Distribution and logistics

Course: Optimization problems in production planning

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Transportation

Accomodates for 10%-20% of final product cost.

Computerized decision support reduces cost by 5%-10%.

- Ship and air transport
  - Network already defined (sparse)
  - Edges in network are capacitated
  - Goods are routed on paths in networks
- Distribution on land
  - Network is road network (dense)
  - Vehicles have capacities
  - Different type of goods are transported on one vehicle
  - Vehicles are assigned least routes in network
Ship and air transport

<table>
<thead>
<tr>
<th>Ship</th>
<th>Air</th>
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<tbody>
<tr>
<td>+ Cheap</td>
<td>- Expensive</td>
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<tr>
<td>+ Large quantities</td>
<td>- Small quantities</td>
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<tr>
<td>- Slow</td>
<td>+ Fast</td>
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Although opposite characteristics same combinatorial solution method.

1. Design network
2. Route commodities

Solution methods:
1. Is often solved for itself. By assigning ships/planes to frequently sail/fly specific edges. This dictates the capacity on the edges.

2. Solved as a Multi Commodity Flow Problem on the designed network. Commodities flow from suppliers to demanding customers.
Multi Commodity Flow Problem

- Network is build by rotations of ship/plane routes.
- Graph is directed in time, i.e. harbors/airports are copied for each time slot
- Rotations may be smaller than time slot, leading to cycles.

Example of rotation [Løfstedt]:

Obstacles:
Due to export/import imbalance (e.g. Asia to Europe) containers needs to be repositioned. (empty commodity, flow balance)

When used for strategical planning problems are very large. (rolling horizon, column generation)
Distribution on land

- Travelling Salesman Problem
- Shortest Path Problem with Resource Constraints
- Vehicle Routing Problem
- Inventory Routing Problem

TSP is the classic routing problem - mostly academic interest.

SPPRC is a common subproblem in many routing (flow) problems. Both academic and practical interest.

VRP and its variants are the most common routing problems addressed. Most common variants are

- VRP with Time Windows
- Pickup and Delivery Problem
- Multi-depot VRP

IRP combines inventory management with the routing aspect. IRP is of great practical use in some industries. Not that well studied.
Solving Routing Problems

**TSP** Optimal solution method is an advanced branch-and-cut algorithm [Cook et al.]. Otherwise metaheuristics are often used.

**SPPRC** Dynamic programming algorithms. [Salani et al., Petersen et al.]


**IRP** Heuristics based on combination of decomposition, IP and metaheuristic [Kleywegt et al.]