Chapter 1: Introduction

Helmut Simonis

Cork Constraint Computation Centre
Computer Science Department
University College Cork
Ireland

ECLiPSe ELearning
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Outline

1. Constraint Programming
2. Chapter Overview
3. Chapter Details
What we want to introduce

- Constraint Programming
- Using ECLiPSe Language
- With Saros Eclipse IDE
Outline

1. Constraint Programming
2. Chapter Overview
3. Chapter Details
Constraint Programming (CP)

- Solve hard combinatorial problems
- With minimal programming effort
- Exploit strategies and heuristics
- Understand and control problem solving
ECLiPSe Language

- Open source constraint programming language
- Flexible toolkit to develop/use constraints
- Contains different constraint solvers
- Here: Use of finite domains/(mixed) integer programming
Aims and Outcomes

- Understand what constraint programming is
- How constraint programs can be applied to a problem
- Which application problems are good candidates for CP
- How to write/run/analyze simple ECLiPSe programs
You should already know about...

- No hard requirements
- Basic understanding of programming assumed
- Useful to have some background in one of:
  - Network Management
  - Integer Programming
  - Combinatorial Optimization
## Choices of materials

<table>
<thead>
<tr>
<th>Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slides</strong></td>
<td>PDF files for computer viewing</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td><strong>Handout</strong></td>
<td>PDF files for printing</td>
</tr>
<tr>
<td></td>
<td><em>2 slides per page</em></td>
</tr>
<tr>
<td></td>
<td><em>Does not contain all animations</em></td>
</tr>
<tr>
<td><strong>Transcript</strong></td>
<td>Text of presentation as articles</td>
</tr>
<tr>
<td><strong>Video</strong></td>
<td>Video presentation with audio (640x480 pixels)</td>
</tr>
<tr>
<td><strong>iPhone</strong></td>
<td>Video presentation tuned for iPhone display (480x320 pixels)</td>
</tr>
<tr>
<td><strong>Wiki</strong></td>
<td>Hyperlink to wiki page on this chapter to add comments, corrections and suggestions</td>
</tr>
</tbody>
</table>
Outline

1. Constraint Programming
2. Chapter Overview
3. Chapter Details
<table>
<thead>
<tr>
<th>Chapters</th>
<th>Video</th>
<th>iPhone</th>
<th>Slides</th>
<th>Handout</th>
<th>Wiki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction (You are here)</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>First Steps - Hello World</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Application Overview</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Basic Constraint Reasoning</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Global Constraints</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Search Strategies</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Optimization</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Symmetry Breaking</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Choosing the Model</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Customizing Search</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Limits of Propagation</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Systematic Development</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Visualization Techniques</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Finite Set and Continuous Variables</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>Network Applications</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
<tr>
<td>More Global Constraints</td>
<td>Video</td>
<td>iPhone</td>
<td>Slides</td>
<td>Handout</td>
<td>Wiki</td>
</tr>
</tbody>
</table>
More Chapters

Using Mixed Integer Linear Programming
A Hybrid Model
Comparing Technologies
Working with Implications
Adding Material
Lessons Learned

Video  iPhone  Slides  Handout  Wiki
Video  iPhone  Slides  Handout  Wiki
Video  iPhone  Slides  Handout  Wiki
Video  iPhone  Slides  Handout  Wiki
Video  iPhone  Slides  Handout  Wiki
Video  iPhone  Slides  Handout  Wiki
Applications

Application Overview
SEND+MORE=MONEY
Sudoku
N-Queens
Routing and Wavelength Assignment
RWA - Demand Acceptance 1
RWA - Demand Acceptance 2
RWA - Static Design 2
Balanced Incomplete Block Designs
Sports Scheduling
Progressive Party
Costas Array
SONET/SDH Ring Design
Network Applications
Car Sequencing
Shikaku
Introduction

- Aims and Outcomes
- Overview of chapters
- Hyperlinks to all materials

Video  iPhone  Slides  Handout  Wiki
First Steps - Hello World

- How to install ECLiPSe and Saros
- Writing a first program
- Running the program
- Where to find information
Application Overview

- Why constraint programming is interesting
- Solving industrial problems with CP
- Main application areas
  - Assignment
  - Scheduling
  - Network problems
  - Transportation
  - Personnel Assignment
Basic Constraint Reasoning - SEND+MORE = MONEY

- Finite Domain variables
- CP: Variables + Constraints + Search
- Bounds reasoning on arithmetic constraints
- Simple visualizers
Global Constraints - Sudoku

- Modelling the Sudoku puzzle
- One model, different behaviours
- Global constraint: alldifferent
- Bounds and domain consistency
- A domain consistent alldifferent

Video  iPhone  Slides  Handout  Wiki
Search Strategies - N Queens

- How to search for a solution
- Variable and value choice
- How to avoid deep backtracking
- Partial search strategies
Optimization - Routing and Wavelength Assignment

- Optimization
- Graph algorithms library
- Integer Programming with `eplex`
- Problem decomposition
- Routing and Wavelength Assignment in Optical Networks
Symmetry Breaking - Balanced Incomplete Block Designs

- Balanced Incomplete Block Designs
- Planning Experiments and Testing Features
- Problems with highly symmetrical structure
- Symmetry Breaking with $\texttt{lex}$ constraints
Choosing the Model - Sports Scheduling

- Complex sports scheduling problem
- How to decide which model to use
- Improving reasoning by channeling
Customizing Search - Progressive Party

- Scheduling Meetings between Teams
- Teams only meet once
- Capacity Limits
- Build customized search routines tailored to problem
- Problem decomposition: decide which problem to solve
Limits of Propagation - Costas Array

- Antenna/Sonar Design
- Hard Benchmark Problem
- Naive Enumeration works best
- When clever reasoning doesn’t pay off
- Cautionary Tale
Systematic Development

- Developing Programs
- Testing
- Profiling
- Documentation
Visualization Techniques

- How to visualize constraint programs
- Variable Visualizers
- Understanding Search Trees
- Constraint Visualizers
- Complex Visualizations
Finite Set and Continuous Variables - SONET Design Problem

- Finite set variables
- Continuous domains
- Optimization from below
- Advanced symmetry breaking
- SONET design problem without inter-ring traffic
Network Applications

- Overview of Network Applications
- Traffic Placement
- Capacity Management
- Network Design
- Using Advanced Techniques
More Global Constraints - Car Sequencing

- New global constraints: \texttt{gcc} and \texttt{sequence}
- Choosing a better search strategy
Using Mixed Integer Linear Programming - RWA
Demand Acceptance 1

- Mixed Integer Linear Programming in ECLiPSe
- eplex Library
- Alternative Models for Routing and Wavelength Assignment in Optical Networks
Hybridisation by decomposition
Combination of MIP and FD solver
Best current solution to routing and wavelength assignment problem
Comparing Technologies

- Compare static design and demand acceptance versions of RWA
- See impact of objective function
- Compare finite domain, MIP and SAT solutions
Solving a placement problem without specialized constraints

Decomposition into pattern generation and set partitioning

Using implications to propagate information
Adding Material

- How to add new chapters
- Copying template files
- Configuring templates
- Adding frames to body
- Integrating with other chapters
Lessons Learned

- New ELearning course for ECLiPSe
- Modelling and programming with constraints
- Based on sample problems solved and explained in detail
- A view on core constraint programming skills
- Strong dependence on visualization to explain behavior
Branch from here to all materials
Choose presentation form which suits you