Tome, Inc.
304 W 4th St.
Royal Oak, MI 48067

Mobile Device Capabilities for Broadcasting and Receiving VRU Safety Messages Over Bluetooth® Wireless Technology

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Contacts

Mike Bush, Tome Safety Team - mike.bush@tomesoftware.com

Tome, Inc.
304 W 4th St.
Royal Oak, MI 48067

Background

As cars, infrastructure, mobile devices and accessories all become smarter, the opportunity for improving driver awareness of vulnerable road users (VRUs) such as bicyclists, scooterists, road workers and pedestrians has never been greater. Tome Inc., in conjunction with Ford Motor Co. , has been researching the feasibility of sending and receiving safety messages from the VRU to the vehicle using Bluetooth® Low Energy (Bluetooth LE) wireless technology. This investigation has included the use of dedicated Bluetooth LE hardware as well as mobile devices to transmit and receive personal safety messages (PSMs) for alerting vehicles in situations where normal ADAS (Advanced Driver Assistance Systems) sensors might not be sufficient.

Broadcasting Safety Messages with Bluetooth Low Energy version 5

Unlike a standard Bluetooth wireless transmission which requires two devices to be paired, a safety message is intended to be broadcast 10 times per second and freely available (i.e. without pairing) to nearby receivers. A PSM, defined by standard SAE J2735, contains the following required information: VRU type, millisecond count, message count, ID, position (latitude, longitude, elevation), and accuracy[1]. For research purposes, this message requires a minimum of 34 bytes of data to be broadcast. In real world applications, this transmission size will significantly increase with the additional need for security bytes to verify the message's authenticity and path prediction data to give better accuracy.

Currently, the specification for Bluetooth LE wireless technology describes three different physical (PHY) layers which may be supported by the hardware: 1M, 2M, and Coded. 1M PHY is the traditional physical layer and its support is mandatory per the Bluetooth core specifications. Coded PHY is the slowest but uses techniques to boost transmission range up to 4 times[2]. 2M PHY supports the fastest speeds but sacrifices about 20% of its range to achieve those speeds. Each of these PHY layers may or may not support extended advertisements which increase transmission size from 31 bytes up to 255 bytes.

Given the 34-byte minimum, extended advertisements become a hard requirement for transmitting or receiving a PSM. Though the extended range of Coded PHY is tempting, initial investigations by Ford have shown the range of 1M PHY to be "good enough" when line of sight

is obstructed and more than enough with a clear line of sight. Furthermore, the wide device support for 1M PHY outweighs the advantages of the extra range.

When transmitting information via Bluetooth® LE wireless technology, there are three methods (as of Bluetooth version 5.2) to get information across to the receiving device: pairing, service data broadcasts, or manufacturer data broadcasts.

- Pairing, once configured, allows for a constant data stream between two devices.
- Service data broadcast provides information on what services a device offers.
- Manufacturer data broadcast, a perfect fit for our use case, allows transmitting arbitrary data for nearby devices to consume.

Summary: The current safety message broadcasts require Bluetooth LE extended advertisements using 1M PHY.

Each broadcast contains a safety message within a manufacturer-specific data segment, and within that segment is a SAE J2735 Personal Safety Message. This technique is well suited for broadcasting J2735 safety messages.

Safety Messages on Android Mobile Devices

The modern Android OS meets the mobile device requirements of Bluetooth LE 1M PHY, extended advertisements on Android API 26 and later. In our tests with different manufacturers' Android mobile devices using the Android API, the device would broadcast safety messages at approximately 8 times per second. The desired message frequency is 10 times per second.

Safety Messages on iOS Mobile Devices

While the methods of broadcasting safety messages are promising and may have many applications, this approach has some challenges with the capabilities of Apple's popular mobile devices, which comprise approximately 50% of the US smartphone market[3].

As of 2019, Apple iPhones support 1M PHY, 2M PHY, and extended advertisements. The first step to validate this is to scan for the 1M extended advertisements being transmitted. When one installs a simple iPhone application made for this purpose, taps the run button and....nothing. Upon further investigation, it was discovered that iOS supports extended advertisements only

on the 2M PHY layer and not 1M PHY. In addition, iOS only supports up to 124 bytes for received messages[4]. This means that iOS can only receive a PSM if it is under 124 bytes and transmitted on 2M PHY; the 2M PHY is not as widely supported and has a limited range.

With the limitations of message reception understood, we then investigated safety message transmission. This was a much shorter investigation, as Apple does not provide a way to configure broadcasts from an iPhone. It appears Apple reserves this functionality for the Apple device ecosystem[5]. It provides the ability to turn broadcasts on or off and even change the name, but does not provide a way to set data into the manufacturer-specific data segments. While the device itself may be capable of the desired functionality, further investigation is required to discover the exact capabilities and determine how to enable these functionalities by engaging with appropriate partners.

Summary: Apple has created a rich and seamless ecosystem for their products, which consumers appreciate, and Apple's mobile devices are most likely capable of broadcasting safety messages using the existing methods described in this paper. However, limitations in the implementation of Bluetooth Wireless Technology need to be addressed to enable the transmission of safety messages from iOS devices.

The Path to Safer Roads

Whether on a bike, scooter, or pushing a stroller, most VRUs carry smartphones. Smartphone-to-vehicle communications could be an essential tool for making vehicles more aware of their surroundings. To be effective and have this technology widely adapted it needs to be implemented and available on the most common devices. Working with Apple's iOS teams to understand and enable needed functionalities will be the next major step toward making roads safer.

Summary: Smartphones are ubiquitous but manufacturers of Bluetooth Wireless Technology implementations can and do vary. Therefore, to make a major impact we need to work with smartphone manufacturers to address the various challenges that arise from the different implementations. For a broad-based implementation to be most effective and achieve the desired results, the methodology and lessons learned from the cooperative effort should be shared in order to effectively address any respective equipment limitations with Bluetooth Low Energy transmissions for consistent implementation which meets the previously defined requirements.

Conclusion

Bluetooth® Low Energy wireless technology could be well suited for the broadcast of safety messages because of its ubiquity, simplicity, clear standards, and low chip cost. The Bluetooth LE manufacturer-specific data segment, as described in the Bluetooth specification documents, has sufficient capacity and throughput to contain a J2735 Safety Message that is broadcast 10 times a second. As smartphones offer Bluetooth Wireless Technology, and this technology is vastly more capable than just driving wireless earbuds, it makes sense to incorporate safety message broadcasts into smartphone applications.

Smartphones are found everywhere but manufacturers' Bluetooth Wireless Technology implementation can vary, making it difficult to adapt a universal safety message solution. Open communication between safety stakeholders and manufacturers is needed to meet minimum requirements to help make roads safer.

References

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