Symbolic Top-k Planning

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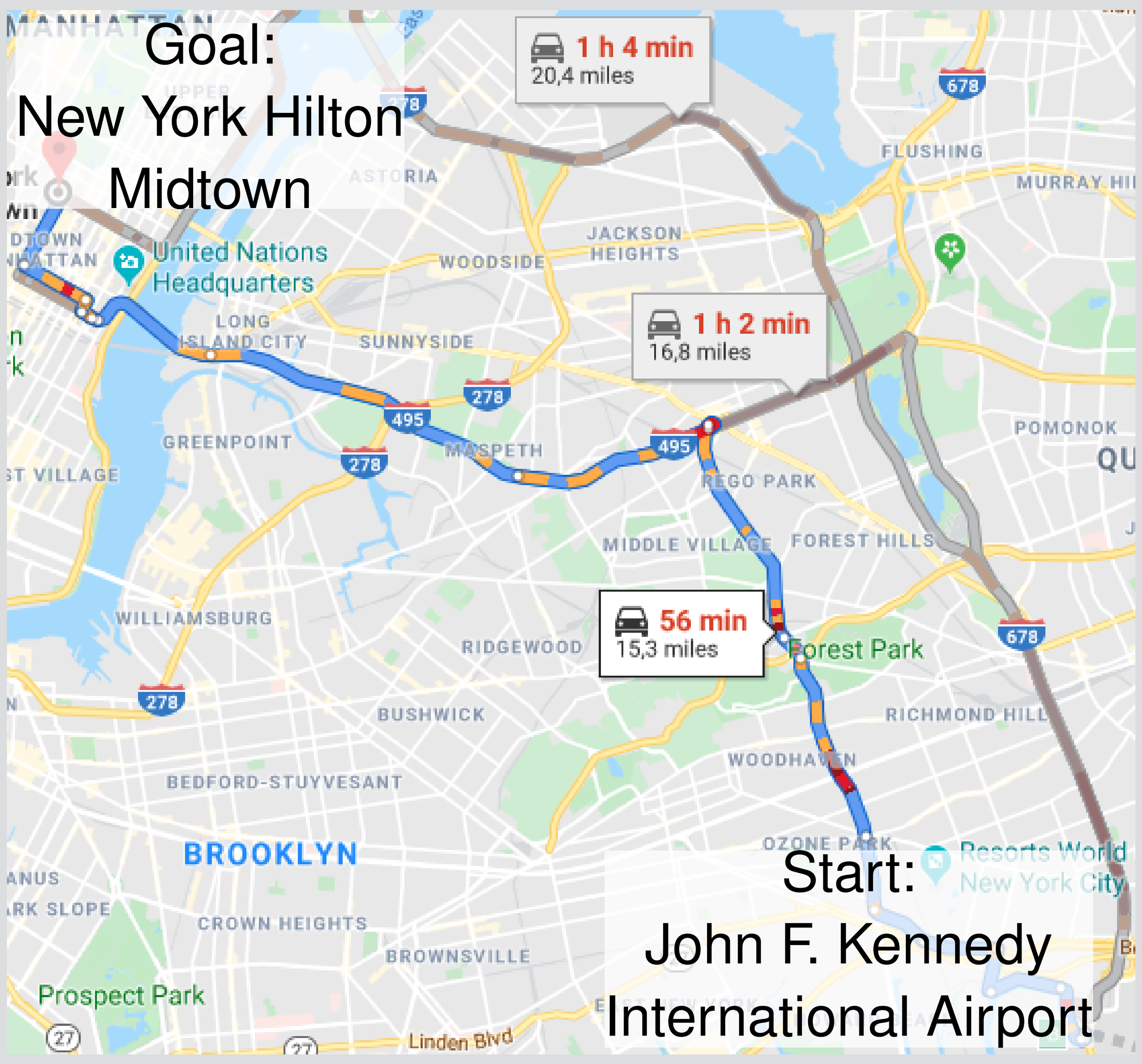
Motivation

- **Find a set of k different plans with lowest cost**
- Consider complex concepts without modelling
  - user preferences
  - environmental changes

Real World Example



Classical Top-k Planning Problem

Given:
- Planning task Π
- Number desired plans $k \in \mathbb{N}$

Find: A set of plans $P \subseteq P_\Pi$ such that

- there exists no plan $\pi' \notin P$ that is cheaper than some plan $\pi \in P$, and
- $|P| = k$ if $|P_\Pi| \geq k$, and $P = P_\Pi$, otherwise.

P_Π: set of all plans for planning task Π.

Complexity Results

Bounded top-k-existence

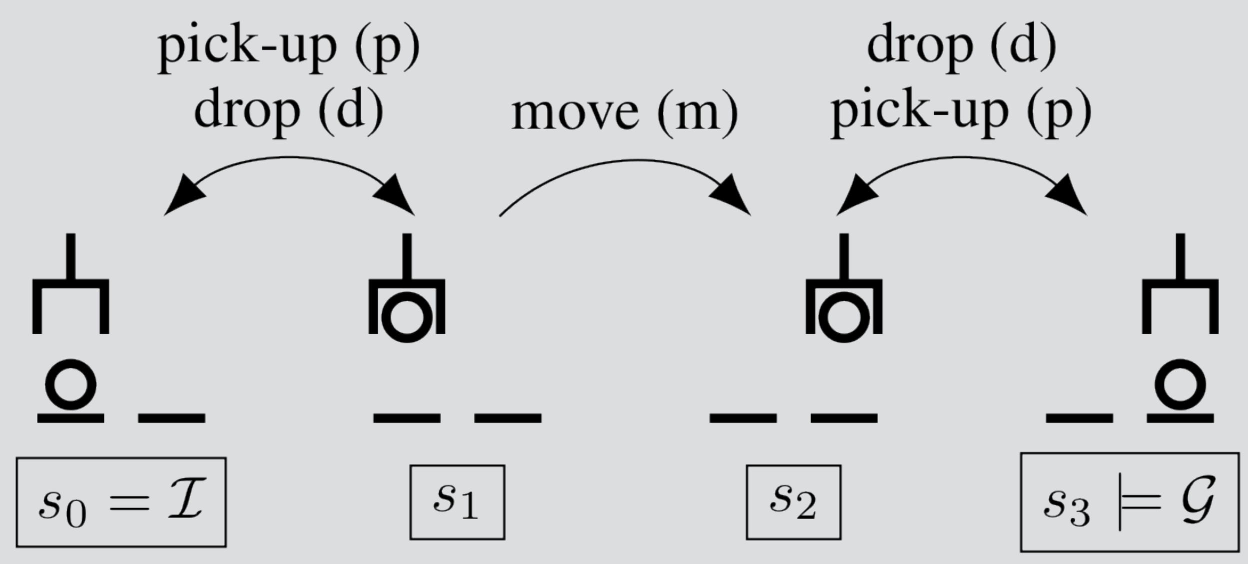
Given a planning task Π and two natural numbers ℓ and k, are there at least k different plans of length at most ℓ?

- In general: **PSPACE-complete**
- Short plans (poly.-bounded): **PP-hard**
- In practice: very likely to be much harder than ordinary planning

Symbolic Planning

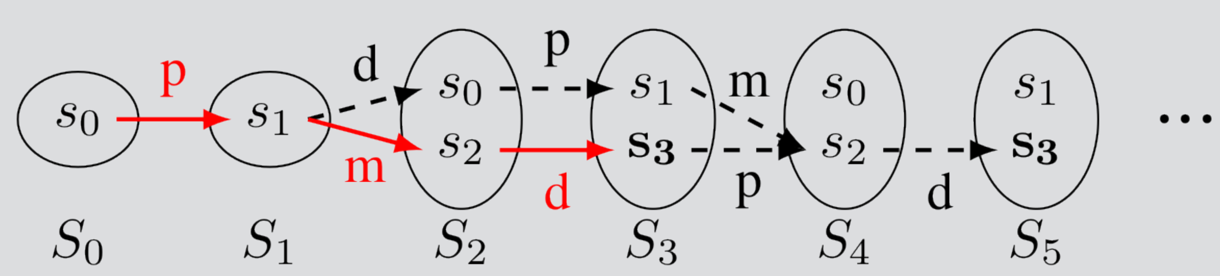
- Operations on sets of states $S \subseteq \mathcal{S}$
- $S \subseteq \mathcal{S}$ represented by *characteristic function* χ_S
- Manipulating $S \triangleq$ Transforming χ_S
  - e.g. $S \cap S' \triangleq \chi_S \wedge \chi_{S'}$

Symbolic Top-k Planning

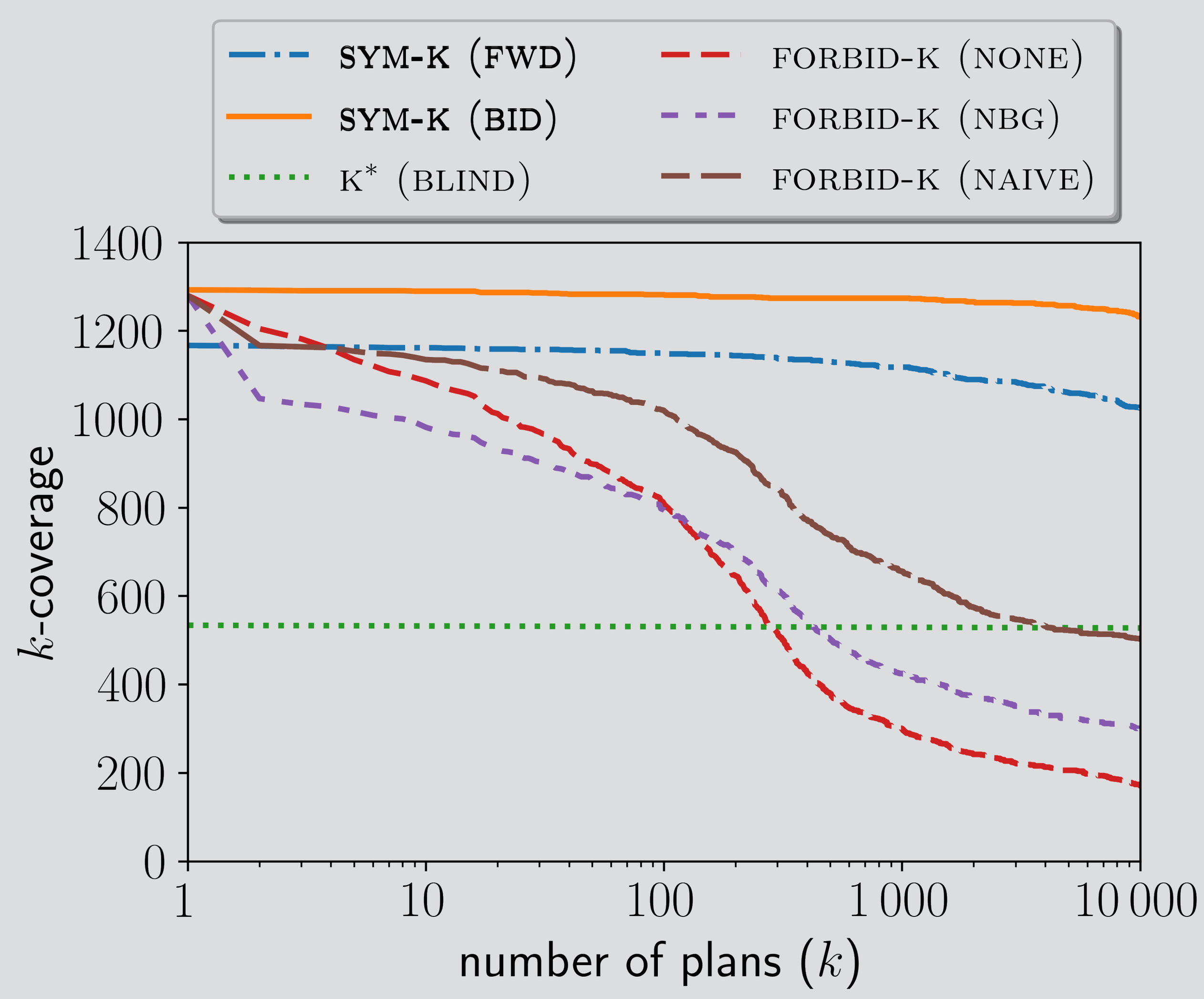


SYM-K algorithm

- Perform symbolic search without closing states
- If goal states are expanded
  - Reconstruct all corresponding plans
  - Continue if not enough plans found



Experiments



- k-coverage: #instances for which the top-k planning problem was solved
- SYM-K is competitive for small numbers of plans
- SYM-K scales best to large numbers of plans