DRAMCO

Internet of Things, 5G
Connect the unconnected.

Localization
Indoor positioning systems.

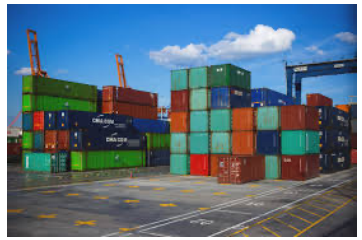
Visible light communication
Communicate at the speed of light.

KU LEUVEN | DRAMCO

Use Case Agnostic Platform for Energy Aware Devices in the Internet of Things

GUUS LEENDERS





Use Case Agnostic Platform for Energy Aware Devices in the Internet of Things

CONFIGURABLE FIGURE OF MERITS

LOW POWER / RELIABILITY OF CONNECTION / ENERGY PER EFFECTIVE BIT / BATTERY LEVEL / AVAILABLE NETWORKS / LATENCY / HEARTBEAT / LOCALIZATION ACCURACY / STATIC VS DYNAMIC

Use Case Agnostic Platform for Energy Aware Devices in the Internet of Things

PURSUING MINIMAL ENERGY: ADAPTIVE ALGORITHM

- Measure real-time power consumption
- Predict ‘best’ communication tech.

Use Case Agnostic Platform for Energy Aware Devices in the Internet of Things

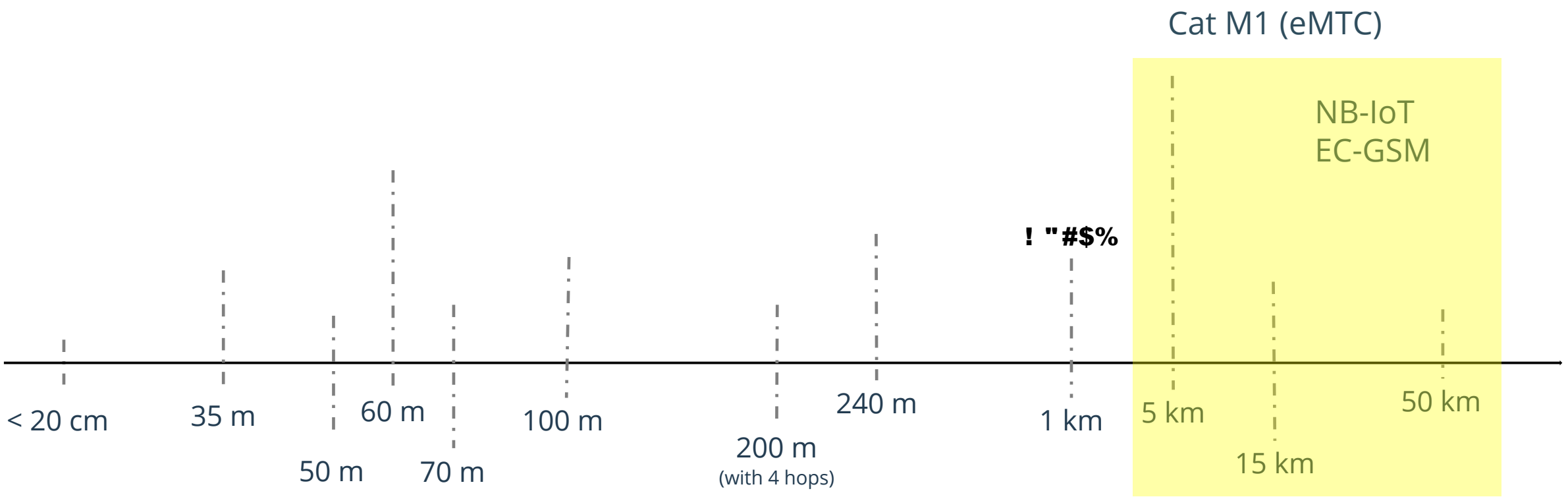
LPWAN COMMUNICATION FUSION

INTRODUCTION

LPWAN LANDSCAPE

LPWAN ENERGY CONSUMPTION

LPWAN LANDSCAPE | IOT TECHNOLOGIES



LPWAN LANDSCAPE | LOW POWER WIDE AREA

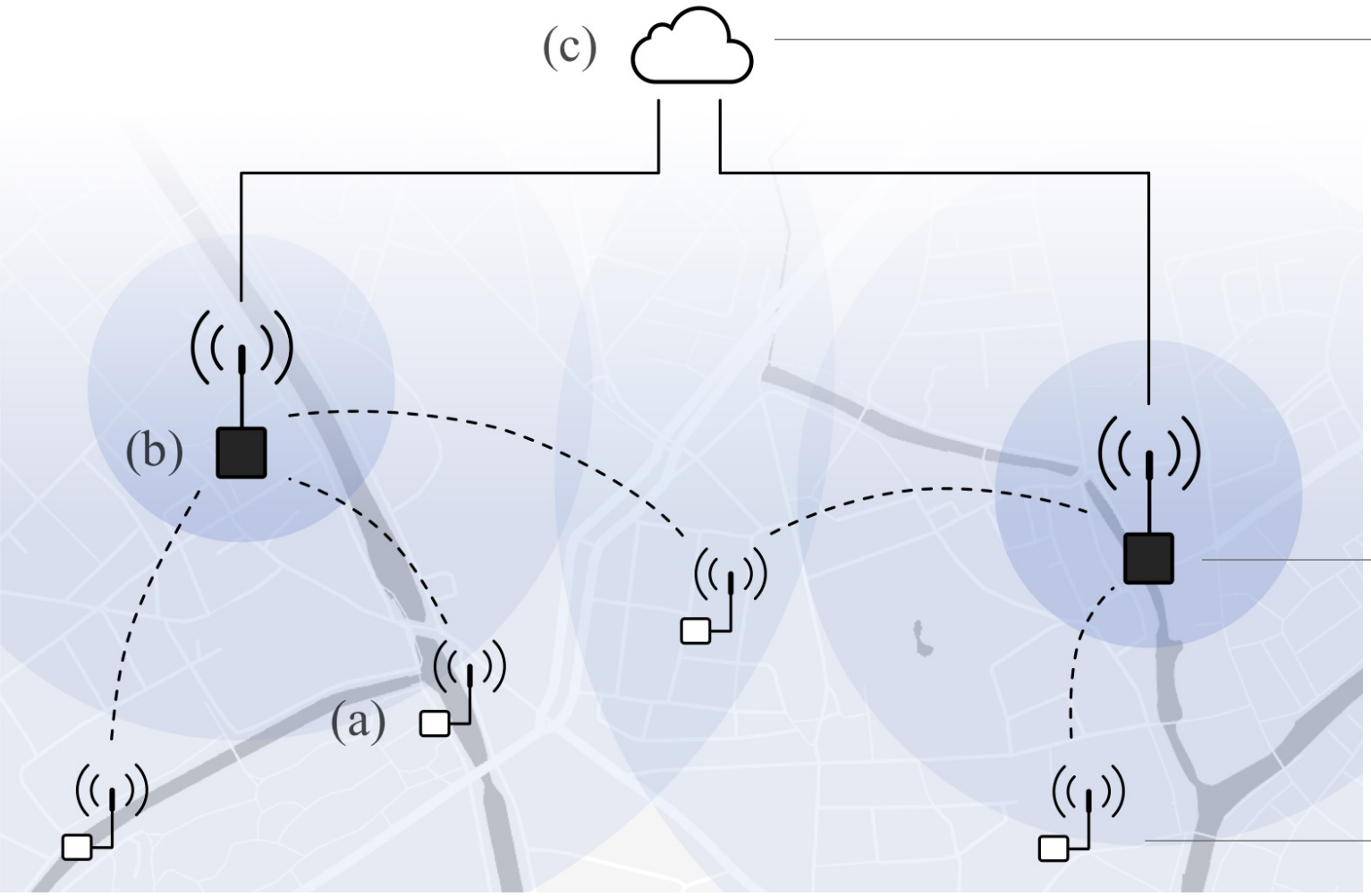
Low cost

Low energy

High coverage

Low data rate

LPWAN LANDSCAPE | COMMON LPWAN ARCHITECTURE



IoT cloud

Saving and processing data

IoT gateway

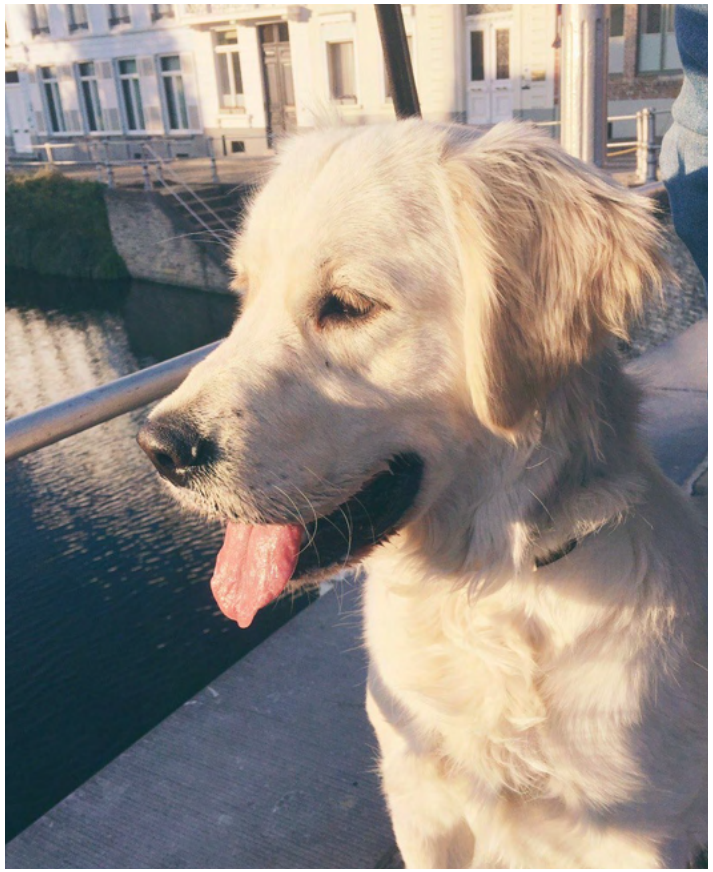
LoRaWAN transmission to internet

IoT sensor

Send data with LoRaWAN

LPWAN LANDSCAPE | DATA IN LORAWAN

- Worst case: `51 byte`



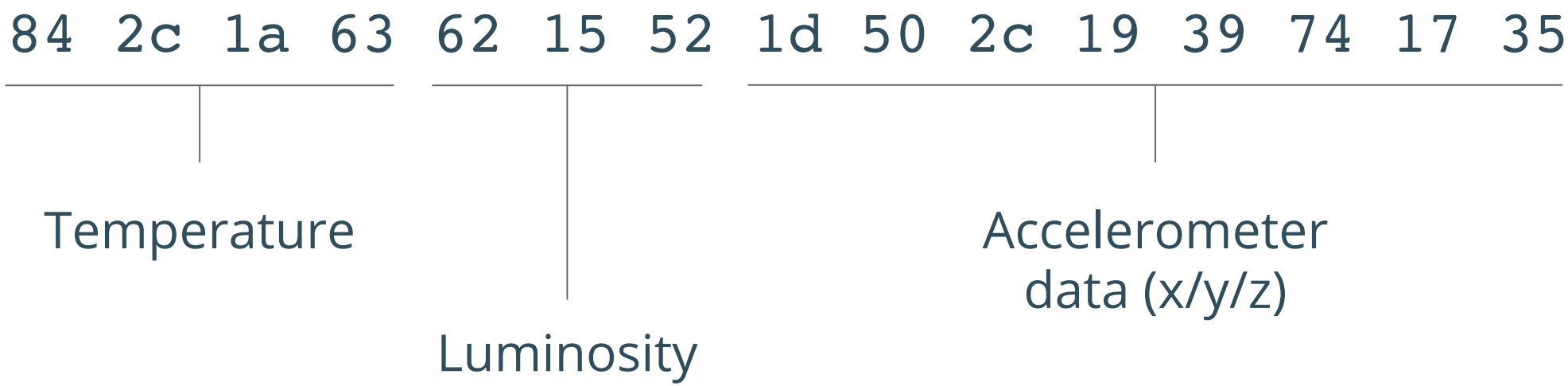
2.3 MB
300 kB compressed

6000 LoRaWAN messages

360 messages per day allowed
(every 4 minutes)

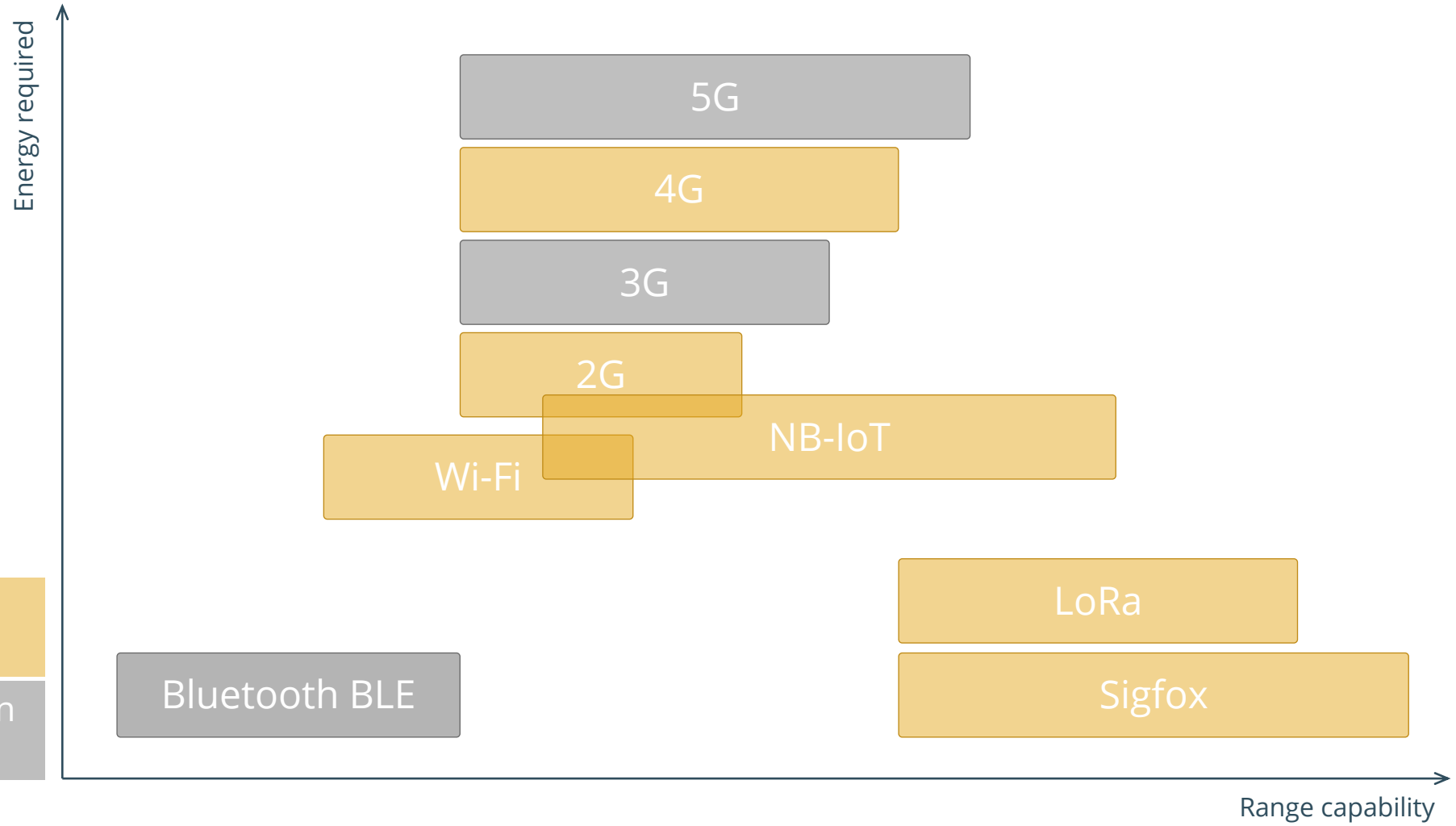
LPWAN LANDSCAPE | DATA IN LORAWAN

- Worst case: ~~`51 byte`~~ `15 byte`
- How to use data in LoRaWAN:



- 720 messages per day allowed (every 2 minutes)

LPWAN LANDSCAPE | MULTI MODEM



Communication fusion

No communication fusion

LPWAN LANDSCAPE | DIVERSITY

sigfox

- Global IoT provider
- Limited downlink messages
- Controls, builds and maintains the cloud

LoRaWAN™

- Create your own network
- Crowd-sourced networks available
- Roaming in 25 networks

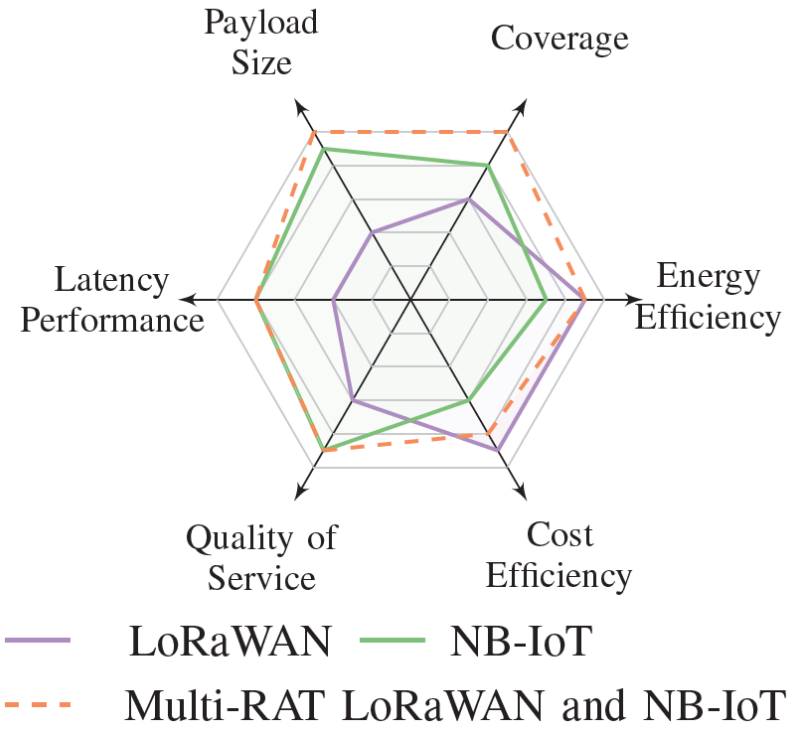
NB-IoT™

- Licensed spectrum
- Higher data speeds and more UL/DL messages
- Mature

LPWAN LANDSCAPE | DIVERSITY

	sigfox	ENGIE	LoRaWAN proximus	LoRaWAN THE THINGS NETWORK	NB-IoT proximus orange
UL/day	2 – 140 messages		2 – 96 messages	30 – 500 (30 sec.)	33 kByte
DL/day	0 – 4 messages		0 – 4 messages	10 messages	
cost/year	€ 3 – 7		€ 3.6 – 15.6	/	€ 10

LPWAN LANDSCAPE | MULTI MODEM



Comparative study of the explored IoT network technologies, presenting the main IoT feature requirements

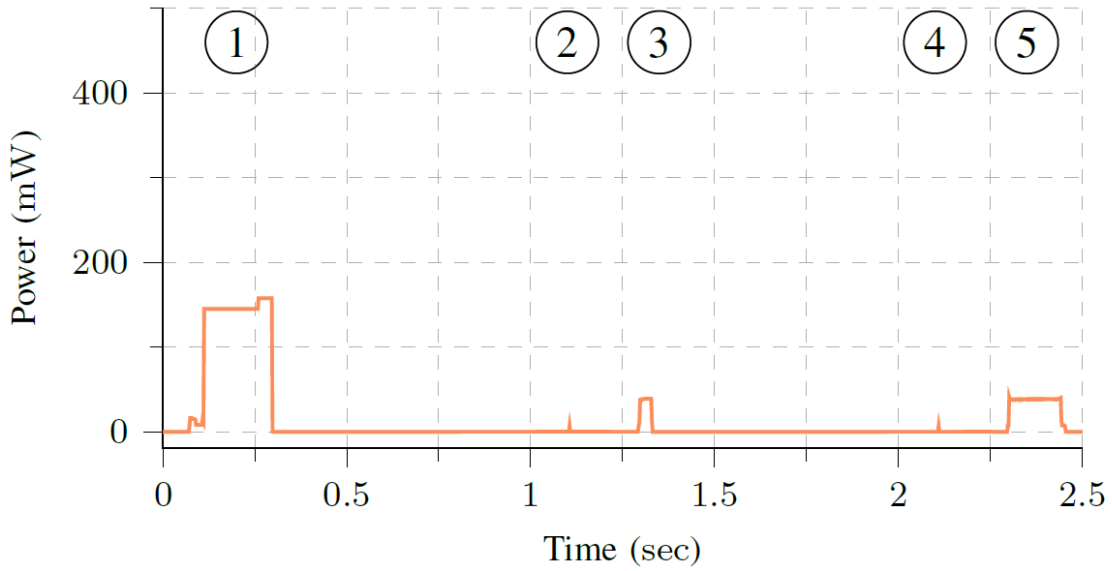
G. Leenders, G. Callebaut, G. Ottoy, L. Van der Perre, L. De Strycker, “Multi-RAT for IoT , the potential in combining LoRaWAN and NB-IoT”

INTRODUCTION

LPWAN LANDSCAPE

LPWAN ENERGY CONSUMPTION

RESULTS | POWER USAGE IN LORAWAN

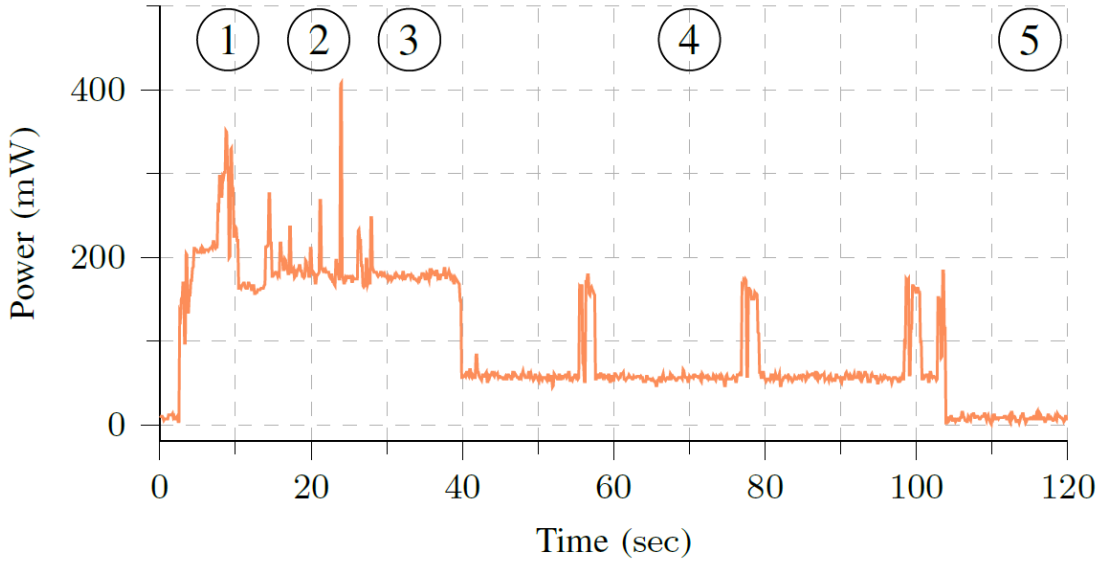


1. Transmit
2. Processing
3. First receive window
4. Second receive window

Measured power consumption of a LoRaWAN node.

G. Leenders, G. Callebaut, G. Ottoy, L. Van der Perre, L. De Strycker, “Multi-RAT for IoT , the potential in combining LoRaWAN and NB-IoT”

RESULTS | POWER USAGE IN NB-IOT



1. Search and join
2. Data
3. Connected DRX
4. Extended DRX
5. Power Saving Mode

Measured power consumption of a NB-IoT node.

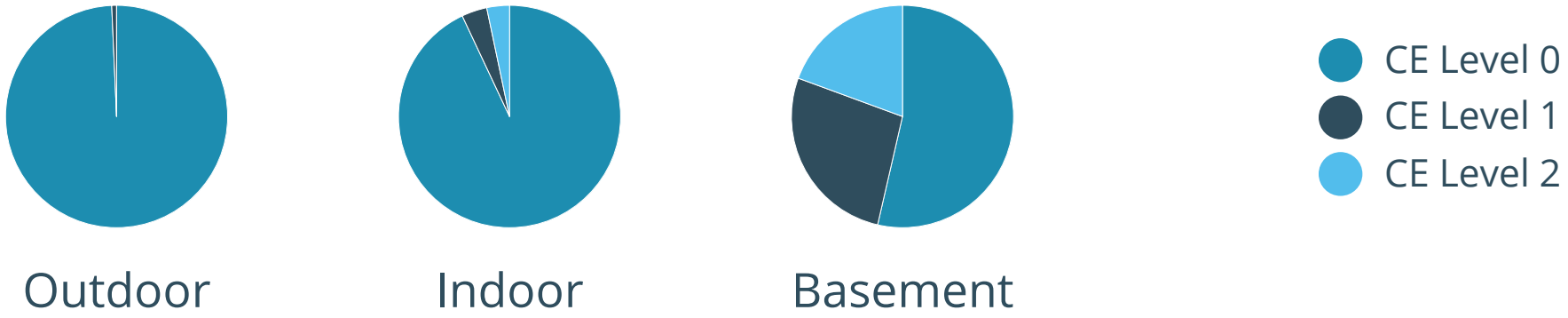
G. Leenders, G. Callebaut, G. Ottoy, L. Van der Perre, L. De Strycker, “Multi-RAT for IoT , the potential in combining LoRaWAN and NB-IoT”

RESULTS | ENERGY USAGE IN NB-IOT

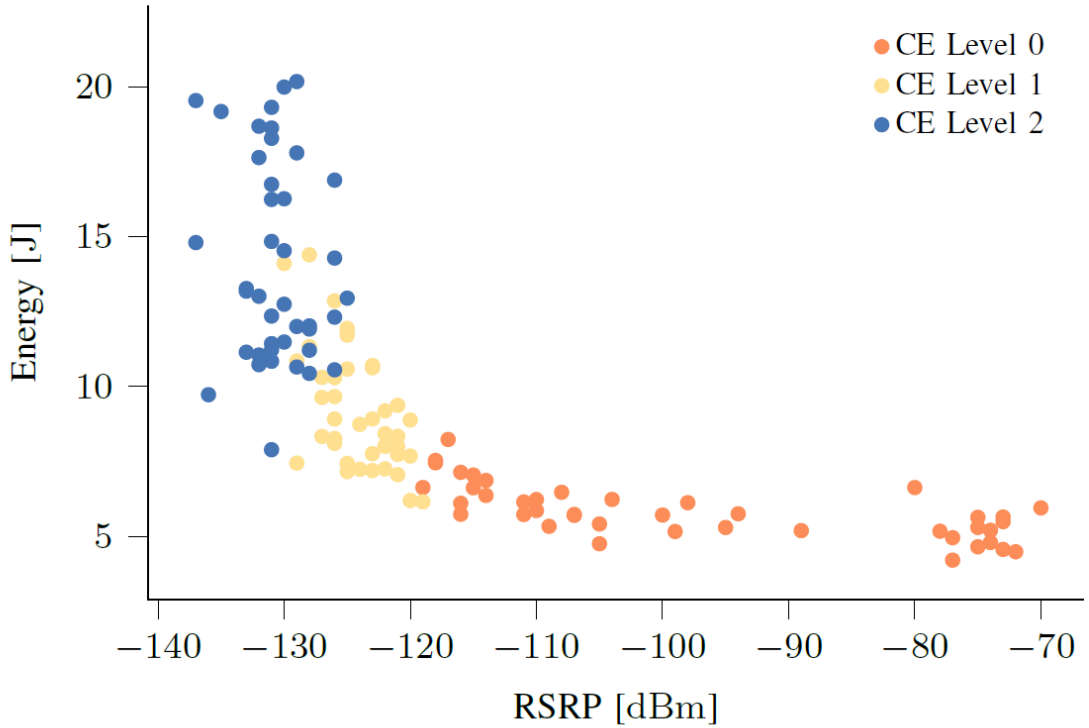
Coverage Extension mechanism in NB-IoT: **CE-Level**

- More transmissions
- Higher transmit power

→ Higher energy consumption



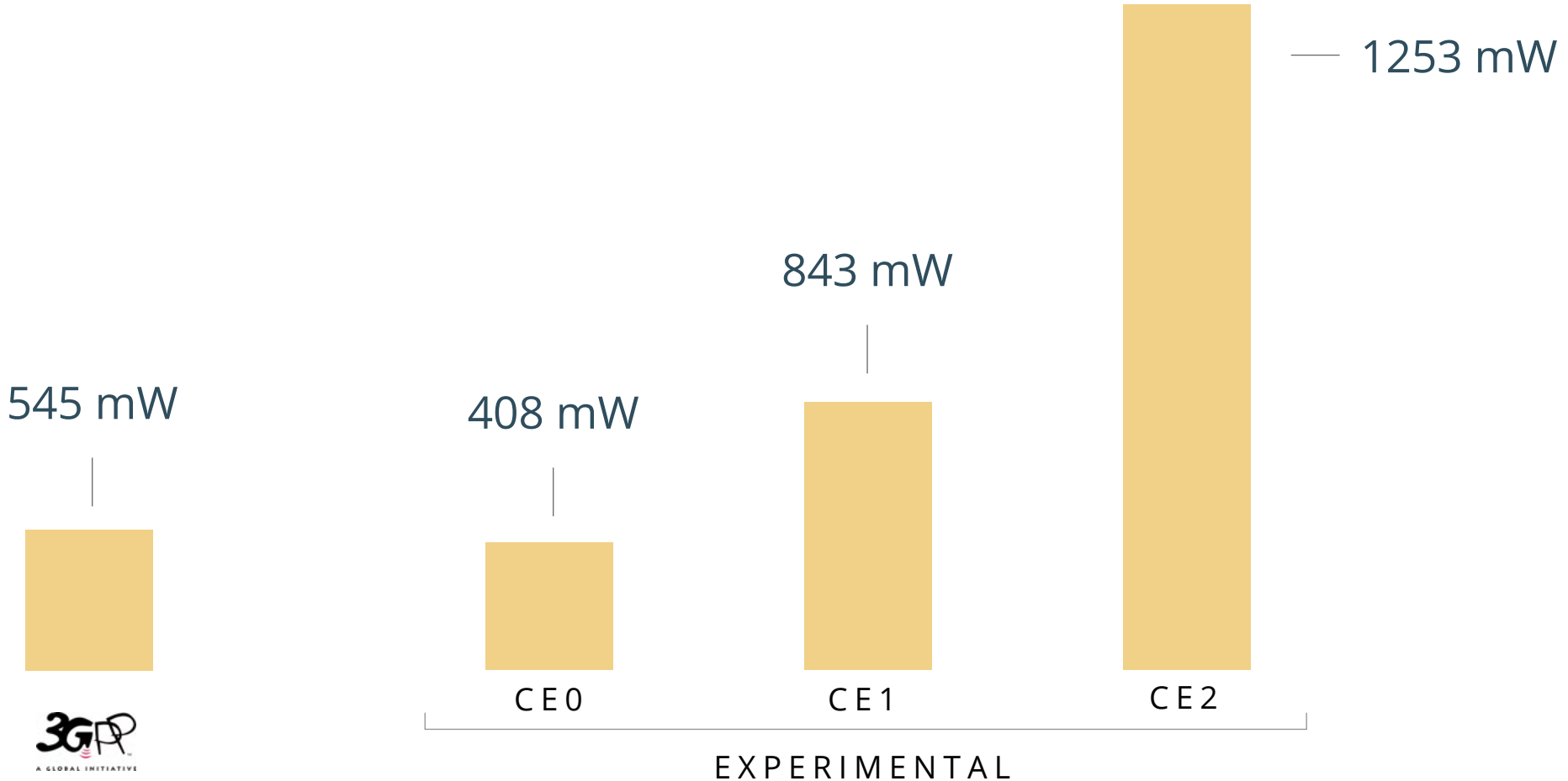
"Narrowband Iot Delivers Insights From The Largest Nb-iot Indoor Measurement Campaign," Deutsche Telekom AG, Tech. Rep., January 2019. [Online]. Available: ista.com/fileadmin/twt customer/global/content/Documents/NB-IoT ista EN.pdf



Total energy consumed when sending a 5-byte payload.

G. Leenders, G. Callebaut, L. Van der Perre, L. De Strycker, “An Experimental Evaluation of Energy Trade-Offs in Narrowband IoT”

FIRST RESULTS | 3GPP NB-IOT POWER LEVELS

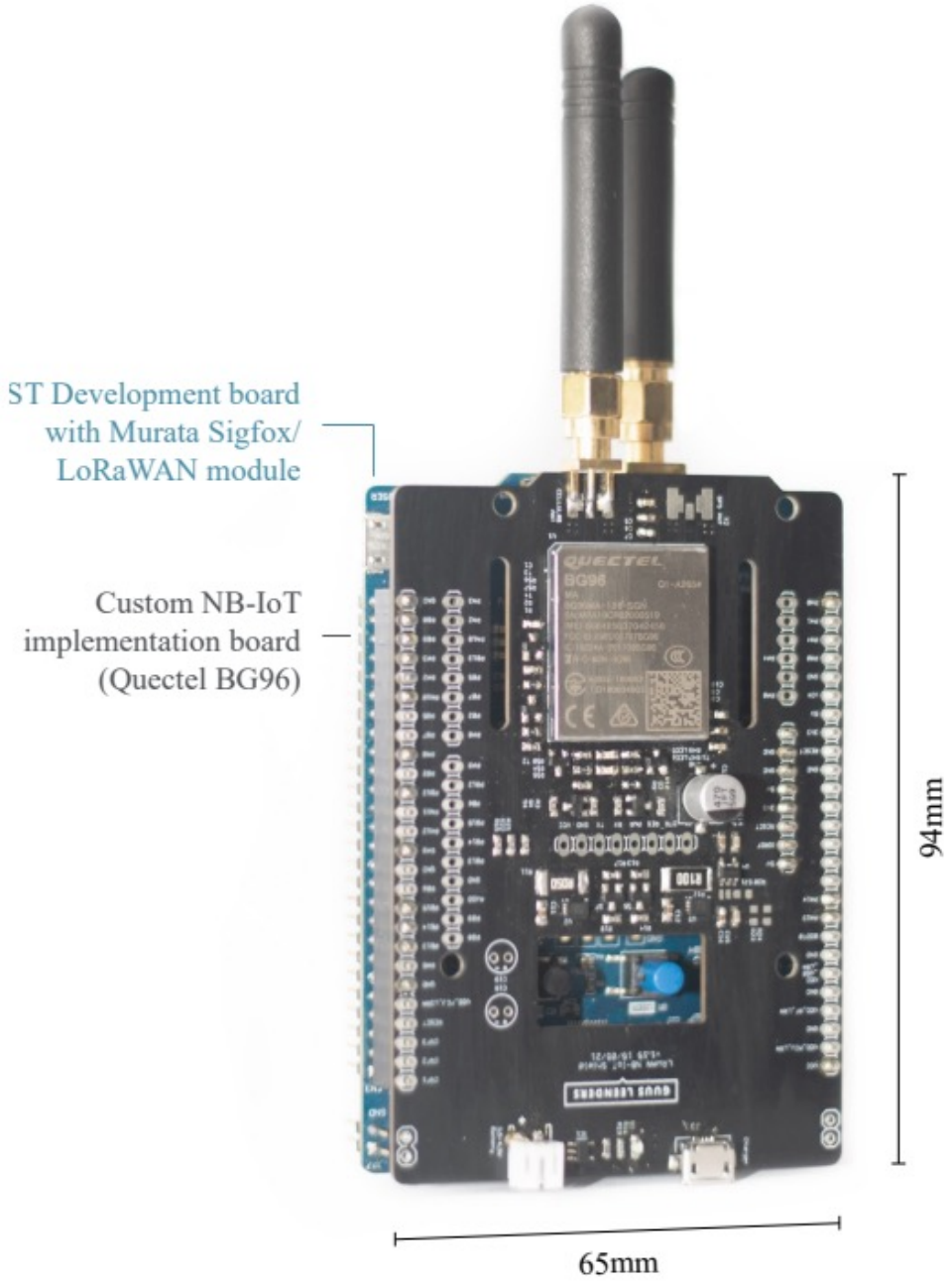


Comparing assumed power Level versus experimental power level.

G. Leenders, G. Callebaut, L. Van der Perre, L. De Strycker, "An Experimental Evaluation of Energy Trade-Offs in Narrowband IoT"

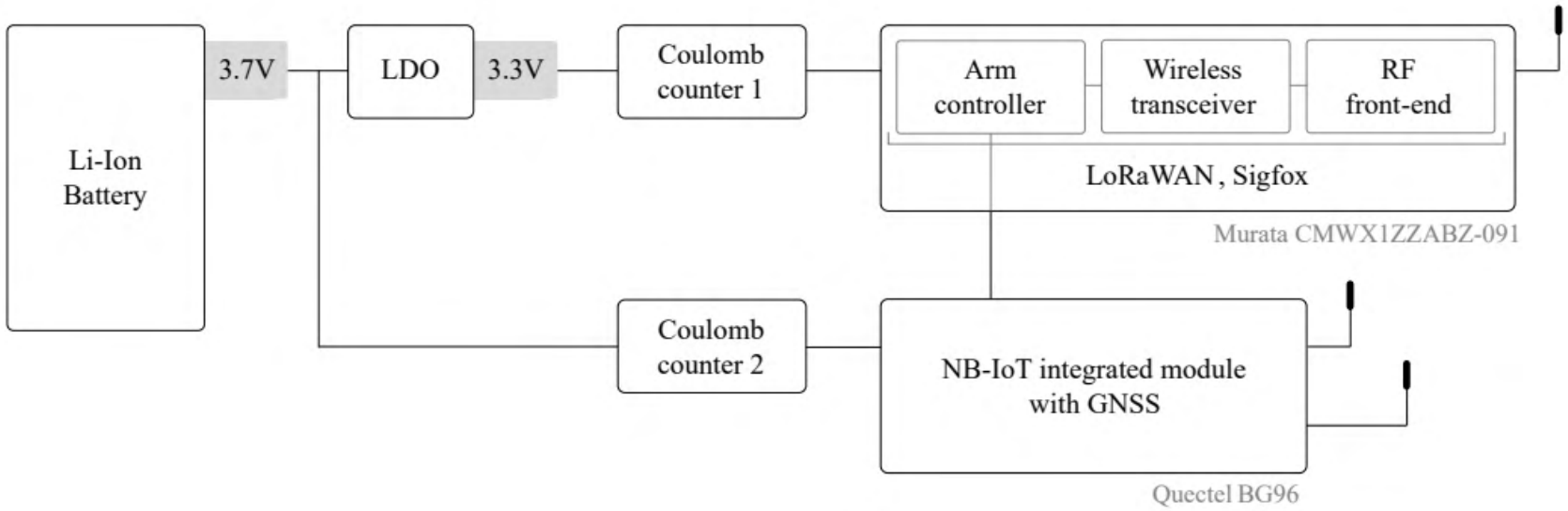
RESULTS | FUSION HARDWARE

- Communication fusion
  - LoRaWAN
  - Sigfox
  - Cellular IoT
    - 2G
    - NB-IoT
- In-the-field energy consumption analysis
- Measurement/testing platform



G. Leenders, G. Callebaut, L. Van der Perre, L. De Strycker, "Platform for Dynamic Energy Consumption Measuring for IoT Multi-RAT Setups"

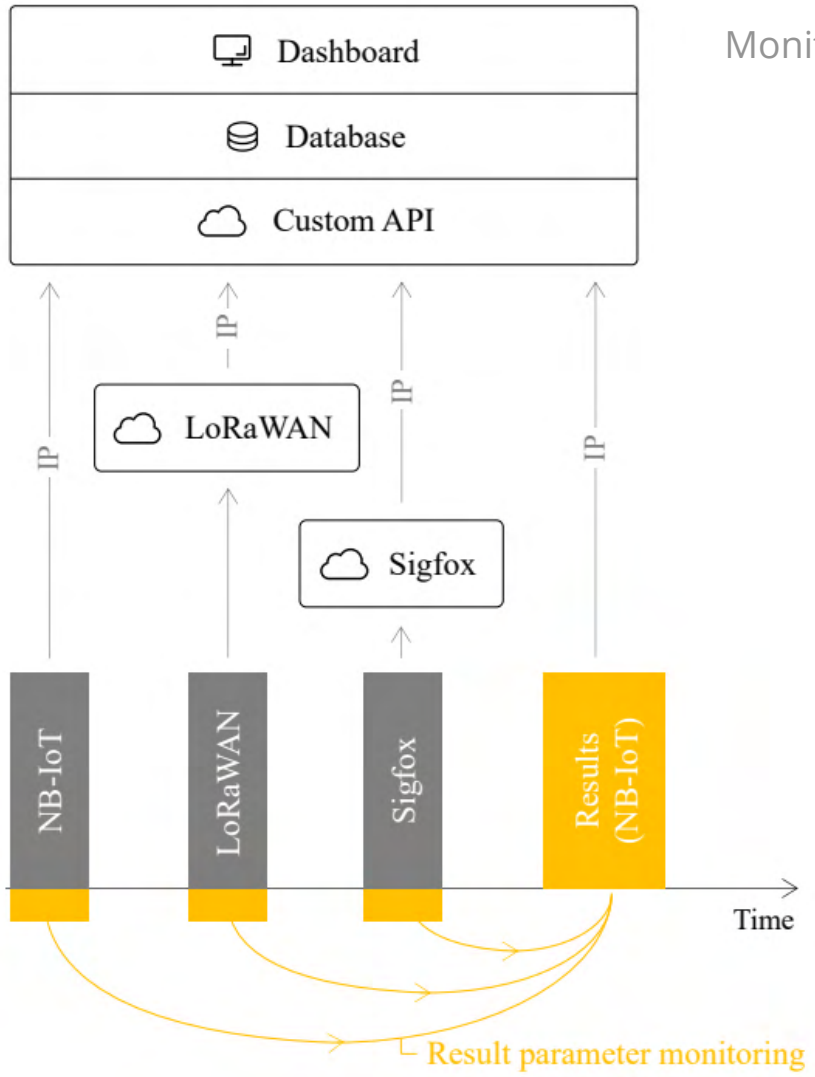
RESULTS | FUSION HARDWARE



Schematic overview of the proposed testing platform.

G. Leenders, G. Callebaut, L. Van der Perre, L. De Strycker, "Platform for Dynamic Energy Consumption Measuring for IoT Multi-RAT Setups"

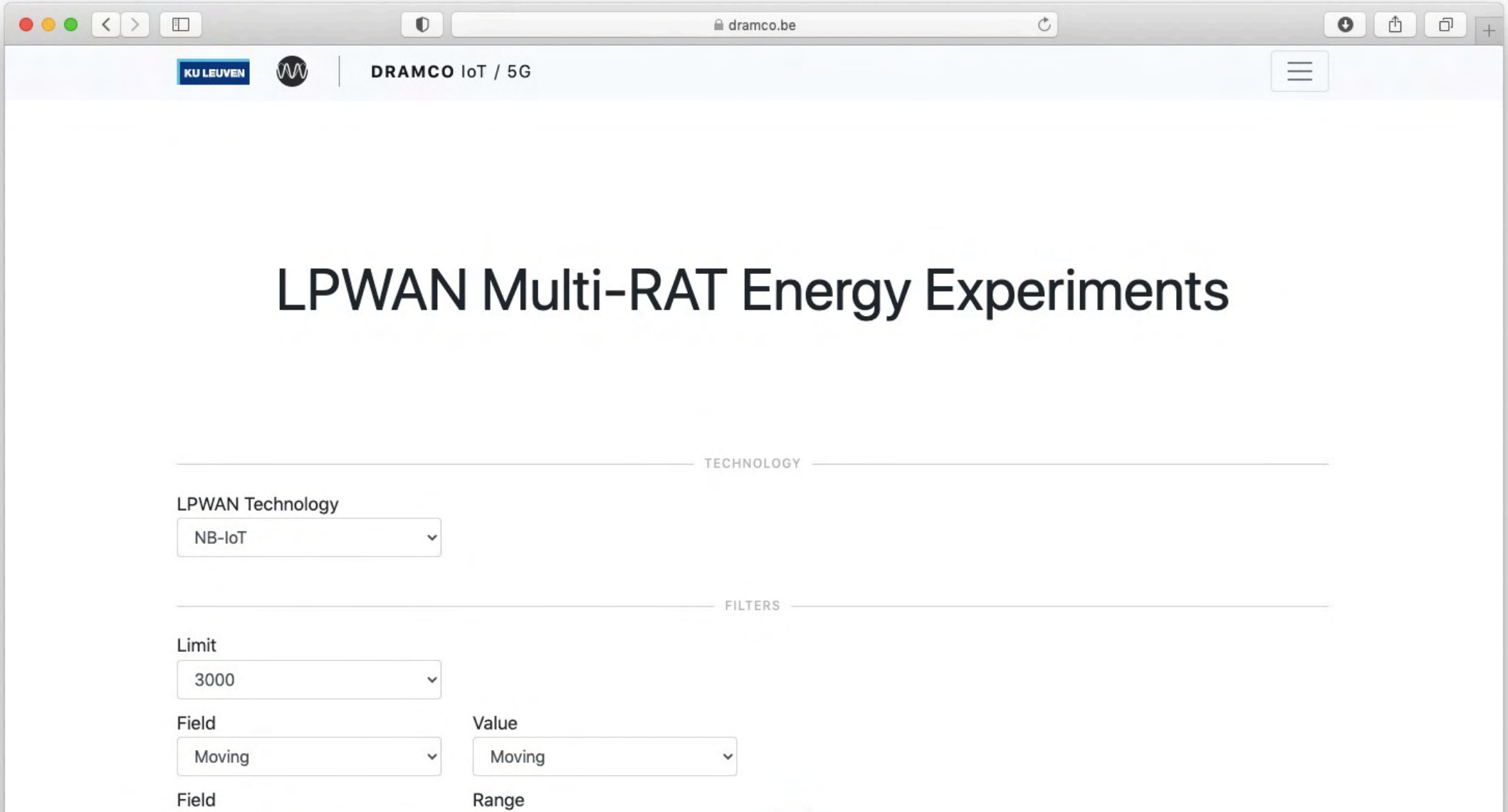
RESULTS | FUSION HARDWARE



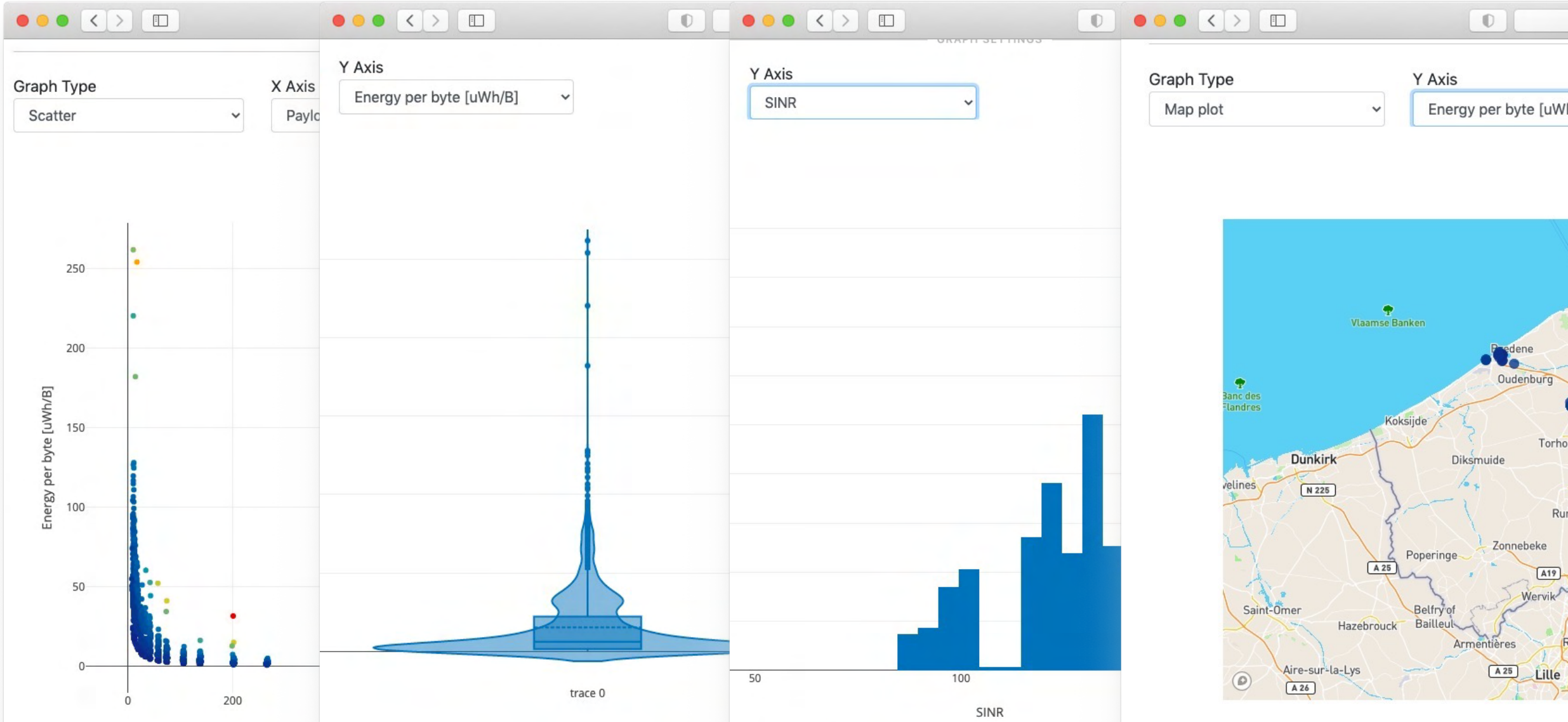
Monitoring algorithm overview.

G. Leenders, G. Callebaut, L. Van der Perre, L. De Strycker, "Platform for Dynamic Energy Consumption Measuring for IoT Multi-RAT Setups"

RESULTS | DIAGNOSTICS DASHBOARD

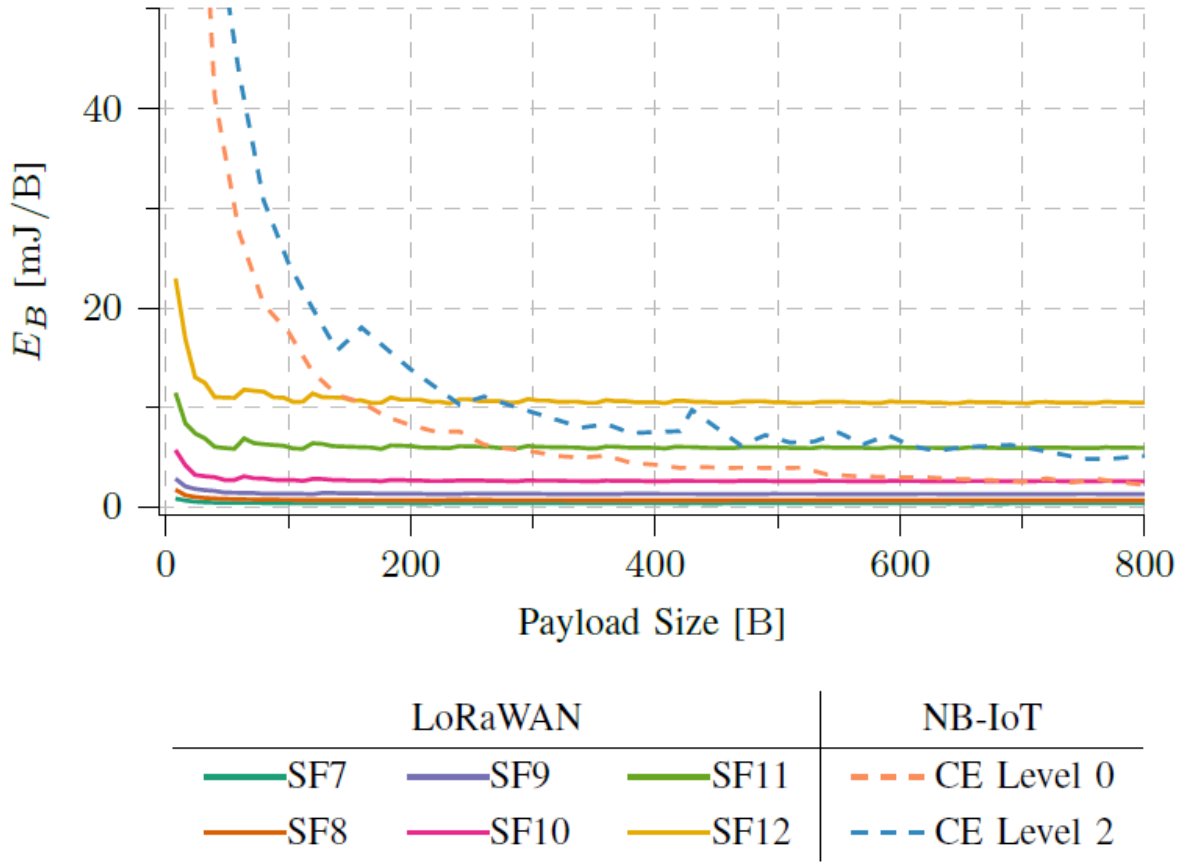


RESULTS | DIAGNOSTICS DASHBOARD



RESULTS | FUSION ENERGY RESULTS

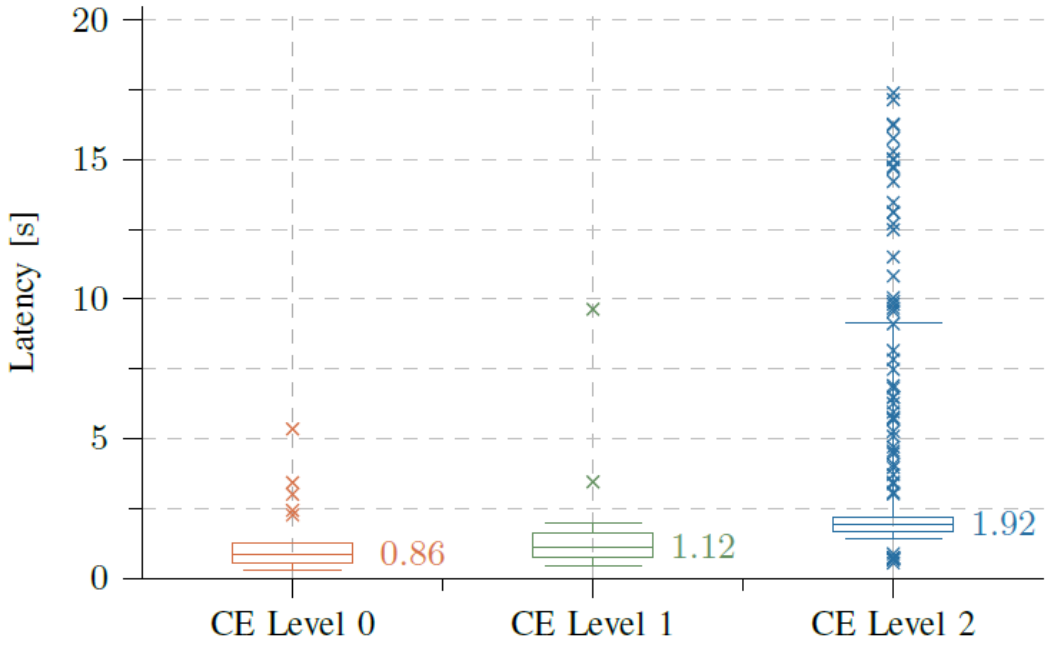
1. Payload diversity



Energy consumption per byte comparison between LoRaWAN and NB-IoT

RESULTS | FUSION ENERGY RESULTS

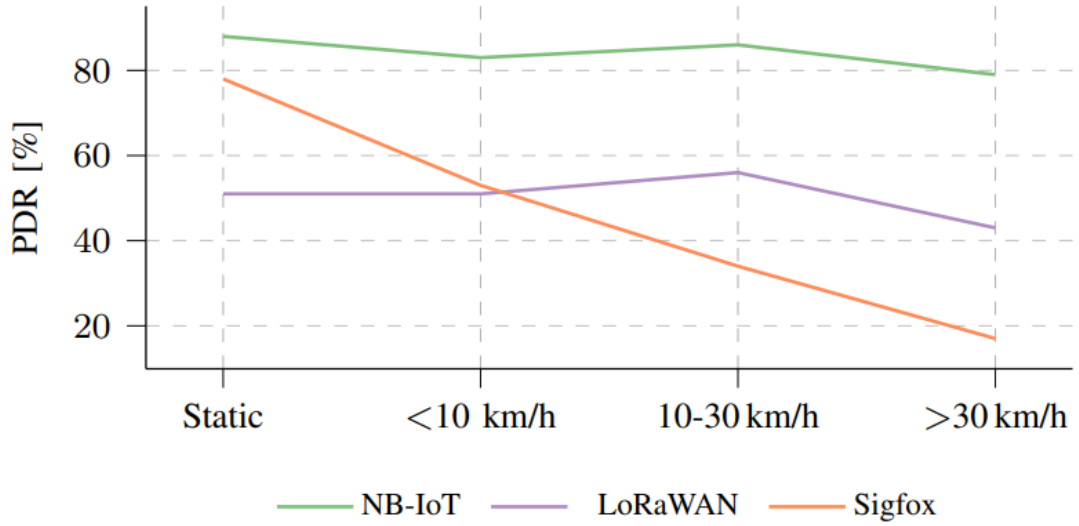
1. Payload diversity
2. Latency optimalization



Boxplot of measured NB-IoT latency when sending a package

RESULTS | FUSION ENERGY RESULTS

1. Payload diversity
2. Latency optimalization
3. Mobility optimalization



Comparison of Packet Delivery Ratio (PDR) of NB-IoT, LoRaWAN and Sigfox in function of speed of the IoT node for packet payloads of 1 B12 B

RESULTS | FUSION ENERGY RESULTS

1. Payload diversity
2. Latency optimalization
3. Mobility optimalization
4. Ongoing research: more to come!

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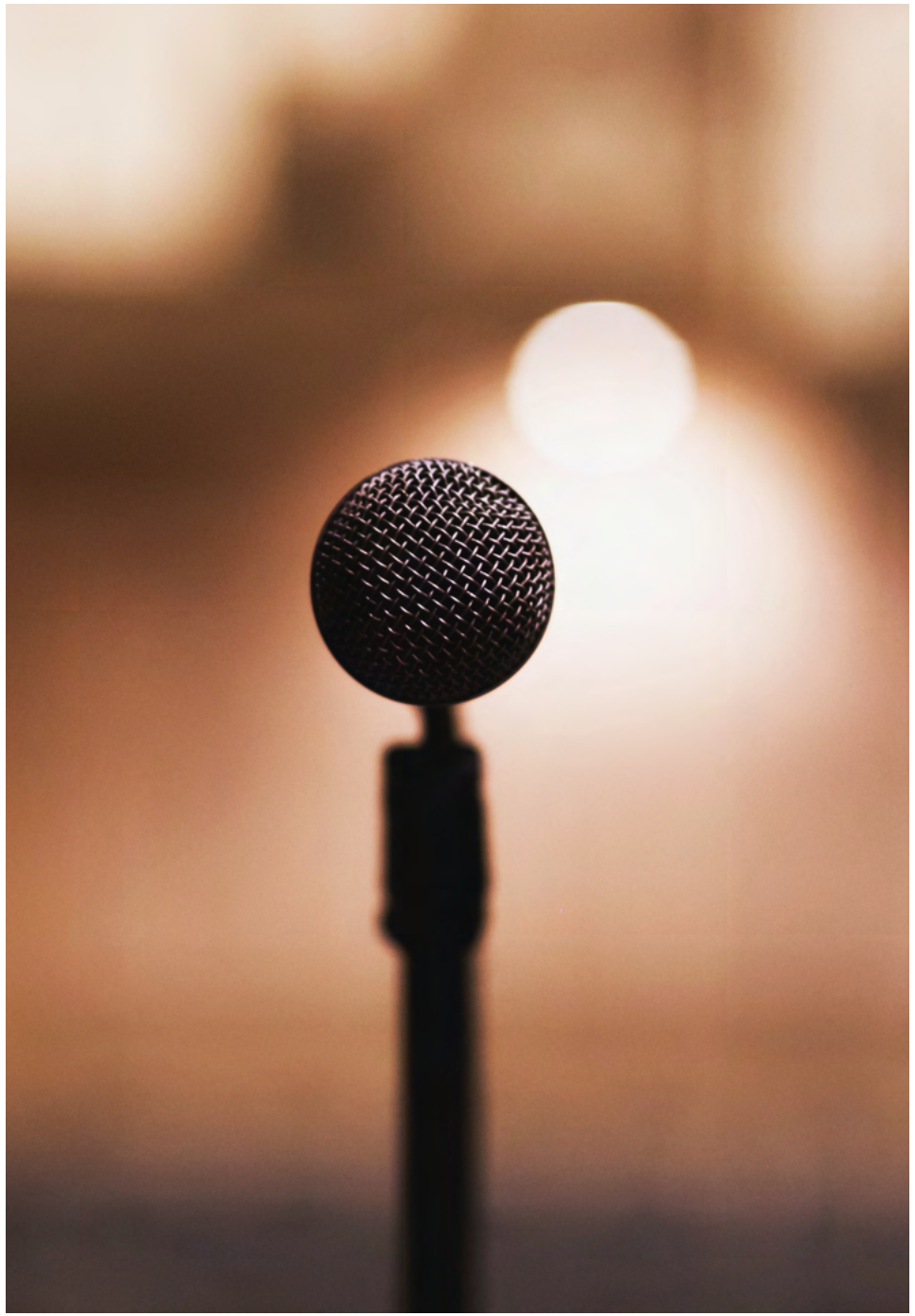
Smart sensing platform for urban sound event monitoring

CHESNEY BUYLE

DEPLOYMENT MOTIVES

- Human complaints are only indication of noise nuisance
- Sensor networks as **unbiased source** of noise pollution
- Results should only provide **indication**
  - Estimate seriousness of situation
  - Distinguish between urgent reports
- Current strategies
  - Noise maps: only long-term
  - Crowd sourced platforms: reliability
  - Wireless Acoustic Sensor Networks: often too costly



DESIGN AND DEPLOYMENT CONSTRAINTS

Easy deployment

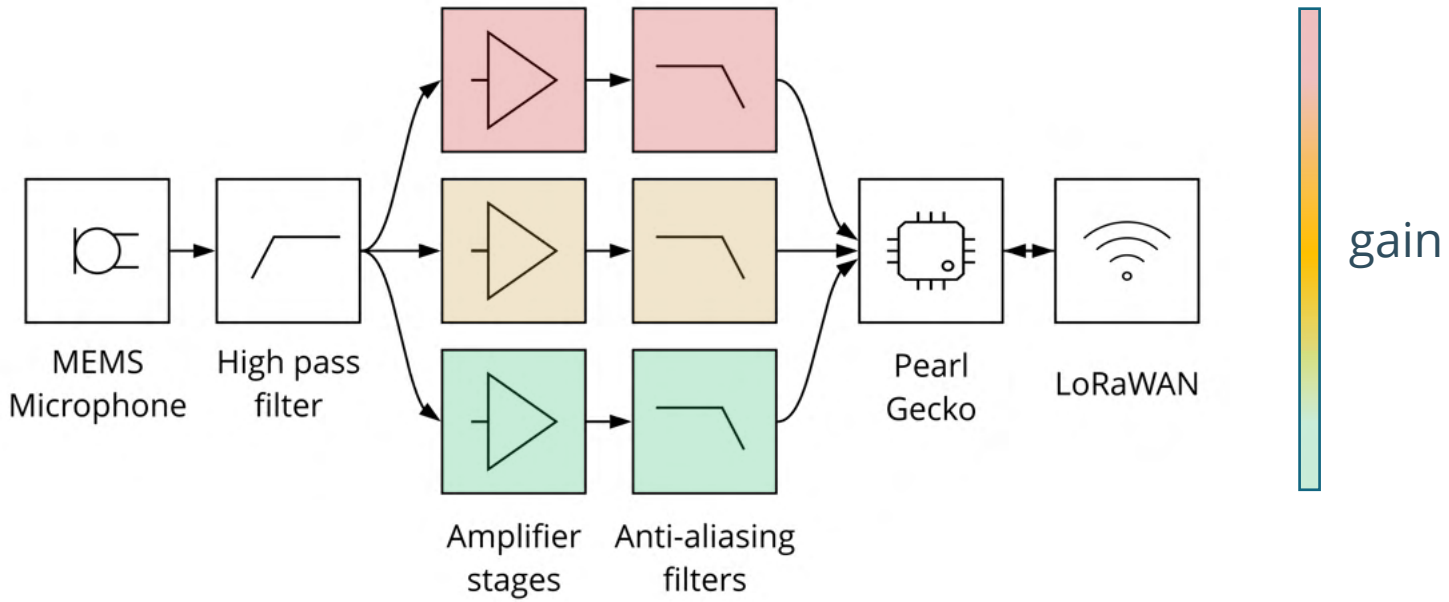
Low power

Low cost

Wireless & Long range

Privacy

WIRELESS ACOUSTIC SENSOR NODE | APPROACH



Schematic overview of the proposed acoustic sensing platform.

MEASUREMENT STRATEGY

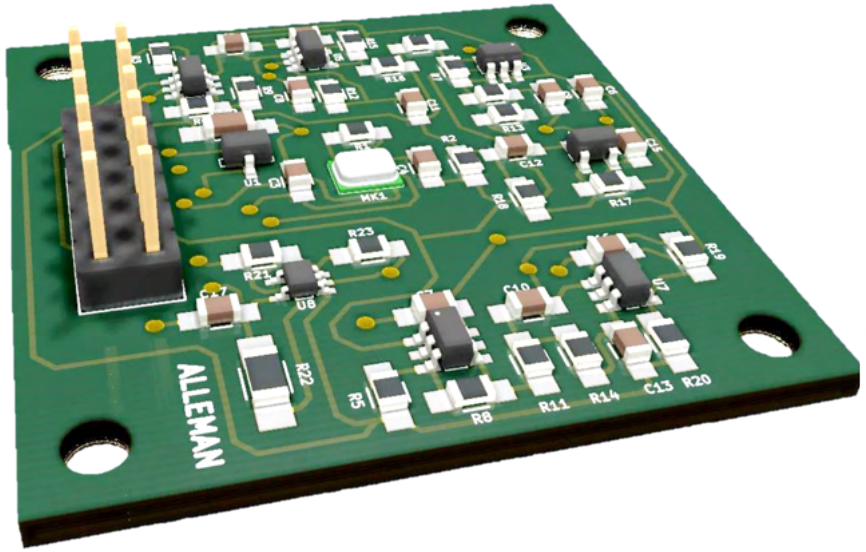
Wake-on sound

amplification, filtering & processing

dB_{SPL} -algorithm

LoRaWAN

WIRELESS ACOUSTIC SENSOR NODE | DESIGN



SLEEP MODE

	Mic.	Pearl Gecko	LDO	LoRaWAN	Total
Power [µW]	33	9.9	3.3	0	49.5

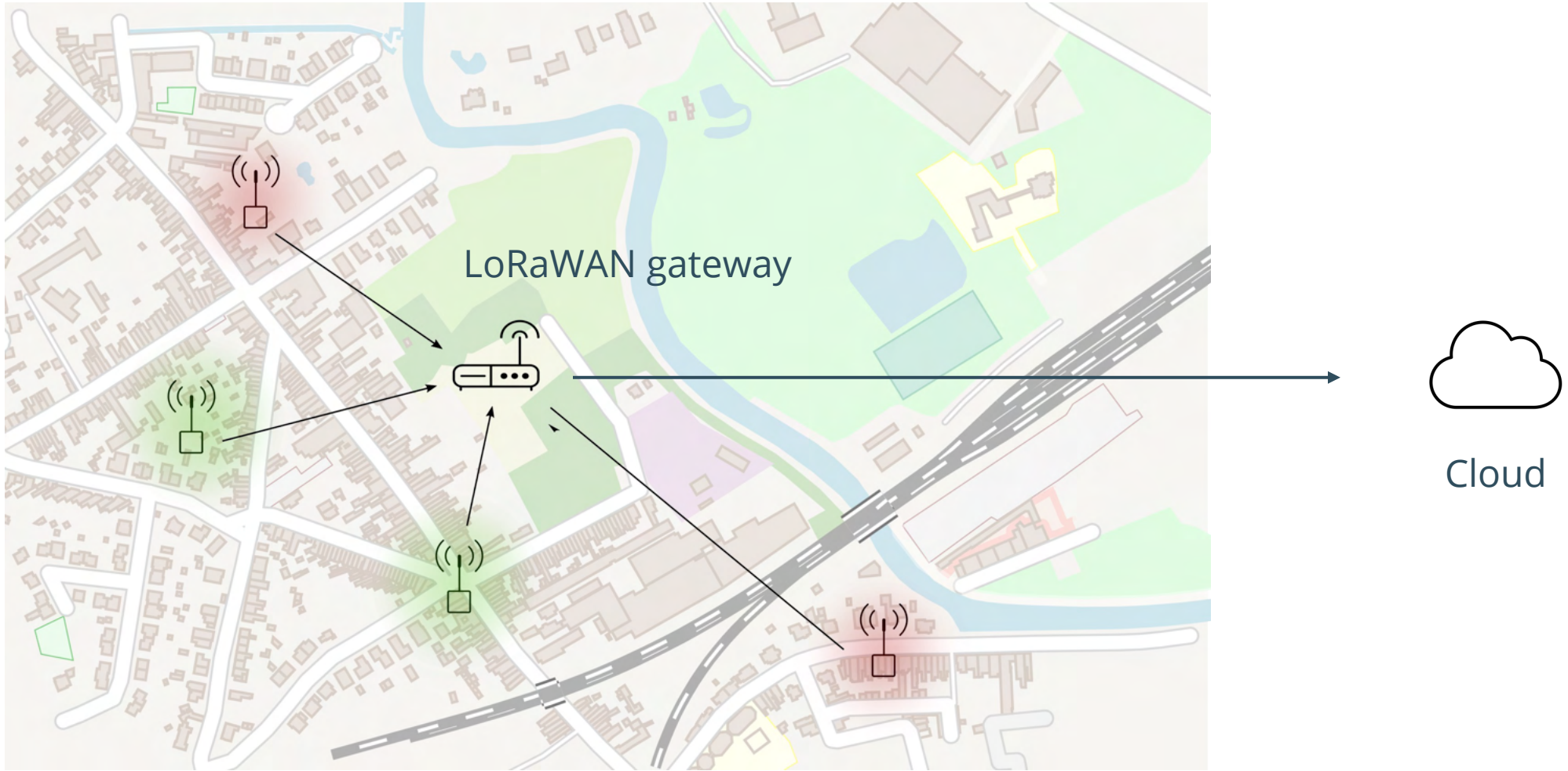
PROCESSING MODE

	Mic.	ADC	FFT	Amp.	Power+ filter	LoRaWAN
Power [µW]	289	7920	19800	1553	32	128400

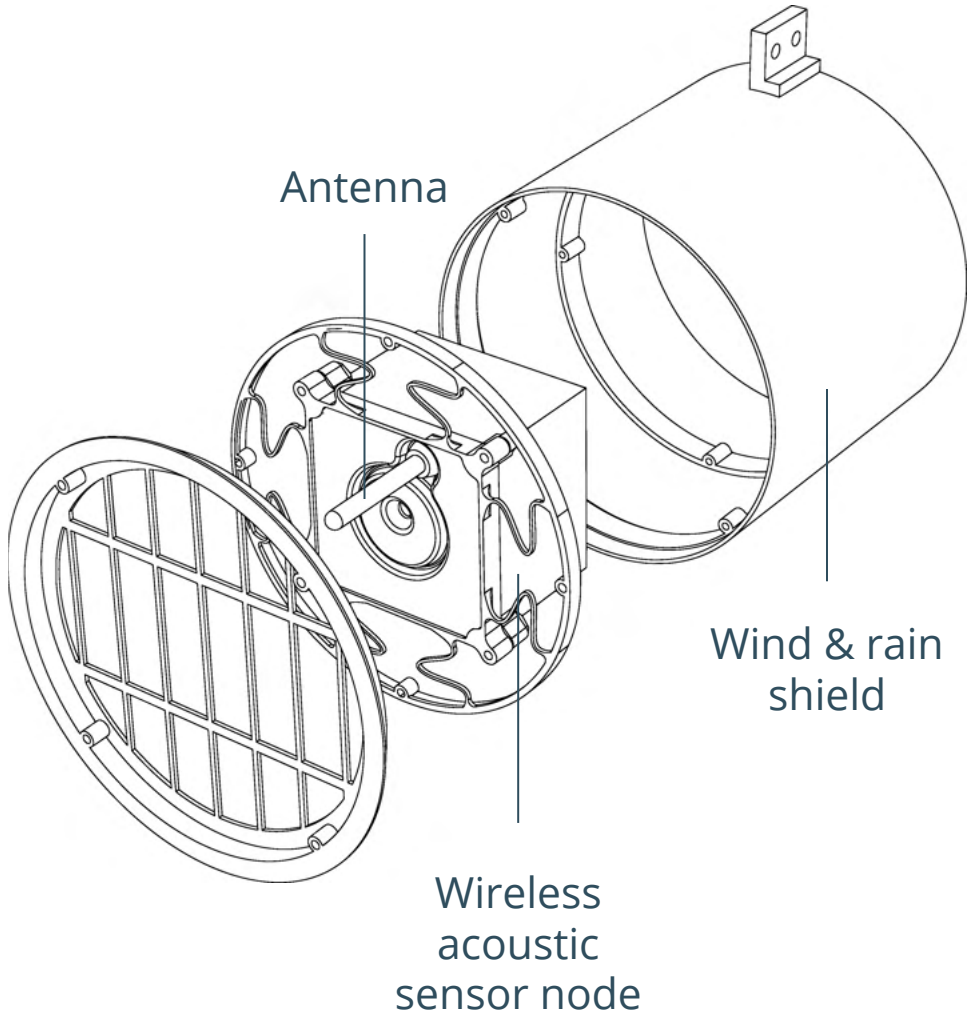
~ 595 µJ @ 15.5 ms sampling time

PCB designed for acoustic monitoring.

FROM SENSOR TO THE CLOUD



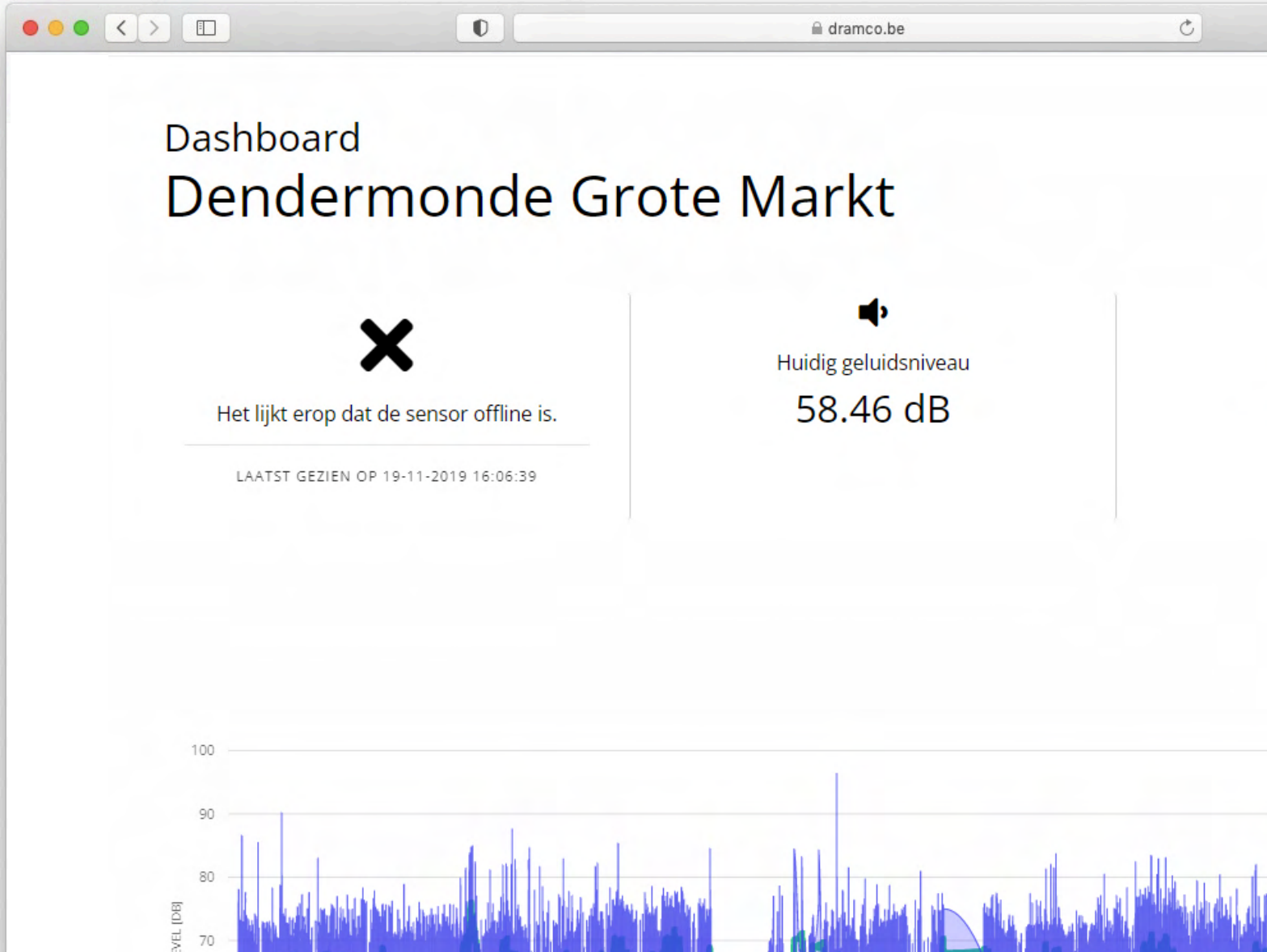
OUTDOOR SENSOR



RESULTS


Vlaamse Banken
Westerschelde & Saeftinghe
Ostend
Bruges
Dunkirk
Roeselare
Ypres
Kortrijk
Tourcoing
Roubaix
Lille
Villeneuve-d'Ascq
Tournai
Antwerp
Sint-Niklaas
Aalst
Mechelen
Brussels
Leuven
Waterloo
Wavre

RESULTS

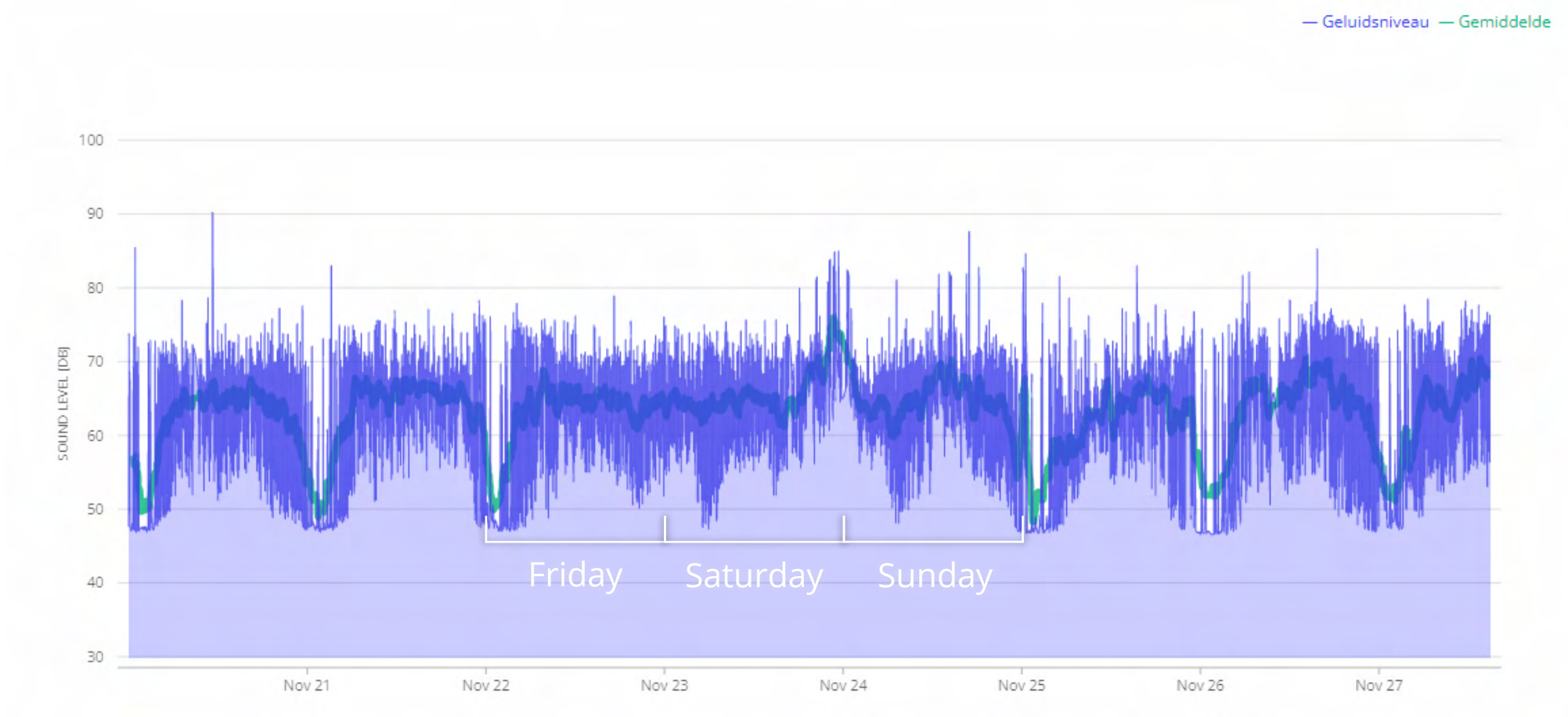

dramco.be
Dashboard
Dendermonde Grote Markt
Het lijkt erop dat de sensor offline is.
LAATST GEZIEN OP 19-11-2019 16:06:39
Huidig geluidsniveau
58.46 dB
100
90
80
70

RESULTS


dramco.be
Het lijkt erop dat de sensor offline is.
LAATST GEZIEN OP 19-11-2019 16:06:39
58.46 dB
96.45 dB
— Geluidsniveau — Gemiddelde
SOUND LEVEL [DB]
100
90
80
70
60
50
40
30
Nov 24
Dec 01
Dec 08

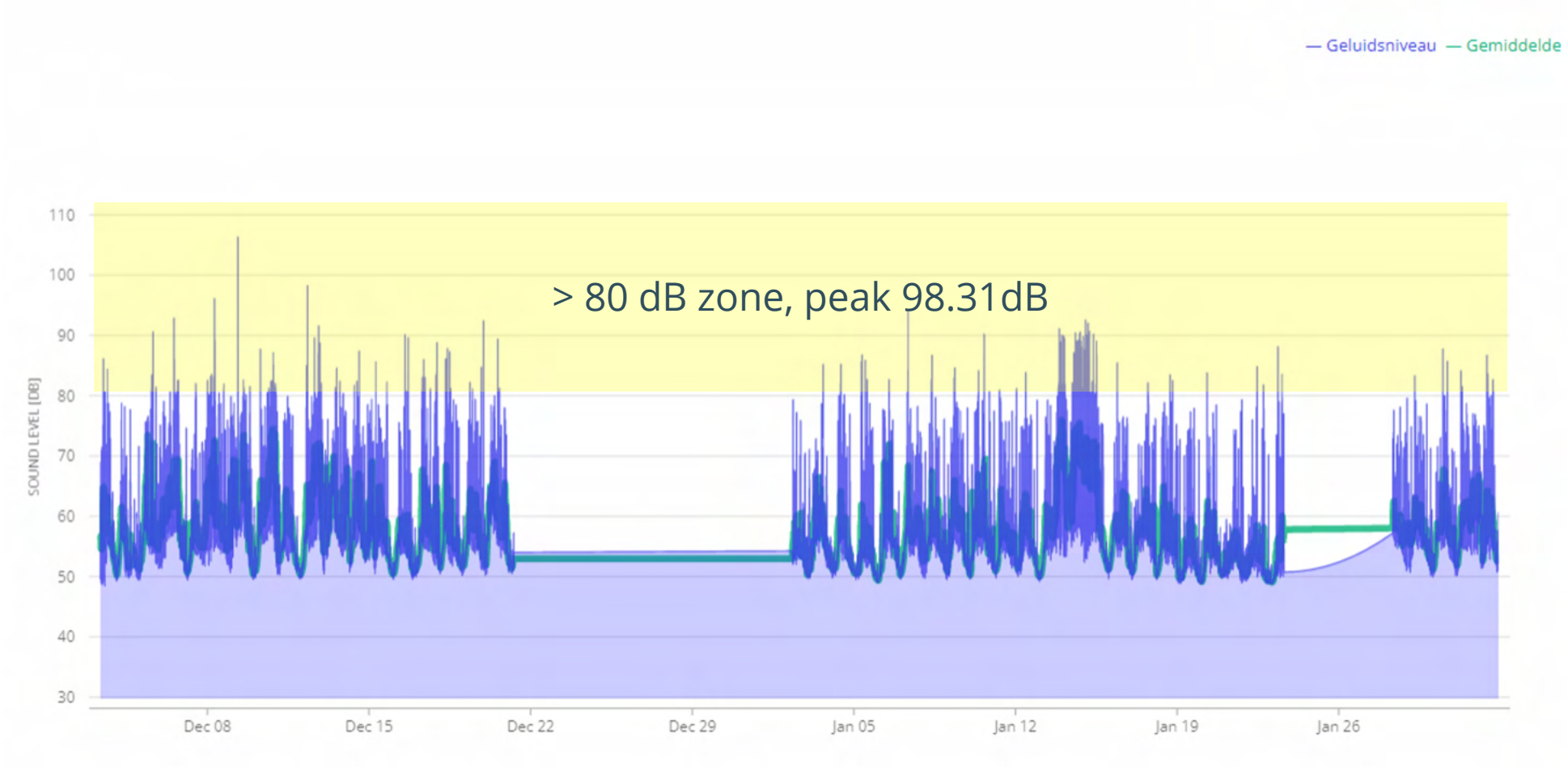
RESULTS

Weekend of “Sinterklaas” in Dendermonde



RESULTS

Node near fire station (and youth center)



FUTURE WORK

1. Design and integration of smart, but low power signal processing algorithms

2. Remote adjustment of sensor node settings
   e.g., in case of unusual amount of noise: high battery drain

KU LEUVEN | DRAMCO

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CHESNEY BUYLE chesney.buyle@kuleuven.be