The effect of ignoring inventory when planning routes

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The effect of ignoring routes when planning inventory

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Abstract: In physical distribution the location of depots and vehicle routes are interdependent problems, but they are usually treated independently. Here, we evaluate the effect of ignoring routeing when locating depots by using a two stage process (location and routeing). Using data from standard problems, it is shown that the best solution after the location stage does not necessarily generate the lowest cost solution after the routeing stage. This feature is found both when the best locations obtained from a variety of methods are compared, and when a single method is evaluated for different numbers of depots. A sensible way to determine the best combination of methods used in location and routeing is proposed.

Keywords: Depot location, vehicle routeing, distribution
Usually, the inventory situation at the depot(s) is simplified.
In reality, companies supply more than one (type of) product
Mathematical model

- Depots, Customers, Products
- Capacity constraint vehicle (homogeneous)
- Capacity constraint depots
  
  (All customers can be supplied)
- * Each customer can be supplied by multiple depots
  
  (But only one supply per product and customer)
Inventory constraints with multiple products make MDVRP even harder for linear solvers (CPLEX)

<table>
<thead>
<tr>
<th>Instance</th>
<th>Runtime in sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Customers</td>
<td>#Depots</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
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<td>11</td>
<td>2</td>
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</tbody>
</table>
A heuristic for the MDVRP with inventory constraints (MPMDVRP)

- MPMDVRP
- MDVRP
- VRP
- TSP

Guided Search (Mester & Bräysy)

N-opt (Lin- Kernighan)
Powerful local search operators

**Ejection chain**
Relocate Individual nodes

**Multi-Swap (chain)**
Relocate multiple nodes

**Lin-Kernighan**
A Route is always optimal in itself

Efficient implementation
A guided local search heuristic (VRP)

While (improvement) {
  Ejection chain
  Lin-Kernighan
  Multi-Swap
  Lin-Kernighan
}
Penalize one edge *
Restart..

**Benchmarks:**
- 60-80 nodes (Augerat)
  - 0.3% gap
  - < 1 sec
- 200 - 483 nodes (Golden)
  - 1.2% gap
  - < 30 sec

* Preferably long, intersecting, wide
A heuristic for the MDVRP
A guided local search heuristic (MDVRP)

for each depot
{
    extract VRP
    GLS ( VRP )
    reinsert VRP
}
GLS ( MDVRP ) *
Restart..

Benchmarks:
50-100 nodes (Cordeau)
• 0.4% gap
• < 2 sec*

250 nodes (Cordeau)
• 1.0% gap
• < 20 sec*

*10 times faster than ALNS (2007)
*20 times faster than HGSDAC (2012)

* Emphasize changes between depots
A heuristic for the MPMDVRP
A guided local search heuristic (MPMDVRP)

- Additional inventory constraints in construction phase
- Additional inventory constraints in GLS (MDVRP) phase
- * Customers who demand multiple products can be splitted / merged
The effect of ignoring inventory when planning routes

- Generate N random instances
- For each instance, vary the tightness of the inventory constraint

Each depot can serve all customers

Together, all depots can exactly serve all customers
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*Single supply chain: all depots store all products*
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Collaboration: one product per depot vs all products per depot

2 products / depots: 30% savings
3 products / depots: 45% savings
4 products / depots: 54% savings
Application in parcel distribution

Home Delivery (no collaboration)  Shared drop-off points with bike delivery
Summary

- A new planning problem which integrates supply chain interaction
- A competitive local-search based heuristic
- Study on the effect of inventory planning on routing