BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION
department of telecommunications

Advanced Smart Grids: Utilization of the 5G+ and Cyber Security

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IMA InfoDay 2022

Praha, November 15, 2022

Outline

- About Department of Telecommunications
- 5G Networks
- BUT/Vodafone UniLab - place for research and development in 5G+
  - 5G and Smart Grids
- *(Post)Quantum Cryptography, HW-accelerated cryptography – BUT research activities*

Department of Telecommunications

- belongs to the largest departments at the faculty
- 80 staff (FTE)
- 61 doctoral students
- 10 Study programmes (3 bachelor, 3 master, 4 doctoral)
- 64 R&D projects in 2021 v (4.7 MEUR)

Main R&D Areas

High speed data networks

Internet of Things, Industry 4.0 and sensors

Energy and Smart Grids

Cyber security

Processing of biomedical signals

Artificial intelligence, data processing and analysis

Analysis and processing of audio signals

Hardware development, analysis and testing

R&D Partners

> **50** INDUSTRY PARTNERS

> **40** PARTNER UNIVERSITIES AND R&D CENTRES

Mobile Connectivity

The Evolution of Mobile Connectivity

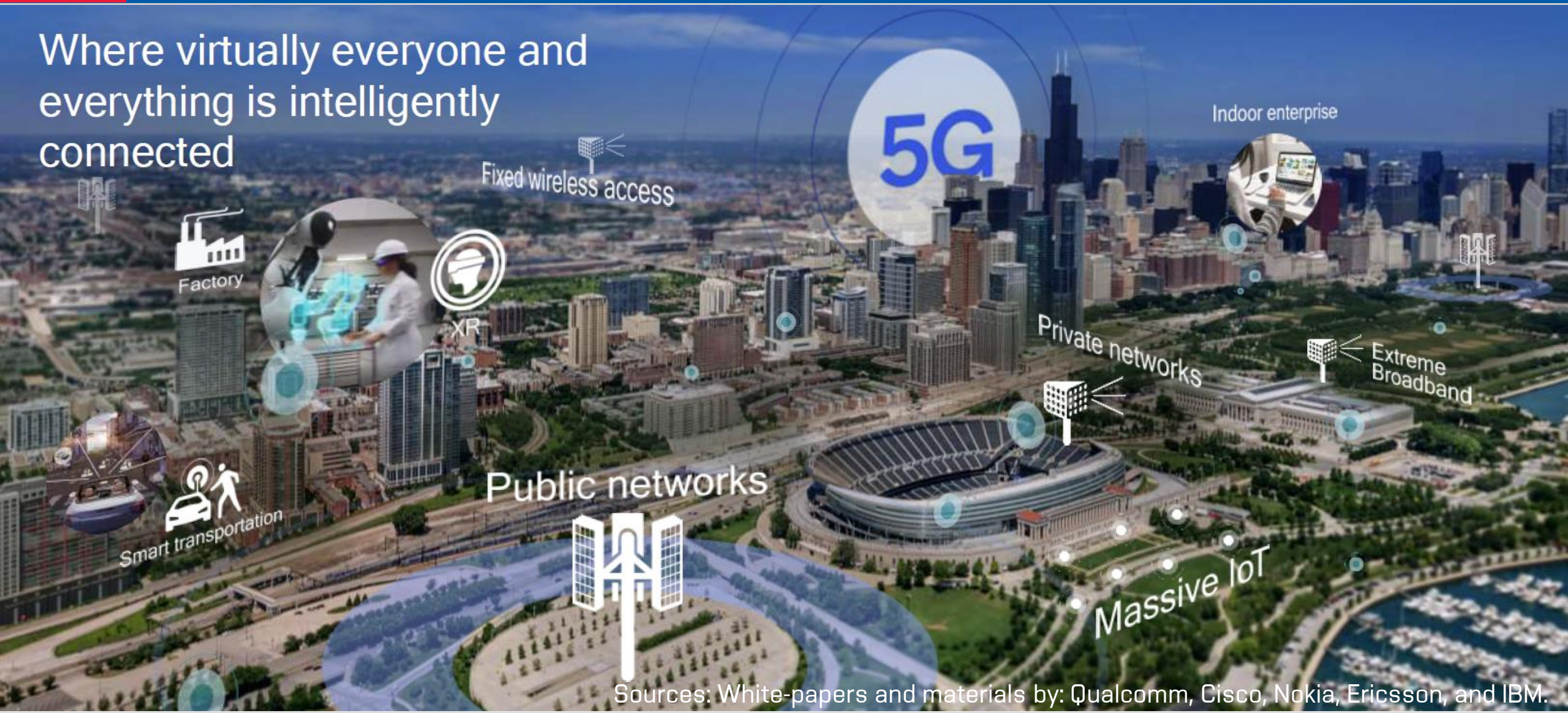
- **1910 – -1G**
  - Lars Magnus Ericsson and his wife used the first car phone.
- **1946 – 0G**
  - First commercial mobile service (in the US - 50 mil coverage)
- **1983 – 1G**
  - 1973 - The first public cell phone call, 1983 – the first commercial cell phone
- **1991 – 2G**
  - Voice calls, message sending (SMS, MMS)
- **2001 – 3G**
  - Mobile internet, websites are completely redesigned and optimized for the mobile environment (2007 - first iPhone)
- **2008 – 4G**
  - Data transfer speeds up to 500× faster than 3G
- **2018 – 5G NR (New Radio)**
  - Data transfer speeds up to 20× faster than 4G, IoT, M2M communications

5G Motivation and Vision

5G Motivation

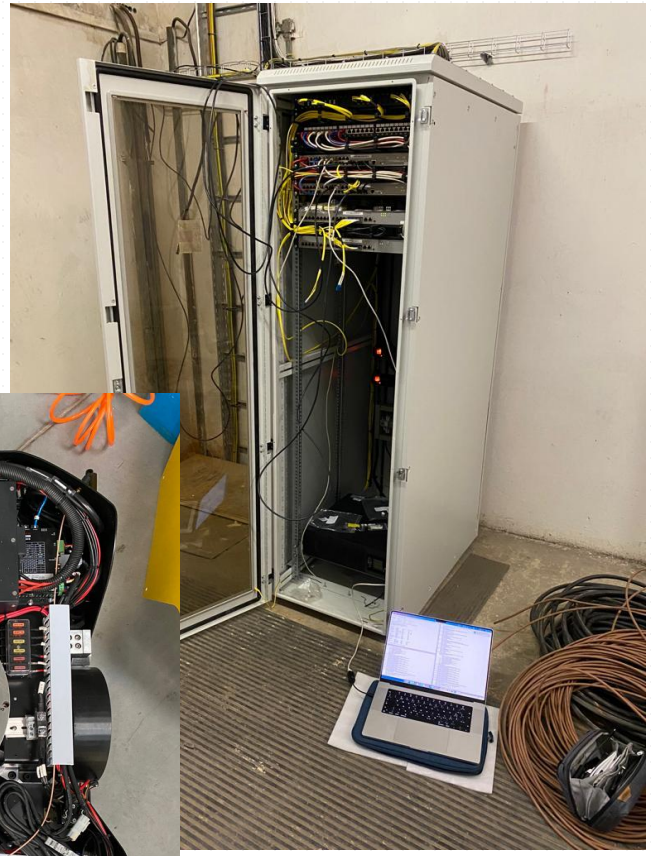
- 5G will address the insatiable demand for mobile broadband
  - Over 60x growth in mobile data traffic from 2013 to 2024
- Aprox. 136 B Gigabytes
  - Monthly global mobile data traffic in 2024
- In 2024
  - **Approx. 75%** of mobile data traffic from multimedia creation&consumption
  - **Approx. 25%** of mobile data traffic will be carried by 5G networks

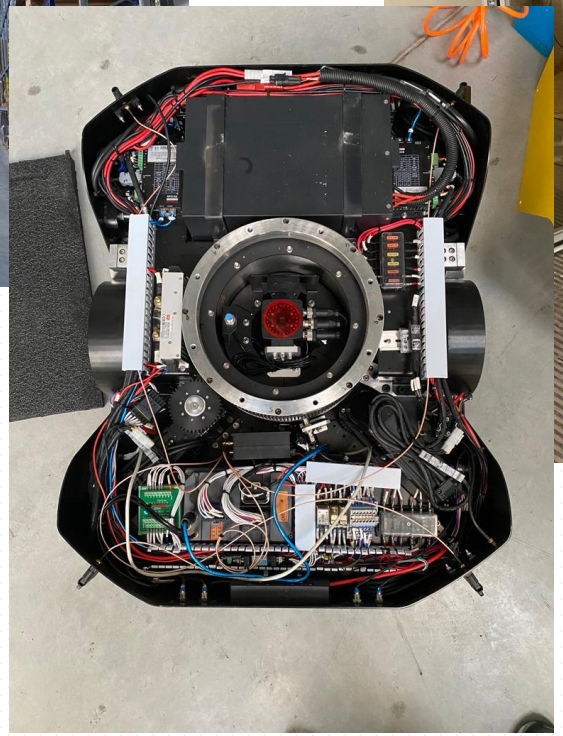
Delivering on the 5G Vision



Sources: White-papers and materials by: Qualcomm, Cisco, Nokia, Ericsson, and IBM.

5G Private Network example

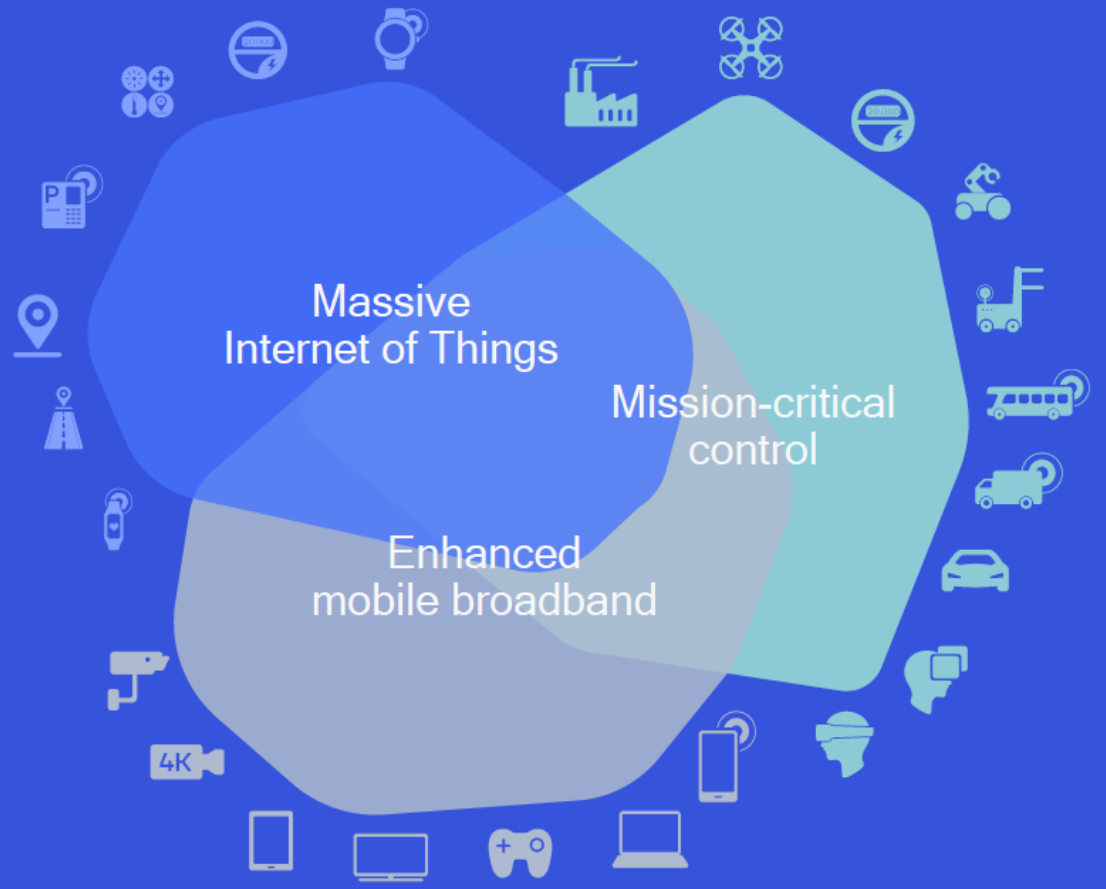




Delivering on the 5G Vision

5G is
the common connectivity platform
for the IoT

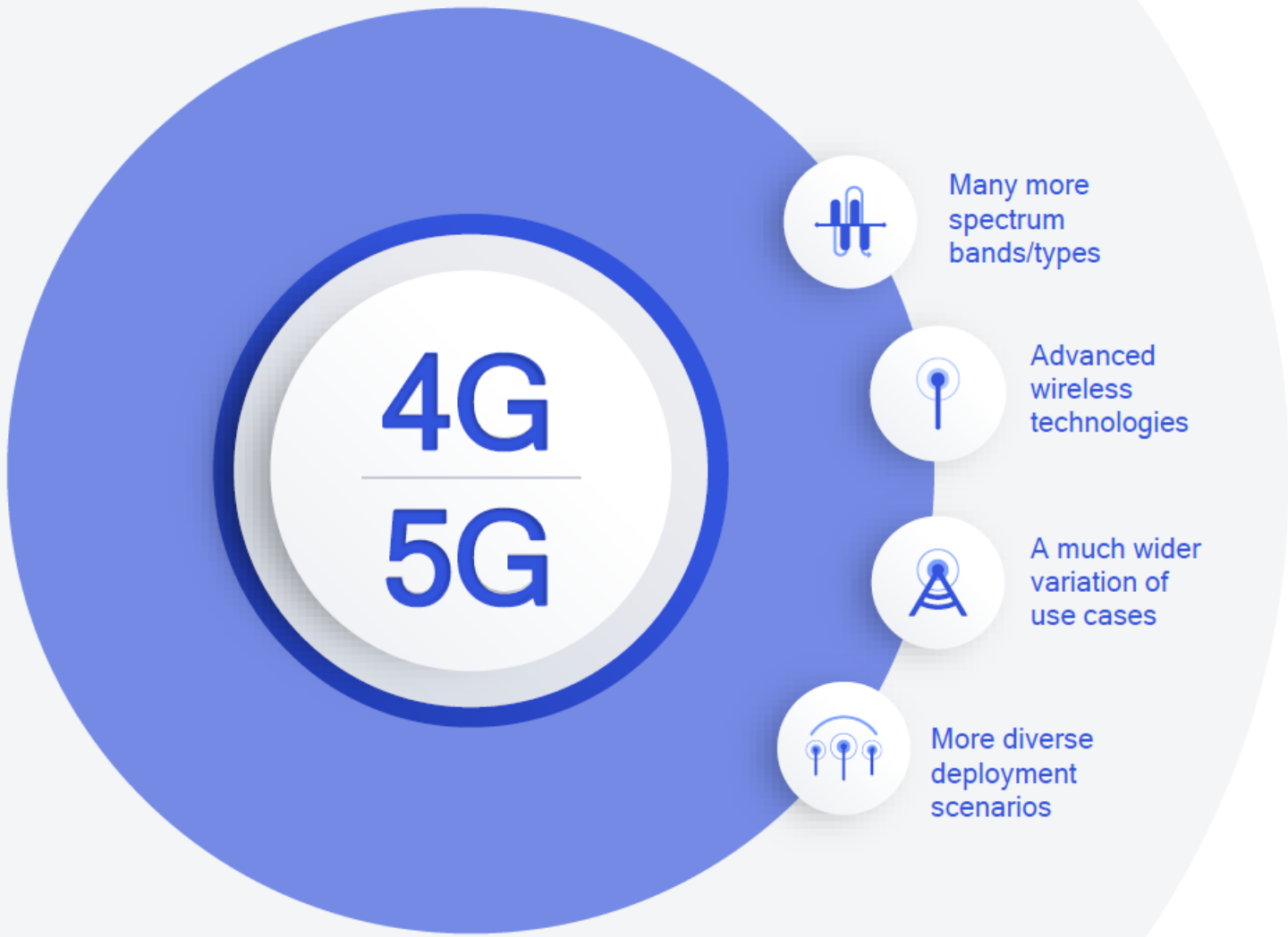
Broad set of devices and services
For all spectrum bands[1] and types[2]
Public and private networks

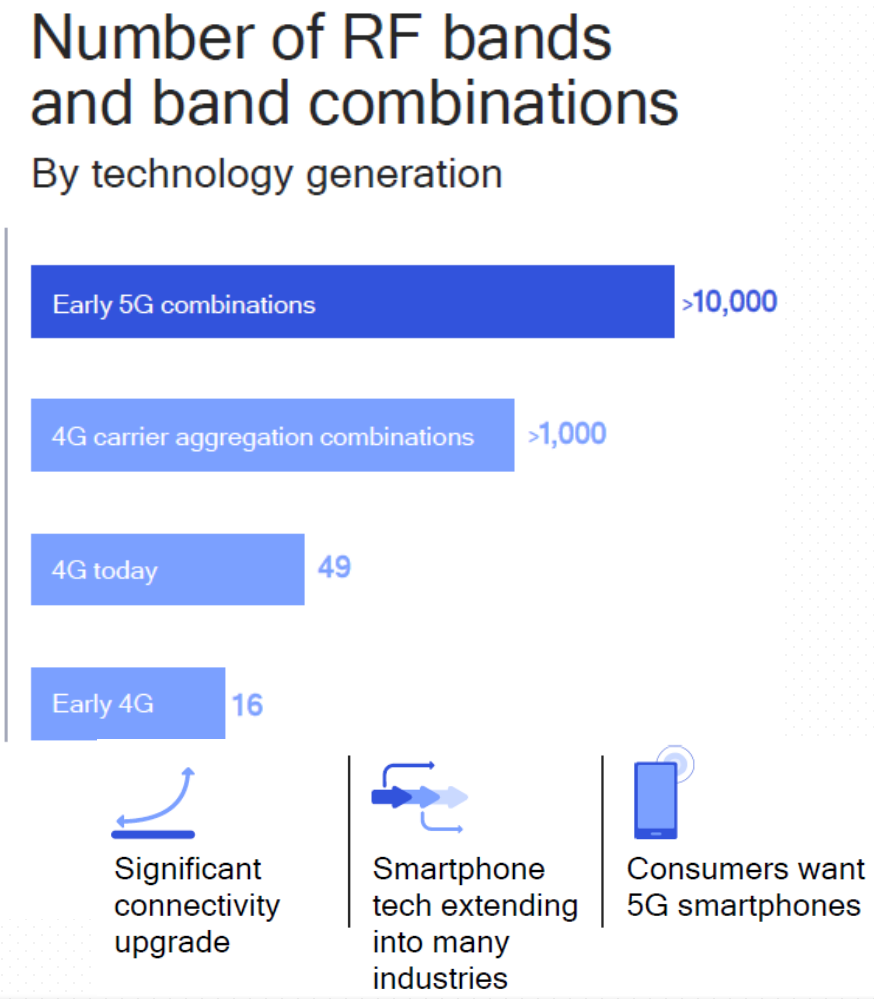


1. Low, mid, high bands; 2. Licensed, unlicensed, share licensed

Sources: White-papers and materials by: Qualcomm, Cisco, Nokia, Ericsson, and IBM.

A New Kind of Network to Drive Innovation and Growth





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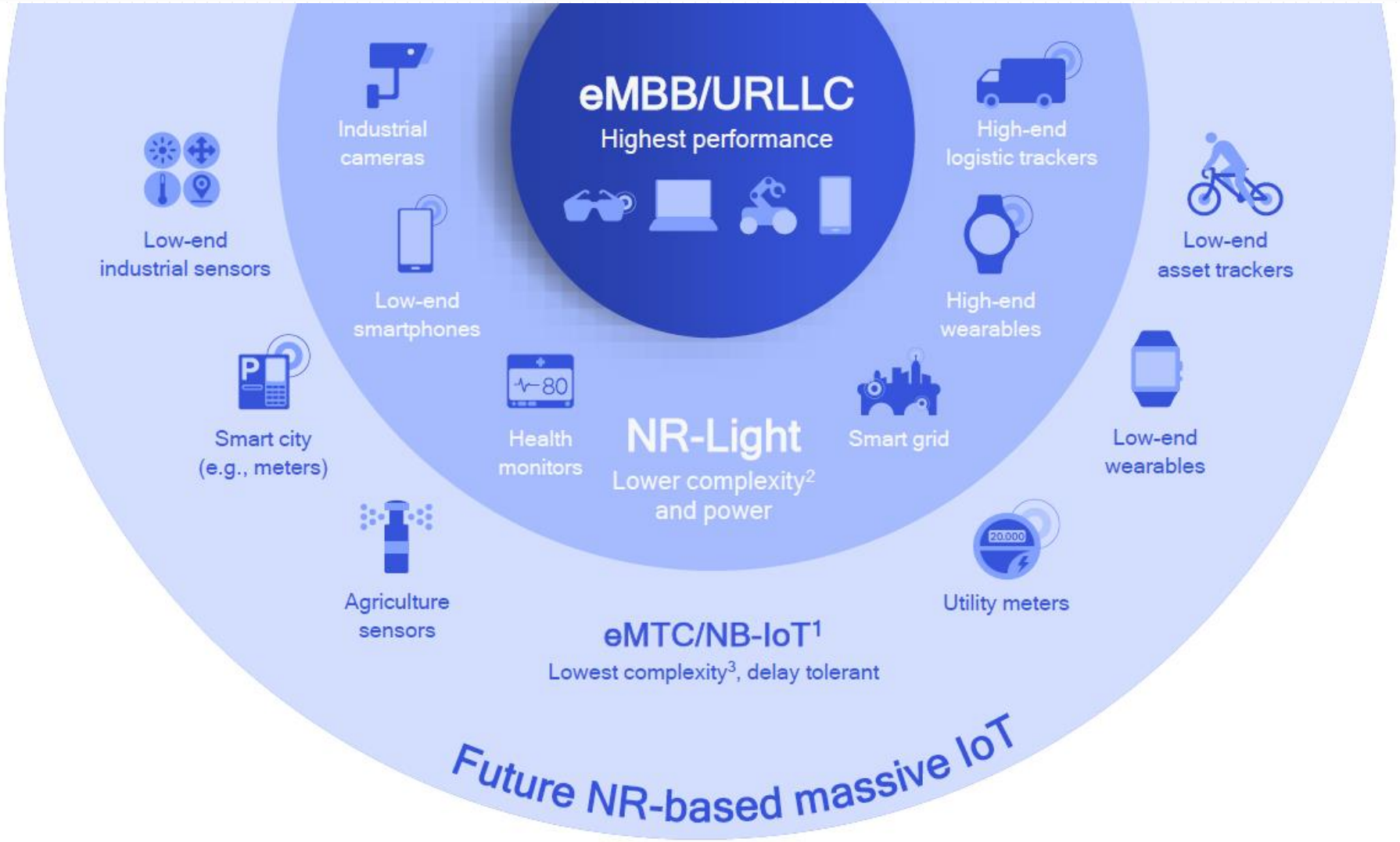
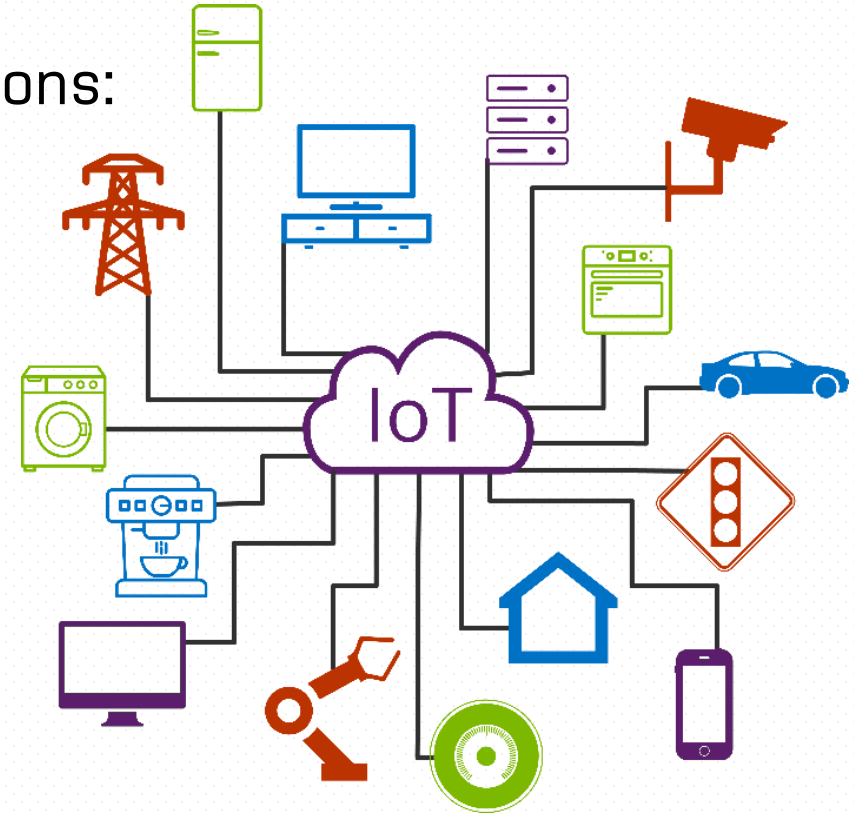
Scaling Down 5G NR for Lower Complexity IoT Devices



Sources: White-papers and materials by: Qualcomm, Cisco, Nokia, Ericsson, and IBM.

Internet of Things

- „The **Internet of Things** refers to the use of **sensors, actuators, and data communications technology built into physical objects**“.
- IoT enables those objects to be tracked, coordinated, or controlled across a data network or the public Internet.
- There are three steps in Internet of Things applications:
  - **Capturing data from the objects** (e.g., simple location data or more complex information data sets).
  - **Aggregating** that information across a data network.
  - **Acting** on that information – taking immediate action or collecting data over time to design process.



5G NR-Light Brings New Efficiencies for the IoT

Lower device complexity

Narrowband operation (down to 10 MHz), single/dual receiver antenna, half-duplex operation

Optimized power consumption

Enhanced low-power modes (PSM and eDRX), lower output power (e.g., 23/20 dBm)

Network enhancements

Coexistence of half- and full-duplex devices, reduced control signaling, small data transmissions

Coverage recovery

Repetition and bundling of small payloads, frequency hopping, also use of relay and/or sidelink

Continue to drive IoT expansion as part of 3GPP Release 17

Sources: White-papers and materials by: Qualcomm, Cisco, Nokia, Ericsson, and IBM.

Low-Power Wide-Area Networks

Up to 23dBm (200mW)

Low-Power Wide-Area Networks

10+ years on simple battery

15-70km rural outdoor

Low-Power Wide-Area Networks

2-3km urban indoor

License-exempt

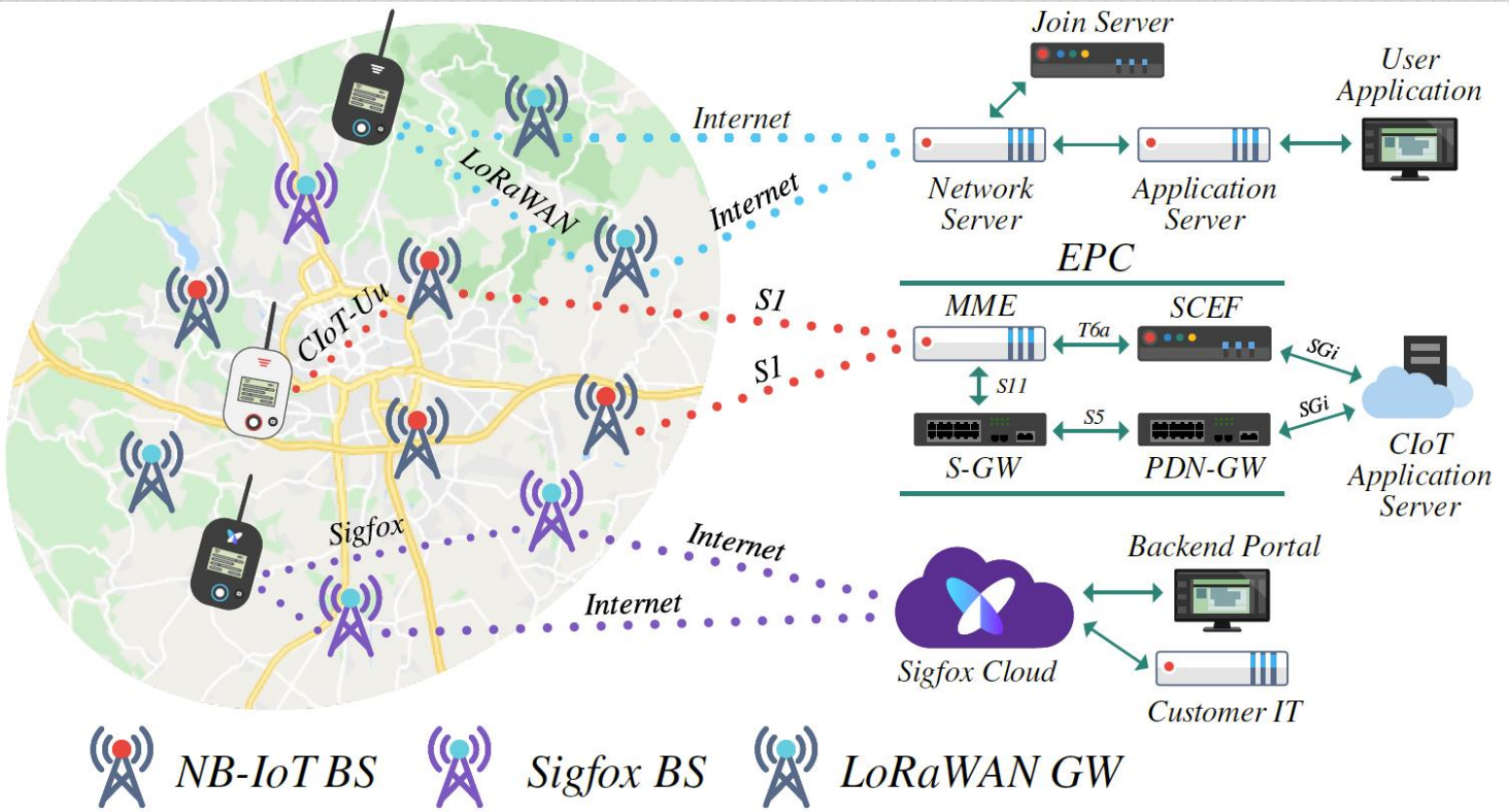
Low-Power Wide-Area Networks

Licensed spectrum

Low-Power Wide-Area Networks

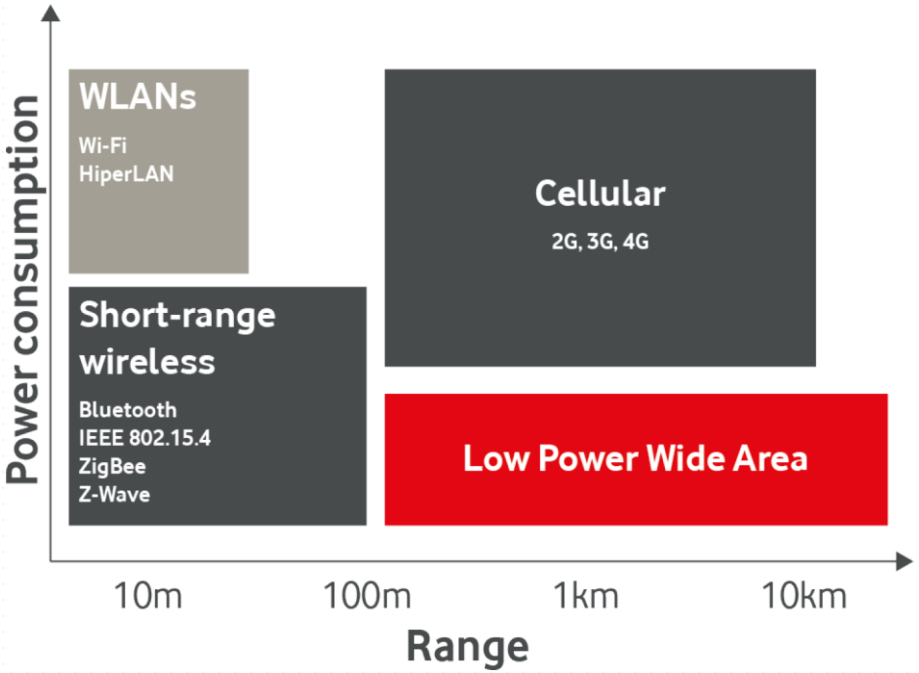
	Sigfox	LoRaWAN	NB-IoT	LTE Cat-M
Coverage (MCL)	162 dB	157 dB	164 dB	155 dB
Spectrum	Unlicensed	Unlicensed	Licensed (LTE)	Licensed (LTE)
Duty cycle limit	Yes	Yes	No	No
TX power restrictions	Yes (25mW)	Yes (25mW)	Yes (200mW)	Yes (200mW)
DL data rates	0.6 kbps	0.3 – 50 kbps	0.5 – 27.20 kbps	< 300 kbps
UL data rates	0.1 kbps	0.3 – 50 kbps	0.3 – 32.25 kbps	< 375 kbps
Max. message size DL	12 B	243 B	1600 B	8188 B
Max. message size UL	8 B	243 B	1600 B	8188 B
Battery life	10+ years	8+ years	10+ years	10+ years
Security	AES-128	AES-128	LTE security	LTE security

LPWA – Communication Infrastructure

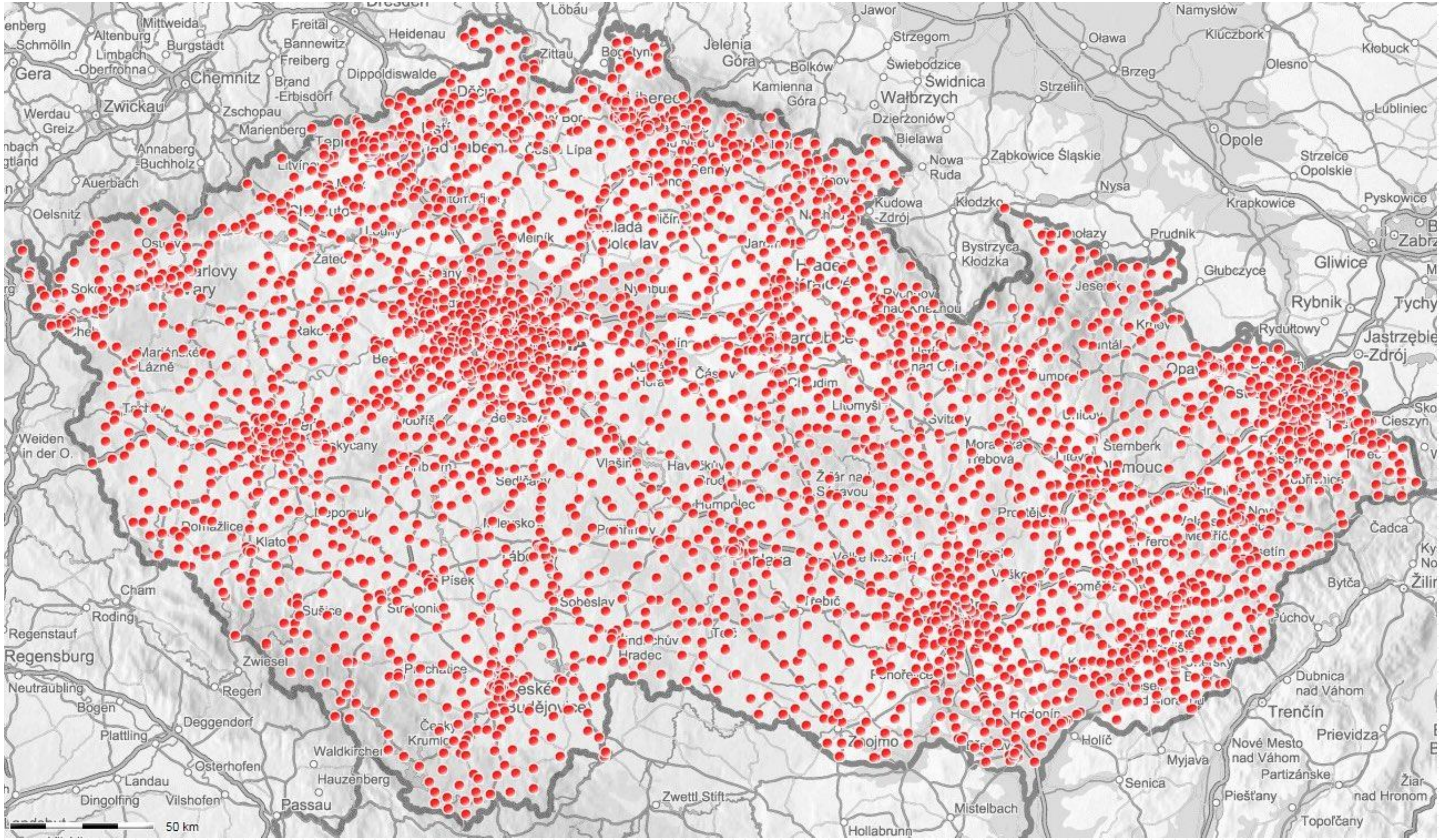


LoRaWAN sigfox

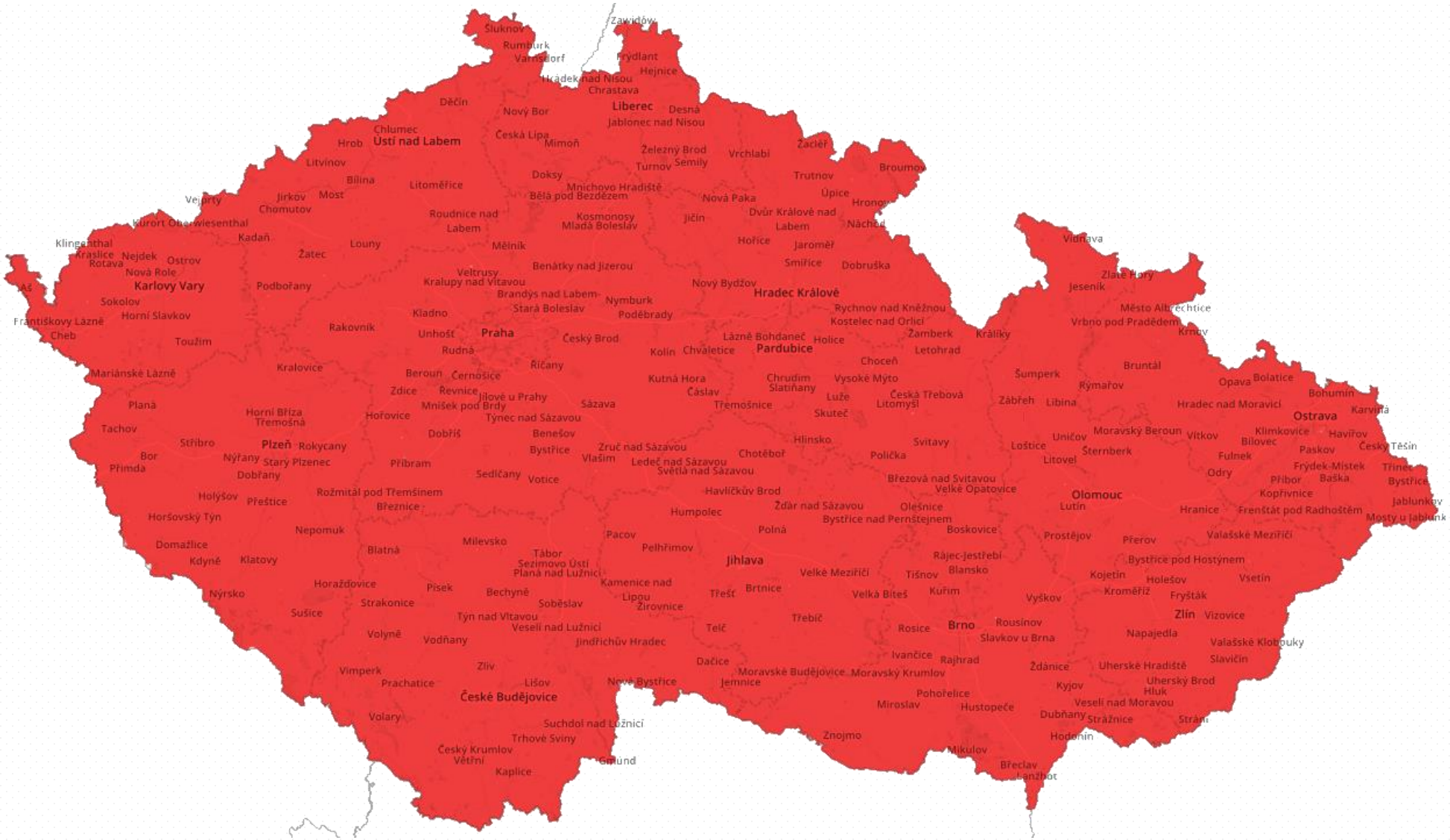
NB-IoT LTE-M



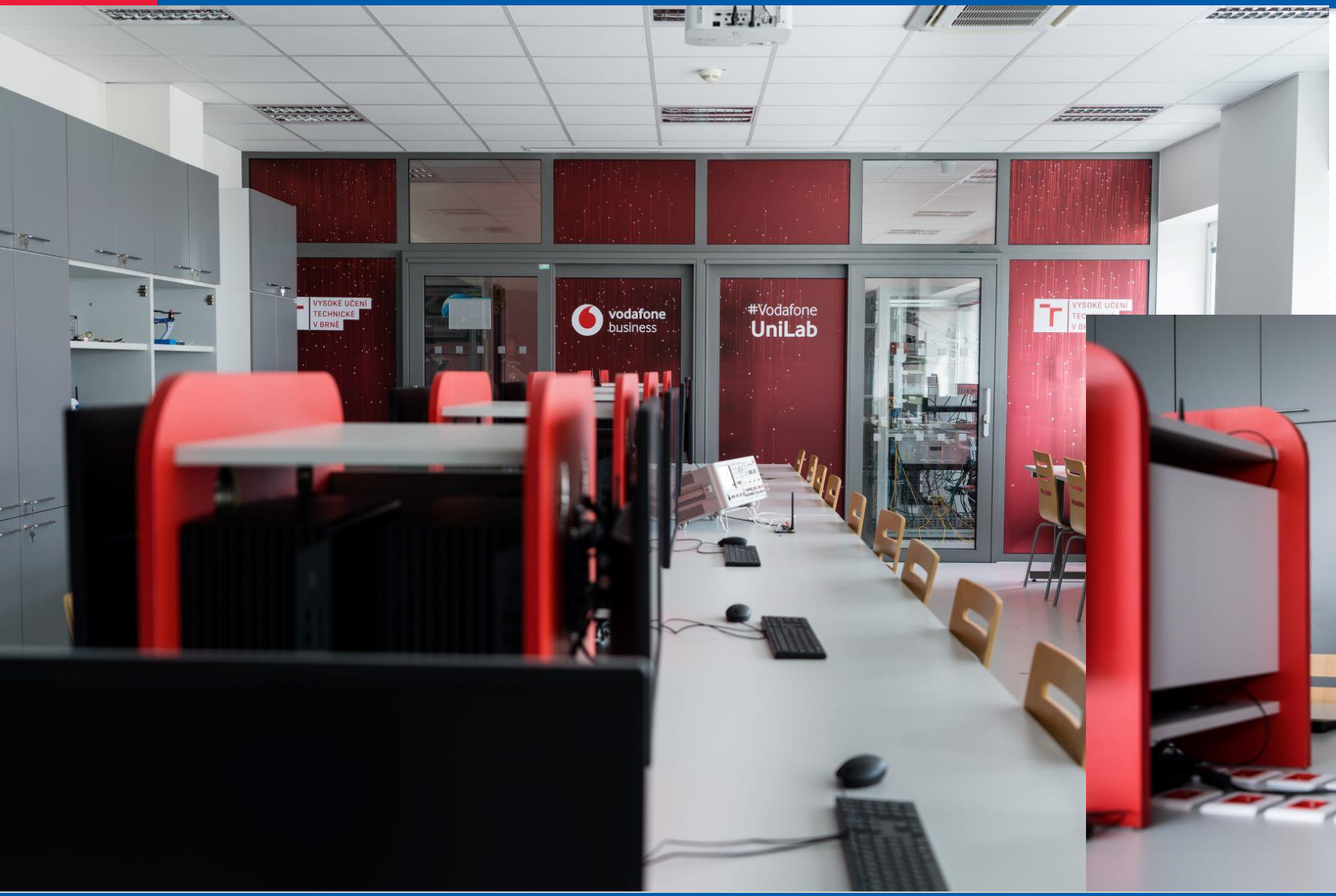
NB-IoT / LTE Cat-M1 Deployment In Czech Republic (VF)



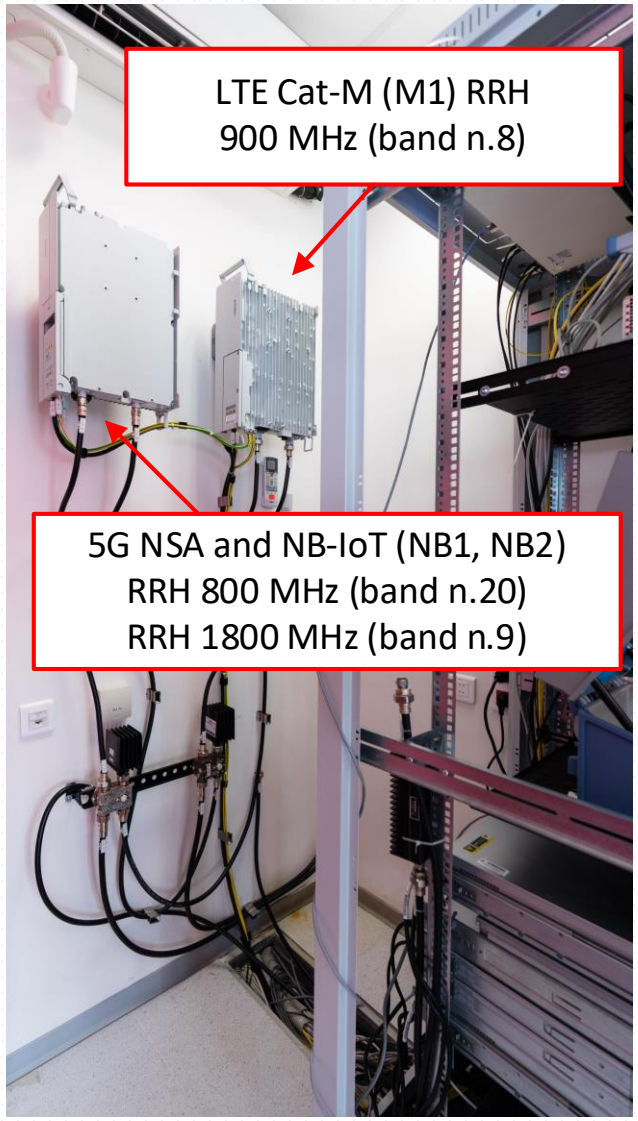
NB-IoT – Coverage Czech Republic (02/2022)

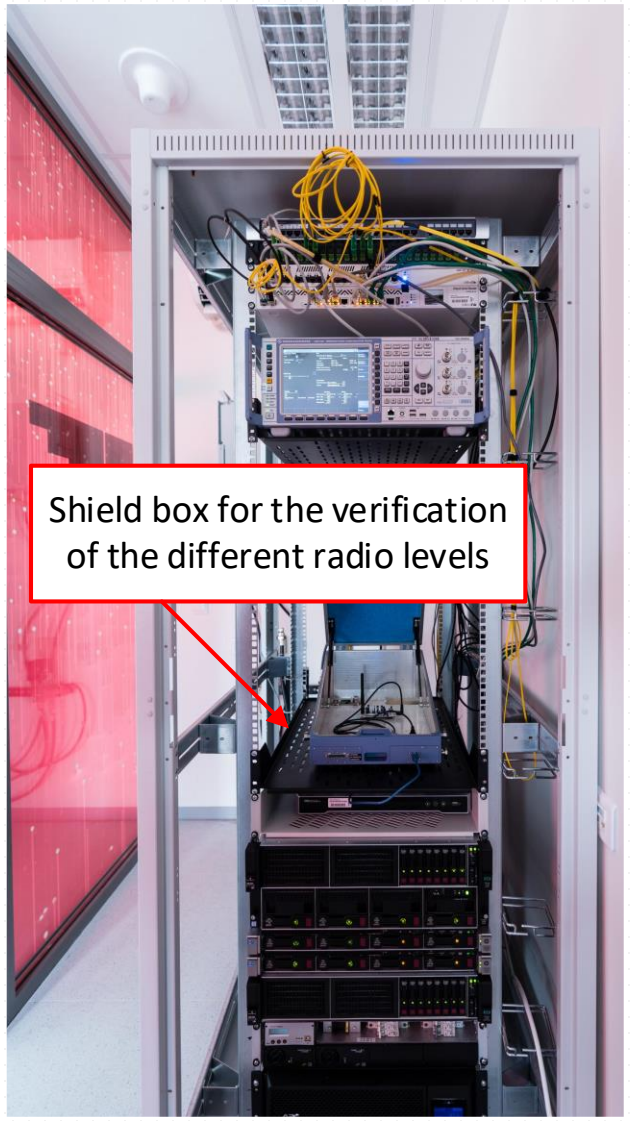


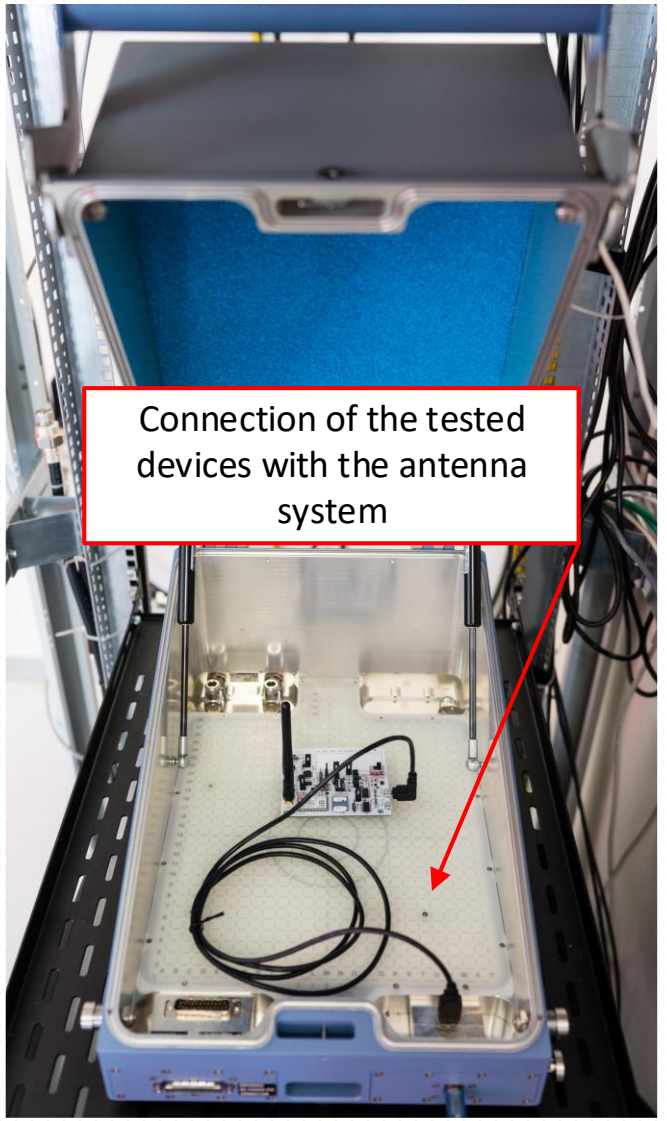
#Vodafone Unilab - 5G+ Laboratory at BUT



#VodafoneUniLab (vodafone.cz/unilab)

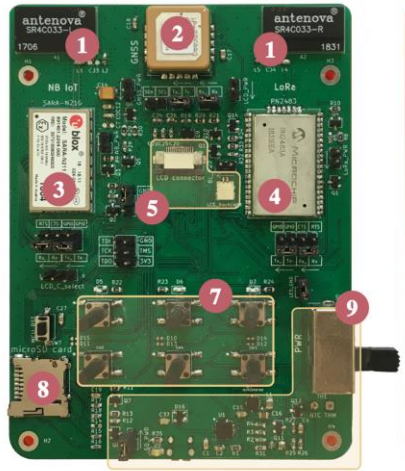






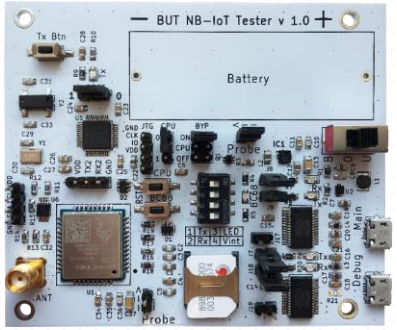
UniLab Research Activities

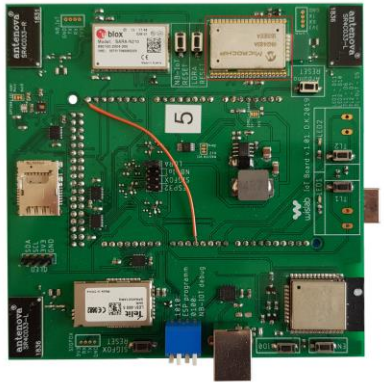
- **Contributor to 3GPP standards.**
- **Recent joint research areas:**
  - 5G NR communication systems
  - LPWA networks
  - Industry 4.0, SmartGrid infrastructure
  - HW design and prototyping
  - Lab. measurements and benchmarking
  - Advanced field testing

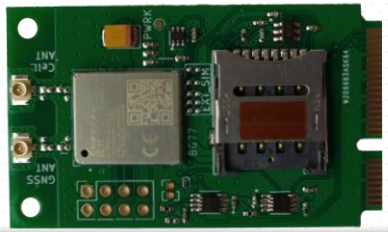


From Research to Production

Research → Design → Verification → **Production**







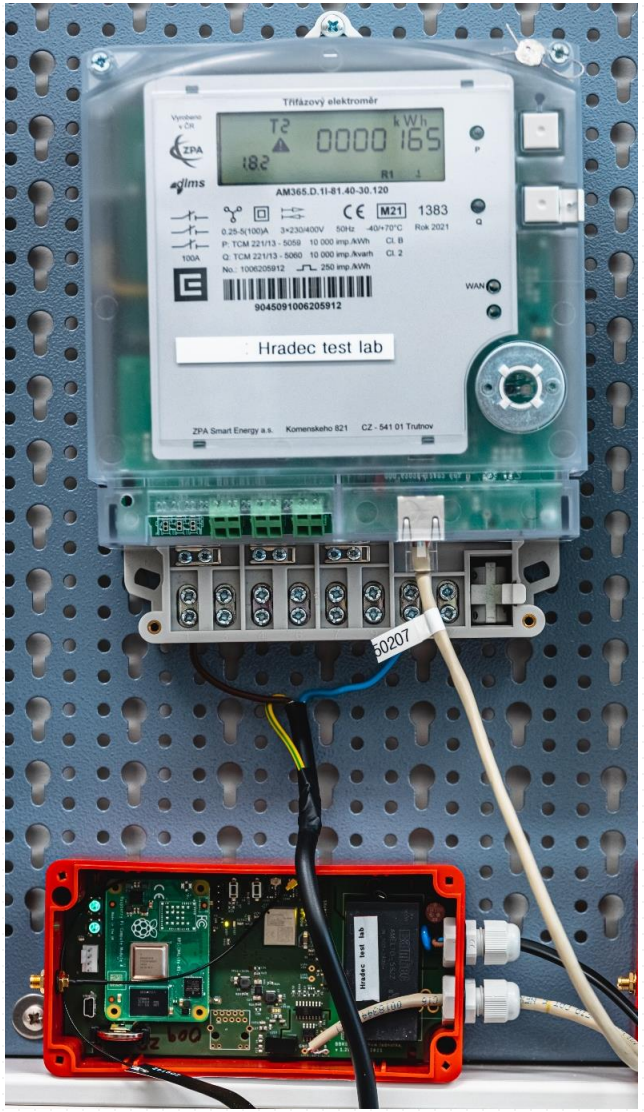
Smart Metering - NB-IoT a LTE Cat M communication unit

The communication unit is designed for scenarios:

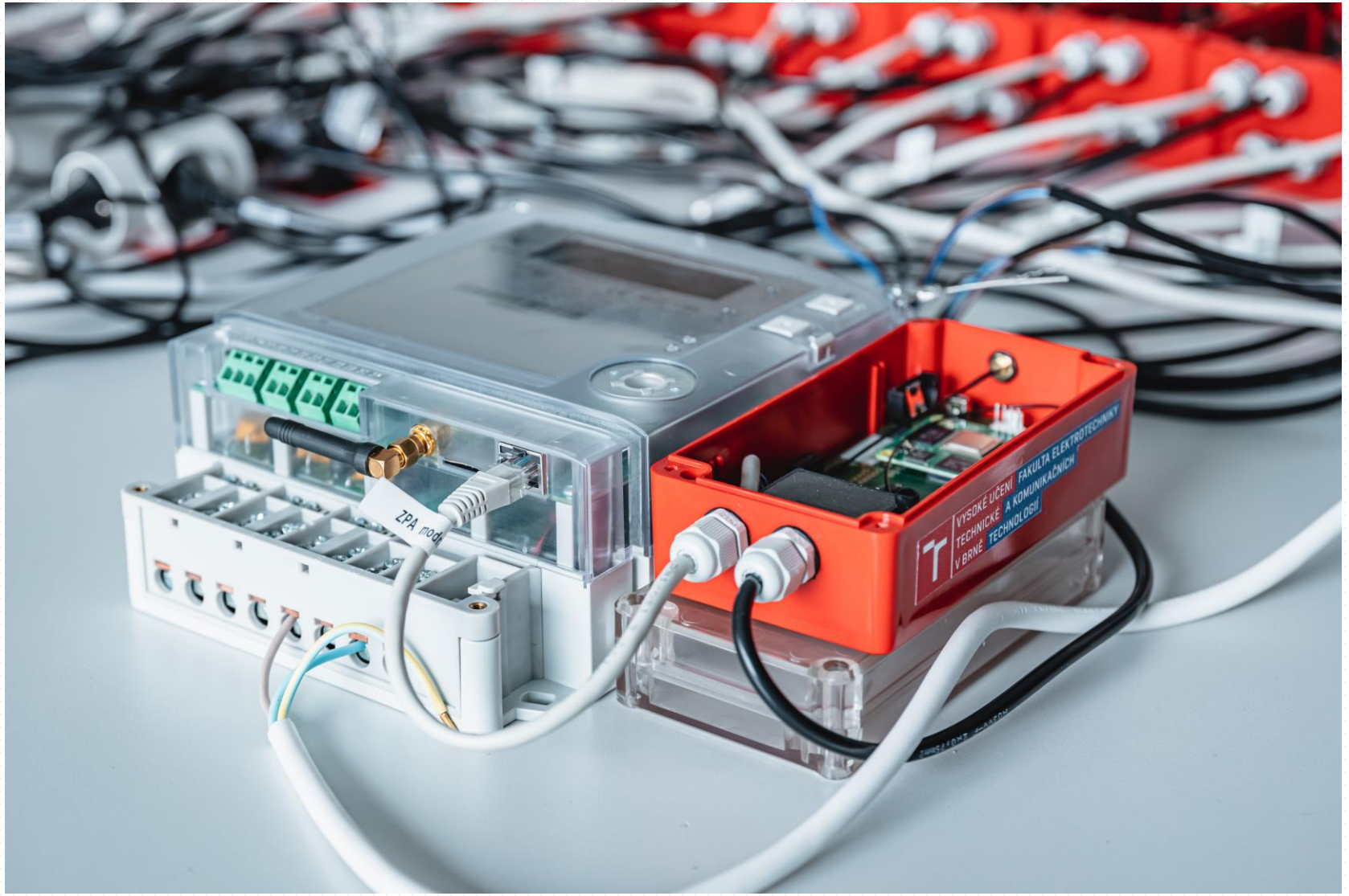
- Smart metering - communication module for smart meters or connection to the meter via local interface (RS-485).
- Substation automation - communication unit for PQ or universal monitors (connection to ETH interface).

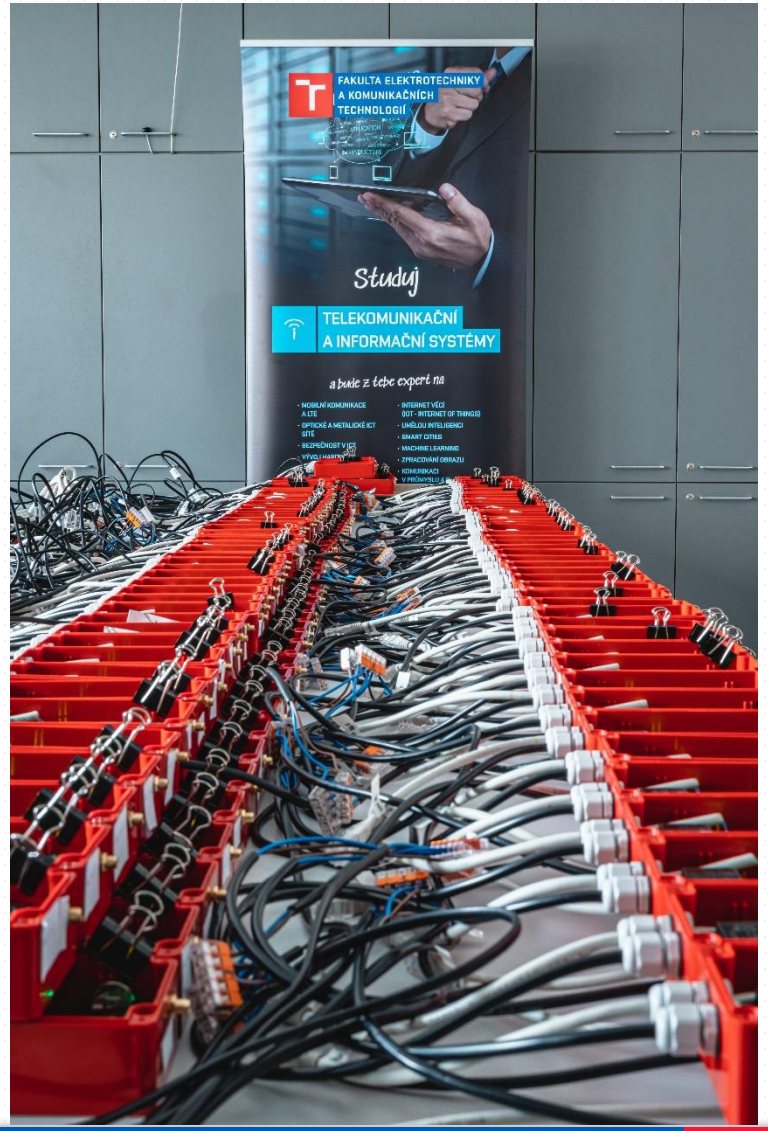
NEW:

- Fulfillment of cyber security requirements - according to Annex 4 to Decree No. 359/2020 Coll. + Compliance with recommended NIST and NUKIB.
- Receiver sensitivity better than for LTE and GPRS, suitable for deployment in ambient and "deep indoor" environments.
- Analysis of radio communication (spectrum usage) and communication parameters (sensitivity to threshold signal levels).



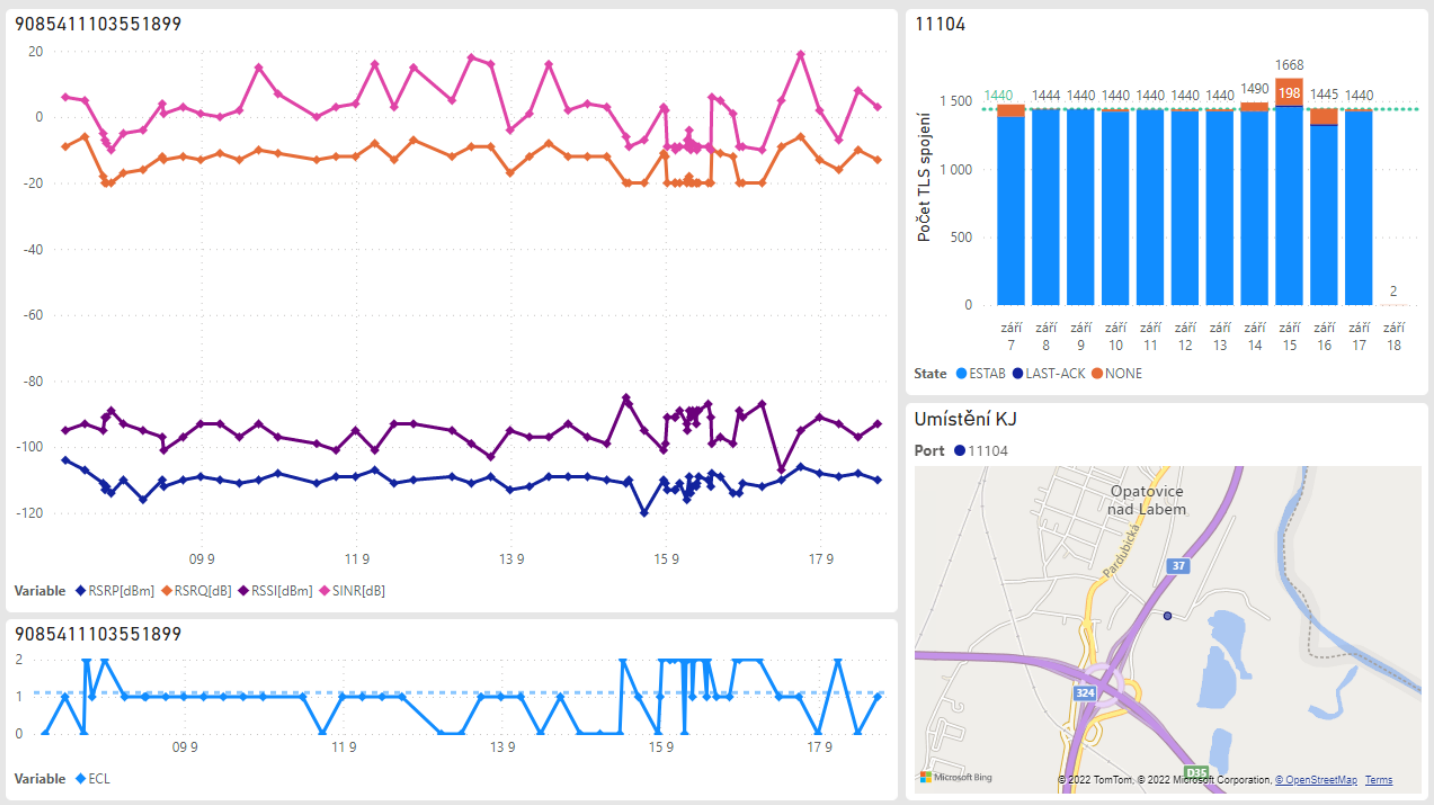
NB-IoT a LTE Cat M communication unit

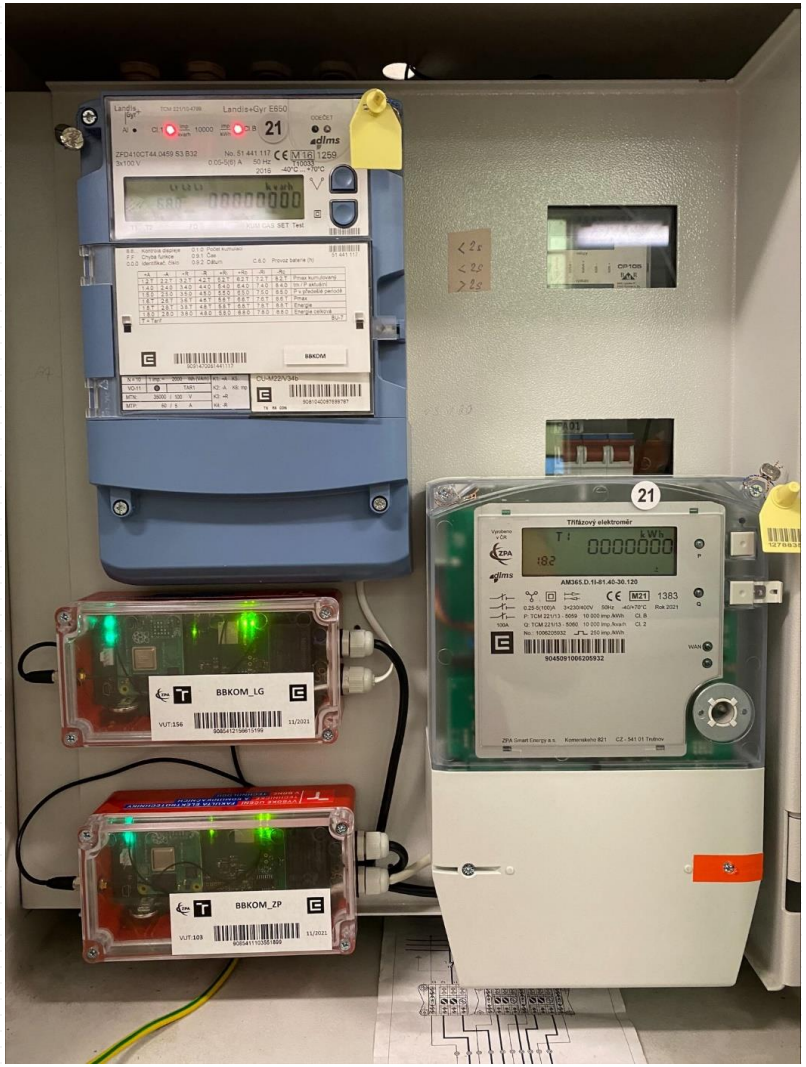




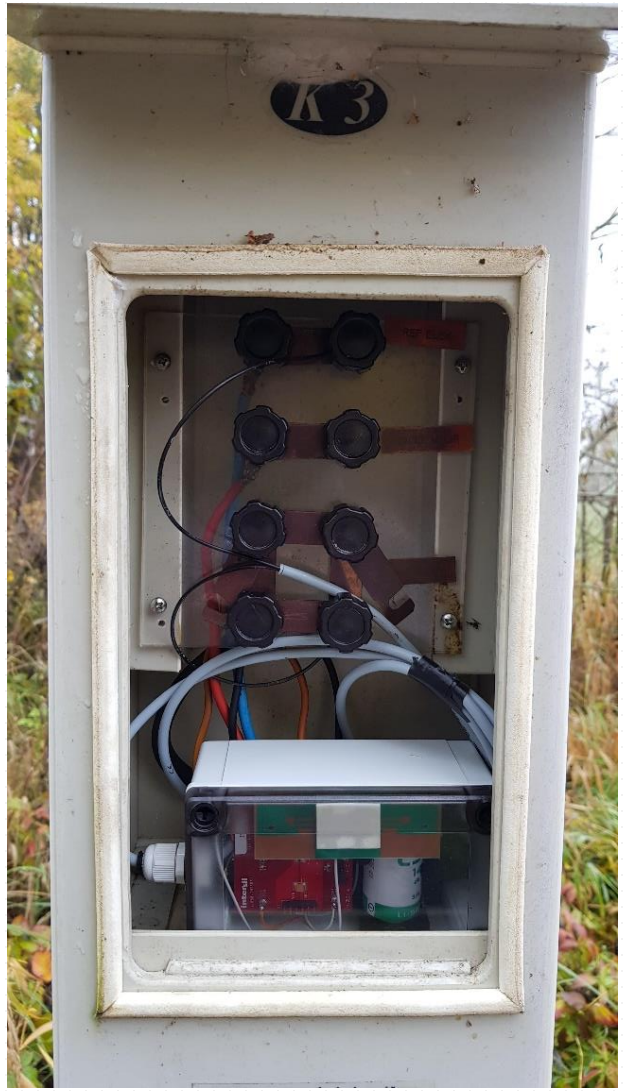
Implementation

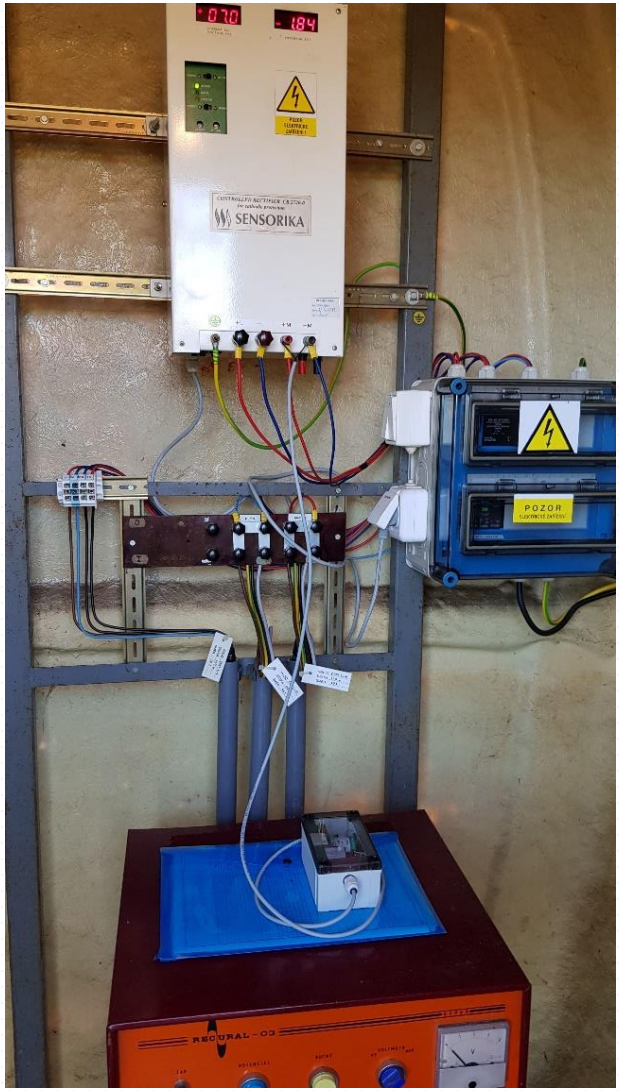
- deployed in the distribution network





Implementation





Thank you for your attention

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