2016-38TS
Published January 2017

DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES & LIBRARY

TECHNICAL SUMMARY

Technical Liaison:
Ken Johnson, MnDOT
Ken.Johnson@state.mn.us

Project Coordinator:
Nelson Cruz, MnDOT
Nelson.Cruz@state.mn.us

Principal Investigator:
Chen-Fu Liao, University of Minnesota

PROJECT COST:
$99,650

BLE tags, shown in a 3.5-inch by 4.5-inch protective enclosure, can be mounted on traffic barrels, signs or lampposts.

Bluetooth Technology Delivers Work Zone Alerts to Highway Drivers

A new work zone alert system can warn drivers of upcoming work zone activity that is 125 meters away. This system, which uses a smartphone app, may ultimately improve work zone safety by reducing driver distraction. Future research will evaluate what form the alert messages should take.

What Was the Need?

Nationwide, more than 20,000 workers are injured in work zones each year, and 12 percent of those are due to traffic incidents. To improve work zone safety and mobility, the Federal Highway Administration is promoting smarter work zones with strategies such as incident management, traffic control, work zone speed management and intelligent transportation systems (ITS).

Bluetooth Low Energy (BLE) tags are a promising technology that MnDOT and other agencies are considering for work zones and other ITS applications. The tags emit a wireless signal that most smartphones can receive to alert drivers when they enter a work zone.

MnDOT has previously investigated the use of Bluetooth technology for applications such as helping the visually impaired safely navigate work zones and measuring travel times on arterial roads. In this project, MnDOT wanted to investigate whether BLE tags could help raise driver awareness, reduce driver distraction and improve work zone safety.

What Was Our Goal?

The objective of this project was to develop a prototype in-vehicle system that would supplement roadside signs by alerting drivers on their smartphones when their vehicle enters a work zone. The primary goal was to evaluate whether BLE tags can effectively deliver messages to drivers traveling at highway speeds.

What Did We Do?

Researchers developed a system that includes a work zone database, middleware that facilitates data transactions, BLE tags and a smartphone app. BLE tags placed in or ahead of work zones broadcast a wireless signal at all times. Nearly all smartphones can receive this signal, so researchers developed an Android app, called Workzone Alert, that scans for these work zone BLE signals and presents feedback to the driver when one is detected. This project did not evaluate what form that message should take, but options include vibrating, emitting an alert tone, making an audible announcement or displaying a message on the smartphone screen.

Researchers also customized the BLE tags' programming to allow the app to recognize only tags within work zones and ignore other Bluetooth devices.

Constantly scanning for BLE signals would rapidly drain a smartphone's battery. To address this issue, the system includes a spatial database that stores the location of all work zone BLE tags and the message content they should deliver. The app operates as a background service of the smartphone, using the phone's Global Positioning System (GPS) sensor to monitor the vehicle's location. The app only begins scanning for BLE signals when the vehicle approaches a work zone.

To help maintain the system, researchers developed a second app that work zone deployment contractors can use to update the message that Workzone Alert displays for a specific BLE tag.

continued

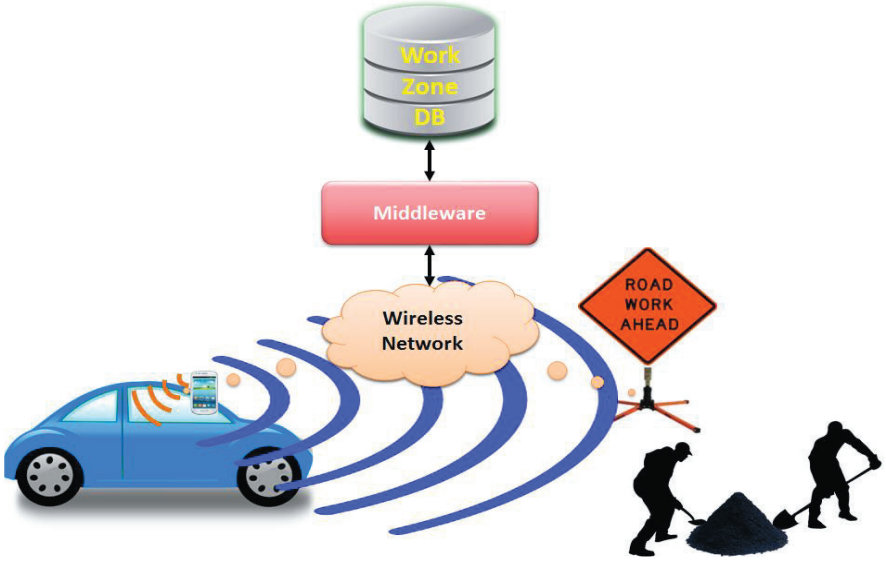
"This was a proof of concept that showed that smartphones can receive Bluetooth signals at highway speeds and deliver messages to drivers. Future research will look into how we should implement and maintain a driver alert system."

—Ken Johnson,
Work Zone, Pavement Marking and Traffic Devices Engineer, MnDOT Office of Traffic, Safety and Technology

"Reducing driver distraction has the potential to improve safety in work zones. The app developed in this project could provide more information than road signs, letting drivers know if construction activity is underway."

—Chen-Fu Liao,
Research Scholar, Center for Transportation Studies, University of Minnesota

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services & Library
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research



In the work zone alert system, BLE tags mounted in a work zone broadcast a signal wirelessly, aided by middleware that facilitates the data transaction. When a smartphone receives this signal, it can display or announce a message to alert and instruct the driver.

Researchers tested the prototype system on residential streets and county roads as well as at the MnROAD test facility. Vehicles traveled at various speeds up to 70 mph, and researchers measured the range at which the app could detect the BLE signal.

Researchers also analyzed how much power the app and the BLE tag consume.

What Did We Learn?

Tests demonstrated that the system is capable of providing in-vehicle messages to motorists approaching a work zone at highway speeds. When the test vehicle was driving 70 mph, the app detected the Bluetooth signal from 125 meters away. Travel speeds of 45 to 55 mph typically had detection ranges from 150 to 170 meters. In one test, the app detected the signal from 281 meters away.

On the test phone, a Samsung Galaxy S6, the phone's battery lasted nine hours while the app was in a work zone and running in continuous scanning mode. Outside a work zone when the app was running in the background of the phone, battery life was 15 hours.

The BLE tags can continuously transmit and receive signals for up to 3.5 days on a single charge. A commercially available solar panel could potentially provide enough power to constantly recharge the tags' batteries.

What's Next?

This project demonstrated that a smartphone app can successfully detect BLE signals at highway speeds and deliver a message to drivers. Currently the HumanFIRST Laboratory at the University of Minnesota is conducting a second project that will investigate human factors related to the system to evaluate what form the message should take to safely and effectively alert drivers. Results from that project are expected in early 2017.

A third phase, which has not yet been funded, would investigate how to effectively maintain the BLE tag database, including who needs approval to make changes and who will be responsible for ensuring different tags transmit the appropriate messages. This phase may also investigate implementation options, such as how MnDOT can encourage drivers to download and use the app, or if it can be connected to existing apps like Google Maps, Waze or the 511MN app.

This Technical Summary pertains to Report 2016-38, "Investigating the Effectiveness of Using Bluetooth Low-Energy Technology to Trigger In-Vehicle Messages in Work Zones," published December 2016. The full report can be accessed at mndot.gov/research/TS/2016/201638.pdf.