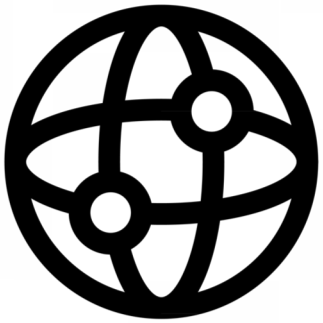
Measuring the performance of Narrowband-IoT (NB-IoT)

Ahmed Elmokashfi, Foivos Michelinakis and Anas Al-selwi

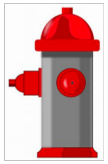


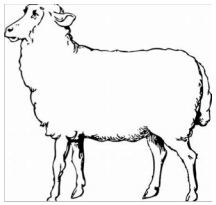
simulamet

Simula Metropolitan Center for Digital Engineering AS

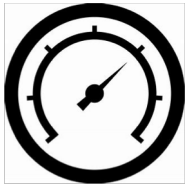
IoT applications have diverse requirements

Shorter to medium battery life
Medium coverage
Some mobility
Latency in order of seconds

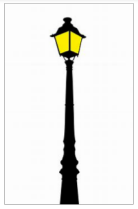




Battery life 5-10 years
Ubiquitous outdoor coverage
Some mobility
Medium to high reliability
Latency < 10 seconds



Battery life 10-15 years
Outdoor and deep indoors (+20dB)
Stationary
Medium to high reliability
Latency 10 to 60 seconds



Mains powered
Outdoor and indoors
Stationary
low to high reliability
Latency < 30 seconds

GSMA white Paper. 3GPP Low Power wide Area Technologies

Mobile-IoT must be scalable, energy efficient and ubiquitous

Long battery life

Low device cost

Low deployment cost

Extended coverage

Support for many devices

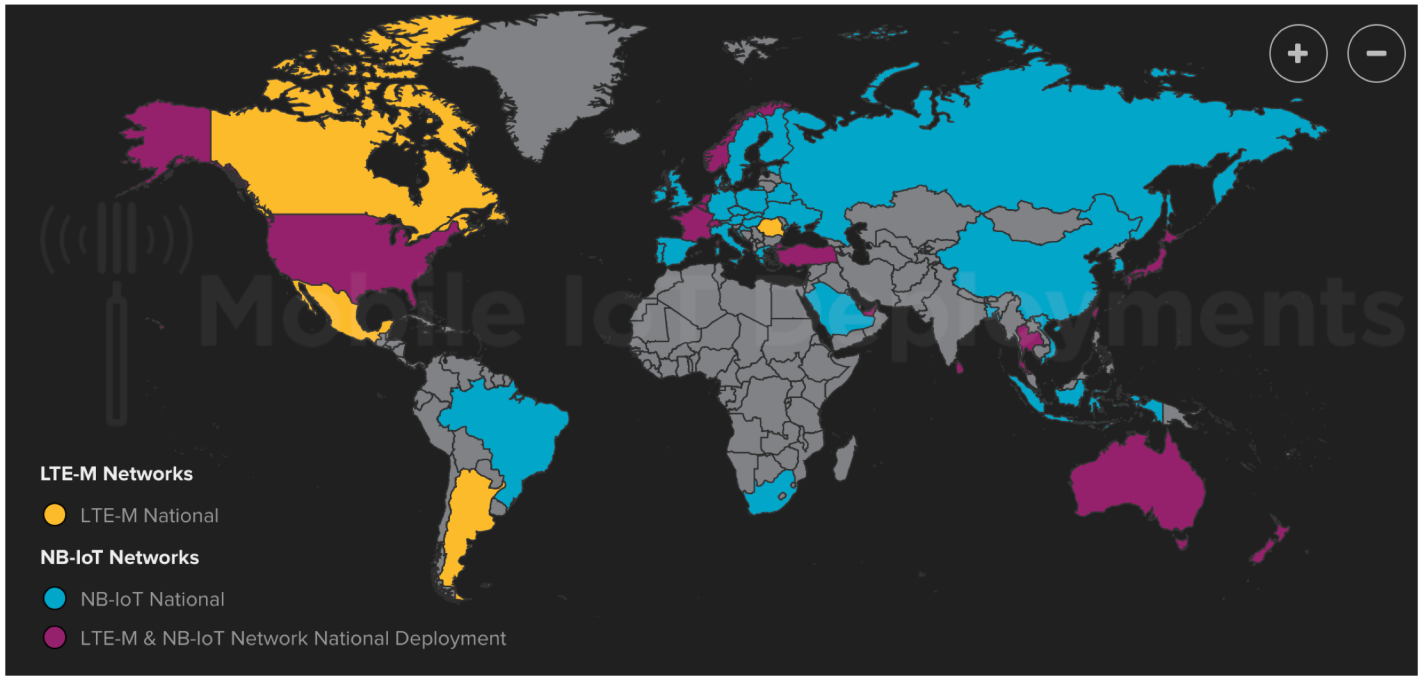
User security, control & service API

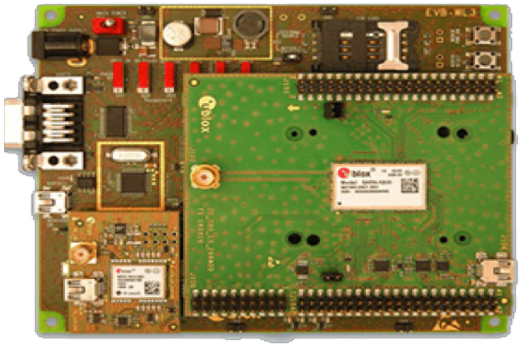
3GPP Release 13 standardized two solutions for current and future IoT

	NB-IoT LTE Cat. NB	eMTC LTE Cat. M1
Deployment	In-Band LTE, guard-band LTE and standalone	In-Band LTE
Bandwidth	180 KHz	1.08 MHz
Peak data rate	~150 kbps	1 Mbps
Latency	1.6s-10 s	10-15 ms
Max UE tx power	23 or 20 dBm	23 or 20 dBm
Power Saving	PSM, eDRX	PSM, eDRX
Duplex	Half	Full/Half
Complexity relative to LTE	10%	20-25%

NOKIA. LTE-M – Optimizing LTE for the Internet of Things, 2015

NB-IoT is now deployed in several countries





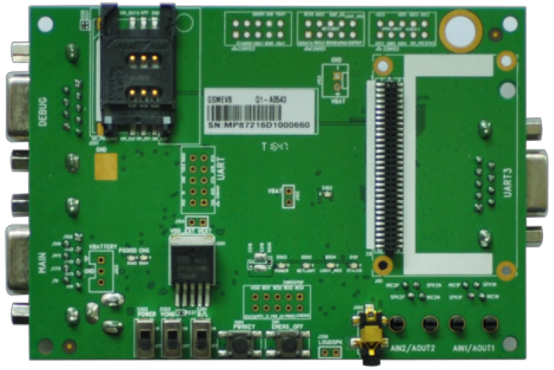
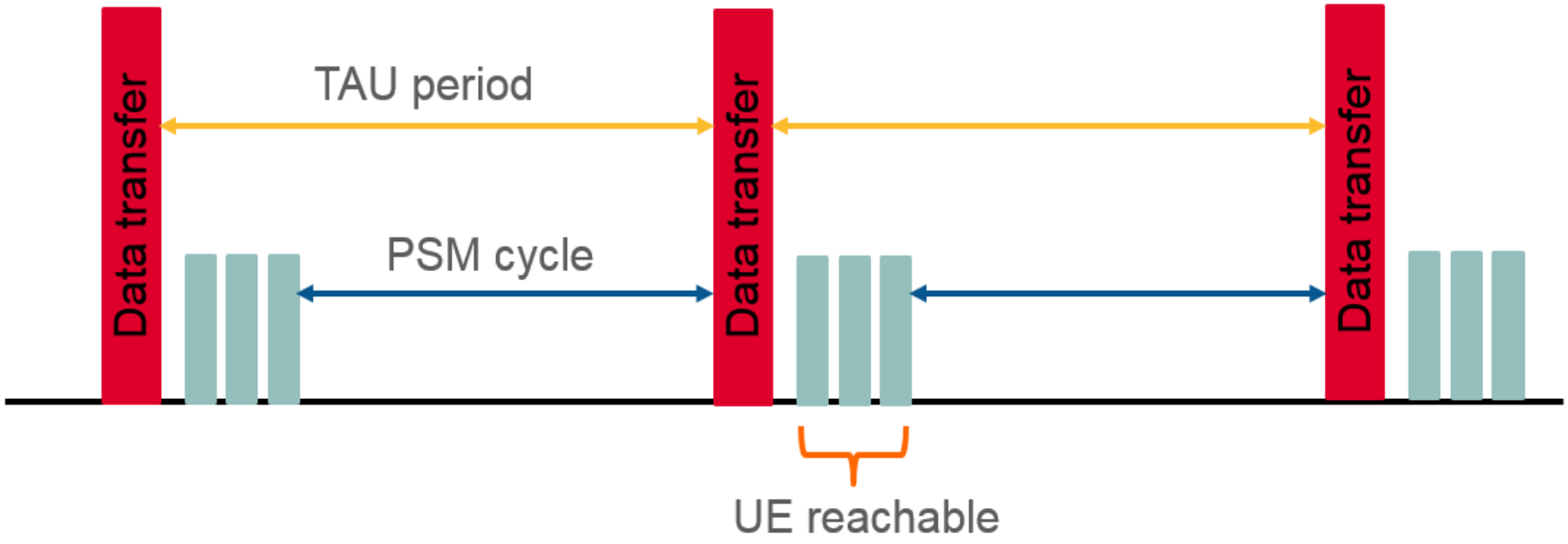


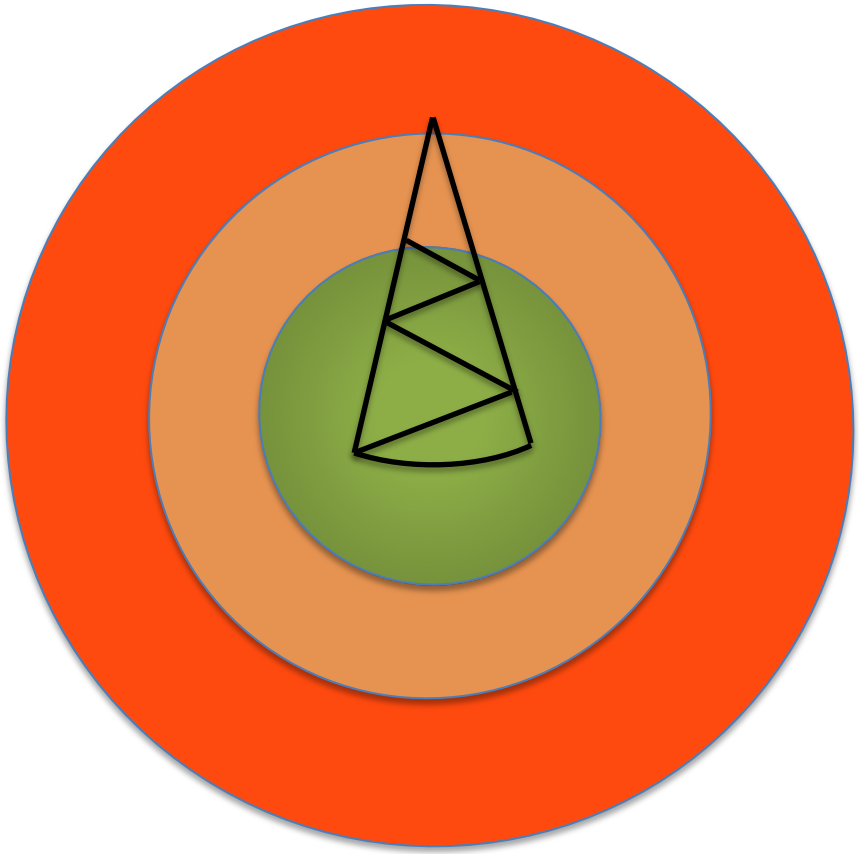
Image source GSMA

NB-IoT has two mechanisms to help devices conserving power



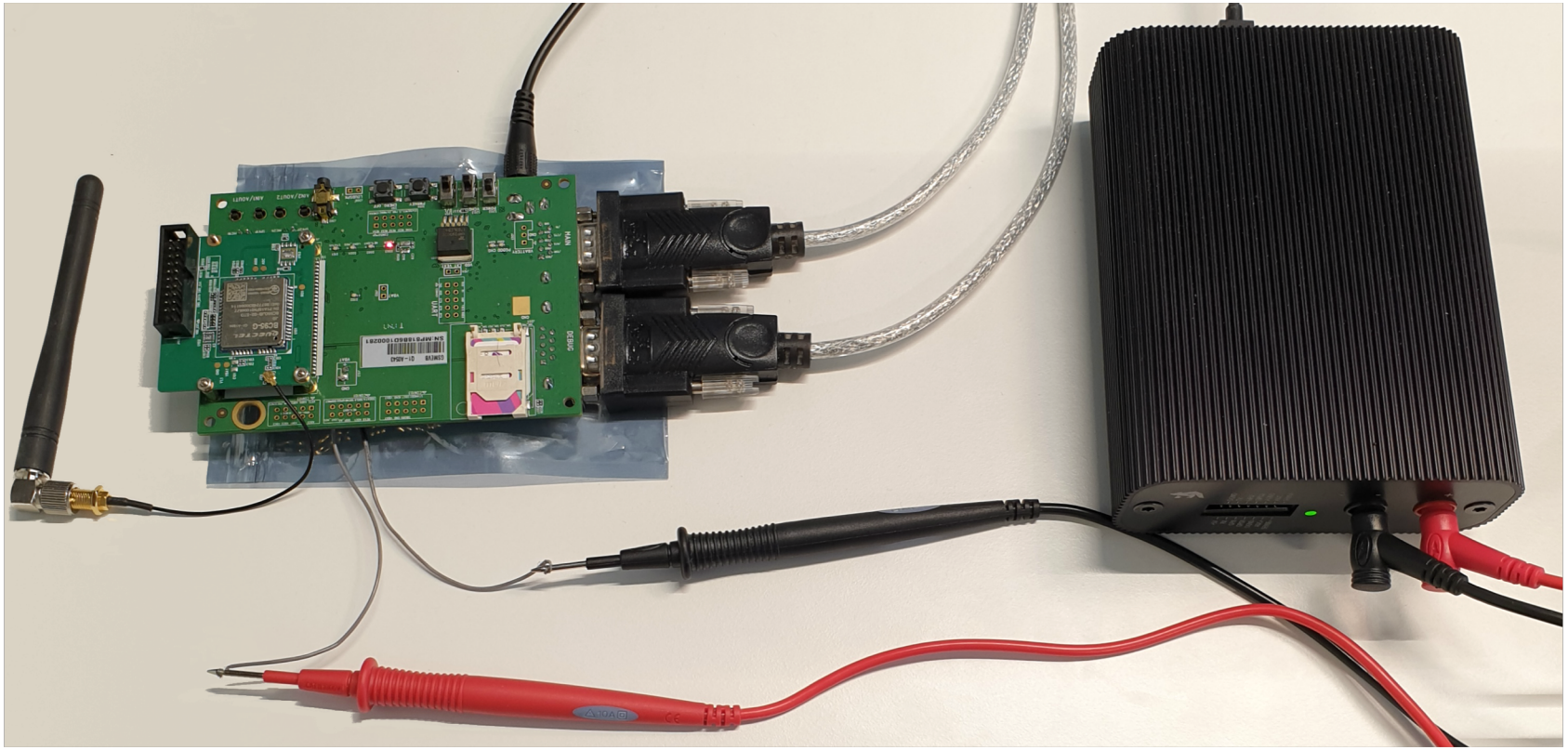
GSMA. NB-IoT DEPLOYMENT GUIDE to Basic Feature set Requirements April 2018

NB-IoT enhances coverage by using transmission repetitions



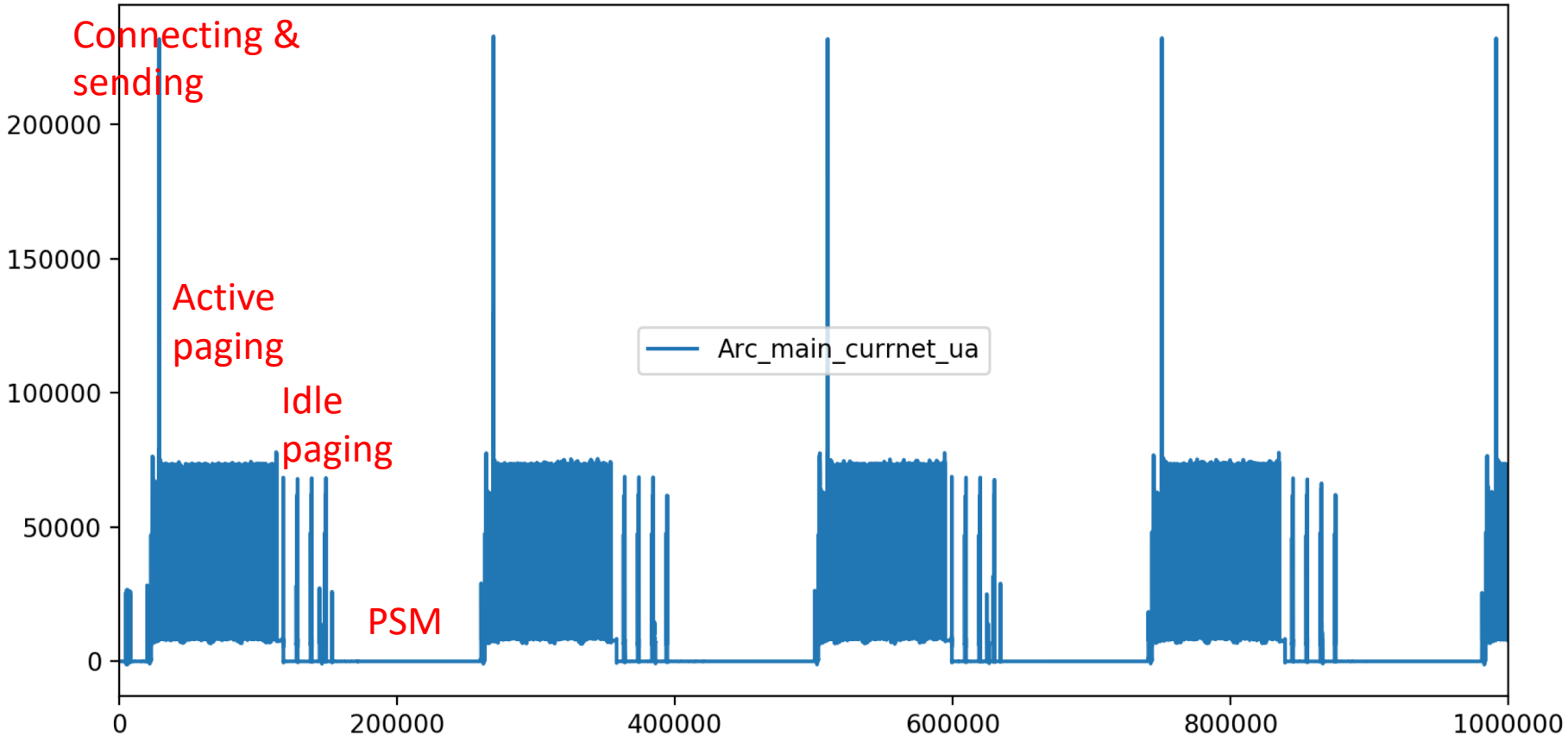
- 2x repetitions translates into 3dB coverage gain
- 2x repetitions results in 0.5x speed and 2x latency

Early measurements of NB-IoT commercial deployments

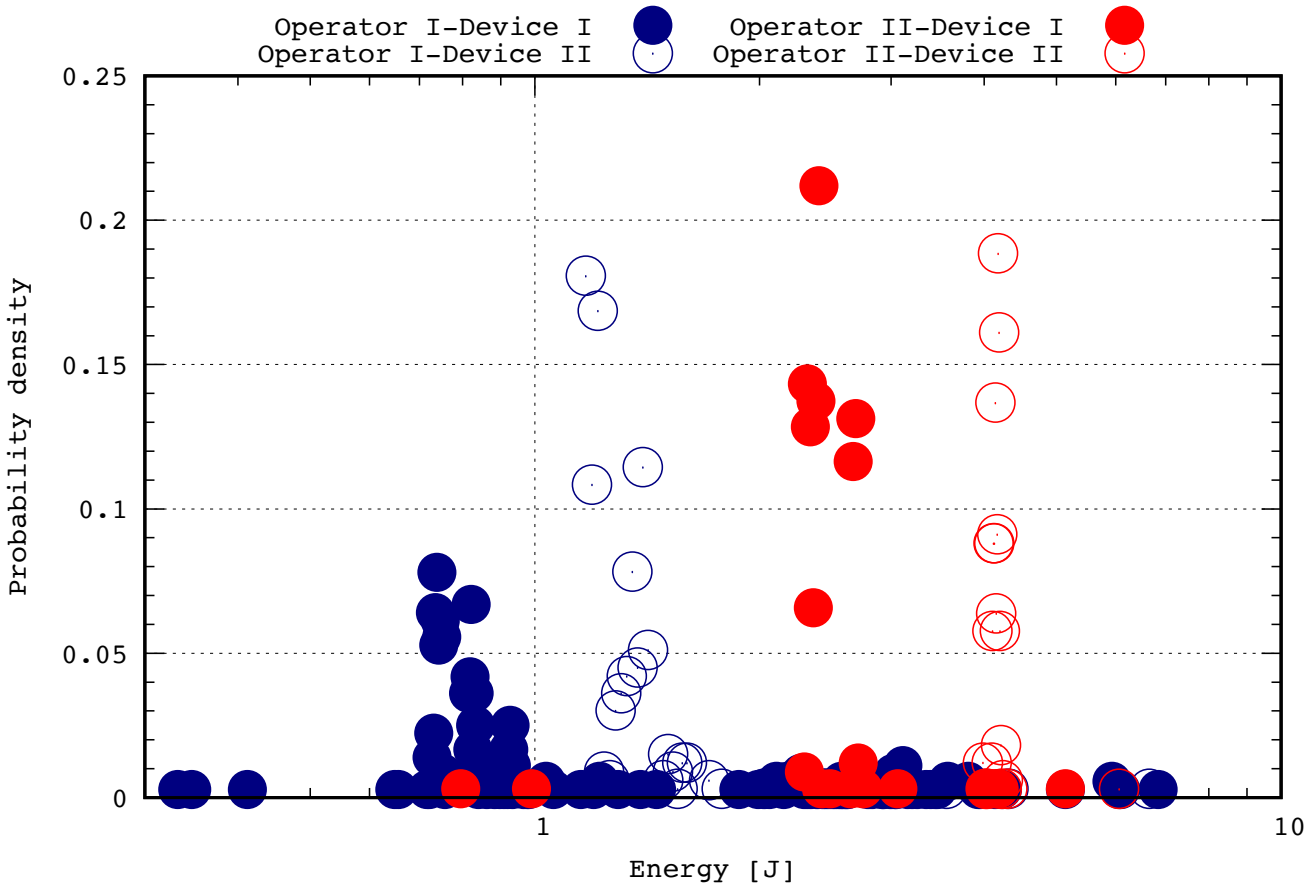


- 2 mobile operators + 2 NB-IoT modules
- UDP ping every minute with packet sizes in the range 20 to 512 bytes

Measurements traffic pattern

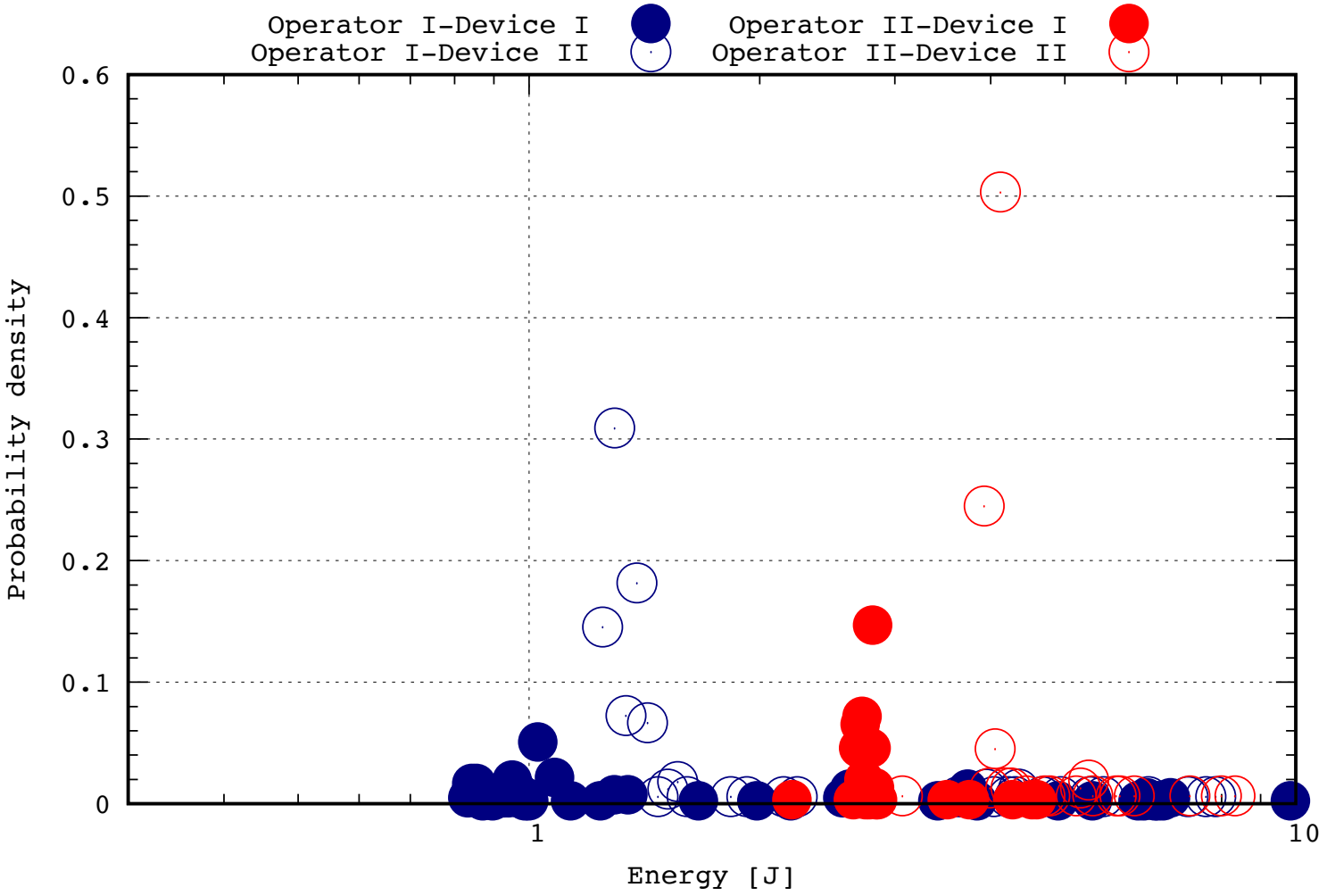


Clear differences in energy consumption between operators and devices

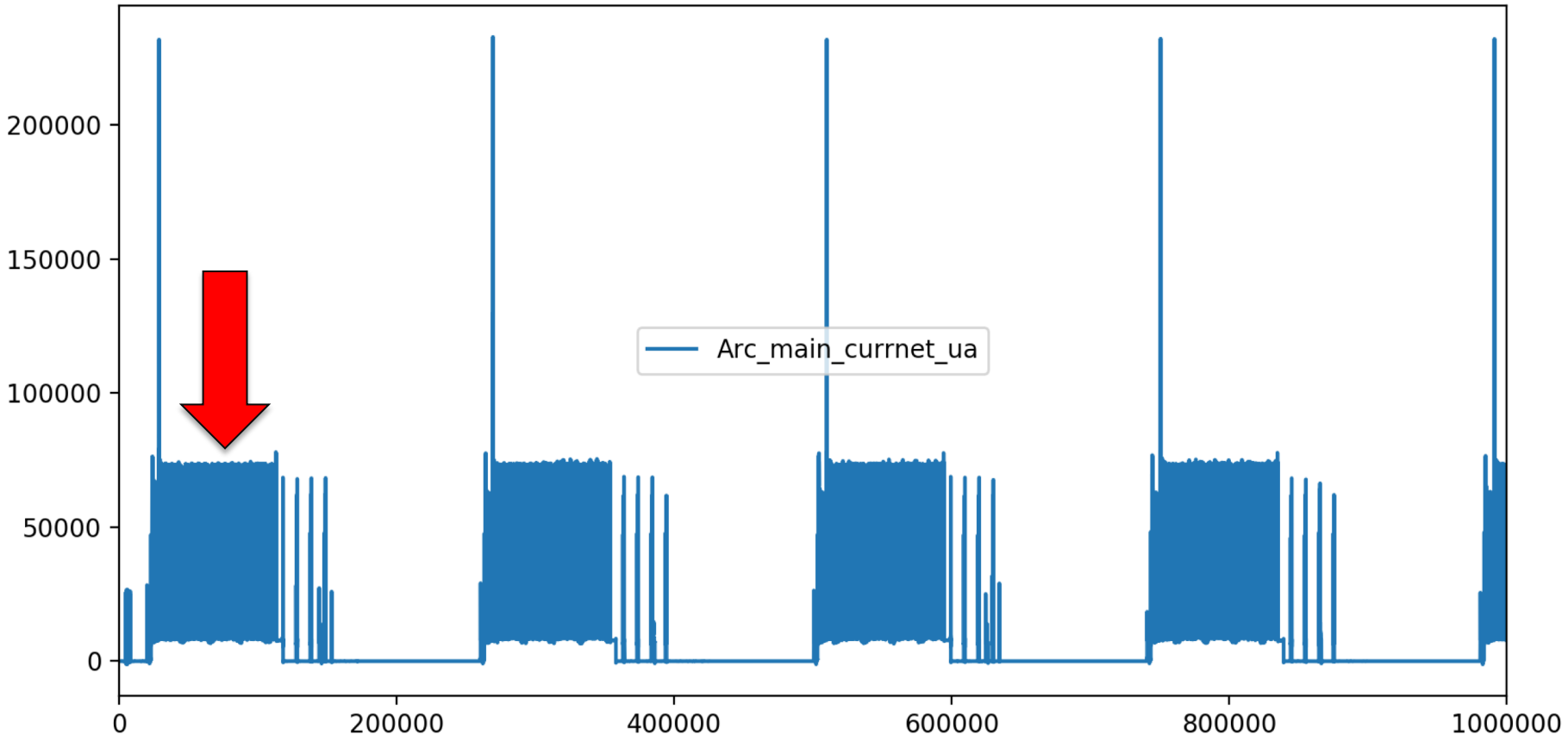


These differences can reduce battery lifetime by 6 years (assuming that we are using a CR2032 battery with 235mAh capacity and 1 activity period per day)

The differences are also evident when the coverage is poor



The two operators configure power management differently



Measurement id

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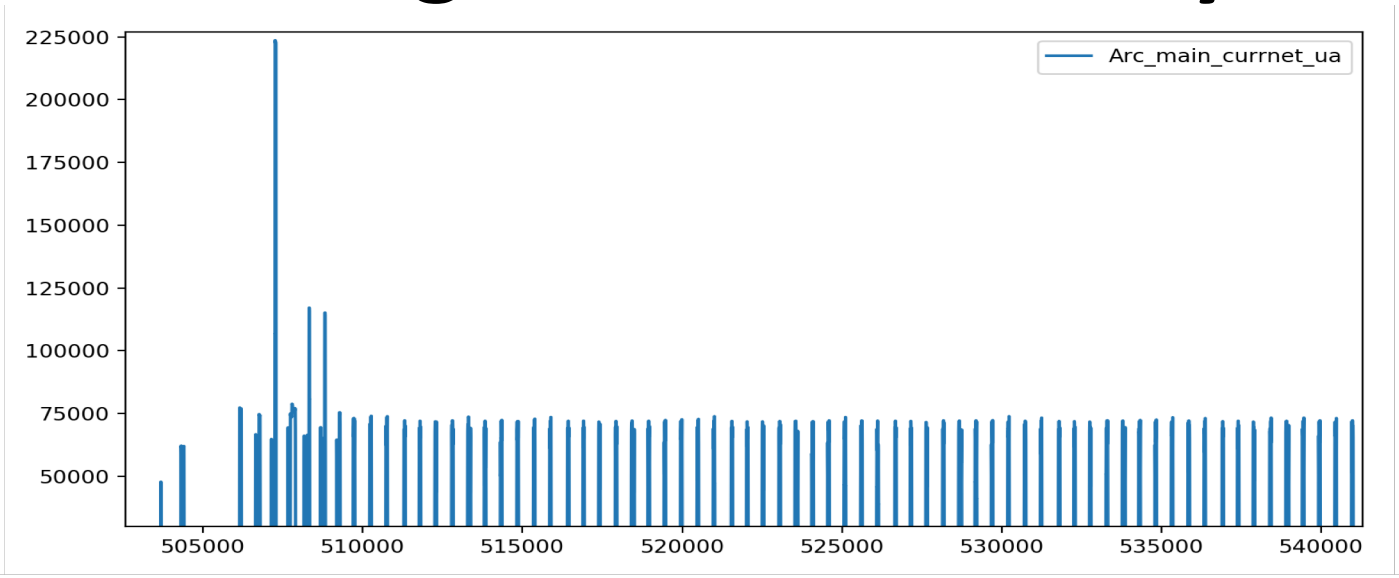
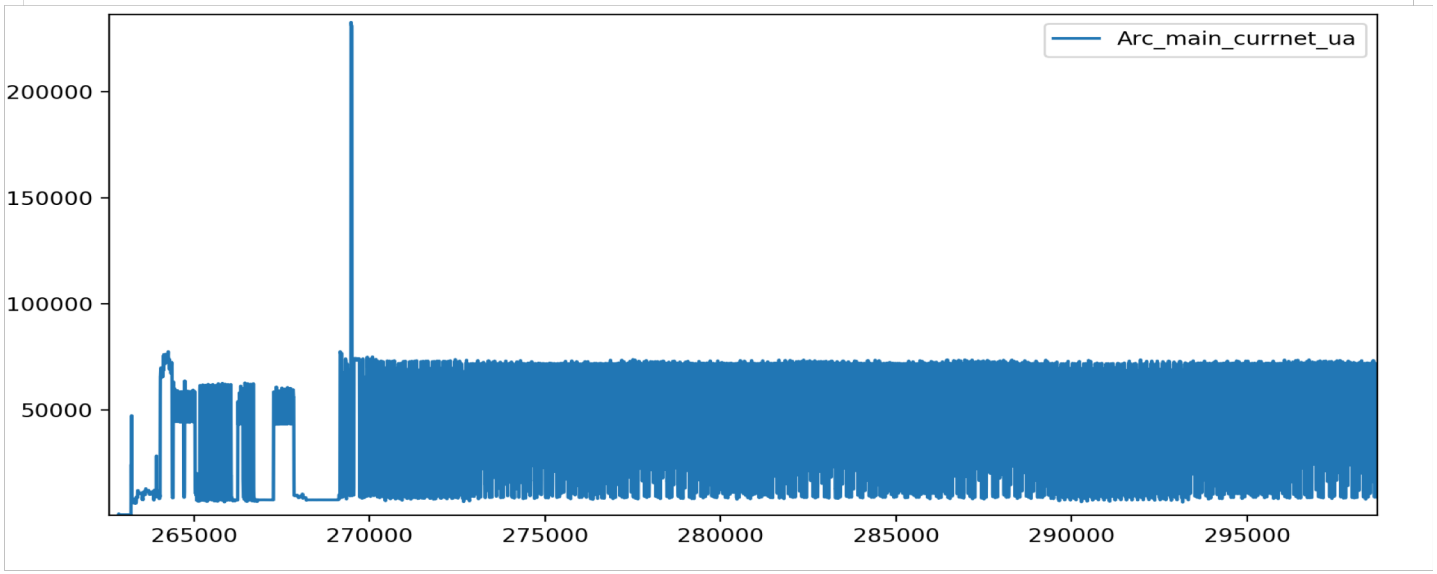
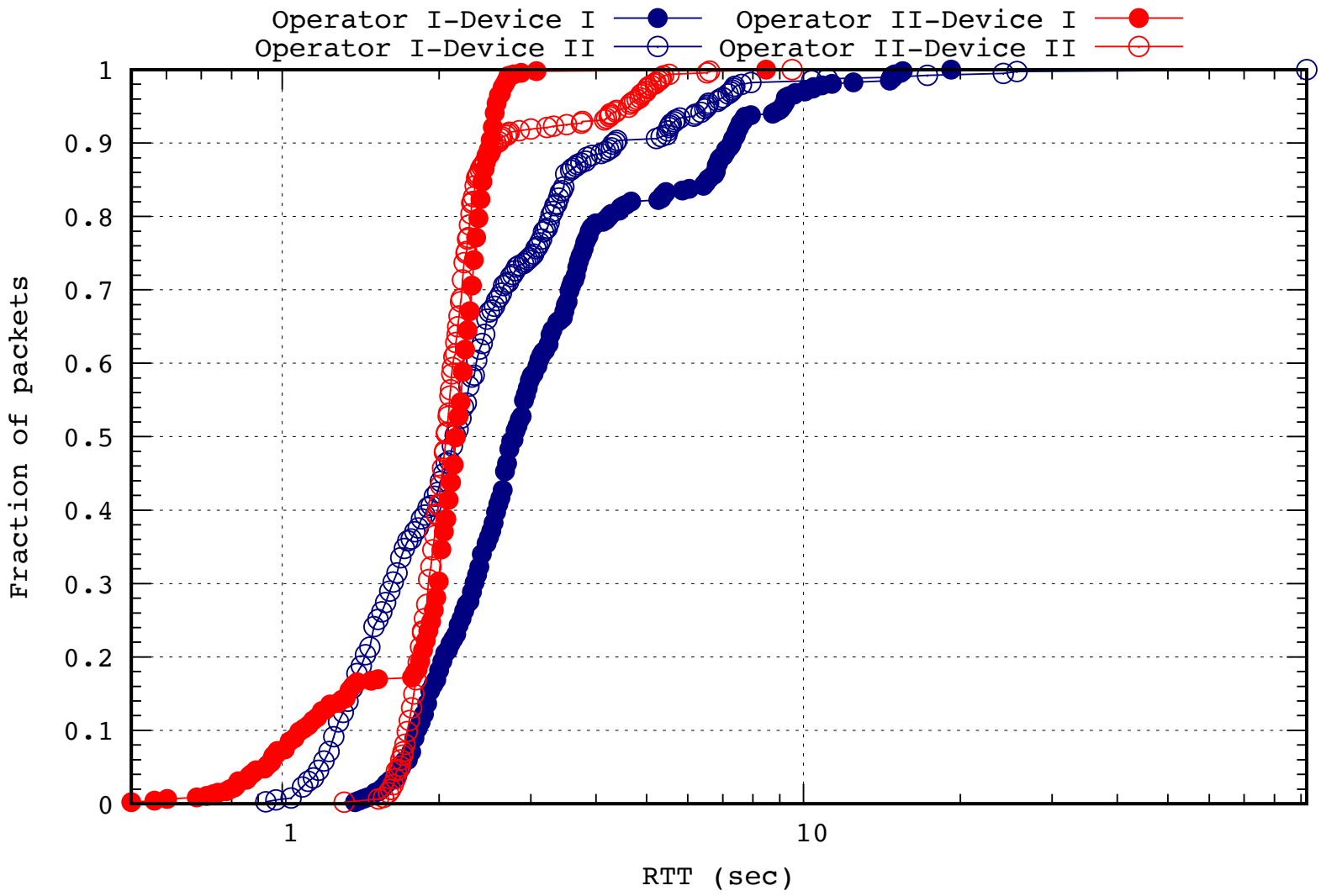


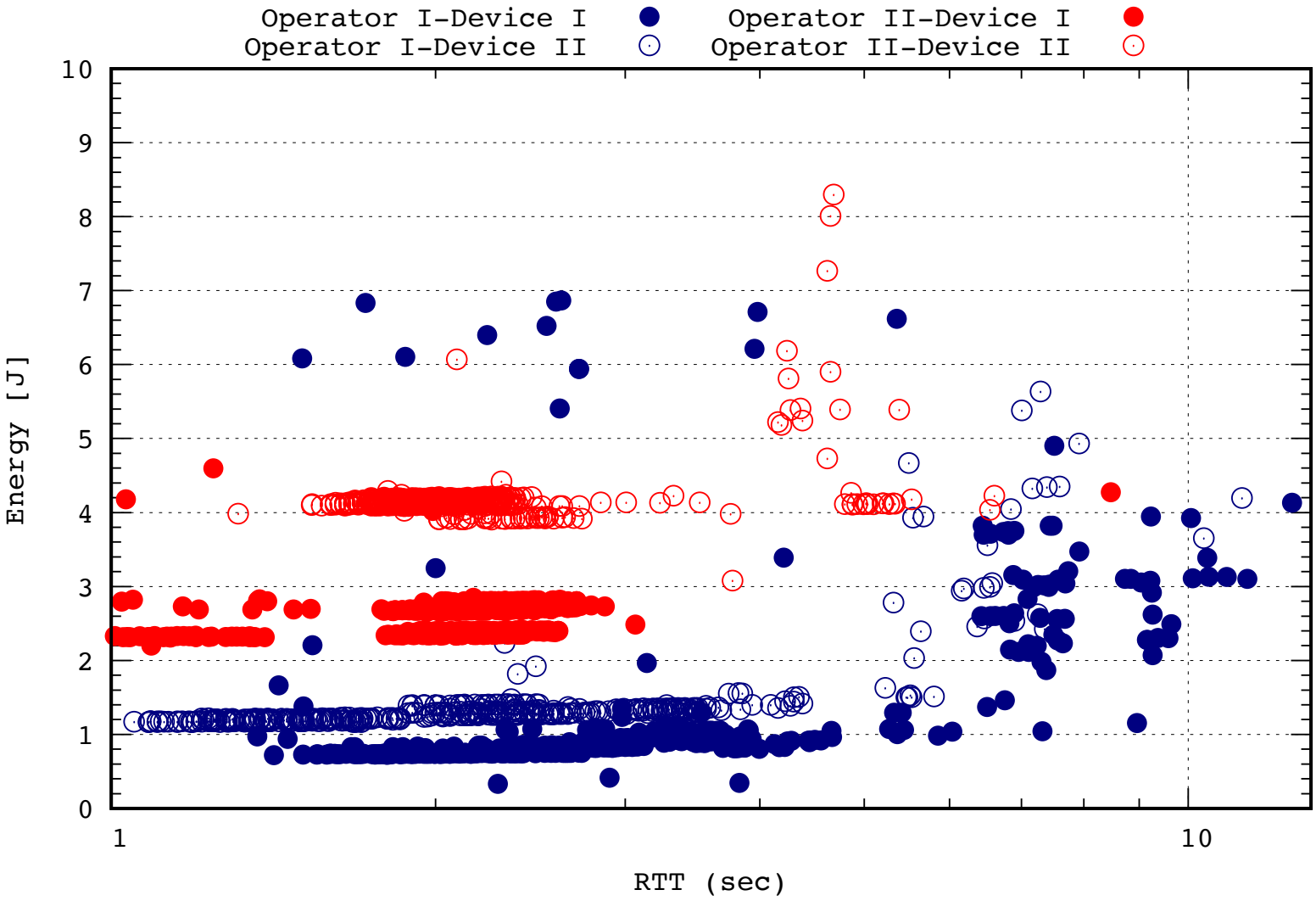


Measurement id

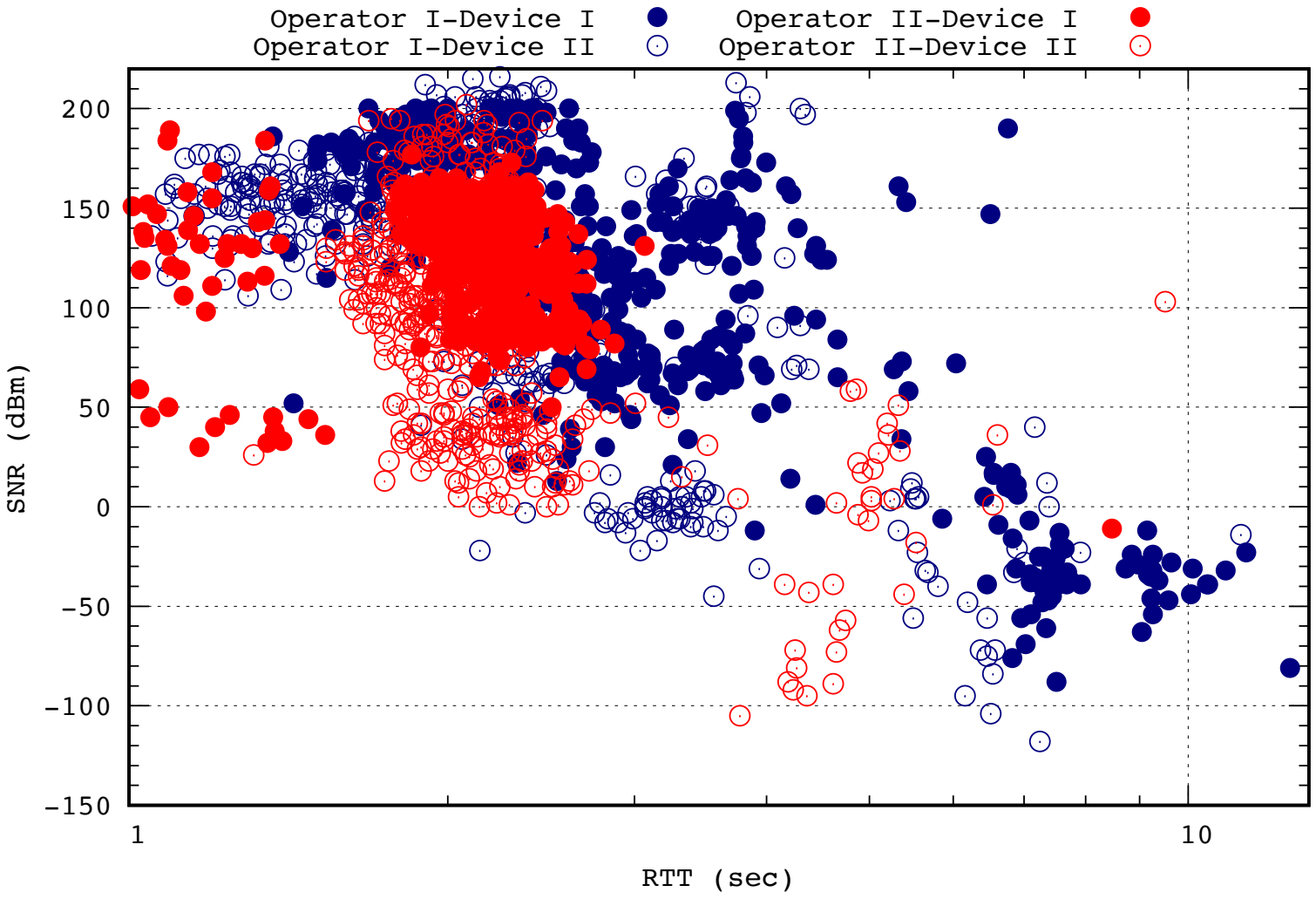
RTTs are mostly below 10 seconds but are characterized by wide variability



Achieving a similar delay may correspond to different energy consumption levels



RTT variability can partially be attributed to differences in coverage

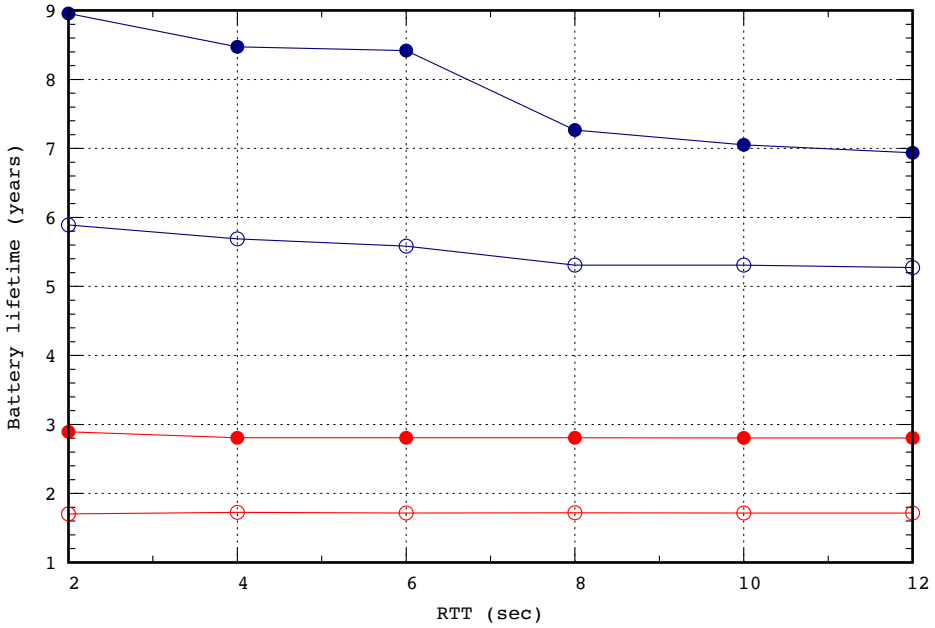


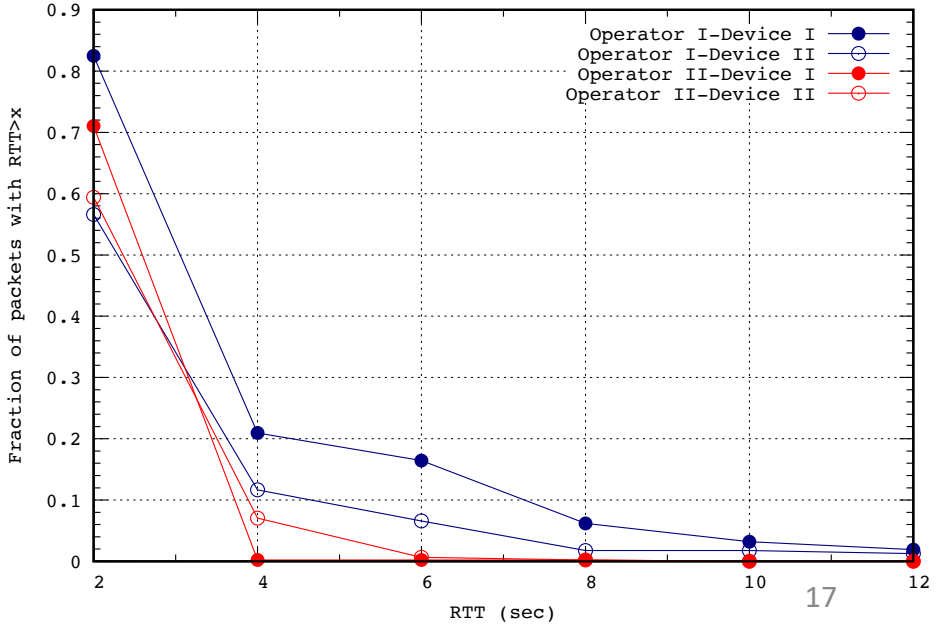
Probability (RTT | Energy consumption)

What is my target battery lifetime?

What is corresponding max RTT?

How likely I get RTTs higher than max?





There is a need for new metrics for describing NB-IoT reliability and performance

- Several questions remain unanswered
  - Can we generate realistic traffic patterns?
  - Understand how transport protocols perform over NB-IoT e.g. COAP, MQTT

- NB-IoT large parameter space makes interpreting measurements difficult
  - Power management timers
  - Repetitions