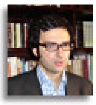

Recent Advances in Transportation and Logistics

By Dr. Christos D. Tarantilis, Lecturer, AUEB

Imagine yourself be the Logistics Director of a company and you need to obtain **quickly high quality solutions** for the following core logistics problems:

Problem 1.

Determine a set of routes performed by a fleet of 100 heterogeneous (i.e. different capacities) company's trucks, based at 6 different depots to serve 3000 geographically dispersed customers' locations. Moreover, additional constraints and operational characteristics such as

- time-windows, associated with each customer wherein the customer has to be served,
- customers, served in a route, may require both pickups and deliveries,
- all information needed is not known when the routing process begins,
- information changes dynamically after the initial routes have been produced and the routing plan is being executed,
- stochastic travel times due to traffic flow variability, accidents and breakdowns,
- different priorities or penalties associated with partial or total lack of customers' service,

further complicate the picture.

Problem 2.

Determine the best possible arrangement of items inside a container, in order to achieve maximum utilization of container's space. It is broadly known that containers represent the most important component of rail and maritime intermodal transportation. This problem involves a container with known dimensions, heterogeneous cargo (different types of boxes), while several constraints related to the physical arrangement of the load and transportation requirements may be considered, such as boxes orientation, cargo stability and the container volume.

Problem 3.

Determine the locations of facilities (i.e. warehouses, loading-unloading areas, parking areas, headquarters etc.) within the area of each depot. This problem involves

- a number of facilities, which are to be located in a number of locations (sites) within the area of each depot (i.e. one facility at a site),
- "goods" flow between pairs of facilities and
- distance between the locations.

To measure the cost of each possible assignment (explosive number of possible assignments!!!), one need to multiply the prescribed flow between each pair of facilities by the distance between their assigned locations, and sum over all the pairs In other words, the aim is to minimize the overall cost of the layout. Similar problems are the facility allocation-layout in manufacturing systems, the allocation of emergency service facilities, the allocation of buffer capacities in production lines, the assignment of project tasks.

It is obvious that transportation (airlines, trucking, rail, and shipping) and logistics industry involves a wide range of business in manufacturing, pickup and delivery, packaging, warehousing, transportation, and distribution of goods. This industry is huge and is growing fast, encompassing companies involved in the entire supply chain process, from the purchasing of raw materials and the production of goods to the distribution to end customers and the employment of intelligent decision support systems to optimize revenue and profit. What do you need to follow this competitive environment? How can you get a routing plan like the one demonstrated in Figure 1?

Figure 1

Figure 1: The routing plan for 900 customers obtained in 5 minutes, using one depot (blue square)[1]. The area of the customers in this figure is proportional to the quantity (demand) ordered.

Most of the real-world transportation and logistics problem are large-scale combinatorial problems posing both operational (problems 1, 2) and strategic (problem 3) planning. In such problems, all possible combinations of decisions and variables must be examined to find a solution; consequently, no partial enumeration-based exact (mathematical) algorithm can consistently solve them. This occurs because sharp lower bounds on the objective value are hard to derive, thus causing a slow convergence rate [2]. By exploiting problem-specific characteristics, classical heuristic methods, such as constructive and iterative local search methods, aim at a relatively limited exploration of the search space, thereby producing acceptable-quality solutions in modest computing times.

As a major departure from a classical heuristic, a metaheuristic method implies a higher-level strategy controlling and coordinating lower-level heuristic methods. Metaheuristics exploit not only specific problem characteristics but also ideas based on artificial intelligence approaches, such as use of different types of memory structures and learning mechanisms [3,4], analogies with optimization methods found in nature [5], dynamic objectives and solution-search functions[6,7,8]. In addition, metaheuristics can combine powerful and sophisticated concepts of different metaheuristics (hybrid metaheuristics) to provide a more effective performance and a higher flexibility when dealing with real-world applications [9,10]. Solutions produced by metaheuristics typically are of much higher quality than those obtained with classical heuristic approaches, while their swift execution speed allows them to be used on combinatorial problems where a complete enumeration would be completely impractical [11].

Concluding, we strongly believe that there exists a wealth of opportunities for Greek companies to adopt technologically advanced Management Information Systems [12] (Decision Support Systems-DSSs, Geographical Information Systems-GISs, Enterprise Resource Planning Systems-ERPs etc.), which will incorporate efficient and effective metaheuristic methodologies to enable managers, dispatchers or schedulers to make both operational and strategic decisions.

References

1. Tarantilis, C.D. and Kiranoudis, C.T. (2002). BoneRoute: An effective memory-based method for effective fleet management, *Annals of Operations Research* 115(1) 227-241.
2. Cordeau, J.-F., Gendreau, M., Laporte, G., Potvin, J.-Y. and Semet, F. (2002). A guide to vehicle routing heuristics. *Journal of the Operational Research Society* 53(5) 512-

522.
3. Reimann, M., Doerner, K. and Hartl, R.F. (2004). D-Ants: Savings Based Ants divide and conquer the vehicle routing problem. *Computers & Operations Research* 31(4) 563-591.
4. Crainic, T.G., Malucelli, F., Nonato, M. and Guertin, F. (2005). Meta-Heuristics for a Class of Demand-Responsive Transit Systems. *INFORMS Journal on Computing* 17(1) 10-24.
5. Li, F., Golden, B. and Wasil, E. (2005). Very large-scale vehicle routing: New test problems, algorithms, and results. *Computers & Operations Research* 32(5) 1165-1179.
6. Mester, D. and Braysy, O. (2005). Active guided evolution strategies for large-scale vehicle routing problems with time windows. *Computers & Operations Research* 32(6) 1593-1614.
7. Audet, C., Brimberg, J., Hansen, P., Le Digabel, S. and Madenovic, N. (2004). Pooling Problem: Alternate Formulations and Solution Methods. *Management Science* 50(6) 761-776.
8. Lapierre, S.D., Ruiz, A.B. and Soriano, P. (2004). Designing Distribution Networks: Formulations and Solution Heuristic. *Transportation Science* 38(2) 174-187.
9. Tarantilis, C.D (2005). Solving the vehicle routing problem with adaptive memory programming methodology. *Computers & Operations Research* 32(9) 2309-2327.
10. Gen, M. and Syarif, A. (2005). Hybrid genetic algorithm for multi-time period production/distribution planning. *Computers & Industrial Engineering* 48(4) 799-809.
11. Tarantilis, C.D., Gendreau, M. and Spinellis, D. (2005). The Impact of Metaheuristic Strategies in Transportation and Logistics Applications, *Editorial of the Special Issue on "Advanced Heuristics in Transportation and Logistics". IEEE Intelligent Systems* (to appear in 2005).
12. Tarantilis, C.D., Diakoulaki, D. and Kiranoudis, C.T. (2004). Combination of geographical information system and efficient routing algorithms for real life distribution operations. *European Journal of Operational Research* 152(2) 437-453.

Christos Tarantilis is a Lecturer in the Department of Management Science and Technology at the Athens University of Economics and Business. Dr. Tarantilis' research concentrates on the quantitative and analytical study of operations management and transportation-logistics systems. He combines advanced operations research techniques with modern information technology to attack complex real-life problems. He has more than 60 scientific papers, 26 of them in top-rated academic journals as well as in international books and conferences. During the academic period 2004-2005, he has also acted as Guest Editor in the following issues: a) Special Issue: *Operational Research and Food Logistics*, Journal of Food Engineering (Elsevier), Guest Editors: C.D. Tarantilis and C.T. Kiranoudis and b) Special Issue: *Advanced Heuristics in Transportation and Logistics*, IEEE Intelligent Systems, Guest Editors: C.D. Tarantilis, D. Spinellis, M. Gendreau. Contact him at **tarantil@aueb.gr**