Universidad Politécnica de Cartagena

MIEMBRO DE EUT+ EUROPEAN UNIVERSITY OF TECHNOLOGY

MINISTERIO DE CIENCIA E INNOVACIÓN

NextGenerationEU

Plan de Recuperación, Transformación y Resiliencia

AGENCIA ESTATAL DE INVESTIGACIÓN

smartDUMP

IoT communication technologies

Blended Intensive Programme on IoT

Index

Part 1.

IoT communication technologies

WiFi

- High speed
- Medium distance
- Robustness
- High energy consumption

Bluetooth

- Medium speed
- Short distance
- Robustness
- Bluetooth Low Energy

LTE

- High speed
- Long distance
- Robustness
- High energy consumption

Zigbee

- Medium speed
- Short distance
- Low energy consumption
- Mesh topology

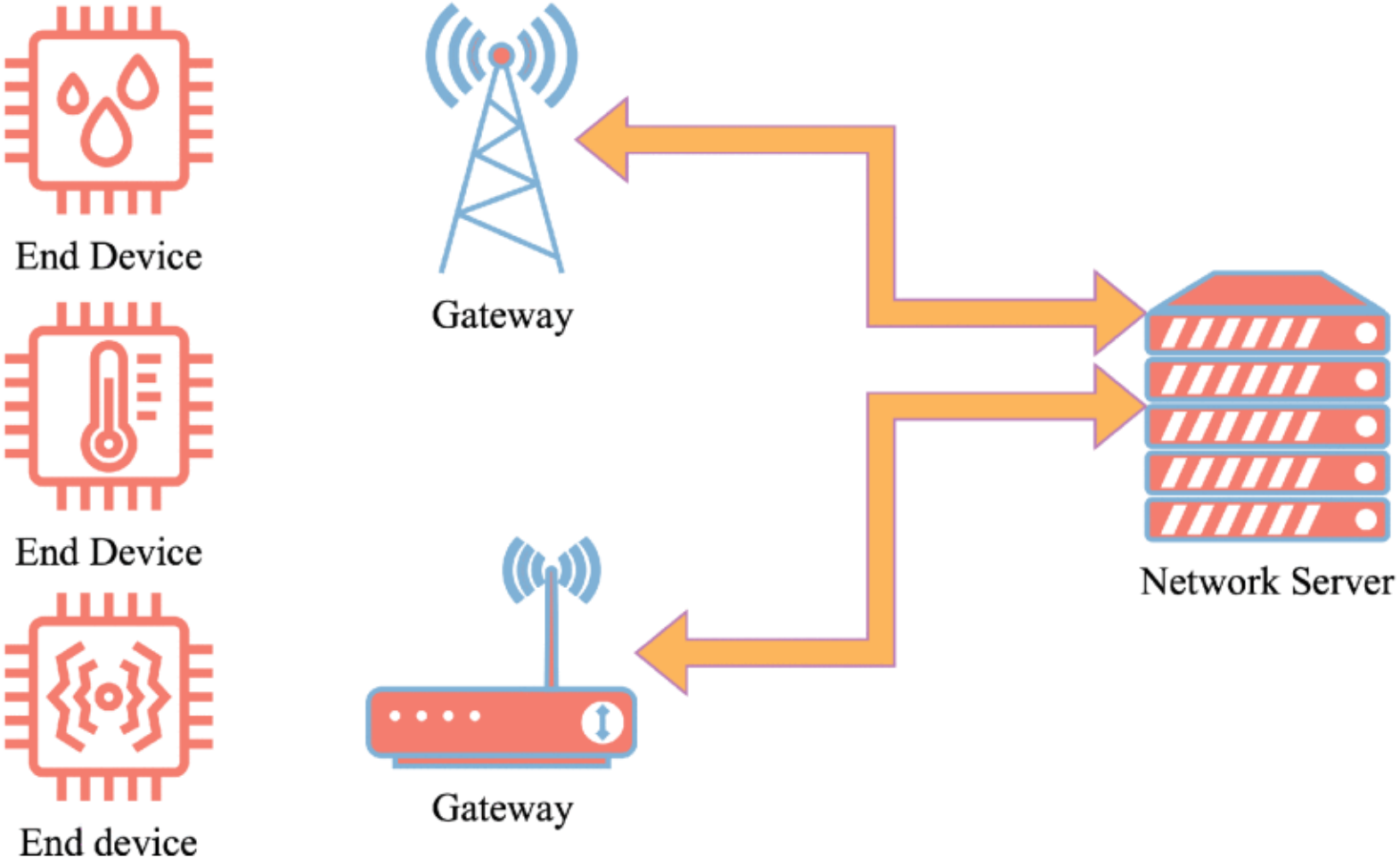
LoRa

- Low speed
- Long distance
- Low energy consumption
- Star-of-stars topology
- Available gateways

Part 2.

LoRa

LoRaWAN architecture



LoRa physical layer: spreading factor

Example values for Europe with a 125 kHz bandwidth and CR = 4/5

Spreading factor	Bitrate (bit/s)	Receiver sensitivity (dBm)
SF7	5470	-124
SF8	3125	-127
SF9	1760	-130
SF10	980	-133
SF11	440	-135
SF12	250	-137

LoRa physical layer

Parameters

- Spreading factor (**SF**) → determines bitrate and sensitivity
- Frequency (**f**) → depends on the region
- Bandwidth (**BW**) → depends on up/downlink and region
- Transmission power → depends on the region
- Code rating (**CR**) → determines robustness

$$CR = \frac{4}{4+n} \text{ with } n \in \{1,2,3,4\}$$

LoRa physical layer

Parameters for Europe

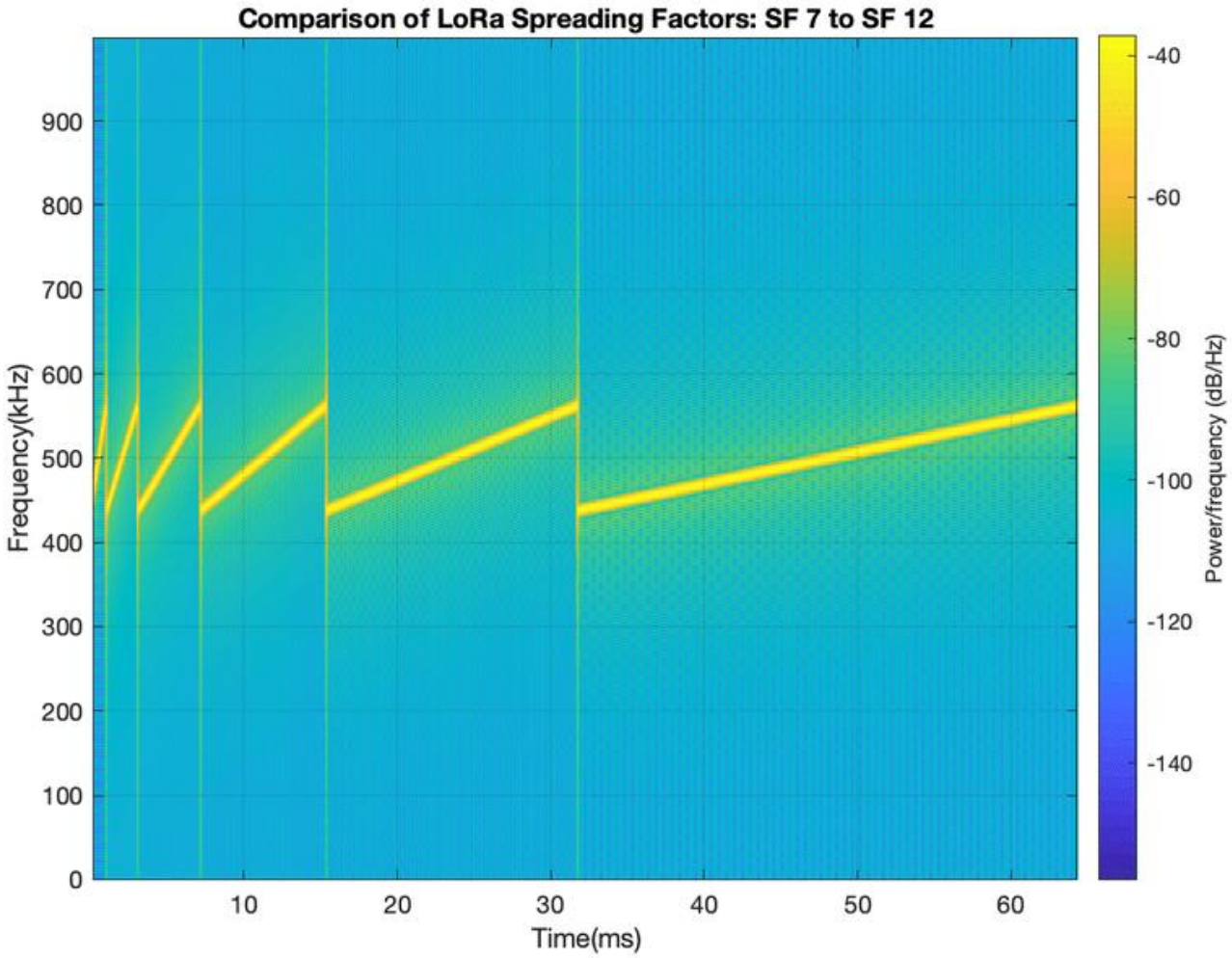
- Spreading factor (**SF**) → 7-12
- Frequency (**f**) → 868 MHz (867-869 MHz)
- Bandwidth (**BW**) → 125/250 kHz uplink, 125 kHz downlink
- Transmission power → 14 dBm
- Code rating (**CR**) → $CR = \frac{4}{4+n}$ with $n \in \{1,2,3,4\}$

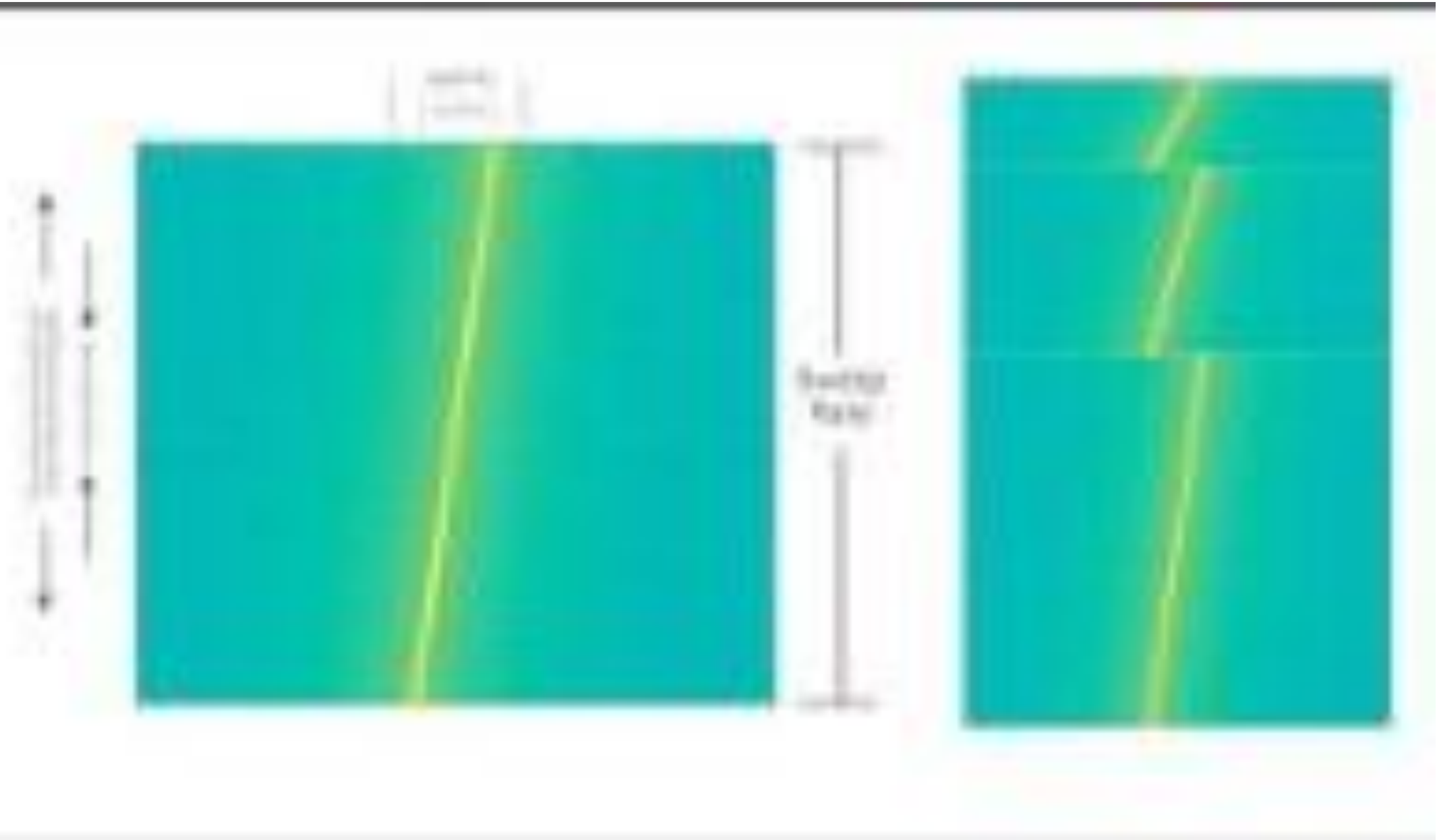
$$DR = SF \times \frac{BW}{2^{SF}} \times CR$$

LoRa physical layer: CSS

Chirp Spread Spectrum

- Robust to noise
- Chirps use different frequencies in the same BW
- Orthogonality: different SFs do not interfere
- Increases the capacity

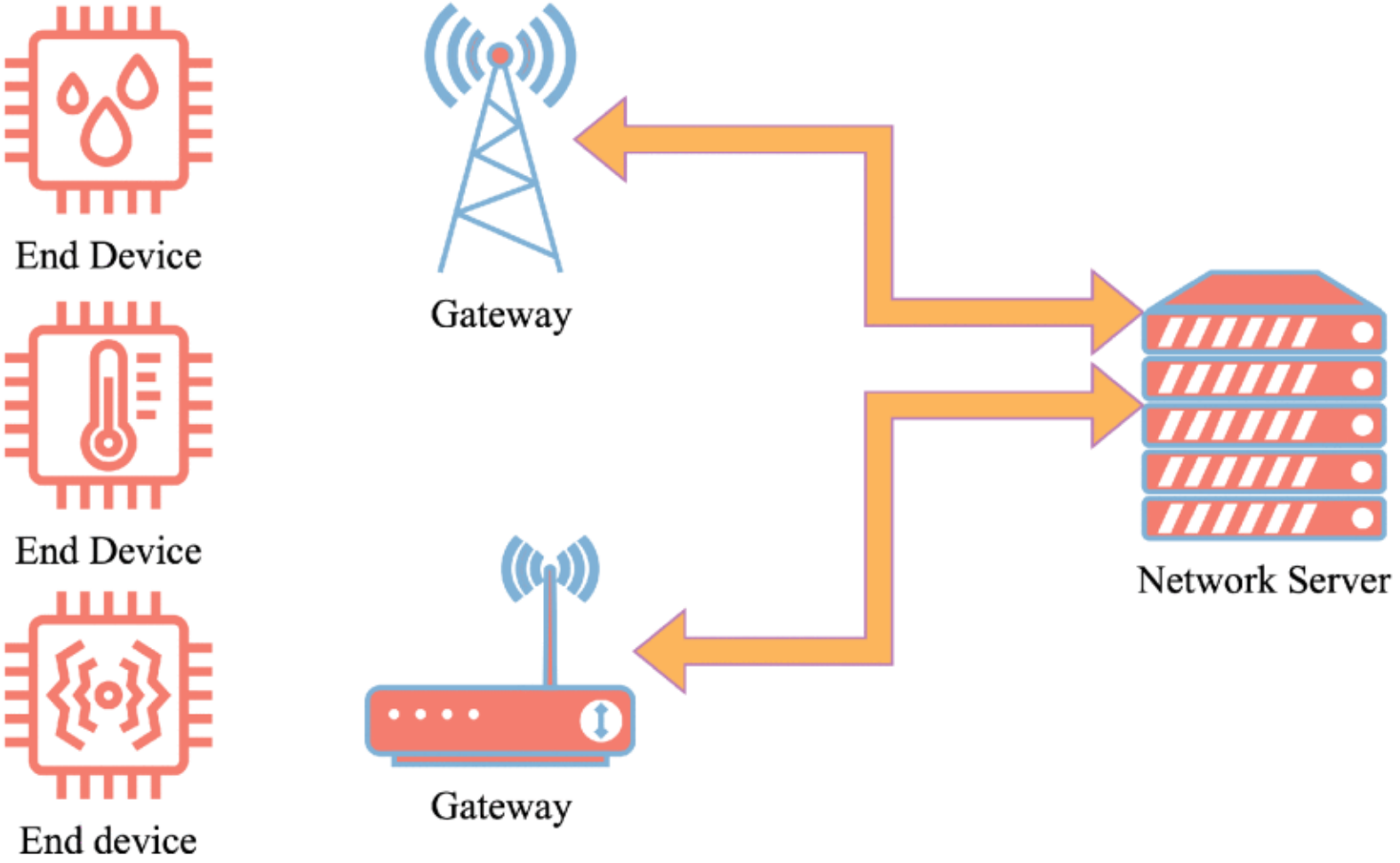




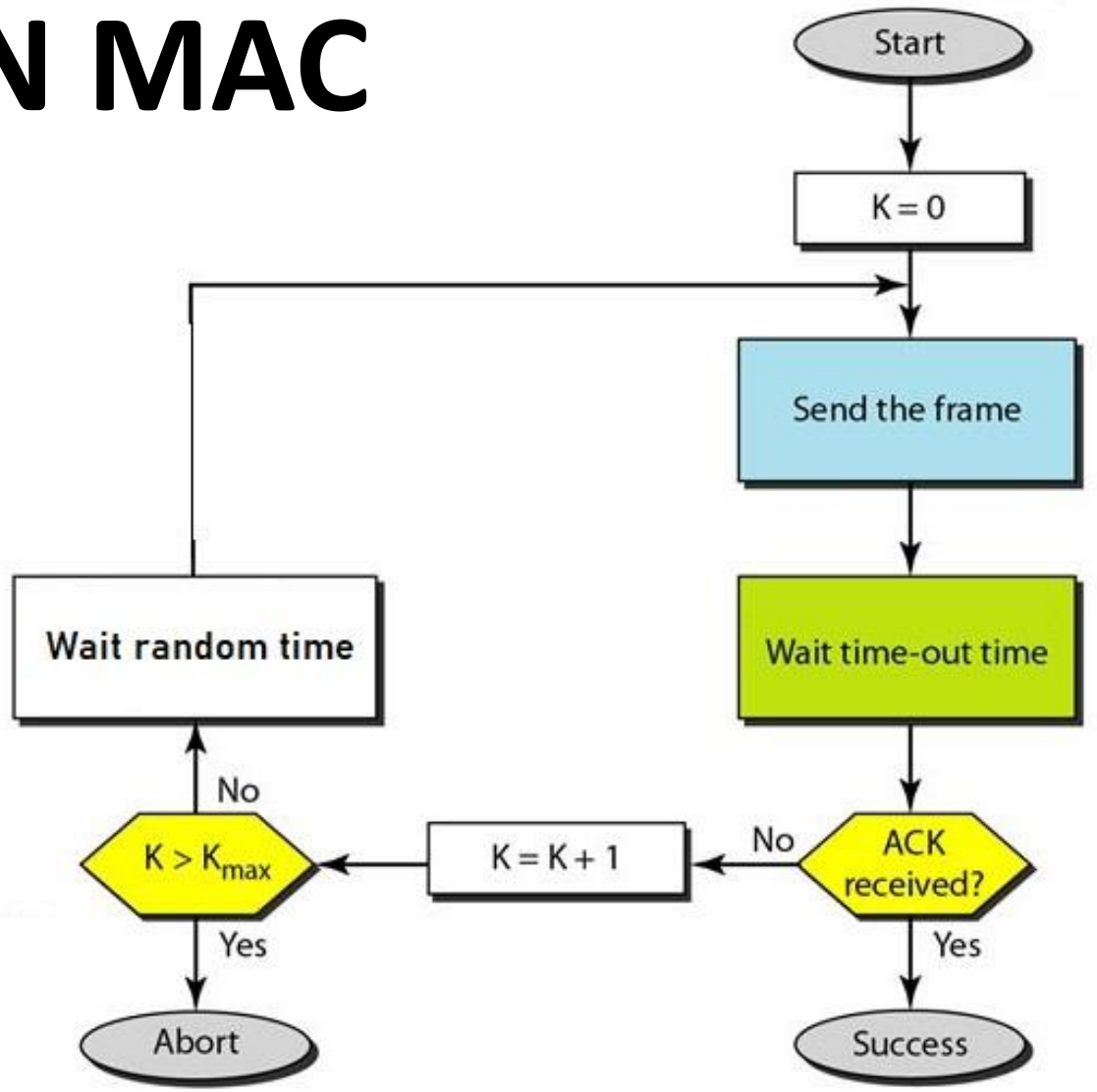
Part 3.

LoRaWAN

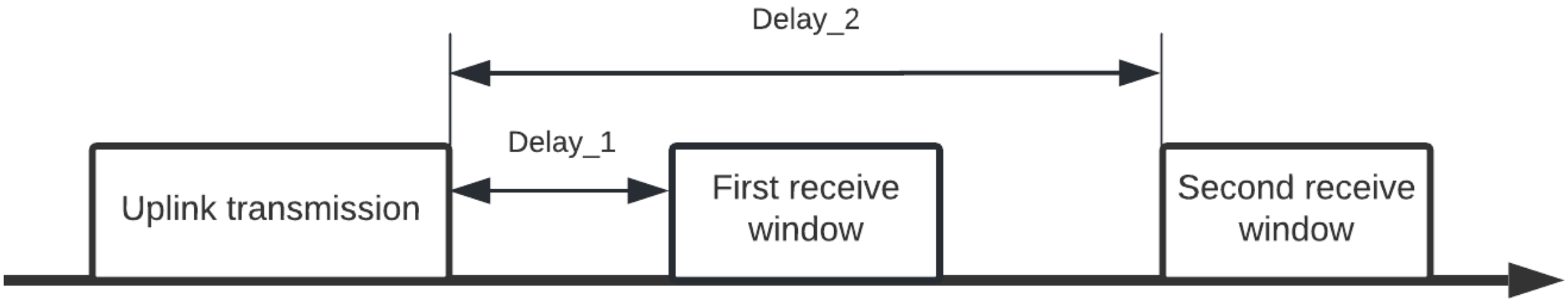
LoRaWAN


End Device
End Device
End device
Gateway
Gateway
Network Server

LoRaWAN MAC


Start
K = 0
Send the frame
Wait time-out time
ACK received?
No
K = K + 1
K > K_max
No
Yes
Success
Yes
Abort
Wait random time

LoRaWAN: Class A behavior



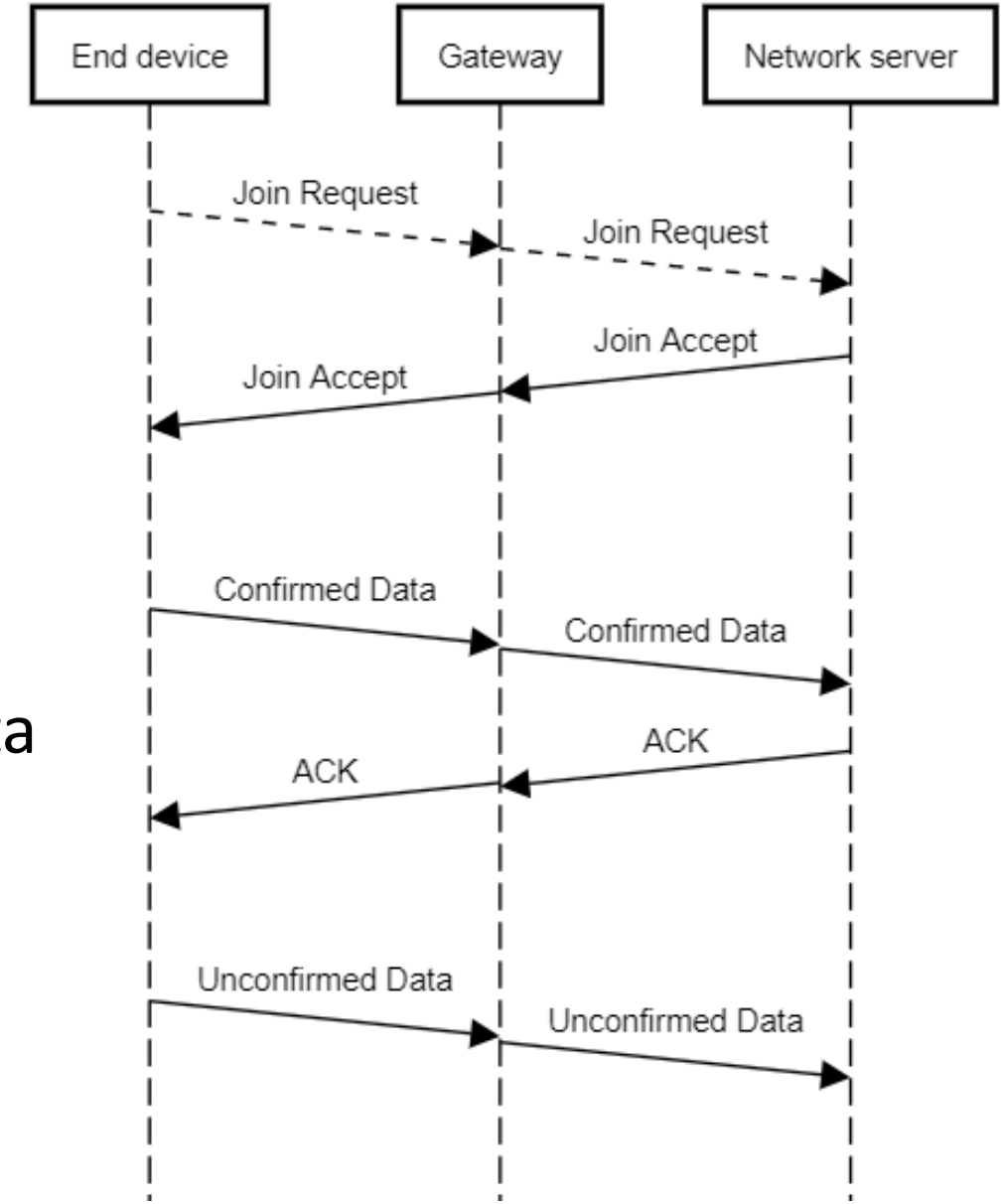
LoRaWAN

- Three communication classes
- Confirmed transmission ACK (usually)
- Single-hop topology
- Single packet at a time

LoRaWAN

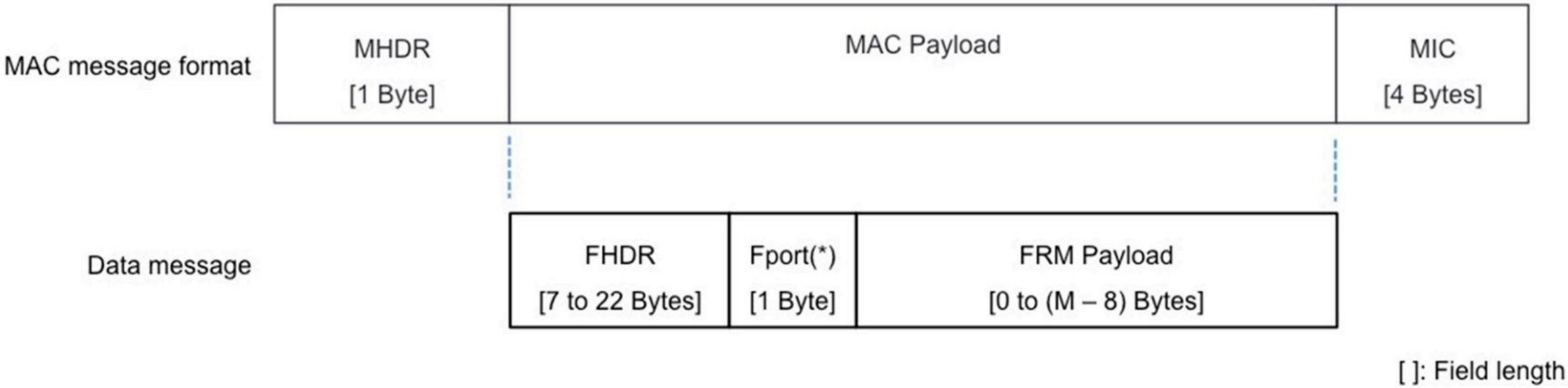
Basic types of MAC messages:

- Join
- Confirmed Data
- Unconfirmed Data



LoRaWAN: message format

Basic types of MAC messages: Join, Confirmed Data and Unconfirmed Data



Part 4.

LoRa performance in an experimental setting

LoRa Gateway – LG01

Flame sensor

DHT11 sensor

Photosensitive sensor

Soil humidity sensor

LoRa shield

Arduino Uno

Physical settings

Arduino ID	SF	BW (kHz)	CR
7-125-5	7	125	1
7-125-8	7	125	4
9-125-5	9	125	1
9-125-8	9	125	4
11-125-5	11	125	1
11-125-8	11	125	4
7-250-5	7	250	1
7-250-8	7	250	4

Physical settings

Measurements:

$$RSSI \qquad PDR = \frac{D}{T}$$

	100m		150m		200m	
Arduino ID	*PDR*	*RSSI*	*PDR*	*RSSI*	*PDR*	*RSSI*
7-125-5	66%	-71.74	81.77%	-77.48	41.74%	-92.66
7-125-8	88.08%	-69.22	91.78%	-78.46	85.33%	-90.64
9-125-5	95.11%	-71.98	91.78%	-84.5	78.66%	-95.04
9-125-8	96.22%	-76.27	92%	-77.59	93.11%	-90.97
11-125-5	99.11%	-78.74	98%	-80.67	82.67%	-93.81
11-125-8	98%	-75.74	97.33%	-77.08	98.44%	-90.77
7-250-5	78.67%	-70.20	88.67%	-72.35	73.11%	-86.80
7-250-8	84.67%	-69.99	99.11%	-77.59	69.67%	-88.38

Any questions?

Links

- Helium Network - Coverage in Cartagena
- Helium Network – Prices
- The Things Network
- Video Lora Chirp
- Tree Farm Paper