IPS 101
An introduction to Indoor Positioning Systems
What is Indoor Positioning Systems?

The best way to explain indoor positioning systems is that it's like GPS, but for indoor environments. There are some similarities, and some differences, but to the end-user both mean being able to leverage your location to find people, things and places.

So why doesn't GPS work indoors? Since the weak signals from satellites that GPS rely on are easily blocked by a roof or walls, the system loses its efficacy when indoors. The result is a significant drop in accuracy when the user enters a building. That is where the indoor positioning system (IPS) comes in.
Where IPS is used

Just like GPS there are many use cases where IPS can be leveraged – everywhere from corporate office campuses to shopping malls and airports.

**Smart Offices**

In the modern office, agile work methods are becoming increasingly adopted. Indoor positioning is used to reduce friction and increase productivity by helping employees book and cancel resources, help colleagues find each other more easily, find their way to meeting rooms as well as measure occupancy. Combining location and calendar information, proactive assistance can be given to the employee about things that are about to happen.

**Shopping Malls**

Enable a personalized shopping experience in the visitors’ smartphones. Provide dynamic indoor GPS wayfinding to the stores, right in the smartphone. Analyze the physical flow of shoppers through detailed statistics and heat maps.
Reactive vs Proactive location services

Similar to GPS, indoor positioning systems is a technology platform that in turn can enable a multitude of different services depending on the situation and use case. One way to think about the different types of possible services are reactive and proactive services aided by IPS.

**Reactive services**
The reactive services take origin from the end-user, i.e. the user of the application initiates the service. One example of this could be a shopping mall visitor looking for a specific store or product and gets wayfinding to the destination. Or it could be an employee in an office trying to find his or her way to a specific meeting room.

These types of services usually use the indoor position to provide information like “you are here”, “what you’re looking for is here” and “here’s the shortest route to your destination”.

**Proactive services**
The other category, proactive services, takes a different perspective on the use of location. These services leverage the user position to understand the user’s context, and provide services that are relevant to that context. One example of this could be detecting if an employee walks into an unbooked room in the office. The app would combine the user location with the booking information of the room to understand that “the user just entered a meeting room that is unbooked”. From this context, the application can proactively deliver a service (booking the room on behalf of the user) that is relevant to the context (walking into an unbooked meeting room).
How does it work?

Indoor Positioning Systems use two types of sensors built into the smartphone: Internal Motion Sensors and Radio Signal Sensors.

The Internal Motion Sensors include the accelerometer, which measures acceleration; the gyro, measuring how the device is turning; the altimeter, which measures air pressure; and, the magnetometer, which functions as a compass. When combined, these sensors provide information about the user’s orientation and how the device is moving. Unfortunately, these sensors only provide an understanding of how the position of the phone changes, not about its location.

Radio signal sensors refer to the Wi-Fi and Bluetooth receivers in the phone. They can determine which Bluetooth beacons are within range and can evaluate signal strength. When comparing signals from radio signal sensors to a map of locations in the building where different radio signals should be heard, a rough understanding of the location of the smartphone is given.
Sensor fusion is the technology of combining information from multiple complementary sources to create one estimate of, for example, a position. This joint position estimate provided through sensor fusion is more precise and reliable than an estimate made from information that is treated separately.

Reduced latency through local computations

A potential pitfall of IPS is lag time. With many people in the same general area, in a shopping mall, for instance, data sent to a server to compute the user position must traverse a data connection link, introducing possible time delays in the system. However, when computations are made on the individual user devices, there are no limits to how many people can use the system at the same time, and the issue of potential lag time is eliminated. Performing the computations on the device allows for the positioning to work even if there is no internet connection available. Using clever algorithms, the computational power of a smartphone is more than enough and the positioning system does not slow down the device or drain the battery.
Diverse Radio Environments

When it comes to radio signals for indoor positioning there are different approaches, each with its pros and cons. Both Wi-Fi and Bluetooth can be used for radio measurements, but there are important differences.

**Worldwide Wi-Fi presence**

Today, Wi-Fi is available nearly everywhere. In a shopping mall, for instance, a device might recognize 50 to 100 Wi-Fi access points at the same time. However, iOS-based devices are restricted from accessing these measurements, so Wi-Fi-based Indoor Positioning is not possible on an iPhone or an iPad. For Android, the Wi-Fi measurements are available and can be readily used by the positioning system.

Wi-Fi usage for positioning does have some significant shortcomings. Wi-Fi has been designed with one main purpose: maximizing data throughput. This means various optimizations are being made on the phone and on the access points to maximize data throughput, which affect the radio measurements, thereby affecting the positioning performance. The difference between different phones and different access points is also significant, which is why the quality of a positioning system based on Wi-Fi tends to vary widely depending on phone and Wi-Fi system.

**Beacons provide robustness**

A beacon is a small, battery-powered box that broadcast the signals picked up by the Wi-Fi system. The Bluetooth Low Energy (BLE) technology, also known as Bluetooth 4.0, is power conservative, making it perfect for a chip in each beacon, where it can broadcast a signal for years.

Most smartphones manufactured in the last couple of years are equipped with BLE capacities, making a beacon based positioning system possible. Once the beacons have been mounted in the building, and the system has been calibrated, the system typically can run for years without maintenance. It is simple, effective, low on battery, and robust
over time. In installations requiring many beacons, for instance a hospital with 500 beacons, changing batteries frequently would be time- and labor-intensive. This is why our beacons are equipped with long-lasting batteries enabling 5–8 years of battery life.

Bluetooth Beacons for IPS
A good Bluetooth beacon for indoor positioning should be small and discreet, have a powerful broadcasting signal that is sent at least twice per second, yet have a battery strong enough to make it run for many years.

It's also important to know where each beacon is installed and whether it is still running. A Beacon Management System can easily provide an overview of the entire positioning system as well as individual status of each beacon, including location, battery life and more.

Quick and Easy Installation

Installing an IPS system in a building should be a quick and straightforward procedure. The first requirement is an accurate and up-to-date floor plan. The next step involves mounting the beacons in designated positions and registering each beacon in the Beacon Management System during an installation. When all beacons have been mounted, the calibration begins. The calibration is performed by walking a number of paths while
holding a smartphone. The paths are determined and assigned by an app. The calibration procedure takes as long as it takes to walk throughout all parts of the building.

Unlike many other IT-infrastructure installations, IPS 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, a shopping mall of about 150 000 m² would take two people a week or less to install.

Attracting roughly 40 million annual visitors, Mall of America is continually looking for ways to improve the guest experience. In 2017, the mall rolled out Indoor Positioning to allow its guests to easier find their way around the complex. StepInside allows us to offer step-by-step wayfinding, a more personalized visit that caters to the guest preference, and a way for visitors to more easily connect with our brands and attractions,” says Jill Renslow, SVP Marketing at Mall of America.

With 4 000 employees scattered across several buildings, finding a certain meeting room at Ericsson’s HQ in Stockholm can be a major challenge. To help employees save time and hassle, they decided to integrate StepInside® Indoor Positioning into their Smart Office Platform. “Our initial roll-out focuses on productivity improvements by saving employees time they might waste searching for things, such as conference rooms or places to work.”
Positioning success factors

For an indoor positioning system to be not only technically viable but also valuable for the end-user, a number of criteria need to be fulfilled. From our research and extensive testing, we have identified six major factors that will determine the success of an indoor positioning system.

Checklist: Success Factors

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<th>Accuracy</th>
<th>The position given by the system should be within 1–3 meters of the user’s actual position.</th>
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<td>Background</td>
<td>The positioning system should function continuously in the background to enable push services to the user.</td>
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<td>Responsiveness</td>
<td>The position should move as the user moves, without delay.</td>
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<td>Robustness</td>
<td>The positioning system should work just as well after two years as the day it was installed</td>
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<td>Device Agnostic</td>
<td>The system should work equally well on iOS as on Android smartphones.</td>
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<td>No User Limit</td>
<td>There should be no limit to how many devices can use the system at the same time.</td>
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<td>Battery Drain</td>
<td>The positioning system should not consume excessive energy, which will reduce the user experience.</td>
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Unless these requirements are met, chances are that the IPS will not work well in a real-world situation. A positioning system that cannot accurately read a user’s position, lags ten seconds behind, dies in the background or works on just a few phone models, is unlikely to deliver useful Location-Based Services (LBS).
About Senion

Senion is a global leader in digital workplace solutions for corporate campuses, utilizing indoor positioning solutions to assist employees throughout their work day and to measure occupancy of office spaces.

Senion’s comprehensive services include proactive meeting room management, wayfinding, colleague meet up, and location-based reminders, all utilizing Senion’s world class indoor positioning system. With more than 300 IPS installations globally, Senion has worked closely with corporate campuses, shopping malls, hospitals and more to improve workflows and space utilization.

Learn more about solutions for the smart office at senion.com