LoRa

Wireless Network for the Internet of Things

Content

The Internet of Things

when your lightbulb has more processing power than your first phone

The Internet of Things

- Network of physical devices
  - Sensors
  - Vehicles
  - Various kinds of embedded systems

- Requirements depend on application
  - safety and critical infrastructure -> low latency and reliability (QoS)
  - surveillance cameras -> high bandwidth
  - battery powered devices -> low power consumption

Networking the IoT

Cables: Photo by Annie Spratt on Unsplash

Wireless Comparison Chart

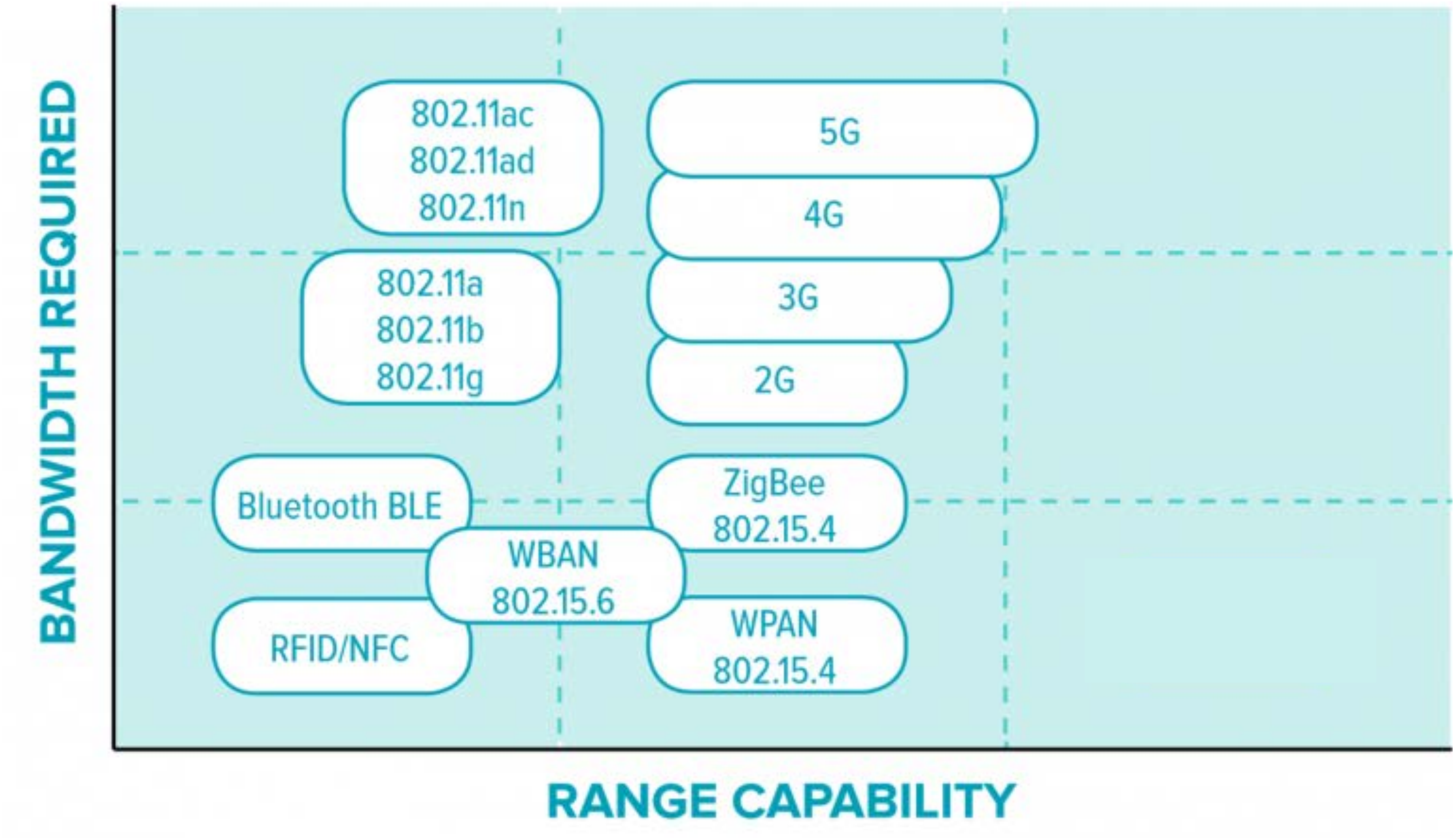

Figure 1: Wireless Comparison Chart from [6]

Picking a Network

- Compromise out of:
  - long Distance
  - Bandwidth
  - low Power Consumption

Low-Power Wide-Area Network

sometimes we want to decrease the bandwidth

LPWAN - Motivation

- Motivation
  - Cellular is not suited
  - WiFi neither
- Requirements
  - Long Range (LPWAN)
  - Low Power (LPWAN)
    - we operate on battery
  - Cheap Hardware
    - IoT comes in quantity
- As a consequence -> Low data rate

LPWAN - How?

- Compromises
  - Sub 1 GHz frequency
    - Sometimes unlicensed frequencies
  - Small bandwidth
    - Rate limitation
  - Conservative duty-cycling and listening
  - Robust modulation technique

LoRa (Long Range)

LoRa - Architecture

- 3 components
  - End-devices, gateways and the network server
- Gateways act as link layer relay (protocol converter)
- star topology of end-devices
  - No mesh – only device to gateway communication

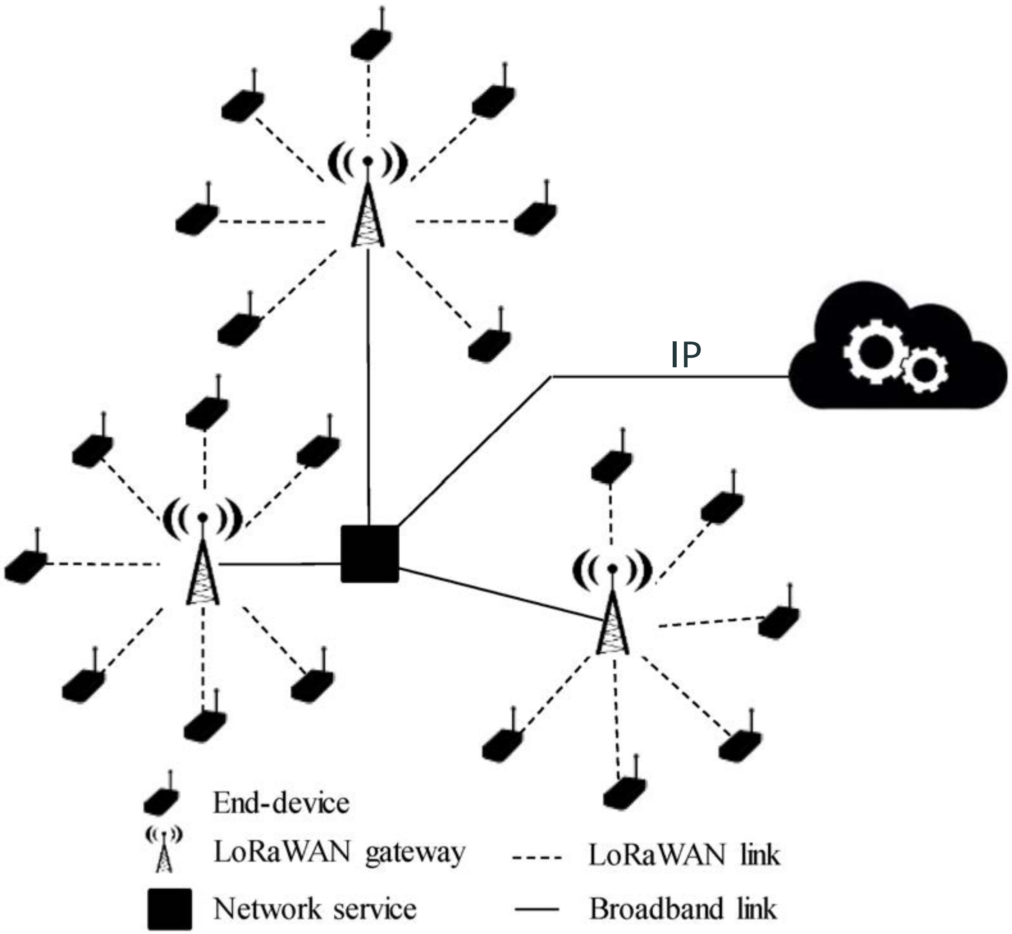

Figure 2: LoRa stars-of-stars topology from [12]

LoRa - Layers

- LoRa refers to the PHY layer
  - Frequency & Modulation
  - Closed and proprietary
- LoRaWAN refers to the MAC layer
  - communication between gateways and nodes

LoRa - PHY

- Operates at un-licensed (ISM) bands
  - 433, 868, 928 MHz -> differ for each region
- Duty Cycling
  - Limitation of 1% per sub band in Europe
  - Device has to wait 100-times the duration of the last frame

Figure 3: Duty Cycle Example 25% from [7]

- Data rate from 250 bps to 5.5 kbps
- Distance
  - Advertised with up to 15km
  - World Record of 354km to a balloon

LoRa - PHY

- Chirp Spread Spectrum (CSS)
  - Linear variation of frequency over time

  - Up-Chirp &
  - Down-Chirp

- Resilient and robust
  - Frequency offsets are equal to timing offsets
    -> Cheap oscillator

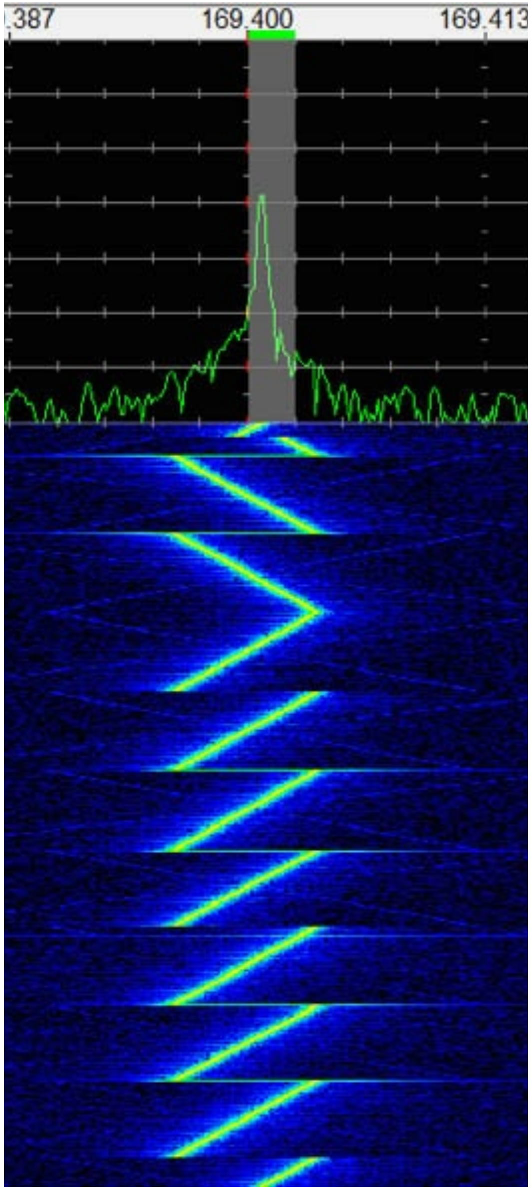

Figure 4: Chirp Waterfall Diagram from [8]

LoRa - LoRaWAN

Layer 2 and 3 (data and network)

- Support for up to ~1,000 devices per gateway
  - Using the maximum duty cycle of 1%
- Bidirectional
  - Not always the case in LPWANs
- MAC is similar to pure Aloha
  - Degrades quickly with increased load on the link
- 3 Classes
  - Adjusting latency and power consumption

LoRa - Classes

- **A:** Two downlink receive windows after transmission
- **B:** scheduled receive slots
  - need for synchronized beacons
- **C:** Continuous receive window

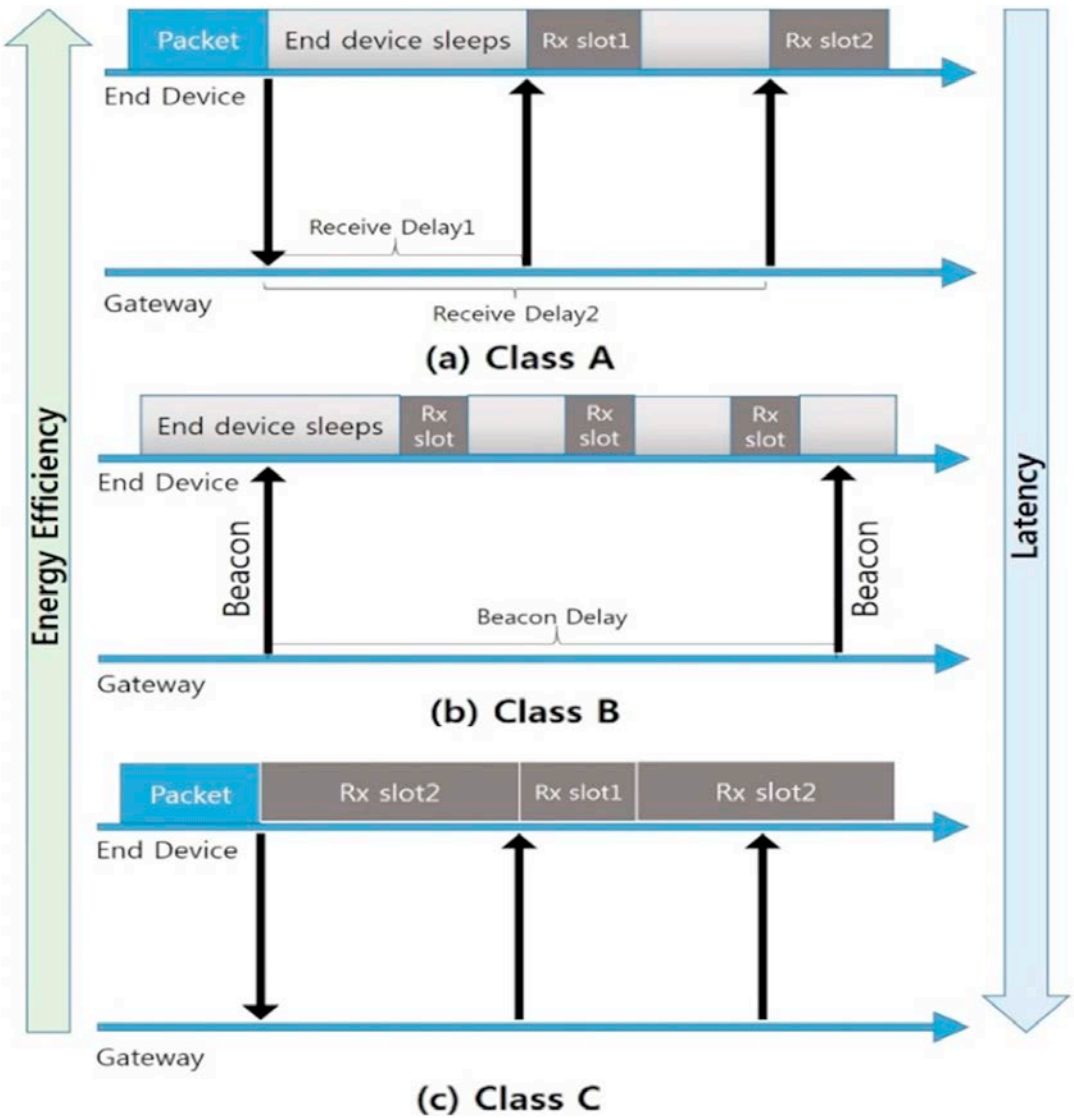

Figure 5 from [1]

LoRa - Problems

- PHY layer is closed source and proprietary
- LoRa was acquired by SemTech
  - Currently the only supplier for LoRa radio chips
- Usage of ISM bands
  - Protocol is not resilient to collisions
  - Competitors can use the same band

LoRa in the Real World

LoRa - Adaption

- LoRa Alliance has more than 500 member companies

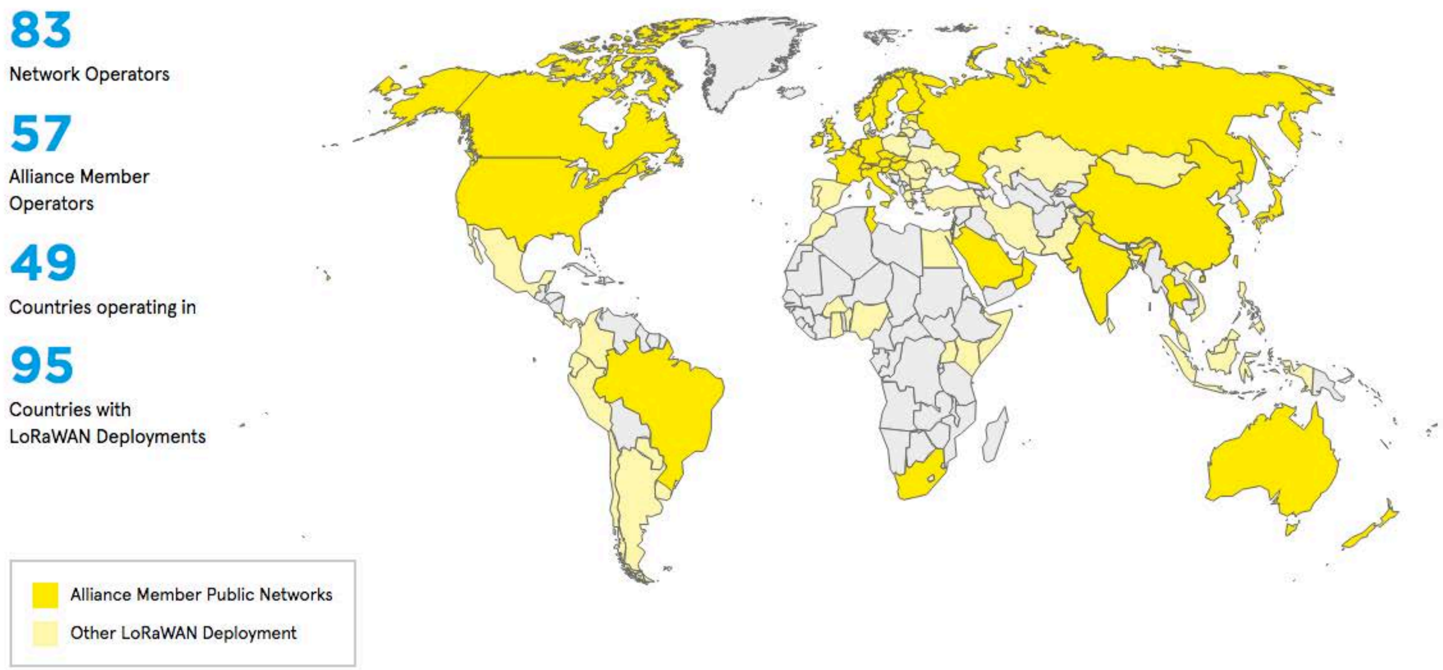

Figure 6: LoRa Adoption from [10]

LoRa – Example Deployment

Internet of Cows

- Geofencing
- Analyze Cow behavior via various sensors

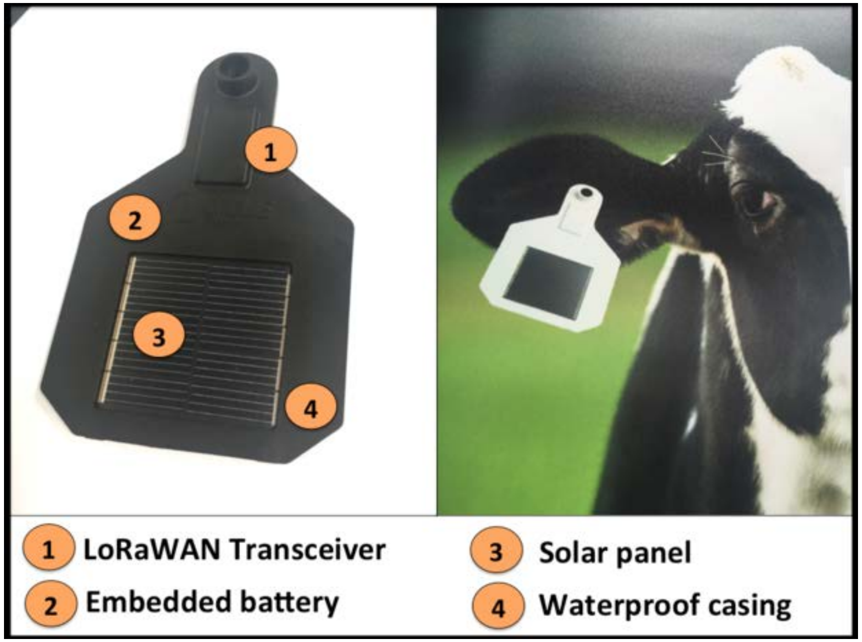

Figure 7: Cow with a LoRa enabled Sensor
From [13]

When to use a LORA?

- **USE**
  - Sensor Data in defined intervals
  - Harsh power constraints
    - Battery powered devices
  - Low cost devices

- **DON'T**
  - Continuous data transmission
  - Need of high data rate
  - QoS guarantee
  - Power connected devices

Other LPWAN Technologies

LoRa is not alone

LPWAN Competitors

- Examples
  - NB-IoT
  - LTE-M
  - Sigfox
  - 5G
- Each protocol has its advantages and disadvantages
- Each application/ device has its own specific requirements

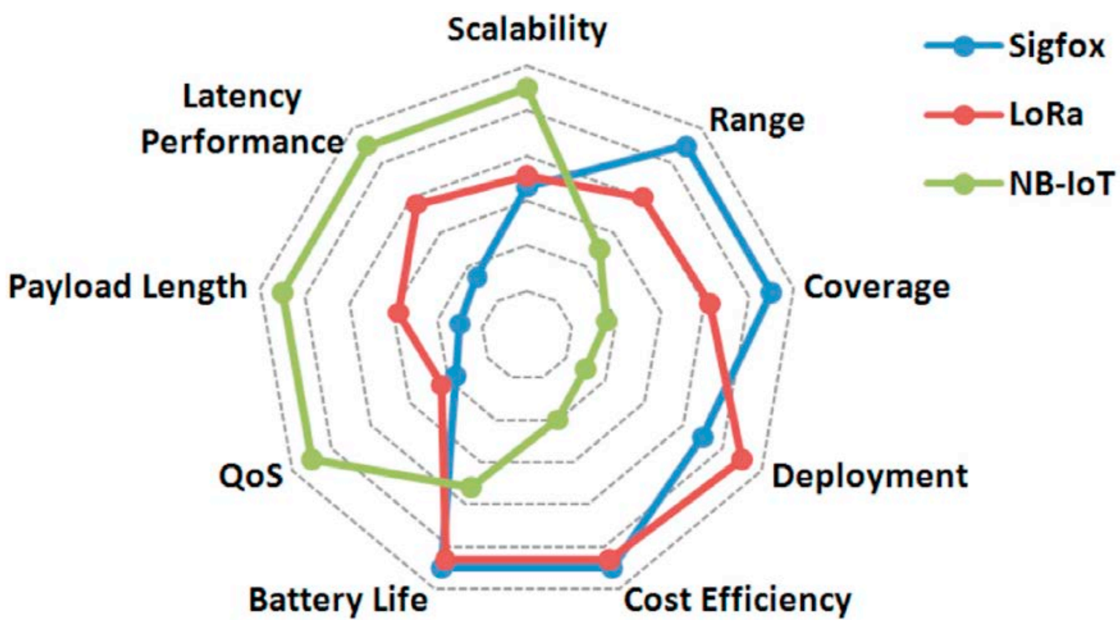

Figure 8: LPWAN Comparison Chart from [11]

Conclusion

do we really need another wireless networking protocol?

Conclusion

- Developing an IoT device
  - Consider device application and therefore its requirements
  - Then chose a wireless network
    - you can chose multiple
- LoRa is a LPWAN
  - PHY layer -> robust and long range
  - Low power consumption
  - Fast growing adaption
- Fragmentation is here to stay
  - Pros and cons of each technology

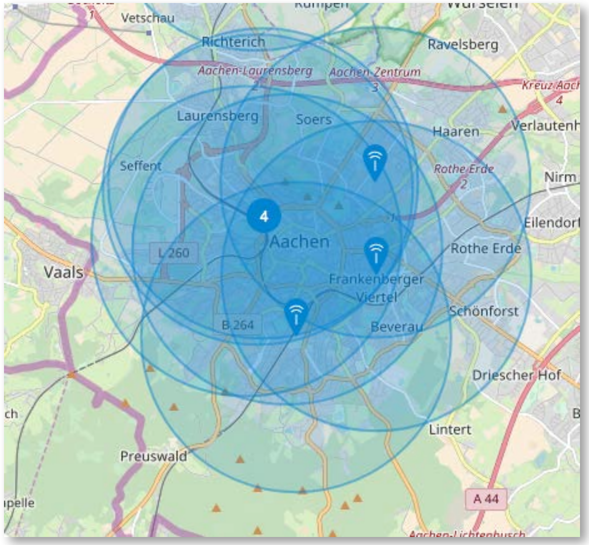

Figure 9: LoRa Gateways in Aachen [14]

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