inFSOFT
smart connected locations

White Paper

Indoor Positioning & Services

Content

Editorial

Dear readers,

The field of indoor positioning and indoor navigation has been undergoing sustainable changes and experiencing exciting new developments since I founded infsoft in 2005. Over the years, we successfully demonstrated our ability to adapt fast to new trends and circumstances, anticipating and inventing new ways to connect locations. Today, positioning and navigation solutions for indoor contexts include technologies based on Wi-Fi, Bluetooth Low Energy (BLE), Ultra-Wideband (UWB), and RFID, just to name a few. We intend to build on this momentum, combining fundamental concepts in hybrid approaches to aim for more accurate, precise, and efficient solutions. There is always plenty of space for improvement and innovation, and I am very excited for what is yet to come!

CEO Tobias Donaubauer

With this white paper, we want to provide you with a guideline to help you find a way through the complex topic of indoor positioning and related services. You can use it to get an overview of the different positioning techniques, learn more about the wide range of possible applications, and get to know our products and solutions. If you want to dig deeper, you can always have a look at our website, or our indoor navigation wiki.

If you have any questions, please don't hesitate to contact us.

Would you prefer to reach out to us via Facebook or Twitter? No problem, please stay connected and let us in on your thoughts!

All the best,

Tobias Donaubauer

1 | The Basics of Indoor Positioning

Indoor positioning systems (IPS) enable you to locate the position of objects and people within buildings. GPS, however, is not available in interior spaces, because there is no visual contact with the GPS satellites. Furthermore, with GPS, it is not possible to determine the floor level a device is located on. That is why an IPS has to rely on other localization methods. There are two approaches to put such an “indoor GPS” into practice.

Quick Start – Client- and Server-Based Indoor Positioning

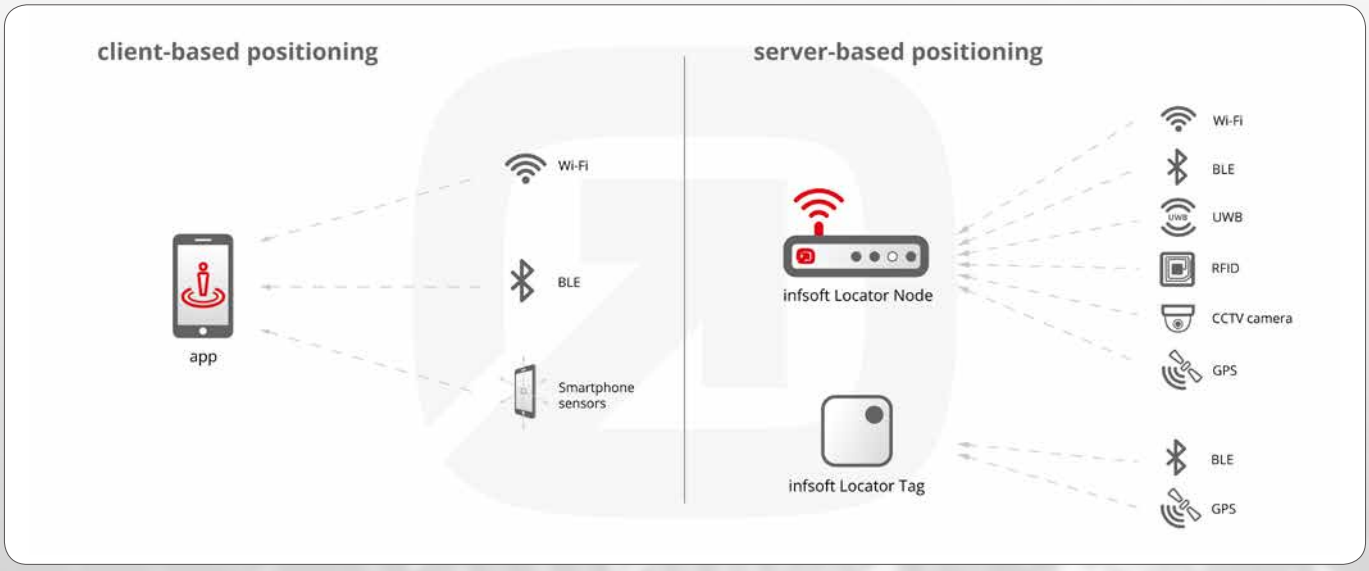
Indoor positioning is based on a transmitter-receiver model where there are two possibilities to determine the current location of a person or asset indoors: client- and server-based approaches.

Client-based:

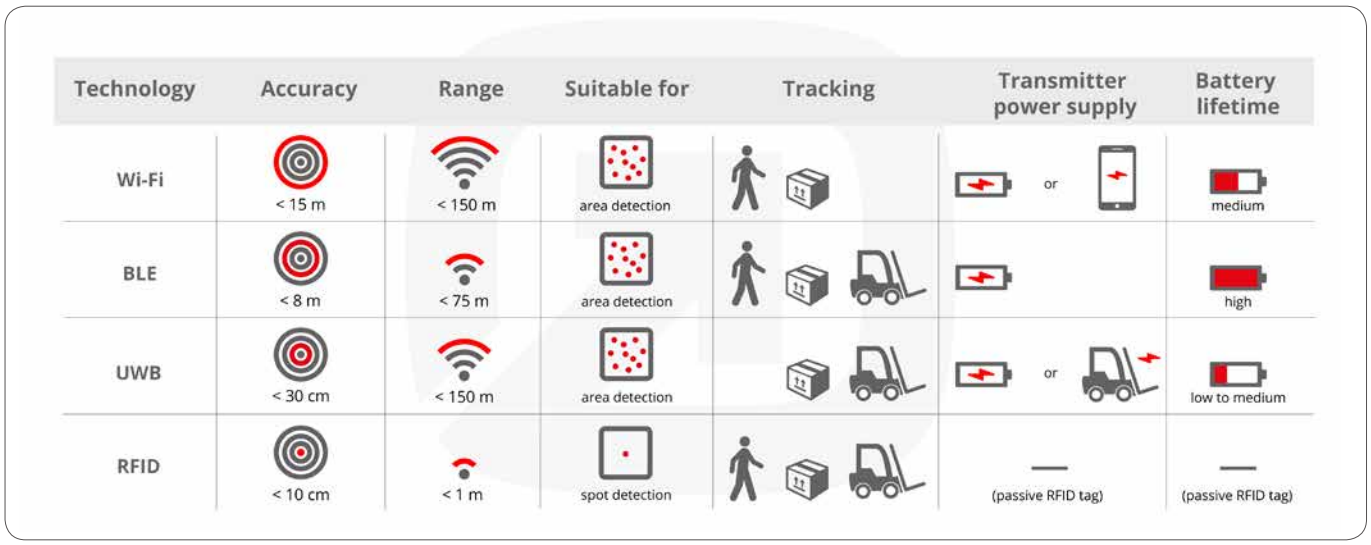
A client-based technology is used to keep track of individuals that might require a back channel for further information exchange (visualization of own position on a map, location-based alerts, task management etc.) and for navigation purposes.

Hence, a smart device with a specific application is handling the indoor positioning based on external signalers such as Wi-Fi and Bluetooth Low Energy (BLE) in combination with the internal smartphone sensors (e.g. accelerometer, gyroscope, magnetic field sensor etc.).

The position is determined on the smart device but can also be transferred continuously to a backend to provide supervisors with the user’s current location. Therefore, the device requires a network connection.



Client-based and server-based indoor positioning



Comparison of different technologies for server-based indoor positioning

Server-based:

A server-based technology is used to keep track of assets and persons and comes with a typical one-way communication towards the receiver. In most use cases, there is no back channel to the transmitting device.

The receiver hardware is installed within the client's premise to capture the signals of the transmitters/ senders and to transfer the data to a backend engine.

infsoft can set up interfaces for indoor positioning from third-party providers such as Cisco, HP Aruba and Xirrus to visualize the position data within our Analytics and Tracking engine.

Technology Overview

To meet the requirements of a client with regard to the requested accuracy, there are several potential sensor technologies available:

Wi-Fi

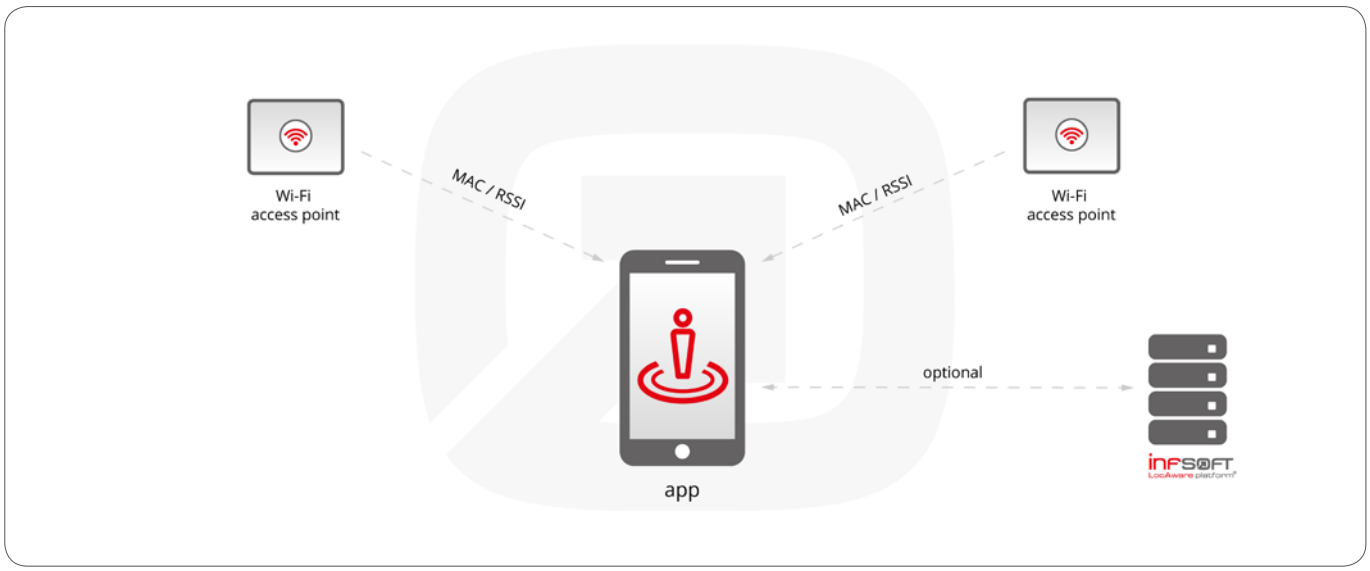
Inside buildings, Wi-Fi is a good alternative to GPS. In most cases it is easy to install a Wi-Fi positioning system (WPS), since existing Wi-Fi infrastructure can be used (e.g. cash register systems, public hotspots, access points of shops or exhibitors). The user doesn't necessarily have to connect with the Wi-Fi, it is sufficient to have Wi-Fi enabled.

Technology	Accuracy	Range	Cross-Platform
Wi-Fi	5-15 m	< 150 m	
BLE	1-3 m	< 30 m	

Comparison of Wi-Fi and BLE for client-based indoor positioning

For positioning, the so-called fingerprinting method is used. The strength of the Wi-Fi signals (received signal strength indication, RSSI) and the MAC address (media access control) are significant. There must be a corresponding app installed on the smart-phone which calculates the current position based on these data.

If a server-based solution is more suitable for the project, infsoft's self-developed hardware – the Locator Nodes – can be used. In this case no app is required, all Wi-Fi capable devices (e.g. smartphones, tablets, Wi-Fi tags) are detected and asset tracking is possible.



Indoor positioning using Wi-Fi

Accuracy depends on multiple factors, such as the number of available access points, reflections for example in corridors and last but not least shielding through walls, ceilings, and your own body. The accuracy of Wi-Fi used for indoor positioning varies from 5 to 15 meters – depending on the preconditions. Sensor fusion (the use of smartphone sensors) can improve accuracy in client-based applications.

Wi-Fi at a glance:

Pros:

- existing Wi-Fi infrastructure can be used
- enabled Wi-Fi is sufficient
- large range (up to 150 m)
- detects floor level

Cons:

- relatively inaccurate (5-15 m) compared to BLE/RFID
- no latency guarantees
- use of randomized MAC address if smartphone is not connected to Wi-Fi network
- client-based positioning is not possible with iOS devices

EXAMPLES OF USE:

- occupancy analysis of office buildings
- utilization analysis in rail traffic

Bluetooth Low Energy (BLE) Beacons

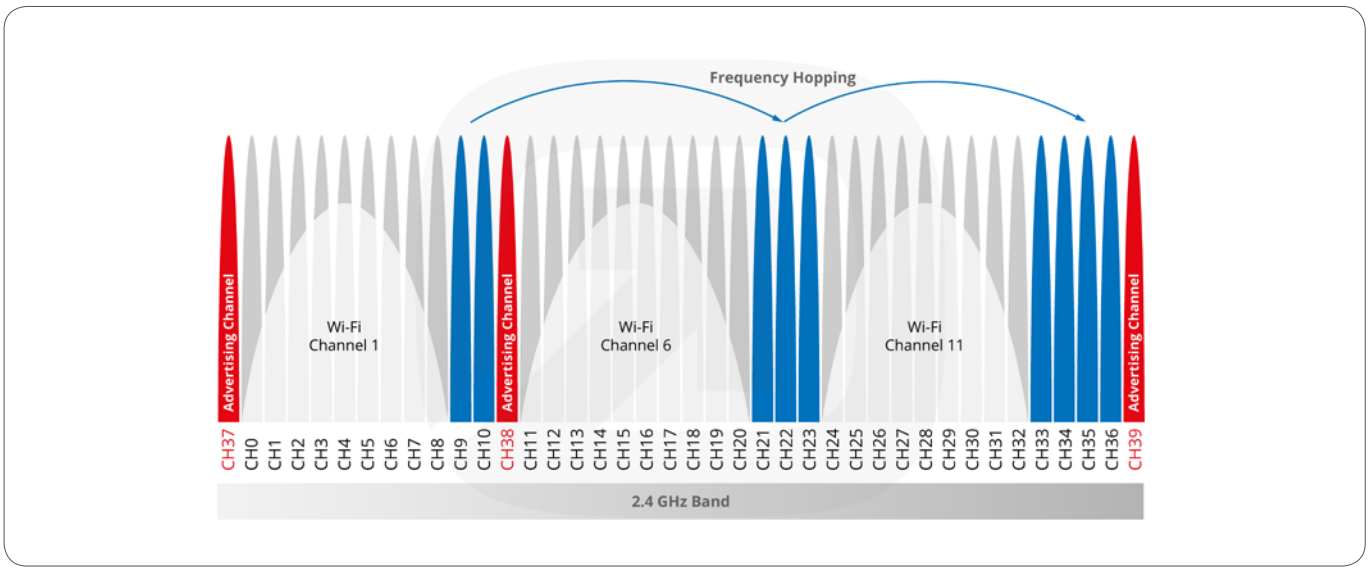
Beacons are small radio transmitters that broadcast signals using Bluetooth Low Energy (Bluetooth Smart) in a radius of up to 70 meters. These signals are detected by a mobile device (e.g. smartphone) in a client-based approach or by a specific hardware (infsoft Locator Nodes) in a server-based approach.

The underlying technology is using a signal strength (RSSI) measurement to determine the beacon's position.

BLE beacons are cost-effective and energy-efficient components that can run on button cells up to five years and more.

For calibrating the position determination in a client-based approach, infsoft provides a calibration app, by which clients can work independently. infsoft also offers a beacon management tool to monitor battery levels and set up business logics to replace batches in certain areas.

During installation and parameterization, attenuation properties of different materials have to be taken into account (e.g. wood or glass with low attenuation properties as opposed to metal or water with high attenuation properties).



Optimal channel utilization for simultaneous use of BLE and Wi-Fi

Bluetooth beacons normally do not affect other radio networks and they also do not interfere with medical devices. However, BLE and Wi-Fi share the same frequency range (2.4 GHz). Interferences can be easily avoided by not using channels 2, 3, 4, 13 and 14 when configuring the Wi-Fi and using 1, 6, 7, 8, 9, 10, 11 and 12 instead. Bluetooth uses the remaining available channels to capacity in a uniform manner (frequency hopping). Advertising channels that are used for positioning are marked in red in the graphic. The blue-colored channels are reserved for additional functions such as a temperature sensor.

The infsoft beacon calculator can help get a rough idea of the number of beacons required for a client-based indoor positioning project.

Various beacon models (picture shows products of Kontakt.io)

BLE beacons are available from numerous suppliers and come in various shapes and sizes. infsoft solutions are compatible with beacons of all manufacturers.

BLE beacons at a glance:

Pros:

- cost-effective, unobtrusive hardware
- low energy consumption
- flexible integration into the existing infrastructure (battery-powered or power supply via lamps and the domestic electrical system)
- works where other positioning techniques do not have a signal
- compatible with iOS and Android
- high accuracy compared to Wi-Fi (up to 1 m)

Cons:

- additional hardware
- relatively small range (up to 70 m)
- instability with layout changes and radio interferences

EXAMPLES OF USE:

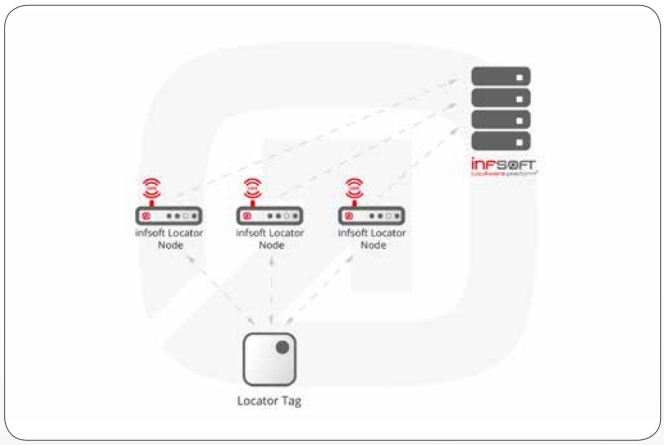
- condition monitoring
- tracking of security guards
- inventory of economic assets

Ultra-wideband (UWB)

Ultra-wideband is a short-range radio technology that is mainly used in industrial environments with high precision needs.

With less than 30 cm, the accuracy is considerably better than when working with beacons or Wi-Fi. Also, height differences can be measured accurately. Another advantage can be the low latency times with position updates up to 100 times / second.

In contrast to Bluetooth Low Energy and Wi-Fi, the position is determined by a transit time method (Time of Flight, ToF) instead of a measurement of signal strengths (Receive Signal Strength Indicator, RSSI). This method measures the running time of light between an object and several receivers (infsoft Locator Nodes).



Server-based positioning with UWB Locator Tag

The asset to be tracked is equipped with a small UWB tag (infsoft Locator Tag) which runs on battery power or can draw its power via a forklift, for example. The tag sends data (ID, ToF, timestamp) to the infsoft Locator Nodes. They have a fixed position in the infrastructure and can use the running time of light to calculate the distance of the asset.

If the positioning data should be immediately displayed on a mobile device (smartphone), the infsoft Locator Tags can directly communicate with the smartphone via Bluetooth or USB interface.

Asset tracking based on Ultra-wideband

Due to the usage of extremely wide frequency bands with a bandwidth of at least 500 MHz, there are almost no interferences. UWB is one of the preferred solutions when it comes to the tracking of a modest number of assets in large industrial areas. However, the price per unit is significantly higher and the battery lifetime is shorter compared to BLE beacons.

UWB at a glance:

Pros:

- high accuracy
- low latency times
- almost no interferences

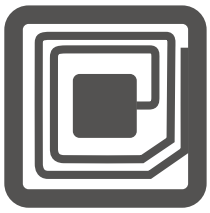
Cons:

- cost-intensive
- shorter battery lifetime than BLE beacons

EXAMPLES OF USE:

- rail wagon tracking
- process optimization in automotive manufacturing
- positioning of overhead cranes

RFID



RFID stands for “Radio-Frequency Identification” and describes systems that use radio waves to identify objects or persons. In a passive RFID system, there is a transponder (“RFID tag”) on whose microchip data (usually a serial number) are stored, which can be forwarded wirelessly to a reader. The reading unit (infsoft Locator Node) generates an energy field that activates the RFID tag. In order to enable information exchange, the distance between Locator Node and transponder must be less than one meter (remote-coupling).

No matter which industry you are thinking of – since it is a very versatile technology, RFID can be used almost everywhere. Common applications are systems for access control, time recording or inventory control in logistics. Since reliable identification of products or objects is required in many industries, RFID is particularly suitable as an asset tracking solution.

Since passive transponders do not have their own energy source, they are almost maintenance-free. As a result, initial acquisition costs will pay off in the long term in most cases. RFID tags do not require visual contact with the reader, and they are durable against impact and environmental factors.

RFID at a glance:

Pros:

- very high accuracy
- immunity to interferences
- no battery needed

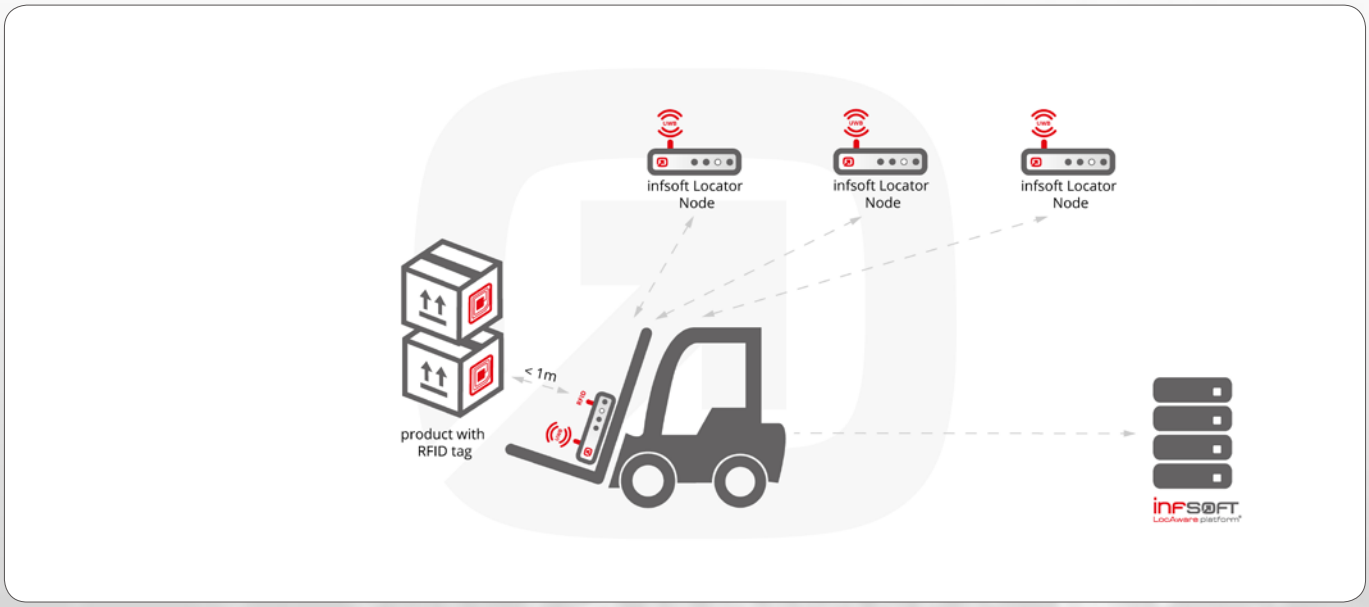
Cons:

- short range (< 1 m)
- only providing a “point-in-time” location
- installation requires significant planning
- infrastructure can be expensive

EXAMPLES OF USE:

- analysis of consumer behavior in a supermarket
- asset tracking in logistics

Combining RFID systems with other positioning technologies can solve the biggest problem of passive RFID technology: objects equipped with RFID tags can only be located at a specific point – namely exactly where RFID hardware (e.g. Locator Nodes) has been installed. However, if for example a forklift truck is equipped with an infsoft Locator Node, whose sensors not only respond to RFID, but also to Ultra-wideband (UWB), a link between the position data of the forklift truck and the identification times of RFID-tagged goods can be established.



Combination of RFID and UWB for identification and localization of goods

2 | Hardware for Indoor Positioning

To address a client's need for a reliable indoor tracking solution, we rely on our own hardware called infsoft Locator Nodes and infsoft Locator Tags.

infsoft Locator Nodes

With the Locator Nodes, infsoft is providing a modular component for tracking and analysis purposes. Integrated into the central data hub – the infsoft LocAware platform® – the Locator Nodes allow for a comprehensive detection of different device types, enabled through the modular system with different sensors.

Beside the consumer standards Wi-Fi and Bluetooth Low Energy (BLE), the infsoft Locator Nodes are able to address high-precision needs with Ultra-wideband (UWB) and can also be equipped with an RFID reader. Data correlations with external camera systems and self-positioning via GPS in mobile scenarios are further capabilities.

Complementary sensors

Locator Nodes can detect all mobile, Wi-Fi-enabled devices (such as smartphones, laptops, wearables) within a building and track them via server (without an app). This works across all mobile operating systems and due to the use of a hash algorithm (SHA-1) in compliance with data protection requirements.

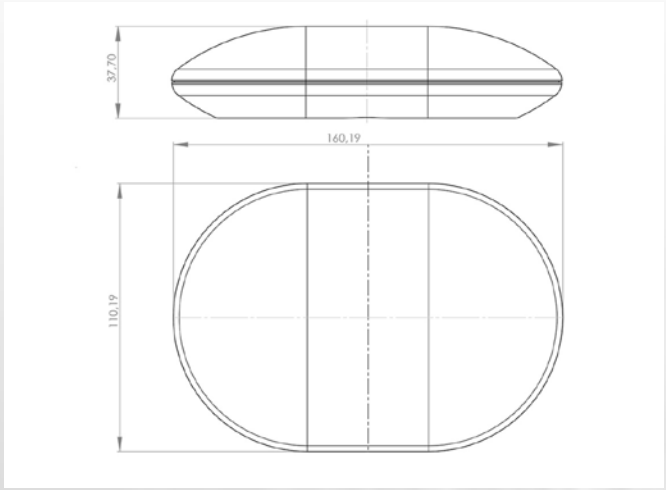
Moreover, the infsoft Locator Nodes enable a detection of Bluetooth Low Energy (BLE) beacons and can also function as beacon controllers to monitor

infsoft Locator Node

fixed beacons, for example in the context of a client-based indoor navigation, and to carry out possible reconfigurations.

Equipped with an integrated Ultra-wideband (UWB) module, Locator Nodes can also achieve a high-precision localization of less than 30cm, which is often used in industrial applications.

The use of RFID (radio-frequency identification) is suitable for a selective object identification. The RFID reader of the Locator Nodes offers a cost-effective tracking option, especially with high quantities in pallet tracking. Intelligent connections with additional sensors can detect and optimize storage location and service life.



Dimensions of an infsoft Locator Node

The addition of imaging systems such as CCTV cameras plays an important role in security and logistics. Connected to the Locator Nodes, a correlation between camera image and position data can be established (for example based on Wi-Fi, BLE or UWB).

In mobile application scenarios, infsoft Locator Nodes can also be equipped with a GPS module, which determines the current location of the Locator Node. The built-in complementary sensor system thus not only enables the detection of goods in a static space context, but also completely flexible.

Seamless integration

The Locator Nodes require a power supply and network connection and are transferring the scanned data to the infsoft LocAware platform® that is available as cloud and on-premise solution. Using the various tools then allows to view positions, analyze movements, or use location-based services.

Integration with third-party systems such as Cisco (CMX, MSE, Meraki), HP Aruba or Xirrus is also possible.

Examples of use for infsoft Locator Nodes:

- localization of casting ladles in a steel mill
- tracking of visitor flows on factory sites
- lone worker protection

infsoft Locator Tags

infsoft Locator Tags are small modular components using LoRa/BLE or Ultra-wideband (UWB) that enable tracking objects and vehicles indoors. They are also suitable for analyzing walking routes. Much like infsoft Locator Nodes, they work with server-based installations, which means that the position is determined on a server (cloud or on-premise).

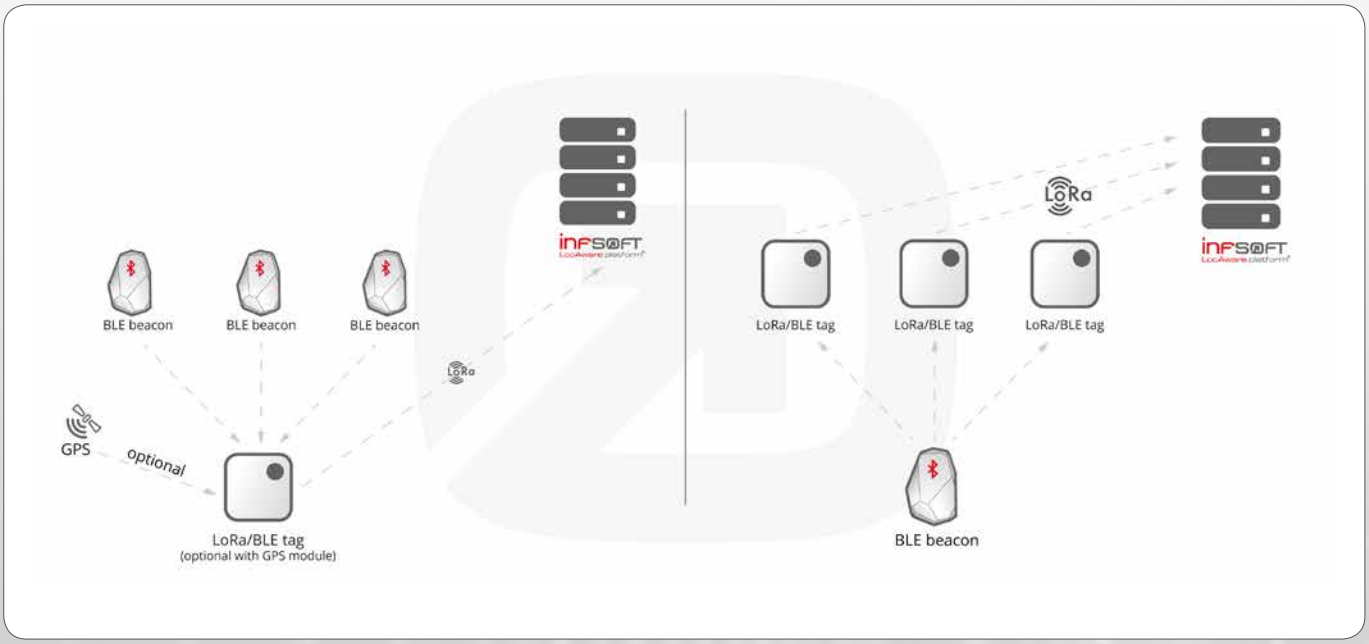
infsoft Locator Tags are designed to fit our client's specific needs. This is why they can be equipped with various modules (LoRa/BLE or UWB), so they can be used in a very flexible way and can be changed according to current requirements.

LoRa/BLE

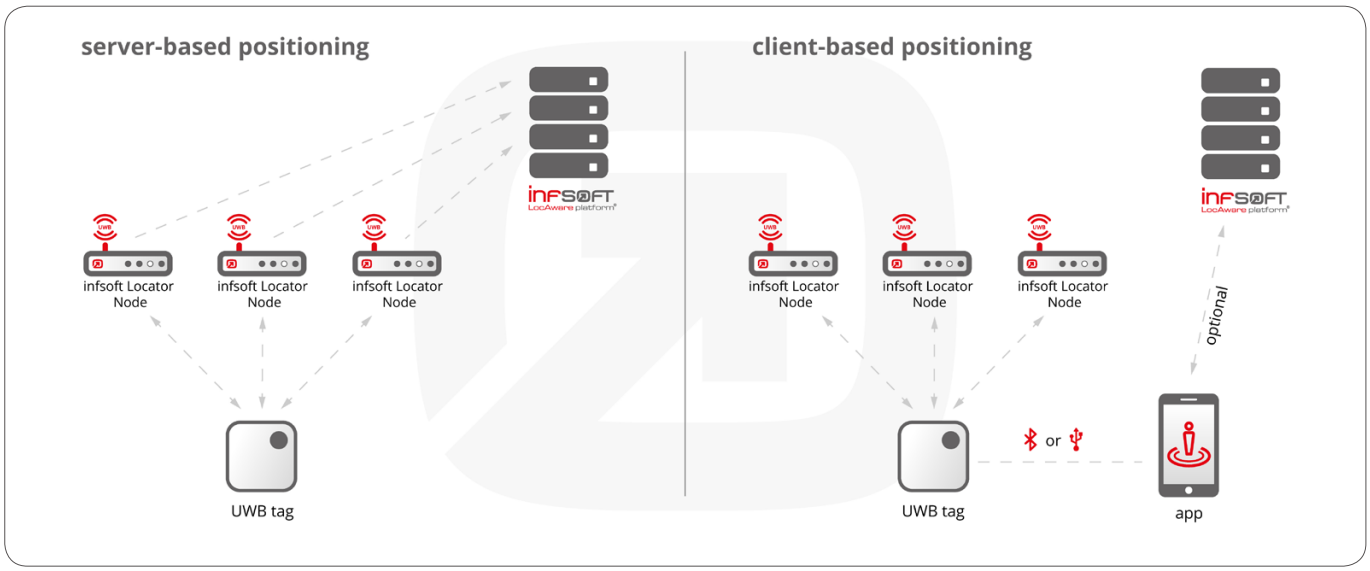
There are two possibilities for indoor positioning with LoRa/BLE Locator Tags: The tags can either be attached to the mobile assets or function as fixed anchors distributed evenly throughout the building.

In both cases, in addition to the LoRa/BLE tags, Bluetooth Low Energy (BLE) beacons are required for positioning. The Locator Tags transmit the location data via LoRaWAN (Long Range Wide Area Network) to the infsoft LocAware platform®. The LoRa network operates in the 868 MHz frequency band. Depending on the amount of data and the spreading factor, transmission is only possible with higher latencies (approx. 30 seconds to 5 minutes), which makes the technology unsuitable for live tracking systems. The position of the Locator Tag is calculated in the backend and provided via web services.

In the first scenario (mobile LoRa/BLE tags), evenly distributed beacons are necessary. Since beacons are relatively cheap (3-30 Euros) and easy to install



Server-based positioning using LoRa / BLE tag



Server-based and client-based positioning using UWB tag

(can be glued to walls/ceilings, battery-powered), they are especially suitable for large areas with just a few items to track. The tag itself is battery-powered or can be operated by electricity. It is adhered to the object to be tracked. The beacons installed in the building can also be used for precise indoor navigation, for example for employees and clients. In order to make use of indoor navigation, an app is necessary. Hence, this option is interesting for all application scenarios in which relatively few objects

LoRa/BLE tag

should be tracked on large areas and a beacon infrastructure already exists or indoor navigation is an interesting additional feature. The LoRa/BLE tag can optionally be equipped with a GPS module for localization in outdoor areas.

In the second scenario (fixed LoRa/BLE tags), the Locator Tags are distributed evenly throughout the premises, while the BLE beacons are attached to the assets to be tracked. Due to the low cost per beacon (and thus per asset), this method is particularly suitable for smaller areas with a high number of assets. The Locator Tags are battery-powered and can also be installed outdoors. The advantage here is that the tags do not have to be wired and there is no need for a power supply or individual connection via Ethernet or Wi-Fi. With a large number of assets, latency times are lower the more Locator Tags are installed.

UWB

Thanks to their modular construction, infsoft Locator Tags can be used in different application scenarios. Besides BLE, Ultra-wideband is a possible module. UWB enables asset tracking in industrial environments with an accuracy of 10-30 cm.

The system can either be set up server-based (visualization of positioning data in the backend, no display on a client (smartphone)) or client-based (visualization of positioning data on a client (smartphone) and if necessary transmission to the backend).

Examples of use for infsoft Locator Tags:

- localization of medical equipment
- vehicle tracking in a car showroom
- indoor tracking of tugger trains

3 | Solutions & Software

infsoft offers customized, comprehensive solutions and powerful software tools that allow for successful implementation of an Indoor Positioning System (IPS).

Solutions

infsoft offers the whole range of indoor positioning services: indoor navigation, indoor tracking, indoor analytics and indoor location-based services.

Indoor Navigation

Indoor navigation deals with wayfinding within buildings. Because GPS reception is normally non-existent inside buildings, other positioning technologies are used here when automatic positioning is desired. Wi-Fi or BLE beacons are often used in this case to create a so-called “indoor GPS”. Contrary to GPS, however, they also enable you to determine the actual floor level. Most applications require an “indoor routing” functionality that guides people precisely through a building and, in this way, automatically determines their position – very similar to the navigation systems that we use in our cars. A typical application is turn-by-turn navigation in an app (displaying directions on a digital map) used for train stations, airports, shopping centers and museums.

Indoor navigation with automatic positioning is normally used as a client-based application. This means that the position is determined directly on the smartphone of the user, which requires an app. The location is determined usually via Wi-Fi or beacons. A feedback channel is also available, for example for sending push notifications.

Smartphone sensors are always called upon to refine the positioning function – for example, GSM, 3G/4G (LTE), magnetic field, compass, air pressure, barometer, accelerometer and gyroscope.

Because all infsoft products are integrated into one platform, it is easy to enable additional features, for example route and visitor analyses.

Indoor navigation by infsoft can also be integrated into existing apps: an SDK (Software Development Kit) is available for the Android and iOS mobile operating systems and as an HTML5 plugin.

Indoor navigation with Wi-Fi

Indoor navigation with Wi-Fi has an accuracy of 5-15 meters. The various signal strengths of several Wi-Fi access points are evaluated for this purpose. Precise positioning within the building, even over multiple floors, is made possible through specific shielding characteristics. The available Wi-Fi infrastructure can be used (e.g. customer hotspots, Wi-Fi-capable point of sale systems, routers) – the user only has to activate Wi-Fi on his/her smartphone, a connection is not required.

However, client-based positioning via Wi-Fi is not supported by Apple devices. Beacons are a good alternative if you want to include all smartphone users.

Indoor navigation with beacons

Indoor navigation using beacons is quite widespread because Bluetooth transmitters function across platforms and have an accuracy of 1-3 meters. The most well-known types are called iBeacon (from Apple) and Eddystone (from Google). Both operate using the BLE standard (Bluetooth Low Energy) and thus are very energy efficient. Numerous hardware manufacturers market these small devices. A beacon should be placed every 7-10 meters depending on the desired accuracy. Beacons are the most popular hardware for indoor positioning due to their high level of flexibility and accuracy.

Indoor navigation using beacons (picture: product of Estimote)

Indoor navigation with Ultra-wideband

Indoor navigation with Ultra-wideband has some significant advantages in industrial environments: high accuracy (10-30 cm), low latency times (position request up to 100 times/second), and accurate measurement of height differences.

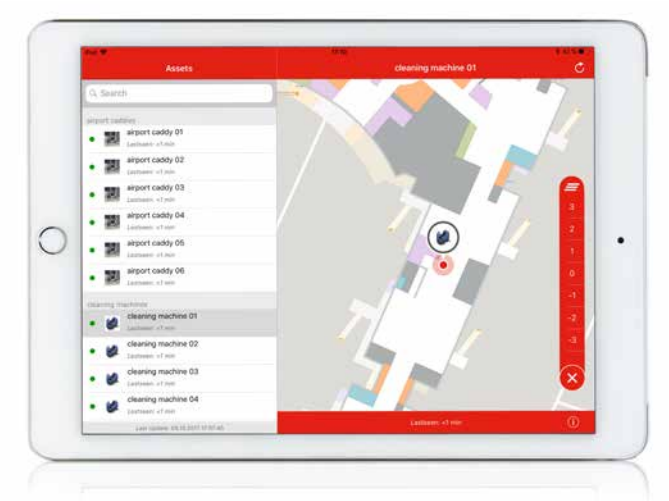
For client-based positioning using UWB, infsoft Locator Tags are required. They transmit their position directly to the smartphone – either via a USB dongle which is directly plugged into the smartphone or via Bluetooth. However, the technique is a special solution which requires appropriate components and thus is mostly suitable for special industry applications. One possible use case are floor conveyors whose drivers should receive precise turn-by-turn directions. Because of their high speed, latency must be kept to a minimum.

Application examples of indoor navigation:

- indoor navigation in a shopping mall
- visitor management in office buildings
- indoor navigation and LED identification of goods

Indoor Tracking

Indoor tracking denotes the real-time localization of persons and objects within buildings. Depending on the application, infsoft deploys indoor tracking based on different sensors. Wi-Fi or BLE localization is cost-efficient and provides accuracies under 5 meters. Ultra-wideband allows a very precise indoor tracking of people and objects. Passive RFID enables selective object identification. All solutions presented here also work seamlessly under the open sky in case the plant grounds are not uniformly covered by a roof.



Localization of objects within buildings

Indoor tracking is normally implemented as a server-based application. No app is required because a back channel to the object to be located is not necessary in most cases. insoft Locator Nodes are used here. They can localize all Wi-Fi devices (smartphones, Wi-Fi tags and wearable Wi-Fi transmitters) as well as Bluetooth Low Energy beacons (e.g. available as an armband or wafer-thin sticker), Ultra-wideband tags and RFID tags. In some cases, client-based positioning is used, e.g. when person tracking is part of an employee app. The position is then determined directly on the user's smartphone and regularly sent to a server. An app is required in this case, and a feedback channel is available.

Indoor tracking by infsoft can also be integrated into existing systems (e.g. apps). An SDK (Software Developer Kit) is available for the Android and iOS mobile operating systems and as an HTML5 plugin.

Indoor person tracking

The indoor tracking of persons can make sense in several situations. On the one hand, it plays a major role regarding safety, e.g. for patients in high-risk categories or for the evacuation of employees from large company premises. On the other hand, it helps with the optimization of work processes, e.g. when the analysis and optimization of walking routes is desired.

Application examples of indoor person tracking:

- localization of elderly people in nursing homes
- asset and personnel tracking in tunneling
- kid finder and crew monitoring on a cruise ship

Indoor object tracking

The indoor tracking of objects is in great demand, particularly in the industrial sector. Here, it is often necessary to determine the current location of work equipment or goods. The systems from infsoft are based on a detailed digital map that shows the current position of the object(s) and that can be displayed on all (even mobile) end user devices.

Application examples of indoor object tracking:

- positioning of tractors
- railway train tracking system
- fill level measurement of waste containers

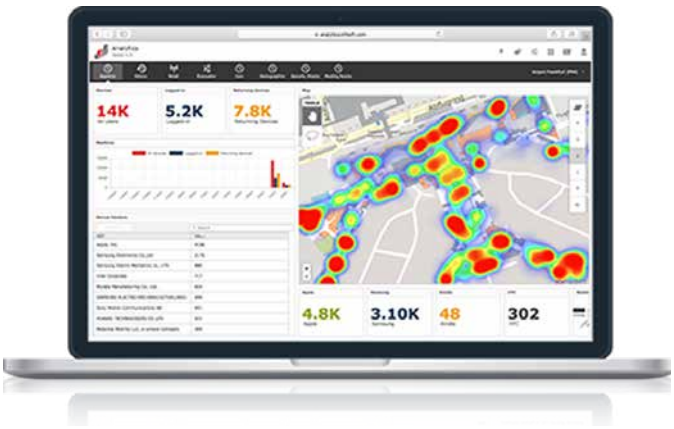
Indoor Analytics

The analysis software from infsoft can be added to existing indoor positioning / indoor navigation systems (client-based or server-based) or set up independently. The technology recognizes end user devices, Wi-Fi and Bluetooth transmitters, RFID and Ultra-wideband tags and measures the time spent in certain areas and which routes were used. This enables you to, for example, find out how many people pass a certain spot during the day or which hours of the day or week are the least busy. The movements of objects, e.g. work equipment, goods or products can also be measured along with the walking paths of visitors. The data is displayed in the form of diagrams and heat maps, enabling easy evaluation and further processing. infsoft's analytics dashboards are highly flexible and can be customized to the individual needs of each client.

Insights on visitor behavior

infsoft Indoor Analytics provides helpful information for business decisions. Heatmaps, route analyses and dwell times allow the targeted analysis of customer or visitor behavior. Indoor Analytics helps to improve customer/visitor satisfaction, product placement, personnel planning and the evaluation of marketing activities.

For example, a retailer can determine how successfully their current layout draws customers' attention to a specific offer. Operators of a shopping mall can make rents in different areas dependent on the respective visitor numbers. A museum director can establish which works of art are especially popular and whether optimization is necessary in the guided



Analyzing visitor behavior within a location

tours. Trade fair organizers can measure visitor numbers at individual points of the premises and set stand prices based on this information. The driving routes of machinery on factory grounds can be measured and visualized so that optimizations can be developed.

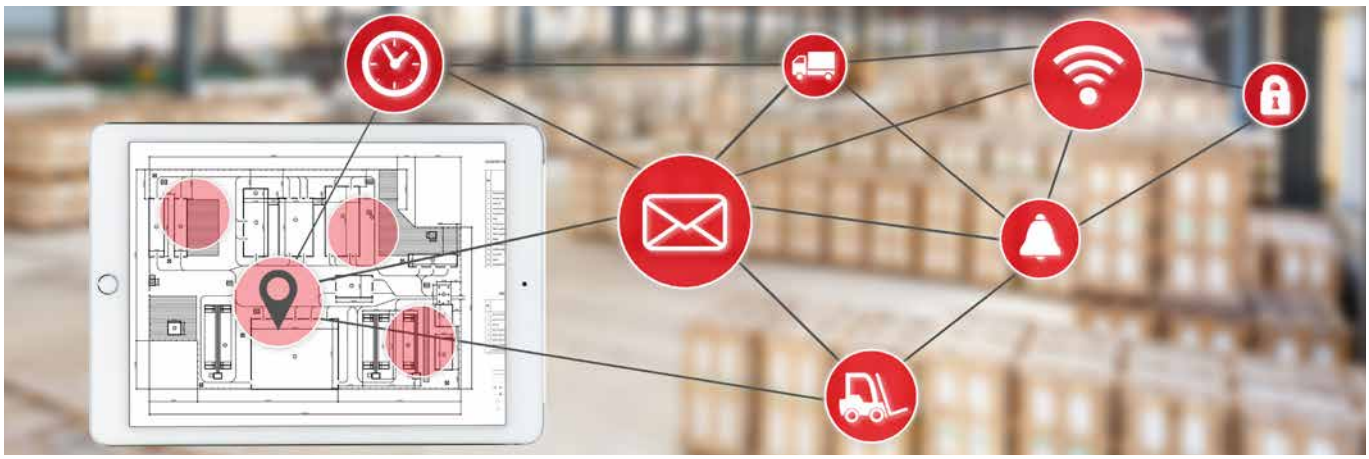
Data Protection and Technical Requirements

When indoor navigation from infsoft is being used, you can work directly with the analysis software. The mobile devices of users that have installed the corresponding app can send their position to the server on a regular basis. No personal data are captured, so that infsoft Indoor Analytics can be used in compliance with data protection regulations.

If you are not using an indoor positioning system from infsoft or you want to generate a wider database, then we recommend server-based data collection. infsoft Locator Nodes are used for this. Thanks to their modular approach, they can not only track smartphones via server, but also beacons, Wi-Fi tags, Ultra-wideband tags or RFID tags.

Application examples for indoor analytics:

- monitoring of shared workspaces
- analysis of visitor flows at a trade fair
- calculation of waiting times

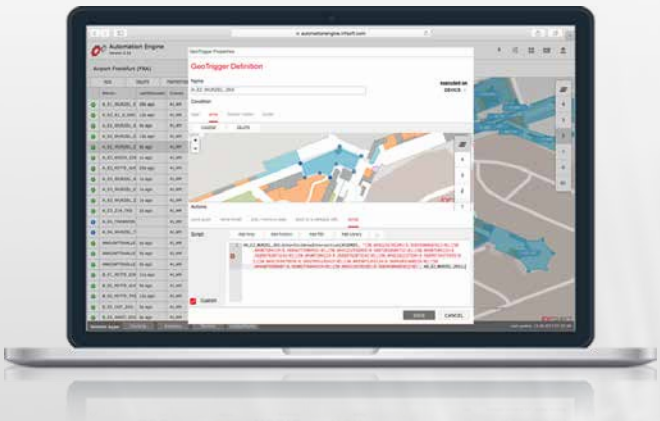


Geo-Based Processes & Services

Location-based services are location-specific mobile services. They provide information or functions to smartphone users, depending on their location. Various methods can be used for indoor positioning within buildings to implement location-based services. A distinction is made here between reactive and proactive services. For reactive location-based services, the user searches for locations in the vicinity directly on his/her device, e.g. for ATMs at the airport. Proactive services "recognize" when a user enters a specific area and trigger an action – e.g. sending information or an offer to the user's smartphone. This is referred to as location-based marketing. An app is required for these services.

Geofencing in Interior Spaces

The triggering of an action when taking a specific path is called geofencing (combination of geography and fencing). This can also be used inside buildings without GPS reception.



Setting up geofences for a location

Geofencing is quite interesting for marketing in shopping centers, airports, train stations and at trade shows, among others. Customers can be assigned anonymous "tags" that are based on their interests and behaviors. This could include characteristics such as age, gender, visited areas / stores and length of stay. This helps to provide customers with information, offers and coupons that are only relevant for them.

Application examples for geofencing:

- content triggering using a mobile app
- emergency zones for evacuation

Process Automation

Geofencing allows intelligent process automation. Using the infsoft Automation Engine, you can define various geo-based triggers along the process chain, speeding up operation and streamlining processes. It is possible to, for example, configure emails and tasks, create alerts, and protect areas by triggering automatic door locking / unlocking.

When talking about geofencing, we need to distinguish between client-based and server-based positioning.

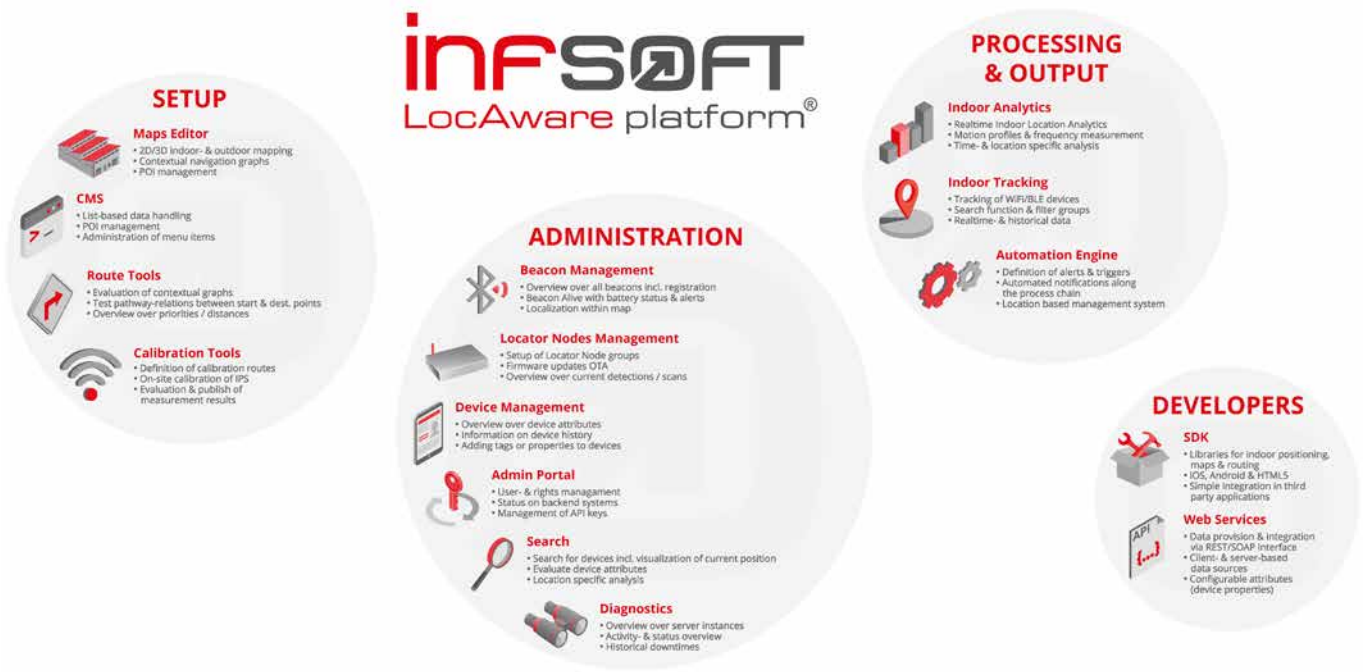
Client-based positioning

The user has a corresponding app installed. A feedback channel is available that can be used to send messages to the user's device.

Server-based positioning

The user cannot be addressed directly. However, interesting conclusions regarding interests and behaviors can be drawn from the location of numerous devices. Server-based positioning can also be used to trigger different actions along the process chain.

The gained data can be analyzed and processed via the infsoft Indoor Analytics and Indoor Tracking tool.



infsoft Software Tools

infsoft offers powerful software products that are bundled and linked in the infsoft LocAware platform®.

As a central data hub, the Locaware platform® represents the center piece of the infsoft tools. All tools required for the setup and data management are bundled here and are accessible with single sign-on.

The web-based tools enable managing a location on all floor levels, analyze traces through the building, manage devices, beacons and Locator Nodes as well as to define geo-based alerts.

Furthermore, all data from the Locaware platform® can be exchanged easily via interfaces (bidirectional connection) with third-party systems.

The platform is available as cloud and on-premise solution.

Setup of Indoor Localization

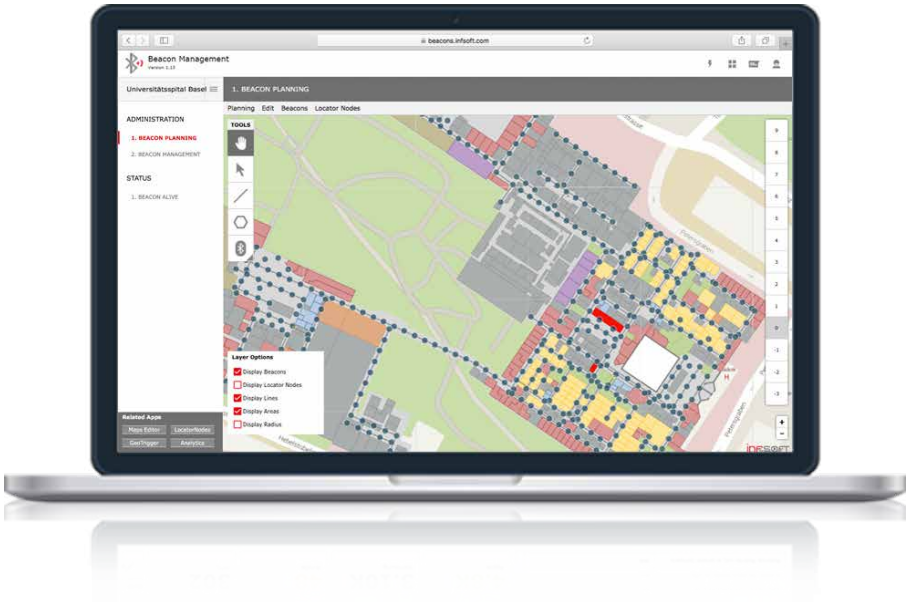
The setup tools include all the required features to set up an indoor positioning system – mapping, calibration, data management, and route definition.

The infsoft Maps Editor allows you to create your location with just a few clicks and then easily manage it afterwards at any time. You can set up outlines of the building, rooms and custom patterns, define points of interest (POI), contextual pathway-relations and much more.

Closely related to the Maps Editor is the infsoft CMS, which provides the information in list format. You can easily manage attributes for a large number of

infsoft Maps Editor

POIs, set information for different menu items and handle data that are not necessarily geo-related.
The infsoft Route Tool allows you to test the contextual pathway-relations you have created. You can evaluate the routing (e.g. barrier-free) over several



infsoft Beacon Management

floors and check the priorities of different navigation graphs. The routing and mapping information shown is provided by the infsoft Maps Editor.

The infsoft Calibration Tools assist you with the setup of a client-based indoor positioning based on Wi-Fi, beacons and sensor fusion and are also used for the calibration of the infsoft Locator Nodes. Within the Calibration Tools you can create calibration routes, manage beacon proximity UUIDs, visualize the detected signalers, check heatmaps of signal strengths and filter access points or beacons that should not be used for the IPS. The tools are synced with the related infsoft Calibration Apps and are exchanging the calibration information.

Administration of Indoor Localization

The infsoft administration tools provide useful functions for managing the deployed indoor positioning system.

In order to simplify the administration of the beacons within your location, the infsoft Beacon Management can be used. You can maintain and register beacons, check their position within the map and monitor the battery status including historical data such as downtimes.

Within the Locator Nodes Management, you can register and organize the infsoft Locator Node hardware in your location. You can set up groups, push firmware updates to the nodes, configure scan intervals and check on the current scans of the Locator Node. The management platform also provides an overview over any downtimes and can be configured with alert mechanisms.

With the infsoft Device Management, you can check on different attributes of devices by entering the UID or MAC address. The information can be provided by an application or the infsoft Locator Nodes and can cover e.g. the current coordinate, last seen timestamps or vendor details. You can also add different properties to tag the device.

The infsoft Administration Portal offers a variety of configuration possibilities that are available for super users. You can manage registered users, give them access to specific tools and check on the status of backend systems such as the tile service, infsoft Automation Engine and infsoft Location Analytics.

The infsoft Search allows to check on all information that has been detected related to a specific device or location. You can search for UIDs, MAC addresses or sort the data by location to get an overview over the transferred data. Beside the device attributes, the current position of the device can be visualized.

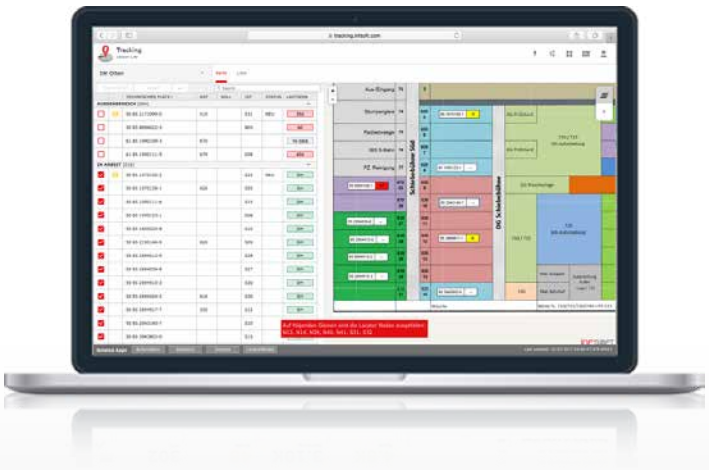
infsoft Diagnostics provides an overview over the status of all server instances and their activities. Users can check on possible downtimes and historical data.

Data Processing & Output

The processing and output tools from infsoft enable real-time analytics, tracking and geofencing.

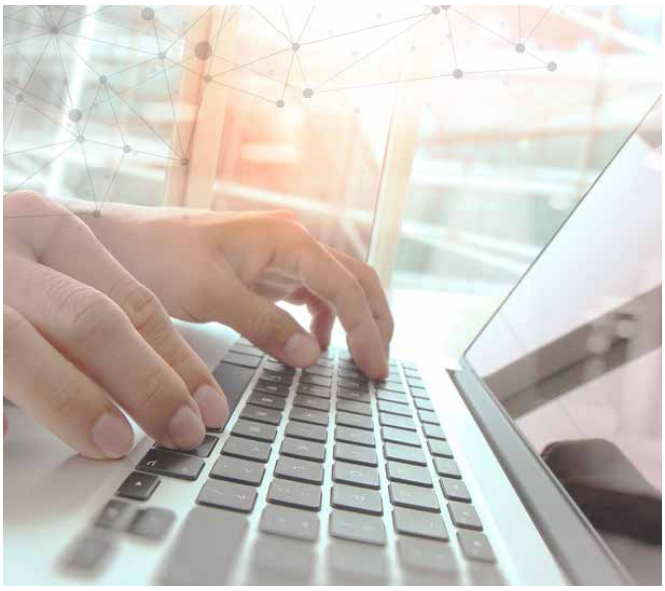
infsoft Indoor Analytics visualizes detected devices within the floor plans and enables real-time monitoring of motion profiles. You can measure frequencies in specific areas, create time- and location-related analyses and combine the system with the infsoft Automation Engine to enrich your data. The live scripting engine can filter information or visualize data links in real time and in retrospect. The tool also provides heat map visualization and route tracing.

Real-time visualization of the position of specific devices is enabled by the infsoft Tracking engine. You can add attributes to a device (e.g. mail address, name etc.), organize devices in groups and send push notifications to selected users. The engine can also be used for asset tracking and can be linked with other tools such as the infsoft Automation Engine to define alerts when a device enters / leaves a defined area.



infsoft Indoor Tracking

The infsoft Automation Engine allows for the definition of various geo-based triggers along the process chain in real time. The automated actions to be triggered can include alerts, notifications (push, email, ...), door locking / unlocking, just to name a few.



SDKs & Web Services

infsoft's technology is also available as plugins for integration into third-party apps. The plugins contain indoor positioning, indoor navigation & routing, 2D/3D building maps and GEOItems. The determined position is issued as virtual GPS coordinates and can be used as such in the app for your own purposes. The SDK (Software Development Kit) is currently available for the Android and iOS mobile operating systems and as an HTML5 plugin. In addition to a native implementation, the use of frameworks such as PhoneGap or Xamarin is also possible.

infsoft's products can also easily be adapted to different system environments. The infsoft web services allow fast and efficient data integration via REST/SOAP interface.

infsoft Developer Hub

The infsoft Developer Hub gives developers access to the full range of functions of the infsoft LocAware platform®. The hub provides API explorer capabilities, code samples and comprehensive guides and documentation to help start working with the platform as quickly as possible.

4 | Industries & Examples of Use

Indoor positioning and services are not restricted to any specific industry – the fields of applications are limitless. Nonetheless, you can point out several industries that are particularly embracing this technology and its benefits.

Industrial Areas

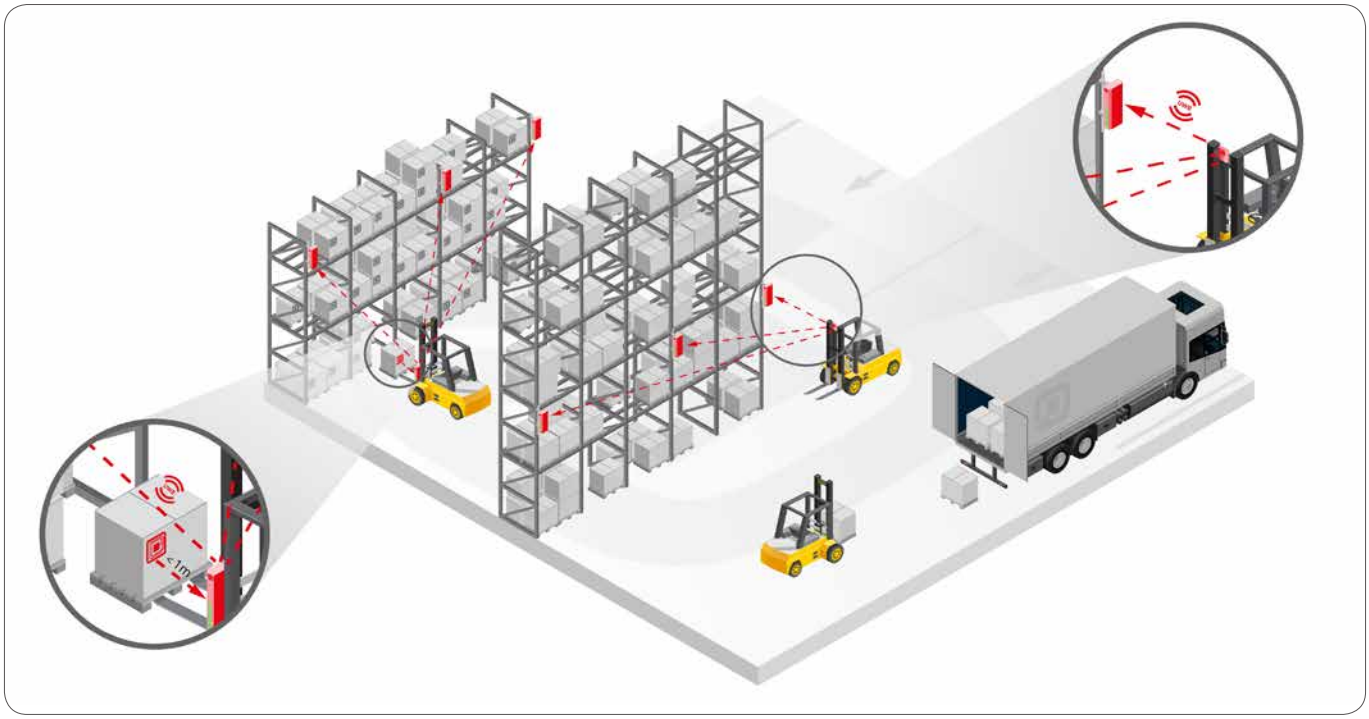
infsoft offers tracking solutions in complex industrial areas. A Real-Time Locating System (RTLS) provides location-relevant data for operators, making the logistics process faster and smoother. An RTLS can not only help with productivity enhancement, but also with real-time decision support and the identification of hidden costs.

Advantages for operators

infsoft provides you with solutions for the monitoring of mobile goods. Whether it is pallets, forklifts, robots or equipment inside complex industrial areas – the tracking solution detects all required goods and allows for seamless tracking. One possible application scenario is tracking pallets along the supply chain in order to monitor the whole process including incoming and outgoing goods, amount, delivery date as well as actions at the point of sale. All data can be accessed at any time via a web-based portal or a standalone app and can also be integrated into existing ERP systems.

Advantages for security administrators

infsoft's indoor tracking solutions offer an operations control system for plant security, which sends the positions of staff and objects to the control center in real time. Security services staff who is located in the vicinity of certain events can be directly assigned to patrols. An alert function notifies the control center as soon as a security-relevant area is entered by a non-authorized person. Thanks to the analysis of movement profiles inside and outside the building, detailed data is available that can be used to undertake refinements to the security concept. Should goods, equipment and vehicles leave a certain area without permission, a warning mechanism can be triggered via geofencing (theft protection). Furthermore, user-specific areas can also be created with individual access authorization.



Tracking of floor conveyors and goods using Ultra-wideband (UWB) and RFID

Airports

When business or leisure travelers go on a trip by plane, they want to keep the waiting times to a minimum and make good use of it. As an airport operator, it is your goal to offer passengers a trouble-free and comfortable stay. Shops and restaurants wish for passengers who have enough free time to consume. All of those needs can be better satisfied by infsoft's branch solutions.

Advantages for passengers

People who travel infrequently may need support in complex infrastructures like airports.

This is where the benefits of indoor navigation become apparent. It shows the exact routing from car park or railway station to the terminal. It is even possible to implement intermodal door to door navigation. When passengers cover the distance quickly, there still remains enough time to discover shops or take a break in a restaurant. Merchants can push tailored advertising directly to the smartphone and offer a lot of added value for the customer. For example, it could be a coupon or a custom-fit offer. Back from the journey, the airport app helps passengers to find back to their car or public transportation. Business travelers have all information concerning their flight and their boarding pass in their pocket and can quickly find a place to work and relax.

Advantages for stores and restaurants

Merchants can push custom-fit offers directly to the smartphone of interested clients: For example, those who have already visited this or similar shops. And for sure everyone is delighted by a discount of his favorite shop. In addition, you learn a lot about visitor flows in or nearby the store. Large shops can also use indoor localization for asset tracking, for example in order to improve theft protection or logistics.

Vehicle and equipment monitoring at an airport using Bluetooth Low Energy (BLE) and GPS

Advantages for airport operators

The advantages for merchants and passengers listed above improve customer satisfaction. Using indoor location analytics, operators can even get detailed information about the stream of visitors. These data can be used as a substantial argument when leasing floor space. It can also help your security staff: As soon as somebody enters a restricted area or when certain areas are overcrowded, predefined actions can be triggered.

In addition, a tracking system provides real-time location information about vehicles and equipment and contributes to improving operational productivity at an airport. Such a solution can be implemented indoors and outdoors and ensures safe and efficient operation and the best possible utilization of equipment (this can include motorized and non-motorized assets, e.g. ground support equipment, cleaning machines and baggage carts). Operators can be alarmed if speed, idle, or location violations occur,

can get reports based upon the assets' historical activities, review utilization, and identify underutilized assets.

Railway Stations

Modern railway stations must satisfy high requirements: Of course, it is extremely important that passengers reach their destination fast and safe. Especially people with reduced mobility may welcome support. The large number of merchants wishes for a good platform to present themselves and the possibility to realize location-based advertising. For the station operator, a lot of opportunities arise considering facility management.

Advantages for travelers

Particularly on longer journeys with several changeovers, things sometimes don't go as planned. Platform changes or delays don't cause so much stress when the passenger is informed about it as early as possible. Passenger applications for smartphones can offer this via push notifications and real-time schedule updates. Being able to book a ticket whilst travelling and having a precise routing towards the right track may save the passenger some valuable minutes. It is even possible to implement intermodal door to door navigation including public transport. Passengers arriving by car can be shown the best possible car park – including a transparent overview of parking fees. If there is any time left in the station, the app helps passengers to quickly find the way to a certain shop or food stall.

Advantages for merchants and restaurants

Merchants can send their potential customers tailored offers – for example picking those who have already been to similar shops or who are returning visitors. And for sure everyone is delighted by a discount of his favorite shop pushed directly on his smartphone.

Advantages for railway station operators

Using infsoft's indoor location analytics, station operators gain a lot of information about visitor flows inside the building. With a clearly arranged web interface, they see much frequented areas and can take action if it tends to become overcrowded. Based on these data, a lot of further functions can be realized.

Intermodal travel planner using Bluetooth Low Energy (BLE)

Health & Care

Indoor positioning systems can not only be beneficial for patients, but also for hospital operators: Mobile medical equipment can be found quicker, staff is being relieved, hygiene rules controlled, itineraries analyzed, appointments coordinated and costs reduced.

Advantages for patients and visitors

Most people who enter a hospital want to reach their destination (e.g. the emergency room, the cafeteria, a treatment room or a patient room) as fast and as easy as possible. An app for patients meets these requirements. In a clear 2D or 3D map, the user can see his/her current location and navigate to a chosen destination – barrier free, if desired. An integrated calendar reminds him of treatment appointments in time and shows the way there. When an appointment is postponed, a message is being sent – this way, everyone's waiting time becomes shorter. Additionally, all services which a hospital offers can be integrated (for example meal selection, TV and phone card booking). The growing sector of medical tourism can profit from these applications as well, since they facilitate orientation in foreign environments.

Advantages for hospital operators

infsoft's solutions follow the internet of things (IoT) approach. More and more things are interconnected and facilitate people's work. Tracking mobile equipment, for example medical devices and hospital beds, ensures preventative maintenance, inventory control and prevents loss and theft. An indoor positioning system for hospitals can be integrated into third-party systems, for example hospital information systems. Possible applications include coordination of appointments and waiting times (leading to saving of time for doctors and patients), monitoring of patients, indoor navigation for patients and visitors, transmission of patient data across several medical stations, control of hygiene regulations, and relief of triage nurses in the emergency room.

Monitoring and asset tracking in the healthcare sector using Bluetooth Low Energy (BLE)

Offices

Indoor positioning and indoor navigation can make the management of large offices a lot easier. Visitor- and invitation management, workplace management and access control systems, among other features, can lead to simplified internal processes and reduced costs.

Advantages for companies

Using an indoor positioning system can create added value for staff and visitors. Visitors can be routed directly to their respective contacts (invitation management). Optional tracking of the movement profile can be realized without breaching data protection policies. In addition, a location memory function for cars (car finder) and the integration of public transport facilitate the arrival. In order to help visitors and new employees orientate themselves in the foyer, the maps can be integrated into terminal solutions.

In a control center, you have a comprehensive overview of your staff's location and can therefore delegate tasks more efficiently. Available staff near a location can directly be assigned tasks using push notifications. Furthermore, additional geo-based information can be collected and forwarded, meaning that, for example, a length of stay analysis can be realized.

Advantages for employees

Within an indoor navigation app, users can search for the offices of individual employees or unoccupied meeting rooms, which can be booked and navigated to. Using the "Colleague Finder" function, employees can share their location with each other and thus better coordinate their work. Company news, messaging, canteen plans and a parking space finder are other useful features.

Location-based employee services using Bluetooth Low Energy (BLE)

Automotive

Mainly due to the high-quality standards that are demanded in the production cycle, the automotive industry is highly advanced in the adoption of precision automation technology. Indoor positioning is one such technology that has made significant forays into the industry. Dealerships and service centers can also benefit from indoor localization since it helps making the customer journey as smooth as possible.

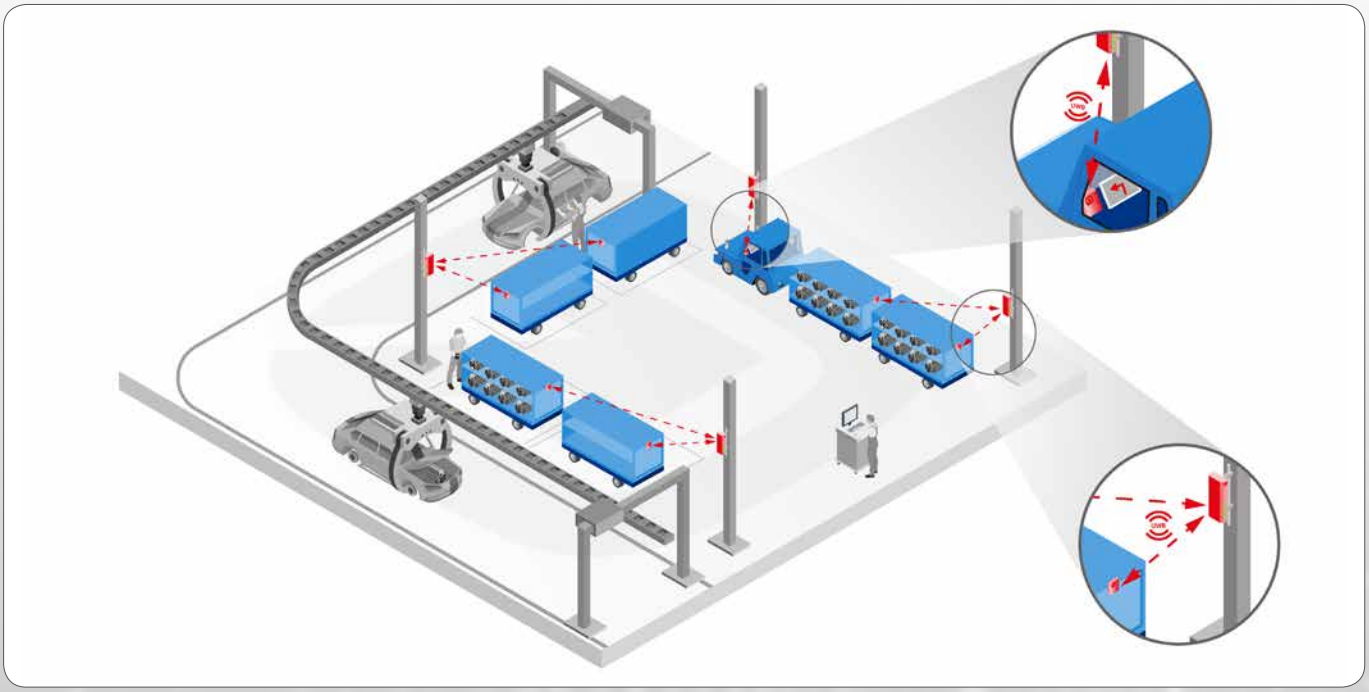
Advantages for manufacturers and suppliers

infsoft's solutions span the entire automotive manufacturing chain. They may be used for vehicle identification and tracking, quality control in production or asset management. A Real-Time Locating System (RTLS) increases manufacturing flexibility and access to real-time production information. A precise tracking solution can allow for a smooth production process and make sure that supplying material to the assembly workstations runs smoothly. Workers can check at any time whether they are still on schedule. Automatic calculations determine whether a material supply will be delayed, which makes it possible to initiate countermeasures in due time.

Advantages for dealerships, workshops and service centers

Car dealerships and service centers can optimize internal processes and customer experience by the use of an indoor positioning system. If the arrival of a car of an (existing) customer is captured, a message can be triggered that is sent to responsible employees who can make preparations to ensure an optimal client experience. Furthermore, the status of a vehicle within the repair / maintenance process can be tracked, which allows a more efficient organization of the maintenance procedures.

Salespersons can get access to the current position of individual cars via app and can use a filter to browse cars that meet certain criteria. The time a car has been standing in the showroom is measured and automatically influences the selling price in all digital systems. Data about itineraries and dwell time of clients can also be accessed. Thus, it is possible to determine which days and times are most popular and which cars attract a lot of interest.



Process optimization in automotive manufacturing using Ultra-wideband (UWB)

Retail

infsoft's solutions can offer operators, shops and customers real added value. They help retailers to increase sales, profits and customer satisfaction. A good mall navigation app improves the shopping experience and increases revenues. Location analytics provide reliable data concerning visitor flows in the building.

Advantages for customers in shopping centers

Shopping center apps improve the shopping experience. Its functionality is not limited to display the latest offers and a list of shops and points of interest. It can also guide customers there – if desired even with means of augmented reality. Additionally, it can recommend offers that might be interesting for them – based on previous stays or purchases.

Advantages for mall operators

A mall navigation app can help customers have a better shopping experience – with the help of routing or location-based marketing. For example, an offer or a coupon can be sent to the smartphone of a customer who is near a certain store. This kind of information is customized and offers him individual added value instead of bothering him with unsuitable advertising.

Using indoor location analytics, mall operators can measure and analyze visitor flows easily. The security department can also take advantage: They can receive a message when people enter restricted areas or when certain sectors are overcrowded.

Advantages for shop owners

Shop owners can easily learn a lot about their clients: How many visitors are near my store at a certain time, how many enter it? How do they move inside? Additionally, they can make use of precisely targeted location-based marketing: For example, purchasing incentives can be sent on the smartphones of a selected group.

Indoor navigation and person tracking in a shopping mall using Bluetooth Low Energy (BLE)

Trade Fairs

Visitors to trade fairs often struggle to keep an overview. Modern indoor navigation solutions can solve this problem. A cross-channel trade fair solution provides added value to trade show organizers, exhibitors and visitors.

Advantages for trade show organizers

The intention of a trade show organizer is to create an attractive event both for visitors and exhibitors. A trade fair application provides information about exhibitors, services, public transport and framework programme. Personalized content matches the right visitors and exhibitors. Using infsoft's analytics engine, you can analyze visitor flows, obtaining precise information about hot spots and preferred routes.

Advantages for exhibitors

Of course, exhibitors have the possibility to present themselves in the trade fair app, including pictures, contact data and description. Furthermore, they can use location-based marketing in order to get the attention of the matching visitors. The analysis of visitor flows makes it possible to choose the best stand location.

Advantages for trade fair visitors

Indoor positioning in exhibition halls helps visitors find the way to certain stands. The app can be personalized, which means that exactly those stands can be highlighted on a map which are interesting for the individual app user. Visitors also benefit from features like an event calendar and the arrival and departure times of public transportation.

Challenges

Due to the large, open halls and the booths which might undergo some (last-minute) changes, trade fairs present a challenging environment for indoor positioning technology. Installation can be problematic because you have to deal with short set-up periods. When installing beacons in a space with lots of Wi-Fi signals, you have to pay attention to avoid interferences by not using the same channels which is tricky, as exhibitors are often configuring their networks as they like.

Indoor navigation and staff tracking using Bluetooth Low Energy (BLE)

About infsoft

infsoft GmbH, located in Großmehring near Ingolstadt (Germany), has been offering solutions for indoor navigation, indoor analytics, indoor tracking and location-based services since 2005. In addition to comprehensive solutions for major clients, infsoft also provides developers with access to its core technologies via scalable Software Development Kits (SDK), enabling integration with third-party applications. infsoft's client base includes Frankfurt Airport, Swiss Federal Railways (SBB), Siemens and Roche.

Indoor positioning systems enable better orientation in complex buildings and allow new applications in the field of geo-based solutions and location-based marketing. "Smart connected locations" is infsoft's guiding principle. All backend tools and collected data are linked and exchanged in the infsoft LocAware platform® to create added value – going far beyond the blue dot on a map.

infsoft
smart connected locations

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