Asset Tracking at Scale Using Bluetooth Low Energy

Introduction

This white paper looks at why asset tracking is an exciting use case for Bluetooth Low Energy (BLE) and examines successful deployments of BLE-powered asset tracking solutions in commercial environments.

Why is Asset Tracking exciting?

Asset tracking is exciting because long-standing use cases are being transformed into data-rich solutions through intelligent IoT deployments. Consider some of the most common uses of asset tracking today:

Locating important items.

- **Healthcare** – The cost of care goes up when staff members must search for wheelchairs or oxygen tanks and can't quickly or easily locate them.
- **Warehouses** – While an extension cord might only cost $15 or $20, if you have to wait 30 minutes to find it and begin working, hundreds of dollars are lost in value through the workers who are stalled.

Knowing how much of something is in inventory.

- **Retail** – Ensuring appropriate stock and flow is key to maintaining and improving revenue and profit.
- **Manufacturing** – Making sure the appropriate supplies are on hand to create a product or build an item is critical to ensuring cost-effective production.

Now consider the areas where technological innovation can be applied. Here are a few new and emerging use cases that both build on past deployments in intriguing ways and also introduce exciting new competencies to businesses:

Understanding traffic and utilization patterns.

- **Anticipating peak times** – Taking the 'locating important things' use a step further to understand the traffic and utilization pattern of an item being used – such as a wheelchair – elevates asset tracking to a next level of value.
- **Improving resource allocation** – In the hospital example, a cache of mission critical assets can be kept in the right place, at the right time, to reduce the cost of operations.

Using machine learning to optimize asset management.

- **Applying algorithms to distributed, real-time decisions** – HVAC systems are one common example where adjustments can be made

intelligently based on how many individuals are located within one part of a building. There are many other deployments that similarly improve outcomes for occupants.

- **Finding non-obvious relationships and patterns** – Like, for example, how dwell time from an occupancy sensor in a stairwell can predict activities taking place there other than stair climbing.

Why is Asset Tracking with BLE exciting?

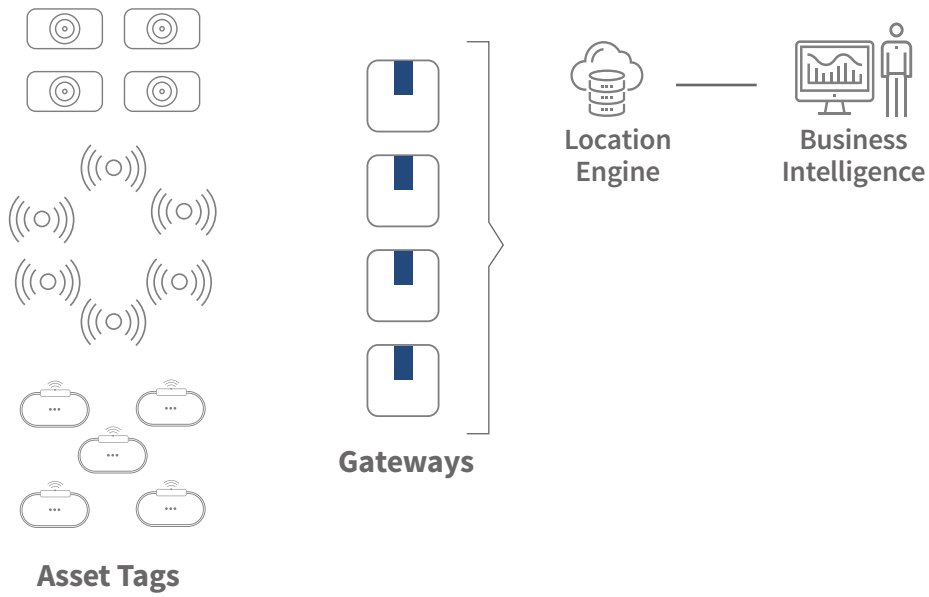
When considering new uses, there is a very strong case to be made that BLE is the appropriate technology to use in order to achieve success. The reason being that the Bluetooth Special Interest Group (SIG) is intentionally building its technology to allow for effective, yet inexpensive, tracking of nearly any item.

Bluetooth provides a robust level of support for sensors of all types, allows for bi-directional communications – which allows over-the-air sensor configuration and firmware updates – and offers an excellent security model. BLE also allows for long range communication. The fact is the infrastructure is not only cheaper, but because of the range, fewer devices are needed than most would expect.

Also important is that the 2.4GHz band, which BLE operates on, is a global standard – not fragmented like 900 MHz – making interoperability within solutions much easier to achieve.

Further, the proliferation of Bluetooth within personal mobile devices means they can participate in an asset tracking solution – eliminating the cost for additional wristbands or employee badges.

That personal use of Bluetooth has also resulted in a trend where chipset vendors have worked to lower the cost of chips and asset tags while improving the RAM, flash memory and CPU power.



We've also seen examples where transmission (TX) power consumption for a 0 dBm output has dropped from 15.6 milliamps down to five milliamps. RF sensitivity has also improved while the receive (RX) current of the power consumption has decreased.

What those numbers mean is Bluetooth power consumption has gotten drastically more effective. And in asset tracking, where battery consumption is a cost worth considering, this trend results in a drastic decrease in expense that is likely to be further reduced through development.

Adding to those benefits, the January 2019 update to Bluetooth introduced precision accuracy in its tracking ability. With the addition to the Core Specification v5.1 for "Continuous Tone Extensions" gateways can now determine the Angle of Arrival (AoA) of a message from a Bluetooth device or enable the Bluetooth device to determine the Angle of Departure (AoD) of a signal from the gateway to the device. Application location accuracy levels that were previously measured within the range of a meter can now be detected down to the centimeter.

In short: the pinpoint accuracy, affordable infrastructure and operating costs, and the ability to get monitoring data (temperature, vibration, motion, etc.) in addition to location all make BLE the right selection for asset tracking.

How are solutions providers designing Asset Tracking solutions leveraging BLE?

Below are three ways BLE data can be used to determine the location of an asset.

Fingerprinting

Solution providers use fingerprinting algorithms in deployments where quick location identification is paramount. In a fingerprinting setup, multiple Bluetooth gateways are set to "listen" for a beacon. When a beacon sends a signal out, each gateway that can hear it reports an individual signal strength. A nearby beacon may report a -65 dBm or -70 dBm result, while a gateway located farther away will report a -90 dBm result.

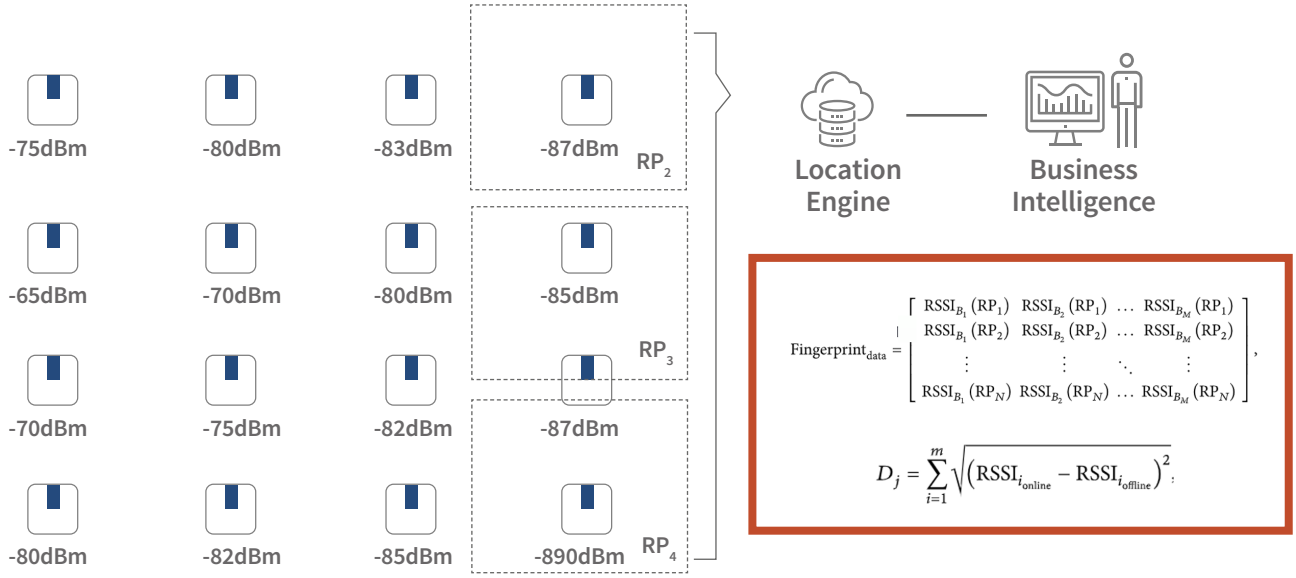
By gathering all these results and processing them with a location engine, which compares those signal strengths from a list it used during a training session. The training session allows for defined zones – be they conference rooms in offices, patient rooms in a healthcare facility, or a location within a warehouse. The setup allows for zones to be set at a level of precision where tools can be tracked to specific toolboxes.

While fingerprinting is excellent for locating items within a facility, there are some drawbacks that mean it isn't an obvious solution for all applications. Fingerprinting does not deliver an X, Y location result. A typical result from fingerprinting looks something like "Tag 1 is located in Region A" or "Wheelchair 42 is located in Room 23."

Fingerprinting also requires multiple gateways for the system to work effectively – the more gateways, the

more accurate a result. That said, there is no required pattern, exact location requirement, or layout that must be used in setup of the gateways. They can be deployed very quickly and more easily fit into your facility's layout.

Finally, the system must be trained for every region you want to define. Machine learning through an algorithm must be used for each location, and thus the computation time is directly affected by the number of regions that need to be defined.



Range-based Approximation

This is the solution most solution providers choose. With range-based approximation, signal strength results are again utilized, however, under this setup the system uses a range calculation – which can be complicated and require lab tuning before field deployment.

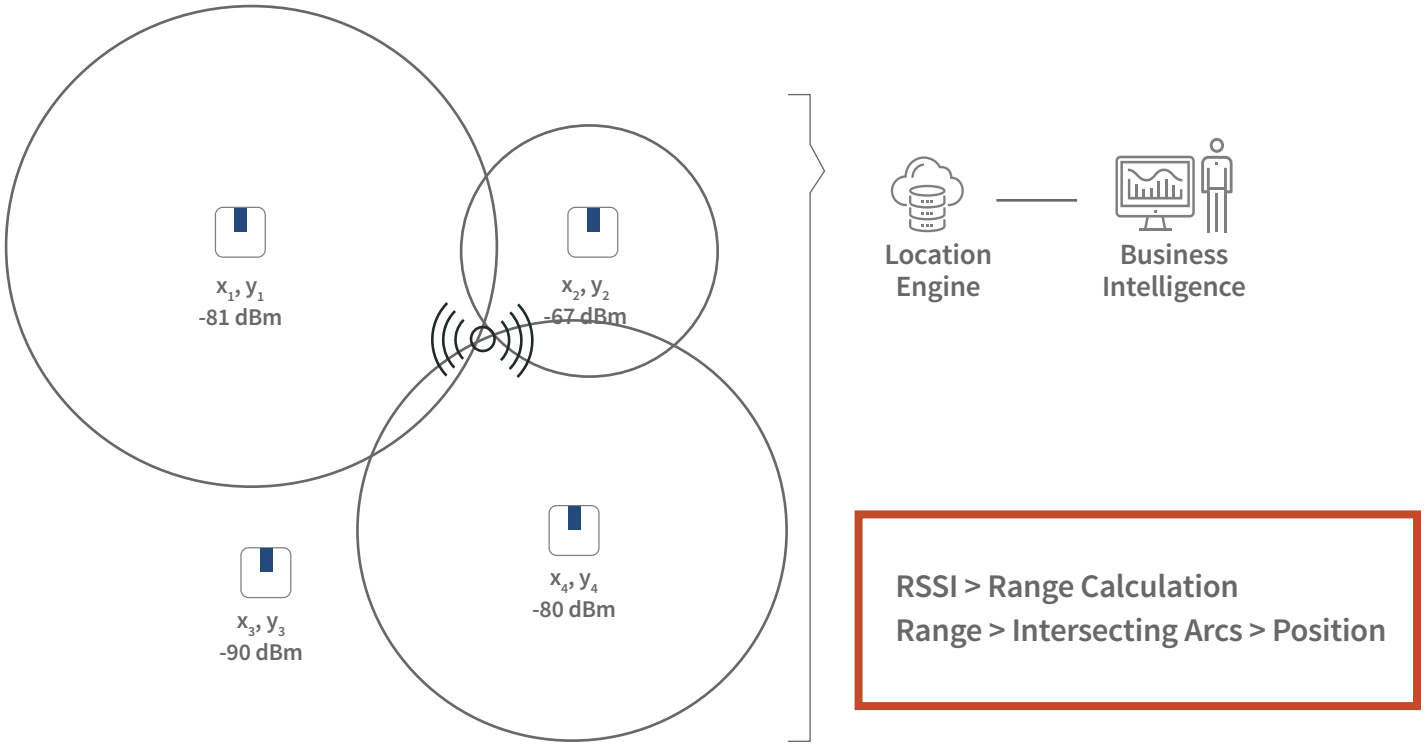
That said, once the calculation is built off the RSSI data provided in the field, the system can construct intersecting arcs where each gateway can report an estimate of how far away a tag or beacon is located. Once three or four of these arcs intersect, the location engine can resolve the data into an approximate position of the beacon.

Range-based approximation does provide the X, Y location result that some solutions demand. Results using this model typically look like "Tag 1 is located at Position X, Y." To get this level of accuracy, the position of gateways must be a known constant. This requires

the fine tuning in the lab previously mentioned, but also requires planning of gateway locations on actual floorplans and precision installations. If an installer must move a gateway, they need to inform the solutions team so the system can be adjusted appropriately.

This is excellent for precision location, but if you need to identify when a tool returns to a toolbox or a wheelchair is returned to a waiting are, geofencing applications must be used in addition to the location solution.

One thing we have learned in deployments of this type is that RSSI can be very noisy, which adds error to the range calculation. Antenna radiation from both the beacon and the gateway can come with variation, which adds to that noise and must be accounted for. Further, different beacon vendors have different output power, and radiation patterns.

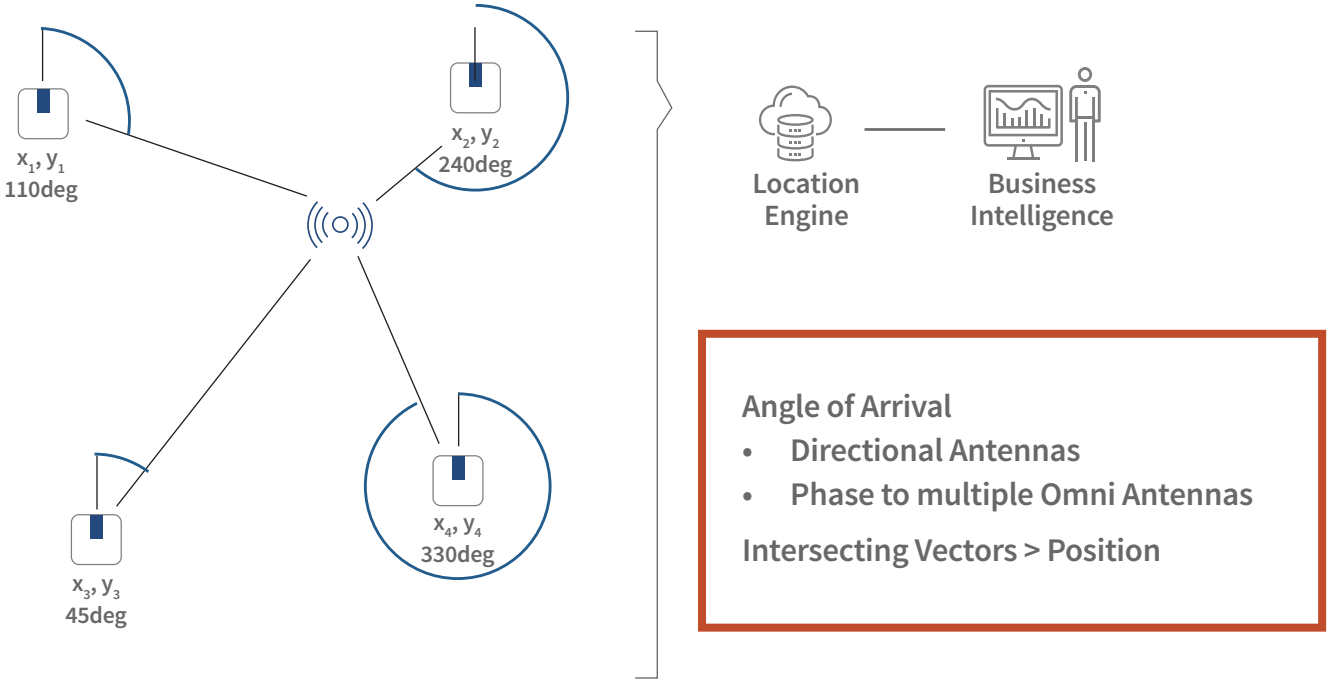


Angle from Gateway to Tag

A newer solution we're looking at is utilizing the Angle of Arrival as updated in Bluetooth Core Specification v5.1. Under this solution, each gateway would report to the location engine the direction from which a beacon signal was received and the angle at which it was received. The result is a more precise model of intersecting vectors and a more precise location.

Much like range-based approximation, the result will read as "Tag 1 is located at Position X, Y," gateway positions must be a known constant, RSSI can be noisy, and geofencing software will be required for specific area alerts.

That said, the benefit of angle from gateway to tag is a more precise and accurate result without any additional drawbacks. The new specification was released in January 2019 and requires significant hardware changes to use. It holds a lot of promise but will take several quarters before it starts showing up as available in new products.



Edge Computing and Processing

One component that all three asset tracking solutions can benefit from is the addition of edge computing and processing at the gateway level.

If you're in an office environment where there are hundreds – or thousands – of competing Bluetooth signals, edge processing at the gateway level can be used to filter for specific IDs or certain MAC addresses. This ensures superfluous data is not sent through to the location engine and helps the system perform more effectively.

A noisy RSSI environment is a drawback with both range-based approximation and angle from gateway to tag solutions. With edge computing capabilities it is possible to deploy a level of low pass filter within

the gateway to allow for RSSI smoothing and mitigate some of the potential errors in calculation.

Angle calculations can also be conducted at the edge, further speeding up the processing speed and accuracy of the final result.

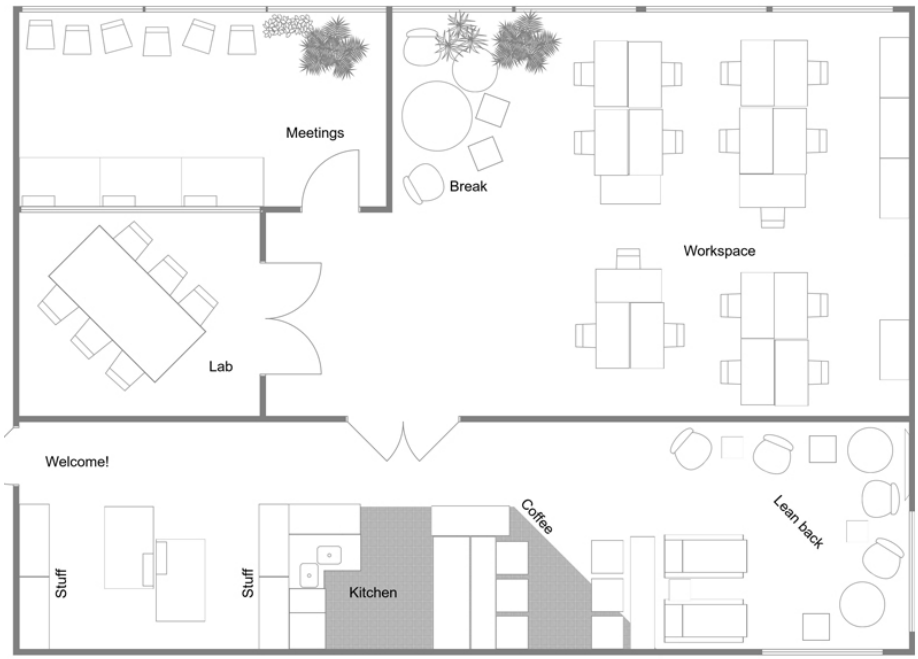
Other uses for edge computing and processing include sensor data filtering, sensor threshold monitoring and sensor data reduction – which can be especially important if gateways are using a cellular connection.

Finally, edge processing can be a huge benefit during the installation phase. Again, with range-based approximation and angle from gateway to tag solutions, a drawback is the need for precise installations. Using an edge computing capable device allows you to build applications into the edge that can greatly assist in installation like calculating a new gateway position based on Bluetooth signals from other, already installed gateways.

What are we learning about BLE Asset Tracking at scale?

In our experience working with asset tracking, we've found there are a few considerations that are critical to choosing the correct asset tracking solution.

Installation costs are massively important. This includes not just the physical act of installing gateways and devices but also the time it takes to train a system. Consider your scale and use to determine which solution might be the most cost effective to get up and running – and to ensure a reasonable return on investment.



- **Installation cost is very important**
  Includes time to "train" the system
- **Good floor plans are hard to find**
  Need to create while installing
- **Location algorithms need iteration**

Another discovery is that good floor plans can be difficult to find. We've seen everything from non-existent floor plans to ones where it is difficult to pinpoint exact locations of gateways. For two of the solutions listed above, that can cause a large problem in ensuring a location engine's accuracy. Do your best to get clear and accurate floor plans when beginning system planning or choose the fingerprinting method if they are not available.

Location algorithms need iteration. It is one thing to roll out a system, but true success comes with managing the system and adding in new revisions of the algorithm.

Antenna performance affects accuracy – both on the asset tag and the gateway. As signals can be inconsistent depending on manufacturer, thought should be put into where you purchase beacons and devices.

IT Departments often demand security audits and can lock down Internet access. Large commercial buildings – especially healthcare facilities – can be stringent with their security requirements. We've built specific tools to help with the security story – including secure boot and secure file systems – to alleviate the concerns. You also might choose to have your gateways connect to your cloud applications using cellular to help alleviate the need for IT Department coordination and network congestion.

Conclusion

We have presented a few ways to use BLE in the tracking of asset tags or beacons at scale – and touched on a method that will enter the mix very soon. Each approach boasts particular locations and uses in which it excels, and each comes with a bit of necessary planning and foresight into how to best leverage the solution.

Rigado offers a number of products that help teams build complete, end-to-end asset tracking solutions. Rigado also comes with the team that helps you plan ahead, choose the right approach, and supports you long term through an Edge-as-a-Service solution that reduces the complexity, risk and cost of projects.

For more information, visit **www.rigado.com**