Presentation Will Begin Shortly

4:00

LPWAN

FEB 8TH	LPWAN 101 - A Look at the Emerging LPWAN Solutions and the Applications They Serve
MAR 14TH	Wi-SUN FAN 1.1 Rollout
APR 18TH	Amazon Sidewalk – New Features and Market Applications
MAY 23TH	Why Sub-GHz?

Welcome

Wi-SUN FAN 1.1 Rollout WIP

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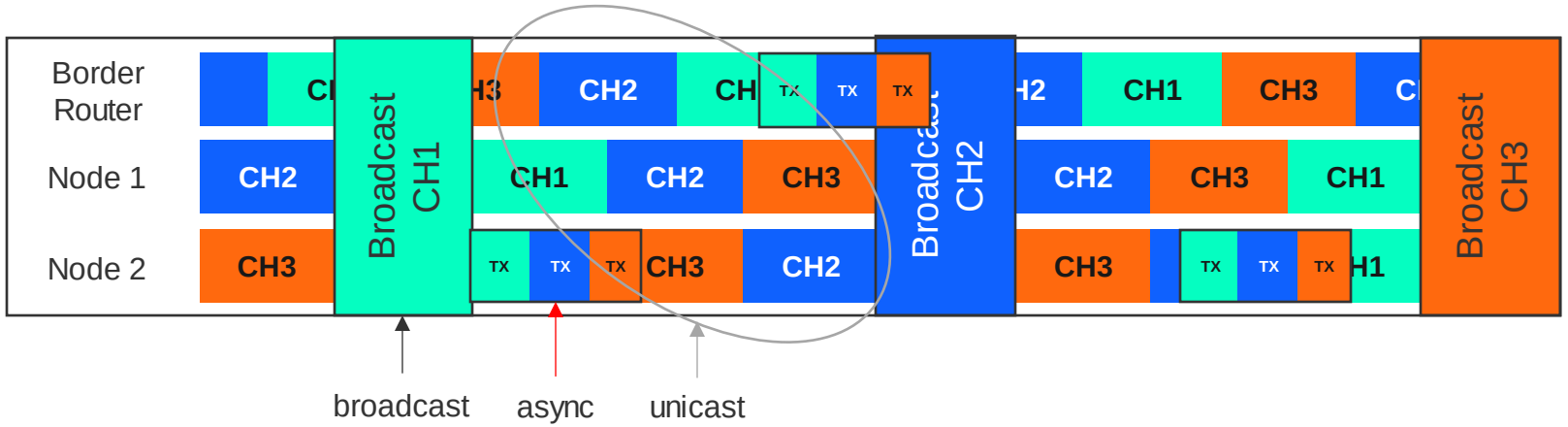
tech talks

Wi-SUN FAN 1.0 Review

- **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

Wi-SUN Communication Summary and frequency hopping



- **Broadcast**
  - Has priority over Unicast
  - All nodes switch to broadcast channel to listen
- **Asynchronous**
  - Has priority over Unicast and Broadcast
  - Transmits on all channels
- **Unicast**
  - Impacted by broadcast and asynchronous traffic
  - The transmitter adapts to receiver node channel

=> Configuration is key to adapt the Wi-SUN stack and its performance to the application.

What is FAN 1.1?

- **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:**

1. **FAN 1.1 Core (aka FAN 1.0+)**
   - Only one feature added: PAN-wide Information Element
2. **FAN 1.1 High Performance option (HP)**
   - Introduces SUN-OFDM PHYs
   - Introduces mode switch
3. **FAN 1.1 Low Energy option (LE)**
   - Introduces Limited Function Nodes (LFN)

FAN 1.1 Low Energy: 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)

xG28: Single or Dual Band SoC for the Next Generation of IoT

Single or Dual Band

More GPIOs

DEVICE SPECIFICATIONS

High Performance Dual Band Radio

- Up to +20 dBm Sub-GHz Output Power
- -125.8 dBm Rx Sensitivity @ 915 MHz 4.8 kbps O-QPSK
- Up to +10 dBm 2.4 GHz Output Power
- -94.2 dBm Rx Sensitivity @ BLE 1 Mbps

Efficient ARM® Cortex®-M33

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

Low Power

- 82.8 mA TX Current (915 MHz, +20 dBm)
- 26.2 mA Tx Current (915 MHz, +14 dBm)
- 4.6 mA RX (915 MHz 4.8 kbps O-QPSK)
- 22.5 mA TX Current (2.4 GHz +10 dBm)
- 5.2 mA RX (BLE 1 Mbps)
- Active Current: 33 µA/MHz @39 MHz
- 1.3 µA EM2 (16 kB Retained) / 2.8 µA EM2 (256 kB Retained)

Protocol support

- Wi-SUN
- Amazon Sidewalk
- CONNECT
- Wireless M-BUS
- Proprietary
- Bluetooth LE

Package Options

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

DIFFERENTIATED FEATURES

Single and Dual Band Support

- Supports Sub-GHz and Sub-GHz + Bluetooth LE

Large memory footprint

- Support larger stacks or applications in a single chip

AI/ML accelerator

- Faster inferencing with lower power

Secure Vault™ Mid and High options

- Flexible platform for evolving security needs

Support for Wi-SUN Mode Switch

- Support for use of multiple FSK PHYs in a single network

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

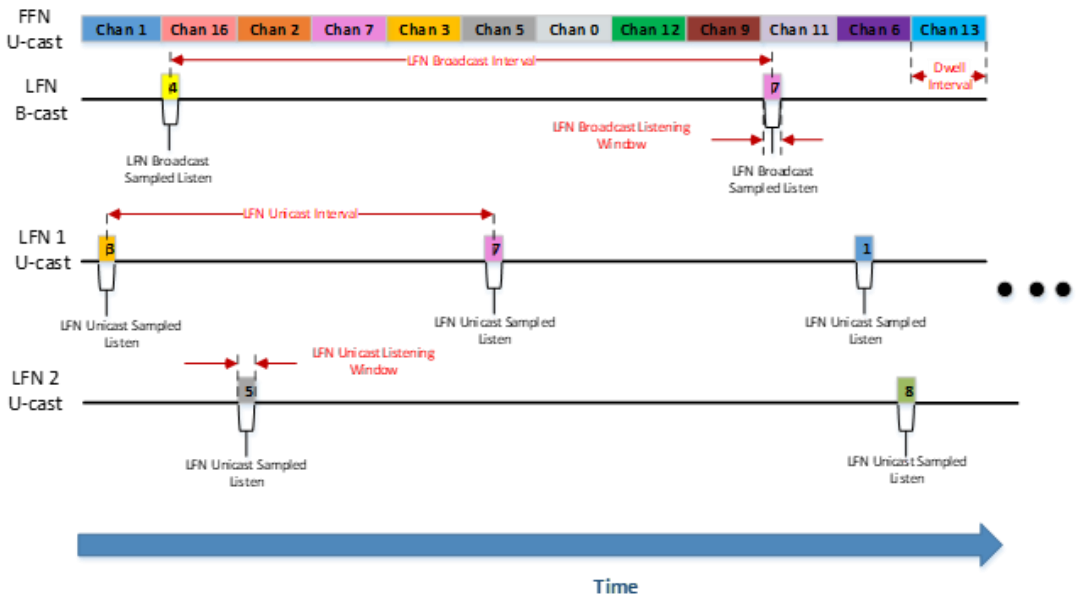
- 4x48 segment LCD

High GPIO count

- Support up to 49 GPIO

Limited Function Nodes (LFN): some figures

Schedules



- **Specific schedules for LFN Unicast and LFN broadcast on top of usual (FFN) schedules**
  - LFN broadcast interval: from 10 sec to 10 minutes
  - LFN Unicast interval: 30 sec to … 4 h

  => Network to be configured to tradeoff latency and consumption

Power Consumption

- **Conditions:**
  - Balanced configuration
    - LFN Unicast interval: 60 sec
    - LFN Broadcast Interval: 5 minutes
  - Traffic scenario
    - 50kbps FSK
    - Transmission of a 100 B packet every 8 hours
    - Wake up for unicast and broadcast listening windows

=> Average consumption 1.5µA on top of EM2, i.e. 6 µA total for EFR32FG28

=> Leads to <u>>30 years</u> lifetime for a 2000mAh battery

FAN 1.1 High Performance: OFDM

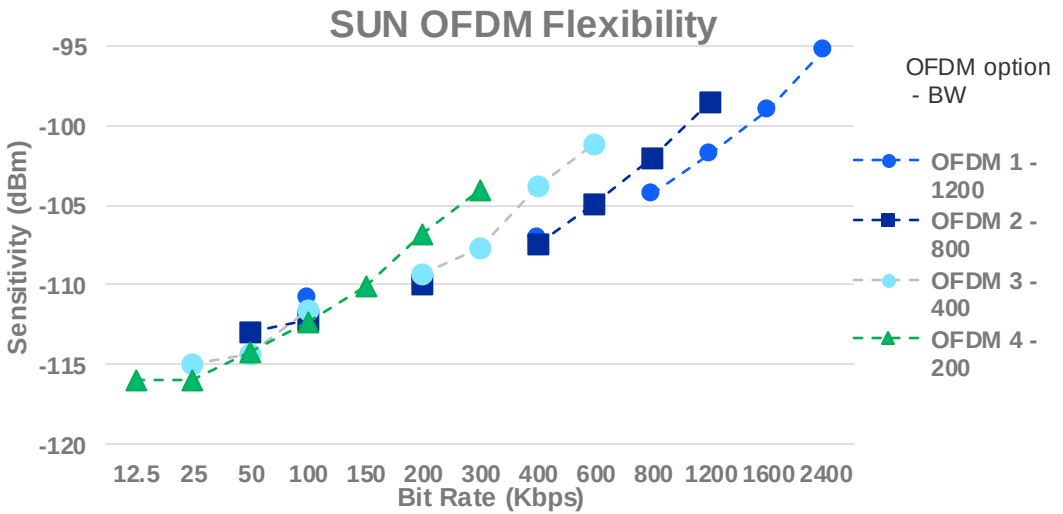
- **OFDM brings**
  - High bit rates, up to 2.4 Mbps
    - 3.6 Mbps w/ EFR32FG25 additional mode
  - Intrinsic flexibility on bit rates and performance levels
    - Sometimes referred to as MR-OFDM (multi-rate)
      - Packet-by-packet flexibility, within the same bandwidth
    - Each option has 7 Modulation 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

OFDM high bit rates

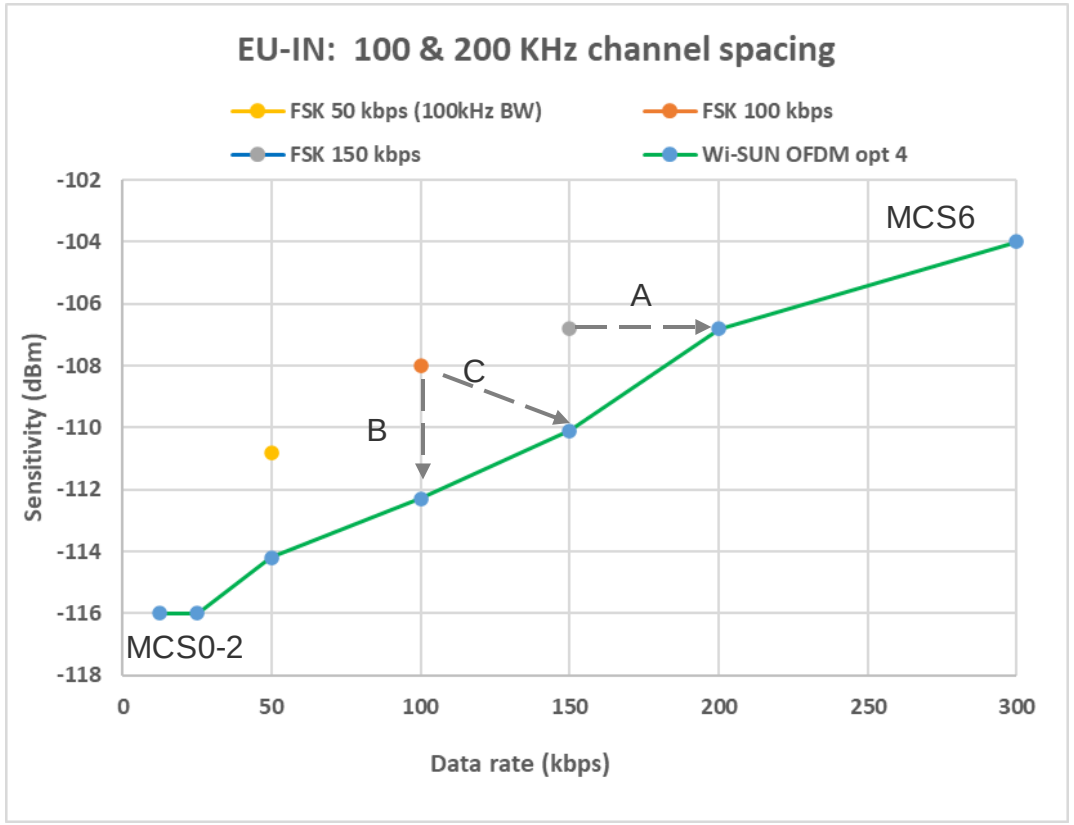
OFDM option	Bandwidth (kHz)	Main regions	Bit rates (kbps)	Sensitivity (dBm)
1	1200	NA, BZ	100 to 2400 (3600*)	-111 to -95
2	800	NA, BZ, JP	50 to 1200 (1800*)	-113 to -98
3	400	NA, BZ, JP	25 to 600 (900*)	-115 to -101
4	200	NA, BZ, JP, EU	12.5 to 300 (450*)	-116 to -104



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

OFDM Performance compared to FSK: Europe – India case

- **Europe, India mainly use 200 kHz channel spacing**



- **OFDM advantage vs FSK:**
  - A: increased bit rate for same range
    - +30 to 50%
    - + 200% from FSK 50kbps (100 KHz BW)
  - B: improved range for same bit rate
    - About 4 dB better sensitivity
  - C: can be a combination of both
    - +50% and 2 dB
- **Note: same comparison applies for other countries**
  - Europe & India are selected as the single channel bandwidth makes the comparison more fair
- **Intrinsic flexibility of OFDM allows**
  - To use low MCS to increase range
  - To use high MCS to increase throughput when conditions allow it

FG25: Optimized Solution for Smart Cities

Advanced MCU

Low Latency

DEVICE SPECIFICATIONS

High Performance Radio

- Up to +16 dBm Output Power
- -125.8 dBm Rx Sensitivity@ 915 MHz 4.8kbps O-QPSK
- -95.3 dBm Rx Sensitivity@ 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 Current (924 MHz 400kbps 4-GFSK)
- Active Current: 30 µA/MHz
- 4.6 µA EM2 (512 kB Retained) / 2.6 µA EM2 (32 kB Retained)

Protocol support

- Wi-SUN FAN 1.1
- Proprietary
- CONNECT

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

- Secure Vault™ Mid and High options for evolving security needs

16-bit ADC

- Up to 14-bit ENOB for better analog resolution

Mode Switch

- Allows for coexistence of FSK and OFDM nodes on a single network

Large Memory Footprint

- Up to 1920kB Flash, 512kB RAM

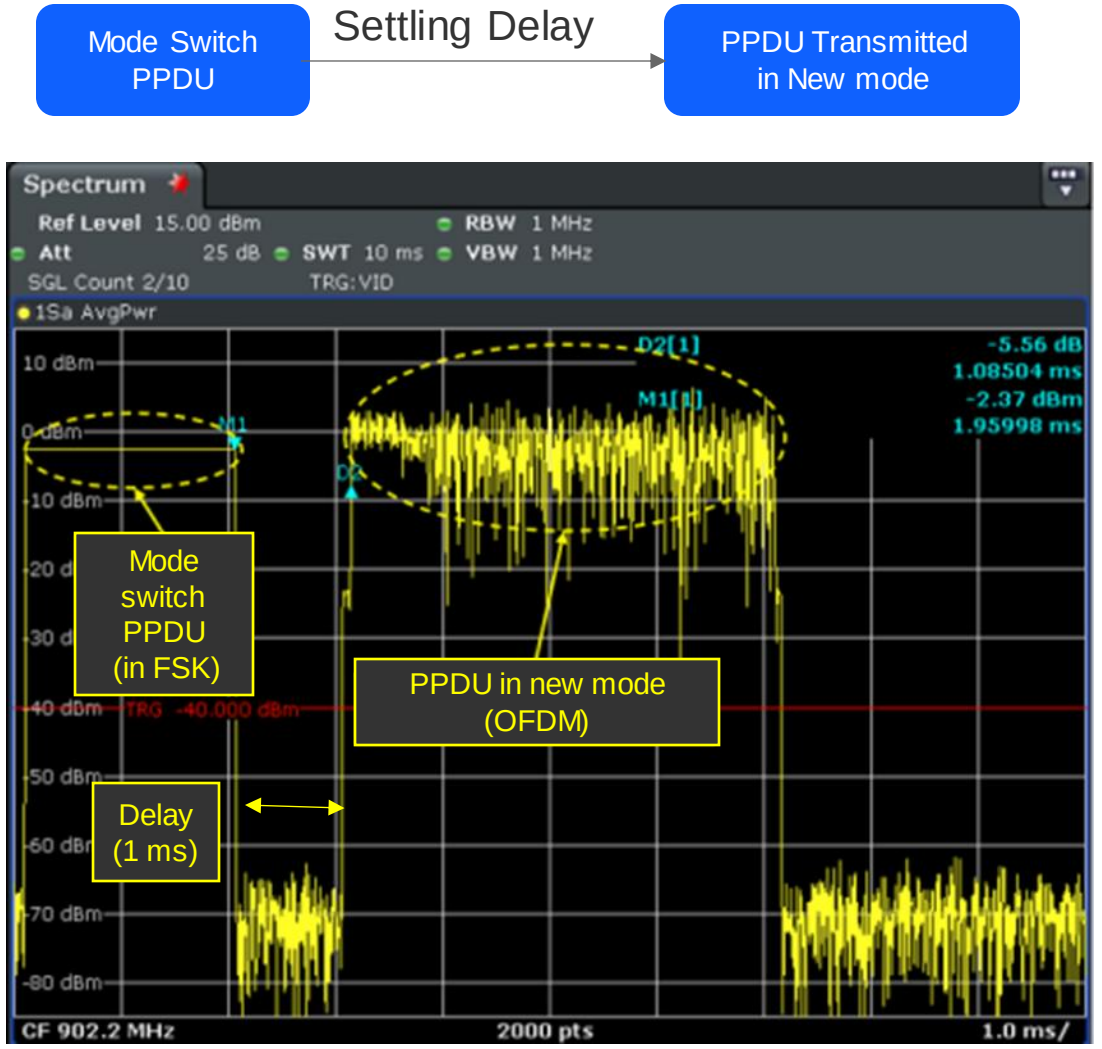
More GPIO

- Up to 37 GPIOs for better system integration

Q&A

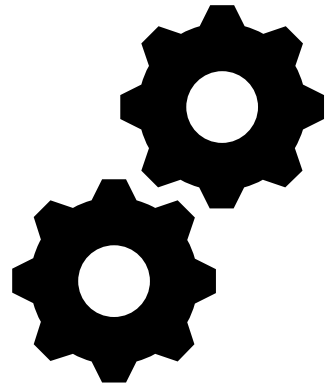
FAN 1.1 High Performance – Mode Switch

- **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



Mode Switch

- **Modulation and Data Rate (MDR) Switching**
  - Introduced in FAN1.1
- **Goal**
  - Temporarily switch from one MDR to another for one or more packets exchange
  - Switching can be used to take advantage of the channel conditions or to meet application requirements
- **Silicon Labs Implementation**
  - As per FAN1.1 spec
  - Provides PHY Mode Switch and MAC Mode Switch APIs



BENEFITS

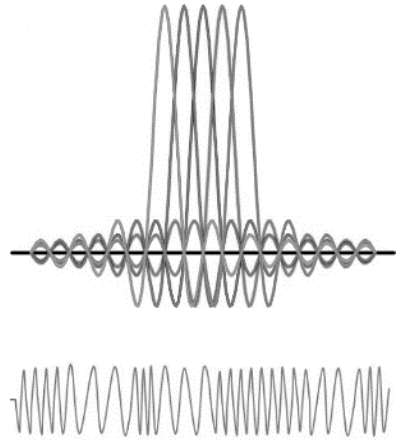
- Best modulation and data rate for a specific channel condition
  - Reduced burst size, then power consumption
- Best modulation and data rate for a specific use-case
- If channel condition allows select higher data rate for cases like OTA [OFDM or FSK]
- Best modulation and data rate based on device capabilities
  - Devices advertise on the modes they support

DRAWBACKS

- Need to transmit a Mode Switch PPDU
- Can be slow due to long CCA (160 micro-Sec) and settling delay (0.5 to 1.5ms as per spec.)
- Reduced co-existence performance in technologies with short CCA
  - For example, 802.11ah (40 micro-second)

Concurrent Detection

- **Concurrent detection of two different PHYs**
  - The device listens to both FSK and OFDM at the same time
  - The first incoming signal triggers reception, the other one is aborted
  - Behaves like mode switch, without the need for the signaling packet (Mode Switch PPDU)
    - Concurrent Mode can be considered as a super Mode Switch
- **Silicon Labs Implementation**
  - Supported on FG25 [FSK & OFDM]
  - Currently available concurrent detection PHY pairs:
    - OFDM_option1_FSK_50kbps_NA
    - OFDM_option3_FSK_100kbps_JP
    - OFDM_option4_FSK_50kbps_EU



BENEFITS

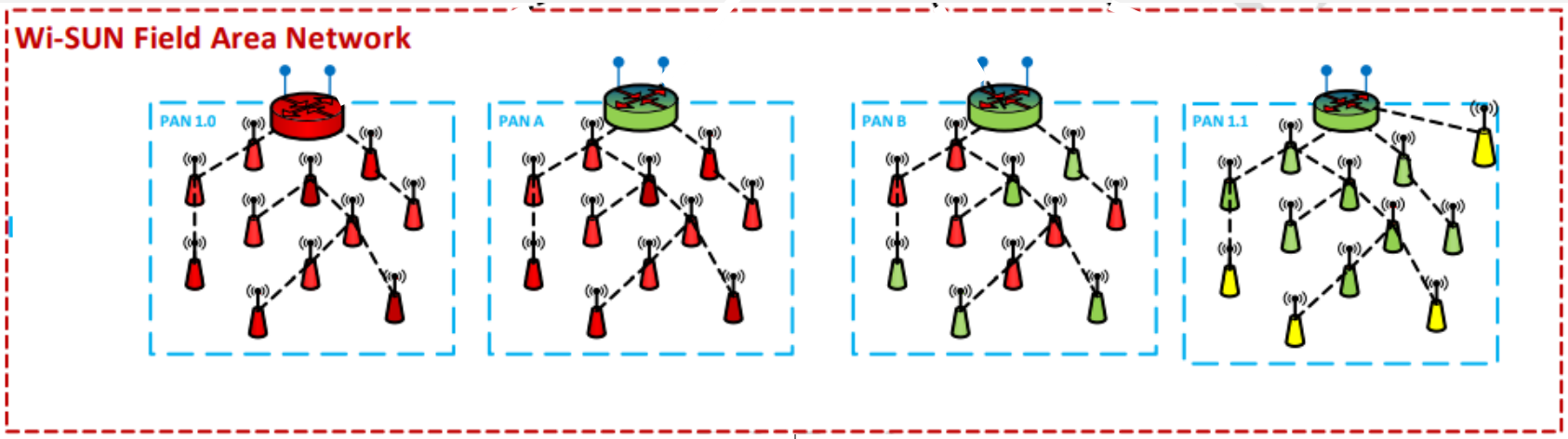
- Faster than Mode Switch
  - No additional signaling and settling time
- Better co-existence performance than Mode Switch
  - Mode Switch performance can degrade in the presence of technologies with faster CCA, for example 802.11ah
- Increase throughputs without the overhead of a signaling packet
- Allows hybrid networks
  - FSK for robustness and legacy, OFDM for high bit rates

DRAWBACKS

- Only one payload can be received at a given time
  - It is not a dual reception
- Limited to single FSK and OFDM PHY concurrently
  - Detection of 2 FSK or 2 OFDM is not possible
- Need pre-defined PHY pairs
  - Additional pairs can be implemented based on customer needs

Concurrent Detection is not specified in Wi-SUN, but a capability of EFR32FG25

FAN 1.1 Coexistence with FAN 1.0



- **A FAN 1.0 Border Router locks the PAN to FAN 1.0**
  - Potential FAN 1.1 Routers would behave as FAN 1.0 routers
- **FAN 1.0 and FAN 1.1 coexistence in a PAN require that**
  - The Border Router is FAN 1.1
  - There is no LFN in the PAN
- **A PAN including LFN must be 100% FAN 1.1 (does not allow FAN 1.0 routers)**

- **Migration path from FAN 1.0 to LFN support**
  - Upgrade the Border Router to FAN 1.1
  - Upgrade all Routers to FAN 1.1
    - And enable LFN parenting
  - Configure the Border Router to
    - disable FAN 1.0 nodes support and
    - enable LFN support
  - Add LFNs
    - An LFN can connect only to routers with "LFN parenting" capability

FAN 1.1 Certification

- **FAN 1.1 Certification is coming**

FAN 1.0

To be stopped once FAN 1.0+/ FAN 1.1 core is ready

FAN 1.0+ = FAN 1.1 Core	BR	R	LFN
PAN-wide IE	M	M	-
MAC-Command Mode Switch	O	O	-
PHY Mode Switch	O	O	-
LFN Parenting	-	-	-
LFN features	-	-	-
FSK	M*	M*	-
OFDM	-	-	-

FAN 1.1 Core + HP	BR	R	LFN
PAN-wide IE	M	M	-
MAC-Command Mode Switch	O	O	-
PHY Mode Switch	M	M	-
LFN Parenting	-	-	-
LFN features	-	-	-
FSK	M*	M*	-
OFDM	M*	M*	-

FAN 1.1 Core + LE	BR	R	LFN
PAN-wide IE	M	M	O
MAC-Command Mode Switch	O	O	O
PHY Mode Switch	O	O	O
LFN Parenting	M	M	-
LFN features	-	-	M
FSK	M*	M*	M*
OFDM	O	O	O

PHY 1.0 (1V08)

PHY1.1 (2v02)	
PHY Mode Switch	O
FSK	M*
OFDM	O

2019 — 2023 — 2024 H1 — 2024 H2

* At least the mandatory data rate modes

Certification of Silicon Labs products

- **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/

- **FAN 1.1 certifications plan**

FAN 1.1			
	EFR32**FG25**		EFR32**FG28**
	HP	**LE**	**LE**
Border Router	**On-going (CTBU)**		**2024***
Router			**2024***
LFN			**2024***
PHY: 800MHz 900MHz	**Yes (CTBU) WSA345 WSA335**		**24Q2**

- **CTBU**: Certification Test Bed Unit - EFR32FG25 is part of the certification test beds (PHY and FAN)
- 2024*: pending certification Test bed completion

Q&A

Thank You

Watch ON DEMAND