

TI-RSLK

Texas Instruments Robotics System Learning Kit



TEXAS INSTRUMENTS

Module 19

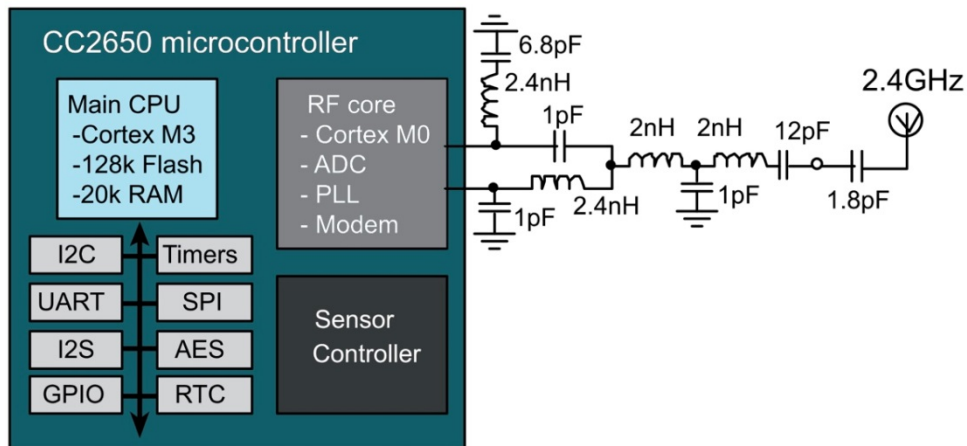
Lecture: Bluetooth low energy - Wireless



Bluetooth Low Energy

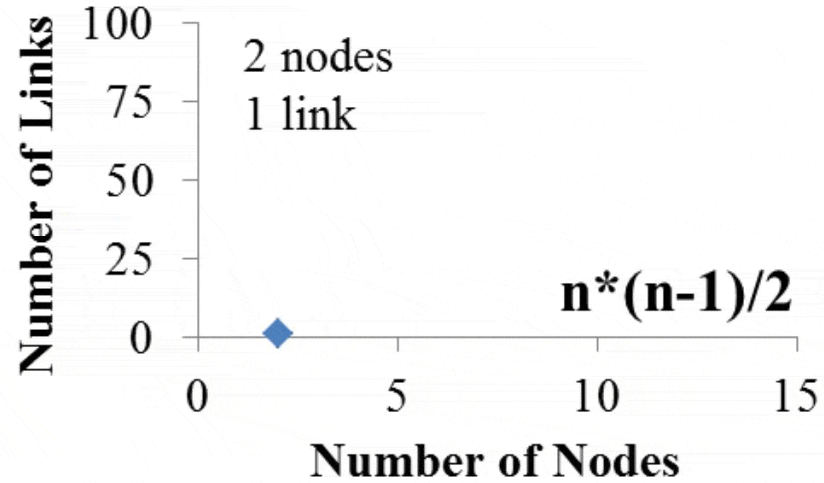
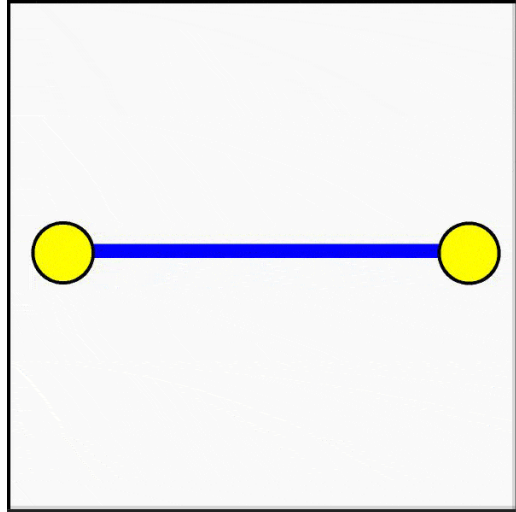
You will learn in this module

- Introduction to Communication
 - Internet
 - Internet of Things
 - Challenges
- Wireless
 - Encode
 - Transmit
 - Decode
- Radio
 - Frequencies
 - Channels



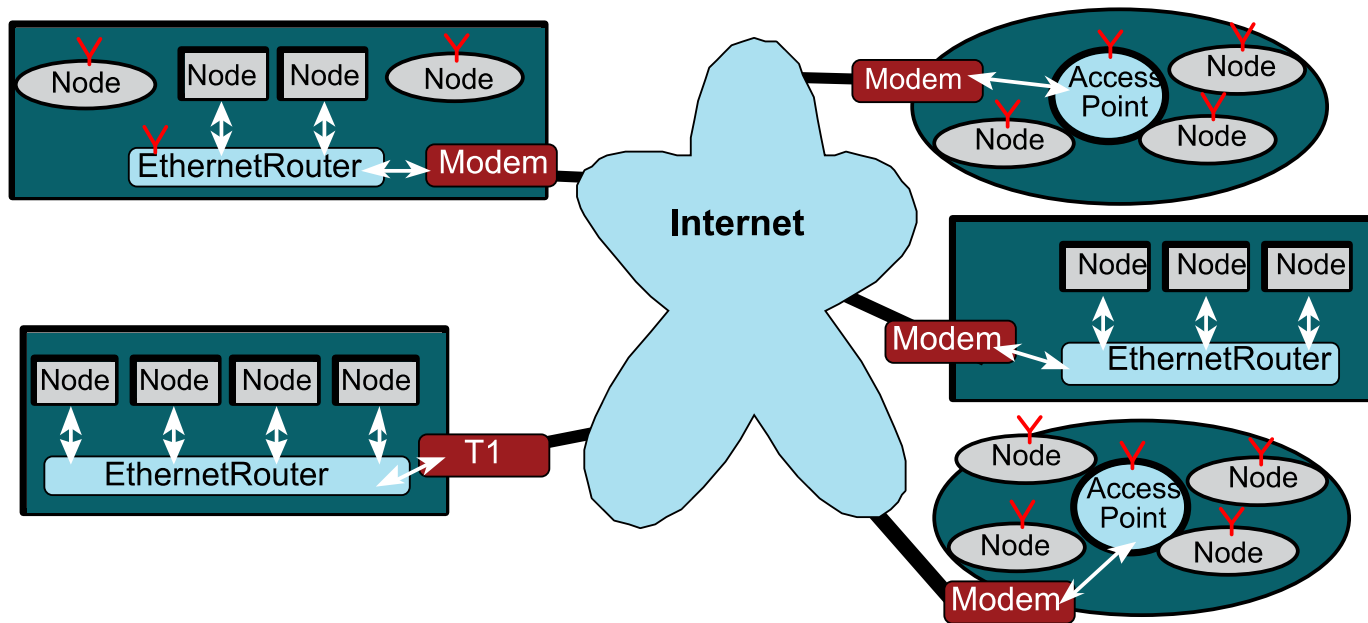


Motivation



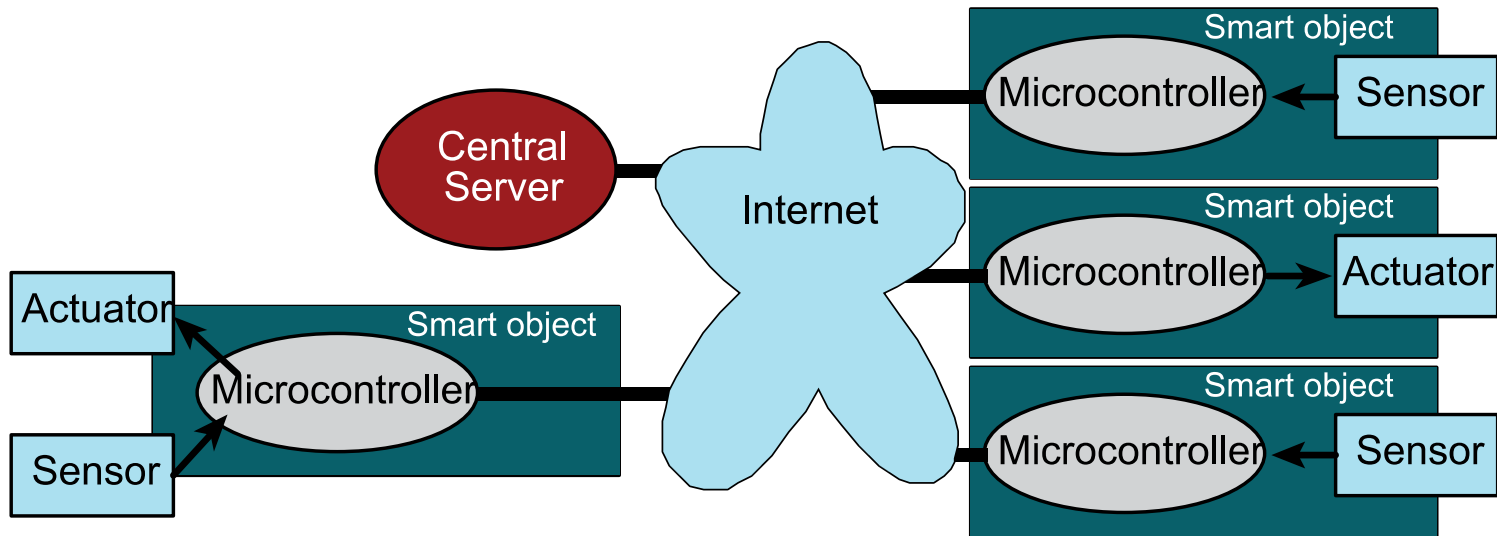


What is the Internet?





What is the Internet of Things?



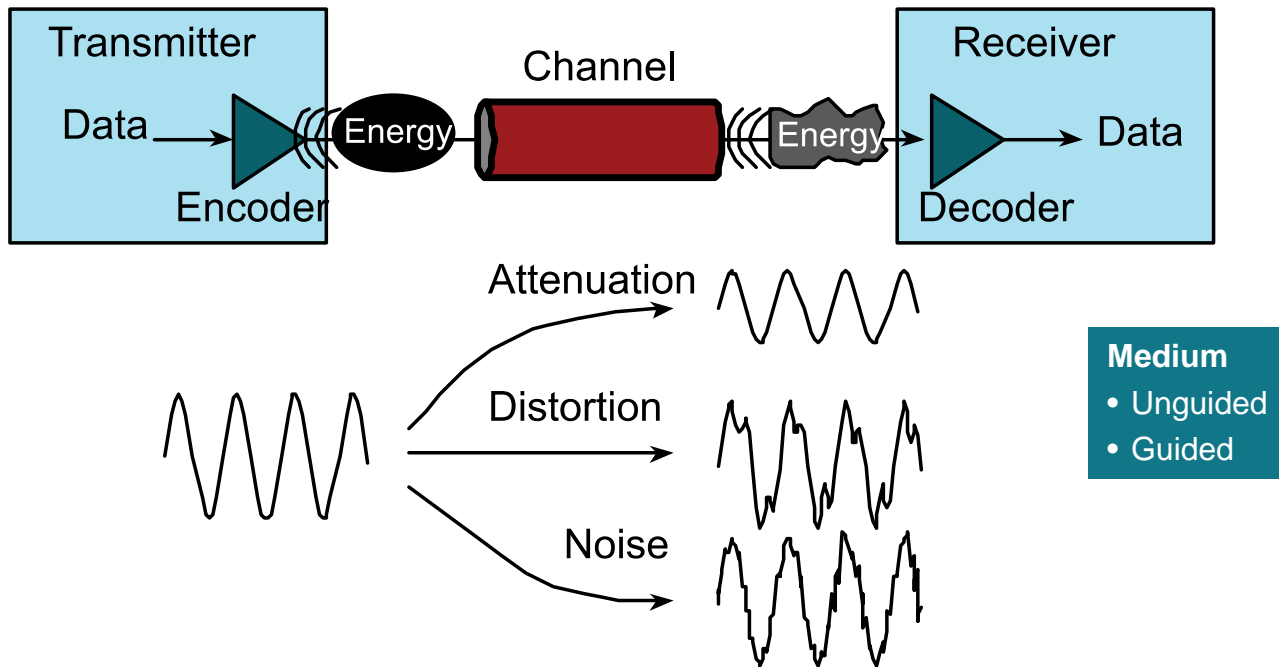


Challenges

- Standardization
 - Bluetooth Low Energy, Simple Network Processor
- Interoperability
 - Technologies, vendors, companies
- Evolution
 - Incremental/continuous vs revolutionary
- Stability
- Abstraction
- Scalability, 50 million to 50 billion
- Security
 - Confidentiality, integrity, availability

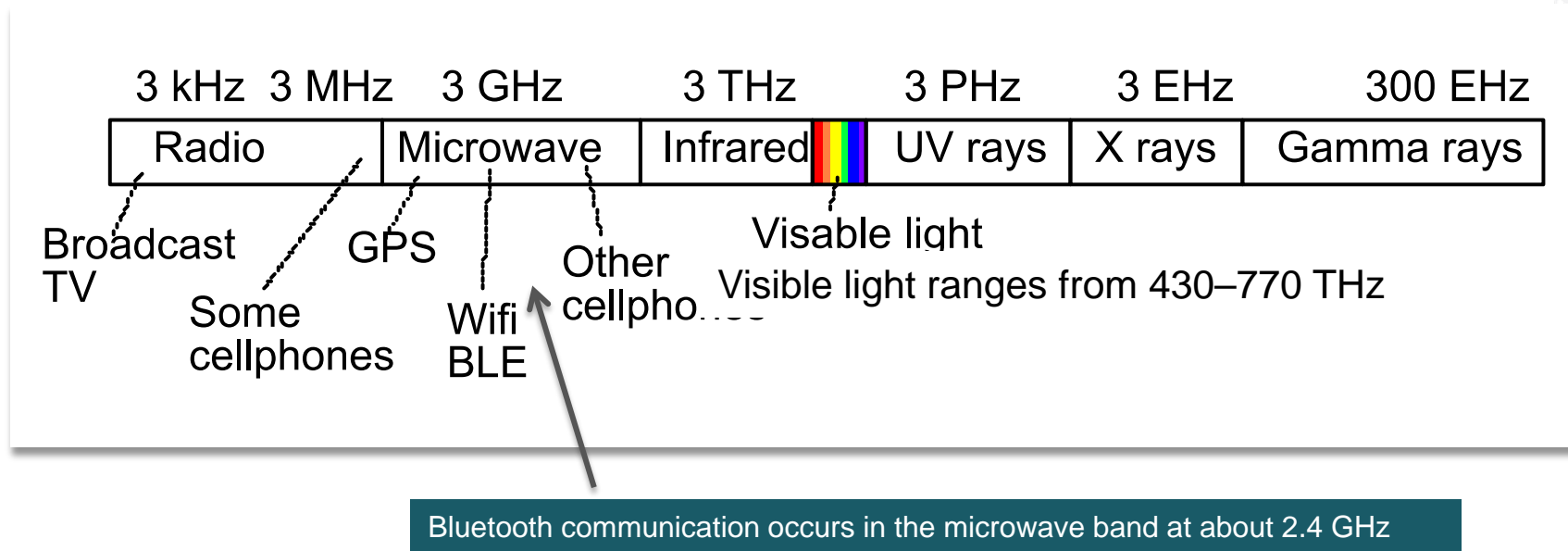


Wireless Communication





Radio





Wifi

Standard	Description
Wifi	Up to 600 Mbits/sec Fixed wide frequency channels Requires lots of power Support for 2.4 and 5 GHz channels Extensive security features



Bluetooth/BLE

Standard	Description
Wifi	Up to 600 Mbits/sec Fixed wide frequency channels Requires lots of power Support for 2.4 and 5 GHz channels Extensive security features
Bluetooth/BLE	Very low power BT up to 2 Mbps Massive deployed base Frequency hopping Good performance in congested/noisy environment Ease of use No roaming

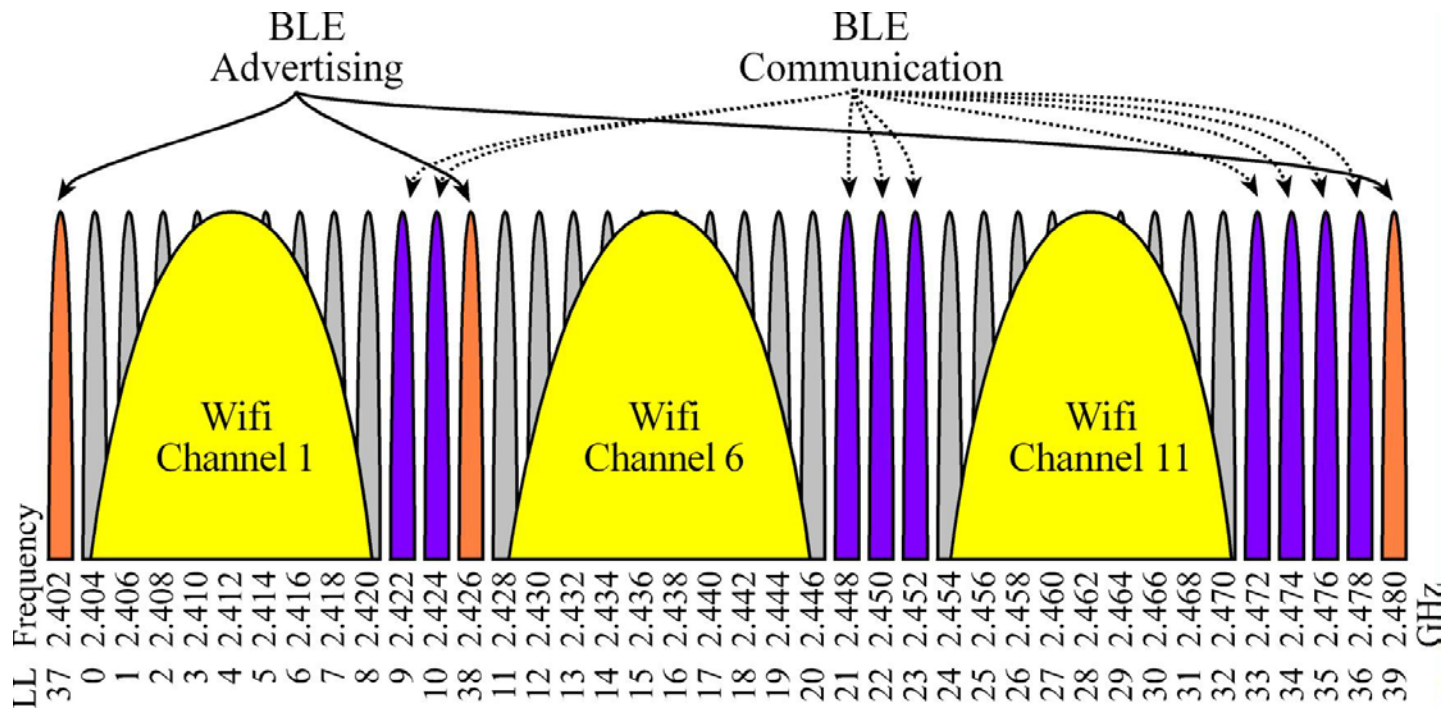


Standard	Description
Wifi	Up to 600 Mbits/sec Fixed wide frequency channels Requires lots of power Support for 2.4 and 5 GHz channels Extensive security features
Bluetooth/BLE	Very low power BT up to 2 Mbps Massive deployed base Frequency hopping Good performance in congested/noisy environment Ease of use No roaming
ZigBee	Very low power Fixed channels Complex mesh network 250 kbps bandwidth



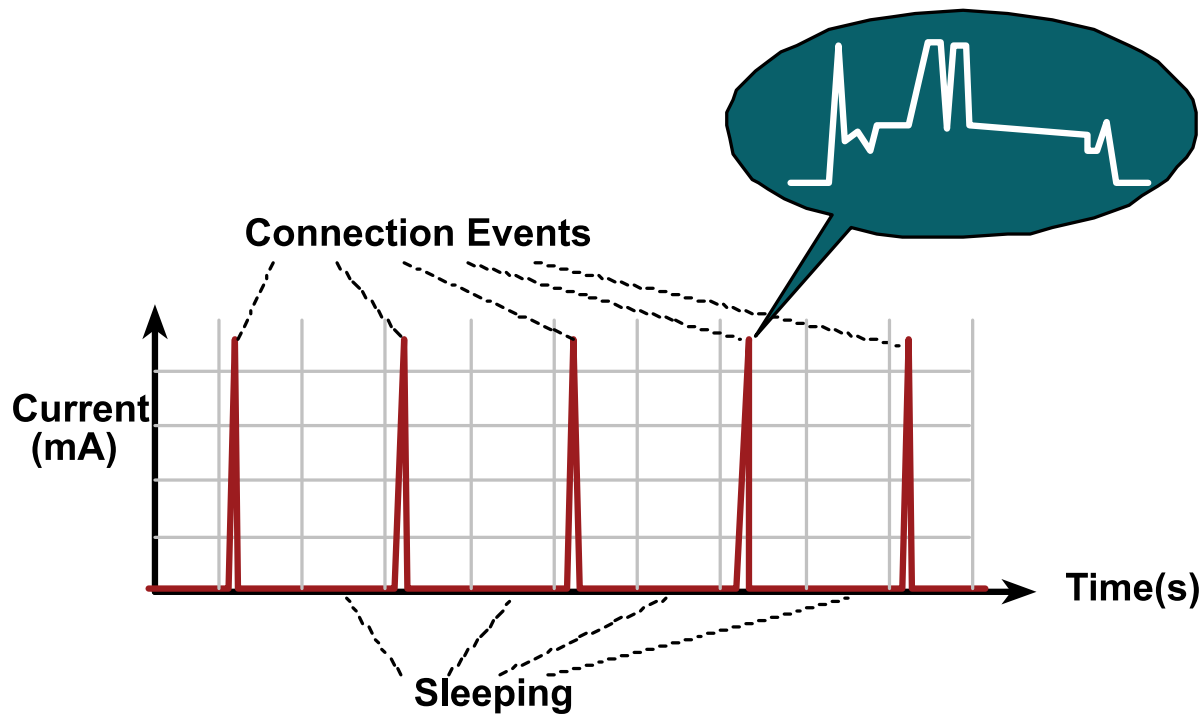
Radio has 40 narrow bands

Each band is ± 1 MHz.





Low power

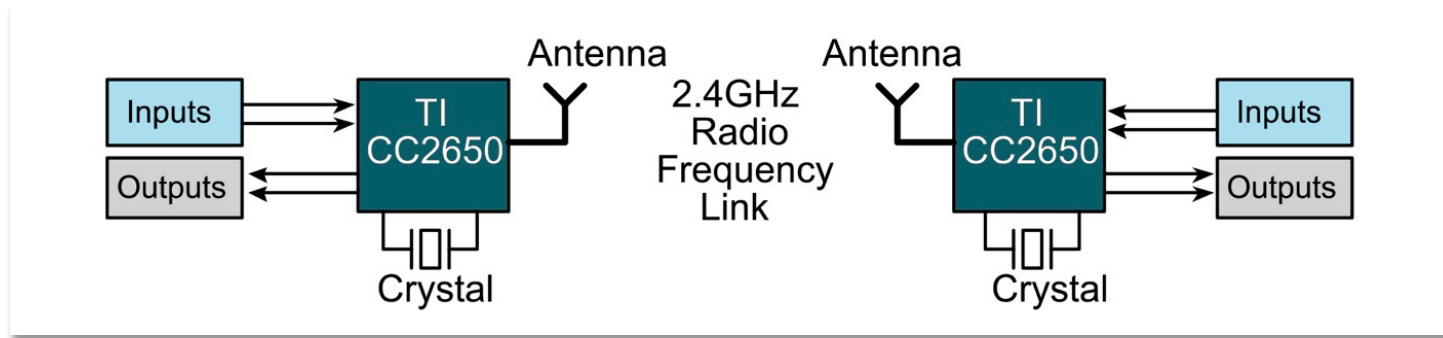




Summary

Wireless Communication

- Internet of Things
- Standardization
- Radio
- Low power



Module 19

Lecture: Bluetooth low energy - Theory



Bluetooth Low Energy

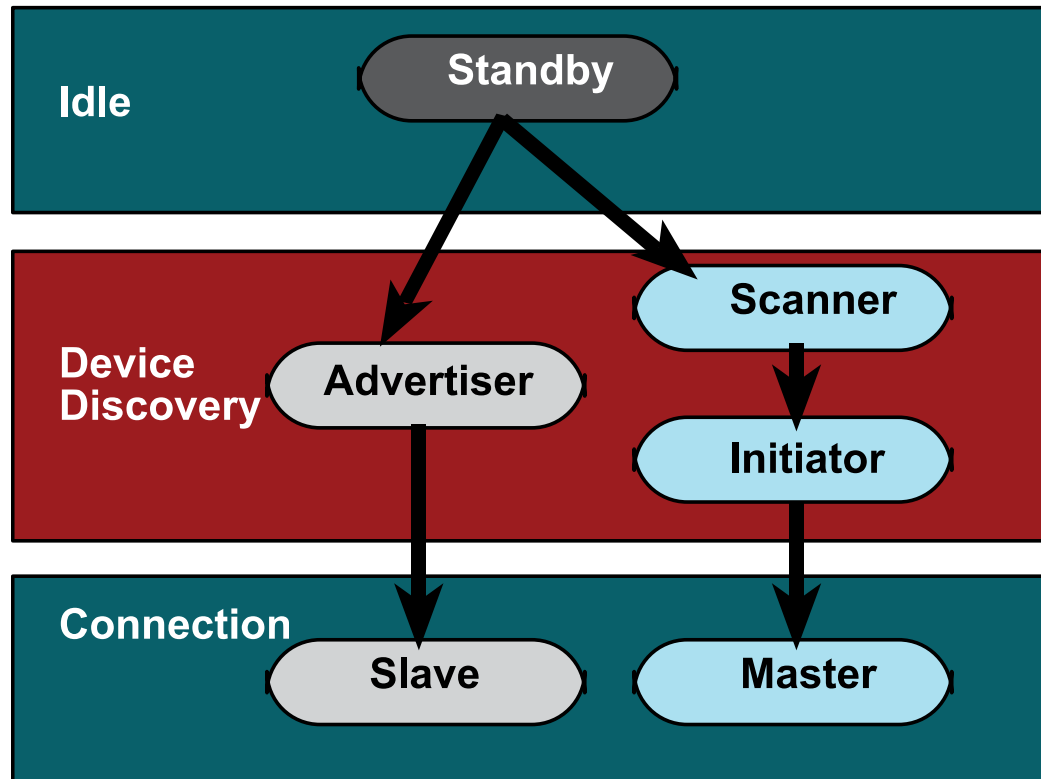
You will learn in this module

- Client-server paradigm
 - Request-response
- BLE
 - Profile
 - Service
 - Characteristic
- CC2650
 - Microcontroller
 - RF radio
 - Sensor interface
- CC2650 – MSP432 BLE Server
 - SNP – SAP



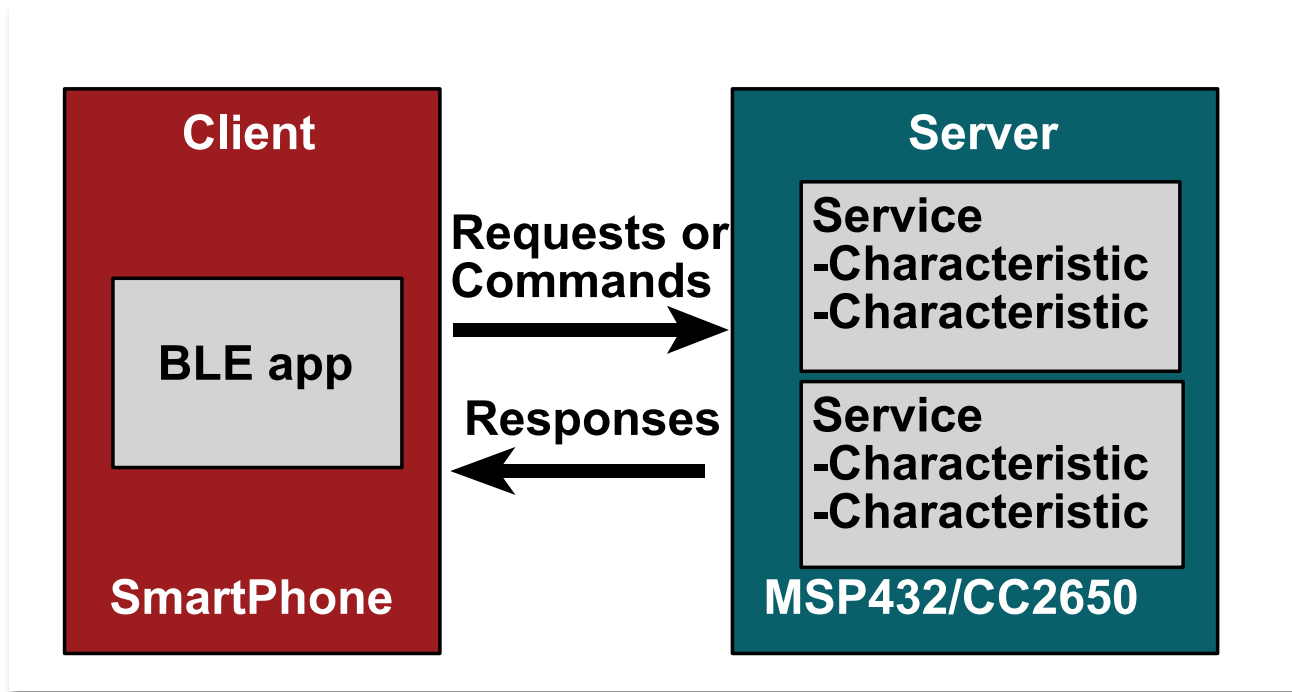


BLE Advertising





Client-server





Generic Attribute Profile (GATT)

Service

Characteristic
UUID=0xFFF1, R/W, "Data"

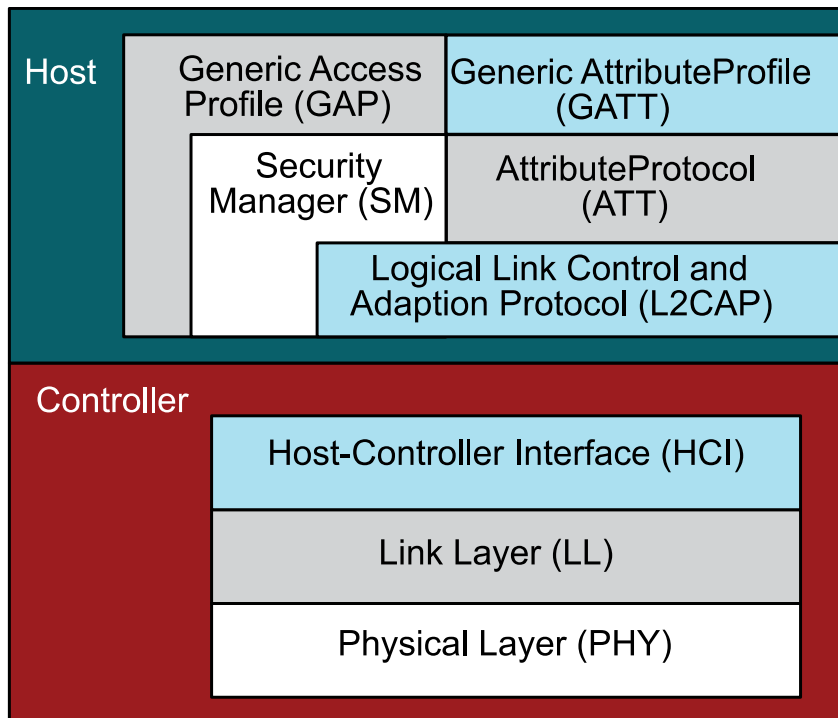
Characteristic
UUID=0xFFF2, R, "Switches"

Characteristic
UUID=0xFFF3, W, "LEDs"

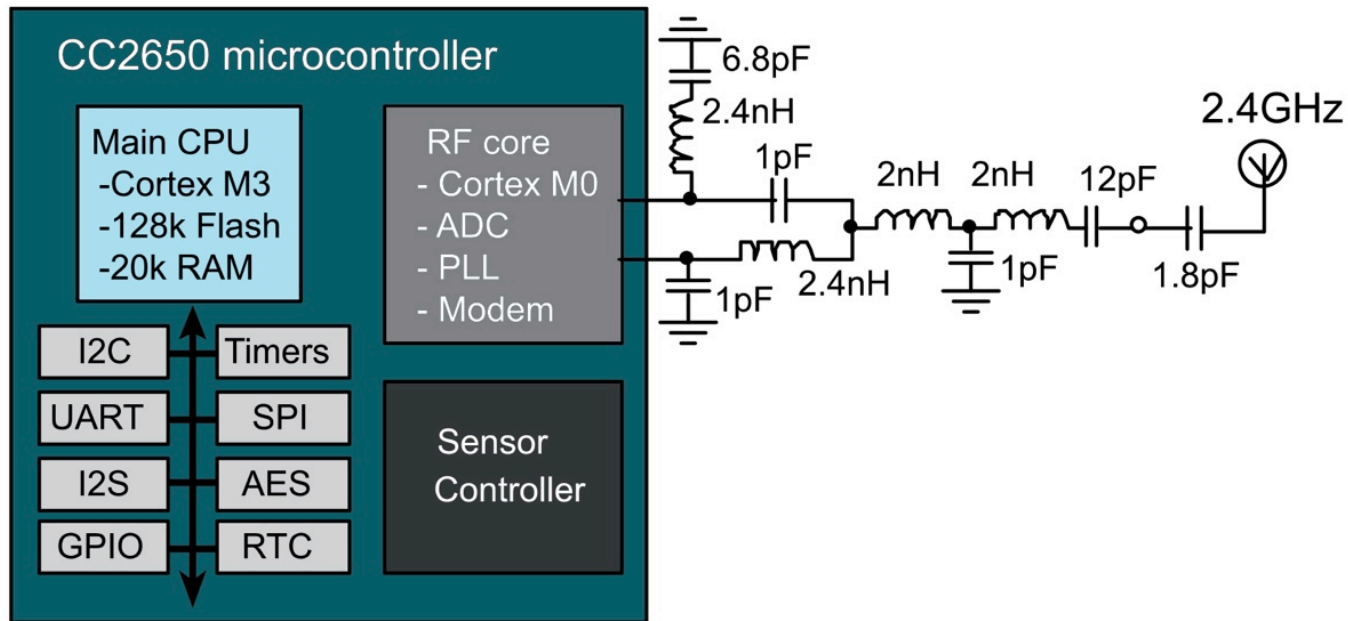
Characteristic
UUID=0xFFF4, Notify, "Count"

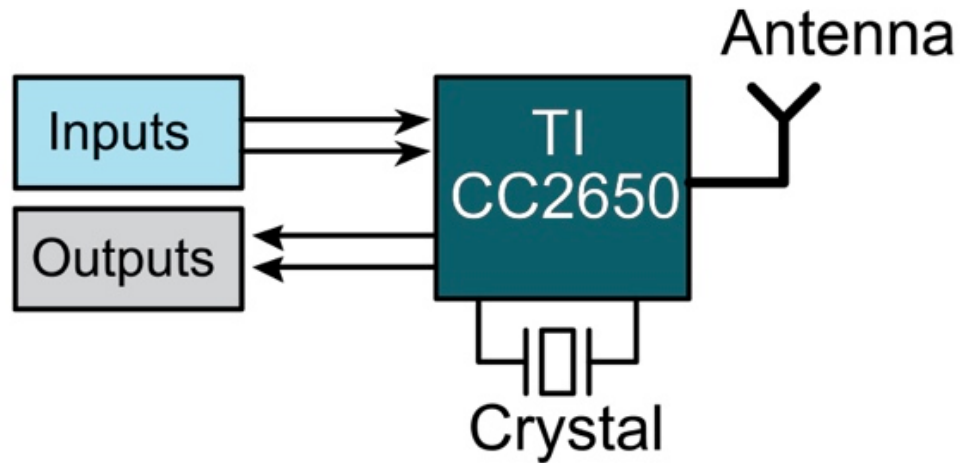


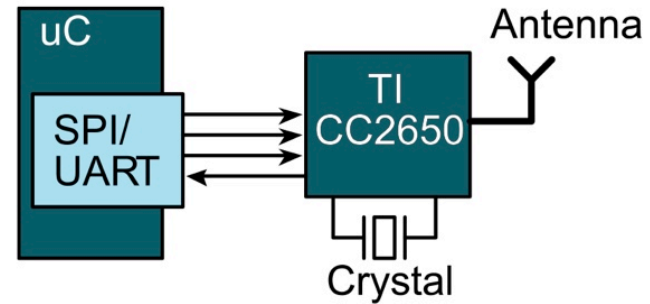
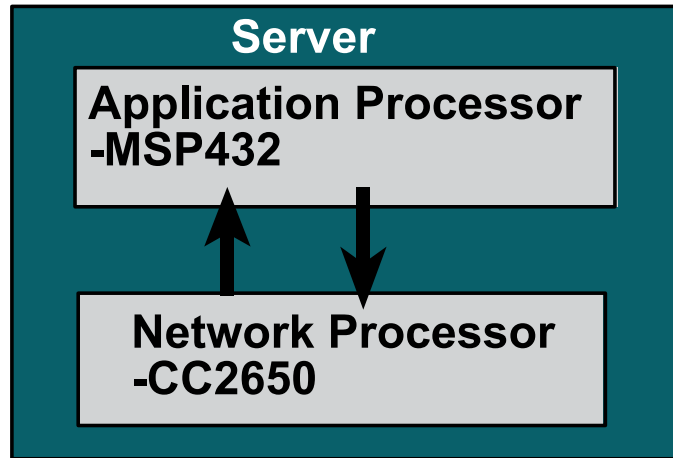
BLE layers



TI SimpleLink™ Bluetooth log energy
CC2650 Module BoosterPack™

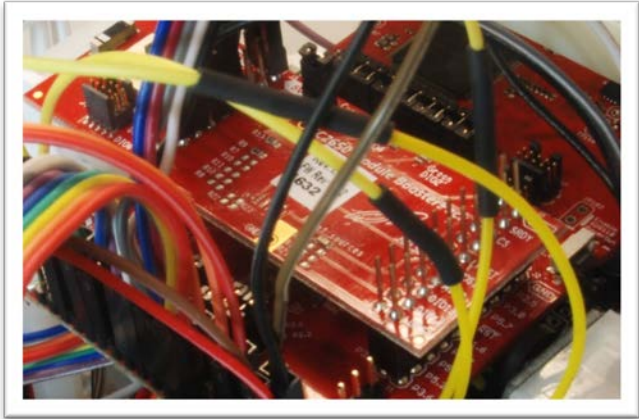
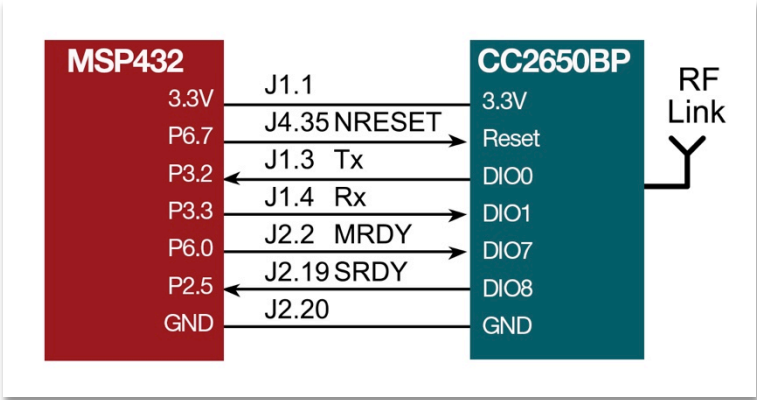








CC2650 – MSP432 BLE Server

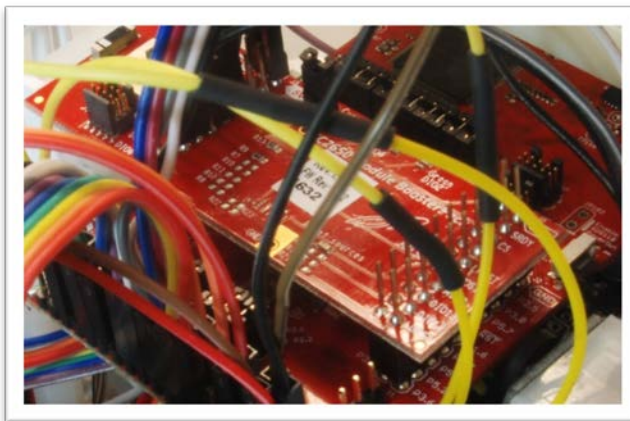




Summary

Bluetooth Low Energy

- Client – server
- Profile, service, characteristic
- Advertising
- CC2650
- CC2650-MSP432 system



Module 19

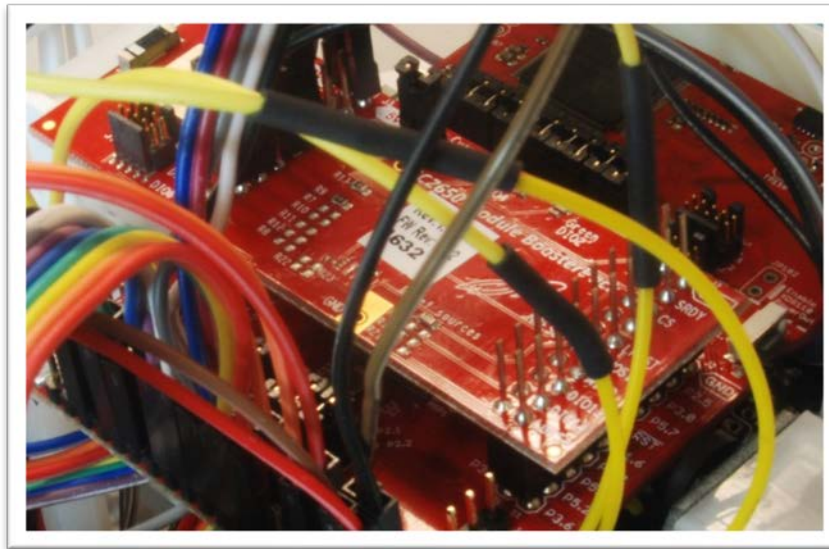
Lecture: Bluetooth low energy - Simple Network Processor



Bluetooth low energy

You will learn in this module

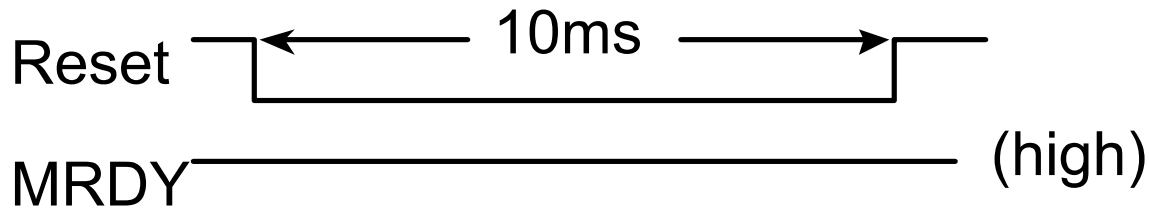
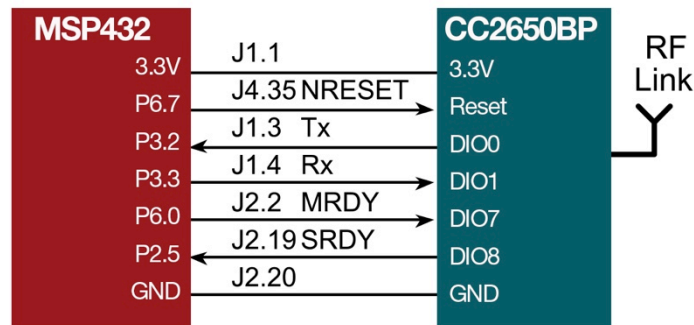
- BLE server
 - CC2650-MSP432 Interface
 - Serial, interrupt driven
- Simple Network Processor
 - Handshake
 - Message protocol



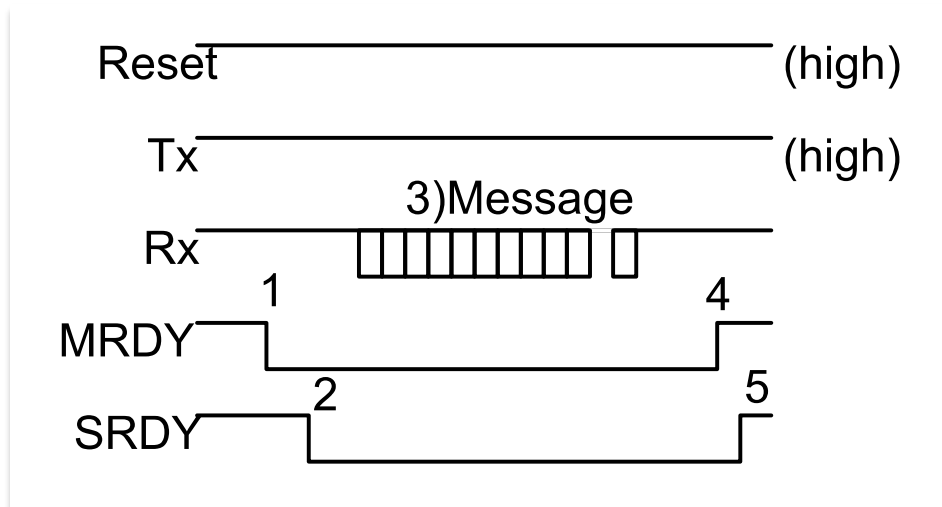
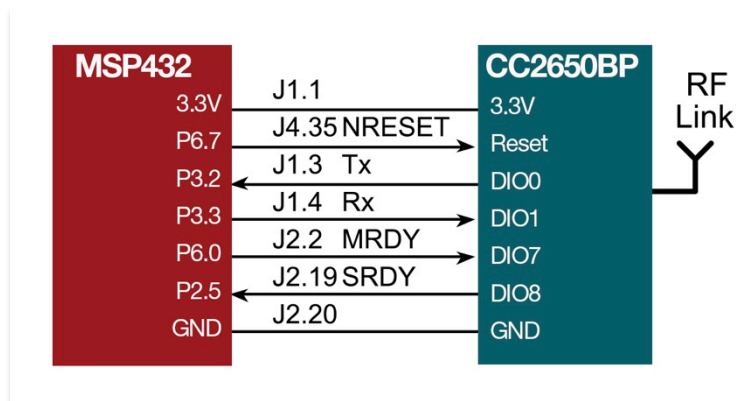


Reset

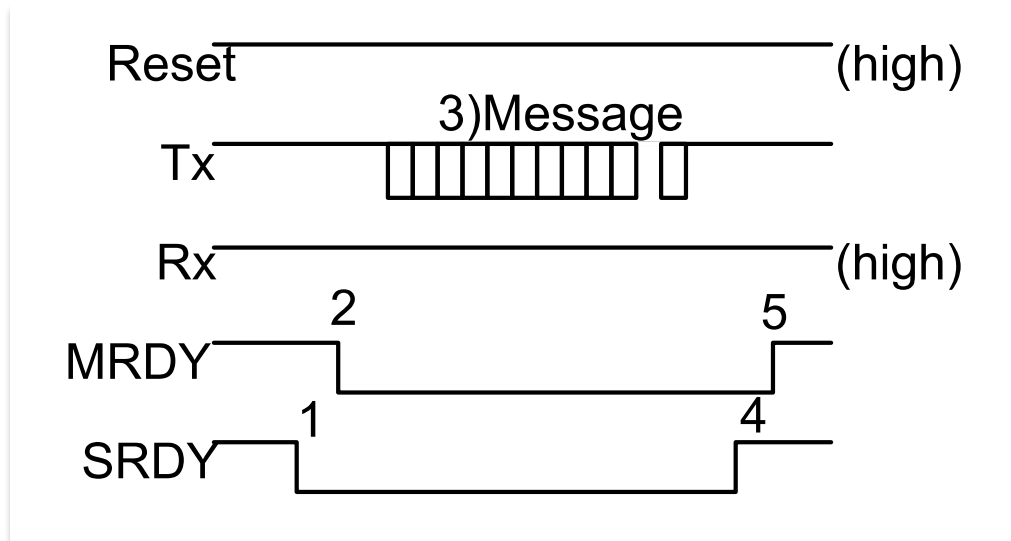
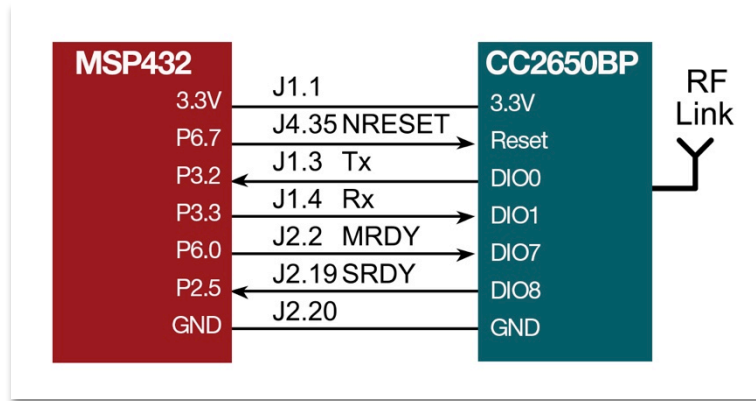
- MSP432 is master
 - MSP432 can reset CC2650
- CC2650 is slave
- Command/response protocol



MSP432 to CC2650 message

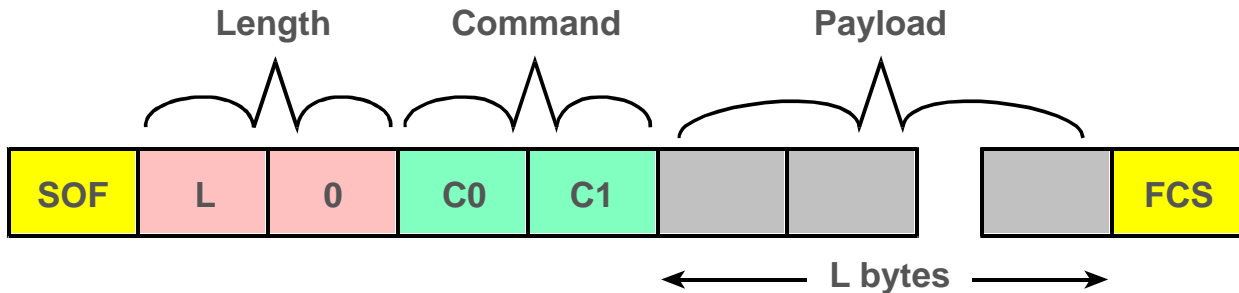


CC2650 to MSP432 message





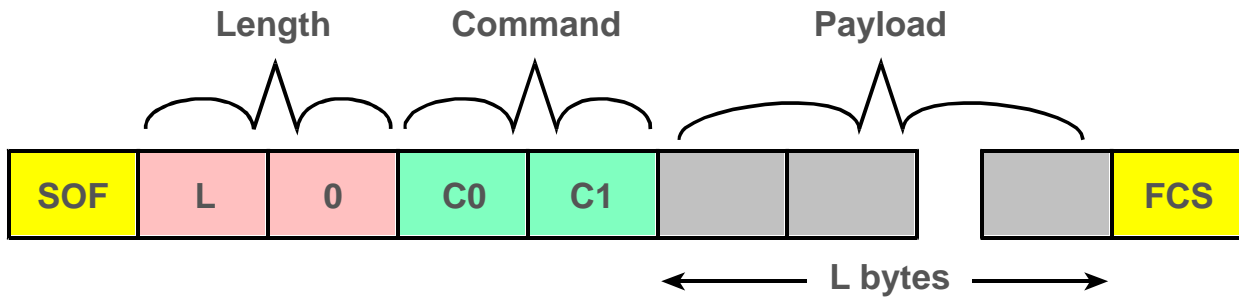
Advertising



```
const uint8_t NPI_GATTSetDeviceNameMsg[] = {  
    SOF, 18, 0x00,           // length = 18  
    0x35, 0x8C,             // Set GATT Parameter  
    0x01,                   // Generic Access Service  
    0x00, 0x00,             // Device Name  
    'S', 'h', 'a', 'p', 'e', ' ', 't', 'h', 'e',  
    ' ', 'W', 'o', 'r', 'l', 'd',  
    0x77};                  // FCS
```




Advertising



GATT Set DeviceName

LP->SNP **FE**,12,00,35,8C,01,00,00,53,68,61,70,65,20,74,68,65,20,57,6F,72,6C,64,**DE**
 SNP->LP **FE**,01,00,75,8C,00,**F8**

SetAdvertisement1

LP->SNP **FE**,0B,00,55,43,01,02,01,06,06,FF,0D,00,03,00,00,**EE**
 SNP->LP **FE**,01,00,55,43,00,**17**

SetAdvertisement2

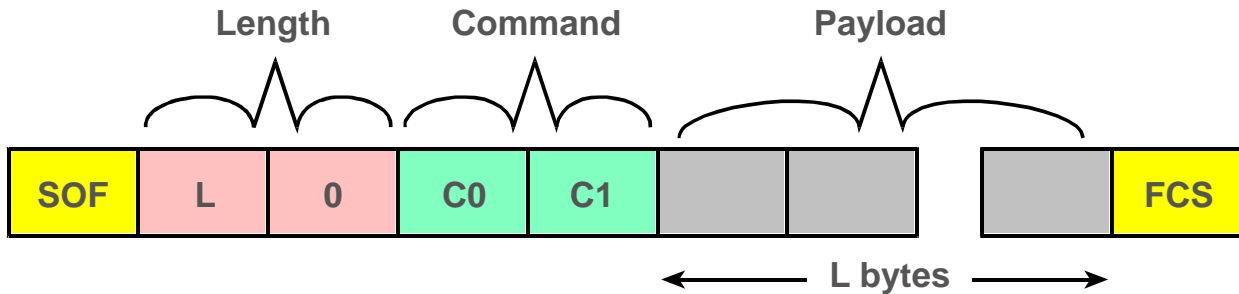
LP->SNP **FE**,1B,00,55,43,00,10,09,53,68,61,70,65,20,74,68,65,20,57,6F,...,00,**0C**
 SNP->LP **FE**,01,00,55,43,00,**17**

StartAdvertisement

LP->SNP **FE**,0E,00,55,42,00,00,00,64,00,00,00,00,01,00,00,00,C5,02,**BB**
 SNP->LP **FE**,03,00,55,05,08,00,00,**5B**



Add service



Add service

LP->SNP FE, 03, 00, 35, 81, 01, F0, FF, B9

SNP->LP FE, 01, 00, 75, 81, 00, F5

Add CharValue1

LP->SNP FE, 08, 00, 35, 82, 03, 0A, 00, 00, 00, 02, F1, FF, BA

SNP->LP FE, 03, 00, 75, 82, 00, 1E, 00, EA

Add CharDescriptor1

LP->SNP FE, 0B, 00, 35, 83, 80, 01, 05, 00, 05, 00, 44, 61, 74, 61, 00, 0C

SNP->LP FE, 04, 00, 75, 83, 00, 80, 1F, 00, 6D

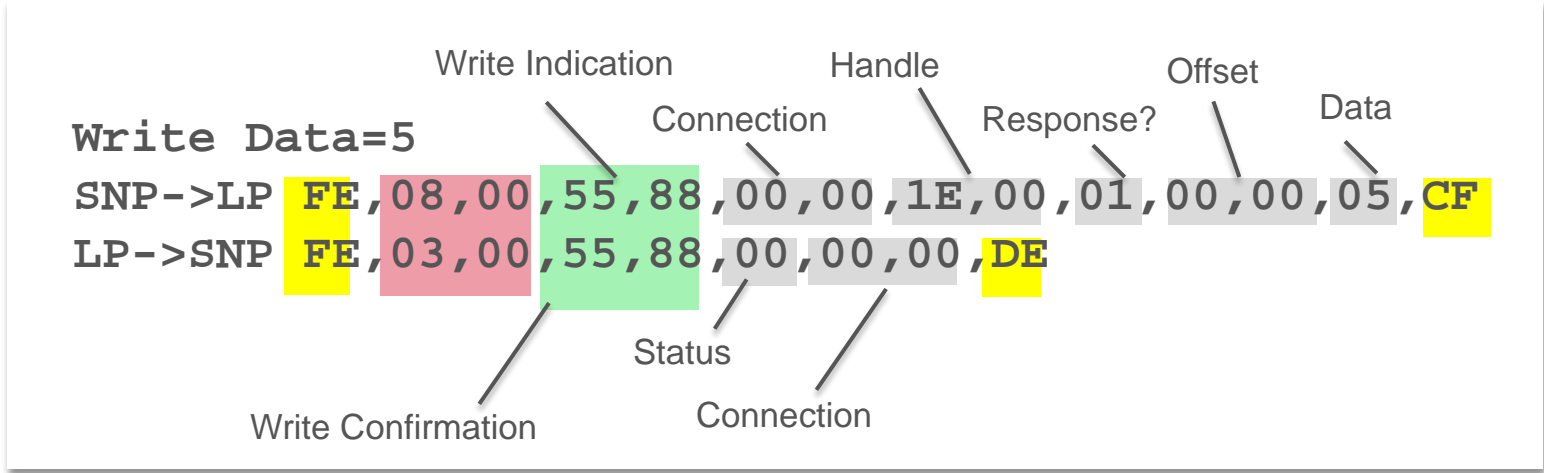
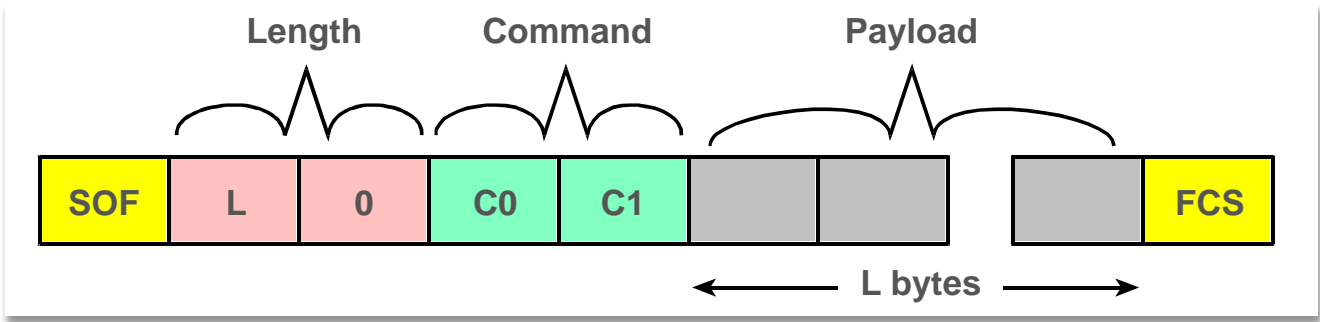
Register service

LP->SNP FE, 00, 00, 35, 84, B1

SNP->LP FE, 05, 00, 75, 84, 00, 1C, 00, 29, 00, C1

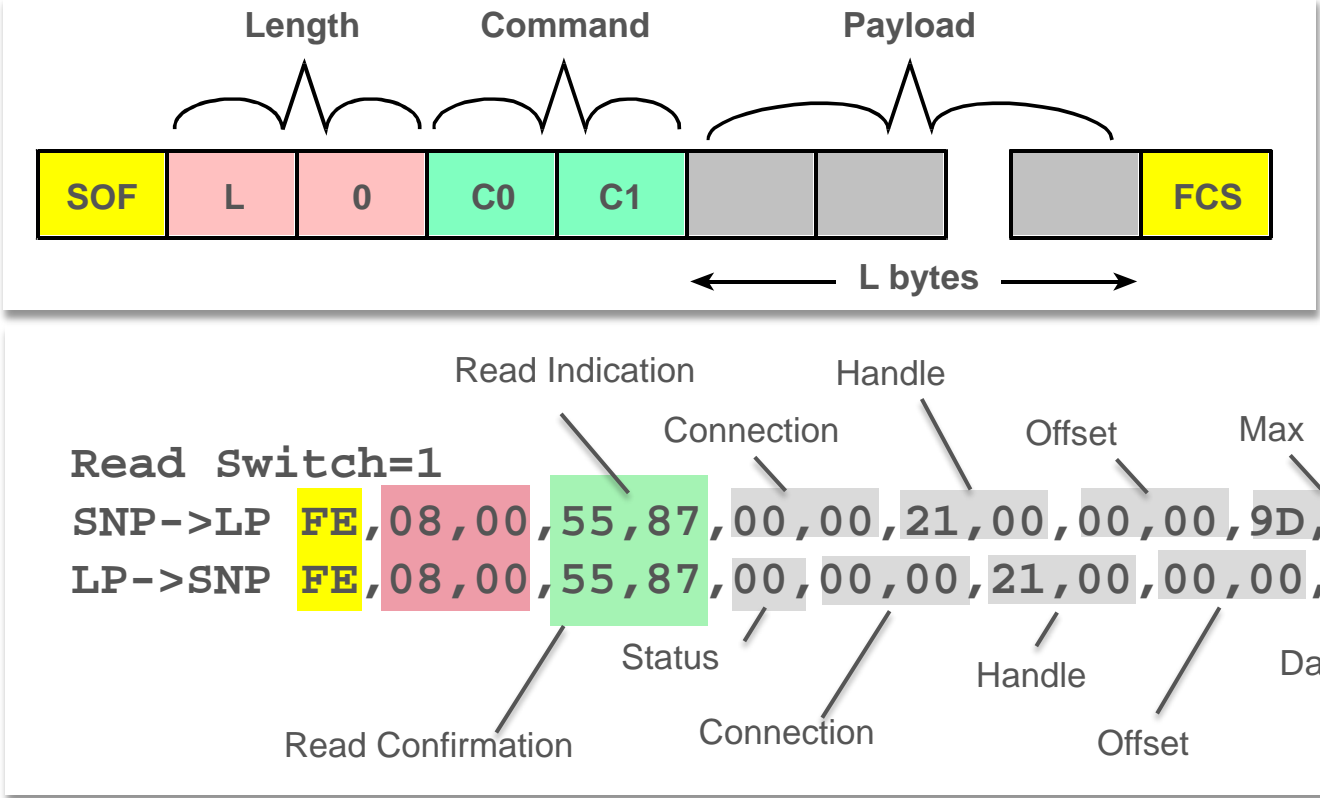


Write indication





Read indication

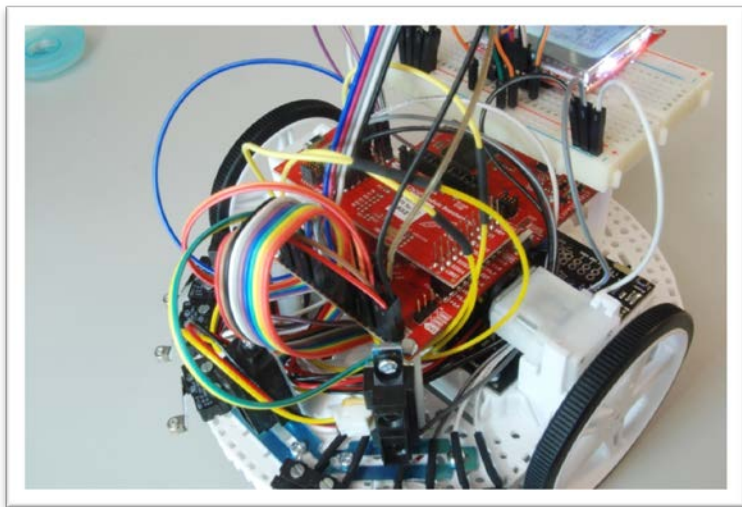




Summary

Bluetooth Low Energy

- Network Processor
- Application Processor



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