Partial Satisfaction Planning

J. Benton, Romeo Sanchez
Minh Do (PARC)
Subbarao Kambhampati

[AAAI 04; ICAPS 05; IJCAI 05]
Yochan Research Group

Plan-Yochan

- Automated Planning
  - Foundational work in classical planning
  - Heuristics for scaling up a wide spectrum of plan synthesis problems
  - Applications to manufacturing, biological pathway discovery, web services, autonomic computing

B. Srivastava; IBM IRL
M. Do; Xerox PARC
T. Zimmerman; CMU RI
R. Sanchez; USC/ISI

Db-Yochan

- Information Integration
  - Mediator frameworks that are adaptive to the sources and users.
  - Applications to Bioinformatics, Archaeological informatics

Z. Nie; Microsoft Research
T. Hernandez; Amazon
U. Nambiar; SDSC/UC Davis

Recent Alumni
In many real world planning tasks, the agent often has more goals than it has resources to accomplish.

Currently *humans* are forced to pick goal subsets

**Example: Rover Mission Planning (MER)**
**Military logistics**
**Most replanning problems (*)**

**Need automated support for Over-subscription/Partial Satisfaction Planning**

Actions have execution costs, goals have utilities, and the objective is to find the plan that has the highest net benefit.
A spectrum of approaches for PSP-Net Benifit

### Optimal Approaches

- **Deterministic MDPs**
  - Reward of a state is equal to the utility of the goals that hold in it.
    - Need to avoid collecting rewards for a goal more than once
  - Optimal, but *SLOW*
- **Optiplan**
  - Integer programming based STRIPS planner
    - Optimal for a given plan length

### Heuristic Approaches

- **AltAlt<sub>ps</sub>/ AltAwlt<sub>ps**
  - Selects the “objectives” up front heuristically
    - Uses a clever modification of relaxed plan heuristic
    - Not optimal, but fast

- **Sapa<sub>ps</sub>/ Sapa<sub>Mps**
  - Models PSP as heuristic search. Can be optimal given admissible heuristics.
  - Sapa<sub>Mps</sub> can handle numerical goals and degrees of satisfaction
Adapting PG heuristics for PSP

**Challenges:**
- Need to propagate costs on the planning graph
- The exact set of goals are not clear
  - Interactions between goals
- Obvious approach of considering all $2^n$ goal subsets is *infeasible*

**Idea:** Select a subset of the top level goals upfront

**Challenge:** Goal interactions

- **Approach:** Estimate the net benefit of each goal in terms of its utility minus the cost of its relaxed plan
  - Bias the relaxed plan extraction to (re)use the actions already chosen for other goals
Some Empirical Results for \( \text{AltAlt}^{ps} \)

Exact algorithms based on MDPs don’t scale at all

[AAAI 2004]
Overcoming Complex Interactions: AltAwlt

- Problems with Goal Selection Procedure
  1. Ignores group interactions
  2. Ignores negative interactions

- Ideas:
  1. Consider multiple groups of sub-goals during the selection process
  2. Add penalty costs for ignoring negative interactions based on mutex analysis
PSP + MTP = SAPA

• In MTP, PSP will involve
  – Partial Degree of satisfaction
    • If you can’t give me 1000$, give me half at least
  • Need to track costs for various intervals of a numeric quantity 😞
  – Delayed Satisfaction
    • If you submit the homework past the deadline, you will get penalty points

Figure 3: The RTPG for our example. Our actions are defined above it.

Figure 4: Comparison of utilities for our rovers domain