LeapFrog Collaboration: Vers les Réseaux Industriels Déterministes

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Outline

Introduction

IoT & Industry 4.0

IoT

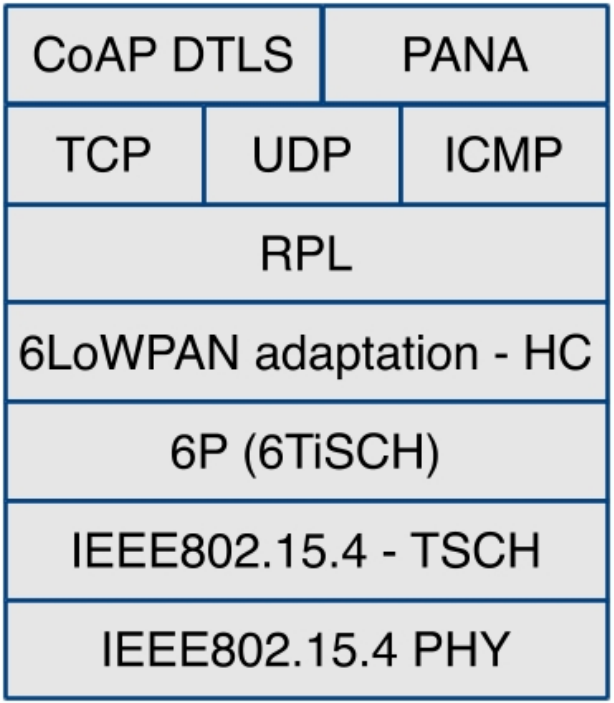
- Devices with embedded systems that connect to Internet

Industry 4.0

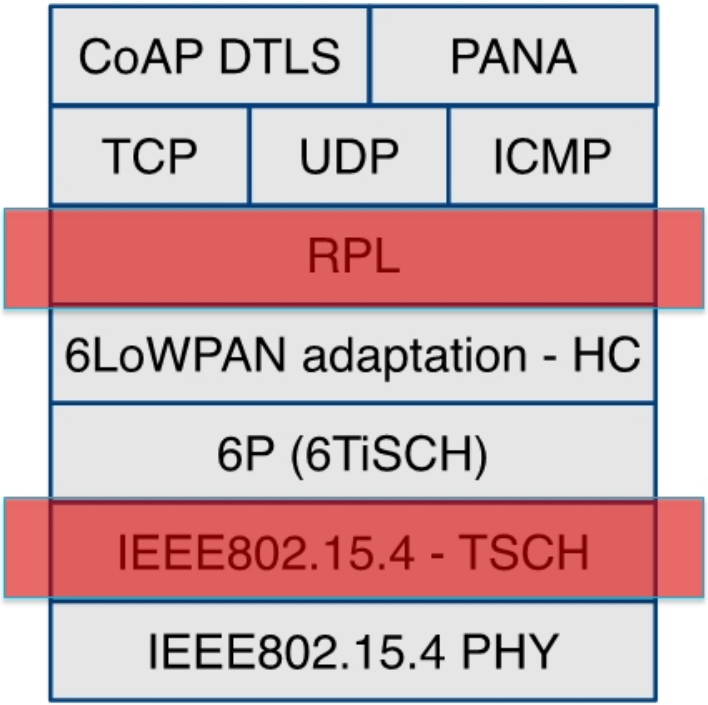
- Emerging application in IoT, objectives:
  - ✓ Simplify the production chains
  - ✓ Ease the deployment
  - ✓ Make the factory more flexible and adaptable
  - ✓ Reduced costs and improved efficiencies
- To do so, the network must be Reliable and Deterministic

Background Protocols

6TiSCH Protocol Stack

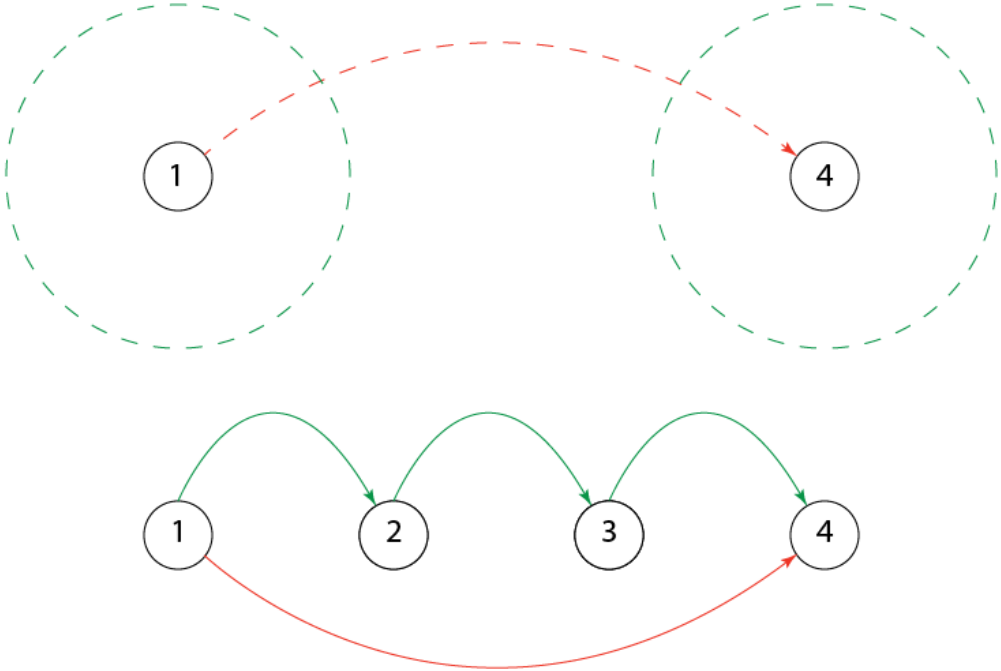


6TiSCH Protocol Stack



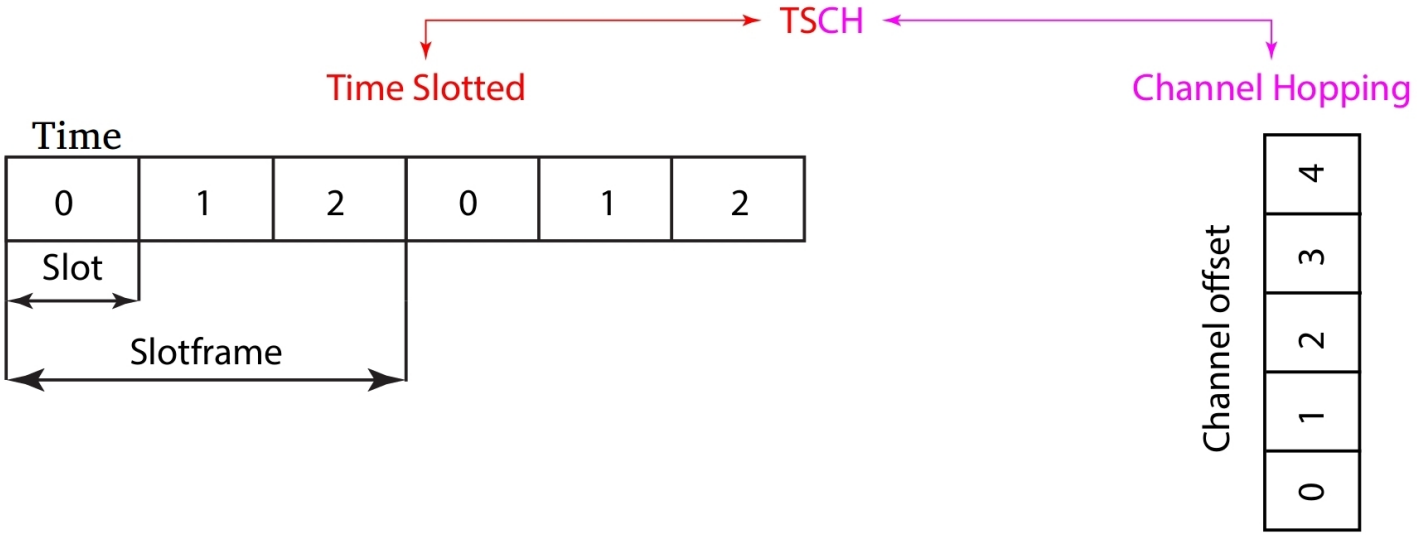
RPL - Routing Protocol

- ✓ Node Collaboration
- ✓ Tree Topology
- ✓ Default Parent (DP)

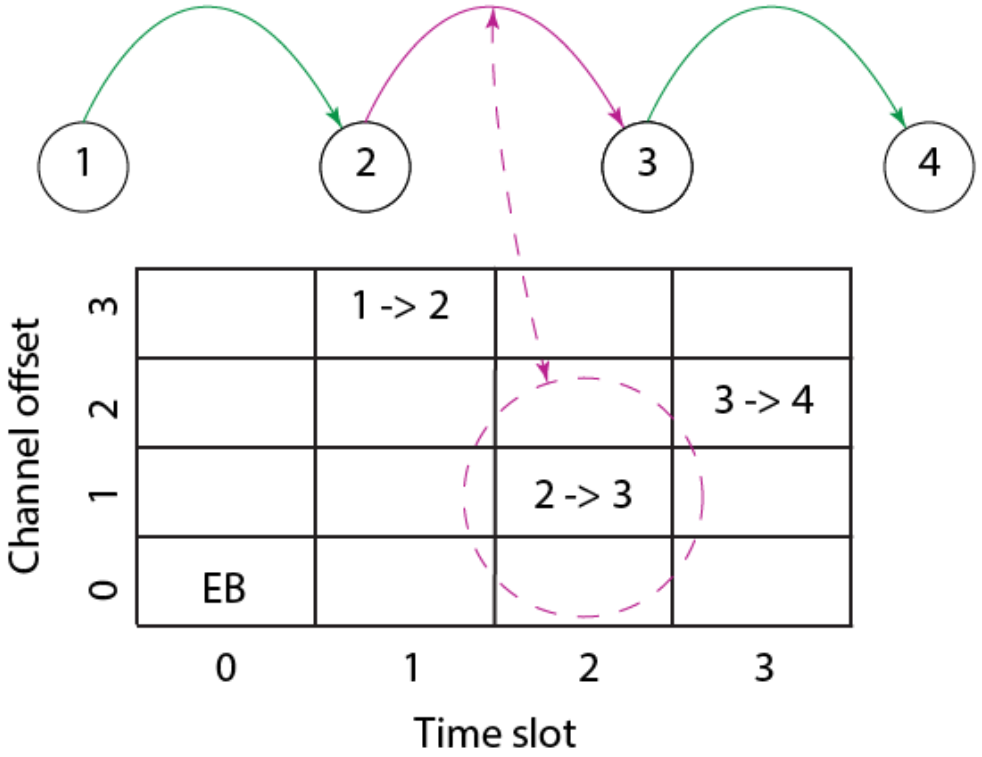


IEEE 802.15.4 - TSCH - MAC Protocol

- ✓ Defines if a node transmits, receives or sleeps
- ✓ Robust against external interference
- ✓ Schedules the transmissions to be done



TSCH + RPL



Problem Statement

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IoT

- Applications
  - ✓ High packet delivery ratio

Now, with **Industry 4.0**

- Controlling industries processes
  - ✓ High packet delivery ratio
  - ✓ **Constant Delay**
  - ✓ **Minimize Jitter**

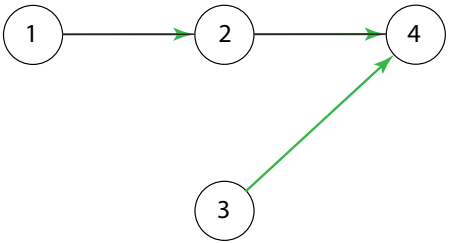
However, the current technologies in IoT are based on best-effort.

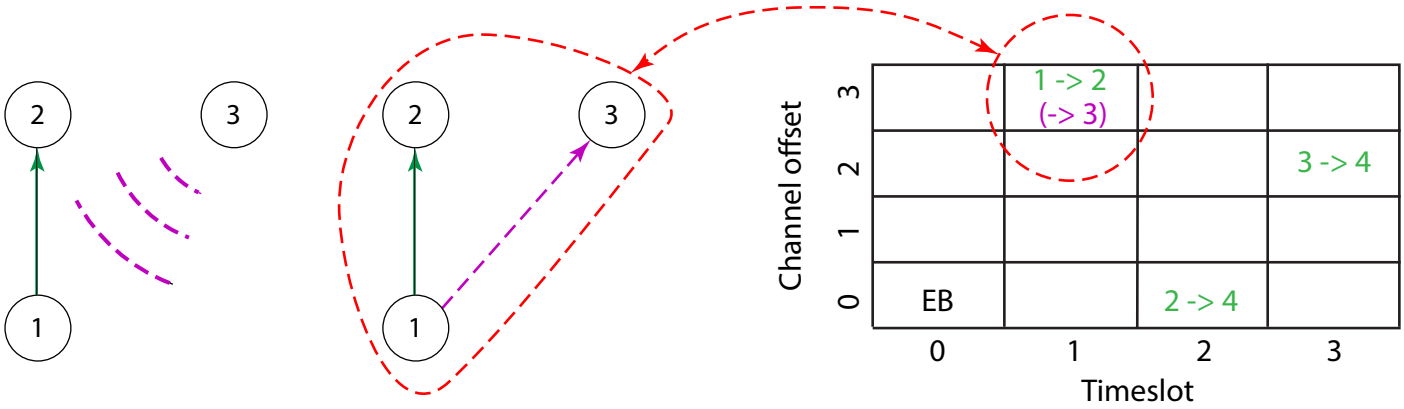
- New Approach
  - ✓ Do not wait for failure to retransmit
  - ✓ Create replicas of packets in different paths

LeapFrog Collaboration

Overhearing

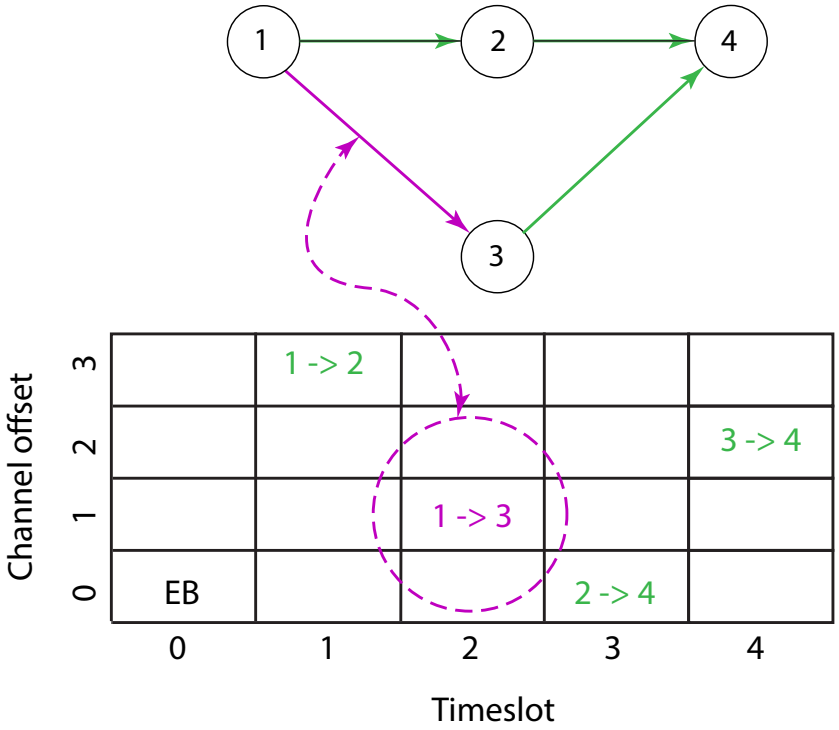
- ✓ The medium is shared
- ✓ A node can listen to other transmissions





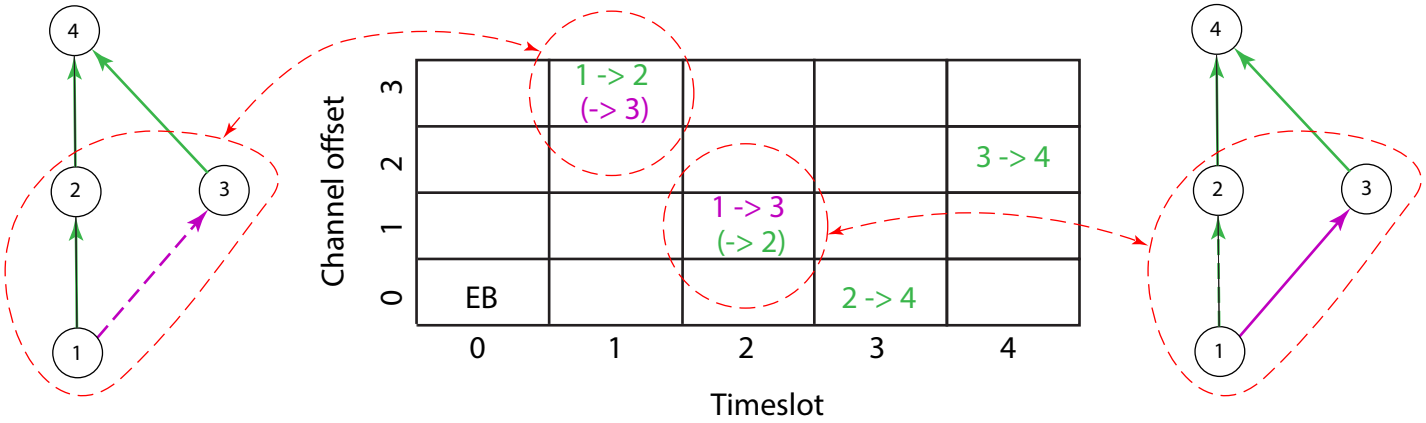
Alternative Parent (AP)

- ✓ Adds a new path for the packet to get to destination
- ✓ The new path is related to the original



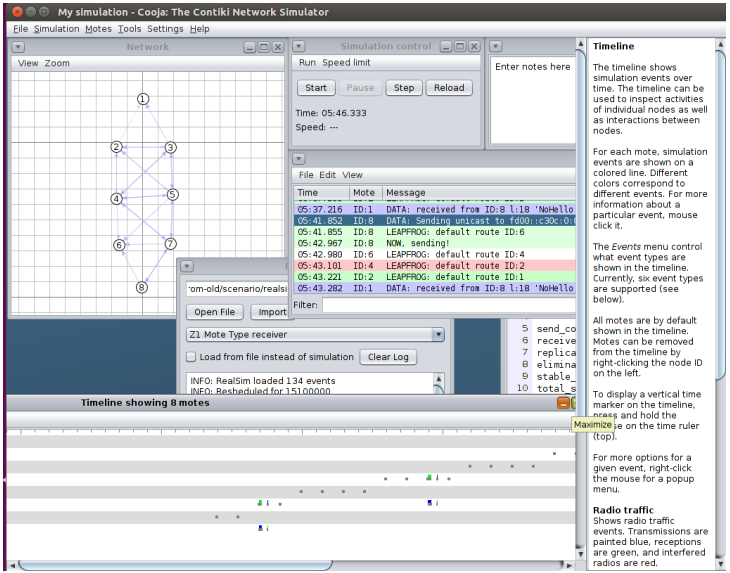
Alternative Parent + Overhearing

- ✓ When we transmit to DF, AP overhears
- ✓ When we transmit to AP, DF overhears



Simulation Setup

COOJA (Contiki OS)

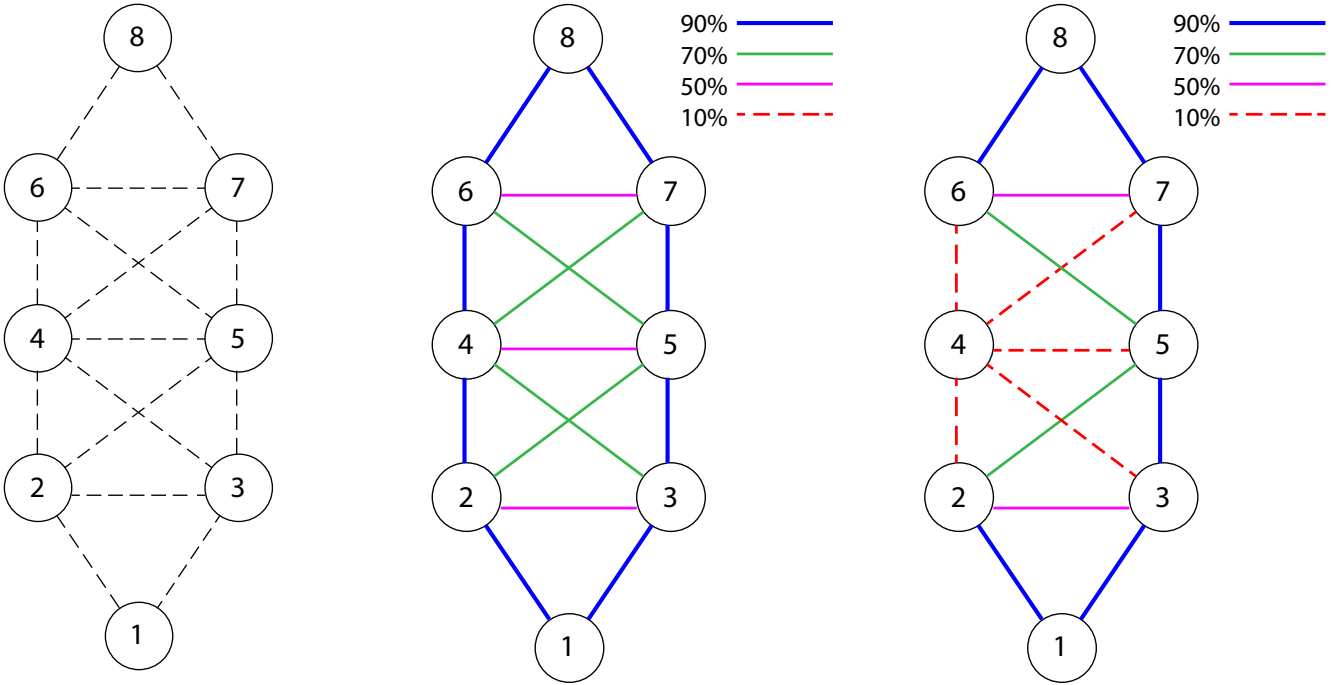


Simulation Setup

Topology	**Value**
Topology	Multi-hop, see Figure 4
Number of nodes	8 (including the sink)
Number of sources	1 source
Node spacing	10 m (in average)
Simulation	**Value**
Duration	31 $minutes$
Traffic Pattern	1 $pkt/10\ sec$
Payload size	17 $bytes$
Routing model	RPL [3]
MAC model	TSCH [1]
TSCH	**Value**
EB period	3.42 sec
LB period	30 sec
Slotframe length	101
Timeslot length	15 ms
Hardware	**Value**
Antenna model	CC2420
Radio propagation	2.4 GHz
Transmission power	0 dBm

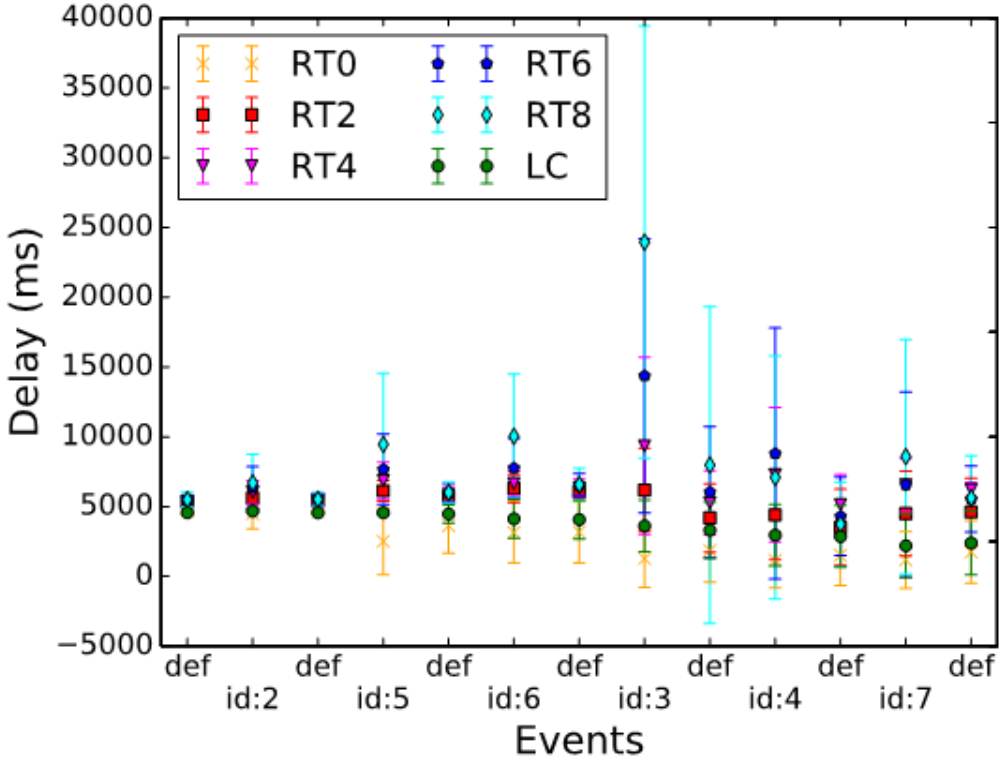
RealSim plugin

- ✓ Default stage has defined values
- ✓ IdX stands for bad links for node X

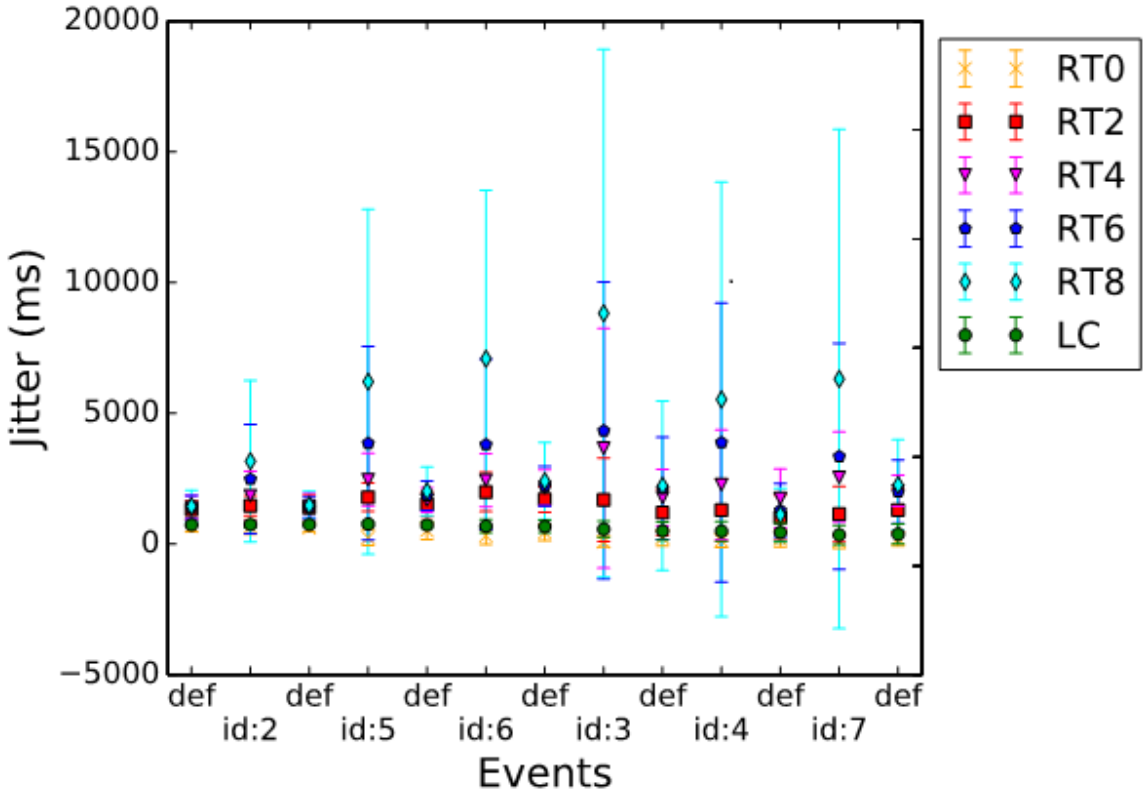


Performance/Evaluation

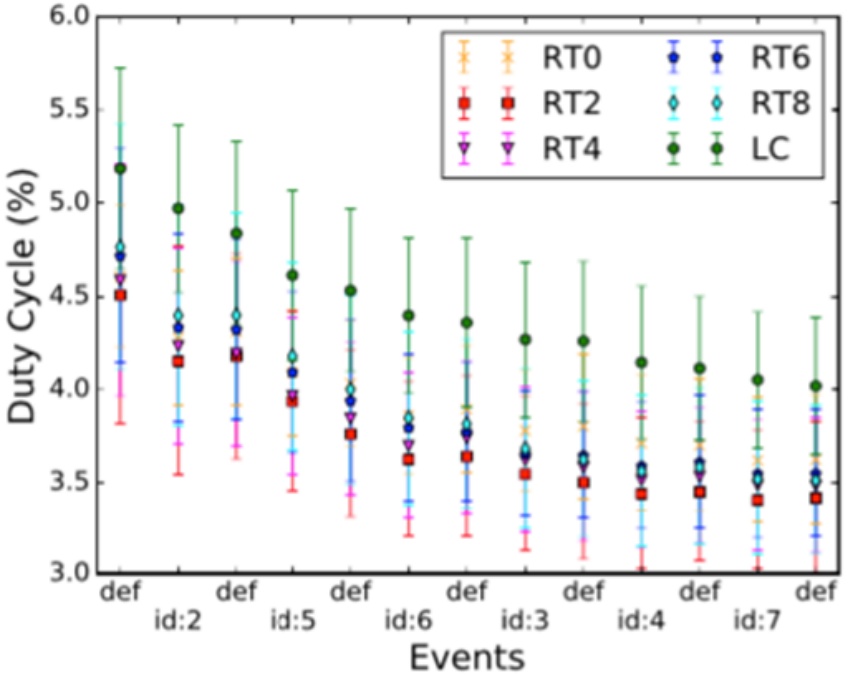
Delay


RT0
RT2
RT4
RT6
RT8
LC
Delay (ms)
40000
35000
30000
25000
20000
15000
10000
5000
0
−5000
def
id:2
def
id:5
def
id:6
def
id:3
def
id:4
def
id:7
def
Events

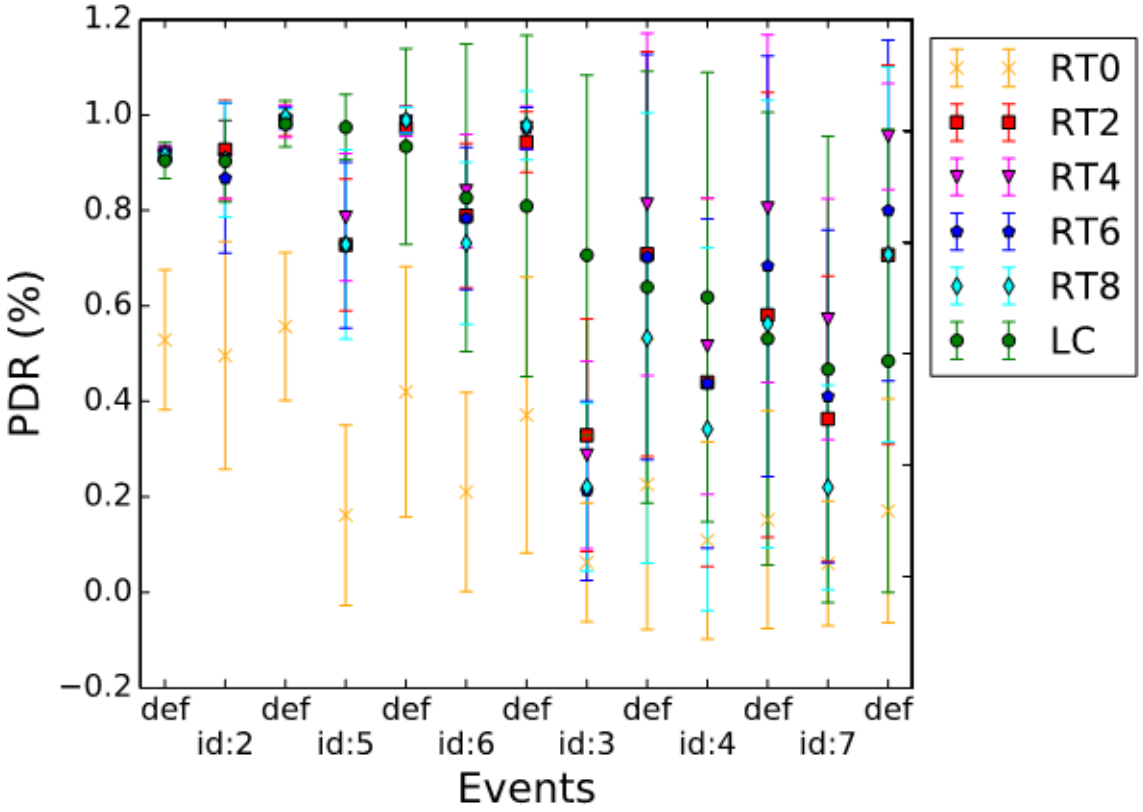
Jitter


20000
15000
10000
5000
0
−5000
Jitter (ms)
def
id:2
def
id:5
def
id:6
def
id:3
def
id:4
def
id:7
def
Events
RT0
RT2
RT4
RT6
RT8
LC

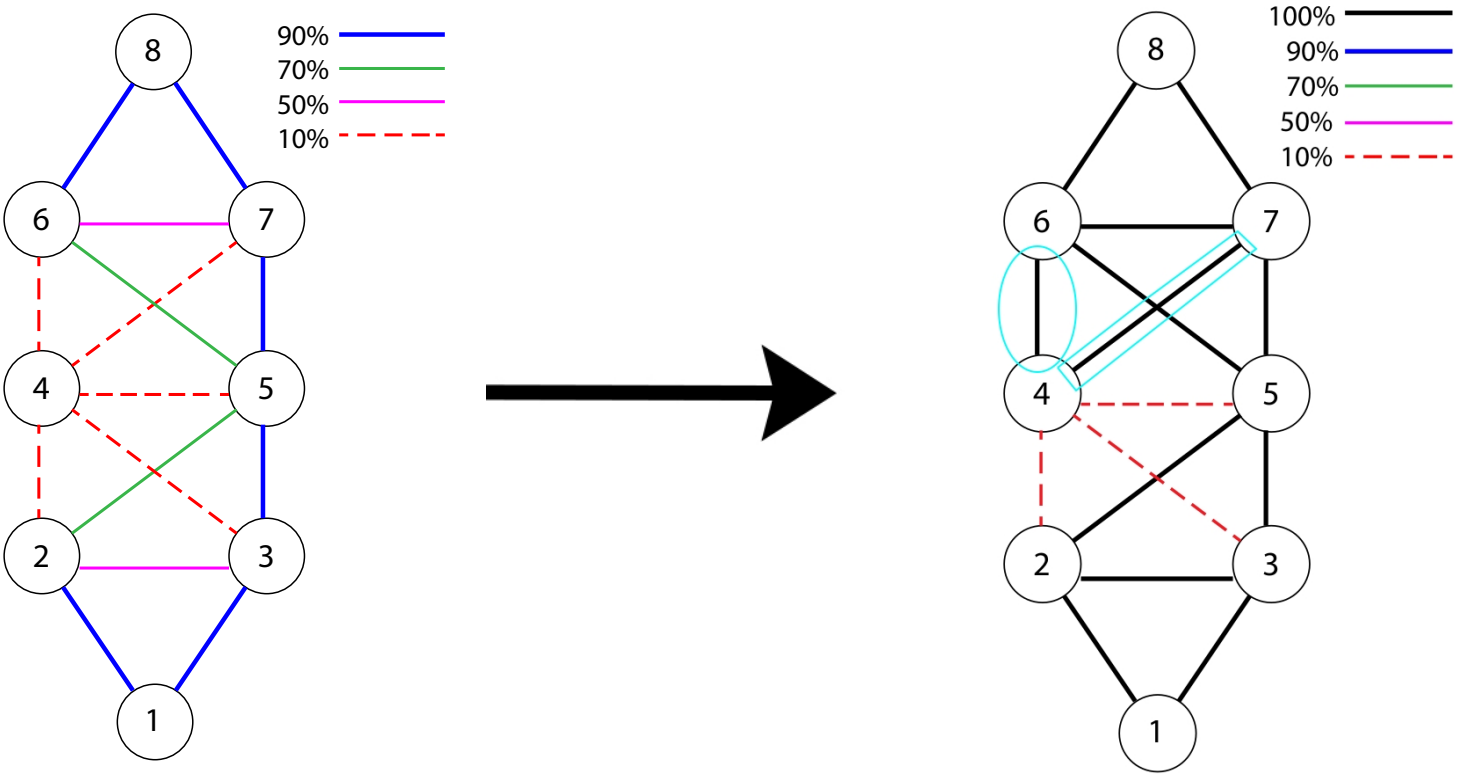
Duty Cycle


6.0
5.5
5.0
4.5
4.0
3.5
3.0
Duty Cycle (%)
RT0
RT2
RT4
RT6
RT8
LC
def
id:2
def
id:5
def
id:6
def
id:3
def
id:4
def
id:7
def
Events

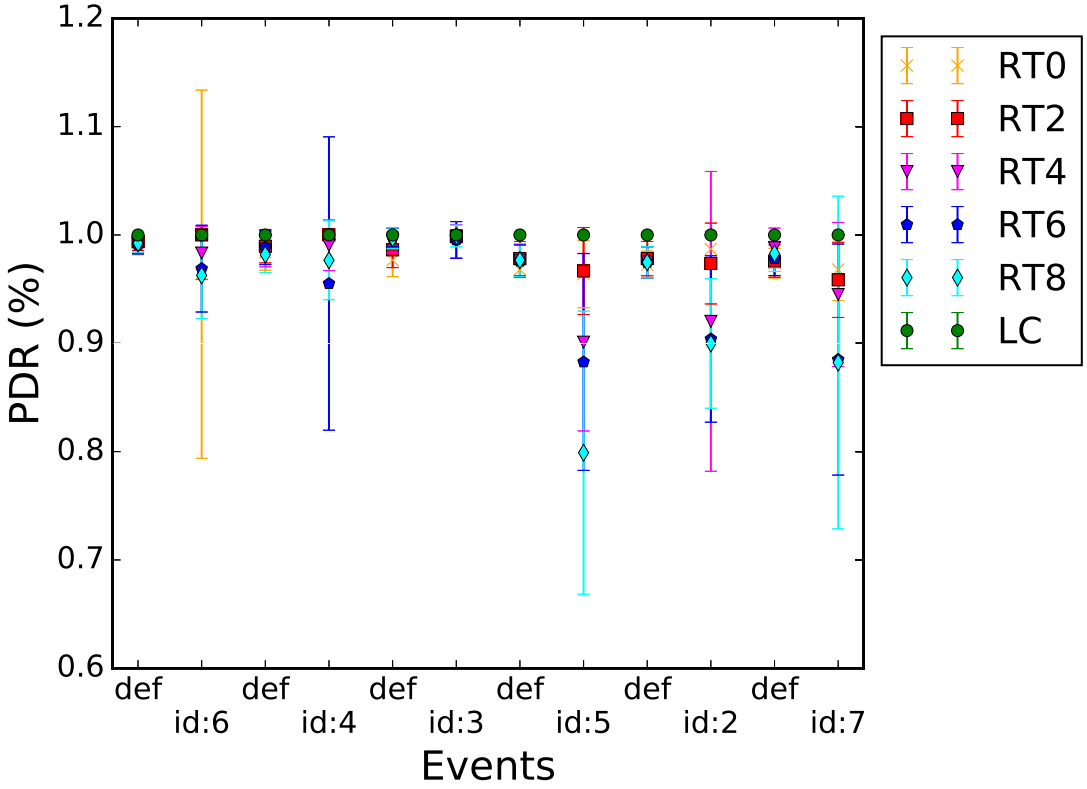
Packet Delivery Ratio



New Scenario



New Results


1.2
1.1
1.0
0.9
0.8
0.7
0.6
PDR (%)
def
id:6
def
id:4
def
id:3
def
id:5
def
id:2
def
id:7
Events
RT0
RT2
RT4
RT6
RT8
LC

Conclusion/Perspective

Conclusion/Perspective

- LeapFrog Collaboration
  - ✓ Outperforms TSCH configurations in terms of delay and jitter
  - ✓ The cost associated is the energy consumption
- Ongoing work
  - ✓ Adding retransmissions to improve PDR
  - ✓ Studying better the scheduling so as to reduce the delay and jitter
  - ✓ Analyzing better the interaction of RealSim and RPL in COOJA

Thank you