Modelling Hauling and Backhauling Modelling on Energy-wood Network

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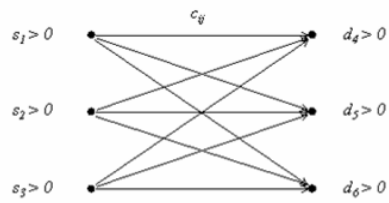
Optimization

In transportation and logistics we can optimize:

- Transportation cost in considering amount and capacity limitations (transportation problem)
- Delivery problem: number of vehicles vs. capacity
- Location problem: minimization of transportation costs by relocating delivery points
- Route optimization based on time, distance or costs
- Timetables (as buses, metros, etc.)
- Selection of most economic transportation methods and time
- Affectivity of material control and management
- Affectivity of terminal functions

Optimization models



1. Linear modeling

Based on

- Transportation problem
- Simplex algorithm
- or variation or two previous ones
- Graphical outputs possible

Application areas

- Selection of vehicles
- Production control
- Control of material
- Planning of sizes (capacity) of storages and terminals

Model - an example

Mathematical model –
transportation problem

$$\min \sum_{i \in I} \sum_{j \in J} c_{ijk} x_{ijk}$$

$$\sum_{j \in J} x_{ijk} \le s_{ik}, \quad \forall \; i \in I, k \in K \qquad \text{(supply)}$$

$$\sum_{i \in I} x_{ijk} = d_{jk}, \quad \forall \; j \in J, k \in K \qquad \text{(demand)}$$

$$x_{ijk} \ge 0, \; \forall \; i \in I, j \in J, k \in K$$

Optimization models 2

2. Dynamic models

Based on

- simple mathematic rules, but done in multiple stages
- proceeds by steps, strategy for action is selected after every step again

Application areas

- Timing of investments
- Timetables
- Line networks for delivery
- Planning of sizes (capacity) of storages and terminals

Optimization models 3

3. Network theory

- Network based on links and nodes

Basic problem types

- “Salesman” problem
- “Postman” problem
- Delivery problem
- Location problem

Application areas

- Route planning
- Planning of time tables
- Planning of locations

Optimization models 4

4. Stochastic models

Based on mathematical interrelations, as

- Probability theories
- Line theories
- Simulation theories

Application areas

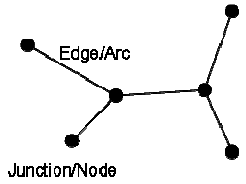
- Control of material flows
- Capacity analysis
- Optimization of waiting times
- Applied in telenetworks

Network analysis

Vector data is the most appropriate data for a network analysis.

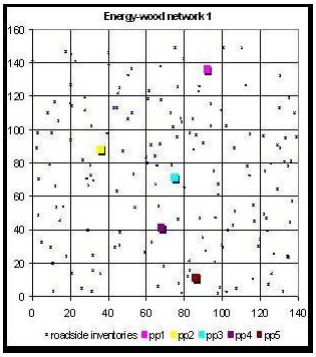
These operations can base on

- Continuous network, in which the topology is in order
- Rules for moving in the network
- Determinitation of units (distance, time,..)
- Cumulation of properties in moving in the network



Role of GIS in transportation problems

A typical problem of routing in the timber hauling



Input data:

- Delivery sites (point data), storage points, customer sites (point data) and road network (line data)
- Each point can contain attribute data about its features

- Route network can contain driving rules, speed limits, restrictions etc.
- Route networks is topologically consistent
- Route network is used to compute distance, delivery time or cost matrixes

Basic data can be used to visualiaze

- Starting point situation
- Routing options
- Solution after optimization

Role of GIS in transportation problems..

More:

GIS can be used in transportation problems, because they also provide tools for data selection, as

- buffer zone analysis
- ”spider net” analysis
- selection of (map) objects for analysis
- by blocking out some areas (points/lines) with given criteria

Notice:

Basic GIS tools seldom do not include cleaver solutions for timber hauling. In energy wood hauling the situation is maybe not so complex, because types of load carriers are often special for this purpose only.

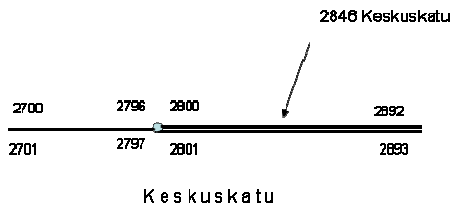
Geocoding

Customer registers or other custemer address data can be located on a map with the help of address information. In geocoding, addresses are in the database, and we must also have a reference database with geomethric information. By using reference data, an address can be located close to its right location.

Geocoding - an example

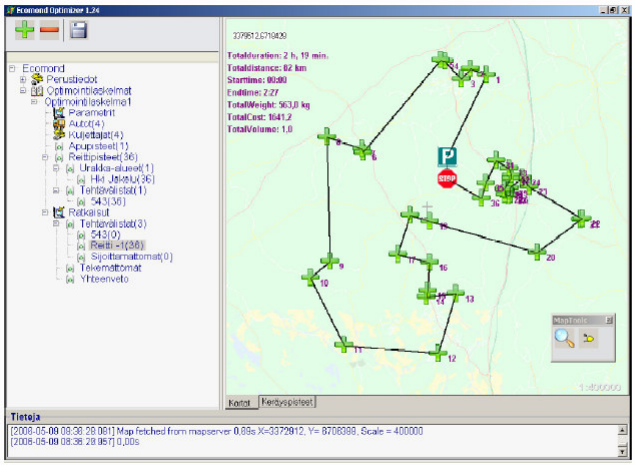
Reference database

- Reference database should contain the addresses (street names and reference points) in its tables. Accuracy (and distance) of reference points affect to the accuracy of geocoding. Each street has split into segments, which has given a starting point address and an ending point address.This makes it possible to locate intermediate street numbers.



Practical applications

TCS- simulointiympäristö:



TCS Simulointi

A case study with backhauling analysis

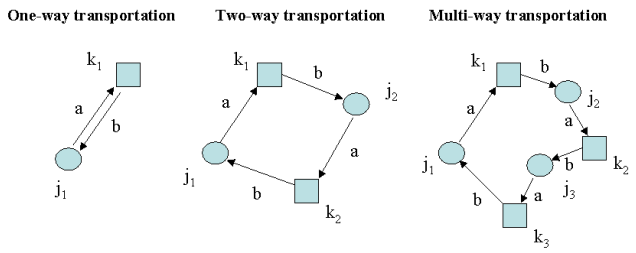
What is backhauling?

- Backhauling means that a truck carries a load when returning from the origin of the first load
- Is minimizing the empty route driving
- Is assumed to reduce transportation costs on long transportation distances

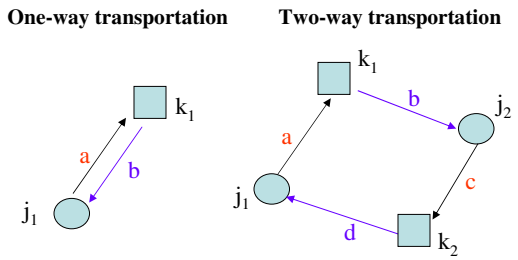
Objectives of this study

- To prove the savings of the minimization of the empty-route driving on energy-wood network in North Karelia
- To test and develop the backhauling model and the routing algorithm

Modelling options



Modeling of empty-route driving

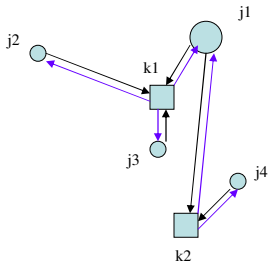


Where:

j_1, j_2, j_3	= inventories
k_1, k_2, k_2	= power plants
b, d, f	= empty loads
a, c, e	= full loads

Simple allocation model for one-way transportation

Minimize $$Z = \left[\sum_{j=1}^{J} \sum_{k=1}^{K} (cy_{jk} Y_{jk}) \right]$$



Z = optimum total cost (€)

D_k = volume (m^3) of energy-wood required by power plant k

Y_{jk} = volume (m^3) of energy-wood delivered from inventory j to power plant k

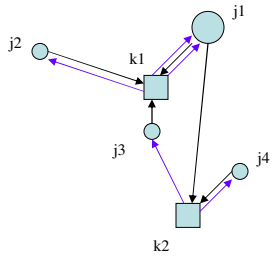
cy_{jk} = timber procurement cost per unit volume (€/m^3) of energy-wood delivered from inventory j to power plant k

J = number of inventories

K= number of power plants

Backhauling model for two-way transportation

Minimize $$Z = \left[\sum_{j=1}^{J} \sum_{k=1}^{K} (cy_{jk} Y_{jk} + cyr_{jk} YR_{jk}) \right]$$



Y_{jk} = volume (m^3) of energy-wood delivered on a one-way transportation from inventory j to power plant k

YR_{jk} = volume (m^3) of energy-wood delivered on a return load from inventory j to power plant k

cy_{jk} = timber procurement cost per unit volume (€/m^3) of energy-wood delivered on a one-way transportation from inventory j to power plant k

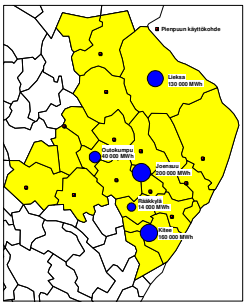
cyr_{jk} = timber procurement cost per unit volume (€/m^3) of energy-wood delivered on a return load from inventory j to power plant k

Routing algorithm

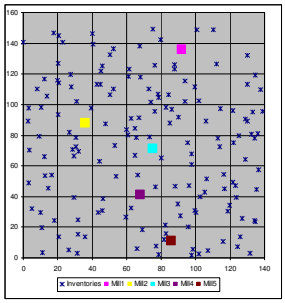
- Determines one possible return route to every one-way route
- Uses shortest distance on a backhaul route as a criterion to choose the best return route

Studies on energy-wood network

A real-world energy-wood network



A simplified energy-wood network



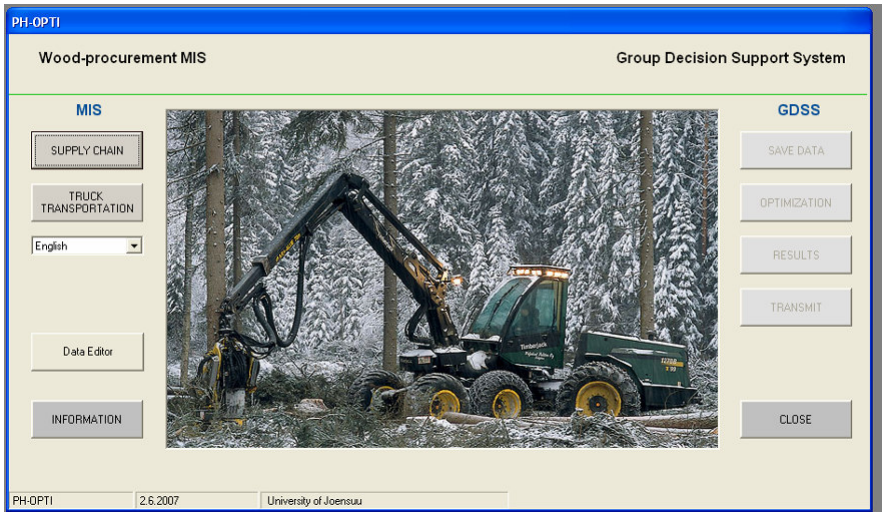
Simplified energy-wood network

- Only energy-wood transportation is modelled
- Inventories are generated by stand generators
- Energy-wood-procurement of the power plants is assumed to be organized by one supplier

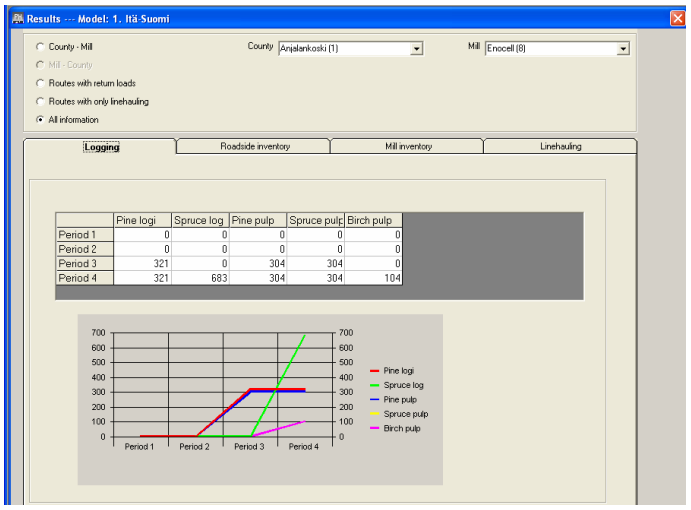
Potential savings of two-way transportation

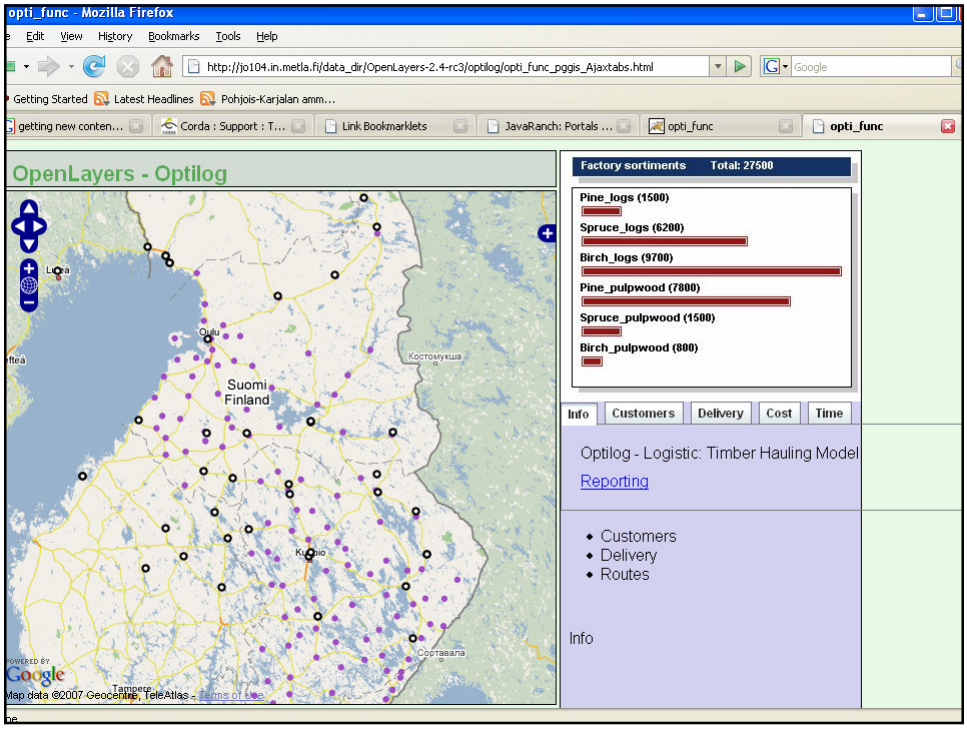
- Potential savings in the unit costs of timber transportation are 1-4 percents
- Even 7 percent savings are possible
- Savings in energy-wood transportation are still under research

Demo : OptiLog



Demo : OptiLog

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Link Bookmarklets
JavaRanch: Portals ...
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OpenLayers - Optilog
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Total: 27500
Pine_logs (1500)
Spruce_logs (6200)
Birch_logs (9700)
Pine_pulpwood (7800)
Spruce_pulpwood (1500)
Birch_pulpwood (800)
Info
Customers
Delivery
Cost
Time
Optilog - Logistic: Timber Hauling Model
Reporting
Customers
Delivery
Routes
Info
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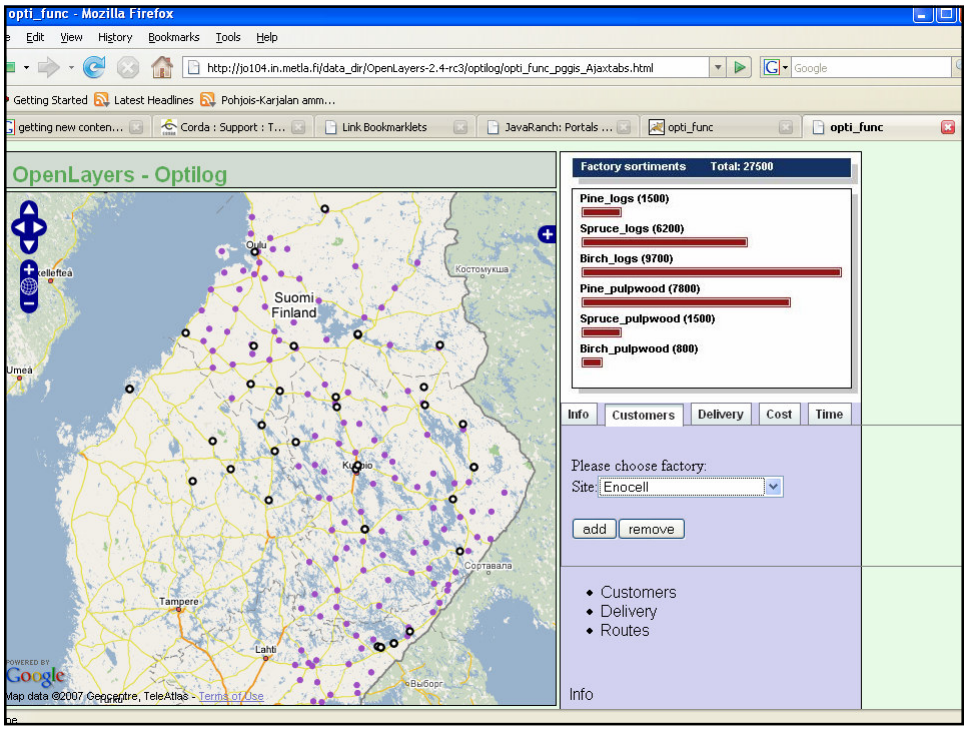
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Delivery
Cost
Time
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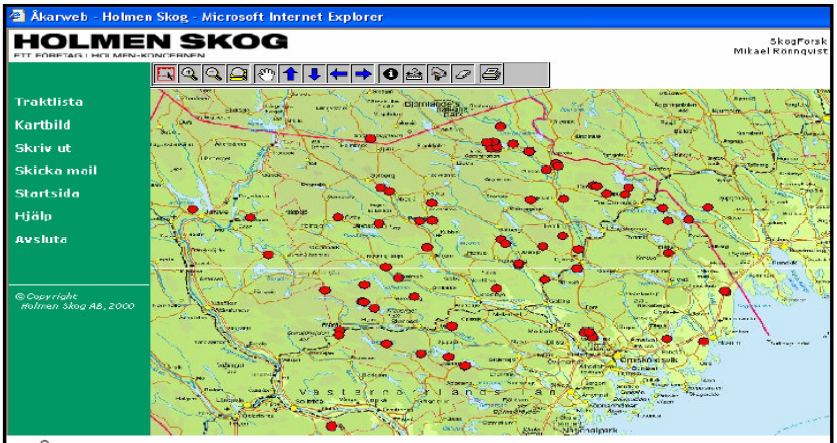
An example - Sweden



Åkarweb – a web based planning system using optimized backhaulage plans

JOENSUUN YLIOPISTO

Danke Schön!

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