# PSMs do IT!*

Summary of track on Sharable and Reusable Problem-Solving Methods of the 10th KAW'96, Banff, Canada

V. Richard Benjamins

*University of Amsterdam, Social Science Informatics (SWI), Roetersstraat 15, NL-1018 WB Amsterdam, The Netherlands*
*and*
*Artificial Intelligence Research Institute (IIIA), CSIC, Campus UAB, 08193 Bellaterra, Barcelona, Spain, E-mail: richard@iiia.csic.es*

Dieter Fensel

*Institute AIFB, University of Karlsruhe, D-76128 Karlsruhe, Germany, E-mail: dfe@aifb.uni-karlsruhe.de*

B. Chandrasekaran

*Laboratory for AI research, The Ohio State University, Columbus, OH 43210, USA. E-mail: chandra@cis.ohio-state.edu*

## 1 Introduction

The track on "Sharable and Reusable Problem-Solving Methods" was one of the nine tracks organised at the tenth Knowledge Acquisition Workshop (1996), Banff, Canada, and was organised by Richard Benjamins (University of Amsterdam), Dieter Fensel (University of Karlsruhe) and B. Chandrasekaran (Ohio State University). The aim of the track was to identify the commonalities and differences in the community, and to know whether the field is converging or diverging. In advance, we expected consensus at a general level, but we would not be surprised to see some fundamental differences at a closer inspection.

To let the cat out of the bag just a bit, we can say that the area of problem-solving methods (PSMs) has become quite mature and stable. And, even stronger, we think that PSMs are ready to cross the borders of the knowledge acquisition community to the IT world and be applied in real life applications.

One of the indications that the field has matured is the existence of shared terminology between the various research groups. Over the last six years, there has been terminological confusion and debate between the different groups (Karbach *et al.*, 1990). However, during KAW'96 this was not an issue anymore, to which the Sisyphus initiatives (Linster,

*To be published in the International Journal of Human-Computer Studies (Bulletin Section).

1994; Schreiber & Birmingham, 1996) probably contributed significantly. If we take the amount of consensus as a measure for maturity, then we observed that newer tracks such as "Corporate Memories" and "Ontologies" are still underway.

Although the PSM field has matured, there still remain issues to be solved before we can advertise PSMs with slogans such as "PSMs do IT with knowledge!", "PSMs do IT efficiently!", "Grab them from the web!" and "Plug and play!".

In this summary, we discuss the main topics and issues raised during the PSM track at KAW'96.

## 2 Main topics

Thirteen papers[1] have been presented at the track which can be classified into four different categories:

- development and construction of PSMs,
- describing PSMs,
- the analytic power of PSMs, and
- reuse of PSMs and their mapping to domain knowledge.

### 2.1 Development

Problem-solving methods are generally viewed as strong methods that efficiently solve problems because they make *assumptions*. Assumptions can have two purposes. First, they can simplify the application (or mapping) of a PSM to realise a task by assuming that they use a common terminological structure. Second, assumptions can weaken the problem to be solved by the PSM in order to enable efficient computation. By making increasingly more assumptions, a general method can gradually be turned into an efficient PSM. For instance, the weak method "Hill-climbing" can be transformed into a strong PSM for the diagnostic sub-task "Select a best explanation" by assuming that each hypothesis node in the domain has a neighbour node which is better (except for the maximum). Assumptions are thus important constructs for developing PSMs. Two ways were presented in the quest for assumptions. Fensel & Benjamins, 1996 provide an extensive list of assumptions used in model-based diagnosis based on a thorough literature study. Fensel *et al.*, 1996 show how (further) missing assumptions of a PSM can be hinted at by analysing failures to formally prove that the competence of a PSM, together with its assumptions, fulfill the task to be realised.

Another way to construct PSMs is to see it as a parametric design task and use the well-known Propose-Critique-Modify method (Chandrasekaran, 1990) to configure a PSM (ten Teije *et al.*, 1996). The components from which the PSM is configured are parameters that characterise the diagnostic solution (such as whether it needs to cover the observations,

[1] The proceedings of KAW'96 are available at
`http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html`

or need only be consistent with them). A configured PSM corresponds to all parameters having a value, and is executable by a theorem prover.

## 2.2 Describing PSMs

The approaches presented, all distinguish explicitly the notion of PSM (e.g. PROTÉGÉ (Molina *et al.*, 1996), CommonKADS (Beys *et al.*, 1996), EXPECT (Gil & Melz, 1996), KSM (Molina *et al.*, 1996), New KARL (Angele *et al.*, 1996)), which is something the field has achieved in the last four years. Before that, PSMs were only implicitly present in the various modelling approaches and compiled out in fixed task decompositions.

Another achievement is that many approaches work on the operationalisation of PSMs, that is, to make them executable (EXPECT, KSM, PROTÉGÉ, New KARL). After all, PSMs can only do IT, if they actually run on a computer.

## 2.3 Analytic power

PSMs are born at the Knowledge Level (Newell, 1982) and it is well known that knowledge-level models greatly help in analysing problem solving. Motta (Motta & Zdrahal, 1996) gave an excellent illustration of this by presenting five versions of the Propose & Revise method applied to the VT domain. An interesting result of this work is that it identified holes in the knowledge. Observing that a PSM does not work as it should, is less serious if you know *why* it does not work. In that sense "(identifying the lack of) knowledge is power!" Zdrahal (Zdrahal & Motta, 1996) showed how these knowledge holes can be taken care of by using case-based reasoning. Also EXPECT (Gil & Melz, 1996) provides mechanisms to track down missing knowledge and errors. Moreover, it suggests remedies to repair them.

## 2.4 Reuse and mapping to domain

One of the most promising aspects of PSMs is their reuse. Reuse of PSMs enables the reduction of KBS development costs considerably (keeping in mind, however, the tradeoff between usability and reusability (Klinker *et al.*, 1991)). There were several interesting papers about reuse of PSMs. One paper (Molina & Shahar, 1996) showed how a PSM, originally developed for a temporal abstraction task in a clinical domain, could be reused for a linear abstraction task in a traffic domain. The main conclusion is that reuse is non-trivial but do-able. Another paper gave a detailed account of how a library with reusable PSMs (Benjamins, 1995) was used in the construction of a problem solver for a real life application at Unilever (Speel & Aben, 1996). Here the main conclusion was that such a library is extremely helpful.

A basic question underlying the two papers mentioned above is "why can we reuse a PSM?" Beys *et al.*, 1996 focussed exactly on this issue and investigated the role of *task-neutrality* in reuse. In general, a PSM can be used if its assumptions are satisfied in a specific application. If a PSM can also be applied (i.e. reused) in another application (which may involve a different task and domain), then obviously these two domains have something in common which underlies both applications. This commonality is what task-neutral assumptions aim to capture. For example, a PSM might assume that a domain relation is asymmetric (e.g. if A causes B, then B cannot cause A), which might hold in very different domains.

Once we know that we can reuse a PSM in a new application, a mapping has to be established between the two, and if necessary, the PSM needs to be adapted (Fensel *et al.*, 1996 speak about "adaptors"). In most approaches, such mappings are performed manually and require considerable effort (Coelho & Lapalme, 1996). An exception is the paper of Beys *et al.*, 1996, where an approach is proposed to partially automate the mapping. A complicating factor in this mapping process is that PSMs can be hierarchically organised with general and specific PSMs, where the general ones possibly subsume the specific ones. This raises the question of how their respective domain mappings relate to one another. As pointed out by Studer *et al.*, 1996, mappings must not only be established between methods and domain knowledge but also between methods and tasks. Even worse, these mappings have to be recursively established between subtasks of a method and the PSMs that perform these subtasks.

Mappings to domain knowledge involve domain ontologies. This constituted the reason to organise a special meeting between the Ontology and PSM track. However, once again it turned out that a common terminological basis (an ontology ☺) is a requirement for fruitful discussion. The only consensus reached, concerned the role of representational ontologies such as the Frame Ontology (Gruber, 1993) in reuse.

## 3 Conclusions

All in all, we can say that there was considerable consensus on the topics that arose during the PSM track. There exists a fairly consistent corporate memory in the community of how to develop/construct problem-solving methods, how to describe them, how to use them for analytic purposes, and how to reuse and map them to domain knowledge.

Last but not least, during a special meeting with the Internet track, several researchers revealed plans to put their PSMs on the World Wide Web[2]. For example, there will be a project to make the CommonKADS library (Breuker & van de Velde, 1994), in executable form, available on the web. This will be a good opportunity to cross the borders of the knowledge acquisition community. It will also give rise to the investigation of important issues such as the combination and integration of problem-solving methods coming from different sites. By the year 2000, we will probably know whether PSMs can survive in cyber space.

## Acknowledgement

Richard Benjamins is supported by the Netherlands Computer Science Research Foundation with financial support from the Netherlands Organisation for Scientific Research

[2]The Sisyphus-IV initiative will collect pointers to research groups that put KA relevant material on the web. See `http://ksi.cpsc.ucalgary.ca:80/KAW/`

(NWO), and by the European Commission through a Marie Curie Research Grant (TMR). Chandrasekaran's work in the preparation of this report was supported by US Defense Advanced Research Projects Agency and monitored by Office of Naval Research, grant no. N00014-96-1-0701.

## References

ANGELE, J., DECKER, S., PERKUHN, R., & STUDER, R. (1996). Modeling problem-solving methods in new karl. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 1.1–1.18, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

BENJAMINS, V. R. (1995). Problem-solving methods for diagnosis and their role in knowledge acquisition. *International Journal of Expert Systems: Research and Applications*, 8(2):93–120.

BEYS, P., BENJAMINS, V. R., & VAN HEIJST, G. (1996). Remedying the reusability-usability tradeoff for problem-solving methods. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 2.1–2.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

BREUKER, J. & VAN DE VELDE, W., editors (1994). *CommonKADS Library for Expertise Modeling.* Amsterdam, The Netherlands, IOS Press.

CHANDRASEKARAN, B. (1990). Design problem solving: A task analysis. *AI Magazine*, 11:59–71.

COELHO, E. & LAPALME, G. (1996). Describing reusable problem-solving methods with a method ontology. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 3.1–3.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

FENSEL, D. & BENJAMINS, V. R. (1996). Assumptions in model-based diagnosis. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 5.1–5.18, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

FENSEL, D., SCHÖNEGGE, A., GROENBOOM, R., & WIELINGA, B. (1996). Specification and verification of knowledge-based systems. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 4.1–4.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

GIL, Y. & MELZ, E. (1996). Explicit representations of problem-solving strategies to support knowledge acquisition. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 6.1–6.19, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

GRUBER, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition*, 5:199–220.

KARBACH, W., LINSTER, M., & VOSS, A. (1990). Models, methods, roles and tasks: Many labels - one idea? *Knowledge Acquisition*, 2(4):279–300.

Klinker, G., Bhola, C., Dallemagne, G., Marques, D., & McDermott, J. (1991). Usable and reusable programming constructs. *Knowledge Acquisition*, 3:117–136.

Linster, M. (1994). Sisyphus'91/92: Models of problem solving. *Int. J. of Human Computer Studies*, 40(3). Editorial special issue.

Molina, M. & Shahar, Y. (1996). Problem-solving method reuse and assembly: From clinical monitoring to traffic control. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 7.1–7.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

Molina, M., Shahar, Y., Cuena, J., & Musen, M. A. (1996). A structure of problem-solving methods for real-time decision support: Modeling approaches using protégé-ii and ksm. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 8.1–8.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

Motta, E. & Zdrahal, Z. (1996). Parametric design problem solving. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 9.1–9.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

Newell, A. (1982). The knowledge level. *Artificial Intelligence*, 18:87–127.

Schreiber, A. T. & Birmingham, W. P. (1996). The Sisyphus-VT initiative. *International Journal of Human-Computer Studies*. Editorial special issue.

Speel, P.-H. & Aben, M. (1996). Applying a library of problem solving methods on a real-life task. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 10.1–10.21, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

Studer, R., Eriksson, H., Gennari, J., Tu, S., Fensel, D., & Musen, M. (1996). Ontologies and the configuration of problem-solving methods. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 11.1–11.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

ten Teije, A., van Harmelen, F., Schreiber, A. T., & Wielinga, B. (1996). Construction of problem-solving methods as parametric design. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 12.1–12.20, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.

Zdrahal, Z. & Motta, E. (1996). Improving competence by integrating case-based reasoning and heuristic search. In Gaines, B. R. & Musen, M. A., editors, *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, pages 13.1–13.12, Alberta, Canada. SRDG Publications, University of Calgary. http://ksi.cpsc.ucalgary.ca:80/KAW/KAW96/KAW96Proc.html.