FOREST GROWERS RESEARCH

HARVESTING TECHNICAL NOTE

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Haptic Proximity System Custom Build

Summary

The design and custom build of a Proximity System that uses haptic feedback to alert workers moving and operating machinery on a landing is described. The prototype used off-the-shelf technologies brought together with a custom application.

Krystal Thompson, Aliesha Staples, Brionny Hooper and Richard Parker

Components of the System

This report details the design and build of a functional haptic feedback proximity system for workers on the landing. The findings of the research provided a pathway for the development of a prototype Haptic Proximity System. The recommended approach was to assemble pre-built wearable devices and beacons. Following this, we plan to create a custom application allowing for the provision of haptic feedback to the workers through the device when within range of the beacons.

Beacon Hardware

The selected beacon was the BlueBeacon Forte+ (Figure 1).

Figure 1. BlueBeacon Forte+

The specifications and other detailed information of the BlueBeacon Forte+ are given in Table 1 overleaf.

Beacon Signals

Our findings were derived from our initial research, discussions with the distributors, and from testing the beacon signals (Figure 2). We learnt that it is possible to estimate the distance to a beacon. The ability to detect the exact distance away from a beacon was less reliable than expected. The first trial revealed an average six-second delay when detecting fast movement. Further investigation demonstrated that the accuracy and delay is influenced significantly by environmental conditions, such as objects blocking the direct path to the beacon, other beacons, and radio signals. This means that the beacon signals cannot be relied on to provide an immediate accurate response.

The reliability of beacon distance accuracy can be increased by employing an 'on/off' method. We can know with higher certainty if someone is in range to access the signal, or if they are not. The suggested method would be to have the app respond to a beacon signal, rather than respond to graded values of the signal.

The range the beacons can accurately sense is from approximately five-meters up to approximately 110-meters. This means that lowering the range to a couple meters is not possible with these beacons, ruling out any 'invisible barriers' that are shorter than five meters.

Forest Growers Research Ltd., P.O. Box 1127, Rotorua. Phone: 07 921 1883, Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

Table 1. BlueBeacon Forte+ Specifications

Advertising	• 8 slots configurable for non-connectable advertising frames: • - 4 slots, each configurable for Eddystone frame types: UID, URL, TLM or EID. Full support for specifications Eddystone Configuration GATT Service by Google • - 4 slots, each configurable for frame types: iBeacon, Quuppa (Direction Finding packet) • Advertising interval (independently configurable for each slot): 0.1 to 5 secs • TX power (independently configurable for each slot): -40 dBm, -20dBm to 4 dBm (4dB steps) • Additional configuration options: non-connectable mode, anonymous mode, programmable • time-period, orientation/motion-detection mode, locked/unlocked mode, change password • Support for Safety packet: beacon ID, battery status, motion detection, button-press (short/long), man-down detection • Configurable with BlueBeacon Manager App for Android and iOS
Radio	• Version: Bluetooth 4.2, Low Energy (Bluetooth5-ready) • Frequency: 2.402 to 2.480 GHz • Module: Nordic SoC nRF52832 (MCU and transceiver) • Antenna: printed meandered planar F-antenna
Battery	• Replaceable: Yes • Model: CR123A (1500 mAh typ. capacity at 25°C) • Expected life: 18 months to 8 years, 24/7 at ambient temperature (configuration dependent); 3.5 years with default settings • Operating temperature: -30°C to +75°C
Sensors & Interfaces	• Sensors: 3-axis linear accelerometer; optional sensor board (temperature, light) • Led: 1 (red), controllable via GATT [only for version HVL: high visibility led]
Enclosure	• Material: polycarbonate • Colour: light grey (RAL 7035) • Size: 52 x 80 x 35 mm • Protection: IP65/NEMA4 (IP67/NEMA6 available on demand)

**Accessed via manufacturer's website address* https://www.blueupbeacons.com/index.php?page=forteplus

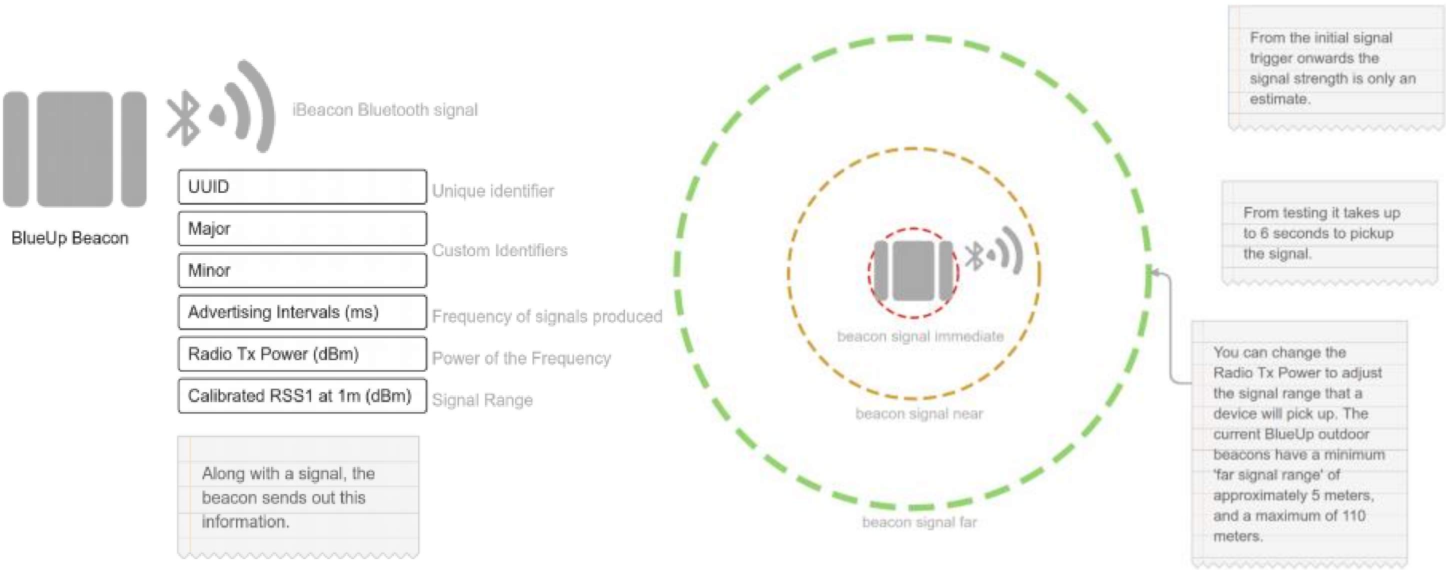

Figure 2. Beacon Signals

Wearable Device

Our research initially indicated the Fitbit Charge 4 would be the most reliable wearable hardware. However, we could not use it due to its inaccessibility in terms of software implementation. We explored all methods of access to the Fitbit, the Device API, the Companion API and the Web API. Often there are ways to communicate with hardware through methods that are not directly supported, produced, or advertised by the manufacturer company. After attempting several 'Work Arounds', we discovered Fitbit has an unusually closed off approach to developer access other than device operating systems. Thus, access through alternative means could not be established on the current version of the device (detailed below):

- The Fitbit device API can only be deployed directly to the Fitbit operating system so only native functions can be utilised. The device sends Bluetooth data but does not have access to Bluetooth signals. This means using this method, we have no way to detect the Bluetooth beacons.
- A companion API is an application that connects to the Fitbit to read metrics and make changes to the device. Unfortunately, this must be created in the software engine 'Fitbit Studio'. An operating system that will not allow us to install a usable Beacon SDK.
- The Fitbit Web API has several restrictions that make it unfit for purpose. There is a limit to requests per hour, meaning that after a time the app may not continue to work based on how often it is used. Permission needs to be granted to collect data, requiring increased user workload. And finally, this connection needs continuous access to the internet (not commonly found on remote forestry sites).

Possible Value Proposition

If a haptic device such as the Fitbit Charge 4 must be used to leverage the durability and long-lasting battery life, there is a solution in pairing the wearable with a mobile phone that can in turn relay the message from the beacon and vice versa. The signal is picked up by the phone, so the wristwatch acts only as a signal receiver from the phone via notification (Figure 3).

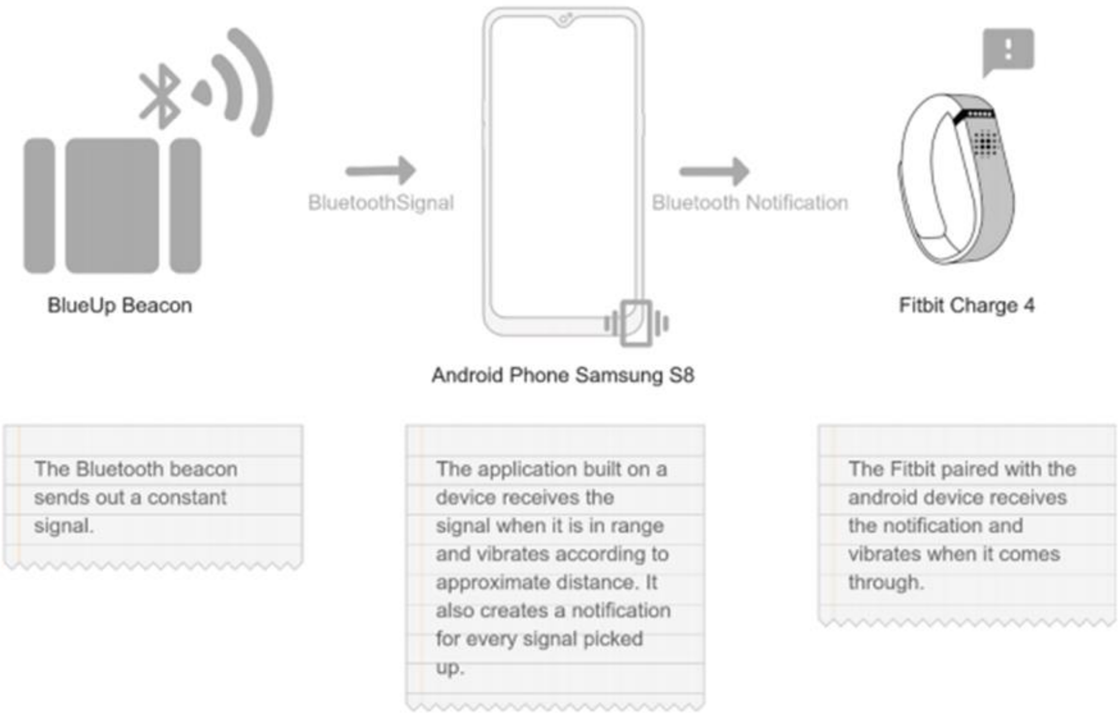

Figure 3. Potential Workaround

Going forward the decision was made to move away from wearable devices due to its limited features and functions. Furthermore, it was considered excessively time intensive to build a compatible application to overcome these restrictions.

Application Features

Below is a list of features we aimed to create within the application to interact with the beacons:

i. Beacon ID Recognition: Detect the unique ID on a beacon and have the app react accordingly.
ii. Beacon Signal Recognition: Detect Bluetooth with no Wi-Fi required to make the connection.
iii. Haptics: Make the device vibrate on command.

Application Functions

Haptic Wearable Vibrates – Instance I

When a person (Person A) enters a beacon's signal range (Person B), the first person's (Person A) haptic wearable will vibrate. When the haptic wearable vibrates, we want the Person A in this scenario to think – *"I know I'm in range of someone else's machine. I am at risk."*

*Haptic Feedback Type 01 – Constant Pulse
**It will not vibrate if the person is in range of their own machine. It only vibrates for other machines.

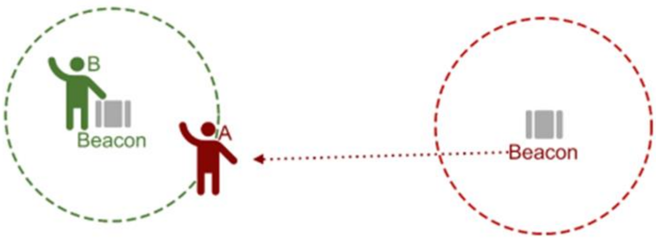

Figure 4. Person Haptic Alert Type 01

Haptic Wearable Vibrates – Instance II

When a person is in their machine (Person B) and a second person enters their beacon's range (Person A), Person B's haptic wearable will vibrate. When the haptic wearable vibrates, we want the Person B in this scenario to think – *"I know someone else is in range of my machine. Somebody else is at risk."*

*Haptic Feedback Type 01 – Constant Pulse

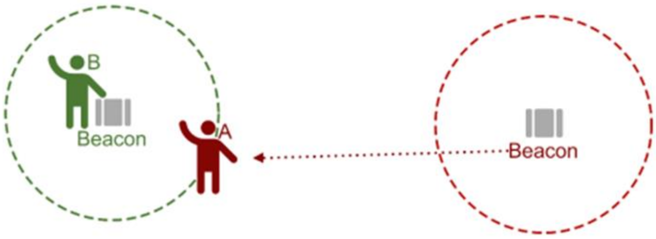

Figure 5. Machine Haptic Alert

Haptic wearable Vibrates – Instance III

When a person (Person A) enters another beacon's signal range, that person's (Person A) haptic wearable will vibrate – regardless of if someone else is the machine or not. Person A – *"I know I'm in range of someone else's machine. I am at risk."*

*Haptic Feedback Type 02 – Staggered Pulse
**It will not vibrate if the person is in range of their own machine. It only vibrates for other machines.

Figure 6. Person Haptic Alert Type 02

Haptic Wearable Stops Vibrating

When a person (Person A) exits the beacon signal range of another machine, the wearable will cease vibrating. This does not apply to their own assigned beacon, as that beacon would not cause any haptic vibration.

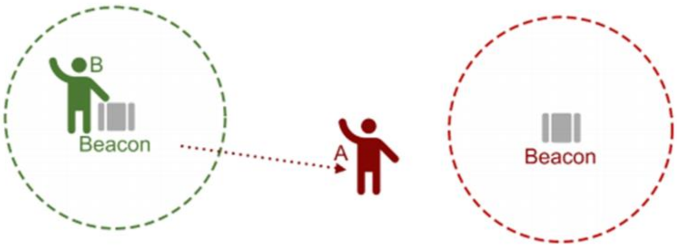

Figure 7. Haptic Alert End

Conclusion

In conclusion, the Haptic Proximity System prototype was developed by pairing an android device with a BlueUp Forte+ beacon. Accuracy and detection speed of signals were ascertained.

Due to the potential six-second delay, the decision was made to implement a “go/no go” strategy of detection rather than a graded system. To simplify the system and minimise potential delays in information exchange, it was decided to utilise an android phone as a ‘wearable’ device (in place of the original intent to use a FitBit 4).

Finally, the haptic functionality was programmed into the prototype system with three main alert scenarios.

The next stage is to get the system into the field with a harvesting contractor and Staples VR (who built the system) and show that it works.

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