SILICON LABS
CONNECTED INTELLIGENCE

2026 tech talks
WEBINAR SERIES

# Bluetooth Channel Sounding: From Performance to Real-World Applications

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BLUETOOTH®

# SPEAKERS

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# Agenda

01 Technology Overview

02 Silicon Labs Algorithm Variants

03 Performance Comparison and Trade-Offs

04 Application Demos

05 Mobile Support

06 Silicon Labs Channel Sounding Offering

07 Q&A

# Why Bluetooth® Channel Sounding?

## THE CHALLENGE:

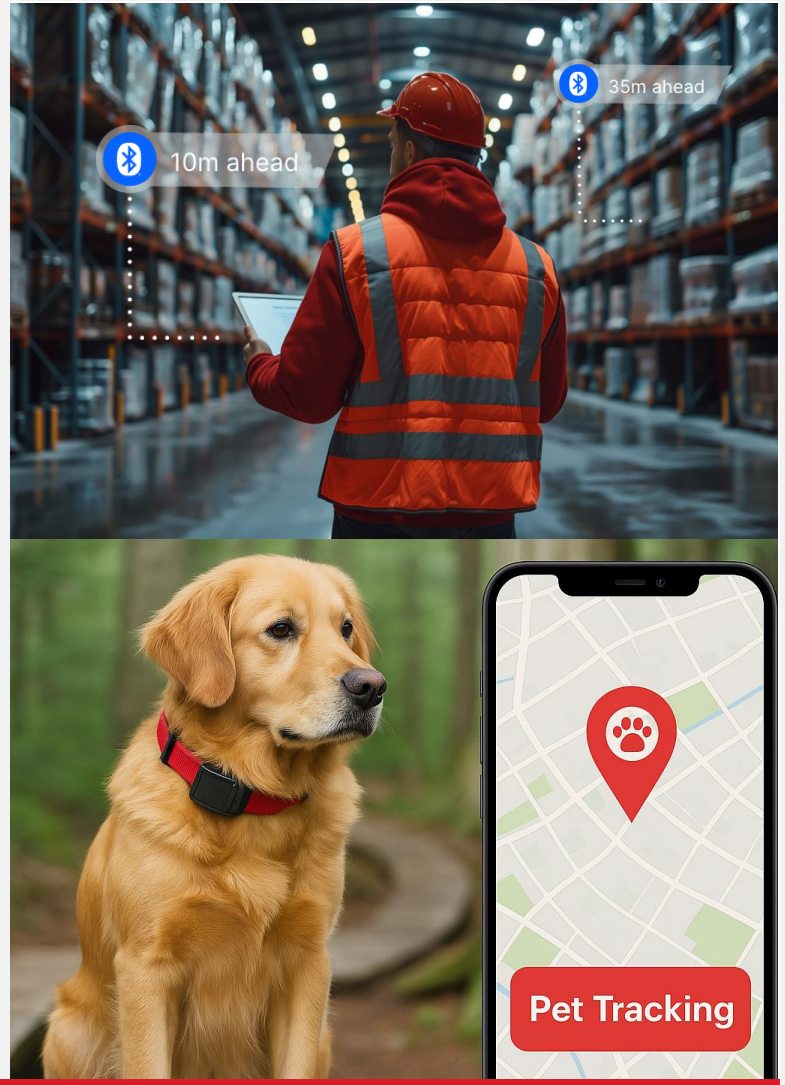
**IOT applications need 'spatial' awareness to be more secure, reliable, and responsive**

- Earlier Bluetooth LE versions lack native support for precise ranging
- RSSI-based ranging is noisy and unreliable in real-world use
- Direction Finding needs multiple antennas, adding cost & complexity
- UWB is accurate but often requires a dedicated chip, adding cost for IoT

## THE OPPORTUNITY:

**Channel Sounding for Bluetooth**

- Standardized approach introduced in Bluetooth 6.0 for accurate, interoperable, and secure ranging
- Enables sub-meter accuracy with robust performance, even in NLOS
- Works with single or dual antenna setups - flexible for different form factors
- More cost efficient than UWB; requires minimal external components




**Built on existing Bluetooth infrastructure, simplifying adoption and ecosystem integration**

# Bluetooth® Channel Sounding Overview

- **Measure distance between two devices using**
  - Phase-based Ranging (PBR)
  - Round Trip Time (RTT)
- **RTT and PBR operates across 2.4 GHz band**
  - Standard specifies up to 72 channels
  - Random channel hopping pattern
- **Connection-Oriented 2-way ranging with two roles**
  - Initiator: device that wishes to calculate distance from itself to another device
  - Reflector: device responding to initiator
- **Supports up to 4 antenna paths between devices**
- **Multiple security features included in the standard**
- **Can be combined with Angle of Arrival / Departure (AoA/AoD)**
  - Enables position estimation with single locator/tag pair

## Additional Resources

- **Webpage** – Learn more about Silicon Labs offerings and demos
- **Tech Talk** – Explore Bluetooth Channel Sounding
- **Workswith 2024** - Enable Accurate Distance Estimation Using Channel Sounding
- **Workswith 2025** - Bringing Bluetooth® 6.0 Channel Sounding to Market: Precision Ranging for Secure & Smart Applications
- **Blog:** Learn more about Antenna Switching with Silicon Labs Channel Sounding
- **API Spec**: Getting Started with Silicon Labs Bluetooth Channel Sounding

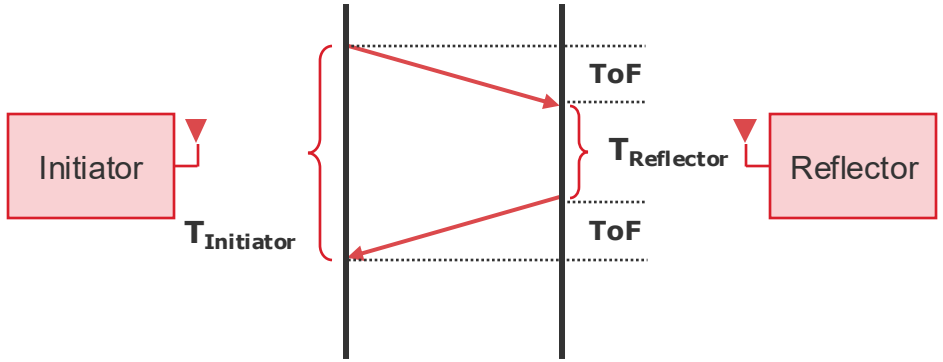
# Channel Sounding Step Modes

## Mode-0: Calibration

- Compensates for clock drift and frequency offset
- Results in fractional frequency offset table

Required

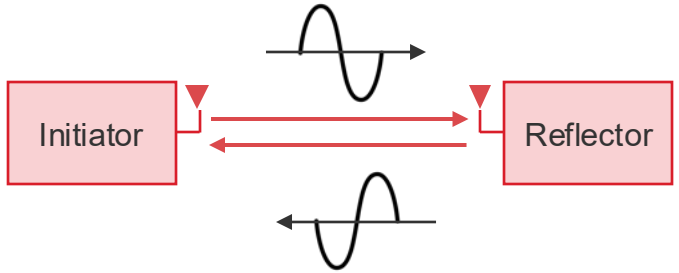
## Mode-1: Round trip time




- CS SYNC packets exchanged between initiator and reflector

Required

## Mode-2: Phase based ranging




- CS Tone exchanged between initiator and reflector
- Each antenna path exercised in each step

Required

## Mode-3: PBR+RTT

- Combined PBR and RTT in each step
- RTT distance measurement can be cross-checked with PBR results
- Provides higher security as a mismatch in distance estimation can indicate relay attack

Optional

# Bluetooth Channel Sounding - Target Markets & Use Cases

## PROXIMITY AWARENESS

Door locks

Keyless entry

Building access systems

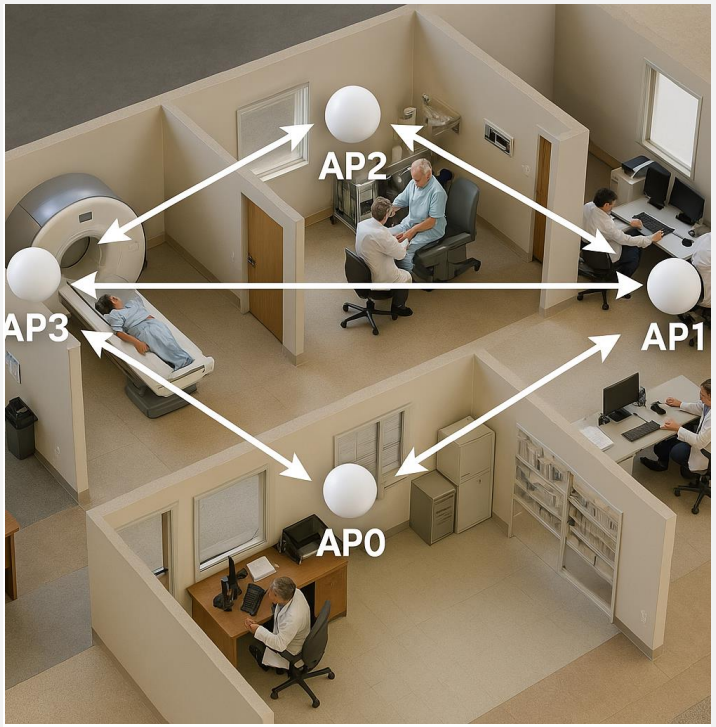
Geofencing - security alerts

## LOCALIZATION

Indoor asset management - hospitals, warehouses

Pet tracking inside home

Item finding - wallet, keys




## AUTOMAPPING

Solar Trackers

Luminaires, Access Points

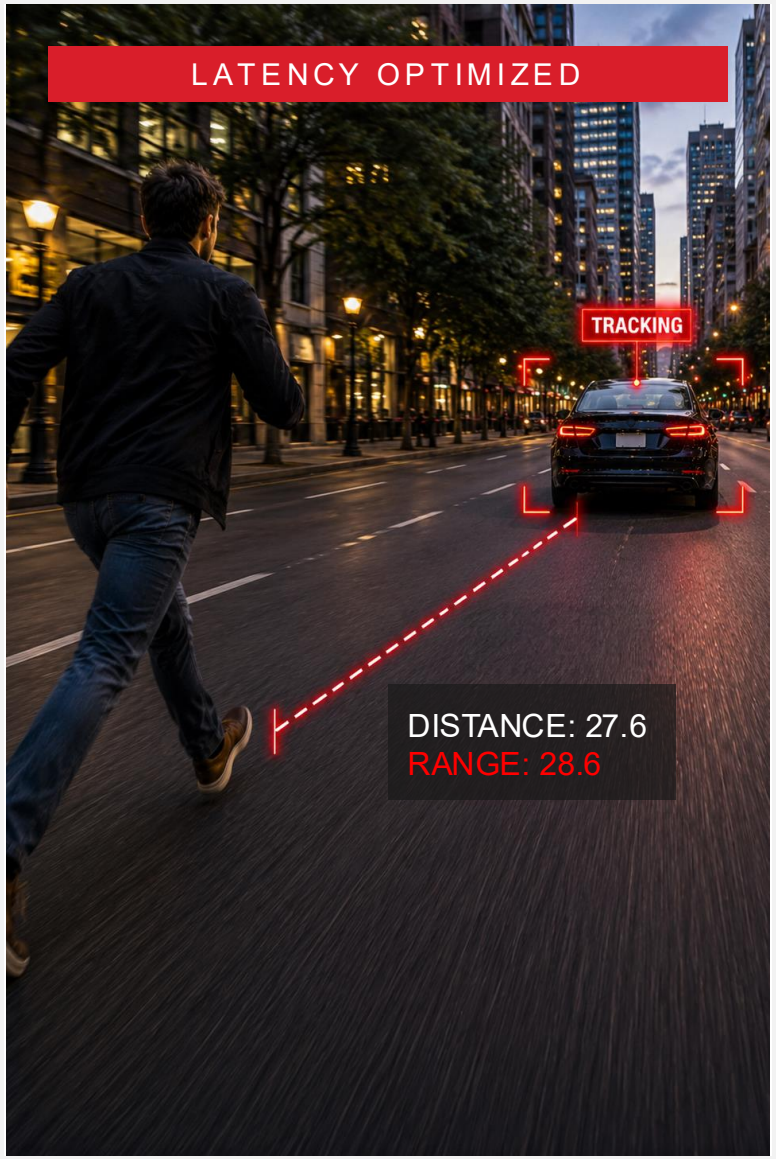
Accurate Mapping for Battery Storage

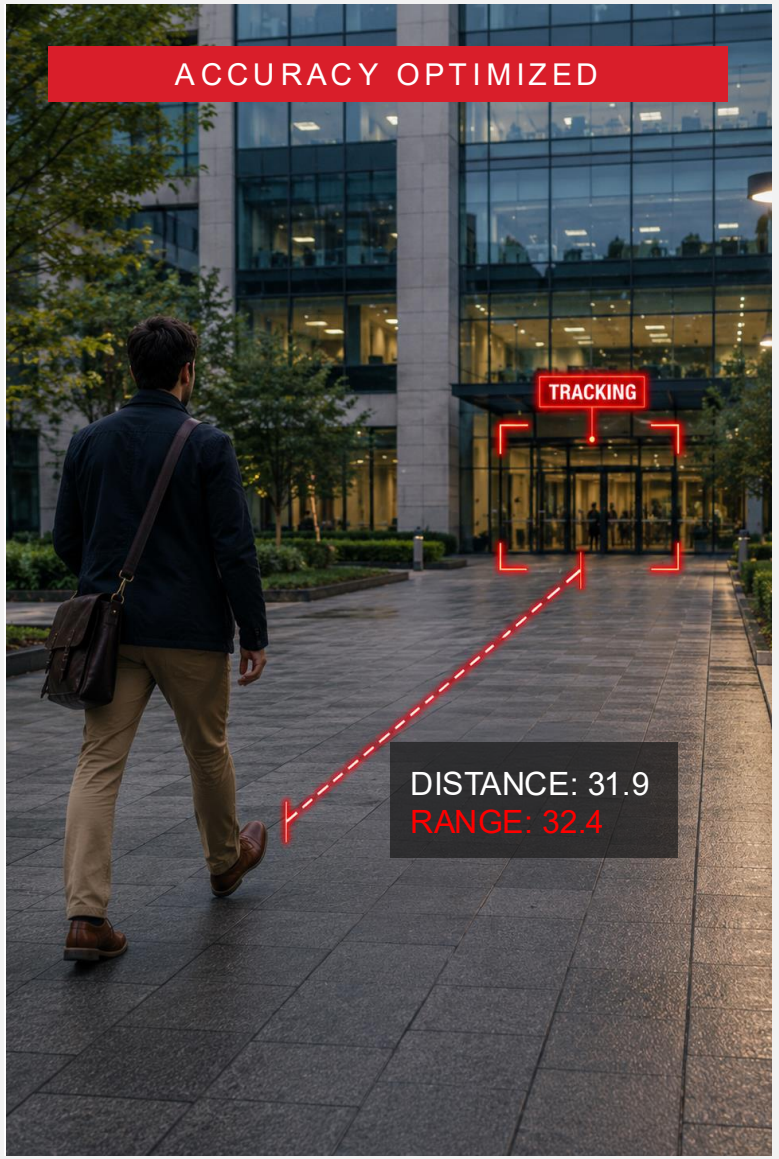
# Bluetooth® Ranging

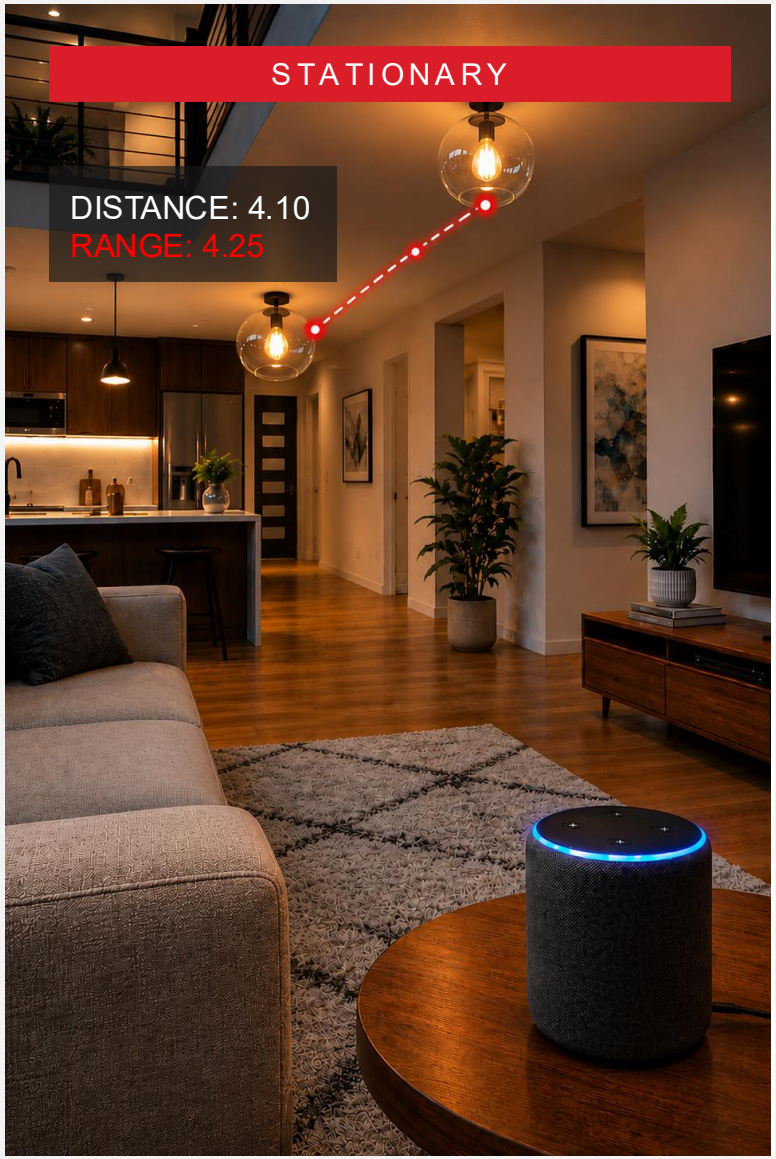
| Category | Bluetooth® RSSI | Bluetooth® Direction Finding | Bluetooth® Channel Sounding | UWB |
|---|---|---|---|---|
| Method | RSSI | AoA/AoD | PBR/RTT | ToF/AoA |
| Measurement Type | Distance Only | Direction + Distance | Distance Only | Direction + Distance |
| Ranging Accuracy | 1-5 m | 1-5 m | < 0.5m – PBR<br>1-5 m – RTT | ~10–30 cm |
| Connection Mode | Connection-oriented or Connectionless | Connection-oriented or Connectionless | Connection-oriented only | Connection- oriented or Connectionless |
| Measurement Latency | 20 ms (typical) | 20 ms (typical) | 100 ms (typical, PBR) | 1 ms (typical) |
| Reliability | Very sensitive to multi-path and interference | Very sensitive to multi-path and interference | Sensitive to multi-path and interferences | Strong immunity to multi-path and interference |
| Security | Not secure, prone to relay attacks | Not secure, prone to relay attacks | Secure, several security features as countermeasure for relay attacks | Very Secure |
| Scalability | 1000’s of tags | 1000’s of tags | 10's tags | 1000’s of tags |
| Smartphone Support | Yes | No | Yes | Yes |
| Device Cost | $ | $ | $ | $$ |

1. Android 16 already supports Channel Sounding Ranging API. Google Pixel 10 officially supports Channel Sounding.

# Ranging algorithm modes in the RTL library



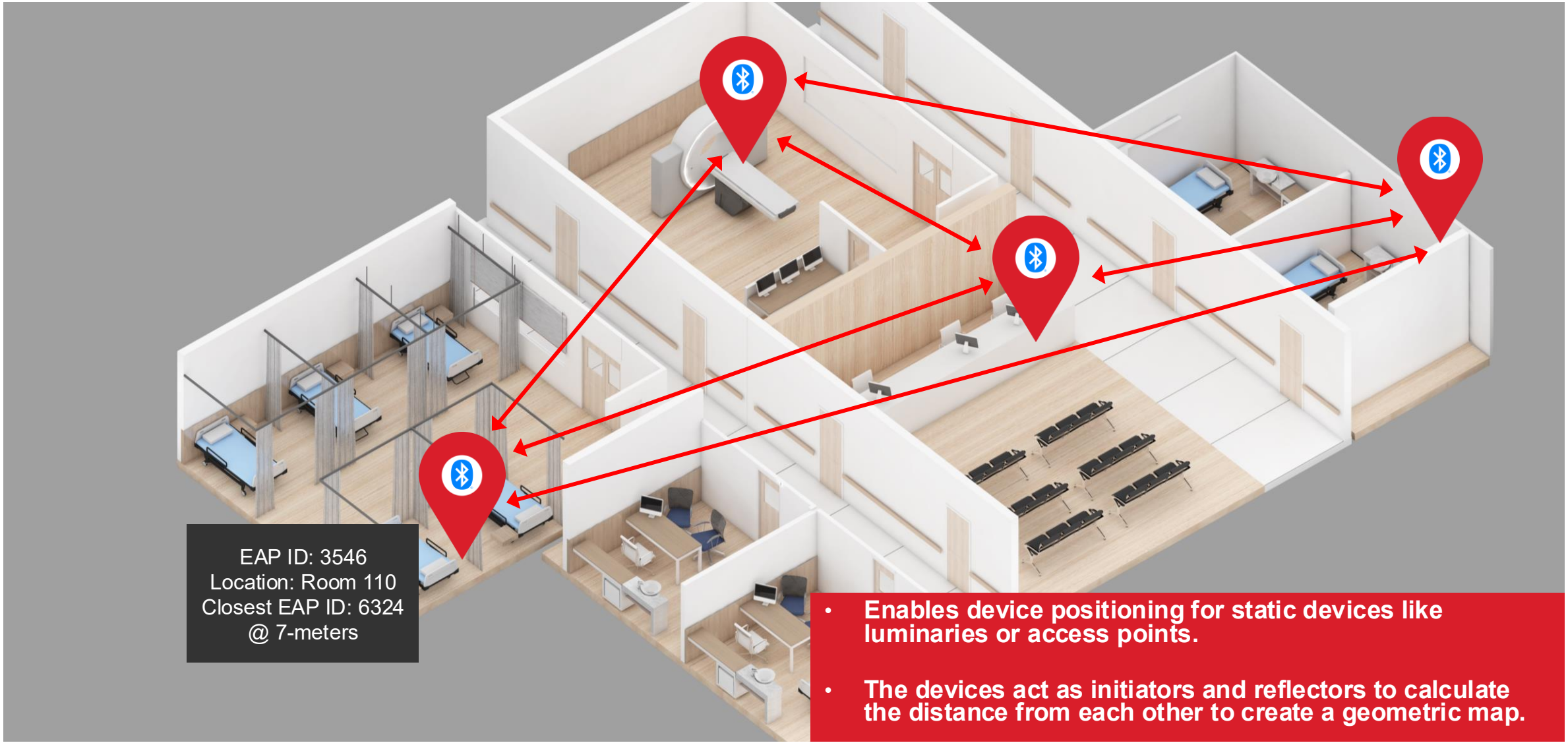
# Channel Sounding Algorithm Modes

| Mode<br>• Config: 1 connection, 4 AP and 72 channels<br>• HW/SW: DK2606A, SiSDK 2026.6 (coming soon) | Tracking | | Stationary |
|---|---|---|---|
| | Latency-optimized | Accuracy-optimized | |
| **LOS accuracy (Typical)** | -1.0...+1.5m | -0.5...+1.0m | -0.5...+1.0m |
| **NLOS** | Body blocking (e.g. back pocket) | | Walls, glass doors, various objects |
| **Max. range** | 40m | > 75m | > 75m |
| **Moving target speed** | < 2.1m/s | < 1.0m/s | N/A |
| **Distance measurement rate** | ~10Hz | ~4Hz | N/A |
| **RAM** | ~8 KB | ~30 kB | ~30 kB |
| **Flash** | ~7 KB | ~16 kB | ~16 kB |

# Point-to-Point Channel Sounding for ”Wake-On Approach”

- Enables distance measurement between a phone and stationary product
- Channel Sounding improves upon RSSI-based “wake on approach” designs
- Compared to RSSI, CS delivers more accurate, reliable, and secure ranging
- Compatible with CS-enabled smartphones using Bluetooth Ranging Service/Profile
- Radial zone entry/exit detection enables improved UI and security features

# Channel Sounding for Static Device Positioning




- **Enables device positioning for static devices like luminaries or access points.**
- **The devices act as initiators and reflectors to calculate the distance from each other to create a geometric map.**

# Automapping Demo

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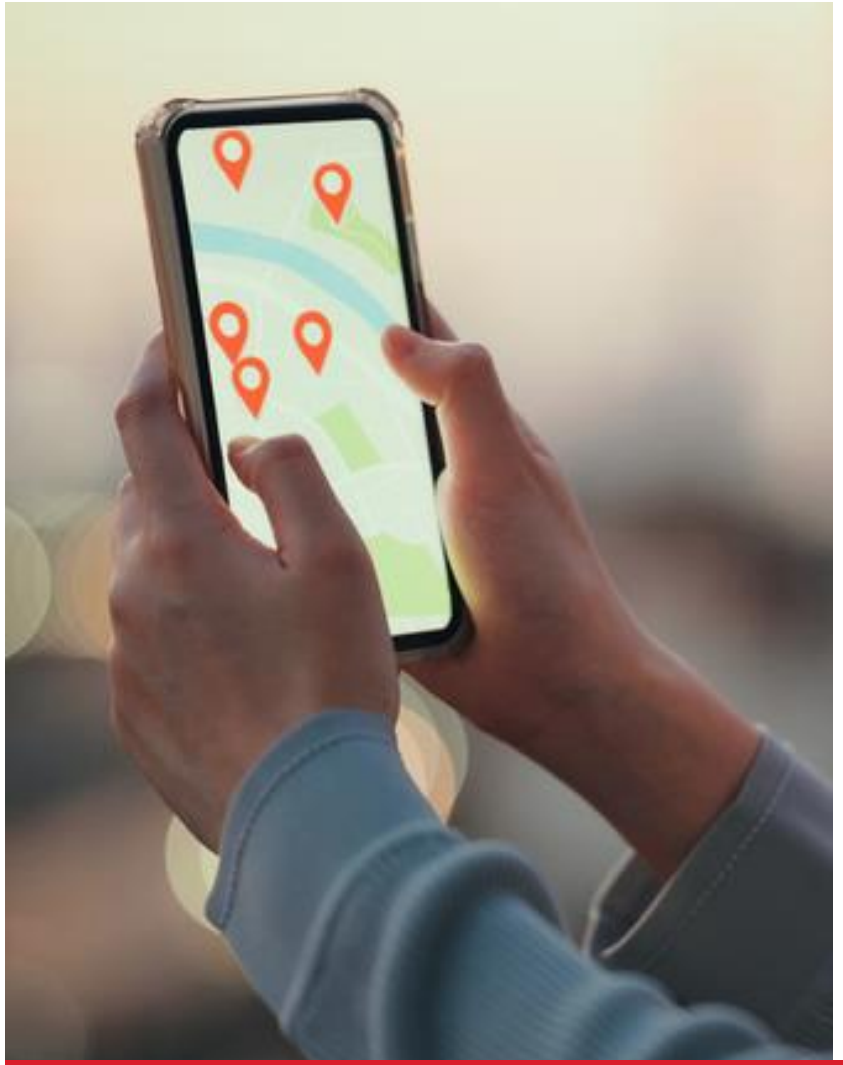
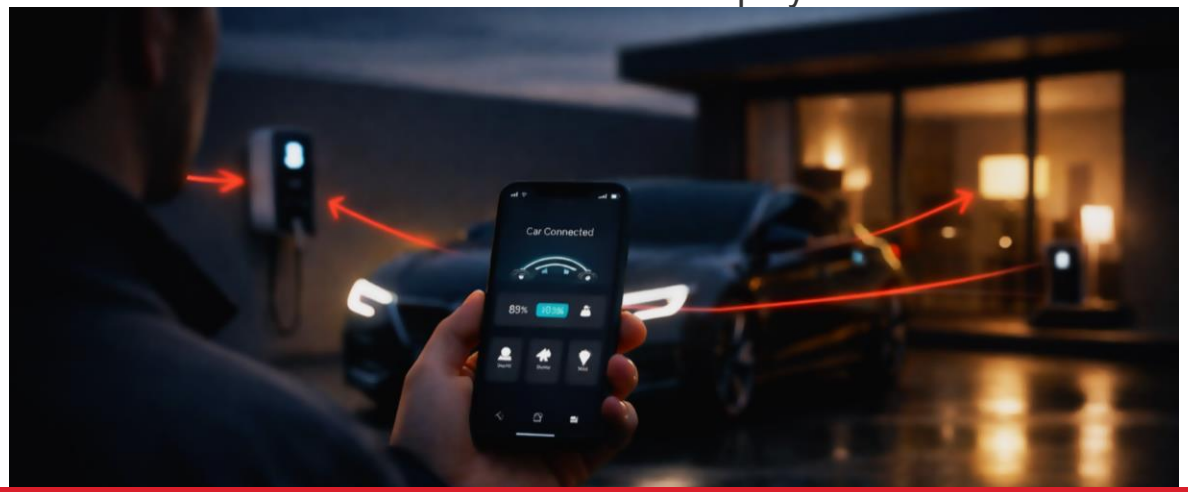
## Static Device Positioning

# Smartphones enable Bluetooth Channel Sounding at scale



- **Smartphone ecosystem is enabling Channel Sounding**
  - Channel Sounding API support available since Android 16
  - Commercial devices beginning to support Channel Sounding
  - Expanding into Find My / asset tracking ecosystems

- **Interoperability across devices is critical**
  - Phones can act as initiator / reflector
  - Interoperate with automotive and IoT endpoints
  - Standardized behavior ensures scalable deployments




**Smartphones accelerate adoption of Bluetooth Channel Sounding across consumer and automotive ecosystems**

# BG24: Optimized for Battery Powered, Channel Sounding-enabled IoT Devices


Bluetooth® Proprietary

- 5x5 QFN40 (26 GPIO), AEC-Q100
- 6x6 QFN48 (32 GPIO), AEC-Q100
- 3.1x3.0 WLCSP42

## DIFFERENTIATED FEATURES

- **Ultra small form-factor**
  - 3.1 x 3.0 WLCSP package
- **+20 dBm output power**
  - Eliminates need for external power amplify
- **AI/ML accelerator**
  - Accelerates inferencing while reducing power consumption
- **Secure Vault High**
  - Protects data and device from local and remote attacks
- **20-bit ADC**
  - 16-bit ENOB for advance sensing
- **Improved Coexistence**
  - Ideal for gateways and hubs
- **PLFRCO**
  - Eliminates need for 32 KHz xtal

## DEVICE SPECIFICATIONS

- **High Performance Radio**
  - Up to +19.5 dBm TX
  - -97.6 dBm RX @ BLE 1 Mbps
- **Efficient ARM® Cortex®-M33**
  - Up to 78 MHz
  - 1536kB Flash, 256kB RAM
- **Low Power**
  - 49.1 µA/MHz (CoreMark)
  - 5.0 mA TX @ 0 dBm
  - 5.1 mA RX (802.15.4)
  - 4.4 mA RX (BLE 1 Mbps)
  - 1.3 µA EM2 sleep
- **Multiple protocol support**
  - Bluetooth 6.0 (1M/2M/LR), Bluetooth mesh, Proprietary 2.4 GHz

# Dual-Antenna Channel Sounding board


- **xG24 Channel Sounding Development Kit**
  - Available since March 2025
  - Development Kit with two PCB antennas
    - Antenna diversity offers increased robustness and accuracy
  - Intra-event antenna switching for optimal non-line of sight performance
  - Includes IMU sensor to detect movement & wake-up the tag
  - Small form factor
    - Ideal for size-constrained applications like key fobs
  - AEC-Q100 Compliant
  - SoC/NCP Sample Apps
    - Initiator and Reflector examples supported
  - Ranging Library
    - Process IQ samples, post-filtering, and compute distance using configurable algorithm

# BGM241S: High Accuracy Bluetooth Ranging with Channel Sounding

Coming Soon


Bluetooth®

**7x7 SiP Module**

## DIFFERENTIATED FEATURES

- **Integrated Power Amplifier**
  - +10 dBm output power
- **AI/ML accelerator**
  - Accelerates inferencing while reducing power consumption
- **Security**
  - Secure Vault High, ARM® TrustZone®
  - Protects data and device from local and remote attacks
- **16-bit ADC**
  - Up to 14-bit ENOB for advance sensing
- **Antenna Diversity**
  - Supports antenna diversity for Channel Sounding using an external 50-ohm terminated SP2T switch.
- **Certifications**
  - **CE, UKCA, FCC, ISED, MIC, KC** – Shielded, Fully Certified
  - Integrated antenna and worldwide RF certifications reduce product development costs
- **PLFRCO**
  - Eliminates need for 32 KHz XTAL

## DEVICE SPECIFICATIONS

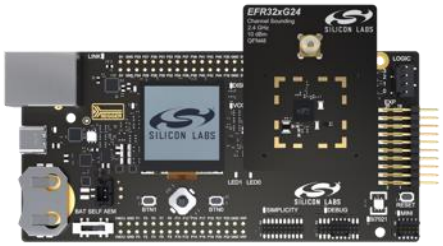
- **Memory**
  - 1536 kB Flash, 256 kB RAM
- **High Performance 2.4 GHz Radio**
  - -97 dBm RX @ BLE 1 Mbps
- **Efficient ARM® Cortex®-M33**
  - Up to 80 MHz
- **Low Power**
  - 49.1 µA/MHz (CoreMark)
  - 4.6 mA TX @ 0 dBm
  - 5.1 mA RX (BLE 1 Mbps)
  - 1.3 µA EM2 sleep with 16 kB RAM retained
- **Wide Operating Range**
  - 1.8 to 3.8 V
  - -40 to +105 C
- **Multiple protocol support**
  - Bluetooth Low Energy 6.x, Bluetooth Mesh, Direction Finding

# Visualizer Tool


## Visualizer Tool displays real-time CS data

- CS configuration
  - Channel map selection
  - Antenna path configuration
  - Algorithm mode selection
- CS data visualization
  - RSSI based distance for comparison
  - Raw distance estimate and likeliness
  - Filtered distance estimate
  - IQ data visualization
- Interfaces with CS enabled EVKs

# Silicon Labs Bluetooth ® Channel Sounding Offering – Complete Solution



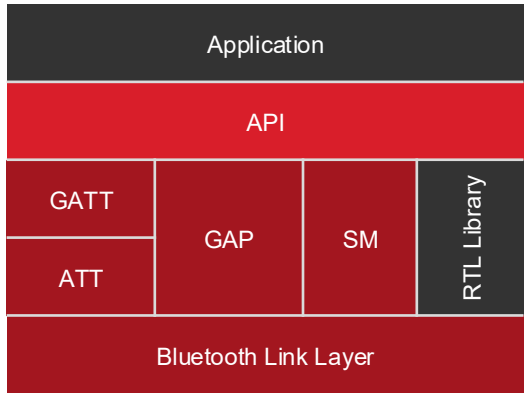

## ICS & DEVELOPMENT KITS

Channel Sounding Supported by **B/MG24**

**Kits:**

**xG24-DK2606A** dual antenna kit

**BGM241-DK2610A** dual antenna kit

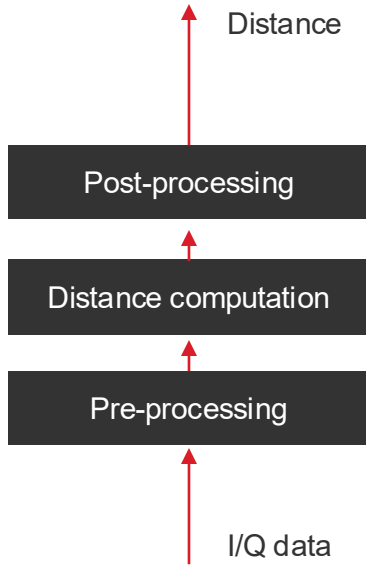



## BLUETOOTH 6.0 STACK

Purpose-built stack, developed and maintained in-house

Bluetooth 6.x qualified

PBR & RTT Modes




## RTL LIBRARY

Computes distance from raw I/Q data

Developed and supported by Silicon Labs

New features added based on market needs

No 3rd party license fees

SIMPLICITY STUDIO

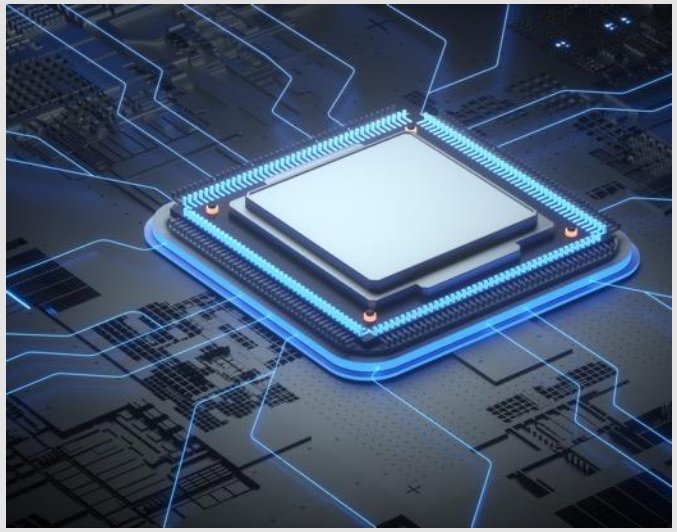
## SDK & TOOLS

Initiator & Reflector examples

Real-time visualization tool for Bluetooth Channel Sounding

Energy Profiler, Network Analyzer etc.

# Learn More About Silicon Labs Channel Sounding



## GETTING STARTED

Channel Sounding Kits Available at:

Visit site

Channel Sounding Developer Guide:

Visit site

## FOR MORE INFORMATION

Learn About Channel Sounding Technology:

Visit site

Explore Bluetooth Channel Sounding Webinar:

Visit site

## CALL TO ACTION

For any questions about SiLabs offerings, please contact our Sales team, or reach out to our developer community.

Developer Community