Bluetooth® 5.1 Introduces Sub Meter Positioning

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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**
  - Transfer 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

How it works?
- Bluetooth 5.0 defines periodic advertising when a scanner can sync to an advertiser'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

Angle of Arrival
Angle of Departure
Bluetooth Direction Finding: Angle of Arrival (AoA)

- **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 triangulation 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

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

**Bluetooth AoA Asset**
- Transmits CTE packets

**Asset**
- $(x_1,y_1,z_1)$

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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

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

Beacon 1

Beacon 2

Mobile (x1, y1, z1)

Mobile (x2, y2, z2)

Mobile (x3, y3, z3)
BG13: Bluetooth 5.1 SoC for LE and Mesh Applications

- **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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