MEETING THE **SCALABILITY** CHALLENGE

RADIO TRACKING TECHNOLOGY IS A GREAT ALTERNATIVE TO GNSS WHEN SATELLITES ARE UNAVAILABLE, SUCH AS WHEN INDOORS. BUT HOW DO YOU MAKE IT WORK WELL WHEN THERE ARE THOUSANDS OF OBJECTS TO TRACK? **THOMAS FÖRSTE** OFFERS A SOLUTION

Precise real-time tracking radio technology that works independently of satellite navigation is now being deployed across industries such as mining, manufacturing and healthcare to optimise management, increase productivity and drive compliance with safety regulations. Existing tracking technologies are highly accurate, but it has often been difficult to meet demands for scalability, such as when tracking thousands of objects in a defined area.

The most obvious way to track people, objects and vehicles is GNSS. However, this relies on navigation satellites being visible, which is hardly the case inside buildings,

tunnels or underground shafts. Furthermore, the accuracy of GNSS tracking is typically in the tens of metres, it has a relatively slow response time and is power-hungry, which can be a problem in battery-powered applications.

To address these issues, a neat alternative is provided by precise real-time tracking radio technologies. The basic principle is that an electronic RF transceiver measures the time that it takes a radio packet to travel a certain distance. Multiplying this time by the speed of light (the speed of radio signals) gives us the distance. For example, 1ns of travel time equates to 30cm.

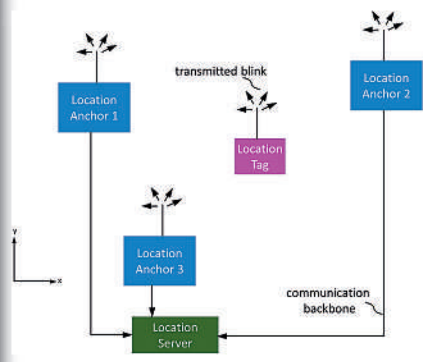
For battery-operated devices, integrated location controllers are required. They usually consist of a transceiver with a digital data interface housed on a single silicon chip. They are small, power-efficient and inexpensive.

An example is nanoLoc, the first location controller launched by nanotron Technologies in 2007. This chip uses chirp spread spectrum radio technology in the 2.4GHz ISM band. More than a million of these devices have been sold and they are still in production. A more recent development is Decawave's DW1000 Ultra Wideband (UWB) location controller, launched in 2012.

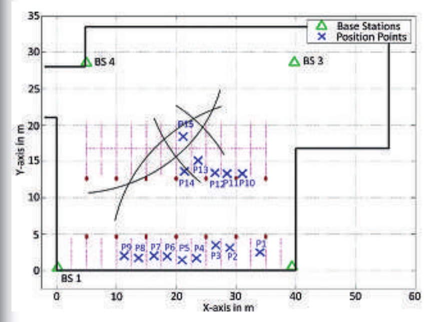
Two approaches

The simplest way to calculate the position of a tagged object is to apply time of flight (TOS) methodology within a network of fixed reference points. These reference points, also called readers or anchors, and tags are all fitted with location controller chips.

TOF location methodology uses triangulation to calculate the distances between the tag and anchor reference points. In two-dimensional space this requires three distance values (see Figure 1). The nanoLOC chip requires approximately 2ms of airtime to measure each distance, meaning that calculating one position requires 6ms of airtime plus the processing overhead for each tagged object. Scalability rapidly becomes a serious issue as the cumulative time consumed by thousands of sequential calculations can quickly balloon out of control and overwhelm the tracking system, just when it is most needed.



TDOA methodology



TDOA trilateration

An alternative solution is time difference of arrival (TDOA), which eliminates the scalability problem and enables the tracking system to seamlessly grow when more tags and anchors are added.

The principle of TDOA is shown in Figure 2. Location tags transmit broadcast messages (blinks), which are received by anchors in known locations. These anchors then generate time stamps for the blinks they receive, recording each one's time of arrival (TOA).

TOA stamps are then transmitted to a location server through a wired or wireless communication backbone. The server then uses these TOA stamps and the known positions of the location anchors to calculate the position of the tag.

The TDOA solution drastically reduces the required airtime. With the nanoLOC location controller, for example, this is only 0.5ms. The process easily accommodates multiple reference points (location anchors) for receiving packets, enabling more than three anchors to be used to substantially improve robustness.

Let's compare TOA with TDOA. With TDOA, the total airtime per position will be 0.5ms even when eight anchors are used, whereas with TOF 2ms would be required for each of the eight anchors, adding up to 16ms of airtime – 32 times that of TDOA. Hence, the more anchors and tags deployed in a system, the greater this difference becomes. That is scalability!

Synchronisation issues

For TDOA to work, of course, the clocks of all the location anchors receiving a signal need to be perfectly synchronised. Earlier implementations used dedicated clock networks to synchronise all the location anchors in a system. However, this was expensive and complex to operate under real production conditions.

To overcome this problem, nanotron developed a patented virtual synchronisation method in which anchors and tags exchange timing information over the air. This eliminates the need for equipment-heavy clock synchronisation networks.

Synchronisation results are reported back to the server and used for calculating tag locations. TOA location blinks are processed using powerful location engine software and adjusted using the time information from the anchors. This means that a TDOA system continuously runs in the background from a single 'virtually synchronised' clock source.

Since it does not require any cell structure or hierarchy of network of readers, TDOA eliminates the need for expensive synchronisation mechanisms, is easy to deploy and scales smoothly.

In one real-world example, this technology has been used by nanotron and ATUT in a tracking system for the Park Thermic mine in Turkey. This system tracks 2,360 miners, as well as equipment and assets in real time, providing smooth 24/7 operation. It is highly scalable and covers tens of kilometres of mining tunnels and four excavation blocks.

"Automation and process optimisation, and the use of advanced tracking technologies has delivered substantial cost savings and improvements in efficiency. However, improved safety in intrinsically hazardous mining environments is a key benefit of TDOA; collision avoidance is but one example," said Michal Szebesta, project lead at the Park Thermic Coal Mine.

Conclusion

Initially, users of satellite-independent tracking technology focused on location accuracy as the key performance metric. It turns out, however, that scalability and flexibility of the solution are equally important.

Any TOF approach quickly hits its limits of scale – the more devices that are added, the more airtime is 'consumed', which puts a natural brake on the system's continued expansion. On the other hand, TDOA scales well and uses a very light yet effective virtual synchronisation infrastructure.

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