CSE190 Winter 2022

Lecture 20

Wireless

Wireless Embedded Systems
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Bluetooth, Zigbee, and WiFi contend

• Competes with Wi-Fi for bandwidth..
  – Only four usable bands in Wi-Fi intensive scenarios

![ZigBee RF4CE Frequency Agility](http://fosiao.com/system/files/misc/zigbee_wifi_channel.jpg)
WiFi

• Dual Bands: 2.4GHz and 5GHz
• 802.11a/b/g/n
  o Cost vs Speed vs Interference (2.4/5.8 GHz) tradeoff
• Roaming
• Global standard
• High speed
  o Up to 300 Mbps
• High power consumption
  o Concern for mobile devices
• Range
  o Up to 100m
WiFi adapts speed to signal (802.11g)
Protocol Comparisons

- 802.15.4 ZigBee
- 802.11 Wi-Fi
- Proprietary ISM
- Bluetooth

Graph showing range and data rate comparisons between different protocols.
## Protocol Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Bluetooth</th>
<th>Zigbee/802.15.4</th>
<th>WiFi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>Moderate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>Moderate-High</td>
<td>High</td>
<td>High</td>
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<tr>
<td><strong>Power Consumption</strong></td>
<td>Low-Moderate</td>
<td>Low</td>
<td>High</td>
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</table>
Design requirement of outdoor radios for IoT applications

- Can we use WiFi/Bluetooth/ZigBee/Ant radios to support IoT applications deployed outdoor?
  - Can we achieve kilometer communication distance?
  - Can we support 3~5 years lifetime with a coin battery?
  - Can we support the communication with thousands of IoT devices with the coverage of a base station?
  - We only need to transmit 100 bits per second data compared to the mega bits per second case in WiFi

We are willing to trade data rate for range, lifetime, and the number of devices supported.
Design requirement of outdoor radios for IoT applications

- Power
  - Indoor radios
    - Data rate
  - IoT radios
    - Data rate

- Range
  - Indoor radios
    - Data rate
  - IoT radios
    - Data rate

- Number of devices
  - Indoor radios
    - Data rate
  - IoT radios
    - Data rate

- Life time
  - Indoor radios
    - Data rate
  - IoT radios
    - Data rate
LoRA

• Deploy your own indoor/outdoor base stations to support IoT applications
  – 10 Kilometer communication distance
  – Connect thousands of devices
  – 100 bits per second date rate
  – 5 years battery lifetime
LoRA is Extremely Reliable

• Uses special modulation technique
  – Bits encoded as “chirps” that are robust to interference and can be received with low signal

• Built as a collaborative network
  – LoRAWAN allows multiple base stations to receive signal and whichever decodes properly forwards to the next hop

• Few collisions (Narrow band)
  – Many channels and base stations listen to all channels simultaneously
Narrow Band

• Reduce the transmitted signal bandwidth
  – Reduced noise power
  – Therefore, we can reduce the transmission power
  – Therefore, we can reduce the power consumption of radio communication
Ultra Narrow Band

200 simultaneous messages within a 200kHz channel
NB-IoT is also being built into LTE