

Indoor Positioning Systems are location-based services

that utilise alternative localisation methods to GPS.

From wayfinding to food delivery and location sharing, there are many applications of GPS in our everyday life.

However, GPS cannot be used reliably, if at all, inside buildings.

That's because GPS relies on signals sent by satellites orbiting the earth. Once you go inside a building or venture underground, that signal is distorted.

The result is a significant drop in accuracy when the user enters a building.

That is where Indoor Positioning Systems comes in.

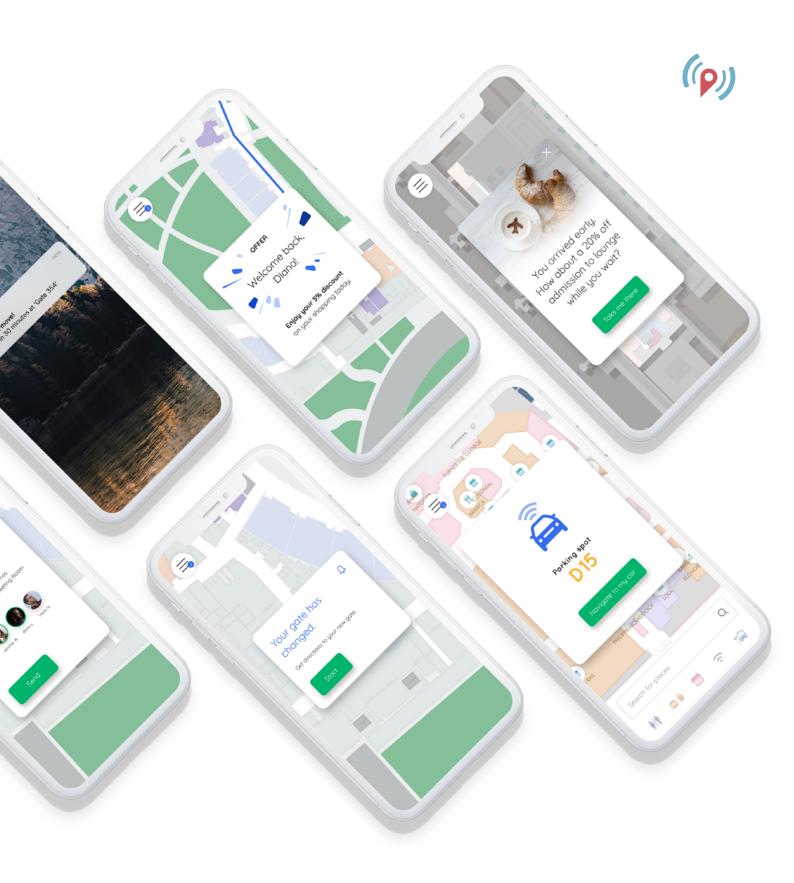
In this guide, we will look at a few technologies and how they are used to overcome the challenges surrounding indoor location services.



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Where is

Indoor Positioning used?

Everywhere from **airports** to **shopping malls**, **hospitals** to **hotels** and **corporate offices** to **campuses**.



Smart Workplace



Indoor Positioning is used to help employees and visitors find each other easily, book available meeting space and navigate an unfamiliar campus. Facility managers leverage location analytics in the workplace to make data-driven decisions that optimise space utilisation and improve operations.

Retail



With location-based services and proximity marketing, retailers can enable a personalized shopping experience. Shopping malls and retail stores can also provide indoor wayfinding right in the visitor's smartphone. They are able to analyse the physical flow of shoppers through detailed statistics and heatmaps.

Transport Hubs



Airports and train stations can be difficult to navigate. Indoor positioning systems allow passengers to search for facilities and services on a map and to navigate to their destination easily. It also allows airport and rail operators and on-site businesses to send location-based notifications to visitors and to improve their operations thanks to asset tracking and location-based analytics.

Hospitality



Hotels can drive revenue, improve employee safety and reward customer loyalty with location technology. Real-time location tracking enables hotels to ensure the safety of their staff (wireless panic buttons), improve the efficiency of cleaning operations through live updates and direct employees to customers needing assistance or areas of the hotel which require urgent attention. Moreover, loyal guests can be rewarded with great features such as food delivery via the app at their live location, mobile navigation and AR experiences.



What are the applications of **Indoor Positioning?**

From mobile navigation to location-based engagement and analytics, Indoor Positioning has plenty of use cases.



Location-based **Services**

Provide the finest location experience for your visitors.



Location-based

Analytics

Real-time analytics to help you make data-driven decisions.

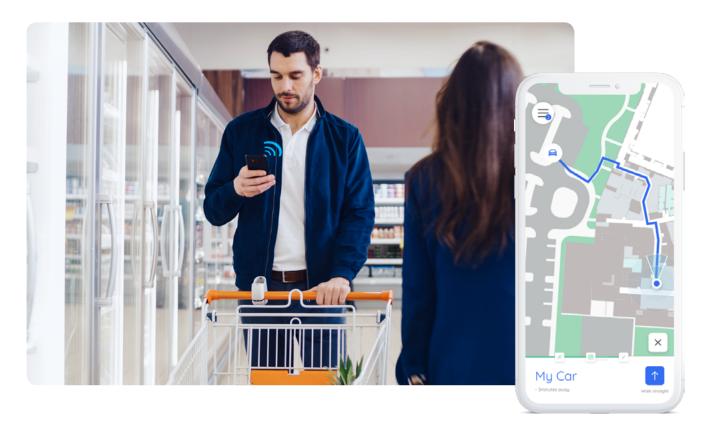


Location-based

Marketing

Engage with users based on their real-time location.





Location-based Services

With an accurate indoor positioning system, venue owners can guide visitors with turn-by-turn navigation as they walk through the venue. Routes are personalised for visitors, who can navigate to their car or to their favourite shop. This is particularly useful in large venues such as airports, shopping centres, resorts or workplaces. Indoor positioning systems also have the added advantage of being able to understand which floor of a building you are on. This is not possible with GPS.

With indoor wayfinding at their fingertips, visitors enjoy a better, more relaxed experience at the venue. Navigation is just one of many use cases a better indoor experience. Other use cases include:

- · Share your live location with colleagues, friends or family when you're indoors
- Order food at your exact location inside a venue
- Search live information about products, stores and services available
- Provide assistance for visually impaired people

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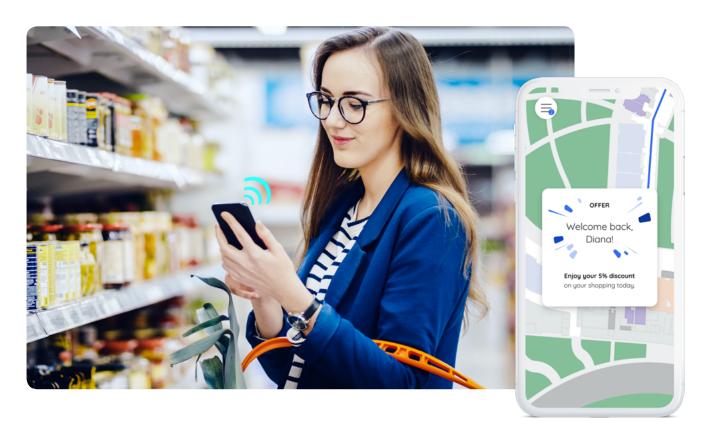
Location-based Analytics

Indoor Positioning can also be used to give venue managers insights into the volume of people in a particular area, plus finer detail such as returning customers or clients and the location and concentration of crowds.

Shopping centres can use this intelligence to drive informed leasing strategies. Airports can react to real-time data and ensure that resources are being allocated in an optimal way. Asset tracking makes it possible to get the real-time position of trolleys and wheelchairs and ensure they are available when customers need them. Crowd analytics makes it easy to check the passenger density in a specific area so that queues are kept to a minimum.

By leveraging smartphones, smart IoT sensors and Bluetooth and Wi-Fi networks, it is now possible to get location analytics solutions up and running quickly and easily in physical venues.





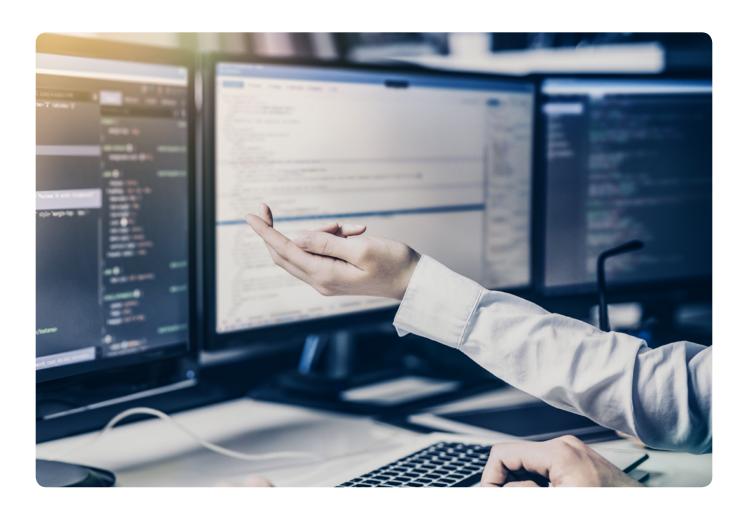
Location-based Marketing

Indoor Positioning can be used to recognise when a user's smartphone or tablet has moved into a specific location, thanks to a technique called geofencing. The system can then send a notification to the smartphone, alerting them to special offers, opening times, freebies; anything that increases customer engagement.

Common places to find contextual notifications are:

- Airports, particularly around duty-free
- Shopping centres, supermarkets
- · Other transport hubs, like train stations
- Conventions and exhibitions

Someone walking to their flight in an airport may pass duty free. If they have accepted to receive offers, they can receive a personalised notification informing them of special offers tailored to their needs. Another notification can inform them that they need to make a move to their gate when boarding is starting, and guide them through the airport. That's just one example of the multitude of uses for location-based marketing.



The Check-list for

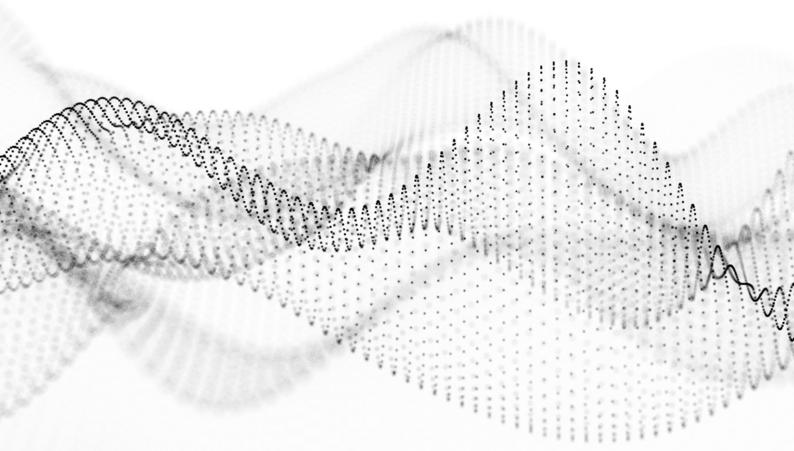
Successful Indoor Positioning

There are major factors that venue owners must consider before investing in an Indoor Positioning System.



	Criteria	Description
~	Accurate	Location data should be within 1-3 meters of the user's actual position.
~	Fast	Users should be able to see their position within 2 seconds of opening an app.
~	Flexible	Maps and notifications should be easy to configure from a single dashboard.
~	Robust	Must be designed to last several years without modification or calibration.
~	Hardware Agnostic	Equal performance on both iOS and Android devices.
~	Limitless Users	Location data should be calculated on the device to ensure consistent service even during peak demand.
~	Battery-optimised	Software should be optimised to not drain the phone battery.

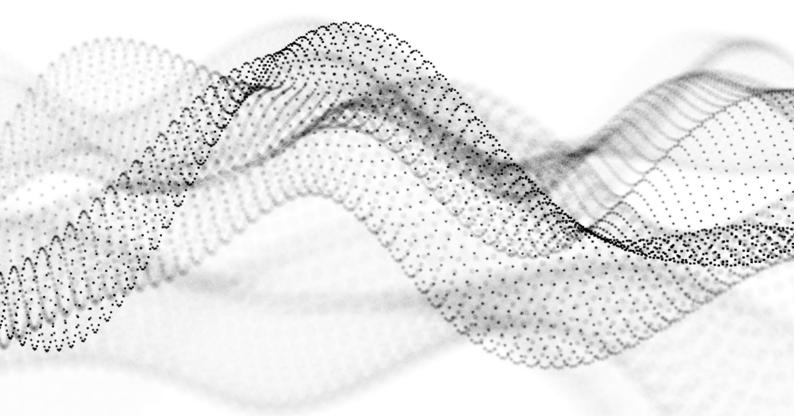




Which Indoor Positioning Technologies are available today?

In the absence of GPS, Indoor Positioning Systems utilise several different techniques, each with slightly different results. In this section, we give an overview of the most common techniques used today.





Bluetooth Low Energy & Beacons

Fingerprinting (WiFi, Geomagnetic)

Pedestrian tracking

Trilateration

Compass

Smart Lighting vs. VLC

Camera / Visual Positioning System

Bluetooth Low Energy & Beacons

Bluetooth Low Energy Beacons are small battery powered devices that connect to Bluetoothenabled devices like smartphones. They use Bluetooth Smart, or Bluetooth Low Energy (BLE) to broadcast a signal for up to 70 metres. The user's device, which may be a smartphone or a tablet, will pick up these Bluetooth signals and use their strength to determine the distance from the beacon, usually in conjunction with an app on the device. The mechanism is very similar to how ships used lighthouses. The lighthouse would emit light which was picked up by passing ships.

As the name suggests, Bluetooth Low Energy is extremely power efficient. A phone's battery drain is less than 1% because of nearby beacons. Beacons are very efficient and cost-effective. They can be used inside WiFi access points or lighting infrastructure, or they can be powered by button cell batteries. Maintenance is often an infrequent necessity, again, making them ideal for high traffic venues.

Unlike any other positioning technique, Beacons provide background capabilities

This enables positioning even when the user is not using the app. For instance, if a visitor in a supermarket has a phone in their pocket, the retailer can still enable geofencing and contextual notifications, provided that the user has given prior consent.

The benefits of **Bluetooth Beacons** for Indoor Positioning:

- Compatible with both Android and iOS
- Low energy consumption they don't drain battery on the user's phone
- Low deployment cost
- Low maintenance batteries don't need to be replaced often
- Provides background tracking capabilities, even when the app is closed

Additional benefits when using Bluetooth Beacons in combination with **Pointr's Deep Location™ technology:**

- High positioning accuracy of 1-3 meters when combined with other sensors
- Works offline with Deep Location, even where there is no data connection

HOW IT WORKS



Pointr Cloud

Analytics



Content Management



Pointr **SDK**Indoor Location









Fingerprinting (WiFi, Geomagnetic)

Fingerprinting is a common indoor positioning technique that involves creating a signature of the venue by walking around the venue step by step and recording signals at every step. By turning the venue into a grid, it is possible to know which signals to attribute at each step and at which signal strength. Signals are typically coming from WiFi Access Points but they could also be magnetic signals, Bluetooth Low Energy signals, light signals, etc.

This is probably the most common technique in use today. Companies like Apple and Google use WiFi fingerprinting to provide indoor location with 15-20 meters accuracy. They insist that this technique is not suitable for places like exhibition centres, where WiFi access points change often and where there's significant changes to the layout.

Meanwhile, several indoor positioning companies rely on geomagnetic fingerprinting. They're experiencing important challenges with accuracy and in particular level detection. The technology cannot detect separate floors accurately as signals are similar on different floors.

Common issues with Fingerprinting:

In addition to these challenges, fingerprinting has a variety of known issues:

• You need to re-calibrate the technology every time venue changes slightly - for instance when you move a metal cabinet to the left, or close an entrance, or a new shop opens.

- This technique only works online because the signature is kept on a server. This means a visitor who doesn't have data or a visitor who is going through a location without signal will have to wait to get back online before they can load their location and navigation capabilities. This is especially problematic at airports, where international travellers typically don't have data and where visitors are navigating underground tunnels with no signal.
- It's a cumbersome process to install. It
 requires walking step by step to configure,
 and in case of a mistake in the calibration,
 the whole process needs to be started again.

Pedestrian tracking

Most smartphones have gyroscope and accelerometer. These two sensors can be used to understand your relative activity. It's relative because the tracker doesn't know where you are. It just knows that since the past 30 seconds, you walked 10 metres straight then made a right move and walked another 5 metres.

Most fitness apps are a good example of this - Apple tells you how many steps you walked in indoor venues but won't tell you where. Fitness apps, however, are able to tell you where you walked in outdoor environments. If you run in a park, they know your starting location via GPS. Then if you start running 500 metres straight at 45 degrees North East compass direction, they can plot your run and they check in with GPS to calibrate the position.

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Common issues with pedestrian tracking:

- The starting point is key. If your starting point is 50 metres off, then your entire run will be shifted of 50 metres. Therefore, it works well outdoors if the GPS signal is good. If it's not, it will not work at all.
- For indoor applications, if the user starts on the street with GPS and then walks into a mall, the accuracy will be 10-20 metres off.
 If the user starts the walk indoors, then it will not work at all.
- The technique relies on the user's phone sensors, which are prone to errors as the user walks. More errors will appear as the user keeps walking. This is a big issue with pedestrian tracking techniques.

Trilateration

Some companies use an indoor positioning technique called trilateration. This consists in calculating a location using 3 distances with signals emitted by Bluetooth Beacons. This technique provides low accuracy as Bluetooth Low Energy signals are very jumpy.

Trilateration is not to be confused with triangulation, the technique used by GPS signals to pinpoint a location in outdoor environments. Triangulation calculates a location using 2 angles and one distance. It is not currently possible to do triangulation in indoor environments because triangulation means 2 angles and 1 distance. With Bluetooth Low Energy or similar sensors, you don't get any angle. All you have is RSSI - received signal strength indicator. This will change with the new

standard Bluetooth Low Energy 5.1, which hasn't been implemented yet.

At Pointr, we devised a unique method that combines Bluetooth Low Energy signals with phone sensors to enhance the accuracy of the indoor positioning, using a large machine learning engine.

Compass

Compass is designed for outdoors. Indoors, radio frequencies from access points, security cameras, other computer systems or lights create too much noise that interferes with the compass on the user's phone.

Pointr is the only company that doesn't use Compass. We tried it and we found serious issues with it, so we stopped using it and devised our own technique to replace Compass. We patented this technique in 2015.

IS YOUR COMPASS ACCURATE?

A good test is to put 3 phones next to each other on a table and run the Compass app. They will all point in different directions at least 50% of the time, especially if you're away from the windows. You can even expect to see a 100-150 degree difference.



WHY DOES IT MATTER?

A good test is to put 3 phones next to each other on a table and run the Compass app. They will all point in different directions at least 50% of the time, especially if you're away from the windows. You can even expect to see a 100-150 degree difference.

A good orientation is particularly important for:

- Indoor wayfinding imagine a system telling you to go straight when you have to make a left turn
- Navigation in Augmented Reality when navigating a venue in AR, good orientation is the key to a good experience. Even if the orientation is only out by five degrees, which will hardly be noticeable on a map, the error will be very apparent to the viewer in an AR world. That small margin could cause a virtual object to suddenly appear inside a wall, or intersect some other object

At Pointr, we don't use Compass

Unlike any other indoor positioning company, Pointr doesn't rely on Compass for orientation. This means we are not just perfect with indoor location, we also provide very high accuracy orientation and motion.

Smart Lighting vs. VLC

Visible Light Communication (VLC) is the use of LED lights as a method of wirelessly transmitting data. Every lightbulb sends out a specific light pattern, invisible to the human eye. The front camera of a user's phone can then pick up different signals from different bulbs.

It's particularly used in retail, where the store lighting acts as the indoor positioning infrastructure. The Visible Light Communication sends out a unique code from each light fixture to the shopper's phone, delivering location-based services such as positioning or contextual notifications. VLC has good positioning accuracy, however it comes with a set of challenges. Data privacy (camera permission) and high cost are the most common reasons why people don't prefer it.

Here are some of the challenges of VLC that we've identified:

- Not every phone has front camera, though some companies can also use back camera
- Asking users for camera permission to enable positioning is poor practice and creates massive data privacy issues. As a user, this means my retailer app can see my face when I'm in the bathroom browsing products on the app. Target, the US retailer & the largest implementer of VLC, have already decided to turn off VLC for this reason.
- It is 10 times more expensive to deploy specialised light bulbs
- It is even more expensive to configure them.

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Each bulb has to be unique and needs to have a specific angle.

- It's only suitable for certain environments like supermarkets but not so much for high ceiling venues. Areas with higher ceilings or gaps such as open staircases do not provide accurate positioning.
- It doesn't work in the background. Getting a
 "Welcome" message when the app is in the
 background is not possible. So some VLC
 companies enable both VLC and Bluetooth
 Low Energy, which makes it even more
 expensive.

Visible Light Communication emerged because venues couldn't get the accuracy they needed from existing positioning techniques combined with Bluetooth Low Energy signals. At Pointr, we are able to provide a very high level of accuracy using Bluetooth Low Energy thanks to our Deep

Location™ technology. This means venues get all the benefits of Bluetooth Beacons, without the high cost and data privacy issues that come with VLC. This makes VLC become obsolete.

DID YOU KNOW?

Bluetooth Low Energy is also available through the lights

It is possible to integrate Bluetooth sensors into a building's smart lighting system. It can then direct the visitor to any destination within the building - whether to a specific product in the store, a meeting room, or a hospital room.

Realising the problems with VLC technology problems, most lighting manufacturers started using BLE instead of VLC already.

A comparison between VLC and Bluetooth technology

	Visible Light Communication (VLC)	Bluetooth Low Energy (BLE)
PRIVACY	Needs camera permission to work	Doesn't need camera permission
AVAILABILITY	Only available for devices with front camera (20% or less)	Available for 95%+ of the mobile device market
SETUP COST	Very expensive	Low cost
DATA COLLECTION	Only when app is running and user is holding it open	Always
DEPENDENCY	Once installed, cannot switch	Very flexible



Camera / Visual Positioning System

Google recently announced that Augmented Reality navigation in Google Maps would use a Visual Positioning System. It is exactly the same as fingerprinting but rather than using a radio frequency such as Bluetooth Low Energy or Wi-Fi, it uses camera pictures. With Street View data, Google have visuals of the entire planet. When you lift up your phone, they combine GPS and Street View footage to figure out precisely the positioning and the orientation of the user. If Google were to use Compass as they do with Google Maps, the orientation would be off most of the time and it would ruin the entire AR experience. This is why they use Street View data in addition to GPS.

There are many challenges with this positioning technique:

- It requires significant data and battery usage. Doing visual processing is the most expensive processing on the phone today.
- It is not a worldwide solution and not designed for the indoors. Just imagine having to analyse millions of photos and having to keep it up to date all the time. There are some companies who use this technique for indoors. They film the venue and use the footage to train the algorithm. The issue is that it requires a lot of maintenance to make it work, as it needs the right footage and it should be updated at any change in the venue layout.

 It only works when users are using the app and pointing the phone. If they're pointing the floor or if it's in the pocket, it won't work at all.

Pointr's Augmenting Navigation doesn't use Visual Positioning Systems.

This means we can roll out our AR technology to all venues around the world with a tap of a button, wherever positioning is enabled.





What is the Future for Indoor Positioning?

Pointr constantly invests in R&D to ensure we stay well positioned to bring you the best in Indoor Positioning technology.

Pointr's Deep Location™ technology utilises a combination of sensors and machine-learning algorithms to bring accurate indoor positioning to airports, large retail spaces, smart workplaces, hotels & resorts and more.

We're particularly excited about the possibility to embed Bluetooth sensors in lighting systems. Unlike VLC, Bluetooth beacons don't require a direct line of sight between the phone and the luminaire, which makes the technology highly reliable - it is also more efficient as the Bluetooth technology requires less luminaires. We're also monitoring carefully developments in the Ultra Wideband space. The technology is still in its infancy but looks promising for future use.

Will Apple disable WiFi, Geomagnetic and VLC for indoor positioning?

This year at Apple's flagship developer conference, Apple SVP of Software Engineering Craig Federighi said that Apple was "shutting the door" on developers' "abuse" of location data. If Apple goes ahead and disables WiFi, Geomagnetic and Light scanning for position calculation on their devices, Bluetooth Low Energy might remain as the only available solution for indoor location.



Bluetooth Low Energy 5.1

Some incredible news here - the new Bluetooth Low Energy standard, BLE 5.1, supports triangulation. No one knows how long it will take before this is available on our phones but once it is, the accuracy of indoor positioning with beacons will go below 1 meter. This is because we will be able to calculate the positioning not just with distance, but also with angles. By knowing the direction of the signal emitted by the beacon, accuracy will improve immediately.

Worth noting that when you read the announcement, it feels as if it will be available out of the box. In reality, Bluetooth Low Energy provides the sensor technology and firmware, not the positioning software. Pointr Deep Location™ will still be required to provide the positioning on mobile.

Ultra Wideband

Ultra Wideband (UWB) is perfect for indoor positioning because it has very high accuracy and better characteristics for indoor positioning such as avoidance of multi-path fading. It is not available on iOS or Android at the moment. However, Apple announced that it will enable it soon for Smart Home use cases (eg. find my earbuds, find my iPad). It would be used for relative positioning, to identify where a device is relative to where the user is ("find my iPad") but it's unlikely that it will be used for indoor positioning.

On paper, Ultra Wideband sounds like an exciting future technology to watch. At Pointr, we will be supporting Ultra Wideband if and when the time is right. However, we don't expect a quick transition due to several challenges.

The challenges with the implementation of Ultra Wideband are:

- Given that BLE 5.1 is coming, UWB's
 additional precision might not be that
 useful if Bluetooth Low Energy already
 provides improved accuracy, which would
 be sufficient for most applications. For
 applications where precision to a centimeter
 is needed, such as warehouse tracking,
 specialised hardware like UWB might be
 deployed.
- 5G will have indoor location capabilities it
 is advertised. It is unclear when the world will
 switch to 5G or how indoor location will work
 on users' phone. It would still require Apple
 and Google to enable 5G positioning. A space
 to watch.
- Even though UWB seems superior to BLE, there is no infrastructure today. Hardware companies have invested a lot of effort in Bluetooth Low Energy deployment so it's likely they will stick to the Bluetooth technology.
- Even if UWB is enabled on Apple devices this year, it doesn't mean it will be available for developers. Apple might decide to limit it to "proximity device" only.
- UWB doesn't go through walls so it's blocked very easily.



How to install

an Indoor Positioning System?

At Pointr, we believe that installing an Indoor Positioning System should be quick and easy.



Bluetooth Beacons are easy to install as they are small and unobtrusive.

Because the batteries tend to last for many years, they are also low maintenance, which can be very useful in venues with high traffic areas. Beacons can also be installed in lighting and WiFi solutions.

Pointr has already installed more than 11,000 beacons in the world in different environments. So, how do we do it?

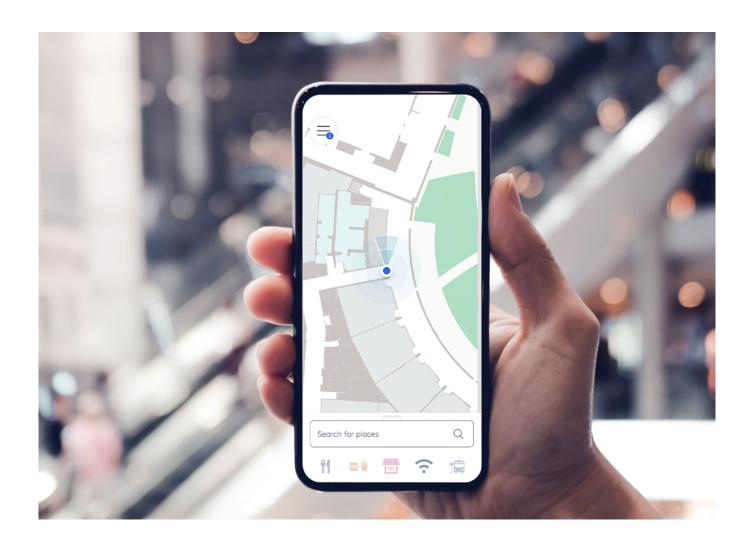
As a first step, we review your floor plans to decide where to install the beacons. We then perform an on-site survey to ensure that the beacons will be at the right place.

We then install the beacons according to the plan. When all the beacons have been installed, we calibrate and test the beacons to ensure excellent positioning accuracy.

The process to deploy Deep Location™

- 1. Identify customer specifications
- On-site survey, solution proposal with floor plans
- 3. Installation of beacons, SDK integration
- Calibration of the positioning, performance testing
- 5. Roll-out
- 6. Training & support

Unlike many other IT infrastructure installations, installing an indoor positioning technology is a swift matter. The entire process, from mounting the first beacon to an up-and-running system can be completed in a few days or a week, depending on the size of the building. As a reference, we can deploy our technology in a venue of about 100,000 sqm in 4 to 8 weeks.



Which Indoor Positioning System is the best?

Not all Indoor Positioning technologies are born equal.



At Pointr, we help you get it right.
We analyse your needs and we decide which technology makes sense for you.



Bluetooth technology

If you're looking to engage customers based on their location or to provide an indoor navigation experience, Bluetooth technology is clearly the best choice. With far greater location accuracy, your visitors will get the best possible in-venue experience.



Wi-fi & Bluetooth analytics

Are you looking solely for location analytics and asset tracking?



Combining WiFi and Bluetooth analytics is your best bet. WiFi access points collect data from customer devices creating invaluable insights for a large portion of visitors.

Bluetooth technology adds an additional level of granularity, allowing you to see how single users interact with your venue and to measure the success of proximity messaging.



Ultra Wideband

UWB can be very accurate, but it is not commonly available today and it will prove very expensive.

The decision should be based on what your organization wants to accomplish. Are you looking for visitor engagement and location analytics in your venue?



Unlock the Power of Location for your Venue.

From mobile navigation to location-based analytics, we bring you **the best performing** indoor location platform available today.



Pointr, the Deep Location™ company.

We are a global technology leader in indoor positioning. We digitise venues, enabling them to create immersive location experiences and to improve their operations. We work with major international customers in aviation, retail, hospitality and smart workplace.

Location-based Services

Provide the finest location experience for your visitors.

- Real-time Indoor Positioning
- Turn-by-turn Navigation
- Search for Points of Interest
- Digital Maps
- Content Management
- Asset Tracking
- Augmenting Reality

Location-based

Analytics

Real-time analytics to help you make data-driven decisions.

- Customer Flow
- Heatmaps
- Crowd Simulation
- Operational Analytics
- Engagement Analytics

Location-based

Marketing

Engage with users based on their real-time location.

- Customer feedback/zonal surveys
- Personalised offers, omnichannel marketing
- Location sharing
- · Loyalty management
- CRM integration

Awards & Press





























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