Introduction to LoRa and LoRaWaN

Source: https://www.univ-smb.fr/lorawan/en/free-book/

Characteristics of systems in IoT

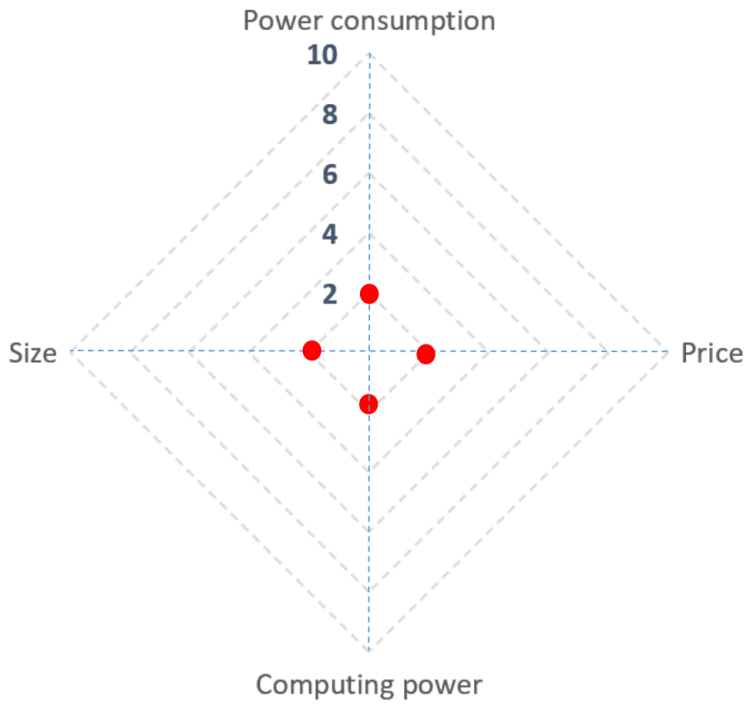
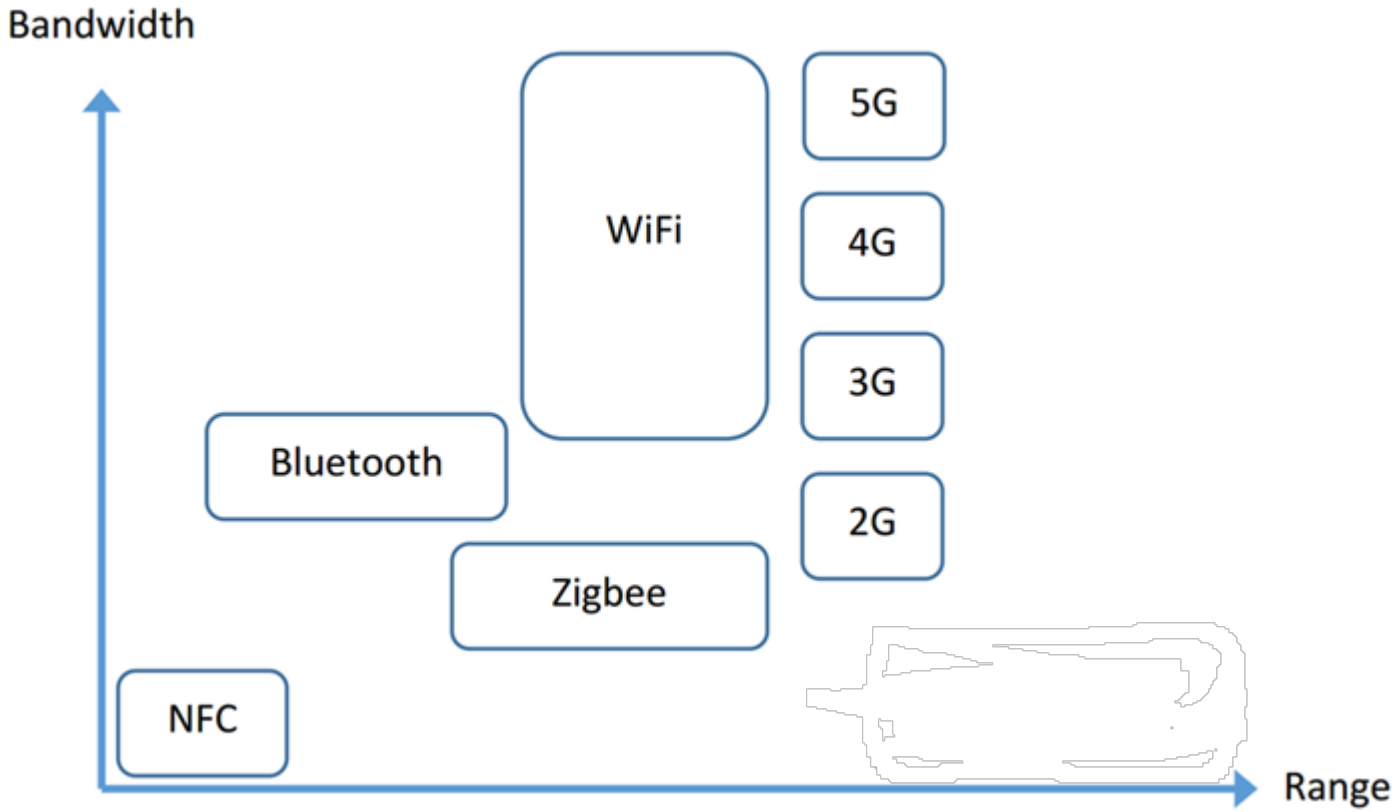


Figure 1: IoT device characteristics

- Low-power consumption
- Low Computing power
- Small size
- Low price
- Ability to communicate data over a wireless network

Wireless Transmission Protocols



Wireless Transmission Protocols (2)

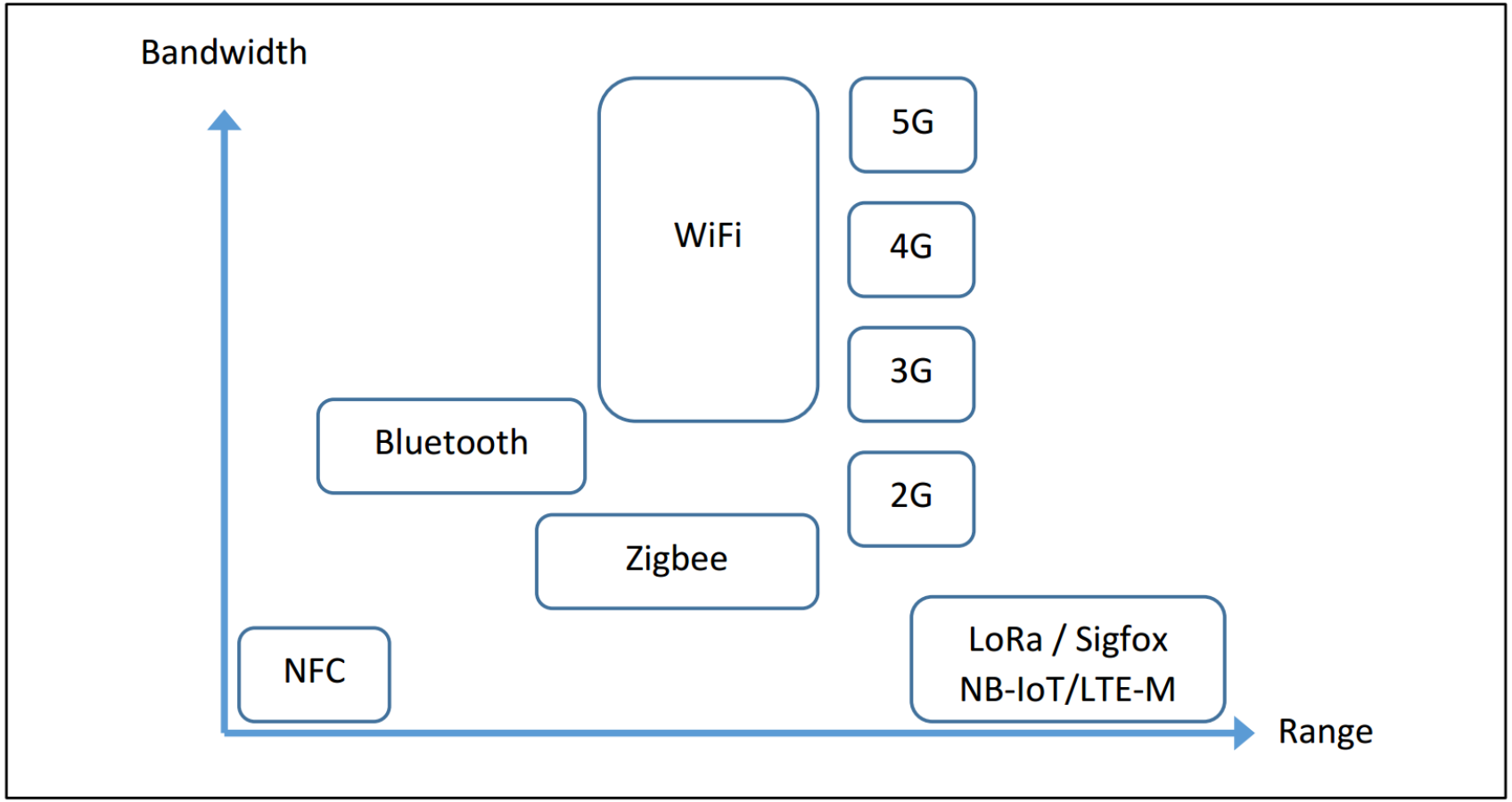
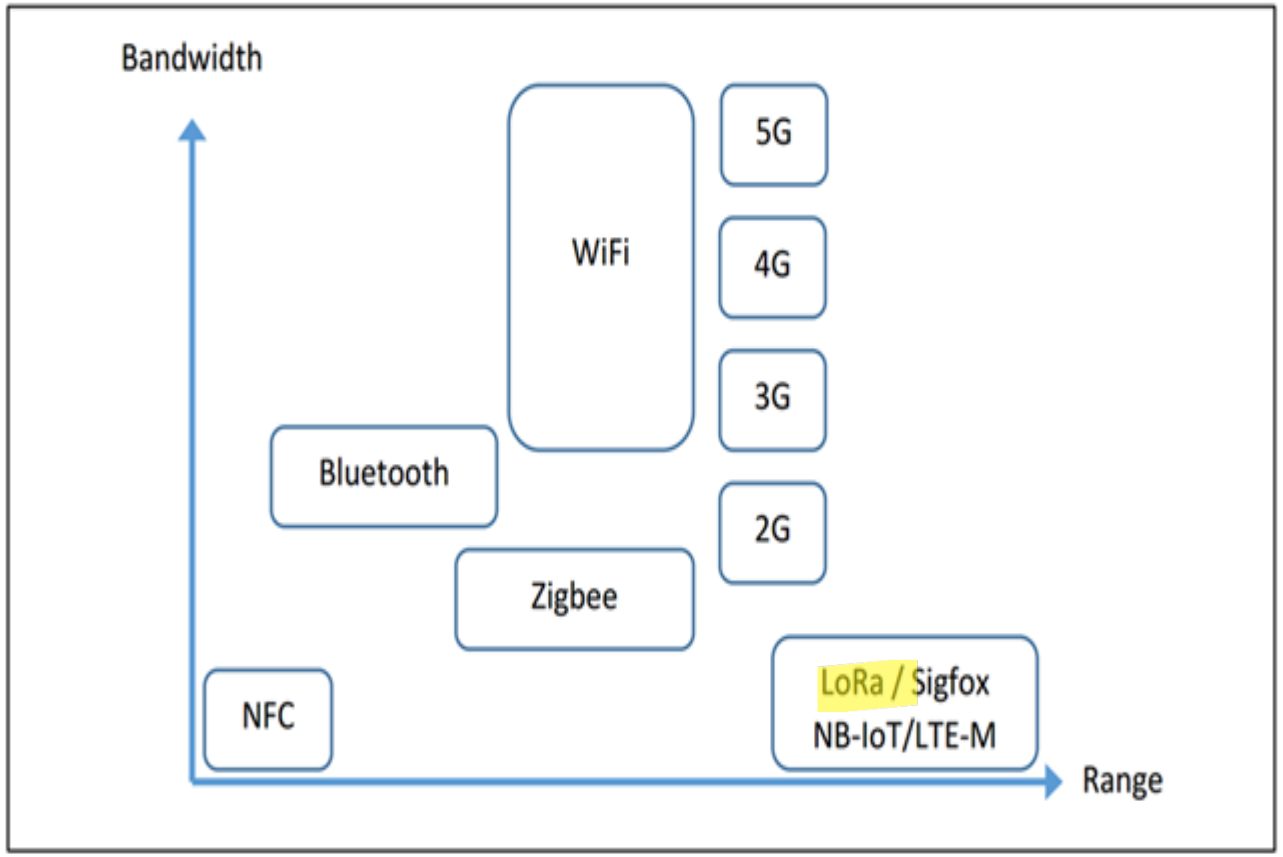


Figure 2: Protocols used in IoT

Wireless Transmission Protocols (3)



LoRa is a "long distance" and "low data rate“ protocol

Theoretical range of 15-20km in ideal conditions

Practical Range:

Urban Areas: typically cover distances of up to 3 kilometers in dense urban areas.

Rural /Open Areas: Can achieve ranges of over 10 kilometers.

Indoor: LoRa can penetrate walls and floors, providing coverage in multi-story buildings

Data Rates 0.3 kbps to 50 kbps.

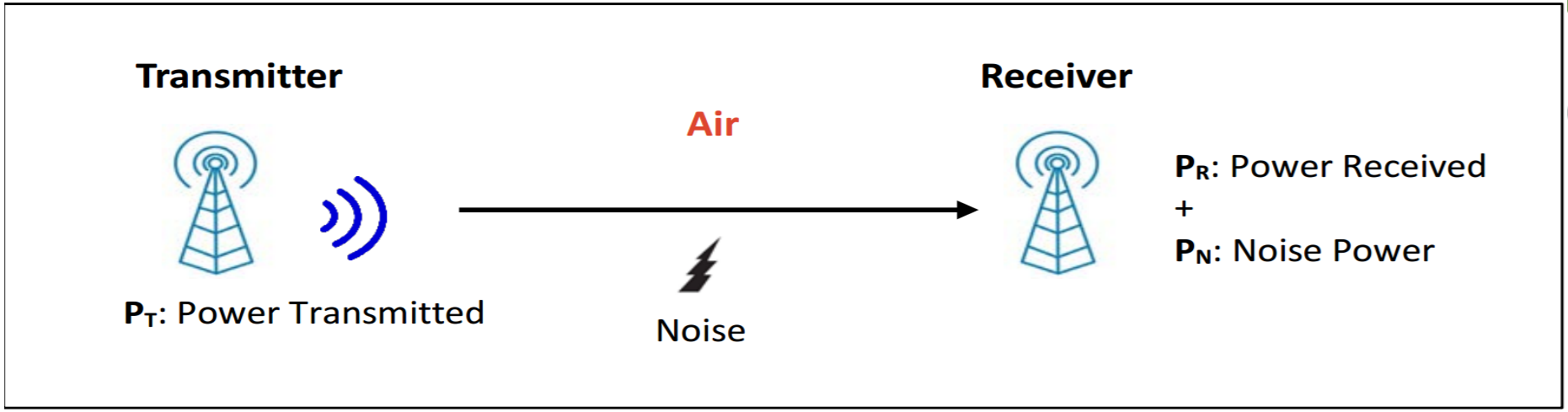
Free-to-use Frequency Bands used in LoRa

Band	Examples of protocols
13.56 MHz	RFID, NFC
433 MHz	Walkie-talkie, remote control, LoRa
868 MHz	Sigfox, LoRa
2.4 GHz	Wi-Fi, Bluetooth, Zigbee, LoRa
5 GHz	Wi-Fi

Table 1: Free frequency bands

- Frequency bands India is **865 MHz to 867 MHz** (denoted as (IN856))for LoRa Technology

Some Terminologies



- The **Received Signal Strength Indication (RSSI)** is the power received (Pr) **Units dB**
- The **Sensitivity** is the minimum Pr (Power Received) (or minimum RSSI) that must be present at the receiver in order to retrieve the signal. If the received RSSI is below the sensitivity level, the signal is undetectable. **Units dB**
- **SNR (Signal over Noise Ratio)** is the ratio of the received power (PR) to the noise power (Pn)

A good reception involves

- RSSI > Sensitivity
- The SNR does not fall below a certain threshold that would make the signal impossible to

Interpreting Specification Sheet

Product Specifications

Module Model	Ra-02
Package	SMD-16
Size	17*16*(3.2 ± 0.1) mm
Interface	SPI
Programmable bit rate	UP to 300Kbps
Frequency Range	410-525 MHz
Antenna	IPEX
Max Transmit Power	18±1 dBm
Power (Typical Values)	433MHz: TX:93mA RX:12.15mA Standby:1.6mA 470MHZ: TX:97mA RX:12.15mA Standby:1.5mA
Power Supply	2.5~3.7V， Typical 3.3V
Operating Temperature	-30 ℃ ~ 85 ℃
Storage Environment	-40 ℃ ~ 90 ℃ , < 90%RH
Weight	0.45g

Receive Sensitivity

Frequency	Spread Factor	SNR	Sensitivity
433MHz	7	-7	-125
	10	-15	-134
	12	-20	-141
470MHz	7	-7	-126
	10	-15	-135
	12	-20	-141

Note: The above data are measured by the Semtech Shenzhen laboratory. The test conditions: power output 20dBm, bandwidth 125KHz.

LoRa Vs LoRaWan

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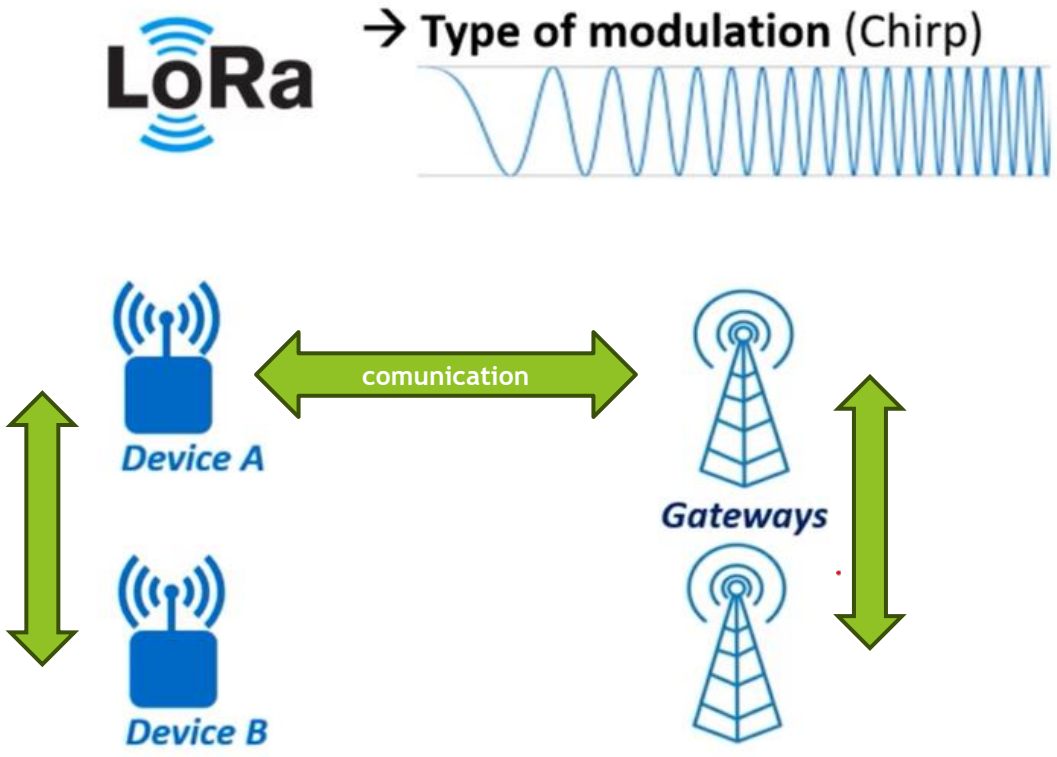
- A technique to modulate the transmitted waves
- A physical layer concept

- A Standardized protocol
- Medium-Access control layer concept

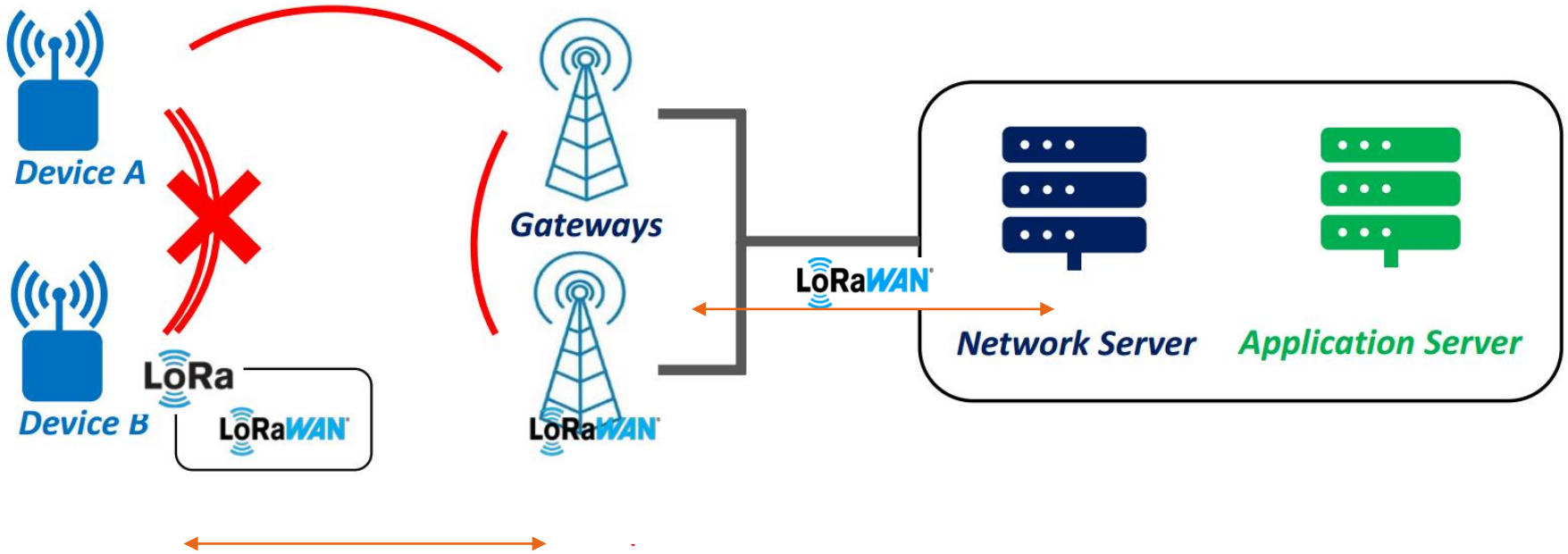
LoRa Vs LoRaWAN



LoRa modulation technique can be used for communication between

- Device to Device
- Device to Gateway
- Gateway to Gateway

LoRa Vs LoRaWAN

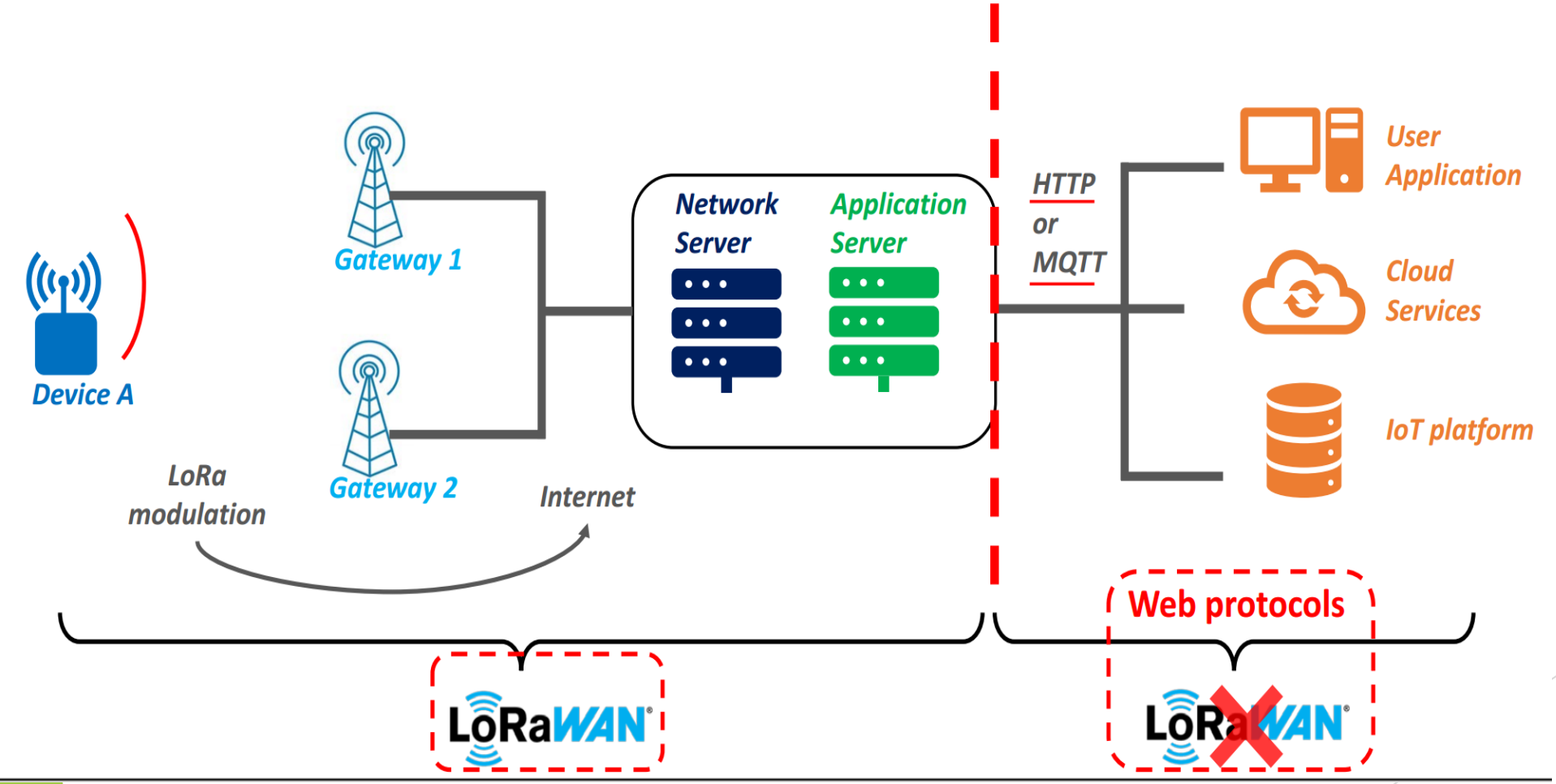


LoRaWAN Protocol is used

- When you need to send the data from the device to network server
- Provides standardization and security
- Only Communication between Device –to- Gateway permitted
- No Communication between devices

LoRaWAN Network Infrastructure

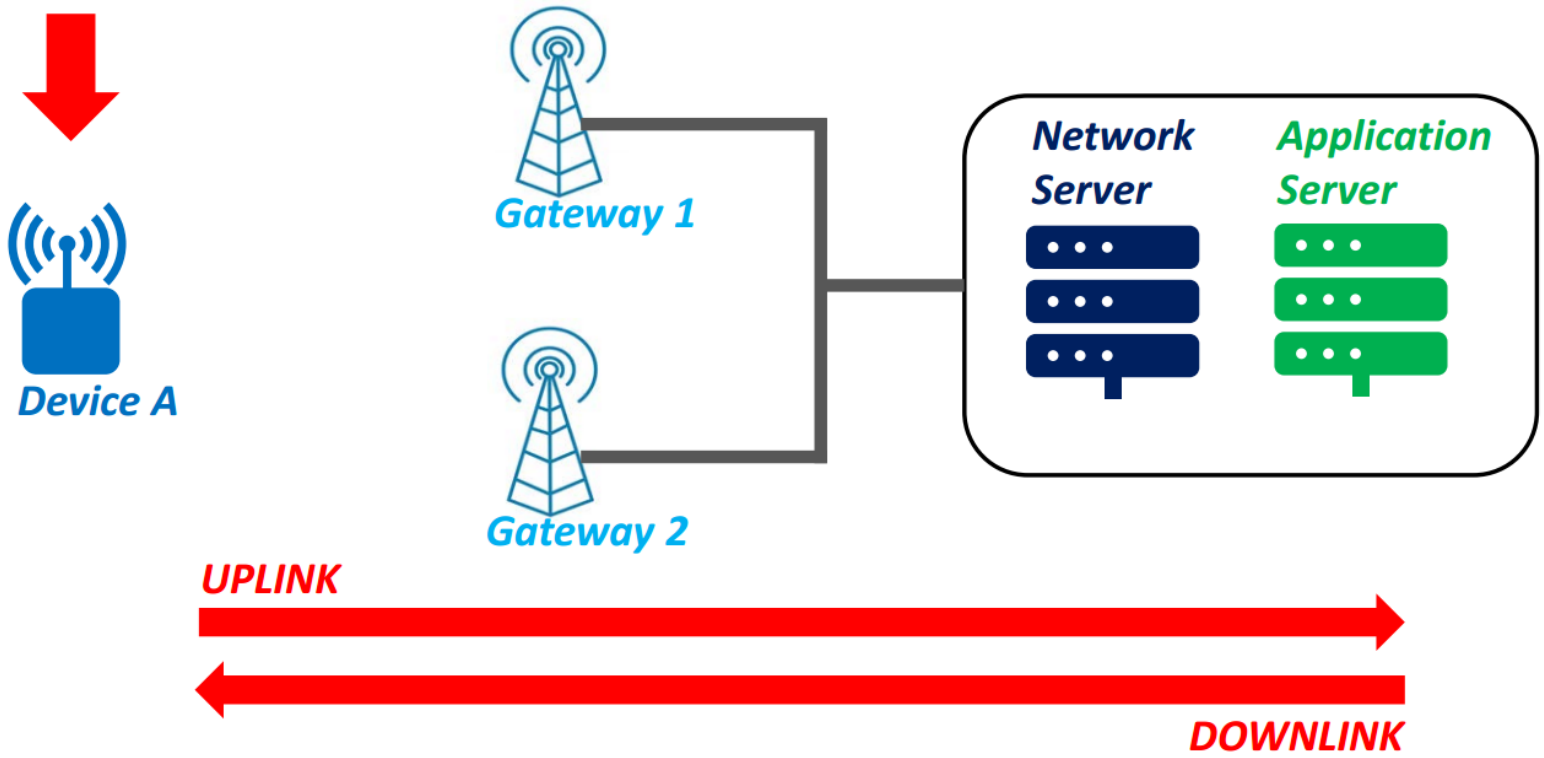
LoRaWAN frame = User Payload + Security information



Devices transmit to all Gateways not just one Gateway

Data is transmitted in the form of packets

Payload refers to the actual data that is needed by Application such as *Temperature data / sensor data*


Device A
Gateway 1
Gateway 2
Network Server
Application Server
UPLINK
DOWNLINK

Role of LoRa Gateways

What Does a LoRa Gateway Do?

1. **Listens for LoRa Packets**

   It continuously listens for uplink messages from many end devices.

2. **Forwards Packets to Network Server**

   It forwards the raw packets (with metadata like signal strength and timestamp) to the LoRaWAN network server.

3. **Receives Downlink Messages**

   It receives data from the network server and sends it back to end devices (usually in scheduled windows).

4. **Supports Multiple Channels**

   Most gateways support multiple spreading factors and channels — they can handle thousands of nodes simultaneously.

5. **No Processing or Decoding**

   Gateways don’t decrypt or interpret data; they’re "dumb pipes" in the LoRaWAN stack.

Role of Network Server

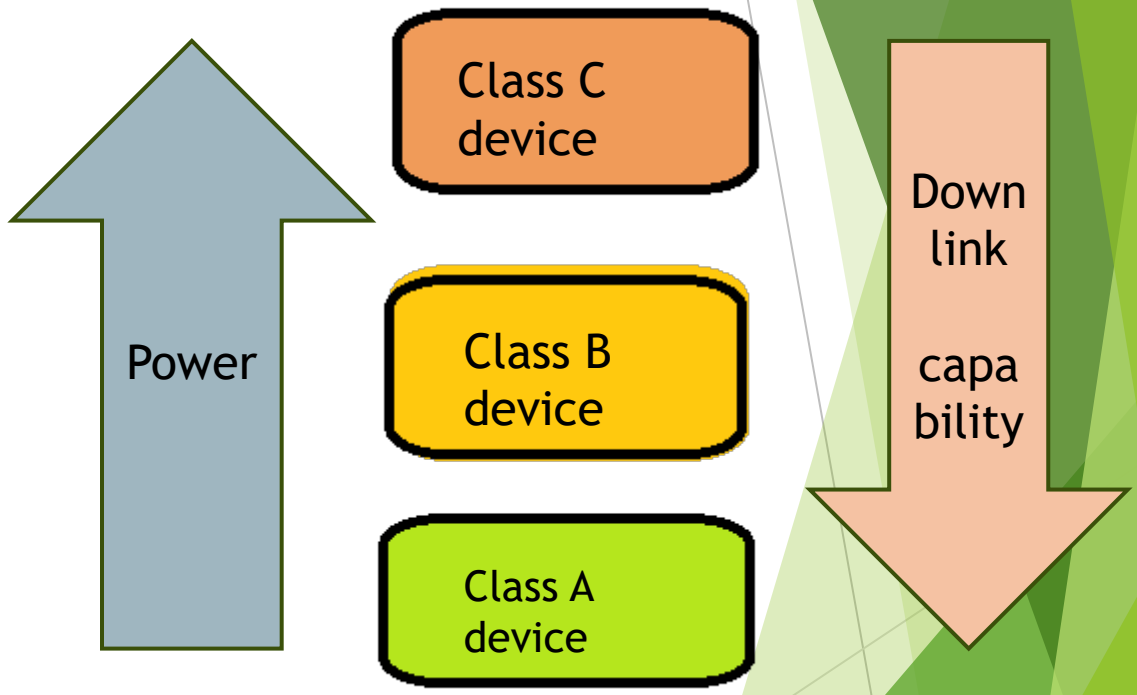
- Receives messages from the gateways
- Removes duplicate packets as several gateways may receive the same message and transmit them to the same Network Server.
- Network Server authenticates the message – ensures packets are sent only by allowed devices
- Validates the integrity of the messages

Role of Application Server

- Processes application-specific data messages received from end devices.
- A LoRaWAN network can have more than one Application Server.
- The collected data can be interpreted by applying techniques like machine learning and artificial intelligence to solve business problems

LoRaWAN end devices classification

- LoRaWAN end-devices are classified in three categories according to their a) power consumption and b) their downlink capabilities: the ease with which a user can transmit a frame to the end-device
- Class A
  - Lowest power consumption
  - Limited downlink capabilities
- Class B
  - All capabilities of class A
  - Has additional downlink slots
  - Class A < Power < Class C
- Class C
  - All capabilities of Class A
  - Always listening
  - High power consumption



BACKUP

Backup

dB is a ratio between two powers: the power on the receiver P_R and the power on the transmitter P_T. The formula for the ratio in dB is:

$$Power\ ratio\ (dB) = 10.log_{10}\left(\frac{P_R}{P_T}\right)$$

With these two formulas, you can easily verify the values in Table 8 below.

Power ratio in dB	Power ratio
+ 10 dB	Multiplication by 10
+ 3 dB	Multiplication by about 2
0 dB	Equality
-3 dB	Division by about 2
- 10 dB	Division by 10

Table 8: Power ratio calculation

Backup

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Table 8: Power ratio calculation

The **dBm** is the power in comparison to 1 mW: 0 dBm corresponds to 1 mW. Using the same ratios as we did in Table 8 for dB, we can fill out Table 9 for dBm.

Power in dBm	Power in mW
10 dBm	10 mW
+ 3 dBm	2 mW
0 dBm	1 mW
- 3 dBm	0.5 mW
- 10 dBm	0.1 mW

Table 9: Comparison of power in dB and mW

🌊 What is Chirp Modulation?

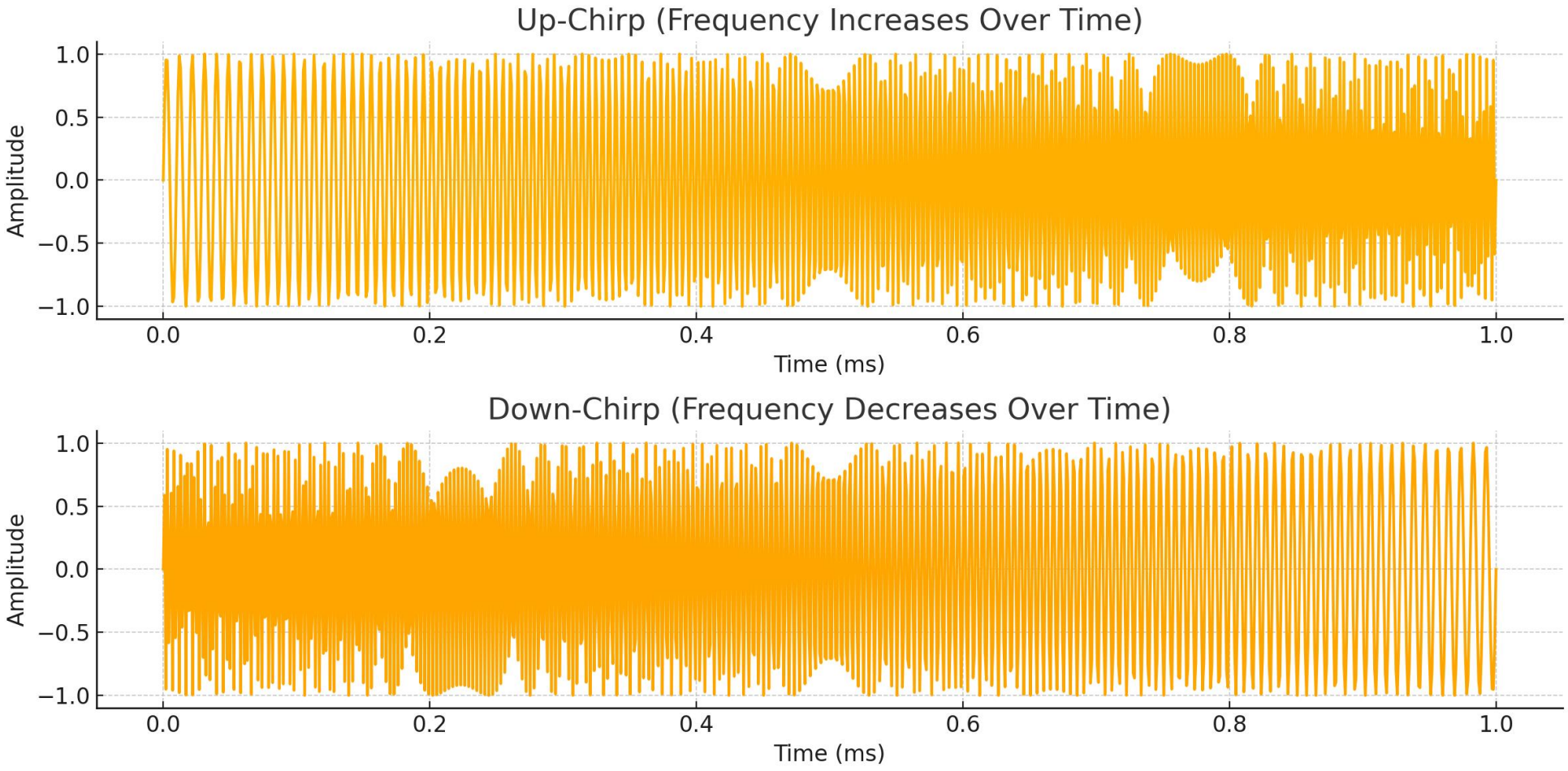
Chirp modulation, specifically **Chirp Spread Spectrum (CSS)**, is a modulation technique where information is encoded into **chirps** — signals that **sweep in frequency over time**.

- A **chirp** is like a "whoop" sound — its frequency rises (or falls) steadily.
- In LoRa, these chirps are used to **represent data symbols**.

🎯 Key Features of Chirp Modulation

Feature	Benefit
Resistant to noise	Works even with low signal-to-noise ratio
Long range	Perfect for outdoor and remote sensing
Low power	Efficient for battery-powered devices
Frequency variation	Makes it harder to interfere or jam

Imagine you're trying to recognize a melody played on a whistle — even if it's faint or there's background noise, the **rising or falling pitch** helps you identify it. That's how chirps carry data in LoRa.


Up-Chirp (Frequency Increases Over Time)
Amplitude
1.0
0.5
0.0
−0.5
−1.0
0.0
0.2
0.4
0.6
0.8
1.0
Time (ms)
Down-Chirp (Frequency Decreases Over Time)
Amplitude
1.0
0.5
0.0
−0.5
−1.0
0.0
0.2
0.4
0.6
0.8
1.0
Time (ms)