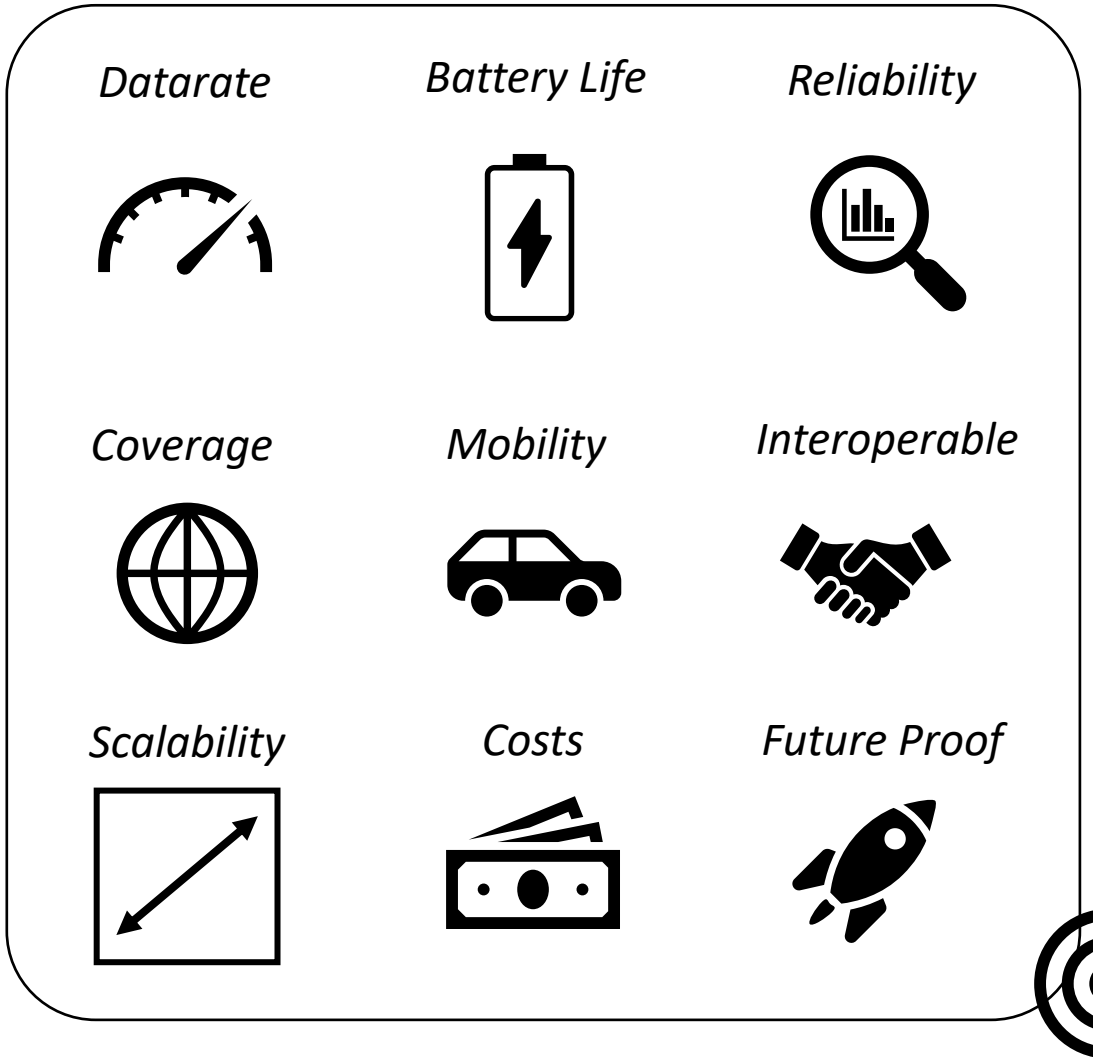
CoSA Center of Excellence

TECHNISCHE HOCHSCHULE LÜBECK

# AN ALTERNATIVE TO SUBGHZ FOR LPWAN

29. Fachtagung Mobilkommunikation

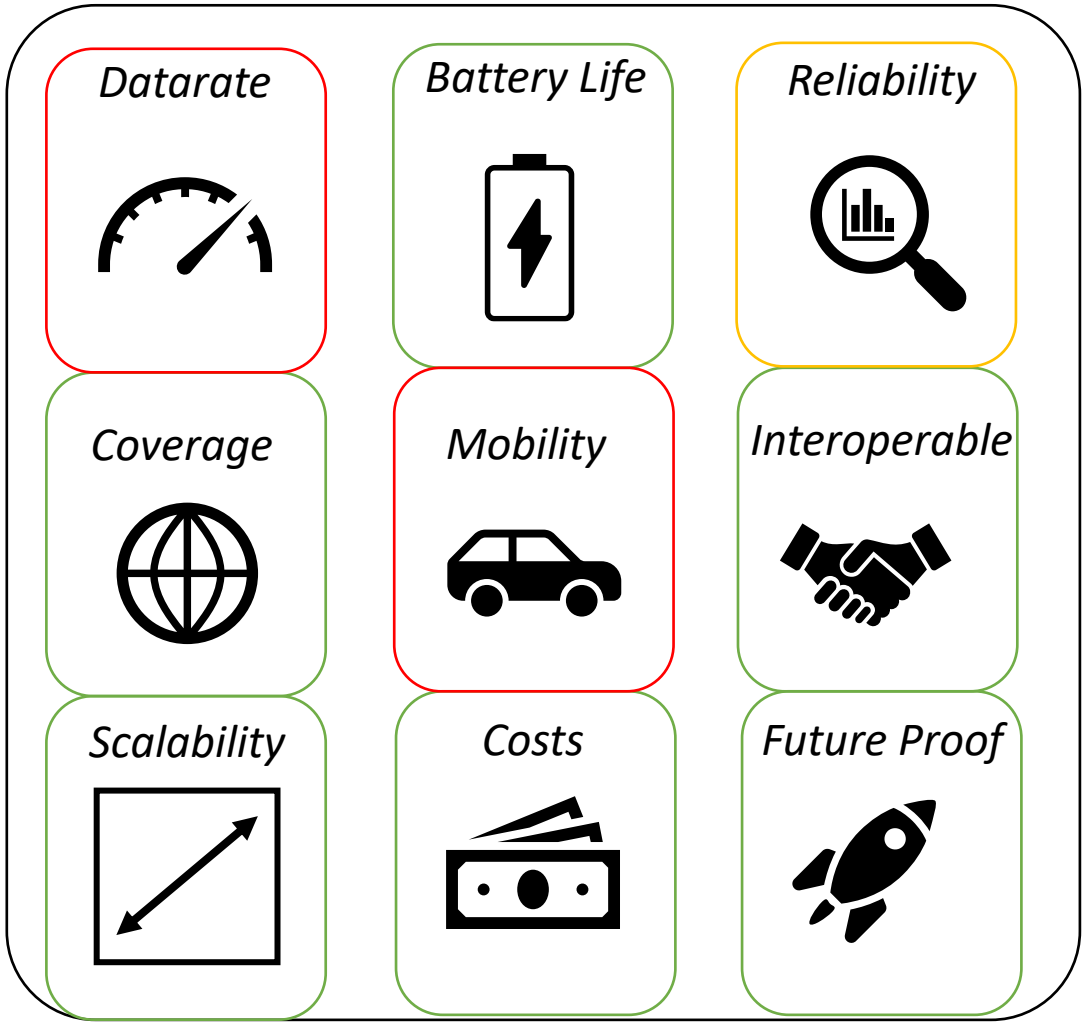
# Which Radio Technology?




- There is no wireless technology that is the solution for everything. Rather, it is a compromise and the search for the best compromise for the application.
- Since there are many radio technologies and each radio technology has its advantages and disadvantages, it is good to get an overview of different radio technologies

**Goal: Provide a service to transport data from A to B**

# LPWAN – Example LoRaWAN 868 MHz




- LoRaWAN 868 MHz performs good
  - Battery Life → up to 10 Years
  - Coverage → up to 10 km
  - Interoperablity → no Vendor Lock
  - Scalability
  - Costs
  - Future Proof → de facto standard for LPWAN
- But there are Shortcomes
  - Datarate is quite low → 292 bit/s – 50 kbit/s
  - Reliability → EU 1% Duty Cycle
  - Mobility → Not really in focus of LoRaWAN

- Upcoming Radio Technologies
  - **LoRa**(WAN) 2.4 GHz
  - **DECT NR+**

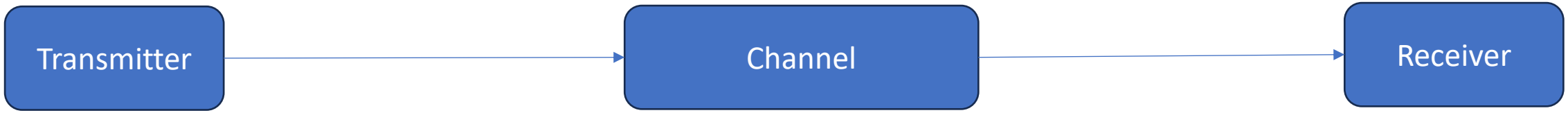
# Motivation

- Research Gap
  - Lack of direct comparison of DECT NR+ and LoRa 2.4 GHz: None of the previous works compare the two technologies directly.
  - Unrealistic range assumptions: Some studies report extremely large or small ranges without systematic modeling.
  - No evaluation of the data rate in real environments: While some papers look at ranges, there is no detailed analysis under real-world conditions.

- Contribution
  - Systematic modeling with the Log-Distance Path Loss Model.
  - Comparative range and data rate analysis for indoor, indoor-outdoor and outdoor scenarios.
  - Practical recommendations for IoT applications based on the results.

# Modelling

- Goal: Estimating the range and data rate for LoRa 2.4 GHz and DECT NR+




- Transmission Power ($P_{Tx}$)
- Antenna Gain ($G_{Tx}$)

- Log Pathloss Model:

$$PL(d) = PL(d_0) + 10 \cdot n \cdot \log_{10}\left(\frac{d}{d_0}\right) + 20 \cdot \log_{10}\left(\frac{f}{1000}\right) + X_\sigma$$

with Distance (d) between Transmitter and Receiver, Reference Distance ($d_0$) at which Pathloss($d_0$) is known, pathloss exponent (n), carrier frequency (f).

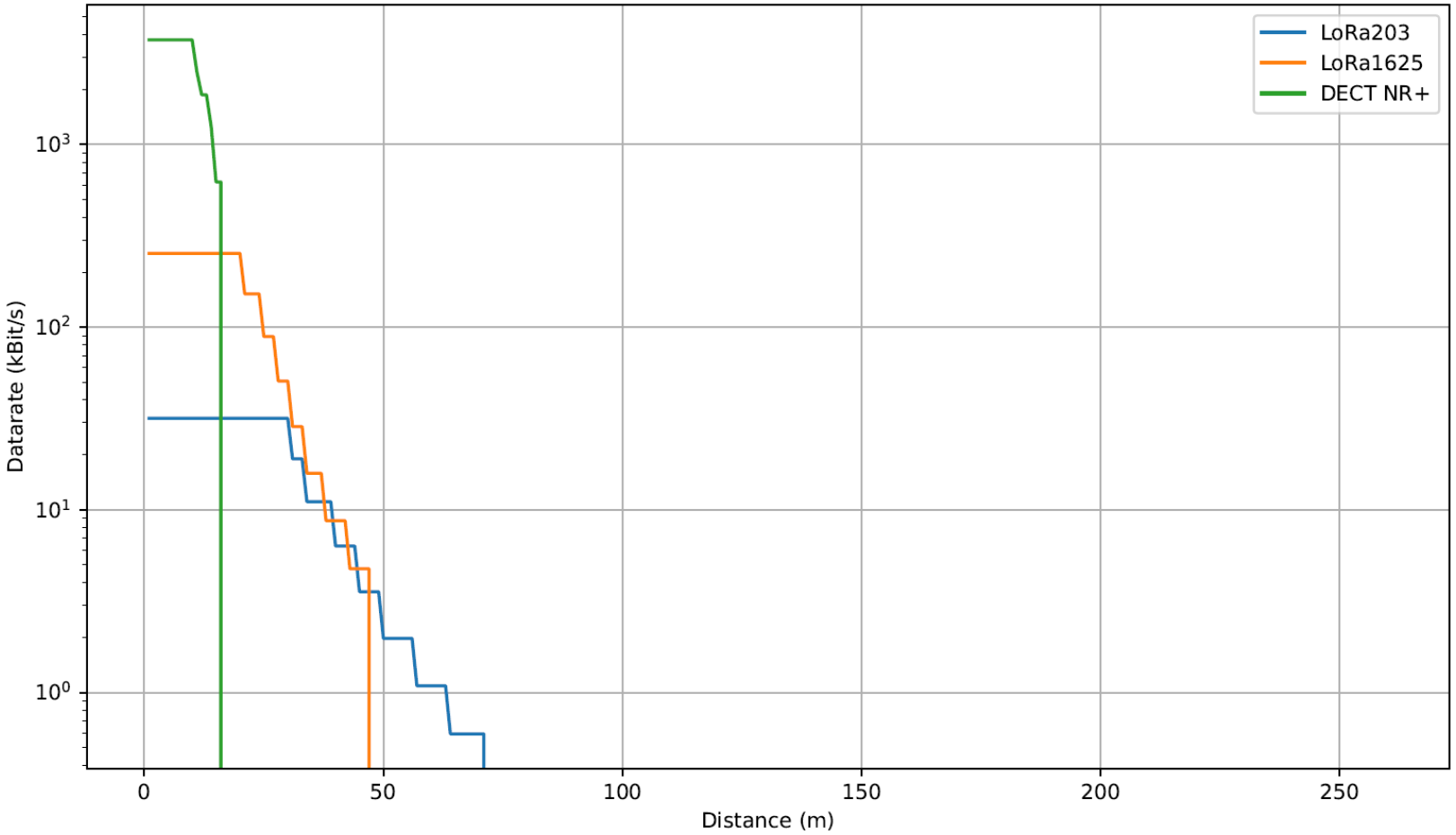
Random gaussian variable ($X_\sigma$) accounts for shadowing effects, but is in our case zero.

- Receiving Power ($P_{Rx}$):

$$P(d)_{Rx} = P_{Tx} + G_{Tx} - PL(d) + G_{Rx}$$

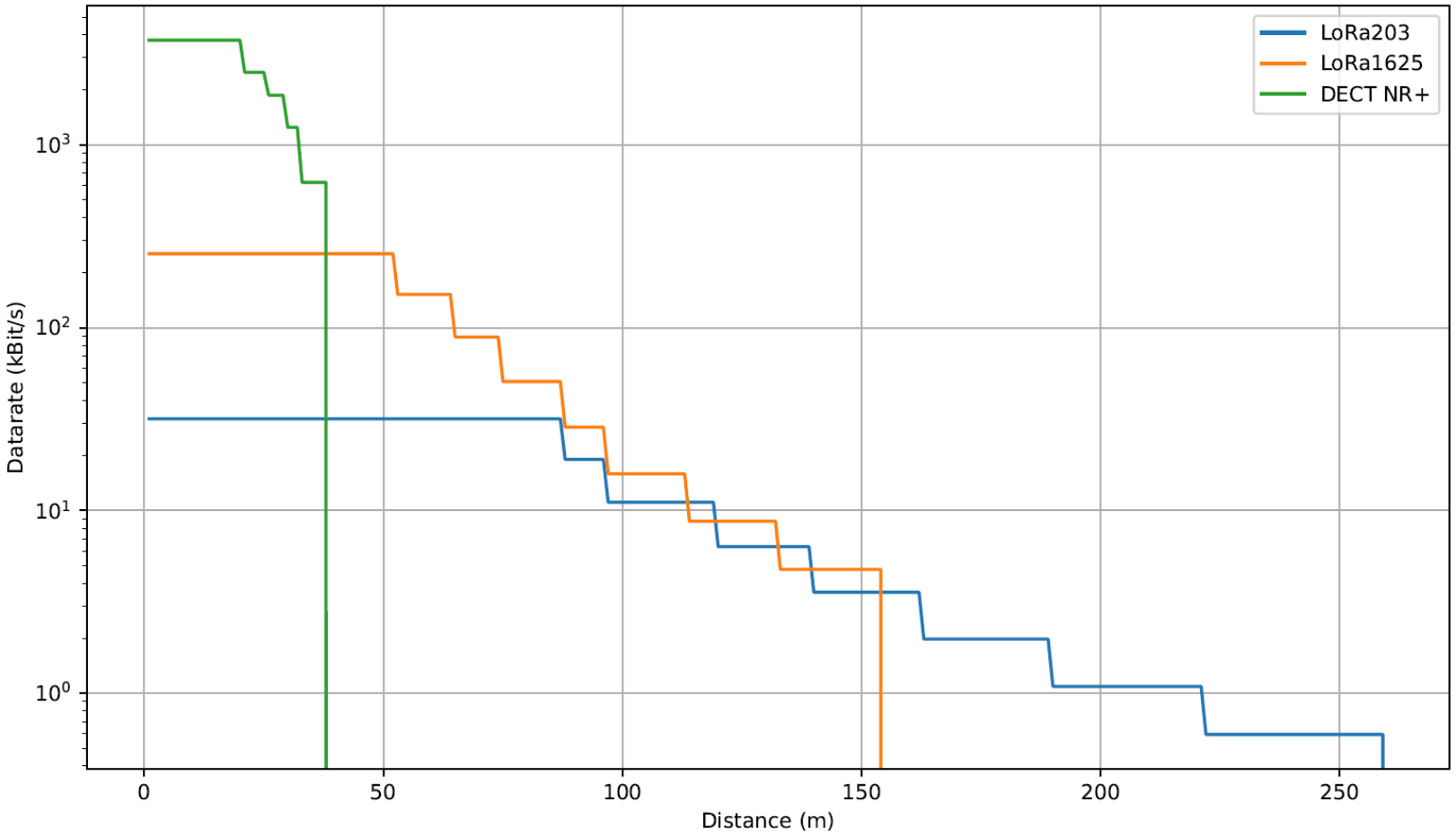
→ The data rate obtained via a lookup table which includes minimum received signal strength for the data rate, according to the radio chip manuals and standards.

# Modelling
## Indoor - Indoor




| Parameter | Indoor-Indoor | Indoor-Outdoor |
|---|---|---|
| $d_0$ | 1.0 m | 1.0 m |
| $PL(d_0)$ | 40.0 dB | 40.0 dB |
| $n$ | 4.45 | 5.8 |
| $X_\sigma$ | 0 | 0 |
| $f_{\text{LoRa}}$ | 2400 MHz | 2400 MHz |
| $f_{\text{DECT}}$ | 1900 MHz | 1900 MHz |
| $P_{\text{TX, LoRa}}$ | 15 dBm | 15 dBm |
| $P_{\text{TX, DECT, EU}}$ | 19 dBm | 19 dBm |
| LoRa $G_{TX}, G_{TX}$ | 5 dBi | 5 dBi |
| DECT NR+ $G_{TX}, G_{TX}$ | 4 dBi | 4 dBi |

# Modelling
## Indoor - Outdoor

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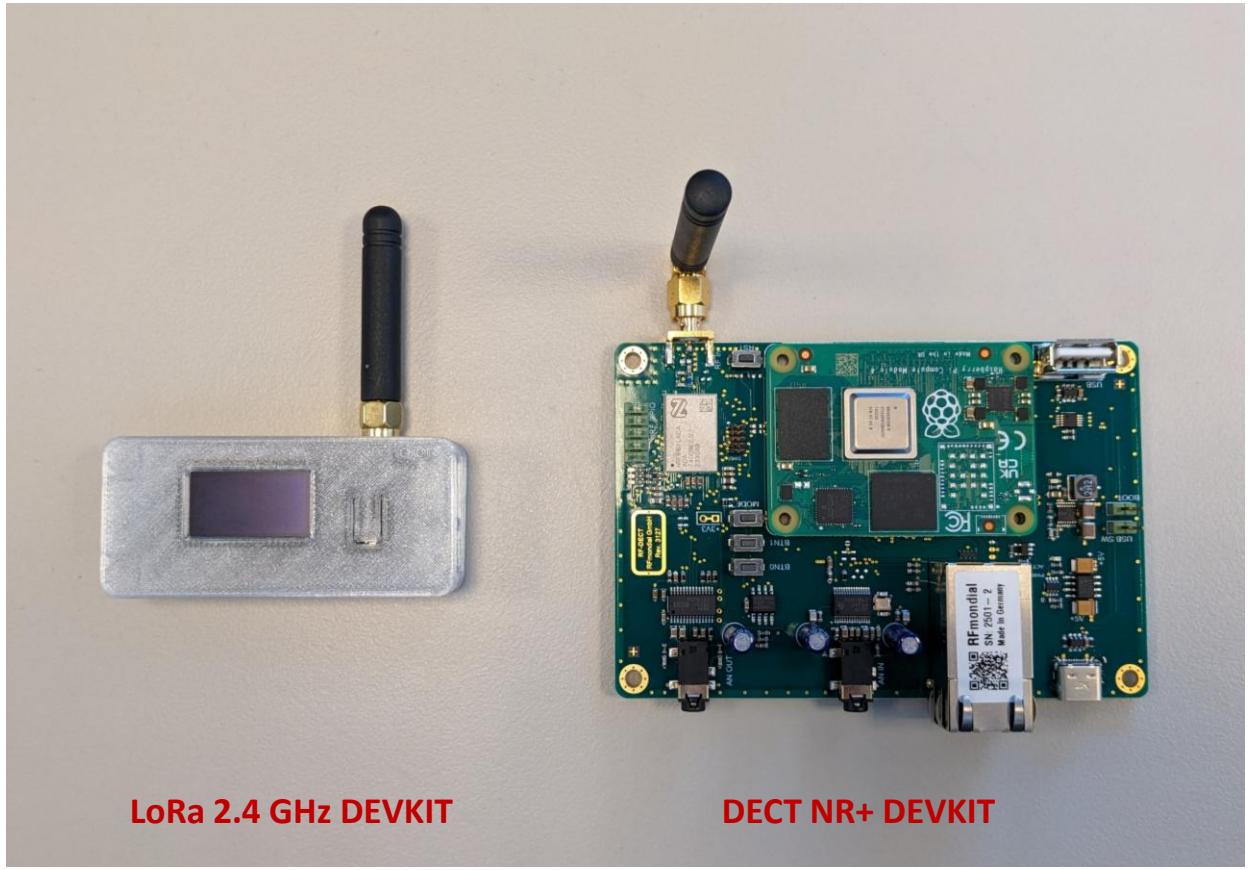
# Range DECT NR vs LoRa 2.4 GHz
## Hardware Overview




**LoRa 2.4 GHz**

- Center Frequency: 2400.5 MHz
- Bandwidth: 203 kHz
- Transmission Power: 20 dBm
- Modulation: LoRa

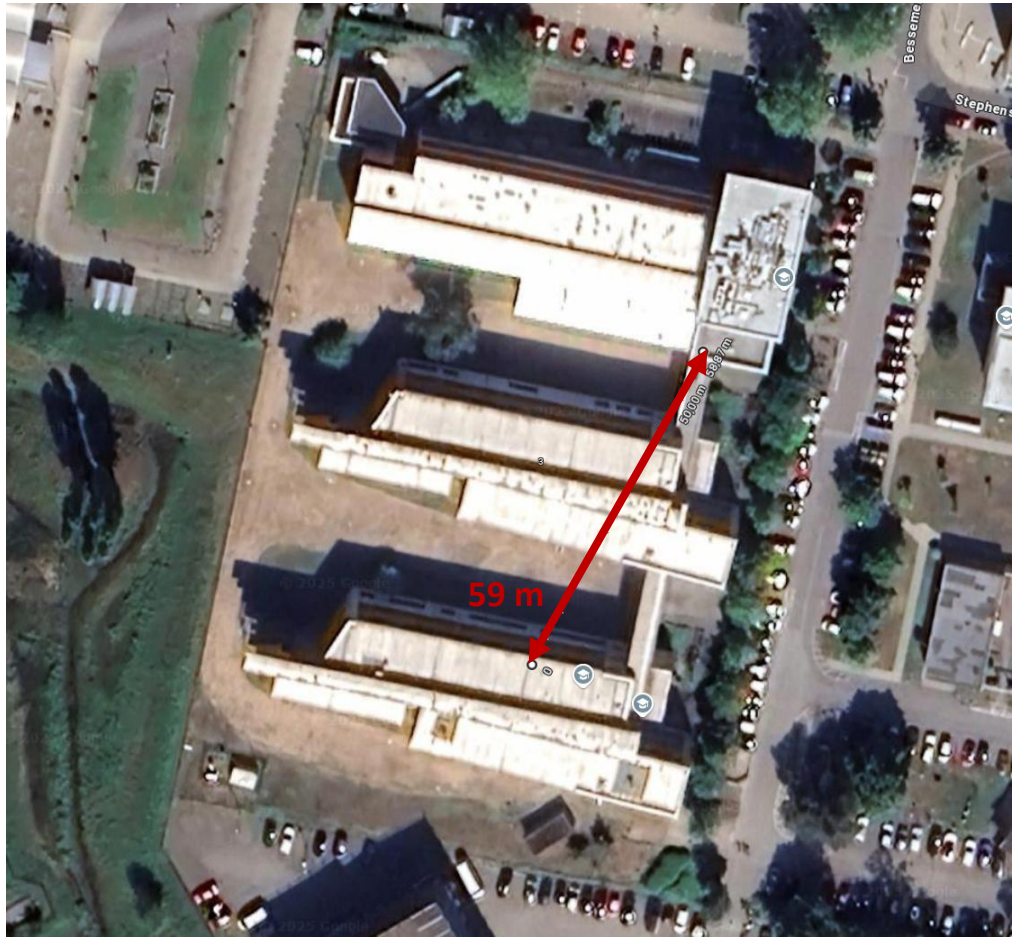
**DECT NR+ DEVKIT**

- Center Frequency: 1881.792 MHz
- Bandwidth: 1.728  MHz
- Transmission Power: 19 dBm
- Modulation Code Scheme: 0

# Range DECT NR vs LoRa 2.4 GHz
## Indoor-Indoor


DECT NR+

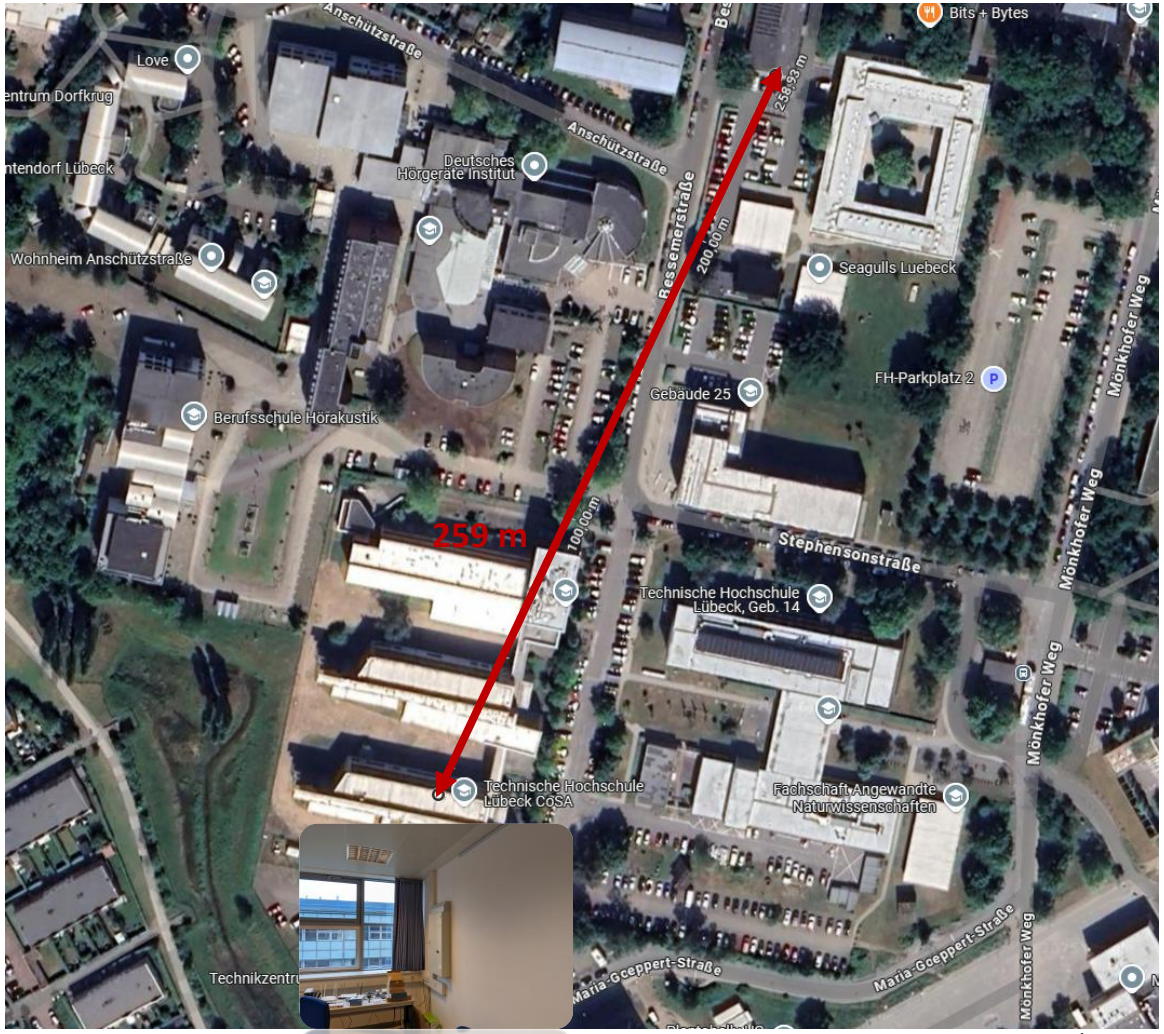
Source: Google Maps




LoRa 2.4 GHz

Source: Google Maps

# Range LoRa 2.4 GHz
## Indoor-Outdoor




Source: Google Maps

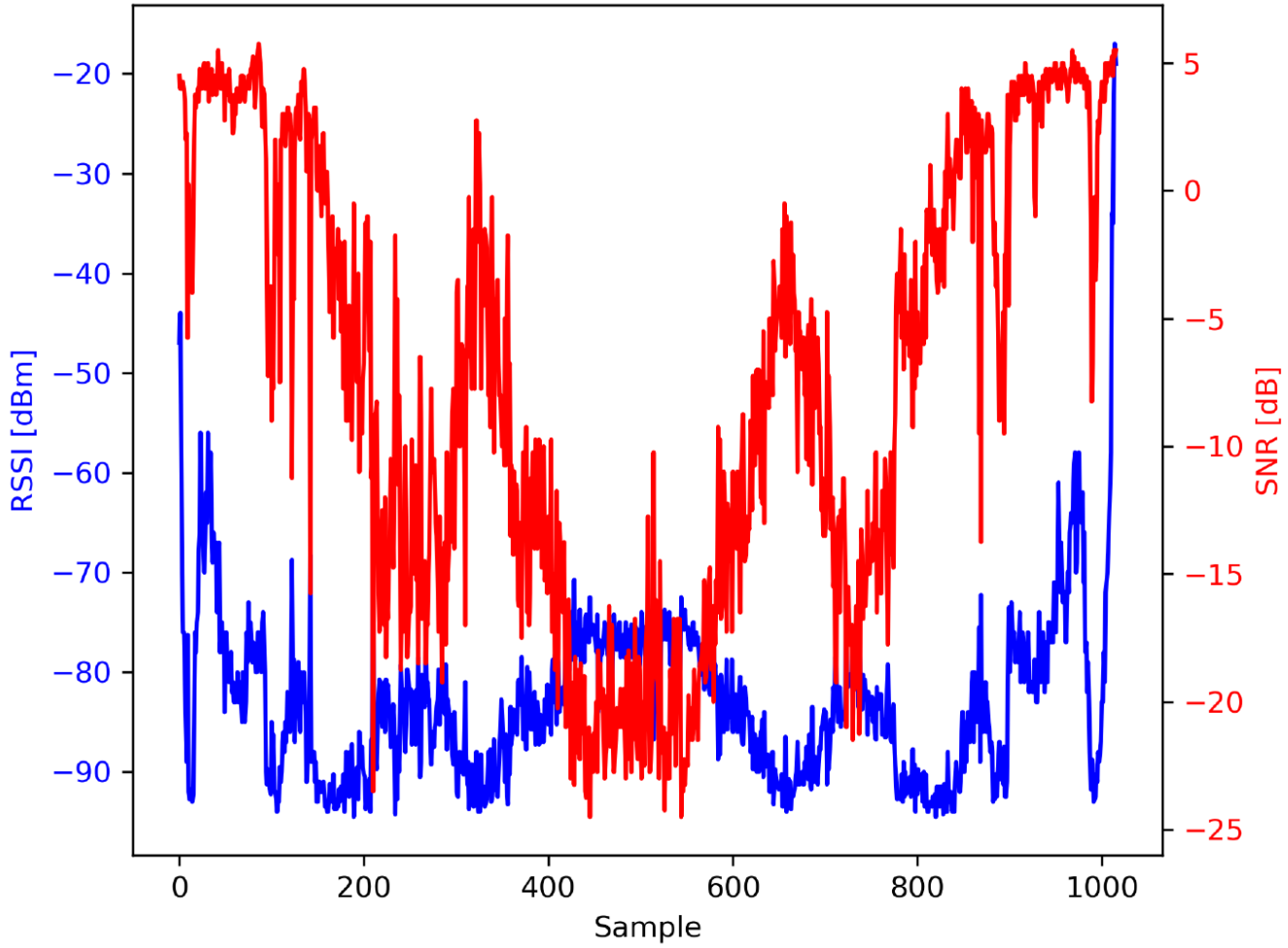
# Range LoRa 2.4 GHz
## Outdoor-Outdoor


Source: Google Maps

# Range LoRa 2.4 GHz
## Outdoor-Outdoor


Source: Google Earth

# Range LoRa 2.4 GHz
## Outdoor-Outdoor




- **Maximum Range:** *Over 1 km in non-line-of-sight conditions*
- **Signal Quality:** *RSSI down to -95 dBm, SNR down to -25 dB*
- **Reception Fluctuations:** *Signal loss when passing through buildings, recovery in open areas*
- **Transceiver Sensitivity Limit:** *Reception becomes unstable in low SNR environments*

# Conclusion

| DECT NR+ | 2.4 GHz LoRa |
|---|---|
| **Strengths**<br>• High data rates up to 3.4 Mbit/s possible<br>• High transmission power of +23 dBm possible<br>• Operates in license free 1.9 GHz band<br>  • Germany: 1880 MHz – 1900 MHz<br>  • Worldwide: Partially exclusive reserved for DECT | **Strengths**<br>• Medium data rates up to about 250 kbit/s<br>• High range (up to 1 km in Urban Environment)<br>• Due to 2.4 GHz available world wide |
| **Weaknesses**<br>• No free complete radio stack<br>• Currently only one manufacturer (Nordic)<br>• Limited range → Multihop needed for higher ranges | **Weaknesses**<br>• 2.4 GHz Band → Coexistence<br>• Only one manufacturer (Semtech)<br>• Transmission Power limited to +20 dBm (EIRP) |
| **Use Cases**<br>• Audio Transmission<br>• Video Transmission (Low Quality) | **Use Cases**<br>• Metering e.g. Water<br>• Telemetry Transmission e.g. Fire Fighters |

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