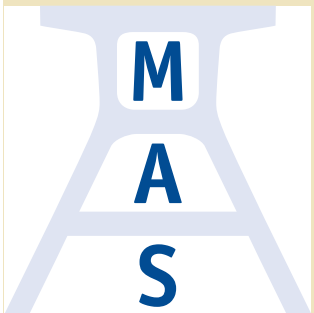

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Open-Minded

Considerations for Non-Commercial IoT Applications

Florian Metzger ■ December 1, 2017

Modeling of Adaptive Systems

https://www.mas.wiwi.uni-due.de/en

MEDIA | 06-26-2017 | CAROLINE BERGMANN | 0 COMMENTS

First NarrowBand IoT service packages launched in Germany

Share Print Read out

- Two entry packages available to experience and pilot NB-IoT solutions
- NB-IoT based smart parking solutions introduced in several German cities
- Rapid NB-IoT network expansion in Germany and across Europe with nationwide rollout in the Netherlands already accomplished

€199 for 25 SIMs, 6 months, 500 kB each

INTERNET DER DINGE

T-Mobile startet Narrowband-IoT-Netz

16.11.17, 10:34 Mail an die Redaktion

Im Februar hat T-Mobile Narrowband-IoT erstmals bei einem Showcase vor dem T-Center in Wien gezeigt: Dort wurden smarte Parkplätze installiert, die mitteilen können, ob sie belegt sind - Foto: T-Mobile

INTERNET DER DINGE

T-Mobile startet Narrowband-IoT-Netz

St. Pölten ist die erste Stadt, die T-Mobile mit dem Kommunikations-Standard Narrowband-IoT für vernetzte Geräte ausstattet. 2018 soll das ganze Land versorgt sein.

T-MOBILE, MOBILFUNK, INTERNET OF THINGS, INTERNET DER DINGE, IOT

€99 for 10 SIMs, 6 months, 500 kB each

NB-IoT Rollout

- Current rollout not targeted at consumers or research
- Scarce availability of NB-IoT devices and modules
- SIMs, subscription model, data caps

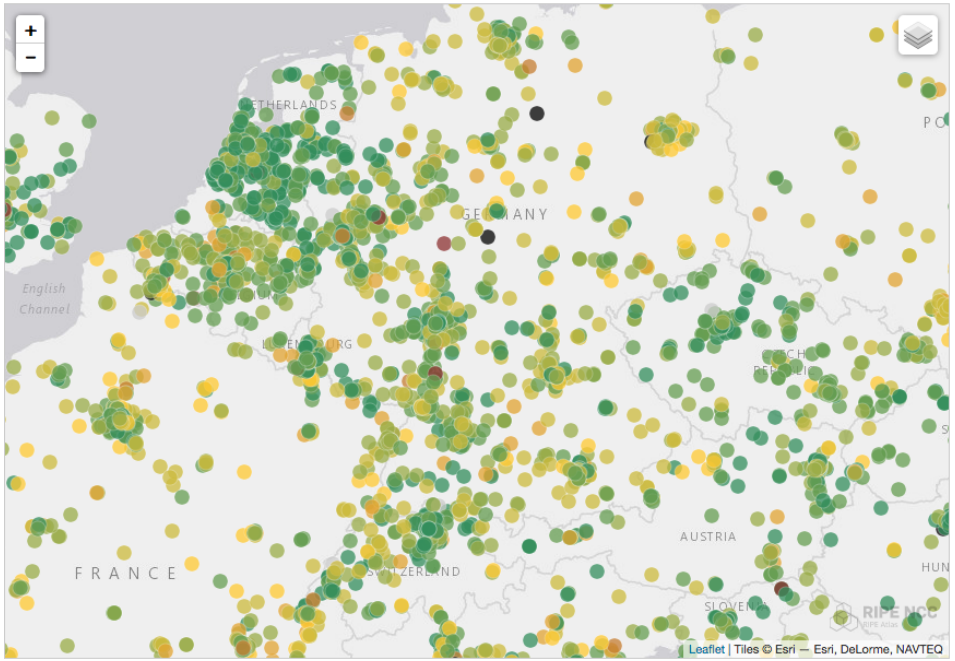
One of the first and only available boards and modules

- What do non-commercial apps want?

IoT Project Examples

RIPE Atlas[1]

- Not-for-profit EMEA Internet registrar
- Volunteers can apply for wired network probes to hook up to their Internet access



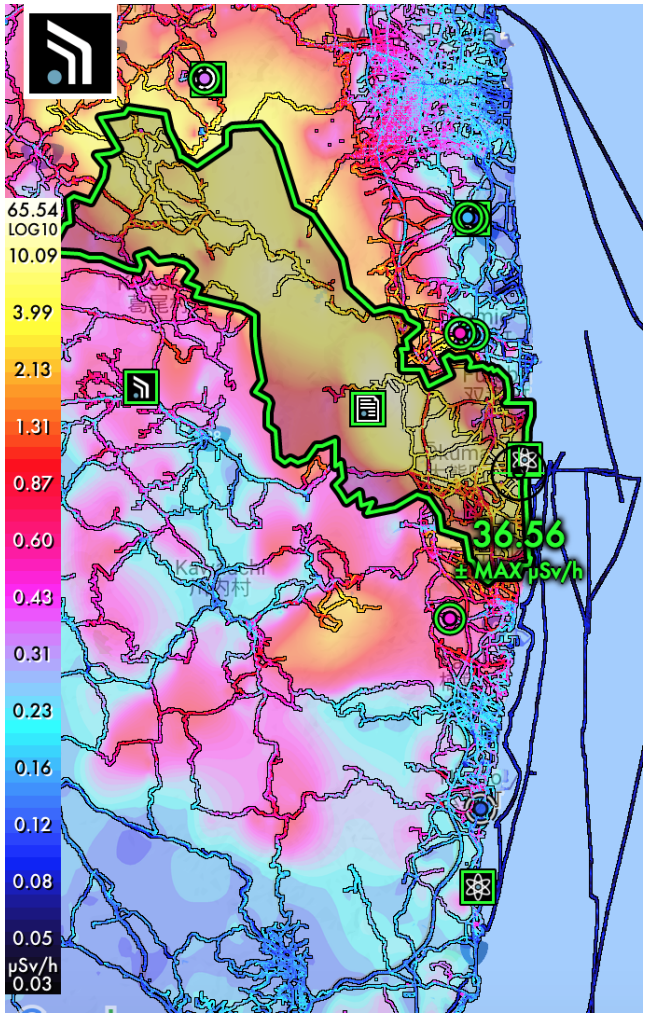
RTT to fixed destinations (e.g. root servers)

[1] https://atlas.ripe.net/landing/measurements-and-tools/

IoT Project Examples

Safecast

- Open data project to collect environmental data (radiation)
- BT-connected probes to mobile apps
- 71M data points, 1000 community probes worldwide



[1] https://blog.safecast.org/

Community, NGO, and Academic IoT Projects

Common Motifs

- Often centered around data collection and **sensing**
  - Often situated in places with no immediate Internet access, ideally suited for **LPWAN**
  - Or in home automation: relies on residential Internet link plus WLAN or **WPAN**
- Crowdsourcing and participatory **Crowdsensing**
- Operate through **volunteers** and **donated resources**
- Recurring and operational costs are undesirable
- Often based on cheap, hackable boards (e.g. **Arduino and derivatives**) and other ready-made tools

Suitability of Existing Cellular Networks

- Well-developed infrastructure with **coverage** pretty much everywhere
- Long range, high throughput
- Not necessarily tuned for low energy appliances
- Hard to directly develop for (baseband), or **deep stack** required (e.g. Android)
- Continuing **subscription** costs
- Users/SIMs are associated to a person/identity
- Older networks (GSM/UMTS) might be turned off soon
- Scaling issues of cellular networks to IoT numbers
  - Radio and core stateful and **signaling**-heavy, vertical integration

IoT-friendly Variants of 3GPP Networks

- E.g. random access channels, narrower RF bandwidth, guard-band usage, cost reductions
- LTE/EPC infrastructure largely unchanged?
  - CN control plane scaling issues?
- **EC-GSM-IoT**: Extended coverage optimizations to 2G, up to 2 Mbit/s
  - No rollouts yet?
- **eMTC/LTE-M**: 1.08 MHz in-band LTE with 1 Mbit/s
  - Limited commercial use
- **NB-IoT**: single random-access PRB (180 kHz, 250 kbit/s)
  - Limited rollout in EU/Australia

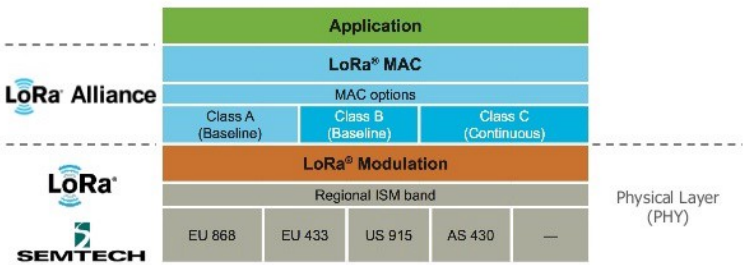
A Look at the IoT Connectivity Landscape

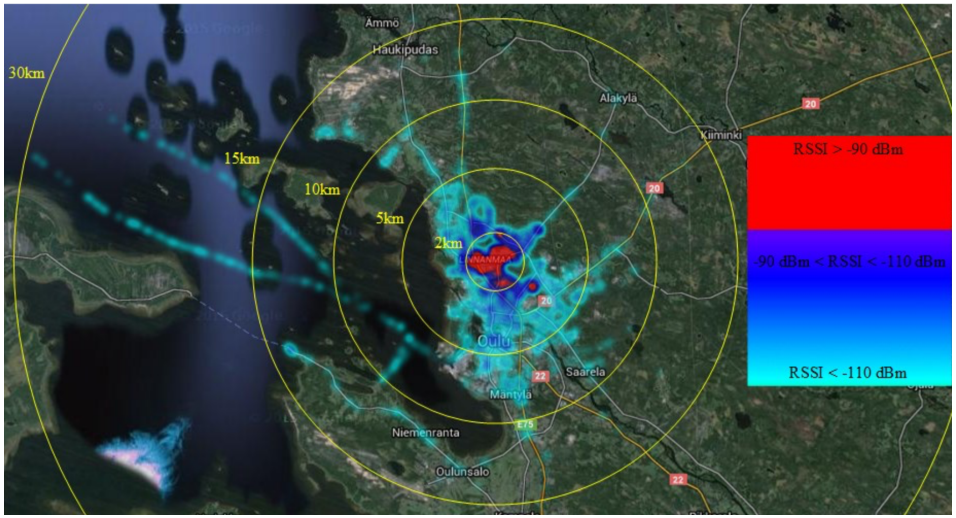
Some Options of Interest

- Existing cellular networks or their IoT variants
- Utilize unlicensed spectrum (esp. ISM & SRD)
- WLAN/WPAN with existing residential Internet access
- RF IoT networks (e.g. LoRa)
- Custom radio (don't do this!)

Standard	f	**Range**	**BW**
BT 4.0 LE	2.4 GHz	$<$ 100 m	1 Mbit/s
ZigBee / 802.15.4	868, 2400 MHz	10 m to 100 m	20, 250 kbit/s
Z-Wave	900 MHz	30 m	9.6, 40, 100 kbit/s
WiFi /802.11n/ac	2.4, 5 GHz	100 m	1.27 Gbit/s for 80 MHz 6.77 Gbit/s with MU-MIMO
NFC	13.56 MHz	10 cm	100 kbit/s to 420 kbit/s
LoRaWAN	433, 868 MHz	$<$ 15 km	0.3 kbit/s to 50 kbit/s
SigFox	900 MHz	$<$ 50 km	10 kbit/s to 1000 kbit/s

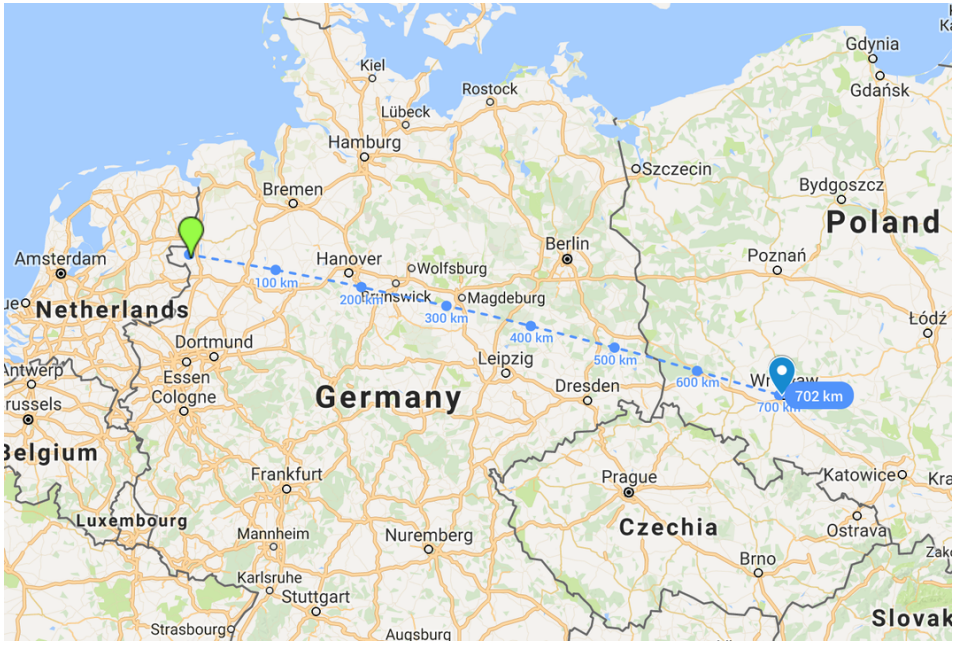
- Long range (chirp spread spectrum modulation, Link budget of 156 dB)
- PHY for 169, 433, 868, and 915 bands
- **Raw L1**, optional L2



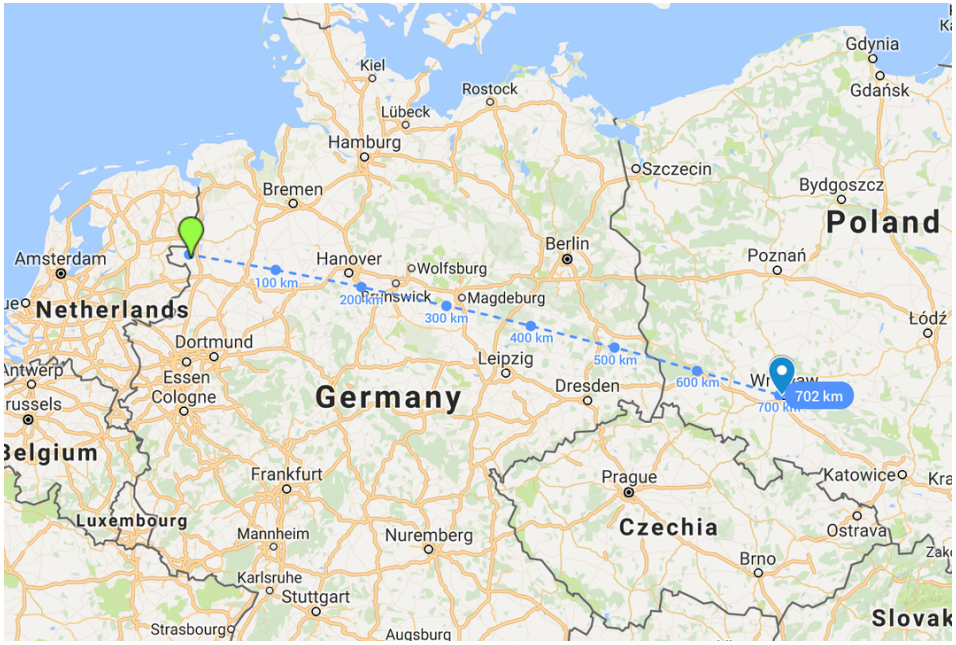


(Source[2])

[2] J. Petajajarvi et al. "On the coverage of LPWANs: range evaluation and channel attenuation model for LoRa technology". In: *2015 14th International Conference on ITS Telecommunications (ITST)*. Dec. 2015, pp. 55–59.



Sensor data TX with 14 dBm TPO received



Sensor data TX with 14 dBm TPO received

…mounted to a weather balloon at 39 km altitude

https://www.thethingsnetwork.org/article/ground-breaking-world-record-lorawan-packet-received-at-702-km-436-miles-distance

Community-run “Cellular” IoT Networks

Example: The Things Network

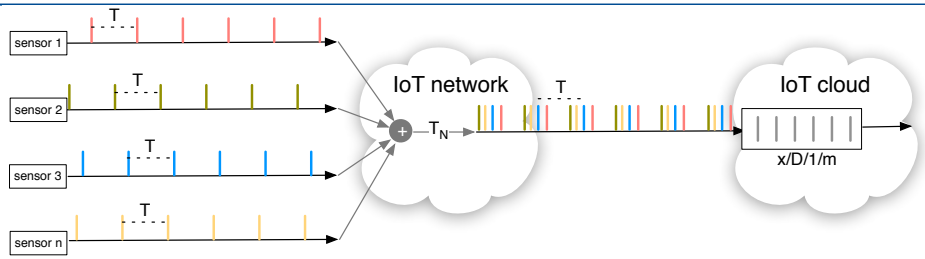
- Community-operated LoRa gateways
- Distributed overlay network with a common API
- Schedules and manages gateway transmissions, duty cycle limits
- Service discovery and traffic routing

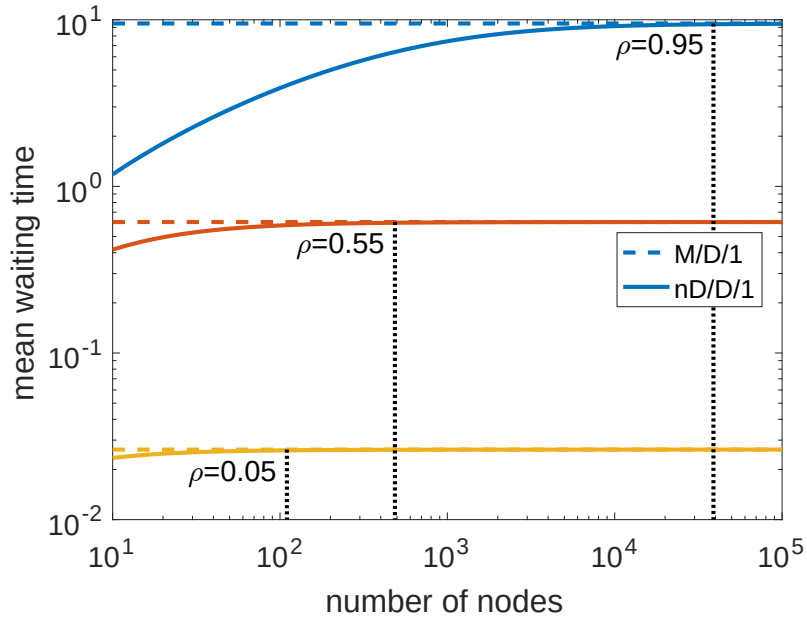
1500 active gateways

- Thriving ecosystem of different platforms and operators

Modeling Cellular IoT[3]

- Aggregate periodic arrival process can be modeled by a Poisson process
- Approximation error depending on the metric under scrutiny
- Good approx. can require a significant number of devices, should be factored into network planning

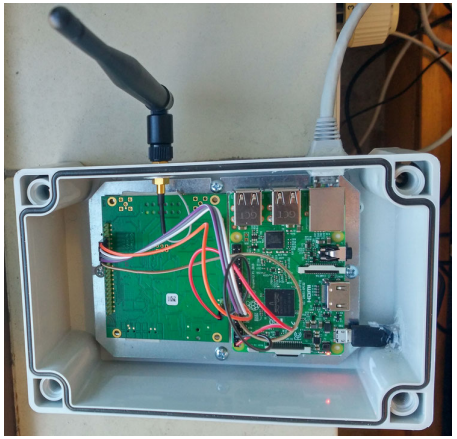


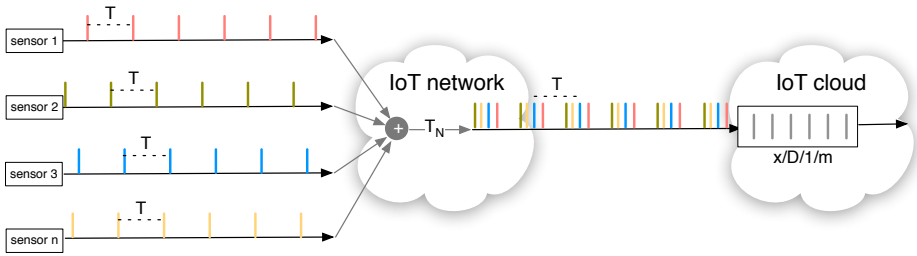


[3] Tobias Hoßfeld, Poul E. Heegaard, and Florian Metzger. "Traffic Modeling for Aggregated Periodic IoT Data". In: *21st Conference on Innovation in Clouds, Internet and Networks (ICIN 2018)*. Paris, France, 2018.

Summary

- Non-commercial IoT and participatory projects have different requirements to commercial
  - Favor unlicensed WPAN/LPWAN standards
  - Disruptive LoRa?
- Unique opportunities to investigate these IoT traffic models





Questions?

Contact: florian.metzger@uni-due.de

Key fingerprint: C98A 32B7 554F C5CC 4E5A 60FB 1CE5 B541 7B20 99C7

Appendix

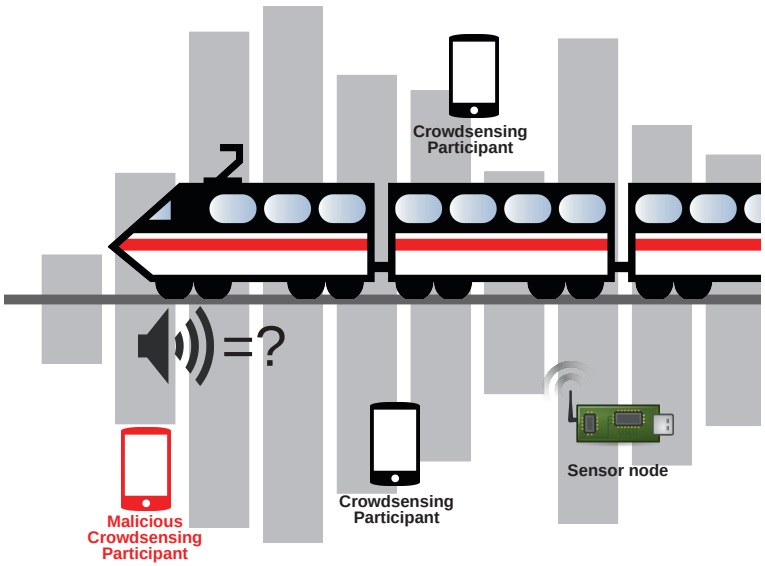
- Instead of dedicated IoT devices, use existing mobile **phones**
- Plethora of built-in **sensors** and ways to interact with environment and user
- Incentivized through **participatory** aspects or with monetary compensation
- Simple participation, huge potential user base
- Suitable for sensing and crowdsourcing projects
  - Must be aware of **Quality of Information** and engagement issues (amongst others)
  - Requires strict security and data protection and **privacy** considerations

Crowdsensing & IoT Project Examples

Noise Sensing[4]

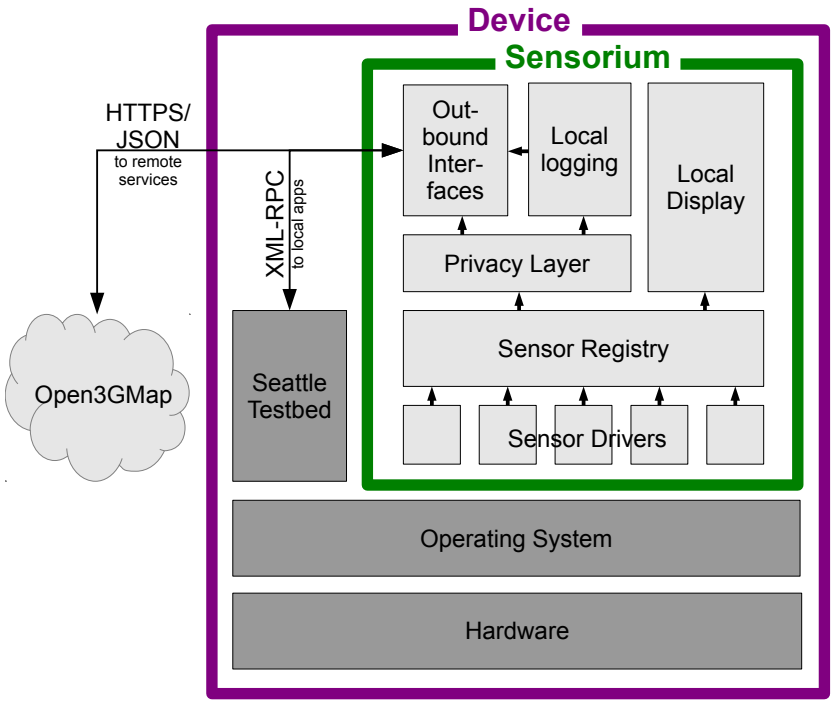
- Goal: Accurate and verified measurement of noise level (high QoI)
- But: Heterogeneous and unreliable devices and users
- Importance of systematic coverage of area

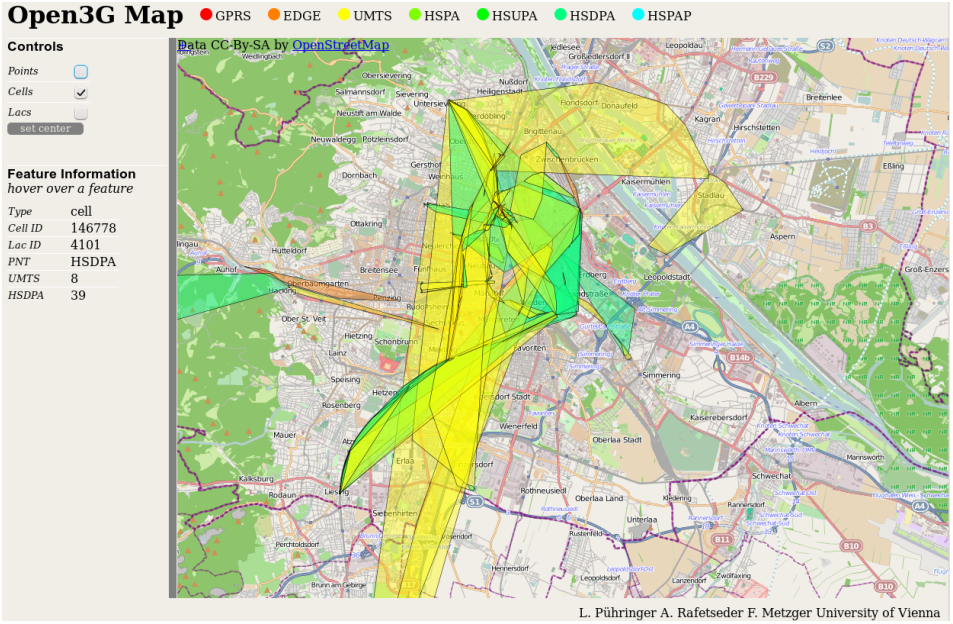
⇒ mixed smartphone and LPWAN use case



[4] Sebastian Surminski. "Reliable Noise Level Measurement Using Crowdsensing (Talk)". In: *ITG FA 5.2 Workshop on Smart Cities*. Lübeck, Germany, 2017.

Sensorium & O3GM[5]



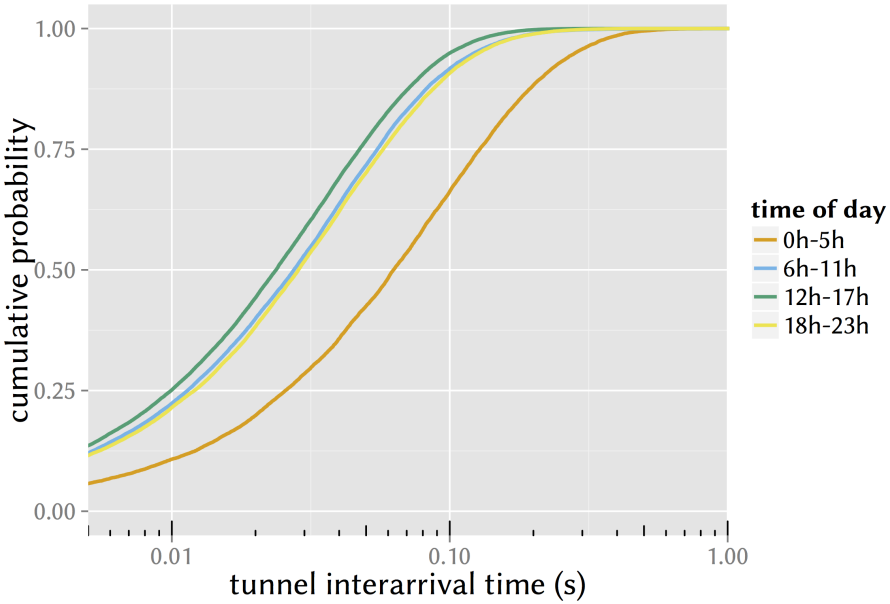


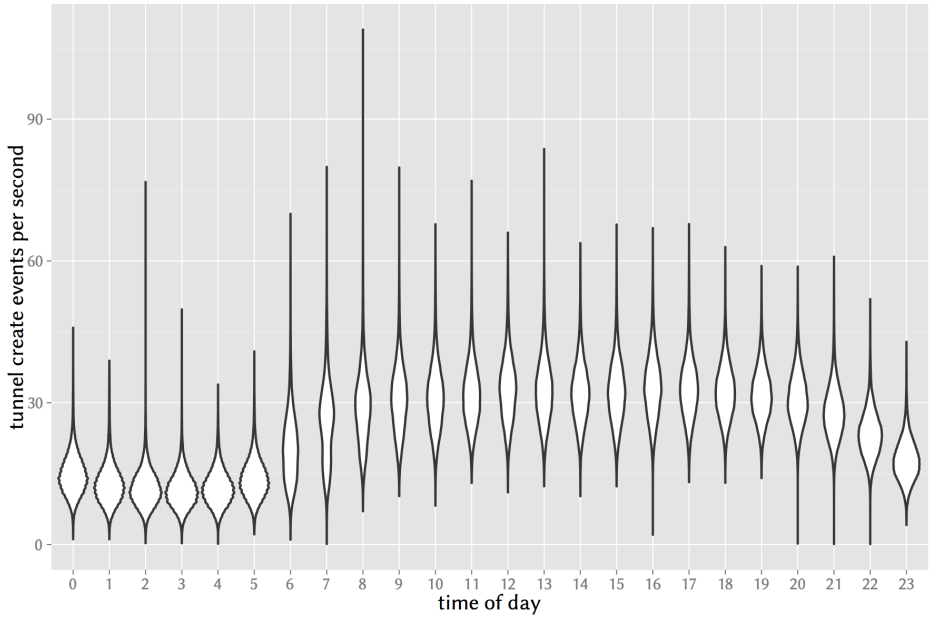
User choice & technical privacy solutions (blurring)

[5] A. Rafetseder et al. "Sensorium – A Generic Sensor Framework". In: *PIK - Praxis der Informationsverarbeitung und Kommunikation* 36.1 (Feb. 2013), p. 46.

Tunnel Arrivals[6]

By Time of Day

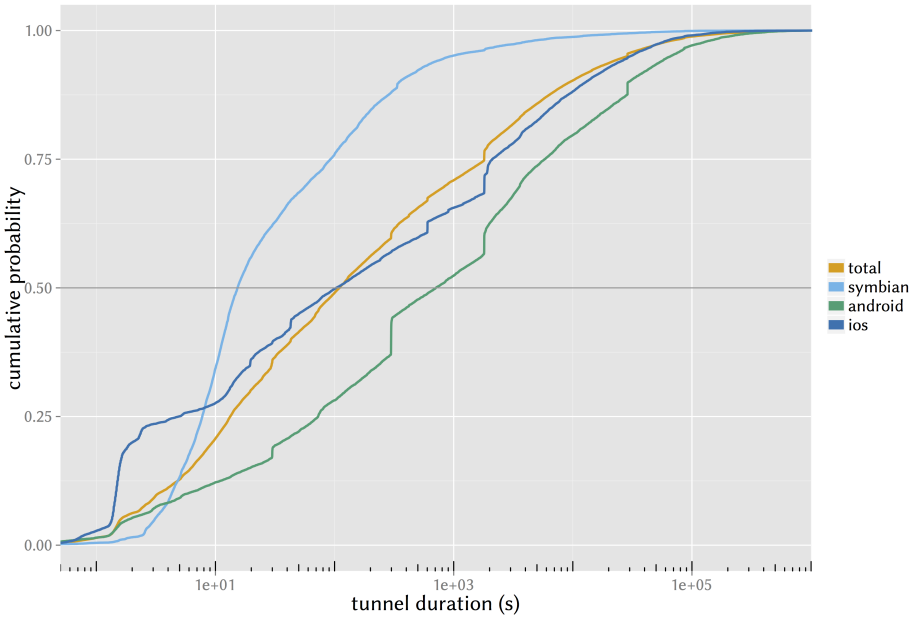


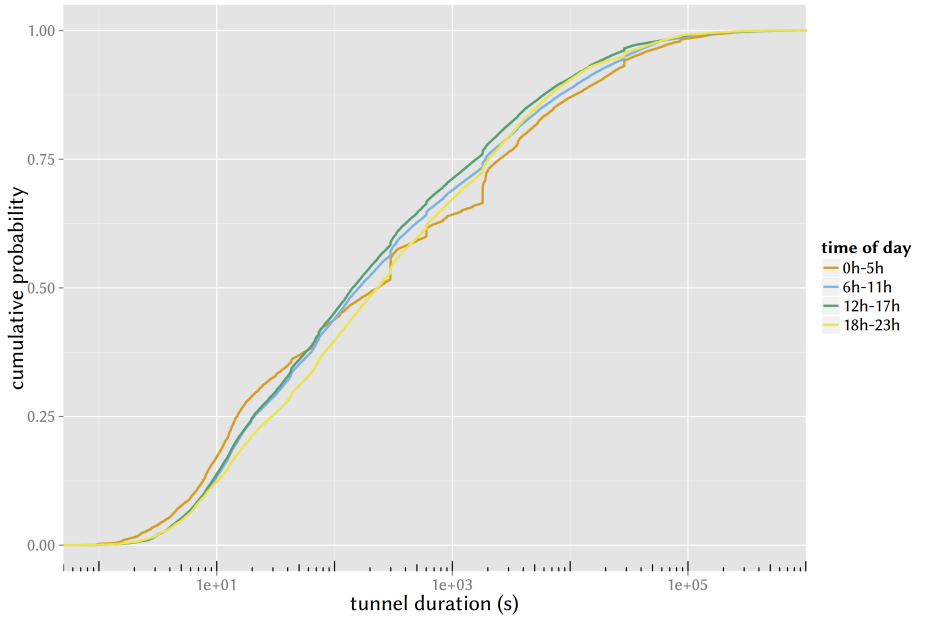


- Strong time of day dependence with busy hour in the early afternoon
- Bimodal character of arrival rate over the total time of day

[6] F. Metzger et al. “Exploratory Analysis of a GGSN’s PDP Context Signaling Load”. In: *Journal of Computer Networks and Communications* (Feb. 2014).

Tunnel Durations





- Strong influence of user device type and OS on duration
- “Signaling storm” visible in CN: many short tunnels for specific devices
- Time of day dependence