

New Developments in Ultra-Wideband

Significant barriers have impeded UWB from being widely adopted in the past, but now—one by one—they're getting knocked down.

Ultra-wideband (UWB) has been a kind of “Cinderella” technology for some time—attractive in many ways, but not fully invited to the technological party. Or, perhaps it's thought of in some circles as the classic “solution in search of a problem.” This article will look at UWB technology, what it's been used for, why it hasn't really become mainstream yet, and why this might change soon.

UWB Technology

As the name suggests, ultra-wideband is a transmission method that involves transmitting over a rather large bandwidth. In quantitative terms, the currently accepted definition by the FCC and ITU is a bandwidth of 500 MHz or at least 20% of the center carrier frequency, whichever of these is smaller.

If one compares UWB with Bluetooth, where applying the above 20% rule would give you around 500 MHz anyway, each channel is in fact only 1 or 2 MHz wide. Wi-Fi channels, operating at a similar frequency, are 20 or 40 MHz wide. Thus, there's a difference of at least an order of magnitude in the channel widths.

This leads to important differences between UWB and more conventional radio transmission methods. The first is that UWB systems can transmit at a lower power level (as defined by spectral density, which is to say the power transmitted in each MHz of bandwidth) than narrowband radio. Indeed, they're transmitting at levels close to the noise floor.

The second is that it's possible to use different types of data encoding. Narrowband systems typically use frequency keying, varying frequency around a central value, amplitude modification, or orthogonal frequency-division multiplexing (OFDM).

The wideband nature of UWB allows for very short pulses (nanoseconds), which enables pulse position or time modulation—essentially, the presence (or not) of a pulse defines a bit of information. More complex OFDM schemes also are

possible. This in turn enables a potentially very high data-rate transmission.

The final point is that the sharp pulses, as defined above, transmitted by UWB make it possible to accurately measure the time of a pulse's arrival, and with more precision than most competing technologies. One can say that the pulse width (duration) of a pulse is approximately $1/\text{bandwidth}$, which works out to 2000 ps. If the time of departure and arrival are fixed, then the distance traveled can be determined.

To quantify, using the speed of light at 3×10^8 m/s, one can simply calculate that 1 meter of travel of a pulse takes 3.3 ns, or alternatively, achieving 1-cm accuracy requires a



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timing accuracy of 33 ps. Thus, the accuracy of any such distance measurement depends on how well the pulse edge can be consistently determined.

In practice, one makes time measurements using specific pulse trains with an achieved accuracy of typically around 200 ps or 5 cm. The limiting factors are the accuracy with which these pulse trains can be determined and the clocking inside the device.

Real-world distance or position measurements are typically made using one of two main approaches: two-way ranging or time-difference of arrival (TDoA). Two-way ranging simply measures the “round-trip” time between two devices to get a linear distance. TDoA measures the difference in arrival time of a pulse from the tag (device to be located) and multiple anchors (receivers at a known location), from which it infers a 3D position. This is like an indoor GPS, only with the signal going in the opposite direction.

Excluding optical methods, UWB offers the best radio-based positioning technology.

Factors Restraining UWB Adoption

So, given all of these possibilities, why isn't UWB technology already ubiquitous? The answer to this lies in the practical issues in implementing solutions.

Although high data-transmission rates are possible, the signal is sensitive to obstructions, which means that in practice one must have a line-of-sight connection. This is a major disadvantage compared to, say, Wi-Fi. At one time, UWB was proposed as a high-speed data-transmission technology, but this drawback was a major issue, shifting the weight of investment to Wi-Fi.

A wideband transmitter/receiver tends to consume significant power. That's not an issue for mains-powered systems, but it becomes problematic for battery-powered devices. Thus, if battery-powered devices are envisaged as part of the ecosystem, UWB may not be the best solution.

For positioning technologies, UWB does have standout characteristics, as mentioned above, where there are few obvious competitors. The main barrier to adoption here has been practicality. Putting a positioning system in place is not straightforward, as it requires a custom infrastructure.

A TDoA system requires multiple anchors with highly synchronized clocks. Then it's necessary to gather data from all of the anchors and sort and combine it in a central system. Installing a UWB system over a large area such as a warehouse is a complex undertaking. Two-way ranging is simpler, but it increases the power consumption by an order of magnitude and can cause other issues in a large system.

A further barrier has been the lack of standards across the industry and the presence of well-known suppliers. Up until recently, the market has been served only by startup companies offering proprietary solutions and little interoperability.

This clearly made all but the most technologically adventurous hesitant to make major investments, as it would be easy to end up with a “stranded” asset due to having chosen the wrong standard and/or the wrong supplier. Relatively low volumes also led to the technology being relatively expensive.

Shifts in the Market

Recently, the market has seen significant changes in several areas, including application demand, market players, standardization, and technical progress. In turn, one major driver of interest to deal with these changes is keyless entry systems.

Keyless entry solutions, or more correctly, wireless key solutions, have been a feature for some time in the automotive market (*see figure*). Unfortunately, these have proved highly insecure. By ensuring the electronic key is truly close to the vehicle, UWB is resilient against the most common hacks (relay attacks) and requires much more sophisticated approaches to break the security.

Driven in part by its resilience to hacks, UWB capability has started to appear on phones. Many in the industry believe physical keys will ultimately become redundant or simply backup devices, and phones will become the dominant device to act as a key. This applies not only to cars, but potentially also for domestic use.

High-end devices from Apple (iPhone 11 and above), Samsung (S21+/Ultra and above), and others from Google and Xiaomi already have UWB capability. Apple's next-generation Air Tags use UWB for positioning.

This would not get us far if we still had a cluster of incompatible standards. Fortunately, the [FiRa \(Fine Ranging\) Consortium](#) is now driving standards, with involvement by all of the above-mentioned phone manufacturers and key chipmakers including NXP, Qorvo, Qualcomm, and others.

The presence of large semiconductor players in the market is another crucial development. Decawave, the most established chip startup company, was bought by Qorvo, and NXP has launched its own device. Apple designed its own chip, and all of these conform to FiRa standards. The risk associated with proprietary technology has therefore largely disappeared.

Semiconductors are largely a volume business—large development overheads see to that—so increased demand and interest drives technological development. The latest generation of devices has much improved performance, particularly in respect to power consumption, making battery-powered devices realistic. Miniature combined UWB/BLE modules such as those from [Insight SIP](#) allow further power savings by the intelligent use of the two radios.

Real-time positioning solutions using TDoA will remain the most challenging application for the reasons mentioned

in this article, and it will take longer to become mainstream. Nevertheless, all of the aforementioned factors will combine to lower resistance to investing in such technology. We have seen with other emerging standards such as BLE that initial projects are simple but become increasingly complex over time.

Conclusion

UWB has long been an interesting technology with some unique characteristics. Major barriers have impeded it from being widely adopted in the past. However, one by one, these barriers are being knocked down. Secure entry offers a relatively simple application in which UWB adds significant value. The presence of UWB chips on phones offers a potential market for device makers (recall how BLE capability on phones arriving from 2011 onwards drove development of that market).

Increased demand for devices will inevitably boost performance and drive costs downward. As the technology becomes established and more widely known, implementing complex solutions such as real-time positioning will be more straightforward.

Technological predictions are never certain. What one can say is the most obvious constraints on UWB adoption are fading. The outlook has never been better.

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