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Avoiding Local Interference in IEEE 802.15.4 TSCH Networks using a Scheduling Function with Distributed Blacklists

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Institute & Research Project

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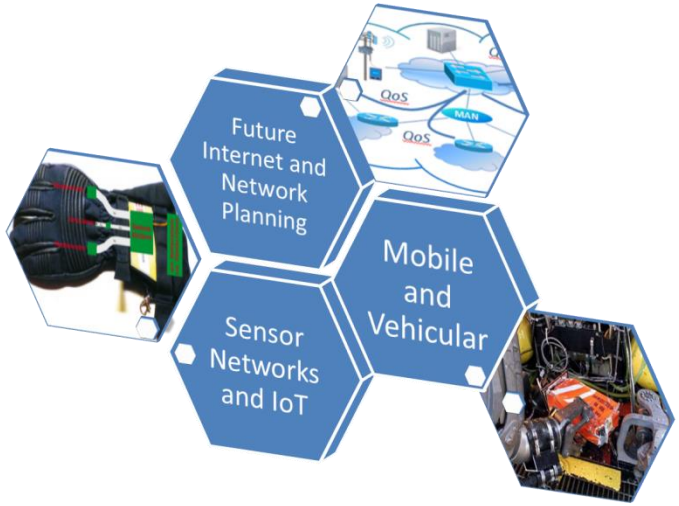


DRAISE

- *Drahtlose, robuste, adaptive, industrielle Systeme für Industrie-Automation und Produktionslogistik*
- KMU-innovativ (BMBF)
- Partner: Virtenio GmbH, TH Lübeck, Krallmann AG
- From February 2016 to April 2019

Motivation

Operation of Wireless Sensor Networks (WSN) in industrial environments

Challenges

- Interference from co-located WLANs
- Frequently changing topologies

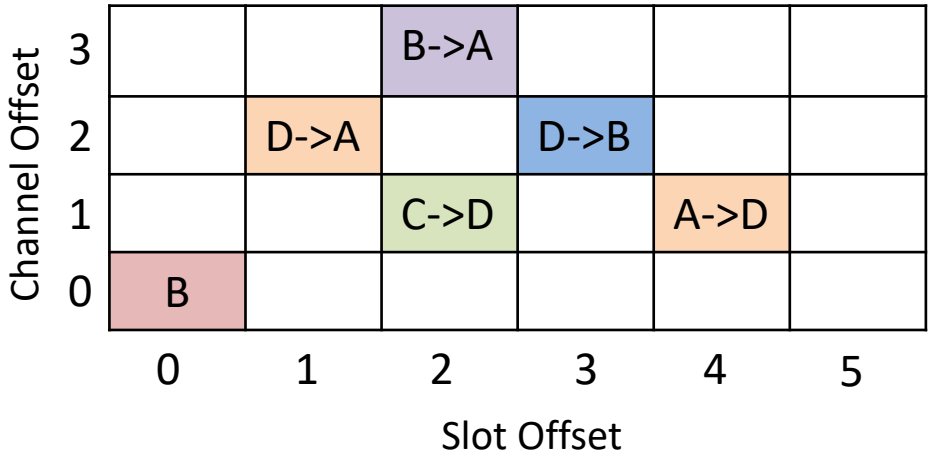
Requirements

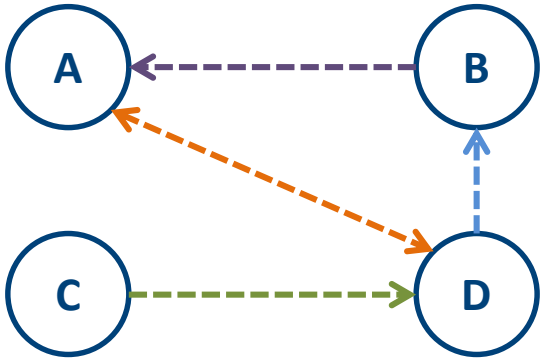
- Adaptivity
- Self-configurability

Assumptions

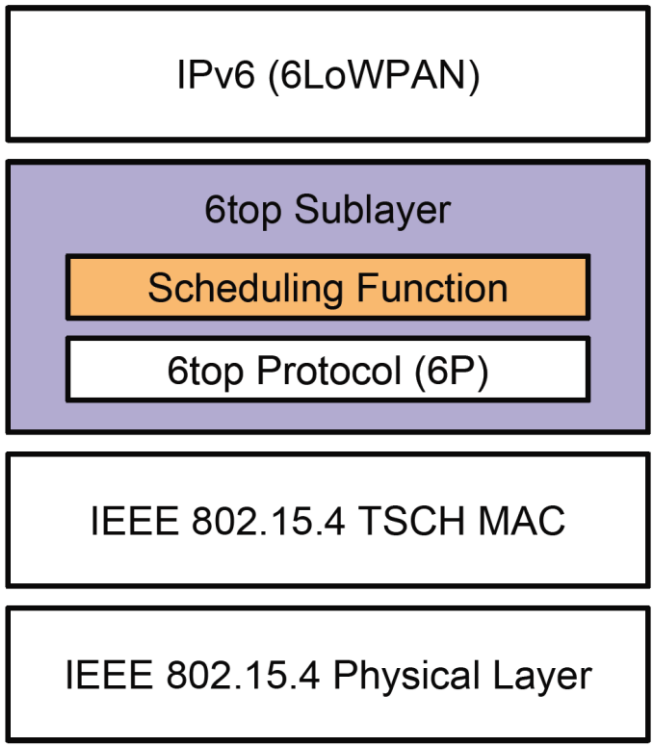
- Machines communicating with each other
- Not a tree topology
- Decentralized mesh networks
- Existing hardware
- Interference is local

Time Slotted Channel Hopping (TSCH)





IETF 6TiSCH stack



- IEEE 802.15.4 Medium Access
- TDMA and channel hopping

SF with Soft Blacklisting (SFSB)

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

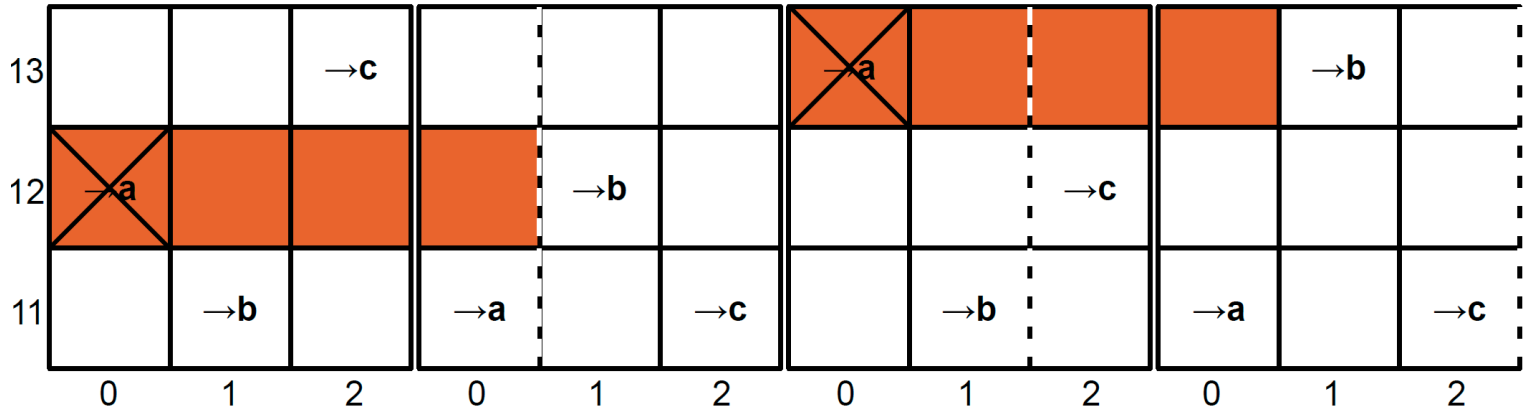
Initial Schedule Negotiation

Continuous Spectrum Sensing

Blacklisting

Interference Avoidance

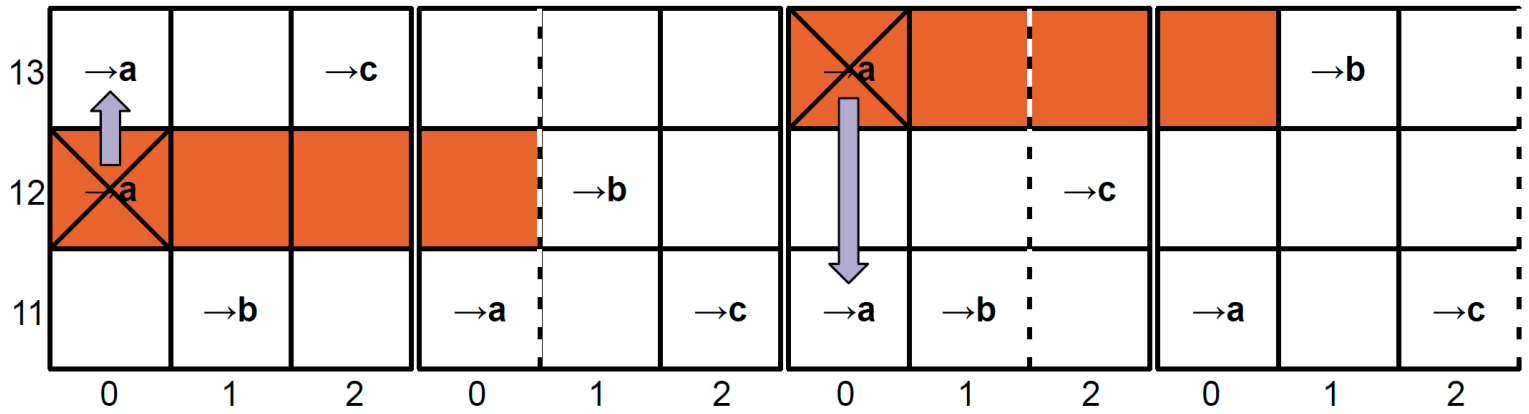
SFSB (simple)



- Nodes do not transmit on blacklisted channels (and do not have to listen)
- Reduces the interference towards the „interferer“

- Reduced amount of available ressources due to blacklisting

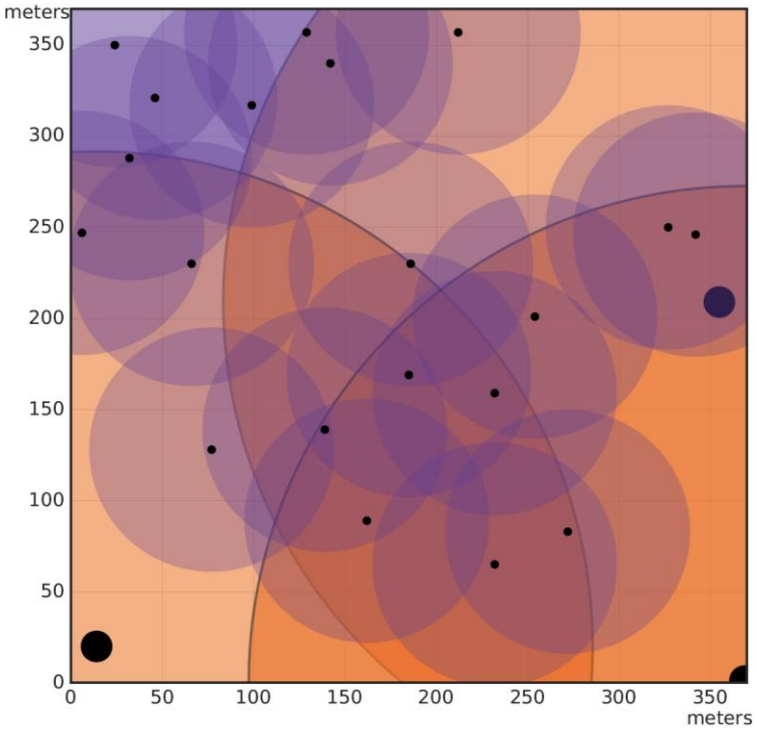
SFSB (extended)

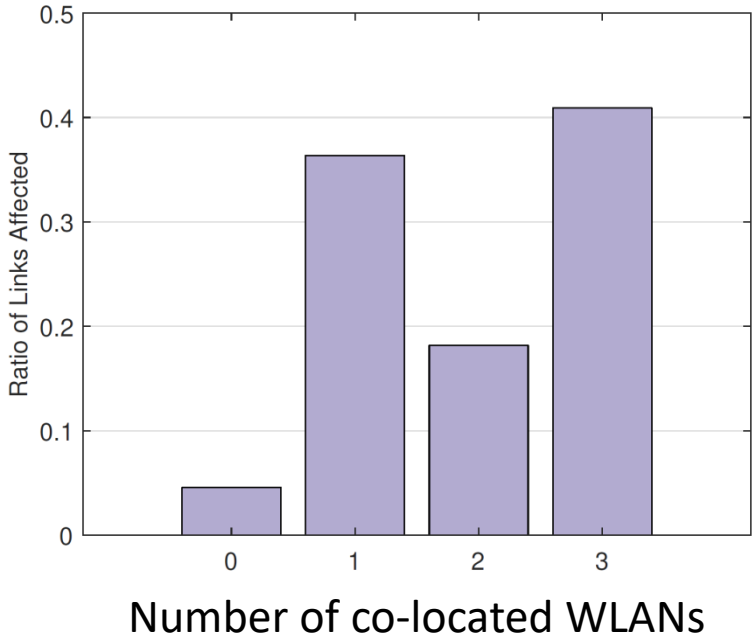


- Diverting to a non-disturbed channel based on local and neighbor blacklist
- New channel is selected iteratively until a non-blacklisted channel is found
- A well-known offset is used to not choose neighboring channels

- More resources available, but higher probability of collisions

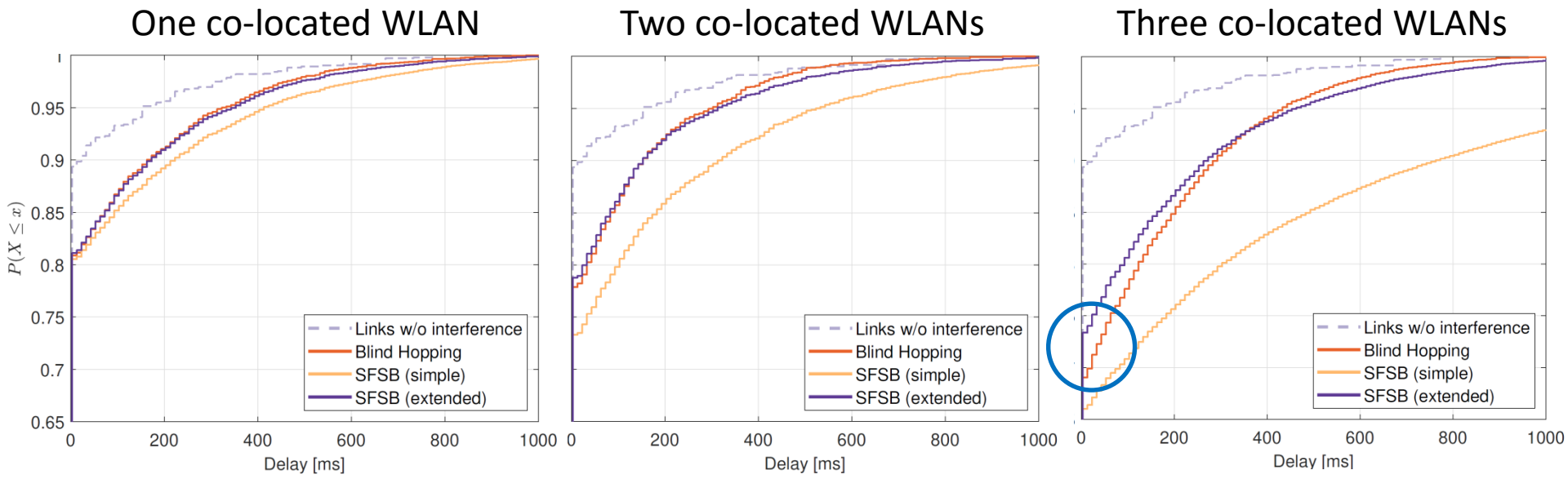
Scenario





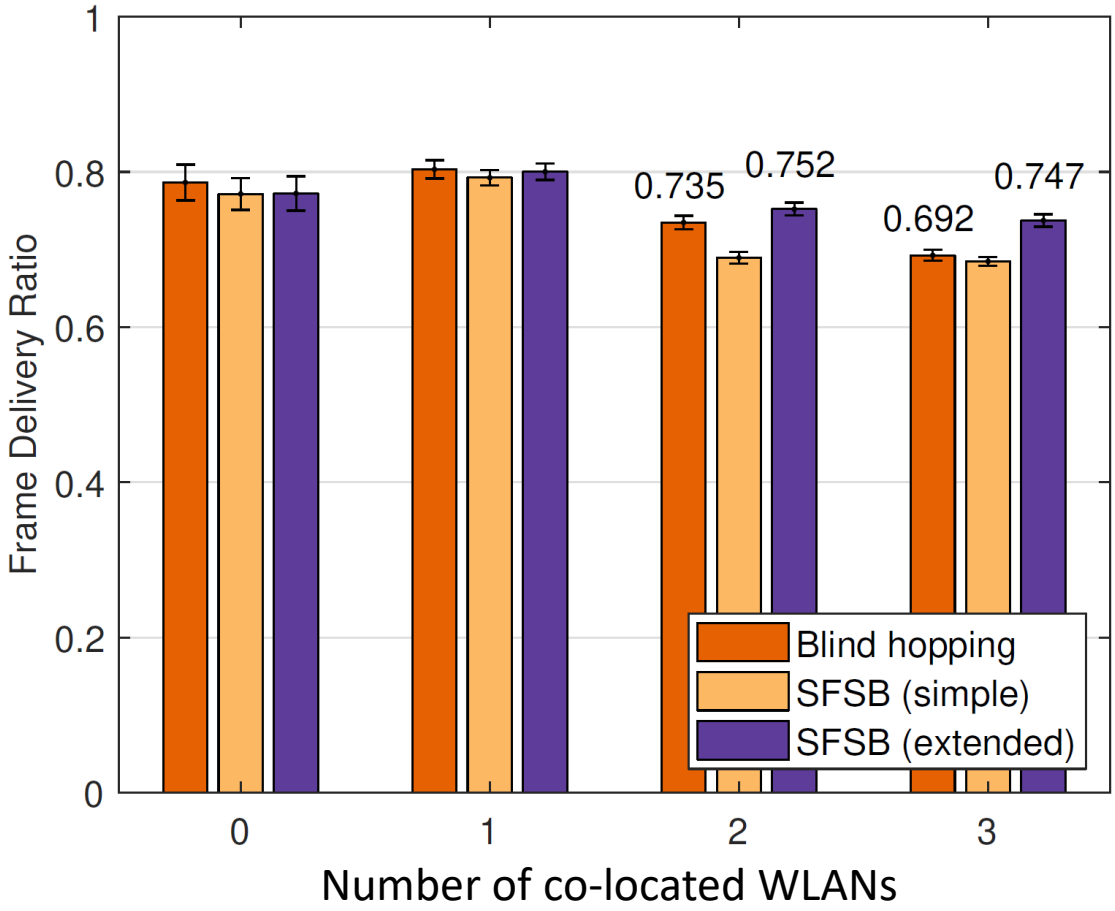
- Evaluation via OMNeT++ simulation model including TSCH, 6top sublayer, and spectrum sensing
- Clustering based on the number of co-located WLANs
- Reference: *blind channel hopping* (→ no blacklisting)

Delay



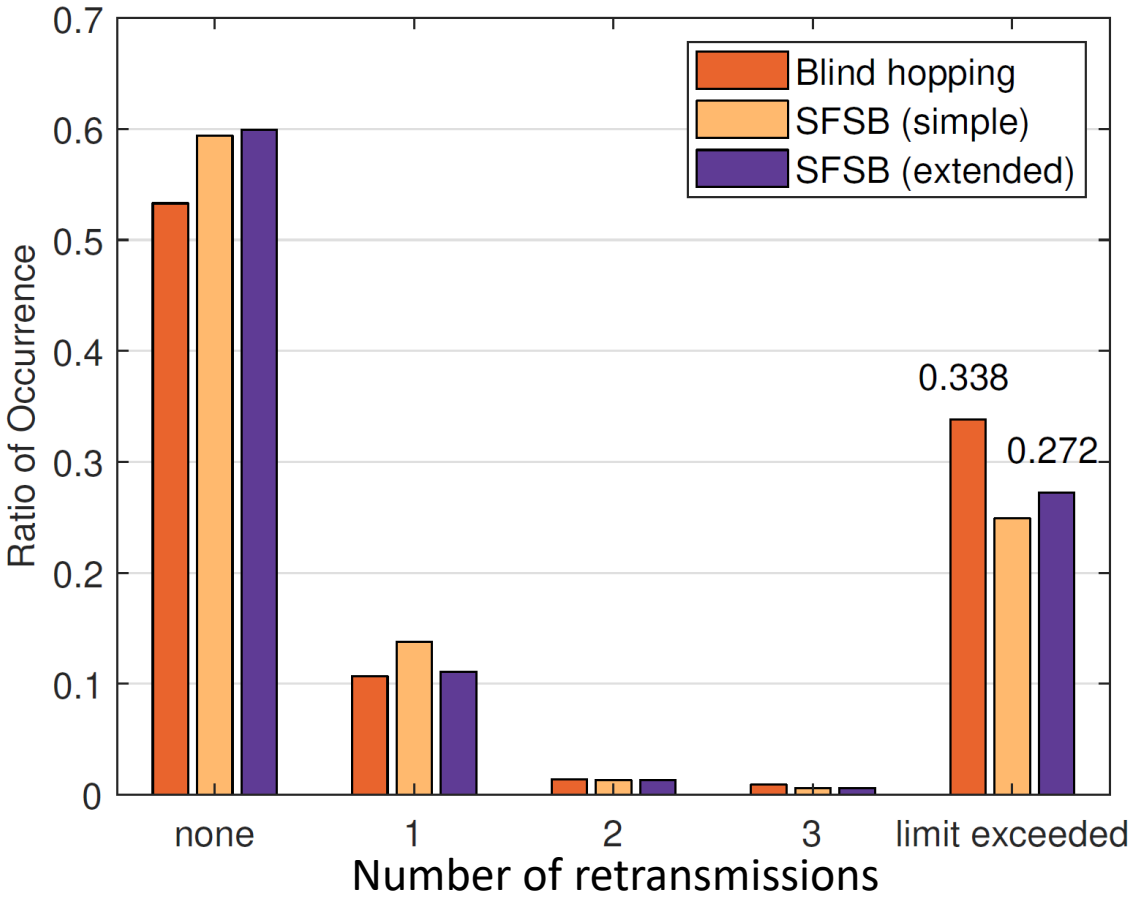
- With an increasing number of interferers, performance of **SFSB (simple)** deteriorates due to the reduced number of available ressources
- Blind Hopping and **SFSB (extended)** show a similar behaviour
- With three co-located networks, **SFSB (extended)** has a higher probability for low delays

Frame Delivery Ratio



- In case of broadband interference, **SFSB (extended)** shows a 4.5% performance increase compared to Blind hopping

Retransmissions



- For **SFSB (extended)** 6.6% less frames reach the retransmission limit

Conclusion & Future Work

- First results are promising
  - Nodes that are subject to heavy interference show a reduction in delay and number of retransmissions
- SFSB (extended) may be preferable to blind channel hopping when co-located WLAN networks cover a large part of the spectrum
- Disadvantage: Increased probability of intra-network interference

- Future work
  - Extensive analysis of SFSB to verify the performance gain, via simulations as well as testbed experiments based on Contiki
  - Comparison of different approaches for spectrum sensing
  - Adaptation to current developments within 6TiSCH Working Group
  - Open sourcing the simulation model

Thank you! Are there any questions?

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