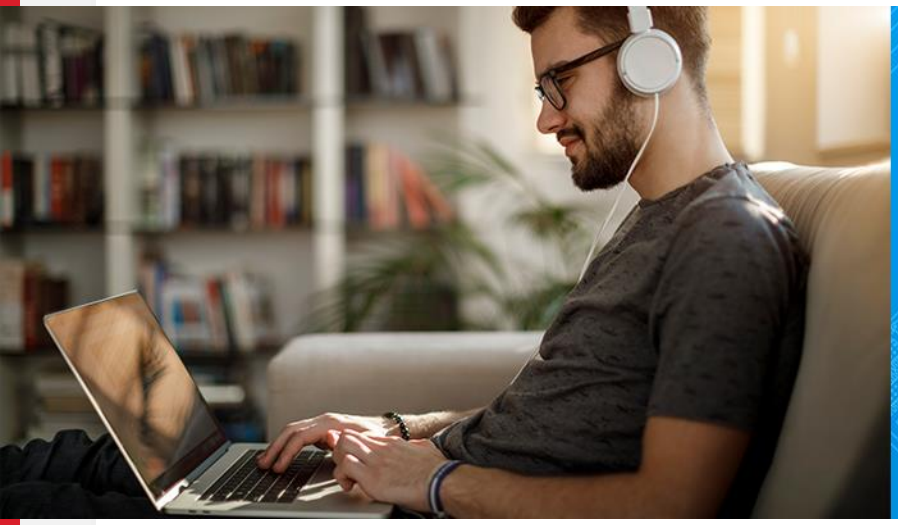
WELCOME



APAC Talk Talks LIVE - Mandarin

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

Speaker

Steven Lin

Sr. FAE, Silicon Labs Taiwan

Steven works as Sr. FAE in Taiwan team of Silicon Labs, focusing on Zigbee, Thread, Proprietary wireless products, and embedded technologies supports to Customers.

SILICON LABS

802.15.4 Mesh Networking Overview

Zigbee and Thread

STEVEN LIN | JUNE 2020

The Leader in IoT Wireless Connectivity

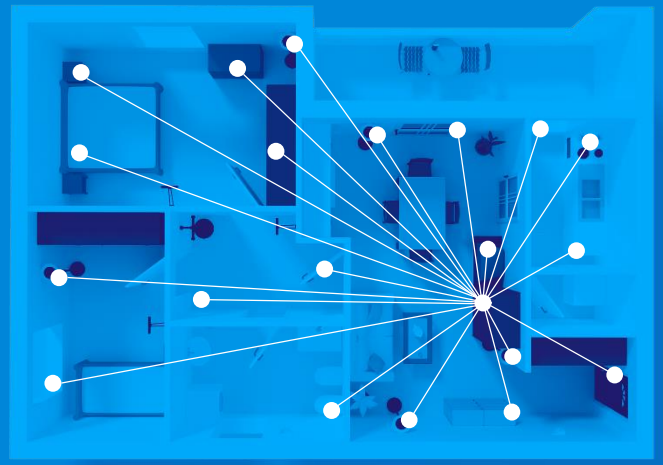
Bluetooth · Proprietary · THREAD · Wi Fi · zigbee · Z-WAVE

>35,000 Customers	>3B Products Shipped
#1 IoT Wireless Solutions	20-30% Wireless Y-Y CAGR*

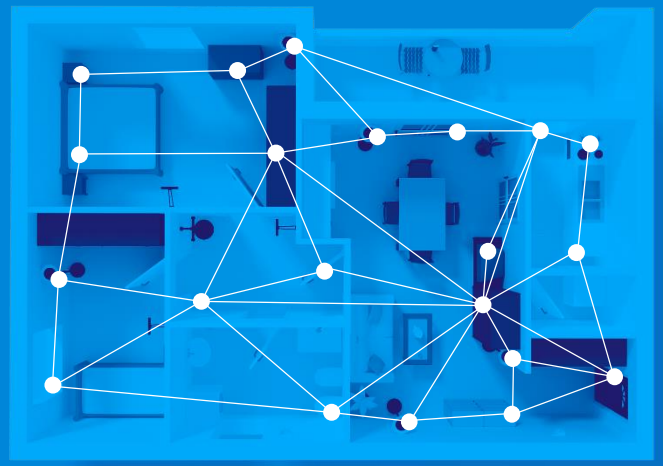
*Across 15.4, BLE, Wi-Fi, Proprietary

The Benefits of Mesh Networks

Star Network



Mesh Network



- **Extend the range** of connections from gateways or mobile devices with multi-hop communication
- **Reduce power consumption** in a system with shorter transmission distances between devices
- **Increase system scale** by supporting hundreds of devices in a single subnet
- **Improve system reliability** with self-healing networks that overcome node failures
- **Deliver optimal responsiveness** with device to device communication

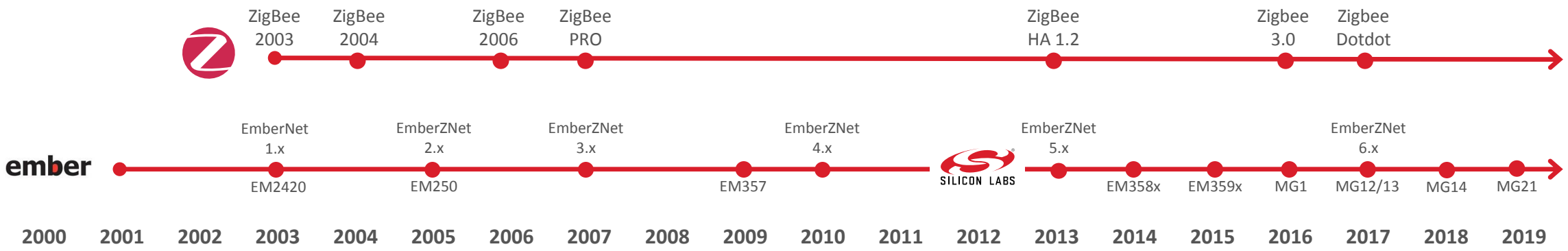
Silicon Labs Zigbee Leadership

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

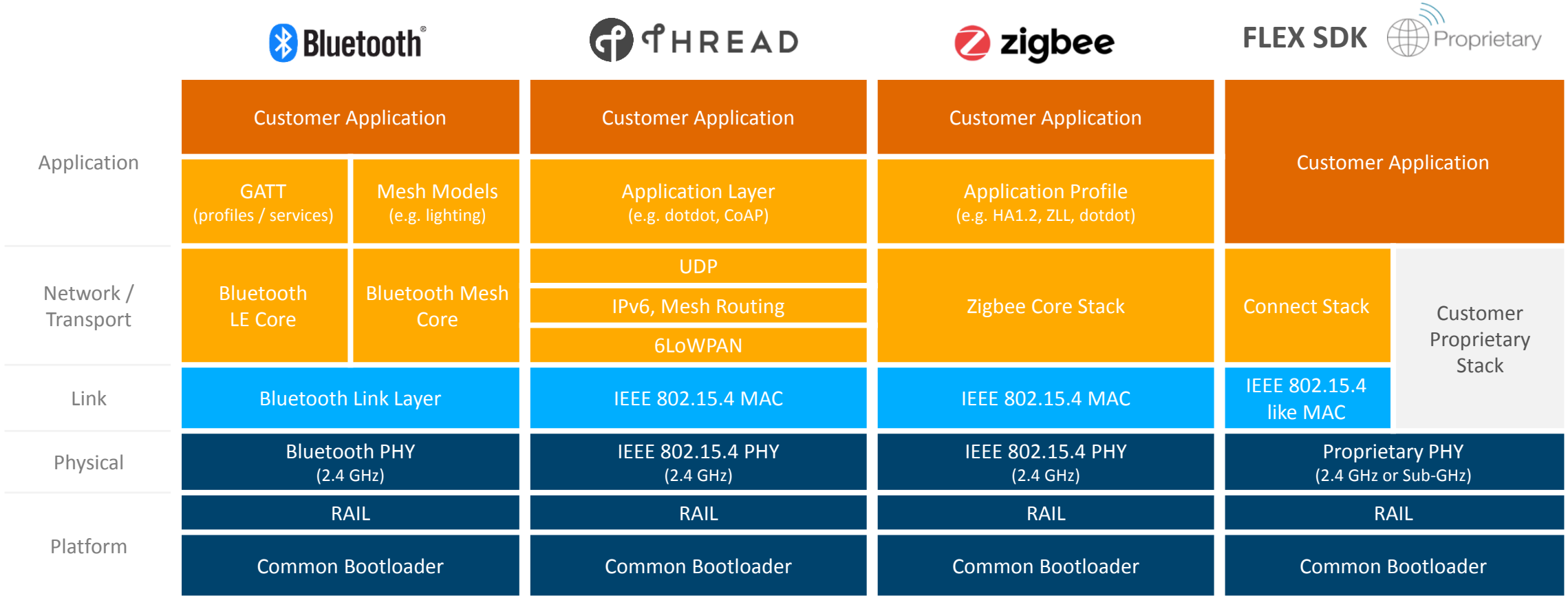
zigbee

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

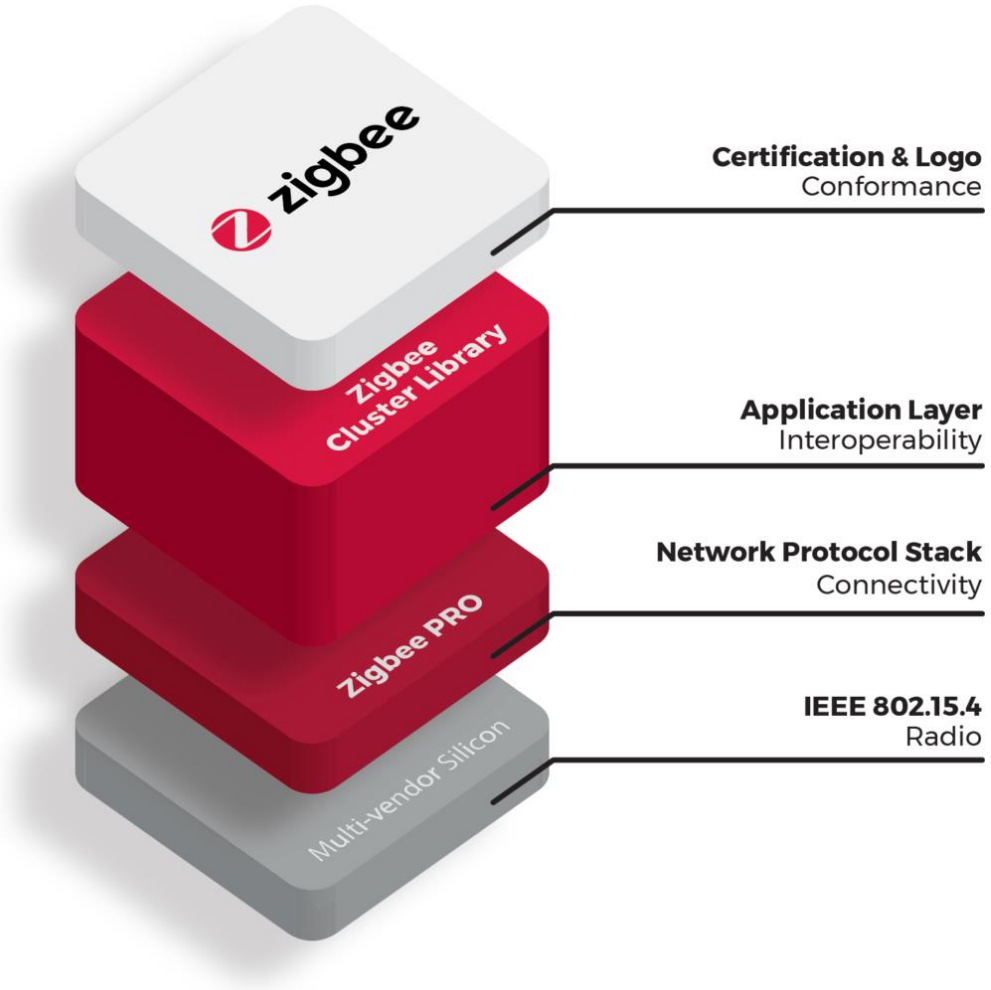
Key Technical Contributor



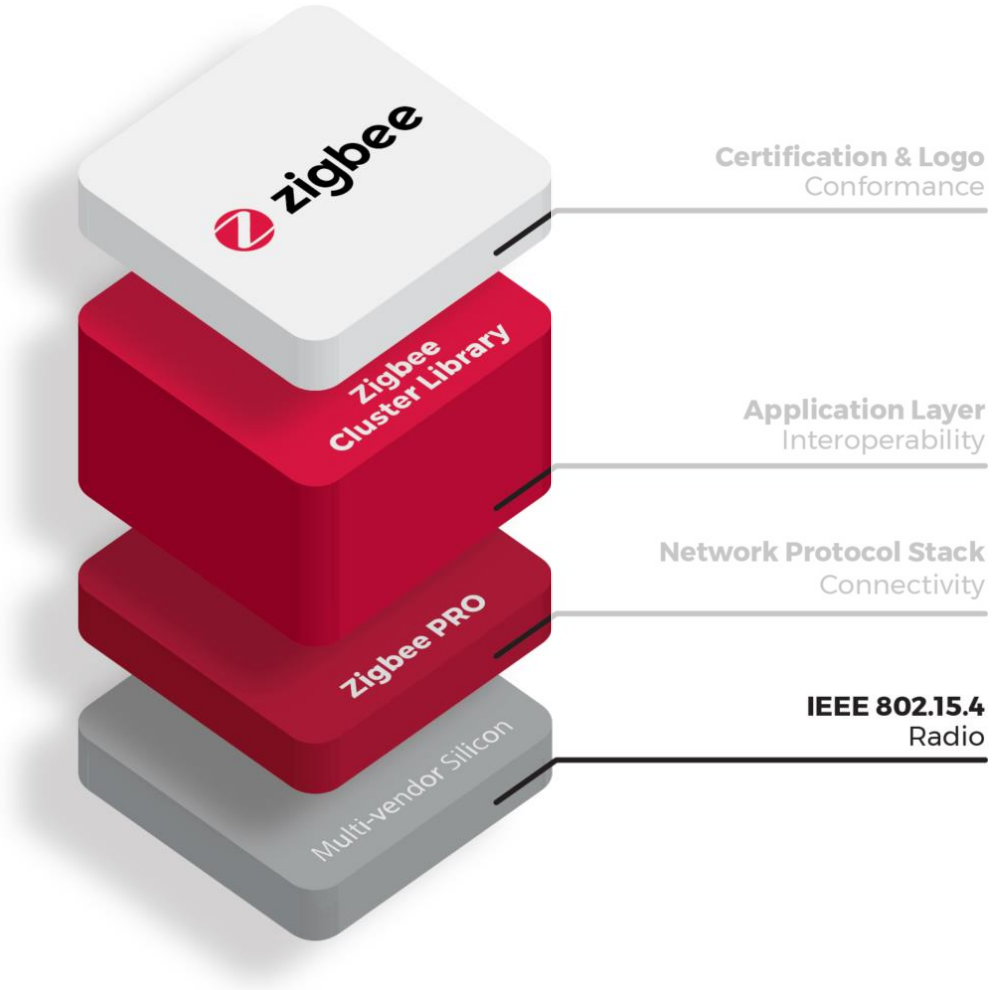
A Common Platform



Zigbee Technology

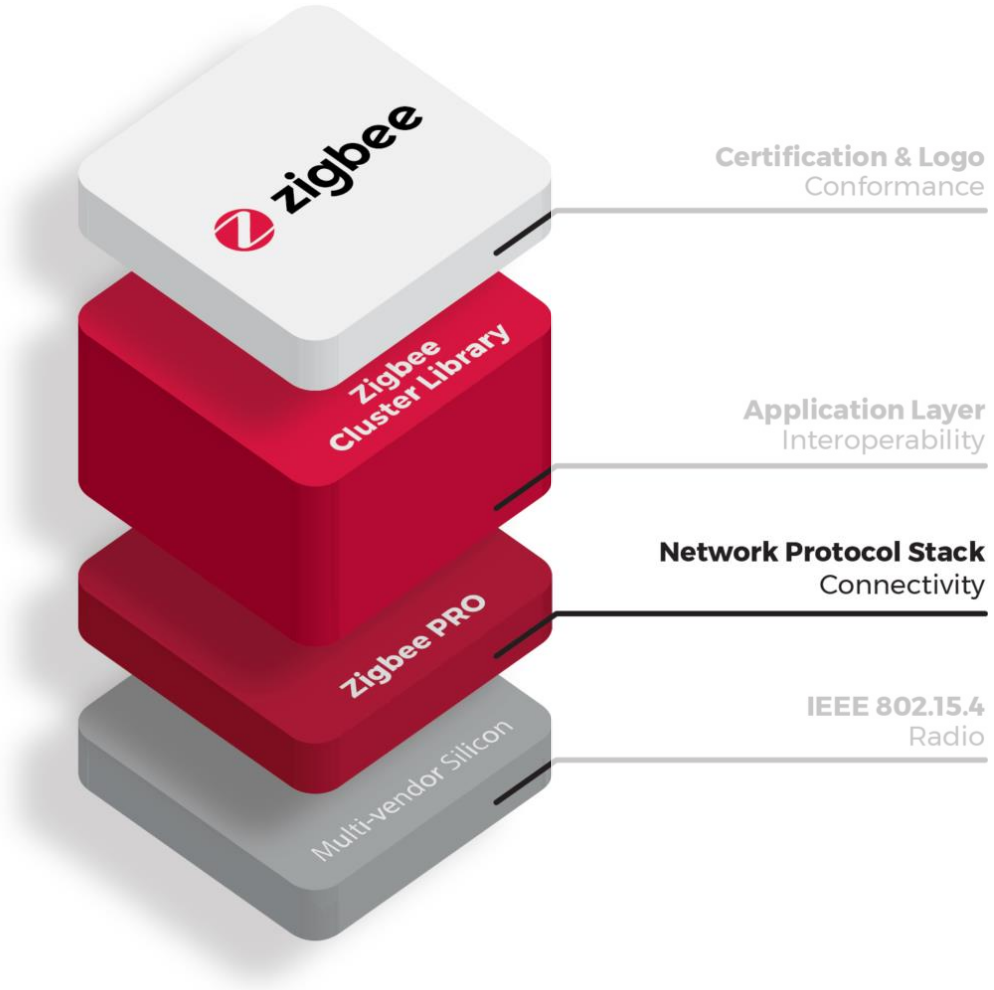


Zigbee Technology

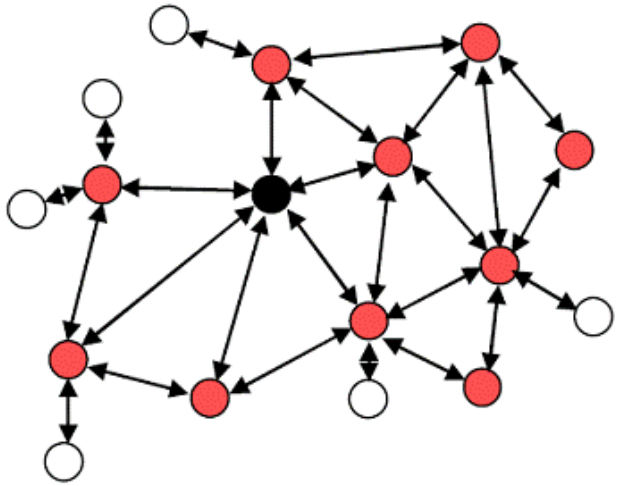


- Standards-based
- Low power
- Low data rate (250 kbps) for monitoring & control
- 2.4 GHz global ISM band

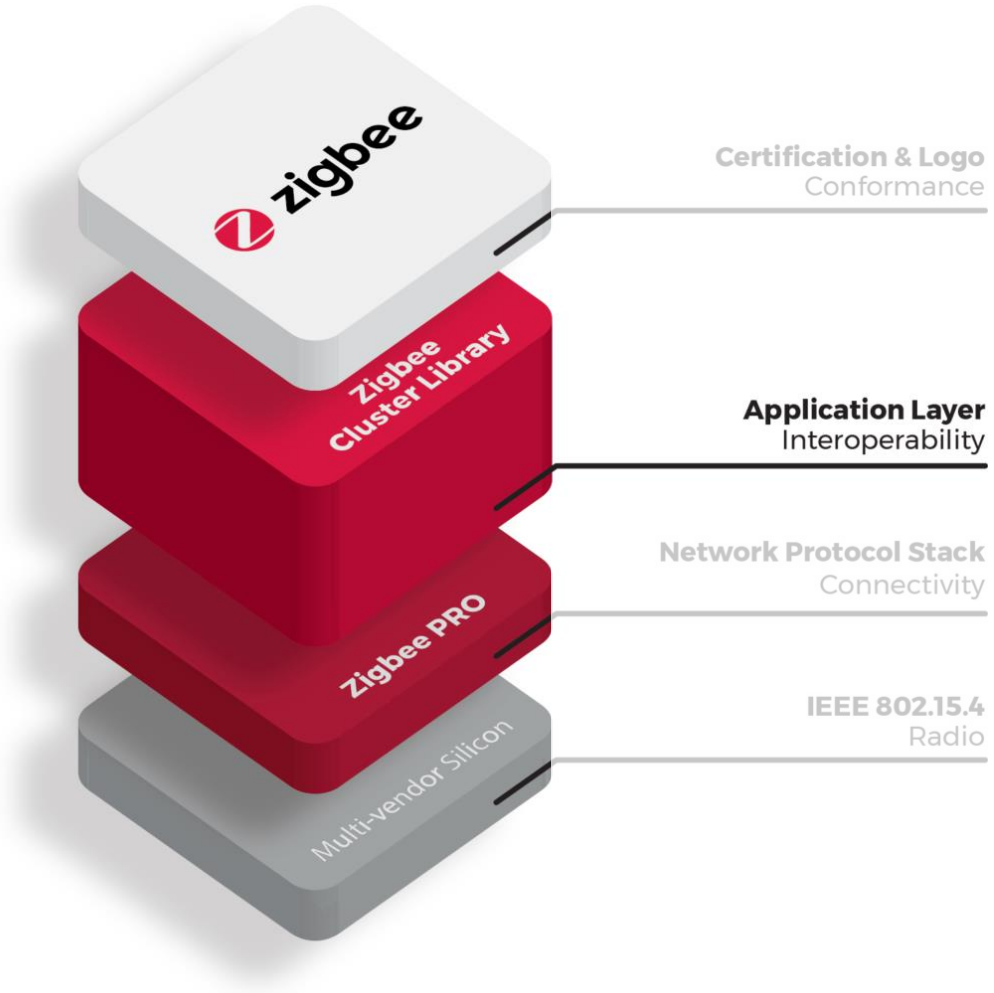
Zigbee Technology



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

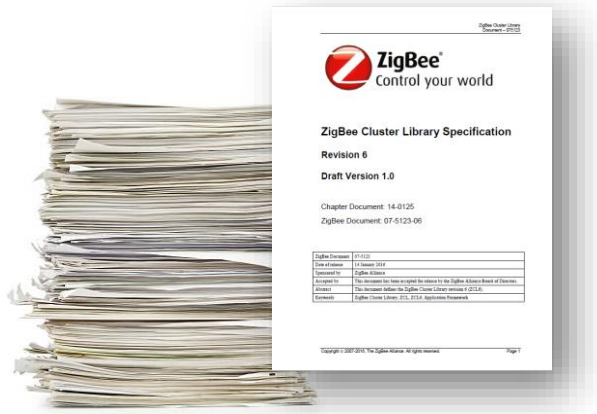


Zigbee Technology

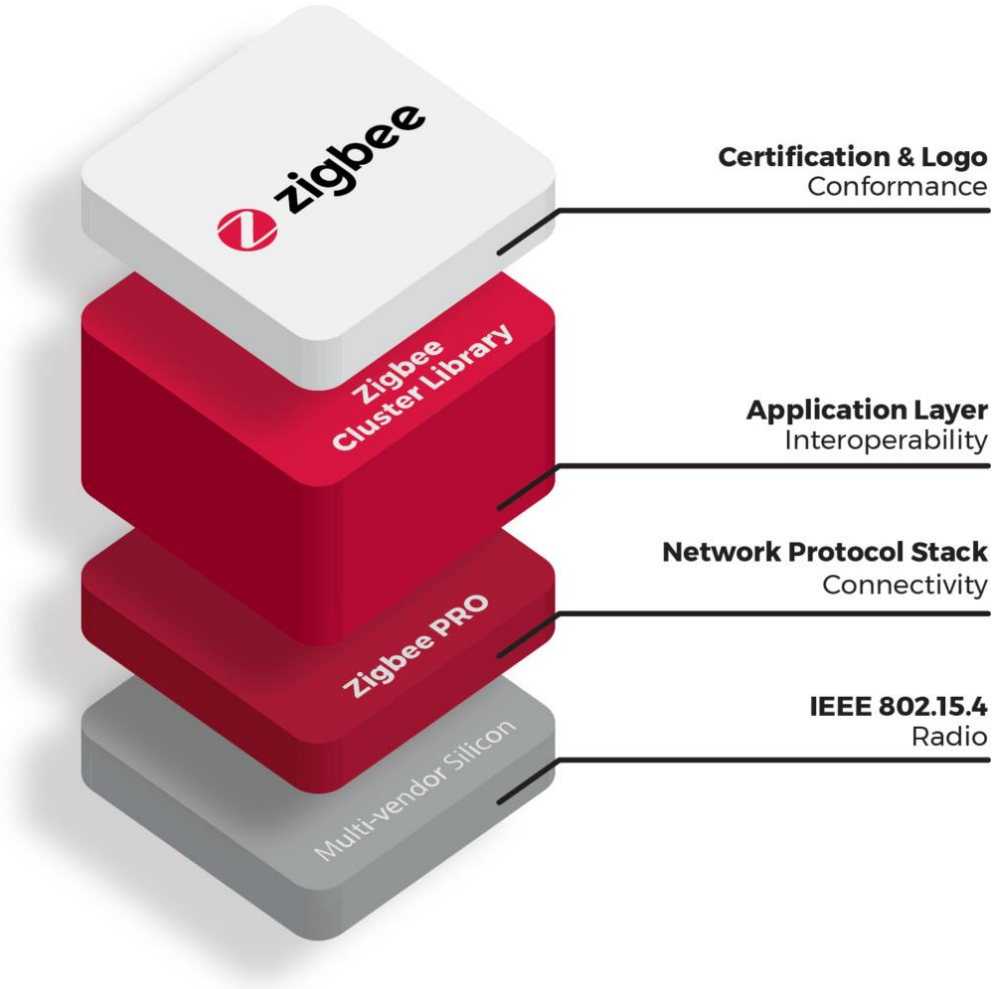


- Zigbee Cluster Library
  - 15 years of development and learning
  - 400+ companies (competing mfg.)
  - 1,000 page specification
  - 100+ clusters and device types

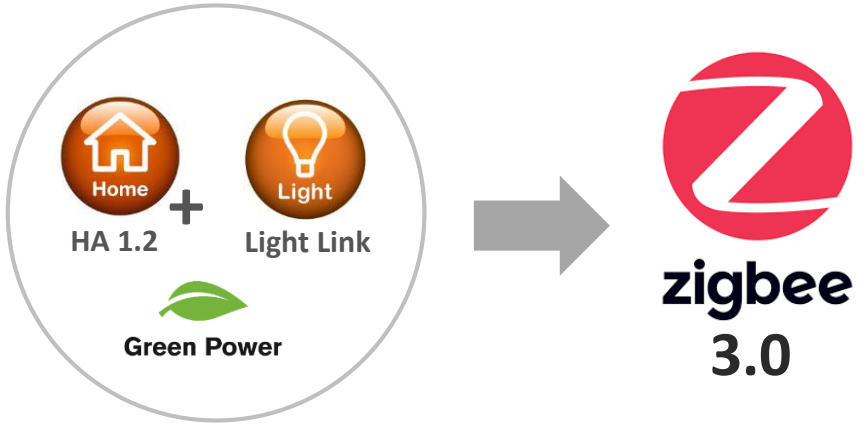
    Cluster = functional building blocks (e.g. level control)
    Device types = shade controller, on/off/dim light, t-stat



Zigbee Overview



- Zigbee 3.0
  - Unification of Zigbee profiles (except Smart Energy and RF4CE)
  - Enhanced networking and security
  - Backwards compatible
  - Mandated since May 2017
- Zigbee Smart Energy 1.4



Zigbee PRO & Zigbee Green Power

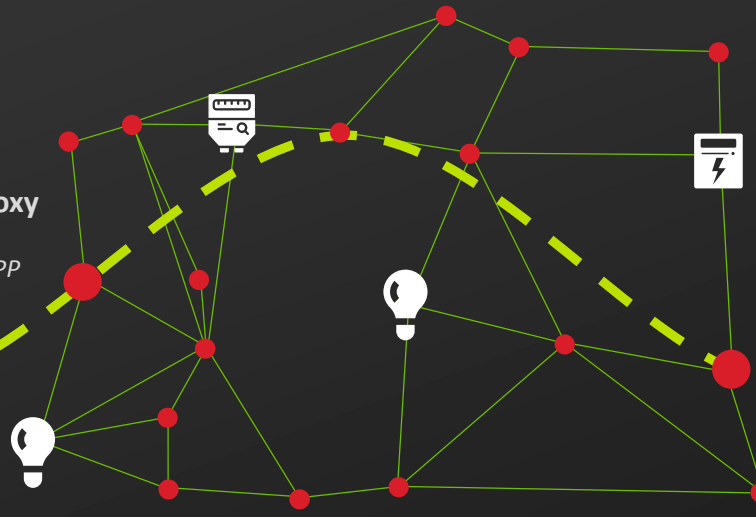
Zigbee Green Power uses the same lower layers, with compressed messages (20% of Zigbee PRO energy)

Low power mesh technology built on 802.15.4 MAC/PHY

green power by zigbee alliance
Energy Harvesting
Battery-less
Interoperable
Flexible
Eco-friendly

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

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



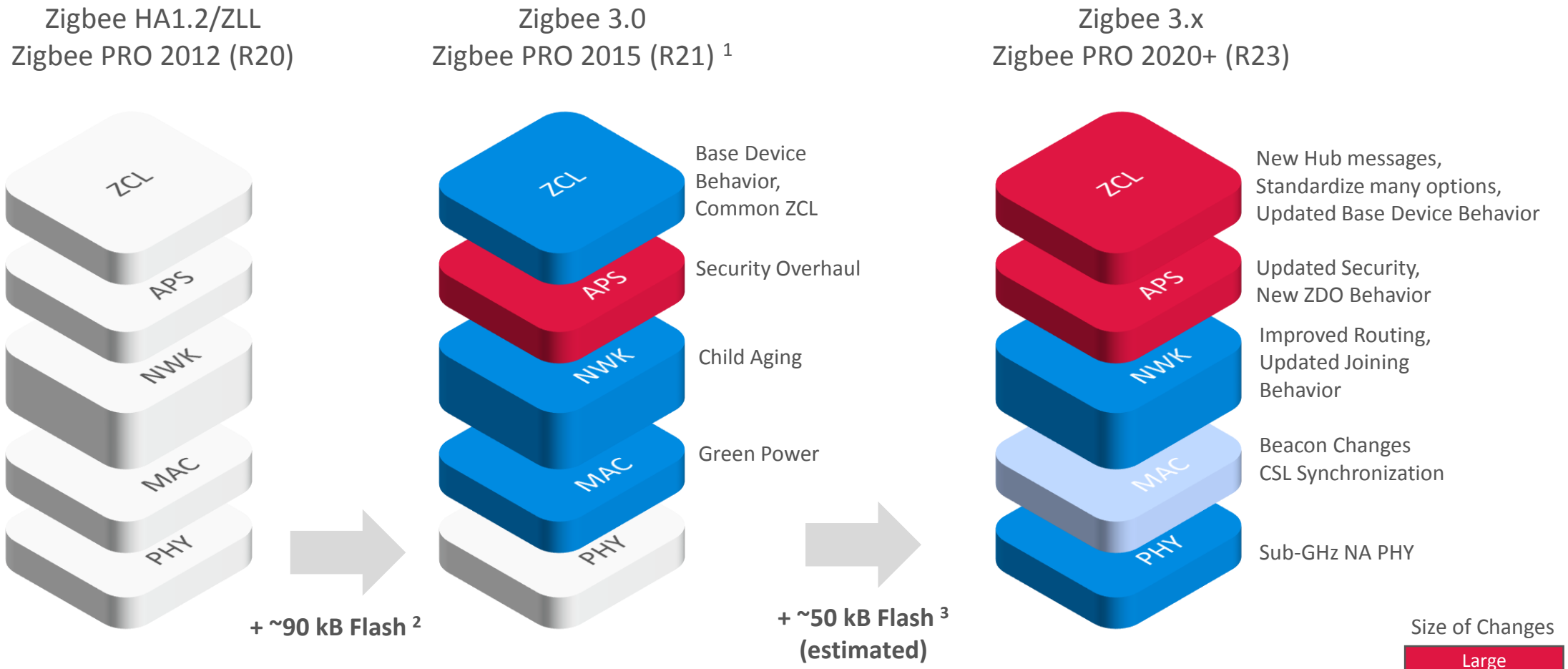
Green Power Proxy
(Always On)
Mains Powered GPP Node

Green Power Proxy

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

Green Power Sink
(Always On)
Mains Powered GPS Node

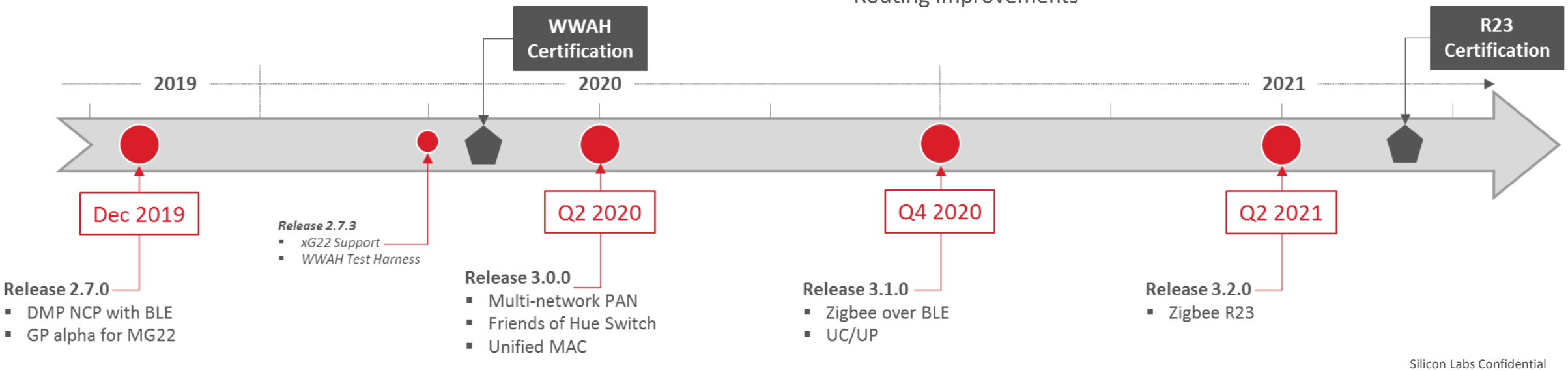
Zigbee Software Flash Memory Requirements Evolution



[1] Zigbee PRO 2017 (R22) changes are primarily dual-PHY capabilities for GB Smart Metering; no significant code changes are seen for lighting applications
[2] Assumes same target device, same toolchain and similar Zigbee application
[3] Some features may be optional based on Zigbee Alliance decisions during R23 specification development

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

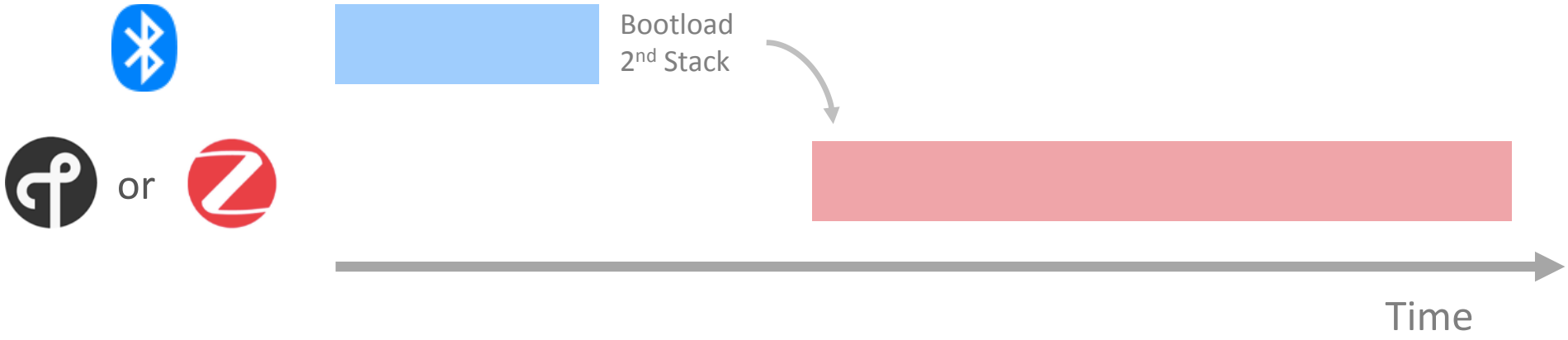


Multiprotocol Definitions

Type	Definition
Programmable	Device programmed with either **Protocol A** or **Protocol B** in manufacturing
Switched	Application switches between **Protocol A** and **Protocol B** via bootloader
Dynamic	Application runs simultaneously (time-sliced) **Protocol A** and **Protocol B**
Concurrent	Application runs both Zigbee and Thread in a single radio (on same RF channel)
Multiradio	Application runs multiple protocols with multiple radios at the same time (no time-slicing)

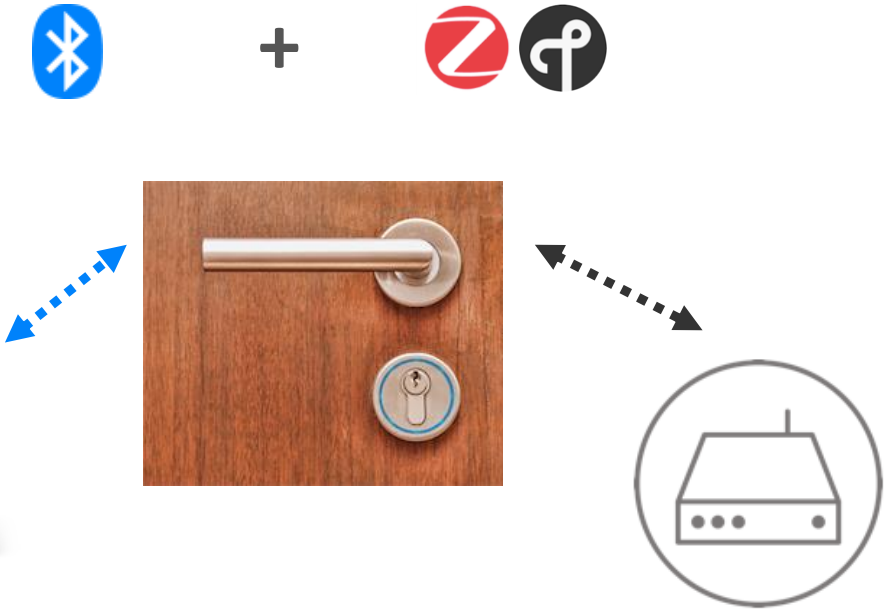
Switched Multiprotocol (SMP)

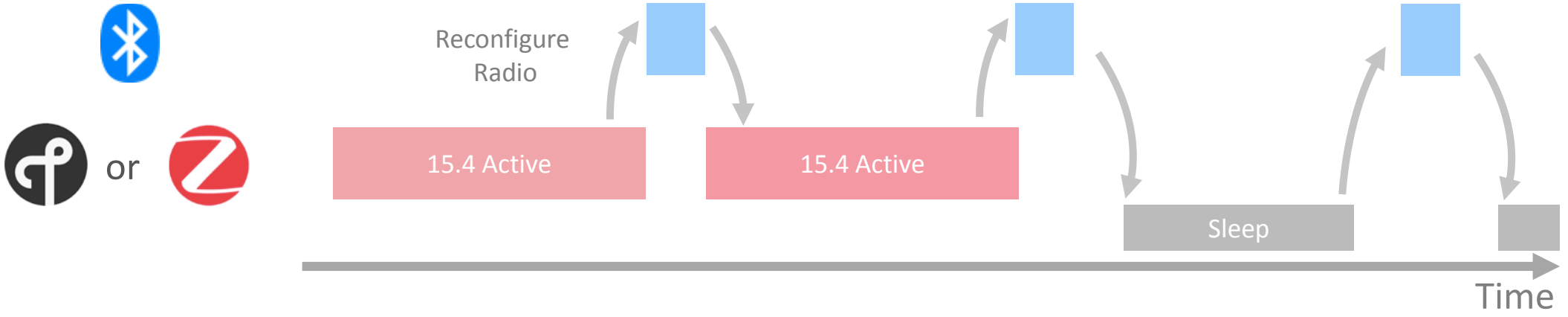
- Use Case 1: Bluetooth Commissioning
  - Initially configured as Bluetooth
  - Use phone to commission Protocol B
  - Switch to Protocol B via bootloader
- Use Case 2: Protocol Migration
  - Deploy with Protocol A
  - Switch to Protocol B in future



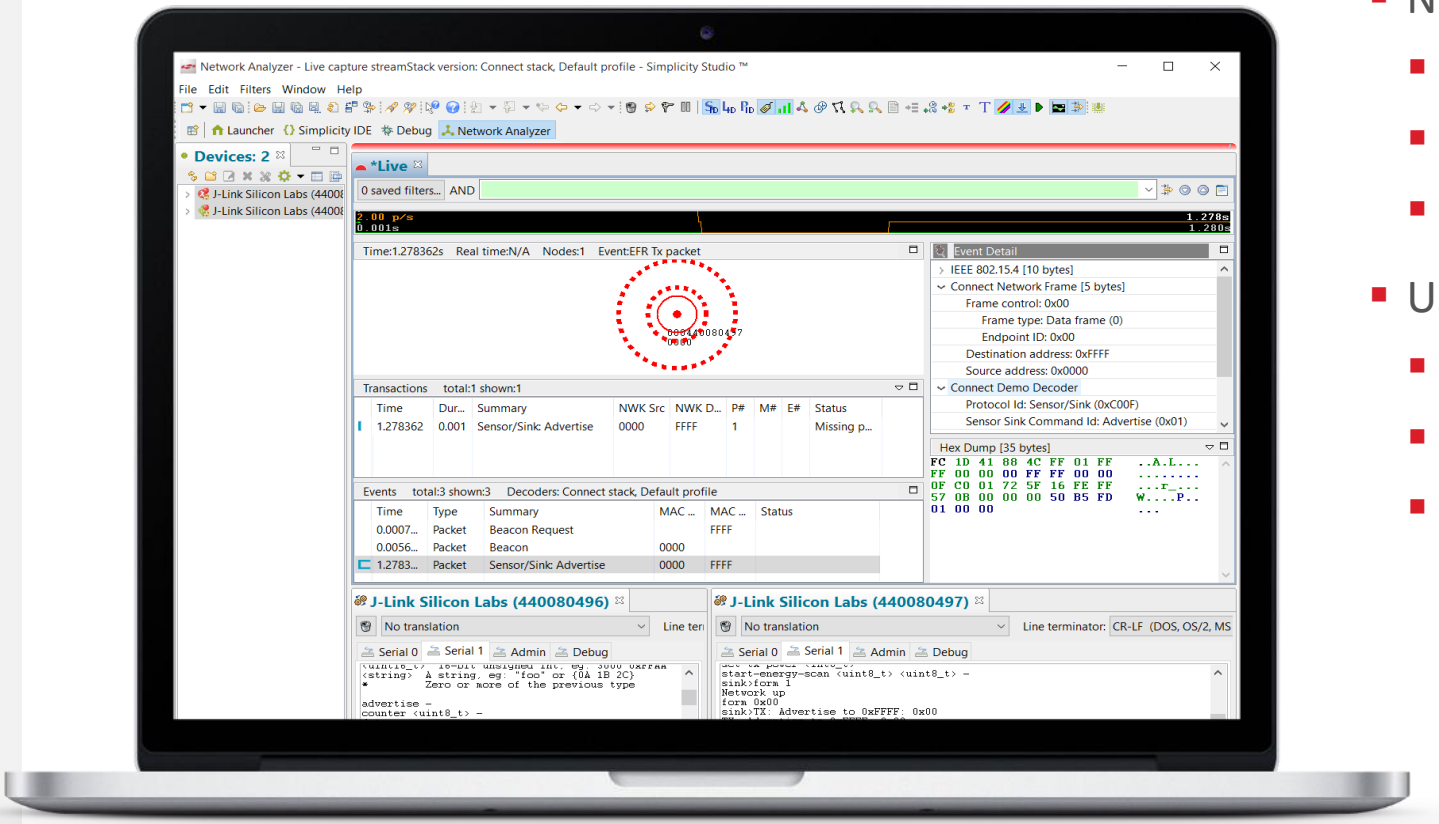
Dynamic Multiprotocol (DMP)

- Time-sliced operation between 2 stacks running on Micrium RTOS
- Enables direct phone connectivity for local control and diagnostics
- Maintains critical Bluetooth connection interval timing
- Sleep mode support for low power





Network Analyzer

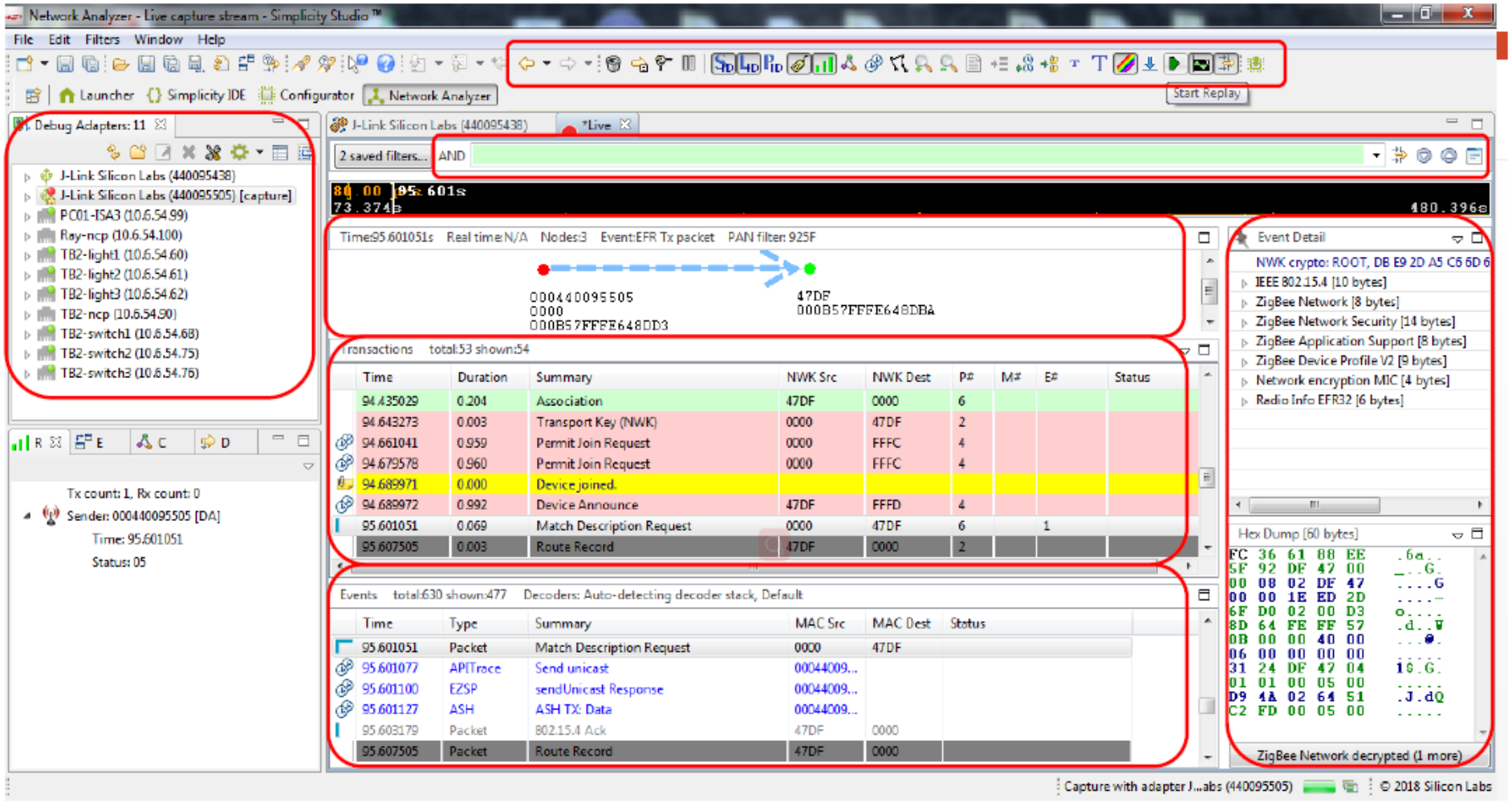


- Network-wide view of all packet activity
  - Correlates network traffic into events
  - Custom decoding and filtering options
  - Log files accelerate Silicon Labs support
- Uses unique Packet Trace Port feature
  - 2-wire interface
  - Outputs every packet TX/RX with link quality
  - Can be used to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

Advanced system-wide network debug and support

Network Analyzer

- Editor Panes
  - Adapters
  - Map
  - Transactions
  - Events
  - Event Details
  - Hex Dump
  - Filters
  - Tools

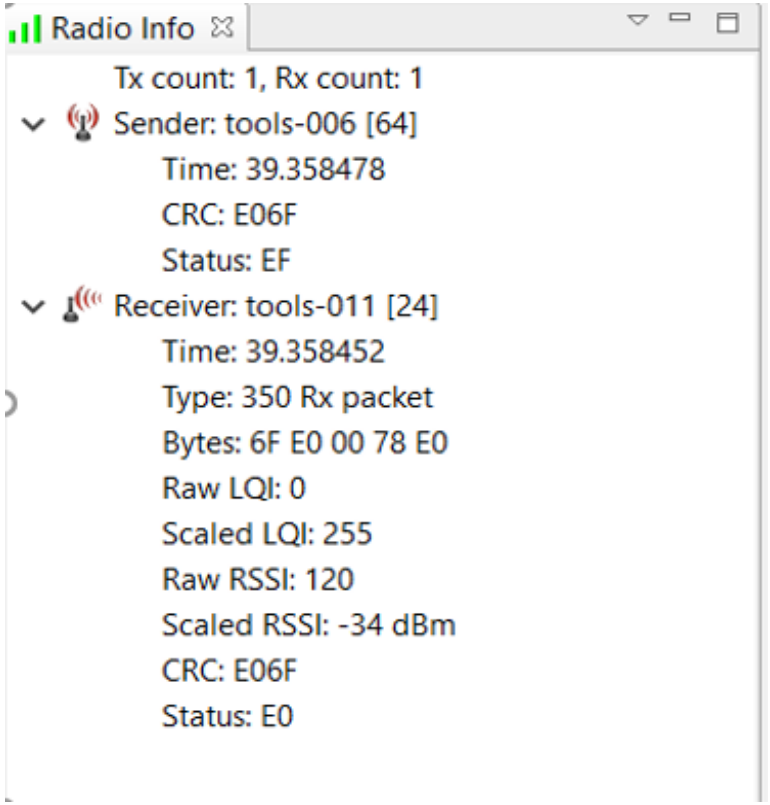


Differences between using PTI and Sniffer

- Advantages when capture packet trace using PTI directly
  - EZSP trace (super important to debug host/NCP issues)
  - API trace and debug prints(enable the debug extended library plugin)
  - Dropped/corrupted packets (could provide useful hints in debugging certain tricky problems)
  - Know what the radio sends/receives without extra work
  - Can capture from multiple nodes simultaneously

2.410207	Packet	Data Request
2.410763	Packet	802.15.4 Ack
2.411828	UART	slept for 955 ms

0.212627	Packet	ZCL: Toggle
0.214563	Packet	802.15.4 Ack
0.220005	APITrace	Message sent
0.220023	APITrace	Stack power down
1.215000	APITrace	Stack power up



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)

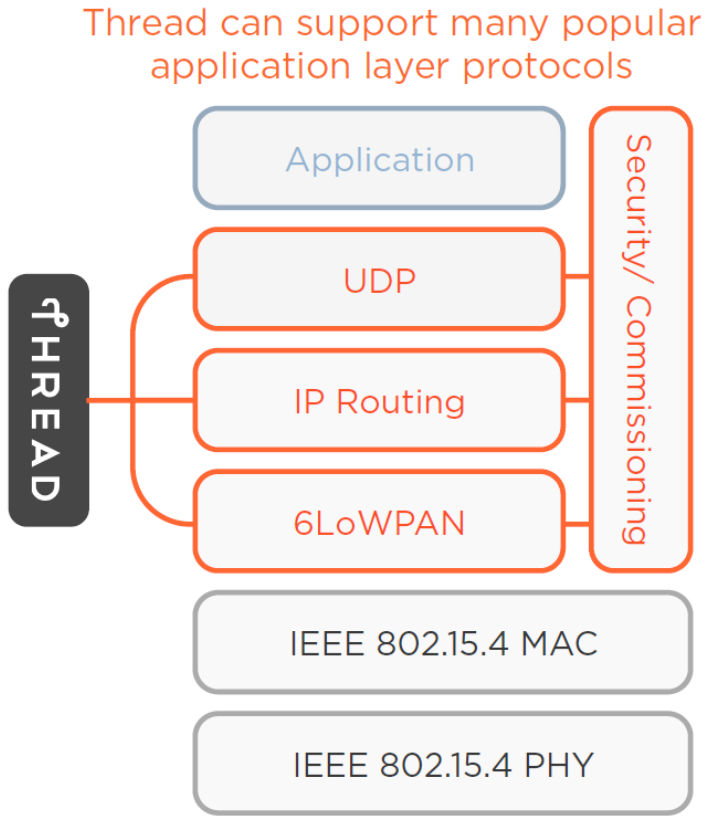
Mesh Module Portfolio




	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°C to +85°C	-40°C to +85°C	-40°C to +85°C	-40°C to +125°C	-40°C to +125°C
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

Thread Overview

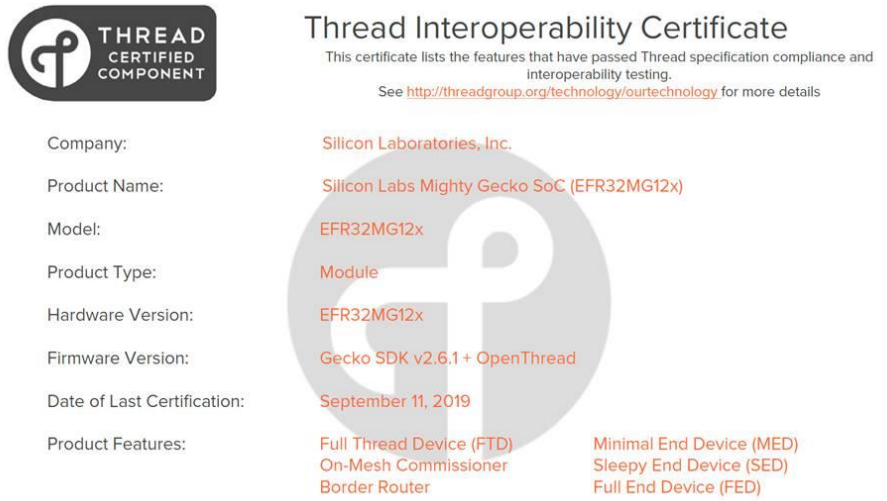
- IPv6-based, low-power, secure mesh networking protocol
- Built for the IoT – smart home, commercial buildings
- Intended for control and automation (250 kbps)
- Scalable to 250+ nodes per subnet
- Runs on existing 802.15.4 wireless SoCs



OpenThread Overview

OPENTHREAD
released by Google

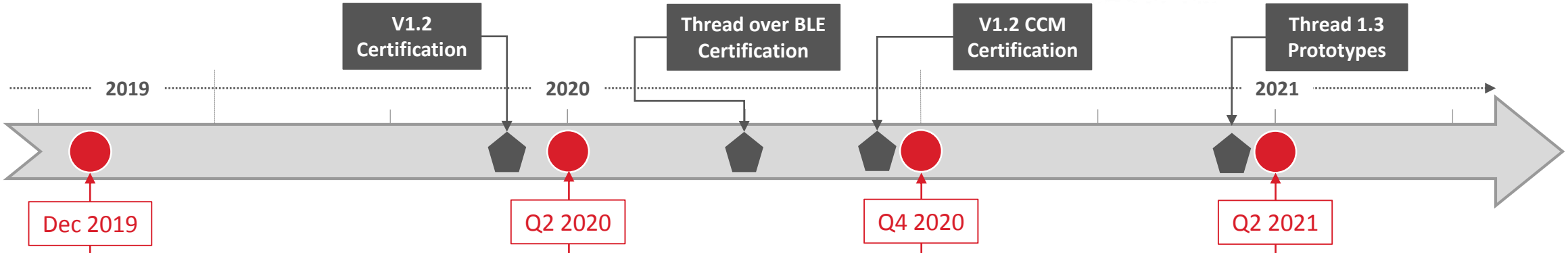
- OpenThread is an open-source implementation of the Thread networking protocol
- Thread 1.1 certification on EFR32 running OpenThread
- OpenThread GitHub example drivers
  - EFR32MG12
  - EFR32MG13
  - EFR32MG21
- Support for OpenThread Border Router
  - Raspberry Pi host
  - EFR32 NCP



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



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

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BY SILICON LABS

SEPTEMBER 9-10, 2020

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Thank You | Questions

Any query, please contact us or email to Denis.Chiang@silabs.com

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

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

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	EFR32MG1/14	EFR32MG22	EFR32MG13	EFR32MG21	EFR32MG12
			256kB Flash	512kB Flash	512kB Flash	768kB/1MB Flash	1MB Flash
			32kB RAM	32kB RAM	64kB RAM	96kB RAM	256kB RAM
Gateways	Single Protocol RCP Mode[6]	External Flash	?[1]	?[2]	✓	✓	✓
	Single Protocol NCP Mode	External Flash			✓	✓	✓
HomeKit/ OpenWeave Devices	Dynamic Multi-Protocol w/ BLE SoC Mode	External Flash			Future[5]	?[3]	✓
		Internal Flash					Future[5]

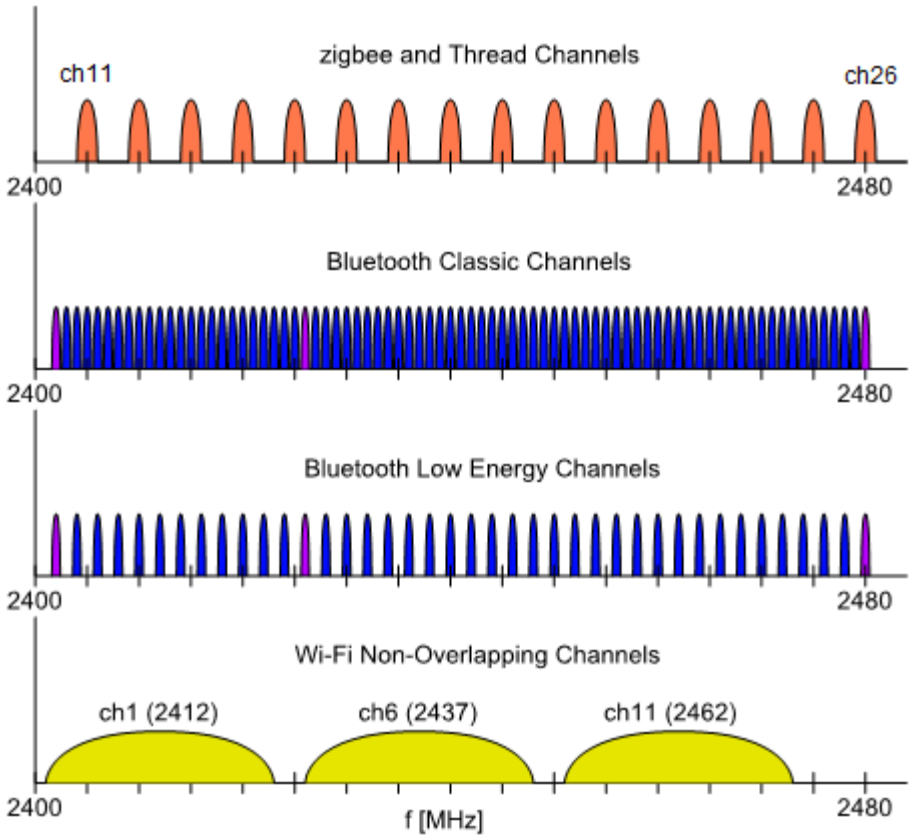
EFR32 MG12 is the recommended device today for HomeKit and OpenWeave SOCs due to the large Flash/RAM requirements
EM35xx devices are not supported
[1]MG1/14 are NRND and not supported
[2]MG22 support is not currently planned

[3]Little to no overhead in RAM
[4]Only MG12 and MG21 are certified today
[5]SoC support on 512kB parts is a goal but there are huge flash and RAM concerns today
[6]RCP mode should work but is still being validated

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

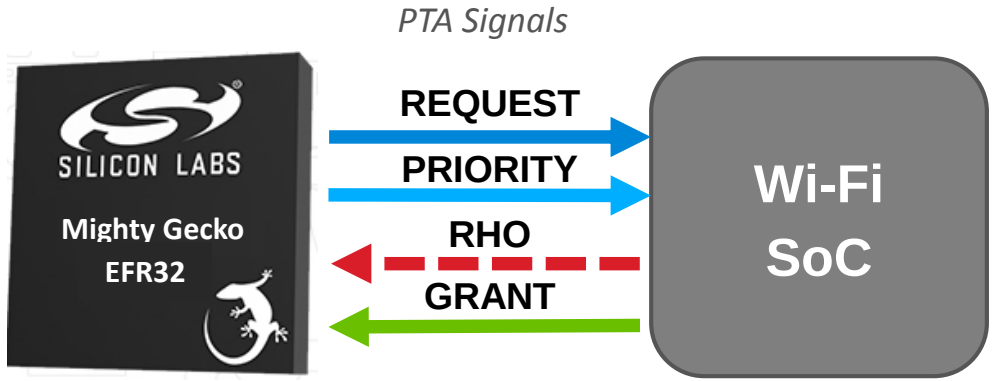
What Is Coexistence?

- Different technologies share the same band
  - Thread, Zigbee, Bluetooth, and Wi-Fi share 2.4 GHz
- Signals from one radio interfere with another
  - Look like unwanted noise to the other radios
- Interference can negatively impact RF performance
  - Increase retries
    - Results in increased latency and reduced bandwidth
    - Negatively effects battery life
  - May result in message failures
    - Desired signal is weaker than the noise



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



Mesh Networking Technology Comparison

	Bluetooth Mesh	Thread	Zigbee
Market Focus	Lighting and Home Automation	Commercial/Industrial	Lighting, Home Automation, Metering
Application Layer	Native Mesh Model	IP based Application Layers (e.g. Dotdot, OCF, Weave)	Comprehensive Zigbee Cluster Library (ZCL)
IPv6	No	Yes	No
Cloud Connectivity	Smartphone (temporary) Gateway	Border Router Gateway	Gateway
Ecosystems	None	Nest	Amazon, Phillips Hue, IKEA, Samsung SmartThings, Comcast, Deutsch Telekom, and others
Routing	Managed flooding	Full Routing	Full Routing
Additional Notes	Beaconing, Direct phone connectivity	-	Most mature

Mesh Protocols

Protocol	Z-Wave	zigbee	Bluetooth Mesh	THREAD	Bluetooth Low-Energy	Proprietary	Wi Fi
Existing Ecosystem	Broad	Broad	Limited	Limited	Broad	No	Broad
Interoperability	Full, Cross-Brand, Backward Compatible	By Application and Profile	Full, Cross-Brand, Backward Compatible	Defined by Application Layer	Full, Cross-Brand	N/A	Partial, not all features
Mature Smart Home Application Layer Command Class	Yes	Yes	Yes	No	No	No	No
Topology	Mesh Routing	Mesh Routing	Mesh Managed flooding	Mesh with Border Routers	Point to Point	Point to Point	Star
Band	Sub-GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	142-1050 MHz + 2.4 GHz dual-band	2.4GHz
IPv6	Yes/Z/IP	No	No	Yes	No	No	Yes
Battery-Friendly Energy Draw	Yes	Yes	Yes	Yes	Yes	By Application	Yes
Direct Node-to-Node Range (Indoor)*	50 -60 meters	40 -50 meters	30 -40 meters	40 -50 meters	20 -30 meters	By Application	50 meters
Maximum Number of Nodes Per Network**	100 verified, 232 theoretical	250 verified, 65,536 theoretical	1,000 verified, 32,767 theoretical	300 verified, >65,536 theoretical	7	By Application	250 theoretical
Automated Setup	Yes, SmartStart	Yes, proprietary implementation	Yes	No	No	No	Proprietary only
Silicon Labs Products	EFR32ZG/ ZGM	EFR32MG/ MGM	EFR32BG/ BGM	EFR32MG/ MGM	EFR32BG/ BGM	EFR32FG	WF200, WFM200S, WGM160P