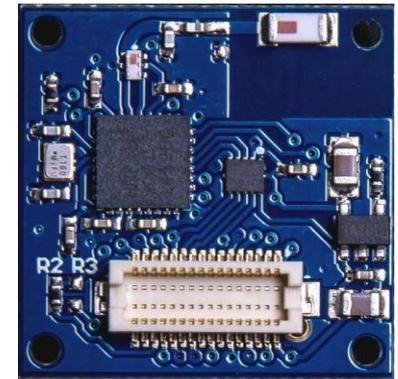
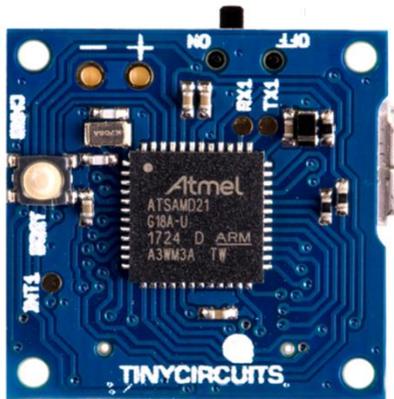


# CSE190 Winter 2025

## Lecture 20

## Wireless



## Wireless Embedded Systems

Aaron Schulman

# Bluetooth, Zigbee, and WiFi contend

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

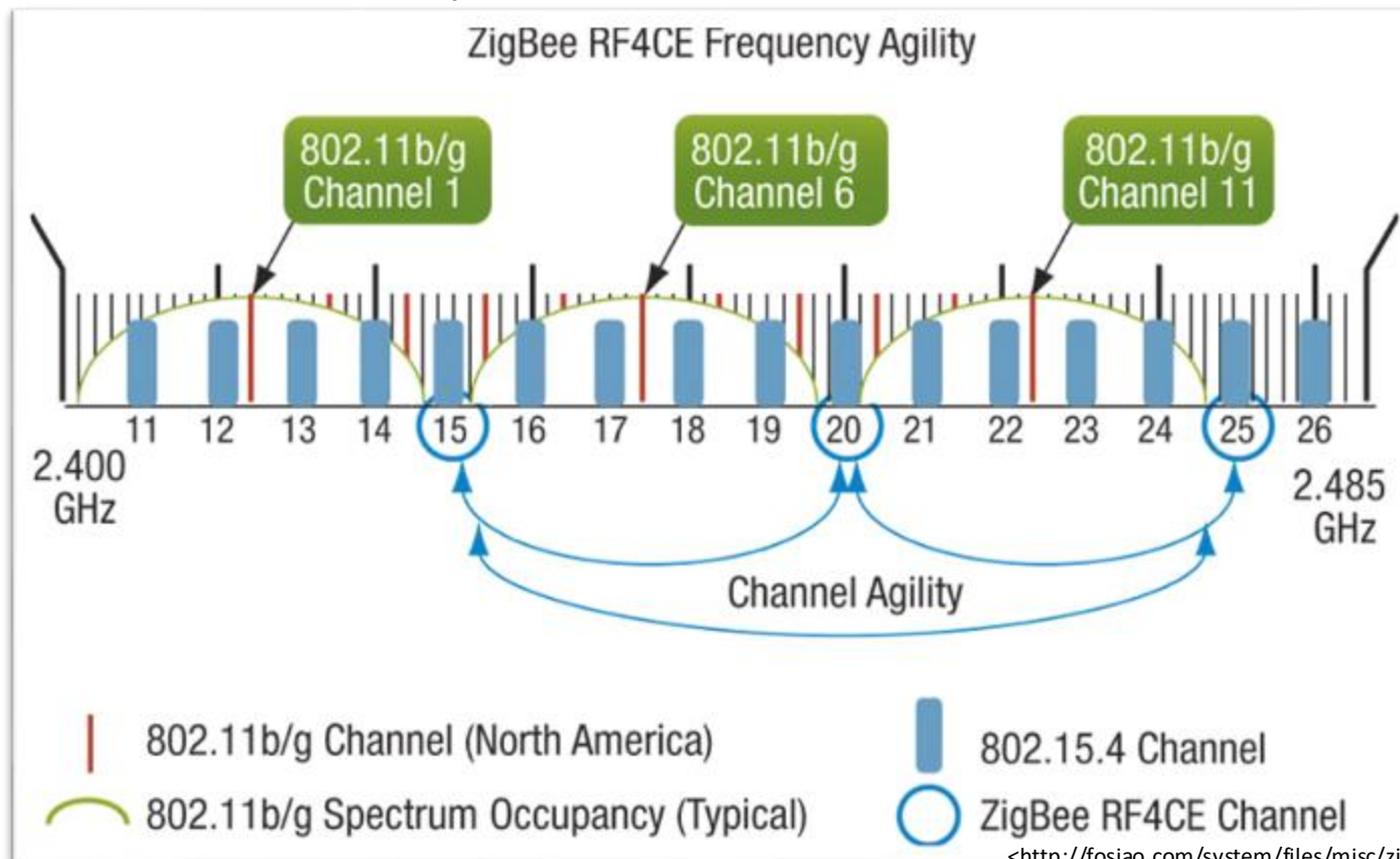
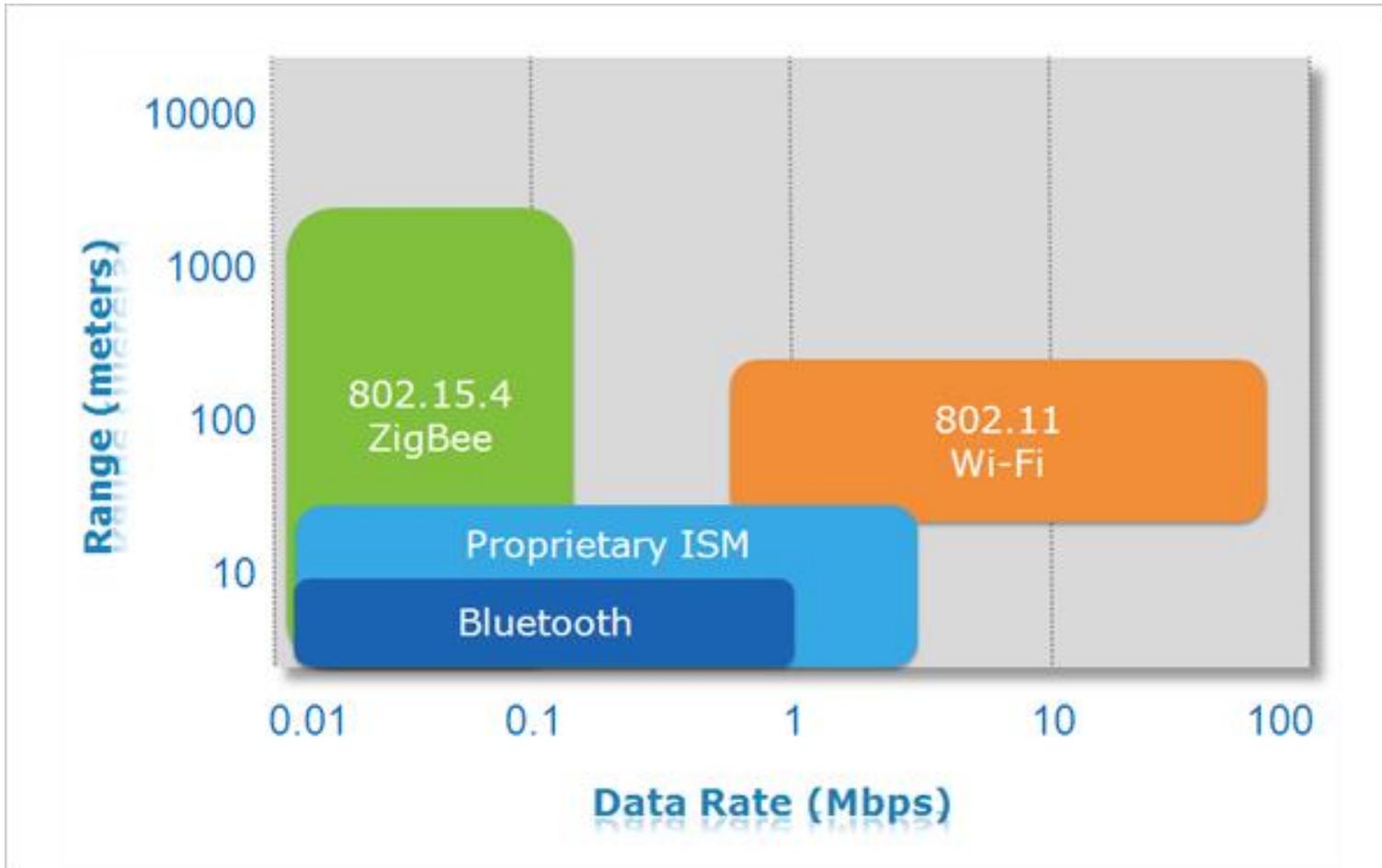


Image & Data Source<sup>2</sup>

<[http://fosiao.com/system/files/misc/zigbee.wifi\\_channel.jpg](http://fosiao.com/system/files/misc/zigbee.wifi_channel.jpg)>

# Protocol Comparisons



# Protocol Comparisons

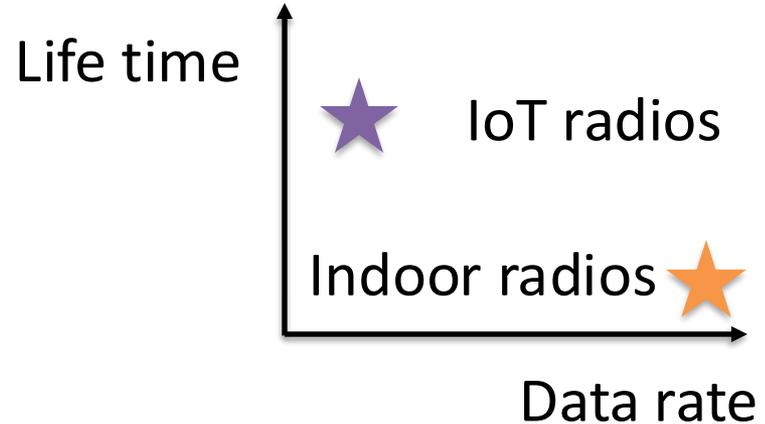
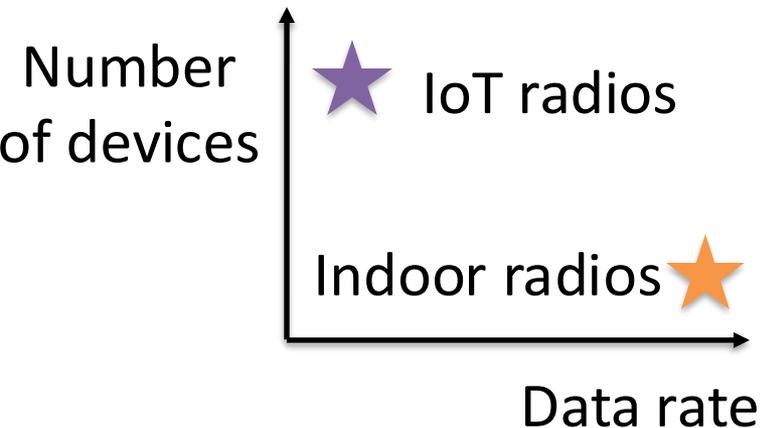
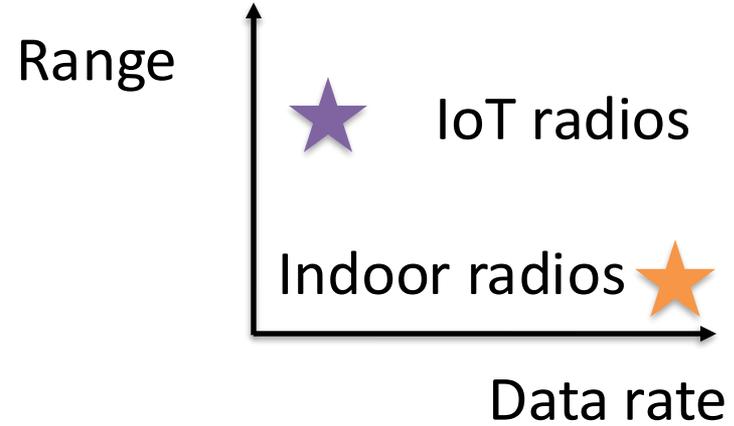
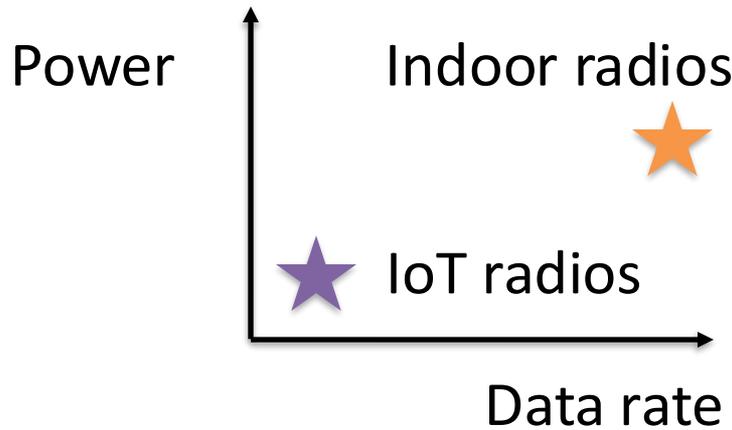
	<b>Bluetooth</b>	<b>Zigbee/802.15.4</b>	<b>WiFi</b>
<b>Speed</b>	Moderate	Low	High
<b>Range</b>	Moderate - High	High	High
<b>Power Consumption</b>	Low - Moderate	Low	High

# 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

For indoor applications: we are willing to trade off higher data rate for shorter range, shorter battery lifetime, and fewer number of devices supported.

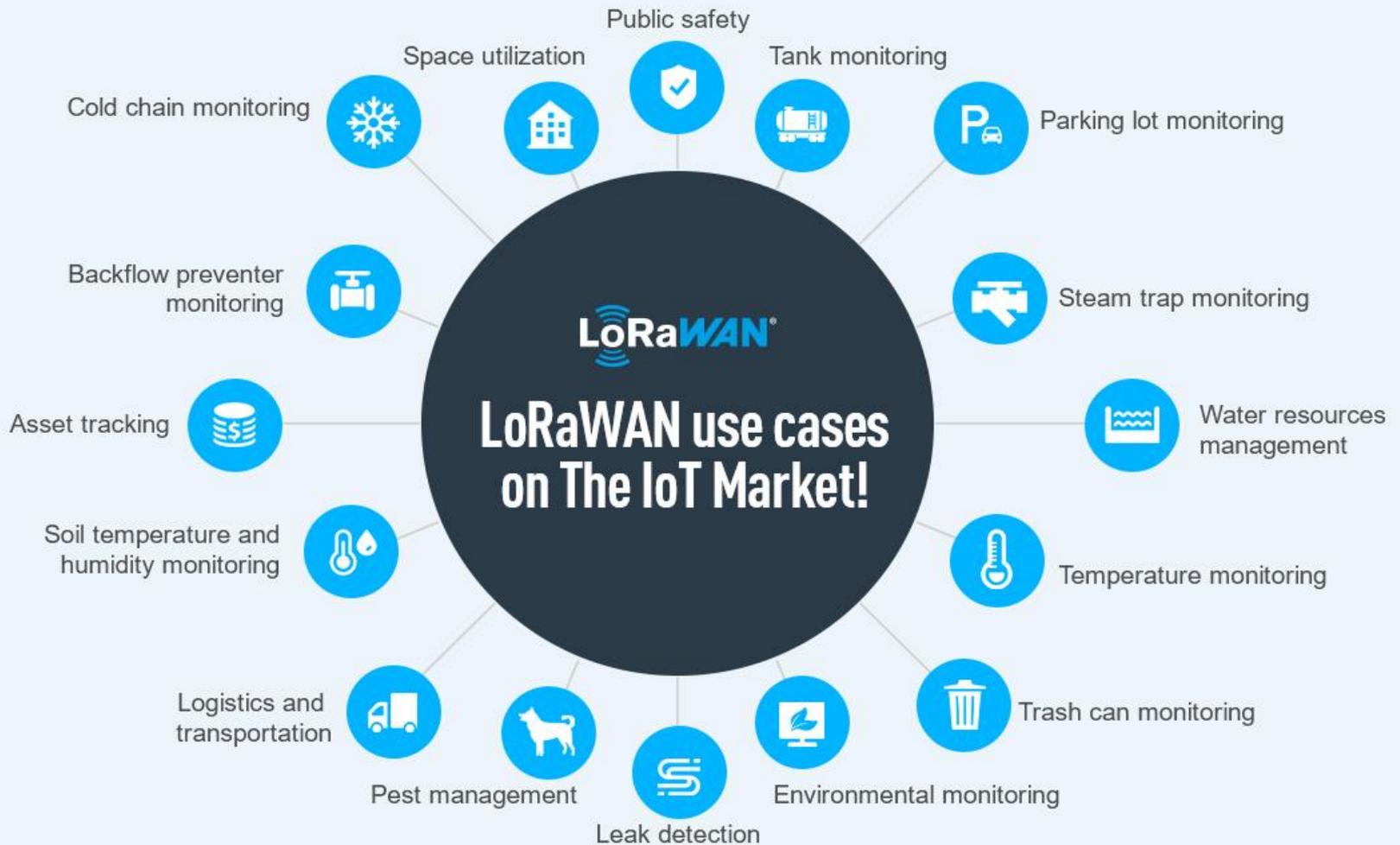
# Design requirement of outdoor radios for IoT applications



# LoRA

- Deploy your own indoor/outdoor base stations to support IoT applications
  - 10 Kilometer communication distance
  - Connect thousands of devices
  - 100 bits per second data rate
  - 5 years battery lifetime

# LoRA use cases





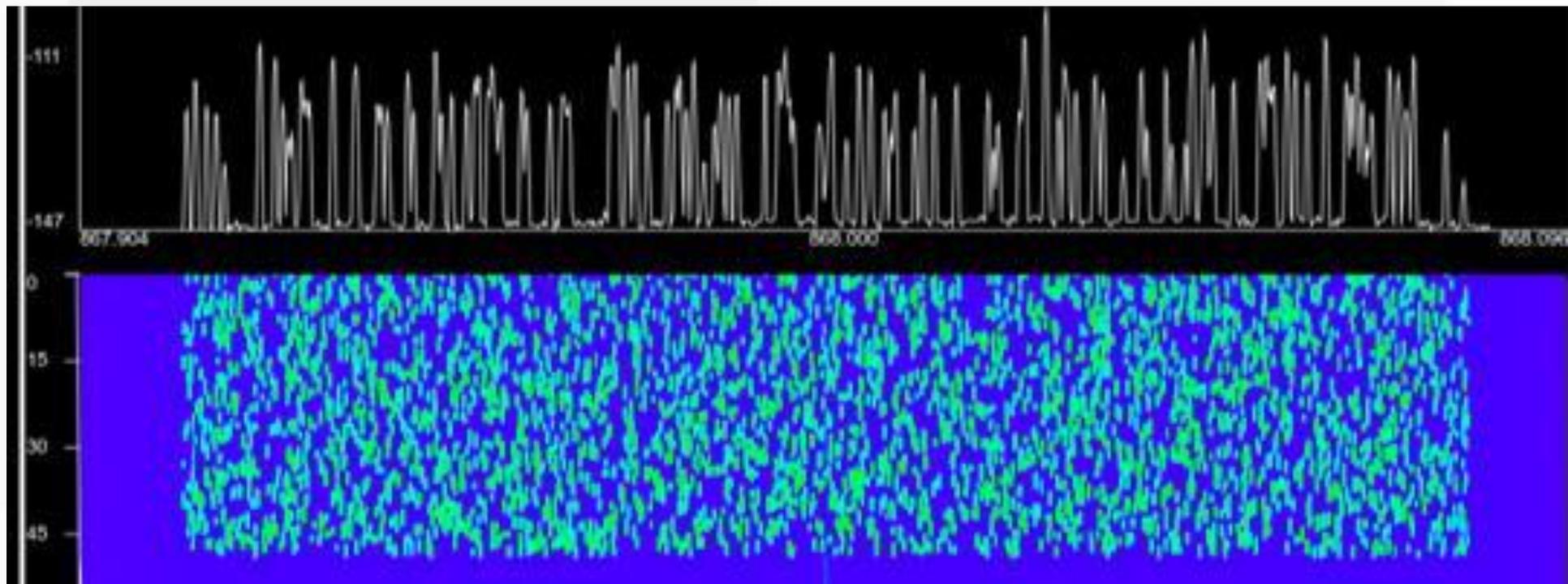
# LoRA is Extremely Reliable

- 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 IoT Communication

- 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

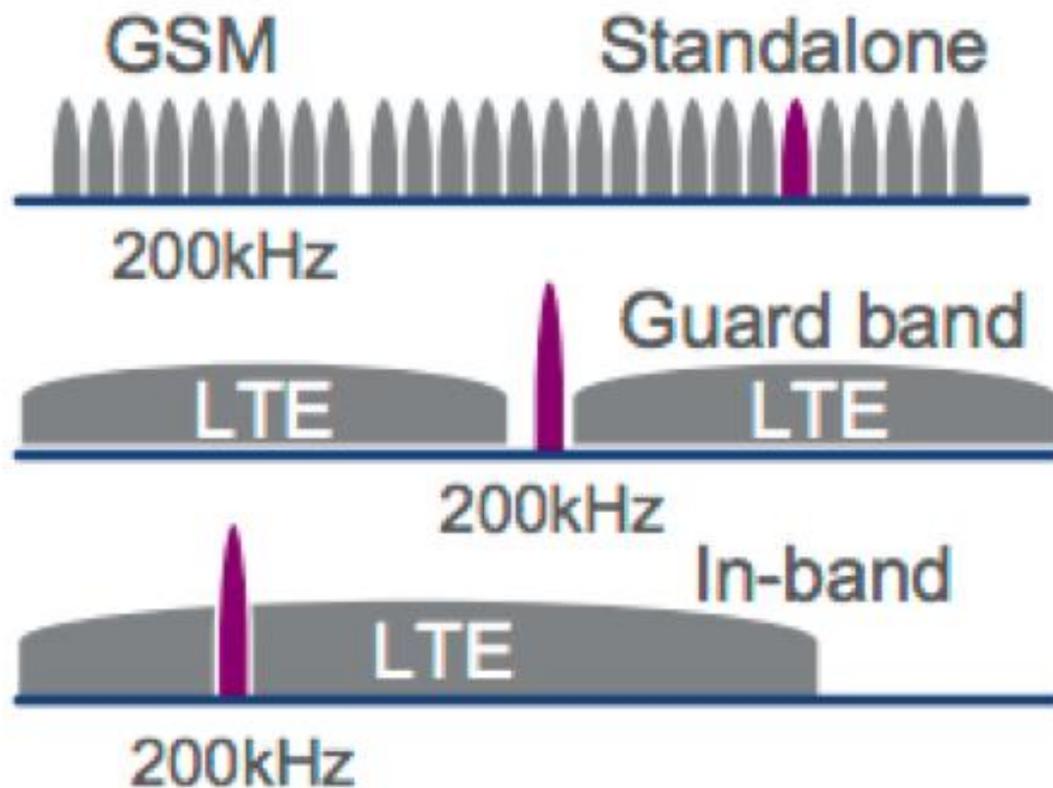


**200 simultaneous messages within a 200kHz channel**

# NB-IoT is also being built into LTE



**NB-IoT**



# NB IoT is a competitor to LoRA

