

Beacon Technology

MARKET, APPLICATIONS,
OPPORTUNITIES AND THREATS
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**LINKED
DATA
ORCHESTRATION**



Executive Summary

This report aims to present an overview of the up and coming domain of proximity tech and more specifically of the beacon technology market, its challenges and opportunities.

Beacons are mini-transmitters of wireless signals that can be picked up by compatible receivers equipped with the proper hardware and protocols and using some API framework on top to manage the signals (Bluetooth LE and iBeacon/Eddystone respectively).

The most notable and widespread application and the one the report is focused on is potential beacons in combination with mobile phones, playing on the scenario where a mobile phone is acting as the observer receiving notifications from beacons.

Key findings of this report are the following:

- *Beacons are already seeing wide adoption, most notably in the retail section, and are heavily touted as one of the next big things by the likes of Gartner and Forrester*
- *Alternative proximity-based technologies at this point seem to be lagging for a number of reasons, so beacons seem to be the option of choice for the immediate future*
- *There are certain issues that need to be addressed in order to unleash the full potential of beacons; some of them are technical (Measurement accuracy, Signal strength, Battery life and Identification) and some are usability-related (Compatibility, Permissions, Nuisance)*
- *While the retail sector is driving adoption, it seems oversubscribed, potentially overhyped and soon to be saturated, leaving little space for small players to enter the field.*
- *In contrast, there are other potential application areas such as a consumer-oriented beacon aggregator and various flavors of indoor navigation applications that seem promising and not currently explored*

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Market: current state and projected growth

Beacons first gained public attention when Apple announced its support for the iBeacon framework in 2013. Even though typically beacons and the iBeacon framework are seen as being synonymous and are used interchangeably, it is important to note that any device that can receive signals over Bluetooth LE is beacon-enabled.

Both iOS and Android devices can work with beacons, though iBeacon can work on both and Eddystone only works on Android. In addition, Apple devices can also function as beacons themselves, a capability exclusive to them at the time of writing.

Though initially overlooked, as support for the framework is increasing, more and more commercial solutions are hitting the market. These range from competing API frameworks to physical beacon transmitters, and fully integrated end-to-end solutions including physical beacons, applications to design campaigns and generate content to push through the beacons and analytics solutions to measure effectiveness.

Application Areas

Retail

Most applications of beacon technology up to date are in the retail section. A recent Business Insider study¹ projected that beacons will directly influence \$4 billion in sales at top retailers in 2015. That number is expected to increase tenfold to about \$44 billion in 2016. Half of all messages sent through beacons are coupons, and so coupon clippers will likely be the key early adopters of beacon-triggered messaging.

Retail shops are among the early adopters and most of the market dynamics is on this area. Many major retailers such as Macy's and Lord & Taylor have already deployed beacons in a majority of their stores after successful pilot programs. It is estimated that by 2016, 85% of major retailers in the US will be using beacons in their stores. For some notable implementations please refer to Appendix I.

Events

Beacons provide event managers an opportunity to engage with attendees and to personalise their conference experience. You can use beacons to streamline the registration process, collect session feedback, help attendees navigate through the venue and much more. For some notable implementations please refer to Appendix I.

Outdoor Venues

Though beacons are often known for their use cases in retail stores and indoor events, they also have the powerful potential to transform large outdoor spaces into interactive, context-aware environments. Beacon technology can bring anything from stadiums to concert venues to public parks to life through interactive content, targeted promotional

¹ <http://www.businessinsider.com/beacons-impact-billions-in-reail-sales-2015-2>

offers, navigation assistance and more. For some notable implementations please refer to Appendix I.

Museums

Museums are continuously seeking to be on the forefront of interactivity and engagement through innovative technology—beacons provide them an opportunity to do exactly that. Through access to supplementary digital content, beacon-enabled self-guided tours and more, museums can successfully educate visitors in more interactive and meaningful ways using beacons. For some notable implementations please refer to Appendix I.

Hotels and Restaurants

The hospitality industry has always been built on responsiveness to specific client needs, whether the time-sensitive requests of a person dining at your restaurant or the preferences of a guest at your hotel. Beacons allow for the flow of targeted, real-time information between hospitality clients and the people and places accommodating them, unlocking ways to mutually improve these experiences.

These innovations may include offering loyalty rewards to frequent guests, enabling automated check-in or offering special deals based off past activity—though the opportunities are endless. For some notable implementations please refer to Appendix I.

Payments

Beacon technology can also be used for mobile payments as it can achieve the same effects with the competing NFC technology used for this purpose. Any Bluetooth LE enabled device could interact with a beacon-enabled device on the side of the merchant to implement a payment protocol. Paypal has already brought to the market a beacon-powered solution for payments called Paypal Beacon. Labwerk has also made available a commercial solution for payments based on beacons utilizing mobile phones².

Transportation

Beacons are already being used in buses for a number of applications, from pushing content to passengers³⁴ to helping visually impaired passengers find their way in the public transport system⁵. The use of beacons in the air transport industry is also on the rise⁶ and options in this area are still being explored⁷⁸.

Banking

² <http://labwerk.com/portfolio/payment/>

³ <http://www.retailintelligencelab.com/blog/2014/12/1/ibeacon-case-offers-in-norwich-buses>

⁴ <http://performancein.com/news/2015/07/01/hundreds-london-buses-be-fitted-ibeacons/>

⁵ <http://www.gizmag.com/ibeacon-smart-public-transport-bucharest/37901/>

⁶ <http://www.airport-technology.com/features/featurewill-ibeacon-technology-transform-the-passenger-experience-at-airports-4454751/>

⁷ <http://www.prnewswire.com/news-releases/martin-outdoor-initiates-pilot-beacon-technology-program-in-the-city-of-los-angeles-279485872.html>

⁸ <http://blog.hedgehoglab.com/2014/09/4-ways-ibeacons-can-improve-public-transport>

A number of banks are reportedly using or planning to use beacon technology in their branches⁹, most notably Barclays and DenizBank that has deployed a beacon project in 200 branches. Projects vary from generic marketing messaging to passers-by to industry-specific uses, such as mobile payments, special services for people with disabilities and queueing management.

Market maturity

Beacons have generated great commercial interest and are considered to be one of the hottest technologies around at this time.

Gartner has included beacons in the Hype Cycle for the Internet of Things for 2015¹⁰ and indicates that they are at the Peak of the Hype cycle. There is also a special Gartner report dedicated to beacons, called "Innovation Insight: Bluetooth Beacons Provide New Value Innovation Inside the Enterprise"¹².

In addition, beacons are part of Gartner's Top 10 Strategic Predictions for 2015 and Beyond, in the Strategic Planning Assumption that by 2020, retail businesses that use targeted messaging in combination with indoor positioning systems will see a 5% increase in sales¹³.

Figure 1. Hype Cycle for Emerging Technologies, 2015

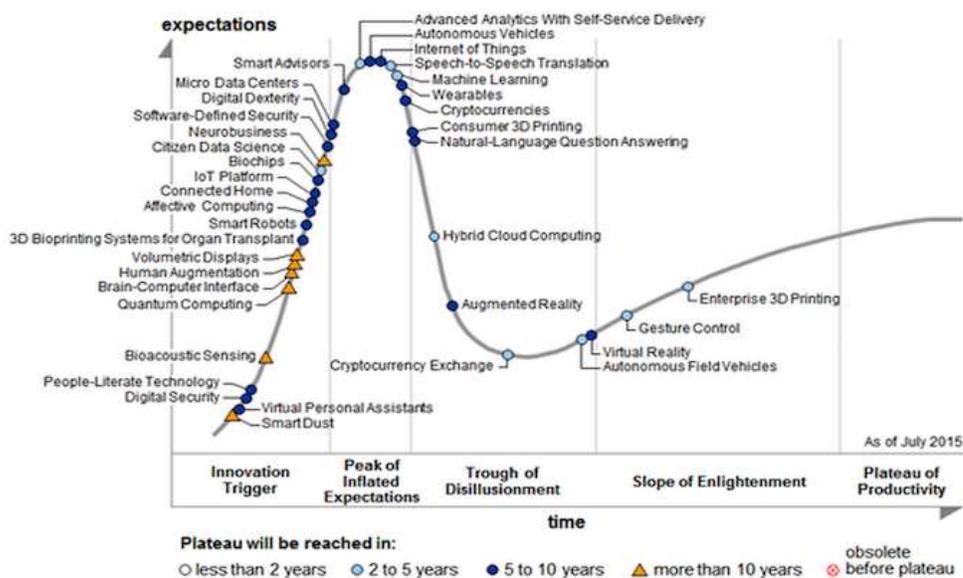


Figure 1: Gartner, 2014: Top 10 Strategic Predictions for 2015 and Beyond: Digital Business Is Driving 'Big Change'

⁹ <http://letstalkpayments.com/7-banks-trialing-beacons-for-in-branch-engagement/>

¹⁰ <https://www.gartner.com/doc/3098434/hype-cycle-internet-things->

¹¹ <http://www.gartner.com/newsroom/id/3114217>

¹² <https://www.gartner.com/doc/3136620/innovation-insight-bluetooth-beacons-provide>

¹³ Gartner, 2014: Top 10 Strategic Predictions for 2015 and Beyond: Digital Business Is Driving 'Big Change'

Forrester also has extensive coverage of beacons, as they have dedicated a number of reports to beacons (4) while they are mentioned favorably in the context of up-and-coming technologies in 5 more reports¹⁴.

A number of articles on beacons have also appeared on venues such as Forbes¹⁵¹⁶ and Business Insider¹⁷¹⁸, indicating that commercial interest is substantial. In addition, Facebook has initiated a beacon-giveaway campaign¹⁹ for retailers as part of its Place Tips feature that was rolled out in New York City in January. Place Tips on Facebook shares users' posts and photos about a retailer while they're in the store. Facebook is now taking the service nationwide and has posted an application for businesses to request a beacon. Twitter has also invested in Swirl, a Boston-based startup specializing in beacon marketing²⁰.

Market size of retail sales influenced through beacons and forecasts

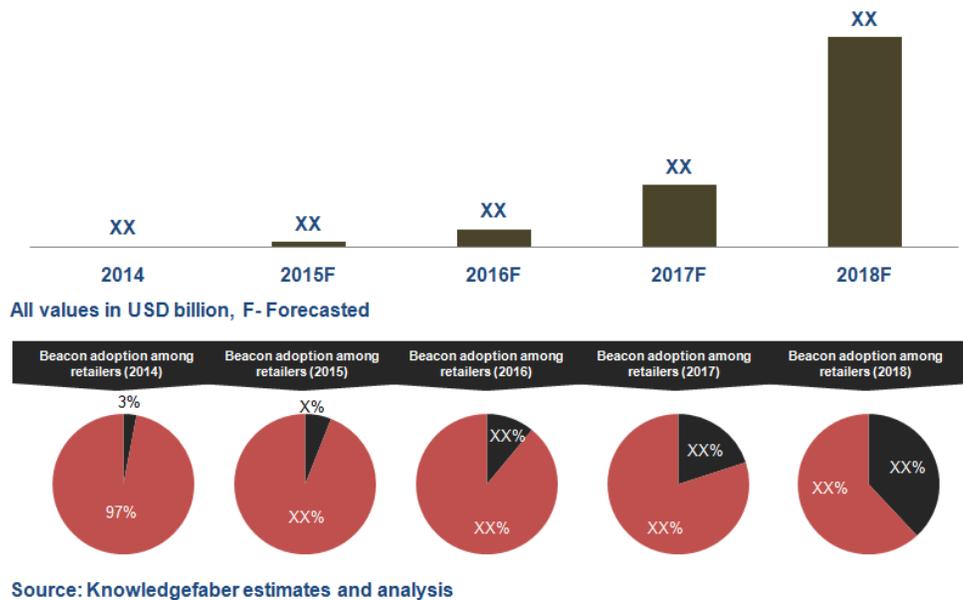


Figure 2: Market size of beacon-influenced retail sales & forecasts. Source: Knowledgefaber

¹⁴ <https://www.forrester.com/search?N=21056+10001&sort=3&everything=true&source=browse>

¹⁵ <http://www.forbes.com/sites/gregpetro/2015/03/06/2015-the-year-of-the-mobile-beacon-part-one/>

¹⁶ <http://www.forbes.com/sites/gregpetro/2015/03/19/apple-got-it-right-in-2013-why-2015-will-be-the-year-of-the-mobile-beacon-part-two/>

¹⁷ <http://www.businessinsider.com/beacons-and-ibeacons-create-a-new-market-2013-12>

¹⁸ <http://www.businessinsider.com/beacons-are-the-most-important-new-retail-tech-2014-7>

¹⁹ <http://www.businessinsider.com/facebook-giving-out-free-beacons-to-compete-against-yelp-and-foursquare-2015-6>

²⁰ <http://recode.net/2015/04/23/twitter-takes-a-look-at-beacons-invests-in-marketing-startup-swirl/>

According to a 2014 ABI Research report, beacon shipments were predicted to hit 60 million per year by 2019²¹. Active Beacons in U.S. are estimated at around 35,000+ in 2014, while about one in five marketers used beacons for marketing. Beacon adoption among retailers and retail sales influenced by beacons is estimated at 3% and USD 1.3 billion plus respectively. Marketing spending through Beacons as a % of U.S. marketing spending was 0.07%²².

Last but not least, there are a number of conferences and events dedicated to beacons and proximity marketing, most notably IoT:Beacons²³, Location & Context World²⁴ and Location Intelligence Summit²⁵, in all of which representatives from key players such as Google, Panasonic and the Madison Square Garden attended and presented.

At the time of writing however, scientific venues dedicated to beacons do not seem to exist - only sporadic publications on various aspects of the underlying Bluetooth LE technology.

Market incumbents

Overall, it seems that the market segment that is by far the more mature one and has attracted the most interest so far is retail. This is where some advanced integrated solutions exist already, such as:

Gimbal

Using a unique combination of geofencing, beacons and analytics, the Gimbal end-to-end platform²⁶ provides a powerful and effective way to engage with mobile app users. It delivers personalized mobile content based on a user's context to drive engagement, boost loyalty and increase sales.

Gimbal provides the most complete and accurate first-party location data for contextual engagement. With powerful controls for customers to safeguard their privacy and easy-to-use APIs for developers, the Gimbal platform bridges the gap between the physical and the digital worlds, creating new possibilities for brands, venues, retailers, advertisers and developers.

Beaconstac

The Beaconstac platform²⁷ is meant to help users deploy beacons, create proximity marketing campaigns and track meaningful analytics with minimal programmatic

²¹ <https://www.abiresearch.com/press/ibeaconble-beacon-shipments-to-break-60-million-by/>

²² <http://letstalkpayments.com/201516-roadmap-beacons-based-proximity-marketing-research-report/>

²³ <http://www.mediapost.com/iot-beacons>

²⁴ <http://locationandcontextevent.com/>

²⁵ <http://www.locationintelligence.net/>

²⁶ www.gimbal.com/platform/

²⁷ <http://www.beaconstac.com/platform>

interference. It provides iBeacon & Eddystone-compatible beacon hardware, an Easy-to-use Beaconstac app to manage a fleet of beacons and experience your proximity-based campaigns and a Proximity marketing and analytics platform to deliver contextual content and gather useful insights on users using a cloud-based CMS.

MiBeacons Platform

The MiBeacons platform²⁸ enables apps to become contextually aware using hyperlocation beacons. By integrating the MiBeacons platform, brands and developers can speed up the development of apps by using a key set of tools, integrated directly into existing or new apps.

The MiBeacons platform consists of SDK's for integration within apps and a CMS that allows management of beacons, content, messaging and analytics. Brands can choose to use standalone beacons that can be easily managed through the platform, or turn existing Bluetooth 4.0 mobile devices into beacons. The platform enables users to dynamically control content and messages within their apps, providing companies with rich location based insight generated through user interaction.

Footmarks iBeacon

Footmarks secure iBeacon solution²⁹ brings digital intelligence to real world surroundings, allowing consumers to connect with the places and brands they love to visit and experience. By placing Footmarks beacons throughout any physical location, Footmarks brings the power of contextual awareness to consumers and businesses alike.

The solution is comprised of Cross Platform SDKs, a Beacon Network Management module to configure and manage a fleet of beacons centrally, Journey & Experiences module to build and integrate experiences and dynamic content with existing content management, and Reporting & BI to gather and assess new contextual data to create new insights and targeting profiles.

As a sidenote, it seems that there is also a Greek startup in stealth mode that is working on indoor consumer behavior analysis called Shop Trace that is part of the Egg incubator³⁰.

²⁸ <http://innovation.mubaloo.com/products-and-services/platform-2/>

²⁹ <http://www.footmarks.com/solutions/>

³⁰ http://www.theegg.gr/en/pages/i_epihirimatikes_omades

Competition: other proximity-based technologies

This section presents other proximity-based and indoor positioning³¹³². Even though each one presents its own merits, they all have drawbacks that make them less suitable than BLE for proximity-based applications at this point. Despite the fact that BLE currently lags in adoption³³, it is already widely supported and adoption is expected to rise as people upgrade to newer phones. One direction worth exploring is the use of hybrid techniques³⁴³⁵.

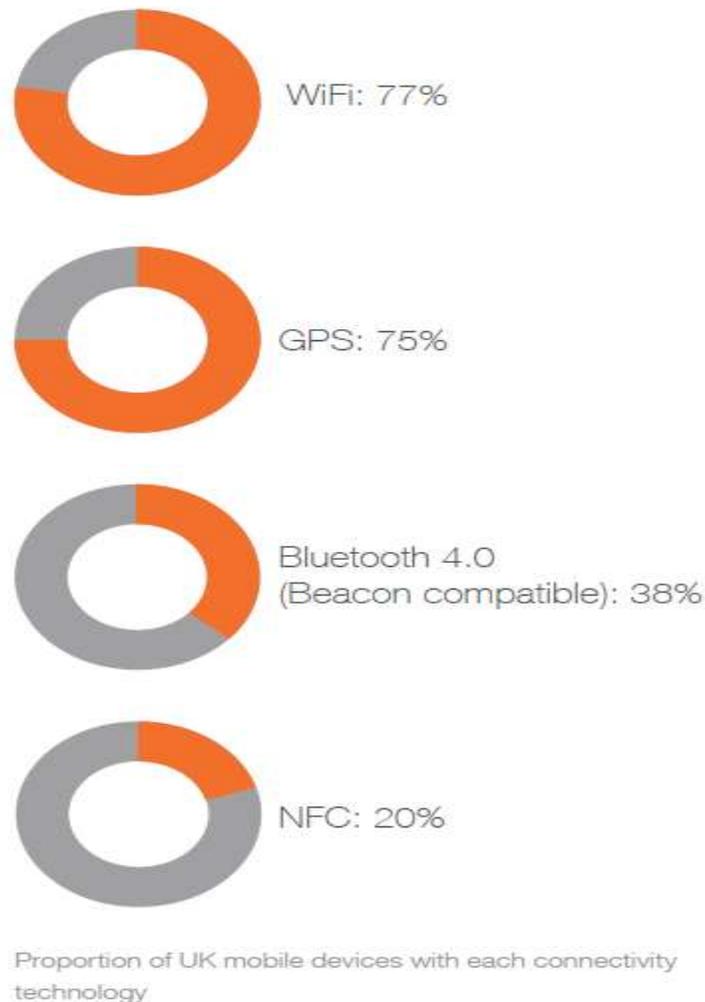


Figure 3: Connectivity technology penetration in the UK. Source: Comscore MobiLens, February 2014

³¹ <http://www.hindawi.com/journals/jcnc/2013/185138/>

³² <http://www.directionsmag.com/entry/10-things-you-need-to-know-about-indoor-positioning/324602>

³³ Comscore MobiLens, February 2014, UK

³⁴ <http://www.purplewifi.net/wifi-or-beacons-for-location-based-services/>

³⁵ <http://www.mdpi.com/2072-666X/6/3/347/pdf>

NFC

NFC (Near Field Communication) is another proximity technology that enables mobile devices to emulate contactless smart cards, read from or write to compliant RFID tags, and to communicate with each other in a peer-to-peer mode. These abilities make it possible for such devices to be used as payment cards, hold electronic tickets, and easily download data from tags and networks without the need for manual interaction such as typing in URLs.

The NFC applications appropriate for the implementation in stationary retail most mentioned in industry publications are mobile payment, loyalty applications, electronic coupons, the download of information from smart posters, and the procurement of product information.

The key difference here is range. NFC only works in very close proximity (around 10 cm), whereas Beacons have a range of around 70 meters. Not every smartphone has NFC chip inserted, whereas every smartphone has Bluetooth - although at the time of writing not all phones support the latest Bluetooth LE standard. In addition, NFC consumes battery, while iBeacons uses Low Energy Bluetooth signal.

NFC and Beacons are significantly different in terms of their range, but their use cases overlap when it comes to finding product information, accessing offers and making payments. Some analysts believe that Apple have decided against building NFC into their products and see Beacons as the superior solution in this area, so NFC could struggle to ever build up critical mass.

So, while NFC is good for contactless payments at a point of sale, it is not as useful as a way to interact with shoppers wandering around a store, and it can definitely not be used to perform tasks such as calculating distance and location³⁶.

Zigbee retail services / telecom services

Zigbee is a set of standards developed and supported by an industrial consortium including heavyweights such as Philips, AT&T and Wincor-Nixdorf³⁷. There are 2 relevant standards for the scenarios under consideration in this report, namely ZigBee Telecom Services³⁸ and ZigBee Retail Services³⁹.

ZigBee Telecom Services aims to offer a global standard for interoperable products to enable a wide variety of value-added services, including information delivery, mobile gaming, location-based services, secure mobile payments, mobile advertising, zone billing, mobile office access control, payments, and peer-to-peer data-sharing services. While ambitious however, the services envisioned by the protocol rely on a ZigBee SIM

³⁶ <http://www.demacmedia.com/merchandising/apple-pay-ibeacon-nfc-ble-debate/>

³⁷ <http://www.zigbee.org/zigbeealliance/our-members/>

³⁸ <http://www.zigbee.org/zigbee-for-developers/applicationstandards/zigbee-telecom-services/>

³⁹ <http://www.zigbee.org/zigbee-for-developers/applicationstandards/zigbee-retail-services/>

card to be implemented, and ZigBee SIM cards are not supported by any known operator at this point, thus rendering the standard irrelevant.

ZigBee Retail Services is a standard designed to help retailers by connecting devices in stores to enhance the shopping experience and help make retailers more efficient. It aims to enhance the shopping experience by enabling faster checkouts, in-store assistance, and in-store item location.

It helps makes the retailer more efficient by reducing stock-outs, support JIT inventory practices, and monitoring temperatures, humidity, spills, etc. It supports a variety of devices including Personal Shopping Assistants, Intelligent Shopping Carts, Electronic Shelf Labels, and Asset Tracking Tags.

ZigBee can also provide data collection for analytics by retailers⁴⁰. For instance, intelligent shopping cart locations can be used to model movement of consumers throughout a store. This data can be used to pinpoint both high and low traffic areas to optimize product offerings or even reduce wait time by forecasting when shoppers will reach check-out lines.

While Zigbee seems to have technical potential, there are 2 main issues with it:

1. At the time of writing there does not seem to be support for it on mobile devices, despite early indications⁴¹.
2. As an umbrella standard it encompasses a wide area of applications, however despite its wide membership and backing its real-world applications seem limited⁴² and its direction questionable.

ANT

ANT is an ultra-low-power, short-range wireless technology designed for sensor networks and similar applications⁴³. The proprietary (but open access) protocol is developed and sold by Canadian company Dynastream Innovations Inc., a subsidiary of GPS personal navigation firm Garmin. So far, its primary application is in the sports and fitness fields to implement personal-area networks for performance and health monitoring. However, it can also be used for other applications.

⁴⁰ <http://retail-site-intelligence.com/>

⁴¹ <https://gigaom.com/2013/07/10/reports-of-zigbee-on-handsets-would-be-a-big-deal-for-the-connected-home-and-zigbee/>

⁴² <https://gigaom.com/2013/08/30/zigbee-wants-to-be-the-bluetooth-of-the-internet-of-things-too-bad-everyone-hates-it/>

⁴³ <https://www.thisisant.com/developer/ant-plus/ant-antplus-defined/>

There is wide support for ANT in mobile devices⁴⁴, and it seems that in most scenarios ANT is used a communications channel from which to get readings from sports and fitness devices to implement personal-area networks for performance and health monitoring. ANT-powered nodes however are capable of acting as slaves or masters within a wireless sensor network concurrently, which means that they can act as transmitters, receivers, or transceivers to route traffic to other nodes.

In addition, every node is capable of determining when to transmit based on the activity of its neighbors. In addition, it seems that using ANT to track location and distance is possible⁴⁵, thus making ANT an alternative that could be explored for this purpose.

Although there are certain technical merits to ANT⁴⁶, the most obvious issue with it is limited industrial support and uptake beyond the sports and fitness domain. For example, there are no known references to its operation and accuracy for tracking location and distance, thus requiring experimentation to determine its suitability.

WiFi

WiFi enabled devices emit regular 'probes' when trying to connect to WiFi. WiFi access points can be placed in a certain way inside a venue, so that the position of a given device in the space can then be calculated, using the strength of the phone's probes and timing to estimate the distance from each access point.

WiFi location can be thought of as an indoor GPS. WiFi based positioning systems can be used where GPS is inadequate for some reason, such as an indoor space, or during signal blockage. Many techniques exist to accomplish this, and these may be classified into four main types: RSSI, fingerprinting, angle of arrival (AoA) and time of flight (ToF) based techniques.

Most positioning systems based on WiFi are available as commercial products or as prototypes based on measurements on the received signal strength (RSS). Google has its own Android positioning system based on Wi-Fi⁴⁷. Microsoft uses Wi-Fi for indoor positioning, as well, and has some research going on regarding the use of signal strength for location determination⁴⁸. Apple recently acquired WifiSLAM⁴⁹ to get into the indoor location game.

However, there are also major drawbacks to WiFi-based positioning⁵⁰. It is a time consuming and labor intensive process, resulting in device battery depletion⁵¹. It is influenced by the

⁴⁴ <http://www.gsmarena.com/glossary.php3?term=ant>

⁴⁵ <https://www.thisisant.com/forum/viewthread/2088>

⁴⁶ <http://electronicdesign.com/mobile/what-s-difference-between-bluetooth-low-energy-and-ant>

⁴⁷ <http://apb.directionsmag.com/entry/android-devices-get-indoor-mapping/217196>

⁴⁸ <http://research.microsoft.com/en-us/projects/radar/>

⁴⁹ <http://www.directionsmag.com/channels/location-based-services/blogs/apple-buys-wifislam-indoor-location-company/318912>

⁵⁰ http://www.hindawi.com/journals/jcnc/2013/floats/185138/floats/185138.tab2_th.jpg

presence of physical objects and signal strength changes in variations due to time and there can be interference with other appliances in the 2.4GHz band. And last but not least, reported accuracy of the method is in the range of 2.0 to 2.5 meters⁵²⁵³, making it unsuitable for a range of applications requiring exact location.

RFID

A number of techniques have been proposed and applied using RFID tags and RFID readers to estimate positioning with rather good results⁵⁴⁵⁵.

The main issue with using RFID for positioning however is that RFID readers do not currently exist in mobile devices. Some add-on dongle solutions can be applied for this purpose⁵⁶, however it is difficult to see casual everyday mobile users buying and applying such devices for the purpose of enabling their devices to read RFID tags.

In theory, NFC-enabled mobile devices could be used to read RFID as well, as NFC supersedes RFID, in practice however it seems that this is not possible⁵⁷⁵⁸. Therefore, the use of RFID for location-aware purposes on mobile phones does not seem feasible at this point.

⁵¹ <http://www.networkworld.com/article/2170751/tech-primers/location-based-wi-fi-services-can-add-immediate-value-to-wi-fi-deployments.html>

⁵² <https://ortus.rtu.lv/science/lv/publications/12372/fulltext>.

⁵³ <http://www.directionsmag.com/entry/apple-buys-wifislam-indoor-location-company/318912>

⁵⁴

http://www.intechopen.com/books/international_journal_of_engineering_business_management/the-study-on-using-passive-rfid-tags-for-indoor-positioning

⁵⁵ http://ceur-ws.org/Vol-1328/GSR2_Bai.pdf

⁵⁶

<http://webcache.googleusercontent.com/search?q=cache:ISqqUccKyV4J:www.rfidjournal.com/articles/view%3F12470/2+&cd=1&hl=en&ct=clnk&gl=gr>

⁵⁷ <https://www.quora.com/Can-NFC-in-mobile-phones-work-like-an-RFID-reader-and-read-RFID-tags-in-an-indoor-environment-How-long-is-its-maximum-range>

⁵⁸ <https://www.quora.com/Can-I-read-long-range-RFID-tags-with-any-NFC-enabled-Android-phone>

Threats: areas that present implementation and/or market risks

There are still certain barriers to overcome in order for beacon technology to unleash its full potential. Some of the barriers are of a technical nature, while others have to do with the way the technology can/should be used to engage users. The most noteworthy of those are listed in this section.

Compatibility

Beacon-compatible phones include all iOS 7 iPhones and any Android phone running Jelly Bean 4.3 or above. At the time of writing, this accounts for nearly 40% of phones in the UK, while WiFi and GPS are on a far higher proportion of phones (77% and 75% respectively). Penetration of Beacon technology is already well ahead of NFC, however, which is built into only 20% of UK phones.

Although only 40% of UK mobile users currently have Beacon-compatible phones, this figure is likely to rise rapidly as people upgrade to newer phones. So Beacon compatibility is unlikely to be a long-term issue, and in the short term, the owners of compatible phones could be targeted as a high value segment.

Permissions

A greater barrier to widespread use comes from the multiple permissions needed to make Beacons work. Let's take the example of a retailer which builds an app to connect with its in-store Beacons. For a consumer to use this app, four layers of user permission are required:

1. Download the app
2. Ensure Bluetooth is switched on
3. Accept a request to use Location Services with the app
4. Accept a request to receive Notifications from the app

Only if all four of these steps are completed will the app start showing Beacon messages when the customer walks into the store. To overcome this, any business contemplating a roll-out of Beacon technology needs to put significant effort into educating consumers about the benefits of opting in to its Beacon-based apps, and making it easy to follow the installation steps⁵⁹.

Nuisance

In a world where we are already bombarded with hundreds of marketing messages a day, how receptive will people be to another intrusive form of push messaging? You could imagine a scenario where, walking down the high street, your phone beeps constantly as countless notifications appear on your screen every minute.

⁵⁹ Orange Digital Perspectives, 2014: Beacons – a digital revolution in the making?

You would quickly succumb to alert fatigue, and the valuable offers would be lost in the clamor for your attention. Tesco has avoided building marketing messages into a trial of Beacons at their Chelmsford store – instead, the Beacons help shoppers find products around the store⁶⁰.

Measurement Accuracy

As demonstrated by empirical experiments⁶¹, the accuracy of beacon-based location tracking degenerates as the distance of the observer device from the beacon increases. For applications triggered by the indication of presence of a customer/user, this may not present a big issue. For more advanced scenarios however where the exact location and/or distance of the user must be known, this could be a show-stopper.

Actual Distance	Mean Measured Distance	DRMS
1.0m	1.0m	+/- 0.1m
2.0m	2.2m	+/- 1.1m
3.0m	3.2m	+/- 0.9m
4.0m	3.3m	+/- 0.9m
5.0m	3.6m	+/- 1.6m
6.0m	6.7m	+/- 2.3m
7.0m	6.0m	+/- 1.7m
8.0m	7.1m	+/- 2.0m

Figure 4: Estimote Beacon accuracy. Source: RepRage / Clinton Freeman

Signal strength

Empirical evidence claims⁶² that beacon signal is heavily affected by the physical arrangement of the space beacons are located in and the presence of objects in the space, most notably walls. It has been reported that when standing within close proximity of a beacon on the other side of a wall, receiving and identifying the signal and distinguishing it from signals from other beacons becomes problematic.

⁶⁰ <https://www.oho.com/blog/top-problems-implementing-ibeacon-marketing-solutions>

⁶¹ <http://reprage.com/post/How-accurate-are-estimote-ibeacons/>

⁶² <https://www.brooklynmuseum.org/community/blogosphere/2015/02/04/the-realities-of-installing-ibeacon-to-scale/>

Battery life

In theory, beacon batteries can last up to 2 years. Since however beacons are a new technology and mass deployments have not been around for long, evidence to support this do not exist at this point. Furthermore, beacons currently available in the market do not seem to offer a way to alert when their batteries reach their end of life period and need replacement, thus leading to situations where either periodic preventive checks have to be conducted or there is the risk of beacons being rendered inoperative without noticing and thus parts of a deployment failing to operate.

Security

Beacons operate by broadcasting a signal with an identifier to smart devices that are programmed to listen for them. As at the time of writing there is no standard for security on beacons, there is nothing stopping a competitor or nefarious character from sniffing your beacon IDs with any generic bluetooth signal app. When that ID is stolen, competitors could potentially try to snatch customers away by sending promotional offers to a customer known in the store.

Moreover, nefarious characters could re-create promotional discount beacons in their own living room if they find out beacon IDs from stores. Enterprises must proceed with caution and find ways to obfuscate beacon IDs when they are in the wild to get ahead of these potential pitfalls⁶³.

Identification

As beacon incarnations are still in their early steps, one of the issues that have been reported has to do with the inability to physically detect which beacon corresponds to which identification. Each beacon is identified by the combination of a UUID, a Major and a Minor⁶⁴. While this information can uniquely identify a physical device, it can only be read by a scanner and does not correspond to visible information (such as a serial number for example) that can be promptly identified on the actual device.

Device sticking problem

Beacons will have a fair amount of sticking substance on its back to stick to walls and table tops, but the real world shop may have different surfaces to stick. Some surfaces do not allow the glue to stay in enough time, so the beacon can be misplaced or lost⁶⁵.

⁶³ <http://www.solstice-mobile.com/blog/retailers-7-pitfalls-to-avoid-with-beacon-technology>

⁶⁴ Beacons technical overview 2015, Mubaloo Innovation Lab

⁶⁵ <http://mindbrowser.com/blog/problems-faced-in-beacon-technology-implementation/>

Opportunities: application areas worth exploring

It is quite clear that the retail section is the one that is driving commercial interest and adoption and most likely revenue at this point. Many major retailers have already deployed beacon-based solutions, others are in the proof-of-concept stage and there are already established solution providers in this area. So while this is an obvious area of application, it is most likely one that will also be heavily subscribed to and in addition one in which the key customers (substantially big retailers) will be hard to approach and to win over.

Beacon aggregator app

Current approaches for leveraging beacons, especially in the case of retailers, rely on the use of a dedicated app on behalf of the user that enables them to receive beacon notifications. As the use of beacon technology is expected to increase in the near future, the amount of messages received via beacons is expected to increase as well as the amount of related apps. This will lead to application and message fragmentation and user fatigue.

One potential way to deal with this would be to develop a beacon message aggregator to be used by consumers as a central management point for beacon messages, enabling them to provide rules and settings as to which messages and under which conditions should be brought to their attention⁶⁶. Monetization of the app needs to be explored.

Museums and cultural exhibitions

Museums and cultural exhibitions is another area of application that is a good fit for beacon technology and has some early success cases to show for, but is not as heavily subscribed to. It also seems that at the time of writing no vertical solutions for this domain exist, therefore making it an area worth exploring.

Banking

A number of ways in which beacons can be utilized for the banking industry have been proposed^{67,68}, and while there are a number of banks utilizing beacon technology, a dedicated solution for the domain does not seem to exist. Proposed applications include Welcome Communication, Customer Recognition, Availability and Wait Times, Personalized Product Offers, Location Specific Offers, Customer Education, Surveying, Branch Analytics, Beacon Enabled ATMs and Post Visit Retargeting.

⁶⁶ <http://quibb.com/links/so-you-ve-installed-an-ibeacon-system-now-comes-the-hard-part-no-one-is-talking-about/view>

⁶⁷ <http://thefinancialbrand.com/38160/ibeacon-bank-branch-mobile-cross-selling/>

⁶⁸ <http://myriadmobile.com/2015/01/8-ways-banks-use-beacons/>

Indoor space navigation

Indoor space navigation also presents a range of potential applications⁶⁹, many of which are largely unexplored at this point:

Navigation aids for people with mobility issues

While early applications exist in this area, there are many scenarios that tracking location via beacons could enable. One could be providing people with vision impairment directions for navigating unknown spaces, a more advanced scenario another one could be integrating beacon navigation in electric wheelchairs, in a concept analogous to GPS navigation for self-driving cars.

Terminal / Station instructions

This is an area of application that is already booming⁷⁰, mostly for US-based airports. The same principles can be applied to other central bus/train terminals, with some potential applications being assisted way finding and “You are here” maps, delivery of mobile FIDS and gate displays onto mobile handsets with alerts, duty free adverts and offers, food and beverage offers, “Virtual Concierge” with shopping and food delivered to the gate or lounges, access to PRM services and tagging baggage to alert passengers when separated from their bags⁷¹.

Real estate tours

The use of beacons to provide additional information to visitors as they walk around a space, similar to what is the key concept behind museum and exhibition space navigation, can also be applied to property tours, either assisting real-estate guides or enabling self-guided walk-ins.

Adventure / Play rooms

The use of beacons strategically scattered around a number of rooms in combination with an interaction scenario can be used to drive either permanent or ad-hoc physically situated single or multi-player games such as adventure room games or even paintball scenarios. An even more ambitious goal would be to develop an integrated game development kit that will be used to devise and deploy beacon-based on-site games.

⁶⁹ <http://www.case-inc.com/blog/beacons-indoor-positioning-in-architecture>

⁷⁰ <http://www.futuretravelexperience.com/2014/10/miami-airport-installs-common-ibeacon-system-stakeholders/>

⁷¹ <http://civil.lockheedmartin.co.uk/transport/insights-%28transport%29/blog/2014/05/ibeacons-how-can-they-enhance-airport-passenger-experience/>

Conclusions

The domain of proximity and location-based technology and its applications is seeing both technical advancement and heavy investment, and beacon technology is a major part of it.

The market is reaching a point of maturity in the U.S., especially in the retail sector, with Europe and the rest of the world following suit. Existing reports point to substantial spending already taking place and forecast ongoing growth.

From a technical point of view beacons are interesting because in contrast to other solutions they can be used for both proximity detection and location estimation, although their signal strength for crowded physical spaces needs to be taken into account and their accuracy needs to be improved for longer distances. Their ecosystem is booming and device support is already substantial and expected to increase in the near future.

In order for beacon-based applications to be successful however, one has to go beyond the obvious and instead of flooding nearby devices with messages aim to provide added value in order to gain consumer consent and attention.

There are still areas of application that are unidentified or underserved, thus making this a domain worth exploring with high potential for return of investment.

Appendix I: Use Cases Reference

Retail

1. Macy's

After beacon trials in New York and San Francisco, Macy's has now deployed 4000 beacons across its various stores in the US. The retail chain took the third-party app route so that anyone with the partner app on their phone will receive the currently available promotions, deals or discounts. Macy's enabled 150,000 associates in 45 states across the country with iPhones or iTouches for increased access to information about customers in-store, allowing them to better meet each customer's needs.

2. Lord & Taylor

Lord & Taylor deployed beacons in seven departments in its Boston store with individualized campaigns. As customers enter the store, they receive a message on their smartphone welcoming them. They are also asked if they would like to opt in to receive further messages. The company has currently deployed 10 beacons per store.

3. American Eagle Outfitter

American Eagle Outfitters also took the third party route with beacons. The company placed beacons at the front entrance and in dressing rooms. When a customer with the partner app enters the store, the beacon senses their smartphone's presence via Bluetooth and notifies them about possible rewards for trying on clothes.

Then the beacon in each fitting room determines if a customer has approached it, and awards points accordingly. More than 10,000 customers took part in this trial. To ensure that only interested customers received offers, the company provided the option to easily disable notifications.

4. Regent Street

Regent Street has become a leader in the use of iBeacon technology with 130 stores installing beacons at their entrances. Shoppers can select the type of information they would like to receive. The technology also allows brands to build a detailed profile of customers who redeem online special offers, respond to mobile advertising and actually enter the physical stores.

5. Tesco

Tesco and Unilever have partnered to carry out their biggest ever trial of beacon technology as part of a campaign promoting new Magnum ice cream flavours throughout London. Customers who download the Mpulse app will receive exclusive coupons for discounts on new Pink and Black Magnums when they pass close to beacons deployed in 270 Tesco Express branches across London.

Events

Beacons provide event managers an opportunity to engage with attendees and to personalise their conference experience. You can use beacons to streamline the registration process, collect session feedback, help attendees navigate through the venue and much more. Here are some examples of events that are using beacons to enhance attendee experience.

1. Cannes Lion Film Festival

In 2014, Cannes Lion Film Festival leveraged beacons to make it easier for attendees to instantly spot, connect with and message influencers around them. The goal of the app was to offer attendees a personalized experience featuring relevant content and meetups with like-minded event-goers. In 2015, the event used beacon-enabled apps to detect attendees and auto-favorite a session when they stayed for at least 15 minutes.

Additionally, the app also added a social discovery element by using LinkedIn to show you if any of your contacts also liked the same session as you did. Moreover, iBeacons were used to offer session recommendations based on user profiles and preferences to offer a more personalized experience.

2. SXSW

At SXSW 2014, beacons were deployed at strategic locations within the venue to enable their attendees to gain easy and quick access inside. To enable this, the event organizers pushed Registration Quick Codes via notifications to the mobile phones of their attendees when they were in the vicinity of the SXSW registration area.

In 2015, the event went a step ahead and deployed 1000+ beacons to allow attendees to network better. Beacons allowed audience members to know who else was attending a session and to get involved in conversations with other participants through the mobile app.

3. Consumer Electronics Show (CES) 2014

One of the best examples of gamifying events is the iBeacon-powered Scavenger Hunt at CES 2014. Users were directed to the instructions page after downloading the CES 2014 mobile app on their phone. The hunt encouraged them to explore the most important exhibits at the show, while collecting badges from each beacon that they encountered. Rewards were given to the first three users who collected the entire list of badges shown on the screen.

4. Chicago Auto Show 2015

This year's Chicago Auto Show used beacon technology to engage attendees and to provide show organizers and exhibitors detailed tracking information about showgoers. Beacons were installed on the show floor and interacted both passively and actively with the app to provide an interactive consumer experience.

For one, attendees received push notifications designed to keep them informed about breaking events and appearances. They were also greeted with personalized messages as they approached new concept cars or vehicles eligible for best of show and offered discounts and rewards as they crossed into new zones.

Outdoor Events

Though beacons are often known for their use cases in retail stores and indoor events, they also have the powerful potential to transform large outdoor spaces into interactive, context-aware environments. Beacon technology can bring anything from stadiums to concert venues to public parks to life through interactive content, targeted promotional offers, navigation assistance and more.

1. NFL

NFL recently leveraged beacons to make a big push into geo-targeted mobile advertisements at the Super Bowl, one of America's most watched sports event every year. They initially installed beacons at the MetLife Stadium and New York's Times Square where the game was being played and used the NFL's mobile app to send notifications and personalized ads to reach out to potential shoppers during the big game. The location-based notifications sent by these beacons contained messages directing users to merchandise, NFL exhibits, and shorter concessions lines.

2. Major League Baseball

MLB recently worked with Apple to integrate the iBeacon indoor mapping technology in iOS 7 to customize its 'At the Ballpark' app in order to provide app users with an interactive game-watching experience at the stadium. MLB installed iBeacons at 20 ballparks around the U.S. to offer spectators using iOS relevant contextual information during the 2014 MLB season.

For example, when a user loads the app on his or her way to the stadium, it immediately identifies the stadium he is heading towards and begins sending stadium-specific information. Once he is near the entrance, it displays the barcode of his ticket and directs him to his seat via a map while highlighting the nearby points of interest. If he had purchased his tickets online using Apple Passbook, the app can even pull them up automatically.

3. Wimbledon

Wimbledon organizers have begun beacon trials at nearby metro stations to communicate important information to attendees of the tennis mega-event. People with the Wimbledon app on their device who walk by these beacons will receive match times and schedules as well as directions to the stadium based on whether they have a ticket or not.

4. Bonnaroo Music Festival

Bonnaroo, an annual four day music festival held in Tennessee that draws up to 80,000 attendees every year, recently deployed 100 beacons at the campgrounds and entryways of the event. However, the manner in which they used iBeacon technology is a great lesson to many brands out there.

Instead of pushing offers or deals, they used beacons to create an enhanced interactive experience for their visitors with non-intrusive proximity-based messaging. In 2014, the Bonnaroo music festival saw attendees spend 102 minutes interacting with content via beacons.

5. Los Angeles Zoo and Botanical Gardens

Drawing 1.6 million visitors each year, the LA zoo recently deployed beacons to revolutionize the way visitors interact and learn about animals in their natural habitat. They leverage their mobile app called 'Rainforest of the Americas' to unlock interactive content in a diverse range of formats, including detailed animal and habitat information, informational audio, and high-resolution images as the visitors move throughout the zoo. Moreover, the app also allows visitors to take the content home with them, creating a strong customer relationship with the Zoo that extends beyond their visit to the park.

Musems

Museums are continuously seeking to be on the forefront of interactivity and engagement through innovative technology—beacons provide them an opportunity to do exactly that. Through access to supplementary digital content, beacon-enabled self-guided tours and more, museums can successfully educate visitors in more interactive and meaningful ways using beacons.

1. National Slate Museum, Wales

Wales' National Slate Museum in Snowdonia was one of the first museums in the world to install beacons that enable visitors to discover more about collections as they walk around a site. The museum is attempting to incorporate bilingual and multilingual materials for a more inclusive learning experience. Content is brought dynamically into the hands of visitors to the museum, with media-rich material appearing on their mobile device as they walk around.

2. Brooklyn Museum

The Brooklyn Museum has adopted a more people-centric approach to using beacons. Museum administration realized that visitors often have questions about displays that go unanswered, unable to find nearby museum staff. Thus, using data from their beacon pilot, the Brooklyn Museum has been able to recognize visitor hotspots and strategically place relevant art experts where they are needed most.

The museum's ultimate goal was to help visitors learn more about the art on display, but it realized it also had no way of knowing what visitors wanted to learn about. Their iBeacon-powered app now enables experts to answer visitors' questions via mobile devices. Users can use the 'Ask' component to ask questions and receive answers in real time from an on-site expert.

3. Groninger Museum, Groningen

The Groninger Museum is the first museum in the Netherlands where beacons have been implemented. The technology has been available at the exhibition “The Collection”, from March 29, 2014 onwards. It is used to send interactive content on artworks to visitors using the museum app. Visitors who do not have a compatible smartphone or tablet can rent these at the museum, so that they too will have access to interactive media. This beacon project has shown that of interactive media can excite, amaze and inspire a unique museum experience—especially when museums make that media available to everyone, regardless of their mobile device.

4. Cleveland Museum of Art

Cleveland Museum of Art chose to use beacons to deliver more information about its art pieces to customers’ mobile devices via the museum’s ArtLens mobile app. The museum has installed 230 access points for beacons to serve additional media such as video, still images and texts to visitors based on where they are standing in the museum. If visitors would like more information about a specific exhibit, they can also scan its ArtLens icon with the app to receive extra content.

5. Philips Museum

Philips Museum in the Netherlands is a great example of the successful gamification of a museum experience using beacons. Visitors to the museum are invited to play an interactive game called “Mission Eureka” on iPads as they walk around the exhibits. Teams are presented with educational challenges in various locations around the museum that they have to solve, such as discovering how LED lights or X-rays work. For an added social dimension, the game allows members to compete against one another, making “Mission Eureka” a fun, competitive learning experience.

Hotels and Restaurants

1. Marriott International

Marriott International recently deployed beacons around the lobbies and other areas within their hotels to push geo-targeted in-hotel discounts and offers from nearby retailers to their loyalty club members. The company revamped its loyalty program by adding two new features – LocalPerks and FlashPerks—that were built on a program that linked loyalty points to social media activity on Facebook, Instagram etc.

Among them, LocalPerks allowed customers to reap the benefits of offers that were available in local neighborhoods around that specific hotel. FlashPerks, on the other hand, allowed them to use reward points as virtual currency redeemable on offers such as a discounted stay at the JW Marriott Marquis Dubai or a test drive of luxury cars such as Porsche and Lamborghini.

2. Starwood Group

Starwood Hotels & Resorts is implementing a new pilot program that will see two key hotel locations in Manhattan and Silicon Valley allowing guests to enter their rooms with their smartphones. After installing the Starwood Preferred Guest (SGP) App, guests will receive a

virtual key on their iPhone, which can then be used to unlock a door with a tap using Bluetooth 4.0. The Bluetooth Low Energy specification, first introduced with the iPhone 4s, has been used in a similar way for many home locking products like the Lockitron and the August Smart Lock, but this is the first time it's being used on a larger scale.

3. The James

The James Hotels, with locations in New York, Chicago, and Miami, has just released a new app, the James Pocket Assistant, featuring iBeacon integration. The app uses beacons to give hotel guests a concierge-like experience, providing locationbased suggestions for dinner, shopping, and activities.

The app also offers basic features such as the ability to check-in, check-out, extend one's stay, view the hotel map, order room service, book a spa appointment and, of course, use one-button communication with the front desk. The app can also give guests a 'self-guided art tour' through the hotel's art collection and send users offers and perks based on their location.

4. The Mook Group

Mook, a German restaurant group, recently integrated iBeacon technology with their existing mobile app to reward their customers for spending time at the restaurant. Beacons were deployed at various parts of restaurant to keep track of the amount of time customers generally spend at the group's establishments.

The app is programmed to use this information to assign ratings such as 'addicted connoisseur' and 'guest', rewarding customers with higher ratings with offers such as a free drink or a quick table allotment on their arrival. Future plans: They are planning to learn what people eat and drink, when peak restaurant hours are, and how often a customer comes into the establishment. Key strategy: Add value and excitement to each visit, rather than simply offering a discount.

5. Eggcellent

Tokyo-based Eggcellent recently started allowing customers to order food and make mobile payments via iBeacon technology. To implement this, they placed these bluetooth-enabled devices on each table at the restaurant. As soon as a customer places his mobile device close to the beacon, the menu app opens up. It even allows customers to view dishes liked by their friends, since it links the app to social networking sites that the customer frequently visits. Once done, the restaurant has a cashless checkout facility by paying through the app.

6. McDonald's

There are 26 McDonald's franchises in Columbus, Georgia that are integrating iBeacon technology with a custom mobile app to give customers an improved dining experience. In the trial, beacons were used for sending special deals for McChicken Sandwiches and Chicken McNuggets. This pushed McChicken Sandwich sales up 8 percent and Chicken McNuggets up 7.5 percent.