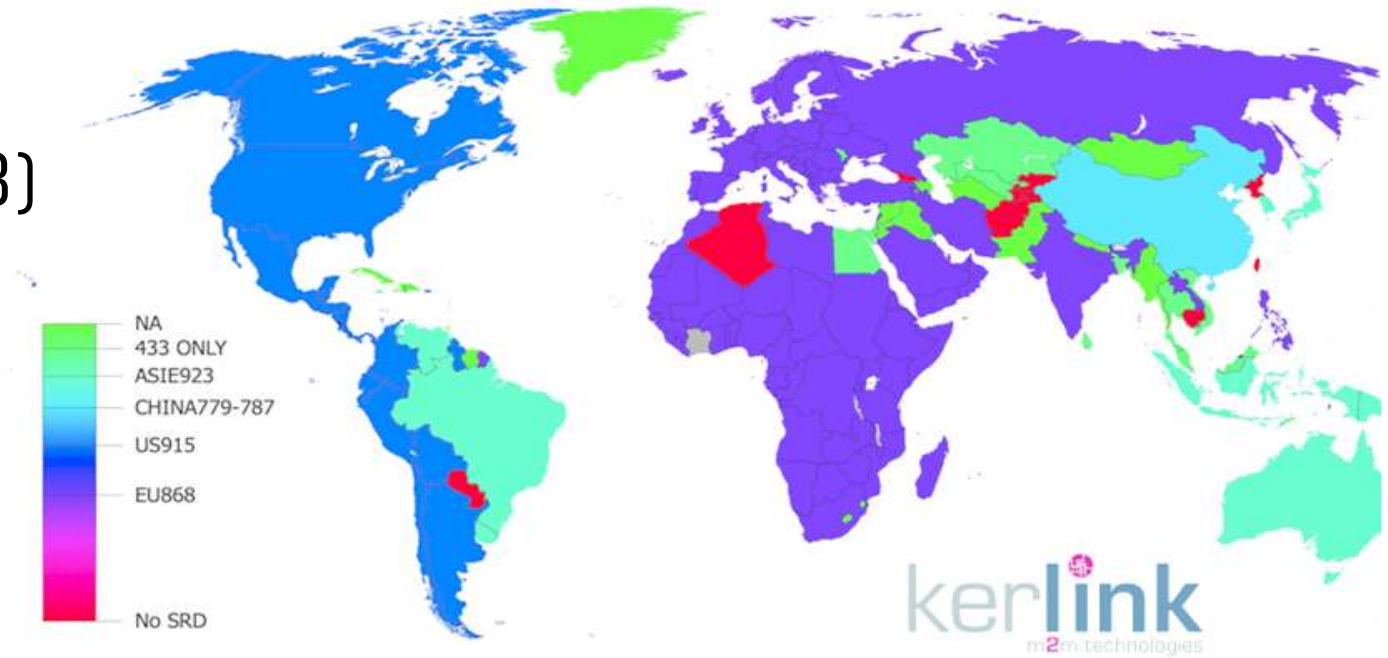
LoraWAN Technology

Luka Mustafa, Institute IRNAS,
November 2018

LoRa ≠ LoRaWan

What is LoRa ?

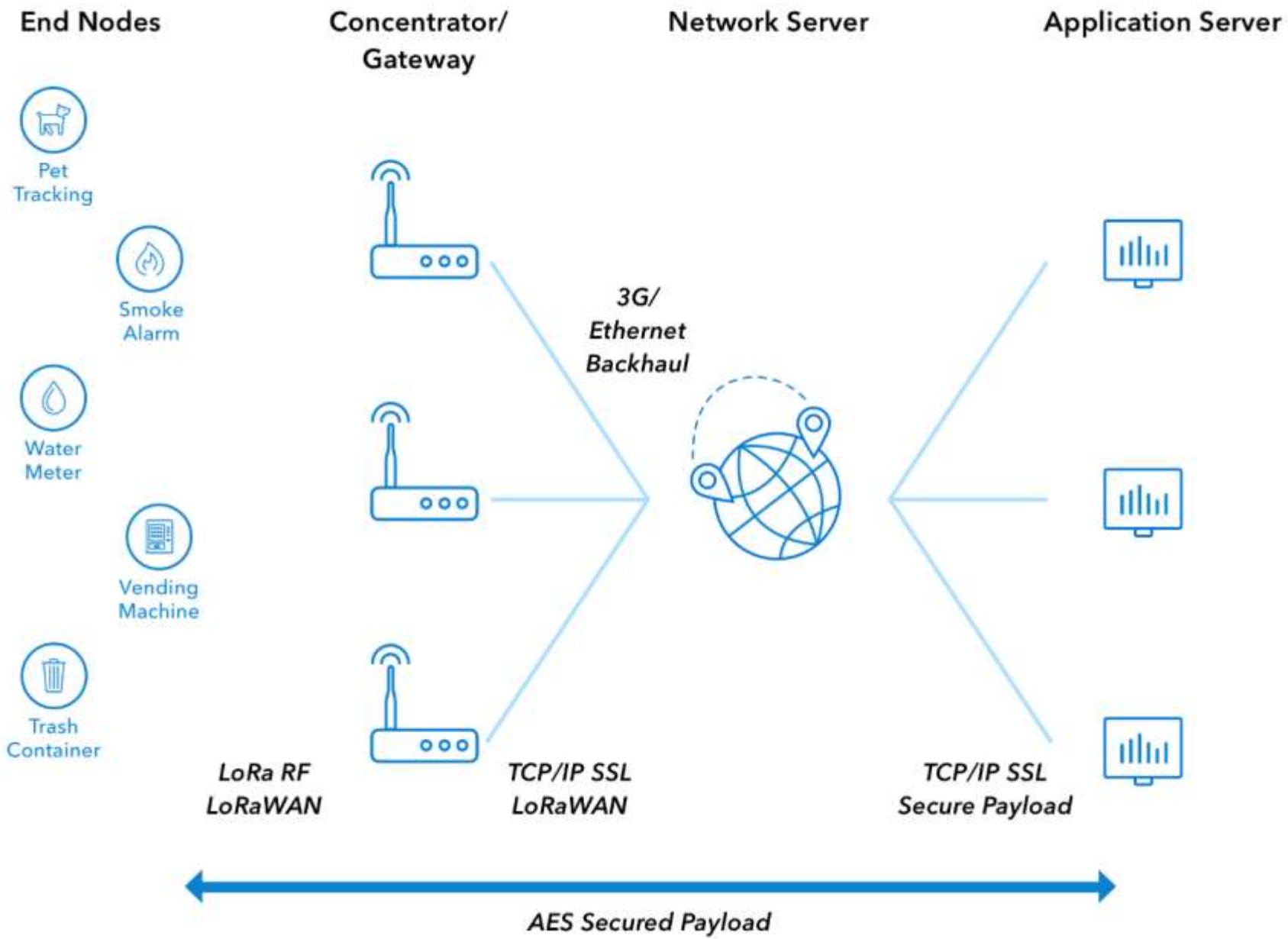
- **Wireless modulation**
- Radio physical layer
- Low bandwidth & energy
- Uses ISM bands
- Great link budget (> 150 dB)



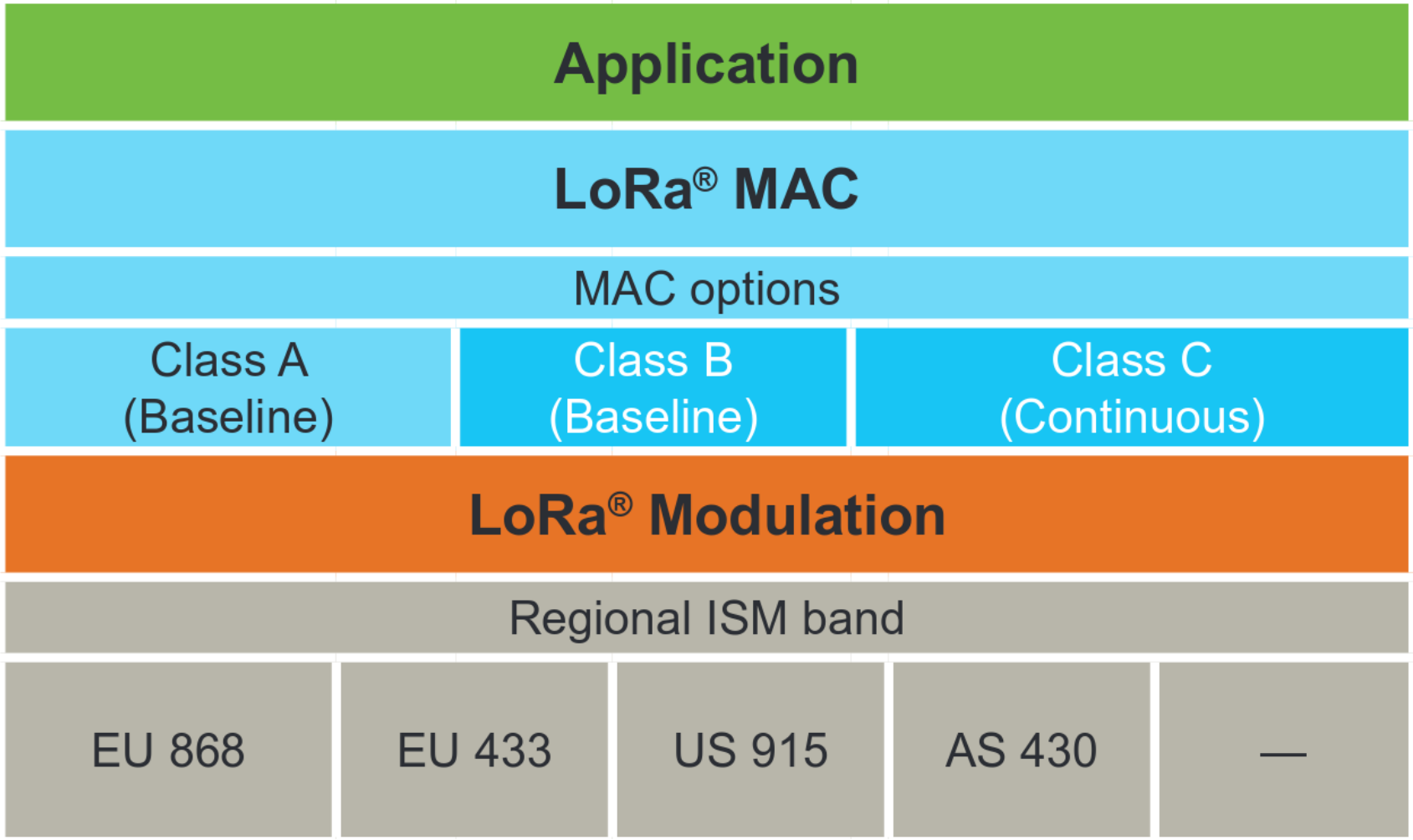
LoraWAN network

What is LoRaWan ?

- **Communication protocol** built above LoRa modulation
- Data rate from 300 bps to 5.5 kbps (up to 50kbps using FSK)
- Features :
  - Bi-directional communication
  - Mobility
  - Localization


End Nodes
Concentrator/
Gateway
Network Server
Application Server
Pet
Tracking
Smoke
Alarm
Water
Meter
Vending
Machine
Trash
Container
3G/
Ethernet
Backhaul
LoRa RF
LoRaWAN
TCP/IP SSL
LoRaWAN
TCP/IP SSL
Secure Payload
AES Secured Payload

LoRa(Wan)

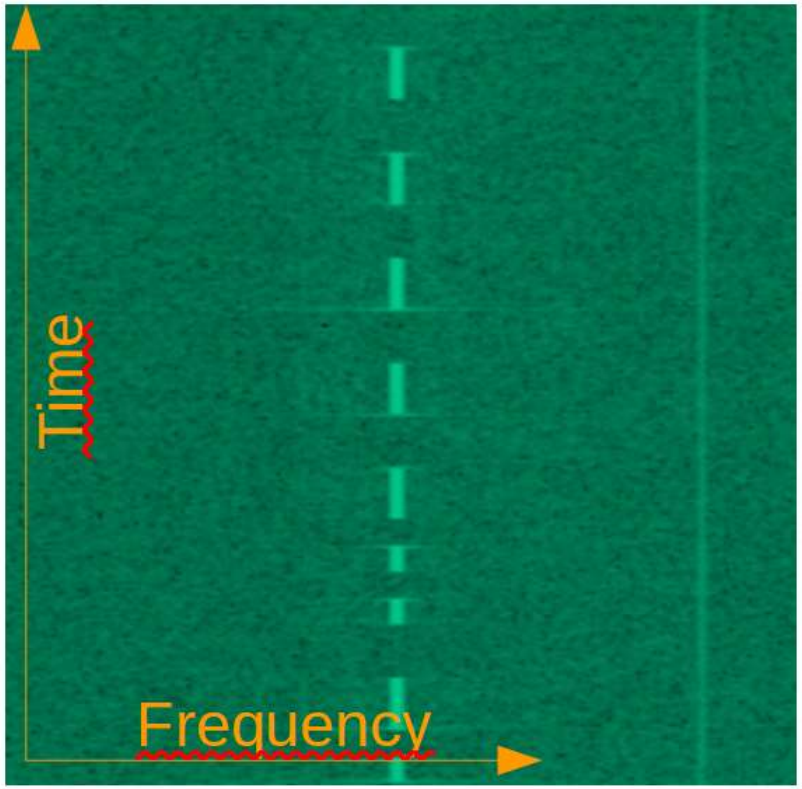


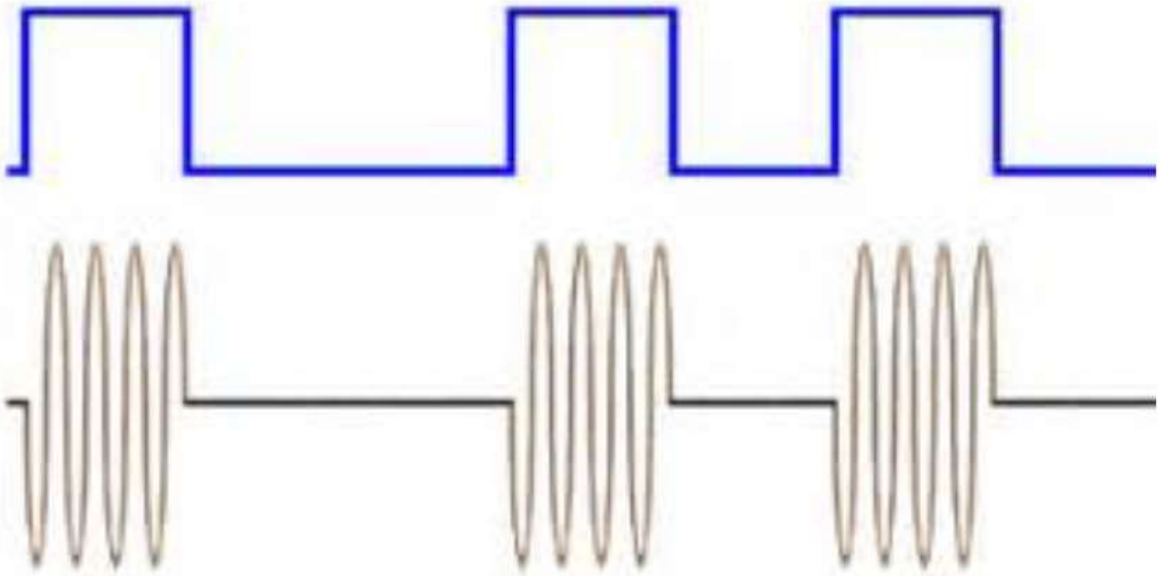
History

- 2007 : Nanoscale-Labs
- 2009 : Cycleo
- 2012 : Semtech
- 2015 : LoRa Alliance

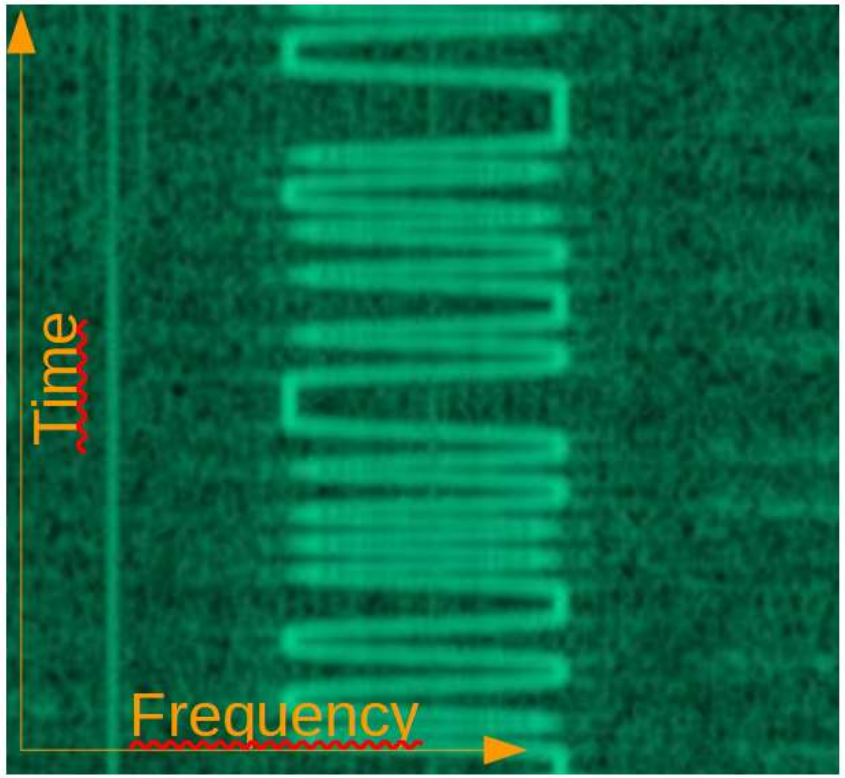
Radio Basics

Radio Keying : OOK

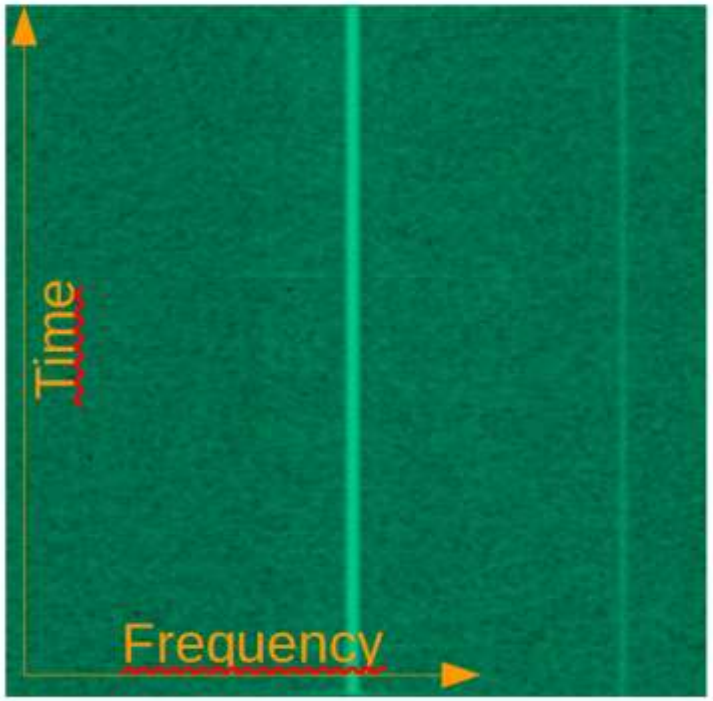


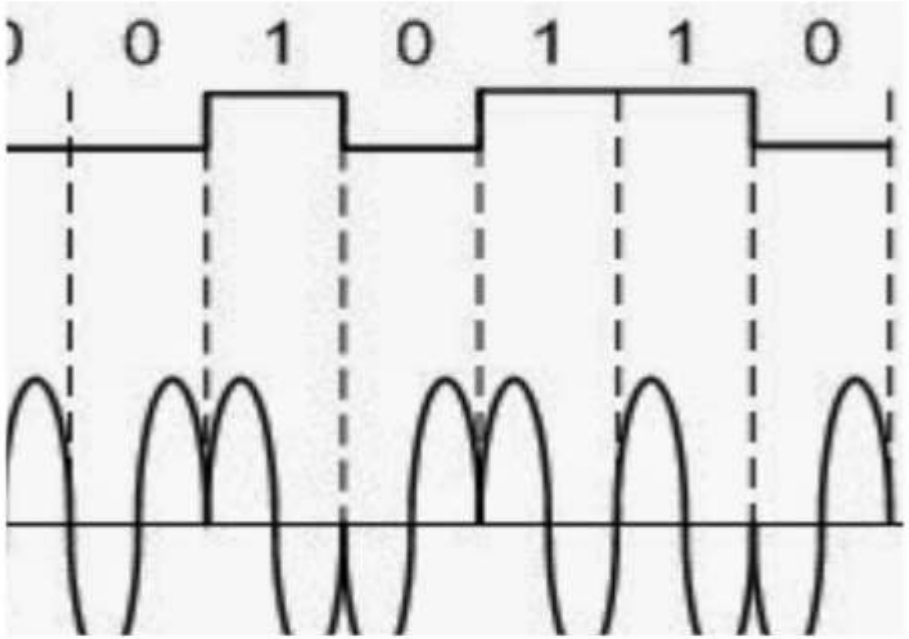


Radio Keying : FSK

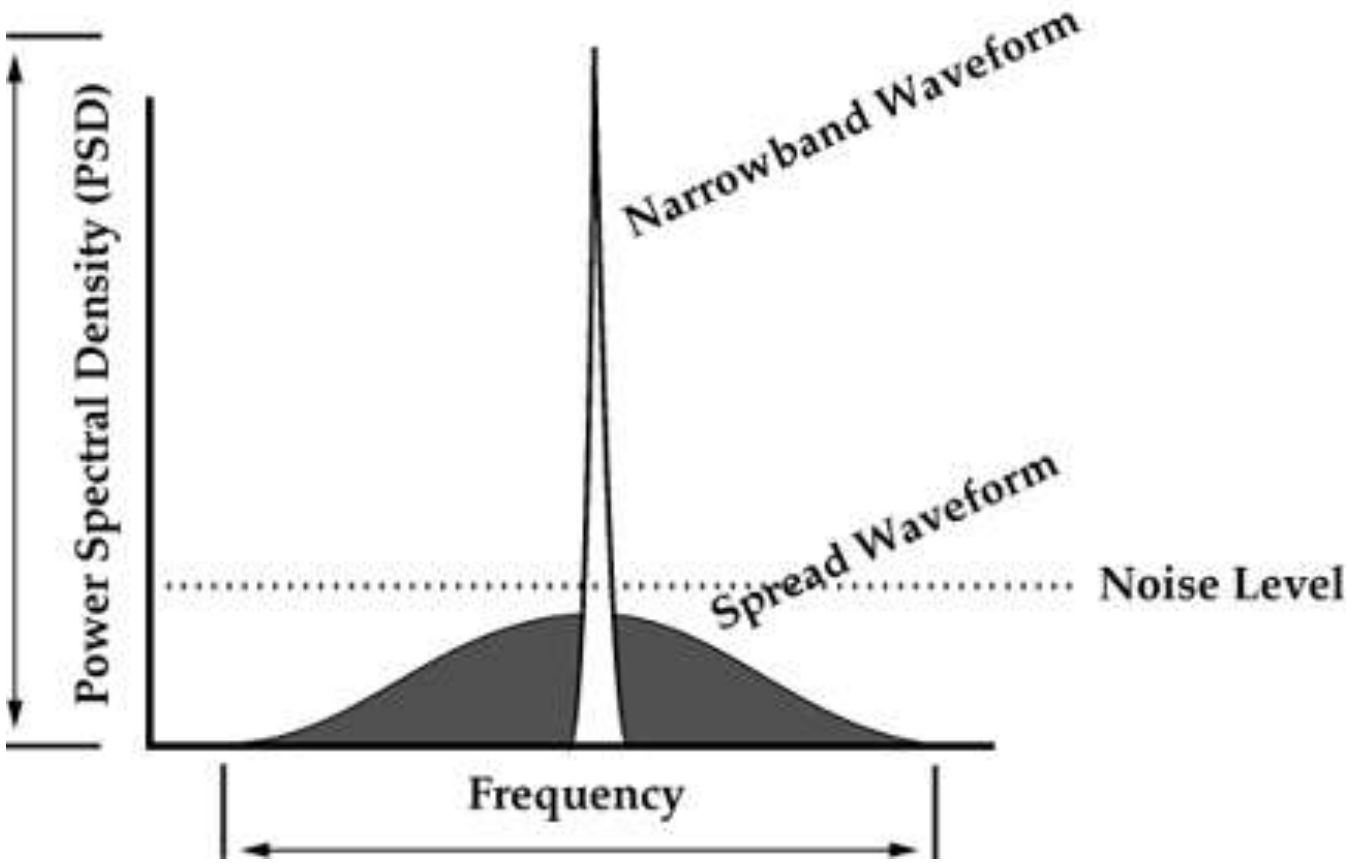


Radio Keying : PSK

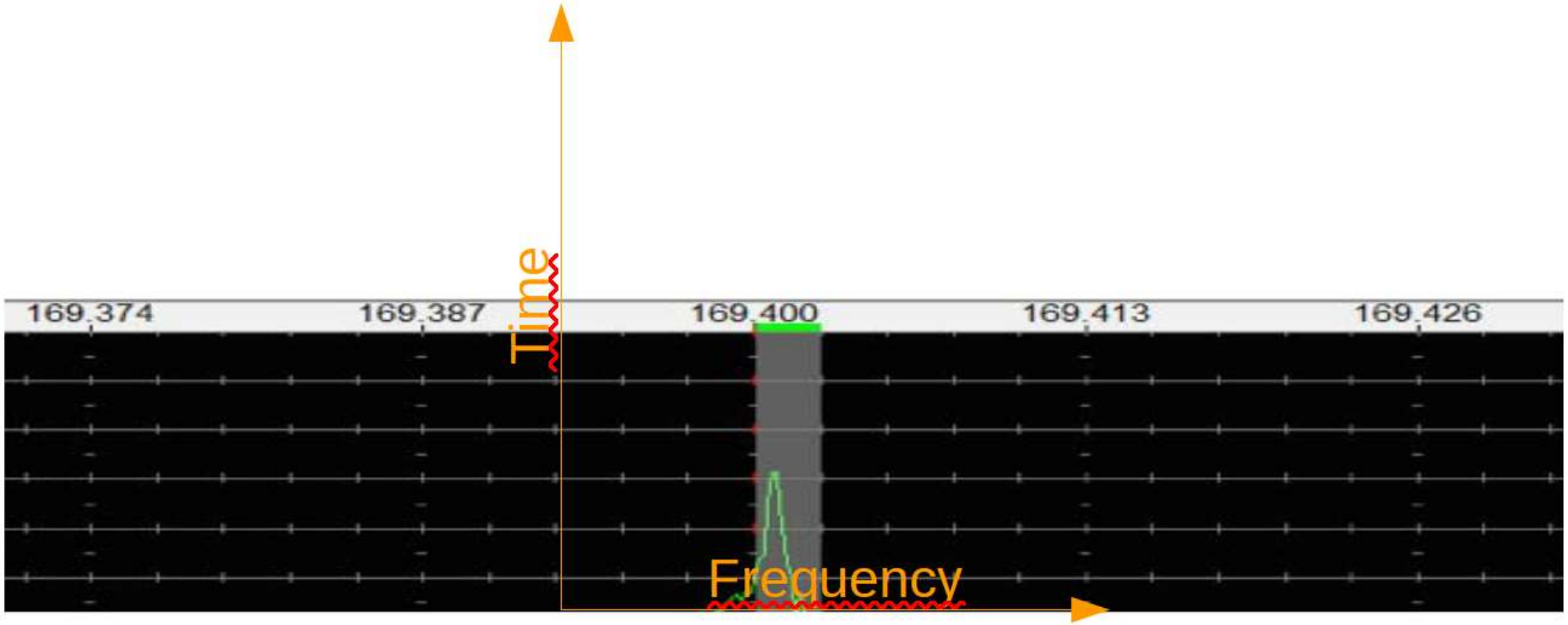




Spread Spectrum

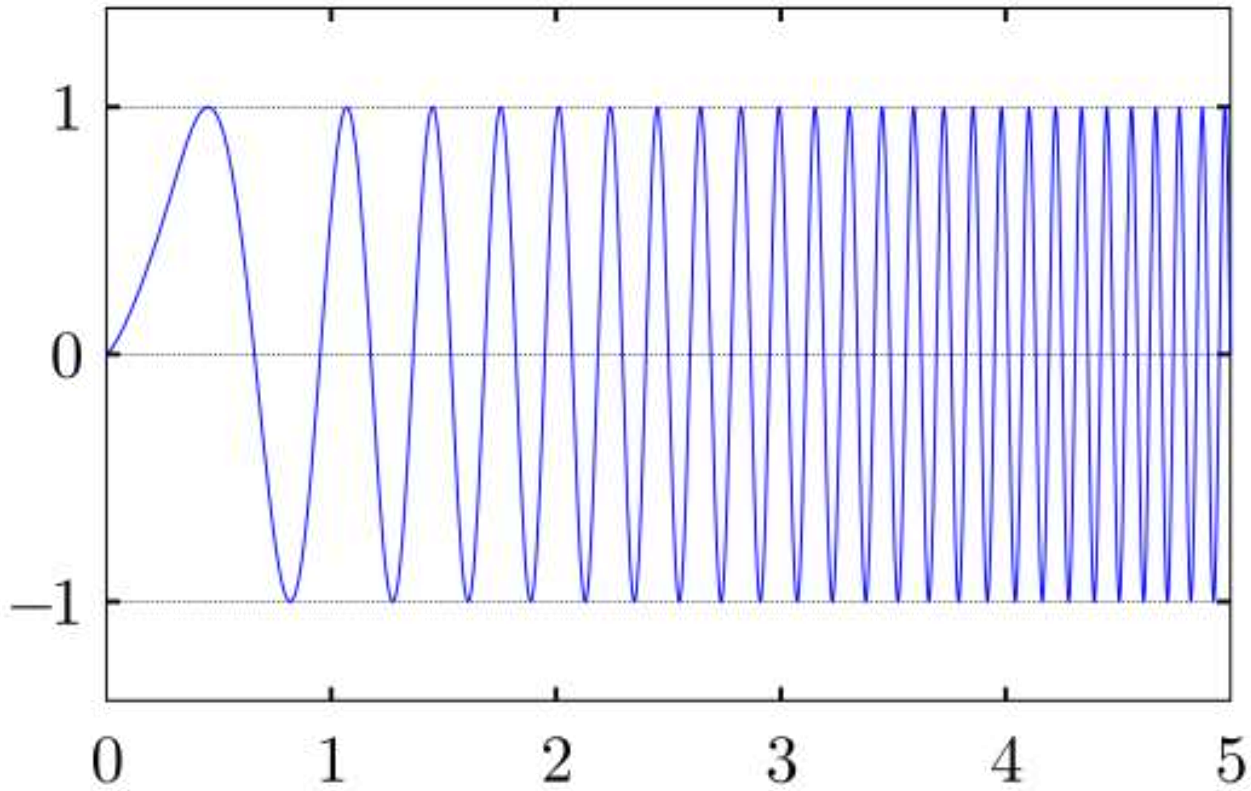


Chirp Spread Spectrum



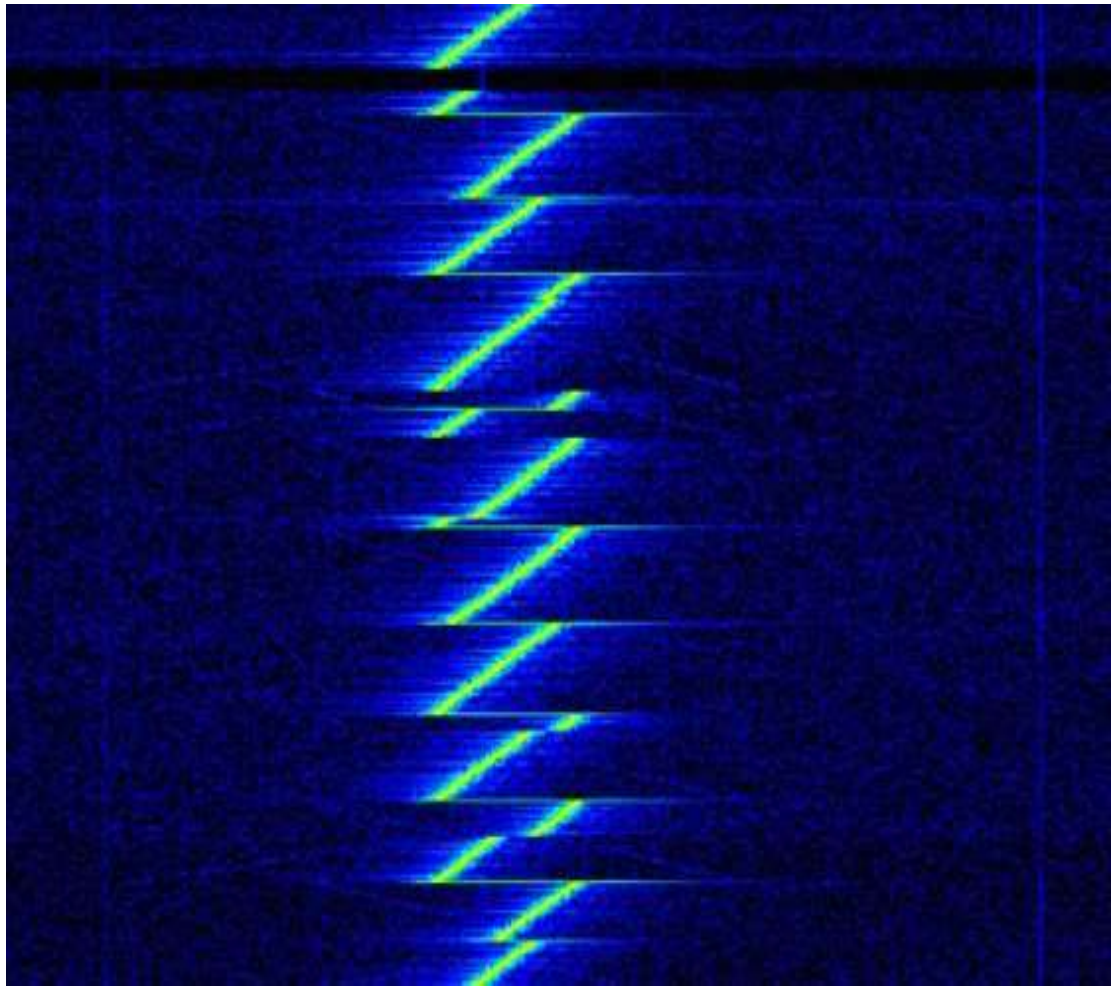
Chirp Spread Spectrum

- Chirp frequency :



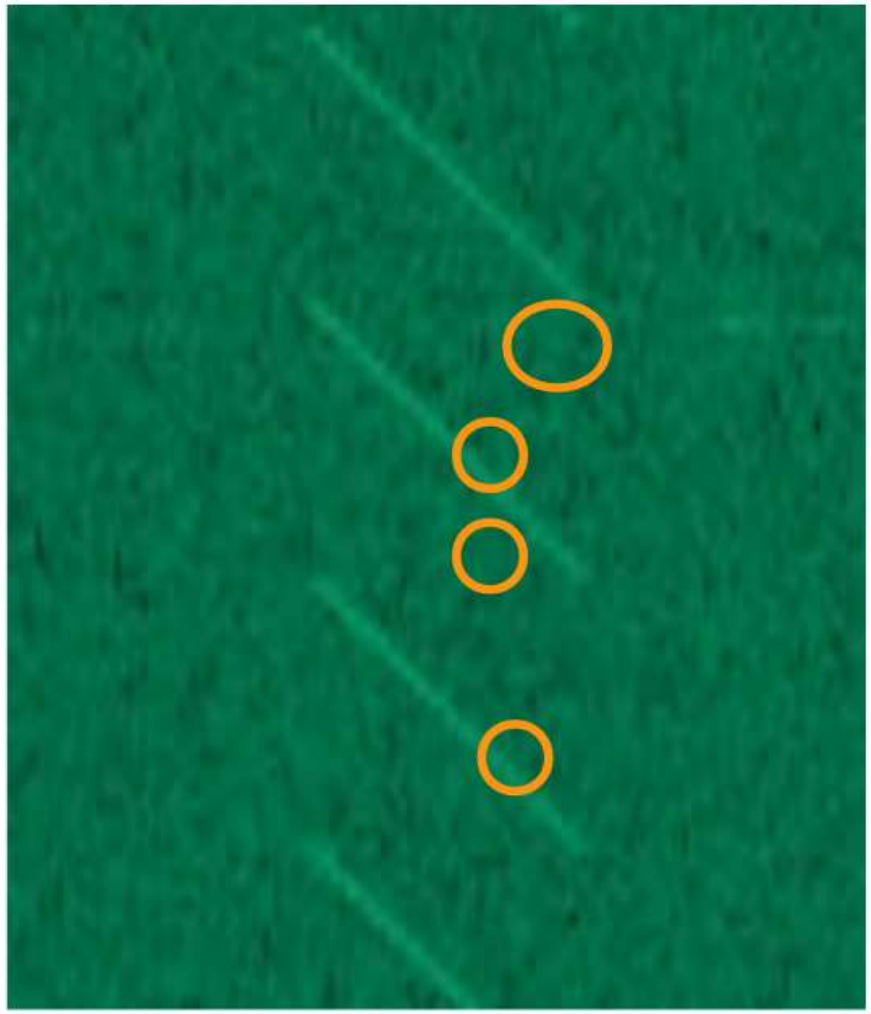
LoRa

Chirp Spread Spectrum in LoRa

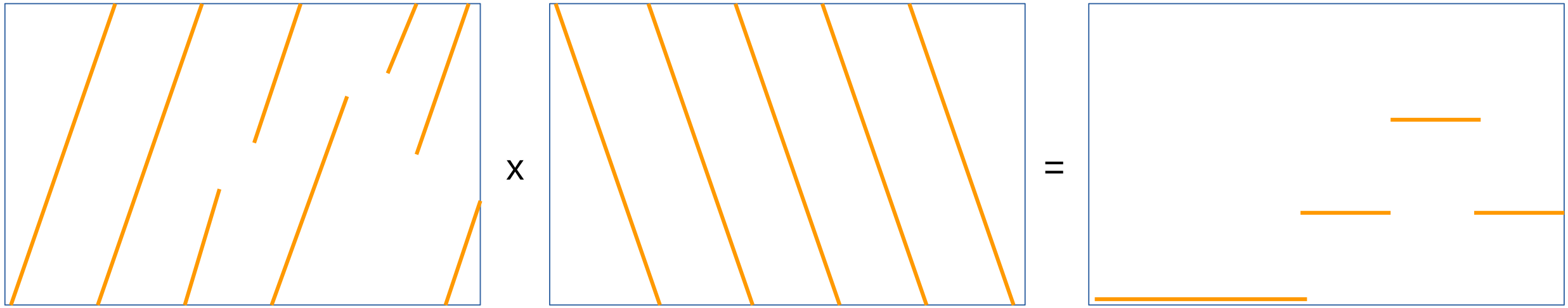


Chirp Spread Spectrum in LoRa

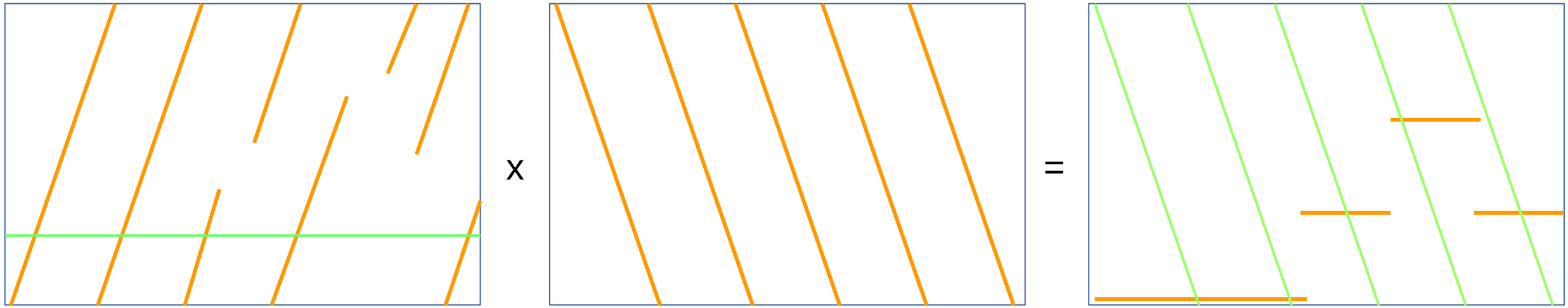
- Phase shiftings
  - = where the data is
  - ~ PSK over chirp



LoRa demodulation



LoRa demodulation, with noise

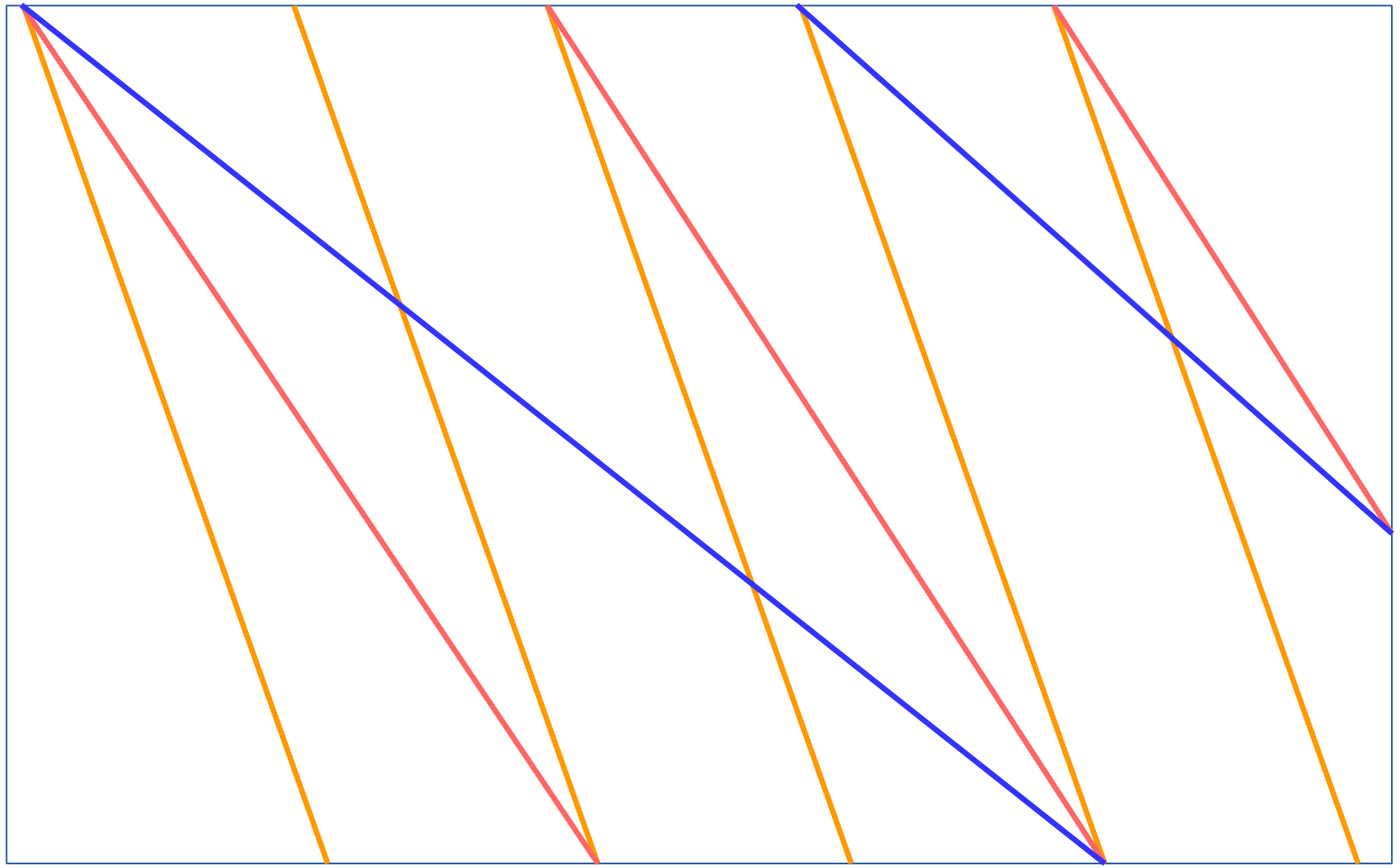


LoRa Modulation

- Spread-spectrum technique and a variation of chirp spread spectrum (CSS)

- LoRa uses Spreading Factors to set the modulation rate (SF7 to SF12)

LoRa Spreading Factors



SF7
SF8
SF9
...

LoRa Spreading Factors

Spreading Factor	Symbols/second	Bitrate	TOA (10 bytes, ms)	SNR limit (dB)
SF 7	976	5469	56	-7,5
SF 8	488	3125	103	-10
SF 9	244	1758	205	-12,5
SF 10	122	977	371	-15
SF 11	61	537	741	-17,5
SF 12	30	293	1483	-20

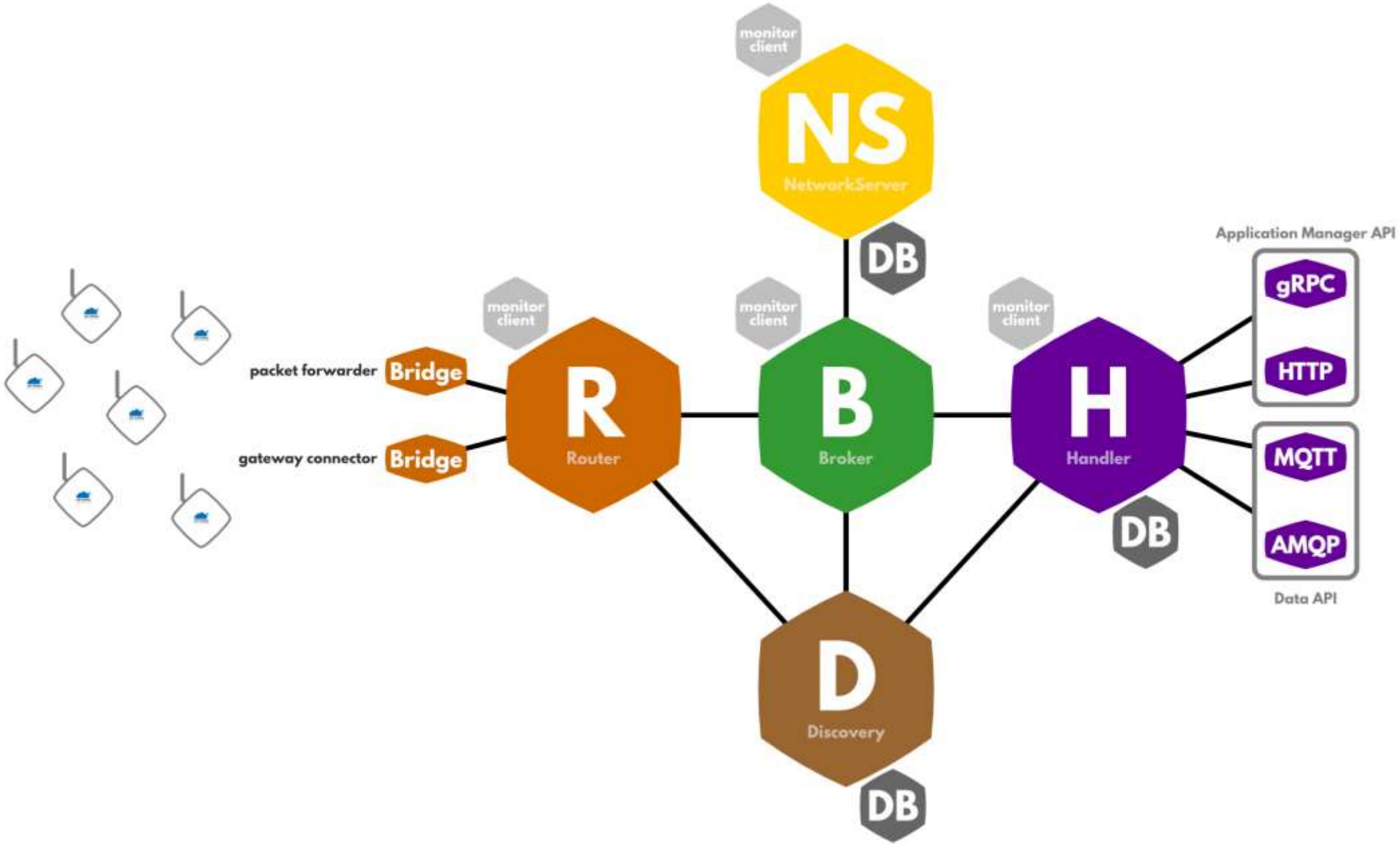
Benefits of the Modulation

- Very resistant to interferences
- Very low sensibility to fading & multipath
- Good sensitivity (below noise level)
- Doppler effect resistant
  - Moving devices
  - High clock tolerance
- LoRa reception is super simple

LoRaWan

LoRaWan protocol : Device class

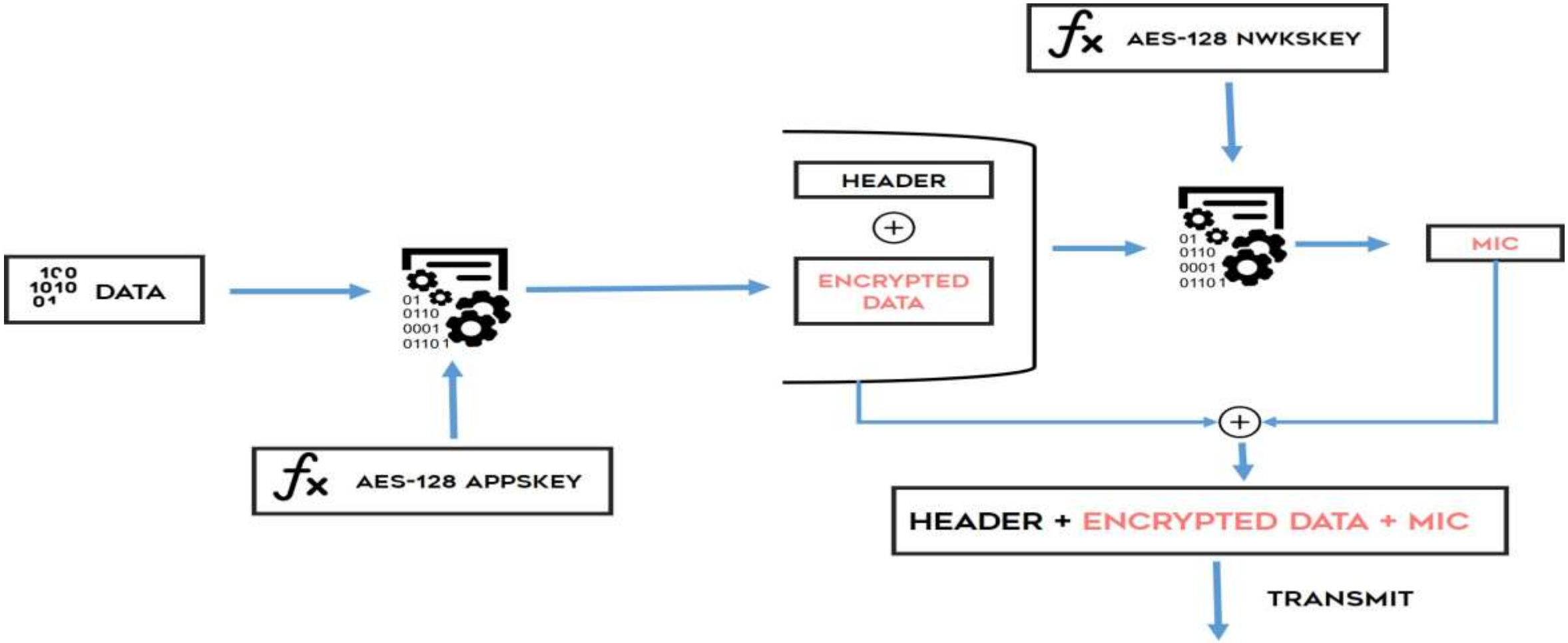
- Class A
  - Emit on request, listen only after emit → ultra-low energy
- Class B
  - Emit on request, listen based on time interval → low energy
- Class C
  - Emit on request, always listen → « high » energy


monitor client
NS
NetworkServer
DB
Application Manager API
gRPC
HTTP
MQTT
AMQP
Data API
monitor client
monitor client
monitor client
packet forwarder
Bridge
gateway connector
Bridge
R
Router
B
Broker
H
Handler
DB
D
Discovery
DB

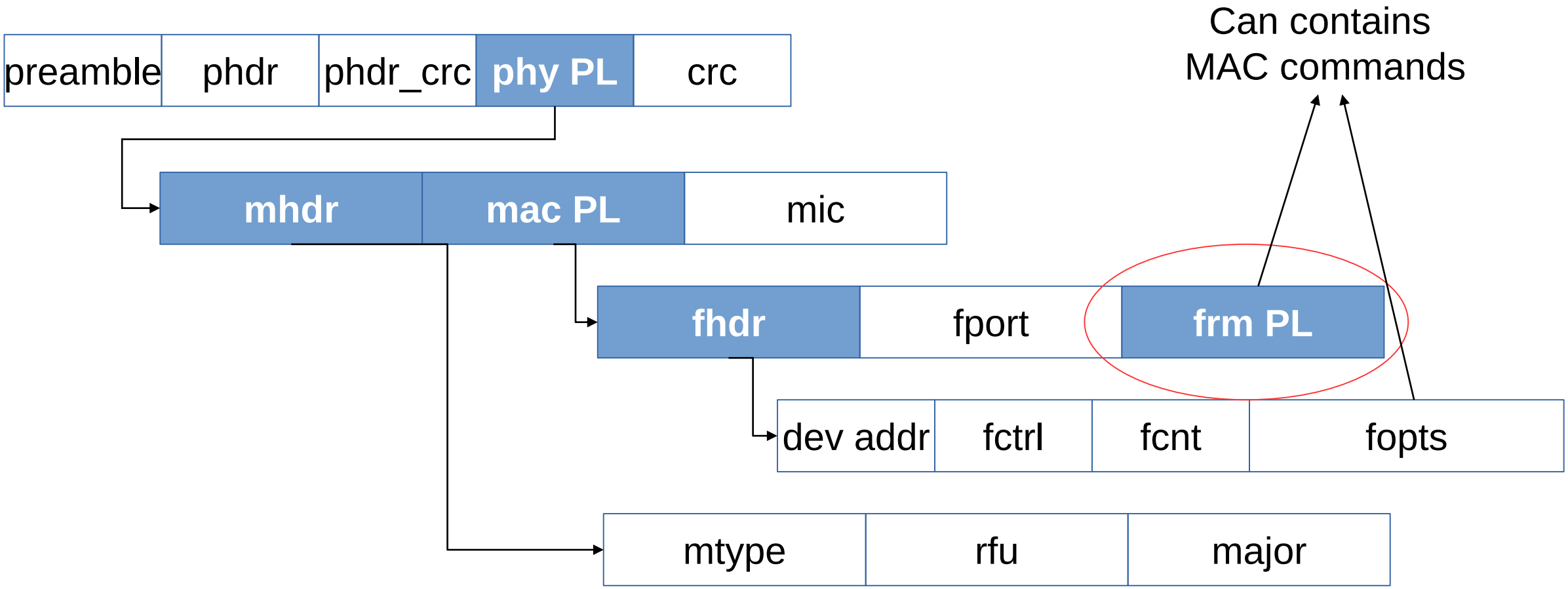
LoRaWan protocol : authentication

- ABP :
  - Dev addr
  - AppSKey
  - NwkSKey
- OTAA :
  - DevEUI
  - AppEUI
  - AppKey
  - AppSKey and NwkSKey derivated from AppKey & Network response

LoRaWan Network Encryption



LoRaWan protocol



LoRaWan protocol : MAC commands

- LinkCheckReq, LinkCheckAns = connectivity check
- LinkADRReq, LinkADRAns = change emit settings like SF
- DutyCycleReq, DutyCycleAns = update device DC
- RXParamSetupReq, RXParamSetupAns = change RX window
- DevStatusReq, DevStatusAns = get dev. status like battery
- NewChannelReq, NewChannelAns= channel upadte
- RXTimingSetupReq, RXTimingSetupAns = change RX window

LoRaWan Network : Devices

- Joining the network (if OTAA)
- Converting your payload as a LoRaWan packet
- Sending the packet
- Listening for downlink packets
- Converting the packet back to payload

LoRaWan Network : Gateways

- Receiving radio packets
- Checking CRC (message integrity, only for uplink)
- Forwarding to network server
- Listening for downlink messages to forward to devices

LoRaWan Network : Network Server

- Dealing with join requests
- Dealing with devices addresses
- Choosing time and gateways to use for downlink
- En/Decrypting MAC payload

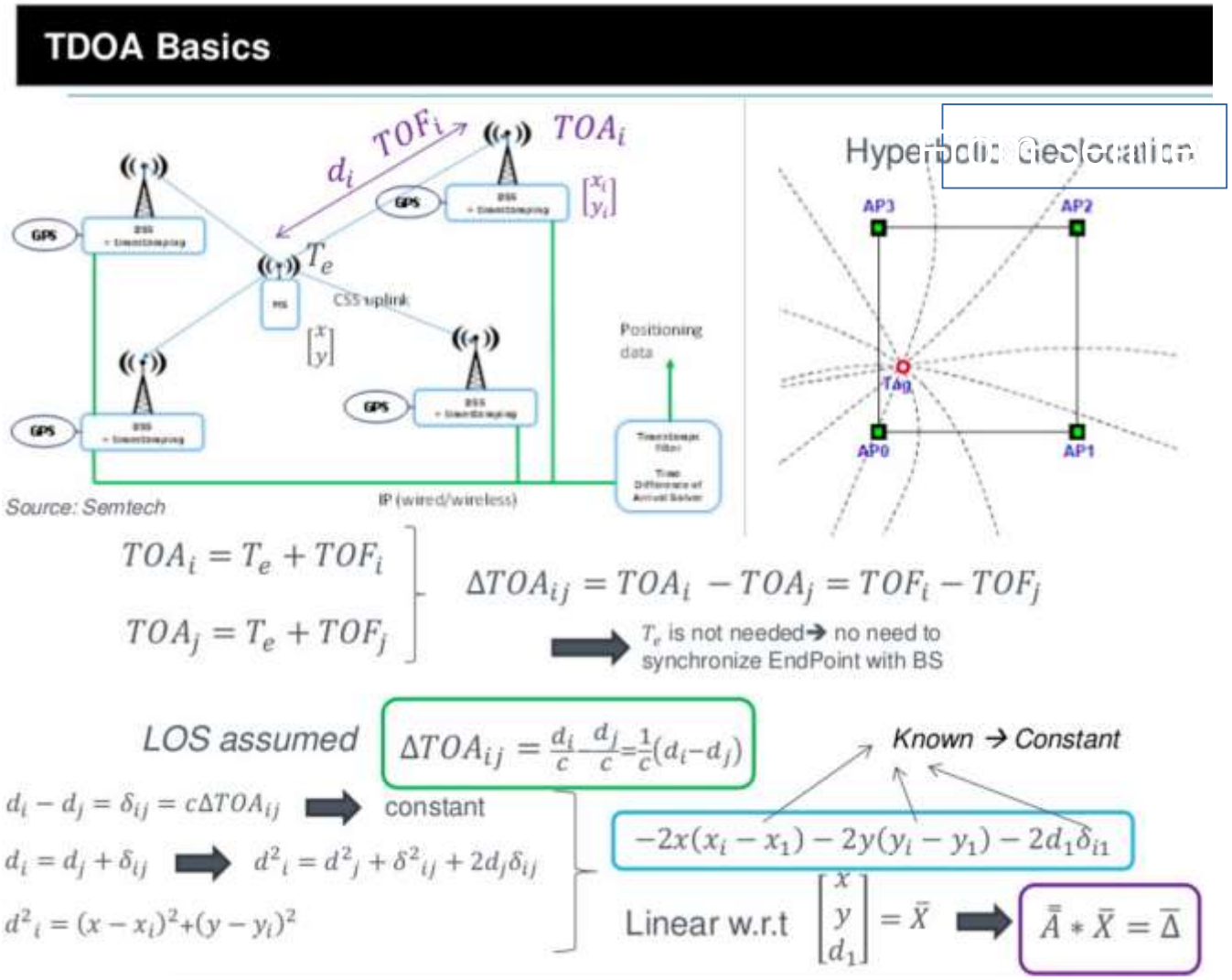
LoRaWan Network : App. Server

- Receiving packets from devices
- Scheduling responses to devices
- En/Decrypting FRM Payload (the real payload)

- In fact, do something with the data...

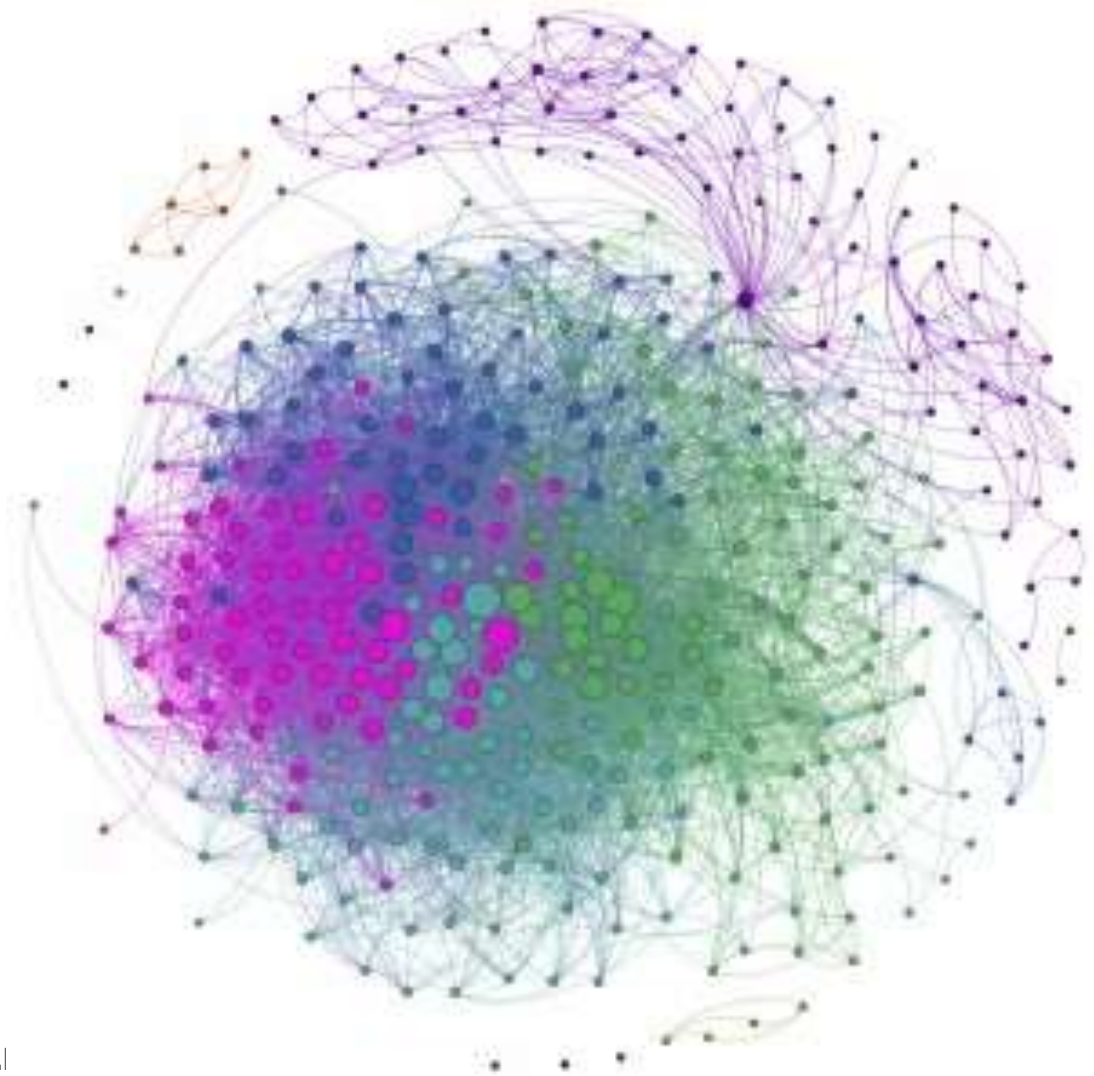
LoRaWan Network : Localisation

- Triangulation
  - Accuracy (3gw) :
    - → ~ 180 m in crowded area
    - → ~ 350 m in clear area
  - Accuracy (4gw)
    - → ~ 95 m in crowded area
    - → ~ 210 m in clear area



LoRaWan Network : Localisation

- Triangulation
- Big-Data
  - Accuracy (3gw) :
    - → ~ 35 m in crowded area
    - → ~ 220 m in clear area
  - Accuracy (4gw)
    - → ~ 22 m in crowded area



LoRaWan protocol : Duty Cycle

- The more messages on the same frequency & SF = the higher collision probability
- We want reliable transmission
- We want a lot of devices per gateway (>1000)
- → we need the keep the collision probability low enough !
- → Typically, < 10 % or even < 5 %

LoRaWan protocol : Duty Cycle

- A gateway listen on 8 frequencies and all SF
- We want > 1000 devices / gateway
- We want < 10% of duty cycle

- → 30 seconds / day / devices gives a DC < 5%

LoRaWan protocol : Duty Cycle

- Fair-use TTN policy: max. 30 seconds/device/day
- For a 10-bytes PL we have max:
  - 20 messages/day at SF12
  - 500 messages/day at SF7
  - Much more using SF7-250 or FSK modulation (lower range & higher energy)
- Downlink is limited to < 10 messages/device/day

LoRaWan protocol : ADR

- Reception of a packet on
- SF12 with SNR = -7,5dB
- Check the best SF with a
- margin of 5dB
- Send MAC command to request
- SF9 on the device

Spreading Factor	SNR limit (dB)
SF 7	-7,5
SF 8	-10
SF 9	-12,5
SF 10	-15
SF 11	-17,5
SF 12	-20

TheThingsNetwork LoraWAN

Luka Mustafa, Institute IRNAS,
November 2018


THE THINGS
NETWORK

The Things Network : Principles

- Standards compliant
- Compliant with spectrum regulations
- Open source
- Designed for distribution and decentralization
- One global, free and open network

The Things Network : History

- Jul. ‘15 : Announce of The Things Network
- Sept. ‘15 : First gateways installed in Amsterdam
  → Croft environment started
- Oct. ‘15 : KickStarter campaign started
- Nov. ‘15 : KickStarter end with > 2x funding!
- Mar. ‘16: Staging environment setup

The Things Network : Numbers

- > 30,000 members
- > 5,000 gateways
- > 200 communities
- > 55 countries
- ... and counting !

The Things Network : Architecture

Gateway

Send data to and
receive data from nodes

Router

Routes raw packets from
gateways to brokers

Broker

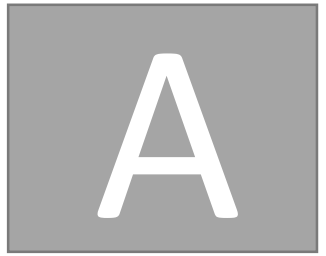
Decoupling from Router
and Application Handler

Network Controller

Node state: data rate and
frequency management

Application Handler

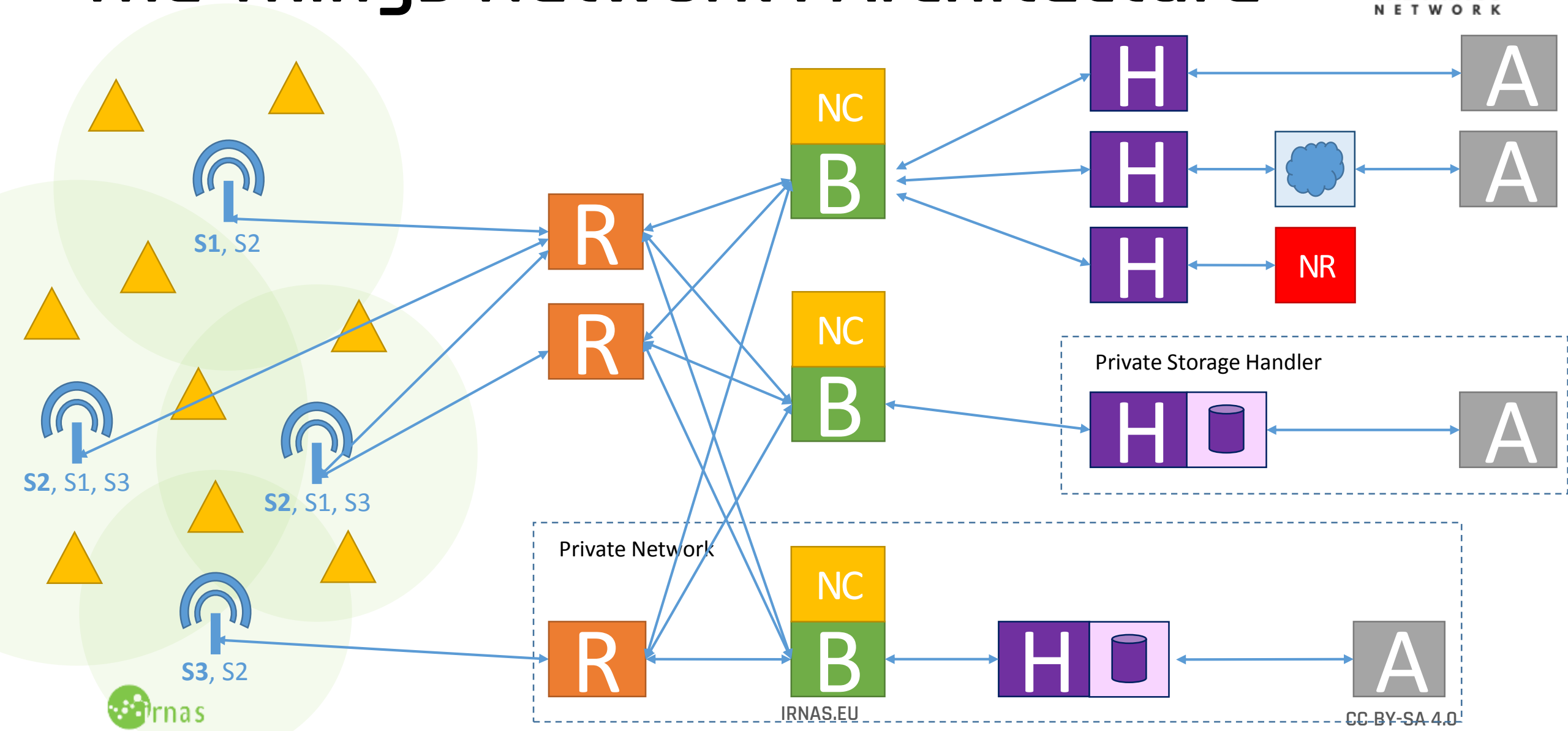
Decryption, deduping,
works on behalf of apps



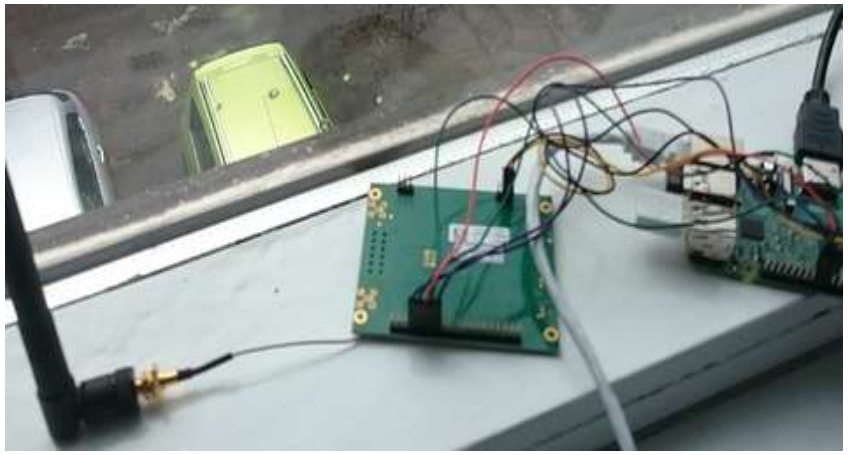
Application

User application

The Things Network : Architecture



The Things Network : Gateways

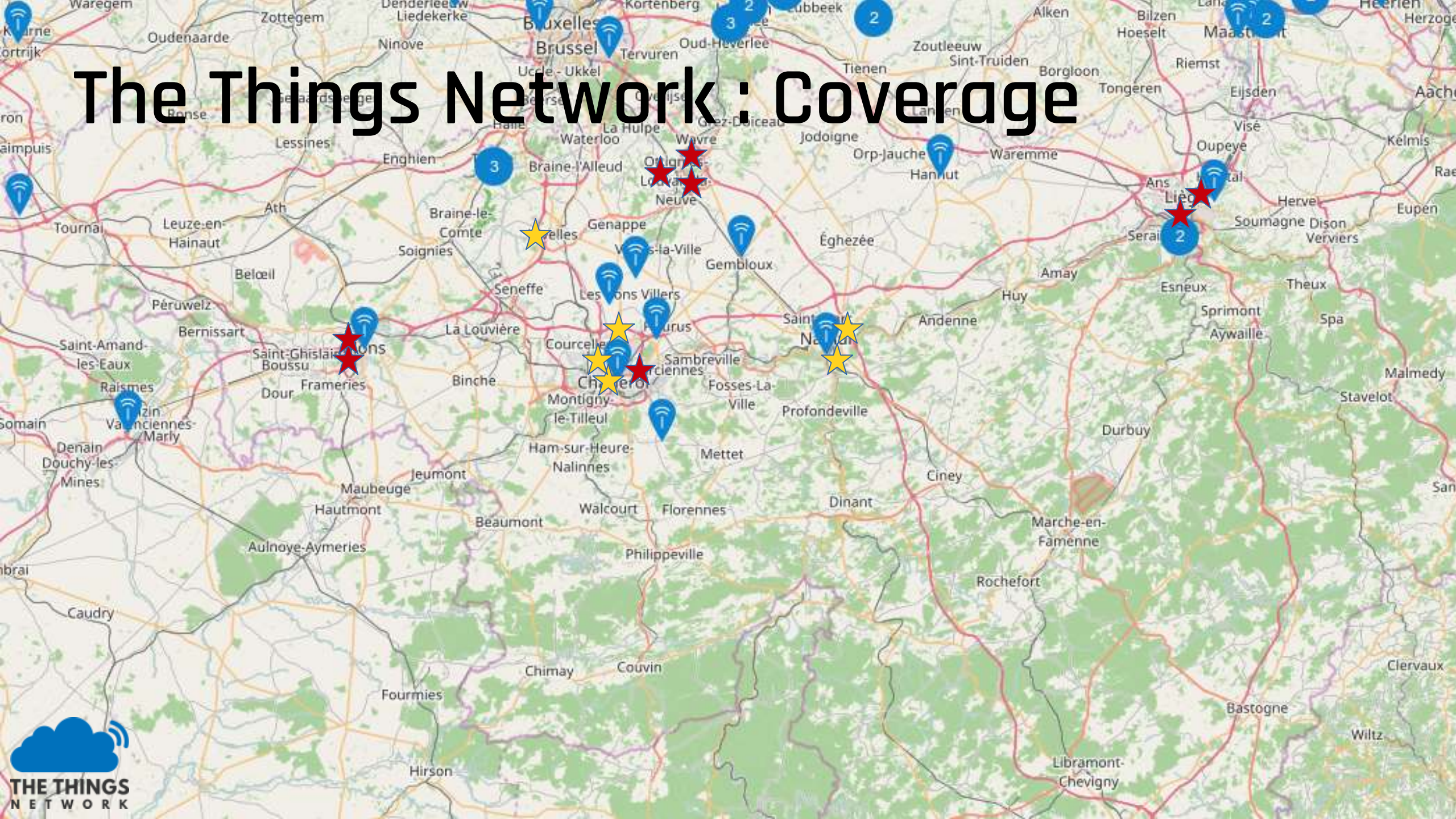


The Things Network : Coverage

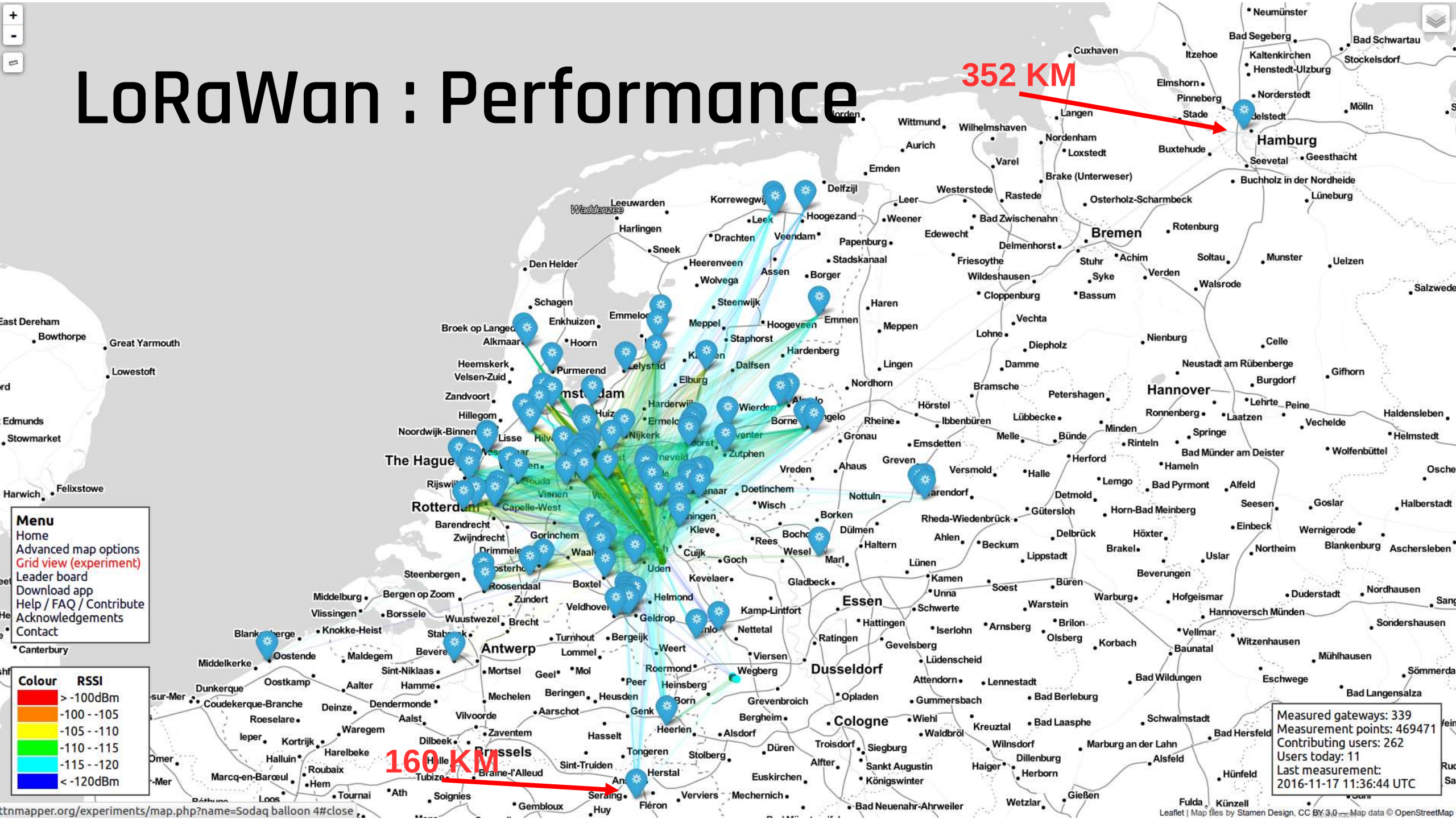
The Things Network : Coverage

THE THINGS NETWORK

The Things Network : Coverage



LoRaWan : Performance



4 October
MARIBOR
Slovenia

THE THINGS CONFERENCE
OnTour

160 PARTICIPANTS
74 ORGANIZATIONS
11 COUNTRIES

thethingsnetworkslovenia.org

rnas THE THINGS NETWORK LoRaWAN

4
October
MARIBOR
Slovenia

THE THINGS
CONFERENCE
OnTour






thethingsnetworkslovenia.org

rnas
THE THINGS NETWORK
LoRaWAN

Network in Maribor

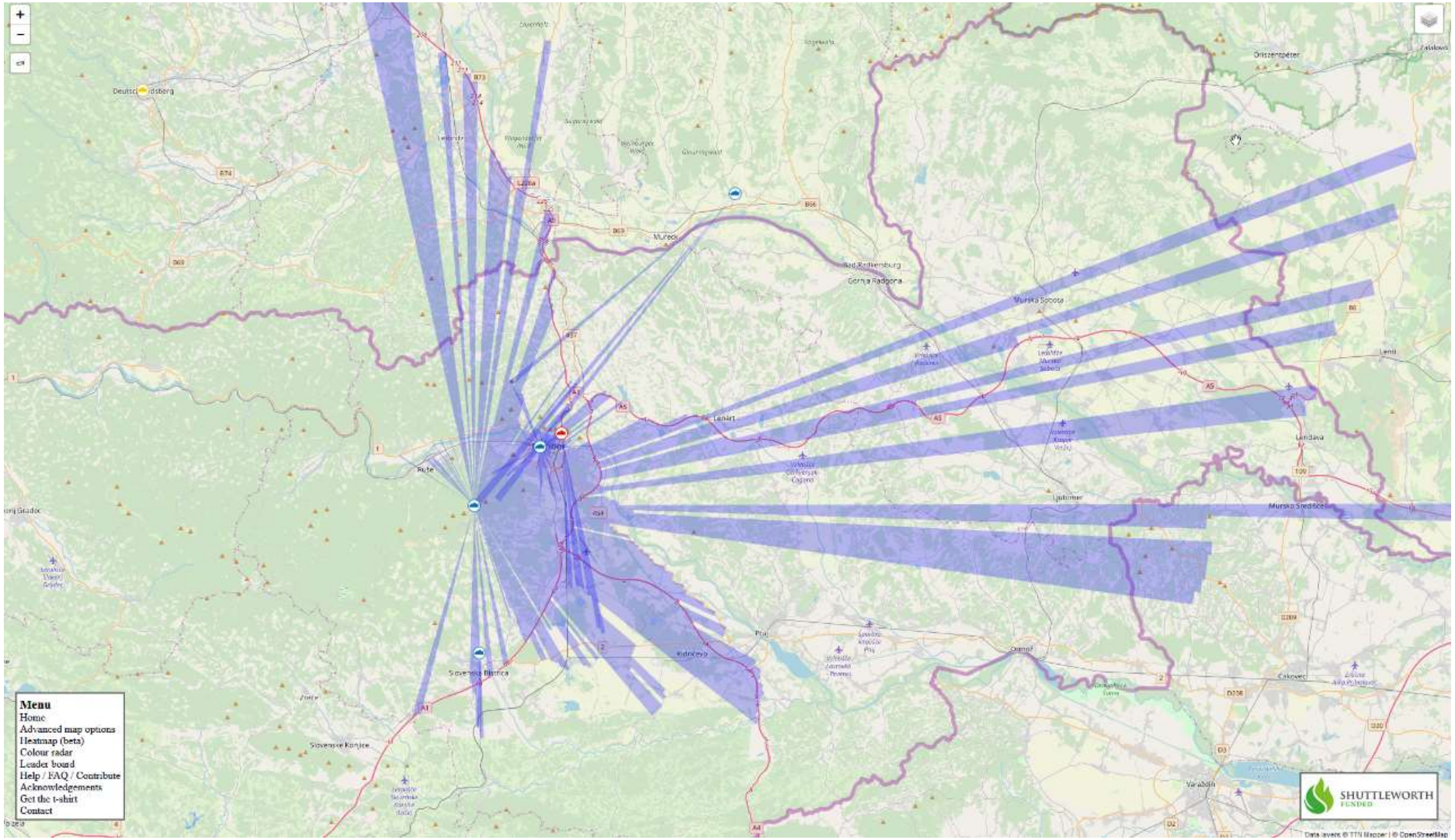
- Gateways on Pohorje and Urban
- Gateways in the city center
- Test network with Kerlink supporting geolocation
- Good coverage of the city center + wide area from Pohorje, up to 100km range, fields of Dravsko polje and much more








TTN mapper



Sources

- Thomas Telkamp - LoRa crash course – 10 Nov. ‘16
- Matt Knight - Decoding LoRa – 05 Oct. ‘16
- Johan Stokking – The Things Network – Jul. ‘15
- TTNMapper.org – Nov. ’16
- Romain Cambier - @r_cambier – shareif – Oct18
- Luka Mali – LTFE – Oct18
- Infiswift Solutions – Oct18