USE OF BLUETOOTH TECHNOLOGY FOR TRAFFIC ANALYSIS IN URBAN ROAD NETWORKS

Şule Yücel
Advisor: Assoc. Prof. Dr. Hediye Tüydeş Yaman
What is Bluetooth?

- Wireless technology using 2.4 GHz special radio frequency
- Transmits Media Access Control (MAC) addresses
- Works in short ranges

<table>
<thead>
<tr>
<th>Class</th>
<th>Transmission power</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>100 mW (20dBm)</td>
<td>100m</td>
</tr>
<tr>
<td>Class 2</td>
<td>2.5 mW (4dBm)</td>
<td>10m</td>
</tr>
<tr>
<td>Class 3</td>
<td>1 mW (0dBm)</td>
<td>1m</td>
</tr>
</tbody>
</table>
Bluetooth Working Principle

A Bluetooth reader can receive signals from any Bluetooth enabled device with time stamp and MAC Address.

A reader scans for signals at every 2.54 seconds (theoretically)

The same device can be scanned multiple times as long as it is within the range of the reader.
Bluetooth Working Principle in Traffic Studies

A Bluetooth reader can receive signals from any vehicle or traveler carrying a Bluetooth enabled device with time stamp and MAC Address.

Use of multiple readers collects data about movements of vehicles/travelers in a network - **MAC Matching**
Bluetooth Working Principle in Traffic Studies

Multiple readings within the range produce ‘stay time’ information.

The difference between the two consecutive readings of the same MAC Address is defined as the ‘Scan time’ (from field data).

Station 1

```
"2012-04-07 16:22:07", "00:0D:18:A0:0C:68",
"2012-04-07 16:22:11", "00:0D:18:A0:0C:68",
"2012-04-07 16:22:15", "00:0D:18:A0:0C:68",
```
Bluetooth Use in Traffic Studies

- Travel Time Estimation
- Origin-Destination Matrix Estimation
- Level of Service calculation
- Bus stop waiting time measurement
- Congestion reporting
- Pedestrian travel time etc.
Bluetooth Data Analyses for Traffic

1. Analysis for single reader
   a. MAC to Volume ratio
   b. Scan time
   c. Stay time

MAC-to-Volume
→ penetration rate
→ ~sampling rate
→ <10% in cities in Turkey
Bluetooth Data Analyses for Traffic

1. Analysis for single reader
   a. MAC to Volume ratio
   b. Scan time
   c. Stay time

2. Inter-reader Analysis
   a. Travel time estimation
   b. Trip/route/path detection
   c. O-D Estimation
Case Studies
Case Study 1: Etlik Region Analyses

Locations of Bluetooth readers in the study region
Travel time distributions for the analysis corridors between J1 and J4, and J4 and J6
Case Studies

Case Study 1: Etlik Region Analyses

MAC-to-Volume rates at the four junctions: Saturday (left) and Wednesday (right)
Case Studies
Case Study 2: Evaluation of Electronic Speed Enforcement on Eskişehir Road and Mevlana Road

Study corridors: Mevlana Road and Eskişehir Road
Travel speed calculation

\[ v_{12} = \frac{d_{12}}{(t_2 - t_1)} \]

\[ v_{23} = \frac{d_{23}}{(t_3 - t_2)} \]

\[ v_{34} = \frac{d_{34}}{(t_4 - t_3)} \]
Study corridors: Mevlana Road (above) and Eskisehir Road (below)
Case Studies
Case Study 2: Evaluation of Electronic Speed Enforcement on Eskişehir Bulvarı and Mevlana Bulvarı

Average travel speeds (above) and Eskişehir Road segment profile (below)
Case Studies

Case Study 2: Evaluation of Electronic Speed Enforcement on Eskişehir Bulvarı and Mevlana Bulvarı
Case Studies

Case Study 2: Evaluation of Electronic Speed Enforcement on Eskişehir Bulvarı and Mevlana Bulvarı
Summary

• Easy and cheap way of travel study
• Bluetooth data processing must be automated to handle complex traffic networks
• Traffic monitoring via Bluetooth data should be verified with another traffic data source, such as Floating Car Data (FCD)
THANK YOU ...