WELCOME

Silicon Labs LIVE:

Wireless Connectivity
Tech Talks

Talk Talks LIVE Schedule

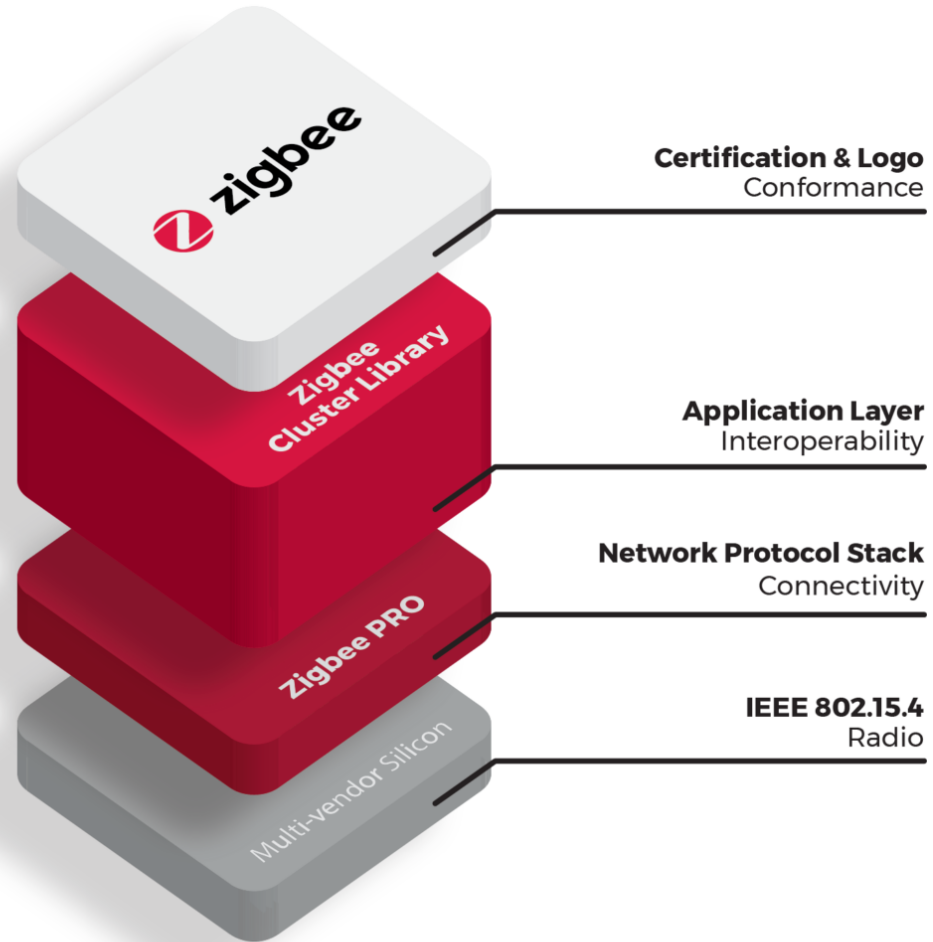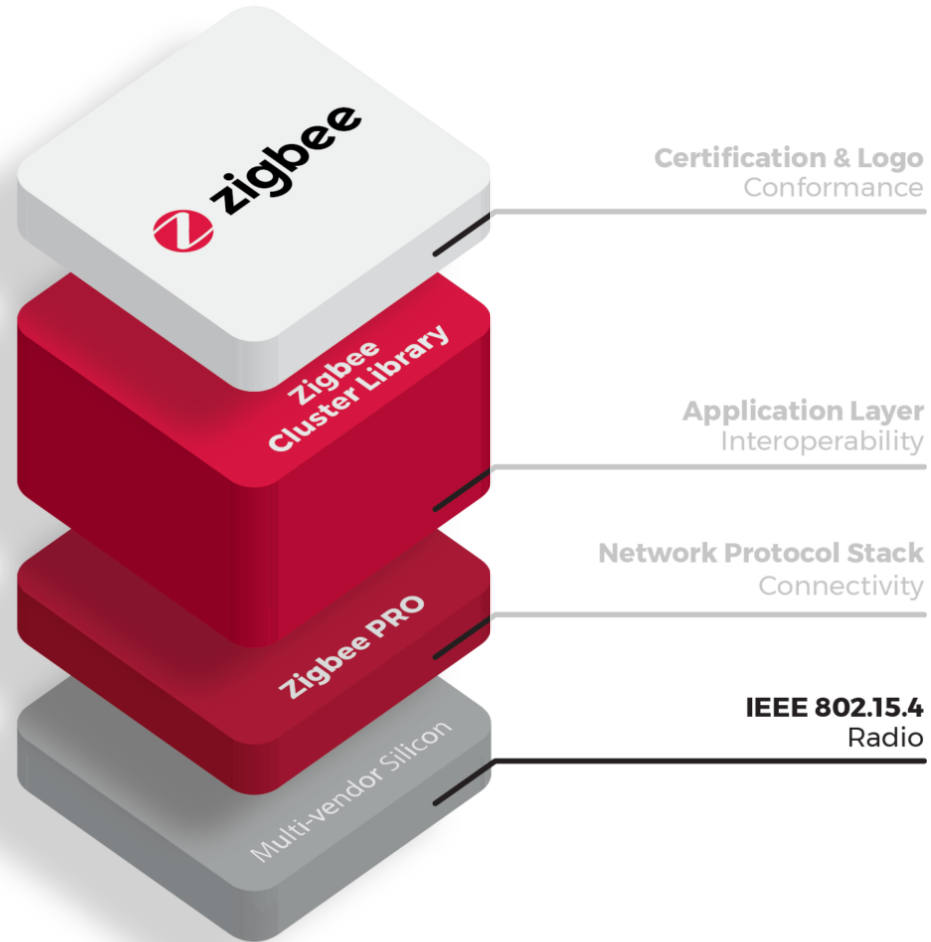| Topic	Date
Bluetooth AoX Solutions	Thursday, April 2
15.4 Mesh Networking Technologies	Tuesday, April 7
Bluetooth Mesh Solutions & Tools	Thursday, April 9
Device & Network Security for the IoT	Tuesday, April 14
Evolution of Bluetooth 5, 5.1, & 5.2	Thursday, April 16
Connected Home Over IP (CHIP) for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

802.15.4 Mesh Networking Overview

Zigbee and Thread

APRIL 2020

Zigbee Technology

Certification & Logo
Conformance

Application Layer
Interoperability

Network Protocol Stack
Connectivity

IEEE 802.15.4
Radio

Zigbee Technology

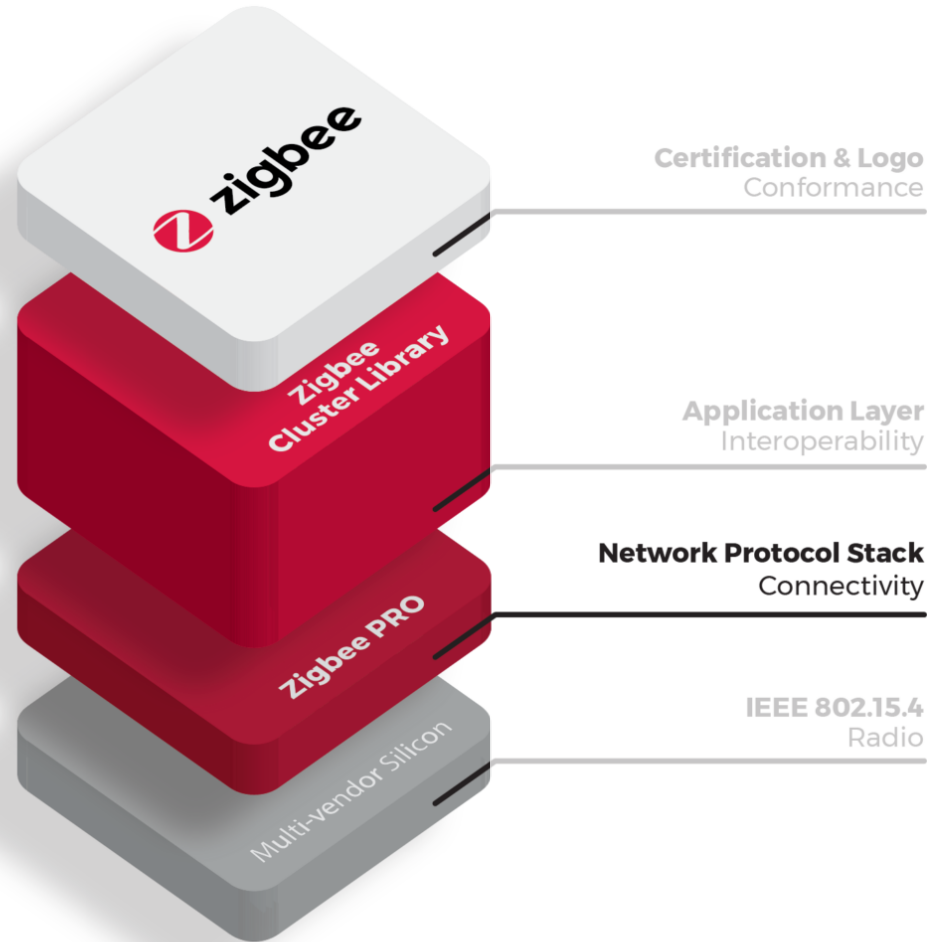|	
Certification & Logo Conformance	
Application Layer Interoperability	
Network Protocol Stack Connectivity	
IEEE 802.15.4 Radio	

- Standards-based
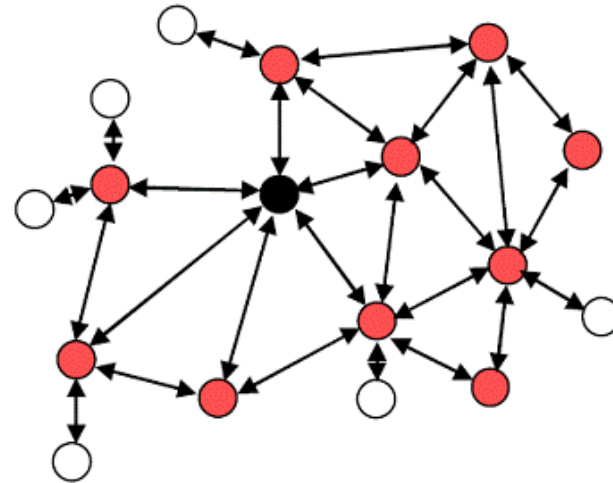- Low power
- Low data rate (250 kbps) for monitoring & control
- 2.4 GHz global ISM band

Zigbee Technology

Certification & Logo
Conformance

Application Layer
Interoperability
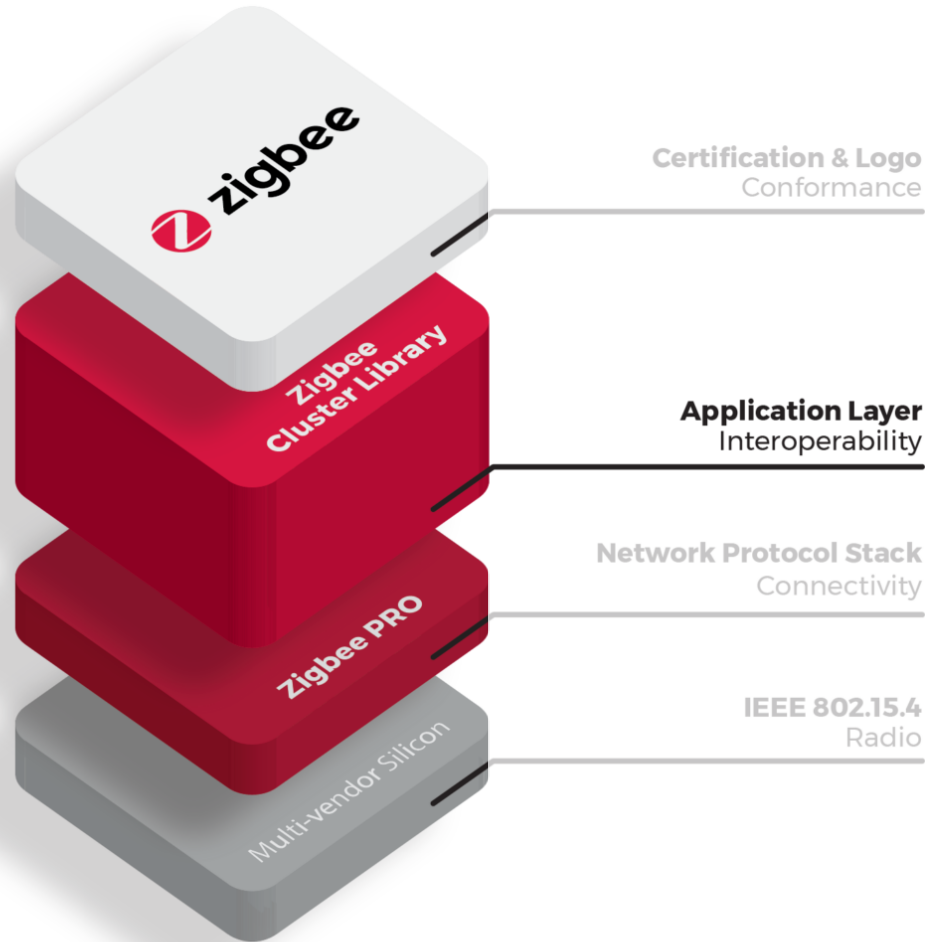
Network Protocol Stack
Connectivity

IEEE 802.15.4
Radio

- Intelligent Mesh Routing
  - Reliable and robust
  - Lower power vs. star topology
  - Efficient use of spectrum
  - Scalable for large networks

Zigbee Technology

Certification & Logo
Conformance

Application Layer
Interoperability

Network Protocol Stack
Connectivity

IEEE 802.15.4
Radio

- **Zigbee Cluster Library**
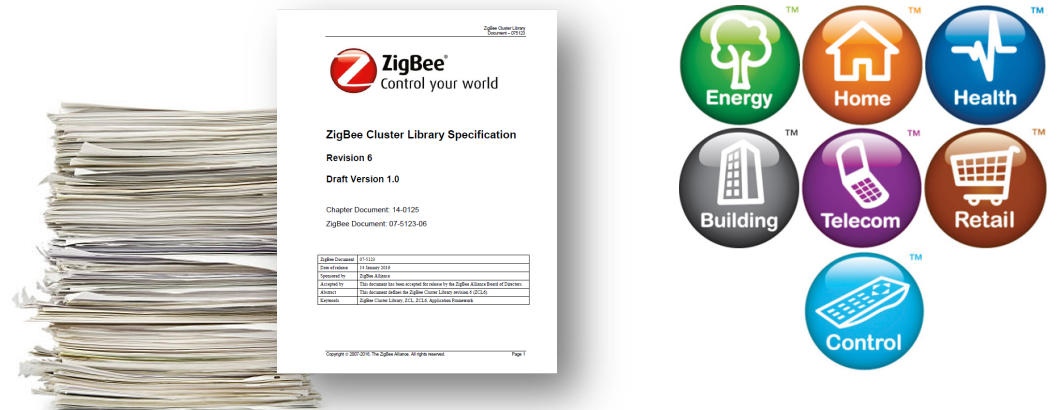 - **15 years** of development and learning
  - **400+** companies (competing mfg.)
  - **1,000** page specification
  - **100+** clusters and device types
    Cluster = functional building blocks (e.g. level control)
    Device types = shade controller, on/off/dim light, t-stat

Zigbee Technology

Certification & Logo — Conformance

Application Layer — Interoperability

Network Protocol Stack — Connectivity

IEEE 802.15.4 — Radio
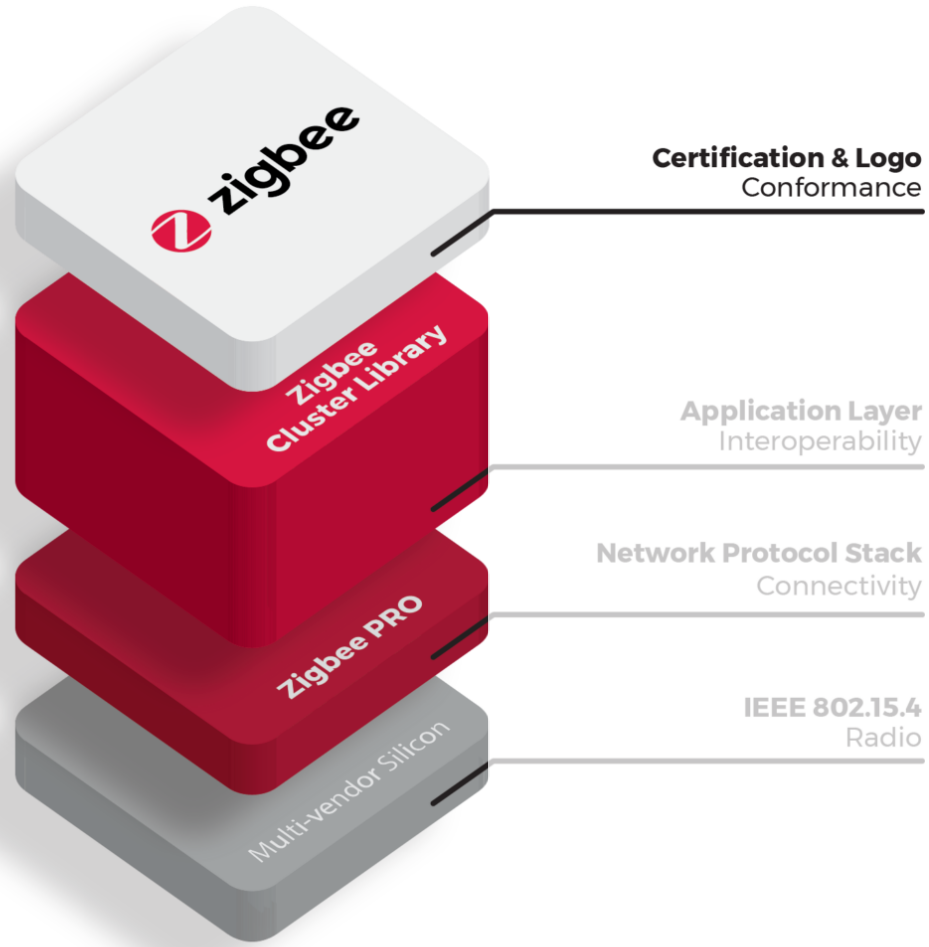
- Certification includes stack and application layer for interoperability

Zigbee Certifications (2017)

■ 3.0 ■ HA ■ ZLL ■ SE ■ GP

Smart Energy 124 · 2 · 32 · Home Automation 121 · Light Link 192

Silicon Labs Zigbee Leadership

zigbee

Board of Directors
Technical Committee Chair
Testing & Certification Chair
Core Stack WG Chair
Mesh IP WG Chair

Key Technical Contributor

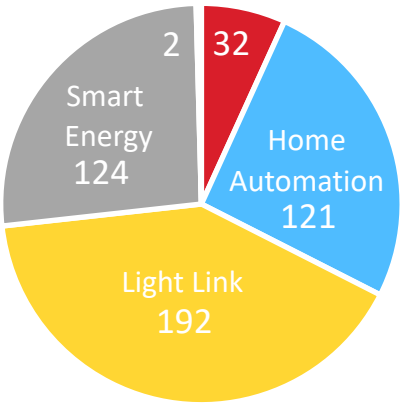- **Pioneers in Mesh Networking**
  - Leadership, Deep Experience, Strong Continued Investment

| | ZigBee 2003 | ZigBee 2004 | | ZigBee 2006 | ZigBee PRO | | | | | | | ZigBee HA 1.2 | | | | | Zigbee 3.0 | Zigbee Dotdot | | |

ember

| | EmberNet 1.x | | EmberZNet 2.x | | EmberZNet 3.x | | | EmberZNet 4.x | | | | EmberZNet 5.x | | | | | EmberZNet 6.x | | |
| | EM2420 | | EM250 | | | EM357 | | | | | SILICON LABS | | EM358x | EM359x | MG1 | MG12/13 | | MG14 | MG21 |

| 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |

Zigbee Software

	Customer Application
Zigbee	Zigbee App Framework (e.g. Zigbee 3.0, Green Power)
	Mesh Routing (Zigbee PRO)
MAC	IEEE 802.15.4
Hardware	PHY (RAIL)
	Gecko Bootloader

- **Fully Integrated Stack Architecture**
  - Zigbee 3.0 certified platform
  - Application Framework
    - Zigbee 3.0 / Green Power/ Smart Energy
  - Support for SoC and NCP architectures

- **Flexible, easy-to-use**
  - Commissioning and security
  - Seamless integration with AppBuilder
  - EZSP serial protocol for NCP over UART or SPI

- **Field Upgradable**
  - Over-the-Air firmware updates
  - NCP firmware updates over serial interface

Zigbee PRO & Zigbee Green Power

Zigbee Green Power uses the same lower layers, with compressed messages (20% of Zigbee PRO energy)

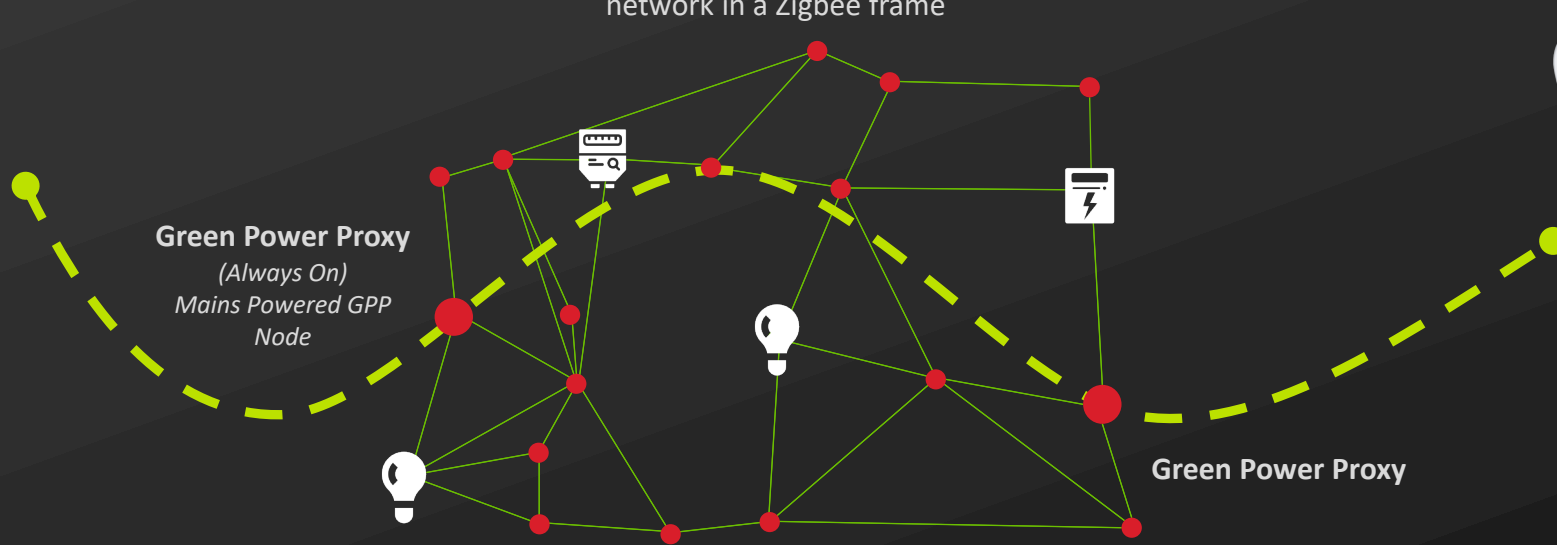Low power mesh technology built on 802.15.4 MAC/PHY

Zigbee Green Power
Extends support of 802.15.4 networks to battery powered and energy-harvesting nodes

Zigbee PRO
GP frame packets are forwarded across the Z3 network in a Zigbee frame

Green Power Proxy
(Always On)
Mains Powered GPP Node

Green Power Proxy

Green Power Device
(Energy Harvesting or Battery Powered)
GPD Node

Green Power Sink
(Always On)
Mains Powered GPS Node

green power
by zigbee alliance

Energy Harvesting
Battery-less
Interoperable
Flexible
Eco-friendly

Zigbee 3.0 (EmberZNet) SDK

- **Dynamic Multiprotocol Zigbee and Bluetooth**
  - Develop devices that work simultaneously over BLE and Zigbee
  - Fully integrated GATT configurator

- **Zigbee Green Power (GPD, Sink, GPPB)**
  - Proxy functionality required for Zigbee 3.0
  - Expand energy savings of Zigbee Pro by 5x

- **Works With All Hubs**
  - Easily integrate into Amazon ecosystem
  - Test harness provided by Silicon Labs running on EFR32

- **Friends of Hue**
  - Easily integrate into Philips Hue ecosystem
  - Sample applications for battery powered switches

- **Low Power Support**
  - EM2 to support long-lasting battery powered sensors

- **Wi-Fi Coexistence**
  - Managed coexistence with PTA interface
  - Un-managed coexistence with great blocking performance

- **Upcoming Zigbee R23**
  - Improved security and commissioning
  - Routing improvements

WWAH Certification

R23 Certification

2019   2020   2021

Dec 2019

Q2 2020

Q4 2020

Q2 2021

Release 2.7.3
- xG22 Support
- WWAH Test Harness

Release 2.7.0
- DMP NCP with BLE
- GP alpha for MG22

Release 3.0.0
- Multi-network PAN
- Friends of Hue Switch
- Unified MAC

Release 3.1.0
- Zigbee over BLE
- UC/UP

Release 3.2.0
- Zigbee R23
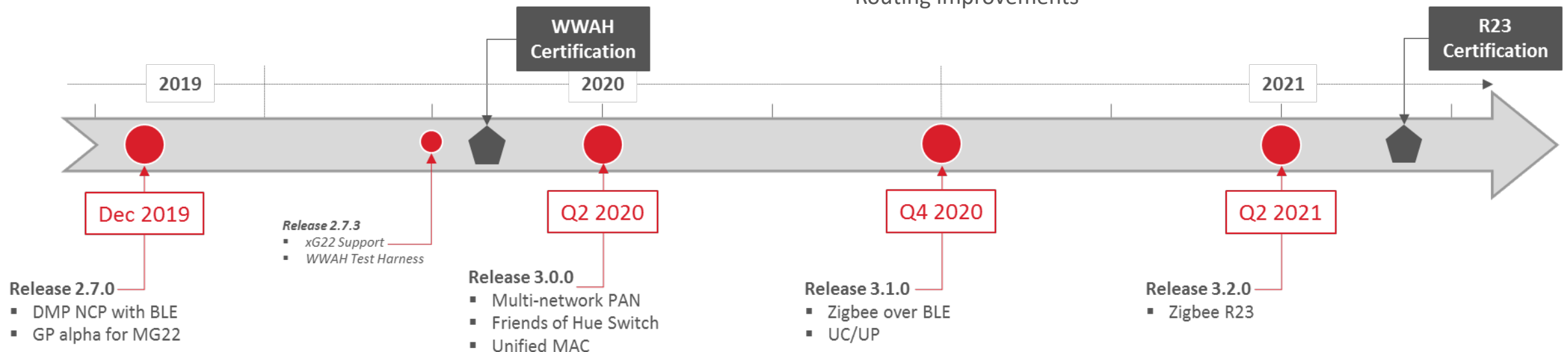
Thread Overview

- IPv6-based, low-power, secure mesh networking protocol

- Built for the IoT – smart home, commercial buildings

- Intended for control and automation (250 kbps)

- Scalable to 250+ nodes per subnet

- Runs on existing 802.15.4 wireless SoCs

Thread can support many popular application layer protocols

| Application |
| UDP |
| IP Routing |
| 6LoWPAN |
| IEEE 802.15.4 MAC |
| IEEE 802.15.4 PHY |

Security/ Commissioning
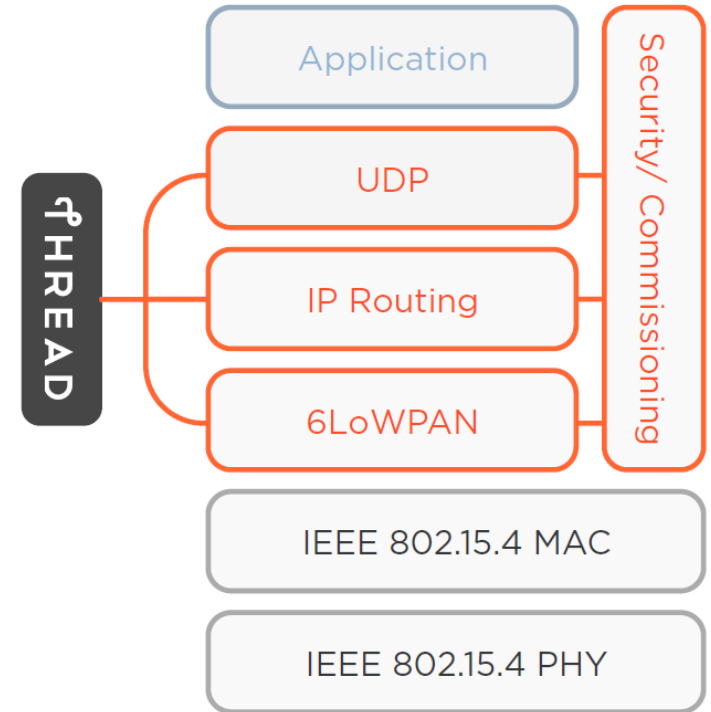
OpenThread Overview

OPENTHREAD
released by Google

- OpenThread is an open-source implementation of the Thread networking protocol

- Thread 1.1 certification on EFR32 running OpenThread

- OpenThread GitHub example drivers
  - EFR32MG12
  - EFR32MG13
  - EFR32MG21

- Support for OpenThread Border Router
  - Raspberry Pi host
  - EFR32 NCP

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Wireless Gecko EFR32

THREAD CERTIFIED COMPONENT

Thread Interoperability Certificate
This certificate lists the features that have passed Thread specification compliance and interoperability testing.
See http://threadgroup.org/technology/ourtechnology for more details

Company:	Silicon Laboratories, Inc.
Product Name:	Silicon Labs Mighty Gecko SoC (EFR32MG12x)
Model:	EFR32MG12x
Product Type:	Module
Hardware Version:	EFR32MG12x
Firmware Version:	Gecko SDK v2.6.1 + OpenThread
Date of Last Certification:	September 11, 2019
Product Features:	Full Thread Device (FTD) Minimal End Device (MED)
	On-Mesh Commissioner Sleepy End Device (SED)
	Border Router Full End Device (FED)

OpenThread SDK

OPENTHREAD
released by Google

- **Dynamic Multi-Protocol Thread and Bluetooth**
  - Develop devices that work simultaneously over BLE and Thread

- **OpenWeave Door Lock Sample App**
  - Control via Thread and BLE
  - Easily integrate into Google ecosystem

- **NCP Support**
  - Develop a border router application using a Raspberry Pi
  - Works with the Thread commissioning app
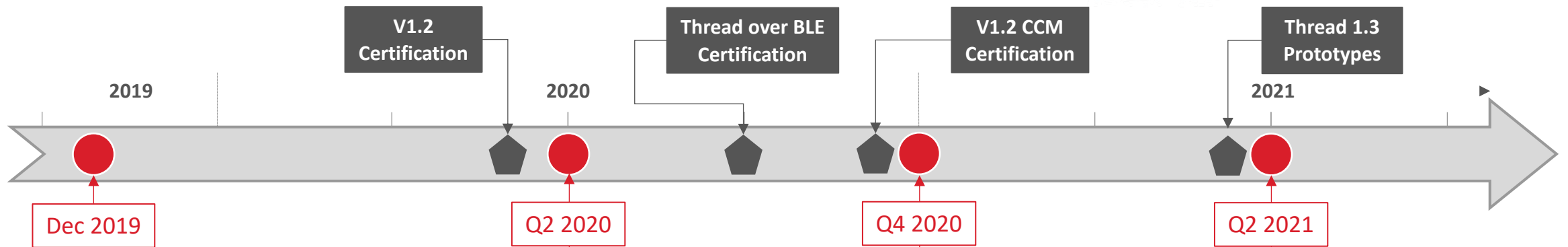
- **Development Tools**
  - Network Analyzer
  - Large Network Testing

- **Certification**
  - Thread 1.1 certification on EFR32 running OpenThread

- **Wi-Fi Coexistence (Roadmap)**
  - Managed coexistence with PTA interface
  - Un-managed coexistence with great blocking performance

V1.2 Certification

Thread over BLE Certification

V1.2 CCM Certification

Thread 1.3 Prototypes

2019

2020

2021

Dec 2019

Q2 2020

Q4 2020

Q2 2021

GitHub Release
- OpenThread GitHub
- OpenWeave GitHub

Release 3.1.0
- DMP OpenWeave GitHub

Release 3.2.0
- Wi-Fi Coex
- Large Network Testing
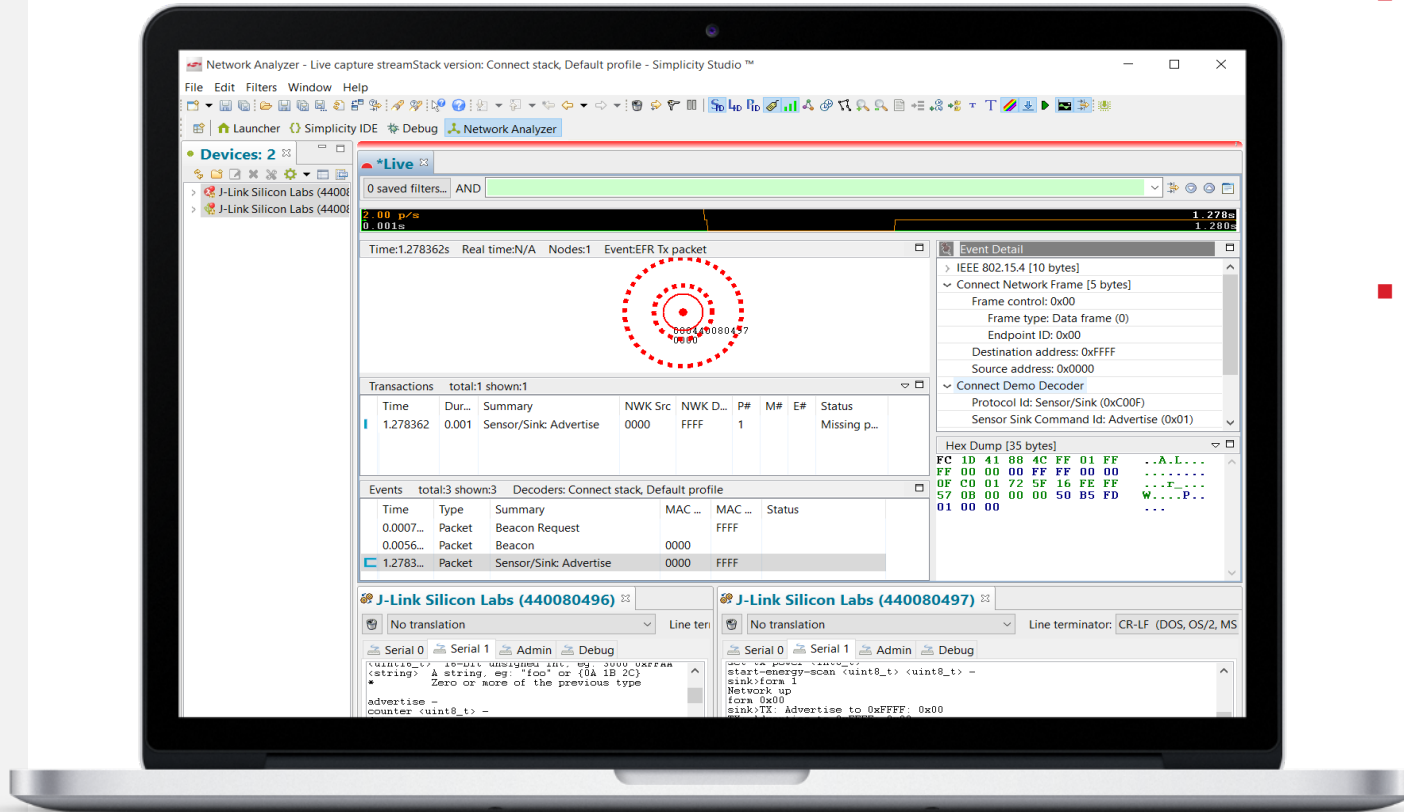- DMP OpenWeave GSDK

Release 3.3.0
- CMP OpenThread + Zigbee

Managed Wi-Fi Co-Existence

- Managed co-existence solutions for Zigbee/Thread/Bluetooth and Wi-Fi

- Based on IEEE 802.15.2 Packet Traffic Arbitration (PTA)

- Supports Network Co-Processor (NCP) architecture for gateway applications

- Flexible interface
  - 1- to 4-wire implementations
  - Configurable pin selections, active high/low, timing, etc.

- Performance tested with leading Wi-Fi chipsets

- See AN1017 app note for more details

PTA Signals

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Mighty Gecko EFR32

REQUEST →
PRIORITY →
← RHO
← GRANT

Wi-Fi SoC
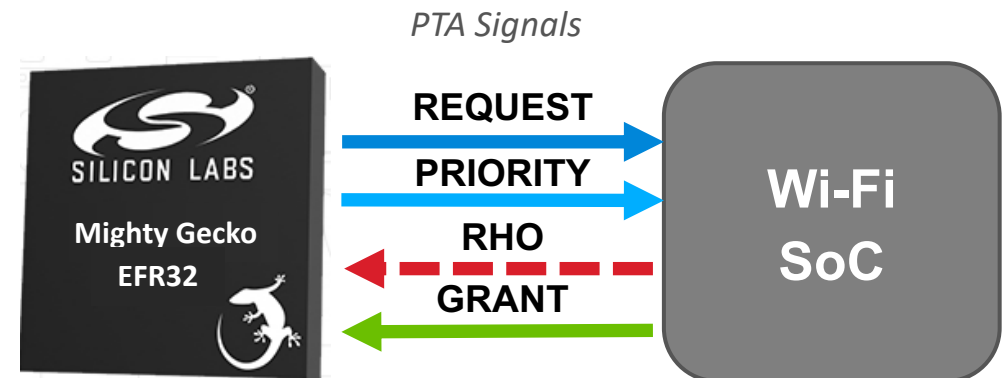
Network Analyzer

- Network-wide view of all packet activity
  - Correlates network traffic into events
  - Custom decoding and filtering options
  - Log files accelerate Silicon Labs support
- Uses unique Packet Trace Port feature
  - 2-wire interface
  - Outputs every packet TX/RX with link quality
  - Can be used to output application debug statements

Advanced system-wide network debug and support

A Common Platform

	Bluetooth	**OPENTHREAD** released by Google	**zigbee**	**FLEX SDK** Proprietary
Application	Customer Application	Customer Application	Customer Application	Customer Application
	GATT (profiles / services) · Mesh Models (e.g. lighting)	Application Layer (e.g. Project CHIP, OpenWeave, CoAP)	Application Profile (e.g. Zigbee 3.0, ZLL, SE)	
Network / Transport	Bluetooth LE Core · Bluetooth Mesh Core	UDP	Zigbee Core Stack	Connect Stack · Customer Proprietary Stack
		IPv6, Mesh Routing		
		6LoWPAN		
Link	Bluetooth Link Layer	IEEE 802.15.4 MAC	IEEE 802.15.4 MAC	IEEE 802.15.4 like MAC
Physical	Bluetooth PHY (2.4 GHz)	IEEE 802.15.4 PHY (2.4 GHz)	IEEE 802.15.4 PHY (2.4 GHz)	Proprietary PHY (2.4 GHz or Sub-GHz)
Platform	RAIL	RAIL	RAIL	RAIL
	Common Bootloader	Common Bootloader	Common Bootloader	Common Bootloader

Multiprotocol Options

Type	Definition
Programmable	Device **programmed** with either **Zigbee** or **OpenThread** in manufacturing
Switched	Application switches between **Zigbee** and **OpenThread** via **bootloader**
Dynamic	Application runs **simultaneously** (<u>time-sliced</u>) **Zigbee and BLE** or **OpenThread and BLE**
Concurrent	Application runs both **Zigbee** and **OpenThread** in a **single radio** (on same RF channel)

Mesh SoC Portfolio Highlights

	Series 1 – MG12	Series 2 – MG21	Series 2 – MG22
Target applications	Mesh Routers and End Devices	Mesh Routers and End Devices	Zigbee End Devices only
Availability	Now	Now	Now
Zigbee features	Zigbee 3.0, Green Power, Concurrent Zigbee/Thread Multiprotocol (Zigbee/BLE)	Zigbee 3.0, Green Power, Concurrent Zigbee/Thread, Multiprotocol (Zigbee/BLE)	Zigbee 3.0 (SoC only), Green Power Green Power Device
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 (802.15.4)	+19 dBm / -102.7 dBm	+20 dBm / -104.5 dBm	+6 dBm / -102.3 dBm
TX Current	9.5 mA (@ 0 dBm)	9.3 mA (@ 0 dBm)	4.1 mA (@ 0 dBm), 8.2 mA (@+6 dBm)
RX Current (802.15.4)	11.9 mA	9.4 mA	3.9 mA
CPU / Clock Speed	Cortex M4 (38.4 MHz)	Cortex M33 (80Mhz)	Cortex M33 (76.8MHz), Cortex M0+ for radio
Flash (kB)	1024	Up to 1024	Up to 512
RAM (kB)	256	Up to 96	32
Sleep Current (EM2)	1.5µA (16kB RAM)	4.5 µA (96 RAM)	1.4 µA (32kB RAM)
Active Current (EM0)	70 µA/MHz	51 µA/MHz	26 µA/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 OTA and secure debug unlock + Secure Enclave (BG21B)	AES-128/256, SHA-1/2 ECC, ECDSA and TRNG Secure boot with RTLS Secure OTA and secure debug unlock
Operating Voltage	1.8V – 3.6V	1.71V – 3.8V	1.71V – 3.8V
Packages (mm)	7x7 QFN48	4x4 QFN32 (20x GPIO)	5x5 QFN40 (26x GPIO) 4x4 QFN32 / TQFN32 (18x GPIO)

Choosing an MG Device

MG12 / MG21

Highest integration
Large memory for dual-protocol and OTA
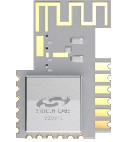Variants with highest security

MG13

Balance of features, size, power, cost
Supports dual-protocol

The new MG22

Focused on simple low cost
Zigbee node applications

- Optimized for simple end nodes
- Lowest power
- Lowest cost
- New Security Features

Increasing Features

Mesh Module Portfolio

	MGM12P	MGM13P	MGM13S	MGM210P	MGM210L
Protocols	Bluetooth 5.0 & mesh Zigbee or Thread	Bluetooth 5.1 & mesh Zigbee or Thread	Bluetooth 5.1 & mesh Zigbee or Thread	Bluetooth 5.1 & mesh Zigbee or Thread	Bluetooth 5.1 & mesh Zigbee or Thread
Status	Production	Production	Production	Production	Production
EFR32 SoC	xG12	xG13	xG13	xG21	xG21
Antenna	Chip or U.FL	Chip or U.FL	Chip or RF pin	Chip or RF pin	PCB trace antenna
Max TX power	+8 / +19 dBm	+8 / +19 dBm	+8 / +18 dBm	+10 / +20 dBm	+12.5 dBm
(250 kbps O-QPSK)	-95 dBm	-95 dBm	-94 dBm	-104.5 dBm	-104.5 dBm
TX (125 kbps GFSK)	N/A	-103.2 dBm	-102.1 dBm	-105 dBm	-105 dBm
(1Mbps GFSK)	-95 dBm	-95 dBm	-94 dBm	-97 dBm	-97 dBm
Flash / RAM	512 / 64 kB	512 / 64 kB	512 / 64 kB	1024 / 96 kB	1024 / 96 kB
GPIO	25	25	30	20	12
Operating Voltage	1.8 to 3.6 V	1.8 to 3.6 V	1.8 to 3.6 V	1.71 to 3.8 V	1.8 to 3.8 V
Operating Temperature	-40℃ to +85℃	-40℃ to +85℃	-40℃ to +85℃	-40℃ to +125℃	-40℃ to +125℃
Dimensions W x L x H (mm)	12.9 x 15 x 2.2	12.9 x 15 x 2.2	6.5 x 6.5 x 1.4	12.9 x 15 x 2.2	15.5 x 22.5 x 2.3
Certifications	BT, CE, FCC, ISED, Japan, S-Korea and Taiwan	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
Other	Options with LNA available	Pin compatible with xGM111	World Smallest IoT Solution	No LF XTAL	No LF XTAL

Thank You!

Q & A

SoC Selection Guidelines for Zigbee 3.x (R23) Specification 2020+

Customer Use Case	Software Mode	OTA Image Storage	512kB Flash EFR32MG22	512kB Flash EFR32MG13/21	768kB Flash EFR32MG21	1MB Flash EFR32MG12/21
Gateways, Touchscreens, Door Locks w/ Host Processor	Single Protocol NCP Mode	External Flash	2			
Lights, Sensors, Door Locks, Actuators, Smart Outlets, Switch/Dimmers, Thermostats	Single Protocol End Devices and Routers	External Flash				
		Internal Flash	1	1		
	Dynamic Multi-protocol w/ BLE SoC Mode	External Flash				
		Internal Flash				

EFR32MG1/14 and EM35xx devices are **Not recommended for new Zigbee designs targeting R23**
[1] Depending on the combination of protocol optional features, it **may require** external flash for OTA
[2] External PA is recommended

Flash estimations include: 50kB for Zigbee R23 code size growth, 16kB for bootloader, 15-36kB for CLI, 36kB for SimEEv2/NVM3, LZMA compression for OTA
Consult Silicon Labs wireless support team or FAEs before making final architecture decisions.

SoC Selection Guidelines for OpenThread Ecosystems

Customer Use Case	Software Mode	OTA Image Storage	EFR32MG13 512kB Flash 64kB RAM	EFR32MG21 768kB/1MB Flash 96kB RAM	EFR32MG12 1MB Flash 256kB RAM
Gateways	Single Protocol RCP Mode	External Flash			
	Single Protocol NCP Mode	External Flash			
OpenWeave/CHIP Devices	Dynamic Multi-Protocol w/ BLE SoC Mode	External Flash	Future[2]	[1]	
		Internal Flash			Future[2]

EFR32 MG12 is the recommended device today for SOCs due to the large Flash/RAM requirements of the application layers
EM35xx devices are not supported

[1]RAM constrained
[2]Future SoC support on 512kB parts is under review

Consult Silicon Labs wireless support team or FAEs before making final architecture decisions.