LPWAN Location Tracking
With the Addition of Dead-Reckoning

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Contents

Declaration

I hereby certify that this material, which I now submit for assessment on the program of study as part of the B.Sc. Single Honours in Computer Science and Software Engineering qualification, is *entirely* my own work and has not been taken from the work of others - save and to the extent that such work has been cited and acknowledged within the text of my work.

I hereby acknowledge and accept that this thesis may be distributed to future final year students, as an example of the standard expected of final year projects.

Signed: Roman Muntean Date: 28/03/2019

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Abstract

The goal of this project is to create a functional complete IoT system that will track a portable SiPy device and display its location to the user from any web browser. The system will use low-power wide area network (LPWAN) technology for communication between the device and the server. This will allow for the device to function while remaining powered by a small battery source for long periods of time. While the server waits for the device to send its next GPS location data, dead-reckoning calculations are used to provide the user with the estimated location of the device in real time based on previous data.

Keywords—IoT sensors; LPWAN; Sigfox

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Chapter one: Introduction

1.1 Topic addressed in this project

The project covers developing an Internet of Things (IoT) application using low-power wide area network (LPWAN) communication to send GPS and kinematic data for the purpose of location tracking. In the case of loss of signal, dead-reckoning navigation can be used to estimate location in real time.

1.2 Motivation

LPWAN sensors are a growing area of interest and development due to a number of advantages they offer over cellular technologies (GSM, UMTS, LTE) which are much more expensive, while Short Range Networks (e.g. Bluetooth, WiFi) are energy intensive and limited in their transmission capacity.

LPWAN, on the other hand, transmit low bit rates over long distances, which is exactly what is needed for IoT devices and systems. The reduced data transmission rates mean significantly less power consumption than other Wireless Wide Area Networks (W-WAN), making these technologies suitable for battery-operated applications as well.

The project is designed to fulfil the need for accessibly-costed, reliable and energy-efficient object tracking sensors. Dead-reckoning estimates facilitate continued tracking in the case of signal loss and in between updates, which is a key consideration of using LPWAN technologies. Use cases include GPS navigation and asset tracking.

1.3 Problem statement

Tracking an IoT device is straightforward, the location can be detected by GPS and reported over the internet back to a server. However there are two conditions under which this fails:

1) when the device loses GPS signal

2) when the device loses its network connectivity.
The problem is to attempt to address these two issues and estimate the device location when its precise position is not available.

Additionally, one of the problems in implementing an effective IoT solution is to select a wireless technology that works at long range, ensuring that the device can maintain communication with the server.

Finally, the data needs to be presented to the end user in the most comprehensive and accessible way possible.

1.4 Approach

Dead-reckoning will be used to estimate the device position when its precise location is not available due to signal loss or delay. By using the device positional data already collected from previous communications with the device, current device location can be estimated on the server end for continued tracking.

Sigfox is chosen as the wireless technology for sending messages from the device. Using LPWAN radio technology, the device will be able to communicate with the Sigfox backend. The SiPy device antenna is fully compatible with this technology and Sigfox callbacks can be used to forward the messages to the server. The Sigfox network fully covers Ireland which will allow for the most streamlined development process. Infrastructure for the network is still growing worldwide. Implementing the tracking system developed in this project using should be feasible across all of the European union, the United States, Australia and most South American countries.

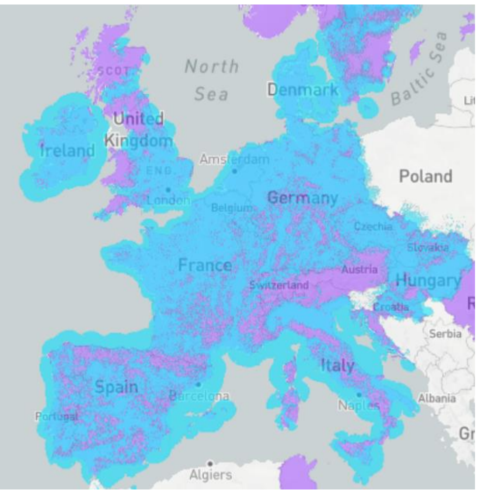


Fig. 1.1. Sigfox network coverage Europe

In the comparison of LPWAN networks done in (Vejlgaard *et al.*,2017) *Coverage and Capacity Analysis of Sigfox, LoRa, GPRS, and NB-IoT* , Sigfox was shown to have the best uplink indoor uplink performance with a maximum probably failure rate of 12%. Since downlink technology will not be used in this project this makes Sigfox a clear choice for the system.

Finalized data will be presented to the end user through a web browser due to common availability, ease of use and customization options. This will include the last reported GPS coordinates of the device, time since last report and the estimated current location. This will be displayed visually in a concise way using the Google map API.

1.5 Metrics

The primary metric for evaluating this project will be the accuracy of the dead-reckoning estimates. Testing the estimated location vs known location will show if the technique helps in solving the limitations of LPWAN to a significant degree.

Accuracy: Testing the accuracy and cumulative error of the dead-reckoning estimates.
Secondary metrics- These cannot be influenced to a major extent but will help in deciding if the technologies being used provide a practical solution to real problems.

Efficiency: Testing the power consumption of the device to provide the expected battery life of various power sources suitable to different use cases.

Reliability: Testing if the coverage in the Republic of Ireland is sufficient for consistent and regular message delivery and using this data to extrapolate how suitable the final device is for use in areas of similar coverage by the Sigfox network.

1.6 Project

IoT tracking device
This project has resulted in a functional and effective tracking device. Development and testing was performed with the SiPy device connected to a laptop as a power source, but all of the functionality is contained on the device itself and the server end. Connecting the SiPy to a preferred power source such as a battery pack will yield a compact, portable and energy efficient IoT device that can be tracked from your web browser.

Dead-reckoning
Dead-reckoning has been implemented as way to estimate device location. The method has been shown to be effective as a way of covering the traditional weaknesses in location tracking such as loss of signal, and significantly improves the effectiveness of tracking methods with limited message frequency such as the Sigfox network used here. Future developments and projects in the field of LPWAN tracking devices could likely benefit from similar methods.

End-user accessibility
The system presents location information in a user-friendly way. Unintuitive GPS coordinate data is interpreted on the server end and presented visually in the user browser with the Google maps API. It’s widespread use and prevalence means it is commonly used and understood by the average layman.

Sigfox coverage data

Using the Sigfox network is shown to be an effective method of device-server communication for LPWAN devices. Chapter four will cover developing with limited message length in mind to develop an application that can be useful despite message length and frequency limitations imposed by the medium. The results of this work present clear benefits in using similar technologies for a variety of use-cases.

Personal

A wide breath of technical knowledge was gained throughout the development process. In particular, key new skills were gained regarding the server-based technologies from the server and database architecture to PHP and JavaScript development. The project also served as an introduction to the growing field of LPWAN technology, microprocessors and MicroPython as well as the many applications and use cases from combining these technologies. The challenges presented during the development of this project have been a learning experience unlike anything else experienced during the course and the experience and skills gained will be directly applicable in a range of fields.

Chapter two: Technical Background

2.1 Topic material

Existing research in the field for using dead-reckoning combine with GPS navigation appears to be currently limited to small-scale, high-complexity use cases. Existing examples include using a waist mounted Pedestrian Dead-Reckoning System (Kim *et al*.,2012) and the personal dead-reckoning system for GPS-denied environments (Ojeda *et al*.,2017) that require significantly more kinematics data than can be feasibly transmitted using LPWAN.

Potentially lucrative use cases of LPWAN tracking combined with dead reckoning such as asset tracking are not yet common. A potential reason for this may be the still-growing infrastructure and acceptance of LPWAN networks such as Sigfox and LoraWAN. (Lingling *et al*.,2017) covers the application of GPS tracking with LPWAN technology for sailing with positive results. This is an example of an application the author feels could benefit from the dead-reckoning system described in this project.

2.2 Technical material

The majority of the development workload for this project was tied to the server-end functionality. The SiPy tracking unit has the relatively simple task of sending location updates to the SigFox backend. Database management, server-end dead-reckoning calculation and the web interface of the system were all developed server-side using Hypertext Preprocessor (PHP) code, JavaScript and MongoDB with the associated server commands.

Pycom: https://docs.pycom.io/
Technical documentation for the SiPy. Includes setup guide, usage and component specifications.

Sigfox: https://support.sigfox.com/docs
Covers setup of custom callbacks for forwarding device messages to a specified server using GET request.

Mongo PHP driver: https://www.php.net/manual/en/class.mongocollection.php
Manual for using the MongoDB server driver within your php code. Used to query and write to the database and a key component for retrieving the variables needed for dead-reckoning calculations and webpage display.

Google Map API: https://developers.google.com/maps/documentation/javascript
Developer documentation for including the Google maps JavaScript API in your webpage, setting markers, styling etc.

While not an exhaustive list of resources, the above covers the irreplaceable technical components that are require for the functioning of the system as presented. Along with these technical resources, communication among peers and my supervisor was key in the creation of this project.

Chapter three: The Problem

3.1 Problem analysis

Successfully implementing a LPWAN location tracking device can provide an efficient solution to a range of GPS tracking needs, but involves several problems:

Message size limitations: The maximum payload of a Sigfox message is 12 bytes.

Message frequency limitations: ETSI (European) regulations say that devices can emit 1% of the time on the public band (868MHz) over the course of 1 hour, translating into 6 Sigfox messages of 12 bytes per hour. Transmitting above this limit can cause the Sigfox backend to prioritize other device and begin to drop messages.

Database storage:
A database is needed for storing the message data. It needs to be accessible from any web browser so the data will need to be stored on the server end rather than a personal device.

Data presentation:
The device message data consists of a latitude and longitude GPS coordinate. Sigfox callbacks timestamp the message using Unix time. None of this data is particularly user-friendly. These need to be presented in a human-readable form.

Chapter four: The Solution

4.1 Solution analysis

Message size limitations:
Using data compression, a full GPS latitude and longitude location can be fit into a single 12 byte message and decoded on the server end. The struct pack and unpack functions are used to interpret the message string as packed binary data. The data is compressed on the device using python and then unpacked using PHP on the server end.

Message frequency limitations:
Using dead-reckoning navigation helps alleviate this unavoidable limitation of LPWAN messaging. The more long-distance the use case, the less relevant regular location updates become once dead-reckoning tracking is considered. For example, once the previous locations of a delivery vehicle in transit are recorded, the kinematic data can be used to estimate its current location since the last message with more than enough accuracy for the majority of use cases. See ch4.1 for the calculation used.

Database storage:
The Mongo PHP driver is used to allow data access using the PHP server scripting language. Entries in the database can be queried from within a php script for use in dead-reckoning calculation or display to the webpage. Using this method the full tracking and calculation process can be separated from physical components and presented to the end user on any device.

Data presentation:
The accepted common standard for presenting GPS location to the user is through a visual interface. The Google Maps API is a widespread and effective tool used for this purpose by countless businesses and consumer applications. The process for including Google Maps in your webpage is well documented as is using JavaScript to tailor the display to specifications.

Last Locations

Time	Longitude	Latitude
1553786681	-6.6017661094666	53.384716033936
1553784920	-6.6028380393982	53.374057769775

latest entry
latitude: 53.384716033936
longitude: -6.6017661094666
timestamp: 1553786681

previous entry
latitude: 53.374057769775
longitude: -6.6028380393982
timestamp: 1553784920

estimated location based on previous reports
latitude: 53.408114585465
longitude: -6.5994128549999
seconds elapsed since last known: 3866

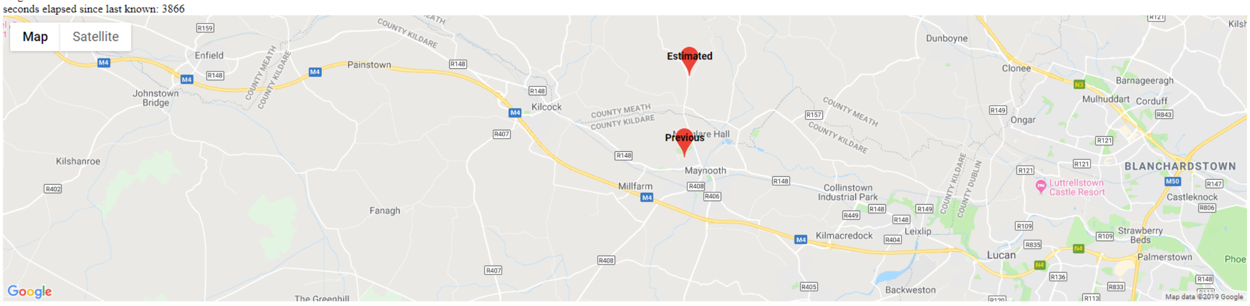


Fig. 4.1. Google Maps API used to display device location

4.2 Architectural Level Implementation

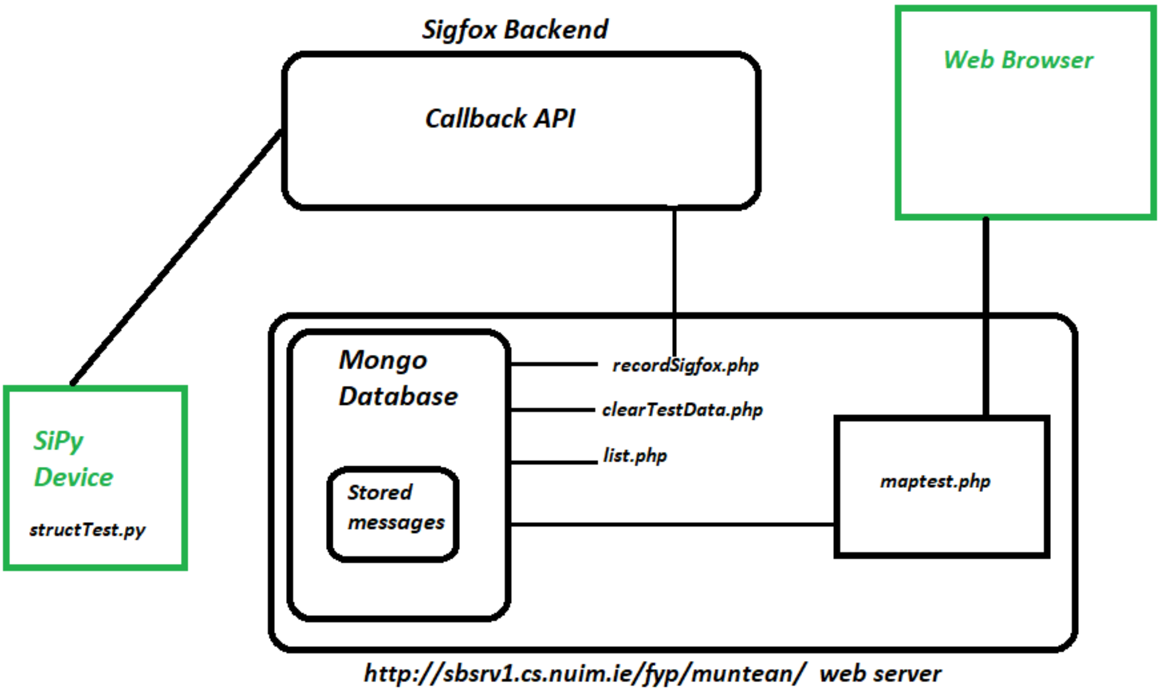


Fig. 4.2. The physical and virtual components of the tracking application

SiPy Device: The strcuctTest.py file on the device sends the GPS latitude and longitude in a bit packed message to the sigfox backend.

Sigfox Backend: The callback API sends the message as a GET request to recordSigfox.php on the server.

recordSigfox.php: Records the message it receives from the Sigfox callback into the database.

maptest.php: Queries the database for the latest two messages. Calculates estimated location using a dead reckoning formula. Displays the location to the end user's browser.

clearTestData: Can be run to clear all messages from the database

list: Displays all entries stored in the database

4.3 Dead-reckoning formula

The following pseudocode dead-reckoning formula is used for the estimated location. The data used is the latest two locations recorded in the database, and the time since the latest recorded location. Dead-reckoning takes in maptest.php

.

```
speedLat=(latitude-oldLatitude)/(timeSent-oldTimeSent)
speedLong=(longitude-oldLongitude)/(timeSent-oldTimeSent)
age=(currentUnixTime-timeSent)

estimateNewLat=latitude+(age*speedLat)
estimateNewLong=longitude+(age*speedLong)
```

Chapter five: Evaluation

5.1 Applicability Survey

The business-focused applications of LPWAN tracking technology have so far been discussed in this paper. From the specifications for existing market solutions we can draw the conclusion that there is a range of applications for LPWAN devices due to their advantages over more common technologies such as GSM and SMS.

During the concept design stage it was also a point of interest as to whether a LPWAN tracking device has more personal applications. This survey is designed to determine if a tracking device with a high energy efficiency appeals to individuals for smaller-scale use due to its small size or longer battery life. The accessed demographic consists of a majority of students and otherwise non-corporate individuals. The individuals who took part in the survey were informed that no personal information was required for the survey and that their data would only be used for the sole purpose of this project.

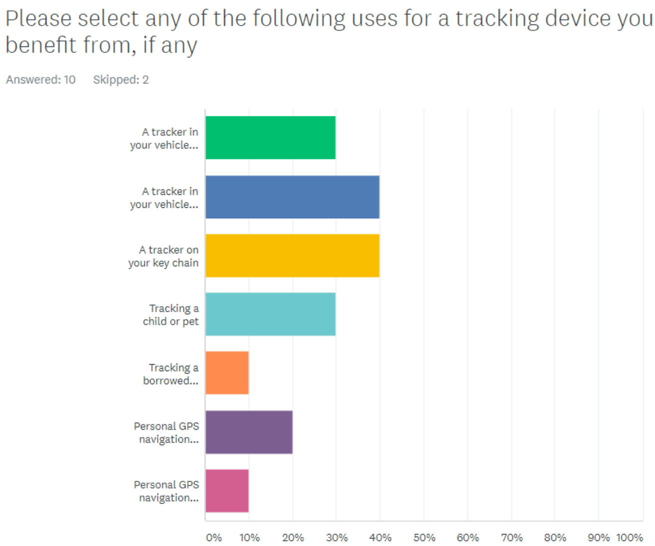


Fig. 5.1.1. Survey question one

The first question is designed to the level of interest in applying tracking devices to solve a range of use cases that are more common to the intended audience.

ANSWER CHOICES	RESPONSES	
A tracker in your vehicle to prevent theft (24 hours)	30.00%	3
A tracker in your vehicle to prevent theft (a few hours parking)	40.00%	4
A tracker on your key chain	40.00%	4
Tracking a child or pet	30.00%	3
Tracking a borrowed vehicle	10.00%	1
Personal GPS navigation (pedestrian)	20.00%	2
Personal GPS navigation (vehicle)	10.00%	1
Total Respondents: 10		

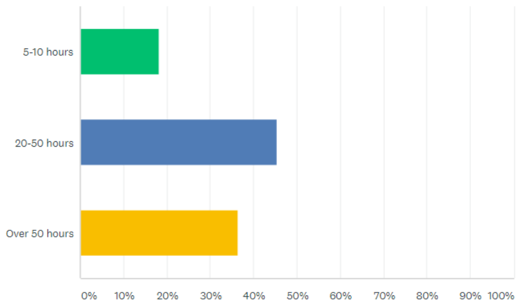
Fig. 5.1.2. Survey question one data

There was a high level of engagement with this question. All respondents selected at least one option, with only one respondent commenting 'none'. Two respondents suggested alternative asset-tracking use cases for small personal belongings that could be practically implemented using this technology. The results of this question indicate that there are a number of areas of interest where the developed technology can be applied in the consumer market.

A much larger sample size of respondents is required to decide if the system developed in this project should be applied to any of these use cases. The varying device and battery size requirements, update frequency and operational duration require development of different implementations of the system. The current SiPy device, for example, could be easily connected to a substantial rechargeable battery unit and installed within a car boot. A key chain tracking device to prevent loss would require a significantly smaller GPS unit, such as the Nano Spider measuring 4x4x2.1mm.

How long of a battery life would you feel comfortable with once the device is powered? Consider the length of your activity, how often you would need to recharge the device and how long the device would be left powered.

Answered: 11 Skipped: 1



ANSWER CHOICES	RESPONSES	
5-10 hours	18.18%	2
20-50 hours	45.45%	5
Over 50 hours	36.36%	4
TOTAL		11

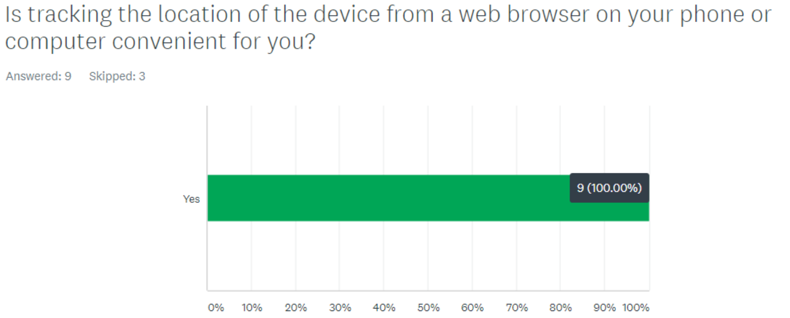
Fig. 5.2.1. Survey question two

The second questions is designed to gauge if LPWAN device efficiency is a relevant benefit for popular use cases.

ANSWER CHOICES	RESPONSES	
5-10 hours	18.18%	2
20-50 hours	45.45%	5
Over 50 hours	36.36%	4
TOTAL		11

Fig. 5.2.2. Survey question two data

Most of respondents expressed an interest in some form of asset tracking application ranging from small possessions to their cars. Only two respondents claimed to be satisfied by a battery life of 5-10 hours, which is the upper-limit standalone powered time of existing non-LPWAN market solutions (Hadwen *et al.*,2017). As expected, energy efficiency is one of the most widely-applicable benefits of the system.



ANSWER CHOICES	RESPONSES	
Yes	100.00%	9
TOTAL		9

Comments (1)

Fig. 5.3.1. Survey question three with data

Question three is designed to gauge user comfort with a web browser interface and offers the potential for users to suggest an alternative interface. Only one user expressed their discomfort with using a web browser interface due to not being able to use a mobile browser while driving.

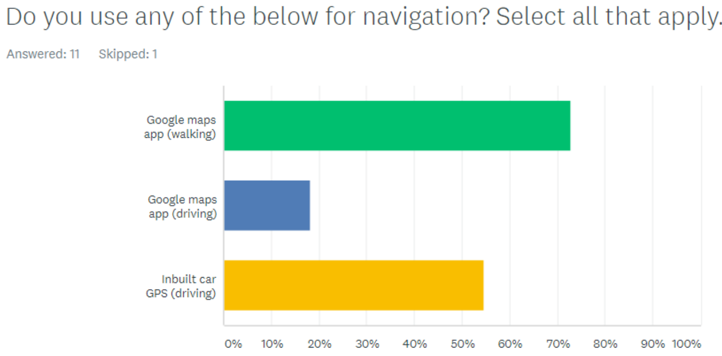


Fig. 5.4.1. Survey question four

Question four considers the prevalence of alternate technologies in the field of navigation assistance where tracking technology sees by far the most consumer use.

ANSWER CHOICES	RESPONSES	
Google maps app (walking)	72.73%	8
Google maps app (driving)	18.18%	2
Inbuilt car GPS (driving)	54.55%	6
Total Respondents: 11		

Fig. 5.4.2. Survey question four data

Almost all respondents already use an existing technology for either pedestrian or vehicular navigation. Navigational rather than tracking use cases are where the developed system may be least applicable because of factors such as the relevance of regular updates not well catered to by LPWAN technology due to energy concerns and legislatorial limitations on radio frequencies used by most providers. An additional point of note is the prevalence of existing solutions provided by Google and the presence of 3G and 4G technology on most phones. The dead-reckoning method used in this system has the advantage of using only data needed for GPS location, which is not of real relevance to technologies with functionally uncapped message lengths.

This data is can be extrapolated into the business use cases closely considered when developing the system described in this project. The applications most well catered to by the benefits of the LPWAN and dead-reckoning technologies used, both physical and server-sided are the situations where it is cost-inefficient to apply 4g, GSM or SMS and where their own benefits are of little relevance.

5.2 Solution Verification

The final application was tested in the field. At 15:00 the device sent its location at the start of the route. This was a known address and the coordinates were confirmed to be accurate. A recorded non-linear distance of 1.96 kilometres (straight line distance: 1.1 kilometres) was traversed to the endpoint where the device was prompted to report its location again. The Sigfox backend received the endpoint location at 15:25. Once again the location was reported accurately.

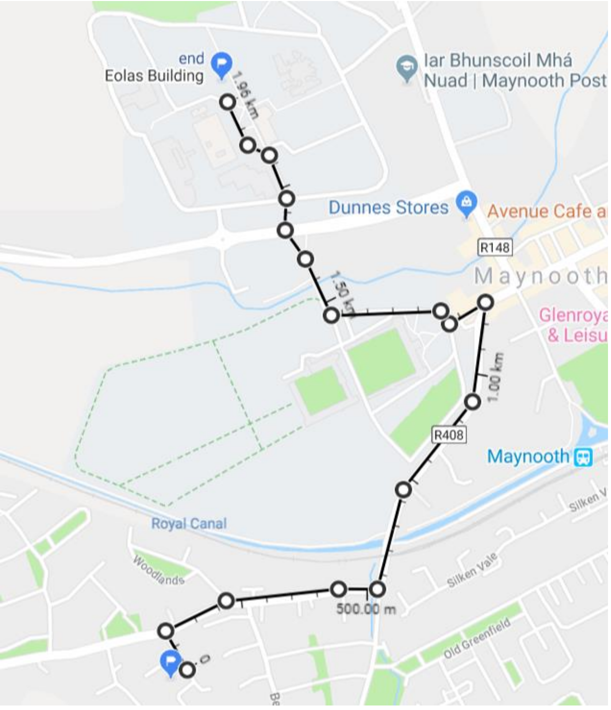


Fig. 5.5. Test route outline

maptest.php was accessed from a web browser. maptest.php displayed the previous reported location and an estimated location based on elapsed time. Every time maptest prompted the browser to refresh itself, the estimated location continued to update in a direction and at a pace consistent with the movement of the device between the two previous points. After 6 hours and 25 minutes, the estimated location had updated to Dunshaughlin, a straight distance of 14.92km North of Maynooth (Fig. 5.2.). This is an accurate extrapolation of the 25-minute journey between the last two recorded points covering a straight line distance of 1.1km, showing the tracking system implementation is working as intended.

Last Locations

Time	Longitude	Latitude
1553786681	-6.6017661094666	53.384716033936
1553784920	-6.6028380393982	53.374057769775

latest entry
latitude: 53.384716033936
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timestamp: 1553786681

previous entry
latitude: 53.374057769775
longitude: -6.6028380393982
timestamp: 1553784920

estimated location based on previous reports
latitude: 53.520362266961
longitude: -6.5881238075768
seconds elapsed since last known: 22412

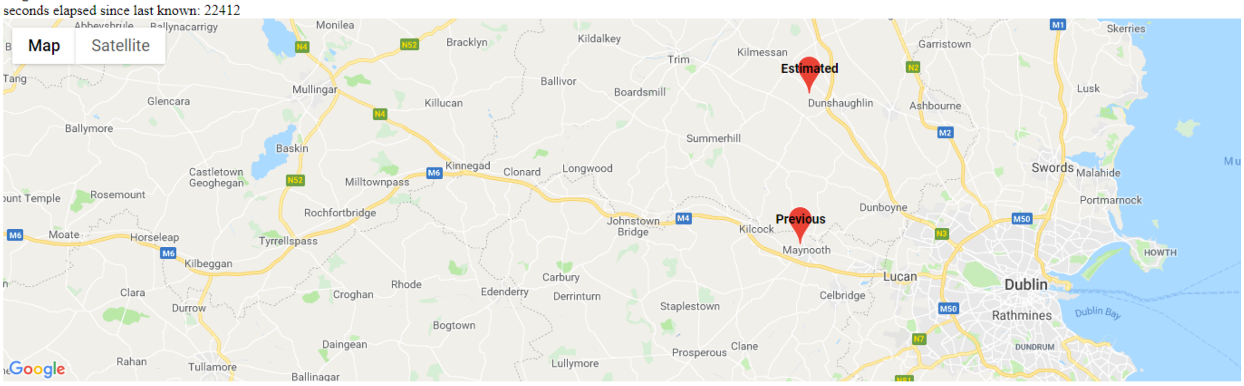

Fig. 5.6. Estimated location: 6h25m elapsed since last message

5.3 Software Verification

Each component (see diagram 4.2) of the software was developed separately to perform a single functionality. Most testing therefore consisted simply of running the functionality to see if it performed its function as intended.

structTest.py: When the device sent a message through structTest, the Sigfox backend was consulted to confirm it received the message. The Sigfox backend displays whether or not the callback was successful.

Time	Data / Decoding	LQI	Callbacks	Location
2019-03-28 15:24:41	f3895542ab41d3c0 ASCII: ..UB.A..			

Fig. 5.7. Sigfox backend displays a received message, indicates successful callback

recordSigfox.php: list.php was run to confirm recordSigfox has added the message sent by the Sigfox callback. Message details were compared between the Sigfox Backend and the Mongo database.

list.php: Run from browser. When a new entry was added to the database, list.php correctly displayed the updated database without fail.

clearTestData.php: Run from the browser. Running list.php afterwards confirmed clearTestData deleted the database contents without fail.

maptest.php: See ch 5.1 solution verification. During all test latest entry details displayed correctly without fail, previous entry details displayed without fail. Estimated location coordinates and time elapsed update in a consistent and expected fashion. Google Map API correctly reflected all know locations.

Sigfox Backend: Out of 60 messages sent to Sigfox by the device over the course of testing, a total 53 are picked up and recorded on the Sigfox backend.

Callback API: The Sigfox callback API was successful for all 40 received after the callback was configured.

5.4 Result Analysis

Accuracy: The GPS coordinates reported by the device were consistently accurate throughout testing. The dead-reckoning estimate becomes increasingly inaccurate for non-linear journeys, however using this method only a very limited amount of data is needed, which is an important consideration due the message frequency limitations. The dead-reckoning estimate is accurate enough to be a considerable benefit for many use cases such as inter-city asset tracking and sailing vessel tracking.

Efficiency: Energy efficiency is one of the main appeals of this system and other LPWAN devices. The energy efficiency of the device can be estimated from a similar system (Hadwen *et al*.,2017) using wrist-mounted LPWAN GPS devices with the use case of tracking dementia patients. Using a small 220mAh battery the device supports 40 hours of continuous GPS tracking with a 60 second location update rate. The system designed in this paper can be connected to any USB-compatible energy source and larger batteries are completely feasible for non-personnel mounted use cases. Adjusting to a larger duty cycling sleep interval of 240 seconds with an identical hour will result in a battery life of 70 hours.

Reliability and Coverage: 83% of all messages sent by the device were received by the Sigfox network. It is expected that there is some data loss due to loss of signal and the system is designed with this in mind. LPWAN messaging is shown to be significantly more affected by trees and tall buildings than other factors such as distance (Lingling *et al*.,2017). In the same paper a packet loss rate of over 20% is recorded in an urban environment. However, in open water 2 km offshore the packet loss rate was under 5%.

These results are reinforced by further research (Laudisten *et al*.,2017) where similarly, a 22-23% probability of interference was calculated in a mainland European business park while more rural areas suffered an interference rate of less than 3%.

Chapter six: Conclusion

6.1 Contribution to the state-of-the-art

This is the first fully-functioning LPWAN service that uses dead-reckoning to increase the effectiveness of tracking. This technology could be used and improved as the field of LPWAN asset tracking and navigation grows, along with the infrastructure used by provider such as Sigfox. By applying a simple dead-reckoning calculation on the server end, additional functionality is added to improve any tracking device imaginable. An example is the application (Lingling *et al*.,2017) concerning tracking a sailing vessel. Using dead-reckoning would be highly beneficial for tracking in this case due to the linear nature of travel over water and generally consistent velocity. LPWAN messaging using larger antennas has been shown in this case to allow consistent tracking as far as 5km offshore. Should a vessel leave the tracking area the estimated location could allow, for example, rescue services to launch a far more efficient search.

6.2 Results Discussion

The results of the testing and evaluation stage are generally positive, showing that there is both a need for the tracking system designed here and that the technologies use are both effective and offer considerable advantages not seen in existing solutions. The dead-reckoning calculation developed is used to provide the user with an estimated location in between the limited updates LPWAN technology can provide. The system provides a rough dead-reckoning estimate, with the upside of requiring no additional information past the GPS coordinates which is a reasonable compromise to the limitations of LPWAN messaging. A more accurate system would require 2 messages per every report to account for the additional data, which would half the daily update frequency. One of the main benefits of the system is energy efficiency, which can be leveraged into either much long operation times or higher update frequencies. Lowering the maximum update frequency as limited by Sigfox and European legislation from 140 per day, or once every 10 minutes, to 70 more complex messages would make the device impractical for a range of the potential use cases.

The results of the evaluation survey highlighted how LPWAN messaging offers very limited benefits for the purposes of navigation, a market already saturated by competing solutions provided by Google and GPS manufacturers. Individuals and cars today are for the most part already equipped with a range of powerful solutions ranging from mobile phones to GPS devices most cars are already furbished with before sale. The applications this technology best caters to with it own benefits of long operation times and cost-efficiency are found where the aforementioned solutions are not readily available, or difficult to implement. Examples include compact tracking devices for small items for recovery in case of loss or theft, or applications where the accuracy provided by the system is perfectly sufficient and appealingly costed such as long-distance tracking of vehicles and cargo.

6.3 Project Approach

The project was approached from a ground-up perspective. Sigfox was selected as the LPWAN technology of choice due to its widespread coverage infrastructure and a focus on support for new developers adopting the technology. Development began with the SiPy itself which comes fully compatible with Sigfox messaging. A short MicroPython development and testing stage followed to establish communication between the device and Sigfox as well as to calibrate factors such as message frequency and content. One of the main challenges at this stage was correctly bit-packing the message to fit the full GPS coordinates into a single message. The Sigfox back end was configured to establish callbacks to the server, and this stage would be regularly revisited to update callbacks to match newly developed PHP programs.

Familiarization with server architecture and development of server scripts for the majority of the project's functionality was by far the most lengthy and technically-intense stage of development. This was combined with the development of server code relating to the Mongo driver so that the database could be accessed by the server scripts. Finally, additional server work completed the user interface. By the project's completion, all the steps of development were combined as the device would report its location to sigfox, be added to the database and processed on the server end as scripts would process data from and add to the database, displaying the final product to the web browser.

6.4 Future Work

To account for use-cases involving international asset tracking, the dead-reckoning calculation will need to be changed from cartesian to spherical coordinates. Assuming a cartesian plane makes no noticeable difference over shorter journeys, however for long-distance tracking the reduced longitudinal distance at the poles needs to be accounted for to maintain a reasonable accuracy.

Improvements to the presentation of the user interface will be necessary for the system to enter the consumer market. Additional functionality such as an Android or App store application with a similar purpose would be beneficial. Following additional research, market-grade applications of the system can be implemented in a range of sizes, power supplies, antenna powers and update frequencies suited to their specific purpose.

Exploring alternative well-established and growing LPWAN system could also be beneficial.

The LoRa Alliance was founded at MWC 2015 and counts today more than 300 members, ranking it as the fastest growing wireless alliance ever. LoRaWAN is a competitor worth considering when designing a similar device.

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