Freescale **Wireless Connectivity** for the Internet of Tomorrow

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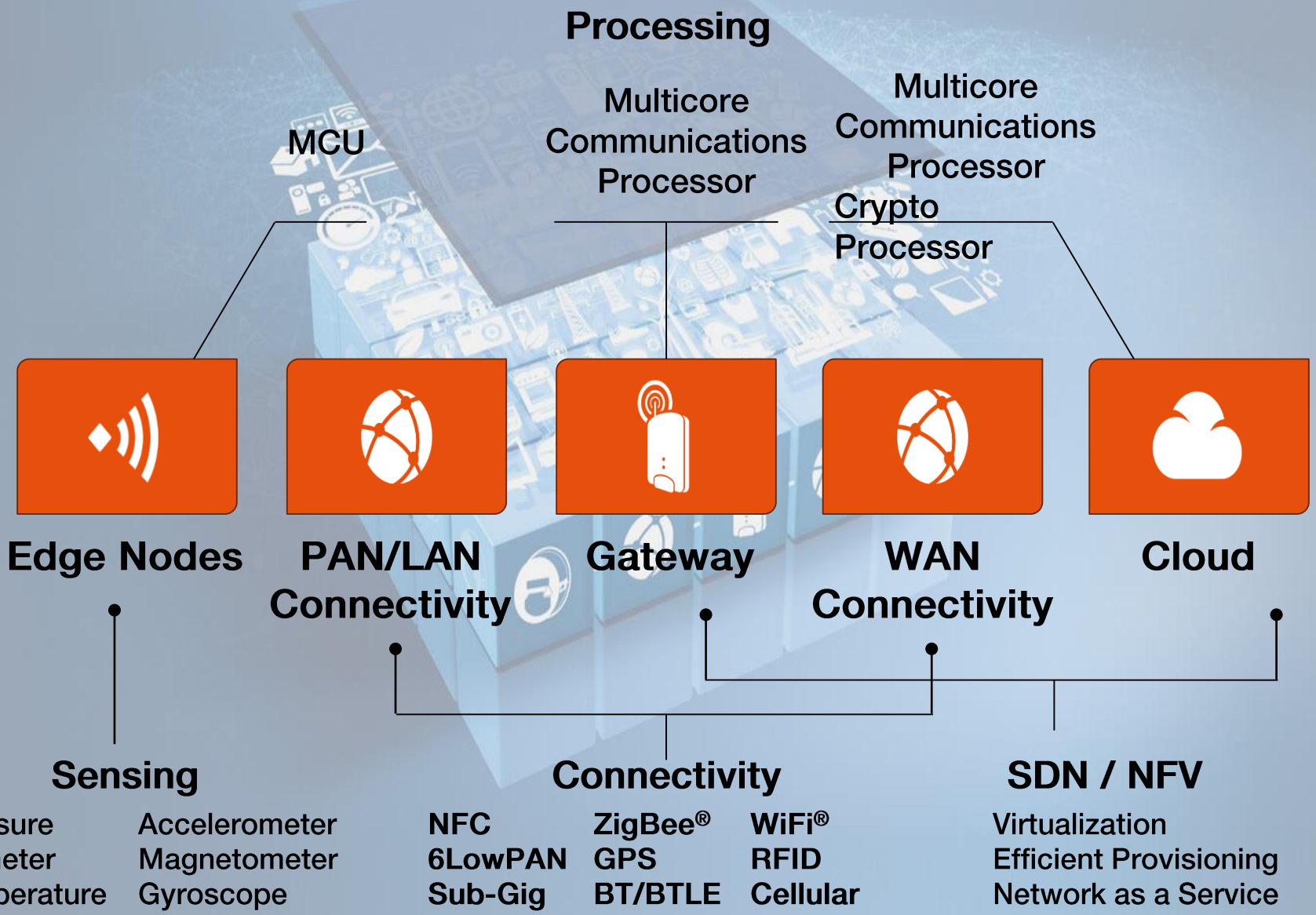
A P R . 2 0 1 5

External Use

Agenda

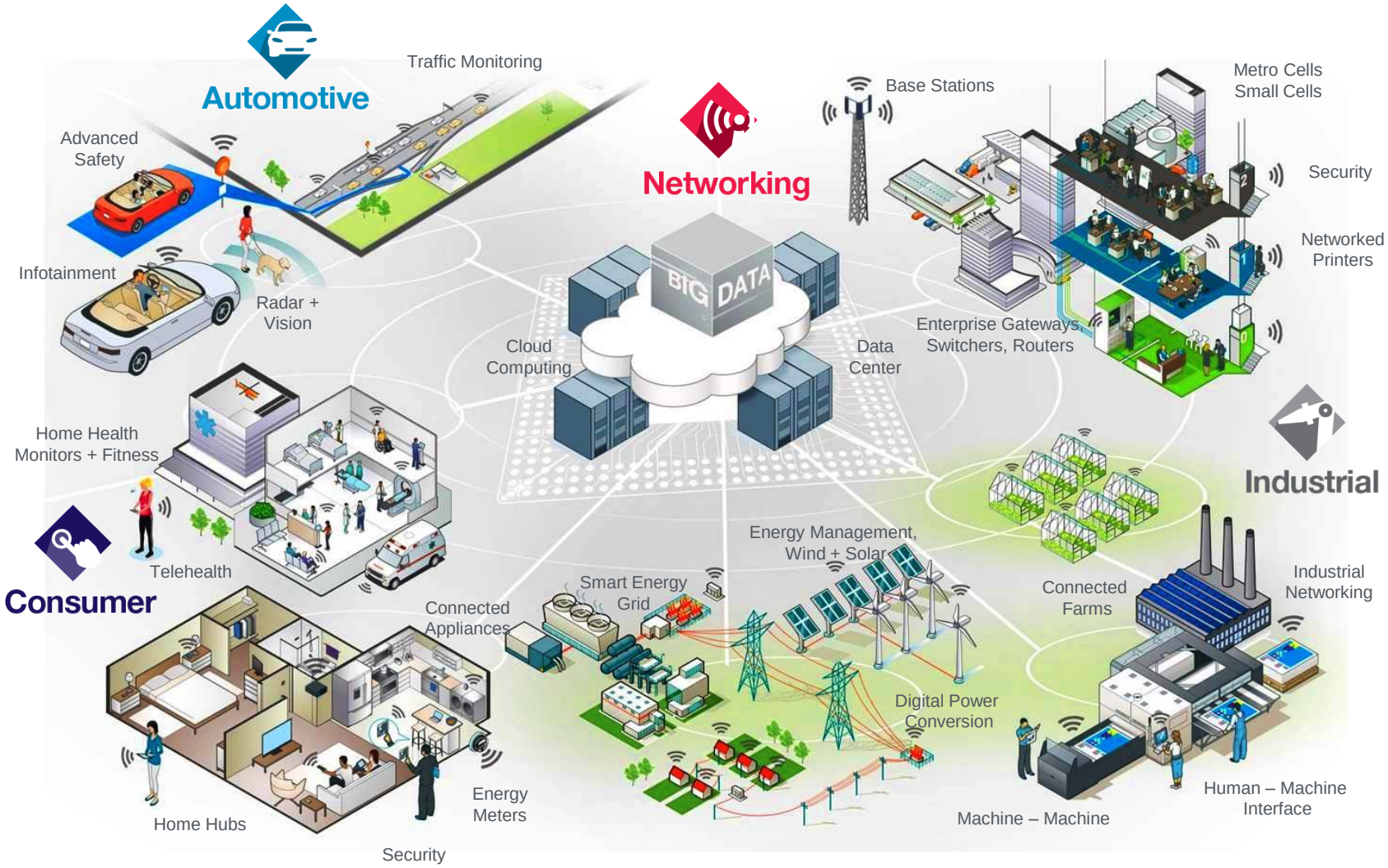
- Wireless connectivity technologies to enable IoT
  - 2.4GHz vs Sub-1GHz
  - Multi-protocol landscape: Which one to choose?
- Kinetis W overview
  - KW01x feature set
  - KW2x feature set
- Development Environment
  - Evaluation boards
  - Software stacks
  - Software tools
  - Support
- Summary
- Q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

IoT Concept


Processing
MCU
Multicore Communications Processor
Multicore Communications Processor
Crypto Processor
Edge Nodes
PAN/LAN Connectivity
Gateway
WAN Connectivity
Cloud
Sensing
Pressure
Altimeter
Temperature
Accelerometer
Magnetometer
Gyroscope
Connectivity
NFC
6LowPAN
Sub-Gig
ZigBee®
GPS
BT/BTLE
WiFi®
RFID
Cellular
SDN / NFV
Virtualization
Efficient Provisioning
Network as a Service

r Products Power The Internet of Things

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



We Have the Broadest 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

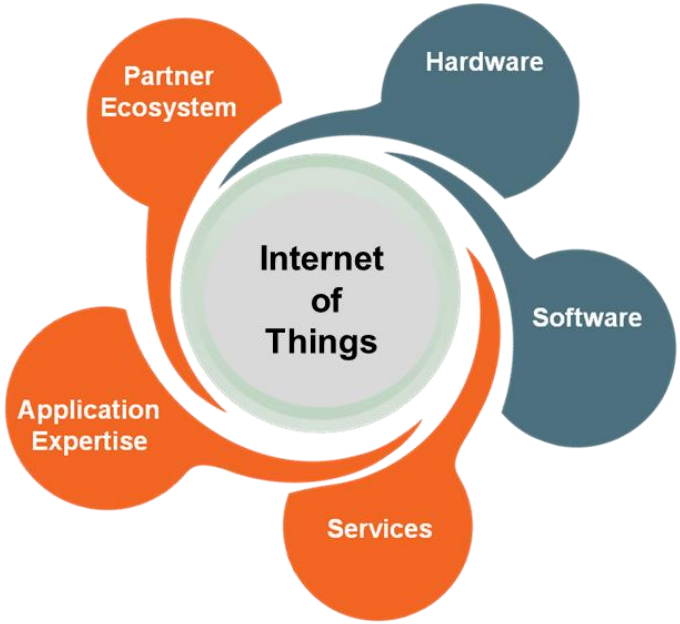
- Improving customer time to market with rapid and easy Kinetis MCU prototyping and development tools and software (MQX, RTOS, SDK, Kinetis Design Studio IDE), turnkey designs, and strategic ecosystem

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

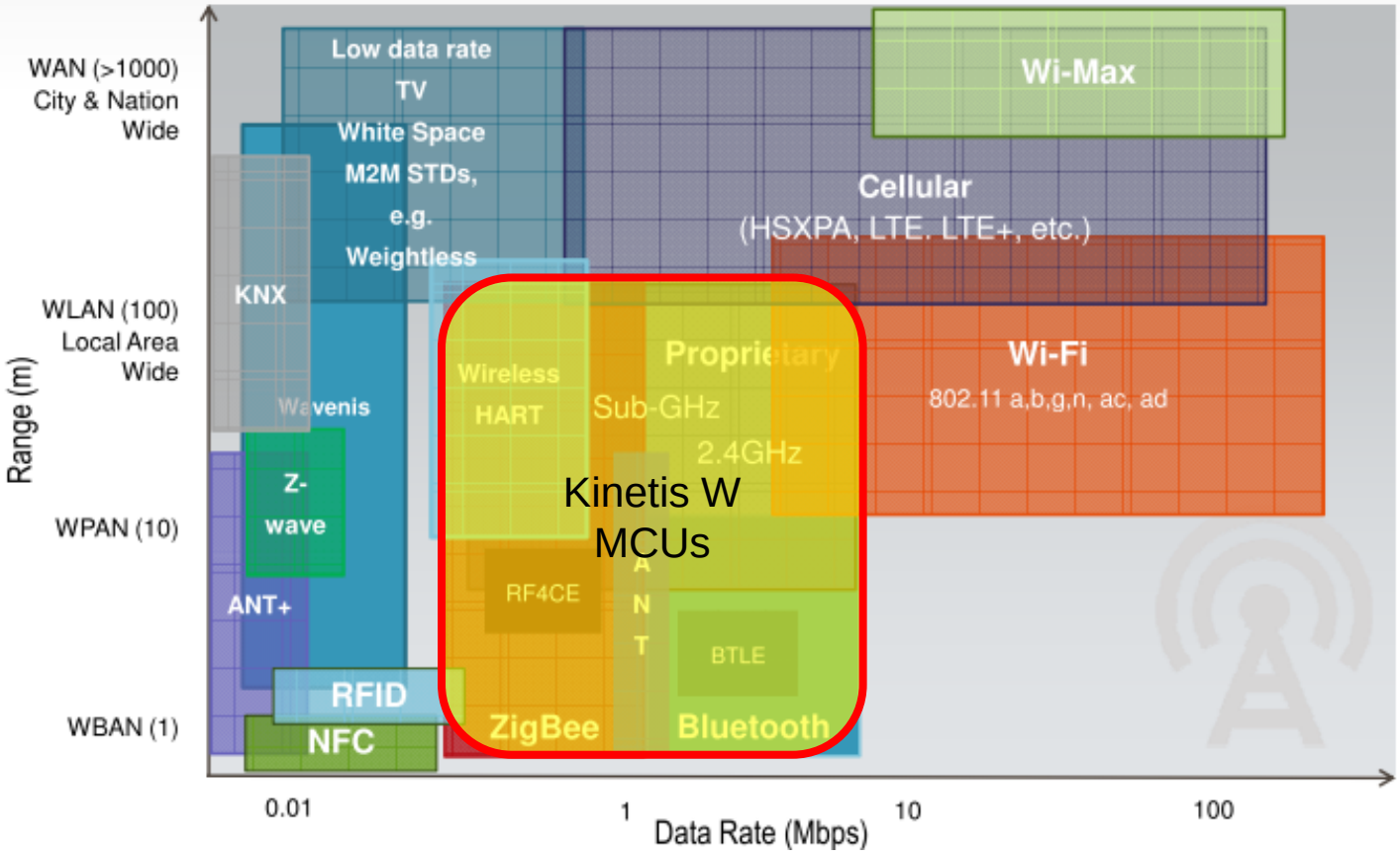
Freescale's Leadership in IoT

- 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



Choosing the Right Wireless Technology

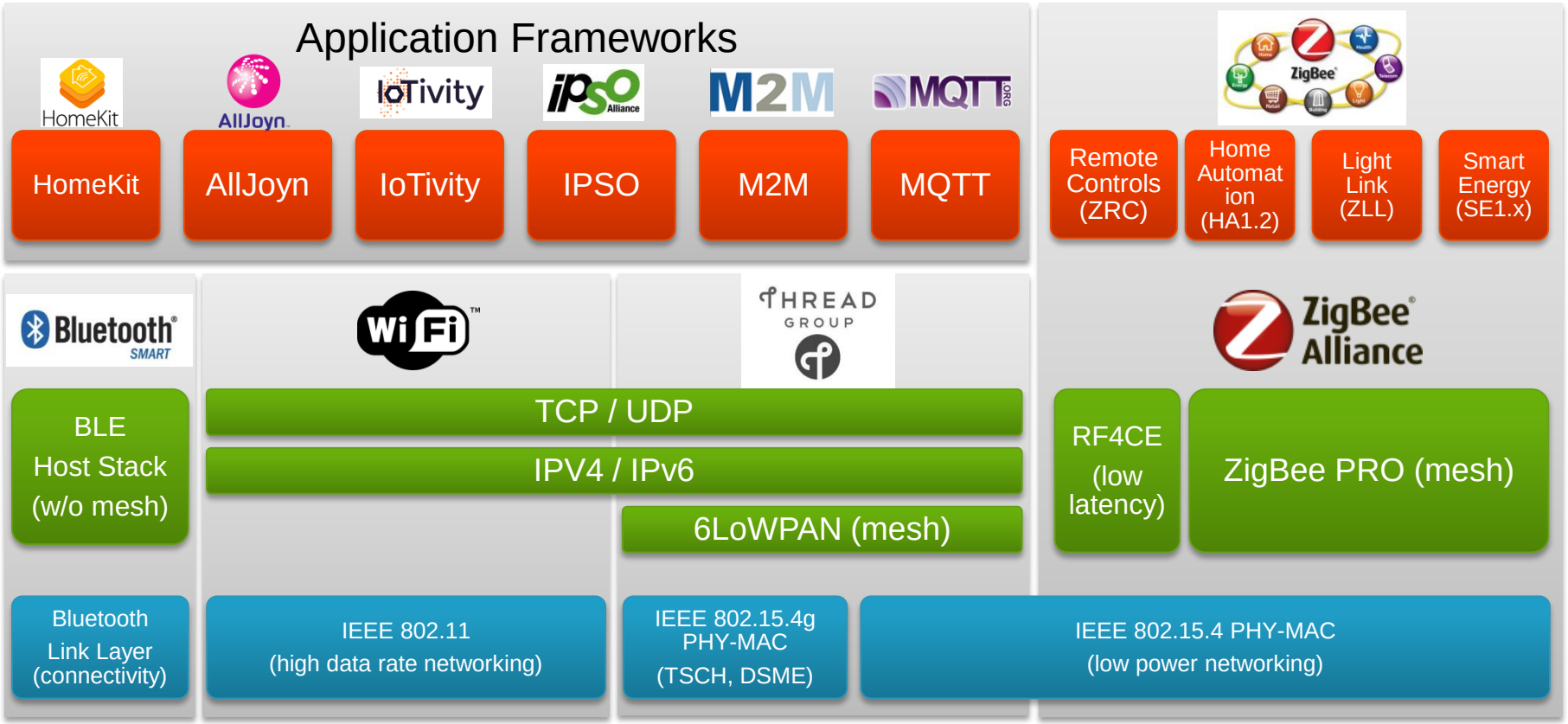
Sub-GHz

- **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 – 100kpbs
- **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

Freescale Connectivity Positioning



2.4GHz protocol stack comparison

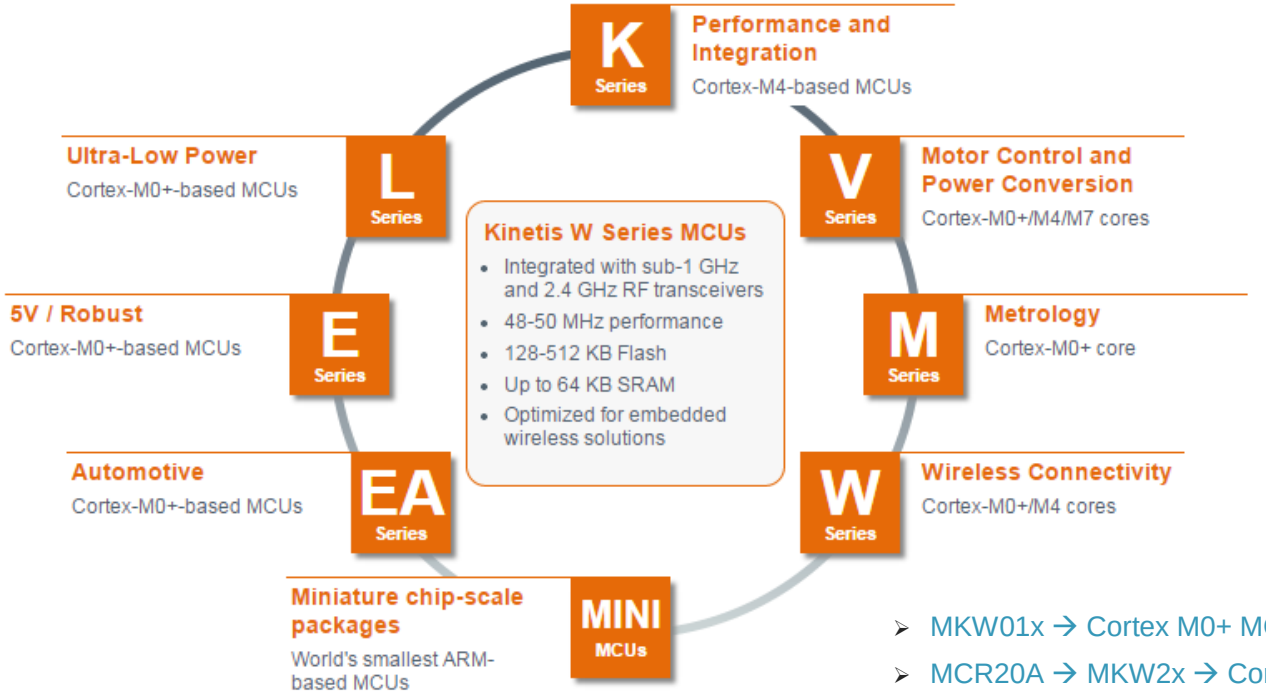
Feature	SMAC	802.15.4 MAC	ZigBee® Pro	Thread
Supported Devices	K64F+MCR20, KL46+MCR20, KW2x	K64F+MCR20, KL46+MCR20, KW2x	K64F+MCR20, KL46+MCR20, KW2x	K64F+MCR20, KL46+MCR20, KW2x
Applications				
Cable Replacement	✓	✓	✓	✓
Remote Control	✓	✓	✓	✓
Home Control			✓	✓
Home Automation			✓	✓
Health Care			✓	✓
Building Automation				✓
Smart Energy			✓	
Network Stack	No	No	Yes	Yes
Application Profiles	No	No	Yes	No
Recommended Device Memory	FLASH: 128K SRAM: 16K	FLASH: 128K SRAM: 16K	FLASH: 256K SRAM: 32K	FLASH: 256K SRAM: 32K
Network Topology	Point-to-Point	Peer-to-Peer	Tree	Mesh
	Star	Tree	Mesh	
Typical Data Throughput	50-115Kbps	90-115Kbps	30-70Kbps	50-70Kbps

Sub-1 GHz Protocol Stack Comparison

Feature	SMAC	802.15.4g/e	Thread for <1GHz	Wireless M-Bus
Supported Devices	KW01	KW01	K64F+KW01, KL46+KW01	KW01
Typical Application	Cable Replacement	Wireless Meter Reading	Application agnostic, could run with AllJoyn, IOTivity, LWM2M, MQTT	Wireless Meter Reading (Europe)
		Building Control		
		Medical		
Standard	Proprietary	IEEE 802.15.4	Thread	EN 13757-4:2013
Network Stack	No	No	Yes	Yes
Network Profiles	No	No	No	No
Recommended Device Memory	FLASH: 128K SRAM: 16K	FLASH: 128K SRAM: 16K	FLASH: 256K SRAM: 32K	FLASH: 128K SRAM: 16K
Network Topology	Point to Point	Peer-to-Peer	Mesh	Point-to-Point
	Star	Tree		Star
		Mesh		
Data Rate	200 Kbps	50-200 Kbps	15-35Kbps	32-100 Kbps
Protocol Stack Provider	FSL Available	FSL Q2'2015	FSL Q2'2015	3rd Party

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

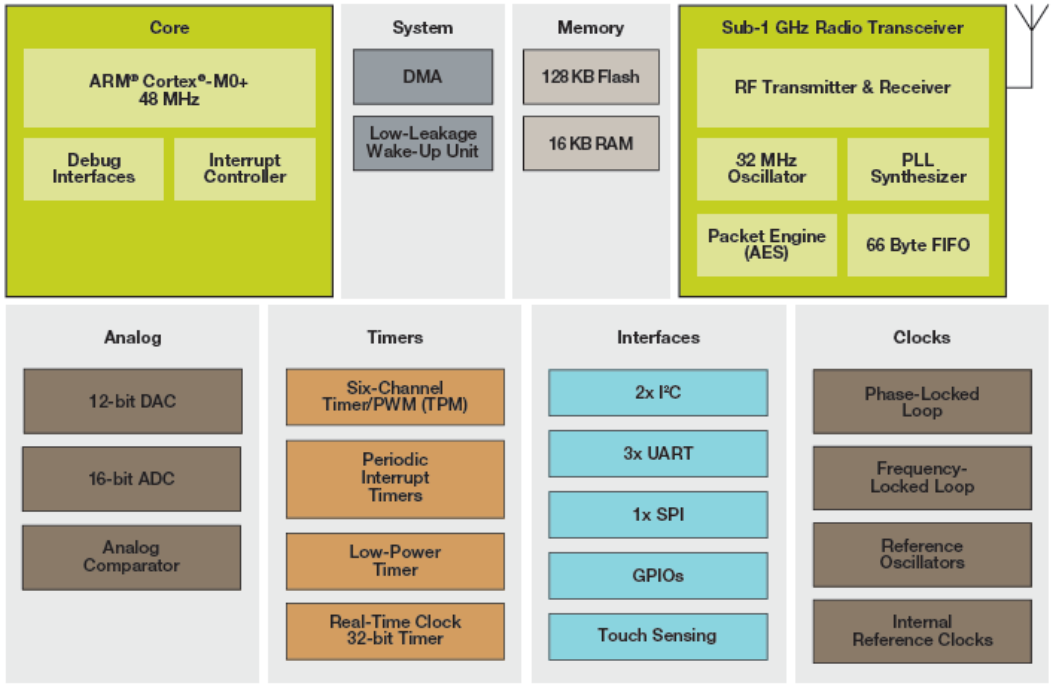
Kinetis Key Pillars by Family

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

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)



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

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

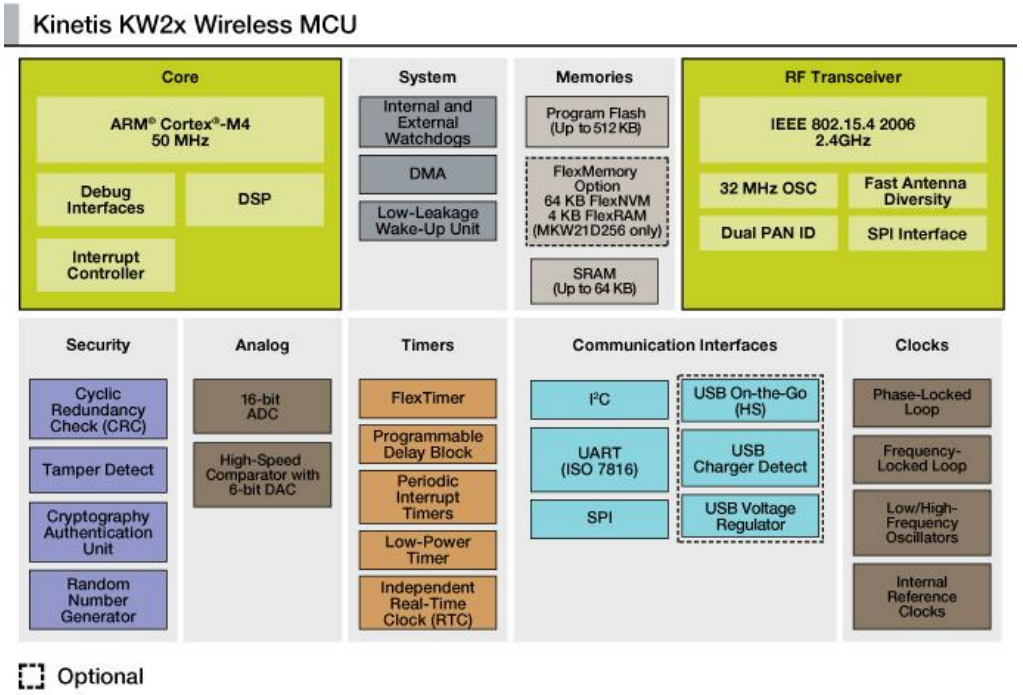
- Highly integrated 2.4 GHz RF transceiver
- 802.15.4 Packet processor
- Supports single ended and diversity antennas
- Dual PAN support
- 110 dBm Link budget
- Programmable output power -30 to +8 dBm
- Sensitivity -102 dBm
- Low Power: TX 15mA @ 0dBm (CPU sleep), RX 15mA (CPU sleep)

Security

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

System

- SPI (1), UART (2), I²C (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



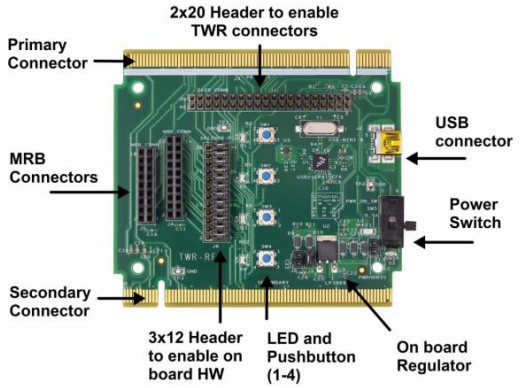
Device	Flash	RAM	Feature	Package
MKW21D256VHA5	256 KB	32 KB	No USB	8x8 56-pin LGA
MKW22D512VHA5	512 KB	64 KB	USB	8x8 56-pin LGA
MKW24D512VHA5	512 KB	64 KB	USB and Smart Energy 2.0	8x8 56-pin LGA

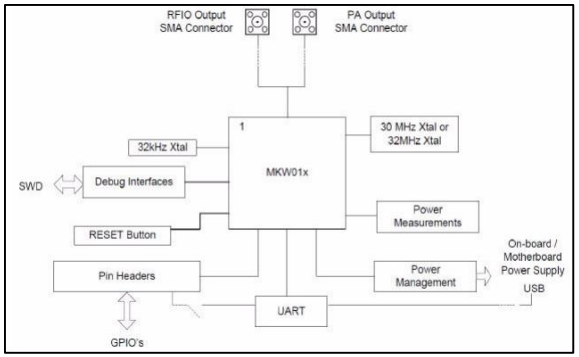
http://www.freescale.com/KW2x

MKW2x key differentiators

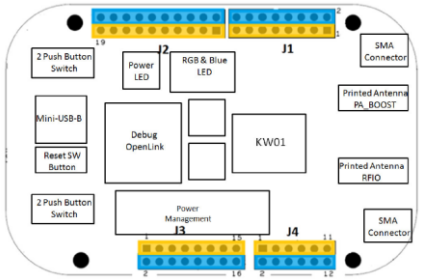
- Dedicated Hardware:
  - Dual PAN ID → Participate in two networks simultaneously
  - Antenna Diversity → Reduce multipath fading
- MCU with powerful core and energy efficiency options
  Flash / RAM capacity
- High radio link budget
  802.15.4 hardware engine
- HW and SW enablement / support

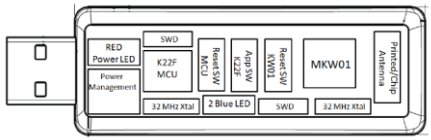
MKW01x evaluation boards





http://www.freescale.com/MRB-KW0x

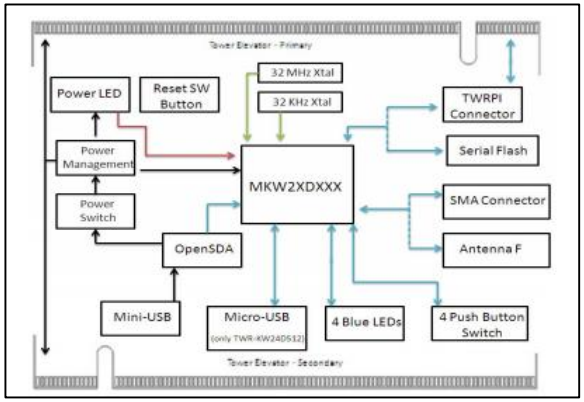




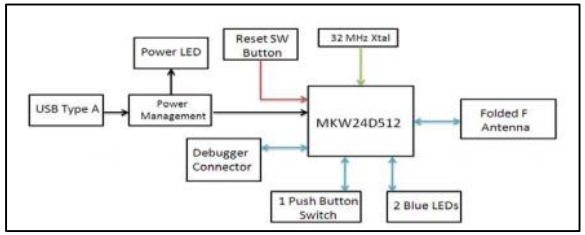
Coming soon

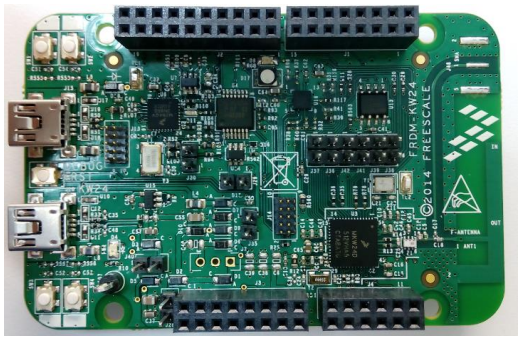
MKW2x evaluation boards

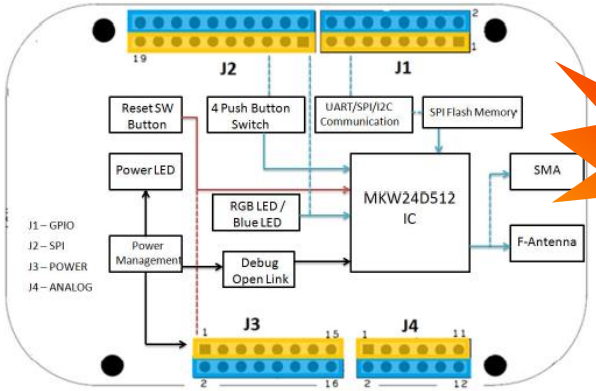
http://www.freescale.com/twr-kw2x



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







Coming soon

MCR20 High Performance 802.15.4 Transceiver

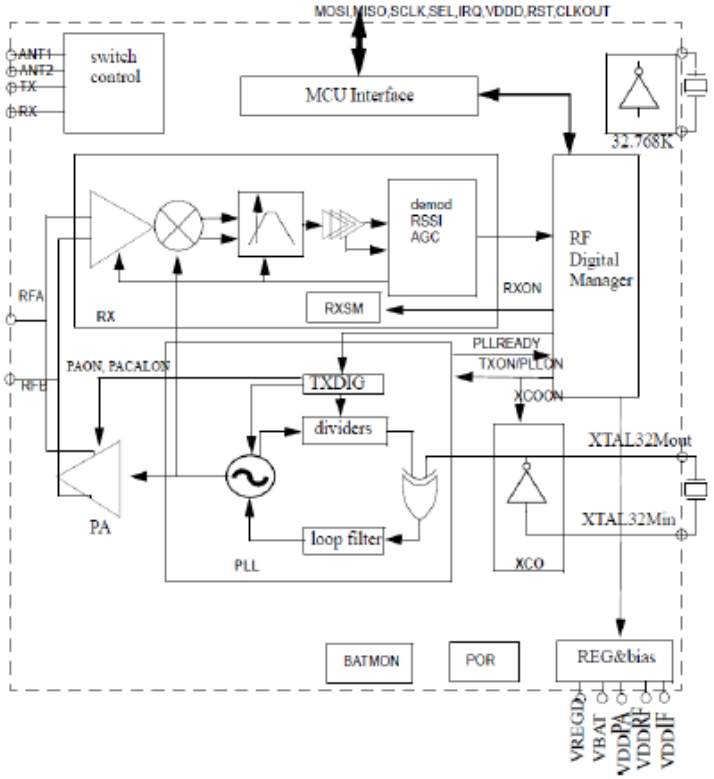
Coming soon

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

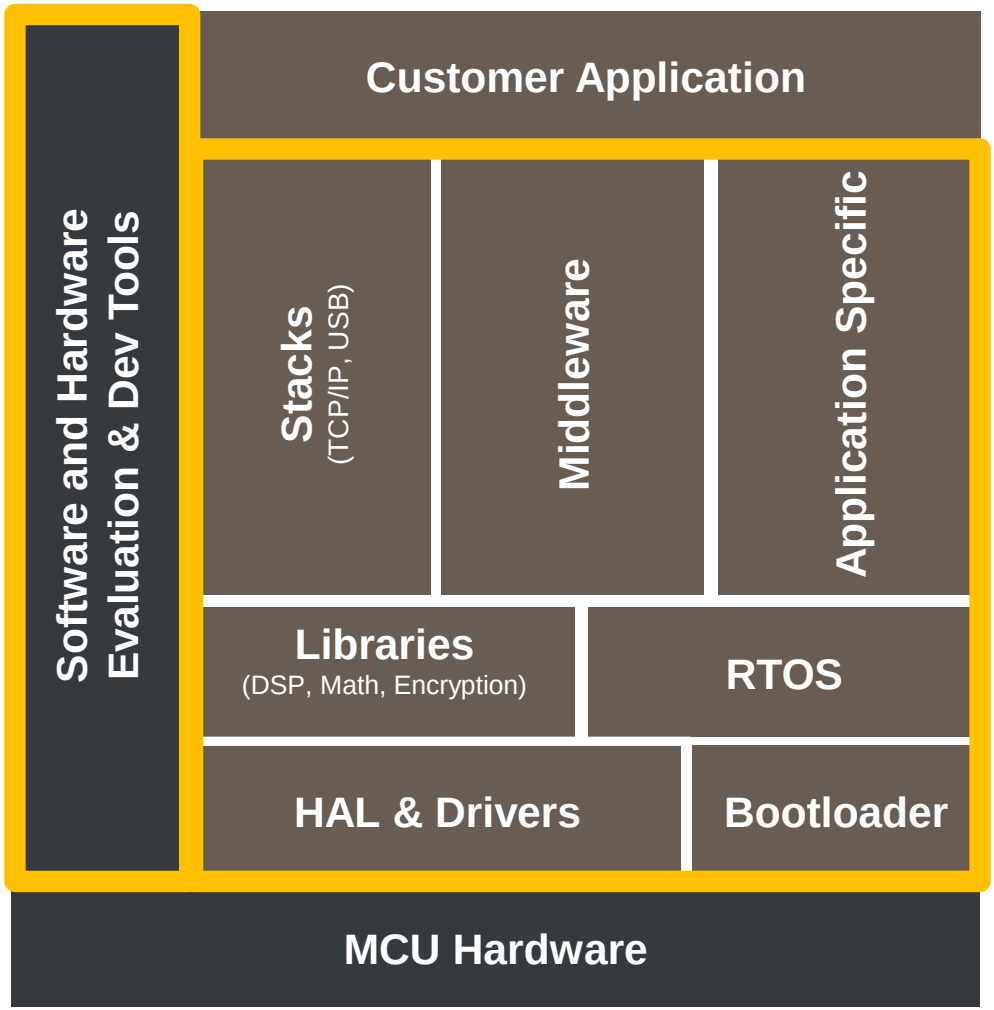
Average MCU Flash size grew x8 in the last decade

+

FIRMWARE now accounts for 83% of MCU implementation cost

+

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



Firmware is MCU developers **BIGGEST** pain point

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

Available Now

ZigBee Certified product

- **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

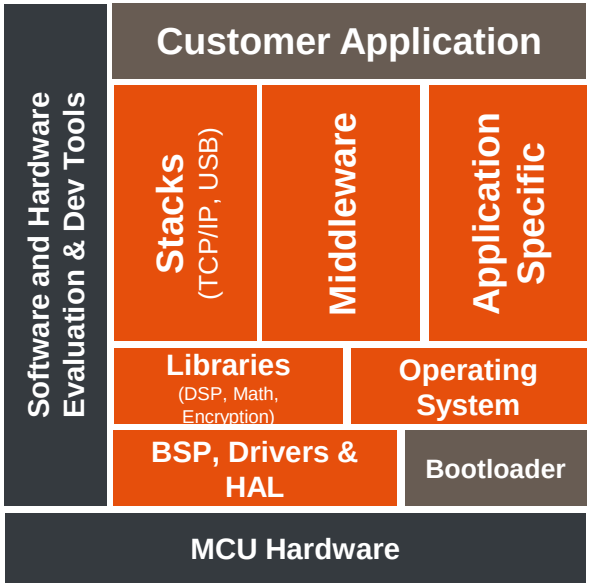
Coming soon

Kinetis Software Development Kit (SDK)

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



Open Source Initiative

CMSIS COMPLIANT ARM® Cortex™ Microcontroller Software Interface Standard

CERTIFIED USB

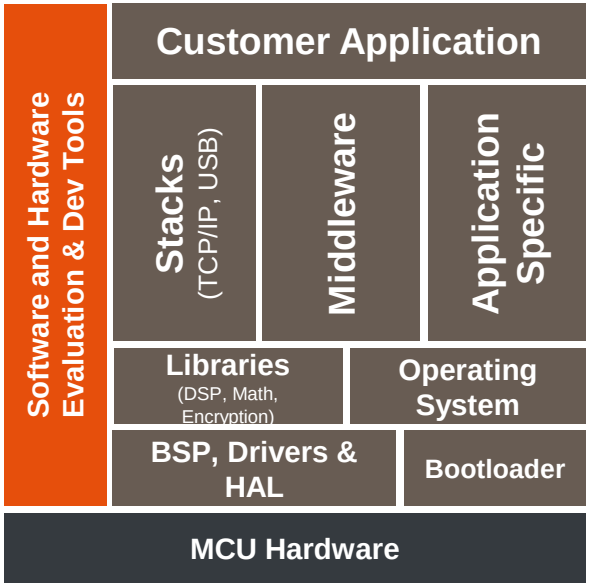
Product Features

- 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 and
- Support for multiple toolchains: GNU GCC, IAR, Keil, Atollic, and Kinetis Design Studio

Kinetis Design Studio

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

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



freescale™ Kinetis Design Studio

Product Features

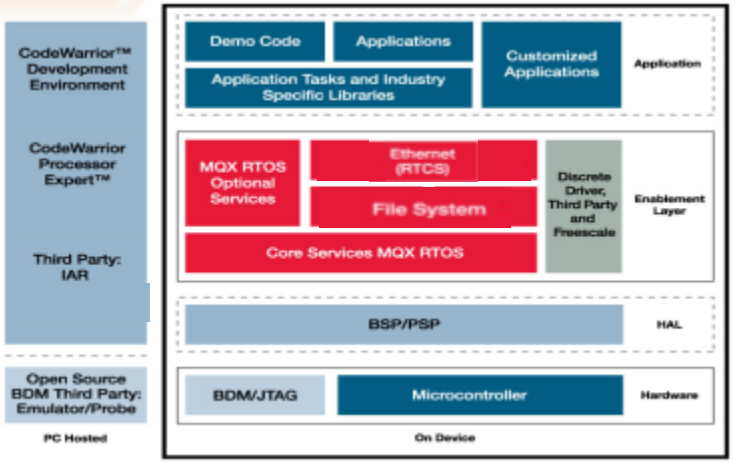
- A free of charge and unlimited IDE for Kinetis MCUs
- A basic IDE that offers robust editing, compiling and debugging
- Based on Eclipse, GCC, GDB and other open-source technologies
- Includes Processor Expert (PEx) with Kinetis SDK integration
  - Supports all existing Kinetis devices via PEx and 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 straight-forward fine-tuning of features
    - Production source code provided
  - **Similar to other "pay-for" software OS**

Software integration headache

$95K of free Software

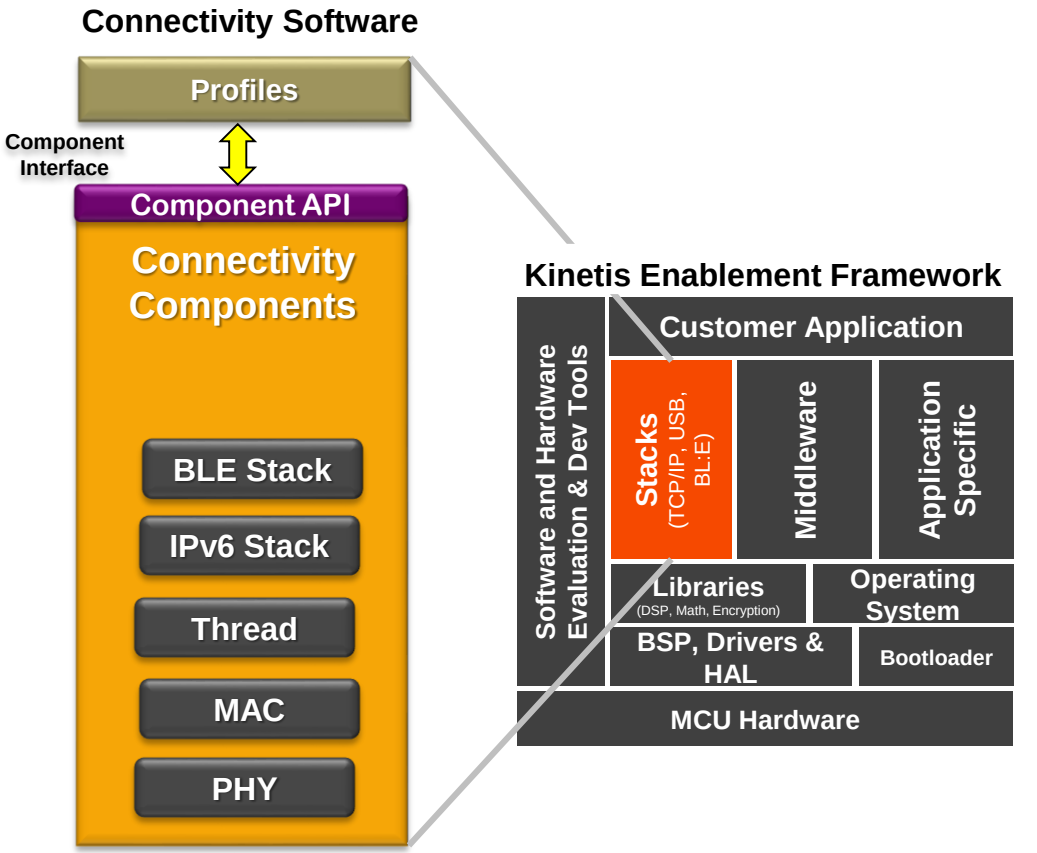


THREADX NUCLEUS Green Hills SOFTWARE INC.

✓Stable
✓Upgradable
✓Easy to maintain

Wireless Connectivity Enablement Overview

Bringing our solutions closer to the customer



Development Hardware

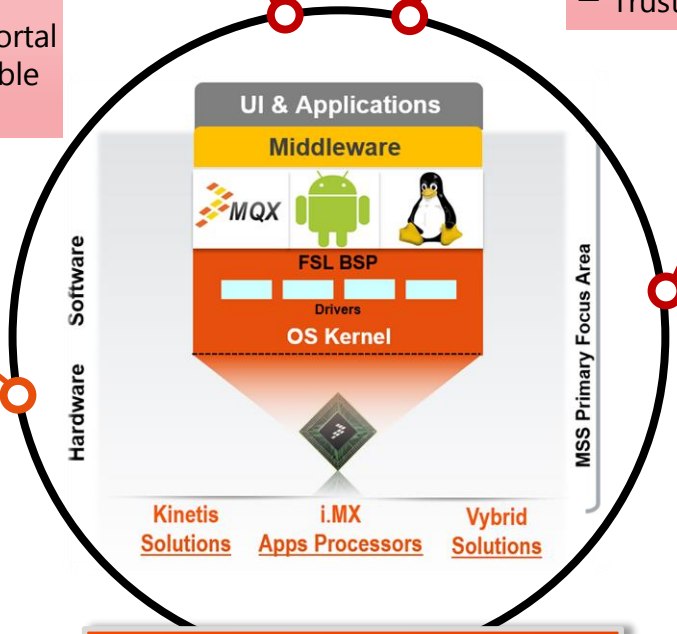
- Freedom Board
  - compatible with the overall Kinetis HW
  - easy solution proof of concept.
- USB dongle
  - Small form factor,
  - end nodes demonstration,
  - sniffer for easy of debugging)

Completely Seamless Solution delivered by Freescale

Support options in details

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



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

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 engagment
- Frozen branch services
- Application specific hardening

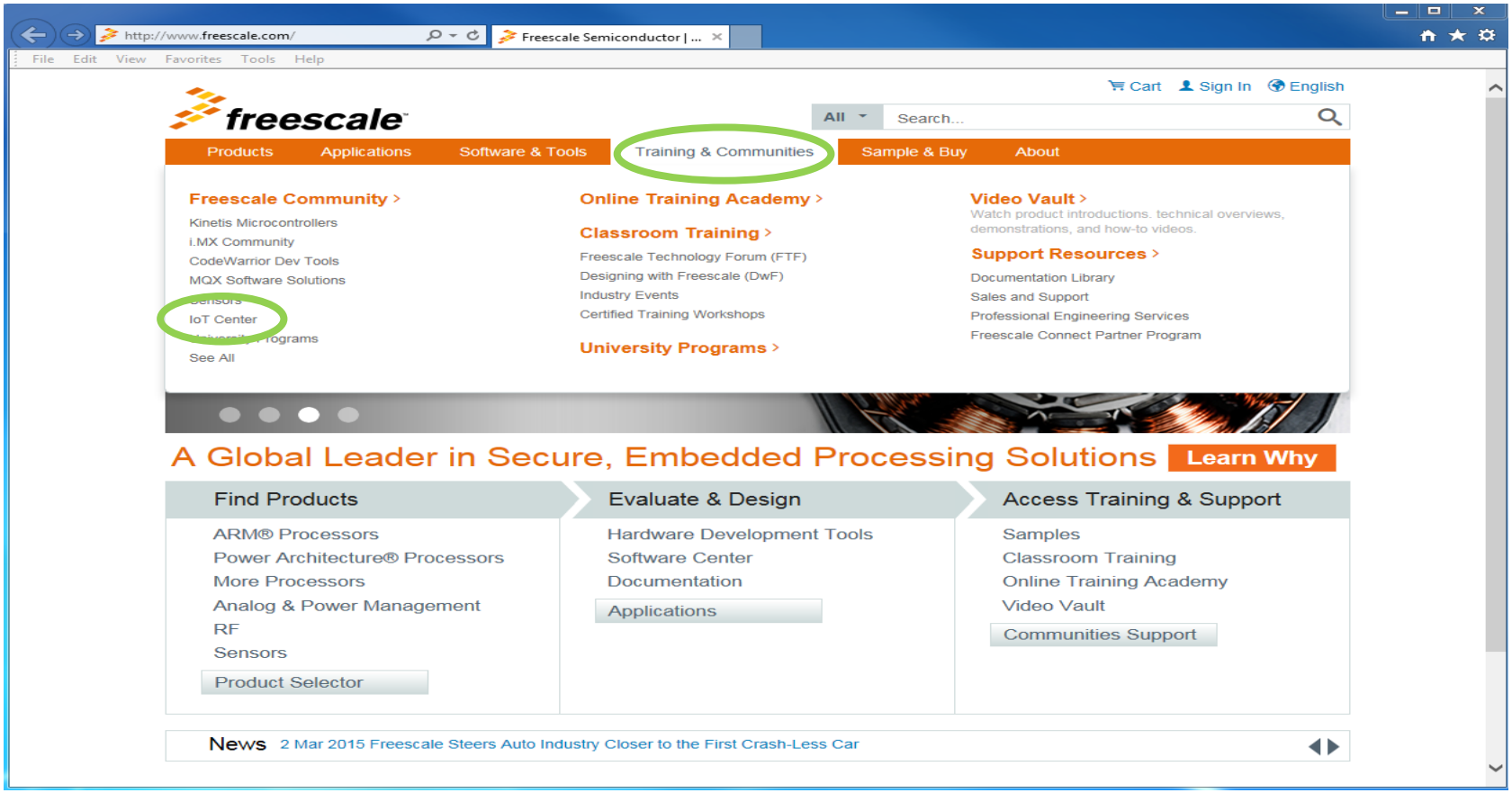
- **Reducing project risk**
- **Increasing team efficiency**
- **Securing time to market**

freescale™ Professional Services

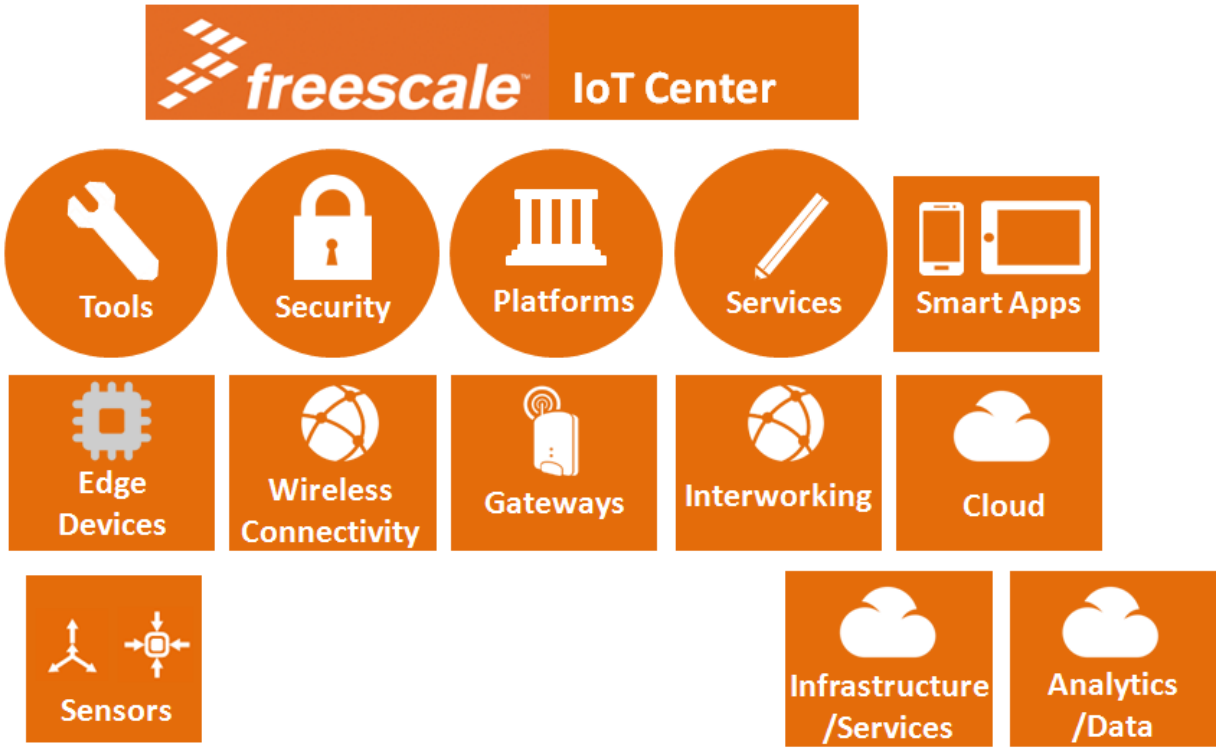
Managed by « **Program Managers** » and/or « **Triage Managers** »

IoT Center Community Website

- Where to find the IoT Center?
  - Training & Communities:
    - www.freescale.com/support
    - 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

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

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Q & A

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