Applications in Mobile Technology for Travel Data Collection

Planning Session

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Ed Hard

2012 TxDOT Short Course
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Technology in Travel Data Collection

- Bluetooth
- GPS data streams
- Cellular location data
- Smart phone ‘Apps’ enabled with GPS
- Combinations of above
Bluetooth Overview

- Wireless technology for exchanging data over short distances
- Bluetooth frequently embedded in mobile phones and in-vehicle navigation systems
- Every Bluetooth device has a unique Media Access Control (MAC) address
- Bluetooth devices can be anonymously detected
- Commonly used in developing travel time and speed estimates
Bluetooth Technology

Roadside Detection System A
- CPU Processor
- Bluetooth radio adapter
- Bluetooth antenna
- Field software component

Roadside Detection System B
- CPU Processor
- Bluetooth radio adapter
- Bluetooth antenna
- Field software component

MAC Address Matching Software
- Data collection server
- Travel time algorithm
- Data archival

MAC Address
- Detector ID
- Timestamp

Bluetooth Enabled Phone

A to B
Travel Time: 1 Minute
Speed: 60 MPH
Anonymous Wireless Address Matching (AWAM) Development

• Late 2000’s: there was desire and direction to monitor arterials and rural highways on a widespread basis

• Methods tested:
  – License plate recognition
  – Bluetooth MAC address readers

• Bluetooth-based MAC address readers were cost effective and provided robust data sets, but there were issues...

• TTI developed a unique system to enhance the typical “standard” Bluetooth reader process

• Testing on arterials and highways began in 2007

• Since – more than 2 million reader-hours on arterials, freeways, & tollways
Privacy

• MAC addresses read by AWAM are not directly associated with a specific user – not tracked in the retail chain
• MAC addresses do not contain any personal data or information that could be used to identify or “track” an individual’s whereabouts
• Users who have privacy concerns are also able to turn off the Bluetooth discovery function of their device which prevents it from being read by AWAM
• All MAC addresses collected by AWAM may be anonymized through truncation and encryption immediately upon receipt in the field process

• Our testing indicates that the first three octets of the MAC address can be removed with typically no loss in data fidelity
Use of AWAM - Representative Projects

• **Highway Projects**
  – Interstate 75, Dayton, Ohio (April 2009)
  – Interstate 45, Houston, Texas to Dallas, Texas; 420 directional miles
  – Interstate 35, San Antonio, Austin, Waco, Texas; 200 directional miles for work zone monitoring
  – Interstate 10 & 45, Houston, Texas (AVI replacements)
  – Interstate 64 & 664, Norfolk, VA; “Reach the Beach” project (60+ readers)
  – Interstate 95 & US 1, Miami, FL; prototype completed

• **Arterial Projects**
  – West Houston, Texas Deployment (May 2010 - current)
    • 50 Readers in a grid network covering 14 Arterials
    • Proposed expansion to 600+ additional readers
  – Harris County, Texas: 380+ readers, OEM integration w/ Siemens 2070ATC
  – Dallas, Texas: Integrated Corridor Management (ICM), 34 readers
  – Phoenix, Arizona
    • Various arterials, 2-4 week travel time data collection on each arterial over several months. Collected for Maricopa Council of Governments (MPO)
  – Other installations have been completed across the US for arterial traffic management and performance management

• More than 2 million estimated in-field reader-hours as of September 2012
I-45 Deployment

Travel Times on 197.5 miles of rural/suburban Interstate Highway
I-45 Deployment

Bluetooth Sensor and Axis Camera installed on a Luminaire Pole
I-45 Deployment

Bluetooth Installation with Solar Power
I-45 Deployment

Individual Travel Time Matches
Rural incident impact on 13 mile segment
I-45 Deployment

Individual Travel Time Matches – Friday PM Northbound (Rural, Longer Segment)
I-45 Deployment

Individual Travel Time Matches – Sunday Southbound Suburban, Shorter Segment

Bluetooth Travel Time Monitor - Matches

- Roadway: IH-45 Gulf
- Direction: Northbound
- Roadway Segment: NASA Parkway to El Dorado
- Date: 6/19/2011
- Data Type: Individual Matches
- Y-Axis: Speed
- Show Invalid Matches: No

IH-45 Gulf Northbound

From NASA Parkway to El Dorado (3.4 miles) - Individual MAC Address Matches - 6/19/2011

Graph showing speed (MPH) over time, with valid matches indicated.

Valid (3567)
I-35 Deployment (Work Zone Support)

- Waco, Austin, San Antonio Districts
- 60 AWAM readers
- 456.8 directional miles of coverage
- Pushing travel times to Portable Message Signs
- Current origin-destination calculations
  - e.g., 60-70% of trips are through Waco District
West Houston Deployment

- 14 Arterials, 160+ directional miles of roadway
- 2 to 8 lane arterials
West Houston Deployment

Example Arterial Data (3 traffic signals between readers)

Vehicles traveling within the Progression Band

Vehicles which did not travel within Progression Band
US 50 Demonstration
Arlington County, Virginia

Results of Floating Car Travel Time Runs – AM Peak Direction

Average Speeds, Eastbound AM Peak Period (12/9/2010)
Key Points About TTI’s Bluetooth for O&D Data Collection

- Collects samples of ‘actual’ trip-making that can be expanded to total traffic
- Each unit collects data in both directions
- Will not double/triple count vehicles with multiple Bluetooth devices
- Collects ample percentages of Bluetooth ‘reads’ to total traffic
  - 5 to 25% of traffic, depending on roadway and area
  - More than adequate sample sizes
O&D Data Collection Using Bluetooth Field Test in Bryan-College Station

- Deployed BT readers at same sites as prior external survey
- Travel time runs prior to data collection
- Collected data for 72 hours
- Vehicle Classification counts at all external sites
- Compared BT results to prior external survey results
# Bluetooth Observations

<table>
<thead>
<tr>
<th>Station # (TAZ)</th>
<th>Site Description</th>
<th>Aug. 16 Tue</th>
<th>Aug. 16 Wed</th>
<th>Aug. 16 Thu</th>
<th>Total</th>
<th>3-day Count*</th>
<th>3-day % Reads</th>
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</thead>
<tbody>
<tr>
<td>479</td>
<td>OSR @ Madison Co Line</td>
<td>86</td>
<td>102</td>
<td>105</td>
<td>293</td>
<td>3,357</td>
<td>8.7%</td>
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<tr>
<td>480</td>
<td>SH 21 @ Madison Co Line</td>
<td>579</td>
<td>627</td>
<td>577</td>
<td>1,783</td>
<td>22,050</td>
<td>8.1%</td>
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<tr>
<td>481</td>
<td>Democrat Rd @ Grimes Co Line</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>22</td>
<td>468</td>
<td>4.7%</td>
</tr>
<tr>
<td>482</td>
<td>FM 2038 @ Grimes Co Line</td>
<td>9</td>
<td>7</td>
<td>15</td>
<td>31</td>
<td>621</td>
<td>5.0%</td>
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<tr>
<td>483</td>
<td>SH 30 @ Grimes Co Line</td>
<td>492</td>
<td>557</td>
<td>477</td>
<td>1,526</td>
<td>20,312</td>
<td>7.5%</td>
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<tr>
<td>484</td>
<td>SH 6 @ Grimes Co Line</td>
<td>2,046</td>
<td>2,180</td>
<td>2,140</td>
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<td>77,643</td>
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<tr>
<td>485</td>
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<td>14</td>
<td>21</td>
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<tr>
<td>486</td>
<td>FM 60 @ Burleson Co Line</td>
<td>592</td>
<td>629</td>
<td>587</td>
<td>1,808</td>
<td>26,070</td>
<td>6.9%</td>
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<tr>
<td>487</td>
<td>SH 21 @ Burleson Co Line</td>
<td>1,057</td>
<td>1,167</td>
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<td>3,453</td>
<td>39,027</td>
<td>8.9%</td>
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<tr>
<td>488</td>
<td>FM 50 @ Robertson Co Line</td>
<td>102</td>
<td>73</td>
<td>87</td>
<td>262</td>
<td>2,940</td>
<td>8.9%</td>
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<tr>
<td>489</td>
<td>SH 6 @ Robertson Co Line</td>
<td>1,563</td>
<td>1,671</td>
<td>1,697</td>
<td>4,931</td>
<td>73,986</td>
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<tr>
<td>490</td>
<td>FM 46 @ Robertson Co Line</td>
<td>89</td>
<td>143</td>
<td>110</td>
<td>342</td>
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<tr>
<td>491</td>
<td>FM 1940 @ Robertson Co Line</td>
<td>42</td>
<td>56</td>
<td>32</td>
<td>130</td>
<td>2,488</td>
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<td><strong>TOTAL</strong></td>
<td></td>
<td>6,679</td>
<td>7,239</td>
<td>7,092</td>
<td>21,010</td>
<td>276,227</td>
<td><strong>7.6%</strong></td>
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</tbody>
</table>
## Unexpanded Through Trips

<table>
<thead>
<tr>
<th>Station #</th>
<th>Site Description</th>
<th>Total Observ.</th>
<th>Through Matches</th>
<th>Local Trips</th>
<th>Percent Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>479</td>
<td>OSR @ Madison Co Line</td>
<td>293</td>
<td>21</td>
<td>272</td>
<td>7.2%</td>
</tr>
<tr>
<td>480</td>
<td>SH 21 @ Madison Co Line</td>
<td>1,783</td>
<td>134</td>
<td>1,649</td>
<td>7.5%</td>
</tr>
<tr>
<td>481</td>
<td>Democrat Rd @ Grimes Co Line</td>
<td>22</td>
<td>1</td>
<td>21</td>
<td>4.8%</td>
</tr>
<tr>
<td>482</td>
<td>FM 2038 @ Grimes Co Line</td>
<td>31</td>
<td>0</td>
<td>31</td>
<td>0.0%</td>
</tr>
<tr>
<td>483</td>
<td>SH 30 @ Grimes Co Line</td>
<td>1,526</td>
<td>84</td>
<td>1,442</td>
<td>5.5%</td>
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<tr>
<td>484</td>
<td>SH 6 @ Grimes Co Line</td>
<td>6,366</td>
<td>755</td>
<td>5,611</td>
<td>11.9%</td>
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<tr>
<td>485</td>
<td>FM 159 @ Washington Co Line</td>
<td>63</td>
<td>2</td>
<td>61</td>
<td>3.2%</td>
</tr>
<tr>
<td>486</td>
<td>FM 60 @ Burleson Co Line</td>
<td>1,808</td>
<td>47</td>
<td>1,761</td>
<td>2.6%</td>
</tr>
<tr>
<td>487</td>
<td>SH 21 @ Burleson Co Line</td>
<td>3,453</td>
<td>215</td>
<td>3,238</td>
<td>6.2%</td>
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<tr>
<td>488</td>
<td>FM 50 @ Robertson Co Line</td>
<td>262</td>
<td>28</td>
<td>234</td>
<td>10.7%</td>
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<tr>
<td>489</td>
<td>SH 6 @ Robertson Co Line</td>
<td>4,931</td>
<td>771</td>
<td>4,160</td>
<td>15.6%</td>
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<tr>
<td>490</td>
<td>FM 46 @ Robertson Co Line</td>
<td>342</td>
<td>13</td>
<td>329</td>
<td>3.8%</td>
</tr>
<tr>
<td>491</td>
<td>FM 1940 @ Robertson Co Line</td>
<td>130</td>
<td>4</td>
<td>126</td>
<td>3.1%</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>21,010</td>
<td>2,075</td>
<td>18,935</td>
<td><strong>9.9%</strong></td>
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</tbody>
</table>
Comparison of 2002 and 2011 Results
Percent E-E Trips

E-E Trips
2002 – 8%
2011 – 10%
Bluetooth O-D Trip Matrix Generator

Bluetooth Travel Time Monitor – Origin-Destination Trip Matrix Generator

Instructions
Generate Origin/Destination trip tables by adding AWAM readers to the Selected Readers list. Specify the parameters for the trip tables including the minimum and maximum travel time as well as the start and end date and time. All travel times must begin and end within the start and end date and time.

* Note that the totals presented are intended to be used for assessing origin and destination trips and are not necessarily “valid” matches.

Reader Locations
- 34th_US290
- BriarForest_SH-6
- BW8-East_JacintoPort
- BW8-East_LittleYork
- BW8-East_Wallisville
- BW8-East_Winfield
- BW8-North_JFK
- BW8-North_JohnRalston
- BW8-North_Wilson
- ClayRoad_SH-6
- Fairbanks_US290
- FM29_BarkerCypress

Selected Readers

Minimum Travel Time
- Hours: 0
- Minutes: 0

Maximum Travel Time
- Hours: 24
- Minutes: 0

Start Date
- 9/7/2012

End Date
- 9/7/2012

Start Time
- 12:00 AM

End Time
- 11:59 PM

Generate O-D Trip Matrix
Developing O-D Matrices Using GPS Data Streams

• TTI Research
  – Establish trips by direction at external stations
  – Evaluate quality/quantity of trip data
  – O&D’s determined using trip end algorithms
  – Analyze for local/through movements and trip tables

• Private firms developing ‘O&D products’

• Challenges
  – Validation of GPS-derived O&D data
  – Acquiring, aggregating GPS data from private sources
O-D Data Using GPS Data Streams
Cellular Locational Travel Data

• Cell signal data used to estimate travel patterns and flows
• Device location determined based on cell tower triangulation, data anonymized
• Device ‘home’ and ‘work’ locations determined
• Provides travel ‘flows’ of population movements
• Uses still evolving, possibly best for long distance travel
• Challenges:
  – Data resolution, infrequent sampling rates
  – Accuracy of positioning data
  – ID’s ‘location events’, not necessarily trip ends
Cellular Travel Data

Home-Work Trips

Source: AIRSAGE TMIP webinar, April 2012
Smartphone ‘Apps’ to Collect Travel Data

• Future of travel survey data collection?
• Real-time GPS and trip/activity logging
  – Interactive or passive data collection
  – Prompted recall on device or via web follow-up
• Trip times, speeds, lengths, purpose, routes can be collected
• Challenges
  – Technical: battery life, data storage, dual functionality
  – Privacy, recruitment, bias
  – Respondent burden
Smartphone Travel Data Apps

Examples

NuStat’s RouteScout

PTV Pacelogger
Questions

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