PLANNING

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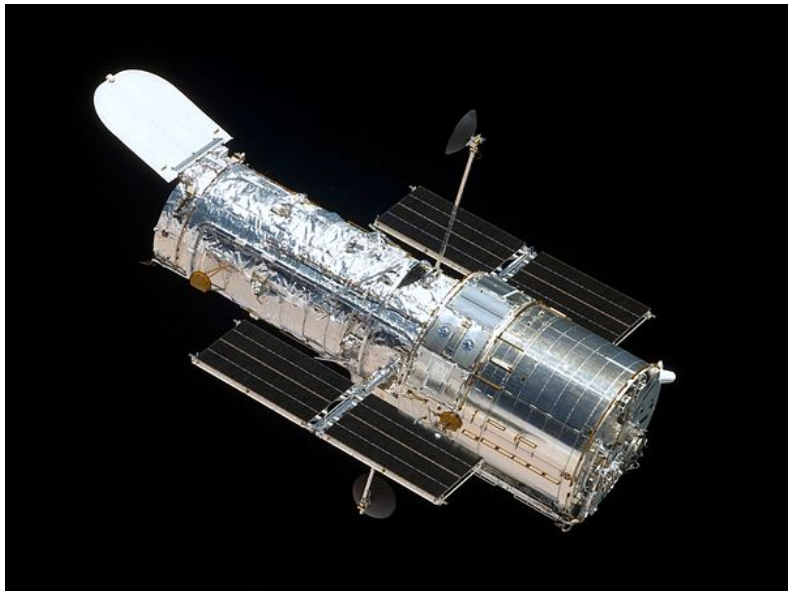
Introduction

Planning:

- central problem in AI,
- general framework that concerns the realization of strategies or action sequences, typically for execution by intelligent agents,
- many variants of different difficulty considered.

Applications

- automated control of industrial processes,
- design of intelligent agents, autonomous robots, and unmanned vehicles,
- natural language processing,
- system verification.



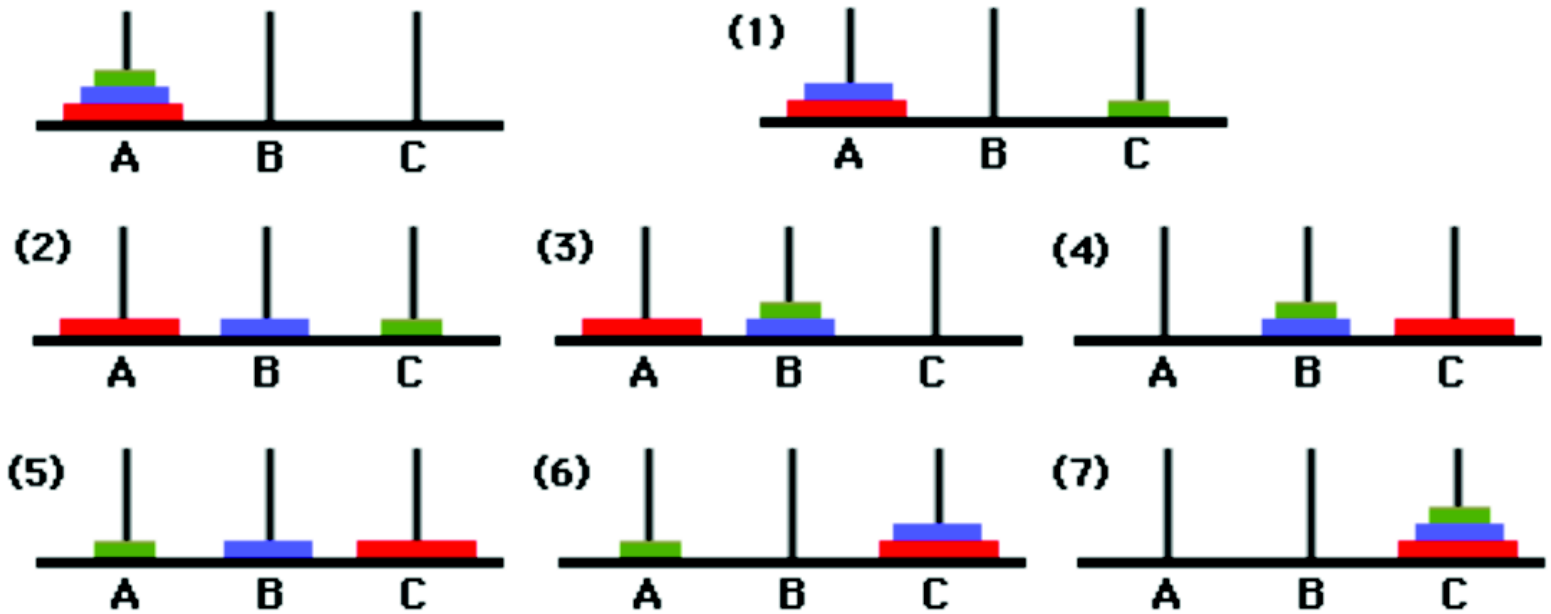
Hubble Space Teleskop

Example: Towers of Hanoi

Initial State

Goal State

Example: Towers of Hanoi



Solution = Plan

Classical Planning

Planning Instance

- set of **variables** together with their **domains**
- set of **actions**, each actions has:
  - a **precondition** and
  - an **effect**

  both precondition and effect are a partial assignment of the variables
- an **initial state** (a complete assignment of the variables)
- a **goal state** (a partial assignment of the variables)

Planning: Problems

Planning

Input: A planning instance P.
Question: Compute a plan for P or output that no plan for P exists.

Optimal Planning

Input: A planning instance P.
Question: Compute a plan of minimum length for P or output that no plan for P exists.

Bounded Planning **Parameter:** k

Input: A planning instance P and a natural number k.
Question: Is there a plan for P of length at most k?

Classical Complexity

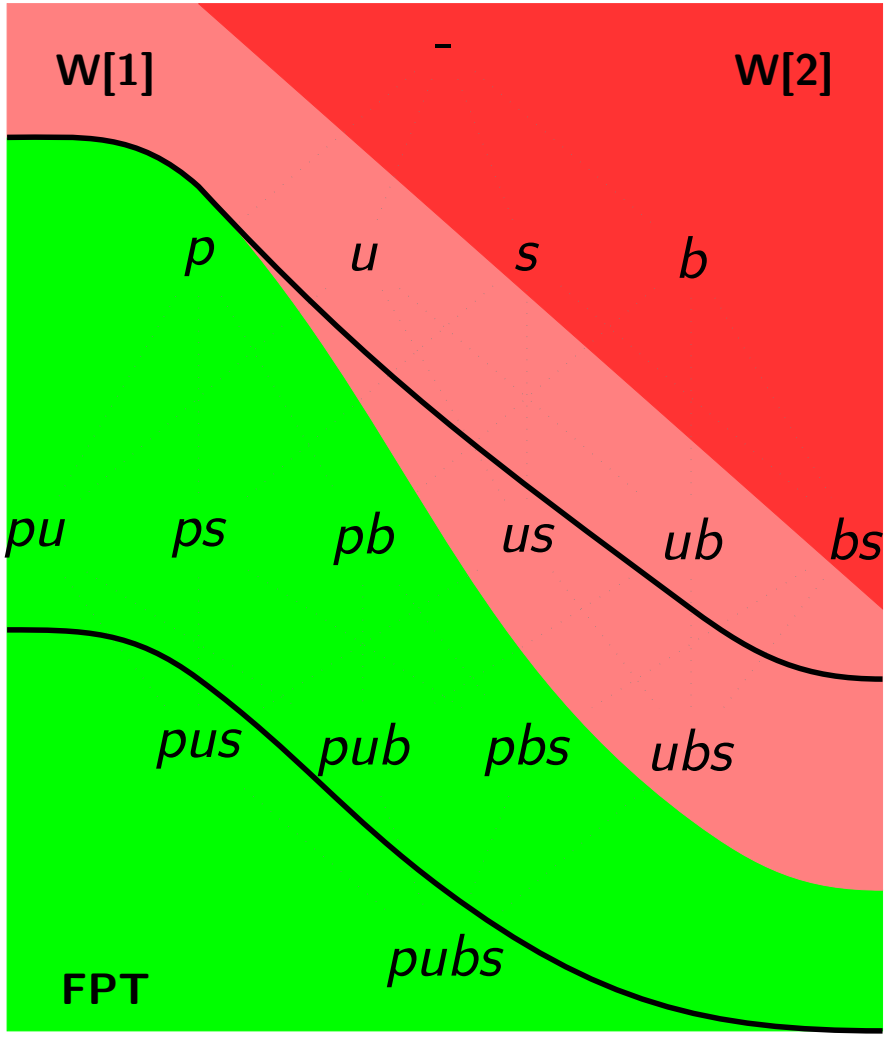
- Classical Planning is **PSPACE**-complete in general.
- However, various natural restrictions are known under which planning becomes (non-deterministic) polynomial-time tractable, e.g.:
  - syntactical restrictions (P,U,B,S)
  - restrictions on the number of preconditions and effects
  - structural restrictions on the causal graph;

Bounded Planning parameterized by "plan length"

	$m_e = 1$	fix $m_e > 1$	arb. m_e
$m_p = 0$	in P in P	in W[1] NP-C	W[2]-C NP-C
$m_p = 1$	W[1]-C NP-H	W[1]-C NP-H	W[2]-C Pspace-C
fix $m_p > 1$	W[1]-C NP-H	W[1]-C Pspace	W[2]-C Pspace
arb. m_p	W[1]-C Pspace-C	W[1]-C Pspace-C	W[2]-C Pspace-C

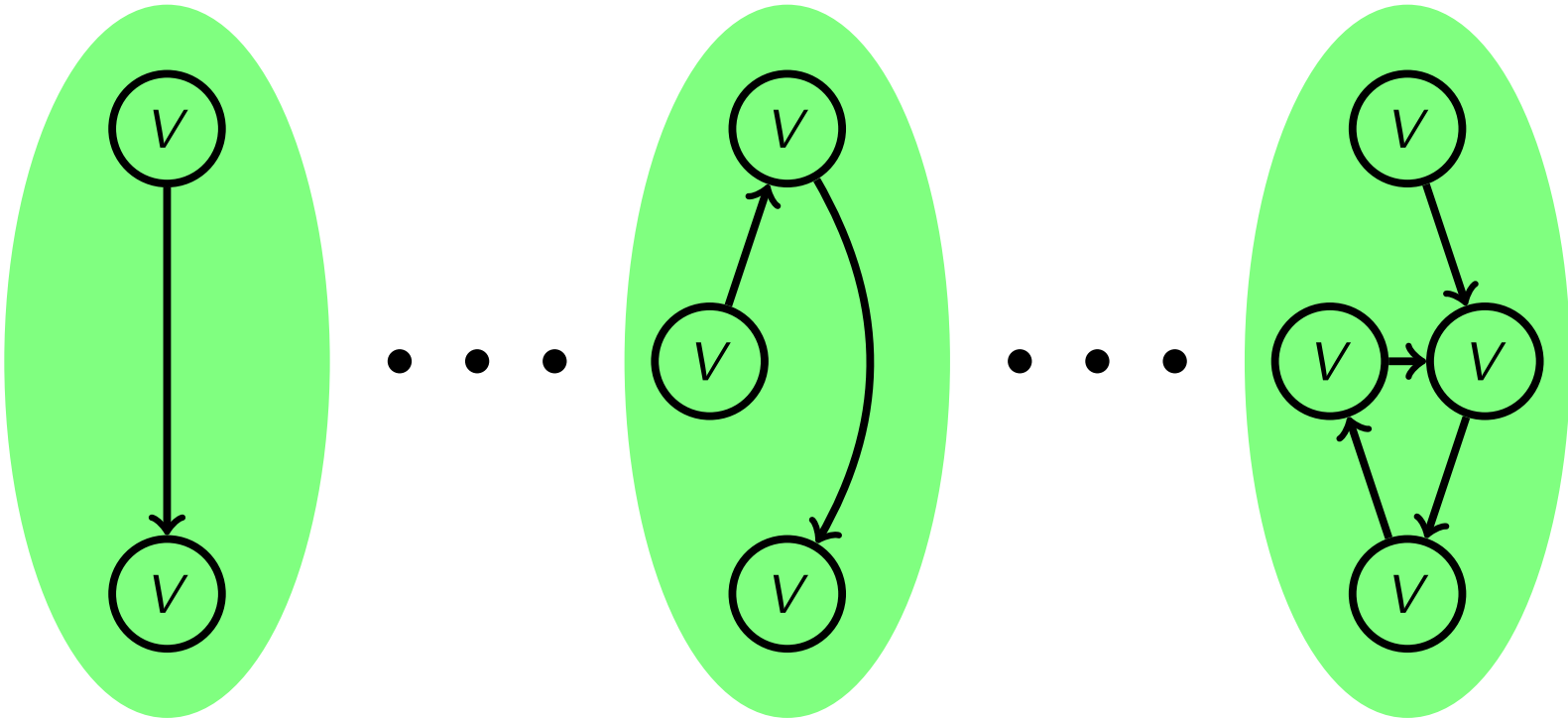
Bylander's restrictions

Bounded Planning parameterized by "plan length"

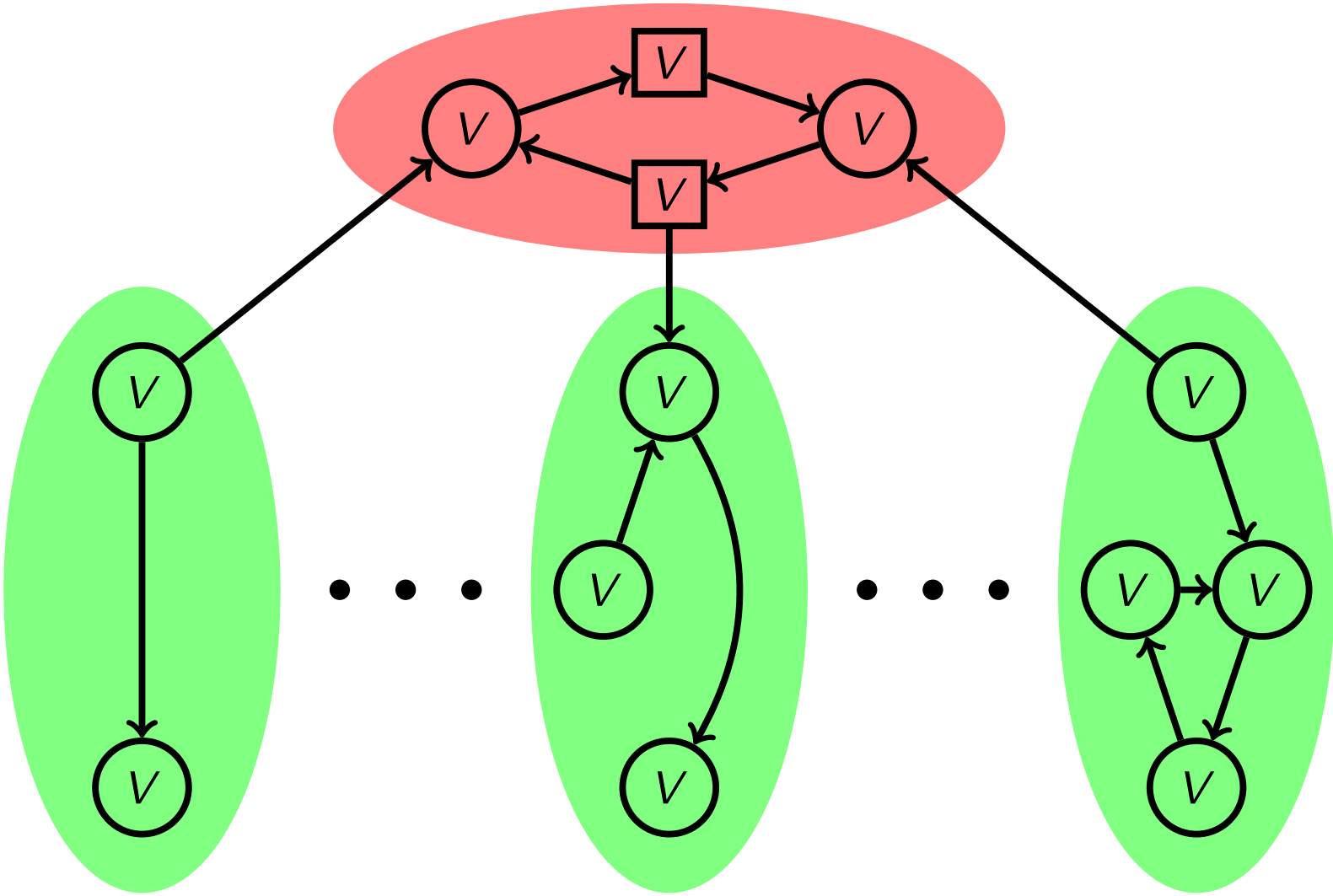


PUBS retrictions

Almost Independent Planning Instances

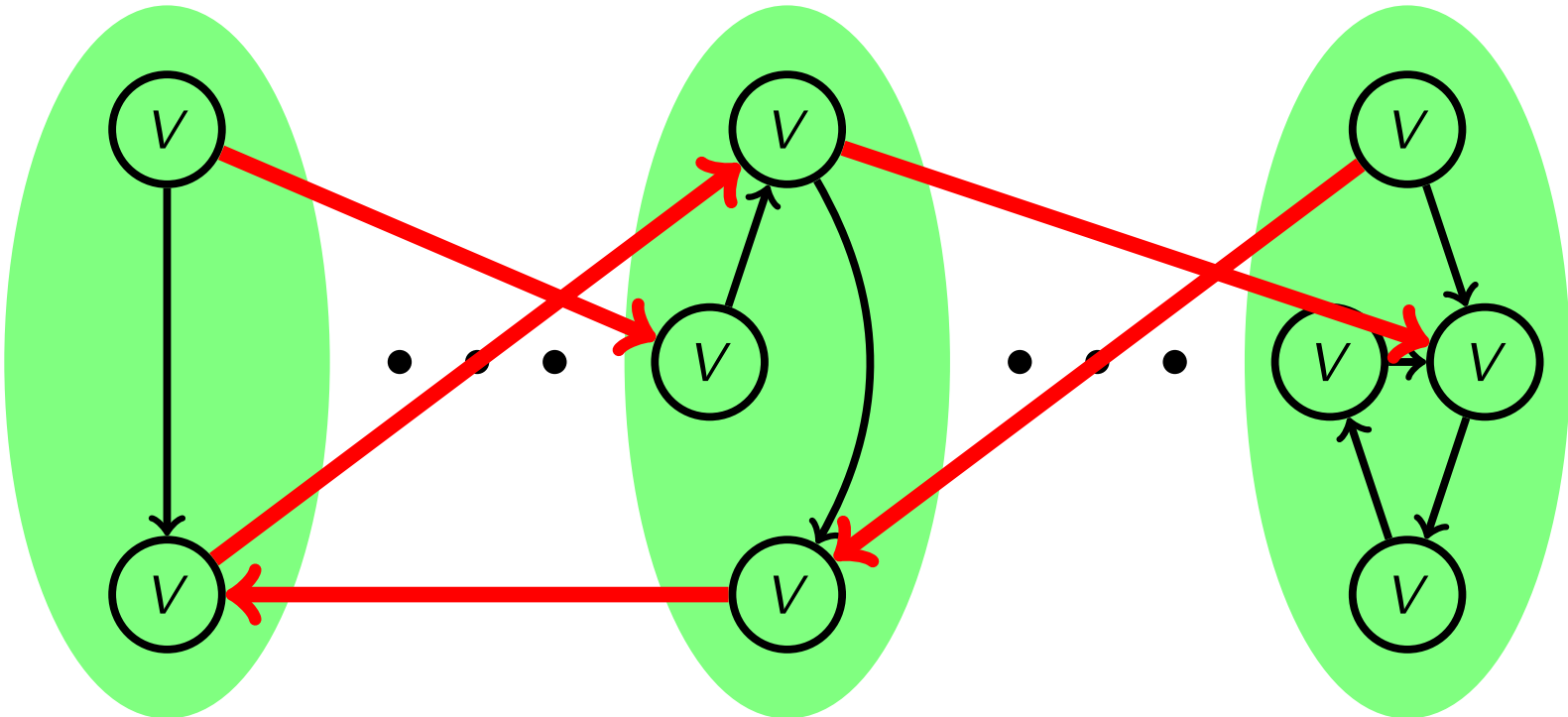


Almost Independent Planning Instances



Few "global variables"

Almost Independent Planning Instances



Few "global actions"

Almost Independent Planning Instances

Theorem

Bounded domain planning is fixed-parameter tractable parameterized by the number of global actions.

Theorem

Bounded domain planning is fixed-parameter tractable parameterized by the number of global variables.[1]

We also obtain matching hardness results for all the other combinations.

[1] We are still working on a constructive version of this algorithm :)

Thank You!