Using Bluetooth Low Energy (BLE) Technology to Trigger In-Vehicle Messages at Work Zones

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Outline

• Background & Objectives
• Our Approach
• Design and Development
• Experiments and Results
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• Summary & Conclusion
Background

• According to FHWA in 2013, there were more than 67,500 crashes in work zones, resulting in 579 deaths and 47,758 injuries in the US.

• More than 20,000 workers are injured in work zones each year, with 12% of those due to traffic incidents.

• Many ITS tools and applications have been developed and implemented to effectively mitigate traffic impacts caused by construction.

• In recent years, challenges to work zone safety and mobility have been exacerbated by the growing issue of distracted driving.


Objectives

• Investigate Bluetooth Low Energy (BLE) tags that can be deployed in or ahead of work zones to provide in-vehicle warning messages.

• Investigate the effectiveness of using in-vehicle spoken messages to measure the drivers’ understanding of the work zone in order to reduce risky behavior, associated with distraction.

• Deploy a BLE based system in or ahead of work zones that can trigger spoken and contextual messages in existing smartphones located in vehicles passing by.

• Such messages can be updated remotely in real time and as such may provide significantly improved situational awareness about dynamic conditions at the work zones.
Two Concurrent Research Projects

- Capturing Driver Attention and Reducing Speed in Work Zones (This presentation)
- Driver Behavior & Distraction Study and In-Vehicle WZ Message Design
- Investigate BLE to Trigger In-Vehicle WZ Messages

Human Factors Study

Engineering Study

Methodology

- Program Bluetooth long-range modules
- Develop a data acquisition and testing program on the smartphone to collect BLE ID and signal strength
- Design test scenarios to evaluate the communication range, latency, and power consumption under a variety of conditions and when the smartphone user is travelling at different speeds
- Develop an in-vehicle app to demonstrate the system capability and performance under a variety of conditions
System Architecture

- Geo-fencing
- Customized Bluetooth firmware
- Automatic Bluetooth scanning
- Auditory feedback through smartphone speaker / car audio system

Bluetooth Low Energy (BLE) Modules

- Model #1: (3.0” x 2.75” x 0.25”)
- Enclosure & Battery: (4.5” x 3.5” x 2.25”)
- Module #2: (1.5” x 1.25” x 0.25”)
Software Development

- Customized firmware for Bluetooth modules
- Geospatial database for Bluetooth location and message
- A local copy of DB on the smartphone
- Geo-fencing and auto scanning
- Smartphone app for in-vehicle application
- Smartphone app for engineers in a work zone

Work Zone Alert App
App for Work Zone Engineers

Experiment and Data Collection

- City Street / County Road / MnROAD
- Minivan / Sedan
- Traffic Barrel / Lamp Post
- Speed 30 ~ 70 mph

Bluetooth LE Module Attached to a Lamp Post (8-ft above ground)
Bluetooth LE Module Placed on a Traffic Barrel
Experiment Setup

Blutooth Module

Work Zone Alert App

Geo-fencing Example

Start

Travel Direction

End
Auto Scan w/ Geo-Fence

WZ-004 @ 50 MPH

240 m (787 ft)

WZ @ 50 MPH

Travel Direction

MnROAD

WZ-002 @ 70 MPH

125 m (410 ft)

WZ @ 70 MPH

Travel Direction
Work Zone at I-35E and Co. Rd E East in Vadnais Heights, MN

battery powered Bluetooth beacon

Speed (MPH)

Time

160 m (525 ft)

Speed Limit 55
350 FT

Work Zone at I-35E & County Rd. E East

160 m (525 ft)
A smartphone app runs as a background service. It provides dynamic work zone information and guidelines (based on results from a human factors study) for engineers and operational staff to determine the placement of tagged landmarks at work zones for triggering in-vehicle messages. The app can potentially be integrated with 511 or other navigation Apps to receive work zone information.
Limitations & Next Step

Limitations

• Line of sight
• BLE module placed at least 1m above ground

Next Step

• Placement of phones in a vehicle
• Incorporate results from human factors study
• Pilot implementation and deployment to evaluate system performance

Summary & Conclusion

• We have developed a Bluetooth Low Energy (BLE) system to provide in-vehicle warning messages to a driver.
• A smartphone app was developed to perform Bluetooth scanning and to announce the appropriate message corresponding to a Bluetooth tag when it is detected.
• A continuous Bluetooth scan is initiated when a vehicle enters a geo-fenced work zone.
• The final message structure and content will be determined from the results of the human factors study
Summary & Conclusion (Con’t)

• Another smartphone app was developed for work zone deployment contractors to request message updates.
• Our system is capable of providing in-vehicle messages for motorists approaching a work zone using the Bluetooth low energy technology.
• Our experiment results indicated that communication between a smartphone and BLE tags at highway speed is feasible.
• Our future effort will focus on validation of the proposed system in a real work zone environment under different traffic conditions.

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Questions?

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