WHITE PAPER

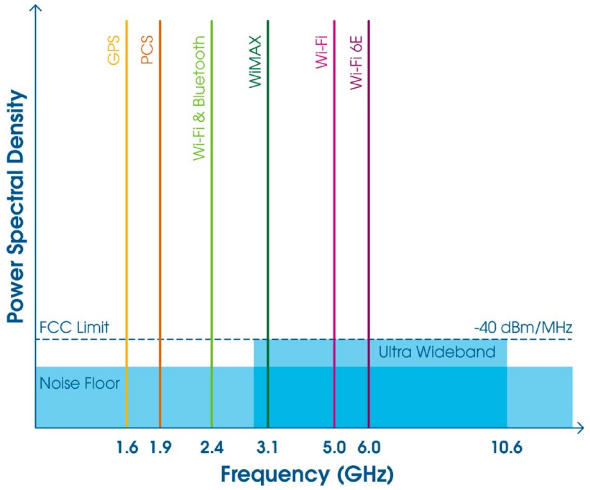
Redefining location, positioning, and security: ultra-wideband technology

flex

Early stumbles

Ultra-Wideband (UWB) was first used by Guglielmo Marconi in the early 1900's for radio communication, but it wasn't until the middle of the 20th century when it came to prominence. At that time, the U.S. government was developing UWB for military applications because it could be used simultaneously as a radar and a communications system.

However, despite its usefulness and the growing interest for industrial and consumer applications, the Federal Communication Commission (FCC) didn't allow the unlicensed use of UWB technology until February 2002. And it did so with strict power emission limits, constraining its usefulness to short distances.



So, 2002 was the true beginning of the development of wireless communication systems for personal devices. At that time, narrowband technologies like Wi-Fi and Bluetooth had not yet been adopted as a global de-facto standard.

The biggest roadblock to those narrowband technologies were their relatively simple signal processing techniques and modulation schemes. The data rates they provided (11Mbps for Wi-Fi, 732Kbps for Bluetooth) were simply not enough to cover the growing needs of data exchange.

By contrast, the large bandwidth available from UWB technology (3.1 GHz to 10.6 GHz) could provide the solution the multimedia industry was looking for as the world entered the era of HD TV.

Short range communication with expected data rates up to 480 Mbps predicted a brilliant future in the Wireless Personal Area Network (WPANs) and digital home applications market. An industry group called WiMedia Alliance was formed to create a standard and promote this technology.

However, UWB never provided the promised data rates. Wi-Fi quickly evolved to provide higher communication speeds that, combined with new video optimized compression algorithms, became the preferred solution for video streaming. As a result, WiMedia Alliance closed its doors in 2010, and this seemed to be the end of UWB.

Down, but not out

However, UWB technology still had unique features to offer, making it relevant for specific applications: the ability to penetrate obstacles, immunity to interference from other wireless technologies and high-precision, real-time location. These capabilities positioned UWB as an obvious choice for enabling location and tracking of people and assets in indoor environments.

Although these capabilities could enable asset tracking in warehouses, factories, and hospitals, or indoor navigation in museums, shipping malls, and supermarkets, obvious roadblocks remained. The high price of the technology at that time, usually linked to a proprietary vertical solution, and the need to deploy a complex and expensive infrastructure, limited its use to spaces like warehouses and factories where the required investment could be justified.

To make indoor positioning and location applications more accessible, researchers attempted to use a combination of Wi-Fi and BLE (Bluetooth Low Energy) as a more cost-effective solution. While using Wi-Fi and BLE also required infrastructure, most of the target locations were already equipped with Wi-Fi, and the necessary hardware for BLE was cheap and easy to deploy.

However, despite everyone's best attempts, Wi-Fi and BLE weren't up to the task. The achievable accuracy with a wireless ranging system is directly dependent on the available bandwidth, and UWB offered 25 and 250 times more bandwidth than Wi-Fi or BLE respectively. This bottleneck meant that Wi-Fi and BLE couldn't achieve truly accurate location tracking.

Change was on the horizon

With each cycle of design and development, UWB became increasingly more accessible. Commercially available low-cost UWB began in earnest with the introduction of the DW1000 UWB transceiver by DecaWave in November 2013, more than a decade after the FCC allowed the unlicensed use of UWB technology.

Other solutions from NXP and BeSpoon soon followed, and the hardware became increasingly accessible. However, the need to deploy an infrastructure and the lack of support in phones and other personal devices meant the work was far from over.

A significant comeback

Though there had been progress made, public interest woke up with the September 2019 announcement that Apple would include UWB in the iPhone 11 with a specifically designed U1 UWB transceiver. This innovation soon encouraged other smartphone makers like Samsung and Xiaomi to follow suit.

Almost instantly, the main hurdle for the adoption of UWB as the location and positioning technology of choice disappeared. Silicon vendors like Qorvo or ST Microelectronics quickly recognized the market opportunity to enter this market through the acquisitions of DecaWave and BeSpoon.

In parallel, the industry started to see the potential application of this technology in areas beyond the traditional location and navigation use cases. For instance, UWB could be used to solve the inconveniences of RFID/NFC (range) or Bluetooth (less accurate positioning) in security access systems.

To proactively avoid isolated incompatible UWB implementations, the UWB Alliance was formed in December 2018. Their initial focus was helping define and promote the IEEE 802.15.4z UWB specification. These efforts added an additional security level to the already existing IEEE 802.15.4a specification, defined in 2007 as a WPAN for data communication of consumer electronic devices. The aim of the new standard was to enhance the accurate position features of UWB.

The UWB Alliance has largely been successful in promoting IEEE 802.15.4z. This standard has been adopted by the Car Connectivity Consortium to define a digital key specification, FiRa Consortium to describe use cases for UWB in the consumer and security access systems domains and OMLOX, a community which aims to define an open location standard for smart factories.

On the consumer side, Apple's U1 chip is now in a wider portfolio of devices such as iPhones, Apple Watches, iPads and AirTags. AirTags are of particular note as their primary use is personal belonging tracking, a capability UWB is uniquely good at.

Apple has also announced plans to open the U1 interface to app developers and sync to the IEEE 802.15.4z standard, making U1 compatible with Qorvo and NXP transceivers. This alignment enables a new range of user location awareness applications, able to behave intelligently depending upon the precisely-determined relative position of the user.

UWB in automotive

At Flex, we recognize the use of Ultra-Wideband is growing everywhere, but most notably in automotive safety and security. We are well-positioned to implement UWB as a clear solution to a difficult problem: relay attacks on keyless entry systems.

Relay attacks occur when thieves remotely replicate the signal communication exchange between a car and its key fob using low-cost radio equipment.

Illustrating the risk, the German automobile club ADAC reported that of 419 vehicles they tested in March 2021, only the 12 models equipped with UWB could not be maliciously opened and operated.

We know the most worrying aspect of relay attacks - they can be used against any wireless system that only uses data exchange as a presence and identification means. This problem extends to not only traditional UHF keyless entry systems, but newer access systems based on Bluetooth or NFC as well.

The additional security available with UWB is intrinsically tied to the technology. The car not only identifies the presence of the fob in its vicinity. It also determines its precise distance by measuring the signal's Time of Flight which cannot be faked in relay attacks or other similar intrusion methods.

We can deploy multiple UWB transceivers and antennas to not only detect the distance and relative position of the key fob outside, but to also possibly locate objects (e.g. smartphones) or passengers inside the vehicle as well.

We've worked with UWB since 2016, and we are ready to implement the technology in a variety of use cases thanks to our experience, reference design, platform and supplier relationships.

We are looking for new applications and opportunities for our customers in automotive, lifestyle, consumer devices and other industries.

For more information, visit **flex.com/connect.**