2023 tech talks
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Welcome

LPWAN Topic
- Optimizing FG23 for Battery life and Performance
- Introducing FG25 for Wi-SUN FAN 1.1

Vikram Pochampally
Sr. FAE, Silicon Labs

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Optimizing FG23 for Battery life and Performance

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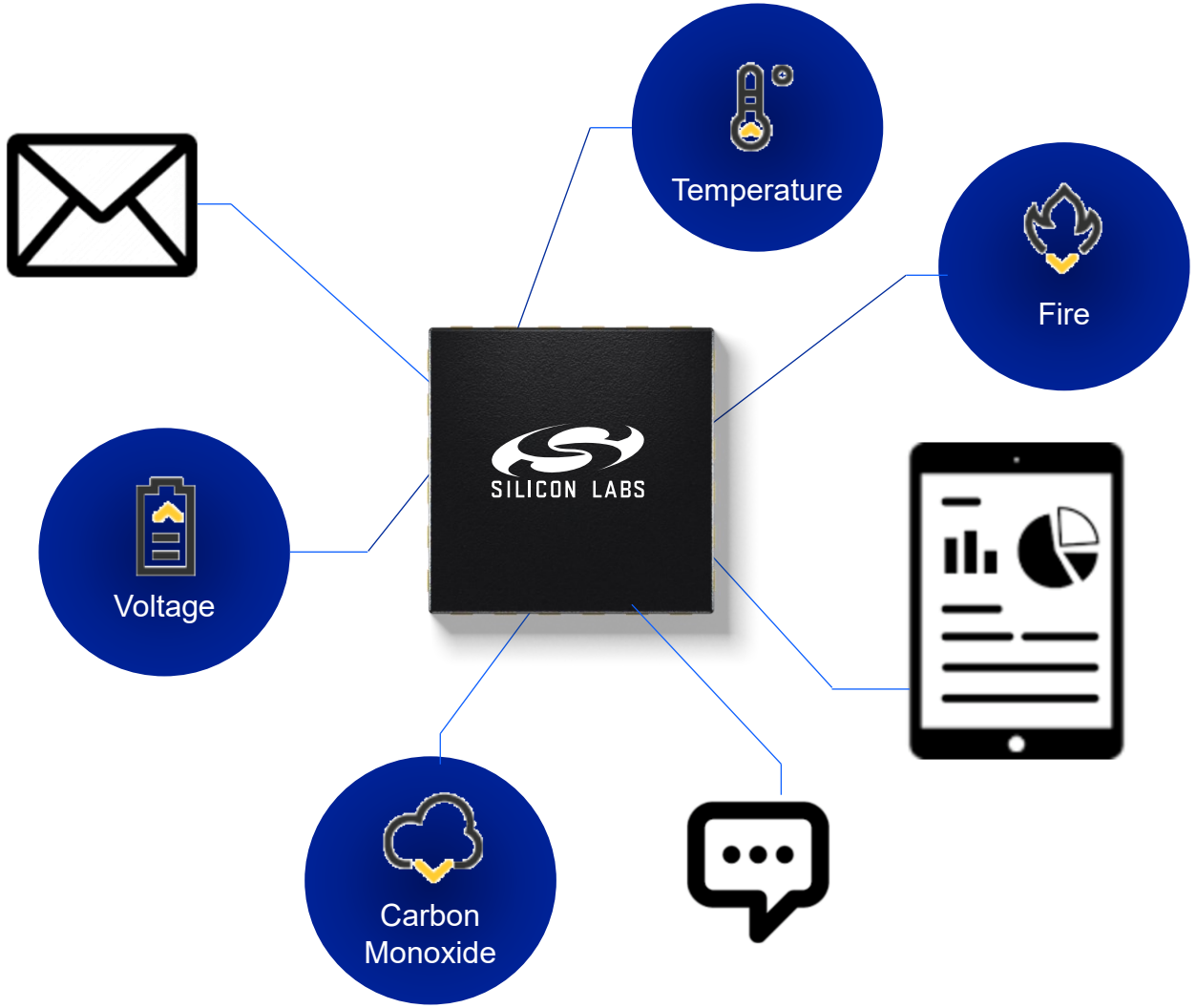
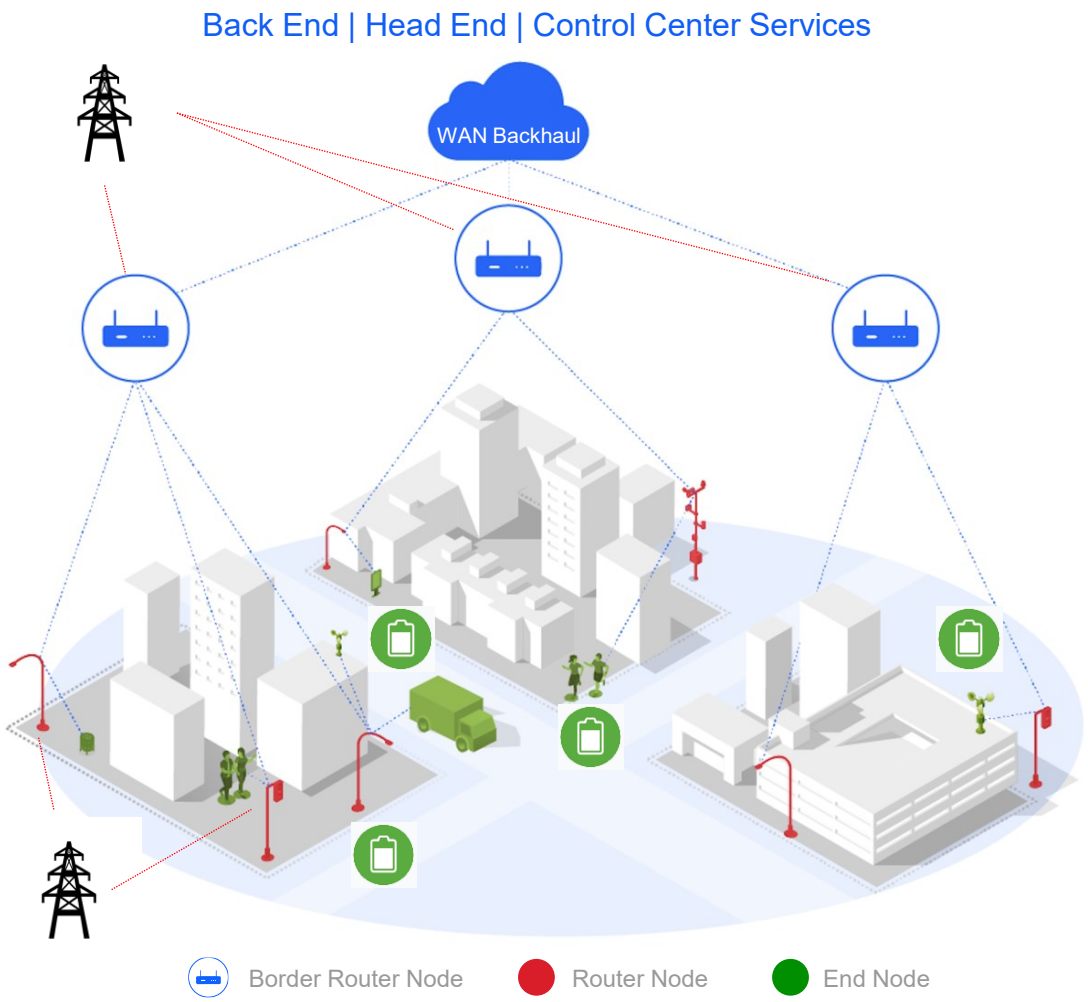
Why Battery Operated?



- Resource sustainability
- Consumer awareness
- Cost impacts
- User convenience
- Regulatory environment
- Functionality additions

Architecture and types of devices



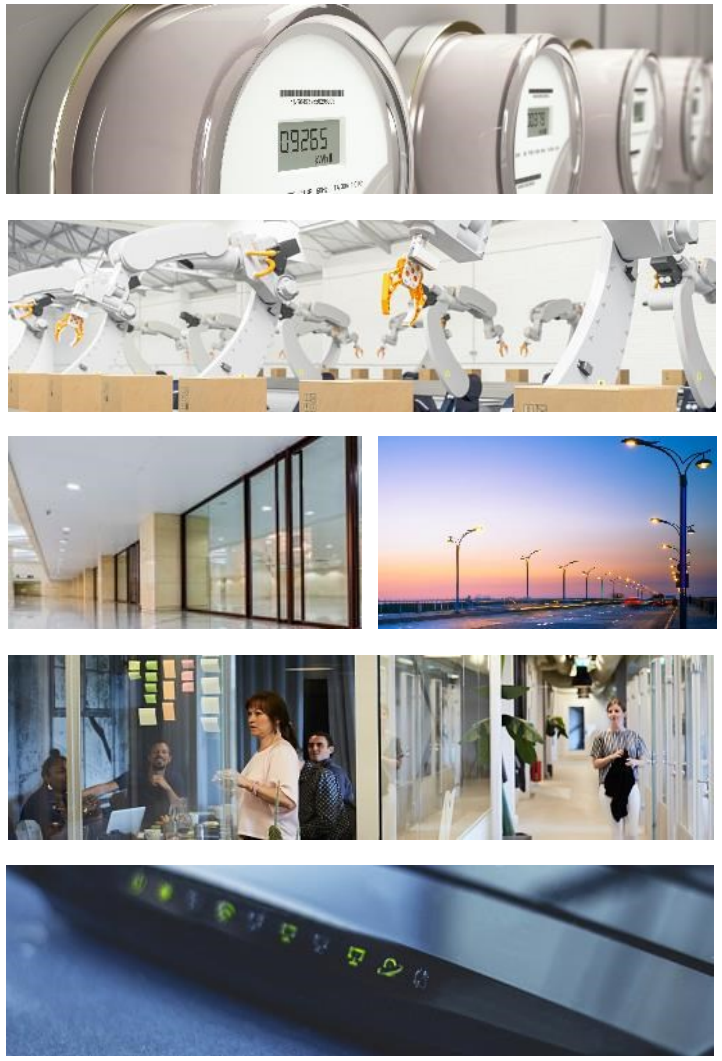
- **Similarities vs. differences in IoT networks**
- **Mix of line-powered and battery-operated nodes**
  - Gateway/Border router
    - Line Powered
  - Routing nodes
    - Line powered or battery operated
  - End nodes
    - Battery operated

Use Cases Drive Battery Requirements

- **Regular vs. User-triggered**
  - Device behavior and connection interval determined by the needs of the network
  - Determination of regular vs triggered reporting strategy can greatly impact power consumption of devices
- **Wireless technology choice affects battery lifetime**
  - Different network selections have different requirements for advertising interval, connection maintenance, and protocol overhead that can greatly affect power consumption

Wi SUN · Proprietary · zigbee · sigfox · Long Range PHY (Proprietary) · Connect

End-device challenges and solutions



- Environment sensing functionality
- MCU wake-up periods affect consumption
- MCU activity minimisation required for sensing
- LESENSE and PRS major contributors for minimising sensing time

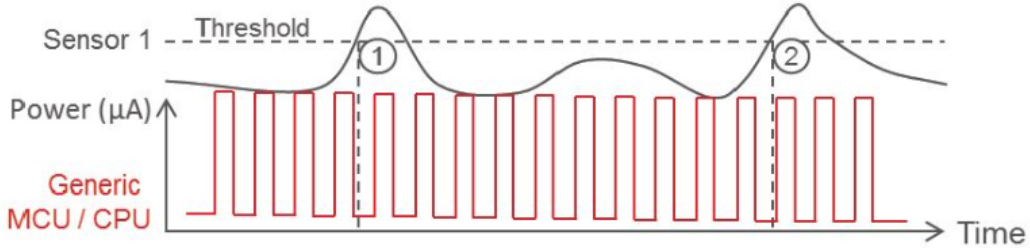


Figure 1: High Energy Consumption with CPU Polling and Active during Every Measurement

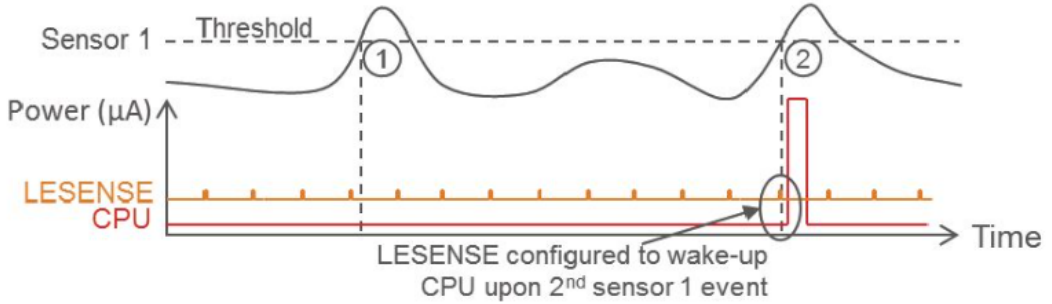
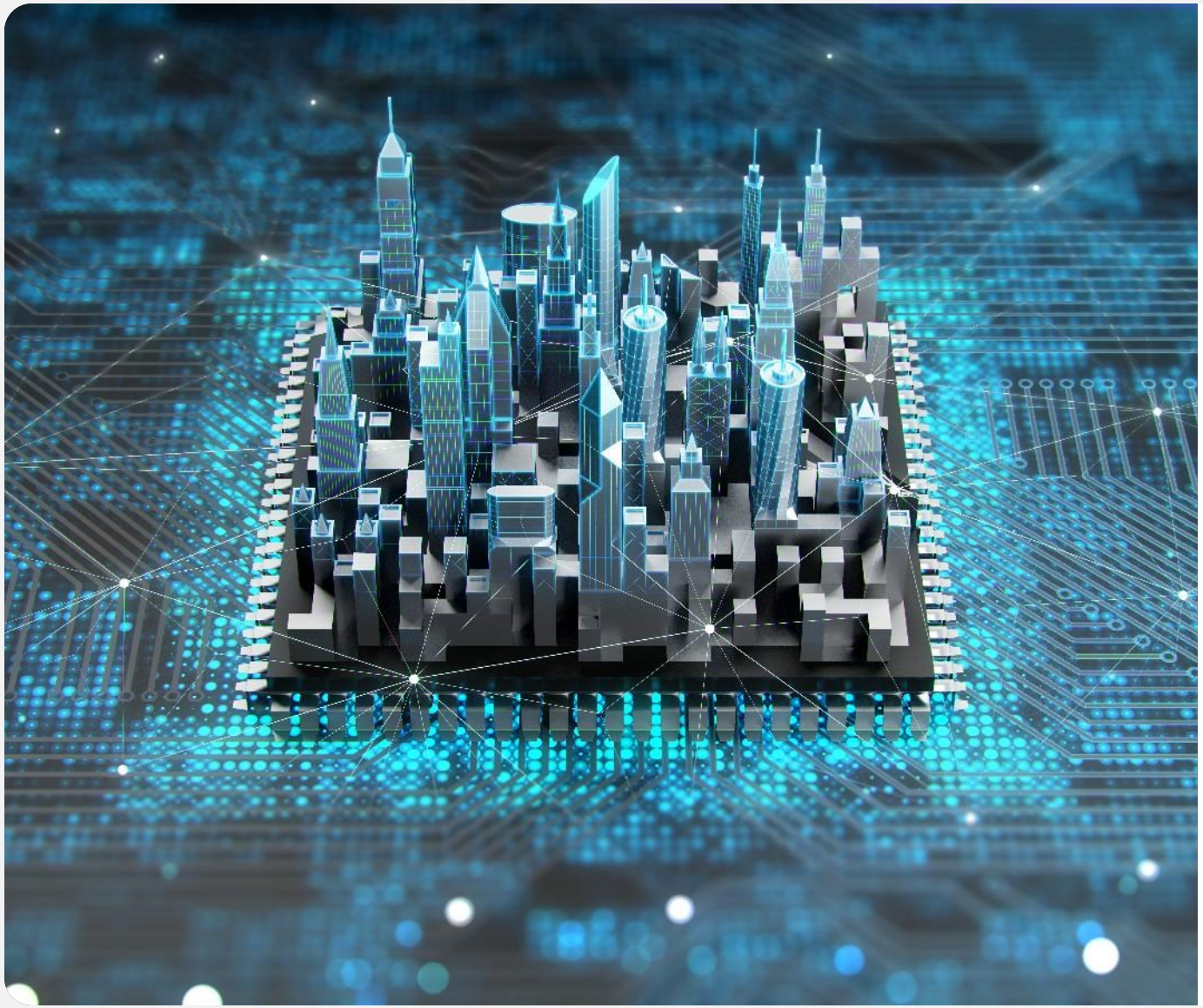


Figure 2: Each LESENSE-Enabled Sensor Input/Output is Independent and Configurable

FG23 and FGM230S for battery operated sub-GHz devices



The first sub-GHz SoCs to combine long-range RF & energy efficiency with PSA™ Level 3 security

- **Simultaneous 1+ mile wireless connectivity & 10+ year battery operation**
- **Secure Vault™ (certified PSA Level 3) safeguards against hardware and software attacks**
- **Broad support for sub-GHz frequencies, modulations and wireless protocols**
- **868 MHz and 915 MHz sub-GHz frequencies, modulations and wireless protocols**
- **Compact form factor and antenna matching with SiP module package**

High-Performance Sub-GHz Wireless SoCs

Low Power.
Long Range.
Secure.

Sub-GHz SoCs Optimized for Metering & Home/Industrial Automation Applications

High Performance Radio
- Up to +20 dBm TX
- -110dBm RX @ 920MHz, 50kbps GFSK
- -126dBm RX @ 915MHz, 4.8kbps O-QPSK
- RX Antenna Diversity

Low Power
- 25 mA TX @ +14 dBm, 925 MHz
- 85.5 mA TX @ +20 dBm, 915 MHz
- 4.2 mA RX @ 920 MHz, 400 kbps 4-FSK
- 26 µA/MHz
- 1.2 µA EM2 with 16 kB RAM
- Preamble Sense

Wireless Technologies
- Amazon Sidewalk
- mioty
- Wireless M-BUS
- Proprietary

ARM® Cortex®-M33 with TrustZone®
- 78 MHz (FPU and DSP)
- 512kB of flash
- 64kB of RAM

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

Low-power Peripherals
- EUSART, USART, I^2C
- 16-bit ADC, 12-bit VDAC, ACMP
- 20 x 4 LCD Controller
- LESENSE, Pulse Counter
- Temperature sensor +/- 1.5°C

Compact Size
- 5x5 QFN40 (22/23 GPIO)
- 6x6 QFN48 (31 GPIO)

Orderable Part Number
- EFR32FG23A/B

High Performance Radio

Output Power

- +14dBm and +20dBm

Sensitivity

- -110.1 dBm RX @ 920 MHz, 50 kbps GFSK
- -125.8 dBm RX @ 915 MHz, 4.8 kbps O-QPSK
- -125.3 dBm RX @ 868 MHz, 2.4 kbps GFSK

Flexibility

- Coverage from 110 to 727 MHz and 742 to 970 MHz
- Supports key sub-GHz modulations
- FSK, GFSK, OQPSK DSSS, MSK, GMSK, and OOK
- Customization via Direct Modulation Mode

Preamble Sense Mode for Channel Scanning and Low Duty Cycle applications

- Allows Core processor to remain in sleep to conserve energy
- Auto Configured from preamble length

High Integration

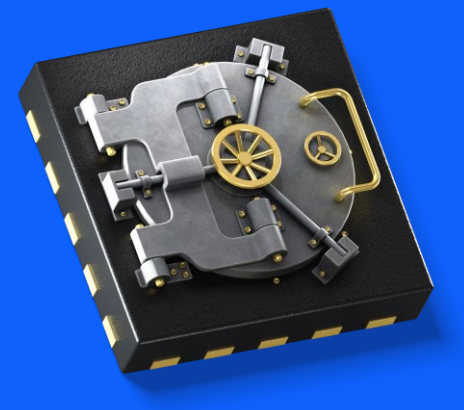
- Integrated PA and LNA
- Single ended, low BOM cost, no balun required
- Supports Antenna Diversity w/ internal switch

Supports Key Standards

- ARIB T-108 RED
- ETSI EN300-220
- FCC

Secure Vault™

Base	Mid	High	Feature
✓	✓	✓	True Random Number Generator
✓	✓	✓	Crypto Engine
✓	✓	✓	Secure Application Boot
—	VSE/HSE	HSE	Secure Engine
—	✓	✓	Secure Boot with RTSL
—	✓	✓	Secure Debug with Lock/Unlock
—	Optional	✓	DPA Countermeasures
—	—	✓	Anti-Tamper
—	—	✓	Secure Attestation
—	—	✓	Secure Key Management
—	—	✓	Advanced Crypto



Designing Secure IoT Devices

Analog Peripheral Focused Techniques

Minimize Analog Energy Use Through Fine-Tuning

- **Suspend the IADC clock when using PRS triggering**
  - Doesn’t matter if the PRS producer is a timer (e.g. LETIMER) or GPIO
  - Current draw reduction is appreciable (5.5x for single-channel sampling at 100 Hz, better still for asynchronous use cases)
- **Use the duty-cycled sample-and-hold ACMP inputs in EM2/3 low-energy modes**
  - Available for the reference options (1.25V, 2.5V, and divided AVDD) and the VSENSE0/1 power supply monitoring channels (AVDD, DVDD, and VDDIO)
  - Per comparator savings of 4 µA for reference inputs and 1.8 µA for supply monitor inputs
- **Minimize VDAC drive time with sample-off mode in EM2/3 low-energy modes**
  - Take advantage of the RC filtering probably already connected to the VDAC main output(s)
  - Use sample-off mode to drive the VDAC outputs at less than 100% duty cycle
  - At 30% duty cycle, for example, current reduction is 50% whether just one or both VDAC outputs are driven

Turn to Hardware Functionality to Save Energy

- **Stop reading the battery voltage with the IADC**
  - Hard to get accurate results when load currents cause the battery output voltage to fluctuate
  - Use the ACMP VSENSE0 channel to monitor AVDD in EM2 instead when quiescent current is low
  - Set an initial trip voltage to request an interrupt to warn about the low battery condition
  - Go into EM4 after tripping at a subsequent lower threshold until the battery can be recharged/replaced
  - Software overhead is zero once the ACMP is configured and until an interrupt is requested

- **Use the LDMA to move data in EM2 instead of waking the CPU via interrupt**
  - Low frequency IADC scan of analog inputs is a prime example
  - At 1 Hz, current draw is around 100 µA to save the results of an 8-channel scan via interrupt
  - Moving the operation to the LDMA reduces this to around 18.5 µA, a reduction of 5.5x
  - The CPU must wake every 8 samples; the LDMA can save 2048 results before waking the system

Other Techniques

Other possible optimizations

- **Turn off parts of the RAM while staying in EM2 / EM3**
  - FG23 has 64 kB of RAM, consisting of 4 RAM banks of 16 kB each
  - If not needed you can turn off one or more RAM banks in EM2 / EM3
  - Current optimizations is approx. 100 nA per RAM bank
  - However, at least one RAM bank (bank 0) must remain enabled

- **Enable Voltage Scaling in EM2 / EM3 and use VSCALE0 level**
  - The internal voltages will go down to 0.9 V which will reduce the current consumption in EM2 / EM3
  - However, when using voltage scaling, the wake-up time from EM2 / EM3 will slightly increase as the internal regulator will need more time to settle on the higher voltage level that is being used in EM0 / EM1 active mode.

- **Turn off debug interface in EM2 / EM3**
  - If debugging is not needed make sure to not keep the debug interface enabled in EM2 / EM3
  - → Clear the EM2DBGEN bit in the EMU_CTRL register

Other possible optimizations

- **Use LESENSE (on xG23 devices) to automate sensor sampling**
  - LESENSE can automatically sample resistive, inductive and capacitive sensors and will trigger an interrupt once certain sensor conditions are met

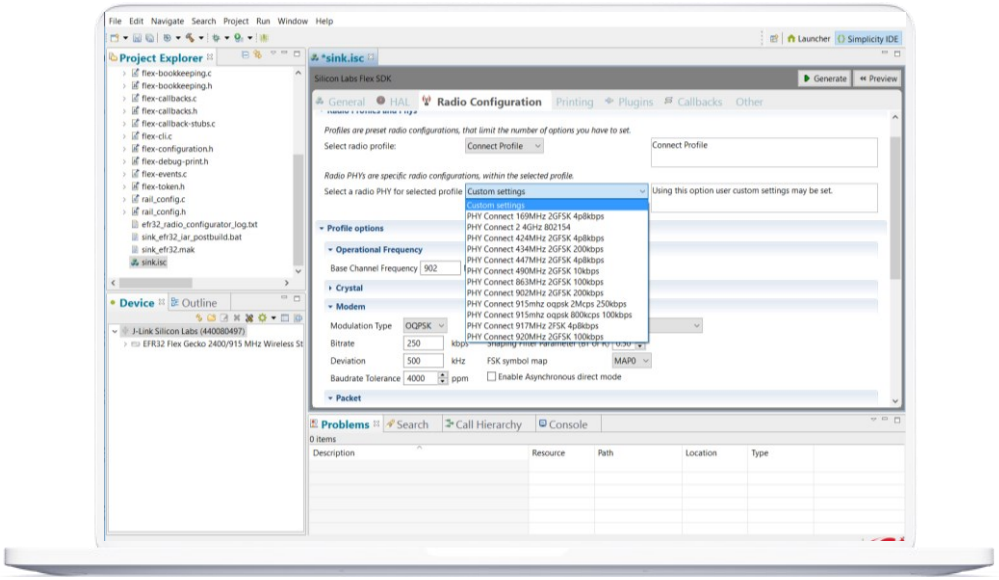
- **Reduce active currents (EM0 / EM1) by:**
  - Reducing the clock speed if the application can run at lower speed.
  - E.g. let the application run from HFRCO and reduce its clock frequency to down to 1 MHz

Simplified Developer Experience

Simplicity Studio 5

- **Interface**
  - Fresh, new & simplified
  - Intuitive out-of-the-box experience
  - Fast access to developer resources
  - Linux, Mac & Windows
- **Tools**
  - Configuration utilities
  - Compiler
  - Error & validation
  - IDE & command line support
  - Graphical hardware configurator
  - Energy Profiler – visual energy analysis
  - Network Analyzer – packet capture & decode

Radio Configurator



Tool to configure and optimize radio performance

Rapid Radio configuration and prototyping

- Predefined PHY settings for most common world regions
- Ability to create custom PHY settings for proprietary wireless applications

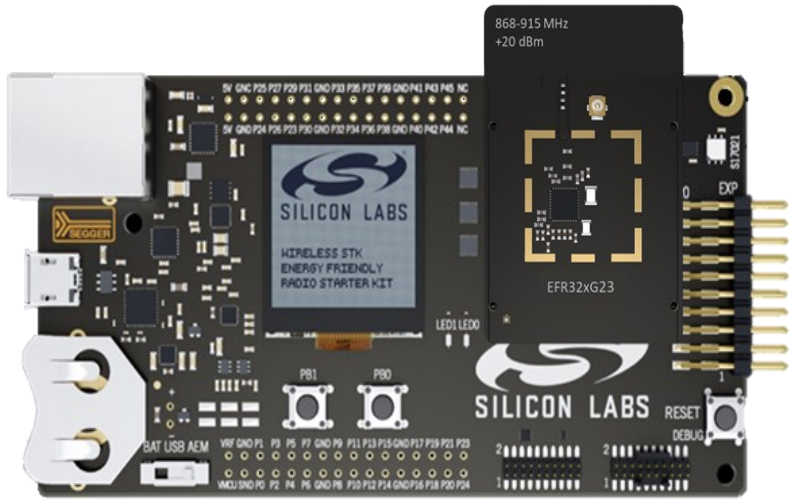
Intuitive GUI to configure PHY parameters

- Frequency bands, channel spacing, modulation
- Bit rate, symbol maps, symbol coding, filtering
- Timing detection, AFC, AGC and many other

Quick learning curve for new radio engineers

- Human readable configurations
- No need to learn specific radio registers and other IC internal information

Getting Started with EFR32FG23 SoCs



Simplified Development Kits for Better User Experience

Simplifies Development

Pro kits contain:

- 1 x WSTK main board
- 1 x radio board
- Antenna(s)
- USB cable

Radio Board kits contain:

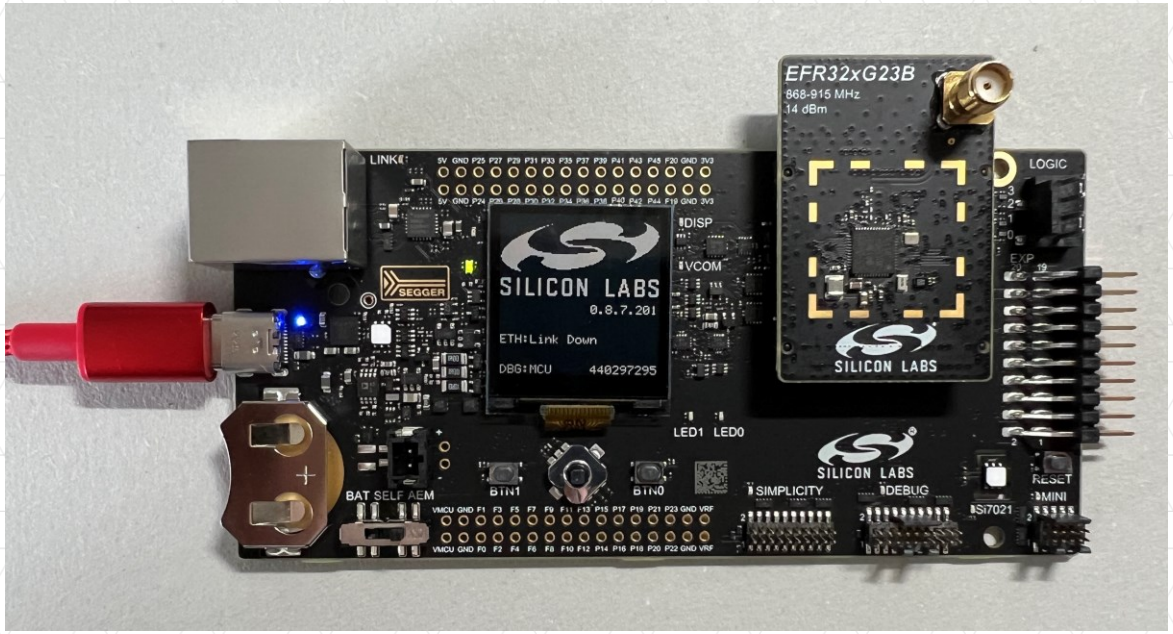
- 1x x radio board
- Antenna(s)

Out-of-Box Application

- Boards are pre-programmed with the range test application
- Configure & control from the development board via buttons and LCD

Order Part Number	Description
xG23-PK4204D	xG23 868-915 MHz +14 dBm Pro Kit
xG23-PK4210A	xG23 868-915 MHz +20 dBm Pro Kit
xG23-RB4204D	xG23 868-915 MHz +14 dBm Radio Board
xG23-RB4210A	xG23 868-915 MHz +20 dBm Radio Board
FG23-RB4265B	FG23 433 MHz +10 dBm Radio Board
FG23-DK2600B	FG23 868-915 MHz +14 dBm Dev Kit

Demo


EFR32xG23B
868-915 MHz
14 dBm
SILICON LABS
0.8.7.201
ETH:Link Down
DBG:MCU
440297295
SILICON LABS
LOGIC
LED1 LED0
SILICON LABS
SIMPLICITY
DEBUG
BAT SELF AEM
BTN1
BTN0
SI7021
RESET
SEGGER

Microsoft Teams

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Vikram Pochampally

Organized by
Vikram Pochampally

Q&A

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Introducing FG25 for Wi-SUN FAN 1.1

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Vikram Pochampally
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Introducing EFR32FG25 and Wi-SUN FAN 1.1

- **EFR32FG25**
  - Optimized solution for longest range Sub-GHz performance
  - Multi-rate OFDM, FSK, O-QPSK, and (G)MSK modulations
  - Integrated PA with up to +16 dBm (Sub- GHz) TX power
  - More Flash, RAM and IOs for better system integration
  - Secure Vault™ - Industry's highest-level of security
- **Wi-SUN FAN 1.1**
  - OFDM Modulation addition allows for up to 2.4 Mbps data rates and achieve low latency
  - Complete solution including Border router, Router, Line-powered End Nodes (including sleepy end devices)
  - Concurrent operation of OFDM and FSK
  - Modulation and data rate switching to enable more robust networks

FG25 Key Differentiators

- **OFDM Support**
  - First Silicon Labs device to support SUN OFDM PHYs
  - Up to 3.6 Mbps data rates
  - Significant range and data rate improvements over FSK type modulations
- **Concurrent Detection (Optimized set of PHYs)**
  - Can detect both FSK and OFDM messages simultaneously
  - Provides additional network flexibility and optimization
- **High Performance MCU**
  - ARM Cortex®-M33 – Up to 97.5 MHz
- **Available Memory and Peripherals**
  - Up to 1920 kB Flash and 512 kB RAM
  - Inclusion of USB device functionality
  - Up to 37 GPIO

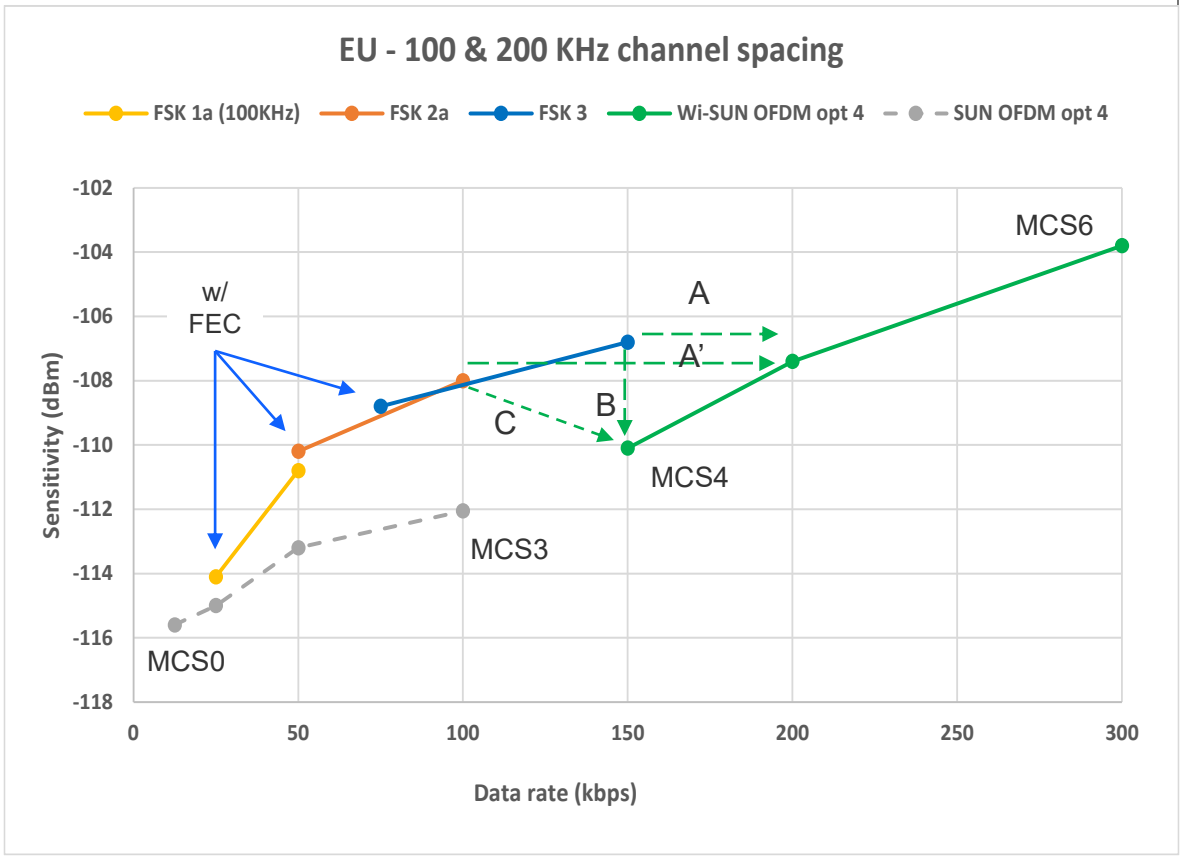
OFDM

- **Invented in 1980's for DAB**
- **Became popular in 1990's with Digital TV (Europe and Japan), then in Wi-Fi (802.11g/n)**
- **Multi-carrier modulation**
- **Main benefits:**
  - Robustness to multipath
  - Carriers dedicated to synchronization, others to data
  - OFDM has built-in flexibility/scalability
    - For a given OFDM option, same synchronization for all MCS modes -> easy switch between modes without configuration (in- packet signaling)
    - Example for Wi-SUN Option 3:
      - From robust modes (-115 dBm, 25 kbps)
      - to very efficient modes (-101 dBm, 600 kbps)

- **Wi-SUN OFDM adds much higher bit rates than available in FSK**
  - Up to 300kbps (EU), 1.2Mbps (JP) and 2.4 Mbps (US)
  - Increased throughputs
  - Reduced on-air time for same payload, thus improved network performance
  - Despite consumption of OFDM Tx is higher than FSK Tx, the much shorter OFDM bursts reduce power consumption

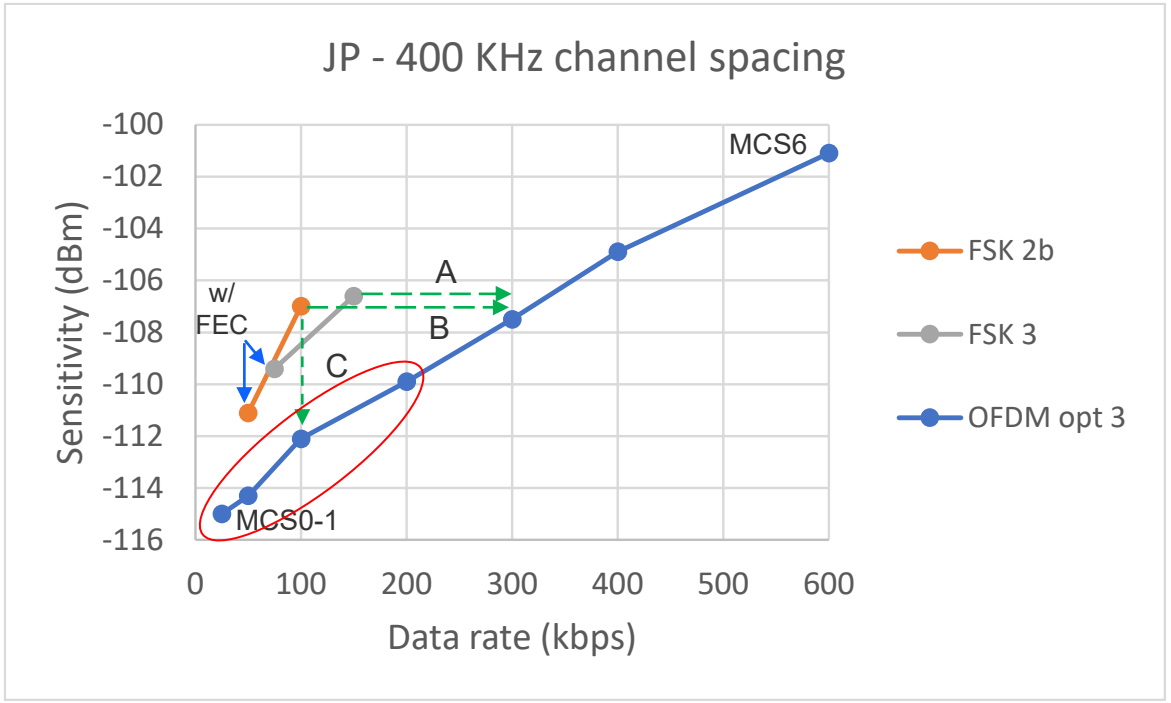
Wi-SUN OFDM benefits – Europe, India & Singapore

- **Europe - India - Singapore:**
  - 100 KHz channel spacing for FSK #1a
  - 200 KHz spacing for FSK #2a, #3 and OFDM option 4



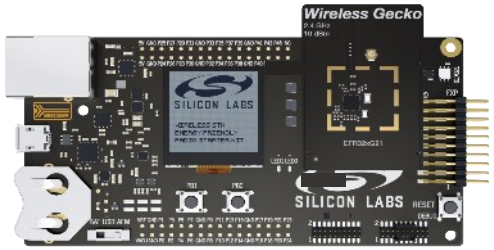
- **OFDM brings**
  - Much higher throughputs when budget link allows
    - Up to 300 kbps vs 100 (#2a) or 150 (#3)
  - Higher bitrate for similar range
    - A: +30% bitrate (FSK #3 to MCS5)
    - A': doubled bitrate (FSK #2a to MCS5)
  - Or better range for a given bitrate
    - B: 3 dB improvement (FSK#3 to MCS4)
  - Or both
    - C: + 50% bitrate and 2 dB better sensitivity
  - Considering 100KHz channel spacing
    - OFDM MCS4 brings tripled bit rate for twice the BW
- **Much better channel usage**
  - Shorter burst times given higher data rate
  - Important in India and Singapore where the band is narrow (2 & 3 MHz)

Example: Wi-SUN OFDM benefits - Japan



- **Example for 400 KHz BW**
- **OFDM brings higher bitrate for similar range (sensitivity)**
  - A: doubled bit rate
  - B: tripled bit rate
- **OFDM brings better range for a given bit rate**
  - C: 5 dB improvement
- **Note: only MCS4, MCS5 and MCS6 are specified in Wi-SUN for the time being**

Getting Started with FG25 Development: End Nodes & Border Routers



EFR32FG25 and Wi-SUN Pro Kits

Kit Contents

Wi-SUN Pro Kits	FG25 Pro Kits
3x BRD4002A WSTK main boards	1x BRD4002A WSTK main boards
3x FG25 +16 dBm	1x FG25 +16 dBm
3x BRD8016 Expansion board	1x BRD8016 Expansion board
3x Antenna	1x Antenna
Wi-SUN-PK6015A – 863-870 MHz + 16 dBm Wi-SUN-PK6016A – 902-928 MHz + 16 dBm	FG25-PK6012A – 863-870 MHz +16 dBm FG25-PK6011A – 902-928 MHz + 16 dBm

Available Radio Boards

FG25-RB4272A – 470MHz +16 dBm
FG25-RB4271A – 868MHz +16 dBm
FG25-RB4270B – 915MHz +16 dBm

Pro Kit can be used for the development of End Nodes and Border Routers

Featured FG25 Case Studies

Learn more about how the FG25 is accelerating smart city applications worldwide

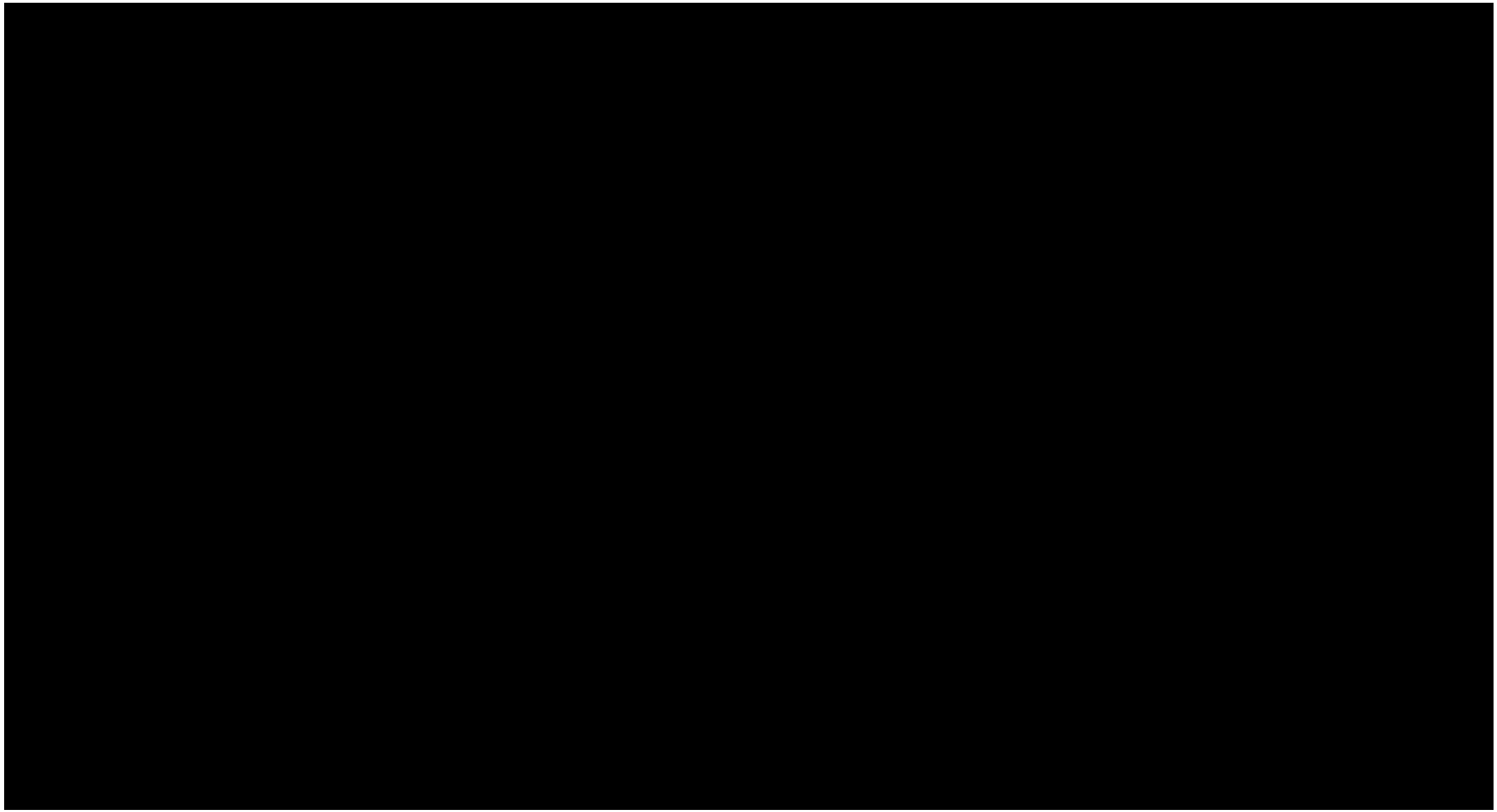
Visit www.silabs.com/case-studies

Landis+Gyr

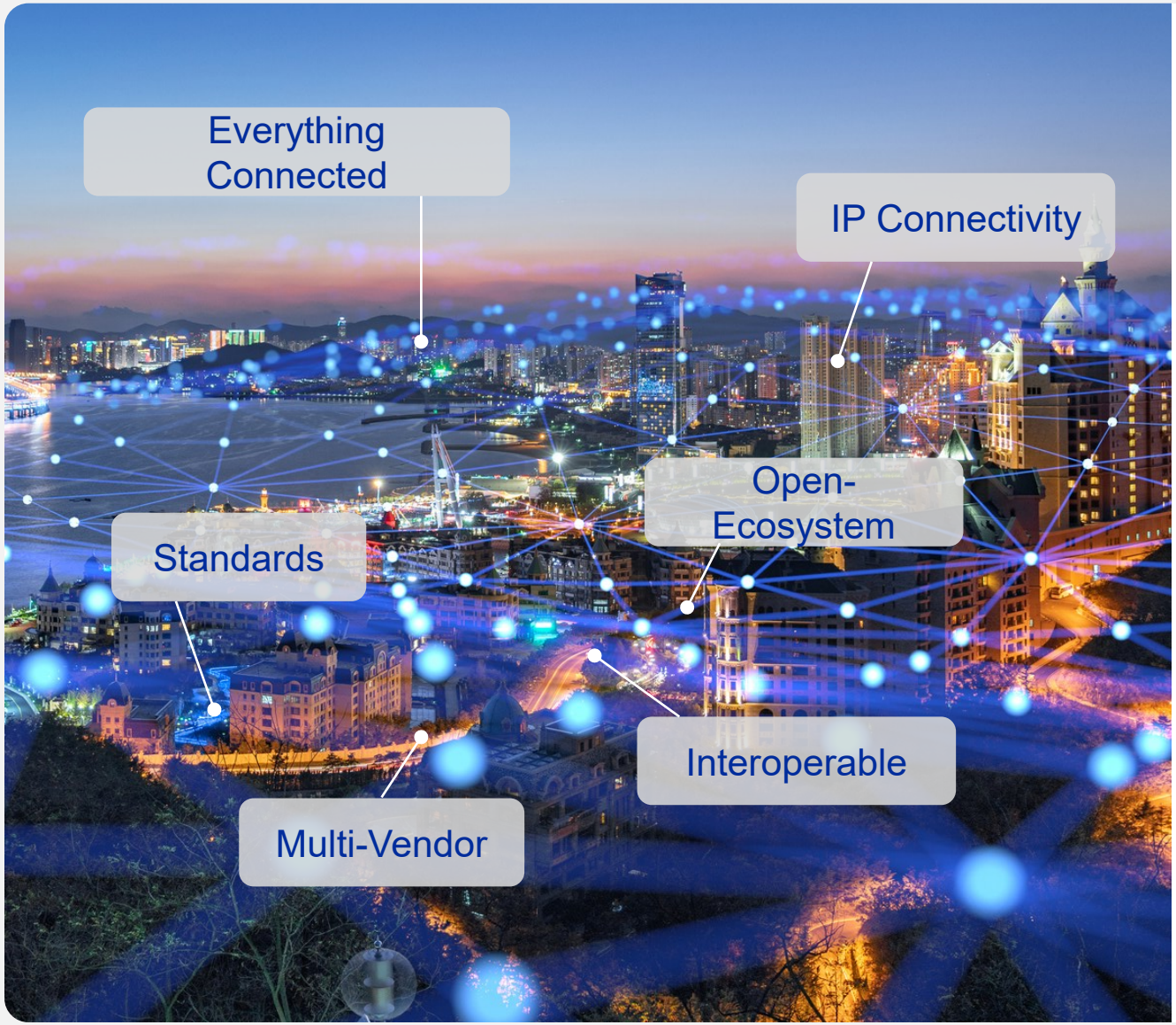
CYANCONNODE

NAGANO
NaganoJRC

View Recording for FG25 Unboxing

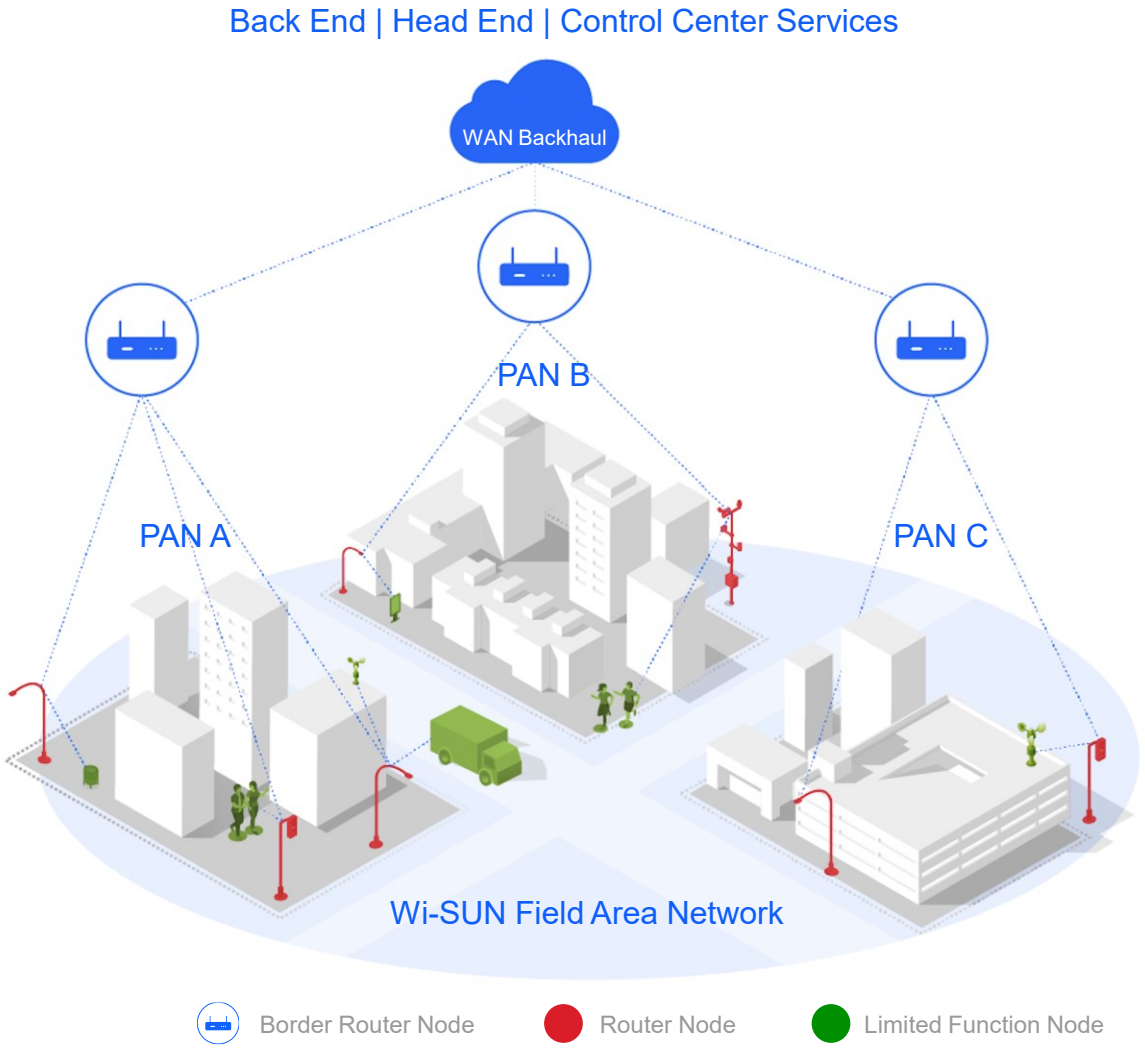


Field Area Network Evolution



- **A move from Proprietary to standards-based solutions**
  - Ease of use
  - Flexibility
  - Avoid vendor lock-in
- **Wi-SUN is a Sub-GHz IPv6 mesh solution for smart infrastructure that provides**
  - Scalable self-healing mesh
  - High performance long range
  - Interoperable & secure

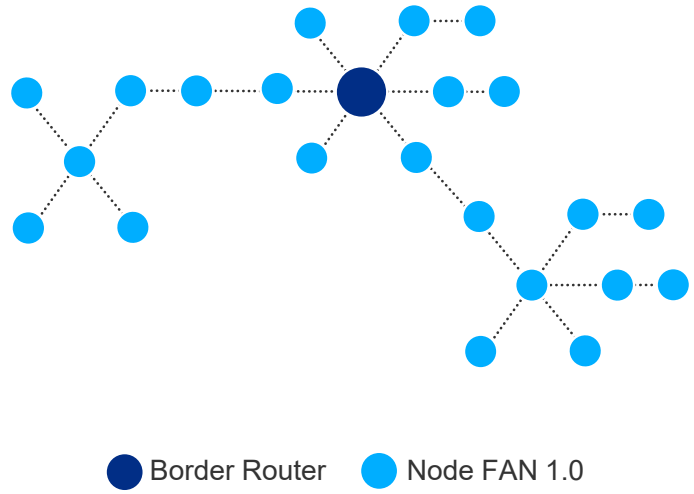
Wi-SUN Solution Architecture



- **Border Router**
  - Provides WAN connectivity
  - Maintains source routing tables
  - Provides node authentication and key mgmt.
  - Relay PAN wide information such as broadcast schedules
- **Router Nodes**
  - Upward and downward packet forwarding within a PAN
  - Relay security & address mgmt. protocols
- **Limited Function Nodes (LFN)**
  - Discover and join a PAN
  - Send/receive IPv6 packets
  - Introduced in FAN 1.1

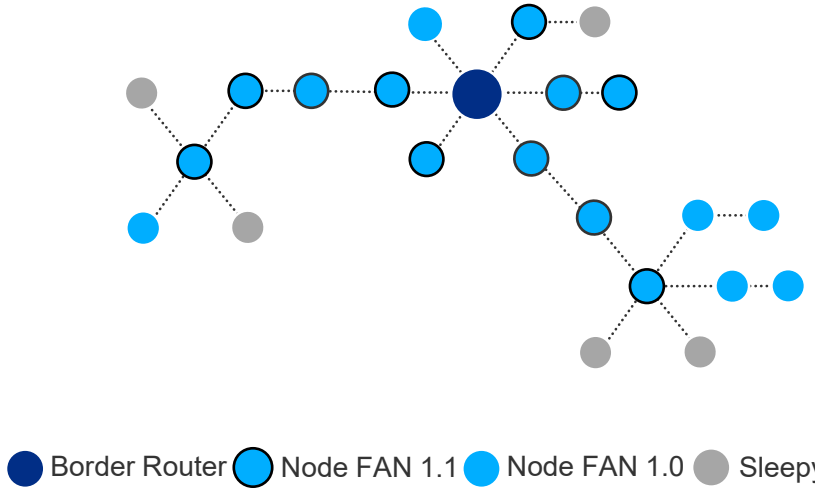
Wi-SUN FAN 1.0 vs FAN 1.1

Wi-SUN FAN 1.0



- Deploy a mesh network with up to several thousands' nodes
- Native IPv6 communication through 6LoWPAN
- Based on FSK PHYs (up to 300 kbps)
- Interoperable
- Secure

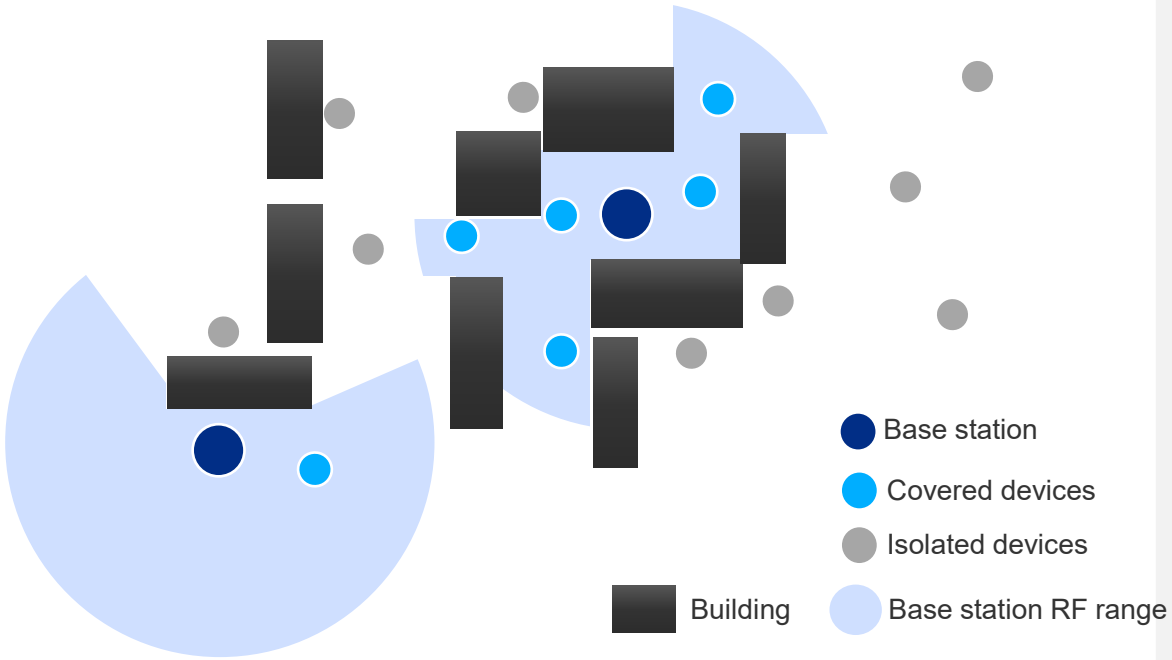
Wi-SUN FAN 1.1



- Enable battery powered devices in the network (water/gas metering, smart city sensing…)
- Expanded global footprint (Japan, Brazil, EU…)
- Introduction of OFDM PHYs (up to 2.4 Mbps) for high performance use cases like distribution automation
- Modulation and data rate negotiation between nodes to make use of the different PHYs for optimum performance

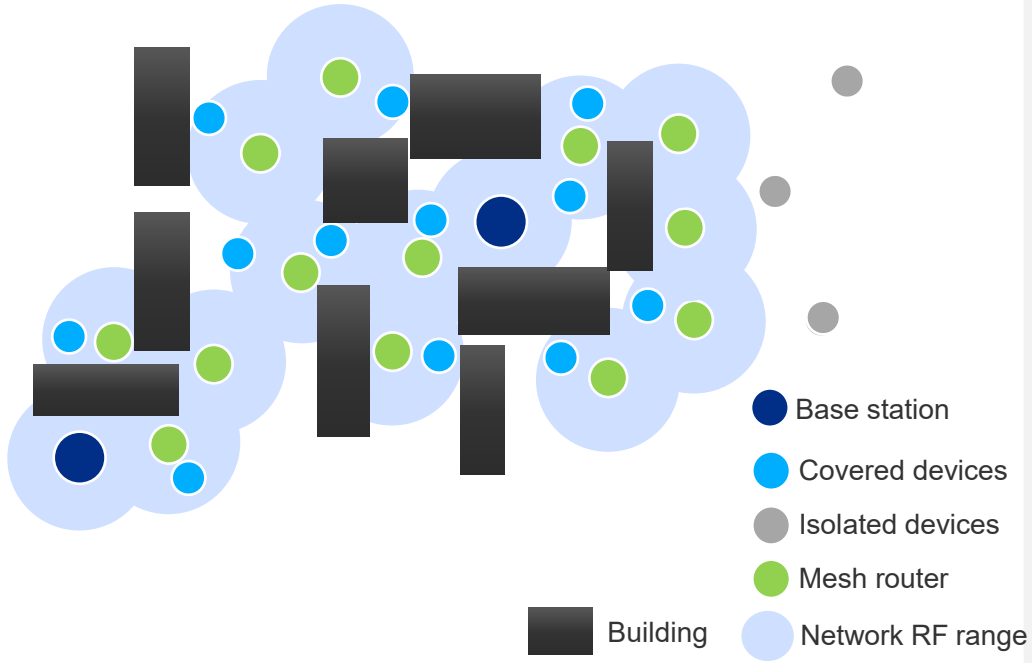
Long Range vs Mesh IoT Protocols

Long-range IoT Protocol



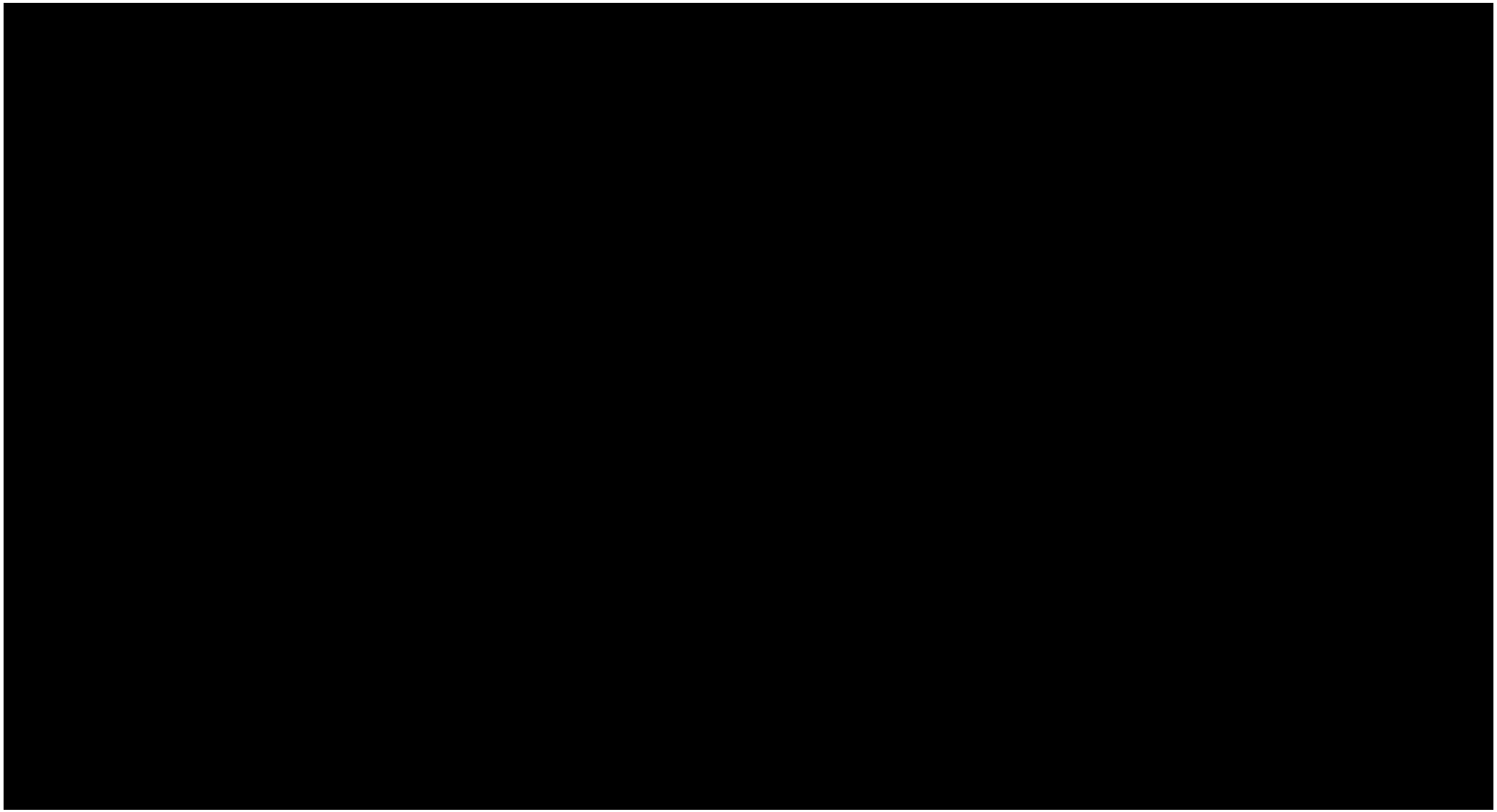
- Star topology includes expensive base stations
- In an urban environment or RF challenging layout, deploying enough base stations to cover the entirety of an area is tedious.

Mesh Network Protocol



- Mesh topology is more flexible
- Mesh routers can be deployed on grid powered devices (electric meters, streetlights…)
- Having a complete RF coverage of such an area becomes possible

View Recording for Wi-SUN Demo



Join the Rest Tech Talks Topics

MATTER

JUN 8TH	Matter: Evaluation to Certification
	Getting Started: Matter Over Wi-Fi
	Start Your Matter Development Journey

BLUETOOTH

JUL 13TH	Unboxing: What's New With Bluetooth
	Bluetooth Portfolio: What's Right for Your Application
	The Latest in HADM With Bluetooth LE

WI-FI

AUG 3RD	Designing Low-Power Applications with Wi-Fi 6
	Building Smart Home Devices with Always-On Wi-Fi 6
	Developing Wi-Fi 6 Sensors Using SiWx917 and Matter

Q&A

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