

Indoor Positioning System for Retail

Ashok Yalamanchili, Venkatesh Babu

Abstract

An indoor positioning system (IPS) is a network of devices used to wirelessly locate objects or people inside a building. With the proliferation of consumers using smart phones and tablets, enabling indoor positioning systems has become easier now with multiple enabling technologies. Today, retail purchases are happening across multiple channels like online, in-store, and mobile with the customer interaction at various touch points. But when a consumer makes a purchase in-store, i.e. in the retailers' brick and mortar store, the shoppers' behavior is not getting captured by the retailer.

IPS is a key enabler for capturing in-store behavior of shoppers. IGATE has created an omnichannel retail solution, with IPS being one of the key technology enablers. The solution enables retailers to link shoppers' behavior across digital and physical channels and provide shoppers with personalized promotional offers / messages during their entire shopping journey. This paper describes the high level architecture for an IPS based solutions, using retail solution as an example. The challenges and limitations in implementing the entire IPS solution, starting from the hardware installation to mobile app integration, are also detailed.

2. Introduction

2.1 What is IPS?

An indoor positioning system (IPS) is a network of devices used to wirelessly locate people or objects in indoor environments

2.2 Why IPS?

Due to the signal attenuation caused by construction materials, the satellite based GPS signals lose significant power indoors. For this reason the receiver cannot get coverage of atleast 4 satellites which is needed to accurately get the location coordinates.

The current smart mobile phones have a maximum location accuracy of 10 meters, when the location is set by the GPS chip. This level of accuracy cannot effectively be used to display a user's current position on the map and also the indoor environments vary a lot at this location accuracy. So there is a need for a solution to determine the user's position with an accuracy of 1-2 meters for a better user experience.

Also, GPS cannot give data about the floor information of the users' location / building.



This brings up the need for a system where a user / object has to be located inside a building accurately and precisely to make positioning and navigation indoors as easy as outdoors.

2.3 How IPS works ?

For the indoor positioning system to work it needs the help of both software and hardware. Figure 2 below has a list of components needed, which are further described in the following sub-sections.



Fig 2: Components of an IPS solution

2.3.1 Hardware

- Bluetooth beacons or Wi-Fi access points (that cover the entire area of interest without any blind spots) are the essential hardware items required for IPS. iBeacon is a specification by Apple used for communication between beacons and a mobile application over Bluetooth. If the beacons are iBeacon compliant then pushing proximity messages / coupons to mobile devices is also possible.

2.3.2 Software

- A mobile application for the consumer that can display maps and calculate the users' current location using the signal fingerprinting data generated by the measurement tool. The mobile application will also detect the beacons and display relevant proximity messages that are configured for that beacon on the server.
- A web based management center application for the retailer that contains all the information about the retailer's product and its mapping to the beacons. The decisions to be taken for a beacon interaction on the mobile are also defined here.
- A desktop / mobile measurement tool for the retailer to manage store and floor plans and also to measure the Wi-Fi / Bluetooth signals and create fingerprint database for all locations in the store. All of this data is stored on a cloud based server.
- IPS SDK for integrating with the mobile applications

2.4 Technology Enablers for IPS Solution

IPS can be implemented by using a different types of technology enablers, some of which are listed below.

- **Wi-Fi access points**
- **Bluetooth Low Energy (BLE) Beacons**
- Sensors (Accelerometer, Gyro, Compass, etc.)
- Indoor Lights
- Magnetic Field
- Low Orbit Satellites
- Camera Technology

IGATE chose to use Wi-Fi access points and BLE Beacons, since they are more ubiquitous and available readily to experiment with. Some sample BLE beacons images are given below in Figure 3.

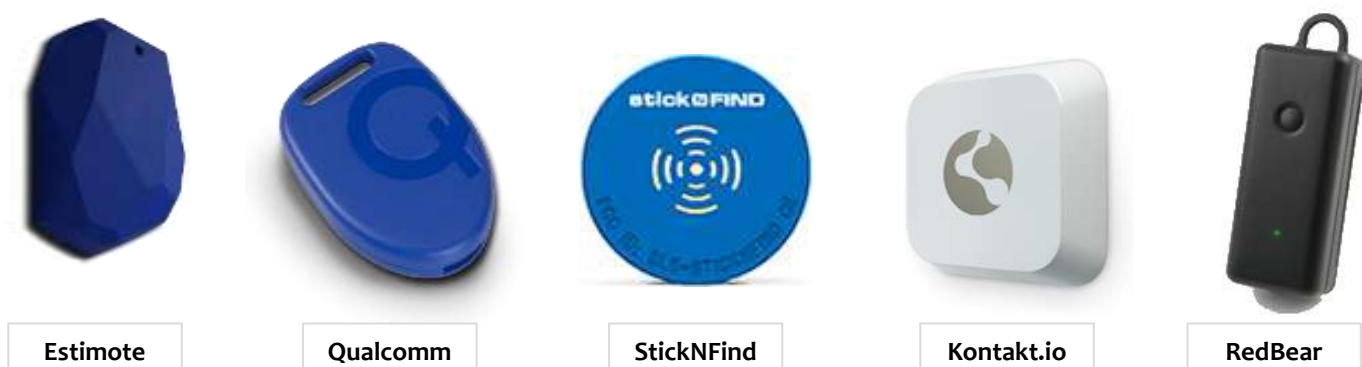


Fig 3: Types of Beacons [Source: Beacon's images are from their respective vendor websites.]

2.5 Usage of IPS

An indicative list of use cases and scenarios where IPS can be used is given below:

- In malls and retail stores, users can find the location of the products they need to purchase indoors. They can also navigate to the location of the products from their current location. Coupons can also be sent to users when they are near a particular store or product category.
- In Events and conferences, users can see the layout of stalls and can navigate to the stall they want to visit. If coupled with context aware intelligence, they can be routed to the sessions in progress. Attendance of persons in a specific seminar / event in the conference venue can also be tracked.
- In Airports users can be routed to their departure gates or places of interest
- Emergency rescue personnel can find the users location even when they are in indoor environments
- Assets can be tracked in warehouses, retail, hospitals etc.

3. IGATE's exploratory activities

IGATE has evaluated many IPS vendors like Indoo.rs, Meridian, Navizon and Aisle411.

Indoo.rs GMBH is an Austria based company involved in providing an accurate real time indoor positioning platform. Their platform includes tools and services for an end to end implementation of an indoor positioning system, such as Measurement Tool, Cloud based backend server, and mobile SDK's for iOS and Android.

IGATE has worked on the technology PoCs for proximity using Estimote's / SticknFind Beacons, positioning and navigation using indoo.rs IPS framework. Once IGATE built the required competencies in IPS, then IPS piece was integrated into a retail solution – Intelligent Retail Omni-Channel Solution (IROCS).

4. IPS in Retail & IGATE's Solution

Businesses today operate in multiple disparate channels with partial or incomplete view of inventory, order and customer transactions, across these channels. This leads to :

- Inconsistent brand experience
- Lower sales conversion
- Higher Channel Inventory
- Inefficient Communications
- Lack of Customer Delight

Web Analytics have helped companies to understand shoppers' behavior in digital channels but this edge is lost when shopper visits the retailers' brick and mortar store.

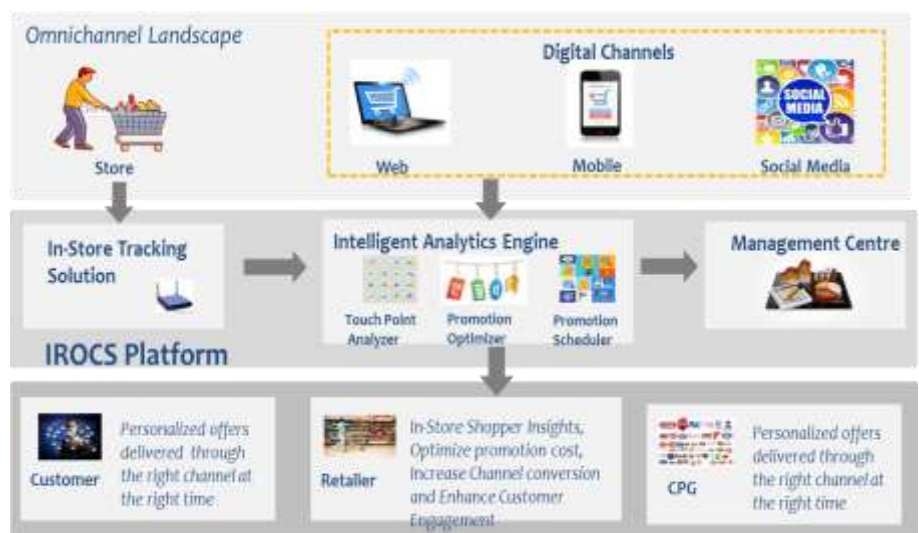


Fig 4: The above depiction is a conceptual view of the IROCS solution

Intelligent Retail Omni-Channel Solution (IROCS) from IGATE is an omni channel solution which will enable retailers to push real time personalised promotions / offers to the customers (using mobile applications). It also identifies the customer behavior across digital and physical stores. The offers, that are pushed to a customer's mobile device, are based on the users' historical shopping habits across different channels like web, mobile, and physical store. In addition to this the solution also gives insights like how the customer has traversed inside the store and dwell times at particular aisles during the entire shopping journey.

3.1 Highlevel Architecture

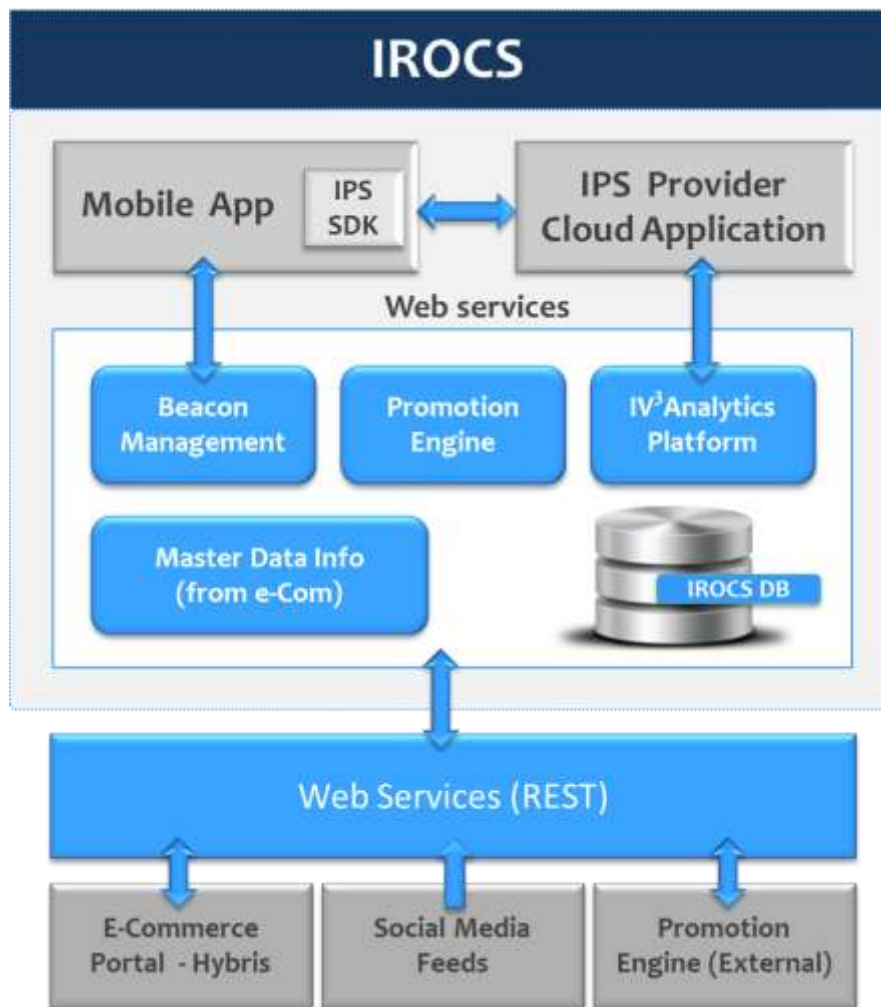


Fig 5: Simplified high level architecture of IROCS

The mobile app provided by the retailer to the end user for enhanced user experience. It has the features to display maps and calculate the users' current location using the signal fingerprinting data generated by the measurement tool. The mobile application will also detect the beacons and display relevant proximity messages that are configured for that beacon on the server. The IPS SDK is integrated into the mobile application which inturn interacts with the IPS provider's cloud application. The product information on the mobile app is synchronized with the e-Commerce portal.

The beacon management module gives the retailer the ability to manage the beacon configuration and its mapping to product / aisle / floor. The minimal required master data from the e-Commerce portal is synchronized seamlessly to the IROCS solution for better performance and response times. The promotion engine enables the retailer to configure and manage promotions for their products.

IV³ is IGATE's proprietary, software-based Big Data Analytics platform. It is designed to work with enterprise class Hadoop distributions providing a layered architecture, end-to-end out-of -the-box

solutions and ready to use components across all functional layers which enables de-risked implementation, Lower TCO and faster time to Market.

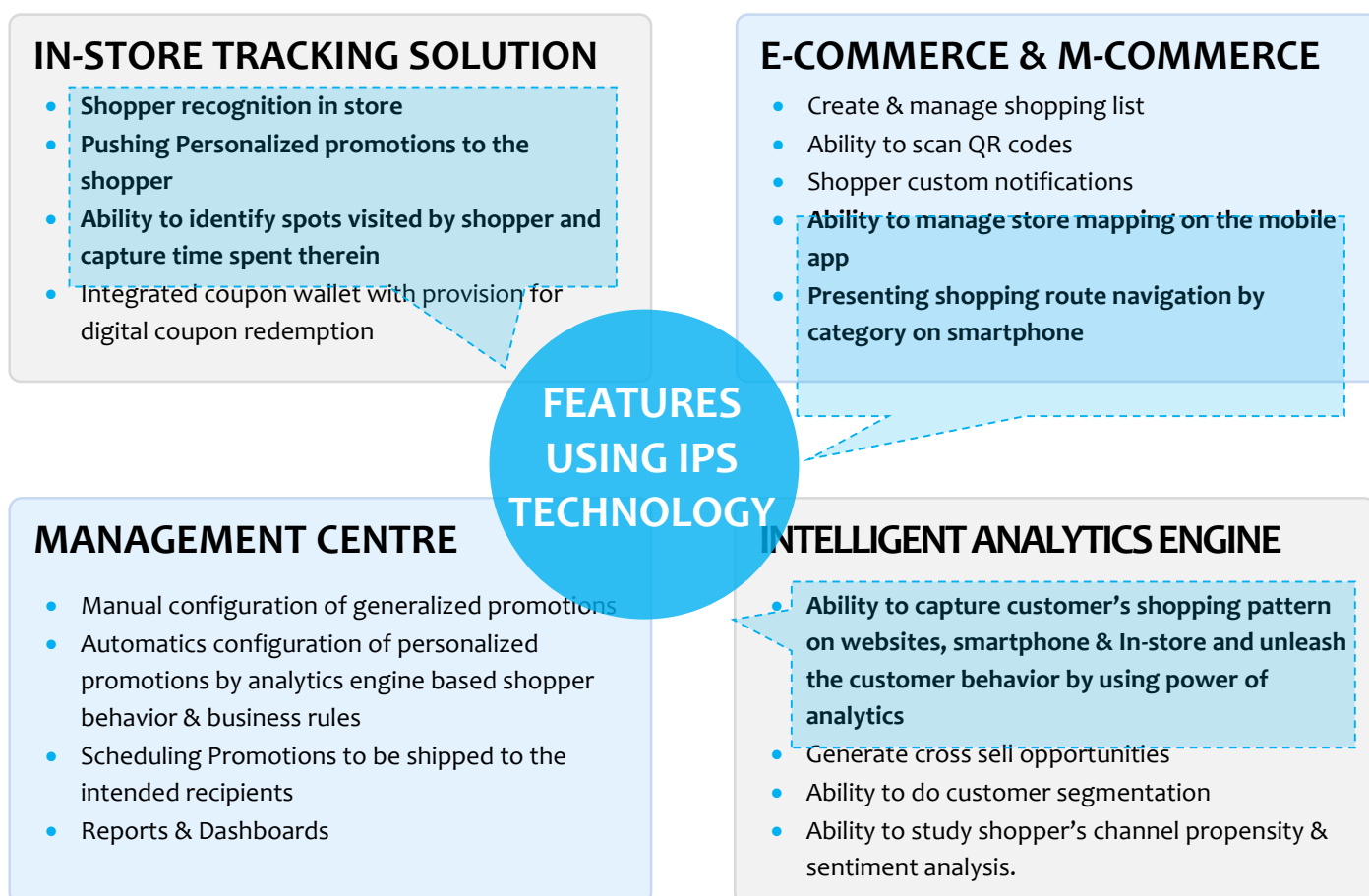
The e-Commerce portal can be any of the standard portals (open source or commercial) where the retailers products are available for online shopping. The social media feeds are from sites like Facebook, Twitter and Pinterest for analytics of customer and shopping behavior.

IROCS uses open standards based integration mechanisms like Webservices to integrate with

- eCommerce portal
- mCommerce - Mobile Application
- Promotion engine of the client
- External vendors like Google Analytics, IPS providers

IROCS strictly adheres to best practices, standards and guidelines w.r.t architecture and design. IROCS follows framework based design & development using the best of open source frameworks & components from Apache, Spring, JBoss etc.,

3.2 Solution highlights



3.3 Implementation highlights

Indoo.rs provided a native iOS SDK that has to be integrated in to mobile app. The SDK provides methods to get the indoor maps that are uploaded to their cloud server. The SDK helps in providing the following features

1. Automatically load the floor map and show the user's current position as a bluedot
2. Update the user's position on the floor map as he/she moves across the store
3. Calculate and draw path for navigation in store
4. Trigger zone-based notifications if the user has entered a predefined zone

Despite these features the Indoo.rs SDK has one shortcoming as it didn't support iBeacon protocol. To overcome this IGATE team had to use Estimote's SDK to trigger proximity based messaging in the app.



Fig1: Proximity (Promotions and Coupons)

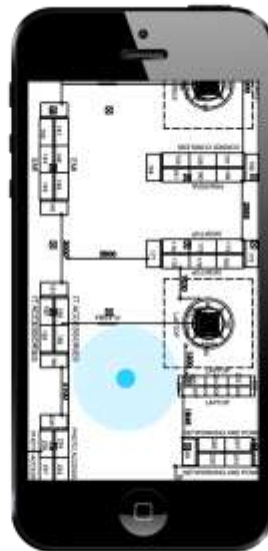


Fig 2: Positioning (Blue dot shows current user location)

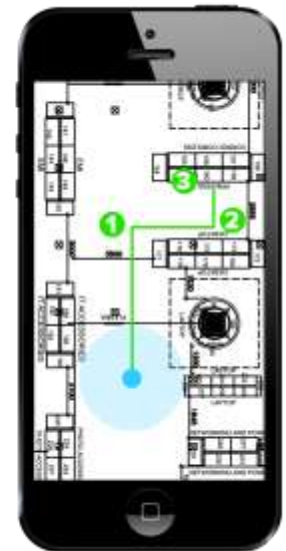


Fig 3: Navigation (Shopping list based navigation showing the sequence for picking up the shopping list items)

3.4 About Estimote SDK integration

The Estimote SDK acts as a wrapper to the native iOS API's to monitor iBeacon Regions using Apple's Core Location API. Using this Estimote SDK IGATE team was able to

1. Monitor iBeacon regions based on their UUID
2. Trigger notifications in the app whenever the device is in the vicinity of an iBeacon. Since the region monitoring is done at an OS level, local notifications can be triggered even when the app is not running either in foreground or background

3.5 Some lessons learnt

During this entire implementation IGATE team has learnt a lot of lessons related to beacon placement, and product to beacon mapping as given below:

1. The beacons have to be placed in such a way that the entire store area is covered

2. The surveying of the floor for signal strength measurements had to be done multiple times to get the optimal indoor location with less latency
3. Displaying the proximity alerts on the mobile depends on the number of iBeacons in the vicinity. For this solution, the closest beacon was taken into account to show the proximity messages
4. If the users are moving too fast inside the store, any latency in showing the proximity messages will defeat the very purpose of sending these messages. So it was ensured that minimal data was download when the application sends a request to the server to get the relevant message configured for the beacon

4. Challenges

There were many challenges encountered by IGATE while implementing an indoor positioning solution for the retail vertical, that are mentioned below

Precision and Latency - The amount of time for which the user can get his current position with maximum accuracy varied a lot from vendor to vendor. A precision of 1-2 mts was obtained for 70% of the time by using BLE beacons and a precision of 5-8 mts for 60% of the time when Wi-Fi access points were used. Typical latency of 5-6 seconds was observed to get the position with good accuracy.

Signal accuracy & stability - The signals emitted from either Wi-Fi AP's / Bluetooth beacons are prone to be absorbed by human bodies, walls, aisles and other structural elements. This creates interference to these signals and it gets more complicated if people are moving which creates more fluctuations ultimately leading to accuracy and stability issues. One of the main challenges for the IPS to work consistently is to minimize the effect of these interferences by filters implemented by IPS providers. It is recommended to survey the site when the floor is empty, half full and full of people, so that the signal strength measurement will get averaged, thereby not impacting accuracy or stability.

Survey and structural changes - Surveying the store for signal fingerprint collection is a challenge as it has to be done after the store operating hours, and also when employees are not re-stocking items. Also any structural changes to the store layout needs a re-survey of the area of interest which increases the effort of the survey.

Beacon maintenance - The beacons can malfunction due to multiple reasons like low battery or hardware failure. In a huge implementation with 500+ beacons, it is a challenge to make sure all the beacons are alive and working in good condition. Constantly monitoring these beacons creates an overhead in terms of manpower and costs. There needs to be an automated system that monitors the beacon's working condition periodically, so that any beacon failure can be preempted or fixed within a short period of time.

Power consumption - Although BLE consumes less power on a mobile device compared to Bluetooth 2.0/3.0, continuously fetching the position will involve significant battery consumption as the location has to be fetched from the server. Beacon vendors specify a battery life of 1-2 years, but during the solution implementation, IGATE found that batteries drained out in less than 6 months. Ideally beacons should have different sources of power for a large implementation to reduce maintenance overheads.

Supporting multiple devices - Another major challenge for these IPS solutions is to have compatibility with multiple platforms, device and operating system versions. As the current mobile market is highly fragmented this becomes a major challenge in selecting the IPS solution.

Access to floor plans - Getting access to floor plans for a store or building is a challenge due to security and privacy concerns of the retailer. Accuracy of floor plans is another concern as the floor plans provided by the retailer are sometimes not to scale or represent wrong information which affects the location accuracy

5. Conclusion

IPS seems very promising which can be leveraged in many scenarios / areas. There are many vendors that are heavily investing in this space. Some of the major players that are having a considerable impact in this space are

- Indoors (<http://indoo.rs/>)
- Navizon (<http://navizon.com/indoors-solutions>)
- Meridian apps (<http://www.meridianapps.com/>)
- Aisle411 (<http://aisle411.com/solutions/publisher-solutions/>)
- Gimbal (<http://www.gimbal.com/>)

Even though there are many vendors in this space, the technology is still at a nascent stage, though it is evolving rapidly, and new technologies, vendors and algorithms will emerge soon. Accurate and easy-to-setup solutions can make IPS realize its full potential in many areas.

Organizations have realized the need to understand the user's devices, contexts and habits as they will impact the indoor location sensing technology selection. Analysts like Gartner and Forrester believe that BLE and Wi-fi are the major technologies which will be used in indoor positioning solutions, while a hybrid solution (Bluetooth and Wi-fi) is a safe bet.

Privacy and the use of personal location information will remain a major concern for both users and regulators.

Beacons have set a trend for basic capabilities for these devices, but there are a few beacon vendors who are providing custom beacons with additional capabilities, which will take the beacons based solutions to new heights altogether.

8. Bibliography

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9. About the Authors

Ashok Yalamanchili is a Technical Lead with more than 7 years of experience in IT industry. At IGATE, he is currently working in the Technology CoE's in Research & Innovation group working on applications of emerging technologies and trends. The technology CoE team works on creating POCs, Solutions, evaluating new technologies and helps in client engagements.

Venkatesh Babu is a Senior Principal Architect working in the Technology CoEs in Research & Innovation group @ IGATE. He has more than 20 years of experience in IT industry and is currently involved in delivering applications of emerging trends & technologies. The technology CoE team works on PoCs, Solutions, and provides thought leadership for evangelization of new trends / technologies for solving business problems of clients.