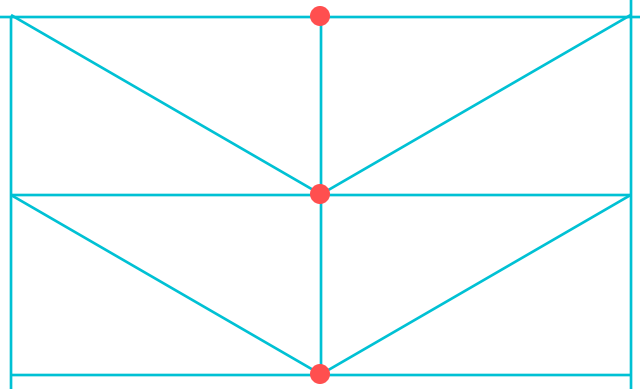
Tutorial: IEEE 802.15.4 TSCH mode

ComNets

TUHH
Institute of Communication Networks



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2nd of October 2024

Course Contents

ComNets

Online lectures

- ~~Lecture 1 - Introduction~~
- ~~Lecture 2 – IEEE 802.15.4~~
- ~~Lecture 3 – IETF 6TiSCH~~

Physical Meeting 13th to 17th of April

- ~~Lecture 4 – Theoretical Analysis~~
- ~~Cooja Simulations and Experiments~~
- ~~Industrial visit and a talk~~
- ~~Team Presentations on self learned material~~
- Lecture 5 – Research Project Results

More details on our padlet,
https://tuhh.padlet.org/c00zll01/enabling-industry-4-0-j88rkh1i3j7rzmv3

Use of TSCH in Industry 4.0 Applications

Project Results of two research projects done together with the industries

DRAISE Project

DRAISE: Drahtlose, Robuste, Adaptive, Industrielle Systeme

- Duration: 02/2016 – 04/2019
- Funding: BMBF KMU-Innovativ

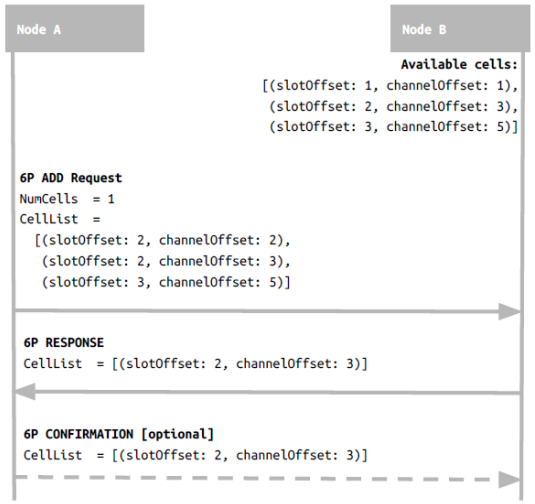
Goal: Develop a reliable, low latency sensor network for industrial environments **based on existing protocols** (IEEE 802.15.4 TSCH mode, Wireless HART, ISA100.11a)

Methods: Redundancy on all layers, optimized schedule by Linear Programming, Cognitive Radio & Cooperative Spectrum Sensing , Mathematical modelling, testbed and simulation

DRAISE Project

ComNets

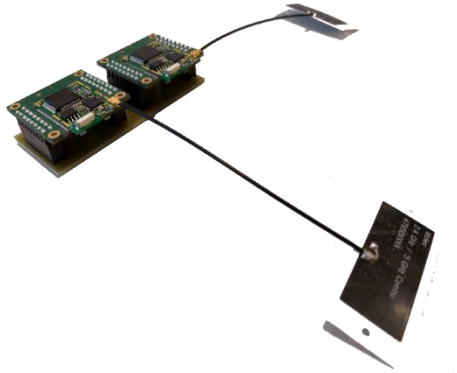
Initial Schedule Negotiation



Continuous Spectrum Sensing

Blacklisting

Interference Avoidance

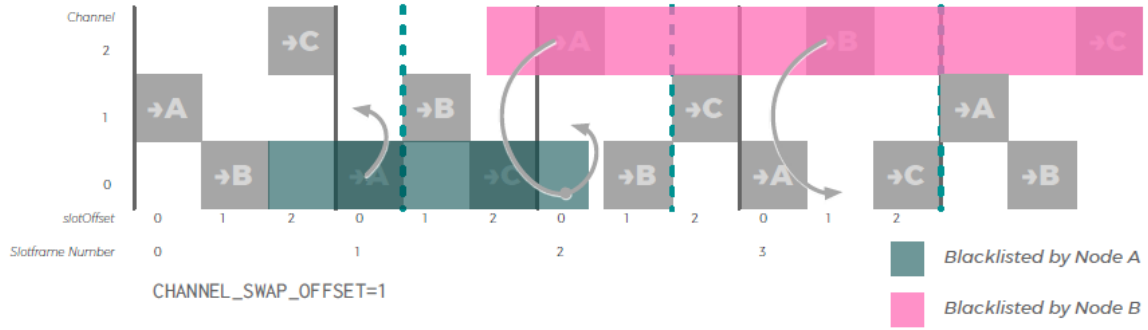


- Scheduling Function that adapts to interference locally
- Designed to be used within the IETF 6TiSCH stack

SF with Soft Blacklisting

- SFSB: Scheduling function based on dynamic cell allocation between node pairs with extended features
- Local Blacklisting for bad channels
  - **Private blacklist**
  - **Neighbor blacklist** per neighbor
- Channel swapping in case the node picks blacklisted channel from either private or neighbor blacklist

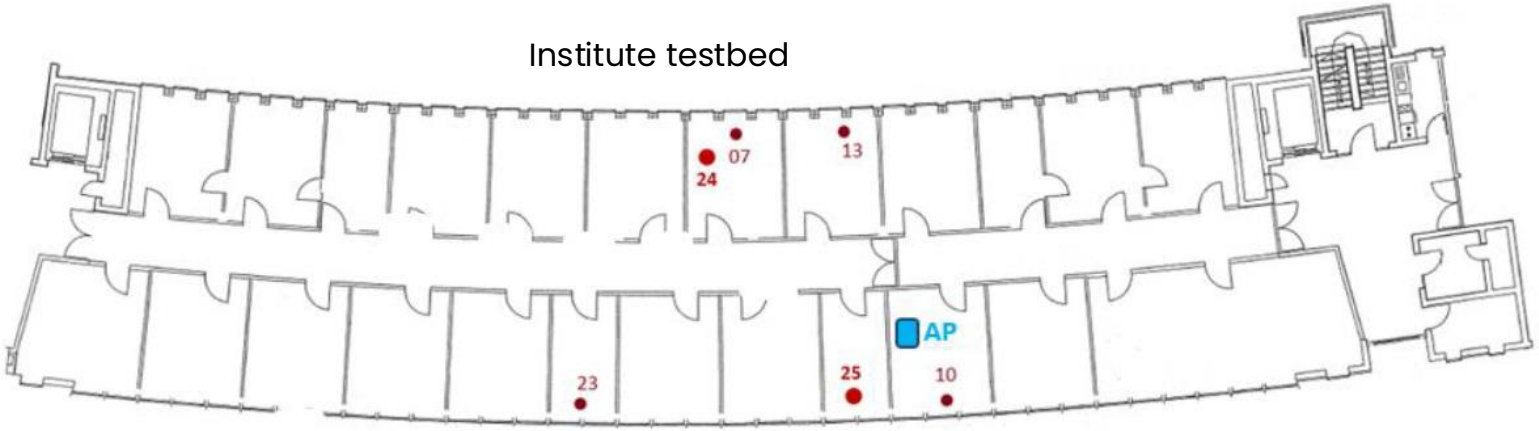
Local vs. global blacklisting

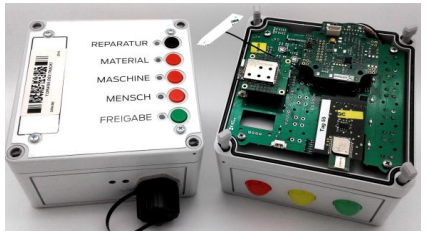


Channel diversion using channel swap offset in SFSB

Performance Evaluation with SFSB

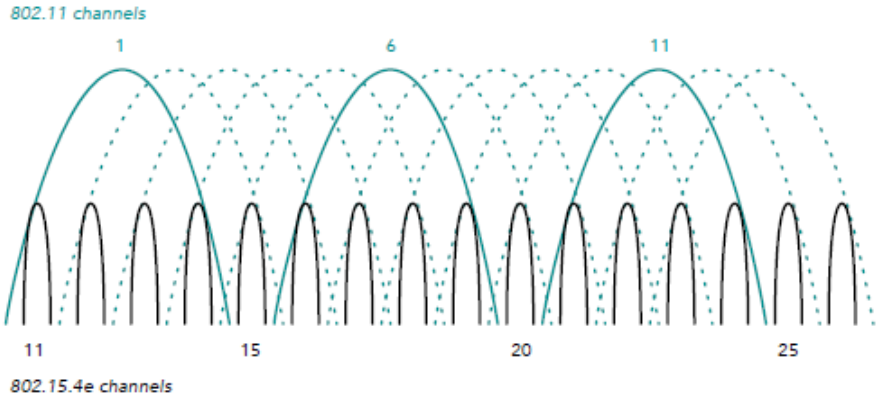
Institute testbed





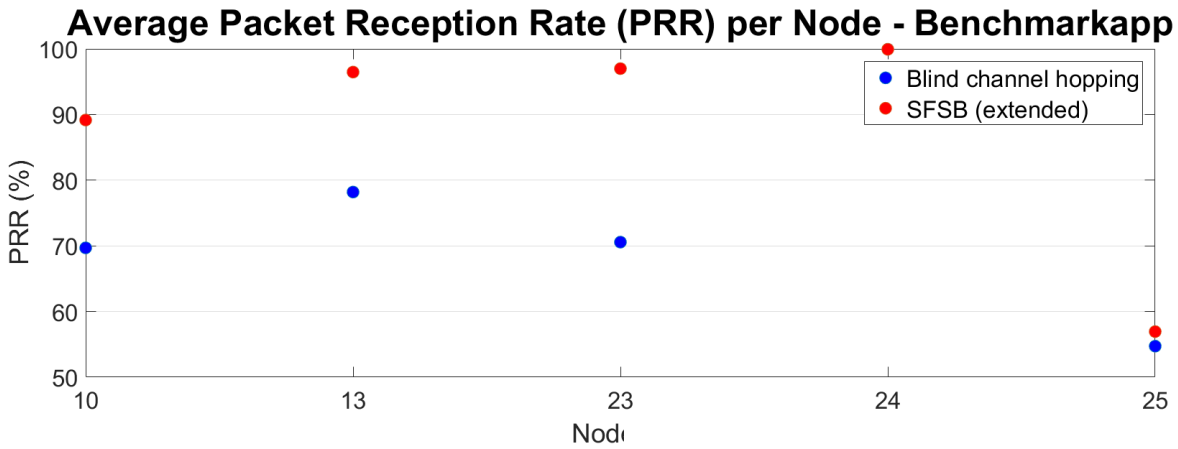
Virtenio Sensor
Node with 6TiSCH

- ComNets Testbed
- 6 Static Nodes and 1 Access Point
  - Node-7 is the sink node
  - Access Point – traffic on channel-6

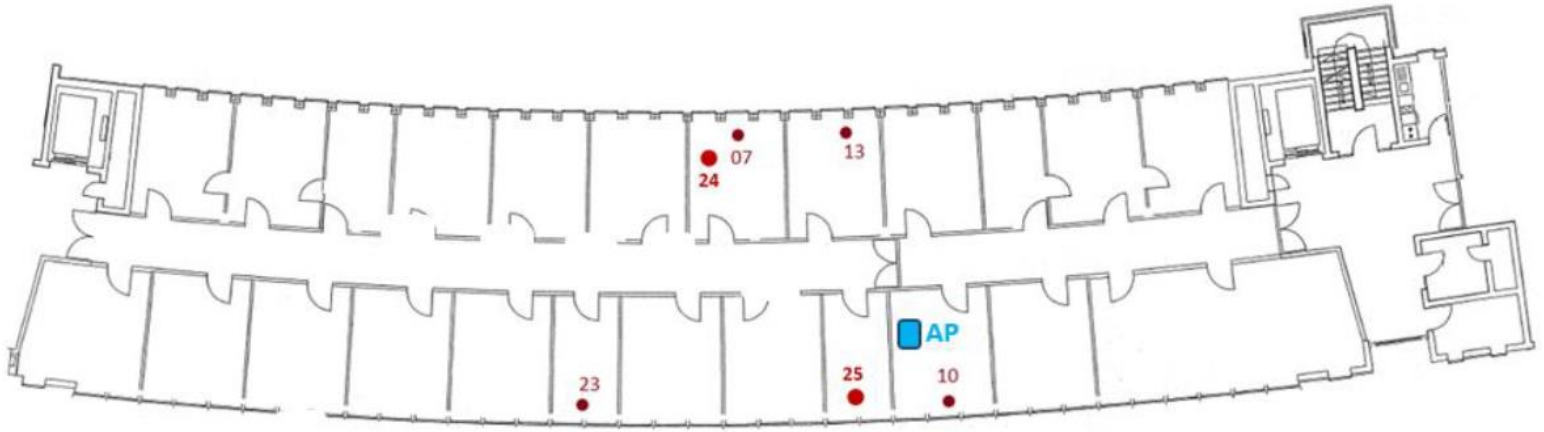


Overlap between IEEE 802.11 and 802.15.4 channels

Packet Reception Ratio



If the node does not hear the blacklist



ReSA Project

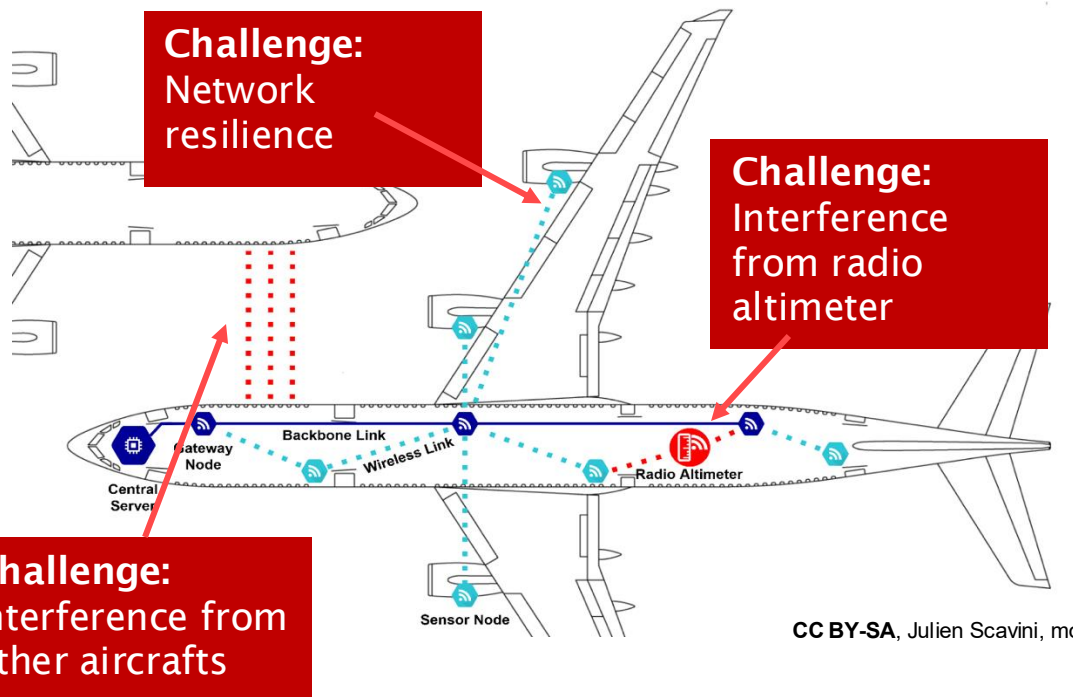
ReSA: Retrofitbare Sensorsystem-Architektur für prädiktive Instandhaltung (ReSA)

- Duration: 02/2016 – 04/2019
- Funding: BMBF KMU-Innovativ

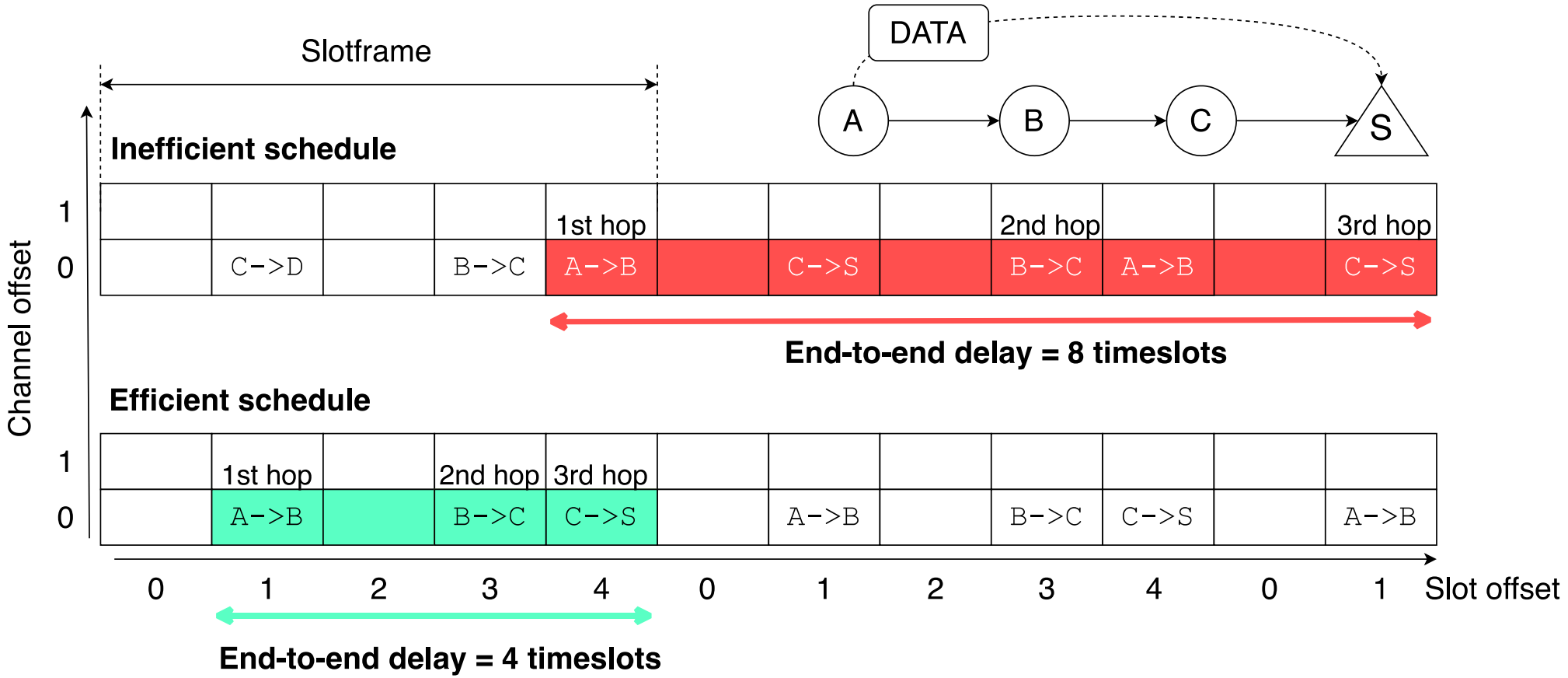
Goal: Ultra-resilient, retrofittable wireless sensor networks for use in commercial aircraft

Methods: Modeling, simulation and evaluation of reliable radio communication including:

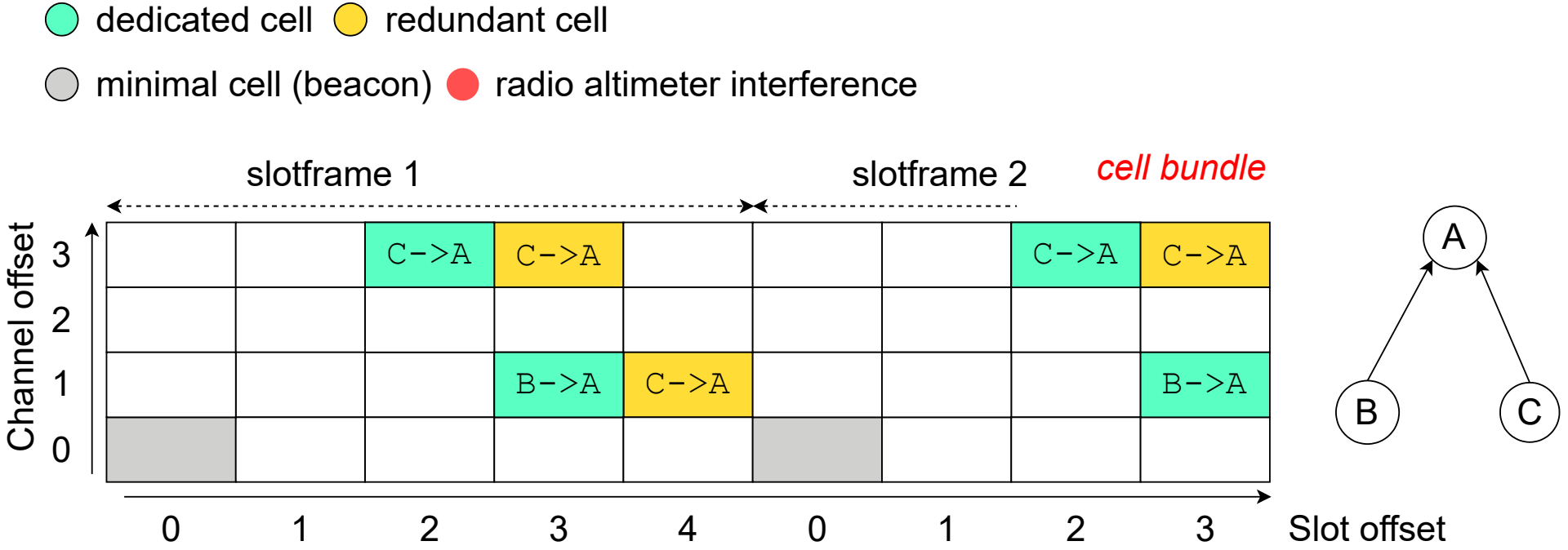
- Suitable MAC for coexistence
- Cross-layer information exchange for compliance with strict Quality of Service requirements



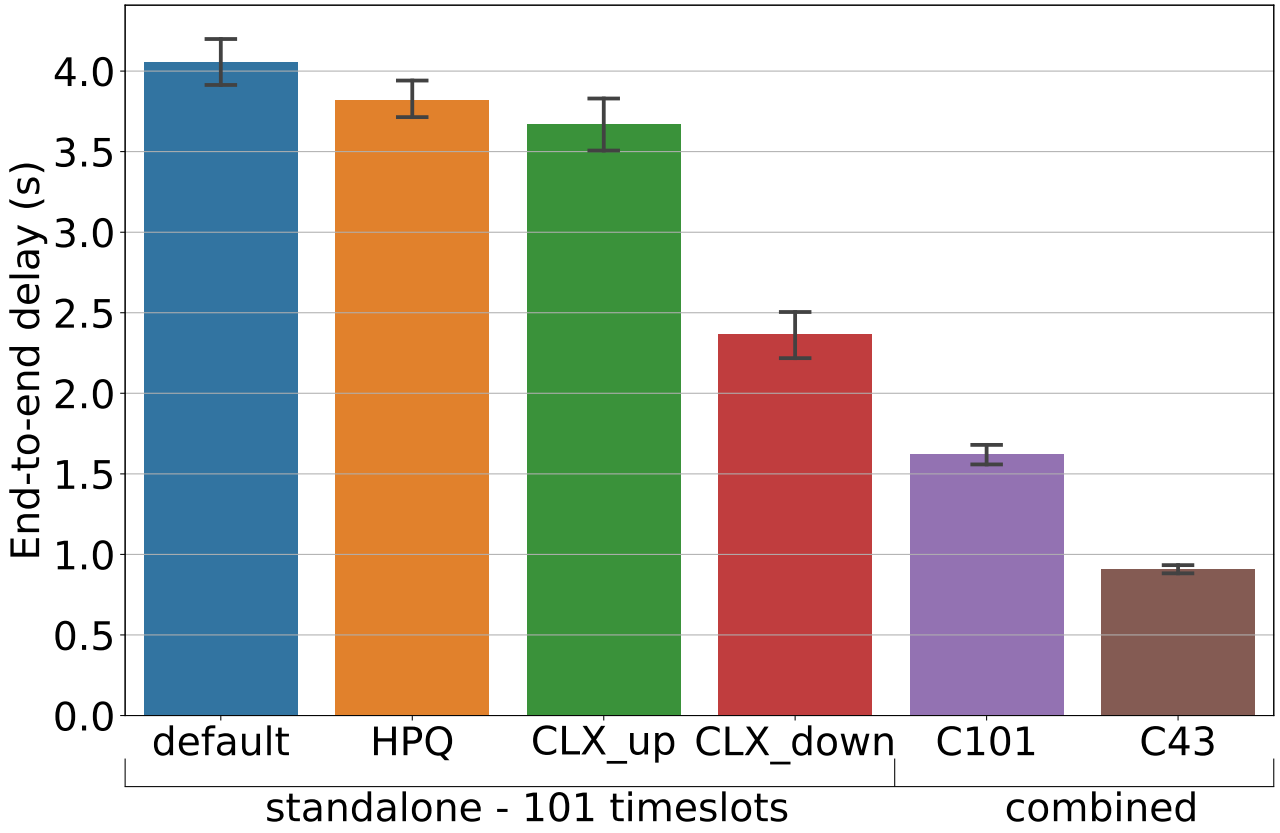
Schedule Daisy-Chaining



Cell Bundling



End-to-End Delay with Cross-Layer Optimization



End-to-end delay of the smoke alarm application under improvements

Label	Improvement
Default (6TiSCH)	-
HPQ	Traffic prioritization
CLX_up	Daisy-chaining
CLX_down	Redundancy in downlink
C101/C43	Default/reduced slotframe size