Bidirectional wireless communication between IBM Cloud and Bluetooth Low Energy peripherals through SimpleLink™ Wi-Fi®
30.7B connected devices by 2020, 75.4B by 2025

Top IoT concerns…

Security
Complex standards
Required expertise
Power consumption

Sources: IHS Markit and Bain & Company
New SimpleLink™ MCU platform

Microcontroller
- MSP432™
- Bluetooth™
  - low energy
  - C62640R2F

Wireless Microcontrollers
- Dual-band
  - C61850
- Sub-1GHz
  - C61810

Wireless Network Processor
- Wi-Fi®
  - C63220
- Wi-Fi®
  - C63120

Common Software
SDK
Unified Toolchain & Resources

[Diagram showing the integration of these components]
SimpleLink™ MCU Platform SDK

Customer Applications

SDK PLUG-INS

Middleware
- Graphics
- Sub-1GHz/802.15.4
- BLE/WiFi

TI Drivers

DriverLib (HAL)

OS Kernel

POSIX

EXAMPLES

TI SimpleLink™ MCU SDK

Delivered by TI Resource Explorer

TI SimpleLink™ MCUs

MSP432

CC2640R2F

CC3220

CC13xx

Texas Instruments
SimpleLink™ Wi-Fi® CC3220

Raising the Bar

LOW POWER  SECURITY  TIME TO MARKET
Lowest Power Enables Wi-Fi for New Applications

2AA Batteries Lifetime*

Always Connected

Interritently Connected

Transceiver

Up to 5 years

Up to 3 years

Over 1 year

SimpleLink™ Wi-Fi® low-power mode

* Estimated (actual life time depends on customer system configurations)
SimpleLink™ Wi-Fi® – Comprehensive Security Features

Physical Access
- Hardware crypto engines
- Trusted root-certificate catalog
- Debug security
- Secure content delivery
- TI root of trust public key
- Secure boot
- Initial secure programming

Local Network Access
- Unique key – cloning protection
- Software tamper detection
- File encryption
- File authentication
- File access control
- Factory image recovery
- File bundle protection

Remote Access
- Hardware crypto engines
- Trusted root-certificate catalog
- Secure sockets (TLS/SSL)
- Device Identity
- Secure key storage
- Secure content delivery
- Personal and enterprise Wi-Fi security
- HTTPS service

File System Security Features
- Unique key – cloning protection
- Software tamper detection
- File encryption
- File authentication
- File access control
- Factory image recovery
- File bundle protection

Local Network Security Features
- Hardware crypto engines
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Remote Access Security Features
- Hardware crypto engines
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- Device Identity
- Secure key storage
- Secure content delivery

Physical Access Security Features
- Hardware crypto engines
- Trusted root-certificate catalog
- Debug security
- Secure content delivery
- TI root of trust public key
- Secure boot
- Initial secure programming
SimpleLink™ Wi-Fi® Wireless MCU CC3220
Low Power, Advanced Security, Easy Integration

Applications MCU
- Physically separate MCU and memory, dedicated to the user’s applications.

Programmable Applications MCU
  - Peripheral drivers and Libraries
  - Supports no-OS, TI-RTOS, or FreeRTOS

Application-dedicated Memory
  - 256KB RAM
  - Additional 1MB XIP Flash (Opt.)

Rich Set of Peripherals
  - 27 I/O pins with flexible muxing options
  - 2x UART
  - 1x I2C
  - 1x SPI
  - 1x SD
  - 1x McASP with I2S or PCM
  - 4-ch 12-bit ADC
  - 8-bit parallel camera

Enhanced Features
  - Multi-layer security features, to help protect IP and data
  - HW Crypto Engine: AES, DES, SHA, MDR, CRC
  - Supports HomeKit Technology
  - OTA support
  - SimpleLink™ Connected MCU Platform

Network Processor
- The network processor offloads networking and internet tasks from the application MCU

Wi-Fi Core
  - 802.11 b/g/n at 2.4GHz
  - Modes: STA, AP, Wi-Fi Direct®
  - Provisioning: APmode, SmartConfig™, WPS, WAC

Built In Power Management
  - Integrated DC2DC
    - $V_{Bat}: 2.1\,\text{V} \text{ to } 3.6\,\text{V}$
    - Pre-regulated: $1.85\,\text{V}$
  - Low power modes
    - Hibernate ($4.5\,\mu\text{A}$)
    - Low power deep sleep ($135\,\mu\text{A}$)
    - Rx beacon listen ($37\,\text{mA}$)

Internet & Application Protocols
  - Embedded webserver (HTTPS)
  - IPv4 & IPv6 TCP/IP Stack
  - 16 Sockets (6 TLS v1.2 / SSL 3.0)

Powerful HW Crypto Engine
  - Fast secured internet connection within 200mSec

Industrial Temp
  - Supports $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
SimpleLink™ Bluetooth® low energy CC2640R2F

Ultra-low power wireless MCU
TI Bluetooth low energy wireless MCU portfolio

**CC2640R2F**

**Lowest power**
- Multi-year on a coin cell: Cortex-M3 MCU and radio with automatic power-management

**Highly integrated**
- Single chip, flash-based wireless MCU with unique Sensor Controller in tiny 2.7x2.7mm package

**Easiest to design with**
- Comprehensive design support: Complete SW stack, wiki guides, dynamic design kits, low-cost tools, & software examples

**Pre-certified module**
Simplify BLE development, integrated antenna, crystal & passives

**CC2640**
Highly integrated single-chip ARM-CM3 wireless MCU

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**CC2540 / CC2540T**
BLE + USB single-chip, long-range (+4dBm TX)
World’s only 125°C graded BLE solution

**CC2541 / CC2541Q1**
Versatile, system cost optimized BLE wireless MCU, Automotive Q-100 Qualified option
**Ultra-low Power Consumption**
- 61 µA/MHz ARM Cortex M3
- 8.2 µA/MHz Sensor Controller
- 1 µA sleep with retention and RTC
- 5.9 mA RX (single-ended)
- 6.1 mA TX (single-ended)

**Wireless MCU- SoC Key Features**
- Autonomous sensor controller engine
- 4x4, 5x5, and 7x7 mm QFN
- 1.7 - 1.95 V or 1.8 – 3.8 V supply range
- 128 KB Flash + 8 KB Cache
- 20 KB RAM

**RF Key Features**
- +5 dBm Output power
- -97 dBm Sensitivity
- -103 dBm sensitivity for BLE 125 kbps
- Flexible RF: Single-ended (low-cost) or Differential (high-performance)
Target Applications in Industrial Market

- **Thermostats**
  - Thermostats
  - Control Panels

- **Video Surveillance**
  - Video Doorbells
  - IP Network Camera

- **Access Control**
  - Electronic Smart Locks
  - Garage door openers

- **Appliances**
  - Air Conditioners
  - Robotic Vacuum
  - Coffee Maker

- **Asset Tracking**
  - Logistics
  - High value asset tracking
  - Personel locator

- **Factory Automation**
  - Monitoring sensors
  - Cable replacement
  - Motor monitoring and control
SimpleLink Wi-Fi Gateway for BLE enabled Electronic Smart Locks

Retrofit Existing E-Smart Lock
Gateway System Diagram

Mobile App

BLE Lock

Other BLE Peripheral

Wi-Fi®

Gateway to BLE

CC3220S LaunchPad

CC2640R2 LaunchPad
Easy Network Connectivity

- The Wi-Fi gateway is a headless device and must be provisioned to the local network
- CC3220S has integrated provisioning including
  - Access Point (AP) Provisioning
  - SmartConfig™
- Host application triggers provisioning only if the device does not automatically connect to a network
- Provisioning events automatically sent to host indicate network connection
- WLAN connection event signals main application to start
Provisioning is initiated by a single simple command from the MCU host:
```
retVal = sl_WlanProvisioning(pCtx->provisioningNode, ROLE_STA, PROVISIONING_INACTIVITY_TIMEOUT, NULL, 0);
```

Integrated in provisioning process is a connection confirmation step.

Both AP and SmartConfig provisioning can run at the same time.

*Note:* Out-of-Box application provides reference for integrating provisioning with other tasks.
Interface between CC3220S and CC2640R2

- CC2640R2 is used as a Network Processor
  - HostTest application in the SDK can be used to enable the network processor with support for BLE central role
  - Data layer based on Host Controller Interface (HCI) commands
  - Transport layer based on Network Processor Interface (supports UART or SPI)
- Leverage TI Drivers for UART / SPI driver portability
HCl Command Flow - between CC3220S and CC2640R2

1. Initialize CC2640R2 as a BLE central device
2. Discover BLE peripherals
3. Select BLE peripheral
4. Read/Write to characteristics

Device discovery can be skipped if device address is already known.
CC3220 MQTT Client

• The Message Queue Telemetry Transport (MQTT) protocol is a light-weight application protocol
• Based on the publish-subscribe model
  – Clients send messages to broker by publishing to a topic
  – Broker distributes messages to other clients that are subscribed to the topic
• Provides scalability through cloud vendor
• MQTT client library is provided in the SimpleLink™ CC3220 SDK
CC3220 MQTT Client

- MQTT Client parameters configured with `MQTTClient_NetAppConnParams_t` structure

```c
#define SERVER_ADDRESS "xxxxx.messaging.internetofthings.ibmcloud.com"
#define PORT_NUMBER 1883

MQTTClient_NetAppConnParams_t Mqtt_ClientCtx =
{
    MQTTCLIENT_NETCONN_URL,
    SERVER_ADDRESS,
    PORT_NUMBER, 0, 0, 0,
    NULL
};
```

- Simple MQTT Client APIs used to set optional parameters, start client, establish connection, and transfer data
  - `MQTTClient_set()`
  - `MQTTClient_create()` / `MQTTClient_run()`
  - `MQTTClient_connect()`
  - `MQTTClient_subscribe()` / `MQTTClient_publish()`
IBM Bluemix™

- IBM Bluemix is an implementation of IBM’s Open Cloud Architecture, based on Cloud Foundry
- Designed to allow user to quickly develop, deploy, and manage cloud applications
- Can be used to create a web interface to monitor and control a cloud connected devices
IBM Bluemix | Setup Summary

1. Sign-up for an account and setup your profile
2. Create a Watson IoT App
3. Add a new device
4. Make a Cloud Foundry App (Node.js)
5. Connect the Watson IoT App and Node.js app
6. Publish JavaScript code to the created Cloud Foundry App
7. Update the CC3220 MQTT Client example code
IBM Bluemix | Sign-up for an Account

- Log-in and create a profile
  - Create Organization
  - Create a Space
IBM Bluemix | Create a Watson IoT App

Apps
You don't have any apps yet. Get started with one of the options that follow, or go to the catalog to create an app.

Create app

Services
Data & Analytics
Watson
Internet of Things
APIs
Network
Storage
Security
DevOps
Application Services
Integrate

Internet of Things Platform
This service is the hub of all things IBM IoT. It is where you can set up and manage your connected devices.

1 2 3
IBM Bluemix | Add a New Device

1. Add Device
   - Choose Device Type
   - Create device type

2. Create Device Type
   - Create type
   - Create gateway type

3. Create Gateway Type
   - Name: myWiFiGateway
   - Description: Enter description

The device type name is used to identify the device type uniquely, using a restricted set of characters to make it suitable for API use.

The device type description can be used for a more descriptive way of identifying the device type.
IBM Bluemix | Store Device Credentials

- Adding an instance of the gateway device generates set of credentials
- Device credentials are used by the MQTT client to authenticate and connect to cloud
IBM Bluemix | Create Node.js App

- Create a Cloud Foundry App (SDK for Node.js)
- Install the Cloud Foundry CLI which lets you configure your Node.js application and deploy your code
- Develop JavaScript application and publish code with CLI
Update CC3220 Code - IBM Bluemix

```json
{
  "iotf-service": {
    "credentials": {
      "iotCredentialsIdentifier": "a2g6k39s16r5",
      "mqtt_host": "2a10gy.messaging.internetofthings.ibmcloud.com",
      "mqtt_u_port": 1883,
      "mqtt_s_port": 8883,
      "http_host": "2a10gy.internetofthings.ibmcloud.com",
      "org": "2a10gy",
      "apiKey": "a-2a10gy-cep3qursbq",
      "apiToken": "J3+3Zmy_wa0b2dlwy!
    },
    "syslog_drain_url": null,
    "volume_mounts": [],
    "label": "iotf-service",
    "provider": null,
    "plan": "iotf-service-free",
    "name": "Internet of Things Platform-jg",
    "tags": []
  }
}
```

```c
#define SERVER_ADDRESS "2a10gy.messaging.internetofthings.ibmcloud.com"
#define SERVER_IP_ADDRESS "192.168.178.67"
#define PORT_NUMBER 1883
#define SECURED_PORT_NUMBER 8883
#define LOOPBACK_PORT 1882
```
char *ClientId = “g:[orgId]:[deviceTypeName]:[deviceId]”

‘g’ for gateway

orgId is given in credentials (i.e. “2al0gy”)

const char *Username = “use-auth-token”  // “use-auth-token”

const char *Password = “[password set for device]”  // Authentication Token

---

<table>
<thead>
<tr>
<th>Organization ID</th>
<th>2al0gy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Type</td>
<td>myWiFiGateway</td>
</tr>
<tr>
<td>Device ID</td>
<td>WiFiGateway1</td>
</tr>
<tr>
<td>Authentication Method</td>
<td>token</td>
</tr>
<tr>
<td>Authentication Token</td>
<td>myGatewayPassword</td>
</tr>
</tbody>
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Leveraging Sample Code in Released SDKs

- SimpleLink™ Software Development Kits (SDK) provide the key software resources needed to quickly build a solution.
- Leverage key components from the SDK, so you can focus on your application.

<table>
<thead>
<tr>
<th>SimpleLink™ Wi-Fi® CC3220</th>
<th>SimpleLink™ BLE CC2640R2</th>
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</thead>
<tbody>
<tr>
<td>1. SimpleLink™ CC3220 Software Development Kit (SDK)</td>
<td></td>
</tr>
<tr>
<td>• Updated quarterly</td>
<td></td>
</tr>
<tr>
<td>• TI Drivers included</td>
<td></td>
</tr>
<tr>
<td>• MQTT client library included (source and binary)</td>
<td></td>
</tr>
<tr>
<td>2. Provisioning Example</td>
<td></td>
</tr>
<tr>
<td>3. MQTT Client Example</td>
<td></td>
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<tr>
<td>4. UART Driver Example</td>
<td></td>
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</tbody>
</table>

1. SimpleLink™ CC2640R2 Software Development (SDK) |
   • Updated quarterly |
   • BLE 4.2 and BLE 5 Stack |
2. HostTest Example Application |
Demo of System

[Video from FAE Summit Demo Night to be inserted]
Build Your Own Gateway

1. Get your EVMs
   - CC3220S-LaunchPad
   - CC2640R2 LaunchPad

2. Download the SimpleLink MCU Platforms SDK
   - Simplelink-CC3220-SDK
   - Simplelink-CC2640R2-SDK

3. Create an IBM Bluemix account
   Build with Infrastructure, Watson, Software, and services on the Bluemix cloud platform.

4. Develop your own gateway for BLE Peripherals

Get your EVMs

Download the SimpleLink MCU Platforms SDK

Create an IBM Bluemix account

Develop your own gateway for BLE Peripherals
End-to-end Development – Available Resources

- SimpleLink
- ARM®-based MCUs
- Development Kits
- Code Composer Studio™ IDE
- TI Resource Explorer
- Common software
- SimpleLink Academy
- ti.com/simplelinkwifi
- ti.com/ble
Visit ti.com/simplelink
Thank you

Q & A