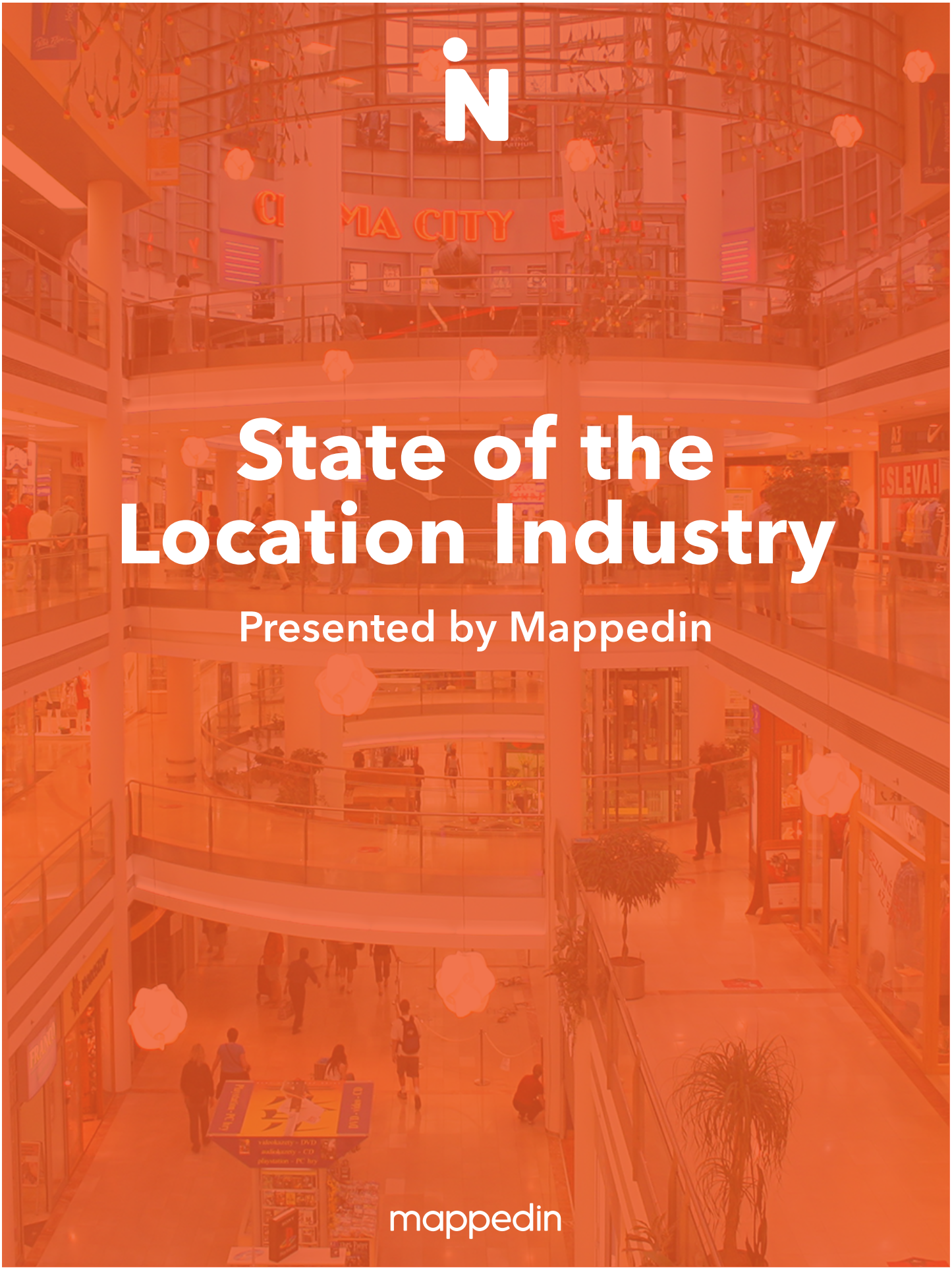

State of the Location Industry

Presented by Mappedin

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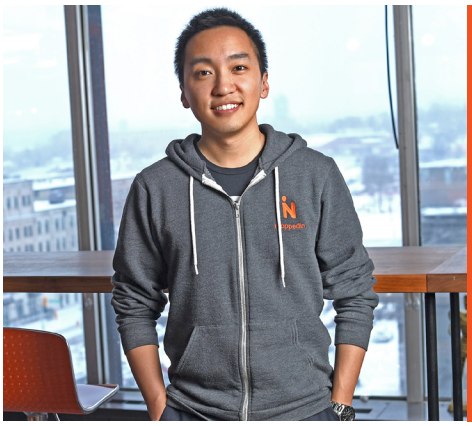

Introduction

Hongwei Liu
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With indoor positioning systems (IPS) constantly evolving, it can be challenging to know which solutions are the best for your business. IPS enabled platforms provide consumer insights like traffic patterns and dwell time, at a scale and accuracy never before achieved. These new insights enable businesses to provide additional consumer benefits such as highly accurate navigation, targeted promotions, predictive search, and more.

While we don't have a stake in nor are we trying to solve for indoor positioning, we do have a unique, front row seat to the rapid evolution of this market. We've written this piece to provide guidance on IPS solutions available and how they each compare. We will dive into the leading IPS technologies, how they work, and evaluate their respective strengths and weaknesses. Ultimately we hope this information helps you determine which IPS solution is best for your business.

Current Market Landscape

It's truly amazing to see the range of solutions being used to navigate indoor locations. Below is a review of the current options and an explanation of how they work and differ:

Inertial Navigation

Many companies, including chipset manufacturers, have used onboard motion sensors built into every cell phone to perform what is called "inertial navigation" - guessing positions using physical motion sensing and last known position.

Point-cloud

Stereo cameras enable users to capture three-dimensional images with the use of two or more images. Google initially used stereo cameras in Project Tango, the platform that allows developers to create experiences that incorporate indoor navigation, 3D mapping, and augmented reality, to calculate positioning by point-cloud geometry. Later, Apple bought the company behind it and recently released a dual front-facing iPhone camera.

Wifi

Existing WiFi access point providers (APs) like Cisco and Aruba have added geo-fencing and proximity capabilities to their enterprise offering. Users on the network running an enabled application can determine their rough location indoors. The more access points, the better the accuracy.

Beacons

Apple and Google released Bluetooth Low Energy (BLE) specifications for iBeacons and Eddystone beacons, respectively. These offer similar proximity capabilities to WiFi APs but at lower unit costs.

Smart Lighting

More novel approaches continue to crop up, such as Philips using smart lighting to transmit location IDs via high-frequency switching, or others using the Earth's EM field as a universal compass.

Sensor Fusion

Sensor fusion is relatively new. It combines inertial navigation and beacons/point-cloud systems. I will cover more on sensor fusion later in this piece.

To see all of these solutions in one place, one can attend the annual conferences of the In-Location Alliance, where all of the above are members (or quiet observers). Each proprietary vendor has abounding reasons why their solution is better.

Determining Best in Show

Rather than get lost in the technical details, it is easier to simply evaluate performance.

Real accuracy (as opposed to theoretical accuracy)
What is the realistic expectation under normal or sub-optimal conditions? For reference, accuracy of assisted GPS is approximately three meters outdoors.

Cost to achieve desired performance
How much will it cost to implement, own and maintain? For example, your implementation and ownership costs may be low, but the system requires a lot of maintenance at an additional cost.

Response time
How long does it take for the system to respond? For example, on-device calculations are faster than server-side ones, because of the latency involved for the signal to travel there and back.

Reliability
How well will the solution function indoors? New systems sometimes get a pass when they start out buggy, but navigation is often mission critical (eg. getting you to your gate at the airport).

	Accuracy	Cost	Response Time	Reliability
Sensor Fusion	Outstanding	Outstanding	Outstanding	Outstanding
Point-Cloud	Outstanding	Outstanding	Good	Good
Intertial Navigation	Satisfactory	Outstanding	Outstanding	Outstanding
Wifi	Satisfactory	Poor	Good	Good
Smart Lighting	Poor	Satisfactory	Satisfactory	Outstanding
Beacons	Good	Satisfactory	Satisfactory	Poor

See Appendix on pgs. 8-10 for measurement justification

And The Winner is...

Combining inertial navigation with beacons/point-cloud, otherwise known as the methodology of sensor fusion, achieves accurate, cost-effective, and reliable positioning.

Sensor Fusion

Combining inertial navigation with beacons/point-cloud, otherwise known as the methodology of sensor fusion, achieves accurate, cost-effective, and reliable positioning.

Inertial navigation on it's own fails on accuracy because of the small errors in measurement, also known as "drift". As it turns out, this issue was already solved for. Miners have relied on inertial navigation for the past 40 years to guide their machinery underground. With enough external references, inertial navigation works perfectly, however, expecting users to scan barcodes as they walk around a mall or airport is unrealistic. Enter beacons, while inaccurate for exact positioning, are effective for geo-fencing.

You may be skeptical. Why have you heard so little about sensor fusion and so much about every other solution we've outlined?

Sensor fusion for indoor location is relatively new, it really only became available in the past 10 years. We're just starting to see real implementations of sensor fusion solutions - early trials always relied more on external geo-fences than internal sensors. Another reason is because smaller sensor fusion companies don't have the same marketing budgets as the big, proprietary infrastructure companies. They have less to gain, too, since their value proposition is to save you infrastructure spend. However, we think you'll be hearing more about them in 2017. Better products win, eventually. Indeed, I've heard from many customers recently that "beacons are dead." Everyone has tried them and are moving on. Some are working with vendors that have good track records and honest solutions. Yet others are being pitched new "silver bullets" that promise to do everything beacons were supposed to do, with none of the drawbacks. I personally remain skeptical of the latter.

Three years from now, stereo imagery positioning using point-cloud models of the indoors could really be the silver bullet everyone is searching for. But three years is a long time in technology, only one day sooner than never.

Making the Right Choice

"While I've concluded that Sensor Fusion is the best option today, I realize that it's important to continue to track the evolution of these technologies. My goal with this piece is to provide you with the information required to make an informed decision on indoor positioning technology. As these technologies evolve and new ones get added, I will continue to offer my viewpoint on how they stack up against one another."

Appendix

Market technology evaluation and measurement justification

	Accuracy	Cost	Response Time	Reliability
Sensor Fusion	Outstanding	Outstanding	Outstanding	Outstanding
Point-Cloud	Outstanding	Outstanding	Good	Good
Intertial Navigation	Satisfactory	Outstanding	Outstanding	Outstanding
Wifi	Satisfactory	Poor	Good	Good
Smart Lighting	Poor	Satisfactory	Satisfactory	Outstanding
Beacons	Good	Satisfactory	Satisfactory	Poor

Onboard Motion Sensors

Accuracy

Inertial motion sensors within phones are very accurate for the first three steps (starting from a known fixed location) and gradually less accurate after that. The challenge is integration "drift," small errors in measurement that compound quickly over time.

Cost

Like point-cloud, this method requires no outside infrastructure. It also doesn't require setup.

Response Time

The calculation is done device-side, using direct inputs from the motion sensor IC.

Reliability

Aside from the known degradation of accuracy over time, there are no complex systems that can break (other than the laws of physics).

Appendix

Stereo Cameras (theorectical projection 3 years out)

Accuracy The initial "fingerprint" can be generated manually. After that, a critical mass of active users is required to contribute back stereo imagery data. Any discrepancies, such as a new poster on the wall, are integrated into the master fingerprint using a method called SLAM. With a reliably accurate fingerprint, point-cloud based positioning is accurate to <1m.

Cost Best of all, no additional infrastructure is required. Initial setup may require a contract from an approved vendor, but ongoing usage needs only your customers' phones.

Response Time The calculation will almost certainly still happen server-side, since the server needs to see all incoming data to perform SLAM updates. Even years in the future, this isn't an easy look-up.

Reliability The edge-case for point-cloud will be in venues less travelled. With fewer users actively using the system and contributing back data, the fingerprint may erode over time and require manual resetting.

WiFi

Accuracy The WiFi specification was designed for data transfer, not positioning. However, one can use the RSSI reading of signal strength from a known access point (AP) to guess position. It sounds straightforward enough until you take into account that electromagnetism isn't linear, or really predictable at all. But with enough APs, it's possible to get ~5m accuracy throughout a facility.

Cost Now for the bad part. To get 5m accuracy, the APs needed are roughly ten times the number otherwise required for just data transfer. APs, especially the enterprise grade ones, are not cheap.

Response Time Calculating position happens AP/server side, which adds some latency. WiFi APs are broadcasting constantly however, so there is no delay in getting a signal on demand.

Reliability WiFi APs are built to be reliable. Enterprise grade ones are wired in, monitored 24/7, and built to operate for years. The only challenge is that when they do go down, others automatically crank up power levels, effectively skewing any positioning system fingerprinted to a certain configuration.

Appendix

Beacons

Accuracy Beacons work roughly the same way as WiFi, physically speaking. Meaning that signal strength isn't always what you expect. However, because beacons are so cheap, you can stick 10x-100x the number of them in a facility, effectively brute-forcing physical limitations of RF-based positioning to get ~5m accuracy.

Cost Battery powered beacons cost around $15-$50 per unit. Wired ones cost roughly ten times that. It would take three hundred beacons to cover approximately 200,000 sqft of space. If one opts for the cheaper, battery-powered setup, they have to factor in replacement costs over the next 12-18 months for every unit.

Response Time Since beacons aren't used for data transfer, they typically do not broadcast all the time. Thus, there is an additional latency in getting the initial signal before server-side calculations.

Reliability Beacons go down. Two year lifespan batteries sometimes die in six months. Their low price point and intended use as a proximity tool (versus positioning tool) means that QA isn't applied as rigorously.

Smart Lighting

Accuracy A user may not always have his camera/phone oriented perfectly, so to compensate the light must be shone broadly. Problematically, light bounces. So a network of lights emitting different signals embedded in its switching frequency or spectrum will heavily overlap. A tough trade-off must be made: have a system that doesn't work unless users hold their phones exactly right or tolerate high amounts of errors.

Cost Similar to beacons, a smart lighting system must be deployed densely throughout a facility. Hundreds of lights per 100,000 sqft at $50-$200/unit.

Response Time Calculating position happens server side. Additionally, the number of overlapping units means that any IDs will take longer to broadcast, receive, and distinguish.

Reliability Being plugged in, one doesn't have to worry about batteries running out. Also, new LED lights are rated to last a decade. If the trade-off mentioned in accuracy is made in favour of less overlap, reliability becomes a major issue (phone orientation).

The guide to what's inside

Mappedin powers search and discovery indoors. The software platform provides industry leading tools for REITs and retailers to manage their dynamic indoor information and build digital wayfinding experiences into their customer-facing applications. Mappedin is currently utilized by industry-leading REITs including Simon and Cadillac Fairview.

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