Tech Talks Schedule – Presentation will begin shortly

tech talks

Tuesday, May 17	**AI/ML: Bringing Intelligence to the Edge on the MG24**
Tuesday, May 31	Matter: Securing your IoT devices
Tuesday, June 14	Wi-Fi: Coexistence with RS9116

We will begin in: 0:00

SILICON LABS | tech talks

Welcome

AI/ML: Bringing Intelligence to the Edge on the MG24

Andy Halstead

The Leader in IoT Wireless Connectivity

100%
IoT Focused

Bluetooth · Multiprotocol · Proprietary
THREAD · Wi Fi · Wi SUN · zigbee
Z-WAVE · amazon sidewalk · matter
Breadth and Depth of Wireless IoT Protocols

#1
Share in Mesh

1st
To Market with Multiprotocol, BLE Mesh, BLE 5.1

Innovation
Performance, Power, CoEx, Modules, SecureVault™

ember	ENERGY micro	bluegiga	telegesis	Micrium	ZENTRI	Z-WAVE	REDPINE SIGNALS
2012	2013	2015	2015	2016	2017	2018	2020
Software ZigBee SoC	Low-power 32-bit MCUs	BT Smart Modules	ZigBee/Thread Modules	Software RTOS	Cloud Connected Wi-Fi	Smart Home Protocol	Ultra Low Power Wi-Fi

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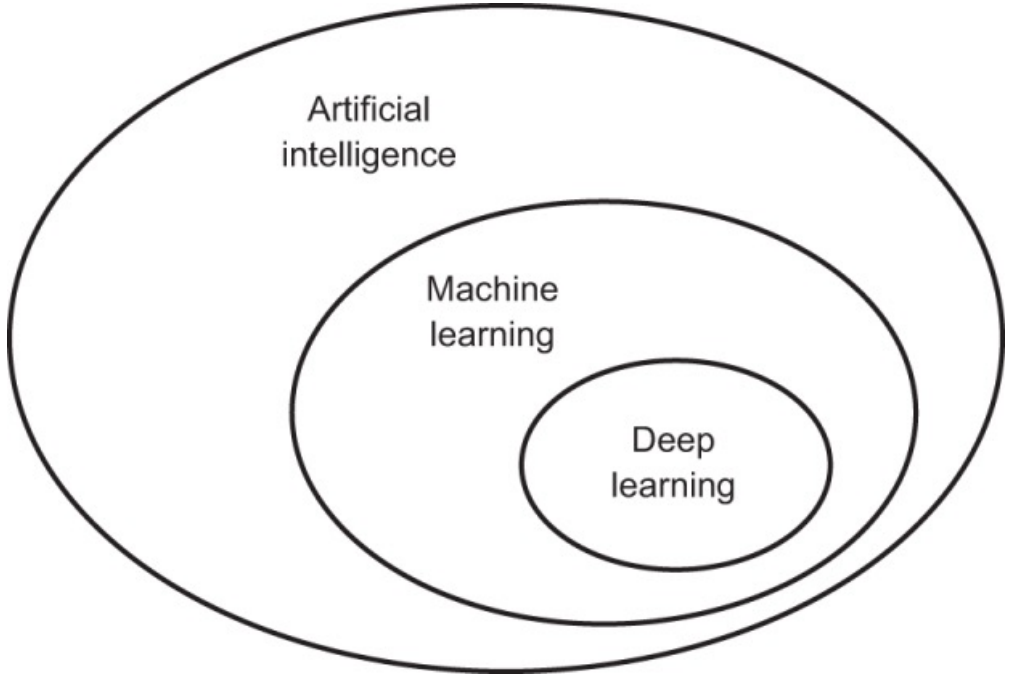
Artificial Intelligence, Machine Learning, and Deep Learning.

- AI can be broadly defined as the effort to automate intellectual tasks normally performed by humans
- Encompasses ML and DL but also includes other approaches that do not involve learning
- AI Circa 1950s-1980s: Heuristics-based, uses set of explicit rules to manipulate knowledge
- Rules-based approach often does not work: it is intractable to figure out rules for many types of problems



Where is the drivable lane?

- **A rules-based approach: intractable problem**

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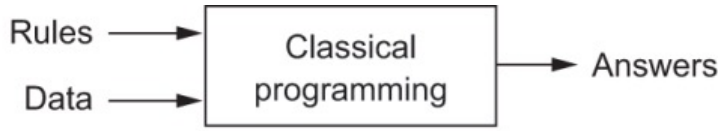
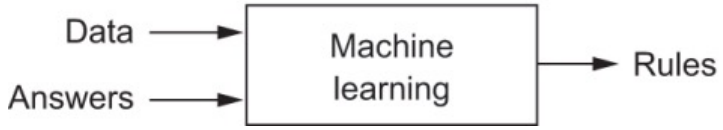
Machine Learning

- **Machine Learning model is trained rather than explicitly programmed with rules**
- **During training model is presented with many examples relevant to a task**
- **Model finds statistical structure in these examples and comes up with rules for automating the task**



Classical programming paradigm:
humans write “code” (encode rules into bits)



New programming paradigm:
algorithm writes “code” based on I/O specification

- **ML: automated discovery of rules to execute a data processing task given examples of what is expected**
- **ML algorithms are based on calculus and linear algebra**
- **Inference: transformation of new input data into meaningful outputs (by trained algorithm) = PERCEPTION**

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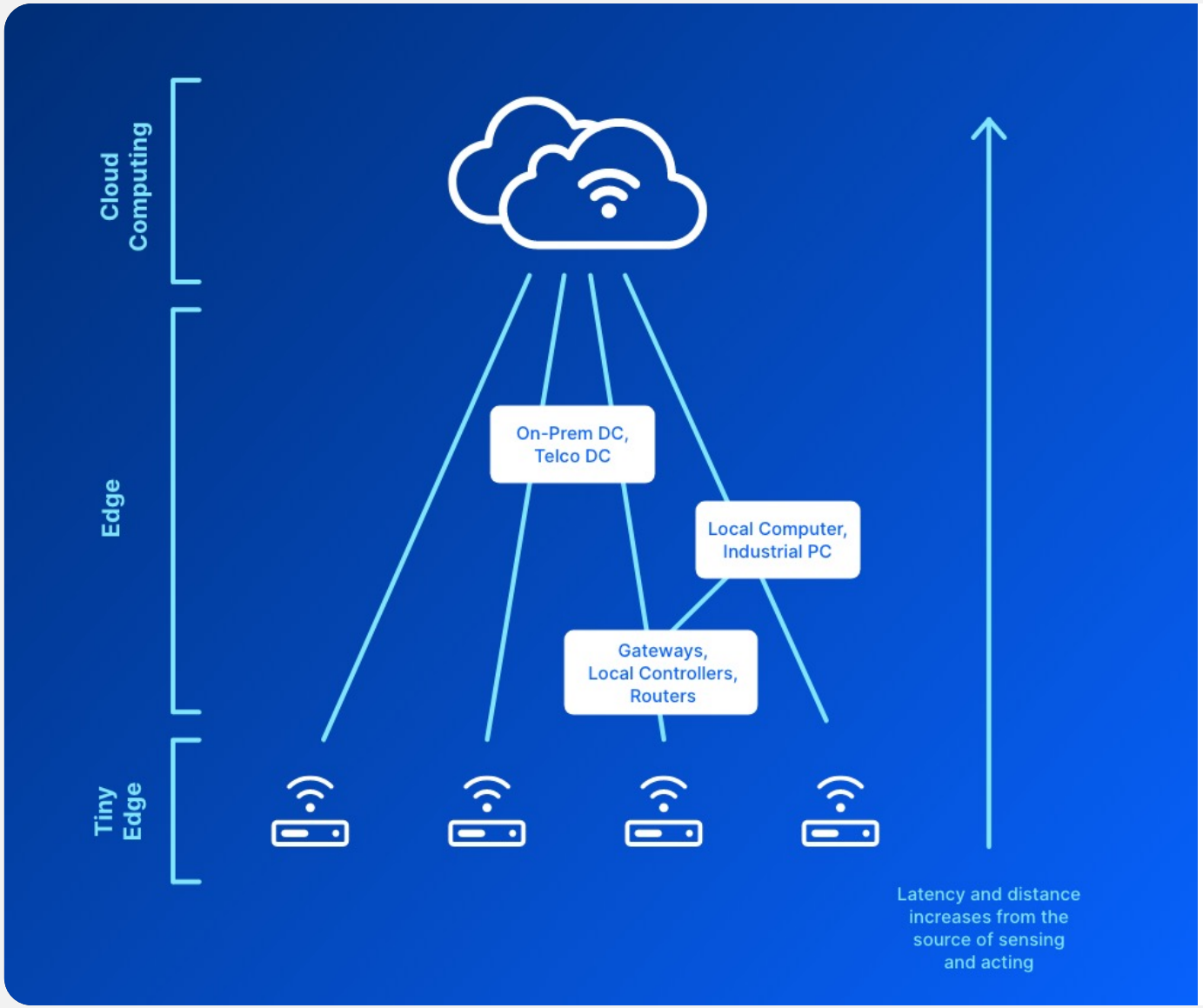
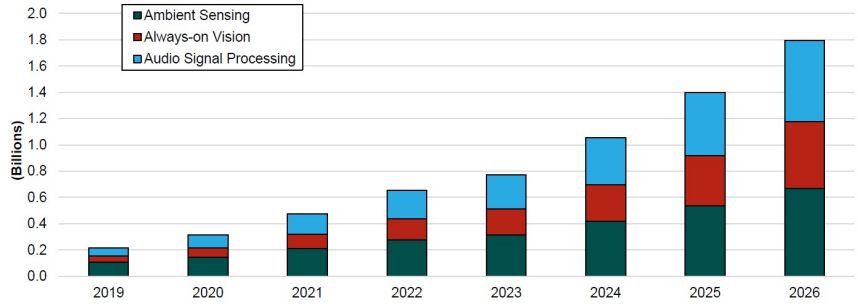
Artificial Intelligence(AI) and Machine Learning(ML) at the Tiny Edge



Key Benefits

- Low Latency
- Privacy, IP Protection, Security
- Bandwidth Constraints
- Offline Mode Operation
- Cost Reduction

1.8B Devices with TinyML in 2026



Source: ABI Research, Artificial Intelligence and Machine Learning, 2 QTR 2022

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Silicon Labs Machine Learning Solution Benefits

- Industry's widest portfolio of wireless solutions combined with ML for Tiny Edge devices
  - Bluetooth, 802.15.4/ZigBee/Thread, Matter, Z-Wave, Prop, Wi-Sun, Sidewalk
- Integrated ML hardware accelerator (xG24) provides 4X faster ML inferencing with 1/6th of energy
  - Reduces BOM, footprint and design complexity while minimizing latency
- ML development tools and solutions for explorers to experts for faster application development
  - TensorFlow Lite Micro supported in GSDK
  - Partnerships with Edge Impulse, SensiML and MicroAI accelerate embedded ML development
  - Silicon Labs' ML Tool Kit on GitHub provides complete control & flexibility for the expert developers
- Wide range of use cases including low data rate sensors, audio/voice and low-res images

End-to-End Machine Learning Solution for Wireless IoT Edge Devices

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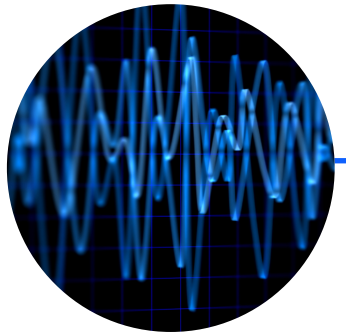
Event Detection using Machine Learning

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

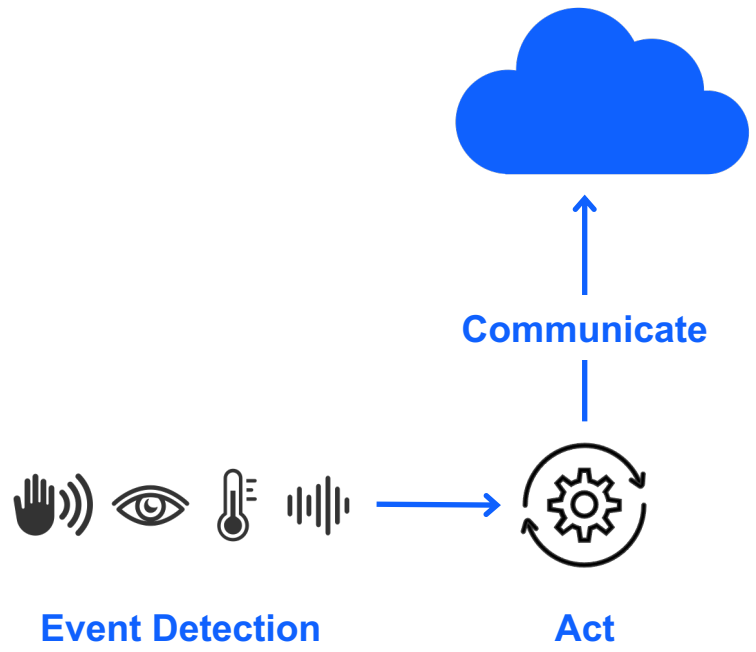
ML methods based on Audio
- Audio pattern matching (ex. glass break)

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

Camera

Low resolution imaging
- Image capture (including fingerprint reader)

ML methods based on Vision
- Fingerprint reading
- Always-on vision (comparing snapshot images)
- Image/object classification and detection



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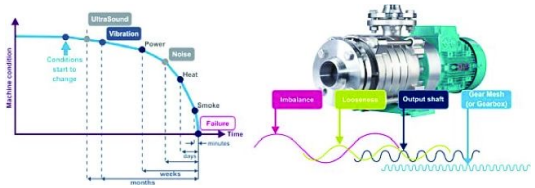
Machine Learning Applications Supported by Silicon Labs

Sensor



Signal processing (time series low-rate)

- Predictive/Preventative Maintenance
- Bio-signal analysis (healthcare and medical) e.g., pulse detection, EKG
- Cold chain monitoring
- Accelerometer use-cases e.g., fall detection, pedometer, step counting
- Battery monitoring
- Agricultural use-cases e.g., moisture sensing
- Anomaly detection

RAM*: 96kB
Ops/s: 5M

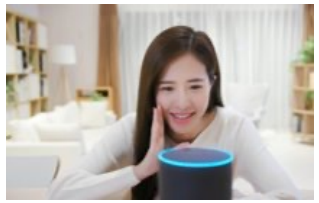
Audio

Audio pattern matching

- Security applications e.g., Glass break, scream, shot detection
- Cough detection
- Machine malfunction detection
- Breath monitoring

RAM*: 128kB
Ops/s: 6M

Voice

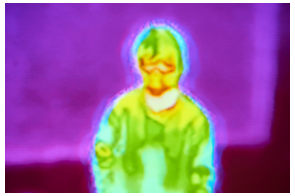


Voice commands

- 10 words command set for smart appliance
- Wake-word detection (Always-On voice)
- Smart device voice control
- Voice assistant

RAM*: 128kB
Ops/s: 40M

Vision



Low-resolution vision

- Wake-up on object detection
- Presence detection
- People counting, people-flow counting
- Movement detection
- Fingerprint

RAM*: 256kB w/hardware accelerator,
Ops/s: 100M

*Suggested minimum chip RAM size

ML Applications at the Tiny Edge with Silicon Labs Series 1, Series 2 Wireless SoCs

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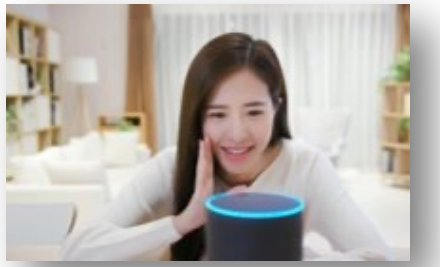
Machine Learning Sample Use Cases



Product segment	Health Monitoring, Elderly Care	Voice Control	Predictive Maintenance	Security
Use-case	Track biometric signals, predict or identify health disruptions, fall detection and other elderly applications	Voice control of lights, blinds, HVAC, etc.	Monitor and predict failures, prevent total appliance break-down	Glass break, noise detection, smart lock
Benefit of Machine Learning	Identify various types of deviations from normal signal variation	Better detection accuracy, improve user-experience	Reduce the unplanned downtime, predict a machine failure early enough to provide the plant operators to schedule maintenance.	Better detection accuracy, avoid false alarms
ML Method	Time-series data anomaly detection	Audio pattern matching, keyword detection	Anomaly Detection (i.e., vibration fingerprint)	Audio/vision pattern matching

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AI/ML on Wireless Gecko Series 1 and Series 2 in Production

Series 1 SoCs

High Performance Platform
- 32-bit ARM® Cortex®-M4 core (up to 40 MHz)
- Line power/battery power

AI Software
- TensorFlow Lite for Microcontrollers
- 3rd Party end-to-end tools

All Series 1 SoCs support ML

Battery Powered Mesh Devices

EFR32xG12

Developer kit: **Thunderboard Sense 2**

Up to 1MB / 256kB
2.4 GHz
20 dBm TX Power
BG12 and MG12

Series 2 SoCs

Higher Performance Platform
- ARM Cortex M33 (78 MHz)
- Improved radio performance
- Lower power (MCU active, TX/RX)

Improved Security
- Secure Vault - Mid
- Secure Vault - High (select OPNs)

Acceleration (xG24)
- AI/ML acceleration
- Faster AoA/AoD calculation

AI Software
- TensorFlow Lite for Microcontrollers with accelerated kernels
- 3rd Party end-to-end tools

All Series 2 SoCs support ML

Battery Powered Mesh Devices

EFR32xG24

Developer kit: **xG24-DK2601B**

Up to 1.5MB / 256kB
2.4 GHz
Up to +19.5 dBm TX Power
Secure Vault - Mid
Secure Vault – High
BG24 and MG24
AI/ML accelerator

Common Machine Learning software and tools on both Series 1 and Series 2 Wireless SoCs
Use cases are dependent on RAM and wireless stack

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BG24 and MG24: Optimized for Battery Powered IoT Mesh Devices

Sensing at the Edge

AI/ML Hardware Accelerator Key Features

- Optimized Matrix processor to accelerate ML inferencing with a lot of processing power **offloading the CPU**
- Real and complex data
- **2x to 4x faster** inferencing over Cortex-M
- Up to **6x lower power** for inferencing

Low-Power SoCs and Modules Optimized for Battery Powered IoT Mesh Devices

High Performance Radio
-Up to +19.5 dBm TX
-97.6 dBm RX @ BLE 1 Mbps
-105.7 dBm RX @ BLE 125 kbps
-104.5 dBm RX @ 15.4
Improved Wi-Fi Coexistence
RX Antenna Diversity

Low Power
5.0 mA TX @ 0 dBm
19.1 mA TX @ +10 dBm
4.4 mA RX (BLE 1 Mbps)
5.1 mA RX (15.4)
33.4 µA/MHz
1.3 µA EM2 with 16 kB RAM

World Class Software
Simplicity Studio 5
Matter[1]
Thread[1]
Zigbee[1]
Bluetooth (1M/2M/LR)
Bluetooth mesh
Dynamic multiprotocol[1]
Proprietary

ARM® Cortex®-M33
78 MHz (FPU and DSP)
Trustzone®
Up to 1536kB of Flash
Up to 256kB of RAM

Dedicated Security Core
Secure Vault™ - Mid
Secure Vault™ - High

Low-power Peripherals
EUSART, USART, I2C
20-bit ADC, 12-bit VDAC, ACMP
Temperature sensor +/- 1.5°C
32kHz, 500ppm PLFRCO

AI/ML
AI/ML Hardware Accelerator

SoCs and Modules
5x5 QFN40 (26 GPIO) -125ºC
6x6 QFN48 (28/32 GPIO) -125ºC
7x7 SiP Module (+10 dBm)
12.9x15.0 PCB Module (+10 dBm)

[1]Requires MG24

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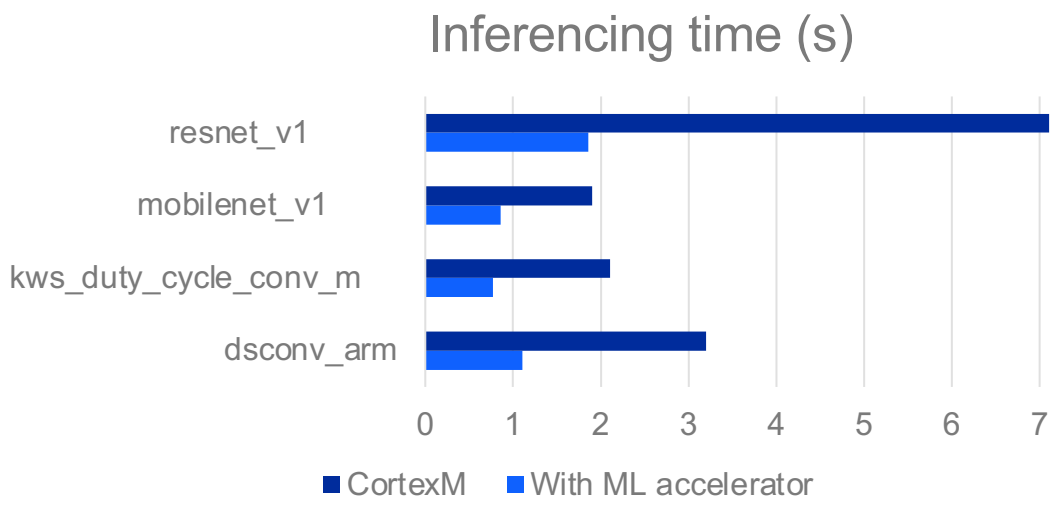
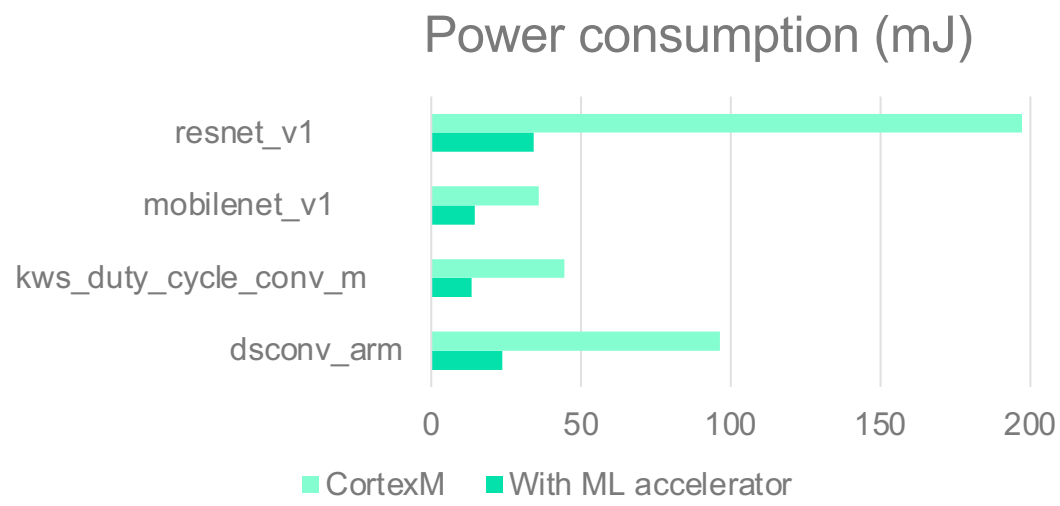
Inferencing with ML hardware accelerator vs. CortexM*





2-4x Faster Inferencing and up to 6x Lower Power Consumption (ML model dependent)

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

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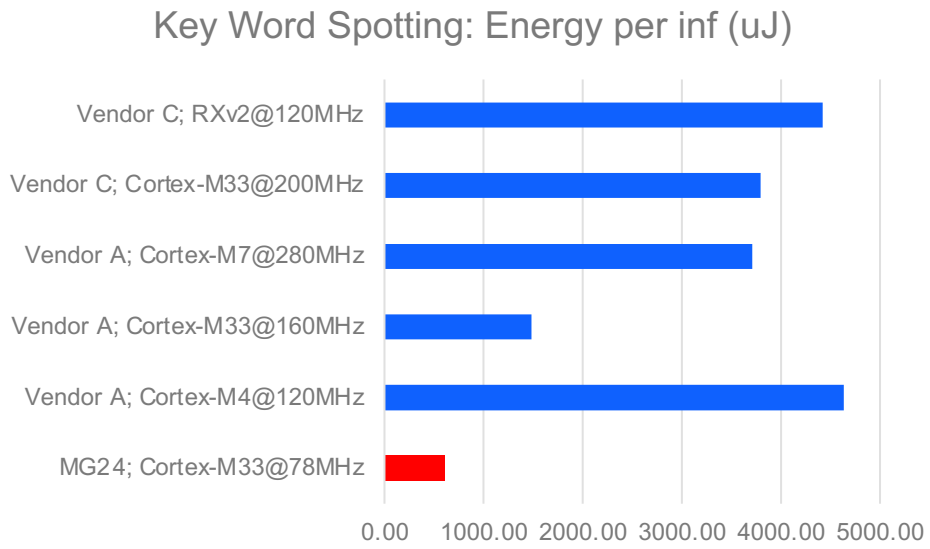
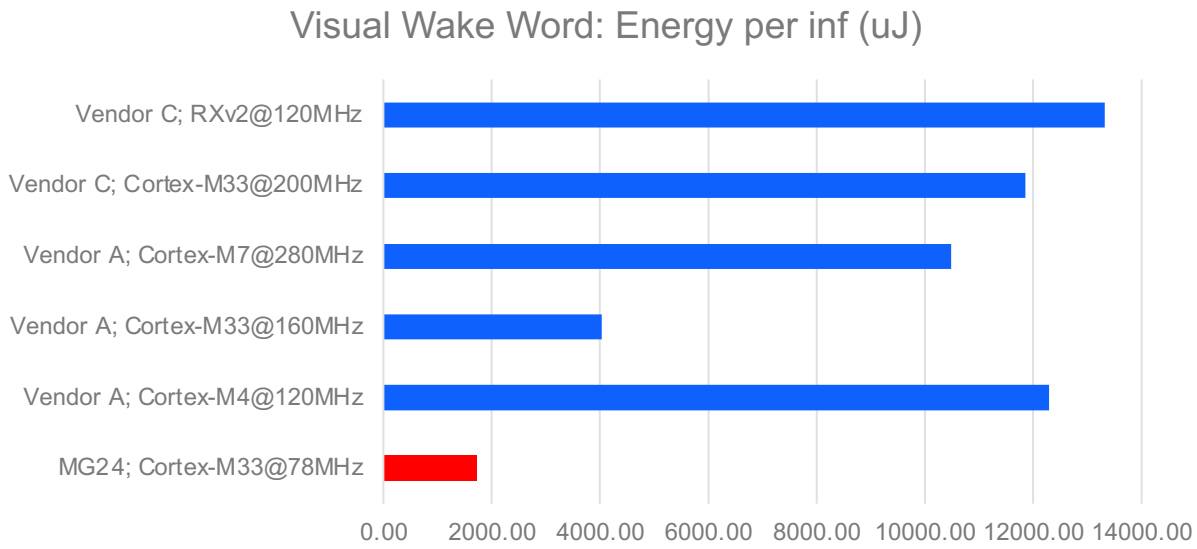
ML Perf Tiny v0.7 Performance Benchmark* for Power Efficiency



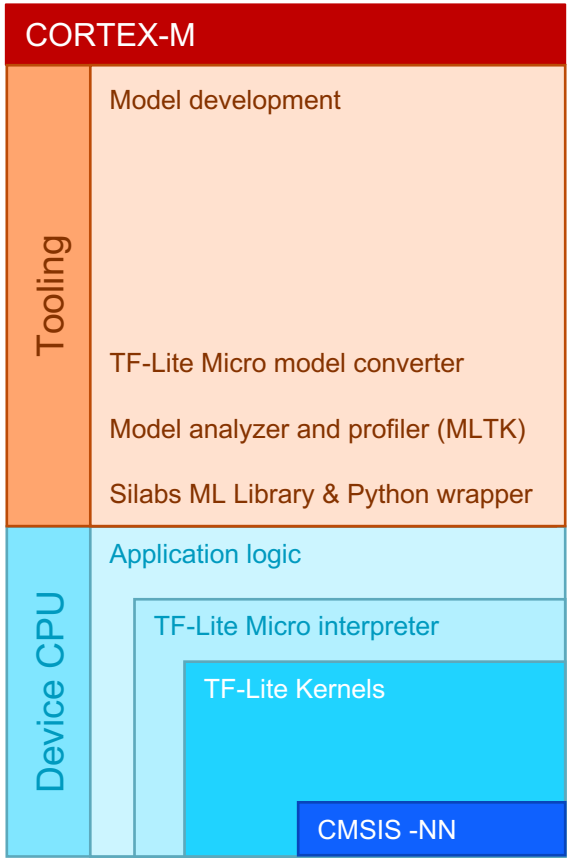


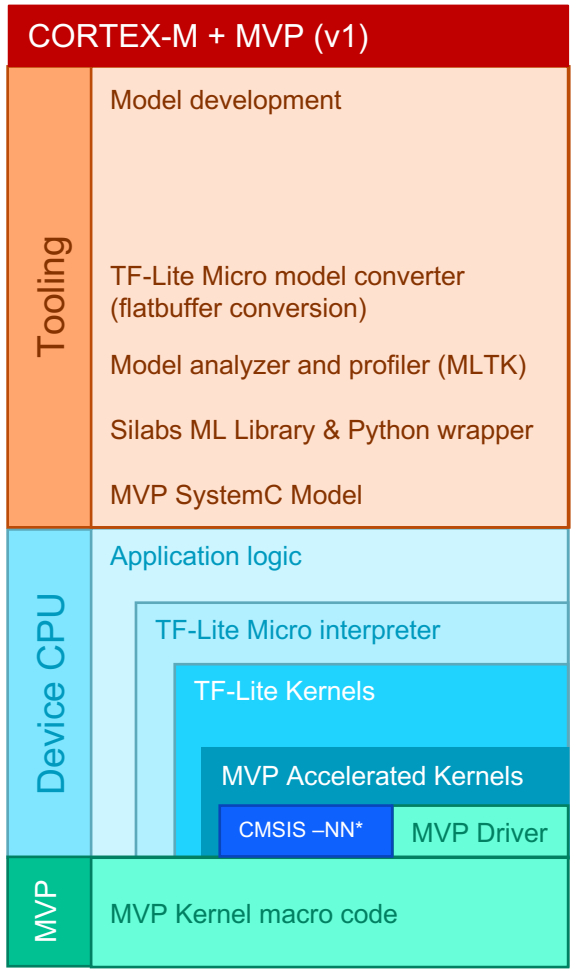
MLPerf Tiny 0.7 benchmark results on xG24-DK2601B board; source: mlcommons.org

*Standardized performance benchmark validated by independent benchmarking body. Results are for inferencing only (not complete application).

Software Architecture

- Series 1 and 2 (excluding xG24) can be seen on the left diagram.
- xG24 architecture can be seen on the right. Note use of the MVP is largely transparent, and operations when supported will be offloaded else they will fall back to the CMSIS-NN implementation.





* fallback to CMSIS-NN in case of unsupported input

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Software and Tool Support

ML Expert

Python scripts

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 | NPU

ML Explorer

GUI Developer Tools

EDGE IMPULSE

www.edgeimpulse.com

SensiML™

www.sensiml.com

TFLite-micro Interpreter

CMSIS-NN Kernels | Silicon Labs HW-based Kernels

Cortex M | NPU

ML Explorer

Anomaly Detection

Micro.ai

www.micro.ai

Cortex M

ML Solutions

Solution Libraries

Wake Word

Stay Tuned!

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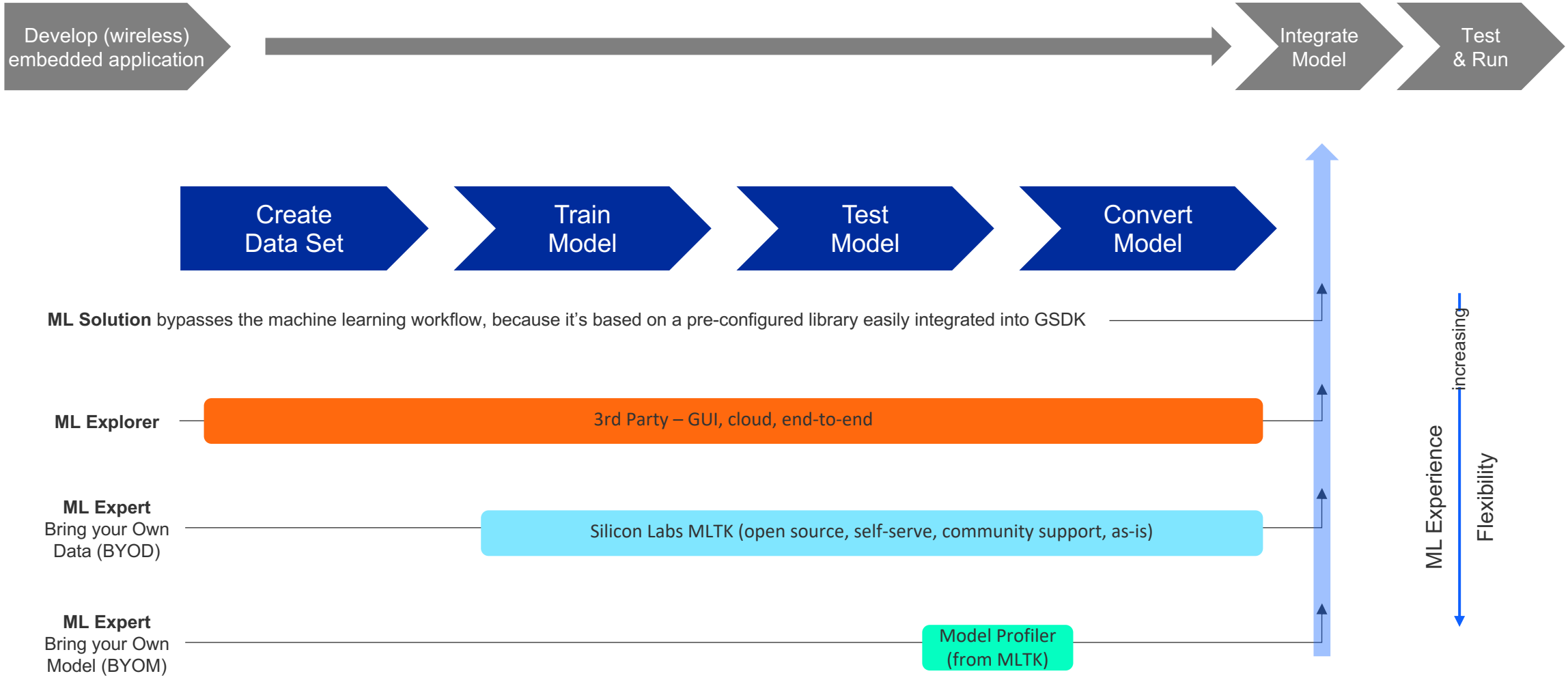
Embedded Development with Machine Learning (supervised)



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ML Partner: Edge Impulse

EDGE IMPULSE

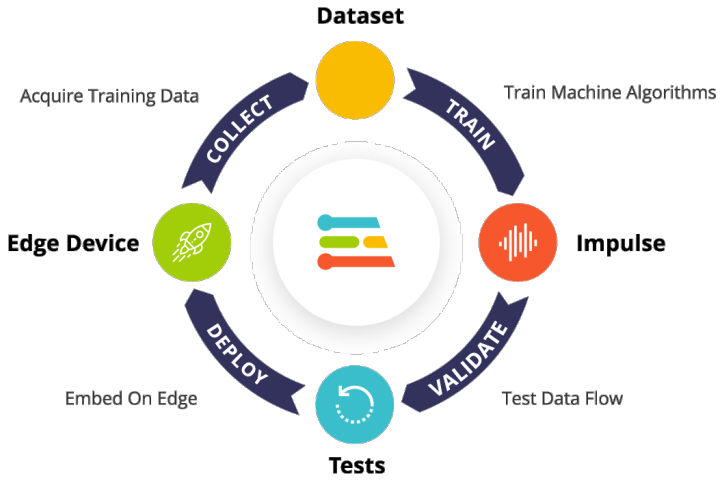
Company Name	Edge Impulse
Sales Contact	Sally Atkinson sally@edgeimpulse.com
Website	www.edgeimpulse.com
Headquarters	San Jose, CA

Product Name	Edge Impulse platform
Pricing Structure	• Free developer tier • Enterprise license – monthly fee per project (annual commitment)
Silicon Labs Support	EFR32, EFM32, xG24 Dev Kit, Thunderboard Sense 2

The Edge Impulse approach:

·**One platform** to manage all data engineering and edge machine learning development
·**Best-in-class solutions engineering** team to help **validate and develop** your use cases in months
·**Develop edge ML development skills** in-house over time

One platform, custom models, hardware agnostic, short development timelines (3-6 months)



Product Description	Edge Impulse enables advanced machine learning on edge devices, instead of sending data inefficiently to the cloud, maximizing privacy and energy efficiency. Unlike data science tools, Edge Impulse is designed for developers and engineers targeting a huge range of devices, from tiny microcontrollers to powerful edge devices for real-time sensor, audio and image data
Key Value Prop	• Full end to end MLOps platform • Any data with any device • Time to market substantially decreased • Low code and accessible for SMEs, no data science skills required • Complete transparency, no black box approach, allowing your customers to create their own IP

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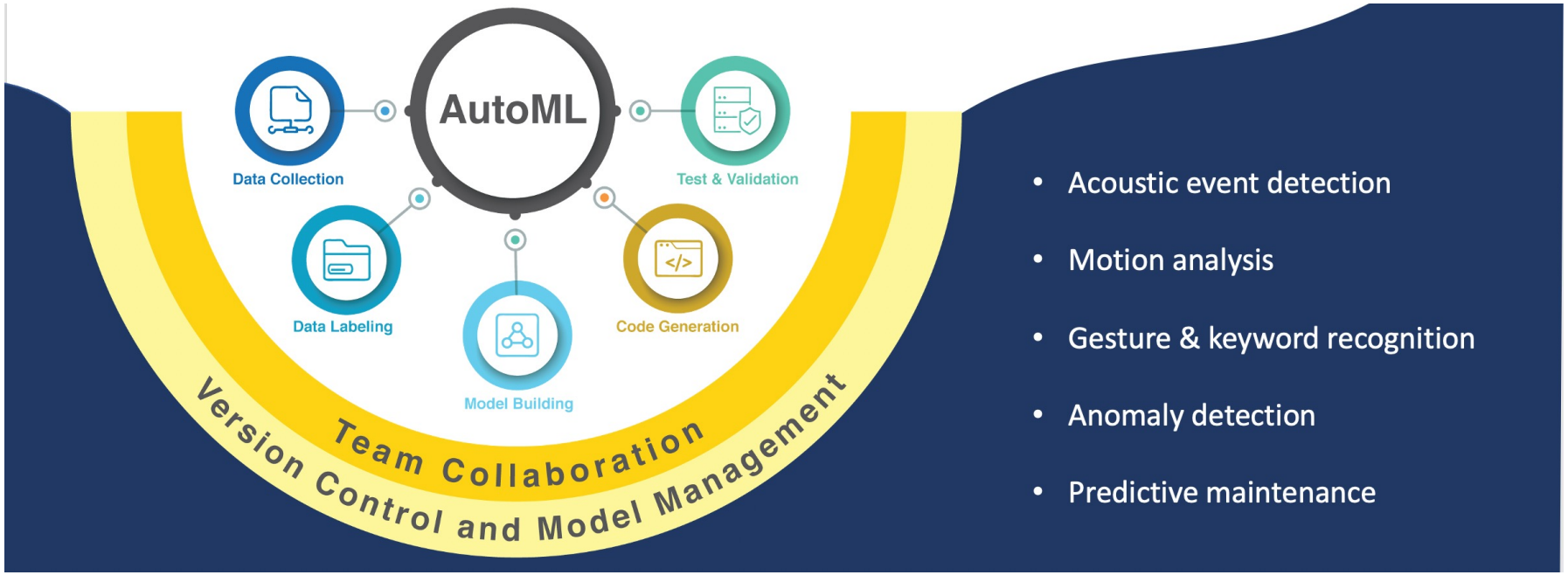
ML Partner: SensiML

Company Name	SensiML
Sales Contact	Chris Rogers chris.rogers@sensiml.com
Website	sensiml.com
Headquarters	Beaverton, Oregon

Product Name	SensiML Analytics Toolkit
Pricing Structure	https://sensiml.com/plans/
Silicon Labs Support	EFR32, EFM32, xG24 Dev Kit, Thunderboard Sense 2



Product Description	AutoML Software for Building Intelligence into the IoT Edge
Key Value Prop	• Complete end-to-end AI workflow. • Full code transparency and greatest flexibility. • Solution scalability with expansive AI and DSP libraries • Built from the ground-up for commercial development teams

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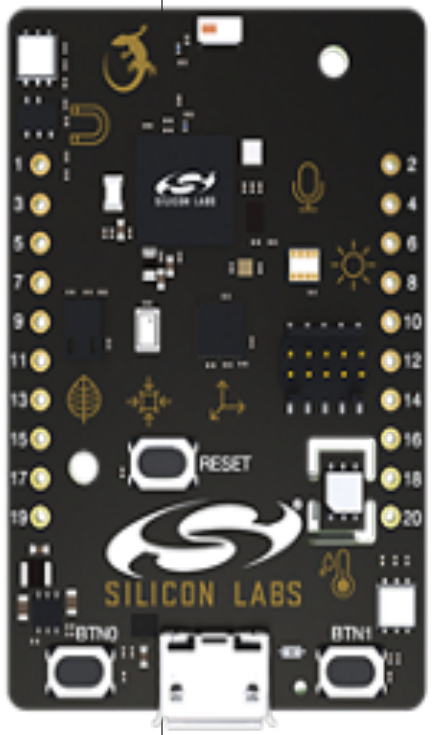
Machine Learning Development Kits

xG24-DK2601B Dev Kit (on MG24)

- **Wireless SoC with multi-protocol radio**
- **ARM® Cortex-M33 with TrustZone, 256 kB RAM and 1536 kB Flash, 80 MHz**
- **AI/ML Hardware Accelerator**
- **Broad Range of Sensors**
  - 9-axis Inertial Sensor
  - 2 Digital Microphones
  - Pressure Sensor
  - Indoor Air Quality and Gas Sensor
  - Relative Humidity and Temperature Sensor Si7021
  - UV and Ambient Light Sensor
  - Hall-effect Sensor Si7210
- **https://www.silabs.com/development-tools/wireless/efr32xg24-dev-kit**



Thunderboard Sense 2 (on MG12)

- **Wireless SoC with multi-protocol radio**
- **ARM® Cortex-M4 core with 256 kB RAM and 1024 kB Flash, 40 MHz**
- **Broad Range of Sensors**
  - 6-axis Inertial Sensor
  - Digital Microphone
  - Pressure Sensor
  - Indoor Air Quality and Gas Sensor
  - Relative Humidity and Temperature Sensor Si7021
  - UV and Ambient Light Sensor
  - Hall-effect Sensor Si7210
- **https://www.silabs.com/development-tools/thunderboard/thunderboard-sense-two-kit**

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Video Demonstrations:

Smart Building IoT Sensing Solutions with a Silicon Labs Thunderboard 2.

https://sensiml.wistia.com/medias/8hc6omi11j

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Summary: Machine Learning for the Tiny Edge

- ML integrated with wireless SoCs
  - Combining ML with our proven set of wireless stacks
- Support for deep learning with neural network algorithms
  - In addition to classical machine learning algorithms
- Rich set of tools available for all ML developers from first time to experts
  - 3rd party tools supporting end-to-end development with a GUI based platform for first timers
- Developer kits with a wide range of sensors
  - Thunderboard Sense 2, xG24 Dev Kit
- Support for wide range of use cases including:
  - Low-rate sensors, audio/voice and low-res images
- AI/ML hardware accelerator – seamless integration with xG24
  - 2x to 4x faster inference performance and 6x lower power consumption vs Cortex-M

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Resources

- **Silicon Labs AI/ML Resources:**
  - ML Web Landing Page
  - ML Doc Landing Page
  - Machine Learning Fundamentals
- **Demos Available:**
  - Sensor Signal Processing
  - Audio Pattern Matching
  - Voice Command
  - Low Resolution Vision
  - MLTK + Command Word Detection
- **Partners' Resources:**
  - Edge Impulse
  - SensiML
  - MicroAI

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tech talks
Thank You


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tech talks
Q&A