[Lozovskiy, 1979] В.С.Лозовский, Ситуационная и дефиниторная семантика системы представления знаний, "Кибернетика", No. 2, 1979, стр. 98 – 101

[Lozovskiy, 1990] В.С.Лозовский, Сетевые модели, разд. 1.3 в кн.: Искусственный интеллект, в 3-х кн., Кн. 2: Модели и методы. Справочник, п/р Д.А.Поспелова, М., "Радио и связь", 1990, стр. 28 - 49

[Lozovskiy, 1998] Lozovskiy Vitaliy (UA): Common Sense Semiotics, Conference Proceedings: Knowledge-Based Software Engineering (Smolenice, Slovakia), P. Navrat and H. Ueno (Eds.), IOS Press, Amsterdam, Berlin, Oxford, Tokyo, Washington, DC, ISSN: 0922-6389, ISBN: 90 5199 417 6 (IOS Press), 1998, pp.232-240

[Lozovskiy, 1999] Vitaliy Lozovskiy, On the Road to Parasemiotics, ASC/IC'99 - Труды 4-го международного семинара по прикладной семиотике, семиотическому и интеллектуальному управлению, Институт программных систем РАН, Российский университет дружбы народов, Российская ассоциация искусственного интеллекта, Москва, октябрь 1999, ISBN5-89574-064-2, с. 158-166

[Lefebvre, 1973] В.А.Лефевр, Конфликтующие структуры, «Советское Радио», М., 1973.

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PLANNING TECHNOLOGIES FOR THE WEB ENVIRONMENT: PERSPECTIVES AND RESEARCH ISSUES

A. Milani, S. Marcugini

***Abstract**: This work will explore and motivate perspectives and research issues related with the applications of automated planning technologies in order to support innovative web applications. The target for the technology transfer, i.e. the web, and, in a broader sense, the new Information Technologies (IT) is one of the most changing, evolving and hottest areas of current computer science. Nevertheless many sub-area in this field could have potential benefits from Planning and Scheduling (P&S) technologies, and, in some cases, technology transfer has already started. This paper will consider and explore a set of topics, guidelines and objectives in order to implement the technology transfer a new challenges, requirements and research issues for planning which emerge from the web and IT industry.*

Sample scenarios will be depicted to clarify the potential applications and limits of current planning technology. Finally we will point out some new P&S research challenge issues which are required to meet more advanced applicative goals.

***Keywords**: Planning, Web, IT, technology transfer*

Introduction

The Information Society (IS) is announced by a set of interrelated emerging technologies where the web it is certainly one of the most apparent and popular elements. These technologies envision new relationships of the individuals between his/her own tasks and the new tools.

Individuals are forced to develop new methods of work in order to exploit the ITs at their best, new tools and application should reflect and model these new methods in order to be effective.

Despite of the successful buzzword “web” (and popular e-*something* terms such as: "e-commerce", “e-business” etc.), it is important to focus on a wider vision of the potential role of planning and scheduling

technologies (P&S) in the Information Society not limited to the web applications. An exponential number of internet based services, low cost mobile devices over GSM and UMTS networks, tools which integrate traditional and knowledge based systems, represent promising application fields where P&S can have a primary or a supporting role.

P&S is a research area which dates back to [Fikes1971], scientific and technological results are due to a wide community of researchers and scientific programs on the topic.

P&S can convey the flexibility typical of AI technologies in order to answer to expectations and requirements of new methods of work and for the exploitation of the new I

There are some important elements which facilitate the application of P&S technologies to the web:

- *Digital content*, the web is machine readable and it provides a large quantity of machine readable data and software entities to interact with; automatic knowledge acquisition can be potentially realised in the web environment;
- *Virtual is real*, the web offers the chance having "real" planning application bypassing the complex robot machinery needed in traditional planning application fields such as aerospace or robotics, for example the actions "browse a list of available books" and "buy-a-book" can be easily executed in the digitalised world thus producing a real and useful effect;
- *Scalable complexity*, web applications can have different degree of complexity, simple applications can exists for simple existing planning models. As an example it is worth citing machine translation as a case of a technology which is not mature (i.e. for literature translation) but it could be worthwhile in niches applications (i.e. web pages automated translation)

Planning and scheduling technologies represent a key factor in the framework of the service technologies for the global new IS especially with respect to the current scenario of web applications, they provide:

- *Knowledge based flexibility*, P&S convey the flexibility typical of knowledge based technologies in support of new modalities of work, production, commerce, entertainment, education etc.;*Models of change and interaction*, P&S provides models of change and interaction, this research area has developed systems which provide automated generation of plans, tasks monitoring, plans checking etc.

Another key factor which motivates the application of P&S technologies to the web is its dimension: web is *large*. In other words, a massive audience of personal end-users and business end-users is developing the need of customised versions of services, and consequently the need for web industry of tools and technologies to support them. This scenario is made more complex by the increasing diffusion of personal mobile devices which fosters the development of new modalities of work and interaction between the individuals and the business organisations, and it tends also to modify the traditional modality of B2B interaction.

For this purpose the relevant issues to be supported and managed by services and applications over the information infrastructure are in general: *autonomy, adaptation, distribution, mobility, agent interaction, automatic collaborative support* etc.; which are also typical issues deeply related with P&S research.

Another important element has been the proposal of Semantic Web [Berners-Lee 2001], which has the ambitious goals of allow reasoning on a web of knowledge and meanings, with respect to the initial web made of presentation tags (i.e. HTML) and a web of syntactic structures and terms (i.e. XML). The data on the semantic web are defined and linked in a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications. Semantic Web is of great important in the future of knowledge bases applications for the web, because of its success among the research community, the growing number of available tools and application and the standardisation factor, since it is supported and coordinated by W3C Consortium. Despite of the initial focus on ontologies and relationships, research started under the Darpha Agent Markup Language (the DAML program [DAML 2000] has lead to models of more dynamical aspects of the web. For example, DAML-S is oriented DAML-based Web Service Ontologies in order to facilitate the automation of Web service tasks including automated Web service discovery, execution, interoperation. It is worth mentioning the DAML-PDDL translators [PDDL2.1][DAML-PDDL] [McIlrait 2002] which apply P&S to the semantic web.

Defining the Scenario: The Web as an Environment

In this view the *web is a planning environment*, i.e. web entities are the object of P&S systems.
Web entities exists (a simple *web planning domain* is made of elements such as web pages, emails, files etc.) on which typical *actions* can be executed by users (e.g. pay, subscribe, supply, order, browse, look for, find, download etc.) or provided by service systems (e.g. web page servers, search engines, mail servers, messenger servers etc.). Moreover user and systems are pursuing *web tasks*, i.e. tasks which involve web entities (e.g. find a book, buy it and download), and in general user transactions and user activities over the web (e.g. informative tasks, educational tasks, distance work tasks etc.). Sometimes these tasks are not given automatic support, i.e. they rely on the user decisions, or, if automatic support is given, then it uses a too rigid and procedural approach, which does not satisfy the wide variety of user/business needs.
Planners can develop plans to act on the web virtual world in order to reach goals on *web entities*, a key point is that web entities do not necessarily have a "real" counterpart, and they are not necessarily designed as a part of a single distributed system.
Consider for example the following completely *virtual* plan for the *virtual* goal of promoting a web site: *buy disk space, transfer your old site to a popular web portal in order to obtain a better click rate*. The synthesis of this plan would require the ability of describing a model of change (e.g. defining the meaning of acting on the web), goals (defining concepts such "a better visibility"), and a model of the actions to be taken to execute it (i.e. pay, subscribe, download etc.), i.e. web entities should be represented as part as part of a planning domain.
In addition there are some traditional planning phases that need to be reconsidered in the web domain:

- *domain knowledge acquisition* can be realised by activities of information gathering, information discovery and comparison (about existing portals, rates and prices), with respect to more traditional planning domain in which domain knowledge has not frequent variations;
- *action execution* in the web could imply to take into account of a dynamical scenario, in which not only actions can have unpredictable failure, but the domain can change during execution.

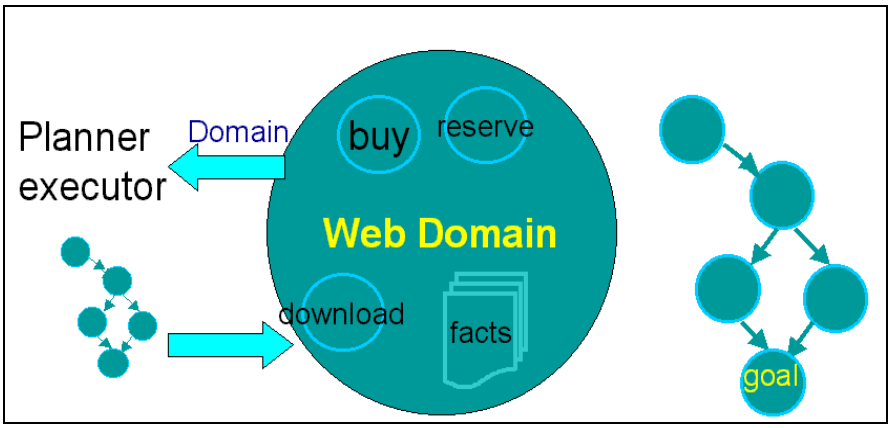

Fig.2 The Web as a Planning Environment

A more general scenario is characterised by activities which take place only *partially* on (or through) the web.

A simple example is that of a personal planner assistant, which suggests the user to buy a textbook online as part of *the plan "successfully preparing an exam", which contains some other* not web *steps such as* going to lessons *and* doing exercises *. User tasks and goals are in general related with real world activities and should interact and be coordinated with actions and plans which act in the web domain.*

When more production related activities become available on the web (for example: *suppliers chains, customers, markets, delivery, payments etc.*) the manufactures planning activity will need to model the web as part of the production plans.

A Glossary of Terms for Mapping Planning on the Web

In this section it will be shown how the basic features of planning domain model can be mapped into corresponding web entities, and contribute to solve and support web tasks and goal oriented activities on the web. On the other hand the mapping allows pointing out the limits of the current planning models and the research issues which are required to be solved in order to give a complete account of operating on the web domain.

Glossary Terms: State, Initial State, Goal State.

The notion of state is central to most planning models. In the web the concept of state is represented by the sum of the states of the various component of the web domain:

- *user internal state*, the set of features and facts describing the user state (e.g. maintenance conditions, general constraints, preferences, but also info about users such as identities and passwords);
- *web-state facts*, the state of info as available on the web, in the simplest form web-state is represented by the set of current web pages, existing files etc., more likely the state description would address the content and the semantic of available information (e.g. stock quotations, available item on e-markets etc.)
- *web actors state,* this is represented by the internal state of interactive services, consider, for example, activities which require multiple steps in order be carried out, such as online reservation of a flight (it is necessary to be able to represent the current step of a given transaction), or consider services which require access authorisation (it is necessary to represent that certain existing resources are/are not available for use).

The concept of *state that is used in planning to model initial states, goals state, and to model change as modification of state* will need reformulation in the framework of web applications, because of the inadequacy of current planning model to fully describe the state of a web domain in all its aspects.

Research Issue: the main drawback of the current planning models of states derive from the fact that the web is a *vast and dynamical environment of active resources*, on the other hand planning domains are usually characterised by domain states which are fully knowledgeable and somewhat static, i.e. the planner is the only one (or one of the few) agent in the domain.

Summarising, the main P&S research issues that should be addressed in order to fully capture the main features of a *web state* are:

- *managing uncompletness*, web state is vast and not completely knowledgeable, the web domain is inherently incomplete there is no hope to model inside the planner *a complete* description of all the web, then mechanisms and strategies are required in order to do knowledge acquisition and to *circumscribe* the domain description for the planning problem at hand ;
- *managing events*, web state changes independently of the planning actor, this is usually addressed in planning models by the concept of *events*, i.e. state changes which are out of the control of the planner [Ghallab 1998]; in the web domain the amount of *planning time* appear to be a crucial factor, since dynamical changes can occur during planning;
- *managing inconsinstency*, web state can contain contradictory information coming from different sources, consider for example info about the weather conditions used by a travel planner; concepts such as trust and believes and should be modelled [Ambite 1998];
- *managing richer knowledge representation,* P&S models usually focus more on actions and plans than on the adequacy of the knowledge representation formalism to capture the *static* aspect of the domain; since the web offers information in different but equivalent forms, the planners should be aware of ontologies and mechanisms for relating information from different sources, consider for example the problem of representing the concept of *price*, in the sense of amount of money to be payed for buying a good, an effective representation requires that *stock exchange market quotations*, *monthly renting rates*, *price of a book* and *currency exchange rates* would represent instances of the same concept of price [Berners-Lee 2001],

Glossary Terms: Actions and Operators

The other fundamental concept in planning models is the notion of *action* and *operators* , which represents the basic elements to model change in the domain.

Actions (i.e. istances of *operators*) represent the state transiction which occurs during the execution. Operator and action are usually modelled in term of precondition/effects.

In a web domain actions are represented by the available services, which change the user/web state according to a preconditions/effects model. For example available services on the web such as *buying a book, reserving a meeting room, downloading a satellite image of a town, moving a remote webcam* , *sending an email*, are actions in the sense that are allowed to take place only under certain preconditions on the web state (e.g. *having enough money on the account, availability of the tow sat picture etc.*) and produce effects on it (e.g. *changing book ownership, meeting room reservation state, a copy of the picture locally available etc.*).

Research Issues: it is worth noticing that an effective model of *web actions* should take into account the elements formerly pointed out about web states (uncompletness, inconsistency in particular), but it requires, in addition, to consider some *web specific* P&S research issues about the actions/operators model:

- *operators can change, appear and disappear*, new services become available and changes over time, issue: dynamical discovery, monitoring and maintaining of domain models;
- *actions execution time,* actions on the web take time (depending on bandwith and servers overhead factors) , issue: timing constraints and failure recovery;

Glossary Term: Plan

"A *plan* is a set of ordered actions, that, if executed in the initial state will transform it in the goal state". This definition of solution plan is common to most planning models since [Fikes 1971], and it is easy to see that the definition easily applies also to the web domain. Currently most web tasks and goal oriented activities which take place on the web can be described basically as sequences of actions, i.e. on the web, *plans are sequences of interrelated services requests made on web entities*, (consider for example a typical user driven web-plan such as*: look for items sellers on search engine, browse and compare prices, order one and pay for it*).

Research Issues: although plan as sequences or partially ordered sequences are a formalism that is sufficient for planning in the web at a basic level, it is worth to investigate on planning models which

- *provide expressive and flexible models of plans*, few planning models have a satisfactory management of actions with duration, loops, conditionals [Lin 1995];
- *combine plan knowledge with task oriented languages*, planning models based on a hierarchical approach [Erol 1995], as well as of workflow management models [WorkFlow-Roadmap 2003] offer examples of task oriented formalisms which should be included into generative planning models.

The objective should be to reflect also in the structure of plans, some typical element of the web domain, we have already pointed out, such as contingency, non-determinism, and dynamical aspects of the domain.

Glossary Terms: Plan Monitoring, Execution, Sensing, Re-planning

Planning terms such as *plan monitoring, execution, sensing* and *re-planning* regard the phase that follow plan synthesis and aimed at actually reaching the goals by executing the plan in the real world. In the web domain (where *virtual and real* are somewhat overlapping) can characterised in a "web specific" way traditional planning concepts like *execution* and *sensing*:

•*Execution*, since the web is *large*, execution can involve complex decisions about choosing the service to invoke among a plurality of available and equivalent ones; moreover *execution takes time* also for processing and data transfer, then criteria are needed to combine the issue of execution time with the issue of bandwidth; finally note as the implementation of *actuators* would be greatly favoured by the diffusion of web services, but the use of *wrappers* or similar mechanism should also be considered as an intermediate solution for interacting with services initially designed for human users;

•*Sensing*, in the web environment sensing mainly means: *actively* looking for info, i.e. gathering info [Knoblock 1995] [Golden 1996b] [Naveen 1997] and results from web sources (for example *web pages, searching databases, streaming video, results from called services*)*;* main open problems in this area are related with the integration of information from different non-homogeneous sources, and with decisions to be

taken about *what to sense* (consider for example criteria like: *time for sensing and processing vs bandwidth vs timing goals and execution constraints*)
It is also worth noticing that the dynamical nature of the web suggests the investigation of theoretical models [Haigh1996] [Friedman 1997], where the plan synthesis phase is interleaved with execution and sensing.

Conclusion

It is not easy to envision the future of technology transfer in an area where the target industry, i.e. the web and the broader IT society, is moving and developing at an high unprecedented pace toward hard to predict directions. For these reason, previsions and objectives in the long term are not very realistic, and should be limited only to short term and medium term scales.
On the basis of the current achievements and potentiality of P&S technologies depicted in the previous sections some conclusive guidelines for future perspectives and goals can be drawn along two main dimensions: End-user requirements and Research goals.
The first examples of the technology transfer between P&S and the Web have been in the area of:

- automation and autonomy for machine to machine services, (P&S, softbot and agents technologies Etzioni 1994])task support, Travel Assistant [Ambite 2001], i.e. P&S based dynamic integration of web sources for travel organisation (managing and combining multiple sources for airfares, parking fares, timetables, weather conditions etc)automatic maintenance of web applications, web info and web services [Smith 2001] [McIlraith 2001] [Marcugini 2002][Thakkar 2002]; (the P&S knowledge based representation of change, constraint checking and failure repairing techniques has been applied to support automatic maintenance in not web domains [Chien, 1998]);

End-user requirements,

End-users are intended to be in most cases personal users, but in the following we also means by end-user a company, an organisation as a whole, (e.g. in organisational workflow management) or an industry using the technology as a component of more complex systems.
The application issues that are expected to be asreached in a short term are mainly in the area of

- support/automation of personalised services and user adaptive services on the web (educational, e-learning, recreation, information; automatic synthesis/monitoring of online courses and educational plans based on the personal skills/advancements; automatic synthesis of personalized newspaper based on user models);
- supporting mobility and distribution in organisation: scheduling activities & information workflow in distributed organisation through the web and new devices/communication media, supply chain management
- *supporting user web tasks*, (e.g. cooperative recognition, automation, monitoring and repairing of user web tasks, consider, for example, a planning based systems which support the user in task such as “organize a vacation” or “organize a meeting”);
- automatic integration of Services/Web Services, goals directed synthesis and maintenance in specific domains

There are potential applications of P&S as components for the new IT systems:

- *components for web servers and tools*, (e.g. applications to goal guided synthesis and maintenance of web sites/pages)
- *components for supporting online services*, (e.g. scheduling load distribution to online assistance operators, activation of assistance/emergency chains, online configuration of products);
- *component in systems for online supply chains management*, (issues: logistics, resources management, workflow management, tasks scheduling and assignment)

On a medium/long term horizon, we expect increasingly to met higher requirements on tools and techniques for automation of Web Services, and increasing requests for personal support services, either on the web or onboard of personal assistant devices, such as:

- robust automatic integration of Web Services, in broader application domains, support for automatic discovery of services and failure recovery

- autonomous web agents, goals directed software agents which operate over the web on user's behalf (e.g. auctioning systems, stockbot etc.);
- support to massive adaptative services on small personal devices, planning and scheduling support for daily activities (e.g. home devices);
- cooperative and distributed planning which integrates personal devices/web services/web agents for global user goals*online P&S services*, general or specialized tools which plan or schedule on demand (e.g. for checking/rescheduling activities) and are available on the web,

Research goalsThe following research goals are prerequisites for supporting the initial and next steps of the technology transfer, on the other hand it seems to exist an increasing autonomous interest of the research community on topics such as modelling dynamic domains, time management, interleaving planning/execution and others, which can be exploited for modelling the web environment, the main topics related to this purpose include:

- modelling domain discovery during planning
- contingency and sensing in web environment
- time duration, failure recognition, and repair
- expressive and robust model of execution plans, (loop iterations)
- mixed initiative planning models, task support models
- incorporating web oriented extension in PDDL-like language (see [KE-Roadmaps] and [WorkFlow-Roadmap])
- wrappers and planning operator wrappers

in a second phase advancements in the previous topics are needed, as well as an increasing the research efforts toward more technology oriented topics such as *portability*, *interoperability, scalability* and advanced planning models, these objectives include:

- portability for planning algorithms, strategies, heuristics, preprocessing
- interoperability: mapping between planning models
- models and measures of planning scalability (small devices/ small domains)
- models for cooperative distributed planning, (domains/problem partitioning/integration)

It is generally expected that knowledge based technologies (the semantic Web proposal for instance) can give effective contribution to web applications. We have pointed out that planning technologies, in particular, can positively exploit on the web their ability of modelling action and changes. We also point out the potential scalability of the technology transfer of P&S to the web in a short/medium term perspective from simple applications which use ready-off-the-shelf planning technologies to more complex applications which need appropriate innovative models. On the other hand web and IT applications represent a source of interesting open research issues such as managing of uncomplete and dynamical domains; interoperability among domains, planners and planning tools.

Bibliography

[Ambite 2001] J.L. Ambite, *Heracles: Building Planning and Information Assistants* , Proceedings of the ECP/PLANET Workshop on Automated P&S in New Methods of Electronic, Mobile, and Collaborative Work, Toledo, Spain, September 2001,

[Berners-Lee 2001] Berners-Lee T., Hendler J., Lassila O., *The Semantic Web*, Scientific American, May 2001

[Chien,1998] S. Chien, F. Fisher, H. Mortensen, E. Lo, R. Greeley, A. Govindjee, T. Estlin, X. Wang, *Using Artificial Intelligence Planning Techniques to Automatically Reconfigure Software Modules*, Artificial Intelligence and Knowledge-based Systems, Lecture Notes in Artificial Intelligence, Springer-Verlag, 1998

[DAML 2000] Burke M. manager, *The Darpha Agent Markup Language Project DAML* , www.daml.org

[DAML-S 2002]The DAML Services Coalition (Anupriya Ankolenkar et al.), *DAML-S: Web Service Description for the Semantic Web*, The First International Semantic Web Conference (ISWC), Sardinia (Italy), June, 2002.

[DAML-PDDL] Mc Dermott D., Dou D., Qi P., *PDDAML:An Automatic Translator Between PDDL and DAML* http://www.cs.yale.edu/homes/dvm/daml/pddl_daml_translator1.html

[Erol 1995] K. Erol, D. Nau, J. Hendler, *HTN Planning: Complexity and Expressivity,* in AAAI-94, Seattle, July, 1994

[Etzioni 1994] Etzioni O., Weld D. *A Softbot-Based Interface to the Internet*, Communications of the ACM, 1994

[Fikes 1971] Fikes, R. and Nillson, N., *STRIPS: A new approach to the Application of Theorem Proving to Problem Solving*, Artificial Intelligence 2, 1971, pp. 189-208.

[Friedman 1997] Friedman M., Weld D.S., *Efficiently Executing Information Gathering Plans* Proceeding of International Joint Conference on Artificial Intelligence, IJCAI 97, Nagoya, Japan, August 1997

[Ghallab 1998] Ghallab M. *Chronicles as a practical representation for dealing with time, events and actions*, Proceeding of the 6th Italian Conference on Artificial Intelligence (AIIA'98), Padova (Italy), Lecture Notes on AI, pp.6-10, September 1998

[Golden 1996a] Golden K., Etzioni O., Weld D.S., *Planning with Execution and Incomplete Information*, Technical Report, University of Washington, n.UW-CSE-96-01-09, 1996

[Golden 1996b] Golden K., *Leap before you look: information gathering in the PUCCINI Planner*, Proceedings of AIPS 1998

[Haigh 1996] Haigh K.Z., Veloso M., *Interleaving Planning and Robot Execution for Asynchronous User Requests,* AAAI Spring Symposium on Planning with Incomplete Information for Robot Problems, 1996

[KE-RoadMap 2003] T.L. McCluskey editor, *Knowledge Engineering for Planning Roadma*, PLANET-II Technical Coordination Unit on Knowledge Engineering, March 2003, available on line at http://www.planet-noe.org/TCUs

[Knoblock 1995] Knoblock G.A., *Planning Executing, Sensing and Replanning for Information Gathering*, Proceeding of the International Joint Conference onAI, IJCAI 1995

[Laithwaite 2001] Laithwaite B., *BritishTelecom Workforce Management System*, Proceedings of the ECP/PLANET Workshop on Automated P&S in New Methods of Electronic, Mobile, and Collaborative Work, Toledo, Spain, September 2001,

[Lin 1995] Lin, S.-H., Dean, T. (1995). *Generating optimal policies for high-level plans with conditional branches and loops*. In Proceedings of the Third European Workshop on Planning, pp. 205--218.

[Marcugini 2002] Marcugini S., Milani A., *Automated Planning of Web Services,* Proceedings of the 3rd International Conference on Electronic Commerce, ICEC 2002, Hong Kong, October 2002

[McDermott 2002] McDermott D., *Estimated-Regression Planning for Interactions with Web Services*, Proceedings of the AI Planning Systems Conference (AIPS'02), June 2002.

[McIlraith 2001] McIlraith, S., Son, T.C. and Zeng, H., *Semantic Web Services* , IEEE Intelligent Systems. Special Issue on the Semantic Web. 16(2):46--53, March/April, 2001

[McIlrait 2002] McIlrait S., Fadel R., *Planning with Complex Actions,* Proceedings of AIPS 2002 Workshop on Exploring Real World Planning, Tolouse, France, April 2002

[Naveen 1997] Naveen A., Knoblock G. A., Levy A.Y., *Information Gathering Plans with Sensing Actions,* in Recent Advances in AI Planning: Proceedings of European Conference on Planning ECP97, Springer-Verlag, New York, 1997

[PDDL2.1] Fox M., Long D. editors, *PDDL 2.1: Planning Domain Description Language* http://www.dur.ac.uk/d.p.long/IPC/pddl.html

[Sahuguet 1999] Sahuguet A., Azavant.F. *WysiWyg Web Wrapper Factory*. In WWW8, 1999.

[Smith 2001] Stephen F. Smith S.F., Hildum D., Crim D. *Toward the Design of Web-based Planning and Scheduling Services*, Proceedings of the ECP/PLANET Workshop on Automated P&S in New Methods of Electronic, Mobile, and Collaborative Work, Toledo, Spain, September 2001,

[Thakkar 2002] Thakkar S., Knoblock G.A., Ambite J.L., and Shahabi C., *Dynamically Composing Web Services from On-line Source,* Workshop on Intelligent Service Integration, AAAI02, Edmonton, Alberta, Canada, 2002 , *http://www.isi.edu/info-agents/dotnet/aaaiworkshop2002.pdf*

[WebTCU] A.Milani editor, *Website of the PLANET-II Technical Coordination Unit on Planning and Scheduling for the Web*, http://www.planet-noe.org/TCUs

[WorkFlow-Roadmap 2003] D. Borrajo Editor, *Planet Workflow Management R&D Roadmap*, PLANET-II Technical Coordination Unit on Workflow Management, February 2003, available on line at http://www.planet-noe.org/TCUs

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