The Ohio Department of Transportation Office of Research & Development Executive Summary Report

Application of Bluetooth Technology to Rural Freeway Speed Data Collection

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Problem

The Ohio Department of Transportation (ODOT) currently employs a network of side fire speed radar devices to measure travel speeds and travel times on their interstate network. While these devices measure the instantaneous spot speed, segment level speeds may be more advantageous. Bluetooth devices are used in a data collection technique to support the measurement of travel times and speeds by comparing two or more time-stamped positional measurements. The purpose of this research is to develop a Bluetooth device capable of recording the media access control (MAC) addresses of target radios on Interstate 71 and calculating the resulting space mean speed. Based on the development of these Bluetooth devices, recommendations including node spacing configurations are developed for urban and rural settings along I-71.

Objectives

There are four objectives in this study:

- Objective One – Develop a system that uses Bluetooth technology to capture and match signals from vehicle based Bluetooth devices.
- Objective Two – Determine minimum required spacing of devices to produce accurate travel times.
- Objective Three – Deploy sensors along a designated roadway and collect data in real time.
- Objective Four – Summarize the final results.

Description

There are two main research areas within this study.

- Research Area One – Develop the Bluetooth Data Collection System (BTDCS). The BTDCS includes the development of the node hardware, node software, and the server hardware. In developing the node hardware, the Bluetooth radio with the highest receiver sensitivity is desired in order to receive more responses from Bluetooth devices. The nodes are powered using solar or battery power. The solar powered nodes require a more permanent deployment since the solar panel and the cabinet must be mounted to a pole. The battery powered nodes are contained in weatherproof cases that allow for easy relocations of the nodes. The nodes use a Verizon wireless card on the Verizon 3G network in order to upload data from the field. The 3G software allows the nodes to synchronize times using the network time protocol (NTP) and upload data to the server. The server is the single point where all data processing occurs. Algorithms are developed to clean duplicate MAC hits and match the hits to various nodes in order to calculate vehicle speeds. These algorithms are repeated in very short intervals to produce real-time speed data.

- Research Area Two – Deployment of the Nodes. A database of bridges and overpass locations on Interstate 71 is created using ArcGIS to determine future node locations. These locations are chosen to deploy nodes because they are typically accompanied by guardrails. Guardrails are used to protect the Bluetooth nodes and personnel from traffic, and they provide a structure to which the nodes are locked. Various deployments schemes are utilized in order to determine the optimal deployment strategies for the nodes and various applications the nodes may be used for.

Conclusions & Recommendations

Ten Bluetooth node placements are deployed from August 2011 to July 2012. The initial deployments are used in the development of the technology including the optimization of the hardware, software, and data processing of the BTDCS. Nodes are placed at various distances throughout the remainder of the project in order to determine the optimum spacing. The nodes are also used to determine the amount of Bluetooth hits lost at interchanges, determine congestion in work zones using travel times and travel speeds as surrogate measures of congestion, and to test the feasibility of using fewer nodes to cover large distances in urban areas.

As the project progresses, the nodes are optimized and additional Bluetooth nodes are placed in the field. Distances between nodes are recommended based on the area of interest. Closer node spacing of two to five miles is recommended in urban and suburban areas, where interchange density is higher. In more rural areas, a node spacing of five to ten miles is feasible, as there are fewer interchanges in these areas and hits between nodes are less likely to be lost. With closer node spacing, the resolution of data is higher.

Battery powered portable nodes may be used in construction zones for evaluating travel times and travel speeds, and the data from these nodes may be used as surrogate measures of congestion. The portable nodes also may be used to identify areas with a higher probability of incidents or reoccurring congestion. Once these areas are determined, the permanent solar powered nodes may be deployed for an extended period of time.

Along with being deployed in work zones, the nodes may be used for incident detection. With many nodes, the length of congestion may be determined by using nodes farther from the incident to see the influence of the queue. Since the Bluetooth nodes require vehicles to be recorded on two nodes, it may take much longer to gather travel speed data when incidents occur, since vehicles may reduce speed or stop. These reduced speeds will be detected sooner by spot speed systems than the Bluetooth systems. To improve detection time, total Bluetooth hits are compared to unique Bluetooth hits. The unique hits do not include repeated hits from the same MAC address, while the total hits count all hits from all devices. When travel speeds are reduced or stopped during incidents, a vehicle with a Bluetooth device may stay in the effective range of a Bluetooth node for a longer period of time; this results in more duplicate hits from that device, which may indicate that congestion is occurring.

This research report proves that Bluetooth nodes are a viable technology to collect travel times and travel speeds under multiple configurations for extended periods of time. The resulting data may be used in several applications of interest to ODOT, including work zones and high incident areas.

Implementation Potential

The results of this research are based on the data collected from the BTDCS over the course of the project. These nodes and system may be implemented after the training of key ODOT personnel who will be handling the system. The nodes currently in use are turned over to ODOT at the conclusion of the project and may be implemented immediately after training.

The only issues with the long term feasibility of the nodes are the decreased discoverable time of new cell phones. However, recent legislation the Ohio Revised Code sections 4511.204 and 4511.205 prohibit texting while driving for adults and all cell phone use for minors. This legislation is considered a first step and may encourage motorists to use hands free devices, which commonly use Bluetooth technology.