Internet of Things: TI's Wireless Connectivity Solutions

TEXAS INSTRUMENTS

Why the IoT is attractive

Market Size (units)

- 10B+
- 1B
- 0.1B

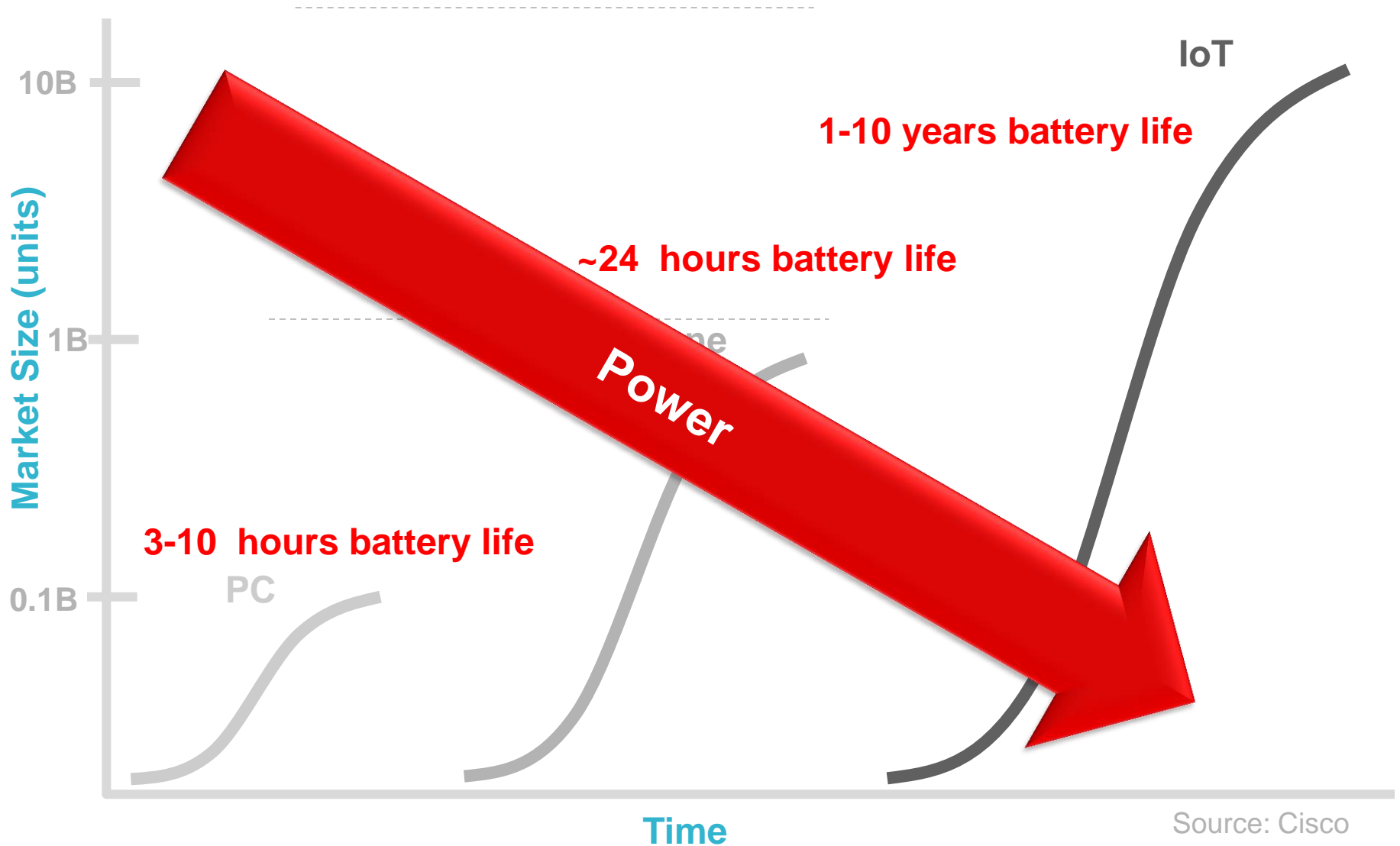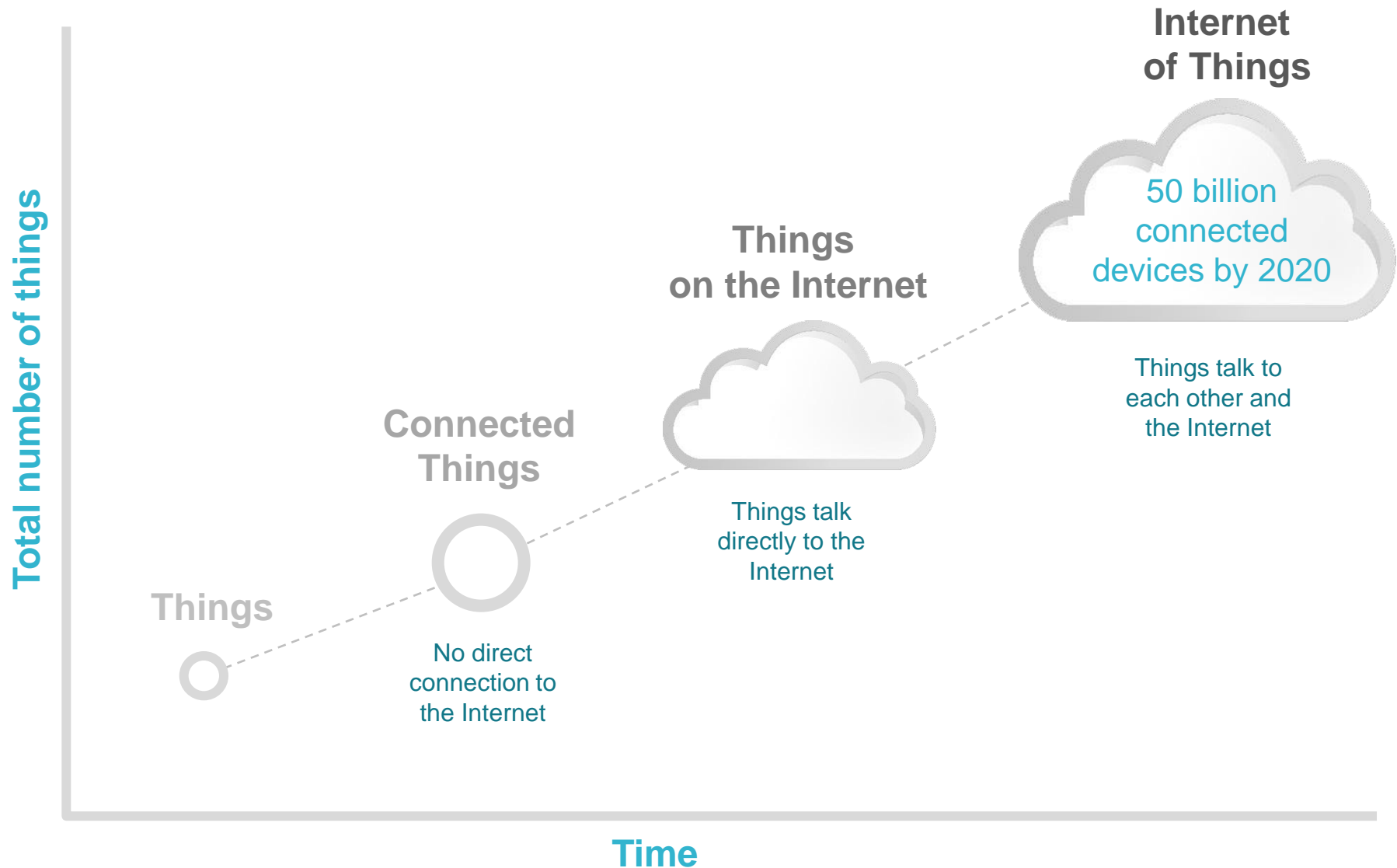The IoT is an enabling technology that will serve thousands of end products

PC

Cell phone

IoT

Time

Source: Cisco

TEXAS INSTRUMENTS
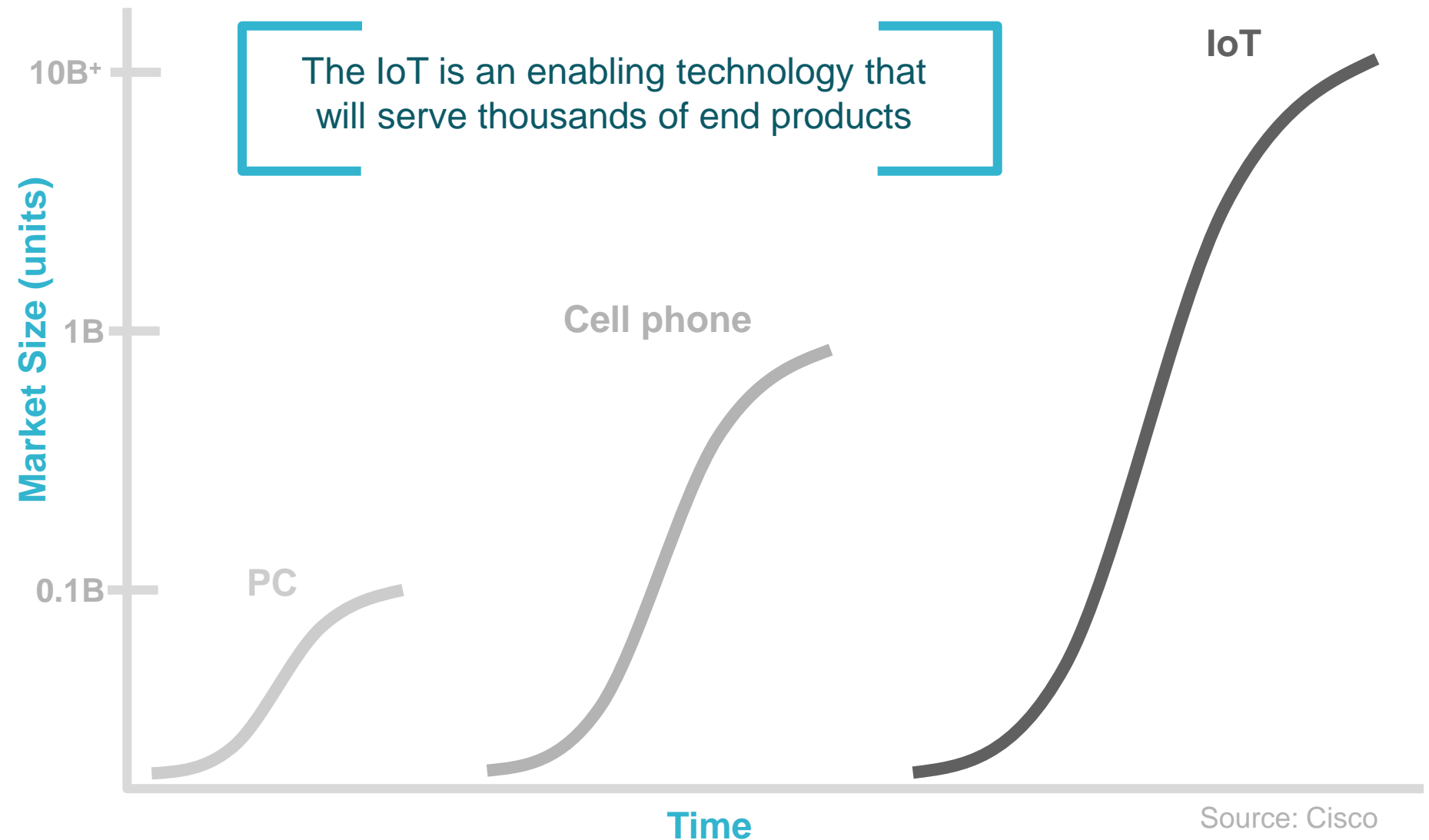
IoT – Connectivity at the heart

Market Size (units)

- 10B
- 1B
- 0.1B

IoT

Cell phone

PC

- Connectivity is at the heart of the IoT
- Wireless solutions will lead over time
- No one standard likely to win

- Ethernet
- WiFi
- BT

- 4G
- WiFi
- BLE

- BLE
- WiFi
- 6LoWPAN
- <1GHz
- Zigbee
- Ethernet
- PLC
- 2G-4G

Time

Source: Cisco

IoT – Power is key

Market Size (units)

- 10B
- 1B
- 0.1B

IoT

1-10 years battery life

~24 hours battery life

Power

3-10 hours battery life

PC

Time

Source: Cisco

TEXAS INSTRUMENTS

The Evolution of the IoT

Total number of things (y-axis)

Time (x-axis)

Things

Connected Things
No direct connection to the Internet

Things on the Internet
Things talk directly to the Internet

Internet of Things
50 billion connected devices by 2020
Things talk to each other and the Internet

The IoT will impact all segments

Industrial

Auto

Fitness and Healthcare

Home

How the IoT works
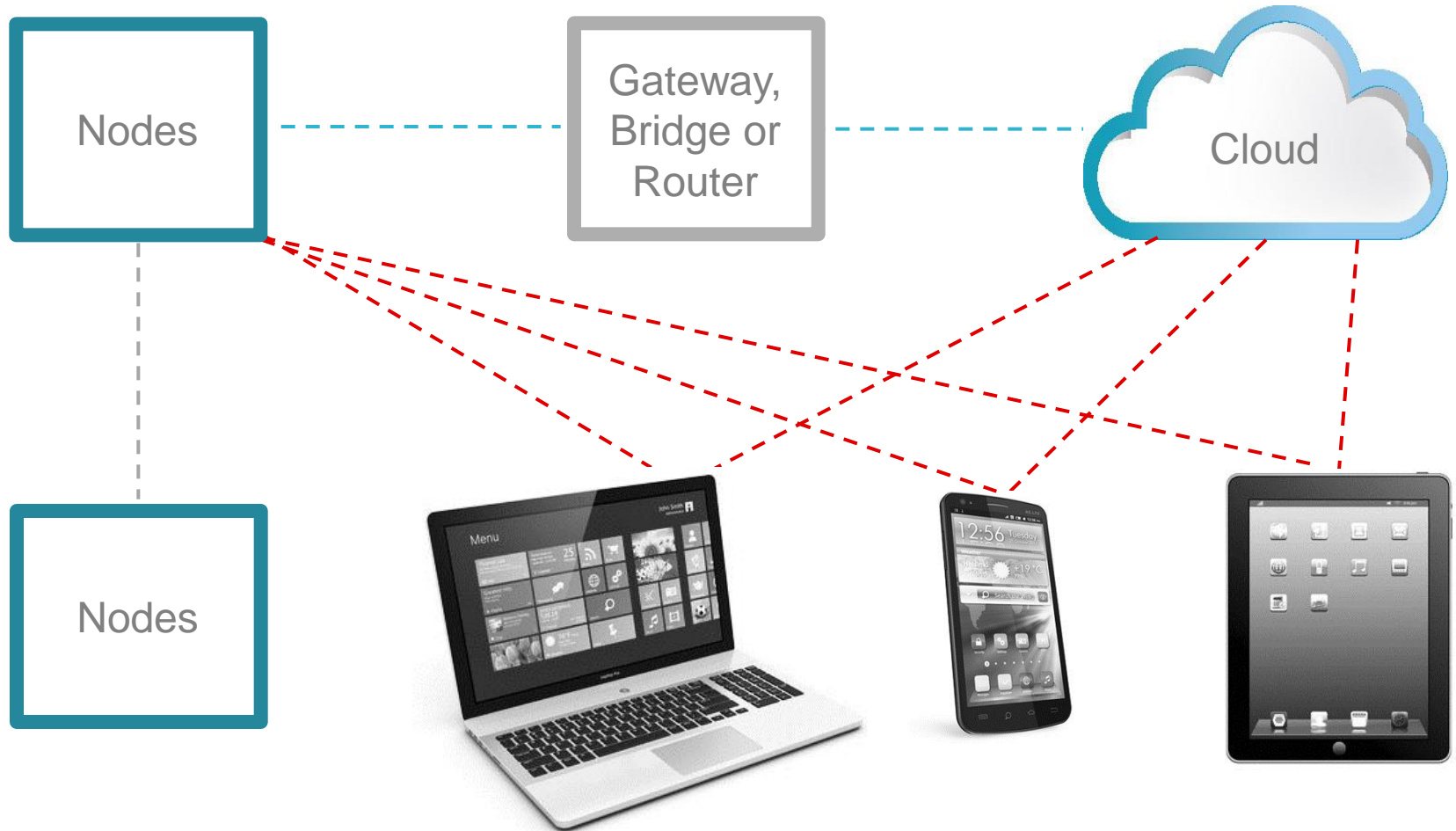
Only TI has all the IoT building blocks

Nodes

- MCUs
- Processors
- Wired & Wireless Connectivity
- Sensors
- Analog Signal Chain
- Power Management

Gateway, Bridge or Router

- MCUs
- Processors
- Wired & Wireless Connectivity
- Analog Signal Chain
- Power Management

Cloud

- Multicore Processors
- Analog Signal Chain
- Power Management

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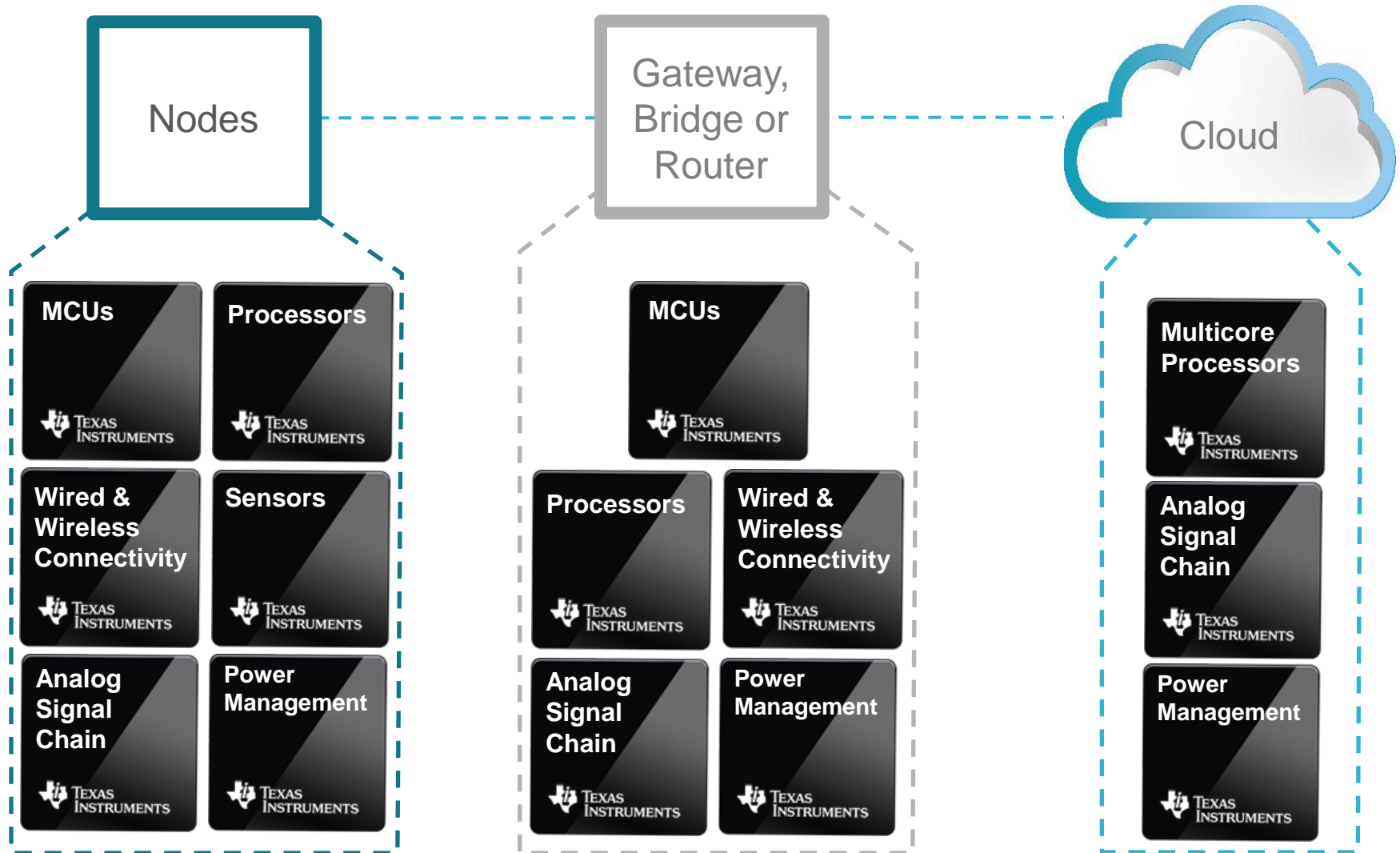
IoT – The United Nations of connectivity

CHALLENGE

Connectivity:
One size doesn't fit all

WHAT IS NEEDED

Broad variety of wired or wireless standards

TI DELIVERS

ZigBee™
- Low power mesh network
- Smart metering & lighting
- Moving into home automation

Sub-1GHz Low Power, Robustness, Long Range
- Low power & long range
- Proprietary & open protocols
- Metering, security systems

WiFi®
- Fast – 10Mbps++
- Direct Internet connection
- Home & enterprise apps

Bluetooth® SMART
- Lowest power
- Connect to tablet/phone
- Moving to industrial, automotive

PRIME ALLIANCE / G3-PLC Alliance
- Data over power lines (OFDM)
- Developed for smart grid
- Lighting, solar, appliances

EtherCAT® ETHERNET
- Fast, low latency Ethernet
- Real-time industrial control
- Information technology

NFC   RFid™   *Bluetooth®*   *IEEE P1901.2*   ANT+   RF4CE

GPS   *2.4GHz*   6LoWPAN   EtherNet/IP™   PurePath™ Wireless Audio   *IEEE 802.15.4*

TEXAS INSTRUMENTS

System-level approach to power is required

Power is critical

The lowest power solutions for any application

TI DELIVERS

Technology for billions of battery- or harvested-powered devices

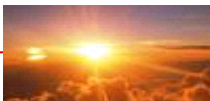| Power management & precision analog ICs	Low-power microcontrollers	Low-power wireless connectivity

MSP430™ MCUs   Tiva™C Series MCUs

Wi-Fi   Bluetooth   ZigBee   Sub-1 GHz

Harvesting power and stretching battery life

Light   Vibration   Thermal   RF

TEXAS INSTRUMENTS

Security vital at all layers

Security is a must

Built-in hardware security technology

TI DELIVERS

Security solutions to prevent, detect and respond to unintended or malicious behavior

Hardware	**Software**	**Connectivity**	
Symmetric cryptography	Authentication & anti-cloning	IP protection	Tamper protection

Protecting manufacturers' and consumers' devices, solutions and services

TEXAS INSTRUMENTS

The IoT must be easy

Complexity

**IoT solutions for everyone,
not just experts**

TI DELIVERS

Solutions that are making the IoT easy for manufacturers and consumers

**Manufacturers:
Easy to develop and add to designs**

- Simplified RF

- Easier Internet connectivity
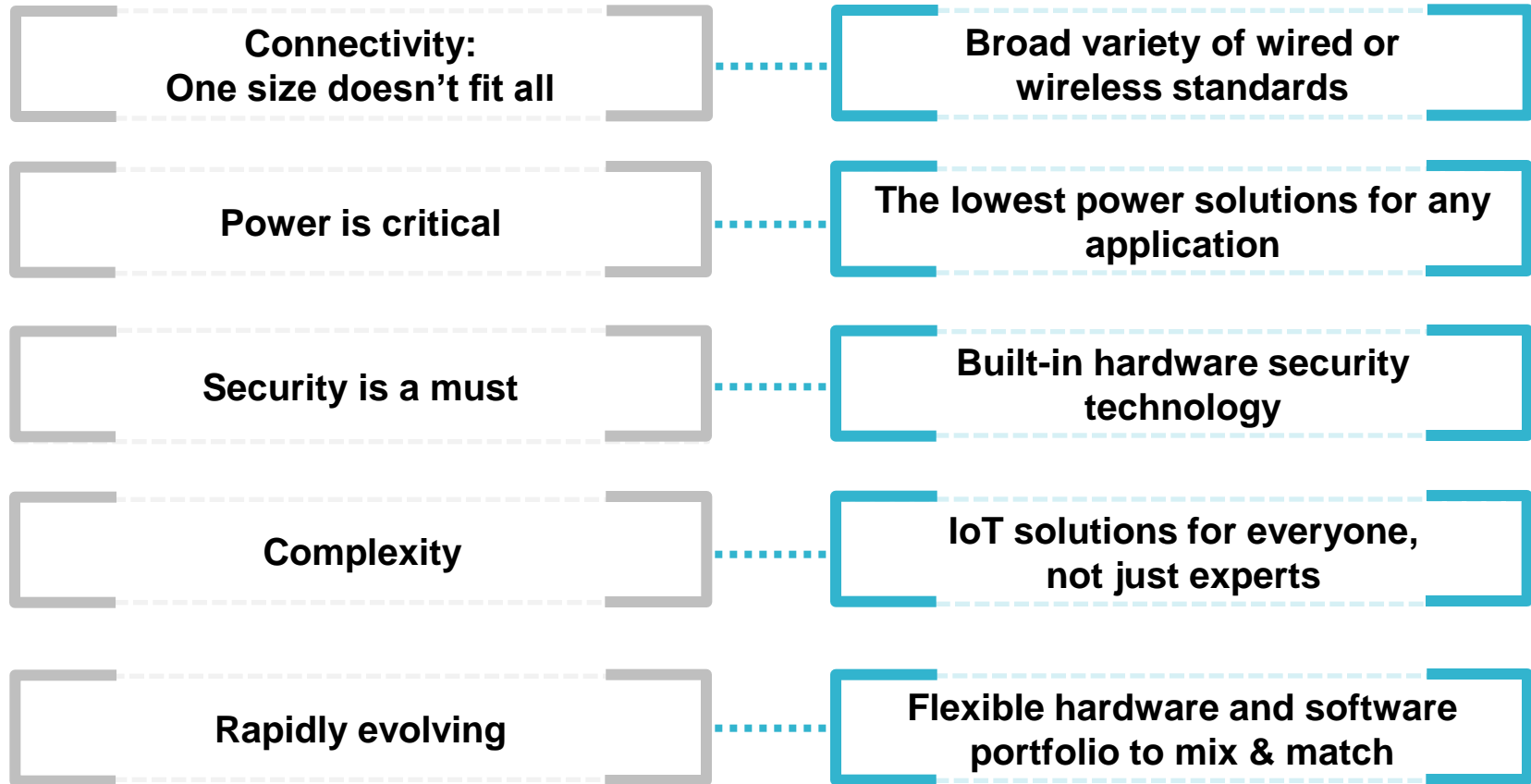
- Tools, software & support

**Consumers:
Easy to set up and use**

TEXAS INSTRUMENTS
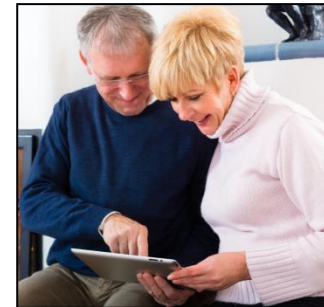
Making the IoT of 2020 happen

CONNECT
M**RE
WITH TI

Challenges	What is needed
Connectivity: One size doesn't fit all	Broad variety of wired or wireless standards
Power is critical	The lowest power solutions for any application
Security is a must	Built-in hardware security technology
Complexity	IoT solutions for everyone, not just experts
Rapidly evolving	Flexible hardware and software portfolio to mix & match

TI has the broadest "IoT-ready" portfolio

Different Technologies for Different Applications

The industry's broadest wireless connectivity portfolio

Supported standards						
134KHz /13.56MHz	**Sub 1GHz**	**2.4GHz to 5GHz**				**Satellite**
RFID NFC ISO14443A/B ISO15693	SimpliciTI 6LoWPAN W-MBus	SimpliciTI PurePath Wireless	ZigBee® 6LoWPAN RF4CE	*Bluetooth*® technology *Bluetooth*® low energy ANT	Wi-Fi®	GNSS

Example applications

Product line up

TMS37157 TRF796x TRF7970	CC1110 CC1190 CC11xL CC430 CC112X CC120X CC1180	CC2500 CC2543/44/45 CC2590/91 CC8520/21 CC2530/31	CC2530 CC2530ZNP CC2531 CC2533 CC2520	CC2560/4 CC2540/1 CC2570/1	WL127x WL18xx CC3000 **CC31xx** **CC32xx**	WL18xx CC4000

TEXAS INSTRUMENTS

Question	Answer	Technology
What's your application?	Data	All
	Audio	WiFi, Bluetooth
	Video	WiFi
What are you connecting to?	Phone	WiFi, Bluetooth, BLE
	Internet	WiFi: Direct Connect 6LowPAN, Zigbee: Via Gateway
	Other	All
What's the transmit range?	Personal (<30m)	WiFi, Bluetooth, BLE
	Home (<100m)	WiFi, ZigBee, Sub 1Ghz
	Outdoor (<1km)	Sub 1Ghz/6LowPAN
How many units in network?	≤10 Units	BLE, WiFi, Zigbee, 6LowPAN
	<100 Units	WiFi, Zigbee, 6LowPAN
	<500 Units	Zigbee
	<1000 Units	6LowPAN
Power source	Harvesting and/or Coin cell	Sub 1GHz, 6LowPAN, BLE, Zigbee
	AAA/AA	All
	LiIon rechargeable	All

Wireless focus technologies

Bluetooth low energy / CC2541
Easiest way to connect to iOS and smartphones

TI SensorTag   Smartphone w/BLE   TI App

Get TIs SensorTag + App on your phone today!
www.ti.com/sensortag

Wi-Fi / SimpleLink Wi-Fi Family
Wi-Fi connect any product in one day

Dev Kit   Any Smartphone

Self-containted wifi solution, SmartConfig for pairing
Easiest way to deploy wifi in a product
www.ti.com/wifi

Bluetooth + Bluetooth low energy
CC256x Family - *new module CC2564MODN*
Flexible solution for audio and long range Bluetooth

Flexible, Best in class performance, low cost
Bluetooth dual mode –
www.ti.com/bluetooth

All technologies support Internet-of-Things!

Sub1-GHz / CC1200, CC110L
Low-cost full house RF coverage
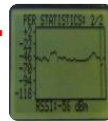
Smart RF Studio, Packet Sniffer, Link Test
Tools to make RF development easy
www.ti.com/rfvalueline

ZigBee Light Link / CC2530, CC2538
Complete solution for wireless lighting

Wireless Lighting with TI is winning the market!
www.ti.com/zigbee

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Bluetooth low energy *Target Markets*

Retail	Health & Fitness	Medical	Automotive
Beacons ESL / Price Tags Locationing	Heart Rate Speed / Cadence Watches	Thermometer Patches Blood Glucose Meter	Remote Keyless Entry Tire Pressure Non-critical Sensors

HID	Industrial	Toys	Home Automation
Remote Control Keyboard & Mouse	Remote Display Maintenance Cable Replacement	Toys Proffesional Toys	Lightning Home Automation

TEXAS INSTRUMENTS

Bluetooth low energy *Solutions*

Hardware

	CC2540	CC2541	CC2543
Max Output Power	+4dBm	0 dBm	+5 dBm
TX current (0 dBm)	26 mA	18.2 mA	26 mA
Flash	128/256kB	128/256kB	32kB
Ram	8kB	8kB	1kB
Sleep Timer	Crystal or RC	Crystal or RC	RC
Dual Boot	YES	YES	NO
Size	40 pin 6x6 QFN	40 pin 6x6 QFN	32 pin 5x5 QFN
Key Benefits	Full BLE stack USB	Full BLE stack I2C	Broadcast Only Low Cost

Software

Bluetooth low energy SDK
- Fully Featured BT4.0 LE Stack
- BT 4.0 Qualified
- Broadest range of certified profiles
- Unique Features
    - Over-the-air-download
    - High throughput

miniBLEBroadcaster
- Standalone Solution for CC2543
- Size optimized BLE Broadcaster

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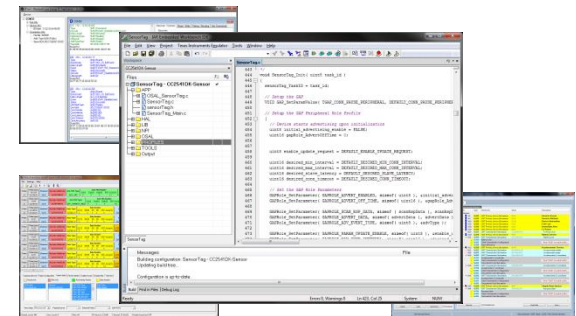
CC256x
TI Bluetooth Classic & Dual-Mode

Features

- High Performance Bluetooth 4.1
    - Best in class in RF performance
    - 2x Range for traditional BLE solutions
    - Based on 7th Generation technology
- Cost Effective
    - Low cost HW - QFN package, TI module, Reference designs
    - Quick software development - SW examples and multiple profiles supported
- Flexibility
    - Flexible SW options - Royalty free Bluetooth + Bluetooth LE stack, profiles and sample apps
    - Customization options from partner Stonestreet One
    - Flexibility for HW options – devices and pre certified modules

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Getting Started with TI *Bluetooth*

Kit Name Price	Technology	Kit Contents	Additional HW Needed
CC256xQFNEM Now with CC256xB $59	Bluetooth, Bluetooth + BLE or Bluetooth + ANT	• 1 CC256x EM board with TI QFN device • Jumpers for MSP-EXPF5438 and MSP-EXPF5529	MCU board such as MSP-EXP430F5438 or MSP320F5529 or DK-TM4C123G or DK-TM4C129X
BT-MSPAUDSINK $59	*Bluetooth* Audio Sink Reference Design board	• 1 BT-MSPAUDSINK board	Speaker, USB cable or battery for power
CC2564MODNEM Coming SOON	*Bluetooth* module EM board	•1 CC2564MODNEM board with TI module • Jumpers for MSP-EXPF5438 and MSP-EXPF5529	MCU board such as MSP-EXP430F5438 or MSP320F5529 or DK-TM4C123G or DK-TM4C129X
EZ430-RF256x $99	Bluetooth	• 2 Bluetooth target Boards • 1 USB emulator • 1 Battery board and batteries	None

TEXAS INSTRUMENTS

CC3100/CC3200 product highlights

Next generation embedded SimpleLink™ Wi-Fi® family connecting new classes of devices to the IOT

SimpleLink™
Wi-Fi® Family
CC3100 Internet on chip
CC3200 Internet on chip + MCU

Texas Instruments

Cost effective

- **Highly integrated**
  - ❑ 2.4GHz embedded Wi-Fi
  - ❑ Embedded TCP/IP stack
  - ❑ Integrated Apps MCU (CC3200)

- **Low-cost HW design**
  - ❑ QFN package *or*
  - ❑ Certified module – coming soon
  - ❑ No RF expertise needed

- **Quick software development**
  - ❑ CCS (GCC) & IAR supported
  - ❑ Standard BSD APIs

Secure

- **Secured protocols**
  - ❑ WPA2 personal & enterprise
  - ❑ SSL 3.0 / TLS 1.2

- **On-Chip HW encryption**
  - ❑ Real-time encryption
  - ❑ Fast TLS connection in 200mSec

Low Power

- **Low power radio**
  - ❑ 37 mA listen
  - ❑ 54 mA receive

- **Low power modes**
  - ❑ 4 uA hibernate
  - ❑ 120 uA sleep
  - ❑ 95 mSec wakeup time from hibernate to secured Wi-Fi connection

- **Runs on 2xAA batteries over 1 year**

Deep dive into CC3100 & CC3200

Two pin compatible products based on the same Wi-Fi network processor

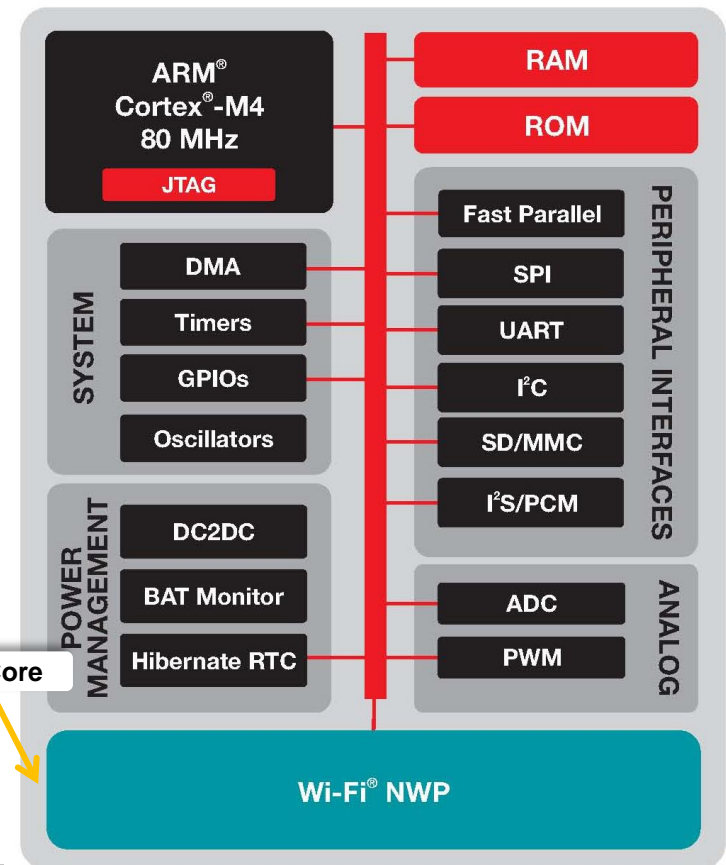## CC3100 Internet on a chip
Wi-Fi Network Processor
Embedded TCP/IP stack for systems using external low-cost MCU
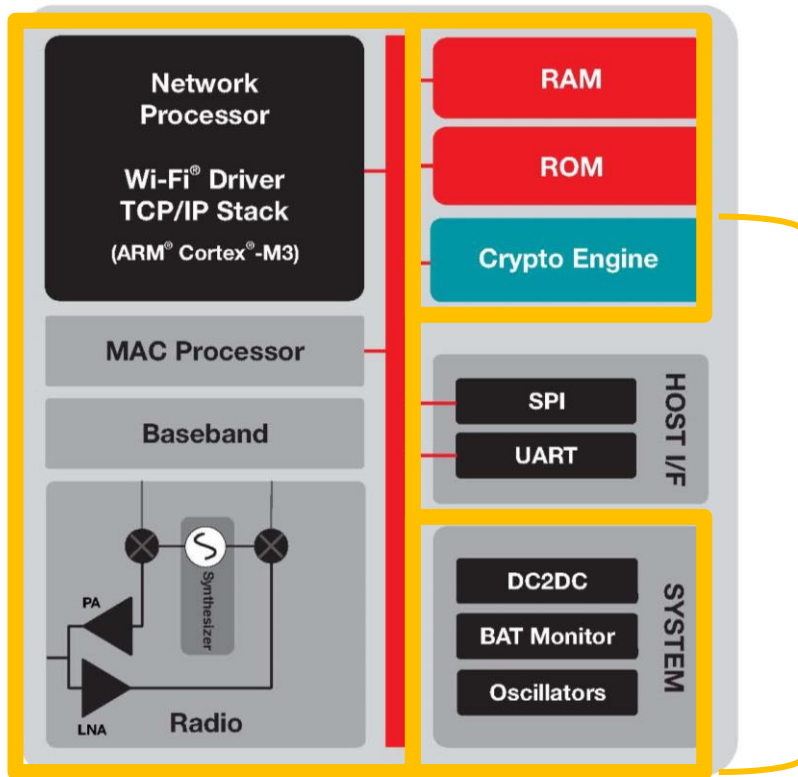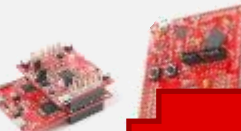
CC3200 Internet on a chip + MCU
Wireless MCU
80MHz ARM® Cortex™-M4 integrated + Wi-Fi network processor

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CC3100/CC3200 kits

Kit Name	Description	Why buy this?
CC3200-LAUNCHXL $29.99	• CC3200 Launchpad • Single-chip Internet of Things Solution with Integrated MCU	Want to use Wireless MCU – single chip Internet-on-a-chip
CC3100BOOST + CC31XXEMUBOOST + MSP-EXP430F5529LP $49.99 Bundle	• CC3100 Boosterpack + MSP430F5529 Launchpad	Want to evaluate all CC3100 Sample apps, using TI's ultra low power MSP430F5529 family
CC3100BOOST-CC31XXEMUBOOST $36.99 Every customer needs at least 1 EMUBOOST Bundle	• CC3100 Boosterpack + Flashing and advanced debug capability • Compatible Launchpads (sold separately)	Want to use CC3100 with any other MCU. Need 1 EMUBOOST board for flashing, using radio tool, using simplelink studio (MCU dev on PC) or advanced debug
CC31XXEMUBOOST $22.99	• Flashing and advanced debug capability for CC3100BOOST	Needed for flashing CC3100BOOST, using radio tool, using SimpleLink studio (MCU dev on PC), doing advanced debug with CC3100
CC3100BOOST $19.99	• CC3100 Boosterpack – cannot flash device without CC31XXEMUBOOST – only 1 needed for all CC3100BOOST • Compatible Launchpads (sold separately)	If buying additional CC3100BOOST boards – assume already have CC31XXEMUBOOST for flashing, radio tool, and possible advanced debug

SimpleLink™ Sub-1GHz CC1200 RF Performance Line Transceiver

Features

High performance
- Up to 1.25 Mbps radio
- Supports 169 / 433 / 868 / 915 / 920 MHz ISM/SRD bands with possible support for additional frequency bands: 137-160, 205-240 and 274-320 MHz

Best-in-class range and co-existence -up to 143dB link budget
- +16 dBm output power
- -127 dBm sensitivity using built-in coding gain
- 60 dB selectivity and 90 dB blocking

Leading low power consumption
- 0.3 µA power down current, 0.5 µA sleep current with timer running and 2 mA RX sniff mode
- Quick transition between power modes

Low cost design
- Compact reference design with few external components, and small and efficient PCB antenna

TEXAS INSTRUMENTS

SimpleLink™ CC2538 Features /Benefits

Features

Highly Integrated solution
- ❑ Single-chip and WNP solution
- ❑ Flash-based 128/256/512 options

Powerful and Ultra-Low Power
- ❑ M3 Cortex 32 MHz MCU
- ❑ 97dB link budget
- ❑ Great blocking features reduce retransmission (low PER)
- ❑ Very low-power sleep modes

Low Cost HW Design
- ❑ IEEE802.15.4 Radio low power
- ❑ M3 Cortex core
- ❑ Multiple I/O options
- ❑ HW security accelerator- fast commissioning times
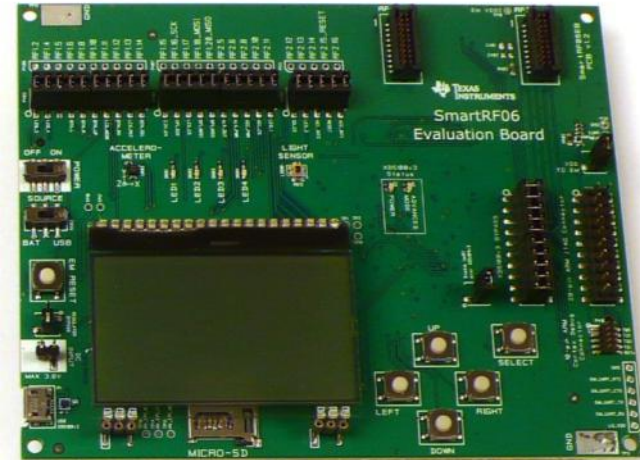
Flexible configuration
- ❑ Capable of running Dual Profiles HA 1.x/ SE1.X
- ❑ Over-the-air SW Update
- ❑ Boot Image Manager

TEXAS INSTRUMENTS

CC2538 Development Kit

- 2 fully featured SmartRF06EB with EM modules

- Useful peripherals for prototyping:
  - Dot-matrix display
  - Accelerometer
  - Buttons and LEDs

- Easy debugging with on-board emulator

- USB dongle for packet sniffing

- Smart RF Studio tool for RF performanace optimization

NEW:
Z-STACK
Free
Download

Sample Applications

Home Management
Water Sprinklers	ON OFF
Coffee Pot	ON OFF
Garage door	UP Down
Light setting 1	ON OFF
Light setting 2	ON OFF
Thermostat	72 ▲▼

- **Various ZigBee sample applications available**

- **Packet error rate measurement for RF testing**

SmartRF06 Evaluation Board

- Coordinator
- Router
- End Device

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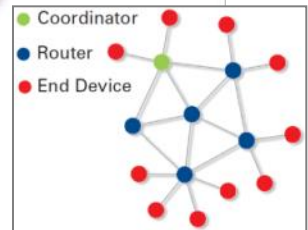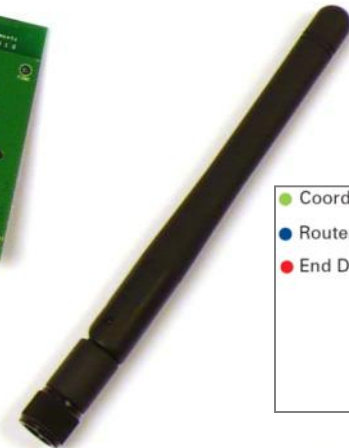
ZigBee Light Link Solution

Lighting Kit

- A19 Bulb size LED lighting reference design includes LEDs, drivers, RF, Antenna
- 125° C qualified CC2530SOC
- Low BOM cost
- Supported by the Z-Stack Lighting Stack

Remote control

- Hardware Reference Design
- Provides full feature in button control
- Supported by the Z-Stack Lighting Stack

Z-Stack^{TM} Lighting

Fully compliant with ZigBee PRO 2012 protocol stack

- Golden unit of ZigBee Light Link

Thanks!

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