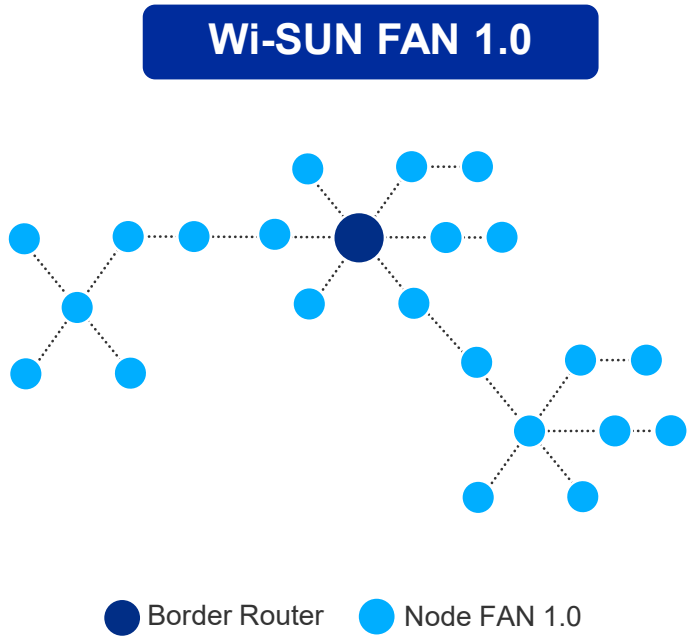
贶赋谴酗屠进辊Wi-SUN魍铂鼓滪肱

Steven Yu – Silicon Labs

2025 tech talks WEBINAR SERIES

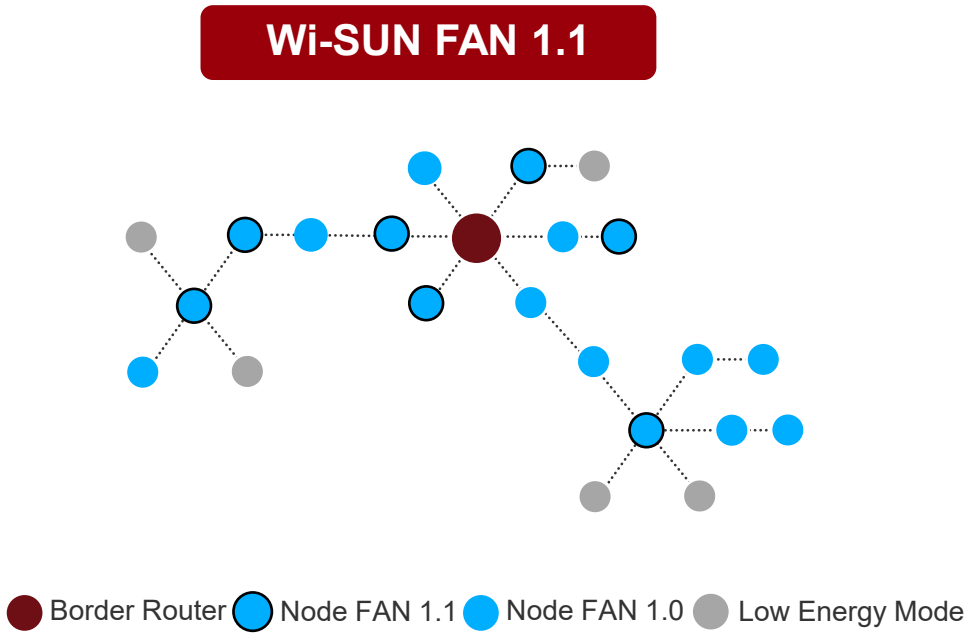
LPWAN

Wi-SUN FAN 1.0 嚙踝蕭



- **Wi-SUN Network Topology: Routing Mesh**
  - More like a tree than true mesh
  - All nodes are routing nodes and are always active
  - Border router maintains routing tables and ensures network backhaul
- **Primary Applications:**
  - Smart Cities
  - Smart Metering
  - Infrastructure
  - Energy Distribution
- **3 Types of Network Messages**
  - Unicast
    - From one node to another, communication flowing through neighbors
    - Routing with RPL (**R**outing **P**rotocol for **L**ow-Power and Lossy Networks)
  - Broadcast
    - Messages transmitted to all nodes within the range
    - Propagated with MPL (**M**ulticast **P**rotocol for **L**ow-Power and Lossy Networks)
  - Asynchronous messages
    - Messages transmitted to all nodes within the range
    - Mainly used for network discovery and configuration (PAN Advert, PAN config, …)
- **PHYs**
  - A single PHY is used for all messages (base PHY), i.e. all nodes talking the same language
  - Selection between 50, 100, 150, 200 & 300 kbps FSK
    - The PHY is selected upon the higher distance (range) between nodes and regional regulation
  - Frequency hopping is used

乾三旰FAN 1.1匐譯?



- **FAN 1.1 is an extension of FAN 1.0 to address higher bit rates and low power nodes**
  - Keeps the basis of FAN 1.0
- **Indeed, these new topics are optional in FAN 1.1 specification, so we get 3 pieces:**
  - FAN 1.1 Core (aka FAN 1.0+)
    - Only one feature added: PAN-wide Information Element
  - FAN 1.1 High Performance option (HP)
    - Introduces SUN-OFDM PHYs
    - Introduces mode switch
  - FAN 1.1 Low Energy option (LE)
    - Introduces Limited Function Nodes (LFN)

FAN 1.1 骚忨肽: OFDM

- **OFDM brings**
  - High bit rates, up to 2.4 Mbps
    - 3.6 Mbps w/ EFR32FG25 additional mode
  - Intrinsic flexibility on bit rates and performance levels
    - Sometimes referred to as MR-OFDM (multi-rate)
      - Packet-by-packet flexibility, within the same bandwidth
    - Each option has 7 Modulation and Coding Schemes
      - MCS0 (low bit rate) to MCS6, in-packet signaling
- **High bit rates bring**
  - Higher throughputs which are helpful for OTA
  - Shorter burst duration leading to
    - Better latency
    - Improved network performance & less congestion

bandwidth (KHz)	modulation	bit rate (kbps)	Tx duration (ms)
200	FSK 1b	50	241.92
	FSK 2a	100	120.96
	OFDM 4 MCS6	300	41.52
400	FSK 3	150	80.85333333
	FSK 4a	200	60.64
	OFDM 3 MCS6	600	21.48
600	FSK 5	300	40.74666667
800	OFDM 2 MCS6	1200	11.52
1200	OFDM 1 MCS6	2400	6.12

Example for 1500-Byte frame

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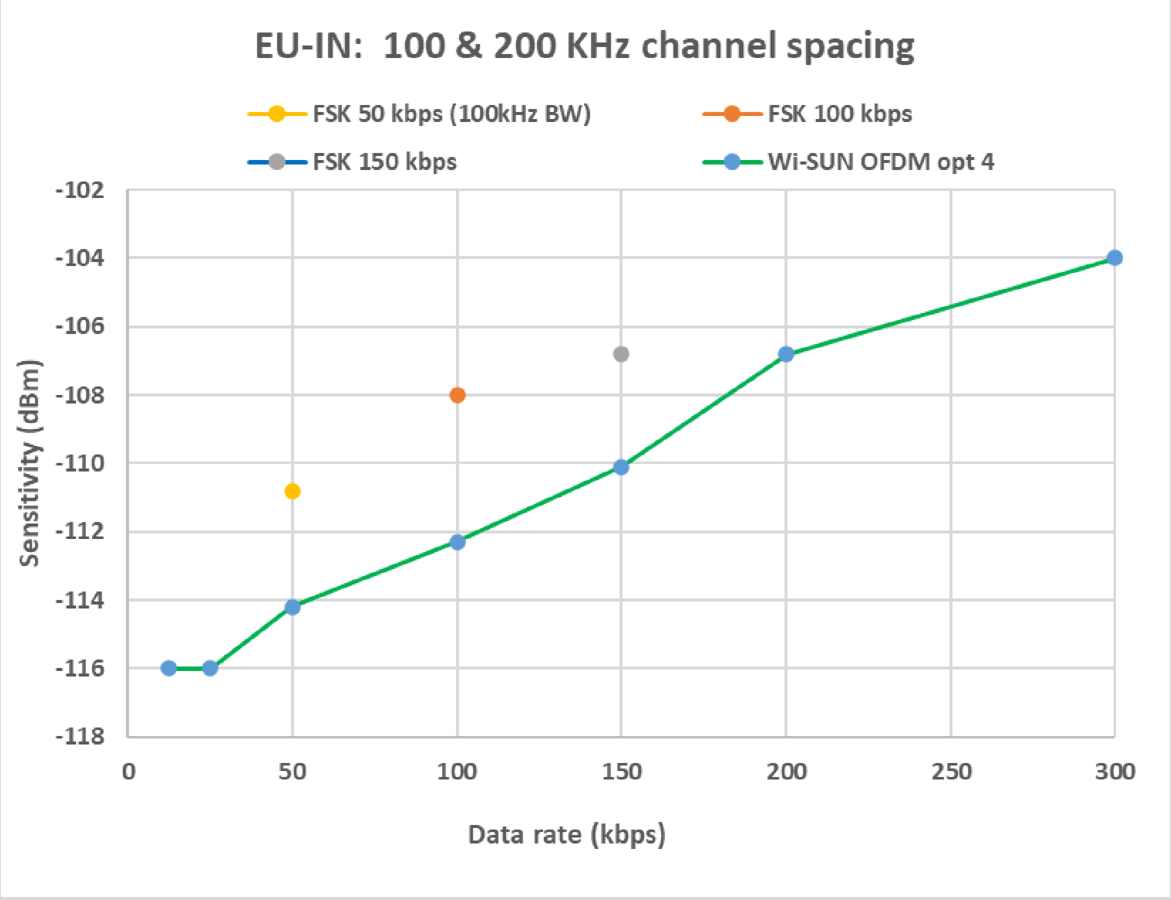
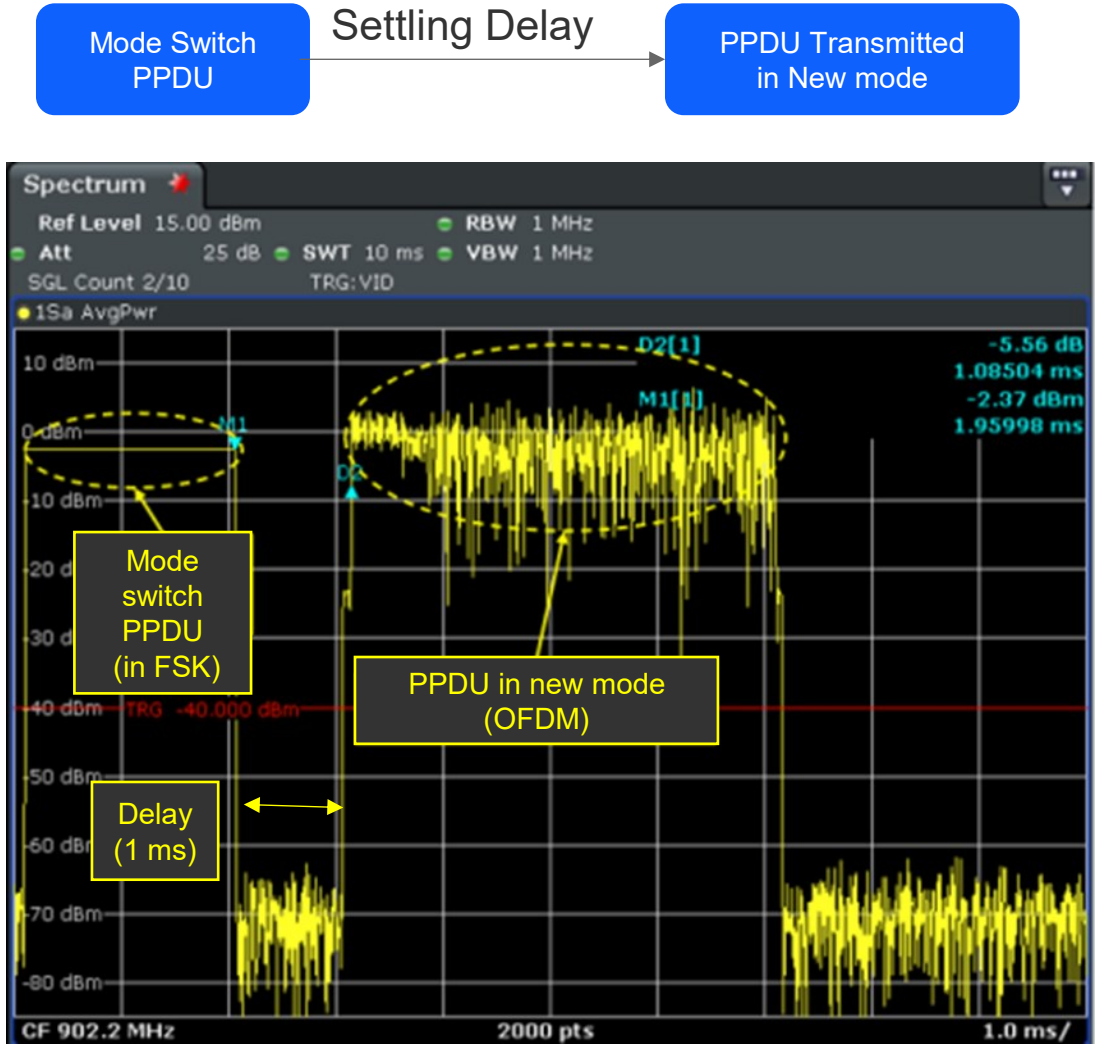


NA: North America, BZ: Brazil, JP: Japan, EU: Europe

FAN 1.1 骚怃肽– Mode Switch

- **Entire Wi-SUN network uses single base PHY**
  - Defined by border router for Broadcast, Unicast, and Asynchronous messages
- **Mode Switch allows for use of an alternate PHY for unicast messages**
  - Signaling packet sent on base PHY
- **Allows for switch between FSK PHYs or FSK to OFDM**
  - Enables higher bandwidths for short amount of time for use cases like OTA
- **Supported on both FG25 (FSK and OFDM) and FG28 (FSK only)**
  - Exists natively as part of Silicon Labs Wi-SUN stack



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FAN 1.1 LE: Limited Function Nodes (LFN)

- **LFN allows battery_powered_applications as nodes are sleeping most of the time**
- **The typical use case is a node transmitting 1-2 kB per day**
  - The goal is to reach a lifetime of 20 years with a typical LiMnO2 3.x volt / 2 AH battery
- **These nodes cannot be routers, so this is limited to leaf nodes**
  - Routers are referred to as Full Function Nodes (FFN)
- **The “LFN parenting” feature is required on a router to allow support of LFN children**
  - The FFN parent is managing LFN Broadcast and Unicast schedules
  - The FFN parent is buffering the message to be delivered to the LFN
- **LFN is available for**
  - EFR32**FG28** (FSK only)
  - EFR32**FG25** (FSK & OFDM)

籠佞酸砥**Wi-SUN?**

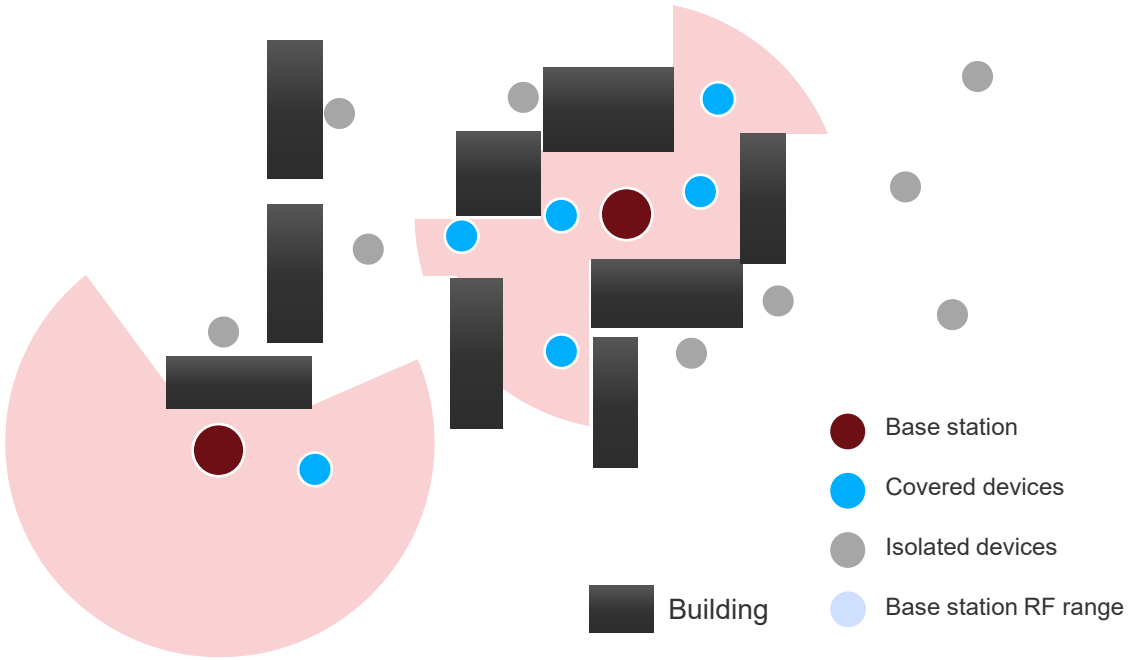
- **Standards based LPWAN technology**
  - Makes deployment of interoperable devices easier than other LPWAN topologies
- **Enables both line and battery powered devices**
  - Battery powered devices can be easily added to existing infrastructure
- **Inclusion of OFDM and FSK modulations**
  - Allows for increased data rates, better network performance, and network optimization
- **Self-Forming and Self-Healing Mesh Topology**
  - Easy to deploy and maintain networks as devices are added or removed from the network
- **Governed by Wi-SUN Alliance**
  - Alliance members are leaders in infrastructure and focus application segments
- **Highly secure mesh network**
  - Significantly reduce vulnerability to cyber security threats

Wi-SUN 鼢LoraWAN NB-IoT癗殕轄

	Wi-SUN	LoRaWan	NB-IoT
Topology	Mesh, 24 Hops	Star (Gateway)	Star
Data Rate	FSK up to 300 Kbps OFDM up to 2.4Mbps	300bps to 62.5 Kbps	140Kbps Uplink 80Kbps Downlink
Latency	0.02 to 1 seconds	1 - 2 seconds	1.4 -10 seconds
Security	AES、Certificate	AES、CMAC、Shared Key	LTE encryption、AES
Ecosystem	Wi-SUN Alliance	LoRa Alliance	3GPP standard

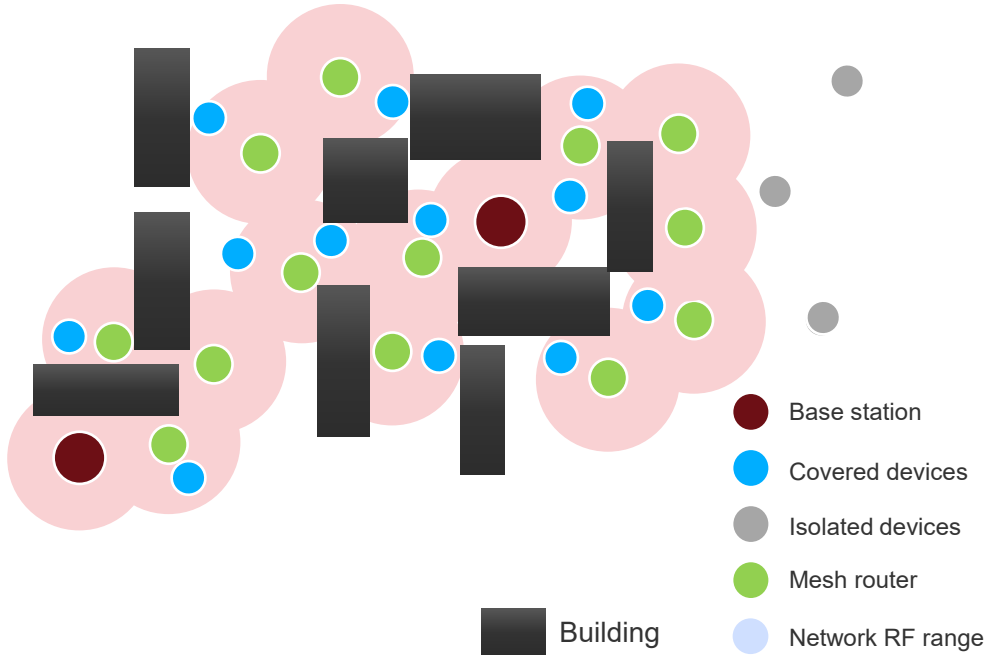
Wi-SUN Mesh困垏蜇獰塄癗仙劀

LONG-RANGE IOT PROTOCOL



- Star topology includes expensive base stations
  - More GW needed for coverage
- 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

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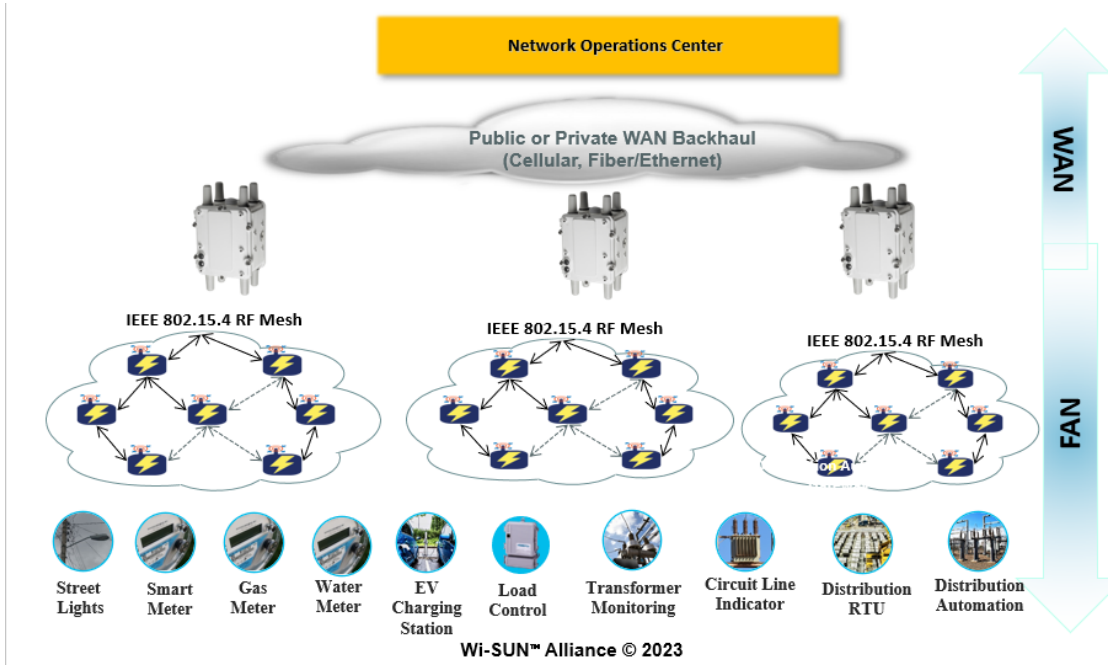
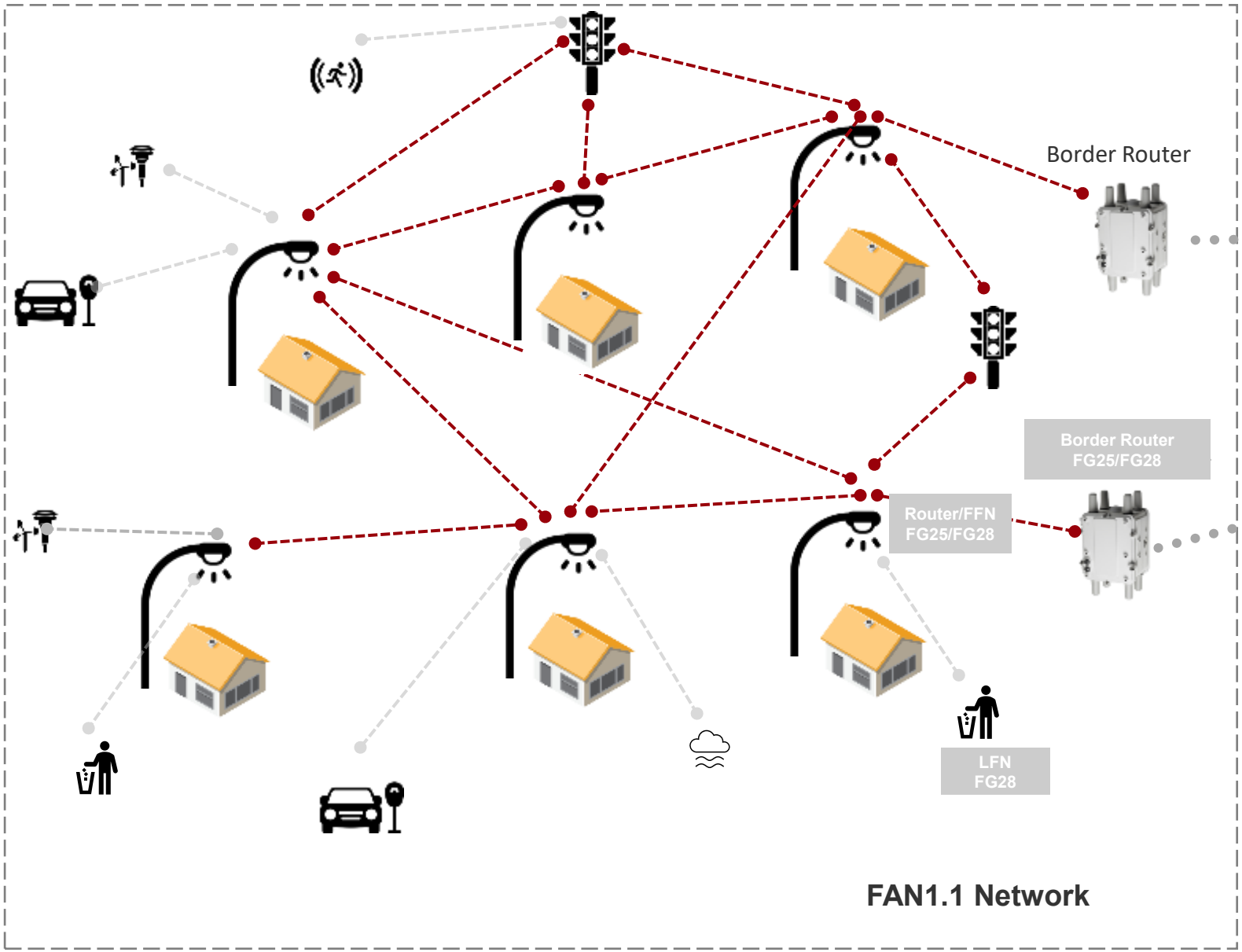


- **Smart Cities**
  - Smart Street Lighting
  - Infrastructure Management
  - Intelligent Transportation Systems
  - Parking Management
- **Utility Industry**
  - Advanced Metering Infrastructure (AMI)
  - Distribution Automation
  - Home Energy Management
  - Gas Meter, Water Meter
- **M2M**
  - Structural health: bridges, buildings etc
  - Agriculture
  - Monitoring and Asset Management
- **Home Automation:**
  - Smart Thermostats
  - Air Conditioning and Heat Controls
  - Energy Usage Information Displays

Wi-SUN FAN1.1 典型智能城市网络



Local Authority Office

Cellular, Fiber, Ethernet

LFN – Limited Function Node / Battery Powered
FFN – Full Function Node / Line Powered

High Data Rate [OFDM or FSK]
City wide MESH, Line Powered Routers / FFN, FG25/FG28

Low Data Rate [FSK]
Battery powered LFN Nodes (FG28) <> FFN (FG25/FG28)

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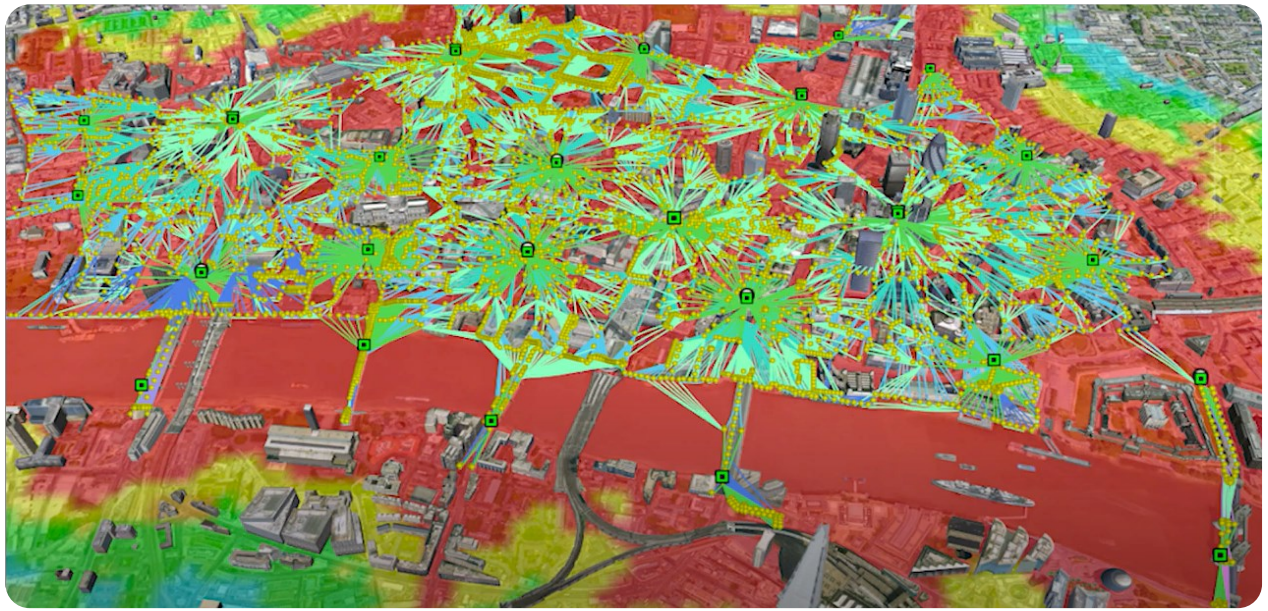

- **Control Management System (CMS)**
  - Street lighting
  - Utilities
  - Parking
- **15,000 connected Wi-SUN devices**
- **12 Wi-SUN border routers**
- **Major benefits**
  - Enables real-time remote management
  - Reduces electrical energy usage
  - Automatically generates service orders
  - Future proof system that can scale as the city converts old infrastructure to new

Additional information here:

https://wi-sun.org/latest-news/wi-sun-technology-provides-the-platform-for-city-of-london-smart-city-initiative/

籠佞迺拇艰褖褖扁伝籠**Wi-SUN**鯢夭歐栻作幕唇淫

擰抿OFDM呿FSK评厙

- **Portfolio to support both OFDM and FSK modulations with FG25 and FG28**
  - Support for up to 2.4 Mbps data rates with OFDM on FG25
- **Optimized solution for LFN nodes with FSK support**
  - FG28 provides best in class RF and low power performance
- **Support for mode switch on FG25 for multi-use network optimization**
  - Simplifies mixed modulation network architecture

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- **PHY Certification on multiple devices**
  - FSK and OFDM certification with FG25
  - FSK certification on FG12 and FG28
- **Stack certification to cut down on development time and risk**
  - Tested and proven to work on all Silicon Labs devices
- **Certified Border Router reference design**
  - Customers passed certification using this design
- **Certified Test Bed Unit as part of Wi-SUN certification plan**

僅辞癗剔肢爺怃

- **Concurrent Detection**
  - Eliminates needs for signaling packet within transmission
- **Support for OFDM data rates up to 3.6 Mbps**
  - Future proof for addition of MCS7 to Wi-SUN specification
- **Additional modulation support for longer range capability**
  - MR-OQPSK modulation improves link budget over FSK and OFDM
- **PHY Flexibility**
  - Tools to enable custom PHY creation to address additional network configurations

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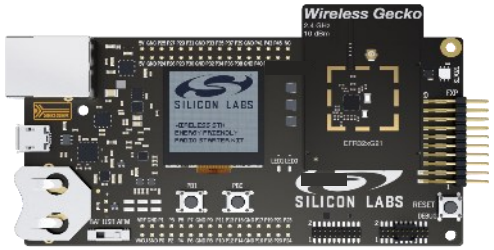
- **Certified Reference Designs:**
  - Border Router (FG12, FG25)
- **Reference Designs:**
  - Router Node (FG12, FG25)
  - LFN Node (FG28)
- **Development Kits:**
  - Wi-SUN specific kit for FG25 Router Nodes (Wi-SUN-PK6015A and Wi-SUN-PK6016A
  - FG28 Pro Kit for LFN development (FG28-PK6025A)

Wi-SUN碰廉厕压杀



EFR32FG25/FG28 and Wi-SUN Pro Kits

套件包含

FG28 Pro Kits
1x BRD4002A Mainboard
1x FG28-RB440xB Radio Board
1x 868 / 915 MHz antenna
1x 2xAA Battery Holder

FG25 Pro Kits
1x BRD4002A WSTK main boards
1x FG25 +16 dBm
1x BRD8016 Expansion board
1x Antenna

可选择的射频板

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

xG28-RB4400C (+14 dBm)
xG28-RB4401C (+20 dBm)

开发套件可用于开发路由节点、边界路由器和LFN

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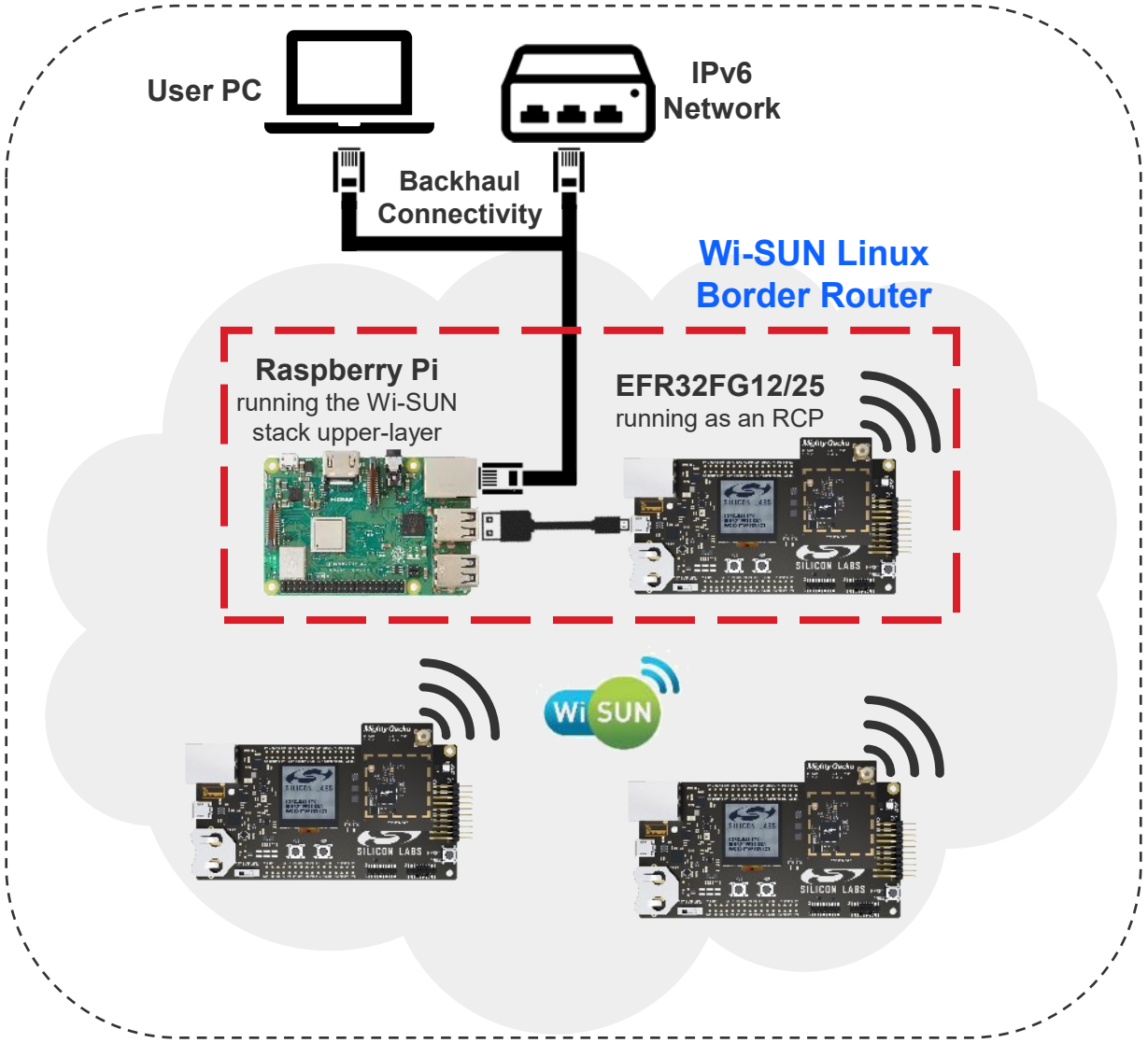
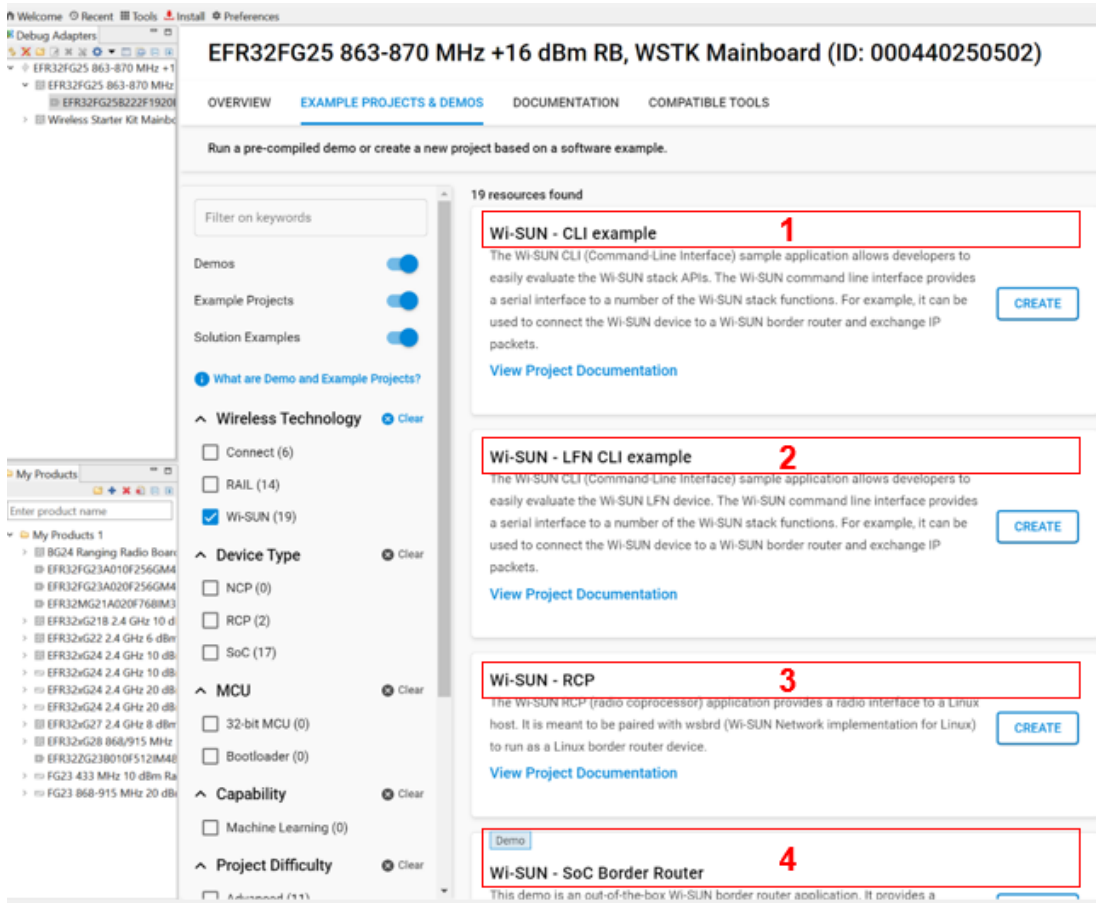
Wi-SUN 轼甍趯砘褥产翍譸謐



- **Host API**
  - Based on Spinel & extended to Wi-SUN needs.
- **Border Router Configuration & Visualization**
  - Web GUI for configuration & network visualization
- **Wi-SUN Network Layer**
  - Provided as source code
  - Implemented in C
  - Easily portable to any Linux distribution
- **Wi-SUN Link Layer**
  - Wi-SUN RCP Binary (PHY/MAC)
- **Documentation**
  - Readme, configuration guidelines, application note
- **Wi-SUN Tools**
  - Direct Connect
  - Dynamic Data Provisionin

Border Router Source Code - https://github.com/SiliconLabs/wisun-br-linux

Wi-SUN仳秋



- Wi-SUN Bluetooth DMP - SoC Empty
- Wi-SUN Bluetooth DMP - SoC SPP
- Wi-SUN – DDP
- Wi-SUN - CLI example
- Wi-SUN - LFN CLI example
- Wi-SUN – RCP
- Wi-SUN - SoC Border Router
- Wi-SUN - SoC CoAP Collector
- Wi-SUN - SoC CoAP Meter
- Wi-SUN - SoC Empty
- Wi-SUN - SoC Network Measurement
- Wi-SUN - SoC Ping
- Wi-SUN - SoC Socket

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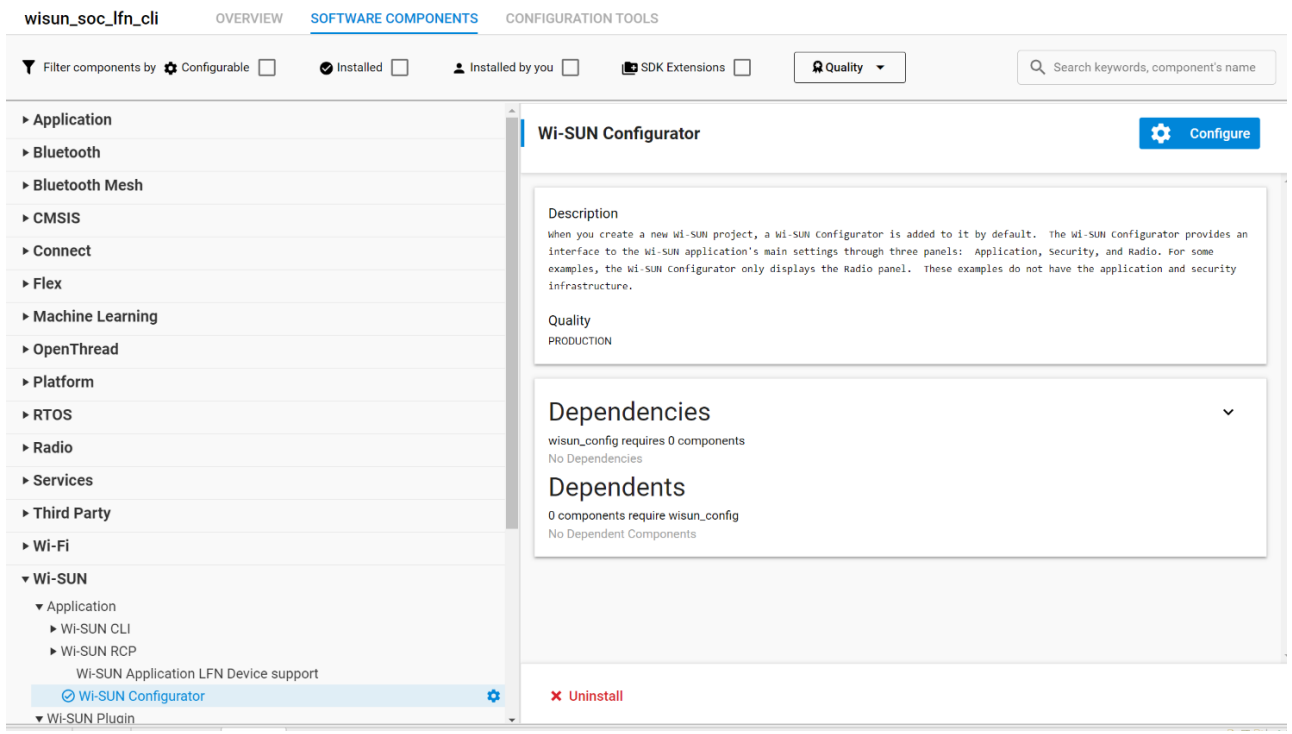
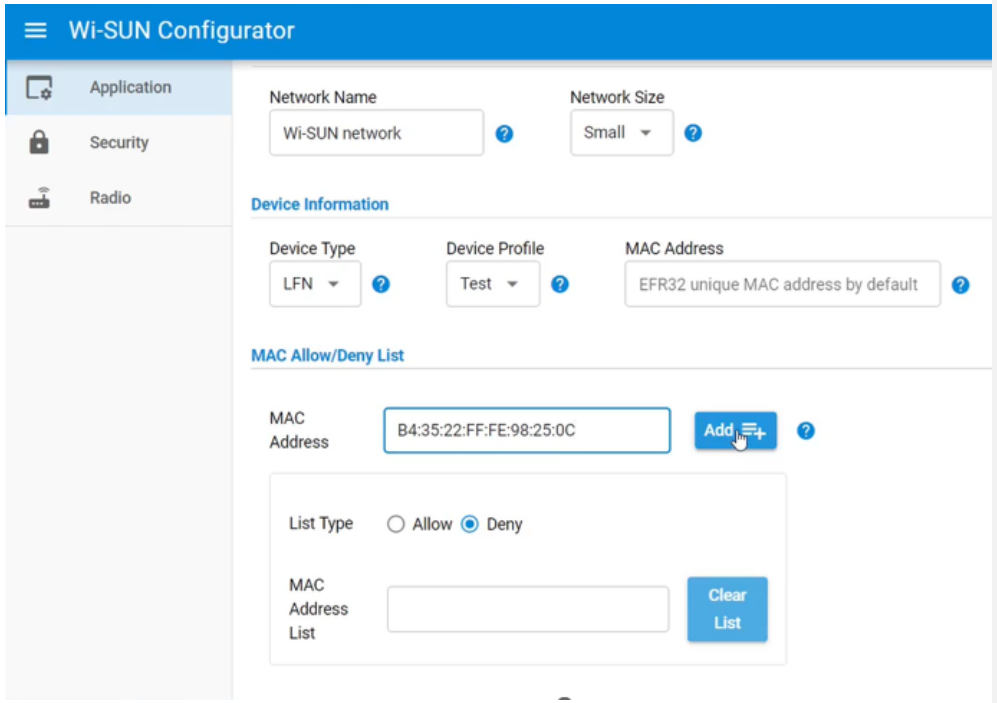


软件组件配置



Wi-SUN应用配置

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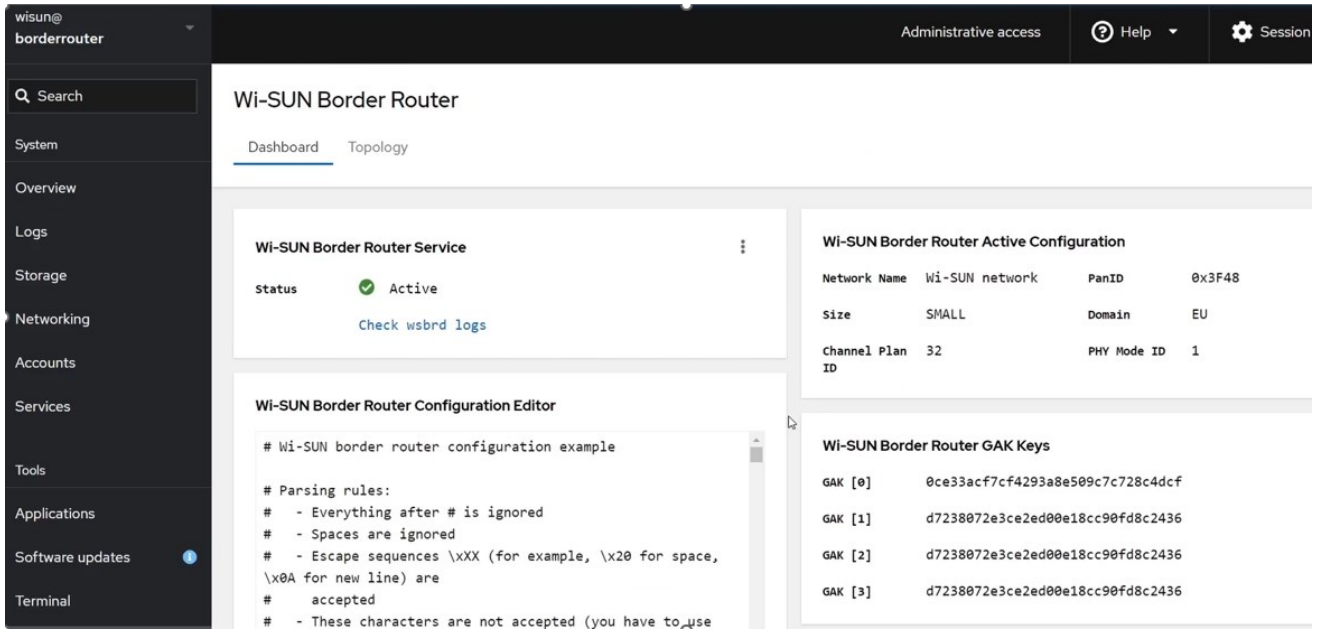
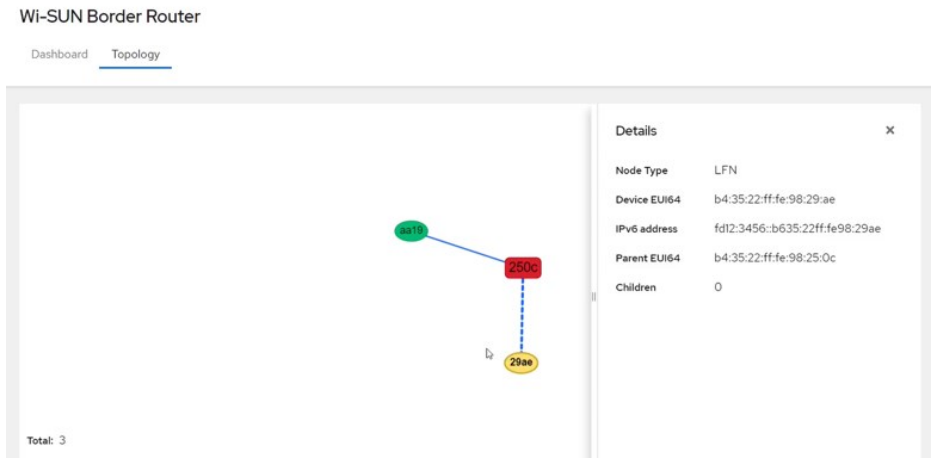


BR可视化管理界面



可视化网络拓扑和节点信息

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Wi-SUN 认证产品

FAN 1.0 certified products

FAN 1.0		
	EFR32**FG12**	EFR32**MG12**
Border Router	**WSA285**	**WSA286**
Router	**WSA265**	**WSA266**
PHY: 800MHz 900MHz	**WSA291** **WSA258**	**WSA292** **WSA259**

- Find WSA certificates at: https://wi-sun.org/certified-products-list/
- **FAN1.0 deprecation date is TBD**

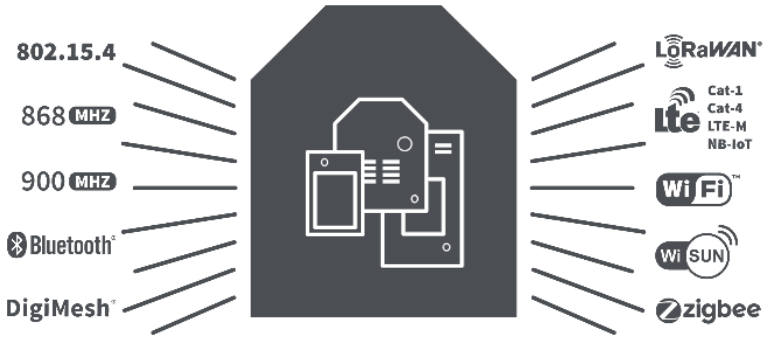
FAN 1.1 certifications plan

FAN 1.1			
	EFR32**FG25**		EFR32**FG28**
	HP	**LE**	**LE**
Border Router	**WSA0392**		**2025***
Router	**WSA0391** **On-going (CTBU)**		**2025***
LFN	**On-going**		**2025***
PHY: 800MHz 900MHz	**Yes (CTBU)** **WSA345** **WSA335**		**2025***

- **CTBU Candidate**: Certification Test Bed Unit - EFR32FG25 is part of the certification test beds (PHY and FAN)
- 2025*: Pending certification availability/launch from the alliance

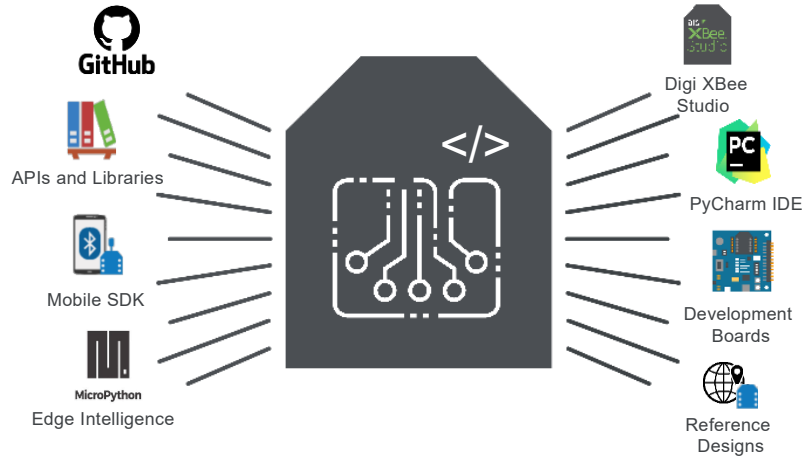
Digi XBee® 琪作瀡泼怃□嬬優怃呿歷截尕怃

FLEXIBLE AND FUTURE-PROOF



SECURE AND SCALABLE

OPEN DEVELOPMENT TOOLS



OVER 25 MILLION DEPLOYED GLOBALLY

亏窒凰窒烬缴带筢珅恩癗**Wi-SUN**绲纁

Wi-SUN RF 榴團

Digi XBee® for Wi-SUN

- Multiple standard form factors
- Sub-GHz connectivity with up to 2.4 Mbps bandwidth
- Support for battery powered applications
- Local edge logic (MicroPython)
- Cisco OpenCSMP interoperability
- Wi-SUN CERTIFIED™

轼甍趯砘褥

Digi XBee® Hive Border Router

- Cost-effective design with support for 200-300 nodes
- Cellular, Wi-Fi, and Ethernet backhaul
- Built-in IPv6/v4 address translation
- Linux Containers for applications
- Wi-SUN CERTIFIED™

绲纁筢珅

Digi Remote Manager®

- Cloud-based Wi-SUN network configuration + management service
- Device life cycle management with Over-the-Air (OTA) updates
- Digital certificate management

Prototype enclosure shown. Not final design

A FLEXIBLE, INTEROPERABLE WI-SUN SOLUTION

运砸乏黩曉幕砸圄是癗辩捻肽剜

Digi XBee® for Wi-SUN Routing Node Module

- EFR32FG25 with Secure Vault™
- Maximum output power: + 16 dBm
- Routing node capabilities
  - Full Function Node – FFN
- Support for high-performance and low-power links
  - FSK data rates 50 to 300 Kbps
  - OFDM data rates 12 Kbps to 2.4 Mbps
- Line-powered operation only
  - No low-power sleep
- Local edge intelligence
  - Custom MicroPython scripts

Digi XBee® for Wi-SUN Leaf Node Module

- EFR32FG28 with Secure Vault™
- Maximum output power: +20 dBm
- Sleeping node capabilities
  - Limited Function Node – LFN
- Support for long-range, low-power links
  - FSK data rates 50 to 300 Kbps
- Bluetooth LE support
  - Local provisioning, sensor connectivity
- Support for battery-powered applications
  - ”Leaf” node with 10-20 years battery life
- Local edge intelligence
  - Custom MicroPython scripts

- All modules are pre-certified for US, Canada, Europe, India, and Japan
- Available in surface mount (MMT, SMT) and through-hole form factors with U.FL and RF pad antenna options

瀡泼烳繳斀鏏懣鬱擢皋

Digi XBee Hive Border Router

- Cost-effective with multiple connectivity options
- Supports 200-300+ Wi-SUN nodes
- Full Digi Remote Manager integration

Intelligent edge platform

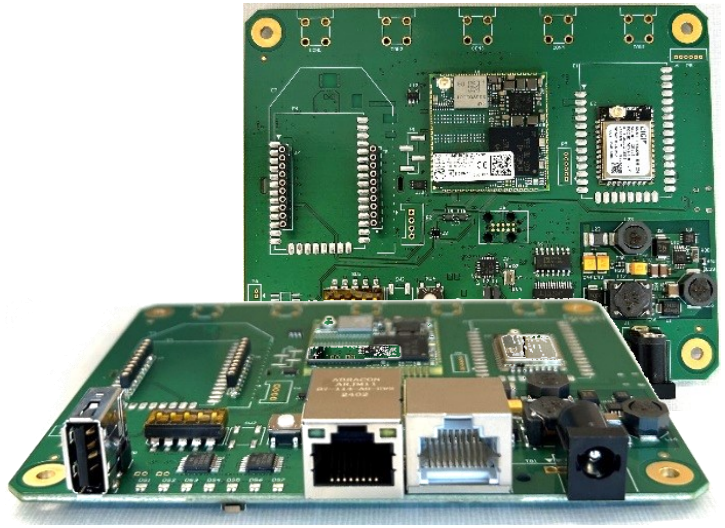
- Dual Cortex-A7 @ 650 MHz with Cortex-M4 @ 209 MHz
- Full routing capabilities, including IPv6/v4 translation
- Container support for customer specific applications

Two form factor options

- Enclosed and PCB only

Expansion options

- LTE-M/NB-IoT, LTE Cat 1 / 4
- Wi-Fi, Ethernet, Bluetooth
- Additional Digi XBee population options



Prototype enclosure shown. Not final design.

鄗缊□烳缴带筢珅恩癗**Wi-SUN**绲纁

Digi Remote Manager for Wi-SUN

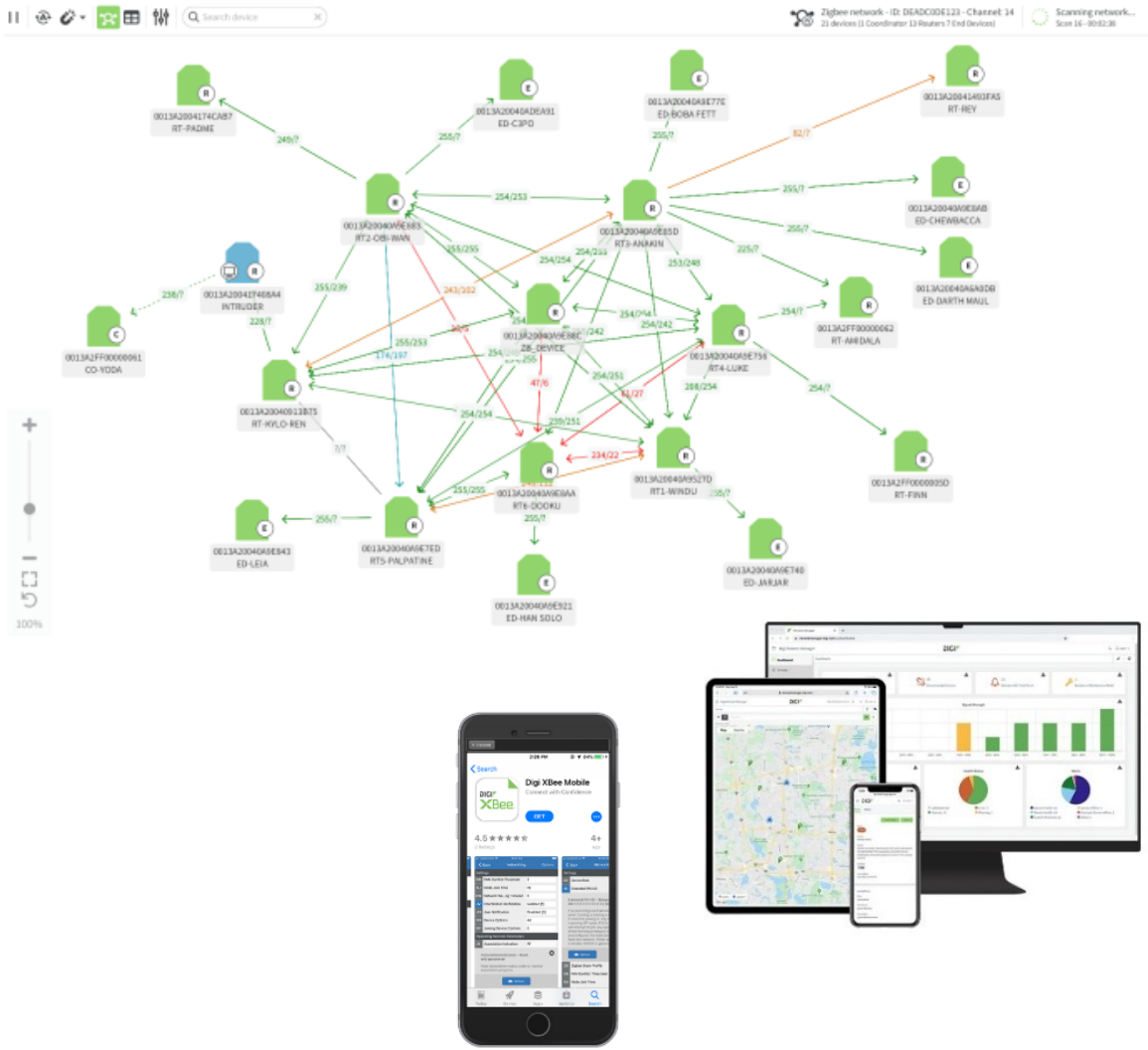
- Cloud-based Wi-SUN network configuration and management platform
- Device lifecycle management with Over-the-Air (OTA) updates
- End-to-end digital certificate management (PKI)

Digi XBee Studio

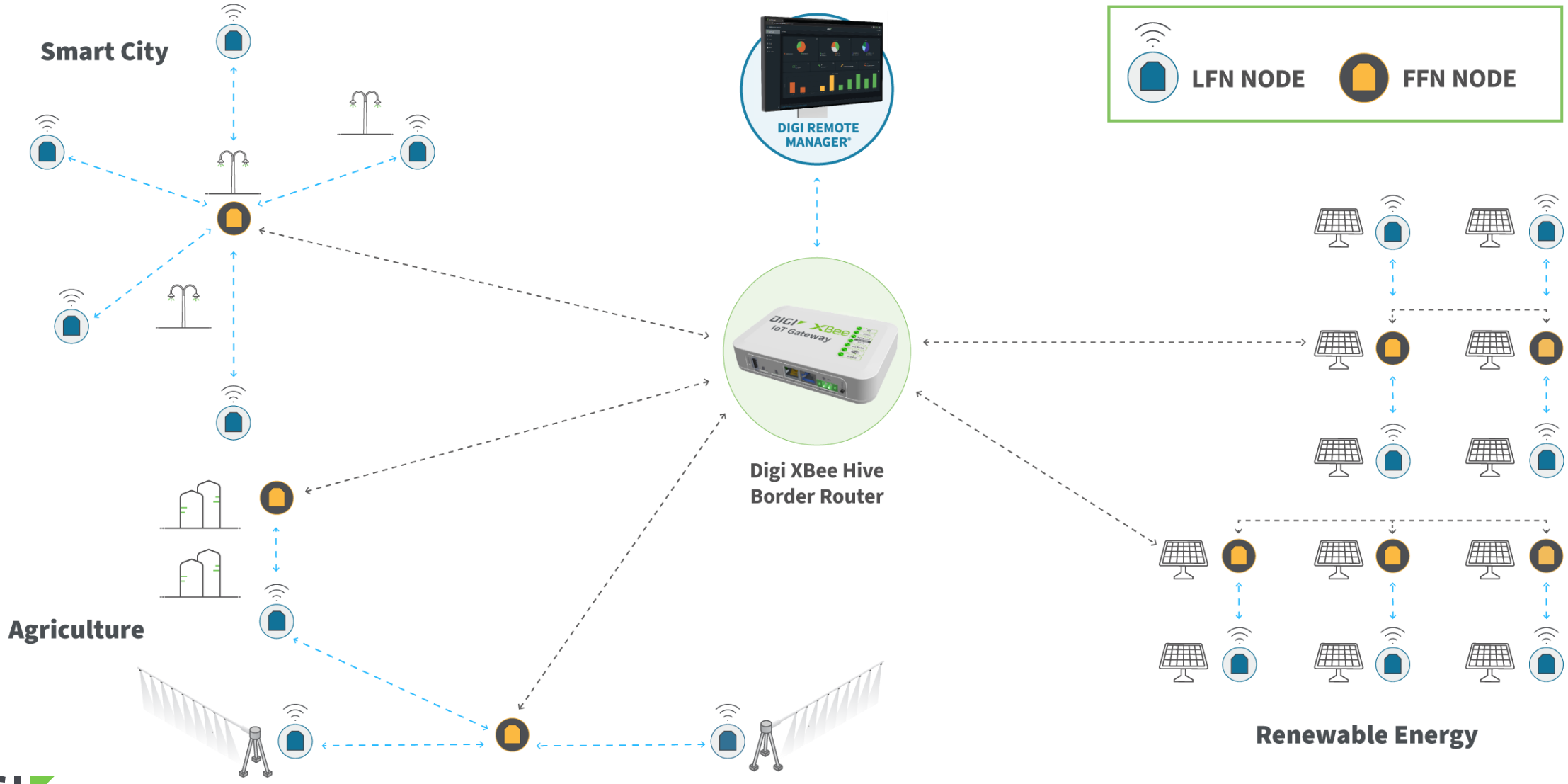
- Wi-SUN support for network configuration
- Quick Setup, Quick Actions
- Firmware updates

Digi XBee Mobile App

- Mobile field configuration & commissioning
- Ease-of-use experience for Digi XBee &Wi-SUN
- Connectivity option via Bluetooth Low Energy



磕佻屠FAN 1.1 XBee Wi-SUN Solution Overview



进辊**Wi-SUN**囝叁蠌鼱禁迡唇鼱弹侻





Build smart connected products faster with Digi XBee® for Wi-SUN®

Quick deployment options with Digi XBee® Hive Border Router for Wi-SUN®

Built-in security with Digi TrustFence® protection and digital certificate mangement

Scalable management and deployment with Digi Remote Manager®

Connect to your backend systems with open third party integration options

Wi-SUN® delivers scalable, secure, and interoperable IP-based wireless mesh networking
with 100+ MILLION devices already deployed worldwide