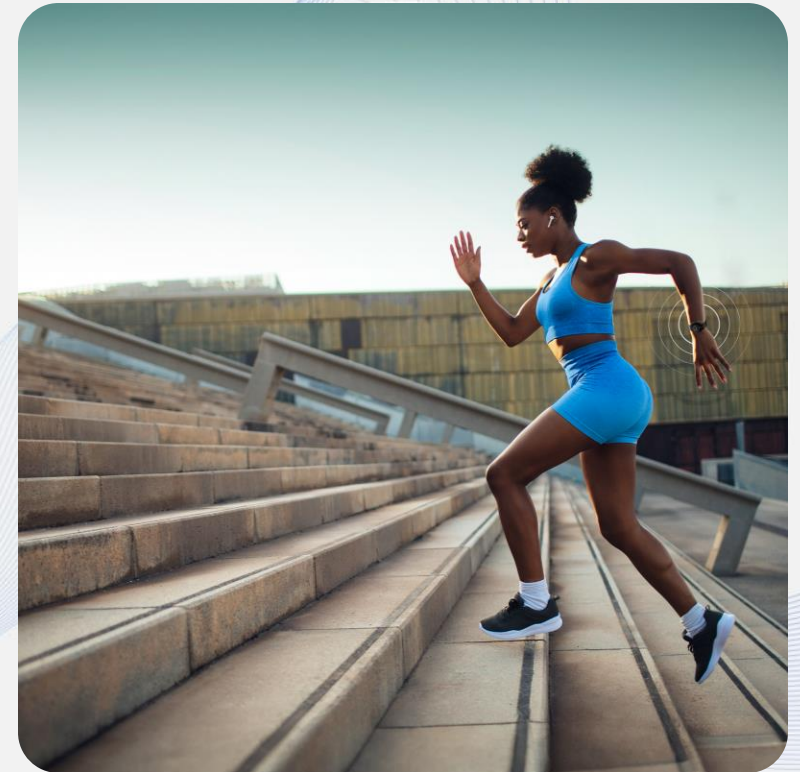BLE-201

Accelerating IoT End Device Development

Parker Dorris
Staff Product Manager

SILICON LABS

Agenda

Challenges with IoT Product Creation
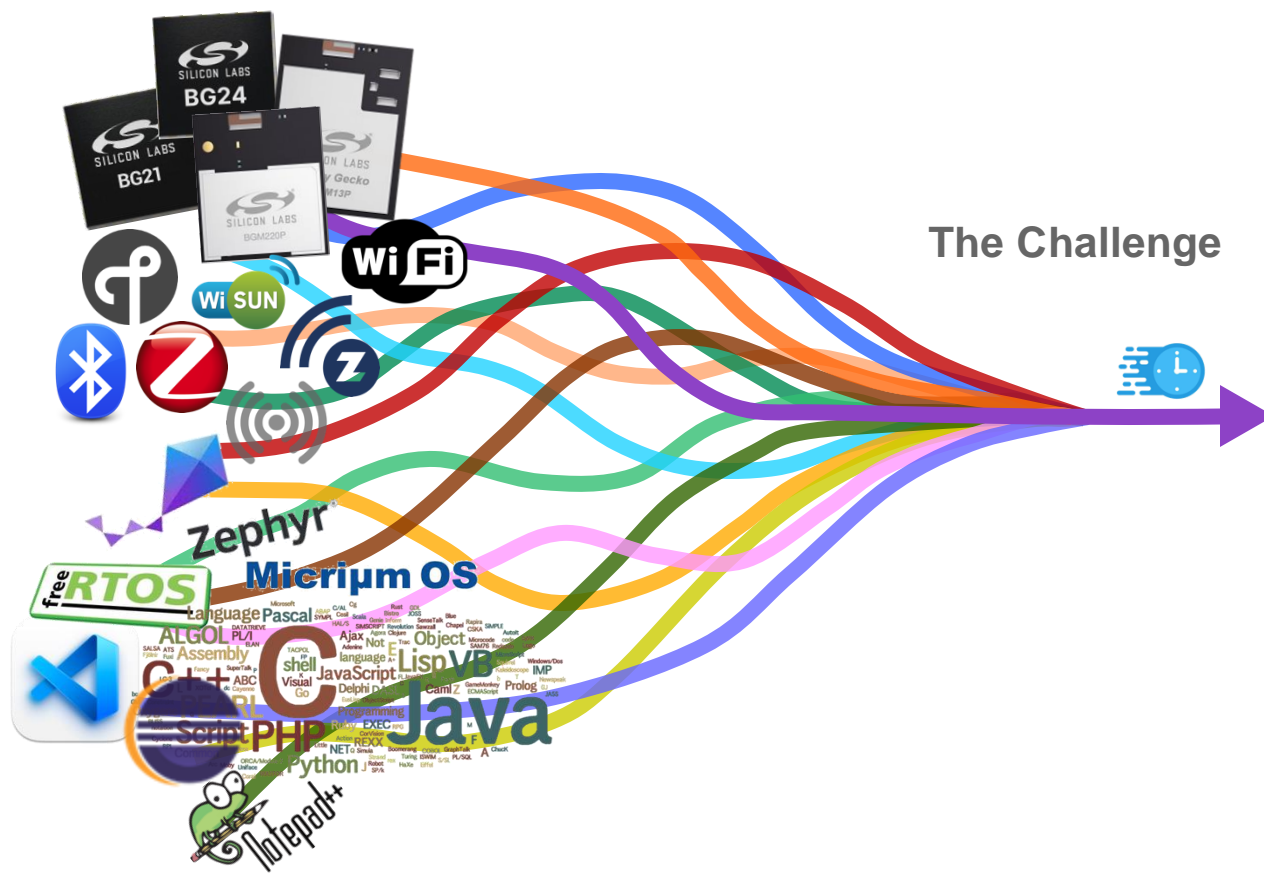
Software Solution Differentiators

Tools

Large-Scale Test Networks

Bluetooth Developer Journey

Silicon Labs solutions

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The Challenge of IoT Product Creation

IoT HW & SW offering

The desired IoT Product

The Challenge

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A Complete and Robust Bluetooth® Offering

DESIGN	DEVELOPMENT	DEPLOYMENT

Developer Kits
- Exploratory kits with standard connectors
- Full featured kits with LCD, Power Measurement, etc.
- Demo kits w/ built in sensors

200+ OOB demos and sample applications

Cutting-edge BT Stack
- Bluetooth LE and Mesh
- Supporting most BLE features
- Certified against latest spec

~1B BLE units deployed

Mobile Apps
- BLE scanner/advertiser
- Demos
- IOP testing with smartphones
- Bluetooth Mesh ADK and App

100+ Mobile phones with next-gen IOP testing

ICs and Modules
- QFN, CSP ICs
- PCB and SiP modules
- Antenna Design (int/ext)
- Optimized size
- Pre-certified modules

1st in the market with PSA L3 certification

Superior Developer Tools
- GATT Configurator
- Bluetooth NCP Commander
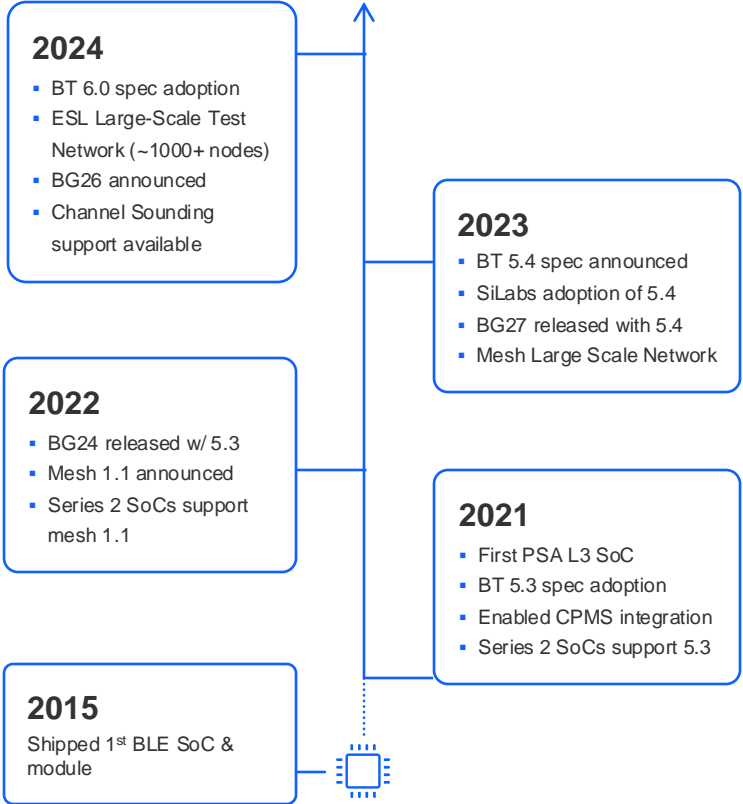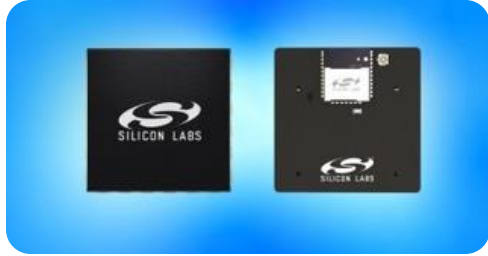- Network Analyzer
- AoA Analyzer
- Energy Profiler

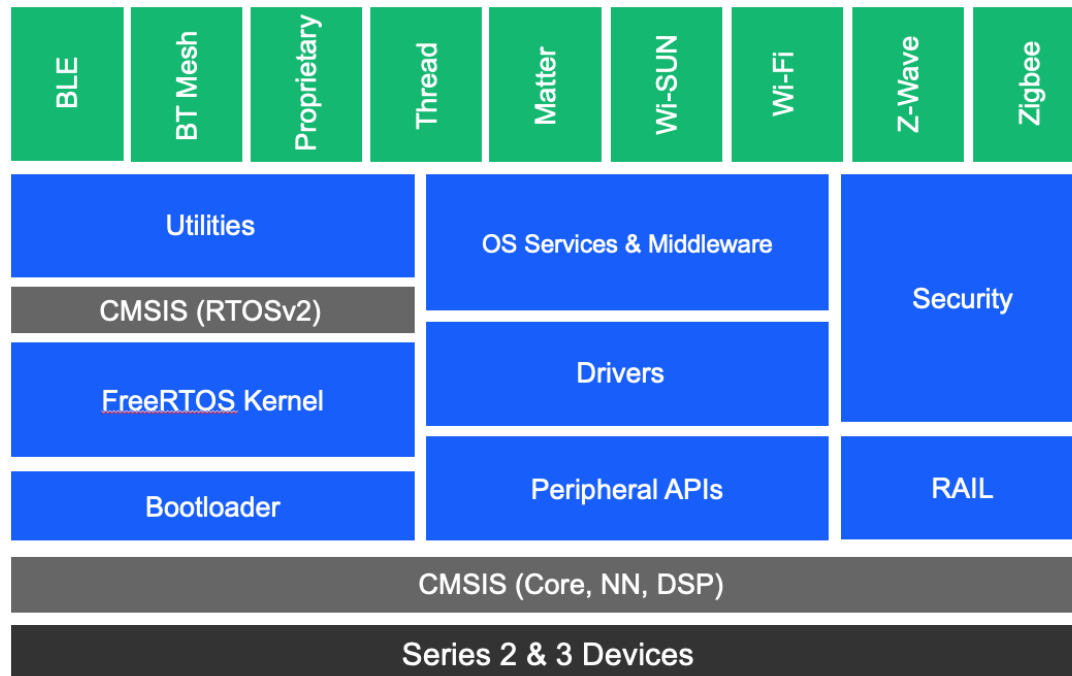**~1M** Packets transmitted daily for Mesh endurance testing

Reliability Testing, IOP
- Large Scale Test Network
- IOP testing
- Regression testing & CI
- Throughput and range test

7,000+ functional tests for Bluetooth and mesh

2024
- BT 6.0 spec adoption
- ESL Large-Scale Test Network (~1000+ nodes)
- BG26 announced
- Channel Sounding support available

2023
- BT 5.4 spec announced
- SiLabs adoption of 5.4
- BG27 released with 5.4
- Mesh Large Scale Network

2022
- BG24 released w/ 5.3
- Mesh 1.1 announced
- Series 2 SoCs support mesh 1.1

2021
- First PSA L3 SoC
- BT 5.3 spec adoption
- Enabled CPMS integration
- Series 2 SoCs support 5.3

2015
Shipped 1st BLE SoC & module

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Software Solution Differentiators

All wireless stacks integrated into a single SDK

- Production-ready: Certified, full featured and up-to-date with latest specs

- Proven: Customer deployment and long-term, large-scale testing

- Secure: Integrated with secure vault

- Quick start: 100s of sample apps as a starting point

Common software platform for all products

- Portable: Common APIs across all hardware platforms

- Low-power: Power Manager utility enables lowest energy mode

- Secure: Secure boot, secure OTA, run-time integrity checking

- Optimized radio: RAIL manages the complexity and provides simple APIs to stacks and customer applications

Developer Experience

- Consistent tools and workflows across technologies

- Same SW for all HW: learn it once and reuse on next project

Our SW is tightly coupled with our HW to enable power & performance differentiation

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Software Components

Software Components Tab
- Developers can search for desired technologies
- Components can be easily added to an application
- Modular and adjustable for specific needs of a project

Covers Various Functionalities
- Peripheral drivers, middleware, and application-specific features
- Supports a wide array of Silicon Labs devices, including microcontrollers and wireless SoCs

Improved Workflow
- Streamlines the addition of new functionalities to projects
- Flexible way to customize software and hardware solutions
- Simplifies the development process by reducing the need for manual coding
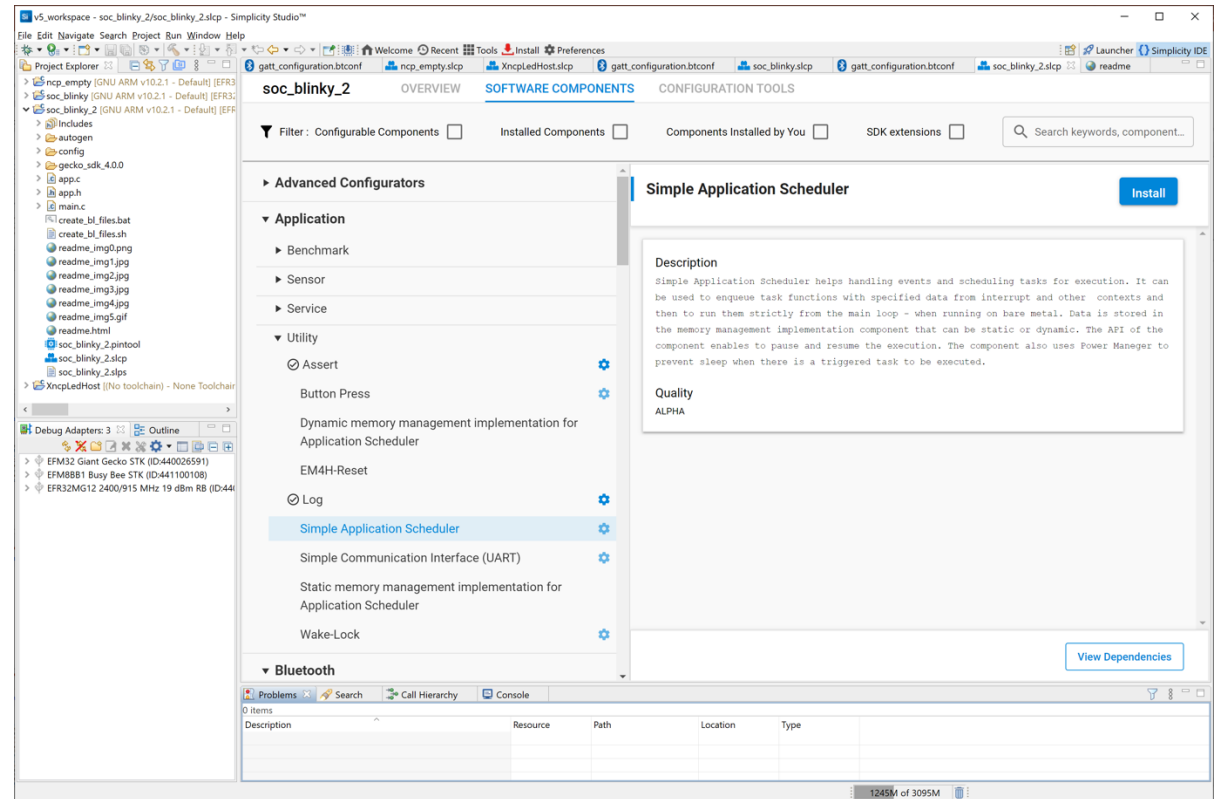
Pin Tool

Enables developers to:

- Assign peripheral function to designated pins
- Enable/Disable pins
- Define pin function

Data-Driven Approach:

- Identifies compatible SW components dynamically using SDK metadata

Reduces time spent on HW configuration

- Streamlines the definition of pin functions
- Assists in prototyping during board bring-up
- Select and assign compatible SW components to specific pins/peripherals
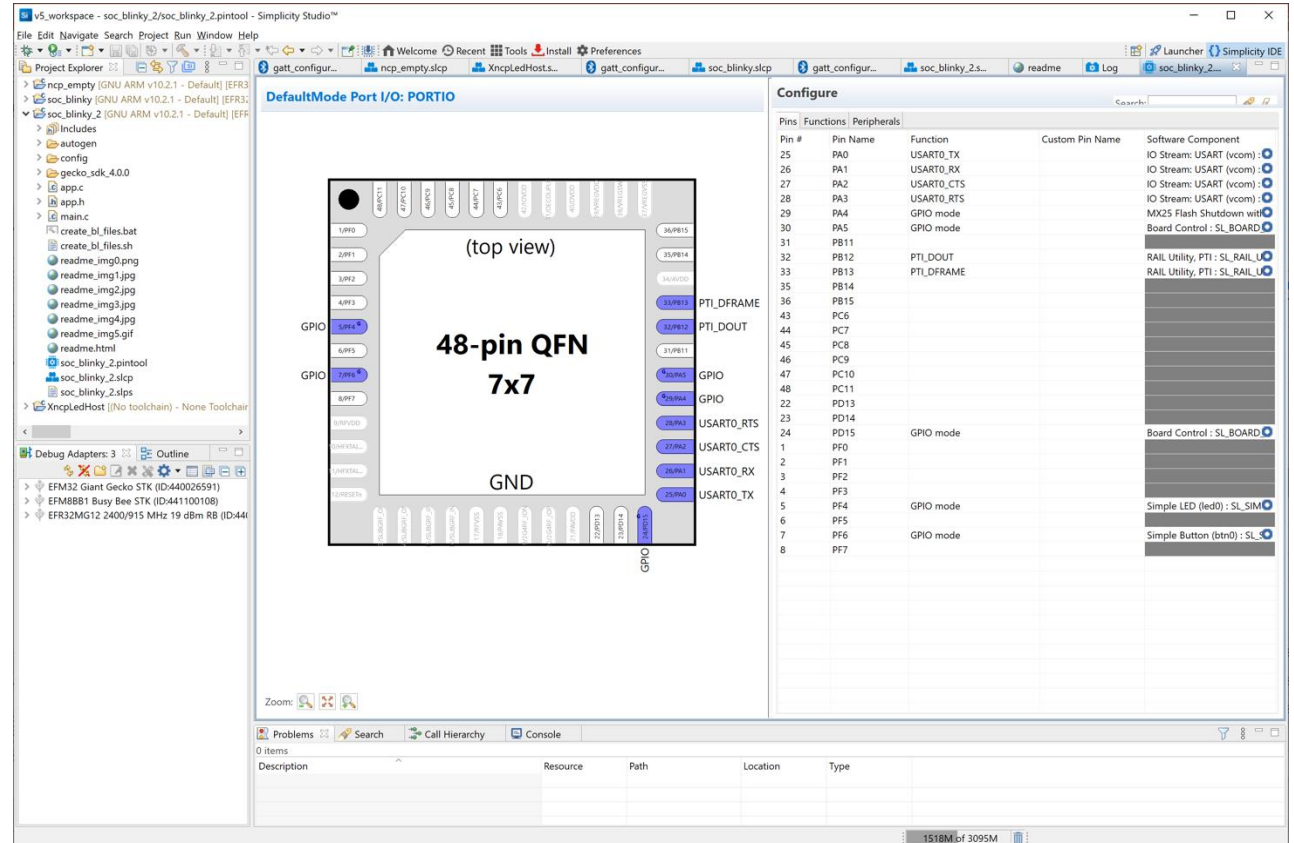
Simplicity Studio for VS Code

Modern and Lightweight
- Providing a smoother experience

Simplicity Studio for VS Code Extension
- Available on Visual Studio Code Marketplace

Powerful and user-friendly Debugging Tools
- Enables Build/Flash/Debug from within VS Code

Integrated Terminal
- Enables users to run command line tools and scripts without leaving the IDE

## Cross-Platform Support
- Windows, macOS, and Linux

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Simplicity Connect Mobile App

Test and Debug

- BLE embedded application code, OTA FW updates, data throughput, and interoperability with Android and iOS mobile devices

Main Navigation Bar w/ distinct purpose views

- **Demo**: Ready-to-go demos with a matching sample app on Simplicity SDK pre-compiled for numerous kits
- **Scan**: for searching, connecting and interacting with remote devices
- **Configure**: Local Advertise and GATT Configurator for mobile phone
- **Test**: (IOP) to assess behavior against Silicon Labs' Bluetooth SW and HW
- **Settings**: For System configuration and app information

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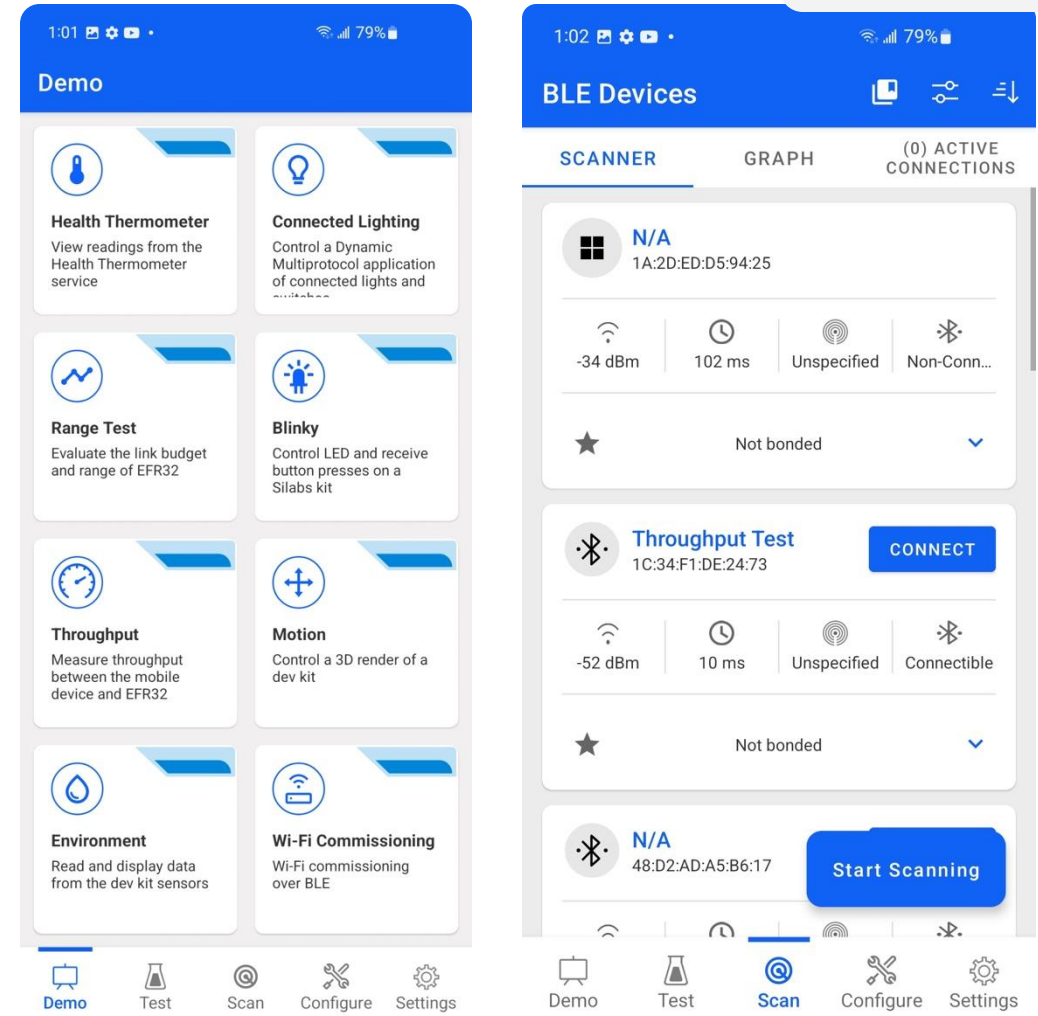
Software Tools

Bluetooth GATT Configurator

Enhanced visualization of GATT design

- Simplifies building customized Bluetooth GATT database for projects

Allows import and adoption of standard GATT Profiles

- Services, and Characteristics (e.g. Heart Rate)

More user-friendly than managing Services and Characteristics in source code

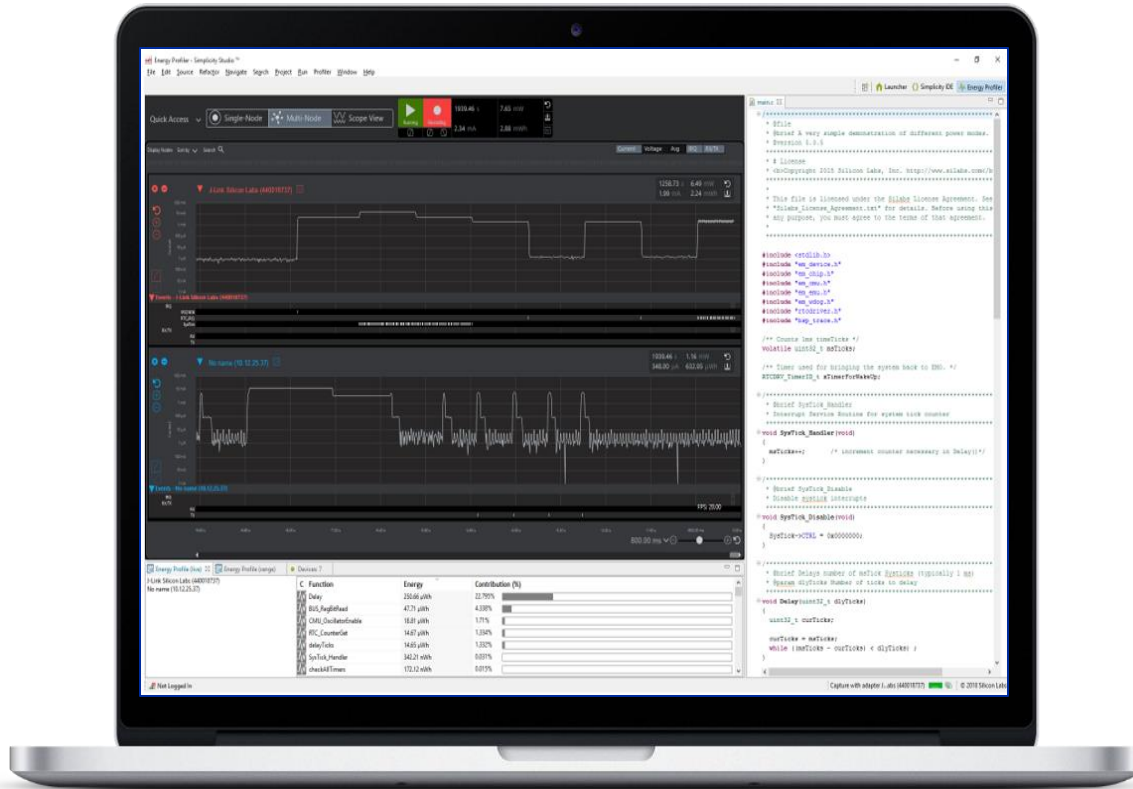**Integrated access to information on Bluetooth SIG defined elements**

- Profiles, Services, Characteristics

Allows defining custom Services and Characteristics

- [UG438: GATT Configurator User's Guide for Bluetooth® LE and Bluetooth Mesh](#)

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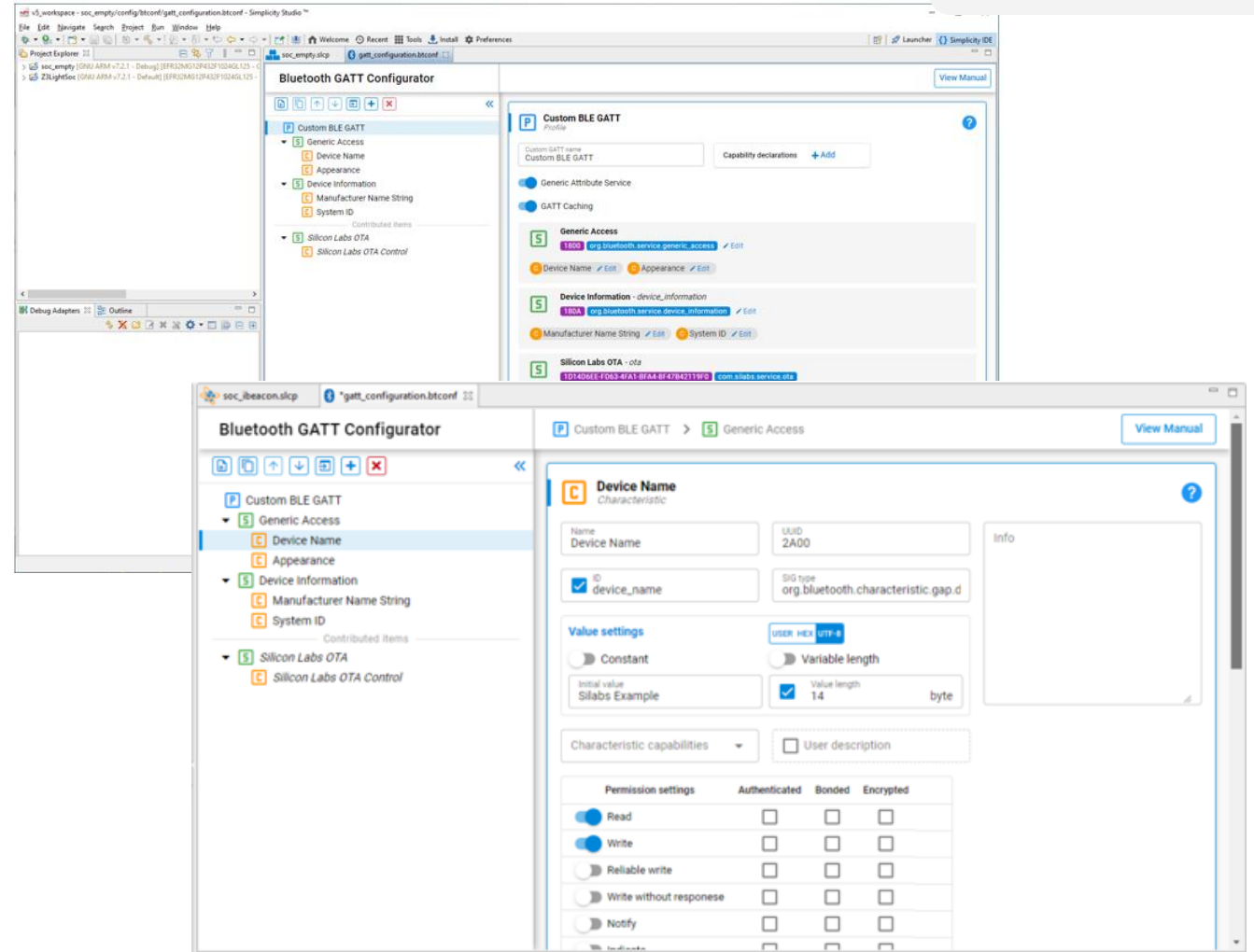
Energy Profiler

Analyze real-time current consumption

- Peak current consumption
- Sleep mode current measurement.

Correlate energy consumption to code

- Enabling application developers to focus their efforts where they will have the greatest impact
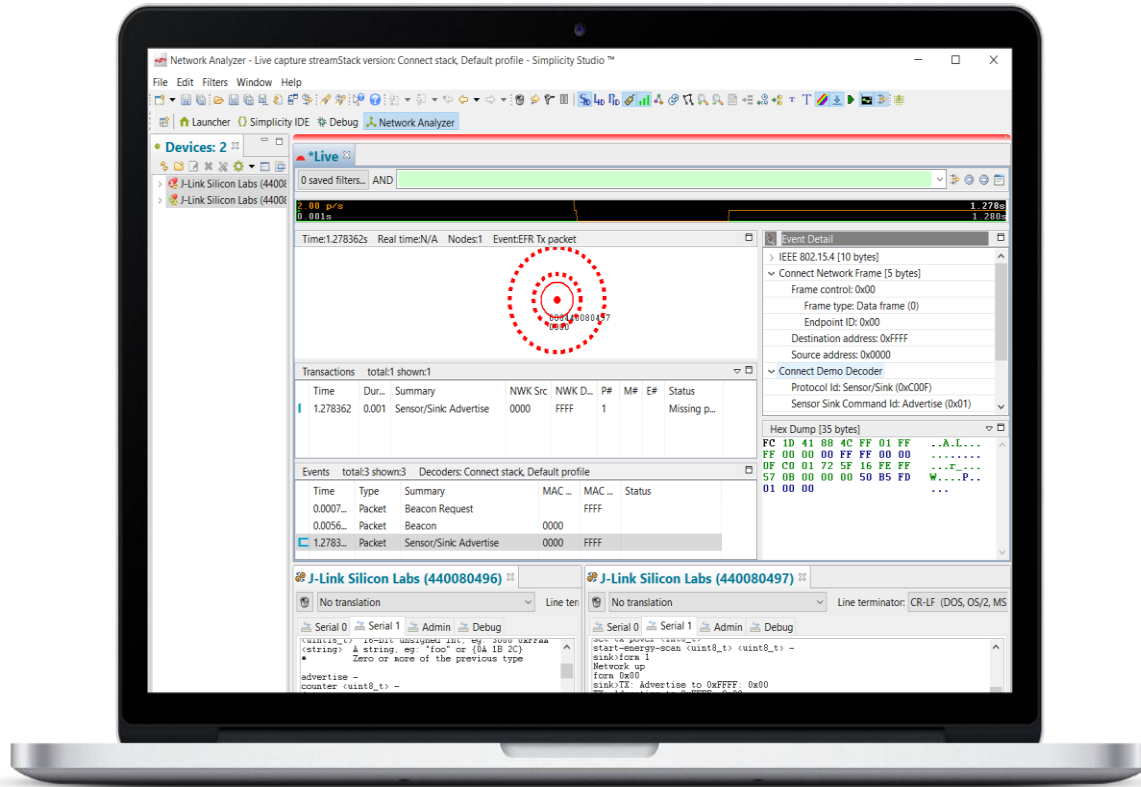
Simple Logic Analyzer

- Interfaces with pins, buttons and/or LEDs
- Set triggers to pause the graph of an event you wish to capture or to start and stop recording

Ability to monitor multiple nodes

Improve battery life

Advanced real-time energy profiling tools for optimization and debugging

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Network Analyzer

Debugging of Complex Wireless Systems

- Captures a trace of wireless activity
- Can be examined in detail; either live or at a later time

More than a packet sniffer

- Works with the packet trace interface (PTI)
- Provides Network wide view of what's happening
- Available on the PTI-enabled Silicon Labs Wireless SoCs and modules
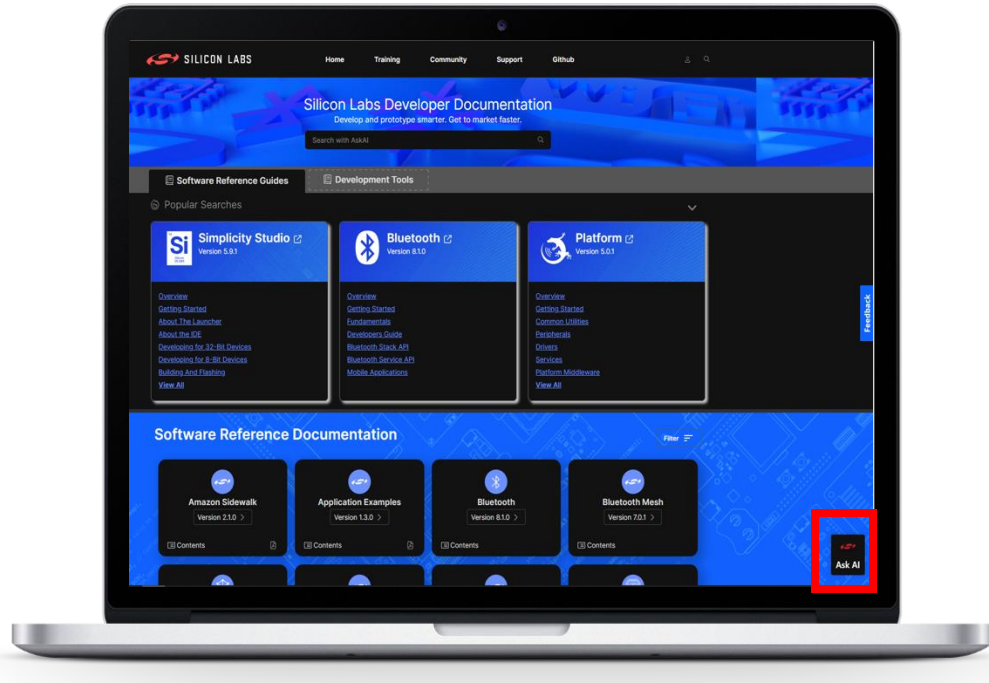
Direct Feedback from radio device(s)

- Detailed package Tx/Rx data
- Timestamps
- Link Quality (LQI)
- Receive Sensitivity (RSSI)
- CRC pass/fail results

Advanced system-wide network debug and support

Ask AI

AskAI Widget on docs.silabs.com

Comprehensive Knowledge Base

- Trained on all docs.silabs.com content, relevant GitHub repositories, approximately 2500 PDFs of technical documentation, and Silicon Labs YouTube videos

Efficient and Accurate Responses

- With a steadily increasing response certainty rate, currently at 94% as of July 2024, AskAI reliably answers nearly 4,000 questions per month with a 2:1 upvote to downvote ratio

Continuous Improvement

- Enhancements based on user feedback ensure that AskAI's knowledge base and response quality are always evolving to meet your needs
- Continuously monitored by our Apps support teams
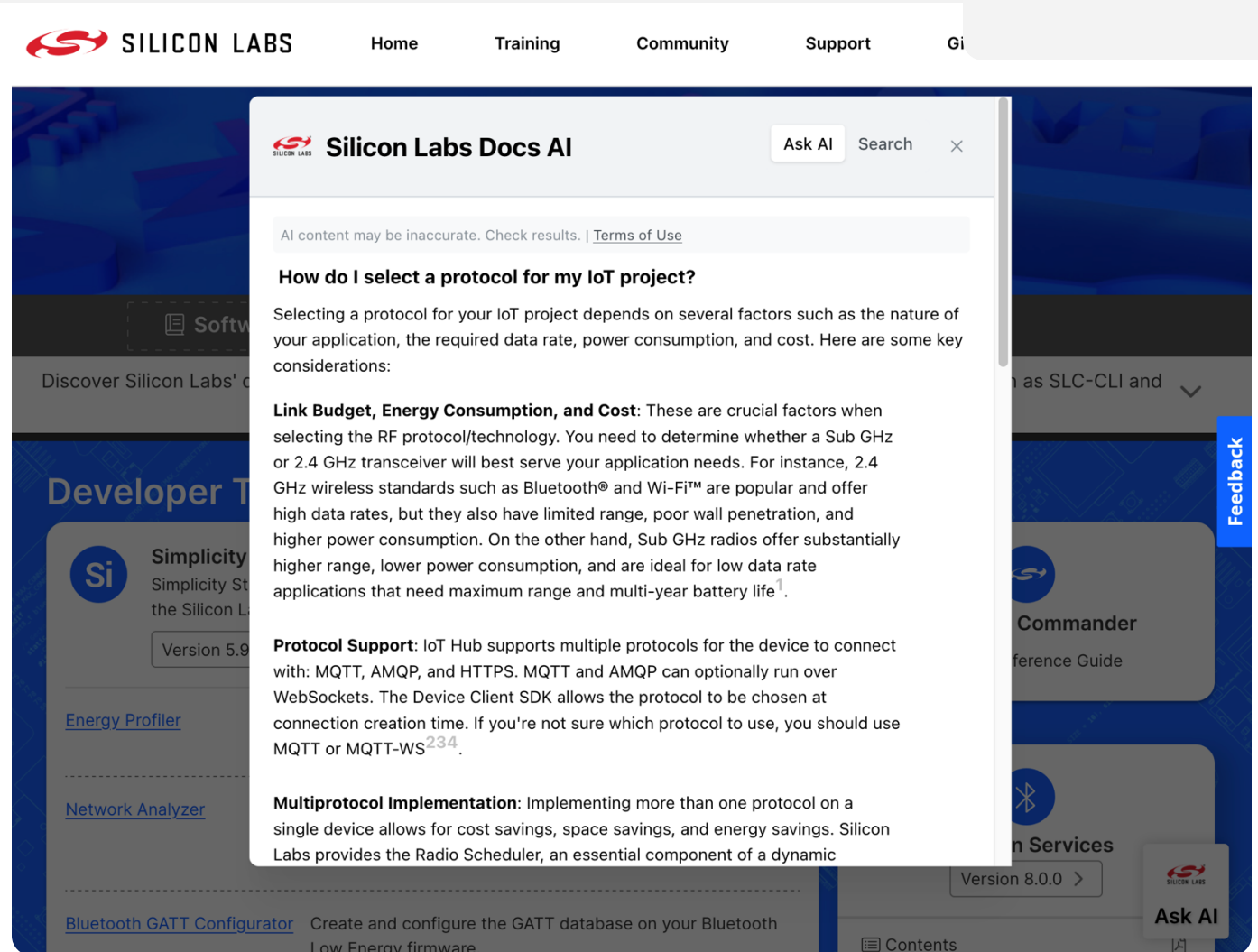
Ultimate IoT development support tool for discovering relevant content

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AskAI Widget Overview

- Kapa.ai - vendor we found and piloted in Dec 2023

- Widget and Slack Channel that allows a GenAI ChatBot style content search

- Perfect fit for DSC because public markdown is ideal for GenAI pipelines

Next steps:

- Add to Silabs Community
- Add to silabs.com
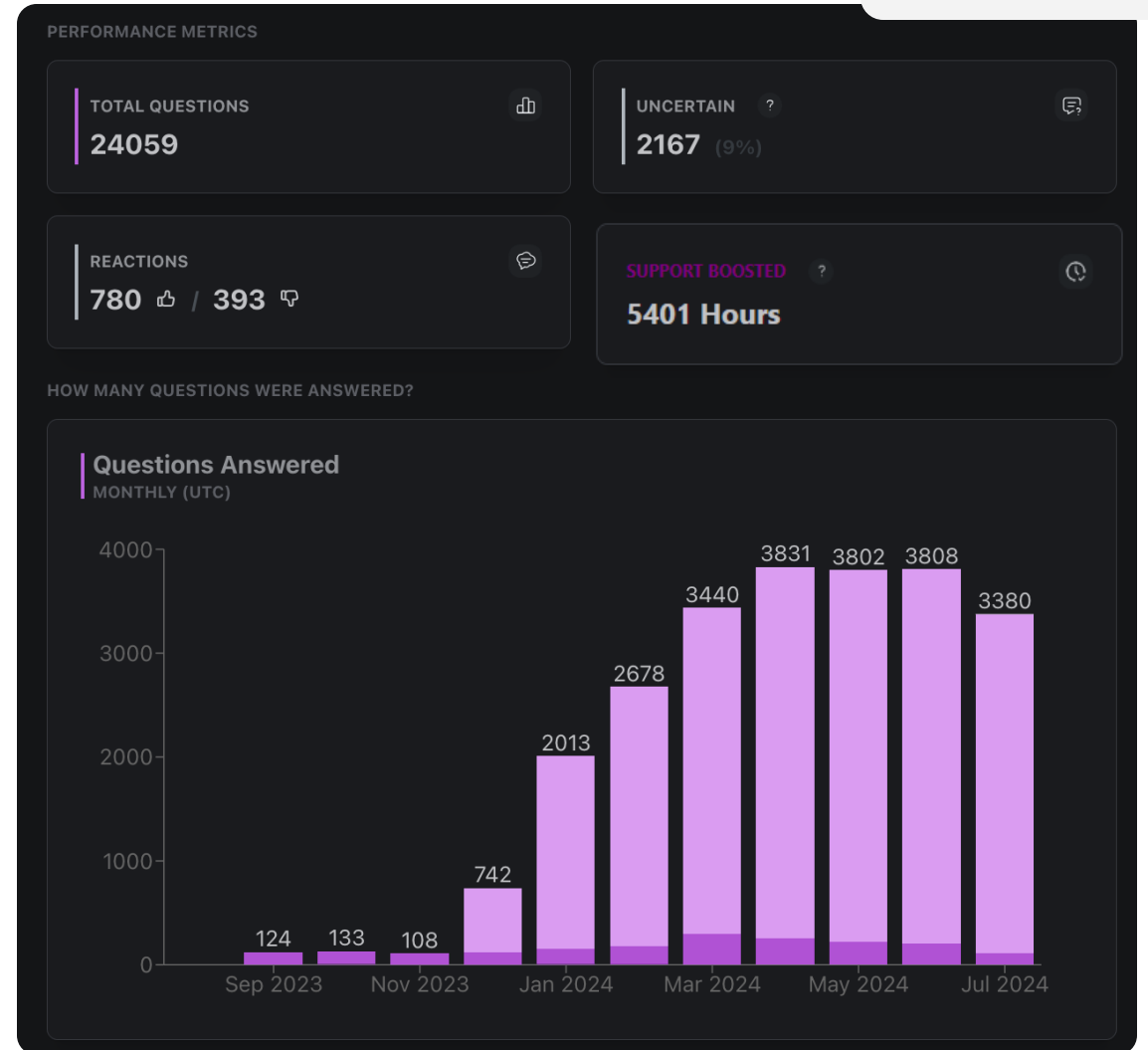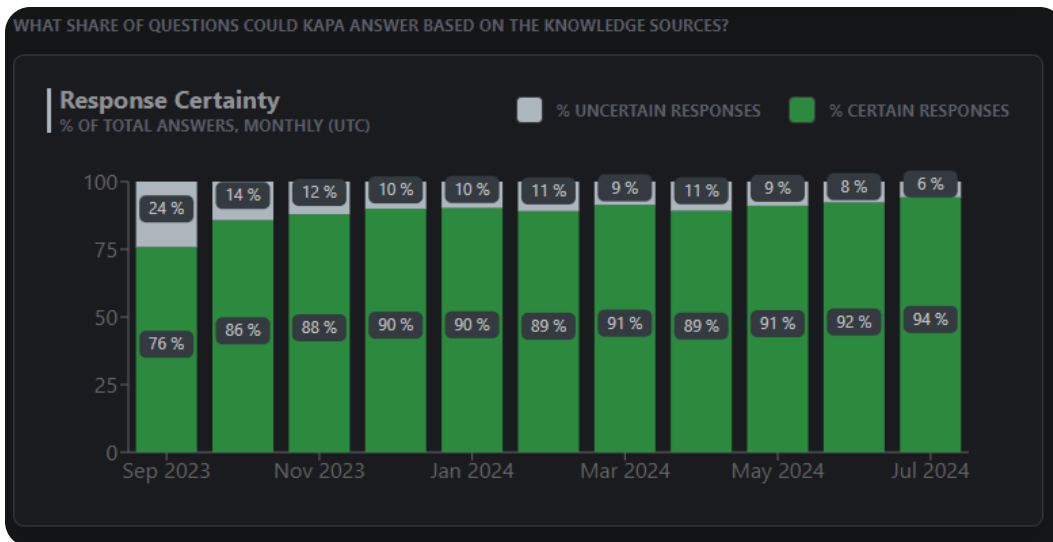- Continuous improvement of source quality based on user feedback

AskAI Widget Metrics – All time

- Sept 2023 – July 2024
- Steady increase in usage since launch
- 24000+ questions answered since launch
- 5000+ hours of support boosted

PERFORMANCE METRICS

TOTAL QUESTIONS	UNCERTAIN ?
24059	2167 (9%)

REACTIONS	SUPPORT BOOSTED ?
780 👍 / 393 👎	5401 Hours

HOW MANY QUESTIONS WERE ANSWERED?

Questions Answered
MONTHLY (UTC)

WHAT SHARE OF QUESTIONS COULD KAPA ANSWER BASED ON THE KNOWLEDGE SOURCES?

Response Certainty
% OF TOTAL ANSWERS, MONTHLY (UTC)

% UNCERTAIN RESPONSES   % CERTAIN RESPONSES

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AskAI 24Q2 Developer Survey Feedback

Positive Feedback (9)

- "This is the absolute best feature you could have come up with. Now I can't live without it and I use it extensively. It has helped me a lot more than what I would normally get in and from the community. It needs a bit more training but so far, the experience has been awesome"

- "Very powerful in finding the right information"

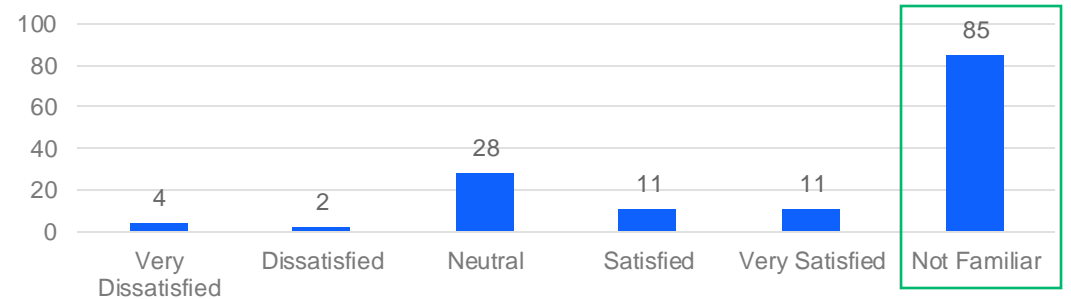- "Been using this more to help forum users and is great"

Visibility (3)

- "Interesting…did not realize it was there!"

- "Haven't used"

- "AskAI widget doesn't seem to be everywhere. What's the coverage?"

Criticisms (2)

- "Some of the keywords were hard to find"

- "Bad links take me here and it is always wrong"

CSAT SCORE BREAKDOWN

Overall, how would you rate your experience with AskAI Search (found on docs.silabs.com)?

| Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Not Familiar
4	2	28	11	11	85

TAKE AWAYS

- Overall, feedback is very positive from customers who have encountered this feature

- It is essential to make the use of AskAI more universal
  - More prominent on website
  - Marketing campaign

- Further training will only make this feature more useful for developers

Bluetooth Developer Journey

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The New Silicon Labs Bluetooth Developer Journey Webpage
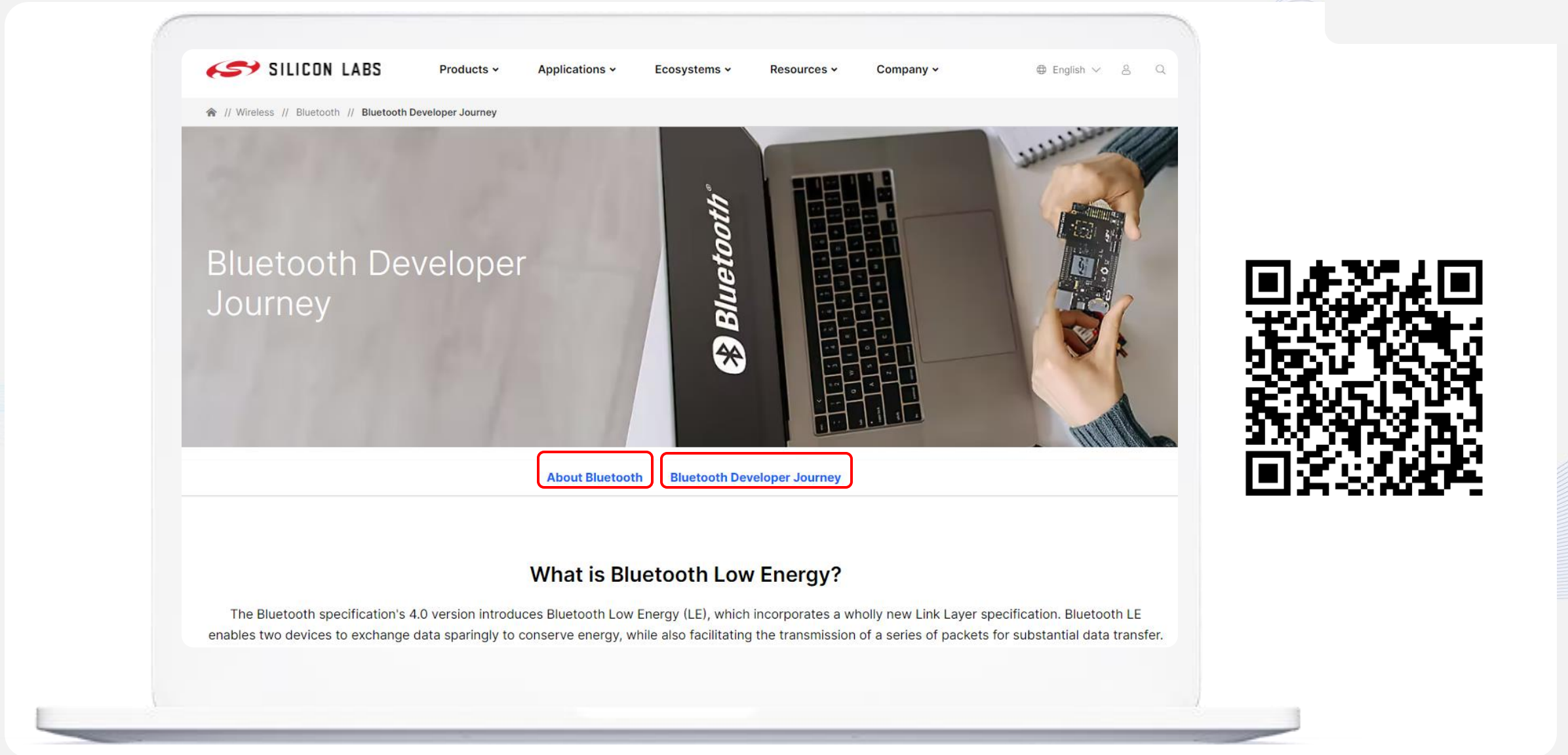
Large-Scale Test Networks

Why Large-Scale Testing?

Scalability

- There is a growing number of smart devices with a need for thousands of interconnected nodes
- Testing ensures these networks can handle the higher loads even under constraints

Flexibility

- Bluetooth has traditionally been used as a short-range protocol
- This testing aims to show its wider capabilities

Interoperability

- To check seamless device compatibility with other mobile devices
- Bugs, if any, can be found out at this stage and fixed in a timely manner before deployment
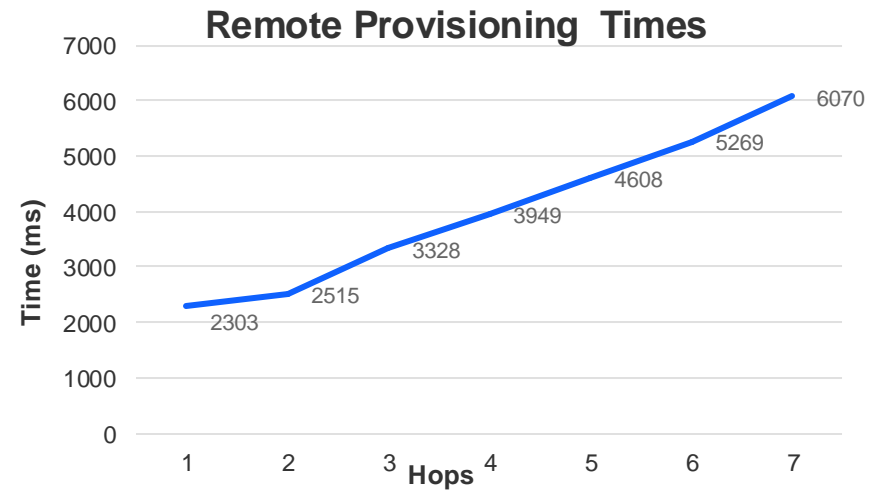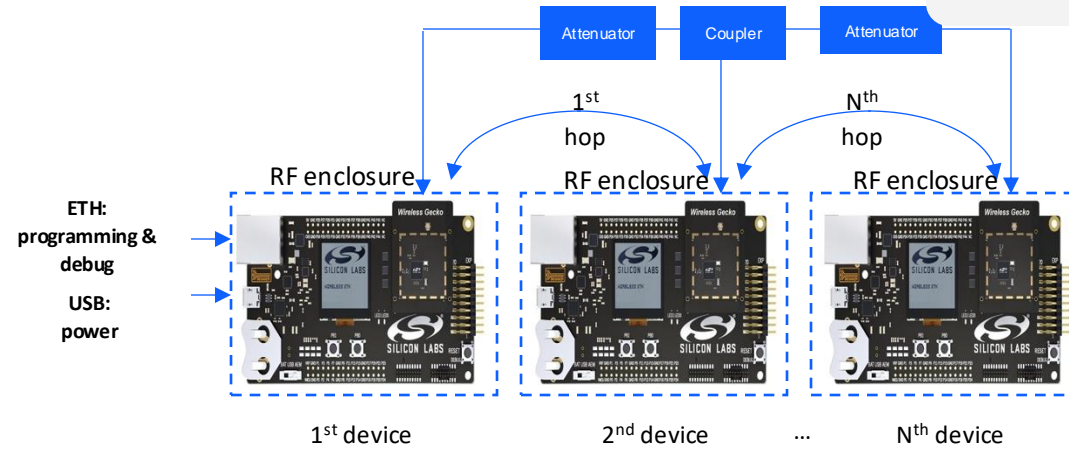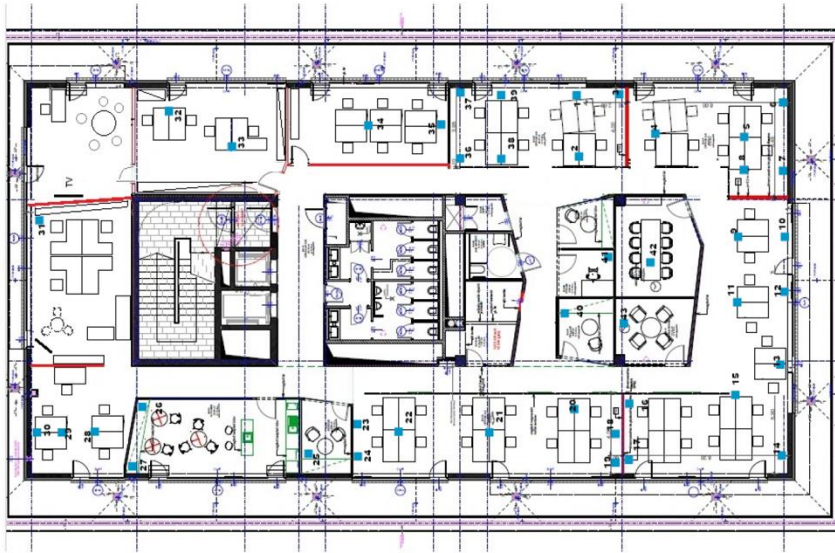
Stability

- Network performance over a long period of time under different conditions can be tested
- Recovery characteristics after a failure or power outage can be determined

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Bluetooth Mesh Test Network

Mesh 1.1 Test Setup

Attenuator Coupler Attenuator

1st hop   Nth hop

RF enclosure   RF enclosure   RF enclosure

ETH: programming & debug

USB: power

1st device   2nd device   ...   Nth device

Remote Provisioning Times

Time (ms)

2303
2515
3328
3949
4608
5269
6070

Hops: 1 2 3 4 5 6 7

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Mesh 1.1 Performance Tests

LATENCY TEST

- **Test conducted on 10, 50, 100 and 256 node networks**
  - Latency increases as number of nodes increases
  - 8-byte payloads are sent and received with the highest efficiency followed by 16 and 32-byte payloads
  - <10 ms to receive most 8-byte payloads
  - <120 ms to receive most 8-byte payloads with 6 hops

- **Advertising Extension**
  - Larger data packets can be sent with AE
  - Improvement in latency
  - More faithful transmission and reception of messages

REMOTE PROVISIONING TEST

- **Multi-hop network setup with 6 hops was used**
  - RF-shielded to avoid interference

- **Time to completion progressively tested from 0 to 6 hops**

- **Provisioning time increases with increase in number of hops**
  - Acknowledged messages take more time

OTA DFU TEST

- **60-node setup used**
  - Two cases, one with advertising extension and one without, were tested
- **Mesh NCP Empty v1.1 example application was run on initiator**
  - Mesh SoC DFU example application was run on distributor
- **Python script available in released GSDK**
  - Time to update software lesser with AE enabled

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PAwR Mesh Test Network

Bluetooth ESL using PAwR - Test Lab Network

**Rack-mounted device farm based on MG24 development kits**

- Capacity for ~1500 devices
- Network mimics a large-scale, real-life scenario

Controlled test framework

- Network deployment, ping with PAwR and network recovery tests conducted on ESL tag groups
- Results show encouraging signs for a variety of use cases other than ESLs
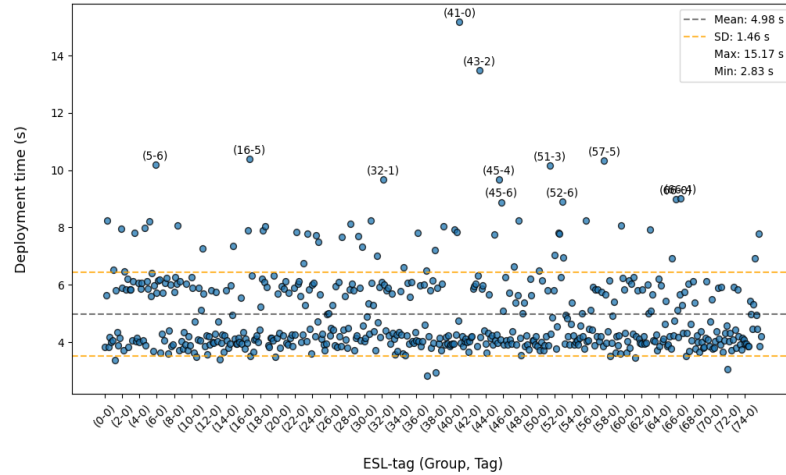
Generating realistic radio environment for PAwR testing

- Flexible configurations demonstrated to show low latency and high reliability
- Bluetooth PAwR viable for ultra-low power, centralized networks for industrial and commercial use
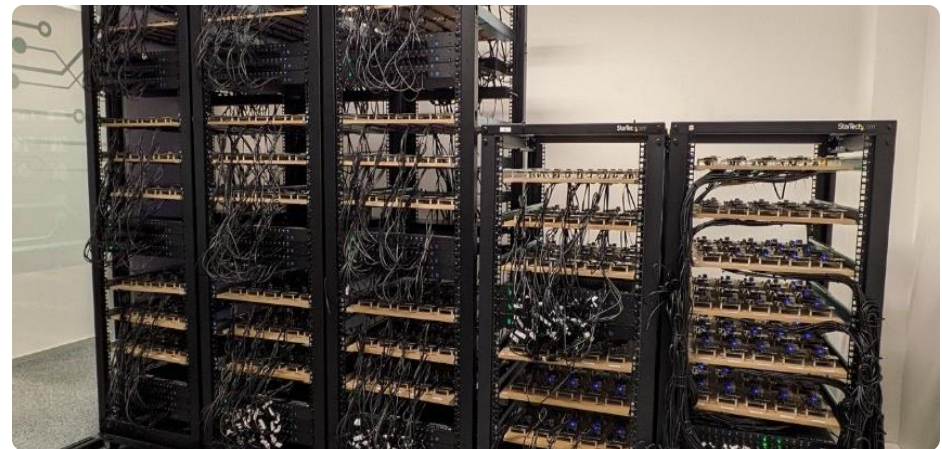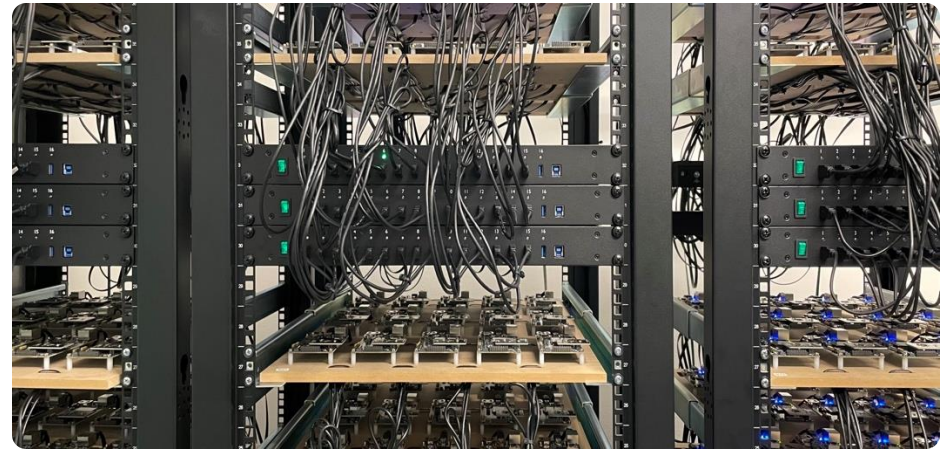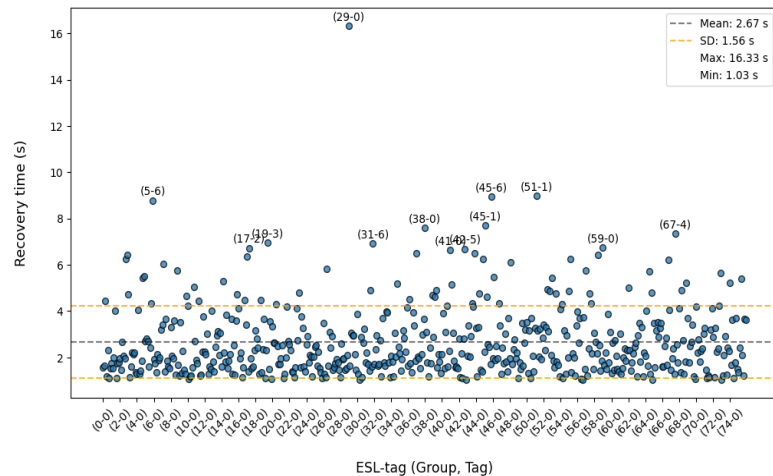
PAwR Test Results

ESL-tag deployment time (532 tags, no autoconnect)

ESL-tag recovery time (532 tags, no autoconnect)

Network Deployment Test

- Average time of <5 seconds to configure a tag into the network using a PAwR train

- ~6.5 minutes for the entire network with 500+ tags

Network Recovery Test

- Periodic Advertisement interval of 2 s

- 2.67 s with single connection and 1.69 s with multiconnection

Channel Sounding Test Network

Channel Sounding Test Infrastructure


Ceiling rail infrastructure

- Internal test environment
- Multiple stationary EFR32 devices placed at different locations
- Mobile EFR32 device for controlled measurements (repeatability)

Challenges - heavy multi-path in an indoor office setting

Statistical analysis

- Static measurements at multiple distances up to 30 meters
- Hundreds of measurements per distance to determine min/max, mean, median, std, absolute error

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Interoperability Test Flow
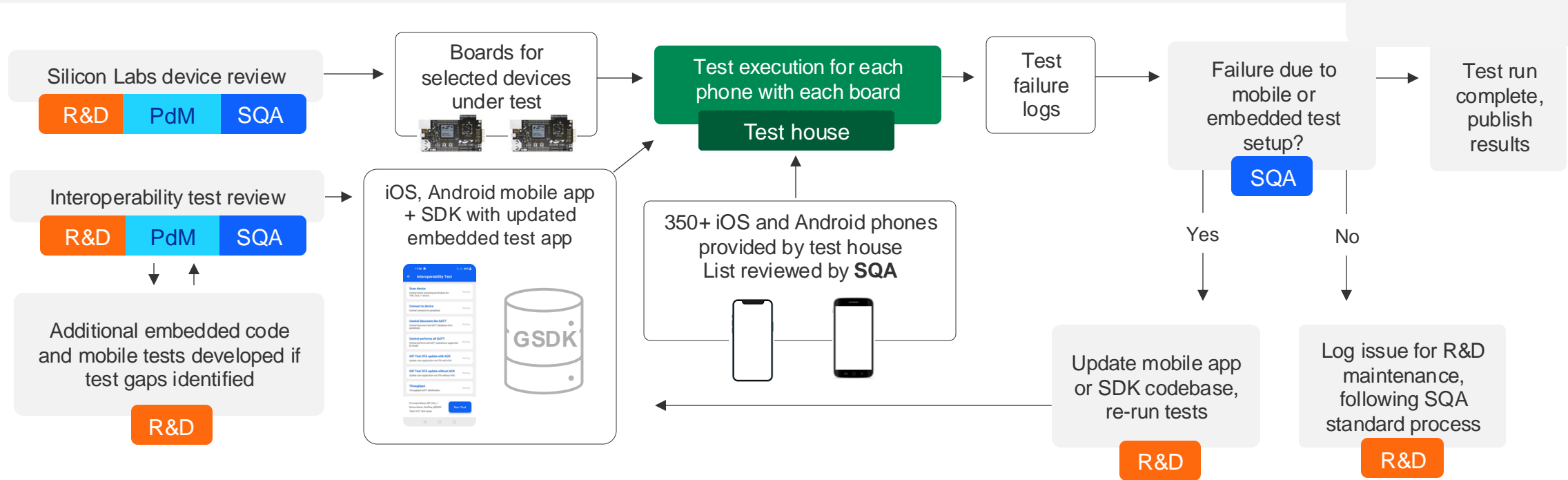
Test process repeats twice per year, with every SDK development cycle
Mobile phones under test updated to latest OS version, verified in test logs
Silicon Labs device review ensures representative subset of EFR devices chosen, providing maximum test coverage
Embedded+mobile test additions based on:

- New Bluetooth specification features and requirements
- Customer input

Upon process completion, test results published in app note on silabs.com (latest results available here)

R&D — Software development

SQA — Software quality assurance

PdM — Product management

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The Portfolio of SoCs and Modules

Increasing Features →

BG22/22E SoC

BGM220S SiP & PCB Modules

Industry-leading energy efficient SoC

BG22

- Lowest power Bluetooth LE
- Direction Finding
- Bluetooth Mesh LPNs
- SoC, PCB Module and SIP
- Balance of features, size, power, cost

BG22E

- Efficient, low-energy cold start
- Low-energy deep sleep wake-up
- Power-efficient energy mode transitions
- Bluetooth Mesh LPNs

BG27 SoC

Most Battery Versatile SoC for Connected Health, Smart Home, Portable Products

- Supports button cells
- DCDC Buck and Boost
- Coulomb counting
- Small form factor WLCSP
- Wake-up pin (BOOST_EN)
- Bluetooth mesh Relay, Proxy, LPNs

BG21 SoC

BGM210L & PCB Module

Optimized for LED lighting, Gateway/Hub, and Bluetooth mesh applications

- Highest output power in Industry
- Line-powered devices
- Secure Vault High, PSA L3
- Bluetooth mesh

BG24 SoC

BGM240S SiP & PCB Modules

Feature rich device with Highest integration

- High I/O pin count
- AI/ML hardware accelerator
- High sensing ADC
- Small form factor WLCSP
- Secure Vault High, PSA L3
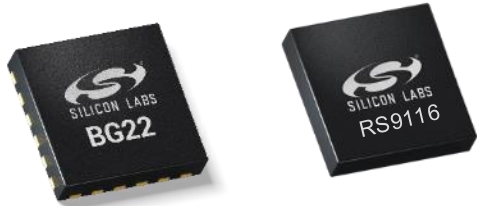- Bluetooth mesh

BG26 SoC

Maximum Flash and RAM ensuring device longevity

- Largest Flash/RAM
- High I/O pin count
- Secure Vault High, PSA L3
- Robust RF Performance
- AI/ML Accelerator
- High sensing ADC
- Bluetooth Mesh
- Available in BGA packages

Increasing Flash/RAM →

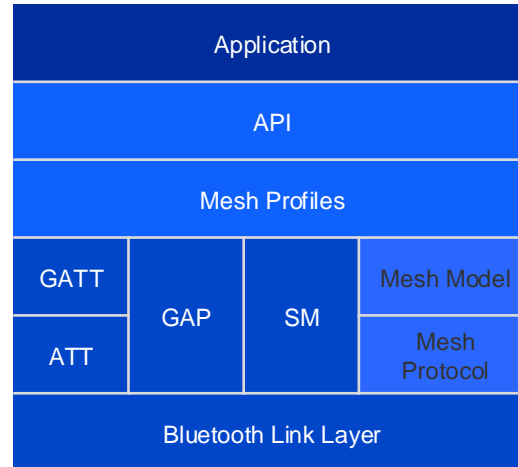works with | SILICON LABS

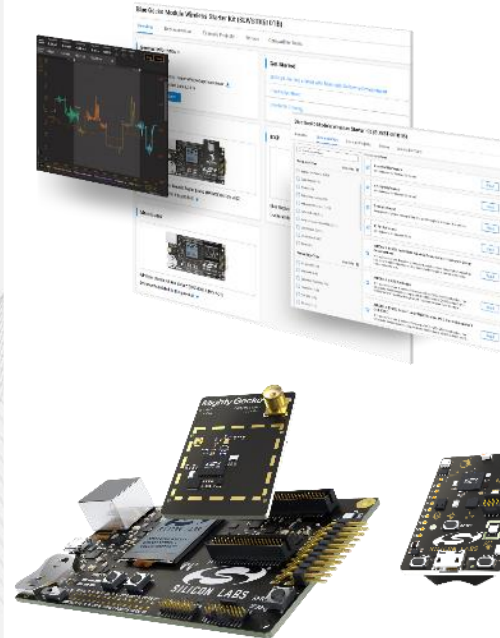# A Complete Solution for Enabling Bluetooth Products

SoCS AND MODULES

Industry leading Bluetooth 5.4 SoCs and pre-certified modules
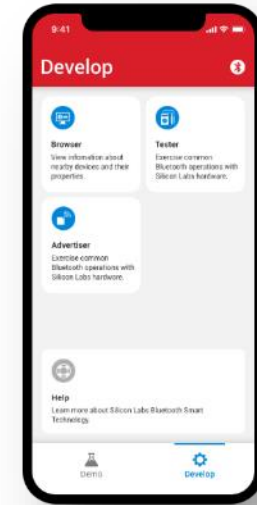
STACK SOFTWARE

In-house developed stacks with latest Bluetooth 5.4 and Bluetooth mesh features

DEVELOPMENT TOOLS

Advanced development hardware and software simplify development and speed time to market

MOBILE APPLICATIONS

Reference applications and source code for iOS and Android

Phone interoperability test program

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Thank You