NRENs and Internet-of-Things

Paul Dekkers

September 23, 2016

SURF NET

NRENs and the Internet of Things

SURFnet activities on IoT (LoRaWAN),

what can we do in the future (together)...

- Kind of IoT/sensor-networks
- LPWAN, LoRaWAN
- Architecture
- Where does the NREN fit in

Sensor networks, Things

MESH TOPOLOGY

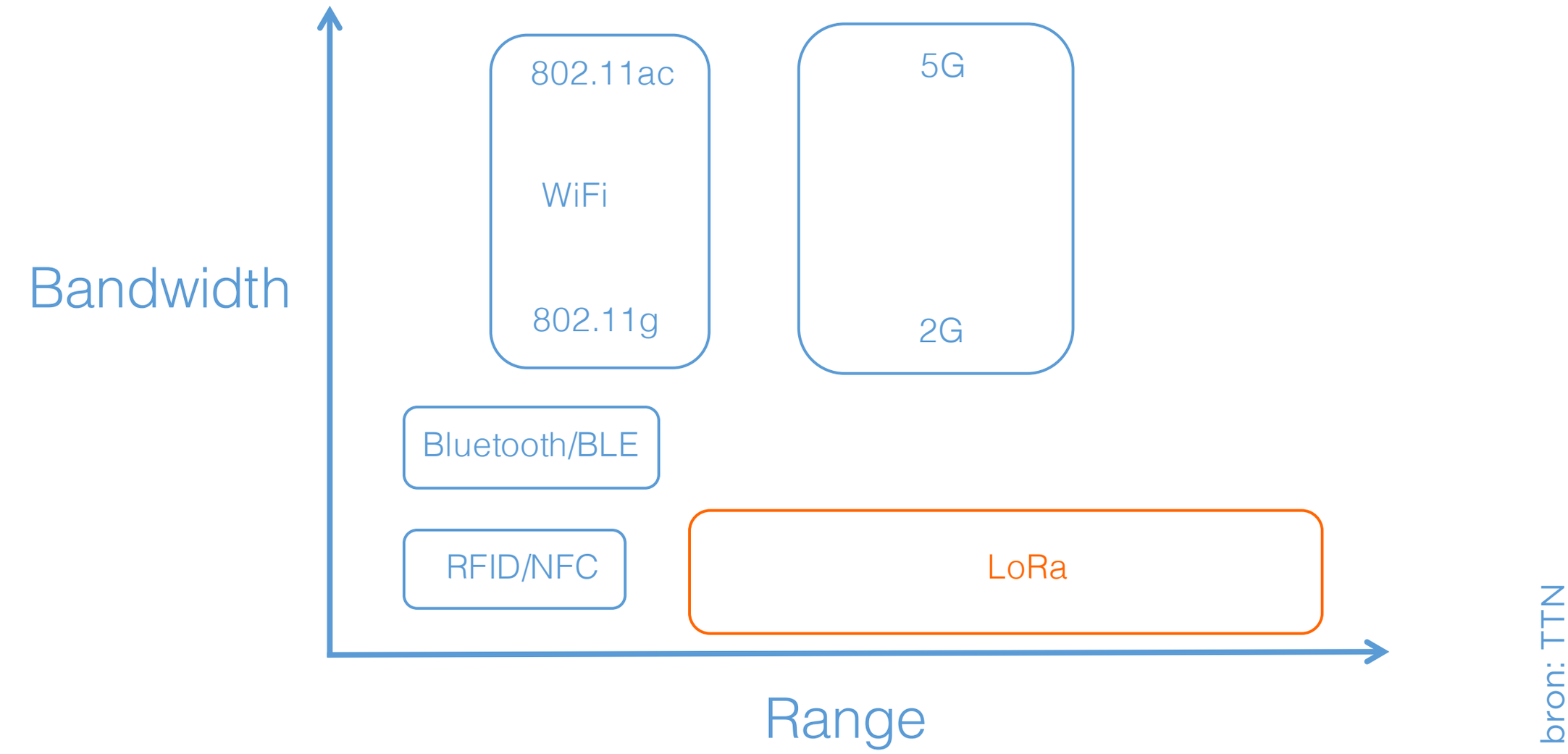
STAR TOPOLOGY

A mesh network is impractical: low range, passing on data costs energy, coordination

bron: link-labs

LoRa: bandwidth vs. range

When Bluetooth, BLE, WiFi, NFC, Zigbee limited range, and M2M 2-4G too costly...



LoRa, LoRaWAN, LPWAN...?

- LPWAN name for Low Power WAN
  - Star topology
  - Long range
  - Low bandwidth

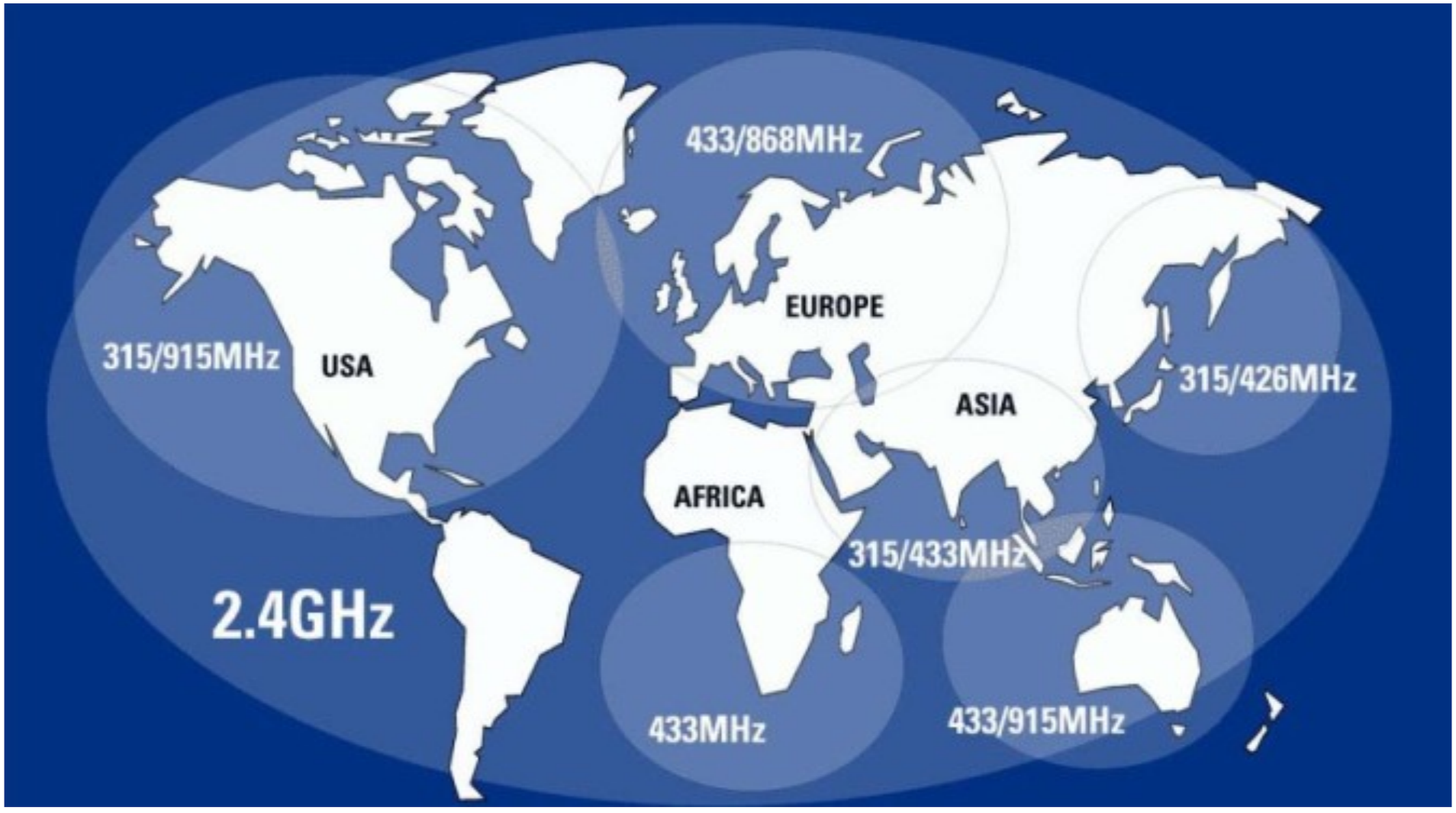
- Unlicensed spectrum under 1 GHz, range! (433, 868, 915 MHz) but regulated

- Multiple solutions, LoRa(WAN) extra interesting:

SIGFOX
One network A billion dreams

LoRa™

Global ISM bands

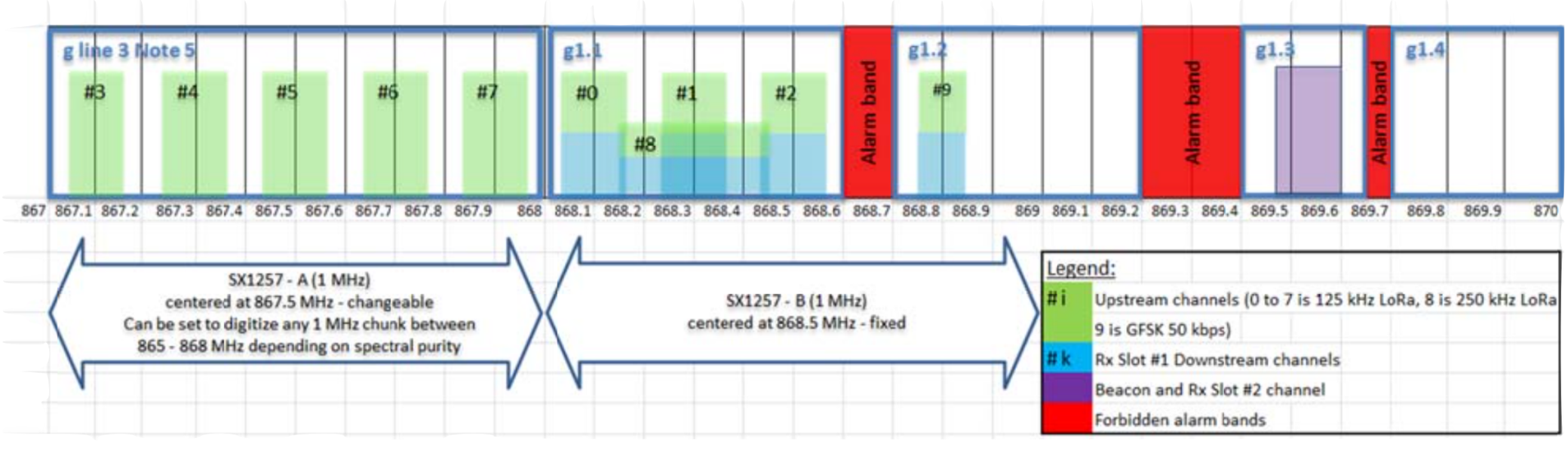


source: predictabledesigns.com

Frequencies, bw, duty-cycle, power

In the EU:

band	frequenties	max. power	duty cycle
433	433.175 433.375 433.575	10 dBm (10 mW)	0,1% (3,6 sec/hour)
867, g	867.1 867.3 867.5 867.7 867.9	14 dBm (25 mW)	1% (36 sec/hour)
868, g1	**868.1 868.3 868.5**	14 dBm (25 mW)	1%
869, g3	**869.5**	27 dBm (500 mW)	10% (6 min/hour)



LoRaWAN in the world

	Europe	North America	China	Korea	Japan	India
Frequency band	867-869MHz	902-928MHz	470-510MHz	920-925MHz	920-925MHz	865-867MHz
Channels	10	64 + 8 +8	In definition by Technical Committee	In definition by Technical Committee	In definition by Technical Committee	In definition by Technical Committee
Channel BW Up	125/250kHz	125/500kHz				
Channel BW Dn	125kHz	500kHz				
TX Power Up	+14dBm	+20dBm typ (+30dBm allowed)				
TX Power Dn	+14dBm	+27dBm				
SF Up	7-12	7-10				
Data rate	250bps- 50kbps	980bps-21.9kpbs				
Link Budget Up	155dB	154dB				
Link Budget Dn	155dB	157dB				

LoRaWAN in the US: dwell time

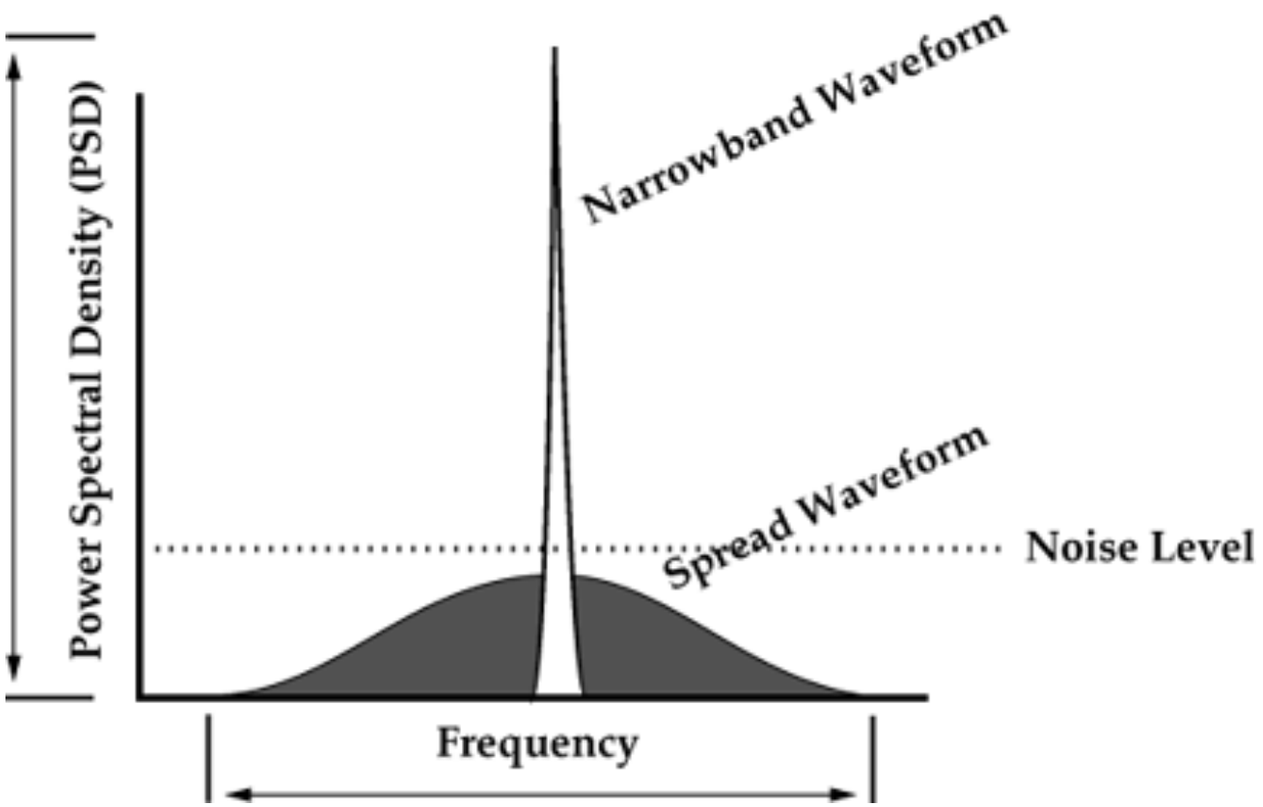
- Dwell time requirement: 400ms
  time spent at a particular frequency during any single hop

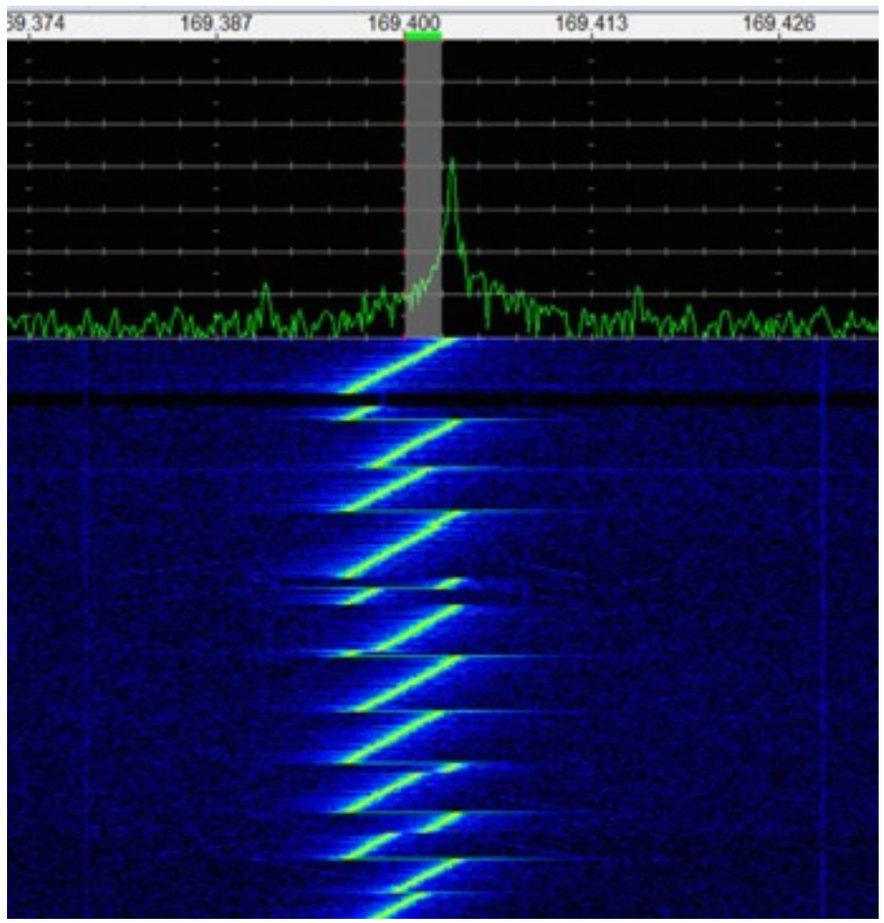
- Maximum 400ms transmissions before hopping channel:
  rules out SF11 and SF12, transmission would take too long

- Normally 50 channels in US; “hybrid mode” allows 8 channels with reduced power (+21dBm)

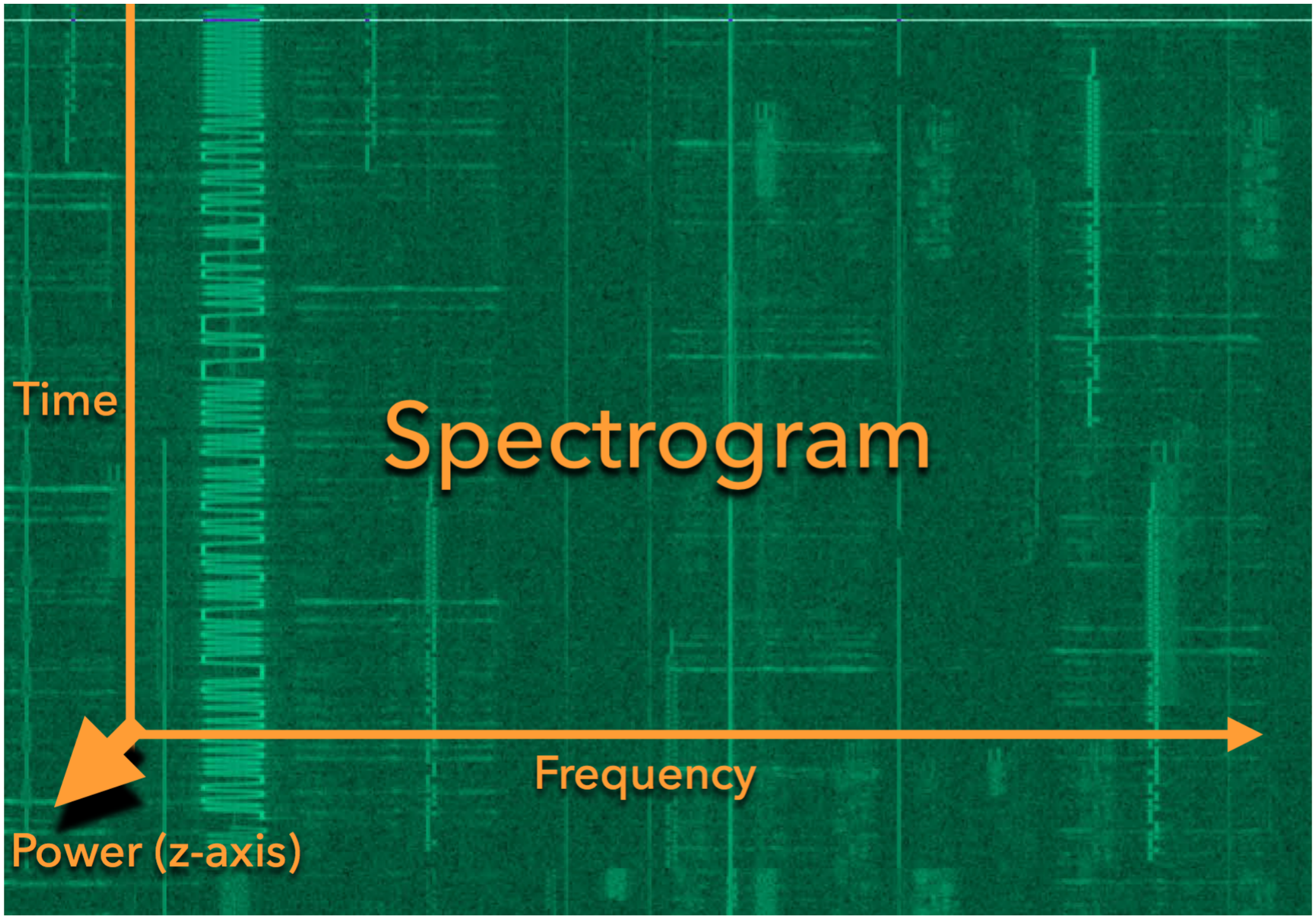
LoRa (PHY, modulation technique)

- **Chirp Spread Spectrum**: bandwidth, decodable under noise-level, even with interference and fading
- Lower speed when higher speeds don’t work
- Localisation, timing



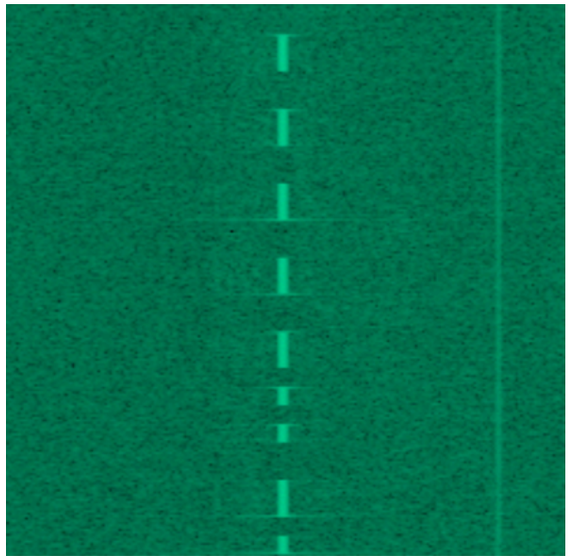


Spectrogram

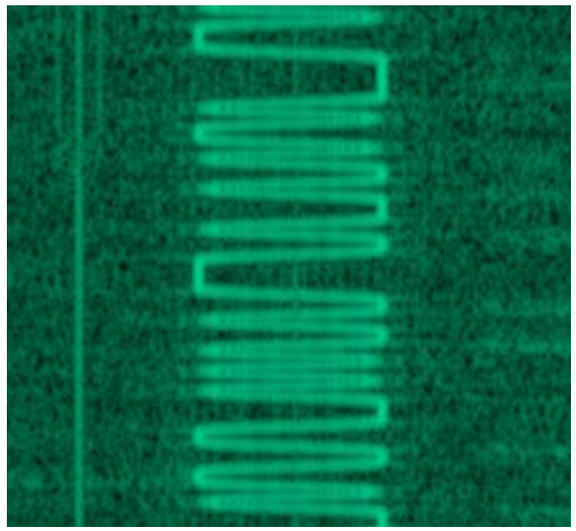


Source: Matt Knight

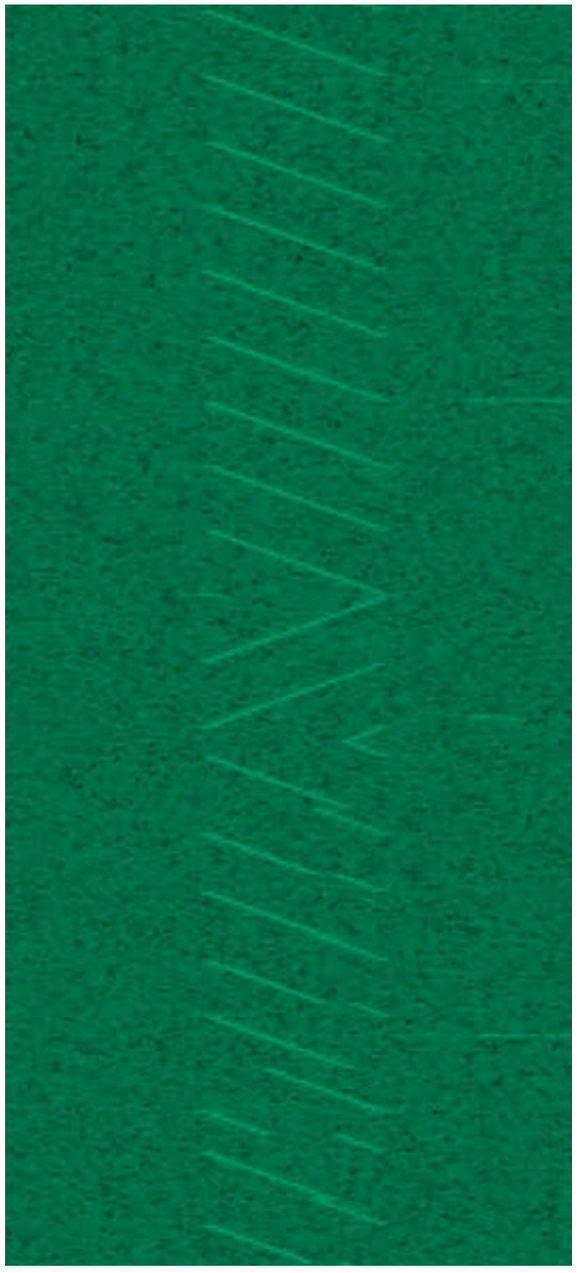
Spectrogram LoRa



On-Off Keying



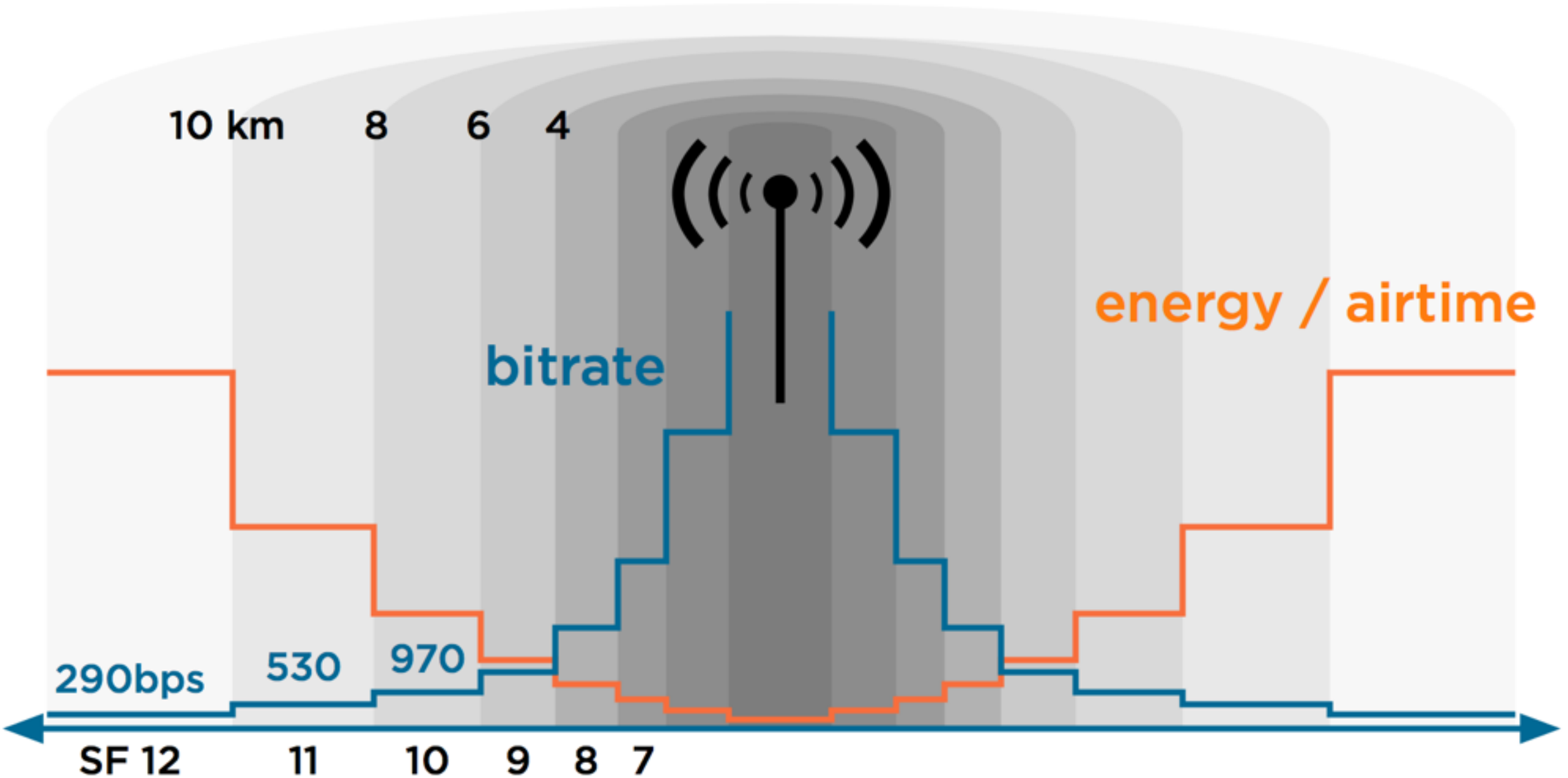
FSK
Frequency Shift Keying



LoRa

Source: Matt Knight

LoRa speeds


10 km
8
6
4
energy / airtime
bitrate
290bps
530
970
SF 12
11
10
9
8
7

LoRa speeds

- **Spreading Factor** (SF), modulation speed

Spreading Factor	Chips/symbol	SNR limit	Time-on-air (10 byte packet)	Bitrate
7	64	-7.5	56 ms	5469 bps
8	128	-10	103 ms	3125 bps
9	256	-12.5	205 ms	1758 bps
10	512	-15	371 ms	977 bps
11	1024	-17.5	741 ms	537 bps
12	2048	-20	1483 ms	293 bps

bron: TTN

Short time-on-air preferable for power, duty-cycle, fair-use

LoRaWAN: adaptive data rate (ADR)

- Dynamic choice for SF based on received signal

Received packet

SF = 12
SNR = -10 dB

Spreading Factor	SNR limit
7	-7.5
8	-10
9	-12.5
10	-15
11	-17.5
12	-20

Can increase rate to SF10:
-10 dB (SNR) - 5 dB (margin)
= -15 dB

Link ADR request: SF10

bron: TTN

LoRaWAN classes: we use A

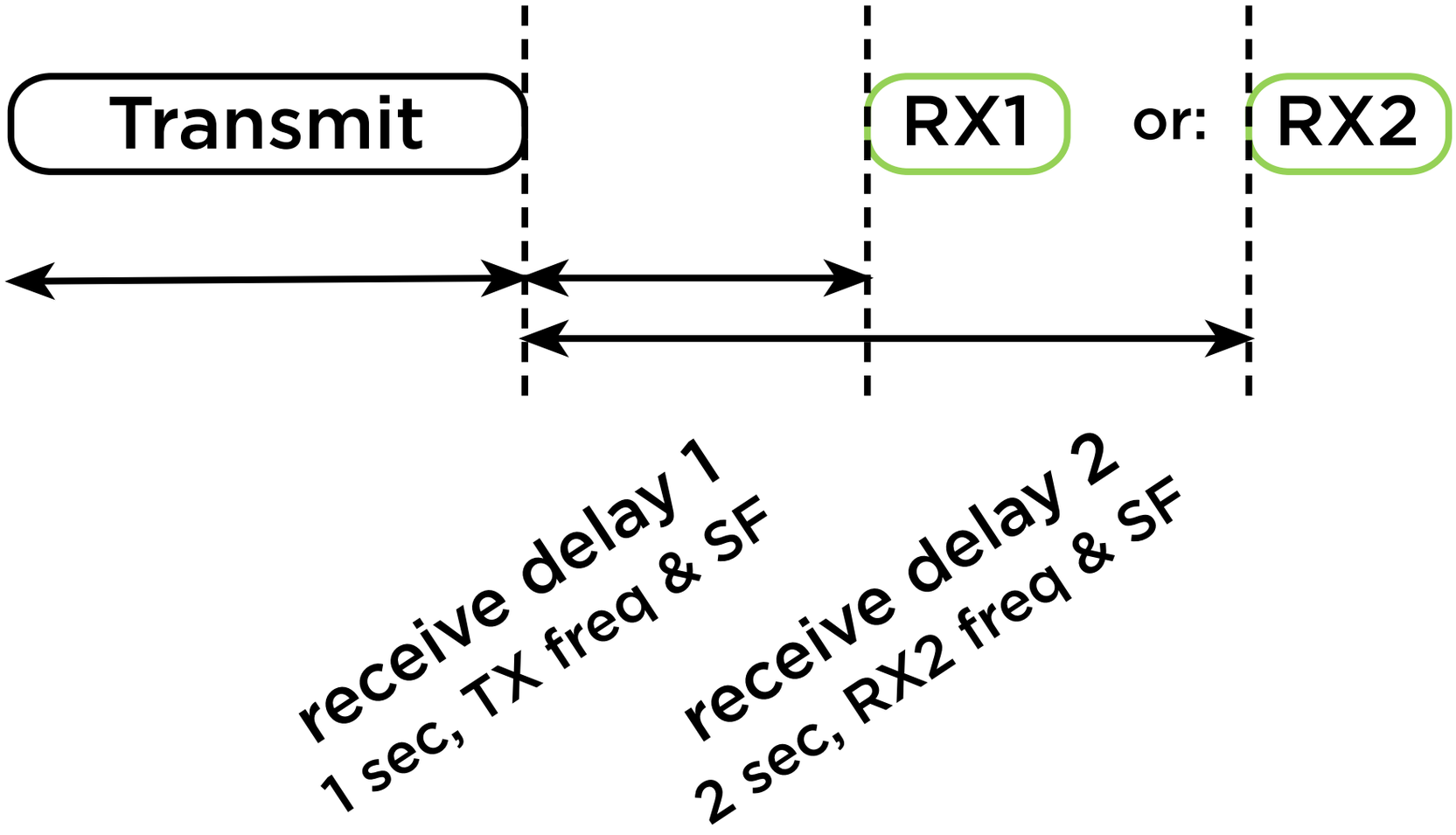
Three classes:

Class A: transmit from a node, transmit window (~52 bytes), 2 receive windows (ACK, evt. data, ~10 bytes)

(**Class B**: besides A also receive windows on set intervals, time-synchronisation beacons - in development)

Class C: continuous receive window (except while sending), if there is sufficient power (and low latency is required)

Class A, packet windows



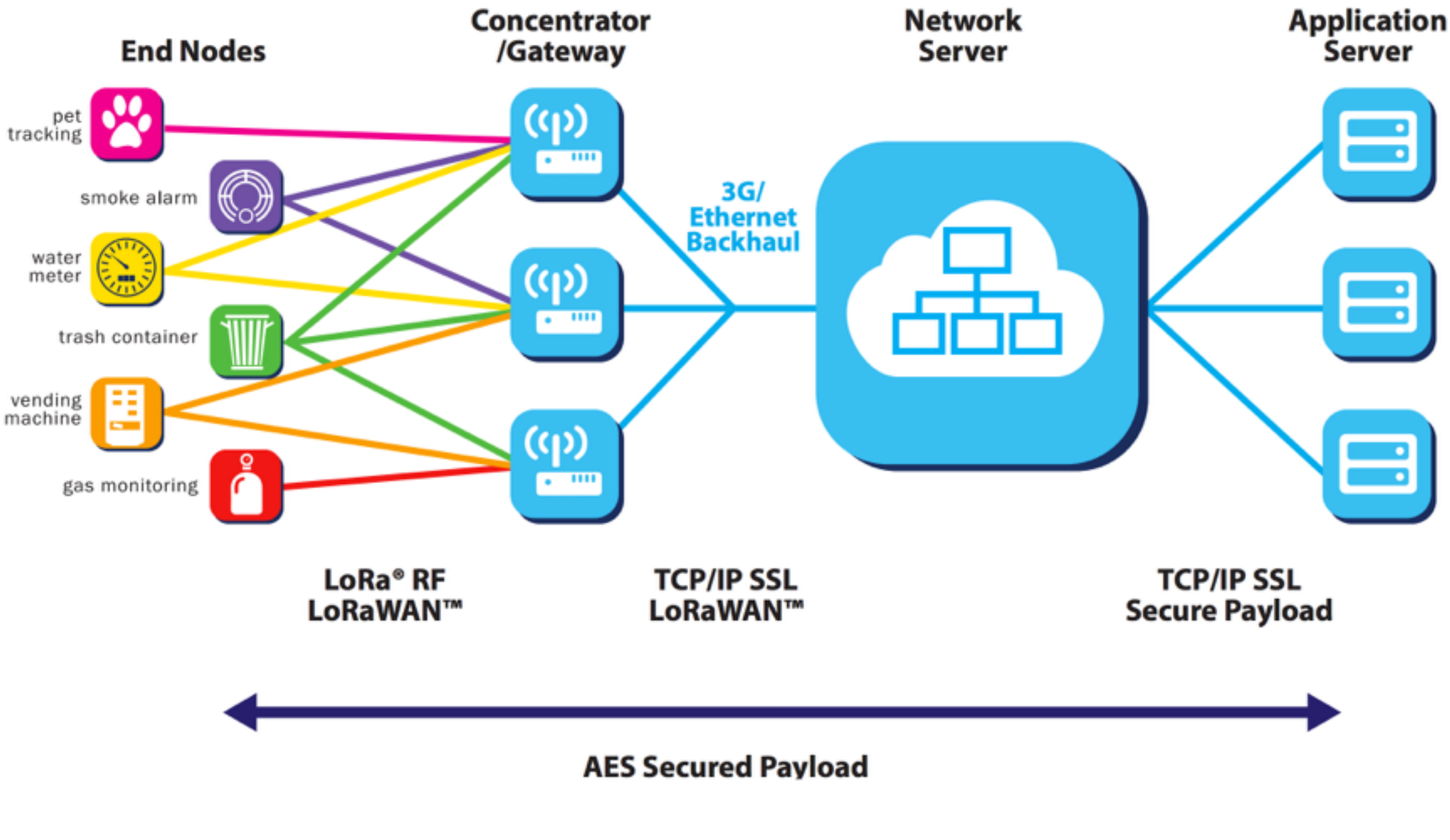
~52 bytes ~10 bytes ~10 bytes

max. payload & airtime depends on SF

LoRaWAN addresses, security

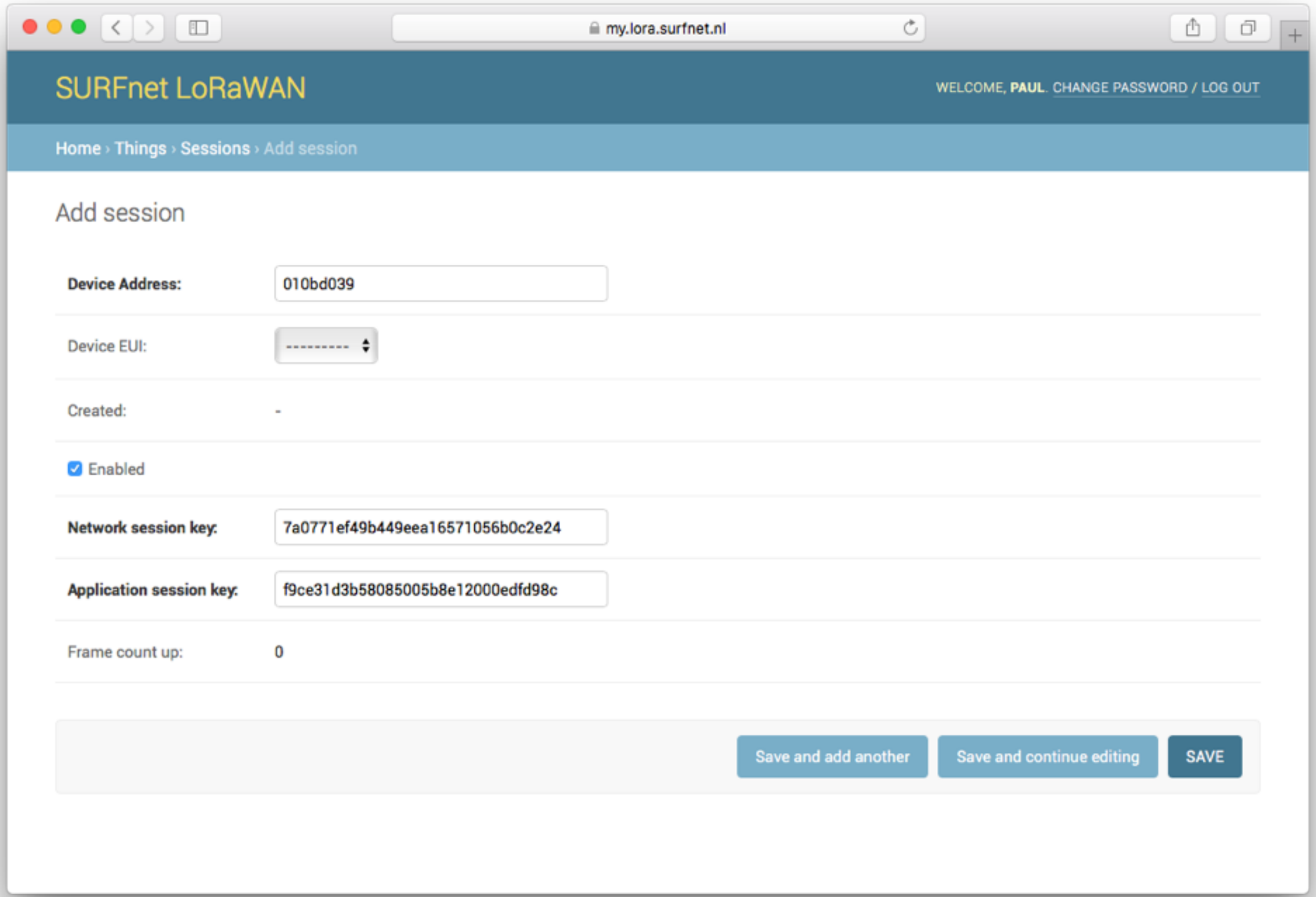
- **Network key** (Message Integrity Check, 128-bit)
- **Application key**
  - 128-bit AES encryption
- **Activation by Personalisation** (ABP)
  - Fixed device address (32-bit)
  - Replay-attacks possible
- **Over The Air Activation** (OTAA)
  - Shared secret
  - Roaming

Typical LoRaWAN network

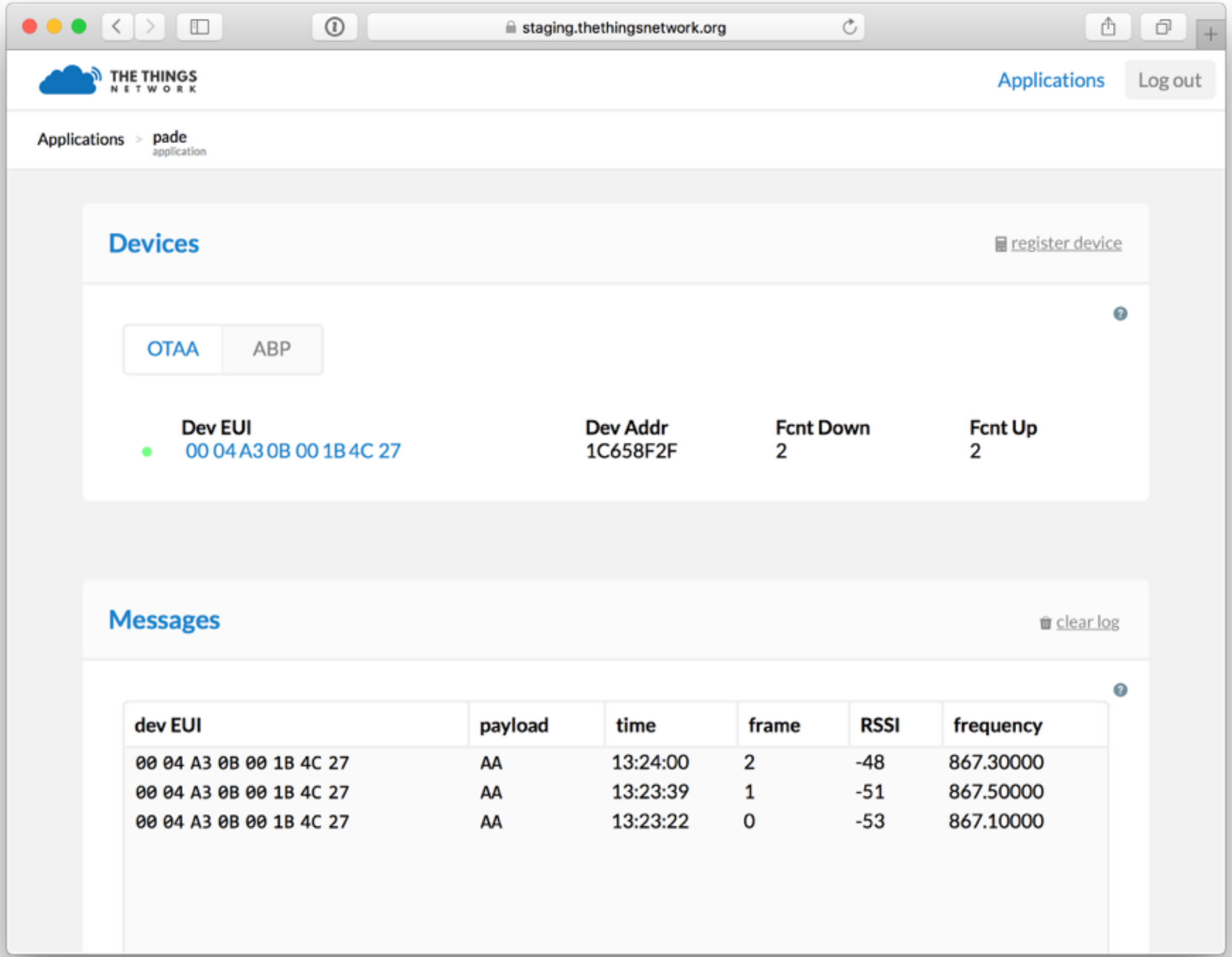


bron: LoRa Alliance

SURFnet demo-portal



The Things Network (staging) portal



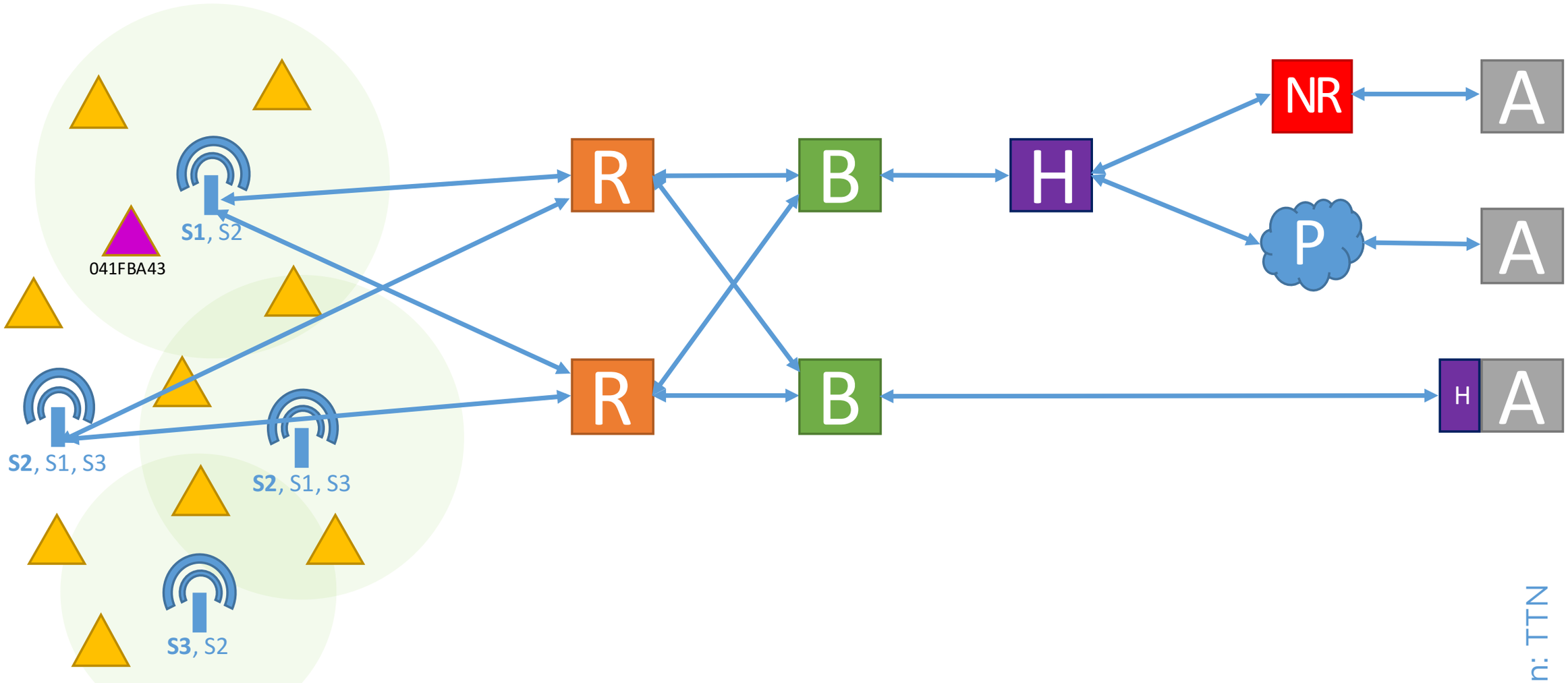
The Things Network

- **Global community LoRaWAN network crowdsourced** (think eduroam)
- **No “single point of control”**
- End-to-end encryption
- Can be combined with private LoRaWAN
- No country borders

The Things Network, Architecture

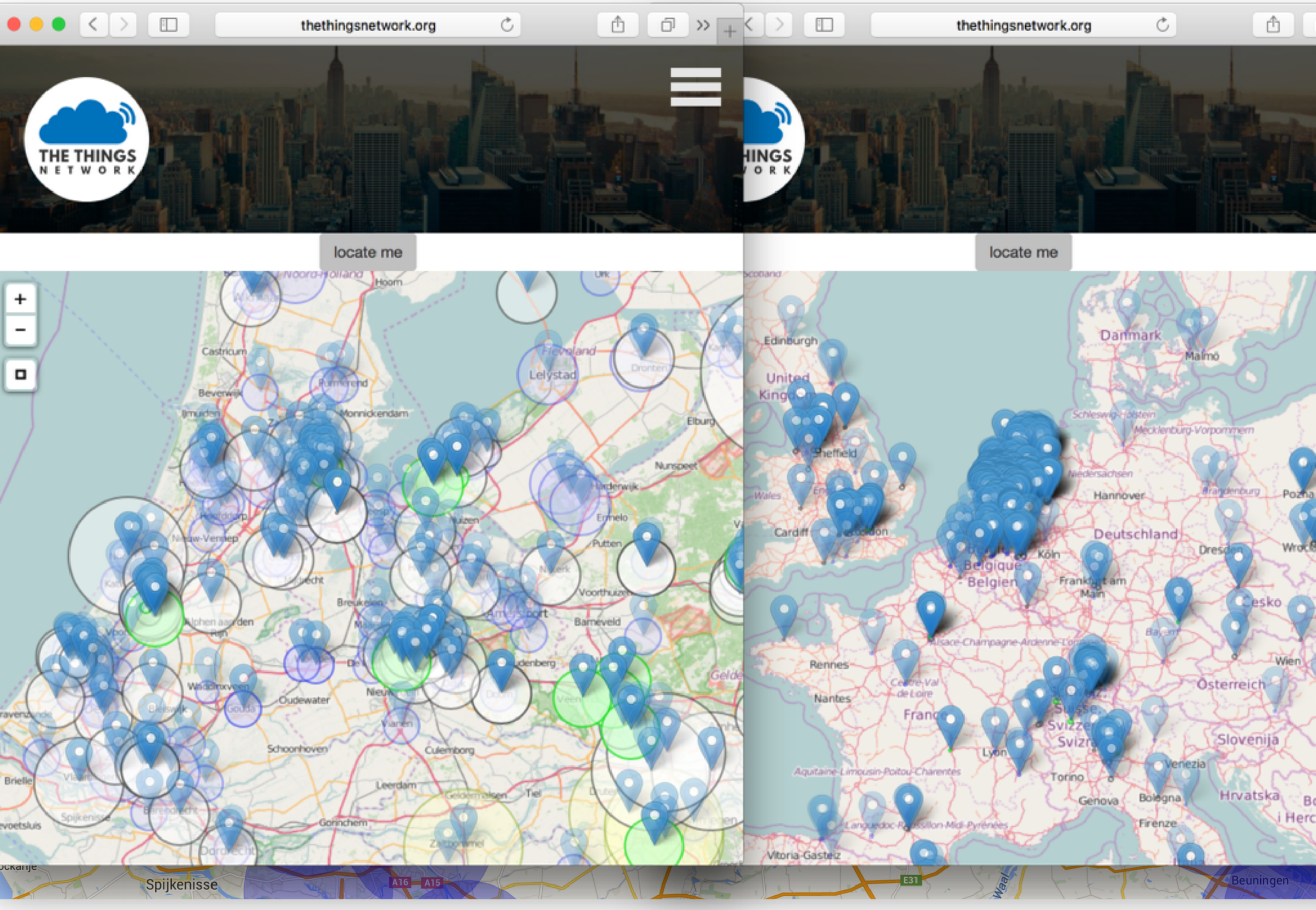
Community network, no centralised infrastructure:

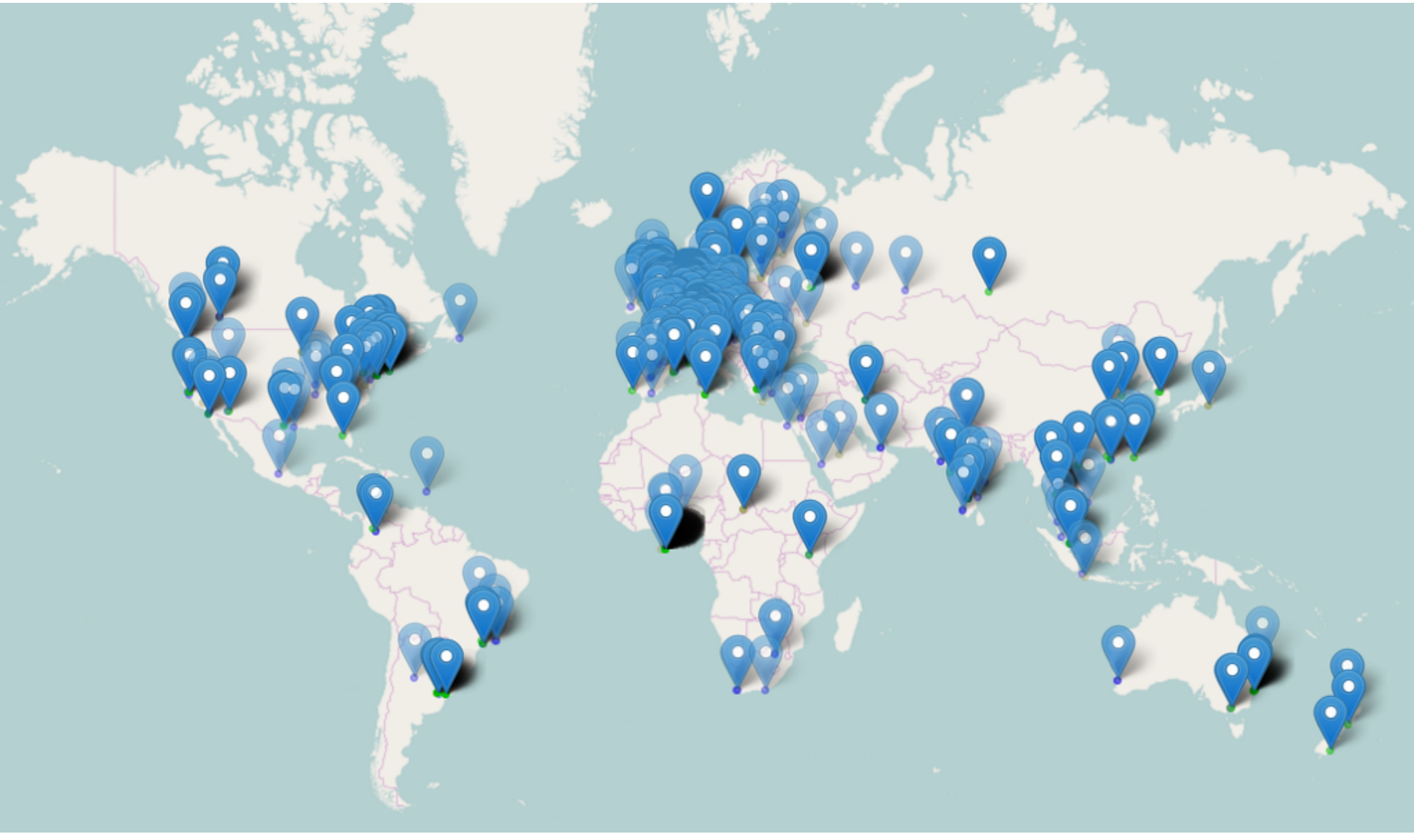
we can be part of this infrastructure!

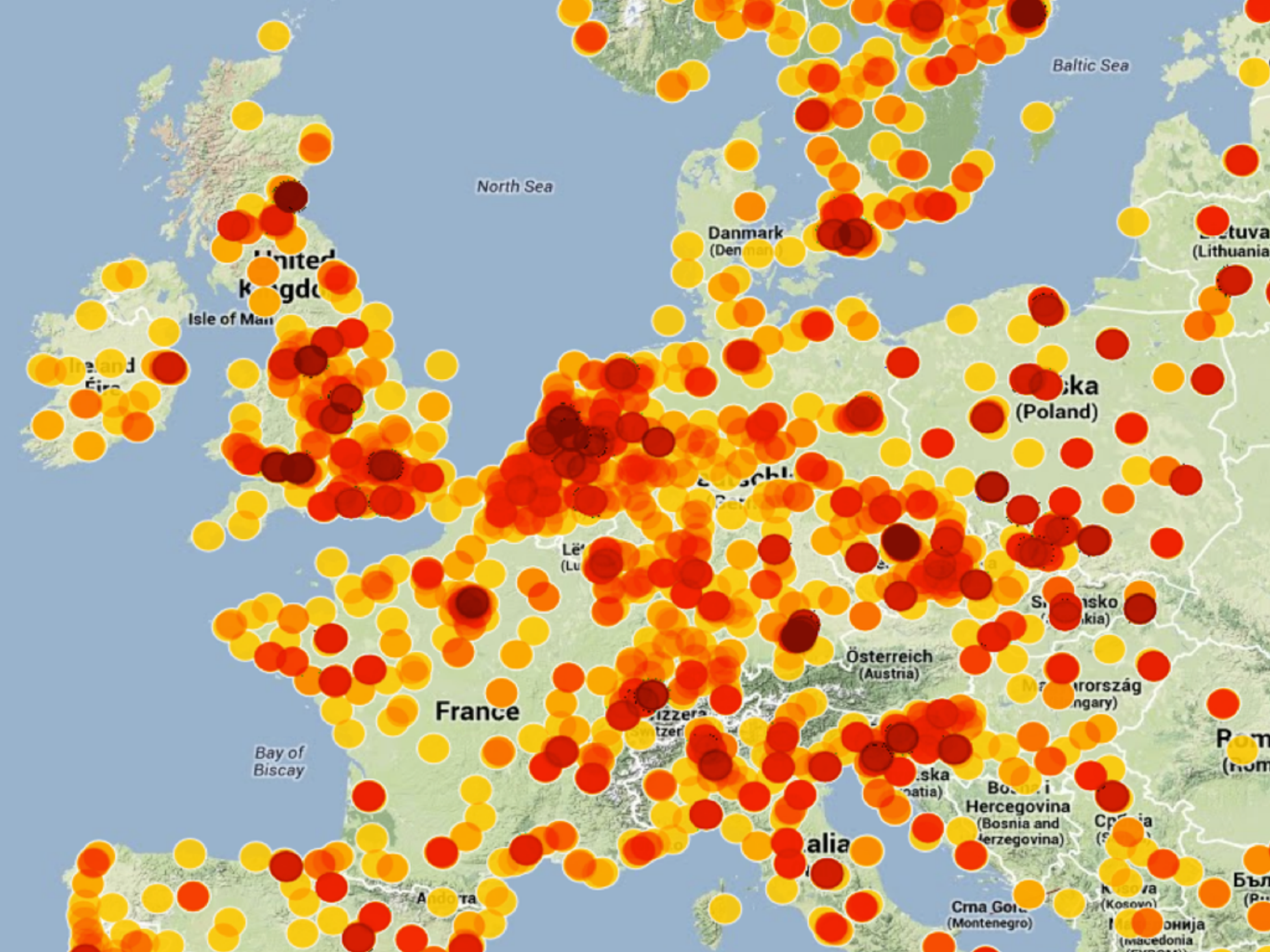


bron: TTN

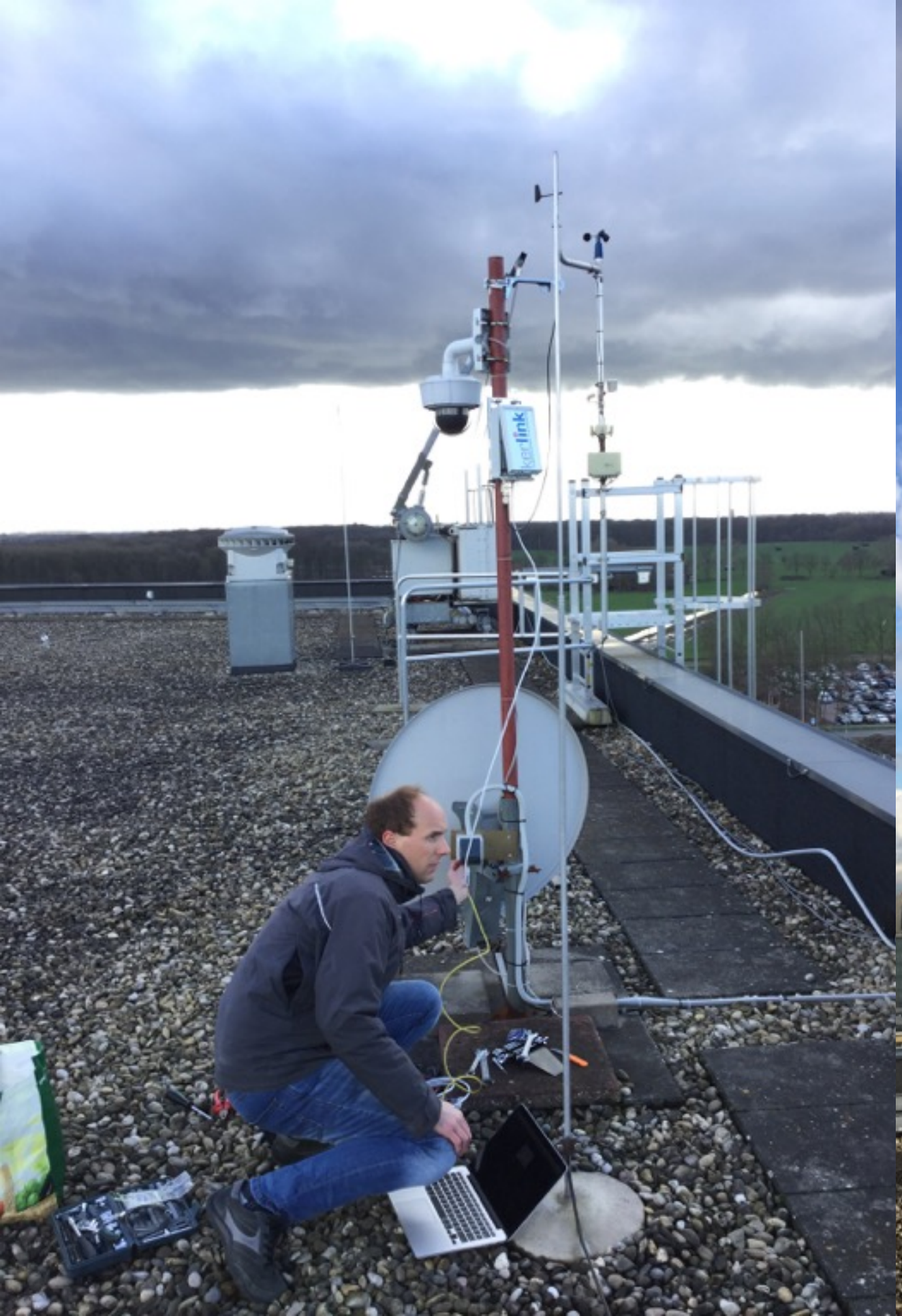
Routers and brokers create message-bus for applications to subscribe to


thethingsnetwork.org
THE THINGS NETWORK
locate me
Castricum
Beverwijk
Ijmuiden
Monnickendam
Lelystad
Elburg
Nunspeet
Harderwijk
Ermelo
Putten
Voorthuizen
Barneveld
Breukelen
Oudewater
Schoonhoven
Culemborg
Leerdam
Tiel
Gorinchem
Brielle
Spijkenisse
Edinburgh
United Kingdom
Sheffield
Cardiff
London
Danmark
Malmö
Schleswig-Holstein
Mecklenburg-Vorpommern
Niedersachsen
Hannover
Brandenburg
Deutschland
Köln
Belgique
Belgien
Frankfurt am Main
Dresden
Česko
Bayern
Wien
Österreich
Rennes
Nantes
France
Lyon
Suisse
Svizzera
Svizra
Torino
Genova
Bologna
Firenze
Venezia
Slovenija
Hrvatska
Vitoria-Gasteiz
Beuningen
A16
A15
E31




North Sea
Baltic Sea
Danmark
(Denmark)
Isle of Man
France
Bay of
Biscay
Österreich
(Austria)
(Poland)
Hercegovina
(Bosnia and
Herzegovina)
(Montenegro)
(Kosovo)
(Macedonia)
(Lithuania)

MULTITECH
MultiConnect Conduit


kerlink

kerlink

LoRa

Paul

pade.nl/lora/?gateway=AA555A00080605B7

Westbroek
Maarssen
Noorderpark
Kasteel de Haar
Utrechtse golfclub De Pan
Soesterb
Maxmapark
Utrecht
Zeist
Nieuw Wulven
Nieuwegein
Houten
Driebergen Rijsenburg
Leaflet

LoRa

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pade.nl/lora/?gateway=AA555A00080605B7

Haarlem
Amsterdam
IJmeer
Almere
Harderwijk
Amsterdamse Waterleidingduinen
Amsterdamse Bos
Hoofddorp
Leiden
Nieuwkoopse Plassen
Leusderheide
Nieuwegein
Ede
Tiel
A1
A2
A4
A5
A6
A9
A12
A20
A27
A28
A30
A44
A15
Leaflet

Measuring coverage gateway

Gateways

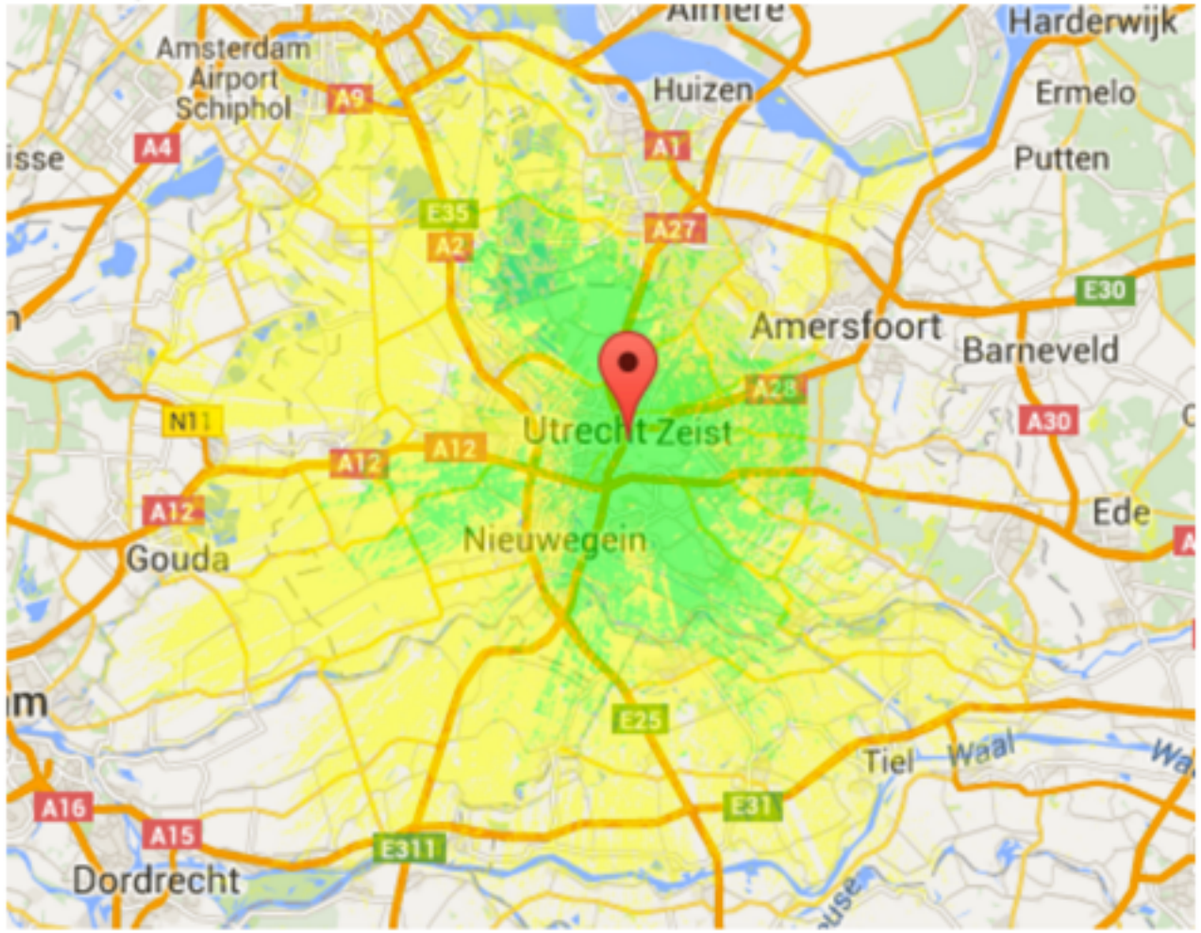
PH3V 21d + Reply

Today i did some Predicted vs Realtime calculations ..

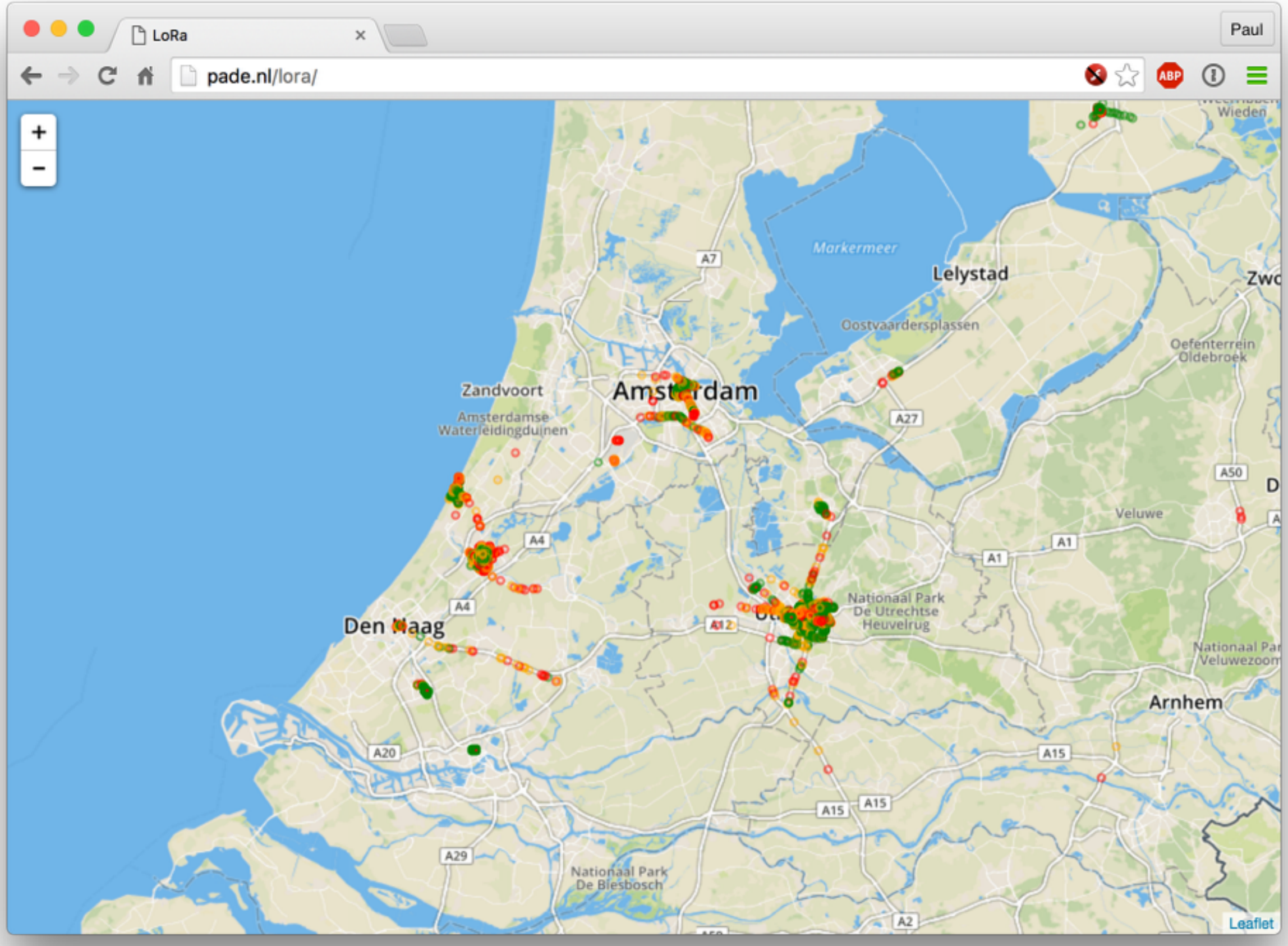
Remarkable how well the prediction comes close to the real-time measurements.
The original contains pixels of 50 by 50 meters.
For example, on the bridge at Zaltbommel there is indeed, albeit limited, coverage.
It is also clear to see that there is less eastward coverage. That's because of the hills. (Utrecht Ridge)

The same prediction made on the basis of my antenna setup ... Antenna 7 meters, urban canyon.
That was a big disappointment compared to Utrecht setup 😉

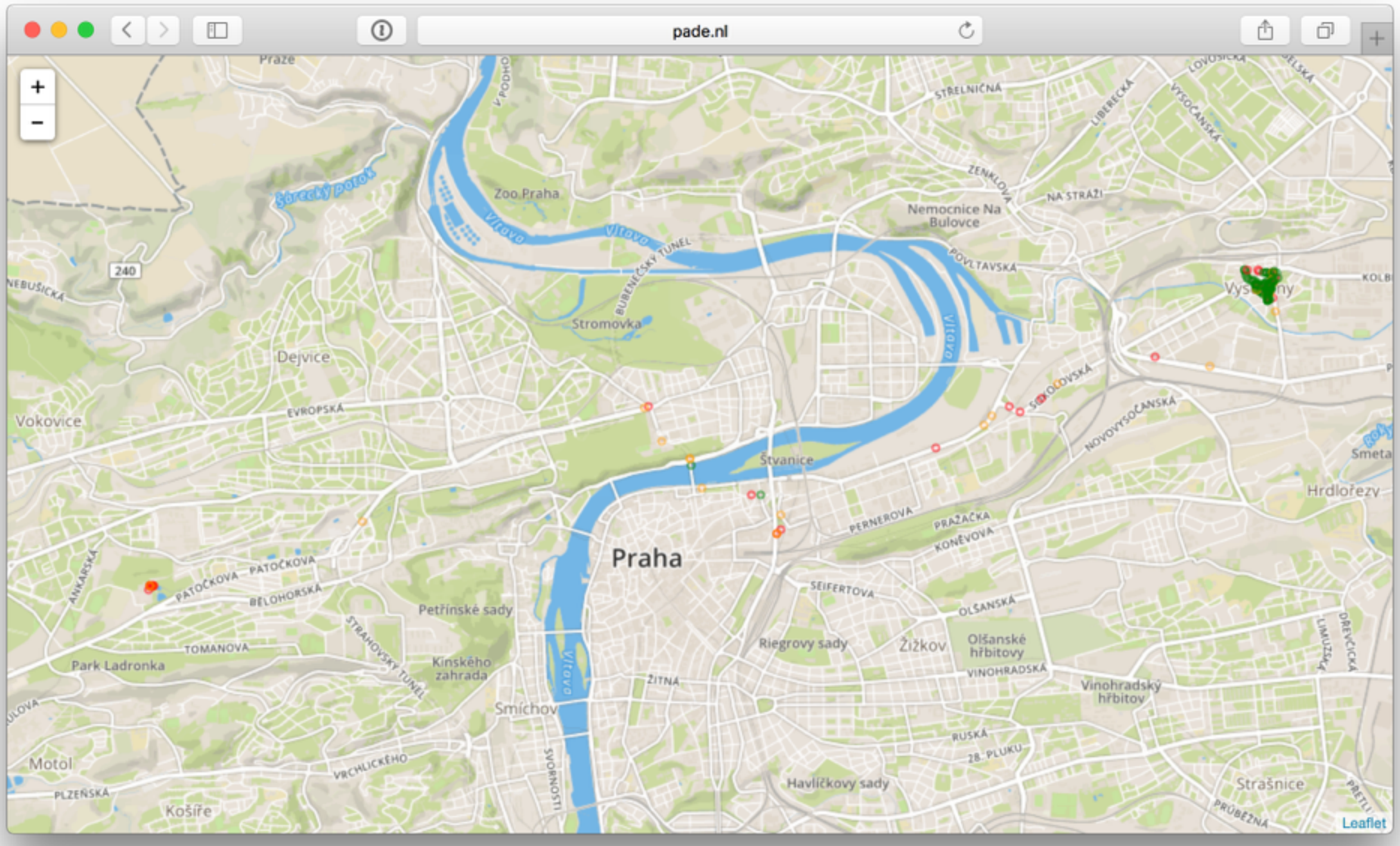
Gateway AA555A00080605B7 'De Uithof' Utrecht, The Netherlands

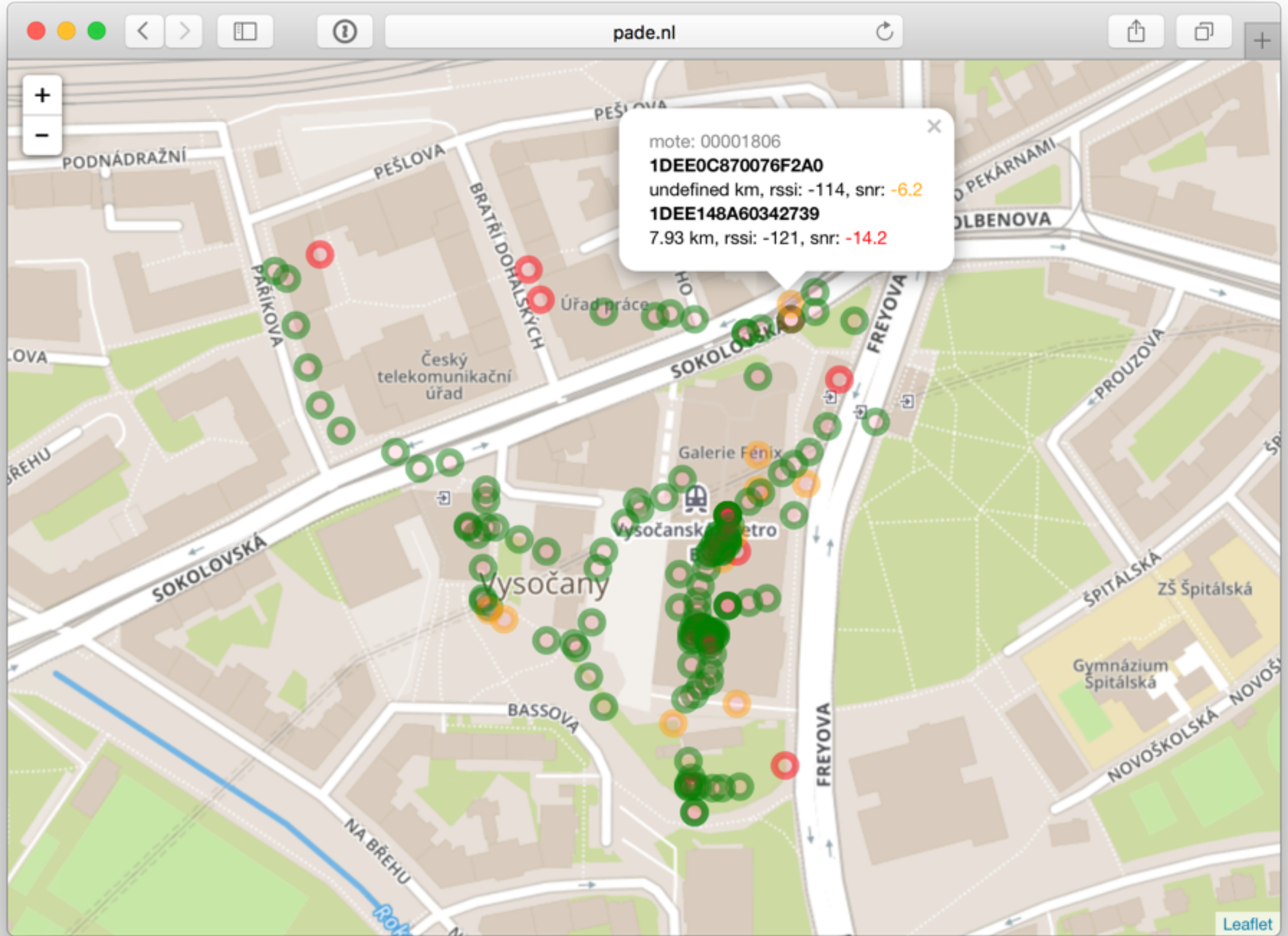


Green > -112dBm
Yellow > -127dBm < -112 dBm



ook metingen in Eindhoven... ;-)


pade.nl
Praha
Zoo Praha
Vltava
Šárecký potok
Stromovka
Dejvice
Vokovice
Štvanice
Nemocnice Na Bulovce
Petřínské sady
Kinského zahrada
Park Ladronka
Smíchov
Motol
Košíře
Riegrovy sady
Žižkov
Olšanské hřbitovy
Vinohradský hřbitov
Havlíčkovy sady
Strašnice
Hrdlořezy
Smeta
Leaflet


pade.nl
mote: 00001806
1DEE0C870076F2A0
undefined km, rssi: -114, snr: -6.2
1DEE148A60342739
7.93 km, rssi: -121, snr: -14.2
PODNÁDRAŽNÍ
PEŠLOVA
BRATŘÍ DOHALSKÝCH
PAŘÍKOVA
Úřad práce
Český telekomunikační úřad
SOKOLOVSKÁ
FREYOVA
PROUZOVA
Galerie Fénix
Vysočanská metro
Vysočany
ŠPITÁLSKÁ
ZŠ Špitálská
Gymnázium Špitálská
NOVOŠKOLSKÁ
BASSOVA
NA BŘEHU
Leaflet

Applications? The network is there...

vacuum pump

environmental, air-quality, noise

asset-management

CO2 in lecture rooms

dikes

digital seal

cleaning-cart

trash-containers

earthquakes

smart meters

maintenance bridges

track OV-bike usage (maintenance)

traffic

overstroming

building mgmt

trains

fridge researchers

streetlights

parking spots

leakage

water plants

track wildlife

Biologisch

https://map.flood.network

Paul

https://map.flood.network

Flood Network

Live River Levels (Beta)

HOME JOIN

Godstow Lock

Eynsham Lock

Minns Estate

New Botley

Wareham Stream

Cherwell

Osney

Osney Lock

Folly Bridge (Thames)

Whitehouse Road Basement

Eastwyke (Hogacre)

22:00 Jan 31 now

every 4 hours

now

NOMINET

Oxford

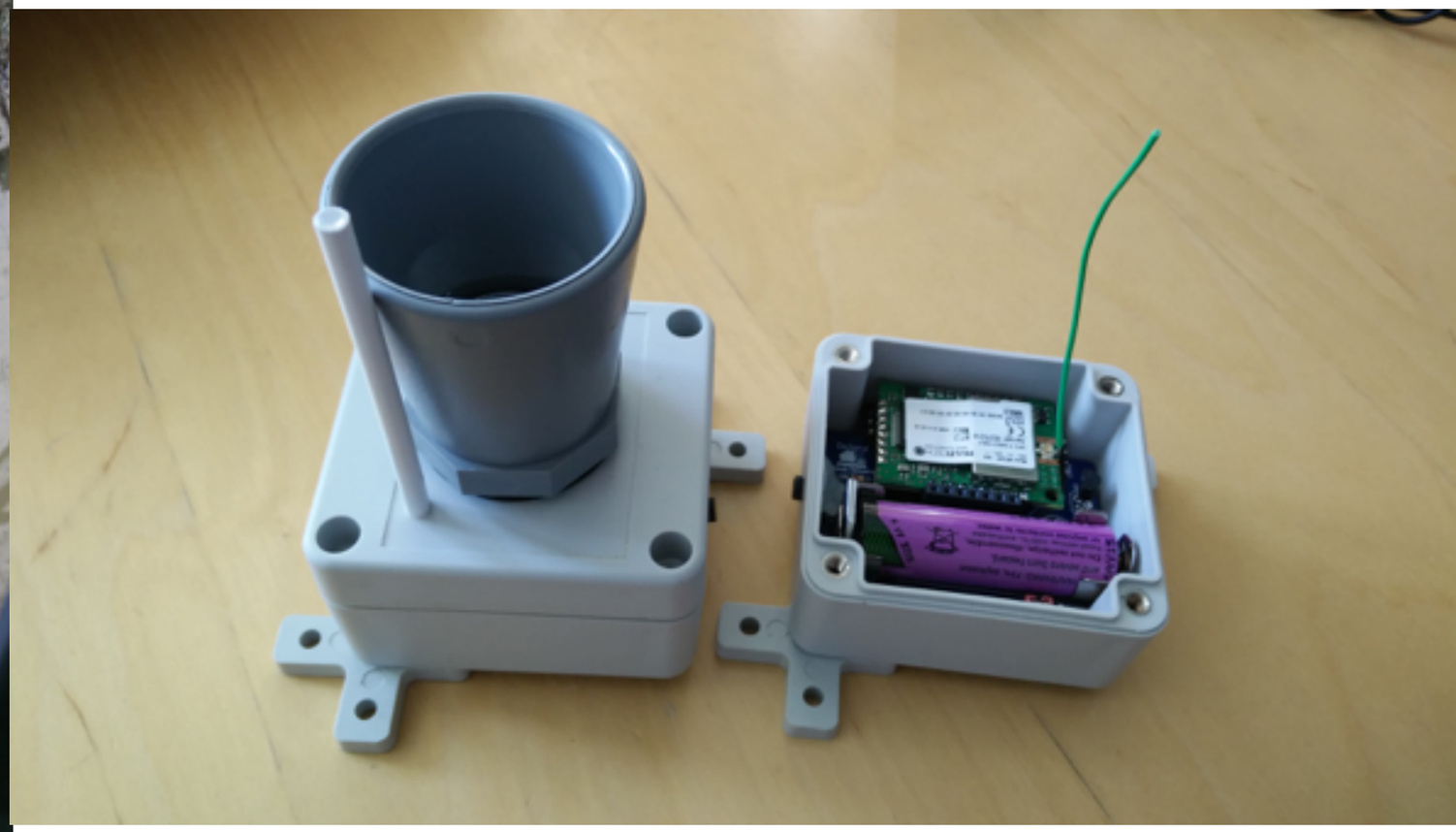
Could you become a flood watcher? x

Find out more

Sources

© Mapbox © OpenStreetMap

Legend High water Low No data Our sensor EA sensor



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LoRa, the Internet of Things

Paul Dekkers Internet of Things, IoT, LoRa, LoraWAN 25 JAN 2016

Previous post Next post

‘Things’ online

We are constantly surrounded by things; as far as I am concerned, there is no need for them to be online all the time – although I wouldn’t have minded if my fridge had let me know there was still some old bread in the freezer compartment. Come to think of it, quite a few things in life might be better if they were online: just take a walk through the city and you’ll see full waste containers, half submerged boats, parking spaces, bicycles, lantern posts. The air quality in some places also seems a bit suspect, and could certainly do with the odd measurement. I also keep running into more amusing and useful ‘Internet-of-things’ applications developed by LoRa users, such as beehive monitoring systems.

Tag Cloud

App MOLGENIS learning feedback network management IaaS OAuth IDP

Blogs

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- Cloud »
- Security & Privacy »
- Mobile & Wireless »
- SURFnet corporate »

SURFnet
@SURFnet

RT @raoulteeuwen: Hands-on LoRaWAN workshop @SURFnet door @pauldekkers

and SURFnet / NRENs?

- Collaborate with The Things Network
  - create infrastructure connected to NREN, eduGAIN / SURFconext
  - collaborate to create open courseware (future MOOC)

and SURFnet / NRENs?

- Workshops, share knowledge, collaborate
- Gateways at some institutions: applications and coverage on campuses, challenge use
- eduroam monitoring sensor, report via LoRaWAN
- Strong authentication, not connected 2nd factor
- **How do we help researchers, lecturers, students, ...?**

Questions?

paul.dekkers [at] surfnet.nl