WI-FI SERIES

Presentation Will Begin Shortly

AUG 22ND-23RD

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

We will begin in: 0:00

SILICON LABS

2023 tech talks WEBINAR SERIES

Welcome

Designing connected Wi-Fi 6 Sensors Using SiWx917 and Matter

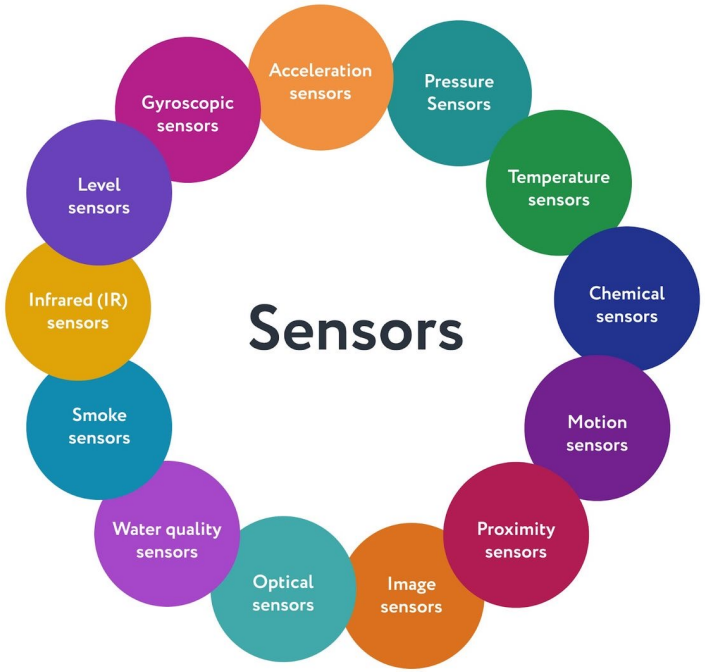
Abhilash Yarragolla

SILICON LABS

Agenda

- Introduction to sensors and key types
- Requirements for Smart IoT sensors
- Wi-Fi 6 key feature review for sensors
- Wi-Fi 6 Power Saving Feature (TWT) for sensors
- Matter benefits for sensors
- SiWx917 ultra low power for battery-based sensors
- SiWx917 features for designing sensors(Sensor hub)
- AI/ML advantages for sensors
- Summary of Silicon labs portfolio
- Q&A

What is a Smart IoT Sensor Device?



SMART BUILDING

SMART HOME

COMMERCIAL

LIFE

INDUSTRIAL

HEALTH & FITNESS

- Sensors are devices that detect and respond to physical or environmental stimuli, real-time, converting them into measurable signals
- These signals are processed allowing for detection of change anomalies or time critical events and used for various applications and notifications (locally or cloud)
- Sensors are widely used for automation, safety and security in industries, smart buildings, commercial, healthcare, Smart Homes, and many other fields
- They enable customizations, optimization of process and help improve productivity, energy and cost savings through automation

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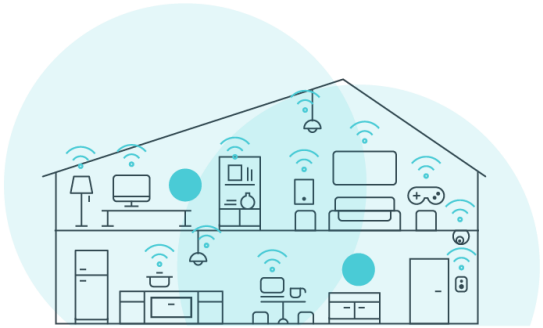
Smart IoT Sensor Requirements



CONNECTIVITY AND RANGE

Wired or Wireless Connectivity

Cloud or local network

Long range – whole home or office

Interoperability

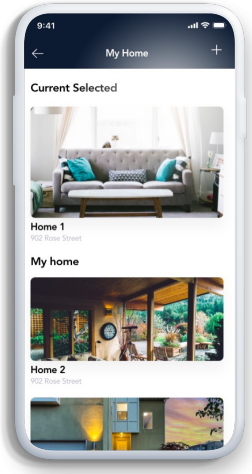
SIZE AND BATTERY LIFE

Small form-factor size designs

Long battery life (months or years)

Limited resources (MCU, memory, etc.)

Lower requirements (lower throughput)



EASE OF USE AND DEPLOYMENT

Easy commissioning of Wi-Fi

Bluetooth for Mobile Phone communication

Use of existing infrastructure

SECURITY AND EDGE COMPUTING

Protect data and user privacy

Edge processing for local decisions

Security from online and physical attacks

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NDA Required

Wi-Fi – Key Enabler in the evolution of the Smart IoT Sensors

- Global Standard – widely deployed interoperable technology
- Proven security
- Existing infrastructure – no specialized gateway required
- Low power capabilities
- Local Network and Cloud Support
- Reliable and long range
- Matter compatible

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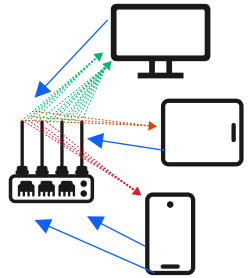
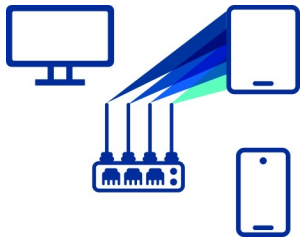
Wi-Fi 6 Key Features and Benefits for Sensors

Better Performance/Connectivity

Full Duplex
Multi-User MIMO



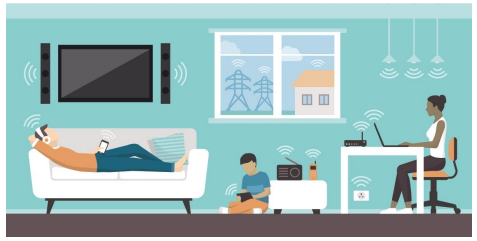
Beamforming



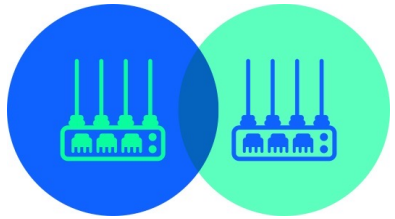
Higher Throughput, Reduced Overhead

Support Denser Environments

OFDMA



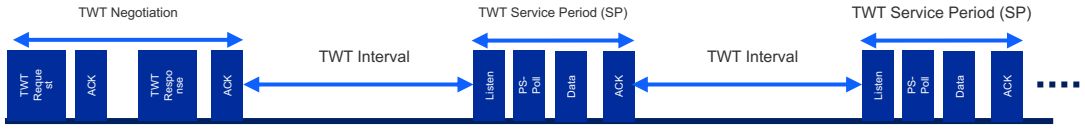
Spatial Reuse,
BSS Coloring



Network Efficiency

Longer Battery Life

Target Wake Time



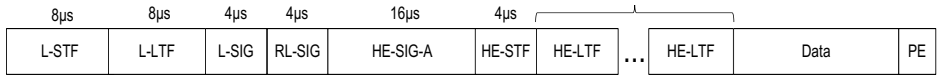
2.4GHz, 20 MHz Channel

BSS Max Idle

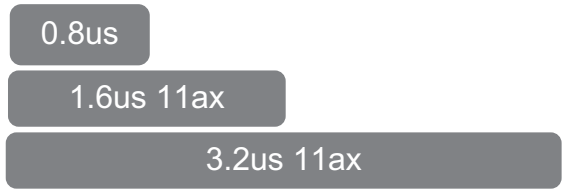
Improved coverage/Longer Range

2.4GHz, 20 MHz Channel

Extended range packet structure



Enhanced delay spread protection-long guard interval



The time is NOW to utilize Wi-Fi 6 for Best Performance and User Satisfaction

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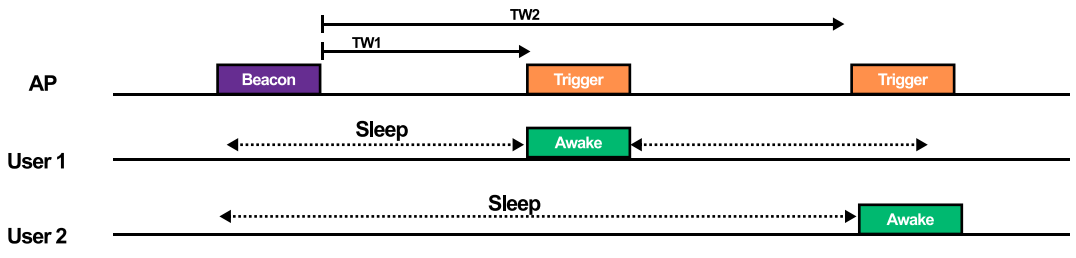
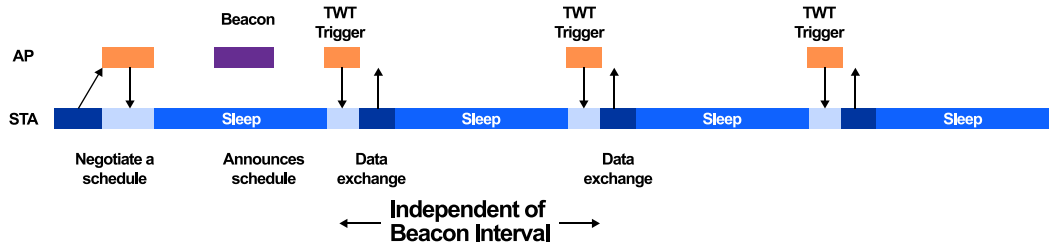
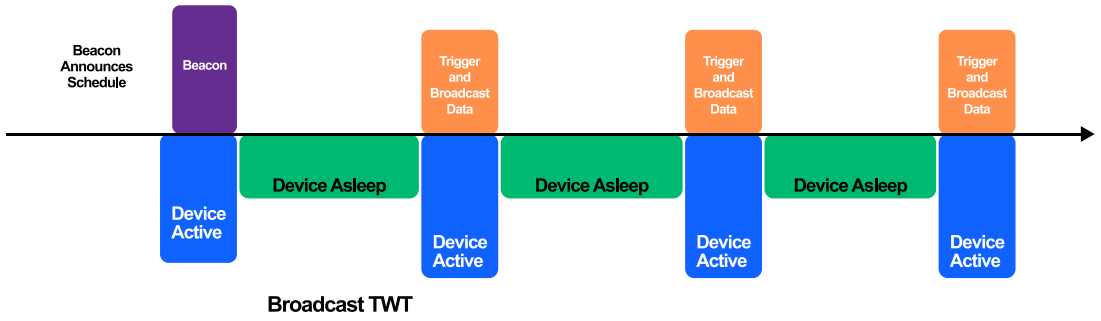
Target Wake Time (TWT)



Individual TWT





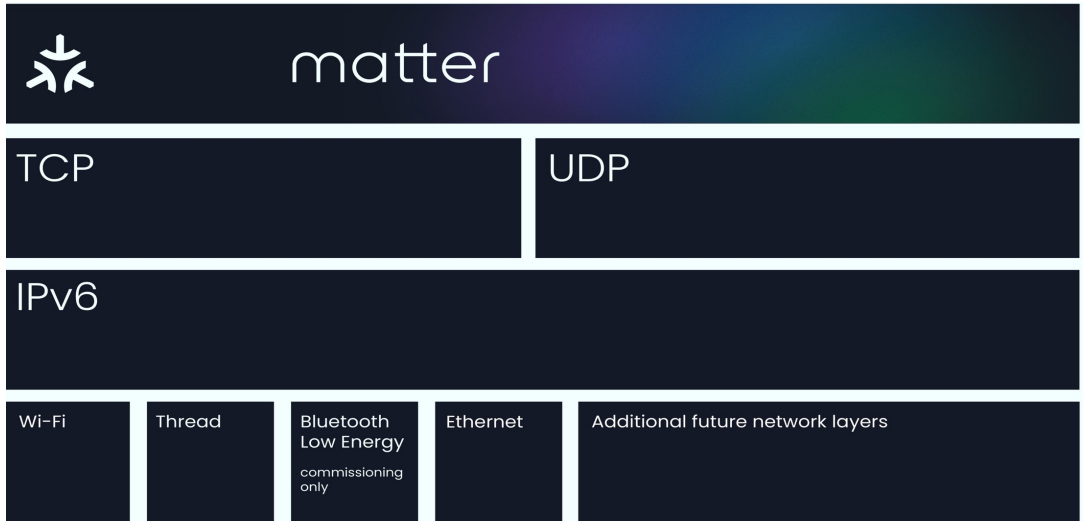
Broadcast TWT

- **TWT enables wireless AP and devices to negotiate and define specific times to access the medium.**
  - Enables devices to determine when and how frequently they will wake up to send or receive data (independent of Beacon)
- **TWT has two methods available**
  - 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**
  - Further reduces power consumption for devices on battery
  - Eliminates interop issues due to client long sleep durations
  - Optimize spectral efficiency by reducing contention
  - Combined with other Wi-Fi 6 features helps significantly reduce power consumption in congested environments compared to previous generation Wi-Fi
- **TWT provides three major benefits**
  - Allows Wi-Fi stations to increase their sleep times
  - Reduces contention between stations by scheduling air usage times.
  - Helps collect information from devices on the network through channel sounding
  - TWT Reduces Congestion in denser environment

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

Matter and its benefits for Smart Sensors

- **What is Matter?**
  - Unified approach to IoT device development.
  - Matter is open-source connectivity standard
    - Smart home and IoT devices, which aims to improve their compatibility and security.
  - An application layer over existing protocols Wi-Fi and Thread
    - Not an entirely new protocol
  - Matter drives the convergence between the major IoT ecosystems
    - Create one easy, reliable, and secure wireless protocol to connect all IoT devices and networks
  - Matter works over Wi-Fi, ethernet, and Thread.
- **Benefits of Matter**
  - Interoperability - With multiple ecosystems like Google, Apple, Samsung, Amazon
  - Security – secure application layer for data protection
  - Simplicity - Ease of use through unified approach
  - Reliability – common and consistent connectivity standard



Simplicity
Easy to use

Interoperability
Devices from multiple brands work natively together

Reliability
Consistent and responsive local connectivity

Security
Robust and streamlined for developers and users

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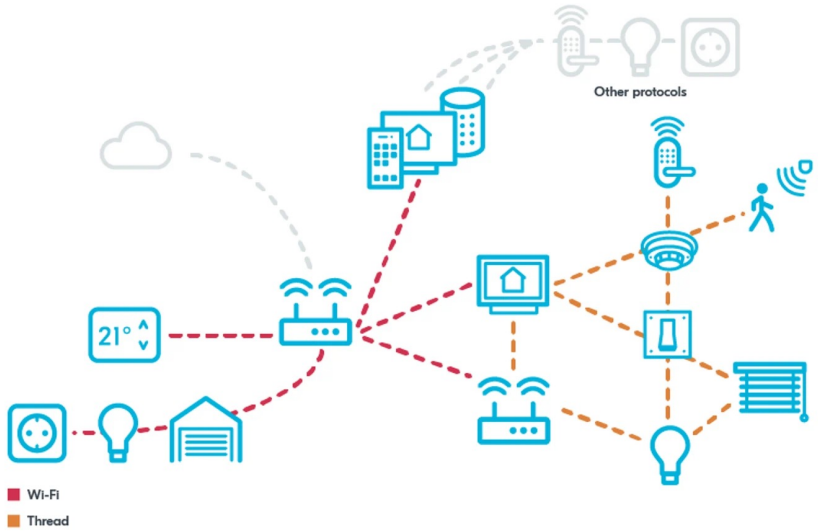
Silicon Labs Wi-Fi 6 IoT Optimized Sensor Solution - SiWx917



Wi Fi 6 + Bluetooth + Thread

Ultra Low Power
Multi Protocol
Secure

- Multiprotocol support Wi-Fi 6 + Bluetooth LE 5.4
- Ultra low power Wi-Fi 6 for long battery life
- Integrated applications MCU, SRAM, FLASH for sensor apps
- Matter support for coexistence with multiple ecosystems
- AI/ML Accelerator for smart edge processing
- Best in class security for sensors via PSA-L2 certifiable security engine
- Robust Interoperability, better coverage and range with 2.4GHz
- Bluetooth LE multiprotocol for easy provisioning
- Single-chip solution to simplify design, reduce cost and speed up time to market

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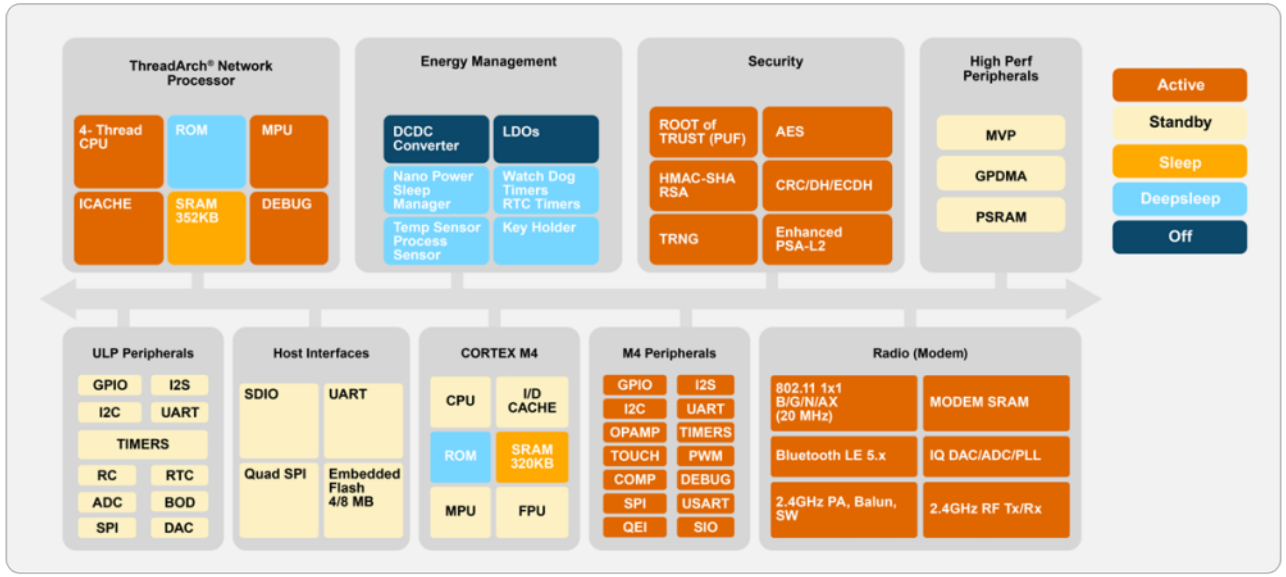
In addition to Wi-Fi 6 - SiWx917 Power Save Capabilities



- Big Little Radio Design (listen/Beacon)
- Dynamic voltage scaling
- Clock Scaling
- High performance and ultra-low-power MCU peripherals and buses
- Hardware based wakeup from Standby/Sleep/Shutdown states
- Using low leakage cells
- Multiple voltage domains
- Fine grained power-gating including buses and pads
- Two integrated buck switching regulators
- Multiple Active states using “gear-shifting” approach based on processing requirements

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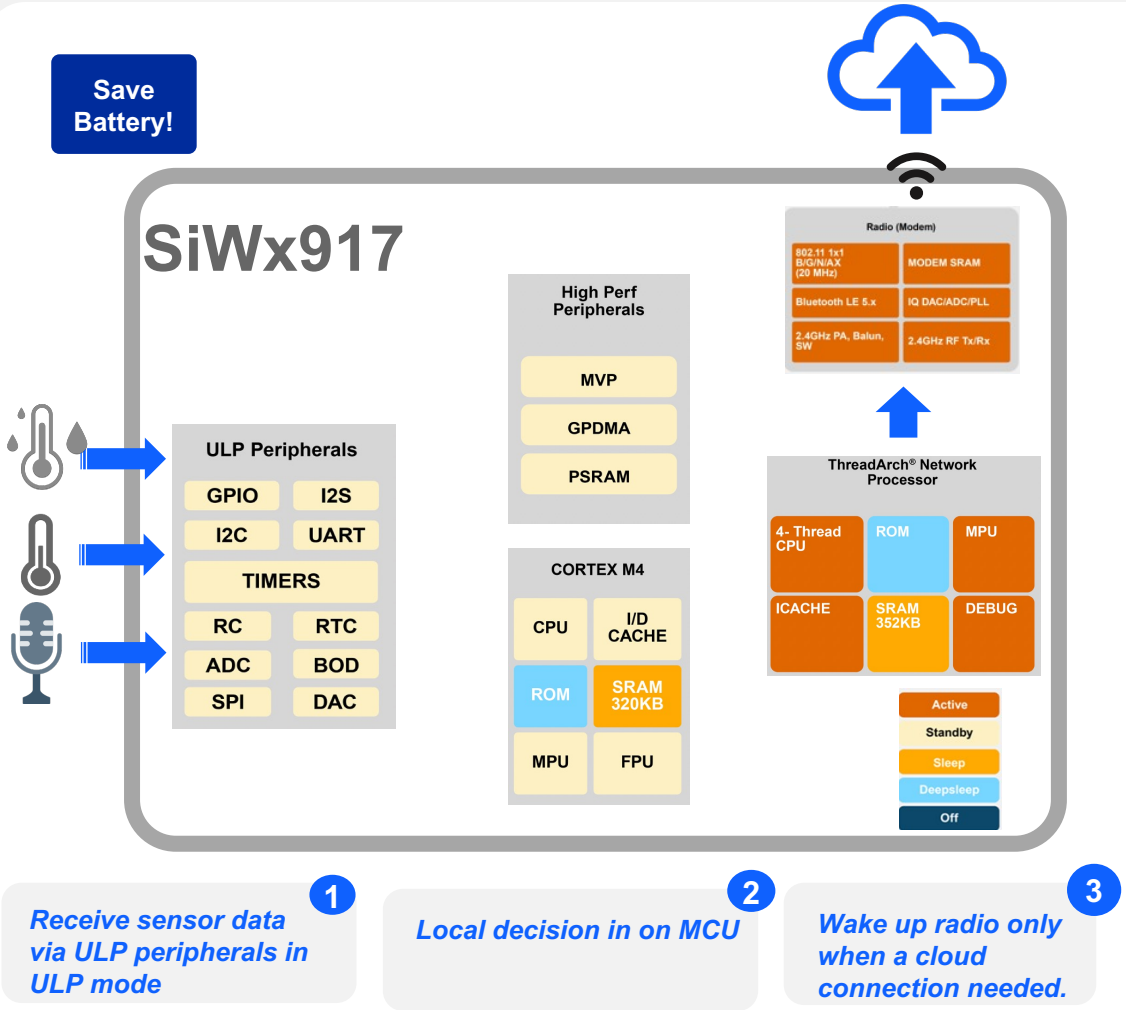
SiWx917 power save architecture with sensors



- Si917 has four major power save modes.

1. **Active mode**
   - There are four power states within active mode PS4-PS1
   - The difference between Power states (PS4/3/2/1) is based on CPU operating frequency, voltages and SRAM availability.

2. **Standby mode**
   - There are three power save states PS4 – PS2 within the standby mode.
   - In this mode and these states, CPU is clock gated and between the three states voltage differs.

3. **Sleep mode**
   - Within sleep mode there are three power save states PS4 – PS2.
   - In this mode and these states, CPU will be power gated & the amount of RAM can be retained varies.

4. **Deep Sleep mode**
   - In deep sleep mode, CPU & RAM is power gated.

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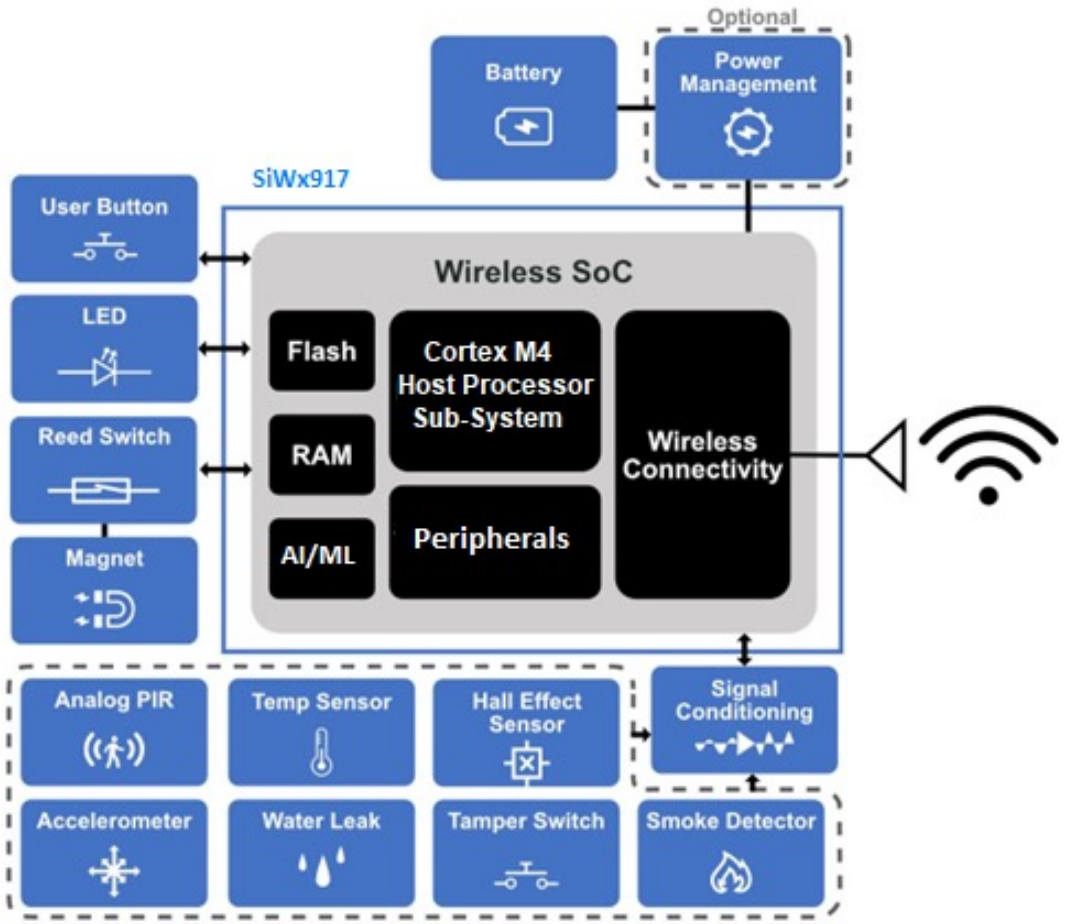
SiWx917 features for designing Sensors (Sensor hub)



- Sensor Hub is a sensor management component
- Sensor hub aids in processing and integrating data from several sensors.
- It assist in off-loading various tasks from a product's primary core, reducing energy consumption and enhancing performance.

- The Sensor Hub address low power and high-performance sensor applications

- Decouple the software dependencies from peripheral drivers and sensor drivers.

- Reduce complex sensor implementations

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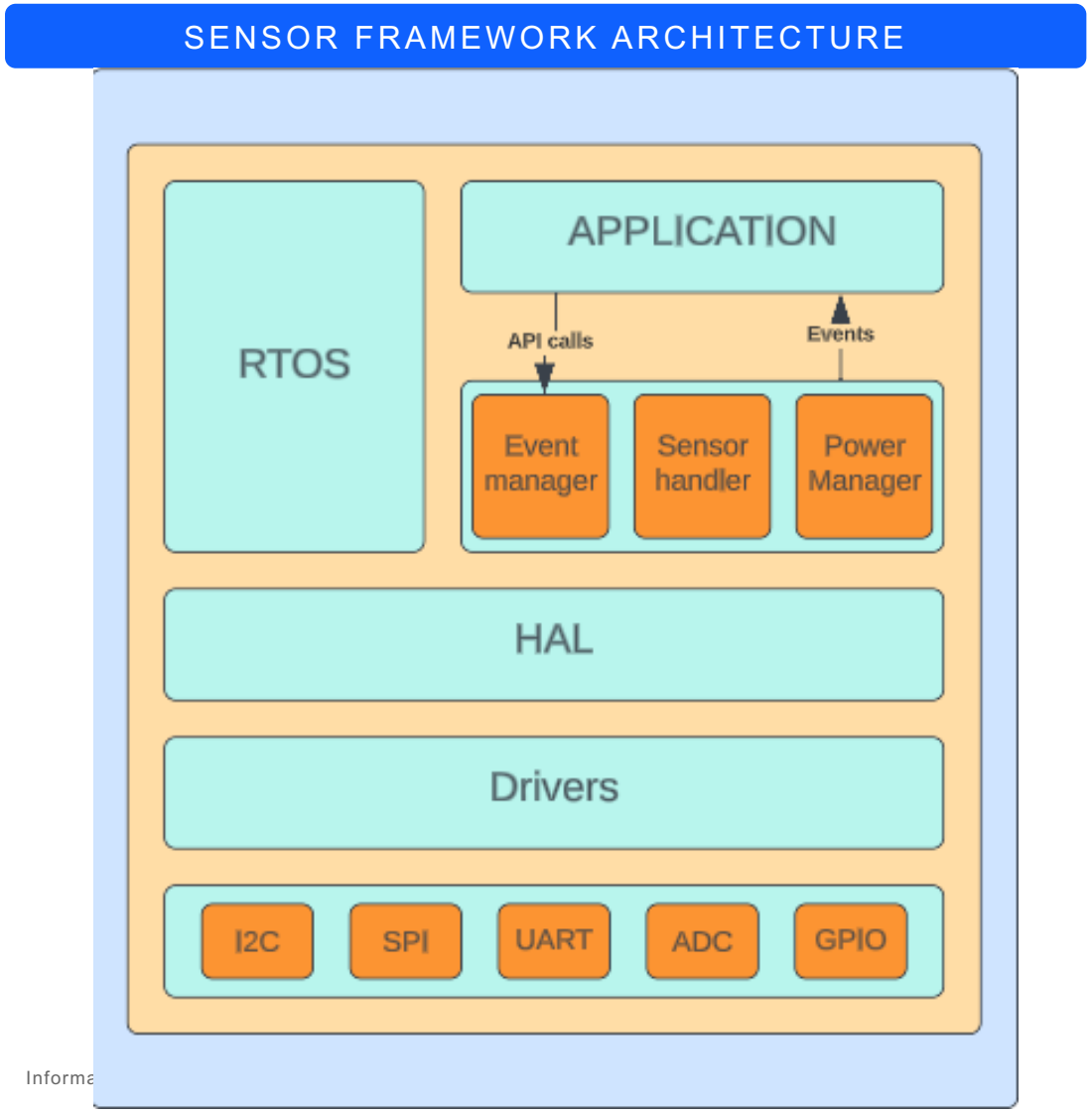
SiWx917 Sensor framework Architecture



Framework and API for efficient management and allocation of ULP memory

- Sensor Data RAM mapped to ULP memory
- API to confirm RAM is available

Sensor Implementation utilizes the HAL

HAL interface for all developer defined sensors

Sensor_Hal.c file stores the information of the HAL

- **Three Data Attributes (when the Sensor Hub should hand over the data to the application)**
  1. Based on user defined threshold for that specific sensor
  2. Time out
  3. Number of samples
- **Data Attributes created and maintained for each individual sensor**

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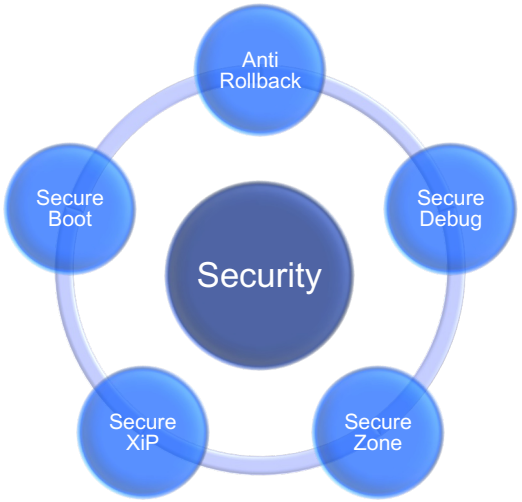
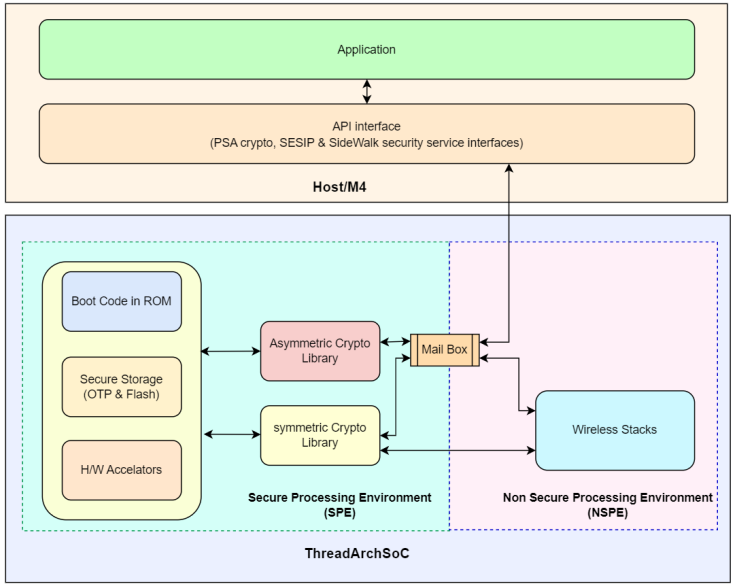
SiWx917 Security Features for Sensors

- **Secure Boot**
  - Authenticate flash contents, Wireless and MCU firmware based on digital signature, MIC before booting based on device configurations.
  - Flash Image can be encrypted and authenticated using signatures.
- **Anti Rollback**
  - When enabled, downgrading of the firmware to a lower version will not be allowed.
- **Secure Debug**
  - Wireless and MCU debug ports are disabled by default in hardware
  - Debug ports can be enabled in software using host interface commands based on token exchange between an authorized host and bootloader
- **Secure Zone**
  - Logically idea is similar to Secure Vault implementation(barrier between secure and non-secure stuff)
  - **Access to memory and hardware registers to security processor is disabled from external devices including On Chip M4 processor.**
- **Secure XIP**
  - Images are saved in encrypted format and decrypted using PUF intrinsic keys specific to each device while executing.
  - Key holder holds PUF keys
  - In-line decryption based on-the-fly AES engine(based on PUF keys)
  - Supported modes: XTS & CTR





Why AI/ML for sensors at the Edge?

Low Latency Required

- Mission or safety-critical applications require real-time reactions
- Large data to process - typically at vision use cases - no time to upload to anywhere to process

Privacy and IP Protection, Security

- Data never leaves the sensing device, only inference result/metadata is transferred
- Less sensitive data to transmit, less chance to be hacked
- Protecting IP

Bandwidth and Power Constraints

- Long range, low power, and slow networks can't transfer all TimeSeries data to process somewhere else
- Overloading of mesh network is an issue
- Large data to chunk
- Process vs. transmit tradeoff in power cons.

Offline Mode Operation

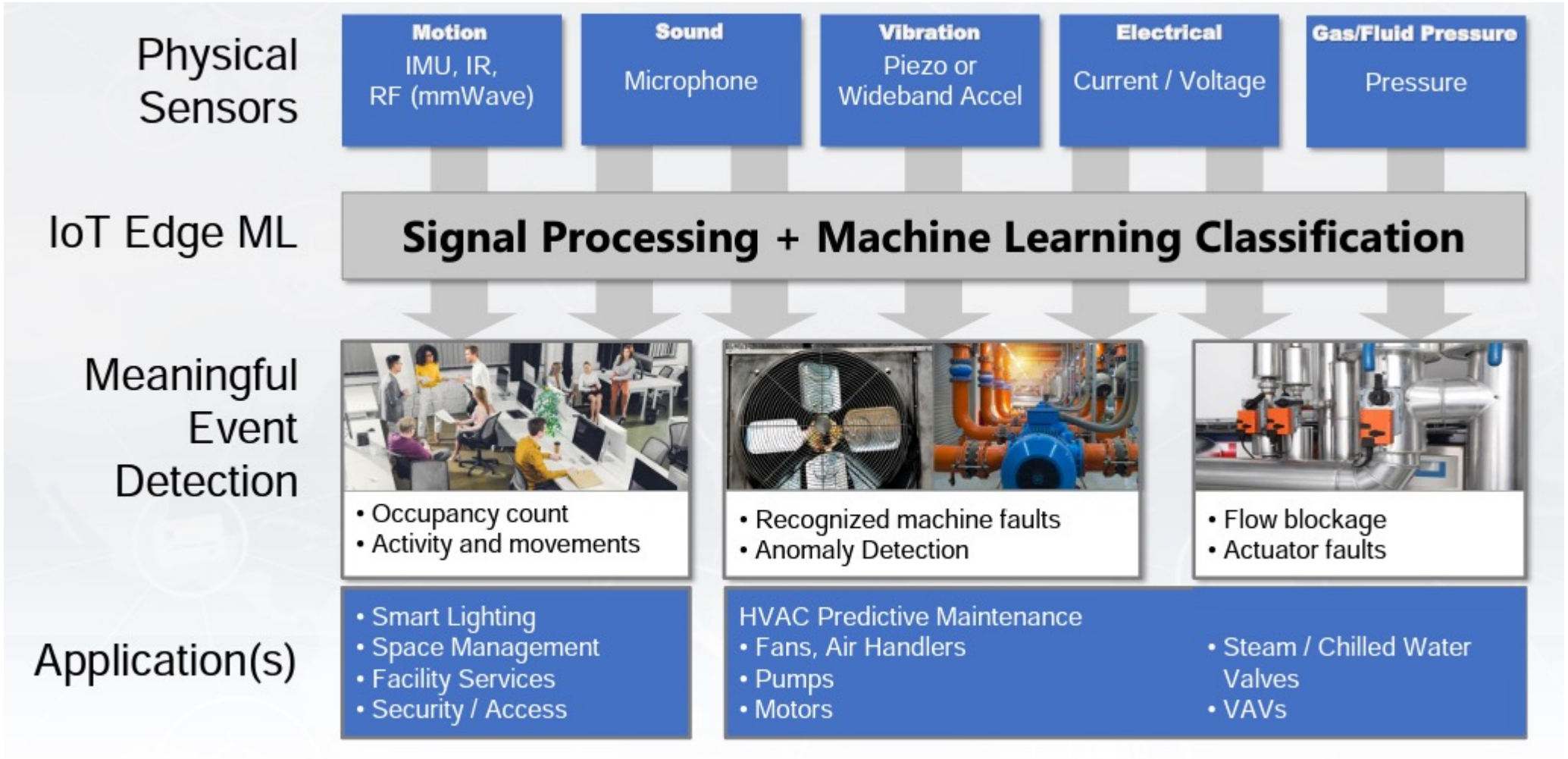
- Local system keeps operating standalone in case of any network issue
- Connectivity is occasional or blocked by admin

Cost Reduction

- Network and infrastructure costs
- Data ingestion costs
- Data storage costs
- Cloud services
- Ops, maintenance
- Compact edge with ML solutions integrated to wireless SoC

Data processing is more efficient with AI/ML at the Tiny Edge – various new use cases enabled

Use Cases for AI/ML on the Edge in Predictive Maintenance



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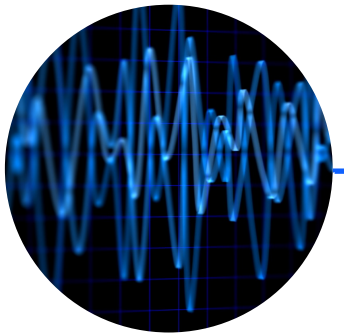
Event Detection using Machine Learning

Sensors
- Acceleration, Temperature, Current/Voltage
- Time-series data on ADC or GPIO

ML methods based on Time-series Data
- Data anomaly detection
- Data pattern matching



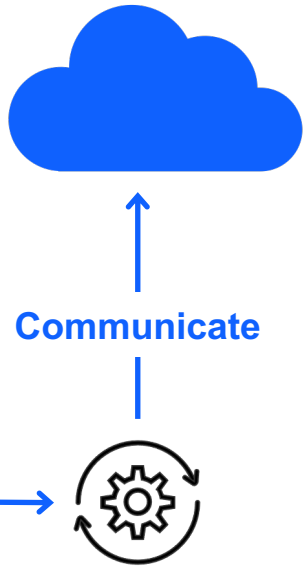
Microphones

Analog or Digital
- Audio mic array with beamforming
- Audio mic input with Audio Front End, DSP

ML methods based on Audio
- Audio pattern matching (ex. glass break)

ML methods based on Voice
- Wake word/command word detection

Event Detection



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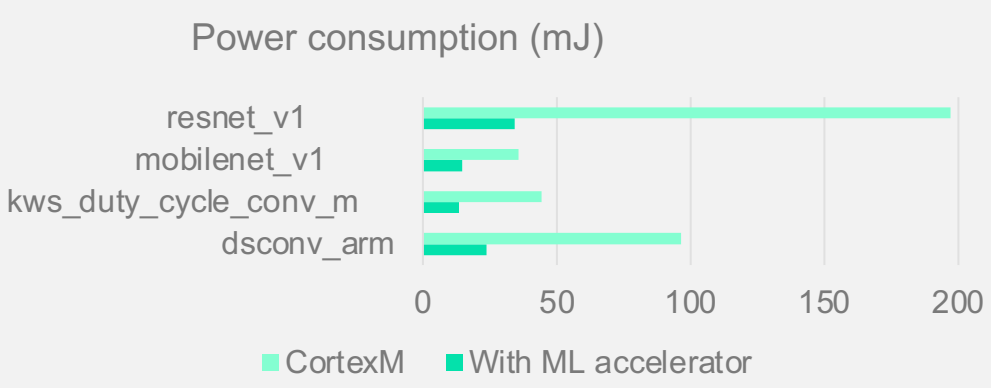
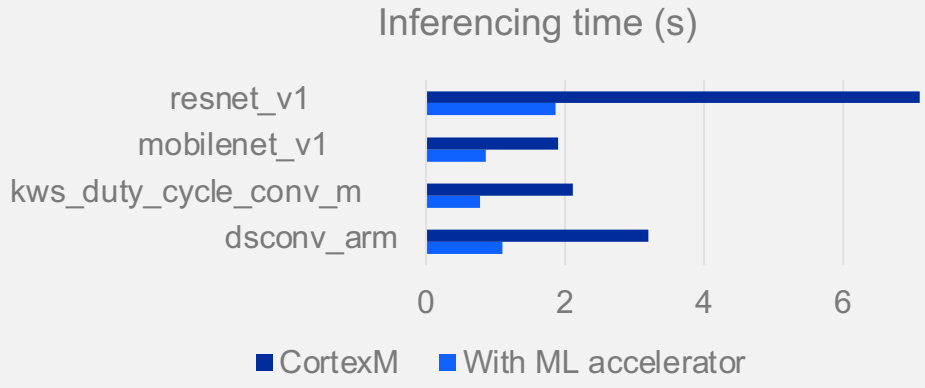
AI/ML Hardware Accelerator

- Dedicated **ML computing subsystem** next to the CPU
- Optimized Matrix Vector Processor (MVP) accelerates ML inferencing with a lot of processing power, **offloading the CPU**
- **Real and complex data**
- **2-8X faster** inferencing over Cortex-M
- Up to **6X lower power** for inferencing

- Benefits of processing AI/ML in device
- Lower power
- Save bandwidth
- Lower latency
- Ensure Privacy
- Higher Security
- Lower Cost

Inferencing with ML hardware accelerator vs. CortexM*





Internal performance benchmarking with standard ML models. Results are for inferencing only (not for the complete application)

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Software and Tool Support for ML

ML Expert

Python scripts and tutorials

SILICON LABS
Machine Learning Toolkit*

siliconlabs.github.io/mltk

TensorFlow

TFLite Flatbuffer

TFLite-micro Interpreter

CMSIS-NN Kernels | Silicon Labs HW-based Kernels

Cortex M | MVP (NPU)

ML Explorer

GUI Developer Tools

EDGE IMPULSE

edgeimpulse.com

SensiML™

sensiml.com

TFLite-micro Interpreter

CMSIS-NN Kernels | Silicon Labs HW-based Kernels

Cortex M | MVP (NPU)

ML Solutions

Solution Libraries

Wake Word / Voice Command — sensory

sensory.com

Anomaly Detection — Micro.ai

micro.ai

System Integrators

KLIKA·TECH GLOBAL IOT SOLUTIONS

4IZIP

AITAD

Talent·Technology·Solutions Bellintegrator

Cortex M (& MVP)

*Machine Learning Toolkit is public but pre-alpha release

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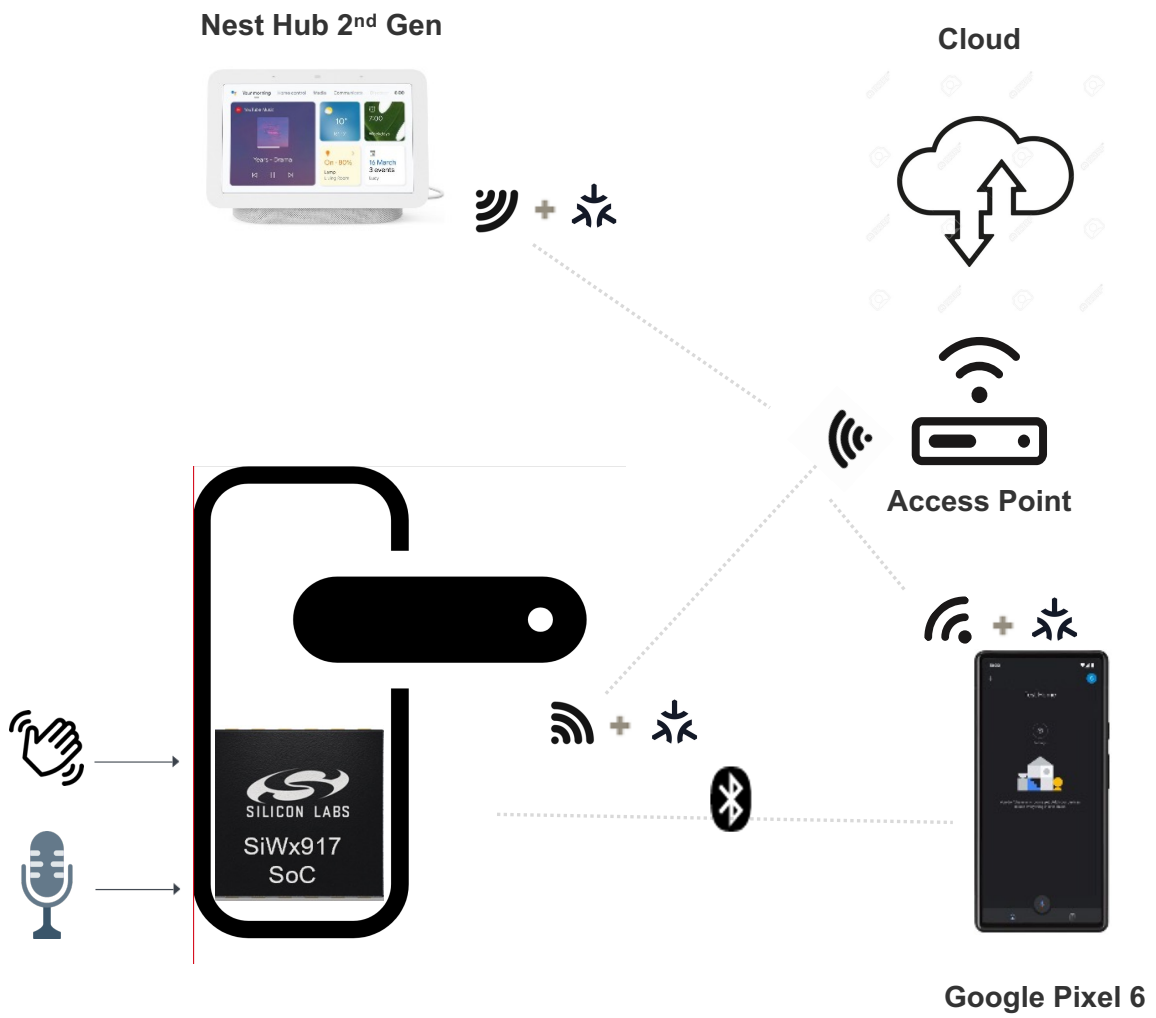
SiWx917 use case with sensors using Matter



Sensor use case with SiWx917

- BLE commissioning to connect SiWx917 to AP connected to cloud.
- Integration of sensors for image, voice, object detection. The input from the sensors is processed in AI/ML Edge Hardware Accelerator to notify the user about the activity.
- Status of the Device is updated to the cloud over MQTT using Wi-Fi.
- Matter node (Si917) work reliably together with Google Home, Samsung SmartThings, Apple Home, or Amazon Alexa over Matter.

Optimal Wi-Fi 6 SoC solution for longest battery life secure cloud connected IoT sensors (devices)

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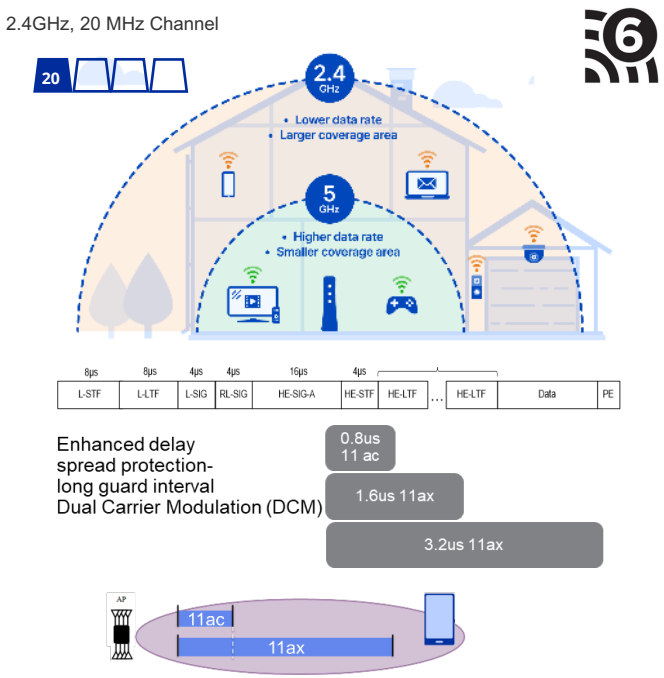
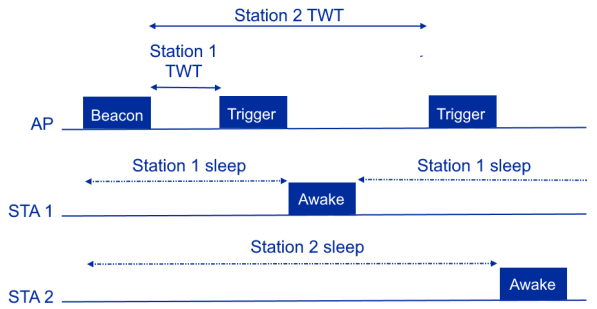
SiWx917 Key benefits for IoT Sensor: Long Range & Battery Life



EXTENDED RANGE

Achieve whole home coverage including the yard

- 2.4GHz Long Range - better penetration through walls
- Longer guard interval to handle echoes from further away objects
- Extended range packet format - some fields are boosted by 3dB



LONG BATTERY LIFE

TWT helps Reduce unplanned replacing of batteries

- Allows devices to schedule their wake-up times and reduce unnecessary communication with AP
- Reduces power consumption and increases battery life significantly

SiWx917 power save enhancements helps to further lower current consumption.

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SiWx917 Benefits for IoT Sensor: Easy & Secure

EASE OF INSTALL

Optimal user experience

- Bluetooth Low Energy-based commissioning options.
- BLE used for sensor connectivity and easy provisioning of IoT devices in the home.
- Improve user experience and interoperability with the new Matter protocol

SECURITY AND EDGE COMPUTING

Protect user privacy

- Uses latest WPA3 for Wi-Fi security
- Secure boot with Root of Trust , Secure XIP, Secure zone.
- SiWx917 SoC supports best in class security (PSA Level 2 Certifiable)

Efficient Edge processing

- AI/ML hardware accelerator - MVP

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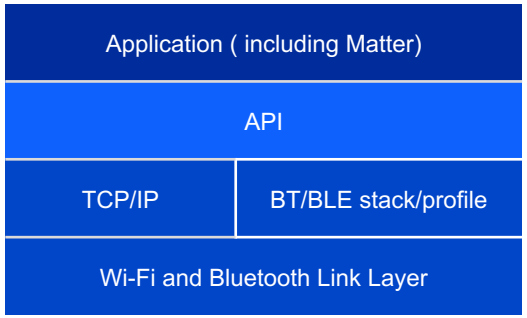
Silicon Labs - Complete Solution for Enabling Wi-Fi Products

SoCS AND MODULES

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

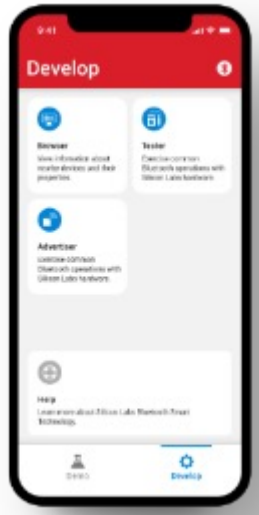


EMBEDDED SOFTWARE

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

DEVELOPMENT TOOLS

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



MOBILE APPLICATIONS

SiWx917 Connect for Wi-Fi Provisioning using BLE

Q&A

SILICON LABS

WI-FI SERIES

Presentation Will Begin Shortly

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

2023 tech talks
WEBINAR SERIES

Thank You

Watch ON DEMAND