From industrial Gateway to functional safety with TI Cortex based MCU

Texas Instruments Inc.

Nov, 2015

MCU Trends

Ultra-low power

- Pushing the limits of power consumption toward a world without batteries

Real-time control

- Enabling "green" end equipments that use less energy and operate more efficiently

Communications

- Connecting and automating home, building and industrial systems.

Security

- Securing data flow over all means of communication

Safety

- Bringing intelligence to safety-critical applications to prevent and protect

TEXAS INSTRUMENTS

Building a Stronger MCU Portfolio

Low Power MCUs

Performance MCUs

Ultra-low Power
Applications where the majority of device life in standby

Real-time Control
Applications needing low latency closed loop control

Low Power Performance
Mostly 'On' battery powered applications with significant computational requirements

Control + Automation
Exceeding real-time control platforms with Host Control & Industrial Communications

Security + Communications
Datalogging applications that securely over RF

Safety
Applications that require functional safety

Ultra-low power

Real-time control

Communications

Security

Safety

TEXAS INSTRUMENTS

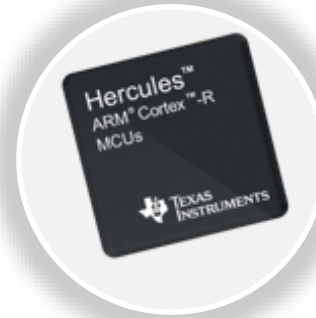# Texas Instruments MCU Portfolio

MSP Low-power MCUs

C2000™ Real-time control MCUs

Includes dual-core ARM+DSP MCUs

Hercules Safety ARM® Cortex™-R4 & Cortex-M3 MCUs

Tiva™ C Series ARM® Cortex™-M4F MCUs

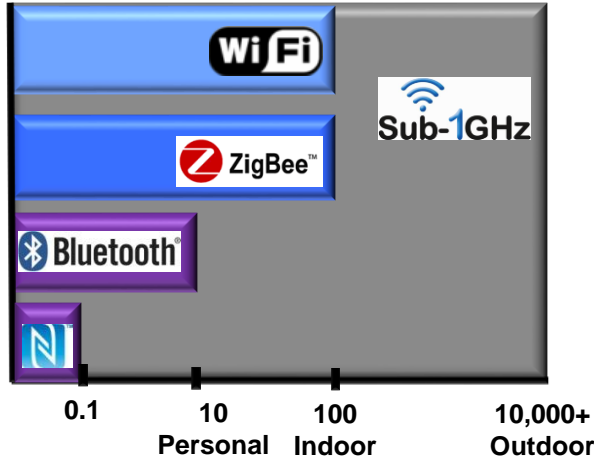*System expertise, integrated analog, software, tools, training and support*

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World's Broadest Portfolio

Wireless Connectivity Portfolio

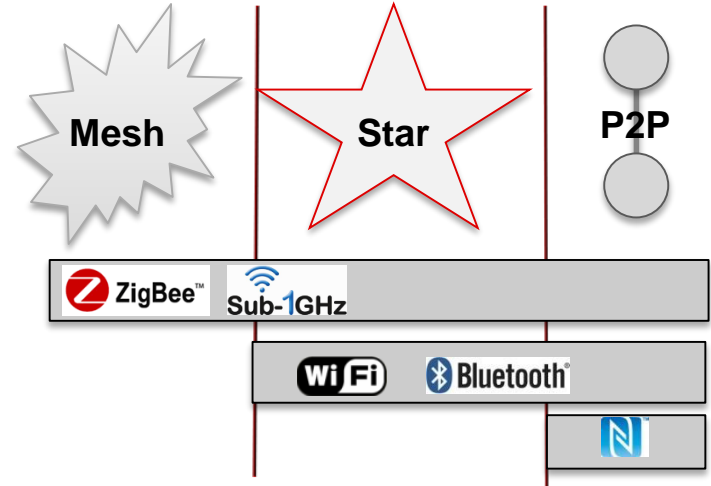| Proximity	Personal area networks		Local area networks			Wide area networks
NFC RFID *Identification*	*Bluetooth® Bluetooth* LE *Personal Connection*	Proprietary 2.4GHz *Customizable*	ZigBee RF4CE *Mesh*	6LoWPAN *IP Mesh*	Wi-Fi® *Existing Infrastructure*	Proprietary Sub-1GHz *Customizable*
Key Differences						
Up to 848Kbps No battery to coin cell	Up to 3Mbps Coin cell to AAA	Up to 1Mbps Coin cell	Up to 1Mbps AAA battery	Up to 1Mbps AAA battery	Up to 100Mbps AA battery	Up to 1Mbps Coin cell
Key Attributes						
• Low / no power • Diverse apps	• IOP • Large install base • In mobile devices	• Longest range • Customizable to application • Robust RF	• Standardized mesh • Large area coverage • Redundancy	• IPv6 stack • Ultra low power • IoT platform	• Existing infrastructure • High throughput	• Longest range • Customizable to application • Robust RF

cm   **Up to 100m**   **Range**   **km**

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Choosing the Right Technology for IOT

Range (m)
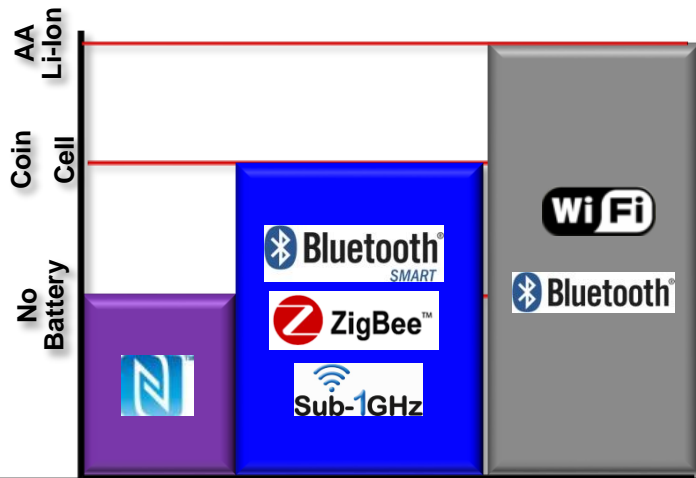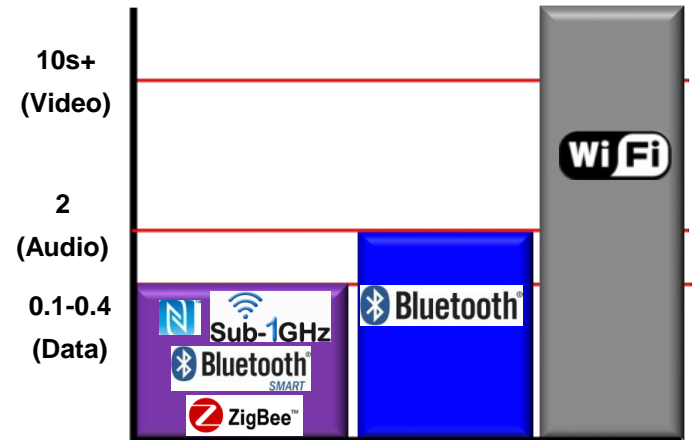
0.1	10	100	10,000+
	Personal	Indoor	Outdoor

Technologies: Wi-Fi, Sub-1GHz, ZigBee, Bluetooth, NFC

Topology

Mesh — Star — P2P

ZigBee, Sub-1GHz / Wi-Fi, Bluetooth / NFC

Power source

AA Li-Ion — Coin Cell — No Battery

Bluetooth SMART, ZigBee, Sub-1GHz / Wi-Fi, Bluetooth / NFC

Data Rate (Mbps)

- 10s+ (Video)
- 2 (Audio)
- 0.1-0.4 (Data)

NFC, Sub-1GHz, Bluetooth SMART, ZigBee / Bluetooth / Wi-Fi

TM4C Applications

Home, Building & Industrial Applications
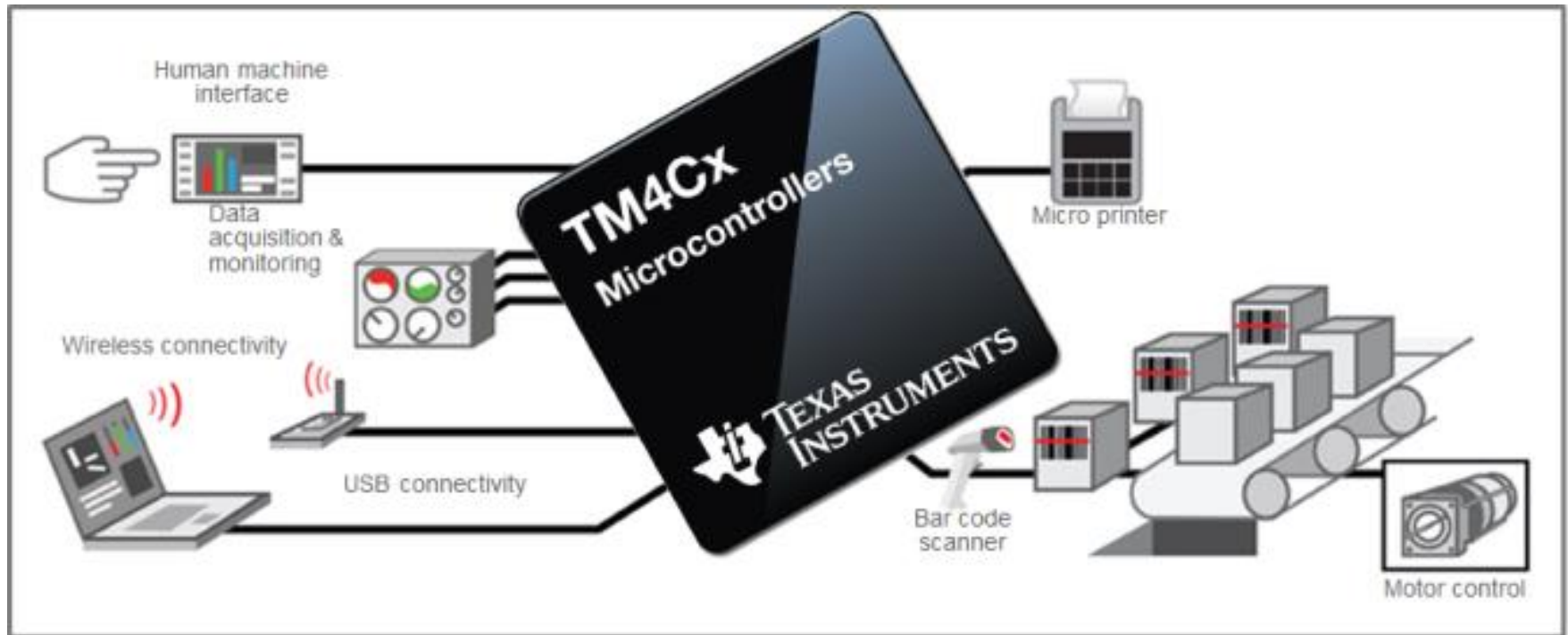
On-board peripherals for a myriad of connected applications

- Headroom for extended functionality
- Low power for portability
- Scalability for tailored product lines and extensibility
- Integration for cost-efficiency

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TM4C Series Microcontrollers – TM4C123x

Differentiation

- **Integrated floating-point core at +80MHz** — *provides higher performance*
- **High-performance analog integration**
- **TivaWare™ software** – *Enables easy migration to Cortex™-M4F capabilities for maximum code reuse*
- **Low power modes as low as 1.6µA**

Tools

EK-TM4C123GXL LaunchPad
Available Today!

$12.99 USD

DK-TM4C123 Development Kit
Available Today!

$149 USD

TM4C123x

Temperatures	85°C	105°C

ARM® Cortex™-M4F
Up to 80 MHz

FPU	MPU
NVIC	ETM	SWD/T

Memory
- Up to 256 KB Flash
- Up to 32 KB SRAM
- 2 KB EEPROM
- ROM

Power & Clocking
- Precision Oscillator
- RTC Battery-Backed Hibernate
- DMA (32 ch)

System Modules
- 6× 32-bit Timer/PWM/CCP
- 6× 64-bit Timer/PWM/CCP
- Systick Timer
- 2× Watchdog Timer

Debug
- Real-time JTAG

Control Peripherals
- 2× Quadrature Encoder Inputs
- 16x PWM Outputs

Comms Peripherals
- 8× UART
- 4× SSI/SPI
- 6× I²C
- 2× CAN
- USB Full Speed (Host/Device/OTG)

Analog
- 12ch, 1 S/H 12-bit 1 MSPS ADC
- 12ch, 1 S/H 12-bit 1 MSPS ADC
- LDO Voltage Regulator
- 3× Analog Comparators
- Temperature Sensor

Software

- **TivaWare for TM4C Series**– Integrated ROM, including peripheral driver libraries, boot loader, and check sum
- **Code Composer Studio™ IDE**
- **TI RTOS Support**
- **ARM 3rd Party Ecosystem**

Packages

- 168BGA
- 157BGA
- 64LQFP
- 100LQFP
- 144LQFP
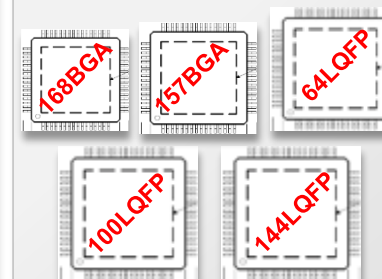
TM4C Series Microcontrollers – TM4C129x

Differentiation

- **Integrated floating-point core at +120MHz** — *provides higher performance*
- **Integrated 10/100 ENET MAC & PHY**
- **Integrated LCD controller**
- **Integrated data protection features**
- **High-performance analog integration**
- **TivaWare™ software** – *Enables easy migration to Cortex™-M4F capabilities for maximum code reuse*

Tools

Connected LaunchPad Evaluation Kit EK-TM4C1294XL
Available Today!

$19.99 USD MSRP
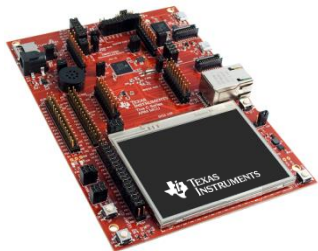
Connected Development Kit DK-TM4C129X
Available Today!

$199 USD MSRP

TM4C129x

Temperatures	85°C	105°C

ARM® Cortex™-M4F Up to 120 MHz

FPU	MPU
NVIC	ETM	SWD/T

Memory
- Up to 1 MB Flash
- Up to 256 KB SRAM
- 6 KB EEPROM
- ROM
- DMA (32 ch)

System Management
- 1-Wire (SW)

Debug
- Real-time JTAG

Power & Clocking
- Precision Oscillator
- RTC Battery-Backed Hibernate

System Modules
- 8× 32-bit Timer/PWM/CCP
- EPI
- LCD
- Systick Timer
- 2× Watchdog Timer

Control Peripherals
- 8× MC PWM
- Quadrature Encoder Inputs

Data Protection
- 4x Tamper Inputs
- CRC Accelerator
- AES, DES, SHA & MD5 Accelerators

Comms Peripherals
- 8× UART
- 4× QSSI/SPI
- 10× I²C
- 2× CAN
- 10/100 Ethernet MAC / PHY (IEEE 1588)
- USB Full/High Speed (Host/Device/OTG)

Analog
- 2x 12ch, 12-bit ADCs up to 2 MSPS
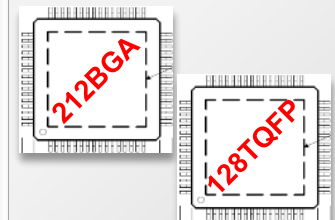- LDO Voltage Regulator
- 3× Analog Comparators

Packages
- 212-BGA (10x10x1, 0.5)
- 128-TQFP (16x16x1.2, 0.4)

Software

- **TivaWare for TM4C Series, Sensor Lib** – Integrated ROM, including peripheral driver libraries, boot loader, and check sum
- **Code Composer Studio™ IDE**
- **TI RTOS Support**
- **ARM 3rd Party Ecosystem**

Packages

212BGA

128TQFP

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TM4C: Focused on Differentiated IP

C Series
Connected

10/100 Ethernet w/ PHY

10/100 Mbps Ethernet Media Access Control (MAC) and Physical (PHY) layers. Including hardware assist for IEEE1588 Precision Time Protocol (PTP) support.

SH **Sensor Hub**

Technology combines data from multiple sensors—accelerometer, gyroscope and magnetometer—to deliver accurate, real-time, motion-related information.

Dual CAN

CAN bus is a message-based protocol, designed specifically for automotive applications but now also used in other areas such as aerospace, industrial automation and medical equipment.
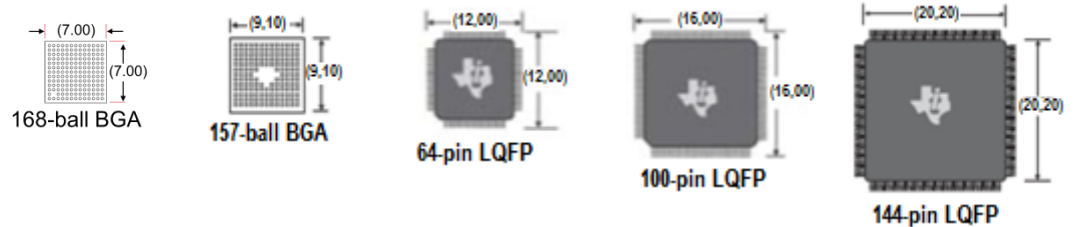
USB 2.0 Host/Device/OTG + PHY

Full-speed USB 2.0 OTG/Host/Device. Supports control, interrupt and bulk transfers of 12 Mbps.

TM4Cx Microcontrollers

Texas Instruments

Connect, Communicate Control

- Connecting and automating home, building and industrial systems.
- Sensor hub for consumer and industrial
- Motion control

TM4C series	Benefits
TM4C123x	Rich Connectivity Options w/ Sensor Hub & USB

(7.00) (7.00) 168-ball BGA
(9,10) (9,10) 157-ball BGA
(12,00) (12,00) 64-pin LQFP
(16,00) (16,00) 100-pin LQFP
(20,20) (20,20) 144-pin LQFP

TM4C series	Benefits
TM4C129x	Ethernet MAC+PHY, Hardware Encryption, Tamper, USB High-speed, External memory interface, LCD

(10,00) (10,00) 212-ball nfBGA
(16,00) (16,00) 128-pin TQFP

How do things connect to the IoT ?

Via IoT Gateways

Internet

Internet Router

IoT Agent
IoT Gateway

ZigBee Node | BLE Node | Wired Node

Sensors & Actuators

Directly - IoT Nodes

Internet

Internet Router

IoT Agent
Wi-Fi Node

IoT Agent
Ethernet Node
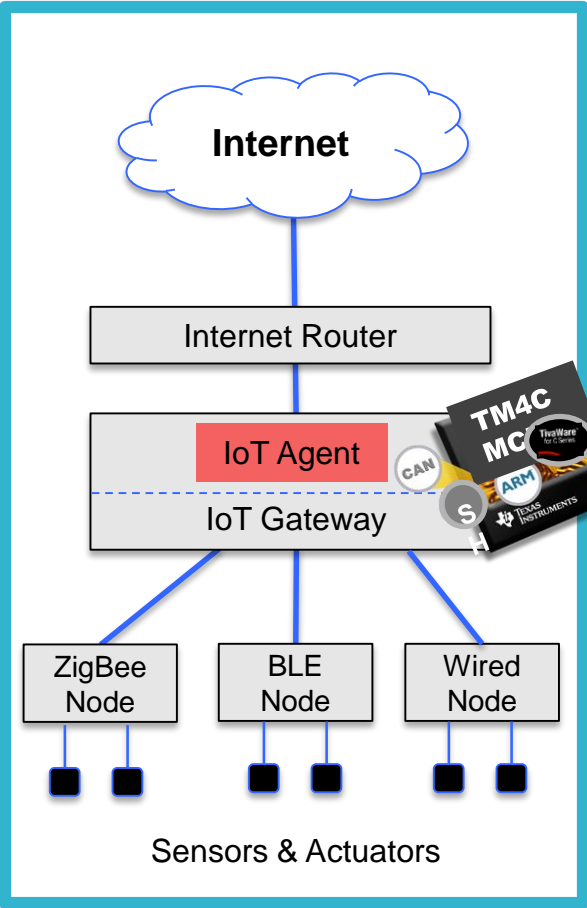
Sensors & Actuators

Directly - Lite IoT Nodes

Internet

Internet Router
6LoWPAN Edge Router

IoT Agent
6LoWPAN Node

IoT Agent
6LoWPAN Node

Sensors & Actuators

TM4C MC
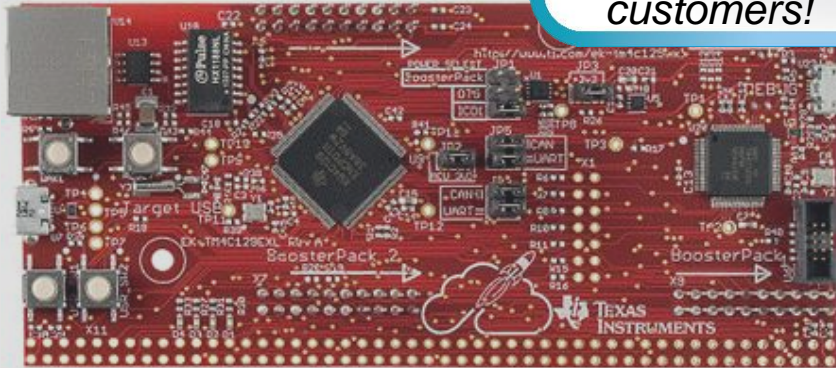TivaWare for C Series
CAN
USB
ARM
S H
TEXAS INSTRUMENTS
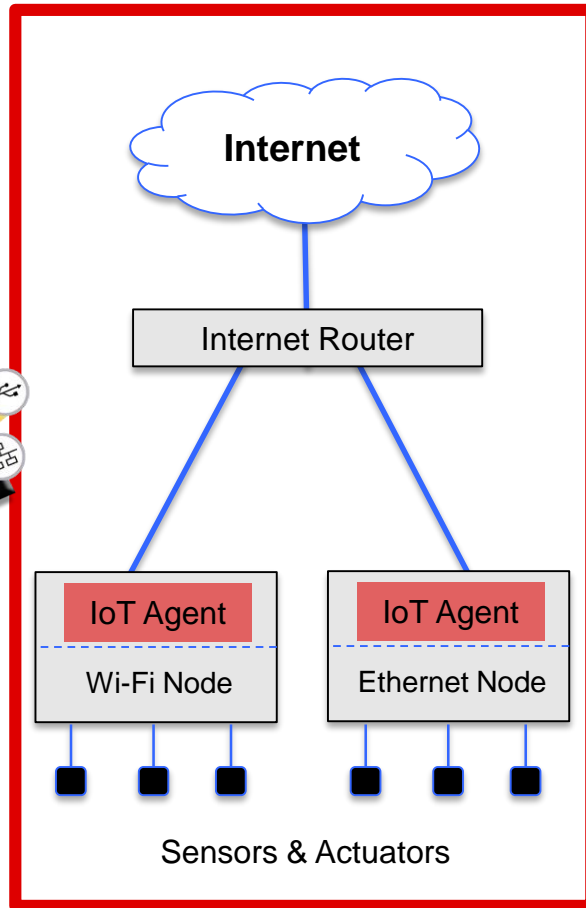
TEXAS INSTRUMENTS
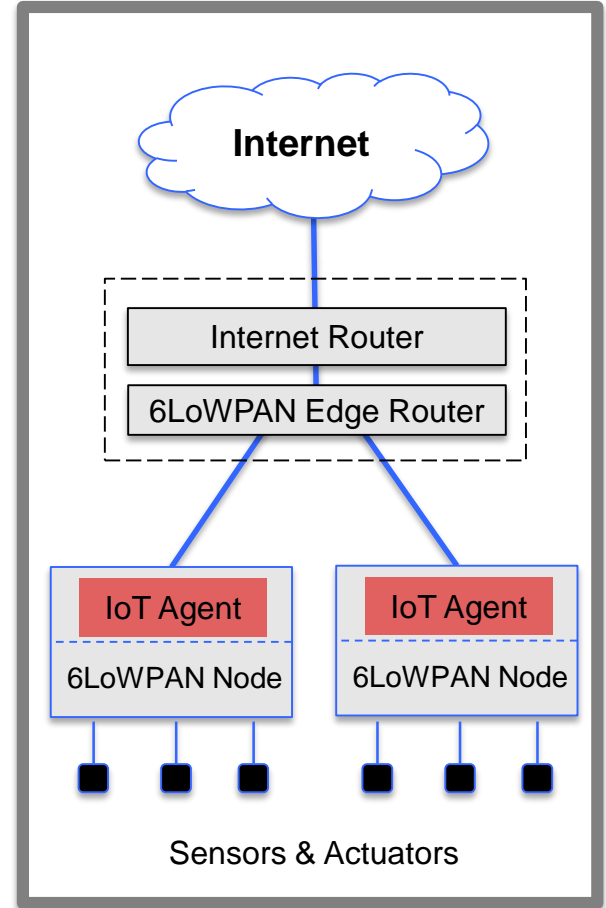
TM4C Connected LaunchPad

Evaluation Kit
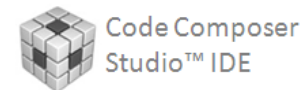EK-TM4C1294XL

Connect with end customers!
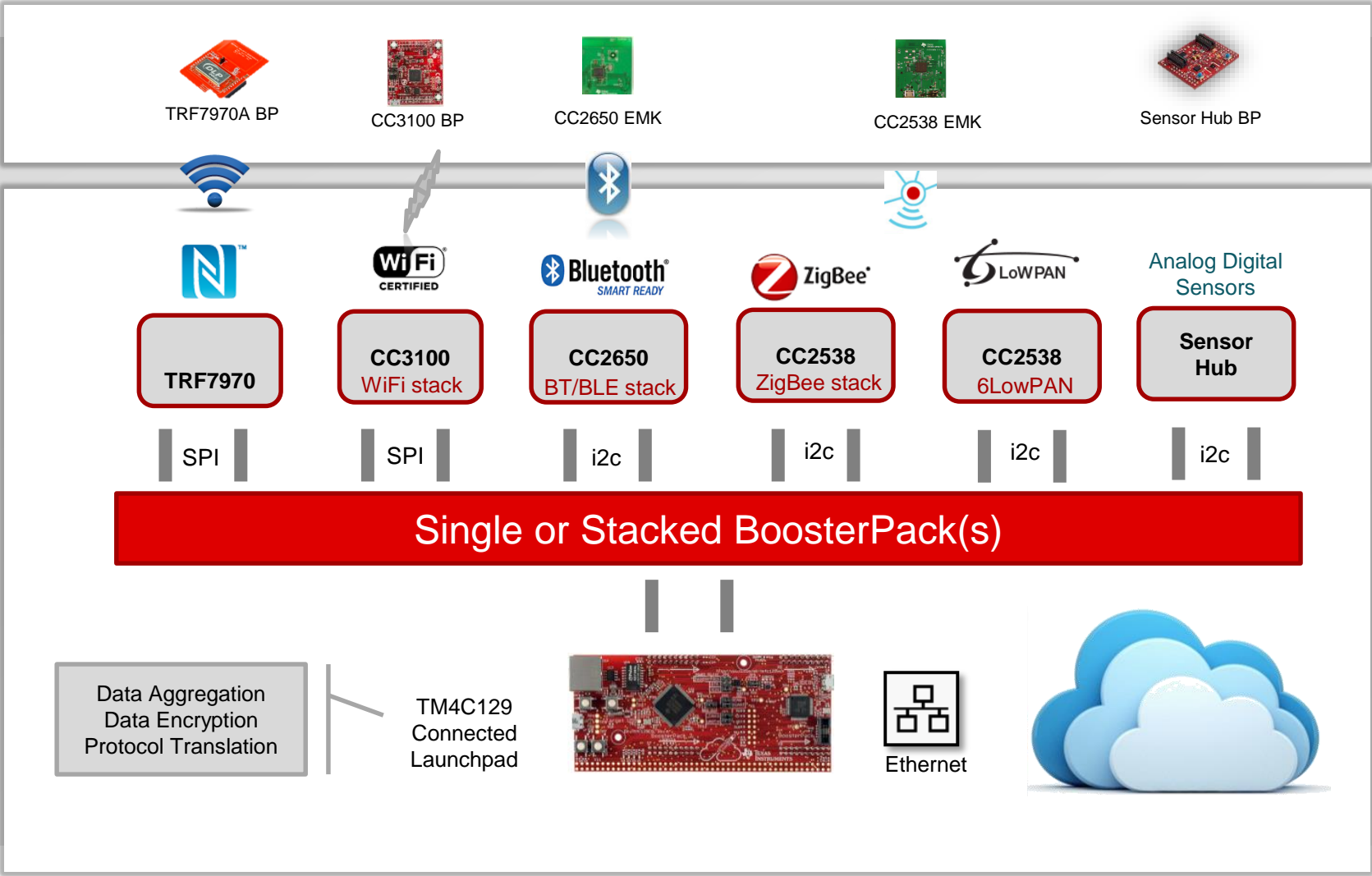

Based on TM4C Series TM4C1294NCPDTI

- 120 MHz ARM® Cortex™-M4F CPU
- 1MB Flash | 256K SRAM | 6K EEPROM
- 8x32-bit timers (16x16-bit), plus SysTick & WDGs
- 10 I²C, 8 UART, 4 QSPI, 2 CAN, EPI, USB FS | HS
- CRC accelerator, Tamper inputs, Data protection
- 10/100 Ethernet MAC & PHY
- 128 TQFP w/ up to 90 GPIOs

- RJ45 Ethernet jack
- Dual BoosterPack XL connection sites
- USB Host | Device | OTG port
- I/O connection grid (board interconnect)
- User buttons & LEDs, reset switch & power indicator LED
- In-Circuit Debug Interface (ICDI)
- Tool chains: CCS, Keil, IAR, Mentor & GCC
- TivaWare DriverLib under TI BSD-style license
- MSRP $19.99 USD

Code Composer Studio™ IDE

IAR SYSTEMS

mentor embedded

KEIL Tools by ARM

GCC

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TM4C129 IOT Gateway Concept

Development Tools & IDEs

Tool Chain ->	mentor embedded	IAR SYSTEMS	ARM KEIL An ARM Company	Code Composer Studio™ IDE
Eval Kit License	30-day full function. Upgradeable.	32KB address-limited or 30-day full function. Upgradeable.	32KB address-limited. Upgradeable.	Full functional; locked to board. Upgradeable.
Compiler	GNU C/C++	IAR C/C++	RealView C/C++	TI ARM Compiler
Debugger / IDE	gdb / Eclipse	C-SPY / Embedded Workbench	µVision	CCStudio / Eclipse
Full Upgrade (indicative only, please refer to vendor's website)	US$ 399 personal edition, US$ 3000 USD professional edition	US$ 4000 full for CM4 devices, US$ 3300 256KB address limited	US$ 5200 full for CM4 devices	US$ 445 (node locked single user), or US$ 79 with XDS100 limited time only!
JTAG Debugger	On-board ICDI	I-jet, J-Link, J-Trace, JTAG-Jet	Ulink-Me, UlinkPro, J-Link ARM	TI XDS100 and On-board ICDI

TM4C Middleware & Protocol Partners

- ThreadX Real-Time RTOS
- Supported in CCS & IAR
- NetX IPv4 & IPv6 Protocol & Security Stacks
- TM4C129x is among the first devices with GUI-X builder and runtime support

- embOS Real-Time RTOS
- Supported in CCS & IAR
- emWin GUI Library ported to TM4C129x with full support in PC GUI Builder Tools
- embOS/IP IPv4 & IPv6 Protocol Stacks

Ready Start™

- Nucleus RTOS
- Supported in CCS & CodeBench
- Nucleus Net IPv4 & IPv6 Protocol & Security
- Industrial EE Examples tailored to Tiva C HW

- RTX CMSIS Compliant RTOS
- Supported in Keil MDK Professional Version
- TCP/IP, USB, CAN, File and GUI (emWIN)
- Full CMSIS Platform Support

- Unison RTOS with POSIX compliant API
- Supported in CCS, IAR, Keil-RV & CodeBench
- Robust IPv4 & IPv6 Protocol & Security Stacks
- Complete IoT & M2M Examples on TM4C HW
- Wireless: WiFi, BT (Classic), BTLE (Smart), 6loWPAN, Zigbee, Cellular (2G, 3G, 4G), UHF

TI-RTOS & NDK

- Real-Time RTOS fully supported in CCS
- Support for IAR coming soon
- Robust IPv4 & IPv6 Protocol Stacks
- Created for MPU platforms, now optimized for MCUs

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TivaWare™ for C Series Features

Peripheral Driver Library

- High-level API interface to complete peripheral set
- License & royalty free use for TI Cortex-M parts
- Available as object library and as source code
- Programmed into the on-chip ROM

USB Stacks and Examples

- USB Device and Embedded Host compliant
- Device, Host, OTG and Windows-side examples
- Free VID/PID sharing program

Extras

- Wireless protocols
- IQ math examples
- Bootloaders
- Windows side applications
- Open Source TCP/IP Stacks – Micro IP (uIP) and Light-weight IP (lwIP)

Ethernet

- lwip and µip stacks with 1588 PTP modifications
- Extensive examples

Graphics Library

- Graphics primitive and widgets
- 53 fonts plus Asian and Cyrillic
- Graphics utility tools

Sensor Library

- An interrupt driven I^2C master driver for handling I^2C transfers
- A set of drivers for I^2C connected sensors
- A set of routines for common sensor operations
- Three layers: Transport, Sensor and Processing

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TM4C IoT Out-of-Box Experience Partner

Enabling rapid prototyping w/ LaunchPads + BoosterPacks

Your creations connected to the cloud with Exosite

EXOSITE
Cloud Service Provider
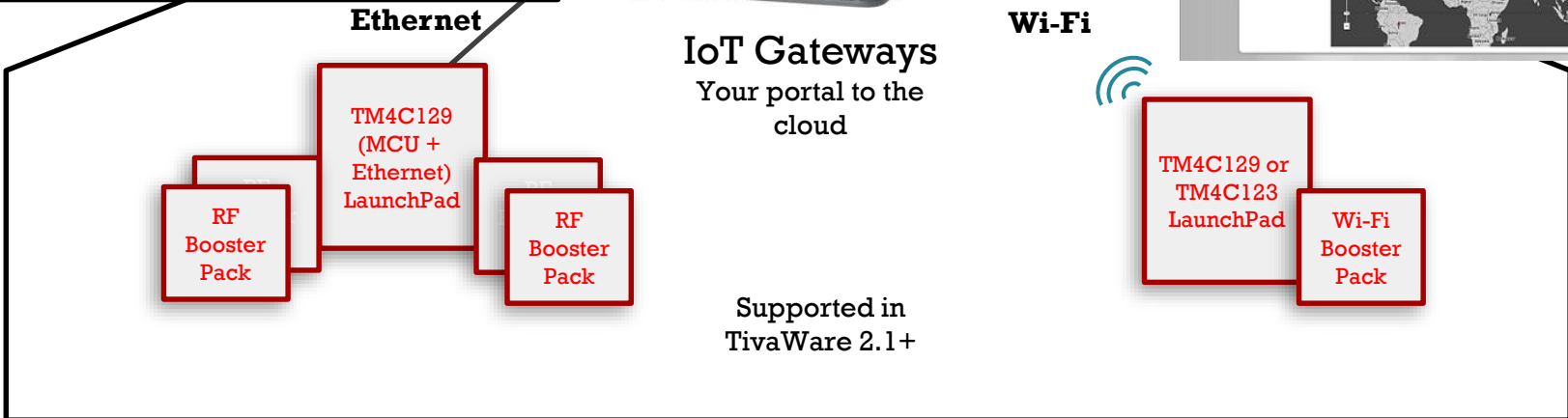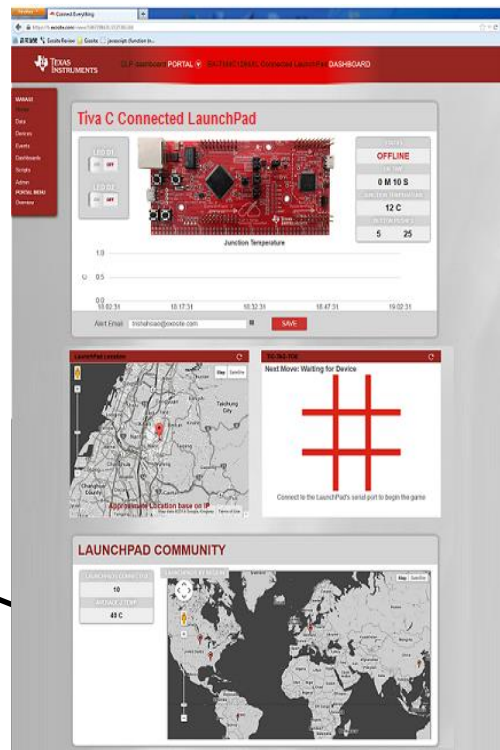
Widgets
Alerts
Scripts
SMS
Mobile
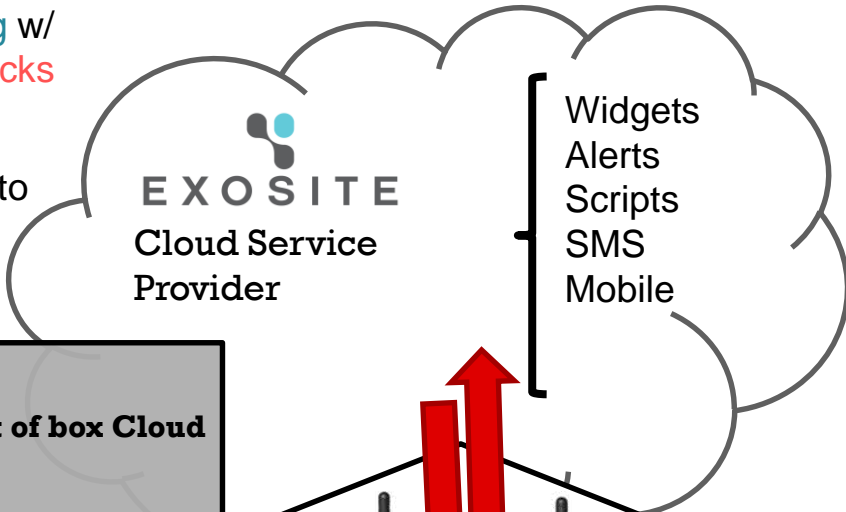
TI Branded Seamless out of box Cloud experience:
- Low-cost hardware
- Link into Exosite Cloud within minutes
- iOS/Android app for interfacing with your cloud-connected platform

Ethernet

Wi-Fi

IoT Gateways
Your portal to the cloud

RF Booster Pack

TM4C129 (MCU + Ethernet) LaunchPad

RF Booster Pack

TM4C129 or TM4C123 LaunchPad

Wi-Fi Booster Pack

Supported in TivaWare 2.1+

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Our Commitment to Your Success!

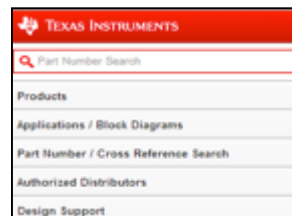|			
TI'sCutting Edge 65nm Technology	**State of Art Software Libraries**	**Scalable Evaluation Platform & Kits**	**Vast Ecosystem of IDE & Tools**
	TivaWare™ For TM4C		
Support & Training	**Documentation**	**Web Resources**	**Global Presence**

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