Connecting to the Cloud with TI
Enabling IoT with MSP432 MCU & CC3100 WiFi

Texas Instruments
Jason Kriek – Digital Field Apps
What is IoT?

A diverse collection of technologies and devices designed to connect everyday objects to the Cloud to keep track of people, assets and events effortlessly and in real-time, providing enhanced personal and societal awareness and control.
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
TI’S INDUSTRY-LEADING LOW-POWER MCU PORTFOLIO: SCALABILITY FROM 16-BIT TO 32-BIT, PLUS WIRELESS MCUs

**16-bit MSP430 MCUs**
- The industry leader in ultra-low-power, rich peripherals and analog integration.
- World’s only portfolio of ultra-low-power embedded FRAM MCUs.
- Growing portfolio of more than 500 ultra-low-power MCUs across 13,000+ customers.

**32-bit MSP432 MCUs**
- Industry’s lowest power ARM® Cortex®-M4F MCUs. Period.
- High performance MCUs without sacrificing power consumption.
- Pin-for-pin platform scalability up to 2MB; sampling 256KB today.

**SimpleLink Wireless MCUs**
- Focus on ease of use and low power.
- Support for more than 14 wireless protocols including Bluetooth Smart, Sub-1 GHz, 6LoWPAN, ZigBee and more.
- Portfolio includes SimpleLink Wi-Fi and new ultra-low power platform.
# MCU & Wireless: Essential IoT components

<table>
<thead>
<tr>
<th>Architecture</th>
<th>MCU and RF SOC</th>
<th>MCU as Host</th>
<th>MCU as Host and running Network Stack</th>
<th>MCU as Sensor Hub or Power management to Host MPU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MCU + RF</td>
<td>MCU</td>
<td>RF</td>
<td>MPU</td>
</tr>
<tr>
<td></td>
<td>Appl</td>
<td>Appl</td>
<td>Stack</td>
<td>Appl Stack</td>
</tr>
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<td></td>
<td>Stack</td>
<td>Stack</td>
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<td>Stack</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CC3200, CC2640, CC1300, CC430</td>
<td>MSP432 + CC3100</td>
<td>MSP + CC2560</td>
<td>WL18xx + AM335x + MSP</td>
</tr>
<tr>
<td></td>
<td>MSP430 + CC3100</td>
<td>MSP432 + CC2640</td>
<td>MSP + TRF79xx</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MCU Memory needs</th>
<th>Max</th>
<th>Min</th>
<th>Max</th>
<th>Task-dependent</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>MCU Flexibility/Scalability</th>
<th>Min</th>
<th>Max</th>
<th>Middle</th>
<th>Max</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>MCU Cost</th>
<th>$$$</th>
<th>$</th>
<th>$$</th>
<th>Task-dependent</th>
</tr>
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</table>
MSP432™ MCUs: PERFORMANCE AT ITS CORE

Selecting the high-performance ARM® Cortex®-M4F core

Highest Coremark score: 3.41/MHz

48MHz ARM® Cortex®-M4F
- Full ARM instruction set
- DSP extensions
- FPU engine

Industry-leading ultra-low-power
- Active power: 95 μA per MHz
- Sleep mode: 850 nA (with RTC)
- ULPBench score: 167.4

Incorporating high-performance peripherals and features
- Simultaneously read and erase from flash
- Execute up to 200% faster with DriverLib in ROM vs. Flash
- 14-bit 1MSPS ADC with 13.2ENOB, differential mode & 2 window comparators

Wide voltage range: 1.62-3.7V
Integrated LDO & DC/DC
Selectable RAM retention

Independent flash banks
DriverLib in-ROM
128-bit Flash buffer & pre-fetch
14-bit ADC
8-channel DMA
NVIC with tail-chaining
Peripheral & SRAM memory bit-band

MSP432 MCU

Texas Instruments
MSP432™ MCUs: LOW-POWER AT ITS BEST

Optimizing the architecture for ultra-low power

Industry’s lowest power ARM Cortex-M4F MCU

Industry-leading ultra-low-power

- Active power: 95 μA per MHz
- Sleep mode: 850 nA (with RTC)
- ULPBench score: 167.4

Optimizing peripherals for ultra-low power

- Save 40% more power with the integrated DC/DC vs. LDO
- Save 30nA per RAM bank with selectable RAM retention
- Consume minimal power (375uA) when sampling sensors at 1MSPS with 14-bit ADC
- DriverLib in ROM consumes up to 35% less power than Flash

48MHz ARM® Cortex®-M4F
- Full ARM instruction set
- DSP extensions
- FPU engine

Wide voltage range: 1.62-3.7V

Integrated LDO & DC/DC

Selectable RAM retention

Independent flash banks

Driver Lib in-ROM

128-bit Flash buffer & pre-fetch

14-bit ADC

8 channel DMA

NVIC with tail-chaining

Peripheral & SRAM memory bit-band
MORE ECOSYSTEM WITH EASY-TO-USE TOOLS AND SOFTWARE

1. Get started here

MSP432™ LaunchPad
Easy to use, low-cost evaluation kit with integrated emulator and EnergyTrace+ technology

2. Connect to your computer

Booster Packs
Expand MSP432 LaunchPad evaluation with easy to use, low-cost Booster Pack add-on daughter boards

Software optimized for low-power

3. Choose from your favorite IDEs

- CCS
- IAR
- Keil

4. Develop or access code and collateral online, instantly

TI Cloud IDE:
- Resource Explorer
- Code Composer Studio™
- PinMux

5. Ease code development with easy to use APIs and examples

MSPWare™:
- Driver library
- App notes & user’s guides
- Example code
- Tutorials

6. Optimize your code and system for ultra-low-power operation

Optimization tools:
- ULP Advisor
- EnergyTrace+™
SimpleLink Wi-Fi CC3100 & CC3200 brings...

Industry’s first single-chip Wi-Fi solution with built-in programmable MCU

Ability to run on two AA batteries for over a year, bringing the capabilities of Wi-Fi to battery-operated end-equipments

All you need to easily create IoT solutions - robust security, quick connection, cloud support and more
SimpleLink™ Wi-Fi® CC3100 Solution

Features/Benefits

- **Supported protocols and roles** – 802.11 b/g/n, Station, Access Point, and Wi-Fi Direct with fully integrated radio, baseband, and MAC
- **Wi-Fi network processor** – on-chip WLAN and TCP/IP stack, industry standard API. No previous Wi-Fi experience needed
- **Embedded Crypto engine** – 256-bit encryption, SSL/TLS, personal and enterprise security, allows fast secure connection
- **Low power** – low power radio with advanced low power modes enabling battery powered Wi-Fi (2AA over a year)

Design Kits & EVMs

CC3100 BoosterPack + EMU board – CC3100BOOST-CC31XXEMUBOOST

Note: CC31XXEMUBOOST must be purchased to flash CC3100BOOST plus other functions

Dev Tools & Software

- **Flexible Provisioning** - AP mode, WPS, SmartConfig™, + 1
- **Uniflash**, RF Performance Tool, PLT
- **CC3100 SDK Download** – Driver, 30+ sample apps
- **SimpleLink™ Studio for CC3100** – MCU dev on PC

Target Applications

- **Home Automation** – lighting, access control
- **Home Appliance** – washer & dryer, refrigerator
- **Safety and Security** – wireless camera, video surveillance
- **Smart Energy** – smart meter, thermostat control, smart plug
- **Industrial M2M Communication** – web interface industrial control
- **Wireless audio streaming** - speakers, remote controls, sound bars

CC3100 Network Processor

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Radio</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPv4 TCP/IP Stack</td>
<td>2.4 GHz</td>
</tr>
<tr>
<td>SSL 3.0</td>
<td>Wi-Fi 802.11 b/g/n</td>
</tr>
<tr>
<td>TLS 1.2</td>
<td>STA, AP, Wi-Fi Direct</td>
</tr>
<tr>
<td></td>
<td>WPA2 Personal</td>
</tr>
<tr>
<td></td>
<td>WPA2 Enterprise</td>
</tr>
<tr>
<td></td>
<td>WPS2</td>
</tr>
<tr>
<td></td>
<td>802.1x</td>
</tr>
<tr>
<td></td>
<td>EAP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Protection</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>DES</td>
<td>SPI (Host I/F)</td>
</tr>
<tr>
<td>DES3</td>
<td>UART (Host I/F)</td>
</tr>
<tr>
<td>AES256</td>
<td></td>
</tr>
<tr>
<td>MD5</td>
<td></td>
</tr>
<tr>
<td>SHA2</td>
<td></td>
</tr>
<tr>
<td>RSA</td>
<td></td>
</tr>
<tr>
<td>ECC</td>
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</tbody>
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<tr>
<th>Power &amp; Clocking</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC2DC</td>
<td>64-pin 9x9mm QFN</td>
</tr>
<tr>
<td>BAT Monitor</td>
<td>17.5 x 20 5mm Module</td>
</tr>
<tr>
<td>Hibernate RTC</td>
<td>Memory</td>
</tr>
<tr>
<td>Oscillators</td>
<td>Embedded ROM</td>
</tr>
<tr>
<td></td>
<td>Host Memory Footprint</td>
</tr>
<tr>
<td></td>
<td>10 KB (Flash)</td>
</tr>
<tr>
<td></td>
<td>2 KB (RAM)</td>
</tr>
</tbody>
</table>

Note:

- CC31XXEMUBOOST must be purchased to flash CC3100BOOST plus other functions.
SimpleLink™ Wi-Fi® CC3200 Wireless MCU

**Features/Benefits**

- **Supported protocols and roles** – 802.11 b/g/n, Station, Access Point, and Wi-Fi Direct with fully integrated radio, baseband, and MAC
- **On-chip ARM Cortex M4** – 80MHz processor allows custom APIs to be done on-chip, lower total BOM cost
- **Wi-Fi network processor** – on-chip WLAN and TCP/IP stack, industry standard API. No previous Wi-Fi experience needed
- **Additional embedded Crypto engine** – 256-bit encryption allows fast secured connection to the cloud

**Design Kits & EVMs**

- **CC3200 LaunchPad** - CC3200-LAUNCHXL

**Dev Tools & Software**

- **Flexible Provisioning** - AP mode, WPS, SmartConfig™, + 1
- **Uniflash, RF Performance Tool, PLT**
- **CC3200 SDK Download** – Driver, 40+ sample apps
- **Code Composer Studio™ & IAR IDE** support

**Target Applications**

- **Home Automation** – lighting, access control
- **Home Appliance** – washer & dryer, refrigerator
- **Safety and Security** – wireless camera, video surveillance
- **Smart Energy** – smart meter, thermostat control, smart plug
- **Industrial M2M Communication** – web interface industrial control
- **Wireless audio streaming** – speakers, remote controls, sound bars

---

**CC3200 Wireless MCU**

- **Protocol**
  - IPv4 TCP/IP Stack
  - SSL 3.0
  - TLS 1.2

- **Comms Peripherals**
  - SD/MMC
  - 2x UARTs
  - 2x SPI
  - I2C

- **Power & Clocking**
  - DC2DC
  - BAT Monitor
  - Hibernate RTC
  - Oscillators

- **System Modules**
  - DMA
  - Timers
  - GPIO
  - EPI

- **Radio**
  - 2.4 GHz
  - Wi-Fi 802.11 b/g/n
  - STA, AP, Wi-Fi Direct
  - WPA2 Personal
  - WPA2 Enterprise
  - WPS2
  - 802.1x
  - EAP

- **Memory**
  - Embedded ROM
  - Up to 256KB RAM

- **Data Protection**
  - DES
  - DES3
  - AES256
  - MD5
  - SHA2
  - RSA
  - ECC

- **Interfaces**
  - Parallel Camera I/F
  - McASP (I2S)

- **Analog**
  - 4-Ch ADC
  - 4 PWM Control

- **Packages**
  - 64-pin 9x9mm QFN
  - 17.5 x 20.5mm Module
Best in class security – chip to cloud FAST

On Chip Wi-Fi® security
- WPA2 Personal
- WPA2 Enterprise
- WPS2
- 802.1x
- EAP Fast
- EAP PEAPv0/1
- EAP PEAPv0 TLS
- EAP PEAPv1 TLS
- EAP TLS
- EAP TTLS TLS
- EAP TTLS MSCHAPv2

On-Chip Internet security
- SSL 3.0
- TLS 1.2
- X.509
- DES3
- AES256
- MD5
- SHA2
- RSA
- ECC

HW encryption engines establish TLS/SSL connection in 200mSec
# Most Flexible Wi-Fi provisioning Options

<table>
<thead>
<tr>
<th>Provisioning Method</th>
<th>Access Point Mode</th>
<th>SmartConfig™</th>
<th>WPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What’s needed</strong></td>
<td>Web browser</td>
<td>Android or iOS phone app</td>
<td>Push button on router</td>
</tr>
<tr>
<td><strong>Networks supported</strong></td>
<td>Any Network</td>
<td>Networks connections with MIMO, 5GHz, SISO-40MHz, and proprietary modulation schemes, are not supported</td>
<td>WPS enabled routers only</td>
</tr>
<tr>
<td><strong>How many Steps</strong></td>
<td>Multiple Steps</td>
<td>1 step</td>
<td>1 step (push button)</td>
</tr>
<tr>
<td><strong>Number of devices configured</strong></td>
<td>Configure one device</td>
<td>Configure multiple devices</td>
<td>Configure one device</td>
</tr>
<tr>
<td><strong>Home network connection</strong></td>
<td>Phone must disconnect from home network</td>
<td>Phone stays connected to the home network</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Secure</strong></td>
<td>Can be secure</td>
<td>Can be secure</td>
<td>Not secured</td>
</tr>
<tr>
<td><strong>Remote App</strong></td>
<td>Not Required</td>
<td>Required</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supported by Android 4.2+, and iOS 6+</td>
<td></td>
</tr>
<tr>
<td><strong>Additional Notes</strong></td>
<td>N/A</td>
<td>SSID in Chinese or Asian characters are not recognized</td>
<td>N/A</td>
</tr>
</tbody>
</table>

💡 **Note:** Products with SmartConfig, **should** also have AP mode or WPS as provisioning fall backs

For more details on provisioning see [Provisioning Wiki](#)
Bringing Wi-Fi power to a new low

**Always Connected**
- 120uA sleep current while connected to the network
- 37 mA Rx listen current for beacon reception
- Long Sleep Intervals up to 2 seconds (typical wake up is every 100mSec)

**Intermittently Connected**
- 4 uA hibernate current, with multiple wake up sources
- 95 mSec wake up time from hibernate till secure Wi-Fi connection
- 200 mSec TLS connection time

*Battery life can vary significantly depending on use case and system design*
## CC3100/CC3200 benefits for Internet of Things

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP/IP DUMMIES</td>
<td>Industry standard BSD socket APIs for TCP/IP communication → Build Internet applications quickly, reuse industry available Internet code</td>
</tr>
<tr>
<td>Small driver footprint</td>
<td>As low as 7KB host code → Enable integration with low-cost MCUs like MSP430</td>
</tr>
<tr>
<td>HW crypto engine</td>
<td>HW crypto engine for TLS/SSL Internet security → Establish TLS connection in 200mSec for fast and secured user experience</td>
</tr>
<tr>
<td>Low power radio and advanced low power modes</td>
<td>Low power radio and advanced low power modes → Wi-Fi® sensors stay connected to the network for over a year using two AA batteries</td>
</tr>
<tr>
<td>Most Flexible Provisioning options</td>
<td>Most Flexible Provisioning options – Access Point mode, WPS, Smartconfig™, plus others → Enables customers to set up headless devices easily and fast</td>
</tr>
<tr>
<td>TI modules certified</td>
<td>TI modules certified for WW regulatory and Wi-Fi Alliance → Fast time to market Save customers over $50K of test cost and test time per product family</td>
</tr>
</tbody>
</table>
SimpleLink Wi-Fi Modules Now Available

Key module features
• Includes on module clocks, SPI Flash, and passives
• Connects to an external on-board antenna
• 17.5x20.5 mm Land Grid Array footprint with 1.27mm pitch for low cost PCB design
• Modular FCC, IC, CE & TELEC Certifications to save customer effort, time and money
• CC3100 Wi-Fi network processor and CC3200 wireless MCU pin compatible variants

Resources
• Hardware Design
  – CC3200 module TI Design
  – CC3100 module TI Design
• Software – same as for QFN Device
  – CC3200 SDK & Firmware
  – CC3100 SDK & Firmware
• Evaluation Tools and Support
  – Module LaunchPad CC3200MODLAUNCHXL - $59.99
  – Module BoosterPack CC3100MODBOOST - $49.99
  – CC3100MODBOOST-CC31XXEMUBOOST - $71
  – CC3100MODBOOST-CC31XXEMUBOOST-MSP-EXP430FR5969 - $86.99
  – E2E Support Forum
CC3100/CC3200 Module Certification Summary

Save substantial costs and time using TI’s FCC ID and modular certifications

TI’s FCC/ETSI test reports can be used to file for certifications with 40+ other countries

No Part 15.247 radio testing required to obtain FCC/IC certifications

• Save 1-2 months of reporting and filing
• Save upfront certification (~$30k) and RF design resources (~$10-15K contracted)
• No risk of testing failure, which is common without RF expertise resources
• Less paperwork and simpler application process for full certification

Design has an external antenna, but is still certified

More information can be found on the certification website for CC3100 & CC3200
TI IoT & Cloud Ecosystem Partners

TI IoT solutions offer support for various cloud partners & protocols via WiFi or Ethernet.
Prototyping an IoT solution with modular open source hardware.
LaunchPad is TI’s Common Denominator
Modular hardware enables developers to explore new ideas quickly

LaunchPad kits featuring TI MCUs & standardized BoosterPack interface
- MSP430 (Ultra-Low Power)
- TM4C (ARM Cortex M4F)
- C2000 (Real-time Control)
- Hercules (Safety)
- CC3200 (MCU + WiFi)

Wireless BoosterPacks enabled by TI transceivers
- Sub-1GHz (CC110L)
- NFC/RFID (TRF7970A)
- WiFi (CC3100)
- ZigBee (CC2530)
- BLE (CC2541)
- Bluetooth (CC2564)
- Thermocouple BoosterPack (ADS1118)
- MEMS Temp Sensor BoosterPack (TMP006)
- ePaper Display BoosterPack (RePaper)
- LiPo Battery BoosterPack (BQ fuel gauge)
- SensorHub BoosterPack (various sensors)

Additional BoosterPacks for analog, sensors, displays & more from TI, Third Parties & Maker community.
CC3100BOOST-MSP-EXP432P BUNDLE
Order and develop your IoT application today


MSP432 LAUNCHPAD $12.99 + CC3100 BOOSTERPACK $19.99 = $31.00

Where to go next

• Get started with MSP432 MCU: ti.com/msp432
• Official LaunchPad Portal: ti.com/launchpad
• Official SimpleLink site: ti.com/simplelink
## CC3100/CC3200 kits

<table>
<thead>
<tr>
<th>Platform</th>
<th>Kits &amp; Bundles</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC3200</td>
<td><strong>Kits</strong></td>
</tr>
</tbody>
</table>
|Industry's first single-chip Wi-Fi solution with user-dedicated programmable microcontroller (MCU) | - **NEW** Module LaunchPad [CC3200MODLAUNCHXL](#) - $59.99  
- QFN Device LaunchPad [CC3200-LAUNCHXL](#) - $29.99 |
|**CC3100** | **Kits**  |
|Internet-on-a-chip™ solution Connect any MCU to the Internet of Things | - **NEW** Module BoosterPack [CC3100MODBOOST](#) - $49.99  
- QFN Device BoosterPack [CC3100BOOST](#) - $19.99  
- BOOST required to Flash CC3100 - [CC31XXEMUBOOST](#) - $22.99|

**Bundles**
- [CC3100BOOST-CC31XXEMUBOOST](#) - $41  
- [CC3100BOOST-CC31XXEMUBOOST-MSP-EXP430F5529LP](#) - $53.99  
- [CC3100BOOST-MSP-EXP430FR5969](#) - $34  
- [CC3100MODBOOST-CC31XXEMUBOOST](#) - $71  
- [CC3100MODBOOST-CC31XXEMUBOOST-MSP-EXP430FR5969](#) - $86.99 |
Creating a cloud-connected moisture sensor.
Creating a cloud-connected sensor.

MSP432 LaunchPad
CC3100 Wi-Fi BoosterPack
Grove Base BoosterPack from Seeed Studio
Grove analog moisture sensor
TI CLOUD TOOLS @ dev.ti.com

Code Composer Studio Cloud

- Browser based code editing tool to get your started quickly
- Cross Platform and allows you to upload firmware using TI Cloud Agent
- Supports MSP430 & MSP432 LaunchPads

TI Cloud Resource Explorer

- Entire MSPWare available online: complete one-stop shop for MSP MCU developers
- Access latest software, examples, documentation, training, application notes, and more collateral
## Quick demo recipes

Enable customers to experience TI differentiation in minutes

<table>
<thead>
<tr>
<th>WiFi-enabled Meat Probe “iGrill”. Send a tweet when temp exceeds threshold.</th>
</tr>
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<tr>
<td>WiFi CC3100 BoosterPack</td>
</tr>
<tr>
<td>Thermocouple BoosterPack (ADS1118)</td>
</tr>
<tr>
<td><strong>MSP430F5529 LaunchPad</strong></td>
</tr>
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<td>CC3200 Wi-Fi LaunchPad</td>
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<td>NFC/RFID (TRF7970A)</td>
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<td>LiPo Battery BoosterPack (BQ fuel gauge)</td>
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<tr>
<td>MSP430G2553 LaunchPad</td>
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<tr>
<td>Sub-1GHz (CC110L)</td>
</tr>
<tr>
<td>MEMS Temp Sense BoosterPack (TMP006)</td>
</tr>
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<td><strong>MSP430G2553 LaunchPad</strong></td>
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</table>
Energia IDE

- Fork of the Arduino/Wiring IDE & framework
  - Use instantly from a browser @ dev.ti.com
  - Download @ www.energia.nu
- Mac / Windows / Linux support
- Supports various TI LaunchPad dev kits
- Free & open source (git) // Support forum
- Many libraries have been ported:
  - Wi-Fi & Ethernet (HTTP client, MQTT, JSON, etc) + various cloud services
  - Sensors, displays & more
- **Import Energia projects to TI’s CCS IDE for debug capability** (set breakpoints, step through Energia sketches, etc)
What can you innovate in IOT

MSP432 + CC3100 provides
- Low-power & performance
- Integration
- Secure & Cost-effective
- Low power Wi-Fi

for next generation IOT application

What will you design next?

50 Billion Connected Devices by 2020