Talk Talks LIVE Schedule

Topic	Date
Bluetooth AoX Solutions	Thursday, April 2
15.4 Mesh Networking Technologies	Tuesday, April 7
Bluetooth Mesh Solutions & Tools	Thursday, April 9
Device & Network Security for the IoT	Tuesday, April 14
Evolution of Bluetooth 5, 5.1, & 5.2	Thursday, April 16
Connected Home Over IP (CHIP) for Beginners	Tuesday, April 21

https://www.silabs.com/about-us/events/tech-talks

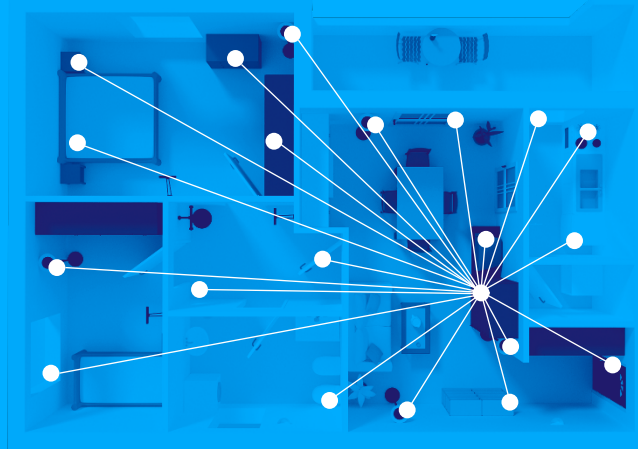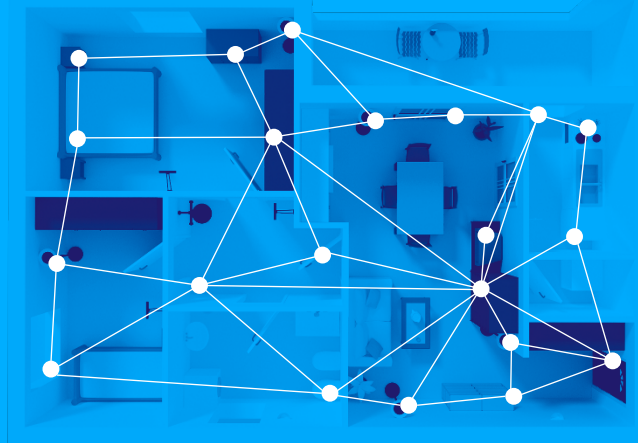# Silicon Labs *Bluetooth*® Mesh Solutions

Why Mesh Networking?

Star Network

Mesh Network

- **Extends the range** of connections from gateways or mobile devices with multi-hop communication

- **Increases system scale** by supporting large amount of devices in a single network

- **Improves system reliability** with multipath messaging network is not dependent on single nodes or routes

- **Delivers optimal responsiveness** with device to device communication

*) Silicon Labs has tested up to 240 devices

4

Why Bluetooth Mesh?
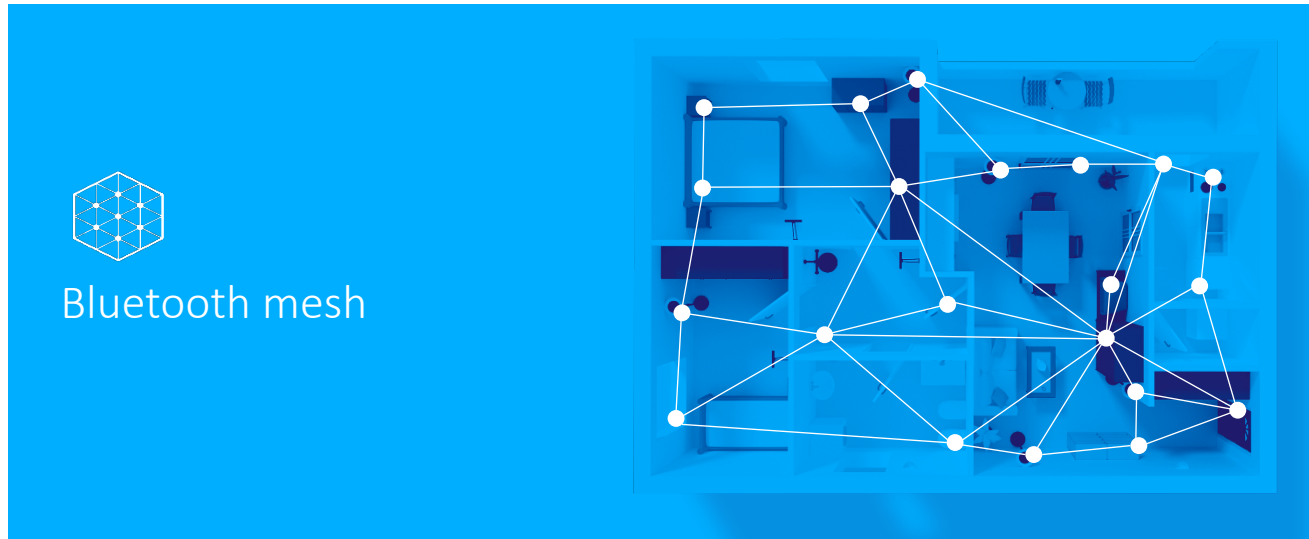
Bluetooth mesh

- **Scale:** Bluetooth mesh scales from small ten node networks to commercial grade networks with hundreds of nodes

- **Phone connectivity:** Phones can be used for easy network setup and configuration and mesh network can be used to deliver location services

- **Gateway is optional** in Bluetooth mesh networks, but can be used when it makes sense

- **Industrial grade security:** Bluetooth mesh implements state-of-the-art two-layer security with protection against all known security attacks

- **Full stack interoperability:** A Bluetooth SIG defined and driven standard from RF to application layer

Bluetooth Mesh Messaging

Proxy ● Relay ● Friend ● Low power
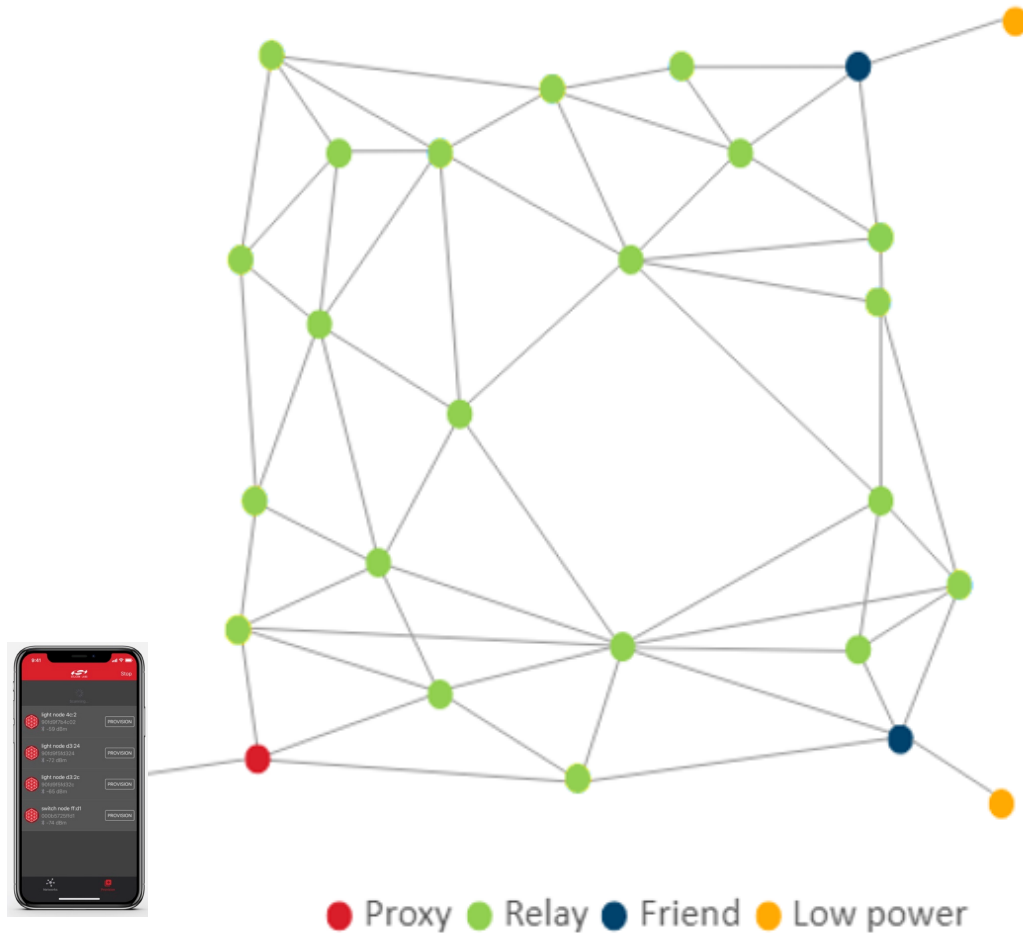
- **Unicast, multicast and broadcast:** Bluetooth mesh supports unicast, broadcast and multicast to address everything from a single node, to a group or a whole network

- **Multipath**: Bluetooth mesh uses a managed flood message relay that can inherently provide multipath delivery

- **Managed flooding:**
  - **Time To Live (TTL):** TTL is used in all Bluetooth mesh messages to control the number of hops over which a message will be relayed
  - **Message cache:** A message cache is implemented by all nodes and it is used to prevent recently seen messages from being transmitted again
  - **Relaying is optional**: All nodes do not need to implement relay feature

Bluetooth Mesh Publish - Subscribe
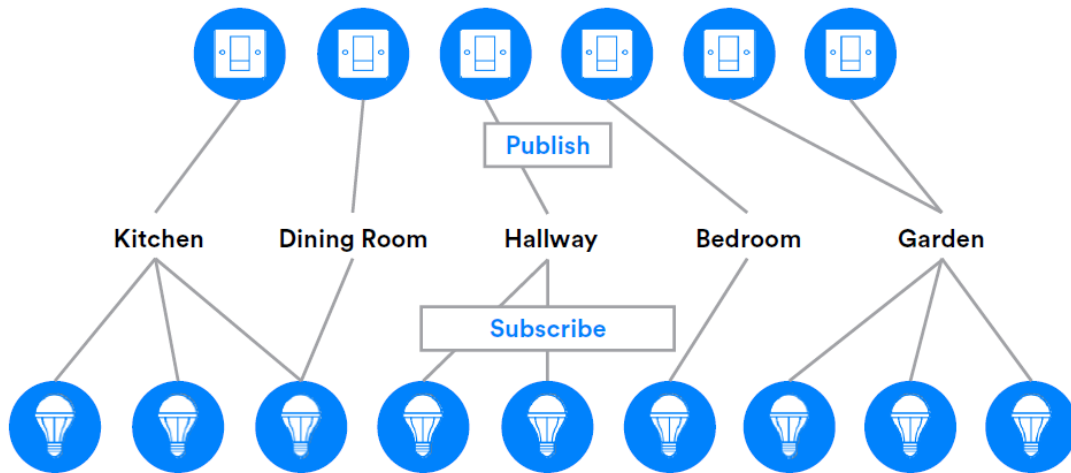
- The act of sending a message is known as **Publishing**

- Nodes are configured to select messages sent to specific addresses for processing, and this is known as **Subscribing**

- Typically, messages are addressed to group or virtual addresses

- The configuring application (i.e. mobile app or gateway) can assign meaningful names to the group/virtual addresses, making them easy and intuitive to use

- Only the device that is installed or replaced needs to be configured

Bluetooth Mesh: Models

- Standard functionality defined by the Bluetooth SIG

- Client / Server
  - Server – has data
  - Client – reads or writes data

- Lighting Models
  - Light Lightness Client/Server
 - Light OnOff Client/Server
  - Light LC Server

Sensor Client / Sensor Server

- Over 100 standardized properties (Current, Voltage, Light Level, Temperature, Device Run Time, Occupancy, etc.)

- https://www.bluetooth.com/specifications/mesh-specifications/mesh-properties/

- Each sensor server can send one or more properties on a defined interval or as the data changes
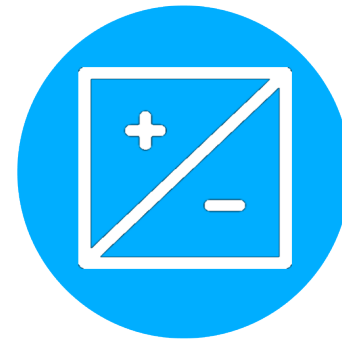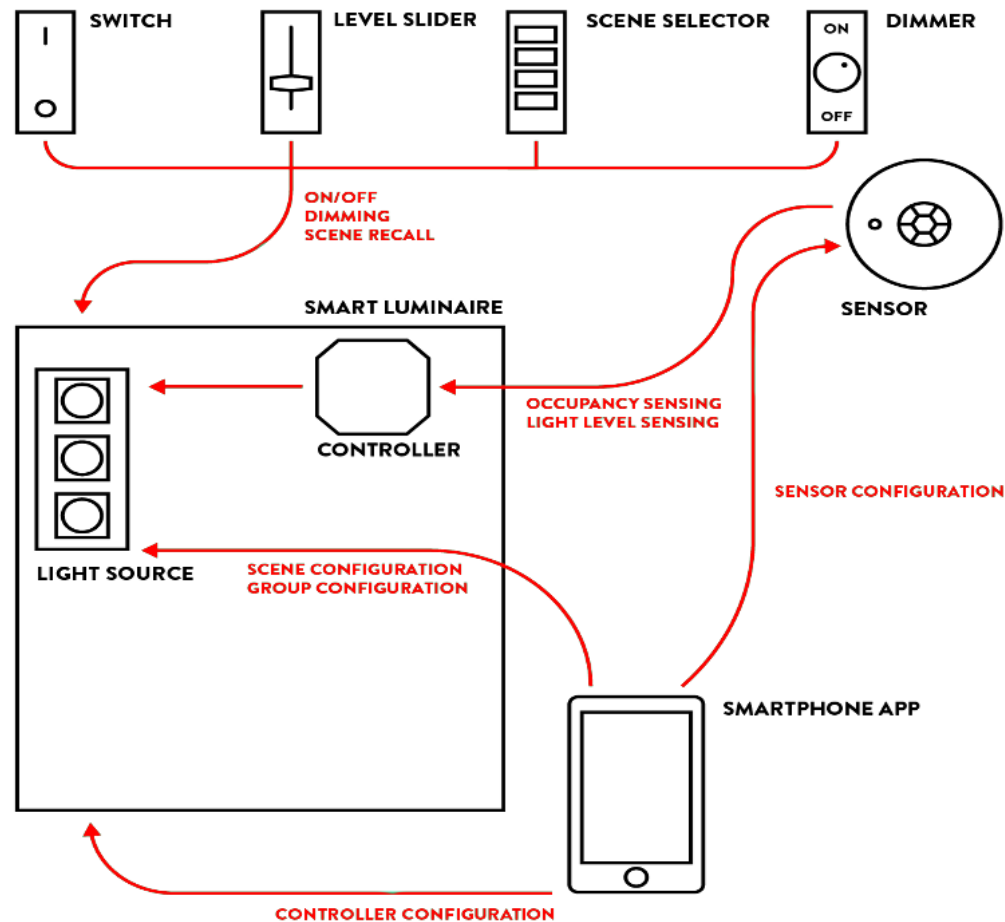
Vendor Model

- Used to implement custom functionality that's not defined by the SIG models
- Can stand alone and also be used on top of standard models to extend functionality
- Defined by custom opcodes that are used in the messaging
- For example:
  - opcode 0x1 = Command Set
  - opcode 0x2 = Status Get
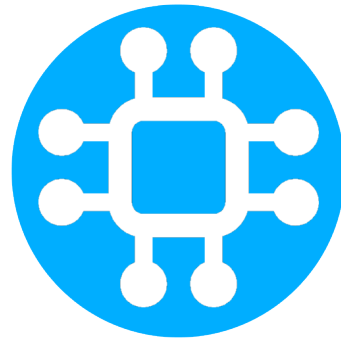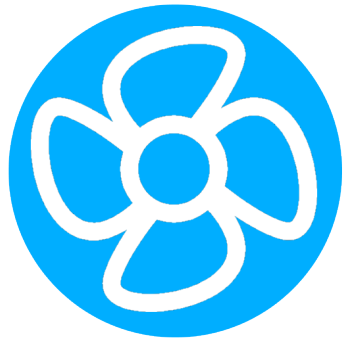
Example: Bluetooth Mesh for Lighting

- **Lighting controls**
  - Multiple controls are supported from simple On/Off to composite devices with On/Off, dimming and scene capablities
  - Controls can be mains or battery powered

- **Sensors**
  - Typical use cases for sensors are occupancy and ambient light level sensing
  - Again sensors can be mains or battery powered

- **Led bulbs, drivers and luminaires**
  - Light sources are controlled by control or sensors
  - For commercial lighting the Bluetooth mesh provides a Light Controller (LC) that controls lighting automatically based on inputs from controls and sensors
  - These devices are typically mains powered and could for example also support Bluetooth beaconing

- **Smart phone apps or gateways**
  - Smart phone apps can be implemented for easy and fast network setup and configuration and management of devices
  - Gateway is optional as intelligence is distributed to devices but it can be used where is makes sense

Example: Bluetooth Mesh for HVAC
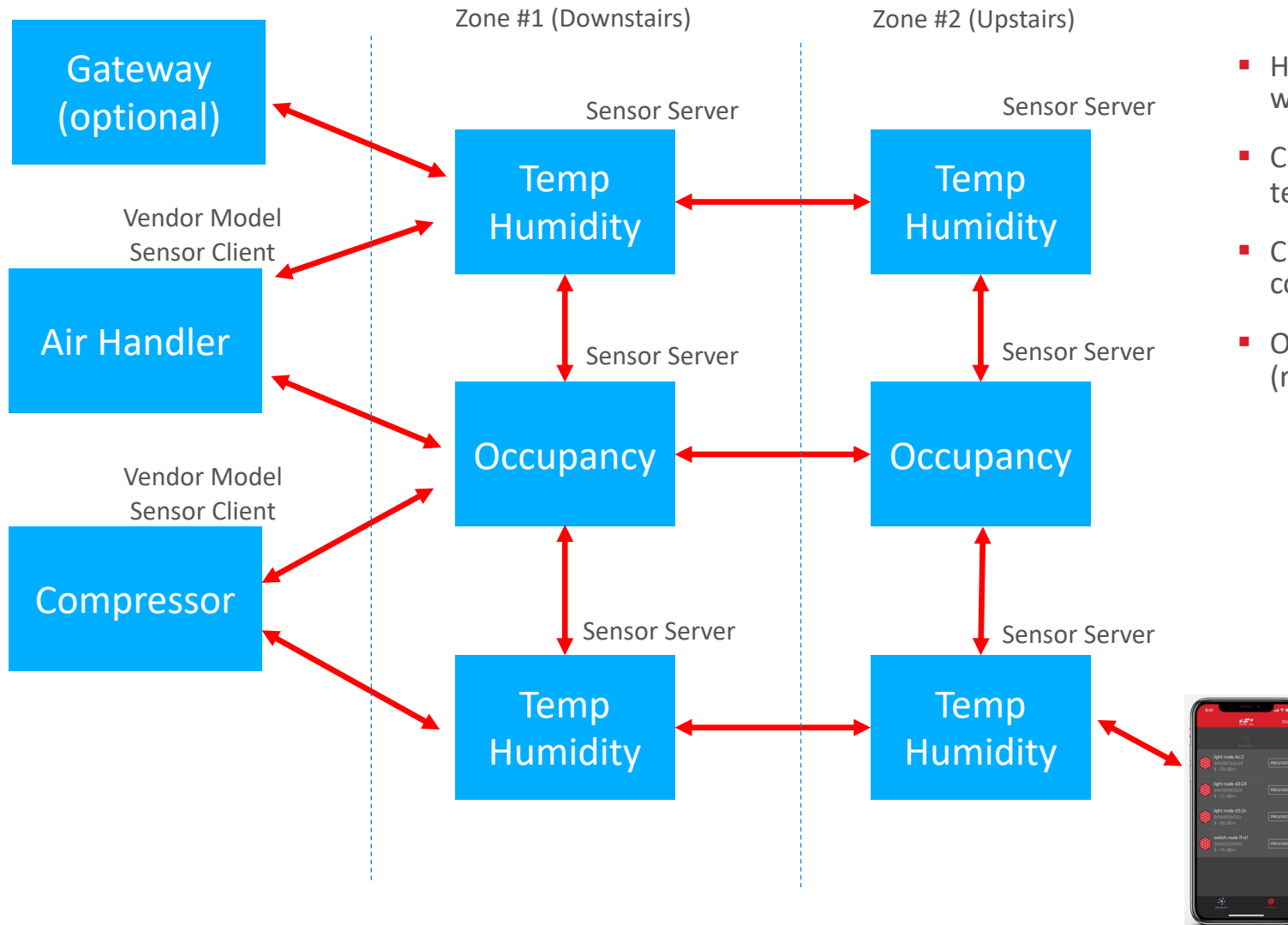
- HVAC compressor and air handler implemented with vendor models
- Can use off the shelf sensors for occupancy, temperature/humidity
- Can perform local control via mobile device when connected
- Optional gateway enables cloud connectivity (remote control, diagnostics, etc.)

Silicon Labs: A Complete Solution for Enabling Bluetooth Products

SoCs AND MODULES

Industry leading Bluetooth 5.1 and 5.2
SoCs and pre-certified modules

STACK SOFTWARE

Application
API

GATT	GAP	SM	Mesh Model
ATT			Mesh Profile

Bluetooth Link Layer
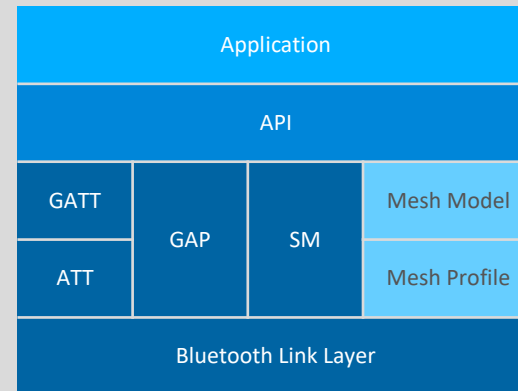
In-house developed stacks with latest Bluetooth 5.2 and the *industry's most complete mesh model implementation*

MOBILE APPLICATIONS
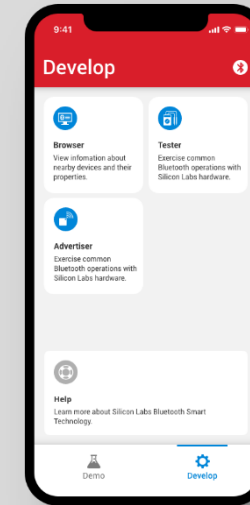
ADK, reference applications, and source code for iOS and Android

DEVELOPMENT TOOLS

Free-of-charge software development and protocol analysis tools to boost productivity

Bluetooth Mesh - Mesh 1.0 Profile Features

EFR32BG21/13/12

Support all Bluetooth mesh features
(Relay, Proxy, Friend etc.)
768-1024kB flash recommended for OTA

EFR32BG22

512kB parts support Bluetooth mesh LPN

No support for Relay, Proxy or Friend

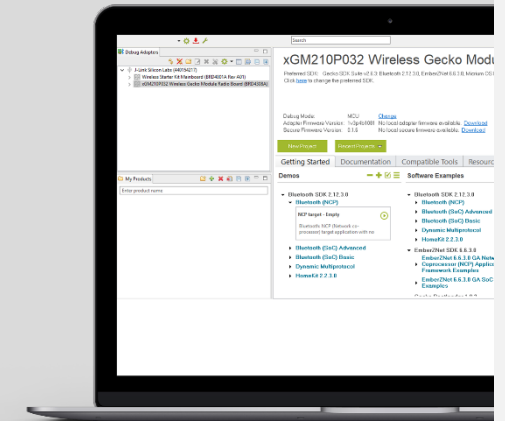| Feature	Value(s)
Supported features	Relay Proxy Friend Low Power Simultaneous BLE + BLE Mesh (GATT, custom beacons, etc.)
Provisioning bearers	PB-ADV PB-GATT
GATT services	Proxy Provisioning
Security	OoB authentication Replay protection Key refresh (blacklist) ECDH AES-128 encryption, authentication and obfuscation

Bluetooth Mesh Application Development Kit (ADKs)

Provision Bluetooth mesh devices

Control Bluetooth mesh nodes
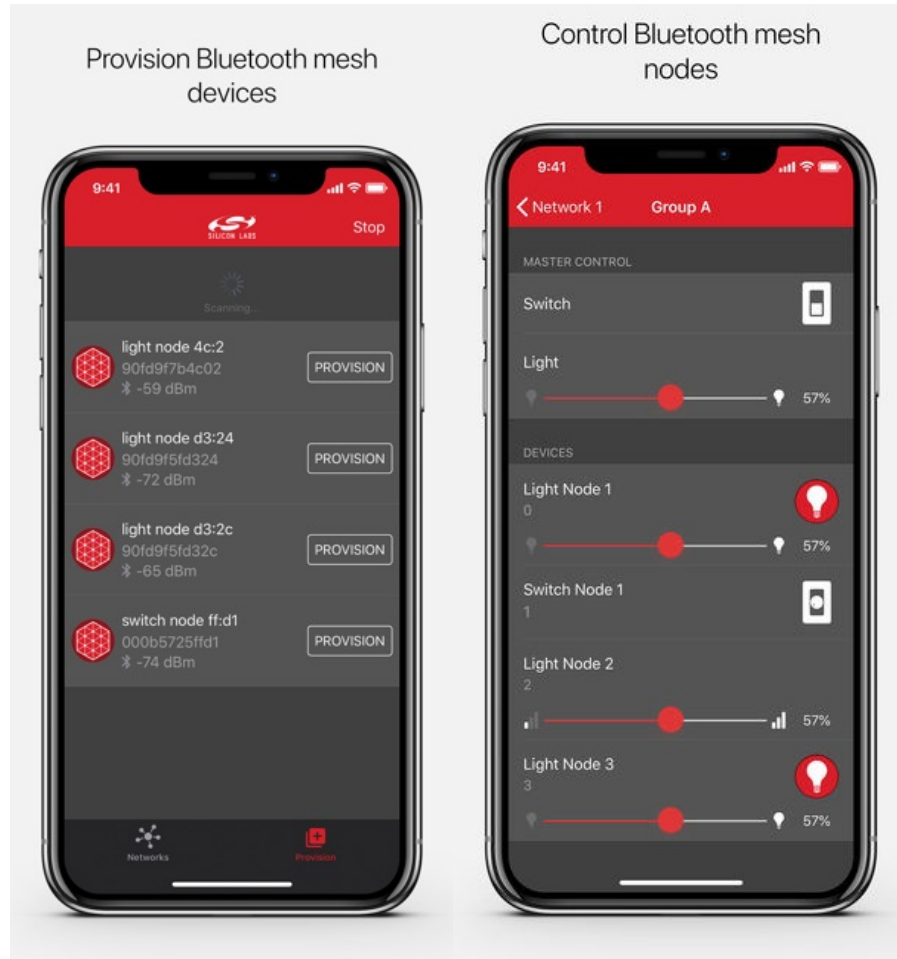
- **ADKs enable Bluetooth mesh application development for phones**
  - Both iOS and Android platform are supported
  - ADKs provide a Bluetooth mesh stack for both platforms
  - ADK contains example code how to provision, configure and control mesh devices
  - LE connectivity uses the underlying Bluetooth API provided by the OS

- **Features**
  - Node provisioning over LE connection and PB-GATT
  - Mesh node settings configuration
  - Mesh model configuration
  - Node control
  - Mesh database import/export

- **Download for evaluation from iTunes or Google**

Supported Bluetooth Mesh Models

Model Group	Model	Stack/APIs	Example app(s)	iOS APIs	iOS reference app	Android APIs	Android reference app
Vendor	Any vendor model	✓		✓		✓	
Generic	OnOff	✓	Light & Switch	✓	✓	✓	✓
	Level	✓	Light & Switch	✓	✓	✓	✓
	Default Transition Time	✓	Light & Switch	✓		✓	
	Power OnOff	✓	Light & Switch	✓		✓	
	Power Level	✓		✓			
	Battery	✓		✓		✓	
	Location	✓		✓			
	Admin property	✓		✓			
	Manufacturer property	✓		✓			
	User property	✓		✓			
	Client property	✓		✓			
	Property	✓		✓			
Lighting	Lightness	✓	Light & Switch	✓	✓	✓	✓
	CTL	✓	Light & Switch	✓	✓	✓	✓
	LC	✓	Light	✓	✓	✓	✓
	HSL						
	xYL						
Sensors	Sensor	✓	✓	✓		✓	
Time and Scenes	Scene	✓	Light and Switch	✓		✓	
	Time	Q2'20		Q2'20		Q2'20	
	Scheduler	Q2'20		Q2'20		Q2'20	

SDK = Bluetooth Mesh SDK
ADK = Bluetooth Mesh ADK for Android and iOS

Gateway Building Blocks: Network Co-Processor (NCP)
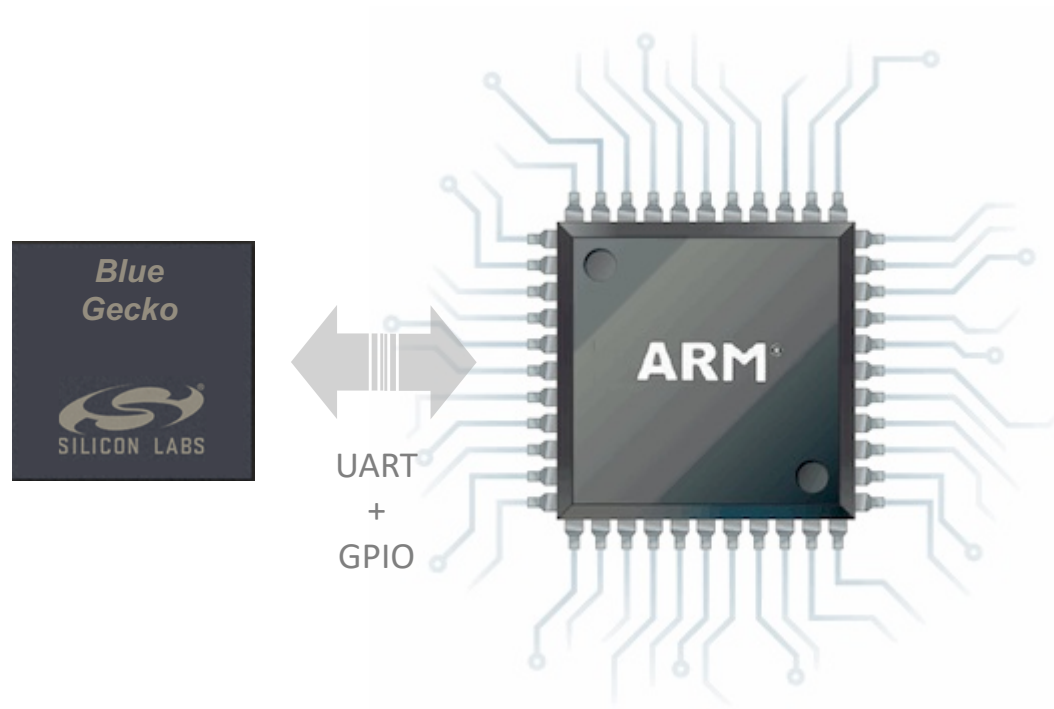
UART
+
GPIO

- **Network Co-Processor (NCP) architecture**
  - Bluetooth stack runs on the Blue Gecko SoC
  - Provides Bluetooth API over UART I/F
  - Application runs on a separate MCU

- **Host API**
  - Host API is 100% identical to SoC API
  - Provided in source code and implements BGAPI serial protocol parser and API
  - Various host example applications provided in the SDK

- **NCP features**
  - AES-128 encrypted UART communications
  - 4-wire UART with RTS/CTS
  - 1x GPIO for EM2 low-power management (optional)
  - 1x GPIO to wake up host on Bluetooth events (optional)
  - 1-3x 802.11 co-existence interface via GPIO pins
  - NCP can be extended with custom APIs

- **Firmware update**
 - Secure firmware update over UART

Best Development Tools for Bluetooth Mesh

- **Network analyzer**: Captures and decodes all Bluetooth traffic from every node in the network from a single PC

- **Energy Profiler:** Run time analysis of nodes energy consumption to optimize battery life

- **WSTK**: Development kits that can be Ethernet connected to build and test large mesh networks
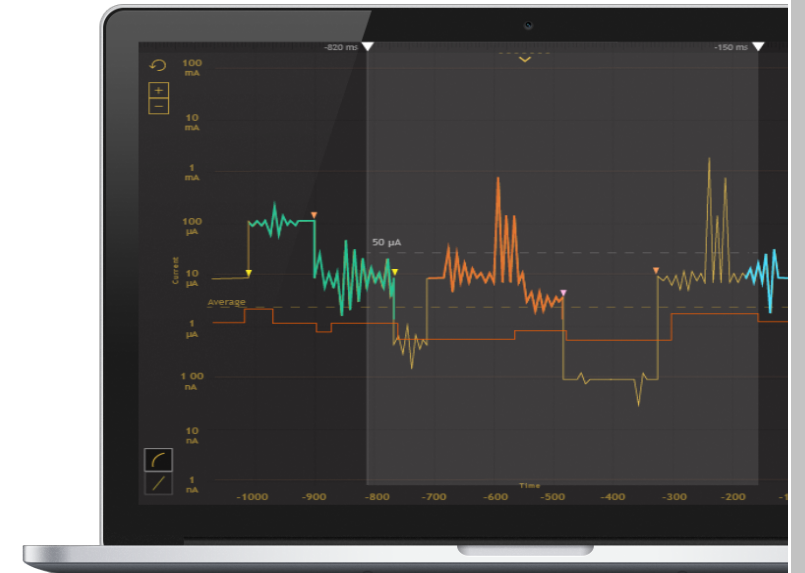
Bluetooth
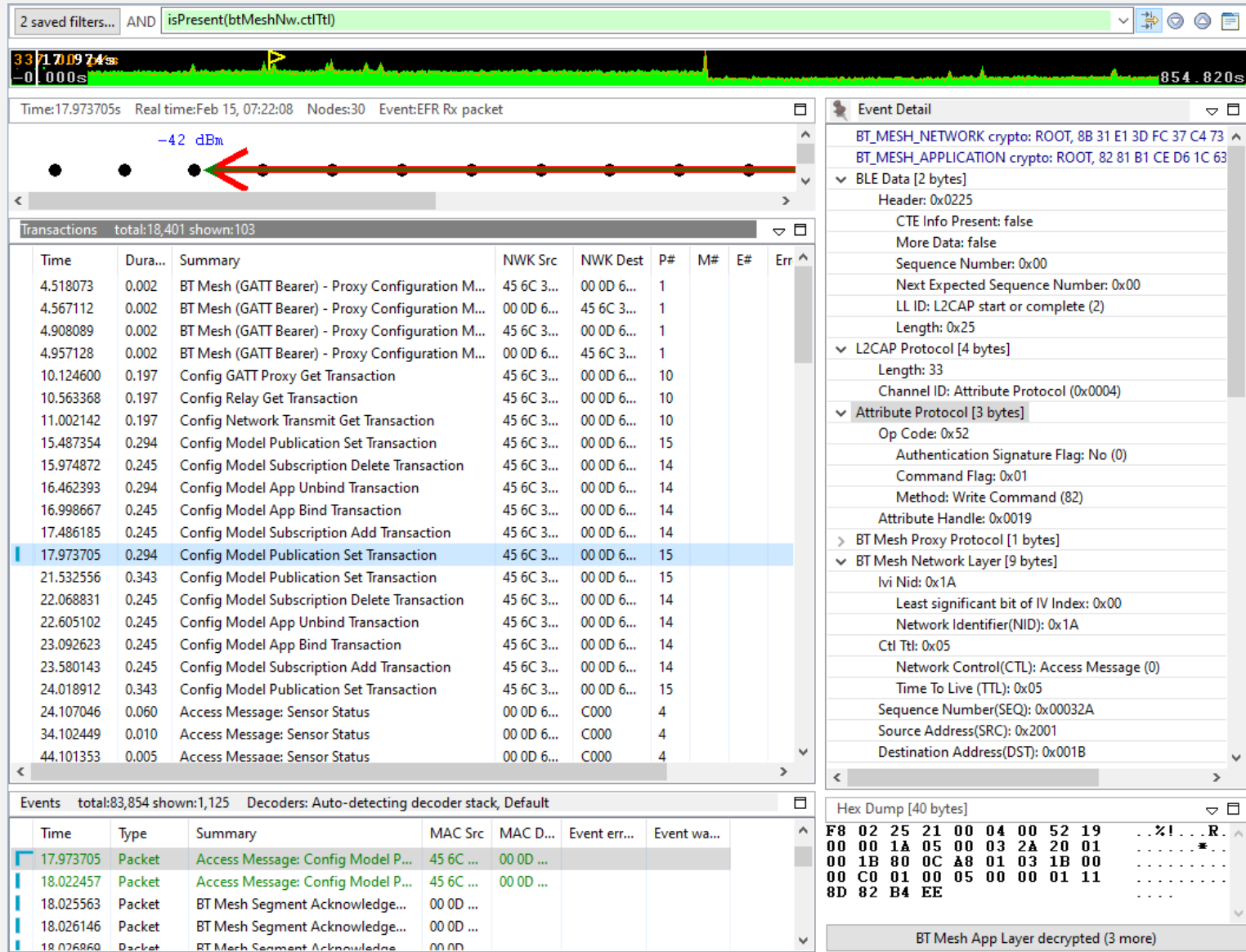
Network Analyzer

- **Network Analyzer captures and decodes Bluetooth LE and mesh packets**
  - Understand the network traffic easily
 - Debug connectivity or protocol issues

- **Packets are received from a dedicated interface on EFR32**
  - Accurately captures what a device transmits or receives
  - A Bluetooth sniffer only captures what it hears

- **Capture directly from WSTK's USB or Ethernet**
  - Live capture from multiple Ethernet networked WSTKs from a single PC
  - Allows much more coverage than a sniffer

Advanced Energy Monitor (AEM)
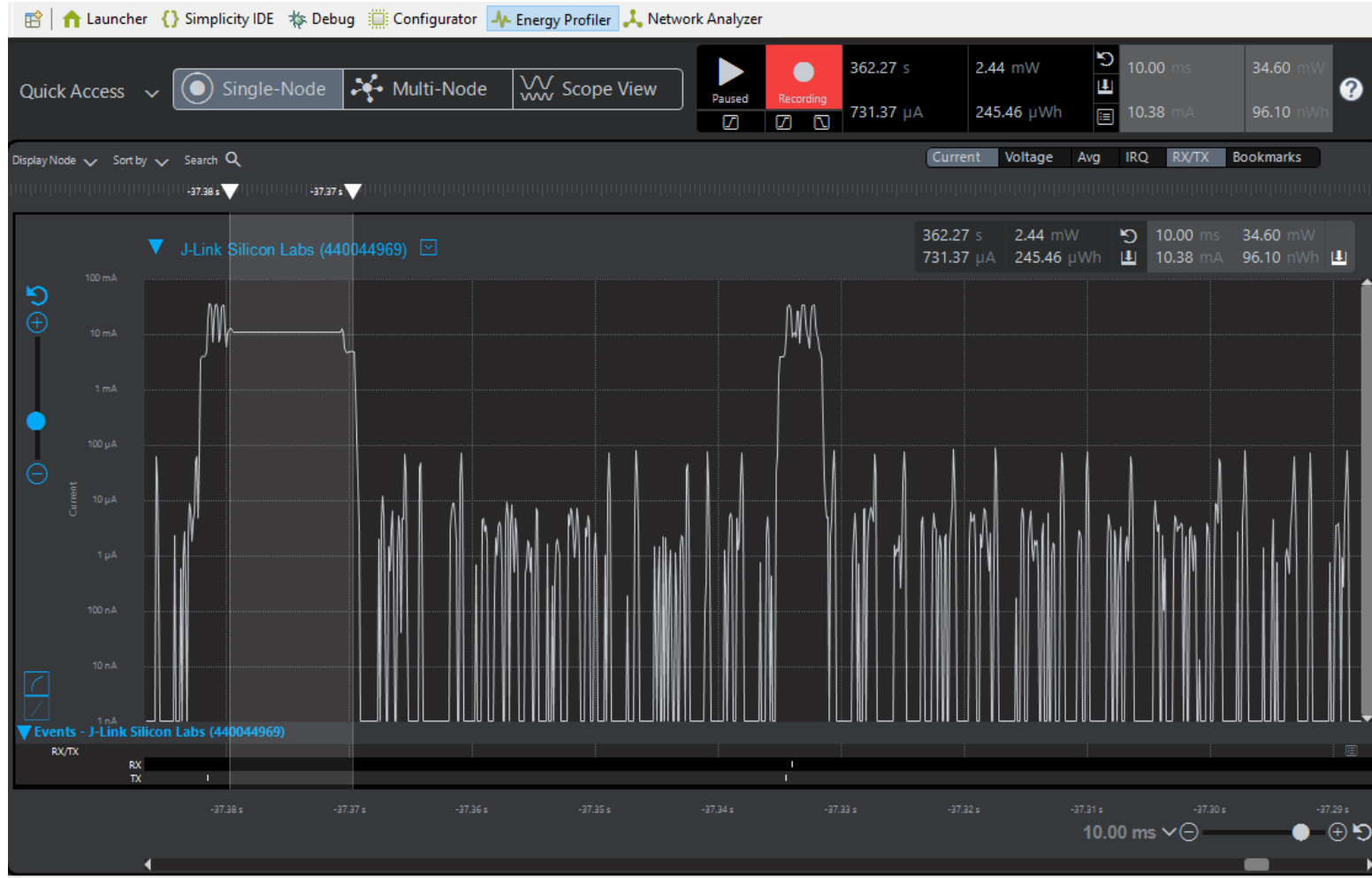
- **Capable of measuring currents in the range of 0.1uA to 50mA**
  - 0.1mA resolution at current > 250uA
  - 1uA resolution at current < 250uA
  - Can detect changes as small as 100nA when < 250uA

- **Sample rate 10 ksps**

- **Correlation capabilities**
  - Packet trace
  - Code instructions
  - Interrupts
  - Radio Activity (RX/TX)

Wireless Starter Kit (WSTK)
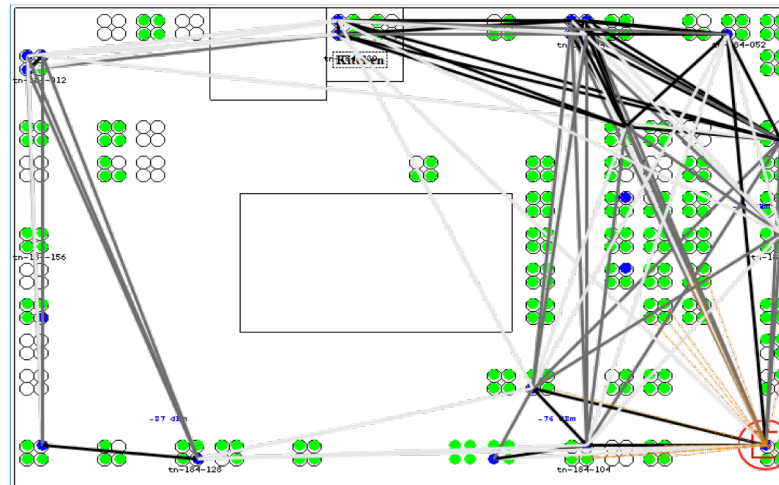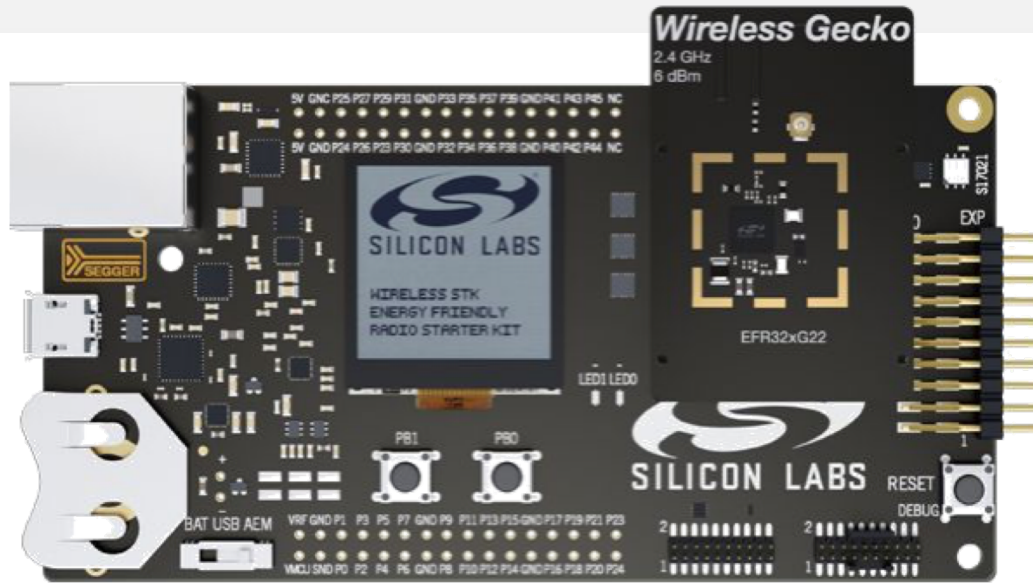
- **Interfaces: Ethernet/TCP and USB**

- **Functionality (Available over USB or TCP)**
  - Packet Trace
  - Firmware flashing and debugging
  - Serial console interface
  - Advanced Energy Monitor

- **Works with installed Silabs radio modules as well as external targets connected to WSTK via debug cable**

- **WSTKs can be used to build large test networks**
  - Silicon Labs has WSTK networks sized at 200+ nodes

BG21: Optimized for Secure Mains Powered Devices

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 92kB 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

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

BG22: Optimized for Battery Powered Bluetooth LE and Mesh

Optimized

SILICON LABS
BG22

Secure Bluetooth 5.2 SoCs for High-Volume Products

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

Ultra-Low Power
3.6mA Radio TX
2.6mA 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 ^{o}C
32kHz, 500ppm PLFRCO

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

BG22 (512kB flash variant) only support Bluetooth mesh Low Power Node feature and software support is available in Q2'20 SDK

BG13 or BG21+EFP can also be used for low power applications

Silicon Labs' Bluetooth SoC Families

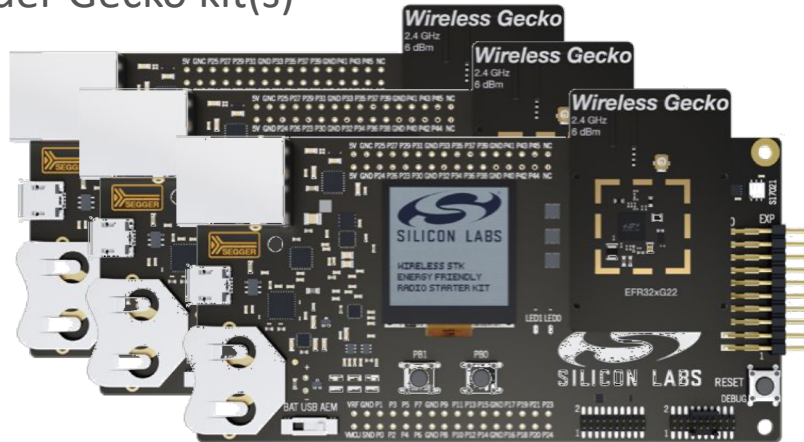|	Series 1 - xG13	Series 2 - xG21	Series 2 - xG22
Target applications	General purpose Bluetooth LE and mesh	Mains powered Bluetooth LE and mesh	Lowest power Bluetooth LE, Direction Finding and Bluetooth mesh LPNs
Bluetooth features	5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)	5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)	5.2 and Bluetooth mesh LPN (1M, 2M, LE Coded PHYs, AE and AoA/D)
Proprietary 2.4G	2/4(G)FSK, OQPSK/(G)MSK, DSSS, BPSK/DBPSK TX, OOK/ASK	N/A	2/4(G)FSK, (G)MSK, OQPSK, DSSS
TX / RX (1M, GFSK)	+19 dBm / -95.8 dBm	+20 dBm / -97.5 dBm	+6 dBm / -99 dBm
TX Current (0 dBm)	10.5 mA	10.5 mA	4.1 mA 7.4 mA (6 dBm)
RX Current (1M, GFSK)	9.5 mA	8.8mA	3.6 mA
CPU / Clock Speed	Cortex M4 (38.4 MHz)	Cortex M33 (80Mhz)	Cortex M33 (up to 76.8MHz) Cortex M0+ for radio
Flash (kB)	512	Up to 1024	Up to 512
RAM (kB)	64	Up to 96	32
Sleep Current (EM2)	1.3µA (16kB RAM)	4.5 uA (96 RAM)	1.24 uA (8kB RAM) - 1.44 uA (32kB RAM)
Active Current (EM0)	70µA/MHz	51uA/MHz	25uA/MHz
Security	2x AES-128/256, ECC, SHA-1/224/256, TRNG	AES-128/256, SHA-1/2 ECC, ECDSA and TRNG DPA countermeasures Secure boot with RTSL Secure debug with debug lock/unlock	AES-128/256, SHA-1/2 ECC, ECDSA and TRNG Secure boot with RTSL Secure debug with debug lock/unlock
Operating Voltage	1.8V – 3.6V	1.8V – 3.8V	1.71V – 3.8V
Packages (mm)	7x7 QFN48, 5x5 QFN32	4x4 QFN32 (20x GPIO)	5x5 QFN40 (26x GPIO) 4x4 QFN32, TQFN32 (18x GPIO)

Silicon Labs' Bluetooth Module Families

	BGM13P	BGM13S	BGM210P	BGM210L	BGM220P (Q3'20)	BGM220S (Q3'20)
Protocols	5.1 and mesh (1M, 2M, Coded PHY and AE)	5.1 and mesh (1M, 2M, Coded PHY and AE)	5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE)	5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE)	5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D)	5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D)
EFR32 SoC	BG13	BG13	BG21	BG21	BG22	BG22
Antenna	Built-in or U.FL	Built-in or RF pin	Built-in or RF pin	Built-in	Built-in	Built-in or RF pin
Max TX power	+8 / +19 dBm	+8 / +18 dBm	+10 / +20 dBm	+12.5 dBm	+8 dBm	+6 dBm
Sensitivity (1M)	-94.8 dBm	-94.1 dBm	-97 dBm	-97 dBm	-98 dBm	-98 dbm
Flash (kB)	512	512	1024	1024	512	512
RAM (kB)	64	64	96	96	32	32
GPIO	25	30	20	12	24,25	25
Operating Voltage	1.8V – 3.6V	1.8V – 3.6V	1.8 – 3.8V	1.8 – 3.8V	1.71V – 3.8V	1.71V – 3.8V
Operating Temp.	-40 to +85C	-40 to +85C	-40 to +125C	-40 to +125C	-40 to +105C	-40 to +105C
Dimensions W x L x H (mm)	13.0 x 15.0 x 2.2	6.5 x 6.5 x 1.4	13.0 x 15.0 x 2.2	13.0 x 15.0 x 2.2	13.0 x 15.0 x 2.2	6 x 6 x 1.3
Certifications	BT, CE, FCC, ISED, Japan, S-Korea and Taiwan	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea

Getting Started

https://www.silabs.com/support/getting-started/bluetooth/bluetooth-mesh
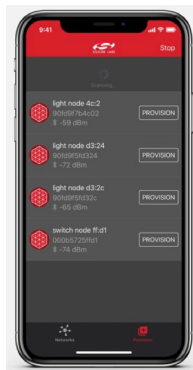
1. Order Gecko kit(s)

SLWSTK6006A

2. Install Simplicity Studio

3. Download the Bluetooth Mesh mobile app for iOS or Android

4. Explore our online resources

LEARNING CENTER

Bluetooth Mesh Technology Resources

Learn More ›

VIDEO

Bluetooth Mesh Stack

Review the Bluetooth mesh stack architecture and implementation options

▶ View Video

VIDEO

Messaging and Node Types

Learn how different Bluetooth mesh nodes communicate with each other

▶ View Video

VIDEO

Bluetooth Mesh in Action

See the Bluetooth mesh technology and mobile application in action.

▶ Watch Now

BG22 Virtual Workshop

Learn how to develop and deploy more powerful, efficient, and secure IoT products with your own BG22 Thunderboard – free for all registrants!

North America: May 19th–21st, 2020

10:00AM –11:30 AM CST

(Other sessions available for Asia Pacific and Europe)

Register today! https://www.silabs.com/about-us/events/virtual-bluetooth-workshop

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Thank You!

Q & A

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Bluetooth AoX Solutions	Thursday, April 2
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