Sustainable Urban Traffic Management using Advanced Technologies

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Civil and Environmental Engineering
University of Massachusetts Amherst

T3e Webinar, ITS PCB Program
The Volpe National Transportation Systems Center

May 26, 2016
Eleni Christofa, Assistant Professor

**Expertise:**
Intelligent Transportation Systems
Public Transportation Systems
Traffic Operations and Control

**Interests:**
• Sustainable management of multimodal transportation systems
• Use of innovative technologies to better monitor and manage traffic operations for multimodal transportation systems
• Improve transit operations without excessively compromising car and pedestrian traffic operations
• Innovative intersection designs and their impact on safety and emissions
Presenter Introduction

**Yashar Zeinali Farid**, PhD Candidate

- **Research Interests:**
  - Intelligent Transportation Systems
  - Transportation Demand Modeling
  - Transportation Systems Analysis
  - Simulation-based analysis of transportation systems

- **Dissertation title:**
  Transit Preferential Treatments at Signalized Intersections: Person evaluation and Real-time Control

- **Honors/Awards:**
  - IRF Road Scholar Award, 2013
Presenter Introduction

Farnoush Khalighi, PhD Student

- **Research Interests:**
  - Sustainable signal control strategies
  - Public transportation
  - Emission modeling
  - Traffic flow theory and operations

- **Dissertation title:**
  Signal Control and Design for Improved Person Mobility and Air Quality in Urban Multimodal Transportation Systems

- **Honors/Awards:**
  - Claire Barrett Memorial Scholarship, WTS Boston, 2015
  - 2nd position for best poster at the 16th Annual UMass Technical Day & Student Research Symposium, 2015
The Center includes:

- Regional Traveler Information Center (RTIC)
- Local Technical Assistance Program (LTAP)
- Transportation Training Institute (TTI)
- Cooperative Research Program
- UMass Traffic Research Safety Program (UMassSafe)
- Aviation Center
- University Transportation Centers (UTC)
  - New England UTC (Region I)
  - Safety Research Using Simulation (SAFERSIM)
  - Tier I Crash-Imminent Safety UTC
The UMass Amherst Transportation Engineering Program

- 5 research active faculty in transportation engineering (+1)
  - Traffic operations and control
  - Public transportation
  - Systems analysis
  - Transportation safety
  - Human factors
  - Air traffic modeling and control

- Variety of courses that include elements of ITS
  - Intelligent Transportation Systems
  - Public Transportation Systems
  - Transportation Sustainability
  - Traffic Flow Theory and Simulation I & II
Outline

1. *Real-time queue spillback control using Connected Vehicle data*
2. *Person-based evaluation of transit preferential treatments*
3. *Real-time emission-based signal timing optimization*

Source: busimages.blogspot.com

Source: safercar.gov
Motivation
Motivation

Source: busimages.blogspot.com
1. Arterial Queue Spillback Detection and Signal Control Based on Connected Vehicle Technology

Research Objectives

- Develop methods for detecting the occurrence of a spillback on a signalized arterial using only Connected Vehicle data.

- Design a real-time signal control strategy to prevent the occurrence of spillbacks using only Connected Vehicle data.

Source: US DOT
Gap-based potential queue spillback detection

\[ X = \frac{4}{K_i} \]

Unequipped vehicles

Equipped vehicles
Shockwave-based potential queue spillback detection
Real-time Signal Control Strategy to avoid Queue Spillbacks
Test Site: Four-intersection segment of San Pablo Avenue

San Pablo Avenue
Dwight Way

604 m (1980 ft)

Allston Way

159 m (520 ft)

Addison Street

137 m (450 ft)

University Avenue

Critical intersection

N
Spillback Detection Results: Gap-based
Spillback Detection Results: Shockwave-based
# Real-time Signal Control Strategy Results

<table>
<thead>
<tr>
<th></th>
<th>Average Delay (sec/veh)</th>
<th>Maximum Queue Length (veh)</th>
<th>Number of Stops (per veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Signal Settings</strong></td>
<td>40.12</td>
<td>14.42</td>
<td>1.00</td>
</tr>
<tr>
<td>$p = 10%$</td>
<td>40.81</td>
<td>14.80</td>
<td>1.01</td>
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<tr>
<td>$p = 20%$</td>
<td>39.59</td>
<td>14.63</td>
<td>0.95</td>
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<tr>
<td>$p = 50%$</td>
<td>36.86</td>
<td>14.27</td>
<td>0.88</td>
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<td>$p = 75%$</td>
<td>36.70</td>
<td>13.67</td>
<td>0.88</td>
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<tr>
<td>$p = 100%$</td>
<td>36.19</td>
<td>13.90</td>
<td>0.88</td>
</tr>
</tbody>
</table>
### Real-time Signal Control Strategy Results

<table>
<thead>
<tr>
<th></th>
<th>Travel Time (sec/veh)</th>
<th>Number of Stops (per veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northbound direction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Signal Settings</td>
<td>116.54</td>
<td>1.52</td>
</tr>
<tr>
<td>(p = 10%)</td>
<td>154.23</td>
<td>2.27</td>
</tr>
<tr>
<td>(p = 20%)</td>
<td>134.25</td>
<td>1.85</td>
</tr>
<tr>
<td>(p = 50%)</td>
<td>124.85</td>
<td>1.64</td>
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<tr>
<td>(p = 75%)</td>
<td>123.03</td>
<td>1.63</td>
</tr>
<tr>
<td>(p = 100%)</td>
<td>120.39</td>
<td>1.58</td>
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<tr>
<td><strong>Southbound direction</strong></td>
<td></td>
<td></td>
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<tr>
<td>Fixed Signal Settings</td>
<td>86.02</td>
<td>0.74</td>
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<tr>
<td>(p = 10%)</td>
<td>101.03</td>
<td>1.05</td>
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<tr>
<td>(p = 20%)</td>
<td>95.41</td>
<td>0.92</td>
</tr>
<tr>
<td>(p = 50%)</td>
<td>92.13</td>
<td>0.84</td>
</tr>
<tr>
<td>(p = 75%)</td>
<td>92.12</td>
<td>0.85</td>
</tr>
<tr>
<td>(p = 100%)</td>
<td>92.96</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Findings

• Both methods result to correct detection of the spillback in more than 80% of the cycles for CV penetration rates higher than 20%.

• The shockwave-based detection method is more effective for CV penetration rates as low as 10-20%.

• For high CV penetration rates the signal control strategy can effectively reduce the maximum queue length at the critical link and therefore, result in avoidance of queue spillbacks and a reduction in the delay for the cross-street traffic.

• For low CV penetration rates the signal control strategy may be triggered inconsistently and result to worse performance for the critical link and the whole arterial.