Variable neighborhood descent for two-echelon distribution network with capacity constraints, multi-sourcing and lot-sizing for perishable products

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1 Introduction

A mixed integer linear programming (MILP) and a greedy heuristic were developed to solve a real planning problem in a complex two-echelon distribution network with capacity constraints, multi-sourcing and lot-sizing for perishable products. The heuristic is an alternative to the mixed integer linear program to quickly solve some large instances taking into account original and difficult constraints. For some instances the gap between the solution provided by the solver (MILP) and the heuristic becomes quite significant. A variable neighborhood descent (VND) procedure has been implemented to improve the quality of heuristic solutions.

2 Problem description

This article presents a planning problem in a two-echelon distribution network (warehouses provide finished products to various distribution centers) integrating inventory stock for perishable products, lot-sizing, multi-sourcing and a homogeneous fleet of vehicles. A distribution center may be supplied by several warehouses. The choice of sourcing (warehouses) is determined by the availability of products in warehouses inventory, fleet of vehicles, and transport costs on routes. The goal is to come up with a compromise between the transportation costs, the warehouses and distribution centers inventory costs, the loss due to products perishability. Furthermore, we comply with : flow conservation, inventory conservation at warehouses and distribution centers, capacity constraints and supply constraints (lot-sizing, minimum order quantities and dates).

3 Solution method

Hansen and Mladenović [1] proposed the variable neighborhood search (VNS) in which several neighborhoods are successively used. VNS does not follow a single trajectory but explores increasingly distant neighbors of the incumbent and jumps from this solution to a new one in case of improvement. Local search is used to get from these neighbors to local optima. VNS is based on the principle of systematically exploring several different neighborhoods, combined with a perturbation move (called shaking in the VNS literature) to escape from local optima. Variable neighborhood descent (VND) is essentially a simple variant of VNS, in which the shaking phase is omitted. Therefore, contrary to VNS, VND is usually completely deterministic. A greedy heuristic is used to get initial solution and VND procedure is used to improve this solution. The applied movements are more or less complex. Simple movements are to increase or reduce the supplied amounts to the distribution centers and the warehouses. Complex movements can transfer amounts:

- from a time period to another to supply the distribution centers and the warehouses,
- between distribution centers sharing the same sourcing (warehouses),
- between products sharing the same transport road (warehouse-distribution center edge).

4 Computational evaluation

The tested instances vary from 2 to 50 products, from 2 to 11 warehouses, from 2 to 145 distribution centers and from 10 to 30 time periods. The greedy heuristic and VND are implemented in C + + development environment Visual Studio 2010 and the MILP is solved with the CPLEX solver version 12.6. For some instances, the solver does not provide a good lower bound after 1 hour and half of calculation. The average gap between the solver solution and greedy heuristic solution (initial solution) is 29.57 % and this gap decreases by 23.37% when the VND is applied (the average gap is 6.20%). The average computational time for the solver is 2577.35 seconds and for the VND, using the greedy heuristic as initial solution, is 227.08 seconds.

5 Conclusion

The problem under study is a common issue in industrial sectors such as dairy products. A mixed integer linear programming (MILP) was developed. However, an approximate method is necessary for two reasons, namely: solving very large problems and better understanding the construction of the solution (solutions constructed by linear programming commercial solvers is often difficult to explain to the users). The variable neighborhood descent method, which was included in an APS (Advanced Planning System), is compared with an exact resolution of the MILP, on two types of instances : derived from actual data or built using a random instance generator to have wider diversity for computational evaluation. The VND procedure significantly improves the quality of solutions and average computational time is much shorter than MILP resolution. An iterated local search (ILS) with a shaking phase will be implemented to improve the solution quality.

References

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