Chapter 1: Introduction

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ECLiPSe ELearning

Overview
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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

**Slides**  PDF files for computer viewing
- Contains animations of visualization
- Large file sizes

**Handout**  PDF files for printing
- 2 slides per page
- Does not contain all animations

**Video**  Video presentation with audio (640x480 pixels)

**iPhone**  Video presentation tuned for iPhone display (480x320 pixels)
Outline

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2. Chapter Overview
3. Chapter Details
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More Chapters

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

1. Constraint Programming
2. Chapter Overview
3. Chapter Details
Introduction

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

Video iPhone Slides Handout
First Steps - Hello World

- How to install ECLiPSe and Saros
- Writing a first program
- Running the program
- Where to find information
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: \texttt{alldifferent}
- Bounds and domain consistency
- A domain consistent \texttt{alldifferent}
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 $\text{lex}$ 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: gcc and 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
A Hybrid Model - RWA Demand Acceptance 2

- 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
Working with Implications - Shikaku

- 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
To continue

- Branch from here to all materials
- Choose presentation form which suits you