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Bluetooth 5.1

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Bluetooth is a short-range wireless standard for the interconnection of mobile phones, computers, and other electronic devices. It allows the transfer of files wirelessly between mobile devices and computers. You can pair a smartphone, tablet/laptop, or PC together and use Bluetooth to wirelessly send files back and forth. There have been many revisions and changes to the Bluetooth standard over the years, from Bluetooth 1.1 in 2002, Bluetooth 2.0 EDR (Enhanced Data Rates), the Bluetooth 3.0 HS (High Speed and Ultra-Wideband), to today's Bluetooth 5.1 with direction and asset tracking services.
The Bluetooth Special Interest Group (SIG) https://www.bluetooth.com is the industry group that oversees Bluetooth.

NOTE: The difference between WiFi and Bluetooth is: Bluetooth is primarily used to connect devices without using cables, while WiFi provides high-speed access to the internet.
A major feature in the Bluetooth 5.1 is direction finding, which brings the possibility of absolute positioning of products and things in three-dimensional space to the world of low-power wireless connectivity. However, there will need to be some hardware upgrades to make this technology a reality. This depends on if you plan to use Angle of Arrival (AOA) or Angle of Departure (AOD), which would require the use of phase-based antenna arrays at the Beacon or the Locator devices.
Circuit design considerations would need to be made to account for variables in signal noise, clock jitter, and signal propagation delays. Depending on the system scale, the RAM and especially CPU requirements can be demanding for an embedded system. Many of the well performing angle estimation algorithms require a significant amount of processing power from the CPU.

5.1 is a very important addition to Bluetooth's Low Energy capability arsenal. It's believed it can have a similar impact for indoor navigation, the way GPS did for global positioning. GPS has fundamentally changed the world of traveling and tracking on the macro scale for cars, people, and objects. Bluetooth 5.1 LE direction-finding technology can make a similar impact on the micro scale inside buildings, properties, asset tracking, and many others.

This technology gives you the ability to know where all your assets are at any given time. For example, it gives you the ability to locate expensive equipment in a warehouse, job site, or even to track an item down to 1 centimeter. Imagine, not only knowing in what room you left your keys in, but under which cushion on the couch they are.

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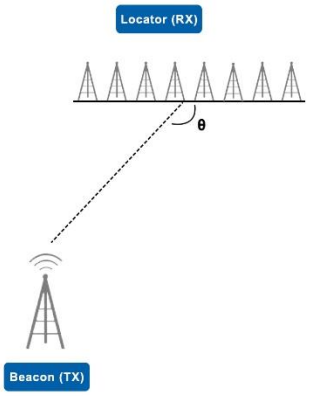
What are the methods and how do they differ.

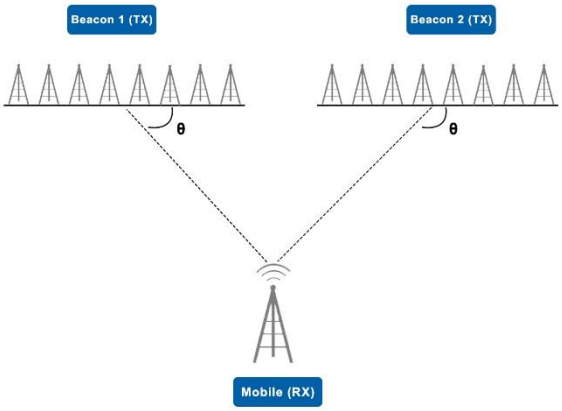
Angle of Arrival (AoA)

- Beacons broadcast (TX) their location to an AoA locator such as a wireless access point
- Locators measure the signal's arrival angle
- Beacons only need a single antenna, can be low power, and simultaneously support additional Bluetooth LE functionality
- Locators require 3 x 3 or 4 x 4 antenna arrays and switches (See Antenna's descriptions below)



Angle of Departure (AoD)

- Beacons transmit AoD information, such as coordinates, using multiple antennas
- Mobile devices, including smartphones receive the beacons and calculates position
- Beacons require 3 x 3 or 4 x 4 antenna arrays and switches
- Mobile devices like smartphones need to support AoD algorithms. Beacons coordinates must be known by the location services system



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Uniform Linear Array (ULA) is a one-dimensional array. All the antennas in the array are on a single line, and you can measure only the azimuth (angular measurement in a spherical coordinate system) angle.

Uniform Rectangular Array (URA) two-dimensional arrays, meaning the antennas are spread in two dimensions (on a plane). You can measure both azimuth and elevation angles in the 3D half-space.

Uniform Circular Array (UCA) is two-dimensional arrays, meaning the antennas are spread in two dimensions (on a plane). You can measure both azimuth and elevation angles in the 3D half-space.

Application: RF & Baseband/MAC Reference Clocking
Both Beacon and Mobile designs incorporate a RF transceiver and a baseband/MAC that operates with a common reference clock input. Some of the more common reference frequencies are: **16.0 MHz, 24.0 MHz, 26.0 MHz, 32.0 MHz, 37.40 MHz, 38.40 MHz, 40.0 MHz and 32.768 kHz**. These are used by RF-ASICs that support wireless standards like Bluetooth Low Energy (BLE), Bluetooth, WiFi, and IoT or other standards being used in wireless applications.

Since these applications require tight frequency stability and low Equivalent Series Resistance (ESR) these crystals are designed to meet the high requirements that are essential for the performance of the wireless protocol.

NOTE: The equivalent series resistance (ESR) is one of the most **important** characteristics of a crystal. The ESR of a crystal blank is inversely proportional to the size of its crystal element. Therefore, when crystal blanks are miniaturized, the ESR value increases. ESR is expressed in ohms (Ω), and the lower this number is, the better the crystal. As ESR gets higher, the start and run load to the amplifier gets higher and can hinder oscillator start and run, especially at low temperatures. Lw ESR Crystals require less power to start up and keep running. That makes it more appealing to the design engineer.

The following products have been engineered to meet all wireless clocking requirements.

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Image	Model Info	Package Code	Min. Freq.	Max. Freq.	Size LWH (mm)	Temperature Range	Stability	Data Sheet
	ECX-1048	48	24 MHz	54 MHz	1.2 x 1.0 x 0.33	-40 ~ +85°C	±10 PPM	Data Sheet
	ECX-1247	47	24 MHz	80 MHz	1.6 x 1.2 x 0.3	-40 ~ +125°C	±20 PPM	Data Sheet
	ECX-1637B	37B	16 MHz	50 MHz	2.0 x 1.6 x 0.45	-30 ~ +85°C	±10 PPM	Data Sheet
	ECX-1210	1210	32.768 KHz	32.768 KHz	1.2 x 1.0 x 0.5	-40 ~ +85°C	-0.04 ppm /°C²	Data Sheet
	ECX-16	16	32.768 KHz	32.768 KHz	1.6 x 1.0 x 0.5	-40 ~ +85°C	-0.04 ppm /°C²	Data Sheet
	ECX-12R	12R	32.768 KHz	32.768 KHz	2.0 x 1.2 x 0.6	-40 ~ +85°C	-0.04 ppm /°C²	Data Sheet
	ECX-31B	34B	32.768 KHz	32.768 KHz	3.2 x 1.5 x 0.9	-40 ~ +85°C	-0.04 ppm /°C²	Data Sheet