Constraint Programming Methodology

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What we want to introduce

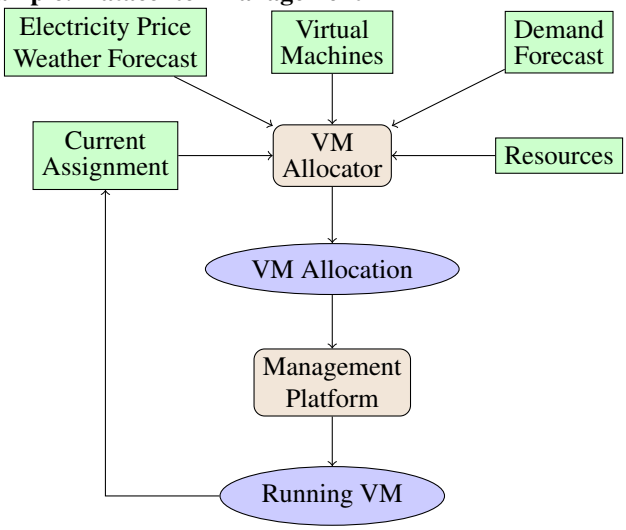
- How does a Constraint Model fit into a bigger system
- Interaction with stakeholders
- You define what the problem is
- 12 Steps to success

1 The Bigger Picture

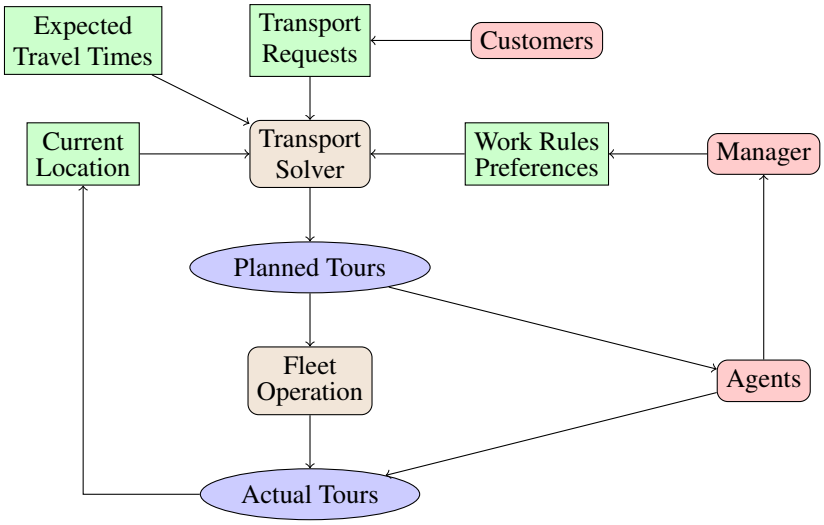
CP Model is Part of a Larger System

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

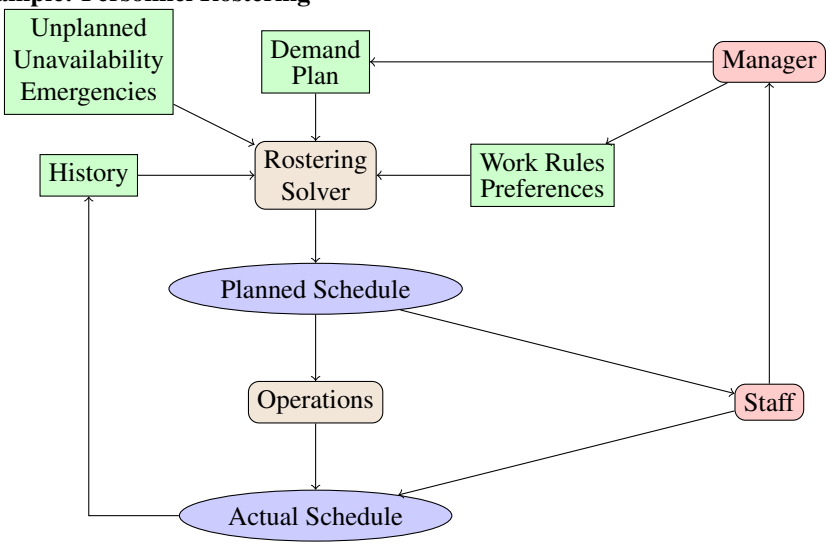
Example: Datacenter Management



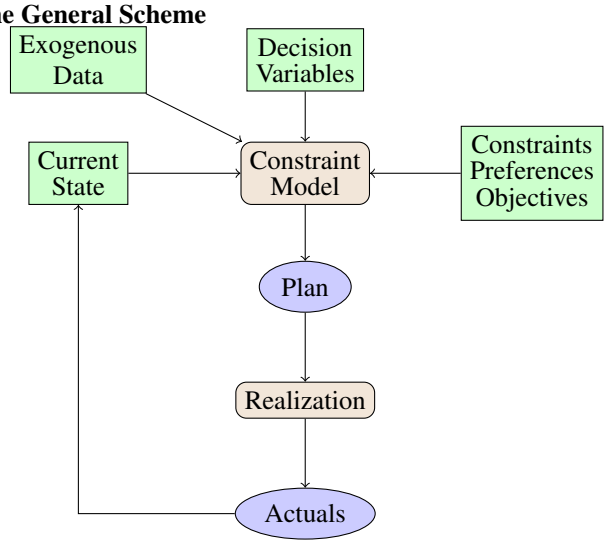
Example: Transport



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?)

2 12 Steps to Success

Step 1: Literature Review

- Which problem are other people solving?
- What are the favourite tecniques, 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

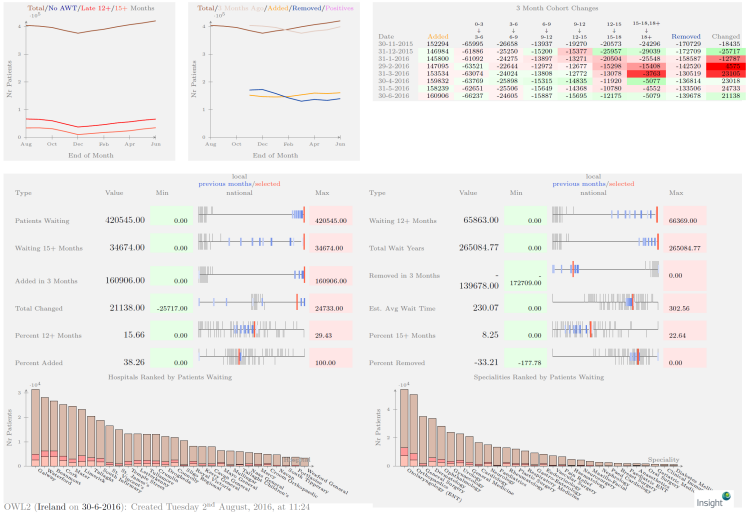
Step 3: Example Data and Solution

- 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



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

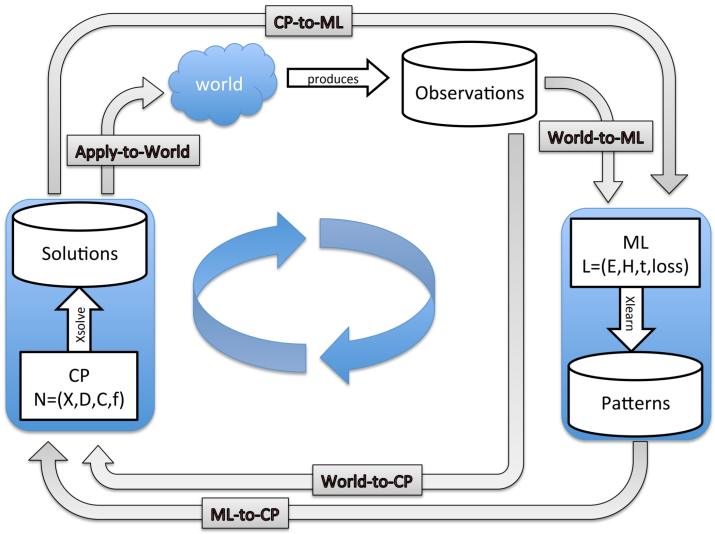
- What is really required?
- Remove experimental code
- How far can we push model?
- Code review against model description
  - Allow changes in description

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

3 Constraints in an Uncertain World

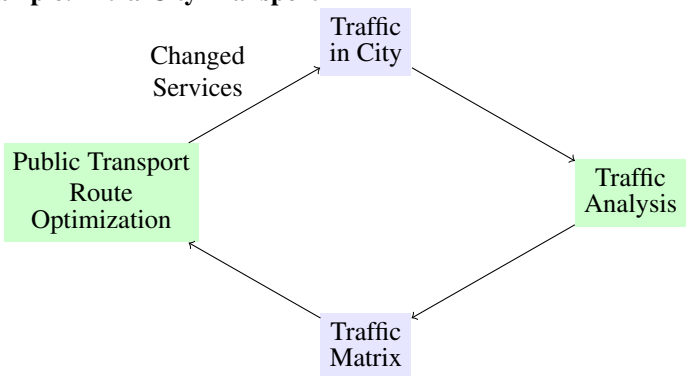
The ICON Loop



A Blueprint for Interaction

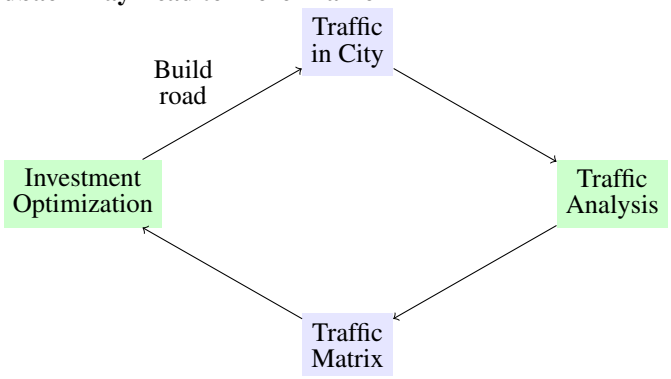
- Developed in the European ICON project
- Partners KU Leuven, Montpellier, Pisa, UCC
- Ways of combining Machine Learning with CP

Example: Intra-City Transport



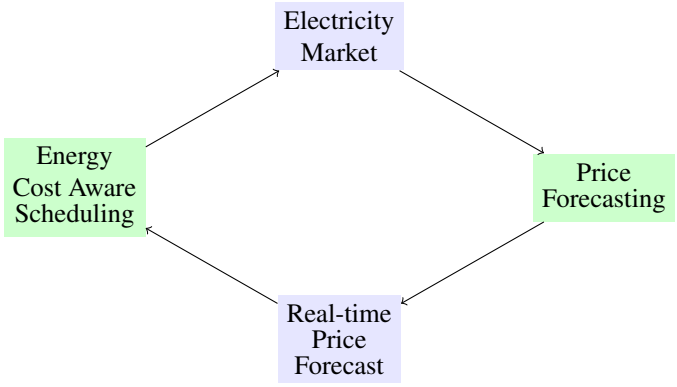
- Optimization only as good as data feeding into it

Feedback May Lead to More Traffic



- The "world" reacts to changes
- That may be difficult to predict

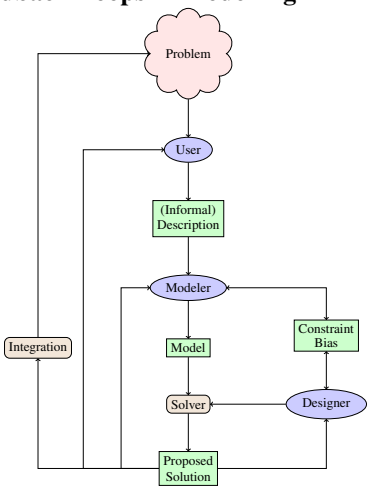
Reacting to Real-time Electricity Prices



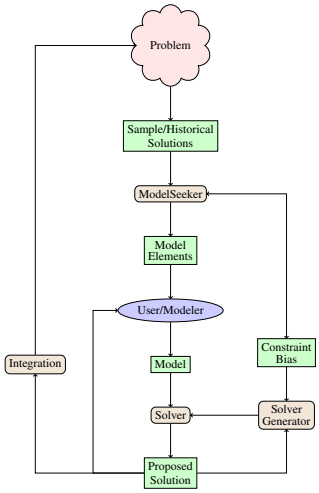
- Good way to optimize cost individually
- May lead to oscillation if everybody does it

4 There is no “The Model”

Feedback Loops in Modelling



The Future: Automated Modelling



5 Conclusion

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