Optimization of the mid-term master production schedule using SAP-APO

Dr. Ulf Neuhaus, Dr. Markus Storz
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GOR-Arbeitsgruppentreffen
Agenda

01 Introduction

02 Planning problem

03 Model overview

04 Numerical results

05 Conclusion
Bayer Business Services in the Bayer Group

Bayer AG

Business Areas

Bayer HealthCare
Bayer CropScience
Bayer MaterialScience

Service Areas

Bayer Business Services
Bayer Technology Services
Currenta
Bayer Business Services is the Bayer Group’s international competence center for IT-based services.

~ EUR 1 billion in sales*
~ 5,000 employees*

* 2007 globally
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Introduction

- **Environment:**
  - Pharmaceutical industry
  - Capacitated lot sizing
- **Horizon:**
  - up to 36 months
- **Scope:**
  - API-production ➔ Formulation ➔ Packaging
- **Tool:**
  - SAP SCM 5.0 ➔ SNP-Optimizer
Step 1: (SNP heuristics)
Step 2: (SNP optimization)
Step 3: (PPDS)
Step 4: (SNP deployment)
SNP optimization - Overview

Function
- Bucket based rough cut planning
- Determine optimized campaign sizes (considering setup-, inventory holding costs)

Features
- Monthly buckets
- Multi-level simultaneous (formulation, packaging)
- Dynamic (real demands)
- Finite capacity planning
- Only bottleneck resources and major items considered
- Usage of alternative resources
- No rounding values and minimal lot sizes

Diagram:
- Input:
  - Demand (customer VMI orders, Dist. demands)
  - Actual Plan (PP/DS planned orders)
- Process:
  - Erase not fixed PP/DS orders
  - Perform SNP-Optimization
- Output:
  - SNP planned orders
Hierarchical planning approach

- **SNP (36 m)**
  - SNP Pl.-ord. finite

- **PP/DS (12 m)**
  - Det. Scheduling (6 m)
  - SNP Pl.-ord. finite
  - PP/DS Pl.-ord. infinite
  - PP/DS Pl.-ord. finite scheduled

Time: month M, month M+1, month M+2, ...

- **MRP (12 m)**

Information content of the planning levels:
- Campaign sizes
- Capacity utilization
- Dep. demands for all components
- Technical lot sizes
- Sequence dep. setup times

- Campaign sizes
- Capacity utilization
- Dep. demands for all components
- Technical lot sizes
- Sequence dep. setup times

- Campaign sizes
- Capacity utilization
- Dep. demands for major components

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## Former methodology

- **Annually determination of the „optimal“ lot-size based on Andler**
  → Used as fixed lot size in MRP

- **Assumptions:**

<table>
<thead>
<tr>
<th></th>
<th>Andler</th>
<th>SNP-Opt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demands</td>
<td>Constant rate</td>
<td>Real demands → i.e. seasonal fluctuations</td>
</tr>
<tr>
<td>Set-up costs</td>
<td>Average value (product specific)</td>
<td>Average value (product specific)</td>
</tr>
<tr>
<td>Storage costs</td>
<td>Capital lockup (product specific)</td>
<td>Capital lockup (product specific)</td>
</tr>
<tr>
<td>Production process</td>
<td>Single-level</td>
<td>Single- or Multi-level</td>
</tr>
<tr>
<td>Products</td>
<td>One</td>
<td>N</td>
</tr>
<tr>
<td>Resources</td>
<td>Infinite</td>
<td>Finite</td>
</tr>
<tr>
<td>Receipts</td>
<td>Date: Depending on demands Quantity: Fixed</td>
<td>Date: Depending on demand/capacity Quantity: Dynamic</td>
</tr>
<tr>
<td>Determination</td>
<td>Iterative</td>
<td>Simultaneous</td>
</tr>
</tbody>
</table>
Agenda

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Overview: SNP optimization

- Actual Plan
  - Demands
  - Fixed PP/DS planned orders

- Constraints
  - Production capacity
  - Production calendar
  - Due dates
  - Safety stock

- Technical Settings
  - Optimization profile

- Cost model
  - Storage
  - Set-up
  - Penalties
  - Priorities

- Updated Plan
  - SNP-Planned orders
SNP optimization - Constraints

Constraints to be taken into account:

**Hard**
- Production capacity
- Calendar

**Pseudo Hard**
- Material availability

**Soft**
- Due dates (demand)
- Safety stock
- Shelf life
The following cost model is used

1) inventory holding cost
   (based on standard price R3)

2) fixed production cost
   (based on cost calculation for setup / cleaning / qc)

The following additional penalties are considered

3) penalty for safety stock violations

4) penalty for non delivery

5) penalty for shelf life (maximum range of coverage)
Storage cost

Inventory holding costs based on standard price R3 for plant location product
Setup cost

- Calculate set-up costs, using cost estimation for each material, based on the standard production version
- Identify relevant cost elements by a set of activity types (per plant)
- Product calculation (R/3):

<table>
<thead>
<tr>
<th>Itm...</th>
<th>Resource</th>
<th>Resource (Text)</th>
<th>Σ</th>
<th>Total Value</th>
<th>Currency</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>EE20608760 074</td>
<td>IMA C90</td>
<td></td>
<td>207,03</td>
<td>EUR</td>
<td>62,000</td>
</tr>
<tr>
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<td>EE20603760 074</td>
<td>IMA C90</td>
<td></td>
<td>62,31</td>
<td>EUR</td>
<td>18,345</td>
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<td>3</td>
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<td>IMA C90</td>
<td></td>
<td>140,70</td>
<td>EUR</td>
<td>0,700</td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>168,59</td>
<td>EUR</td>
<td>3,617</td>
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<td></td>
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<td>51,22</td>
<td>EUR</td>
<td>1,999</td>
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<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>114,19</td>
<td>EUR</td>
<td>2,450</td>
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<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td>701,80</td>
<td>EUR</td>
<td>1</td>
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<tr>
<td>8</td>
<td></td>
<td>Sample</td>
<td></td>
<td>199,64</td>
<td>EUR</td>
<td>130,000</td>
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</table>

- Changeover-costs (APO):

<table>
<thead>
<tr>
<th>Material Number</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>SAMPLE</td>
<td>830,15</td>
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</tbody>
</table>

Bayer Business Services
Maximum range of coverage

Soft shelf life (with continued using of expired product)

Storage costs per BMU and bucket

Max. Range of coverage

Range of coverage

Penalty
Supply of relevant costs (1)

Customizing Table
Additional Parameter

<table>
<thead>
<tr>
<th>R/3 Transaction</th>
<th>CIF</th>
<th>Master-Data</th>
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<tbody>
<tr>
<td>Master data maintenance</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>CIF</th>
<th>Master-Data</th>
<th>Transactional-Data</th>
</tr>
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</table>

<table>
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<tr>
<th>APO Planning</th>
</tr>
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</table>
### Supply of relevant costs (1)

<table>
<thead>
<tr>
<th>Cost element</th>
<th>Source</th>
<th>Supply</th>
<th>Detail</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>R/3</td>
<td>Automatic (CIF)</td>
<td>Manually (Mass)</td>
</tr>
<tr>
<td></td>
<td>Cust. table</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set-up</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Non Del.</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Shelf Life</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Safety stock</td>
<td></td>
<td>X</td>
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<td>Manually (Mass)</td>
<td>Detail</td>
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<tr>
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<td></td>
<td></td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Decomposition sub-plants

Parallel processing of disjunctive sub-models:

**Formulation**

- FormSol
- FormLiq

**Packaging**

- PackSol
- PackLiq
- MatPrim

Sub-model 1:

- PackSol
- MatPrim
- FormSol

Sub-model 2:

- PackLiq
- FormLiq
Product-Decomposition

■ Solution step 1
  ■ Determination of the global solution
    → Pre-allocation

■ Solution step 2
  ■ Definition of sub-models for connected components
  ■ Sequential solution of the sub-models
    → Local optimization
## Numerical results Solida

### Model data

<table>
<thead>
<tr>
<th>Sub-plants</th>
<th>SolPack</th>
<th>+SolForm</th>
<th>+MatPr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td>2.148</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDSe</td>
<td>3.978</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demands</td>
<td>14.081</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizon (Months)</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binary variables</td>
<td>64.371</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Solution indicator

<table>
<thead>
<tr>
<th>CPU</th>
<th>Intel Xeon (Netburst) 4 X 3 Ghz</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU-time (h)</td>
<td>~ 2:50</td>
</tr>
<tr>
<td>Planned orders</td>
<td>1.688</td>
</tr>
<tr>
<td>Service level</td>
<td>~ 98 %</td>
</tr>
<tr>
<td>Opt. Gap</td>
<td>~ 0.005 %</td>
</tr>
<tr>
<td>Opt. Gap*</td>
<td>~ 3.3 %</td>
</tr>
</tbody>
</table>

*(Based on production-/storage costs)*
Benefits

- Capacitated, dynamic lot sizes
  - Based on real demands
  - Consideration of production capacities
  - Multi level optimization (packaging <> formulation)
- Generation of a feasible and optimized medium term plan
- Reduction of manual planning activities
- Alert based planning

- Decision support
  - Capacity planning
  - Material requirements planning
Challenges

- High expectations
  - Short term planning horizon
  - Optimization based on real costs

- Quality of input data
  - Master data → Reviewing process
  - Transactional data

- User acceptance
  - Transparency of solution
  - Global vs. local view

- Problem complexity
  - CPU-time vs. level of detail
  → Appropriate modeling approach