Rule-based Vehicle Routing Planning System for Inbound Supply Chain

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Contents

- Introduction
  - Inbound supply chain
  - Inventory routing problem (IRP)

- Rule-based job packing algorithm
  - Supplier-driven job packing
  - Event-driven job packing

- Simulation

- Conclusion
Introduction

- **Supply Chain Management (SCM)**
  - One of the most important issues in improving enterprises’ profit
  - **Optimization** of the supply networks
  - Pursue the *flexibility, robustness* of supply chain

- **In the logistics aspects,**
  - Inbound supply chain
  - Intercompany supply chain
  - Outbound supply chain

```
Acquire raw materials
Convert raw material into specified final products
Deliver final products to retailers
```
Introduction

- **Outbound supply chain**
  - Transportation of end products
  - Consider market dynamics & customer demand
  - VMI, transshipment, etc.

- **Intercompany supply chain**
  - Material flows in manufacturing site
  - Minimize total cost through optimization
  - Factory layout design, process design, facilities planning, etc.

- **Inbound Supply Chain**
  - Treated as a kind of outbound supply chain
Inbound supply chain

**Inbound flows**
- The activity of **receiving**, **storing**, and **disseminating** incoming goods or material for use
- Failures of inbound case **affect** a high shock on the entire SC
- Focused on the **risk analysis**

**Inbound vs. Outbound**

<table>
<thead>
<tr>
<th></th>
<th>Outbound flows</th>
<th>Inbound flows</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand</strong></td>
<td>Stochastic &amp; periodic repetition</td>
<td>Fixed, not identical</td>
</tr>
<tr>
<td><strong>Backorder (Delay)</strong></td>
<td>Inevitable</td>
<td>Unacceptable</td>
</tr>
<tr>
<td><strong>Operation Policy</strong></td>
<td>VMI, etc.</td>
<td>Based on JIT</td>
</tr>
<tr>
<td><strong>Inventory Management</strong></td>
<td>Lenient</td>
<td>Strict</td>
</tr>
</tbody>
</table>

**Inventory control & transportation problem should be considered**
Inventory routing problem (IRP)

**IRPs**
- Concerned with the *distribution logistics* in SCM
- Transportation management + Inventory control
  - Determine *which customer* must be served and *amount* to supply each customers
- **Long-term problem**

**Single–period model**
- Treats single-period, one (or two) item problem
- Non-linear mixed integer programming model
  [Fedegruen et al. (1986), *Operations Research*, 34, 75-82]
- Mixed integer programming model
  [Chien et al. (1989), *Transportation Science*, 23, 65-76]
Inventory routing problem (IRP)

- **Multi-period Model**
  - Extension of single-period model
  - Mixed integer programming using penalty & incentive
    [Dror & Ball (1987), *Naval Research Logistics Quarterly*, 34, 891-905]
  - Vendor managed resupply model

- **Focused on the outbound supply chain**

- **In inbound case**
  - Demand type is different: no periodic repetitions
  - Under the JIT philosophy, more frequent deliveries are needed
Rule-based job packing algorithm

- **Supplier-driven job packing**
  - Make one-truckload Job using only one supplier’s shipments
  - Single round trip
  - JIT violation

- **Event-driven job packing**
  - Using production start time & travel time
  - Complex process & routes
  - Distance between vendors
Supplier-driven job packing

Procedure

**Step 1**: Classify the production plan based on the suppliers

**Step 2**: Spread out the production plan by standard time of each product

**Step 3**: Pack parts to their appropriate carts according to the capacity

**Step 4**: Pack the parts and make a full-truckload job. If a shipment is less than one-truckload and the next shipments are discrete less than 4 hr., the shipments are include (JIT violation)

**Step 5**: Rearrange the production plan using the jobs and departure time
Event-driven job packing

Procedure

**Step 1**: Sort the production plan base on product start time and travel time

**Step 2**: Calculate the departure time of parts from a supplier to the manufacturing site considering set-up data

**Step 3**: Pack parts to their appropriate carts according to the capacity

**Step 4**: Make a job using carts within the same time slot. If the shipments are less than one-truckload, search the nearest supplier (~10 min. travel time or 10 min. JIT violation) has shipment.

**Step 5**: Generate a rearranged production plan considering the job and departure time
Simulation

**Simulation condition**
- 3 manufacturing sites, 9 suppliers
- 200 kinds of products
- Production capacity: about 14,000 units/day
- 30 days production plans
- Time allowance of JIT: 1 hr.
- Stock for the next day: 2 hrs.

**Dependent variable**
- Number of vehicles
- Maximum stock level
- Average idle time of vehicles
Simulation result

- **Number of Vehicles**
  - S-driven job packing
    - Better performance
  - E-driven job packing
    - Due to Peak time

- **Maximum stock level**
  - S-driven job packing
    - Due to JIT violation
  - E-driven job packing
    - Maintain less stock level

![Graph showing number of vehicles and maximum stock level over days](image)
Simulation result

- **Average idle time**
  - E-driven job packing
    - Need to consider the **distance** between vendors
    - Due to **Peak time**

- **Performance**

<table>
<thead>
<tr>
<th></th>
<th>S-driven</th>
<th>E-driven</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Vehicles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Avg.</td>
<td><strong>19.4</strong></td>
<td>21.1</td>
</tr>
<tr>
<td>Min.</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td><strong>Max Stock Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>170</td>
<td>155</td>
</tr>
<tr>
<td>Avg.</td>
<td>140.9</td>
<td><strong>130.8</strong></td>
</tr>
<tr>
<td>Min.</td>
<td>111</td>
<td>105</td>
</tr>
<tr>
<td><strong>Average Idle Time</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>2:15</td>
<td>2:34</td>
</tr>
<tr>
<td>Avg.</td>
<td>1:41</td>
<td>1:42</td>
</tr>
<tr>
<td>Min.</td>
<td>1:04</td>
<td>0:51</td>
</tr>
</tbody>
</table>
Conclusion

- **Job packing algorithm**
  - Need to managing the *inbound supply chain*

- **Supplier-driven job packing**
  - Generate *simple vehicle routes*
  - Less required the number of vehicles
  - Higher stock level due to the JIT violation

- **Event-driven job packing**
  - More appropriate to the JIT philosophy
  - Less stock level
  - Need more vehicle due to the peak time

- **Further study**
  - *Peak time relaxation method* in the event-driven job packing process
  - *Goal model* for evaluating the performance of the generated plans through each job packing process
Thank you!