



**SILICON LABS**

CONNECTED INTELLIGENCE

# 探索多协议无线技术的最新进展

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2025

**tech talks**

WEBINAR SERIES



**MULTIPROTOCOL**

# 议程大纲

**01** 为什么协议共存是不可或缺的？

**02** 如何管理协议共存？

**03** 动态多协议和并发多协议

**04** 深入了解技术

**05** 架构视图

**06** 芯科科技多协议解决方案

# 为什么协议共存是不可或缺的？



## CO-LOCATION

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



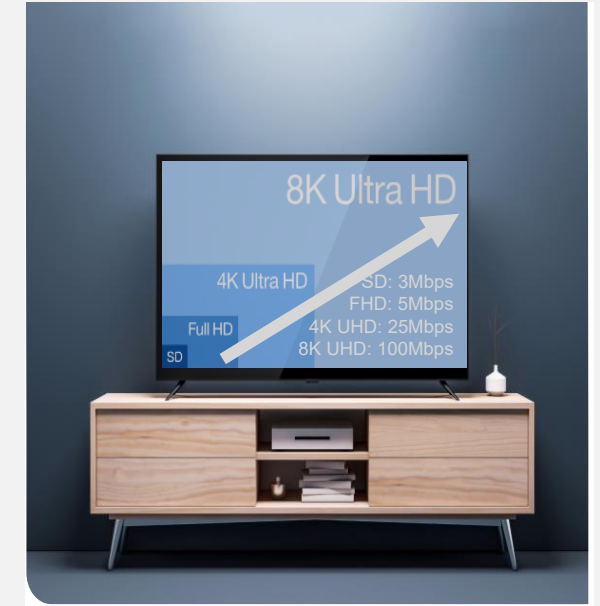
## ECOSYSTEM DEMAND

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



## PRODUCT VERSATILITY

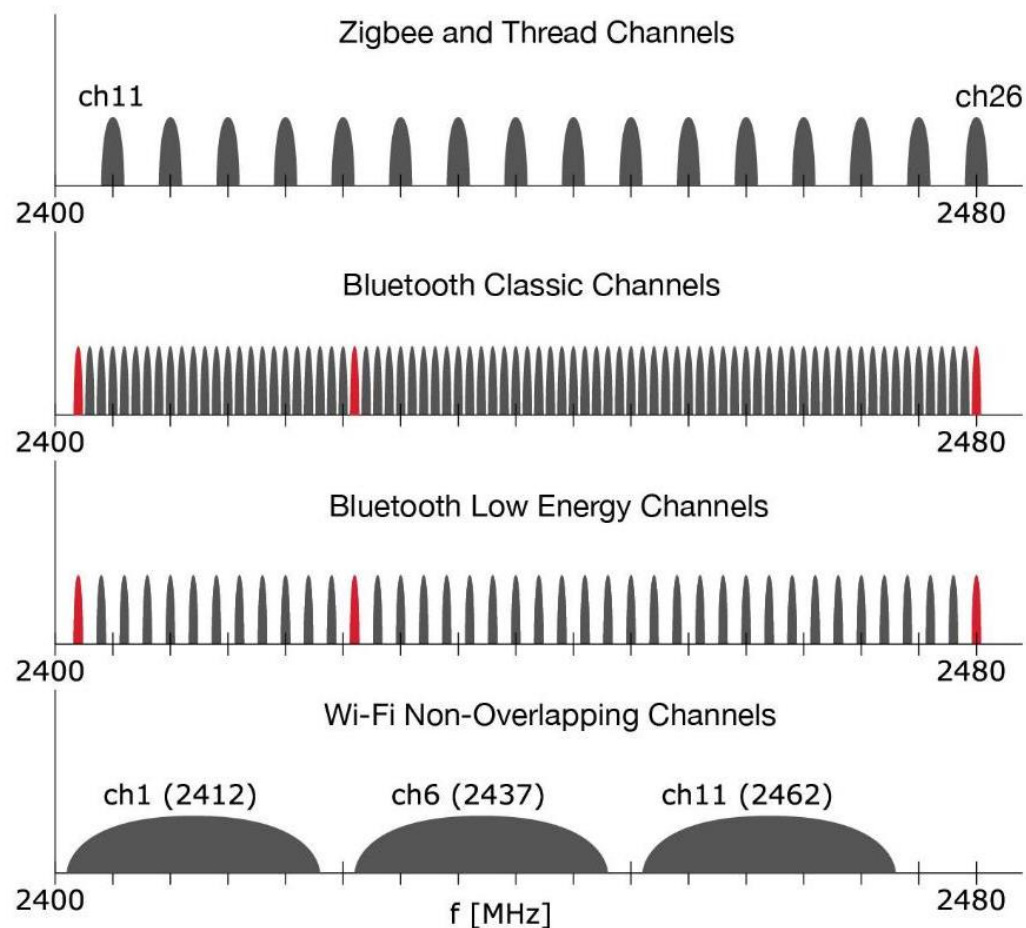
To maximize market reach, a single product is typically positioned to serve multiple use cases



## PERFORMANCE

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

## 2.4GHz ISM频段的挑战



- 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



# 对物联网设备的影响



## END DEVICE / ACCESSORY

**Delayed or missing packets**

**High rate of retries**

**Reduced battery life**



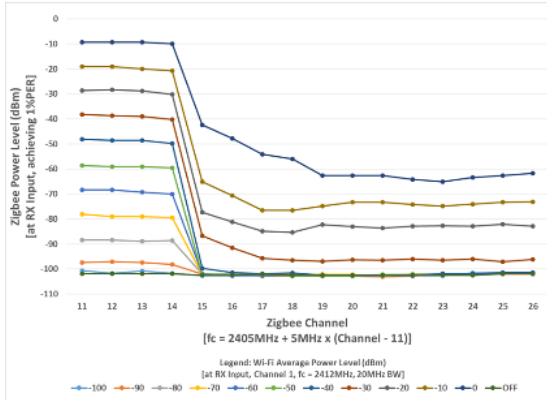
## GATEWAY / HUBS

**Missing devices events**

**Poor commands responsiveness**

**Dropped connections**

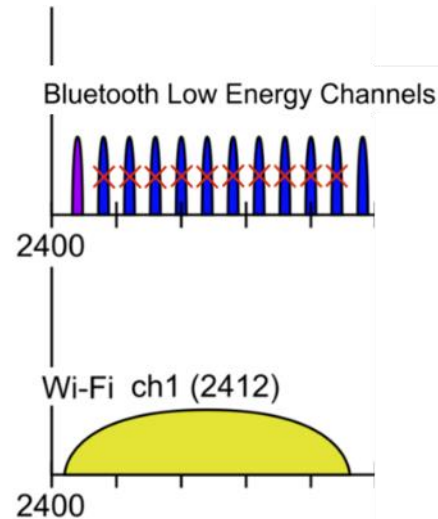
# 管理协议共存



## UNMANAGED COEX

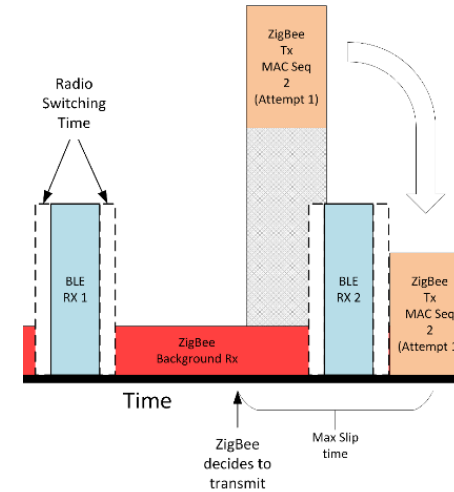
### Customized run-time radio performance:

- Blocking & Selectivity
- Adjacent channel rejection
- Enhanced MAC features



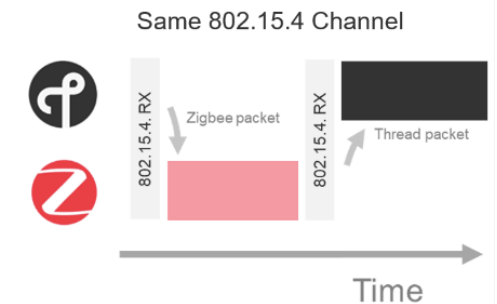
## FREQUENCY PLANNING

- Bands Planning
- Channels Planning
- Channel Agility
- Frequency Hopping



## TIME SLICING

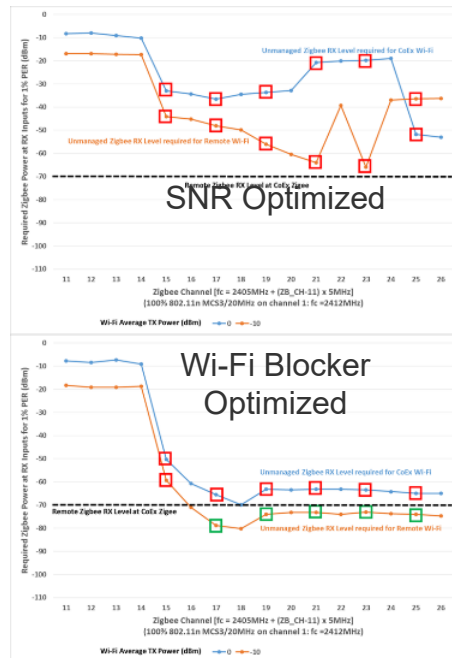
- Dynamic Multiprotocol
- Concurrent Listening
- Selective RX Diversity
- Packet Traffic Arbitration



## CONCURRENCY

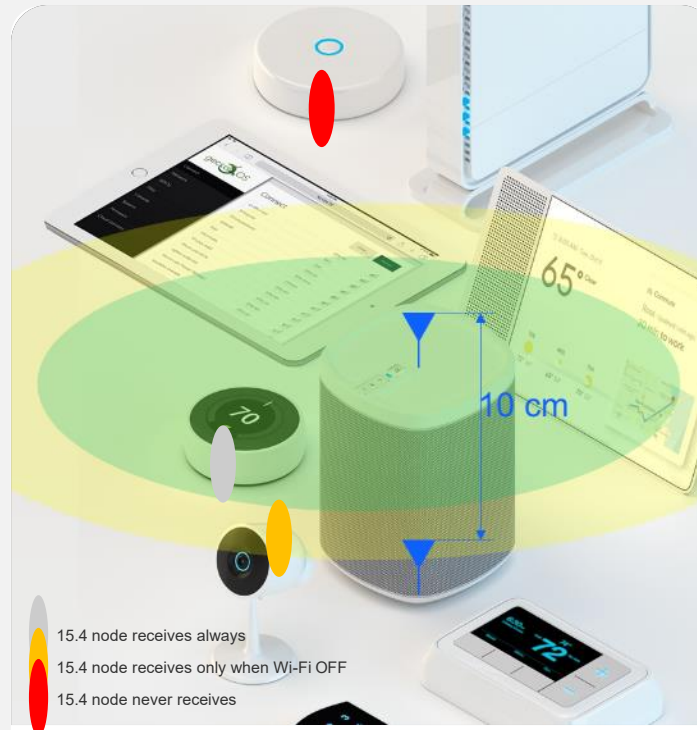
- Concurrent Multiprotocol
- Multi-chip solutions
- \* Multi-RF & Multi-Radio

# 一、非受控的协议共存



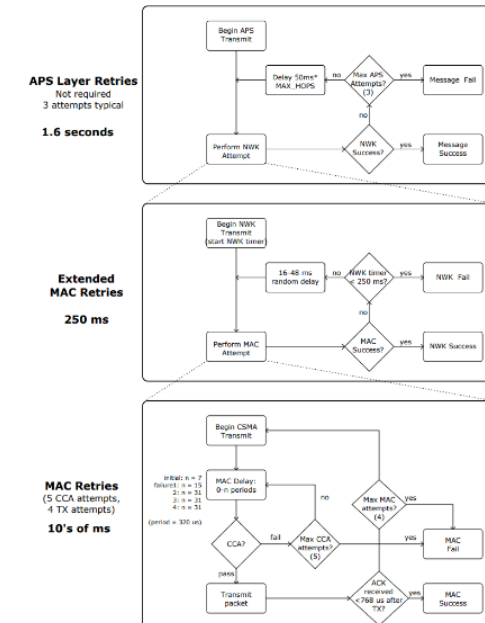
## BLOCKING & SELECTIVITY

- 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

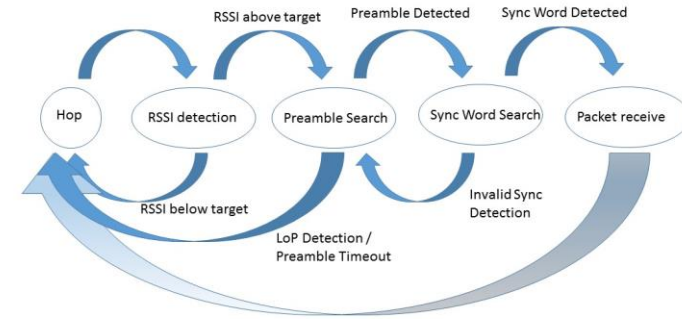
- Extended **MAC retries** algorithm
- Configurable CCA thresholds
- Configurable CCA timeouts

## 二、频率规划

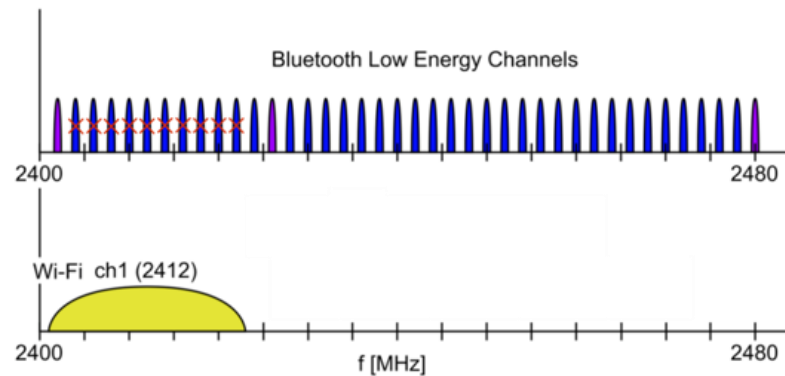
### METHODOLOGY

- **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

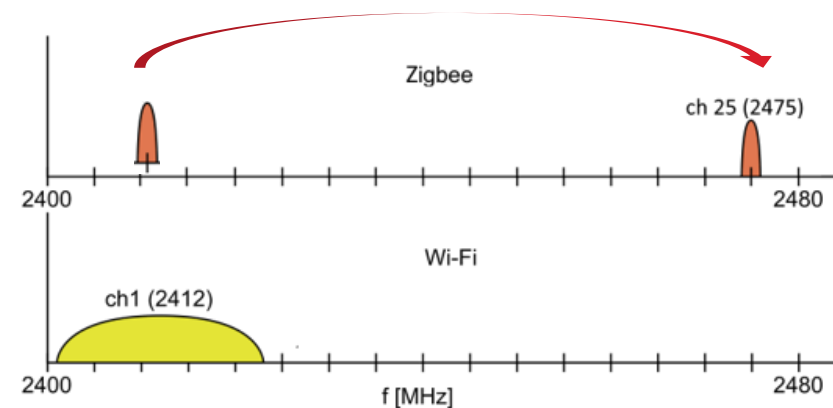
### FREQUENCY HOPPING



### BANDS AND CHANNELS PLANNING

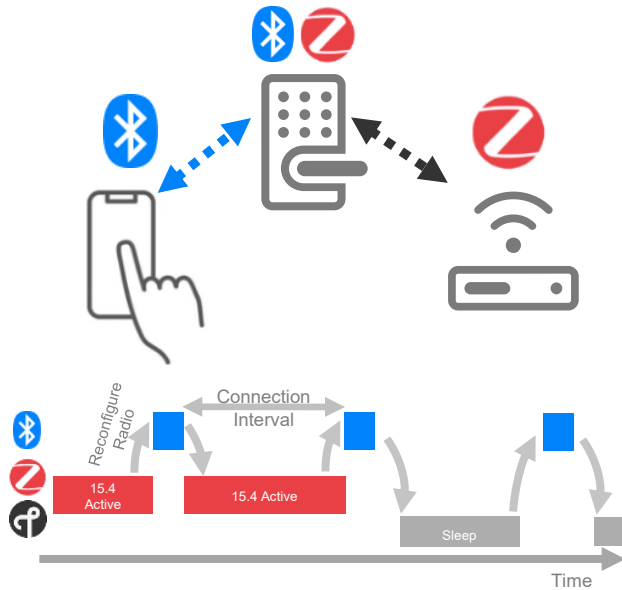


### CHANNEL AGILITY



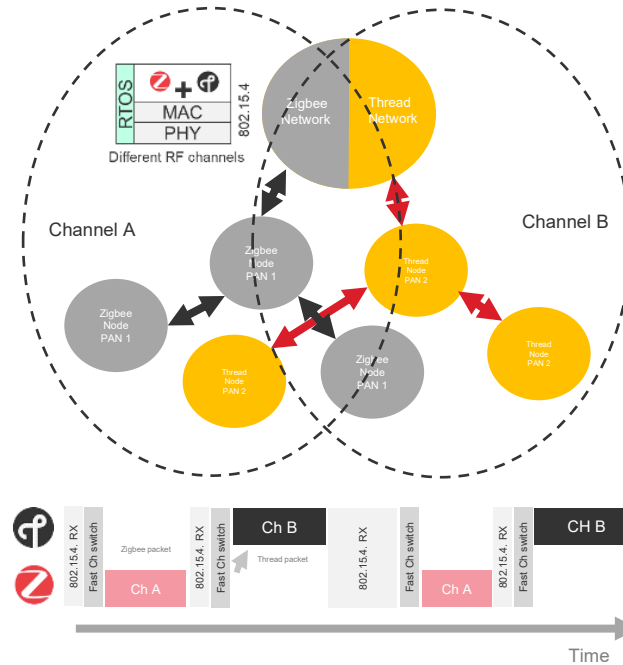


### 三、时间切片 (Time Slicing)



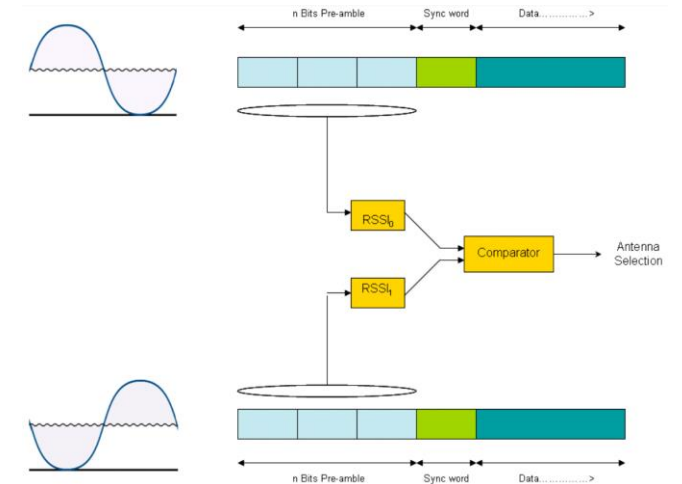
#### DYNAMIC MULTIPROTOCOL

- 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

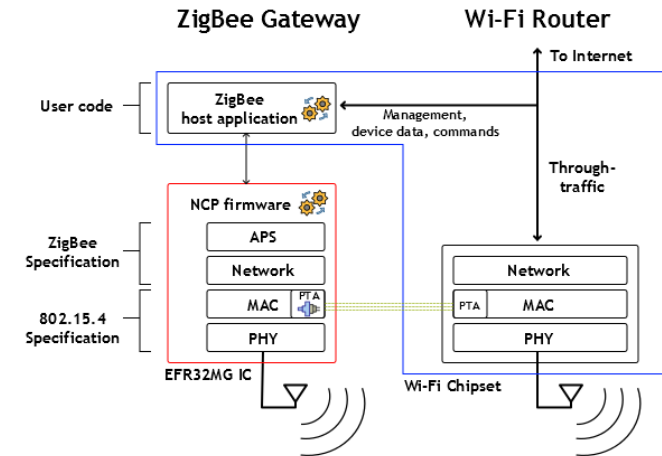
- Use two antennas  $\frac{1}{4}$  wave apart
- Fast switching during preamble detection to select the best antenna
- Improve SNR and RSSI to reduce PER for multi-path and/or blocking

### 三、时间切片—数据包流量仲裁（Packet Traffic Arbitration）

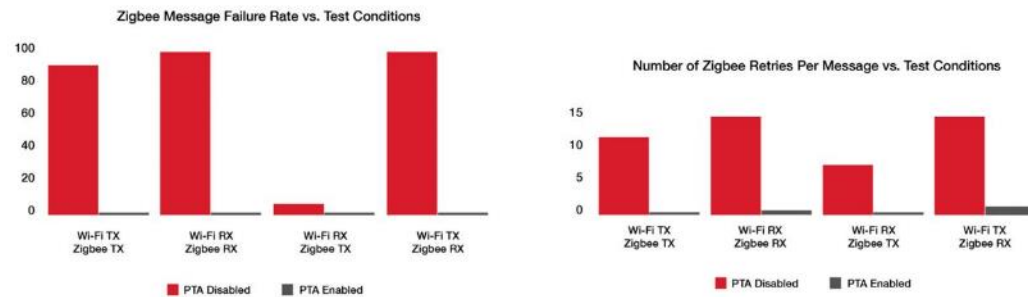
#### MODE OF OPERATION

- 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:**
  - IoT device asserts REQUEST and optionally PRIORITY
  - Wi-Fi accepts request and asserts GRANT
  - Wi-Fi device stops transmitting and IoT device can RX/TX
  - When done IoT device de-asserts REQUEST and Wi-Fi releases GRANT

#### WI-FI ENABLED IOT GATEWAYS / BR ARCHITECTURE

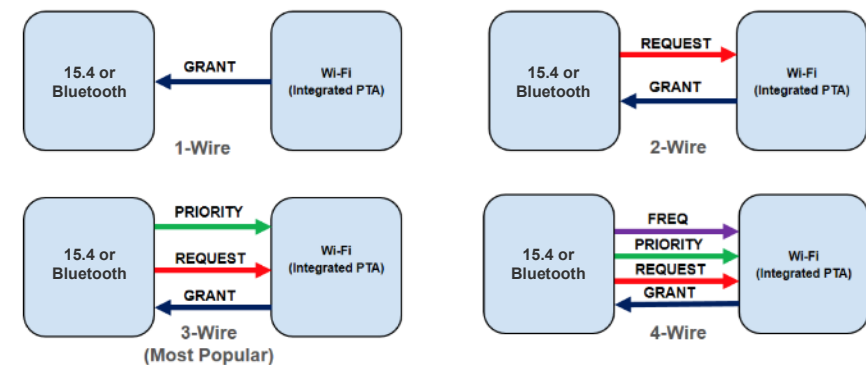


#### NETWORK PERFORMANCE w/o VS w/ PTA ENABLED

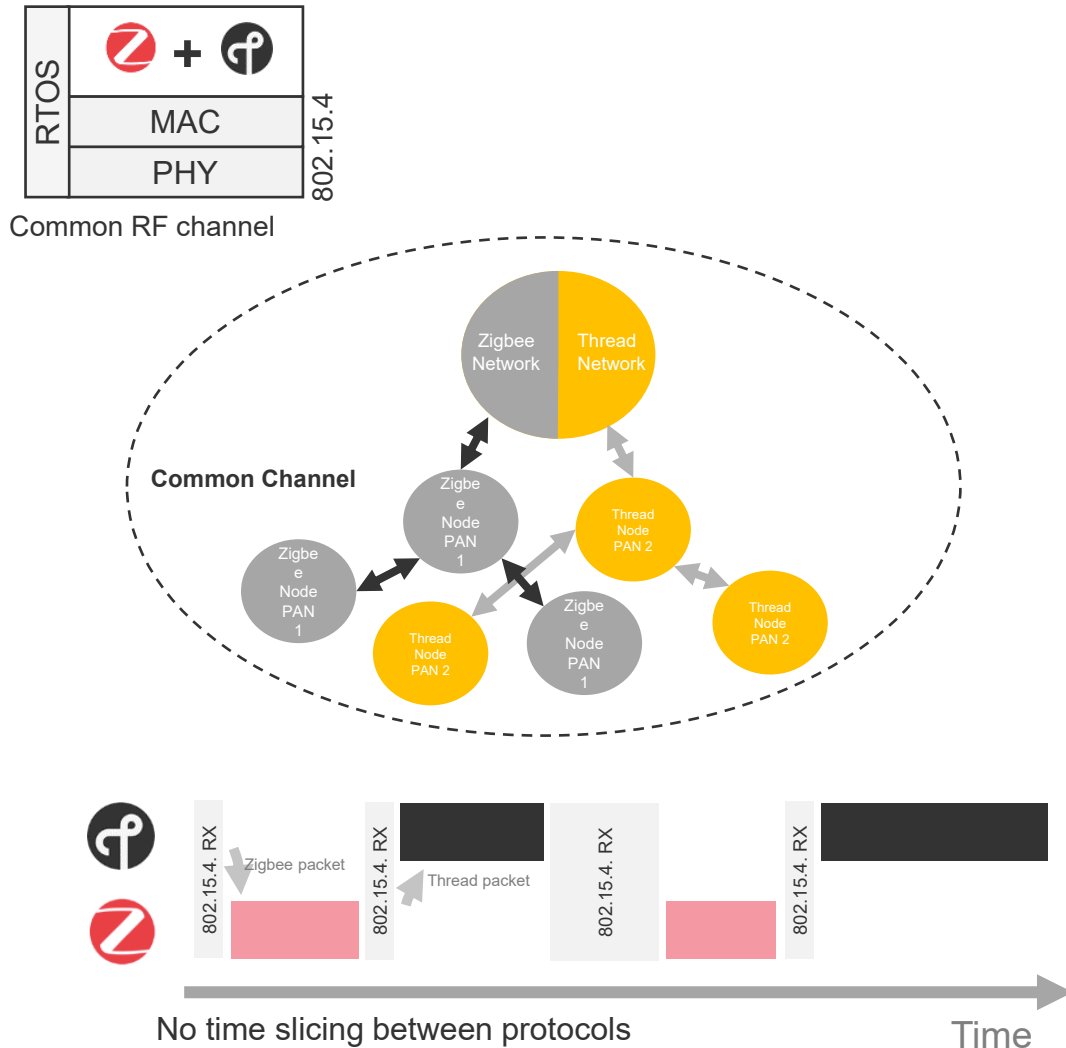


Increased performance with PTA enabled due to reduced retries and packet losses

#### PACKET TRAFFIC ARBITRATION WIRING OPTIONS



## 四、并发性 (Concurrency)



### ▪ 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)

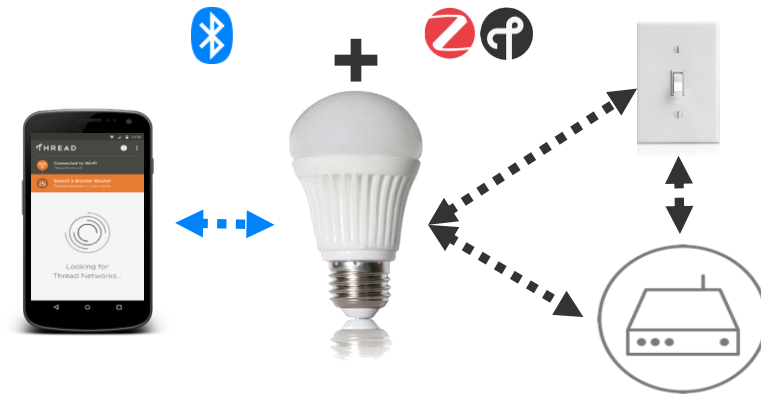
- Simultaneous RX in a single IC using two RF AFEs and one or two modems
- TX is usually still time sliced due to interferences

### ▪ \* MIMO RX Diversity (MRC)

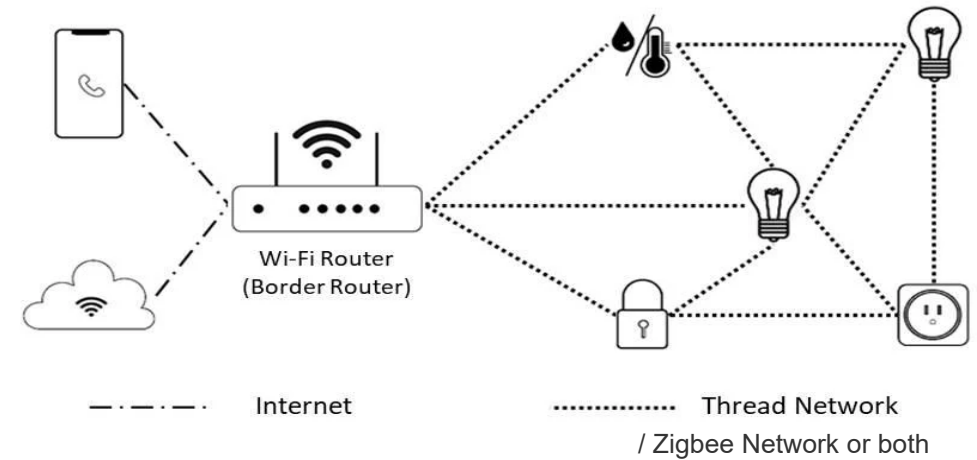
- Allows multiplexing wireless medium in space to reduce multi-path fading and increase RX sensitivity
- Requires two RF AFEs and one or two modems

# 常见的动态多协议（**DMP**）和并发多协议（**CMP**）应用场景

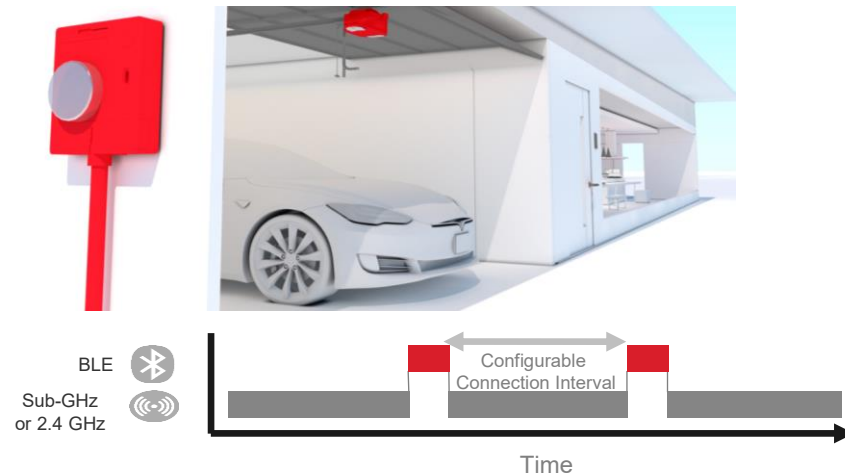
## DMP FOR LIGHTING SOLUTIONS



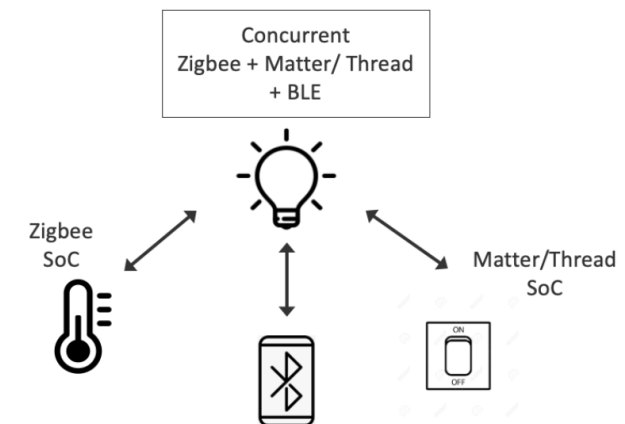
## MULTIPROTOCOL GATEWAYS



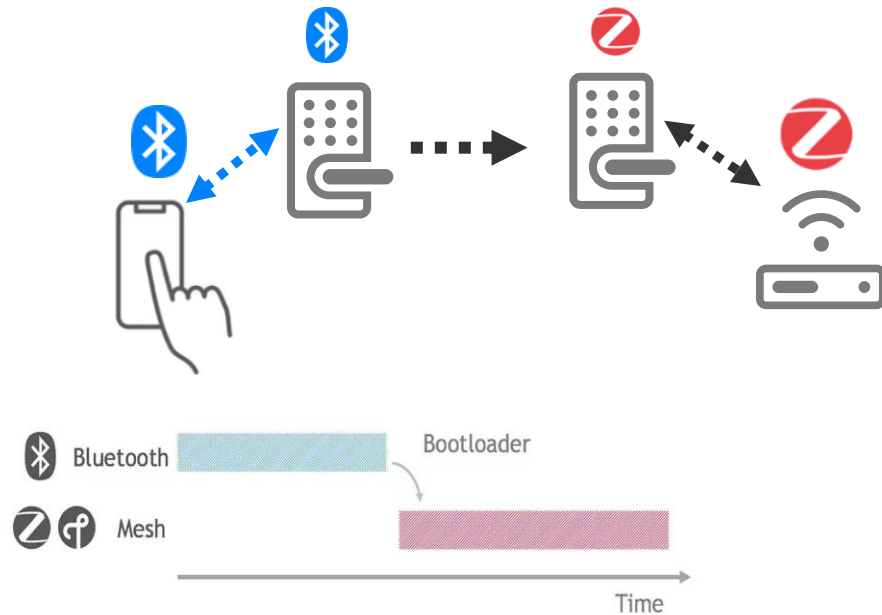
## MULTIPROTOCOL SUB-GHZ IOT DEVICES



## MULTIPROTOCOL LIGHTING SOLUTIONS

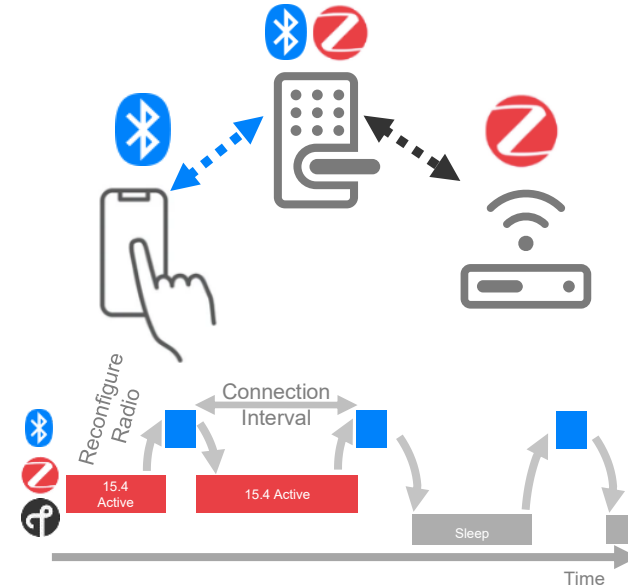


## 切换式与动态多协议（**SMP**与**DMP**对比）



### 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)

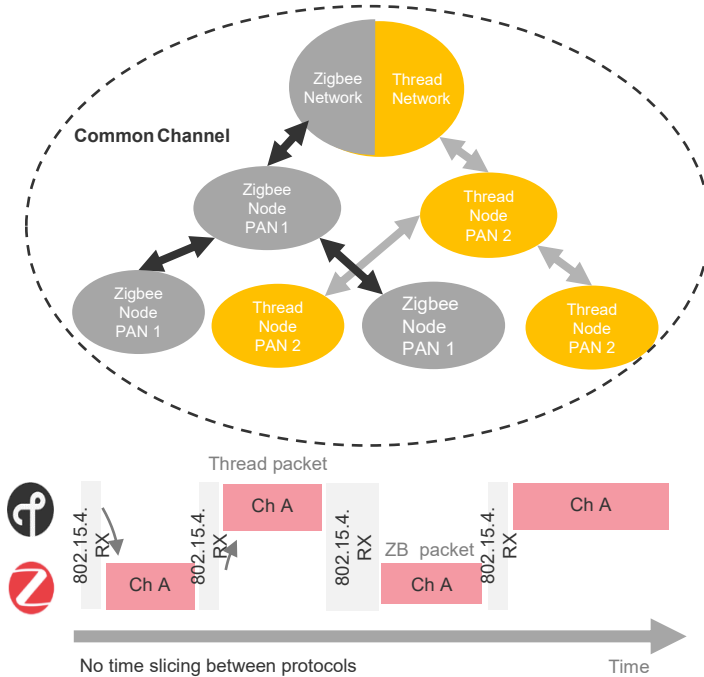


### DYNAMIC MULTIPROTOCOL

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

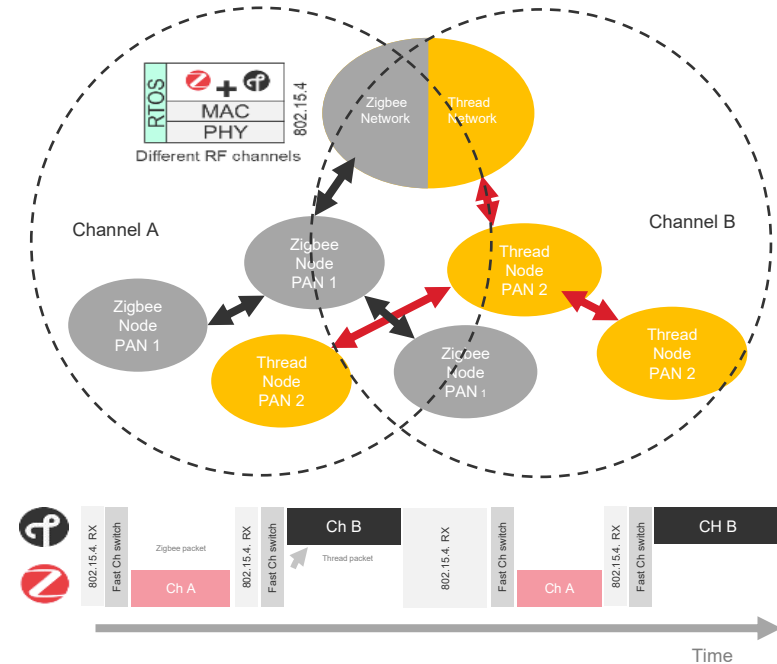


# 并发多协议与并发监听 (Concurrent Listening)



## 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

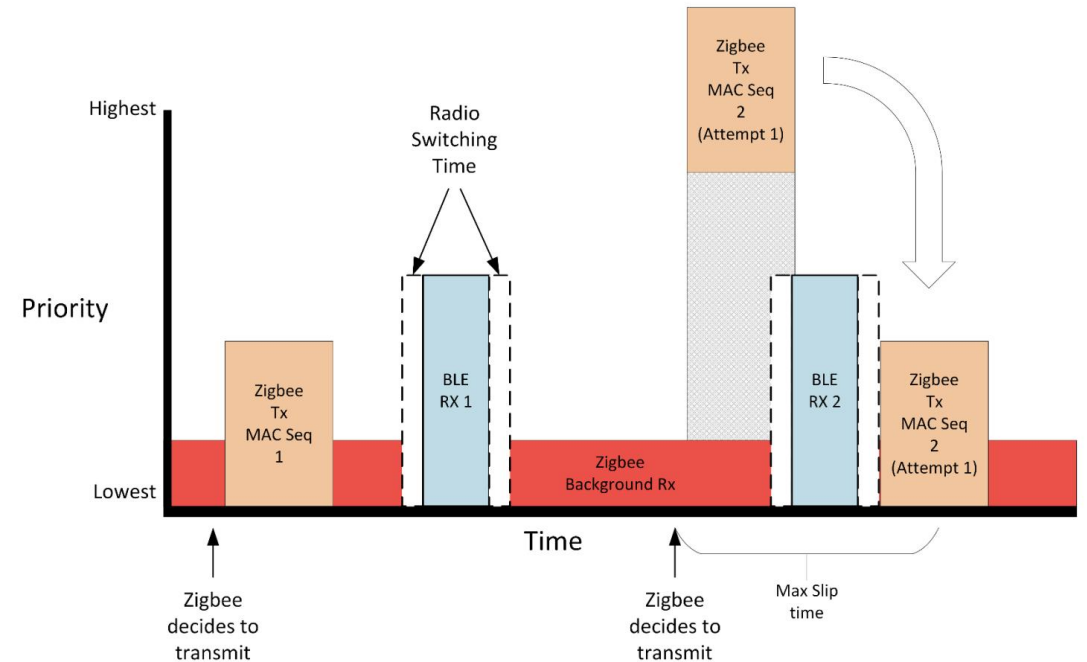
# 动态多协议

## 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:

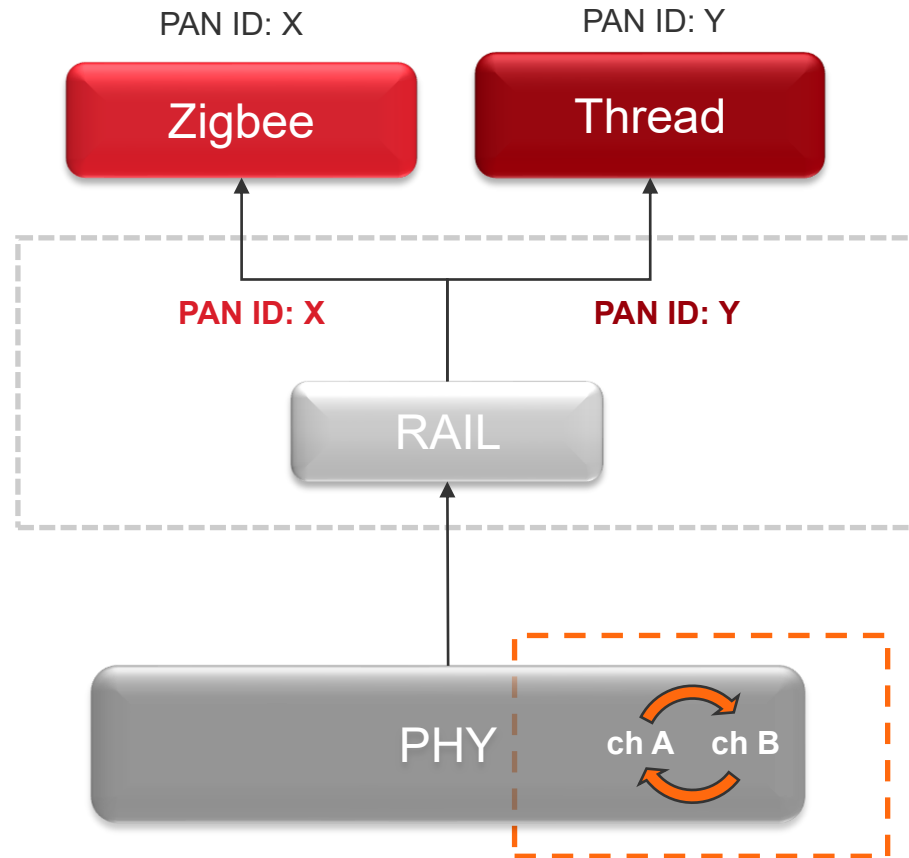
- Commissioning / device on-boarding
- Network diagnostics



Example: DMP BLE + Zigbee

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

# 并发多协议相关术语



## 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

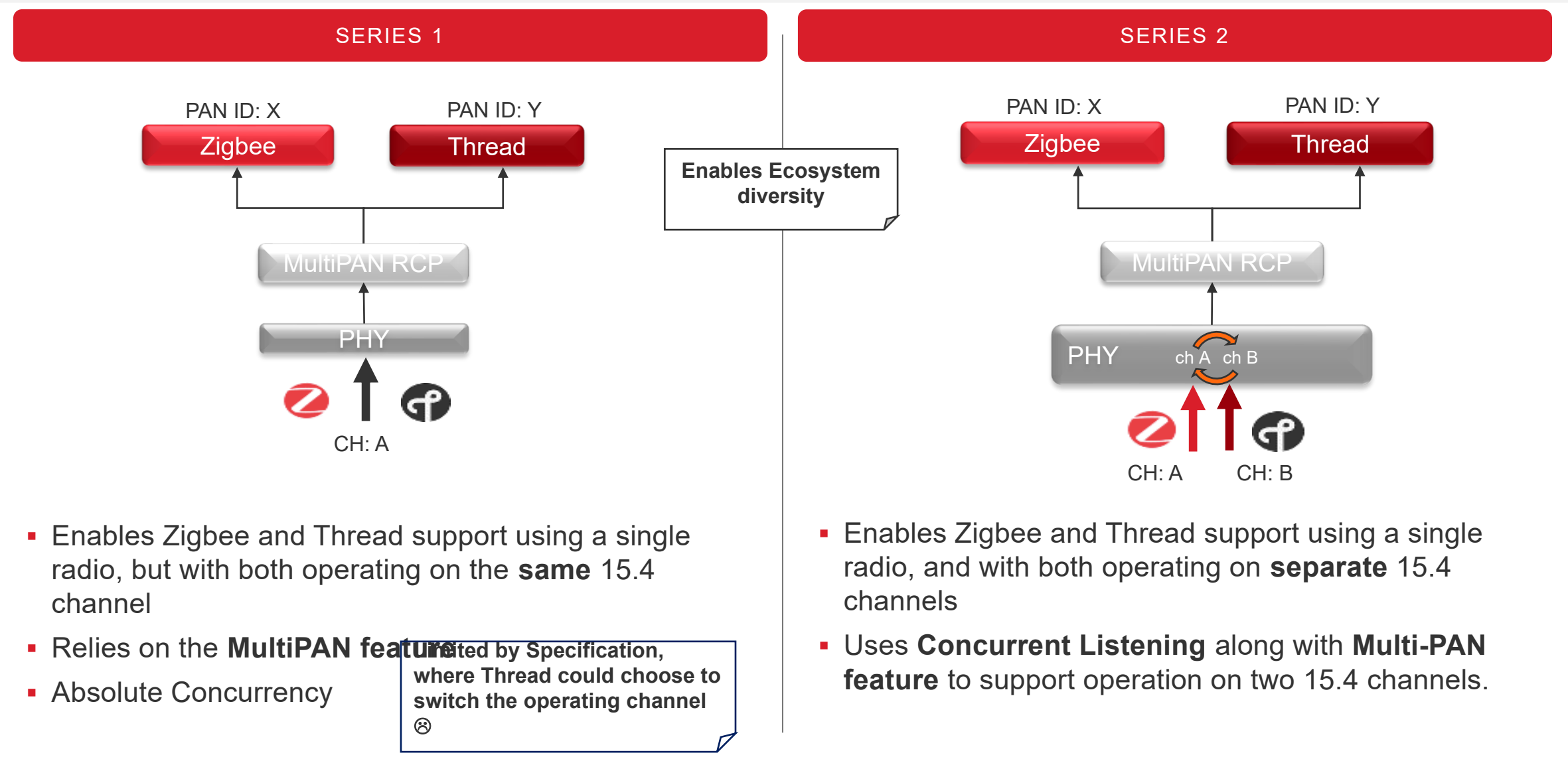
## MultiPAN support:

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

# 并发多协议：第一代无线平台 **vs** 第二代无线平台



## 第二代无线平台的并发监听（或称快速信道切换）

### Concurrent Listening:

- Uses **RX antenna diversity hardware block** with **synth reloading** to switch extremely rapidly between two 15.4 channels, after every  $\sim 48 \mu\text{sec}$
- 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  $\mu\text{s}$  out of 128  $\mu\text{s}$ ) on each RF channel.

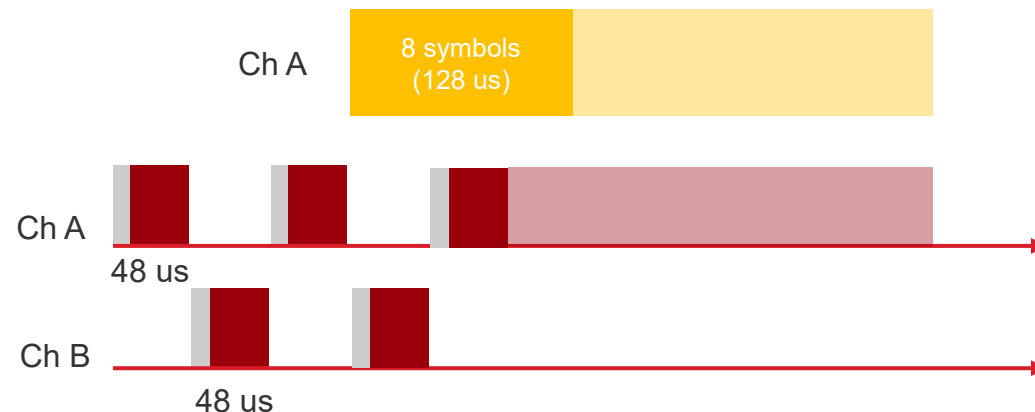
### Limitations:

- 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 ( $\sim 16 \mu\text{s}$ )
- Listen for preamble (2 symbols,  $\sim 32 \mu\text{s}$ )
- Load RF synth for channel B and settle ( $\sim 16 \mu\text{s}$ )
- Listen for preamble ( $\sim 32 \mu\text{s}$ )
- Repeat until preamble detected

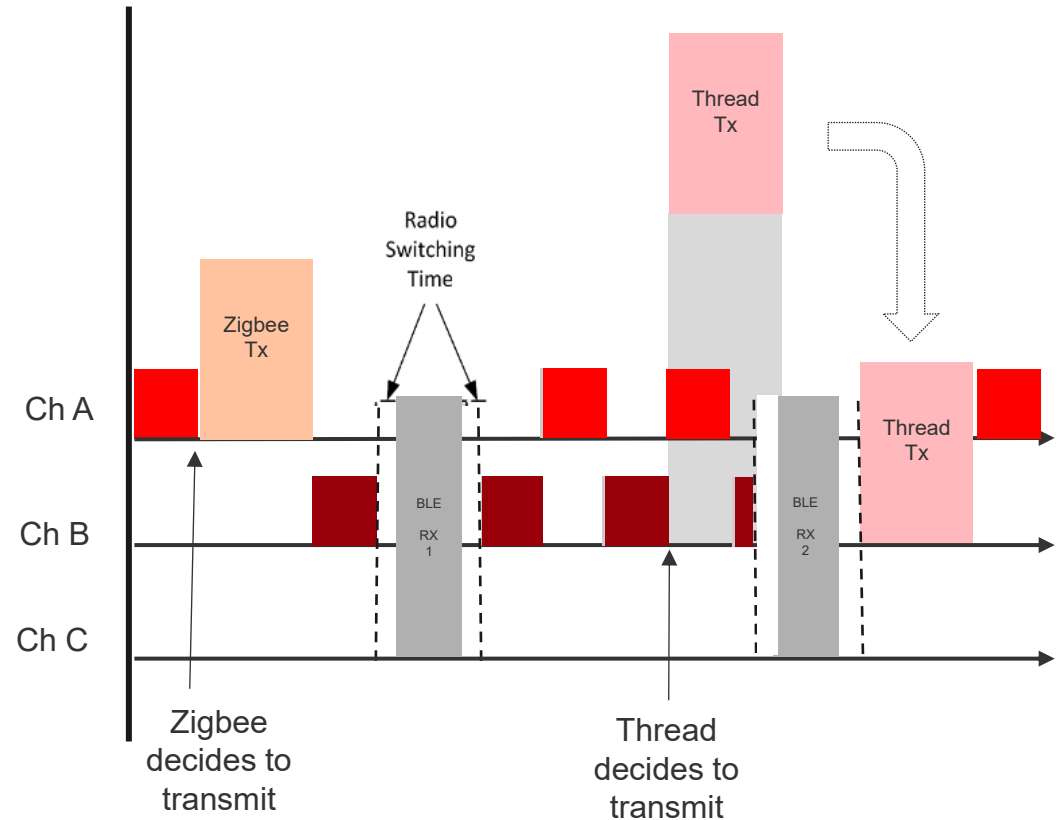


# 动态多协议蓝牙和并发多协议 (Zigbee + Thread)

## 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)

# RCP模式的动态多协议蓝牙 + 并发多协议 (Zigbee + OpenThread)

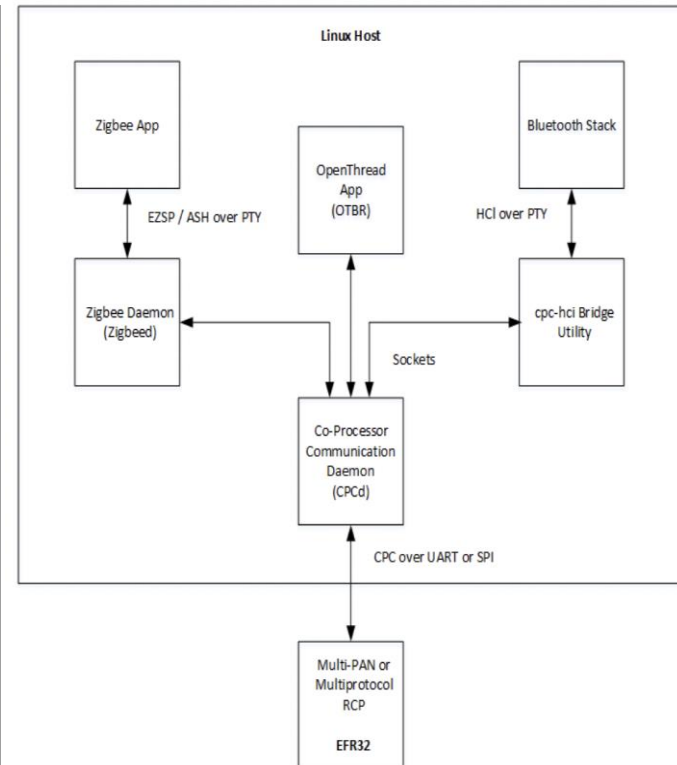
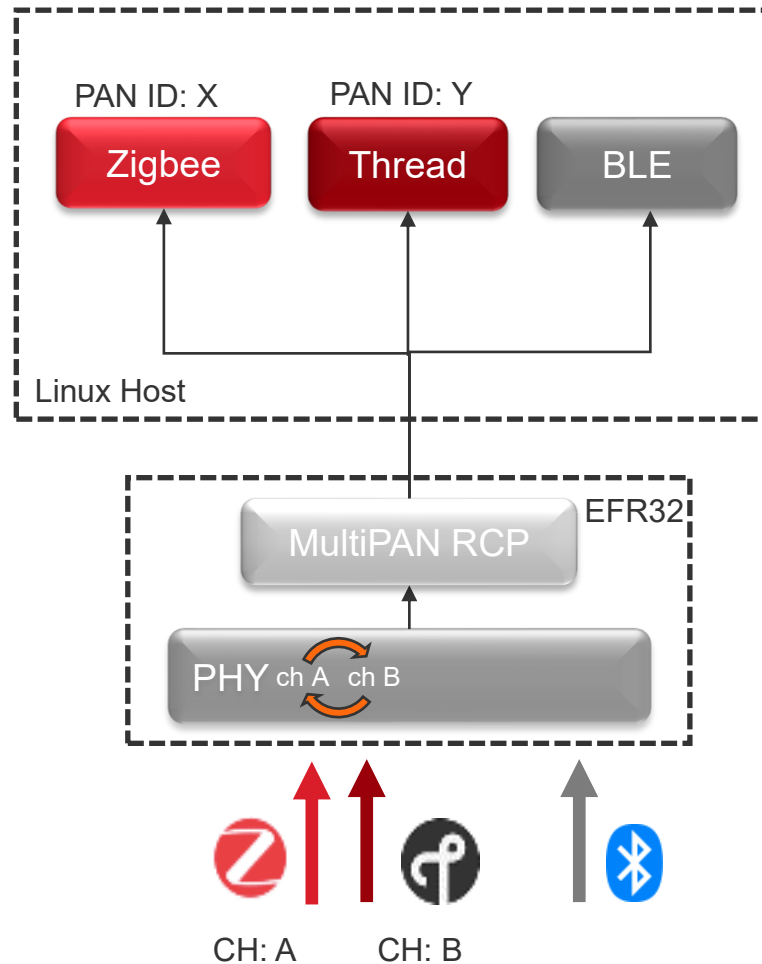


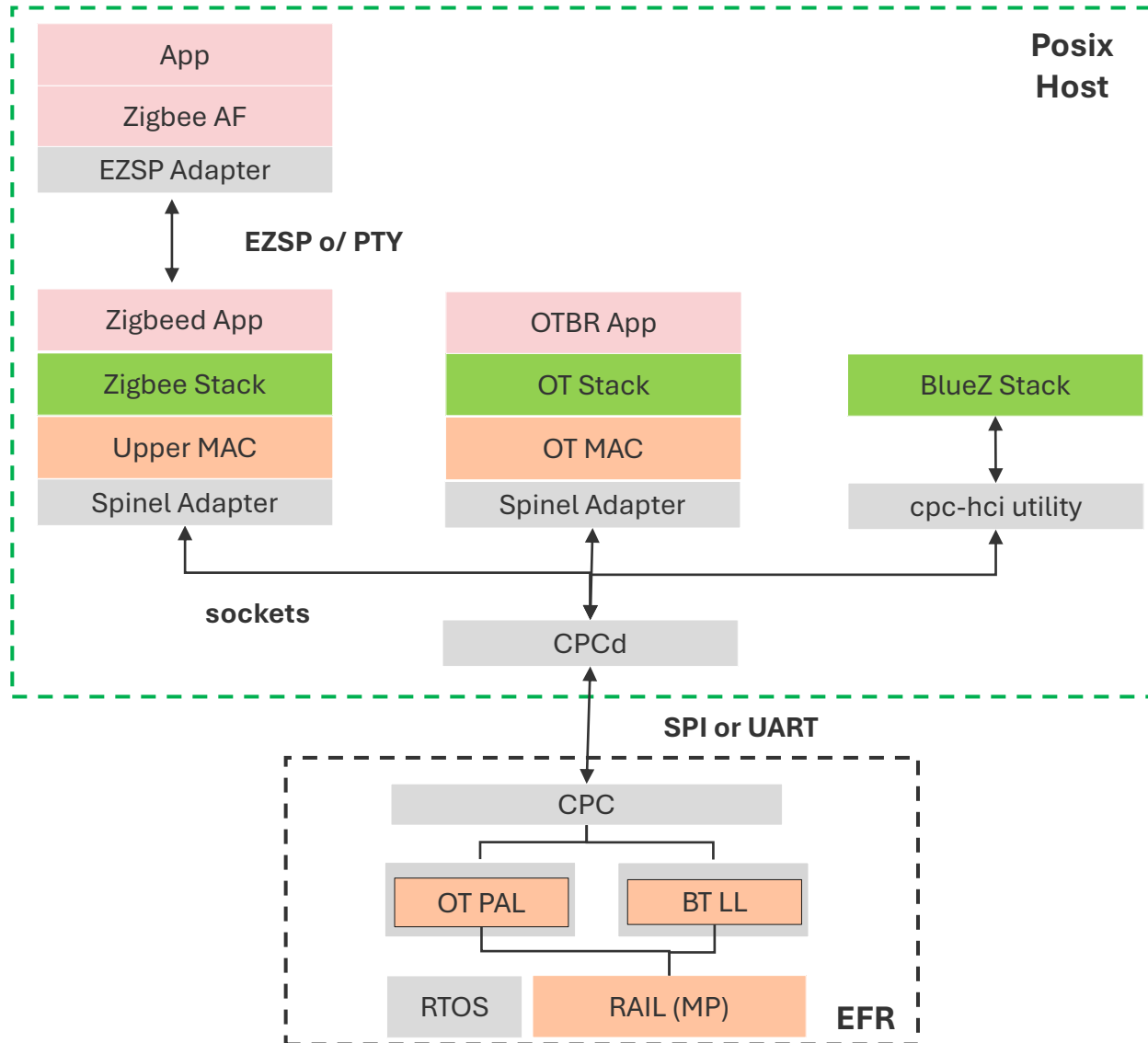
Figure 1-1. System Architecture for the Multiprotocol RCP

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

# RCP模式的动态多协议蓝牙 + 并发多协议 (Zigbee + OpenThread) 一架构视图



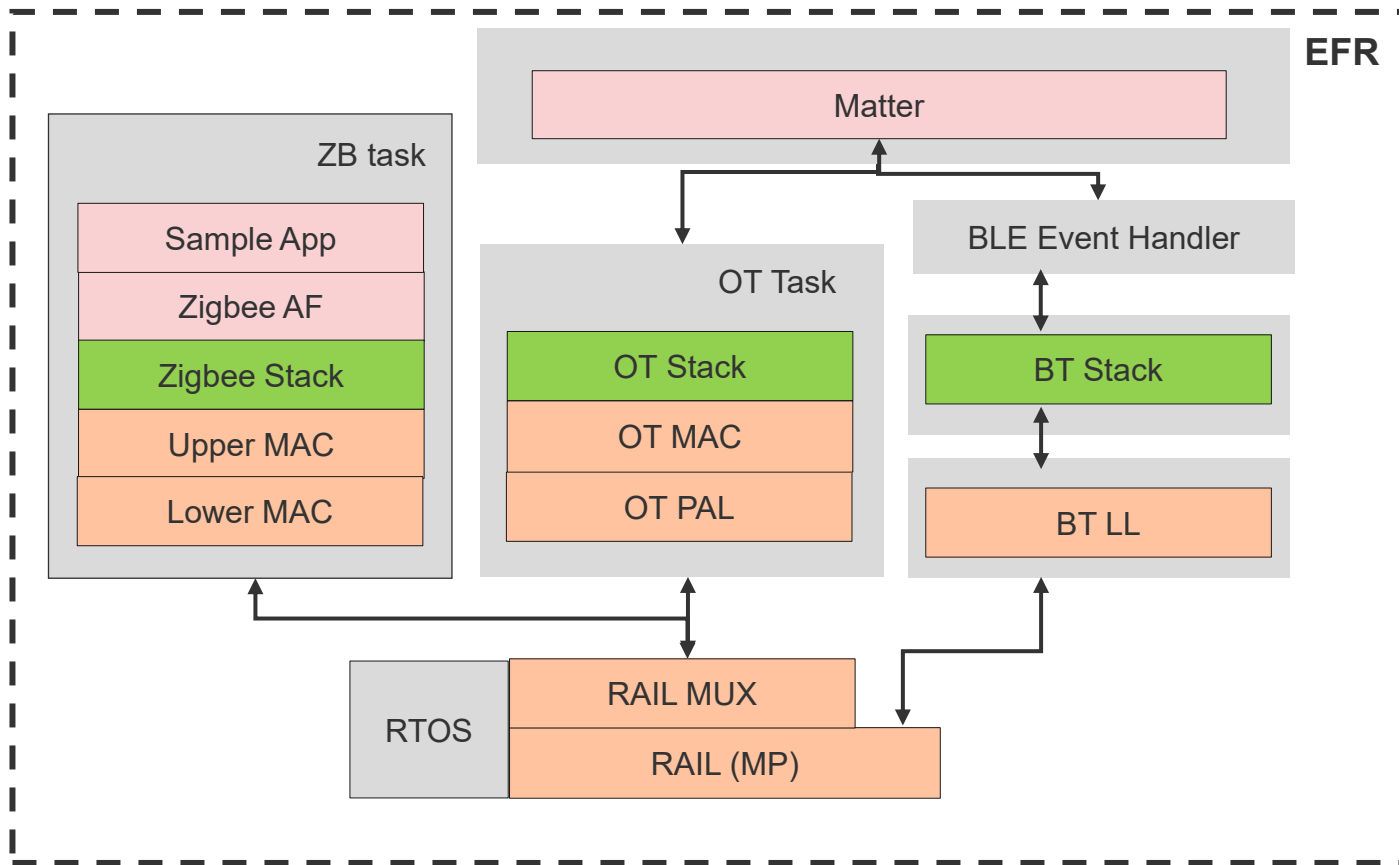
- Zigbee & Thread can operate on:
  - Same ch. (no time slicing) or
  - Different ch. (via concurrent listening)
- Uses MultiPAN feature for filtering 15.4
- Bluetooth operates in DMP mode
- RCP has a flash footprint (~250K)
- RCP App uses RTOS

## Common Platform components such as:

- Wi-Fi coexistence
- RTOS
- NVM3 & Memory manager




































Enable seamless integration of platform features critical to the application

# SoC模式的动态多协议蓝牙 + 并发多协议 (Zigbee + OpenThread) — 架构视图



- 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.

# 蓝牙 + 15.4 多协议解决方案

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.



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