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What’s New in Real-Time Location Systems?

Indoor location technology is reaching market, but wireless solutions are needed to achieve the accuracy and reliability that users want.

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Real-time location systems (RTLS), which enable devices to determine location in the absence of GPS, are gaining popularity. Google is promoting Google Maps indoors, and Apple acquired WiFiSLAM and announced iBeacons. Every week, indoor location application trials are running in museums, malls, airports, and casinos. However, we haven’t seen smartphones that can track their locations indoors as accurately and reliably as they can outdoors with GPS. Outdoors, users can see their locations move smoothly straight down the road, but today’s indoor location systems have trouble knowing which aisle a consumer is in at stores. To understand the new technologies coming to market that can help make this happen, an overview of current RTLS technologies is required.

The first approach is used by most smartphones when GPS is not available, and is used to estimate the location by looking at the signals received from nearby cellphone antennas or Wi-Fi access points. It retrieves the estimated locations of those antennas or access points from a database, and triangulates them based on signal strengths.
This approach has an advantage of working everywhere, as long as the estimated locations are available for antennas and Wi-Fi access points nearby. This approach can be inaccurate, because the estimated locations of antennas and Wi-Fi access points are only rough estimates, and the device cannot determine how close it is to an antenna or access point since it has no information about objects in the area that might be obstructing the signal. There are some efforts to improve this approach, but systems of this sort have the advantage of generality and the disadvantage of inaccuracy.

The second and most common approach in apps being rolled out in stores and museums is for the app developer to walk through the site and gather “signal fingerprints.” This database of signal fingerprints is then used by an app to guess its current location based on the signals that it receives, which is more accurate than triangulation since the fingerprinting accounts for obstructions and other things that affect signal strengths.
A lot of work to gather the fingerprints at each site is required. Moreover, Wi-Fi signal strengths vary and are not precise enough to distinguish different places that may have very similar signal strengths from the same set of Wi-Fi access points. Systems of this sort tend to be accurate within 5 to 7 meters, and have challenges in big areas with sparse Wi-Fi coverage.

The third approach, sensor fusion (also called inertial navigation or dead reckoning), is now reaching market. In this approach, an application tracks its location indoors by sensing its movements using the sensors in the phone, such as accelerometers, gyroscopes compasses, and barometers. When the sensors indicate that the phone moved north for 10 seconds at two meters per second, the phone updates its location to be 20 meters north of where it was previously. This is conceptually an ideal approach because it doesn't rely on external signals, but in practice the sensors in smartphones have tiny errors that add up over time to significant discrepancies. Also, software applications that check the sensors every fraction of a second may miss changes that happen in between polling. In practice, this approach is often combined with other approaches, so that a device can use radio signals to compensate for errors in the motion tracking.

Due to the tradeoffs involved in these approaches, many applications have combined them in attempts to achieve the benefits of all, but most of these apps have only achieved an accuracy of 5 to 7 meters. While a 5- to 7-meter accuracy is good, in practice this means that an application might not know which aisle of a supermarket the device is in, or which hospital bed a nurse is standing near. This 5- to 7-meter accuracy also fluctuates over time.

BLE・ BASED BEACONS

Recent developments in RTLS focus on the addition of dedicated radio hardware. These radio "beacons" are deployed around a site, and the signals that they send or receive can enable devices to determine their location more accurately than signals from previously-existing Wi-Fi access points or motion sensing. The most common wireless protocol for positioning beacons is Bluetooth 4.0, also known as Bluetooth Low Energy (BLE). BLE is very common on iPhones and the newest generation of Android smartphones.

Many BLE-based beacon positioning systems, including those in which radio beacons were added to systems that had previously used Wi-Fi signals, simply deploy the beacons and incorporate their signals to the collections of signals in their fingerprints. BLE beacons certainly add accuracy when used in this way, and enable systems to work when Wi-Fi signals are unavailable, or on phones in which Wi-Fi received signal strength data is unavailable. However, the results are not more accurate than fingerprinting-based systems in general.

Other BLE systems achieve better accuracy using trilateration, the process of determining absolute or relative locations of points by measurements of distances, some by adding information in the wireless transmissions that enable more accurate positioning.

CHALLENGES OF LOCATION POSITIONING

Inherent challenges to location positioning using Bluetooth or any narrowband radio system remain. First, the increased signal length in a narrowband transmission reduces the accuracy of time-of-arrival measurements. Second, when there are multiple paths of arrival for a signal, including reflections and interference, narrowband modulated signals are likely to overlap with themselves. Third, when signal strength indicators are used, up to 10 percent of them will vary, requiring some sort of averaging or other selection process.

Other radio systems can solve these problems.

IEEE 802.15.4a is an ultra-wideband (UWB) protocol that was designed specifically to include time-of-arrival computation support, originally as a means of overcoming multipath propagation. This can be used for location positioning, providing advantages in many of the challenges found in Bluetooth. Wideband pulses are much shorter than narrowband ones, and have sharp slopes resulting in less noise and more precise time-of-arrival measurements. Wideband also has transmissions in a smaller percentage of the frequency range, reducing the chance of signal interference.

All of these factors enable 802.15.4a to compute precise time-of-arrival measurements and give distance measurements within five centimeters, which can be multi-laterated to determine a location position to an accuracy of around 10 centimeters. This positioning is based fully on standard-compliant 802.15.4a.

In industrial deployments, this level of accuracy opens up a variety of applications. Location positioning, with this high level of accuracy, can track which drug cabinet a person is standing in front of, and guarantee that the medical staff is standing at the hand-washing station every few minutes.

New consumer applications are also possible. Imagine if an in-store shopping application knew not only that a customer was walking down aisle four, but knew that they were standing in front of a certain brand of a particular product. All of these applications will work much more effectively when location positioning is accurate within tens of centimeters.

The downside is that UWB and 802.15.4a are not yet available on standard smartphones or tablets, so the application will primarily be industrial in the short term.

As it rolls out and higher accuracy location positioning is seen in the market, those applications will provide pressure for its incorporation into new devices.

If the 5- to 7-meter accuracy of today's positioning systems is sufficient for a user's situation, deploying one of the current solutions based on existing Wi-Fi infrastructure may serve their needs. If consumers really want to know exactly where their devices are, precise, reliable, and higher precision indoor positioning is coming soon, as wireless approaches evolve from protocols designed for data transfer to protocols that are truly appropriate for location positioning. **WDD**