Extending Collaborative Privacy Preserving Planning by formulating an algorithm to solve domains with stochastic effects

### Stochastic Collaborative Privacy Preserving Planning (SCPPP)

An SCPPP problem is a tuple \( P, \{A_i\}_{i=1}^n, tr, G, C > \)

- \( P \) = set of propositions
- \( S \) = set of CPPP states made of all possible assignments to \( P \)
- \( A_i \) = set of actions for agent \( i \), \( k \) = number of agents
- \( tr \) = transition function \( tr : S \times A \rightarrow R \)
- \( I \) = initial state
- \( G \) = goal state
- \( C \) = cost function \( C : S \times A \rightarrow R \)

#### Message Types:
- Q value request = request Q value of a state for Bellman Update
- Q value answer = answer a Q value request
- Trajectory = pass a trajectory to another agent by sending the state from which it should advance

Every iteration of trajectory advancement requires message passing in order to perform the Bellman Update. The algorithm runs identical trajectories to normal RTDP on the joint problem thus maintaining the same convergence properties.

### Experiments

Three domains adapted from CPPP:
- Blocksworld = robots stacking blocks on a table.
- Different robots can interact with different blocks. Collaboration requirement depends on problem setup.
  - Little private information, deep goals.
- Depot = drivers moving crates between depots and warehouses, lifts loading, unloading, and stacking in the depots / warehouses.
  - Collaboration always required, medium amount of private information.
- Logistics = trucks and airplanes moving packages between cities.
  - Collaboration depends on problem setup. Most information is private. Deep goals.

### Results

<table>
<thead>
<tr>
<th>Domain</th>
<th># Actions</th>
<th>Best Cost</th>
<th>Expansions ( \times 10^4 )</th>
<th>Messages ( \times 10^4 )</th>
<th># trajectories + restarts</th>
<th>Total Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>blocks-6-2</td>
<td>746</td>
<td>(14.8 / 16.5)</td>
<td>(68.322 / 68.977)</td>
<td>(399.718 / 117.096)</td>
<td>(900 / 2140 + 7057)</td>
<td>(497.8 / 427.7)</td>
</tr>
<tr>
<td>depot-2-5</td>
<td>245</td>
<td>(11.4 / 11.14)</td>
<td>(4.342 / 5.050)</td>
<td>(89.343 / 23.417)</td>
<td>(350 / 170 + 1389)</td>
<td>(55.7 / 23.9)</td>
</tr>
<tr>
<td>depot-3-5</td>
<td>407</td>
<td>(16.78 / 16.78)</td>
<td>(55.045 / 59.236)</td>
<td>(1136.297 / 289.422)</td>
<td>(2330 / 740 + 10437)</td>
<td>(715.4 / 344.8)</td>
</tr>
<tr>
<td>logistics-2-5</td>
<td>203</td>
<td>(27.0 / 21.58)</td>
<td>(122.934 / 40.523)</td>
<td>(2705.937 / 103.567)</td>
<td>(2134 / 220 + 14162)</td>
<td>(848.5 / 81.7)</td>
</tr>
<tr>
<td>logistics-3-4</td>
<td>104</td>
<td>(26.8 / 27.22)</td>
<td>(152.786 / 109.649)</td>
<td>(2570.205 / 250.775)</td>
<td>(8010 / 770 + 27091)</td>
<td>(720.6 / 186.0)</td>
</tr>
</tbody>
</table>