Main Objective for IPPC 2011

• More realistically motivated problems
  – PPDDL cannot represent many probabilistic domains
    • Traffic Control
    • Elevator Control
    • Mars Rovers
  – Needed
    → concurrency
    → independent exogenous effects
    → continuing processes and non-goal rewards
    → partial observability
    → distributions that are complex function of state
    → enumerated, integer, continuous variables (no competitors)

– Required a new language
  • RDDL (new lifted DBN transition semantics)
A Brief History of (ICAPS) Time

- **STRIPS (1971)** Fikes & Nilsson
  - Relational

- **ADL (1987)** Pednault
  - Cond. Effects
  - Open World

- **PDDL 1.2 (1998)** McDermott et al
  - Univ. Effects

- **PDDL 2.1, + (2003)** Fox & Long
  - Numerical fluents,
  - Conc., Exogenous

- **PDDL 3.0 (2004)** Gerevini & Long
  - Traj. Constraints,
  - Preferences

- **PDDL 2.2 (2004)** Edelkamp & Hoffmann
  - Derived Pred,
  - Temporal

- **PPDDL (2004)** Littmann & Younes
  - Prob. Effects

- **Dynamic Bayes Nets (1989)** Dean and Kanazawa
  - Factored Stochastic Processes

  - DBN + Utility: Fact. (PO)MDP

- **RDDL (2010)** Sanner
  - PDDL 2.2 × DBN++

PDDL history from: [http://ipc.informatik.uni-freiburg.de/PddlResources](http://ipc.informatik.uni-freiburg.de/PddlResources)
What is RDDL?

• Relational Dynamic Influence Diagram Language
  – Relational [DBN + Influence Diagram]
  – Everything is a fluent!
    • states
    • observations
    • actions
    • derived (stochastic) predicates
  – Uniform expression language
Other Objectives for IPPC 2011

• Translations to draw in different communities
  – Factored MDP / POMDP community
  – ICAPS PPDDL community
  – 11 competitors!

• Single normalized evaluation criteria
  – Previously
    • plan length
    • goal %
    • planner time
    (skipping hard problems could increase domain averages)
RDDLSim Software

Open source & online at
http://code.google.com/p/rddlsim/
RDDL Software Overview

- BNF grammar and parser

- Simulator

- Automatic translations
  - LISP-like format (easier to parse)
  - SPUDD & Symbolic Perseus (boolean subset)
  - Ground PPDDL (boolean subset)

- Client / Server
  - Java and C/C++ sample clients
  - Evaluation scripts for log files

- Visualization
  - DBN Visualization
  - Domain Visualization – see how your planner is doing
Domains and Evaluation

- Eight domains
  - **Traffic Control**: exogenous, concurrent
  - **Elevator Control**: exogenous, concurrent
  - **Game of Life**: highly combinatoric
  - **SysAdmin**: exogenous, complex transitions
  - **Navigation**: goal-oriented, determinization killer
  - **Crossing Traffic**: goal-oriented, deterministic if move far left
  - **Skill Teaching**: relatively sparse transitions
  - **Reconnaissance**: relatively sparse transitions

- 10 instances per domain
- No discount, finite horizon of 40
- Average normalized score $[0,1]$
  - Min: random / noop
  - Max: best competitor
  - Scores $< 0$ set to 0
Boolean Traffic
Boolean Elevators
Crossing Traffic (aka Frogger)
Navigation
(aka deteminization killer)
Competition Format

- **Amazon EC2** (Elastic Compute Cloud)
  - 11 instances on demand
    - Ensures everyone has same computational power
    - Everyone has admin access to their machines
  - Just pay for time used
    - received an Amazon EC2 grant of $1000 for competition
    - so running it was free

→ Highly recommended for future competitions!!!
## Competitors: Boolean MDP Track

<table>
<thead>
<tr>
<th>Competitors</th>
<th>Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROST</td>
<td>UCT/Single Outcome Determinization, Caching</td>
</tr>
<tr>
<td>(Eyerich, Keller – Uni. Freiburg)</td>
<td></td>
</tr>
<tr>
<td>Glutton</td>
<td>Iterative Deepening RTDP, Caching</td>
</tr>
<tr>
<td>(Kolobov, Dai, Mausam, Weld – UW)</td>
<td></td>
</tr>
<tr>
<td>MIT-ACL</td>
<td>RL / Linear Fun. Approx, Feature Discovery</td>
</tr>
<tr>
<td>(Ure, Toksoz, Redding, Gemifard – MIT)</td>
<td></td>
</tr>
<tr>
<td>Beaver</td>
<td>UCT, SPUDD Guidance</td>
</tr>
<tr>
<td>(Nadamuni, Joshi, Fern, Tadepalli – OSU)</td>
<td></td>
</tr>
<tr>
<td>SPUDD</td>
<td>Value Iteration with ADDS</td>
</tr>
<tr>
<td>(Zhu, Grzes, Hoey – Uni. Waterloo)</td>
<td></td>
</tr>
</tbody>
</table>
Results: Boolean MDP Track

• 1st Place: PROST
• 2nd Place: Glutton

Additional standard error analysis on non-truncated scores shows separation

<table>
<thead>
<tr>
<th>System</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Std Err 1</th>
<th>Std Err 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROST (Eyerich, Keller)</td>
<td>0.902</td>
<td>± 0.07</td>
<td>0.902</td>
<td>± 0.03</td>
</tr>
<tr>
<td>Glutton (Kolobov, Dai, Mausam, Weld)</td>
<td>0.815</td>
<td>± 0.07</td>
<td>0.812</td>
<td>± 0.03</td>
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<tr>
<td>MIT-ACL (Ure, Toksoz, Redding, Gemifard)</td>
<td>0.109</td>
<td>± 0.06</td>
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<td></td>
</tr>
<tr>
<td>Beaver (Nadamuni, Joshi, Fern, Tadepalli)</td>
<td>0.047</td>
<td>± 0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPUDD (Zhu, Grzes, Hoey)</td>
<td>0.016</td>
<td>± 0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Competitors: Boolean POMDP Track

<table>
<thead>
<tr>
<th>Competitors</th>
<th>Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>POMDPX_NUS (Wu, WS Lee)</td>
<td>SARSOP / UCT (POMCP)</td>
</tr>
<tr>
<td>KAIST-AILAB (D Kim, K Lee, K-E Kim)</td>
<td>Symbolic HSVI (ADDs), Symmetry Detection</td>
</tr>
<tr>
<td>HyPlanClient (Borera, Pyeatt)</td>
<td>~RTDP-Bel</td>
</tr>
<tr>
<td>POND (Bryce, Olsen)</td>
<td>Translation to Conf. Planning, Hindsight Opt</td>
</tr>
<tr>
<td>Symbolic Perseus (Poupart, Hoey, Morrison)</td>
<td>PBVI with ADDs</td>
</tr>
<tr>
<td>McGill (Png, Ong, Pineau)</td>
<td>UCT (POMCP)</td>
</tr>
</tbody>
</table>
Results: Boolean POMDP Track

- Distinguished 1st: POMDPX_NUS
- Tie for 1st (within 95% stderr): KAIST-AILAB

<table>
<thead>
<tr>
<th>System</th>
<th>Score</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>POMDPX_NUS (Wu, WS Lee)</td>
<td>0.559</td>
<td>± 0.10</td>
</tr>
<tr>
<td>KAIST-AILAB (D Kim, K Lee, K-E Kim)</td>
<td>0.529</td>
<td>± 0.19</td>
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<tr>
<td>HyPlanClient (Borera, Pyeatt)</td>
<td>0.175</td>
<td>± 0.08</td>
</tr>
<tr>
<td>POND (Bryce, Olsen)</td>
<td>0.161</td>
<td>± 0.06</td>
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<tr>
<td>Symbolic Perseus (Poupart, Hoey, Morrison)</td>
<td>0.124</td>
<td>± 0.07</td>
</tr>
<tr>
<td>McGill (Png, Sylvie Ong, Joelle Pineau)</td>
<td>0.036</td>
<td>± 0.03</td>
</tr>
</tbody>
</table>
Thanks to All Competitors!