FlowOpt - a Flexible Decision Support Tool for Strategic and Tactical Logistic Planning in Forestry

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Introduction

The forest industry represents a major part of the demand for transportation of goods in Sweden. Transportation related to the forest industry constitutes approximately 25% of all domestic transport by truck and railway. The cost of transportation represent one third of the total cost of raw material, round wood, to the forest industry. Providing the industry with raw material require substantial use of fossil fuels. An efficient use of transportation is vital to the competitiveness and environmental influence of the forest industry as well as the livelihood of many individuals in Sweden. Managing the forest supply chain, see figure 1, is a complex task. It encompasses such different areas as silviculture, harvesting operations, infrastructure and industry investments. The forest supply chain is diverging from the point of origin. Each forest stand contains different assortments suited for use in several different industries and supply chains. The most significant industries are pulp and paper industry, saw mills and power plants. A cross flow is possible between several points towards end use. The complexity of the flow is increasing. This change is caused by industries focusing on sub segments of different markets. As a specific market is served only a specific assortment is needed. Hence, the span of the defined assortment for each industry is smaller. OR problems arising in this supply chain is discussed in Martell *et al.* (1998) and Rönnqvist (2003).

We focus on the transportation activities occurring from the roadside landing site to storage at industry. The management of these activities is commonly divided into three perspectives: strategic, tactical and operational. In short, the strategic management deals with adjusting the capacity of the supply chain with respect to changes in industry production. The time horizon is often several years. Tactical management deals with changes of a shorter time horizon, a few months to a year. Examples are seasonal restrictions or natural disturbances such as storm felling or plagues. Operational management deals with problems of a few hours to a few weeks time horizon. Planning the work schedule for next weeks deliveries of an individual

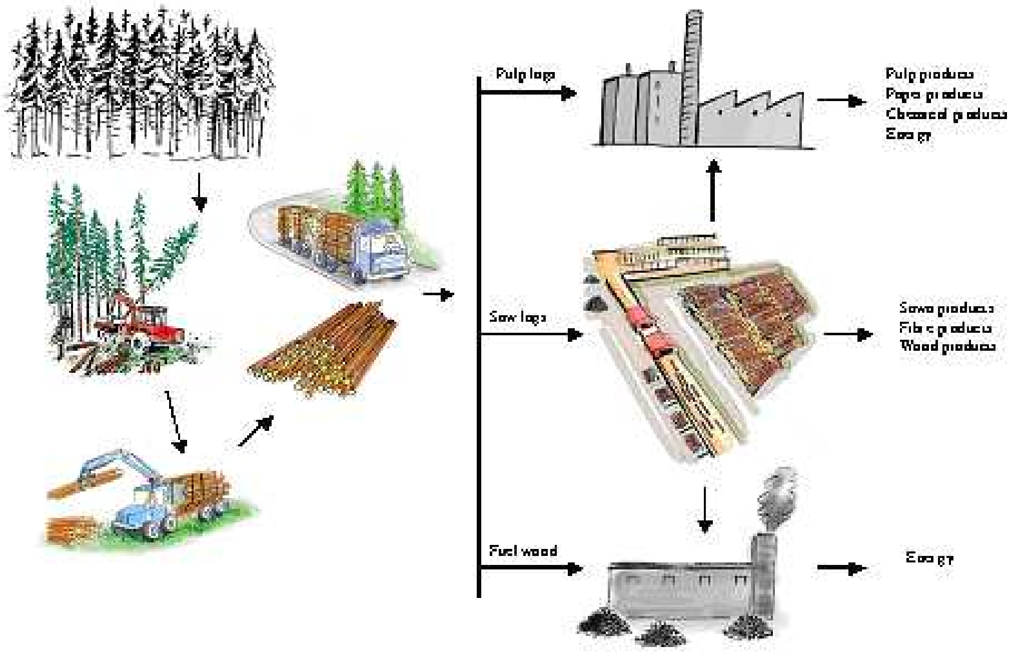

Figure 1: The forest supply chain.

truck driver is one example. Managing the transportation activities encompasses several sub problems in need of an integrated solution. Some of these are:

- What means of transportation will be used? The forest supply chain uses trucks, trains and ships to supply the industry with raw material.
- Cooperation between companies provides significant gains. At the same time different companies will be cooperating and competing creating a need to control what flow of logs are interchanged and what information are conveyed to competitors.
- Which assortments at roadside landing sites should be used to fulfill a specific industry demand? Some industries needs are very specific and others are not.
- Can distant inventories be traded with other supply chains in order to reduce the cost of transportation? Several forest companies operate in overlapping catchments areas.

The size of the problems increase rapidly with the number of industries, assortments and means of transportation. In order to solve these problems advanced Operations Research (OR) methods are needed. Several earlier studies on individual parts of the supply chain have shown potential cost reductions of 5 to 7 percent with a better management of the transportation, see e.g. Carlsson and Rönnqvist (1998) and Eriksson and Rönnqvist (2003). Total distance of driving to landing sites, i.e. unproductive time, could be reduced with between 16 to 28%. Including the flow of round wood of several forest companies in a solution significantly increases the potential cost reductions. An improved management of the transportation activities indicates a potential cost reduction of 5 to 10%. Supply chains with lesser internal possibilities of back hauling can find substantial gains in co-operating with other supply chains. Solving the problems requires the use of several steps of processing with different software packages. This approach is of research type and difficult to use in practice by transportation and logistics managers.

System

In this paper, we describe a system that includes a number of important aspects not included in earlier models tested. This includes the possibility to integrate truck and train transportation, coordination between several companies and interchange of products. An important aspect is the possibility to use information from the new Swedish Road database (NVDB). The system development is a co-operation between the Forest Research Institute of Sweden, Linköping University, The Swedish Agency for Innovation System, software companies Optimal Solutions and Dianthus and five large participating forest companies; Stora Enso, SCA, Holmen Skog, Södra Skog and Sveaskog.

In the development project the new system, called FlowOpt, comprises of parts given in figure 2. The central part is the application which includes maps, editing possibilities, input and output to other modules. The GIS part is given by the Swedish Road Database that include detailed information on all roads in Sweden. Information on supply, demand etc. are taken from company databases and are denoted Raw Information. A critical data is the distances between all supply, demand, terminal and train nodes. This is computed in a separate subsystem where a special network is constructed based on the NVDB data in order to make the computations quick. In the calculation, different conditions of the road are considered in order to find the least cost viable way from supply to demand. The application also generates specific data used for an optimization module. The optimization application consists of several models depending on which particular problem that is to be solved. Results from the optimization application are then inserted into the main application and different report options are possible. All these actions can be done within a user friendly environment.

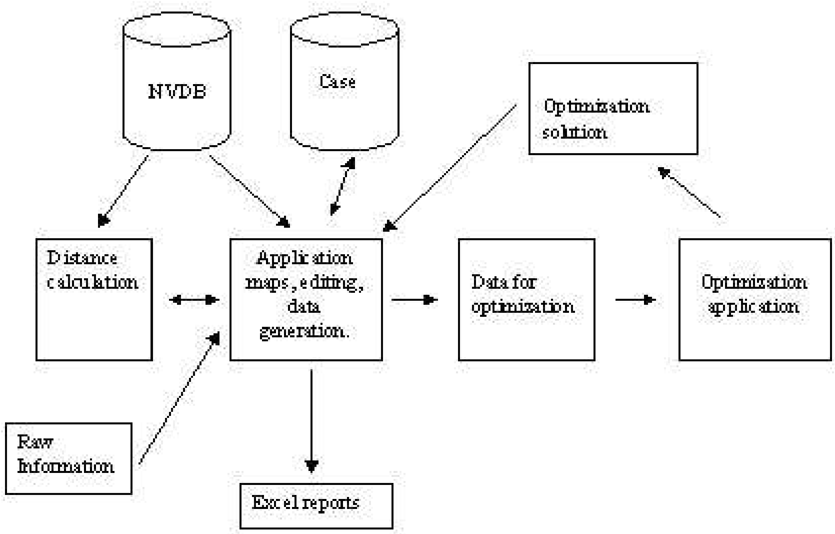

Figure 2: Components in the new system, FlowOpt.

Models

There are several aspects that are included in the optimization models. The models and methods (for example column generation) are implemented in the general modeling language AMPL. We do not provide detailed new models and methods in this paper. Instead we describe the main features and discuss the impact of the optimization models.

- Trains and railway terminals
  To include planning of trains and train terminals with the truck planning is one of the most important aspects. Earlier there was no possibility to make a trade off between trucks and trains. With integrated planning it is possible to make the planning more efficient. Backhauling can be used against supply and demand at train terminals which is not the case otherwise. The model is typically large and column generation is used to solve the overall problem. In figure 3 we illustrate the catchment area for two industries. In this figure, all supply points that transport to the industry is illustrated. In the same figure we also illustrate how a specific path corresponding to a flow between a supply and demand can be viewed. This situation is typical for many companies and it is very difficult to plan these integrated operations.

- Several participating companies
  Existing model deals with the problem as one entity. Including several supply chains or companies will pose restrictions on how the transportation can be altered. Examples on restrictions are that specific demand must be supplied within the company, some companies may supply some companies but not to others, certain volumes must be balanced between companies etc.

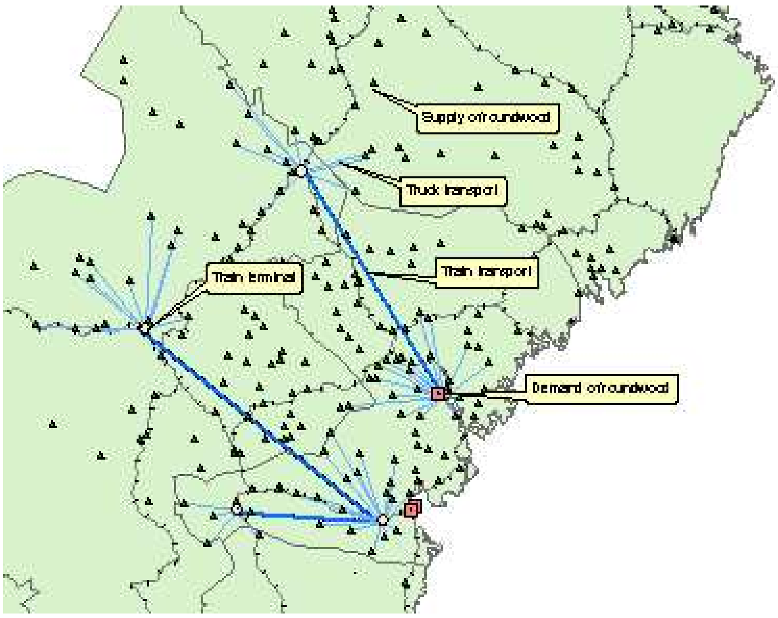

Figure 3: Illustration of the catchment areas of two industries. The transportation is carried out through the use of a combination of trucks and trains.

Case study

In this paper we illustrate one case where Sveaskog, one of the largest forest companies in Sweden, was to make a strategic decision about a new train system. Sveaskog is responsible for 4.6 million hectares of forests of which 3.5 millions are productive. This corresponds to 16% of Sweden's total productive area. Currently Sveaskog is using a train system called *Trätåget* (*eng.* The wood train) to move wood from the northern part to the middle part of Sweden. In this case study a number of scenarios were investigated where an additional train system called *Bergslagspendeln* (*eng.* Pendulum of Bergslagen) is used to move wood from the central/south part of Sweden to the east coast in the middle of Sweden. The new system also includes a number of potential terminals. Different sets of terminals were defined in the different scenarios. The system is also defined by a set of train routes. Each route has a capacity depending on how many times it runs every week and at which terminals it stops for loading and/or unloading. Each terminal has a handling capacity and associated handling cost. Figure 4 illustrate the location of terminals together with supply areas and industries used in the study.

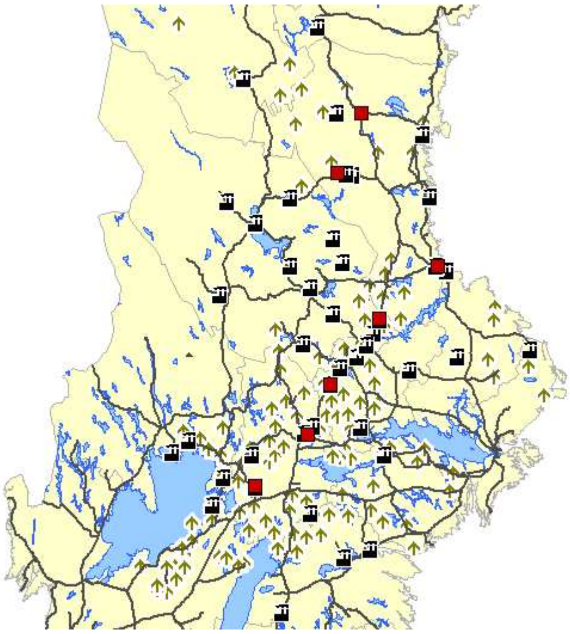

Figure 4: Overview of train network (solid lines), terminals (squares) sources (arrows) and industries (factories) used in the case study.

The cost of the train system relates to a fixed annual fee to use locomotives and wagons, terminal handling costs and a volume related cost (i.e. number of wagons needed) depending on the volume transported. In order to make a decision about investments it is important to compute any savings by finding entire transportation plans with the new train system. With FlowOpt we could quickly find truck and train flow, train usage, terminal usage, train capacities, backhaulage possibilities and different import possibilities. The actual case involve 1,500 supply points, 220 industrial demands, 5 train routes, 10 potential terminals, 12 products, 8 product groups and five scenarios. The optimization problem involves 3,000 constraints and 30 million variables. The solution time depends on scenario and varies between a couple of minutes to one hour. FLOWOPT was flexible and we could in short time establish maps and reports to illustrate the plans for further studies. Figure 5 illustrates the catchment area for one industry and one product when only trucks are used (left part) and when the *Bergslagspendeln* is used (right part). It was also easy to change models to take into account specific capacity restrictions on the train routes used in *Bergslagspendeln*.

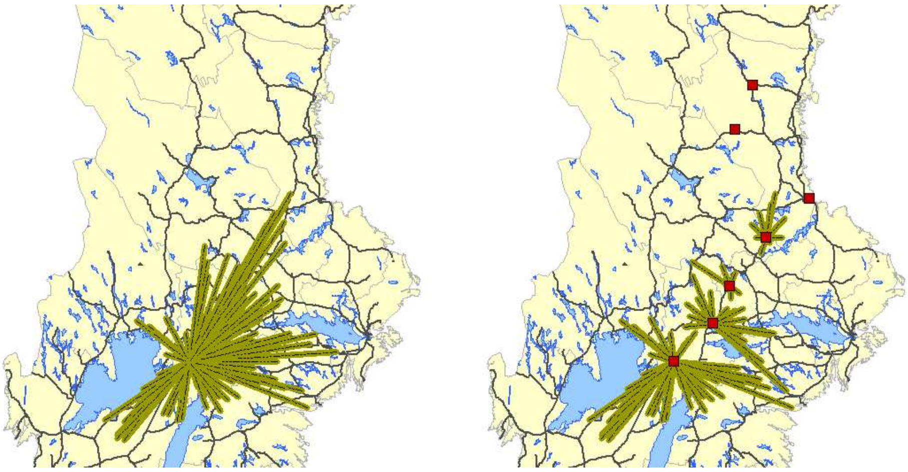

Figure 5: Catchment areas for one industry and one product. Left part is with trucks only and right part with trucks and train.

The result provided valuable and critical information in the negotiations between the company and the train service provider. Using the *Bergslagspendeln* proved substantial gains in terms of systems efficiency. With the pendulum the use of truck transports could be reduced by 35% reducing overall energy consumption by approximately 20%. Whether the pendulum will provide a reduced business cost or not depends on the needed increase in fixed costs, train capacity and infrastructure investments. This is currently negotiated. We have used the system in several case studies at the participating companies. The studies include train and truck integration, cooperation between several companies and interchange of timber and pulp flows. FLOWOPT makes it much more efficient to perform case studies as compared to earlier semi-manual systems. This is true both in terms of time to find an overall and integrated transportation plan and in the solution quality of the integrated planning.

References

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