

# TI-RSLK

Texas Instruments Robotics System Learning Kit



TEXAS INSTRUMENTS

# Module 19

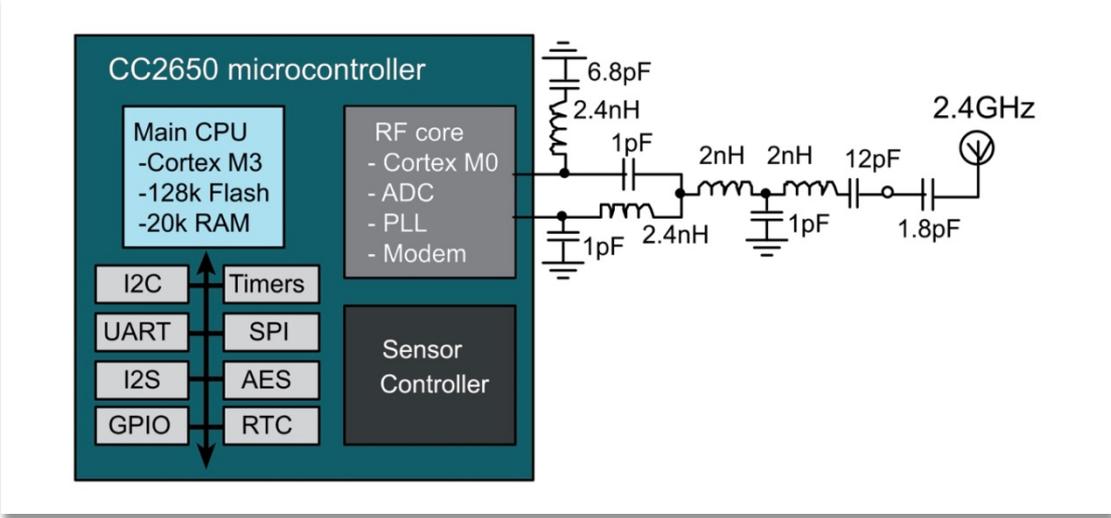
Lecture: Bluetooth low energy - Wireless



# Bluetooth Low Energy

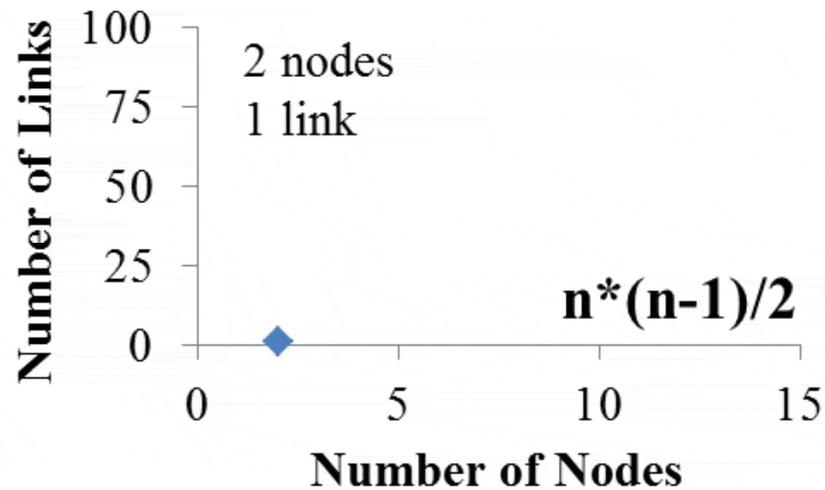
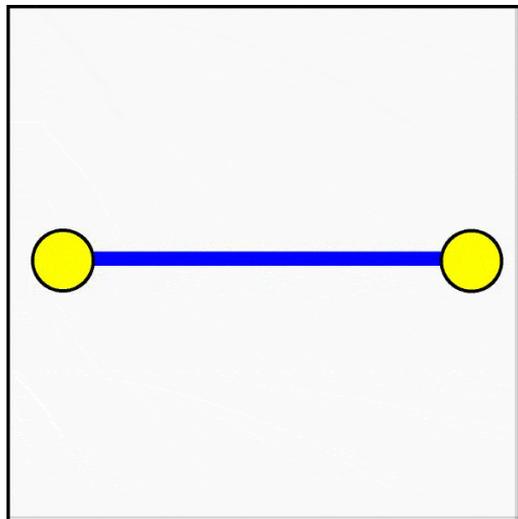
## You will learn in this module

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



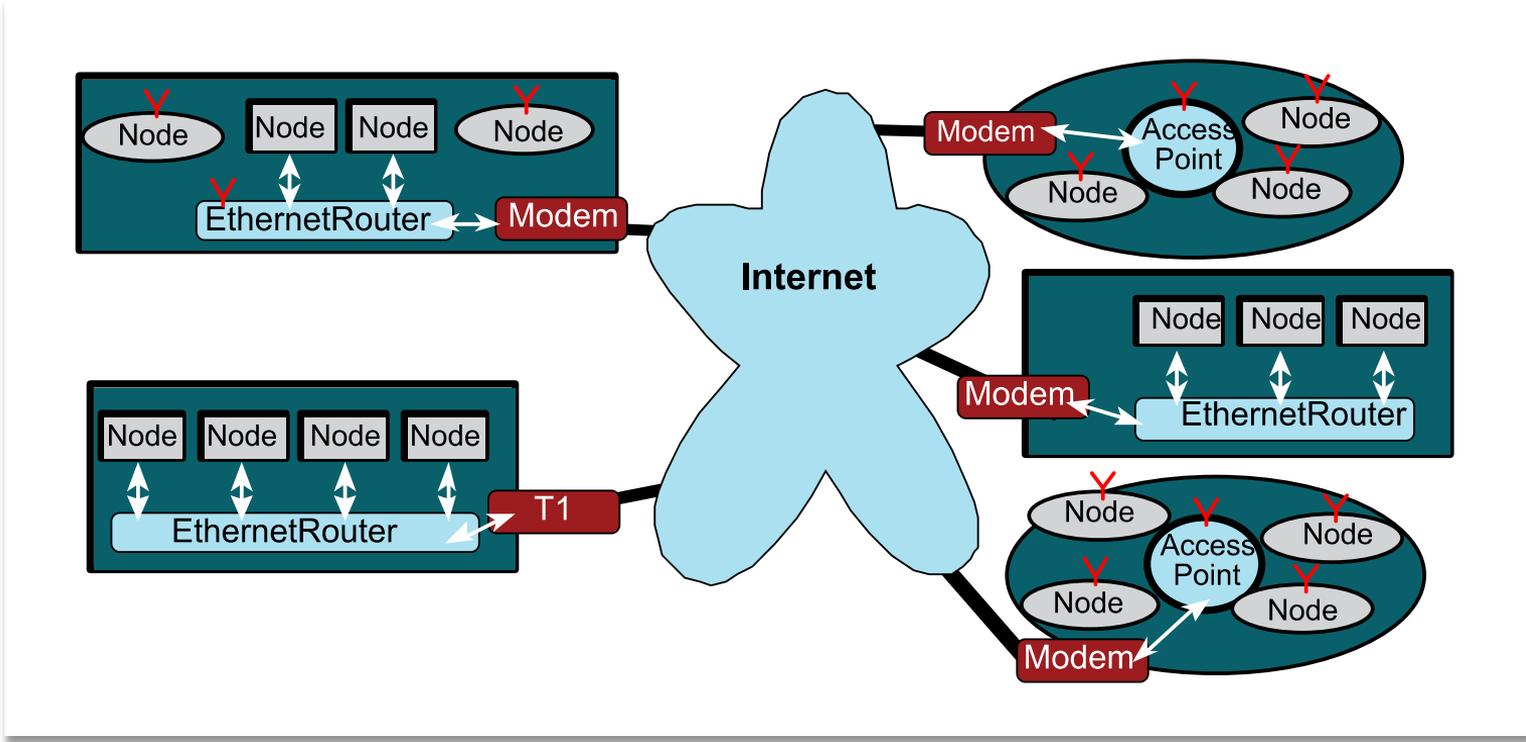


# Motivation



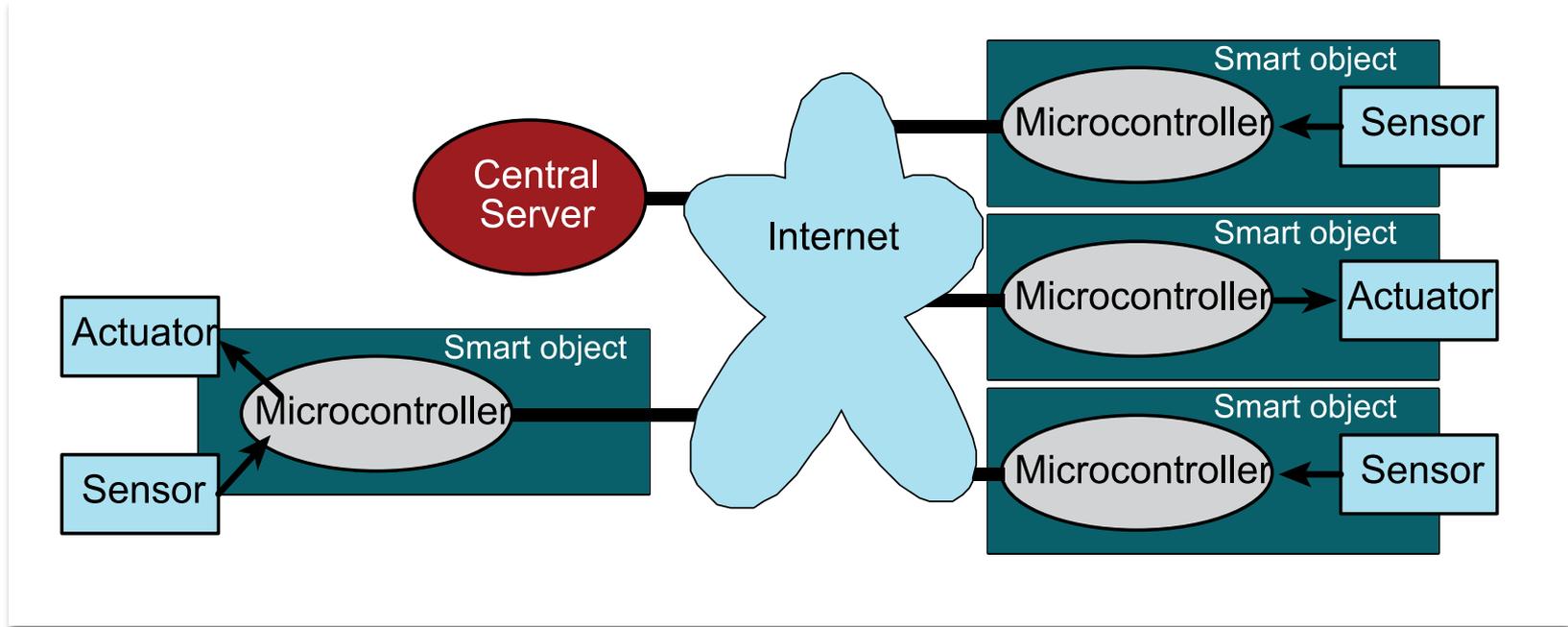


# What is the Internet?





# What is the Internet of Things?



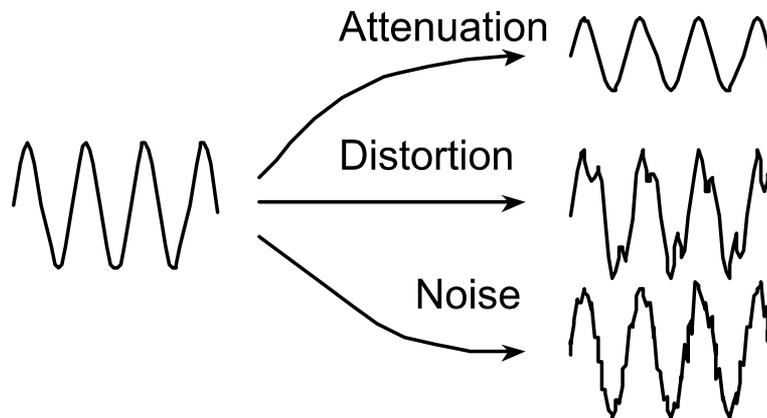
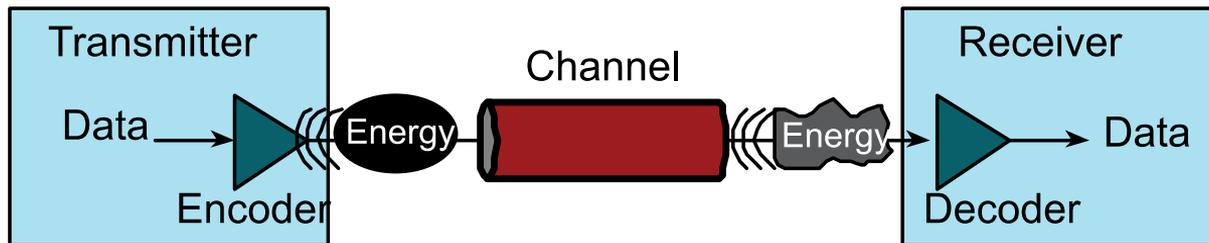


# Challenges

- 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



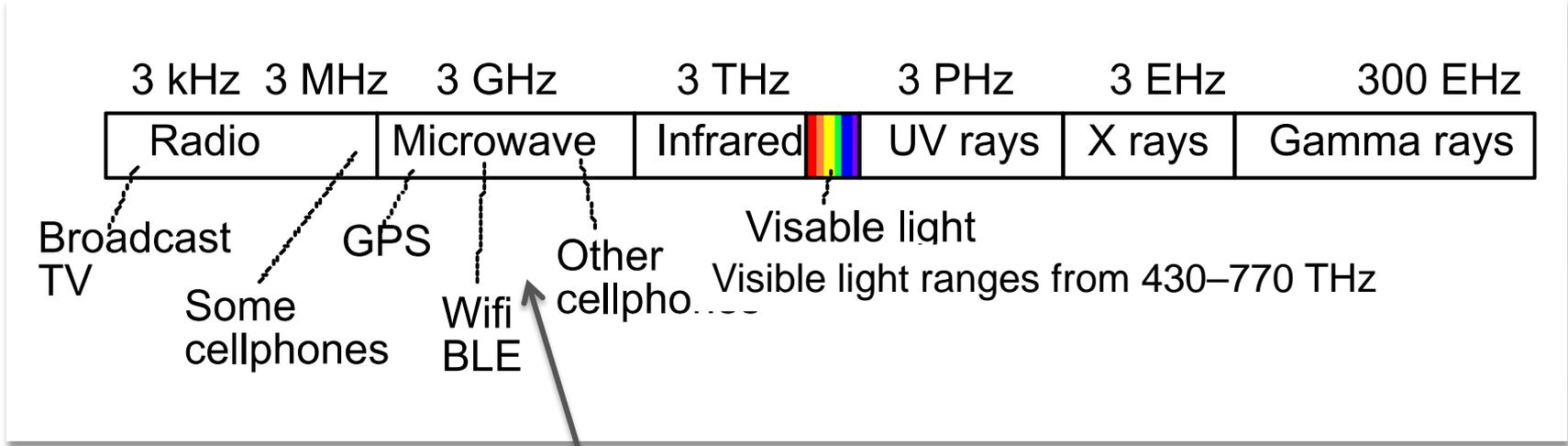
# Wireless Communication



- Medium**
- Unguided
  - Guided



# Radio



Bluetooth communication occurs in the microwave band at about 2.4 GHz



# Wifi

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

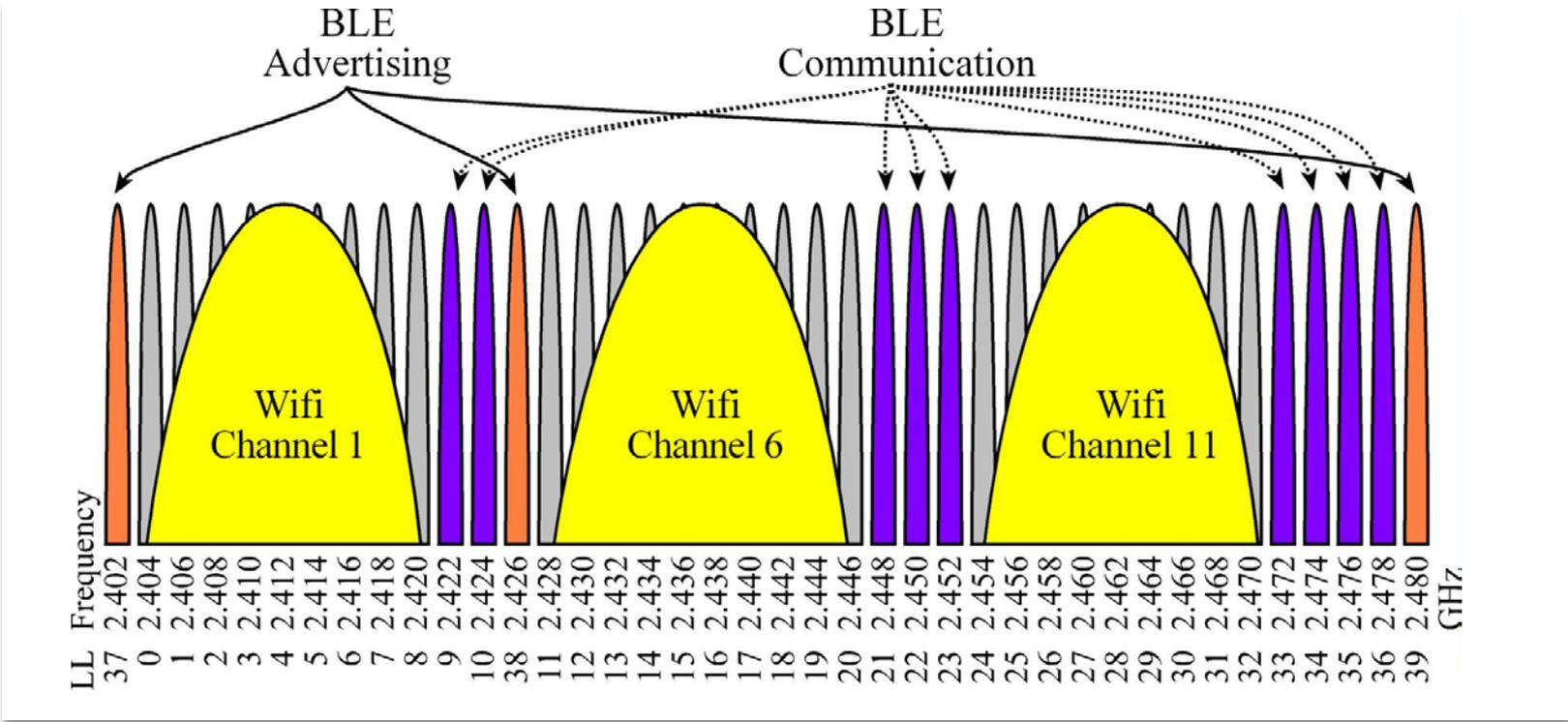


Standard	Description
<b>Wifi</b>	Up to 600 Mbits/sec Fixed wide frequency channels Requires lots of power Support for 2.4 and 5 GHz channels Extensive security features
<b>Bluetooth/BLE</b>	Very low power BT up to 2 Mbps Massive deployed base Frequency hopping Good performance in congested/noisy environment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



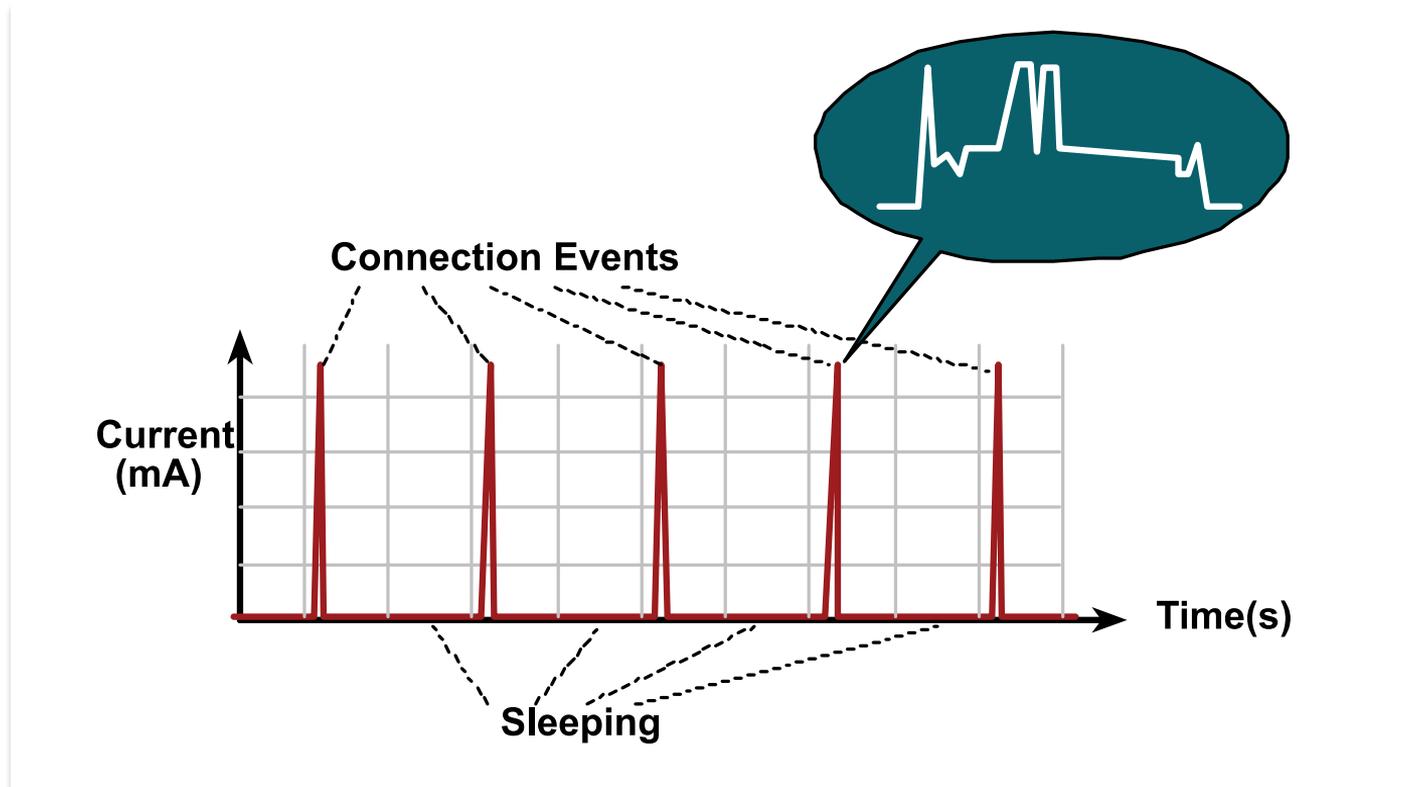
# Radio has 40 narrow bands

Each band is  $\pm 1$  MHz.





# Low power

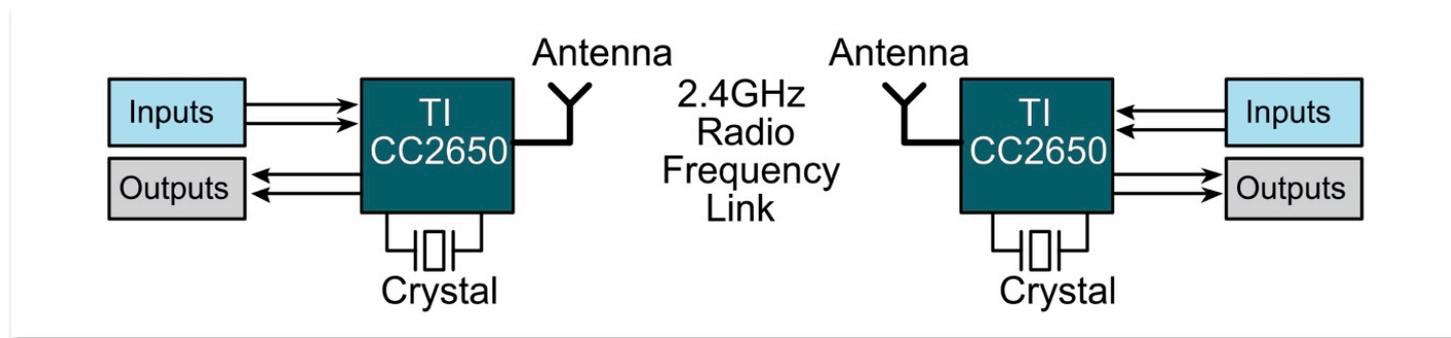




# Summary

## Wireless Communication

- Internet of Things
- Standardization
- Radio
- Low power



# Module 19

Lecture: Bluetooth low energy - Theory



# Bluetooth Low Energy

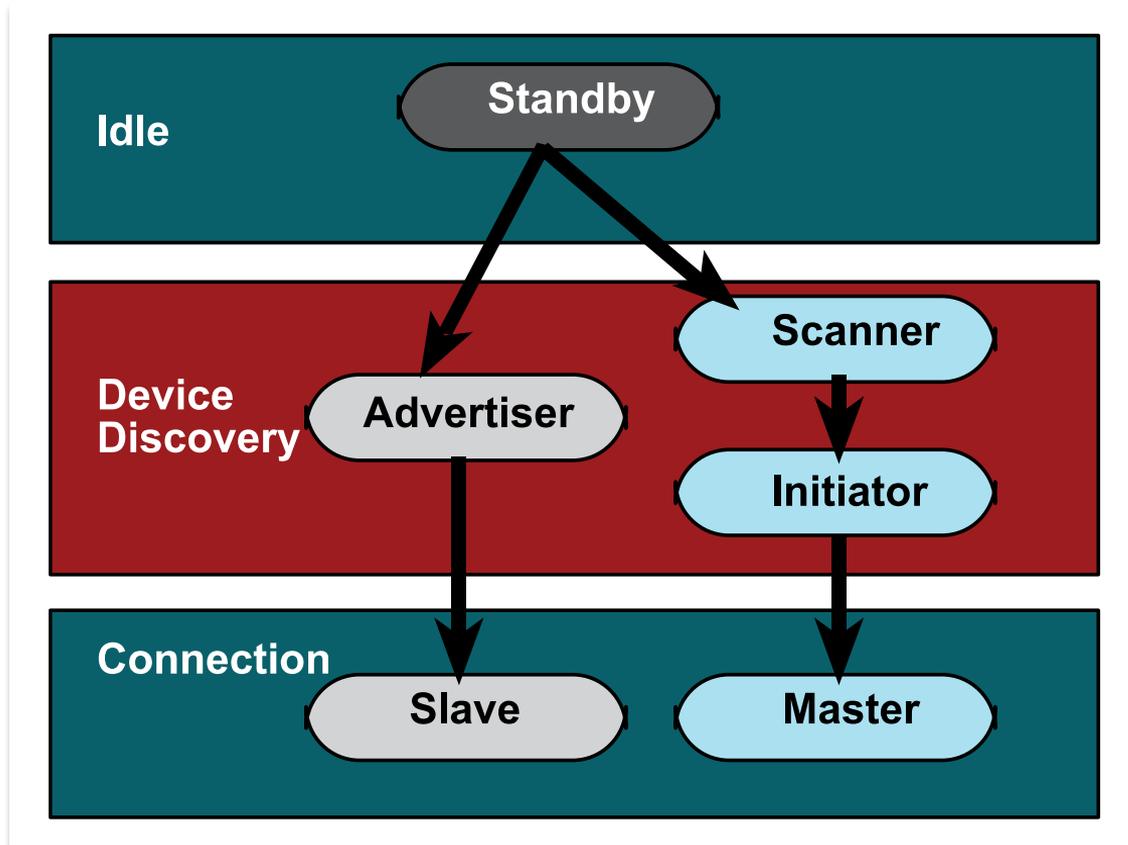
## You will learn in this module

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



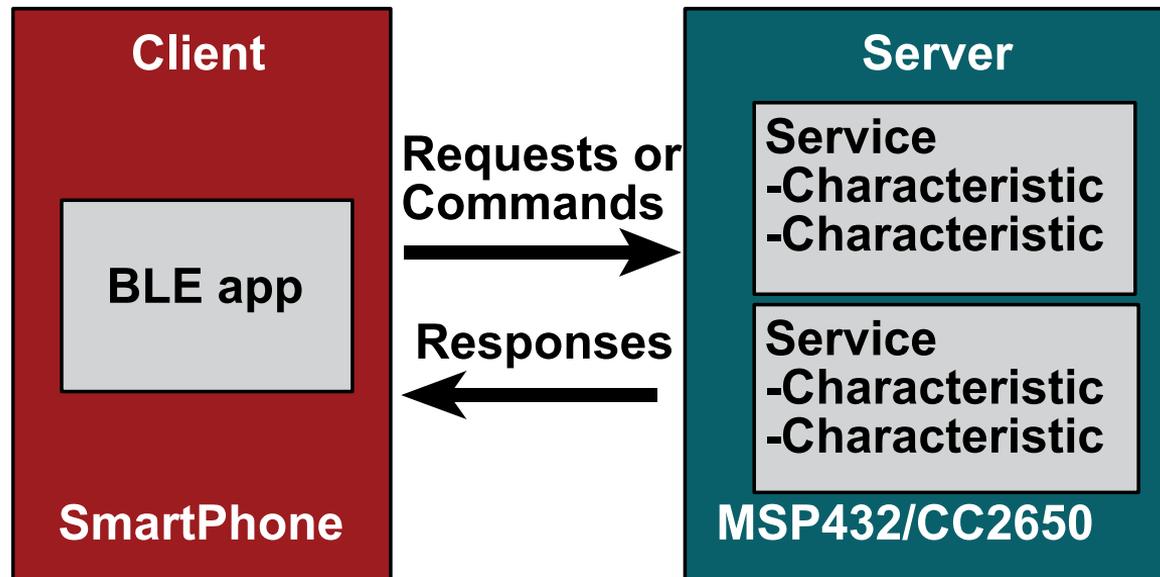


# BLE Advertising





# Client-server





## Generic Attribute Profile (GATT)

### Service

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

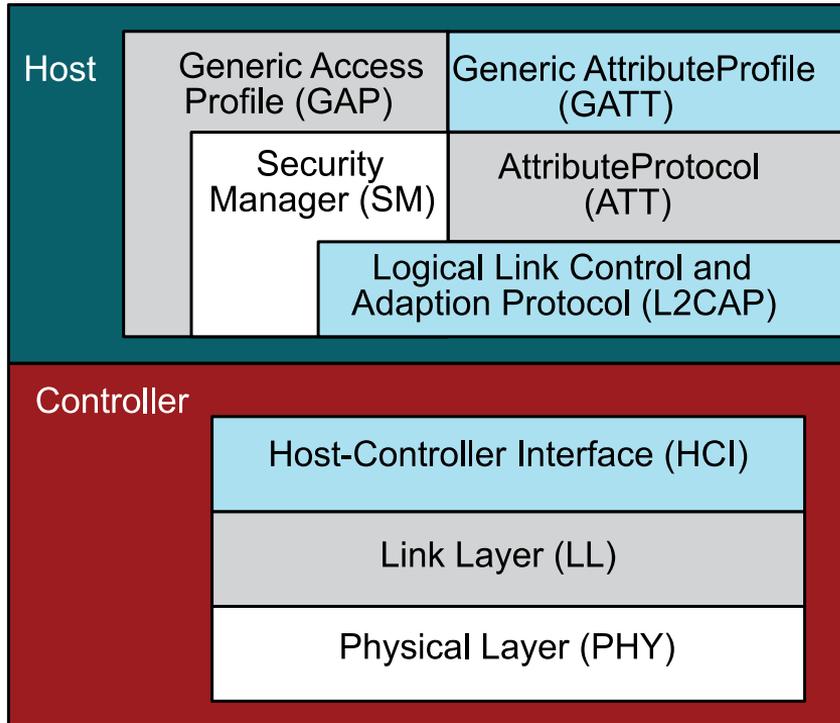
Characteristic  
UUID=0xFFF2,R,"Switches"

Characteristic  
UUID=0xFFF3,W,"LEDs"

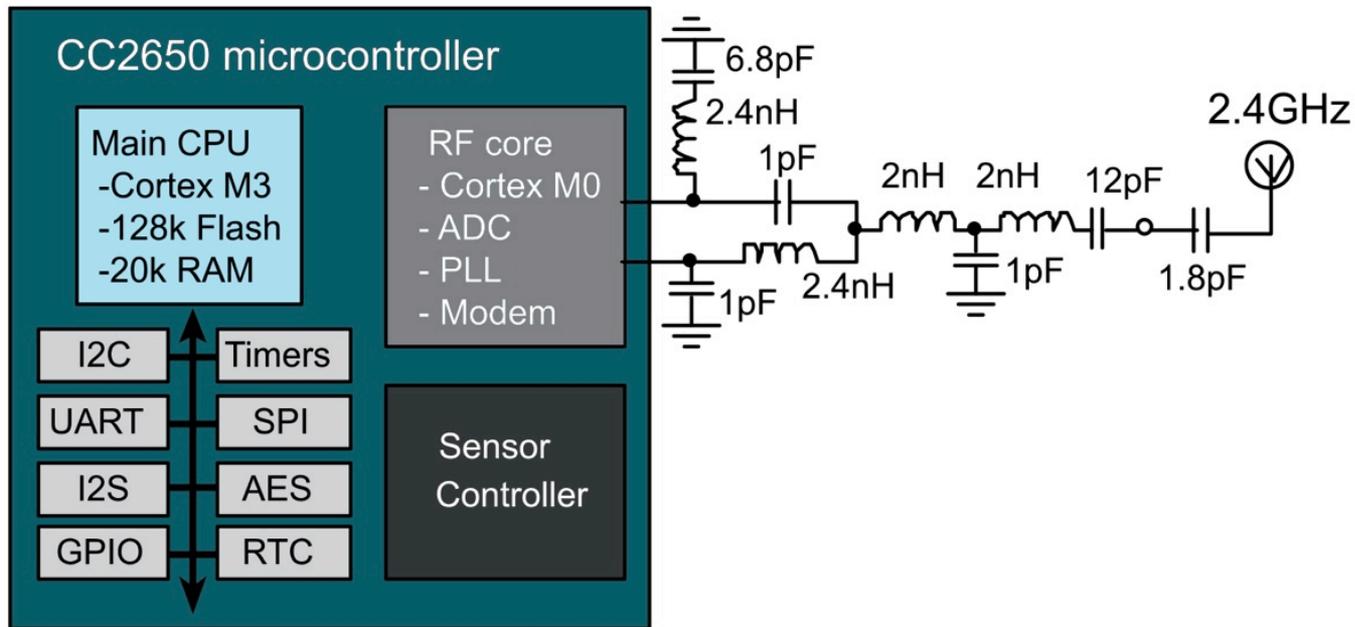
Characteristic  
UUID=0xFFF4,Notify, "Count"

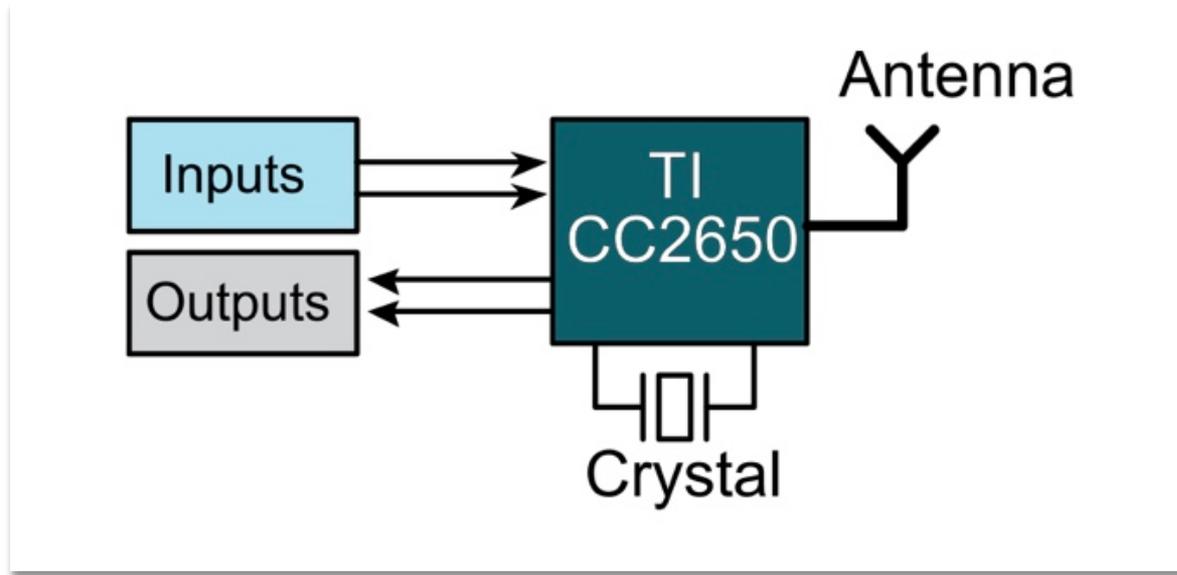


# BLE layers



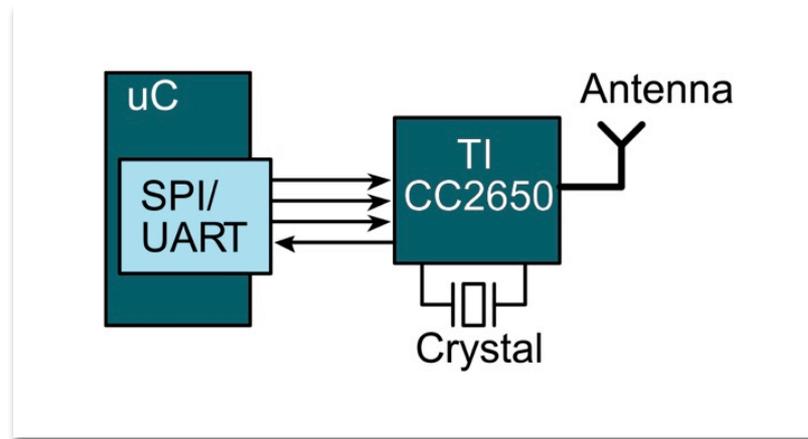
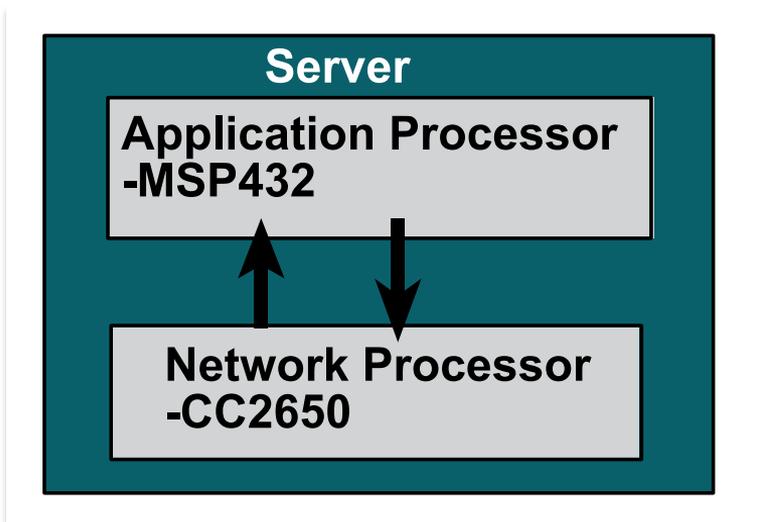
TI SimpleLink™ Bluetooth log energy  
CC2650 Module BoosterPack™

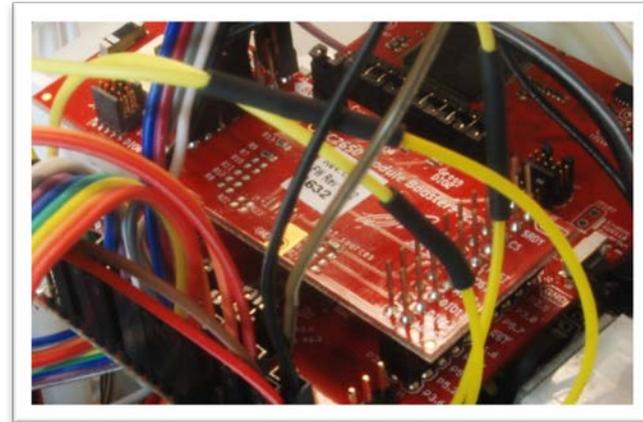
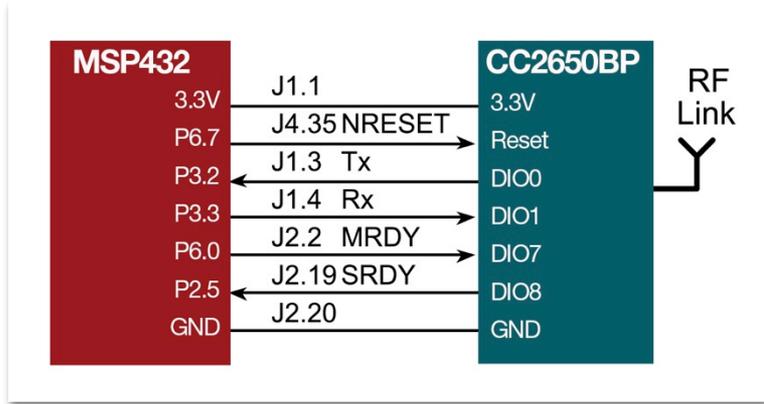






# CC2650 – MSP432 BLE Server



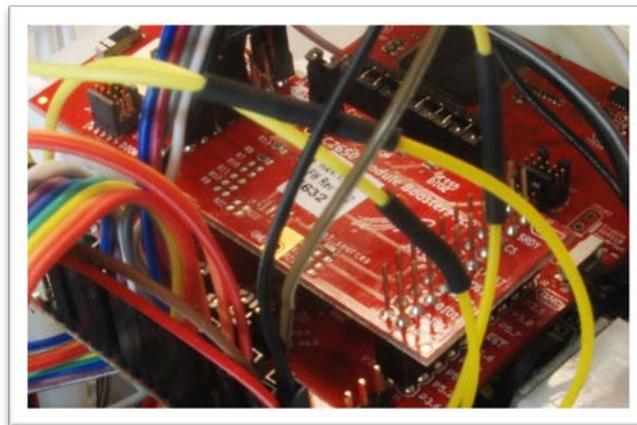




# Summary

## Bluetooth Low Energy

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



# Module 19

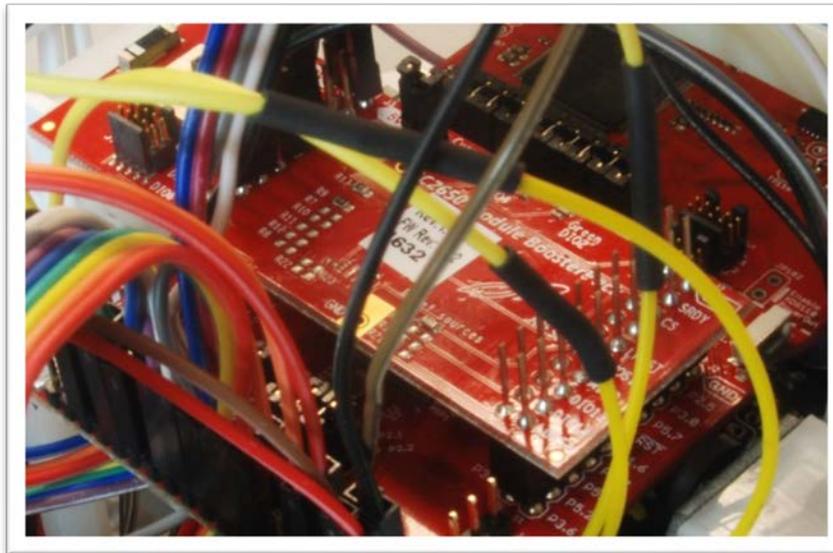
Lecture: Bluetooth low energy - Simple Network Processor



# Bluetooth low energy

## You will learn in this module

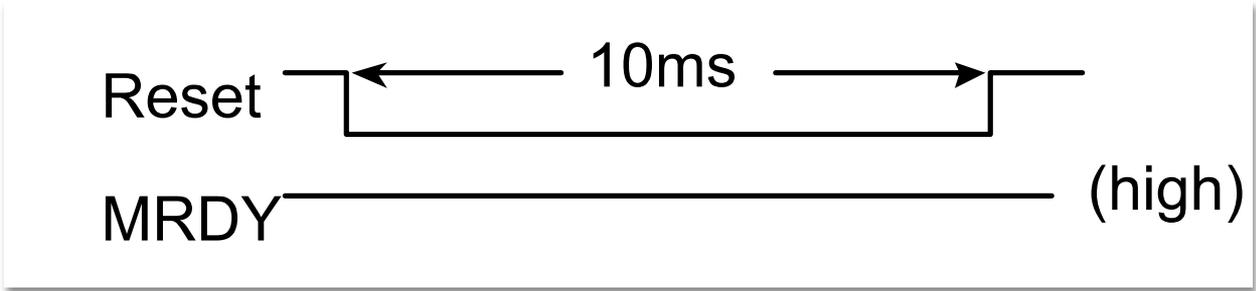
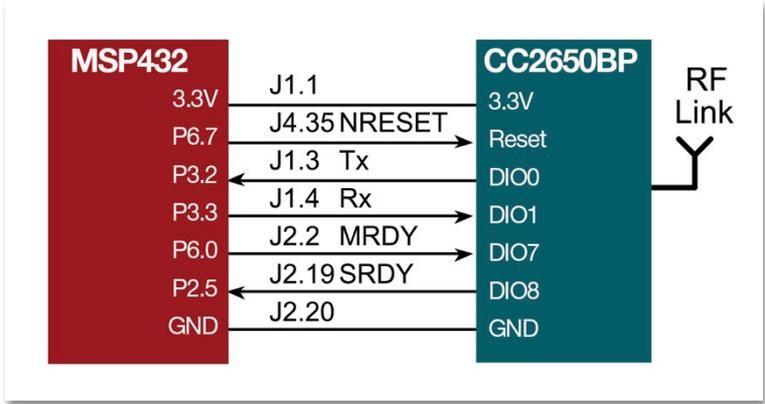
- BLE server
  - CC2650-MSP432 Interface
  - Serial, interrupt driven
- Simple Network Processor
  - Handshake
  - Message protocol





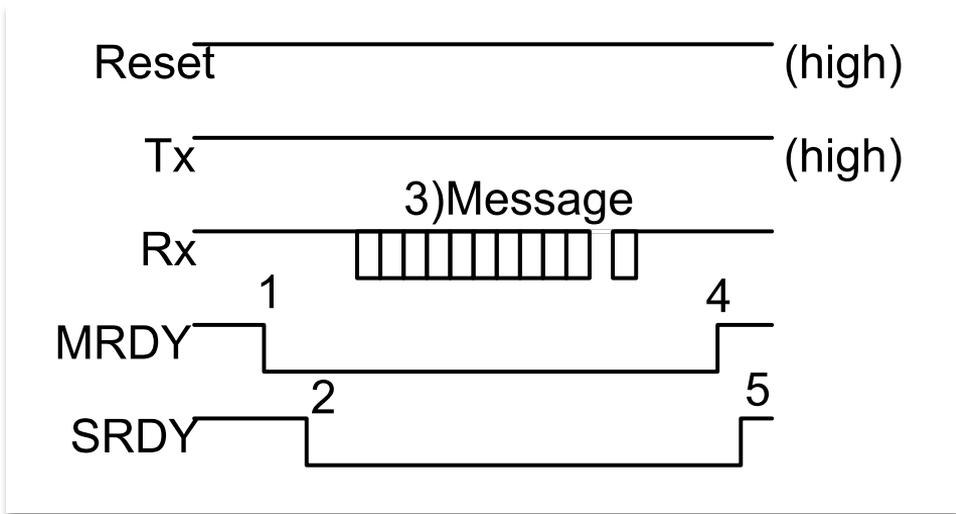
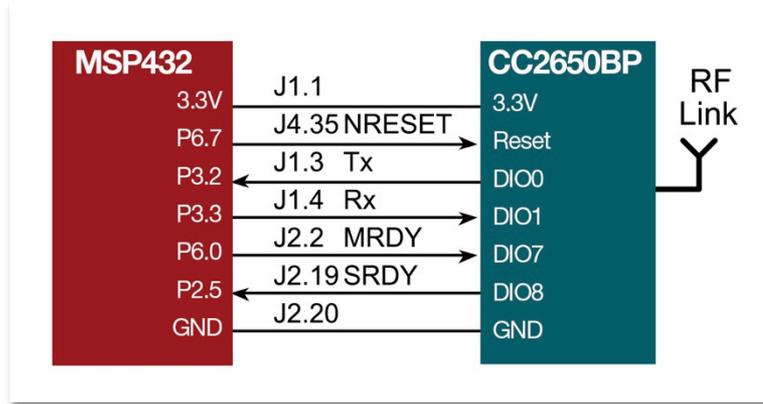
# Reset

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



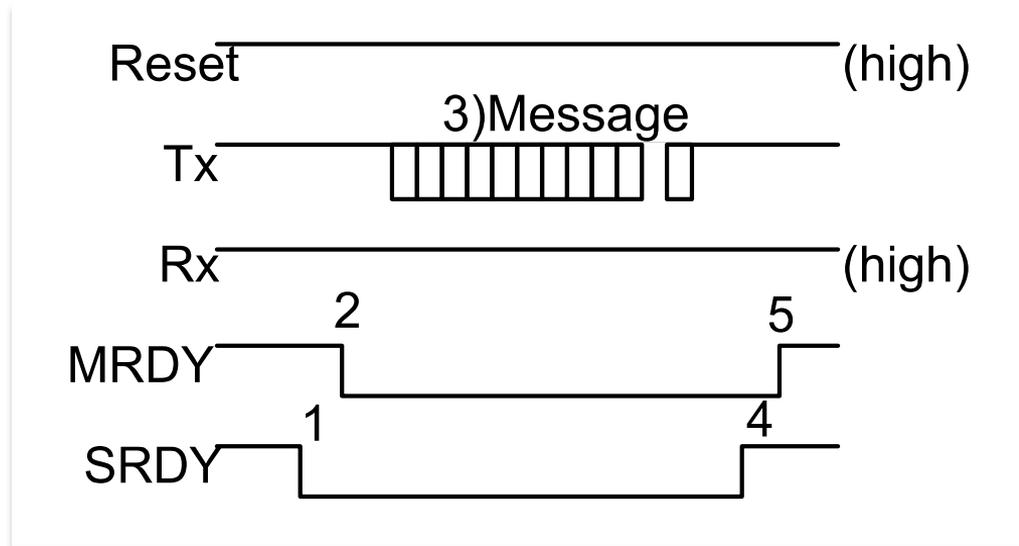
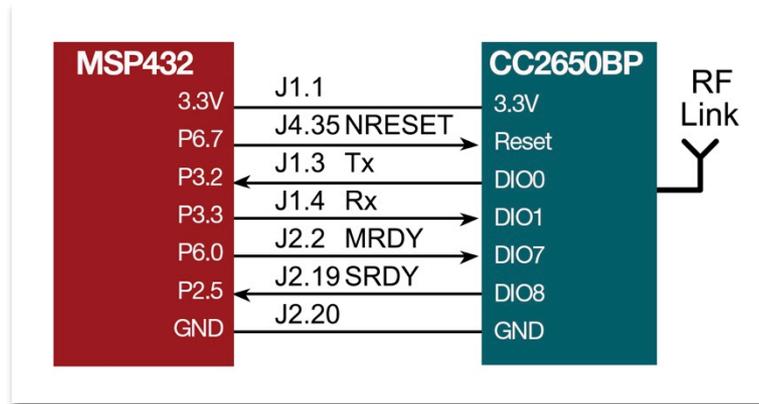


# MSP432 to CC2650 message



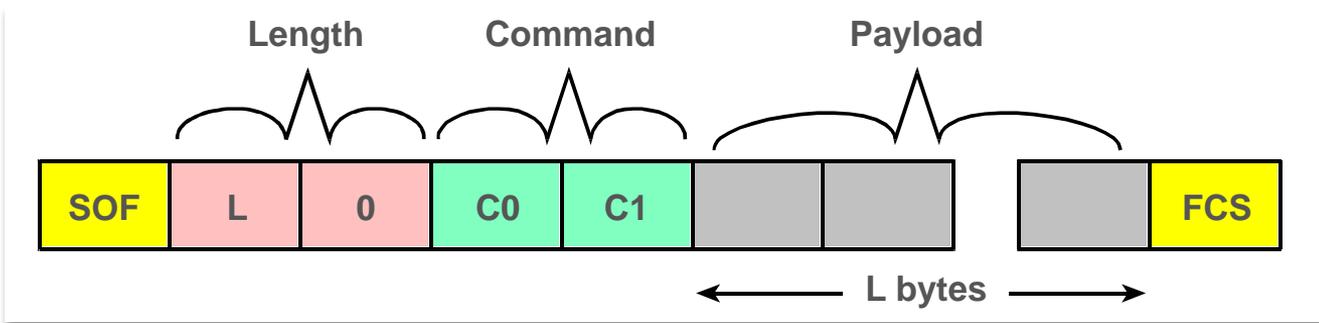


# CC2650 to MSP432 message





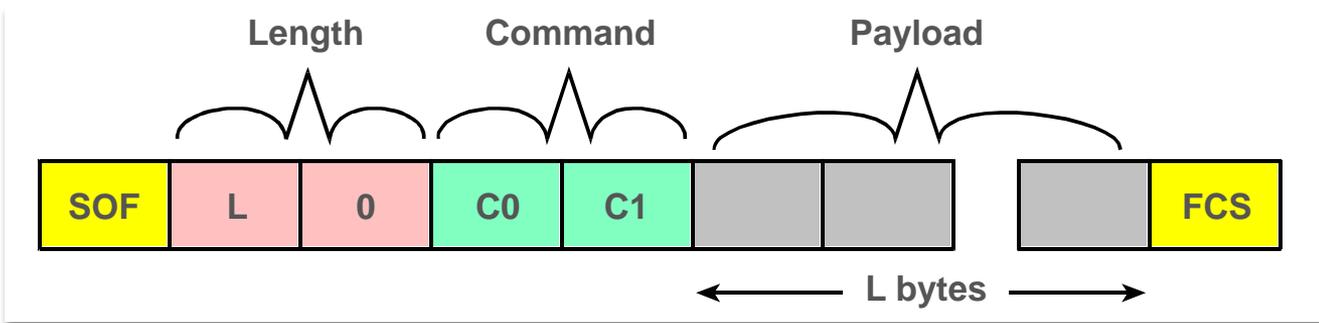
# Advertising



```
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

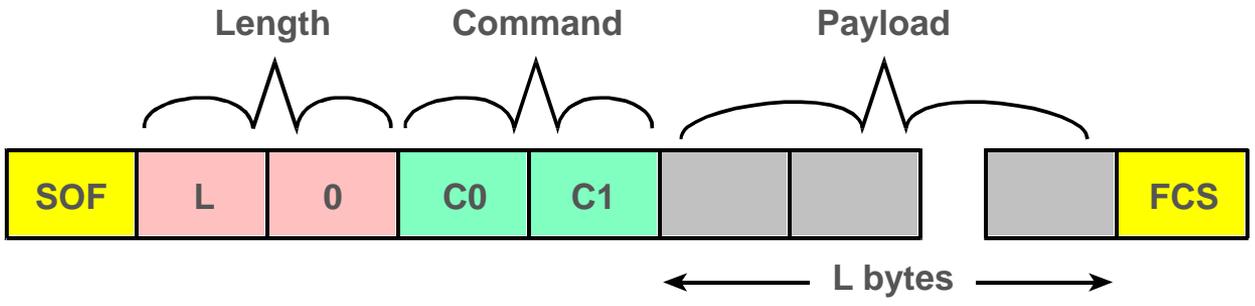
LP->SNP **FE,1B,00,55,43,00,10,09,53,68,61,70,65,20,74,68,65,20,57,6F,...,00,0C**  
 SNP->LP **FE,01,00,55,43,00,17**

## StartAdvertisement

LP->SNP **FE,0E,00,55,42,00,00,00,64,00,00,00,00,00,01,00,00,00,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**

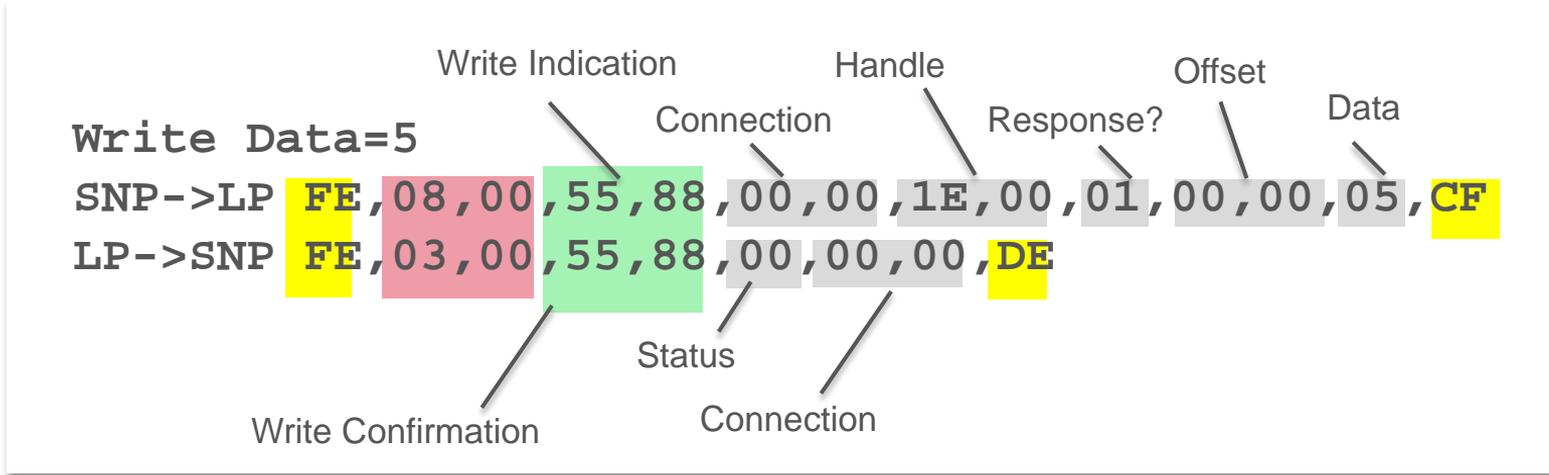
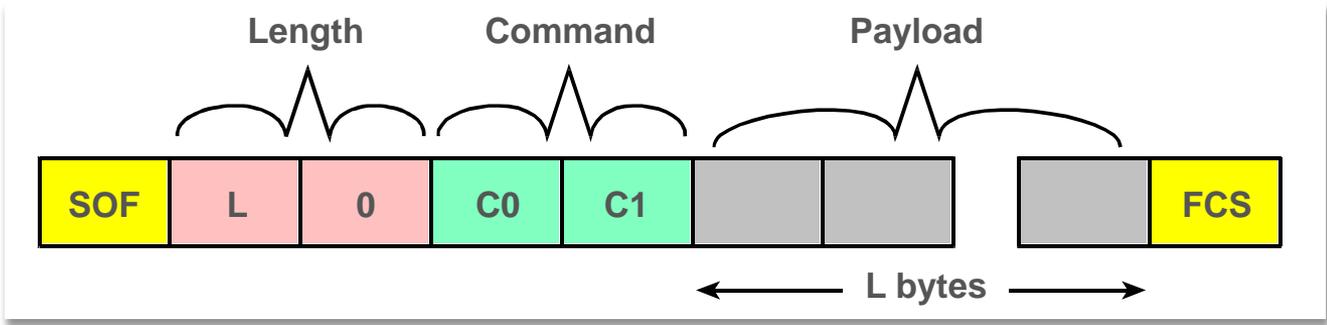
## Register service

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

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

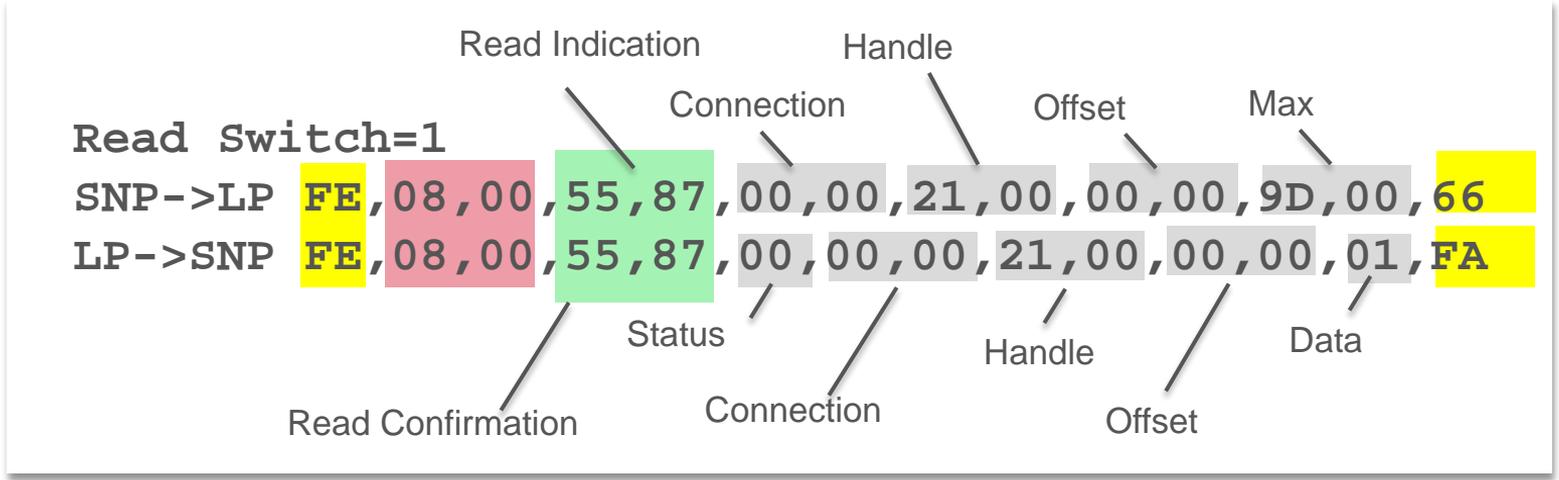
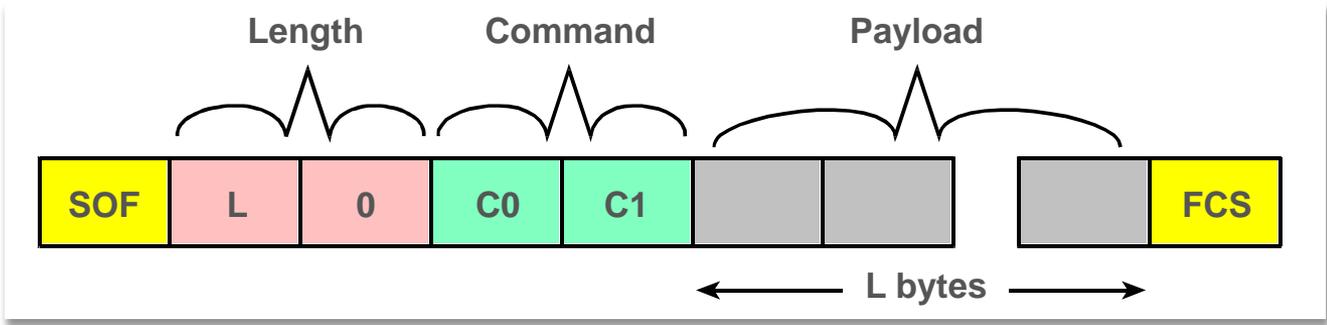


# Write indication





# Read indication

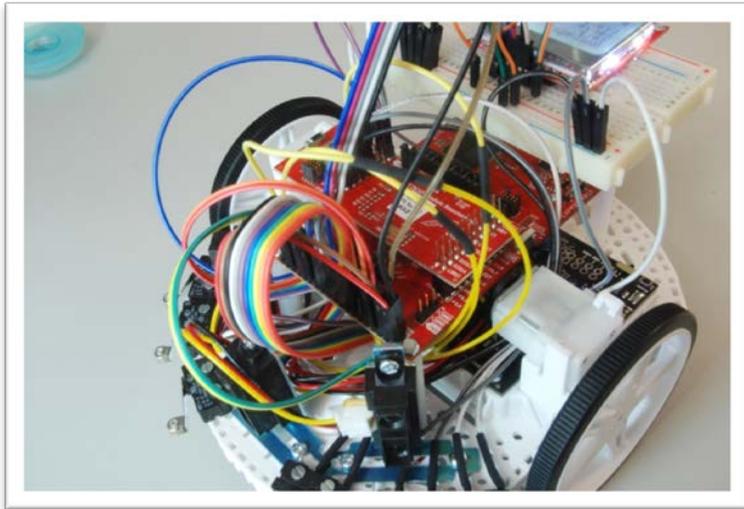




# Summary

## Bluetooth Low Energy

- Network Processor
- Application Processor



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