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WF-101

Key Benefits of Wi-Fi 6

Ravi Subramanian | August 2023

Agenda

01 Wi-Fi Introduction

02 Wi-Fi in IoT – Requirements and Usage

03 Why Wi-Fi 6 for IoT?

04 Wi-Fi 6 Key Features and Benefits for IoT

05 Silicon Labs' Wi-Fi Portfolio

Wi-Fi Introduction

Introduction and Evolution of Wi-Fi

- **Wi-Fi is almost everywhere and expanding**
  - Wi-Fi is a ubiquitous wireless standard
  - Connects wireless ‘things’ to the Internet
  - Uses existing infrastructure and security
- **Wi-Fi is widely deployed in IoT**
  - Over billion “things” (IoT products) & growing
  - Significant power and cost reduction in Wi-Fi solutions have enabled growth
- **Wi-Fi is almost everywhere and expanding**
  - Newer Wi-Fi will further increase deployment

■ New features in a version

IEEE Protocol	802.11a/b/g	802.11n	802.11ac	802.11ax
WFA Naming	N/A	Wi-Fi 4	Wi-Fi 5	Wi-Fi 6, Wi-Fi 6E
Year Introduced	1999	2009	2013	2019, 2021 for 6E
Band(s) (GHz)	2.4,5	2.4, 5 (SB or DB)	5	2.4, 5, 6 (SB, DB, TB)
Channel Bandwidth (MHz)	20	20, 40	20, 40, 80, 160	20, 40, 80, 160
Allowable Streams	1	4	8 (only 4 implemented)	8
Max Data Rates (Mbps)	11,54	600 (40MHz, 4 SS)	433 (80MHz, 1SS) 866 (160MHz, 1 SS) 3467 (160MHz, 4 SS)	143 (20MHz, 1 SS) 600 (80MHz, 1 SS) 9607 (160MHz, 8 SS)
MIMO	N/A	Single User (SU-MIMO)	Downlink Multiuser (DL MU-MIMO)	Multiuser – 8 Users (Uplink and Downlink MU-MIMO)
Subcarrier Spacing (KHz)	N/A	312.5	312.5	78.125
Symbol Duration (us)	N/A	3.2	3.2	12.8
Guard Interval (us)	N/A	0.4, 0.8	0.4, 0.8	0.8, 1.6, 3.2
PHY Modulation	DSSS,OFDM	DSSS, OFDM, HT-OFDM	DSSS, OFDM, HT-OFDM, VHT-OFDM	DSSS, OFDM, HT-OFDM, VHT-OFDM, OFDMA
Multi-user Operation	No	No	(DL MU-MIMO)	Uplink and Downlink OFDMA
Highest Order Modulation	CCK, 64-QAM	64-QAM	256-QAM	1024-QAM
Power Saving Mechanisms	PS-POLL	PS-POLL	PS-POLL	Target Wake Time
Spatial Reuse Mechanisms	No	No	No	BSS Coloring

Wi-Fi 6 is the largest upgrade to Wi-Fi and expect Wi-Fi 6 deployments to grow significantly, yet be backward compatible

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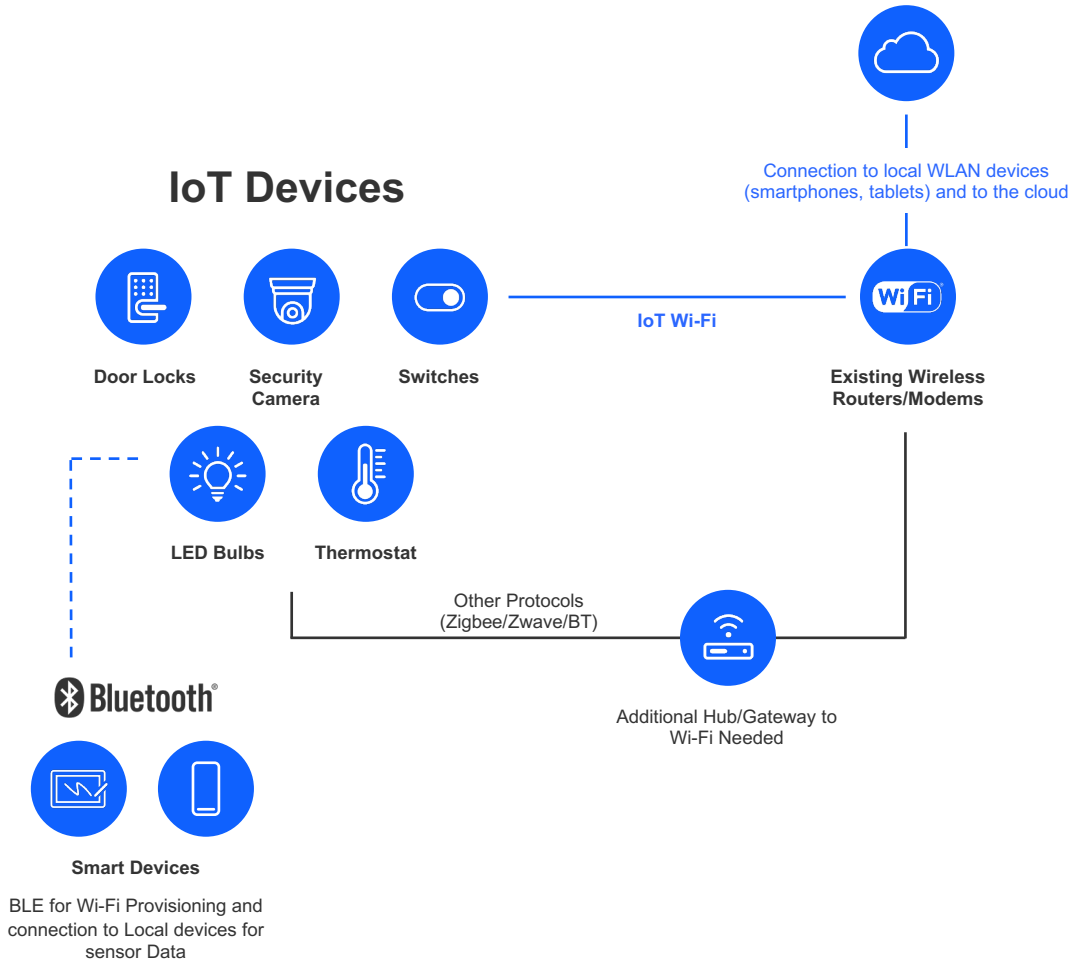
Wi-Fi in IoT – Requirements and Usage

Requirements of Wi-Fi in IoT Devices

- **Traditional Wi-Fi is better for PC/smartphone**
  - Meant for infrastructure, high bandwidth, or mains-powered devices
  - Used with highly resourced hardware (CPU, memory) running Linux/Android/iOS/Windows
  - Move towards 5GHz or 6E (6GHz) bands for high bandwidth and power
- **Wi-Fi for IoT is different**
  - Low power consumption (battery operated)
  - Coexistence, interoperability and long range (2.4 GHz)
  - Secure connectivity, prevent online and physical attacks
  - Limited device resources (MCU, memory etc.)
  - Wireless, networking stack integration
  - Simplified provisioning – lack of rich UI interfaces
  - Cost and size-constrained devices
  - Challenges from crowded RF spectrum
  - Cloud connectivity to multiple cloud providers

Wi-Fi Usage in IoT Applications



- **Simplified installations and cost reductions:**
  - Use existing Wi-Fi router/modem
  - Native IP protocol for internet communication
  - No additional Hub/Gateway required
- **Extended range, battery life, throughput**
  - Power saving capabilities for energy efficiency
  - Longer range 2.4GHz single-band
  - Higher data rate support vs Zigbee/Bluetooth/Zwave
- **Improve user experience and interoperability with**
  - The new Matter protocol
  - Ecosystem cloud integration and connectivity
  - Local area network connectivity
- **Bluetooth Low Energy usage with Wi-Fi**
  - Simplified provisioning
  - Proximity detection
  - Sensor connectivity

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Why Wi-Fi 6 for IoT?

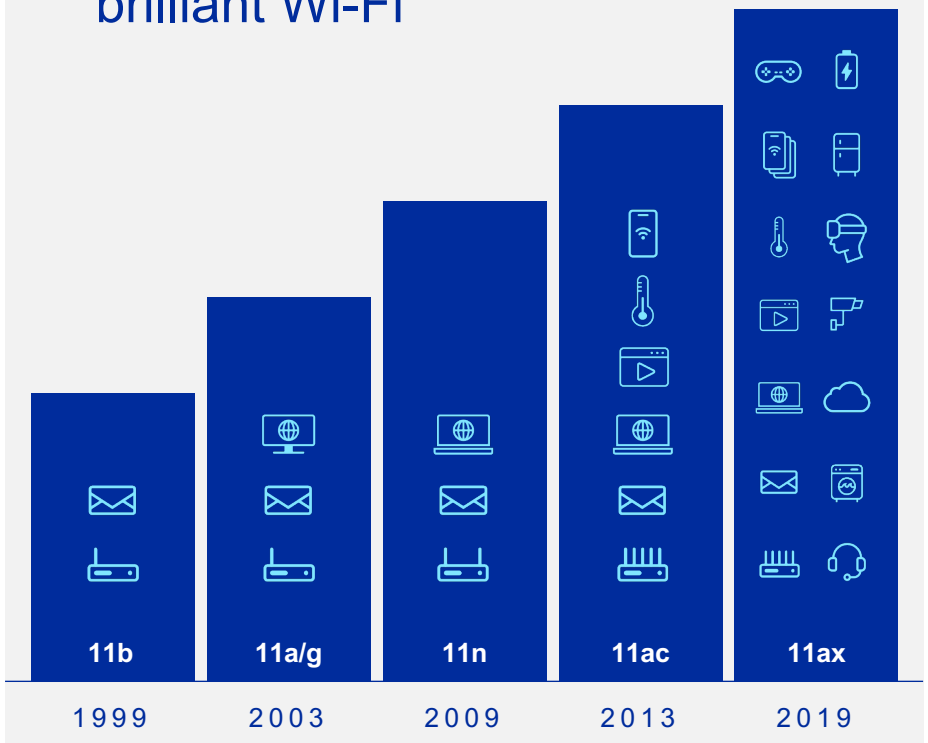
Wi-Fi 6 is Evolving to Serve the Explosion in IoT Devices

TODAY'S DEPLOYMENTS

- **Number of application types is exploding**
- **Number of devices is exploding and some need higher bandwidth**
- **Large number of devices clog the network and cause latency**
- **Higher device traffic cause congestion leading to delays/lower throughput**
- **Many devices are battery operated and need longer battery life**

11AX

The path to truly brilliant Wi-Fi



TOMORROW WITH WI-FI 6

4x **Better In Dense Environments**
Improve average throughput per user in dense or congested environments

Faster Throughput
Deliver higher peak data rates for a single client device

Increase Network Efficiency
Support large number of devices

Extend Battery Life
Of client devices

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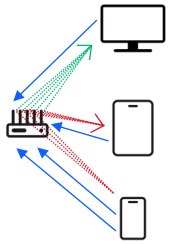
Wi-Fi 6 Key Features & Benefits

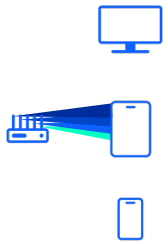
Wi-Fi 6 Key Features and Benefits for IoT Devices

BETTER PERFORMANCE

Full Duplex Multi-User MIMO



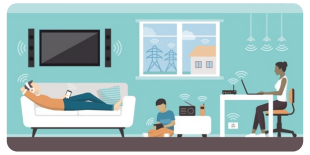
Beamforming



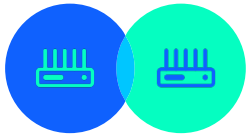
Higher Throughput, Reduced Overhead

SUPPORT DENSER ENVIRONMENTS

OFDMA



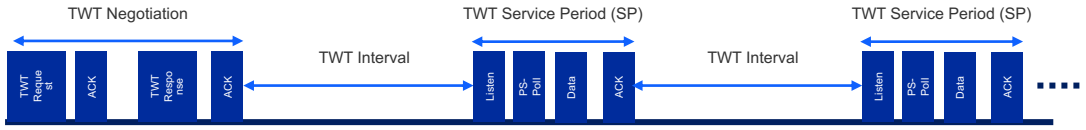
Spatial Reuse, BSS Coloring



Network Efficiency

LONGER BATTERY LIFE

Target Wake Time

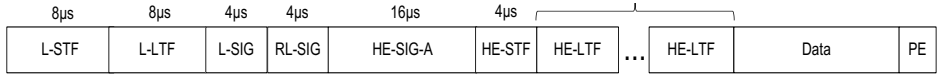


2.4GHz, 20 MHz Channel

BSS Max Idle

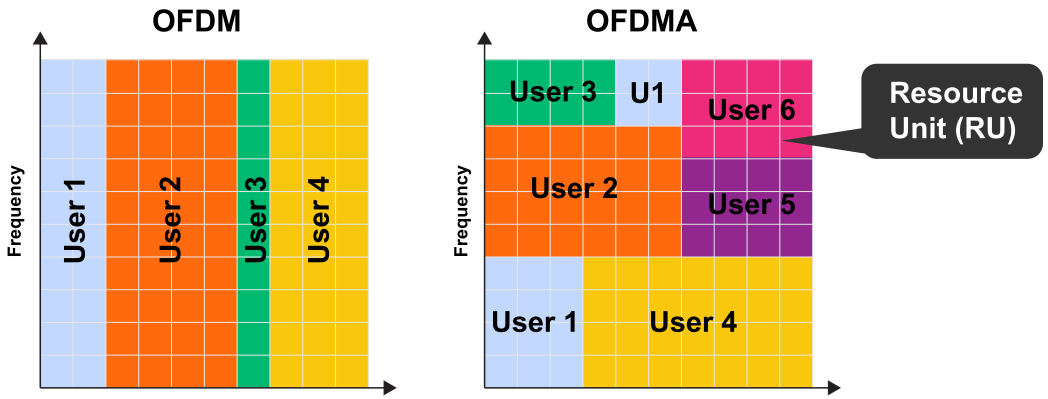
IMPROVED COVERAGE/LONGER RANGE

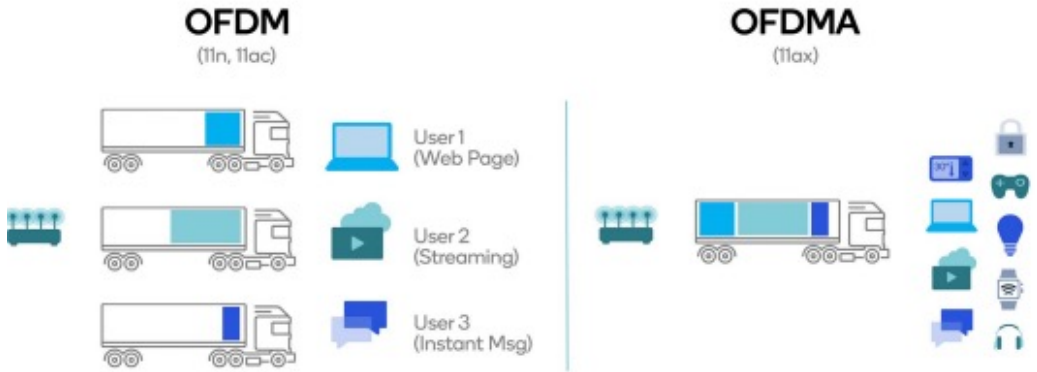
Extended Range Packet Structure



Enhanced delay spread protection-long guard interval

OFDMA vs OFDM: Better Spectral Efficiency and Capacity

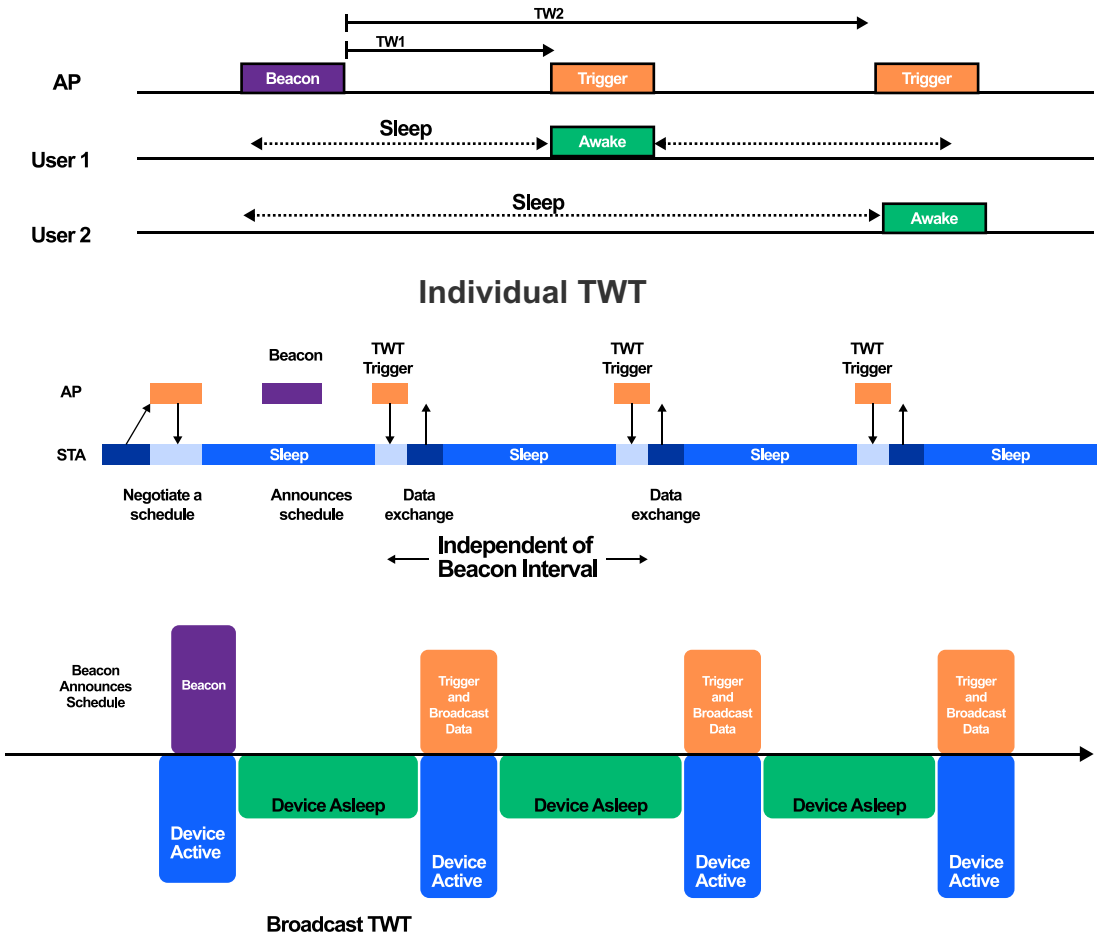




- **OFDMA allows simultaneous communication with multiple devices**
  - Wi-Fi channels divided into smaller sub-channels known as Resource Units (RU).
  - Enables further AP customization of channel use to match client and traffic demands
  - AP can allocate the whole channel (all sub-channels within a channel) to a single user or it may partition the channel to serve multiple devices simultaneously.
- **Increased efficiency for (high percentage of traffic) short data frames**
  - Improves usable throughput for all devices connected to an AP.
  - OFDMA is most useful when multiple connections transmit limited amounts of data
  - Allows the protocol to squeeze smaller data packets through multiple sub-channels (most useful for IoT devices).

OFDMA reduces latency and improves network efficiency, latency and throughput

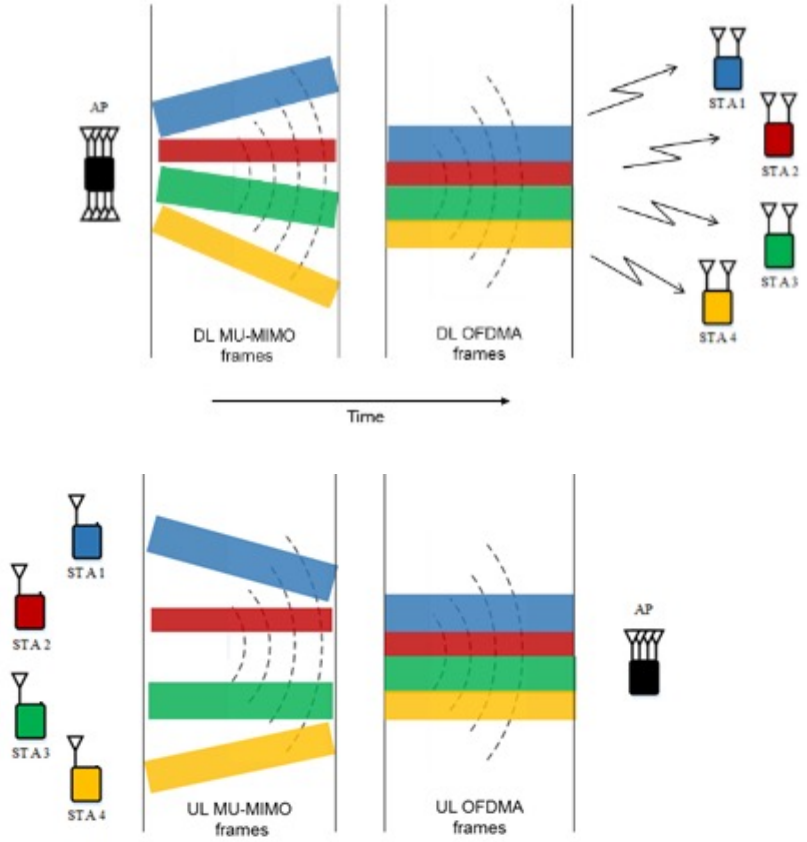
Wi-Fi 6 - Advanced Power-Save for IoT – Target Wake Time (TWT)



- **TWT enables wireless AP and devices to negotiate and define specific times to access the medium.**
- **TWT has two available methods**
  - Individual TWT: each device can negotiate sleep period with AP
  - Broadcast TWT: AP provides sleep period for a group of devices
- **Individual TWT is ideal for battery operated IoT devices**
  - Enables longer sleep duration on a per client basis
  - Longer sleep duration increases battery life
  - Eliminates interop issues due to client long sleep durations
  - Reduces contention and overlap in dense environments
  - Combined with other Wi-Fi 6 features helps significantly reduce power consumption in congested environments compared to previous generation Wi-Fi

Wi-Fi 6 TWT further reduces power consumption for devices on battery, enabling longer battery life

Wi-Fi 6 Uplink Multi-User (UL OFDMA and UL MU-MIMO)

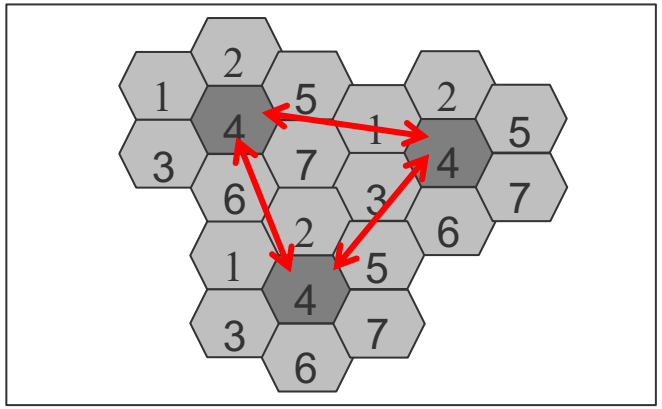


- **Wi-Fi 5 introduced MU-MIMO but with only 4x4 downlink.**
- **Wi-Fi 6 doubled that to 8x8 and added support for Uplink (UL) for both MU-MIMO and OFDMA**
- **UL allows the stations to send their ACK (or other packets) to the AP simultaneously, saving airtime**
- **Enables simultaneous upstream and downstream data transmission improving network throughput and efficiency**
- **Wi-Fi 6's MU-MIMO and OFDMA techniques increase concurrent access capacity, balance throughput, improve range and reduce latency**

Wi-Fi 6 UL/DL OFDMA and MU-MIMO improve device capacity, network efficiency, range and throughput

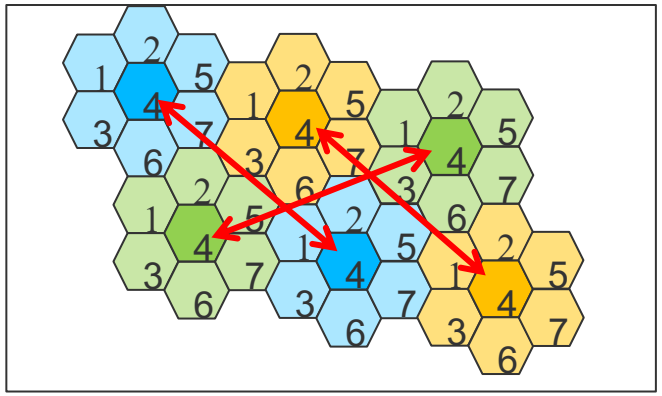
Basic Service Set (BSS) Coloring Enables Additional Ch (Spatial) Re-use

All same-channel BSS block



Same-channel BSS only block on Color Match

Wi-Fi 6

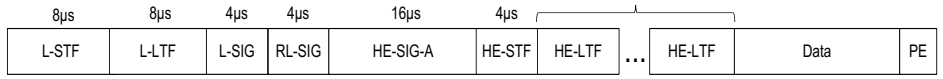


- **What is BSS Coloring?**
  - A subchannel “color” assigned to a Unique BSS (Basic Service Set)
  - Channel is blocked only if color is same
  - Concurrently transmit data to multiple devices in congested areas
- **BSS coloring benefits:**
  - Maximizes network efficiency and performance
  - Reduces interference, collisions and contention
  - Prevents unwanted device on time
- **Enhanced coexistence and user experience with faster, energy efficient and more reliable Wi-Fi connections**

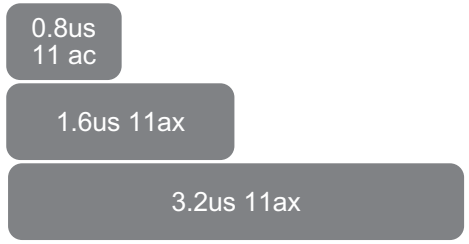
Wi-Fi 6 BSS Coloring improves network performance and reduces device on time – thus better power consumption

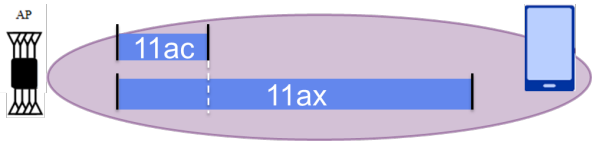
Wi-Fi 6 Range Considerations for IoT

Outdoor / Longer range

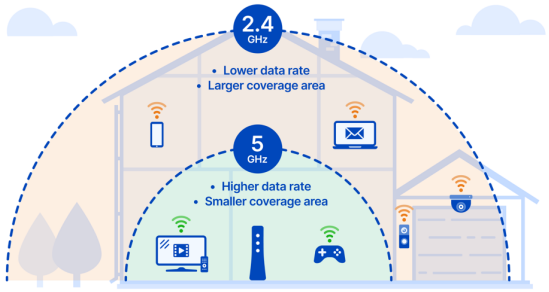


Enhanced delay spread protection-long guard interval Dual Carrier Modulation (DCM)





WLAN coverage area →



- **Often IoT devices are far from access point**
  - Example - humidity sensor or washer/dryer in basement
- **Wi-Fi 6 supports both 2.4 GHz and 5 GHz**
  - 2.4 GHz has better range, 5 GHz offers higher throughput
- **Wi-Fi 6 techniques improve reliability and range**
  - Longer guard interval to handle echoes from further away objects
  - Extended range packet format - some fields are boosted by 3dB
  - Duplicating data over several carriers increasing receiver reliability (DCM)
  - Narrow Band transmission - 2 MHz which reduces noise interference and improves receiver sensitivity
- **Wi-Fi 6 overall provides better coverage and reliability**

Performs well in both indoor and outdoor environments

Wi-Fi 6 – 2.4GHz and 5 GHz Benefits

Wi-Fi 6 Features	2.4 GHz	5 GHz	Benefits to IoT Applications
Range	★★★★	★★	▪ Robust and full home coverage - 2.4GHz travels almost TWICE as far compared to 5GHz ▪ 2.4GHz has better penetration through walls - attenuation is less at lower frequency
Battery Life	★★★★	★★	▪ 2.4 GHz devices consume significantly less current than 5 GHz devices enabling longer battery life ▪ 2.4 GHz Wi-Fi devices are better suited for low power IoT applications
Throughput	★★★	★★★★	▪ 2.4 GHz supports up to 86 Mbps data rates, enough for most IoT applications including some video streaming ▪ 5 GHz offers even higher data rates, but very few IoT applications will ever require those rates
Device Density	★★★★	★★★★	▪ Wi-Fi 6's OFDMA, MU-MIMO, Beamforming, BSS coloring, and Target Wake Time, allow for higher bandwidth and denser 2.4 GHz deployments, reducing the need to move to 5GHz
Regulatory Certifications	★★★★	★★★	▪ 2.4 GHz solutions use the ISM frequency band, with no RADAR restrictions and fewer regulatory steps for worldwide deployment compared to 5 GHz (additional regulatory testing needed for DFS Radar channels)
Lower Cost and Design Complexity	★★★★	★★★	▪ Support for dual-band is more expensive and complex due to support needed for higher frequency 5GHz front end and antenna components.

2.4 GHz single-band is more optimum for IoT, considering the combination of range, low power, throughput, and cost!

Wi-Fi 6 Key Benefits for IoT

Reduces power consumption significantly in higher density which increases battery life

A higher density of IoT devices can be supported per AP or network

Higher throughput, increased efficiency, and reduced latency (better performance and energy efficiency)

2.4 GHz, 20MHz client support for low power and long range

Improved network capacity, robust connectivity, and extended coverage per deployment for IoT devices

Secure (WPA3) and backward compatible with previous generations of Wi-Fi devices

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Silicon Labs Wi-Fi Portfolio

Expanding Silicon Labs Wi-Fi 6 Portfolio

Wi-Fi 6 + BLE
Ultra Low Power
AI/ML, PSRAM
Matter
Secure

The Ultimate Innovation Platform for Intelligent IoT Applications

- The lowest power for Wi-Fi 6 – Up to 2X battery life vs competing SoCs
- Longest Battery Life for Always-on cloud connectivity, Sensing and Edge computing
- Fully-integrated SoC
  - Matter, Bluetooth LE, AI/ML Accelerator, ARM Application Processor
  - 7x7mm QFN, 46 IO, 8 MB Embedded Flash, PSRAM, 105C
- The most advanced Wi-Fi security (PSA – L2 Certifiable)

GENERAL AVAILABILITY – OCTOBER 2023

Wi-Fi 6 + BLE
Low Power
Matter
Secure

Agile Capabilities for Advanced IoT Applications

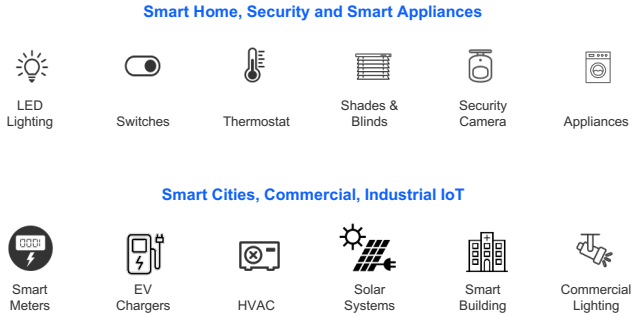
- High-performance and energy-efficient Wi-Fi 6 for line-powered devices
- Always-on cloud connectivity, Sensing, and Edge computing
- Fully-integrated SoC
  - Matter, Bluetooth LE, ARM Application Processor
  - 6x6mm QFN, 20 IO, 4 MB Embedded Flash
- The most advanced Wi-Fi security (PSA – L2 Certifiable)

GENERAL AVAILABILITY – DEC 2023

Introducing - SiWx915: Low-power, High Performance Wi-Fi 6 IoT SoC

Low Power
Matter
Secure

Example Applications:



DEVICE SPECIFICATIONS

High Performance 2.4 GHz Radio
- 802.11b/g/n/ax, 1x1, 20MHz
- Up to +21dBm for Wi-Fi
- Up to +21dBm for Bluetooth
- Ensures reliable communication

Integrated Application MCU
- ARM® Cortex®-M4 with FPU

Memory
- Up to 672kB RAM
- Up to 8MB Flash (or ext flash)

Low Power
- Wi-Fi Standby Assoc current of 120uA @ 1 sec

Multiple protocol support
- Wi-Fi 6 (OFDMA, TWT)
- Bluetooth LE 5.4
- Matter, TCP/IP Networking stack

Package
- 6x6 QFN 52 pin, up to 22 GPIOs

DIFFERENTIATED FEATURES

Multi- Protocol Co-existence
- Wi-Fi 6 + Bluetooth LE 5.4

Low Power
- Energy Efficient

Integrated Stacks
- Wi-Fi, Bluetooth, TCP/IP Networking
- Matter

Best-in-class Security
- Secure PSA-L2 certifiable
  - Protects data, IP and device

Host-less single chip SoC
- Smaller package
- Low RBOM count
- Reduces cost and complexity

Hosted operation
- RCP – OSD Linux Drivers
- NCP – SPI, SDIO, UART

Introducing - SiWx915: Low-power, High Performance Wi-Fi 6 IoT SoC

Wi Fi 6 + Bluetooth

Ultra Low Power
AI/ML, pSRAM
Secure

DEVICE SPECIFICATIONS

High Performance 2.4 GHz Radio
- 802.11b/g/n/ax, 1x1, 20MHz
- +21dBm for Wi-Fi
- +19dBm for Bluetooth
- Ensures reliable communication

Integrated Application MCU
- ARM® Cortex®-M4 with FPU

Memory
- Up to 672kB RAM
- Up to 8MB Flash (or ext flash)
- Optional PSRAM support

Ultra Low Power
- Wi-Fi Standby Assoc current of 50uA @ 1 sec
- Deep sleep current <1 uA
- Sleep/Standby current < 10uA

Multiple protocol support
- Wi-Fi 6 (OFDMA, TWT)
- Bluetooth LE 5.4
- Matter
- TCP/IP Networking stack

Package
- 7x7 QFN 84 pin

DIFFERENTIATED FEATURES

Multi- Protocol Co-existence
- Wi-Fi 6 + Bluetooth LE 5.4

Ultra Low Power
- Long Battery life

Integrated Stacks
- Wi-Fi, Bluetooth, TCP/IP Networking
- Matter

Best-in-class Security
- Secure PSA-L2 certifiable
  - Protects data, IP and device

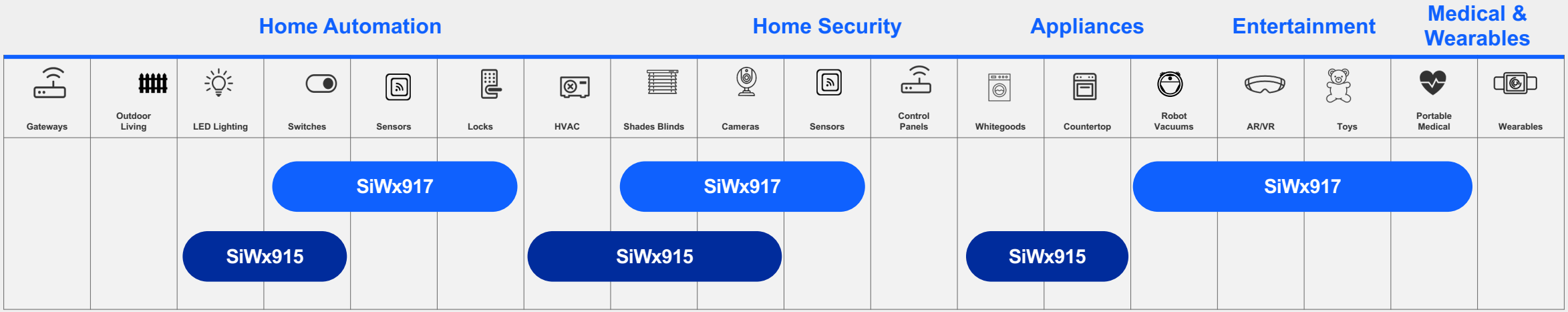
Host-less single chip SoC
- Low RBOM count
- Reduces cost and complexity

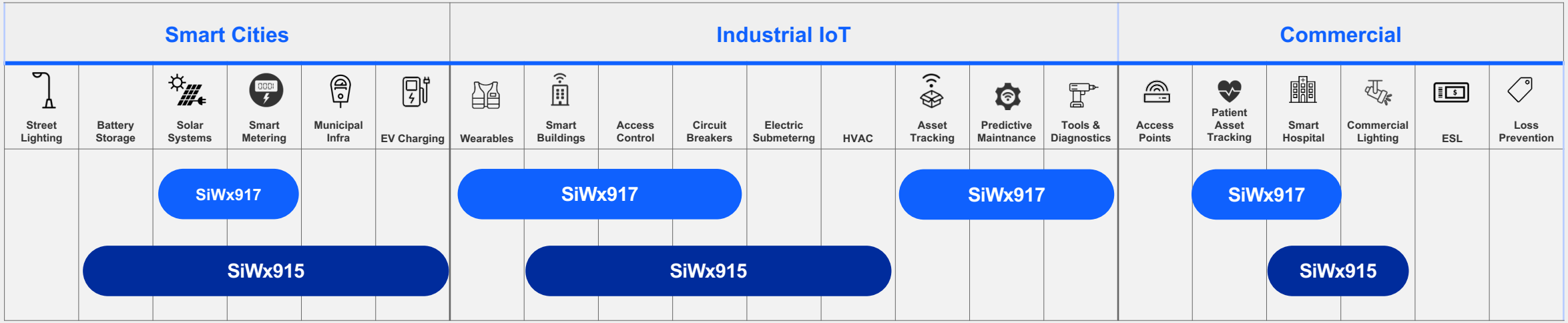
Hosted operation
- RCP – OSD Linux Drivers
- NCP – SPI, SDIO, UART

AI/ML Accelerator
- Faster edge computing

Extended Temperature Range
- -40 to +105 C

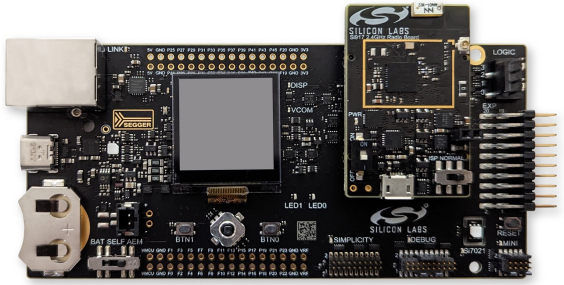
Positioning SiWx917 and SiWx915





SiWx917 SoC Pro Kit Overview

SiWx917
Wi-Fi Radio Board



Pro-Kit Main Board

Supports Standalone SoC Mode

- Example Demo Applications on internal Cortex M4
  - Ultra low power Amazon AWS IoT Cloud Connectivity
  - Advanced Energy Measurement with IDE (SSv5)
  - Matter, Security and AI/ML Examples
  - Peripheral support (Interrupt, I2C, SPI/SSI/SIO, UART/USART, ADC, PWM, GPIO, I2S)
- u.FL for RF measurements/external antenna

SW Development Environment and Support

- Simplicity Studio IDE and Debugger Integration
- Command line interface, Universal Configurator

Documentation

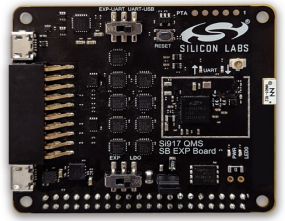
- Datasheet, Getting Started Guide, API and H/W Reference Manuals

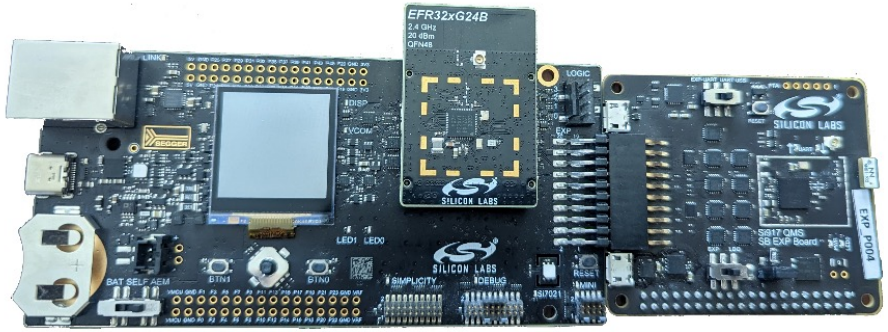
Si917-PK6030A Pro Kit

- Si917-RB4325A (Radio board)
- Si-MB4002A Pro Kit Main board

SiWx917 NCP and RCP Kit Overview

SiWx917
Wi-Fi Expansion Board

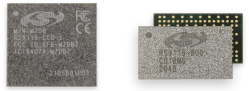




Pro-Kit Main Board
With EFR32 Radio Board

- **Supports NCP and RCP Mode**
  - Example Demo apps on EFR32 as host MCU
    - Bare metal or RTOS based (FreeRTOS or Zypher)
  - Host Interface Support - SPI, UART, SDIO
    - Supports Third Party host MCUs
  - OSD Linux driver available in October
- **Software tools and support**
  - Simplicity Studio Integration
- **Documentation**
  - Datasheet, Getting Started Guide, API Guide
- **Kit OPN**
  - Si917-EX8036A
- **Use with existing EFR32 Pro Kits**

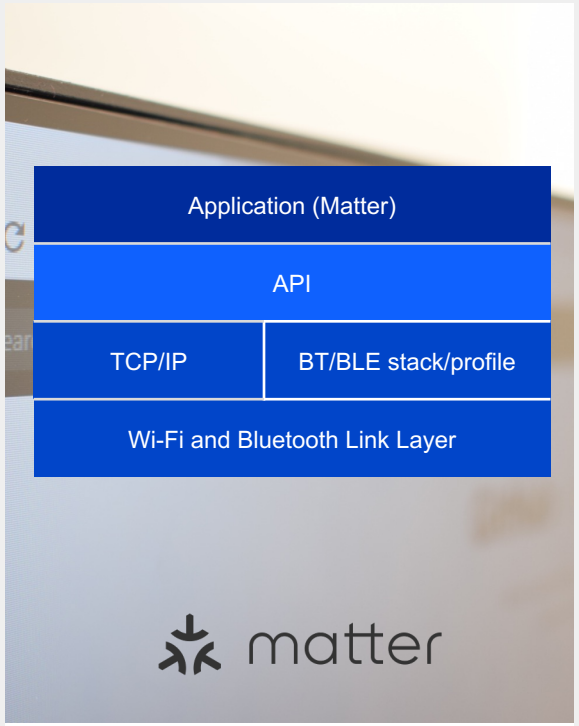
Silicon Labs' Wi-Fi Portfolio Summary

Features	WF200	RS9116	SiWx917	SiWx915
				
Wi-Fi	Wi-Fi 4	Wi-Fi 4	Wi-Fi 6	Wi-Fi 6
BT Low Energy (LE)		✓	✓	✓
BT Classic (w/ Audio)		✓		
Low Power Modes	PS-POLL	PS-POLL, Listen Interval	PS-POLL, Listen Interval, TWT	PS-POLL, Listen Interval, TWT
Wi-Fi Features	OFDM	ODFM	OFDM, OFDMA, MU-MIMO	OFDM, OFDMA, MU-MIMO
Wi-Fi WPA3 Security	✓	✓	✓	✓
Matter over Wi-Fi	✓	✓	✓	✓
Co-processor Modes (RCP, NCP)	✓	✓	✓	✓
SoC Mode (ARM® Apps MCU)			✓	✓
AI/ML Accelerator/pSRAM			✓	
MCU Security (PSA-L2)			✓	✓
Temp range	-40 to +105 C	-40 to +85C	-40 to +105 C	-40 to +85 C
Ultra Low Power		✓	✓	
Modules	✓	✓	✓	✓

Silicon Labs - Complete Solution for Enabling Wi-Fi Products

SOCS AND MODULES

Industry-leading Ultra-Low-Power Wi-Fi 4 and 6 SoCs with pre-certified modules

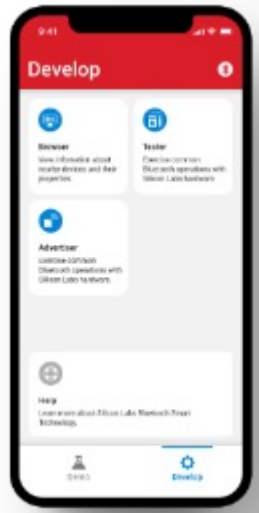


EMBEDDED SOFTWARE

Wi-Fi SDK with Integrated Wi-Fi, BT/BLE, IP networking stacks, Cloud and Matter support

DEVELOPMENT TOOLS

Evaluation Kit hardware plus Studio software to simplify development and speed time to market



MOBILE APPLICATIONS

Readily available EFR Connect app for Wi-Fi Provisioning with Bluetooth Low Energy

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Thank You