Green Logistics: Vehicle Routing & Scheduling

Richard Eglese
Lancaster University Management School
Lancaster, U.K.
Contents

- Journey times and Road Timetable™
- LANTIME scheduler
- Results from current case study
- Future research
Current Journey Time Calculations

- Journeys between two locations
- Many methods of varying complications
  - Straight line calculations
  - Using a road network
  - Using different speeds on different roads
- Based on static times throughout the day
- Some methods will add a congestion factor onto these static times.
Current Journey Time Calculations

Problems:

- “...our (routing and scheduling) system cannot be relied upon to provide accurate results so significant manual adjustments need to be undertaken before we finalise our routes for the next day”
  - Time windows are missed
  - Legal driving constraints stretched
  - Using resources inefficiently
  - Routing into congestion increases pollution
Data Source

A leading provider of traffic information and vehicle security services
http://www.itisholdings.com

- Largest commercial application of FVD™
  - Real road speeds time matched and day matched
  - 96 (15 minute) time bins
Rationale for a Road Timetable

- On one section of motorway in the North of England the same commercial vehicle speeds varied in one week from 5 mph (at 08.45 on the Monday) to 55 mph (at 20.15 on the Wednesday).
- When the recorded speeds were compared over a ten week period the variation in speed recorded for the same time of day and day of the week was less than 5%.
Road Timetable Description

- Using FVD data we can calculate routes between two locations.
  - Firstly we need to create a digital network based on real road junctions and connecting roads.
  - Using a shortest path algorithm to find the quickest route
  - FVD travelling times are dependent on starting times
- Times calculated this way are more accurate than any of the methods discussed earlier.
Time dependent routes

Lancaster to Nottingham
153 miles 2h 21 m

Lancaster to Nottingham
142 miles 2h 42 m
The 96 time bins can in practice be reduced to about 15 different periods of time with different speeds. These 15 represent distinct changes in the day and are narrower around the two peak times and the build up to them.
The LANTIME scheduler

- Given a set of customers and associated demands, central depot, vehicle fleet
- Objective: Min total time
- Constraints:
  - Vehicle capacity (weight and space)
  - Delivery time windows
  - Driving time for each route
- Using time-dependent data requires significant changes to the vehicle routing algorithms
Case Study

- Electrical Wholesale Distribution in the South West of England
- Type of vehicle - all 3.5 tonne GVW box vans. No restrictions on any roads.
- Weight/Cube - No restrictions
- Time Windows - none
- Time constraint – one shift per day
ITIS Data information

- Data based on information aggregated into 15-minute time bins for a 3-month period covering February to April 2007.
- An average speed per time bin is used to construct the relevant Road Timetables.
Sample Comparisons

- For eight-hour shifts including legal breaks for drive time and work time.
- Bristol - 55 locations, 2 vehicle routes
- Plymouth - 57 locations, 2 vehicle routes
Solution using uncongested times

<table>
<thead>
<tr>
<th>Bristol</th>
<th>Time (min)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle [1]</td>
<td>248</td>
<td>66</td>
</tr>
<tr>
<td>Vehicle [2]</td>
<td>438</td>
<td>259</td>
</tr>
<tr>
<td>Total</td>
<td>685</td>
<td>324</td>
</tr>
</tbody>
</table>
Bristol Uncongested routes
Bristol Uncongested routes detail
### Solution using uncongested routes with congested times

<table>
<thead>
<tr>
<th></th>
<th>Uncongested time (min)</th>
<th>Distance (km)</th>
<th>Congested time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle [1]</td>
<td>248</td>
<td>66</td>
<td>281</td>
</tr>
<tr>
<td>Vehicle [2]</td>
<td>438</td>
<td>259</td>
<td>508*</td>
</tr>
<tr>
<td>Total</td>
<td>685</td>
<td>325</td>
<td>789</td>
</tr>
</tbody>
</table>

* Over max time by 28 min
Solution using Road Timetable and LANTIME

<table>
<thead>
<tr>
<th>Bristol</th>
<th>Time (min)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle [1]</td>
<td>460</td>
<td>251</td>
</tr>
<tr>
<td>Vehicle [2]</td>
<td>326</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>785</td>
<td>331</td>
</tr>
</tbody>
</table>

No route too long and total time taken is shorter (even though total distance is 6km longer)
Bristol LANTIME solution detail
Solution using uncongested times

<table>
<thead>
<tr>
<th>Plymouth</th>
<th>Time (min)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle [1]</td>
<td>448</td>
<td>214</td>
</tr>
<tr>
<td>Vehicle [2]</td>
<td>328</td>
<td>182</td>
</tr>
<tr>
<td>Total</td>
<td>775</td>
<td>396</td>
</tr>
</tbody>
</table>
**Solution using uncongested routes with congested times**

<table>
<thead>
<tr>
<th>Plymouth</th>
<th>Uncongested time (min)</th>
<th>Distance (km)</th>
<th>Congested time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle [1]</td>
<td>448</td>
<td>214</td>
<td>489*</td>
</tr>
<tr>
<td>Vehicle [2]</td>
<td>328</td>
<td>182</td>
<td>359</td>
</tr>
<tr>
<td>Total</td>
<td>775</td>
<td>396</td>
<td>848</td>
</tr>
</tbody>
</table>

* Over max time by 9 min
Solution using Road Timetable and LANTIME

<table>
<thead>
<tr>
<th>Plymouth</th>
<th>Time (min)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle [1]</td>
<td>435</td>
<td>195</td>
</tr>
<tr>
<td>Total</td>
<td>879</td>
<td>394</td>
</tr>
</tbody>
</table>

No route too long
Future Work

- Further testing of LANTIME for other cases
- Modifying for least polluting rather than least time
- Measuring how much difference this can make in practice
- Extending to real-time dynamic routing