

OTARI

Decision support system for transport scheduling

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Abstract : this paper describes how FRAMENEC-COGNITECH optimises cattle food production costs for an agricultural co-operative, the CANA company. In particular, the system, based on ILOG SOLVER/SCHEDULE tools, has to reduce raw materials costs, manufacture choices, and transport costs. The objective is also to reduce the round elaboration delay from hours to minutes. A "round" is defined by the CANA company as a set of deliveries. The OTARI prototype allows to minimise constrained rounds and kilometres, taking into account truck features (number of cells, maximum allowable weight), drivers work duration, product density and factory constraints.

After a first computation, the system allows the operator to modify the rounds in order to take into account the specific daily constraints, based on cartography (using Alsoft GeoConcept) and spreadsheets (ILOG VIEWS). At the end, the system establishes the transport orders for the drivers, and inputs to the production management system.

1. INTRODUCTION

The CANA company is an agricultural co-operative which main activities are :

- cereal and raw materials distribution,
- agricultural materials distribution,
- milk cooperative,
- cattle food production and distribution.

The food is produced and delivered in the country of "Pays de Loire", in the western part of France. CANA owns two main factories, one very close to Nantes, the other one to Ancenis, 50 km away from Nantes. It has also contractual relationships with others small factories that are scattered from the country of "Bretagne" to the country of "Vendée".

In the field of cattle food, the main activities are :

- **orders taking** : the orders arrive from the CANA agencies during the day in aim to dispatch products the next morning. But, the orders can also be sent directly to one factory, where the Sales and Order department resides. In the worst case (fortunately rare), a new order can be eventually taken in the morning, produced and delivered at the beginning of the next day ;
- **transport scheduling** : the product orders are grouped into rounds, each one realised by a truck according to several constraints, in particularly in case of specific food, trucks size, delivery hours....
- **factory scheduling** : it is the interface between the transport scheduling and the manufacturing ;
- **manufacturing** : the production is scheduled according to loading and manufacturing possibilities, precedence constraints between products, and production setup delay. A supplementary constraint is that all the products for one day can not be stored in the factory at the same time : there is not enough room in the warehouses, so that finished products must be delivered while manufacturing new ones ;
- **truck loading**,
- **delivery**.

2. THE PROBLEM

During a preliminary study, some problems were identified : they are described in the following sections.

2.1. Transport scheduling complexity

The scheduling has to manage several hundred of delivery points over a total of 25,000 customers. 40 to 60 rounds must be established for 15 to 25 trucks. The number of rounds and the total distance have to be minimised following many constraints :

- the truck slots capacities,
- the carried tonnage,
- the driver (e.g. legal constraints on work time),
- the order particularities (truck size, delivery conditions..),
- the density problem of each product.

The problem is solved currently by two people, only by hand, in a few hours. The main problem is that they have many difficulties to backtrack on the established rounds when a delivery problem occurs.

2.2. Transport scheduling duration and manufacturing temporal constraints

The manufacturing scheduling is constantly waiting for the transport scheduling : the way in which the orders are produced in the factories depends heavily on the choice of customers to be delivered first, mainly because there is not enough room to store all the finished products.

The production should not be stopped between two days, for productivity purposes. To avoid this, the rounds were prepared in two steps, in order to give to the factory scheduling a set of rounds to be served, as soon as possible . It implies that backtracking on products scheduling was very difficult.

2.3. Late orders

The orders arrive at any time in the factory i.e. also hence orders are already scheduled, thus disturbing the delivery organization.

2.4. Loading density problem

The system has to take into account product density. Depending on weather conditions, and raw material quality, the product volume may vary considerably, and in some cases, the intended ordered quantity cannot be put in the truck slot along with other orders : the ordered quantity should be reduced, which requires to call the customer.

2.5. Costs after delivery

The orders are currently widespread on factories according :

- the unloading localisation,
- the ability of the factory to manufacture this product,
- the priority to give work first to particular factories.

The costs were not taken into account by the people in charge of round elaboration ; in fact, some factories have cheaper production costs and for some factories, raw materials importation cost can be cheaper.

3. SOLUTION ARCHITECTURE

In order to solve the problems listed above, FRTC has designed an integrated solution combining a number of advanced software techniques :

- constraint programming using ILOG SOLVER/SCHEDULE, for the round elaboration module ;
- geographic data manipulation, based on ALSOFT/GéoConcept tool, and geographic data from MICHELIN ;
- a graphic interface combining in the Visual C++ framework, ILOG VIEWS and GéoConcept graphical capabilities for map viewing.

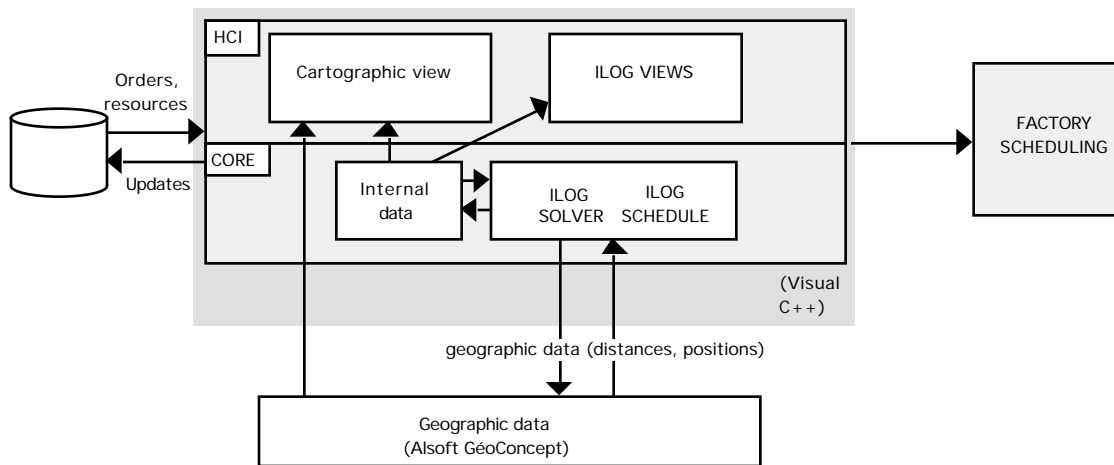


Figure 1 : software architecture

The application is linked at one side to the orders management system, and at the other side to the production management system.

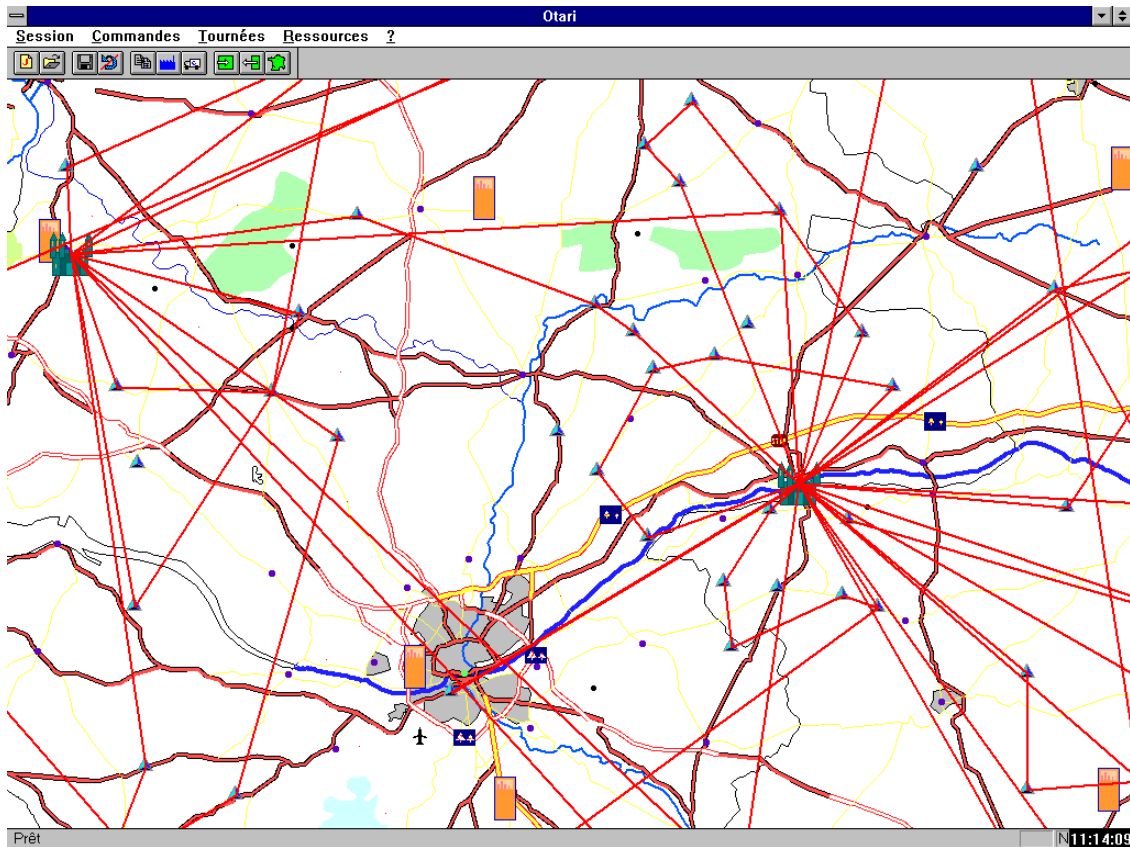


Figure 2 : a typical screen.

4. Problem modelisation

As in every resource allocation problem, the basic objects manipulated by the application are the resources, and the activities :

- resources : trucks and factories ;
- activities : truck loading and delivery rounds.

The sections below describe the resources and the specific constraints they involve.

4.1 Resources : trucks

From the point of view of scheduling, a truck consists of a number of slots, in which the products are stored at truck loading. After loading, the truck starts the delivery round, and empties some of its slots at each delivery point.

A typical truck is shown below :

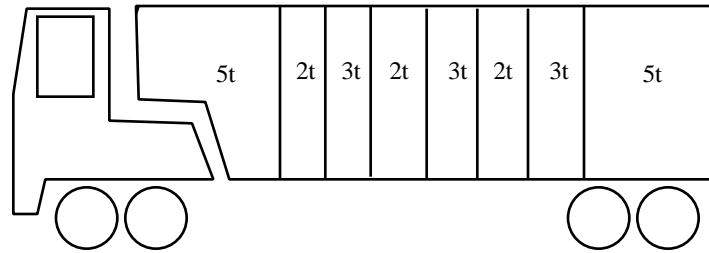


Figure 3 : a standard truck design

- the number of slots varies from 4 to 8, with different capacities (2 slots containing 5t of product, 3 slots containing 3t of product, ...); for a similar capacity, the slots may also vary with respect to their volume;
- the maximum loaded weight is ranging from 10 to 25t;
- the truck is equipped with a delivery system, either an "endless screw", or a pneumatic system: this constraint influences the kind of orders that can be loaded into the truck;
- sometimes, the customer has some particular requirements, for example, having only a small truck for delivering his orders, because there is not much room for the truck to operate in his farm.

Another case arises when the customer has some particular tank to receive the products: distinction are made within the delivery system, whether the "screw" is short or long, the truck is "high" or "low" (so that it can go into the barn or not).

4.2Resource : factories

The CANA group has two main factories situated at 80 km from each other, and several others scattered from the region of Bretagne to the region of Vendée.

Each of them may produce part or all of the 700 products referenced by CANA; each product may be produced in different conditioning, like "granules" or flour: each factory has a limit for the quantity of product to be produced every day. This point implies that, in order to take into account all the orders for a given, most of all the factories have to be taken into account for resource allocation.

One important point is that the main factories are the starting points of all the trucks, but all the factories are possible loading points: this implies that a given truck starts from one main factory, delivers, then arrives at another factory. There, it loads new orders, delivers, and arrives at a third factory, and so on until the day is finished. At the beginning of the elaboration of one complete solution for all the trucks, there is a number of rounds for which the system knows virtually nothing, except the truck number and the name of the driver.

4.3 Activities

A round is decomposed into two activities :

- loading : before delivering, a truck has to load the products ordered into its slots. This operation takes some time, almost one hour in some factories, depending on the number of orders. Consequently, it requires the availability of the factory loading gate during that time ;
- delivering : this activity requires the truck (drivers are not considered as resources : they only constraint the trucks availability). The duration of that operation is not known before the complete round is elaborated, thus allowing to calculate the trip cost.

4.4 Search structure

The search has to minimize the costs of the delivery rounds ; the cost of one round is expressed in terms of driver work time and product cost. A product has different costs, depending on the factory in which it is produced.

The main steps are :

1. for each truck, keep only the possibles orders, given the many constraints (kind of unloading system, capacity) ;
2. given the production limit per factory and the total volume of orders, elaborate a repartition of the possible rounds between the different factories ; production policies are involved in this choice (for example, fill before the main factories) ;
3. choose a round ; this choice follows a number of preferences (for example, choose before the rounds made by trucks that are owned by CANA, before others) ;
4. choose an arrival factory ; this choice is made within the framework elaborated in 2.. Note that the start factory is always fixed, because the trucks have mandatory starting points in the morning. This is the main choice point for the search ;
5. fill the round with orders ;
6. continue for all the rounds, until all the orders are placed or there is no more trucks ;
7. In case of backtrack, alternate arrival factories are identified for the rounds.

5. Conclusion

We described a number of issues related to the developpement of a decision support system in transport scheduling. Currently, the system is going soon under validation, and will integrated to the CANA information system late 1996. After another period of operational validation, the system will move to full production.