

Optimal Multi-robot Task Planning: from Synthesis to Execution (and Back)

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At a Glance

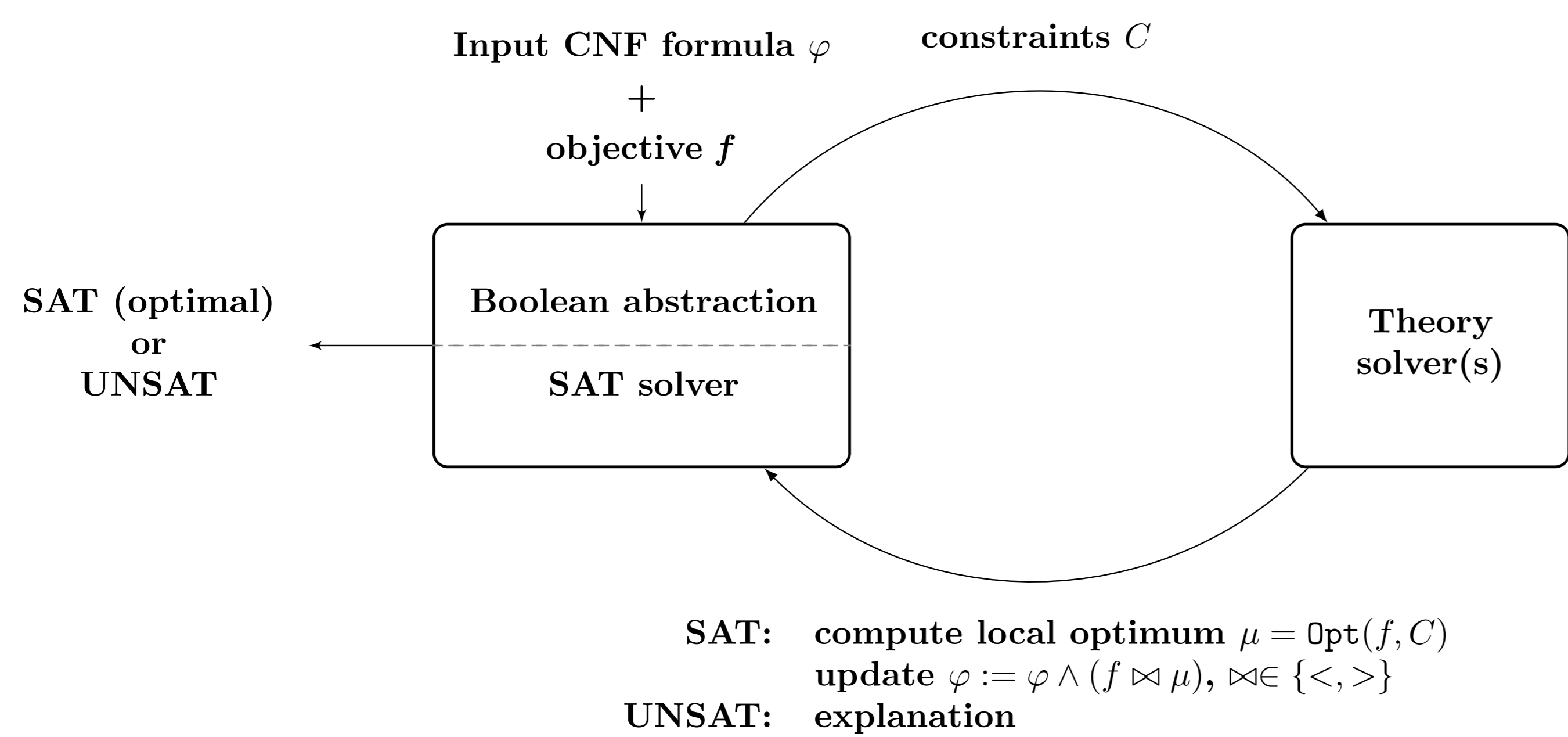
Motivation

- Autonomous robots are increasingly used in modern factories
- How can we provide guarantees and explanations for their behaviors?

Project Overview

- Optimal multi-robot task planning
- Integration with online execution and monitoring agent
- Testbed: RoboCup Logistics League

Optimization Modulo Theories (OMT)

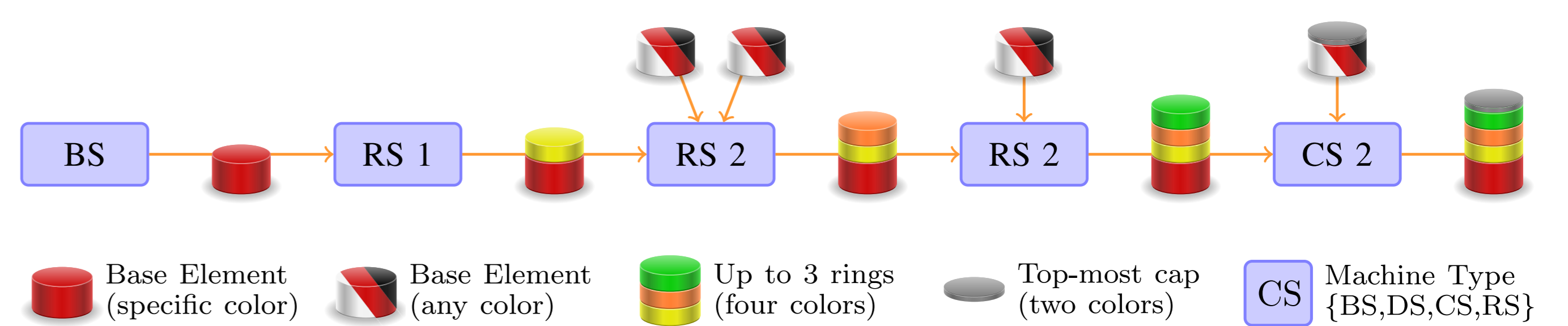


RoboCup Logistics League (RCLL)

[4, 5]

Principles

- Two teams of three robots each compete on a common field
- Task: fulfill orders and deliver goods
- Products consist of colored base, 0 to 3 colored rings, and cap
- Machines of four different types can be used to maintain and optimize production
- Order schedule posted by automated referee
- Complexity and color known at run-time



Optimal Plans with OMT

[1, 2]

Find optimal reward for bounded executions $s_0 \xrightarrow{a_0} s_1 \xrightarrow{a_1} \dots \xrightarrow{a_p} s_{p+1}$

- over states s_0, \dots, s_{p+1}
- executing actions a_0, \dots, a_p
- obtaining rewards r_0, \dots, r_p after transitions $s_i \xrightarrow{a_i} s_{i+1}$

Encode in *linear mixed-integer arithmetic*:

- initial states $I(s)$, transition relation $T(s, a, s')$ and reward function $R(s)$

Solve an **optimal bounded planning problem**

$$\text{maximize } \sum_{0 \leq i \leq p} r_i \quad \text{s.t.} \quad I(s_0) \wedge \left(\bigwedge_{0 \leq i \leq p} T(s_i, a_i, s_{i+1}) \right) \wedge \left(\bigvee_{0 \leq i \leq p+1} R(s_i) \right)$$

Summing up...

- Developed a domain-specific task planner for the RCLL
- Integrated it with an online execution and monitoring agent.

What did we learn?

OMT is expensive... \rightarrow **novel encodings/relaxations needed.**

What's next?

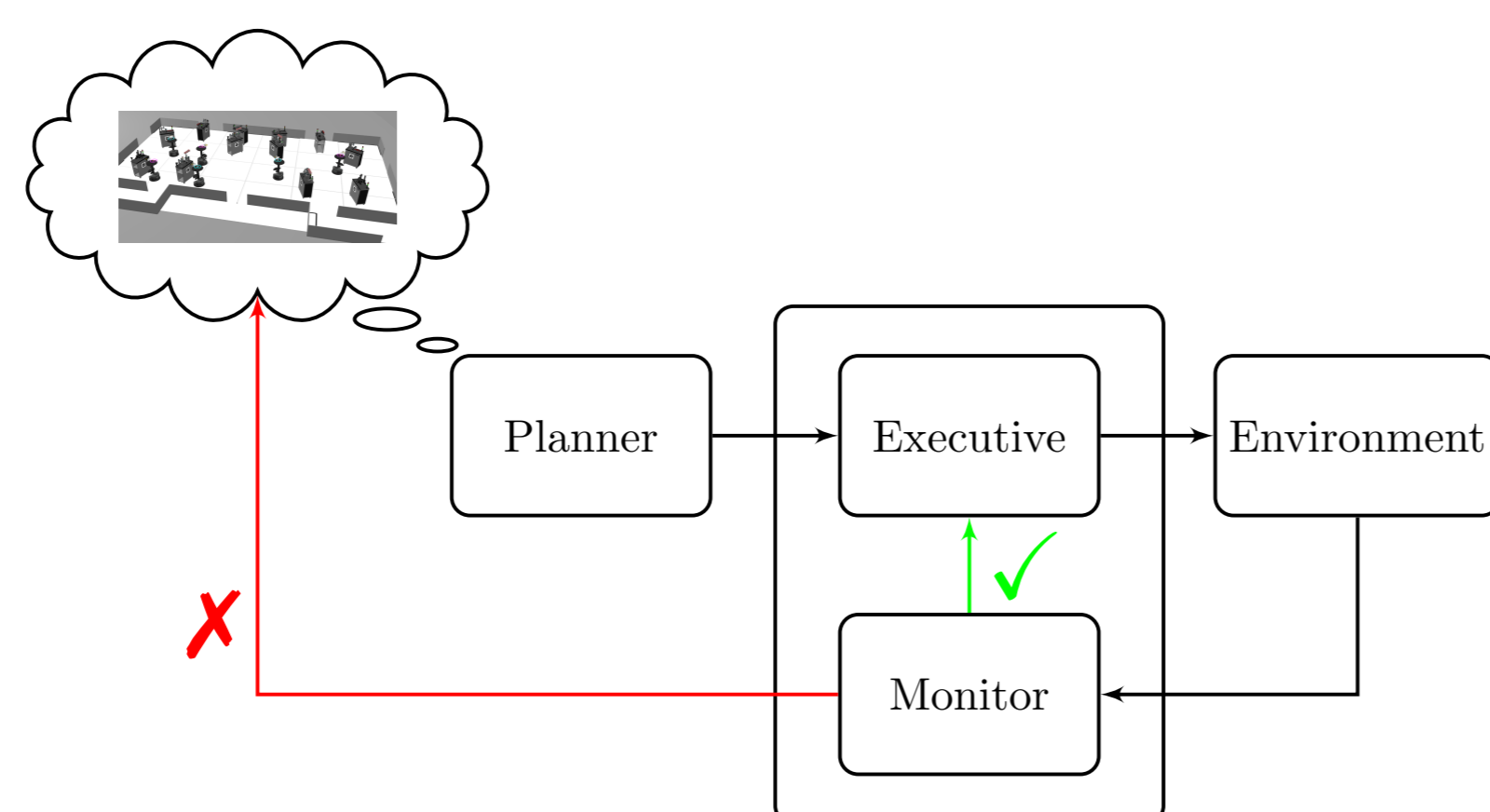
- Implementation of a domain-independent planner based on what we learned with the RCLL
- Assess the impact of our findings on a broader range of AI planning problems.

Stay tuned!

Online Execution and Monitoring

[2, 3]

- Plans are only as good as the model!
- Modelling assumptions may be challenged during execution.
- What happens to our plan?



References

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