1.224J Recitation #4

Freight transportation
Topics

• Homework questions
• Home Depot
• MVRP: Multi vehicle routing problem
  – Applications
  – Formulation
  – Heuristics (Clarke-Wright and Polar sweep)
Homework

• Last week
  – PS 2 constraint formulations
  – No “IF” statements allowed!
  – Concave minimization example

• PS 3 and 4: Set covering and enumeration ideas
Home Depot

- 1999: 7 million LTL loads, 220,000 TL
- Pre 1996: single lane bidding!
  - Very difficult for carriers.
MVRP: Multi vehicle routing problem

- Find lowest cost set of routes with constraints on vehicle capacity and vehicle travel times, while satisfying pickup or delivery requirements
- TSP comparison


transportation management systems
Applications of MVRP

- Newspaper delivery
- Trash pickup
- National Blood Reserve
  - “The Red Cross is establishing a national blood reserve - a strategically located reserve supply of blood supported by a state-of-the-art logistics and distribution system.” redcross.org
Multiple Vehicle Scheduling

### MIP, Set Covering, Column Generation

<table>
<thead>
<tr>
<th>Route 1</th>
<th>Route 2</th>
<th>Route 3</th>
<th>.....</th>
<th>.....</th>
<th>Route M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>C2</td>
<td>C3</td>
<td>.....</td>
<td>.....</td>
<td>Cm</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Stop A</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Stop B</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Stop C</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Stop D</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Stop E</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Stop F</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Stop G</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stop N</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Each Row represents one of the N stops
- Each Column represents a generated vehicle route and its cost
- Each matrix coefficient, $a_{ij}$, is $\{0,1\}$, identifying the stops on the $j$’th route
- Define $Z_{ij}$, $\{0,1\}$, “1” if Stop “$i$” is on Route “$j$”, else “0”
- Define $Y_j$, $\{0,1\}$, “1” if the sum of $Z_{ij} >0$, $i=1,n$ ; else “0”
- Minimize: the sum of $C_jY_j$, $j=1,m$
- Subject to: the sum of $a_{ij}Z_{ij} =1$, $j=1,m$; for all $i$
Optimal Routing Solution
Heuristic Approach – Savings

Clarke-Wright “savings” algorithm, 1964

1. Serve each stop with direct out and back
2. Find savings for each pair
   \[ S = D_{OA} + D_{OB} - D_{AB} \]
3. Combine loads that increase savings and \(< V_{MAX}\)

Heuristic Approach – Polar Sweep,
Gillett and Miller 1974
Polar sweep
Sweep until filled up...
Then solve a bunch of TSPs
Clarke-Wright and Polar sweep demos