BLUETOOTH TRAFFIC MONITORING

CONCEPT OF OPERATION & DEPLOYMENT GUIDELINES

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Introduction to Bluetooth Traffic Monitoring:

The University of Maryland has developed a probe technique to monitor the travel time on highways and arterials based on signals available from the point-to-point networking protocol commonly referred to as Bluetooth. The majority of consumer electronic devices produced today come equipped with Bluetooth wireless capability to communicate with other devices in close proximity. For example, many digital cameras use Bluetooth for downloading pictures to a laptop computer. It is also the primary means to enable hands free use of cell phones. Bluetooth enabled devices can communicate with other Bluetooth enabled devices anywhere from 1 meter to about 100 meters, depending on the power rating of the Bluetooth sub-systems in the devices.

The Bluetooth protocol uses an electronic identifier, or tag, in each device called a Machine Access Control address, or MAC address for short. The MAC address serves as an electronic nickname so that electronic devices can keep track of who's who during data communications. It is these MAC addresses that are used as the basis for obtaining traffic information. The concept for deriving traffic information in this manner is illustrated in Figure 1.

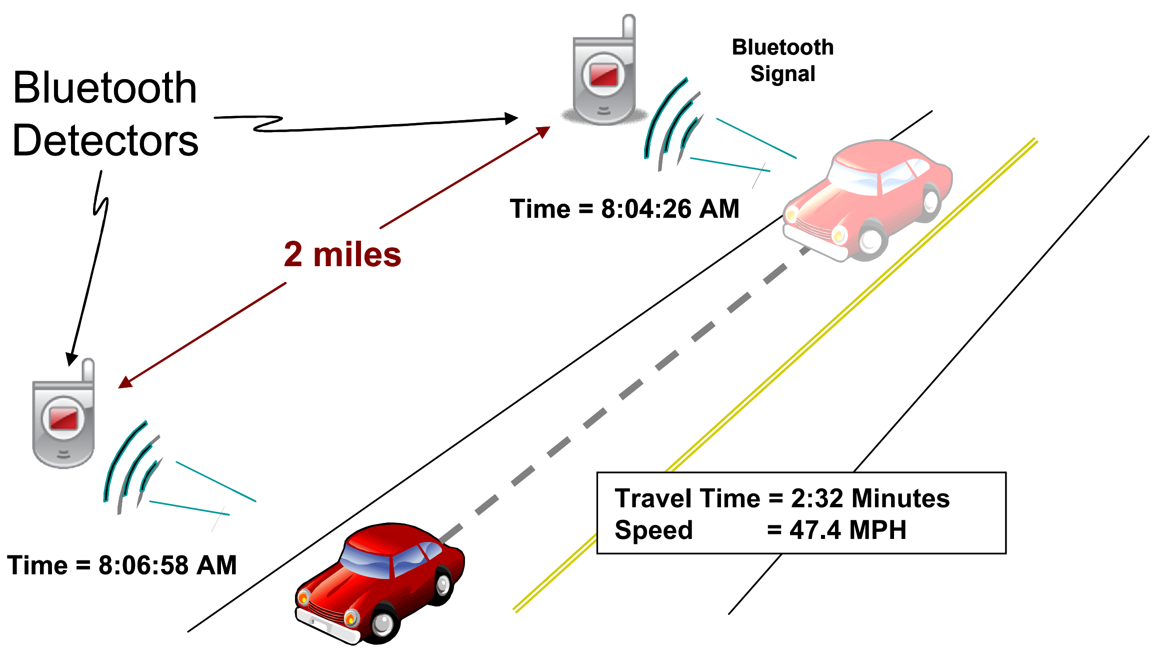

Figure 1 Bluetooth traffic monitoring operation concept

Privacy Concerns

The anonymous nature of this technique is due to the use of MAC addresses as identifiers. MAC addresses are not directly associated with any specific user account (as is the case with cell phone geo-location techniques) or any specific vehicle (as is the case with deriving travel time from automated toll tags). The MAC address of a cell phone, camera, or other electronic devices, though unique, is not linked to a specific person through any type of central database, thus minimizing privacy concerns. Additionally, users concerned with privacy can set options in their device (referred to as 'Discovery Mode' or 'Visibility') so that the device will not be detectable.

Concept of Operation

The University of Maryland has developed a portable Bluetooth monitoring system consisting of several detectors and a central processing unit. These detectors are deployed on a freeway or arterial in proximity to the roadway at the base of a sign post or guard rail post. These units are the size of a large briefcase or small carryon. A photo of the device and a sample placement next to a sign post are shown in Figure 2.

Figure 2 The Bluetooth detector is shown as it would be deployed during data collection. The unit sits on the ground and is tethered to an existing post.

Detectors need to be tethered to a secure object for security reasons. Local transportation and security officials should be notified of the use and appearance of the devices, and the devices should be marked with local contact information. The units contain an internal battery and can operate for three days without recharging. Data is stored to a removable memory card. In a typical application detectors are placed from 2 to 4 miles apart along a corridor for 8 to 72 hours. At the end of the data collection period, the units are collected, data is downloaded from the memory cards and the battery is recharged.

Sample Data

Studies have indicated that approximately 1 automobile in 20 contains some type of Bluetooth device that can be detected, this is referred to as the penetration rate. Not every Bluetooth device is detected at every station so the number of matched detections (a device detected at two consecutive detectors) is lower than the penetration rate. Even so, a majority of the detected devices are seen at multiple stations. These matched pairs can be used to develop a sample of travel time for that particular segment of the roadway. Figure 3 shows data from a segment of Interstate I-495 between Washington, DC and Baltimore, Maryland between 6:30 AM and 12:45 PM. Each data point represents the travel time from a matched detection at each end of the segment. Figure 3 depicts the impact on travel time as a result of an incident that began around 10 AM, was cleared at approximately 10:50 AM and traffic returned to normal flow around 11:15 AM.

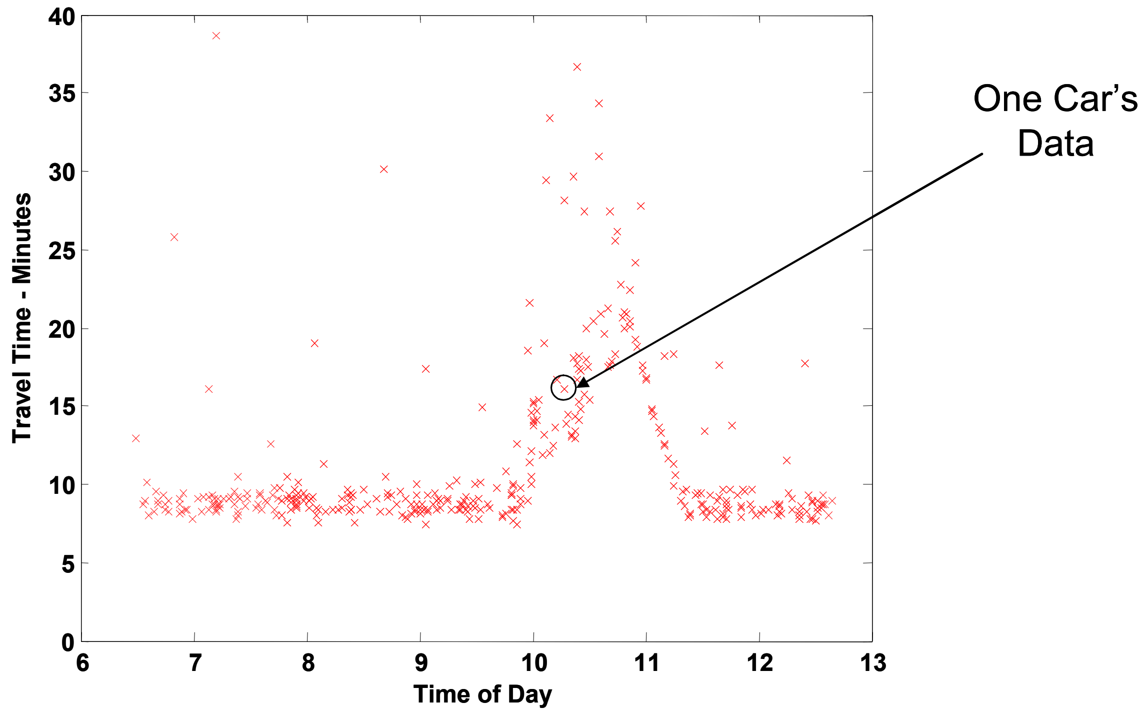

Figure 3 Sample Bluetooth data taken along a segment of I-495 between Baltimore and Washington, DC

Conclusion

The Bluetooth Traffic Monitoring provides an opportunity to collect high quality, high density travel times by sampling a portion of actual travel times from the traffic stream. By matching MAC addresses at two different locations, not only is accurate travel time measured, privacy concerns typically associated with probe systems are minimized. On a cost per data point basis, Bluetooth traffic monitoring are 1000 times more economical than drive testing. Applications for the probes include validation of existing systems, corridor travel time studies, arterial signal synchronization, congestion performance measures, construction zone monitoring, and before and after studies of capital improvements.