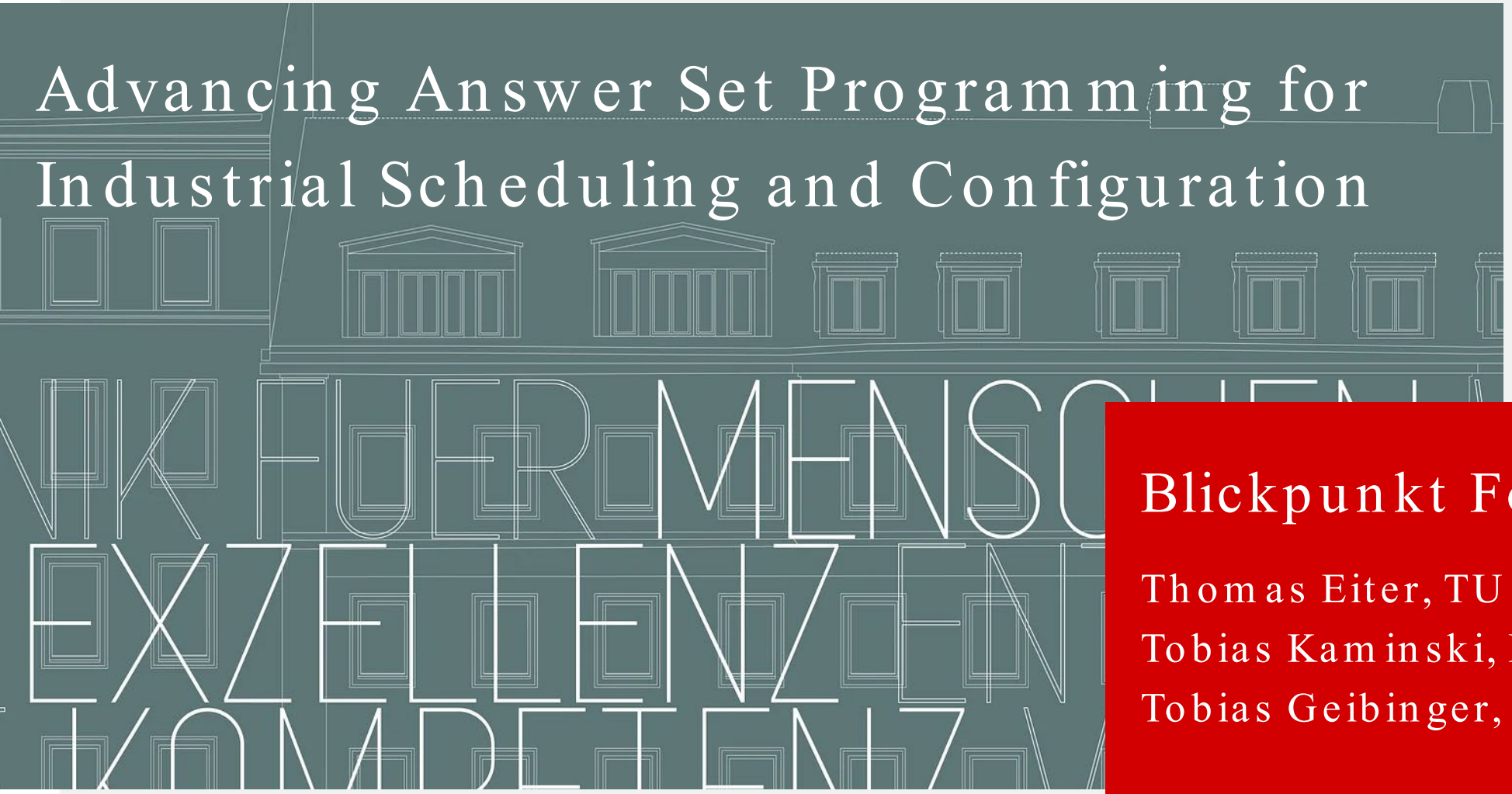
Advancing Answer Set Programming for Industrial Scheduling and Configuration



Blickpunkt Forschung

Thomas Eiter, TU Wien
Tobias Kaminski, Bosch
Tobias Geibinger, TU Wien

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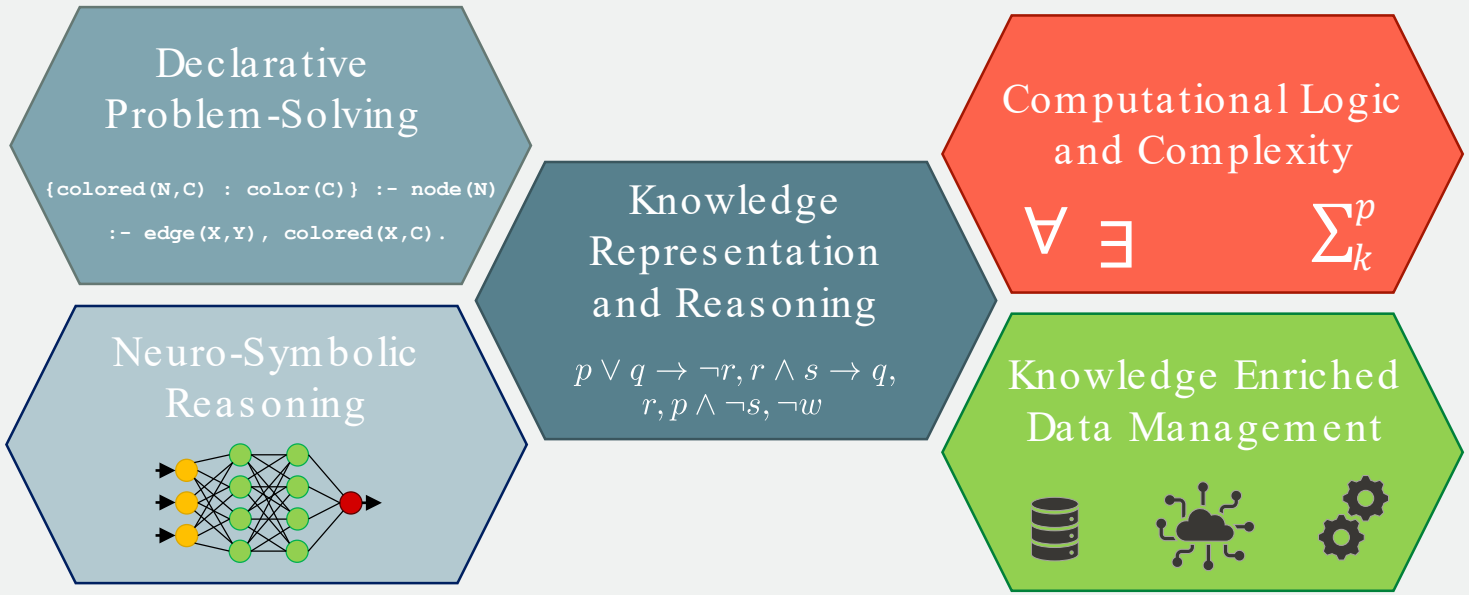
kbs Knowledge-Based Systems Group

Institue of Logic & Computation

Knowledge-Based Systems Group

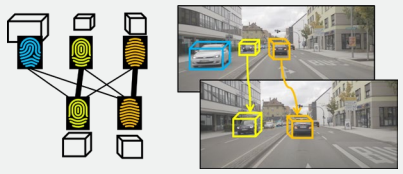
Our **research** focuses on **foundations** and **formal aspects** of **knowledge-based systems** and **Artificial Intelligence**



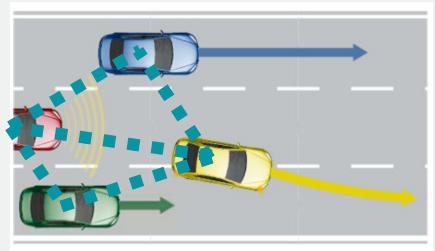
2 Professors, 2 Associated Professors, 4 PostDocs and **8 PhD Students**

Artificial Intelligence Research @ Bosch

Research Fields and Core Competences



Deep Neural Networks for Automated Driving perception



Learning vehicle interactions, behavior predictions, and driver models

Perception and planning for manipulation robotics

- Probabilistic Modeling
- Deep Learning
- NLP & Neuro-symbolic AI
- RL & Control

Locations

- Renningen (Germany)
- Hildesheim (Germany)
- Pittsburgh (USA)
- Sunnyvale (USA)
- Haifa (Israel)
- Shanghai (China)

Major Topics

- **Generative** AI
- **Prediction** and **Planning**
- **Verification** and **Validation** of AI Models
- **Neuro-Symbolic** AI

Application Areas

- Automated Driving
- Embedded AI
- Industrial and Home Robotics
- Knowledge Engineering
- Smart Consumer Goods

Impact

- #1 AI research lab in the European industry
- Since 2017*: 350+ top-tier publications in AI
- 1300+ patent filings*

Collaborations

Our Mission: We are the home of cutting-edge AI research at Bosch– the place where AI is invented for life.

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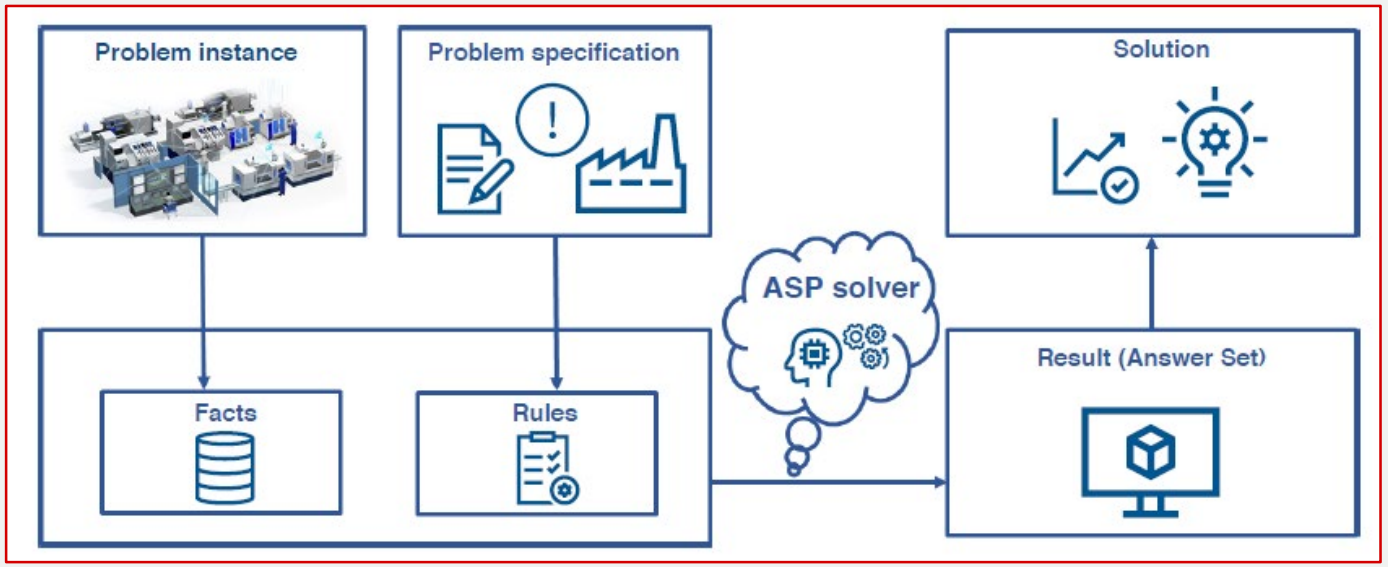
University Collaboration with TU Wien

Knowledge-Driven Problem Solving in Manufacturing



- Parallel Machine Scheduling
- Product Configuration
- Automatic Task Scheduling
- Production Planning
- Model-Based Testing for Autonomous Driving

Benefits of our collaboration:

- Direct access to **basic research** to improve the methods and **to increase their scalability**
- Enhanced innovation through **cutting-edge** academic research
- Mutual growth through **knowledge exchange** and skill development

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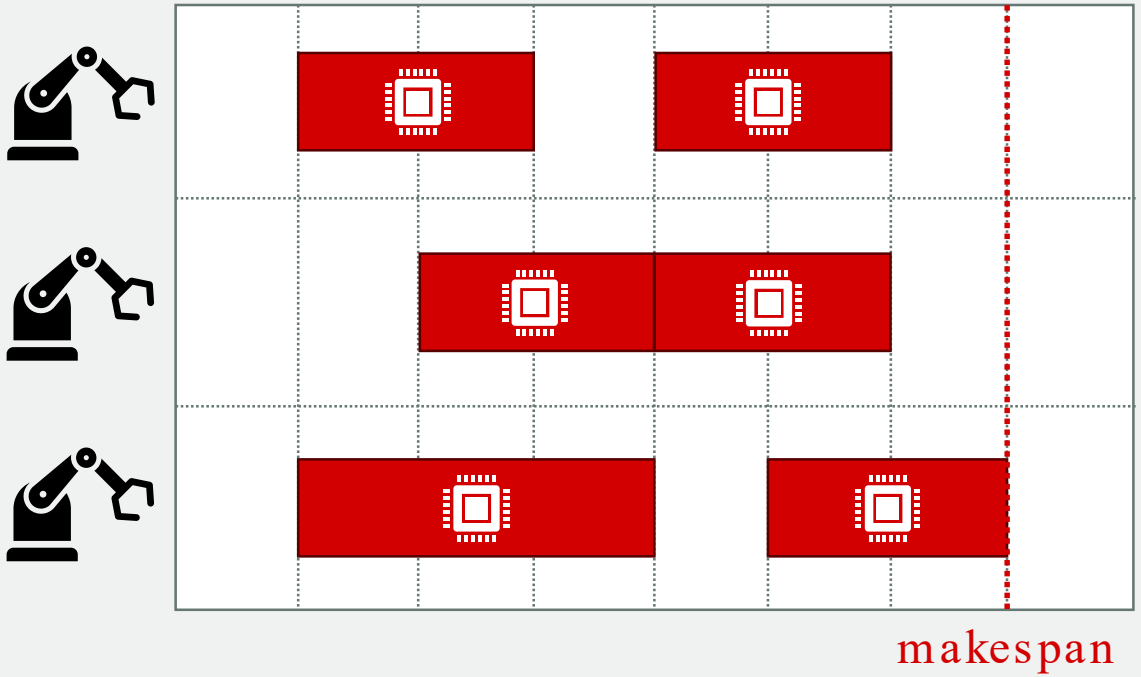
Industrial Problems

Scheduling as an Example

Several **scheduling problems** arise in **semi-conductor production**

For example, scheduling **parallel machines**:



Constraints:

- **Machine capabilites**
- **Release dates**
- **Setup times**

Objective:
minimize makespan

Answer-set Programming (ASP)

Basics

ASP is a type of logic programming ⇒ Origins in deductive databases

Operates on relational information:

Table node

ID
1
2
3
4
5

Table edge

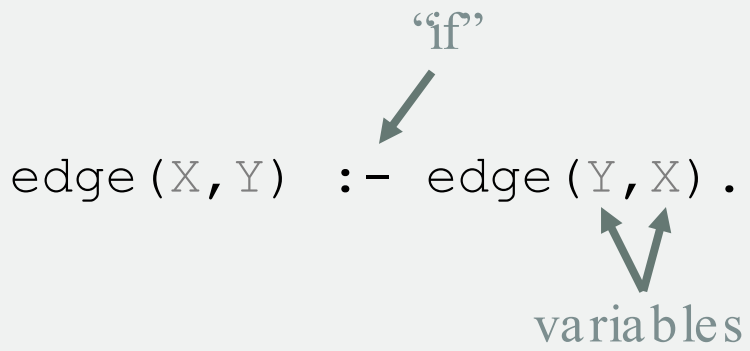
FROM	TO
1	2
2	3
2	5
3	5
4	5
1	4

Facts:

```
node(1). node(2). node(3).
node(4). node(5).
edge(1,2). edge(2,3). edge(2,5).
edge(3,5). edge(3,5). edge(4,5).
edge(1,4).
```

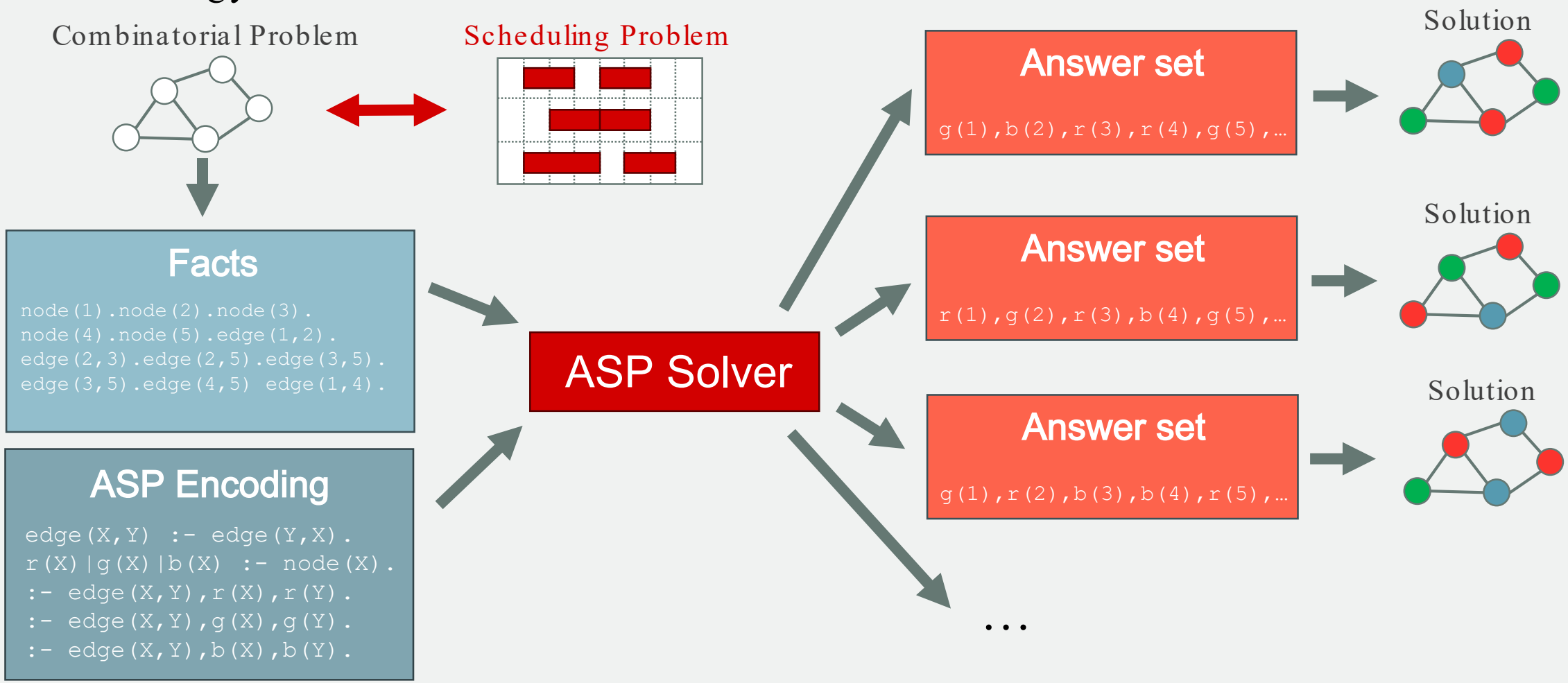
Main construct are rules

Example: edges should be symmetric



Answer-set Programming (ASP)

Methodology



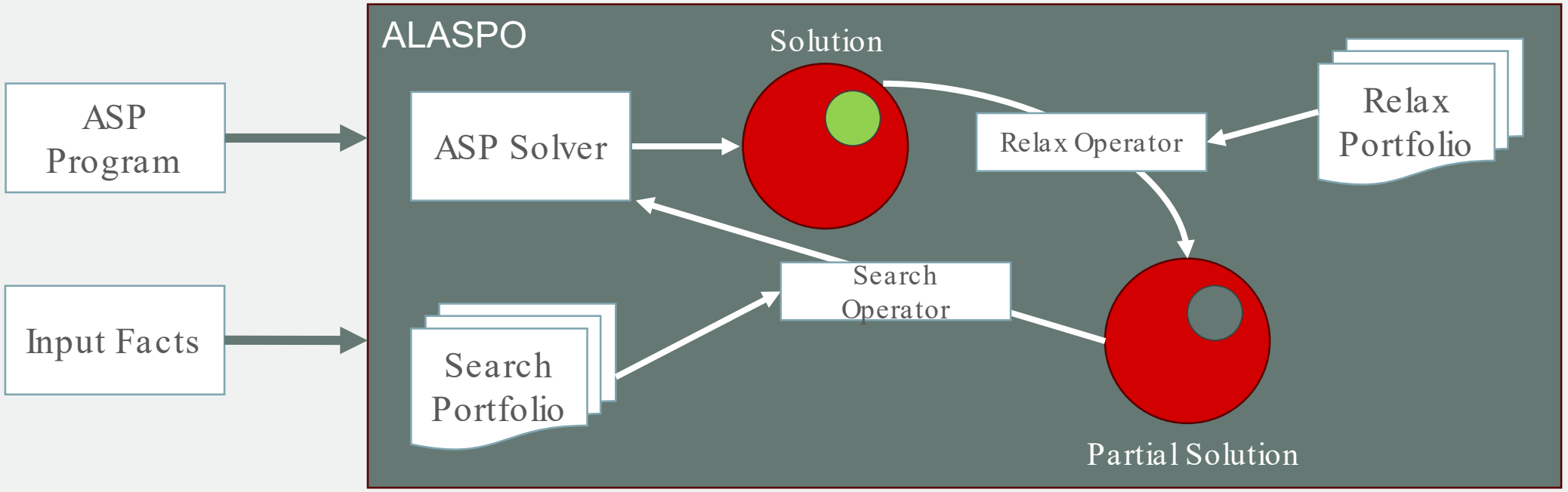
ALASPO

Adaptive Large-Neighbourhood Search for Optimisation in ASP

ASP can also be used for optimisation problems ⇒ Scheduling!

Efficient solvers are available

However, Performance can be lacking for industrial problems ⇒ ALASPO



Summary

Benefits and Future

Benefits

- We increased awareness in Bosch for **ASP as a problem-solving tool**
- Potential **industrial use-cases**
  ⇒ Scheduling for semiconductor production at Bosch
- To **bridge performance gaps**, we developed a **novel adaptive LNS framework for ASP**

Outlook

- Further **use cases** and **improvements** are under exploration
- Future work like a **combination of LLMs and ASP** for problem solving and explainability is being investigated