WELCOME

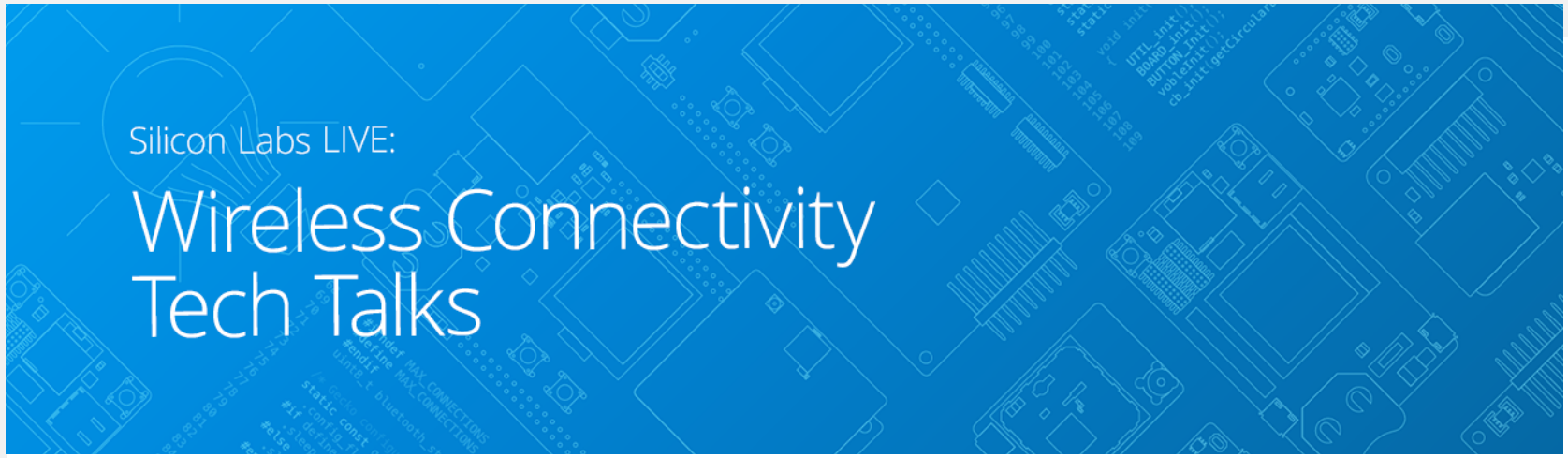
Silicon Labs LIVE:

Wireless Connectivity Tech Talks

eat LOCAL

#ieatlocal

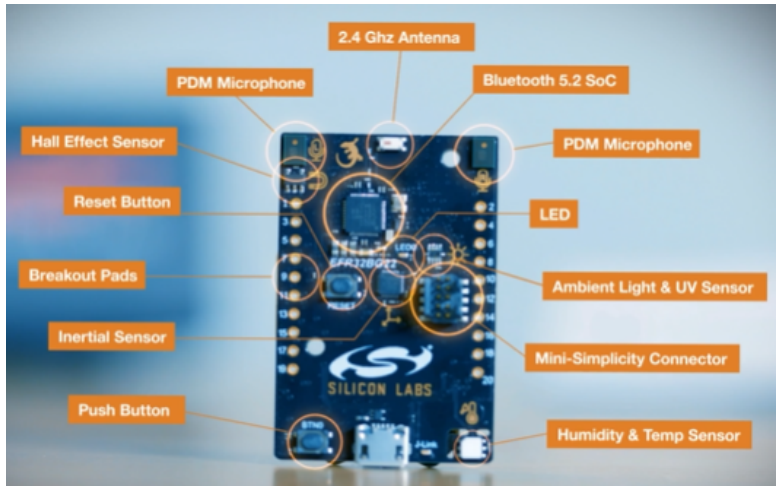
Tech Talks LIVE Schedule – Presentation will begin shortly



Topic	Date
Future Proofing for Connected Home Over IP	Tuesday, April 21
Z-Wave Smart Home Solutions	Thursday, April 23
Battery Optimization with BG22	Tuesday, April 28
Max Performance on BLE – Simultaneous Connections, Beacons and Scanning	**Thursday, April 30**
SubGHz proprietary and Connect software stack	Tuesday, May 5
How to measure and debug network performance - Using Silicon Labs network analyzer	Thursday, May 7

https://www.silabs.com/support/training

Please take the 3 question poll while waiting and be entered to receive a Thunder BG22 Kit.



Tech Talks LIVE Schedule

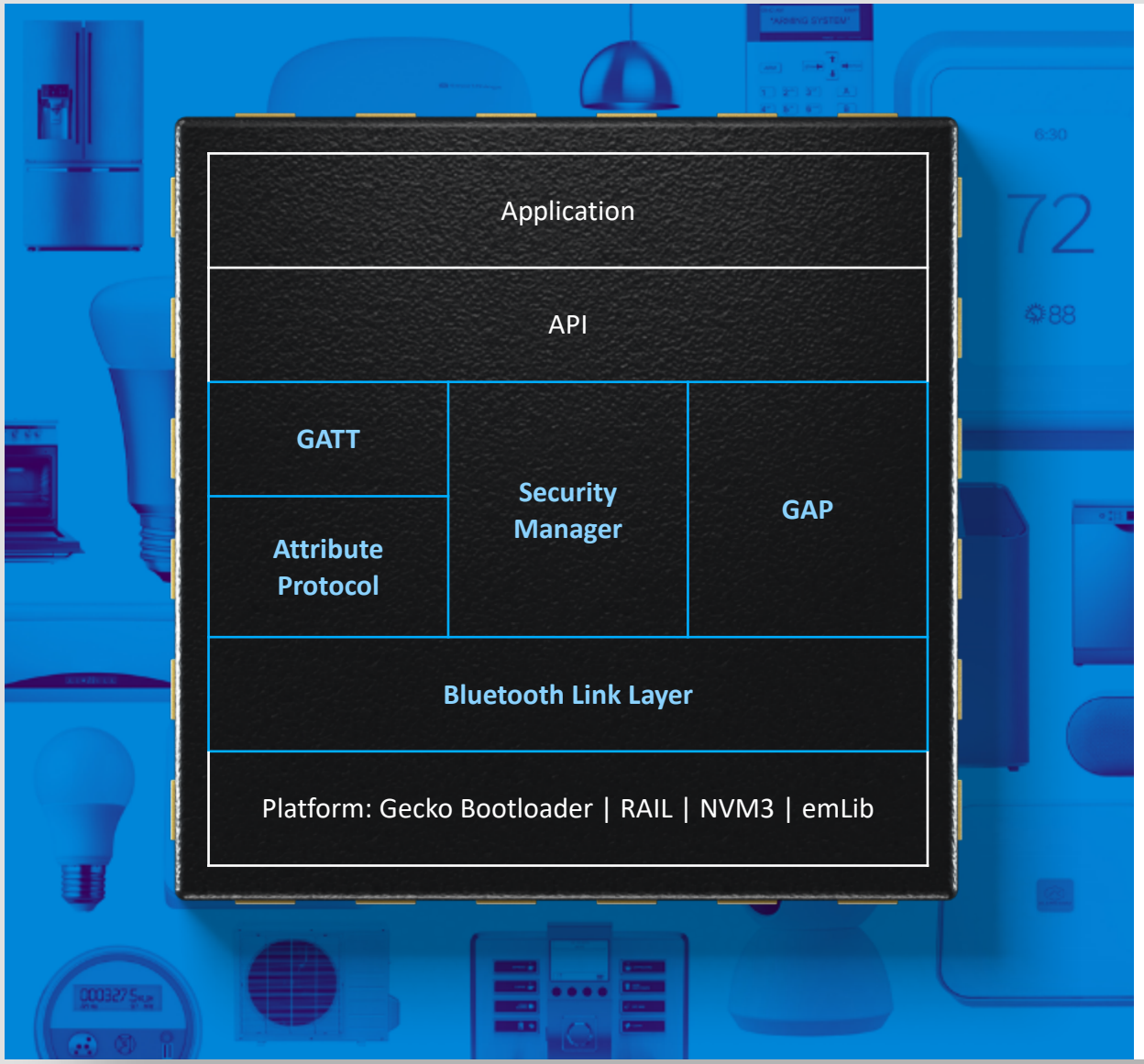
Topic	Date
Future Proofing for Connected Home Over IP	Tuesday, April 21
Z-Wave Overview	Thursday, April 23
Battery Optimization with BG22	Tuesday, April 28
Max Performance on BLE – Simultaneous Connections, Beacons and Scanning	**Thursday, April 30**
SubGHz proprietary and Connect software stack	Tuesday, May 5
How to measure and debug network performance - Using Silicon Labs network analyzer	Thursday, May 7

https://www.silabs.com/support/training

Agenda

- Silicon Labs Bluetooth stack Features
- Silicon Labs Bluetooth Stack overall performance numbers
- Optimization based on your application needs
- Optimization for Responsiveness
- Throughput Optimization
- Optimizing Security

Bluetooth LE Software



A Bluetooth 5.2 compliant Bluetooth stack, with:

- Bluetooth 5.2 Dynamic TX power control
- Bluetooth 5.1 Direction Finding
- Bluetooth 5.0 standard features
- Relevant Bluetooth 4.x features

Packed with advanced functionality

- Multiple connections and advertisers
- Concurrent advertising, scanning and LE connections
- Optimized throughput and power consumption

Built on top of the common EFR32 software platform

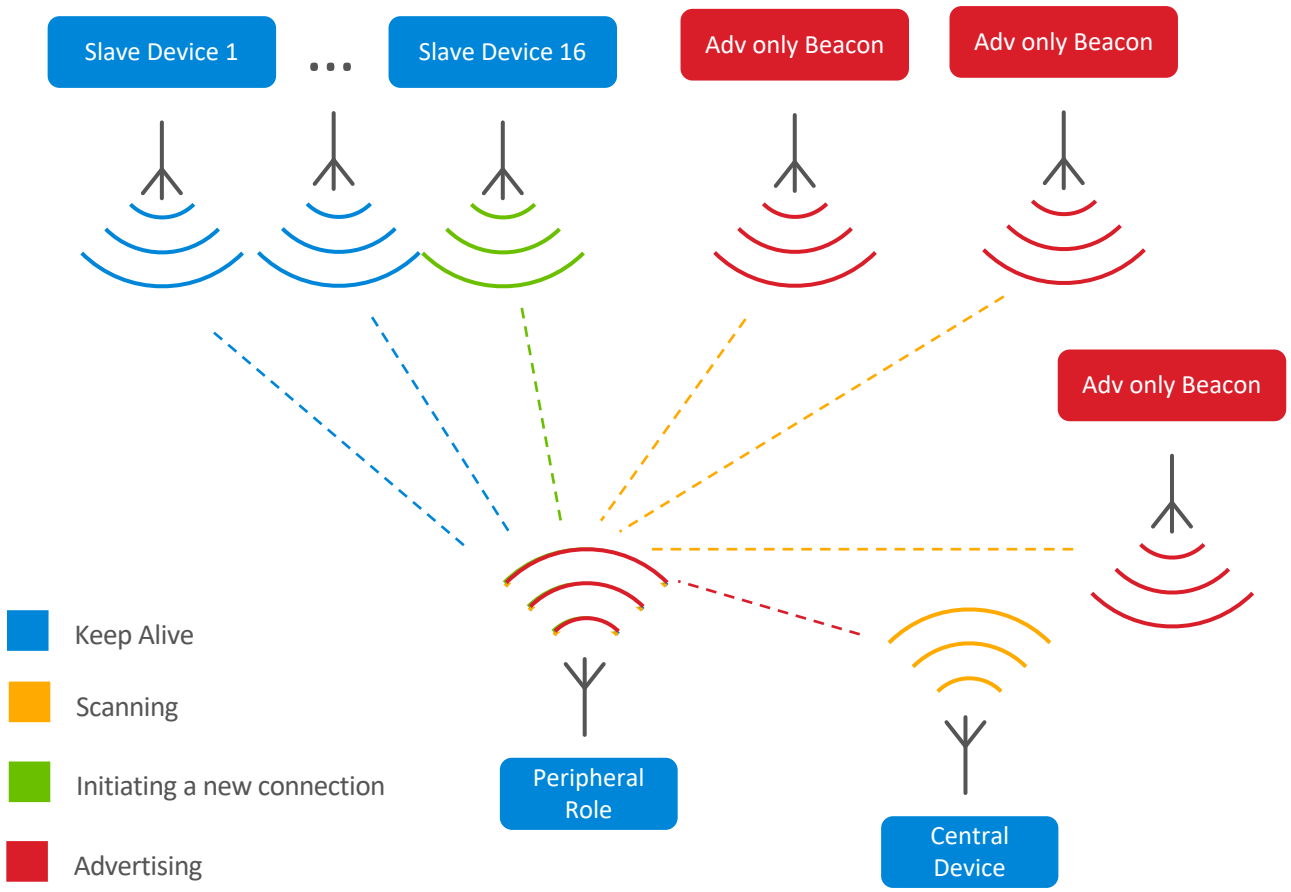
- Gecko bootloader
- emLib for MCU peripherals and drivers
- NVM3 key/value pair data storage with wear leveling
- RAIL radio driver

Bluetooth LE – Performance Figures

Source: Silabs UG136 - **Application Developer's Guide**

Feature	Value	
Simultaneous connections	Up to 8 Up to 16	(xG22 and xG1) (xG21, xG13, xG12)
Throughput (EFR32-2-EFR32)	1M PHY: 2M PHY: 125k PHY:	~700kbps ~1300kbps ~100kbps
Packets per connection interval	Not limited	
Link Layer packet size	Up to 251B	
ADV payload size	Up to 191B (per packet)	
ATT MTU	Up to 250B	
Max bondings	NVM3: Depends on NVM3 size allocation 14	

Optimize for Application - Bluetooth Tasks

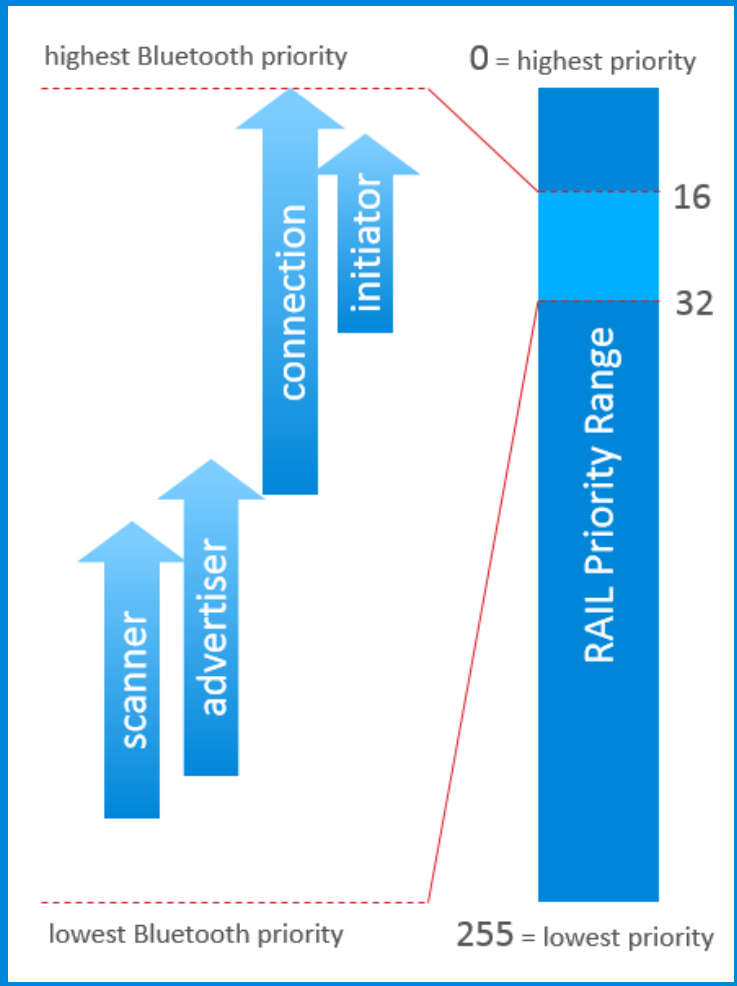


- **The Bluetooth Stack often needs to run Multiple tasks**
- **You can simultaneously:**
  - Keep alive multiple connections
  - Scan for Beacons and new devices
  - Initiate a new connection
  - Send out advertisements

Optimize Application - Stack priorities

```
gecko_bluetooth_ll_priorities priorities = { 191, 143,  //scan_min, scan_max
                                             175, 127,  //adv_min,  adv_max
                                             135,   0,  //conn_min, conn_max
                                             55,  15,   //init_min, init_max
                                             175,       //threshold_coex
                                             16,        //rail_mapping_offset
                                             16,        //rail_mapping_range
                                             0,         //afh_scan_interval
                                             4,4        //adv_step, scan_step
                                           };

// Gecko configuration parameters (see gecko_configuration.h)
static const gecko_configuration_t config = {
  //...
  .bluetooth.linklayer_priorities = &priorities,
};
```



Source: Silicon Labs KBA_BT_0407: Bluetooth Radio Task Priorities

Optimization for Responsiveness: Connection & Advertising Parameters

Connection Parameter Tradeoffs - Cheat Sheet

Low ← Connection Interval → High

	Low	High
Slave Power Consumption:	Increases	Decreases
Master Power Consumption:	Increases	Decreases
Data Throughput:	Increases	Decreases
Slave-to-Master Data Latency:	Decreases	Increases
Master-to-Slave Data Latency:	Decreases	Increases

Low / Zero ← Slave Latency Value → High

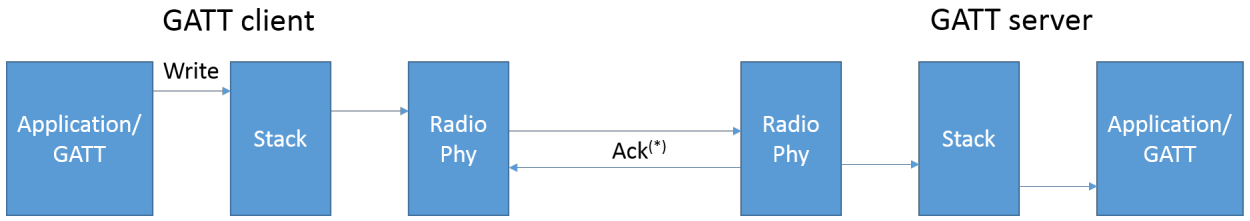
	Low / Zero	High
Slave Power Consumption:	Increases	Decreases
Master Power Consumption:	No Impact	No Impact
Data Throughput:	No Impact	No Impact
Slave-to-Master Data Latency:	No Impact	No Impact
Master-to-Slave Data Latency:	Decreases	Increases

Source: SwaraLink Technologies – BLE Developer's Checklist
https://www.swaralink.com/checklist/

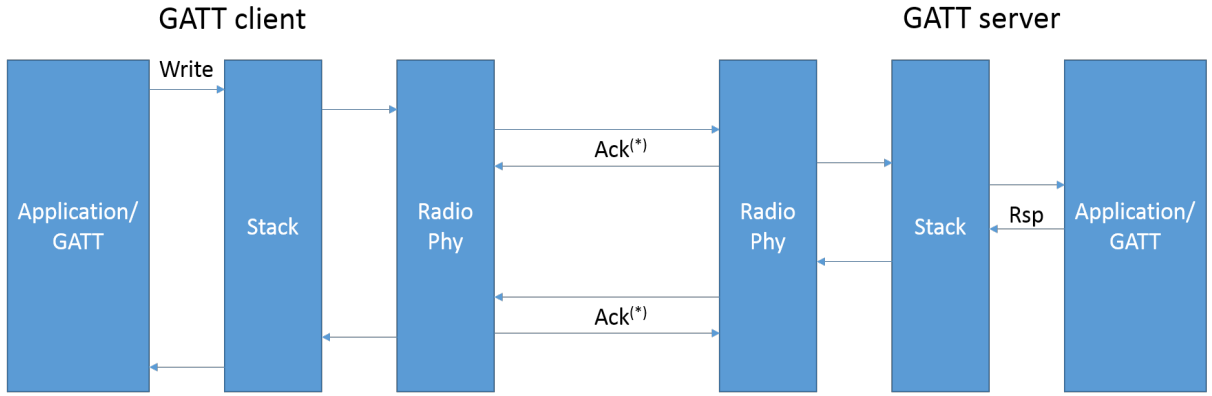
- **The choices of these parameters will have the largest impact on the performance of your device**
- **Default connection parameters may not be optimal for your application's power, latency, or throughput requirements**
- **A well-designed system will have dynamic connection parameters that change as required by the application**
- **Consider using the slave latency feature this is one of the most useful features for reducing power with minimal sacrifice to latency and throughput!**

Throughput Optimization – Attribute Protocol Operation

Write without response (unacknowledged write)



Write with response (acknowledged write)

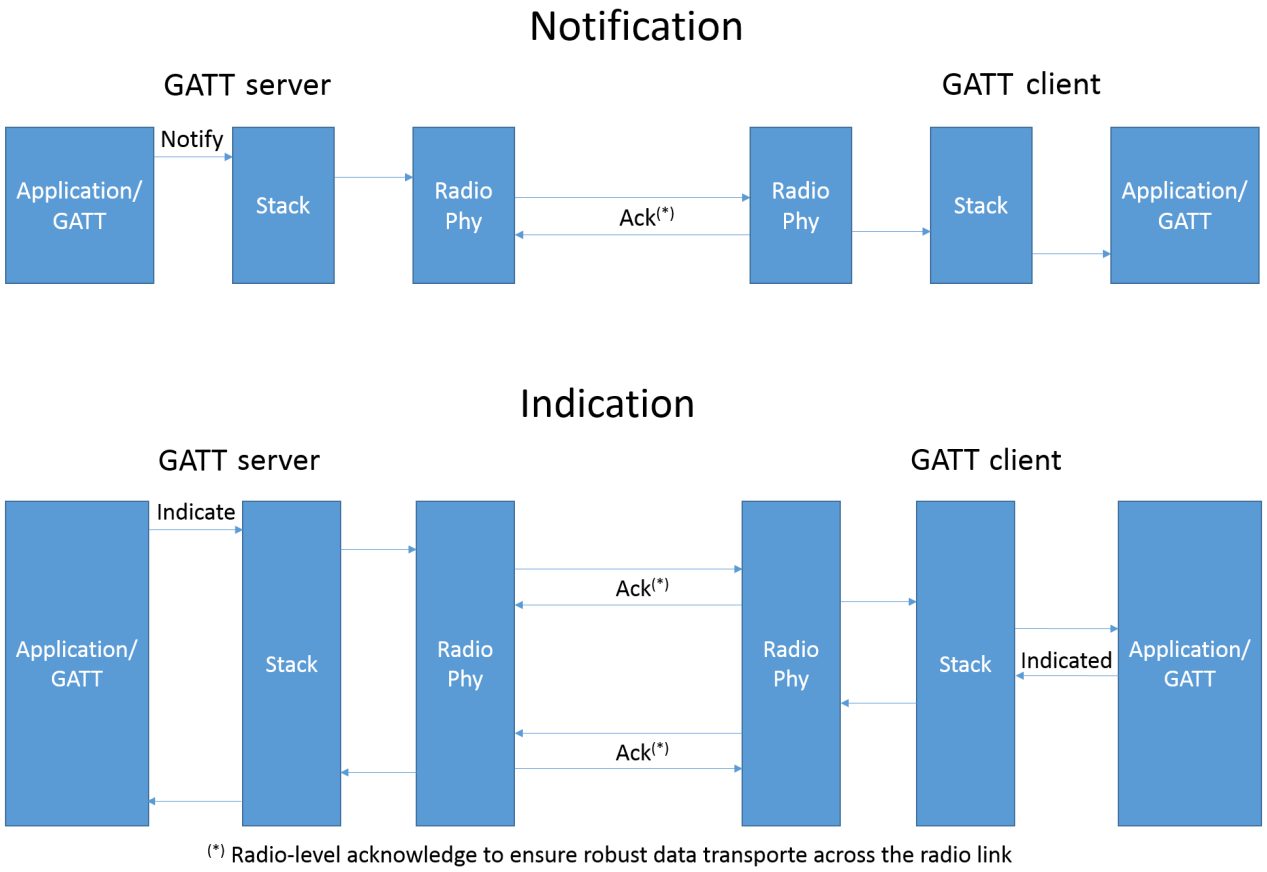


(*) Radio-level acknowledge to ensure robust data transporte across the radio link

Source: KBA_BT_0104: Acknowledged vs Unacknowledged GATT operations

- Unacknowledged Operations are more desirable if a higher throughput is required
- On both acknowledged and unacknowledged GATT operations the data is reliably transported across the radio link.
- If the application can't process the write request, a response will not be sent and a timeout will occur after 30 seconds

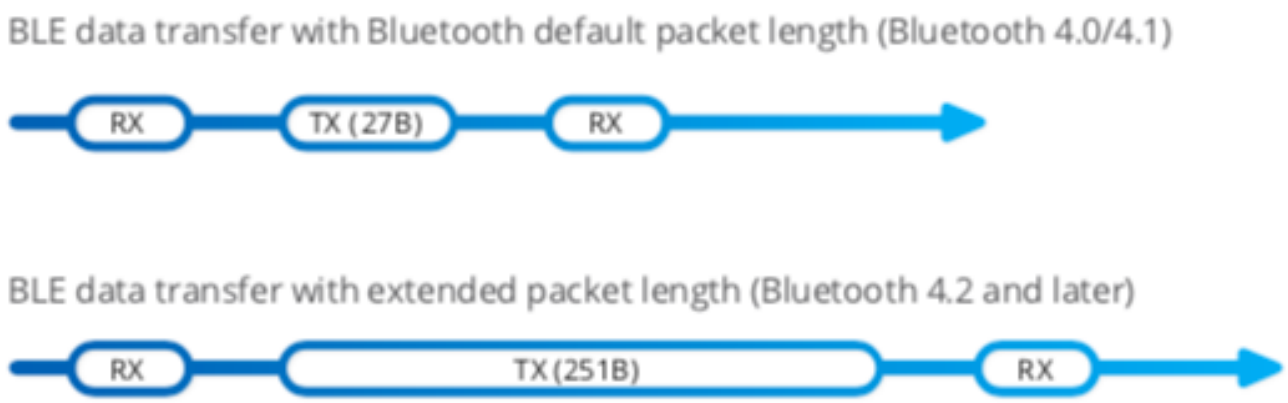
Throughput Optimization – Attribute Protocol Operation



Source: KBA_BT_0104: Acknowledged vs Unacknowledged GATT operations

- Use notifications and write command (write without response) packets as opposed to indications and write requests (write with response)
- These procedures enable your device to send multiple packets during a single connection event, and provide a significant increase in throughput
- The throughput difference between Acknowledge vs unacknowledged Data Transfers can be >7x

Throughput Optimization – Large PDU length and MTU



KBA_BT_0404: Throughput with Bluetooth Low Energy technology

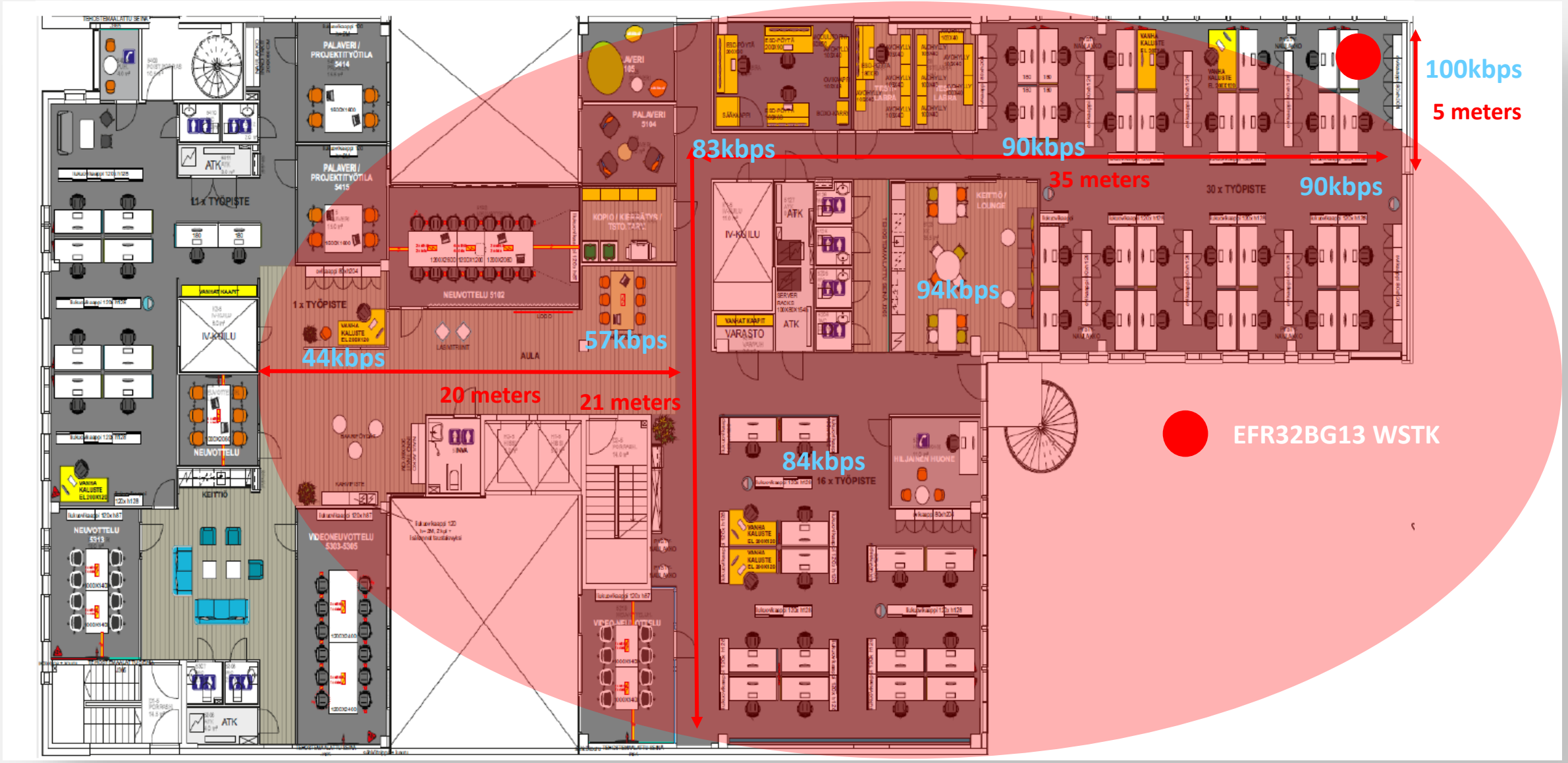
- MTU (maximum transfer unit) specifies the number of bytes that can be sent within one GATT operation.
- The actual PDU length and ATT_MTU size used in a connection are negotiated between the central and peripheral devices.
- The higher the MTU size, the higher the throughput. Twice the MTU size doubles the throughput.
- The Existing 2.13.x Bluetooth SDK supports a 251B MTU

Throughput Optimization - Bluetooth PHY Choices

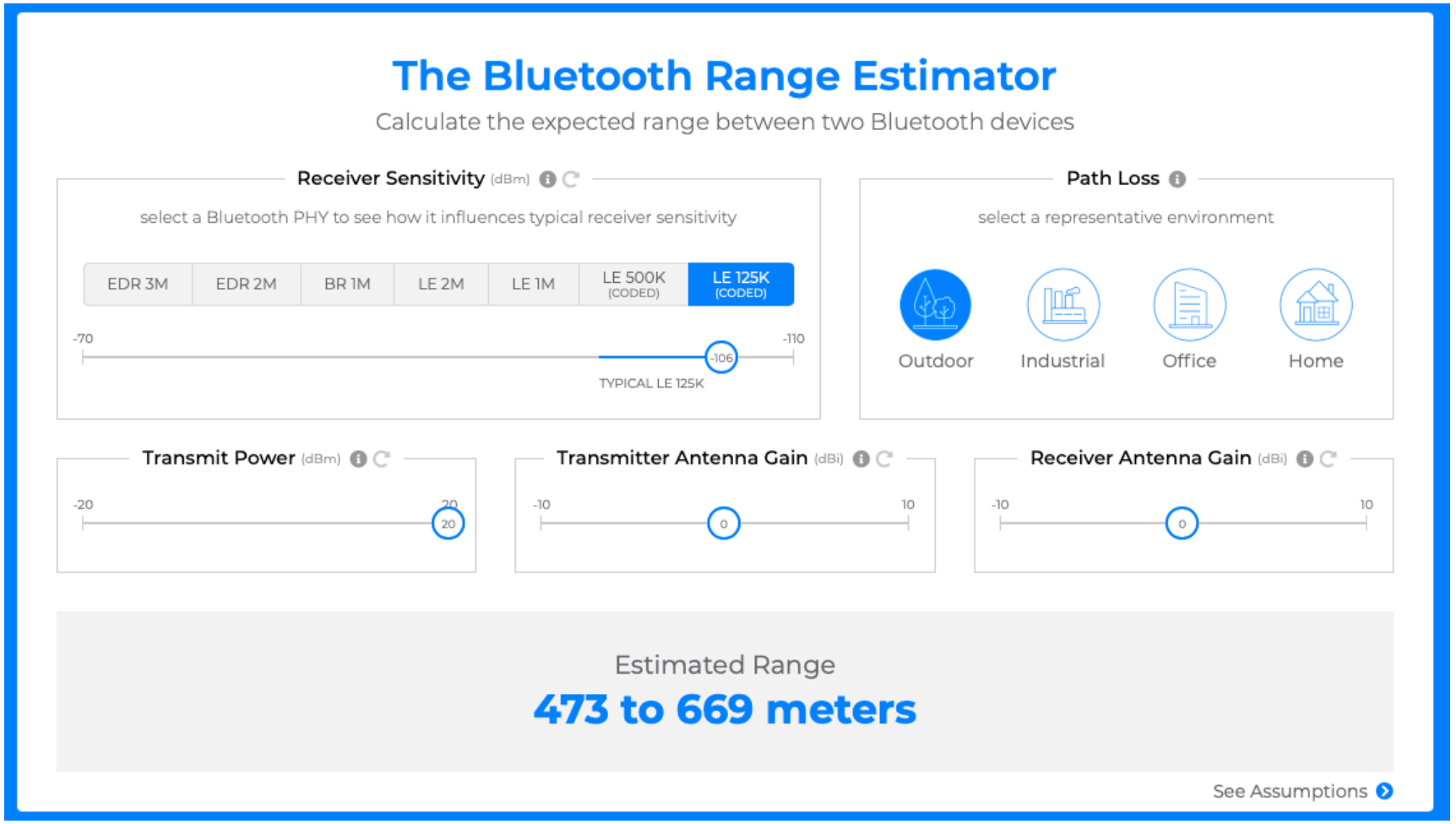
- **Take advantage of the 2M PHY whenever available**
- **Switch PHYs as your application behavior changes**
- **Take advantage of the Built-in PA (BG22 6dBm, BG21/BG13 20dBm)**

PHY	Symbol rate	Range multiplier	PDU Length	Minimum packet time	Maximum packet time	Max Theoretical throughput	Silabs Throughput
1M	1 M symbols/s	1x	0–257 B	80us	2.12ms	800 kbps	700 Kbps
2M	2 M symbols/s	0.8x	0–257 B	44us	1.064ms	1438 kbps	1300Kbps
125 kbps	1 M symbols/s	2x	0–257 B	720 µs	17.04 ms	112 kbps	100 Kbps

EFR32BG13 to EFR32BG13 Indoor Range: +10dBm, 125k PHY, PCB antenna



Bluetooth Long Range Estimator



https://www.bluetooth.com/learn-about-bluetooth/bluetooth-technology/range/

Optimizing Security

www.silabs.com/security

BG22	BG21
True Random Number Generator Generate keys for proper cryptography	**Secure Element Subsystem** Security isolation in hardware
Secure Boot with RTSL Only boot authenticated firmware	**Secure Key Management** Isolate encrypted keys from application code
Crypto Engine Up to 512-bit ciphers and elliptic curves	**Secure Attestation** Ensure integrity and authenticity
Secure Debug with Lock / Unlock Allow enhanced FAs	**Anti-tamper** Detect tamper and protect keys/data
	DPA Countermeasures Resist side channel attacks

BG21: Optimized for Secure Mains Powered Devices

Bluetooth® zigbee THREAD

BG21 can be paired with EFP to reduce active TX/RX current consumption

Radio
Up to +20 dBm TX
Extremely good RX sensitivity
Bluetooth 5.1
802.15.4

Current Consumption
8.8 mA RX (1 Mbit/s GFSK)
10.5 mA TX @ 0 dBm
33.8 mA TX @ 10 dBm
4-8uA EM2

World Class Protocol Stacks
Bluetooth 5.1 and Bluetooth mesh
Zigbee 3.0
OpenThread
Apple HomeKit

Compact Size
4x4 QFN32 (20 GPIO)

ARM Cortex-M33 with TrustZone
80 MHz w/ FPU and DSP
Up to 96kB RAM and 1024kB flash
50.9 µA/MHz

Peripherals Fit for Purpose
3x USART, 2x I2C
1x 12-bit ADC, 2x ACMP
7x timers
Up to 20x GPIO

Security
True Random Number Generator
Hardware Accelerated Crypto Engine
Secure Boot with root of trust
Secure debug with lock/unlock
DPA Countermeasures

With Secure Vault™
Anti tamper
Secure attestation
Secure key management and storage
Advanced crypto

BG22: Optimized for Battery Powered Bluetooth LE, Mesh and AoX

Optimized

Secure Bluetooth 5.2 SoCs for High-Volume Products

Radio
Bluetooth 5.2
+6 dBm TX
-99 dBm RX
AoA & AoD

Ultra-Low Power
4.1 mA Radio TX
3.6 mA Radio RX
1.4uA EM2 with 32kB RAM
0.54uA in EM4
RTC in EM4

World Class Software
Bluetooth 5.2
Bluetooth mesh LPN
Direction Finding

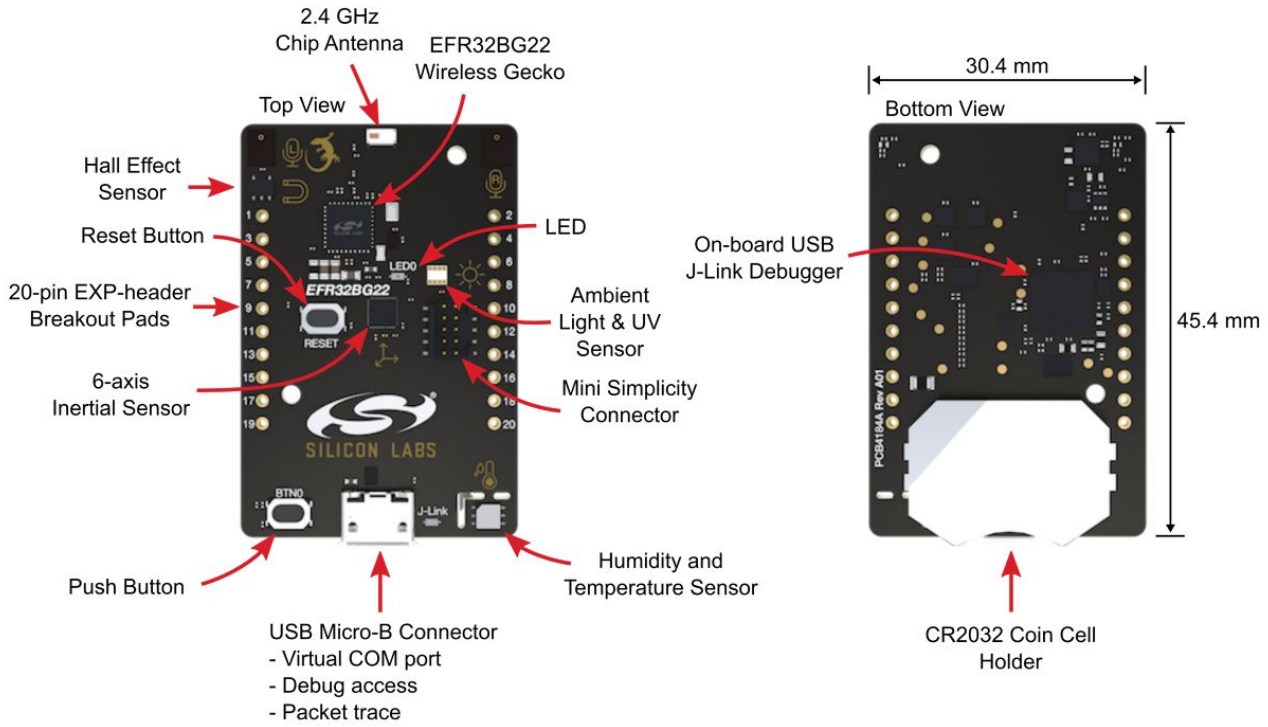
Compact Size
5x5 QFN40 (26 GPIO)
4x4 QFN32 (18 GPIO)
4x4 TQFN32 (18 GPIO)

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

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

Security
True Random Number Generator
Hardware Accelerated Crypto Engine
Secure Boot with root of trust
Secure debug with lock/unlock

Thunderboard BG22



- Bluetooth 5.2 BG22 Soc
- Relative Humidity Sensor
- Ambient Light and UV Index Sensor
- Hall effect sensor
- 6 axis Gyro and Accel Sensor (Asset Tags and Beacons)
- 2 Digital mems Microphones with PDM output
- Built-in Debugger
- Free iPhone and Android App
- $19.99

Documents / User Guides

Main source of Documents - docs.silabs.com

KBA_BT_0407: Bluetooth Radio Task Priorities - https://www.silabs.com/community/wireless/bluetooth/knowledge-base.entry.html/2018/09/28/bluetooth_radio_task-snmO

KBA_BT_0404: Throughput with Bluetooth Low Energy technology - https://www.silabs.com/community/wireless/bluetooth/knowledge-base.entry.html/2015/08/06/throughput_with_blue-Wybp

KBA_BT_0104: Acknowledged vs Unacknowledged GATT operations - https://www.silabs.com/community/wireless/bluetooth/knowledge-base.entry.html/2016/05/02/acknowledged_vs_unac-u6eO

KBA_BT_0105: Bluetooth 5 Features - https://www.silabs.com/community/wireless/bluetooth/knowledge-base.entry.html/2017/05/22/bluetooth_5_features-Hu9N

Throughput Tester Code Example - https://docs.silabs.com/bluetooth/latest/code-examples/stack-features/system-and-performance/throughput-tester-soc-mode

UG136: Silicon Labs *Bluetooth* ® C Application Developer's Guide - https://www.silabs.com/documents/public/user-guides/ug136-ble-c-soc-dev-guide.pdf

Apple Accessories Guidelines: https://developer.apple.com/accessories/Accessory-Design-Guidelines.pdf

Bluetooth SIG Range Estimator - https://www.bluetooth.com/learn-about-bluetooth/bluetooth-technology/range/

Thank You | Questions