

**Intelligible Planning - Engineering Useful AI Planners**

Overview from web page at http://www.aiai.ed.ac.uk/project/plan/

Planners: Traverser (Graph Traverser 4), Interplan, Nonlin. O-Plan and I-X/I-Plan over 4 decades

<http://www.aiai.ed.ac.uk/project/early-planners/>

<http://www.aiai.ed.ac.uk/project/nonlin/>

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

<http://www.aiai.ed.ac.uk/project/ix/>

**History:**

Early work in the late 1960s in the Experimental Programming Unit and its follow on Department of Machine Intelligence at the University of Edinburgh by Dr. Jim Doran and Prof. Donald Michie involved the “Graph Traverser” heuristically guided state-space problem solver. Michie was a Bletchley Park code breaker who worked alongside Alan Turing and an early AI scientist. Austin Tate was perusing an undergraduate degree in Computer Studies at the time at the University of Lancaster and on the AI course given as part of that degree. He carried out a final year undergraduate project to create an improved planner “Traverser (GT4)” (1971-1972) based on the Edinburgh Graph Traverser with technical support from Doran and Michie and written in the Edinburgh POP-2 programming language. Michie subsequently invited Austin to apply to join him as a PhD student in Edinburgh. Austin went on to study AI planning under the supervision of Michie and created the Interplan system in POP-2 as part of his PhD in Machine Intelligence (1972-1975). He had a short period in late 1975 as a researcher on Dr. Robin Popplestone’s project to use the Edinburgh Freddy-II hand-eye robot (now in the National Museum of Scotland) for assembly tasks where he used Interplan to generate plans for Freddy-II. He then joined the UK Science Research Council (SRC) “Planning: A Joint AI/OR Approach project supervised by Prof. Bernard Meltzer with co-researcher Dr. Lesley Daniels, an OR scientist. That project applied AI and OR methods in combination to the task of Turbine Overhaul in collaboration with the UK Central Electricity Generation Board (CEGB). This is an expensive and time consuming process involving opening up large scale machinery, examination and quick changes to replace parts as necessary. Delays can cost a lot of money. The hierarchical planner Nonlin implemented in POP-2 was created which could generate partial order activity plans in the form of “PERT” charts or task networks as used in the CEGB turbine overhaul procedures at that date. This was mated to time and resource reasoning, decision graph based failed plan unravelling, and manual human editing of plan parts. Tate sought funding in 1976 from the UK SRC for an ambitious programme of research into a practical AI planner around the time that funding agency and public discussions of the future AI funding in the UK (and elsewhere) and the publication of a critical Lighthill report on the value of continuing AI and general robotics research . Although this grant was funded, by then Tate had decided to join the Edinburgh Regional Computing Centre where he was a software engineer and project leader working on early relational and Codasyl data base interfaces and exploring semantic net technology. He held a grant with Malcolm Atkinson, then at St. Andrews University for work on Persistent programming languages that integrated with data bases (PS-Algol). He also went on to lead the University of Edinburgh’s early foray into personal computing, office systems and be involved in distributed networked computing. The University used external funding from some of these projects to establish three fellowships (given to Malcolm Atkinson, Peter Denyer and Austin Tate) intended to let Edinburgh entrepreneurial staff to explore ways in which computer science, electronics engineering and AI technologies could be put to good use. This led to many successful initiatives, new research and development institutes, successful companies and national programmes. One of these initiatives was to create the Artificial Intelligence Institute in 1984. Prof. Jim Howe chaired AIAI and Tate joined as a technical assistant director to lead the AI Planning Group. He reapplied to the UK Science Research Council (now EPSRC) for work on the earlier optimistic AI planning research agenda after a gap of nearly 10 years since the original proposal, and that was funded. At the time there had been little further development in AI planning methods in that whole decade. This led to the creation of O-Plan – the Open Planning Architecture implemented in Common Lisp with later user interface elements written in the newly emerging Java programing language. From 2000 a new more general AI systems architecture for synthesis tasks called I-X and planner called I-Plan was created and the implementation language was Java. I-X/I-Plan development was frozen in 2015.

AIAI’s original aim was to recruit a commercial managing director to work with its technical group leaders. Tate funded his involvement in AIAI by working half time with a UK software company, Systems Designers, whose Technical Director was on AIAI’s steering board. This SD Fellowship involved working as part of the SD team involved in using AI, Knowledge-Based Systems and planners for commercial applications. Several successful projects came out of his work. Tate was subsequently invited to join Systems Designers as their AI group leader in Frimley and Camberley. But instead was invited to apply for the Director of AIAI post instead and took on that role, working under the chairmanship of Prof. Jim Howe, who continued as the Head of the department of Artificial Intelligence until that was absorbed along with the Departments of Computer Science and Cognitive Science into the new larger School of Informatics in 2000. Tate became a University of Edinburgh Research Professor shortly afterwards in 1989 and appointed to the Personal Chair of Knowledge-Based Systems in 1995. Planning work continued with a team of research fellows PhD student and visitors throughout this period. A significant portion of the funding came from US government funded collaborative projects, but UK government, scientific research council and corporate funds also supported aspects of the work. AIAI continued to operate with its own staff under Tate as Director until 2016 at which time it’s activities were more closely merged into those of the Centre for Intelligent Systems and their Applications (CISA) in the School of Informatics.

**Planning Group**

|  |  |  |
| --- | --- | --- |
| The Planning and Activity Management Group within the [Artificial Intelligence Applications Institute (AIAI)](http://www.aiai.ed.ac.uk/) in the School of Informatics at the University of Edinburgh is exploring representations and reasoning mechanisms for inter-agent activity support. The agents may be people or computer systems working in a coordinated fashion. The group explores and develops generic approaches by engaging in specific applied studies. Applications include crisis action planning, command and control, space systems, manufacturing, logistics, construction, procedural assistance, help desks, emergency response, etc.  Our long term aim is the creation and use of task-centric virtual organisations involving people, government and non-governmental organisations, automated systems, grid and web services working alongside intelligent robotic, vehicle, building and environmental systems to respond to very dynamic events on scales from local to global. |  |  |

|  |
| --- |
| Objectives  * To put AI planning and activity management technology to productive use * To allow for a shared model of objectives, tasks, plans, options and current world state between human and automated agents * To develop new generic methods for planning and activity management * To participate in relevant standards activities  Technologies  * Shared Plan and Activity Representation * Intelligent Process Management * Knowledge-Based Planning * Adaptive Systems Approaches to Planning * Constraint Management Technology * Knowledge-Based Workflow * Intelligent Agent Technology * Intelligent Activity and Process State Visualisation * Modular, Distributed Systems Integration Architectures  Applications  * Non-combatant Evacuation Operations (NEOs) * Search & Rescue, Personnel Recovery * Emergency Response ([I-Rescue](http://www.aiai.ed.ac.uk/project/ix/i-rescue/), [e-Response](http://www.aiai.ed.ac.uk/project/ix/e-response/)) * Coalition Peacekeeping Operations * Spacecraft Mission Planning * Unmanned Autonomous Vehicles (UAVs) * Construction Planning * Logistics * Engineering Tasks * Systems Management Aids * Business Management Tasks * Help Desks and Assistants * Training and Gaming Environments * Personal Assistants * Robot Companions  People  * Stuart Aitken * Howard Beck * Ken Currie * Jessica Chen-Burger * Jeff Dalton * Roberto Desimone * Brian Drabble * Mark Drummond * Anja Haman * Peter Jarvis * Ken Johnson * John Kingston * Richard Kirby * John Levine * Eva Onaindia * Stephen Potter * Michael Rovatsos * Arthur Seaton * Judith Secker * Jussi Stader * Austin Tate * Richard Tobin * Gerhard Wickler * Ph.D Students:   + Adam Barker   + Punyanuch Borwarnginn   + Peter Clarke   + Thomas French   + Danai Korre   + Natasha Lino   + Tom McCallum   + Steve Polyak   + Glen Reece   + Clauirton de Siebra   + Eleanor Sim   + Henrik Westerberg   + Alan White * Visitors:   + Colin Bell, University of Iowa   + Jeff Bradshaw, IHMC, Pensacola, Florida, USA   + Michal Pechoucek, Czech Technical University, Prague, Czech Republic  Teaching  * School of Informatics M.Sc. Course on [Automated Planning](http://www.aiai.ed.ac.uk/project/teaching/plan) * AI Planning Open On-line Course: [Coursera MOOC](http://www.coursera.org/course/aiplan) [[Local Pages](http://www.aiai.ed.ac.uk/project/plan/ooc/)]  Spinout Company  * [I-C2 Systems Ltd](http://atate.org/i-c2/web/) - Intelligent Communication and Coordination |

### Software Systems

* [Traverser](http://www.aiai.ed.ac.uk/project/early-planners/): (1971-2) a graph search problem solver based on the Graph Traverser algorithms of Donald Michie and his colleagues.
* [Interplan](http://www.aiai.ed.ac.uk/project/early-planners/): (1972-74) an early planning system whose search was directed by finding and debugging "approaches" that handled the goal structure underlying the problem.
* [Nonlin](http://www.aiai.ed.ac.uk/project/nonlin/): (1974-82) the original hierarchical task network, partial-order planner - used as the basis for many text book descriptions of this type of technology. [Excalibur](http://www.aiai.ed.ac.uk/project/excalibur/) was a development of Nonlin which added qualitative process reasoning.
* [O-Plan](http://www.aiai.ed.ac.uk/project/oplan/): (1983-99) an AI planning , execution and plan repair system with extensive representations for temporal, resource and other constraints, support for plan execution monitoring and plan repair "on-the-fly". Runs as a web service.
* [I-X](http://www.aiai.ed.ac.uk/project/ix/): (2000-present) a portable cross-platform Java-based planning and collaboration support environment. Aid to multi-agent cooperative work and external services use. Based on the< I-N-C-A> conceptual model.

### Projects

* **Planning and Activity Representation**   
  [<I-N-OVA>,< I-N-CA> & <I-N-C-A>](http://www.aiai.ed.ac.uk/project/oplan/inova.html)  
  [NIST Process Specification Language](http://www.aiai.ed.ac.uk/project/nist/)  
  [SPAR - Shared Planning and Activity Representation](http://www.aiai.ed.ac.uk/project/arpi/spar)  
  [Cyc Process & Plan Representation](http://www.cyc.com/)  
  [IEEE Suggested Upper Merged Ontology (SUMO)](http://www.ontologyportal.org/) [ [Browse for "Plan"](http://sigma2.cim3.net:8080/sigma/Browse.jsp?kb=SUMO&lang=en&term=Plan) ]  
  [Ontoweb Process Standards Working Group](http://www.aiai.ed.ac.uk/project/ontoweb/)  
  [Semantic Web Services Initiative](http://www.aiai.ed.ac.uk/project/swsi/)
* **Planning and Activity Management Technology**   
  [CoAX](http://www.aiai.ed.ac.uk/project/coax/) - Coalition Agents eXperiment  
  [CoSAR-TS](http://www.aiai.ed.ac.uk/project/cosar-ts/) - Coalition Search and Rescue - Task Support
* **Collaborative and Human/Robotic Systems**   
  [Co-OPR](http://www.aiai.ed.ac.uk/project/co-opr/) - Collaborative Operations for Personnel Recovery  
  [CoAKTinG](http://www.aktors.org/coakting/) - Collaborative Advanced Knowledge Technologies in the Grid  
  [IM-PACs](http://www.aiai.ed.ac.uk/project/impacs/) - Intelligent Messaging - Planning and Collaboration Systems  
  [Project AIBO](http://www.aiai.ed.ac.uk/project/aibo/) - Robotic Task Achieving Team  
  [Project AIAI2](http://www.aiai.ed.ac.uk/project/aiai2/) - AIAI in Second Life  
  [I-Room](http://www.aiai.ed.ac.uk/project/i-room/) - A Room for Intelligent Interaction  
  [Hedlamp](http://www.aiai.ed.ac.uk/project/hedlamp/) - Huddersfield + Edinburgh - Learning and Adaptation of Models for Planning
* **Previous Projects**   
  [Secretarial Co-worker](http://www.aiai.ed.ac.uk/project/plan/no-link-available.html), [Time Management Aid](http://www.aiai.ed.ac.uk/project/pasg/Projects/sharp_home.html), [T-SAT](http://www.aiai.ed.ac.uk/project/pasg/Projects/Figures/t-sat.gif), [PlanERS-1](http://www.aiai.ed.ac.uk/project/pasg/Projects/Figures/ers-1.gif), [Optimum-AIV](http://www.aiai.ed.ac.uk/project/optimum-aiv/), [EUMETSAT](http://www.aiai.ed.ac.uk/project/eumetsat/), [TOSCA](http://www.aiai.ed.ac.uk/project/tosca/), [UK Search & Rescue](http://www.aiai.ed.ac.uk/project/raf-sar/), [GhostWriter](http://www.aiai.ed.ac.uk/project/ghostwriter/), [Rota](http://www.aiai.ed.ac.uk/project/pasg/Projects/pre_rota_home.html), [Process Interchange Format](http://ccs.mit.edu/pif/), [Workflow Management Coalition](http://www.wfmc.org/), [Enterprise](http://www.aiai.ed.ac.uk/project/enterprise), [Task-Based Process Management](http://www.aiai.ed.ac.uk/project/tbpm/)

### University of Edinburgh Associations

* [Centre for Intelligent Systems and their Applications](http://www.cisa.inf.ed.ac.uk/)  
  and it's [Artificial Intelligence Applications Institute](http://www.aiai.ed.ac.uk/)
* [Human Communications Research Center](http://www.hcrc.ed.ac.uk/)
* [Institute for Communicating and Collaborating Systems](http://www.iccs.inf.ed.ac.uk/)
* [Institute for Perception, Action and Behaviour](http://www.ipab.inf.ed.ac.uk/)
* [PEA Pod](http://www.aiai.ed.ac.uk/project/plan/peapod/) - Processes, Events and Activity Collaborative Research Programme
* [Vue - Virtual University of Edinburgh](http://vuw.ed.ac.uk/)

### UK Programme Involvement

* [AKT](http://www.aiai.ed.ac.uk/project/akt/) - Interdisciplinary Research Collaboration in Advanced Knowledge Technologies
* [FireGrid](http://firegrid.org/)
* [UK National e-Science Programme](http://www.nesc.ac.uk/)
* [UK EPSRC Autonomous and Intelligent Systems Programme](http://www.epsrc.ac.uk/newsevents/news/2012/Pages/robotics.aspx)

### International Programme Involvement

* [PLANET](http://planet.dfki.de/) - European Network of Excellence in AI Planning
* [OntoWeb](http://www.ontoweb.org/) - European Network of Excellence in Ontologies for the Web
* [AgentLink](http://www.agentlink.org/) - European Network of Excellence in Agent-based Computing
* [ARPI](http://www.aiai.ed.ac.uk/project/arpi/) - (D)ARPA/AFRL Planning Initiative
* [CoABS](http://coabs.globalinfotek.com/) - DARPA Control of Agent Based Systems Program
* [DAML](http://www.daml.org/) - DARPA Agent Markup Language
* [Fast C2AP](http://www.darpa.mil/ipto/programs/fastc2ap/) - DARPA Fast Connectivity for Coalitions and Agents Project
* [COMPOEX](http://dtsn.darpa.mil/ixo/ixopro_new.asp?id=156) - DARPA Conflict Modeling, Planning, and Outcomes Experimentation
* [MPAT](http://www.mpat.org/) - Multinational Planning Augmentation Team
* OpenKnowledge - e-Response
* [I-Globe](http://www.aiai.ed.ac.uk/project/i-globe/)
* [OpenVCE.net - Open Virtual Collaboration Environment](http://openvce.net/)
* [The Helpful Environment](http://openvce.net/helpful-environment)

**Some notes on Technical Contributions of work on AI planners at the University of Edinburgh**

Goal Structure and Non-linear Approaches to Problem Solving and Planning (1973): defining the plan as a set of goals and sub-goals to be achieved and ordering those goals and sub-goals such that they defined a space within which a set of actions could be selected to achieve the required goals. Hence the underlying teleology of the plan (its "goal structure") was refined or debugged (as in Gerry Sussman's Hacker planner from MIT) during planning. The goals and sub-goals did not have to be fully linear but could be interleaved and activities inserted in a non-linear fashion to meet the goals and sub-goals without goal interaction or conflicts. Goals and sub-goals once achieved in a plan were “protected” so that they were not subsequently nullified by later activities before the condition they achieved was utilised as required. Interplan introduced this for a planner whose final plan was a linear sequence of activities.

Multiple Contributors (1975): allowing the goal structure to be achieved via multiple disjoint pathways and not adding in extraneous ordering constraints on the actions in the plan unless necessary to avoid goal interactions. This preserved robustness in the plan as far as possible by not committing to any one particular goal structure support until necessary.

Partially-Ordered Plans (1975): Nonlin took the obvious step of not introducing ordering constraints between those actions unless they were necessary to achieve the goals and sub-goals in the selected configuration without conflicts ("goal interactions"). This led to plans being in the form of activity networks with the activities only partially ordered.

QA in a Partially-Ordered Network of Nodes (Modal Truth Criterion) (1975): a key algorithm in our AI planners is the ability to ask whether a particular statement is true or not (more generally what the value of a statement or function is) at any point in a partially ordered network of nodes (representing the activities in a partially constrained plan). The answer can be a simple "yes" or "no" or the much more interesting "maybe". "Maybe" answers can be returned with the candidates extra constraints which if added to the plan would allow the answer to become a "yes". "And/Or" trees of the possible ways to introduce extra constraints can be computed and made use of to further constrain and guide search, often without actually taking specific choices early on. We have spent considerable effort to ensure that such an algorithm can be efficient and cope with large plans. We term this algorithm "QA" for Question Answering" but it was formalised by MIT's David Chapman as the "Modal Truth Criterion" (MTC).

Opportunistic Search (1975): Although the core approach is often to maintain plans in a flexible partially instantiated form and only take constraining decisions when necessary, O-Plan in particular, and to some extent I-X/I-Plan sought to take the most constraining" choices where multiple alternatives existed and a choice had to be made to progress. Techniques were used such as searching using heuristic guides such as maintaining an accurate "Branch 1" branching ratio for the immediate choice to hand, and an estimate for "Branch N", a figure of the likely number of choices deeper in the search tree if the top level choice was made.

Heuristic Search (1971): All the planners I have been involved with maintain a search space through which the planner can search and backtrack or unravel as necessary to find solutions. The planners seek to maintain all legitimate alternatives and aim to find a solution if one exists in the search space. Alternative means to modify plans without relying on backtracking have also been used especially in environments where the world state is highly dynamic.

Adequate and Irredundant Planner Research (1977): INTERPLAN-AIR was a modification to Interplan to seek to address redundancy in its search space.

Hierarchical Planning (1975): Nonlin and the later planners O-Plan and I-Plan allow the activities for the domain to be described in a hierarchical way and use multiple levels of abstraction for the world state constraints in them. This is similar to Earl Sacerdoti's ABSTRIPS and his later NOAH (Nets of Action Hierarchies) planner. Earl was a visitor to our group in Edinburgh at the time, and we exchanged experience in creating planners based on hierarchical representations and multiple levels of abstraction. These are now called Hierarchical Task Network (HTN) planners.

Partial Plans and Plan Space Search (1975): moving from state space search where nodes are states of the world to partial plan space where nodes are partial plans or "plan configurations" (essentially a set of constraints on the space of possible plans).

AI/OR (1975): We have sought to productively mix AI and OR methods to plan activities and schedule resources in applications. The UK Science Research Council (now EPSRC) grant which funded the early work on Nonlin was call "Planning: a Joint AI/OR Approach" and my colleague on that, Dr. Lesley Daniels was an OR researcher. We have had PhD students such as Dr. (now Prof.) Carla Gomes who mixed AI and OR methods, and Prof. Colin Bell, an OR professor from the University of Iowa at the time (later on the Microsoft Project product team), was a visitor in our group for an extended period to work on time windows and resource constraint reasoning in O-Plan using OR linear programming techniques.

Plan Refinements (1984): The operators used during planning were considered as refinements to partial plans by introducing constraints (such as ordering constraints between actions or bindings on objects in the plan).

Knowledge-Based Planning (1984): making use of all the domain knowledge in where possible, including constraints beyond those able to be easily manipulated by systems and modules.

Resource Constraints (1977): a range of work on adding reasoning about constraint including consumable constraints (like fuel) and reusable constraints (like keys).

Constraint Reasoning (1984): treating planning consistently as adding constraints on a space of possible plans rather than defining a specific concrete plan and handling issues that arise from adding constraints.

Issue Handling (1984): earlier representation of the "flaws" in a plan (as in Nonlin) and keeping these within the plan representation was generalised as some "flaws" were beneficial and could simplify the plan or mean specific extra actions did not need to be introduced to satisfy goals as they might be achieved via side effects of actions introduced to meet other objectives. The term "Issue" was used instead on the suggestion of Steve Cross of DARPA and this led to a fruitful interaction with the Issue-based design community (gIBIS and sense-making communities).

Situated Planner (1984): a planner in the context of task assignment (objective and requirements setting) and plan execution support.

Mixed-Initiative Planning: human in the loop plan development and need for shared understanding of plans, their relationship to tasks and objectives and the constraints on them.

Sense-making and Planning (2000): linking these communities and using sense-making to give a set of issues to address and constraints to satisfy to guide planning (Co-OPR, Compendium/I-Plan).

PlanWorld Views (1995): multi-modal viewer for plans and plan options both at a technical level and in term of their world state.

Process Panels (IP-2) (2002): user Interfaces for task assignment, planning, option management, plug in specialised PlanWorld viewers, etc.

Modular Design and Parallelism (1984): the design of O-Plan and the later I-X/I-Plan planners sought to allow for maximum potential implementation on parallel computers and systems. It had an agent orientated top level approach which allows for wiodely dispersed distributed computing, even assuming some elements could be on space craft in deep space while parts were Earth-based operations centres. The modular core design allowed for closely coupled similar multi-processor approaches with an assumption of their being 16 to 32 processors available (similar today to multi-core processors, but at the time we were using 8 and 16 processor Sequent Symmetry computers and "Transputer" based parallel machines). Some modules, especially the constraint operation and QA/Graph Operation, were designed to allow for fine grain parallel execution on specialised AI hardware. We experimented with chip design for a plug in Graph Operation processor (GOP) at the time and fabricated sample chips in our Wafer Fabrication facility (MSc projects jointly supervised by Austin Tate and Peter Denyer, who went on to found VLSI Vision, which became VISION Group), one of the first ever producers of solid state camera sensor chips [https://en.wikipedia.org/wiki/Peter\_B.\_Denyer].

Plan Rationale (1975): capturing the rationale behind plans and beyond the decisions made to restrict plans to meet objectives. Nonlin + Decision Graph, O-Plan/I-Plan using annotation constraints.

Plan Execution Monitoring (1982): using goal structure to support condition/constraint monitors so that plan execution issues could be recognised, sometimes well in advance of the downstream implied problem, and the robustness and multiple contributors that may be within the plan used to guide execution, or decide to replan. (Condition Monitoring in a FMS, O-Plan online plan execution support system).

Replanning (1990): O-Plan and I-Plan were designed to allow for replanning in the face of execution failure for plans. Repairing plans “on-the-fly” was intended to cope with high value or high tempo situations where an established plan had to be changed, often after much communication of its contents, or verification and human training in its execution, to allow plans to get the situation back “on track”, e.g. after a test failure in a verification environment such as spacecraft assembly prior to launch, or missions for Army small unit operations.

Plan Representation (2000): Underlying Task, Objectives, Plan, and Agent Capability Ontology <I-N-C-A> and its forerunners such as <I-N-OVA>. Inputs to NIST PSL, DARPA SPAR, etc.

Intelligible Planning (2000): ensuring the plans could be understood by systems and people at various levels of abstraction with some parts seen as specialise constraints understood by agents or modules but bounded at a higher abstraction level.

Applications (1975-): Considered throughout the Edinburgh planner research work. Nonlin - CEGB Turbine Overhaul. O-Plan Lisp paper examples. OPTIMUM-AIV basis, etc. Emergency Response focus for many years. FireGrid.

Agent-Based Systems (1984): agent orientated approach. See CoAX for large integrated intelligent agents demonstrator.

I-Rooms (2002): virtual spaces for intelligent interaction. Instrumented knowledge-based distributed meeting spaces. An application of these techniques for cooperation and coordination in distributed teams.

Helpful Environment (2005): Overall Vision. The long term aim is the creation and use of task-centric virtual organisations involving people, government and non-governmental organisations, automated systems, grid and web services working alongside intelligent robotic, vehicle, building and environmental systems to respond to very dynamic events on scales from local to global.

----------------------

References and Roadmap

Tate, A. (1977) INTERPLAN-AIR: an “adequate” and irredundant linear planner, unpublished, along with communication with David Warren, 31-Aug-1977.

<http://www.aiai.ed.ac.uk/project/oplan/documents/1990-PRE/1977-unpub-tate-interplan-air.pdf>

Tate, A. (2000) Intelligible AI Planning, in Research and Development in Intelligent Systems XVII, Proceedings of ES2000, The Twentieth British Computer Society Special Group on Expert Systems International Conference on Knowledge Based Systems and Applied Artificial Intelligence, pp. 3-16, Cambridge, UK, December 2000, Springer.

Tate, A. (2003) <I-N-C-A>: a Shared Model for Mixed-initiative Synthesis Tasks, Proceedings of the Workshop on Mixed-Initiative Intelligent Systems (MIIS) at the International Joint Conference on Artificial Intelligence (IJCAI-03), pp. 125-130, Acapulco, Mexico, August 2003.

Tate, A., Dalton, J., and Stader, J. (2002) I-P2 - Intelligent Process Panels to Support Coalition Operations, Proceedings of the Second International Conference on Knowledge Systems for Coalition Operations (KSCO-2002), 184-190, Toulouse, France, 23-24 April 2002.

Tate, A., Chen-Burger, Y-H., Dalton, J., Potter, S., Richardson, D., Stader, J., Wickler, G., Bankier, I., Walton, C. and Williams, P.G. (2010) I-Room: A Virtual Space for Intelligent Interaction, IEEE Intelligent Systems, Vol. 25, No. 4, pp 62-71, July-August 2010, IEEE Computer Society.

Tate, A. (2006) The Helpful Environment: Geographically Dispersed Intelligent Agents That Collaborate, Special Issue on "The Future of AI", IEEE Intelligent Systems, May-June 2006, Vol. 27, No. 3, pp 57-61. IEEE Computer Society.

----------------------

O-Plan final report roadmap to refine to show coverage of the various techniques explored during these projects.

Tate, A., Drabble. B. and Dalton, J., An Engineers Approach to the Application of Knowledge Based Planning and Scheduling Techniques to Logistics - O-Plan Final Technical Report RL-TR-95-235 December 1995

Page 37

<http://www.aiai.ed.ac.uk/project/oplan/documents/1995/1995-afrl-oplan-tr-95-235.pdf>

Subbarao Kambhampati’s "Reminiscences of Influential Papers in Planning"

To: [planning@asu.edu](mailto:planning@asu.edu) (Planning List)

Date: Tue, 26 Nov 2002 11:53:08 -0700

http://www.aiai.ed.ac.uk/project/nonlin/nonlin/review.txt

Resources

AI Planning MOOC

<http://www.aiai.ed.ac.uk/project/plan/ooc/>