Tech Talks LIVE Schedule – Presentation will begin shortly

tech talks

Wireless Connectivity Tech Talks

3月31日，星期三	**聚焦Silicon Labs的到达角(AoA)解决方案** **Zoom in on Silicon Labs Angle of Arrival (AoA) Solution**
4月30日，星期五	探索超低功耗 Wi-Fi 解决方案 RS9116W Discover the Ultra-low-power Wi-Fi Solution RS9116W
5月18日，星期二	使用蓝牙 Xpress 模块加速蓝牙开发 Speed up Bluetooth Development with Bluetooth Xpress Modules

Recording and slides will be posted to:
www.silabs.com/training

We will begin in 3:00

WELCOME

聚焦Silicon Labs的到达角(AoA)解决方案
Zoom in on Silicon Labs AoA solution

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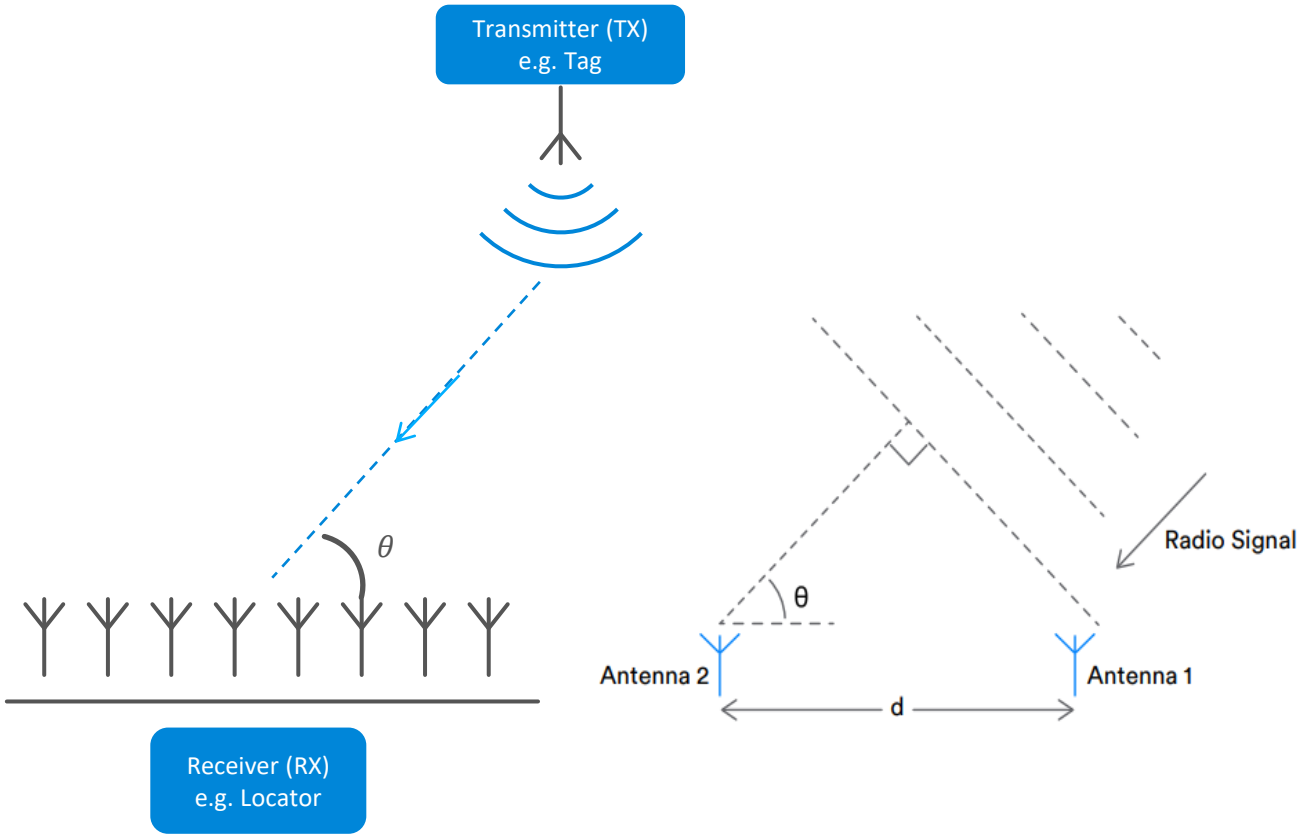
Agenda

- Direction Finding: Angel-of-Arrival (AoA)
- Silicon Labs Enhanced AoA mode
- Overview of Silicon Labs AoA Solutions
- Hardware
  - Bluetooth SoC – BG22
  - Antenna Array Reference Design
- Software
  - Bluetooth SDK
  - Real Time Location (RTL) Library
- Example apps and development kits
- Documentation
- Q&A

How Angle-of-Arrival (AoA) Works?



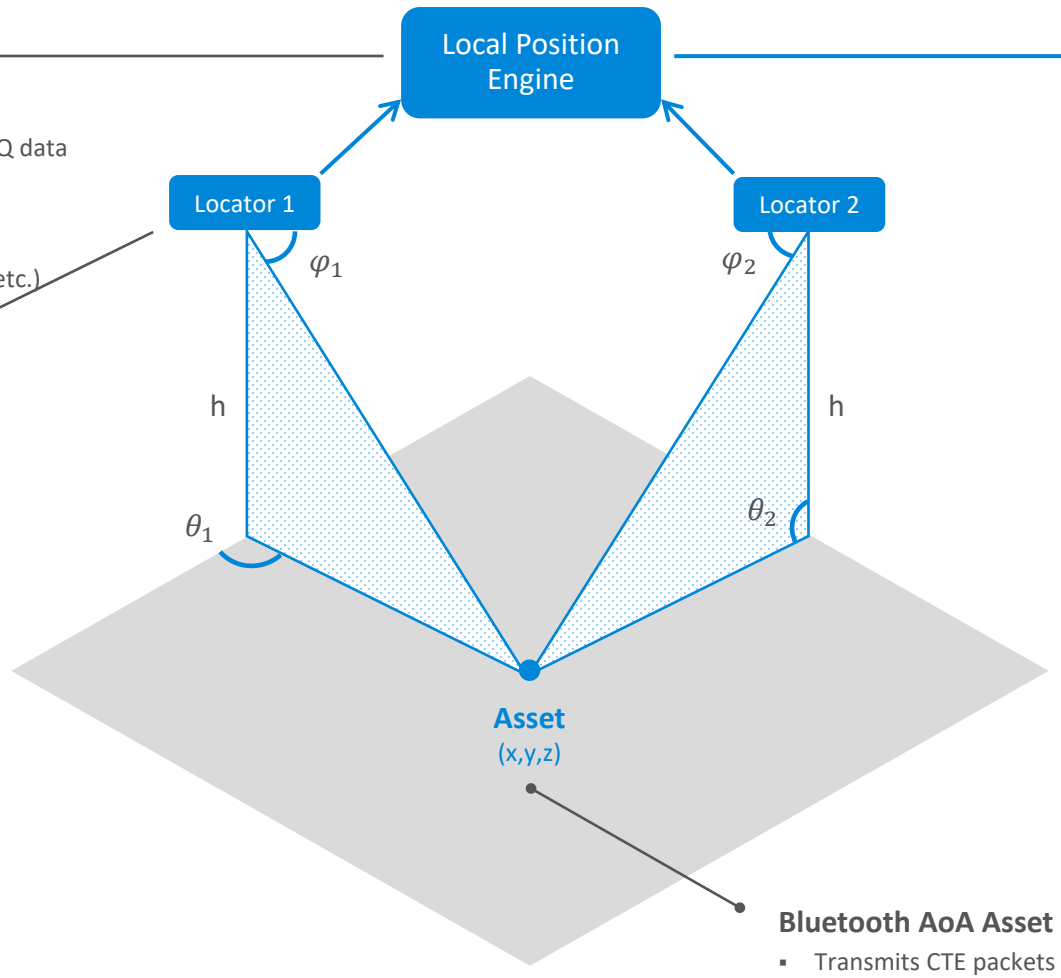
Constant Tone Extension (CTE) -- single tone sine wave

- **An asset wants to broadcast its location**
  - Continuous tone extension (CTE) is added to the end of a Bluetooth advertisement or connection packet
  - Asset can support other Bluetooth functions while being tracked as CTE does not use the payload

A locator wants to find the asset

- A locator needs to have multiple antennas, as antenna is switched during the CTE reception
- A locator listens for CTE packets and measures IQ data from the CTE payload
- Can perform spherical azimuth and elevation calculation, or pass the IQ data forward to back-end processing

How AoA Works at a System Level?



Local Position Engine

- Collects relative raw or pre-processed IQ data from all locators
- Performs X,Yand Z calculations
- Additional applications (site planning zones, alerts, heat maps etc.)

Bluetooth AoA Locators

- While one locator can be used to estimate the assets location, a network of multiple locators improve accuracy and reliability
- Locators with enough processing power can pre-process to IQ data

Cloud Position Engine

Cloud Position Engine

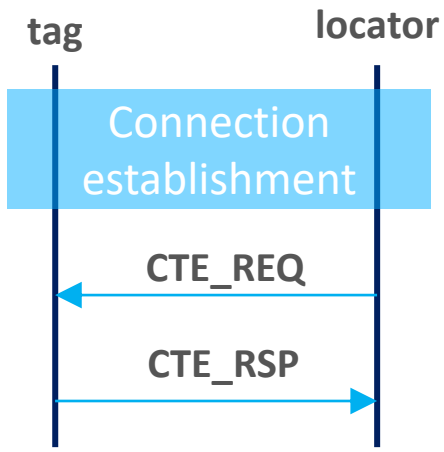
- Collects relative raw or pre-processed IQ data from all locators
- Performs X,Yand Z calculations
- Additional applications (site planning zones, alerts, heat maps etc.)

Bluetooth AoA Asset

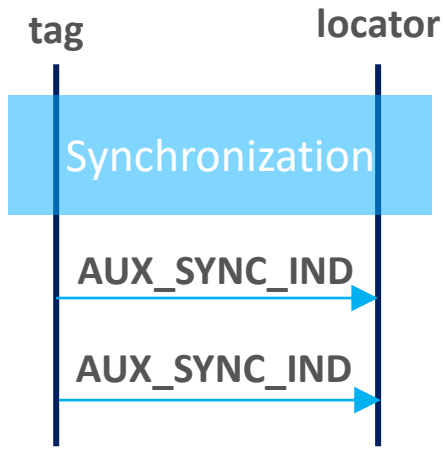
- Transmits CTE packets

Boosting AoA Scalability by Silicon Labs Enhanced mode

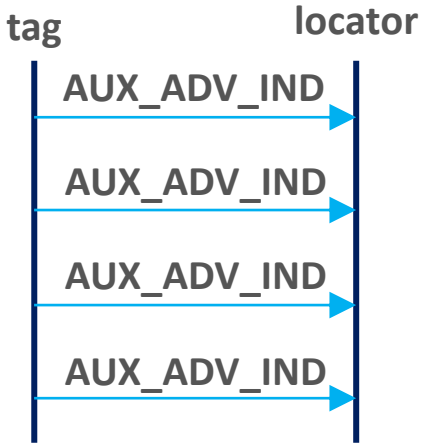
- **Bluetooth 5.1 Direction Finding**
  - Two modes to Tx/Rx CTE
    - Connection mode (based on connection)
    - Connectionless mode (based on periodic advertising)
  - Both require RAM allocation on the locator to maintain the connections or synchronizations
  - Limit the number of supported tags (typically <50)
  - Also establishing connections or periodic advertizing syncs can be time consuming for large number of assets
- **Silicon Labs Enhanced mode**
  - Silicon Labs proprietary
  - CTE transmission in the BT 5.0 extended ADV packets
  - Little RAM is needed in the locator and no time syncing is needed
  - CTE still tranmitted on 37 data channels maximizing spectrum usage
  - Tag implementation is very simple and low power
  - Up to 1000 tags



BT 5.1: Connection mode

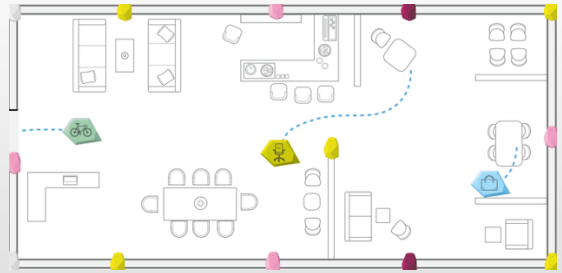


BT 5.1: Connectionless mode (periodic advertising)



Silicon Labs enhanced mode (extended advertising)

Silicon Labs' Solutions for Implementing AoA

TAGS	LOCATORS	POSITIONING ENGINE
		

Hardware	• Bluetooth SoC: BG22	**Hardware**	• Bluetooth SoC: BG22 • 4x4 antenna array ref. design	**Hardware**	• Not supplied by Silicon Labs (e.g. PC, Cortex-A, etc)
Software	• Bluetooth SDK v3.1 or above • Demo and example code	**Software**	• Bluetooth SDK v3.1 or above • Demo and example code	**Software**	• Real Time Location (RTL) Library (on Windows and Linux) • Demo and example code
Development kit	• Thunderboard BG22	**Development kit**	• 4x4 antenna Array Radio Board • SWTK mainboard	**Development kit**	Not supplied by Silicon Labs

Hardware – BG22: Optimized Battery Powered Bluetooth LE SoC

Optimized

Detailed info

Secure Bluetooth 5.2 SoCs for High-Volume Products

Applications
Consumers
Smart Home
Portable healthcare devices
Asset tracking tags
BT mesh low-power nodes

Protocol Support
Bluetooth 5.2
1M, 2M and LE Coded PHYs
Direction Finding (AoA & AoD)
BT mesh Low Power Node (512 kB parts only)
Proprietary

Wide Operation Range
1.71 V to 3.8 V
-40 °C to 125 °C

Radio
Tx: -27 to +6 dBm
Rx:
-106.7 dBm @ 125 kbps GFSK
-98.9 dBm @ 1 Mbit/s GFSK
-96.2 dBm @ 2 Mbit/s GFSK

Ultra-Low Power
3.4 mA @ 0dBm Tx (radio only)
2.5 mA RX (radio only)
4.1 mA @ 0dBm Tx (radio + MCU)
3.6 mA RX current (radio + MCU)
1.4 µA EM2 with 32 kB RAM
0.5 µA w/ RTC in EM4
25 µA/MHz in active mode (EM0)

Compact Size
5x5x0.85mm QFN40 (26 GPIO)
4x4x0.85mm QFN32 (18 GPIO)
4x4x0.3mm TQFN32 (18 GPIO)

ARM Cortex-M33 with TrustZone
38.4/76.8 MHz
352/512 kB of flash
32kB RAM

Peripherals Fit for Purpose
2x USART, 2x I2C, 2x PDM and GPIO
ADC (16 channels)
Built-in temperature sensor with +/- 1.5 °C
Built-in 32 kHz, 500ppm sleep clock

Security
AES128/256,SHA-1, SHA-2 (256-bit)
ECC (up to 256-bit), ECDSA and ECDH
True Random Number Generator (TRNG)
Secure boot with RTSL
Secure debug with lock/unlock

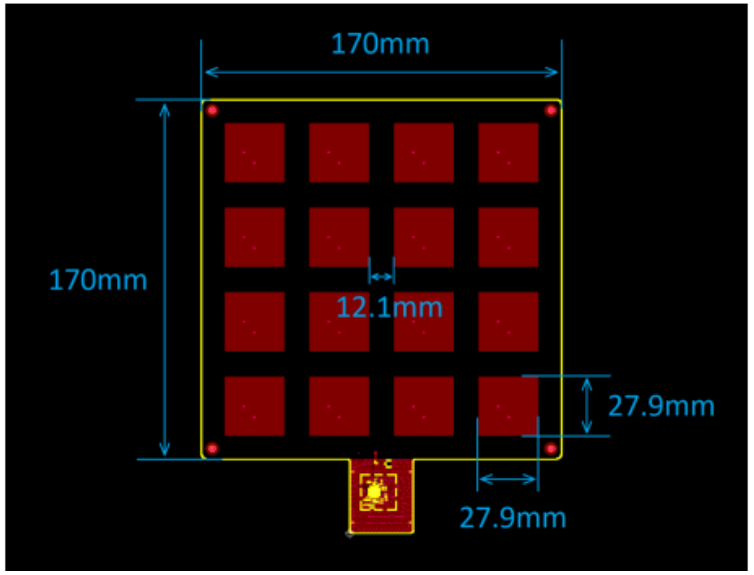
Hardware – 4x4 Antenna Array Reference Design

- **Components**
  - 16 (4x4) patch antennas (4 GPIOs)
  - 1 BG22 SoC
  - 5 (1+4) SP4T RF antenna switches
  - 16 matching circuits
- **Firmware features**
  - Automatically switch by stack
  - Up to 64 antennas with 6 GPIOs
  - Configurable switching sequence

Documentations

- Schematic, PCB, BoM, …etc
- Design Guidelines

- **Measurement results**
  - Refer to AN1195 (link)
- **Development board**
  - Order code: SLWBRD4185A

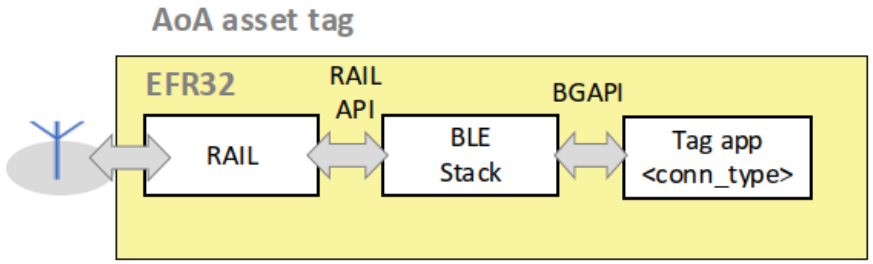


6.2 Environment 2 (1 locator, 1 tag, locator on turntable)

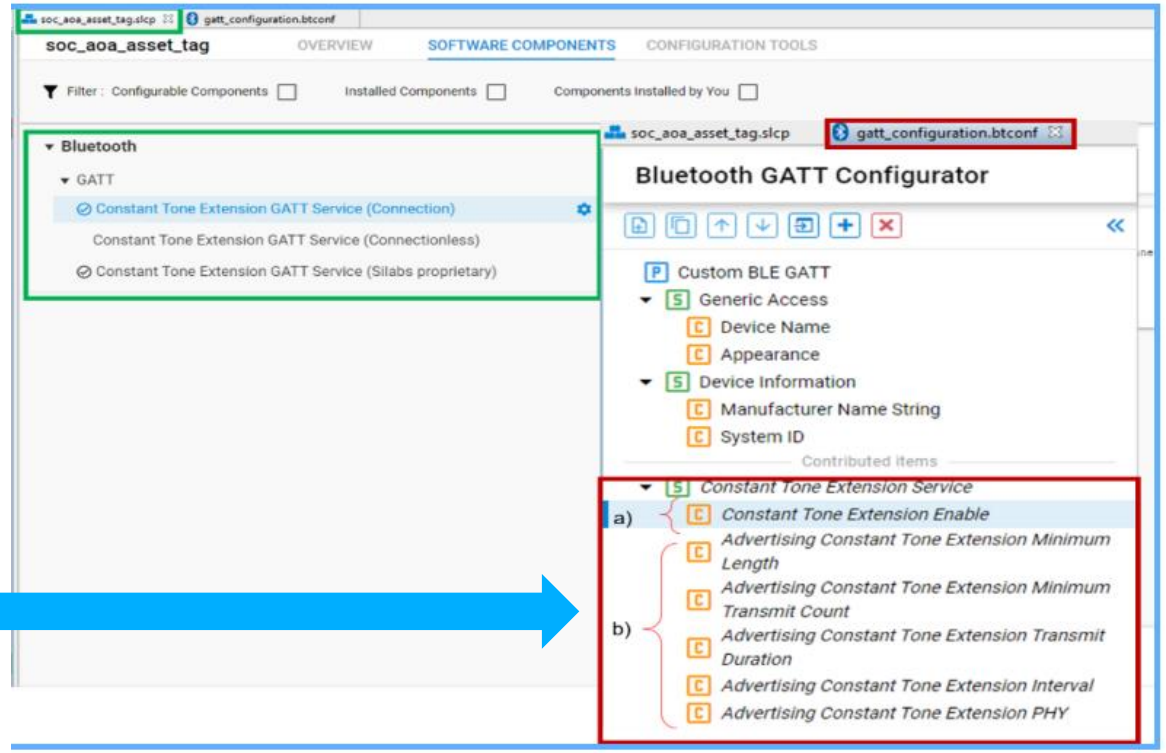
- Location: Indoor, open space, plenty of objects in the measurement area
- Locator height from floor: 0.5 m
- Tag height from floor: 2.4 m
- Testing range: 27 m^2
- Tag position is fixed
- Locator in the middle of a turntable
- Locator is rotated with the turntable
- Average azimuth error: +/- 3°
- Average elevation error at 3.5 m away from the locator: +/- 7°

Software – Bluetooth SDK (1/2)

- **Bluetooth SDK v3.1**
  - Bluetooth 5.2 stack
  - Supports AoA
- **AoA Tag**
  - SoC mode (no external host MCU)

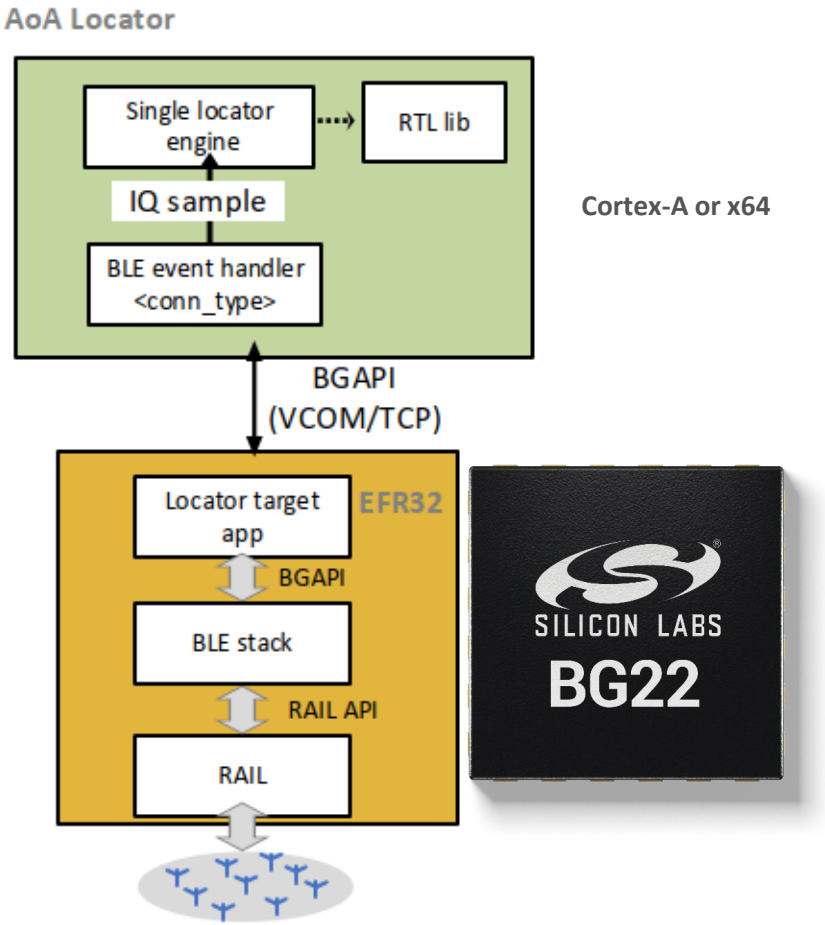


  - Connection, Connectionless, Silicon Labs Enhanced mode
  - Example projects
  - Proprietary Asseting Tracking Profile (ATP)
    - CTE (GATT) Services (e.g. change of CTE parameters)



Software – Bluetooth SDK (2/2)

- **AoA Locators**
  - **BG22 and external host MCU**
- **BG22**
  - NCP mode (so-called slave mode)
  - Bluetooth stack
  - Antenna array switching
  - Output IQ sample data
  - Example
    - NCP AoA locator (locator target app)
- **External host MCU**
  - Application
  - Control BG22
  - IQ samples → angles
  - Angles → x,y,z
  - Example
    - locator host example app



Software – Real Time Location (RTL) Library

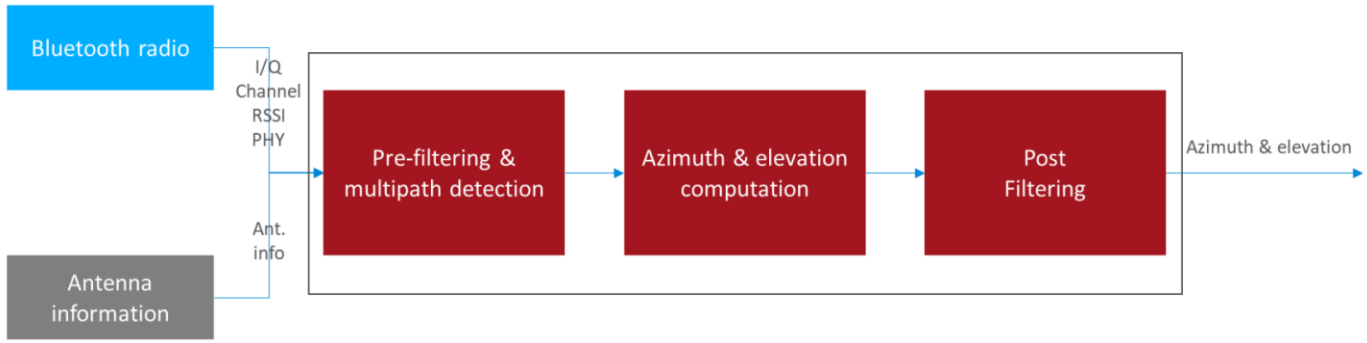


Figure 3-1: Silicon Labs RTL Library Providing Azimuth and Elevation

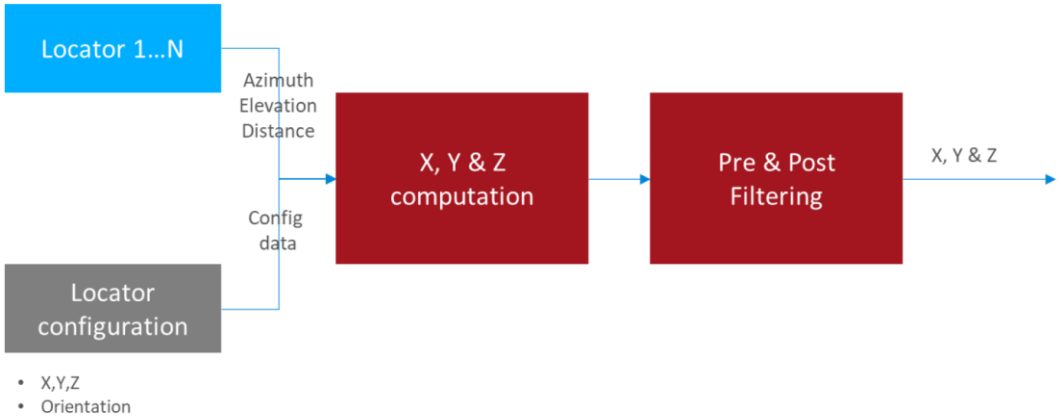


Figure 3-2: Silicon Labs RTL Library Providing X, Y and Z

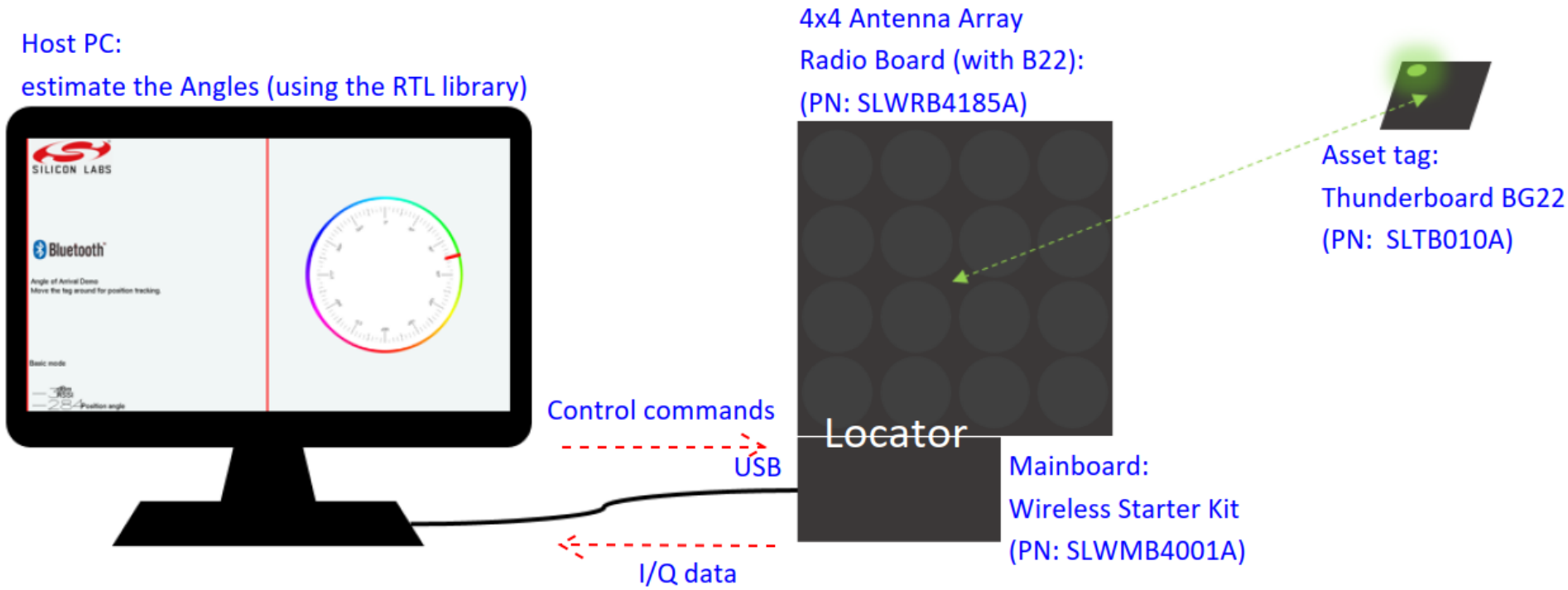
- **Overview of RTL library**
  - Direction Finding (IQ samples → angles)
  - Location Finding (angles → x,y,z)
  - Utility Functions
- **RTL library converts I/Q data to position**
  - Takes I/Q data as input from BG22
  - Detects and filters out multipath
  - Detects and filters out collisions (I/Q quality)
  - Output azimuth & elevation or X, Y and Z
  - Angle and elevation filtering algorithms for different use cases (high accuracy, real time etc.)
- **Features**
  - Supported platforms:
    - Windows , Ubuntu, Raspberry Pi (Cortex A), Darwin
  - Number of locators: 100
  - Silicon Labs' 4x4 antenna array ref. design
  - IQ Sample Quality Analysis tool
  - Example code

Example apps and development kits

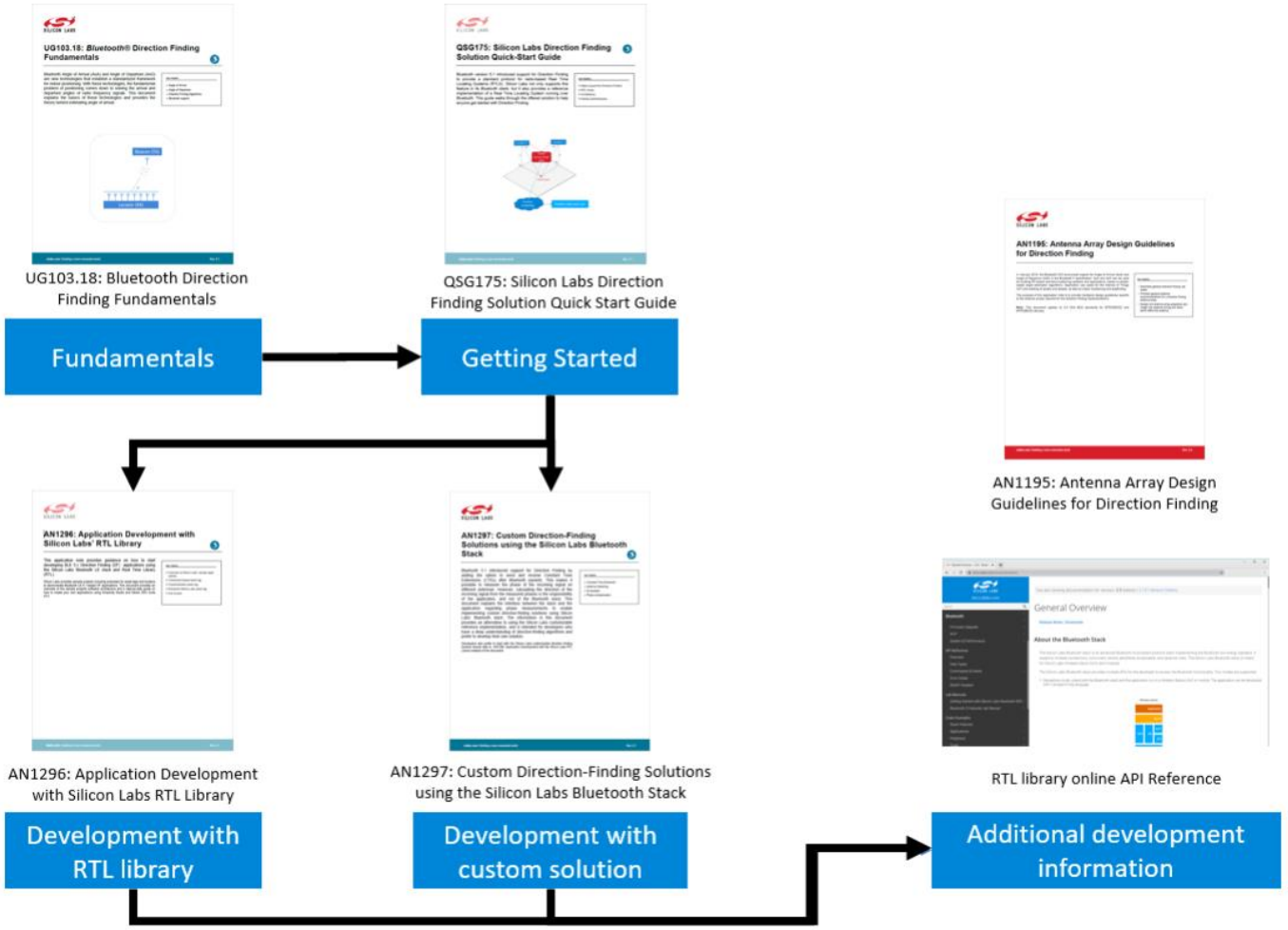
2.1 Hardware Components

The demo consists of three hardware components:

- A Thunderboard BG22 that acts like an **Asset Tag** to be located
- A WSTK with a 4x4 Antenna Array board (BRD4185A) that acts like a **Locator** device
- A host PC, that controls the Locator, runs the calculations and displays the angle estimations



Documentation



- UG103.18: Bluetooth® Direction Finding Fundamentals (link)
- QSG175: Silicon Labs Direction Finding Solution Quick-Start Guide (link)
  - Architecture, Supported features, RTL library, Demos, and Examples
- AN1296: Application Development with Silicon Labs' RTL Library (link)
- AN1297: Custom Direction-Finding Solutions using Silicon Labs' Bluetooth Stack. (link)
- Additional development information
  - Bluetooth SDK v3.1 API (link)
  - RTL API (link)
- AN1195: Antenna Array Design Guidelines for Direction Finding (link)
- Online training (link)
  - AoA Direction Finding in Bluetooth SDK
  - AoA Direction Finding Lab

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Q&A

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THANK YOU

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