http://www.inf.ed.ac.uk/teaching/courses/plan/

Planning in Context

Planning in the Context of Domain Modelling, Task Assignment and Execution

Literature

- **O-Plan Papers http://www.aiai.ed.ac.uk/project/oplan/**
- Tate, A., Dalton, J. and Levine, J., *O-Plan: a Web-based AI Planning Agent*, AAAI-2000 Intelligent Systems Demonstrator, in Proceedings of the National Conference of the American Association of Artificial Intelligence (AAAI-2000), Austin, Texas, USA, August 2000. (2 pages)

- **Optimum-AIV Papers http://www.aiai.ed.ac.uk/project/optimum-aiv/**
- Tate, A., *Responsive Planning and Scheduling Using AI Planning Techniques - Optimum-AIV* - in "Trends & Controversies - AI Planning Systems in the Real World", IEEE Expert: Intelligent Systems & their Applications, Vol. 11 No. 6, pp. 4-12, December 1996. (2 pages)

- **Other Practical Planners**
- Ghallab, M., Nau, D. and Traverso, P., *Automated Planning – Theory and Practice*, chapter 19, 22 and 23. Elsevier/Morgan Kaufmann, 2004.

Overview

- Practical AI Planners
- Planning in the context of execution
- Nonlin
- O-Plan
- Optimum-AIV
- I-X/I-Plan
- Planning++

Edinburgh AI Planners in Productive Use

http://www.aiai.ed.ac.uk/project/plan/

Overview

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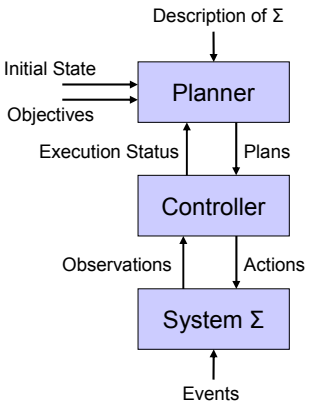
Dynamic Planning



- problem: real world differs from model described by Σ
- more realistic model: interleaved planning and execution
  - plan supervision
  - plan revision
  - re-planning
- dynamic planning: closed loop between planner and controller
  - execution status

Nonlin (1974-1977)

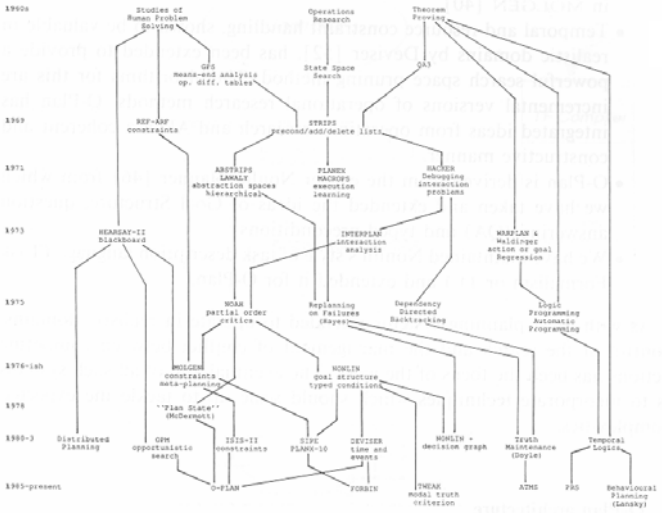
- Hierarchical Task Network Planning
- Partial Order Planner
- Plan Space Planner
- Uses State-Variable (Functional) Representation
- Goal structure-based plan development - considers alternative “approaches” only based on plan rationale
- QA/Modal Truth Criterion Condition Achievement
- Condition “Types” to limit search
- “Compute Conditions” for links to external data and systems (attached procedures)
- Time and Resource Constraint checks

- Nonlin core is basis for text book descriptions of HTN Planning

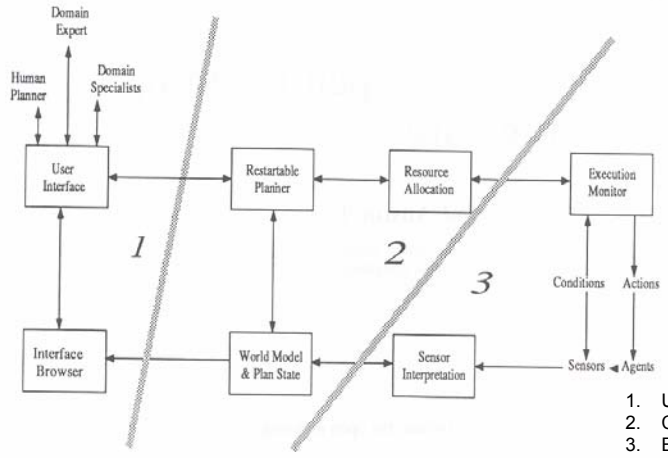
O-Plan (1983-1999) Features

- Domain knowledge elicitation and modelling tools
- Rich plan representation and use
- Hierarchical Task Network Planning
- Detailed constraint management
- Goal structure-based plan monitoring
- Dynamic issue handling
- Plan repair in low and high tempo situations
- Interfaces for users with different roles
- Management of planning and execution workflow

O-Plan (1983-1999) Features

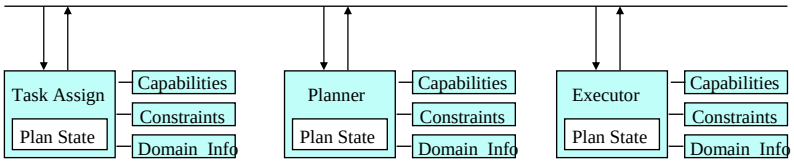


O-Plan Project Components

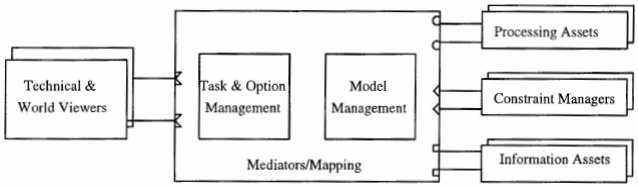


1. User Interface
2. Core Planner
3. Execution System

O-Plan 3 Levels



O-Plan Agent Architecture



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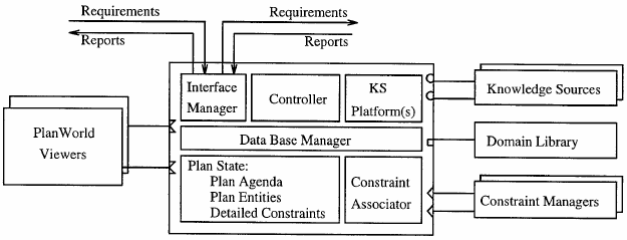

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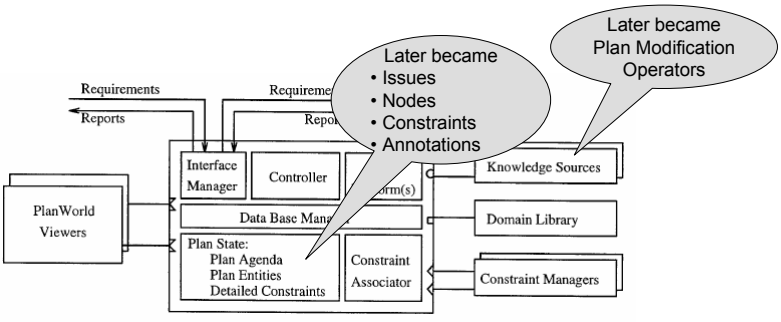
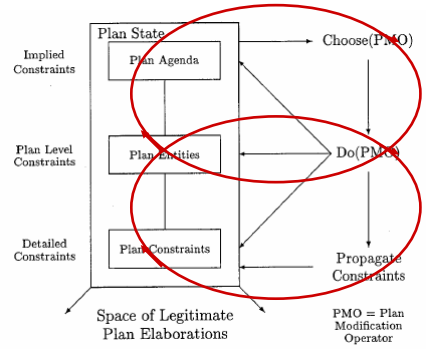
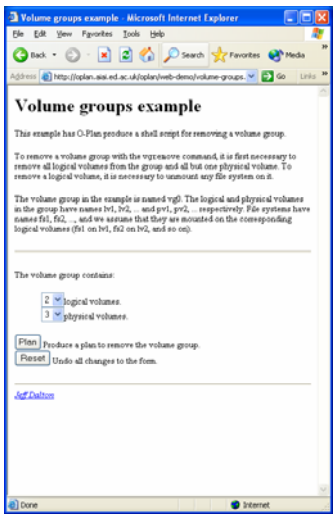
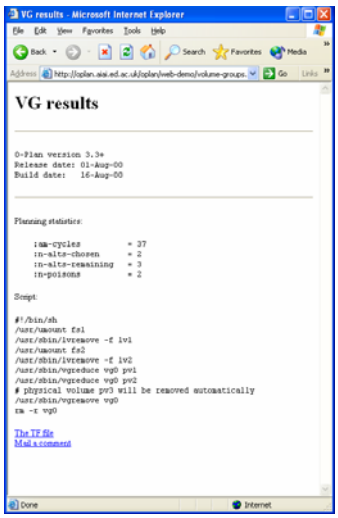


O-Plan Planning Workflow

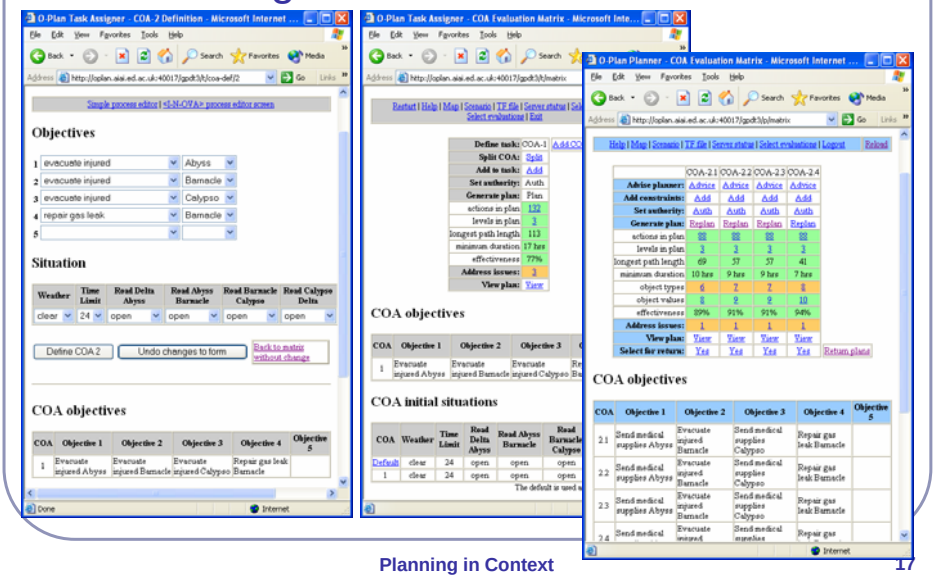


O-Plan Unix Sys Admin Aid





O-Plan MOUT Task Description, Planning and Workflow Aids



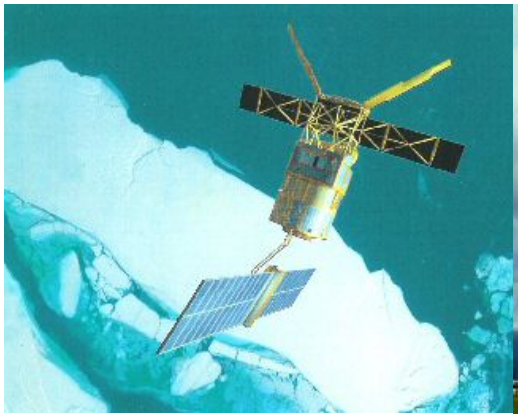
O-Plan Web Service

http://www.aiai.ed.ac.uk/project/oplan/

Check out AAAI-2000 “Introductory Demo” Link

Password for some demos: “show-oplan”

Optimum-AIV



Optimum-AIV (1992-4) Features

- Rich plan representation and use
- Hierarchical Task Network Planning
- Detailed constraint management
- Planner and User rationale recorded
- Dynamic issue handling
- Plan repair using test failure recovery plans
- Integration with ESA's Artemis Project Management System

Planning Research Areas & Techniques

- Domain Modelling — HTN, SIPE
- Domain Description — PDDL, NIST PSL
- Domain Analysis — TIMS

- Search Methods — Heuristics, A*
- Graph Planning Algthms — GraphPlan
- Partial-Order Planning — Nonlin, UCPOP
- Hierarchical Planning — NOAH, Nonlin, O-Plan
- Refinement Planning — Kambhampati
- Opportunistic Search — OPM
- Constraint Satisfaction — CSP, OR, TMMS
- Optimisation Methods — NN, GA, Ant Colony Opt.
- Issue/Flaw Handling — O-Plan

- Plan Analysis — NOAH, Critics
- Plan Simulation — QinetiQ
- Plan Qualitative Mdling — Excalibur

- Plan Repair — O-Plan
- Re-planning — O-Plan
- Plan Monitoring — O-Plan, IPEM

- Plan Generalisation — Macrops, EBL
- Case-Based Planning — CHEF, PRODIGY
- Plan Learning — SOAR, PRODIGY

- User Interfaces — SIPE, O-Plan
- Plan Advice — SRI/Myers
- Mixed-Initiative Plans — TRIPS/TRAINS

- Planning Web Services — O-Plan, SHOP2

- Plan Sharing & Comms — I-X, <I-N-C-A>
- NL Generation — …
- Dialogue Management — …

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Problems to make sense of all these techniques

Deals with whole life cycle of plans

A More Collaborative Planning Framework

- Human relatable and presentable objectives, issues, sense-making, advice, multiple options, argumentation, discussions and outline plans for higher levels
- Detailed planners, search engines, constraint solvers, analyzers and simulators act in this framework in an understandable way to provide feasibility checks, detailed constraints and guidance
- Sharing of processes and information about process products between humans and systems
- Current status, context and environment sensitivity
- Links between informal/unstructured planning, more structured planning and methods for optimisation

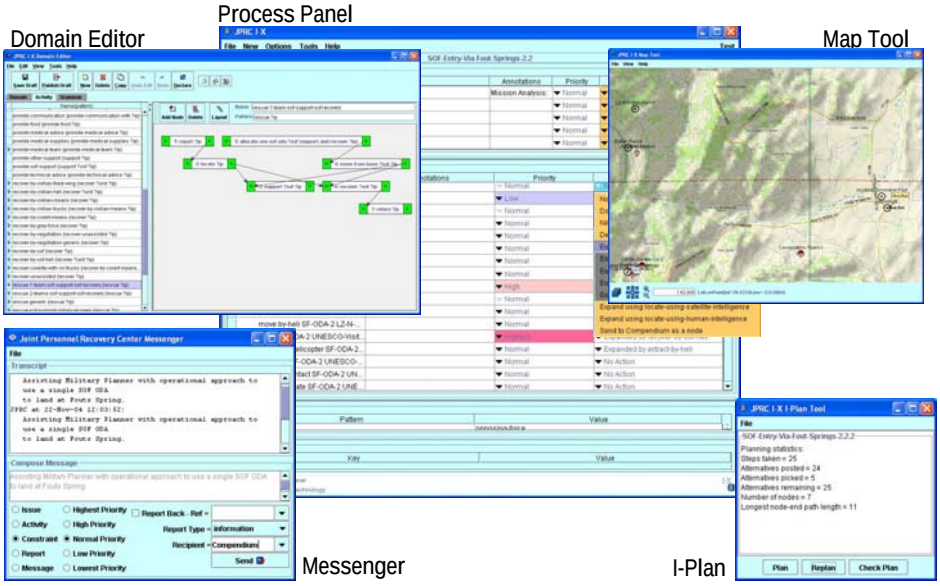
I-X/I-Plan (2000-)

- Shared, intelligible, easily communicated and extendible conceptual model for objectives, processes, standard operating procedures and plans:
  - I Issues
  - N Nodes/Activities
  - C Constraints
  - A Annotations
- Communication of dynamic status and presence for agents, and reports about their collaborative processes and process products
- Context sensitive presentation of options for action
- Intelligent activity planning, execution, monitoring, re-planning and plan repair via I-Plan and I-P^2 (I-X Process Panels)

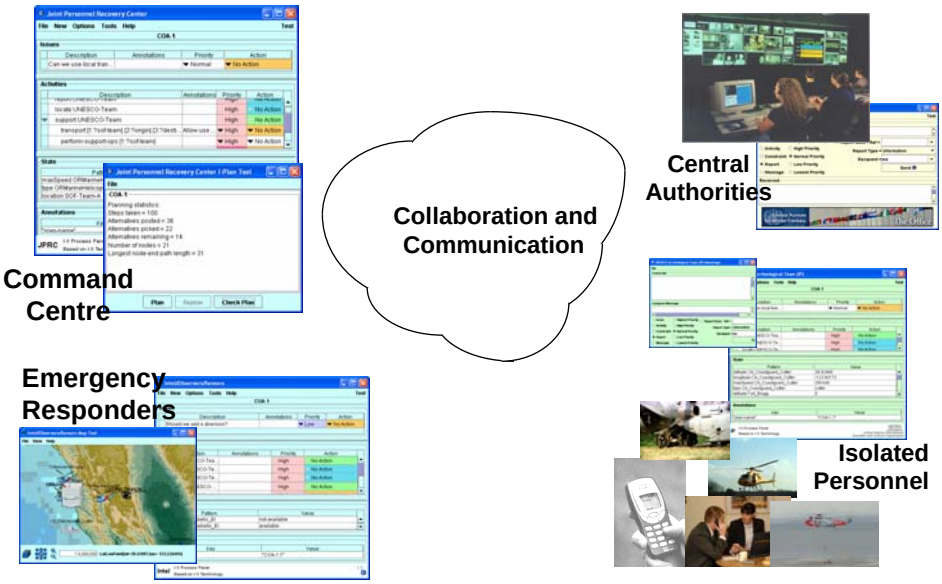
I-P^2 aim is a Planning, Workflow and Task Messaging "Catch All"

- **Can take ANY requirement to:**
  - **Handle an issue**
  - **Perform an activity**
  - **Respect a constraint**
  - **Note an annotation**
- **Deals with these via:**
  - **Manual activity**
  - **Internal capabilities**
  - **External capabilities**
  - **Reroute or delegate to other panels or agents**
  - **Plan and execute a composite of these capabilities (I-Plan)**
- **Receives reports and interprets them to:**
  - **Understand current status of issues, activities and constraints**
  - **Understand current world state, especially status of process products**
  - **Help user control the situation**
- **Copes with partial knowledge of processes and organisations**

I-X Process Panel and Tools



I-X for Emergency Response



Summary

- Practical AI Planning
- Refinement Planning as a Unifying View
- Nonlin and O-Plan Features
- Planning++
- I-X/I-Plan Overview

Literature - Reminder

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