Wireless MCU Product Update

APF-SNT-T1458

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M A Y . 2 0 1 5

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The Languages We Speak

ZigBee

- RF4CE
- ZigBee PRO
- ZigBee IP

IP Stack

IPv4/IPv6

BLE Stack

Core Stack 4.1

MAC/PHY

- Sub-GHz
- 2.4 GHz

BLE LL/PHY

- 2.4 GHz
- Bluetooth 4.1

Wireless Connectivity Solutions

Wireless Connectivity Solutions

Flash Memory (vertical axis): 512KB, 256KB, 128KB, 32KB, TRX

Frequency (horizontal axis): 315 MHz, 434 MHz, 868 MHz, 915 MHz, 2.4 GHz

Technologies: M-Bus wireless, IEEE 802.15.4, IPv6, ZigBee, IEEE 802.15.4, IPv6, THREAD

Products:
- **MKW2x** *Kinetis W*
- **MKW01** *Kinetis W*
- **MC13234/7**
- **MC13211**
- **MCR20**

Legend:
- ARM7™
- Cortex M4
- Cortex M0+
- No MCU
- HCS08 8-Bit

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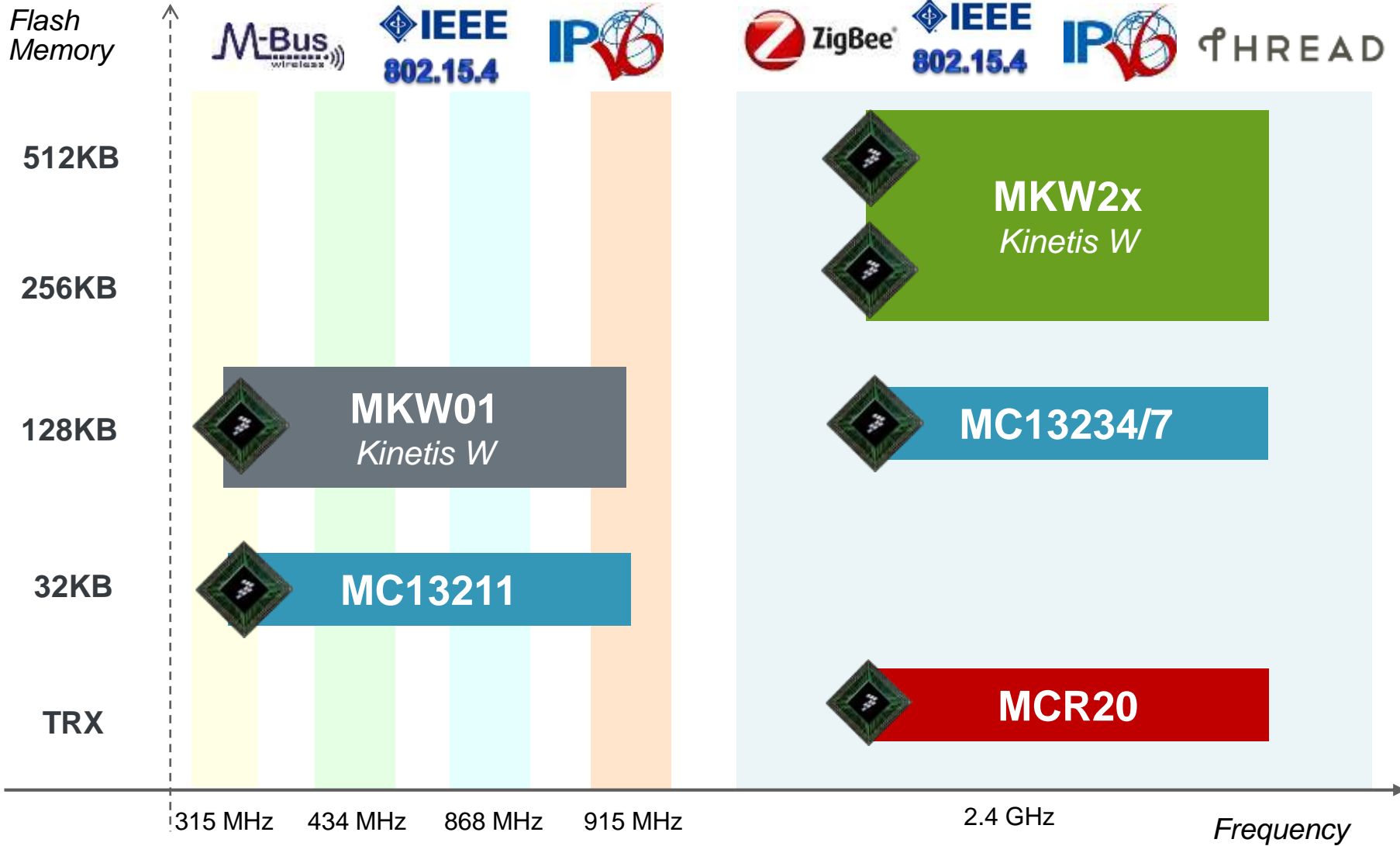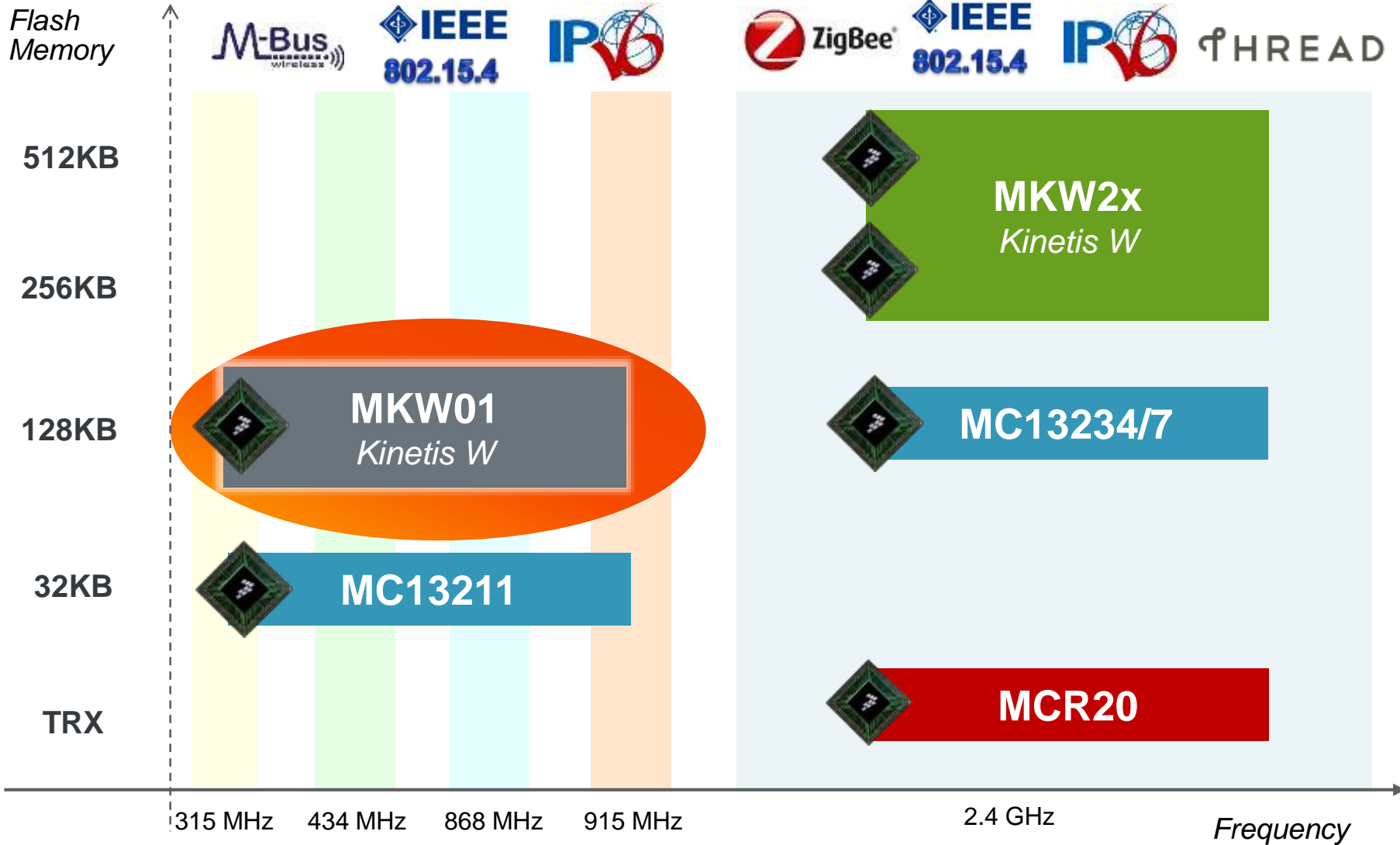
Kinetis KW01 Wireless MCU (Sub 1-GHz)
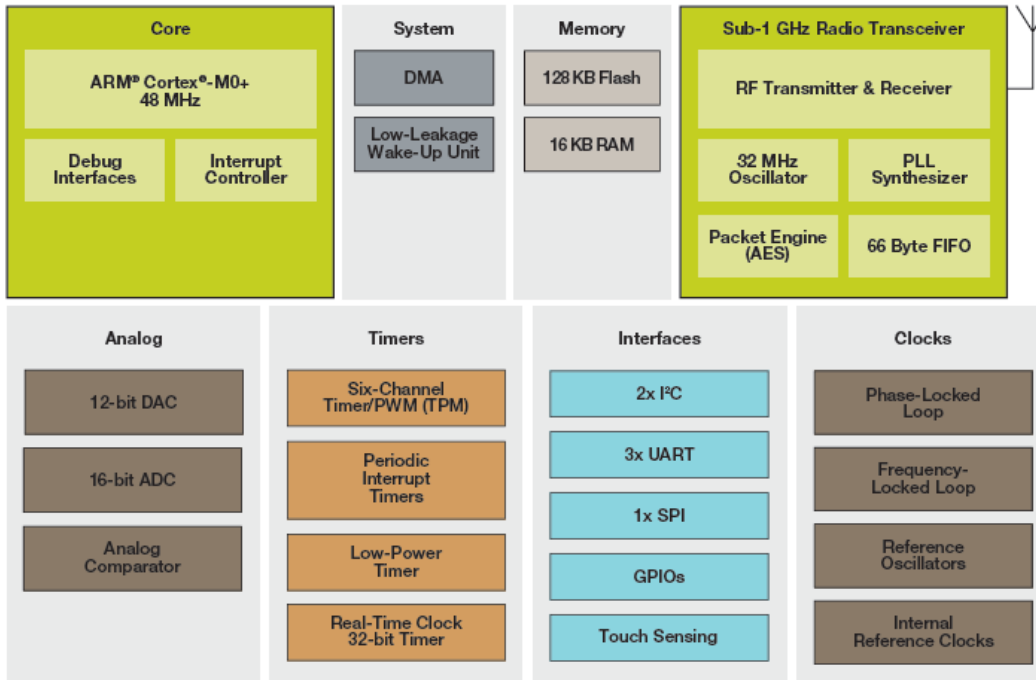
CPU

- 32-bit ARM Cortex M0+ 48MHz Core
- 128KB Flash and 16KB SRAM

Radio Transceiver, Sub 1-GHz

- Supports 290-340MHz, 424-510MHz, and 862-1020MHz frequency bands
- FSK, GFSK, MSK, GMSK and OOK modulations up to 600kbps
- Up to -120dBm RX sensitivity @ 1.2kbps
- -18 to +17dBm TX output power in steps of 1dBm

Ultra Low Power for Battery Operated Devices

- Typical consumption
  - 1.7µA standby
  - <130 µA/MHz CPU system run mode
  - 16 mA RX peak
  - 20 mA TX peak at 0 dBm, 33 mA at +10 dBm

Software

- SMAC (Simple-MAC), user modifiable for proprietary protocols

System

- 16-bit ADC, Capacitive Touch Sensing, I2C, UART, SPI, Timers
- Operating Range: 1.8V to 3.6V, -40C to +85C
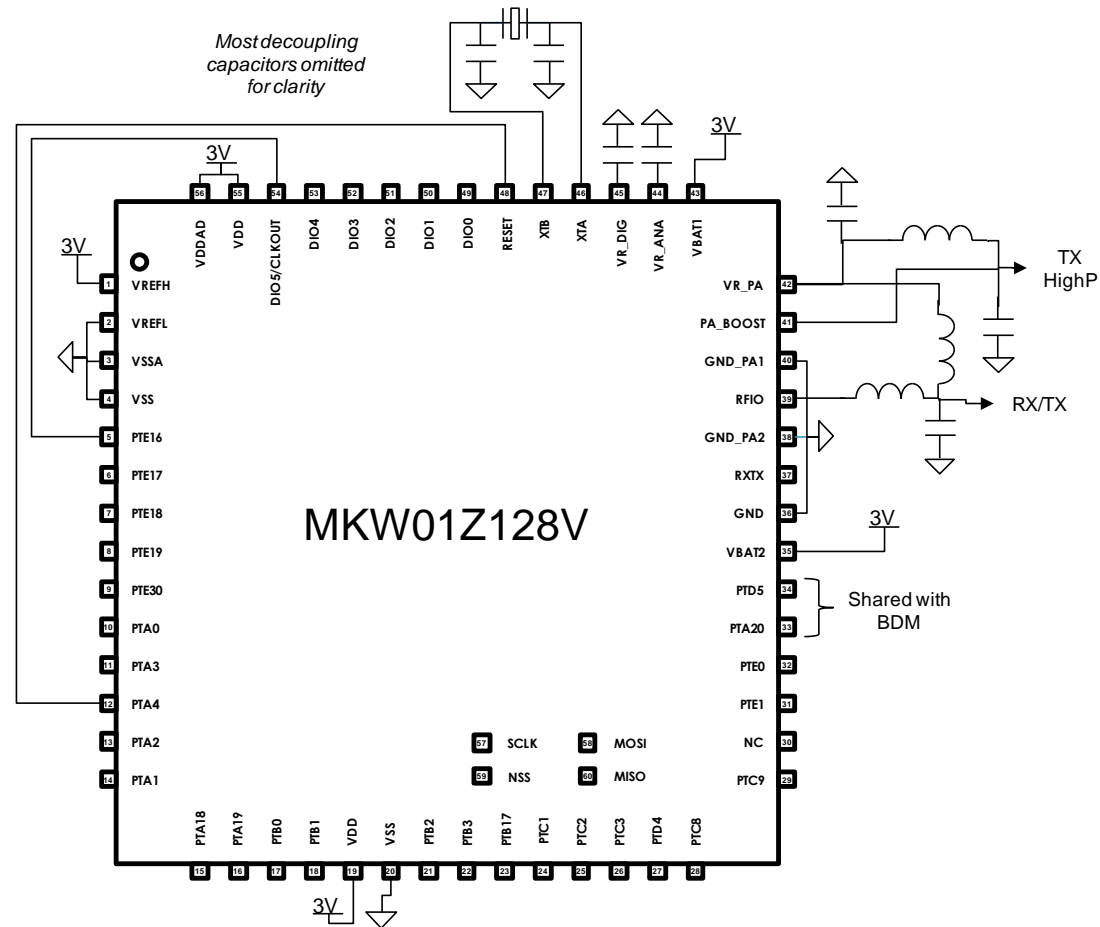
Orderable Part

Part Number	Description
MKW01Z128CHN	• 290–1020 MHz smart radio • 128 KB flash/16 KB RAM • 60 MAPLGA 8 mm x 8 mm • Bulk tray

MKW01Z128CHN Application Schematic

- Minimum requirements (RF+MCU) :
  - A 32MHz crystal for RF operation
  - A matching network to filter harmonics and match antenna (pcb, power and load dependant…)

MKW01Z128V

MKW01x Development Kits

- **Modular Reference Board (MRB).**
  - **Features**
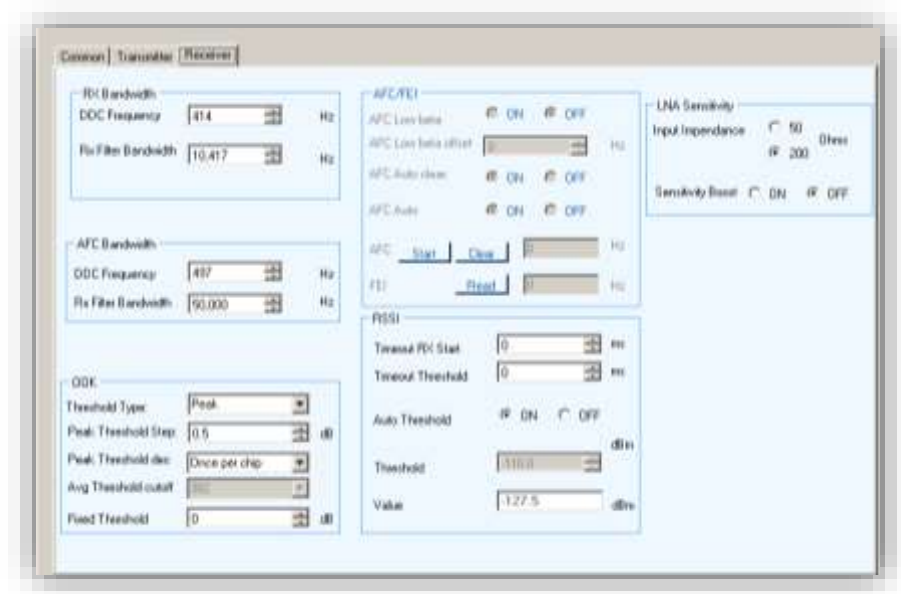   - Flash reprogramming and in-circuit hardware debugging, test points & jumpers.
    - USB port on the MRB to interface with PC
    - Reference design for RF matching networks on board.
    - SMA connectors for RFIO or separate TX/RX.
    - Out-of-box application with Radio Utility GUI and firmware.
    - Quick Start Guide
    - Can be mounted on TWR-RF which can in turn be installed in a TOWER system.

MKW01 – Radio Configuration and Test Tool

- Allow fast evaluation of the radio performance in a lab environment without need for writing software
  - Analysis of TX spectrum (output power, harmonics, ..)
  - Modulation scheme impact (GFSK, BT, Mod index) on spectrum
  - Help on matching network tuning
  - Analysis of RX Sensitivity performance (RSSI, LNA input impedance, OOK threshold, AFC)

- Run on PC connected through USB to Module Radio Board.
- Free of charge, free download from Freescale website

Sub-GHz Wireless Communication Protocols

	Proprietary	W-MBUS	802.15.4g/e	IP / IoT
Application Layer	Customer Software	W-MBUS	Customer Software	Customer Software
Network Layer	S-MAC	W-MBUS		IPv6, TCP, UDP
Media Access Layer (MAC)		W-MBUS	802.15.4e	802.15.4e
Physical Layer (PHY)	CE/FCC		802.15.4g	

MKW01Z128CHN

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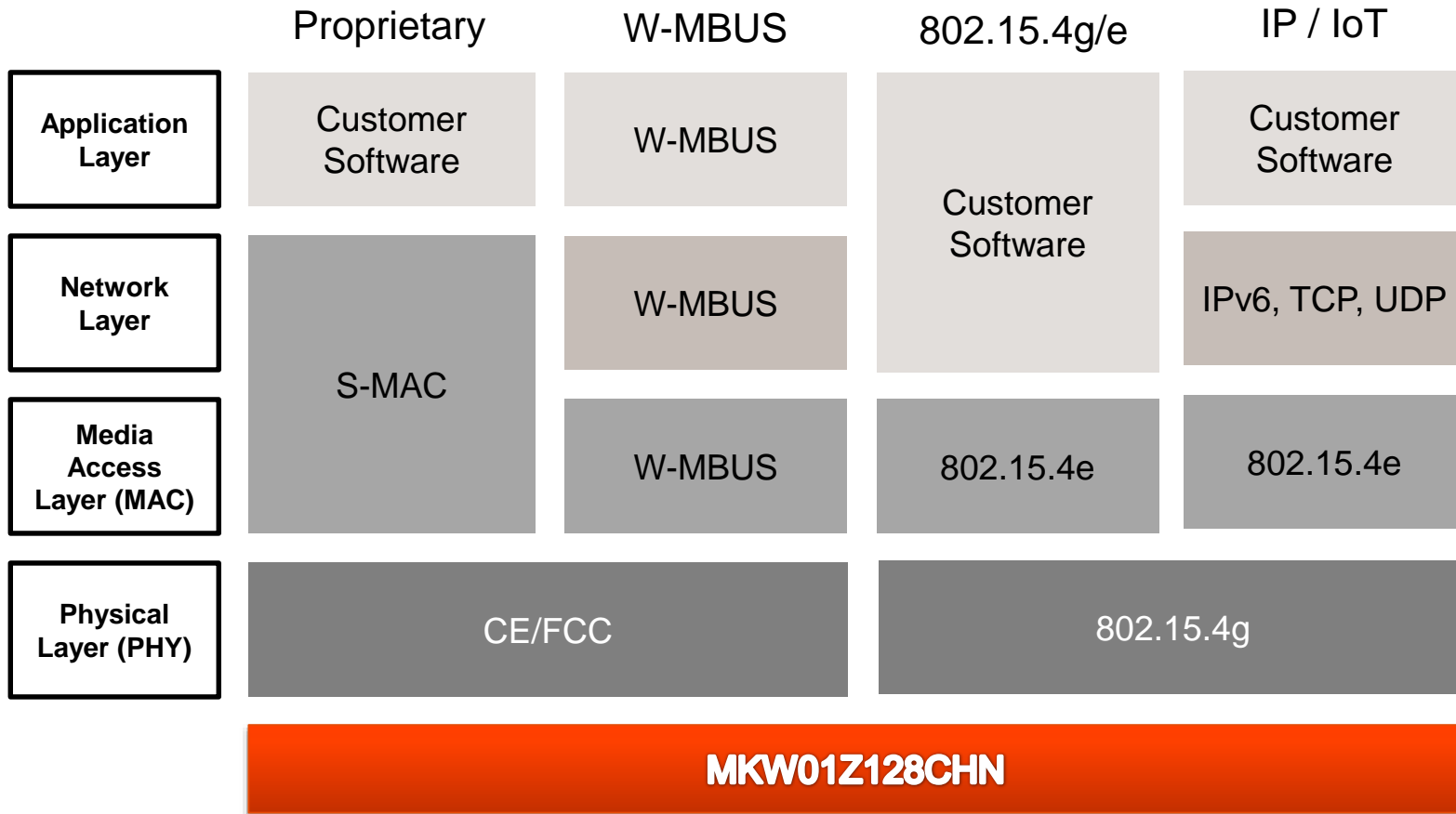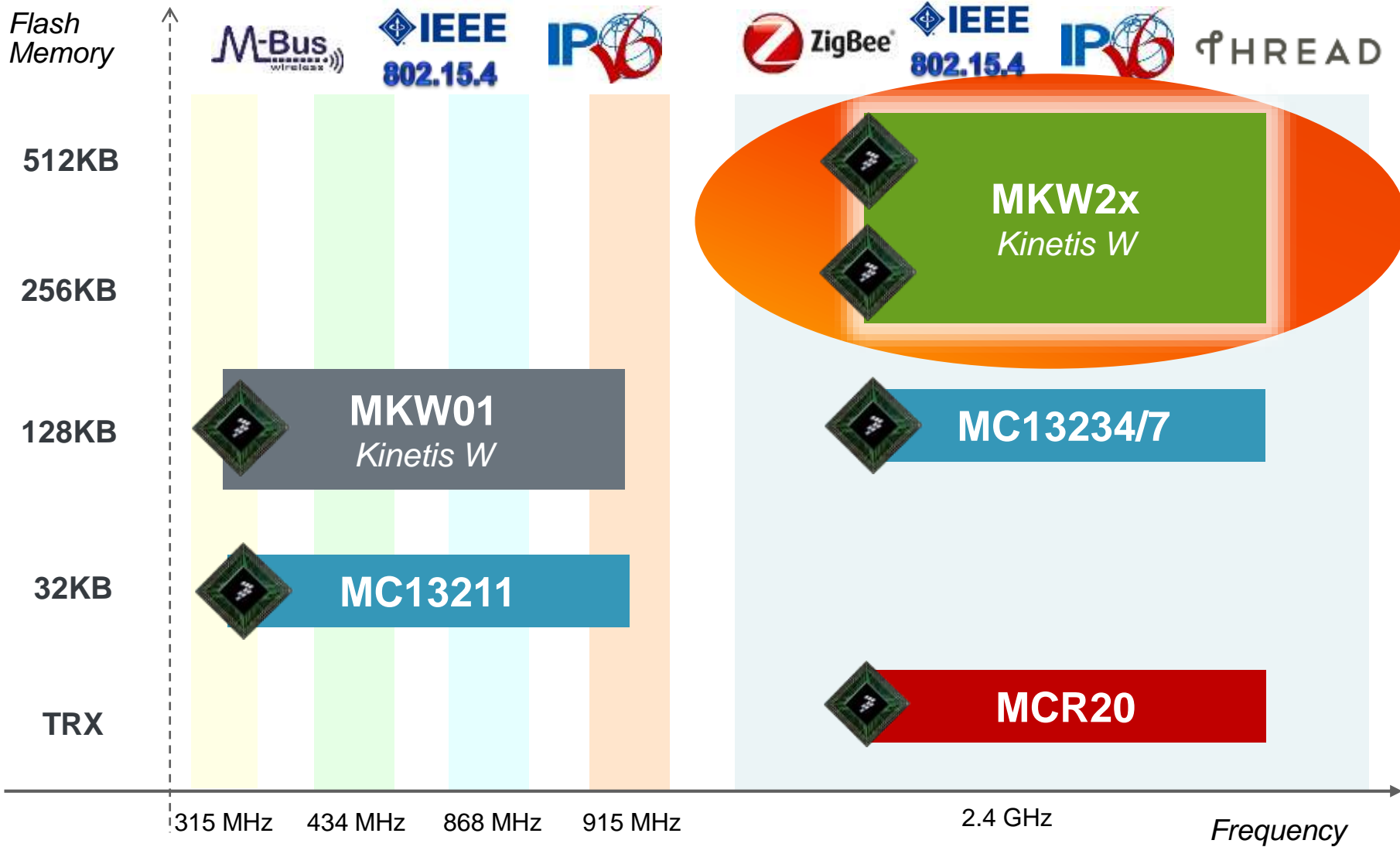
Kinetis KW2x Wireless MCU (2.4Hz)

Core
- ARM Cortex™-M4 50 MHz
- DSP
- Debug Interfaces
- Interrupt Controller

Communication
- I²C
- SPI
- UART (ISO 7816)
- USB On-The-Go (H)
- USB Charger Detect
- USB Voltage Regulator

System
- Internal and External Watchdogs
- DMA
- Low Leakage Wake-Up Unit

Analog
- 16-bit ADC
- High Speed Comparator with 6-bit DAC

Security
- Cyclic Redundancy Check (CRC)
- Tamper Detect
- Cryptography Authentication Unit
- Random Number Generator

Memories
- Program Flash (Up to 512 KB)
- FlexMemory Option 64 KB FlexNVM 4 KB FlexRAM (MKW21D256 only)
- SRAM (Up to 64 KB)

Timers
- Flex Timer
- Programmable Delay Block
- Periodic Interrupt Timers
- Low Power Timer
- Independent Real Time Clock

RF Transceiver
- IEEE 802.15.4 2006 2.4 GHz
- Fast Antenna Diversity
- Dual PAN ID
- 32 MHz Osc
- SPI Interface

Clocks
- Phase-Locked Loop
- Frequency Locked Loop
- Low / High Frequency Osc.
- Internal Reference Clocks

Device	Flash	RAM	Feature	Package
MKW21D256VHA5	256 KB	32 KB	No USB	8x8 63-pin LGA
MKW21D512VHA5	512 KB	64 KB	No USB	8x8 63-pin LGA
MKW22D512VHA5	512 KB	64 KB	USB	8x8 63-pin LGA
MKW24D512VHA5	512 KB	64 KB	USB and Smart Energy 2.0	8x8 63-pin LGA

CPU
- 50 MHz Cortex M4 CPU core
- Up to 512KB Flash & up to 64KB SRAM
- Optional (MKW21D256): 64 KB FlexNVM & 4 KB FlexRAM
- Typical current: 250 uA/MHz run, 1.7uA RTC standby

Radio Transceiver, 2.4GHz
- IEEE-802.15.4 compliant
- -102 dBm RX sensitivity and +8 dBm TX output power
- Peak typical current: 17mA TX and 19mA RX

Security
- Active and passive tamper detection with RTC timestamp
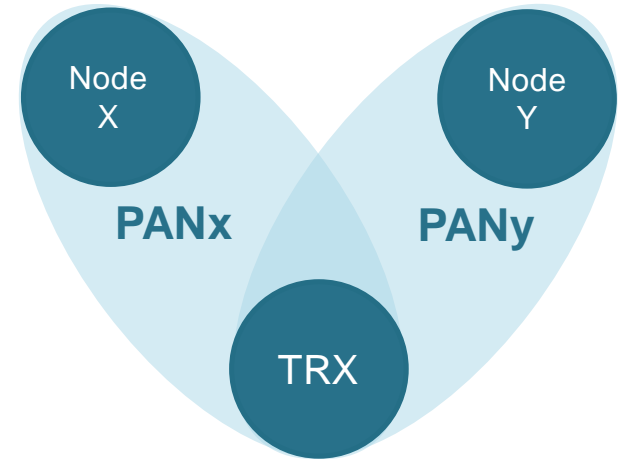- Crypto engine: DES, 3DES, AES 128-256, SHA-1, SHA-256, MD5, RNG

System
- UART, SPI, I2C, optional USB 2.0 FS/LS H/D/OTG
- 16-bit ADC
- Operating range: 1.8 V to 3.6 V, -40C to +105C
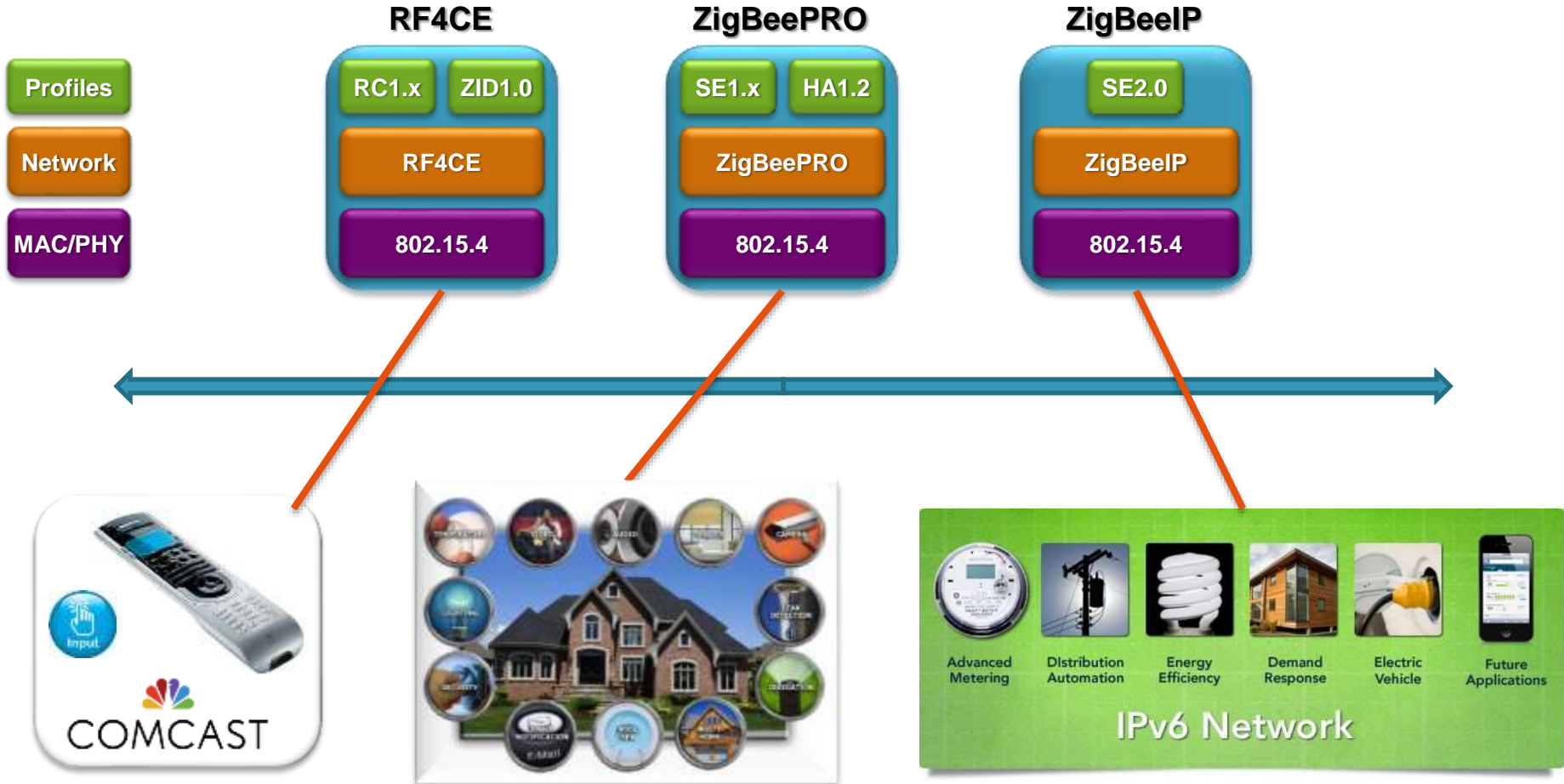
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Cortex

Dual Pan Mode

- In this mode, TRX is able to participate to 2 different PAN (Personal Area Networks)

- 2 sets of parameters are maintained for each PAN :
    - ChannelX
    - MacPanIDX
    - MacShortAddresX
    - MacLongAddrsX
    - PANCORDNTRX

- The transition from one PAN to the other can be manual (under software control) or automatic

- Automatic transition is done using a programmable timer with a PAN Dwell Time from 0.5ms to 3.2s

- If both PAN are defined on the same channel, TRX is able to process both PAN simultaneously (no PAN Dwell Time to define)

Node X

Node Y

PANx

PANy

TRX

ZigBee Stacks

	RF4CE	**ZigBeePRO**	**ZigBeeIP**
Profiles	RC1.x · ZID1.0	SE1.x · HA1.2	SE2.0
Network	RF4CE	ZigBeePRO	ZigBeeIP
MAC/PHY	802.15.4	802.15.4	802.15.4

COMCAST

IPv6 Network

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RF4CE & Home Automation Dual PAN

Closures

Lighting

Fire & Safety

Cloud

Security

Gateway

Switches

Door Locks

Heating/Cooling

KW2x Unique Features

- **Dual PAN Support**
  - Ability to participate in two networks simultaneously
  - Maintains two sets of network parameters
  - Hardware block : No extra software bandwidth required

- **Antenna Diversity**
  - Maximize the communication link quality
  - No loss from orthogonal antennas
  - Ideal if no freedom in device orientation
  - Hardware block : No extra software bandwidth required

- **Security Block**
  - Active and passive tamper detection with RTC timestamp
  - Cryptographic Encryption engine: DES, 3DES, AES 128-256, SHA-1, SHA-256, MD5, RNG

KW2x Development Kit

Kit Features

- Can use PCB "F" antenna or bypass for external antenna via RF connector
- Open-SDA debugging
- USB port to interface with PC
- Configurable I/O access
- LEDs and switches for demonstration, monitoring and control
- Full software stacks and applications
- BeeStack (ZigBee Pro, RF4CE, part of BeeKit)
- Flexible IPv6 Stack (6LoWPAN toolbox)
- Quick Start Guide

USB-dongle Form Factor

- Use is as sniffer hardware
- Host processors

Part Numbers:

TWR-KW21D256 $149
TWR-KW24D512 $149

USB-KW24D512

- *An external antenna needs to purchased separately*

# BeeKit : New Approach to Wireless Applications Development

- Graphical user interface (GUI) to create, and validate network configuration
  - Complementary tool to traditional IDEs
- Codebases deliver libraries, templates and applications
  - Supports Simple MAC (SMAC), IEEE® 802.15.4 MAC, SynkroRF, ZigBee RF4CE, ZigBee and ZigBee Pro
- Exports directly to IDE for development and debug
  - Applications are decoupled from the stack implementation
  - Allows for easy code updates and promotes code reuse
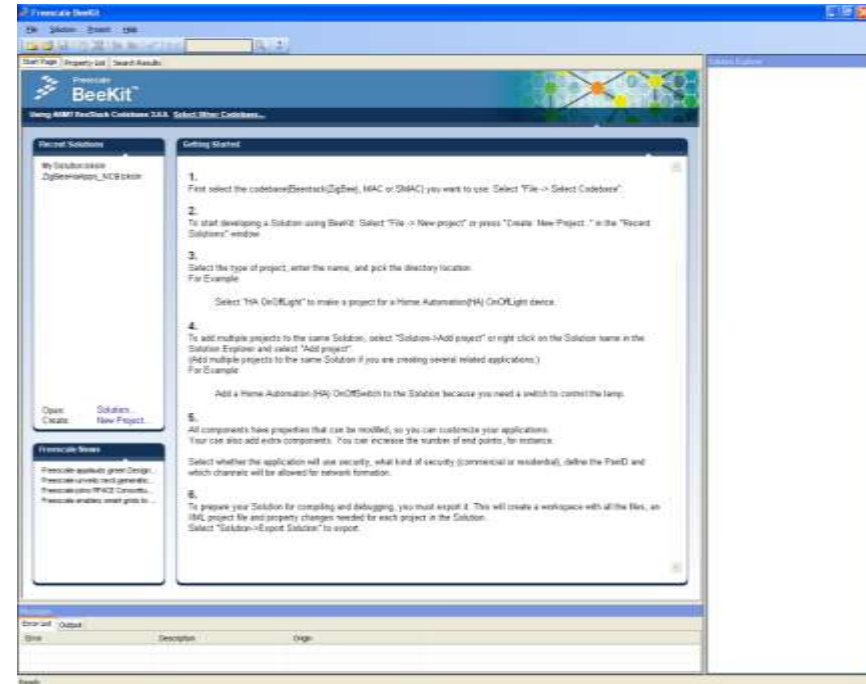
802.15.4 Protocol Stack Comparison

Feature	SMAC	802.15.4 MAC	SynkroRF®	ZigBee® RF4CE	ZigBee® Pro	ZigBee® IP
Applications						
Cable Replacement	✓	✓	✓		✓	
Remote Control	✓	✓	✓	✓	✓	
Home Control			✓	✓	✓	
Home Automation					✓	
Health Care					✓	
Building Automation					✓	
Smart Energy					✓	✓
Network Stack	No	No	Yes	Yes	Yes	Yes
Network Profiles	No	No	No	Yes	Yes	Yes
Memory Requirements	4-8K	32K	<40K	<40K	128-160K	256K
Network Topology	Point-to-Point	Peer-to-Peer	Co-existing Star	Co-existing Star	Tree	Mesh
	Star	Tree			Mesh	
Typical # of Nodes	2-100	2-1000*	32 per Controlled Device	32 per Target Device	2-1000* ZigBee Pro	2-32
Typical IC Cost	$	$	$	$	$$	$$$
Typical Data Throughput	50-115K	90-115K	70-100K	70-100K	30-70K	<50K*

# Wireless Connectivity Solutions
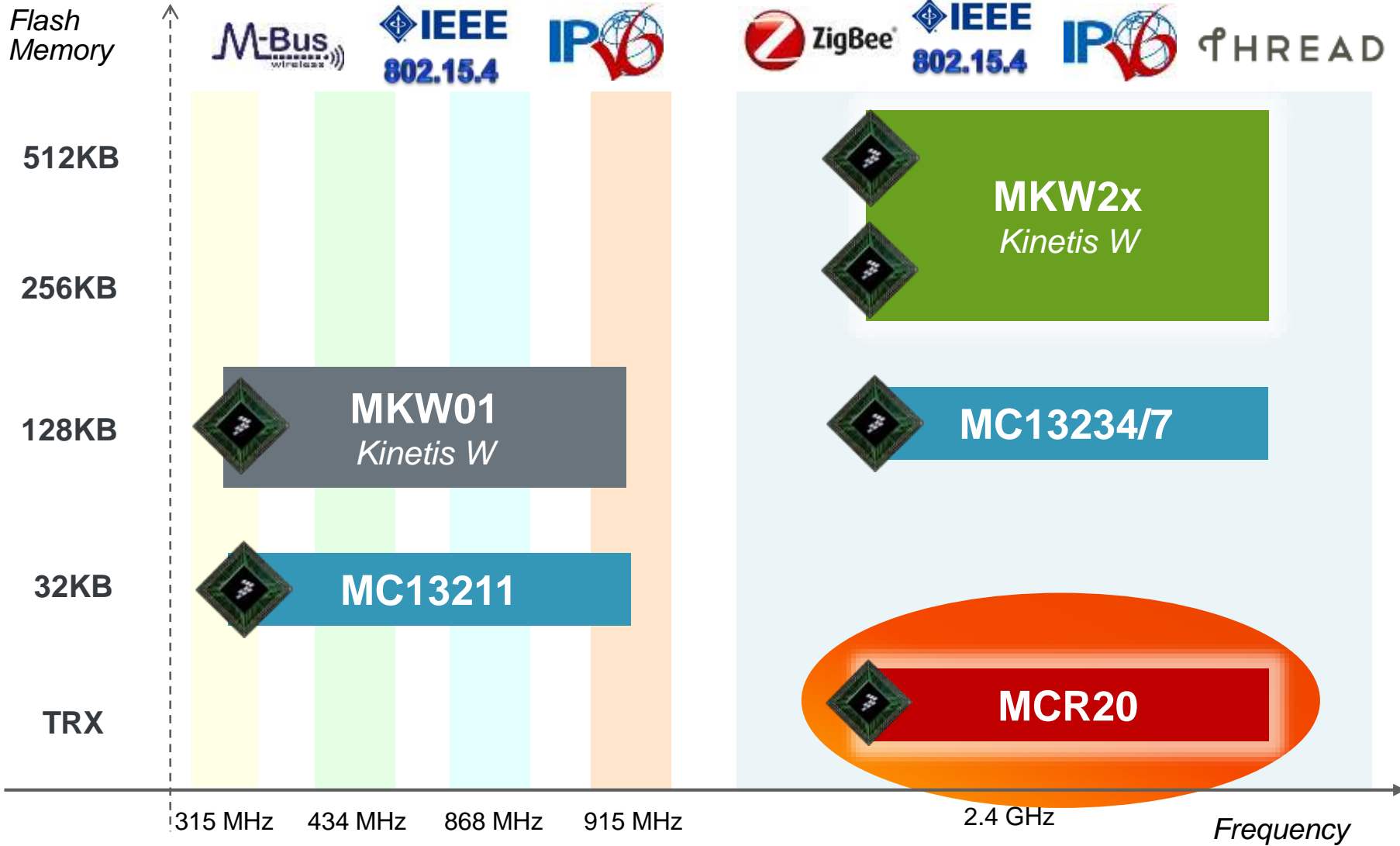
MCR20 High Performance 802.15.4/ZigBee Transceiver

RF Features

- High performance 2.4 GHz IEEE 802.15.4 RF transceiver
- Support for MBAN frequencies (2.36-2.4 GHz)
- Packet processor for hardware acceleration
- Supports single ended and diversity antenna options
- Dual-PAN support
- -30 to + 8 dBm power output
- Support for external PA/LNA (FEM)
- -102 dBm sensitivity
- Tx 18mA @ 0dBm
- Rx 15mA LPPS mode, 19.5mA full Rx
- AES Hardware encryption/decryption
- True Random Number Generator
- SPI Interface (memory mapped)
- 6 GPIO

System Features

- -40°C to 105°C
- 1.8 to 3.6 V
- 5x5 32-pin LGA
- Samples Now, Q2'2015
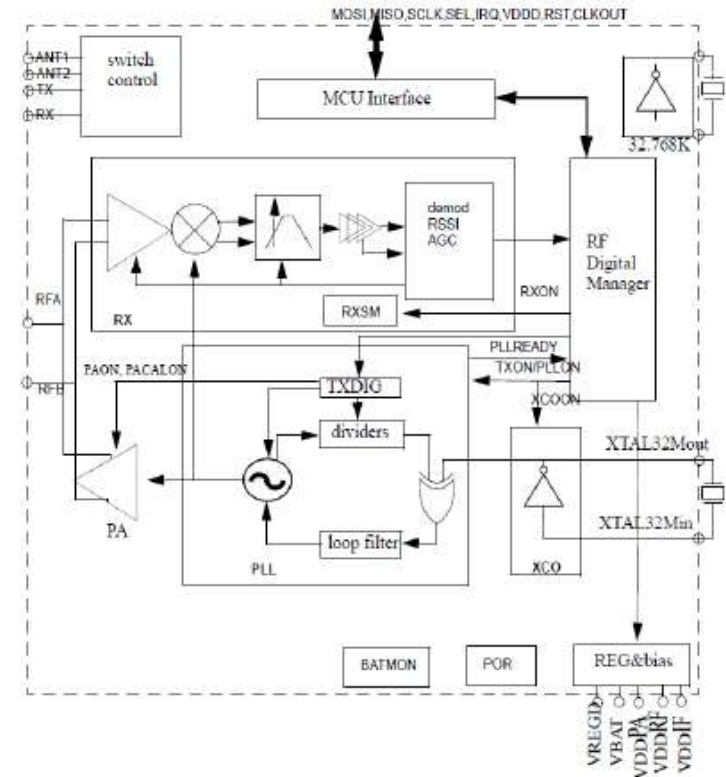
Get to Know the FRDM-CR20A

The FRDM-CR20A is the development platform for MCR20AVHM transceiver and is used for evaluation and application development. It can be used as a daughter card with other Freedom development platforms such as the FRDM-K64F and FRDM-KL46Z, adding additional functionality and wireless connectivity to those boards.

Features:

- MCR20AVHM 802.15.4 Transceiver – 2.36-2.48GHz frequencies
- SPI interface
- Two (2) user push-button switches for interrupts (SW2/SW3) driven by external MCU
- One (1) RGB LED indicator driven by external MCU
- PCB inverted F-type antenna and SMA RF port available
- Minimum number of matching components and external balun
- Form factor compatible with Arduino™ R3 pin layout
- Standard FRDM daughter card mounting interface (shield)
- Can be directly connected to the FRDM-K64F & FRDM-KL46Z

Refer to the *FRDM-CR20A User's Guide* for more information.

Contents

- Quick Start Package Overview

- Get to Know the FRDM-CR20A
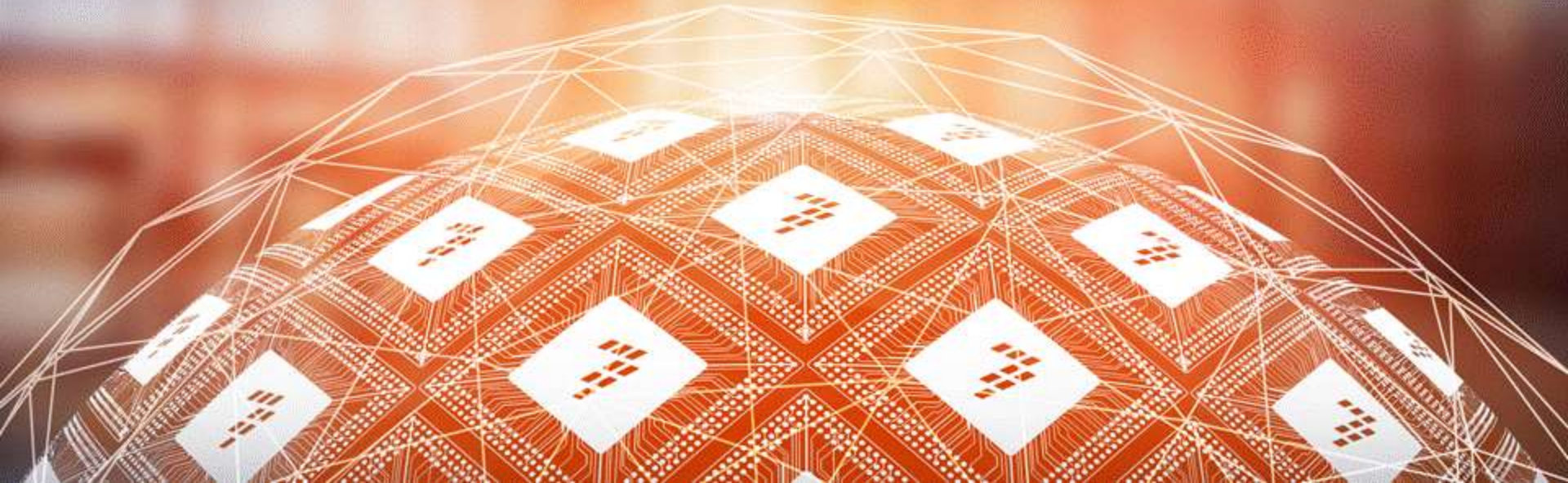
- Explore Further

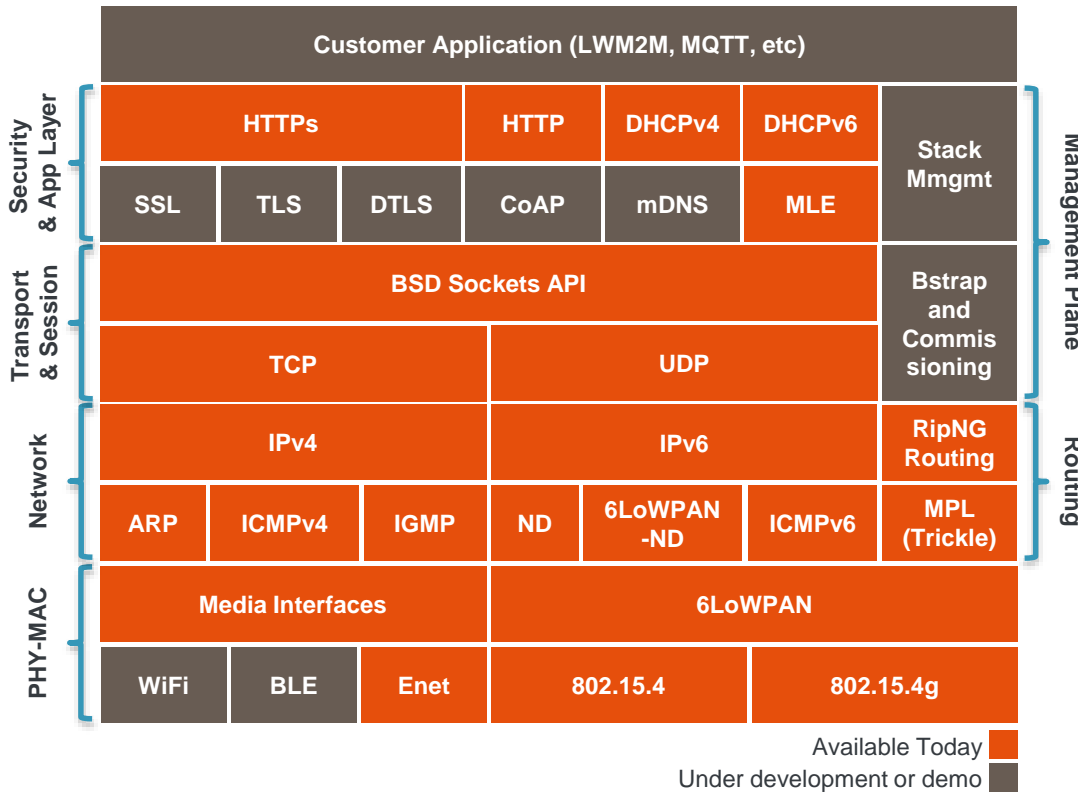FRDM-CR20A + FRDM-K46Z

FRDM-CR20A + FRDM-K64F

Flexible IP Stack
Wireless IPv6 Stack
For MKW01 and MKW2x

Flexible IP Stack Overview

Customer Application (LWM2M, MQTT, etc)					

Security & App Layer

HTTPs		HTTP	DHCPv4	DHCPv6	Stack Mmgmt
SSL	TLS	DTLS	CoAP	mDNS	MLE

Transport & Session

BSD Sockets API			Bstrap and Commissioning
TCP		UDP	

Network

IPv4		IPv6		RipNG Routing
ARP	ICMPv4	IGMP	ND	6LoWPAN-ND	ICMPv6	MPL (Trickle)

PHY-MAC

Media Interfaces		6LoWPAN	
WiFi	BLE	Enet	802.15.4	802.15.4g

Management Plane · *Routing*

Available Today ▮
Under development or demo ▮

Enables the development of real mesh networks for the connected applications of the future

Lightweight configurable and scalable IPv6 solution which is compliant with IPv6 Logo testing

Easy installation and user friendly out of the box experience

Used as starting point for the Freescale Thread

- **Product Features:**
  - **Flexible, configurable and scalable** Dual Stack IPv4 & IPv6 for constrained resources devices
  - **Designed for Low Power**, Quick Wake-up Time and Low Memory footprint
  - **Multiple interfaces support: 802.15.4 & 802.15.4g with 6LoWPAN**, Ethernet, WiFi and BLE
  - **Multiple OS support via Kinetis SDK OSA** and currently running on MQX Lite
  - **6LoWPAN and IPv6 stack successfully proven** interoperability with other vendors in various alliances like ZigBeeIP, PLC G3 and other.

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Supported Features

- **PHY-MAC**
  - IEEE 802.15.4 and 802.15.4g with AES128 MAC security
  - Ethernet and Virtual Ethernet

- **6LoWPAN**
  - RFC4944 – Frame formats, Fragmentation, Mesh and Broadcast Headers (optional)
  - RFC6282 – Stateless and Statefull Header Compression

- **Network**
  - IPv6 (RFC2460, RFC3484, RFC4291, RFC4862, RFC1981)
  - ICMPv6 (RFC4443), ND (RFC4861) and 6LoWPAN-ND (RFC6775)
  - IPv4 (RFC791, RFC919, RFC922 and RFC950)
  - ARP (RFC826), IGMP (RFC3376) and ICMPv4 (RFC792)

- **Routing**
  - RipNG (RFC2080) → Route Over Ip protocol
  - MPL (RFC6206 and draft IETF Trickle-Multicast)

- **Transport**
  - UDP (RFC768) and TCP (RFC793)
  - BSD Sockets API

- **Application & Management**
  - MLE (IETF draft Kelsey)
  - HTTP (RFC2068)
  - DHCPv4 (RFC2131, RFC2132)
  - DHCPv6 (RFC3315, RFC3633, RFC3646, RFC3736)

Flash and RAM memory Requirements:

Component	Flash [bytes]	RAM [bytes]
Virtual ENET	1741	692
6LoWPAN	10820	936
IPv4	3564	42
IPv6	18643	1498
UDP	1388	46
TCP	5413	74
BSD Sockets	3145	1260
DHCPv4	3042	320
DHCPv6	6729	32
RipNG (Routing)	2425	36
MLE (Mesh Link Establishment)	1906	0
MPL (Trickle – Multicast)	2260	213
Stack Manager	2504	156
Total Flexible IP	63580	5305

Other routing options experience:

- LoadNG
  - IETF
  - implemented for PLC G3
  - it is a reactive Mesh Under protocol that computes the route each time a packet is being sent
- RPL
  - RFC6552, RFC6553 and RFC6554
  - implemented for ZigBeeIP
  - it is a proactive Route Over protocol defined for Low Power and Lossy networks which has a series of drawbacks like single points of failure if the DO-DAG dies

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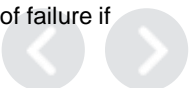
THREAD
for MKW2x

ʔHREAD The need for a new wireless network

- We are entering a new era of connected products
  - There needs to be a low power mesh network in addition to Wi-Fi in your home
- We wanted to use an existing wireless mesh protocol
  - But none fit our requirements well enough
  - Some came close but were not suitable for homes and CE products
- After talking with other companies it was clear that they shared the same concerns
  - So we started working on a new wireless mesh protocol. One that was built on existing standards but legacy-free
  - Working as a group of companies to help make Thread better

Requirements:
New wireless home network

✓ Low power ....

✓ Resilient (mesh) ....

✓ IP-based ....

✓ Open protocol ....

✓ Secure and user friendly

✓ Fast time to market ...

✓ Existing radio silicon ...

ϕHREAD What it delivers

- A secure wireless mesh network for your home and its connected products
  - Built on well-proven, existing technologies
  - Uses 6LoWPAN and carries IPv6 natively
  - Runs on existing 802.15.4 silicon - Product development can start today

  - Designed with a new security architecture to make it simple and secure to add and remove products
  - Supports 250+ products per network
  - Designed for very low power operation

Thread can support many popular application layer protocols

Application	Security/Commissioning
UDP	
ϕHREAD — IP Routing	
6LoWPAN	

| IEEE 802.15.4 MAC |
| IEEE 802.15.4 PHY |
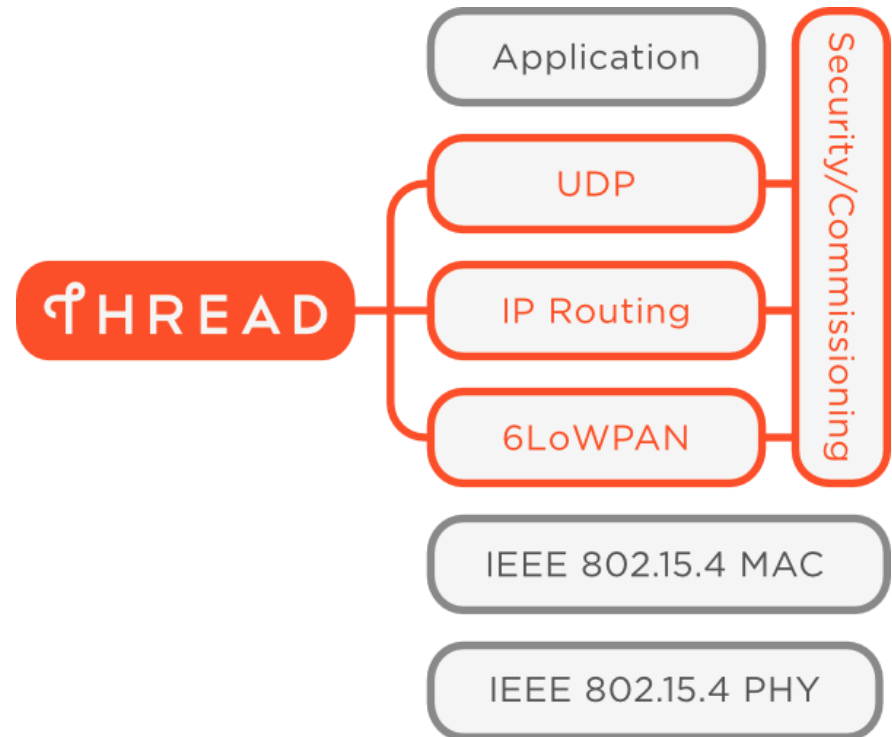
A software upgrade can add Thread to currently shipping 802.15.4 products

THREAD Freescale Involvement

- Freescale is a founding member of the Thread Group

  - We have an officer position on the Board of Directors

- Thread based Freescale solutions

  - Freescale is heavily involved in Organizational, Specification and Certification activities

  - Thread is implemented on Kinetis W (MKW2x)

  - Target is to have an implementation ready when the certification program is released 1H15

  - Alpha customer program in 4Q14

  - Please have customer register interest at www.freescale.com/thread

ZigBee Alliance and Thread Group Collaborate to Aid Development of Connected Home Products

Agreement Opens Doors for ZigBee Cluster Library Application Protocol to Run on Thread Networks

San Ramon, Calif. – April 2, 2015 – The ZigBee Alliance (www.ZigBee.org) and the Thread Group (www.threadgroup.org) today announced they are collaborating to enable the ZigBee Cluster Library to run over Thread networks. By working together, ZigBee and Thread can jointly provide an interoperable solution to help streamline product development and ultimately improve the consumer's experience in the connected home.

The ZigBee Cluster Library standardizes application level functionality for a wide variety of devices used in smart homes and other markets. Thread is a wireless networking protocol that can support multiple low-bandwidth, IP-based application protocols to provide secure and reliable networks, simple connectivity and low power in the home. Both organizations remain committed to their independence while cooperating to benefit their respective members.

"Application level standardization is necessary to provide truly interoperable products to consumers," said Tobin Richardson, president and CEO of the ZigBee Alliance. "We believe this agreement will deliver value to product

developers searching for another solution for connectivity in the smart home."

The ZigBee Alliance is a global association of companies working together to enable reliable, cost-effective, low-power and wirelessly networked monitoring and control products. ZigBee is a wireless standard used to connect a wide variety of everyday devices to improve comfort, security and convenience in homes and businesses.

"By agreeing to work together, ZigBee and Thread are taking a big step towards reducing fragmentation in the industry," said Chris Boross, president of the Thread Group and technical product marketing manager, Nest. "Thread is designed to work with and support many different application layer protocols, and we look forward to working with ZigBee to create a combined solution for the connected home."

Thread enables product developers to create, and consumers to enjoy, products that easily and securely connect to a low-power wireless mesh network, with direct Internet and cloud access for every device. Using proven standards including IPv6 technology with 6LoWPAN and standard 802.15.4 radios as its foundation, Thread gives product developers a reliable low-power, self-healing, and secure network over existing wireless standards.

Reference Document

KW2x series document :
- [MKW2x Data Sheet](#)
- [MKW2x Reference Manual](#)

EVB HW Reference and BSP:
- [USB-KW24D512](#): USB Packet Sniffer/Dongle
  - USB-KW2x Hardware Reference Manual,
    http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=TWR-KW2x&fpsp=1&tab=Design_Tools_Tab
  - [USB-KW24D512 (Sniffer/Dongle Board Support Package)](#)

- **TWR-KW2x**: **Kinetis KW2x Tower System Modules**
  - TWR-KW2x Hardware Reference Manual,
    http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=TWR-KW2x&fpsp=1&tab=Design_Tools_Tab
  - [TWR-KW2x Board Support Package](#)

Integrated development environment (IDE)
- [BeeKit Wireless Connectivity Toolkit](#)
  - [BeeKit Wireless Connectivity ToolKit Rev 3.0.2](#)

BeeKit™ Overview

A New Approach to Wireless Applications Development:

- Graphical user interface (GUI) to create, and validate network configuration

- Codebases deliver libraries, templates and applications

- Exports directly to IDE for development and debug

- Import project for modifying network or platform configuration
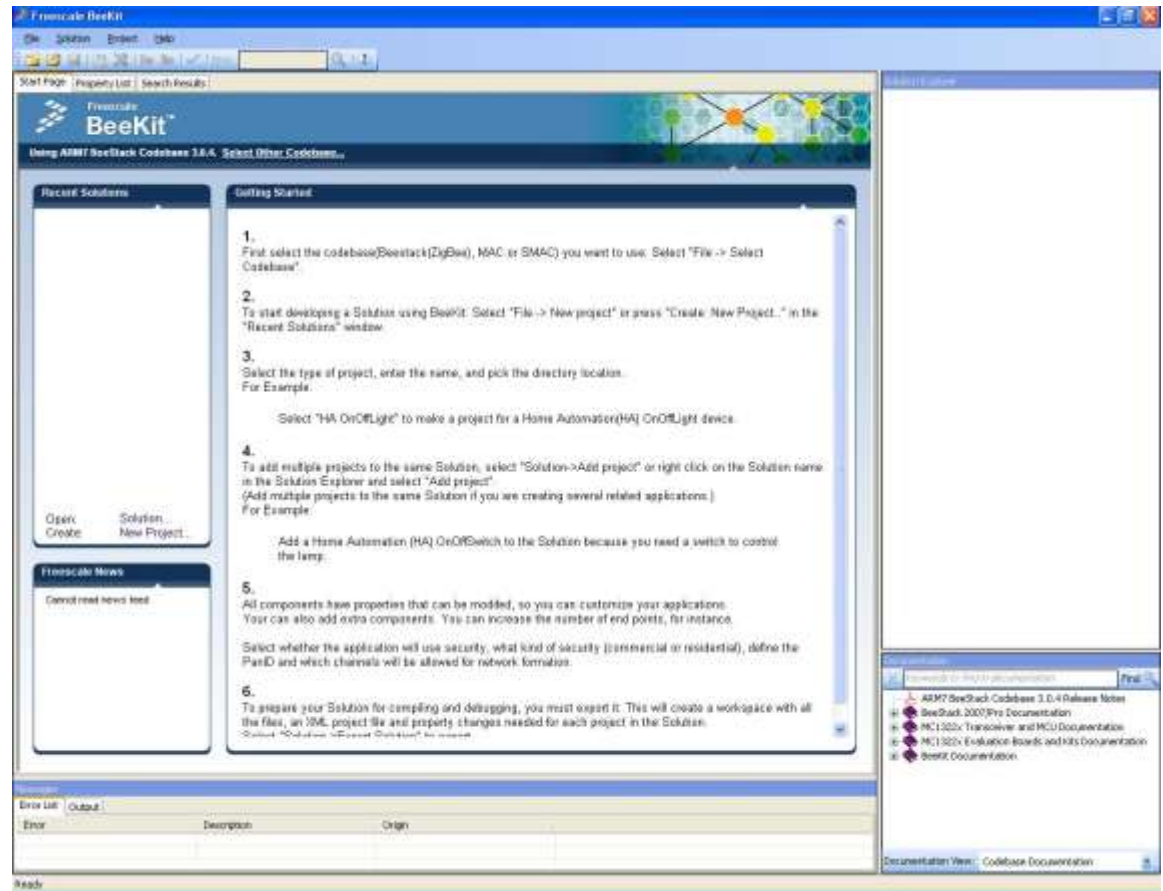
BeeKit™ Overview (continued)

Provides a development environment where wireless link and protocol configurations can be managed in a straightforward, uncomplicated approach.

Complementary tool to traditional IDEs. Not just a tool for generation of static starter code, but rather an extension to embedded application environments.

Supports Simple MAC (SMAC), IEEE® 802.15.4 MAC, SynkroRF, RF4CE and ZigBee (BeeStack) application development on HCS08 and MKW20 Processors

Freescale ZigBee Stack (BeeStack) interface reuses Freescale's 802.15.4 MAC messaging interface for a common user experience. Experience gained with one helps understand the other.

Applications are decoupled from the stack implementation. Allows for easy code updates and promotes code reuse.

BeeKit™ Definitions

A **codebase** contains all the information that is required for BeeKit to interact with the user and create a project for a specific communication stack. Freescale provides a codebase in the form of:

- A database containing the embedded software component source files (platform components, applications, etc.) and pre-compiled libraries (SMAC, MAC, or BeeStack)
- Configuration files that hold information about the organization of the embedded software components, their configurable parameters and features, and the BeeKit GUI information

Freescale provides each codebase. The user does not modify it, but uses BeeKit to generate stack-based directory structures external to the codebase.

A **solution** contains one or more BeeKit projects drawn from a single codebase.

A **project** in BeeKit is a complete collection of attributes that define a stack and application configuration for a particular target platform.

A **project** exported from BeeKit consists of assembled codebase components (source files, libraries) and an XML file (CW) or EWP file (EWARM) that describes the project.

BeeKit™ Development Flow
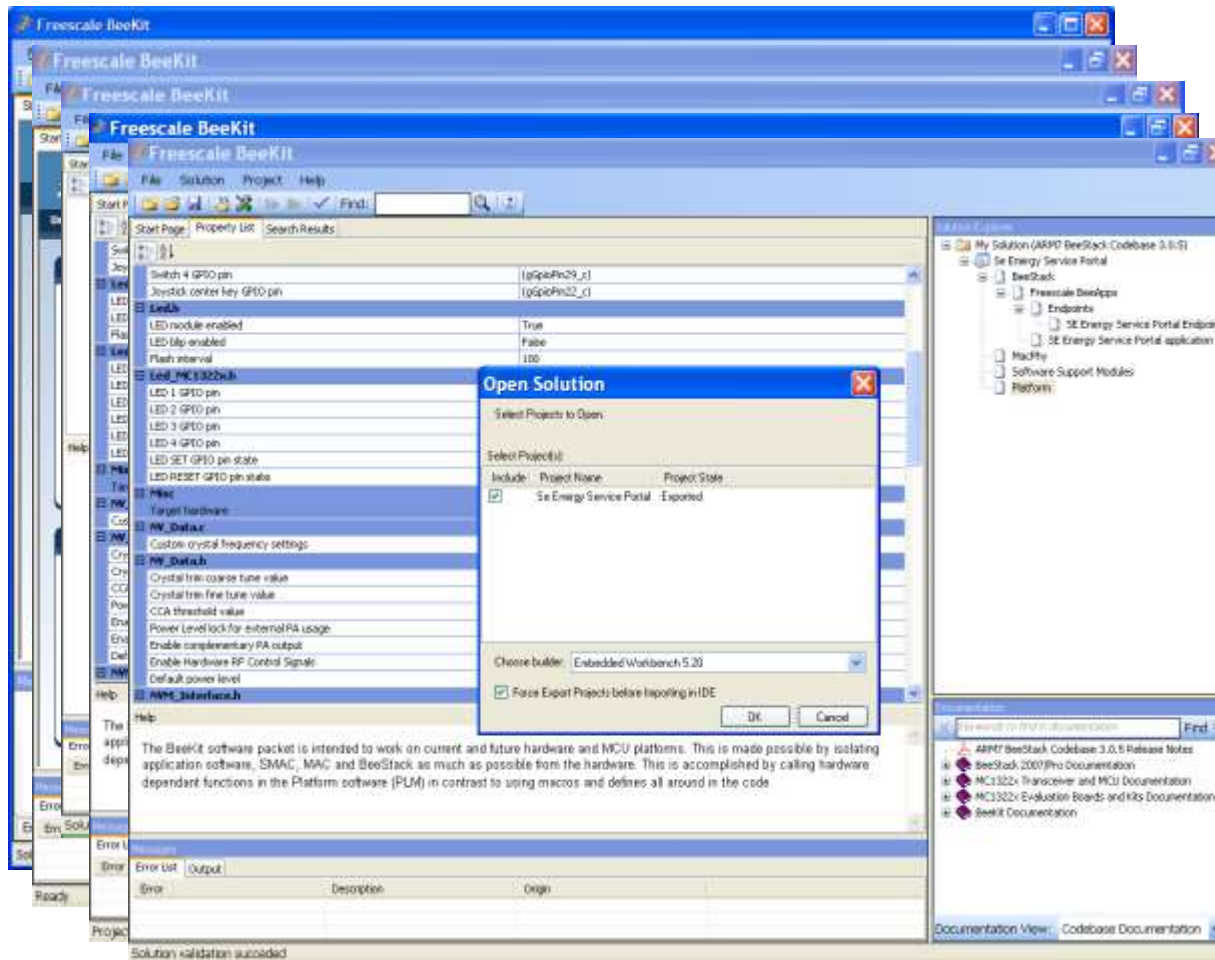
- Start BeeKit
- Select Codebase
- Create project
- Customize & validate Project
- Export Project and Import into IDE

https://community.freescale.com/community/wireless-connectivity

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