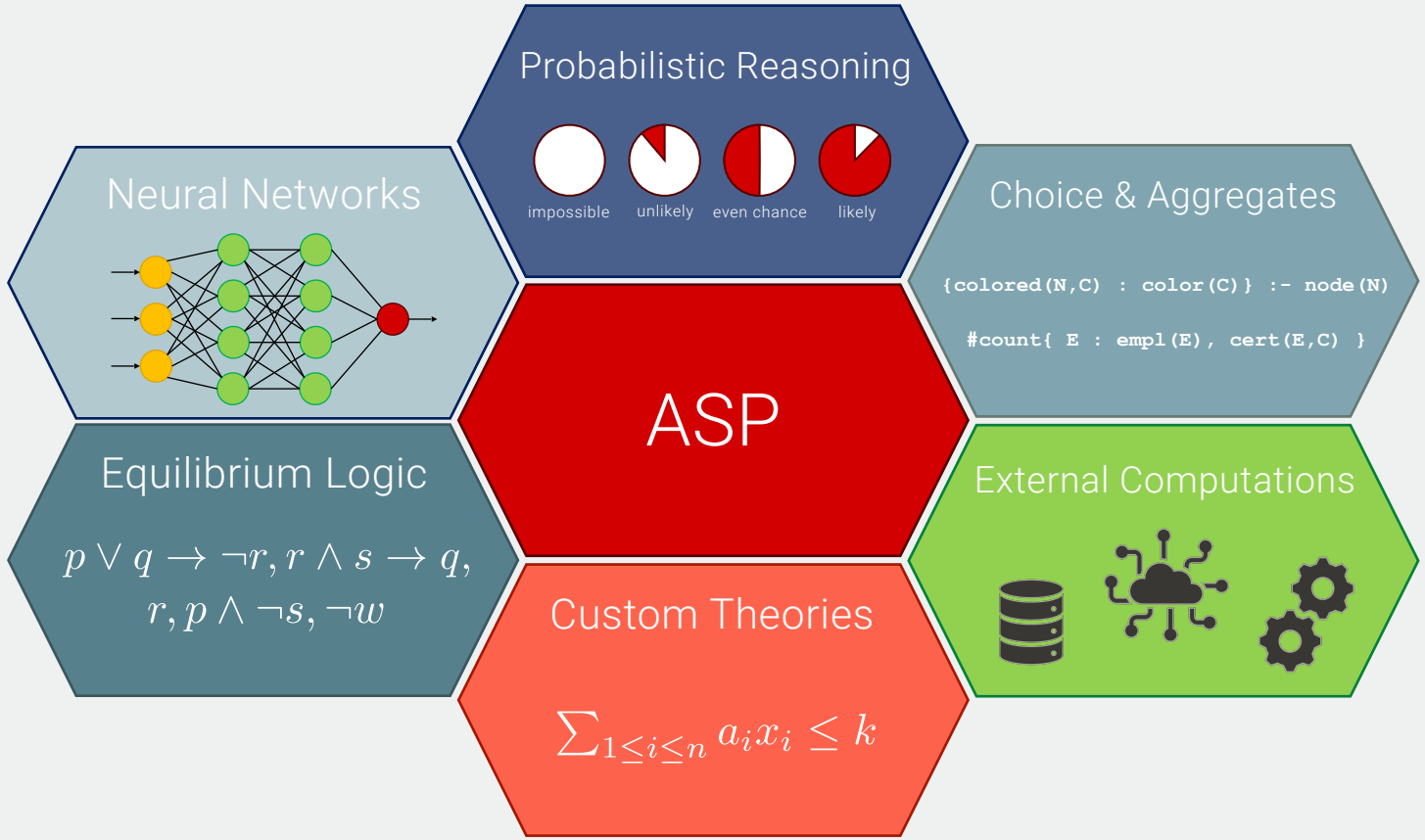

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Answer-set Programming

Explanations

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- Offline justification graphs / `xASP`

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- Offline justification graphs / `xASP`
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Answer-set Programming

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Supported language features vary

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Some **common principles**

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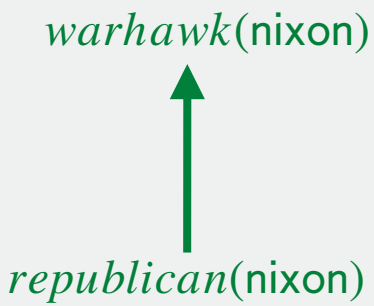

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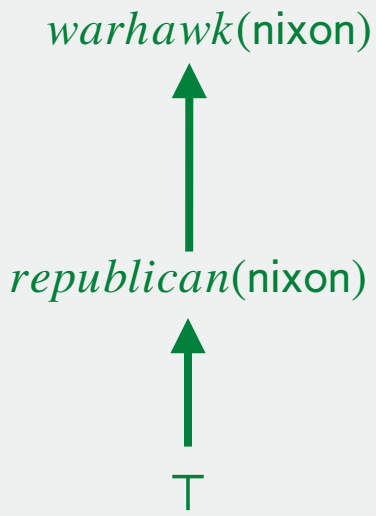

Answer-set Programming

Explanations

For **consistent programs**

- Offline justification graphs / `xASP`
- Causal explanations
- Witnesses
- `xclingo`
- …

Supported language features vary

Some **common principles**

Differences in how **negation** is handled

Example:

$$warhawk(\mathrm{X}) \leftarrow republican(\mathrm{X}),\ not\ pacifist(\mathrm{X})$$
$$pacifist(\mathrm{X}) \leftarrow quaker(\mathrm{X}),\ not\ warhawk(\mathrm{X})$$
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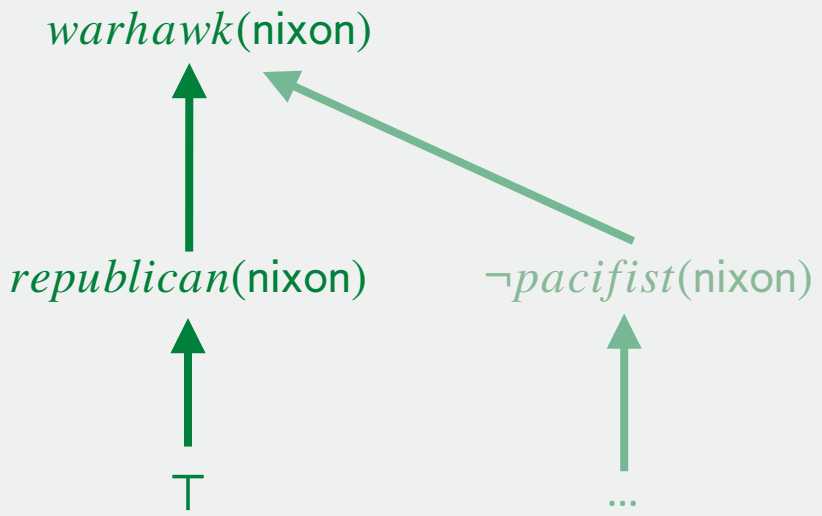

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Explanations are **not always satisfactory**

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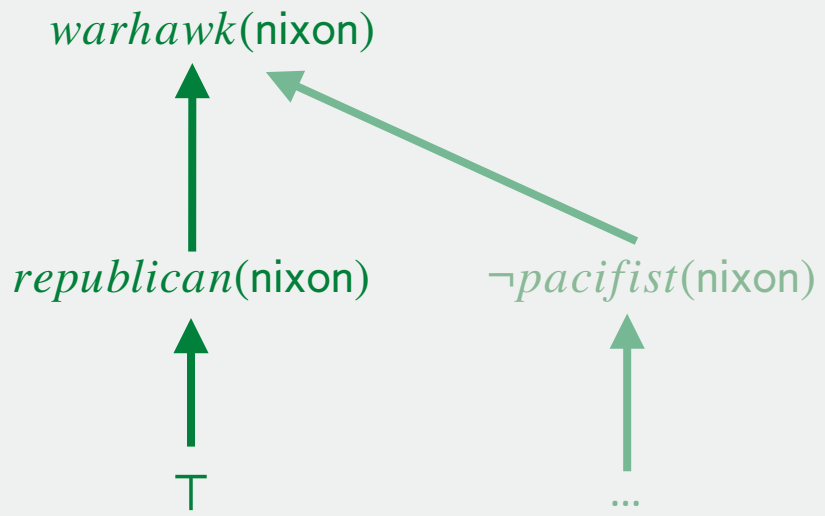

Answer-set Programming

Explanations

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Explanations for **inconsistent programs** are mostly considered for **debugging**

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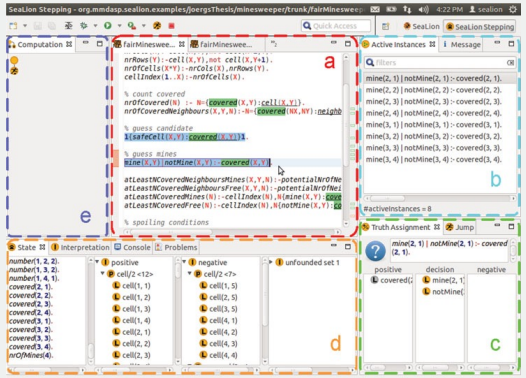

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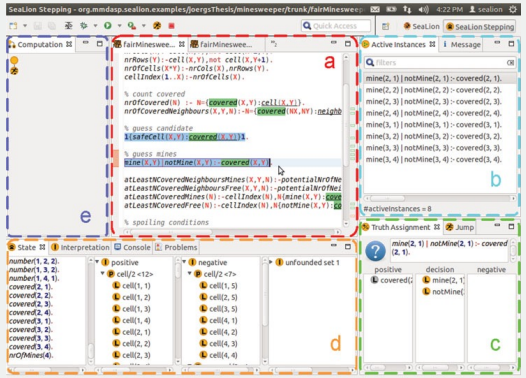

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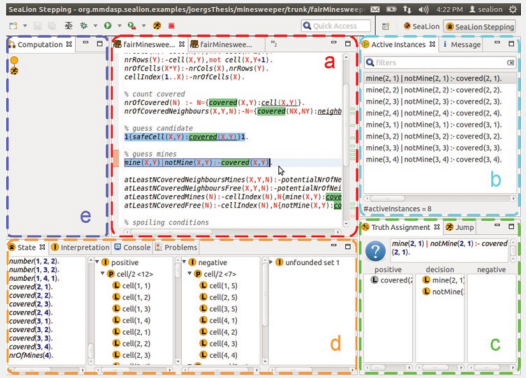
Supported **language features** again vary

The produced explanations are **very technical**!



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- How should we approach **contrastive explanation for ASP**?

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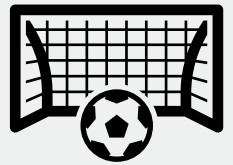
Research Goals



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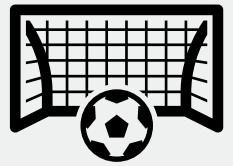

- Explaining ASP **extensions** and **advanced features**

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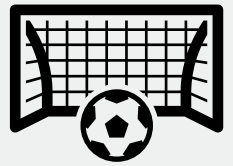

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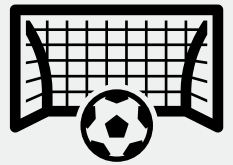

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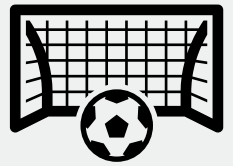

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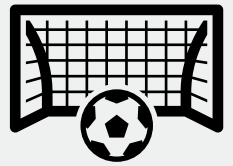

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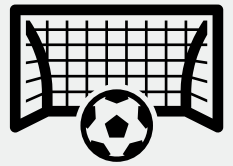

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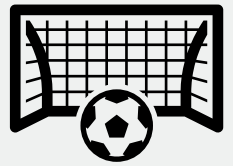

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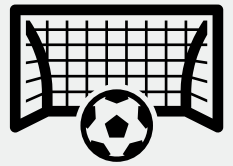

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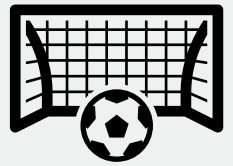

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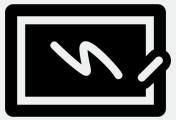

Formal concepts

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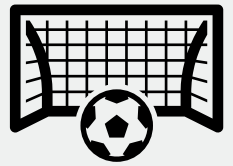

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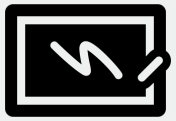

Formal concepts

Analysis

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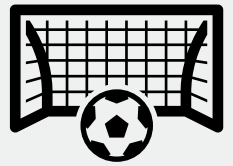

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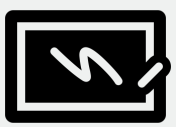

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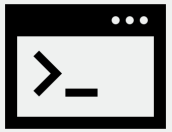

Prototypes

Research Status

Publications

Explaining Answer-Set Programs with Abstract Constraint Atoms

Thomas Eiter and Tobias Geibinger

32rd International Joint Conference on Artificial Intelligence (IJCAI 2023)

Contributions: Formal notions of justification for ASP with choice and aggregates, Complexity Analysis

A Logic-based Approach to Contrastive Explainability for Neurosymbolic Visual Question Answering

Thomas Eiter, Tobias Geibinger, Nelson Higuera Ruiz and Johannes Oetsch

32rd International Joint Conference on Artificial Intelligence (IJCAI 2023)

Contributions: Contrastive explanation approach for the Visual Question Answering domain

Contrastive Explanations for Answer-Set Programs

Thomas Eiter, Tobias Geibinger and Johannes Oetsch

18th Edition of the European Conference on Logics in Artificial Intelligence (JELIA 2023)

Contributions: Problem independent formulation of contrastive explanation for ASP including study of complexity

Research Status

Explaining Answer-Set Programs with Abstract Constraint Atoms

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We introduced **justifications** for ASP programs with **Abstract Constraint Atoms**:

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Model-based justifications:

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Choice rules and **aggregates** are captured by abstract constraint atoms

Example:

$$\texttt{\#sum\{2 : a, 1 : b, 1 : c\} > 1}$$

$$\Updownarrow$$

$$A = \langle \{a, b, c\}, \{\{a\}, \{b, c\}, \{a, b\}, \{a, c\}, \{a, b, c\}\} \rangle$$

$I = \{a, b, c\}$ $\quad I \models A$

Model-based justifications:

$\langle \{a\}, \emptyset \rangle$

Research Status

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minimal partial models

We also define **rule-based justifications** which take the application of rules into account

Research Status

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Thomas Eiter and Tobias Geibinger

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A Logic-based Approach to Contrastive Explainability for Neurosymbolic VQA

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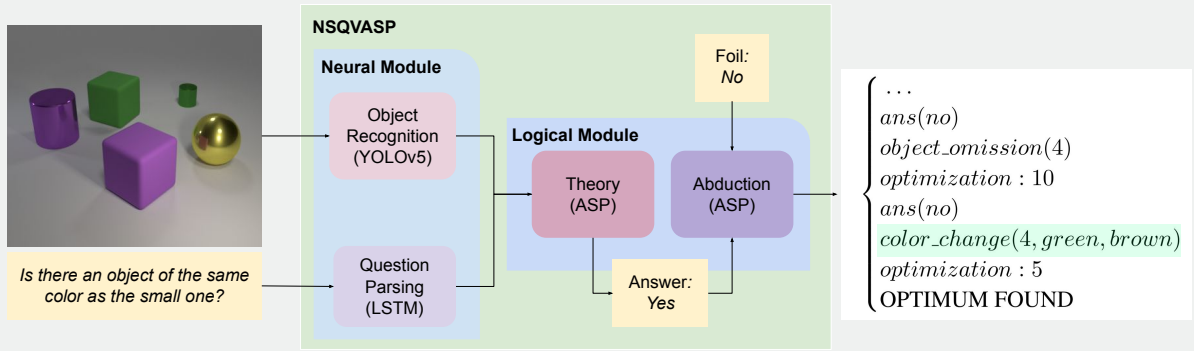
VQA Framework using ASP



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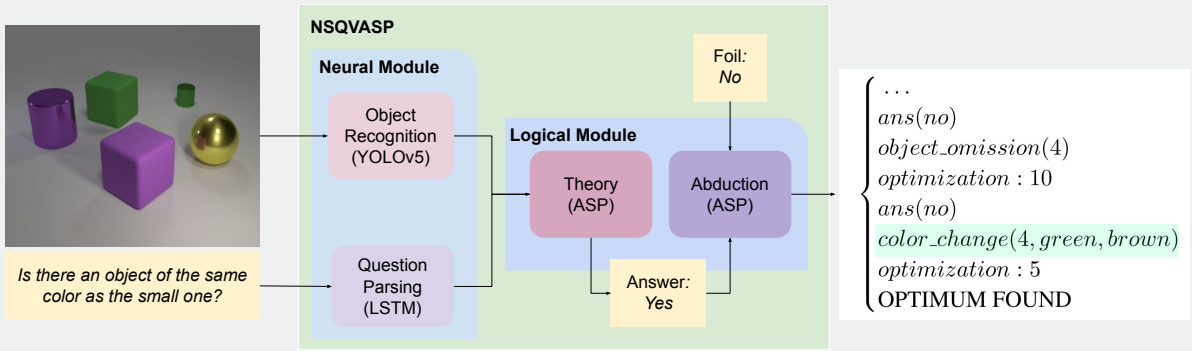

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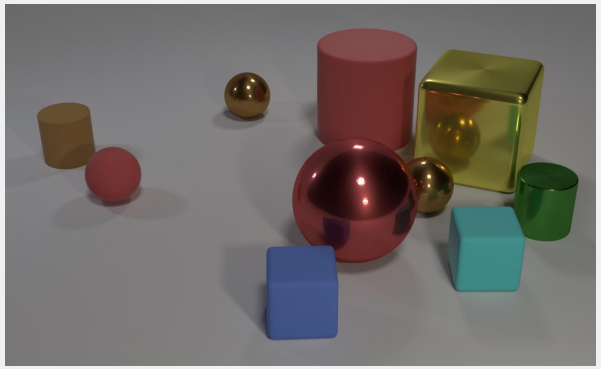

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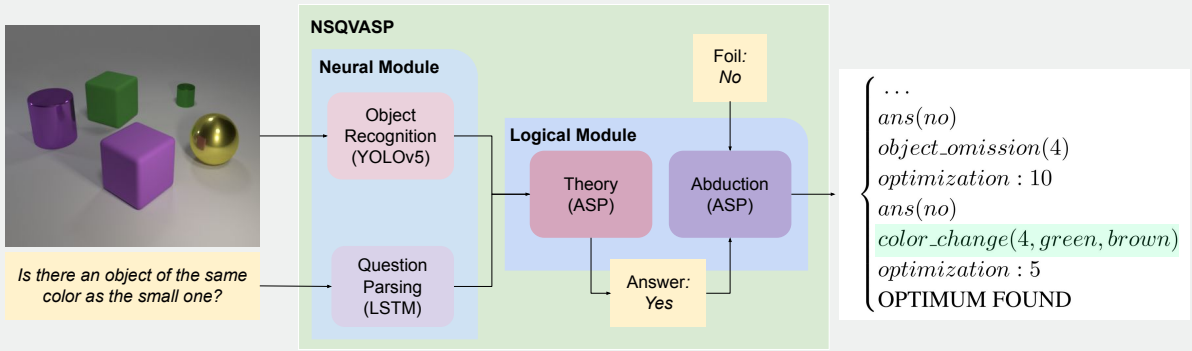

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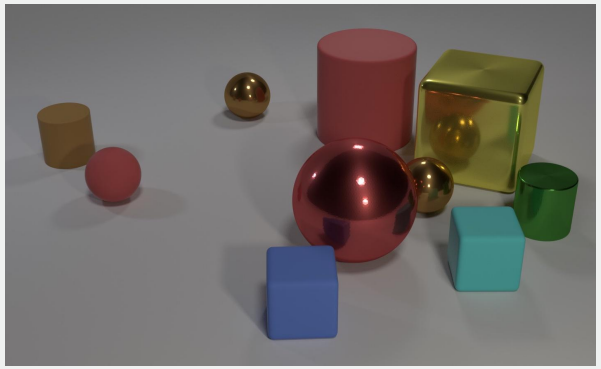

What size is the cylinder that is left of the brown metal thing that is left of the big sphere?

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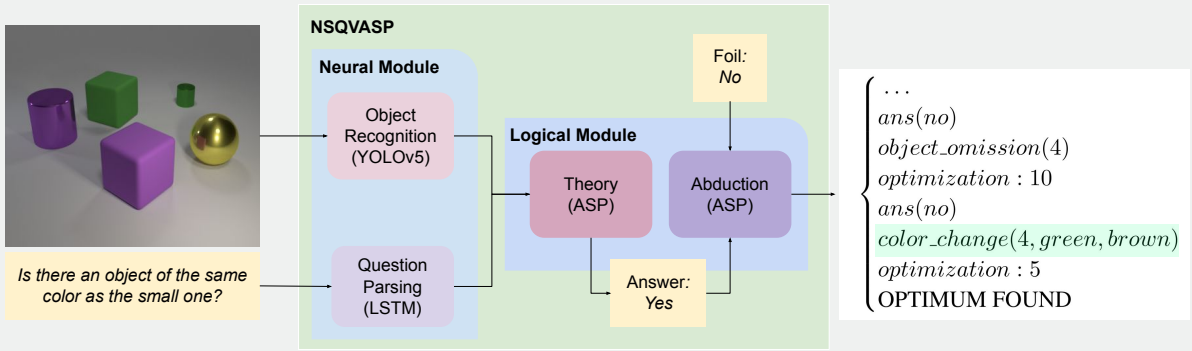

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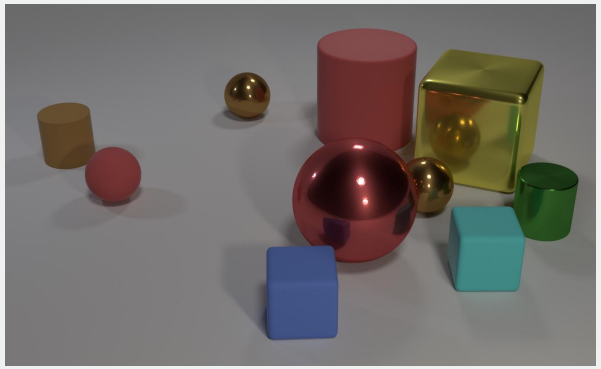

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Answer: small

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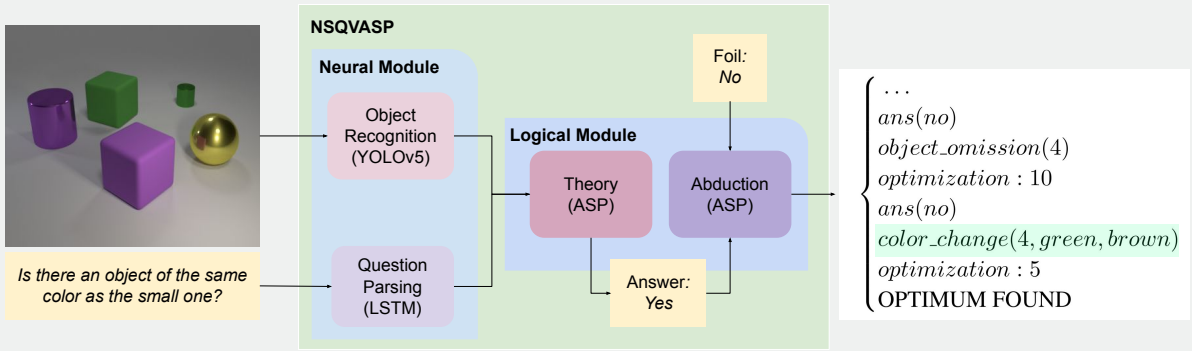

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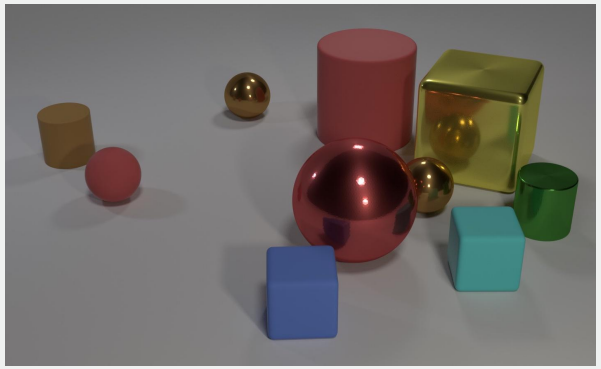

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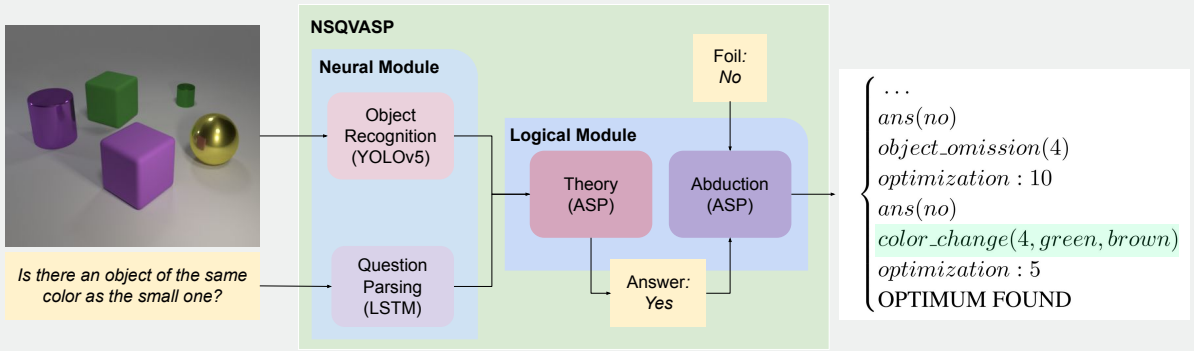

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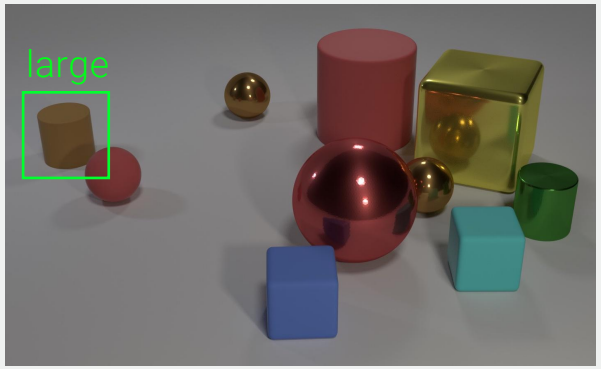

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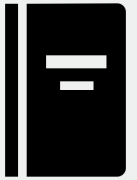

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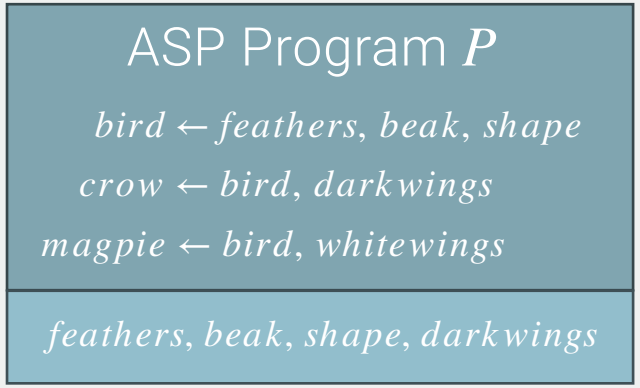

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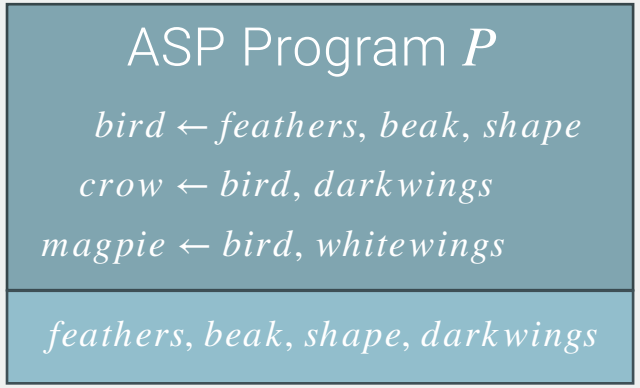

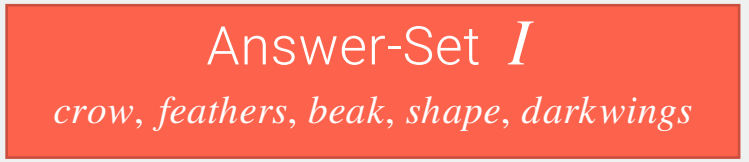

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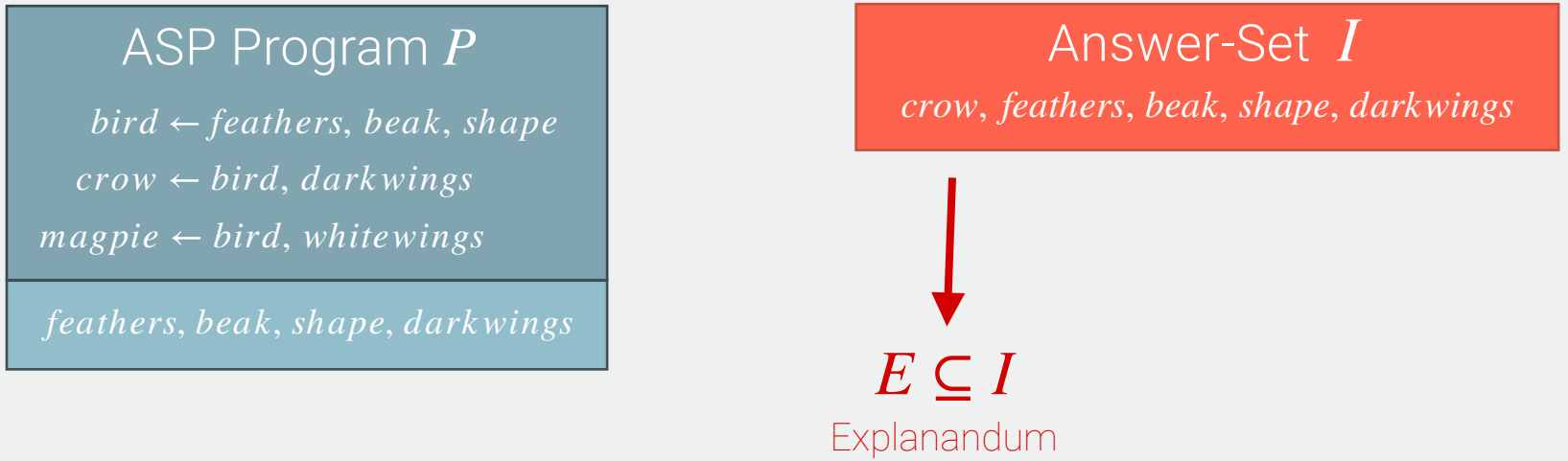

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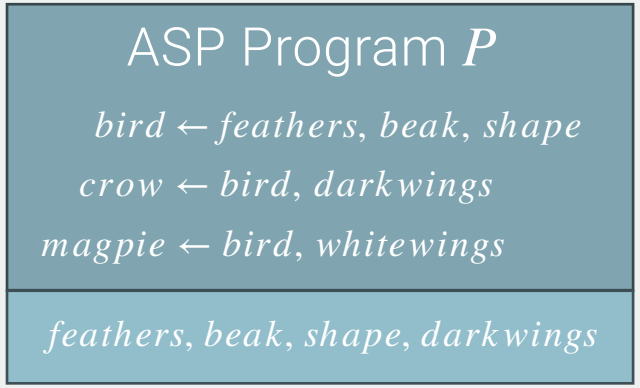

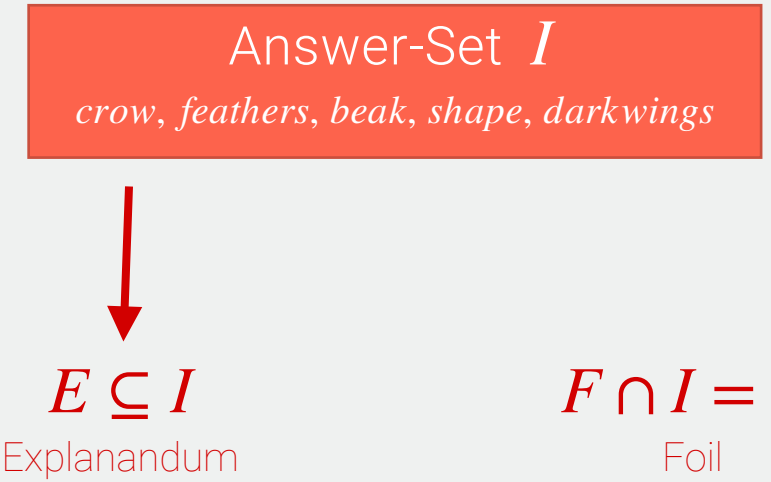

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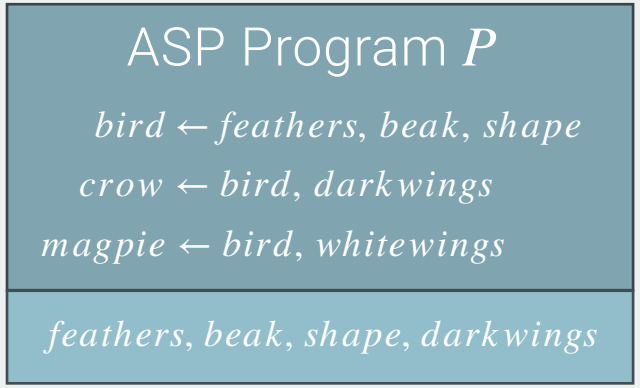

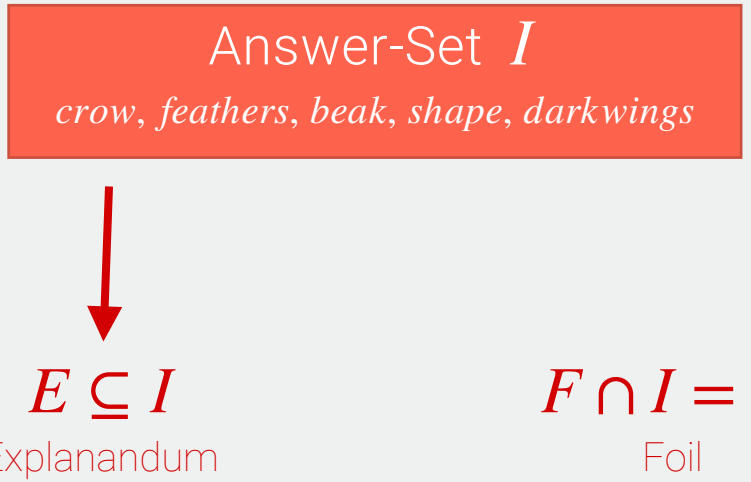

Why E rather than F?

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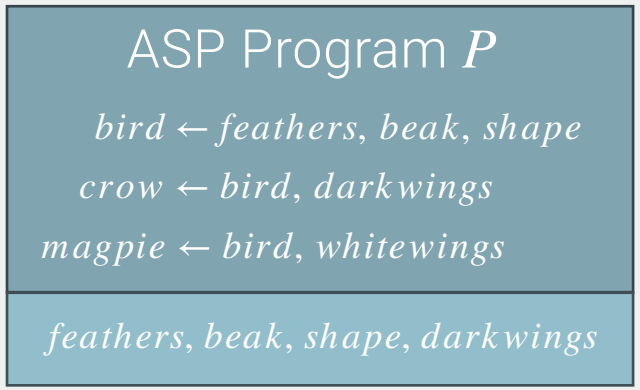

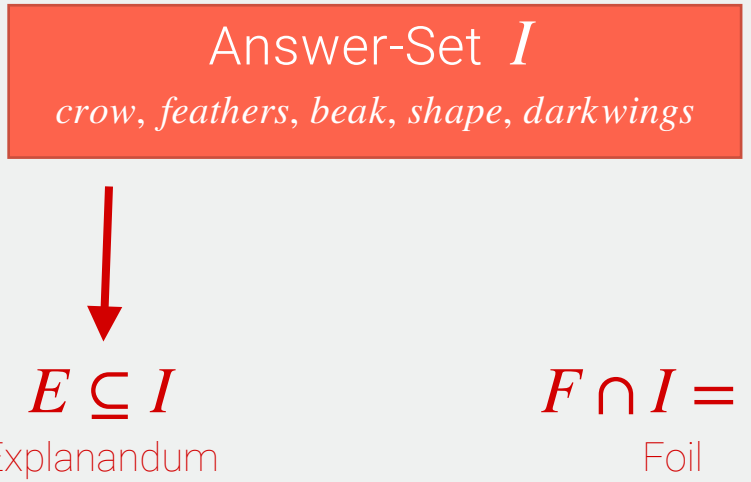

Why E rather than F?

We want to find a program P' with $I' \in AS(P')$ such that $F \subseteq I'$ and $E \nsubseteq I'$

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Continue investigation of **contrastive explanation**

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- Sharpen definitions and **theoretical foundation**
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- white-box, black-box, grey-box

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Development of a prototype using **contrastive** and **non-contrastive explanations** interactively