OKLAHOMA Transportation RESEARCH

PROJECT TITLE
VEHICLE CLASSIFICATION AND BLUETOOTH MACS FOR ORIGIN-DESTINATION MEASUREMENTS

FINAL REPORT ~
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INVESTIGATORS
Mohamed Afify
Samuel Chan
Munzer Alsallakh
Hazem Refai, Ph.D.
The University of Oklahoma

ODOT SPONSORS
Daryl G. Johnson, P.E.
Traffic Data Analyst

Office of Research & Implementation

Oklahoma Department of Transportation
200 NE 21st Street,
Oklahoma City, OK
73105-3204

Implementation of Research for Transportation Excellence

MORE INFORMATION
odot-spr@odot.org

HIGHLIGHTER

VEHICLE CLASSIFICATION AND BLUETOOTH MACS FOR ORIGIN-DESTINATION MEASUREMENTS

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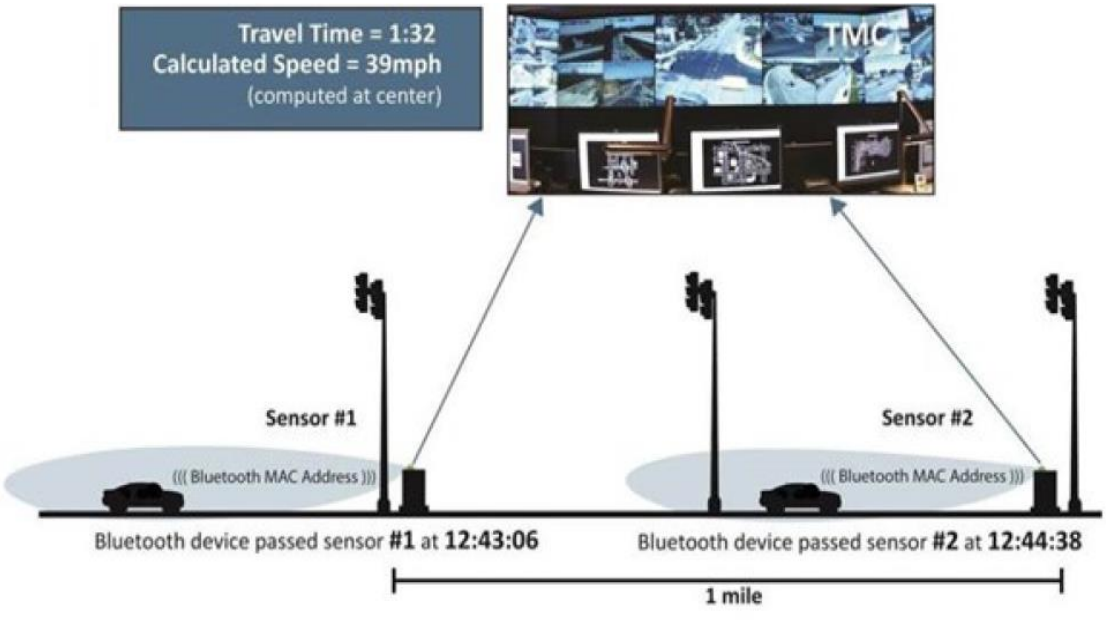
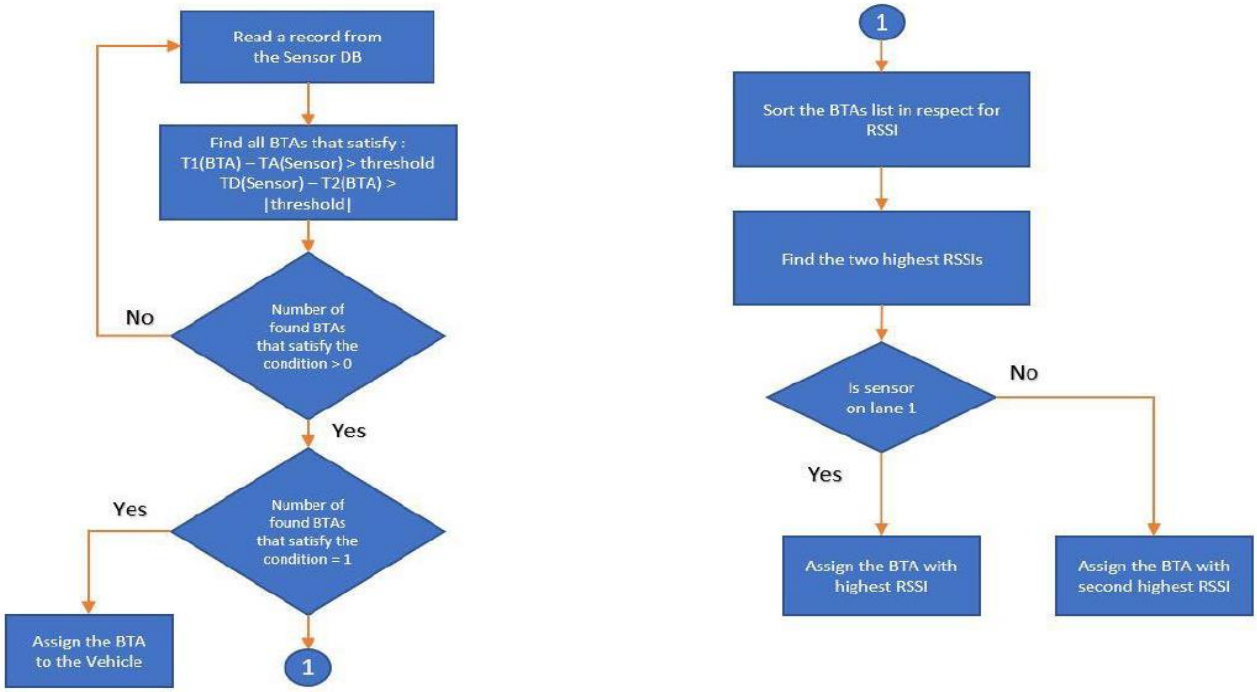
OVERVIEW The USDOT is actively researching intelligent transportation systems (ITS) aimed at reducing traffic incidents, improving safety, and gathering real-time travel time (TT) information. An important aspect of the process is specifying the characteristics of traffic schemes, which include vehicle classification, origin/destination (O/D), TT, and vehicle occupancy, in addition to other factors. This project provides the development of an Internet of Things (IoT) system that integrates a complex system using Bluetooth (BT) sniffing and vehicle classification for monitoring route choices per vehicle class.

RESULTS The first objective of this project resulted in integration of a BT identification sniffer with the OU-designed, magnetometer-based vehicle detector and classifier for monitoring origin/destination (O/D) and travel times (TT) per vehicle class. Various hardware and software designs, including wireless technologies, antenna types, number of antennas, RF multiplexers, and time synchronization schemes, were investigated with the goal of developing an inexpensive, flexible, modular embedded system that can be rapidly prototyped and deployed for collecting O/D measurements per vehicle class. The developed system includes at least two directional antennas for highway segmentation and has the ability to communicate with multiple road- installed vehicle sensors for vehicle classification (as illustrated below).



The second objective resulted in development of algorithms to assign detected BT IDs to their corresponding vehicles (as illustrated in the flowchart below). Assignment errors occur when a detected BT ID is assigned to the wrong vehicle class. This is an extremely challenging activity given many factors that influence BT-vehicle assignment accuracy. One factor is that a BT scanner can detect vehicle IDs located as far as 100 meters away from the scanning station, while vehicle sensors detect vehicle presence within only a few meters. Also, vehicle BT IDs located within the scanning coverage will be received irrespective of traveling lane or direction. Hence, BT scanners do not distinguish BT IDs of vehicles traveling in a specific direction. Another factor is that a BT transmitter may not be functional or available for every passing vehicle, while vehicle sensors installed in every lane will detect and classify every passing vehicle. Yet another factor is that not all BT transmitters in every vehicle are synchronized. Therefore, BT signals are received by the scanner in random order instead of being related to coverage entry time. Various schemes, including sensor layout, highway segmentation, and varying coverage sectors, among others, were investigated during the execution of this project.



The third objective resulted in deployment of the prototyped system in close collaboration with ODOT. The research team conducted a field study to investigate optimal BT/class station configurations, including road sensor placements, number of antennas and highway segmentation, antenna polarization, gain, and directionality. Each of these has a significant impact on coverage sensing, hence, quality of collected BT data.

The fourth objective of this study resulted in development of schemes for investigating the accuracy of paired BT-vehicle assignments and designing techniques to improve accuracy. One simple technique is deploying a duplicate BT/class station to confirm assignments made by the first station detecting a vehicle. Another technique is strategically placing BT-only stations to measure vehicle TT and speed values to segregate large, slower trucks from faster small vehicles.

POTENTIAL BENEFITS This project demonstrated that active monitoring of route choice and TT per vehicle class can be achieved using magnetometer nodes and BT stations. Results will assist ODOT in reducing traffic incidents, improving safety, and gathering real-time travel time (TT) information. Additionally, results provide a process for specifying the characteristics of traffic schemes, which include vehicle classification, origin/destination and vehicle occupancy, in addition to other factors.