Smart Infrastructure for Urban Mobility

Stephen F. Smith
TRAFFIC CONGESTION costs $121 billion per year in the US produces 56 billion pounds of CO$_2$ annually.

40% of time spent on surface streets in urban areas is spent idling.
POORLY TIMED SIGNALS are one big reason why

- Those signal systems with adaptive
- Vast majority of intersections run fixed plans
  - Designed for average traffic conditions
  - Begin “aging” the moment they are installed
  - Are designed strictly for arterials
Scalable Urban Traffic Control

**Goal:** Real-time optimization of traffic flows for urban (grid) road networks

**Technical Approach:**
- Decentralized control
- Coordinated action

**Research Progress**
- 2010-11: Development of core approach
- 2011-12: East Liberty pilot deployment
- 2013-15: Expansion of pilot test site
- 2015: Integration with connected vehicle technology

**Benefits**
- True real-time response
- Multiple dominant flows
- Scalable, incremental deployment
- Multi-modal optimization

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Signal Control as a Distributed Online Planning Problem

1. Current traffic conditions are extracted from sensor data streams.

2. System computes phase schedule that optimizes flow at intersection and sends commands to the controller when it is time to change phases.

3. Schedule is communicated to downstream neighbors to indicate what is coming.

4. **Rolling Horizon:** Scheduling cycle is repeated every few seconds.
## Technologies for Safe and Efficient Transportation

### Surtrac in East Liberty

#### Penn Circle Test Site (Jun 2012):

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<thead>
<tr>
<th></th>
<th>% Improv.</th>
<th>Travel Time</th>
<th># of Stops</th>
<th>Wait Time</th>
<th>Emissions</th>
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<tbody>
<tr>
<td>AM rush</td>
<td>30%</td>
<td>29%</td>
<td>48%</td>
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<td>Mid Day</td>
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<td>Evening</td>
<td>18%</td>
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<td>26%</td>
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#### Bakery Square Expansion (Nov 2013):

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Technologies for Safe and Efficient Transportation

Carnegie Mellon University

Pittsburgh Deployment

Key Capabilities
- True real-time response to traffic conditions
- Manages multiple dominant flows
- Scalable to road networks of arbitrary size
- Multi-modal optimization

In the field...
- 25% lower travel times
- 40% less time idling
- 30-40% fewer stops
- 21% lower emissions

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Carnegie Mellon
Pittsburgh Smart City Challenge
Vision
Integration with Connected Vehicle Technology

- Better sensing
- Use of mode, route info.
- Incident detection and real-time re-routing

24 intersections are equipped with DSRC Radio Communications
Sharing Vehicle Route Information

Basic Concept
- Connected Vehicle (CV) shares its route with the network
- Intersections incorporate this info. into local optimization

Initial Results
- Average delay is significantly improved
- CVs receive immediate benefit
- Little adverse effect and overall flow efficiency improves with level of penetration
The Longer View

• As CV technology emerges the signal network will provide the gateway to real-time control information

• AI planning and machine learning techniques will be a key enabler