Chapter 1: Introduction

Helmut Simonis

Cork Constraint Computation Centre
Computer Science Department
University College Cork
Ireland

ECLiPSe ELearning Overview

Licence

Outline

What we want to introduce

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

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

Transcript Text of presentation as articles

Video Video presentation with audio (640x480 pixels)

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

Wiki Hyperlink to wiki page on this chapter to add comments, corrections and suggestions

Chapters

More Chapters

Using Mixed Integer Linear Programming	Video	iPhone	Slides	Handout	Wiki
A Hybrid Model	Video	iPhone	Slides	Handout	Wiki
Comparing Technologies	Video	iPhone	Slides	Handout	Wiki
Working with Implications	Video	iPhone	Slides	Handout	Wiki
Adding Material	Video	iPhone	Slides	Handout	Wiki
Lessons Learned	Video	iPhone	Slides	Handout	Wiki

Applications

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

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

Video iPhone Slides Handout Wiki

Application Overview

- Why constraint programming is interesting
- Solving industrial problems with CP
- Main application areas
  - Assignment
  - Scheduling
  - Network problems
  - Transportation
  - Personnel Assignment

Video iPhone Slides Handout Wiki

Basic Constraint Reasoning - SEND+MORE = MONEY

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

Video iPhone Slides Handout Wiki

Global Constraints - Sudoku

- Modellimg 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

Video iPhone Slides Handout Wiki

Optimization - Routing and Wavelength Assignment

- Optimization
- Graph algorithms library
- Integer Programming with `eplex`
- Problem decomposition
- Routing and Wavelength Assignment in Optical Networks

Video iPhone Slides Handout Wiki

Symmetry Breaking - Balanced Incomplete Block Designs

- Balanced Incomplete Block Designs
- Planning Experiments and Testing Features
- Problems with highly symmetrical structure
- Symmetry Breaking with `lex` constraints

Video iPhone Slides Handout Wiki

Choosing the Model - Sports Scheduling

- Complex sports scheduling problem
- How to decide which model to use
- Improving reasoning by channeling

Video iPhone Slides Handout Wiki

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

Video iPhone Slides Handout Wiki

Limits of Propagation - Costas Array

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

Video iPhone Slides Handout Wiki

Systematic Development

- Developing Programs
- Testing
- Profiling
- Documentation

Video iPhone Slides Handout Wiki

Visualization Techniques

- How to visualize constraint programs
- Variable Visualizers
- Understanding Search Trees
- Constraint Visualizers
- Complex Visualizations

Video iPhone Slides Handout Wiki

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

Video iPhone Slides Handout Wiki

Network Applications

- Overview of Network Applications
- Traffic Placement
- Capacity Management
- Network Design
- Using Advanced Techniques

Video iPhone Slides Handout Wiki

More Global Constraints - Car Sequencing

- New global constraints: `gcc` and `sequence`
- Choosing a better search strategy

Video iPhone Slides Handout Wiki

Using Mixed Integer Linear Programming - RWA Demand Acceptance 1

- Mixed Integer Linear Programming in ECLiPSe
- `eplex` Libary
- Alternative Models for Routing and Wavelength Assignment in Optical Networks

Video iPhone Slides Handout Wiki

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

Video iPhone Slides Handout Wiki

Comparing Technologies

- Compare static design and demand acceptance versions of RWA
- See impact of objective function
- Compare finite domain, MIP and SAT solutions

Video iPhone Slides Handout Wiki

Working with Implications - Shikaku

- Solving a placement problem without specialized constraints
- Decomposition into pattern generation and set partitioning
- Using implications to propagate information

Video iPhone Slides Handout Wiki

Adding Material

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

Video iPhone Slides Handout Wiki

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

Video iPhone Slides Handout Wiki

To continue

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