Hewlett Packard Enterprise

Business white paper

Accurate indoor positioning with HPE Location Analytics

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Contextualization is the name of the game. It enables you to better service your visitors, giving them a more improved experience, which can generate additional revenue. Indoor location is a technology that enables facility owners, like you, to track visitors and relate to them—based on who and where they are.

Indoor location technologies

Indoor location determines an object's location within a given space, such as an enterprise, warehouse, hospital, or shopping mall. Generally, information is provided in real time with more or less accuracy. In some cases, it provides a range, such as 10 meters of a given point or within a room, or coordinates such as X and Y, or X, Y, and Z. Location information can be stored centrally and tracking, direction, or navigation can be provided.

Many technologies exist for indoor locations:

- **Radio-frequency identification (RFID)** scanners are deployed in buildings to scan RFID tags attached to objects.
- **Infrared (IR)** objects embed an IR emitter with a unique code that can be intercepted by an IR receiver deployed in a building.
- **Sensors and radio frequency (RF)** beacons embed a battery-powered RF emitter that emits a signal continually, with a unique identifier that is received by RF receivers deployed in a building. Time Difference of Arrival (TDOA) measures the time the signal takes between the emitter and receptor, and triangulation can be used to provide location information.
- **Ultra Wideband (UWB)** objects embed UWB emitters, and the signal is captured by UWB receptors, which are less subject to interference with RF or multipath. The location is generally measured using TDOA between multiple signal receivers.
- **GPS objects** with an embedded GPS receiver—most smartphones have this now—get signals from at least three GPS satellites, and measure the signal propagation to determine the object's position. The standard accuracy is 15 meters; it can be augmented with GPS to be accurate within a few meters. A GPS is quite expensive and often requires additional ground servers to be deployed. The signal is also significantly impaired indoors by walls or tall buildings and city surroundings.
- **Wi-Fi 802.11** is commonly available in smartphones and deployed in many buildings, which makes it a natural for location-based services.

Wi-Fi indoor location

Wi-Fi location is becoming more common, given that more indoor buildings offer it; and it's now available on many devices, especially smartphones. Wi-Fi location can use different techniques such as:

- **Trilateration**—This method requires knowing the distance between the mobile and each access point.
- **Triangulation**—The mobile must be aware of the distance between the two access points and the angles ∂ and ƒ3 as shown in Figure 1.
- **Multilateration**—This requires time information rather than distance. TDOA is used to determine position. If the mobile reaches four access points that are synchronized, when the mobile broadcasts a frame, every access point receiving the frame stores information at the local time of reception. It then calculates the difference between this time tag and the one provided by a set of reference access points (See example B on Figure 1). This helps calculate a mobile's location.
- **Fingerprinting**—This is based on pattern recognition. The first step is offline and generally before service activation, collecting some metrics and storing it in a database. The second step is online, when a mobile wants to know its position; metrics are also collected and compared with the database.

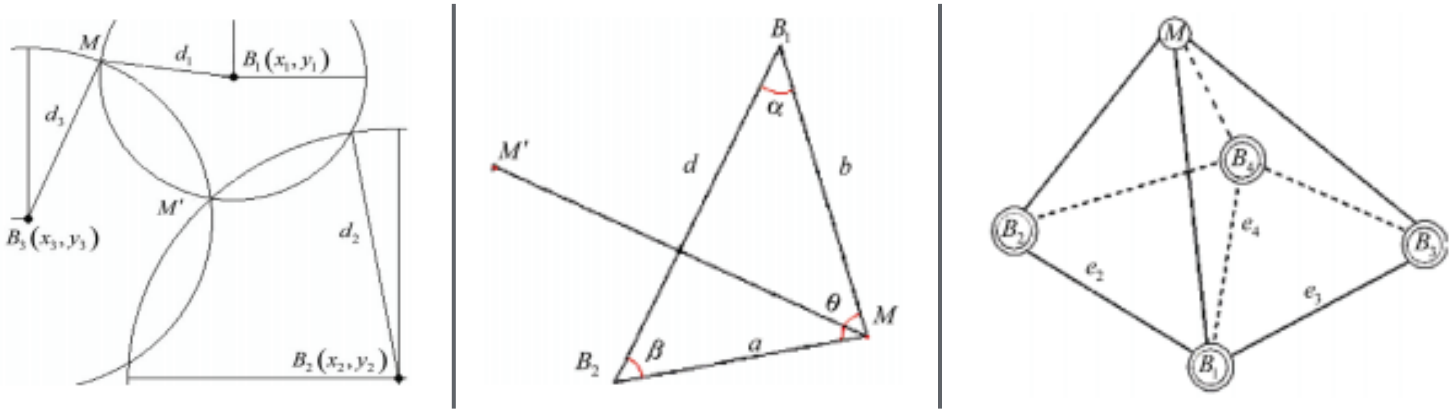


Figure 1: Wi-Fi location methods

Indoor location technology

Wi-Fi-based indoor positioning is getting much more popular, and considered cheap compared to other techniques. But, it has suffered from accuracy due to multipath and environmental variations. Existing Wi-Fi-based approaches typically rely on distance or angles as the major metric for indoor localization. It's possible to estimate distance using signal strength, but received signal strength indicator (RSSI) performs poorly indoors, primarily because of dynamic environmental effects that lead to multipath reflections and shadowing.

Table 1: Comparing different techniques and their feasibility, cost, and typical accuracy

	FEASIBILITY	COST	ACCURACY	CONCLUSION
Trilateration	It's sometimes difficult to establish the distance with all access points.	Cost is based on computing all those distances.	10 meters	This is not used very often.
Triangulation	The mobile may not be aware of the distance between the access points.	Location server is needed to compute the location or provide the distance between the access point and a mobile application.	Not very good if used alone; with multiple access points and some other methods, accuracy can be improved to greater than 10 meters.	A location server knows the distance between the access points. Triangulation can be combined with other methods.
Multilateration	The mobile needs to reach more than one access point.	Location server is needed to compute the time differences and location.	Not very good if used alone; can be combined with other methods for better accuracy of greater than 10 meters.	This is too dependent on multiple access points, and accuracy is not very good.
Fingerprinting	This needs initial set-up and database information consolidation.	It costs a lot to store the data.	Accuracy depends on data collected; variable greater than 10 meters.	It requires too much set-up work and data collection.

Existing angle-of-arrival (AoA) estimation algorithms also have similar shortcomings. A customer's distance can be estimated if it's possible to obtain the distance traversed by the direct path. For example, the signal component traverses along the straight line joining the visitor to the Access Point (AP). However, the key challenge—that has remained unsolved for several years—is it's difficult to discriminate between multipath reflections and the direct path, especially under random environmental variations and fluctuations.

Hewlett Packard Enterprise (HPE) offers indoor location technology—HPE Location Aware Services—that leverages HPE Labs patented technology CUPID 3. Called HPE Location Aware Service, it uses Wi-Fi access points, but introduces an innovative method to calculate the mobile device location.

HPE Location Aware Services uses intelligent algorithms to filter out the effect of random environmental fluctuations that affect the accuracy of Wi-Fi-based indoor positioning. It ignores multipath reflections and estimates a customer's distance from the AP, based only on the direct path. By identifying and relying on only the direct path, it significantly improves accuracy and robustness.

HPE Location Aware Services also automatically learns any environmental variations on the direct path to compute its distance accurately. Thereafter, it computes the customer's location based on distance estimates from three or more APs.

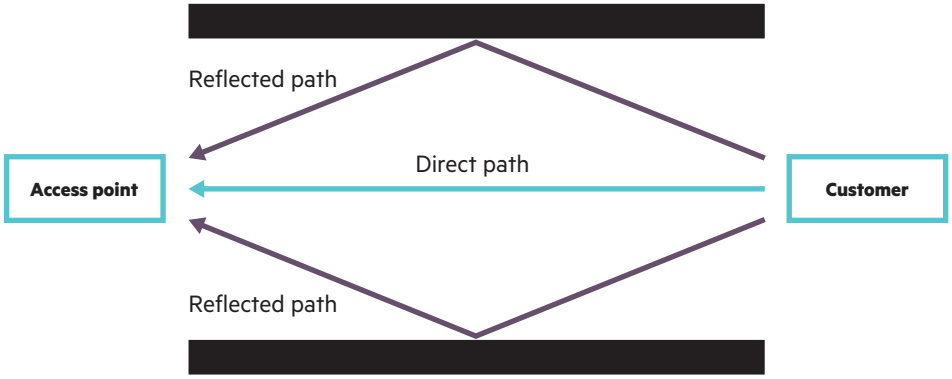


Figure 2: HPE Location Aware Services identifies direct path to estimate

HPE Location Aware Services offers increased Wi-Fi location accuracy—down to two square meters—and requires fewer APs, significantly reducing capital expenditures (CAPEX).

Existing Wi-Fi positioning systems are error prone and lack accuracy—approximately 10 meter accuracy. They also require extensive site surveys.

Compared to traditional Wi-Fi positioning solutions, the Location Aware Services offers these benefits:

- Five times accuracy improvement—less than two-meter accuracy
- No manual calibration required
- No periodic fingerprinting required
- Less density of APs required

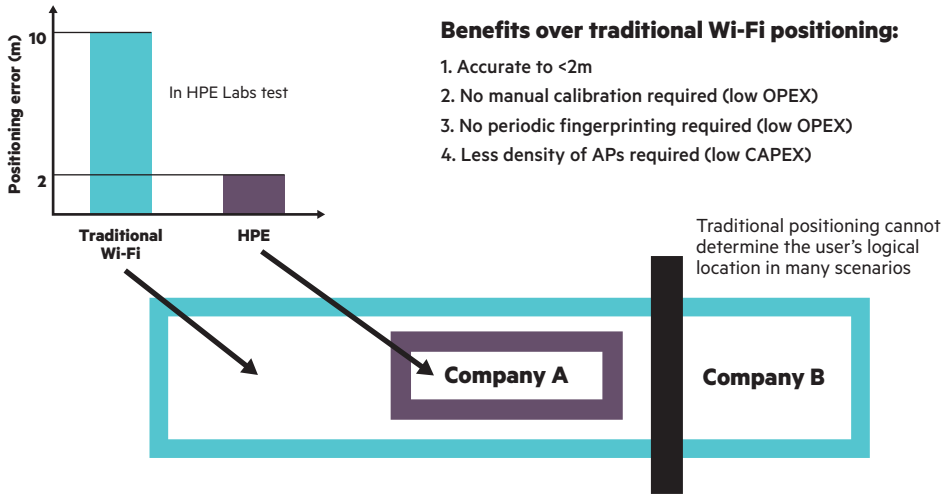


Figure 3: HPE location services vs. current Wi-Fi positioning solution

Regarding energy consumption, HPE Location Aware Services is designed with energy efficiency in mind. Contrary to existing Wi-Fi location schemes that require power-hungry channel scanning—such as fingerprinting or active AP probings (AoA), HPE Location Aware Services can find the customer's location using only a few APs available on the same channel.

When HPE Location Aware Services are compared with other indoor location techniques and their applicability for mobile phones, Table 2 shows that HPE Location Aware Services has many advantages. It supports any mobile phone, provides better accuracy, is by design low energy, does not suffer from interferences, and is available at a reasonable cost. And, unlike some RF sensor and beacon systems, like Apple® iBeacon®, it does not require deploying a specific infrastructure and supports any mobile phone provider.

Table 2: Comparison with other indoor location technologies

	SMARTPHONE SUPPORT	RECEIVERS	ACCURACY	INTERFERENCE	ENERGY	COST
RFID	–	–	+	+	++	–
Infrared	–	–	+	+	+	–
RF sensor & beacons	–	–	+	–	–	–
Ultra wideband	–	–	+	+	–	–
GPS	+	+	–	+	–	+ (AGPS)
Wi-Fi	+	+	–	+	–	+
HPE Location Aware Services	+	+	++	++	++	++

Comparison with Apple iBeacon

Apple iBeacon is an RF sensor/beacon model using Bluetooth® 4.0, which is quite popular. Comparing HPE Location Aware Services with Apple iBeacon shows the following:

- Positioning vs. proximity—Beaconing technology does not provide position as in X and Y coordinates. It only provides proximity as to which beacon you are near. The proximity data is also crude—unlike HPE CUPID, which gives you distance; beacon technologies only report high, medium, and low proximity.
- Accuracy—In general, beaconing technology has poorer accuracy than any Wi-Fi-based positioning system because it does not employ multilateration, which uses multiple Wi-Fi APs intelligently to reduce positioning errors.
- Applicability and cost—Although beacons individually are cheap; to cover an entire facility, a large number of them must be deployed and managed. This may add to operating expenses.

Under the hood—functional architecture

With HPE Location Analytics, facility owners—like you—can get a functional architecture composed of the following elements:

- **Wi-Fi Access Points**—deployed in facility—deliver wireless connectivity to any Wi-Fi-enabled device.
- **HPE Geo-Location Server** talks to the access points and computes the location of any Wi-Fi mobile devices connected to the WLAN network and controller.
- **HPE Smart Profile Server** consolidates information about visitors.
- **HPE API Management** offers an API layer to expose location and user profile information to Aurasma, mobile application providers, and the dashboard.
- **Dashboard** gives location owners a graphical view on movements and interactions with customers in the facility.

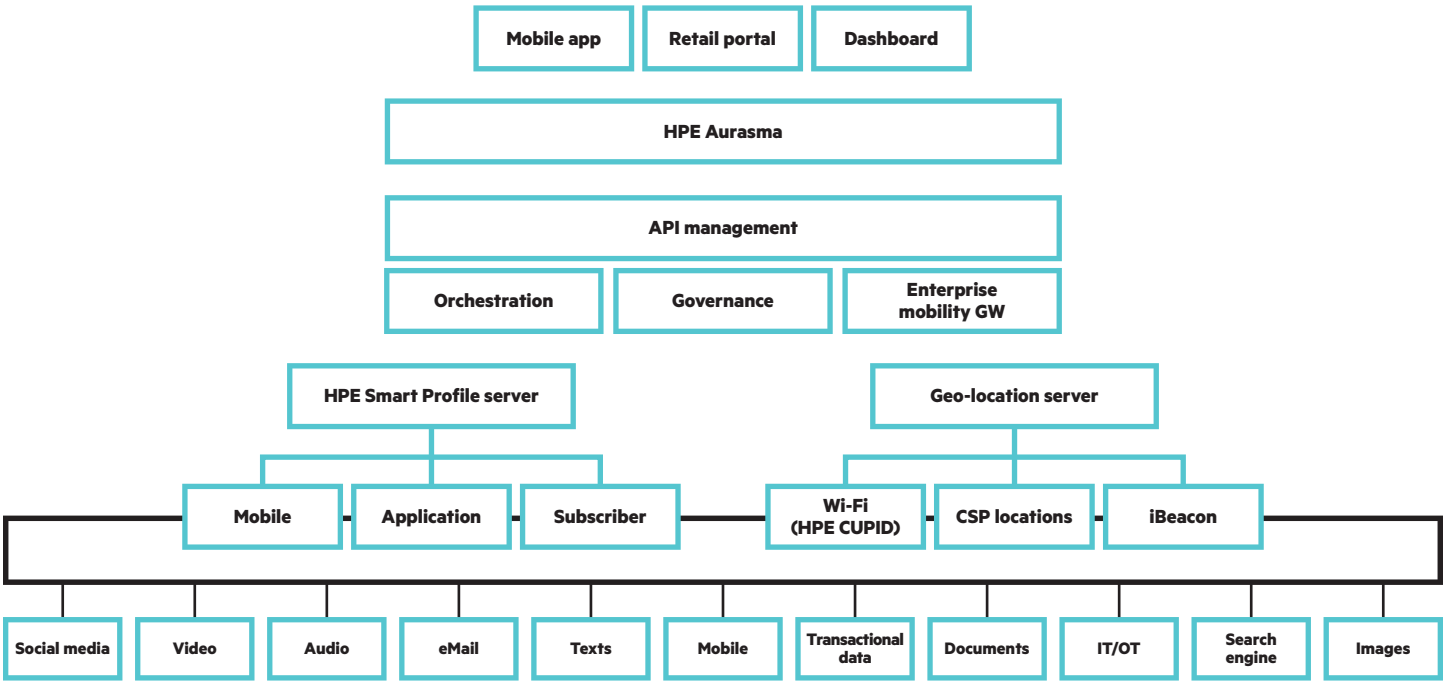
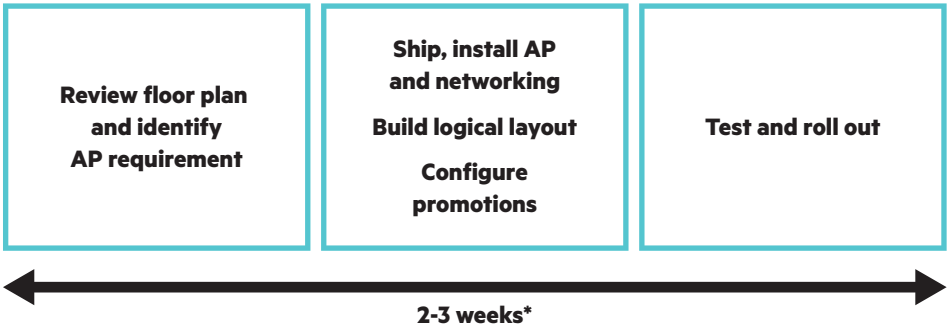


Figure 4: HPE Location Analytics functional architecture

HPE Wi-Fi Access Points

HPE Wi-Fi Access Points and HPE WLAN controller implement HPE Location Aware Services to provide best-in-class indoor location accuracy. While deploying an HPE Access Point, a site survey is performed to position access points appropriately and define geo-fences. Rules are then configured, and systems can be set up, tested, and deployed.



* Based on site size for <20,000 sq. ft. single level

Figure 5: HPE Location Analytics AP deployment model

HPE Geo-Location Server

HPE Geo-Location Server is a unique module in the HPE Location Analytics Services. It's been designed from years of Hewlett Packard Enterprise experience in location services with 911 platforms. It provides an open, flexible platform that today supports Wi-Fi indoor locations, and is designed to support other plug-ins for other access network-based locations, such as 3G/LTE or Bluetooth low energy. It offers a northbound open API, which enables the location server to feed location information to other systems composing HPE Location Analytics. This platform lets users create micro geo-fences, which are the different sections of the facility, and assign the action to be triggered when a visitor walks into the sections.

HPE Smart Profile Server

HPE Smart Profile Server (SPS), a massively scalable, carrier-grade system, collects and analyzes data in real time from your information sources—voice and data networks, application portals, and even Over-the-Top cloud services and applications. Data is statistically analyzed to produce in-depth subscriber insights—preferences, interests, browsing behavior, satisfaction index, loyalty, and churn scores—providing a 360-degree view of your subscribers in real time.

- Permanent data—Age, gender, address, and service plans—mostly collected at the point of sale
- Current data—Device, applications, and services on the device, which are also collected from point of sale, require regular updates as they may evolve over time
- Recent data—Time and location, presence, and roaming status are collected from network equipment, applications, Deep Packet Inspection (DPI) probes, and external sources
- Live data—Indicators collected via network probes, applications, and service elements
- Permanent opt-in data—Preferences require a subscriber option
- Localized data—Wi-Fi hot spot position or Cell-ID actions, based on position

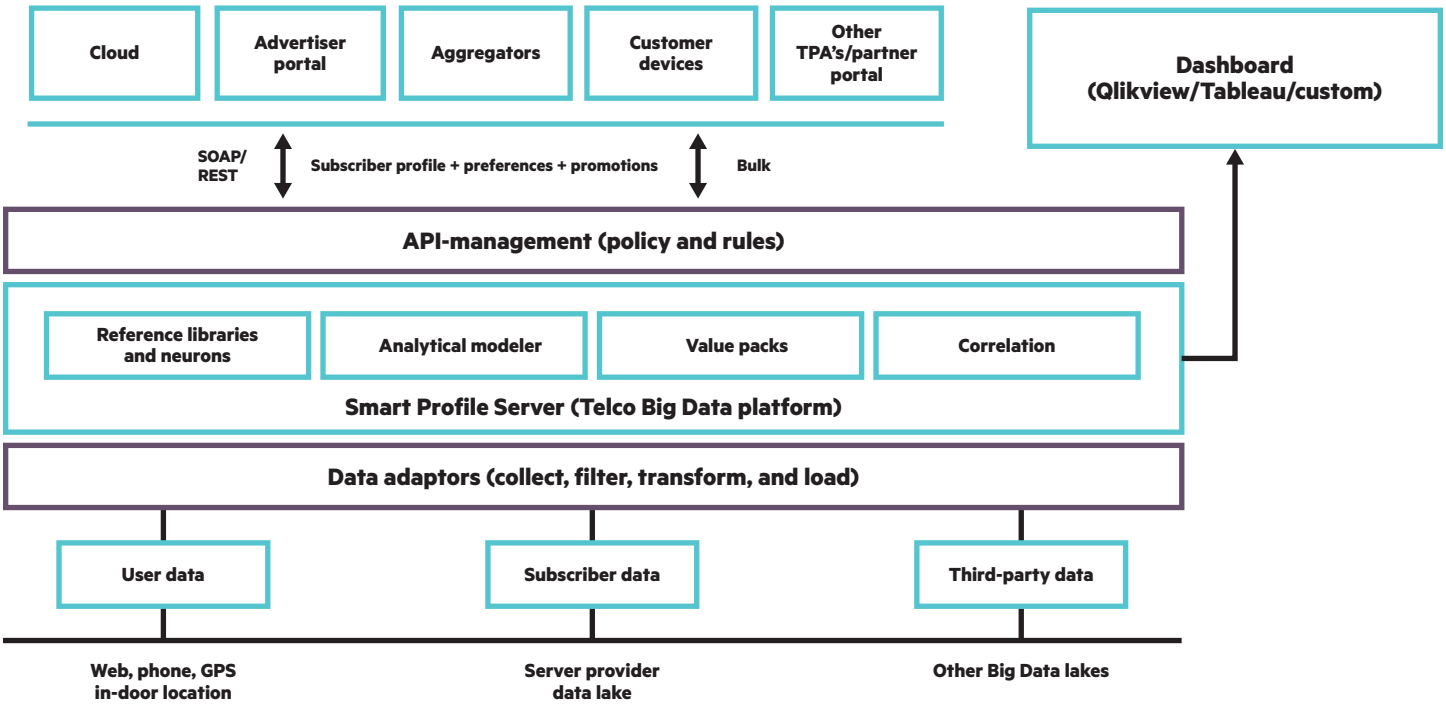


Figure 6: HPE Smart Profile Server

HPE Smart Profile Server runs on top of HPE Vertica, the Hewlett Packard Enterprise analytics platform designed for Big Data business analytics. It drives down the cost of capturing, storing, and analyzing data, and produces answers 50 to 1000 times faster using massively parallel processing.

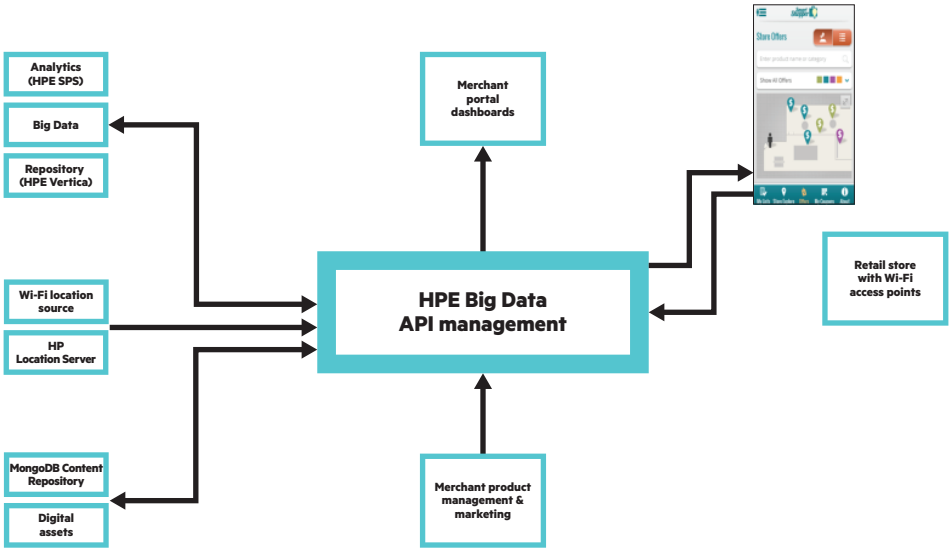


Figure 7: HPE API Management in Location Analytics

HPE API Management

HPE API Management enables context, content, mobile, and Big Data combinations to deliver correlated, real-time, in-session contextual information; it ensures business rule-driven API exposure and control. And it supports mobile backend and automatic software development kit (SDK) generation to simplify applications developers' lives and enhanced mobile apps performance and security.

HPE Location Analytics Dashboard

With HPE Location Analytics, you get a complete solution that provides accurate indoor location positioning of visitors, an indoor navigation tool, and a rich subscriber profile management tool. The solution is robust and scalable, and is very open with REST APIs and supports customization.

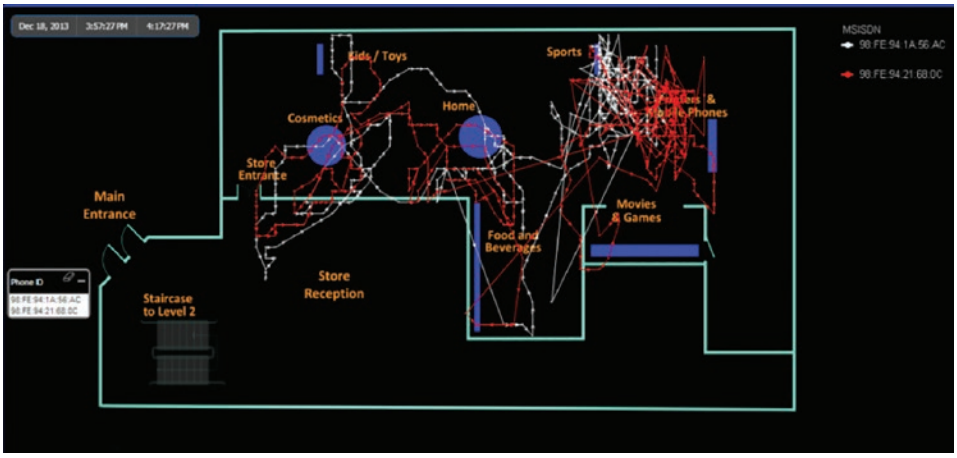


Figure 8: HPE Location Analytics facility view

It's good to be in the know

By combining the most accurate indoor location technology and best-in-class visitor profile and content management, you can know where your visitors are, enhance your ability to relate to them, and in turn, improve their experiences with contextual information.

Learn more at
hpe.com/CSP/TelecomAnalytics

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