

# Application of Optimization Methods at OM Partners nv

October 2004

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- ▷ OM Partners nv
  - Company and Activities
  - Sectors
- **Supply Chain Planning and Optimization Techniques** 
  - Planning Dimensions
  - Supply Chain Design
  - Master Planning
  - Detailed Scheduling
- ▶ Cutting Stock Problems
  - Overview
  - An example: Plastic Films Industry



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  - An example: Plastic Films Industry



## **OM Partners = Provider of Demand and Supply Chain Planning Solutions**





**Solutions = Software Products + Services + Commitment** 

- ▷ Software Products
  - Interactive
  - Intelligent
  - Integrated

#### : intuitive and easy to use

- : unique optimization expertise in Supply Chain Planning
- : integration between planning modules (one data model) and with external systems

#### ▷ Services

- Business consultancy : conceptual knowledge and sector expertise
  - : product knowledge and sector expertise
  - : training, help desk



- To make it work

- Implementation

**Support services** 

- To keep it running





- ▶ Founded in 1985
  - Strong roots in Mathematical Optimization
  - Subsequent evolution towards Supply Chain Solutions
- ▷ Steady growth of key figures (resume past 5 years)
  - **Personnel** : growth from 40 to 80 employees
  - Turnover : rise from 5 to 10 mio €
  - Clients : over 150 clients and 300 implementations





- Headquarters OM Partners (Antwerpen)

- Local offices

**OM Partners Nederland** 

**OM Partners France** 

**OM Partners UK** 

**OM Partners USA** 

- Associated company

Aperia (Paris)



- ▷ 25 % of net sales reinvested in R&D
- European Esprit / IST projects
  - ICEP: integrated and concurrent enterprise planning and scheduling
  - HOPLICCS: planning and scheduling in horticulture
  - Chainfeed: planning and scheduling in animal feed
  - DiSCiPI: debugging in Constraint Programming
  - **OMP/CAST:** software testing tools
- ▶ Cooperation with academic experts
- ▶ Teaching assignments and seminars



## **Sectors: Overview**



## ▷ **Flow Shop**

Corrugated and solid board, paper



## ▷ <u>Semi Process</u>

Animal feed, chemicals, dairy, fertilizers, food and beverages, pharmaceutics, starch,... Metals, plastics, textiles, ...







- ▶ Long routings
  - Up to 15 operations
  - One or more bottlenecks (shifting)
  - Throughput varying from a few weeks (e.g. metals) to a few hours (e.g. corrugated board)
- ▷ Complex sequencing rules
- ▷ Continuous operation, limited intermediate stock (WIP work-in-process)
   e.g.: Blast furnace → hot rolling mill, paper machines
- Optimize capacity, material and resource/tools usage
   e.g.: Cutting optimization, blending optimization
- ▶ Make-to-order (MTO) , make-to-stock (MTS), and combinations MTO MTS
- ▶ Cycle and Campaign Planning



- ▶ Production on stock (continuous or on a lot-basis) followed by packaging
- Inventory policies
- ▶ Tank and silo allocation
- ▷ Co- and by-product planning
- Contamination rules
- ▶ Cycle and campaign planning
- ▶ Reactor planning, lot sizing constraints
- ▷ Pack-to-order (PTO)
- ▷ Shelf life, quarantine, maturation times, ...

## Contents



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## **Planning Dimensions**





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- ▶ Utilization of highly interactive tools
  - clear and concise reporting of problems in a plan
  - drill-down into problems and possible solutions
  - easy adaptation of all handles on the problem
  - instantaneous recalculation of all consequences
- ▶ Supported by correctly chosen optimization algorithms
  - preparation of a first version of the plan
  - application to entire problem or to part of the problem
  - utilization of the right technique for the problem!





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## ▷ **OMP Optimizer**

- OMP Optimizer is developed by OM Partners
  - . joint effort with Prof. F. Louveaux (FUNDP) since 1984
  - . interior point solver Mosek (2001) by Erling Andersen
- state-of-the-art techniques for solving linear and mixed integer problems
- increasing sizes
  - . 64-bit version

#### - type of problems

- . blending optimization (animal feed, alloys, food, ..)
- . product mix optimization (dairy, meat, ...)
- . cutting optimization (paper, steel, plastics, ...)
- . network design (SC network, utilities, ...)
- . multi-site, multi-period production and distribution planning





## ▷ CHIP = Constraint Handling In Prolog

- product of COSYTEC (Paris)
  - . research and implementation partner of OM Partners since 1992
- constraint programming language
  - . domain variables with integer domain
  - . dynamic propagation of knowledge via domain restriction
  - . backtracks are provoked as soon as possible
  - . CHIP global constraints : simple and powerful

#### - type of problems

- . personnel roistering (schools, maintenance teams, camera teams, ..)
- . transport schedules (flights, trains), tour assignment, crew scheduling
- . production scheduling
  - N tasks to be scheduled at finite capacity,
  - on M machines with product dependent capacity and setup times,
  - limited intermediate storage,
  - and precedence constraints, raw material constraints, resource constraints, ...



## COSYTEC



- ▶ Heuristics are a good technique if
  - "mathematical" optimization is not needed or not possible
  - the solution to the problem can be described in a deterministic way
  - constraints can be formulated as if then else rules
  - the end user prefers to determine completely how the system will react

## ▷ **Type of problems**

#### - dispatching tasks

- . assignment of tasks to identical machines (FIFO)
- . allocation of trucks to loading points
- standard procedures
  - . OMP Planner : set plan to requirements and reduce overloads
  - . OMP Scheduler : complex sorting/grouping rules, ALAP scheduling
- customized procedures
  - . OMP Planner : allocation of "unused" capacity following product priorities
  - . OMP Scheduler : adapt production orders in order to empty the tanks completely
- problems too complex to model in LP/MIP or CLP



- ▷ The technique
  - deterministic algorithms going from very simple to very complex
    - .  $if then else \dots sorting \dots enumeration$
  - reflecting human experience and/or way of working/thinking
  - written in deterministic language : C++, OPAL, ...
- ▶ Heuristics in OMP Planner and OMP Scheduler
  - Built-in : Set Plan to, Reduce Overload heuristics, Replan heuristics, ...
  - Customized : OPAL Macros executed automatically or on demand
  - **OPAL : OM Partners Application Language** 
    - . Visual Basic like
    - . Can access all Objects and Attributes of the OM Partners Data Model
    - . Mix of customer-specific vs. generic programming: stored in OM Partners Knowledge base, communicated via internal OM Partners OPAL newsletter



- Developed by OM Partners since 1985
  - based on OMP Optimizer
- Package for Supply Chain Network Design:
  - (re)location studies of plants and depots
  - determination of the number of machines/tools in which plant
  - make or buy/outsource decisions
  - investment studies
  - optimal product mix of co- and by-products





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- Developed by OM Partners since 1994
- Supply Chain Planning (mid- en long term planning)
  - (Collaborative) Sales & Operations Planning (S&OP) and budgeting
  - Master Planning
  - Distribution Requirements Planning and Vendor Managed Inventory Planning (VMI)
- ▷ Sales & Operations Planning (S&OP) and Master planning
  - Global matching of demand (different certainty levels) and capacity
  - Multi-site product-plant allocations (incl. Subcontracting) and distribution policy
  - Optimum service levels and procurement decisions
  - Cost or revenue optimization
  - Finite capacity planning of materials, machines, resources (e.g. manpower, tools) and warehouses
- Planning environment
  - Horizon: weeks, months, years
  - Buckets: days, weeks, months (+mixed)
  - Scenario management & comparison
  - Aggregations or detailed data



## **Planning Modules: OMP Planner**



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## ▷ Objective function

- Minimize costs of (over)production, inventory, backorders, ...

## ▷ Variables

- production/transportation variables
  - . alternative routings, BOMs, machines, manpower, utilities, ...
- integrality due to minimum batch size and lot sizing, campaigns, cycles, ...

#### ▷ Constraints

- Minimum and maximum
  - . machines capacity
  - . resources capacity
  - . production
  - . stock levels
- Stock equilibrium
- Reduce deviations from
  - . previous plan
  - . target stock



Developed by OM Partners since 1992

#### ▷ Short term scheduling

- Finite capacity planning
- Detailed process or routing consideration for each order
- Assignment of operations or routing steps to individual machines (and tanks) and sequencing of these operations
- Planning of warehouses, tanks, resources and materials
- Integration of VMI (Vendor Managed Inventory), truck loading, ...
- Real-time integration of feedback events
- ▷ Planning environment
  - Horizon: hours, days, weeks
  - Continuous time horizon (no bucketing)
  - Detailed data

## **Planning Modules: OMP Scheduler**



OMP Scheduler - Pro	ofile bothsites
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- **Domain variables** 
  - are like integers
  - min/max
  - deduction algorithms can remove values from the domain
    - . e.g. [1,2, ,4, , , ,8,9,10]
- ▷ The "different" constraint is very powerful
  - $X \neq Y$ , hence instantiation of variable X removes value from domain of Y
- ▷ "Labeling"
  - $\approx$  specification of the enumeration/branching
  - implementation of problem specific algorithms to explore the search tree
- ▷ Global constraints with strong deduction algorithms
  - avoid backtracks



▶ Non overlapping tasks on 1 machine



> Non overlapping volumes in a truck



▶ Non overlapping on multiple machines





Different products should be stored in different tanks

**♦** volume



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#### ▶ Cutting Stock Problems

- Overview
- An example: Plastic Films Industry

## **Cutting Stock Problems - Overview**





- Paper
- Plastics
- Steel service centers
- Textile

## **Plastic Film Industry**











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- ⊳ Combine
  - a given set of orders (roll width and length, quantity and tolerances)
    - . order sizes vary from 1 roll to 1000 rolls
  - on a number of alternative mill rolls (specified by width, length and defects)
  - on a number of alternative slitters
- ▷ Minimizing
  - edge losses (trim)
  - change-over time
- ▷ Taking into account
  - slitter restrictions
  - combinable order lengths integer run lengths!
  - preferences in production practices
- ▷ Strong relationship with detailed scheduling
  - make building blocks for detailed scheduling ("programs")



## **Slitter restrictions**



- ▶ Winding stations
  - up to 30 rolls
  - physical limitations
  - sequence-dependent change-overs



- ▶ Strong relationship with detailed scheduling
  - make building blocks for detailed scheduling ("programs")
    - . shortest sequence of set-ups in which each order that is started must finish

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#### ▶ **Difficulties**

- sequence-dependent change-overs
  - . also determined by roll positions in a set-up
  - . AABBCCC is different from AACBBCC
- time-intensive feasibility and cost evaluation of programs





