ISyE 4073  Storage and Distribution Systems Design

Winter 1997

Exam 2

March 6, 1997

Instructions

1. There are 6 pages.
2. Do your own work.
3. Show all calculations.
4. You can use the backs of pages for rough work, but if you want it to be graded, you have to indicate so.
5. Go for it!

Question 1

1.1 Compare the fixed costs and variable costs of pipeline transportation with that of other transportation modes. What are the causes of the differences? (4)

Pipeline transportation has largest proportion of fixed cost, because of high cost of constructing pipeline and pumping facilities. Pipeline transport has lowest variable cost, because no vehicles and very little labor is needed to move product through the pipeline; no drivers and handling of product.

1.2 Which two aspects of transit time are important when evaluating transportation performance? (2)

(1) Average transit time

(2) Transit time variability
1.3 Name 2 coordinated services between trucking and rail transportation. (2)

(1) Trailer on flatcar (TCFC)
(2) Container on flatcar (C0FC)

1.4 How do shippers' associations function? (2)

It is a non-profit cooperative organization of shippers that consolidate the loads of different shippers to obtain cheaper rates from carriers. Shippers contribute in proportion to their loads.

1.5 What was the major reason for transportation regulation before 1920? (1)

The monopoly of the railroads and rate discrimination.

1.6 Name 3 stipulations of the Act to Regulate Commerce of 1887. (3)

(1) Reasonable rates required
(2) No rate discrimination
(3) No undue preference or prejudice
(4) Long-haul-short haul clause
(5) No pooling of freight or revenues
(6) Rates to be published
(7) Establish ICC

1.7 What was the major reason that lead to a decreased need for transportation regulation? (1)

The increased competition between different transportation modes.

1.8 What do contract rates in transportation refer to? (1)

Special rates contractually agreed to between a shipper and a carrier, lower than the carrier's published rates.

1.9 What are deferred rates? (1)

Special rates if the shipper is willing to delay delivery of the loads.

1.10 Name 3 line-haul services provided by carriers. (3)

(1) Diversion and reconsignment
(2) Transit privileges / stop-off privileges
(3) Protection of cargo
Question 2
A computer manufacturer ships assembled computers from an assembly plant in Malaysia to a distribution center in California. We want to determine if it is more economical to ship in 40ft containers by ocean carriers or in airline containers by air carriers. Shipment by ocean costs $9,800 per container, and a 40ft container can hold 320 computers. Handling cost is $550 per 40ft container. The journey by sea takes 25 days on average. Shipment by air costs $25,000 per container, and an airline container can hold 120 computers. Handling cost is $450 per airline container. The journey by air takes 3 days on average (door to door). The forecasted demand is 90,000 computers for the next year, which is also the planned production quantity. No safety stock is kept at the assembly plant, and a shipment is sent to the distribution center as soon as a container is filled. Safety stock of 1700 computers is kept at the distribution center. Inventory holding cost is estimated at 35% per year at the assembly plant and in transit, and 30% per year at the distribution center, based on a value of $800 per assembled computer. Determine the most economical transportation service to use. Show all calculations.

1) Ocean: Inventory cost in Malaysia
   = 0.35 \times 800 \times 320/2 = 44800

   Inventory cost in California
   = 0.35 \times 800 \times (1700 + 320/2) = 446400

   Inventory cost in transit
   = 0.35 \times 800 \times 90000 \times 25/365 = 1726027

   Handling cost = 550 \times 90000/320 = 154688

   Transportation cost = 9800 \times 90000/320 = 2756250

   Total cost = $5128165 per year

2) Air: Inventory cost in Malaysia
   = 0.35 \times 800 \times 120/2 = 16800

   Inventory cost in California
   = 0.35 \times 800 \times (1700 + 120/2) = 422400

   Inventory cost in transit
   = 0.35 \times 800 \times 90000 \times 3/365 = 207123

   Handling cost = 450 \times 90000/120 = 337500

   Transportation cost = 25000 \times 90000/120 = 1875000

   Total cost = $19733823 per year \Rightarrow ocean cheaper.
Question 3
Use Dijkstra's algorithm to determine the shortest path from node 0 to all other nodes in the network. Show your calculations in the given tables, and give the final shortest distances and shortest path predecessors for all nodes. Draw the shortest path tree from node 0 to all other nodes on the given network. (15)

### Distance Labels:

<table>
<thead>
<tr>
<th>Step</th>
<th>Node 0</th>
<th>Node 1</th>
<th>Node 2</th>
<th>Node 3</th>
<th>Node 4</th>
<th>Node 5</th>
<th>Node 6</th>
<th>Node 7</th>
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### Predecessor Labels:

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<th>Node 4</th>
<th>Node 5</th>
<th>Node 6</th>
<th>Node 7</th>
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</table>
Question 4
Admiral Electric manufactures stoves at their plant (P) north of Atlanta, with a production capacity of 600 per week, and production cost of $380 per stove. All distribution takes place through 2 distribution centers (DCs D1 and D2), where the inventory of finished stoves is kept. No more than 400 stoves can be shipped from the plant to any DC in a week. The customers are 2 retail stores (C1 and C2), that place their orders 2 weeks in advance. These orders can be supplied from any of the distribution centers. Assume that stoves can be shipped from the plant to any distribution center and from there to any retail store in the same week that the stoves are to be delivered at the retail stores.

The distribution costs per stove are as follows.

<table>
<thead>
<tr>
<th></th>
<th>To</th>
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<tbody>
<tr>
<td></td>
<td>D1  D2  C1  C2</td>
</tr>
<tr>
<td>From</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>23  19  —   —</td>
</tr>
<tr>
<td>D1</td>
<td>—   —  27  29</td>
</tr>
<tr>
<td>D2</td>
<td>—   —  28  32</td>
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</tbody>
</table>

The number of stoves to be delivered in the next 2 weeks at the different retail stores are as follows.

<table>
<thead>
<tr>
<th></th>
<th>Week 1</th>
<th>Week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>210</td>
<td>290</td>
</tr>
<tr>
<td>C2</td>
<td>305</td>
<td>360</td>
</tr>
</tbody>
</table>

Initially there are 105 and 116 stoves in inventory at D1 and D2 respectively. We want to have a remaining inventory at the end of week 2 at D1 and D2 of 120 and 110 respectively. The inventory holding cost at both D1 and D2 is $7 per stove per week. The storage capacities at D1 and D2 are 125 and 130 respectively.

Determine the optimal logistics plan for Admiral Electric over the next 2 weeks, by formulating this problem as a time-expanded network flow problem. Draw the corresponding network, and explicitly show the unit flow costs and capacities on the arcs in the format (cost, capacity), and the supplies/demands at the nodes. Indicate which arc flows represent the production quantities for the next 2 weeks. Write the corresponding linear programming formulation. (15)
Subject to:

\[ x_{SP_1} + x_{SP_2} = 1174 \]  \hspace{1cm} \text{(Node 5)}

\[ x_{SP_1} - x_{Pt_1D_1t_1} - x_{Pt_1D_2t_1} = 0 \]  \hspace{1cm} \text{(Node Pt_1)}

\[ x_{Pt_1D_1t_1} - x_{Dt_1C_1t_1} - x_{Dt_1C_2t_1} - x_{Dt_1D_1t_2} = -105 \]  \hspace{1cm} \text{(Node Dt_1)}

\[ x_{Pt_1D_2t_1} - x_{D_2t_1C_1t_1} - x_{D_2t_1C_2t_1} - x_{D_2t_1D_2t_2} = -116 \]  \hspace{1cm} \text{(Node D_2t_1)}

\[ x_{Dt_1C_1t_1} + x_{D_2t_1C_1t_1} = 210 \]  \hspace{1cm} \text{(Node C_1t_1)}

\[ x_{Dt_1C_2t_1} + x_{D_2t_1C_2t_1} = 305 \]  \hspace{1cm} \text{(Node C_2t_1)}
\[ X_{sp_1} - X_{pit_2} D_{t_2} - X_{pit_2} D_{t_2} = 0 \]  
(Node Pit_2)

\[ X_{pit_2} D_{t_2} + X_{dit_1} D_{t_2} - X_{dit_2} C_{t_2} - X_{dit_2} C_{t_2} = 120 \]  
(Node Dit_2)

\[ X_{pit_2} D_{t_2} + X_{dit_1} D_{t_2} - X_{dit_2} C_{t_2} - X_{dit_2} C_{t_2} = 110 \]  
(Node Dit_2)

\[ X_{dit_2} C_{t_2} + X_{dit_2} C_{t_2} = 290 \]  
(Node Git_2)

\[ X_{dit_2} C_{t_2} + X_{dit_2} C_{t_2} = 360 \]  
(Node Cit_2)

\[ 0 \leq X_{sp_1} \leq 600 \]

\[ 0 \leq X_{sp_2} \leq 600 \]

\[ 0 \leq X_{pit_1} D_{t_1} \leq 400 \]

\[ 0 \leq X_{pit_1} D_{t_1} \leq 400 \]

\[ 0 \leq X_{pit_1} D_{t_1} \leq 400 \]

\[ 0 \leq X_{pit_2} D_{t_2} \leq 600 \]

\[ 0 \leq X_{pit_2} D_{t_2} \leq 600 \]

\[ 0 \leq X_{dit_1} D_{t_2} \leq 125 \]

\[ 0 \leq X_{dit_1} D_{t_2} \leq 130 \]

All other \( x \)'s > 0