Guidance Research

Class: DB – 03
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Triangulation Research

Questions

1. What methods are there to precisely triangulate a location of a given device?
2. What is the best way to triangulate a location?

MAIN: Which is the most efficient method for precise location triangulation in closed spaces?

Contents

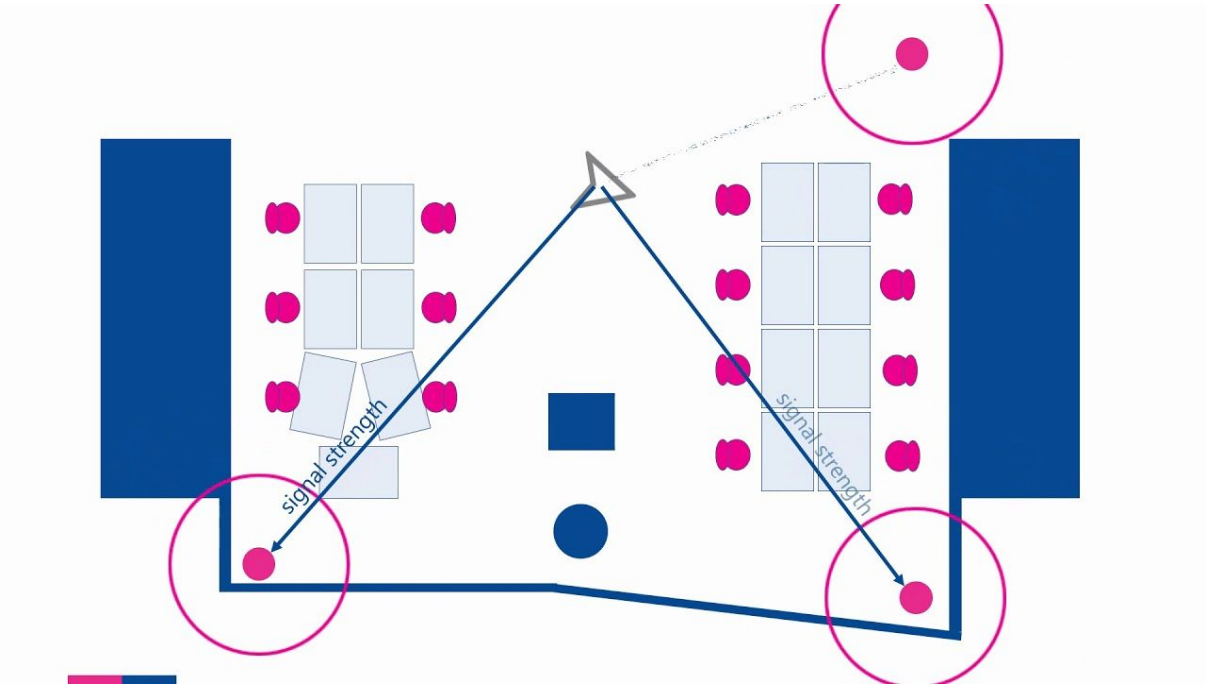
Introduction

This document will act as a short explanation of the decisions that our team had to make in choosing an approach towards location triangulation. Furthermore, this document will not contain detailed explanation of all existing methods and variations for location triangulation there can be, but rather just explain the general process of creating the system that handles a device location triangulation and restrictions there can be in that process. Nevertheless, worded commentary with examples will be present for ease of reading.

What is indoors triangulation?

Triangulation is known to be the process of determining a transmitting point's location by using other known receiving points' locations. A receiving device or a configuration of such can extract a variation of distance parameters. Example can be radio signal, which wifi works with. In that case, the extracted data is called RSSI or Received Signal Strength Indication, which is measured in decibel-milliwatts(dBm). Usually this measurement indication stays in the negative integers. The higher the integer, the better the signal.

For the sake of simplicity, further information will be explained with pictures.



The picture above contains a very simple example of how triangulation works. It contains one receiving point(**the hollow arrow**) and three transmitting points(**the red dots**), each displaying its distance(**blue lines**) to the transmitting point. And all of this is in a given space. Imagine having these three receiving points as bluetooth transmitters located in a room, somewhere in a building and the receiving point as a mobile device that has its bluetooth discovery option turned on. The three bluetooth devices constantly transmit a signal to all bluetooth enabled devices that are within their signal reach within a given

interval. The mobile device then saves and updates locally the data of each transmitter. Data such as: bluetooth device's identification and strength of transmitting signal. Each device has a unique identification. As for the signal strength, the further a mobile device is from a bluetooth device the lower the signal strength value is stored.
Now imagine having the mobile device being relocated every second. Each bluetooth device that has the mobile device within its reach, will have a weaker signal strength value towards the given mobile device.

This data then can easily be converted into some type of distance measurement by using a simple algorithm that takes into account the already known coordinates of the transmitting devices on a given plain, the signal strengths of each bluetooth device towards a mobile device. But what happens, if the mobile device has gone behind a wall?

	Wifi 2.4GHz (dBm) / Bluetooth	**Wifi 5GHz (dBm)**
Concrete – Heavy	22.792	44.769
Lime Brick	4.295	7.799
Drywall Partition	5.388	10.114
Chip Board	0.463	0.838

This table gives a simple example of how much signal strength loss there can be when a signal has to go through a wall to get to the mobile device. Of course, this table is displaying information mainly for wifi signal, but bluetooth signal is known to work on the 2.4GHz frequency, that is why it is applicable in this case.

The signal then can be processed accordingly to compensate for the loss. But how is this done? Comparing all the three main signal strengths needed for triangulation, taking into account known transmitting devices' location on a map, an anomaly can be seen if there is a signal obstruction, which can then be cross-checked with the table above and compensate for the disturbance.

Now, after taking into account possible wall interference, the final algorithm should consist of the following parameters:

- Transmitting devices' locations
- Transmitting devices' signal strengths, already checked for strength interferences and compensated for
- Actual real map overlaid by virtual map with proper ratios

What is our approach to location triangulation and what is the optimal approach?

Our group has discussed what technology would be better for figuring out more precisely an approximate location of a mobile device inside a building. Many technologies provide a solution to our main problem, namely - “How to get from point A to point B indoors as fast as possible”. WiFi and Bluetooth were the two that our group compared toe-to-toe. As a result our group has decided to use Bluetooth technology in our project of location triangulation. But why did our group decide on it?

Many of the features the two technologies offered had different results for our problem. Whilst WiFi has a precision of 10 meters when converting given values to metric measurements, Bluetooth cuts off the second digit and gives an approximate estimation to 1 meter accuracy. This is the main Pro for the Bluetooth technology that led us to choose it rather than WiFi. Additionally, Bluetooth devices are considered to be less costly in the price and maintenance aspects. Another Pro of the Bluetooth is compatibility. Since Bluetooth is a way older technology than WiFi, it has been and still is being implemented in almost all devices. As for the final, but not the most significant Pro of Bluetooth, low energy consumption possibility allows for draining a mobile device’s battery way slower than the WiFi technology does.

Comparison: Wi-Fi vs Beacon technology

	Bluetooth® Beacons	Wi-Fi
Is the location accurate?	+/-1m	+/-10m
Is it compatible with Android phones?	Yes	Yes
Is it compatible with iPhones?	Yes	Yes, but iOS doesn’t support ranging for Wi-Fi. Without ranging, positioning is difficult and inaccurate.
Does it drain battery on the user’s phone?	Low energy consumption	High energy consumption
Does it work offline?	Positioning even when there is no data connection	WiFi can sometimes get overloaded if you have a lot of users connecting to a network
Is it costly to install?	Inexpensive (~20x less than Wi-Fi)	Time consuming & expensive
Is maintenance required?	Beacon replacement process after 2-4 years	Calibration process required & regular check ups

So now that the decision of the group is known, a question should come up - Without considering development costs or the capabilities of a developer, what would be the optimal approach to triangulation? An answer to this question would be both WiFi and Bluetooth combined. WiFi is better analysis technology that has access to more data, whilst Bluetooth is more limited when it comes to ranging data, but has more precision. Combining both technologies might give an organization a better experience and overview with a situation.

Why use triangulation instead of just tracking the location of a device?

While many devices have location-enabled hardware installed on them, such as a GPS receiver, and is used in multiple applications to fetch the exact location of an end user. Enabling a user's location hardware is more than common for applications that require the exact position of someone - such as Google Maps or delivery apps like Uber Eats or Deliveroo. Why bother with triangulation when the technology to extract the exact locale of a person does not just already exist, but is mass spread to the point that everyone has it?

An important point when delving into functions that work with a user's data is morals. Moral coding has been a hot topic for a while and one of the main points of discussion in this sphere is how one should handle a user's location. Of course, there are mobile applications that first ask for permissions, but that is not enough. Once an agreement has been made with the company to allow them to use your location, the company is tied to only fetch that from the user's private data. The issue here is this opens a potential slippery slope into the developers asking for more of the user's private raw information to provide them with more functionality, which on paper sounds beneficial - but at that point the end user's privacy is exposed, which leads to an increased safety risk. To avoid going down that path, triangulation is used as a good alternative to location gathering, because it does not make use of an end user's private data. Instead it requires the signal strength of networks that a device is connected to and calculates a rough estimated location out of them. With this, the approximate location of the user is known, but is done so without using sensitive information - avoiding the risks of unethical coding.

Potential pitfalls during development

Our group did encounter a few bugs throughout the development of the location triangulation feature. Important thing to mention is that this system feature is one of the core ones. Having it relay incorrect data, all other subsystems will be massively impacted. This by itself will render the final product unfinished, or potentially worse - endanger the wellbeing of an end user.

An example of one of the bugs that our group ran into was having to deal with unrecognized bluetooth devices. This may seem like a not so great of a problem, but our application strongly relies on a specific type of bluetooth devices, which relay data indirectly towards our database. If wrong data is saved in the database, a whole chain of misguidance and stream of incorrect information will emerge.

Conclusion

Location Triangulation can be approached in many ways with many levels of granularity and data processing. This document is sure to have documented only a small piece of what this topic needs in order to deplete it.

Firstly, our group documented what triangulation is and how it works. Our group overviewed all factors and requirements to reach the desired result.

Then our group checked out what our approach to our group problem with indoors navigation is. The technologies our group use and their advantages and disadvantages.

Afterwards, our group checked what the desired approach to our situation would be.

In conclusion, our team has decided to use Bluetooth technology rather than other technology, mainly because of its advantages in comparison to other technologies.

Citations

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