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Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

Wireless ZigBee® and Sub-GHz Solution SoC/SiP Supporting Internet of Things (IoT)

AMF-IND-T0274

Derrick Klotz

October 2013

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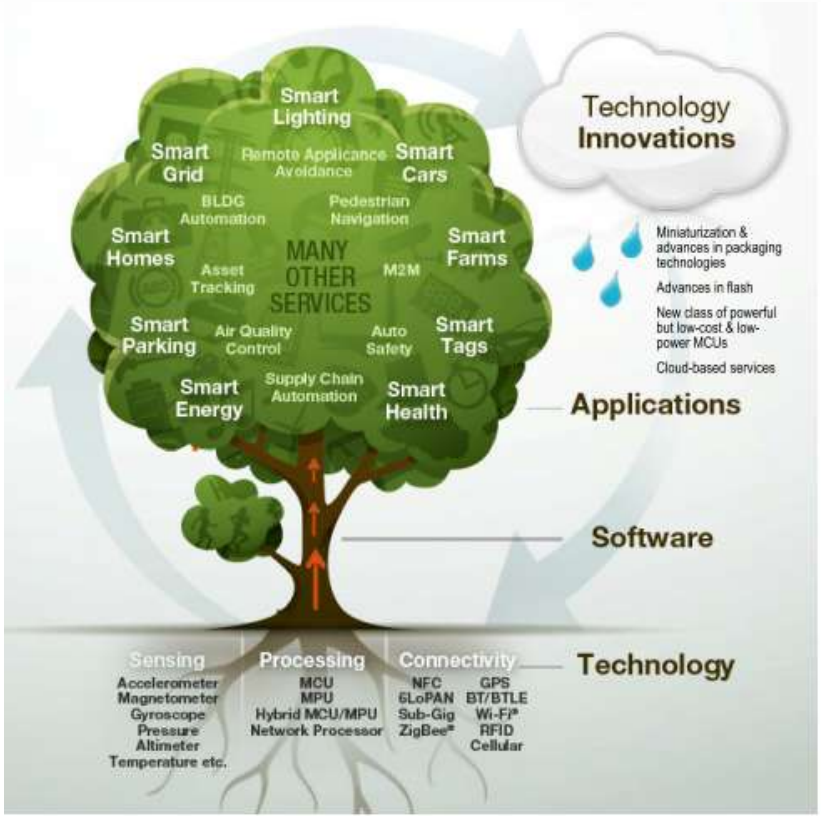
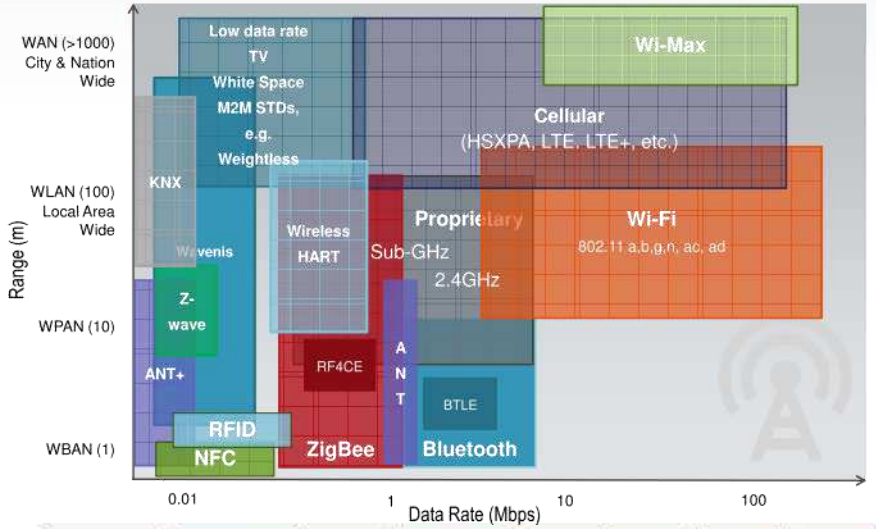
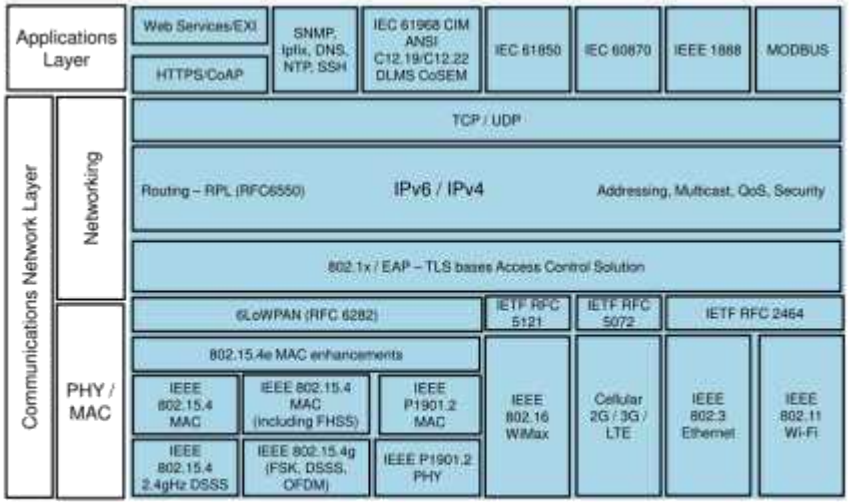
Wireless connectivity for the IoT







Professor David E. Culler
University of California, Berkeley
CWSN Keynote, Sept. 26, 2011

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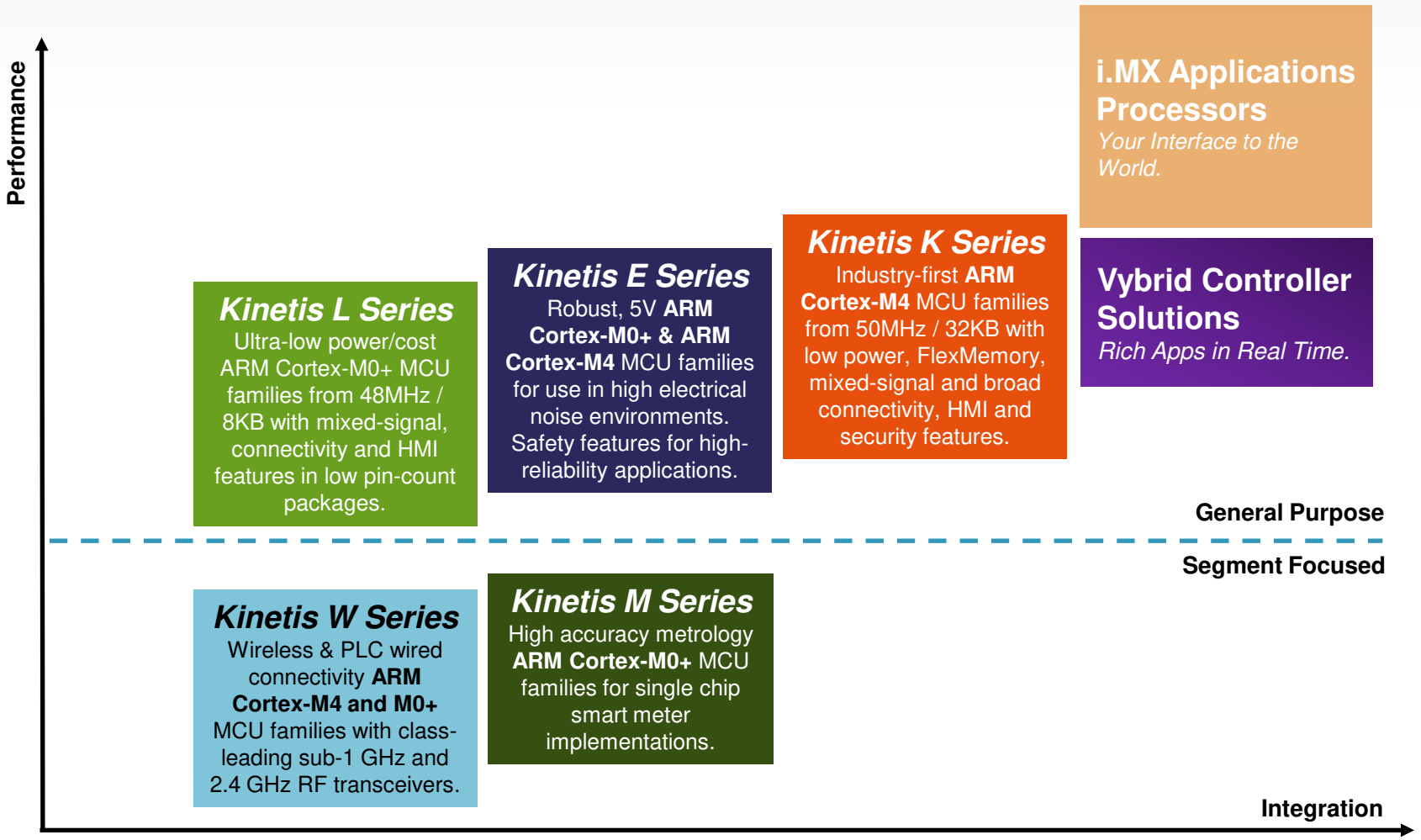
MCU/MPU Portfolio - Current & Future



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Freescale Solutions Enabling the Smart Grid

Power Generation, Transmission, Monitoring & Control, Renewable Sources	Distribution & Sub-station Automation, Protection, Control and Monitoring	Data Concentrator	Neighborhood Area Network (NAN)	Smart Electricity Meters	Home Area Network (HAN)	Home Energy Management (HEM)
MPC8xxx, QorIQ, Kinetis	MSC9130 , MPC8xxx, QorIQ, Kinetis	P102x, MPC8308, i.MX28	RF: Sub Gig 802.15.4g Kinetis KW01 PLC: G3/ PRIME OFDM - Kinetis	1-ph, 2-ph, 3-ph, Sub-Metering Kinetis, Vybrid	ZigBee Kinetis KW2x	i.MX283 Vybrid

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KW2x – 2.4 GHz Smart Energy & Home Automation Solution from Freescale

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What is Kinetis KW2x?

- The new Kinetis KW2x is Freescale next generation 2.4 GHz 802.15.4 platform

- The Kinetis KW2x platform integrates a class leading RF transceiver, ARM Cortex-M4 core and a robust feature set for a reliable, secure and low-power IEEE® 802.15.4 wireless solution.

- Wireless protocol software is seamlessly integrated into Kinetis software development tools for rapid creation of embedded systems.

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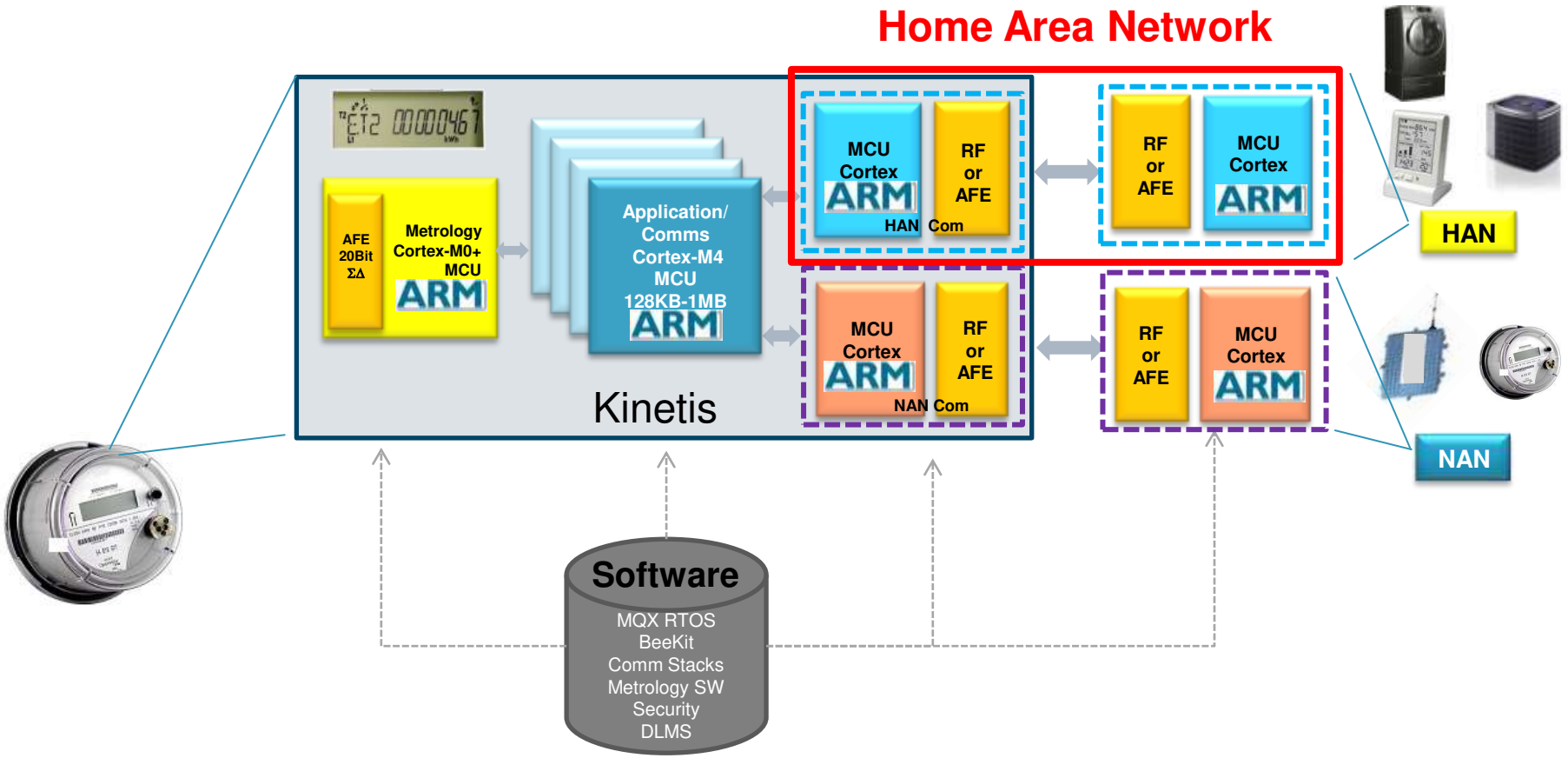
Freescale Smart Metering Solutions – Home Are Network



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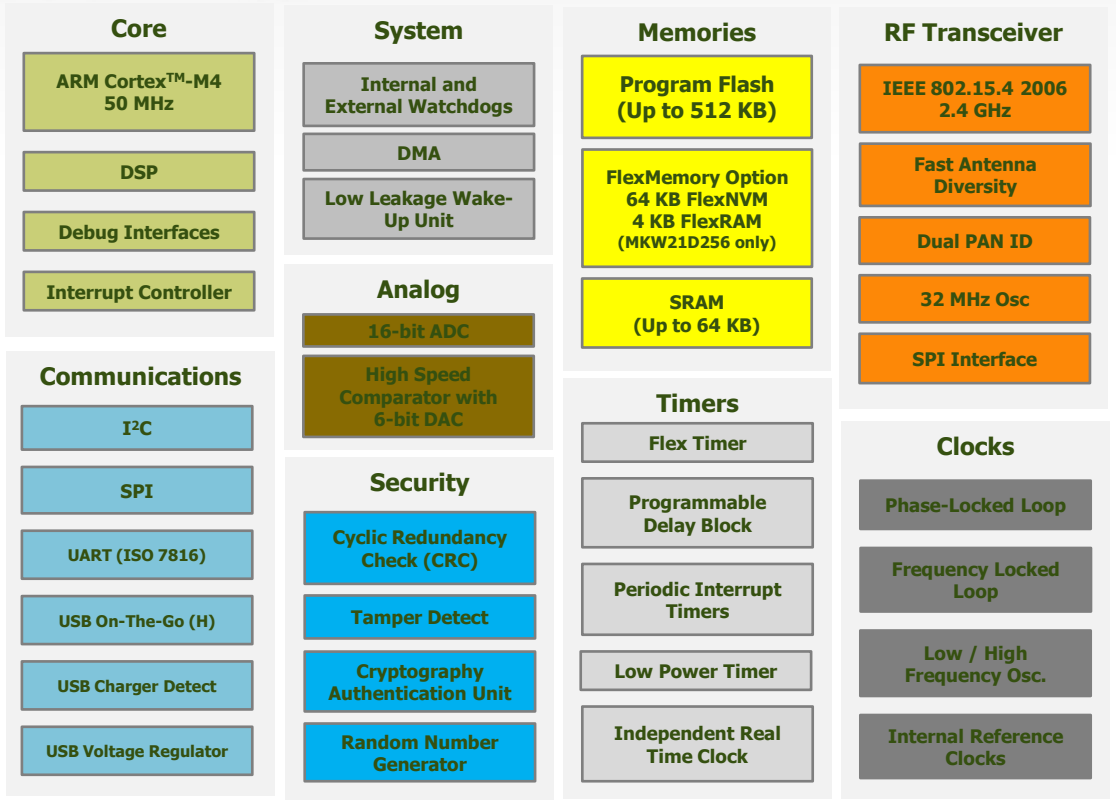
Kinetis MKW2x Wireless MCU

- **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 +10dBm Tx output power
  - Peak typical current: 17mA Tx and 19mA Rx
  - Dual Personal Area Network (PAN) support in hardware
  - Run two RF networks simultaneously
  - Antenna diversity with automatic antenna selection
- **Security**
  - Active and passive tamper detection with RTC timestamp
  - Crypto engine: DES, 3DES, AES 128-256, SHA-1, SHA-256, MD5, RNG
- **Software**
  - 812.15.4 2006 MAC
  - RF4CE, ZigBee Pro, ZigBee IP
  - ZigBee Profiles: ZSE, ZHA, ZHC, ZRC
  - Freescale IPv6 Mote Stack
  - MQX Lite RTOS
- **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



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

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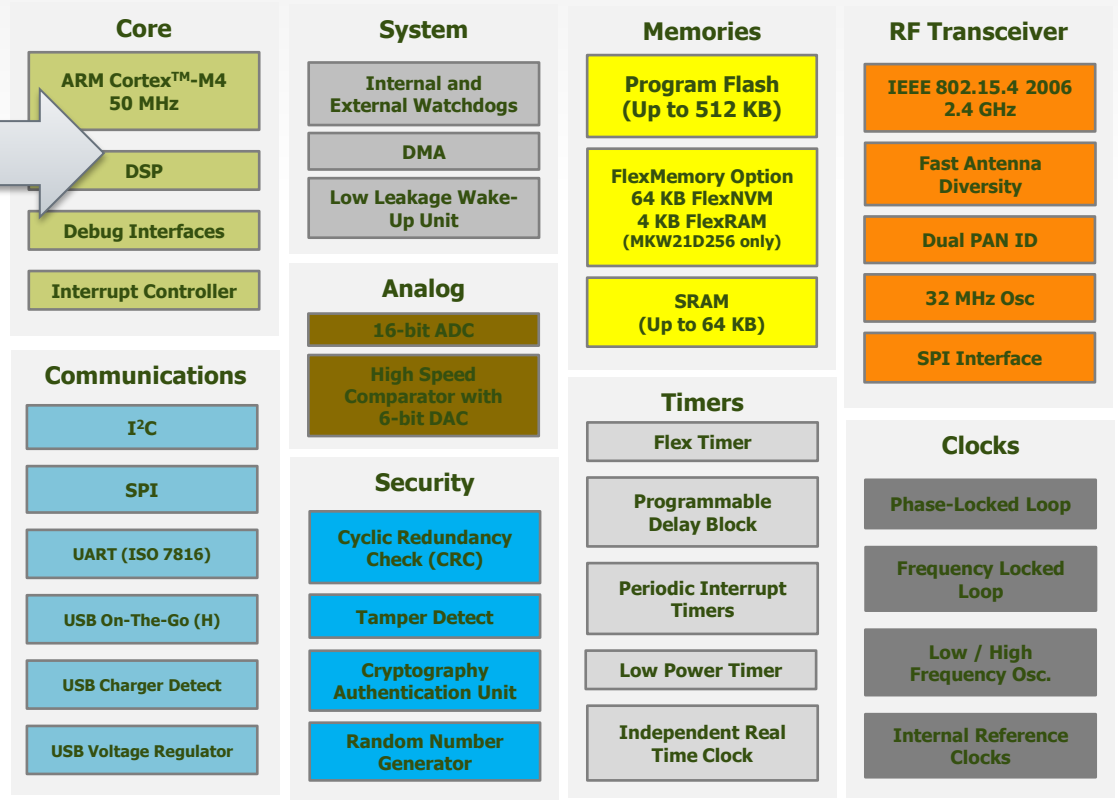
Cortex-M4 MCU

- ARM Cortex M4 with DSP
- Supports up to 50Mhz (1.25 DMIPS/MHz)
- 16-channel DMA
  - Supports up to 128-bit data values
  - Programmable
- Configurable nested vector interupt controller (NVIC)
- Wake-up Interrupt Controller (WIC)
- Advanced debug and trace
- Hardware CRC
- Independent-clocked COP
- External watchdog
- 10 low power modes
  - Low-leakage wake-up, low power timer and low power RTC
  - Fast wakeup times
- FlexTimers
  - Programmable Interrupt Timer (PIT)
  - PWM support
- Carrier Modulator Timer



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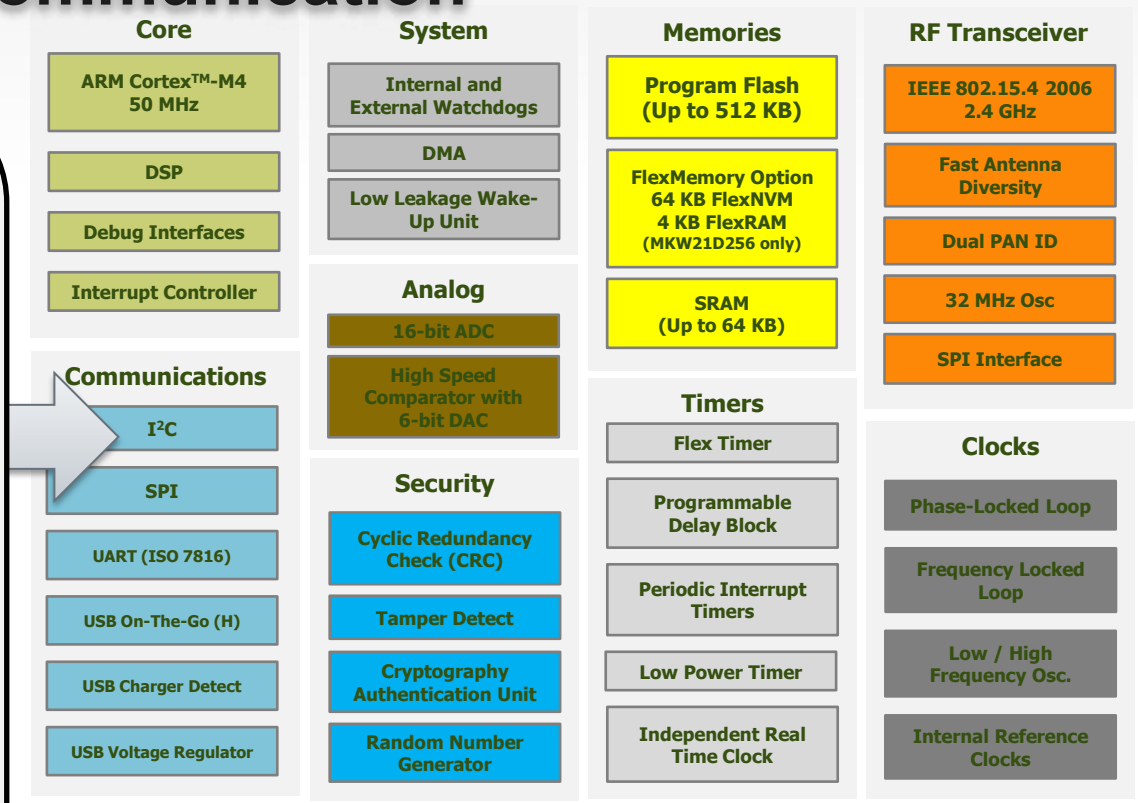
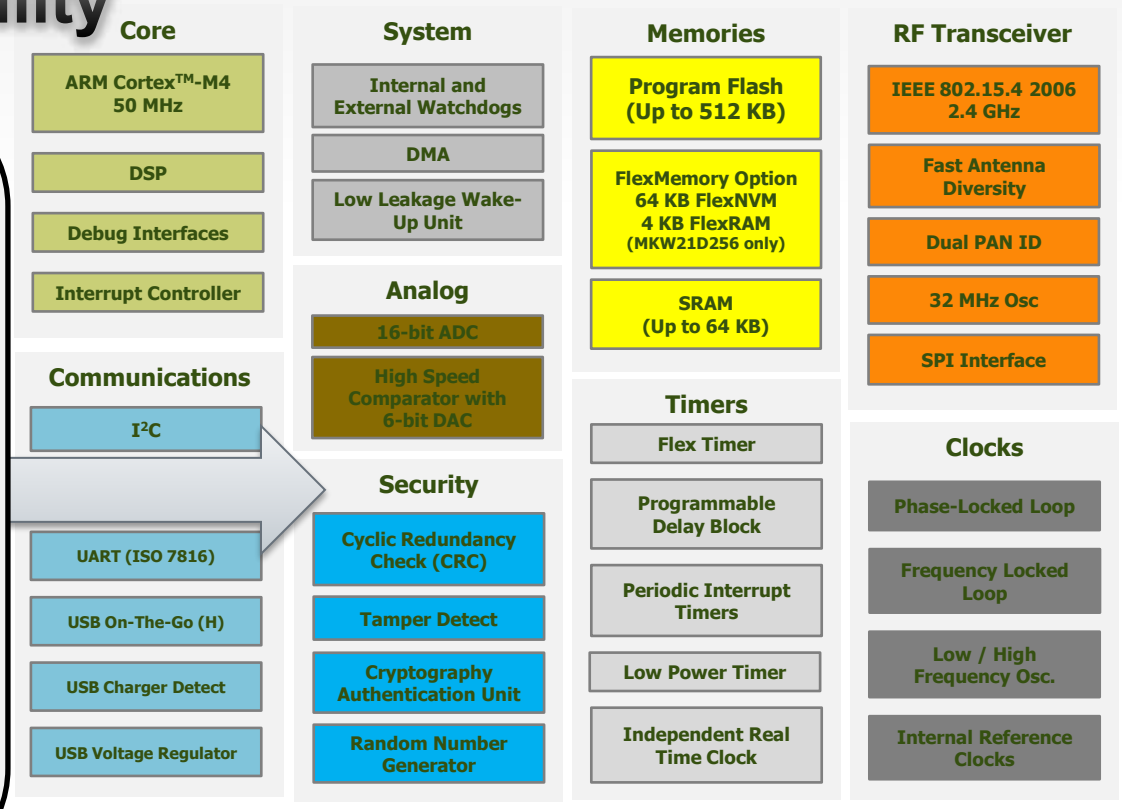
Connectivity and Communication

- SPI
  - Full-duplex
  - Master and slave mode
  - Buffered transmit and receive with FIFOs
  - DMA support for FIFOs
- Inter-Integrated Circuit (I2C)
- I2C SMBus version 2 compatible
- Up to 100 Kbps
- Multi-master operation
- DMA support
- UART
  - Full-duplex operation
  - Programmable TX/RX polarity
  - Idle line or address mark wakeup
  - Hardware parity
  - DMA request
- USB Interface - OTG
  - USB 2.0 compliant
  - On-chip FS and LS transceiver
  - USB host mode
  - USB device mode
  - Suspend mode /low power
  - Supports HS with off-chip transceiver



Security and Reliability

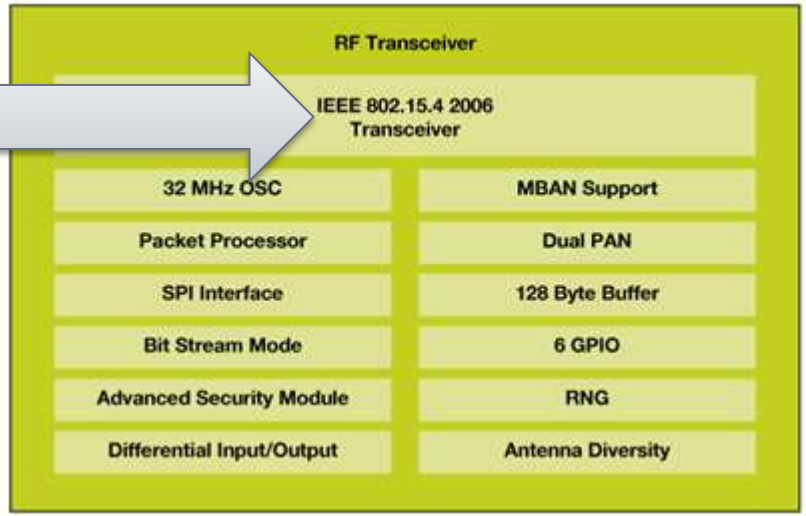
- Tamper detect
  - External tamper detect
  - 256-bit secure storage (erased on tamper)
- CRC
- Hardware encryption
- Cryptography Acceleration Unit (CAU)
- Random Number Generator (RNG)
  - FIPS compliant



Transceiver Features

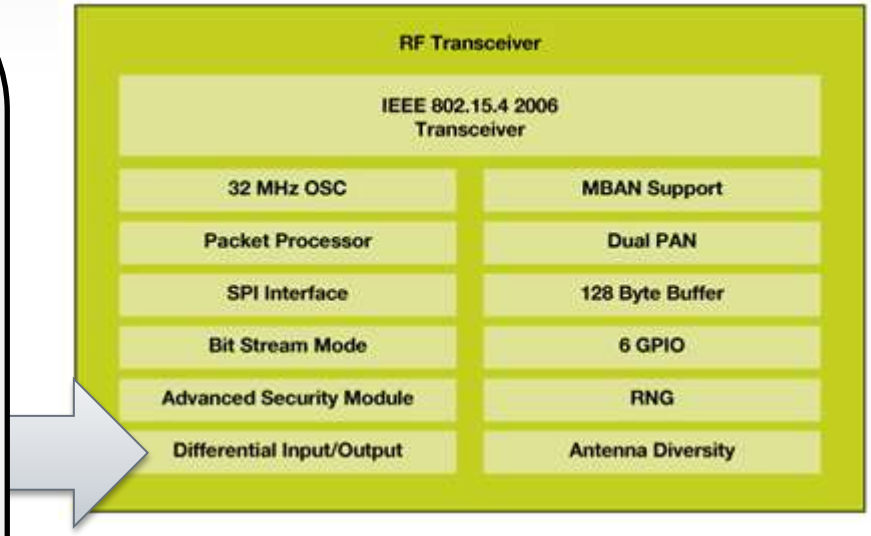
Transceiver Features

- 2.4 GHz frequency band
  - Supports 2.36 to 2.4 GHz Medical Band
- 802.15.4 compliant
  - 250 kbps data rate
  - O-QPSK modulation
  - DSSS with 5 MHz channels
  - 16 selectable channels
- Supports packet and bit stream mode
- 802.15.4 Packet Processor
- Output power varience +/- 2 dBm
- Programmable output power from -30 to +10 dBm
  - 2dB steps
- Low power receive mode
- 32 Mhz crystal oscillator with on board trim capability



RF Front End

- **Differential input/output port**
  - Supports external PA/LNA
- **Single ended antenna option**
  - Integrated transmit/receive switch
- **Antenna diversity option**
- Automatic Gain Control (AGC)
- Receive Strength Signal Indicator (RSSI)
- Temperature compensation



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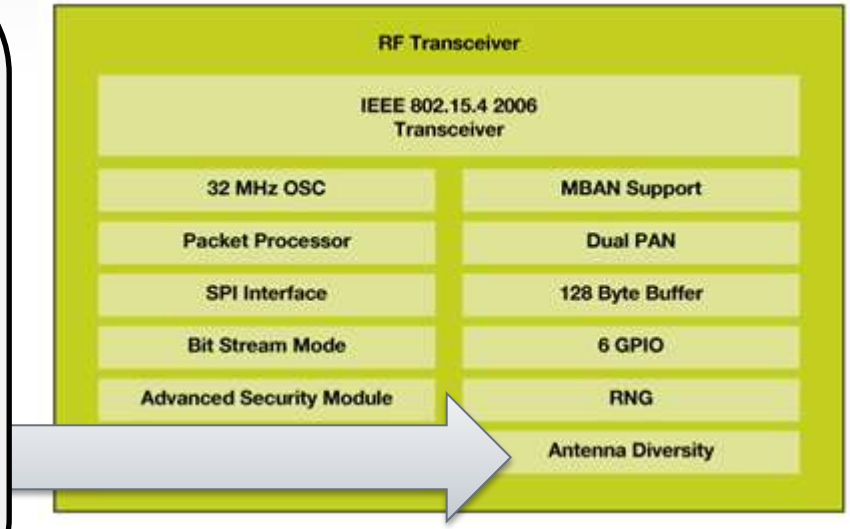
Antenna Diversity

Diversity

- GPIO for Antenna Diversity control
- FAD (Fast Antenna Diversity)
  - Off
  - Preamble detect

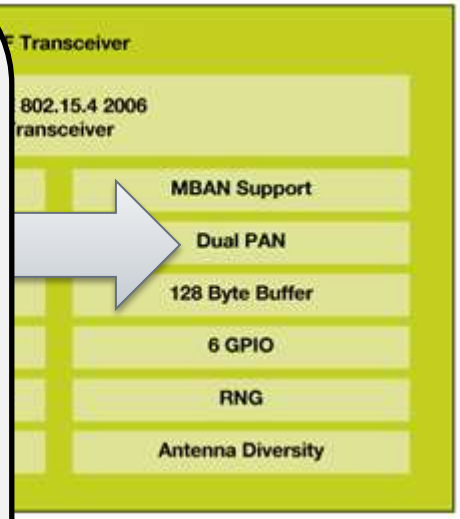


Dual PAN

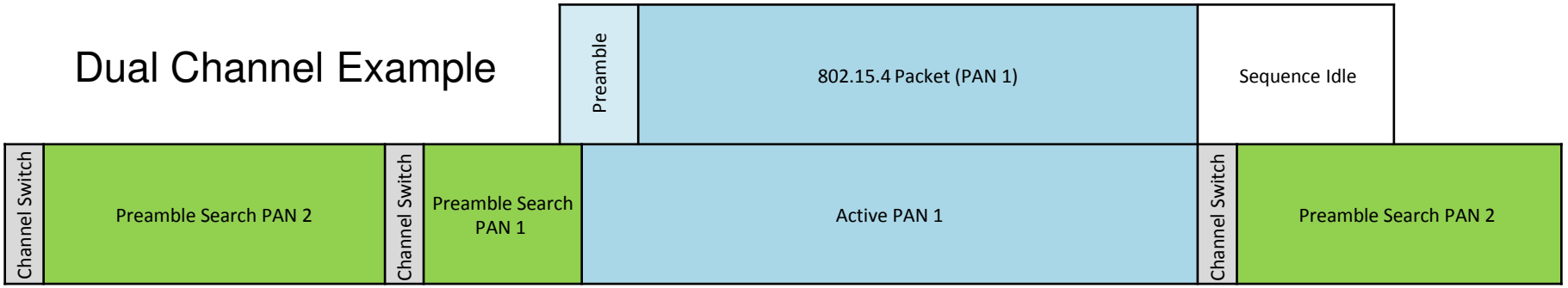
Ability to participate in two networks simultaneously
- Maintains two sets of network parameters
  - PAN, MAC address (short and long), Channel

2 channels, 2 PANs
- Manual mode – software controls which PAN is active
- Automatic mode – hardware controls which PAN is active
  - Time to dwell on channel can be set from .5 mS to 3.2 seconds
  - If PAN is active when timer expired, sequence will complete before channel switch occurs
- Channel switch is 56 uS
  - Time to switch, poll, receive packet and switch back is <10mS

1 channel, 2 PANs
- Address filtering is done simultaneously
- No channel switch is necessary

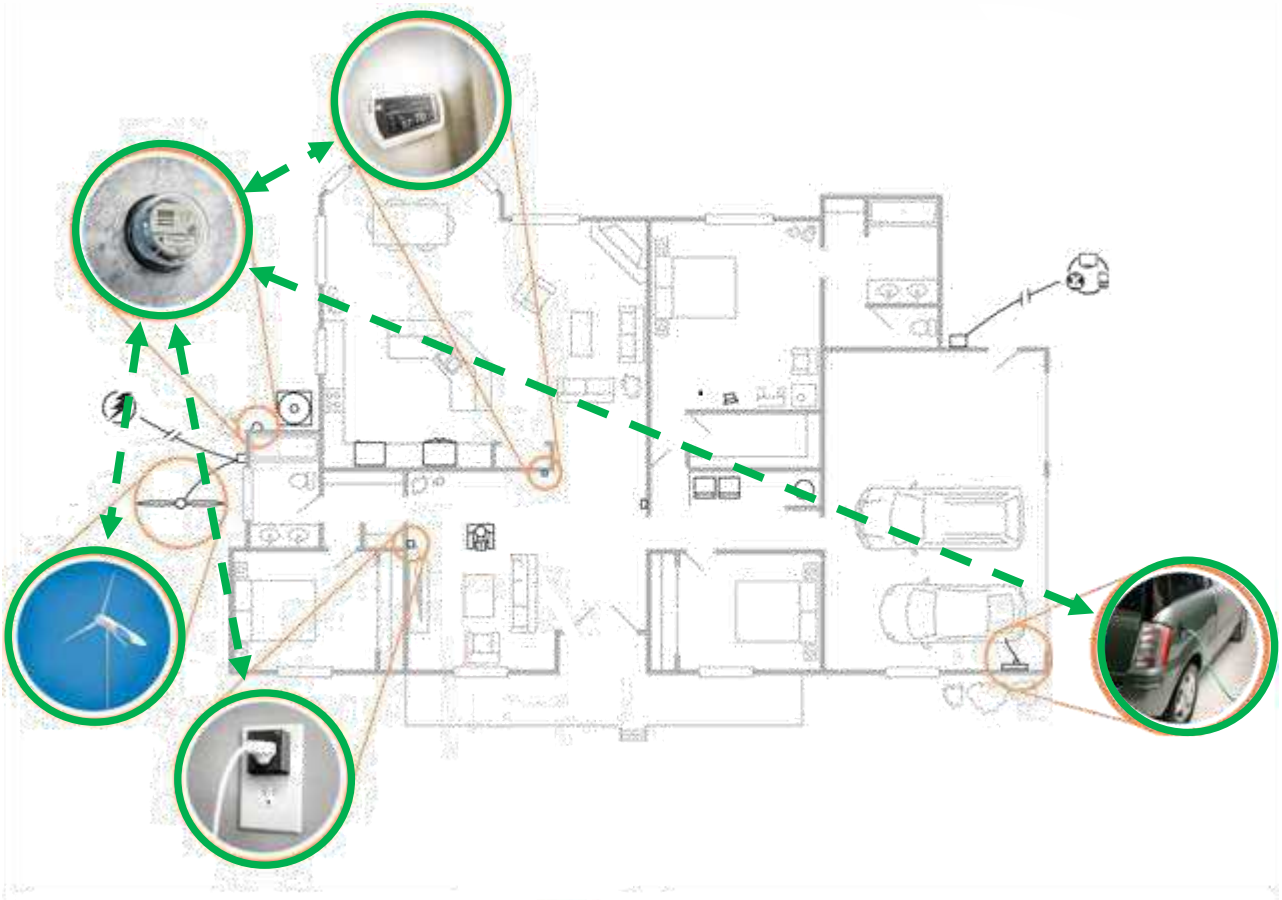


Dual Channel Example



Dual PAN Use Case

- Smart Energy Network (Utility)



Smart Energy

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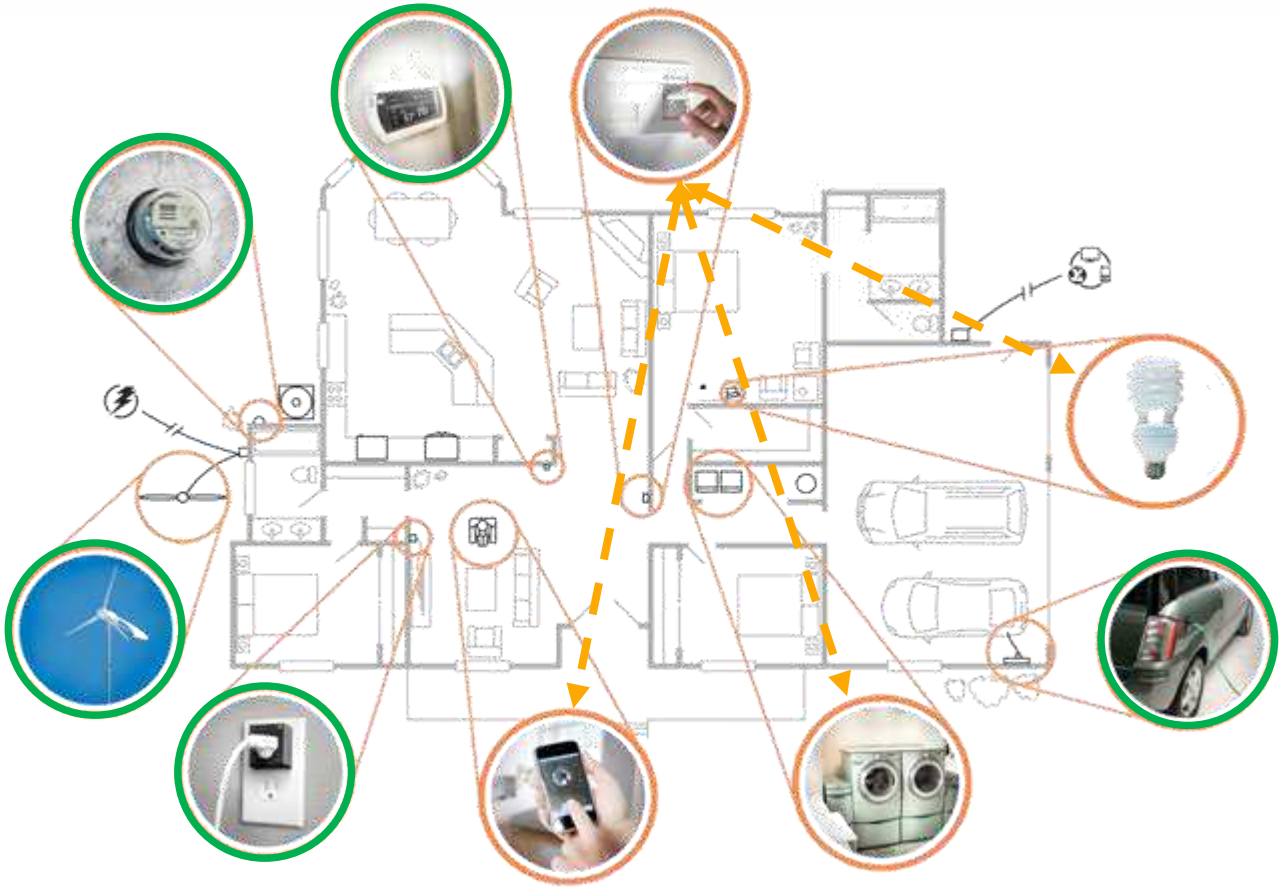
Dual PAN Use Case

- Smart Energy Network (Utility)
- Home Automation Network (Home Owner)



Smart Energy

Home Automation

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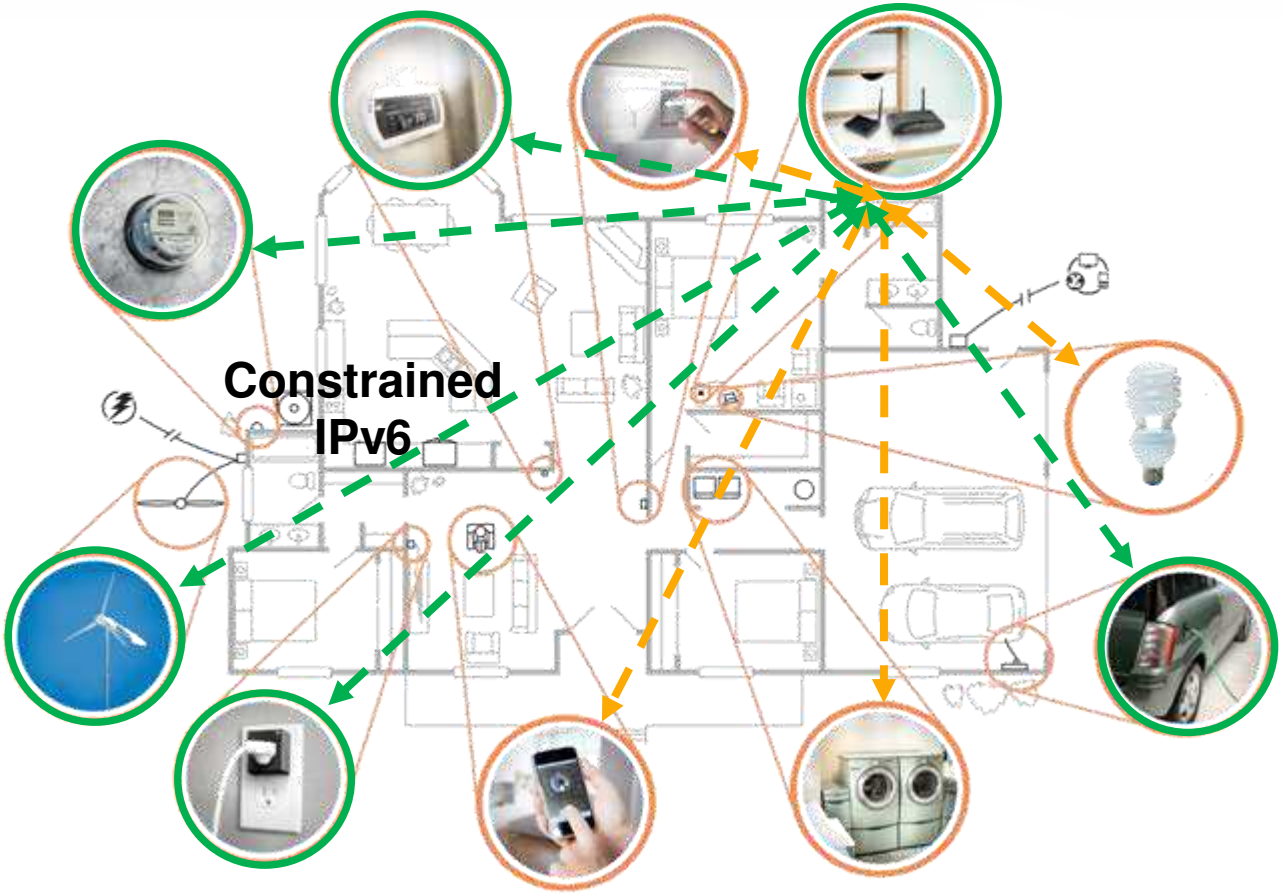
Dual PAN Use Case

- Smart Energy Network (Utility)
- Home Automation Network (Home Owner)
- Dual PAN
  - Smart Energy & Home Automation



Smart Energy Home Automation Dual PAN – SE/HA

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Features and Benefits

Features	Benefits
RF	
• Class-leading link budget	• 112 dB link budget provides greater range, reducing the need for external power amplifiers and lowering cost.
• Low power consumption	• 17mA TX / 19 mA RX power consumption extends battery life
• Dual PAN support	• System can actively participate in 2 networks, eliminating the need for multiple radios.
• Diversity Support	• Freescale's FAD (Fast Antenna Diversity) allows the hardware to automatically select between 2 antennas, improving reliability in high interference environments.

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Features and Benefits

Features	Benefits
MCU	
• ARM® Cortex™-M4 core with DSP	• Up to 50 Mhz core provides a broad range of application support
• Up to 512 KB of Flash and 64 KB of RAM	• Provides enough memory to run complicated protocols or dual stacks and user applications on a single IC
• 256 KB of FlexMemory (MKW21 only)	• Allows user to define configuration of memory between Flash and EEPROM
• Secure Flash	• Protects the code and data from unauthorized access or modification
• Tamper detect	• Protects critical IP by detecting tamper events (NDA required)
• Cryptography Acceleration Unit	• Reduces code size and execution time through hardware support for advanced security protocols
• 128-bit Random Number Generator	• Meets the FIPS 140 Security Requirements for Cryptographic Modules

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MKW2x Enablement

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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
- BeeKit Tool with stacks and applications
  - ZigBeePro R20 with SE 1.1.x, HA 1.1, HC 1.0 profiles
  - Simple MAC and RF Test Tool
  - Dual-PAN example
  - Over-The-Air programming example
  - **Coming: ZigBeeIP and SE 2.0 profile**
- Quick Start Guide

Tower Form Factor

- *Use standalone or in Tower System*
- *Boards sold individually*
- *Combine as many boards as needed*

Part Numbers:

TWR-KW21D256
TWR-KW24D512

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Freescale ZigBee Stacks

IPv6

HID

802.15.4	ZigBee PRO	ZigBee IP	SynkroRF	RF4CE
Customer Defined & Developed	Customer Developed	Customer Developed	Customer Defined	Customer Developed
	ZigBee Profiles	ZigBee Profiles		RF4CE Profiles
	ZigBee NWK	ZigBee IP NWK	SynkroRF NWK	RF4CE NWK
802.15.4 MAC	802.15.4 MAC	802.15.4-2006 MAC	802.15.4 MAC	802.15.4 MAC
802.15.4 PHY	802.15.4 PHY	802.15.4 PHY	802.15.4 PHY	802.15.4 PHY
Hardware	Hardware	Hardware	Hardware	Hardware

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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
Application 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 Data Throughput	50-115K	90-115K	70-100K	70-100K	30-70K	<50K

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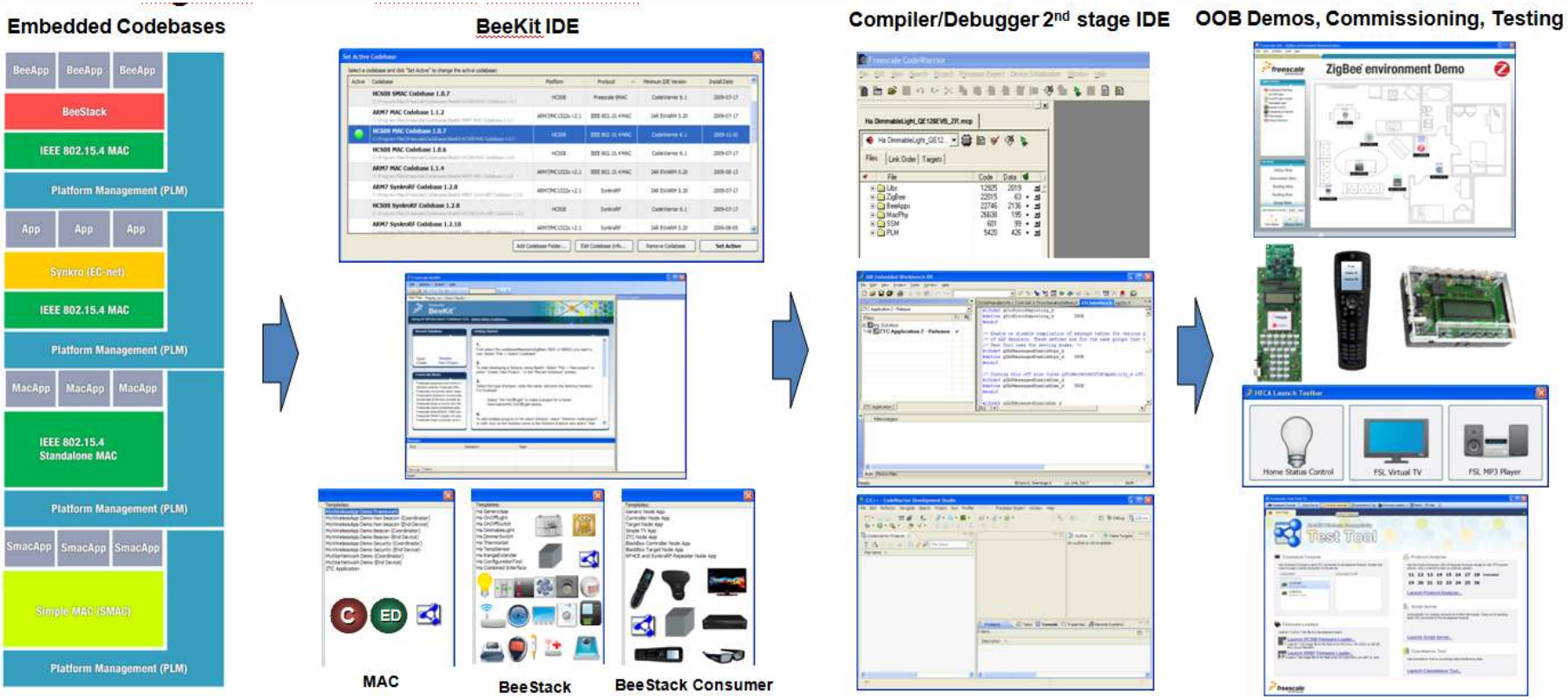
Freescale BeeKit Toolchain



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