# Presentation Will Begin Shortly

# 4:00

## MAY SESSIONS

| DATE | TIME | SESSION |
|---|---|---|
| THURS, MAY 1ST | 10 AM CT | Exploring Multiprotocol Wireless Techniques |
| TUES, MAY 13TH | 10 AM CT | Enabling AI/ML at the Edge — With or Without Connectivity |

## FUTURE DATES

| DATE | TIME |
|---|---|
| **JUNE:** THURS, JUNE 5TH & TUES, JUNE 17TH | 10 AM CT |



SILICON LABS

# Exploring Multiprotocol Wireless Techniques

2025 tech talks
WEBINAR SERIES

MULTIPROTOCOL

**Moderator – Matt Maupin**
**Presenter - Sagar Chinchani**

# Agenda

01 Why coexistence is inevitable?

02 Managing coexistence

03 Dynamic and Concurrent Multiprotocol

04 The details

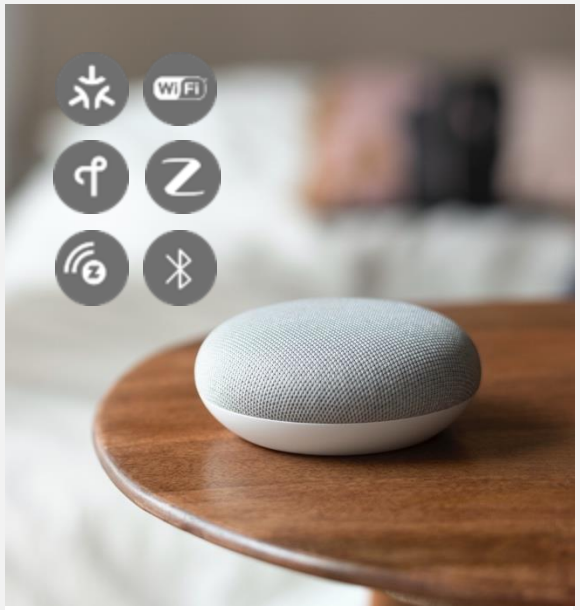
05 Architecture View

06 Silicon Labs Multiprotocol Offerings

# Why Coexistence is inevitable?

## CO-LOCATION

When deployed in the field, many products are co-located within the radio range




## ECOSYSTEM DEMAND

When serving an Ecosystem, a single product is expected to support multiple wireless protocols simultaneously

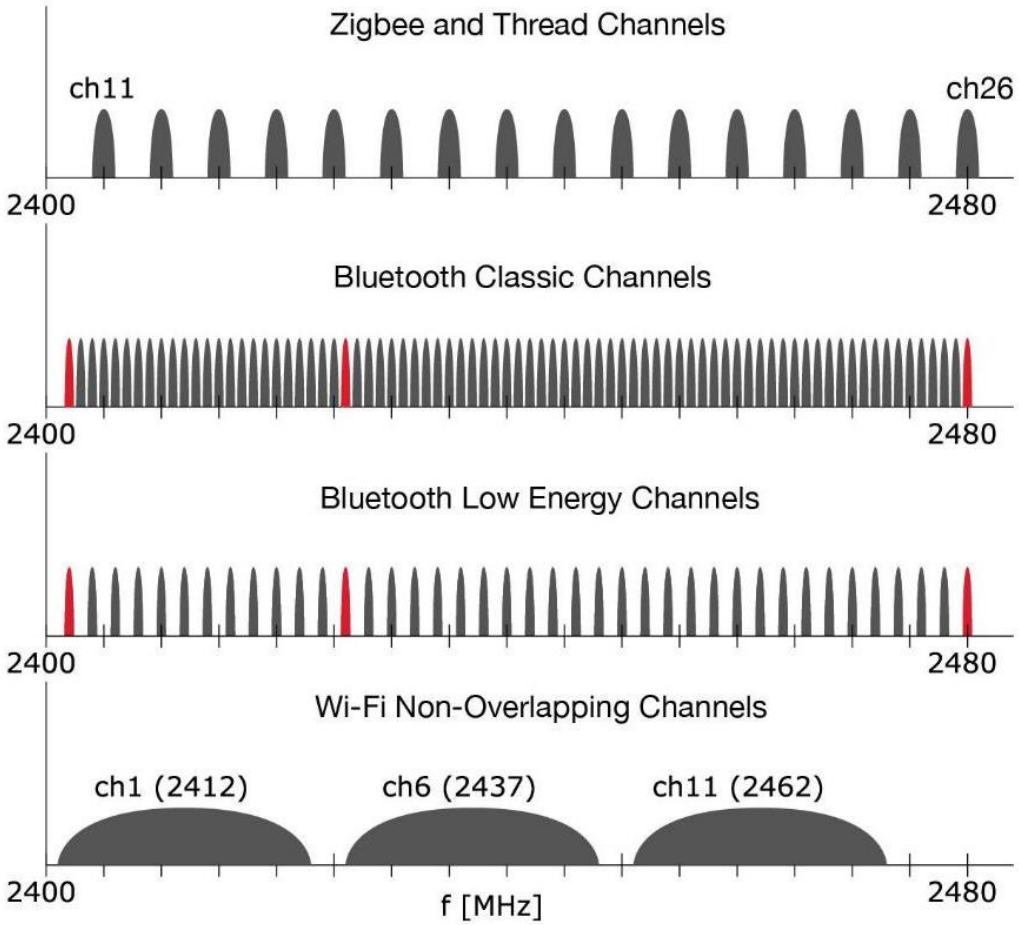
## PRODUCT VERSATILITY

To maximize market reach, a single product is typically positioned to serve multiple use cases


## PERFORMANCE

To gain a competitive edge, products are expected to provide superior performance via increased Tx power or higher bandwidth

# Challenges in the 2.4GHz ISM Band




- Multiple wireless protocols share the same 2.4GHz ISM Band: Wi-Fi, Bluetooth, and IEEE 802.15.4 (ZigBee, Thread)
- These wireless protocols have different modulation schemes, channel frequencies and bandwidth but overlap when co-located
- Signals from one wireless protocol look like unwanted noise for the other protocols

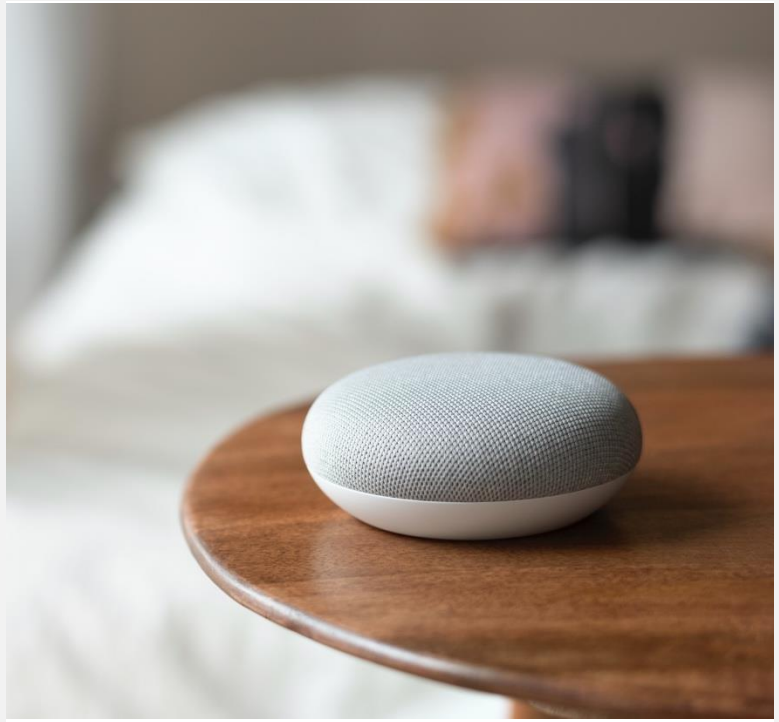
# Impact to IoT Devices

END DEVICE / ACCESSORY

**Delayed or missing packets**

**High rate of retries**

**Reduced battery life**



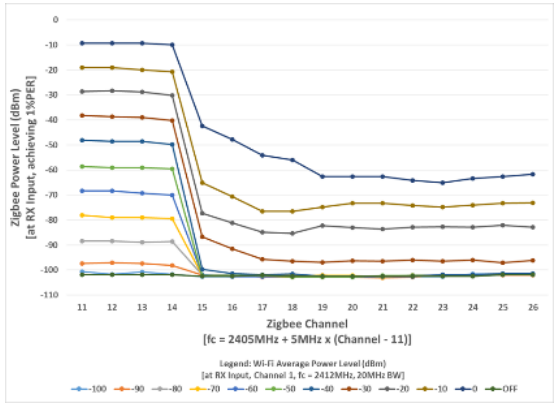
GATEWAY / HUBS

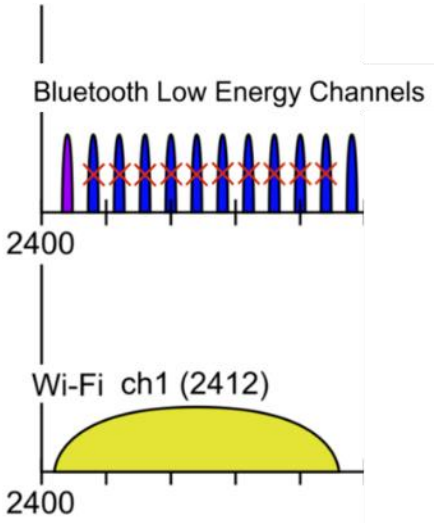
**Missing devices events**

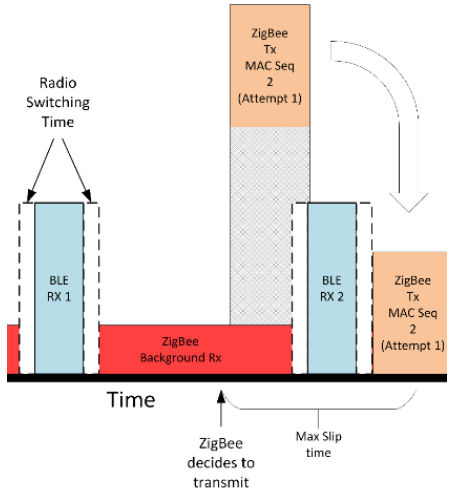
**Poor commands responsiveness**

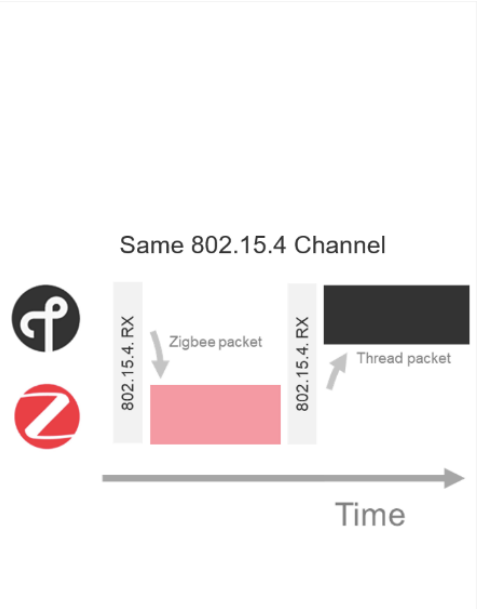
**Dropped connections**

# Managing Coexistence




## UNMANAGED COEX

**Customized run-time radio performance:**

Blocking & Selectivity

Adjacent channel rejection

Enhanced MAC features

## FREQUENCY PLANNING

**Bands Planning**

**Channels Planning**

**Channel Agility**

**Frequency Hopping**

## TIME SLICING

**Dynamic Multiprotocol**

**Concurrent Listening**

**Selective RX Diversity**

**Packet Traffic Arbitration**

## CONCURRENCY

**Concurrent Multiprotocol**

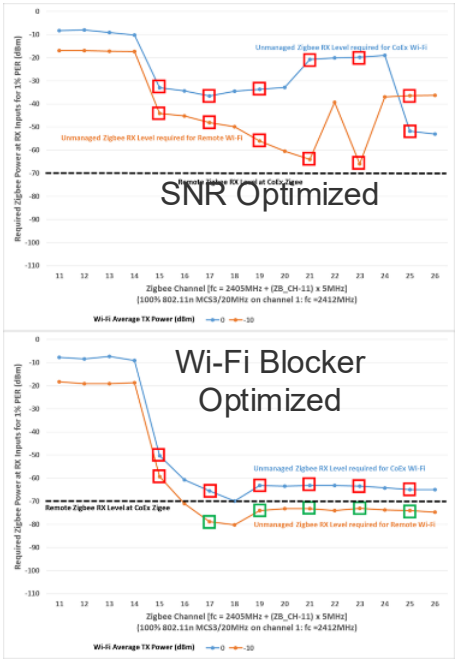
**Multi-chip solutions**

*** Multi-RF & Multi-Radio**



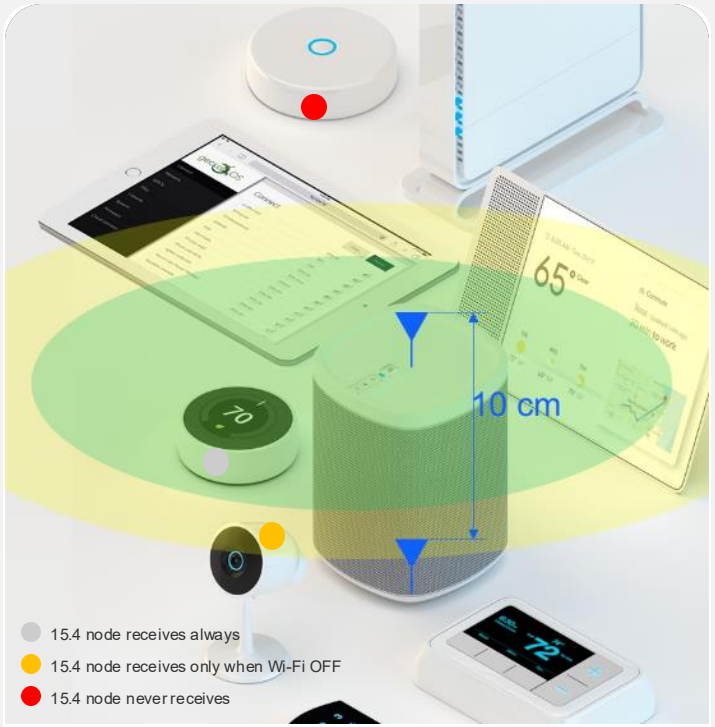

* Not available today, investigating for future products

# I. Unmanaged Coexistence



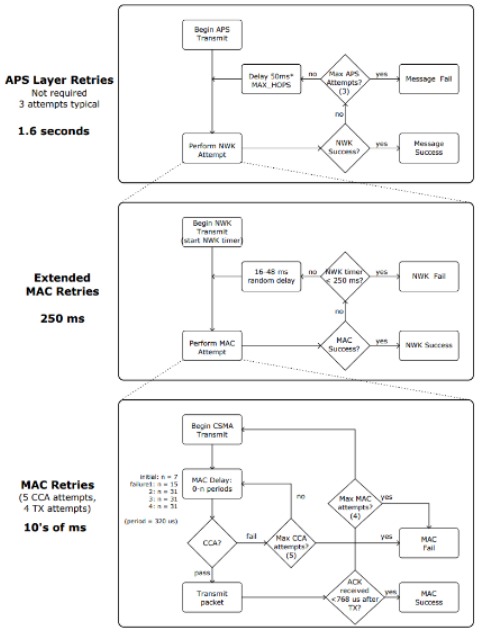

## BLOCKING & SELECTIVITY

- Identify Wi-Fi interferences w/ RSSI
- Detect 15.4 traffic with **Signal Identifier**
- Select SNR PHY vs BLK at run-time
- HW Peak Detectors and AGC loops to manage baseband signal distortion




## ADJACENT CHANNEL REJECTION

- Receive 15.4 traffic up to -45dBm Wi-Fi RSSI on non-overlapping channels
- Operate FEM LNAs in bypass mode
- Increase antenna isolation for GWs




## ENHANCED MAC FEATURES

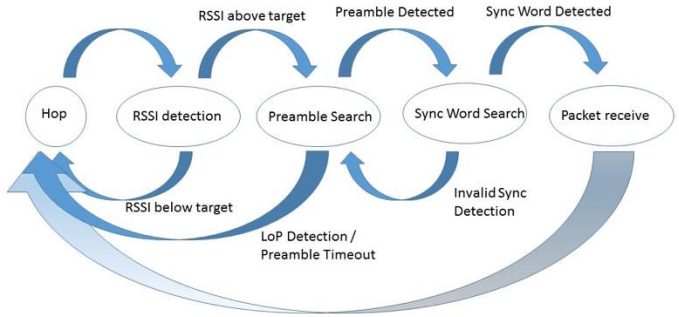
- Extended **MAC retries** algorithm
- Configurable CCA thresholds
- Configurable CCA timeouts

# II. Frequency Planning

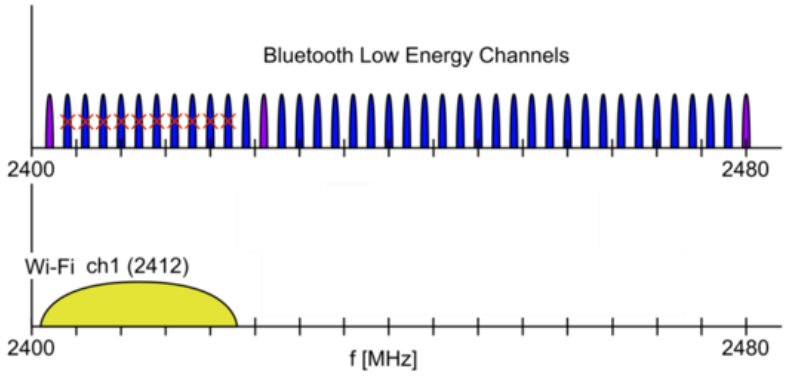
## METHODOLOGY

- **Bands Planning**
  - Connect high Wi-Fi traffic devices on 5GHz bands
  - Have life critical systems and long-range devices on <1GHz bands
- **Channel Planning**
  - Configure 15.4 on further away non-overlapping Wi-Fi Channels
  - Operate Wi-Fi with 20MHz Bandwidth
- **Channel Agility**
  - Protocols detect interferences and change channel for entire network
- **Frequency Hopping**
  - Protocols constantly change channels based on predefined patterns

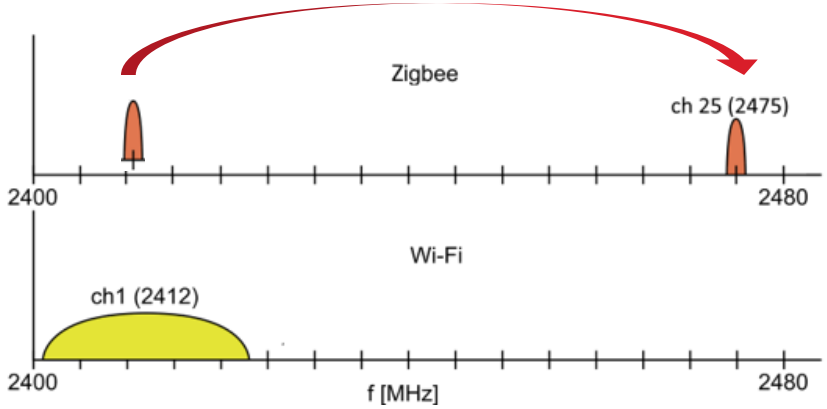
## FREQUENCY HOPPING



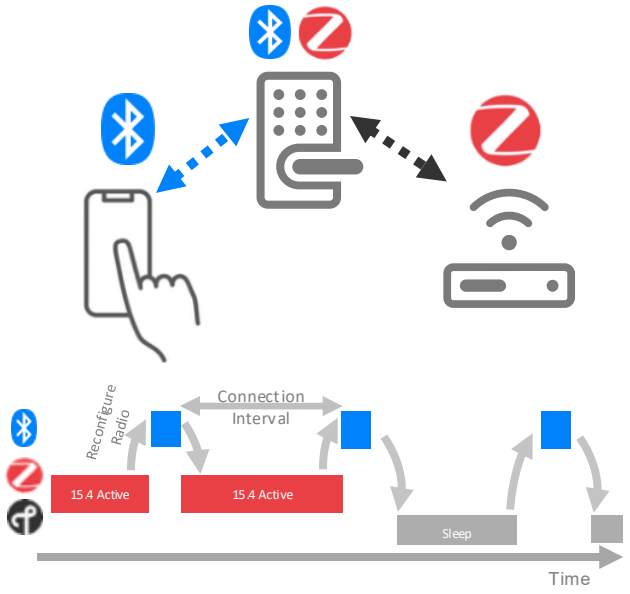

## BANDS AND CHANNELS PLANNING




## CHANNEL AGILITY

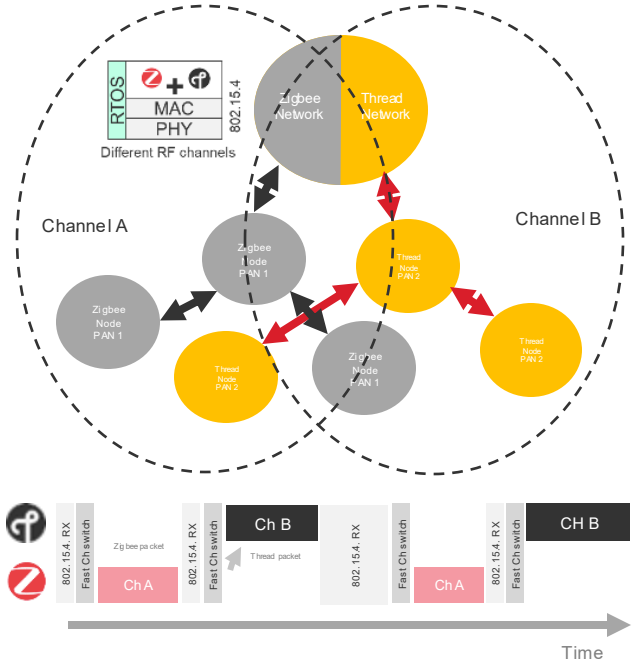


# III. Time Slicing



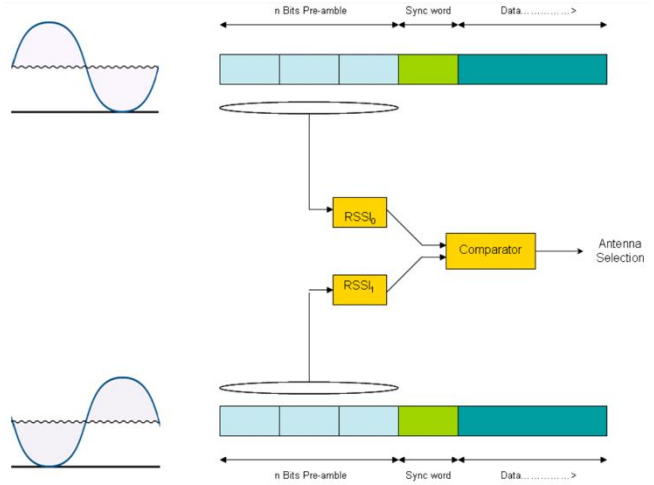

## DYNAMIC MULTIPROTOCOL

- Time-sliced operation of two protocols using an RTOS
- Advanced RAIL Priority Scheduler
- Enables direct phone connectivity




## CONCURRENT LISTENING

- Concurrent operation of Zigbee and Thread on different 15.4 channels
- HW based fast channel switching
- Scan 2 channels within 128us without packet losses




## SELECTIVE RX DIVERSITY

- Use two antennas ¼ wave apart
- Fast switching during preamble detection to select the best antenna
- Improve SNR and RSSI to reduce PER for multi-path and/or blocking

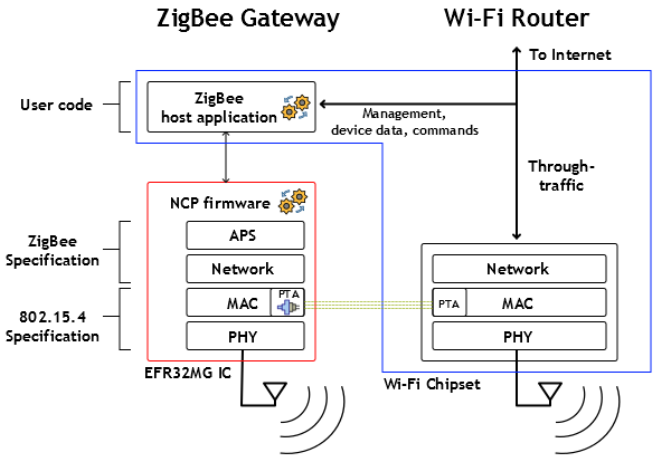
# III. Time Slicing - Packet Traffic Arbitration

## MODE OF OPERATION

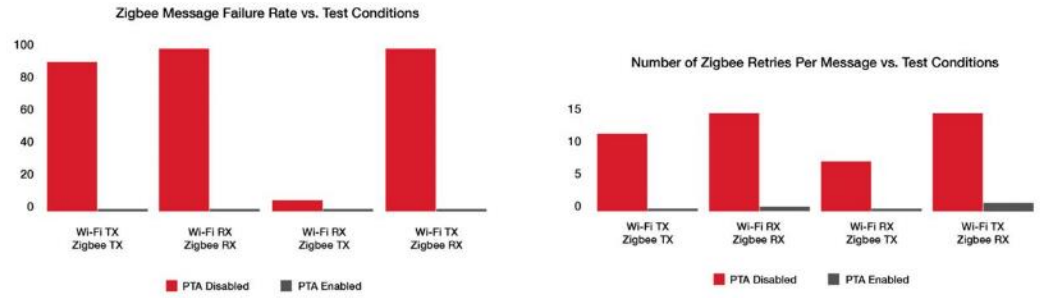
- Separate radio activity in time by coordinating protocols with PTA
- Multiple Wiring Options: 1-wire, 2-wire, 3-wire, 4-wire
- Multiple advanced PTA Strategies available at Silicon Labs:
  - REQUEST PWM, PRIORITY, Shared PTA, Radio Hold-off

- **PTA Basics:**
  1. IoT device asserts REQUEST and optionally PRIORITY
  2. Wi-Fi accepts request and asserts GRANT
  3. Wi-Fi device stops transmitting and IoT device can RX/TX
  4. When done IoT device de-asserts REQUEST and Wi-Fi releases GRANT

## WI-FI ENABLED IOT GATEWAYS / BR ARCHITECTURE

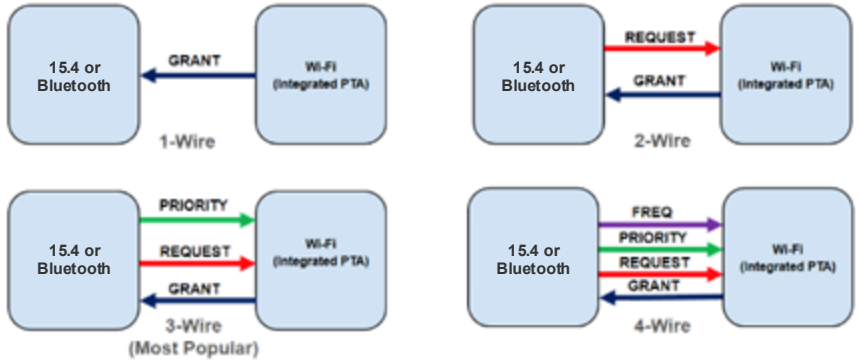



## NETWORK PERFORMANCE w/o VS w/ PTA ENABLED

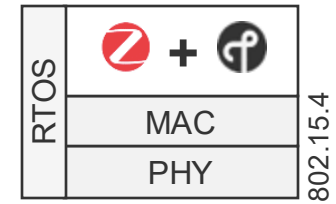



Increased performance with PTA enabled due to reduced retries and packet losses

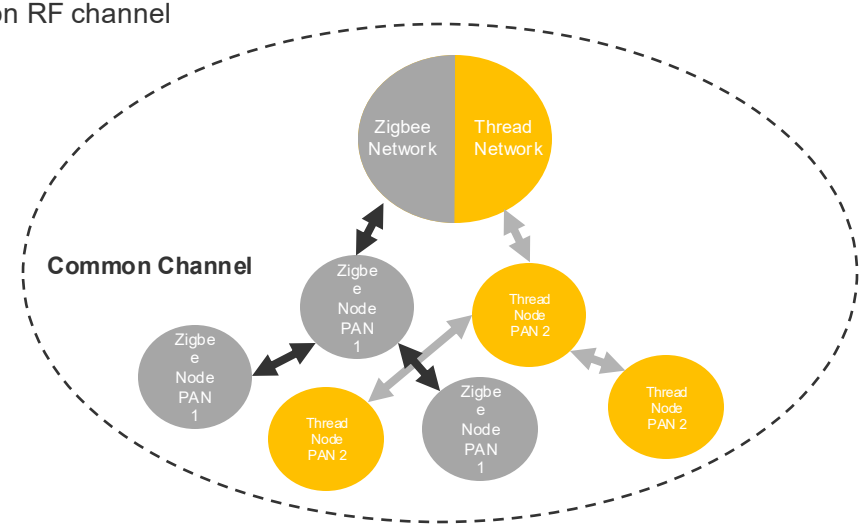
## PACKET TRAFFIC ARBITRATION WIRING OPTIONS

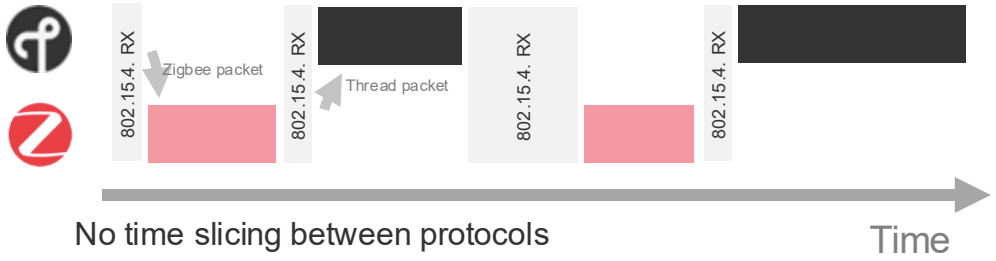


# IV. Concurrency




Common RF channel



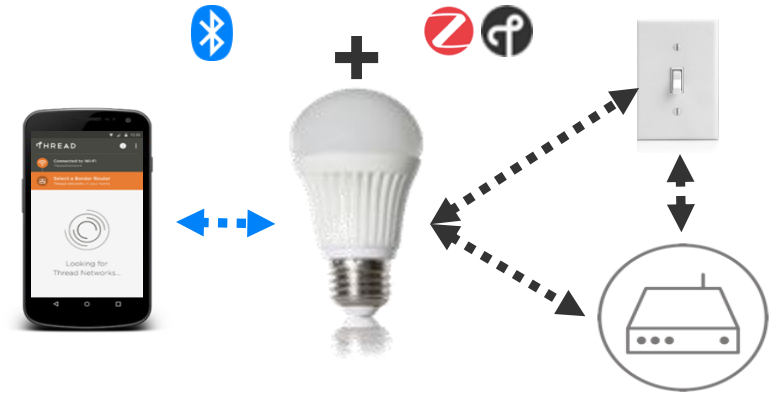




- **Concurrent Multiprotocol**
  - Simultaneous RX/TX operation of Zigbee and Thread on **the same channel** using common 802.15.4 PHY-MAC
  - RX frames differentiated by PAN IDs
  - Channel access managed by normal 802.15.4 CSMA-CA
  - Functional in SoC, NCP and RCP modes
- **Multi-chip Solutions**
  - Simultaneous RX / TX operation on different channels using one IC per protocol connected via UART / SPI
- *** Multi-RF & Multi-Radio ICs (Series-3: Everest)**
  - Simultaneous RX in a single IC using two RF AFEs and one or two modems
  - TX is usually still time sliced due to interferences
- *** MIMO RX Diversity (MRC)**
  - Allows multiplexing wireless medium in space to reduce multi-path fading and increase RX sensitivity
  - Requires two RF AFEs and one or two modems

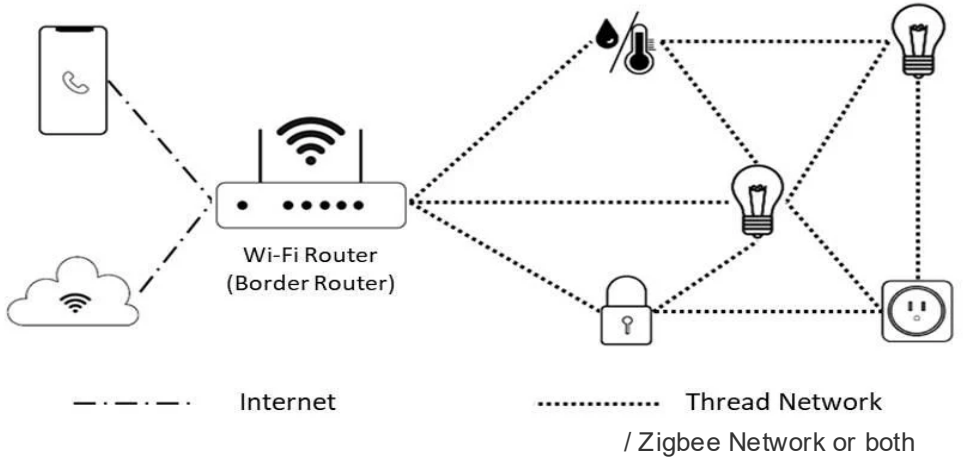
* Not available today, investigating for future products

# Common DMP and CMP use cases

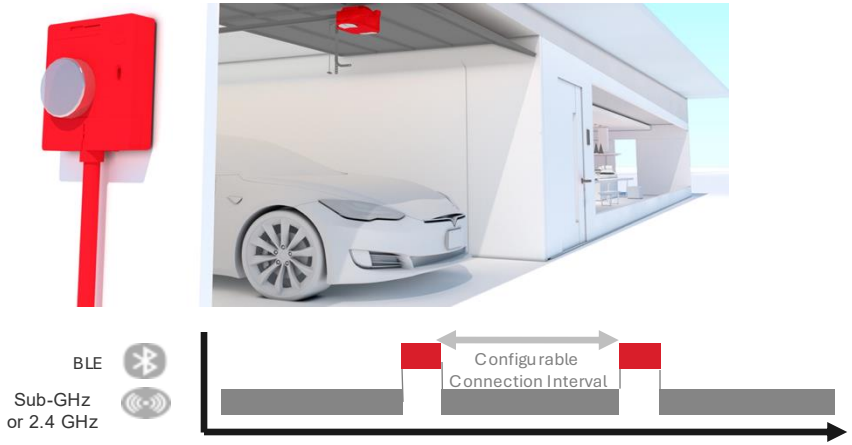
## DMP FOR LIGHTING SOLUTIONS



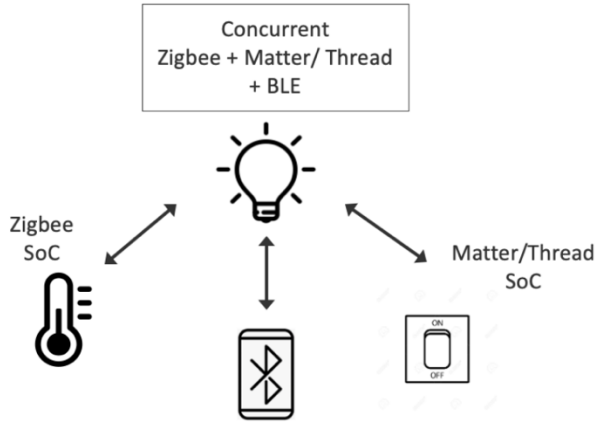
## MULTIPROTOCOL GATEWAYS



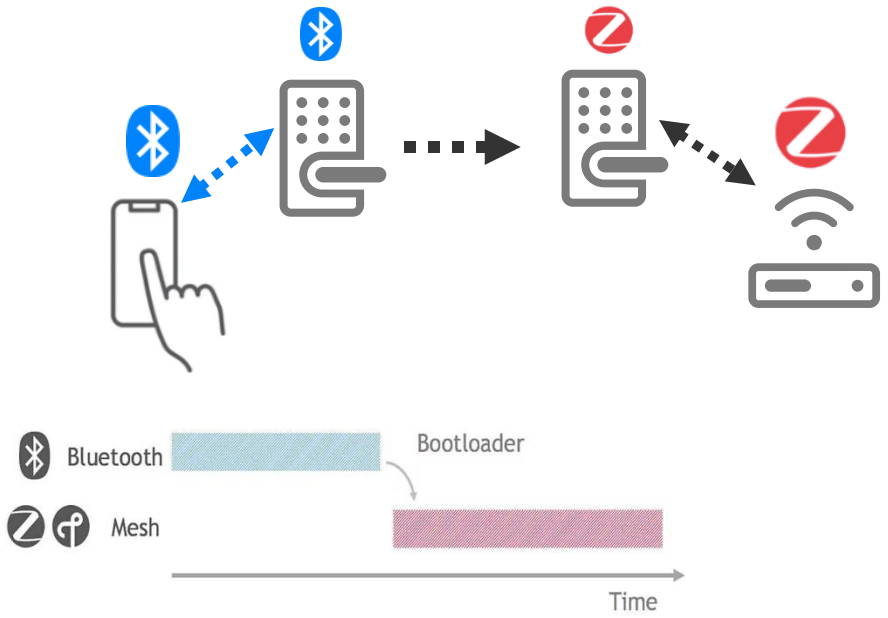

## MULTIPROTOCOL SUB-GHZ IOT DEVICES




## MULTIPROTOCOL LIGHTING SOLUTIONS

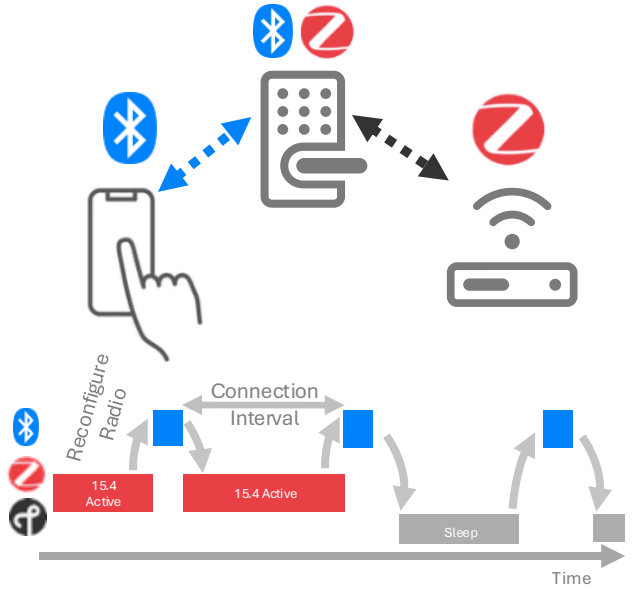


# Switched and Dynamic Multiprotocol (SMP v/s DMP)




## SWITCHED MULTIPROTOCOL

- Bootload the firmware image from one protocol stack to other
- Helps to update devices in the field to changing market needs
- Switching time is usually long (~hundreds of ms)




## DYNAMIC MULTIPROTOCOL

- Time-sliced operation of two protocols using an RTOS
- Advanced RAIL Priority Scheduler
- Enables direct phone connectivity



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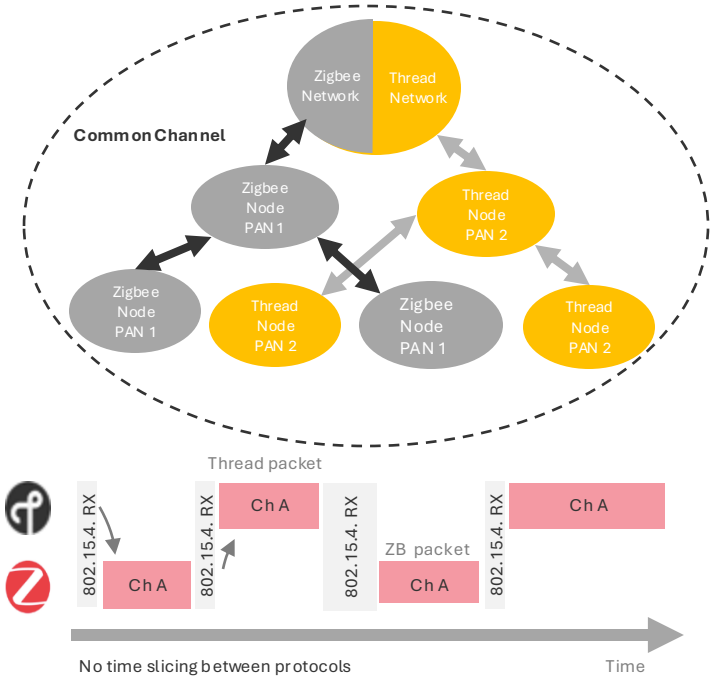
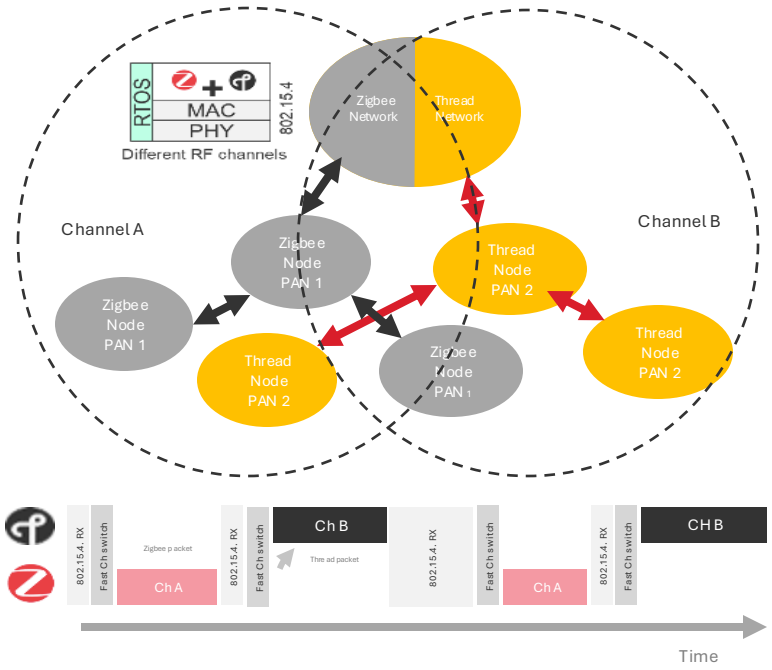
# Concurrent Multiprotocol (CMP) & Concurrent Listening




## CONCURRENT MULTIPROTOCOL

- Simultaneous TX/RX operation of Zigbee and Thread on **the same 15.4 channel**
- RX frames differentiated by PAN IDs
- Channel access managed by normal 802.15.4 CSMA-CA




## CONCURRENT LISTENING

- Concurrent operation of Zigbee and Thread on different 15.4 channels
- HW based fast channel switching
- Scan 2 channels within 128us without packet losses



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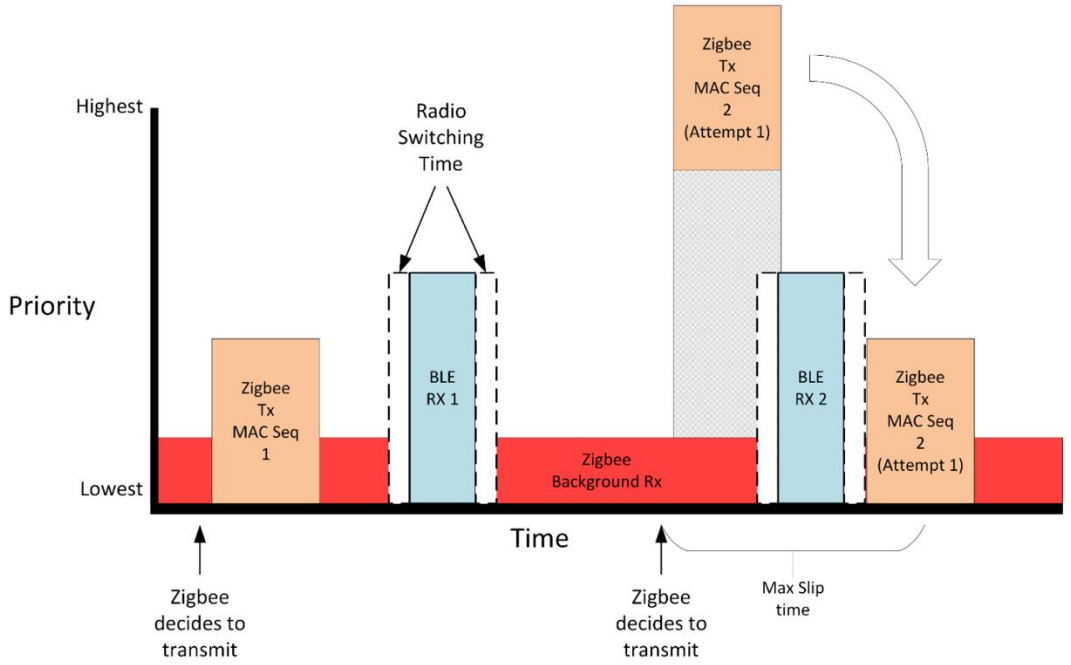
# Dynamic Multiprotocol (DMP)

**Operation:**

- Radio time-sliced to reliably manage multiple protocols
- Used with BLE, in conjunction with a different protocol
- Managed by RAIL Scheduler
- Uses MP RAIL library and RTOS
- Typically, BLE operations get a higher priority but is configurable
- Radio switching time in the order of hundreds of $\mu$s

**Common Use cases:**

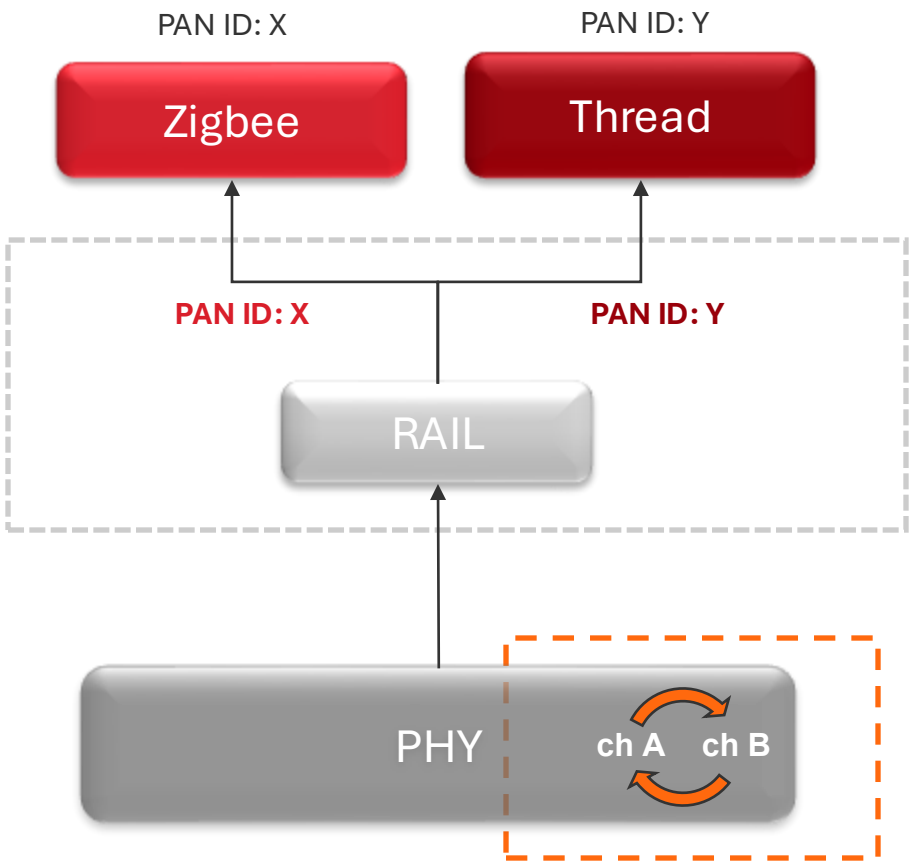
- Commissioning / device on-boarding
- Network diagnostics




Example: DMP BLE + Zigbee

- **Radio operation priorities could be reconfigured based on use case (See UG305)**
- **Can be enabled or disabled on demand**

# Concurrent Multiprotocol terminologies




**Concurrent Multiprotocol (CMP) :**

Ability of Platform to support two 15.4 protocol stacks (such as Zigbee & Thread)

- **Forms basis of CMP.**
- **Can support Zigbee + Zigbee / OT + OT, but with distinct PAN IDs**

**MultiPAN support:**

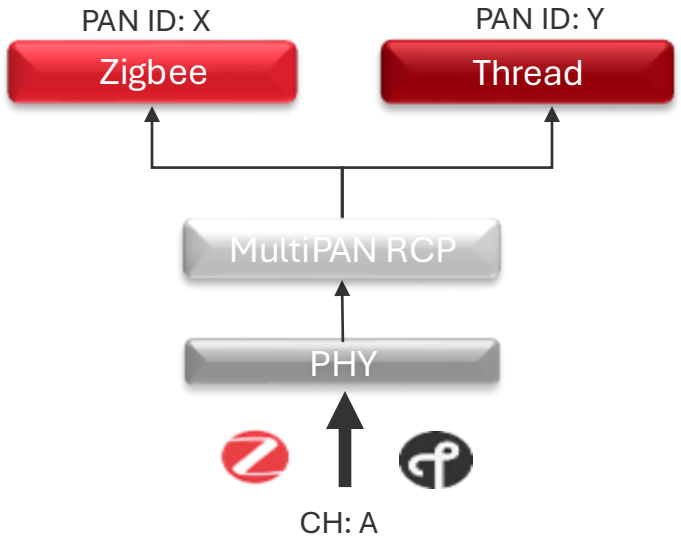
Ability of Platform RAIL to filter packets based on PAN ID.

**Concurrent Listening (aka FCS - Fast Channel switching):**

Ability of the platform PHY to quickly switch & detect 802.15.4 preambles on separate RF channels using a single radio

# Concurrent Multiprotocol (CMP): Series 1 vs Series 2

## SERIES 1

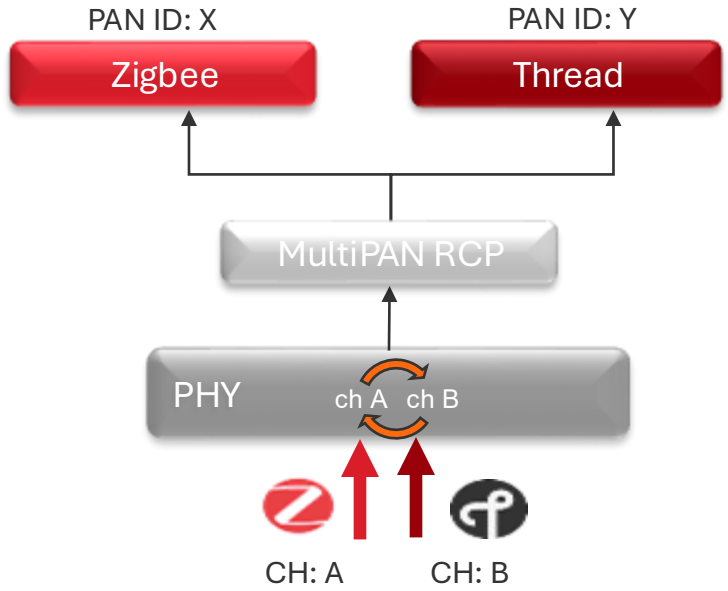



- Enables Zigbee and Thread support using a single radio, but with both operating on the **same** 15.4 channel
- Relies on the **MultiPAN feature**
- Absolute Concurrency

**Limited by Specification, where Thread could choose to switch the operating channel ☹**

**Enables Ecosystem diversity**

## SERIES 2




- Enables Zigbee and Thread support using a single radio, and with both operating on **separate** 15.4 channels
- Uses **Concurrent Listening** along with **Multi-PAN feature** to support operation on two 15.4 channels.

# Concurrent Listening (aka Fast Channel Switching) on Series 2

**Concurrent Listening:**

- Uses **RX antenna diversity hardware block** with **synth reloading** to switch extremely rapidly between two 15.4 channels, after every ~ 48 µsec
- If a preamble is detected, stays on the channel until completion of the packet.
- Successfully detects a 15.4 packet by listening to at least 2 out of the 8 preamble symbols (32 µs out of 128 µs) on each RF channel.

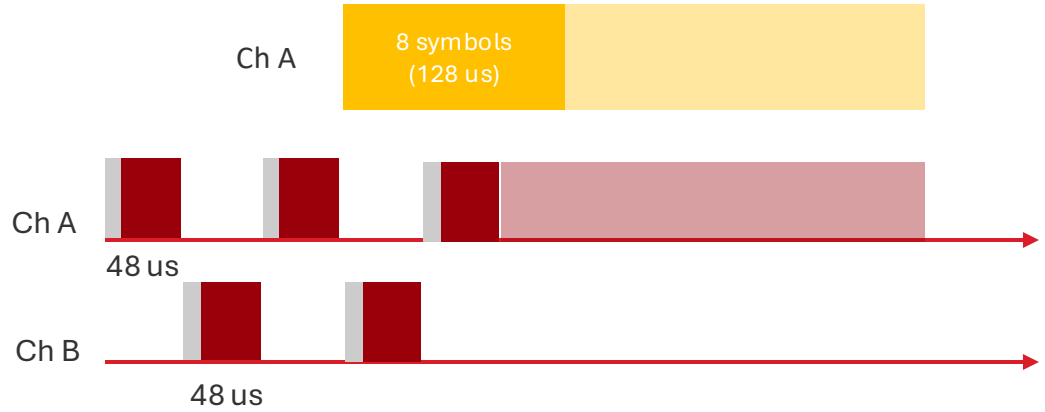
**Limitations:**

- Slight degradation in Rx sensitivity
- Antenna diversity not available.

**Supported Parts & Architecture**

- Currently supported on xG21 and xG24, with Zigbee and Thread operating in RCP mode, and xG26 in SoC mode.

**Time sliced in principle yet concurrent as radio succeeds to monitor traffic on two 15.4 channels simultaneously, unlike DMP**

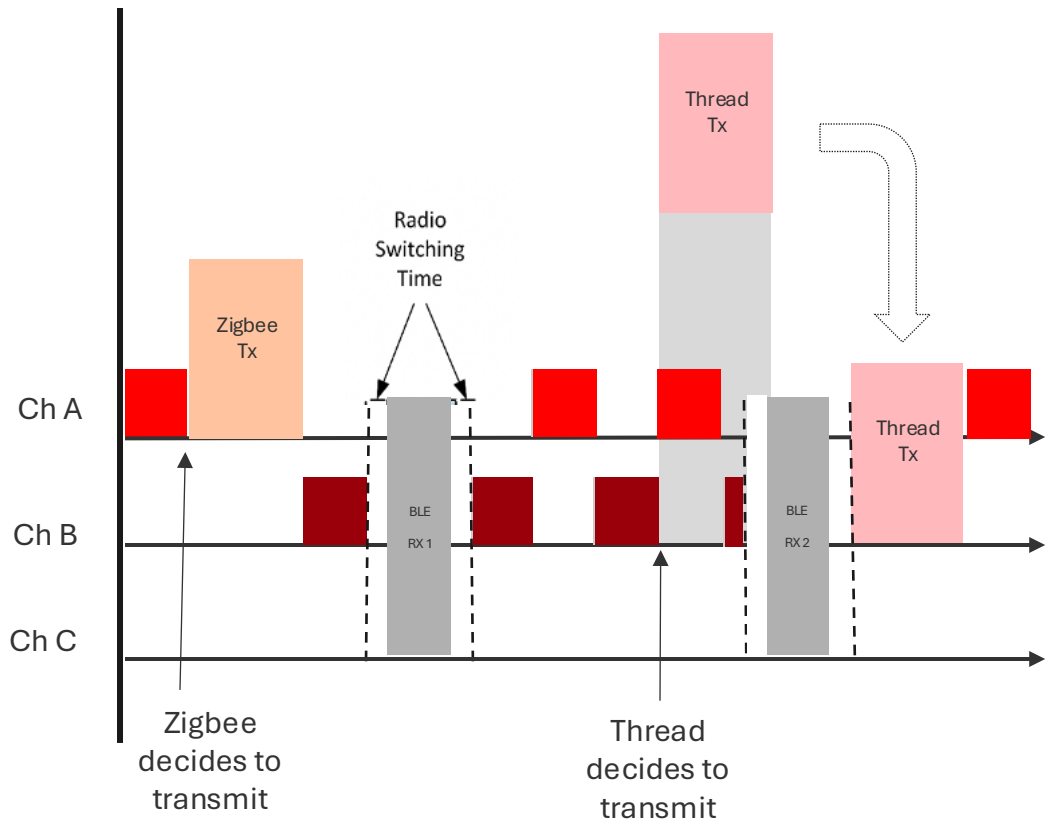

- Load RF synth for channel A & settle (~16 us)
- Listen for preamble (2 symbols, ~32us)
- Load RF synth for channel B and settle (~16 us)
- Listen for preamble (~32us)
- Repeat until preamble detected

# Dynamic Multiprotocol (DMP BLE) with CMP (Zigbee + Thread)

**DMP BLE + CMP:**

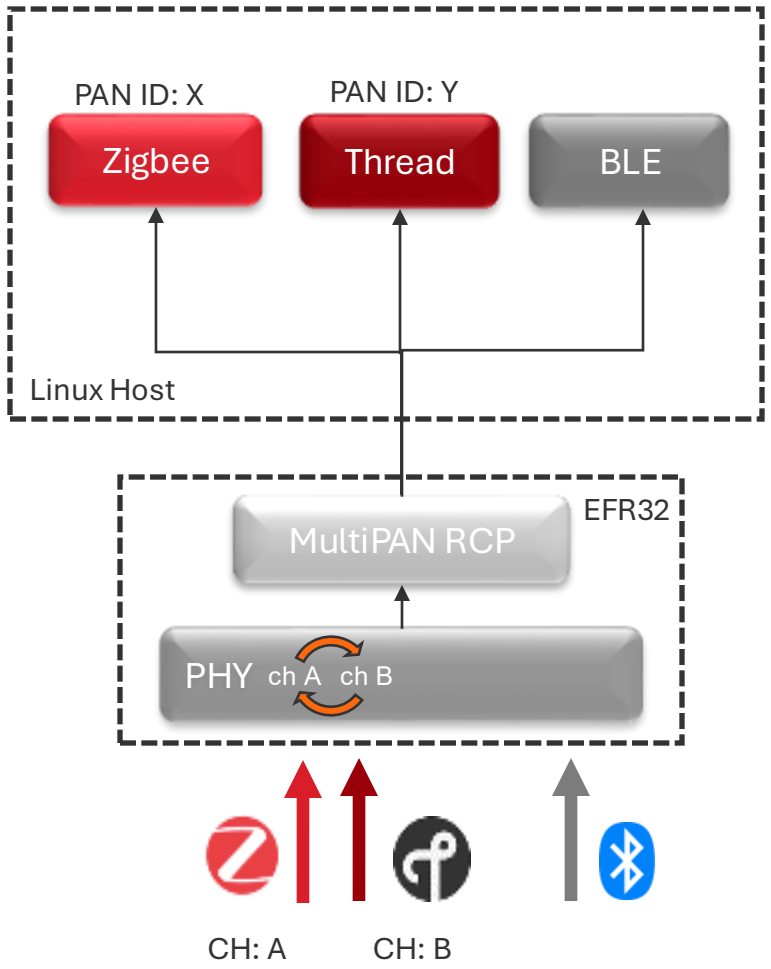
- Extension of BLE DMP with single protocol case
- BLE continues to operate in time-sliced DMP mode, interrupting CMP (Zigbee + Thread) as needed.
- With Concurrent Listening enabled (for Zigbee and Thread to operate on separate channels), the radio rapidly switches between the two 15.4 channels, with switching to BLE channel as configured.
- Does not impact BLE performance

- **Extends capability to support up to 3 protocols**
- **Supports all BLE DMP use cases supported in the single protocol case**




Example: DMP BLE + CMP (Zigbee + Thread)

# DMP BLE + CMP (Zigbee + OpenThread) in RCP mode



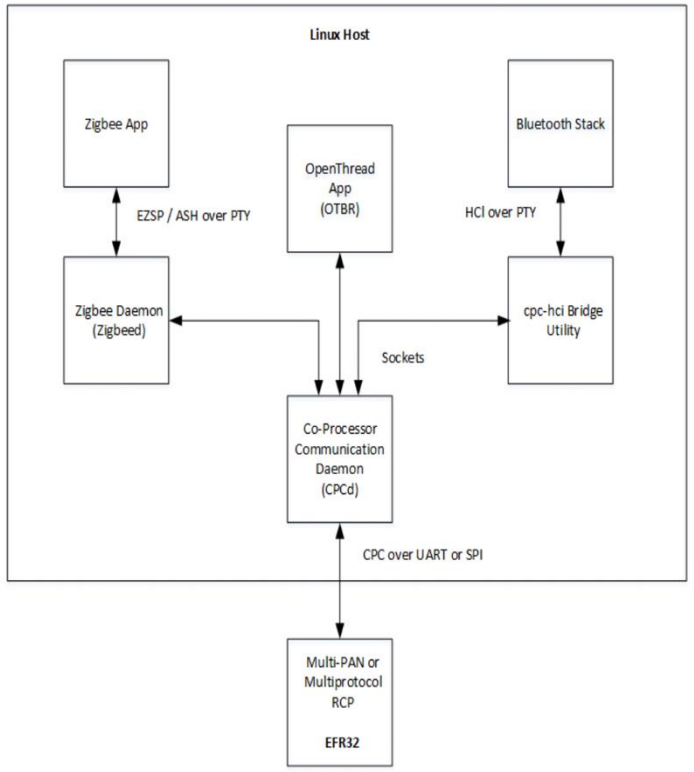
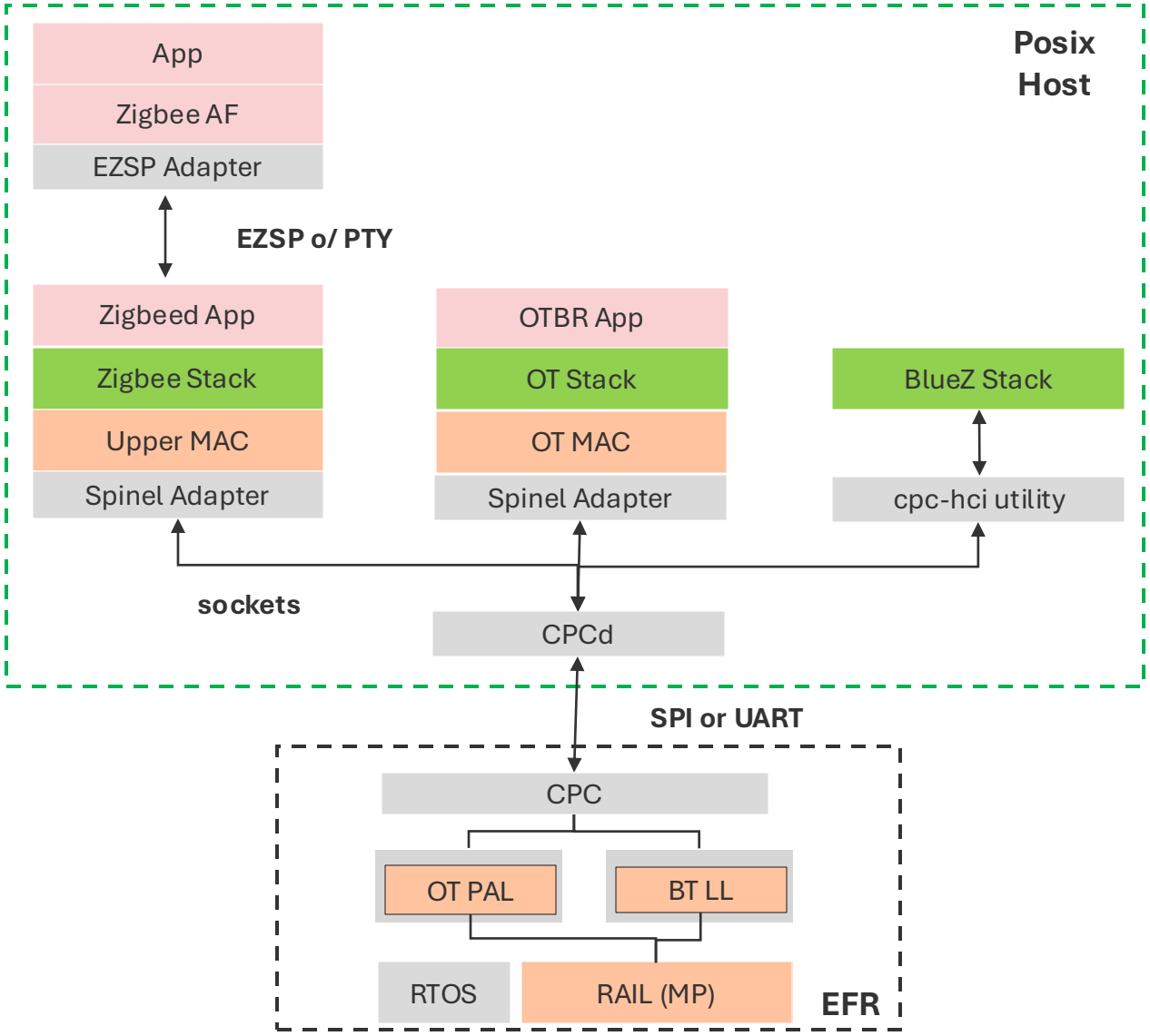




Figure 1-1. System Architecture for the Multiprotocol RCP

**Support enabled in RCP mode**
- **Low memory requirements**
- **Lowers cost**

- **Zigbeed** - A Linux daemon that runs the Zigbee stack & sends and receives Spinel messages to CPCd over a socket
- A **Zigbee host application** that communicates with Zigbeed using EZSP / ASH over a virtual serial port
- An **OT host application** (like OTBR) which includes the OT stack & which connects to CPCd over a socket
- The **BlueZ BT stack**, which communicates with the Bluetooth Controller on the RCP via the Host Controller Interface (HCI) protocol.
- **CPCd** - A Linux host process that communicates with the co-processor over a UART or SPI
- **Multi-PAN RCP w/ Conc. Listening & DMP** enabled on the EFR32

# DMP BLE + CMP (Zigbee + OpenThread) in RCP mode [Architecture view]

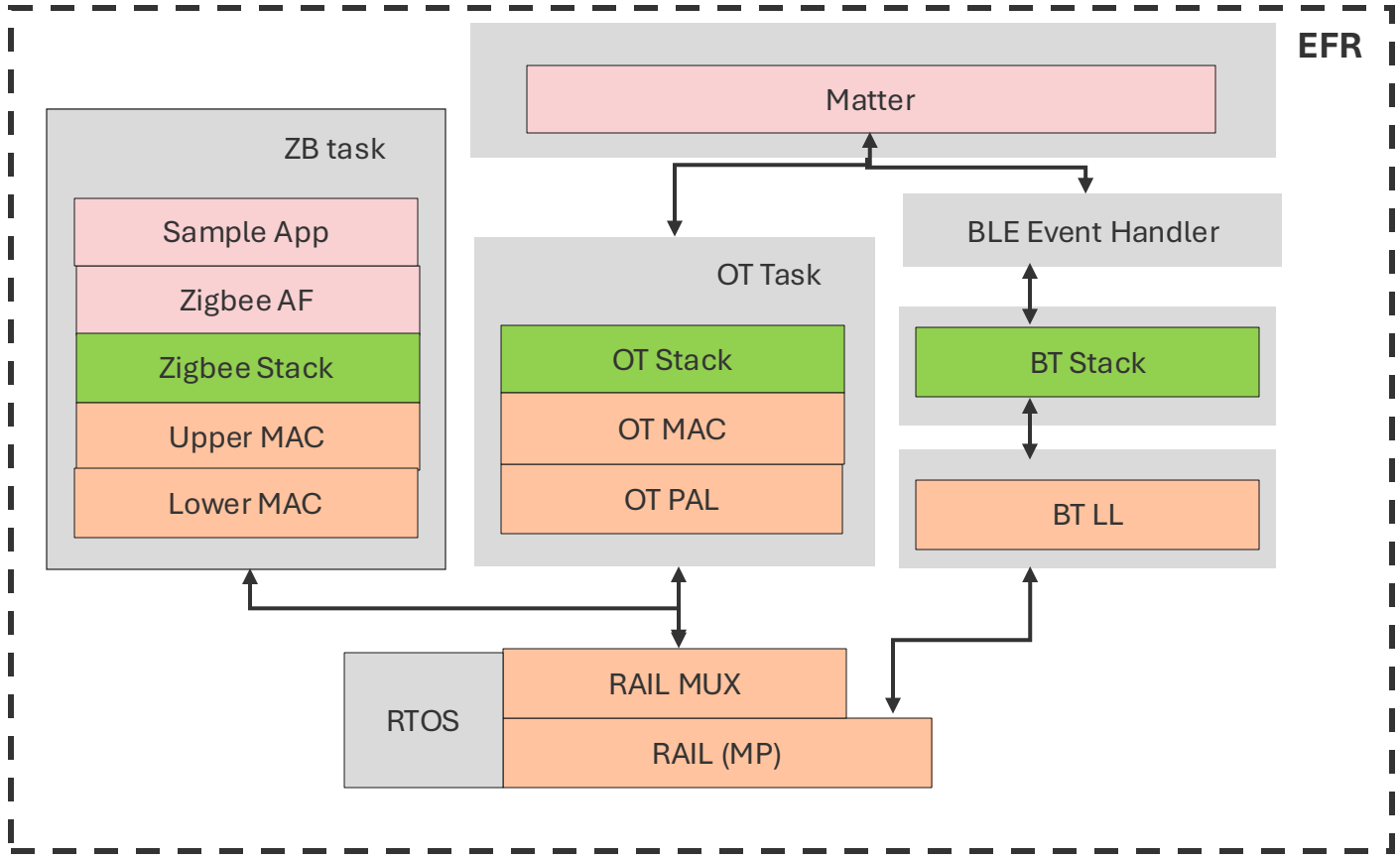



- Zigbee & Thread can operate on:
  - Same ch. (no time slicing) or
  - Different ch. (via concurrent listening)
- Uses MultiPAN feature for filtering 15.4
- Bluetooth operates in DMP mode
- RCP has a flash footprint (~250K)
- RCP App uses RTOS

**Common Platform components such as:**
- **Wi-Fi coexistence**
- **RTOS**
- **NVM3 & Memory manager**

**Enable seamless integration of platform features critical to the application**

# DMP BLE + CMP (Zigbee + OpenThread) in SoC mode [Architecture view]




- Combines Zigbee + Matter/Thread
- Zigbee & Matter/Thread can operate on same or different channels
- Bluetooth operates in DMP mode
- Uses RTOS
- Supported on xG26, and upcoming Series-3 parts.

# BLE + 15.4 Multiprotocol offering

| Targeted Applications | Primary Arch | Technology / Stack | | | | Operation Mode | xG21 | xG24 | xG26 | xG27 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | BLE | Zigbee | OT | Matter | | | | | |
| **Zigbee Lights, Switches, Sensors** | SoC | ✓ | ✓ | | | DMP BLE + ZB | ✓ | ✓ | ✓* | ✓ |
| **Thread Sensors** | SoC | ✓ | | ✓ | | DMP BLE + OT | ✓ | ✓ | ✓* | |
| **Matter Lights, Switches, Sensors** | SoC | ✓ | | ✓ | ✓ | DMP BLE + Matter/OT | | ✓ | ✓ | |
| **Conc. Matter + Zigbee Lights** | SoC | ✓ | ✓ | ✓ | ✓ | CMP (ZB + Matter/OT) | | | ✓ | |
| **Gateways, EAP, Appliances, Hubs & Panels** | RCP | **BLE LL** | **LMAC** | **LMAC** | **Matter capable** | DMP BLE + CMP 15.4 | ✓ | ✓ | ✓* | |
| | NCP | | | ✓ | | OT NCP | ✓ | ✓ | ✓* | |
| | NCP | ✓ | ✓ | | | DMP BLE + ZB | | ✓ | ✓* | |
| | NCP RCP | | ✓ | **LMAC** | | CMP (ZB NCP + OT RCP) | | ✓ | ✓* | |

✓* Supported but with Memory spec exceeding (typical) application requirements.

# Resources

- Multiprotocol Web page
- Concurrent Multiprotocol Blog
- UG305 Dynamic Multiprotocol User's Guide
- Docs.silab.com Multiprotocol
- UG103.16: Multiprotocol Fundamentals

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# Thank you

## MAY SESSIONS

| DATE | TIME | SESSION |
|---|---|---|
| THURS, MAY 1ST | 10 AM CT | Exploring Multiprotocol Wireless Techniques |
| TUES, MAY 13TH | 10 AM CT | Enabling AI/ML at the Edge — With or Without Connectivity |

## FUTURE DATES

| DATE | TIME |
|---|---|
| **JUNE:** THURS, JUNE 5TH & TUES, JUNE 17TH | 10 AM CT |