TIM 125/225, LECTURE #18 (3/6/14)

Agenda

- Project (done)

- Transportation
  - General considerations for Transportation driver design

- Transportation Network Options

- Process for Transportation Network Design

Read chapter on "Transportation..." in the text [3rd edition, Chapter 13]
Notation:

Consider Dell's Build-to-Order supply chain

INTEL (micro-processors) \(\xrightarrow{}\) DELL \(\xrightarrow{\text{Outbound transportation}}\) Customer

\(\xrightarrow{\text{Inbound transportation}}\) SHIPPER \(\xrightarrow{\text{CARRIER (UPS, Fed-Ex)}}\)

1. General considerations in Transportation Network Design

(i) What is the function (purpose) of the transportation network:
   responsive? efficient?

   e.g. Walmart needs to create an efficient transportation system to lower total cost

(ii) Decision making

   - The objective of the carrier (e.g., UPS, Fed-Ex, ...)
     is to design the transportation network (modes, routes, ...)
- The objective of the SHIPPER (e.g. DELL) is to minimize in-bound & out-bound transportation costs.

(iii) Modes of transportation?
- Air, Water, Rail, Trucks, package (USPS, UPS, ...

Read Section 2 of the Transportation chapter.

(iv) Transportation Network Design
- modes (Air, 
- options for networks (see below)
- aggregation: space, time, product
- routing
2. Transportation Network Options

(i) Direct shipping Network

(ii) Direct shipping with Milk Runs (Aggregation)

Suppliers of different products

Retail stores

We can aggregate retailers or suppliers
(iii) Shipping via a central distribution center (DC)
(iv) Shipping using DC & milk runs

Walmart invented a special form of this network called Cross-Docking

Read Section 4 (in the text) on Design Options for a Transportation Network, in particular Table 2.
3. Process for Transportation Network Design

Problem: Design the transportation network connecting suppliers to end-customers with the objective of minimizing total cost.

Five-Step process

Step 1: Q: Which mode of transportation should be used?
A: Choose the mode (air, water, ...) that minimizes total cost

Total cost = Transportation cost +
\[\text{Inventory Holding cost} \]
\[\text{(Cycle + Safety + In-transit)}\]

Create a table of options (see next page)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1 (Air)</td>
<td>Small Lot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode 2 (Truck)</td>
<td>Medium Lot</td>
<td></td>
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<td></td>
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<tr>
<td>Mode 3 (Truck)</td>
<td>Large Lot</td>
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</tr>
</tbody>
</table>

Pick the option for which the total cost (in column 8) is a minimum.
Read the "Eastern Electric/Golden" example in "Transportation" chapter (text)

Electric motor supplier \rightarrow Eastern Electric

Transportation

1 cwt = 100 pounds

(1 furlong = ? \Rightarrow 8 furlongs = 1 mile)

Step 2

Q: Should inventory be aggregated spatially?
A: Yes; explore options for spatial aggregation of inbound transportation

\[
\begin{align*}
\text{Inv1} & \rightarrow A \\
\text{Inv2} & \rightarrow B \\
\text{Inv n} & \rightarrow L
\end{align*}
\]
<table>
<thead>
<tr>
<th>OPTIONS</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stocking locations</td>
<td>x = 50 (say)</td>
<td>x = 50 (say)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Replenishment interval</td>
<td>4 weeks (say)</td>
<td>1 week</td>
<td>1 week</td>
<td>Customer order</td>
</tr>
<tr>
<td>Cycle Inv cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Inv cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Inv Holding Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipment Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipment size</td>
<td></td>
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<tr>
<td>Shipment weight</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Annual Transp. cost</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Annual Total cost = Annual Transportation cost + annual Inv holding cost</td>
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</tr>
</tbody>
</table>
Select the scenario that minimizes the total cost, or provides the best balance between efficiency and responsiveness.

Step 3  Q: Should orders be aggregated in time (temporal)?

A: Explore options for temporal aggregation.

Aggregation of orders in time will reduce transportation costs (i.e., increase efficiency) but will reduce responsiveness (because of delay in shipping items to the customers).

Create a table of options.
<table>
<thead>
<tr>
<th>Day</th>
<th>Customer Demand</th>
<th>Z-Day response</th>
<th>3-Day response</th>
<th>4-Day response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X (# of orders)</td>
<td>x</td>
<td>$C_1$</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Y</td>
<td>y</td>
<td>$C_2$</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Z</td>
<td>z</td>
<td>$C_3$</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>W</td>
<td>w</td>
<td>$C_4$</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>V</td>
<td>v</td>
<td>$C_5$</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>U</td>
<td>u</td>
<td>$C_6$</td>
<td></td>
</tr>
</tbody>
</table>

**Total cost**

$C_1 + C_2 + C_3 + C_4 + C_5 + C_6$

$C_1' + C_2' + C_3' + C_4' + C_5' + C_6'$

$C_1'' + C_2''$

**Explore the trade-off between efficiency & responsiveness**
Step 4: Explore Tailored Transportation
- by customer density and distance
- by product demand & value

Step 5: Plan the routing & scheduling (operational decisions) based on
- savings matrix method
- generalized assignment method
  - (SCM text, 2nd Edition, section 4.7)
  - does not appear in later editions of the text