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The most reliable and scalable Low Power Wide Area Network

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Introduction
LPWAN Overview

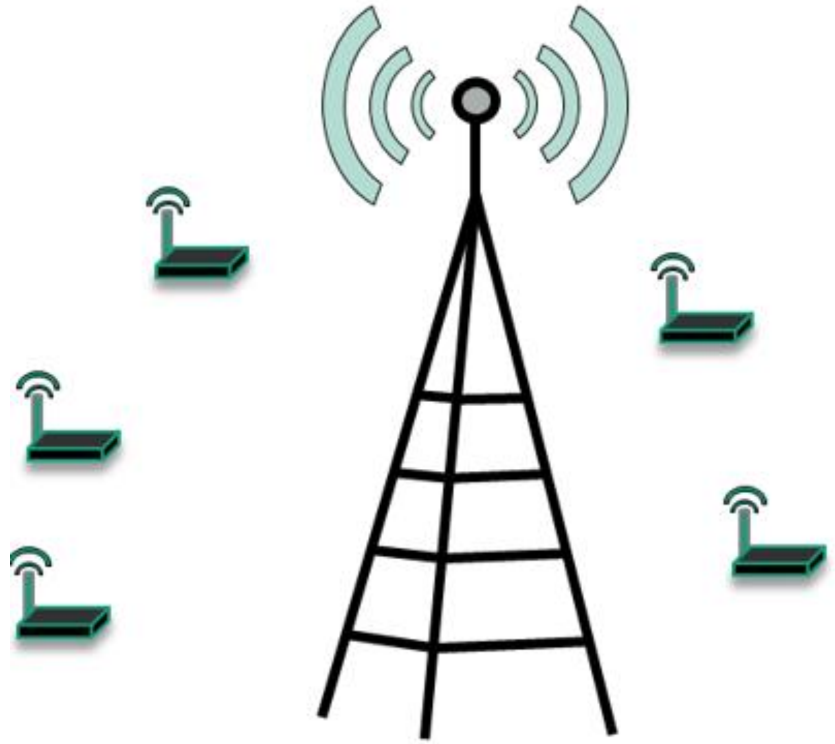
Low Power Wide Area Networks (LPWAN) - a new but established class of radio communications for the Internet of Things (IoT)

LPWAN are characterized by
- **Low Power:** Energy autarkic operation with long battery lifetime
- **Long Range Communication:** Star topology network with several kilometers range

-> Long range & Low Power is a contradiction

Keep the additional energy required to gap the distance as low as possible
- **Low Throughput:** small amount of data with limited message size and low update rate
- **Low Protocol Overhead**
- **Uncoordinated network traffic:** uplink driven random channel access
- **Half Duplex operation:** receive or transmit

Challenge
- Reliability and scalability of the network in a shared spectrum
- Support future demand of IOT applications



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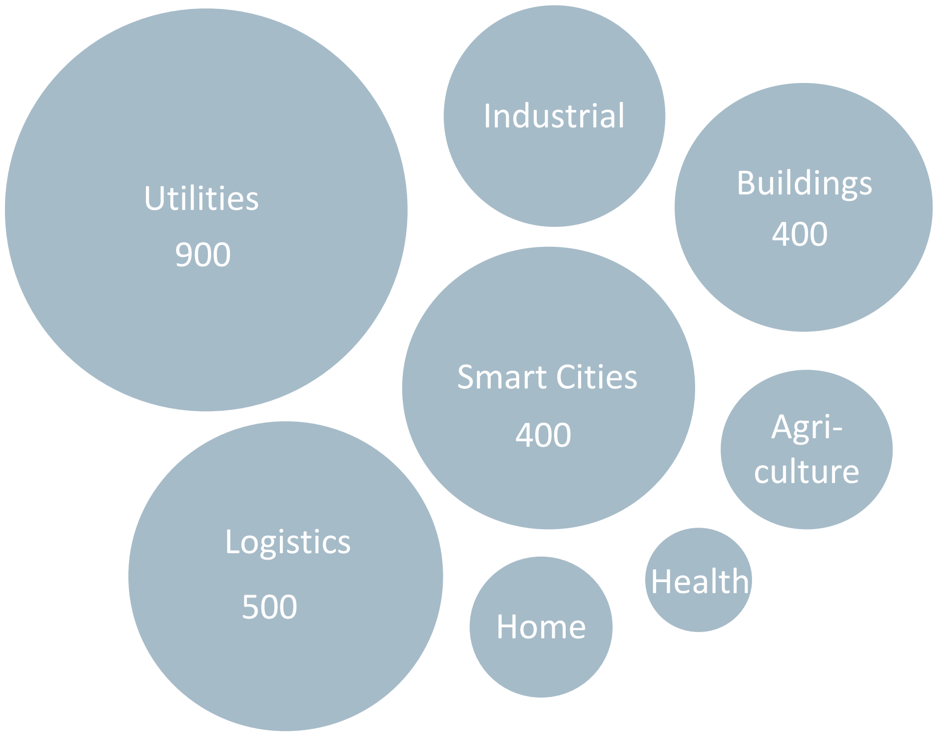
Low Power Wide Area Networks

IOT Landscape

Up to 3 Bn LPWAN Connections in 2026

Worldwide LPWAN connections by verticals (in millions)



Figures: based on IoT Analytics, Analysis Mason and own estimations of the mioty alliance

Implications for LPWAN

Growing number of IOT devices

- **Reliability and scalability:** LPWAN need to handle a massive number of IOT devices, other interfering radio services and coexist with other networks (in unlicensed spectrum)
- **Sustainability:** green power supply not only with long battery lifetime but also with harvested energy from the environment

Growing number of IOT applications

- **Convergence:** integration with existing ecosystems, multi-connectivity networks
- **New demands for downlink communication:**
  - parametrization and configuration of sensors
  - lower downlink latency for actor support (from uplink triggered downlink to on-demand downlink)
- **New functionalities:** localization, embedded AI, IoT over satellite

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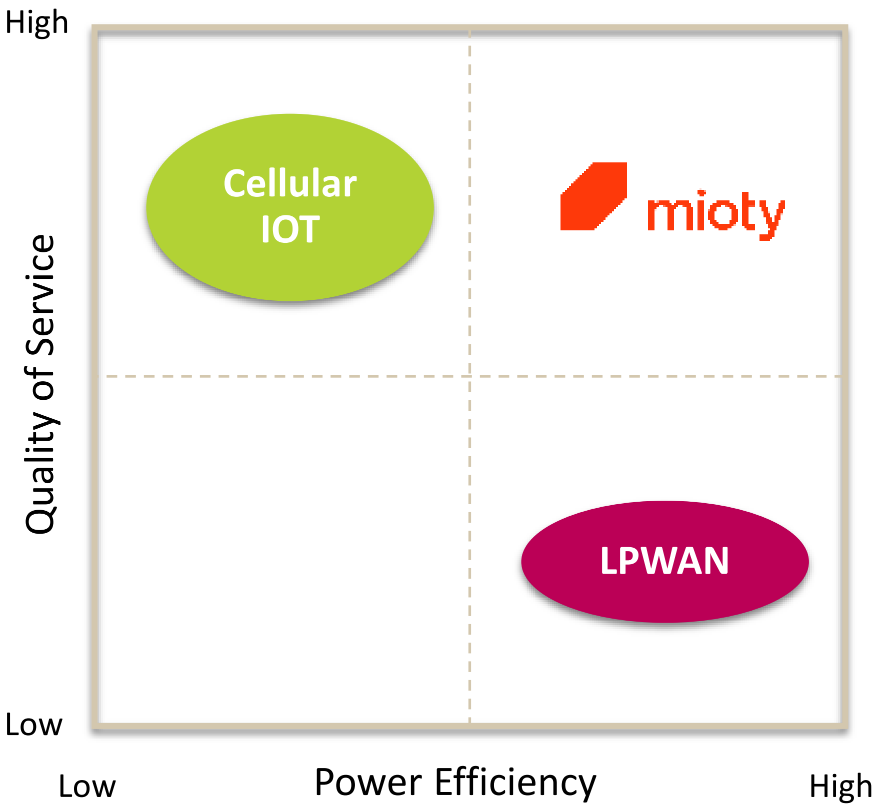
Future proof



Most reliable Low Power Wide Area Network for unlicensed spectrum

- Robust against growing interference in unlicensed spectrum
- Most scalable for growing IOT networks with dense sensor deployment
- Network of Networks: Mioty networks coexist with mioty networks in the same spectrum and in the same area
- High power efficiency for energy harvesting
- Quasi Duplex Operation

Future Enhancements

- reduced downlink latency
- higher datarates
- Multicast
- Satellite support

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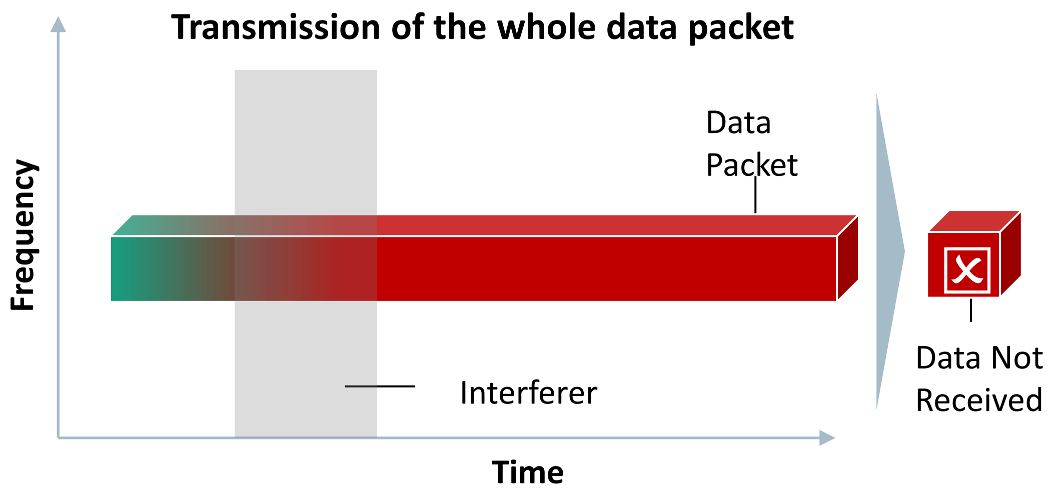
A new approach for wireless data transmission

Traditional Wireless Solutions	mioty: Telegram Splitting

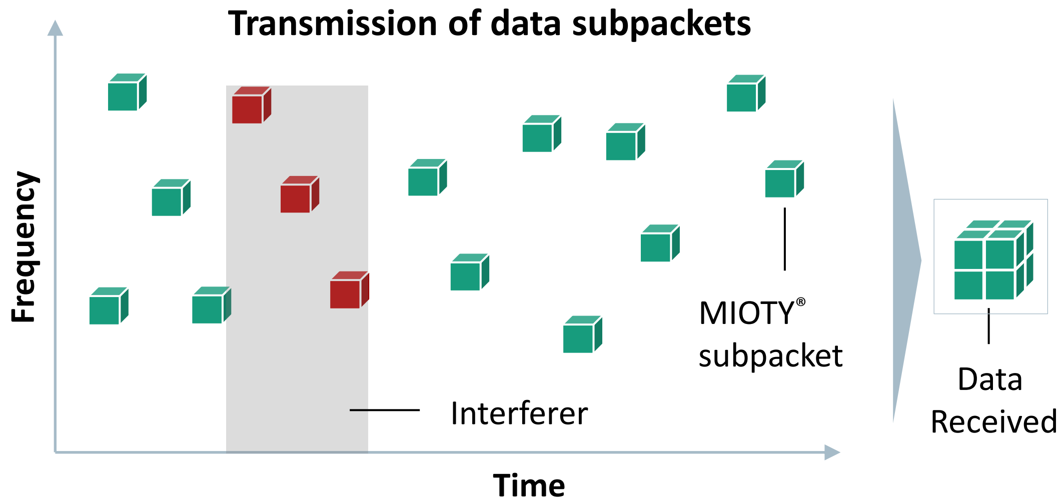
Traditional Wireless Solutions



- The whole data packet is affected by interferer
- Lack of scalability due to Interference issues and coexistence problems with other radio networks
- Packet Error Rates (PER) over 10% are common
- Battery life is severely limited due to inefficient transmission methods

Limited suitability for massive IoT-deployments

mioty: Telegram Splitting



- Only sub-packets affected by interferer
- Forward error correction affords up to 50% loss
- Telegram Splitting Multiple Access (TSMA) scheme with random subpacket distribution for high network capacity
- Transmission free periods allow battery recovery

Achievement of unrivaled scale, density & reliability

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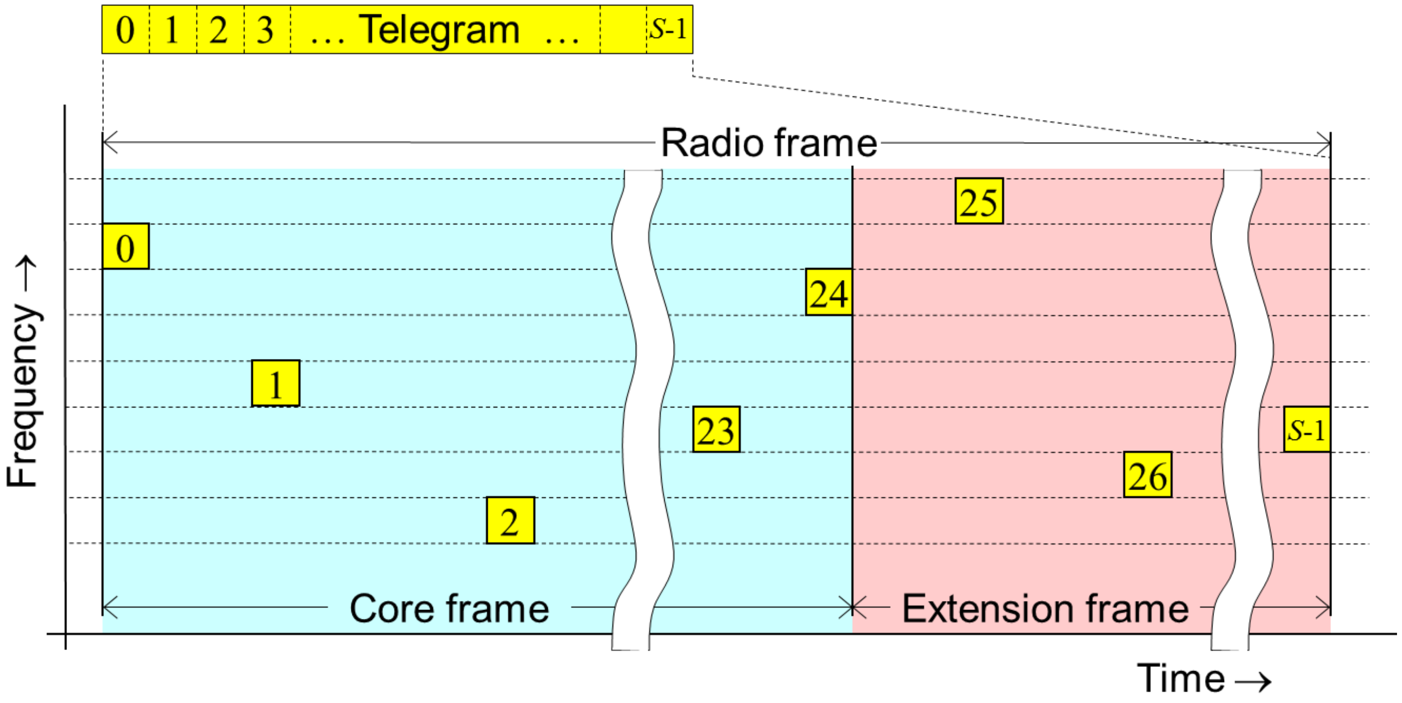
Uplink (Class Z)

- An Uplink telegram is divided into:
  - a **core frame** with 10 Byte application data and a fixed number of 24 radio bursts
  - An optional **extension frame** in which one radio burst is appended for each additional byte of application data
- The distribution of radio bursts is defined by TSMA-pattern
- Different pattern for standard or low latency transmission are used
- No preamble is required



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What makes the difference?

Standardized Ecosystem

- TS-UNB invented by Fraunhofer IIS and specified by a group of radio experts within **ETSI LTN**
- **mioty alliance**, a group of industrial companies together with research organizations driving the technology

Superior Coexistence

- Efficient modulation & coding for **low spectrum occupancy**
- Short radio bursts of 15 ms with transmission free periods for p**olite spectrum access**
- Robustness against any type of interferer for

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Scalability

- TSMA random channel access
- Increased **network capacity of 3,5 million connections** per day in a 200 kHz Band

Ultra Low Power

- **Efficient modulation & coding** for short transmission time
- Lightweight radio protocol
- Transmission free period for battery recovery

Hardware Agnostic

- Use of standard **MSK modulation** supported by most commercial Sub-GHz chipset
- **Software defined solution** with small footprint on processing power and memory size

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Standardized Ecosystem

The mioty alliance e.V.

Overview

mioty alliance

Association of industrial companies and research organizations to promote mioty® as the global standard for massive IoT

Goals:

- Create an interoperable ecosystem along the entire IoT value chain based on ETSI Low Throughput Networks specification
- Certification program for mioty® products
- Enhancing the technology towards new verticals and applications

Members:

- Research and technology leaders driving an open, interoperable and standardized ecosystem
- Leveraging leading edge technologies e. g. in the field of AI, Energy Harvesting or Localization

https://mioty-alliance.com/

Full Members

DIEHL Metering, Fraunhofer IIS, Texas Instruments, STACKFORCE, WIKA, RAGSOL, ifm, SWISSPHONE, WEPTECH, LORIOT

Associated Members

AST-X, Friendcom, Radiocrafts, codecentric, comtac, LANSEN, SILICON LABS, roundSolutions, Ancud IT, AGVOLUTION, FAU, tecnun Universidad de Navarra, Sentinum, Stadtwerke Garbsen, www.iot-shop.de, SAF, ST life.augmented, PAESSLER, ResIOT, safectory, LZE, RELISTE, exXcellent solutions, BEHRTECH, EasyMeter, HELIOT EUROPE, miromico

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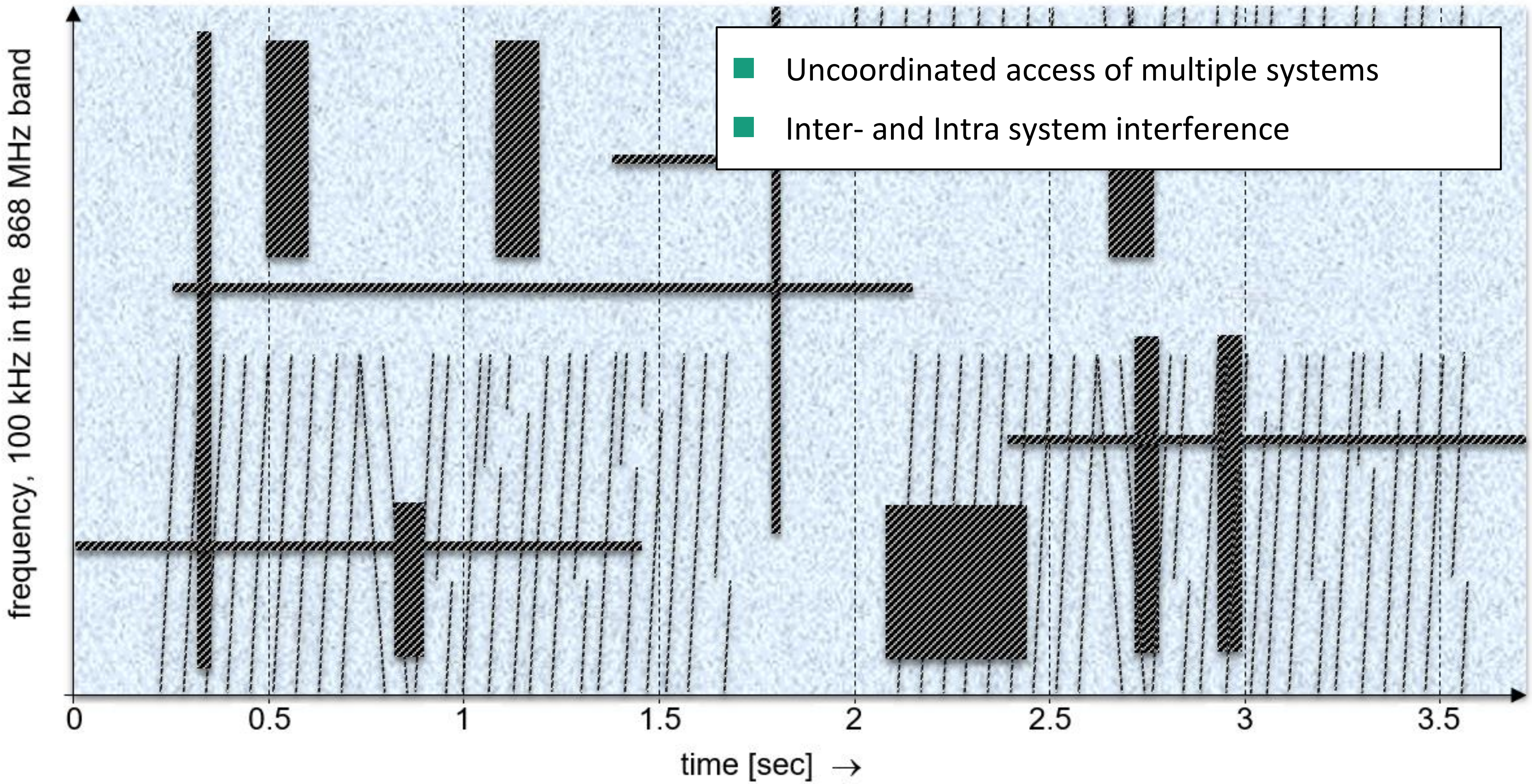
Superior Coexistence

mioty physical layer – improved interference robustness



mioty physical layer – improved interference robustness

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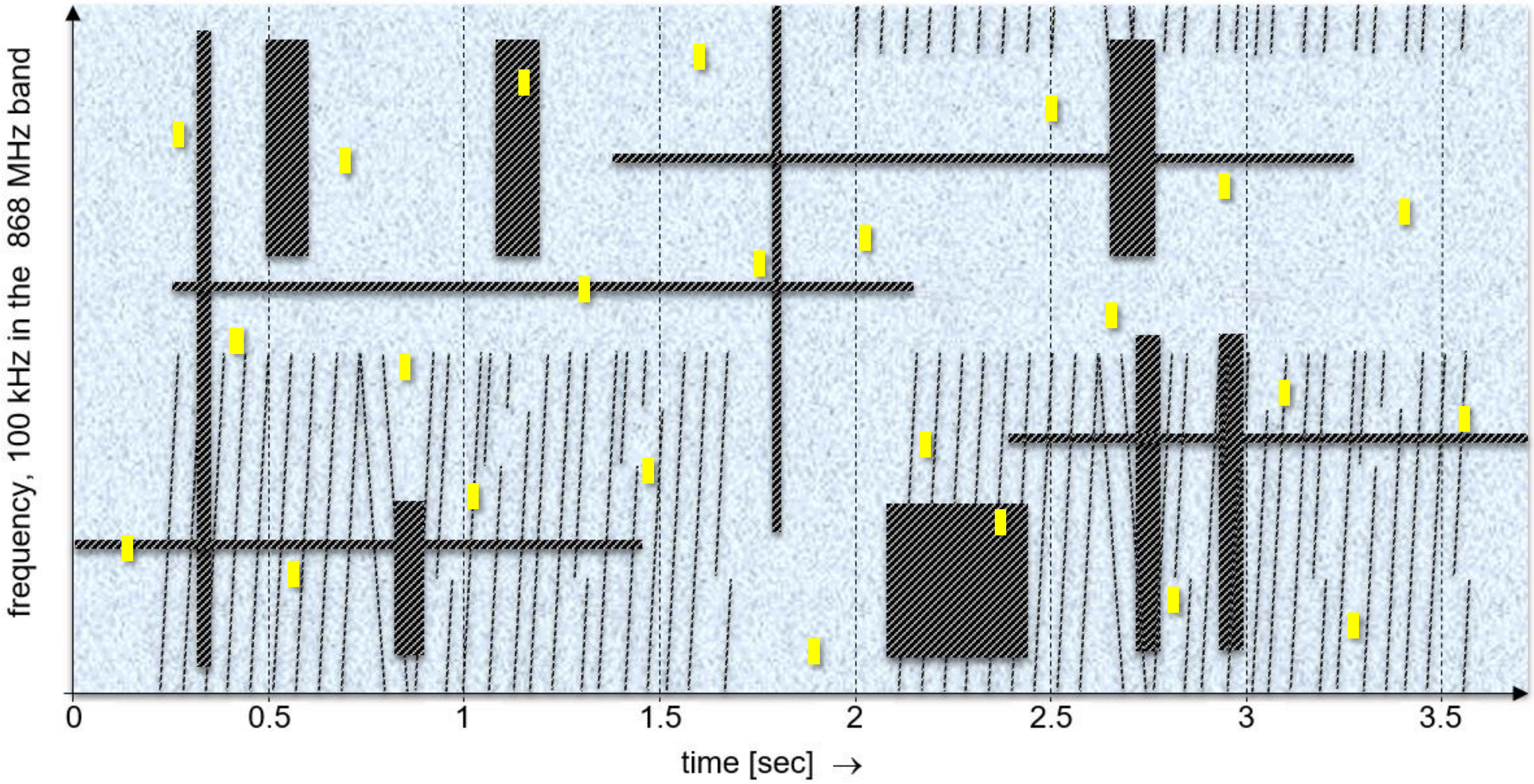

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mioty physical layer – improved interference robustness

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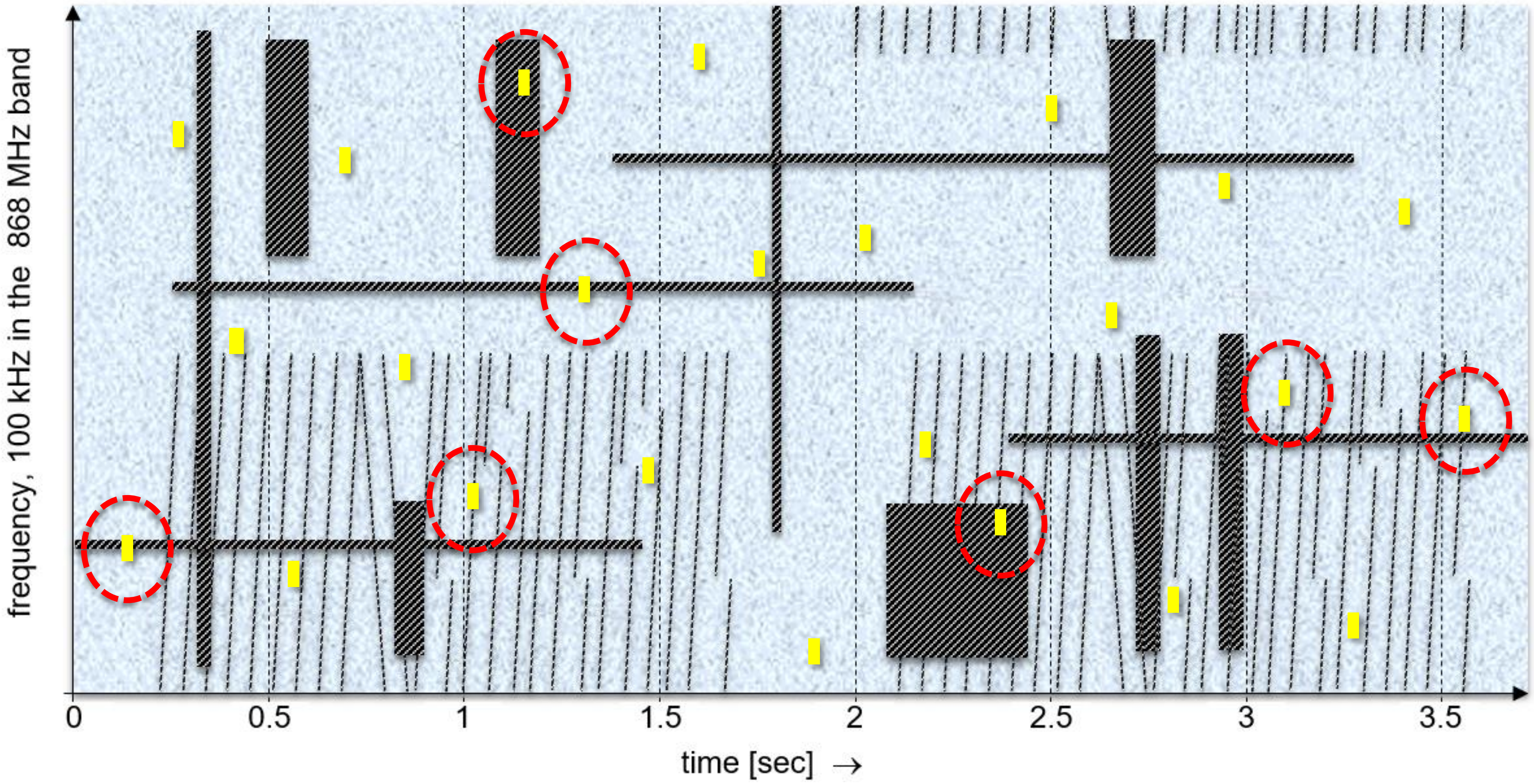

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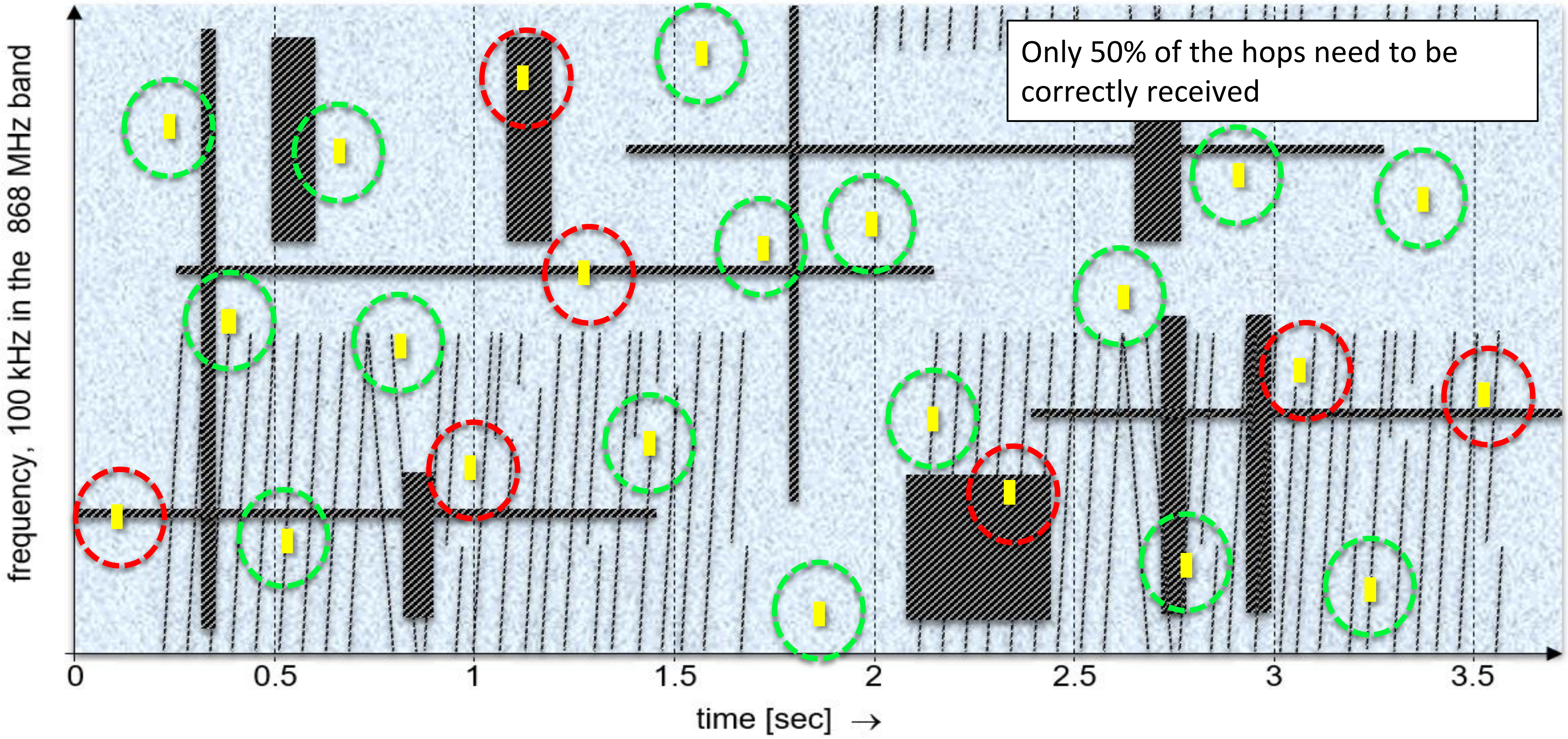
mioty physical layer – improved interference robustness



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Scalability

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Innovative random channel access to reduce loss of data

ALOHA is widely used for LPWAN:

- Success rate of sensor transmissions correctly received by the base station dramatically drops over channel load
- Loss of data is waste of energy, data has to be retransmitted

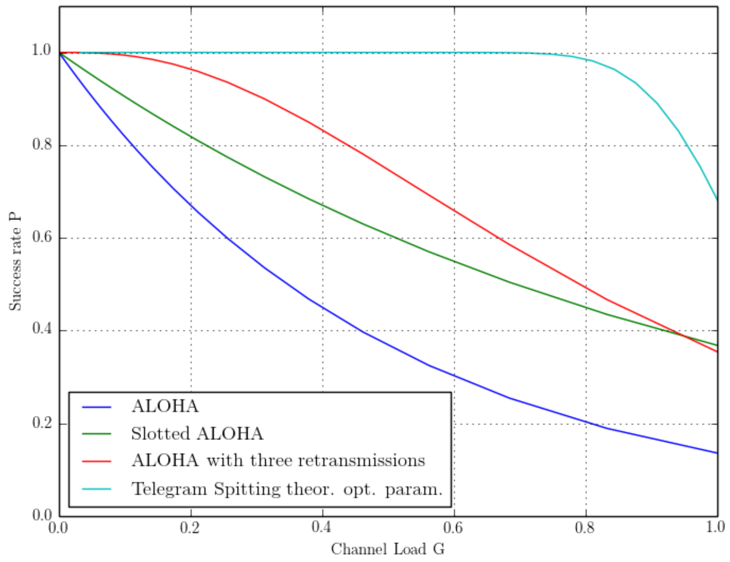
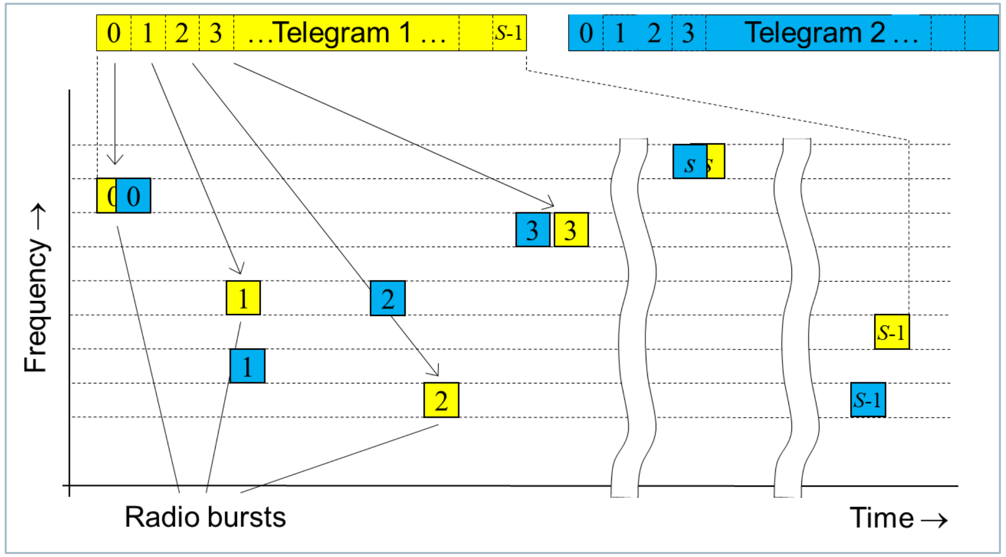


Diagram: Success rate over channel load for different random channel access methods (theoretical values)



Telegram splitting Multiple Access (TSMA) is used by mioty:

- Every telegram uses it’s own TSMA pattern
- Only singular radio bursts of telegrams collide
- High success rate over channel load: network capacity of 3,5 million messages per day & base station in a 200 kHz
- Low loss of data also in interfered channels

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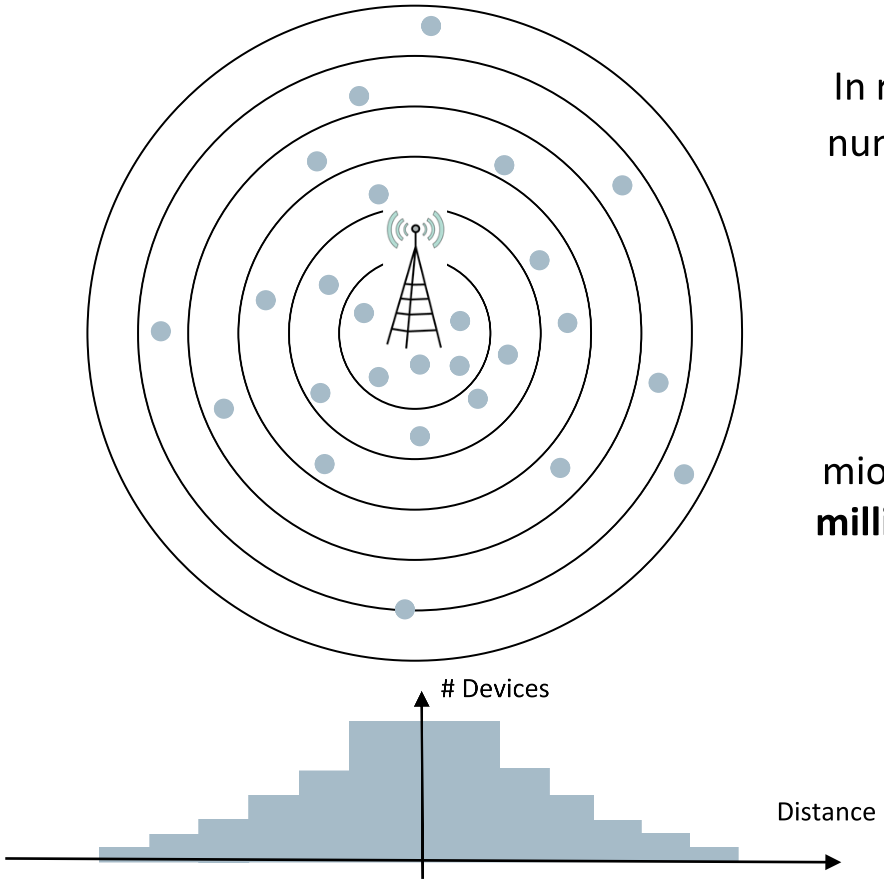
Network deployments

State of the art LPWAN



In real smart city environments the number of devices increases rapidly with distance

mioty is able to receive more than **3,5 million messages** per day with a **single radio setting**

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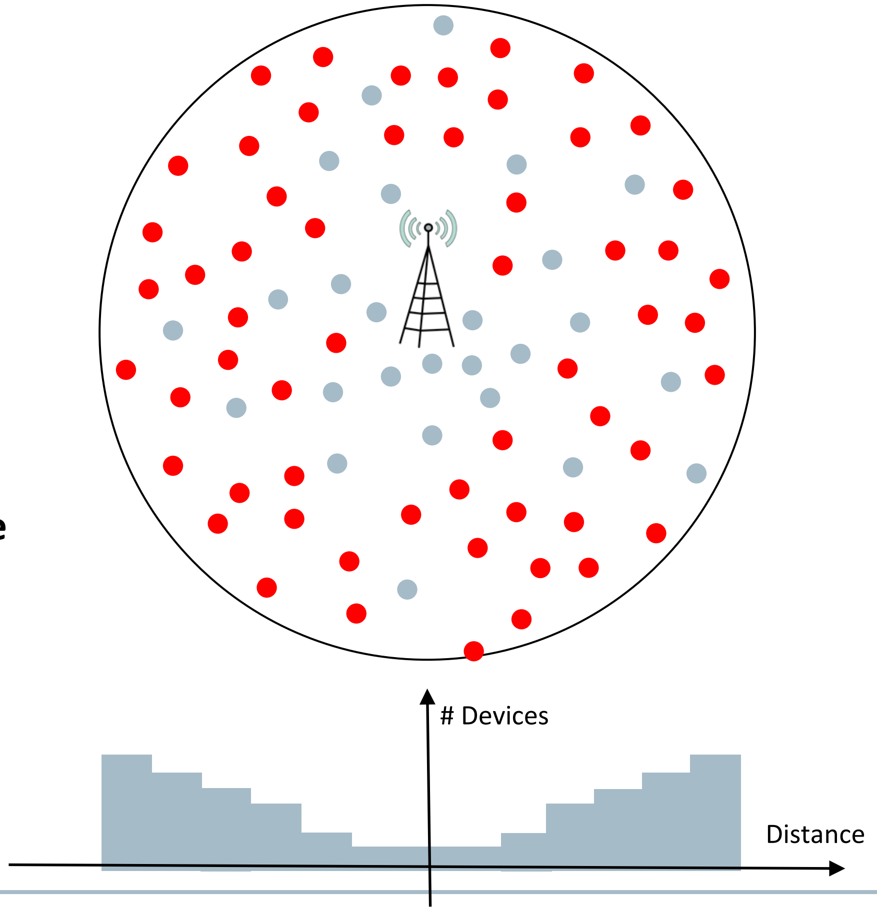


Capacity of LPWA Networks

Power level distribution

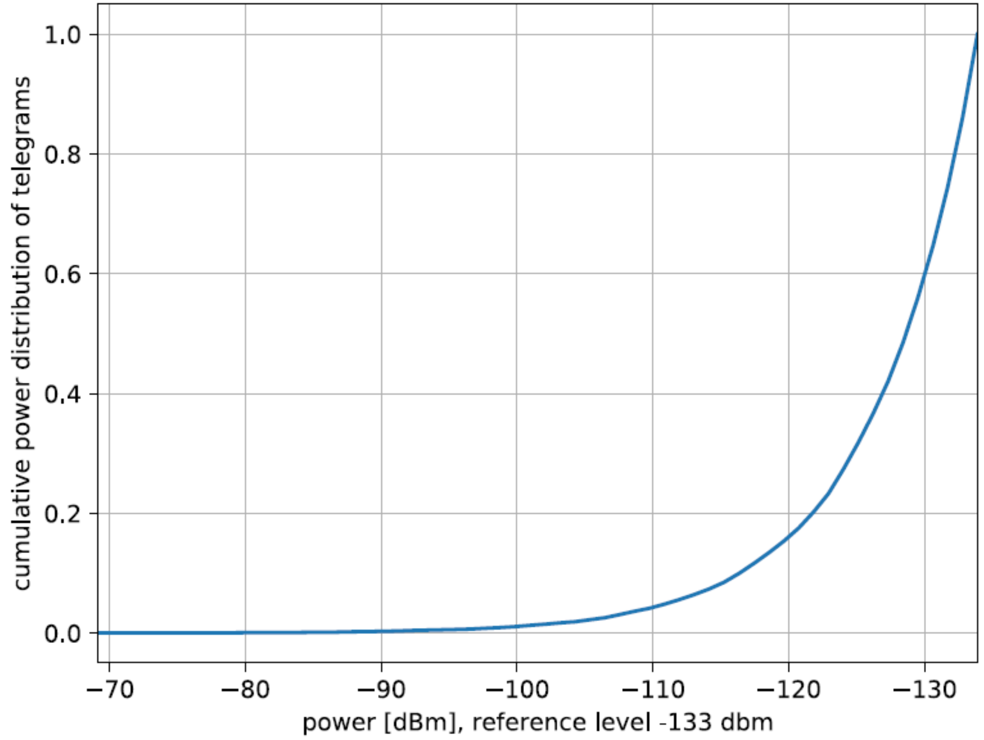
100% of messages received with a reference level of -133 dBm or better (3dB above noise level)

Signal loss according to Friis

$$A_{path\_db} = 20 \cdot log_{10}(f_{carrier}) + 20 \cdot log_{10}\left(\frac{4\pi}{c_0}\right) + 10 \cdot n \cdot log_{10}(r_{dist})$$

with $f_{carrier} = 868{,}13\ MHz,\ c_0 = 299792458\ m/s,\ n = 3{,}5$

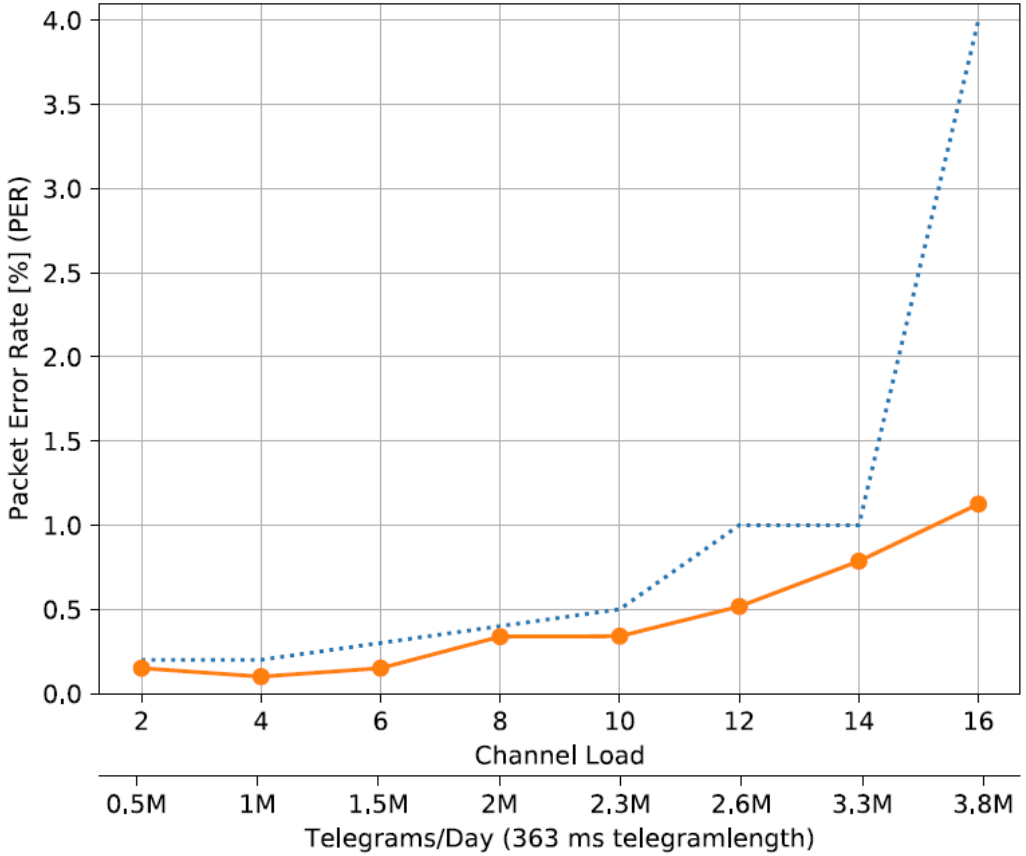
RX Power	Range	No. of messages
Up to -123 dBm	app. 1km	20%
-123…-133 dBm	app. 1…2,5 km	80%



mioty – improved capacity

Measured capacity of current base stations

mioty achieves a high uplink capacity with a high quality of service



Feeding the base station with different channel loads:

- Transmission power of the telegrams according to the distribution function
- Mioty parameters: packet size 10 bytes, data rate 2380 bit/s, bandwidth 200 kHz

Result: More than 140 sensors can be received simultaneously, which corresponds to 3.5 million telegrams per day at a packet error rate < 1%

Uplink Capacity for PER < 1%			
Traffic Model	**10 Byte every 15 min**	**10 Byte every hour**	**10 Byte every 2 hour**
No of devices per BS	> 36,000	> 145,000	> 290,000

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Ultra Low Power

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Efficient modulation

The efficient PHY of mioty allows long range communication at higher modulation rate

MSK modulation is used with differential precoding and forward error correction

- Allows the use of efficient, non-linear power amplifiers in the RF chip
- Transmit power is typically limited to 25 mW
- Coherent reception in the base station receiver with low Eb/N0 = 3,6 dB (@ PER = 10%)

Lower required SNR allows higher modulation rate compared to other existing LPWAN

- Shorter on air time = shorter current load pulses for the battery
- Radio burst duration: 15,1 ms
- Average transmission free period: 150 ms
- On-air-time for 10 Byte user data: 363 ms

Parameter	Value
Modulation rate	2380,371 Sym/s
Sensitivity*@ PER = 10%	-139 dBm
MCL @ TX-Power = 14 dBm	153 dB

* Receiver NF=5 dB assumed

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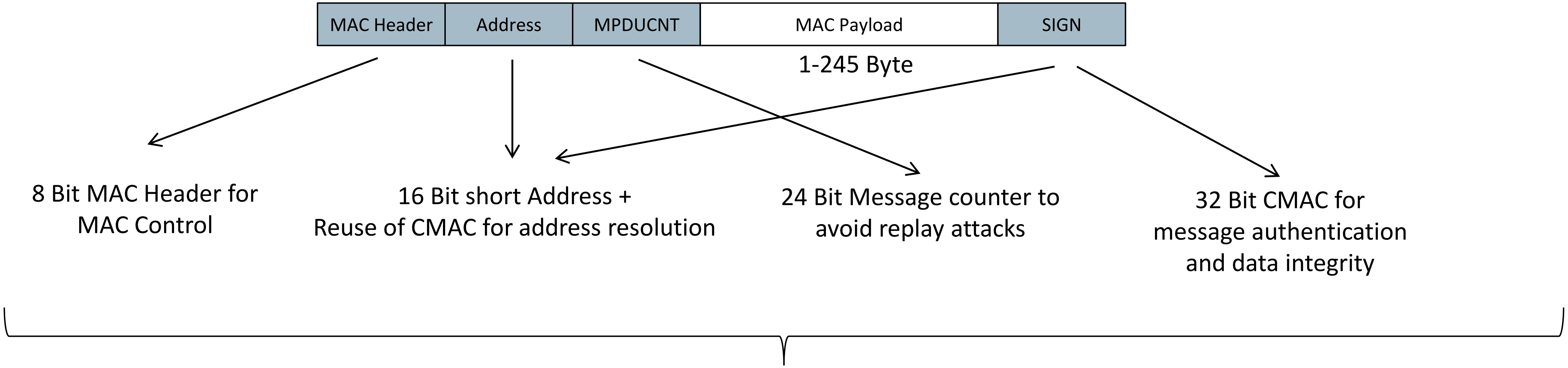
Low radio protocol overhead

Remove unnecessary MAC Overhead in uplink

Uplink Data Format



Total **10 Byte** including security measures

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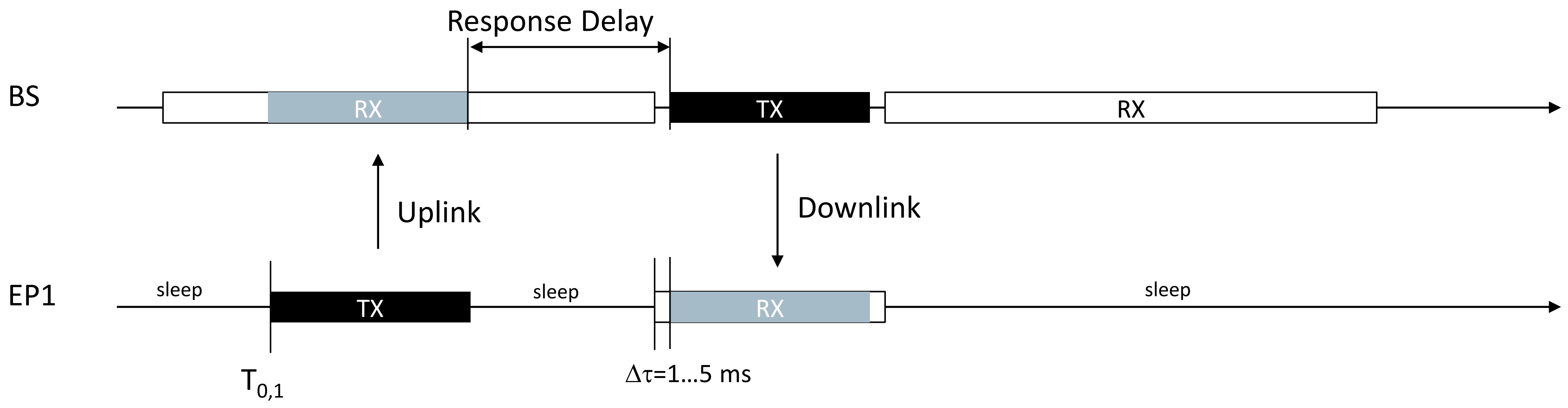
Low receiver activity in downlink

End-Point defines communication timing

- Timely precise downlink after “response delay” time
- End-Point wakes-up short before reception window



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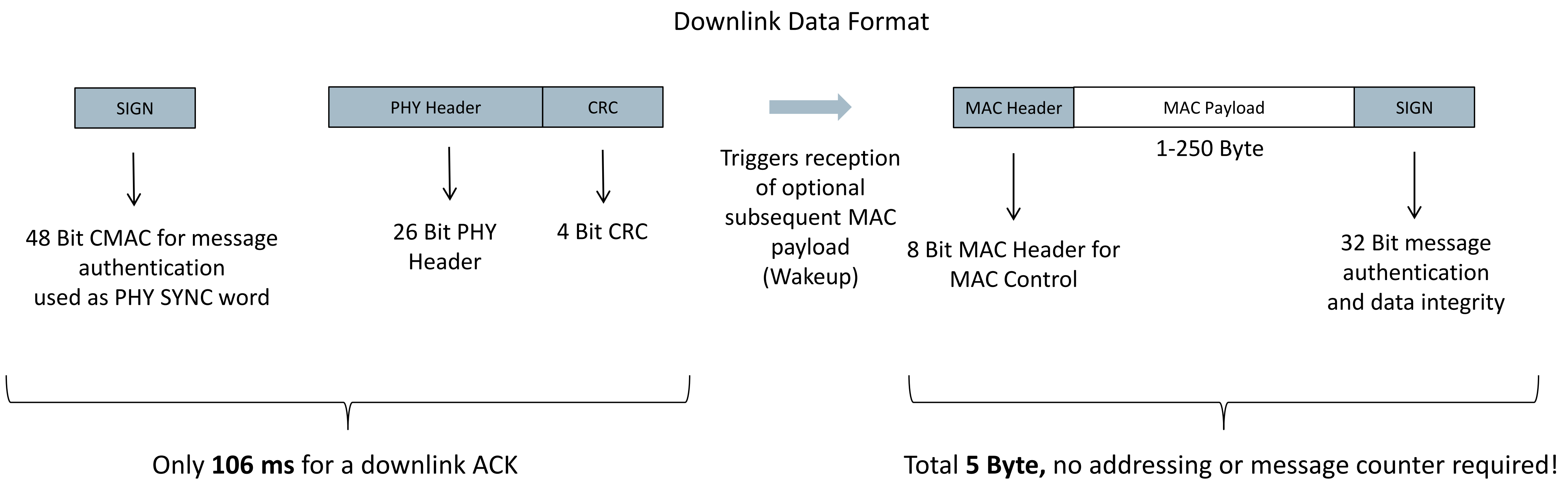
Low radio protocol overhead

Short Authenticated Wakeup and ACK Message with PHY Layer authentication



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Ambient IOT

mioty can be operated from ambient energy

Hardware parameters

- Transmit current I_{TX} = 29 mA
- Receive current I_{RX} =16,5 mA

Mioty energy consumption

- Single radio burst (1 Byte): 1,44 mWs
- Transmission of 10 Byte application data: 34,2 mWs
- Downlink ACK reception : 11,2 mWs

Energy Harvesting Generator sizes for 100µW

- Thermoelectric Generator: ΔT=3K, size 70cm^3
- Solar module: 500 Lux, size 9cm^2
- Piezoelectric vibration harvester: 25 mg acceleration, size 166 cm^3

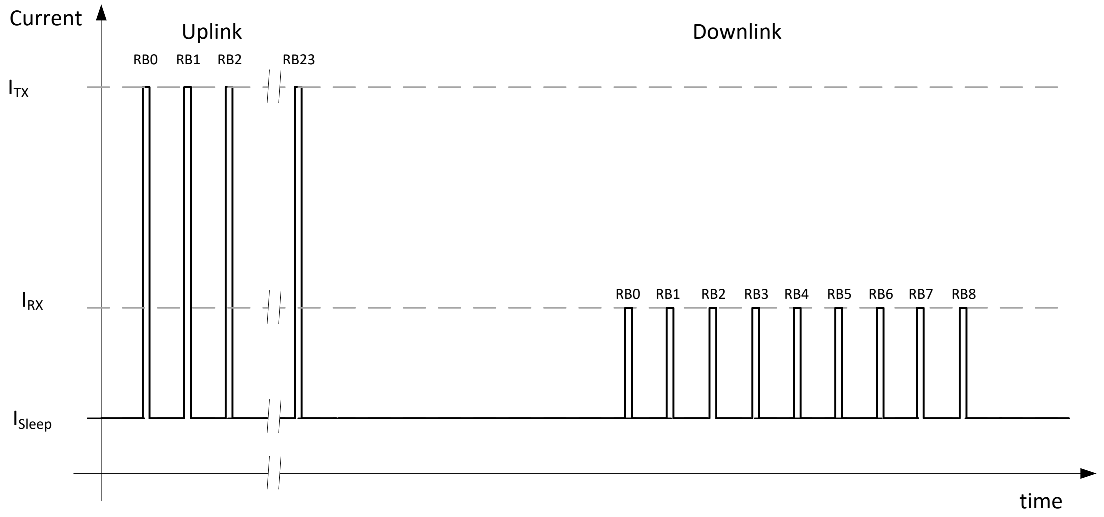
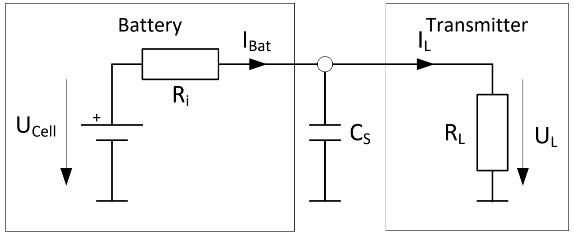
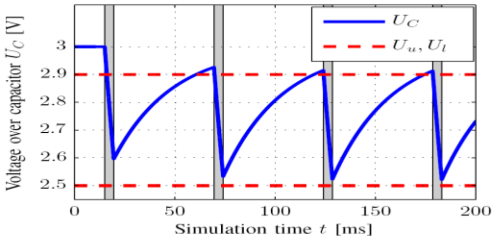


Diagram: Typical current drain of mioty communication with uplink radio bursts with transmission current I_{TX}, downlink receive current I_{RX} and long sleep period with current I_{sleep}





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Summary of technical parameters

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Modulation	Standard (G)-MSK supported by most Sub-GHz chipset
Modulation Rate	2380 Sym/s
Modulation Bandwidth	3 kHz
Coding	1/3 FEC
PHY datarate	512 Bit/s
Operating Band	868/915 MHz (2 x 100 KHz channel / 2 x 750 kHz channel)
Communication	Unidirectional (class Z), Bidirectional Quasi-Duplex (class A)
MCL (@P_{TX} = 14 dBm / 27 dBm)	153 dB / 166 dB
Power Efficiency	4.5 ms on-air time per Bit userdata
Capacity	3.5 Mio. Messages per day
Packet Size	255 Byte (up to 250 Byte userdata)
Mobility	120 km/h

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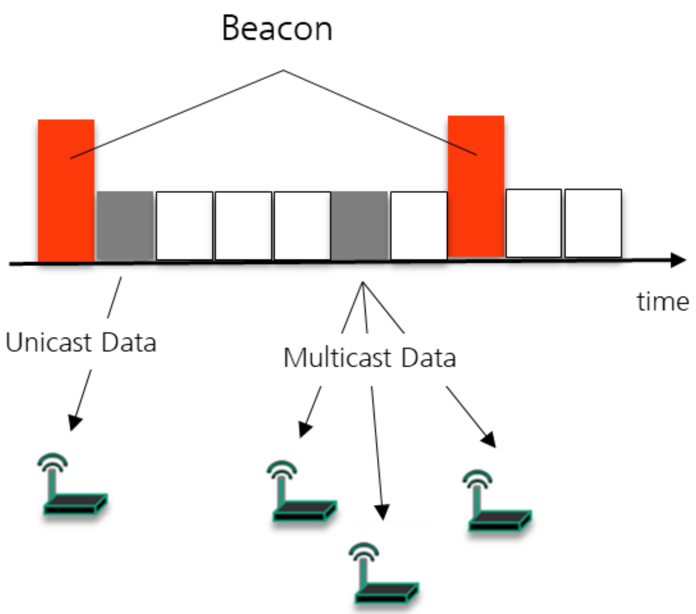
Next Generation

mioty Next Generation
Overview



Request for new features from the market

- over-the-air configuration, parameterization or firmware update that requires a higher amount of data to be transmitted to a group of sensors
- Shorter reaction time for alarm messaging or activation of actors like switches or valves that require lower latency in downlink

Technical Solution

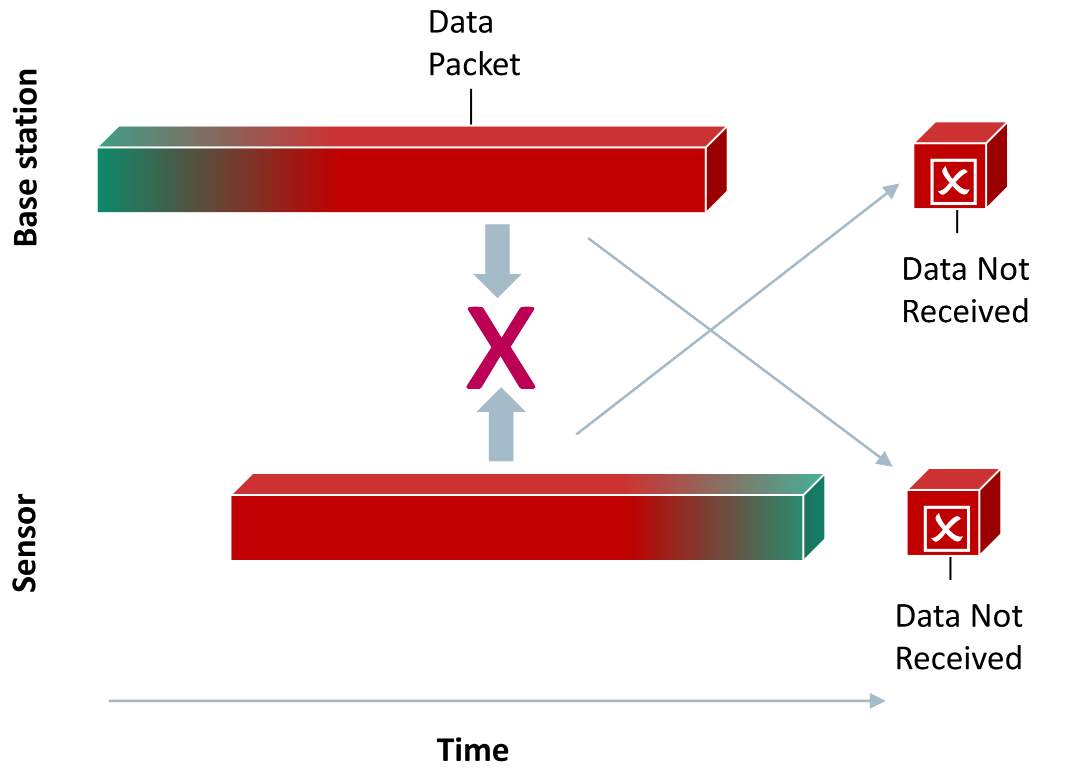
- Introduction of beacons sent out by the base station to synchronize IOT devices in time (class B)
- Communication with a group of IOT devices (Multicast/Broadcast)
- Continuous listening for downlink transmissions from the base station for fast activation of IOT devices (class C)
- Introduction of higher data rates in up- and downlink

mioty Next Generation

Improved Duplex Operation as baseline for new capabilities

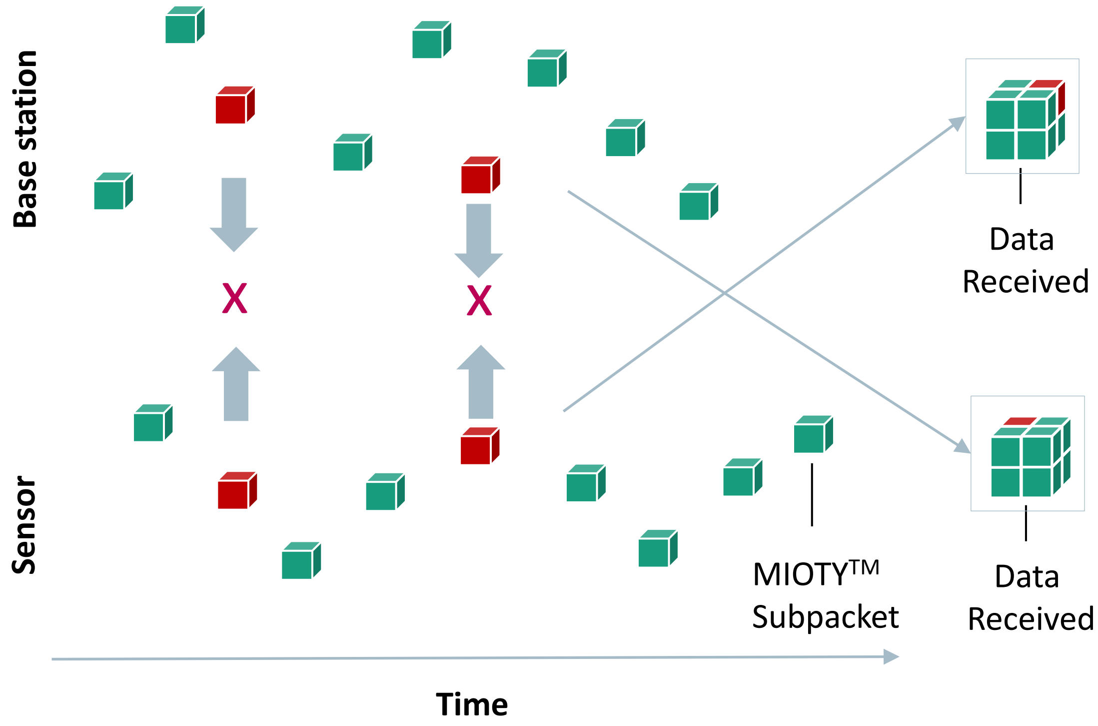
Traditional LPWAN-Solutions: Half Duplex

Transmission of the whole data packet



MIOTY: Quasi-Duplex

Transmission of data subpackets



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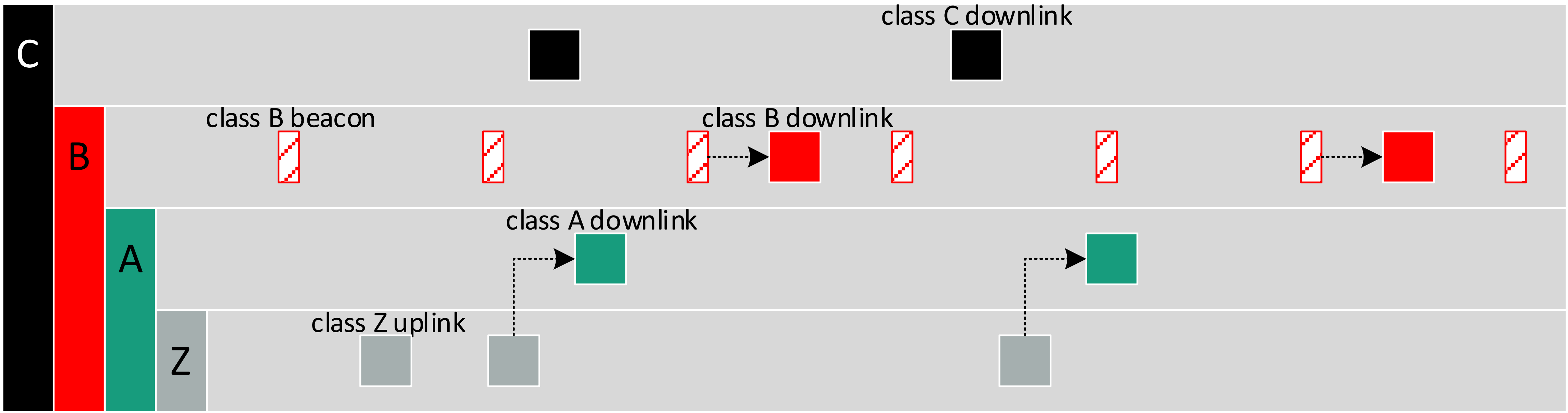
mioty Device Classes

Overview Device Classes and Class Features



All device classes can be combined and used **in parallel**

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