**Asset location using low-cost beacons, smart roaming devices and cloud computing**

Progress Report

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# Abstract

The aim of this project is to design and test a fully scalable, low cost system to provide location tracking of assets, using a combination of intelligent hardware, simple hardware and cloud services.

This combination of different ‘levels’ of hardware allows a flexible on-the-8ground solution that can be adjusted to suit real-life demands, with the ratio of smart to simple devices providing the accuracy desired for each application. Cloud Services used are provided by Amazon Web Services, a popular cloud services provider. In order to provide seamless on-demand scaling, the architecture of the cloud services is of particular interest. Such a system would find many applications in industry, particularly in transport and manufacturing.

In modern times, cloud computing allows organisations to quickly and effectively build IT infrastructure and services. Utilising cloud services to provide a service that can automatically scale to handle any demands seemed interesting. Access to intelligent hardware with current connectivity capabilities has never been easier, potentially providing a means for a low-cost solution to tracking of assets in a domain. This project seeks to explore the effectiveness of combining some of these intelligent devices with simpler, lower cost beacons to provide location information for objects, without the need to attach expensive data and GPS capable modules to every asset.

The current industry technique for providing location tracking over a fleet of objects or devices is generally to attach a GPS and network capable device to every asset, but how much can be learned about the location of an asset using location information from nearby assets?

This report outlines the progress of the project thus far, discusses findings and explores future work.

Technologies of note are WiFi, Bluetooth Low Energy, GPS, Cloud Services, AWS, Raspberry Pi, Python, Node.js

- From old intro

The location of assets in an area such as machinery in a distribution yard can provide useful information and metrics that allow the likes of asset utilization to be monitored and analyzed. Providing a system to do this often requires investment in specific hardware and infrastructure. However, using a few, roaming mobile devices to provide readings on mobile assets provides an interesting challenge.

Reading the data on the edge of the network is the easy part, the challenge lies in processing that data and reasoning to what degree of accuracy can an asset be expected to be in a location, given multiple readings over time from multiple mobile devices. Highly mobile assets would be much more difficult to track than slower moving assets.

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# Introduction

## Background

Asset location has always been useful data to have, but companies generally have to rely on vague data such as last known city/distribution center and next city/distribution center. Fine grained data such as movement of an asset within a yard or site is normally unavailable. Solutions providing location data of Tractor/Trailer assets are common, but are tailored to long haul distances, rather than the real-time tracking of asset movement in a yard. With the increased ubiquity of hardware providing GPS monitoring, tracking of an expensive object such as a forklift within a yard has become possible, but what if the location of the loads the forklift was moving in the yard was also desired? Attaching GPS and network capable hardware to load beds would be financially excessive, particularly compared to a solution where a forklift was able to report nearby assets, with location sensitivity.

Transportation companies are increasingly turning to technology to assist their business. Some countries have passed legislation forcing the use of technology to provide overview and compliance with existing legislation, such as driving working hours. In the US, use of an ELD (Electronic Logging Device) by professional drivers will be mandatory after 16 December 2019 [1]. These devices must GPS capabilities, and almost always provide internet access and Bluetooth. With hardware such as this already a requirement, there is opportunity to utilize this pre-existing hardware to provide further location services e.g. if a Tractor/Trailer arrives in a yard, it can scan for nearby Bluetooth devices during yard movements and loading/unloading, thereby providing data points to allow for context aware tracking of other assets.

This use of existing devices, combined with simple, off the shelf beacons on assets would provide a low-cost solution. Tractor/trailer scannings might not be frequent enough due to the sporadic nature of their being on site, so attaching some intelligent device to a moving asset permanently located onsite, such as a forklift, could provide good readings. Site management workers might also be furnished with a tablet with which to monitor orders, read emails etc, which could also be loaded with an application that could scan for nearby devices using the tablet’s built in Bluetooth and upload location data from the tablet’s GPS radio to some central processing center.

Access to fine-grained location data would provide the data to optimize operations with asset utilization, load-balancing of assets and improved security of assets. Benefits of a RTLS (Real-Time Location System)

* Reduced Downtime. Distance travelled by an asset can be tracked, allowing maintenance intervals to be adjusted.
* Improved Security. With real-time location data, the disappearance of an asset can be tracked
* Safety. With RTLS, location of assets relative to each other and employees can be monitored, and with enough data the trajectory of assets predicted.
* Improved Vehicle utilistation. With accurate vehicle monitoring, operational load can be balanced across a fleet, and empty runs avoided.

Here, an asset can refer to any of the following; a vehicle, a trailer, machinery, a container, cargo, workers.

## Project Objectives

The objective of this project is to design and build a system capable of providing the following features:

* Network and GPS enabled devices (‘smart’) scanning for beacons (‘dumb’) in range
* Scalable cloud services to process data uploaded from ‘smart’ devices
* An API to allow querying of location information for a given device for reporting purposes
* Simulation to test system with simulated devices

The overall desired system is shown in Figure 1.1 below. The system must be capable of utilizing both real and simulated data, and providing reporting capabilities on this data. Basic reporting capabilities should allow querying of a device’s current location, which the system will determine based on historical locations for this device with some level of accuracy.

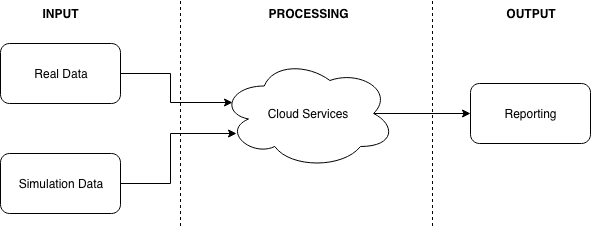


Figure 1.1

# Background Research

## Research and Analysis of Radio Frequency Communication

There are a wide variety of technologies used for wireless communication available commercially. Some of these technologies are very similar in nature but have very different use cases. These technologies have various ranges, complexities, costs and accuracies.

As this project is exploring the use of low-cost beacons that require little installation and maintenance, the beacons must be reliable and simple. To allow for quick installation, a beacon should be a standalone unit capable of operating without the need for external power. As such it will need to be battery powered, and battery-life will be a primary consideration. Generally, range and battery life are closely related, as the larger the range of a devices the more power it will consume to reach this range, so battery capacity along with power consumption will dictate battery life.

The mobile device will likely need to be connected to external power, and can be assumed to have either a constant source of power (as in a machine when the machine is running), or some facility to charge the device. The mobile devices will need GPS radio in order to get a reading for it’s own location. It will also need to have an onboard module capable of communicating with the asset beacons. The mobile device must have a data connection, either in the form of a SIM card based Network connection or WiFi.

### WiFi

WiFi uses radio waves to exchange data between devices. Based on the IEEE 802.11 standards WiFi is commonly found in Computers and mobile devices. It is primarily used to connect many devices to the same network, typically to allow access to the World Wide Web. Typically these devices connect to a wireless access point within 100m. WiFi commonly uses the 2.4 GHz and 5.8 GHz bands.

### RFID

Radio-frequency identification (RFID) uses a combination of readers and tags to identify objects. Tags are attached to objects to be identified and can be active or passive. Passive tags do not require a battery as they use some of the energy broadcast from the reader to send back a signal with their identification. As such, the greater the range desired from a passive system, the more powerful the reader needs to be in order to get enough energy to the tag, particularly if the location of the tag relative to the reader is unknown and the reader must broadcast over a wide area. Passive RFID is typically used where assets must pass through choke points, and the tag will not be far from the reader. Passive RFID systems typically have a range of 12m or less.

Active RFID tags use on board power to power their return signal. An RFID system using active RFID tags can be set up with a lower powered reader as the tag does not rely on drawing power from the reader. Active RFID systems offer a range of 100m or more.

### Bluetooth

Bluetooth uses radio waves from 2.4 GHz to 2.485 GHz to transmit data [2]. Bluetooth is commonly found in consumer devices and is typically used for pairing devices together over a short range – up to 100m outdoors. Bluetooth was designer with the purpose of replacing data cables, for example streaming music from a mobile device to a speaker. Bluetooth allows for 2 way communication between devices.

Bluetooth Low Energy (BLE) operates on the same frequencies as Bluetooth and offers similar range but with significantly less power draw. BLE is only compatible with Bluetooth version 4.0 and onwards, as the same hardware can be used for both technologies. BLE is intended for use in the IoT area.

### Ultra Wideband

Ultra Wideband (UWB) is a wireless technology designed to transmit data over a short range. UWB uses multiple frequency bands which reduces susceptibility to noise. UWB operates in the range between 3.1 GHz and 10.6 GHz. Because UWB uses such a wide frequency band to transmit data, it can transmit through objects more reliably (such as doors) than other radio frequencies. Thus, distance between devices can reportedly be measured within 10cm

# Proposed System

# References

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| [1] | F. M. C. S. Administration, “Electronic Logging Devices Implementation Timeline,” U.S Department of Transportation, 2018. |
| [2] | Bluetooth, “Core Specification v5.0,” 2016. |