Collection and Use of MAC Address Data for the Travel Demand Model

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Short Paper

1. Objectives, Motivations and Innovation

The purpose of this study was to collect travel time and speed data along key corridors in FDOT District 5. The data are used by the Department as part of a larger effort to convert the Central Florida Regional Planning Model (CFRPM) from a regional model to a time of day model. It is also anticipated that the collected link speed data will be used in future studies such as alternative analysis (AA) studies to support transit initiatives and other planning initiatives in the District. The study methodology will use both MAC address data collection and traffic volume data collection for model calibration and validation.

Recently, reading Media Access Control (MAC) identifiers through Bluetooth™ enabled communication systems is a revolutionary new approach to sample roadway users travel characteristics remotely, robustly, while protecting individual privacy. Performance measurement on highways, arterials or nearly any other transportation system is made possible efficiently and effectively through MAC reader systems.

The innovation of this study was to

- Apply the Bluetooth™ data collection method along a variety of corridors in Central Florida to collect real time speed for travel demand model validation. The volume counts are also captured at the same time periods.
- Calibrate the speed flow equations for Central Florida Region Planning Model (CFRPM) time-of-day model using the Bluetooth based travel time observations and concurrent flow rate data.
- The link/segment travel speeds for different roadway types are collected continuously and have much larger sample sizes than conventional GPS runs.

2. Background and Methodology

(1) MAC Address

Bluetooth™ refers to a commonly used protocol for short-ranged wireless transfer of data between two devices. The protocol uses a short-range 2.4 GHz signal sent from one device, such
as a cell phone, to a receiving device, such as an earpiece. Once detected, both the transmitting and receiving device must agree before data is sent. This process, known as pairing, allows data to be transferred to the intended party. If pairing is established, the identifier of the transmitting device is the only aspect acknowledged by the receiving device. This identifier is the media access control (MAC) address. A MAC address is a 48 bit (12 alpha-numeric character) unique address assigned to a device by its manufacturer (e.g. 00:10:86:eb:6y:15). Reading the MAC address with a detection device, such as a Bluetooth™ radio, establishes both a unique and anonymous name representing a vehicle.

(2) Data Collection

Generically, the equipment to record data using Bluetooth™ operates in the following manner. A Bluetooth™ radio is placed along the study corridor in close proximity to the roadway. This radio is attached to a recording device, such as a mini-laptop, where a text file is written containing each MAC address observed by the radio and the time at which this observation occurred. Using a combination of station and antenna placement, it is possible to obtain a rich sample of the passing vehicles labeled with both an anonymous and unique identifier and a time-stamped recording when the vehicle passed the station’s location. Figure 1 provides a conceptual illustration of the set-up.

![Figure 1 MAC address reader set up process](image)

The MAC reader system captures two key elements, (1) a date and time stamp, (2) physical detected MAC address. The effectiveness of the MAC reader system is predicated on matching addresses as they pass through the system. The time and date stamp provides the base information for direction, as well as travel time, speed, and start/end points across segments and through networks. A consistent point of detection is used (in most cases the first point to first point detected) to relatively ensure consistent distances are being used for the data
measurements. This is necessary when a device is picked up multiple times as it passes a roadside MAC reader unit.

The raw output is in a simple text file, we have written automated programs to speed up the data reduction and to sort of typical results for common measures of effectiveness, such as travel time, travel speed, and origin-destinations.

(3) The FDOT District 5 Study

Our study is to collect travel time and speed data through MAC address readers along eighteen key corridors in Central Florida. The selected corridors are on major arterials, minor arterials and local roads. The collected samples are located district wide in Central Florida. Figure 2 has the location map of the study corridors. The data are used by the FDOT Department for the time of day calibration and model validation as part of a larger effort to convert the CFRPM from a regional model to a time of day model.

The MAC address readers were placed in the field Sunday afternoon and collected Saturday morning the following weekend. For each corridor, a team of three members were used to deploy the data collection equipment (both the MAC address readers and the tube counts) and a team of two members were used to take down the equipment. Traffic counting tubes were laid for the same duration as the MAC study. The distances between MAC address readers were also be measured. This distance will be used to calculate travel speeds. Figure 3 illustrates the locations of MAC reader systems and Tube counts for SR 482.
Figure 2 Location Map of Study Corridors
The speed flow equations (Bureau of Public Roads (BPR) curve) were calibrated in this study using the MAC reader collected data. The Bureau of Public Roads (BPR) function is defined as:

\[ S = \frac{S_f}{1 + \alpha \left( \frac{v}{C} \right)^\beta} \]

Where:

- \( S \) is observed speed;
- \( S_f \) is free-flow speed (In CFRPM, the free flow speed is calculated from the equation based on posted speed and facility type.);
- \( \alpha, \beta \) are parameters that need to be estimated from the MAC reader collected data;
- \( v \) is traffic volume measured from Tube counts;
- \( C \) is model practical capacity.
To calibrate the speed flow questions parameters \((\alpha, \beta)\), we defined the study section (MAC reader data collection location pair) for each corridor. The congested travel speed and traffic volume for the defined section were extracted for each hour, half an hour, AM, MIDDAY, PM and NIGHT. The BPR curve parameters were estimated based on the MAC reader collected data and the counts using the statistical program.

3. Major Results

After each deployment, we reduced the MAC address information into a raw database. For each corridor, average speed and counts were summarized and extracted for each 15 minute time period. Figure 4 shows the travel speeds on US 17 during weekdays in a whole week. One person’s MAC address when doing the GPS run was captured in the MAC reader dataset. The 15 minutes speed data can be aggregated to different time resolutions and compared with the time of day model congested speed estimation results for model validation.

![Figure 4 Observed Speed by MAC address data on US 17](image)

Figure 5 shows the observed speed-flow points with different fitting curves on SR 482. During congestion (volume over real capacity), the demand is not equal to flow and will not be captured. The practical capacity in Figure 4 is for LOS C (or D) capacity. The observed MAC reader data shows similar trend to the South Florida Regional Planning Model (SERPM) BPR curve. Both the existing CFRPM and 1964 BPR curves are not very close to the observed data on this road.
The BPR curves were estimated for all the eighteen corridors based on the MAC reader data. The estimation of BPR curve parameters shows difference by direction. For the tested corridors, the fitted BPR curve parameters have minor difference by one hour or by half hour or by time of day periods.

The study results show:

- The MAC address data can help improve the speed flow equations (BPR curves) calibration
- BPR curve parameters across different facility types can be estimated and improved using the MAC address data.

4. Implications for the Science and Travel Modeling

Compared with other speed data collection methods, the Bluetooth data collection methods have the following advantages:

- Variety of data: provides segment (link) travel times and space mean speeds, as well as origin-destination samples.
- Lower cost compared to other traditional manual measurement technologies
- Ground truth data, without adding additional vehicles for measurement
• Longer travel times, ability to measure data over long spans of time and much larger data sets at lower incremental costs than traditional methods
• Protects privacy, filtering addresses to privacy, while retaining very high levels of matching confidence between points
• Real-time potential: could be integrated into existing communication and future software data reduction programs to present data in near-real or real-time
• ITS integration: resultant field data could be used to inform and drive ITS and signal system infrastructures
• Low cost equipment: uses off-the-shelf technology equipment

Bluetooth™ based data provide transportation planners and engineers an exciting new ability to monitor and measure the transportation system. The combination of low relative cost and ease of installation makes Bluetooth™ a viable approach to data collection for numerous projects. This paper demonstrates how Bluetooth™ was used to advance the traffic demand modeling profession toward accurate assessment of road utility by time of day.