47844 – Optimization, Logic and Constraints

Instructor: Willem-Jan van Hoeve

http://www.andrew.cmu.edu/user/vanhoeve/

vanhoeve@andrew.cmu.edu

The main theme of this course is to model and solve combinatorial (optimization) problems with constraint programming. Constraint programming has its roots in artificial intelligence, logic programming, and operations research. Its main strengths are a rich modeling language, efficient solution techniques, and a flexible solving scheme. It has been successfully applied to difficult real-world problems, including workforce rostering, chip verification, sports scheduling, and vehicle routing. The course teaches the fundamental concepts underlying constraint programming, algorithmic techniques, applications, limitations, and the relation to similar solutions methods such as mathematical programming.

Objectives

The objectives of this course are to

- understand the fundamental concepts underlying constraint programming,
- in order to model and solve combinatorial problems;
- design, apply, and evaluate various search strategies;
- design, apply, and evaluate domain filtering algorithms for various structured constraints;
- diagnose applications w.r.t. the merits and limitations of constraint programming.

Plan

1. Introduction, motivation, examples
2. Basic principles: variables, domains, constraints, modeling and solving
3. Inference: domain filtering, consistency notions, constraint propagation
4. Search: variable and value ordering, branching strategies, search tree traversal, phase transitions, randomization
5. Specialized domain filtering algorithms: alldifferent, edge-finder, knapsack, regular, sequence
6. Hybrid solutions methods: integration with mathematical programming

Note 1: This is a tentative plan; topics may be added or omitted.
Note 2: In addition to the lectures, the plan is to see the theory also in action, using practical exercises. The exercises will be calibrated to the programming skills of the students.

Examination

There will be no final written test. Evaluation is based on participation in class and assignments.

Schedule

The course takes place during Mini-1 (08/27/2007 - 10/15/2007). Classes are on Monday and Wednesday, from 8:30-10:20am, in Posner Hall 227.

Reading

Although there exist several textbooks on constraint programming, each of them only covers a subset of topics from this course. Therefore we will not follow any textbook. Instead the material will be covered by hand-outs, lecture notes, and selected articles.

For background reading, the following resources may be useful:

- John Hooker. Logic-Based Methods for Optimization: Combining Optimization and Constraint Satisfaction. Wiley, 2000. ISBN 978-0-471-38521-9
- Roman Barták. Online Guide to Constraint Programming.
  `http://kti.mff.cuni.cz/~bartak/constraints/index.html`
- W.-J. van Hoeve and I. Katriel. Global Constraints. Chapter 6 of F. Rossi, P. van Beek and T. Walsh (eds.), Handbook of Constraint Programming, Elsevier 2006.
  `http://www.andrew.cmu.edu/user/vanhoeve/papers/chapter.pdf`
- F. Rossi, P. van Beek, and Toby Walsh (editors). Handbook of Constraint Programming. Elsevier, 2006. ISBN 0-444-52726-5
- Krzysztof R. Apt. Principles of Constraint Programming. Cambridge University Press, 2003. ISBN 0-521-82583-0
- Rina Dechter. Constraint Processing. Morgan Kaufmann, 2003. ISBN 1-55860-890-7