

Optimization problems in logistics: transportation

Logistics

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Transportation

Shippers originate the demand for transportation.

Carriers supply the transportation service.

Public institutions provide the infrastructures.

Transportation is responsible for a very large fraction of the overall cost of products.

Therefore many **optimization problems** have been studied and many **optimization methods** have been devised.

Classification

A possible taxonomy of transportation problems is the following:

- *long-haul transport*, intercity freight transport, often **multi-modal**, TL (truck-load):
 - customized (on its own or by a carrier);
 - consolidation-type (by a carrier).

Transport operated by *carriers*, i.e. transportation companies that do not own the goods they transport, can be operated in two different ways:

- fixed schedule, line services;
- on-demand services.
- *short-haul transport*, local freight transport (last mile), usually **uni-modal (truck, van)**, LTL (less-than-truck-load).

Optimization in long-haul transportation

The optimization of **line services** requires to solve **service network design problems** and **network flow problems**:

- optimization of the connections between terminals on the basis of the forecasted demand;
- optimization of work shifts for people and vehicles.

The optimization of **on-demand services** requires to solve **on-line optimization problems**:

- dynamic (re-)assignment of requests to vehicles;
- vehicle renting;
- repositioning of empty vehicles.

In both cases one must also optimize the **number** and **type of vehicles** to be used.

Costs and constraints

When a company transports its own goods with its own vehicles, typical cost terms are:

- cost for vehicles (purchase or rent);
- salary of the drivers;
- fuel cost;
- costs for insurance and maintenance;
- administration.

The overall available capacity is limited (constraint).

When a company gives delivers its goods through a shipper, its cost depends on the price for the service, which also includes the shipper's profit margin. The price may depend on the distance, the weight, the volume, the value of the goods. In this case the capacity can be assumed to be unlimited.

Economies of scale

In all cases, costs grow less than linearly with distance and quantity of goods, because of **economies of scale**.

For this reason transportation on its own is only convenient for companies that move very large amounts of goods.

Third party transportation companies (carriers) and especially those operating by trucks and vans (haulers) tend to grow in size or to integrate themselves into consortia, in order to reach better economies of scale.

Short distance

Short distance transport (*short-haul*) occurs when origins and destinations are in the same city or region.

Goods are often picked-up from or delivered to a logistics terminal.

It is often operated by a fleet of trucks or vans of small size, based at a single depot.

Routes are traveled within a working day.

Demand is different in each day.

Reverse logistics

- **Line-haul** transportation: goods are delivered from the depot to the customers.
- **Back-haul** transportation: goods (or used products, waste,..) are collected at the customers sites and brought to the depot;
- **Mixed**: line-haul and back-haul operations are performed by the same vehicles;
 - with back-haul constraints: all deliveries must precede all collections;
 - without back-haul constraint: any order is allowed (provided that the vehicle capacity is not exceeded).
- **Pick-up and delivery**: both operations occur at customers sites, not at the depot.

Today technology allows for **real-time services**, whose management and optimization is more complex.

City logistics

Last mile transportation is much less efficient than long-distance transportation.

However it can be operated by different vehicles, usually smaller and therefore able to reach any point in urban centers.

Finding an optimal trade-off between cost and level of service for the distribution/collection of goods in urban centers is the subject of **city logistics**.