

Constraint Programming Methodology

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<https://eclipseclp.org/ELearning/index.html>

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What we want to introduce

- How does a Constraint Model fit into a bigger system
- Interaction with stakeholders
- You define what the problem is
- 12 Steps to success

Outline

The Bigger Picture

12 Steps to Success

Constraints in an Uncertain World

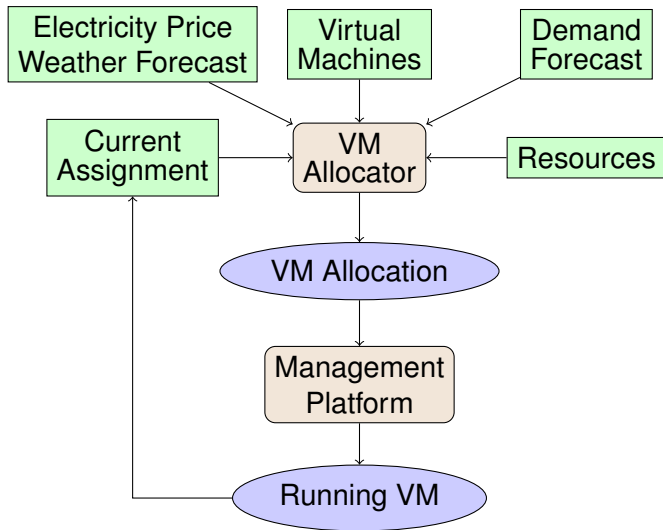
There is no “The Model”

Conclusion

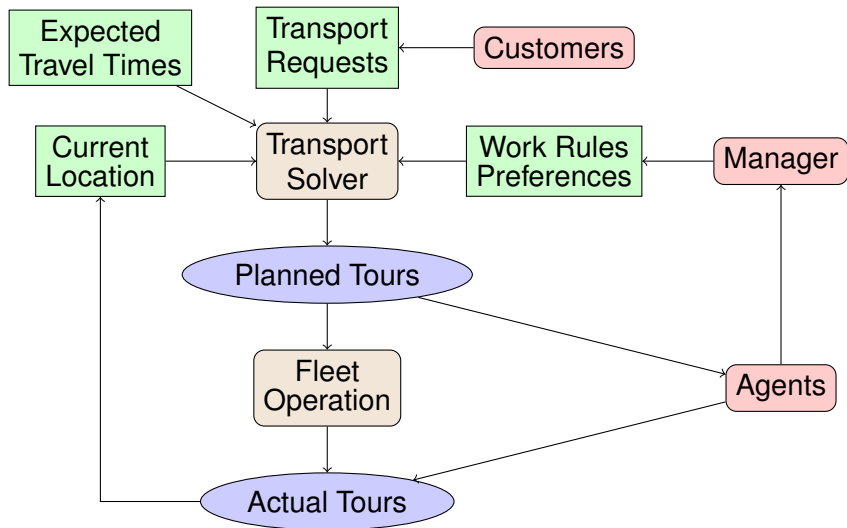
CP Model is Part of a Larger System

- Where do data come from?
- Control over data
- Generated plan
- Externalized representation of constraints
- Implementation of plan
- Feedback from previous runs

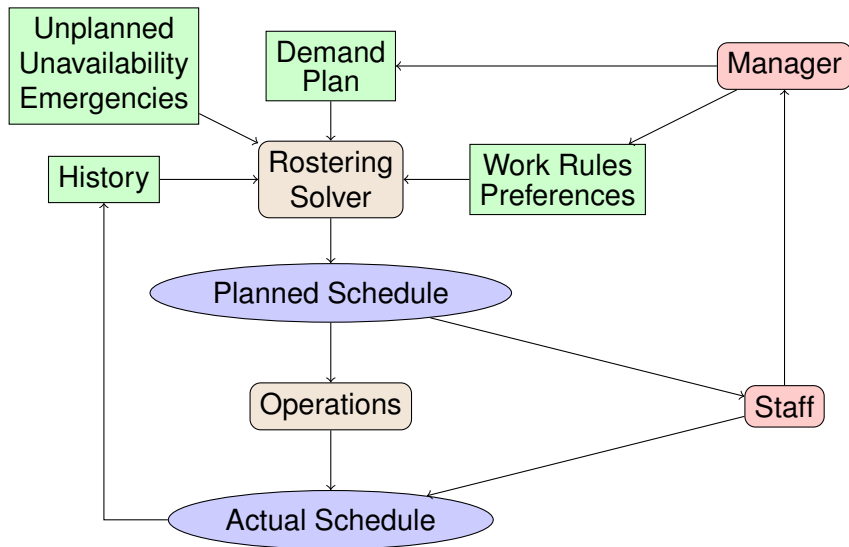
Example: Datacenter Management



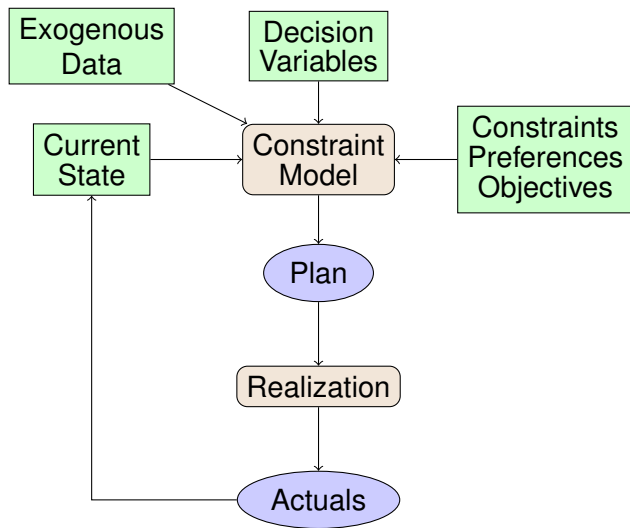
Example: Transport



Example: Personnel Rostering



The General Scheme



Key Questions: How? Who? When? Where?

- (How is work done?)
- Who performs work?
- When is it performed?
- (Where is it performed?)

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Step 1: Literature Review

- Which problem are other people solving?
- What are the favourite techniques, why?
- What tools are used?
- Learn the domain specific language

Step 2: Description of Problem

- Clearly defined use cases, ranked by importance
- Textual description of problem before math
- Important: Involve all stakeholders
- Important: Identify champions and their benefits
- State what is outside the scope

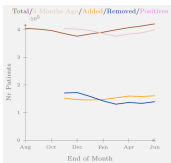
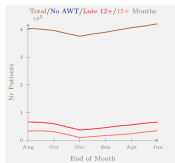
Step 3: Example Data and Solution

- Best is years of existing data and solutions
- Important: Set with manageable problem size
- Independent checker of solutions
- Possible: Trivial problem example for manual exploration

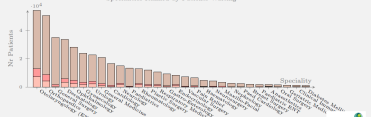
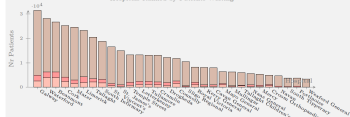
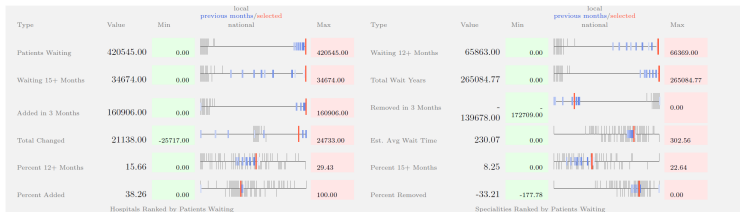
Step 4: Visualizing Results

- Develop before solver
- Visualize existing solutions
- Perhaps end-users have existing visualizations
- Generic views for classes of problems (global constraints)
- Helps to understand poor performance
- Also: Compute KPI (Key Performance Indicators)

Example Dashboard: Patient Waitlists



Date	Added	3 Month Cohort Changes						Removed	Changed
		0-3	3-6	6-9	9-12	12-15	15-18,18+		
30-11-2015	152294	-63995	-26658	-13937	-10270	-20573	-24296	-130729	-15435
31-12-2015	149984	-61886	-25250	-15200	-15377	-25957	-29039	-172709	-25717
31-1-2016	145809	-61092	-24275	-13897	-13271	-20664	-25548	-158587	-127878
30-2-2016	147995	-63521	-23644	-12972	-12727	-13298	-31608	-142230	-30788
31-3-2016	153334	-63074	-24024	-13808	-12772	-13078	-33831	-139019	-33106
30-4-2016	159832	-63769	-23898	-15315	-14835	-11920	-59072	-136814	-23018
31-5-2016	158239	-62651	-25506	-15649	-14368	-10780	-4552	-133506	24733
30-6-2016	160906	-66237	-24695	-15887	-15695	-12175	-5079	-139678	21138



OWL2 (Ireland on 30-6-2016): Created Tuesday 2nd August, 2016, at 11:24



Step 5: Implement Core Model

- One constraint type at a time
- Start with finding feasible, good solutions
- Find lower/upper bounds to estimate solution quality
- Start with basic search strategy

Step 6: Feedback from Domain Experts

- Are you solving the right problem?
- Are all stakeholders happy with solution and objectives?

Step 7: Study Obvious Alternatives

- If you have time (PhD students have time)
- Is there a straight-forward MIP/SAT model of problem?
- Do they work on small scale, large scale problems?
- Can you come up with good, feasible heuristics?

Step 8: Solve Integration Issues

- Not too early, time wasted if solver does not work
- Not too late, without integration solver is just a demonstrator

Step 9: Performance Engineering

- Problem specific search strategies
- Parallelism
- Improved model
- Improved solver
- Parameter tuning

Step 10: Fight Feature Creep

- If it works, then people want more
- Not in first release
- Implement core use case, nothing more
- Exception: Allow all constraints to be optional

Step 11: Improve Stability

- What is really required?
- Remove experimental code
- How far can we push model?
- Code review against model description
 - Allow changes in description

Step 12: Tell the World

- Dozens of good CP applications hidden from view
- Consider writing application paper
 - Involve end-users and stakeholders
 - Describe problem from their perspective
 - If possible, publish data set and constraint description
- Submit instances to solver competitions
 - Other people will work on improved performance of your model

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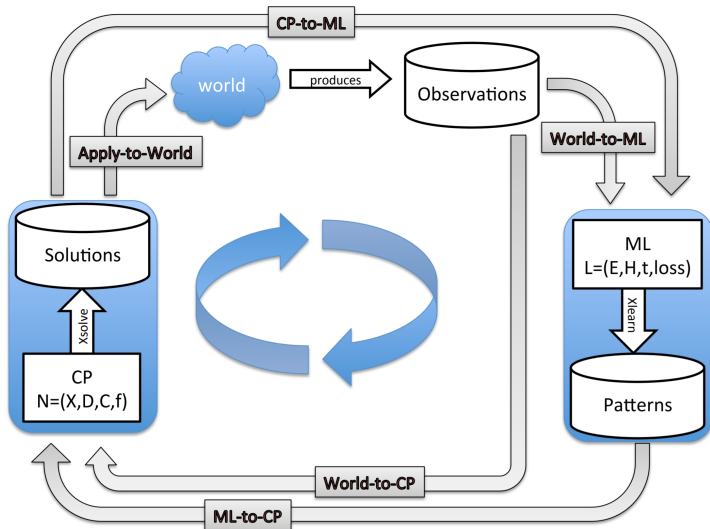
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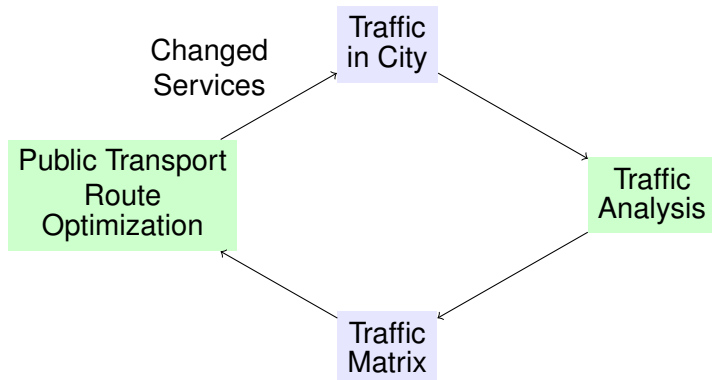
The ICON Loop



A Blueprint for Interaction

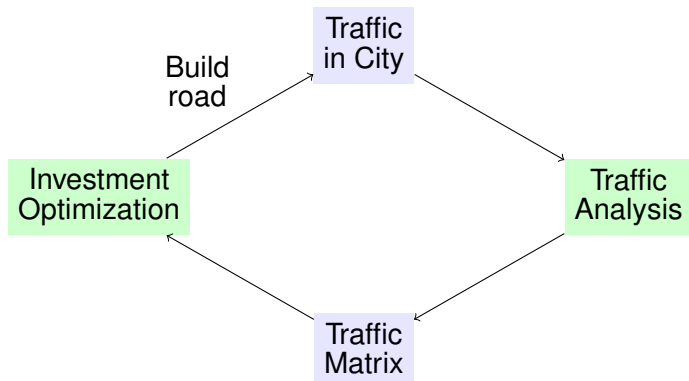
- Developed in the European ICON project
- Partners KU Leuven, Montpellier, Pisa, UCC
- Ways of combining Machine Learning with CP

Example: Intra-City Transport



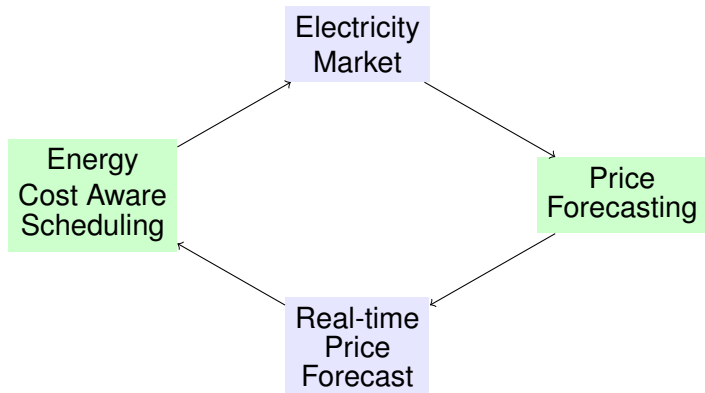
- Optimization only as good as data feeding into it

Feedback May Lead to More Traffic



- The “world” reacts to changes
- That may be difficult to predict

Reacting to Real-time Electricity Prices



- Good way to optimize cost individually
- May lead to oscillation if everybody does it

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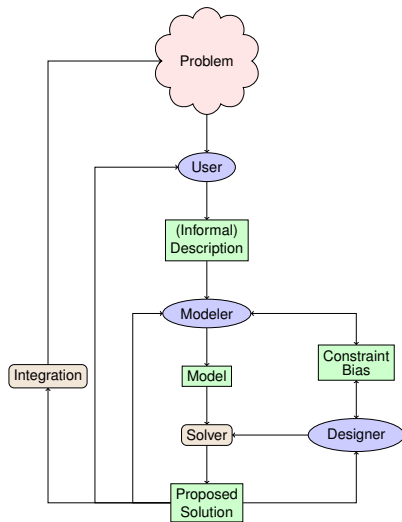
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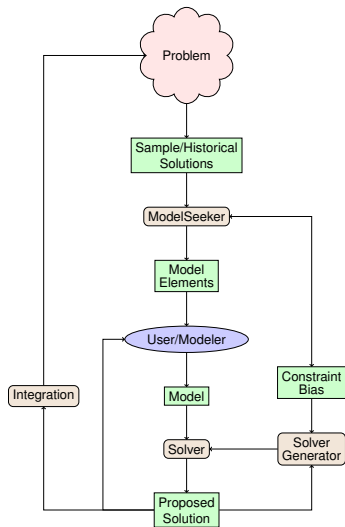
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Feedback Loops in Modelling



The Future: Automated Modelling



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Points to Remember

- A CP application is part of a larger system
- CP Model is rarely cause of project failure
 - No clear champion
 - No clear use case
 - Data not available/data quality
- Every problem is different, you decide what to model
- Understand the interaction between tools and problem