

ASSISTANT SE Case Study

Helmut Simonis

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

Acknowledgments

This publication was developed as part of the ENTIRE EDIH project, which received funding from Enterprise Ireland and the European Commission.

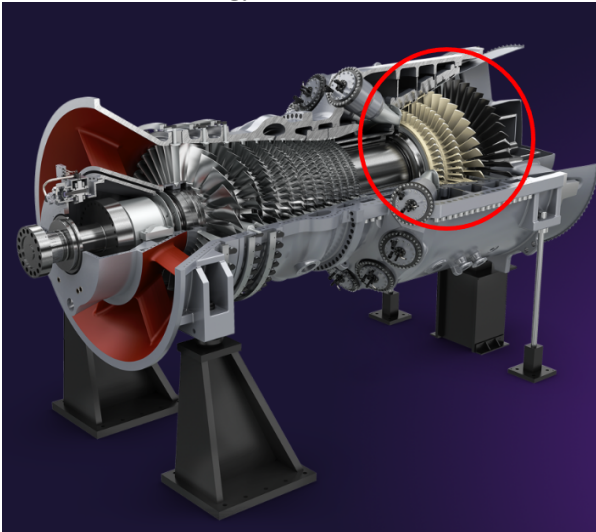
Part of this work is based on research conducted with the financial support of Science Foundation Ireland under Grant number 12/RC/2289-P2 at Insight the SFI Research Centre for Data Analytics at UCC, which is co-funded under the European Regional Development Fund.

Part of this work is based on research conducted within the ASSISTANT European project, under the framework program Horizon 2020, ICT-38-2020, Artificial intelligence for manufacturing, grant agreement number 101000165.

Key Points

- Scheduling/Planning tool for manufacturing industry
- Developed as part of European ASSISTANT project
- Focused on key make-or-buy decisions
- Complex manufacturing process with alternative process paths
- Outperforms both current in-house tool and commercial simulator
- Key Technology: Optimization and Constraint Programming

Assistant Siemens Energy Use Case

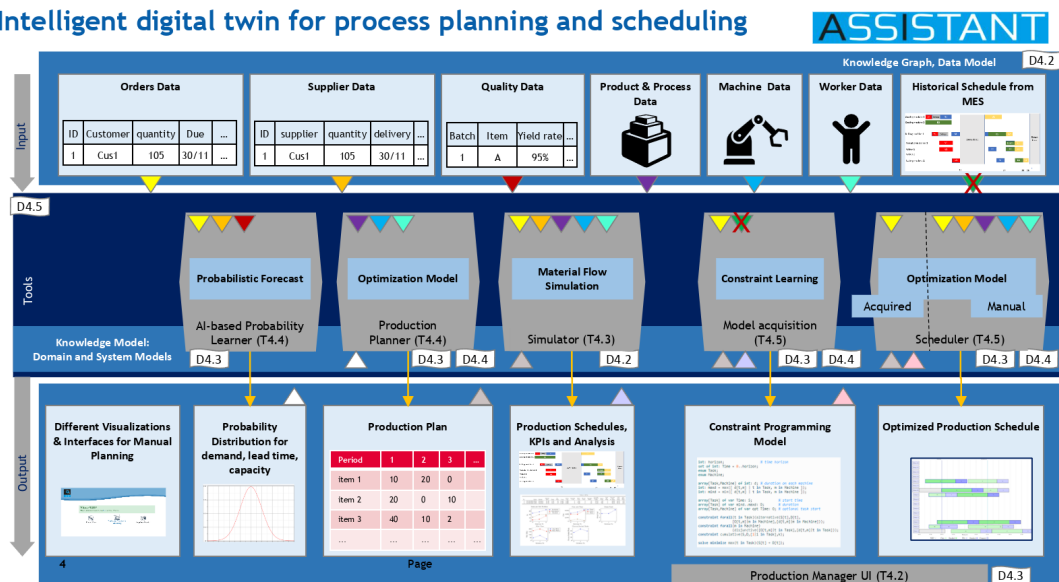


Use Case Scenarios

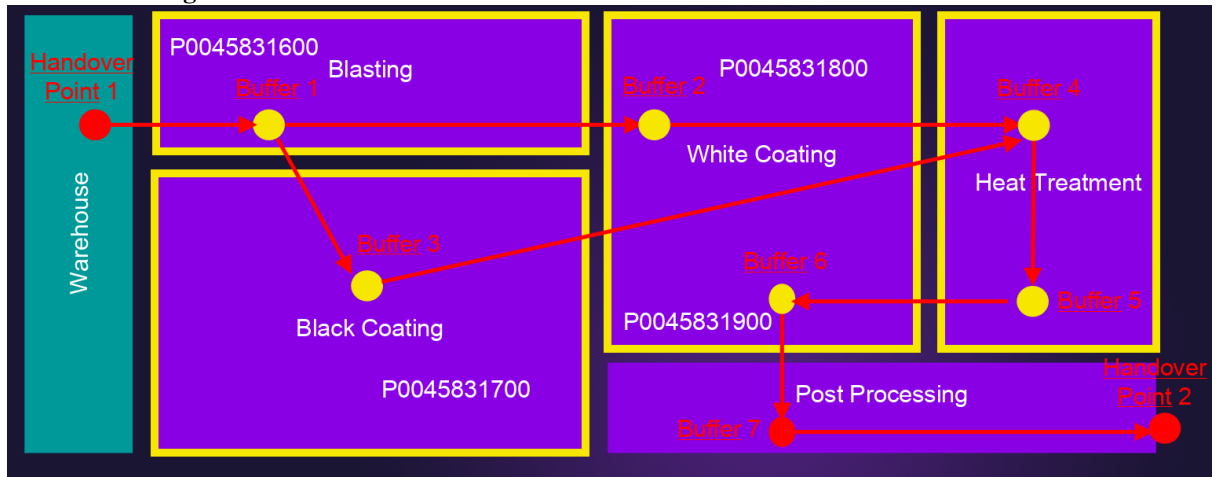
- Schedule *validation* of gas turbine blades and vanes manufacturing operations in Berlin plant
- Schedule *optimization* to manage short-term, mid-term and long-term load fluctuations
- Generate *Make-or-Buy proposals* for workload balancing within the manufacturing network

ASSISTANT Project Overview

Intelligent digital twin for process planning and scheduling



SE Product Routing



Test Datasets

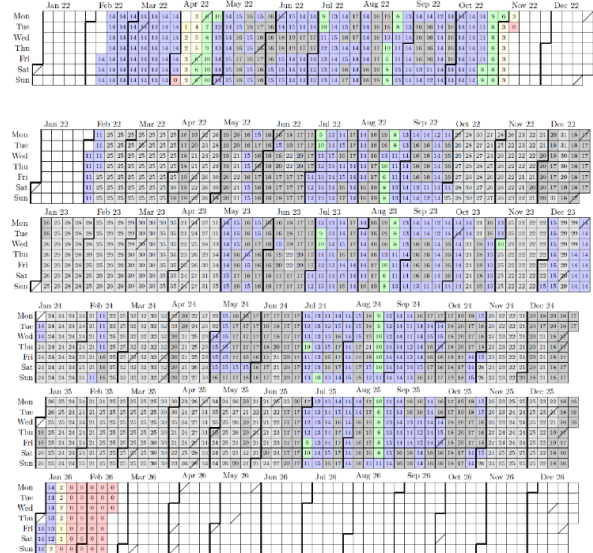
Full Scale Datasets

Berlin06: 96 orders, 9 months horizon, previous review

Berlin07: 450 orders, 4 years horizon

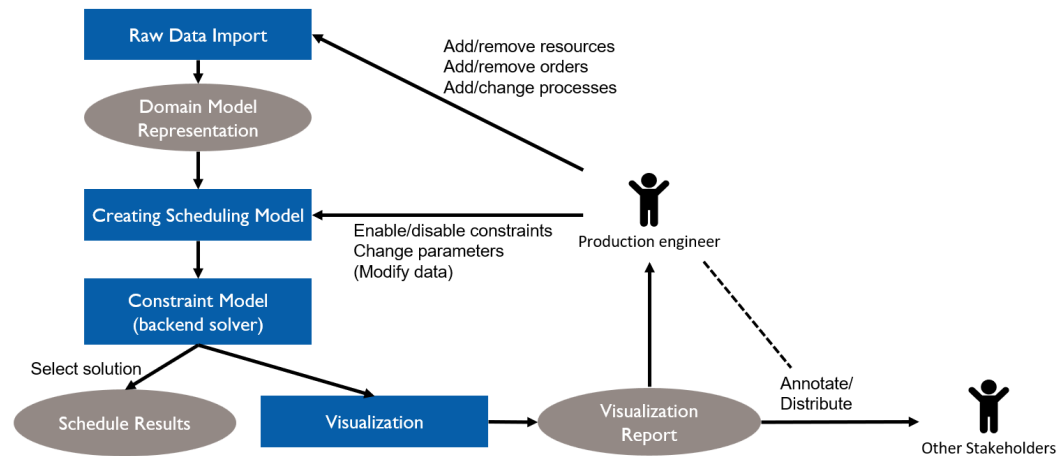
Berlin08: 559 orders, Christmas gap added

Berlin08a: 670 orders, filling gaps



Value in cell indicates active orders
Yellow and red colors indicate low order volume

Optimizer High Level Structure



Raw Data - Manual Data Entry Causes Problems

- Raw data come from spreadsheet
 - 20 tabs
- Excel is a particularly bad input data format
- Realistic, not real data
- Created by hand/automatically from existing test scenarios
- Series of files Berlin01 - Berlin05 were too inconsistent to run
- Berlin06 still contains some errors
- Optimizer explains all issues that it finds

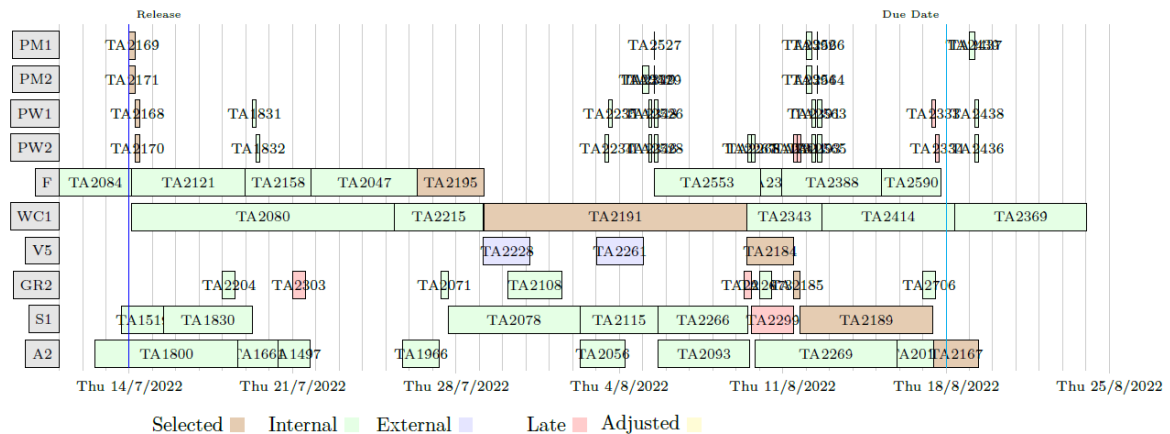
ASSISTANT Project Siemens Energy Use Case - Insight SFI Centre for Data Analytics								
File Edit Scenario View Window Help								
RawIssue X								
Name	Severity	Sheet	RowNr	ColNr	Description			
Issue1	Major	t_Load	129	11	DateTime not formatted correctly, found 2022-02-2800:00:00 format yyyy-MM-dd'T'HH:mm:ss			
Issue2	Minor	t_Products	1	15	Extra Empty Header			
Issue3	Minor	t_Availabilities	1	8	Extra Empty Header			
Issue4	Minor	t_Unavailabilities	1	8	Extra Empty Header			
Issue5	Minor	t_Shift_Segments	1	6	Extra Empty Header			
Issue6	Major	t_Shift_Segments	1	1	TimeOnly not formatted correctly, found 0.250000, format H:mm:ss			
Issue7	Major	t_Shift_Segments	1	2	TimeOnly not formatted correctly, found 0.583333, format H:mm:ss			
Issue8	Major	t_Shift_Segments	2	1	TimeOnly not formatted correctly, found 0.291667, format H:mm:ss			
Issue9	Major	t_Shift_Segments	2	2	TimeOnly not formatted correctly, found 0.302083, format H:mm:ss			
Issue10	Major	t_Shift_Segments	3	1	TimeOnly not formatted correctly, found 0.458333, format H:mm:ss			
Issue11	Major	t_Shift_Segments	3	2	TimeOnly not formatted correctly, found 0.479167, format H:mm:ss			
Issue12	Major	t_Shift_Segments	4	1	TimeOnly not formatted correctly, found 0.583333, format H:mm:ss			
Issue13	Major	t_Shift_Segments	4	2	TimeOnly not formatted correctly, found 0.916667, format H:mm:ss			
Issue14	Major	t_Shift_Segments	5	1	TimeOnly not formatted correctly, found 0.666667, format H:mm:ss			
Issue15	Major	t_Shift_Segments	5	2	TimeOnly not formatted correctly, found 0.677083, format H:mm:ss			
Issue16	Major	t_Shift_Segments	6	1	TimeOnly not formatted correctly, found 0.770833, format H:mm:ss			
Issue17	Major	t_Shift_Segments	6	2	TimeOnly not formatted correctly, found 0.791667, format H:mm:ss			
Issue18	Major	t_Shift_Segments	7	1	TimeOnly not formatted correctly, found 0.916667, format H:mm:ss			
Issue19	Major	t_Shift_Segments	7	2	TimeOnly not formatted correctly, found 0.250000, format H:mm:ss			
Issue20	Major	t_Shift_Segments	8	1	TimeOnly not formatted correctly, found 0.000000, format H:mm:ss			
Issue21	Major	t_Shift_Segments	8	2	TimeOnly not formatted correctly, found 0.010417, format H:mm:ss			
Issue22	Major	t_Shift_Segments	9	1	TimeOnly not formatted correctly, found 0.083333, format H:mm:ss			
Issue23	Major	t_Shift_Segments	9	2	TimeOnly not formatted correctly, found 0.104167, format H:mm:ss			
Issue24	Minor	t_Shift_Segments	10	0	First Column Empty			
Issue25	Minor	t_Shift_Segments	11	0	First Column Empty			
Issue26	Minor	t_Shift_Segments	12	0	First Column Empty			
Issue27	Minor	t_Shift_Segments	13	0	First Column Empty			
Issue28	Minor	t_Shift_Segments	14	0	First Column Empty			
Issue29	Minor	t_Shift_Segments	15	0	First Column Empty			
Issue30	Minor	t_Shift_Segments	16	0	First Column Empty			
Issue31	Minor	t_Shift_Segments	17	0	First Column Empty			
Issue32	Minor	t_Shift_Segments	18	0	First Column Empty			
Issue33	Minor	t_Shift_Patterns	1	9	Extra Empty Header			
Issue34	Minor	t_Shift_Patterns	7	0	First Column Empty			
Issue35	Minor	t_Shift_Patterns	8	0	First Column Empty			
Filter								

Domain Model - Knowledge Graph

- Simulation based tool based on commercial simulator
- System installed at SE site, but not in daily use

Explaining Late Delivery

- Explain why some orders are delivered late
- Find root-cause, show schedule in context



Evaluation - KPIs

KPI	Baseline	Optimizer
OTD	> 80 %	92 %
Bottleneck machine utilization	99.5 %	100 %
Manufacturing defects	10-15 %	< 10 %
Scenarios in 8 hours	15-20	> 100,000

Conclusion by Siemens Energy

“Within less than eight hours the ASSISTANT tools provided us thousands of manufacturing scenarios including different make-or-buy recommendations for making deliberate decisions on the way to proceed for strategic planning.”

from ASSISTANT final project review: Siemens Energy assessment

Summary

- Scheduling/Planning tool for manufacturing industry
- Developed as part of European ASSISTANT project
- Focused on key make-or-buy decisions
- Complex manufacturing process with alternative process paths
- Outperforms both current in-house tool and commercial simulator
- Key Technology: Optimization and Constraint Programming