Finding Dominant Plans Using Plan Evaluation Criteria

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Overview

- Purpose / Motivation
- Goals
- Approach
  - Qualitatively Different Plans
  - Plan Evaluation Visualization
  - Dominant Plans
- Conclusions

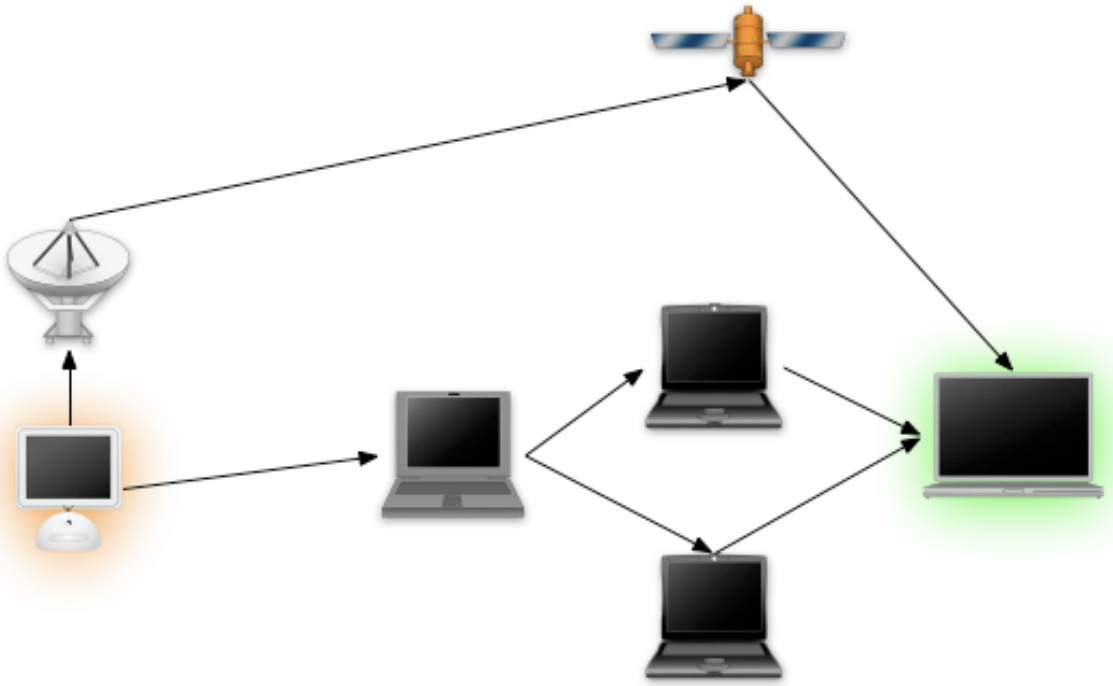
Qualities of Coalition Operations

- Dynamic environments
- Multi-agent cooperation
- Partial-observability
- On-line planning
- Many viable solutions
- Inappropriate actions incur high cost

Planning Under Uncertainty

Coalition Planning

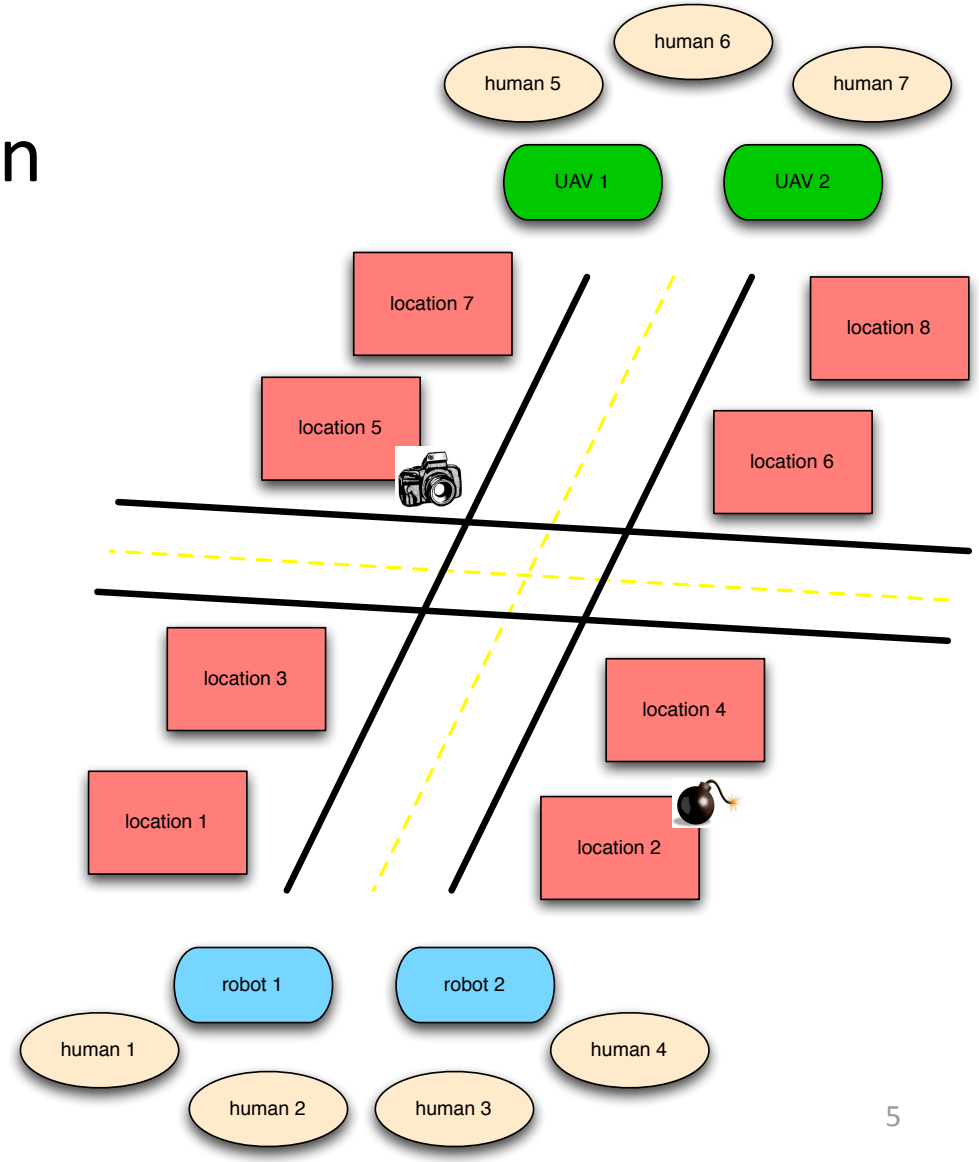
- Challenges
  - Finding plans based on user preference
  - Optimizing unreliable communications



Motivation

- IED Change Detection

IED Change Detection is being developed by the US Army Communications – Electronics Research, Development and Engineering Center (CERDEC), to detect IEDs along travel routes using high resolution aerial/overhead imagery. It uses day and night sights and is currently mounted on manned and unmanned aviation systems. The data is sent to a Change Detection Work Station, where a warfighter views day-to-day thermal or TV imagery that is collected by the airborne asset. This system helps an operator to identify and locate "new" environmental changes on a route which could indicate the presence of IEDs or landmines.[1]



1 - http://defense-update.com/features/du-4-04/IED-Early-Warning.htm

IED Detection Scenario

- Distributed service composition
  (Sirin et al. 04)
- Many valid solutions
- Natural plan evaluation trade-offs
- Complex/dynamic communications network
- 13 actions, 70 world-state conditions

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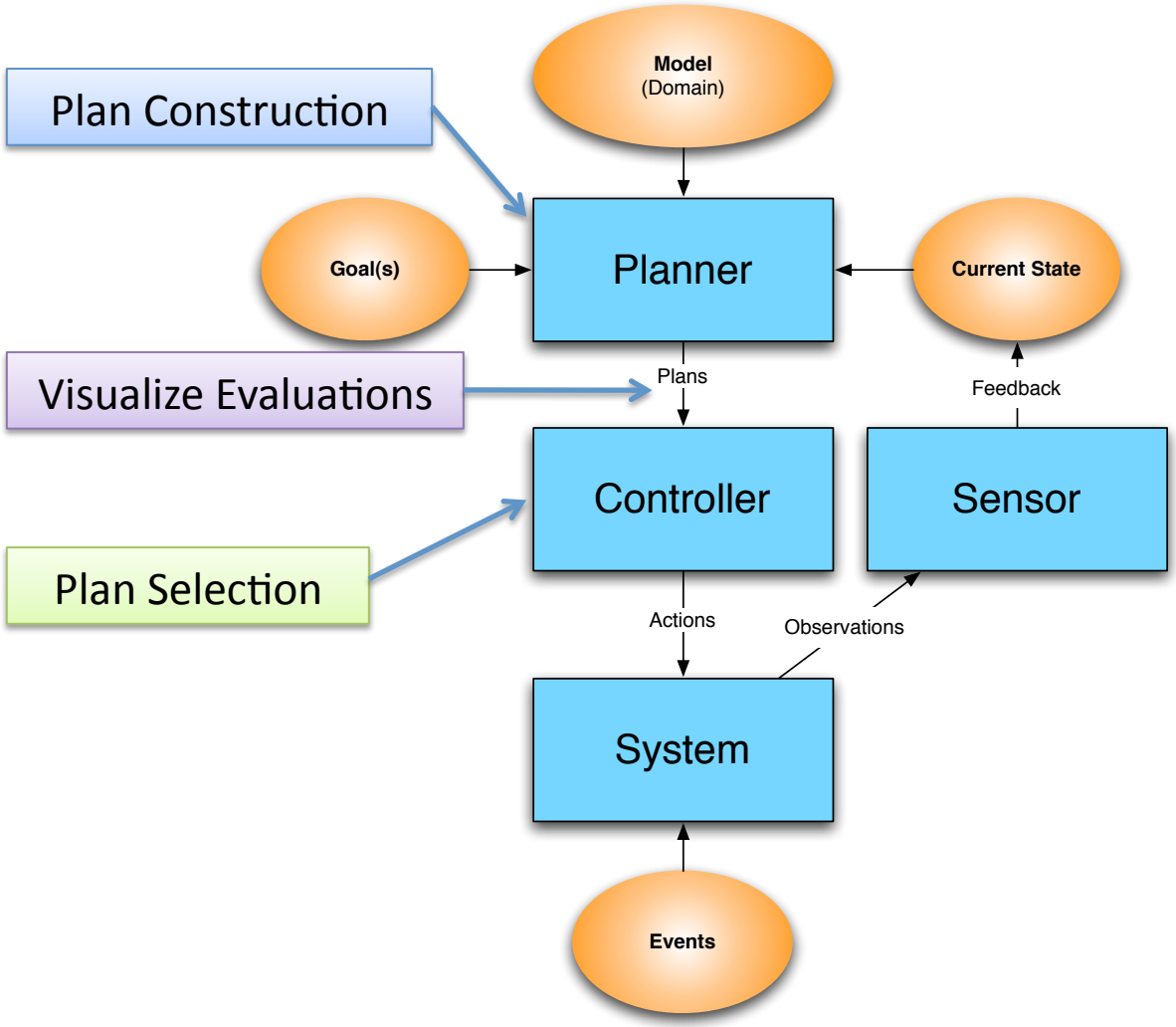
Goals

- Improve plan construction
- Optimize and visualize plan evaluations
- Improve plan selection

Plan Evaluation Criteria

Agents in Planning



Planning

Task Assignment

Execution

(Tate et al. 98)

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Improving Plan Construction / Selection

Domain-independent

- Mixed-initiative *(Ferguson et al. 95)*
- Distance function *(Srivastava et al. 06)*
  - Actions present
  - Set of execution states
  - Causal chains

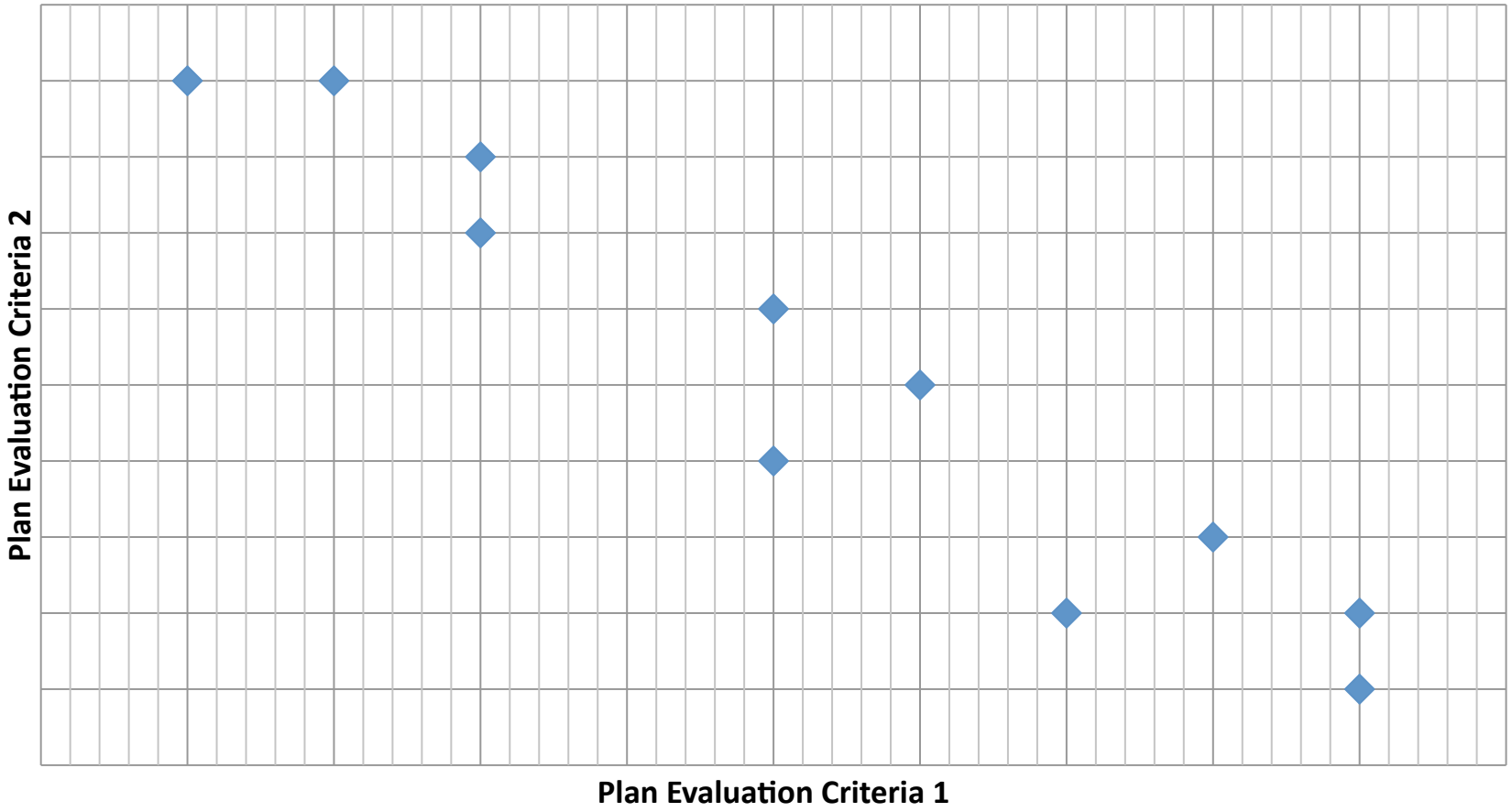
Domain-dependent

- Domain metatheory *(Myers & Lee 99)*
  - Template features
  - Task features
  - Roles

Qualitatively Different Plans

- Goal:
  - Improve diversity of plans
  - Use the same mechanism for domain-dependent/-independent
- Approach:
  - Define quantitative evaluations for important factors (e.g. time, monetary cost, network hops)
  - Natural trade-offs exist between factors
  - Evaluate plans/partial-plans for each criteria
- **Biasing the planner**

Visualizing Plan Evaluations



Plan Evaluation Criteria Statistics

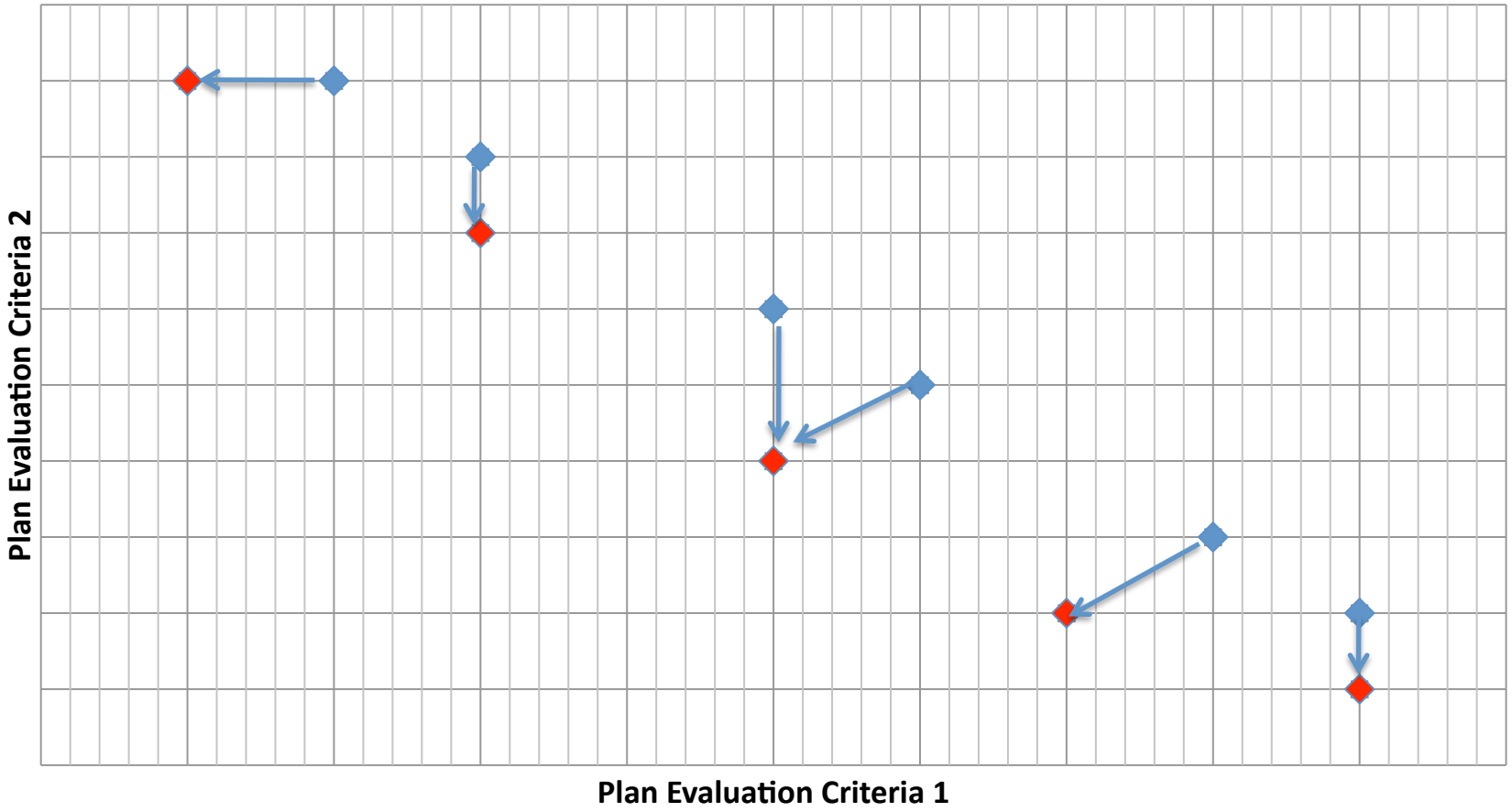
- Range
  - Theoretic
  - Effective
  - Units
- Direction
  - Maximize
  - Minimize
- Statistics
  - Mean, median, mode, std. dev.

IED detection accuracy: [43%, 80%] (0.0, +INF) MAXIMIZE, mean: 68%
transportation cost: [10.53, 11.36] (-INF, +INF) MINIMIZE, mean: 11.15
plan execution time: [42264, 62765] (0.0, +INF) MINIMIZE, mean: 57181
network hop count: [4.0, 6.0] (0.0, +INF) MINIMIZE, mean: 4.65
network bandwidth usage: [5.09, 6.69] (0.0, +INF) MINIMIZE, mean: 5.62
activities in plan: [13.0, 16.0] (0.0, +INF) MINIMIZE, mean: 13.975
longest path length: [10.0, 10.0] (0.0, +INF) MINIMIZE, mean: 10.0
objects used in plan: [4.0, 8.0] (0.0, +INF) MINIMIZE, mean: 5.775

Dominant Plans

- Goal: find best candidate plans
- Approach: Iterative Elimination of Strongly Dominated Strategies

Dominant Plans



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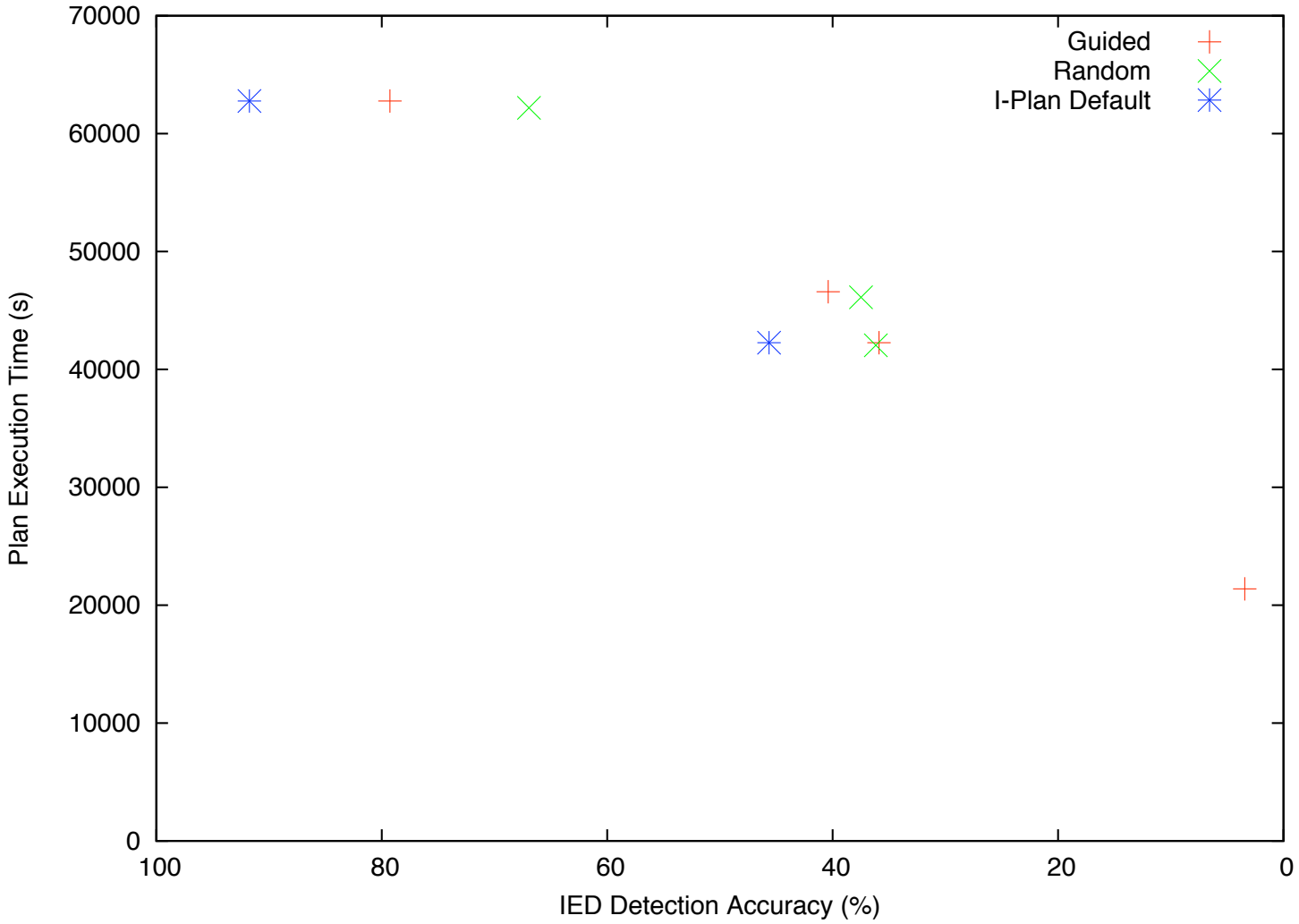
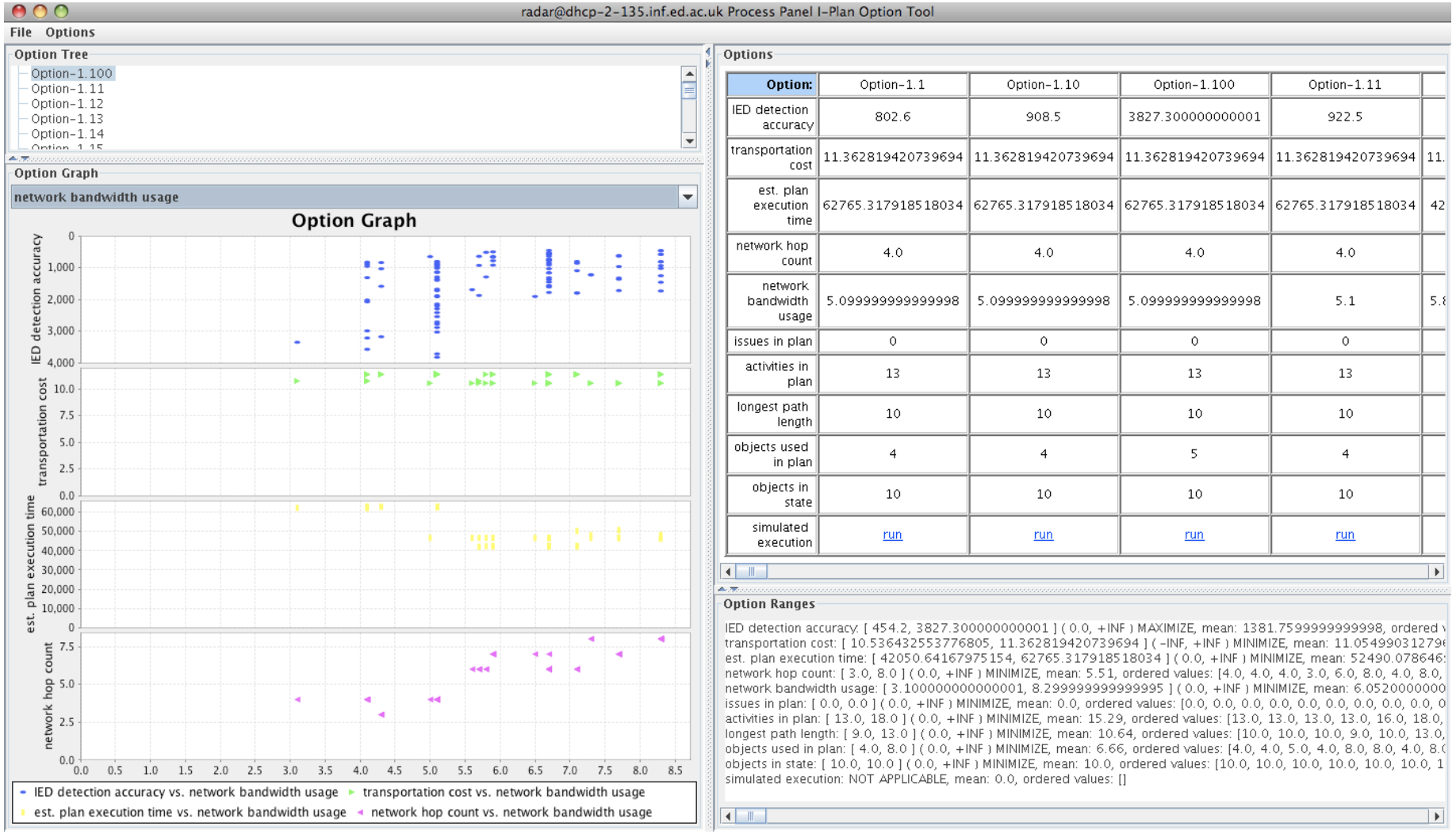
Empirical Results



Contributions

- IED Detection Scenario:
  - Identified key trade-offs between criteria
  - Guided search uncovered a greater variety of dominant plans
- Improve the ability of agents to construct and choose between plans
- Plan evaluation criteria
- Plan evaluation criteria statistics
- Dominant plans
- Plan evaluation visualization

Plan Selection UI



Future Work

- Correlation of partial-plan and complete plan evaluators
- Communication optimization via planning
  - Measuring
  - Execution monitoring
  - Plan repair / replanning

Questions

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