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The ICT Engineer of the 21st Century

Co-funded by the
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Technical details of LPWAN applications

Smart Solutions based on Internet of Things

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15th of May, 2019 Valencia

Lecture outline

- Introduction
- LPWAN benefits
- Technologies
- The telecom. engineers job: planning coverage
- Everyday life example: the demand and motivation
- Application examples
- Definitions
- Key takeaways

Introduction

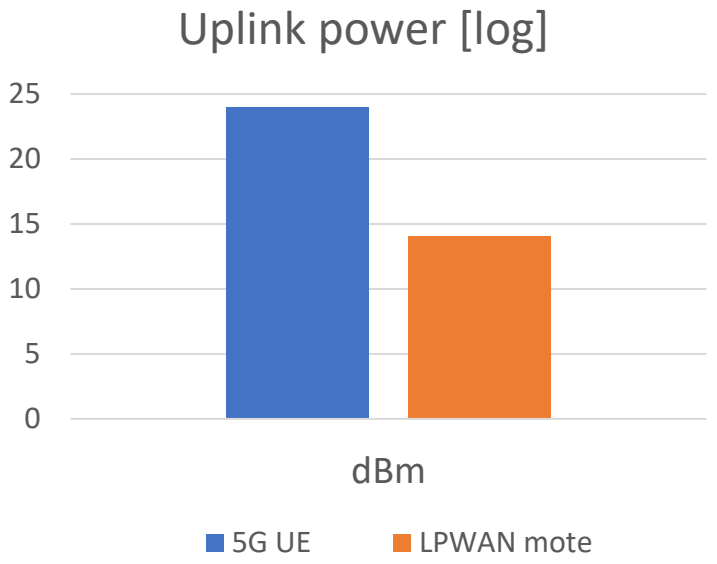
LPWAN

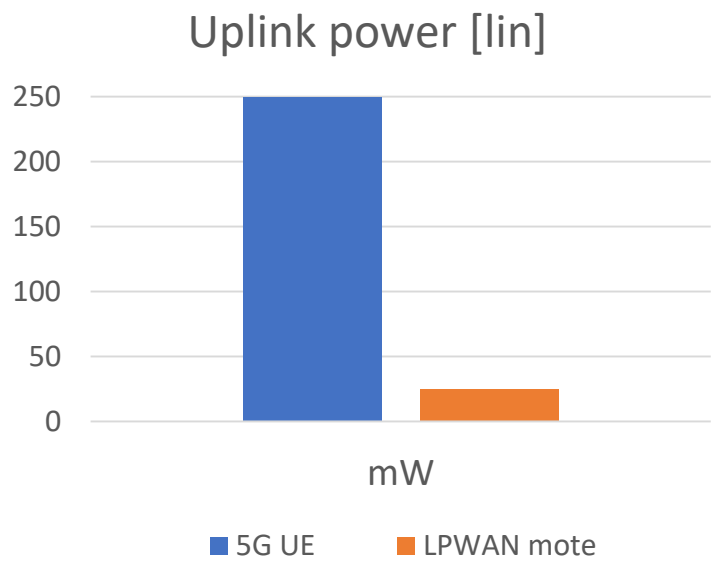
Low-Power Wide-Area Networks

LPWAN

Low-Power Wide-Area Networks

- P_{out} = 25 mW
- ~10 years with one battery
- Short transmitting





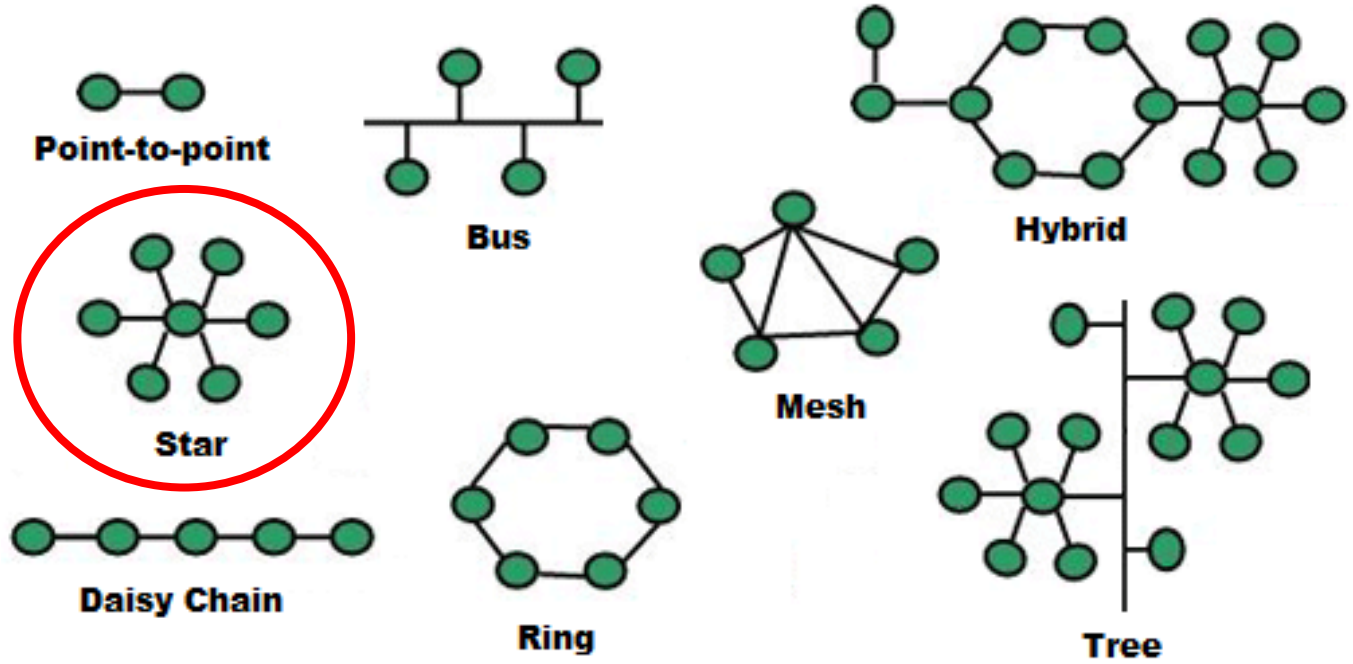
LPWAN

Low-Power Wide-Area Networks

- 2 - 3 km range in urban
- 15 - 50 km range in rural
- High receiver sensitivity

LPWAN

Low-Power Wide-Area Networks



- Star topology
- High density
- Asymmetric links
- Device initiated communication

LPWAN benefits

LPWAN benefits

In our case, we want

- Inexpensive units
- Low power consumption
- Great capacity
- Wide coverage

LPWAN benefits
Cheap

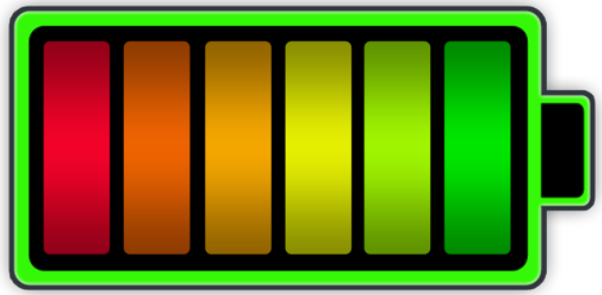
- Cheap end user modules
- Why:
  - ~10000# of modules/km^2

- How:
  1. The minimal important functions
     needs only
  2. Simple architecture
     allows
  3. Mass manufacturing on ONE chip [1] (mote)

LPWAN benefits
Low power consumption

- Modules have low power demand
- Why:
  - Limited source of electric power
  - Can not connect to power source
  - Small module size
  - Energy harvesters are expensive

- How:
  1. Short operational times (30sec/day) compared to
  2. Long sleep intervals (99,965%) allows
  3. ~10 years of satisfactory operation



LPWAN benefits
Capacity

- Base stations / Access points have to handle ~10k units
- Why:
  - One transmitter per utility (electricity, gas, water) at every household
  - Star topology / no trunking, no multiplexing
- How:
  1. Short messages, few data sent
  2. ~1 packets / day
     because
  3. Low data rate per message is satisfactory
     allows
  4. Low overall inbound data at BS or AP

LPWAN benefits
Capacity

- Data throughput consideration

$$4\ byte + 4\ byte + 13\ byte = minimal\ packet\ size$$

LoRaWAN protocol

Identification, higher level crypting

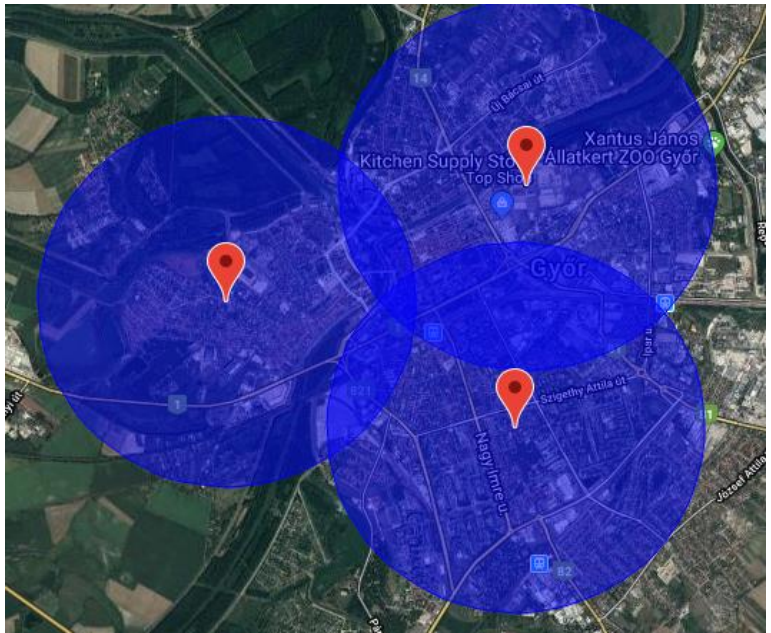
$$8 \times 4 = 32\ payload\ bits = 2^{32} = 4294967296$$

Max. measured volume: $4\ 294\ 967.296\ \mathrm{m}^3$ *METER ID*

- ~1500 m3 consumed average / household

LPWAN benefits
Coverage

- Lets cover as much households as possible!
- Why:
  - Fewer Base Stations/Acces Points means fewer maintenance/legal costs

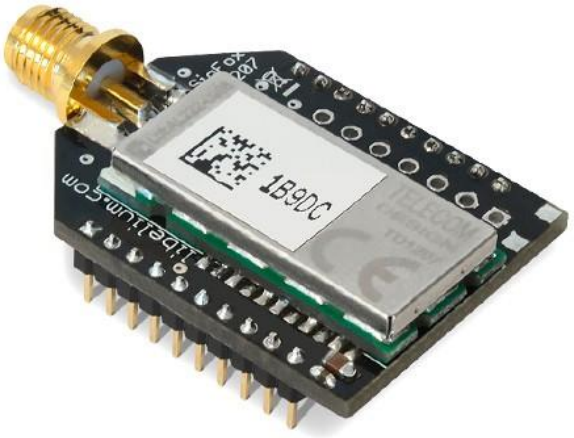


- How:
  1. Longer message/symbol time because
  2. Receiver recognizes better the longer symbols allows
  3. Robustness to the transmission

Technologies [7]

Technology
sigfox

- 2010, Tolouse, France
- Startup
- Have to pay fees to access the infrastructure
- Narrow band, 100-600 bit/s



Technology sigfox

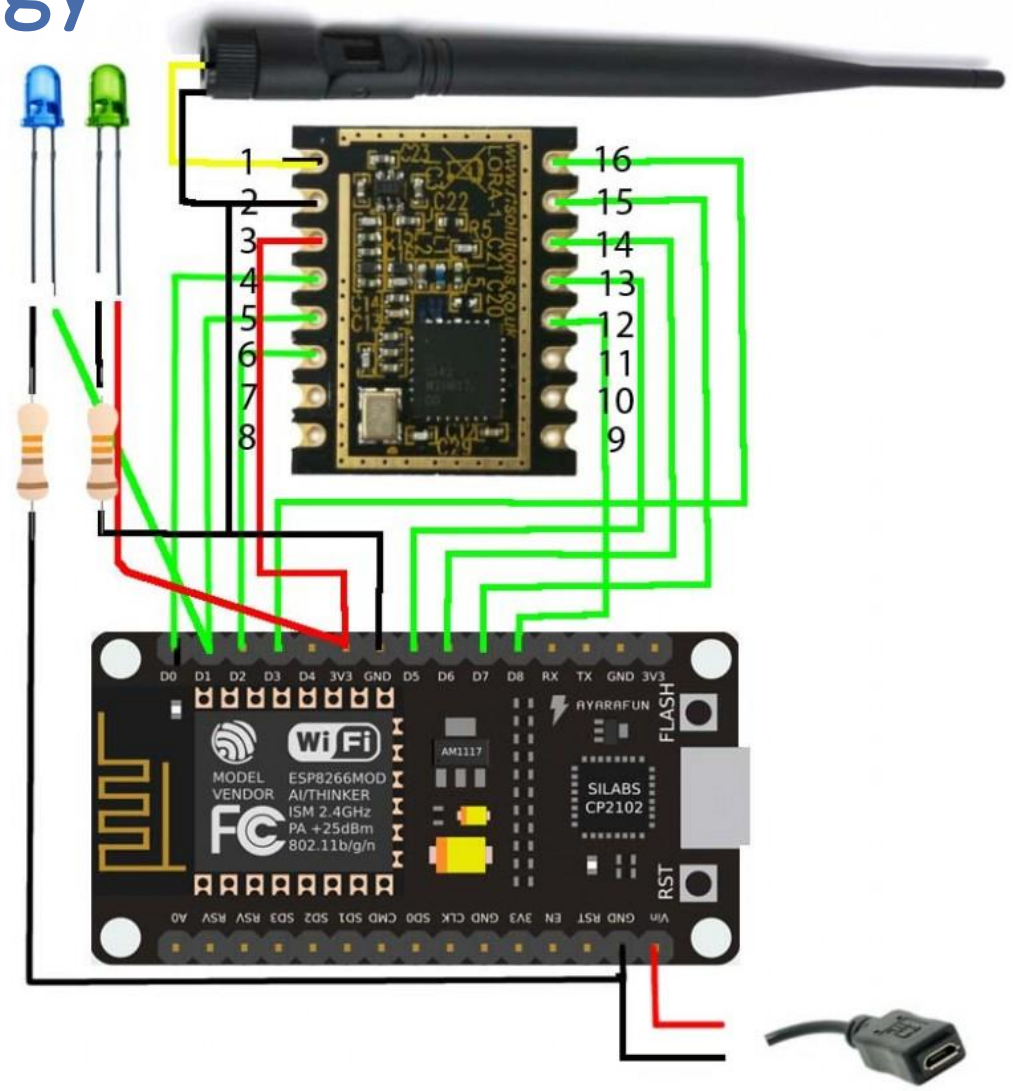
SIGFOX READY

libelium

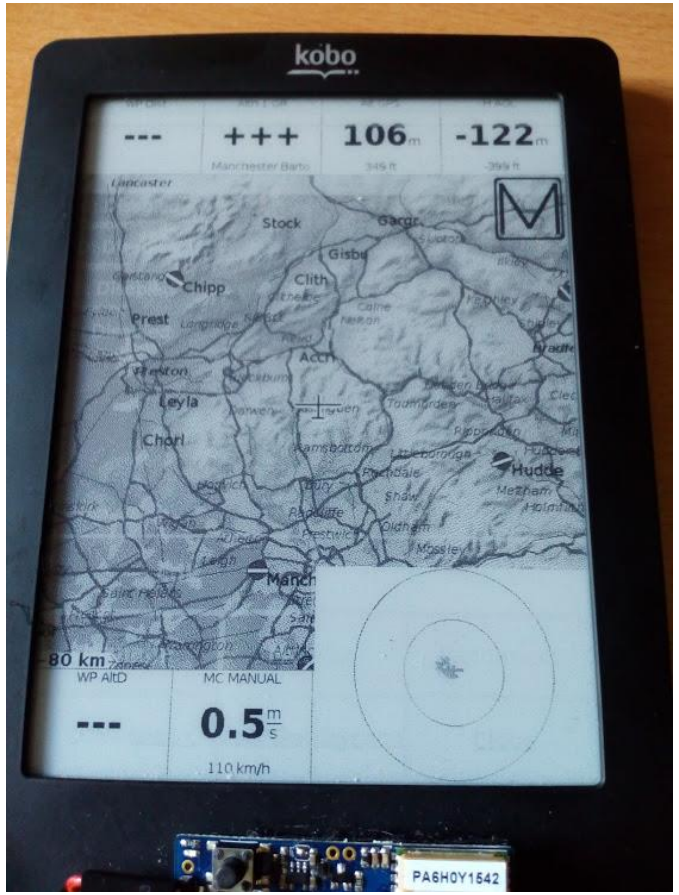
Technology
LoRa

- 2009
- Startup
- Semtech (USA) buys LoRa (2012)
- Utilizes unlicensed ISM bands
- High sensitivity / can be optimized
- Limited downlink accessibility / you have to set up manually

Technology
LoRa



LoRa™

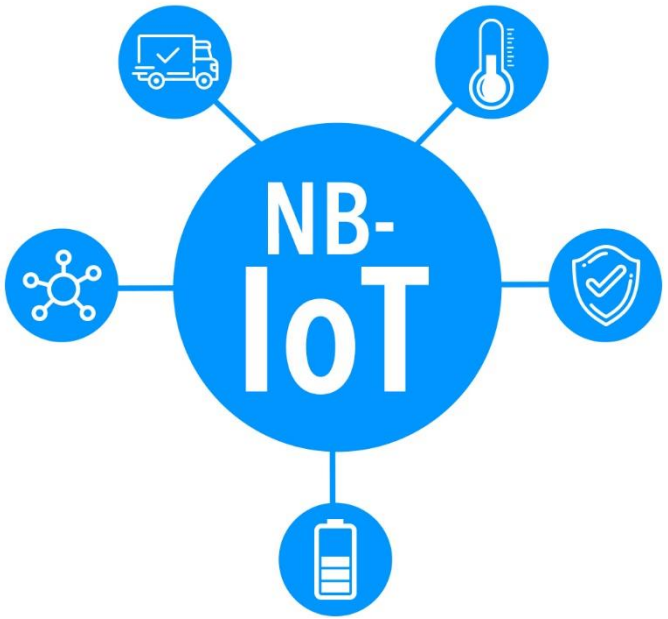


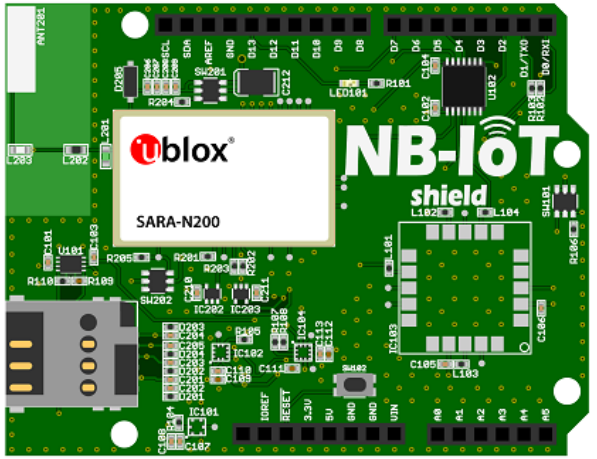
Technology
WEIGHTLESS

- 2008
- Open standard: “not owned” by any company
- Lowest power consumption
- Industrial and medical applications
- Low market penetration, but promising
- Secure at least as GSM, AES-128 and AES-256

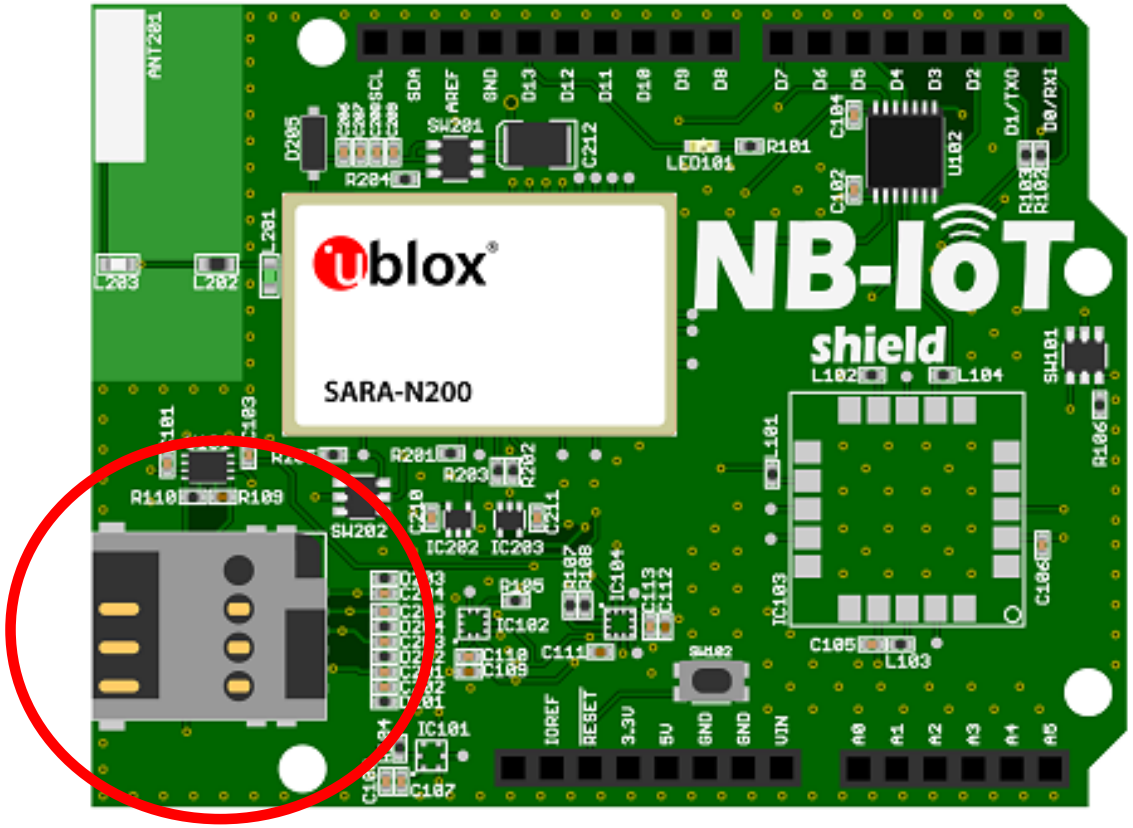
Technology
NB-IoT

- 2016 3GPP (3rd Generation Partnership Project) standardized
- Using narrow bands between mobile application spectrum. LICENSED!
- Based on a DSSS modulation
- High QoS
- Low latency

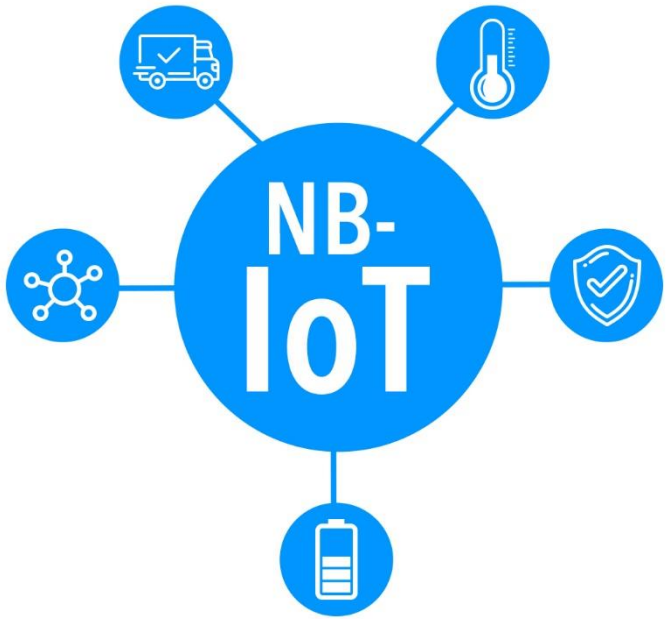




Technology
NB-IoT



- SIM
- Arduino s



Technology
NB-IoT

- Using narrow bands between mobile application spectrum. LICENSED!
- 2016 3GPP (3 Project) stanc
- Based on a D
- High QoS
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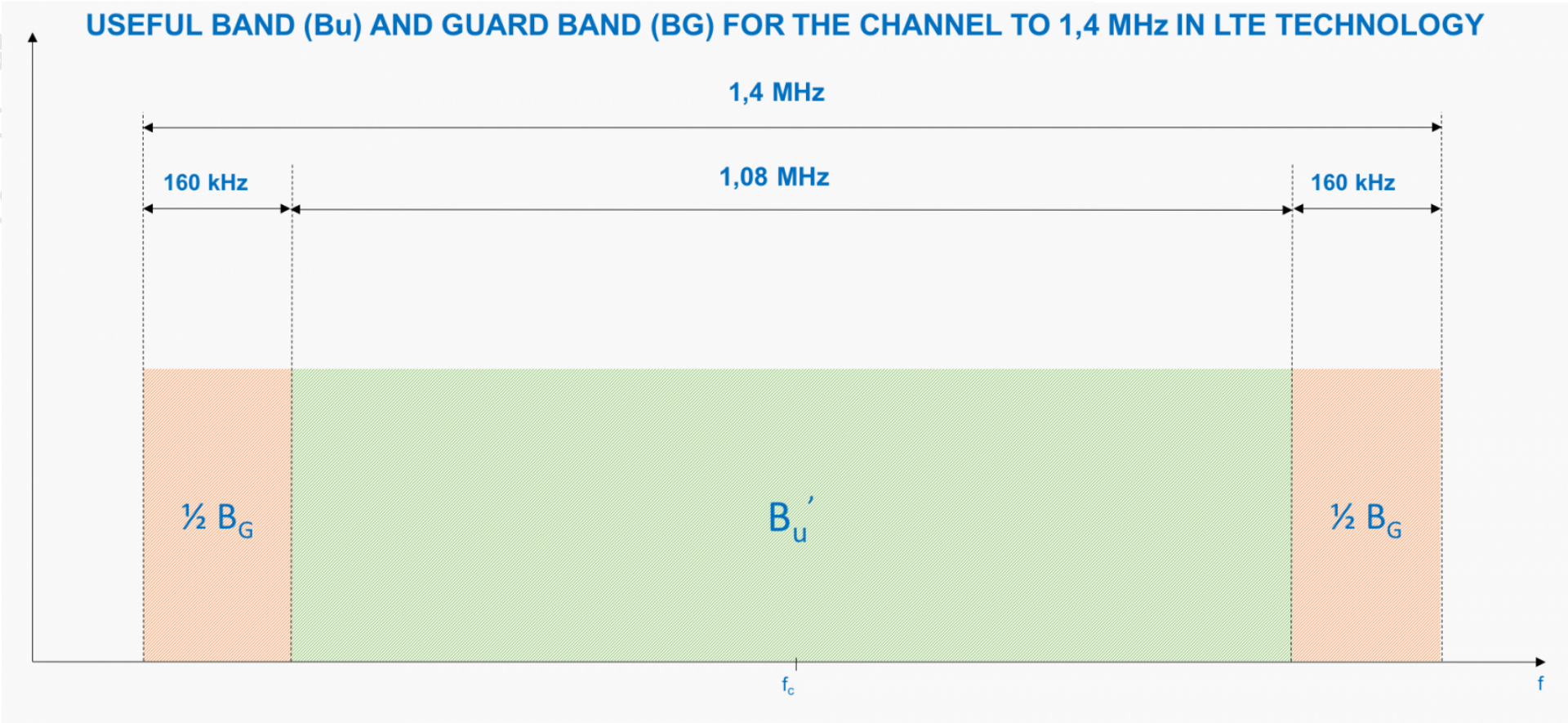

Technology
LTE - M

- Long Term Evolution for Machines
- 3GPP (3rd Generation Partnership Project) on LTE
- Costly, power consuming, LTE dependent
- High data rates, high QoS
- Better to use in roaming applications: Drones, Vehicles
- Transition between M2M/4G

Technology
LTE - M

- Better to use in roaming applications: Drones, Vehicles
- Wearables/medical device
- Device control

Technology
LTE-M vs NB-IoT

LTE-M
Wide range cIoT applications with mobile support

NB-IoT
Highly optimized energy efficient applications

The telecom. engineers job: planning coverage

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Planning LoRa coverage

Made by: Balázs Lukács

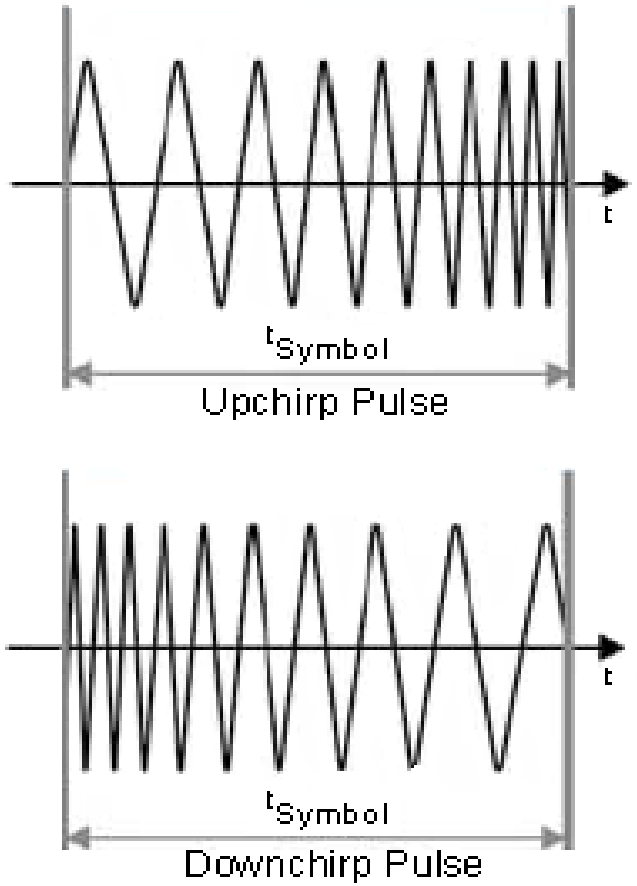
17.12.2018

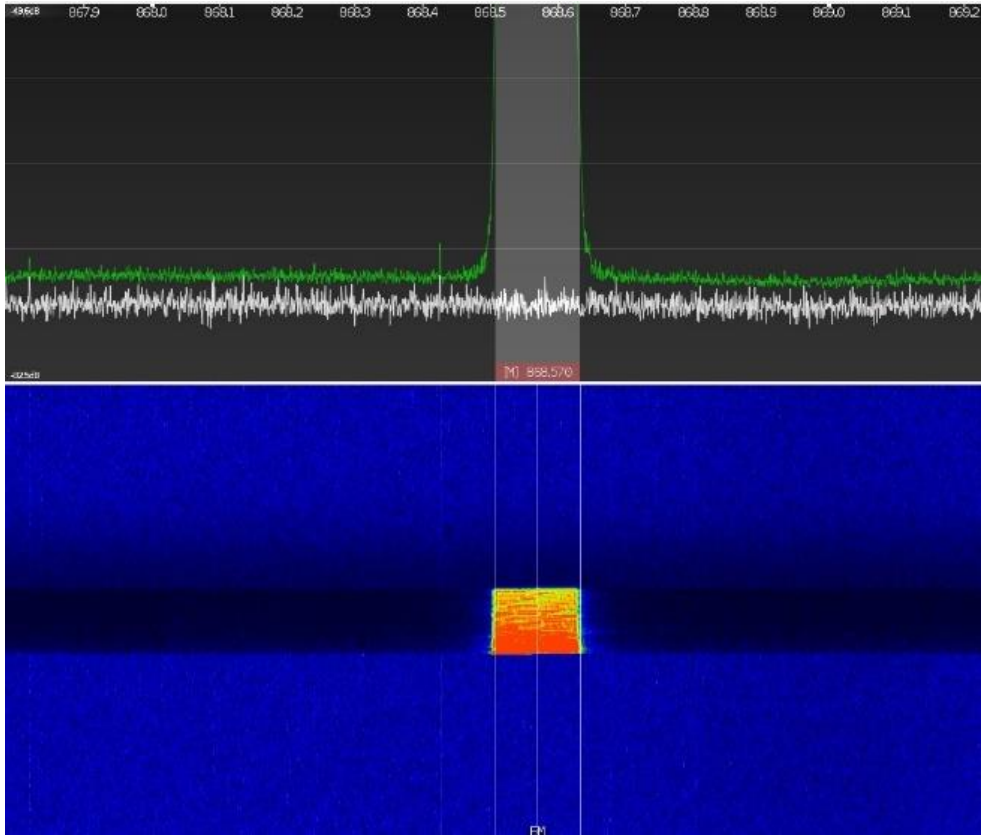
Sub-presentation sections

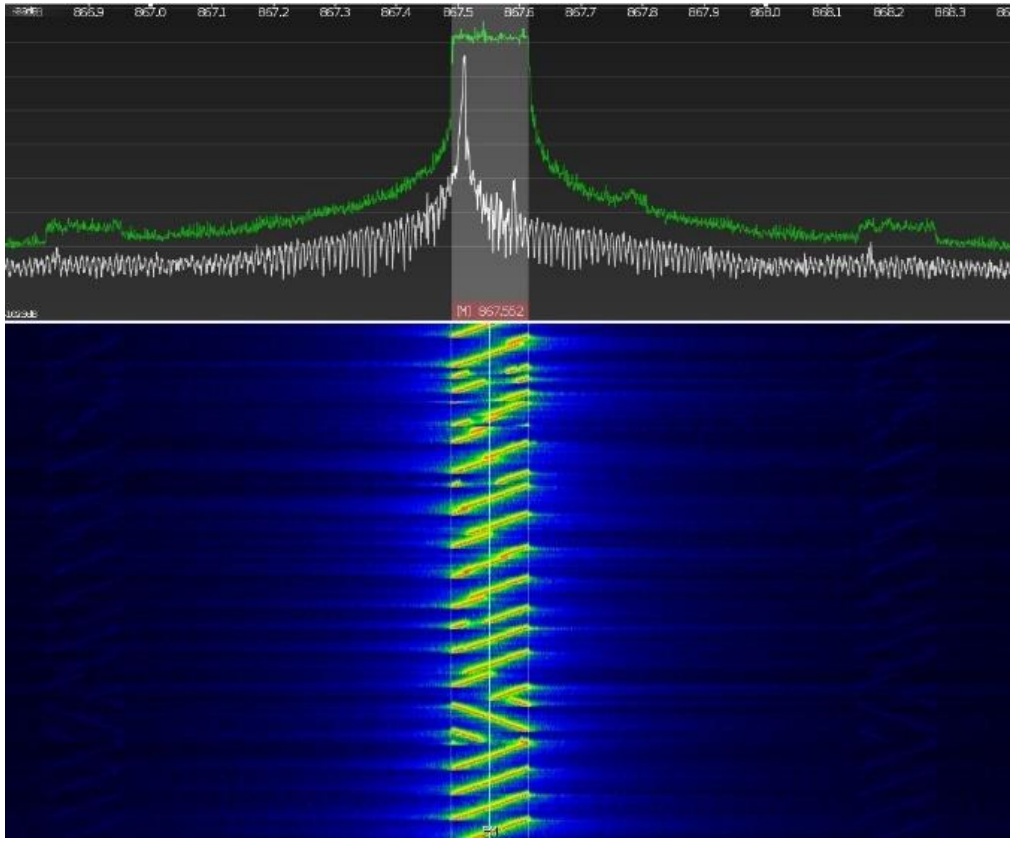
- LoRa and network introduction
- Packet collisions
- Coverage tests
- Current consumption tests
- Conclusions

Introduction of LoRa

- Exclusively for IoT application
- It is an LPWAN technology
- Low data at a time
- Rare, few packets sent daily
- LoRa modulation
- Spreading factor is important parameter







SF=12 => Datarate=0

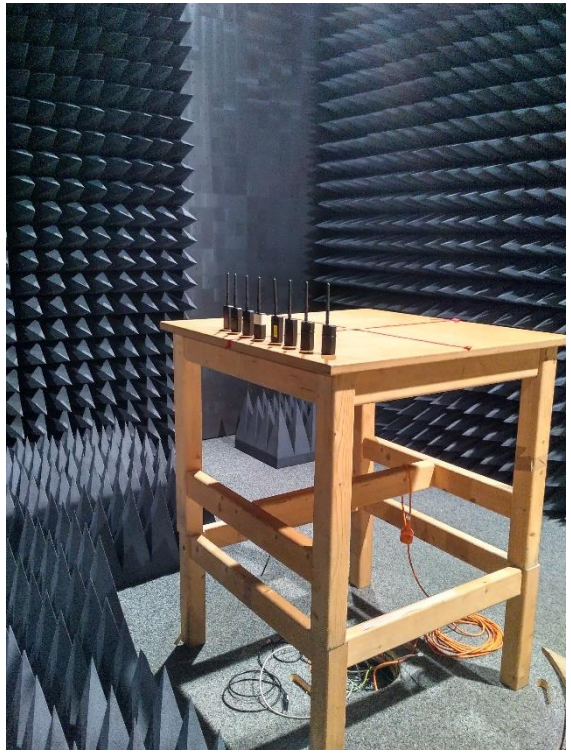
.

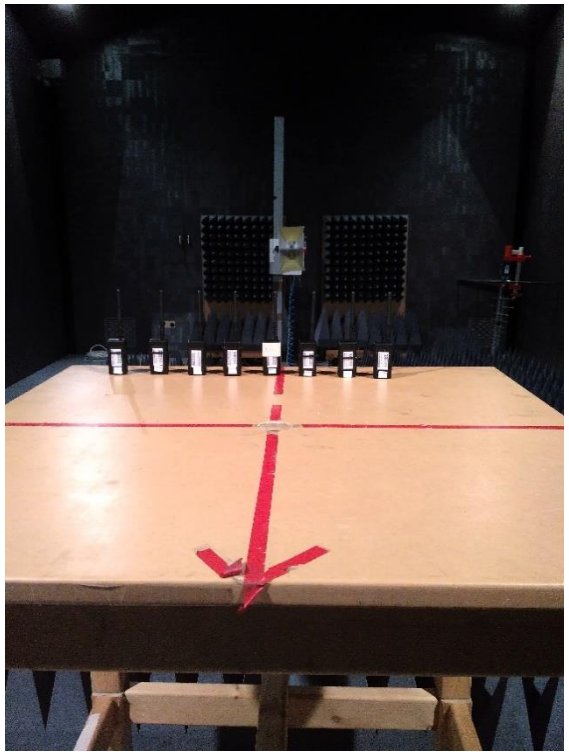
.

SF=7 => Datarate=5

Packet collision tests

- LoRaWan protocol utilizes similar access method with ALOHA, collisions occur
- Anechoic chamber, 8 device
- Channel numbers and datarate limited
- Packets sent often





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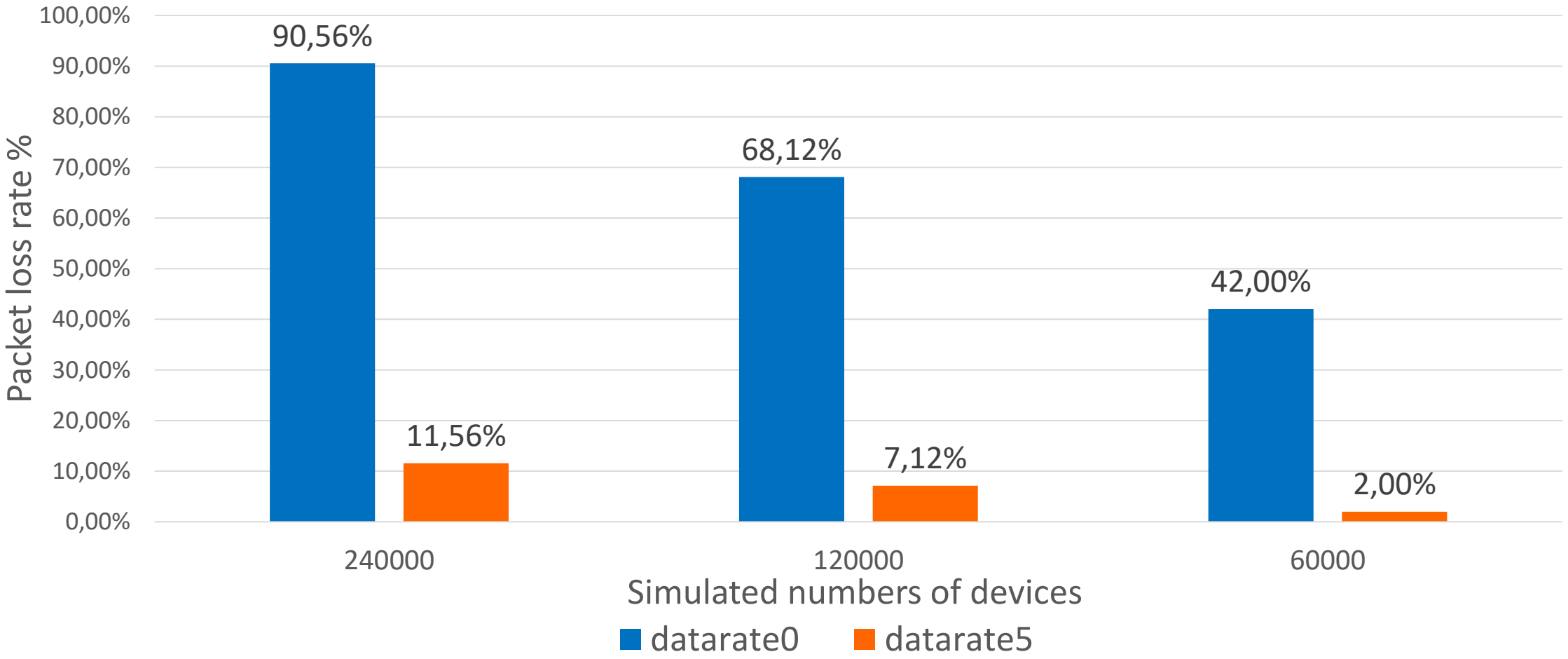
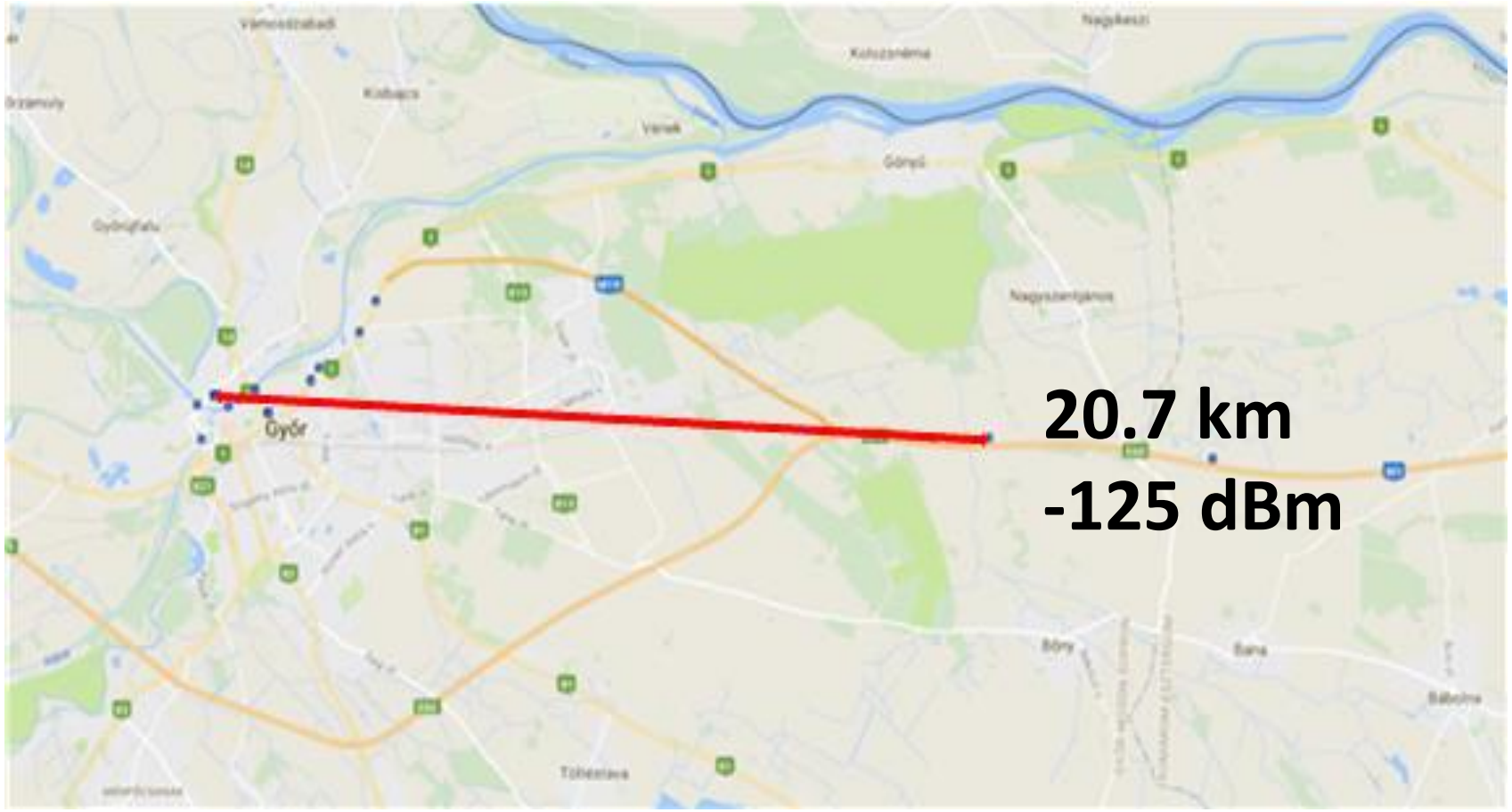
Packet collision test results



Coverage tests

- Coverage of one gateway, test
- Only made with datarate=0 settings to reach maximal coverage
- Database and server installed to store and show the test results

Initial drive test result



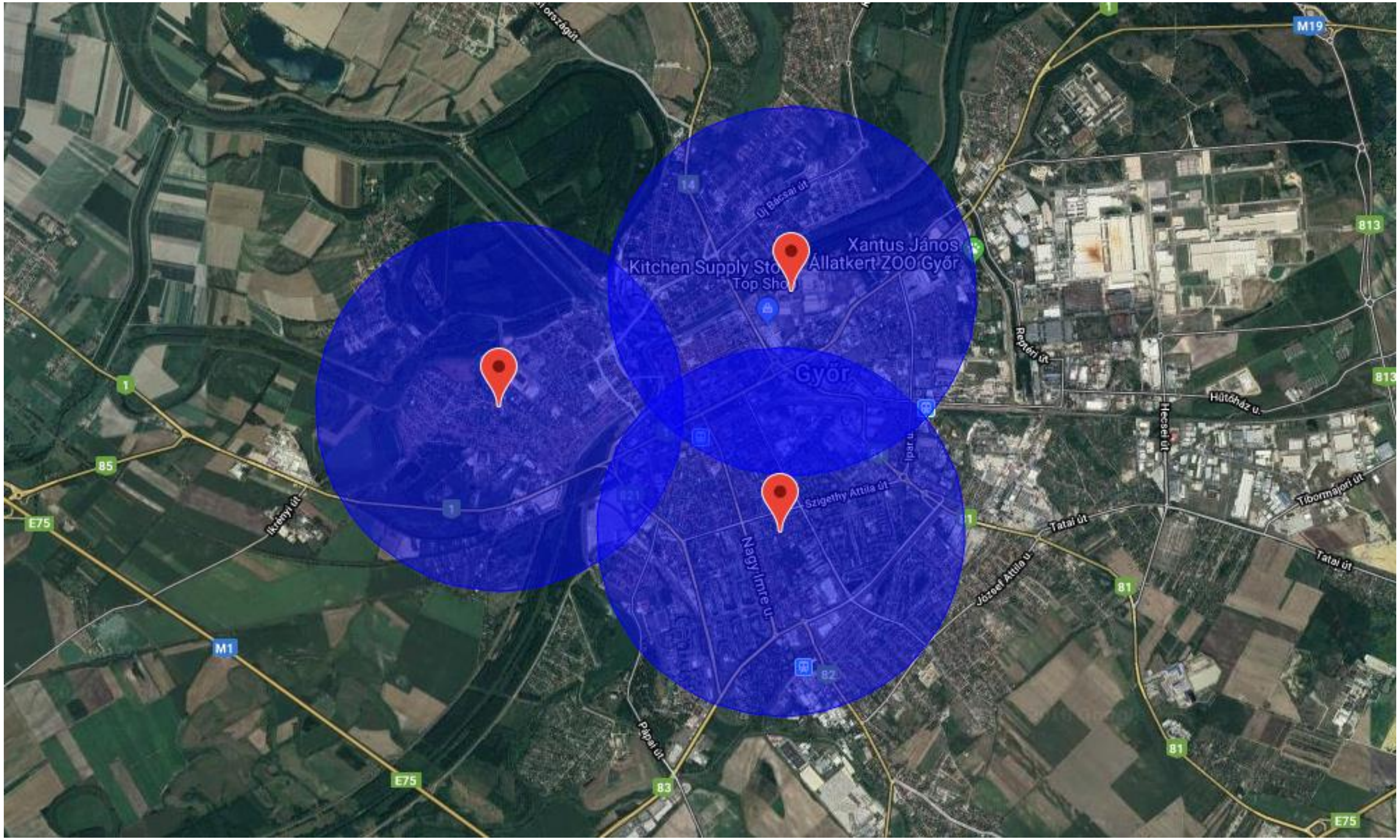
Wave propagation models

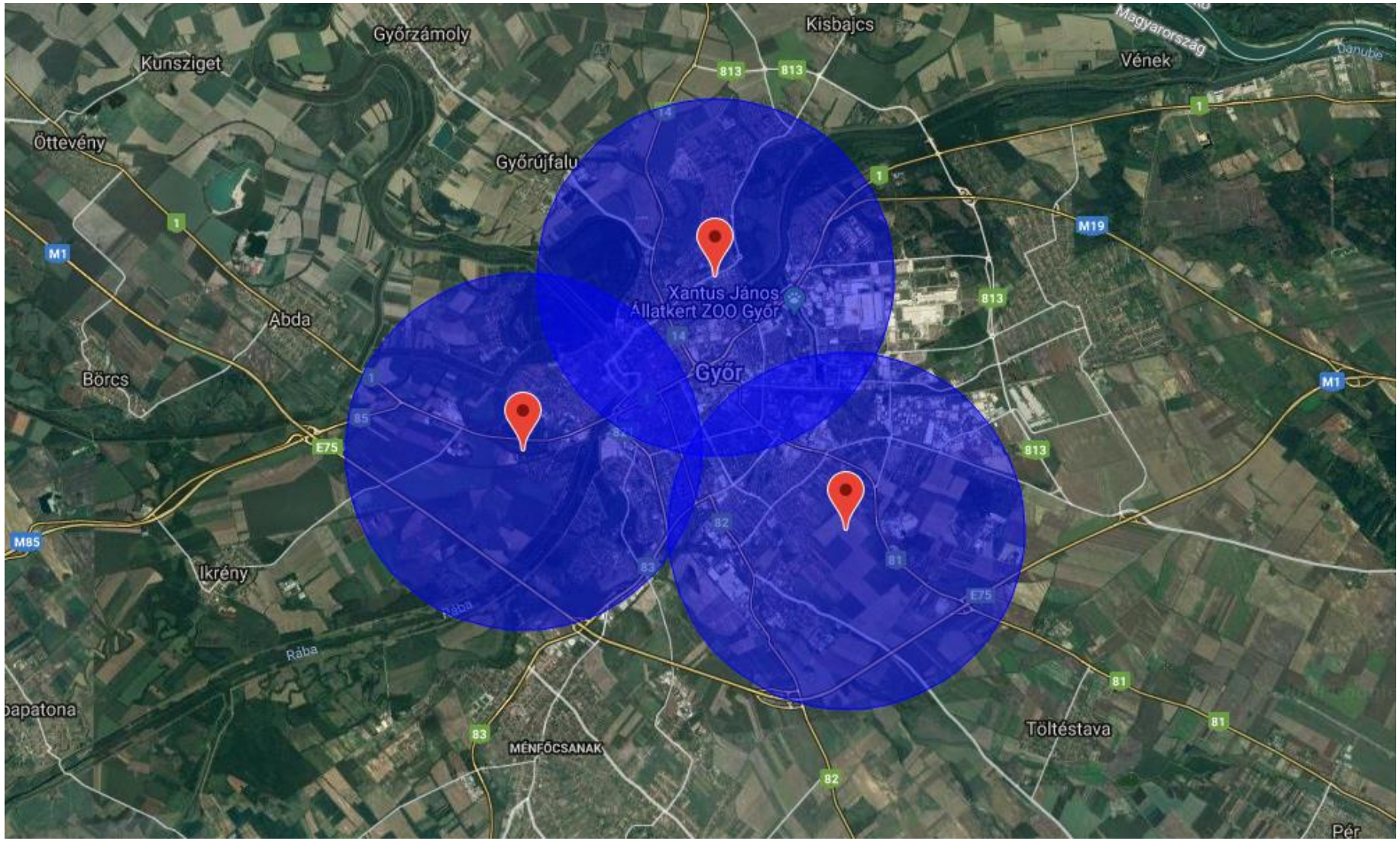
- Okumura
- Hata
- COST-Hata

Maximal coverage radius with one and two fading margin applied

	Okomura	Hata	COST-Hata
One	3300m	2790m	2850m
Two	1700m	1810m	1800m

SZÉCHENYI ISTVÁN EGYETEM
SZE - GYŐR

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Vének
Magyarország
Öttevény
Győrújfalu
Xantus János Állatkert ZOO Győr
Győr
Abda
Börcs
Ikrény
Rába
MÉNFŐCSANAK
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E75
813
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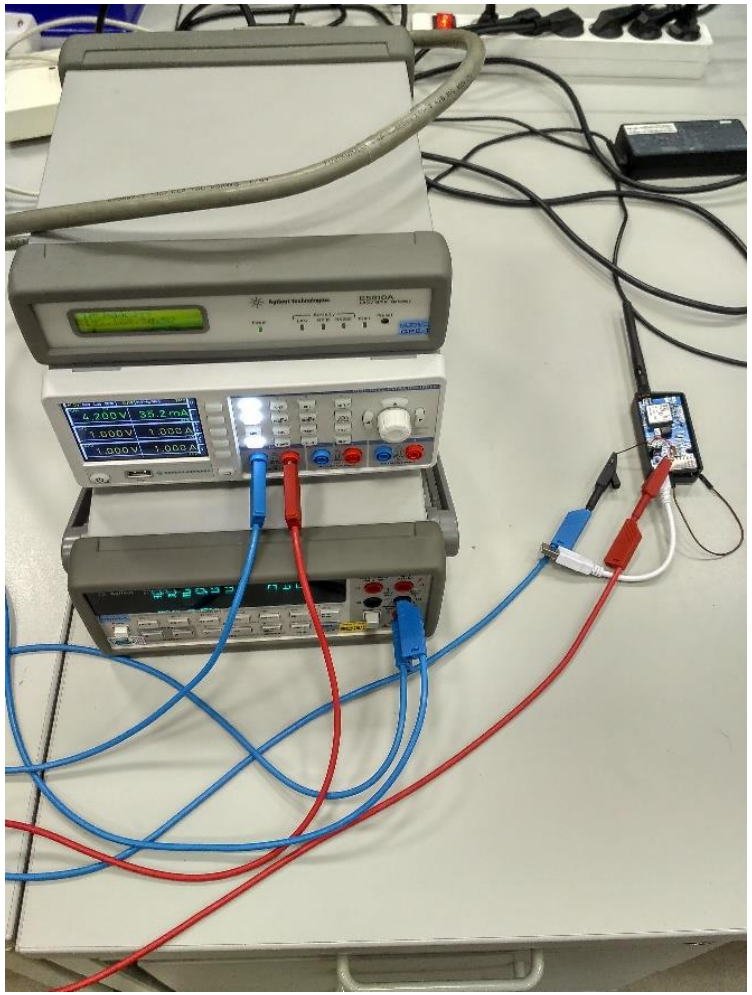
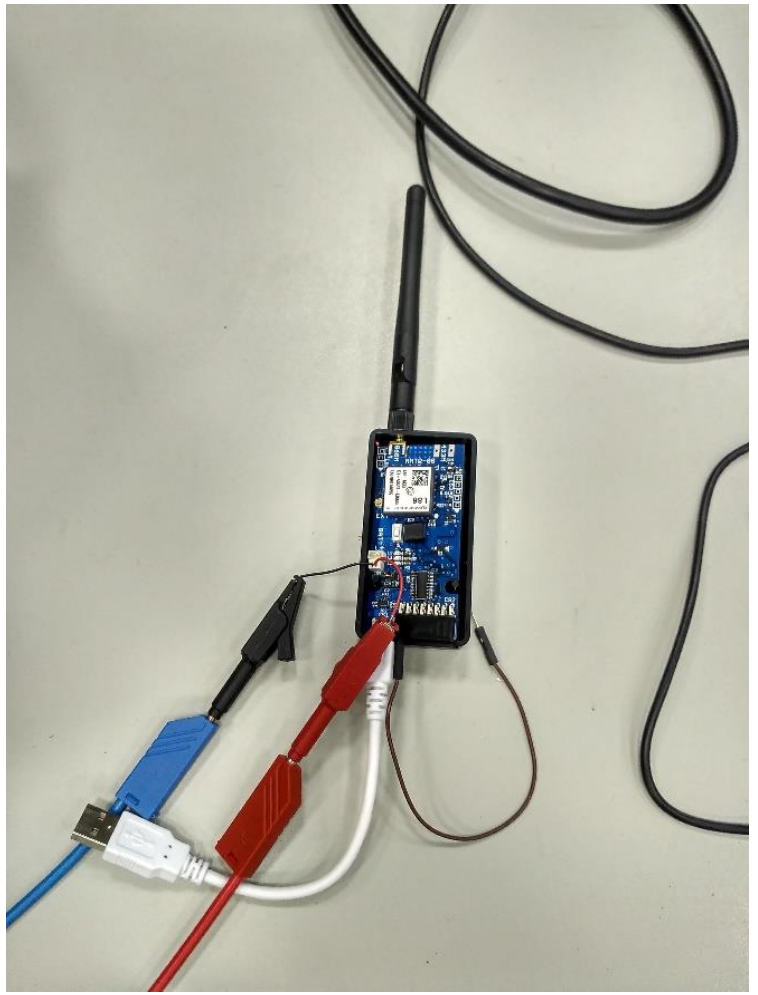
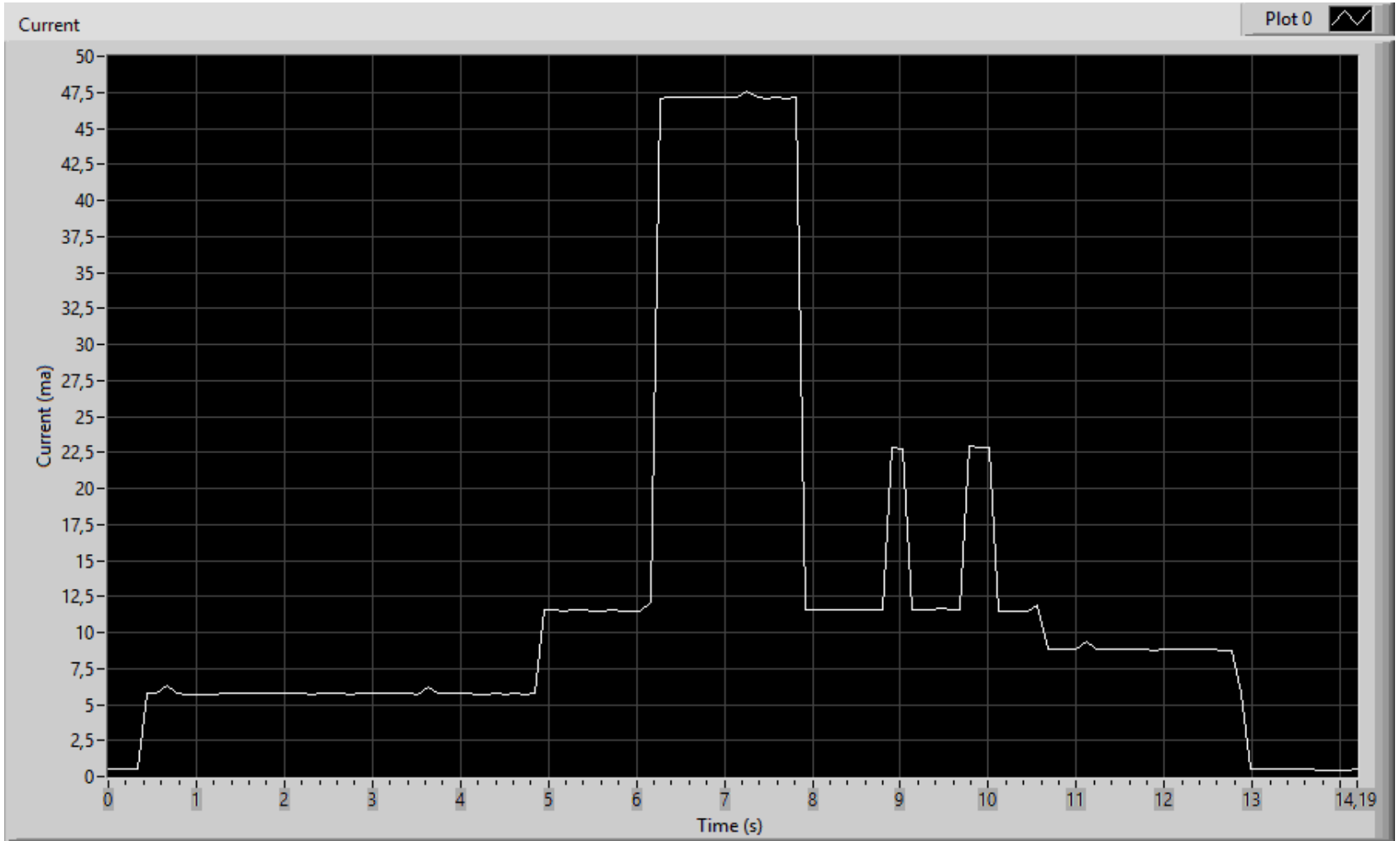
B1

LoRa GPS mote current compsumption



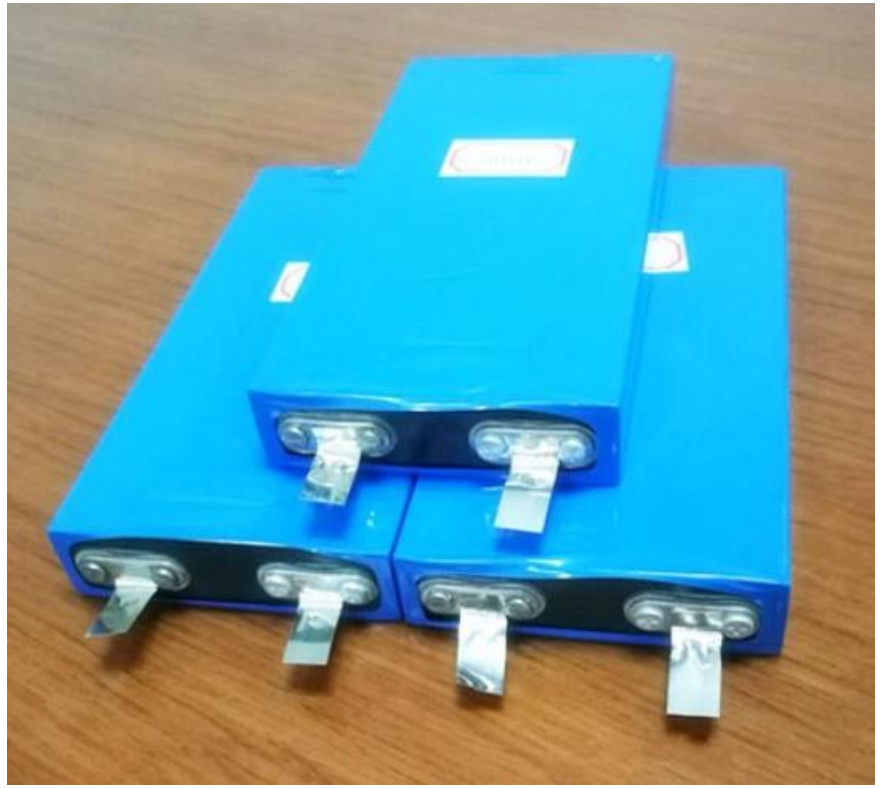


Current consumption in sensor mode

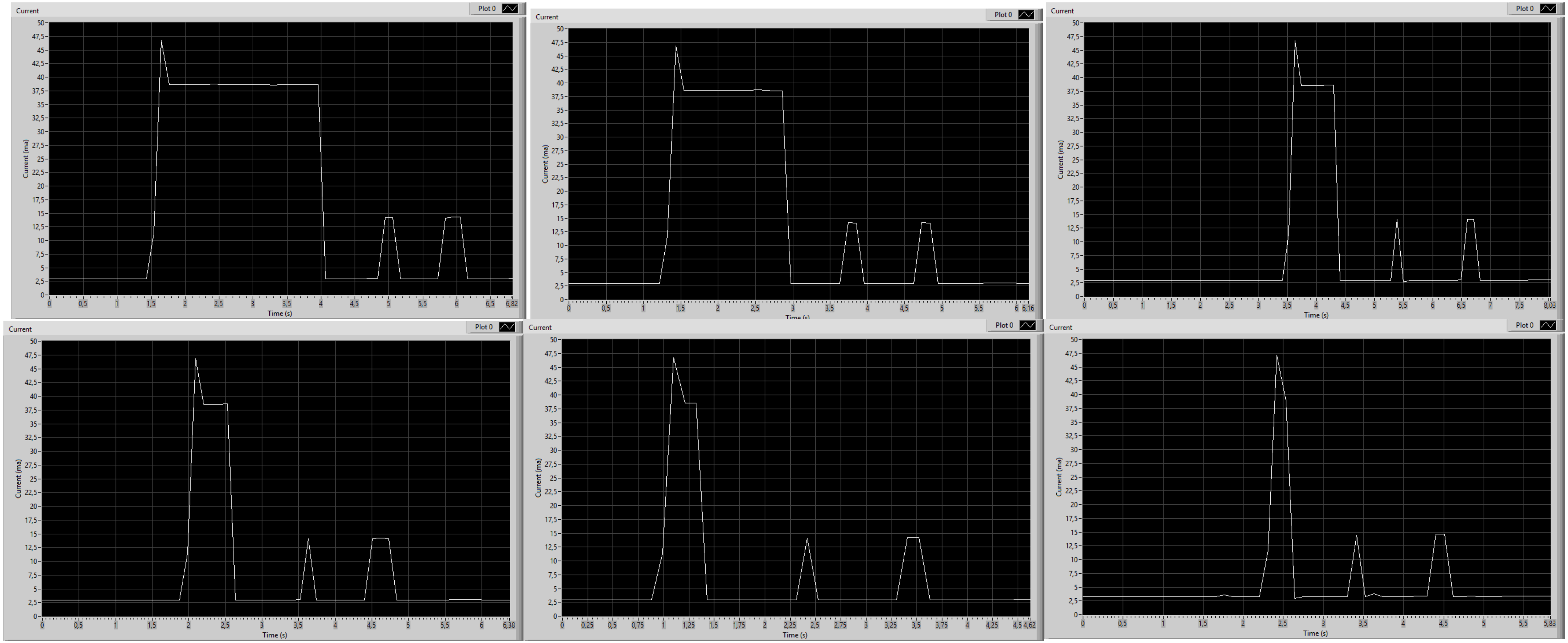


Operation time between 2 charging

- 750mAh capacity
  - Only sleep: 69,44 day
  - Daily one message sent: 69,16 day
  - Message sent every hour: 63,16 day
- 7,5 Ah capacity calculated: 691,6 day
- Battery size of a phone, 18 × 65 × 140 mm
- Prototype was consumed more than 100 uA in sleep mode



Datarate risen – consumption time fallen



Conclusion

- More than ~100000 units handled in one access point coverage / gateway coverage
- Optimized batteries and current consumption resulting a decade of operational time
- 3 gateway for a small town (130 000 inhabitants, maximum 10 storeys block houses)

Everyday life example: the demand and motivation

Life example: the readings

- Provider notices customer: Leave accessible the meter for the technician!
- Uncomfortable, time wasting

Application examples

Application example: Immediate notice system

- Power outage
  - It is easier to detect, the measurement unit is basicly a voltage meter
  - Smart grid application
- Water/Gas outage bc. broken pipe in my neighborhood,
  - It is harder to detect, as the meter is only measuring if there is consumption
- Info goes to the end user and the provider simultaneously, immediately

Definitions

Definitions

- Related terms to use when deciding about technologies to apply, or when an argument made.

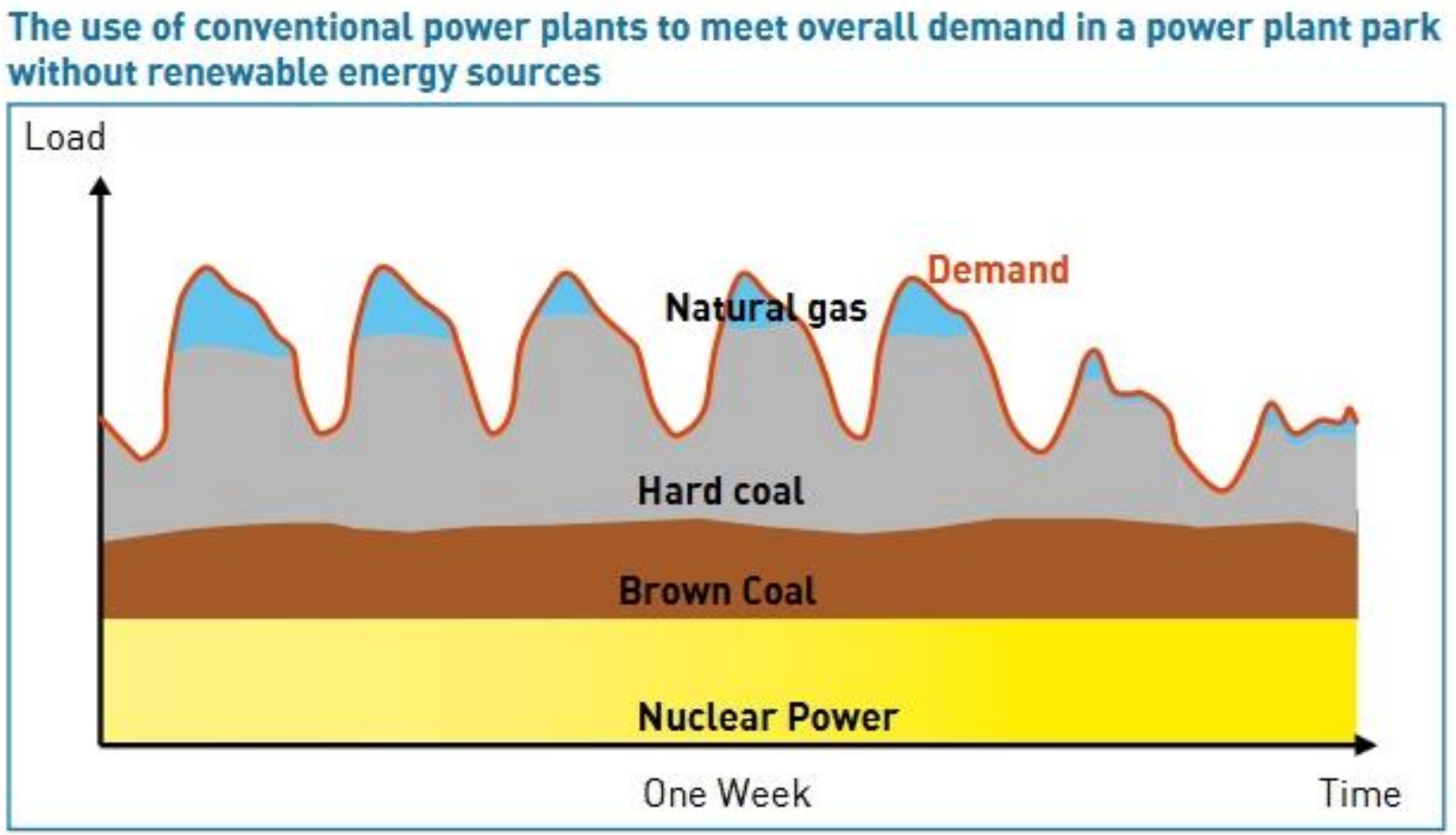
Definitions
Licensed - unlicensed

- Licensed frequency band: National Authorities are responsible for selling frequency bands for providers, and keeping it “clean” from interference.
  - Keeping up the equal competition national-wide.
- Unlicensed band: International Telecom. Union (ITU) declared industrial, scientific and medical band. Free to use, but the users has to be “fair” to each other, as the National Authorities are not responsible for its interference.
  - Giving space to the less profitable or less important applications.

Definitions
Baseload - Peaking power plants, Intermittent plant

- Peaking power
- Baseload power
- Intermittent energy

[4]

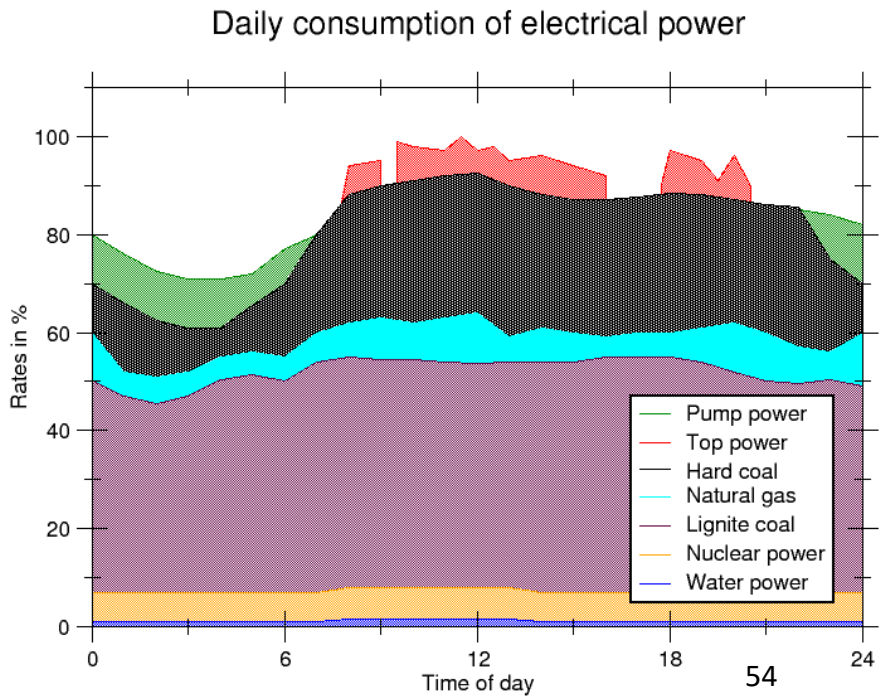


Definitions
Baseload - Peaking power plants, Intermittent plant

- Baseload power: Non-adjustable plants generates this
- Nuclear, continuous coal and gas burning [5]

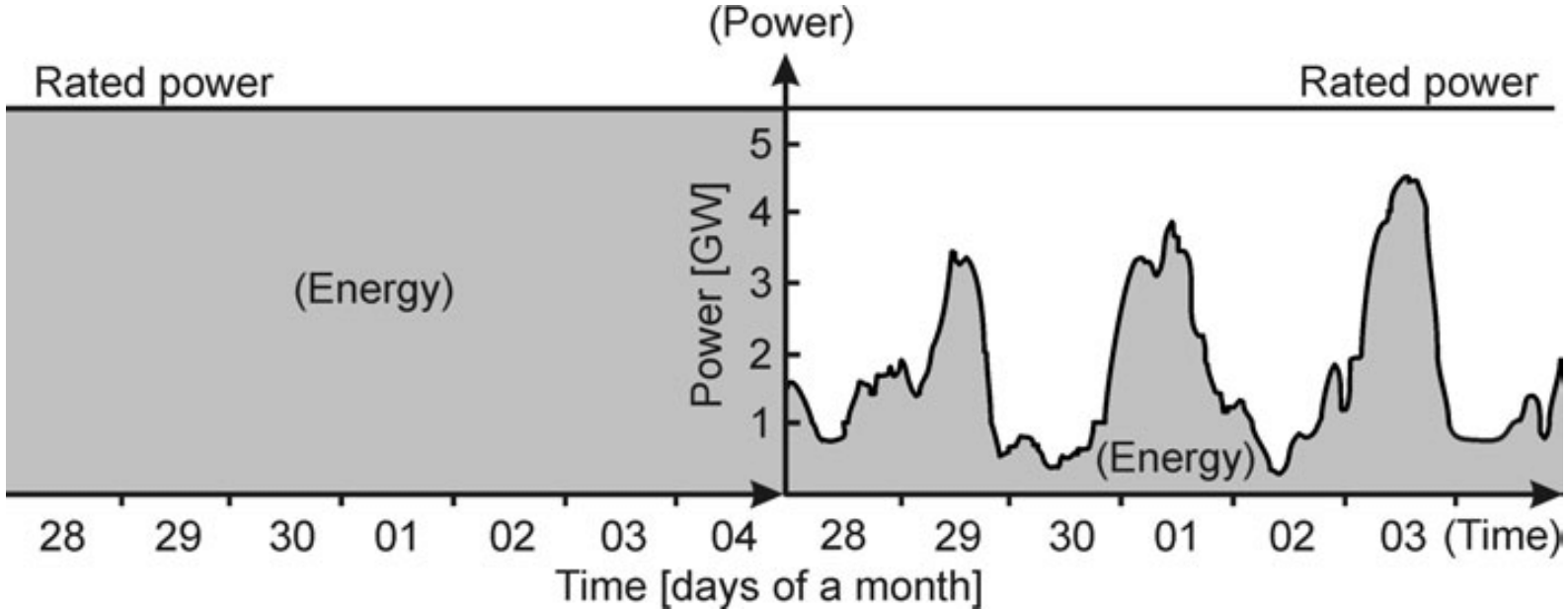
Definitions
Baseload - Peaking power plants, Intermittent plant

- Peak hours usually occur in the morning or late afternoon/evening depending on location
- Peaking power, peaker plants are generally gas turbines that burn natural gas



Definitions
Baseload - Peaking power plants, Intermittent plant

- An intermittent
  energy source is any source of energy that is not continuously available for conversion into electricity and outside direct control because the used primary energy cannot be stored.
- “Not reliable” energy source [3]



Key takeaways

Key takeaways – Technical aspect

- Viewpoints
  - Technologies have to be inspected with given viewpoints, propably a best method is to use a table to compare them
- Engineering, designing
  - Preliminary simulations and planning has to be made before building a viable system with optimized costs
  - Evaluating the simulation results with the real life experiences is very important in the company's life!

Key takeaways – Societal aspect

- Choosing the possible lowest level to start
  - If a company chooses that its tries to build a system of its own, it will be more independent, reliable, suitable.
  - In this way, more workplace generated in the region
  - Expensive
- Choosing and optimizing for the matching technology
  - If the technology fits the purpose, there is no need to modify or redefine the system, so money will be saved.
  - Preliminary market investigation, engineering simulating and planning pays off in the future!

Key takeaways – Business aspect

Where our profit is? At own work.

- Your idea is to get money from selling a solution to the energy provider.
  - The energy company grows dependence on startup companies.
- What if we go deeper in technical layers? We can optimize this solution.
  - If I can know the operation modes of a device, the needed bandwidths, the technical details, I can prevent my company to spend money to outsourcing.
- Be genuine, but in the process stay independent.
  - Stay in the right shine, ask for the same money, but lets develop our process cheaper. Avoid outsourcing.

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