2023 tech talks WEBINAR SERIES

Welcome

Wi-Fi 6 Benefits for IoT Applications

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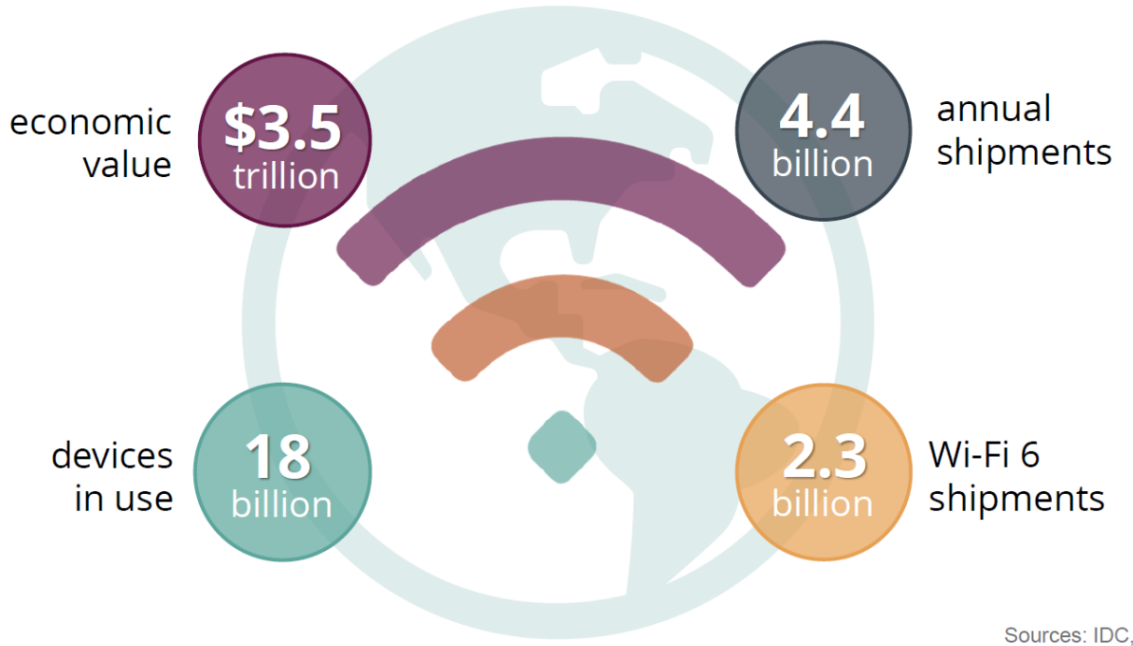
SILICON LABS

Agenda

- Wi-Fi Introduction
- Wi-Fi in IoT – Requirements and Usage
- Why Wi-Fi 6 for IoT?
- Wi-Fi 6 key Features and Benefits for IoT
- Silicon Labs' Wi-Fi Portfolio

Wi-Fi Introduction

Wi-Fi is almost everywhere and expanding



Sources: IDC, Telecom 2021 Study Advisory Services, Wi-Fi Alliance

- **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
- **Newer Wi-Fi will further increase deployment**

Evolution of Wi-Fi

New features in a version

IEEE Protocol	802.11b	802.11a	802.11g	802.11n	802.11ac	802.11ax
WFA Naming	N/A	N/A	N/A	**Wi-Fi 4**	**Wi-Fi 5**	**Wi-Fi 6, Wi-Fi 6E**
Year Introduced	1999	1999	2003	2009	2013	2019, 2021 for 6E
Band(s) (GHz)	2.4	5	2.4	**2.4, 5 (SB or DB)**	5	2.4, 5, **6 (SB, DB, TB)**
Channel Bandwidth (MHz)	20	20	20	20, **40**	20, 40, **80, 160**	20, 40, 80, 160
Allowable Streams	1	1	1	**4**	**8 (only 4 implemented)**	**8**
Max Data Rates (Mbps)	11	54	54	**600** (150 Mbps per stream)	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	N/A	N/A	**Single User (SU-MIMO)**	**Downlink Multiuser (DL MU-MIMO)**	Multiuser (**Uplink** and Downlink MU-MIMO) – 8 Users
Subcarrier Spacing (KHz)	N/A	312.5	312.5	312.5	312.5	**78.125**
Symbol Duration (us)	N/A	3.2	3.2	3.2	3.2	12.8
Guard Interval (us)	N/A	0.8	0.8	**0.4**, 0.8	0.4, 0.8	0.8, **1.6, 3.2**
PHY Modulation	DSSS	OFDM	DSSS, OFDM	DSSS, OFDM, **HT-OFDM**	DSSS, OFDM, HT-OFDM, **VHT-OFDM**	DSSS, OFDM, HT-OFDM, VHT-OFDM, **OFDMA**
Multi-user Operation	No	No	No	No	**(DL MU-MIMO)**	**Uplink and Downlink OFDMA**
Highest Order Modulation	CCK	64-QAM	64-QAM	64-QAM	**256-QAM**	**1024-QAM**
Power Saving Mechanisms	PS-POLL	PS-POLL	PS-POLL	PS-POLL	PS-POLL	**Target Wake Time**
Spatial Reuse Mechanisms	No	No	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 backward compatible

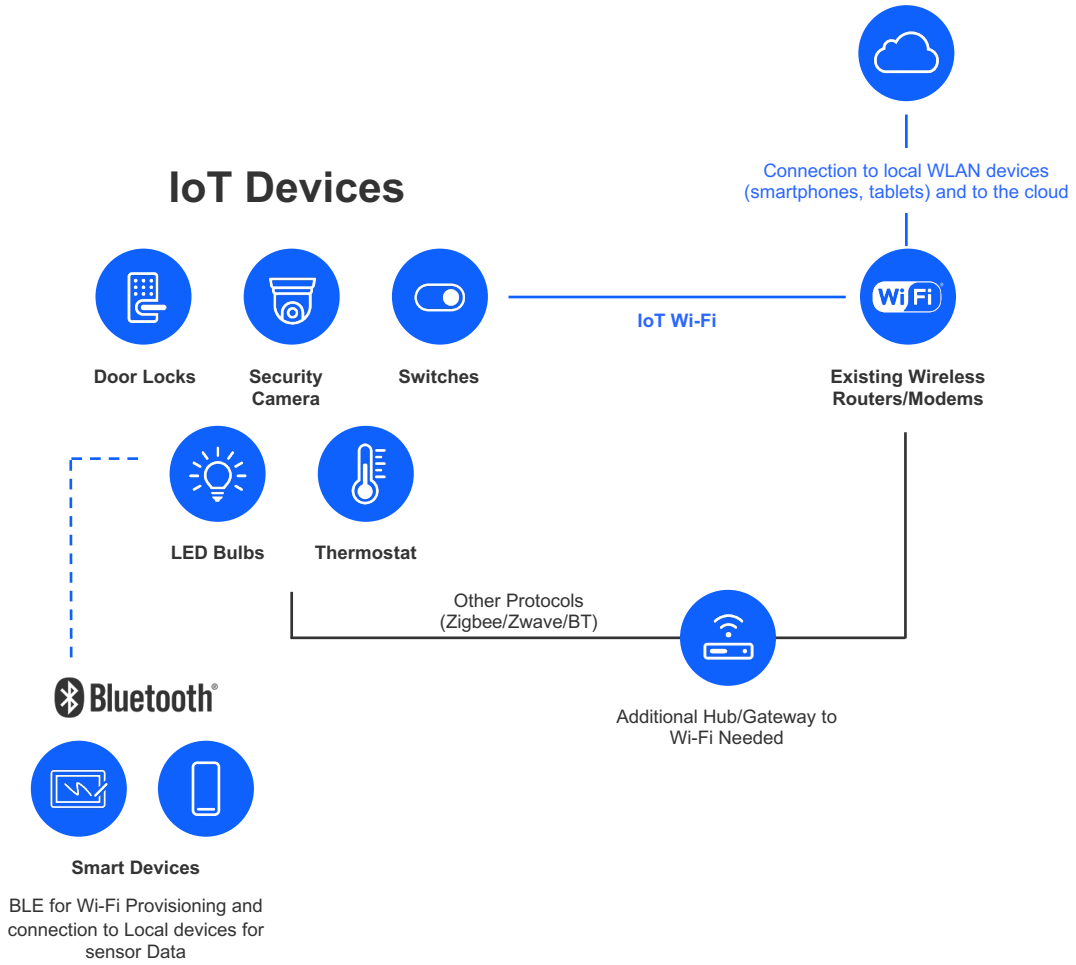
Wi-Fi in IoT

Requirements & How it is used in IoT

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
- **Wi-Fi for IoT is different**
  - Low power consumption
  - Security from online and physical attacks
  - Limited device resources (MCU, memory etc.)
  - Wireless, networking stack integration
  - Cost and size-constrained devices
  - Challenges from crowded RF spectrum
  - Cloud connectivity to multiple cloud providers
  - Coexistence and Interoperability
  - Limited user interface options

Wi-Fi Usage in IoT Applications



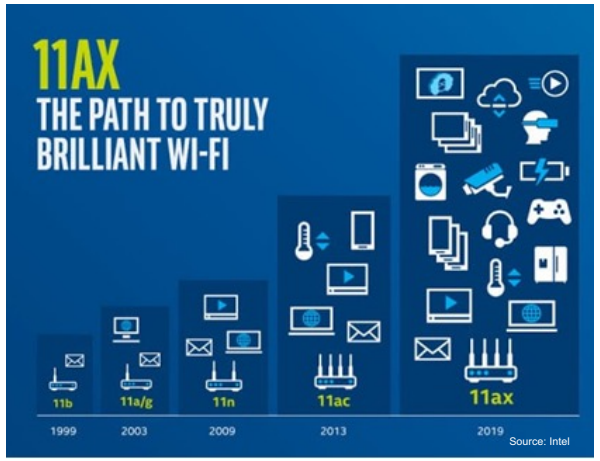
- **Simplified installations and cost reductions:**
  - Use existing Wi-Fi router/modem
  - Native IP protocol for internet communication
  - No additional Hub/Gateway required
- **Extended range, battery life, throughput**
  - Energy efficient and longer range 2.4GHz single-band
  - Power saving capabilities
  - Higher data rate support
- **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

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



Tomorrow with Wi-Fi 6

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

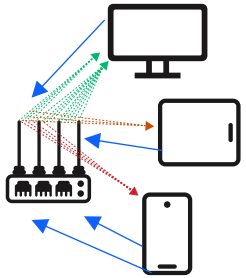
EXTEND BATTERY LIFE
Of client devices

Wi-Fi 6 Key Features & Benefits

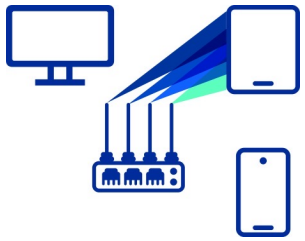
Wi-Fi 6 Key Features and Benefits for IoT Devices

Better Performance

Full Duplex
Multi-User MIMO



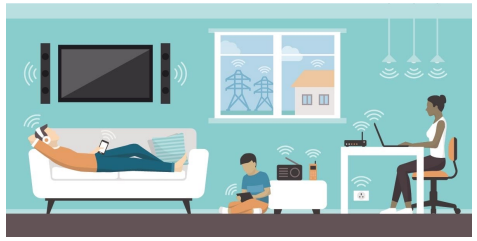
Beamforming



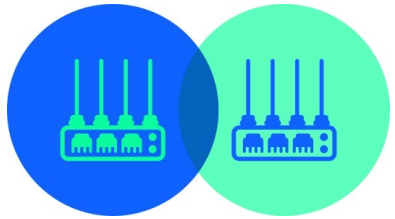
Higher Throughput, Reduced Overhead

Support Denser Environments

OFDMA



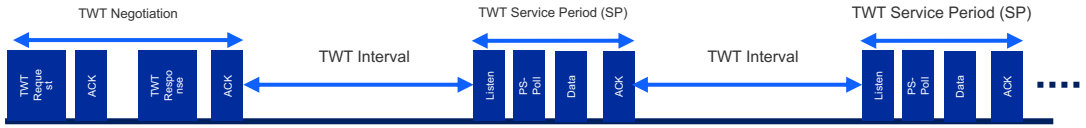
Spatial Reuse,
BSS Coloring



Network Efficiency

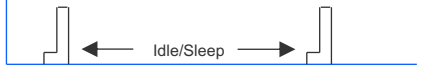
Longer Battery Life

Target Wake Time



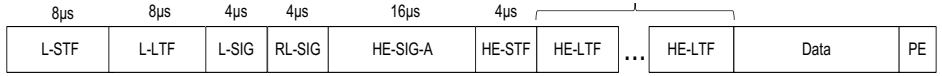
2.4GHz, 20 MHz Channel

BSS Max Idle

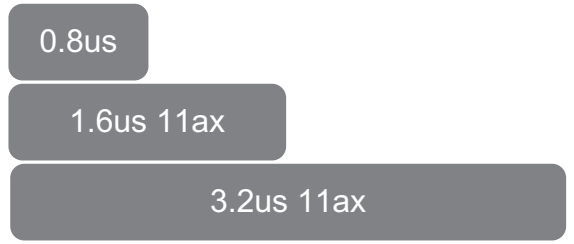


Improved coverage/Longer Range

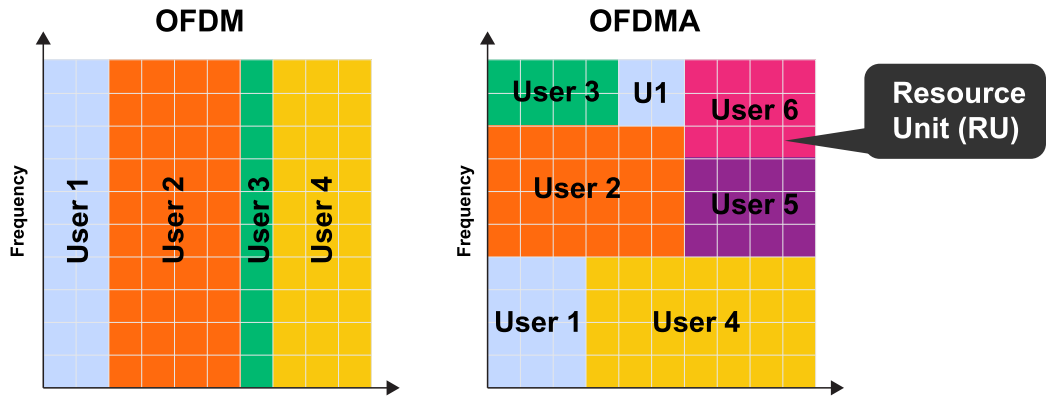
Extended range packet structure

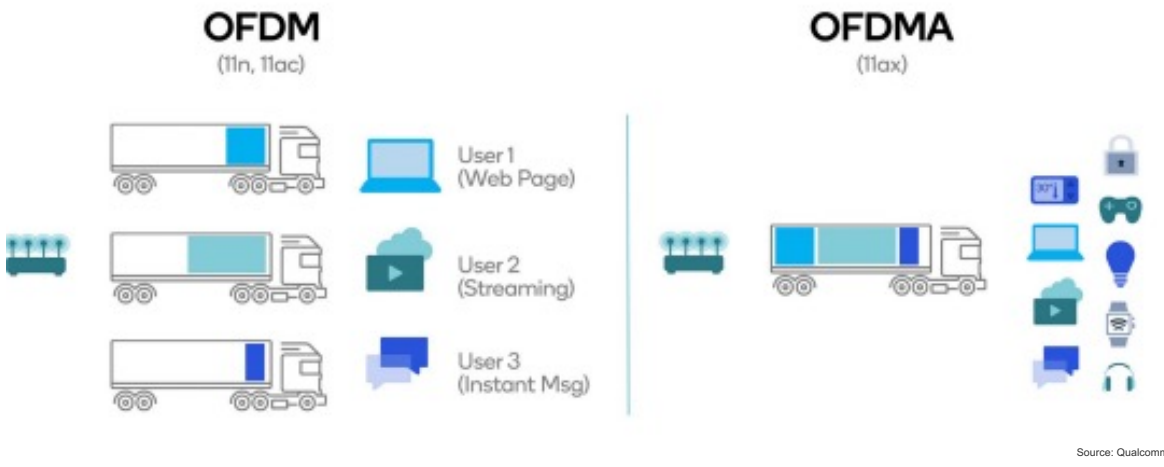


Enhanced delay spread protection-long guard interval



OFDMA vs OFDM: Better Spectral Efficiency and Capacity



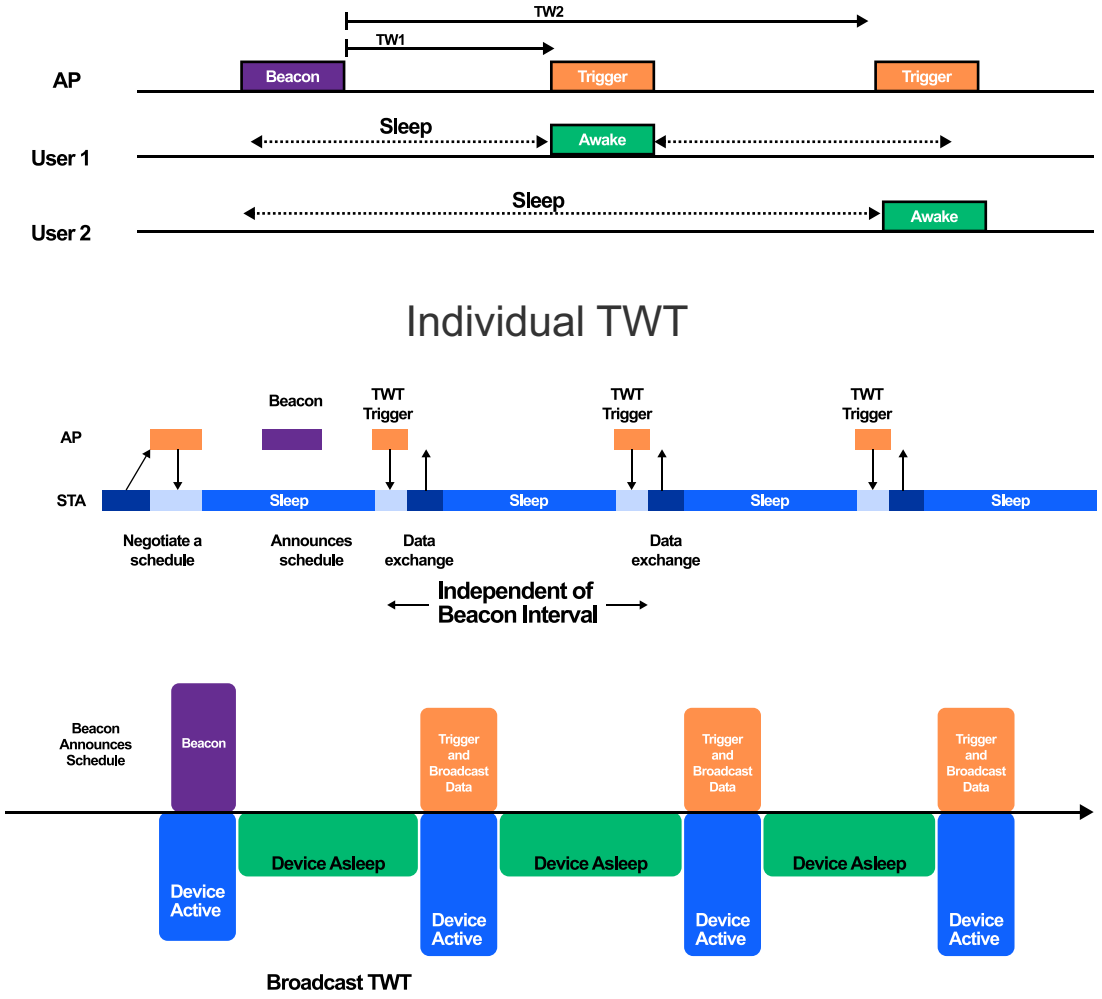


Source: Qualcomm

- **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

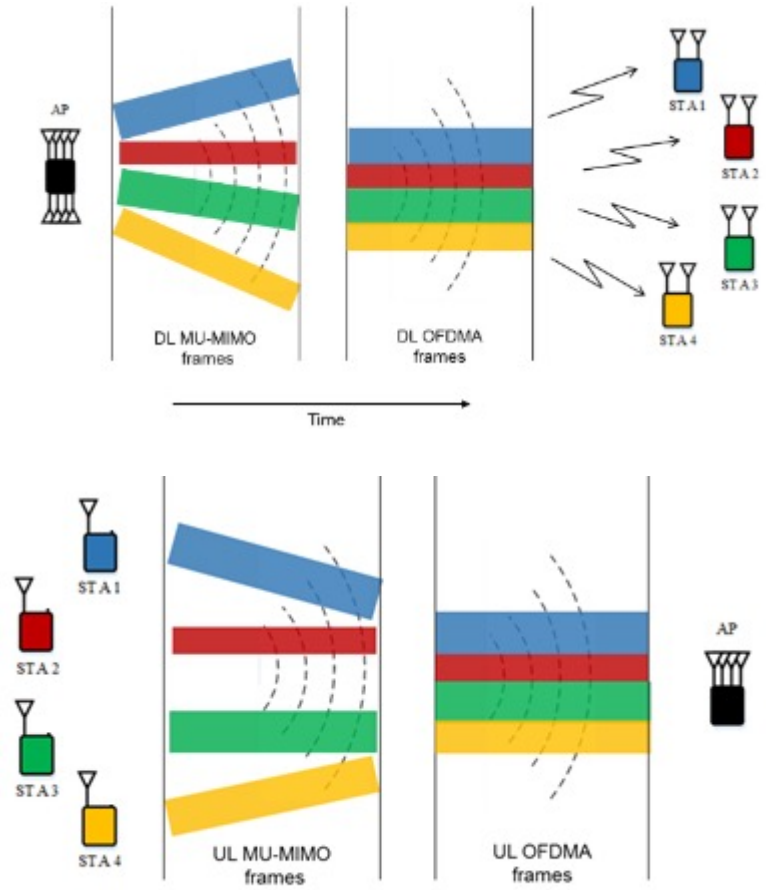
Wi-Fi 6 - Advanced Power-Save for IoT – Target Wake Time (TWT)



- **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)

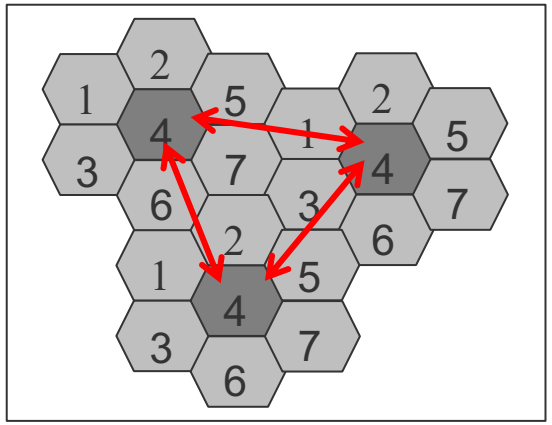


- Wi-Fi 5 introduced MU-MIMO but with only 4x4 downlink.
- Wi-Fi 6 doubled that to 8x8 and added support for Uplink (UL) for both MU-MIMO and OFDMA
- UL allows the stations to send their ACK (or other packets) to the AP simultaneously, saving airtime
- Enables simultaneous upstream and downstream data 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

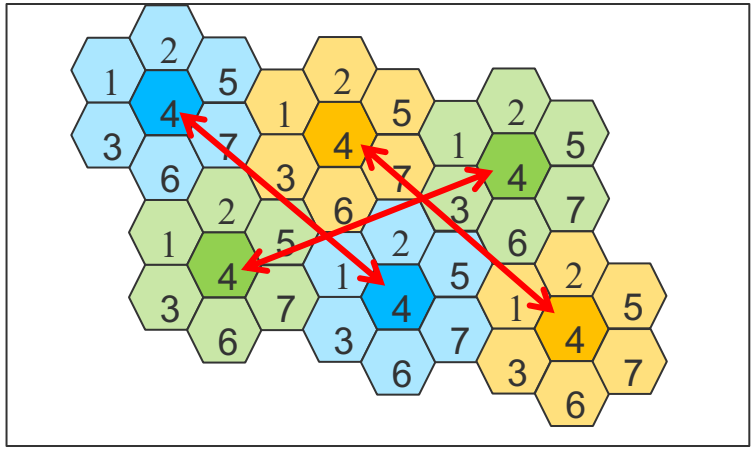
Wi-Fi 6 UL/DL OFDMA and MU-MIMO improve device capacity, network efficiency, range and throughput

Basic Service Set (BSS) coloring enables additional ch (spacial) re-use

All same-channel BSS block



Same-channel BSS only block on Color Match

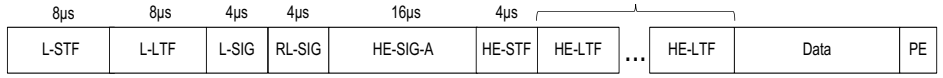


- **What is BSS Coloring?**
  - A subchannel “color” assigned to a Unique BSS (Basic Service Set)
  - Channel is blocked only if color is same
  - Concurrently transmit data to multiple devices in congested areas
- **BSS coloring benefits:**
  - Maximizes network efficiency and performance
  - Reduces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

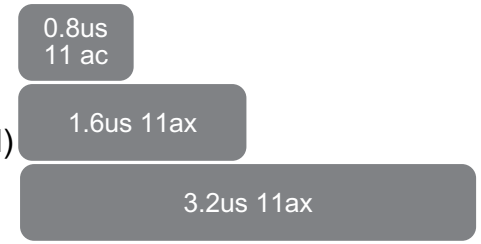
Wi-Fi 6 BSS Coloring improves network performance and reduces device on time – thus better power consumption

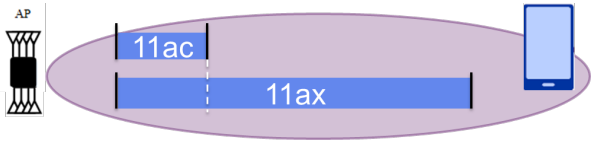
Wi-Fi 6 Range Considerations for IoT

Outdoor / Longer range

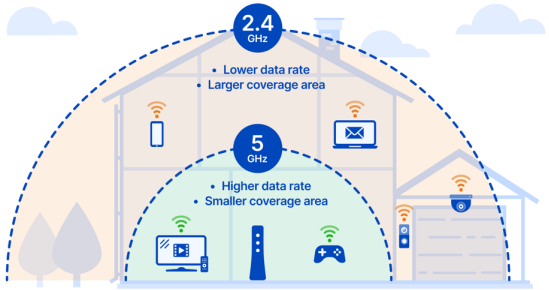


Enhanced delay spread protection- long guard interval Dual Carrier Modulation (DCM)





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

Wi Fi 6 CERTIFIED

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)

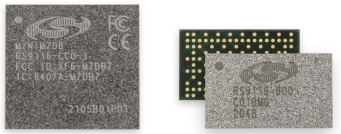
2.4 GHz, 20MHz client support for low power and long range

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

Silicon Labs Wi-Fi Portfolio

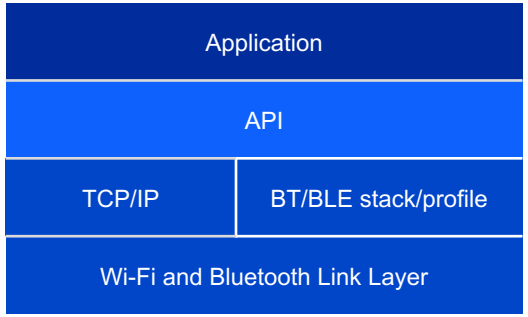
Silicon Labs' Wi-Fi Portfolio Summary

Features	WF200 	RS9116 	SiWx917 
Wi-Fi	**Wi-Fi 4**	**Wi-Fi 4**	**Wi-Fi 6**
BT Low Energy (LE)		✓	✓
BT Classic (Audio)		✓	
Low Power Modes	**PS-POLL**	**PS-POLL, Listen Interval**	**PS-POLL, Listen Interval, TWT**
Wi-Fi Features	**OFDM**	**ODFM**	**OFDM, OFDMA, MU-MIMO**
Wi-Fi WPA3 Security	✓	✓	✓
Co-processor Modes (RCP, NCP)	✓	✓	✓
SoC Mode (ARM® Apps MCU)			✓
ML Accelerator, PSRAM Interface, MCU Security (PSA-L2)			✓
Ultra Low Power		✓	✓
Modules	✓	✓	✓
Matter over Wi-Fi	✓	✓	✓

Silicon Labs - Complete Solution for Enabling Wi-Fi Products

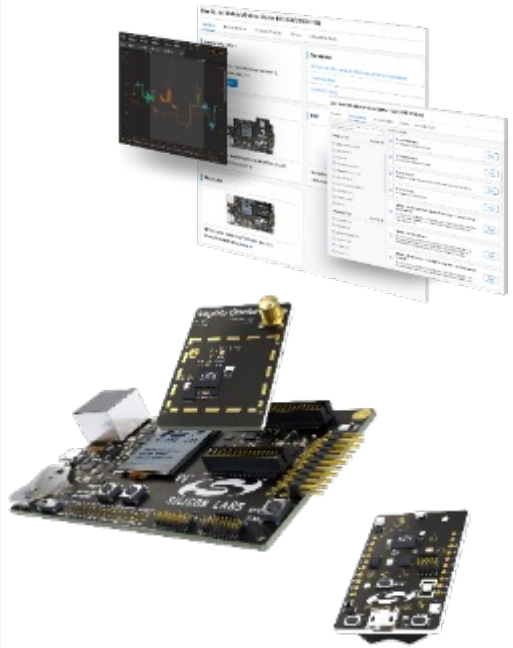
SOCS AND MODULES

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



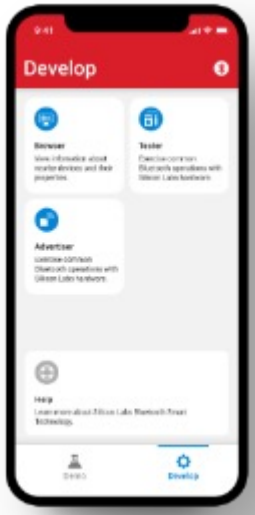
EMBEDDED SOFTWARE

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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WI-FI SERIES

tech talks UPCOMING SESSIONS

FEB 2nd	Wi-Fi 6 Benefits for IoT Applications
MAR 2ND	Designing Low-Power Applications with Wi-Fi 6
MAR 30TH	Fast Track Your Wi-Fi 6 Device Certification
APR 27TH	Design with our New Multiprotocol Wi-Fi Module
MAY 25TH	Building Smart Home Devices with Always-On Wi-Fi 6
JUN 22ND	Developing Wi-Fi 6 Sensors Using SiWx917 and Matter