



# WELCOME



# APAC Talk Talks LIVE - Mandarin

Topic	Date
Evolution of Bluetooth 5, 5.1, & 5.2	10a.m., Tuesday, May 26
<b>Bluetooth Mesh Solutions &amp; Tools</b>	<b>10a.m., Thursday, May 28</b>
15.4 Mesh Networking Technologies	10a.m., Tuesday, June 2
Bluetooth AoX Solutions	10a.m., Thursday, June 4
Connected Home Over IP (CHIP) for Beginners	10a.m., Tuesday, June 9
Device & Network Security for the IoT	9a.m., Thursday, June 11

# Speaker



David Zhou

Sr. FAE, Silicon Labs China

David works as Sr. FAE in North China team of Silicon Labs, focusing on Bluetooth, Mesh and Timing products as well as technical supports to Customers.



# Bluetooth Mesh Solutions & Tools

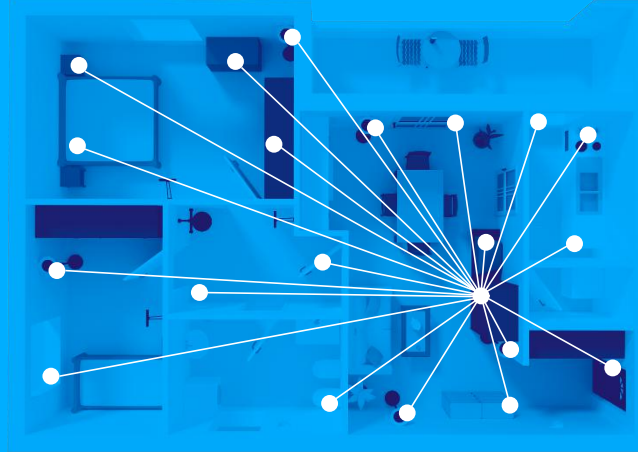
MAY 2020



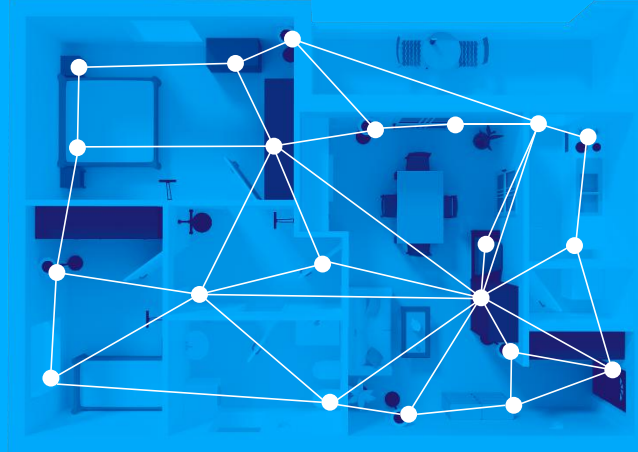
# Why Mesh Networking?



Star Network



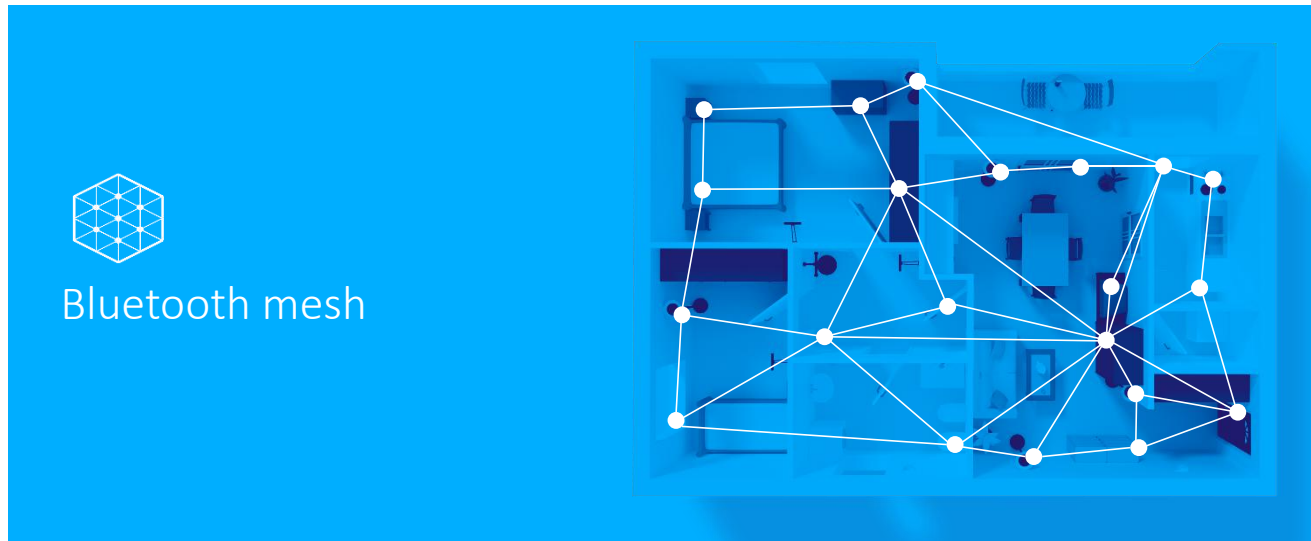
Mesh Network



- **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

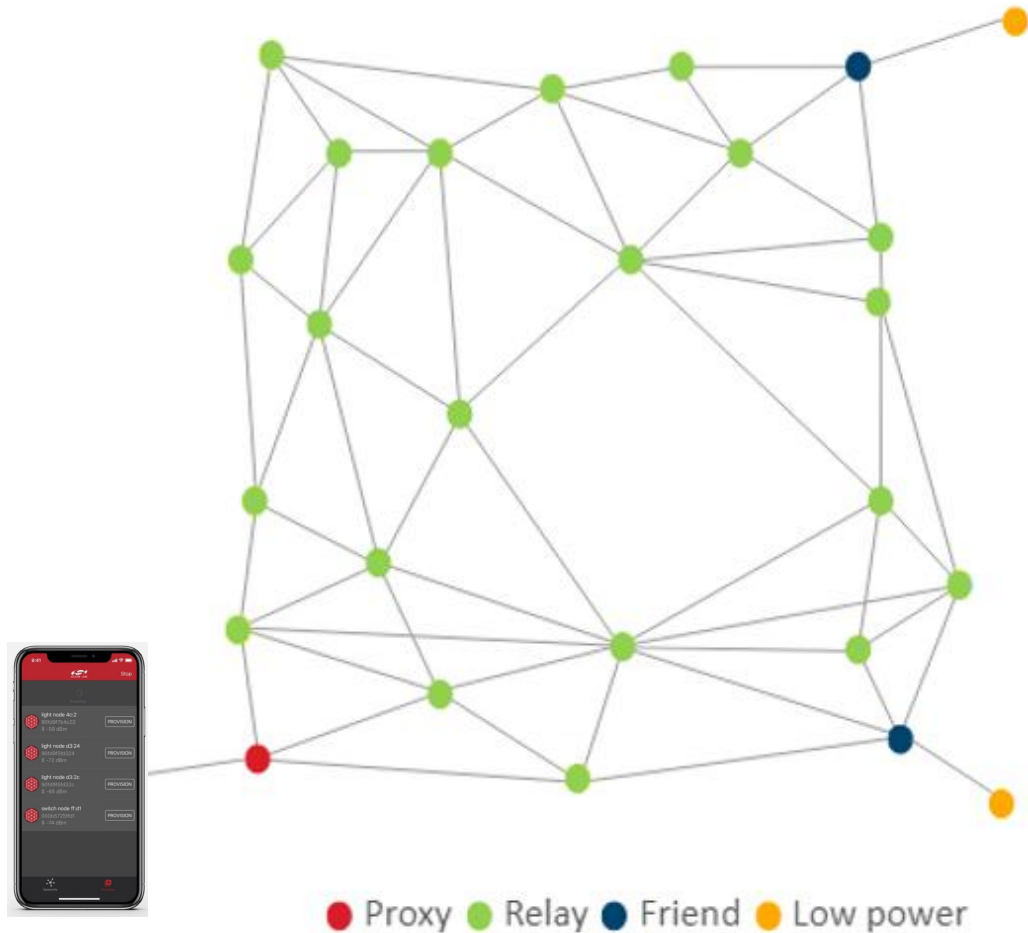
\*) Silicon Labs has tested up to 240 devices

# Why Bluetooth Mesh?



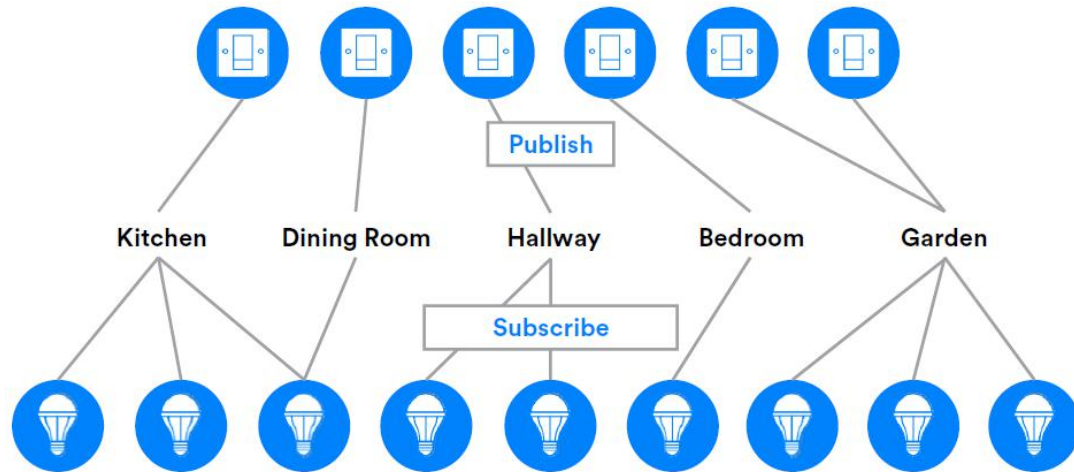
- **Scale:** Bluetooth mesh scales from small ten node networks to commercial grade networks with hundreds of nodes
- **Phone connectivity:** Phones can be used for easy network setup and configuration and mesh network can be used to deliver location services
- **Gateway is optional** in Bluetooth mesh 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



- **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

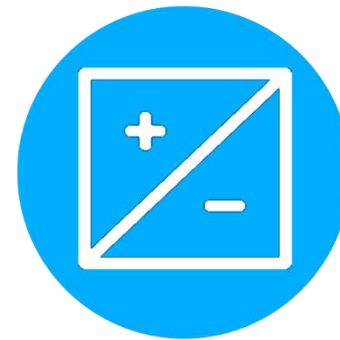


# Bluetooth Mesh: Models

- 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

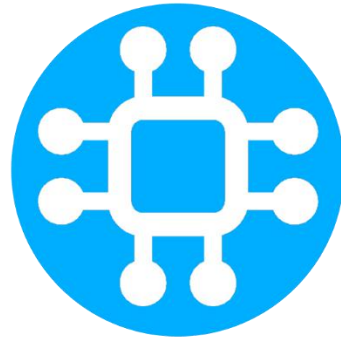
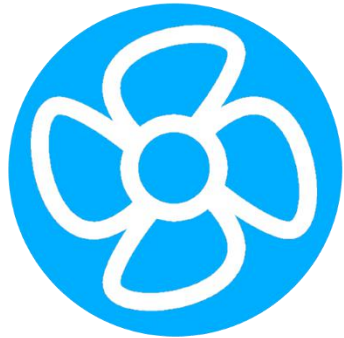
# Sensor Client / Sensor Server

- 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

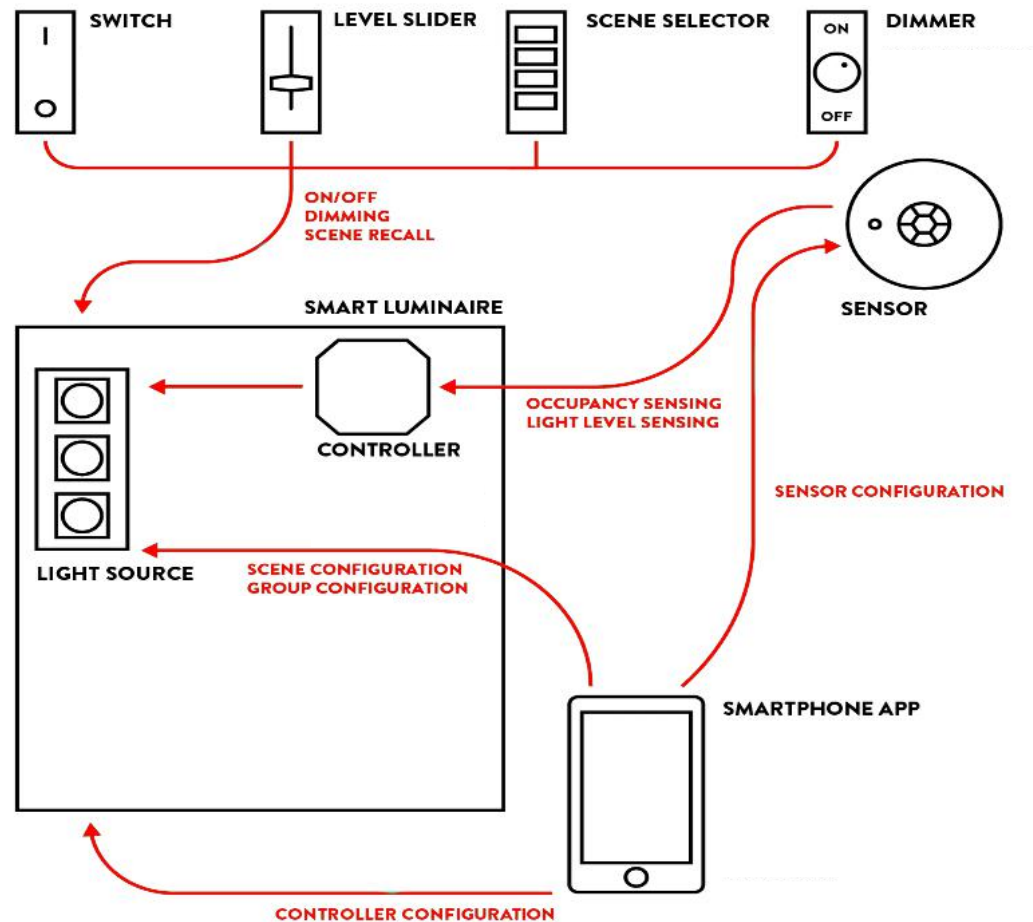


# Vendor Model

- 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 capabilities
- 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

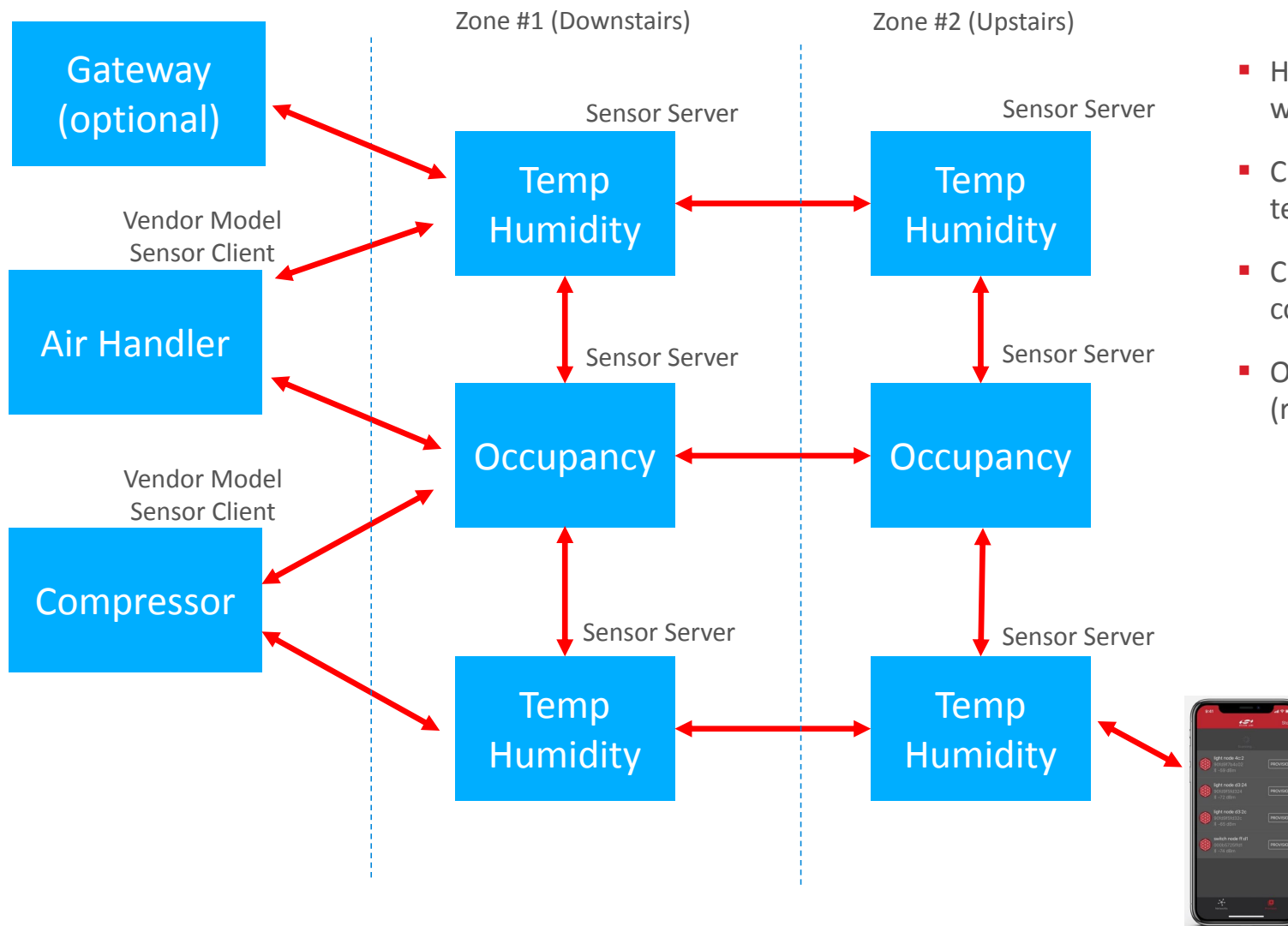
## Led bulbs, drivers and luminaires

- 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 it 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.)

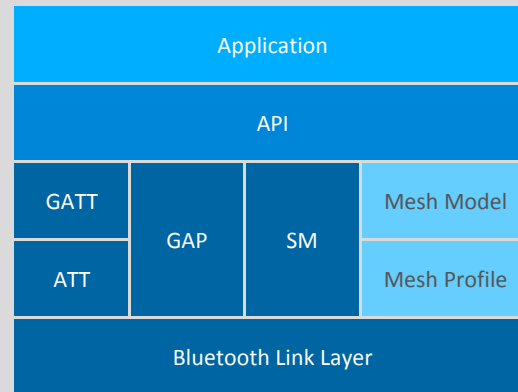
# Silicon Labs: A Complete Solution for Enabling Bluetooth Products

## SoCS AND MODULES



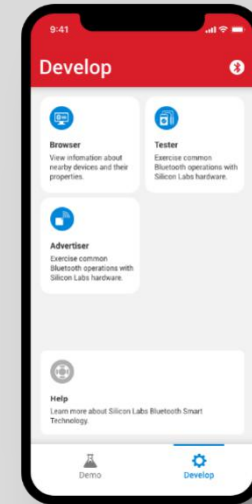
Industry leading Bluetooth 5.1 and 5.2 SoCs and pre-certified modules

## STACK SOFTWARE



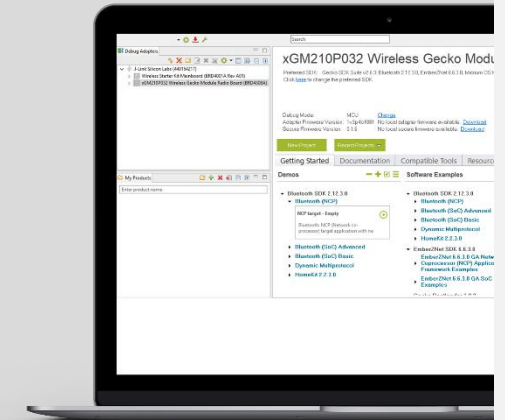
In-house developed stacks with latest Bluetooth 5.2 and the *industry's most complete mesh model implementation*

## 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

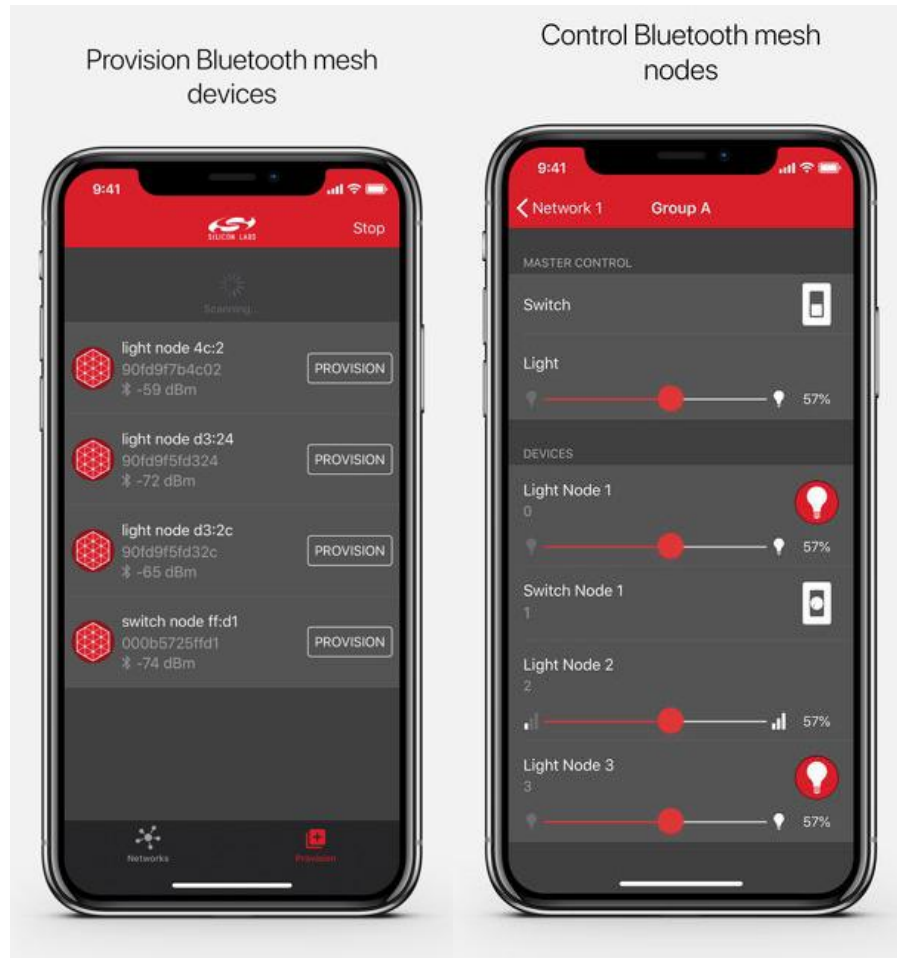


## **EFR32BG22**

512kB parts support Bluetooth mesh LPN  
No support for Relay, Proxy or Friend

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

# Bluetooth Mesh Application Development Kit (ADKs)



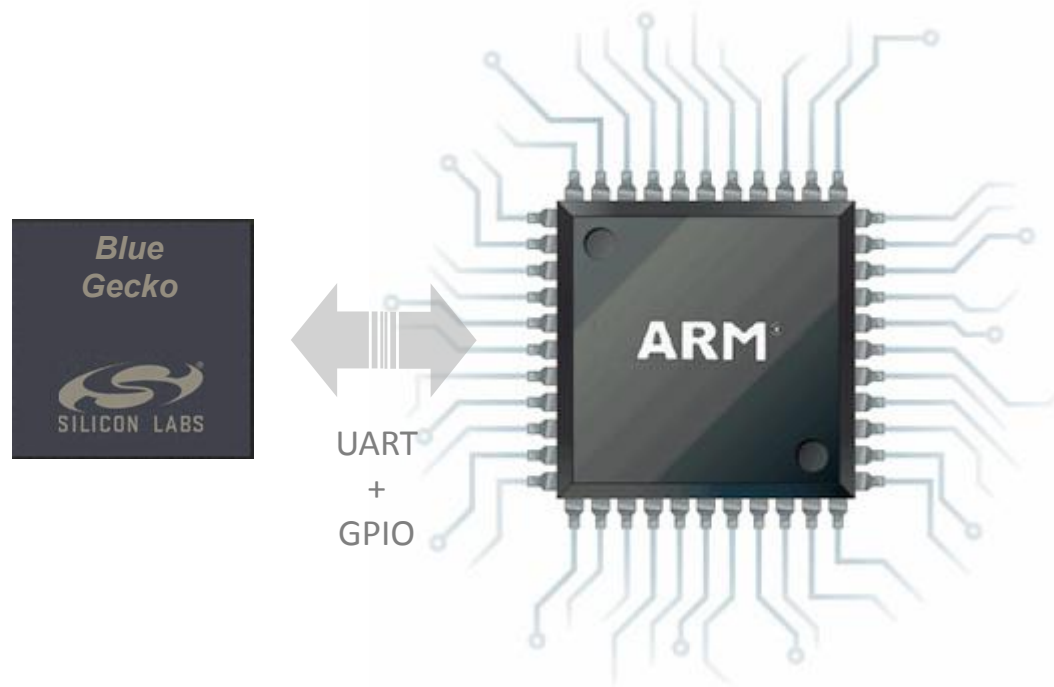
- **ADKs enable Bluetooth mesh application development for phones**
  - Both iOS and Android platform are supported
  - ADKs provide a Bluetooth mesh stack for both platforms
  - ADK contains example code how to provision, configure and control mesh devices
  - LE connectivity uses the underlying Bluetooth 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
<b>Vendor</b>	Any vendor model	✓		✓		✓	
<b>Generic</b>	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	✓		✓			
	<b>Lighting</b>	Lightness	✓	Light & Switch	✓	✓	✓
CTL		✓	Light & Switch	✓	✓	✓	✓
LC		✓	Light	✓	✓	✓	✓
HSL							
xYL							
<b>Sensors</b>	Sensor	✓	✓	✓		✓	
<b>Time and Scenes</b>	Scene	✓	Light and Switch	✓		✓	
	Time	Q2'20		Q2'20		Q2'20	
	Scheduler	Q2'20		Q2'20		Q2'20	

# Gateway Building Blocks: Network Co-Processor (NCP)



- **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



# Network Analyzer

The screenshot displays a Network Analyzer interface with the following components:

- Filter:** 2 saved filters... AND isPresent(btMeshNw.ctiTtl)
- Time/Real time:** 17.973705s Real time: Feb 15, 07:22:08 Nodes: 30 Event: EFR Rx packet
- Signal Graph:** A graph showing signal strength over time, with a red arrow pointing to a peak at -42 dBm.
- Transactions Table:**

Time	Dura...	Summary	NWK Src	NWK Dest	P#	M#	E#	Err
4.518073	0.002	BT Mesh (GATT Bearer) - Proxy Configuration M...	45 6C 3...	00 0D 6...	1			
4.567112	0.002	BT Mesh (GATT Bearer) - Proxy Configuration M...	00 0D 6...	45 6C 3...	1			
4.908089	0.002	BT Mesh (GATT Bearer) - Proxy Configuration M...	45 6C 3...	00 0D 6...	1			
4.957128	0.002	BT Mesh (GATT Bearer) - Proxy Configuration M...	00 0D 6...	45 6C 3...	1			
10.124600	0.197	Config GATT Proxy Get Transaction	45 6C 3...	00 0D 6...	10			
10.563368	0.197	Config Relay Get Transaction	45 6C 3...	00 0D 6...	10			
11.002142	0.197	Config Network Transmit Get Transaction	45 6C 3...	00 0D 6...	10			
15.487354	0.294	Config Model Publication Set Transaction	45 6C 3...	00 0D 6...	15			
15.974872	0.245	Config Model Subscription Delete Transaction	45 6C 3...	00 0D 6...	14			
16.462393	0.294	Config Model App Unbind Transaction	45 6C 3...	00 0D 6...	14			
16.998667	0.245	Config Model App Bind Transaction	45 6C 3...	00 0D 6...	14			
17.486185	0.245	Config Model Subscription Add Transaction	45 6C 3...	00 0D 6...	14			
17.973705	0.294	Config Model Publication Set Transaction	45 6C 3...	00 0D 6...	15			
21.532556	0.343	Config Model Publication Set Transaction	45 6C 3...	00 0D 6...	15			
22.068831	0.245	Config Model Subscription Delete Transaction	45 6C 3...	00 0D 6...	14			
22.605102	0.245	Config Model App Unbind Transaction	45 6C 3...	00 0D 6...	14			
23.092623	0.245	Config Model App Bind Transaction	45 6C 3...	00 0D 6...	14			
23.580143	0.245	Config Model Subscription Add Transaction	45 6C 3...	00 0D 6...	14			
24.018912	0.343	Config Model Publication Set Transaction	45 6C 3...	00 0D 6...	15			
24.107046	0.060	Access Message: Sensor Status	00 0D 6...	C000	4			
34.102449	0.010	Access Message: Sensor Status	00 0D 6...	C000	4			
44.101353	0.005	Access Message: Sensor Status	00 0D 6...	C000	4			
- Event Detail:**
  - BT\_MESH\_NETWORK crypto: ROOT, 8B 31 E1 3D FC 37 C4 73
  - BT\_MESH\_APPLICATION crypto: ROOT, 82 81 B1 CE D6 1C 63
  - BLE Data [2 bytes]
    - Header: 0x0225
    - CTE Info Present: false
    - More Data: false
    - Sequence Number: 0x00
    - Next Expected Sequence Number: 0x00
    - LL ID: L2CAP start or complete (2)
    - Length: 0x25
  - L2CAP Protocol [4 bytes]
    - Length: 33
    - Channel ID: Attribute Protocol (0x0004)
  - Attribute Protocol [3 bytes]
    - Op Code: 0x52
    - Authentication Signature Flag: No (0)
    - Command Flag: 0x01
    - Method: Write Command (82)
    - Attribute Handle: 0x0019
  - BT Mesh Proxy Protocol [1 bytes]
  - BT Mesh Network Layer [9 bytes]
    - Ivi Nid: 0x1A
    - Least significant bit of IV Index: 0x00
    - Network Identifier(NID): 0x1A
    - Ctl Ttl: 0x05
    - Network Control(CTL): Access Message (0)
    - Time To Live (TTL): 0x05
    - Sequence Number(SEQ): 0x00032A
    - Source Address(SRC): 0x2001
    - Destination Address(DST): 0x001B
- Hex Dump [40 bytes]:**

```
F8 02 25 21 00 04 00 52 19  . . % ! . . . R .
00 00 1A 05 00 03 2A 20 01  . . . . * . . .
00 1B 80 0C A8 01 03 1B 00  . . . . . . . .
00 C0 01 00 05 00 00 01 11  . . . . . . . .
8D 82 B4 EE
```
- Events:** total: 83,854 shown: 1,125 Decoders: Auto-detecting decoder stack, Default

- **Network Analyzer captures and decodes Bluetooth LE and mesh packets**

- Understand the network traffic easily
- Debug connectivity or protocol issues

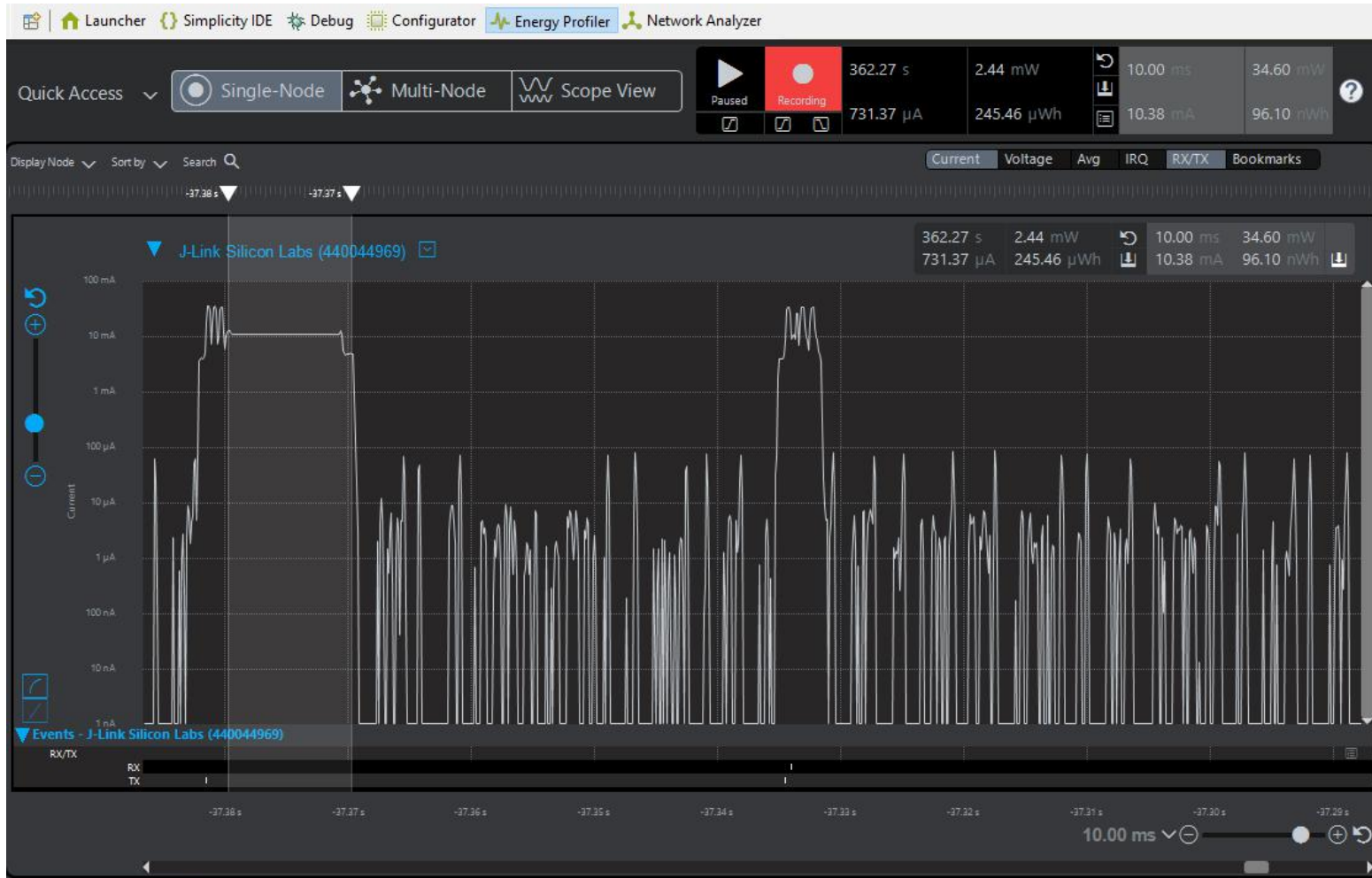
- **Packets are received from a dedicated interface on EFR32**

- Accurately captures what a device transmits or receives
- A Bluetooth sniffer only captures what it hears

- **Capture directly from WSTK's USB or Ethernet**

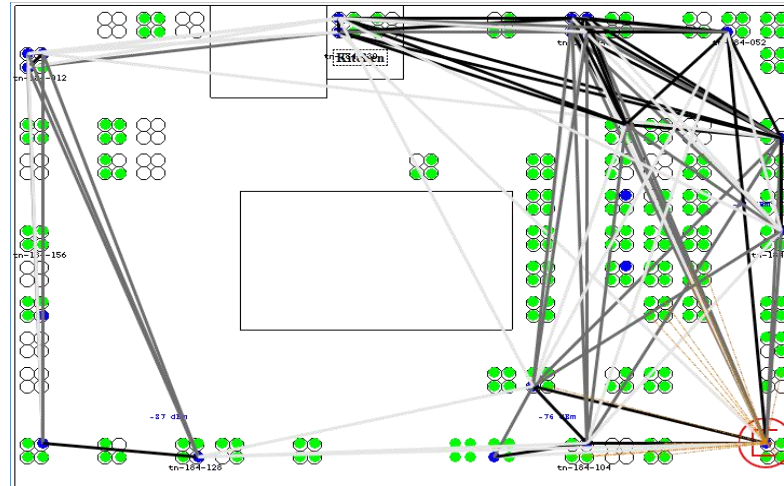
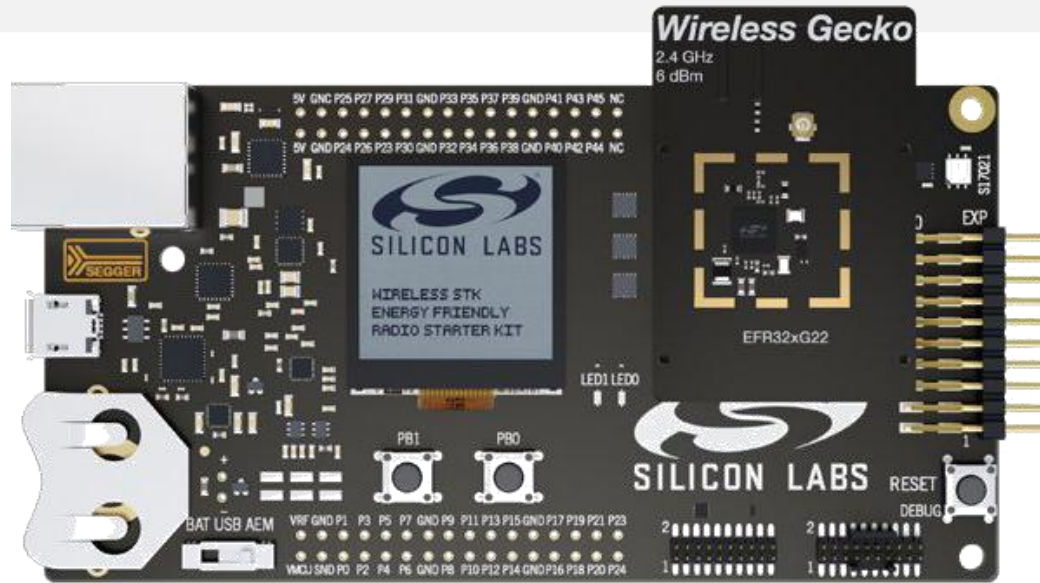
- Live capture from multiple Ethernet networked WSTKs from a single PC
- Allows much more coverage than a sniffer

# Advanced Energy Monitor (AEM)



- **Capable of measuring currents in the range of 0.1 $\mu$ A to 50mA**
  - 0.1mA resolution at current > 250 $\mu$ A
  - 1 $\mu$ A resolution at current < 250 $\mu$ A
  - Can detect changes as small as 100nA when < 250 $\mu$ A
- **Sample rate 10 ksp/s**
- **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  $\mu$ A/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



## 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 °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
<b>Target applications</b>	General purpose Bluetooth LE and mesh	Mains powered Bluetooth LE and mesh	Lowest power Bluetooth LE, Direction Finding and Bluetooth mesh LPNs
<b>Bluetooth features</b>	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)
<b>Proprietary 2.4G</b>	2/4(G)FSK, OQPSK/(G)MSK, DSSS, BPSK/DBPSK TX, OOK/ASK	N/A	2/4(G)FSK, (G)MSK, OQPSK, DSSS
<b>TX / RX (1M, GFSK)</b>	+19 dBm / -95.8 dBm	+20 dBm / -97.5 dBm	+6 dBm / -99 dBm
<b>TX Current (0 dBm)</b>	10.5 mA	10.5 mA	4.1 mA 7.4 mA (6 dBm)
<b>RX Current (1M, GFSK)</b>	9.5 mA	8.8mA	3.6 mA
<b>CPU / Clock Speed</b>	Cortex M4 (38.4 MHz)	Cortex M33 (80MHz)	Cortex M33 (up to 76.8MHz) Cortex M0+ for radio
<b>Flash (kB)</b>	512	Up to 1024	Up to 512
<b>RAM (kB)</b>	64	Up to 96	32
<b>Sleep Current (EM2)</b>	1.3µA (16kB RAM)	4.5 uA (96 RAM)	1.24 uA (8kB RAM) - 1.44 uA (32kB RAM)
<b>Active Current (EM0)</b>	70µA/MHz	51uA/MHz	25uA/MHz
<b>Security</b>	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
<b>Operating Voltage</b>	1.8V – 3.6V	1.8V – 3.8V	1.71V – 3.8V
<b>Packages (mm)</b>	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)**



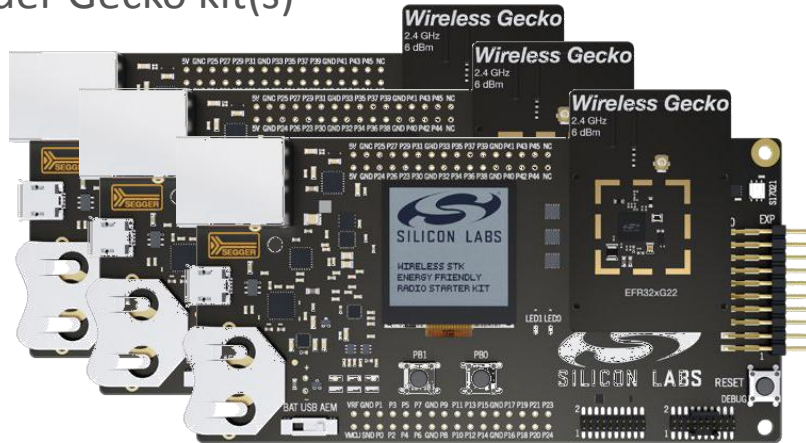
**BGM220S (Q3'20)**

	BGM13P	BGM13S	BGM210P	BGM210L	BGM220P (Q3'20)	BGM220S (Q3'20)
<b>Protocols</b>	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)
<b>EFR32 SoC</b>	BG13	BG13	BG21	BG21	BG22	BG22
<b>Antenna</b>	Built-in or U.FL	Built-in or RF pin	Built-in or RF pin	Built-in	Built-in	Built-in or RF pin
<b>Max TX power</b>	+8 / +19 dBm	+8 / +18 dBm	+10 / +20 dBm	+12.5 dBm	+8 dBm	+6 dBm
<b>Sensitivity (1M)</b>	-94.8 dBm	-94.1 dBm	-97 dBm	-97 dBm	-98 dBm	-98 dbm
<b>Flash (kB)</b>	512	512	1024	1024	512	512
<b>RAM (kB)</b>	64	64	96	96	32	32
<b>GPIO</b>	25	30	20	12	24,25	25
<b>Operating Voltage</b>	1.8V – 3.6V	1.8V – 3.6V	1.8 – 3.8V	1.8 – 3.8V	1.71V – 3.8V	1.71V – 3.8V
<b>Operating Temp.</b>	-40 to +85C	-40 to +85C	-40 to +125C	-40 to +125C	-40 to +105C	-40 to +105C
<b>Dimensions W x L x H (mm)</b>	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
<b>Certifications</b>	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)

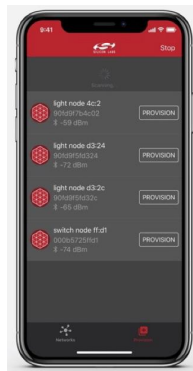


SLWSTK6006A

## 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](#)

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## Thank You | Questions

Any query, please contact us or email to [Kenny.Kong@silabs.com](mailto:Kenny.Kong@silabs.com)

Topic	Date
Evolution of Bluetooth 5, 5.1, & 5.2	10a.m., Tuesday, May 26
Bluetooth Mesh Solutions & Tools	10a.m., Thursday, May 28
15.4 Mesh Networking Technologies	10a.m., Tuesday, June 2
Bluetooth AoX Solutions	10a.m., Thursday, June 4
Connected Home Over IP (CHIP) for Beginners	10a.m., Tuesday, June 9
Device & Network Security for the IoT	9a.m., Thursday, June 11