inventors for the digital world

Multi-channel Distributed MAC protocol for WSN-based wildlife monitoring

V. Toldov, L. Clavier, N. Mitton

Brandon Foubert

16 October 2018

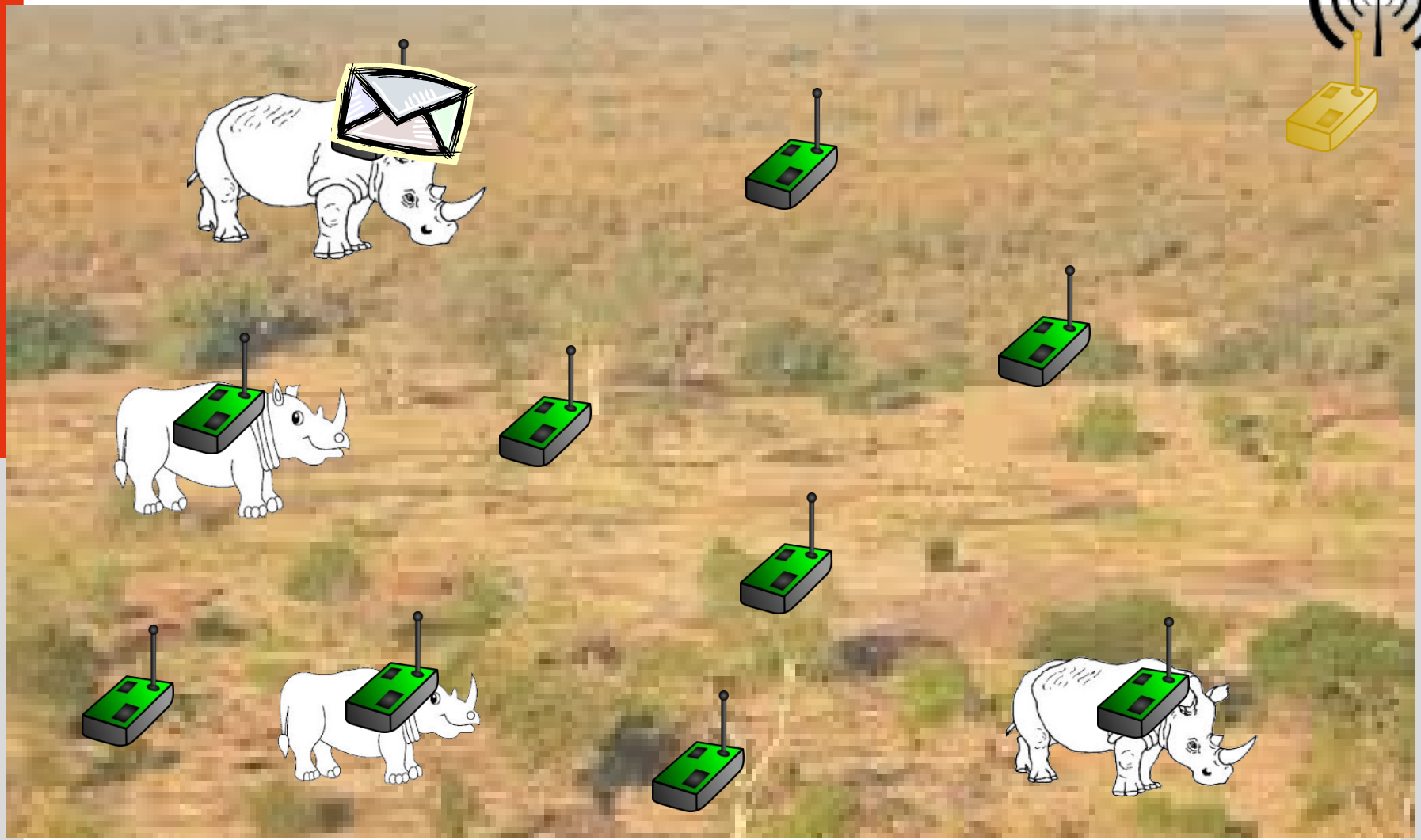
inventors for the digital world

Monitoring and protection of wildlife

Understand the behavior of wild animals
Fight against rhino poaching

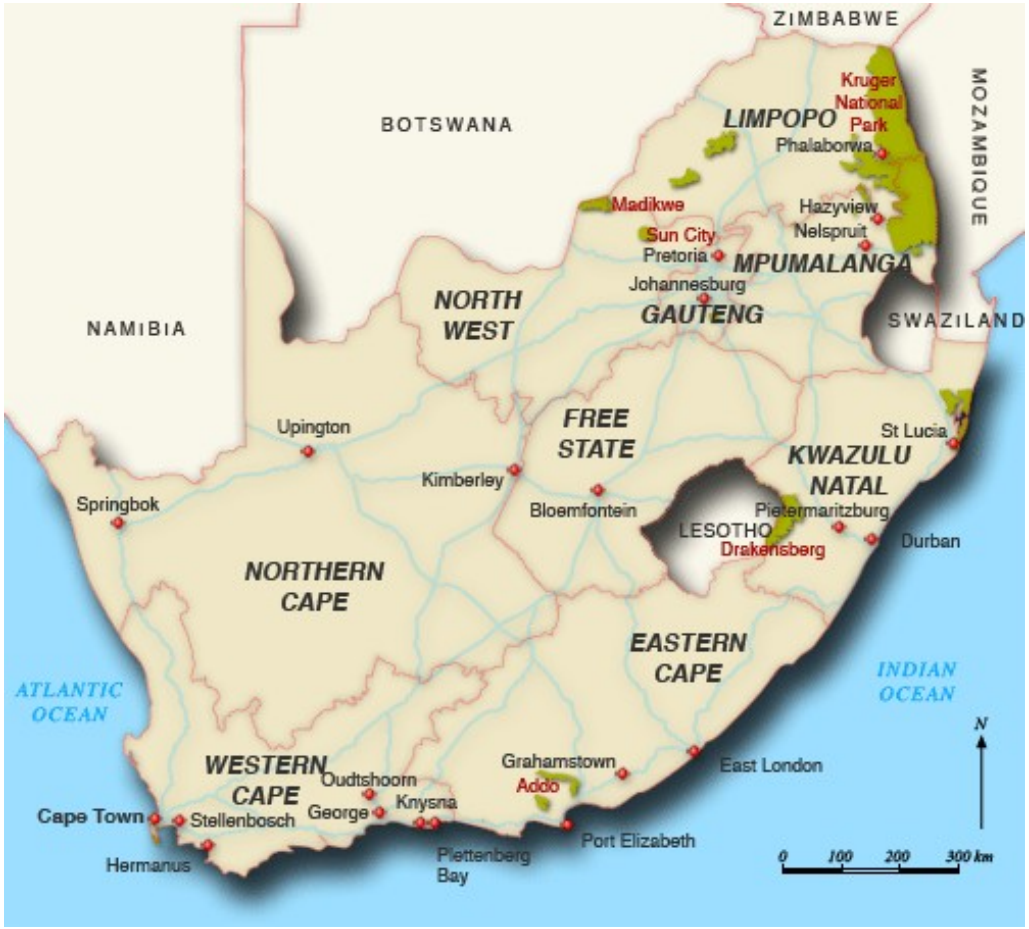
Collaboration with Stellenbosch university, South Africa

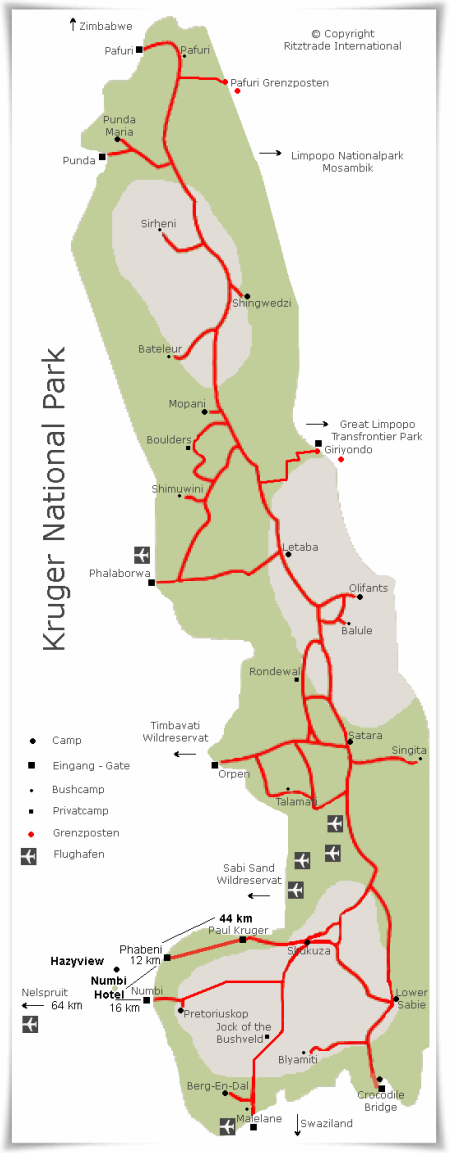
PREDNET Project



The Kruger Park

20000 km²





Communication challenges

Hardware constraints
QoS requirements

- Limited available energy
- Huge target area to cover (Kruger park)
- Lack of infrastructure
- Animal mobility

- 2 communication modes (Monitoring and alarm)

Which technology to use?

Cellular?
Cons: energy consumption; coverage holes

IEEE 802.15.4, 802.11?
Cons: require large number of hops to cover the area; isolated nodes

Satellite solutions ? (Argos, Iridium, Globalstar)
Cons: expensive; energy consumption; limitations on data transmission

LPWAN ✓
Pros: low energy consumption; long range

LoRa

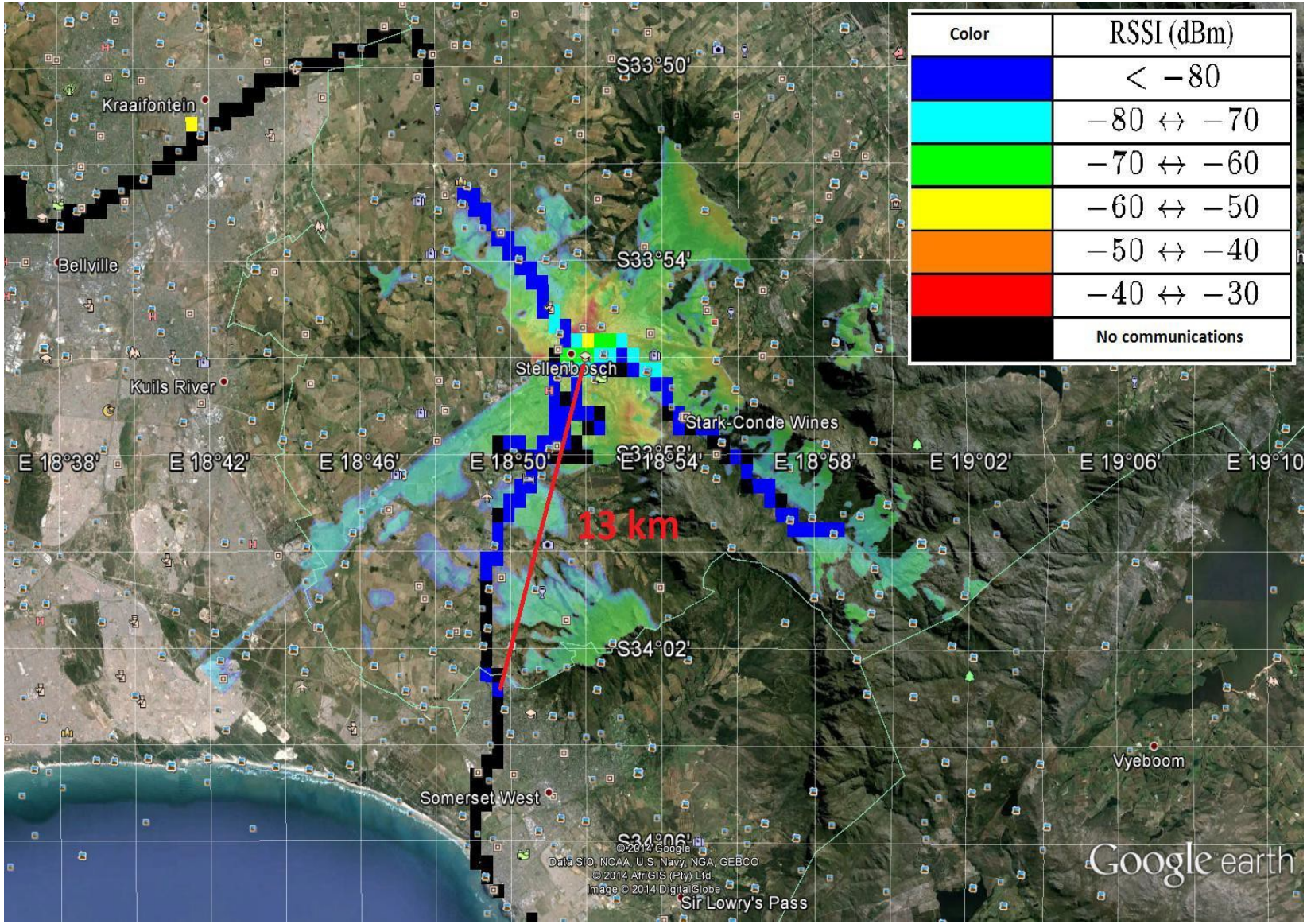
Semtech long range technology

137 – 175 MHz; 410 – 525 MHz; 820 – 1020 MHz
Depending on geographical localization

Spreading Factors from 6 to 12
Higher SF values correspond to more robust communications but lower data rates

Capture effect
First transmission detected is totally received

Range test and coverage simulation

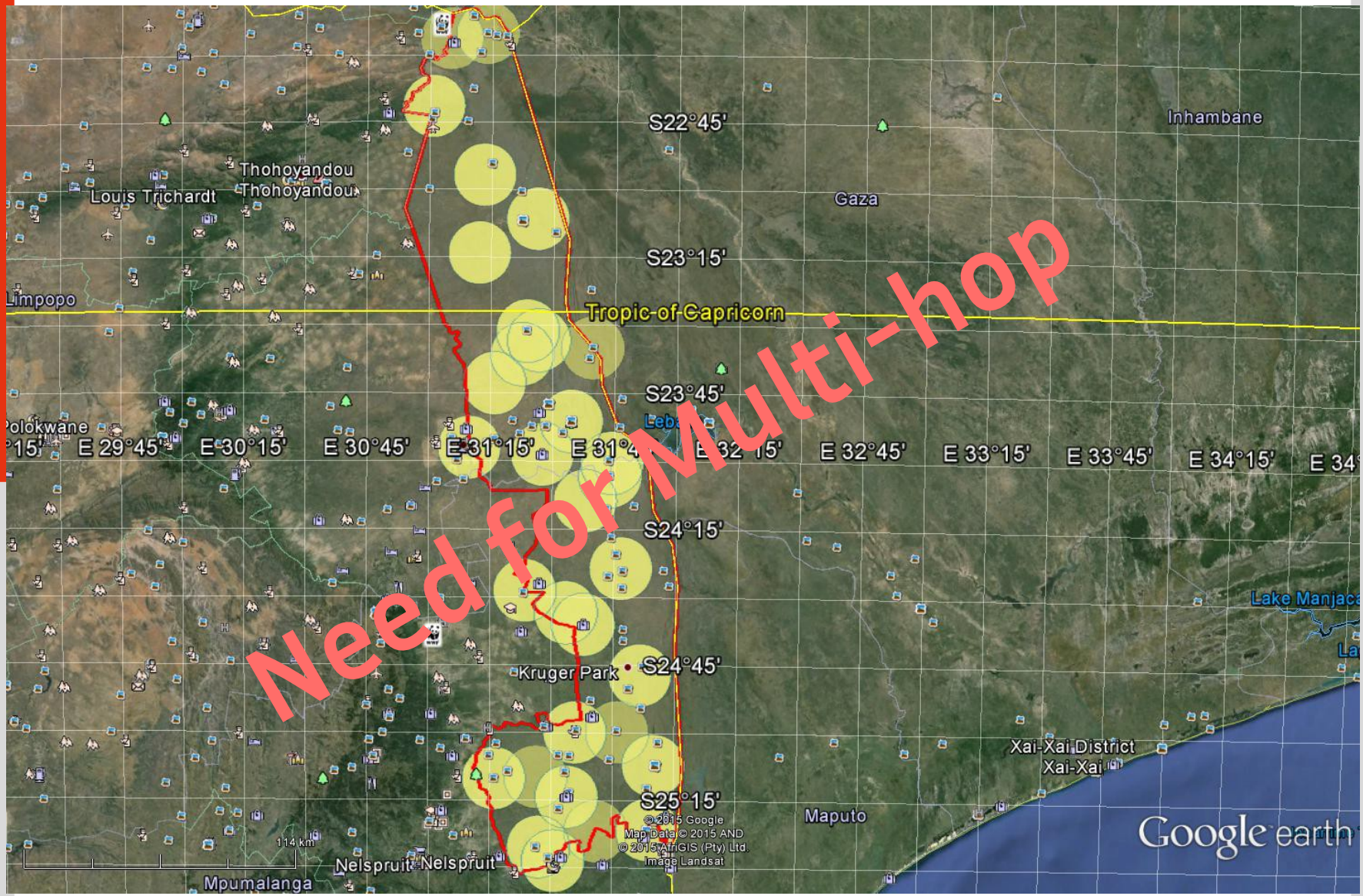


f= 434MHz Transmit power: 14dBm

Performance evaluation of LoRa radio solution for PREDNET wildlife animal tracking project Viktor Toldov, J.P. Meijers, Román Igual-Pérez, Riaan Wolhuter, Nathalie Mitton, Laurent Clavier *LPWAN 2016*, May 2016, Paris, France

inria inventors for the digital world

Coverage estimation



Inria
inventors for the digital world

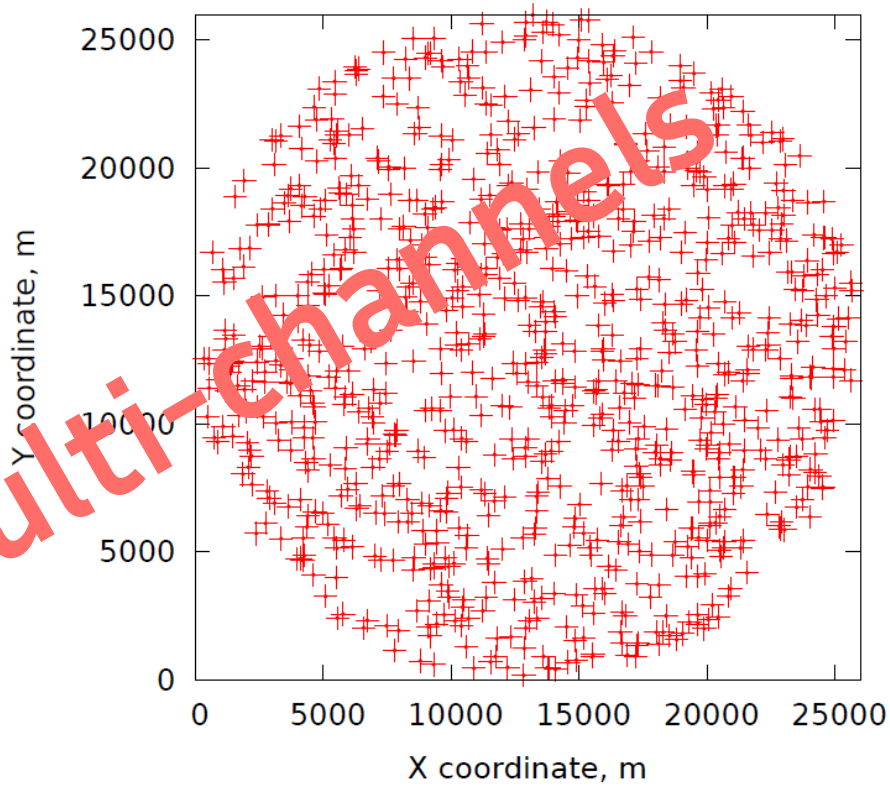
Cell capacity estimation

Cell area = $\pi \cdot r^2 \approx 3.1415 \cdot 13^2 \approx$ **531 km²**

Animal density λ = 1.7 animals/km²

Avg. Nb. of animals/cell = $531 \cdot 1.7$ **= 903**

Data transmission period = 15 min (900 s)
12 Bytes payload
Timeslot duration = 3 s
900 / 3 = 300 < 903



Need for multi-channels

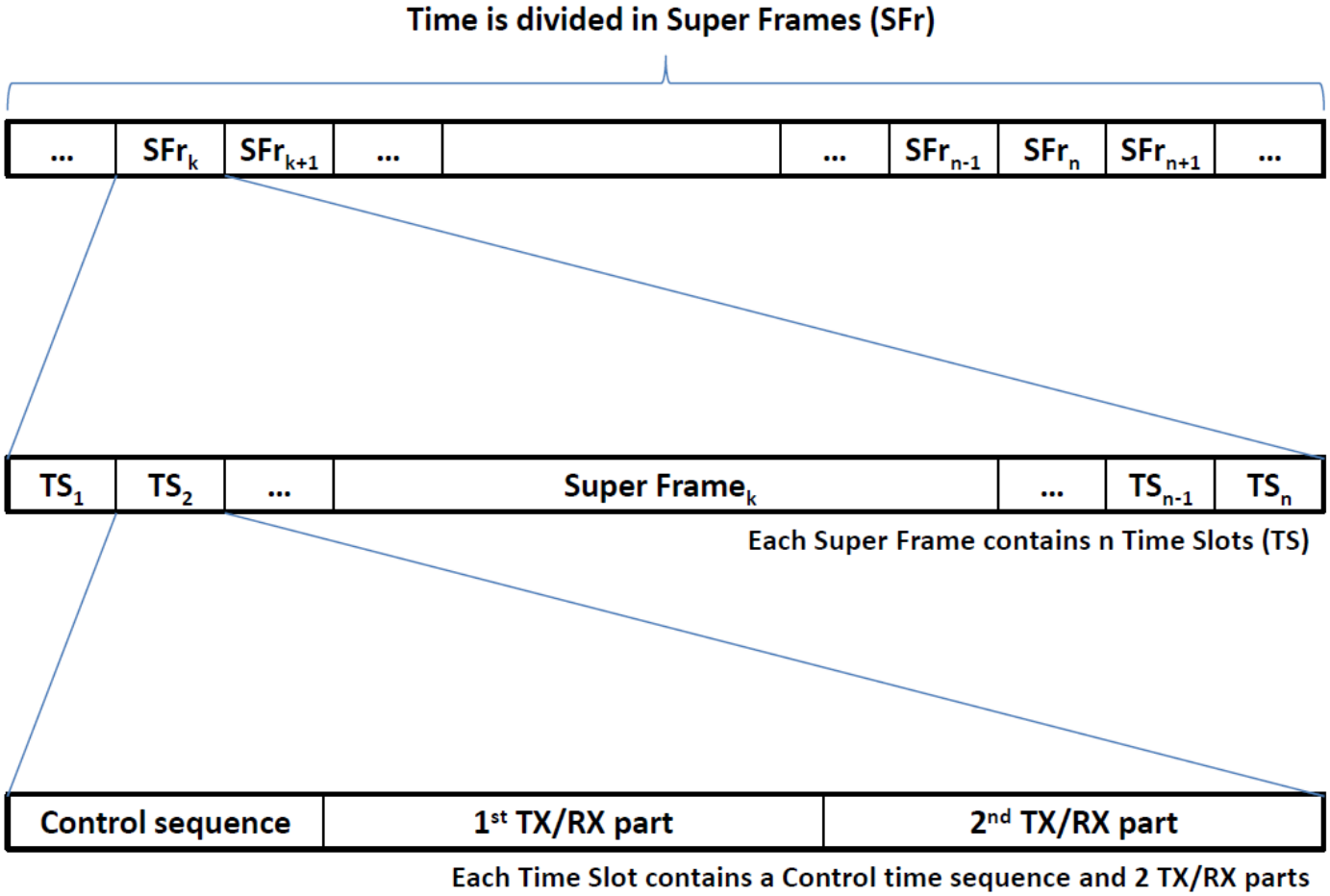
The idea of Rank

I am a **Rank 3** node. I need at least 3 hops to reach the sink

I am a **Rank 1** node. I need only 1 hop to reach the sink

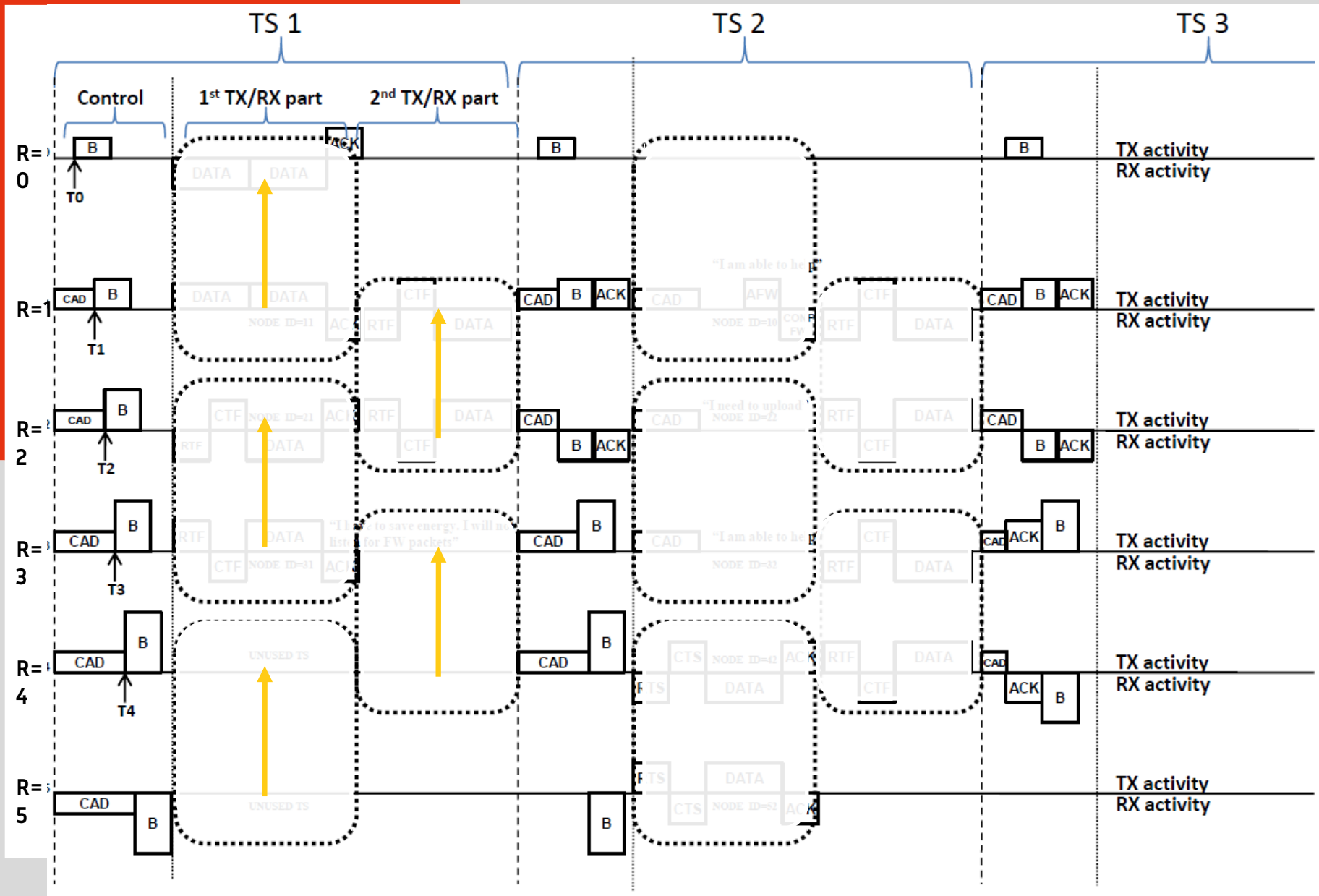
I am a **Rank 2** node. I need at least 2 hops to reach the sink

General time-division structure



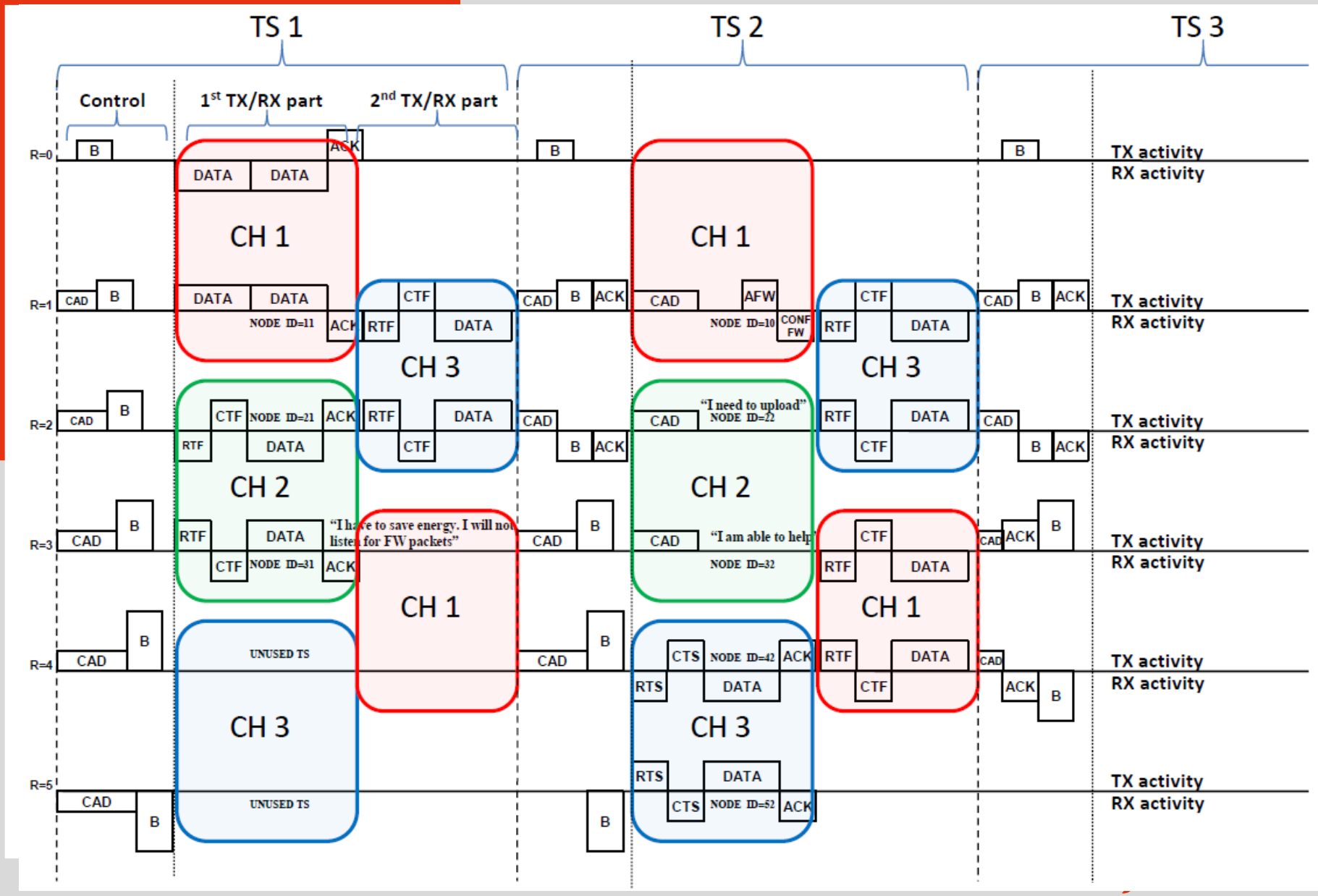
The super frame length is sized according to alarm messages requirements and network density.

Timeslot structure

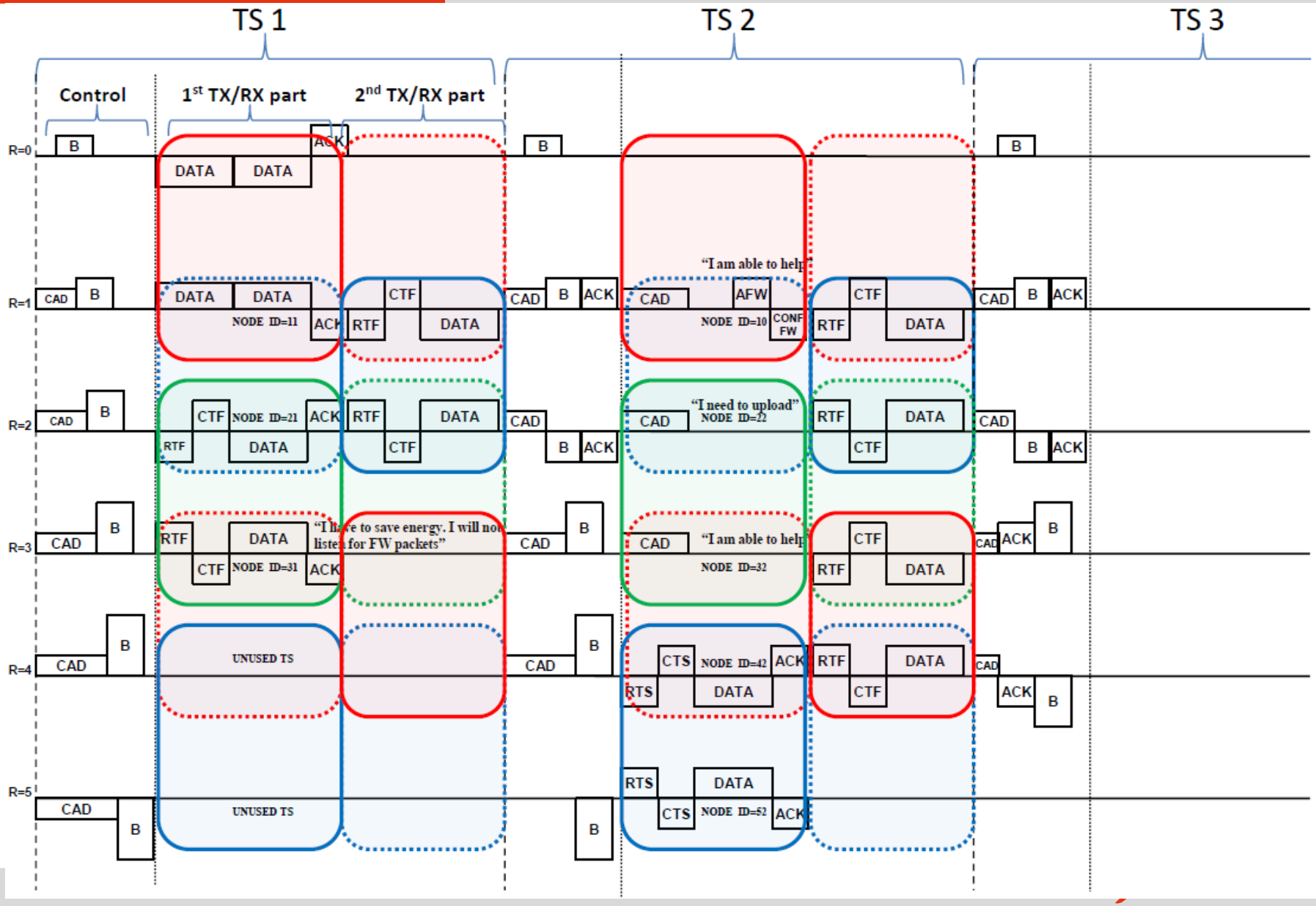


inria
inventors for the digital world

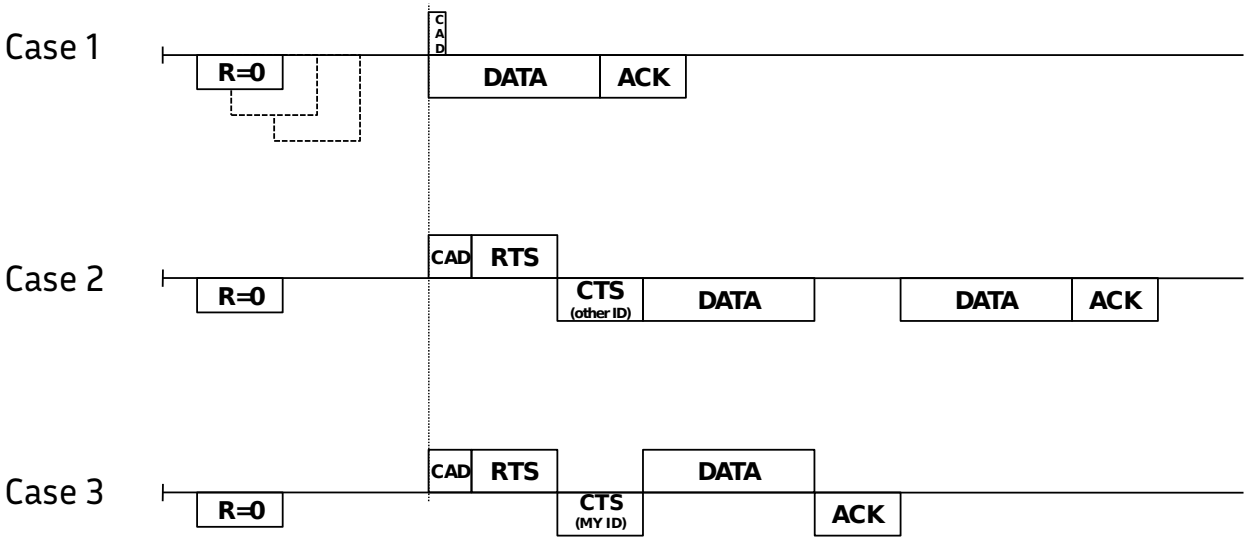
Multichannel operation



Multichannel operation



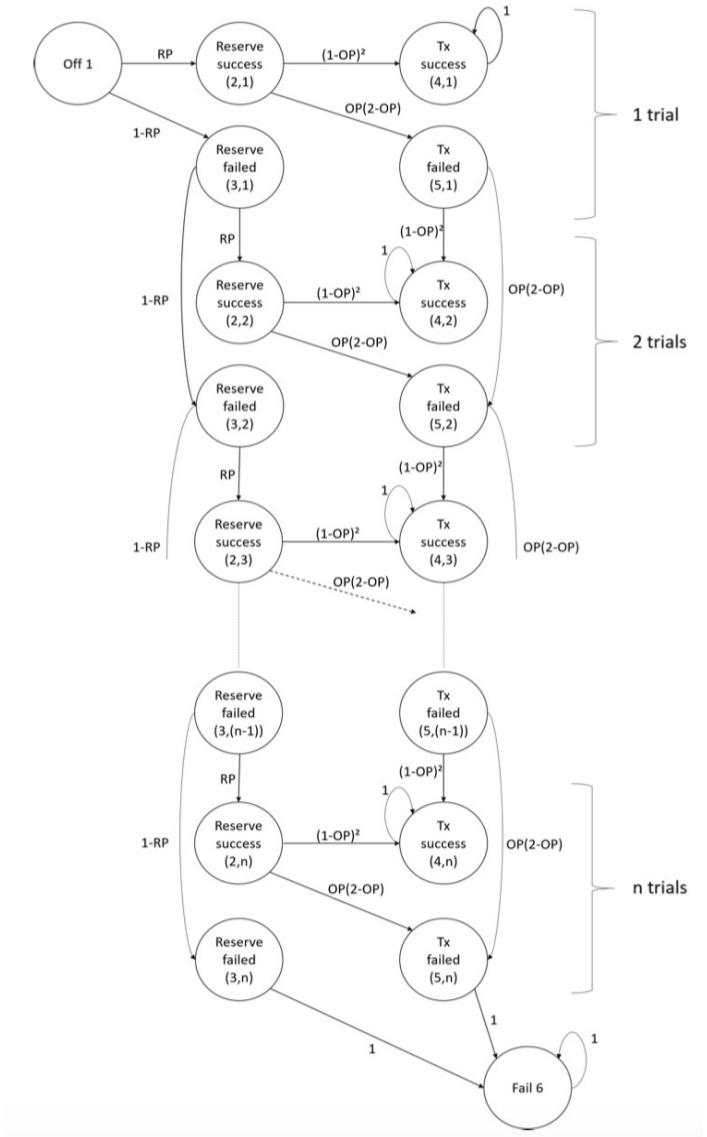
Time Slot reservation

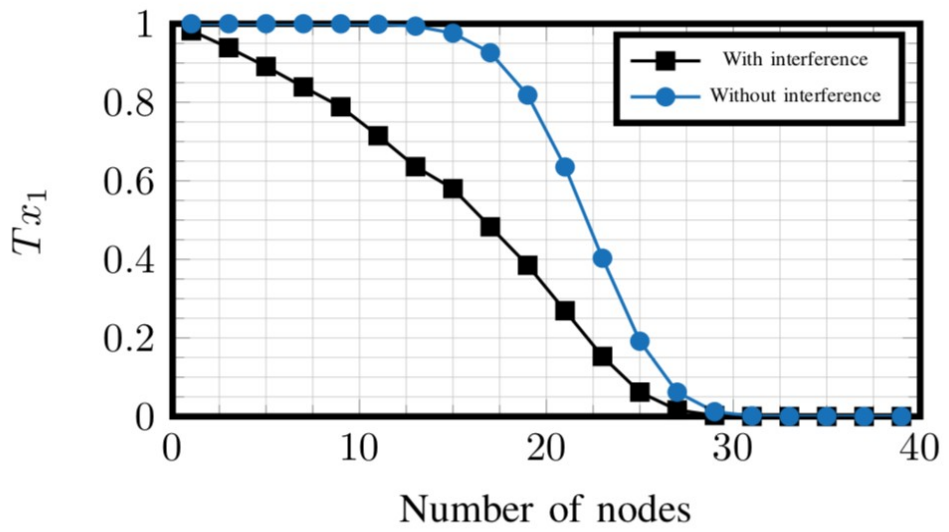


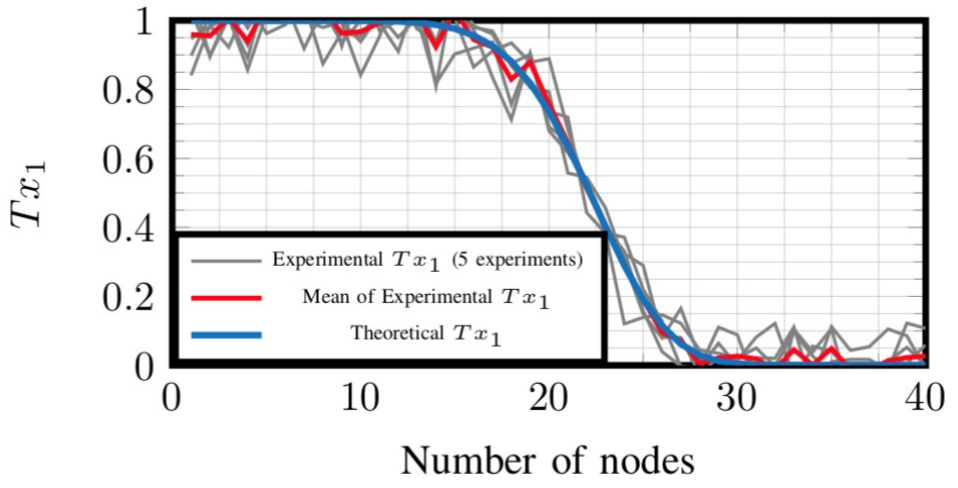
Rank 1 nodes: one reservation and keeps the timeslot forever

Higher ranked nodes: reservation at each data sending for other ranks

Time Slot reservation analysis







From Outage Probability to ALOHA MAC Layer Performance Analysis in Distributed WSNs
Mohamed El Amine Seddik, Viktor Toldov, Laurent Clavier, Nathalie Mitton *WCNC 2018 – IEEE Wireless Communications and Networking Conference*, Apr 2018, Barcelona, Spain.

inria inventors for the digital world

Time Slot reservation analysis (2)

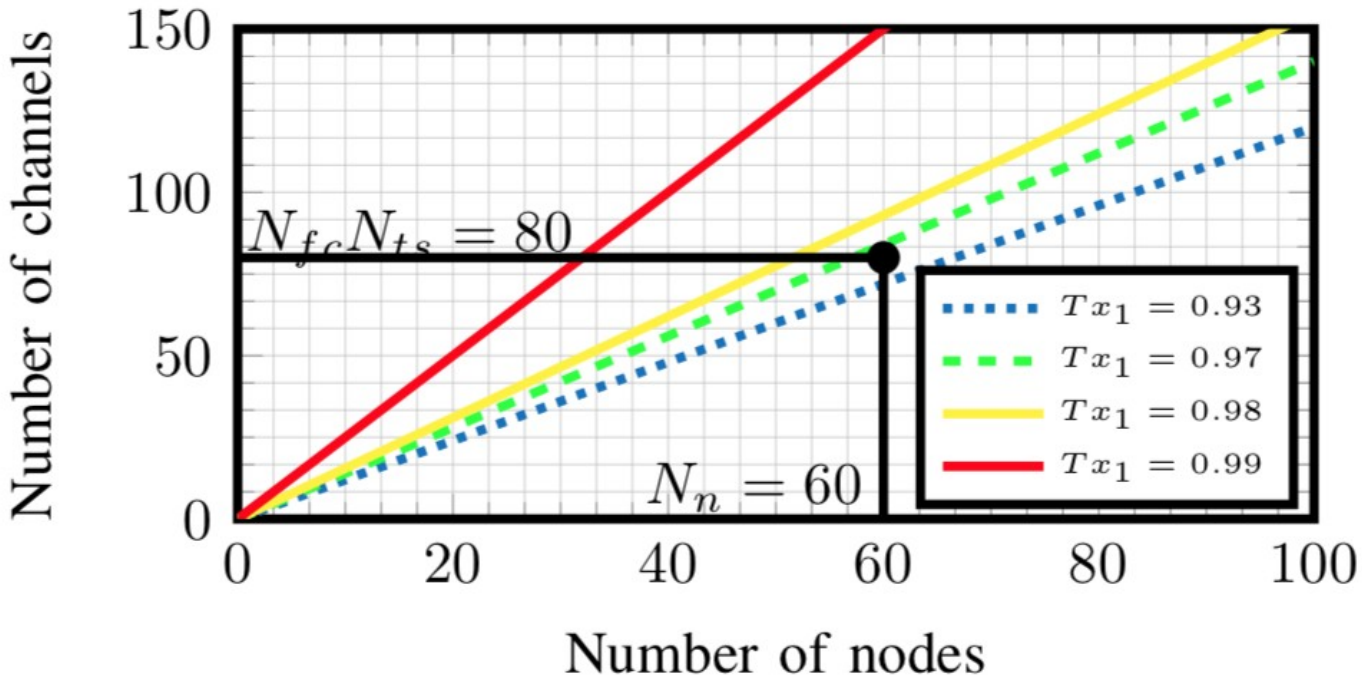
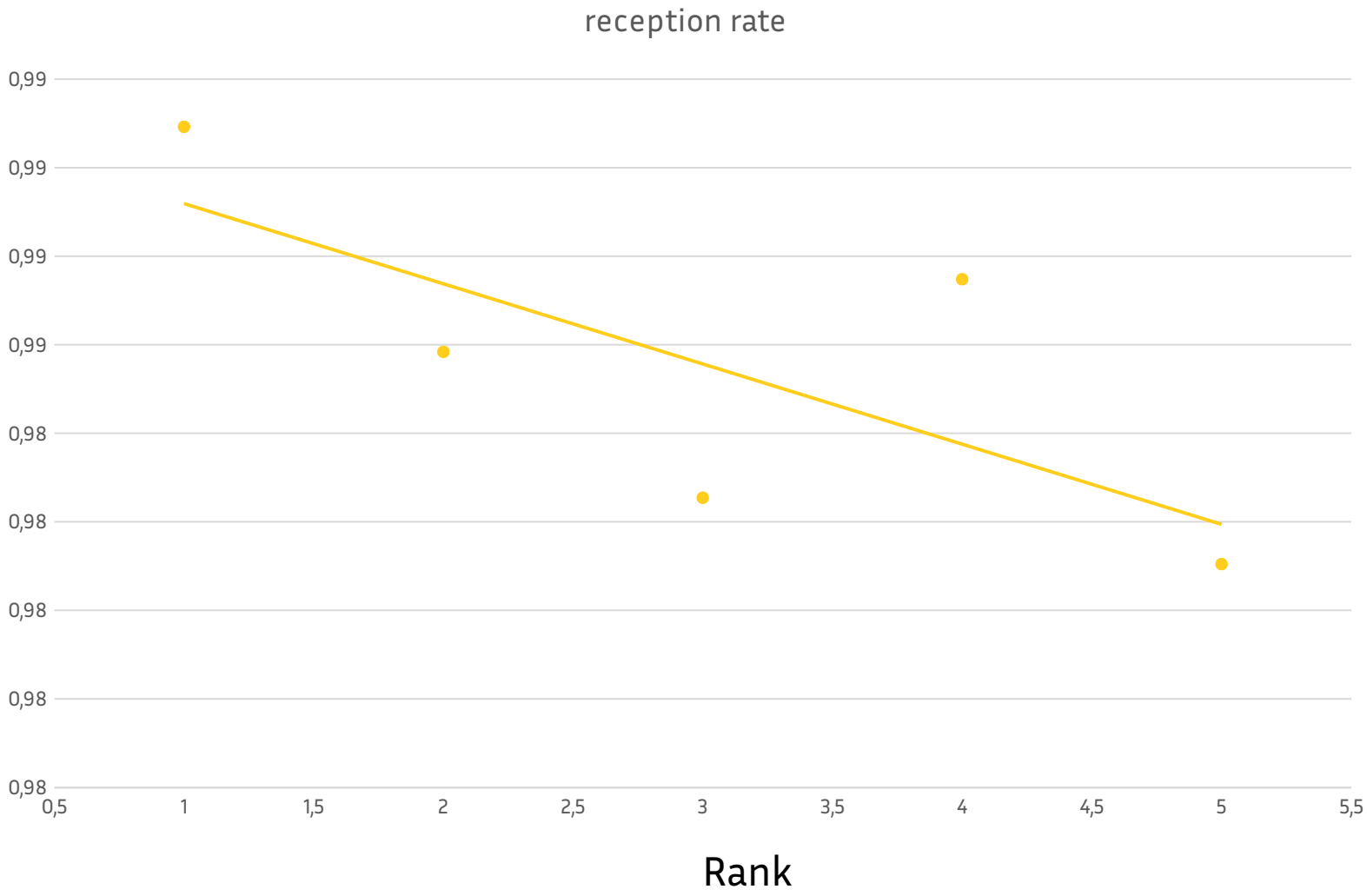


Fig. 8. Transmission success likelihood in terms of number of nodes in the network and number of channels assuming the presence of interfering nodes in the out range of the BTS.

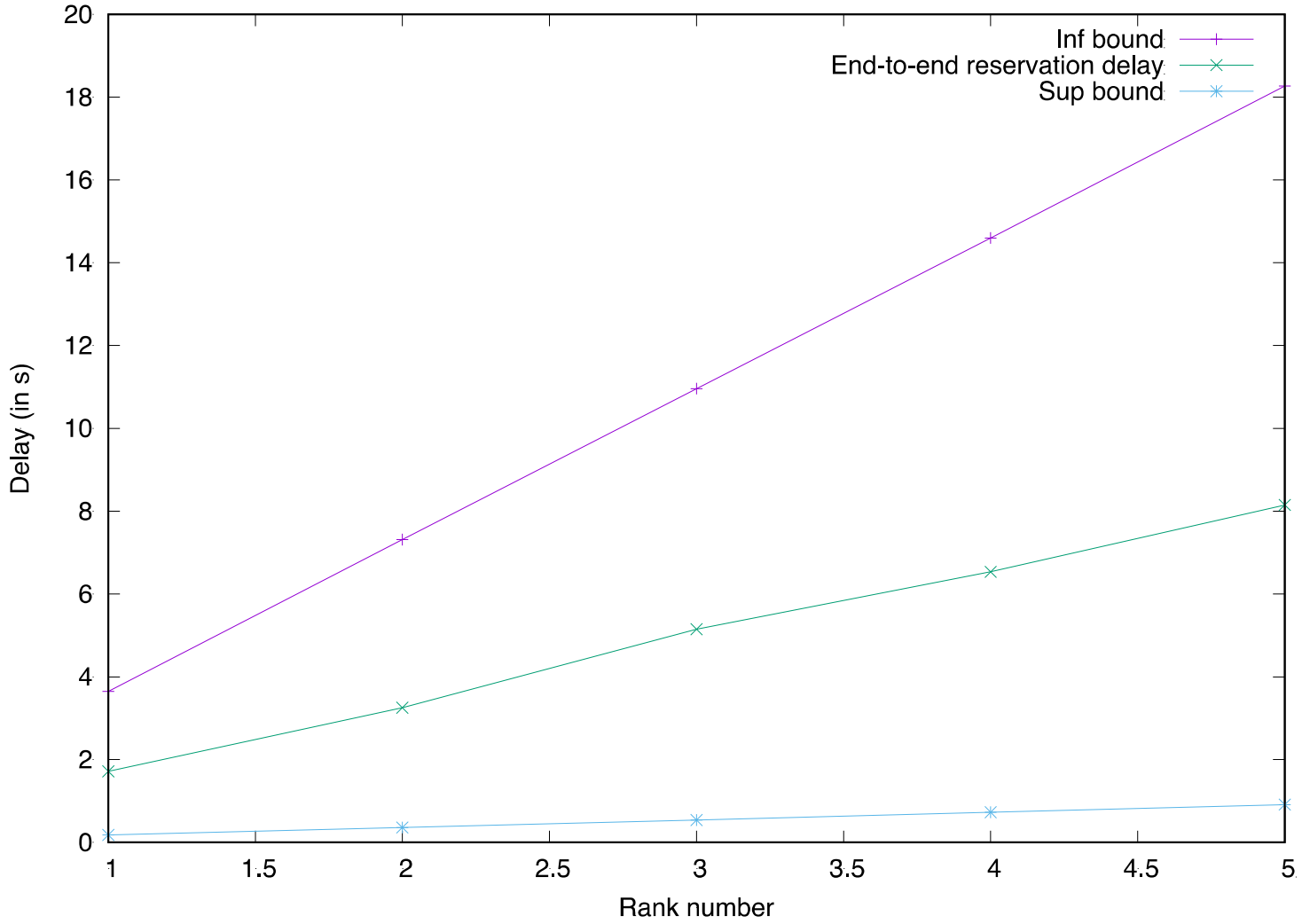
From Outage Probability to ALOHA MAC Layer Performance Analysis in Distributed WSNs
Mohamed El Amine Seddik, Viktor Toldov, Laurent Clavier, Nathalie Mitton *WCNC 2018 – IEEE Wireless Communications and Networking Conference*, Apr 2018, Barcelona, Spain.

inria inventors for the digital world

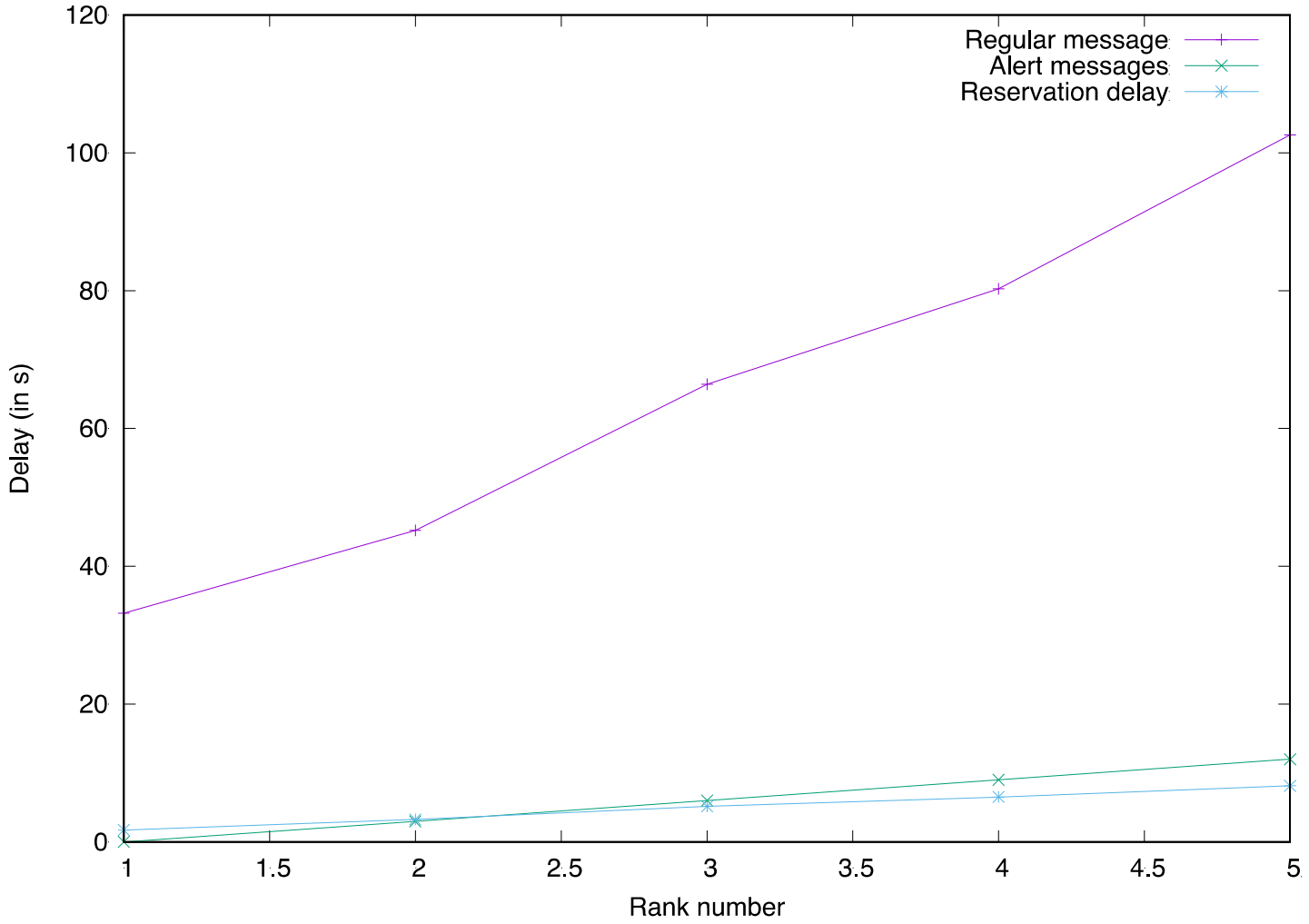
WildMac evaluation results

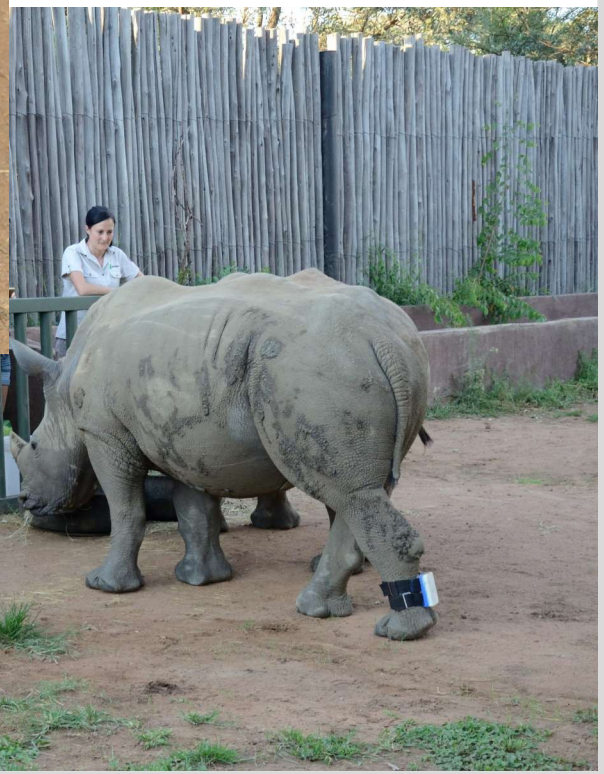


End to end results



End to end results





Takeaways

- Adaptive techniques of the WildMAC protocol help to improve the performances of wireless communications in the challenging environment of the animal tracking scenario
- Still a tradeoff between SF and throughput to investigate
- Still a need to improve energy consumption.
- Network density is an important factor to take into account.
- Still a huge experimental work to do.

Thank you for attention

Any questions ?

- Base station location: 33.92845S, 18.86606E (120.3m elevation)
- Frequency: 434MHz
- Surface refractivity (N-Units): 301 (default)
- Ground conductivity (S/m): 0.005 (default)
- Relative ground permittivity: 15 (default)
- Mode of variability: Spot, 70% of situations
- Climate: Continental temperate
- Additional loss: City, 100%
- Antenna Polarization: Vertical
- Antenna type: omni
- Antenna gain: 2.15dBi (0dBd)
- Transmit power: 14dBm
- Receiver threshold -136.6dBm
- Line loss: 0.5dB (losses in cable, filter, connectors)
- No additional cable loss
- Mobile station antenna height above ground level: 2m
- Base station antenna height above ground level: 20m