Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg

INTERNET DES OBJETS

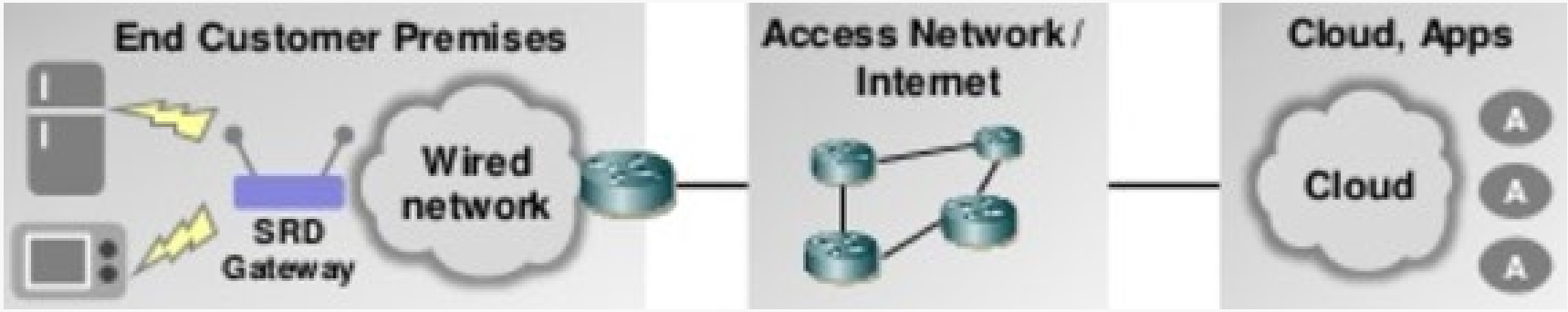
LOW POWER WIDE AREA NETWORKS: INTRODUCTION

SERGE AYER - HEIA-FR – TÉLÉCOMMUNICATIONS
CLASSES ISC-ID-2/ 2023-2024

WHAT IS THE NEED?

- Things are installed in the field on residential premises, public places or industrial plant sites
- The use of short range radio is possible, but it also has drawbacks:
  - It requires the use of a short range radio gateway
  - The gateway is typically connected to the on-site wired network (not under control of the IoT provider)
  - The setup may be complicated due to the implications of wired on-site connectivity (firewalls, NAT, port and protocol filtering, etc.)

WHAT IS THE NEED?

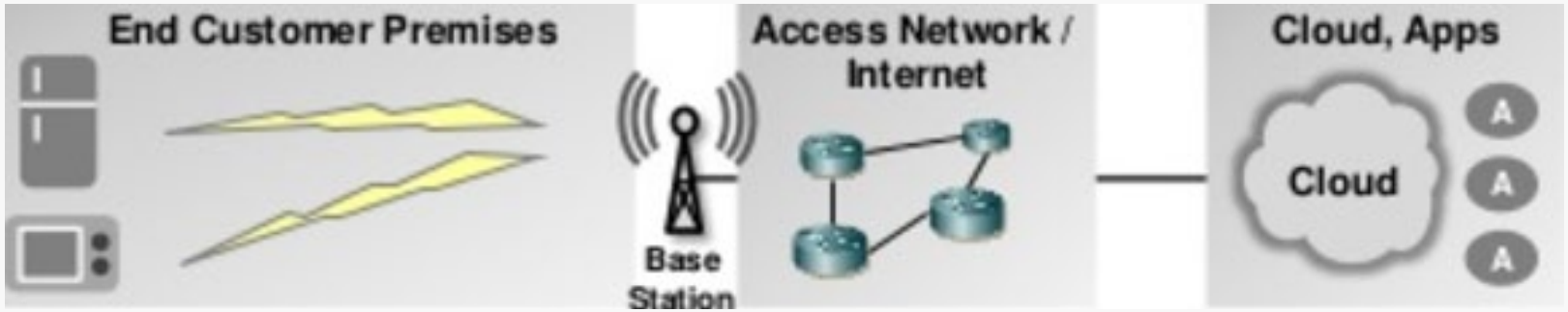


Source: https://www.slideshare.net/PeterREgli/lpwan

- Short-range radio devices get access to the Internet through a gateway that is connected to the on-site wired network
- Requires a setup that may be complicated.

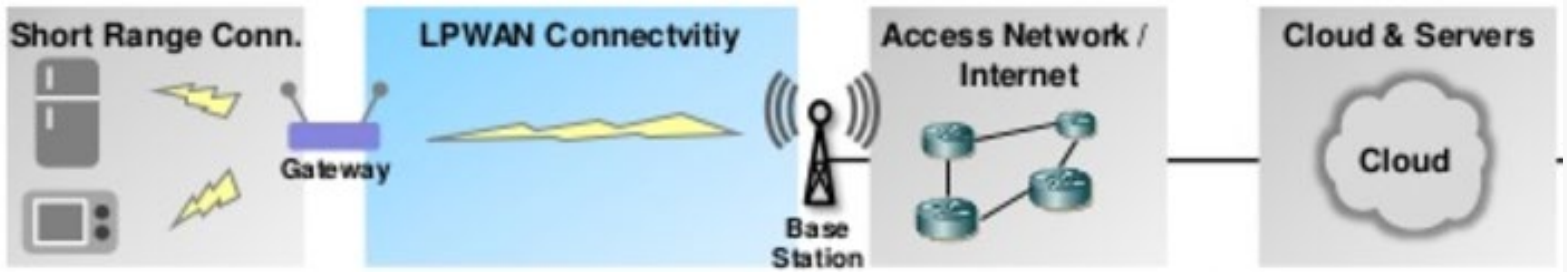
WHAT IS THE NEED?

- A solution to this issue is to allow direct long range connectivity for IoT end devices
  - Using a base station serving a large number of devices
  - Costs are reduced by the scale factor
  - The base station is under control of the IoT provider
  - The wireless part implements a star topology
  - The network servers are responsible for translating IoT protocols to application protocols (HTTP)

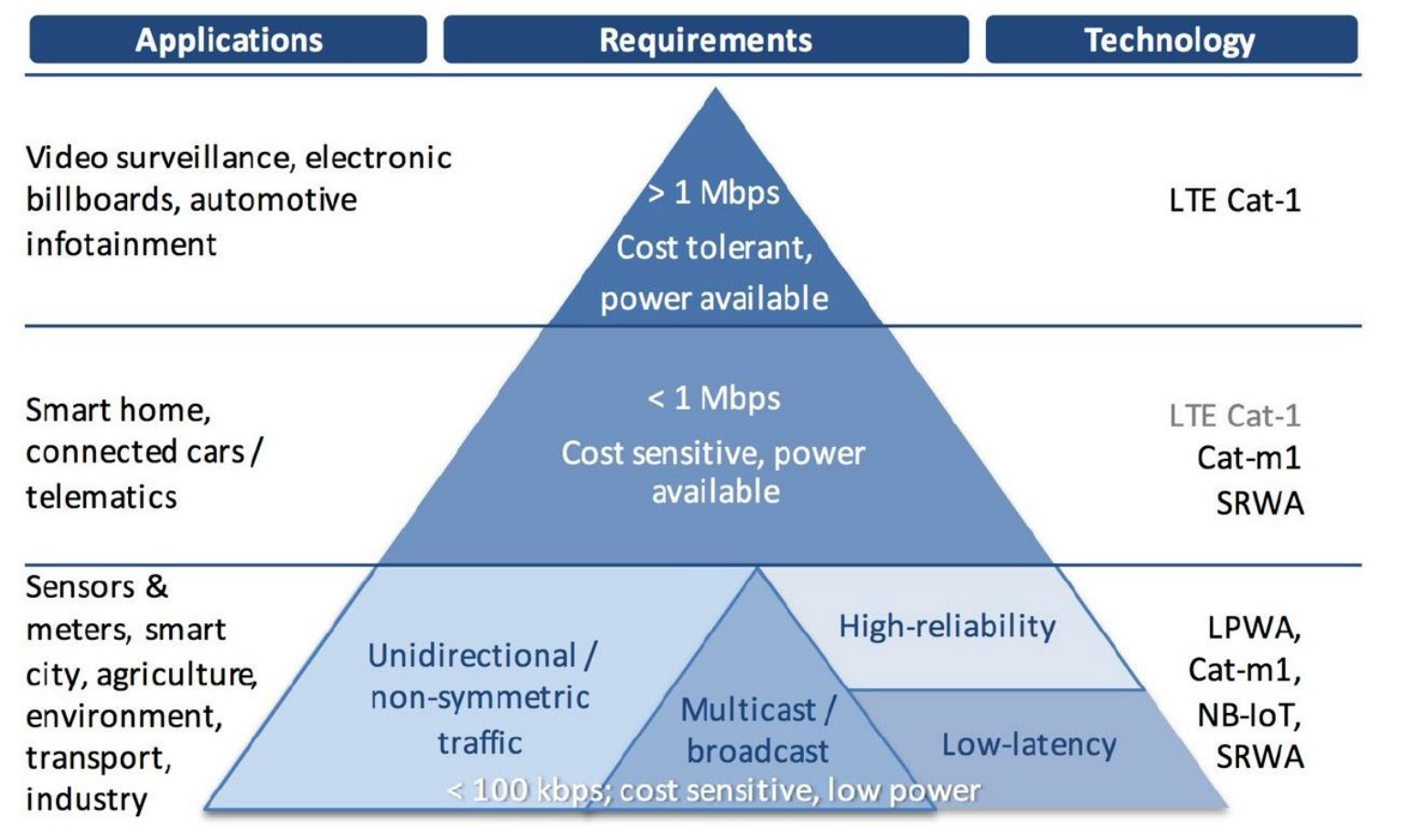


WHAT IS THE NEED?

- Another solution is to provide indirect device connectivity through a long range gateway
  - In setups where end devices cannot be directly reached through a long range base station
  - Mix of short and long range radio, with a gateway usually running on main power



CONNECTIVITY OPTIONS



WHAT MATTERS?

- Choosing connectivity is complex
- A lot of features and benefits, often conflicting, have to be balanced
  - Capacity
  - Quality of Service (QoS)
  - Range
  - Reliability
  - Battery life
  - Security
  - Cost
  - Proprietary vs Standard
  - Licensed or not / Worldwide availability

WHAT MATTERS ?

- Capacity: has to be adapted to IoT needs, meaning
  - Short messages
  - Random timing
  - Power adjustment
  - Multiple overlapping networks
  - Supporting broadcast/multicast
- Quality of service:
  - Allowing fully acknowledged transmissions
  - Depends on physical and upper protocol layers
- Long range:
  - In urban and rural environment
  - Typically, 2 km in an urban environment
  - Range vs. Data rate: long range requires a large link budget

WHAT MATTERS?

- Reliability driven by the use case
  - Cases where cost and power consumption are not critical and where QoS and reliability are priorities
  - Or alternatively cases where cost and power consumption are critical
  - Interference may cause lack of reliability
- Power
  - Needs ultra-low energy consumption when operating on battery
  - Is highly dependent on idle, receiving and transmitting times
  - Depends on scenario but must be carefully designed

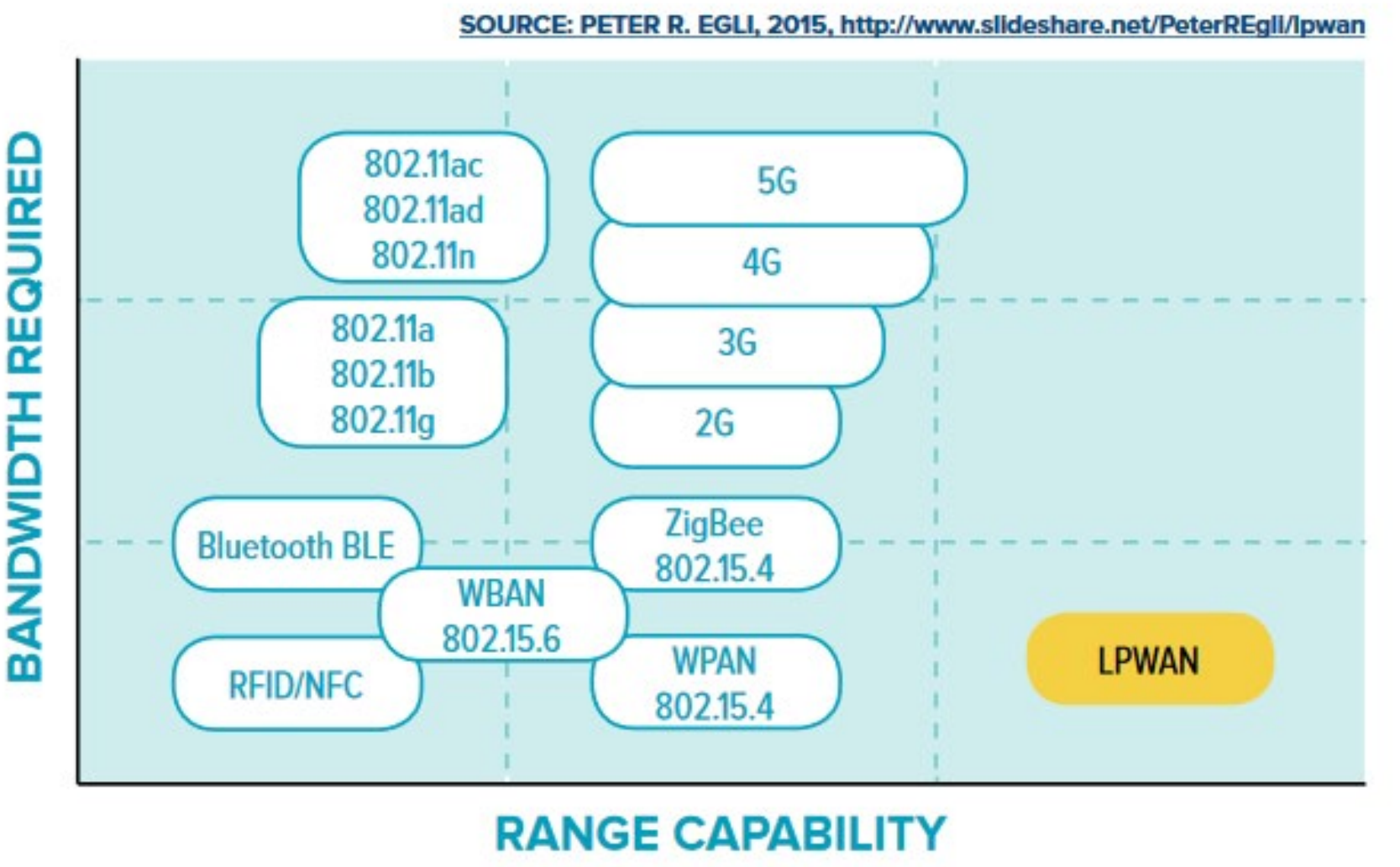
WHAT MATTERS?

- Security
  - Keep data and privacy secure
  - End-device / station authentication
  - Encryption
  - Prevention of attacks
  - Embed or not a secret within the end-device (such as the secret embedded in each SIM card)
- Cost: Low cost and complexity are often required
- Open or proprietary
  - Historically, only open standards have delivered sustainable wireless technologies
  - This is a condition for stimulating competition, allowing interoperability

WHAT MATTERS?

- Licenced vs Unlicensed
  - Every country has different rules about using the sub-GHz spectrum
- Availability worldwide
  - In the sub-GHz spectrum, no single band is available worldwide
  - The only ISM band available worldwide is the 2.4 GHz ISM band
- Localization capabilities
  - Localization is a very useful feature for many IoT scenariis, but no or very few communication technologies provide this feature

THE SWEET SPOT FOR LPWAN



WHY LPWAN FOR THE IOT?

- When long-range is required
- Because standard cellular networks:
  - Are costly (hardware and services)
  - Consume a lot of power
- LPWAN is suited for
  - Connecting devices that need to send small amounts of data
  - Over a long range
  - While maintaining long battery life
- Many IoT applications
  - Only need to transmit very little amount of data
  - Require low power consumption
  - With minimal cost
- The match between LPWAN and IoT exists

AREAS FOR APPLICATIONS USING LPWAN

- In cities or buildings
  - Lighting controllers in cities
  - Asset tracking in campus
  - Large building control and monitoring
- In rural environments (at the neighborhood level)
  - Metering
  - Agriculture
  - Environmental sensors

LPWAN OPTIONS

- Many options that are all subject to the same fundamental laws of physics
  - Relationship between range, data rate and transmit power
  - Greater range means reduced data rate or increased transmit power
  - Higher data rate means shorter range at constant transmit power
  - Lower transmit power means shorter range or lower data rate.
- Ultimately, the use case determines what the best compromise is

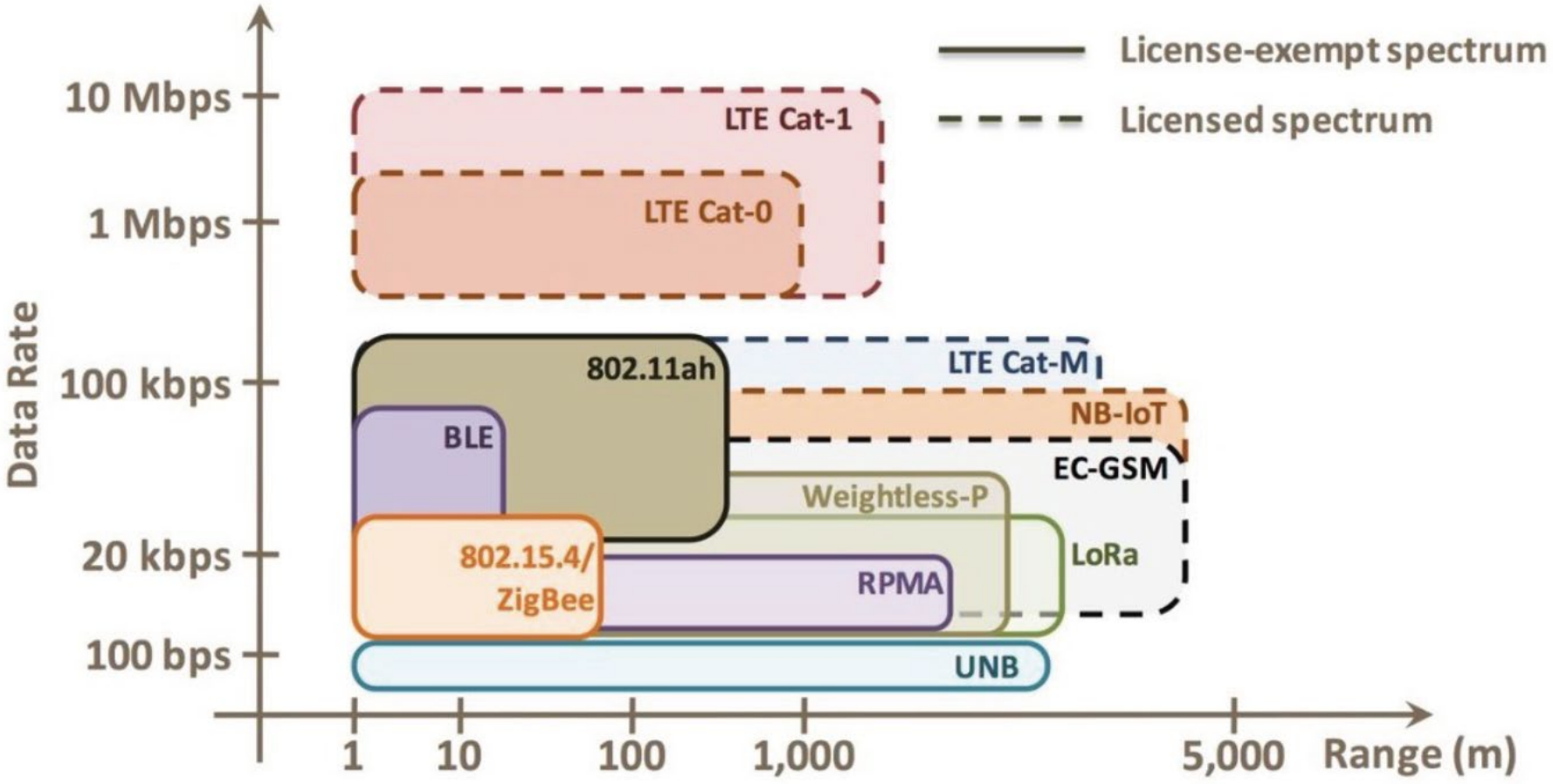
LPWAN FROM A MODULATION PERSPECTIVE

- Ultra narrow band
  - Concept: reduce the amount of noise entering the receiver by reducing the transmission bandwidth
  - By reducing the noise floor, the range is increased for a low transmit power.
  - But a ultra narrow channel can only carry low data rates and bidirectional communication is not really possible.
- Narrow band
  - Compromise between ultra narrow and wide bands, usually with a bandwidth of 12.5 kHz
  - Good compromise regarding QoS, cost and network efficiency, for uplink dominated traffic

LPWAN FROM A MODULATION PERSPECTIVE

- Wide band
  - Wide channel around 500 kHz to over 1 MHz
  - Use spreading of the data to gain range.
  - Flexible approach because:
    - The spreading factor can be varied depending on the channel conditions
    - High data rates can be achieved in smaller cells
  - However, end devices and base stations need to share the same spectrum
    - For avoiding collisions, different spreading factors must be used
    - Not very easy to implement.

LPWAN OPTIONS



OVERVIEW OF MAIN LPWAN TECHNOLOGIES

- LoRa/LoRaWAN
  - Uses the LoRa physical layer (provided by Semtech)
  - Through the LoRa Alliance, promotes an open standard for the upper layer (MAC)
  - Allows private deployments
- Symphony Link (by Link Labs)
  - Uses the LoRa Physical Layer
  - Does not use the LoRaWAN MAC layer
  - Proprietary – openness not very clear

OVERVIEW OF MAIN LPWAN TECHNOLOGIES

- Sigfox:
  - For sending very small amount of data (12 bytes) very slowly (300 baud)
  - Uses BPSK
  - Well suited for basic alarm systems, location monitoring and simple metering
  - The RF chip is manufactured by a number of vendors like TI or Silicon Labs
  - Must use the infrastructure provided by Sigfox – coverage dependent on Sigfox deployment plan

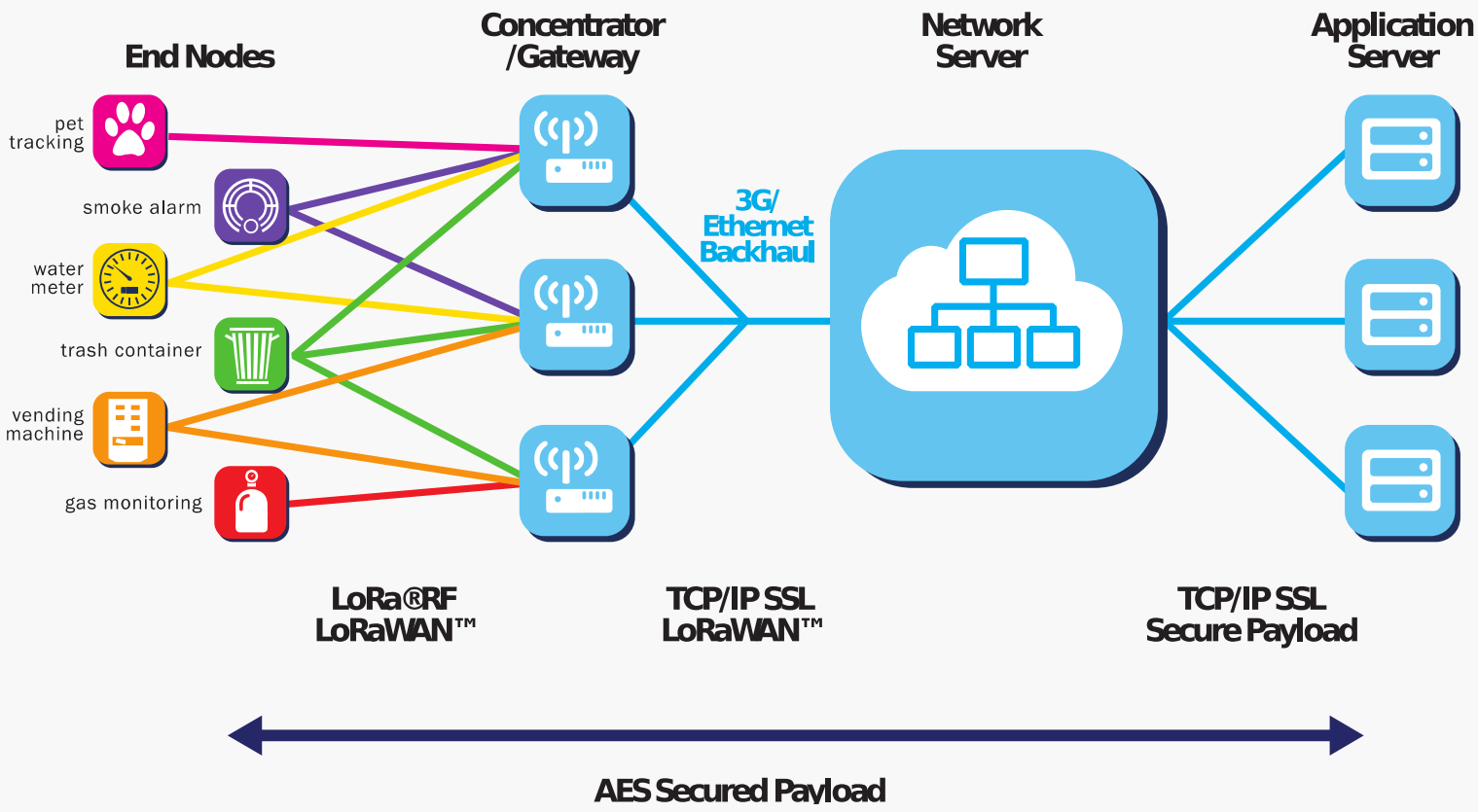
OVERVIEW OF MAIN LPWAN TECHNOLOGIES

- Weightless
  - Open standard, allowing open software innovation
  - Three standards:
    - Weightless-N: one-way communication, very long battery life
    - Weightless-P: two-way communication, shorter battery life
    - Weightless-W: most extensive option, shortest battery life, more expensive
  - Weightless SIG (Special interest group)

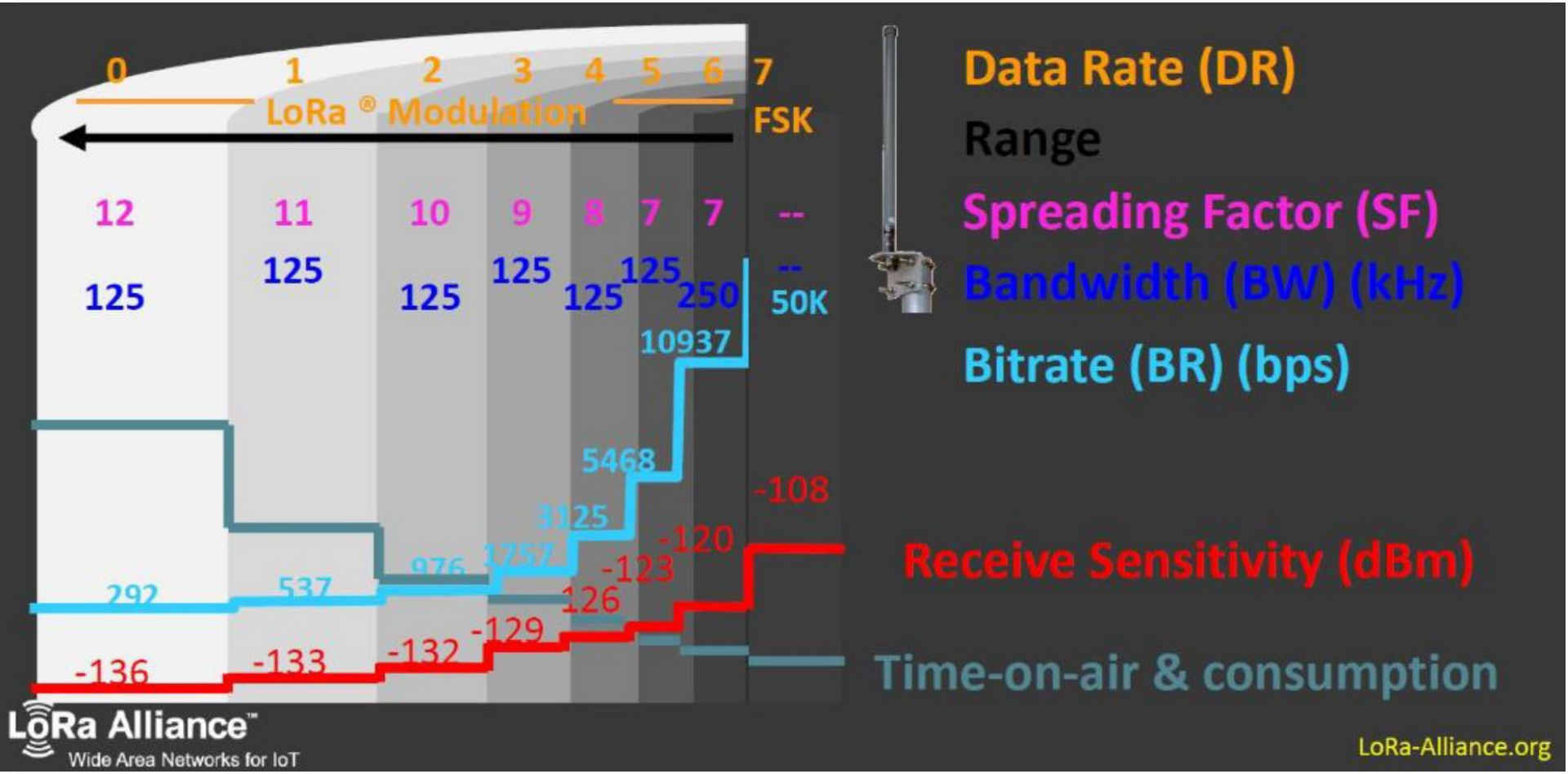
OVERVIEW OF MAIN LPWAN TECHNOLOGIES

- Ingenu (formerly On-Ramp)
  - Wireless technology called Random Phase Multiple Access (RPMA)
  - Member of IEEE 802.15.4k
  - Uses the 2.4 GHz ISM band
  - Not well suited for battery-powered applications
  - Is not an open standard
- Nwave
  - Using ultra narrowband (UNB) radio
  - Operating in sub-GHz ISM bands

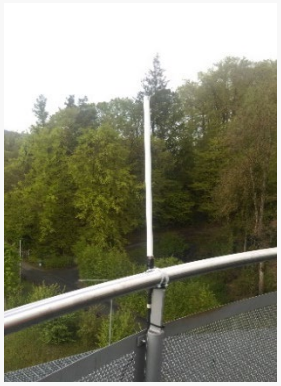
LORAWAN ARCHITECTURE

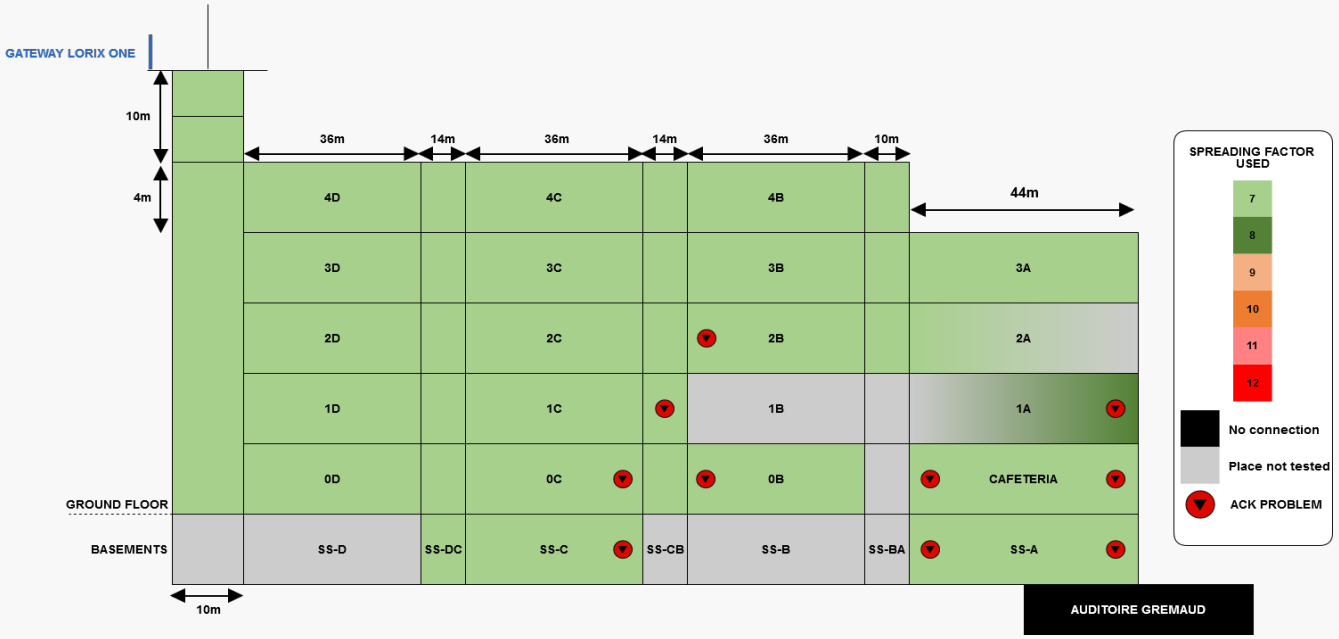


LORA RADIO


0 1 2 3 4 5 6 7
LoRa ® Modulation
FSK
12 11 10 9 8 7 7 --
125 125 125 125 125 250 50K --
10937
5468
3125
1757
976
537
292
-108
-120
-123
-126
-129
-132
-133
-136
Data Rate (DR)
Range
Spreading Factor (SF)
Bandwidth (BW) (kHz)
Bitrate (BR) (bps)
Receive Sensitivity (dBm)
Time-on-air & consumption
LoRa Alliance
Wide Area Networks for IoT
LoRa-Alliance.org

LORAWAN AT HEIA-FR





CELLULAR TECHNOLOGIES FOR THE IOT?

- Cellular technologies were designed for human-to-human communications
  - Designed for supporting high data rate and high mobility
  - High power
    - Up to 31 dBm output power
    - Wideband communication
    - Complex transceiver
  - Limited user capacity
- IoT requires low power
  - Low data rate is not an issue
  - Low mobility is not an issue

CELLULAR TECHNOLOGIES FOR THE IOT?

- Cellular technologies must be adapted for matching those needs, while reusing the existing infrastructure
  - Improved coverage
    - 20dB better
  - Low power consumption
    - 10 years battery life
  - Low cost
    - Terminal (end-device) cost < $5

CELLULAR TECHNOLOGIES FOR THE IOT?