



## Metaheuristic Projects

### – *What would you like to do ?*

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## Outline

- Set Cover
- Quadratic Knapsack Problem
- Open Shop
- Cutting Stock
- Turbine Balancing Problem
- TSP problem
- Your own optimization problem ....



## Set Cover Problem

- Given a set of elements, a set of sub-sets, cover the elements in the set.
- Each element has a corresponding row.
- Each set has a positive price ...



## Formulation

**objective:** minimise

$$\sum_i c_i \cdot x_i$$

**s.t.**

$$\sum_i a_i^j \cdot x_i \geq 1 \quad \forall j$$

$$x_i \in \{0, 1\}$$





## Data and Inspiration

- Data: “<http://people.brunel.ac.uk/~mas-tjib/jeb/orlib/scpinfo.html>”
- Inspiration: “A genetic algorithm for the set covering problem” J.E. Beasley & P.E. Chu
- ... and many others ...



## Quadratic Knapsack Problem

A more complex version of the knapsack problem ...

- Still only one constraint (which is good, constraints are difficult to handle ...)
- ... but a quadratic objective ...



## Formulation

**objective:** maximize

$$\sum_{i,j} p_{ij} \cdot x_i \cdot x_j$$

**s.t.**

$$\sum_j w_j \cdot x_j \leq c$$

$$x_i \in \{0, 1\}$$



## Data and Inspiration

- “<http://www.diku.dk/~pisinger/heuristics/>”
- Inspiration ? I could not find any metaheuristics for the problem ...





## Open Shop

Given a number of jobs (items ...) and a set of machines:

- Each job needs to be performed on each machine
- For each job and each machine there is a processing time ...
- Minimize the time required before ALL the jobs have been performed



## Data and Inspiration

- ["http://ina.eivd.ch/Collaborateurs/etd/problemes.dir/ordonnancement.dir/ordonnancement.html"](http://ina.eivd.ch/Collaborateurs/etd/problemes.dir/ordonnancement.dir/ordonnancement.html)
- "Benchmarks for basic scheduling problems", E. Taillard ( I will have that article in a couple of days ...)
- "A tabu search algorithm for the open shop scheduling problem", C-F. Liaw



## Cutting Stock

Assume you own a sawmill:

- You receive logs of one size ...
- You receive customer orders of many different (smaller) sizes ....
- Satisfy the customer demand with as few log's as possible ...



## 1. Version

You have no further information ...





## 1. Version formulation

**objective:** minimise

$$\sum_j y_j$$

**s.t.**

$$\sum_j x_{i,j} \geq D_i \quad \forall i$$

$$\sum_i L_i \cdot x_{i,j} \leq L \cdot y_j \quad \forall j$$

$$x_i \in N_0, y_i \in \{0, 1\}$$



## 2. Version

You have cutting patterns (and a lowerbound):

- Select which cutting patterns and how many to use in order to satisfy customers
- A somewhat more complex version of set-cover ...

The cutting patterns and lowerbound comes from a column generation algorithm (more on that later in course)



## Formulation

**objective:** minimise

$$\sum_j x_j$$

**s.t.**

$$\sum_j a_{i,j} \cdot x_j \geq D_i \quad \forall i$$

$$x_i \in N_0, a_{i,j}, D_i \in N_0$$



## Data

- Generated by GAMS program CuttingStock.gms
- Also generates lower bounds !



## Turbine Balancing

Given a turbine, the center of mass should coincide or be as close as possible to the geometric center.

- The blades have different masses ....
- Where to put the blades ?



## Formulation

**objective:** minimise

$$\sum_i \sum_j \sum_k \sum_l M_i M_k \cdot \cos(\theta_j - \theta_l) x_{ij} x_{kl}$$

**s.t.**

$$\sum_i x_{ij} = 1 \quad \forall j$$

$$\sum_j x_{ij} = 1 \quad \forall i$$

$$x_{ij} \in \{0, 1\}$$



## Data

We do not have access to data for the problem, but a description of how they should be generated: "Balancing hydraulic turbine runners: A quadratic assignment problem", G. Laporte & H. Mercure



## TSP

You can do TSP as a problem, but:

- TSP is very well researched ...
- ... so don't expect to get world class performance ...
- Be inspired by others .... best material: D.S. Johnson and L.A. McGeoch ...
- Data from TSPLIB



## Your Own Problem !

I will be **happy** if any of you decide to work on your own problem ...