UNIVERSITÀ DEGLI STUDI DI PADOVA

MIME

Master's degree ICT Internet Multimedia Engineering

Department of Information Engineering (DEI)
Master degree on ICT for Internet and Multimedia Engineering (MIME)

Internet of Things and Smart Cities
L07 – Sigfox

Marco Giordani (marco.giordani@unipd.it)
Department of Information Engineering (DEI) – SIGNET Research Group
University of Padova – Via Gradenigo 6/B, 35131, Padova (Italy)

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L07 – Internet of Things and Smart Cities
IoT technologies (long-range)

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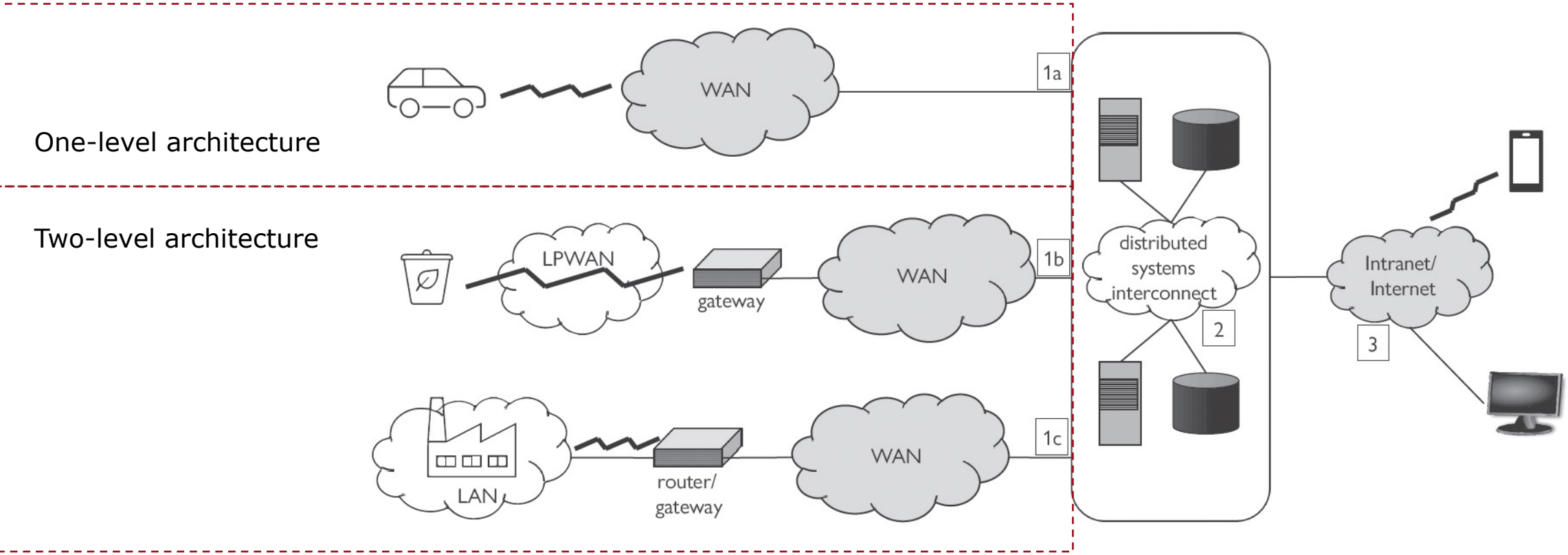
Do you remember?

Network architectures

One-level architecture

Two-level architecture



Long-range

Introduction

- **Long-range**: (generally) cell diameter of (several) kilometers.
- Generally, this is enabled by cellular networks:
  - High complexity and infrastrucutre cost.
  - Support for very high data rates.
  - Not designed for energy efficiency (recharging batteries of mobile terminals is normal).
- **Low-Power Wide Area Networks (LPWAN)**: jointly optimize a combination of energy efficiency, data rate, communication range, cost per device.

Long-range

Introduction

Parameter	WSN	WLAN	Cellular networks	LPWA
Range	Very short (~1-3 m)	Short (~10-100 m)	Long (~1-5 km)	Very long (~5-20 km)
Energy efficiency	Very high (tx. power < 1 mW)	Medium (tx. power ~80 mW)	Low (tx. power ~500 mW)	Very high (tx. power ~ 20 mW)
Data rate	Low	Very high	High	Very low
Cost	Low	Medium	Medium	Very low

Long-range

Introduction

- **LPWAN features:**
  - Long-range coverage (up to 10 km).
  - Low communication(infrastructure cost.
  - Very high energy efficiency (duration of the battery up to 10 years).
  - Low data rate per device, but very large number of devices.
  - Mostly static (simple core network, with limited support for handover and mobility).
  - Easy network implementation and deployment (no need for detailed radio planning).

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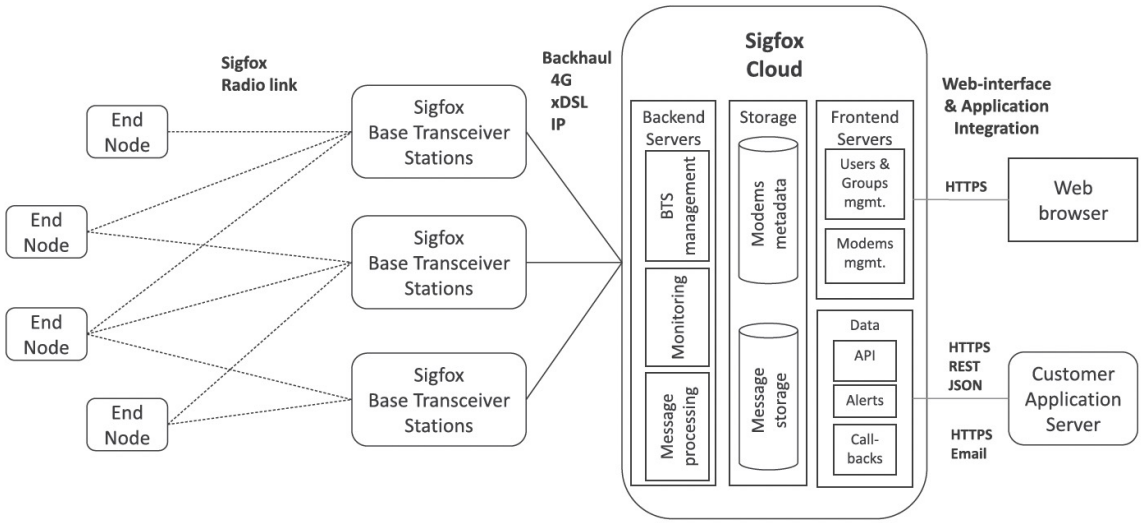
Sigfox

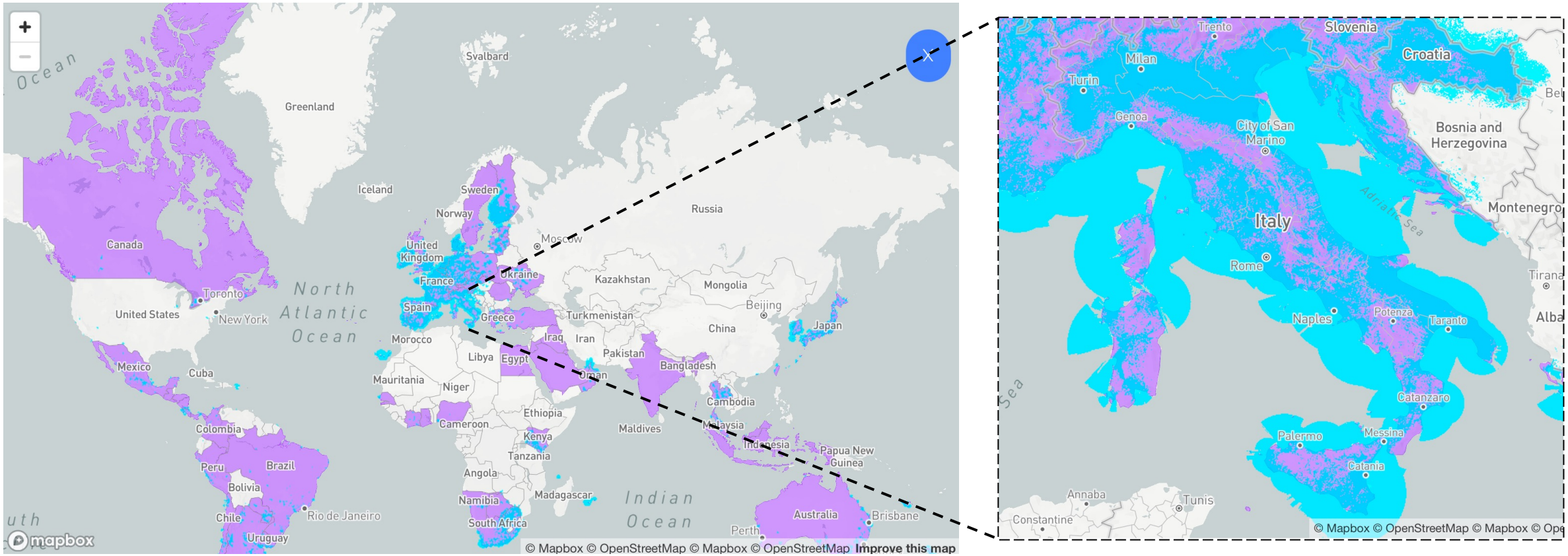
Overview

- First LPWAN technology, developed by the French company Sigfox.
- Idea: provide a **Sigfox cloud platform** via a **subscription-based model.**
  - Communication between the end nodes and base stations is managed by local operators.
  - Base stations forward data to the Sigfox cloud for storage, processing, etc.



Sigfox

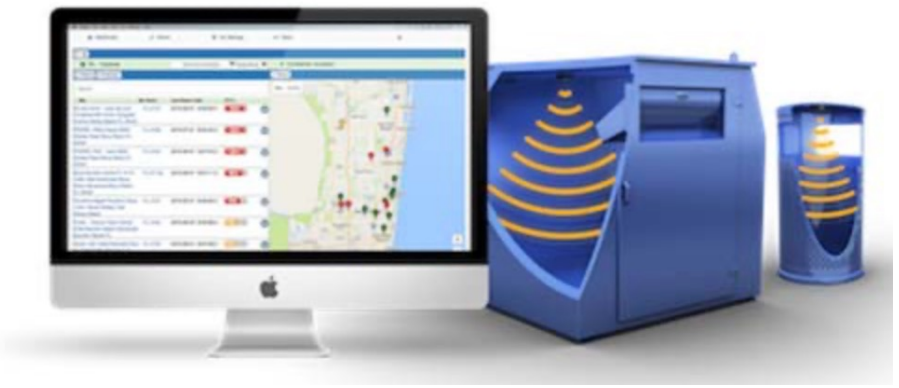
Coverage



Sigfox

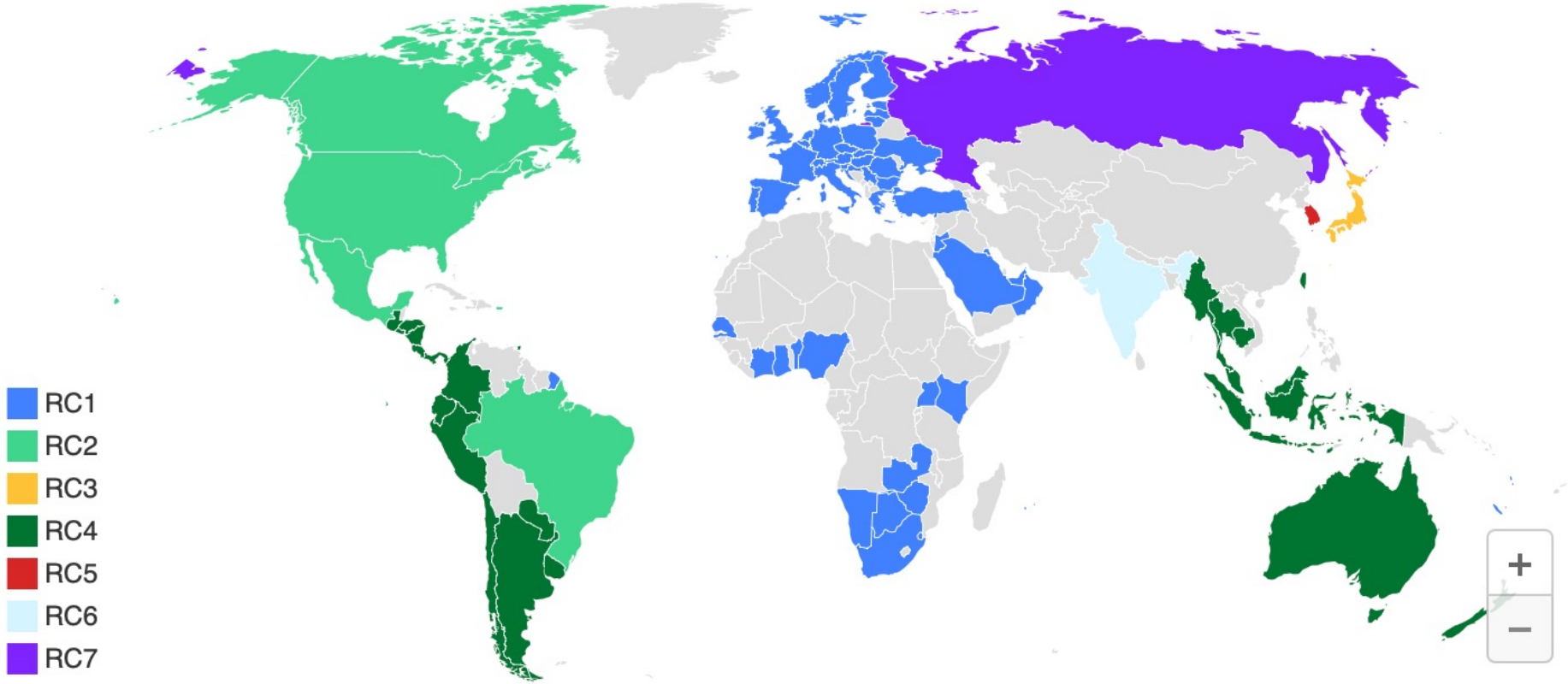
Applications

- **Long-range large-scale** IoT applications:
  - Connected dumpsers (e.g., OnePlus Systems, Sayme)
  - Gas tank remote monitoring (e.g., Silicon Controls, Ijinus)
  - Street lightning (e.g., Kawantech)
  - Smart parking (e.g., IoTMalta, Libelium, Sterela)



Sigfox

Frequency range



https://build.sigfox.com/sigfox-radio-configurations-rc

Sigfox

Frequency range

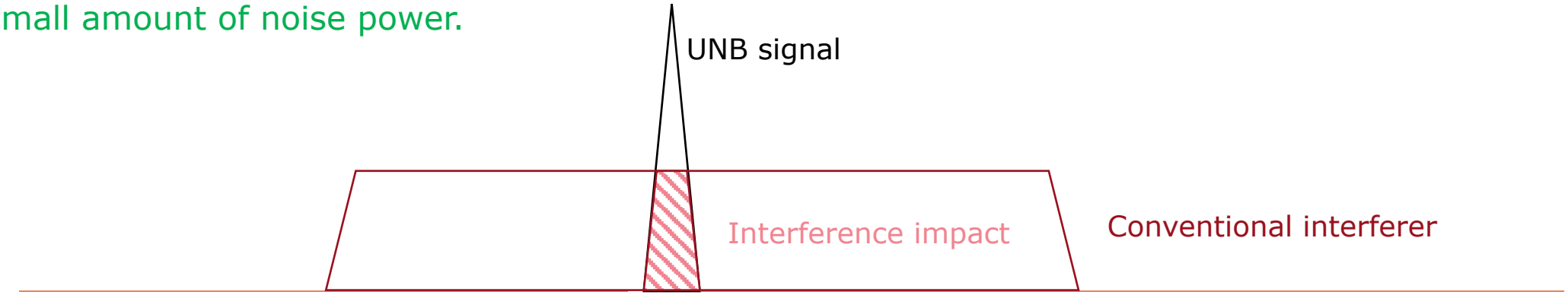
Parameter	RC1	RC2	RC3	RC4	RC5	RC6	RC7
UL frequency (MHz)	868.130	902.200	923.200	920.800	923.300	865.200	868.800
DL frequency (MHz)	869.525	905.200	922.200	922.300	922.300	866.300	869.100
UL data rate (bit/s)	100	600	100/600	600	100/600	100/600	100/600
DL data rate (bit/s)	600	600	600	600	600	600	600
EIRP (dBm)	16	24	16	24	14	16	16
Specifics	DC 1%	FH	LBT/DC 1%	FH	LBT	DC 1%	DC 1%

https://build.sigfox.com/sigfox-radio-configurations-rc

Sigfox

PHY layer

- The keyword is **simplicity**: no connection, no configuration, no signaling.
- Sigfox defines a proprietary **Ultra-Narrow Band (UNB)** wireless technology.
  - Energy is concentrated into a very tiny portion of the **bandwidth**.
    - Very limited data rate.
    - Interference-immune.
    - Small amount of noise power.

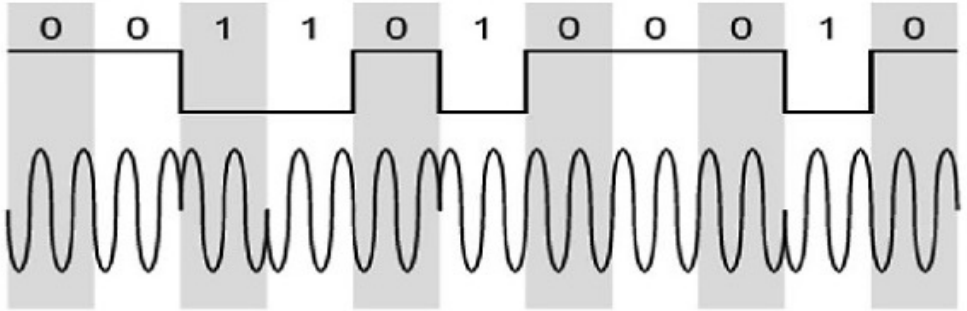


Sigfox

PHY layer

- Modulation: **Differential Binary Phase Shift Keying (DBPSK)** and **Gaussian Frequency-Shift Keying (GFSK).**
  - Bits are encoded as changes in phase of the signal.
- **Repetition scheme**: each message is transmitted **3 times**:
  - More robustness (it is more likely that at least one Sigfox station receives the signal).
  - The Sigfox cloud / back end will take care of possible duplicates.

If the data bit is Low i.e., 0, then the phase of the signal is not reversed, but continued as it was. If the data is a High i.e., 1, then the phase of the signal is reversed.



Sigfox

Frame structure

- Max. frame size: 26 bytes.
  - **Uplink frame**: payload up to 12 Bytes.
    - UL is more common than DL (e.g., for sensors to report data measurements).

Preamble	Sync.	Device ID	Payload	Auth.	FCS
4 bytes	2 bytes	4 bytes	0÷12 bytes	variable	2 bytes

  - **Downlink frame**: payload up to 8 Bytes.

Preamble	Sync.	Flags	FCS	Auth.	Error codes	Payload
8 bytes	13 bits	2 bits	1 byte	2 bytes	variable	0÷8 bytes

Sigfox

Transmission times (example)

- Let's consider Sigfox Europe.
  - Duty cycle: 1% → I can transmit 36 s/h.
  - UL data rate: 100 bit/s → With the DC, I can transmit 3600 bit/h = 450 byte/h.
  - Repetition code: 3 → For «new» data, it is 450/3 = 150 byte/h.
  - Frame size: 26 bytes → I can transmit $460/(26 \cdot 3) \simeq$ **6 frames/h.**
  - Max. payload size: 12 bytes → I can transmit up to $12 \cdot 6 =$ **72 bytes/h** → **very limited!**

- Applications have (limited) requirements, and benefit from the simple design.
  - GPS coordinates (lat x long) : 6 bytes
  - Temperature: 2 bytes
  - State reporting : 1 byte

Sigfox

MAC layer

- Transmission is **initiated by end devices**:
  - End devices periodically wake up to transmit UL data.
  - Then, it briefly listens for messages to be received (e.g., ACKs or commands).
  - Then, it goes to sleep mode.
  - This approach is good for regular data collection and monitoring, but not for command-and-control applications (**command always follows sensors-based transmissions**).