Fully Observable Nondeterministic HTN Planning – Formalisation and Complexity Results

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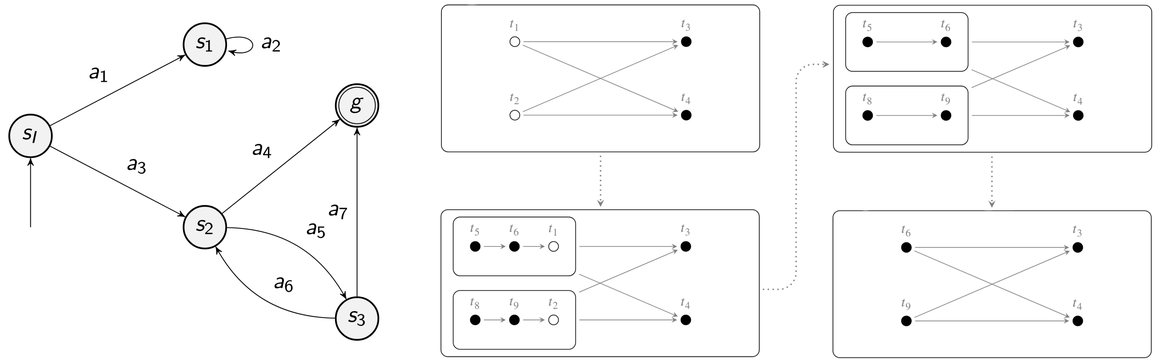
HTN planning in a nutshell

- Aim of classical planning: reach a goal state with a sequence of actions.
- Aim of HTN planning: execute a given set of tasks with task decomposition.
  - tasks either compound or primitive
  - compound tasks can be decomposed into another set of tasks
  - primitive tasks = actions



Why HTN planning?

- Expressive - complexity ranges from tractable to undecidable
- Nice compilation from classical planning
- Easy to encode domain dependent knowledge
- Levels of abstraction helpful for communicating with users

Adding uncertainty

- Classical planning: actions may have several effects
- HTN planning: actions may have several effects
  - same!

Defining solutions

- Nondeterministic planning: sequence or policy of actions
- Nondeterministic HTN planning: decompose away all compound tasks followed by sequence or policy of actions
  - alternatively, integrate decomposition into policy

executing a policy π:

- $s \leftarrow s_I$
- while $\pi(s)$ exists:
  - execute $\pi(s)$
  - $s \leftarrow$ senseState()
  - if $s = s_G$: return success

Complexity results

- (almost all) weak FOND HTN problems can be compiled into deterministic problems
- totally ordered FOND HTN problems can be compiled into deterministic problems
- partially ordered FOND HTN problems made at least one class harder

Hierarchy	Order	FOD	FOND: Weak		FOND: Strong: *linearisation-dependent*		FOND: Strong: *outcome-dependent*	
primitive	total	P*	NP	[4.1]	P*	[4.8]		
	partial	NP$^{\alpha}$	NP	[4.2]	NP	[4.7]	PSPACE	[5.1]
no recursion (acyclic)	total	PSPACE$^{\beta}$	PSPACE	[4.4]	PSPACE	[4.8]		
	partial	NEXPTIME$^{\beta}$	NEXPTIME	[4.4]	NEXPTIME	[4.7]	EXPSPACE*	[5.2]
regular	total	PSPACE$^{\alpha}$	PSPACE	[4.5]	PSPACE	[4.8]		
	partial	PSPACE$^{\alpha}$	PSPACE	[4.5]	PSPACE	[4.7]	EXPSPACE*	[5.3]
tail-recursion	total	PSPACE$^{\beta}$	PSPACE	[4.4]	PSPACE	[4.8]		
	partial	EXPSPACE$^{\alpha,\beta}$	EXPSPACE	[4.4]	EXPSPACE	[4.7]	semidecidable*	[3.1]
arbitrary recursion	total	EXPTIME$^{\beta}$	EXPTIME	[4.4]	EXPTIME	[4.8]		
	partial	semi- & undecidable$^{\alpha,\gamma}$	semi- & undecidable	[3.1]	semi- & undecidable	[3.1]	semi- & undecidable	[3.1]

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