Principles of Constraint Programming

Krzysztof R. Apt

Chapter 1
Introduction

Constraint Programming

- Alternative approach to programming.
- It relies on a combination of **reasoning** and **computing**.
- **Constraint** on a sequence of variables: a relation on their domains.
- **Constraint Satisfaction Problem** (**CSP**): a finite set of constraints.

Constraint programming **approach** to programming:

- **Formulate** your problem as a CSP (**modeling**).
- **Solve** the chosen representation using
  - **domain specific methods**,

  or

  - **general methods**.

Solving CSP's

- determine whether it has a solution (is **consistent**),
- find a solution,
- find all solutions,
- find an **optimal** solution,
- find all **optimal** solutions.

Domain Specific Methods

Special purpose algorithms (**constraint solvers**).

Examples:

- Program for solving systems of **linear equations**,
- Package for **linear programming**,
- Implementation of the **unification algorithm**.

General Methods

- **constraint propagation algorithms**,
- **search methods**.

Basic Characteristics of Constraint Programming

- **Two phase** programming process:
  - **Generation** of a problem representation as a CSP,
  - **Solution** of it.
- **Flexible representation**:
  constraints can be added, removed or modified.
- **Support** in the form **built-ins** that deal with
  - constraint solvers,
  - constraint propagation algorithms,
  - search methods.

Applications

- **interactive graphic systems** (to express geometric coherence in the case of scene analysis),
- **operations research problems** (various optimization problems),
- **molecular biology** (DNA sequencing, construction of 3D models of proteins),
- **business applications** (option trading),
- **electrical engineering** (location of faults in the circuits, computing the circuit layouts, testing and verification of the design),
- **numerical computation** (solving polynomial constraints with guaranteed precision),
- **natural language processing** (construction of efficient parsers),
- **computer algebra** (solving and/or simplifying equations over various algebraic structures).

Some Recent Applications

- generation of coherent music radio programs,
- software engineering applications (design recovery and code optimization),
- selection and scheduling of observations performed by satellites.

Course Outline

- Constraint Satisfaction Problems: Examples
- Constraint Programming in a Nutshell
- Some Complete Constraint Solvers
- Local Consistency Notions
- Some Incomplete Constraint Solvers
- Constraint Propagation Algorithms
- Search