Probabilistic Planning with Formal Performance Guarantees for Mobile Service Robots

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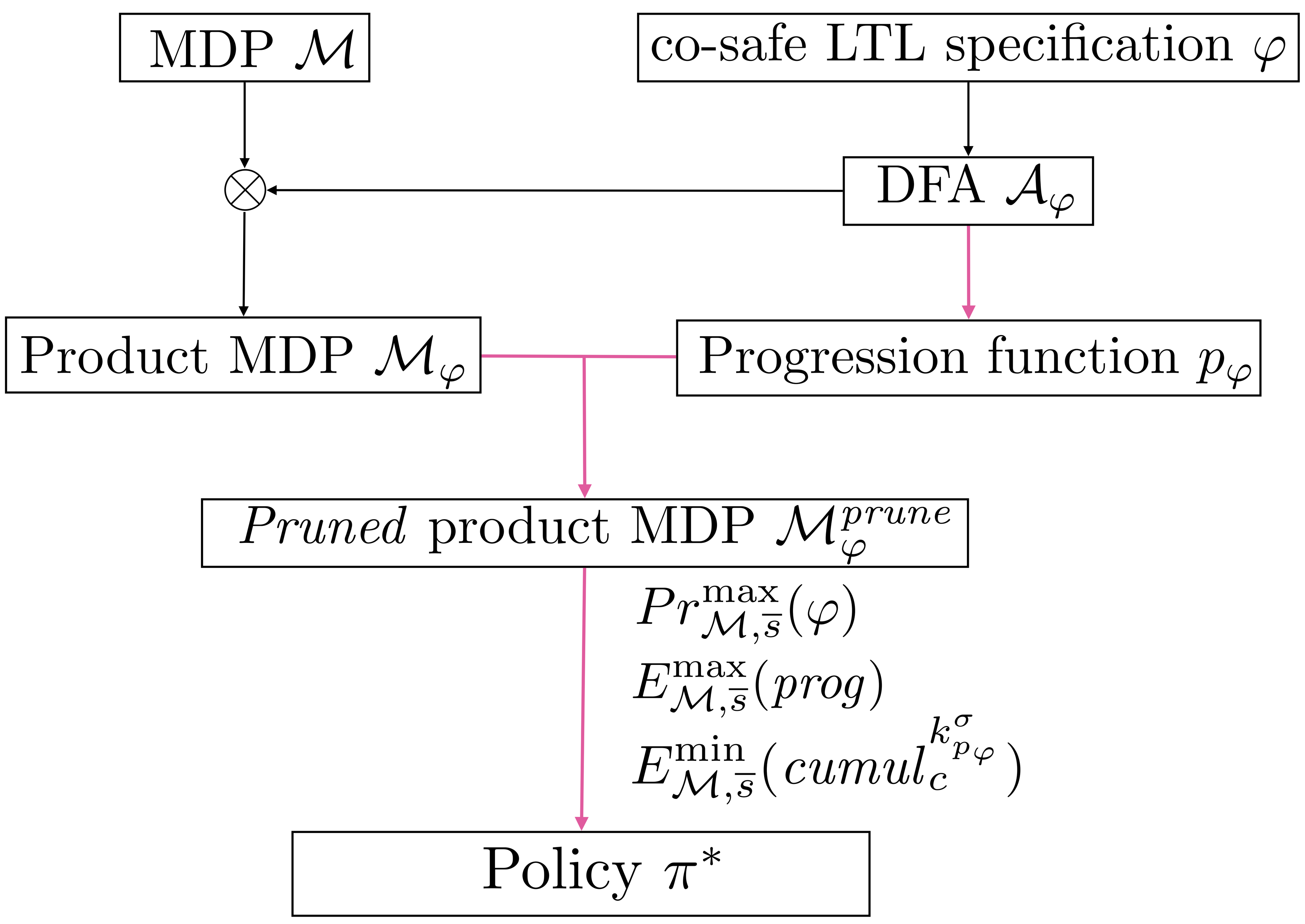
Overview & Contributions

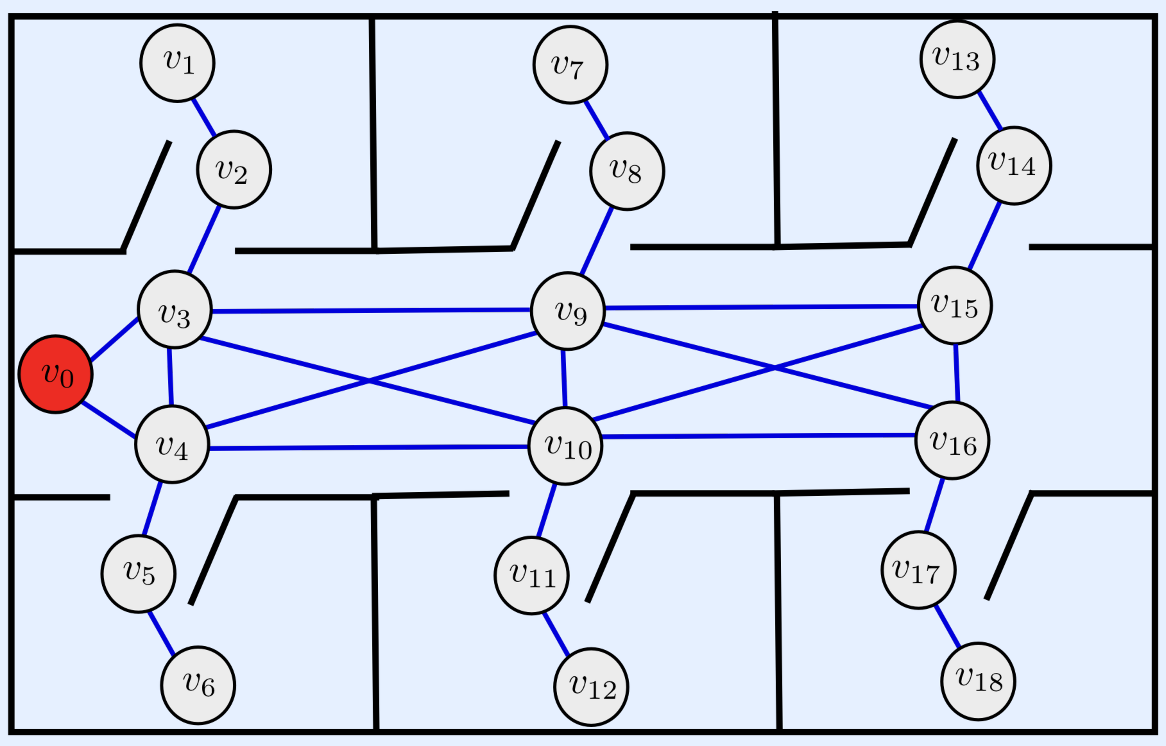
- Modelling approach for task planning for mobile service robots in everyday environments
- Approach for synthesising optimal policies for **Markov decision processes**, with **co-safe temporal logic specifications that are not satisfiable with probability 1**
- **ROS integration**

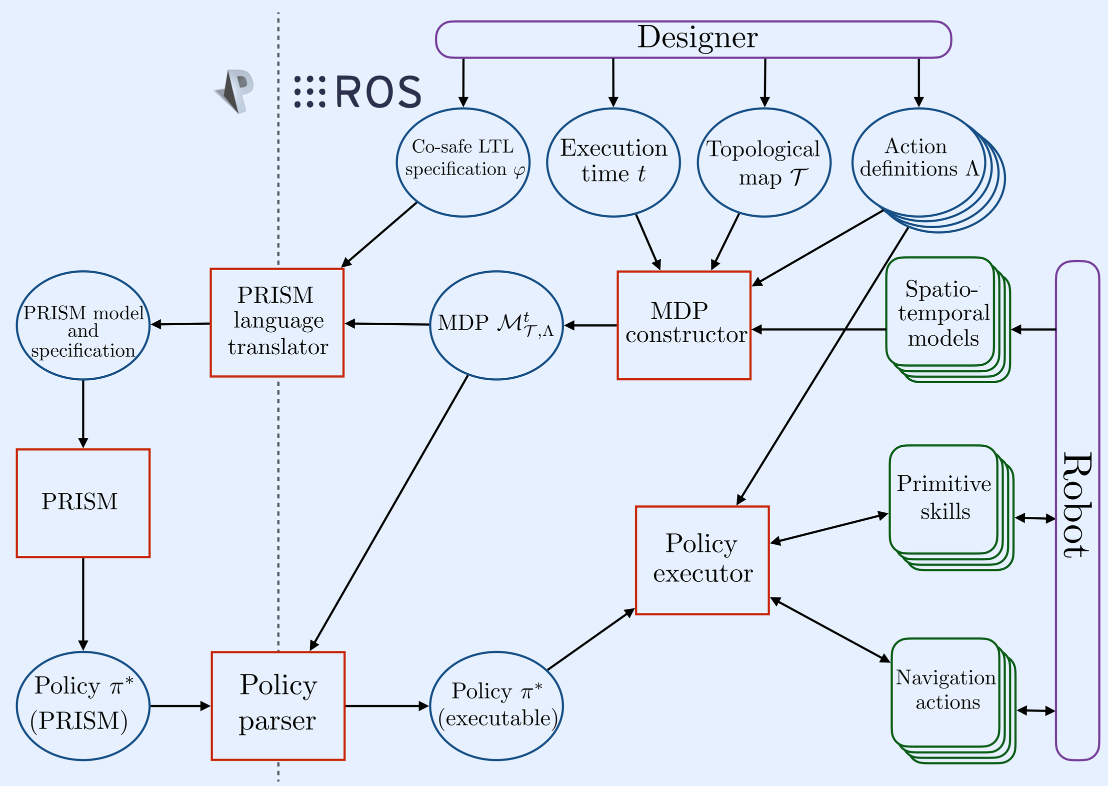


Addressing Partial Satisfiability

- Novel additions represented as pink arrows
- Progression function formalises notion of "doing as much as possible"
- Product pruning removes states from where no more progression can be achieved, ensuring convergence of value functions corresponding to each objective
- Nested value iteration, a generalisation of value iteration to handle prioritised objectives is introduced to synthesise policies that, in **decreasing order of priority**:
  1. Increase robustness by **maximising probability of success**
  2. Do "as much as possible" by **maximising progression towards the goal**, even when it becomes **unachievable**
  3. Improve efficiency by **minimising expected execution cost**

Evaluation





"Visit locations 1, 6, and 18, while avoiding location 0."

$$((\neg v_0)\mathtt{U}v_1) \wedge ((\neg v_0)\mathtt{U}v_6) \wedge ((\neg v_0)\mathtt{U}v_{18})$$

#Offices	$\lvert S\rvert$	$\lvert\delta_{\mathcal{M}}\rvert$	$\lvert S_\varphi\rvert$	$\lvert\delta_{\mathcal{M}_\varphi}\rvert$	NVI	VI
6	10,206	49,572	33,129	169,002	~3.3 sec	~2.6 sec
8	120,285	632,043	393,984	2,095,956	~27 sec	~21 sec
10	1,338,444	7,223,661	4,408,263	24,038,046	~7.5 min	~4.5 min

Discussion

- Used for task planning of a **mobile service robot**, with **meaningful probabilistic guarantees** on task execution
- Allows **flexible goal specification**
- Probabilistic guarantees can be used to **inform end users**, or other software components (e.g., **execution monitor**, or **higher level task scheduler**)

Further Work

- Uncertain models
- Multi-robot systems
- Multi-objective reasoning