Lessons Learned from Developing an On-line Constraint Programming Course

Helmut Simonis*

Cork Constraint Computation Centre
Department of Computer Science, University College Cork, Ireland
h.simonis@4c.ucc.ie

This talk describes some of the lessons learned from developing an on-line constraint programming course based on ECLiPSe [6]. The course consists of more than 15 video lectures, slides, handouts and exercises and is available from `http://4c.ucc.ie/~hsimonis/ELearning/index.htm` under a Creative Commons “Attribution-Non commercial-Share Alike” license.

The most important question in developing the course was “What can be left out?”. Constraint programming is a wide area of research, with many interesting results for particular aspects of the field. ECLiPSe as a platform contains a multitude of constraint solvers, and is very well suited to developing new constraints or hybrid combinations of constraint solving techniques. We decided to concentrate on the finite domain solver and solution techniques based on global constraints, and to describe other solvers and hybrid techniques only in passing.

The key concepts we tried to introduce are

- basic structure of constraint programs
- global constraints
- controlling search
- optimization
- symmetry breaking
- choosing the right model
- limits of propagation

The course is focused on *programming* with constraints, showing the complete source code for each example problem, and discussing modelling alternatives. This is important to give students enough exposure of the actual programming to get them started with writing programs themselves.

For a number of the examples, new implementations of global constraints had to be provided in ECLiPSe, Kish Shen and myself added implementations of *alldifferent*, *gcc*, *lex-ordering*, *bin packing*, *sequence*, *inverse* and others. This task was made much easier by the existing infrastructure in ECLiPSe to add new constraints, and the very useful graph algorithms library.

As well as describing key concepts of finite domain constraint programming, we tried to give examples of application types that can be handled competitively with constraint programming. Besides classical puzzles (send + more =

* This work was supported by Science Foundation Ireland (Grant Number 05/IN/I886). Support from Cisco Systems and the Silicon Valley Community Foundation is gratefully acknowledged.

money, nqueens, sudoku) we look at balanced incomplete block designs, the progressive party problem, sports scheduling, routing and wavelength assignment, car sequencing, costas arrays and optical network design. For some of the problems, the results were good enough to be published as standalone papers [3,2,4]. The course also contains chapters on a general overview of industrial constraint applications and on specific network applications.

Another important aspect of the course is the use of visualization to explain the behavior of the constraint programs at every step. Together we my colleague Paul Davern we developed a number of new tools for the visualization of variables, constraints and the search tree. Rather than linking them tightly into the ECLiPSe platform, we decided to use a solver-independent intermediate format that allows us to reuse the tools with minimal effort in other constraints systems. A sample integration with CP-Inside [1] has already been implemented.

References

1. Jacob Feldman, Eugene C. Freuder, and James Little. CP-INSIDE: Embedding constraint-based decision engines in business applications. In van Hoeve and Hooker [5], pages 323–324.
2. Helmut Simonis. A hybrid constraint model for the routing and wavelength assignment problem, 2009. submitted for publication, `http://4c.ucc.ie/~hsimonis/rwa.pdf`.
3. Helmut Simonis. Progress on the progressive party problem. In van Hoeve and Hooker [5], pages 328–329.
4. Helmut Simonis. Solving the static design routing and wavelength assignment problem. In *CSCLP 2009*, Barcelona, Spain, June 2009.
5. Willem Jan van Hoeve and John N. Hooker, editors. *Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems, 6th International Conference, CPAIOR 2009, Pittsburgh, PA, USA, May 27-31, 2009, Proceedings*, volume 5547 of *Lecture Notes in Computer Science*. Springer, 2009.
6. M. Wallace, S. Novello, and J. Schimpf. ECLiPSe : A platform for constraint logic programming. *ICL Systems Journal*, 12(1), May 1997.