Because Location Matters
January 2019
Agenda

💧 Decawave Overview
💧 Overview of location services and UWB
💧 Network topologies and real world examples
  🌦️ TWR
  🌦️ PDoA
  🌦️ TDoA
  🌦️ Car access
💧 Other considerations, certification and regulations
💧 Q&A
Decawave Overview

What We Bring

- Accurate & Reliable Location Data
- Secure Location & Communication
- Low Power & Low Cost Technology

Who We Are

- Registered in 2004, HQ in Dublin (Irl.)
- Raised > $65M equity
- 86 staff, 77 engineers, 43 in R&D

What We Do

- Single chip Impulse Radio UWB Xcvr
- 1st Chip in production with 5.5 Mu shipped, 2nd Generation on the bench
- 49 Patents: 28 granted, 21 Pending

Who Do We Sell To

- Industrial
- Automotive
- Phone/Consumer
What UWB offers

- The only technology designed specifically to deliver micro-location!

- Ultra-Accurate: Centimeter accuracy – 100x better than WiFi/BLE
- Ultra-Reliable: High immunity to multipath and interference
- Real Time: Low latency – 50 times faster than GPS
- Affordable: Low power, low cost, low processing
Location Services: Finding where things are ...

Location Services Goal: Measure distance between objects to determine their precise location.

Basic Principle: Time taken for signals to travel between transceivers allows calculation of range.

\[ \text{distance} = \frac{(t1 + t2) \times \text{signal speed}}{2} \]

‘Two Way Ranging’ can be used to calculate distance from ‘Time of Flight’ (ToF) measurements.
Real Time Location Systems (RTLS)

- Distance measurements between a moving tag and fixed anchors can be used to determine the tag’s location.

- If distance measurements are performed in rapid succession... then the tag’s location can be mapped in real-time, thereby enabling... Real-Time Location Systems (RTLS).
Radio Technologies

- Radio technology has a long association with direction and location

- Radar – reflected RF energy used to determine location, traditionally over long distances, e.g. air traffic control

- GPS – satellite based location service for outdoor use, accurate to 5m ... good enough to find a restaurant

- WiFi and Bluetooth beacons – indoor location systems with accuracy down to a few metres

- All good location systems ... but none of them are accurate enough for micro-location

- UWB provides RF technology for micro-location, with an accuracy of 10cm or better
Why Impulse Radio UWB outperforms other technologies?

Resolving Multipath Components, given that: Resolution $\alpha = 1/BW$ and $d = c \cdot t$; thus

- 802.11: 20 MHz $1/BW = 0.05$ $\mu$s $= 15$ m
- 802.15.4a: 1300 MHz $1/BW = 0.8$ ns $= 24$ cm

Why UWB?

<table>
<thead>
<tr>
<th>Measurement Method</th>
<th>Characteristics</th>
<th>Performance</th>
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| Ultra Wideband with Reflections | • Immune to Multi-Path  
• Immune to Interference | <0.1 m  
100% |
| Ultra Wideband with Noise | | |
| Narrowband Time of Flight | • Sensitive to Multi-Path  
• Sensitive to Interference | >2 m  
70% |
| Narrowband with Interference | | |
| Wifi and Bluetooth | • Sensitive to Multi-Path  
• Sensitive to Interference  
• Sensitive to NW load  
**Very** Sensitive to obstructions | >5 m  
70% |
Ranging techniques/topologies

There are several ways the DW1000 can determine location using Time-of-Flight measurements:

- Two Way Ranging (TWR)
- Time Difference of Arrival (TDoA)
- Phase Difference of Arrival (PDoA)
- Car access (secure bubble)

These techniques have different merits, choosing the correct one for your application is a key initial design consideration.

Let’s look at each technique in more detail.
Location based on TWR

- One of the simplest RTLS techniques
- Minimum 3 fixed anchors
- Mobile tags and a location engine

- Tag measures ‘round-trip’ ToF between itself and anchors
- Tag passes range measurements to Location Engine (LE) which calculates tag position
- LE can run on a PC, dedicated MCU, or the Tag’s embedded MCU
MDEK TWR RTLS system example

- The anchors and tags are based on the same hardware, a Nordic nRF52832 with Cortex-M4.
- Anchor/tag configuration can be changed via android app or a cloud interface.
- Developers can take RTLS binary, add their customization to the tag or anchor software.
TWR Product example

- Contextual remote control
- Control objects by simply pointing at them
- Need exact location of the remote and objects
- UWB location and motion tracking, sensor fusion combo
- https://sevenhugs.com

Click to launch Video
Location service based on TDoA

- TDoA solves the Tag density, battery-life limitations of TWR but at the cost of extra complexity
- Tags regularly send simple ‘Blink’ messages
- All Anchors in range receive the Blinks
- Blink arrival time sent to LE over the ENET connection
- Anchors synchronised by UWB Clock Calibration Packets
TDoA Product Example

- Typically used in factory automation

- A recent deployment at a VW factory in Slovakia yielded a 20% increase in warehouse utilization [https://www.sewio.net/customer-projects/volkswagen].

- They delivered an indoor positioning system covering a warehouse area of 10,000 m² with hundreds of shelves, tracking 70 objects – both automatically navigated AGVs and manually driven forklifts. The system works with 50 cm accuracy and a refresh rate of 333 milliseconds.

- Other TDoA examples Sports analytics - Shottracker NBA, Zebra NFL, STATsport US/China Soccer
Location service based on PDoA

- Simplifies infrastructure - Tag located by a single Anchor
- Range is determined using TWR
- Bearing is extracted from signals arriving at the two antenna

- Used in ‘follow me’ robot application
- Anchor in following device calculates range/bearing to user’s Tag
- Real-time tracking of relative separation
- No fixed infrastructure
Designed-In Next Gen Alarm System

Current Alarm systems require user interaction to activate/de-activate the system

SmartThings wants a better user experience with a seamless activation/de-activation of the alarm system

keypads, remote control, NFC keyring...

Exhibited at CES

UWB Technology is the only one which can deliver this -

Product Launched @CES Q1’19
PDoA Example Products

- Robotic Lawn Mower
  - Design Ongoing

- Follow-me robots, suitcases, golf carts... for consumer convenience

- Launched June 28th 2017
- Video of Ninebot products
PDoA considerations

- Simplifies deployment, infrastructure and cost
- Multi tag systems possible with a single anchor
- $Y = c/f$ -- CH5 antenna 2.5cm, CH2 closer to 4cm
- Anchor node requires two DW1000's, each with an antenna
- Operating area confined to 180° arc in front of the Anchor
- Tags positioned behind the operating arc ‘appear’ in front
Relay Attack is a real concern for ALL car manufacturers

Just a pair of $11 radio gadget can steal a car

Decawave Technology Fixes the Security issue by creating a secure bubble

Adds a new layer of security based on physical position

In-Production since July 2017
UWB regulations

- Regulatory and certification requirements need to be adhered to
- FCC and ETSI among others

802.15.4 UWB band plan and worldwide regulations
What’s next?

- UWB Alliance launched late 2018
- Updated standard 802.15.4z with big guns!
- CH5 and CH9 global homologation
- DW3000 secure+, smaller BOM, lower power

HRP UWB PHY frame format
Mode = 1

| SYNC | SFD | Cipher sequence | PHR | PHY Payload |

HRP UWB PHY frame format
Mode = 2

| SYNC | SFD | PHR | PHY Payload | Cipher sequence |

Alliance Rallys UWB for Location Services

The chairman of the UWB Alliance, launched today, discusses the outlook for the technology and the group promoting it.

The UWB Alliance was officially launched today with founding members including Hyundai, Kia, Zebra, Decawave, Alereon, Novelda, and Ubirae. The Alliance aims to develop the market for ultrawideband (UWB) technology across vertical applications, foster coexistence with other technologies, and expand the global regulatory acceptance of the technology.
What if UWB is in the Phone?

Enabling better and more secure services