Answer Set Solving in Practice

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Motivation: Overview

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Outline

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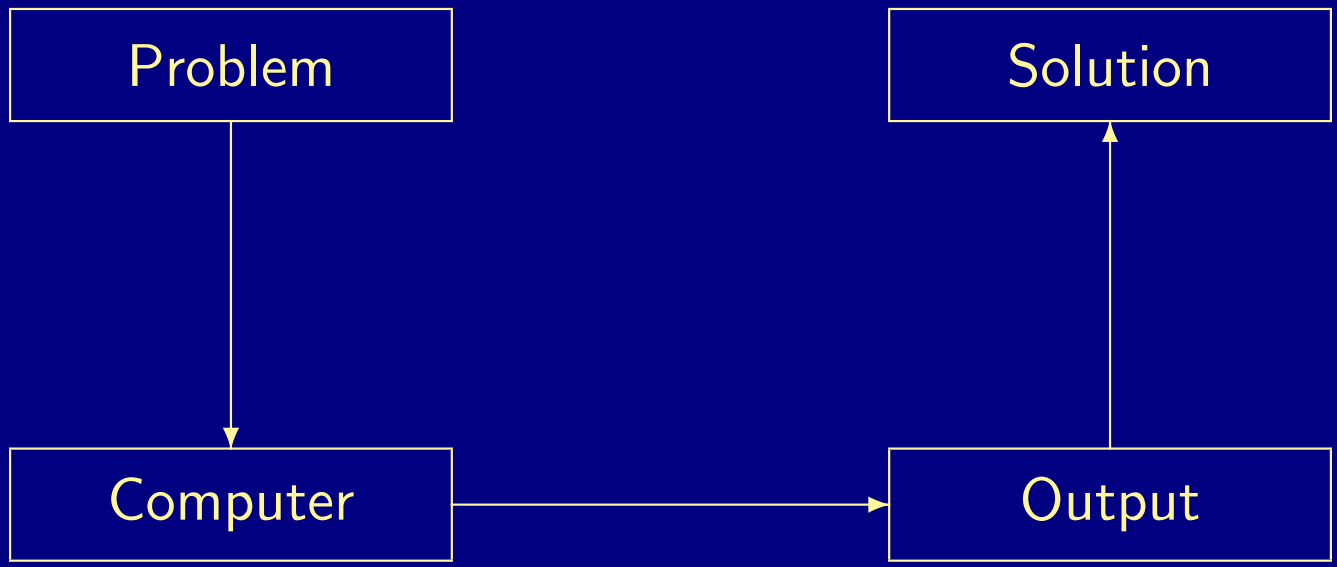
Informatics

"What is the problem?" versus *"How to solve the problem?"*



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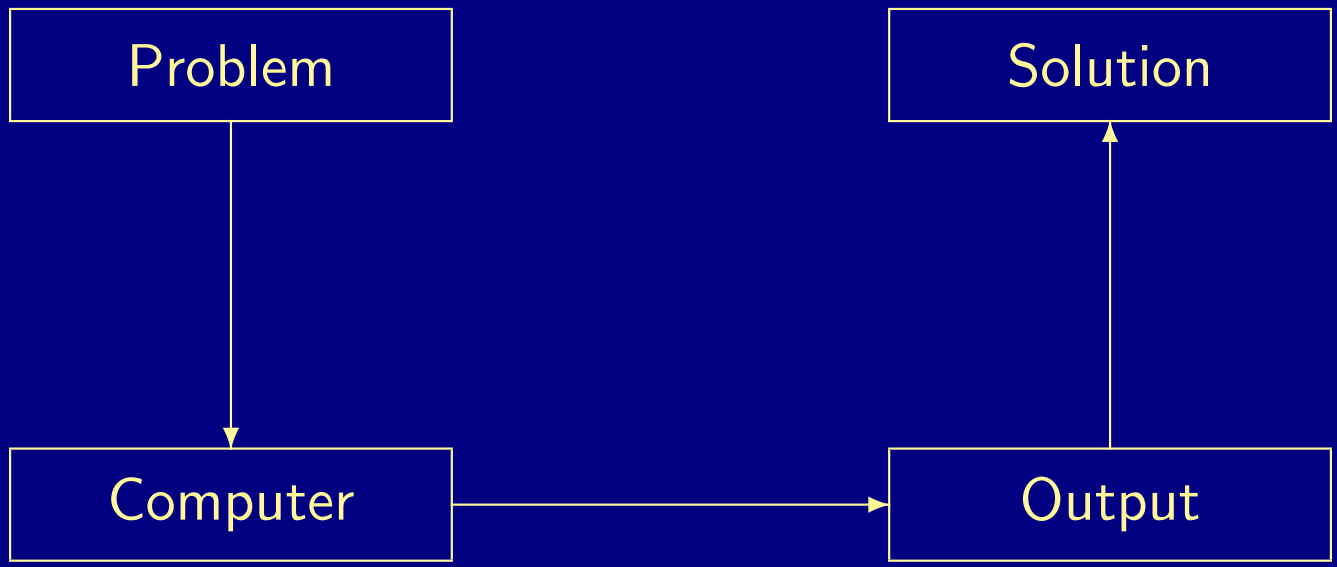

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Traditional programming

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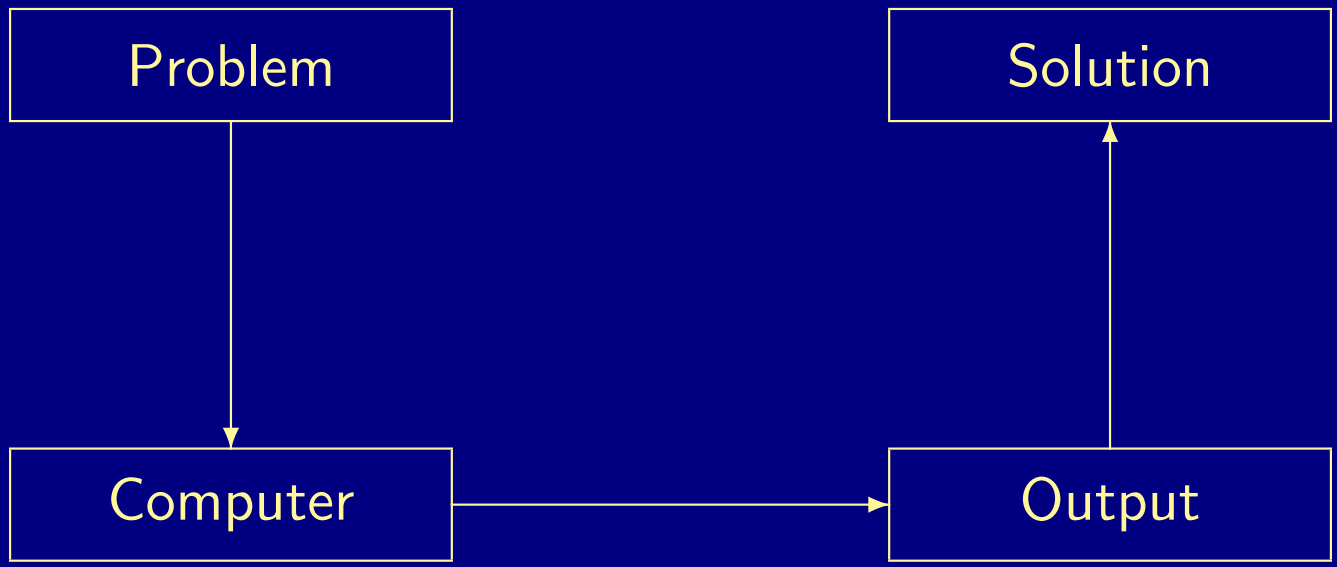

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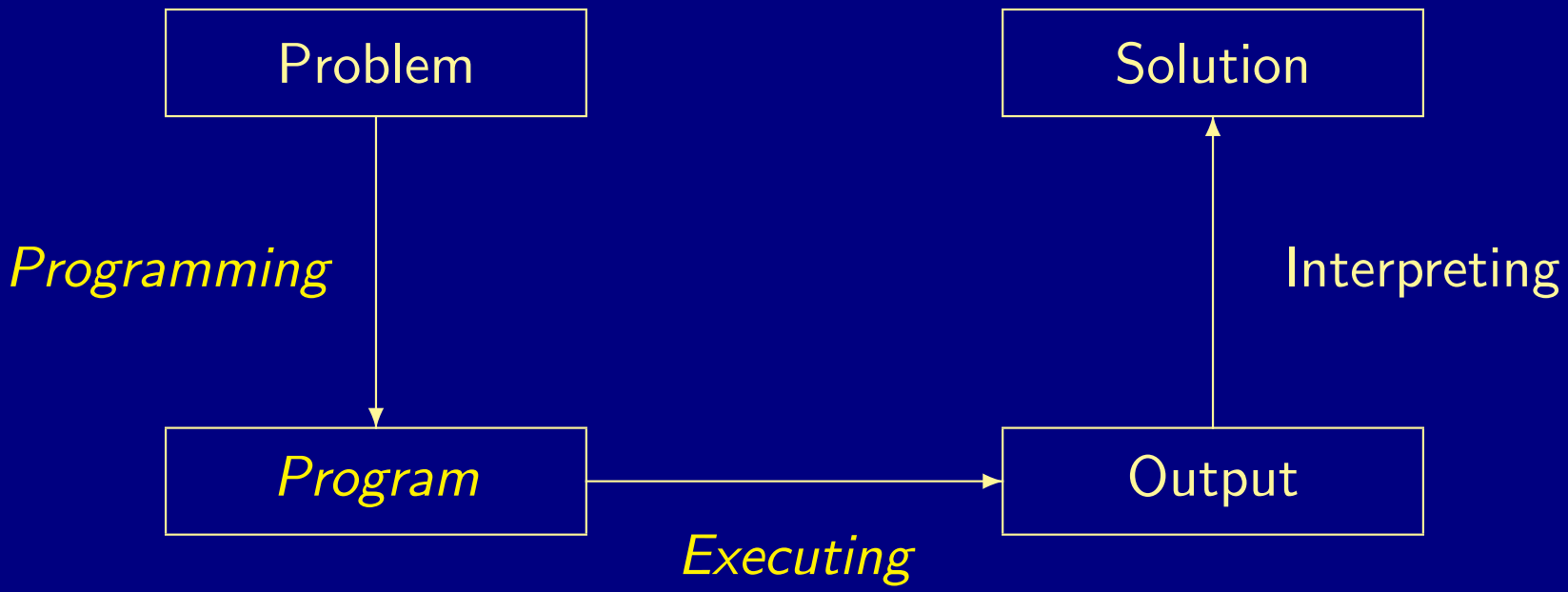

Declarative problem solving

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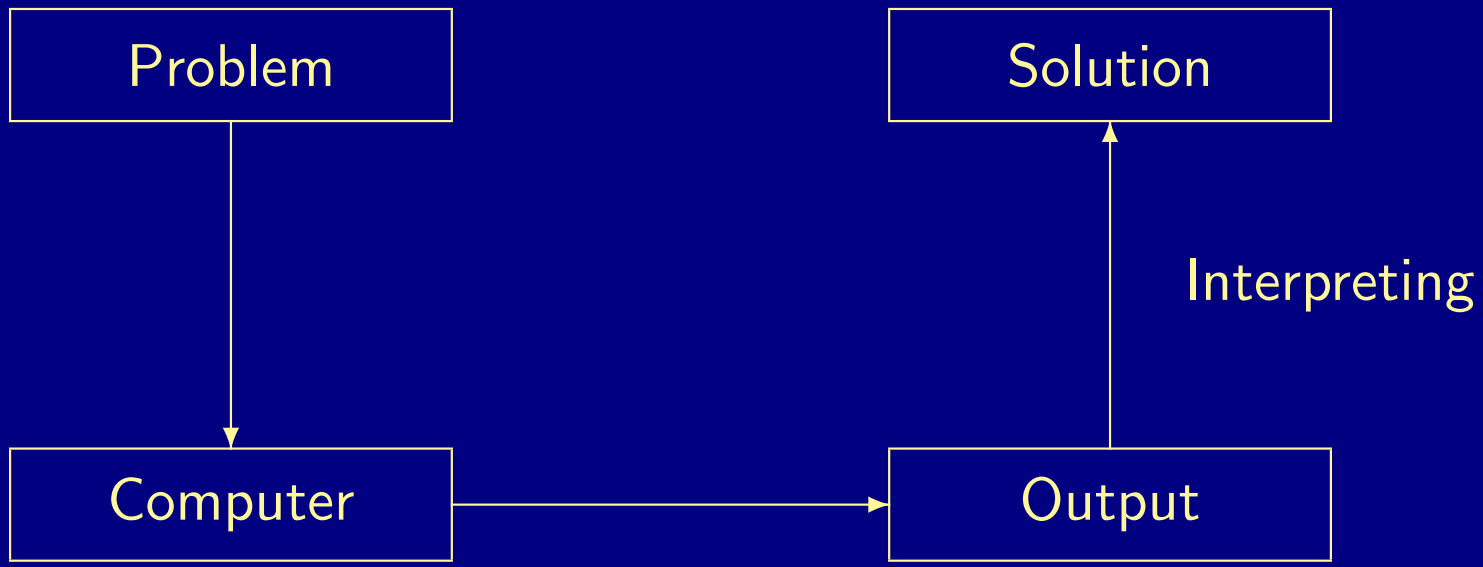

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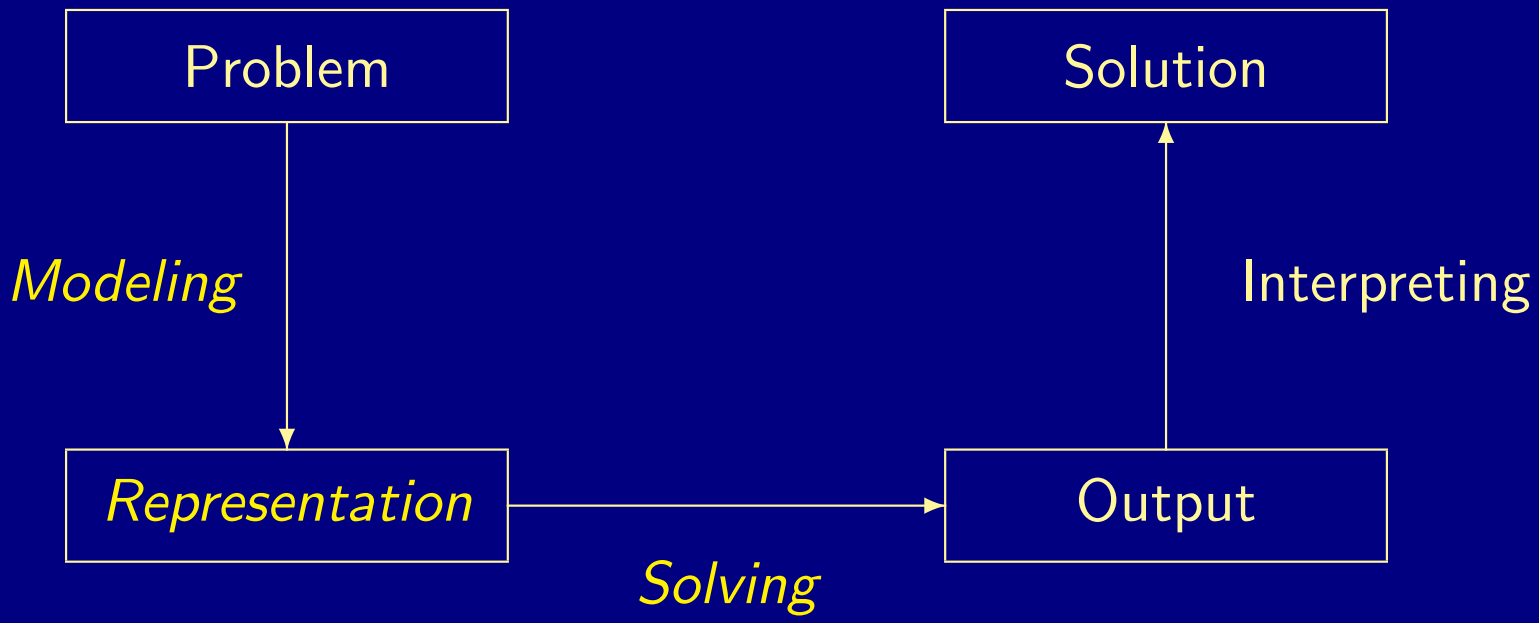

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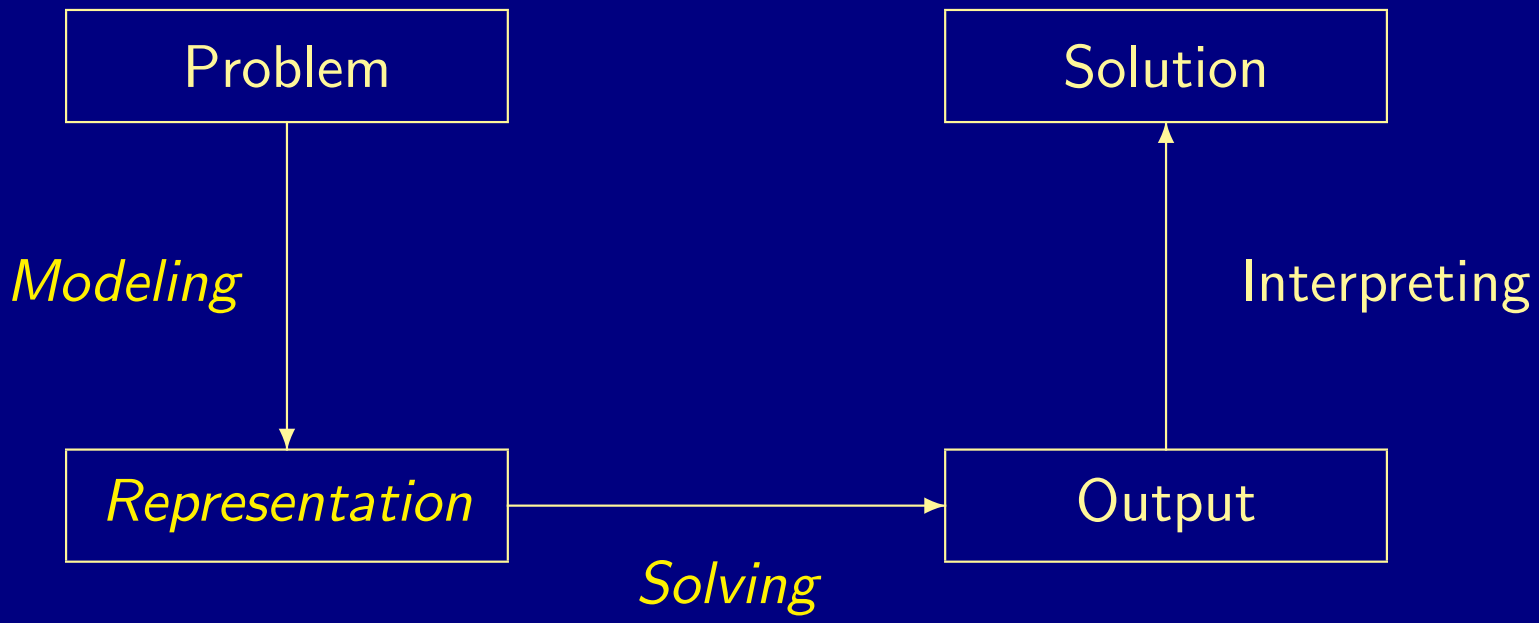

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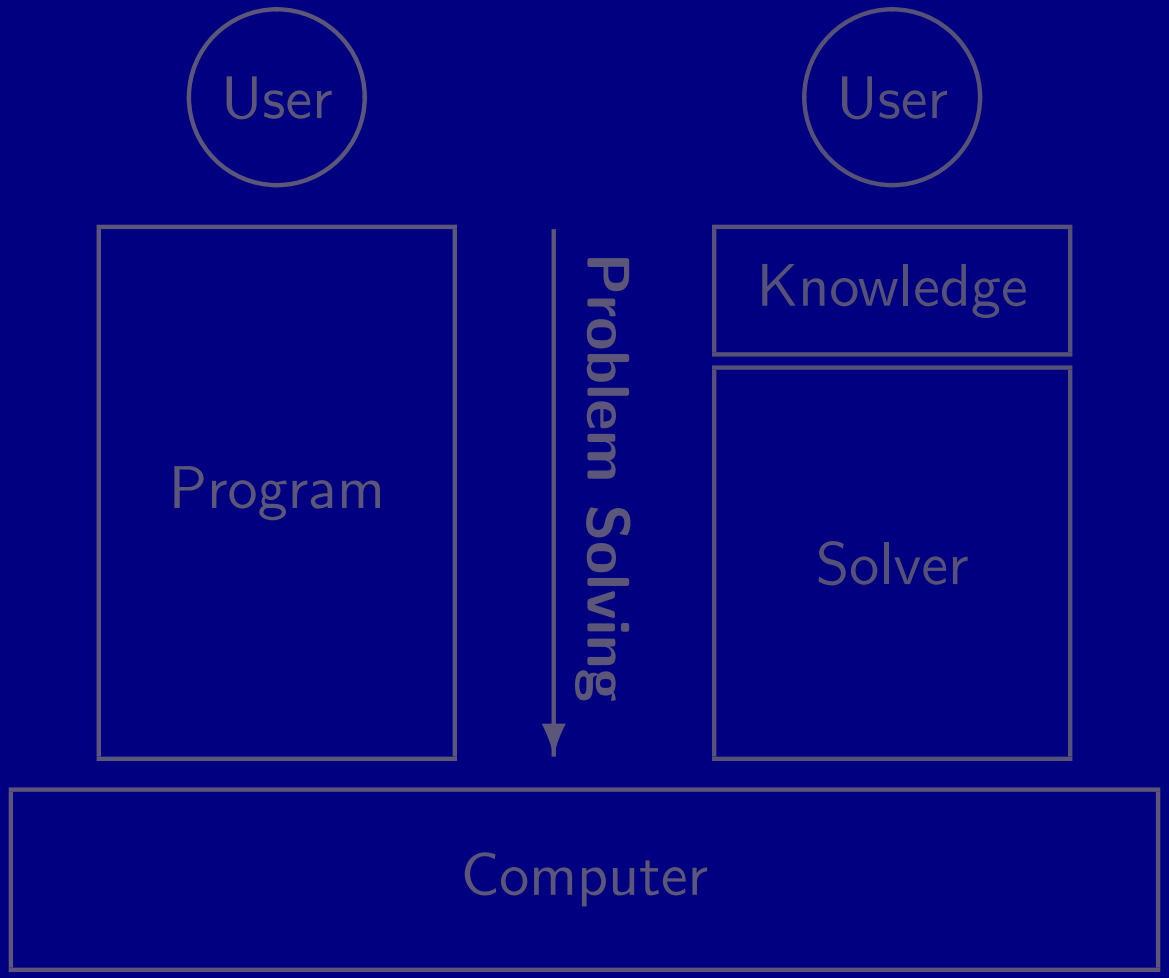

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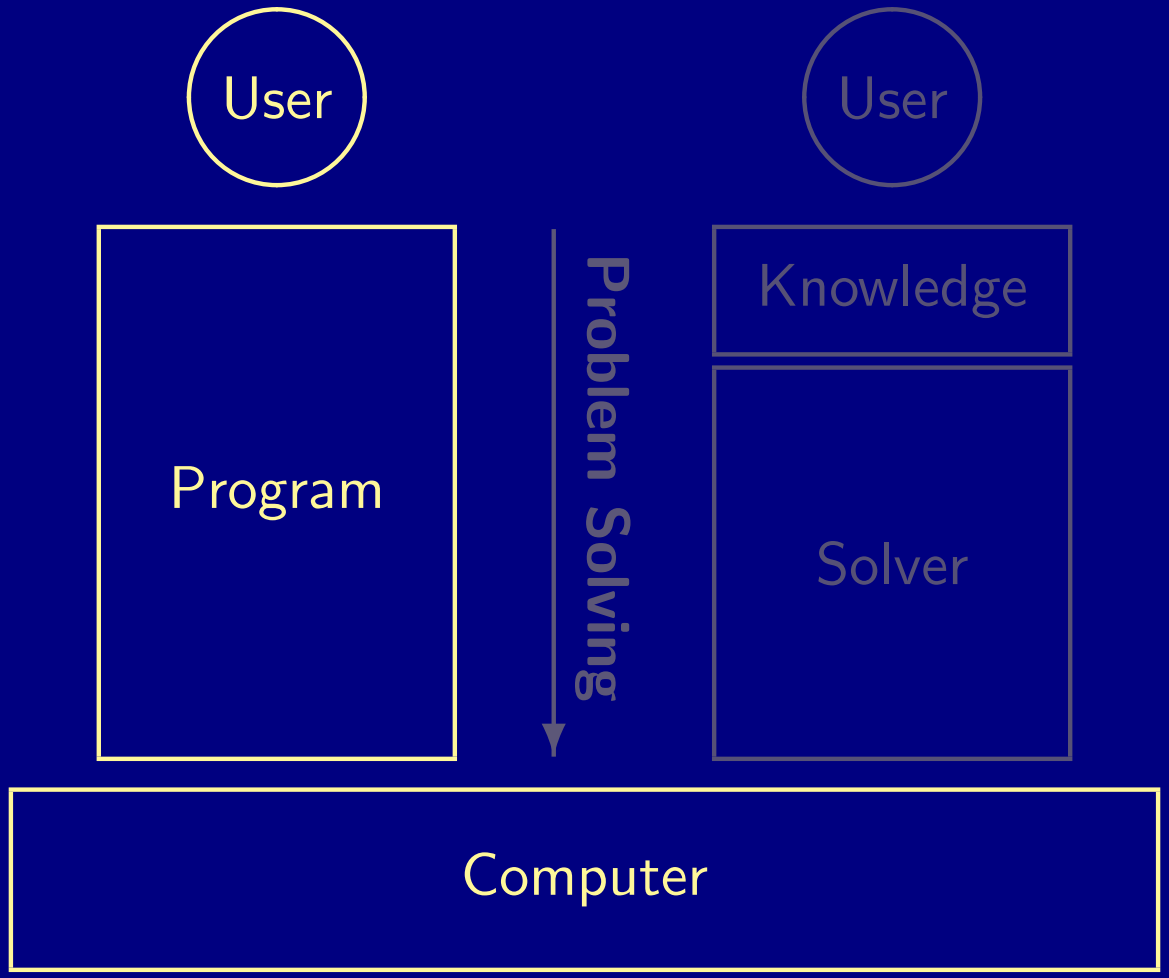

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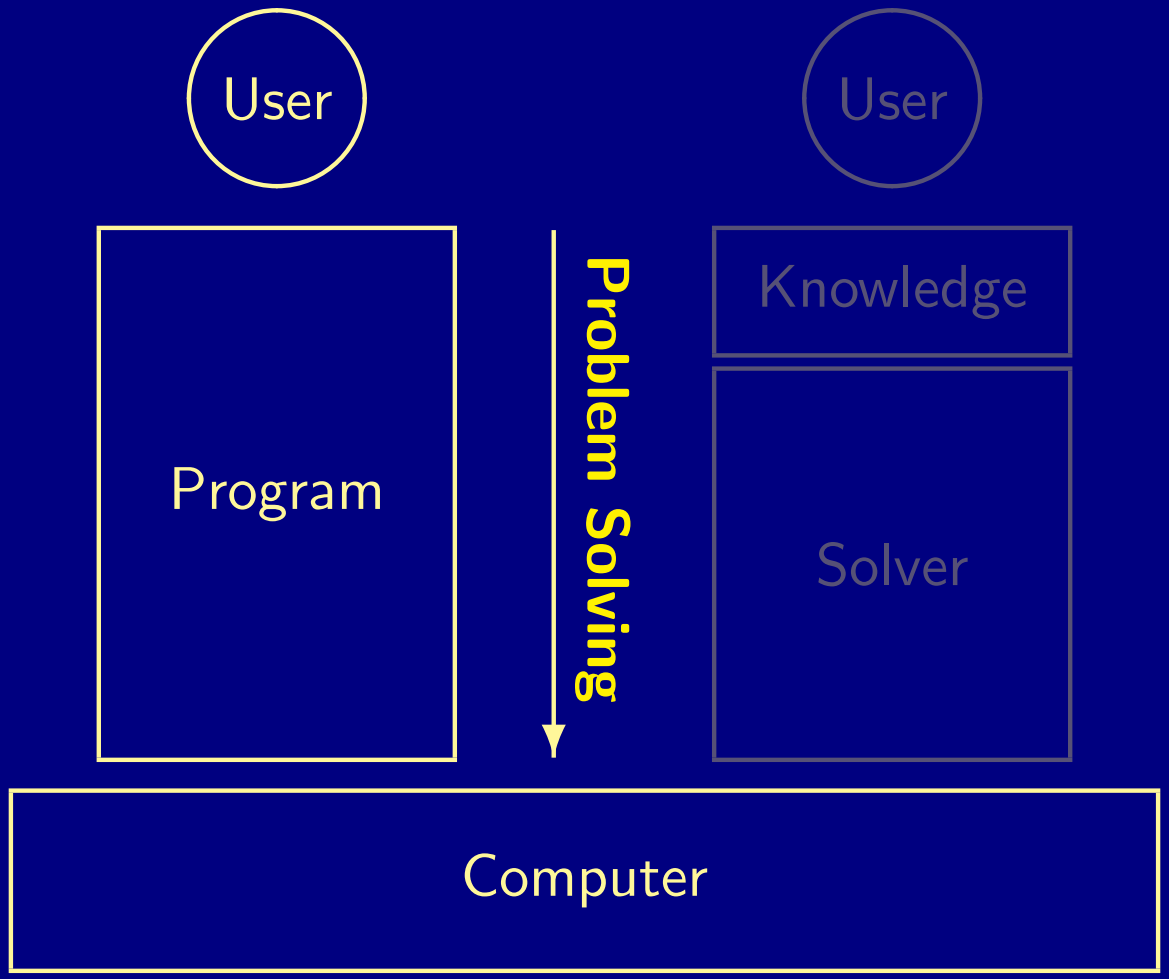

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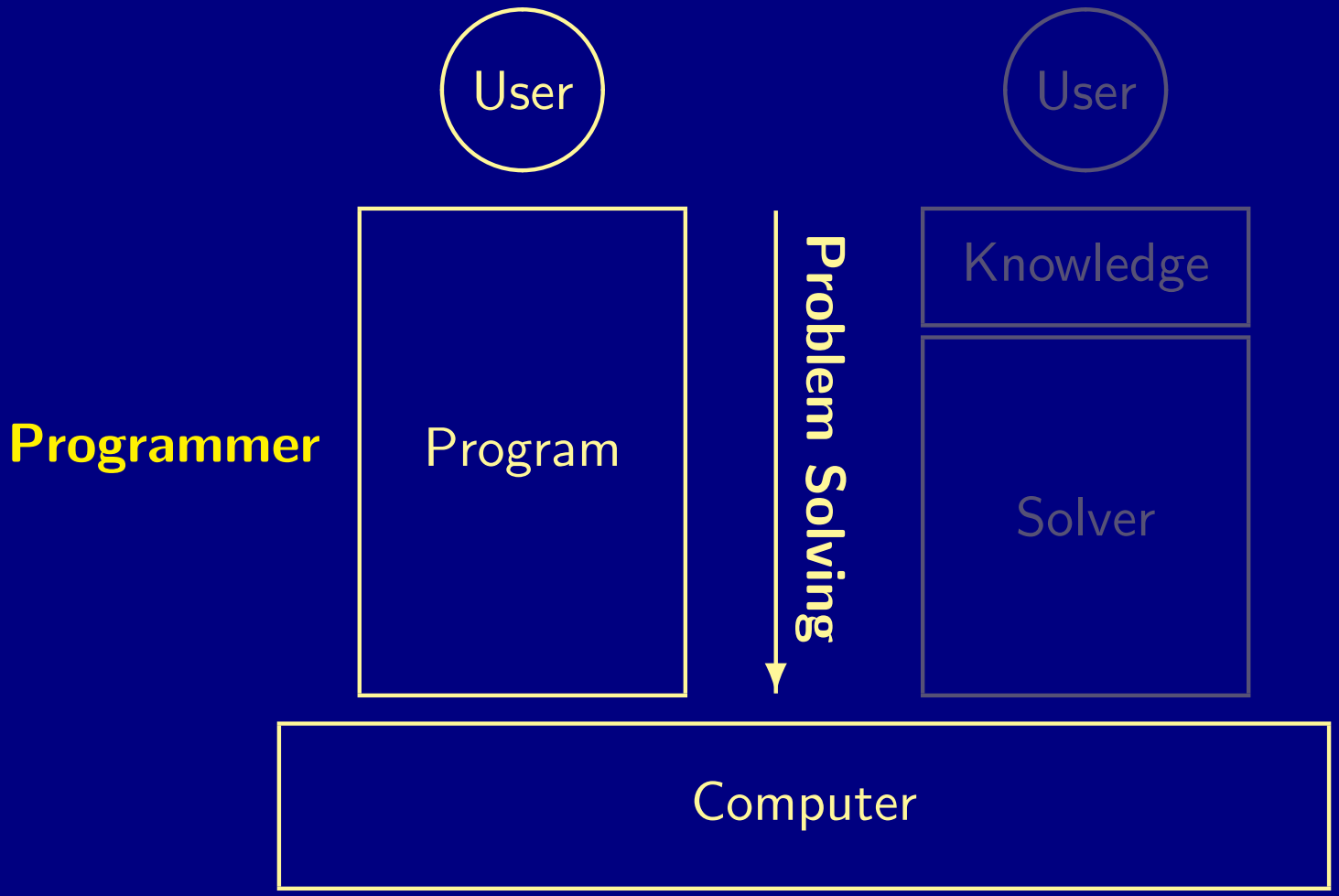

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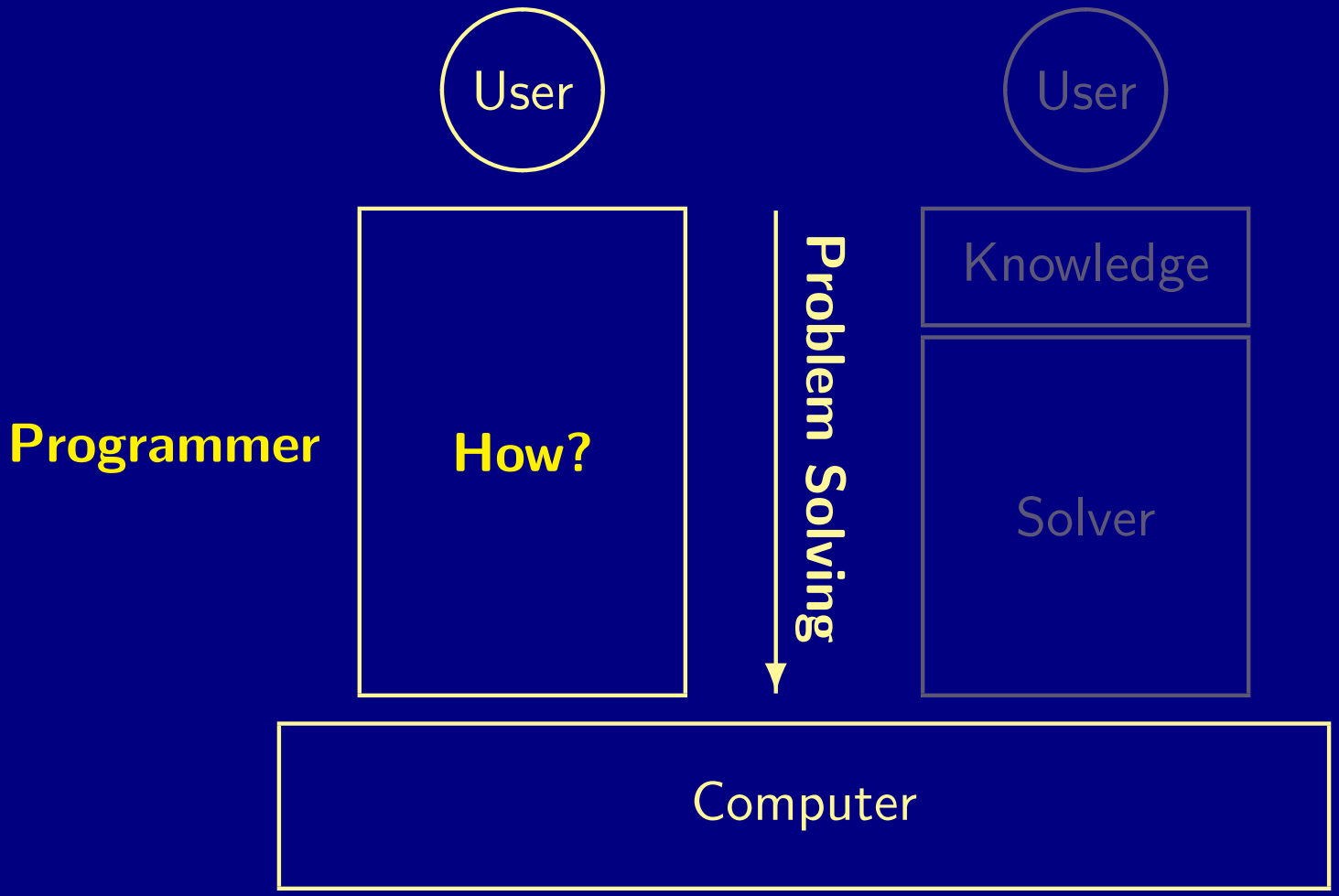

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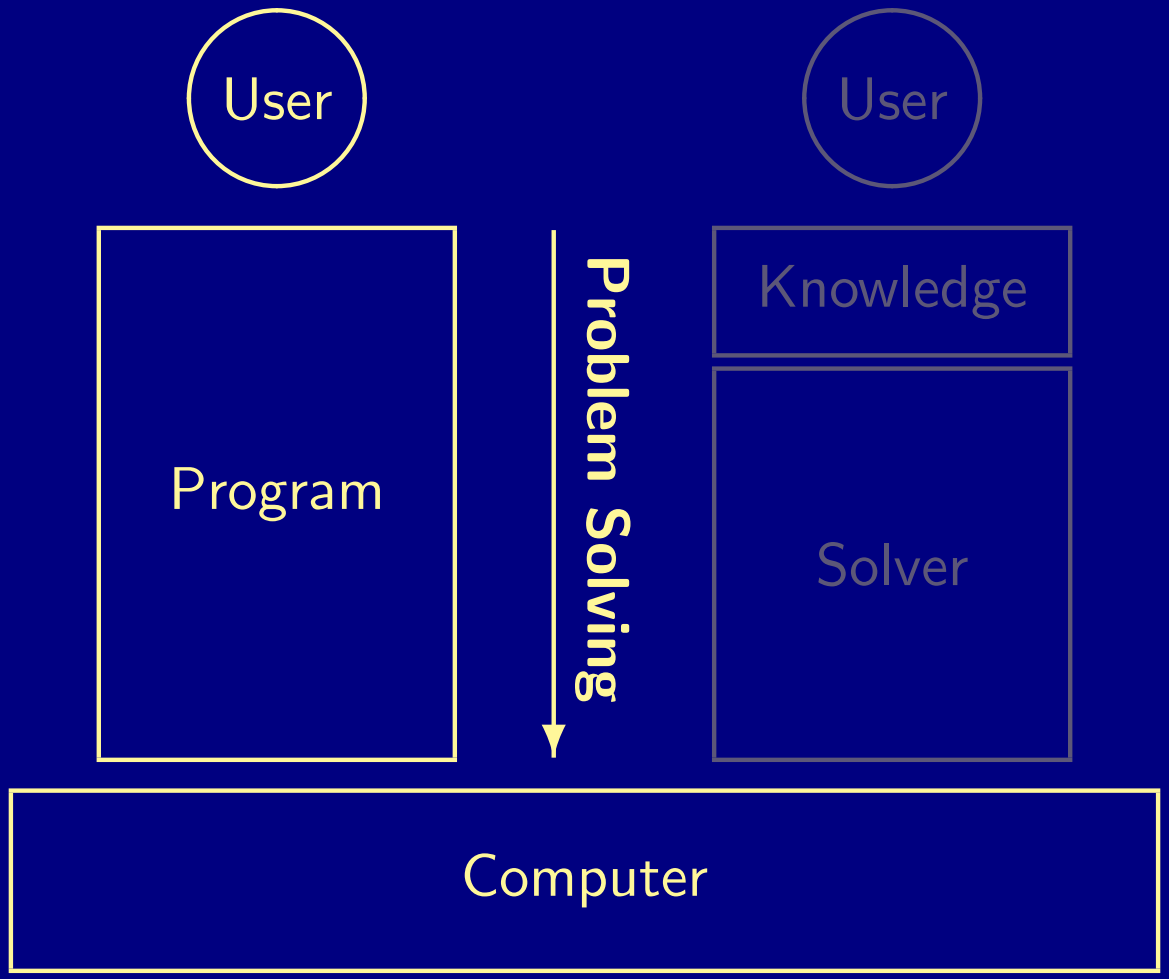
Knowledge-driven Software



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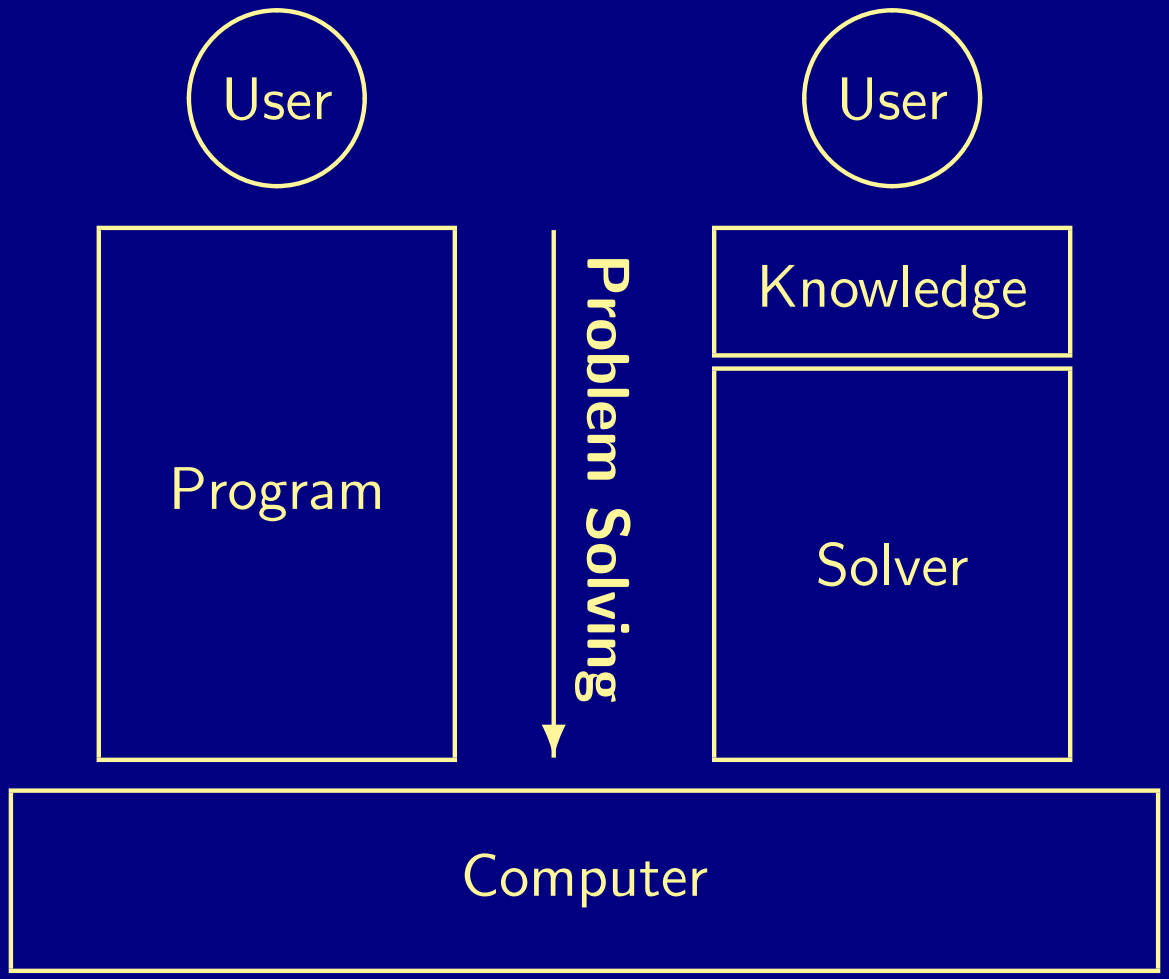

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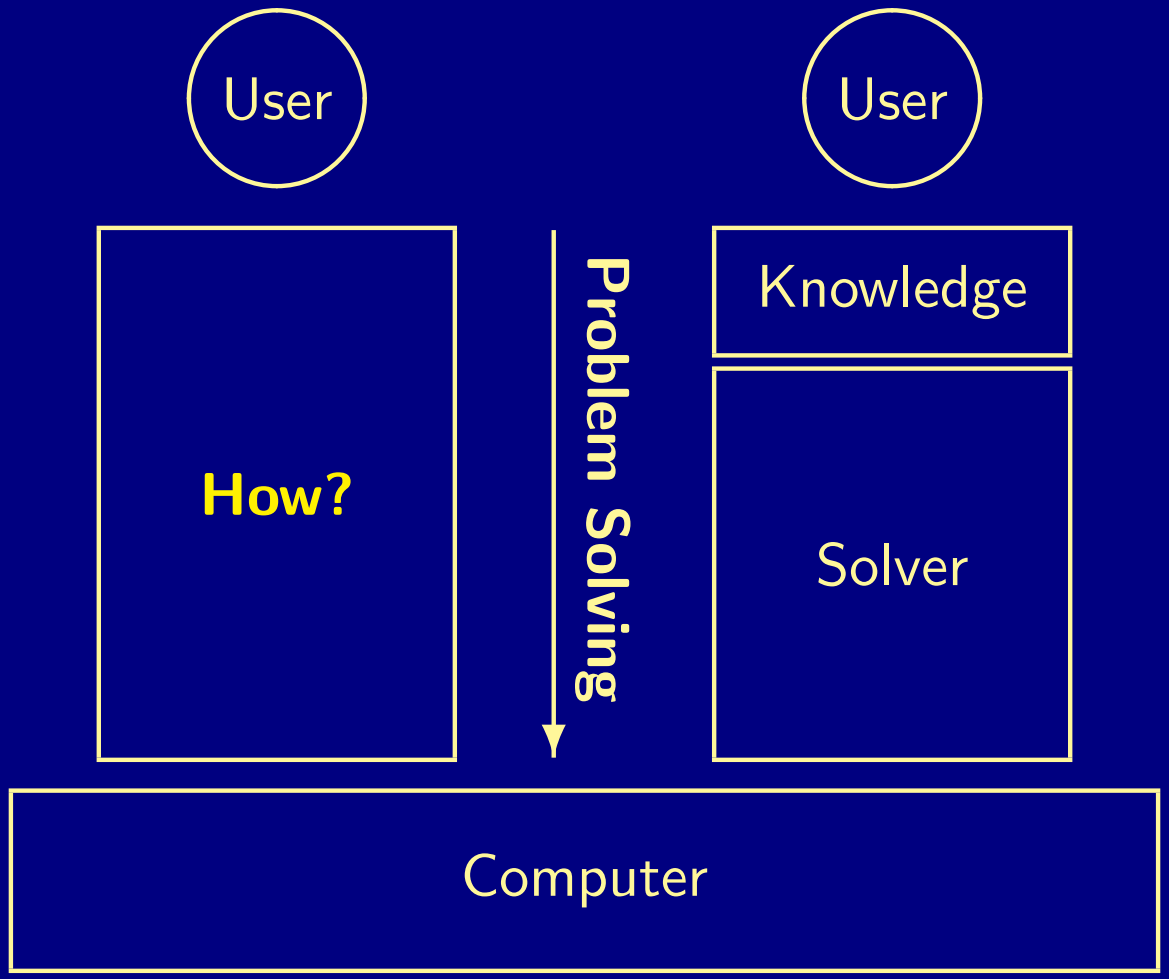

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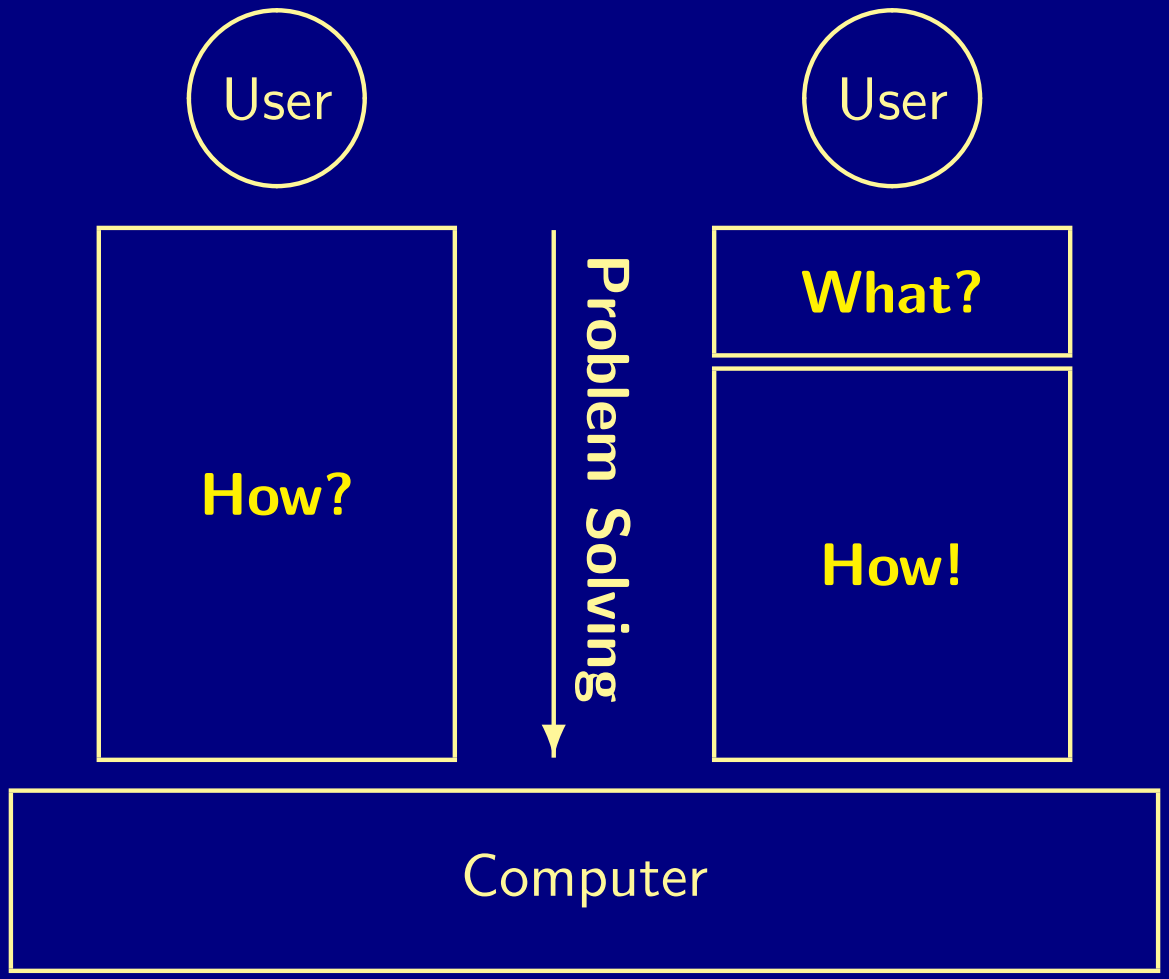

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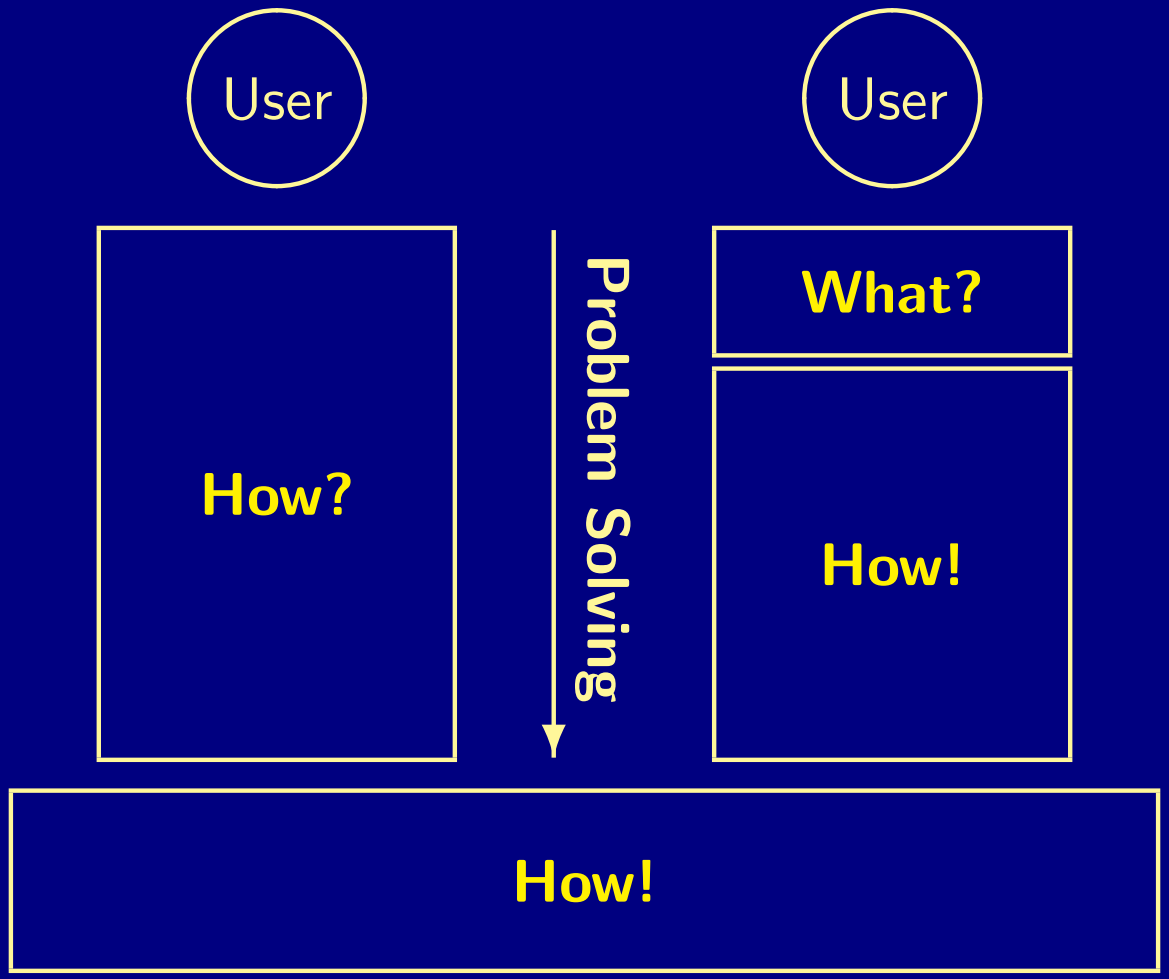

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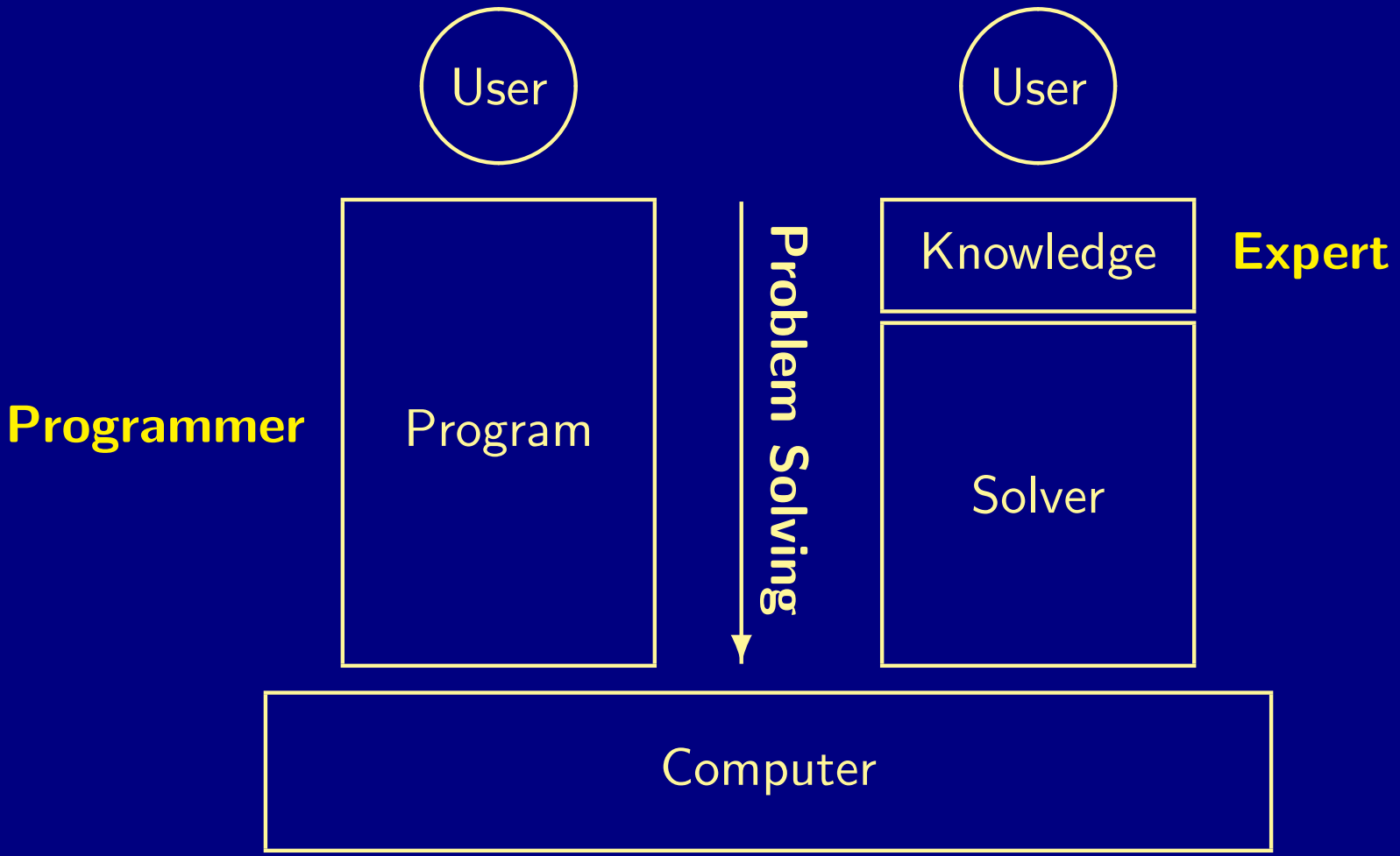

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+ Maintainability
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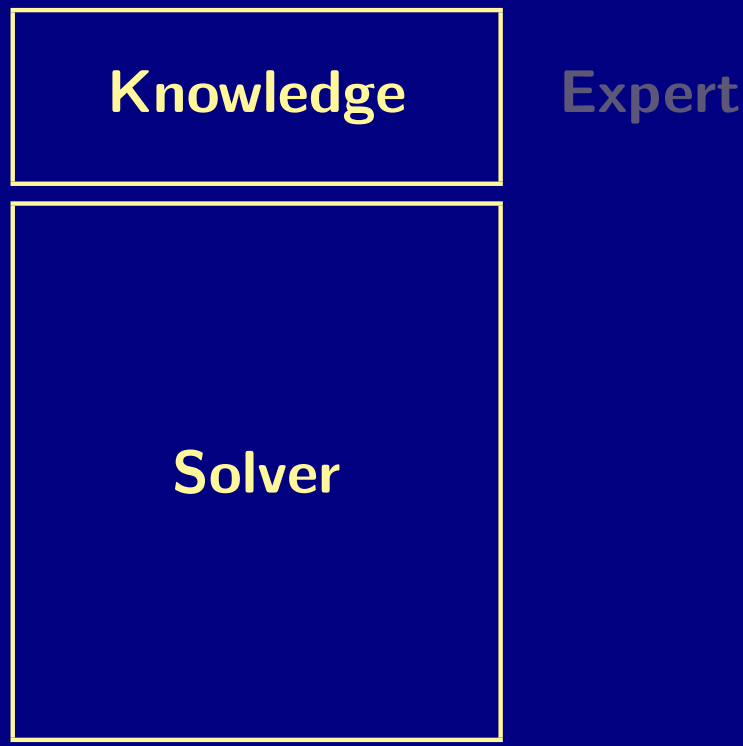

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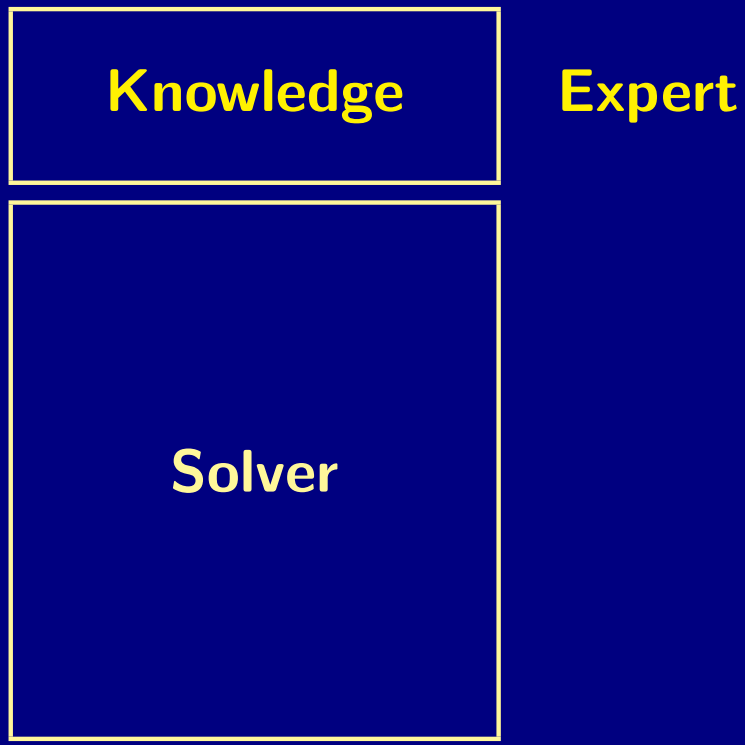

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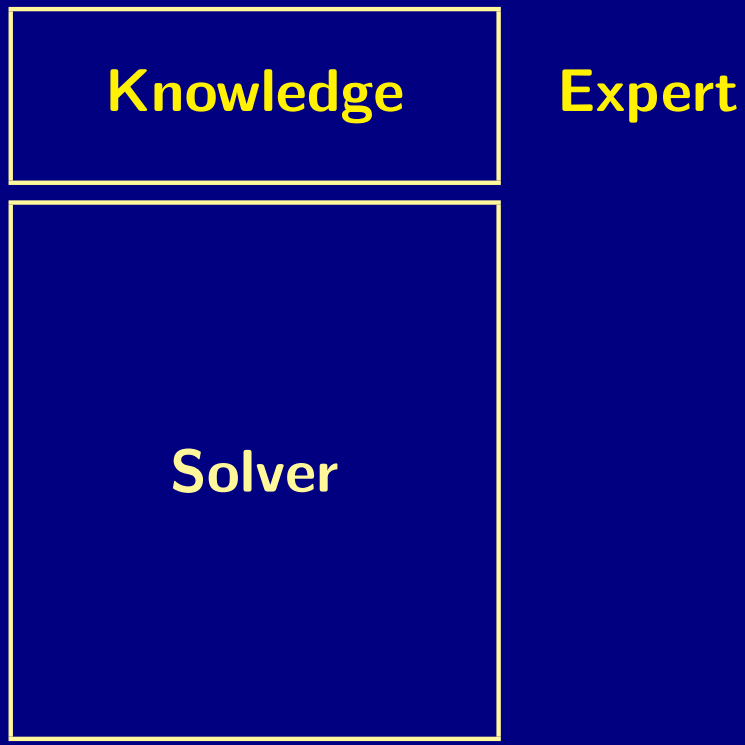

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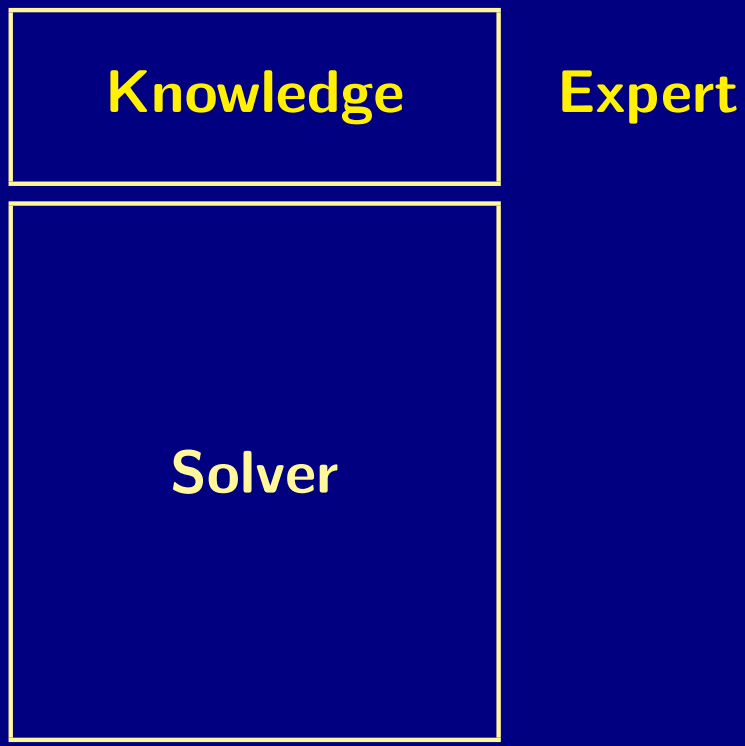

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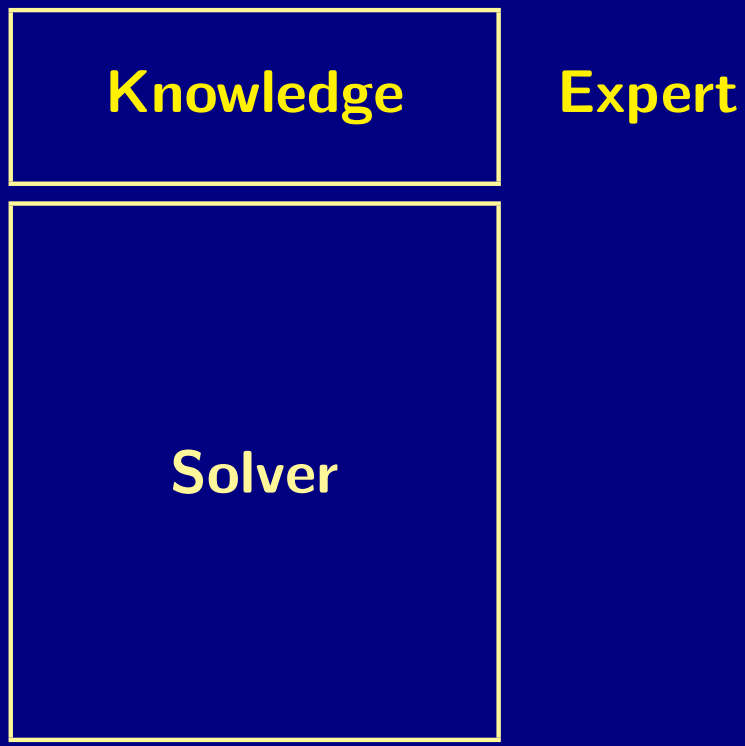

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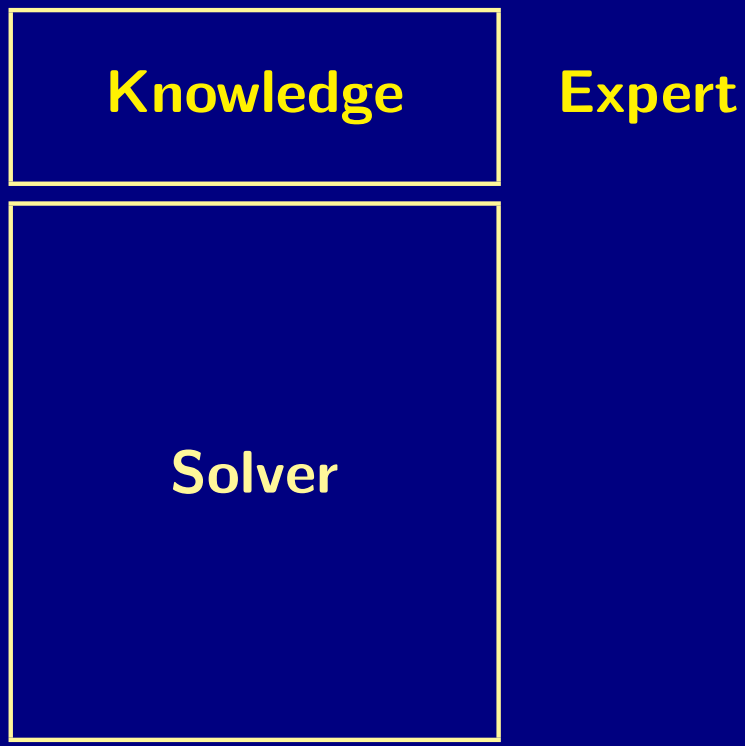

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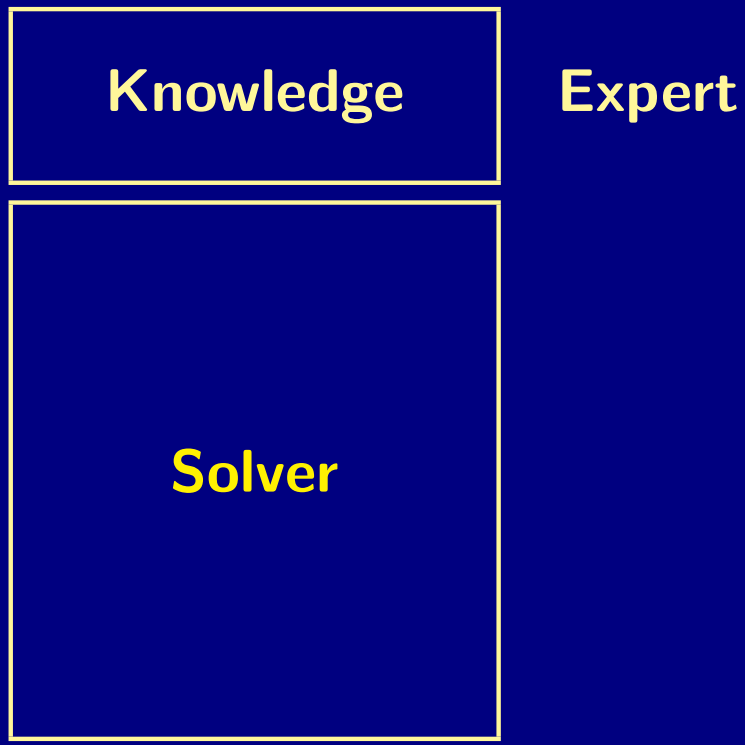

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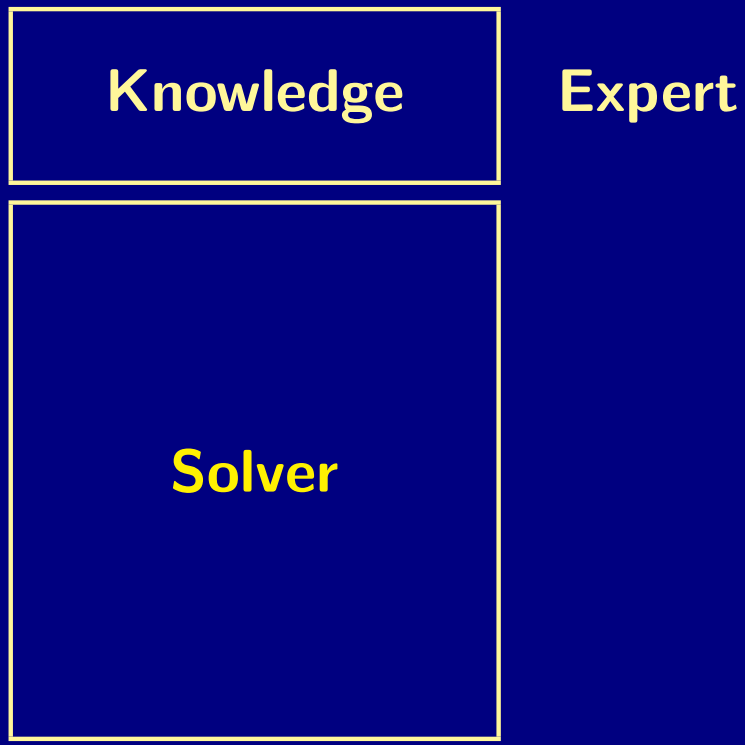

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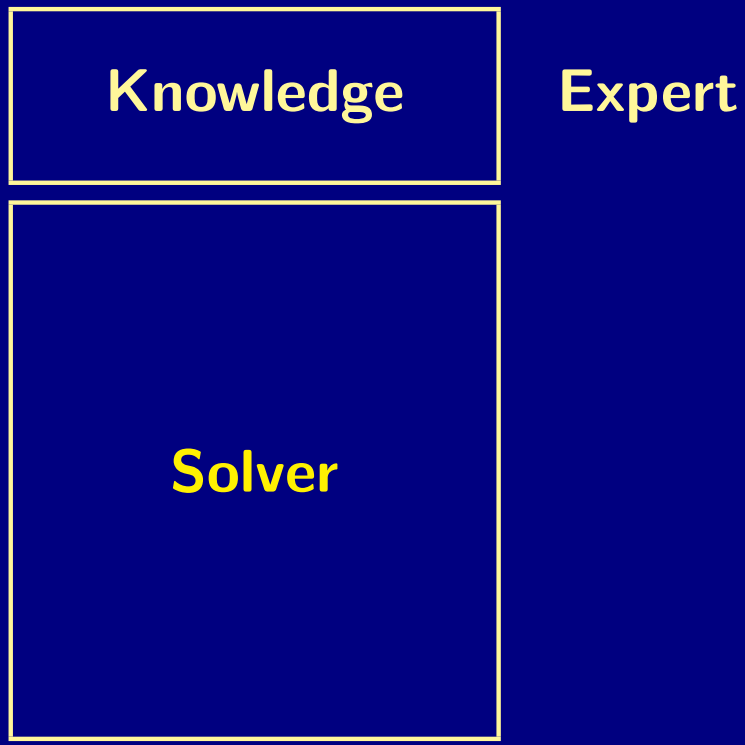

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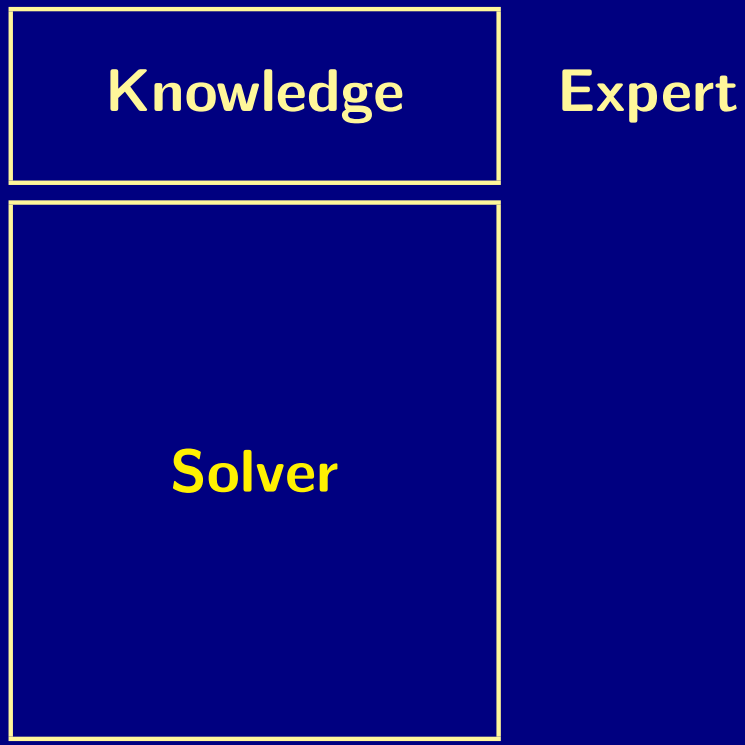

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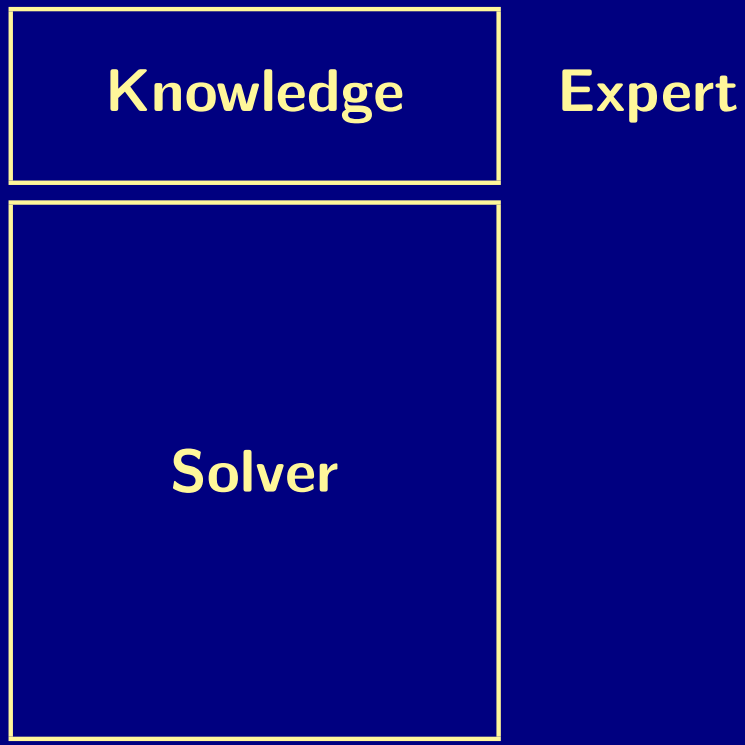

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  - Databases
  - Logic programming
  - Knowledge representation and reasoning
  - Satisfiability solving

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Over 13 months in 2016–17 the US Federal Communications Commission conducted an "incentive auction" to repurpose radio spectrum from broadcast television to wireless internet. In the end, the auction yielded $19.8 billion, $10.05 billion of which was paid to 175 broadcasters for voluntarily relinquishing their licenses across 14 UHF channels. Stations that continued broadcasting were assigned potentially new channels to fit as densely as possible into the channels that remained. The government netted more than $7 billion (used to pay down the national debt) after covering costs. A crucial element of the auction design was the construction of a solver, dubbed SATFC, that determined whether sets of stations could be "repacked" in this way; it needed to run every time a station was given a price quote. This

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- Anything not so good for ASP?
  - Number crunching

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- '70/'80 Capturing incomplete information

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  - Databases Closed world assumption
  - Logic programming Negation as failure
  - Non-monotonic reasoning
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    - Extensions of first-order logic
    - Modalities, fix-points, second-order logic

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    - Modeling — Grounding — Solving
    - Icebreakers: `lparse` and `smodels`

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    - Roots: Logic of Here-and-There , G3

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- '10 Integration

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Paradigm shift

Theorem Proving based approach (eg. Prolog)

1. Provide a representation of the problem
2. A solution is given by a derivation of a query

Model Generation based approach (eg. SATisfiability testing)

1. Provide a representation of the problem
2. A solution is given by a model of the representation

Automated planning, Kautz and Selman (ECAI'92)

Represent planning problems as propositional theories so that models not proofs describe solutions

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Model Generation based Problem Solving

Representation	Solution
constraint satisfaction problem	assignment
propositional horn theories	smallest model
propositional theories	models
propositional theories	minimal models
propositional theories	stable models
propositional programs	minimal models
propositional programs	supported models
propositional programs	stable models
first-order theories	models
first-order theories	minimal models
first-order theories	stable models
first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
⋮	⋮

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Model Generation based Problem Solving

Representation	Solution
constraint satisfaction problem	assignment
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first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
⋮	⋮

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Model Generation based Problem Solving

Representation	Solution	
constraint satisfaction problem	assignment	
propositional horn theories	smallest model	
propositional theories	models	**SAT**
propositional theories	minimal models	
propositional theories	stable models	
propositional programs	minimal models	
propositional programs	supported models	
propositional programs	stable models	
first-order theories	models	
first-order theories	minimal models	
first-order theories	stable models	
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⋮	⋮	

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LP-style playing with blocks

Prolog program

```
on(a,b).
on(b,c).

above(X,Y) :- on(X,Y).
above(X,Y) :- on(X,Z), above(Z,Y).
```

Prolog queries

```
?- above(a,c).
true.

?- above(c,a).
no.
```

Potassco

LP-style playing with blocks

Prolog program

```
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Prolog program

```
on(a,b).
on(b,c).

above(X,Y) :- on(X,Y).
above(X,Y) :- on(X,Z), above(Z,Y).
```

Prolog queries (testing entailment)

```
?- above(a,c).
true.

?- above(c,a).
no.
```

Potassco

LP-style playing with blocks

Shuffled Prolog program

```
on(a,b).
on(b,c).

above(X,Y) :- above(X,Z), on(Z,Y).
above(X,Y) :- on(X,Y).
```

Prolog queries

```
?- above(a,c).

Fatal Error: local stack overflow.
```

Potassco

LP-style playing with blocks

Shuffled Prolog program

```
on(a,b).
on(b,c).

above(X,Y) :- above(X,Z), on(Z,Y).
above(X,Y) :- on(X,Y).
```

Prolog queries

```
?- above(a,c).

Fatal Error: local stack overflow.
```

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LP-style playing with blocks

Shuffled Prolog program

```
on(a,b).
on(b,c).

above(X,Y) :- above(X,Z), on(Z,Y).
above(X,Y) :- on(X,Y).
```

Prolog queries (answered via fixed execution)

```
?- above(a,c).

Fatal Error: local stack overflow.
```

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Paradigm shift

Theorem Proving based approach (eg. Prolog)

1. Provide a representation of the problem
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1. Provide a representation of the problem
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Potassco

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1. Provide a representation of the problem
2. A solution is given by a derivation of a query

Model Generation based approach (eg. SATisfiability testing)

1. Provide a representation of the problem
2. A solution is given by a model of the representation

SAT-style playing with blocks

Formula

$$
\begin{array}{ll}
 & on(a,b) \\
\wedge & on(b,c) \\
\wedge & (on(X,Y) \rightarrow above(X,Y)) \\
\wedge & (on(X,Z) \wedge above(Z,Y) \rightarrow above(X,Y))
\end{array}
$$

Herbrand model

$$
\left\{
\begin{array}{ccccccc}
on(a,b), & & on(b,c), & & on(a,c), & on(b,b), & \\
above(a,b), & above(b,c), & & above(a,c), & above(b,b), & above(c,b)
\end{array}
\right\}
$$

SAT-style playing with blocks

Formula

$$
\begin{array}{ll}
 & on(a,b) \\
\wedge & on(b,c) \\
\wedge & (on(X,Y) \rightarrow above(X,Y)) \\
\wedge & (on(X,Z) \wedge above(Z,Y) \rightarrow above(X,Y))
\end{array}
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\begin{array}{ccccccccc}
on(a,b), & & on(b,c), & & on(a,c), & & on(b,b), & & \\
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\end{array}
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\end{array}
\right\}
$$

SAT-style playing with blocks

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\begin{array}{ll}
 & on(a,b) \\
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\wedge & (on(X,Z) \wedge above(Z,Y) \rightarrow above(X,Y))
\end{array}
$$

Herbrand model (among 426!)

$$
\left\{
\begin{array}{ccccccccc}
on(a,b), & & on(b,c), & & on(a,c), & & on(b,b), & & \\
above(a,b), & above(b,c), & & above(a,c), & & above(b,b), & & above(c,b) &
\end{array}
\right\}
$$

Paradigm shift

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➥ Answer Set Programming (ASP)

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Model Generation based Problem Solving

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first-order theories	minimal models
first-order theories	stable models
first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
⋮	⋮

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Answer Set Programming *at large*

Representation	Solution
constraint satisfaction problem	assignment
propositional horn theories	smallest model
propositional theories	models
propositional theories	minimal models
propositional theories	stable models
propositional programs	minimal models
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first-order theories	models
first-order theories	minimal models
first-order theories	stable models
first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
⋮	⋮

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Answer Set Programming *commonly*

Representation	Solution
constraint satisfaction problem	assignment
propositional horn theories	smallest model
propositional theories	models
propositional theories	minimal models
propositional theories	stable models
propositional programs	minimal models
propositional programs	supported models
propositional programs	stable models
first-order theories	models
first-order theories	minimal models
first-order theories	stable models
first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
⋮	⋮

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Answer Set Programming *in practice*

Representation	Solution
constraint satisfaction problem	assignment
propositional horn theories	smallest model
propositional theories	models
propositional theories	minimal models
propositional theories	stable models
propositional programs	minimal models
propositional programs	supported models
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first-order theories	models
first-order theories	minimal models
first-order theories	stable models
first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
⋮	⋮

Potassco

Answer Set Programming *in practice*

Representation	Solution
constraint satisfaction problem	assignment
propositional horn theories	smallest model
propositional theories	models
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propositional programs	minimal models
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first-order theories	models
first-order theories	minimal models
first-order theories	stable models
first-order theories	Herbrand models
auto-epistemic theories	expansions
default theories	extensions
first-order programs	stable Herbrand models

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ASP-style playing with blocks

Logic program

```
on(a,b).
on(b,c).

above(X,Y) :- on(X,Y).
above(X,Y) :- on(X,Z), above(Z,Y).
```

Stable Herbrand model

$\{ \texttt{on(a,b)}, \texttt{on(b,c)}, \texttt{above(b,c)}, \texttt{above(a,b)}, \texttt{above(a,c)} \}$

Potassco

ASP-style playing with blocks

Logic program

```
on(a,b).
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above(X,Y) :- on(X,Y).
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```

Stable Herbrand model

{ on(a, b), on(b, c), above(b, c), above(a, b), above(a, c) }

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Logic program

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on(a,b).
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```

Stable Herbrand model (and no others)

$\{ \texttt{on(a,b)}, \texttt{on(b,c)}, \texttt{above(b,c)}, \texttt{above(a,b)}, \texttt{above(a,c)} \}$

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ASP-style playing with blocks

Logic program

```
on(a,b).
on(b,c).

above(X,Y) :- above(Z,Y), on(X,Z).
above(X,Y) :- on(X,Y).
```

Stable Herbrand model (and no others)

{ on(a, b), on(b, c), above(b, c), above(a, b), above(a, c) }

ASP versus LP

ASP	Prolog
Model generation	Query orientation
Bottom-up	Top-down
Modeling language	Programming language
Rule-based format	
Instantiation Flat terms	Unification Nested terms
(Turing +) $NP(^{NP})$	Turing

ASP versus SAT

ASP	SAT
Model generation	
Bottom-up	
Constructive Logic	Classical Logic
Closed (and open) world reasoning	Open world reasoning
Modeling language	—
Complex reasoning modes	Satisfiability testing
Satisfiability	Satisfiability
Enumeration/Projection	—
Intersection/Union	—
Optimization	—
(Turing +) $NP(^{NP})$	NP

Outline

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Propositional Normal Logic Programs

- A logic program P is a set of rules of the form

$$\underbrace{a}_{\text{head}} \leftarrow \underbrace{b_1, \ldots, b_m, \neg c_1, \ldots, \neg c_n}_{\text{body}}$$

  - a and all b_i, c_j are atoms (propositional variables)
  - $\leftarrow$, ,, $\neg$ denote if, and, and negation
  - intuitive reading: head must be true if body holds

- Semantics given by stable models, informally,
  models of P justifying each true atom by some rule in P

Logic Programs

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Normal Logic Programs

- A logic program P is a set of rules of the form

$$\underbrace{a}_{\text{head}} \leftarrow \underbrace{b_1, \ldots, b_m, \neg c_1, \ldots, \neg c_n}_{\text{body}}$$

  - a and all b_i, c_j are atoms (propositional variables)
  - $\leftarrow$, ,, $\neg$ denote if, and, and negation
  - intuitive reading: head must be true if body holds

- Semantics given by stable models, informally,
  models of P justifying each true atom by some rule in P

- Disclaimer The following formalities apply to normal logic programs

Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	
F	F	T	
F	T	F	
F	T	T	
T	F	F	
T	F	T	
T	T	F	
T	T	T	

Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**F**	$(\neg\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
F	**F**	**T**	$(\neg\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
F	**T**	**F**	$(\neg\mathbf{T} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{F})$
F	**T**	**T**	$(\neg\mathbf{T} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$
T	**F**	**F**	$(\neg\mathbf{F} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
T	**F**	**T**	$(\neg\mathbf{F} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
T	**T**	**F**	$(\neg\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{T} \rightarrow \mathbf{F})$
T	**T**	**T**	$(\neg\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$

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Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**F**	$(\mathbf{T} \rightarrow \mathbf{F}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
F	**F**	**T**	$(\mathbf{T} \rightarrow \mathbf{F}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
F	**T**	**F**	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{F})$
F	**T**	**T**	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$
T	**F**	**F**	$(\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
T	**F**	**T**	$(\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
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Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	$(\mathbf{T} \rightarrow \mathbf{F}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
F	F	T	$(\mathbf{T} \rightarrow \mathbf{F}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
F	T	F	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{F})$
F	T	T	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$
T	F	F	$(\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
T	F	T	$(\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
T	T	F	$(\mathbf{F} \rightarrow \mathbf{T}) \wedge (\mathbf{T} \rightarrow \mathbf{F})$
T	T	T	$(\mathbf{F} \rightarrow \mathbf{T}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$

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Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**F**	$\mathbf{F} \wedge (\mathbf{F} \rightarrow \mathbf{F})$
F	**F**	**T**	$\mathbf{F} \wedge (\mathbf{F} \rightarrow \mathbf{T})$
F	**T**	**F**	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge \mathbf{F}$
F	**T**	**T**	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$
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T	**T**	**F**	$(\mathbf{F} \rightarrow \mathbf{T}) \wedge \mathbf{F}$
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Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	$\mathbf{F} \wedge (\mathbf{F} \rightarrow \mathbf{F})$
F	F	T	$\mathbf{F} \wedge (\mathbf{F} \rightarrow \mathbf{T})$
F	T	F	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge \mathbf{F}$
F	T	T	$(\mathbf{F} \rightarrow \mathbf{F}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$
T	F	F	$(\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{F})$
T	F	T	$(\mathbf{T} \rightarrow \mathbf{T}) \wedge (\mathbf{F} \rightarrow \mathbf{T})$
T	T	F	$(\mathbf{F} \rightarrow \mathbf{T}) \wedge \mathbf{F}$
T	T	T	$(\mathbf{F} \rightarrow \mathbf{T}) \wedge (\mathbf{T} \rightarrow \mathbf{T})$

Potassco

Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	F $\wedge$ T
F	F	T	F $\wedge$ T
F	T	F	T $\wedge$ F
F	T	T	T $\wedge$ T
T	F	F	T $\wedge$ T
T	F	T	T $\wedge$ T
T	T	F	T $\wedge$ F
T	T	T	T $\wedge$ T

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Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	F
F	F	T	F
F	T	F	F
F	T	T	T
T	F	F	T
T	F	T	T
T	T	F	F
T	T	T	T

Some truth tabling, back to SAT

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	F
F	F	T	F
F	T	F	F
F	T	T	T
T	F	F	T
T	F	T	T
T	T	F	F
T	T	T	T

- We get four models: $\{b, c\}$, $\{a\}$, $\{a, c\}$, and $\{a, b, c\}$

Some truth tabling, and now ASP

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	F	F	
F	F	T	
F	T	F	
F	T	T	
T	F	F	
T	F	T	
T	T	F	
T	T	T	

Potassco

Some truth tabling, and now ASP

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**F**	$(\neg \mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
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T	**T**	**T**	$(\neg \mathbf{T} \rightarrow a) \wedge (b \rightarrow c)$

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Some truth tabling, and now ASP

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**F**	$(\mathbf{T} \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**T**	$(\mathbf{T} \rightarrow a) \wedge (b \rightarrow c)$
F	**T**	**F**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
F	**T**	**T**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
T	**F**	**F**	$(\mathbf{T} \rightarrow a) \wedge (b \rightarrow c)$
T	**F**	**T**	$(\mathbf{T} \rightarrow a) \wedge (b \rightarrow c)$
T	**T**	**F**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
T	**T**	**T**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$

Potassco

Some truth tabling, and now ASP

a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
F	**F**	**F**	$a \wedge (b \rightarrow c)$
F	**F**	**T**	$a \wedge (b \rightarrow c)$
F	**T**	**F**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
F	**T**	**T**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
T	**F**	**F**	$a \wedge (b \rightarrow c)$
T	**F**	**T**	$a \wedge (b \rightarrow c)$
T	**T**	**F**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
T	**T**	**T**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$

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F	**T**	**F**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
F	**T**	**T**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
T	**F**	**F**	$a \wedge (b \rightarrow c)$
T	**F**	**T**	$a \wedge (b \rightarrow c)$
T	**T**	**F**	$(\mathbf{F} \rightarrow a) \wedge (b \rightarrow c)$
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T	**F**	**F**	$a \wedge (b \rightarrow c)$
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T	**T**	**F**	$(b \rightarrow c)$
T	**T**	**T**	$(b \rightarrow c)$

Reduct

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a	b	c	$(\neg b \rightarrow a) \wedge (b \rightarrow c)$
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F	F	T	$a \wedge (b \rightarrow c)$
F	T	F	$(b \rightarrow c)$
F	T	T	$(b \rightarrow c)$
T	F	F	$a \wedge (b \rightarrow c)$
T	F	T	$a \wedge (b \rightarrow c)$
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T	T	T	$(b \rightarrow c)$

Reduct

Potassco

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F	T	F	$(b \rightarrow c)$	
F	T	T	$(b \rightarrow c)$	$\models$
T	F	F	$a \wedge (b \rightarrow c)$	$\models a$
T	F	T	$a \wedge (b \rightarrow c)$	$\models a$
T	T	F	$(b \rightarrow c)$	
T	T	T	$(b \rightarrow c)$	$\models$

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F	T	T	$(b \rightarrow c)$	$\models$
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T	F	T	$a \wedge (b \rightarrow c)$	$\models a$
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T	F	F	$a \wedge (b \rightarrow c)$	$\models a$
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Reduct

Potassco

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F	**T**	**T**	$(b \rightarrow c)$	
T	**F**	**F**	$a \wedge (b \rightarrow c)$	$\models a$ Stable model
T	**F**	**T**	$a \wedge (b \rightarrow c)$	
T	**T**	**F**	$(b \rightarrow c)$	
T	**T**	**T**	$(b \rightarrow c)$	

Reduct

- We get one stable model: $\{a\}$

Some truth tabling, and now ASP

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F	F	F	$a \wedge (b \rightarrow c)$	
F	F	T	$a \wedge (b \rightarrow c)$	
F	T	F	$(b \rightarrow c)$	
F	T	T	$(b \rightarrow c)$	
T	F	F	$a \wedge (b \rightarrow c)$	$\models a$ Stable model
T	F	T	$a \wedge (b \rightarrow c)$	
T	T	F	$(b \rightarrow c)$	
T	T	T	$(b \rightarrow c)$	
			Reduct	

- We get one stable model: $\{a\}$
- Stable models = Smallest models of (respective) reducts

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Outline

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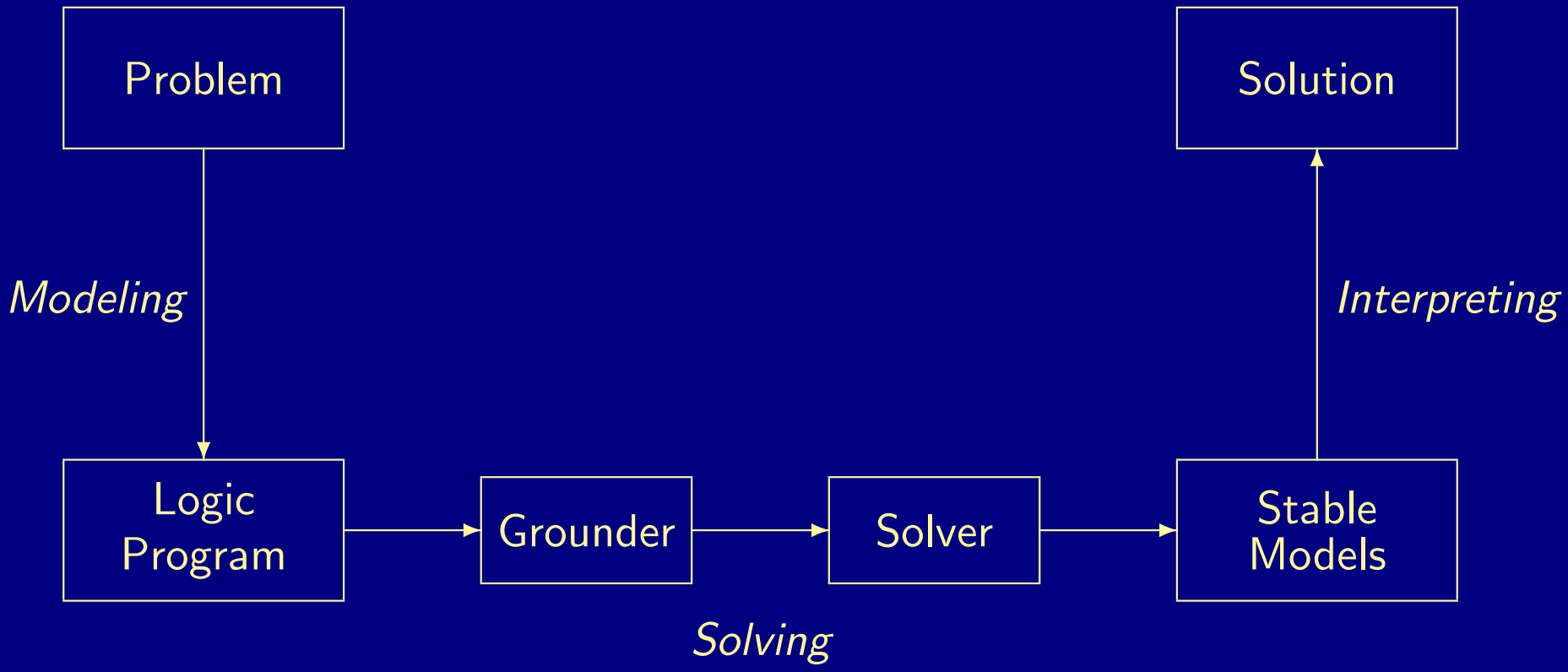
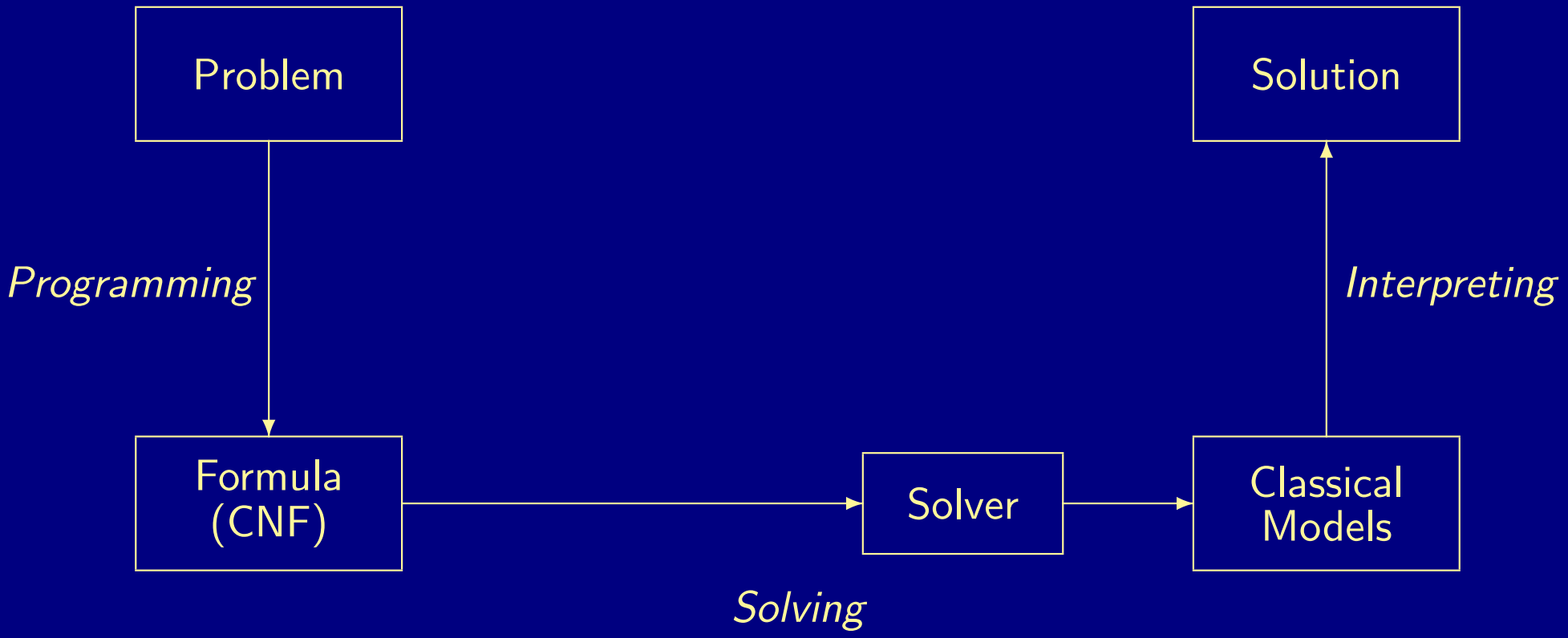
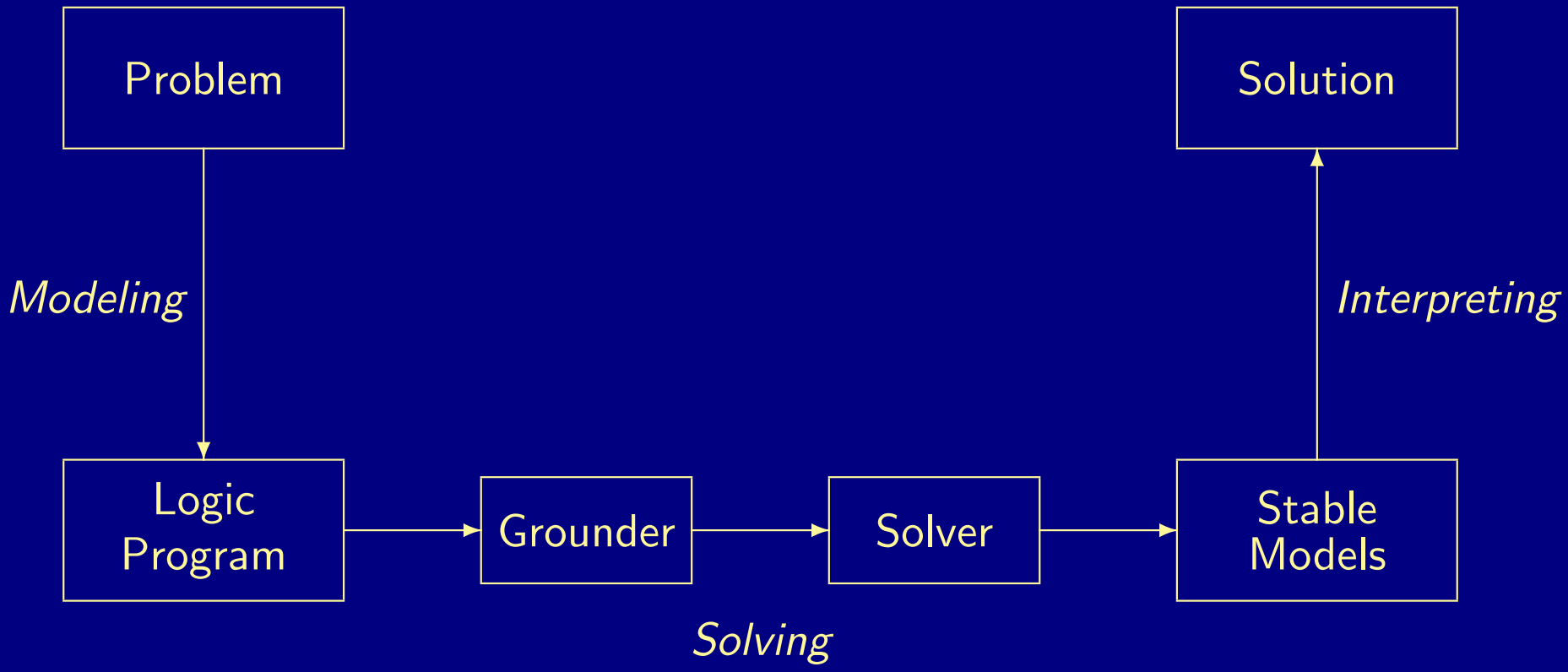
ASP modeling, grounding, and solving



SAT solving


Problem
Solution
Programming
Interpreting
Formula
(CNF)
Solver
Classical
Models
Solving

Rooting ASP solving



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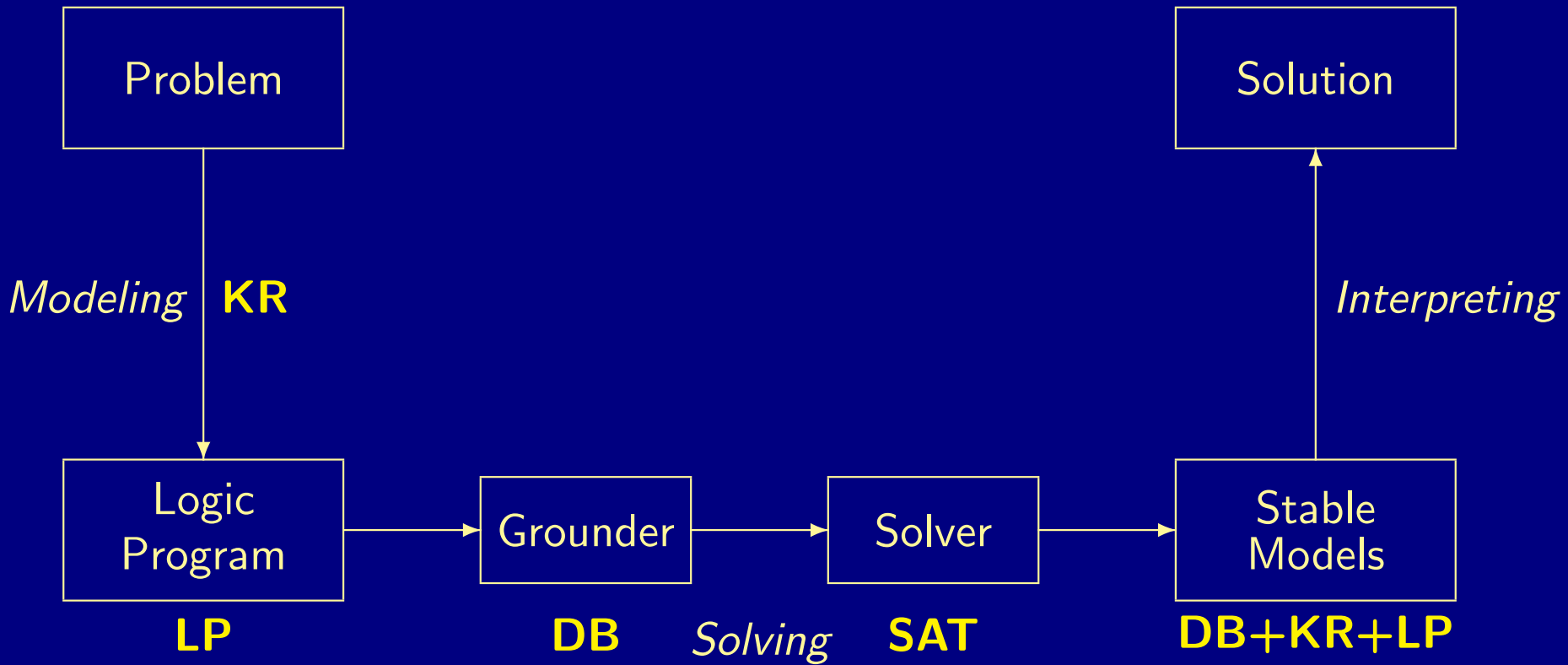
Rooting ASP solving

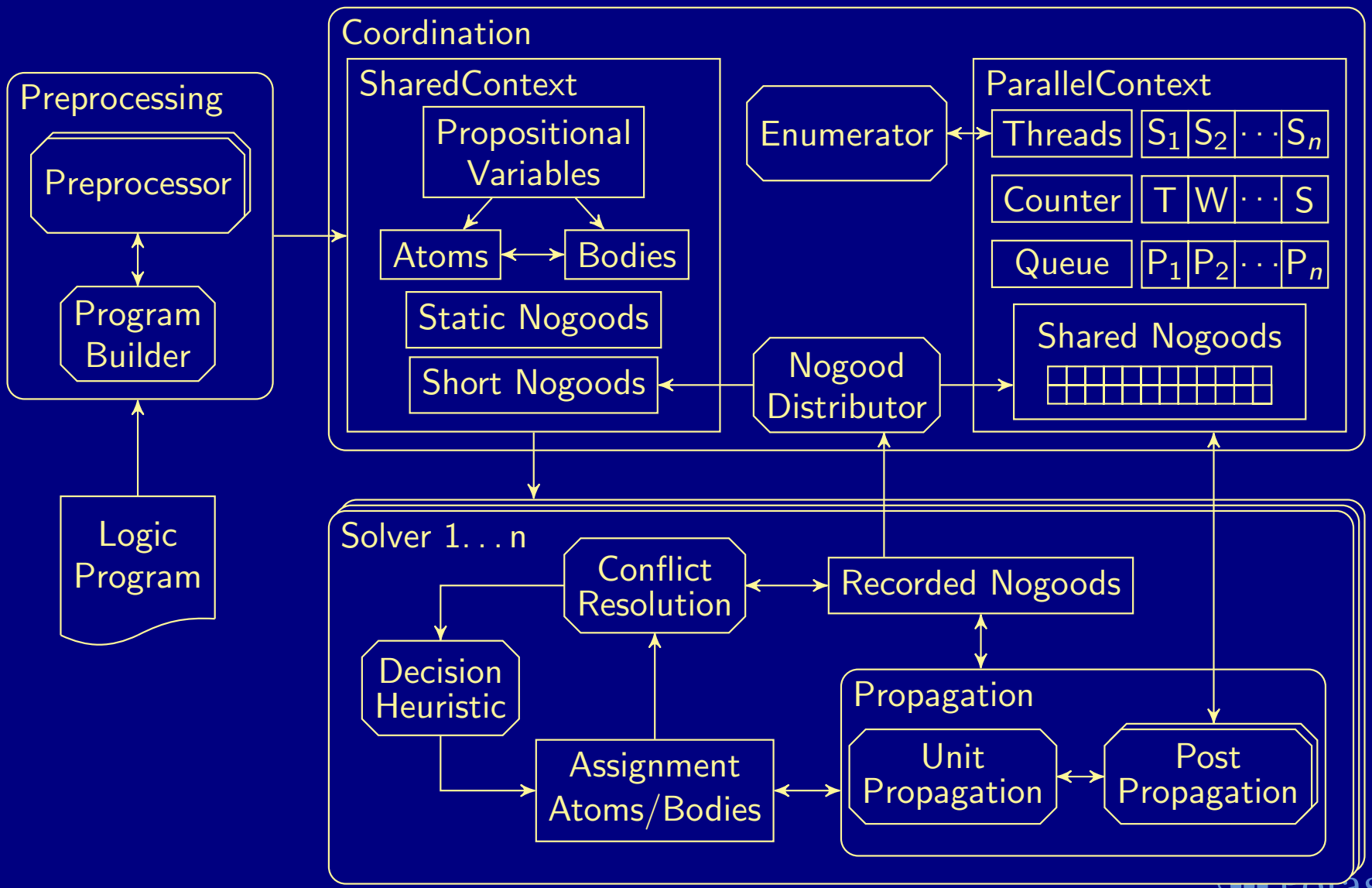


Potassco

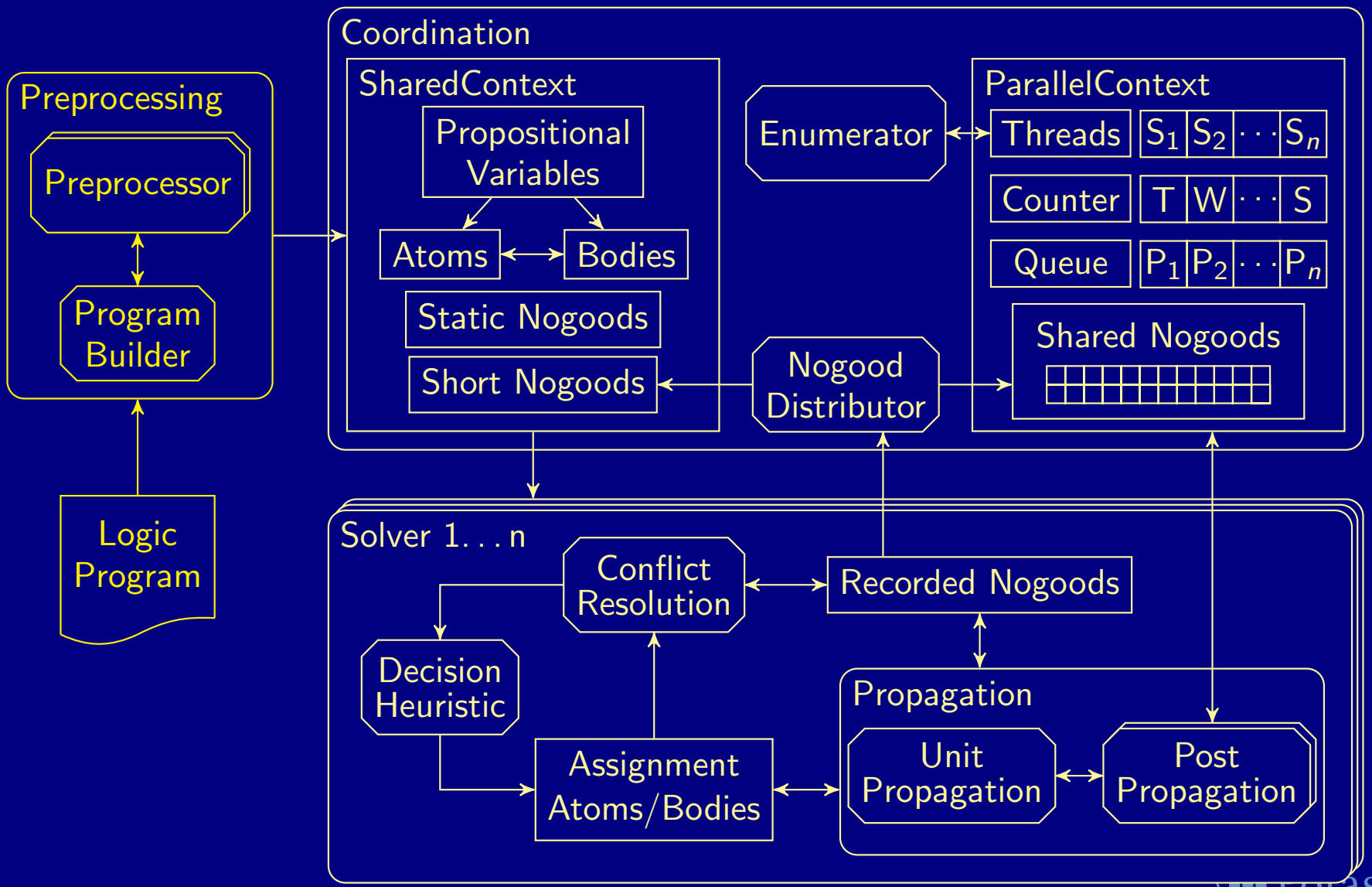
Outline

Potassco

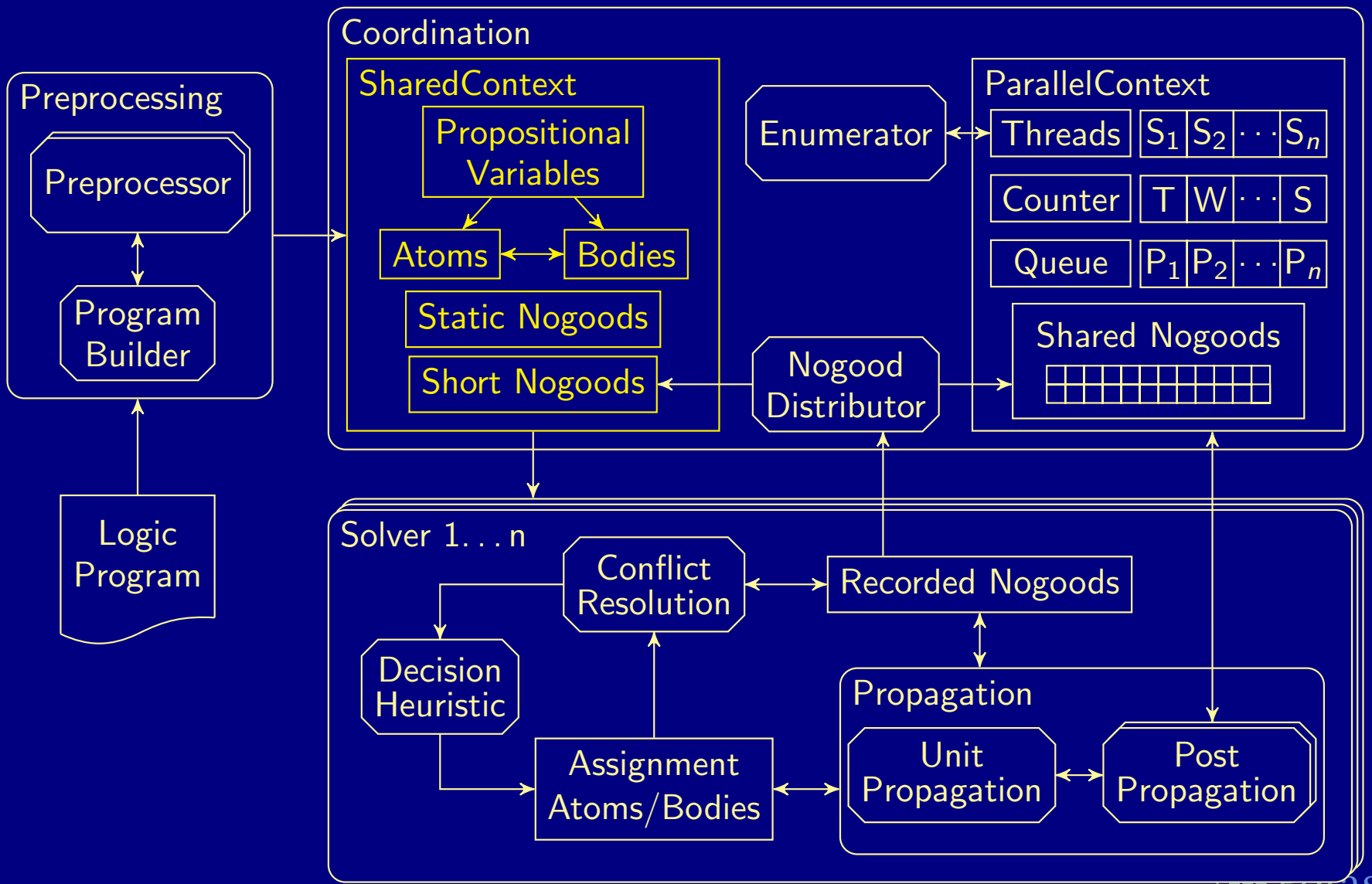
Multi-threaded architecture of *clasp*



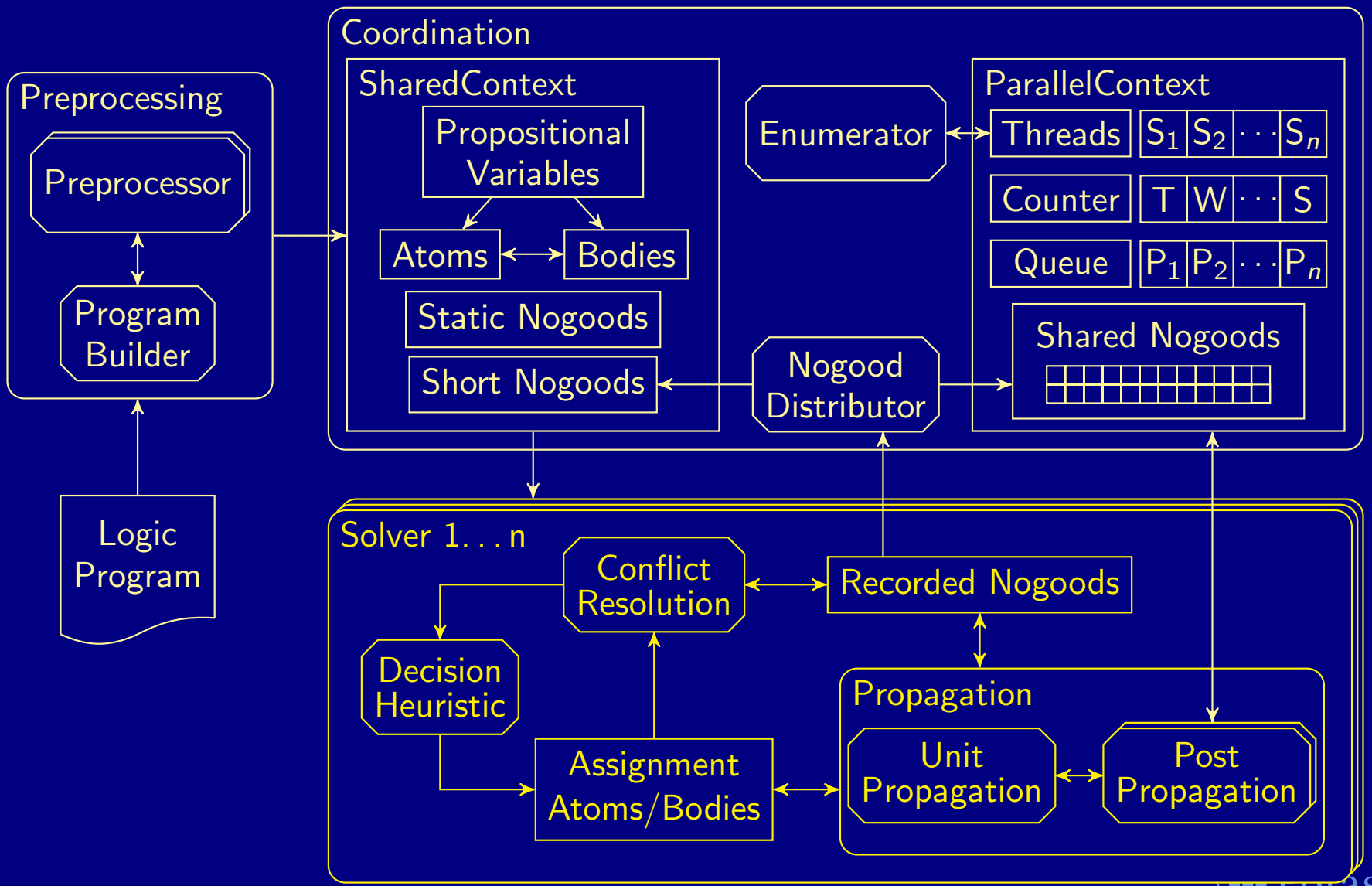
Multi-threaded architecture of *clasp*



Multi-threaded architecture of *clasp*



Multi-threaded architecture of *clasp*



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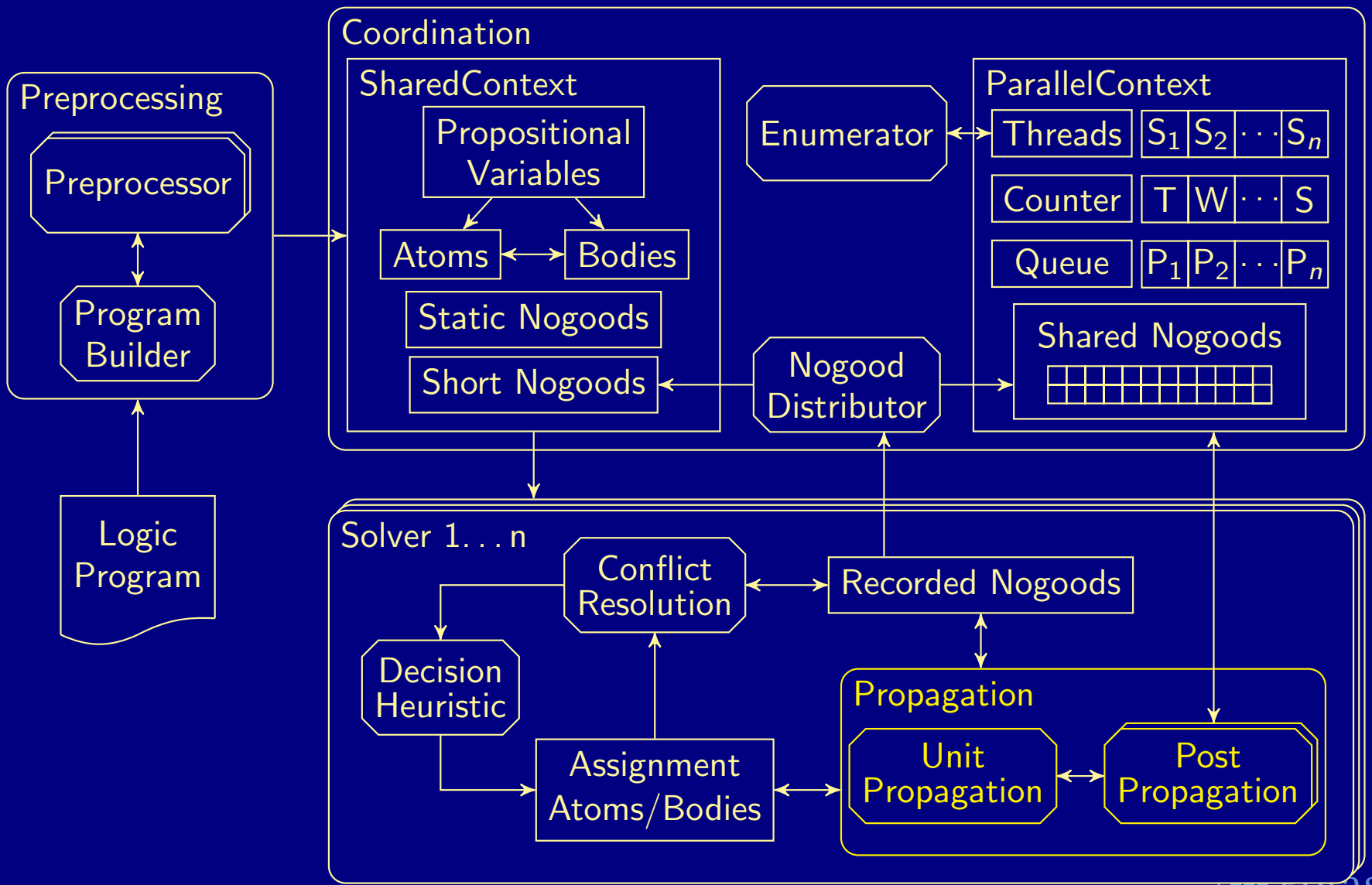

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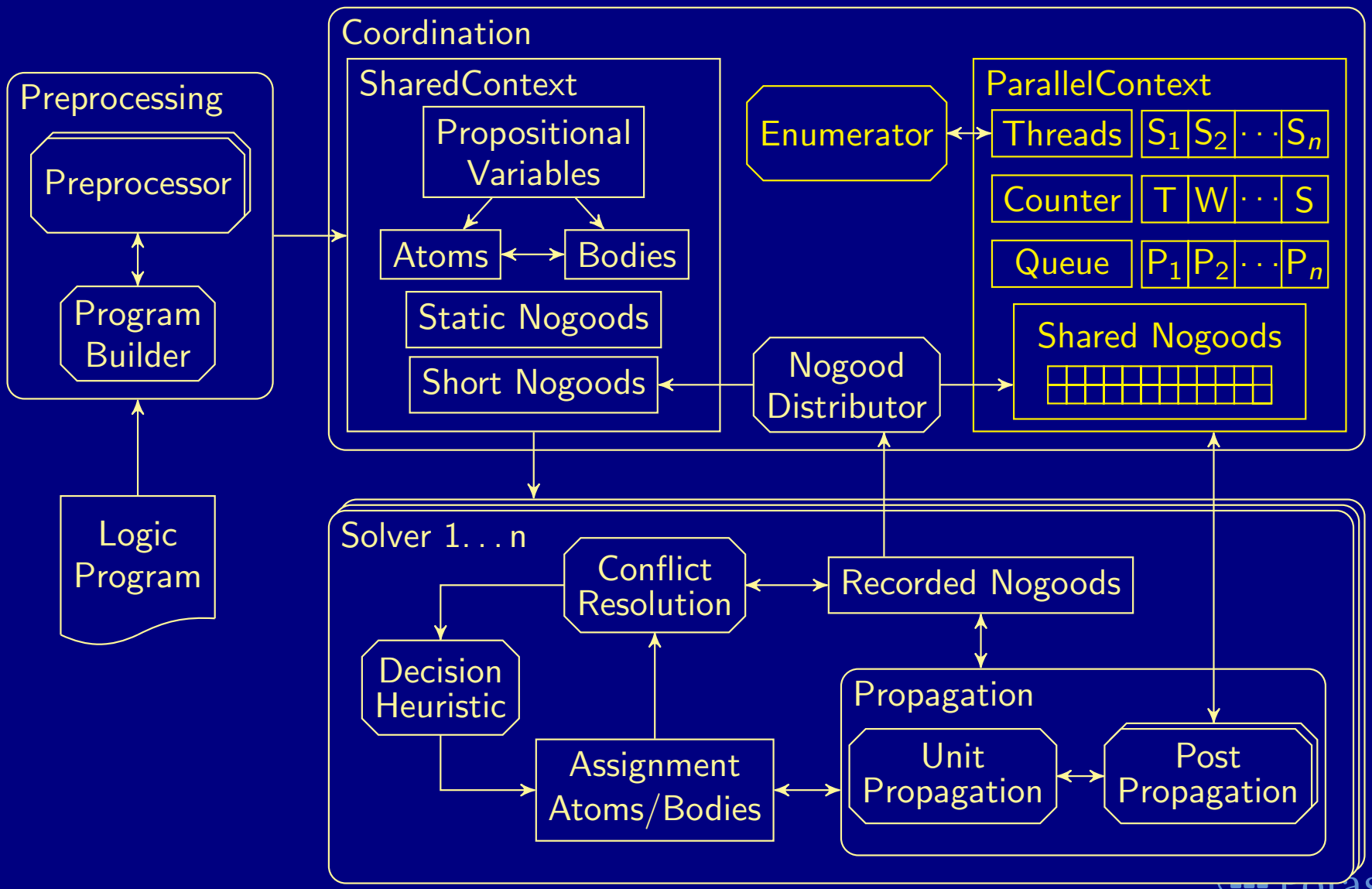

Outline

Potassco

Two sides of a coin

- ASP as High-level Language
  - Express problem instance as sets of facts
  - Encode problem class as a set of rules
  - Read off solutions from stable models of facts and rules
- ASP as Low-level Language
  - Compile a problem into a set of facts and rules
  - Solve the original problem by solving its compilation
- ASP and Imperative language

  Control continuously changing logic programs

Potassco

Two sides of a coin

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Two sides of a coin

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Potassco

Two sides of a coin

- ASP as High-level Language
  - Express problem instance as sets of facts
  - Encode problem class as a set of rules
  - Read off solutions from stable models of facts and rules
- ASP as "Low-level" Language
  - Compile a problem instance into a set of facts
  - Encode problem class as a set of rules
  - Solve the original problem by solving its compilation
- ASP and Imperative language
  - Control continuously changing logic programs

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Two and a half sides of a coin

- ASP as High-level Language
  - Express problem instance as sets of facts
  - Encode problem class as a set of rules
  - Read off solutions from stable models of facts and rules
- ASP as "Low-level" Language
  - Compile a problem instance into a set of facts
  - Encode problem class as a set of rules
  - Solve the original problem by solving its compilation
- ASP and Imperative language
  - Control continuously changing logic programs

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Outline

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Upcoming experience

- ASP is a viable tool for Knowledge Representation and Reasoning
  - Integration of DB, LP, KR, and SAT techniques
  - Combinatorial search problems in the realm of NP and NP^{NP}
  - Succinct, elaboration-tolerant problem representations
    - rapid application development tool
  - Easy handling of knowledge-intensive applications
    - data, defaults, exceptions, frame axioms, reachability etc
- ASP offers efficient and versatile off-the-shelf solving technology
  - `http://potassco.org`
  - winning ASP, CASC, MISC, PB, and SAT competitions
- ASP has a growing range of applications, and its's good fun!

Potassco

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ASP = DB+LP+KR+SAT

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Upcoming experience

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ASP = DB+LP+KR+SMT^n

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