Meet LoRa, Your New Best Friend
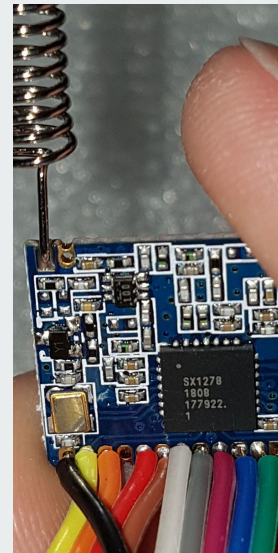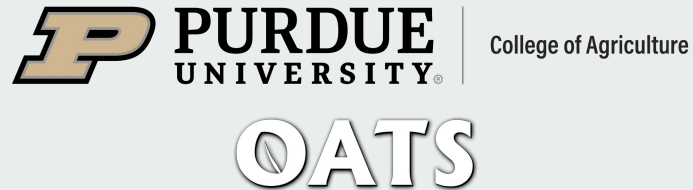
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OATS

What is LoRa/LoRaWAN?

LoRa is a **Lo**ng **Ra**nge, low power, wide-area radio (900 MHz) owned by Semtech.

LoRaWAN is a protocol and system architecture that uses LoRa to manage communication between devices and applications. LoRaWAN is an open standard maintained by the LoRa Alliance (non-profit industry consortium).
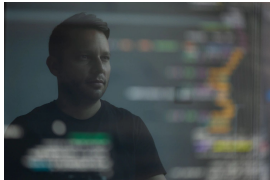
Wait.
What are we trying to achieve?

Producer

I feel this is a key to real, field-scale IoT adoption in Ag.

This is what LoRaWAN brings

Inexpensive IoT devices
ROI

Easy + available infrastructure
Can't someone else just do it?

Device Engineers

Inexpensive radios
Need to connect all the things

Low power radios
Long battery life

Long range/penetration
Simpler/cheaper network deploy

High capacity
Many customers

Network Operators

*Of course these have **always** been the goal*

Wait. What's the end game?

A lot of "IoT" (including much of Ag's) have needs like this:

Spread out (range)

Little power (battery life)

Numerous (cheap)
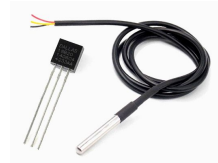
Very little data to send
　　few bytes per measurement

Very low duty cycle
　　measurement once per hour

Purchasable network
　　install and it works

I feel this is a key to real, field-scale IoT adoption in Ag.

Why not something existing?

My hot takes on wireless options (you might disagree?)

	Cellular	Wi-Fi	Cat-M1	NB-IoT	Bluetooth	LoRa
Range Installing towers is hard	Long ✓	Short ✗	Medium	Long ✓	Very short ✗	Long ✓
Power Solar, battery, etc.	High ✗	High ✗	Medium	Medium	Low ✓	Low ✓
Capacity Devices per gateway	Medium	Medium	High ✓	High ✓	Medium for its range	Low ✗
Cost Many, many devices	High ✗	Low ✓	Medium	Medium	Low ✓	Low ✓
Data rate Not a high priority	Very high	Very high	Medium	Low	Low	Low to Very low

✓

LoRaWAN
to the rescue!

Cat-M1/NB-IoT solve capacity through network architecture in a similar way LoRaWAN does
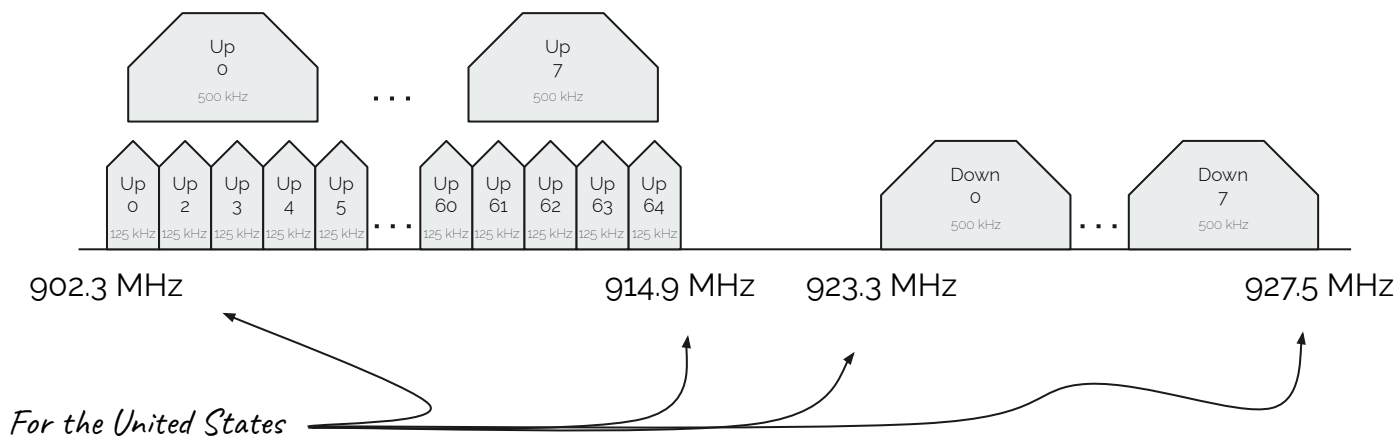
How slow is LoRa?
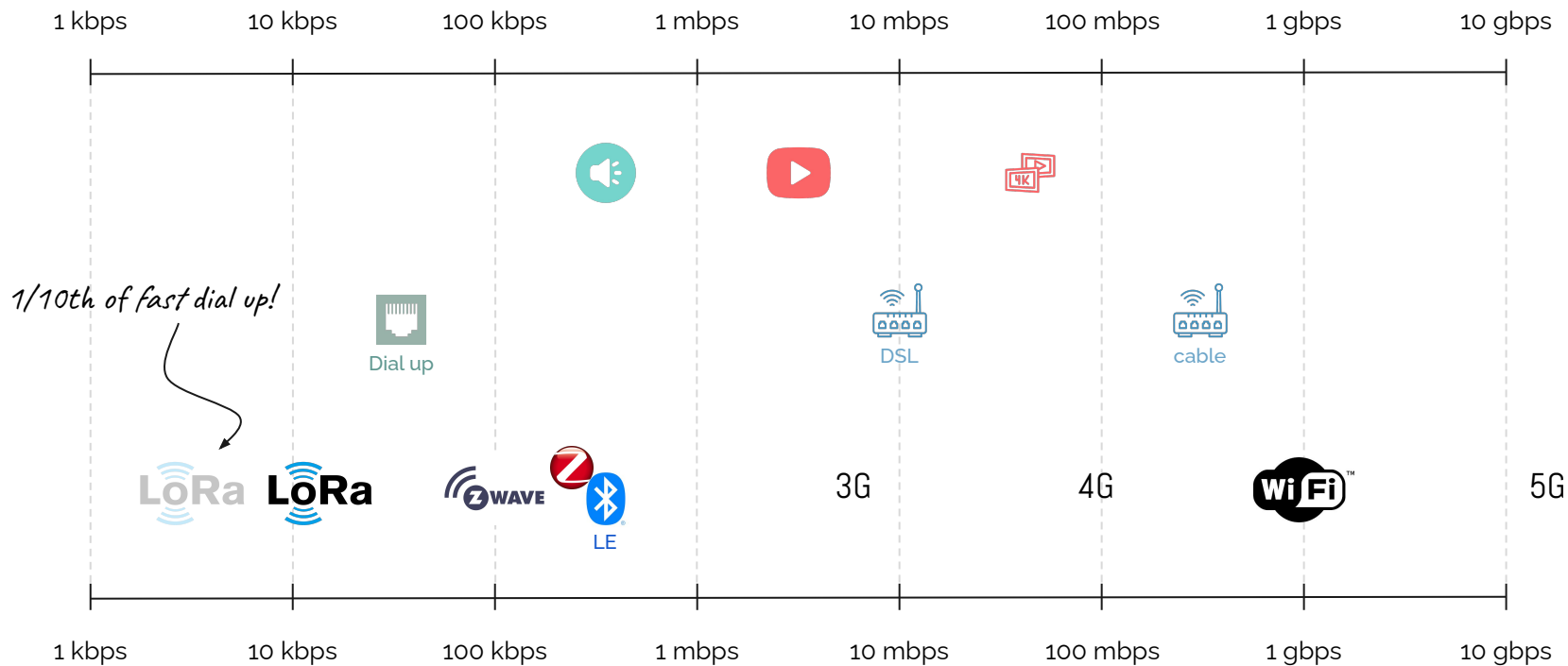
So, why LoRa then?

LoRaWAN adds capacity

LoRaWAN is a standard network protocol that *uses* LoRa radios

LoRaWAN creates many channels that can be used simultaneously by end-devices

	LoRa(WAN)	
Range	Long	✓
Power	Low	✓
Capacity Devices per gateway	High (lots of LoRa)	✓
Cost	Low	✓
Data rate	Low to Very low	

For the United States

A modest 8 channel gateway can receive >100,000 msg/day.

If devices sends 10 messages/day, then a small gateway can serve >10,000 devices.

Power vs. rate

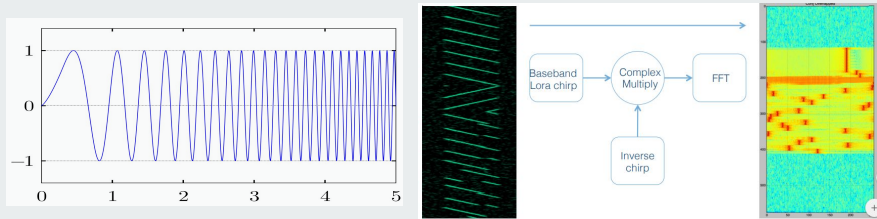LoRa's design trades typical low power

Chirp Spread Spectrum
Efficient power amplifiers
  A primary energy consumer for radios

No very spectrally efficient

Quick on and off
  no waste time during "high power" mode

Source: Matt Knight

But ... low power is actually achieved by limited air-time.

In LoRaWAN
Class A devices only listen (twice) after uplink

Class B devices listen periodically

Class C devices always listen.

Transmit   **Receive**

                                    Receive

Transmit

Receive Delay 1

Receive Delay 2

Most common: Class A

Source: The Things Network

It get slower yet!
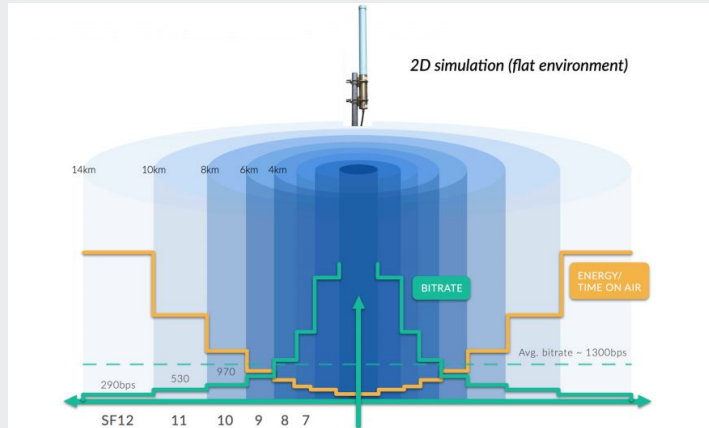
LoRa can trade *speed* for *range*.

Critical idea

The *longer* data is transmitted over the air, the *easier* it is to receive.

Short beeps and boops   🔊   🔊   Long beeps and boops

Thomas Telkamp
https://www.kivi.nl/uploads/media/584e9180f3822/cr-platform-lora-workshop-shared.pdf

LoRaWAN Uplink (US)

Data Rate LoRa ID	Configuration Bandwidth, Spreading Factor	Bit rate Bits/second	Range miles	Time 10 bytes, ms
0	125 kHz, SF10	980	~ 5	371
1	125 kHz, SF9	1760	~ 3.75	206
2	125 kHz, SF8	3,125	~ 2.5	113
3	125 kHz, SF7	5,470	~ 1.25	62
4	500 kHz, SF8	12,500	~ 2.5	28

LoRaWAN Downlink (US)

8	500 kHz, SF12	980	~ 7.5	330
9	500 kHz, SF11	1760	~ 6.25	185
10	500 kHz, SF10	3,125	~ 5	93
11	500 kHz, SF9	5,470	~ 3.75	52
12	500 kHz, SF8	12,500	~ 2.5	28
13	500 kHz, SF7	21,900	~ 1.25	15

Adaptive rate saves power.

Lower data rate means *lower battery life*!
Large spreading factor -> large transmission time.

-- or --

Shorter range means *longer battery life*!
Small spreading factors -> small transmission time.

LoRaWAN can do adaptive rate negotiation to optimize device data rate based on reception strength.

Spreading factors improve capacity.

LoRa's spreading factors are orthogonal, which means they do not interfere with each other.

Multiple sensors using different spreading factors can transmit on the same channel, at the same time.

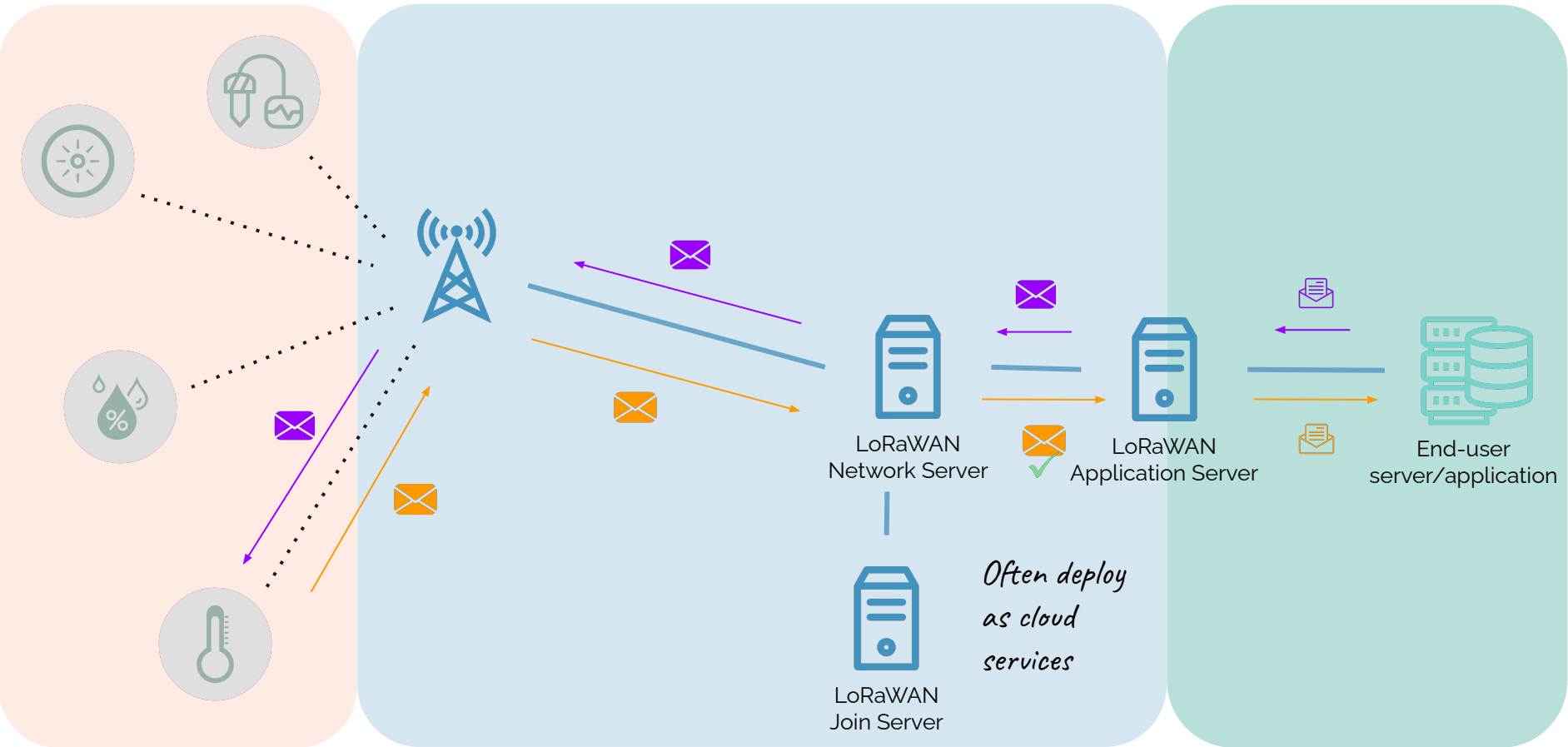LoRaWAN can adjust device data rate to accommodate network needs.

Simply adding more gateways not only improves capacity, but can also improve sensor life!

LoRaWAN Architecture
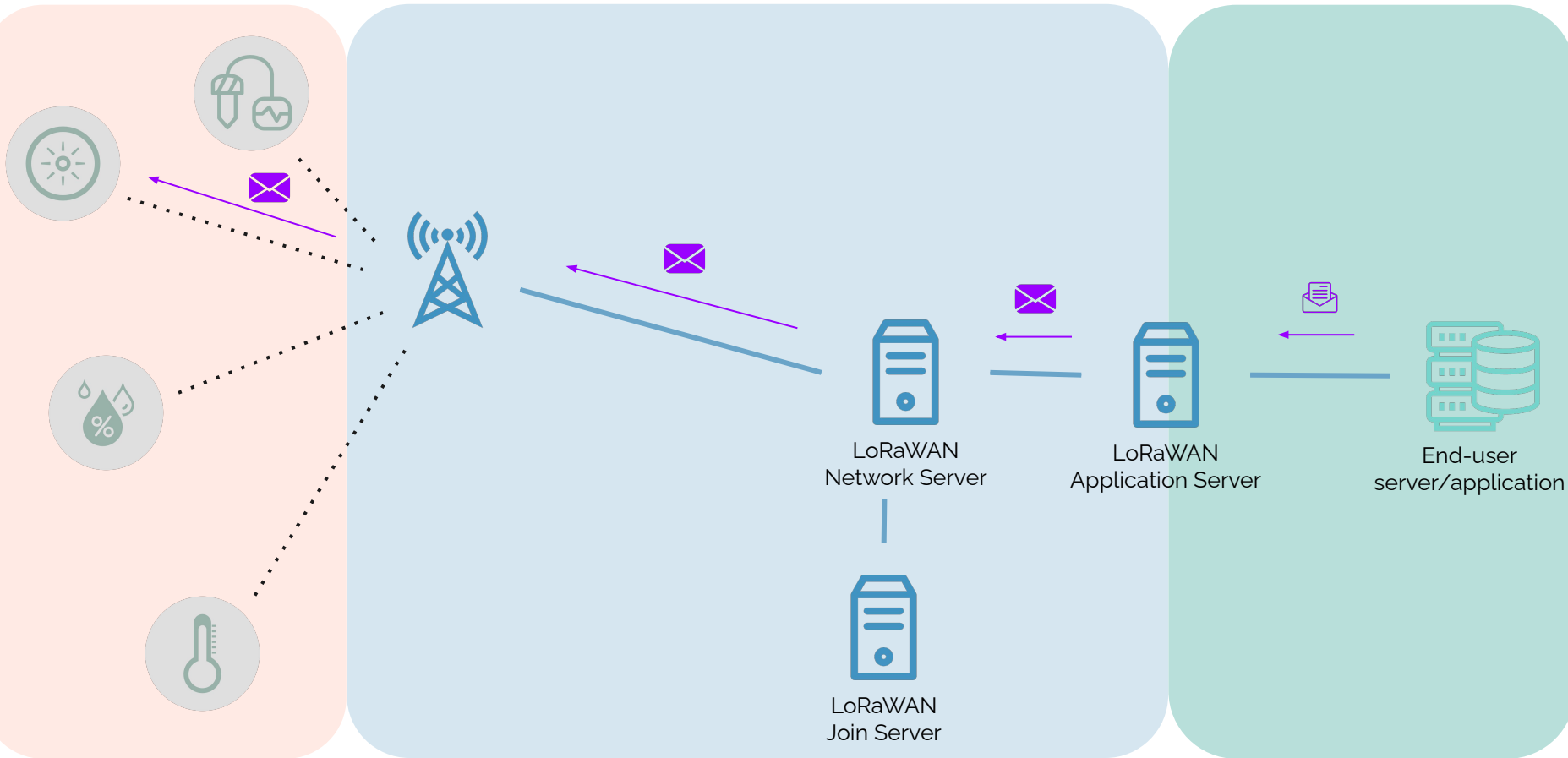

Device owner

LoRaWAN Service Provider

Trusted vendor

LoRaWAN
Network Server

LoRaWAN
Application Server

End-user
server/application

LoRaWAN
Join Server

*Often deploy
as cloud
services*

LoRaWAN Architecture - downlink / actuator

Device owner

LoRaWAN Service Provider

Trusted vendor

LoRaWAN
Network Server

LoRaWAN
Application Server
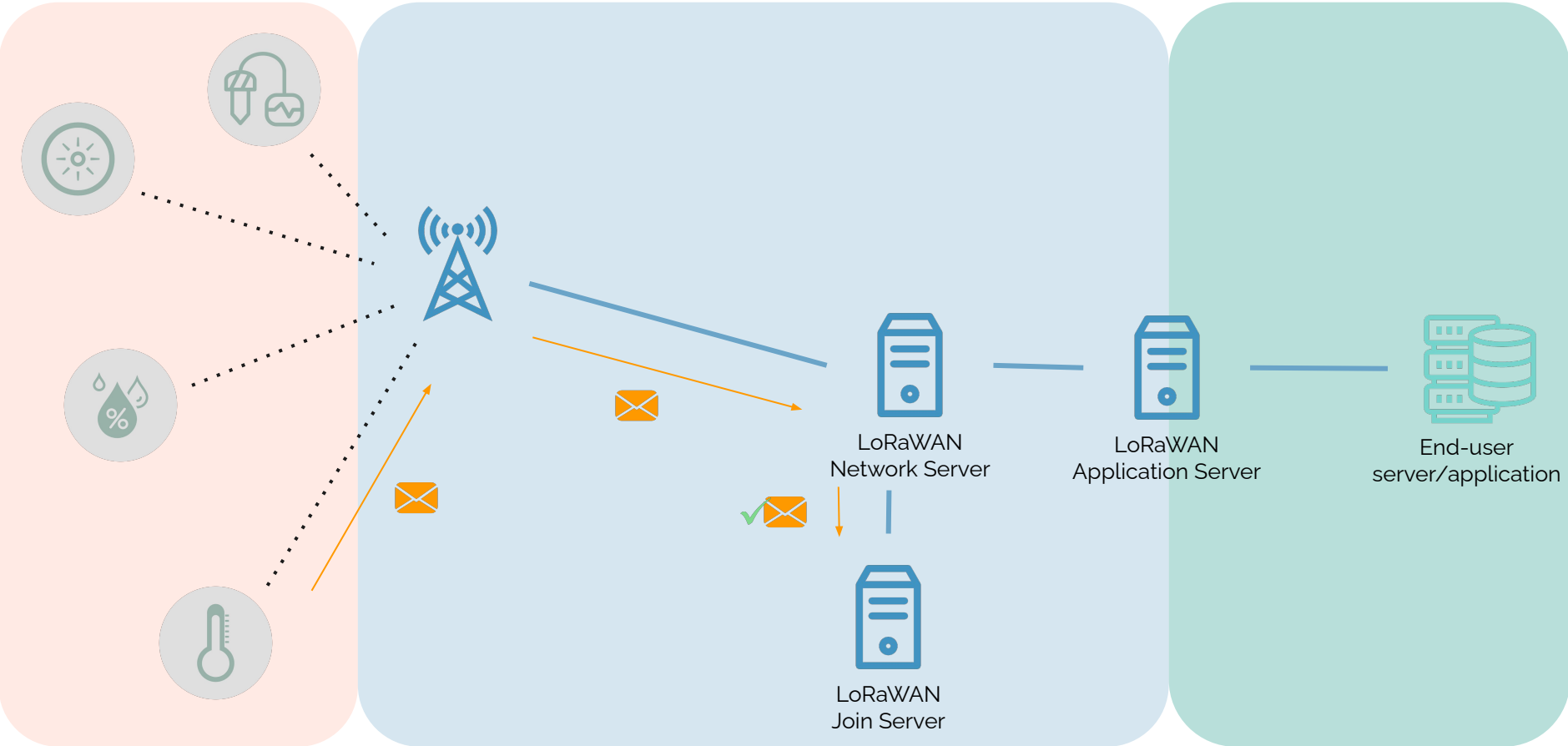
End-user
server/application

LoRaWAN
Join Server

LoRaWAN - Encryption

Device owner

LoRaWAN Service Provider

Trusted vendor

Session key

Application key

LoRaWAN Network Server

LoRaWAN Application Server

End-user server/application

Service provider's do not have to be "trusted"

LoRaWAN Join Server
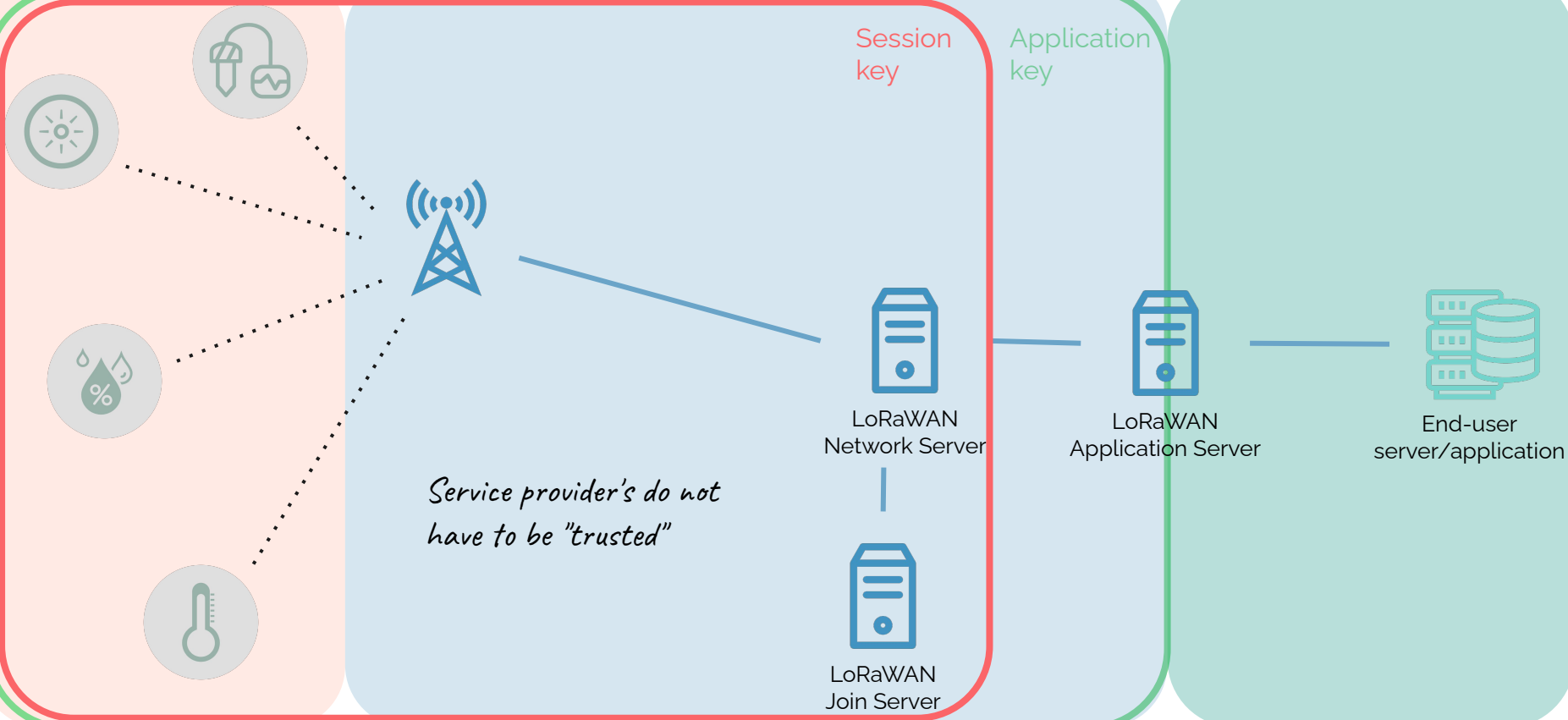
LoRaWAN - Joining (request)

LoRaWAN - Joining (key exchange)

LoRaWAN - Many Gateways

All receptions are delivered to network server and de-duplicated before passing to application server

LoRaWAN
Network Server

LoRaWAN
Application Server

End-user
server/application

LoRaWAN
Join Server

Fun fact: Some LoRaWAN implementations can do rough triangulation of device position!
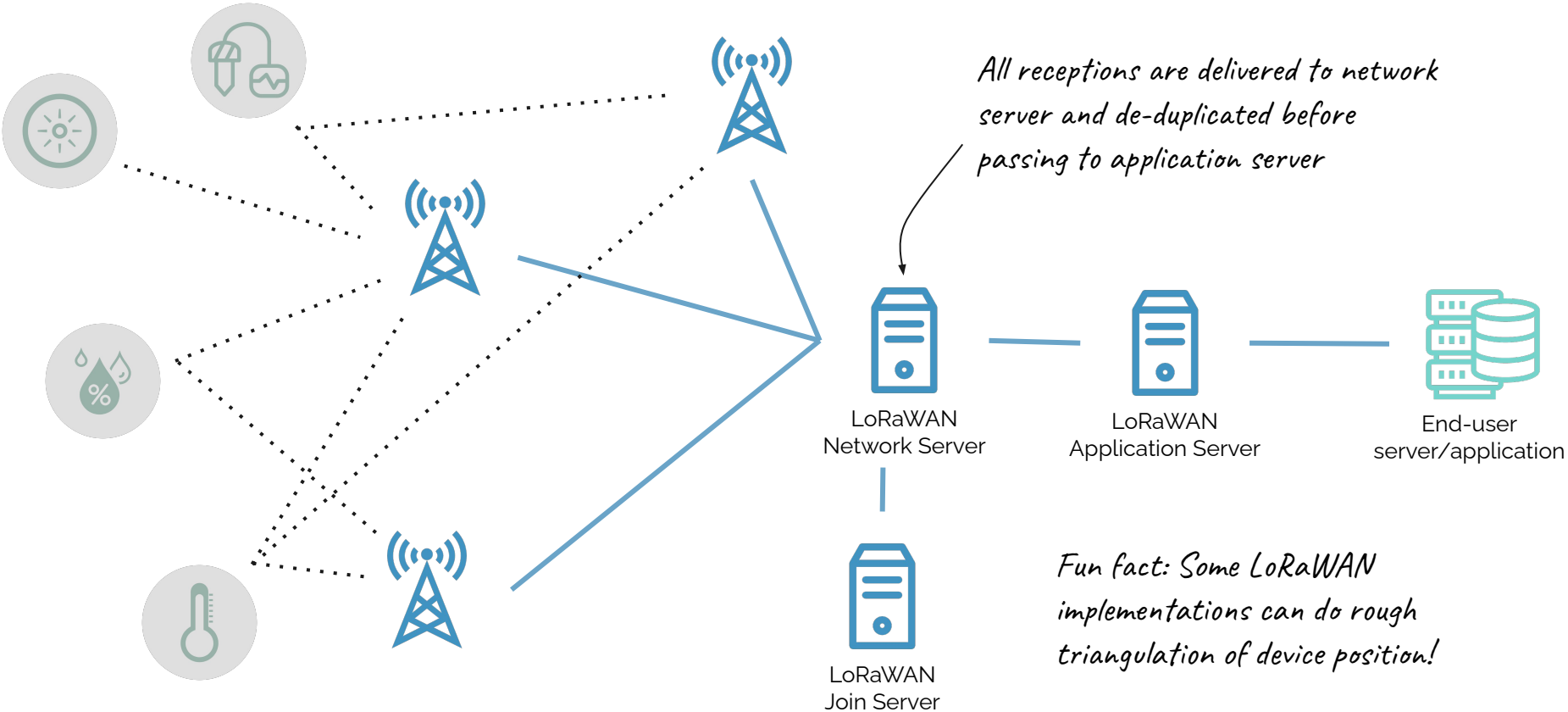
LoRaWAN - Many Application Servers

End-user server/application

LoRaWAN Network Server

LoRaWAN Application Server

End-user server/application

LoRaWAN Join Server

LoRaWAN Application Server

End-user server/application
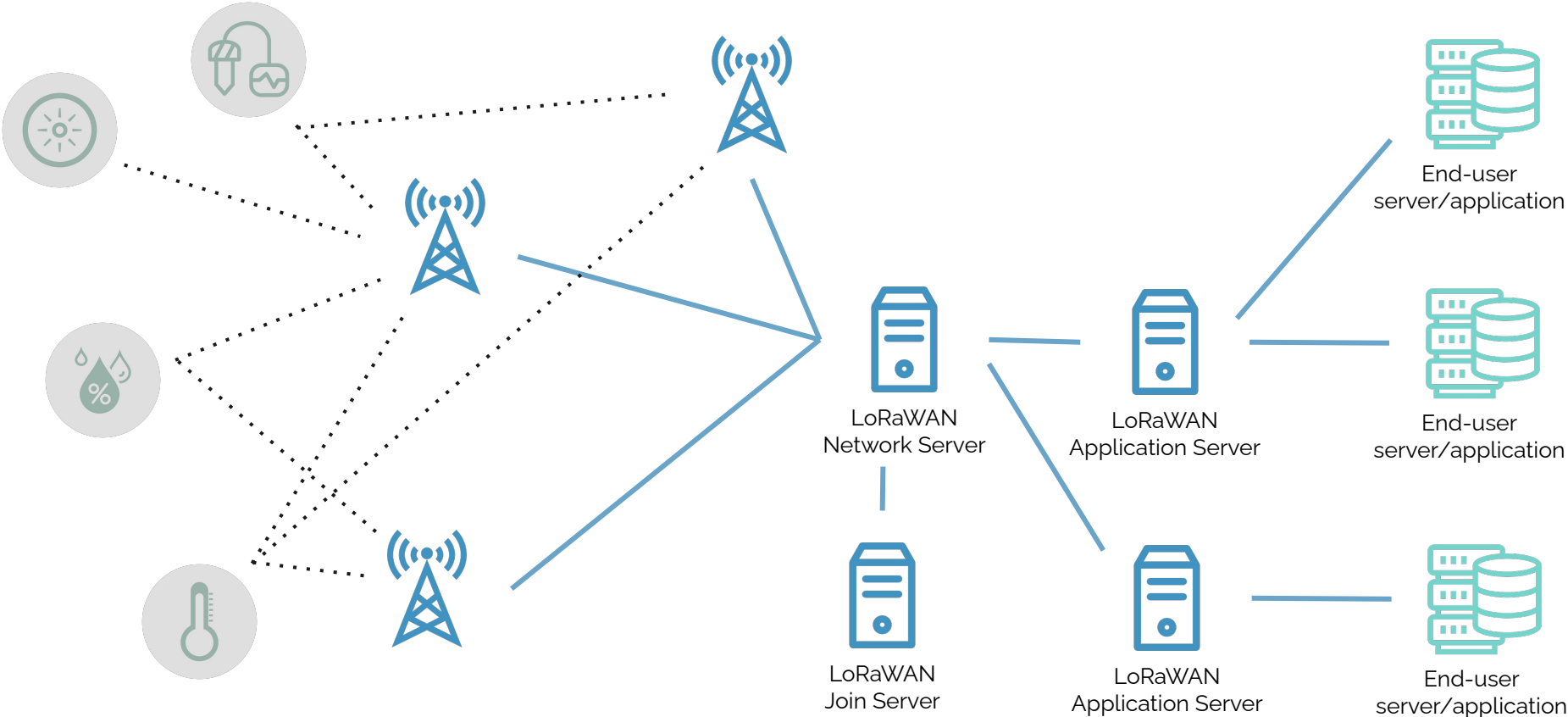
LoRaWAN - Downlink / actuators

The network server selects the "closest" gateway to the device of interest

LoRaWAN Network Server

LoRaWAN Application Server

End-user server/application

LoRaWAN Join Server

Here's Jack!