Location/positioning/ranging using UWB/BLE

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Short-range location/position

Wide-area GPS/equivalent services have made a big impact on many associated applications

Indoor navigation for both personal and industrial use cases could be the next big thing

Proximity services, finding objects, keyless entry and many such things are also on the radar for both personal and commercial use cases could be a big business opportunity

Candidate technologies

WiFi APs present everywhere..smartphones/ laptops/tablets/.. All have WiFi..most of the focus is on high-speed data transfer.. Power hungry

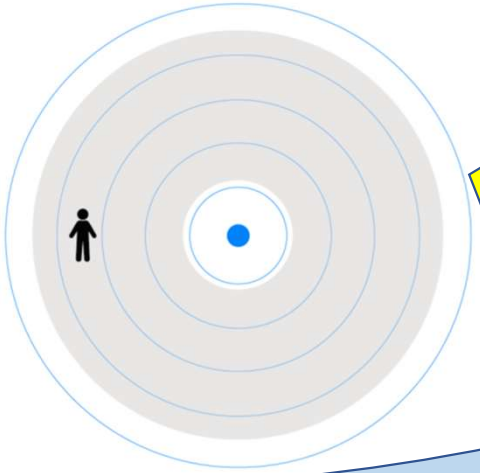
UWB based on 802.15.4

Specialized technology for precision location/ positioning

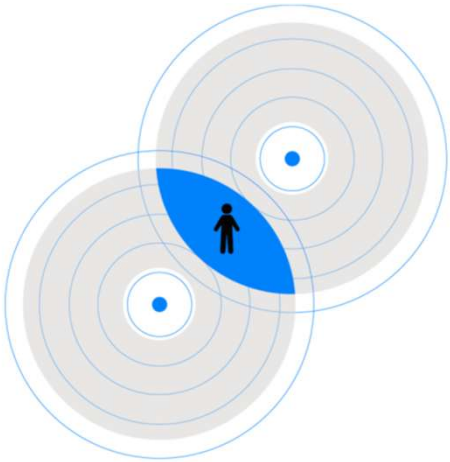
Bluetooth® SMART READY

Strong presence in phones/laptops/ watches..etc. .. Power efficient..IOT friendly technology

Approaches - RSSI



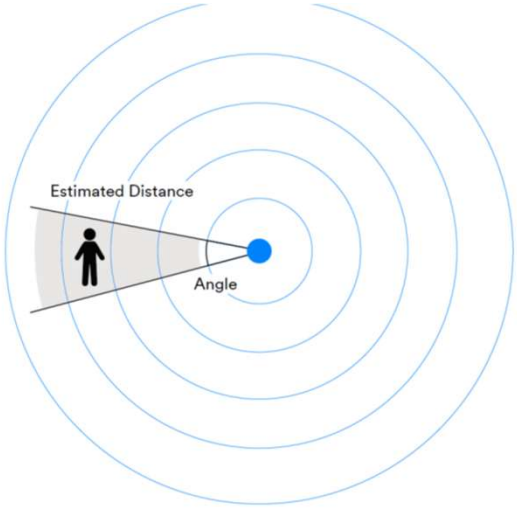
Has been used in many WiFi and BLE based solutions

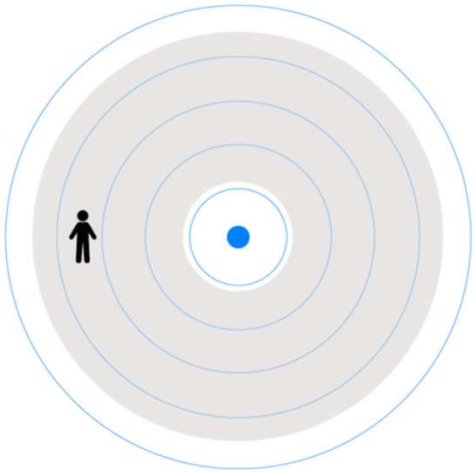


RSSI based positioning can give an idea of distance which can be useful in some applications..environment can have an effect on this

RSSI measurements by independent entities can help nail down location better but environment impacts and placement of reference nodes for making RSSI measurements have to be taken care of

Approaches – Other information



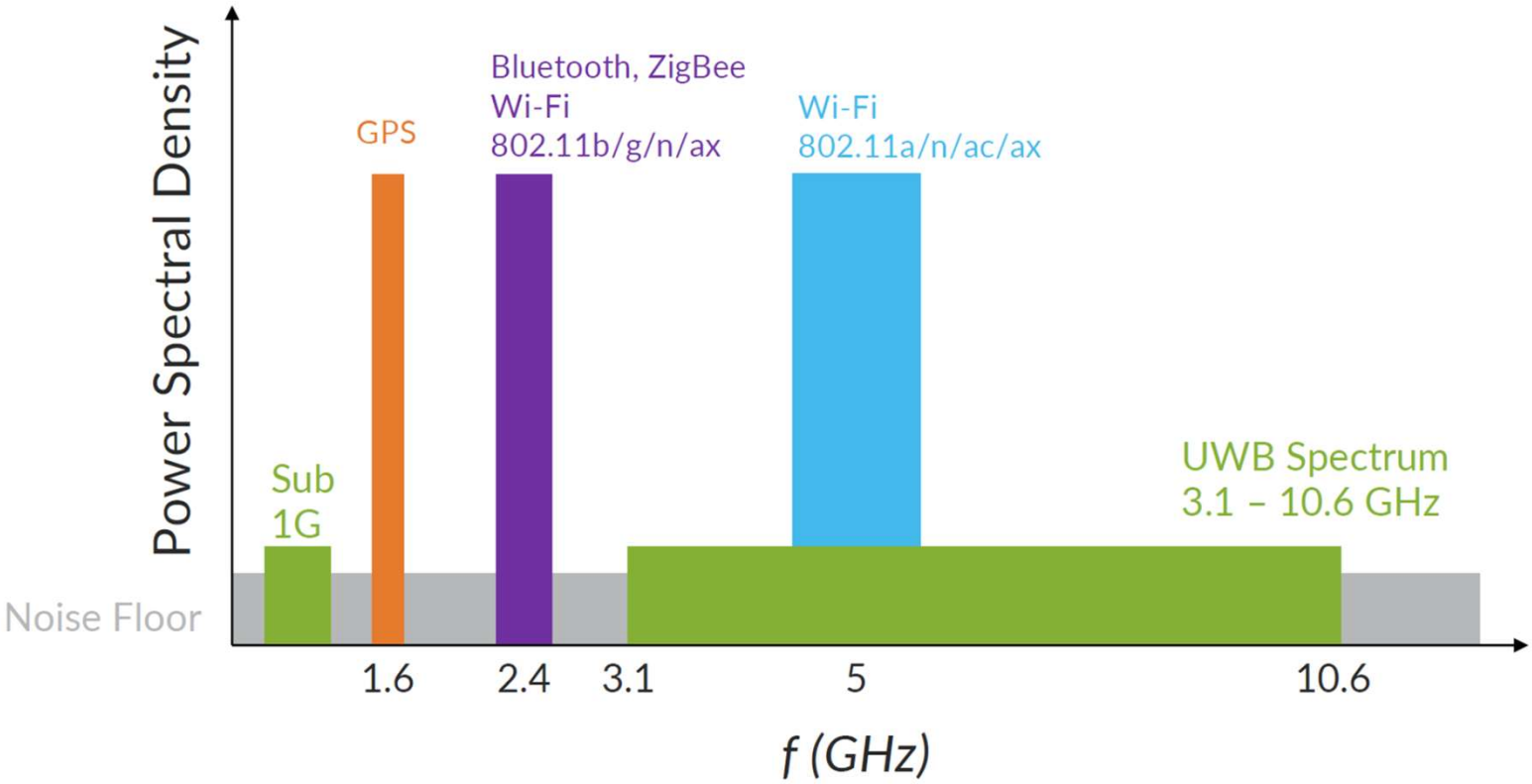


Angular information useful in improving accuracy of location for many applications

Use TOF information to obtain instead of RSSI; can avoid environment related challenges

Security/privacy are important and crucial for location based services.. Since signal's time/frequency/angle are being leveraged, protection from attackers has to be thought through carefully; phase based approaches coming

UWB Spectrum



UWB and 802.15.4 standards

802.15.4a-2007

- Completed in Aug.,2007
- 1st standardization of UWB
- Evolved from OFDM-based to use impulse radio (UWB-IR),2ns pulse width
- Indoor positioning for WSN or IIoT

802.15.4-2011

- Completed in Sep.,2011
- Decawave chipset based on this spec on market

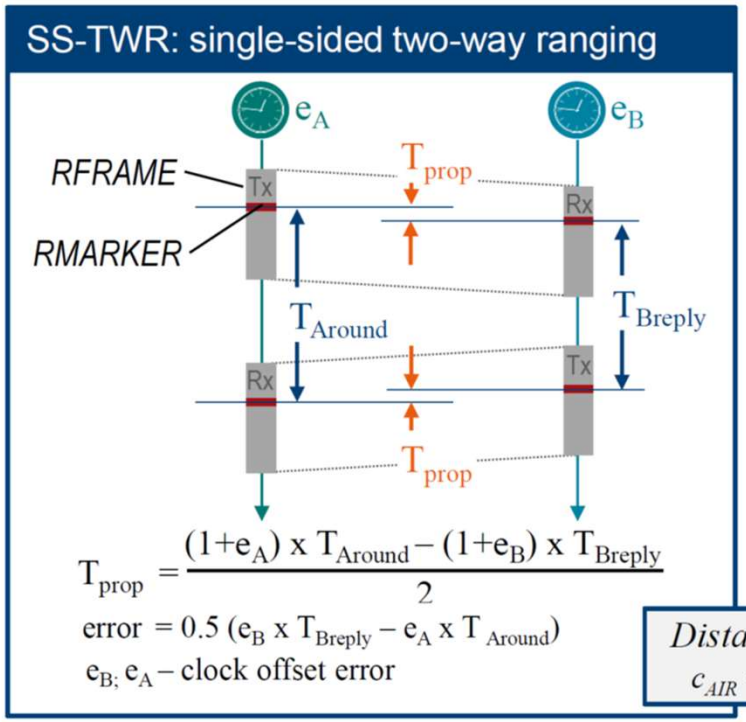
802.15.4-2015

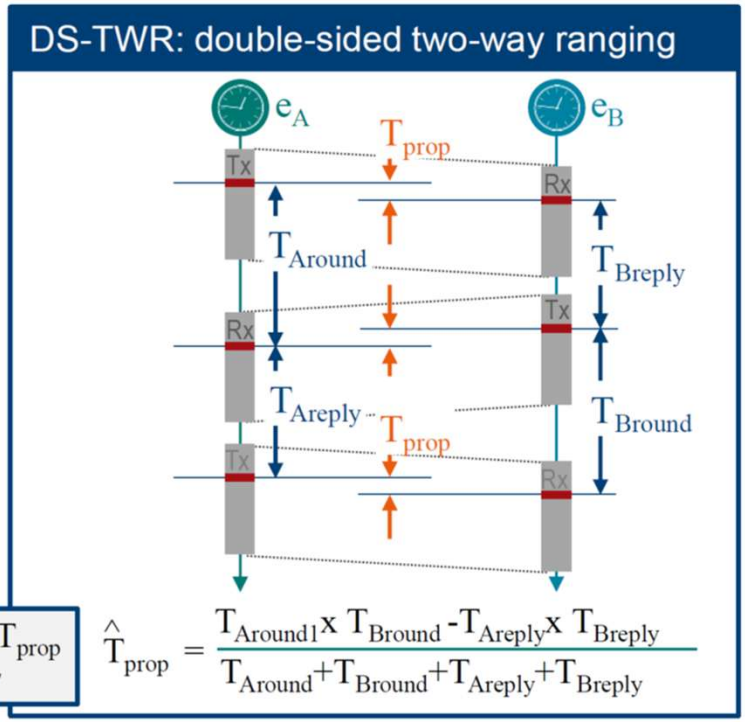
- Completed in Dec.,2015
- 2 UWB PHY defined:
  - HRP (High Rate Pulse) asa/802.15.4-2011
  - LRP (Low Rate Pulse) as 802.15.4f-2012(aka Active RFID)

802.15.4z-2019

- Active working group(TG4z)
- Enhancements of Security extension to HRP & LRP UWB PHYs & MAC
- Introduce ERDEV (Enhanced Ranging Device) mode including BPRF or HPRF

SS-TWR vs. DS-TWR





$Distance = c_{AIR} \times T_{prop}$

$c_{AIR} = 29.97\ cm / ns$

A initates ..B responds..errors in clocks can lead to errors in distance measurements

A initates ..B responds..then A and B engage to obtain better estimates

UWB based locationing

Typically short-range with lots of interesting protocol enhancements possible on top of the basic ranging mechanisms

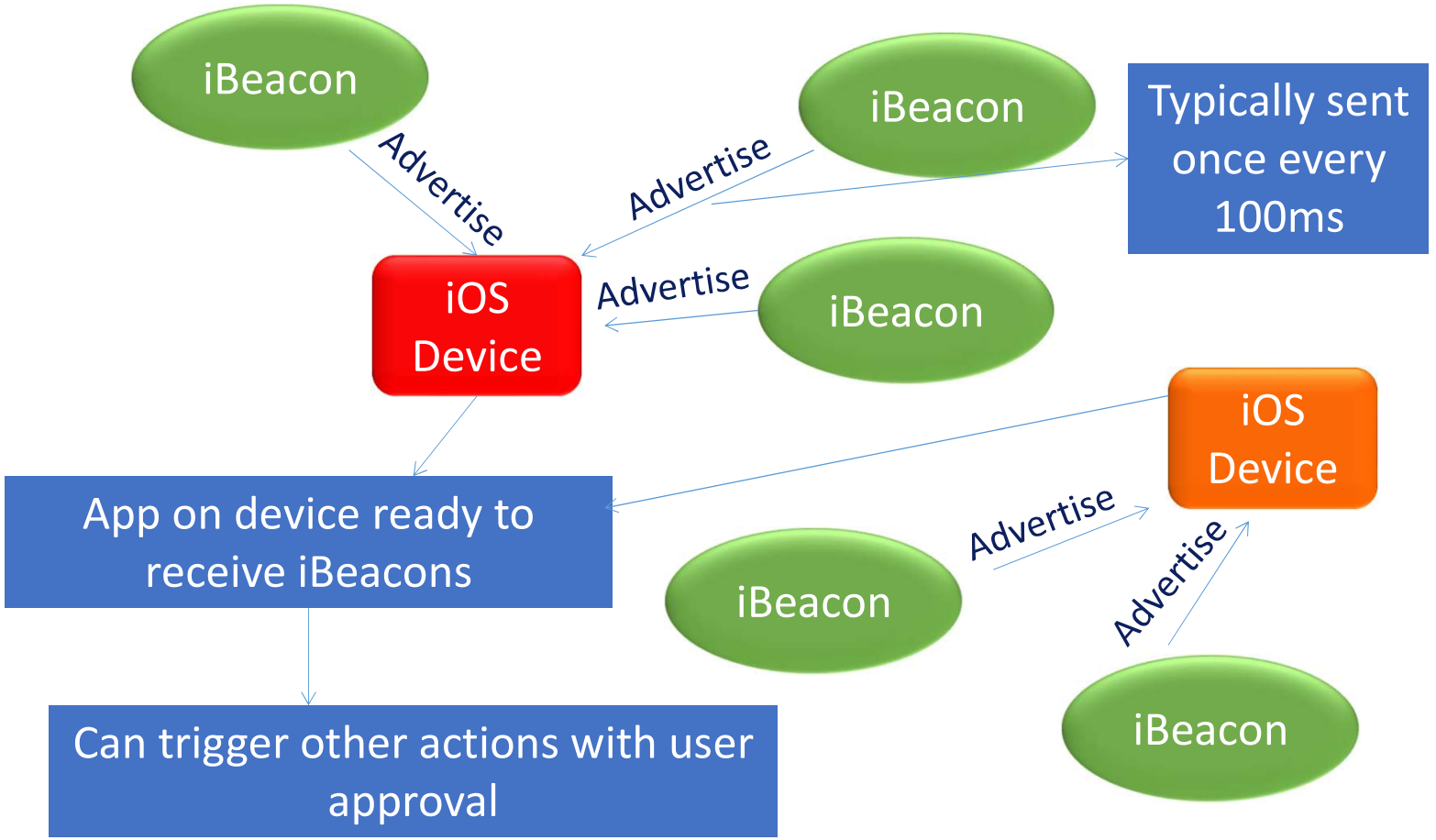
Security enhancements to the ranging process has been important for some applications

Protocol support to address applications wherein a high-density of users have to be supported has been included !!

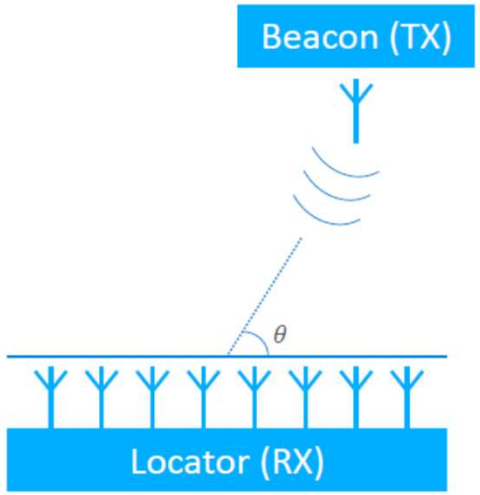
Data transfer along with ranging possible and useful in some applications !!

Apple devices have made UWB desirable for many other vendors !!

iBeacons – How do they work



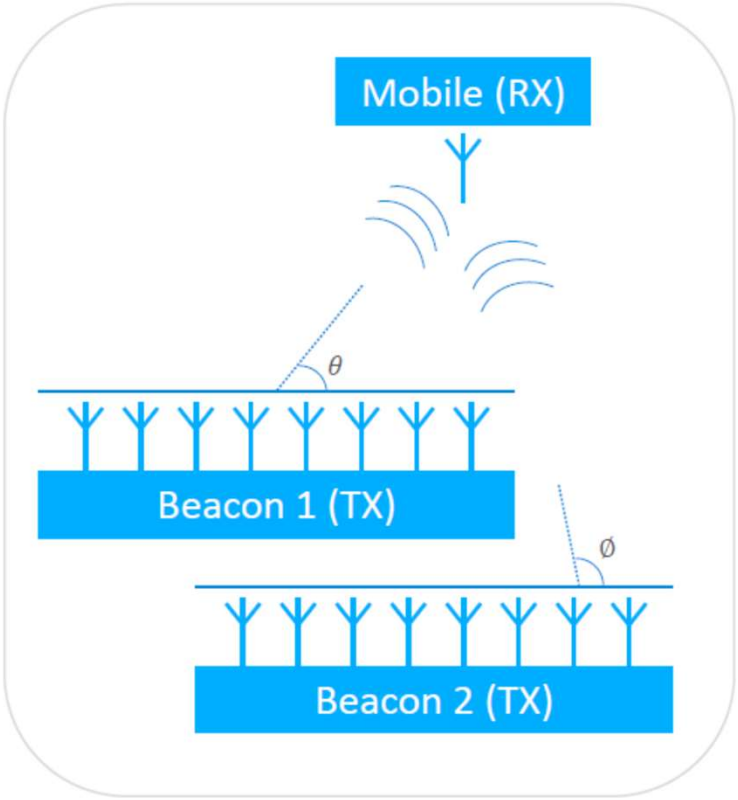
AOA Method



- General idea: In Angle of Arrival the tracked device is sending a special beacon signal using 1 antenna
- Receiver devices called locators
  - Have multiple antennas arranged in an array
  - Take IQ-samples from the received signal while sequentially switching the currently active antenna
  - Angle of arrival estimate is calculated based on the input data
- Antennas in the receiving array will (theoretically) see phase differences because of different line-of-sight distances to the TX
  - Light speed vs. wave length vs. antenna distance
  - In practice not easy: multi-path and antenna array properties

Special CTE signals are added to the BLE transmission to enable phase estimation leading to angle estimation for AOA and AOD methods

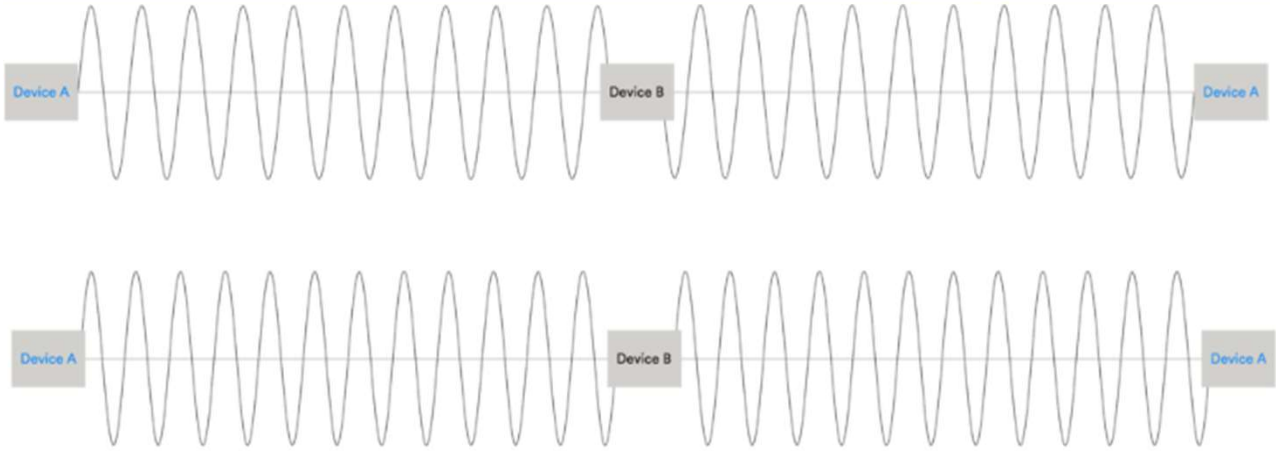
AOD Method



- In Angle of Departure, the fundamental idea of measuring phase differences is the same but device roles are swapped
  - The tracked device is using only one antenna. Beaconing devices use multiple antennas.
- From the application point of view, the fundamental difference to Angle of Arrival is:
  - AoD: the receiving device can calculate its own position in space using angles from multiple beacons and their positions
  - When in AoA: the receiving device tracks arrival angles for individual objects
- All kinds of combinations are possible. When measuring RSSI / distance data, we'll get even more possibilities.
- Expected accuracy can be around a half meter.

Both connected and connectionless modes are allowed

BLE Phase based ranging



Channel sounding using multiple frequencies and then reporting the phase..calculate distance using phase differences observed for different frequencies

$$r = \left(\frac{c * (P_{f2} - P_{f1})}{2\pi (f_2 - f_1)}\right) mod \left(\frac{c}{(f_2 - f_1)}\right)$$

Source : BT SIG

BLE positioning summary

- RSSI based BLE beacons with tx. power information
- AOA/AOD schemes to augment RSSI
- New channel sounding schemes introduced; PBR and RTT