Bluetooth**tap**

An overview and quick guide to good practices

1. Introduction

Bluetoothtap combines the rough proximity ranging of Bluetooth Low Energy with the accuracy and reliability of magnetism.

Bluetoothtap is not without its limitations and in order to achieve the desired results it is important one understands the basic principles behind using RF and magnetic sensors.

1.1 Beacons

For the prototype you have received, we have implemented an off-the-shelf Estimote beacon. This technology is beacon agnostic so any beacon with any protocol can be used, however, RSSI gating can and will change.

The beacon configuration can be found in the appendix at the end of this document

2. Radio Frequency (RF)

2.1 RF Limitations

Bluetooth sensors (antennas), although somewhat normalized, are not standardized and thus differences in behaviour per mobile handset arise. For example a Samsung Galaxy S3 placed 10 cm away from a Bluetooth radio will produce a Received Signal Strength Indicator (RSSI) of −13dBm where as a Sony Xperia Z2 in the same position and distance from the same radio will produce −45dBm. Due to large differences like these if a single magnitude threshold was to be adopted across all devices the proximity calculation would face an offset error on depending on phone brand/model.

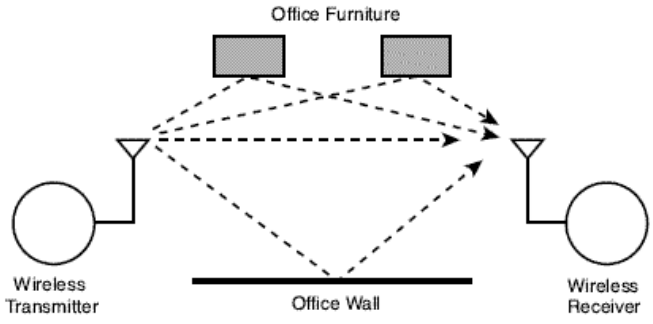


Figure 1 Multipath Signal Propagation example

Additionally, depending on phone brand/model of each handset the RSSI calculation might be different; some average the RSSI over 5 seconds - some Motorola's and the Sony Xperia's - others might provide unfiltered raw values every half second – some HTCs.

In any case, in real world applications RF signal strength is subject to error caused by the random nature of multipath signal propagation (shown in Figure 1), constructive and deconstructive interference, etc., which causes the measured signal to fluctuate even when the handset is placed at a static distance from a Bluetooth beacon device in open space. Hence RSSI is only used as a rough means to determine distance.

2.2 Good practices

Use RSSI as a rough and tolerance "gate". Once the user is within, say, 20-30 cm of the Bluetoothtap device wait for magnetic events (which determine the moment of impact on the Bluetoothtap device). If you wish to increase the RSSI gate to 50cm or above, we recommend you increase the magnetic threshold to protect against magnetic events that are not Bluetoothtap related.

3. Magnetism

3.1 Magnetic Limitations

In the market today, an overwhelming majority of mobile handsets contain tri-axis magnetometers which are able to sense magnetic fields in three dimensions. However, just like with Bluetooth RSSI these sensors will not behave exactly the same cross brand/model.

The developer should also be aware that if the magnetic threshold is set too low, local magnetic fields could start to influence the magnetic processing. E.g. the Earth's magnetic field.

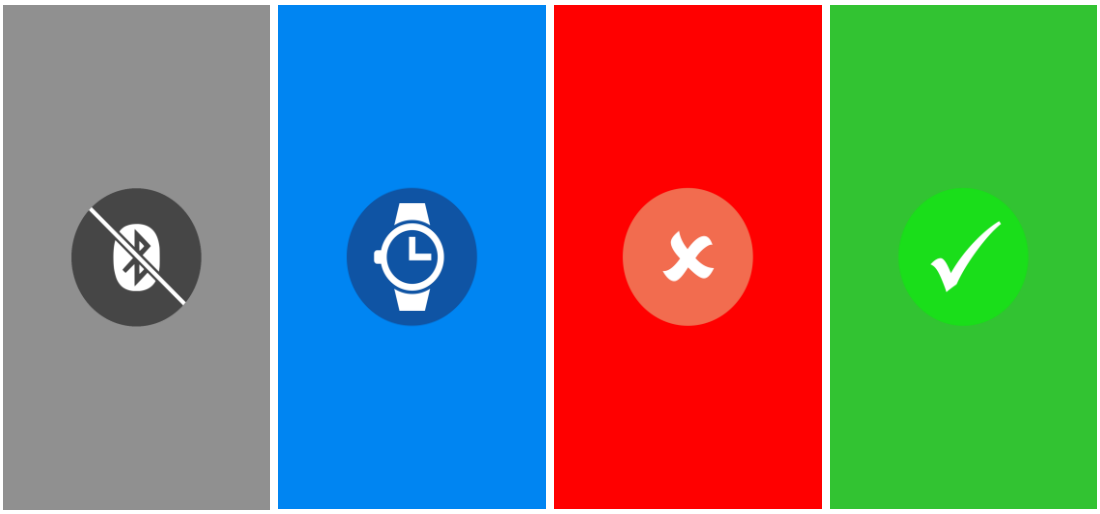
3.2 Good Practices

Generally speaking, setting a threshold below the default value of 200 is risky as one might risk interference with the Earth's magnetic field. A lower value of, say, 100 can be used for difficult to work with handsets but if so we advise decreasing the RSSI gate distance to compensate

4. User Experience (UX)

A lot of difficulties using sensors in any deployment can be overcome with clever UX. For example, we need to communicate to the user if their Bluetooth is off and once it is turned on, when it is ready for a touch in. If Bluetooth is off, generally speaking, it will take the handset a couple of seconds to boot the chip up and another few seconds to start ranging any Bluetooth signals.

In the demo app, we have various states to show the user when their Bluetooth is ready. The most salient point here is to telegraph to the user to wait, for whatever reason, when the Bluetooth is not ready. In most devices this usually a fraction of a second, but as mentioned above, some devices can average RSSI over time, which could delay a user getting a Touch-in. Getting the user to wait should help aid the user receiving a touch in every time they come into contact with the Bluetoothtap terminal.



"Bluetooth OFF"

"Wait"
Bluetooth is turning on AND searching for a known UUID

"Ready to tap"
Bluetoothtap signal acquired but outside thresholds

"Touch-in"
All thresholds are passed, User has touched in.

5. Profiles and calibration

To achieve a consistent Touch-in experience across every mobile handset bespoke device by device calibration could be adopted, but doing so is not ideal. Using magnetic fields helps close the gap needed for any bespoke calibrations as we do not have to rely solely on Bluetooth for ranging. However, as there are 3000+ different Android phones on the market it is somewhat impossible to anticipate how all of them will react.

We advise the use of "Profiles", which can be seen in the comments in the demo app code. Each profile contains slightly different threshold parameters that can be attributed to different behaving handsets. This builds on the "Good practices" explained in the above sections: if there is a handset group that has very poor Bluetooth sensitivity or very slow polling then a more tolerant RF profile could be used for the RSSI threshold. Or in select cases when a phone does not have a magnetometer at all then a less tolerant RSSI gate is advised. For example, on Android:

#	Name	RSSI Threshold	Magnetic Threshold
0	No Sensor	-52	n/a
1	Accurate (default)	-45	200
2	Tolerant	-60	100
3	Very tolerant	-80	200

6. Location Services (iOS only)

Intuitively, if Bluetooth is on Bluetoothtap should work, however, in order to use Bluetooth Low Energy to range on iOS, both Bluetooth and Location services (LS) must be enabled. This can be problematic as Apple are clamping down on apps that use location too often and hence have made it very easy for the user to turn LS off. This usually appears in the form of a dialog box when the app is started, and once off most users struggle to find the setting to turn it back on.

Ideally the user will accept the use of LS right from the beginning, but if not a good way of handling this is to prompt the user they must have LS to use Bluetoothtap and have some way to indicate to the user if LS is off.

Appendix

Bluetoothtap Beacon Default Settings

The beacon supplied is a standard Estimote beacon with the following properties:

Packet Type: Estimote default
UUID: B9407F30-F5F8-466E-AFF9-25556B57FE6D
Transmit Power: +4dBm
Advertising Interval: ~450-490ms

We recommend keeping the transmit power and advertising interval as above to allow for the best user experience. If changed then we advise you run additional tests to ensure the RSSI gate is suitable for your needs.