RPL at scale: Experiences from a performance evaluation on up to 700 IEEE 802.15.4 devices

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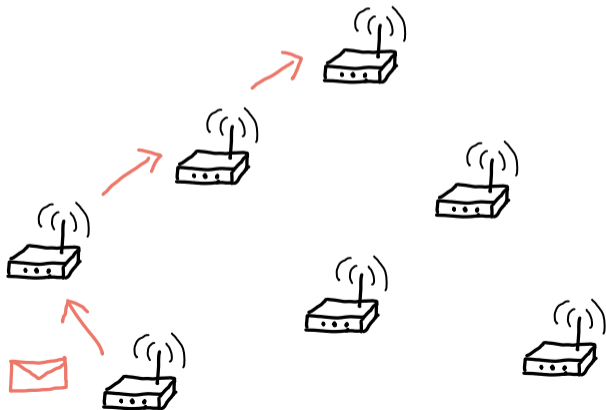Carlo Alberto Boano
Graz University of Technology
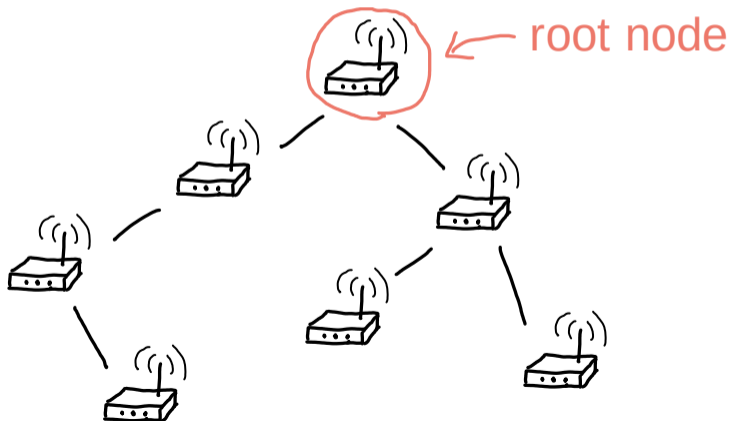
Does RPL work with 500+ devices?

Does **RPL** work with **500+ devices**?
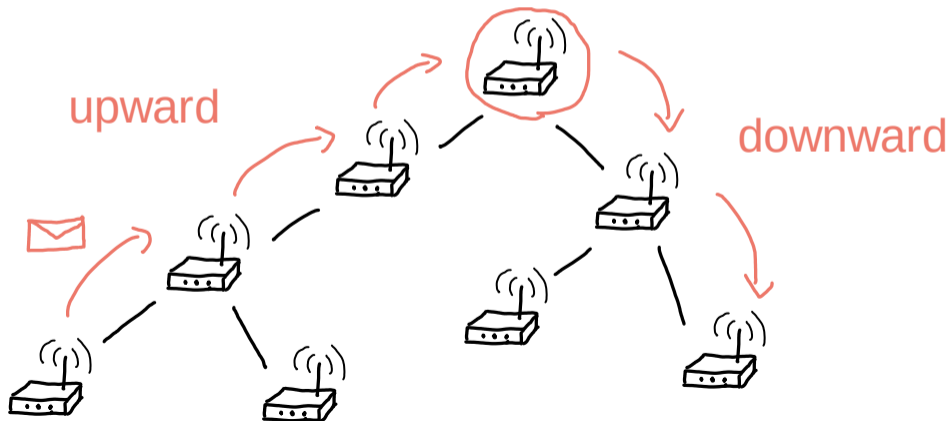
YES, BUT...

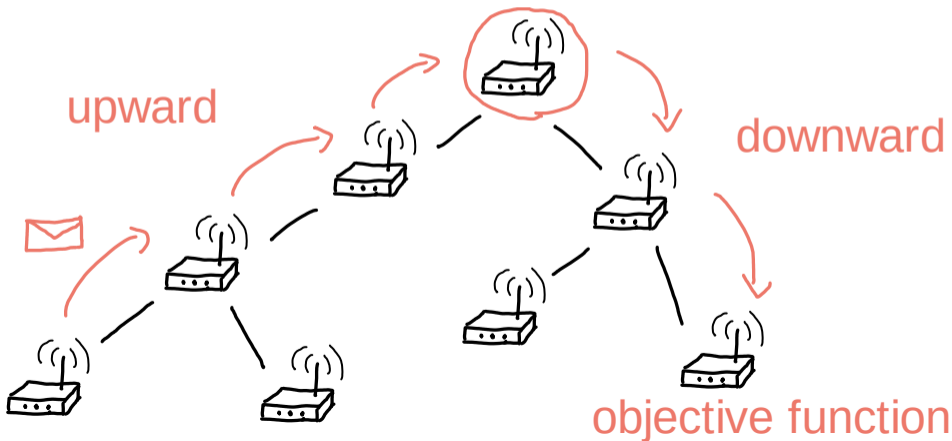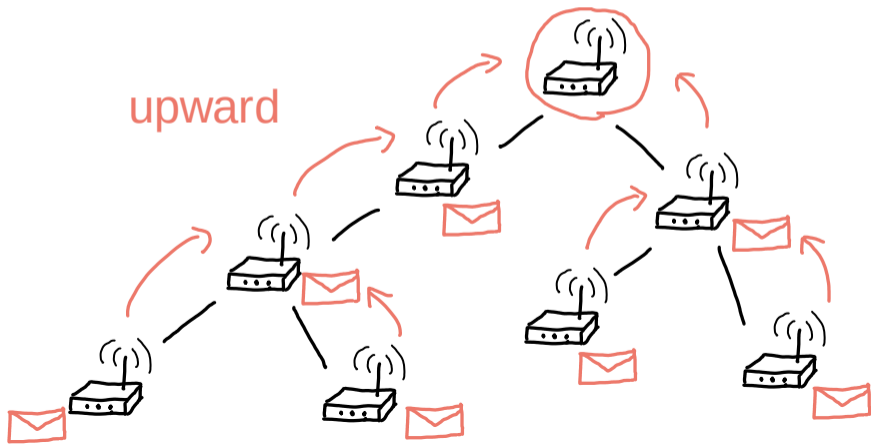# IPv6 **r**outing **p**rotocol for **l**ow-power and lossy networks (RFC 6550)

IPv6 **r**outing **p**rotocol for **l**ow-power and lossy networks (RFC 6550)

root node

IPv6 **r**outing **p**rotocol for **l**ow-power and lossy networks (RFC 6550)

upward

downward

IPv6 **r**outing **p**rotocol for **l**ow-power and lossy networks (RFC 6550)

upward

downward

objective function

Scenario: Data collection with RPL

upward

Challenge: Scaling up the RPL network
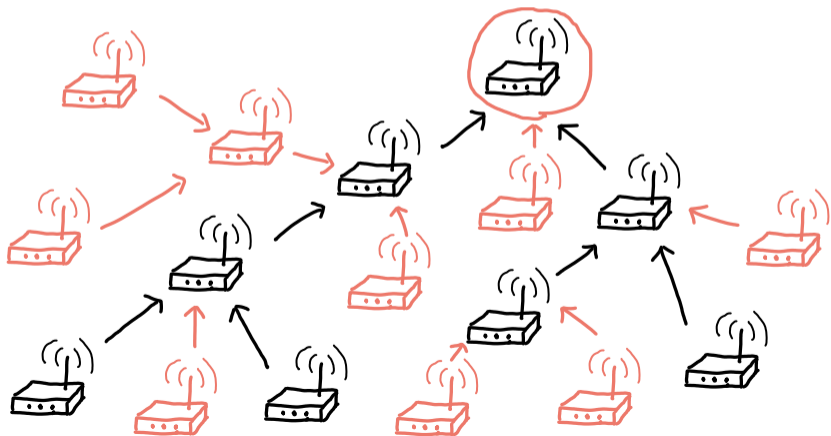
A literature review
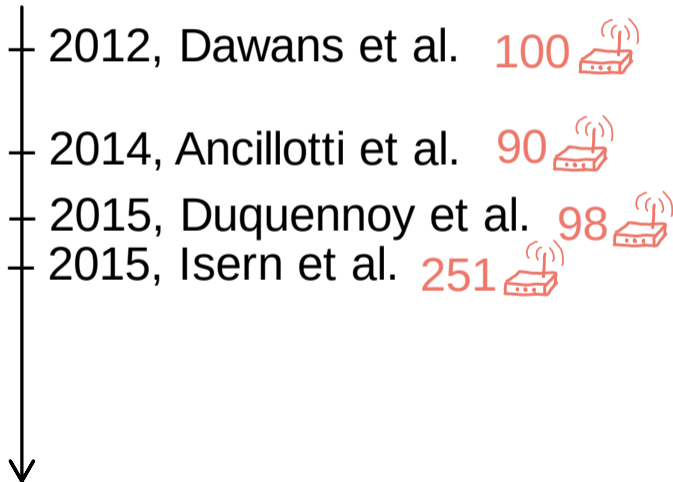
upward:

2012, Dawans et al. 100

2014, Ancillotti et al. 90

2015, Duquennoy et al. 98

2015, Isern et al. 251

A literature review

upward:

2012, Dawans et al. 100

2014, Ancillotti et al. 90

2015, Duquennoy et al. 98

2015, Isern et al. 251

downward:

2017, Duquennoy et al. 352

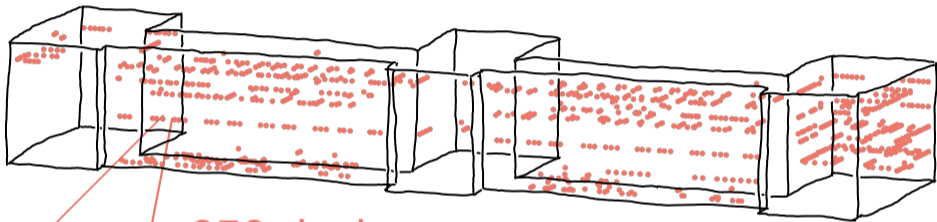2018, Eriksson et al. 500+
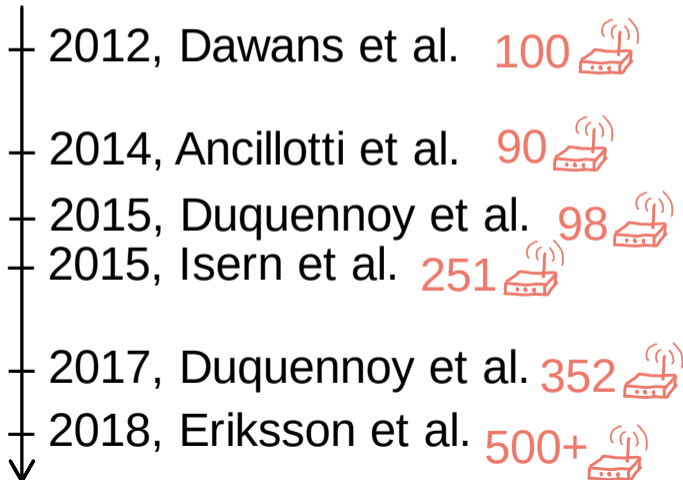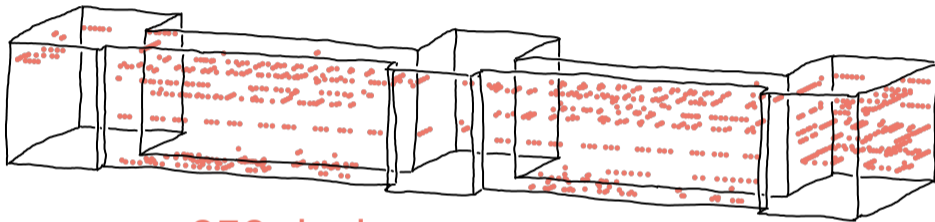
The **1KT** testbed

950 devices in human spaces

5-story **university building** 3390 m²
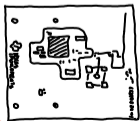
The **1KT** testbed
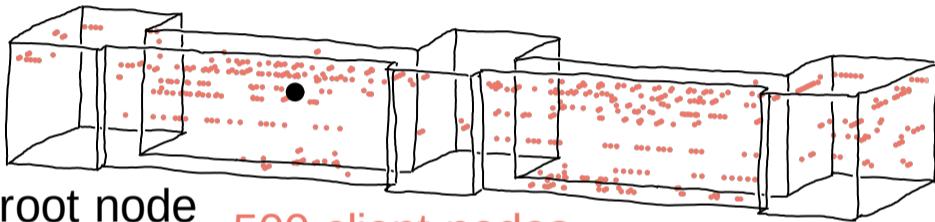

950 devices
in human spaces

5-story
university building
3390 m^2

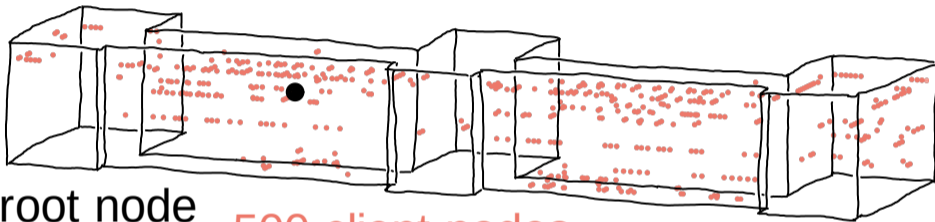TI CC2650
ARM Cortex-M3
IEEE 802.15.4

Experimental setup

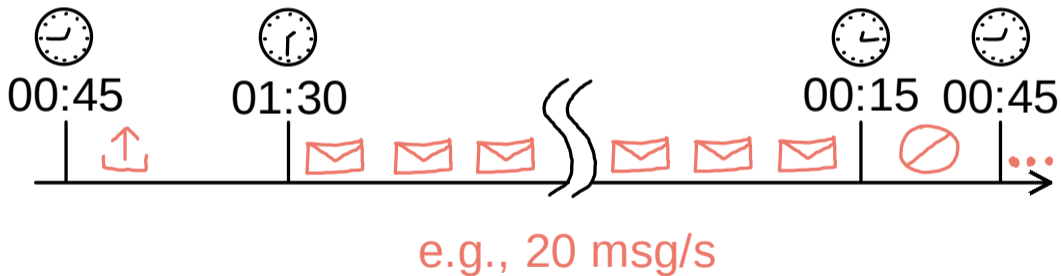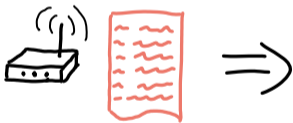1 root node   500 client nodes

Experimental setup

1 root node   500 client nodes

Contiki-NG OS: RPL-Lite with always-on CSMA

Experimental methodology

e.g., 20 msg/s

Metrics of interest

packet reception ratio (PRR)

transmission attempts
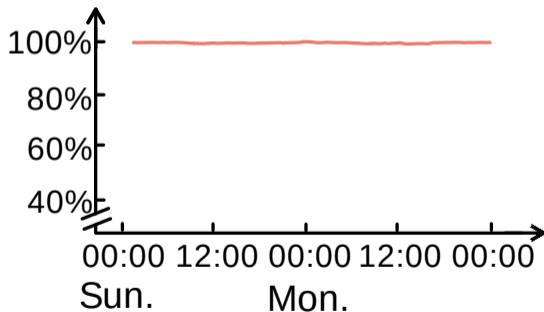
avg. length of routes

max. length of routes

parent changes

quality of routes' links

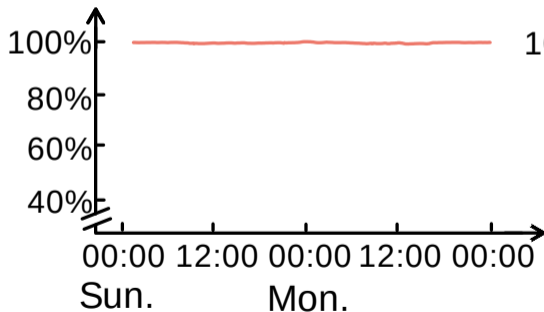# **Performance at scale: Weekend & workday**
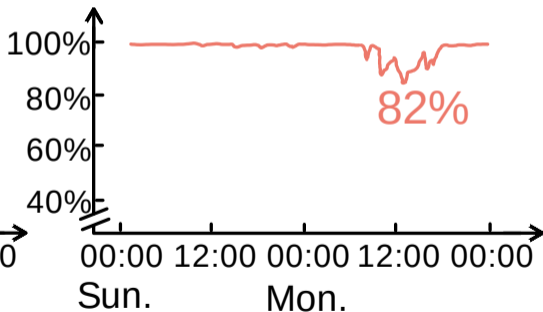
packet reception ratio

20 msg/s

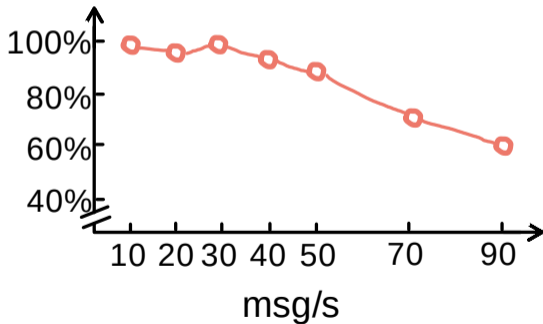# Performance at scale: Weekend & workday
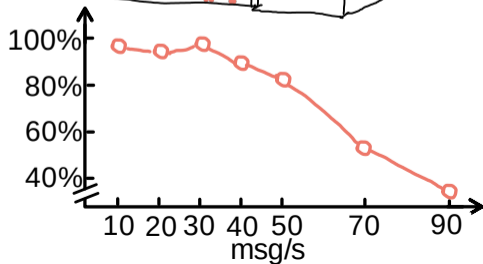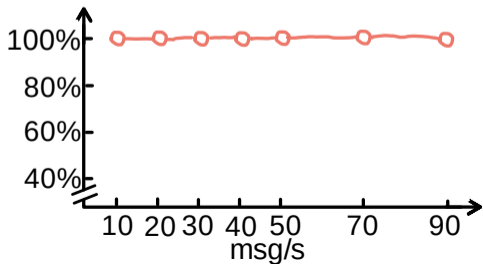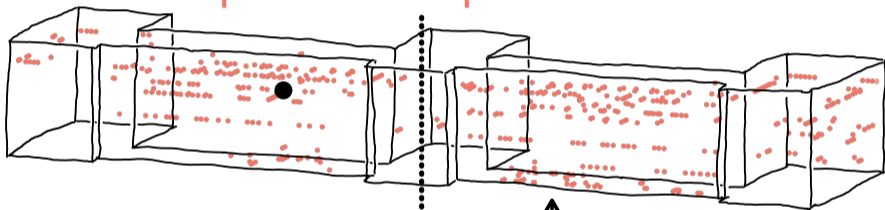
packet reception ratio

20 msg/s

40 msg/s

Impact of **traffic load**
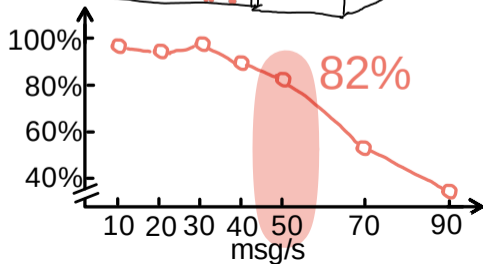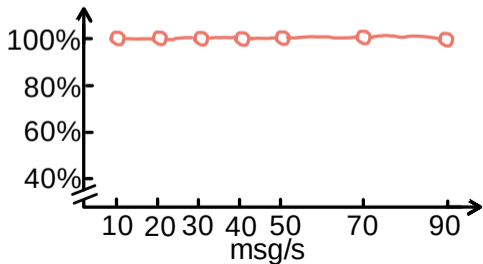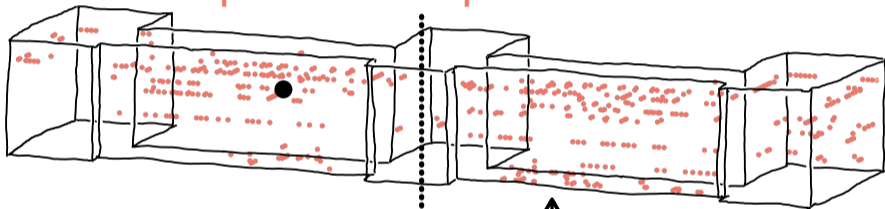
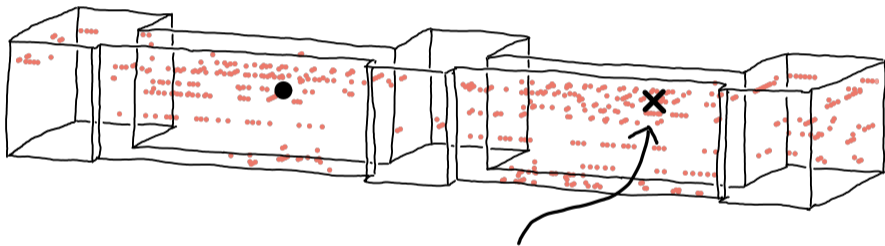packet reception ratio

Heterogeneous performance

packet reception ratio

Heterogeneous performance
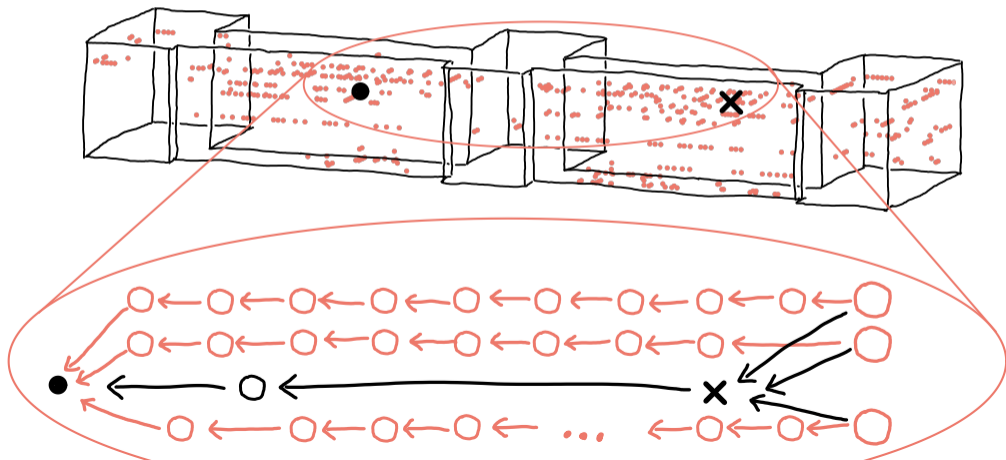

packet reception ratio

82%

Investigating the poor performance

drops up to 80% of messages
TX queue overflows

Investigating the poor performance

Investigating the poor performance

78 meters
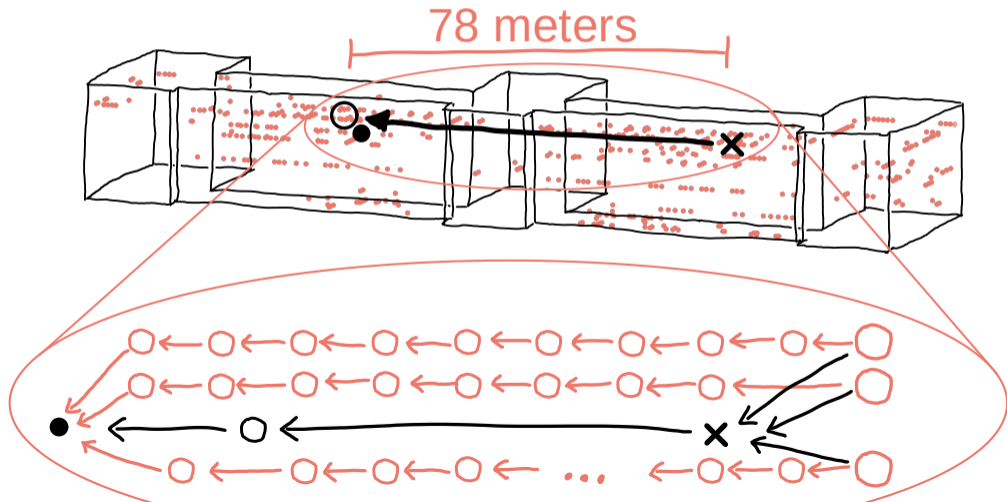
Introducing load balancing

packet reception ratio

unmodified
objective function $\longrightarrow$ with a penalty
for TX overflows

82% $\longrightarrow$ 89%

in the right wing, 50 msg/s

Impact of **root location**

packet reception ratio

87%   96%   98%   72%
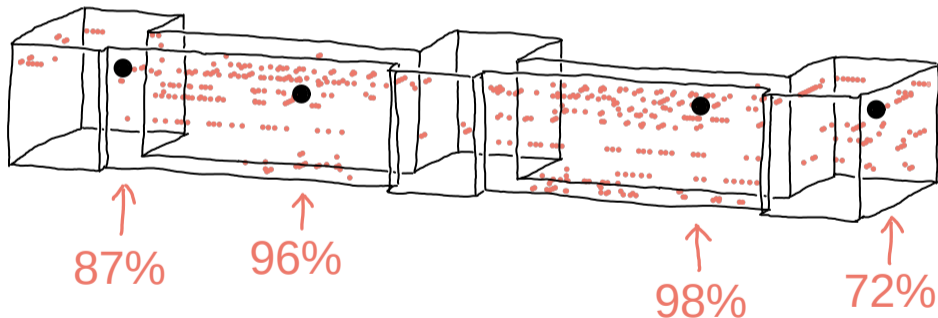
40 msg/s

Impact of **network density**

packet reception ratio

+5 dBm $\longrightarrow$ +1 dBm

96% $\longrightarrow$ 87%
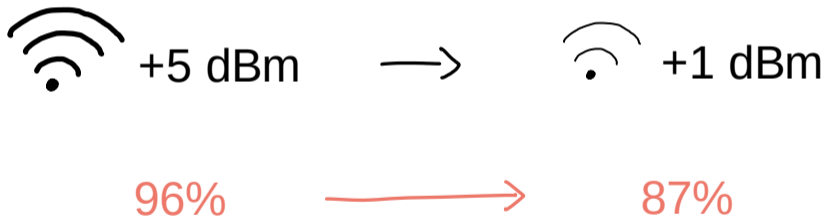
40 msg/s

Scaling up the network
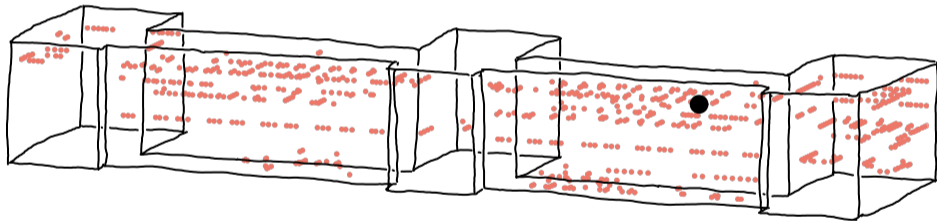
700 client nodes

1 root node

Performance with 700 devices
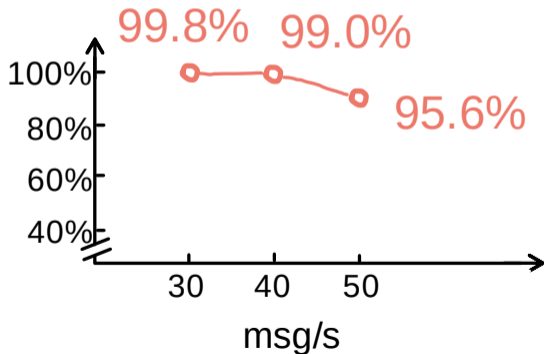
packet reception ratio

Does **RPL** work with **500+ devices**?

YES, BUT...

Does RPL work with 700 devices?

YES, BUT...

Does **RPL** work with **700 devices**?

YES, BUT...

...root node location
...transmission power
...exceptionally long links (load balancing!)

Thank you!

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