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LPW-202

Wi-SUN Ecosystem for Large-Scale Outdoor IoT Wireless Networks

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Agenda

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- Wi-SUN Product Certification considerations
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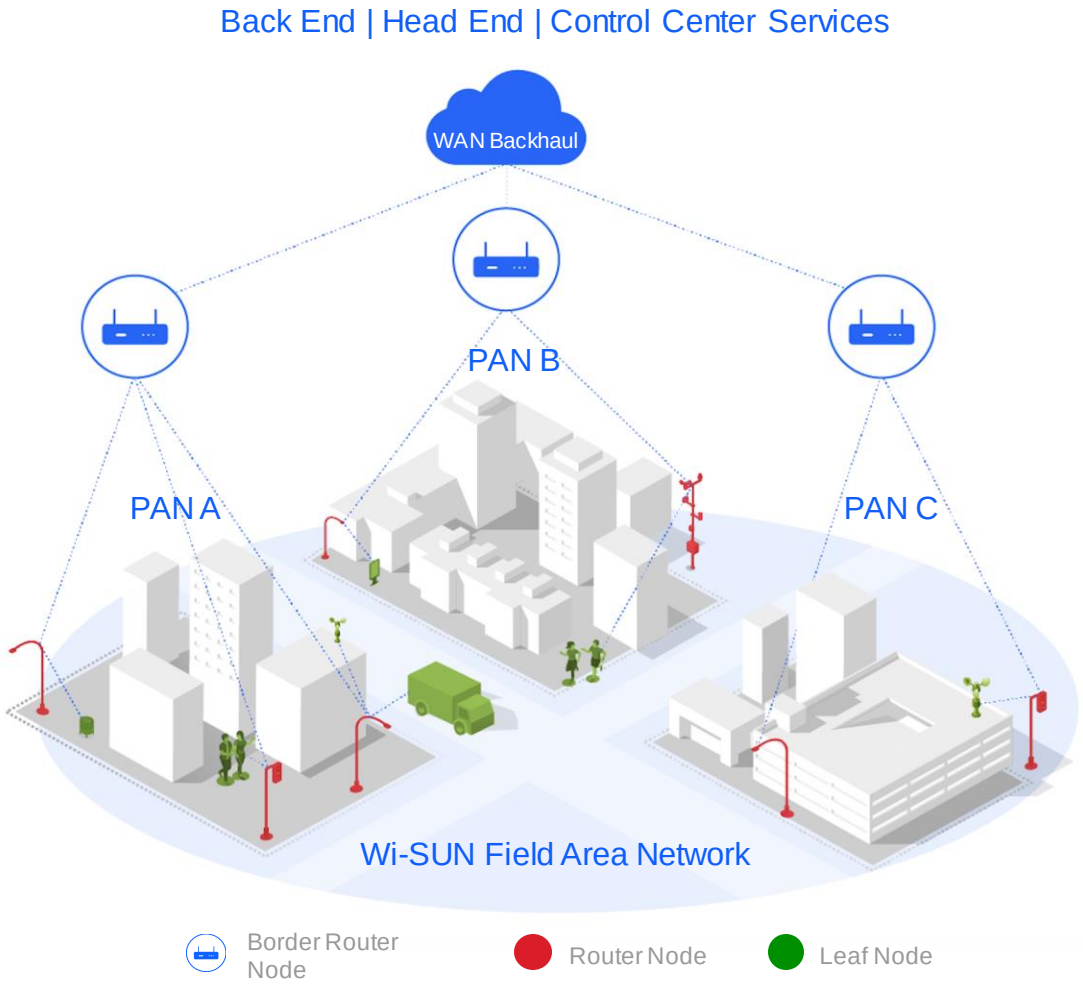
Wi-SUN Overview

Wireless Smart Ubiquitous Networks (Wi-SUN) is a leading IPV6 Sub-GHz mesh technology for smart city and smart utility applications.

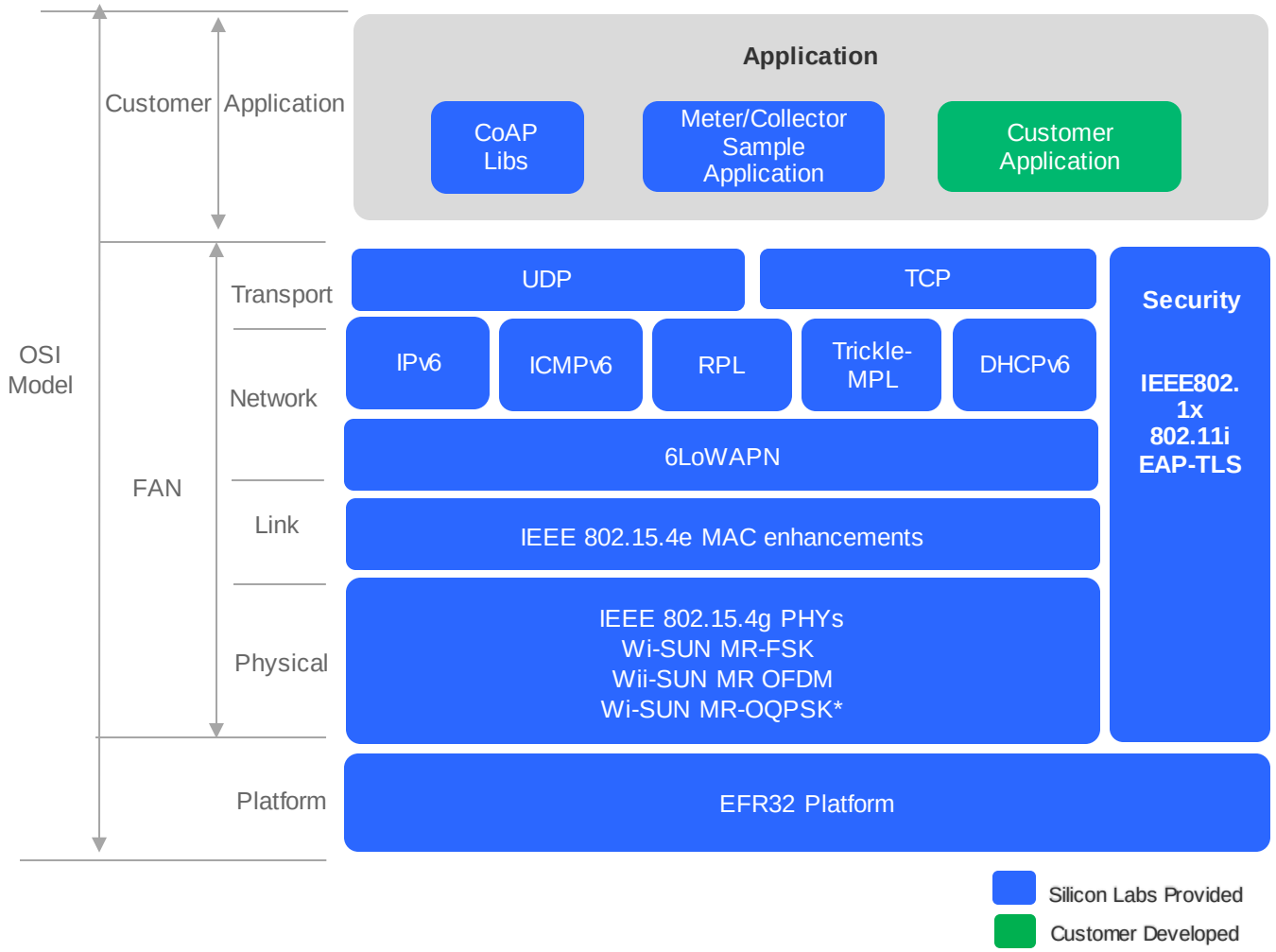
- A move from Proprietary to standards-based solutions
  - Ease of use
  - Flexibility
  - Avoid vendor lock-in
- Wi-SUN specifications bring Smart Ubiquitous Networks to service providers, utilities, municipalities/local government and other enterprises, by enabling interoperable, multi-service and secure wireless mesh networks.
- Wi-SUN can be used for large-scale outdoor IoT wireless communication networks in a wide range of applications.
  - Scalable self-healing mesh
  - High performance long range
  - Interoperable & secure

Wi-SUN Ecosystem - Keywords



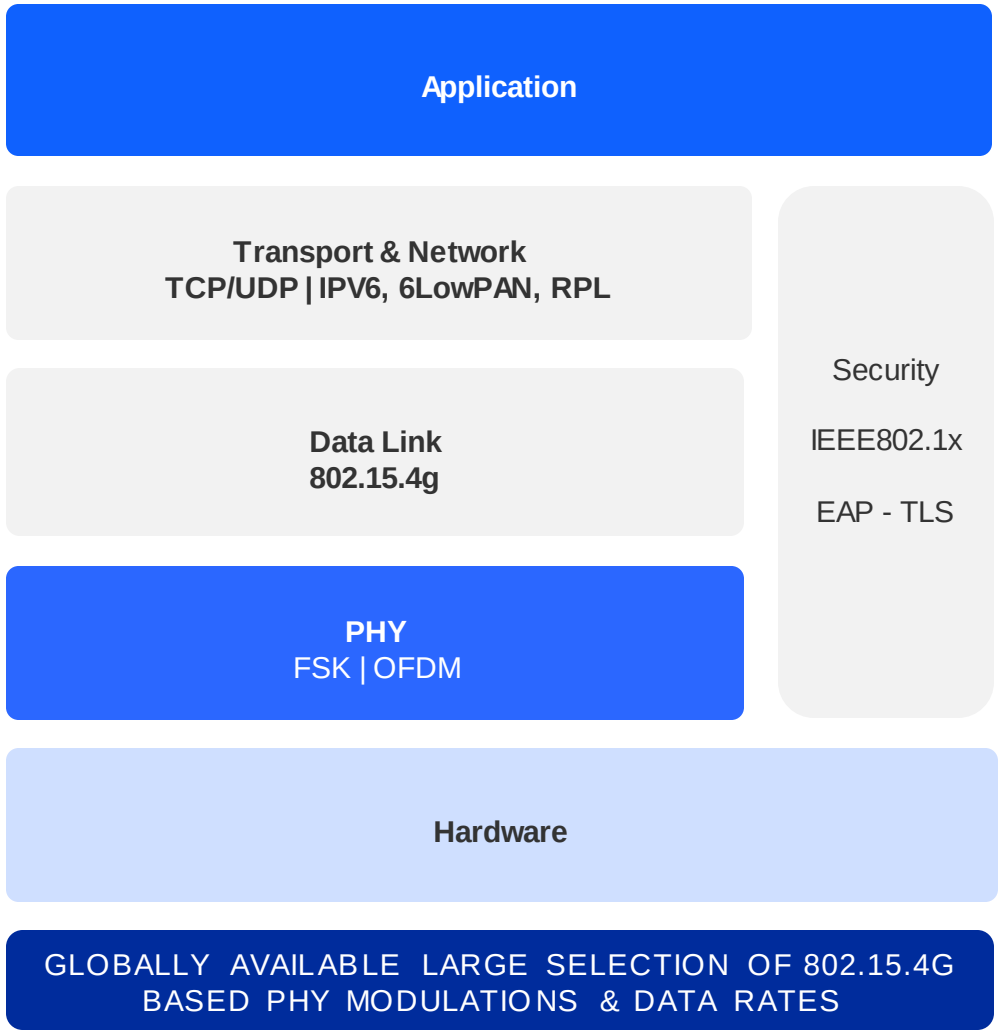
- **Border Router**
  - Provides WAN connectivity
  - Maintains source routing tables
  - Disseminate PAN wide information such as broadcast schedules
- **Router Nodes**
  - Upward and downward packet forwarding within a PAN
  - Services for relaying security and address management protocols
- **LFN(Limited Function Nodes) / Leaf Nodes**
  - Discover and join a PAN
  - Battery powered devices
  - Send/receive IPv6 packets

Wi-SUN Stack Architecture



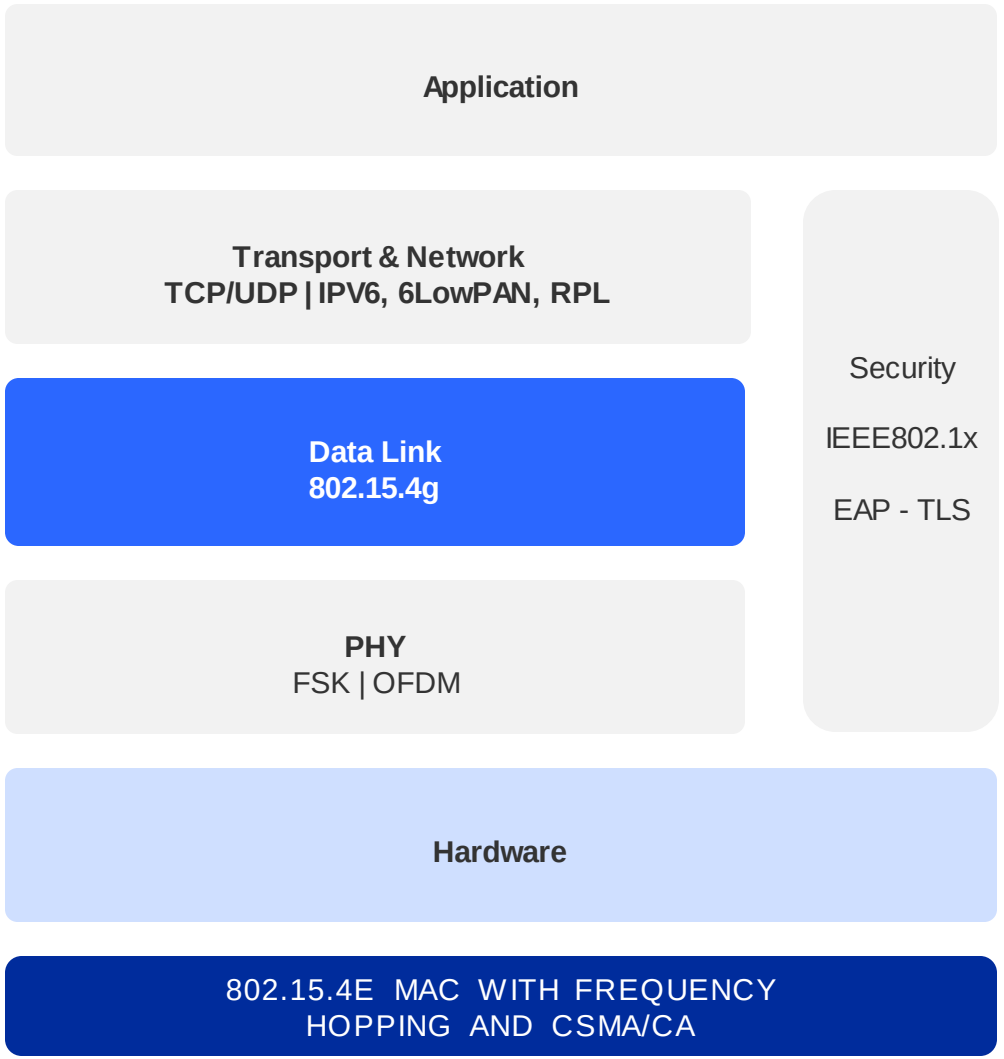
- Protocol Suite (IPv6)
  - UDP and TCP
  - 6LoWPAN Adaptation + Header Compression
  - DHCPv6 for IP address management
  - Routing using RPL & Trickle
  - ICMPv6
  - Unicast and Multicast forwarding
- Security (802.1x)
  - EAP-TLS/PKI Authentication
  - 802.11i Key Management
  - AEC-CCM 128b Encryption
- MAC (802.15.4e)
  - Frequency Hopping
  - CSMA-CA
- PHY (802.15.4g)
  - FSK – Multiple data rates & region support
  - OFDM – Multiple data rates & region support
  - *MR-OQPSK – Future consideration

Wi-SUN - PHY Layer



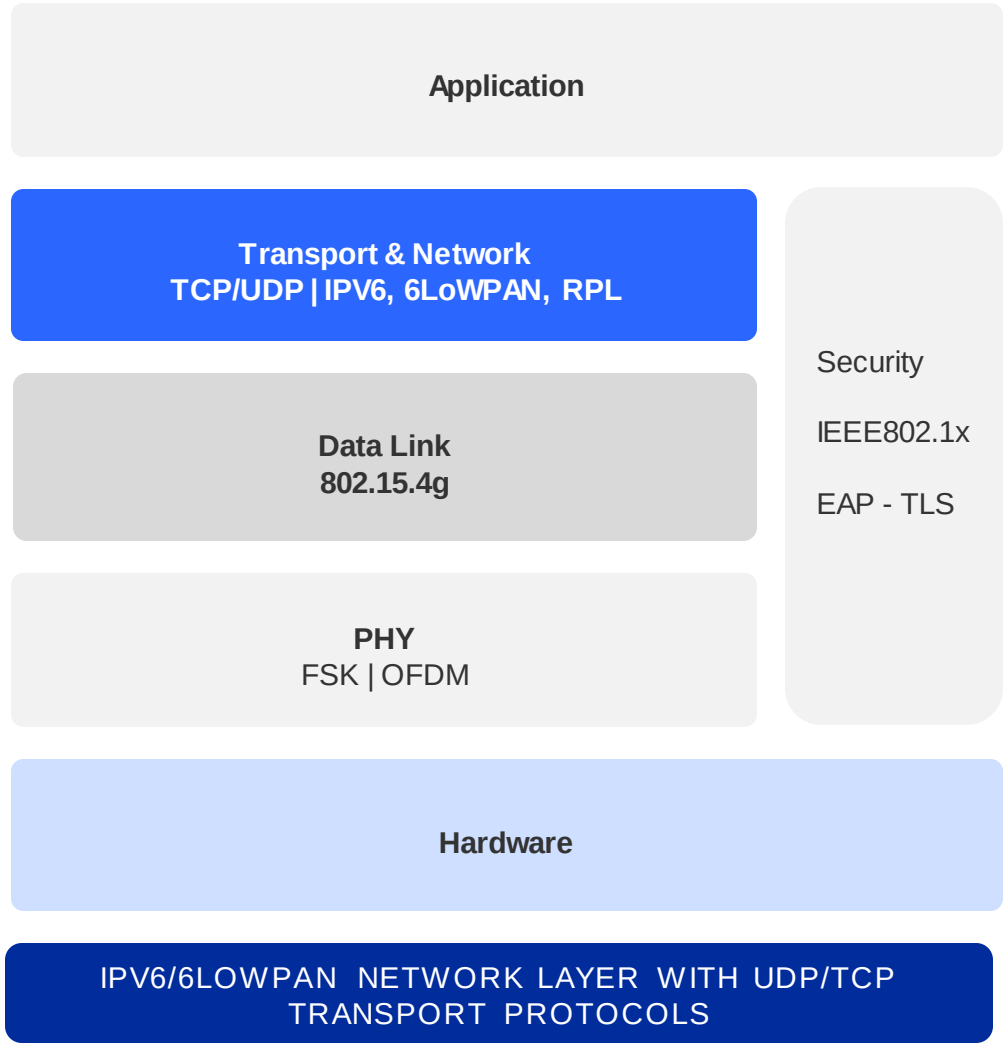
- **Specification:**
  - Subset of 802.15.4g SUN FSK and SUN OFDM PHYs
  - Ref. - PHY Working Group - PHY Technical Profile Specification 2v00
- **Flexible modulation and data rates**
  - FSK PHY – ubiquitously deployed modulation in smart infrastructure
    - 50 kbps – 300 kbps
  - OFDM – high throughput low latency PHY for next generation products
    - 50 kbps – 2.4 Mbps
- **FAN 1.0 supports – FSK only**
- **FAN 1.1 supports – FSK, OFDM**
- **PHY layer support both sub-GHz and 2.4 GHz**

Wi-SUN - Data Link Layer



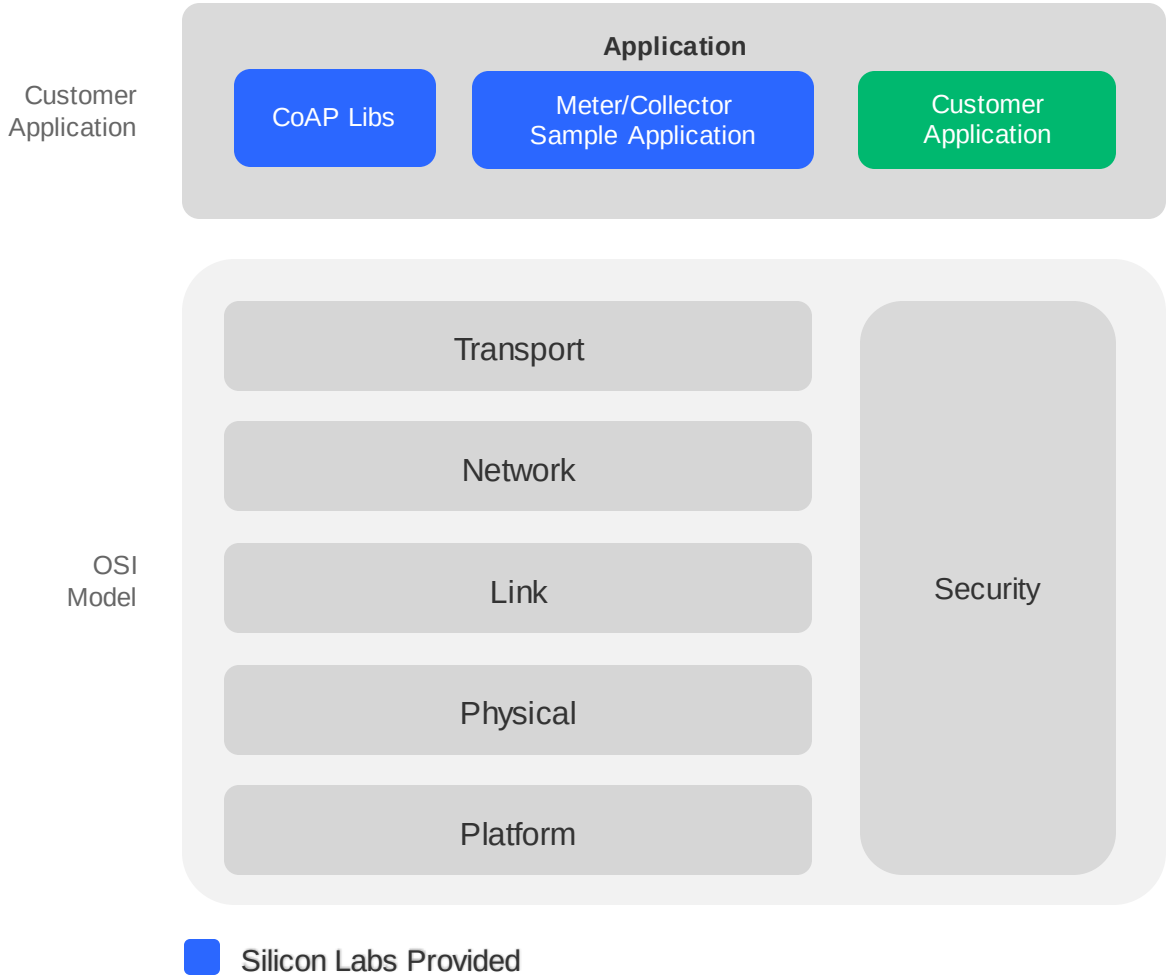
- **LLC sub-layer**
  - Upper sub-layer, defines software processes that provide services to network layer protocol
  - Allows access to different types of media defined by lower layers *(15.4, 802.11, 802.3 based media)*
- **MAC Sub-layer**
  - Lower sub-layer, defines media access processes performed by the hardware
  - 802.15.4e expands the MAC layer feature to fix MAC reliability, unbounded latency, and multipath fading issues
  - Frequency Hopping
    - The MAC sub-layer supports neighbor synchronized channel hopping for both unicast and broadcast frame transmissions.
    - Unicast and broadcast synchronization information is exchanged between neighbors but there is no dependency upon PAN-wide time synchronization.
    - A fixed channel mode of operation is supported for situations in which channel hopping is not desired
  - Supports Carrier Sense Multiple Access/Collision Avoidance

Wi-SUN - Transport Layer



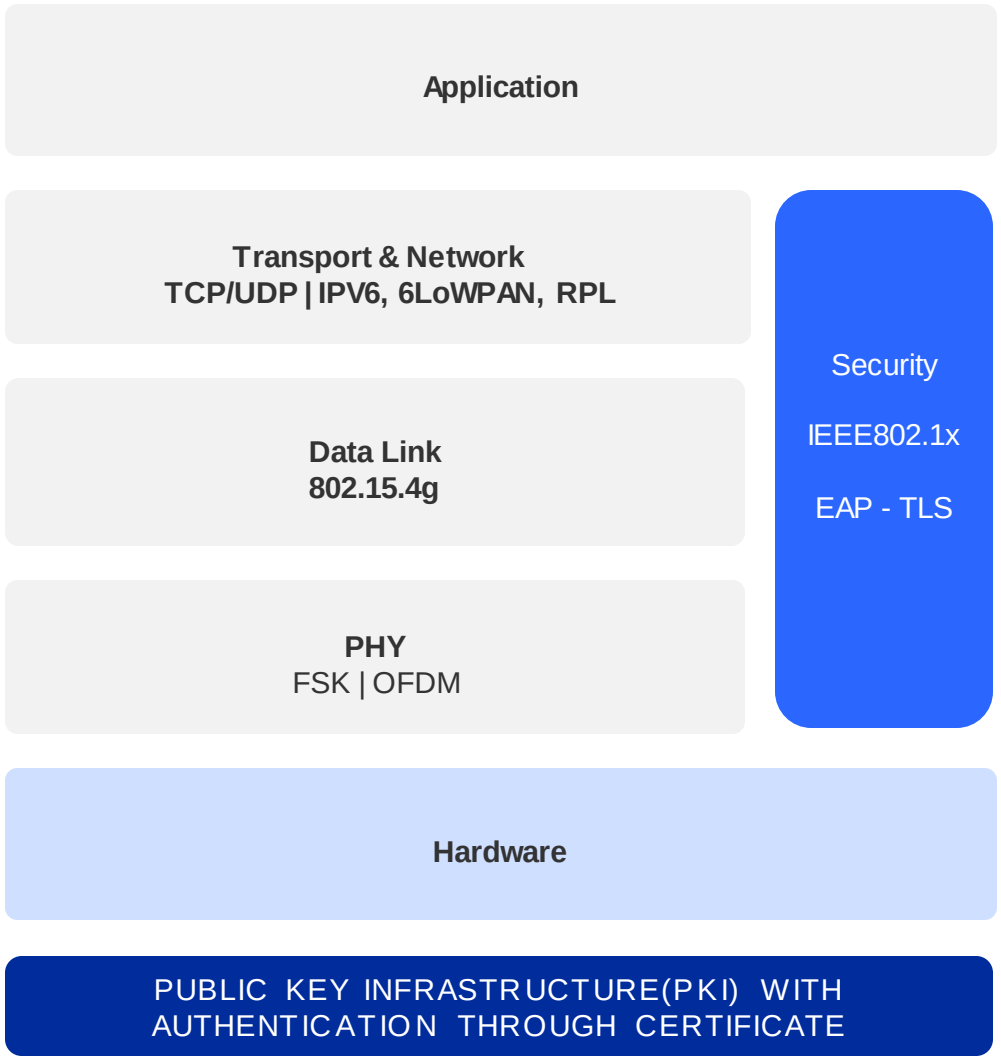
- **Specification:**
  - 6LoWPAN between MAC & Network layer
  - IPv6 based network layer with unicast & multicast
  - Uses RPL as the primary routing protocol
  - Transport layer - UDP (mandatory), TCP (optional)
- **Why 6LoWPAN?**
  - It defines IPv6 data encapsulation over a 15.4 low power, memory constrained radio link
  - It is needed to efficiently transmit IPv6 packets over low power and lossy networks (LLNs)
  - 6LoWPAN provides
    - header compression, fragmentation & reassembly, stateless auto-configuration
- **RPL (Ripple)**
  - Routing protocol for low power lossy networks
  - RPL is optimized for large networks upstream data flow
  - Downstream is source routing

Wi-SUN - Application Layer



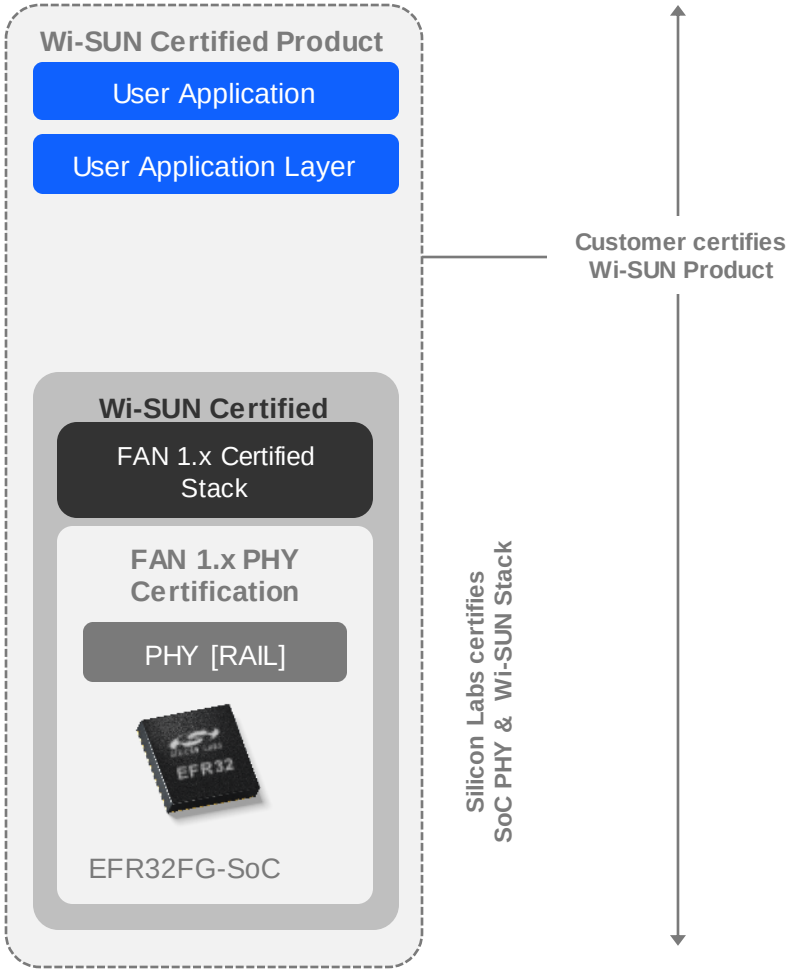
- **Application layer is not part of the Wi-SUN specification**
  - The technology is applicable to several different verticals, challenging to have a common app layer
- **Prevalent application layers**
  - Smart metering
    - DLMS - Device Language Message Specification
    - Smart Energy 2.0
    - CoAP - Constrained Application Protocol
  - **Street lighting**
    - uCIFI - uCIFI is defining a unified data model on IoT networks and open-source sub-GHz mesh
  - **Parking, smart city applications**
    - Other partners

Wi-SUN - Security



- **Access control is based upon**
  - **Public key infrastructure [PKI]**
  - Modeled after Wi-Fi security framework (IEEE 802.1X and IEEE802.11i)
- **Each Wi-SUN device uses two X.509 certificates**
  - They are signed by an official Certification Authority (CA)
  - The device certificate is used to authenticate the device to an authentication server
  - The CA root certificate is used by the device to verify the authentication server
- **Authentication uses EAP-TLS protocol over EAPOL.**
  - Authentication results in Pairwise Master Key (PMK)
  - A unique key shared between the border router and the device.
- **Frame Security**
  - **FAN nodes MUST implement AES-CCM 128b based Frame Security**

Wi-SUN Product Certification Considerations



Customers Can Leverage Silicon Labs FAN Certification

- Certified Router
- Certified Border Router
- Certified PHYs
  - Modulation - FSK, OFDM
  - Data Rate – All FSK and OFDM data rates
  - Regions – NA, Brazil, EU and India

EFR32FG25 is a FAN1.1 PHY Certification Test Bed Unit (CTBU)

Wi-SUN Test Labs

Allion-Taiwan* | JEMIC-Japan | TELEC-Japan | **TUV-Japan*** | TUV-USA | **TUV-India***

**Test labs used by Silicon Labs for certification*

Note - Wi-SUN Alliance promotor or contributor membership is required for certification

FAN Certification

FAN 1.0	PHYs	FG12 & MG12 for NA/BZ/EU/India
	Router	FG12 & MG12
	Border Router	FG12 & MG12
FAN 1.1	PHYs	FG25 for NA/BZ/JP, FG25 is a FAN1.1 PHY Certification Test Bed Unit (CTBU)
	Router	Roadmap
	Border Router	Roadmap

Wi SUN

Product Certificate

This certificate lists the features that have successfully completed Wi-SUN Alliance Conformance and Interoperability Testing conducted at a Wi-SUN Approved Test Laboratory

For details, see www.wi-sun.org

Certification Identifier: **WSA 0308**
Date of Certification: **January 30, 2023**
Company Name: **Silicon Labs**
Product Name: **EFR32FG25**
Model Number: **EFR32FG25**
Hardware Version: **EFR32FG25**
Firmware Version: **Gecko SDK version 4.2.0**

Product Category: **Radio Module**
Product Profile: **PHY Layer for FAN 1.1 Profile**
Frequency Band(s): **902-928MHz (NA/BZ), 920-928MHz (JP)**

Certification Summary
CRSL Version Number: **CRSL 1V31**
CRSL Date: **January 18, 2023**

For and on behalf of Wi-SUN Alliance:

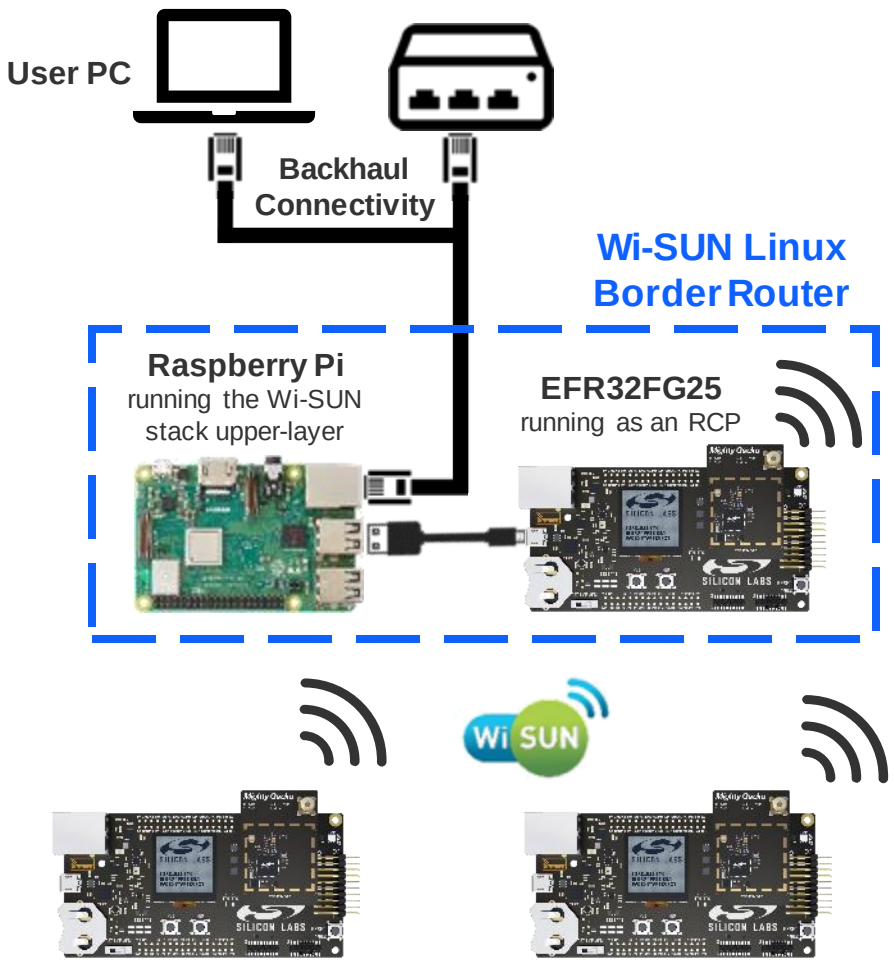
Chin-Seah Sum,
Certification Program Manager

Developer Experience

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**
    - Wi-SUN Configurator
    - Configuration utilities
    - Compiler
    - Error & validation
    - IDE & command line support
    - Graphical hardware configurator
    - Energy Profiler – visual energy analysis
    - Network Analyzer – packet capture & decode

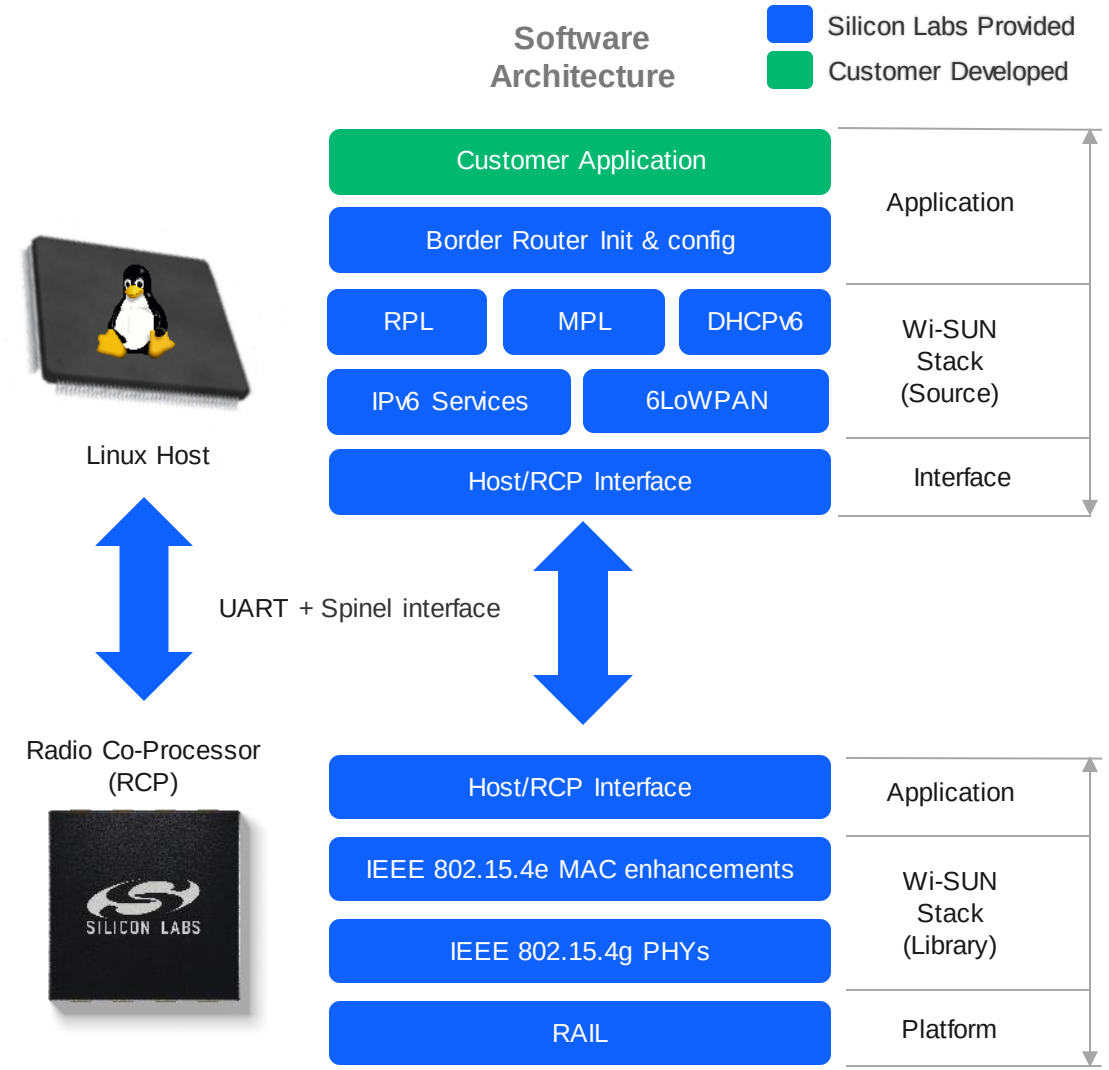
Wi-SUN Border Router Reference - HW Solution



- **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
- **Delivery Mechanism**
  - PHY/MAC (RCP) library via Studio
  - Via GitHub
    - Docker Image
    - Source code for the Network Layer (wsbrd)

Wi-SUN Border Router Reference - Linux Host & Radio Co-Processor

- **Radio co-processor (RCP) architecture**
  - Stack is split at the MAC layer
  - Core networking components is on the Linux host
  - Standard interface between host & EFR32
- **Benefits**
  - Scalable design
    - Select Linux host based on network requirements
  - Flexible design
    - Can work with any Linux host
    - Portable and Open
    - Utilize the resources on the Linux host processor
      - Backhaul support (Ethernet, Wi-Fi, LTE etc..)
      - Protocols (MQTT, LWM2M etc..)
      - Tool (Ping, iPerf, NAT64, Firewall, VPN etc…)



Router Node (RN) - EFR32FG25 Overview

Advanced MCU

Low Latency

DEVICE SPECIFICATIONS

High Performance Radio

- Up to +16 dBm Sub-GHz
- -125.8 dBm Rx @ 915 MHz 4.8kbps O-QPSK
- -95.3 dBm Rx @ 914 MHz 2.4 Mbps Wi-SUN OFDM Option 1, MCS6

Efficient ARM® Cortex®-M33

- Up to 97.5 MHz
- Up to 1920kB Flash, 512kB RAM

Low Power

- 186 mA Tx Current (914 MHz +16 dBm)
- 6.3 mA Rx (924 MHz 400kbps 4-GFSK)
- Active Current: 30 µA/MHz
- 4.6 µA EM2 (512 kB Retained) / 2.6 µA EM2 (32 kB Retained)

Multiple protocol support

- Wi-SUN FAN 1.1
- Proprietary

Package Options

- 7x7 QFN56 (37 GPIO)

DIFFERENTIATED FEATURES

Advanced Radio Functionality

- Supports OFDM and up to 3.6 Mbps data rates
- Concurrent Detection of OFDM and FSK

Robust Security

- Supports up to PSA Level 3

16-bit ADC

- Up to 14-bit ENOB for better analog resolution

Mode Shift

- Allows backward compatibility via operation between OFDM and FSK

Large Memory Footprint

- Up to 1920kB Flash, 512kB RAM

More GPIO

- Up to 37 GPIO for better system integration

Kits & Boards: Router Node & Border Router

Wi-SUN US/Japan Pro Kit
Wi-SUN-PK6016A

Kit Contents

3x BRD4002A WSTK main boards
3x FG25 902-928 MHz +14 dBm Radio Board
1x BRD8016 Expansion board
3x 915Mhz antenna

Wi-SUN Europe/India Pro Kit
Wi-SUN-PK6015A

Kit Contents

3x BRD4002A WSTK main boards
3x FG25 863-870 MHz +14 dBm Radio Board
1x BRD8016 Expansion board
3x 868 MHz antenna

Supports FSK & OFDM | **Supports Router & Border Router**

Limited Function Node (LFN) – EFR32FG28 (Dual band SoC)

Dual Band

Multiprotocol

More GPIO

Secure

DEVICE SPECIFICATIONS

High Performance Dual Band Radio

- Up to _20 dBm Sub-GHz
- -111 dBm RX @ 915 MHz 50kbps GFSK
- Up to +10 dBm 2.4 GHz
- --94 dBm @ BLE 1 Mbps

Efficient ARM® Cortex®-M33

- Up to 78 MHz
- Up to 1024kB Flash, 256kB RAM

Low Power

- 25 mA Tx Current (2.4 GHz +10 dBm)
- 6 mA RX (BLE 1 Mbps)
- Sub-GHz Tx Current: 89 mA (+20 dBm)
- 4.3 mA RX (915 MHz 50kbps GFSK)
- Active Current: 42 µA/MHz
- 1.6 µA EM2 (16 kB Retained)

Multiple protocol support

- Wi-SUN FAN 1.1
- Amazon Sidewalk
- Z-Wave
- Proprietary
- Bluetooth (1M/2M)

Package Options

- 6x6 QFN48 (31 GPIO)
- 8x8 QFN68 (49 GPIO)

DIFFERENTIATED FEATURES

Dual Band

- Supports Sub-GHz + 2.4 GHz Bluetooth LE

Secure Vault™ Mid and High

- Protects data, IP and device

+20 dBm output power

- Eliminates the need for an external power amplify

16-bit ADC

- Up to 14-bit ENOB for better analog resolution

Preamble Sense

- Ultra low power receive mode

Antenna Diversity

- 6-8 dBm better link budget (Sub-GHz only)

Segment LCD

- 4x40 segment LCD

High GPIO count

- Support up to 49 GPIO

AI/ML accelerator

- Reduce power consumption for AI/ML applications

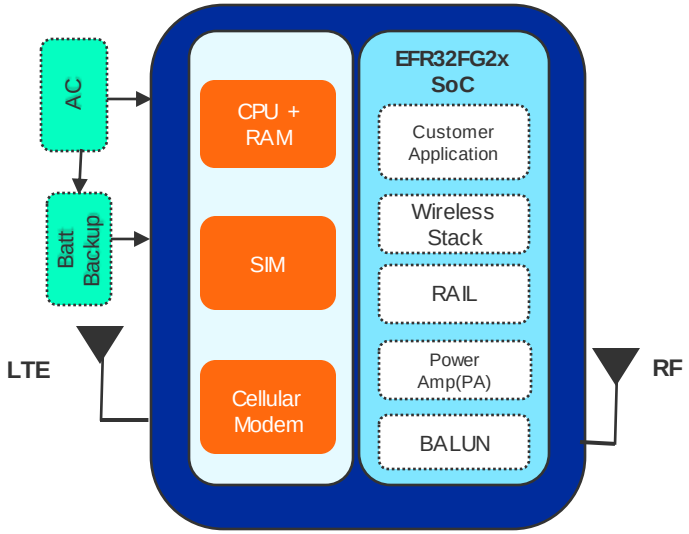
RF to Cellular - Border Router / Gateway (FG28/FG25)

DESIGN CONSIDERATIONS

- Security
- Robust connectivity
- Environmental conditions
- Latency
- Interoperability

RECOMMENDED KITS

- **FG25**
  - FG25-PK6011A – EFR32FG25 Pro Kit
  - Wi-SUN-PK6016A – Wi-SUN Pro Kit
- **FG28**
  - FG28-PK6025A Pro kit (+20 dBm)
  - xG28-EK2705A Explorer Kit



HARDWARE SOLUTIONS

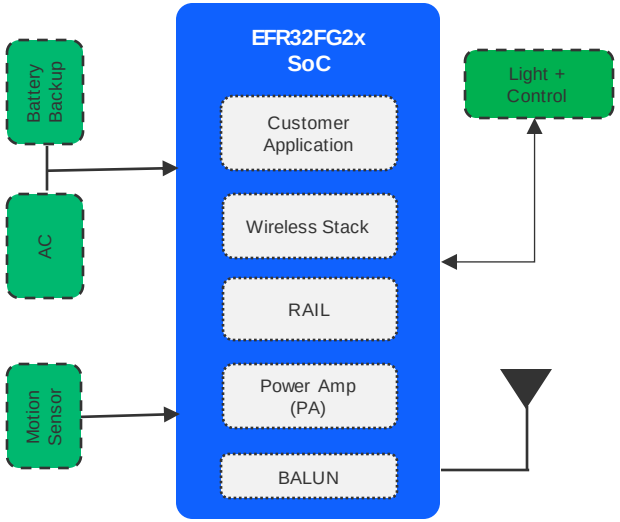
- **FG25 (FSK, OFDM)**
  - OFDM support for high bandwidth
  - FSK, OFDM switch
  - Large memory footprint (1920kB Flash, 512kB RAM)
  - Certified Wi-SUN PHYs
  - Suitable for Wi-SUN BR & Router nodes
- **FG28 (FSK only)**
  - High GPIO count (49)
  - Superior RF performance (Link budget)
  - AI/ML Accelerator
  - Suitable for Wi-SUN battery-powered LFN nodes
  - Dual band support (Sub-G, 2.4G BLE)

SOFTWARE FEATURES / SOLUTIONS

- **Wi-SUN BR (FG25)**
  - Certified stack
  - Certified PHYs (FG12, FG25)[1]
  - Complete ecosystem support
- **Proprietary (FG23, FG25)**
  - Complete software development suite for proprietary wireless applications (Flex SDK)
  - Simplified Developer Experience - (Simplicity Studio 5)
- **CPMS -** Custom Part Manufacturing Service

1 – FG28 PHY certification scheduled to be completed in 23Q4

Smart Street Lighting - Wi-SUN Router Node (FG25/FG28)



DESIGN CONSIDERATIONS

- Security
- Robust connectivity
- Environmental conditions
- Latency
- Interoperability

RECOMMENDED KITS

- **FG25**
  - FG25-PK6011A – EFR32FG25 Pro Kit
  - Wi-SUN-PK6016A – Wi-SUN Pro Kit
- **FG28**
  - FG28-PK6025A Pro kit (+20 dBm)
  - xG28-EK2705A Explorer Kit

HARDWARE SOLUTIONS

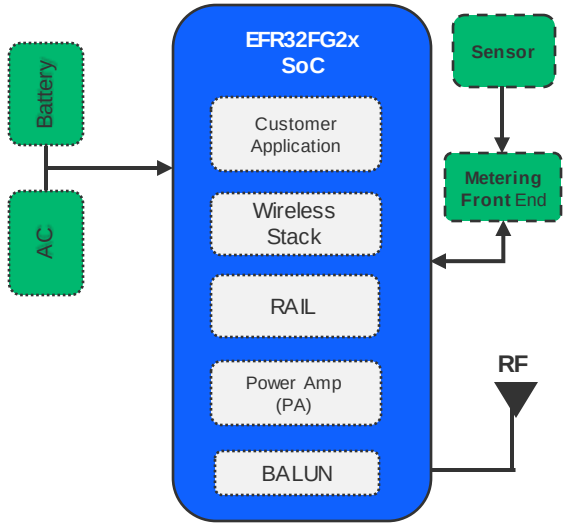
- **FG25**
  - Suitable for Wi-SUN router nodes
  - OFDM support for high bandwidth
  - FSK and OFDM concurrent detection and mode switch
  - Large memory footprint(1920kB Flash, 512kB RAM)
  - Certified Wi-SUN PHYs
- **FG28**
  - High GPIO count (49)
  - Superior RF performance (Link budget of ~146 dBm)
  - AI/ML Accelerator
  - Suitable for Wi-SUN battery-powered LFN nodes
  - Dual band support (Sub-GHz, 2.4GHz BLE)

SOFTWARE FEATURES / SOLUTIONS

- **Wi-SUN (FG25, FG28)**
  - Certified stack
  - Certified PHYs (FG12, FG25)[1]
  - Integration into GSDK
  - Reference designs for all node types
- **Proprietary (FG25, FG28)**
  - Complete software development suite for proprietary wireless applications (Flex SDK)
  - Simplified Developer Experience - (Simplicity Studio 5)

1 - FG28 PHY certification scheduled to be completed in 23Q4

Smart Electric Metering - Wi-SUN End node



DESIGN CONSIDERATIONS

- Interoperability
- Higher levels of system integration
- Robust Connectivity
- Latency
- Security

RECOMMENDED KITS

- **FG25**
  - FG25-PK6011A – EFR32FG25 Pro Kit
  - Wi-SUN-PK6016A– Wi-SUN Pro Kit
- **FG28**
  - FG28-PK6025A Pro kit (+20 dBm)
  - xG28-EK2705A Explorer Kit

HARDWARE SOLUTIONS

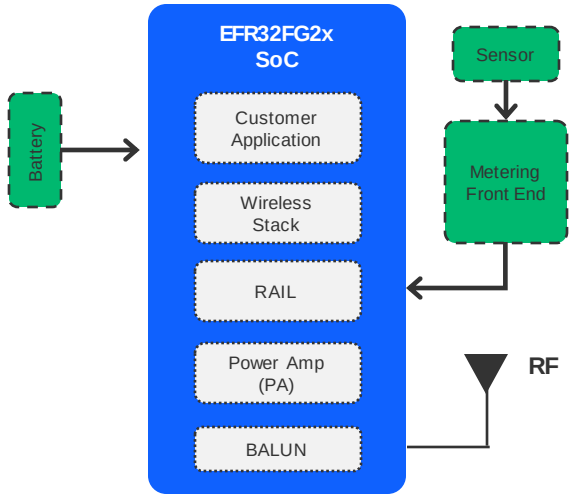
- **FG25 (FSK, OFDM)**
  - OFDM support for high bandwidth
  - FSK and OFDM concurrent detection and mode switch
  - Large memory footprint(1920kB Flash, 512kB RAM)
  - Certified Wi-SUN PHYs
  - Suitable for Wi-SUN BR & Router nodes
- **FG28 (FSK only)**
  - High GPIO count (49)
  - Superior RF performance (Link budget ~146 dBm)
  - AI/ML Accelerator
  - Suitable for Wi-SUN battery-powered LFN nodes
  - Dual band support (Sub-GHz, 2.4GHz BLE)

1 – FG28 PHY certification scheduled to be completed in 23Q4

SOFTWARE FEATURES / SOLUTIONS

- **Wi-SUN (FG25, FG28)**
  - Certified stack
  - Certified PHYs (FG12, FG25)[1]
  - Integration into GSDK
  - Reference designs for all node types
- **Proprietary (FG23, FG25, FG28)**
  - Complete software development suite for proprietary wireless applications (Flex SDK)
  - Simplified Developer Experience - (Simplicity Studio 5)
- **Custom Part Manufacturing Service**
  - Custom programming and security services
  - Security certificate injection
  - Encryption key management and programming

Battery Powered Metering - Wi-SUN LFN Node



DESIGN CONSIDERATIONS

- Battery Life
- Robust Connectivity
- Environmental Conditions
- Security
- Total System Cost

RECOMMENDED KITS

- **FG23**
  - xG23-PK6068A - EFR32xG23 Pro Kit
- **FG28**
  - FG28-PK6025A Pro kit (+20 dBm)
  - xG28-EK2705A Explorer Kit

HARDWARE SOLUTIONS

- **FG23**
  - Superior RF Performance (Link budget of ~146 dB)
  - Lower cost BOM with integrated DC/DC power supply, PA and BALUN
  - Low power consumption via Preamble Sense Mode, LESENSE
  - Can operate temperatures up to +125 °C
  - Secure Vault™ (certified PSA Level 3)
- **FG28**
  - High GPIO count (49)
  - Superior RF Performance (Link budget of ~146 dB)
  - AI/ML Accelerator for battery power consumption
  - Suitable for Wi-SUN battery-powered LFN nodes
  - Dual band support (Sub-GHz, 2.4GHz BLE)

1 – FG28 PHY certification scheduled to be completed in 23Q4

SOFTWARE FEATURES / SOLUTIONS

- **Wi-SUN (FG28)**
  - Certified stack
  - Certified PHYs[1]
  - Complete integration into GSDK
  - Reference designs for all node types
- **Power management solutions for low power consumption**
  - Option to turn off the power to unused RAM blocks
  - Voltage Scaling
  - Peripheral Reflex System (PRS)
  - Low Energy Sensor Interface (LESENSE)
- **Custom Part Manufacturing Service**
  - Custom programming and security services
  - Security certificate injection
  - Encryption key management and programming

Large scale outdoor Applications

Street Lighting

Traffic Control/Lights
Parking Meters

Oil/Gas Production
Gas / Oil Production

Utility Meters

Environmental Monitoring

Waste Management

Consumption, Flow rate, Valve Control

Smart Agriculture

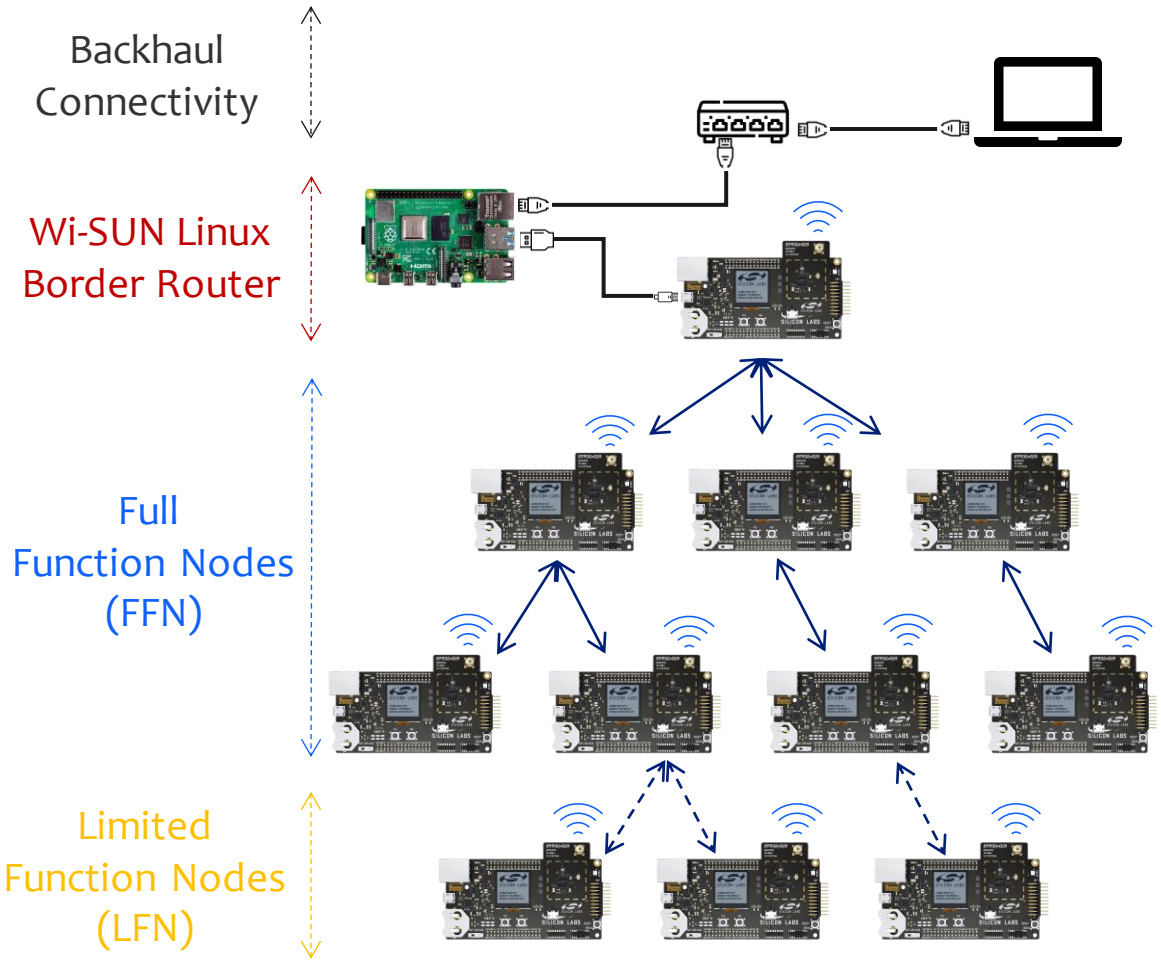
Key Design considerations for Large scale outdoor networks

- Long Wireless Range and robust connectivity
- High transmit data rate and Latency
- Self forming and Self healing
- Battery Life of Remote Sensors
- OTA
- Interoperability
- Longevity

Demo

Demonstration

- **Goal:**
  - Configure and start a Wi-SUN Network using Wi-SUN Border Router GUI
  - Join an FFN and an LFN to a large Wi-SUN Network
  - Get Metering data from an LFN using CoAP
- **Prerequisites:**
  - Raspberry Pi
  - 2 x EFR32FG25
  - 1 x EFR32FG28
  - 3 x Wireless Pro Kit Mainboard
  - Simplicity Studio v5
  - GSDK 4.3.0 or later
  - wsbrd-br-linux GitHub repository
  - wsbrd-br-gui GitHub repository
- **Network PHY Configuration:**
  - FAN 1.1 FSK 150Kbps



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Thank You