

# Chapter 1: Introduction

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ECLiPSe ELearning [Overview](#)



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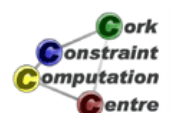
# Outline

- 1 Constraint Programming
- 2 Chapter Overview
- 3 Chapter Details



# What we want to introduce

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



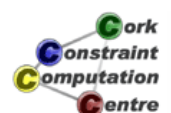
# Constraint Programming (CP)

- 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)



# Chapters

Introduction ( <b>You are here</b> )	Video	iPhone	Slides	Handout
First Steps - Hello World	Video	iPhone	Slides	Handout
Application Overview	Video	iPhone	Slides	Handout
Basic Constraint Reasoning	Video	iPhone	Slides	Handout
Global Constraints	Video	iPhone	Slides	Handout
Search Strategies	Video	iPhone	Slides	Handout
Optimization	Video	iPhone	Slides	Handout
Symmetry Breaking	Video	iPhone	Slides	Handout
Choosing the Model	Video	iPhone	Slides	Handout
Customizing Search	Video	iPhone	Slides	Handout
Limits of Propagation	Video	iPhone	Slides	Handout
Systematic Development	Video	iPhone	Slides	Handout
Visualization Techniques	Video	iPhone	Slides	Handout
Finite Set and Continuous Variables	Video	iPhone	Slides	Handout
Network Applications	Video	iPhone	Slides	Handout
More Global Constraints	Video	iPhone	Slides	Handout



## More Chapters

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

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## 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

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# Introduction

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

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[Handout](#)



# First Steps - Hello World

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

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## 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



## Basic Constraint Reasoning - SEND+MORE = MONEY

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

Video

iPhone

Slides

Handout





## Global Constraints - Sudoku

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

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## Search Strategies - N Queens

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

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# Optimization - Routing and Wavelength Assignment

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

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# 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

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## Choosing the Model - Sports Scheduling

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

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## 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

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## Limits of Propagation - Costas Array

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

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## Systematic Development

- Developing Programs
- Testing
- Profiling
- Documentation

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# Visualization Techniques

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

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# 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

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# Network Applications

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

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# More Global Constraints - Car Sequencing

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

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# Using Mixed Integer Linear Programming - RWA Demand Acceptance 1

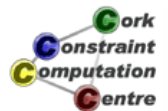
- Mixed Integer Linear Programming in ECLiPSe
- `eplex` Library
- Alternative Models for Routing and Wavelength Assignment in Optical Networks

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# 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

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## Comparing Technologies

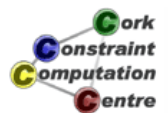
- Compare static design and demand acceptance versions of RWA
- See impact of objective function
- Compare finite domain, MIP and SAT solutions

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## Working with Implications - Shikaku

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

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## Adding Material

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

Video

iPhone

Slides

Handout



## 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



## To continue

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

