Freescale Wireless Connectivity for the Internet of Tomorrow

Alan Collins | Business Development Wireless Applications Engineer

A P R . 2 0 1 5
Agenda

• Wireless connectivity technologies to enable IoT
  - 2.4GHz vs Sub-1GHz
  - Multi-protocol landscape: Which one to choose?
• Kinetis W overview
  - KW01x feature set
  - KW2x feature set
• Development Environment
  - Evaluation boards
  - Software stacks
  - Software tools
  - Support
• Summary
• Q & A
IoT Concept

**Processing**
- Multicore Communications Processor
- Crypto Processor

**Edge Nodes**
- Sensing
  - Pressure
  - Altimeter
  - Temperature
- Accelerometer
- Magnetometer
- Gyroscope

**PAN/LAN Connectivity**
- NFC
- 6LowPAN
- Sub-Gig
- GPS
- BT/BTLE

**Gateway**
- ZigBee®
- WiFi®
- Cellular

**WAN Connectivity**
- Cellular

**Cloud**
- SDN / NFV
  - Virtualization
  - Efficient Provisioning
  - Network as a Service
Our Products Power The Internet of Things

Microcontrollers | Digital Networking | Auto MCU | Analog and Sensors | RF

We Have the Broasted Portfolio of Solutions for IoT
we Enable the Key Development Forces

Secure Data
- Diverse Data Sources
- Optimized Networks
- Security, Security, Security

Small, Fast, Energy Efficient
- Product Longevity
- Balanced Performance/Power
- Shrinking Power Envelopes

Easy to Use
- Integrated, Compatible, Scalable
- Global Partners
- Faster Time to Market

50 BILLION CONNECTED DEVICES by 2020

We are Enabling the Next Growth Wave
Kinetis MCU Innovations for IoT Market

1. Security
   • Driving enhanced protection for customers' IP and the end customers' personal information with standard on-chip cryptographic accelerators and industry-leading security mechanisms

2. Enablement
   • Improving customer time to market with rapid and easy Kinetis MCU prototyping and development tools and software (MQX, RTOS, SDK, Kinetis Design Studio IDE), turnkey designs, and strategic ecosystem

3. Low Power
   • Leading innovation with an optimized ultra-low-power architecture designed for maximum flexibility with efficient ARM Cortex-M cores, low power boot capabilities, smart peripherals and various power modes
Freescale’s Leadership in IoT

• Ecosystem of over 400 partners, from Fortune 50 to specialized IoT providers

• Launch of Software Center and Software Services BU

• Driving technology standards such as Thread

• Largest ARM portfolio from the smallest 32-bit microcontroller, to multicore applications processors and MPU’s
  - Continued leadership in Power Architecture in Networking and Automotive

• Portfolio to target the 3 primary areas of IoT:
  - Industry, Home and Automotive

From the edge node to the network and the cloud, Freescale accelerates Internet of Things innovations with smart and secure hardware and software solutions
Wireless Connectivity for the IoT - Complexity

Kinetis W MCUs
Choosing the Right Wireless Technology

**Sub-GHz**
- Frequency bands regulated and vary by country
- **Exhibits significantly longer range**
  - ~ 100m indoor,
  - ~ 500-800m outdoor
  - Better building penetration capability.
  - Mostly proprietary NWK protocols
- **Typically lower data rate**
  - 50 – 100kbps
- **Reduced power consumption**
  - Low interference = easier transmissions + fewer retries
  - Years of battery life
- **Antenna Size**
  - 433MHz ~17.3cm
  - 915MHz ~8.2cm
- **Proprietary standards → Lower deployment and operating costs**

**2.4GHz**
- Unlicensed Frequency bands available worldwide
- **Range:**
  - ~ 30m indoor,
  - ~ 100-300m outdoor
  - Robust NWK protocols (like ZigBee and Thread) enable multi hop mesh networks.
- **High effective data rate**
  - Ex: 802.15.4 (250kbps)
- **PWR consumption**
  - Less time on-air
  - Years of battery life
  - Quick TX/RX turnaround time
  - Retries and ACKS mechanism
- **Smaller Antenna Size**
  - 2.4 GHz ~ 3.1cm
- **Global standards for the IoT**
  - ZigBee PRO & IP
  - Thread
  - Bluetooth
# 2.4GHz protocol stack comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>SMAC</th>
<th>802.15.4 MAC</th>
<th>ZigBee® Pro</th>
<th>Thread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported Devices</td>
<td>K64F+MCR20, KL46+MCR20, KW2x</td>
<td>K64F+MCR20, KL46+MCR20, KW2x</td>
<td>K64F+MCR20, KL46+MCR20, KW2x</td>
<td>K64F+MCR20, KL46+MCR20, KW2x</td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable Replacement</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Remote Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Home Control</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Home Automation</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Health Care</td>
<td></td>
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<td>✓</td>
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<tr>
<td>Building Automation</td>
<td></td>
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<td></td>
<td>✓</td>
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<tr>
<td>Smart Energy</td>
<td></td>
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<td></td>
<td>✓</td>
</tr>
<tr>
<td>Network Stack</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Application Profiles</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Network Topology</td>
<td>Point-to-Point</td>
<td>Peer-to-Peer</td>
<td>Tree</td>
<td>Mesh</td>
</tr>
<tr>
<td></td>
<td>Star</td>
<td>Tree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Data Throughput</td>
<td>50-115Kbps</td>
<td>90-115Kbps</td>
<td>30-70Kbps</td>
<td>50-70Kbps</td>
</tr>
</tbody>
</table>
# Sub-1 GHz Protocol Stack Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>SMAC</th>
<th>802.15.4g/e</th>
<th>Thread for &lt;1GHz</th>
<th>Wireless M-Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported Devices</td>
<td>KW01</td>
<td>KW01</td>
<td>K64F+KW01, KL46+KW01</td>
<td>KW01</td>
</tr>
<tr>
<td>Typical Application</td>
<td>Cable Replacement</td>
<td>Wireless Meter Reading</td>
<td>Application agnostic, could run with AllJoyn, IOTivity, LWM2M, MQTT</td>
<td>Wireless Meter Reading (Europe)</td>
</tr>
<tr>
<td>Standard</td>
<td>Proprietary</td>
<td>IEEE 802.15.4</td>
<td>Thread</td>
<td>EN 13757-4:2013</td>
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<tr>
<td>Network Stack</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Network Profiles</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Network Topology</td>
<td>Point to Point</td>
<td>Peer-to-Peer</td>
<td>Mesh</td>
<td>Point-to-Point</td>
</tr>
<tr>
<td></td>
<td>Star</td>
<td>Tree</td>
<td>Mesh</td>
<td>Star</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Rate</td>
<td>200 Kbps</td>
<td>50-200 Kbps</td>
<td>15-35Kbps</td>
<td>32-100 Kbps</td>
</tr>
<tr>
<td>Protocol Stack Provider</td>
<td>FSL Available</td>
<td>FSL Q2’2015</td>
<td>FSL Q2’2015</td>
<td>3rd Party</td>
</tr>
</tbody>
</table>
What is KW Series?

Extension of Kinetis line to include wireless connectivity technologies

- MKW01x → Cortex M0+ MCU + Flexible Sub-1GHz radio.
- MCR20A → MKW2x → Cortex M4 MCU + IEEE-802.15.4 2.4GHz radio

More information available in the following link: [http://www.freescale.com/wireless](http://www.freescale.com/wireless)
## Kinetis Key Pillars by Family

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>E</th>
<th>K</th>
<th>X</th>
<th>W</th>
<th>M</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Power</td>
<td>5V Robustness</td>
<td>High Performance &amp; Rich Integration</td>
<td>Extreme performance &amp; integration</td>
<td>Integrated RF Connectivity, 2.4 GHz, sub-GHz</td>
<td>Integrated metrology engine</td>
<td>Motor and Power Conversion</td>
</tr>
<tr>
<td></td>
<td>48MHz Cortex M0+</td>
<td>Up to 48MHz Cortex M0+</td>
<td>Up to 180MHz Cortex M4</td>
<td>Up to 400MHz Cortex M-next</td>
<td>Up to 120MHz Cortex M4, Cortex M0+</td>
<td>Up to 48MHz Cortex M0+</td>
<td>Up to 200MHz, Cortex M4, Cortex M0+</td>
</tr>
<tr>
<td></td>
<td>8KB to 512kB Flash</td>
<td>8KB to 128kB Flash</td>
<td>32KB to 2MB Flash</td>
<td>0KB to 16MB Flash</td>
<td>32KB to 1MB Flash</td>
<td>32KB to 128kB Flash</td>
<td>16KB to 2MB Flash</td>
</tr>
<tr>
<td></td>
<td>Up to 128KB RAM</td>
<td>Up to 16KB RAM</td>
<td>Up to 256KB RAM</td>
<td>Up to 512KB RAM</td>
<td>Up to 256KB RAM</td>
<td>Up to 32KB RAM</td>
<td>Up to 256KB RAM</td>
</tr>
<tr>
<td>Now!</td>
<td>Now!</td>
<td>Now!</td>
<td>Now!</td>
<td>Q4 ‘15</td>
<td>Now!</td>
<td>Now!</td>
<td>Now!</td>
</tr>
</tbody>
</table>

**Leading Performance – Low Power – Scalability – Industrial Grade reliability & temp**

**Freescale Bundled IDE, RTOS & Middleware – Rapid Prototyping Platform – Broad ARM Ecosystem Support**
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
- 802.15.4g/e with TSCH
- Wireless MBUS

**System**
- 16-bit ADC, Capacitive Touch Sensing, I2C, UART, SPI, Timers
- Operating Range: 1.8V to 3.6V, -40C to +85C
MKW01x key differentiators

- **Very low power suitable for battery operated equipment**
  - Cortex M0+ Breakthrough power efficiency
  - Low-power features such as 100nA with radio configuration retention.

- **Demonstrates exceptional RF performance with a budget link up to +137dB**

- **High Integration Level**
  - Includes the exclusive ARM Cortex M0+ core with up to 48MHz performance, embedded 128KB Flash and 16KB of RAM supporting wireless communication protocol + application in one chip

- **Flexibility and Compliancy with Multiple Standards**

- **Full set of peripherals**
  - Offers multiple 16-bit timers, 13-bit port keyboard interrupt and Touch Sensing Interface, 16-bit ADC, SCI, I2C, SPI
## Kinetis W Series: KW2x Wireless MCUs

### CPU
- Up to 50 MHz **Cortex®-M4**
- 16-channel-DMA
- Up to **512 KB Flash, 64 KB RAM**, and 4k bytes of enhanced EEPROM/FlexRAM. Up to 64K FlexNVM (MKW21D256 only)
- Typical current consume: 250 uA/Mhz run, 1.7uA RTC standby

### Radio Transceiver, 2.4GHz
- Highly integrated 2.4 GHz RF transceiver
- 802.15.4 Packet processor
- Supports single ended and diversity antennas
- Dual PAN support
- 110 dBm Link budget
- Programmable output power -30 to +8 dBm
- Sensitivity -102 dBm
- Low Power: TX 15mA @ 0dBm (CPU sleep), RX 15mA (CPU sleep)

### Security
- Cryptography Acceleration Unit (CAU)
- AES encryption (FIPS 140)
- External tamper detect
- 32-bit CRC

### System
- SPI (1), UART (2), I^2C (2), USB FS OTG (KW22 and KW24)
- 8-channel 16-bit SAR ADC, 6-bit DA
- Real-Time Clock (RTC)
- Up to 24 GPIO, Multiple KBI
- Operating temperature of -40°C to 105°C

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### Device Details

<table>
<thead>
<tr>
<th>Device</th>
<th>Flash</th>
<th>RAM</th>
<th>Feature</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKW21D256VHA5</td>
<td>256 KB</td>
<td>32 KB</td>
<td>No USB</td>
<td>8x8 56-pin LGA</td>
</tr>
<tr>
<td>MKW22D512VHA5</td>
<td>512 KB</td>
<td>64 KB</td>
<td>USB</td>
<td>8x8 56-pin LGA</td>
</tr>
<tr>
<td>MKW24D512VHA5</td>
<td>512 KB</td>
<td>64 KB</td>
<td>USB and Smart Energy 2.0</td>
<td>8x8 56-pin LGA</td>
</tr>
</tbody>
</table>

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http://www.freescale.com/KW2x
MKW2x key differentiators

- Dedicated Hardware:
  - Dual PAN ID ➔ Participate in two networks simultaneously
  - Antenna Diversity ➔ Reduce multipath fading

- MCU with powerful core and energy efficiency options
  - Flash / RAM capacity

- High radio link budget
  - 802.15.4 hardware engine

- HW and SW enablement / support
MKW01x evaluation boards

http://www.freescale.com/MRB-KW0x
MKW2x evaluation boards

http://www.freescale.com/twr-kw2x

http://www.freescale.com/usb-kw24d512

Coming soon
MCR20 High Performance 802.15.4 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 17mA @ 0dBm
- Rx 15mA LPPS mode, 19mA 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, Production Summer

Ordering Part Number: MCR20AVHM
Growing Importance of Enablement

Average MCU Flash size grew x8 in the last decade

FIRMWARE now accounts for 83% of MCU implementation cost

53% of projects are delayed >3 months due to FIRMWARE

Firmware is MCU developers BIGGEST pain point

Stacks (TCP/IP, USB)

Middleware

Application Specific

Libraries (DSP, Math, Encryption)

HAL & Drivers

RTOS

Bootloader

MCU Hardware

Customer Application

Software and Hardware Evaluation & Dev Tools
Software Strategy for Connectivity Stacks moving forward

- Port all the software stacks to Kinetis SDK drivers and ecosystem
- Adding support for MQX and FreeRTOS via Kinetis SDK OS Abstraction
- Provide initial support for IAR Embedded Workbench and later add support for Kinetis Design Studio with GCC compiler
Connectivity Software Offering

• BeeKit
  ▪ Bare metal solution for Kinetis KW2x series
  ▪ SMAC
  ▪ 802.15.4 – 2006 PHY-MAC
  ▪ ZigBeePRO Stack with
    - Home Automation 1.2
    - Smart Energy 1.1
    - Healthcare Profiles
  ▪ Test Tool 12

• Kinetis SDK based stacks
  ▪ RTOS based solution for Kinetis KW01, KW2x, K64F+MCR20, KL46+MCR20
  ▪ SMAC
  ▪ 802.15.4 PHY-MAC
  ▪ Thread Stack
  ▪ BLE Host Stack and BLE Profiles
  ▪ ZigBee PRO stack with HA1.2 and ZigBee Light Link profiles

Available Now

Coming soon
Kinetis Software Development Kit (SDK)

A software framework for application development across all Kinetis MCUs

Hardware abstraction, peripheral drivers, stacks, RTOS’s, utilities, and usage examples; delivered in C source

Product Features

- Open source hardware abstraction layer (HAL) provides APIs for all Kinetis hardware resources
- BSD-licensed set of peripheral drivers with easy-to-use C-language APIs
- Comprehensive HAL and driver usage examples and sample applications for RTOS and bare-metal
- GUI configurable projects and peripheral drivers using Processor Expert
- CMSIS-CORE compatible startup plus CMSIS-DSP library and examples
- RTOS Abstraction Layer (OSA) with support for Freescale MQX, FreeRTOS, Micrium uC/OS, and bare-metal
- Integrates new Freescale unified USB stack, open source TCP/IP stack (lwIP), open source FAT file system, encryption math/DSP libraries, and more
- Support for multiple toolchains: GNU GCC, IAR, Keil, Atollic, and Kinetis Design Studio

Learn more at: www.freescale.com/KSDK

The OSI logo trademark is the trademark of Open Source Initiative.
Kinetis Design Studio

No-cost integrated development environment (IDE) for Kinetis MCUs

Eclipse and GCC-based IDE for C/C++ editing, compiling and debugging

Product Features

- A free of charge and unlimited IDE for Kinetis MCUs
- A basic IDE that offers robust editing, compiling and debugging
- Based on Eclipse, GCC, GDB and other open-source technologies
- Includes Processor Expert (PEx) with Kinetis SDK integration
  - Supports all existing Kinetis devices via PEx and new project wizard
  - All new Kinetis devices will also feature the Kinetis SDK with PEx configurability
- Host operating systems:
  - Windows 7/8 (32 and 64-bit)
  - Linux (Ubuntu, Redhat, Centos)
- Support for SEGGER, P&E and Open SDA/CMSIS-DAP debugger targets
- Support for Eclipse plug-ins including RTOS-awareness (i.e. MQX, FreeRTOS)
- CodeWarrior project importer
Freescale Bundled MQX RTOS

• **Free Scalable**, fully-featured and proven RTOS with 32-bit MCUs
  - **Full-featured and powerful**
    - BSPs incorporate tightly integrated RTOS, Middleware (USB, TCP/IP stacks), file system, and I/O drivers
    - Designed for speed and size efficiency
  - **Market proven**
    - Available on Freescale processors for > 15 years
    - Used in millions of products including Medical and Heavy Industrial applications
  - **Simple and scalable**
    - As small as ~10KB for smallest implementation, or scale up to support sophisticated networking and threading
    - Intuitive API & modular architecture enables straightforward fine-tuning of features
    - Production source code provided
  - **Similar to other “pay-for” software OS**

Software integration headache

- $95K of free Software
- **Stable**
- **Upgradable**
- **Easy to maintain**
Wireless Connectivity Enablement Overview
Bringing our solutions closer to the customer

Connectivity Software
- Profiles

Component API

Connectivity Components
- BLE Stack
- IPv6 Stack
- Thread
- MAC
- PHY

Kinetis Enablement Framework
- Customer Application
  - Stacks (TCP/IP, USB, BLE)
  - Middleware
  - Application Specific
- Operating System
  - Libraries (DSP, Math, Encryption)
- Bootloader
- Software and Hardware Evaluation & Dev Tools
- MCU Hardware

Development Hardware
- Freedom Board
  - compatible with the overall Kinetis HW
  - easy solution proof of concept.
- USB dongle
  - Small form factor,
  - end nodes demonstration,
  - sniffer for easy of debugging)

Completely Seamless Solution delivered by Freescale
Support options in details

**Standard Support**
- Optional channels; Online, TIC, Freescale FAEs, Distributor FAEs
- Free of charge
- Optimized on standard BSPs and reference boards
- Standard issue resolution priority
- Best effort response time
- Report bugs for fix in public releases
- Technical support professionals

**Commercial Support**
- Works with Standard Support
- Prioritized access in queue
- Managed by senior staff
- Guaranteed response time
- Delivered through private portal
- Hot fixes and patches available immediately

**Commercial Products**
- PEG, Wireless Charging
- Miracast (Linux)
- Audio Video Bridge
- Trusted Execution Environment

**Professional Services**
- Custom support / HW services development on Client setup
- Direct access to experts
- BSP, drivers/stacks:
  - GFX services
  - Development / Porting / Migration/ Integration
  - Customization / Optimization
  - Feature dvpt & Acceleration
  - Testing / Validation
  - Issue analysis, Debug & Fix
- SOW-driven
- Longer term engagement
- Frozen branch services
- Application specific hardening

**Managed by « Program Managers » and/or « Triage Managers »**
15. Center Community Website

• Where to find the IoT Center?
• Training & Communities:
  - [www.freescale.com/support](http://www.freescale.com/support)
  - [https://community.freescale.com/community/wireless-connectivity](https://community.freescale.com/community/wireless-connectivity)
IoT Center Technical Topology

**Physical Components**
- Edge Devices
- Gateways
- Wireless Connectivity
- Sensors
- Smart Apps

**System Capabilities**
- Device Management
- Cloud / Infrastructure
- Interworking
- Security
- Analytics / Data

**Development Capabilities**
- IoT Platforms
- Embedded Tools
- Services
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Secure Embedded Processing Solutions for the Internet of Tomorrow

June 22-25, 2015 | JW Marriott Austin

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Q & A