

Advanced Concepts

Helmut Simonis

email: helmut.simonis@insight-centre.org
homepage: <http://insight-centre.org/>

ENTIRE EDIH
Insight SFI Centre for Data Analytics
School of Computer Science and Information Technology
University College Cork
Ireland

Constraint Based Production Scheduling

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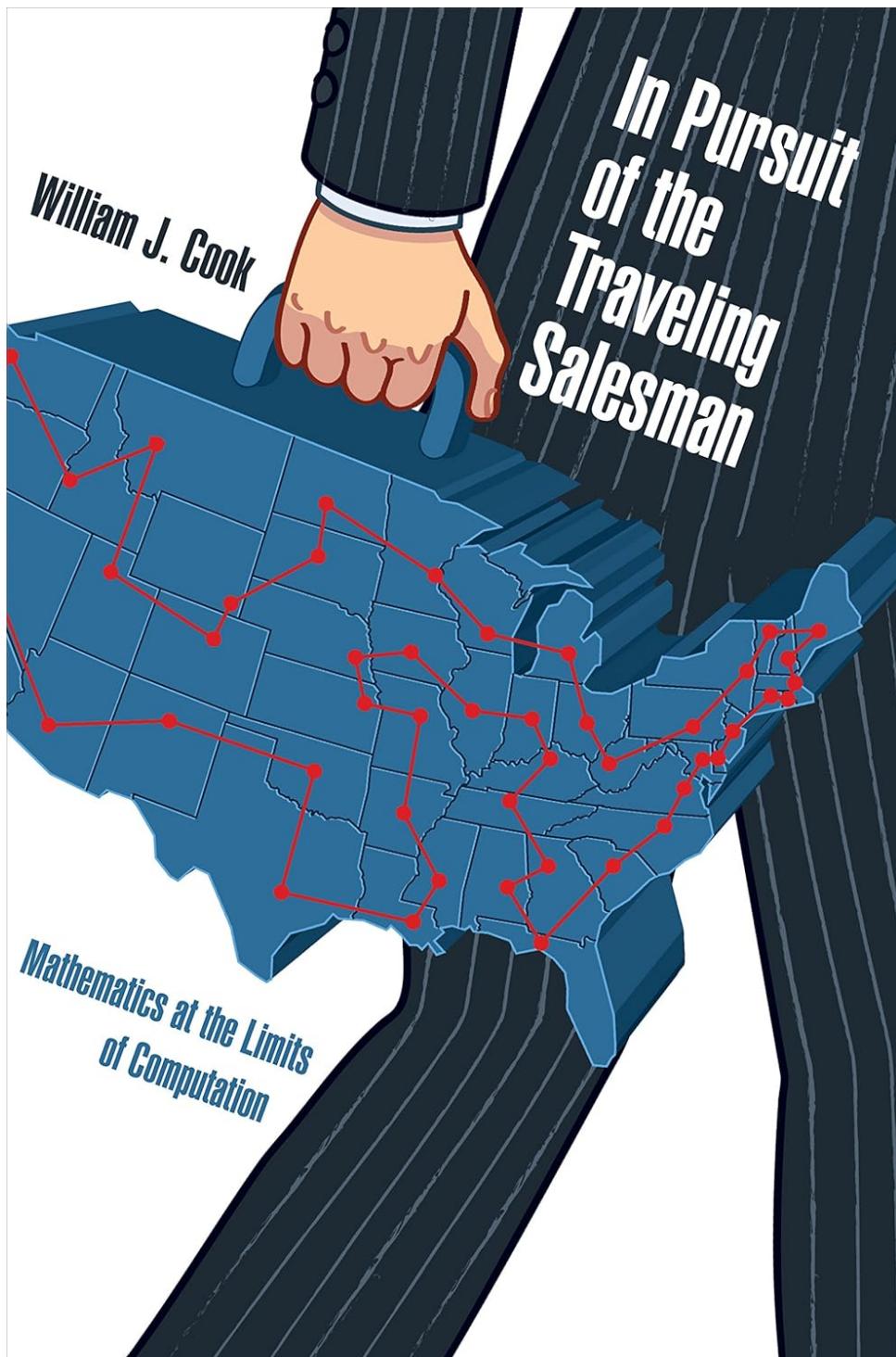
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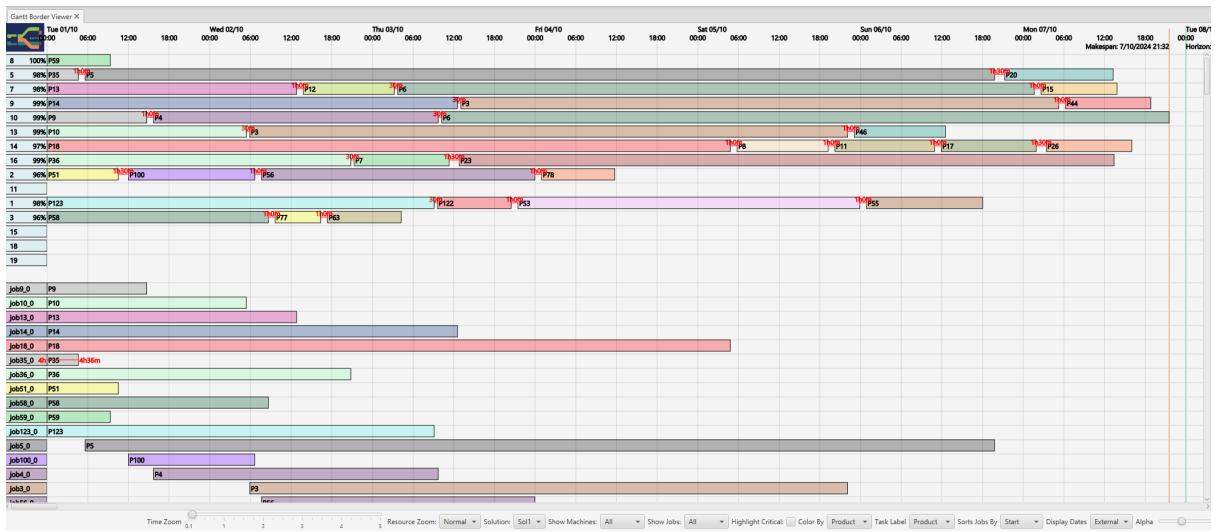
- Using a simple rule about product compatibility produces best results
- Example: dark-chocolate → milk chocolate → white chocolate → milk chocolate → dark chocolate
- Problems get more difficult when release/due dates need to be respected
- This is the equivalent to the *VRPTW* (*Vehicle Routing Problem with Time Windows*)

Xmas Shopping Hint

- W. Cook. In Pursuit of the Travelling Salesman. Princeton University Press, 2011
- Entertaining general science presentation of the TSP and related issues



Setup Times Constraints can be Included in Model



- Shown in Machine Gantt chart, enable display in Layout tab
- So far, only in CPO, not in CPSat model

Related Problem: Forbidden Transitions X

- For safety reasons, it may be forbidden to change from some product to some specific other products
- Contamination risk is considered too high
- Examples
 - In food production: Is this product peanut free?
 - In food production: Directly changing from dark to white chocolate is not allowed
 - In chemical plants: Contamination may lead to explosions
- These transitions are called *forbidden*, and must be avoided
- Careful, it is easy to paint yourself into a corner!

2 Transportation Time

Dealing with Transportation Times

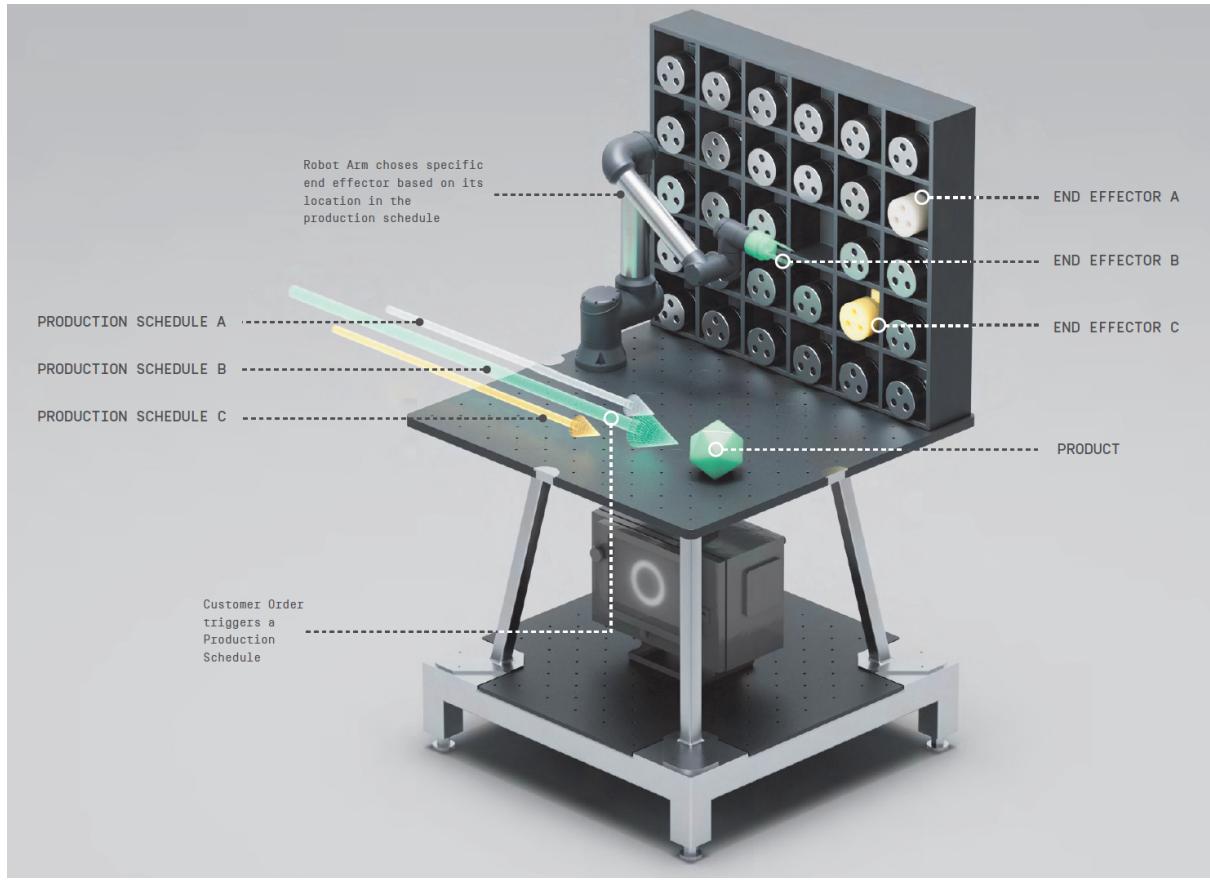
- Really two different problems
 - In one, the resources are in fixed locations, and we transport the jobs between the locations
 - In the other, the tasks are in fixed locations, and we transport the resources between them

2.1 Transportation of Materials

Transportation of Jobs

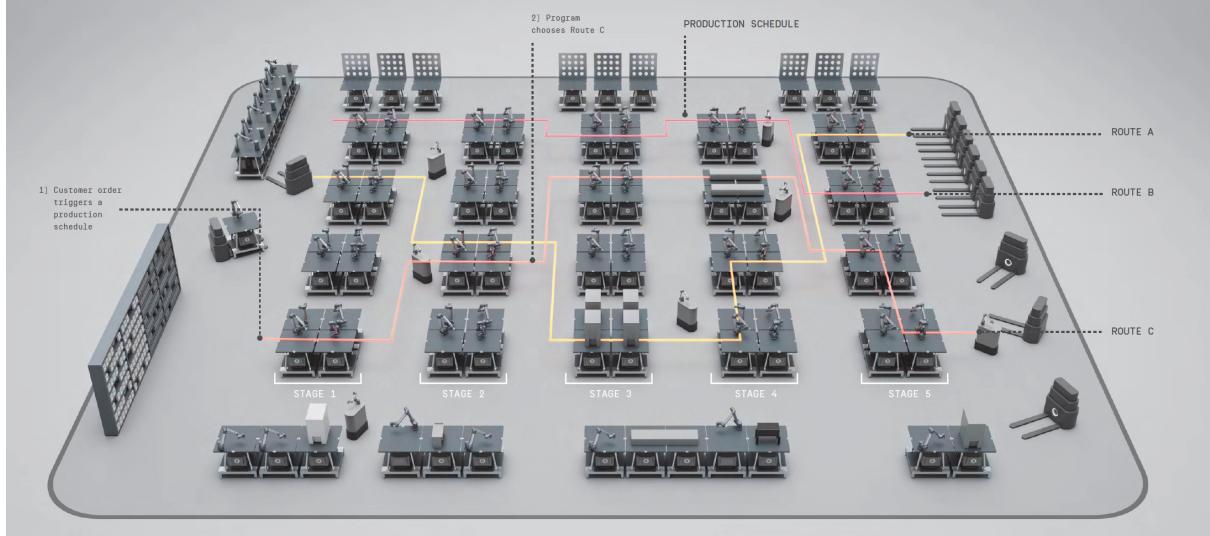
- Example from a project with J&J in Limerick
- Considering a *factory of the future* based on agile machines
- Robots that can be configured to perform many different tasks
- These robots may be inside one or more factories

- How to arrange them to minimize impact of transport on production



from J&J

Layout of Factor in Matrix Form



- Materials are transported between stations by moving robots
- Layout of factory determines delay caused by transport

Inclusion in Model (✓)



(from ACP Website <http://cp2016.a4cp.org/program/acp-challenge/>)

2.2 Transportation of Resources/Personnel

Scheduling Service Visits X

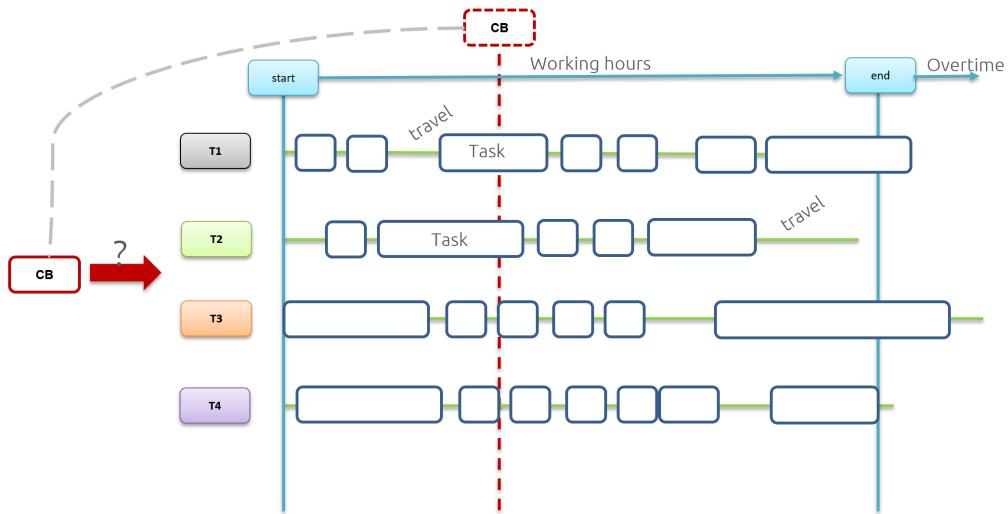
- Based on a project with UTRC-I, UTRC, OTIS
- Schedule visits to maintain equipment installed in customer premises
- Resources are the service engineers
- They have to travel between locations and perform work there
- The tasks are the maintenance operations required to keep equipment working
- Also called *Traveling Repair-person Problem*

Planning Maintenance Visits for Service Personnel



- Include single day trips, multi-day tours
- Most of the time spent at customer locations

Re-scheduling Problem



- How to react when a customer is trapped in an elevator
- All your engineers are on service calls
- *Who you gonna call?*

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- This will be described in more detail in a new course
- AI Fundamentals: Skill Development Program on Transportation Optimization
- Arriving in 2025 at this location

3 Summary

Summary

- We presented some more advanced topics
 - Sequence dependent setup
 - Transportation time
- Not available in every solver
- Useful concepts when dealing with specific scheduling problems
- Leading to another *Skills Development Program*