

IoT & LPWAN in R&E

**Sebastian Büttrich, NSRC / IT University of Copenhagen, Kampala
20200219**



IoT & LPWAN

Research &

Education

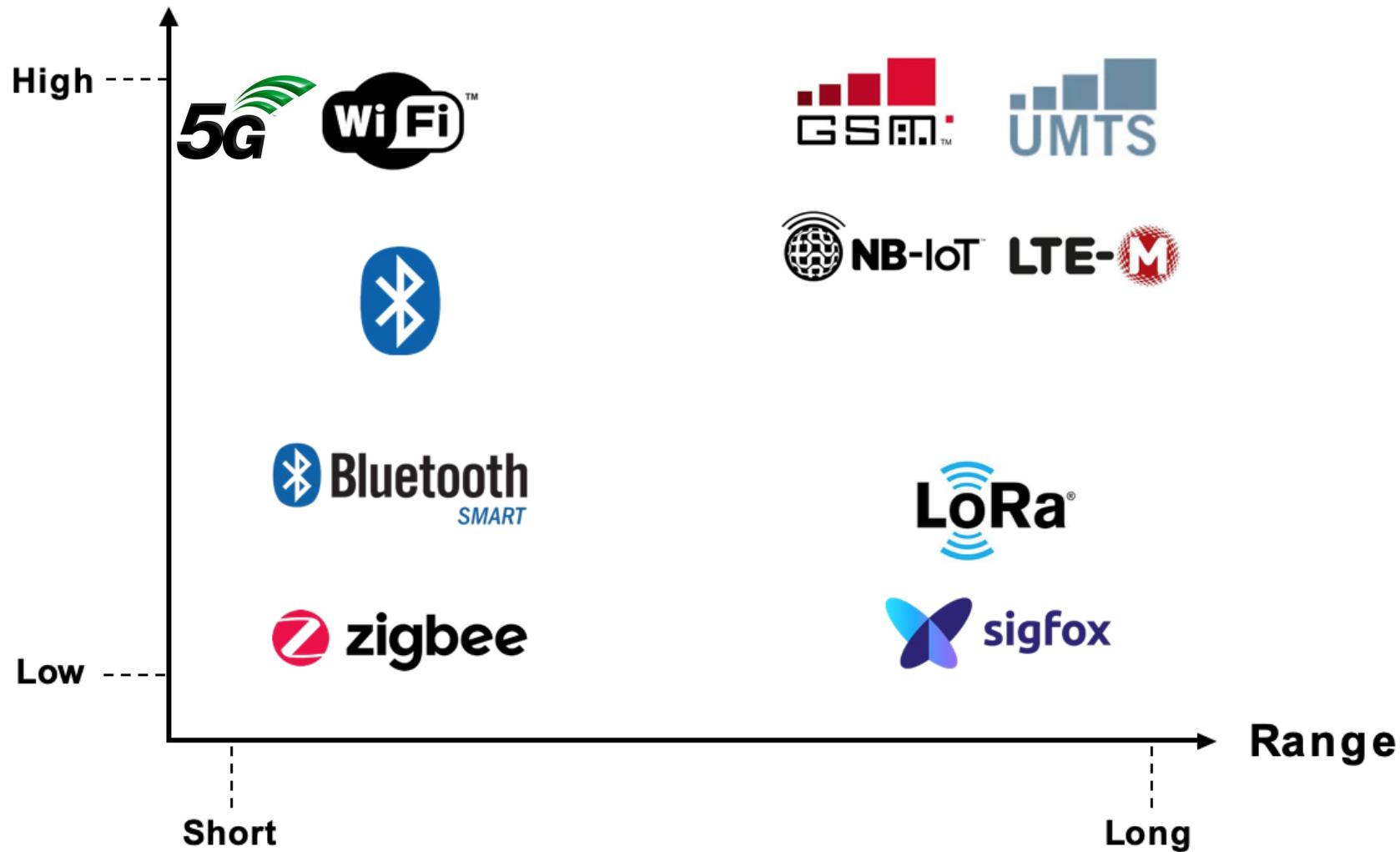


icons:

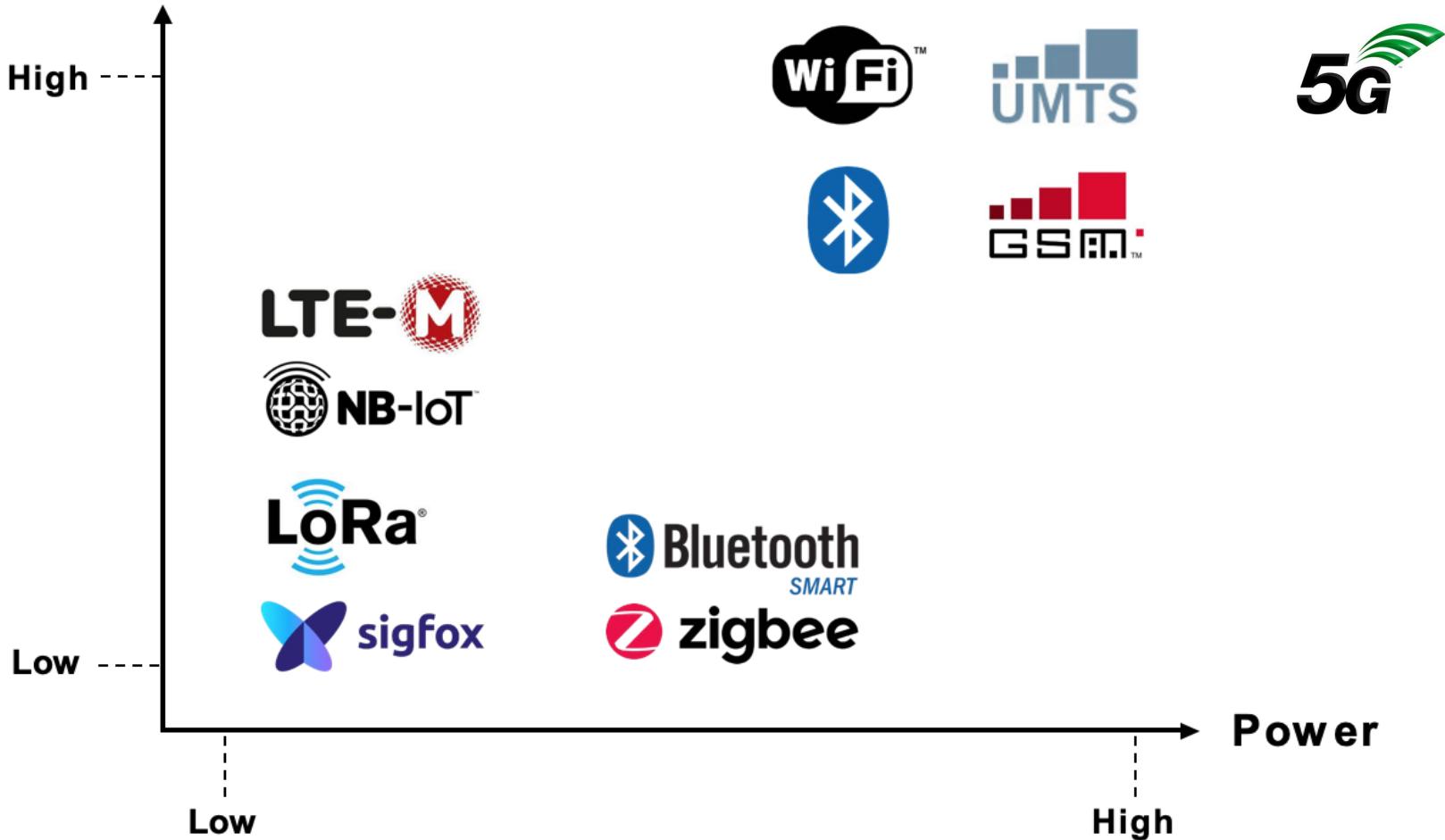
Watch by la-fabrique-créative from the Noun Project &

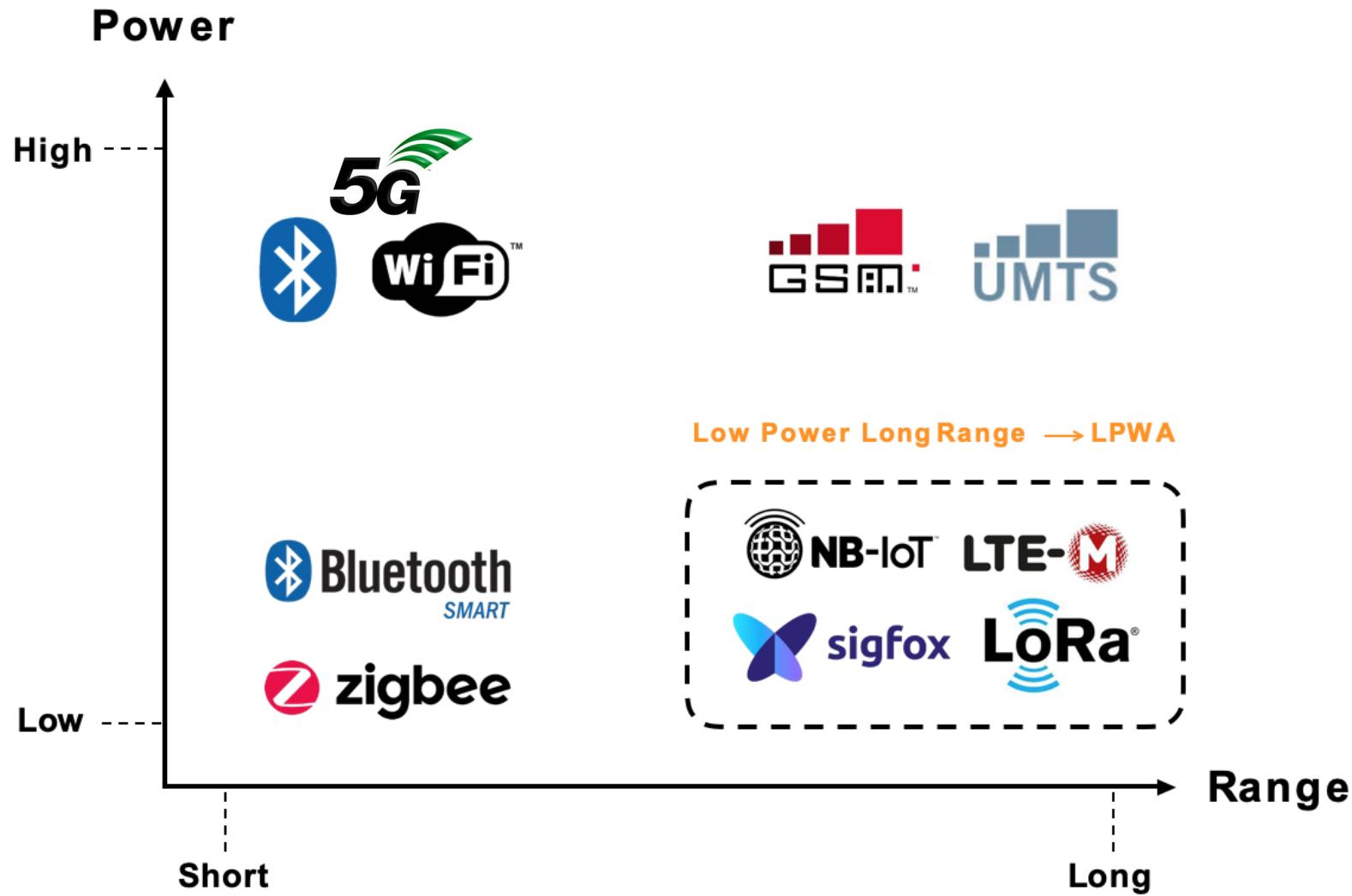
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Data Rate



Data Rate





Low Power Wide Area Networks (LPWAN):

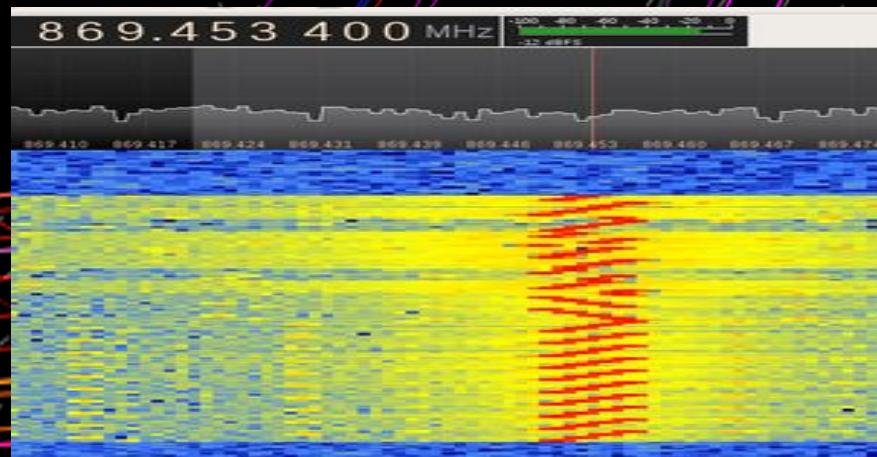
Long Range
Low Power
Low Cost

Small Data

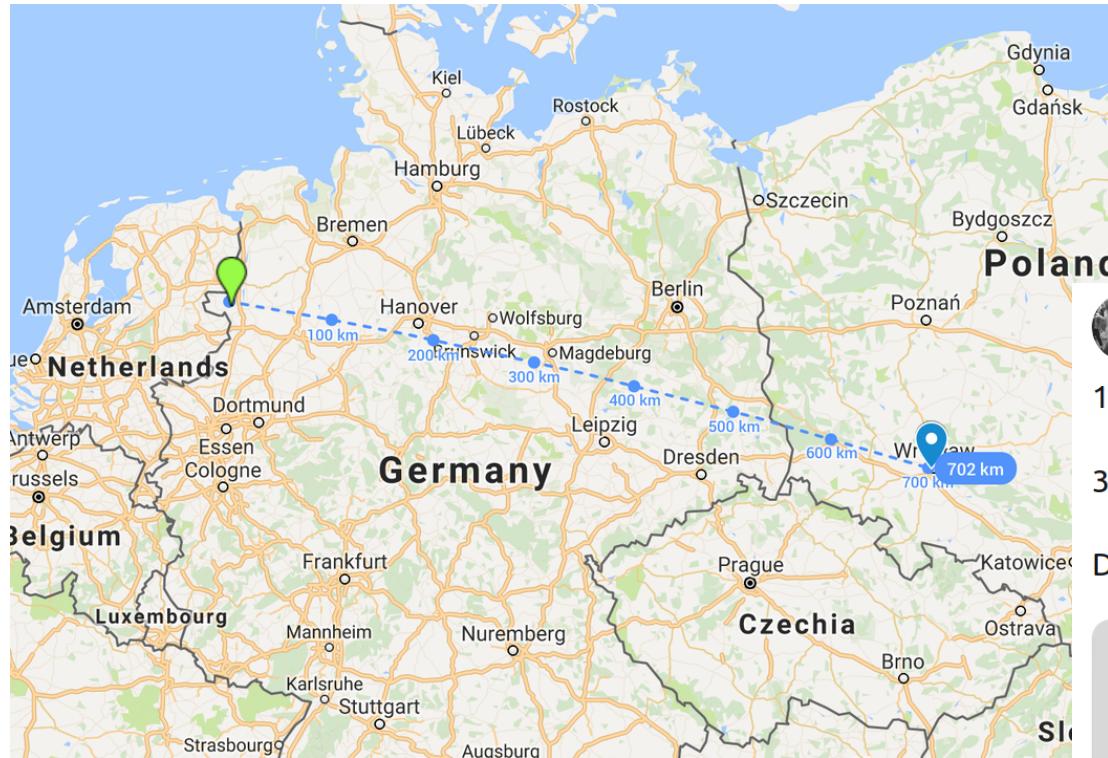
Why do LPWANs excel at long range?

Higher sensitivity (< -140 dBm)

(about 4-5 powers of ten
more sensitive than mobile or Wi-Fi)



About Range - LoRa World Record(s)

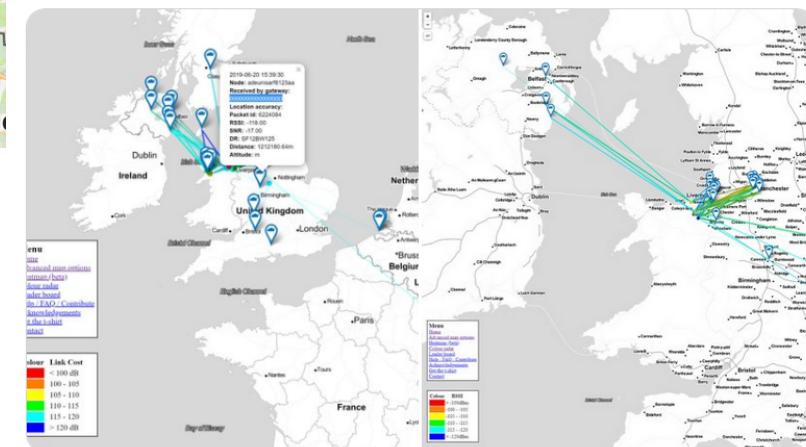


John Cassidy (M7DXO)
@JohnCassidyGB

1212km (SF12) from England to Italy.

385km (SF7) from Wales to England.

Done on [@adeunisrf](#) and [@pycomIOT](#) devices.



Terrestrial & with balloon: 766 km (maybe 1212 km)
Satellite record: 71,572 km (Outernet, 2019)

LPWAN - LoRa World Record(s)

John Cassidy (M7DXO)
@JohnCassidyGB

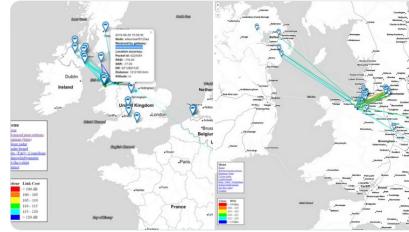
1212km (SF12) from England to Italy.

385km (SF7) from Wales to England.

Done on @adeunisrf and @pycomIoT devices.



14 dBm / 25 mW! pycom gear



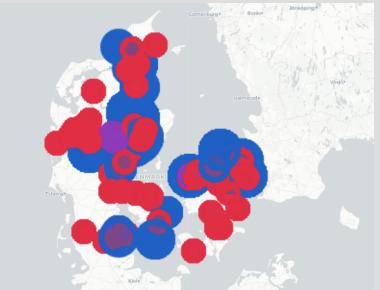
Low Power Wide Area Networks

LoRa

Sigfox

LTE-M

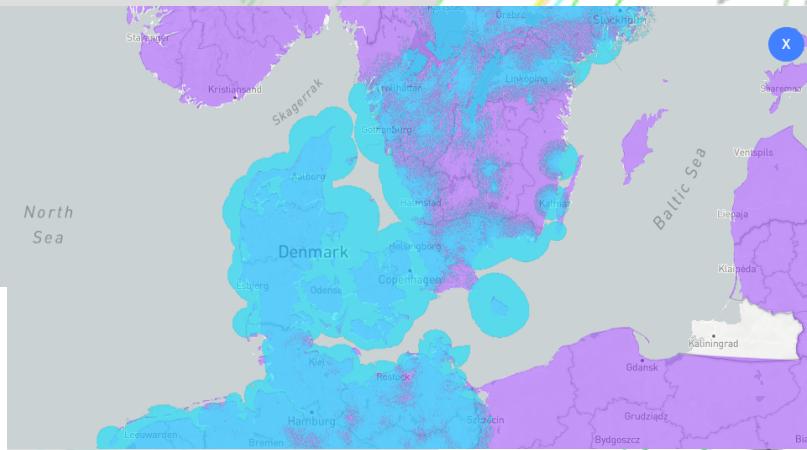
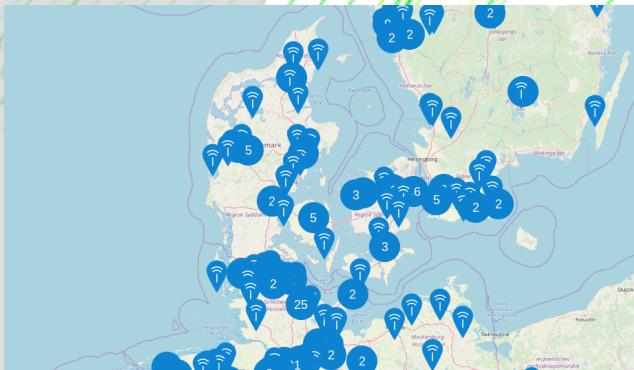
NB-IoT



Coverage comparison of GPRS, NB-IoT, LoRa, and SigFox in a 7800 km² area

Lauridsen, Mads; Nguyen, Huan Cong; Vejlgaard, Benny; Kovacs, Istvan; Mogensen, Preben Elgaard; Sørensen, Mads

Published in:
2017 IEEE 85th Vehicular Technology Conference (VTC Spring)



Coverage is a secret .

COMPARISON – main LPWAN technologies

Feature	LoRAWAN	SIGFOX	LTE Cat 1	LTE M	NB - LTE
Modulation	SS chip	UNB / GFSK / BPSK	OFDMA	OFDMA	OFDMA
Rx Bandwidth	500 – 125 KHz	100 Hz	20 MHz	20 – 1.4 MHz	200 KHz
Data Rate	290bps – 50Kbps	100 bit / sec 12 / 8 bytes Max	10 Mbit /sec	200 kbps – 1 Mbps	Average 20K bit / sec
Max. # Msgs/day	Unlimited	UL: 140 msgs / day	Unlimited	Unlimited	Unlimited
Max Output Power	20 dBm	20 dBm	23 – 46 dBm	23/30 dBm	20 dBm
Link Budget	154 dB	151 dB	130 dB+	146 dB	150 dB
Battery lifetime – 2000 mAh	105 months	90 months		18 months	
Power Efficiency	Very High	Very High	Low	Medium	Med high
Interference immunity	Very High	Low	Medium	Medium	Low
Coexistence	Yes	No	Yes	Yes	No
Security	Yes	No	Yes Oui	Yes	Yes
Mobility / localization	Yes	Limited mobility, No localization	Mobility	Mobility	Limited mobility, No localization

Source: LoRAWAN Alliance, 2015

www.vertical-m2m.com

Source: LoraWAN Alliance, 2015

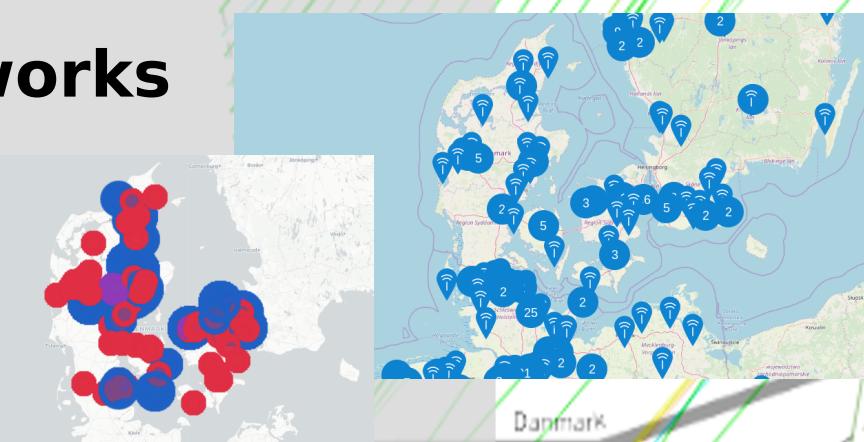
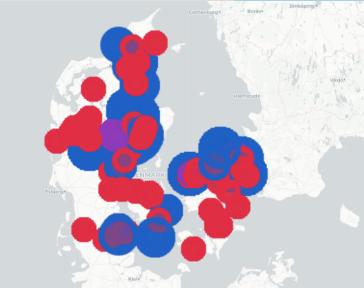
Low Power Wide Area Networks

Markets?

Metrics?



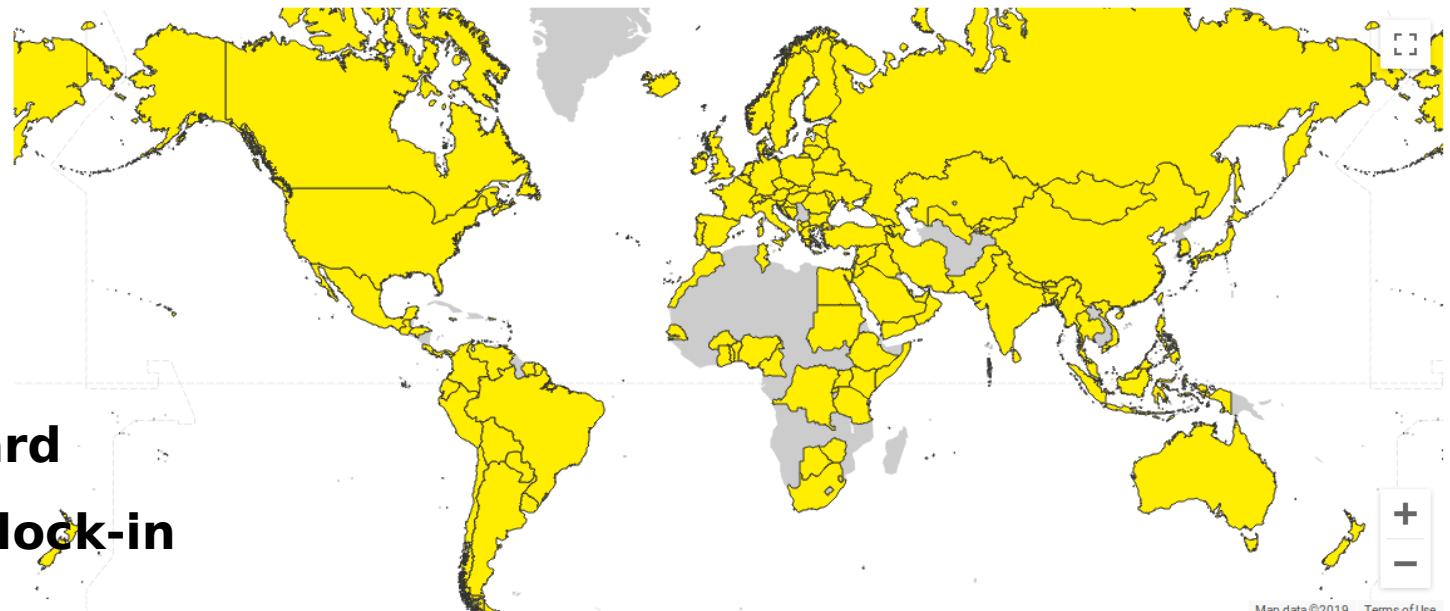
Decisions are not
technology-driven!



142 Countries with
LoRaWAN® Deployments**121** Network Operators in
58 countries**76** LoRa Alliance®
Member OperatorsLoRaWAN®
Global Network CoverageLoRaWAN®
Public Network OperatorsLoRaWAN®
Open Community NetworksLoRaWAN®
Network System Integrators

Why LoRaWAN for us?

- Open standard
- No provider lock-in
- DIY
- Learn on one LPWAN, apply anywhere



Map data ©2019 Terms of Use



The Things Network



**THE THINGS
N E T W O R K**



Anyone shall be [free](#) to set up "Things" and connect to "Things Gateways" that may or may not be their own.

Anyone shall be [free](#) to set up "Things Gateways" and connect to "Things Access" that may or may not be their own. Their "Things Gateways" will give [[free](#)] access to all "Things" in a net neutral manner, limited by the maximum available capacity alone.

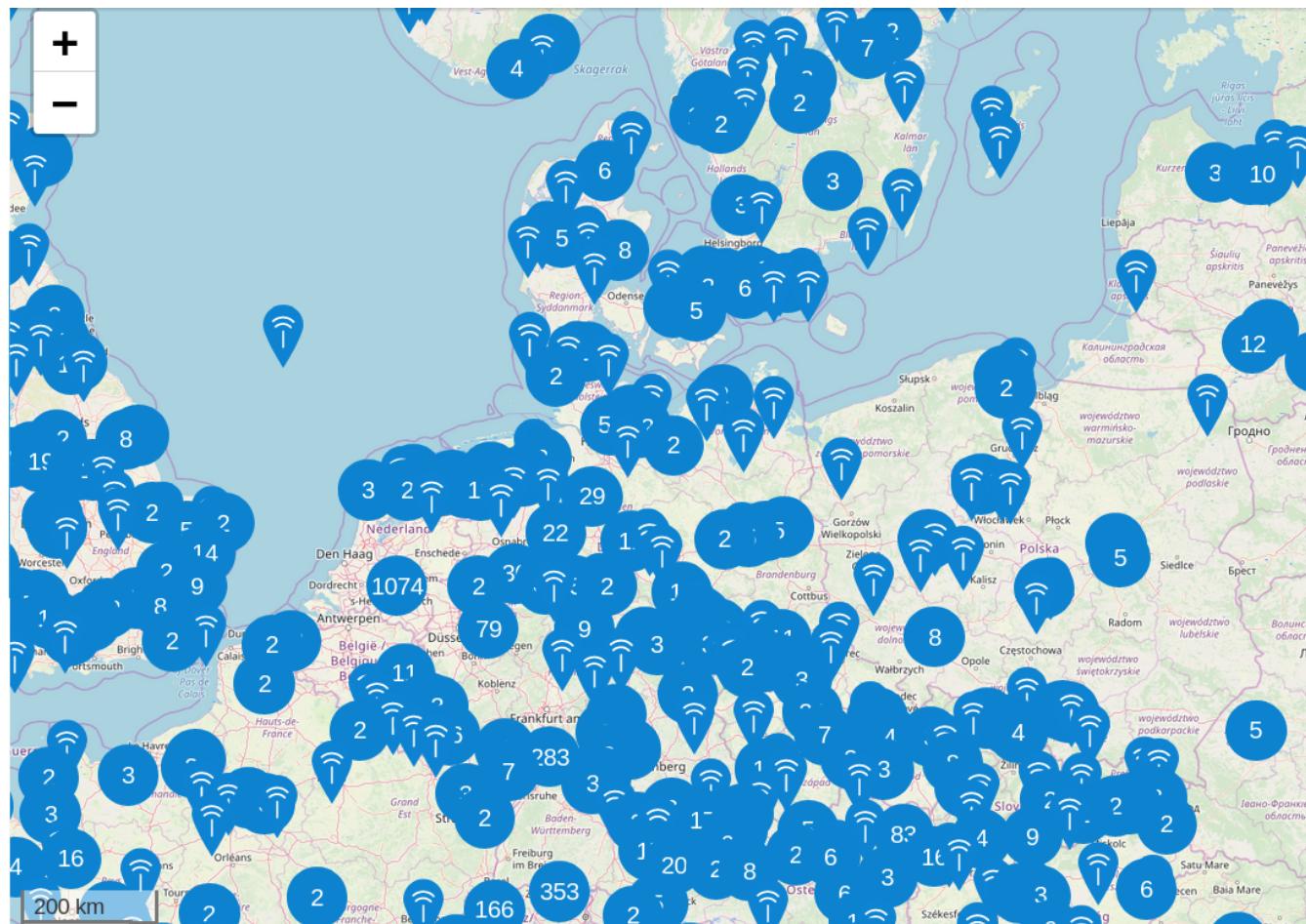
The Things Network / World

[Communities](#)[Learn](#)[Support](#)[Forum](#)[Marketplace](#)[Sign Up](#)[Login](#)

At this moment, there are 9307 gateways up and running



The Things Network / Central Europe

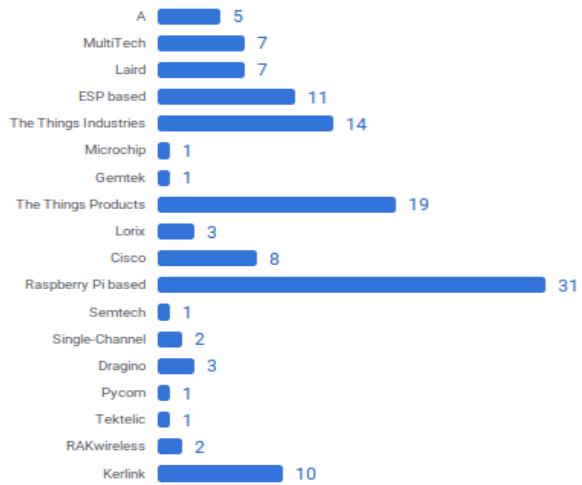




Gateways Total

Updated: 2019-10-28 09:47:26

Gateways DK by Brand



More about ... [The Things Network - TTN Community Copenhagen](#)

More data & analytics: [Ask the PITLab](#)

IoT @ ITU



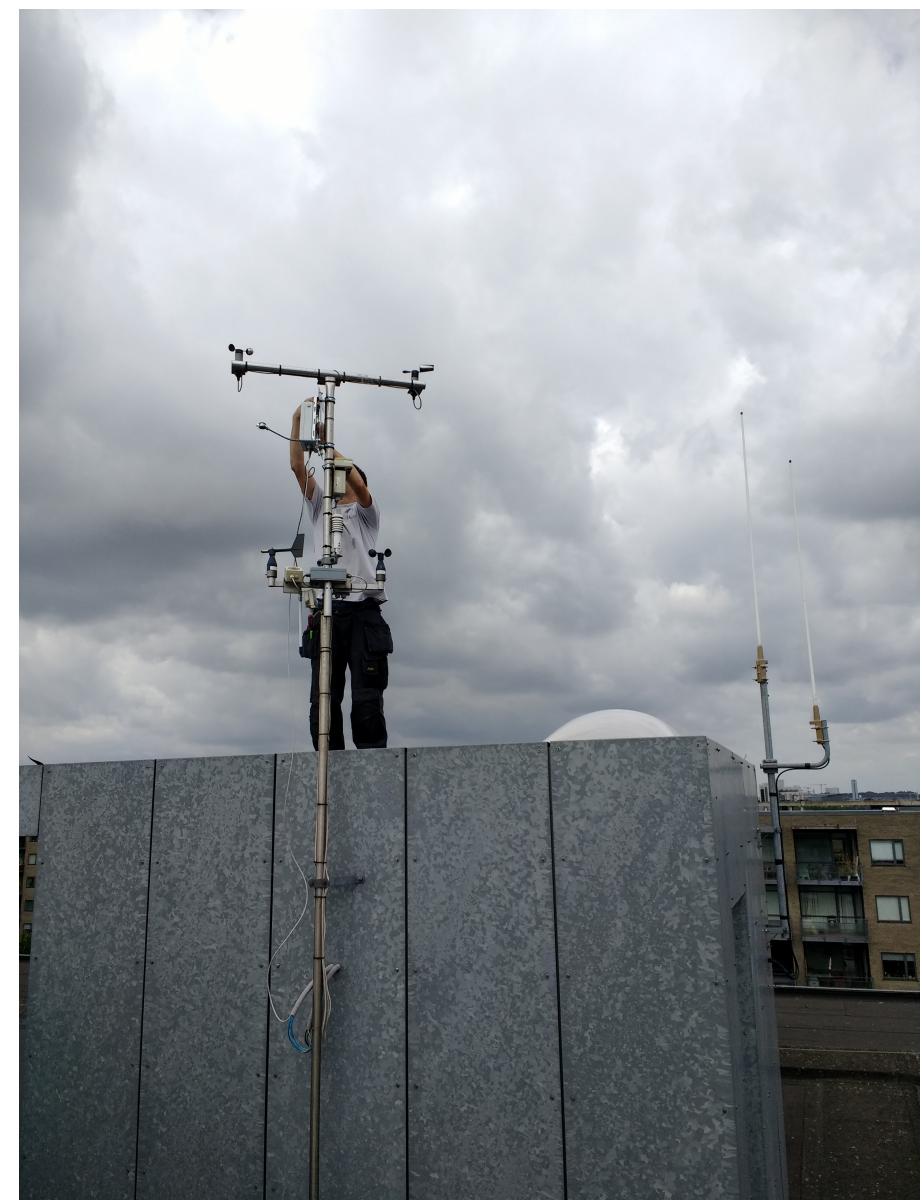
CENTER FOR INFORMATION
SECURITY AND TRUST



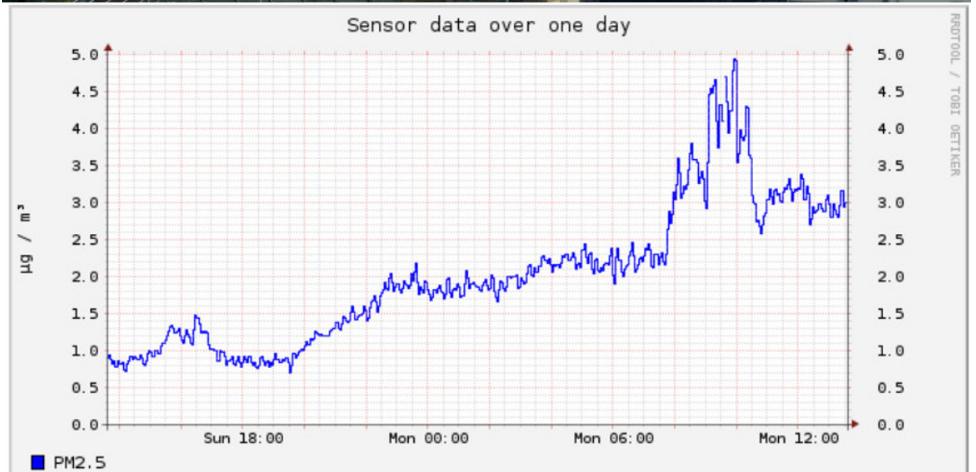
PIT LAB



IoT @ ITU



Air Quality @ ITU

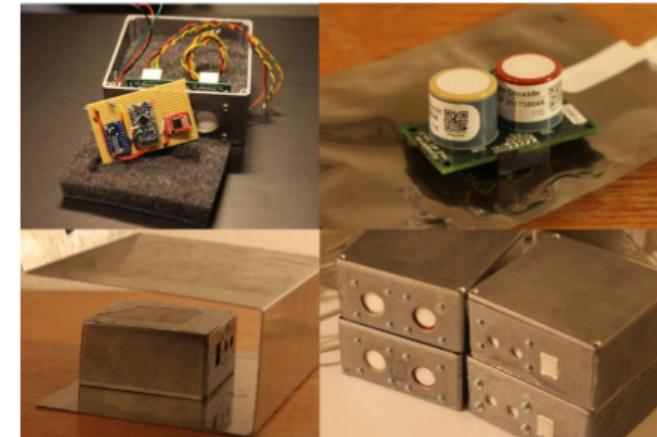
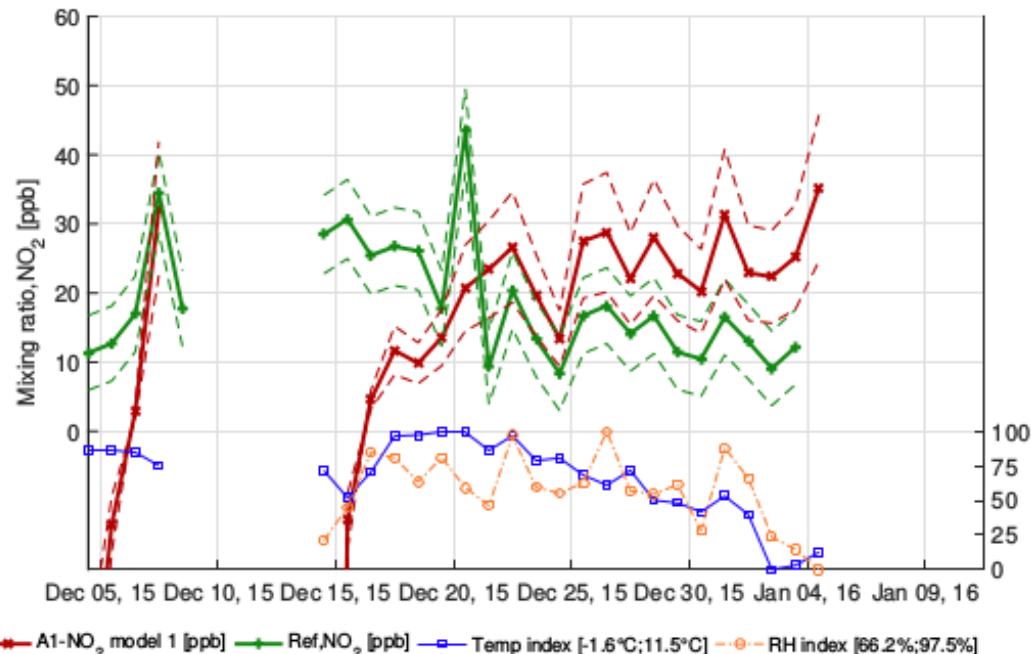


Sensors / Air IX / PITLab & AU - NO₂, PM

- We collaborate with Department of Environmental Science, AU - NO₂ series, calibration, networks, PM sensor collocation at HCAB



IT UNIVERSITY OF COPENHAGEN



Assessing the applicability of low-cost electrochemical gas sensors for urban air quality monitoring

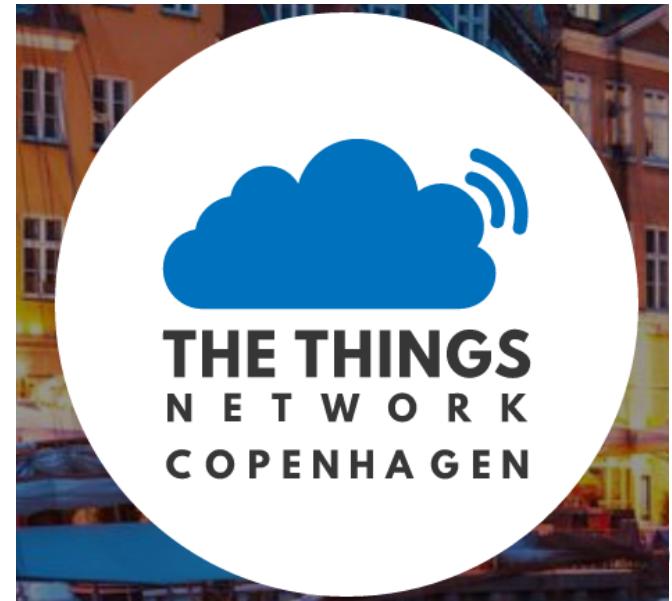
Our choice in IoT:

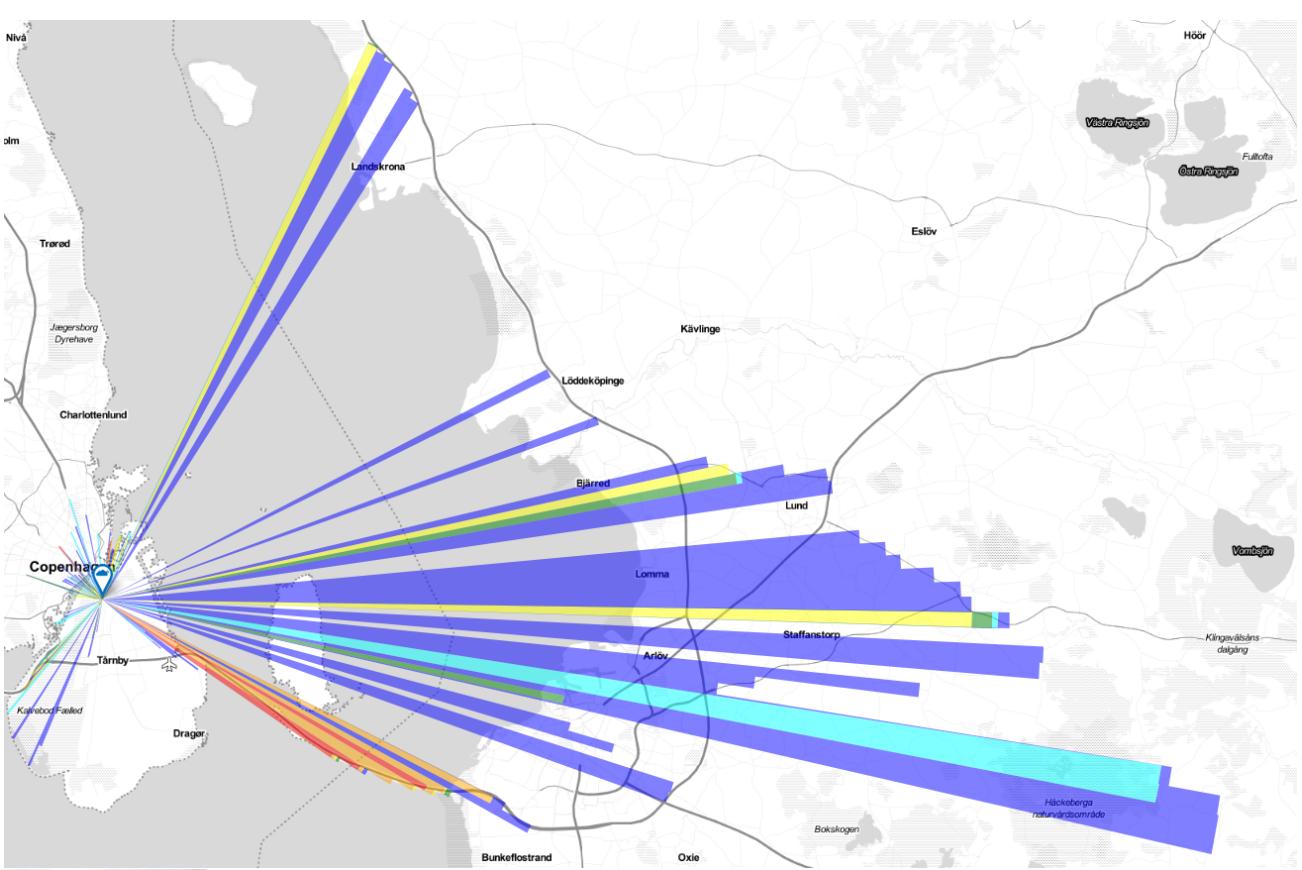
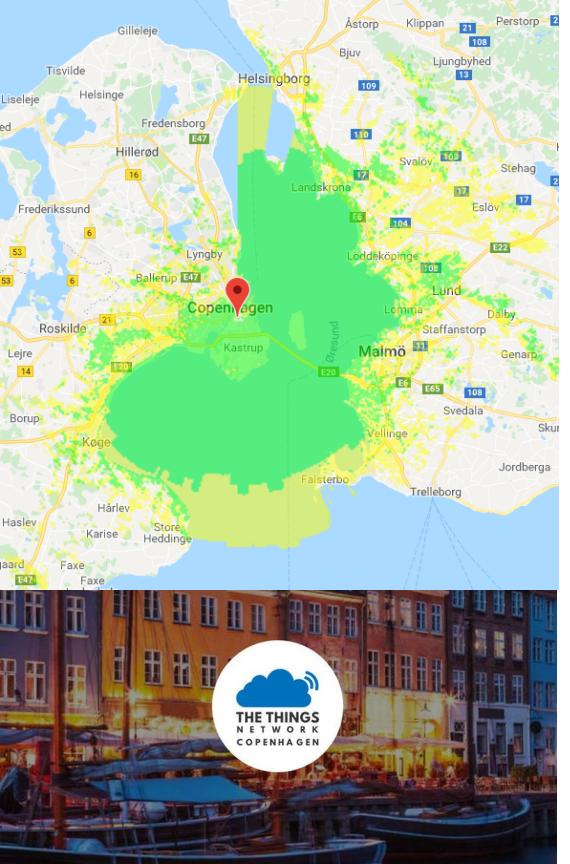
LPWAN

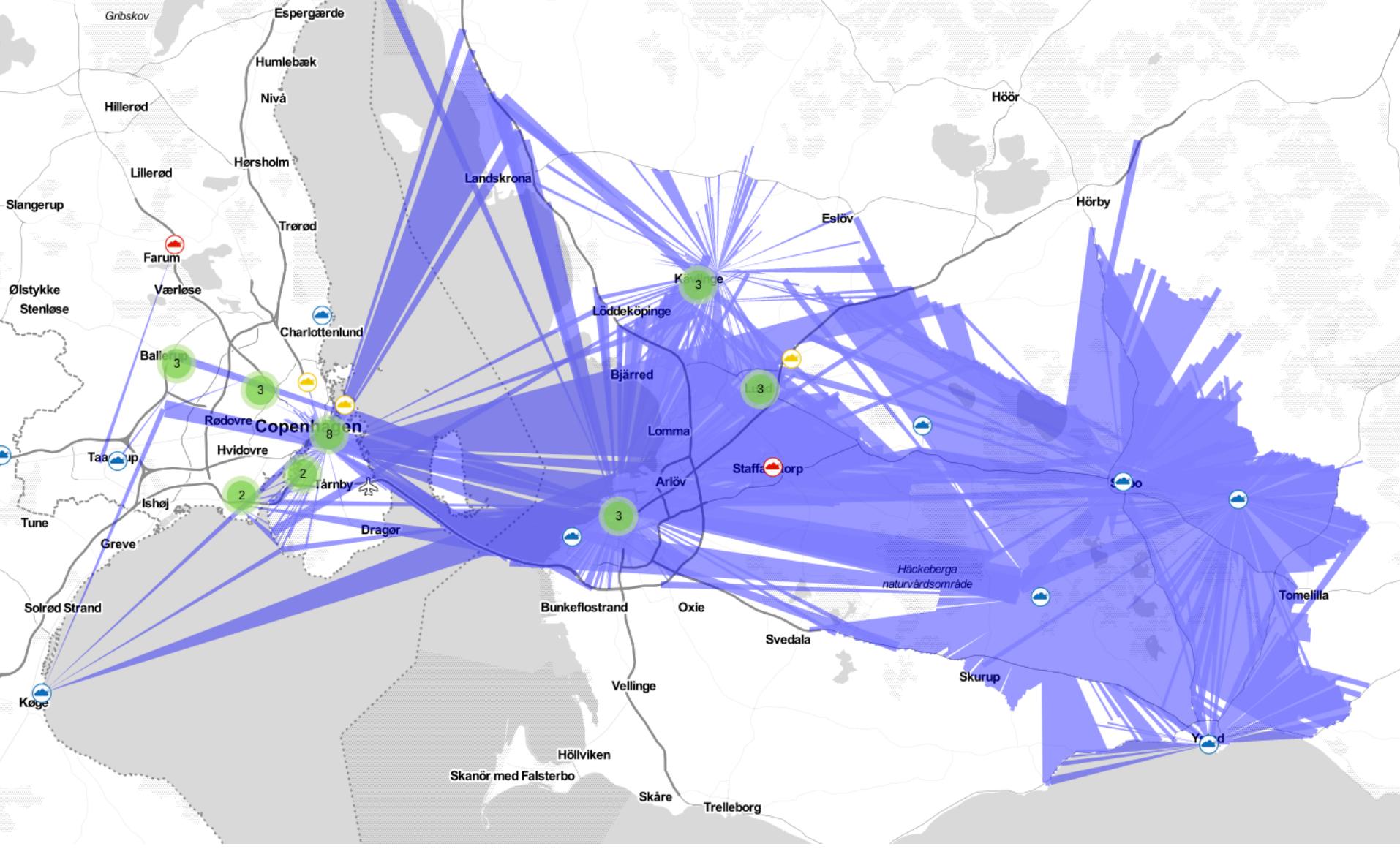
Indenfor LPWAN:

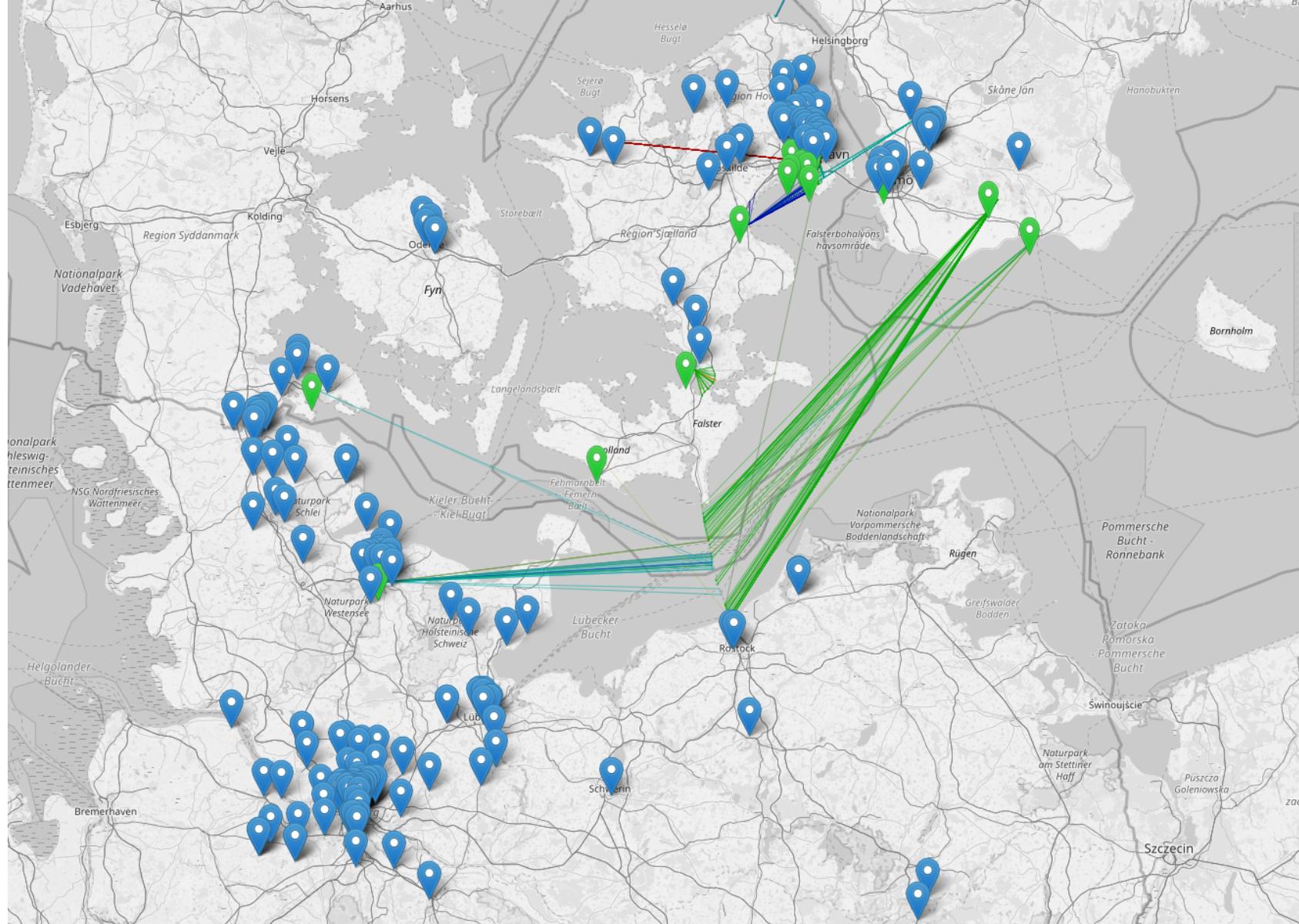
LoRaWAN

The ThingsNetwork

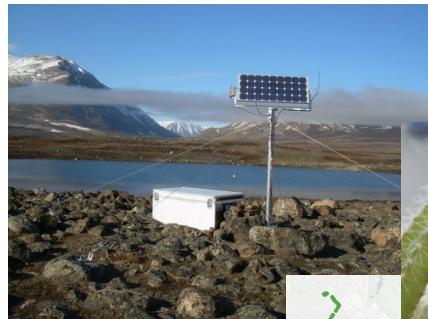




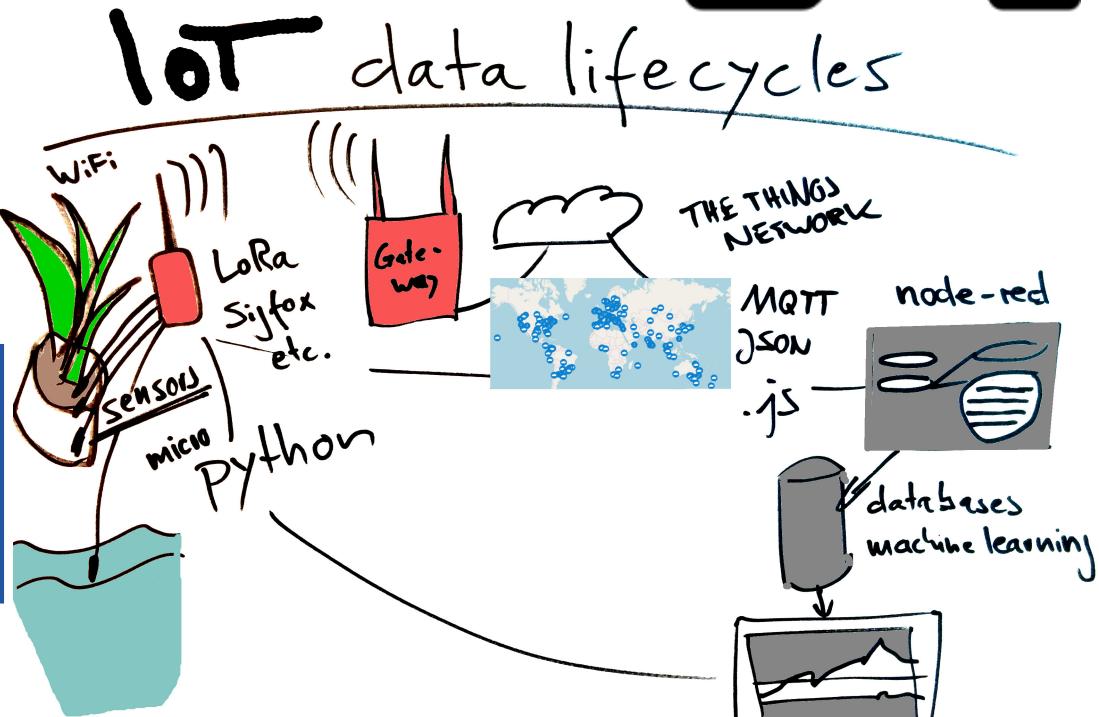




IoT at IT University



IoT, Networks, Data Systems, ML

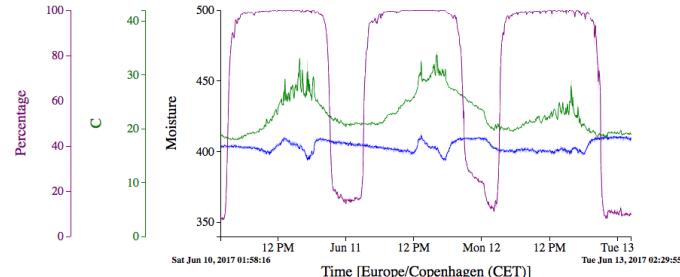


Student Projects: Urban Gardening



Watering System

“Human-Plant Interaction”



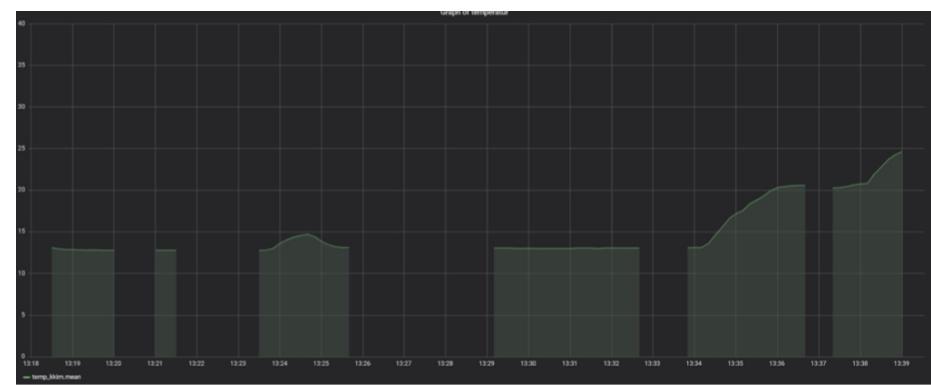
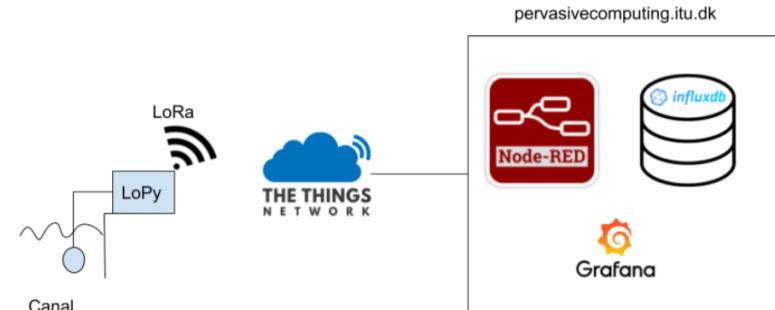
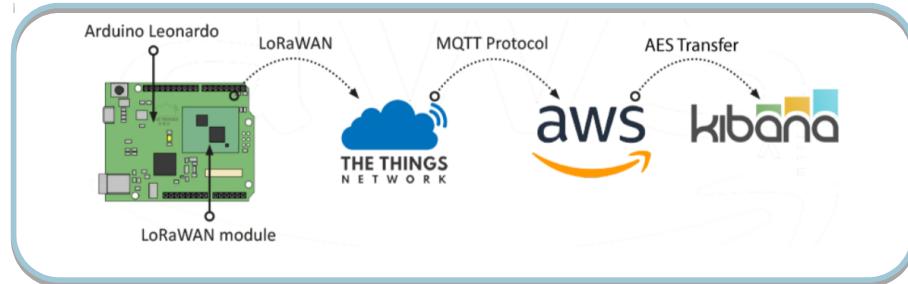
Data Analytics



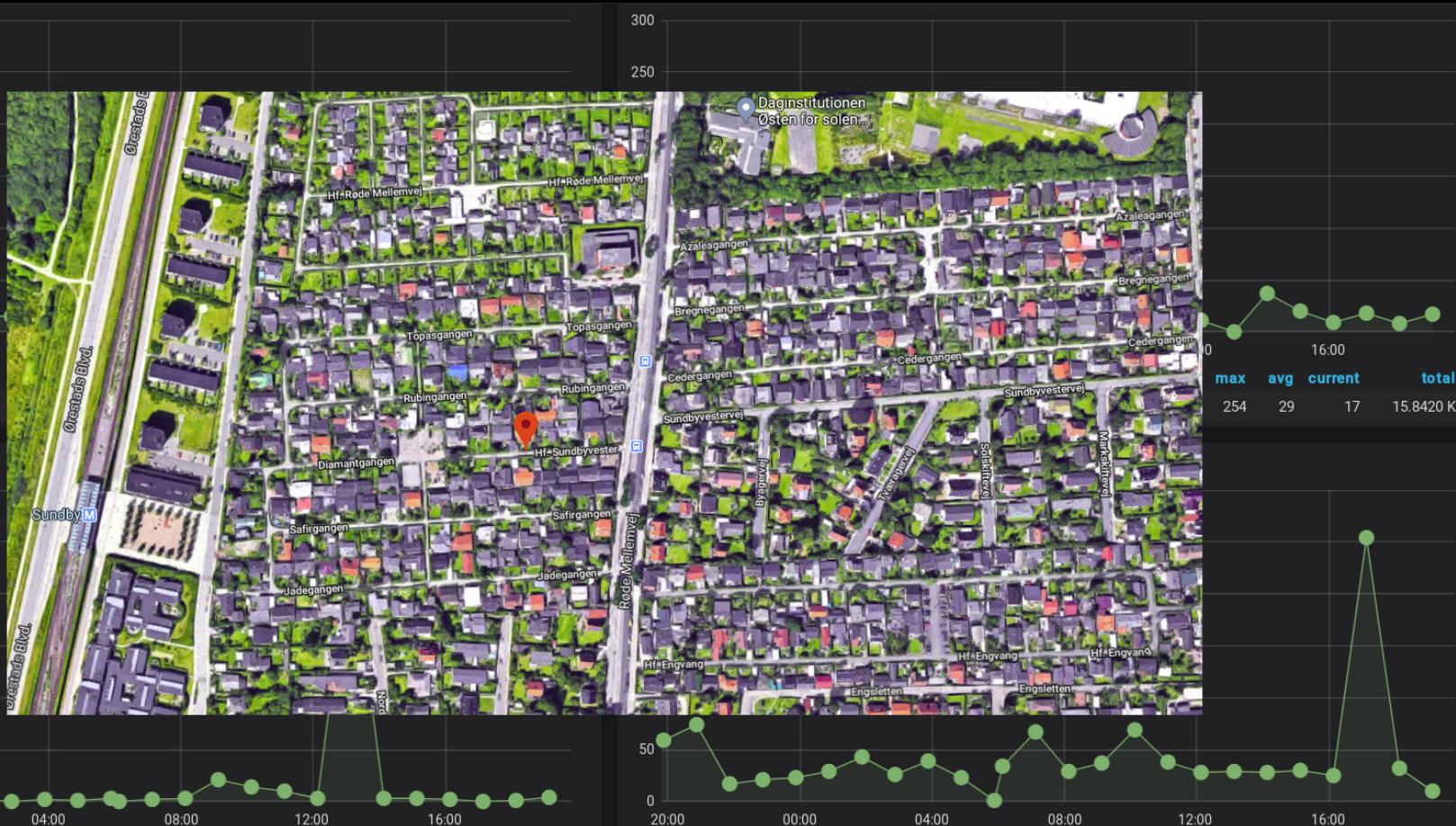
Social Media



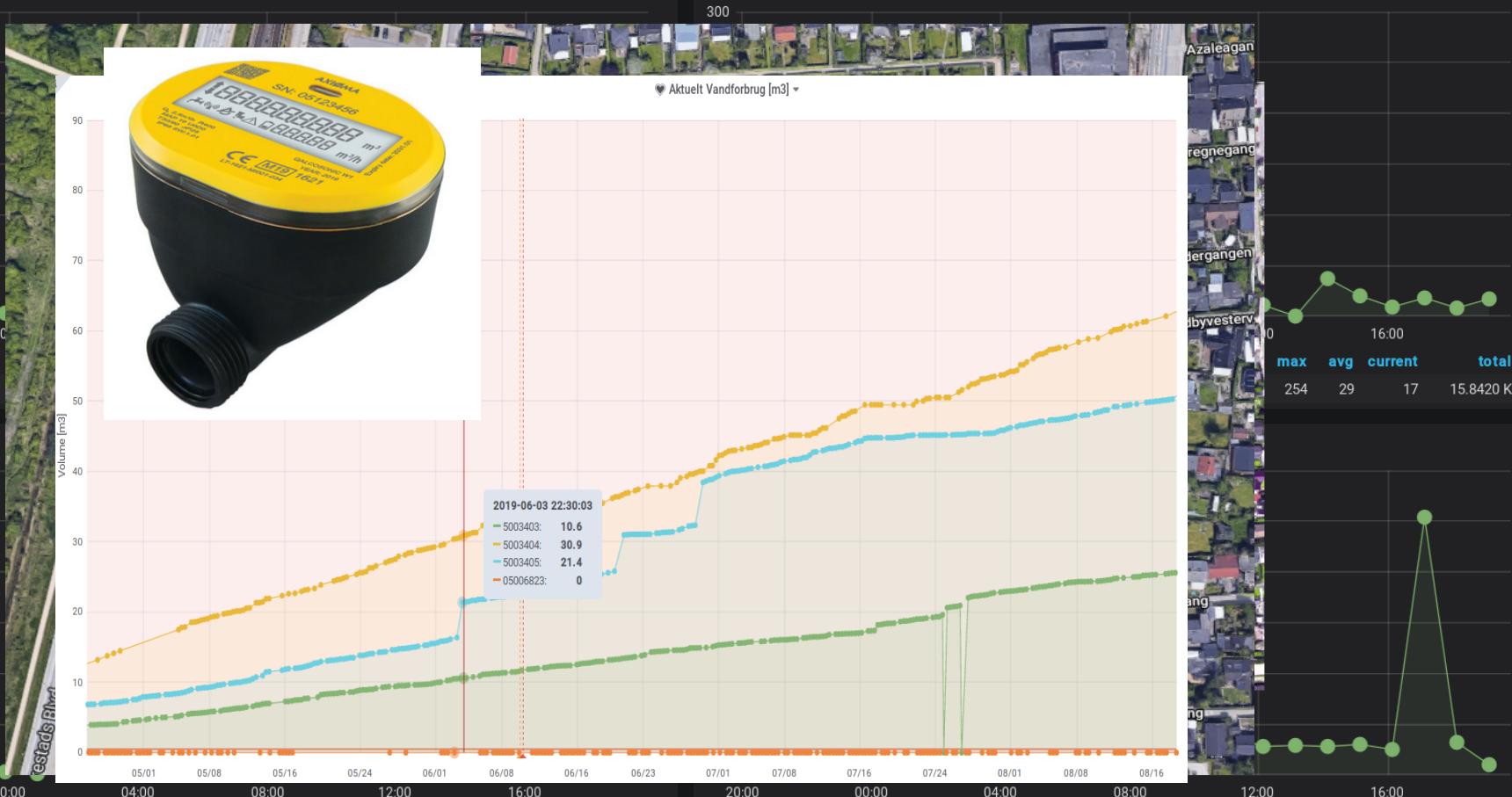
Student Projects: ITU Canal Temperature



Living Lab / Small Smart City: Housing Coop Sundbyvester

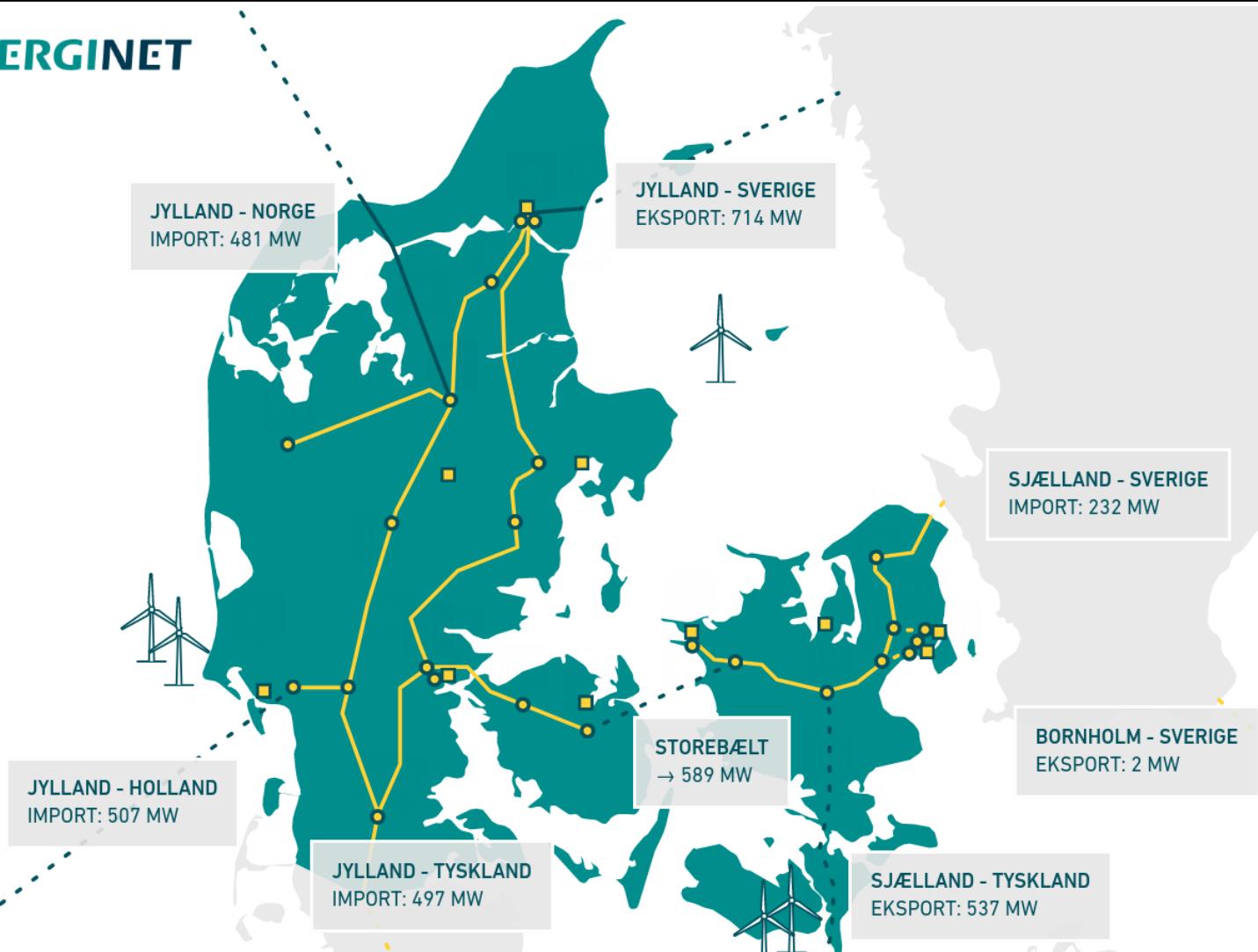


Living Lab / Small Smart City: Housing Coop Sundbyvester



Energy networks and LoRaWAN

ENERGINET



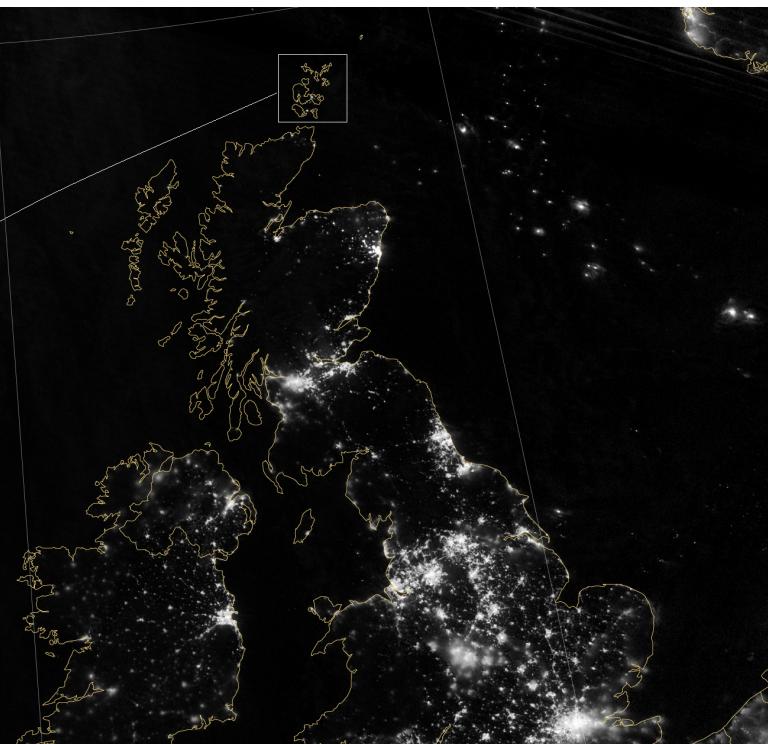
International Research Projects

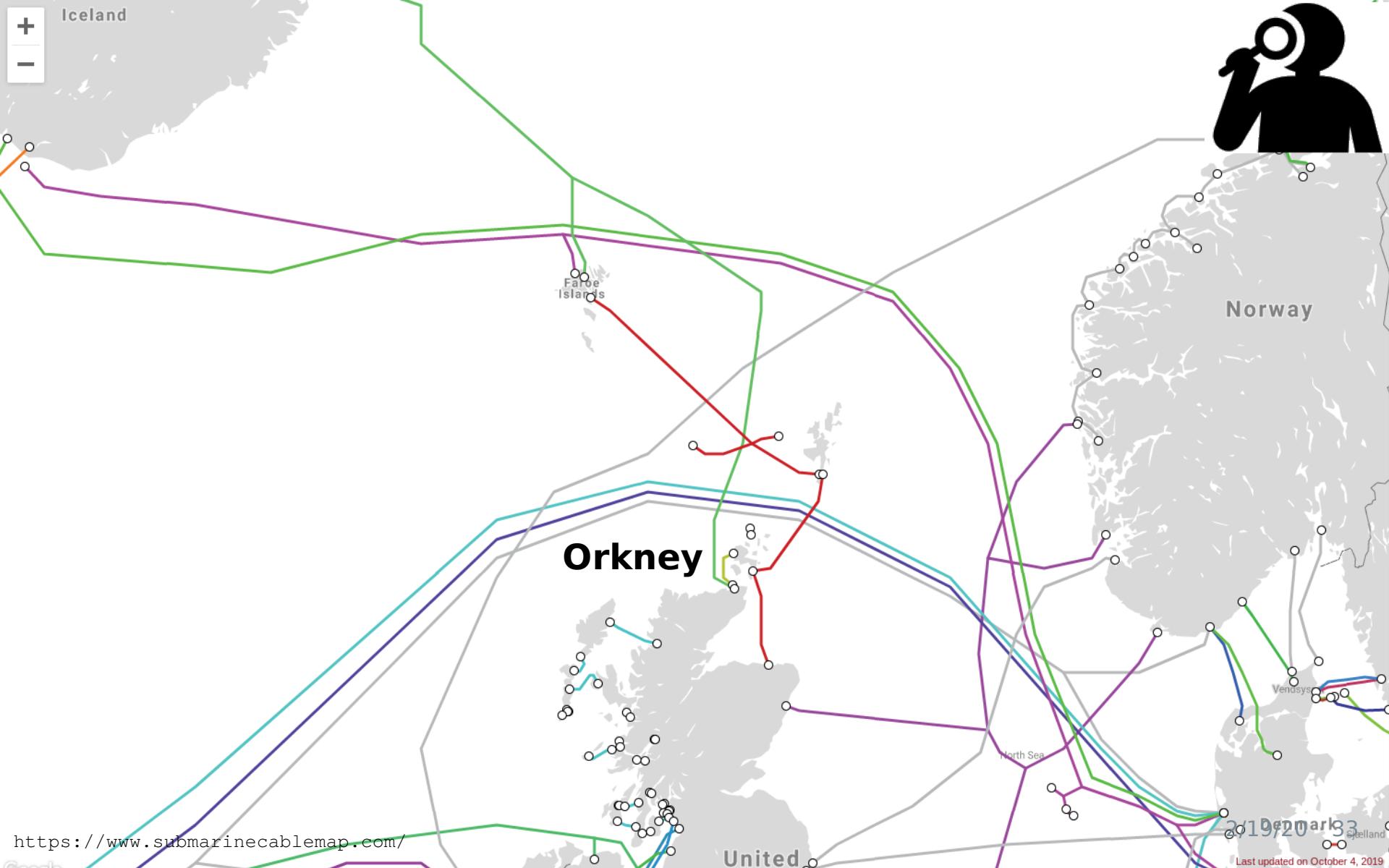


Orkney Cloud

=> Extremely remote networking

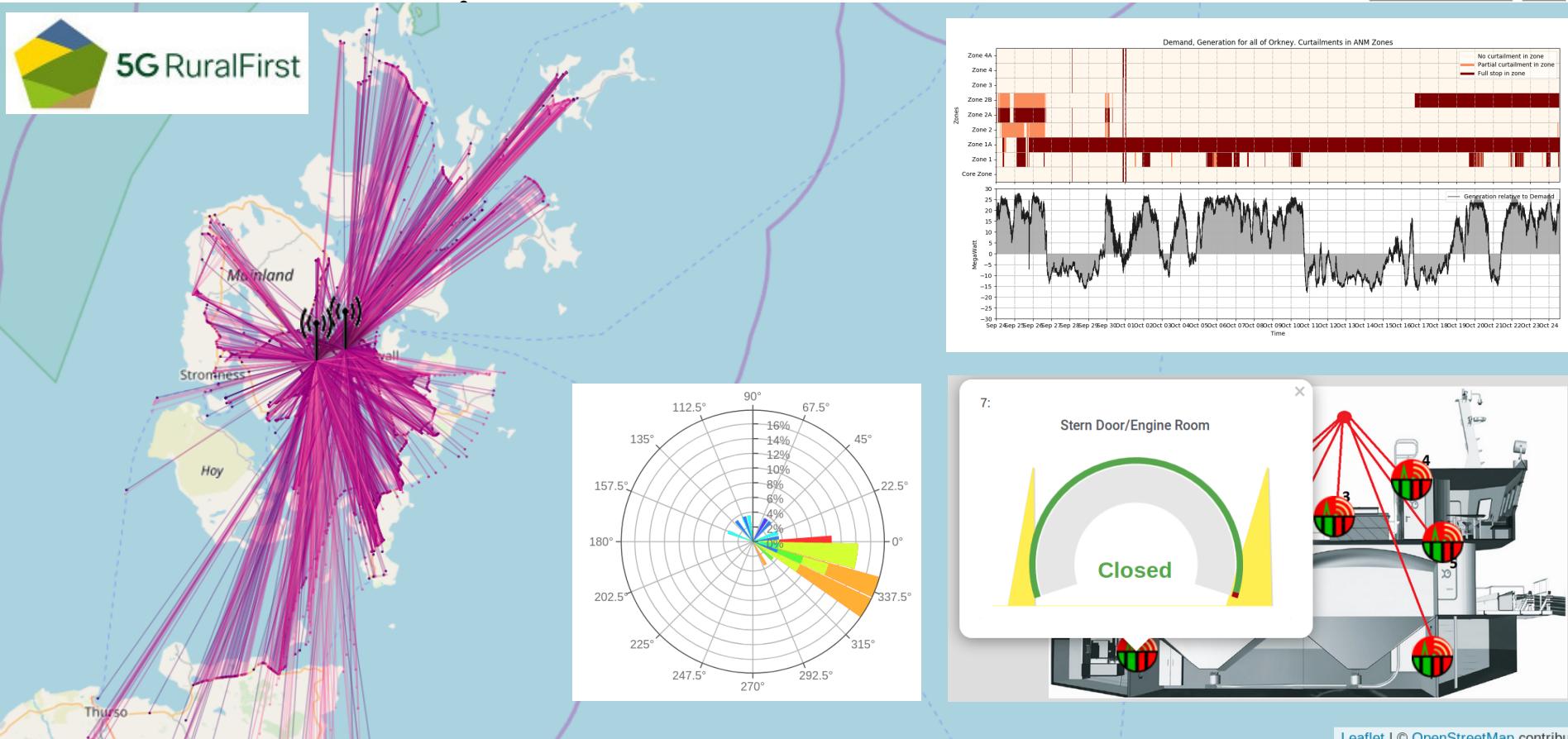
Orkney





International Research Projects

Orkney Cloud, 5GRuralFirst, ReFLEX



International Research Projects



Thailand - LoRaWAN for Air Pollution Monitoring

SEA-HAZEMON@TEIN Workshop on Internet of Things and Air Pollution Monitoring

16 - 20 September 2019, intERLab, AIT, Thailand

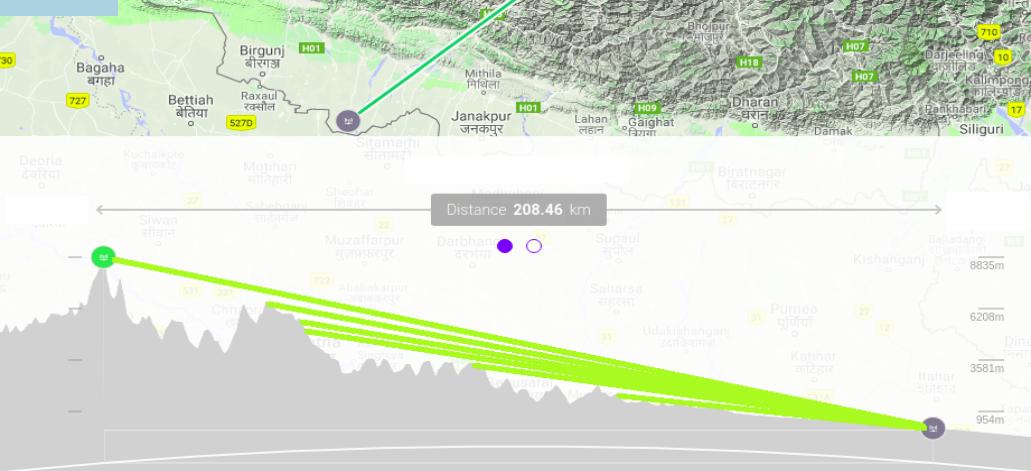
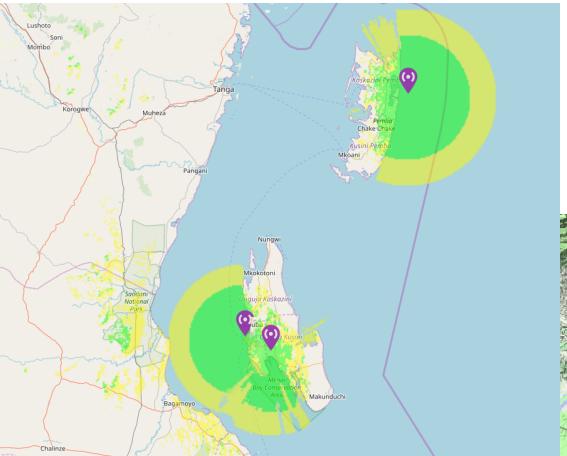


International Research Projects

In preparation:

Nepal

Zanzibar

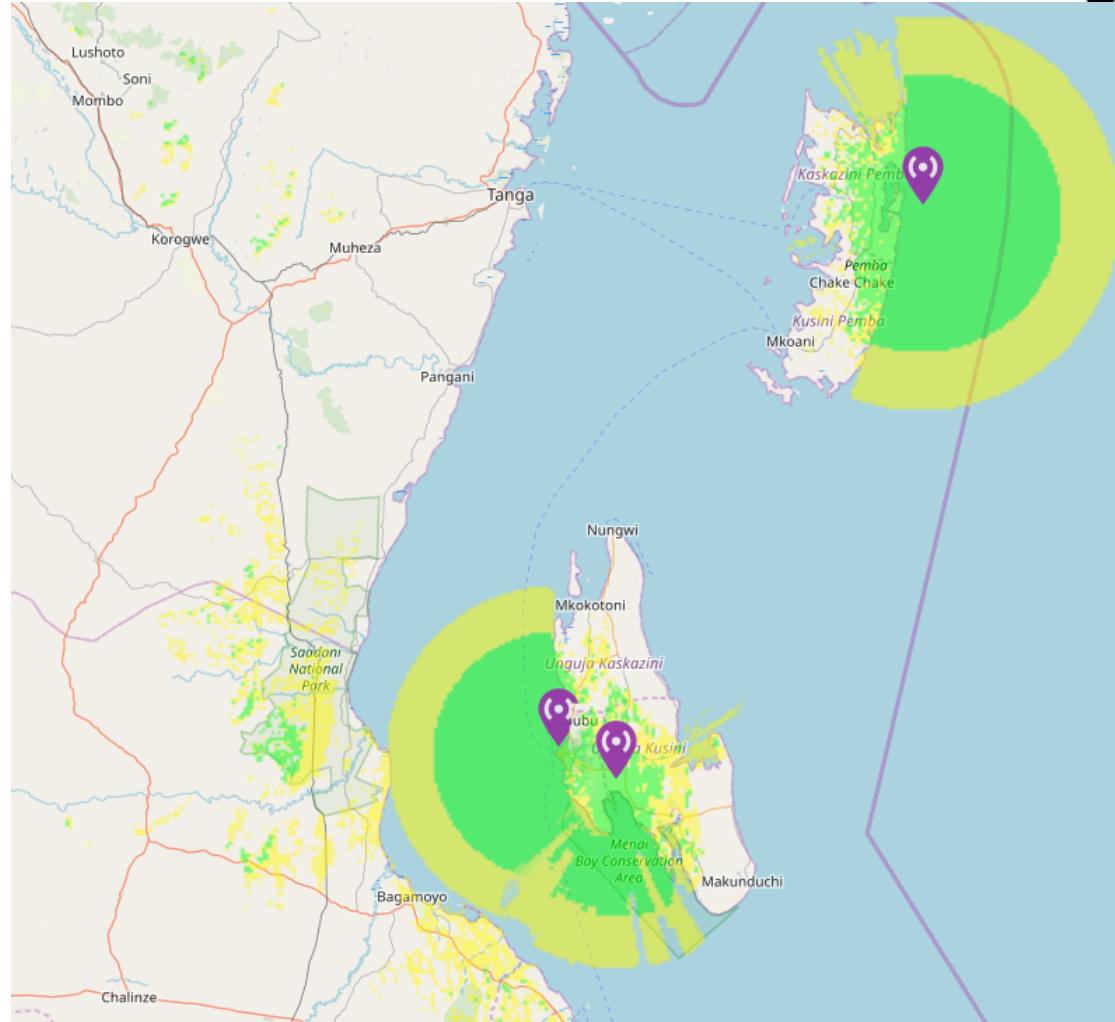


Zanzibar



Fisheries
Aquaculture
Tourism

...



Research interests @ ITU:

Geolocation / TDOA location i LPWAN

Tropospheric propagation

Coastal Networks

Satellite LPWANs

5G & LPWAN

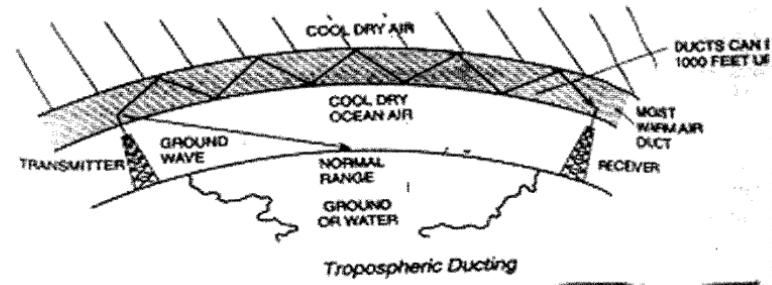
Interoperability

IoT & Usability



Tropospheric Ducting

Is when radio waves, normally blocked by the curvature of the earth, are carried in a "duct" between two different areas, beyond normal line-of-sight, which would normally not be carried said distance.



Satellite LoRa

Lacuna



Discussion:



Forskningsnettet

Supercomputere

Tjenester

Datamanagement

Hjem > "Forskere skal ikke bruge tid på it-infrastruktur"

"Forskere skal ikke bruge tid på it-infrastruktur"

Translation:

**Researchers should not spend
time on IT infrastructure**

**Researchers should not spend
time on IT infrastructure -**

But what about NRENs?

**Where does Infrastructure come
from?**

Inspiration: NRENs & IoT

Evaluating the performance of NRENs in deploying IoT in Africa: the case for TTN

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STF Porto 12 october 2018

What about a LoRaWAN academic network ?

afnic

Dashboard | GEANT APM | Service and Technology Forum

15th STF - Lisbon, October 2018



Workshop on LPWAN Solutions for the Internet of Things

17 - 21 February 2020
Makerere University, Kampala, Uganda

Further information:
Activity URL: <http://indico.ictp.it/event/9033/sm3437@ictp.it>

Directors:

- N. BONNIMA
Research and Education Network for Uganda (REN), Uganda
- L. CHEMANE
Mozambique Research and Education Network (MoRENet), Mozambique
- M. KASHORIDA
Kenya Education Network (KENET), Kenya
- M. MUSABA
Tanzania Education and Research Network (TENET), Tanzania
- J. SANSA-OTIM
Makerere University, Uganda
- M. ZENNARO
ICTP, Italy

Description:

- The involvement of National Research and Education Networks (NREN) in East Africa is key for the growth of Internet of Things (IoT) applications in the region, as they can host the access infrastructure to foster research in IoT and to serve the IoT community at large.
- The growth of the Internet of Things will depend crucially on the establishment of a low cost infrastructure to handle traffic generated by IoT nodes. Low Power Wide Area Network (LPWAN) solutions based on open standards that address the requirements of mobility, reliability, security, security and connectivity will be presented in the workshop. We will focus on the Things Network (TTN), an initiative to build a world-wide open platform to enable the deployment of the Internet of Things. TTN operates by allowing users to share the access to gateways. We think NRENs in the region should play a leading role in this regard. LPWANs are well suited for low-bandwidth communications over long distances, if can facilitate the deployment of applications relevant to East African countries.

Topics:

- Wireless solutions for IoT
- LoRa and LoRaWAN protocols
- Prototyping of sensor boards
- Planning and deployment of a LPWAN network;
- Collection and visualization of the data.

ICTP Scientific Contact:

M. ZENNARO
ICTP, Italy



A trusted academic IoT network

Why NRENs could/should provide IoT/LPWAN infrastructure



(a kind of

- own connectivity backbones on national/regional scale
- can provide bandwidths that can easily accommodate the (small) amounts of additional traffic
- have points of presence in universities and other research institutions
- Cooperate internationally/globally
- are organisationally and culturally close to the R&E sector
- can foster entrepreneurship
- create ecosystems for innovation, startups and business well beyond the limits of the campus

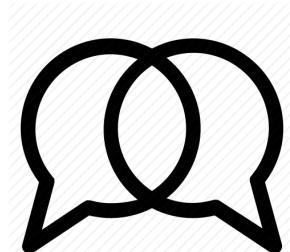
Concrete elements of an **NREN LPWAN** initiative



Universities / Institutions

- **Deploy and maintain LoRaWAN gateways**
 - **on one or some suitable campus locations**
- **Deploy one stable node / probe for monitoring**
- **Provide backhaul network for gateways**
- **Offer/disseminate LPWAN connectivity in education/research**
- **Optional: provide monitoring and reporting on behalf of NREN**

Concrete elements of an **NREN LPWAN** initiative



NRENs

- **Coordinate project**
- **Coordinate choice of network backend(s) / LORAWAN stack**
- **Delegate monitoring/reporting to one of involved partners**
- **Dissemination and support**

Concrete elements of an **NREN LPWAN** initiative



Costs

- **CAPEX:** Depending on choice of equipment, EUR/\$ 250 - 2500 per location
- **OPEX:** tbd
 - Ops network/app server, monitoring, reporting
- plus hours

Tak!



sebastian@itu.dk

PIT LAB