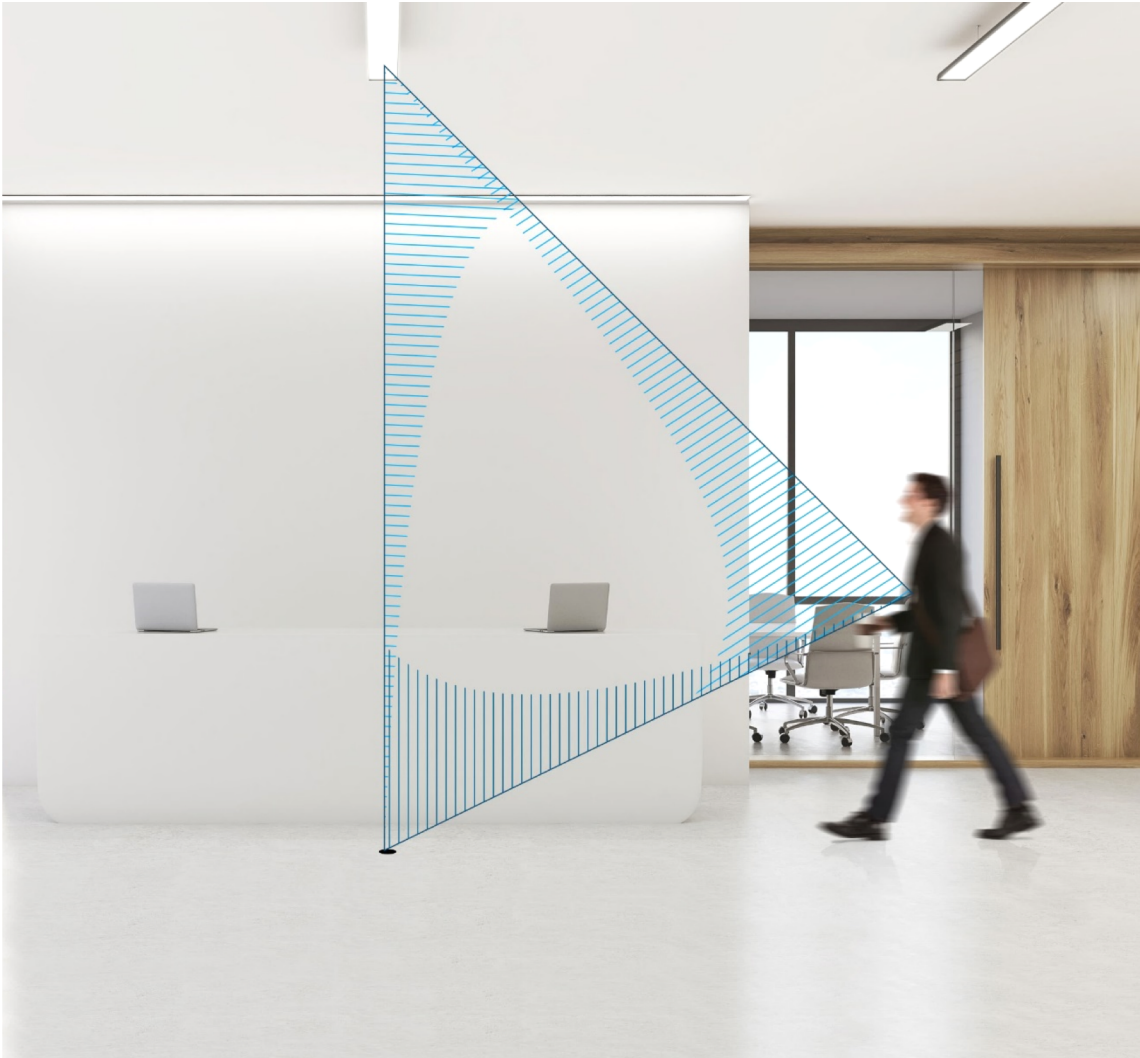# Bluetooth® 5.1 Introduces Sub Meter Positioning

MIKKO SAVOLAINEN | SR MARKETING MANAGER

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Bluetooth 5.1 Summary

- **Direction finding**
  - Detecting Bluetooth signal direction with AoA
  - Adding signal direction to outgoing packets with AoD
  - Benefits asset tracking and indoor positioning applications
  - <1m accuracy vs. 3-5m accuracy with RSSI

- **Faster and lower power connections**
  - GATT caching
  - Reduces need for GATT service discovery
  - Faster and lower power connections

- **Reduced interference for busy RF environments**
  - Randomizing the advertisement packet collisions
  - Reduces the number of packet collisions and improves PER

- **Periodic advertising sync transfer**
  - Trasfer of periodic advertising sync between devices

- **Other minor enhancements**

GATT Caching
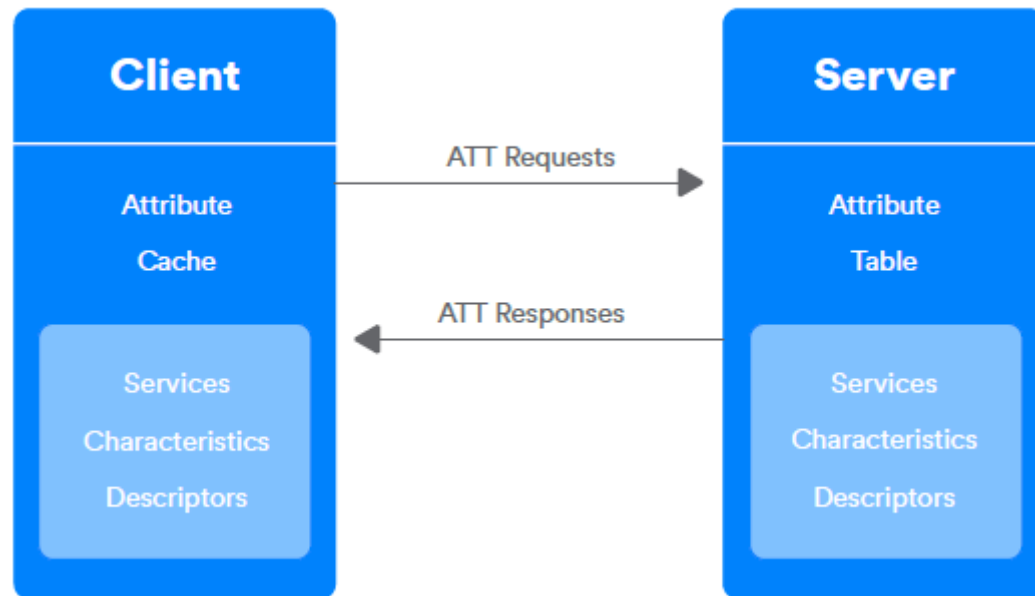
- **How it works?**
  - A hash value is calculated over the GATT service database
  - Its value is exposed via Generic Attribute Service
 - Reading the value does not require bonding

- **Benefit**
  - Client device can easily check if GATT database has changed
  - Reduces the need for service discovery and therefore saves power and enables faster connections
  - If client connects to multiple same type devices, can reduce the need for service discovery significantly

- **Applications that benefit**
  - Any that use connections

Randomized Advertising Channel Indexing
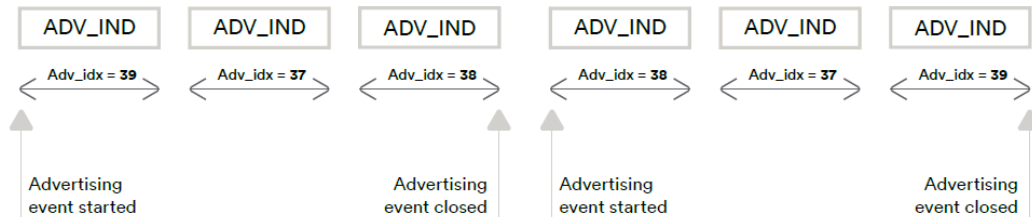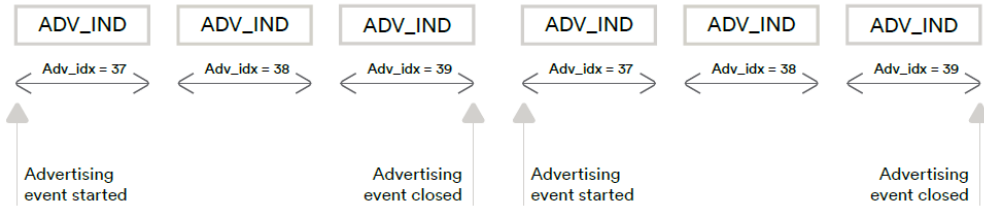
- **How it works?**
  - In Bluetooth 5.0 advertisements, packets are sent sequentially on 1st, 2nd and 3rd advertising channel
  - In Bluetooth 5.1 ,this order can now be randomized
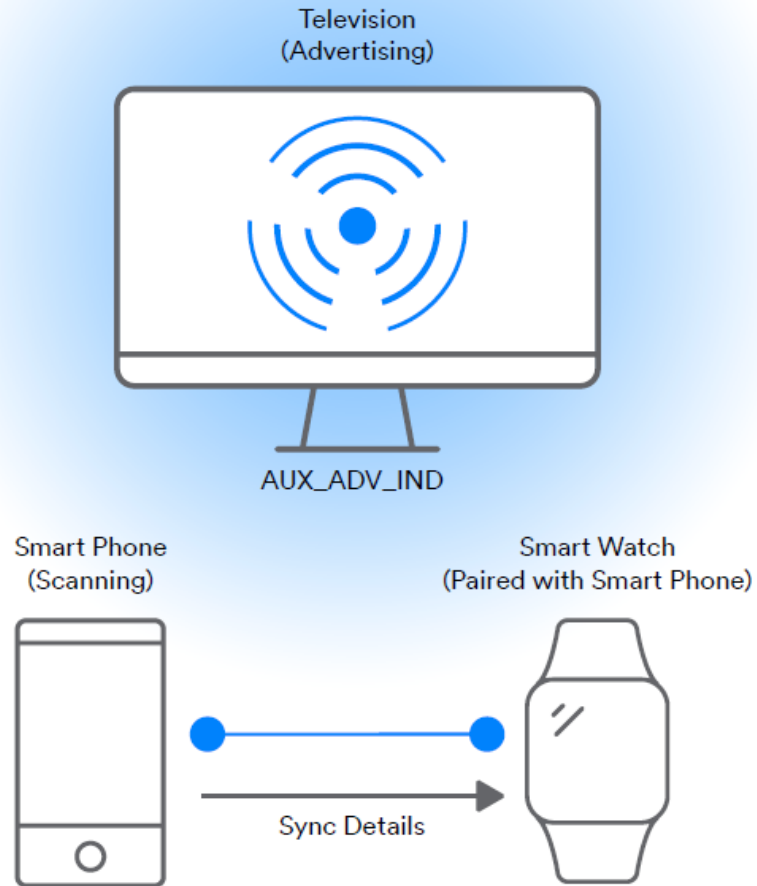
- **Benefits**
  - Lower chance for packet collisions and improved PER
  - Lower latency and better scalability

- **Applications that benefit**
  - Bluetooth mesh
  - IPS, PoI and asset tracking

Periodic Advertising Sync Transfer

Periodic Advertising Sync Transfer

Television
(Advertising)

AUX_ADV_IND

Smart Phone
(Scanning)

Smart Watch
(Paired with Smart Phone)

Sync Details

- **How it works?**
  - Bluetooth 5.0 defines periodic advertising when a scanner can sync to an advetiser's periodic advertising stream
  - Bluetooth 5.1 allows this sync info to be transferred between devices
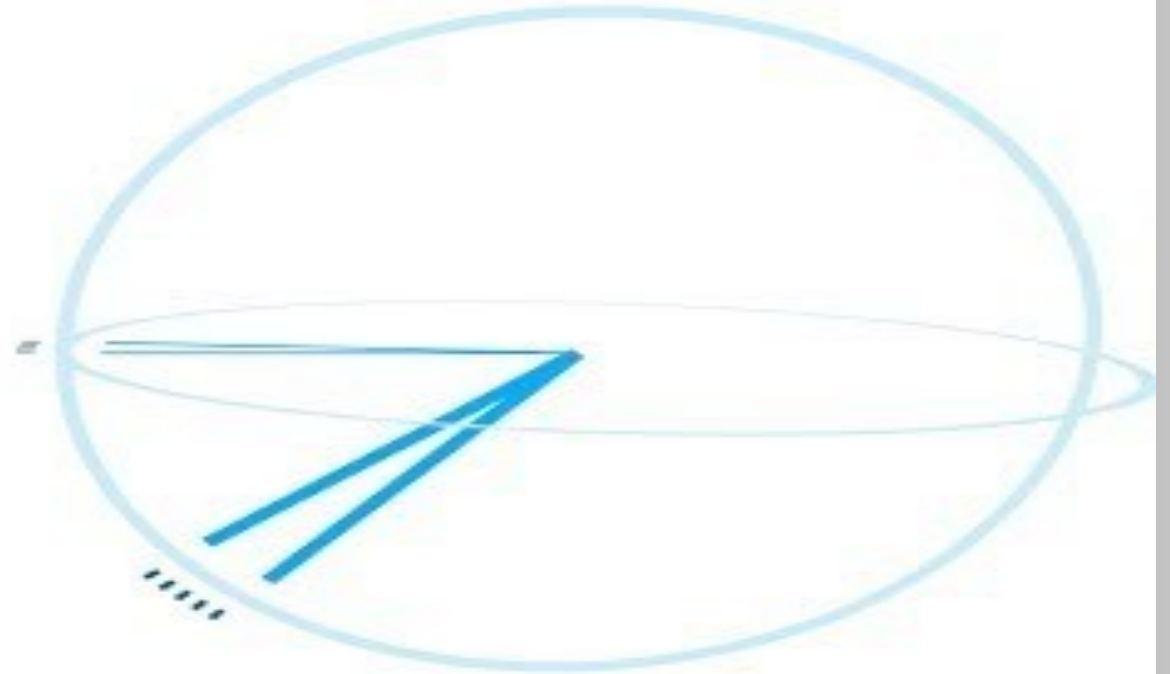
- **Benefits**
  - The periodic advertising sync can impact power consumption
  - A higher end device like a smartphone and figure out the sync and transfer the information to low-power devices like hearing aids, smart watches, etc.

- **Applications that benefit**
  - Low-power devices using periodic advertisement

Bluetooth Direction Finding

Bluetooth Direction Finding: Angle of Arrival (AoA)

Locator (RX)

θ
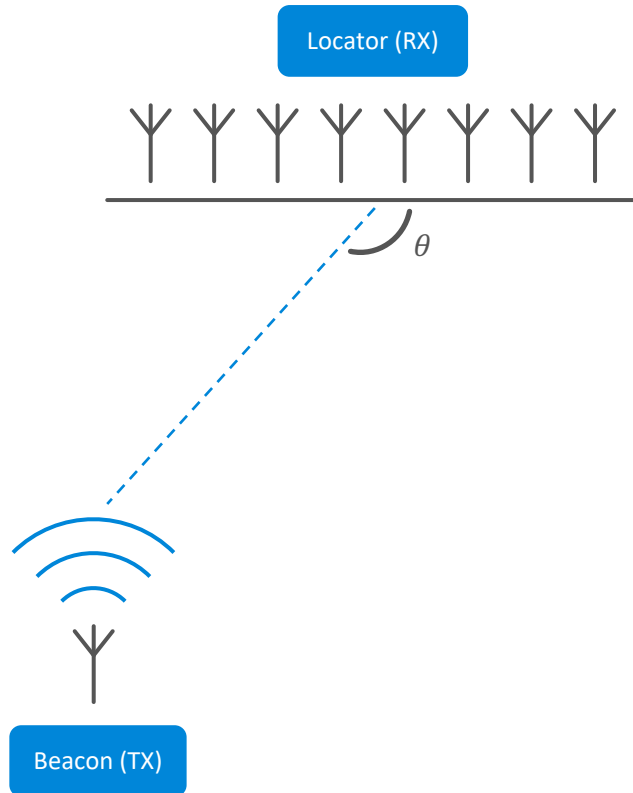
Beacon (TX)

- **An asset wants to broadcast its location**
  - Continuous tone extension (CTE) is added to a beacon or connection packet
  - Asset can support other Bluetooth functions while being tracked
  - Asset can be a single antenna Bluetooth device supporting Bluetooth 5.1 and AoA

A locator wants to find the asset
  - A locator listens for CTE packets and measures IQ data
  - Can perform spherical azimuth and elevation calculation, but not distance or pass the IQ data forward
  - Locator needs an antenna array, switches and Bluetooth 5.1 AoA capable radio

AoA Improves Asset Tracking

Edge Gateway
- Collects relative angle or IQ data from all locators
- Performs triangulaton and trilateration or passes the data to a position engine

Bluetooth AoA Locators
- Receive CTE packets
- Perform relative angle calculation or transmit raw IQ data forward

Edge Gateway

Position Engine

Locator 1

Locator 2

φ_1

φ_2

h

h

θ_1

θ_2

Position engine
- Collects relative angle or IQ data
- Performs triangulaton and trilateration
- Additional intelligence (zones, alerts, heat maps etc.)

Asset
(x1,y1,z1)

Bluetooth AoA Asset
- Transmits CTE packets

Bluetooth Direction Finding: Angle of Departure (AoD)
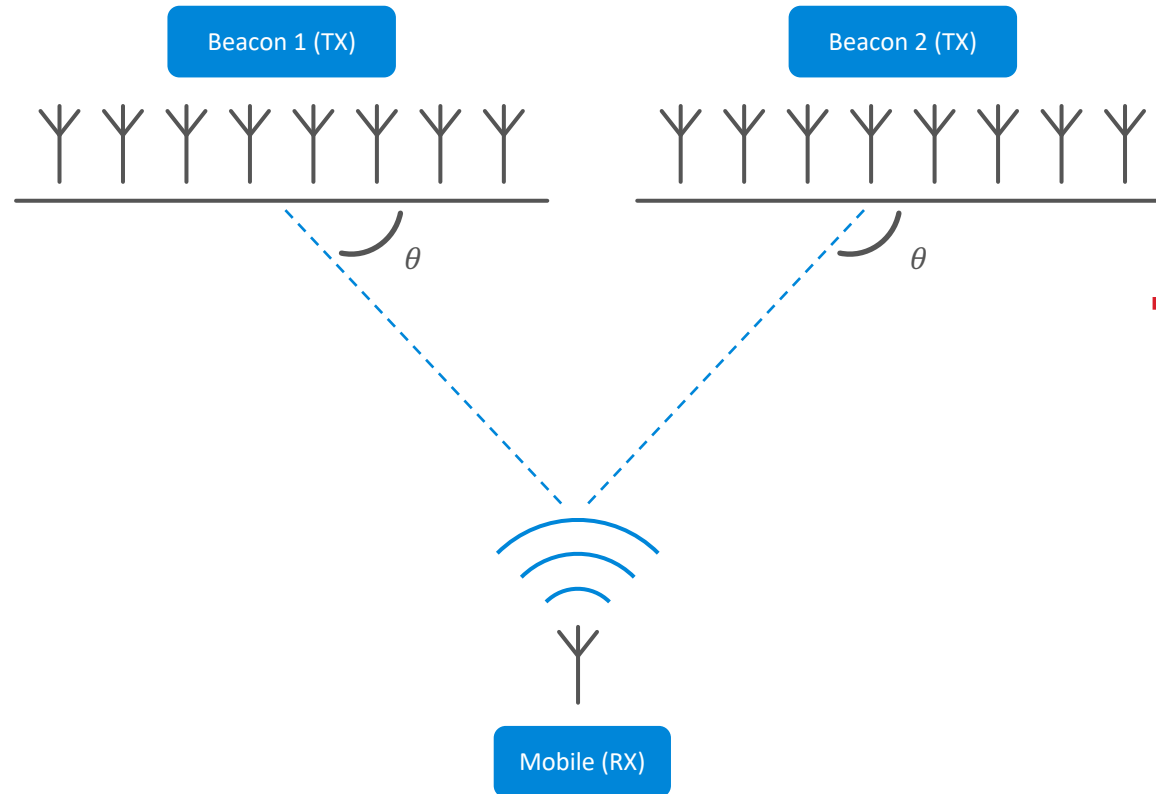
- **Beacons broadcast indoor position**
  - The beacons switch antennas while sending AoD beacons
  - Beacons can also transmit their absolute coordinates
 - The beacons need an antenna array, switches and Bluetooth 5.1 AoD capable radio

- **A mobile device wants to know its position**
  - The mobile devices listen for AoD beacons
  - The mobile device reads IQ and computes relative angles
  - If a beacon transmits its absolute coordinates, the mobile device can also compute its location

AoD Enhances Indoor Positioning Systems

Bluetooth AoD Beacons
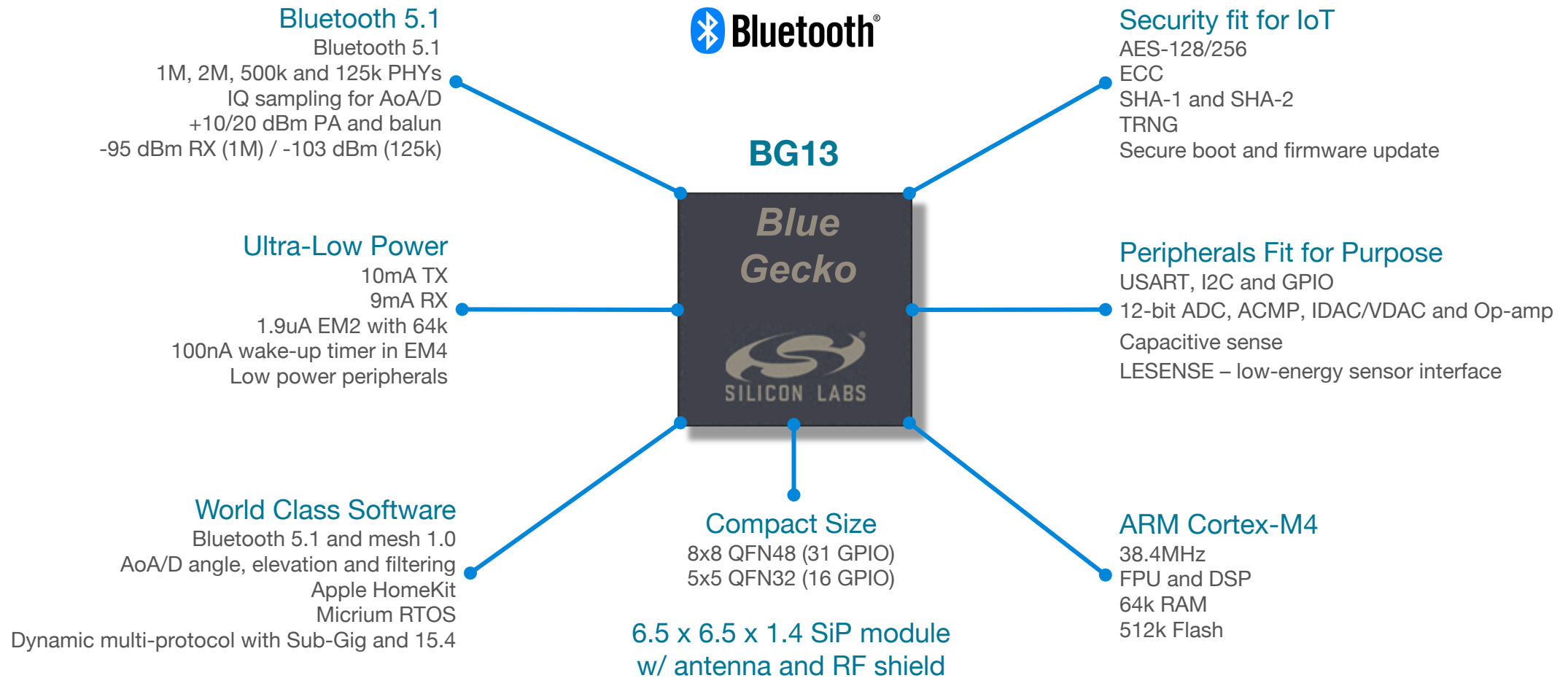- Transmits AoD beacons and additional data such as absolute coordinates
- Use AoD connectionless profile

Beacon 1

Beacon 2

φ_1

φ_2

h

h

θ_1

θ_2
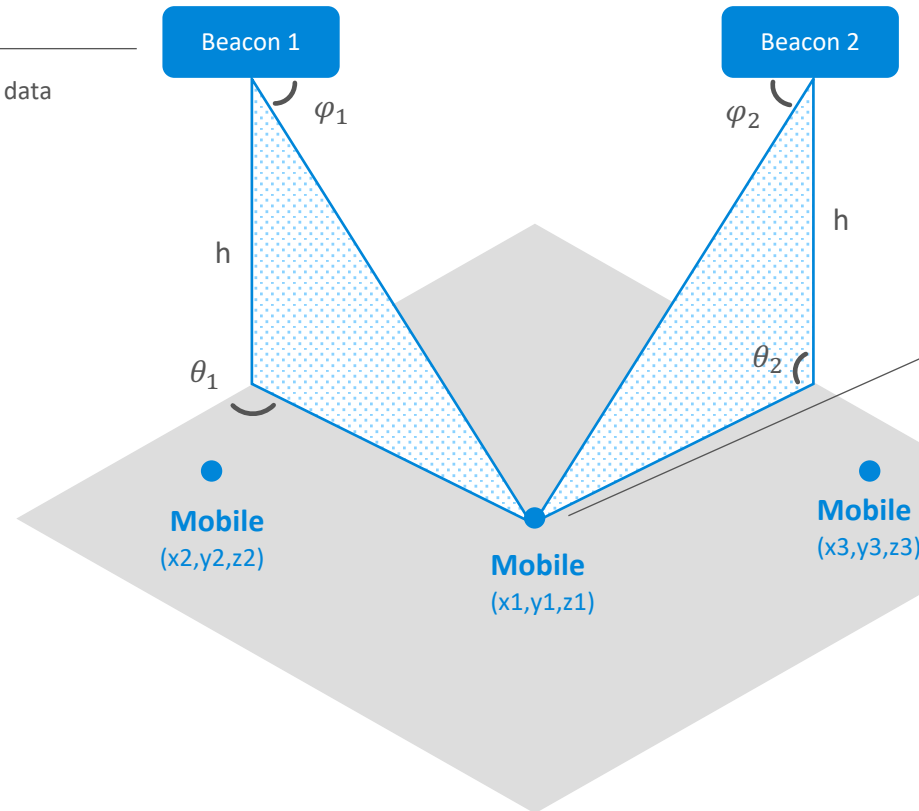
Bluetooth AoD Mobile
- Receives AoD beacons and additional data
- Perform relative angle and position calculation

Mobile
(x2,y2,z2)

Mobile
(x1,y1,z1)

Mobile
(x3,y3,z3)

BG13: Bluetooth 5.1 SoC for LE and Mesh Applications

Bluetooth

BG13

Blue Gecko

SILICON LABS

Bluetooth 5.1
Bluetooth 5.1
1M, 2M, 500k and 125k PHYs
IQ sampling for AoA/D
+10/20 dBm PA and balun
-95 dBm RX (1M) / -103 dBm (125k)

Ultra-Low Power
10mA TX
9mA RX
1.9uA EM2 with 64k
100nA wake-up timer in EM4
Low power peripherals

World Class Software
Bluetooth 5.1 and mesh 1.0
AoA/D angle, elevation and filtering
Apple HomeKit
Micrium RTOS
Dynamic multi-protocol with Sub-Gig and 15.4

Security fit for IoT
AES-128/256
ECC
SHA-1 and SHA-2
TRNG
Secure boot and firmware update

Peripherals Fit for Purpose
USART, I2C and GPIO
12-bit ADC, ACMP, IDAC/VDAC and Op-amp
Capacitive sense
LESENSE – low-energy sensor interface

Compact Size
8x8 QFN48 (31 GPIO)
5x5 QFN32 (16 GPIO)

6.5 x 6.5 x 1.4 SiP module
w/ antenna and RF shield

ARM Cortex-M4
38.4MHz
FPU and DSP
64k RAM
512k Flash

World's 1st Bluetooth 5.1 Qualified SoCs, Modules and Software

Thank You & Questions

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