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Journées LPWAN – collectivités et infrastructures publiques
LPWAN days – local authorities and public infrastructure

Large Scale Smart City Networks with mioty

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mioty®
Overview

mioty® is a Low Power Wide Area network solution

- based on ETSI TS 103357 TS-UNB
- Ultra low power (efficient modulation and coding)
- High reliability (interference immunity)
- High network scalability (TSMA channel access)
- Hardware agnostic (software solution, standard MSK modulation)

mioty alliance

- Alliance members from industry and research
- Create an interoperable ecosystem along the entire IoT value chain
- Certification program for mioty® products
- Enhancing the technology towards new verticals and applications

https://mioty-alliance.com/

mioty alliance

Full Members

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

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Large Coverage with a single antenna

The challenges

High altitude antennas are very attractive to cover a large area, but what are the drawbacks?

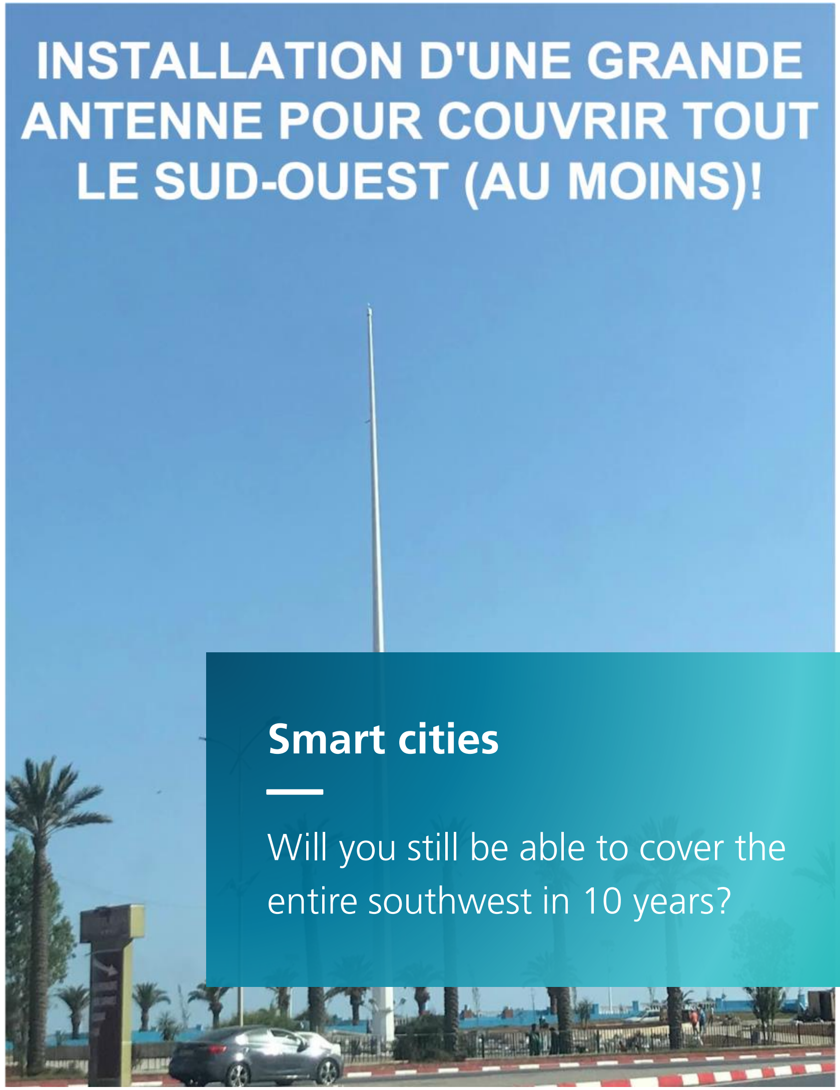
Better path loss with high antenna sights:

- Ability to receive IOT devices from far, but also all devices inbetween

Number of received devices grows rapidly with coverage area:

- More wanted devices (increased network load)
- More unwanted radio signal (interference)

Situation becomes worse with the growth of IOT and IOT applications, especially in smart city networks!



Smart cities

Will you still be able to cover the entire southwest in 10 years?

Smart city and Smart Metering

Challenges

Smart City

Cities have many IoT applications

- Waste management
- Parkside management
- Flood control and managment
- …

Many smart city projects

- showing the feasibility of this applications
- installation and operation of wireless networks based on Low Power Wide Area Network (LPWAN) technology
- Operated by the municipalities, covering large (urban) area
- Growing number of networks and applications

Still limited number of devices in a network (e.g. 50-200 devices per gateway)

Smart Metering

Wireless readout of metering data

- Water
- Energy (electricity, gas, heat)

High Quality of Service required

- Expected Packet Delivery Rate (PDR) of at least 95%
- Deep Indoor installation

Interoperability to existing standards

- OMS and Wireless M-Bus (EN13757)
- Limited range of OMS/W-MBus devices today (walk-by / drive-by)

High number of metering devices according to OMS/W-MBus are already deployed. They are waiting to be switched to LPWAN and to be integrated into smart city networks!

OMS LPWAN

New specification

OMS Group

The Open Metering System Group (OMS Group e.V.) is an interest group developing standards for communication interfaces for metering systems based on Wireless M-Bus (EN13757)

Overview OMS 5 specification

- OMS Group has recently published Generation 5 specification
- New Annex Q of Vol. 2: Primary Communication 5.01. covers radio protocols for long range “fixed network” communication (“OMS LPWAN”, https://oms-group.org/en/open-metering-system/oms-specification)

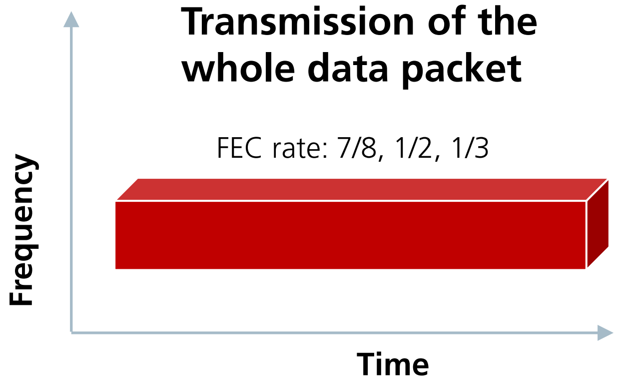
OMS LPWAN comprises the following sub-modes

- Single burst mode
- Multi bust mode
- Splitting mode according to ETSI TS 103357-2 TS-UNB = mioty®

OMS LPWAN

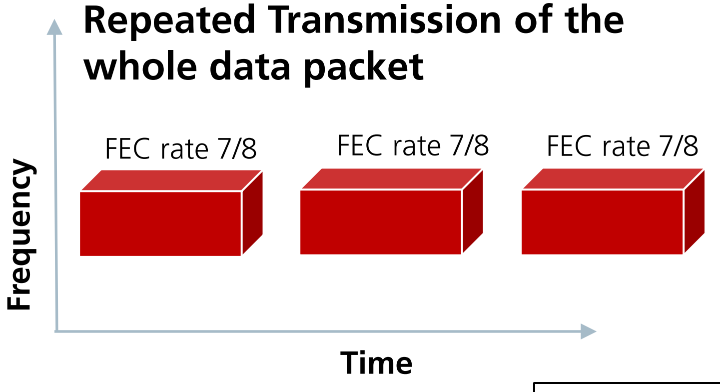
Overview

Single Burst



- MSK modulation
- Symbolrate: 125 & 10 ksps
- Coding: different code rates
- Channel access: ALOHA
- Link Budget: app. 134 dB

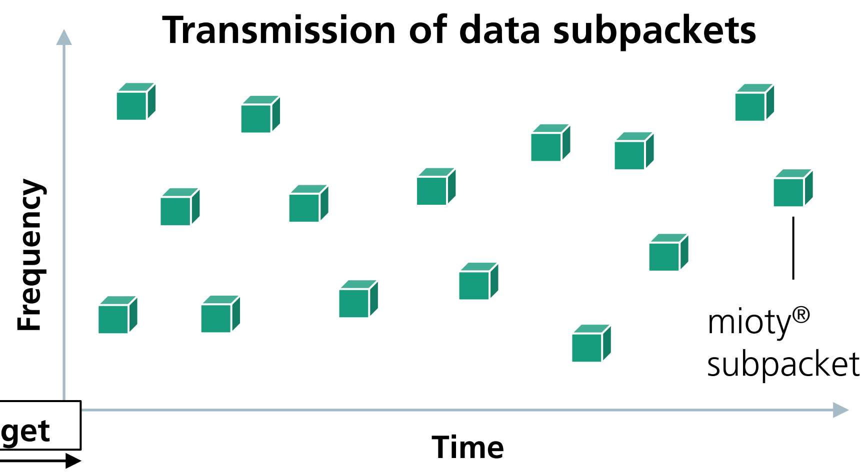
Multi Burst



- MSK modulation
- Symbolrate: 125 & 10 ksps
- Coding
  - Only FEC rate 7/8
  - Code combining of bursts
- Each burst contains complete information
- Channel access: ALOHA with coded retransmission
- Link Budget: app. 134 dB

+ 18 dB Link Budget

Splitting mode (ETSI TS 103357)



- MSK modulation
- Symbolrate: 2,38 ksps
- Each burst contains a fragment of information
- Code rate: 1/3
- Channel access: Telegram Splitting Multiple Access (TSMA)
- Link Budget: app. 152 dB

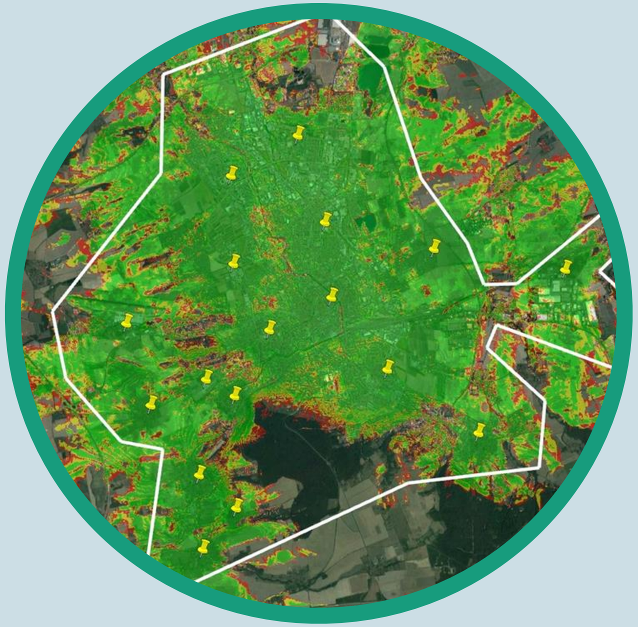
Smart Metering with mioty®

Current Rollout of water meter devices in Erfurt, Germany

Current installatíon

- Area: 122 km^2
- Network: 17 mioty® Gateways
- Device Deployment:
  - 29.000 Metering devices (238 devices per km^2)
  - On avg. 1705 devices per gateway
  - Reporting rate: 1 msg. per hour (40.920 messages per day per gateway)
  - Message size: 100 byte (OMS)
  - PDR > 98%

mioty®



Source: Diehl Metering, Stadtwerke Erfurt, 2023

Future deployment

- Future deployment expected to grow up to 90.000 Smart Metering and Smart City Devices (738 devices per km^2) in the same area
- Gateway requirement:
  - Capacity: 5.300+ Devices per Gateway
  - Reporting rate: 1 msg. per hour (127.200 messages per day per gateway)
  - Message size: 100 byte (OMS)
  - PDR > 98%

Feasible with mioty?
And what about other technologies?

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Capacity of LPWA Networks

Deployment Scenario

Increase of receiver sensitivity by 18 dB leads to more than 10 times higher network load at the gateway!

Signal loss according log distance

$$A_{path\_db} = 20 \cdot log_{10}(f_{carrier}) + 20 \cdot log_{10}\left(\frac{4\pi}{c_0}\right) + 10 \cdot n \cdot log_{10}(r_{dist}/r_0)$$

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

Assuming 5 dB margin in available link budget

Deployment assumptions

- Device Density: 750 devices per km^2
- Reporting Rate: 1 message per hour
- Message size: 100 byte
- Resulting message density: 18.000 per km^2

	Path loss	Range	Coverage Area	Devices per Gateway	Messages per gateway per day
Burst Mode	129 dB	app. 0,6 km	1,1 km^2	848	20.358
Splitting mode	147 dB	app. 2 km	12,6 km^2	9.425	226.195

>10 times more devices per gateway

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Random Channel Access

Comparing TSMA and ALOHA

ALOHA is widely used for LPWAN:

- Every device randomly access the channel
- Transmitted bursts can overlap in time (collision)
- Colliding transmissions get lost

- Packet Delivery Rate:

$$PDR = e^{-2CL}$$

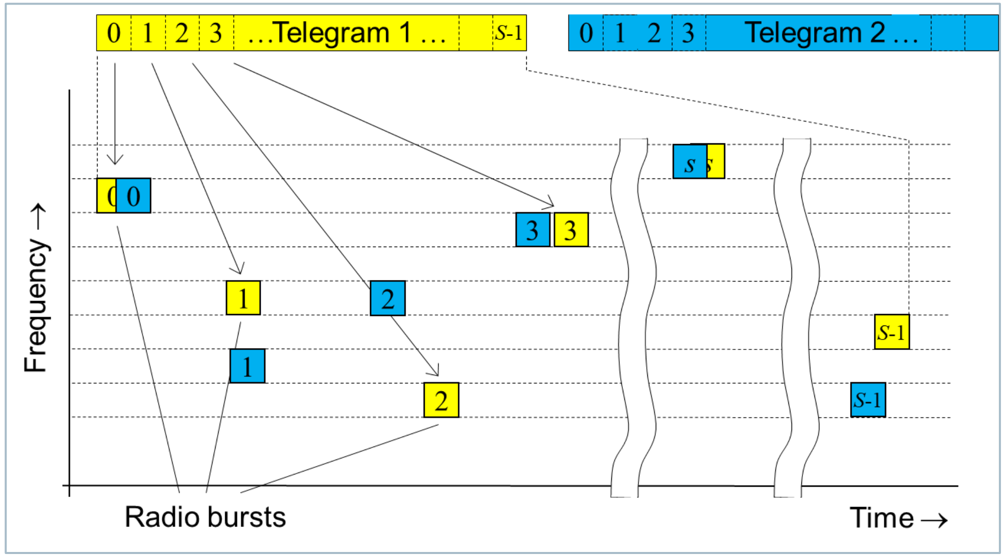
with Channel Load

$$CL = \lambda \cdot \tau$$

where

λ: number of transmissions per time unit

τ: transmission duration



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

- Message is split into short bursts
  –> reduces collision interval
- Every telegram uses it's own TSMA pattern
  -> avoiding full message collision
- Only singular radio bursts of telegrams collide

Comparison of TSMA performance to ALOHA
Simulation Parameters

ALOHA

- Analytical calculation of OMS Burst mode like approach
- unconfirmed uplink without retransmission
- No capture effect

TSMA

- Running mioty® Software receiver feed with simulated load:
  - Log distance Path-loss model for the amplitude distribution at the receiver
  - Minimum Rx-Level: -133 dBm

Analysis of the System PDR and not per device PDR

	ALOHA	**TSMA (mioty®)**
Channel	1 x 125 kHz	2,38 kHz subchannels spread over 200 kHz
Payload	10 Byte	10 Byte
Symbols per transmission	536	864
Burst time τ_{burst}	4,3 ms	15,1 ms
Transmission duration τ	4,3 ms	363 ms

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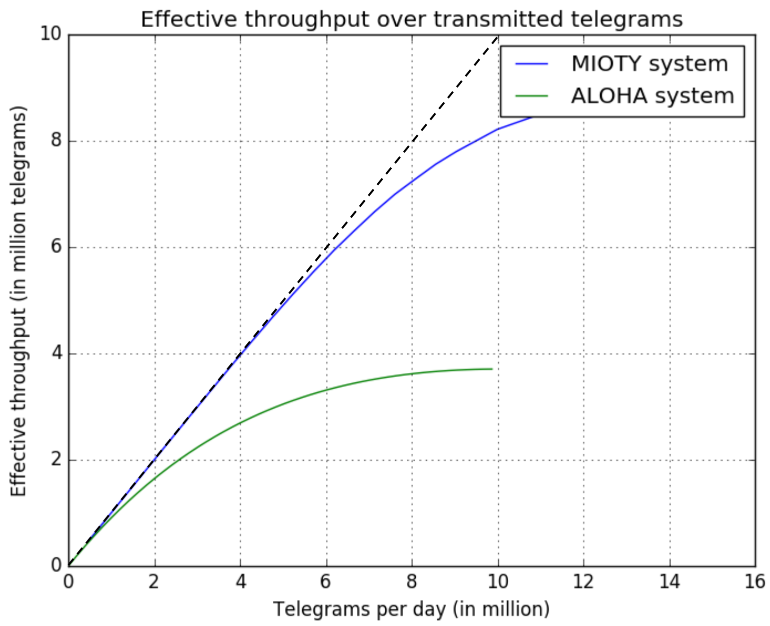
Comparison of TSMA performance to ALOHA

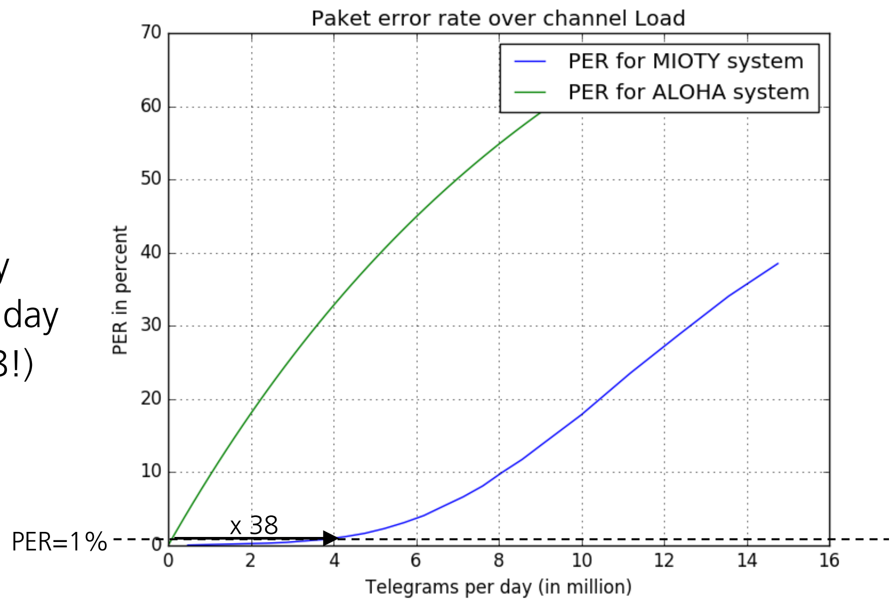
Simulation results

Even though transmission duration τ is longer, mioty can achieve significantly higher network capacity

Dotted line: PDR = 100%



For Packet delivery rate > 99%
ALOHA: app. 100.000 Msg. per day
TSMA: app. 3,8 Million messages a day
(outperforms ALOHA by factor of 38!)



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Comparison of TSMA performance to ALOHA

Conclusion

Channel Access method is key for network scalability

- ALOHA:
  - Capacity under real conditions might be slightly higher (e.g. due to capture effect)
  - Capacity of ALOHA seems to be sufficient to fulfil PDR requirements at medium range
  - High gateway density required (10 times)
- TSMA:
  - Only System PDR has been considered, per device PDR might differ
  - mioty easily fulfils requirements on PDR and future network capacity and still has room for further growth
  - No need to increase gateway density

	ALOHA	**TSMA (mioty®)**
Network capacity @ PDR>99% for 10 byte	app. 100.000	app. 3.800.000
Network capacity @ PDR>99% for 100 byte	app. 20.000 (required 20.358)	app. 800.000 (required 226.195)

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Outlook
Future demands

From sensor network to IOT connectivity

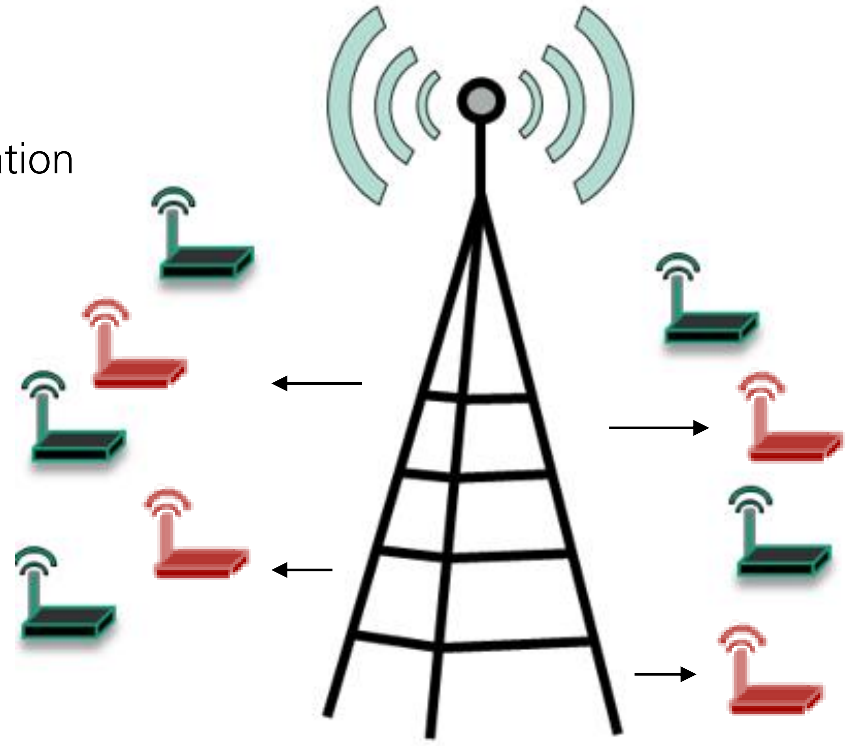
LPWAN today: mainly used for collecting sensor data

- Long Range Communication: data rate is low, transmission time is high
- Low Power Operation: Mainly uplink communication without network synchronization
- Large number of sensors

LPWAN tomorrow: additional control of actuators/config&firmware updates

- Increased Downlink traffic
- Lower Latency: Reach out to IOT devices within a certain time window
- Requirements:
  - Multicast transmission to limit downlink traffic
  - Network synchronization
  - Backward compatible and harmless to existing solutions

mioty next generation supports these requirements



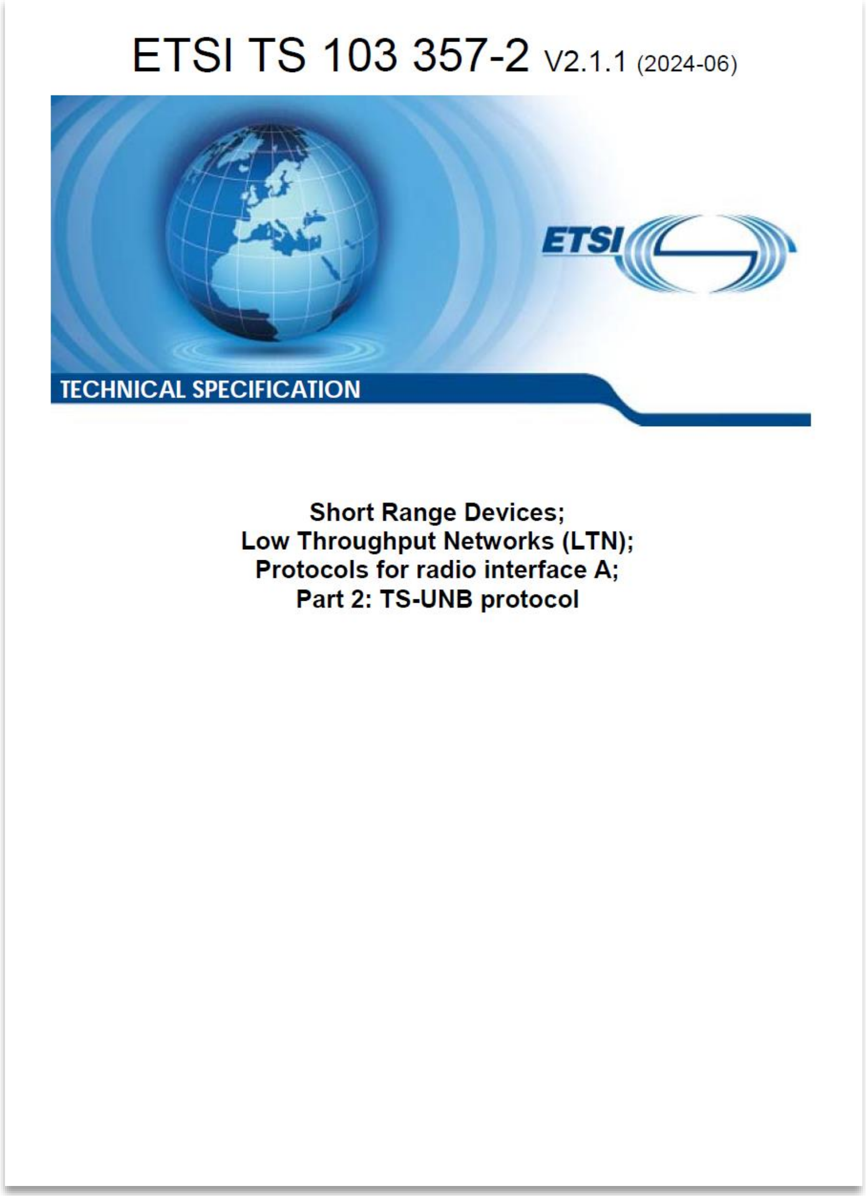
mioty®
Next Generation

New Version of ETSI Specification has just been released

Baseline protocol for mioty®

New Features:
- Synchronous downlink transmission with class B und class C
- Multicast transmission
- Higher datarates in uplink and downlink
- Timing flexibility in TSMA for power supply optimization
- Latency optimization

Full backward compatible


ETSI TS 103 357-2 V2.1.1 (2024-06)

TECHNICAL SPECIFICATION

Short Range Devices;
Low Throughput Networks (LTN);
Protocols for radio interface A;
Part 2: TS-UNB protocol

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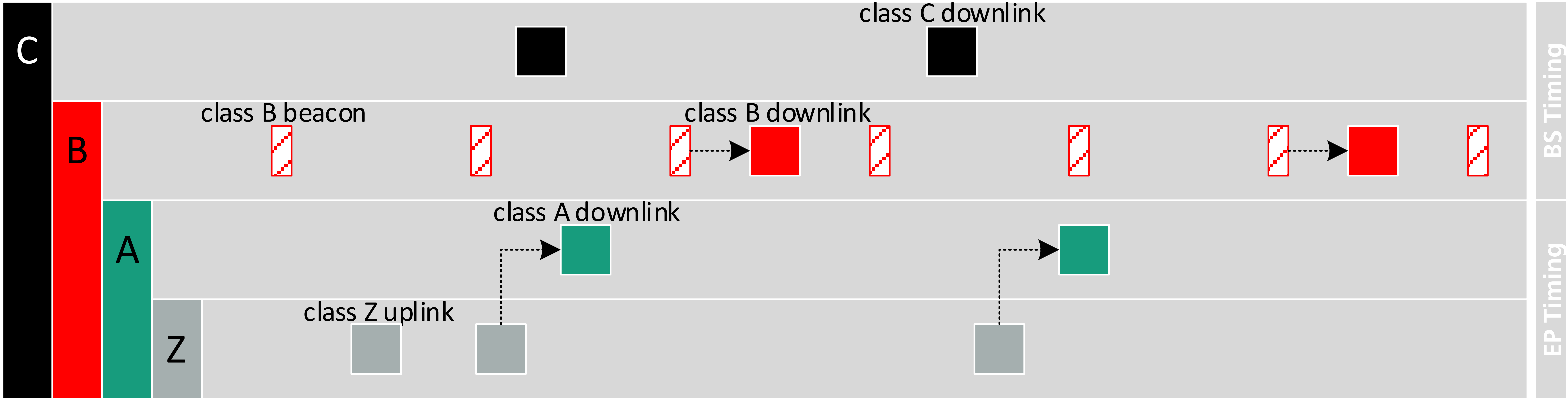
mioty® - Next Generation

Overview Device classes



Device classes can be mixed without conflict

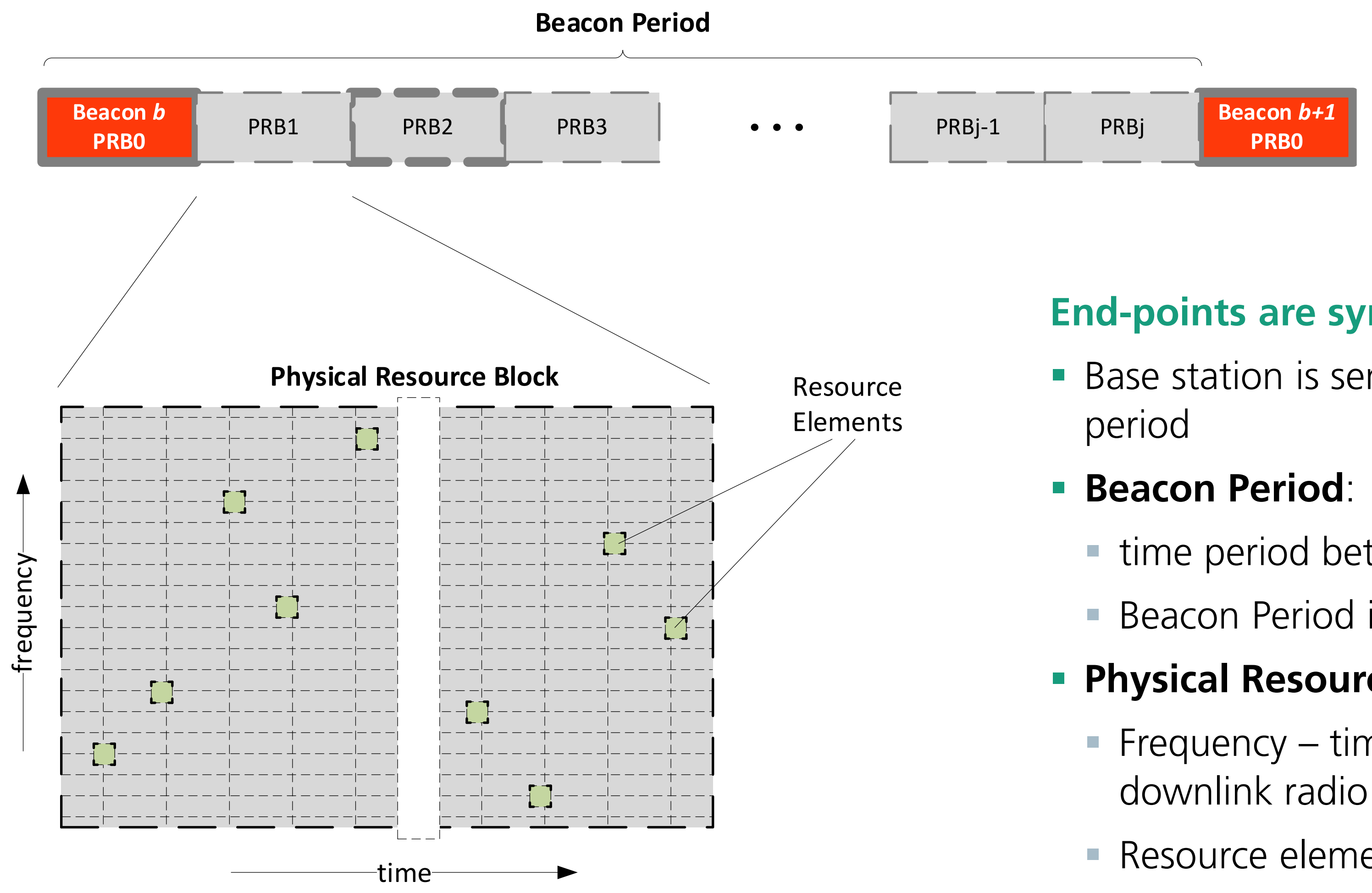
- **Class Z:** (immediate) uplink transmission -> **collect data**
- **Class A:** downlink response after uplink -> **acknowledgement of uplink reception, sending commands (unicast)**

- **Class B:** scheduled downlink -> **periodic device configuration & update (unicast & multicast)**
- **Class C:** immediate downlink -> **device activation, low delay control (unicast & multicast)**

New

mioty® new device classes

Frame structure for synchronized downlink



End-points are synchronized to a Base station

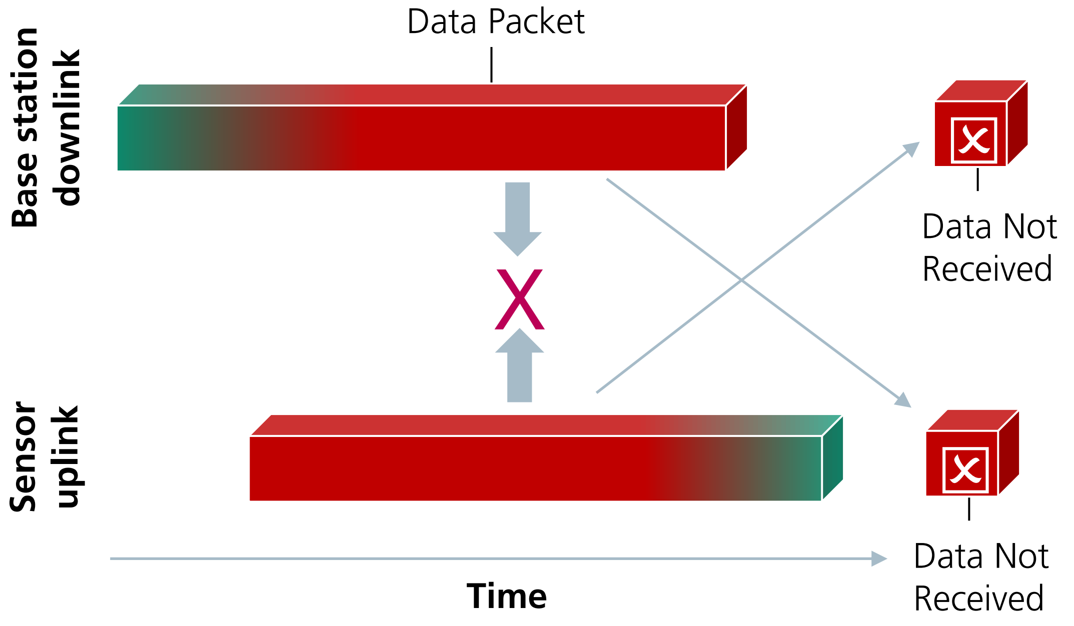
- Base station is sending regular beacons to schedule a beacon period
- **Beacon Period**:
  - time period between two beacons
  - Beacon Period is divided into Physical Resource Blocks
- **Physical Resource Blocks (PRB)**:
  - Frequency – time window carrying resource elements for downlink radio burst transmissions
  - Resource elements are pseudo randomly distributed (TSMA)

mioty® - Next Generation

How to achieve a mix of asynchronous and synchronous transmission

Traditional LPWAN-Solutions: Half Duplex

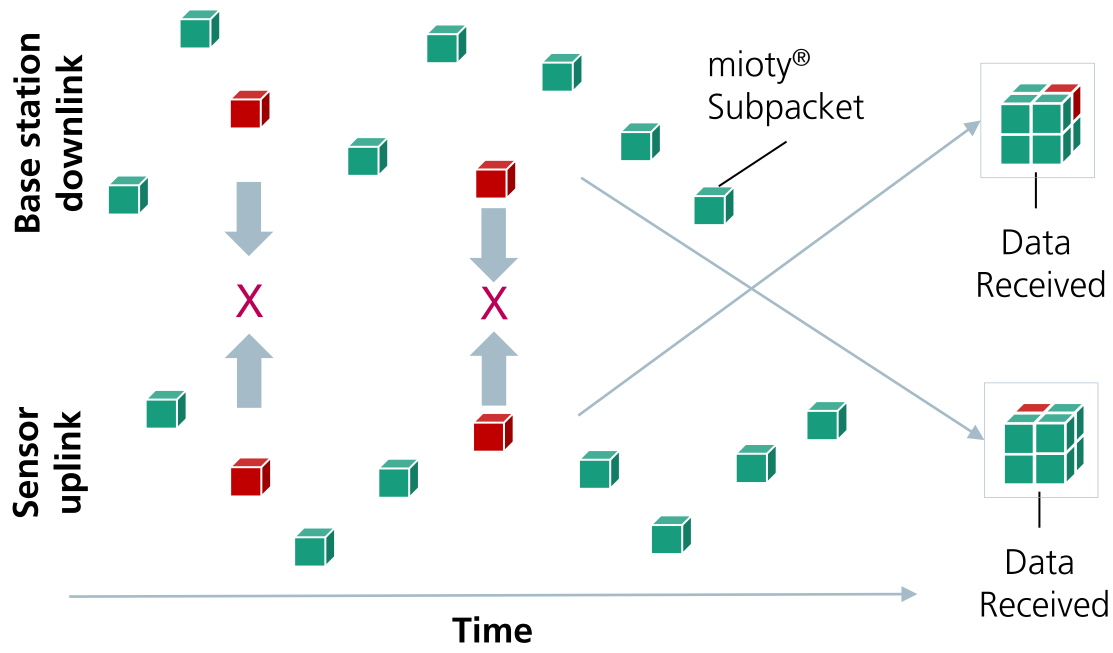
Transmission of the whole data packet



Downlink Duty Cycle 10%
=> Up to 10 % of uplink data can get lost!

MIOTY: Quasi-Duplex

Transmission of data subpackets



Downlink Duty Cycle 10%
=> Up to 10% of sub-packets can get lost
TS-UNB can afford up to 50% loss without loosing data!

Large Scale Smart City Networks

Summary

Smart City and Smart Metering are growing together. The new OMS LPWAN and ETSI LTN specifications support the future demands of large scale smart city networks.

mioty

1. **Network scalability:** Device density in smart city networks will significantly grow the coming years
2. **Reliability:** Smart Metering applications require high Packet Delivery Rate even in dense smart city networks
3. **OMS LPWAN:** New OMS specification is addressing the need for standardized radio protocols and data formats for integrating smart metering into smart city
4. **OMS LPWAN Splitting mode (mioty®):** Random channel access via TSMA outperforms existing methods by far
5. **mioty® Next Generation:** New version of ETSI TS 103357 addresses upcoming demands of future IOT Networks

Thank you for your time

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References

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8. G. Kilian, M. Breiling, H. H. Petkov, H. Lieske, F. Beer, J. Robert, and A. Heuberger, "Increasing transmission reliability for telemetry systems using telegram splitting," IEEE Transactions on Communications, vol. 63, no. 3, pp. 949–961,March 2015.

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