

<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.

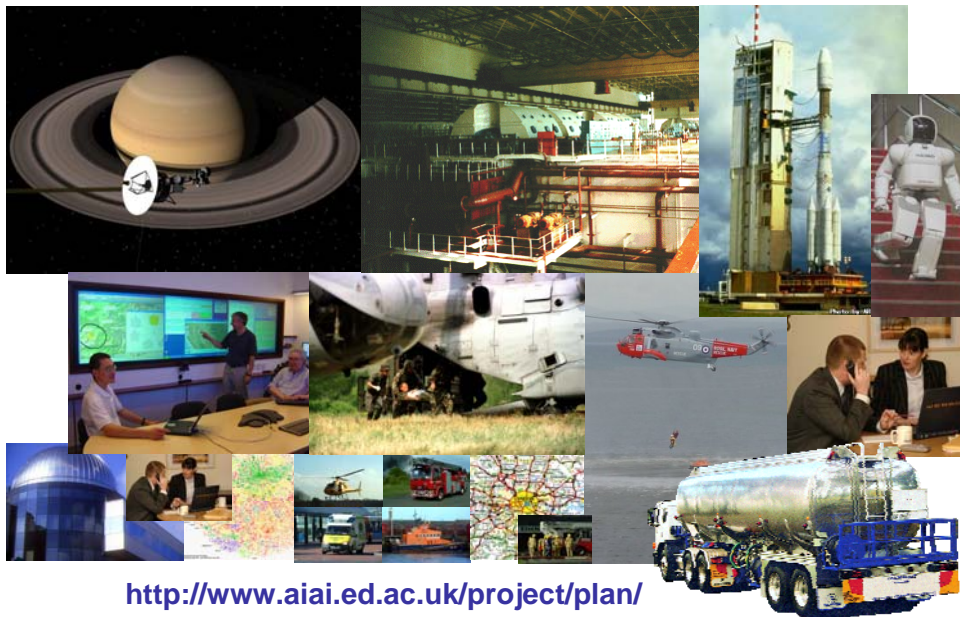
Overview

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

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Edinburgh AI Planners in Productive Use



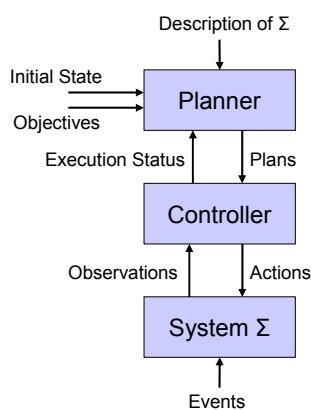
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Dynamic Planning



- 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

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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

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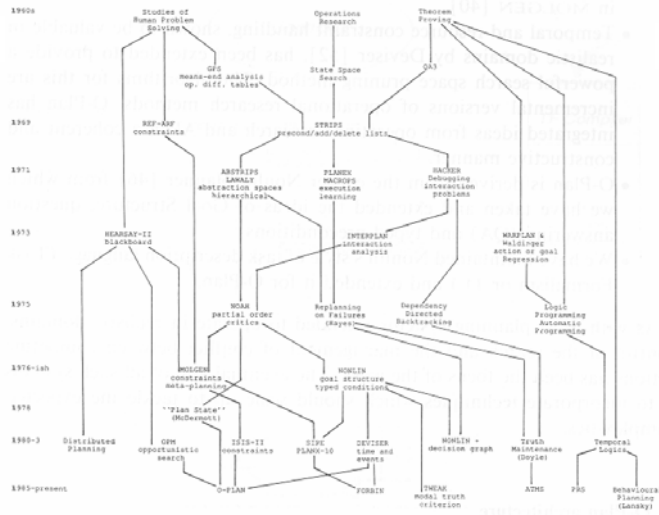
O-Plan (1983-1999) Features

- 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

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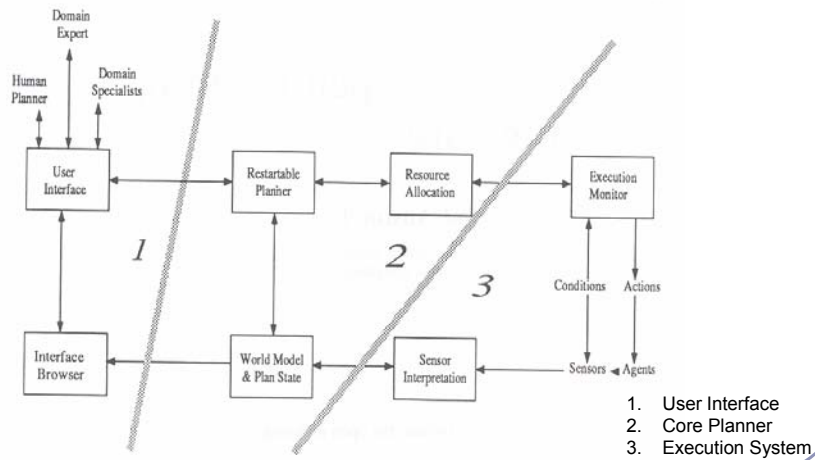
O-Plan (1983-1999) Features



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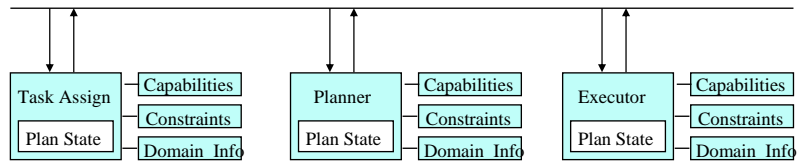
O-Plan Project Components



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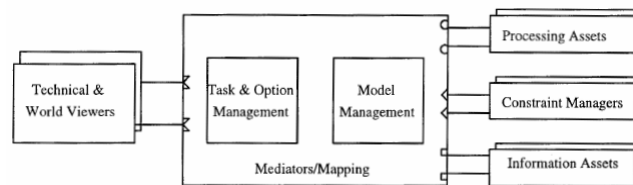
O-Plan 3 Levels



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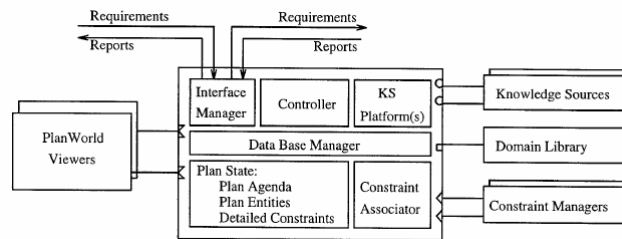
O-Plan Agent Architecture



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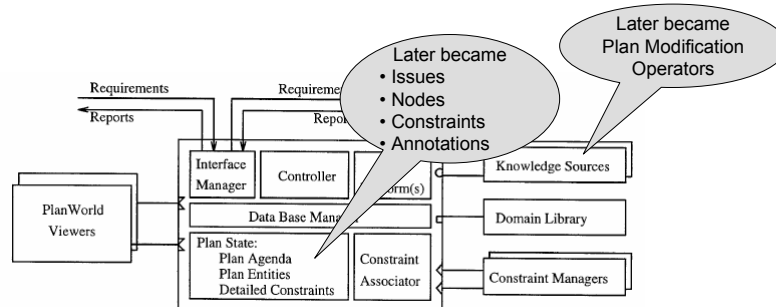
O-Plan Agent Architecture



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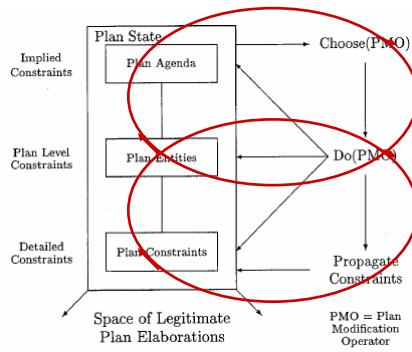
O-Plan Agent Architecture



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O-Plan Planning Workflow



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O-Plan Unix Sys Admin Aid

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O-Plan MOUT Task Description, Planning and Workflow Aids

The image displays three screenshots of the O-Plan web application interface, illustrating the process of task definition, evaluation, and planning.

Left Screenshot: O-Plan Task Assigner - COA 2 Definition
 This window shows the 'Objectives' section with a list of tasks:

- evacuate injured (Location: Abyss)
- evacuate injured (Location: Barnacle)
- evacuate injured (Location: Calypso)
- repair gas leak (Location: Barnacle)
- (Location: dropdown)

 Below this is the 'Situation' section with a table for weather and road status:

Weather	Time Limit	Road Delta Abyss	Road Abyss Barnacle	Road Barnacle Calypso	Road Calypso Delta
clear	24	open	open	open	open

 The 'COA objectives' section shows a table with columns for Objective 1 through 5, with the first row containing: Evacuate injured Abyss, Evacuate injured Barnacle, Evacuate injured Calypso, Repair gas leak Barnacle, and an empty cell.

Middle Screenshot: O-Plan Task Assigner - COA Evaluation Matrix
 This window displays the 'Define task: COA-1' configuration options:

- Split COA: Split
- Add to task: Add
- Set authority: Auth
- Generate plan: Plan
- effort to plan: 100
- levels in plan: 3
- longest path length: 113
- minimum duration: 17 hrs
- effectiveness: 77%
- Address issues: 1

 Below this are sections for 'COA objectives' and 'COA initial situations'.

Right Screenshot: O-Plan Planner - COA Evaluation Matrix
 This window shows the 'Adhise planner' interface with a table of COA-2.1 through COA-2.4. The table includes columns for 'Adhise planner', 'Add constraints', 'Set authority', 'Generate plan', 'levels in plan', 'longest path length', 'minimum duration', 'object types', 'object values', 'effectiveness', and 'Address issues'. The 'Address issues' row shows values: 1, 1, 1, 1, 1. Below this is another 'COA objectives' table with columns for Objective 1 through 5, and rows 2.1 through 2.4.

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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



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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

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Planning Research Areas & Techniques

- Domain Modelling HTN, SIPE
- Domain Description PDDL, NIST PSL
- Domain Analysis TMS

- Search Methods Heuristics, A*
- Graph Planning Alghms 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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- NL Generation ...
- Dialogue Management ...

Problem: 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**

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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-P² (I-X Process Panels)**

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I-P² 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

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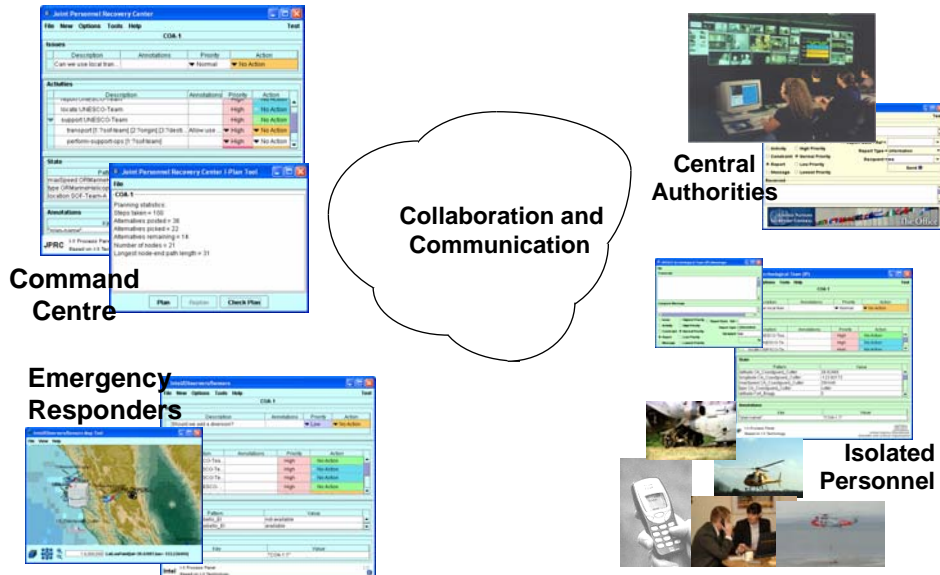
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I-X Process Panel and Tools

The screenshot displays the I-X Process Panel and Tools interface, which is a complex multi-windowed application. The main window, titled "I-X Process Panel", is divided into several sections:

- Domain Editor:** Located on the left, it shows a hierarchical tree structure of tasks and activities, with a central workspace for editing these elements.
- Process Panel:** The central area, featuring a table with columns for "Annotations", "Priority", and "Status". It lists various mission analysis tasks such as "Mission Analysis", "Expand using intelligence", and "Send to Compendium as a node".
- Map Tool:** On the right, it displays a topographic map with various markers and overlays, used for visualizing mission data.
- Messenger:** At the bottom left, it shows a "Joint Personnel Recovery Center: Messenger" window with a "Compose Message" form, including fields for "Issue", "Activity", "Constraint", "Message", "Priority", and "Recipient".
- I-Plan:** At the bottom right, it shows an "I-Plan" window with a "Planning statistics" section, displaying metrics like "Steps taken = 25", "Alternatives pruned = 24", "Alternatives picked = 5", "Alternatives remaining = 25", and "Number of nodes = 7".

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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