Stop Spacing Analysis and Optimization

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Current Spacing and its effect

- **US practice – 200 m (650 ft or 1/8 mile)**
  - Shorter walk access
  - Longer travel time (delay due to stopping)
  - Higher Operating Cost

- **Europe – 320 m (1250 ft or ¼ mile)**
  - More walk time
  - Faster service (less delay due to stopping)
  - Lower Operating Cost
Stop Spacing Impacts

Stop Spacing Impacts

Region "A"
Region "B"
Region "C"

Access Time
In-Vehicle Time
Oper. Time

Oper. Time

Time (min)

Oper. Time

Stop Spacing (m)

Stop Spacing Impacts

optimum
Modeling Stop Spacing

• Modeling tool
  – Voronoi Algorithm
  – Analysis by Removing and/or Inserting Stops
  – Optimization through multi-dimensional state-space Dynamic Programming
Parcel-level Modeling – around Mount Hood Rd.
Determining Service Areas
Minimum Travel-time

On Chiswick
WT = 3.53
RT = 22.91
TT = 26.44

On Mt Hood
WT = 6.04
RT = 21.12
TT = 27.16

On Sutherland
WT = 3.66
RT = 21.90
TT = 25.56
Discrete Optimization

• Enumerate candidate stops
• For each one: keep it or not?
• “Dynamic Programming” – a series of partial optimizations
• Key: isolating the impacts at a single stop
Simple DP Immediate Cost Computation

- To find costs at j, need to specify 1 predecessor and 1 successor stop
- 3-dimensional search space
Complex DP Immediate Cost Computation

- To find costs at j, need to specify 2 or more predecessor and 2 or more successor stops
- $\geq 5$-dimensional search space
Algorithmic Innovations

1. Network Voronoi algorithm
2. Minimum scenario generator to determine stop-level costs
3. DP algorithm itself

Max. Stops to be skipped, $s = 2$, $m = s + 1 = 3$
Min. Cut Arcs = $m^6 + m^2(2m) + m^3$
\[= m^4[m + 1]/2 = 2 \times 3^4 = 162\]
Study Area I Transit Details

• Green Line Light Rail “B”
  – Kenmore to Boston College station with 23 existing stops
• Peak ridership
  – AM East Bound to Kenmore
  – PM peak Westbound to Boston College
Study Area II Transit Details

• Albany Route 55 Bus Line
  – 59 WB, 61 EB existing stops
• Peak ridership
  – AM East Bound to Albany
  – PM peak Westbound to Schenectady
Triplet-Arc Network Diagram

No. Of Stops, n = 10
Max. Stops to be skipped, s = 2,
Min. Cut Arcs = m^2[2m + 1]/2 = 18

Scenario – A path from start (s) to terminal (t)
Minimum number of paths needed to cover arcs = M = 18
Boston “B” Light Rail Triplet & Quintuplet DP Comparison Vs Scenario

![Graph showing comparison between Triplet and Quintuplet DP for Ons+Offs]

- Triplet
  - Δ(Ons+Offs)
- Quintuplet
  - Δ(Ons+Offs)
Boston “B” Light Rail Triplet & Quintuplet DP Comparison Vs Scenario for W/R = 2
The Benefit of Quintuplet DP

<table>
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<tr>
<th>DP Comparison</th>
<th>Δ∑Ons Pax/Hr</th>
<th>Δ∑Offs Pax/Hr</th>
<th>Δ∑Total Cost ($/pd)</th>
<th>ΔOns%</th>
<th>ΔOffs%</th>
<th>ΔTotal Cost %</th>
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<tbody>
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Boston Greenline “B”
Quintuplet DP Stop Set for W/R=1
Albany Rte 55 Quintuplet DP Stop Set for W/R=1
Quintuplet DP Costs / No. of stops vs. W/R Cost for Boston Greenline
Quintuplet DP Costs / No. of stops vs. W/R Cost for Albany Rte 55 Bus Line
Summary and Future Work

• Optimization is feasible with increased state space
• Policy objectives sensitivity on value of time & Access Speed.
• GIS data conversion refinement
Questions?