EWSN 2019 Dependability Competition

4th Edition

Results & Presentations by the top teams

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Graz University of Technology, Austria
Competition Co-Chairs

EWSN'19: The 16th International Conference on Embedded Wireless Systems and Networks

Beijing, China - 26.02.2019

EWSN Dependability Competition Series

- 4th edition
  @ EWSN 2019
  (Beijing, China)

- 3rd edition
  @ EWSN 2018
  (Madrid, Spain)

- 2nd edition
  @ EWSN 2017
  (Uppsala, Sweden)

- 1st edition
  @ EWSN 2016
  (Graz, Austria)

Why a Dependability Competition?

- Two decades of low-power wireless networking research
  - → Reliable wireless multi-hop networking is now a reality
- Performance rarely benchmarked under the same settings!
  - → Yet unclear which protocols perform best in a given scenario
- Increasing need for a fair and objective comparison of protocol performance, especially in harsh RF environments
  - → Safety-critical IoT applications require communication protocols to convey info in a reliable, efficient, and timely manner

Why a Dependability Competition?

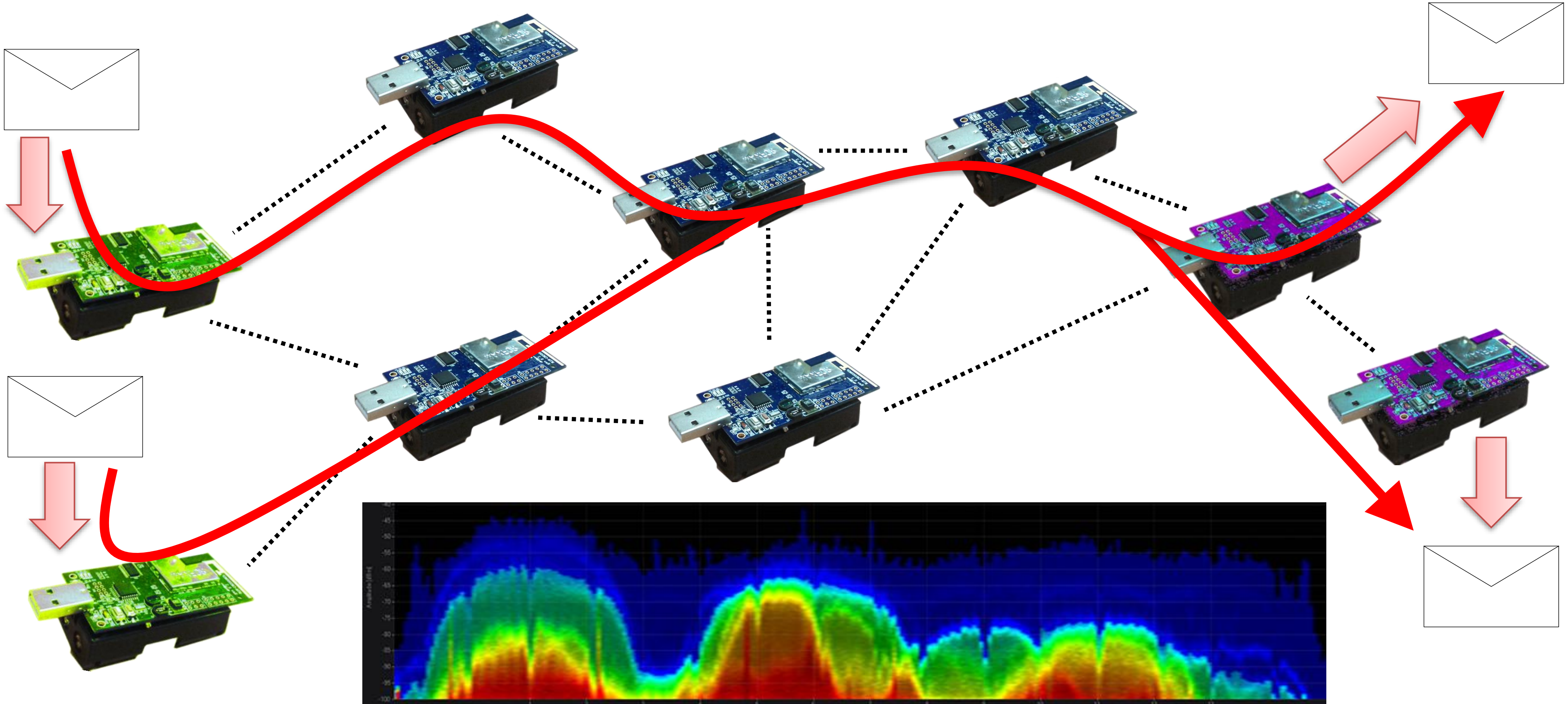
1. To define common test scenarios and to benchmark the performance of state-of-the-art IoT solutions

2. To bring academia and industry together

... and many others!

Competition: What is it all about?

- Low-power wireless communication in multi-hop harsh settings resembling an industrial wireless sensor and actuator network



Competition: What is it all about?

- Low-power wireless communication in multi-hop harsh settings resembling an industrial wireless sensor and actuator network

Do solutions allow a reliable, timely, and energy-efficient communication?

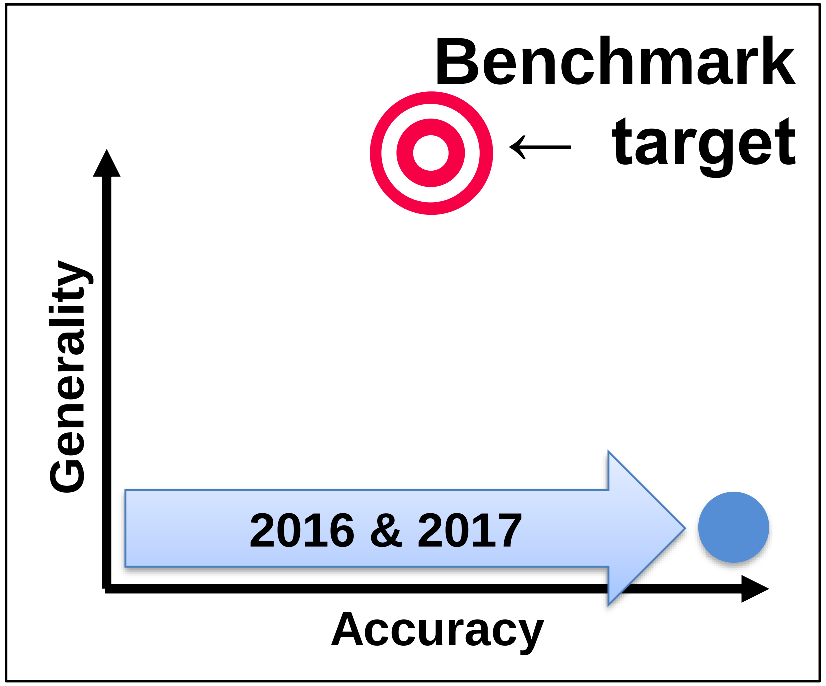
Competition Format

Competition: Evolving over the years

- 2016 & 2017: first editions
  - P2P communication only
  - Dense (2016) or sparse (2017) network
  - Hackathon-style (participants on-site)
  - Single evaluation run
  - Fixed interference type

  - 1-bit message (event detection)
  - Aperiodic traffic only
  - Fixed source/destination nodes

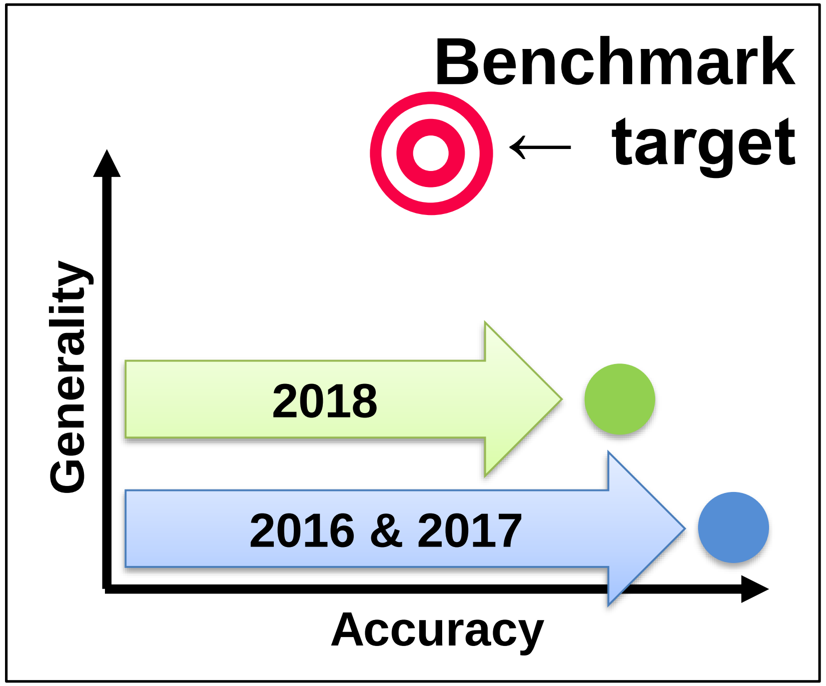
Very specific scenario, favouring engineered solutions



Competition: Evolving over the years

- 2018: raising the bar
  - ~~P2P communication only~~ → P2P, MP2P, and P2MP communication
  - ~~Dense (2016) or sparse (2017) network~~ → Both dense and sparse
  - ~~Hackathon-style (participants on-site)~~ → Remote competition (2 months)
  - ~~Single evaluation run~~ → Multiple runs
  - ~~Fixed interference type~~ → Multiple types

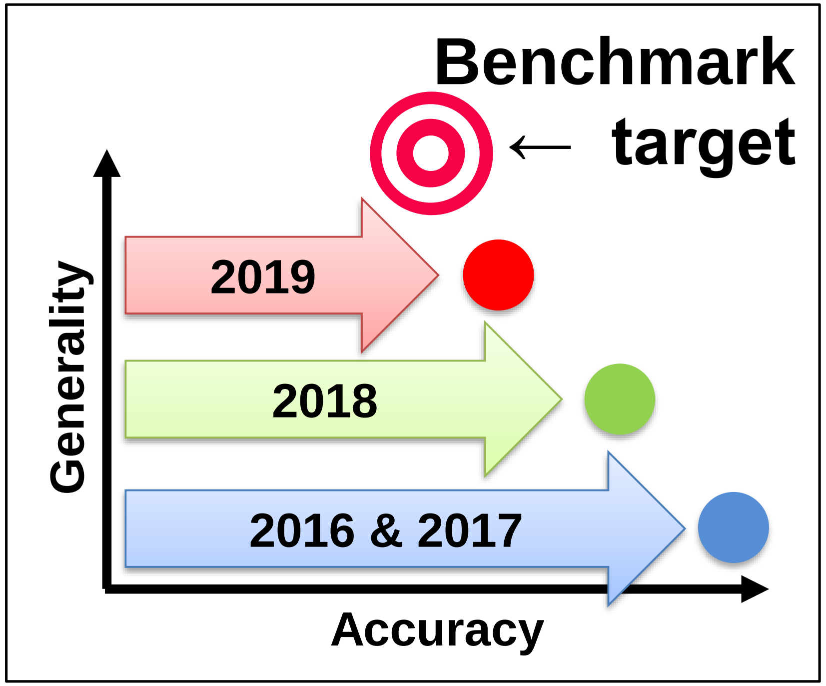
  - 1-bit message (event detection)
  - Aperiodic traffic only
  - Fixed source/destination nodes



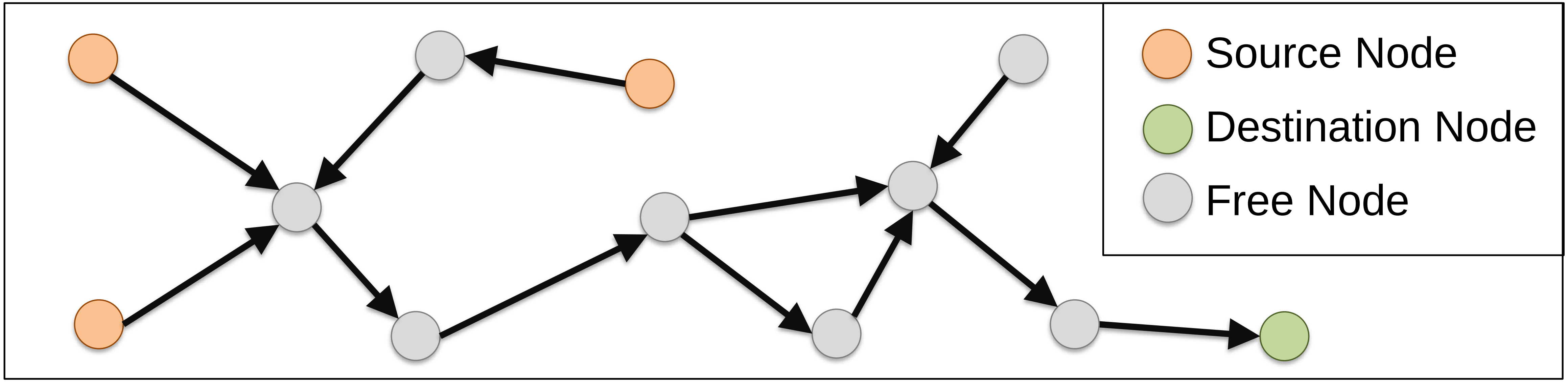
Less specific scenario, but still not fully generic!

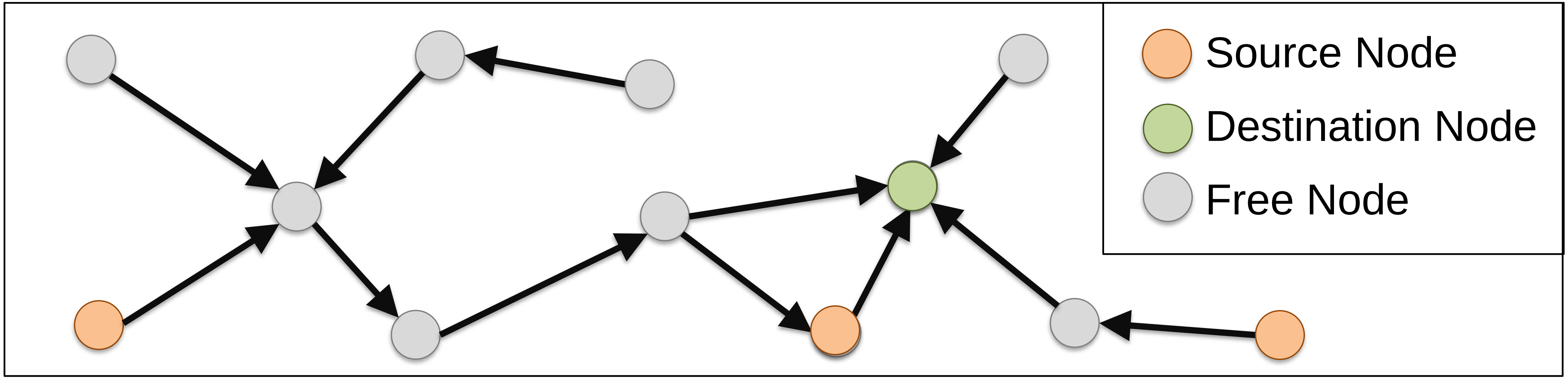
Competition: Evolving over the years

- 2019: one more step towards a general benchmark
  - ~~1-bit message (event detection)~~
    - → Different message lengths (8, 32, or 64 bytes)
  - ~~Aperiodic traffic only~~
    - → Aperiodic traffic
    - → Periodic traffic (5 or 30 seconds)
  - ~~Fixed source/destination nodes~~
    - → Different sets of source and destination nodes

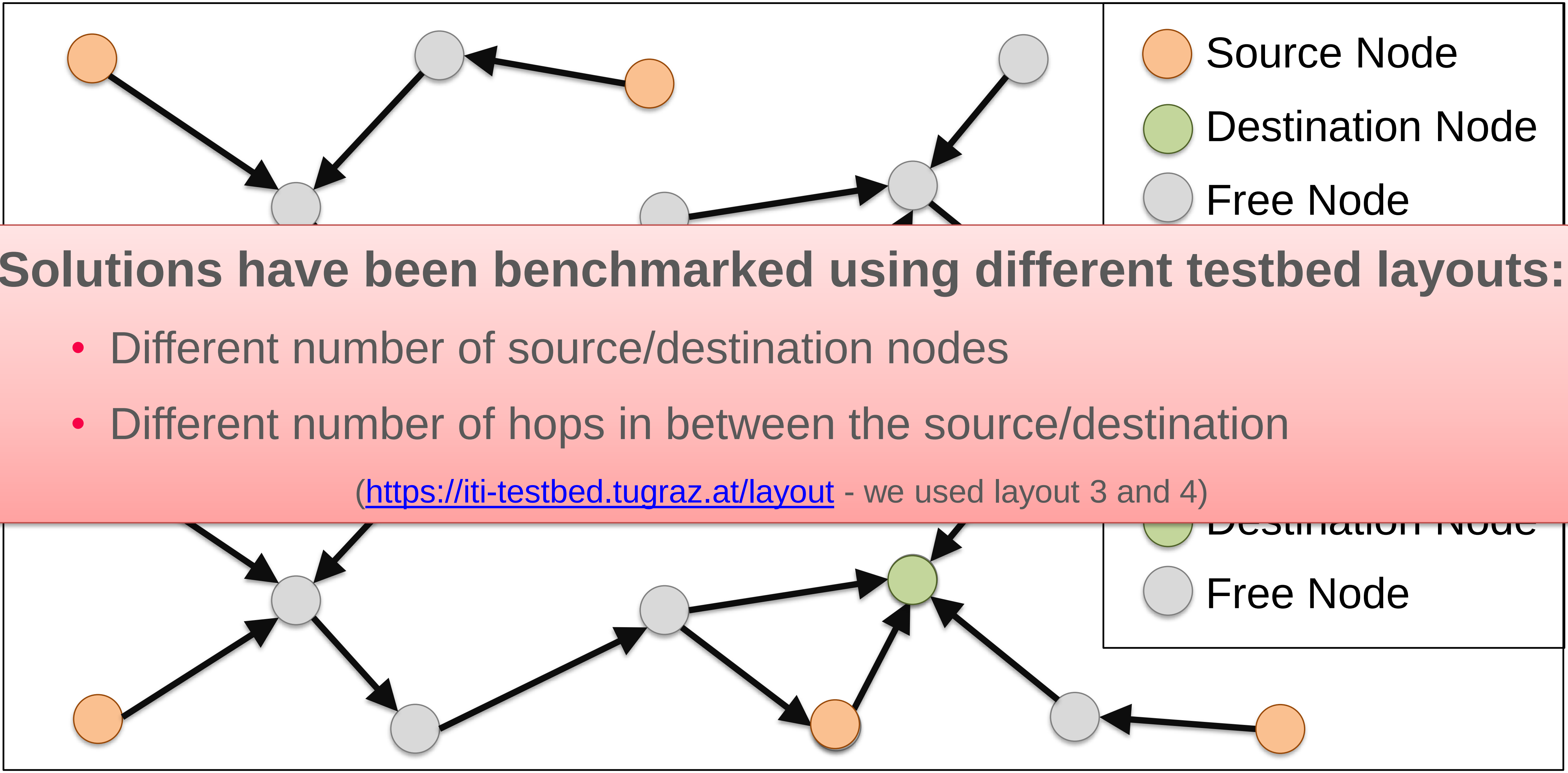


Competition: Evolving over the years





Competition: Evolving over the years



Solutions have been benchmarked using different testbed layouts:

- Different number of source/destination nodes
- Different number of hops in between the source/destination

(https://iti-testbed.tugraz.at/layout - we used layout 3 and 4)

Competition: Evolving over the years

- Benchmarking infrastructure based on D-Cube

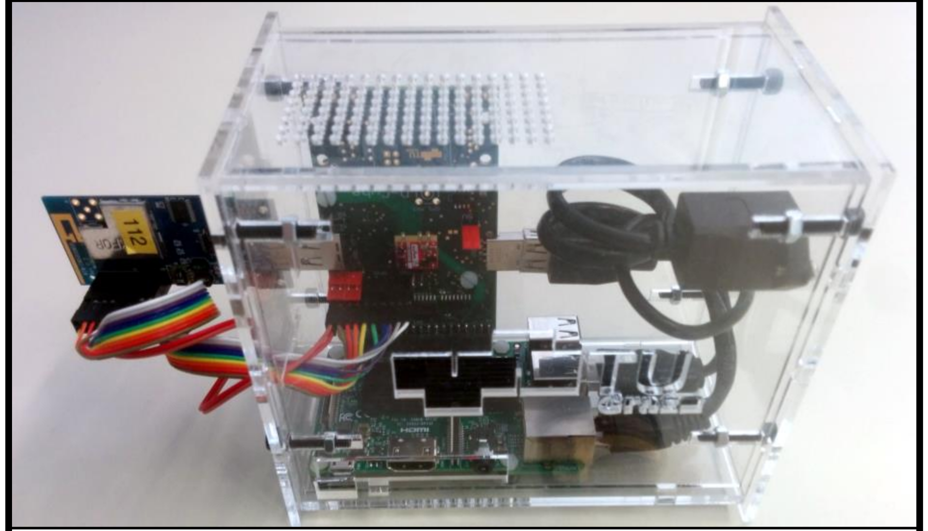
- Binary patching unit
  → Infrastructure autonomously injects input parameters into the firmware
    - # of source and destination nodes
    - ID of source and destination nodes

- Asynchronous messaging
  → Infrastructure supports TX / RX of messages of different length

- JamLab-NG for interference generation
  → Learn more tomorrow!

D-Cube v2.1

(now also available in Indriya2)



http://iti.tugraz.at/d-cube

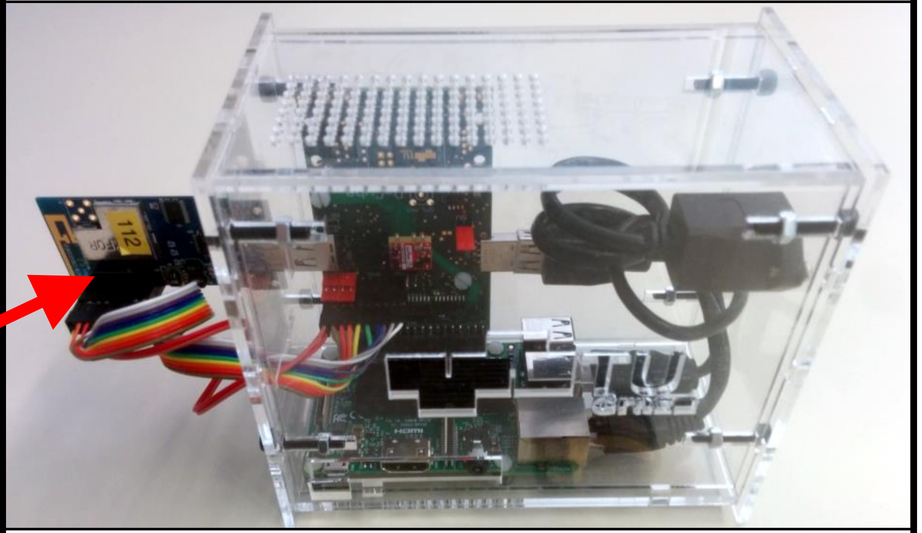
More info: M. Schuß et al. **Moving Beyond Competitions: Extending D-Cube to Seamlessly Benchmark Low-Power Wireless Systems**. In Proc. of the 1st CPSBench Workshop, 2018.

Competition: Evolving over the years

- Benchmarking infrastructure based on D-Cube
  - Unobtrusively tracing GPIO, energy consumption, and latency in hardware
  - Agnostic to the device under test (Advanticsys MTM-CM5000-MSP)
    - → Still the one available in most public testbeds
    - → Still the one for which most protocols have been developed

D-Cube v2.1

(now also available in Indriya2)



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Facts and Figures

2019 Edition: Facts and Figures

- Two categories
  1. Data collection for condition monitoring
  2. Dissemination of actuation commands

- Highest participation since 2016
  - 13 competing teams (11 in the first category, 8 in the second category)
  - 50 researchers and practitioners
  - Several countries represented (China, Cyprus, France, Germany, India, Italy, Singapore, Sweden, Switzerland, and United Kingdom)
  - Academia - Industry split: 70% - 30%

2019 Edition: Facts and Figures

- Roughly three months of (remote) preparation
  - Oct – Dec 2018
  - 4274 jobs run by all teams (up to 300 seconds each)
- Final firmware submission (Dec 23, 2018)
  - Only one single `.ihex` per category
- Two months of evaluations
  - Jan – Feb 2019
  - 3240 jobs run (of 600 seconds each)

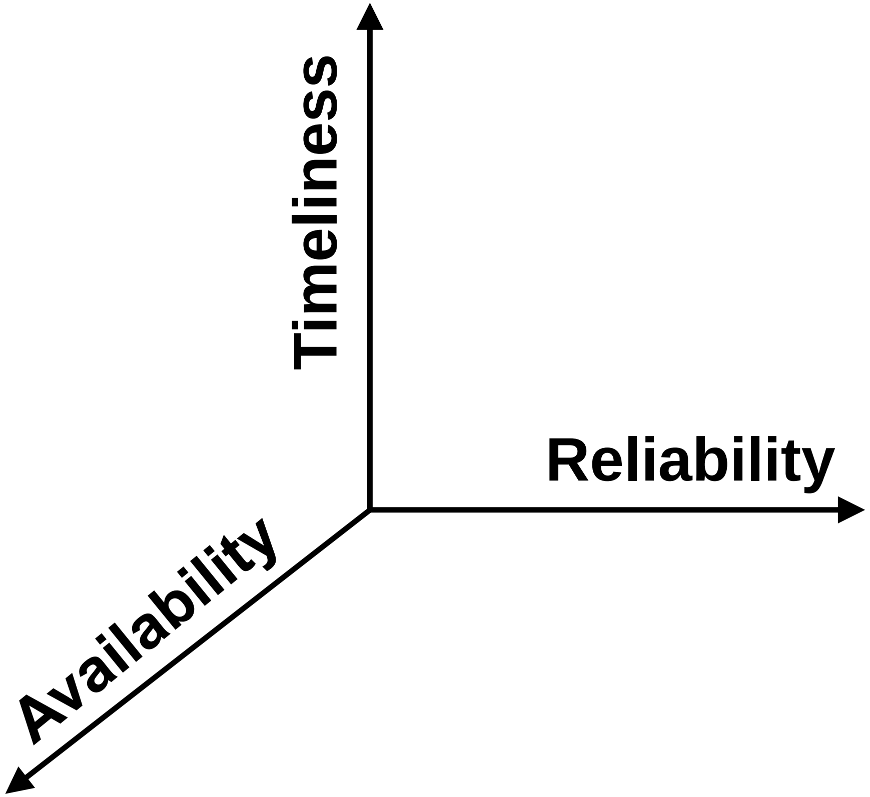
2019 Edition: Facts and Figures

- 10 teams submitted a final firmware
  - Team 01: Using DeCoT+ to Collect Data under Interference
    (X. Ma, P. Zhang, Y. Liu, X. Li, W. Tang, P. Tian, J. Wei, L. Shu, and O. Theel)
  - BASELINE Team 02: Low-Power Wireless Bus Baseline (F. Mager, R. Jacob, R. Da Forno, and M. Zimmerling)
  - Team 03: Keep it Simple, let Flooding Shine (J. Mueller, A. Schaper, R. Jacob, and R. Da Forno)
  - Team 05: Alternating Multicast with Aggregated Data Collection in Wireless Sensor Networks
    (A. Naureen and N. Zhang)
  - Team 06: Adaptive Software Defined Scheduling of Low Power Wireless Networks
    (M. Baddeley, A. Stanoev, U. Raza, Y. Jin, and M. Sooriyabandara)
  - Team 07: Centrally Scheduled Low-Power Wireless Networking for Dependable Data Collection
    (O. Harms and O. Landsiedel)
  - Team 08: Actuating Network with Multi-Channel Codecast
  - (E.K. William, P. Appavoo, M.C. Chan, and M. Mohammad)
  - Team 10: RedNodeBus, Stretching Out the Preamble
    (A. Escobar-Molero, J. Garcia-Jimenez, F. Moreno-Cruz, J. Klaue, B. Saez, F.J. Cruz, U. Ruiz, and A. Corona)
  - BASELINE Team 11: CRYSTAL Baseline (M. Trobinger, T. Istomin, A.L. Murphy, and G.P. Picco)
  - Team 12: OpenWSN, a Development Environment for 6TiSCH (T. Chang, T. Watteyne, and X. Vilajosana)

Evaluation Phase

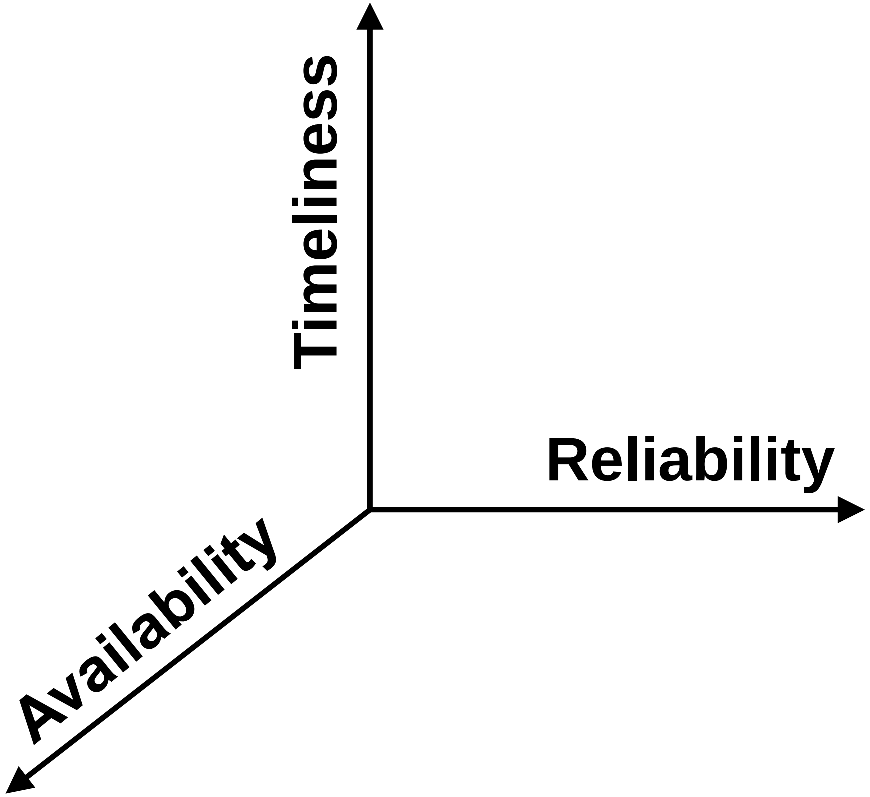
Evaluation Phase

- Three evaluation metrics
  1. Availability (energy efficiency)
     - $E_{Metric} = E_{total} - E_{setup}$
     - $\sum$ over all nodes in the network (E_{total})
     - First 60 s are excluded (E_{setup})
  2. Timeliness (end-to-end latency)
     - $L_C = (L_{mean} + L_{median}) \,/\, 2$
     - Mean heavily penalizes even for a few outliers
     - Median allows to delay some messages arbitrarily



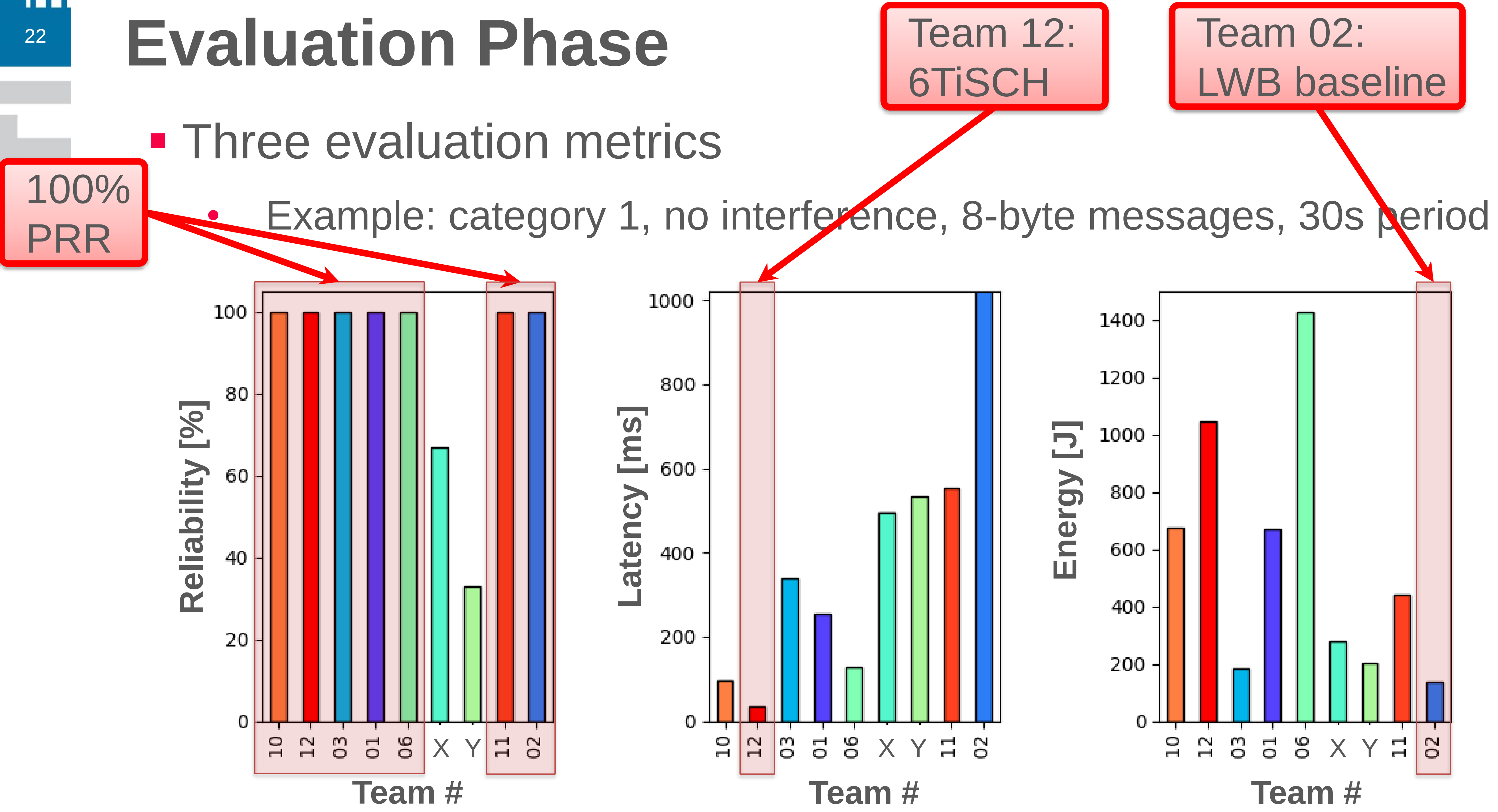
Evaluation Phase

- Three evaluation metrics
  3. Reliability (correct delivery)
     - Computes the number of messages correctly delivered
     - Reduced for duplicated or corrupted messages
     - $$R = \underbrace{\frac{C}{E_S}}_{\substack{\text{PRR} \\ \text{(correct / sent)}}} \cdot \underbrace{\left(1 - \frac{K_S \cdot S}{E_S}\right)}_{\substack{\text{Penalty for corrupt or} \\ \text{duplicate messages} \\ (K_S = 2)}} \cdot \underbrace{\left(1 - \frac{K_C \cdot O}{E_S}\right)}_{\substack{\text{Penalty when receiving a} \\ \text{message before being sent} \\ (K_C = 2)}}$$



Evaluation Phase

- Three evaluation metrics
  - Example: category 1, no interference, 8-byte messages, 30s period



Evaluation Phase

These results are only for one specific scenario!
(data collection, no interference, 8-byte messages, 30s period)

Scenarios in both category 1 and 2

- 4 types of RF interference
  (none, mild, strong, dynamic)
- 2 different node topologies
  (layout 3 and 4)
- 3 message lengths
  (8, 32 or 64 Bytes)
- 3 traffic loads
  (aperiodic, periodic 5 s, periodic 30s)

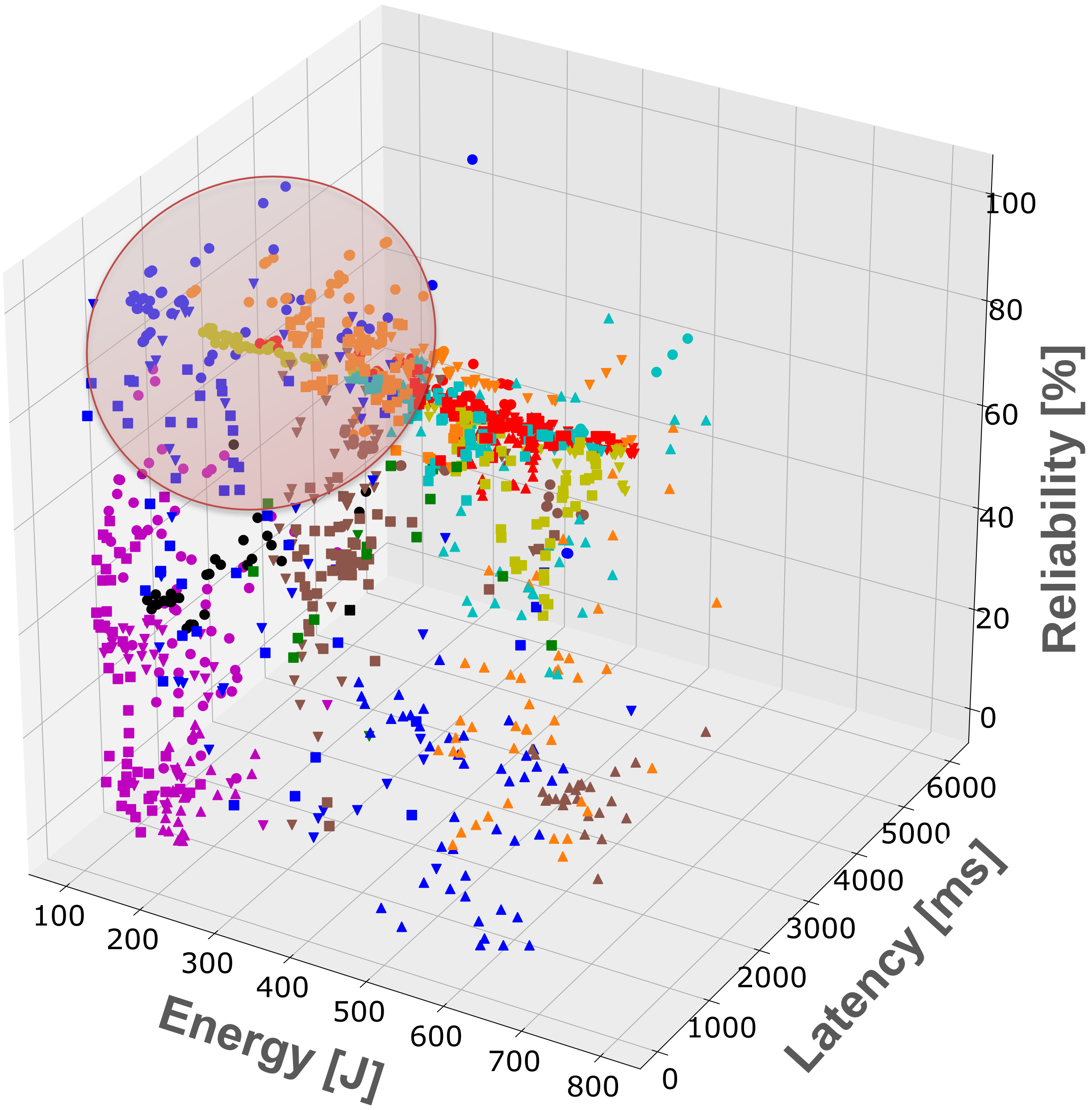
→ This means 72 permutations!

→ We look for teams performing best in most of them!

Evaluation Phase

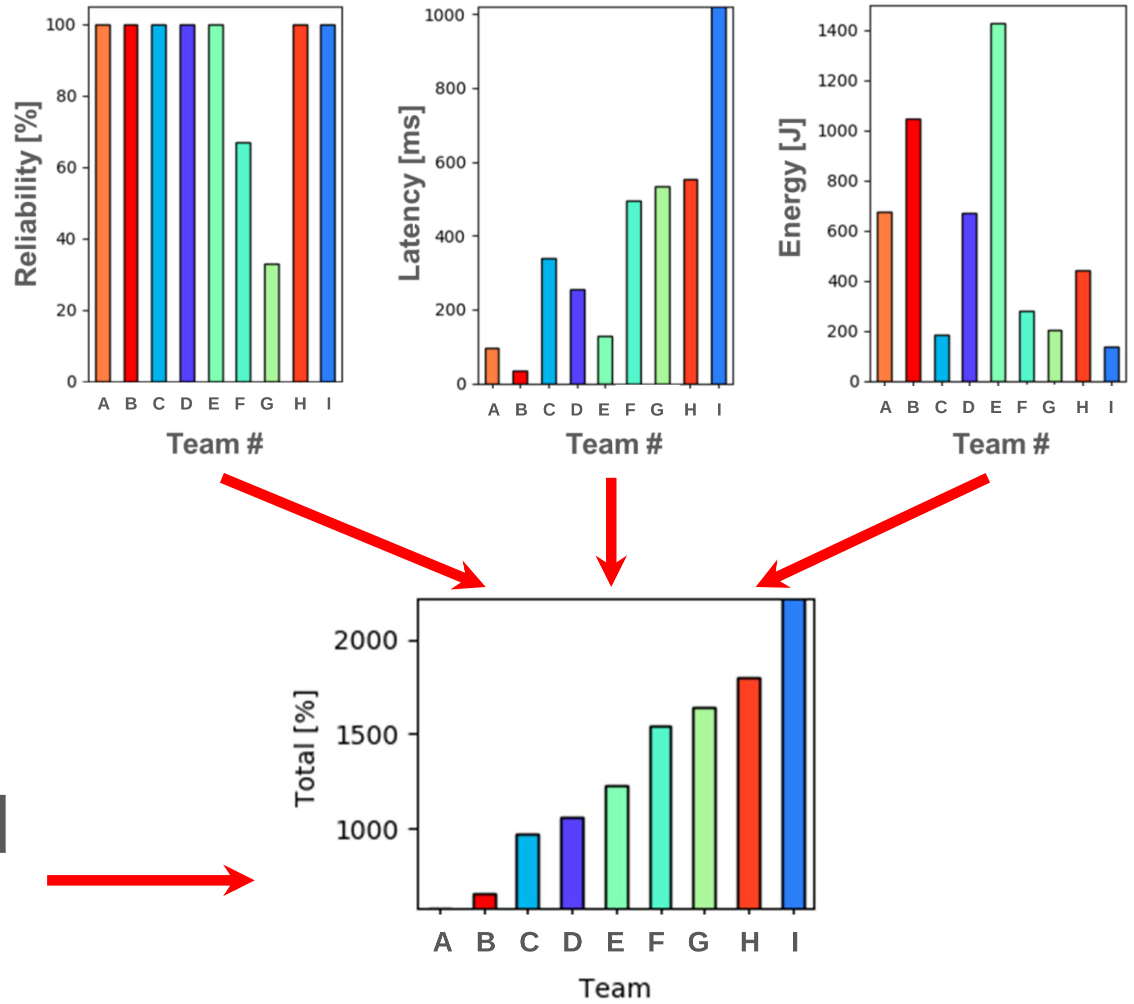
- Example: category 1 (all scenarios together)
  - Each axis is one metric
  - Colors identify teams
  - Shapes identify different interference levels

→ Too many dimensions!



Reducing Dimensions

- First step: derive a single metric (T) for each scenario
  - For each metric, consider the best absolute achieved value
  - Compute relative performance (%)
  - $T = E * K_E + L * K_L + R * K_R$
    - E = relative energy
    - L = relative latency
    - R = relative reliability
    - $K_E = K_L = 1$; $K_R = 20$ (reliability has a higher weight)
- Second step: sort teams based on T (decreasing order)

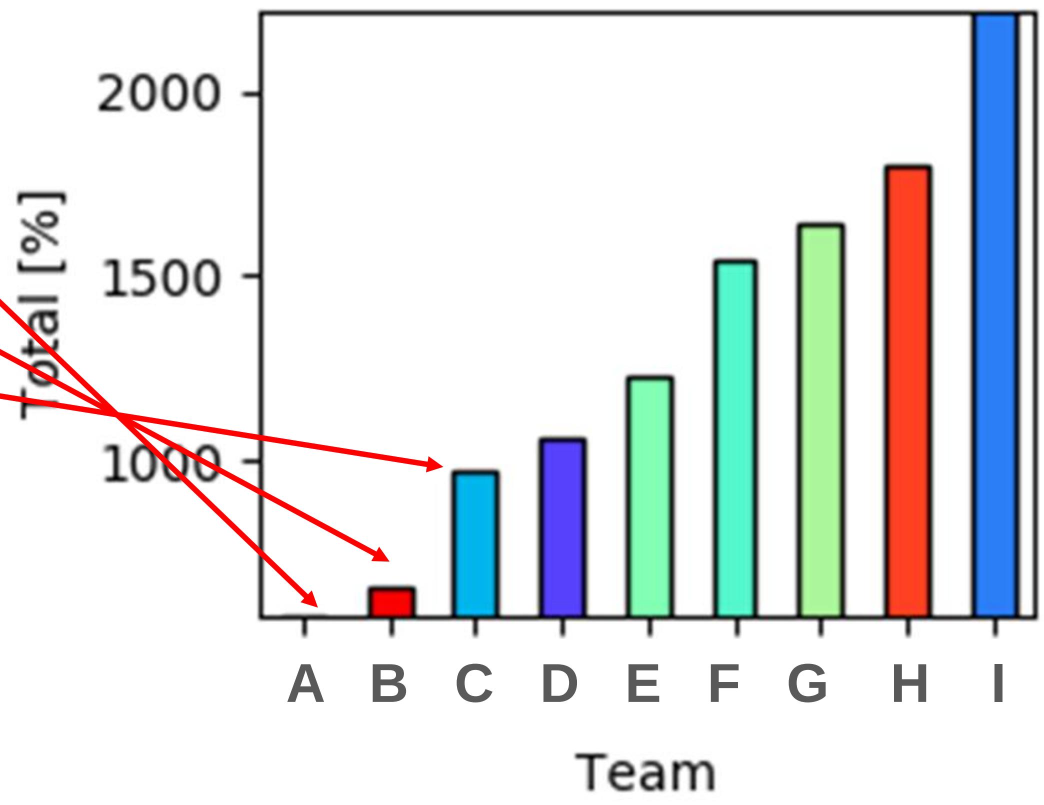


Reducing Dimensions

- Last step: assign a score to each team for every scenario

Metric	Points
1st	9
2nd	6
3rd	4
4th	3
5th	2
6th	1
7th +	0

...



Reducing Dimensions

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5^{th}	2
6^{th}	1
7^{th} +	0

- Rationale
  - Award excellence with exponential weight
    (a team that excels in most scenarios beats those having average performance)
  - If two solutions are within 10% → tie
    (same amount of points awarded)
  - Only runs with ≥ 30% reliability considered

1 score / scenario → ∑ of all 72 scenarios

Final Results

Category 1: Data Collection – WINNERS

Team 01

Using DeCoT+ to Collect Data under Interference

Xiaoyuan Ma, Peilin Zhang, Ye Liu, Xin Li, Weisheng Tang,
Pei Tian, Jianming Wei, Lei Shu, and Oliver Theel

Shanghai Advanced Research Institute, Chinese Academy of Sciences, China
ShanghaiTech University, School of Information Science & Technology, China
University of Chinese Academy of Sciences, China
Carl von Ossietzky University of Oldenburg, Germany
Nanjing Agricultural University, China

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Category 1: Data Collection – RESULTS

- 1st place

  Using DeCoT+ to Collect Data under Interference
  Team 01: X. Ma, P. Zhang, Y. Liu, X. Li, W. Tang, P. Tian, J. Wei, L. Shu, and O. Theel

- 2nd place (ex-aequo)

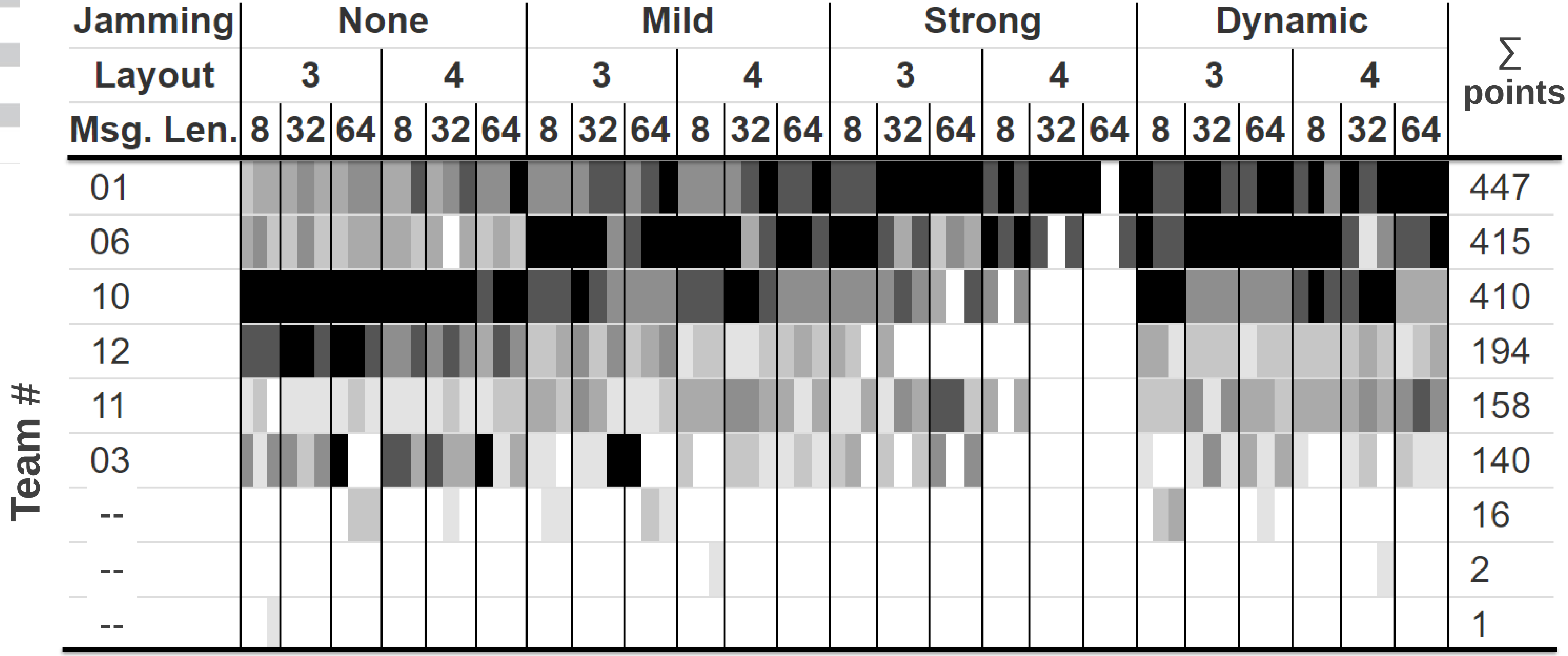
  Adaptive Software Defined Scheduling of Low Power Wireless Networks
  Team 06: M. Baddeley, A. Stanoev, U. Raza, Y. Jin, and M. Sooriyabandara

  RedNodeBus, Stretching Out the Preamble
  Team 10: A. Escobar-Molero, J. Garcia-Jimenez, F. Moreno-Cruz, J. Klaue, B. Saez, F.J. Cruz, U. Ruiz, and A. Corona

- 4th place

  OpenWSN, a Development Environment for 6TiSCH
  Team 12: T. Chang, T. Watteyne, and X. Vilajosana

Category 1: Data Collection – RESULTS



Legend 9 6 4 3 2 1

- From left to right, for each message length: aperiodic, periodic 5s, periodic 30s

Category 1: Data Collection – RESULTS

Team #

Jamming	None						Mild						Strong						Dynamic						Σ points
Layout	3			4			3			4			3			4			3			4			
Msg. Len.	8	32	64	8	32	64	8	32	64	8	32	64	8	32	64	8	32	64	8	32	64	8	32	64	
01																									447
06																									415
10																									410
12																									194
11																									158
03																									140
--																									16
--																									2
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Team #

Legend 9 6 4 3 2 1

- From left to right, for each message length: aperiodic, periodic 5s, periodic 30s

Category 2: Dissemination – WINNERS

Team 10

RedNodeBus, Stretching Out the Preamble

Antonio Escobar-Molero, Javier Garcia-Jimenez, Jirka Klaue,
Fernando Moreno-Cruz, , Borja Saez, Francisco J. Cruz,
Unai Ruiz, and Angel Corona

Infineon Technologies AG, Germany
Bernitz Electronics GmbH, Germany
eesy-innovations GmbH, Germany
RedNodeLabs, Germany

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Category 2: Dissemination – RESULTS

- 1st place

  RedNodeBus, Stretching Out the Preamble

  Team 10: A. Escobar-Molero, J. Garcia-Jimenez, F. Moreno-Cruz, J. Klaue, B. Saez, F.J. Cruz, U. Ruiz, and A. Corona

- 2nd place

  Adaptive Software Defined Scheduling of Low Power Wireless Networks

  Team 06: M. Baddeley, A. Stanoev, U. Raza, Y. Jin, and M. Sooriyabandara

- 3rd place

  CRYSTAL

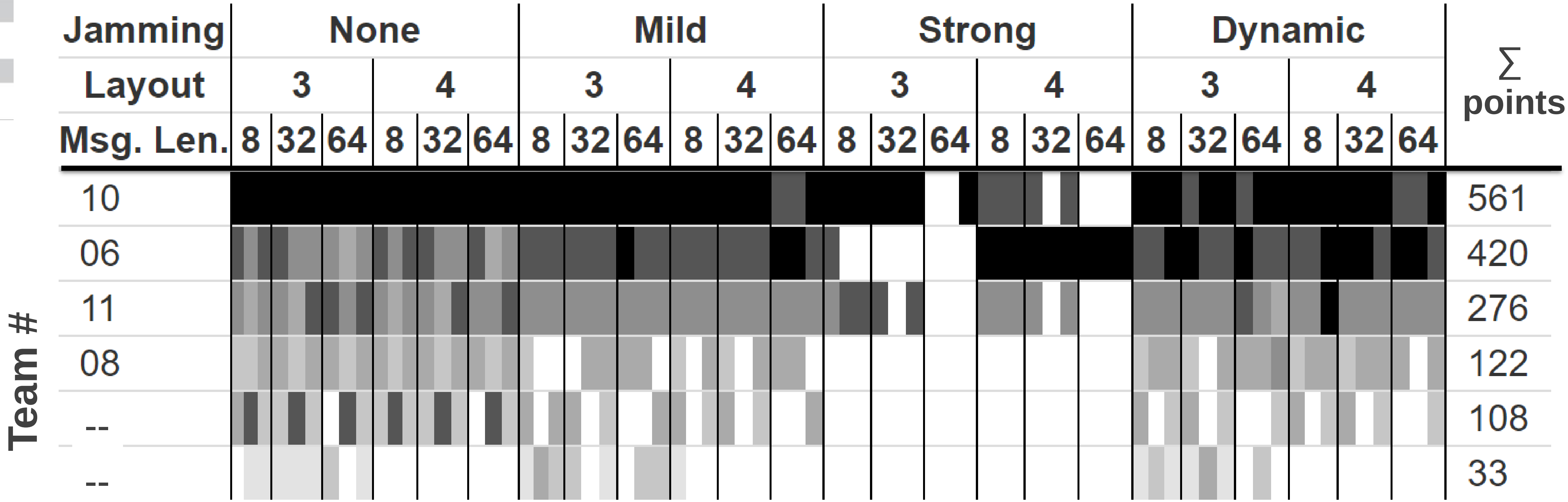
  Team 11: M. Trobinger, T. Istomin, A.L. Murphy, and G.P. Picco

- 4th place

  Actuating Network with Multi-Channel Codecast

  Team 08: E.K. William, P. Appavoo, M.C. Chan, and M. Mohammad

Category 2: Dissemination – RESULTS



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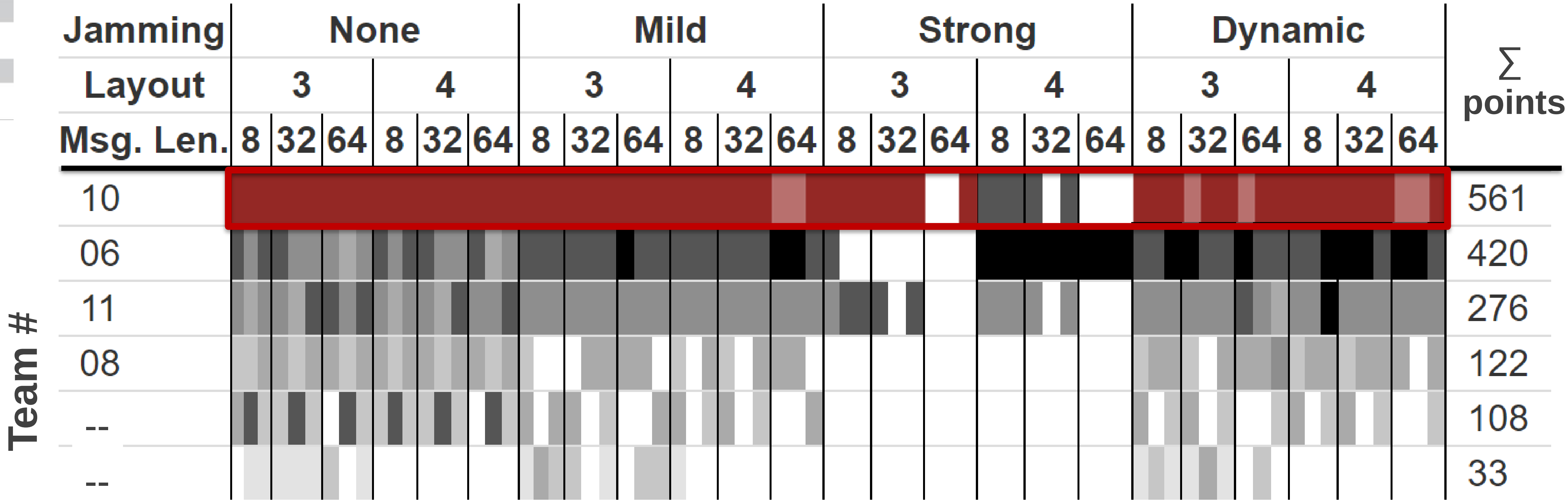
Category 2: Dissemination – RESULTS



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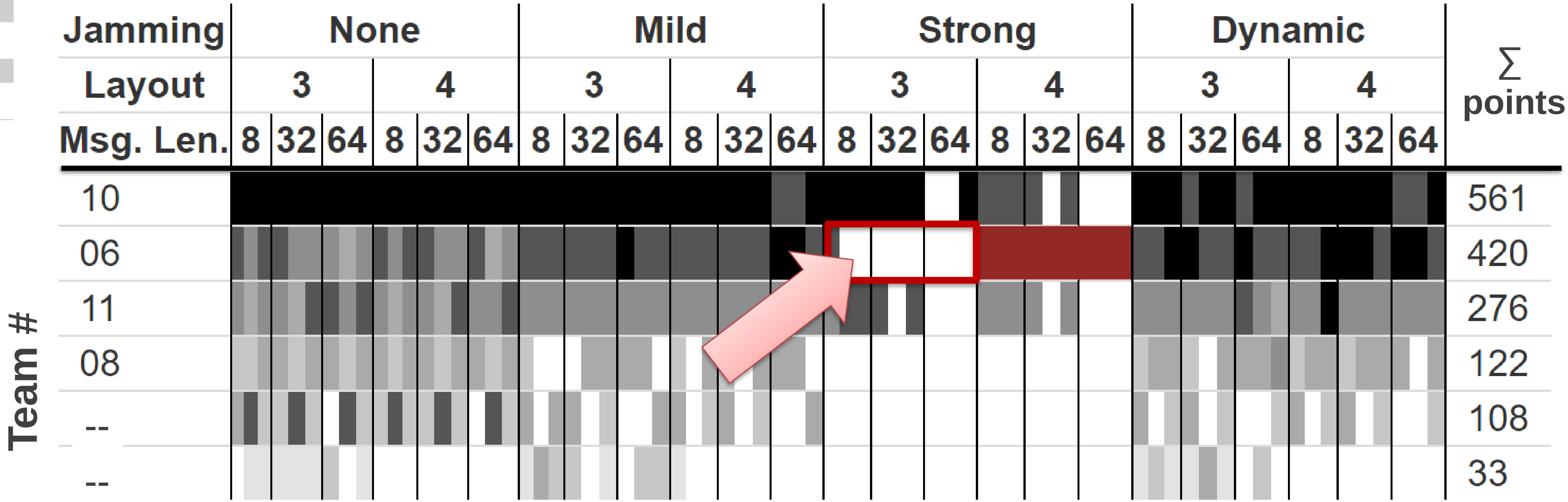
Category 2: Dissemination – RESULTS



Legend 9 6 4 3 2 1

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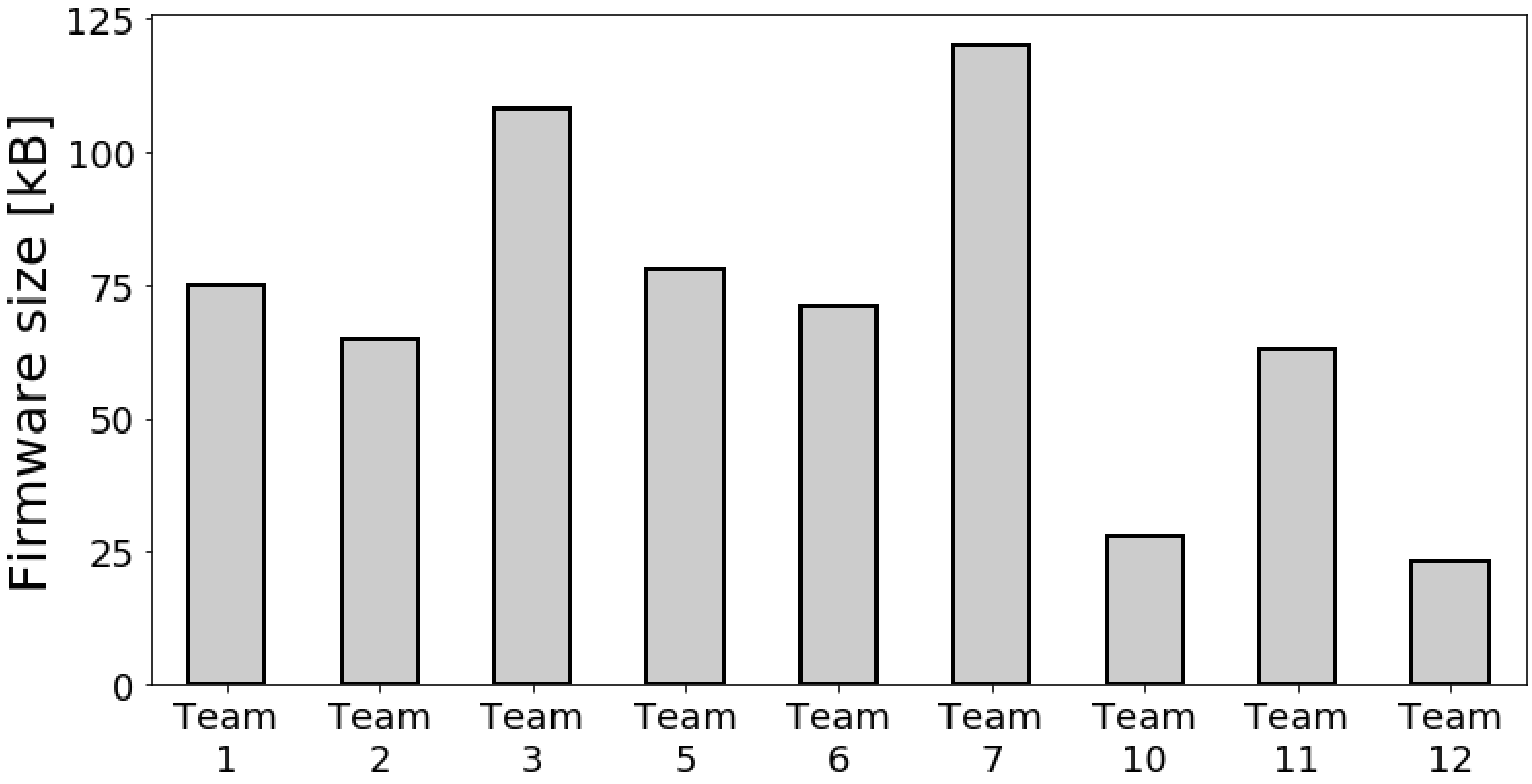
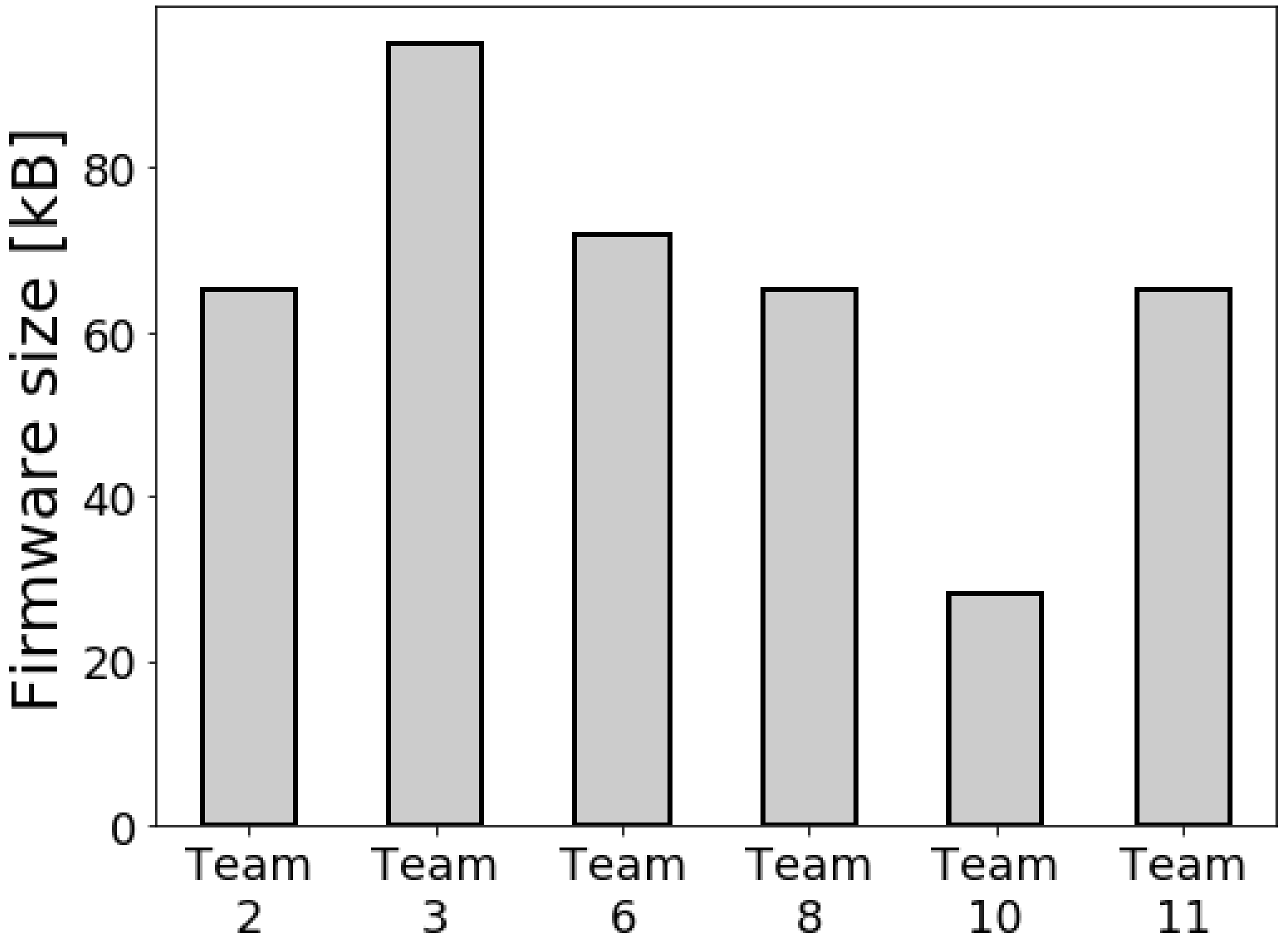
Firmware Size

- Category 1: Data collection



Firmware Size

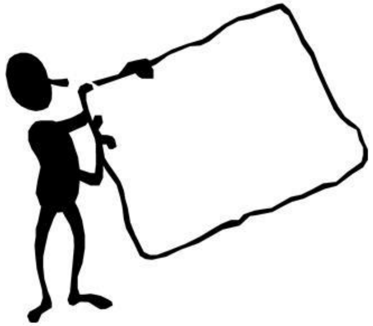
- Category 2: Dissemination



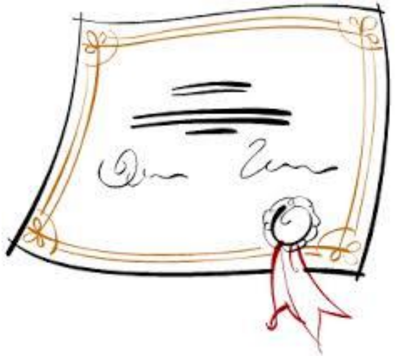
What’s Next?

- Presentations of the top teams
  - Category 1: Team 01, Team 06, Team 10
  - Category 2: Team 06, Team 10

- Poster session (17:30 – 19:00)
  - Meet and speak to all contestants!



- Awards ceremony
  - Tonight, during the banquet!



Presentation of Top Teams

Team 01

Among the top 3 teams in category 1 (“Data collection”)

Using DeCoT+ to Collect Data under Interference

Xiaoyuan Ma, Peilin Zhang, Ye Liu, Xin Li, Weisheng Tang,
Pei Tian, Jianming Wei, Lei Shu, and Oliver Theel

Shanghai Advanced Research Institute, Chinese Academy of Sciences, China
ShanghaiTech University, School of Information Science & Technology, China
University of Chinese Academy of Sciences, China
Carl von Ossietzky University of Oldenburg, Germany
Nanjing Agricultural University, China

EWSN 2019
Dependability Competition

Using DeCoT+ to Collect Data Under Interference

Category I: Data Collection for Condition Monitoring

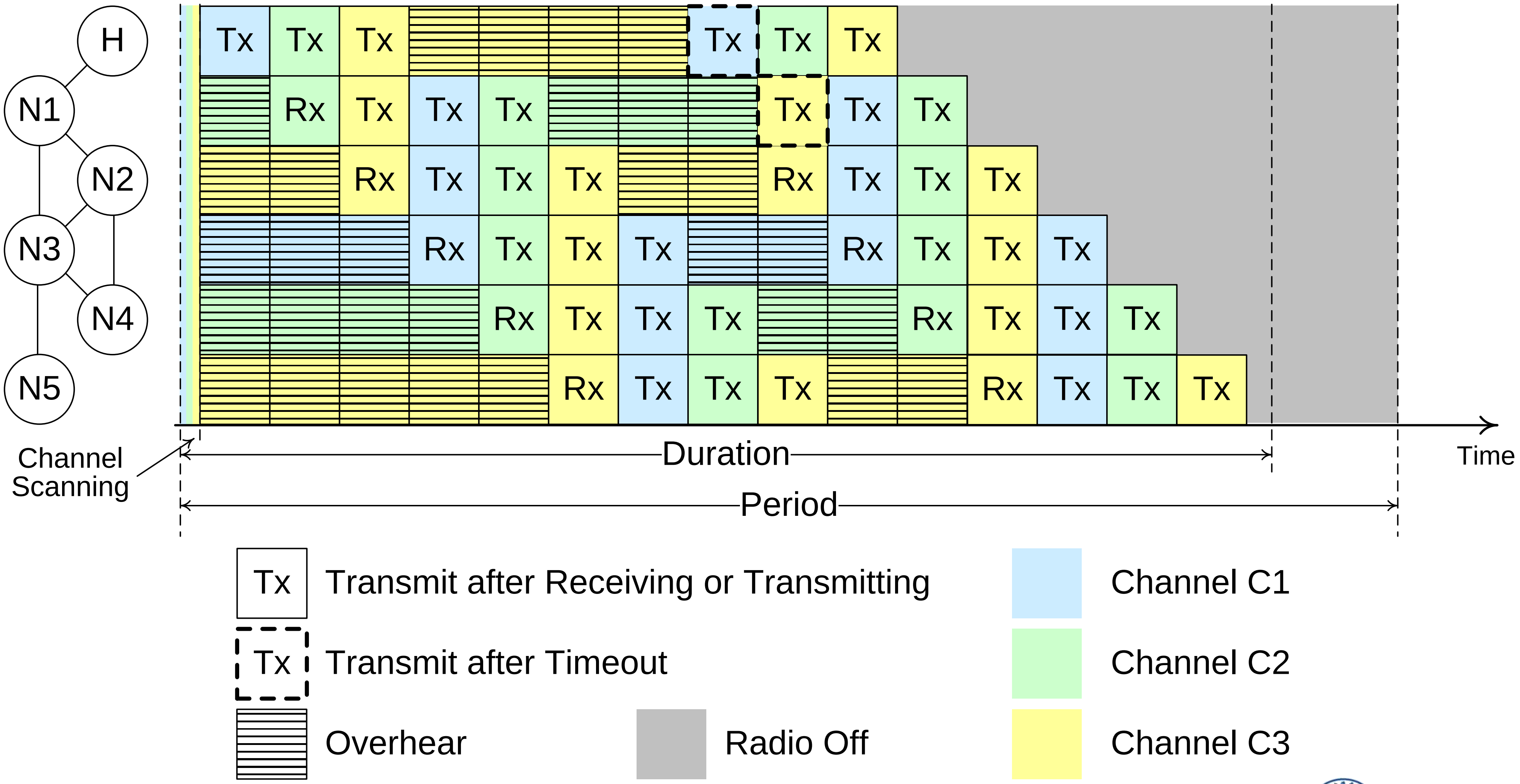
Xiaoyuan Ma[1,3], Peilin Zhang[4], Ye Liu[5], Xin Li[2], Weisheng Tang[1,3], Pei Tian[1,3], Jianming Wei[1], Lei Shu[5], Oliver Theel[4]

1. Shanghai Advanced Research Institute, Chinese Academy of Sciences, China
2. ShanghaiTech University, School of Information Science & Technology, China
3. University of Chinese Academy of Sciences, China
4. Carl von Ossietzky University of Oldenburg, Germany
5. Nanjing Agricultural University, China

http://www.sari.cas.cn

DeCoT+: Based on DeCoT [1]

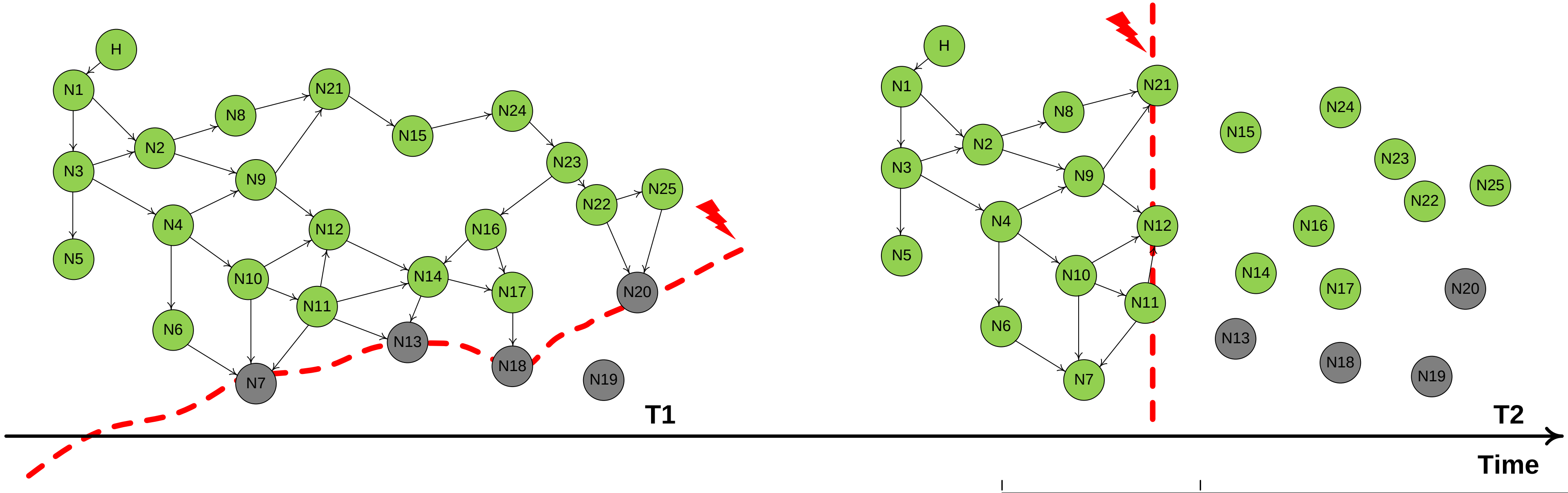
Channel Hopping Mechanism: Scan-and-Lock

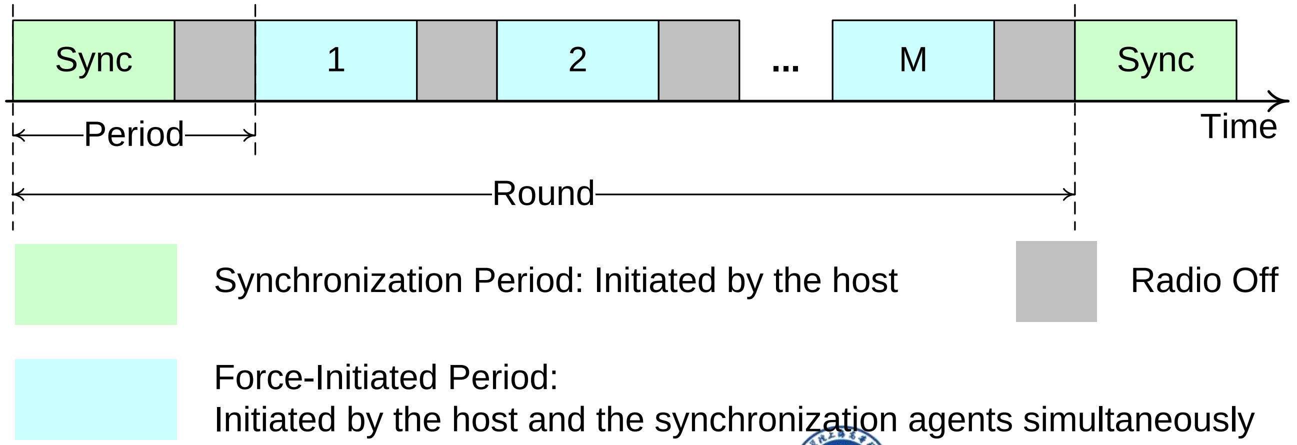


[1] Ma, Xiaoyuan, et al. "DeCoT: A Dependable Concurrent Transmission-Based Protocol for Wireless Sensor Networks." *IEEE Access* 6 (2018): 73130-73146.

DeCoT+: Based on DeCoT [1]
Decentralized Mechanism: Force-Initiated Mechanism

Interference unexpectedly partitions a CT-based network: Gray nodes would never synchronize with the host.





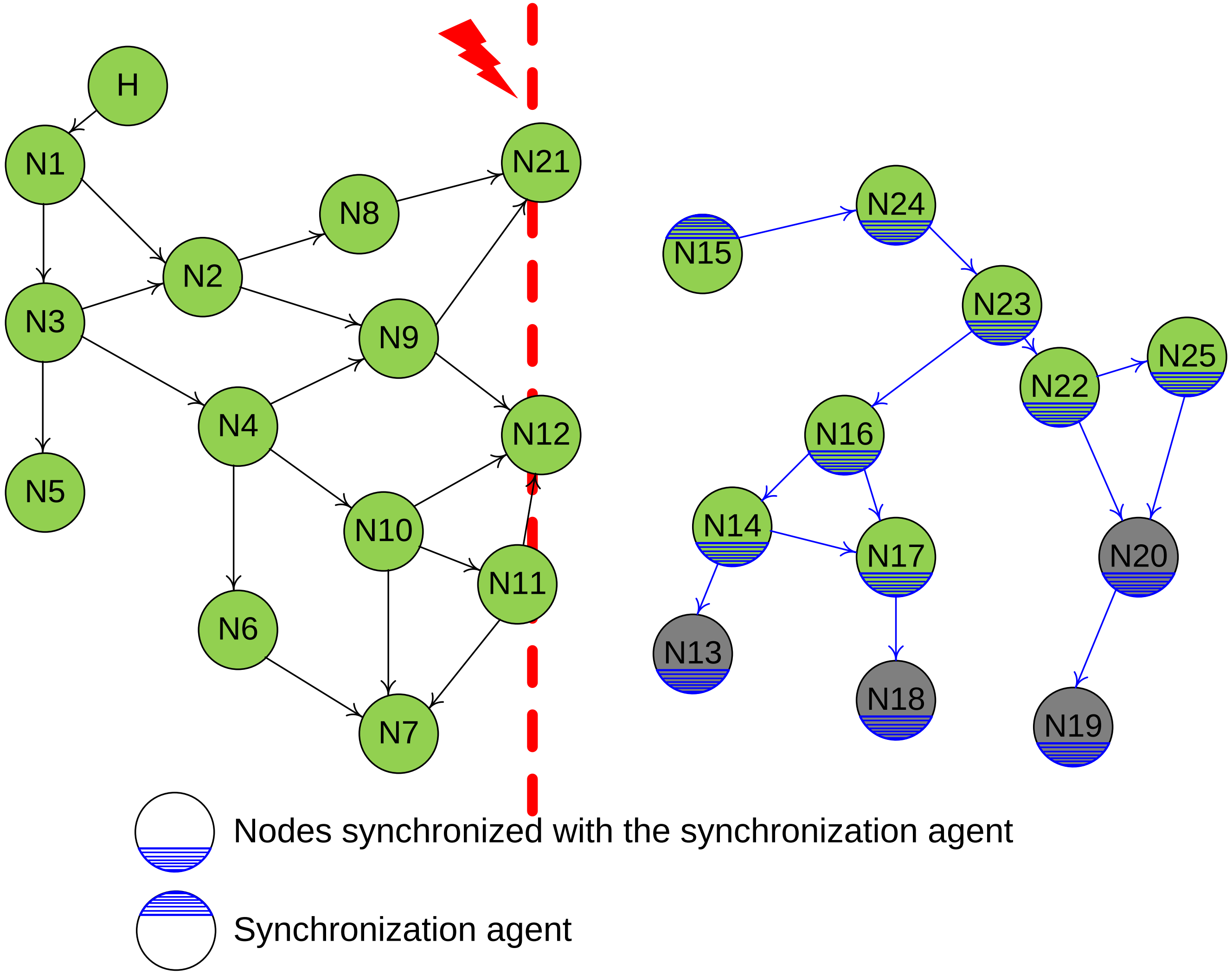
Force-Initiated mechanism is introduced to decentralize a CT-based network.

[1] Ma, Xiaoyuan, et al. "DeCoT: A Dependable Concurrent Transmission-Based Protocol for Wireless Sensor Networks." *IEEE Access* 6 (2018): 73130-73146.

DeCoT+: Based on DeCoT [1]

Decentralized Mechanism: Force-Initiated Mechanism

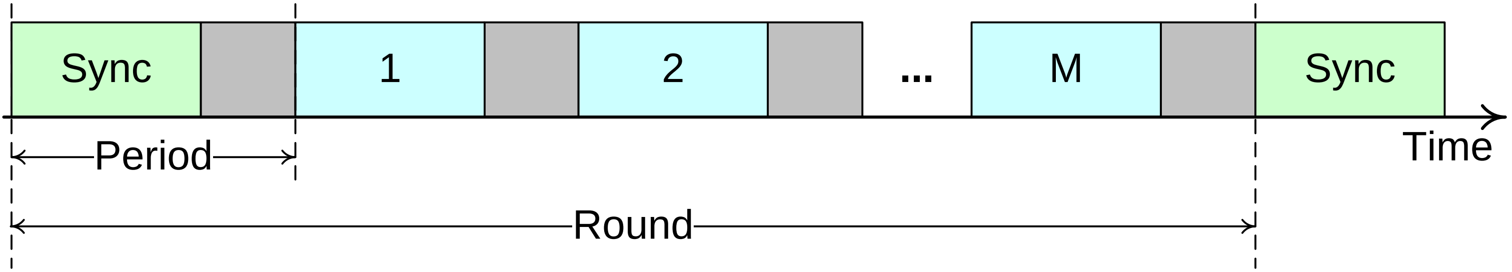
Nodes in the partitioned network get synchronized with an agent. In the competition, all the source nodes work as agents.



[1] Ma, Xiaoyuan, et al. "DeCoT: A Dependable Concurrent Transmission-Based Protocol for Wireless Sensor Networks." *IEEE Access* 6 (2018): 73130-73146.

DeCoT+: Nego-and-Action Framework

Force-Initiated mechanism in DeCoT

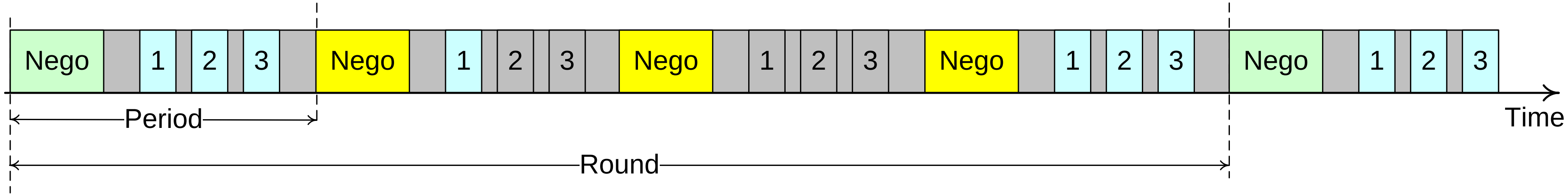


Synchronization Period: Initiated by the host

Radio Off

Force-Initiated Period:
Initiated by the host and the synchronization agents simultaneously

Nego-and-Action framework in DeCoT+ is designed for long payloads



Synchronization period: initiated by the host

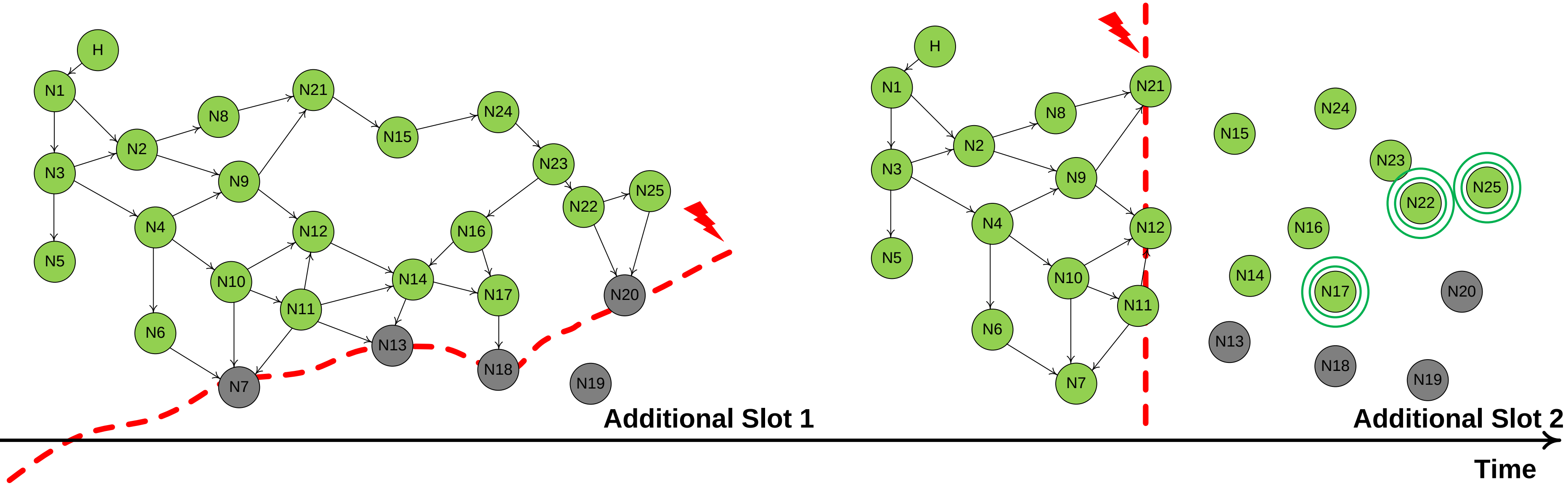
Radio off

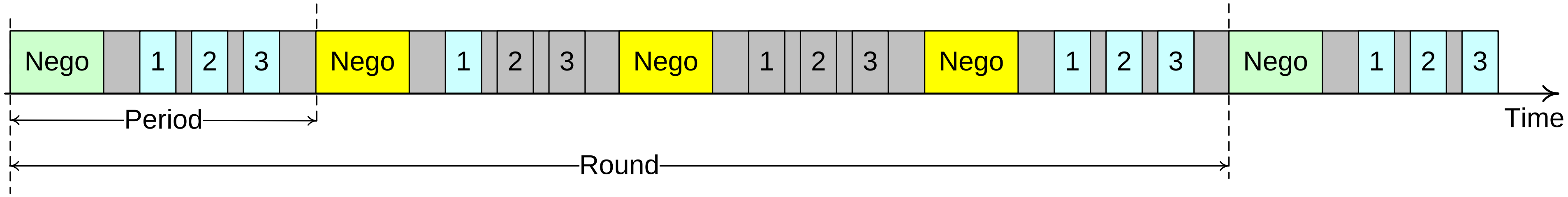
Additional slot

Force-Initiated period:
initiated by the host and the synchronization agents simultaneously

DeCoT+: Data Freezing Mechanism

An example, we assume that N3 has a packet to N20. The interference varies as the red dashed line.





Synchronization period: initiated by the host

Radio off

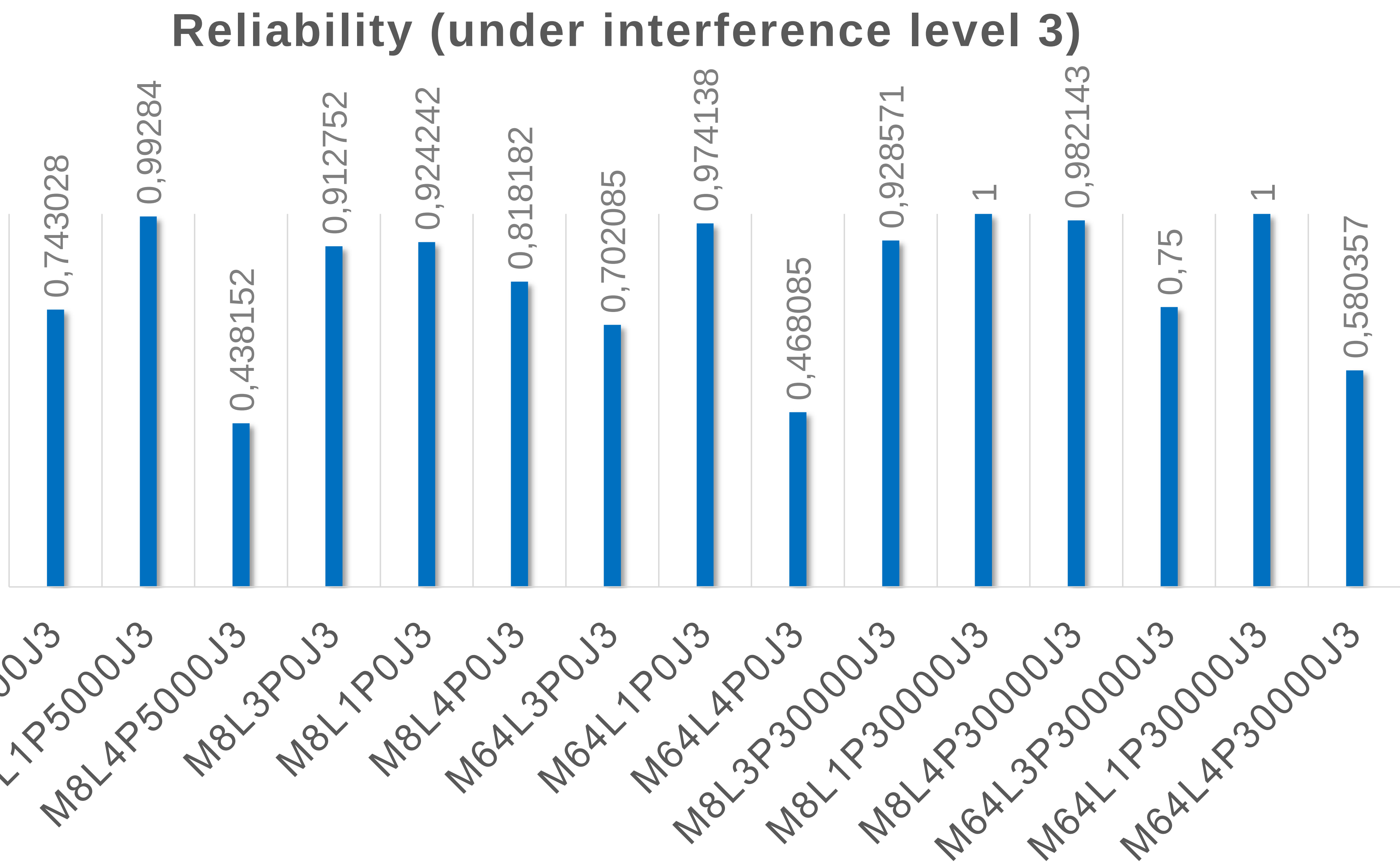
Additional slot

Force-Initiated period:
initiated by the host and the synchronization agents simultaneously

中國科學院上海高等研究院
SHANGHAI ADVANCED RESEARCH INSTITUTE, CHINESE ACADEMY OF SCIENCES

Preliminary Evaluation

Legend
M: message length (B)
L: layout
P: periodicity (ms)
J: interference level



Acknowledgements

- Carlo Alberto Boano and Markus Schuß,
  Graz University of Technology, Austria

- DFG-GRK 1765: System Correctness under Adverse Conditions (SCARE), Germany

Q & A

Thank you!

Xiaoyuan Ma, maxy@sari.ac.cn
Peilin Zhang, peilin.zhang@informatik.uni-oldenburg.de
Ye Liu, yeliu@njau.edu.cn

Team 06

Among the top 3 teams in category 1 (“Data collection”)

Among the top 2 teams in category 2 (“Dissemination”)

Adaptive Software Defined Scheduling of Low Power Wireless Networks

Michael Baddeley, Aleksandar Stanoev, Usman Raza,
Yichao Jin, and Mahesh Sooriyabandara

Toshiba Research Europe Ltd., United Kingdom

TOSHIBA

Adaptive Software Defined Scheduling of Low Power Wireless Networks

EWSN 2019 DepComp

Toshiba Research Europe Limited, TRL
26/02/19

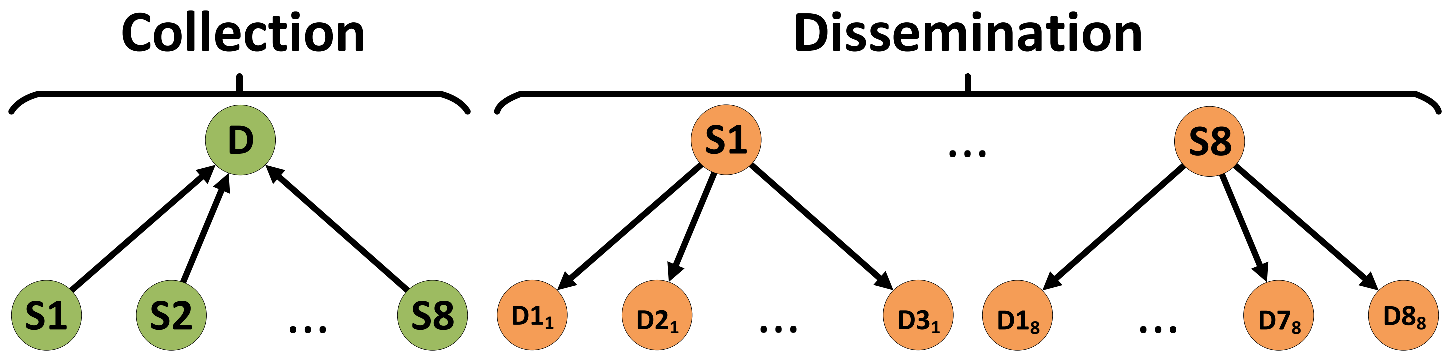
Scope of Disclosure	Whom it may concern
Head of Information Owner Section	**TREL**

Contents

01

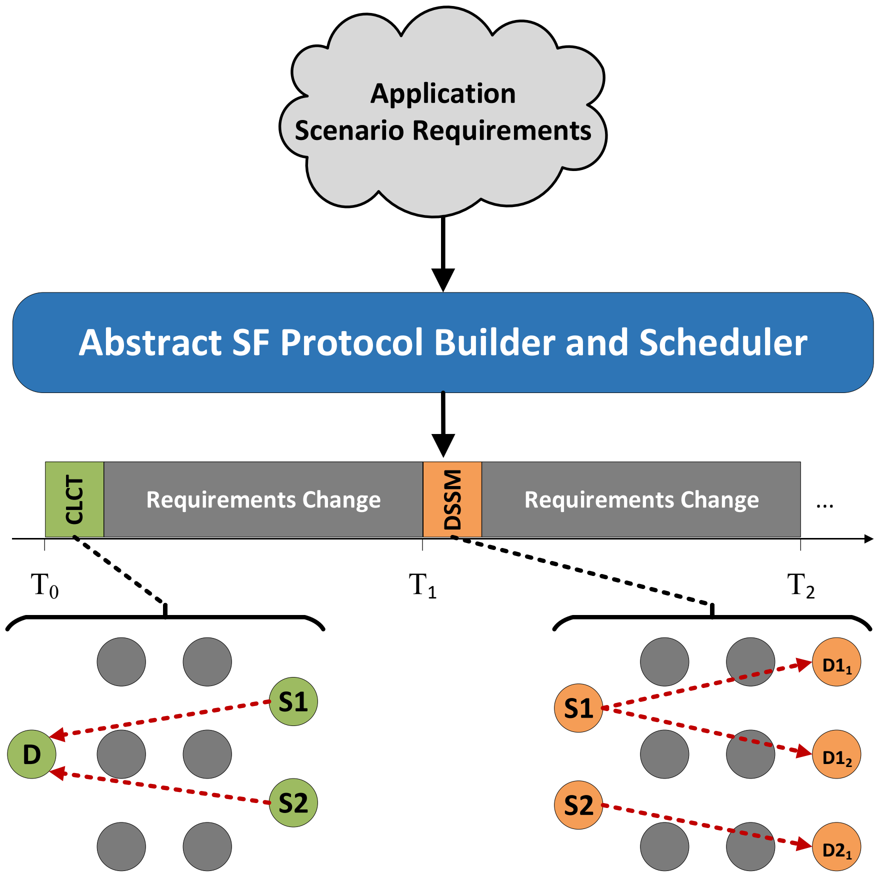
One Architecture to Rule Them All...

Higher Layer SF Framework: One Architecture to Rule Them All



One architecture, two solutions.

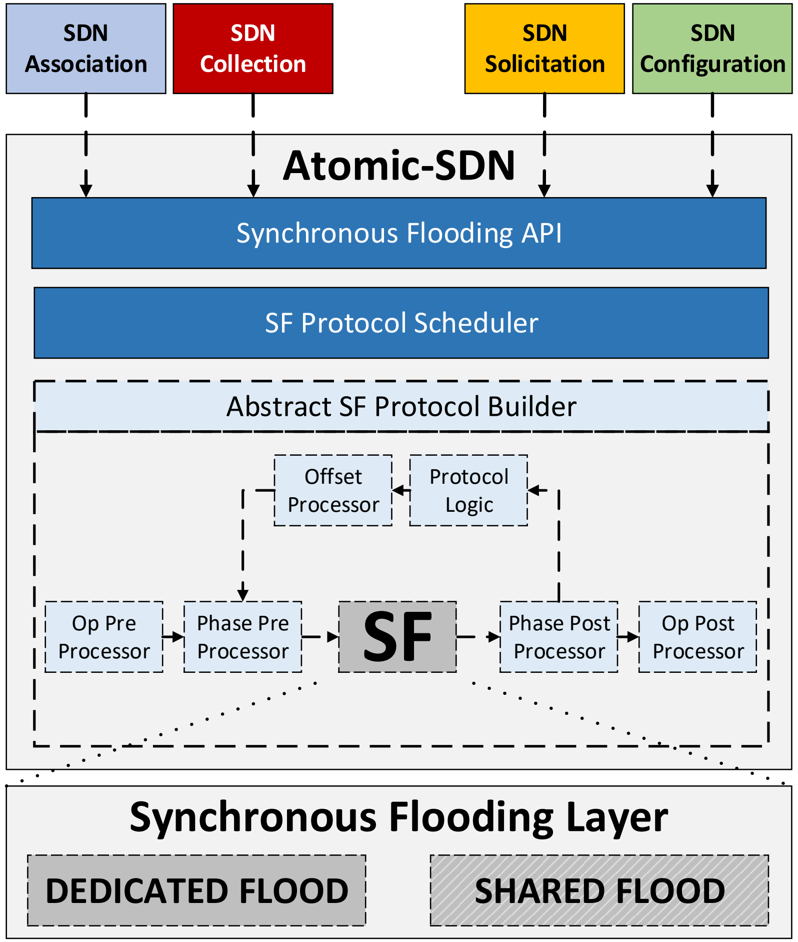
Higher Layer SF Framework: One Architecture to Rule Them All



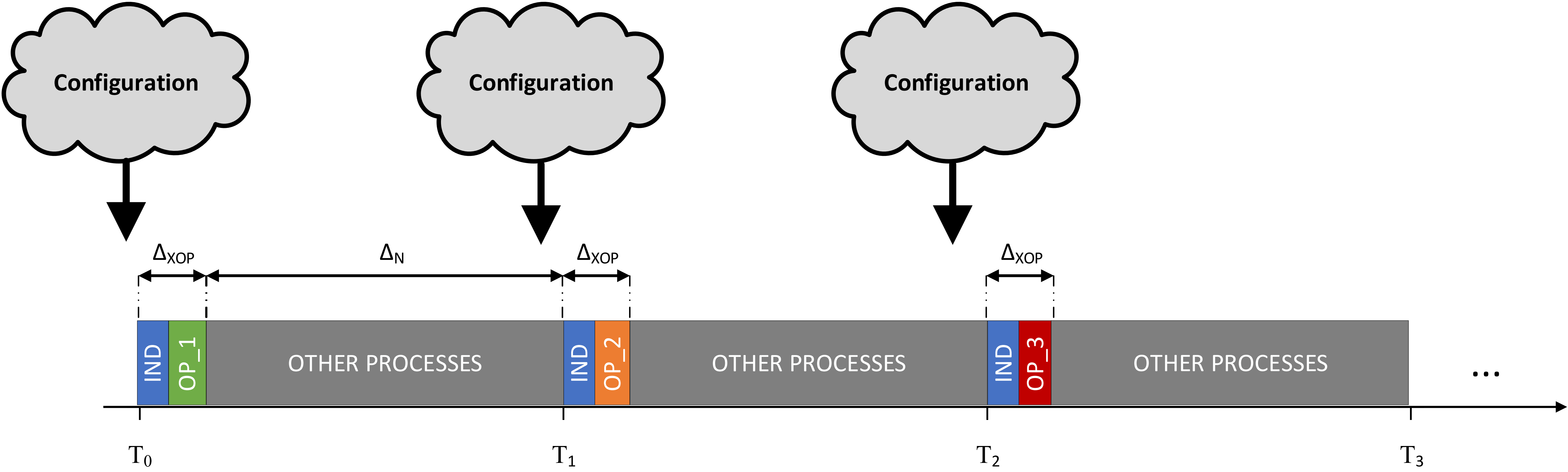
One architecture, two solutions.

Higher Layer SF Framework: One Architecture to Rule Them All

- Flooding primitives are designated either shared or dedicated
- Primitives configured through offsets, guards, and logic blocks
- Primitives are linked together to form protocol operation
- Protocols are constructed and scheduled based on the competition configuration requirements.

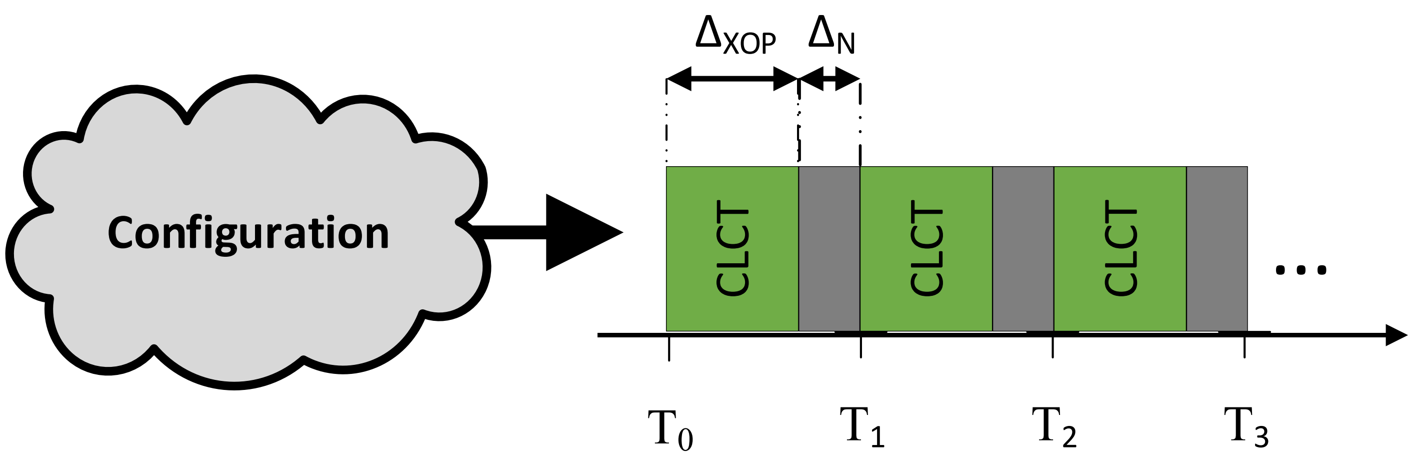


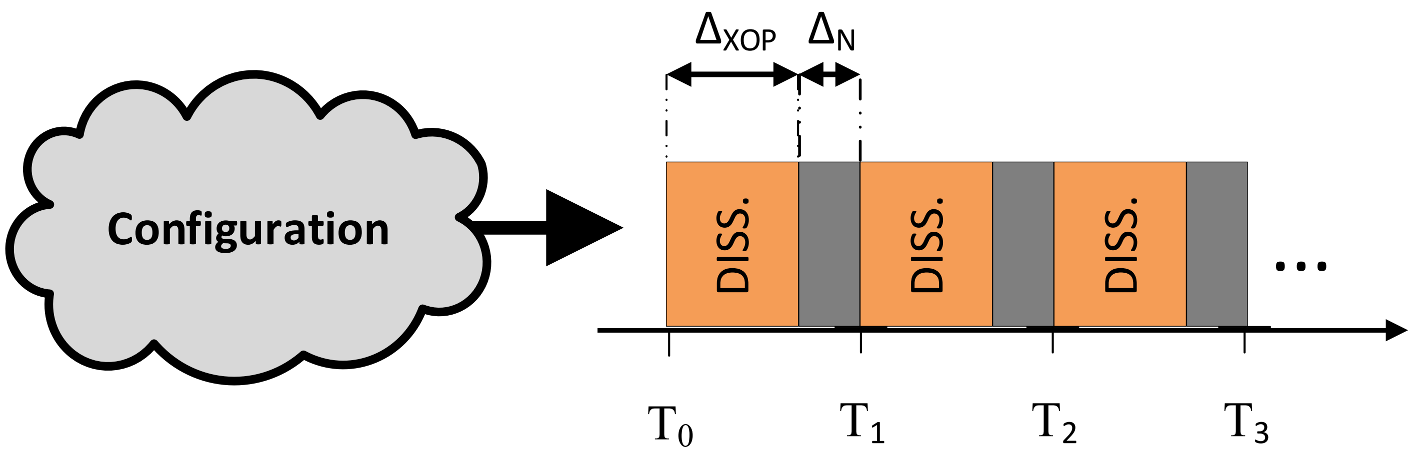
Higher Layer SF Framework: One Architecture to Rule Them All



The basic idea… Configure. Indicate. Control. Other Processes. Repeat.

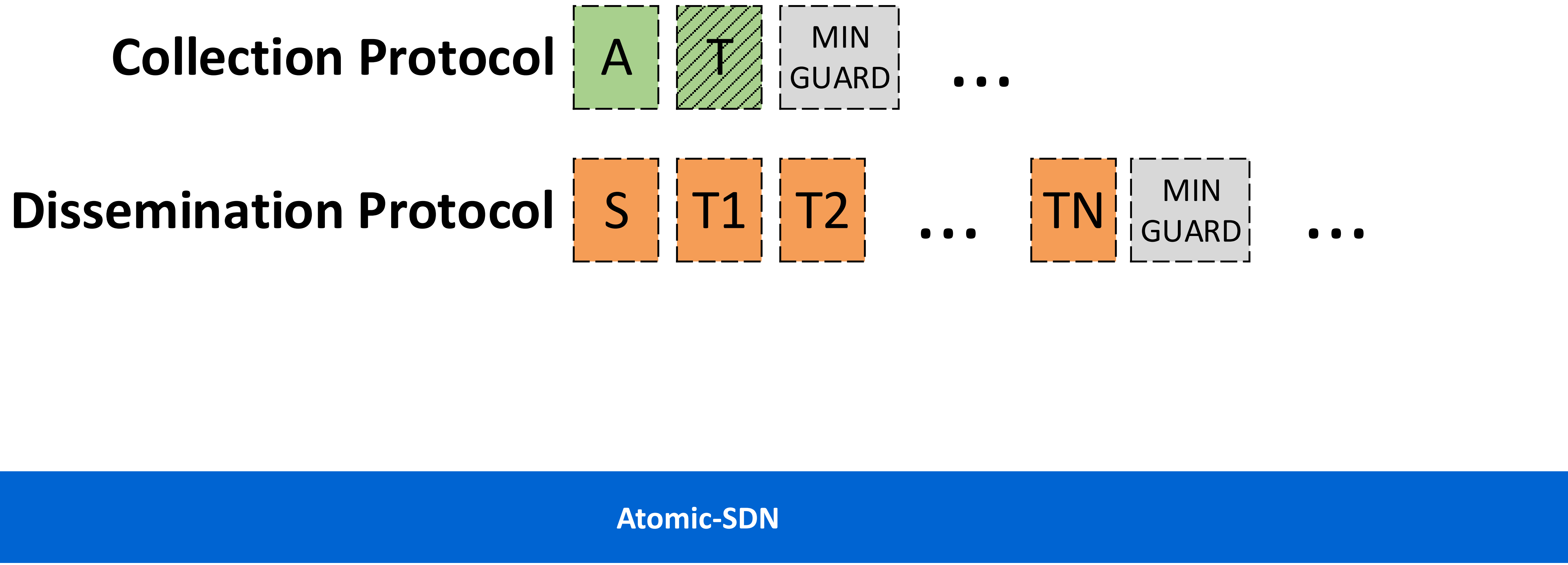
Higher Layer SF Framework: One Architecture to Rule Them All





Configure, Repeat, Repeat, Repeat, Repeat...

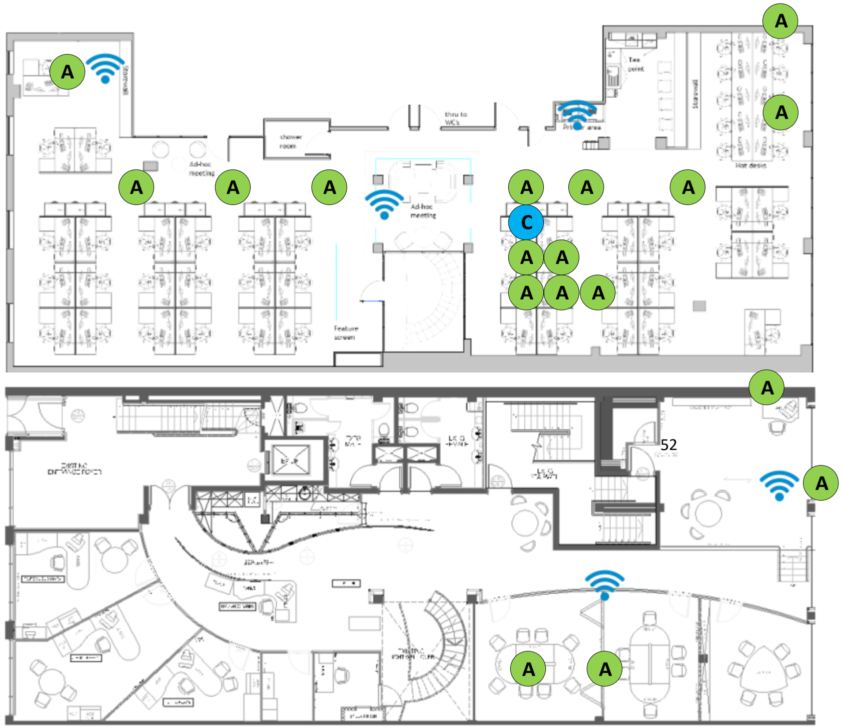
Higher Layer SF Framework: One Architecture to Rule Them All

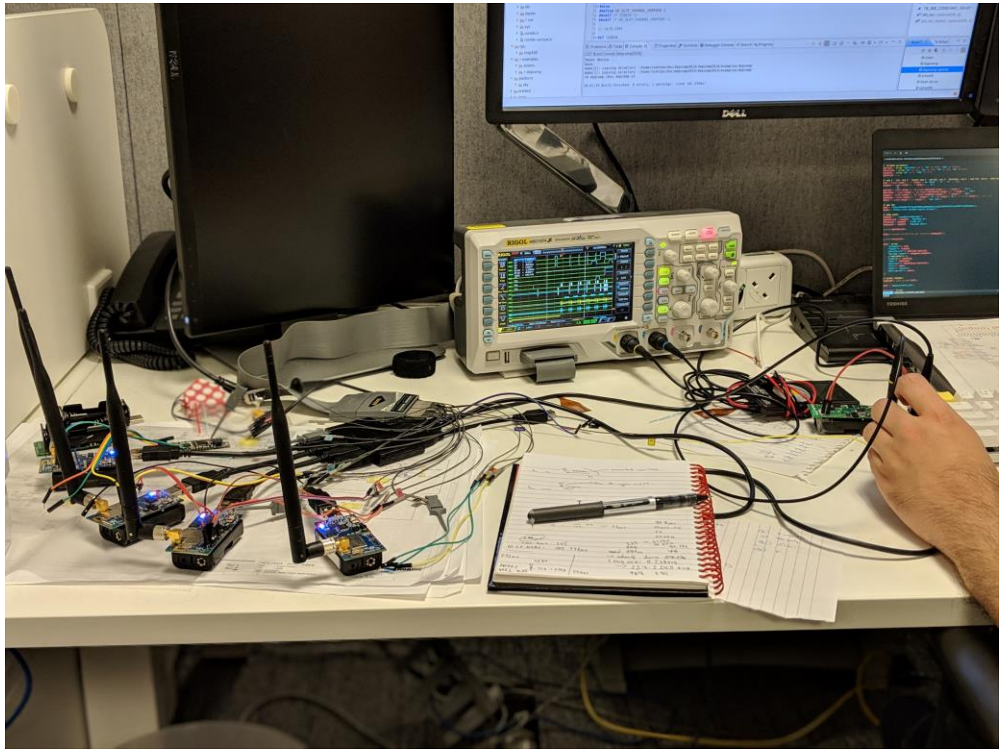


02

Timings, Timings, Timings!

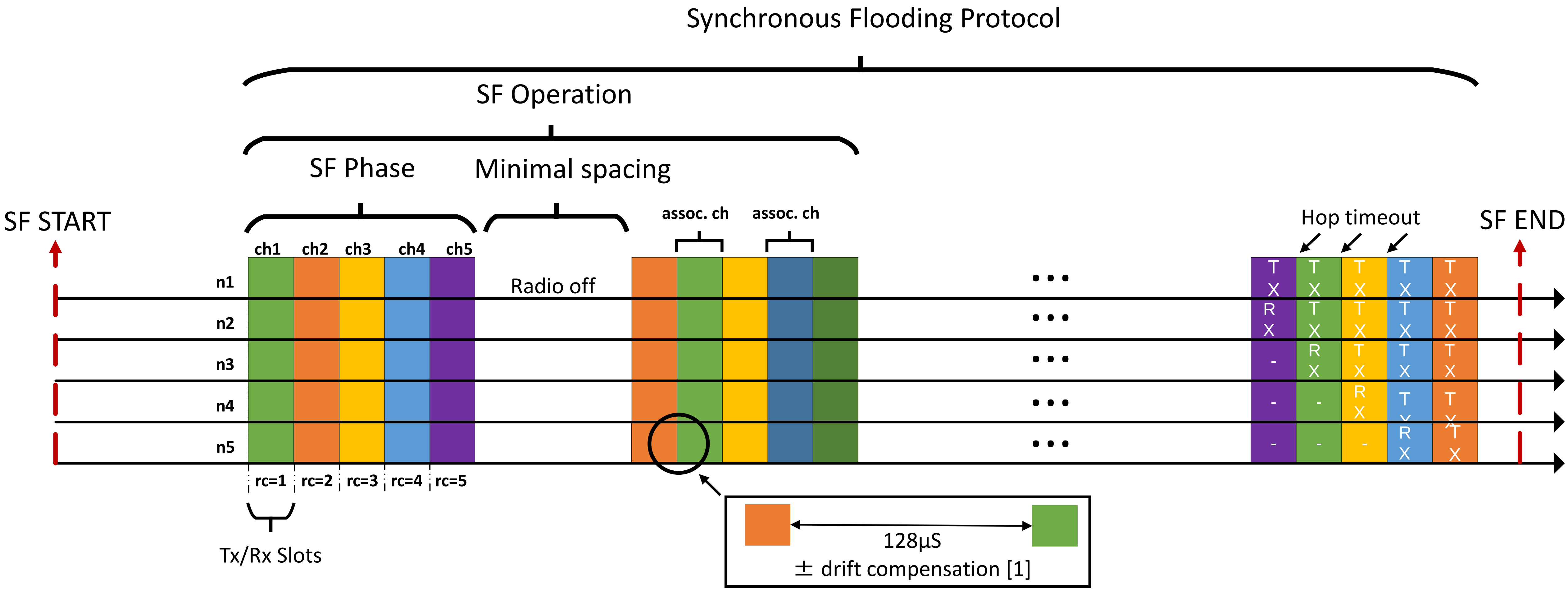
Lower Layer Optimisation: Timings, Timings, Timings!





Test Locally, Measure Everything

Lower Layer Optimisation: Timings, Timings, Timings!



Beating Interference with Space, Time, and Frequency Diversity

[1] M. Brachmann, O. Landsiedel, and S. Santini. Keep the Beat: On-The-Fly Clock Offset Compensation for Synchronous Transmissions in Low-Power Networks. In *IEEE LCN, Oct. 2017*.

03

Challenges + What Next?

Challenges + What Next?

- Single time synchroniser
  - Selected as the one of the sources/destinations
  - Resulted in extremely variable performance depending on location
  - Can we improve this?

- Clocks will drift, transmissions will be misaligned

- Systematic testing is crucial
  - Change one thing at a time and test extensively

A single timesync is a single point of failure!

TOSHIBA

Questions?

Team 10

Among the top 3 teams in category 1 (“Data collection”)

Among the top 2 teams in category 2 (“Dissemination”)

RedNodeBus, Stretching Out the Preamble

Antonio Escobar-Molero, Javier Garcia-Jimenez, Fernando Moreno-Cruz,
Jirka Klaue, Borja Saez, Francisco J. Cruz, Unai Ruiz, and Angel Corona

Infineon Technologies AG, Germany
Bernitz Electronics GmbH, Germany
eesy-innovations GmbH, Germany
RedNodeLabs, Germany

RedNodeBus

Stretching Out the Preamble

Motivation

Industry 4.0

Wireless Sensor and Actuator Networks (WSANs)

Deterministic low-latency required to run control loops wirelessly

Harsh environments

Smart Cities

Self-organized multi-hop topology

Transparent node deployment

No routing needed

Automotive

Robust and scalable car-to-car communication

Reliable high-priority alarm signals

RED NODE LABS

Motivation

Ariane

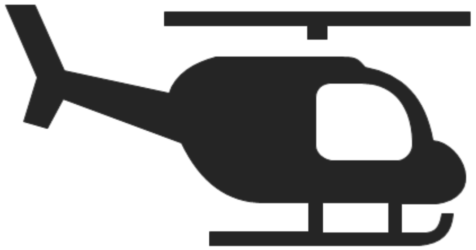
Wireless sensors/actuators

Fixed Wing

Cabin network
Health monitoring
Flight test
Landing gear

Rotorcraft

Flight test
Health monitoring

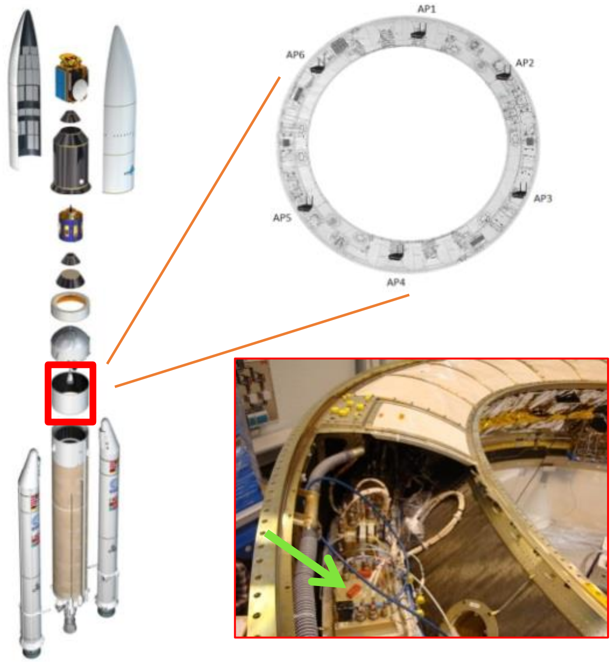


RED NODE LABS

Motivation

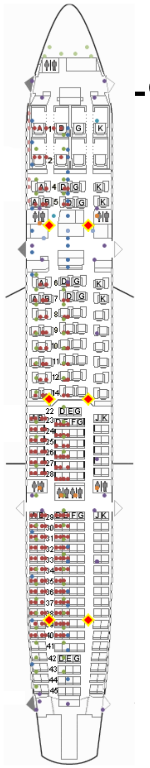
Ariane

Wireless sensors/actuators



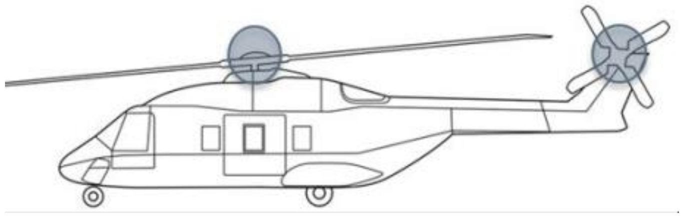
Fixed Wing

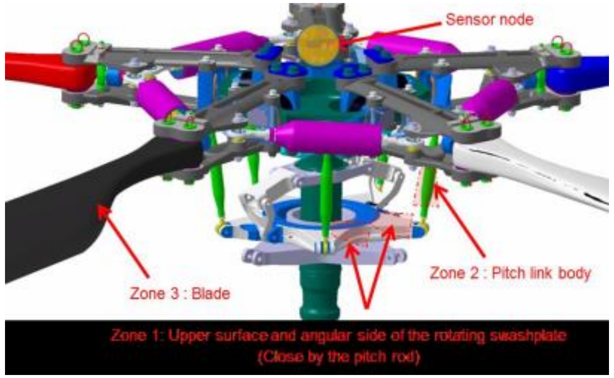
Cabin network
Health monitoring
Flight test
.anding gear



Rotorcraft

Flight test
Health monitoring



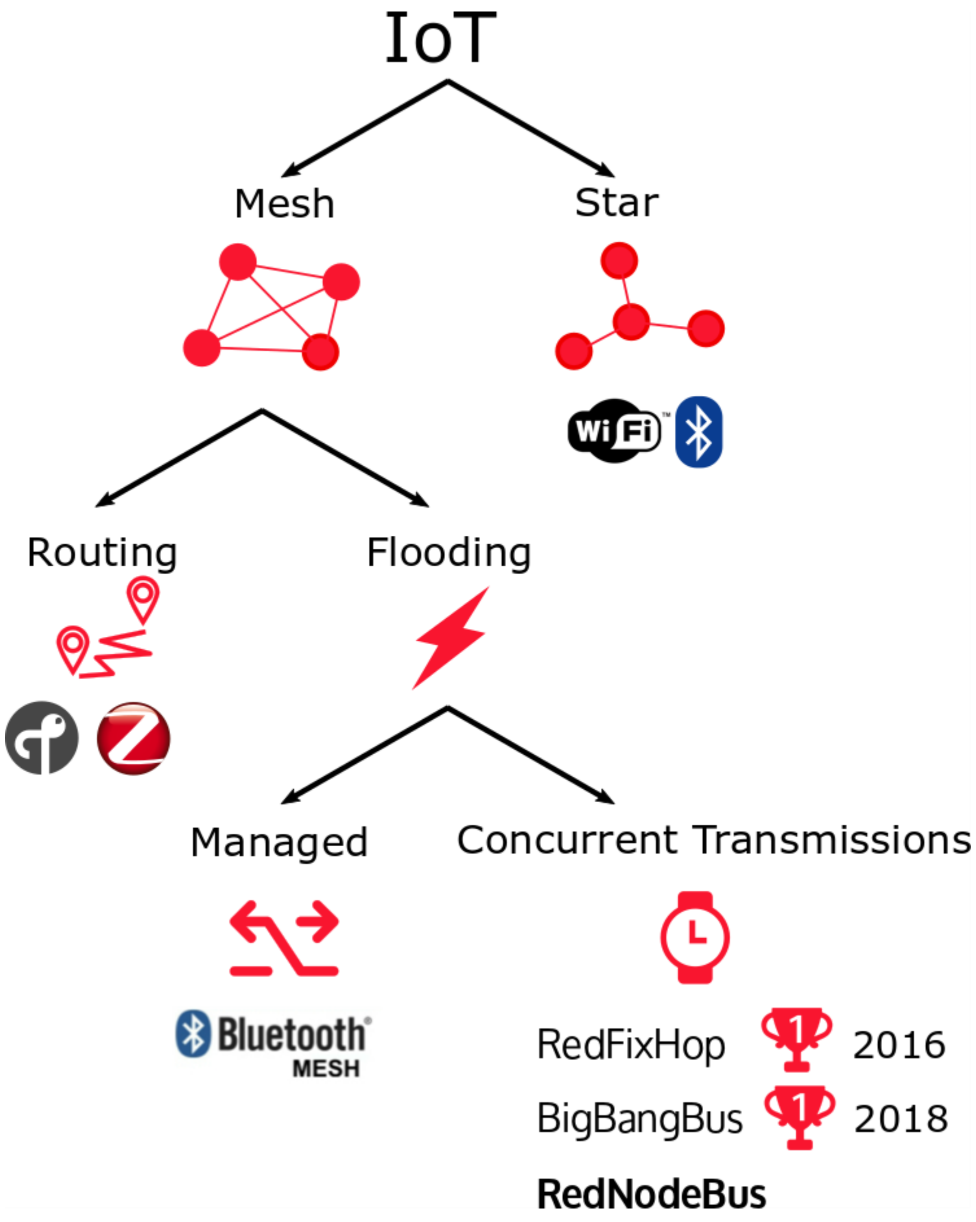


RED NODE LABS

Concurrent Transmissions

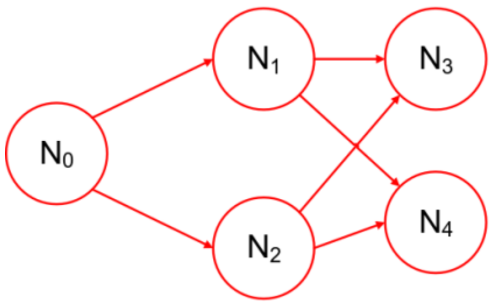
RedNodeBus is an all-to-all **mesh protocol** based on **flooding** and **concurrent transmissions**.

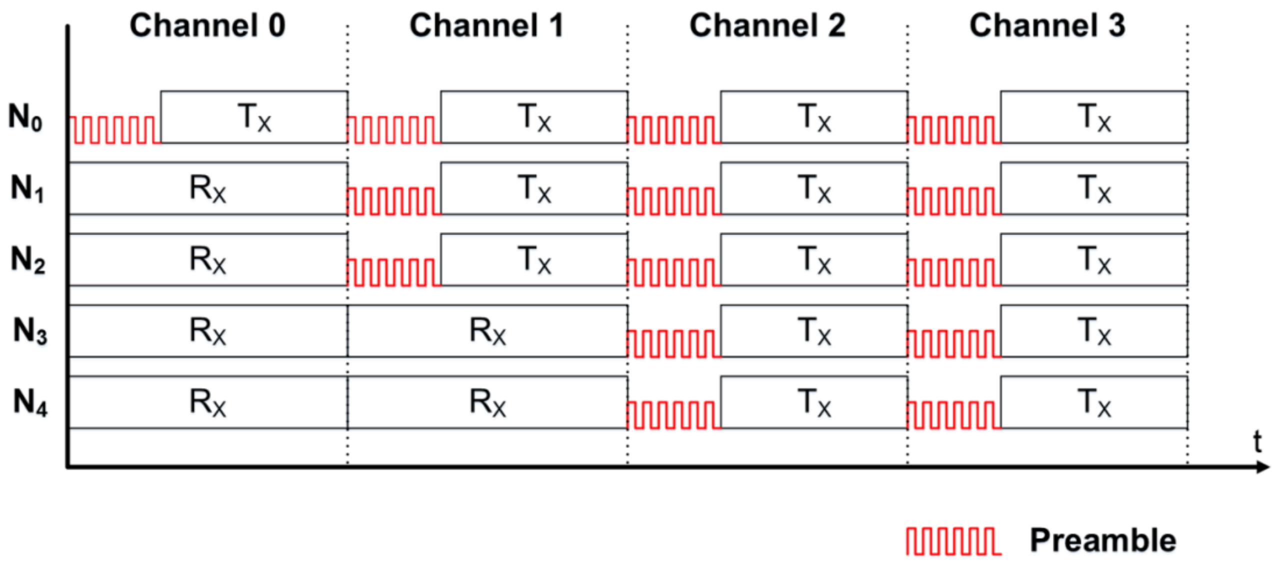
It follows the same principle as the **RedFixHop** and **BigBangBus** protocols, with an **increased packet preamble**.



RED NODE LABS

RedNodeBus





New Features

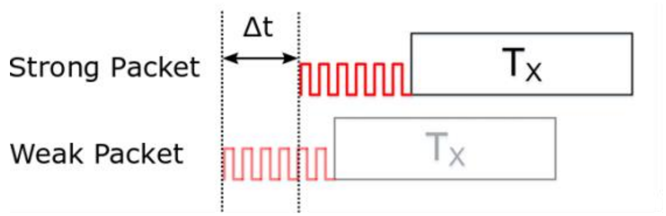
Increased Packet Preamble

Bounded Latency (Packet TTL)

Packet Source Diversity

Synchronization Beacons

RED NODE LABS



Capture Effect is triggered more frequently

Thank You

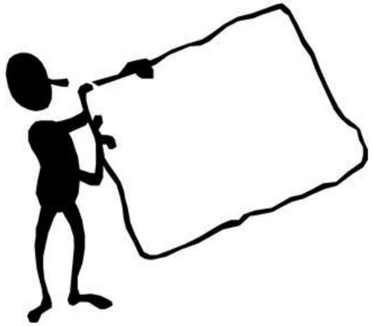
www.rednodelabs.com

info@rednodelabs.com

RED NODE LABS

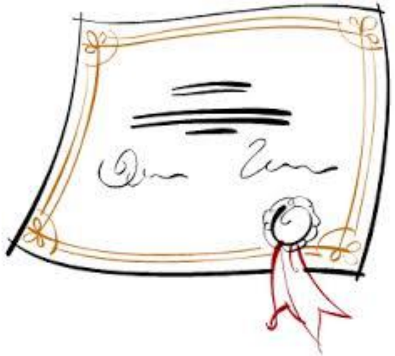
What’s Next?

- Presentations of the top teams
  - Category 1: Team 01, Team 06, Team 10
  - Category 2: Team 06, Team 10



- Poster session (17:30 – 19:00)
  - Meet and speak to all contestants!

- Awards ceremony
  - Tonight, during the banquet!



Acknowlegements

- Thanks to everyone supporting this year's competition!
  - All contestants
  - All EWSN organizers
  - Engelbert Meissl for his help in setting up and maintaining the competition infrastructure

- Thanks to our sponsors for financing the set-up of the competition infrastructure and the cash awards!

TU Graz

DEPENDABLE THINGS

Dependable Internet of Things in Adverse Environments

HUAWEI

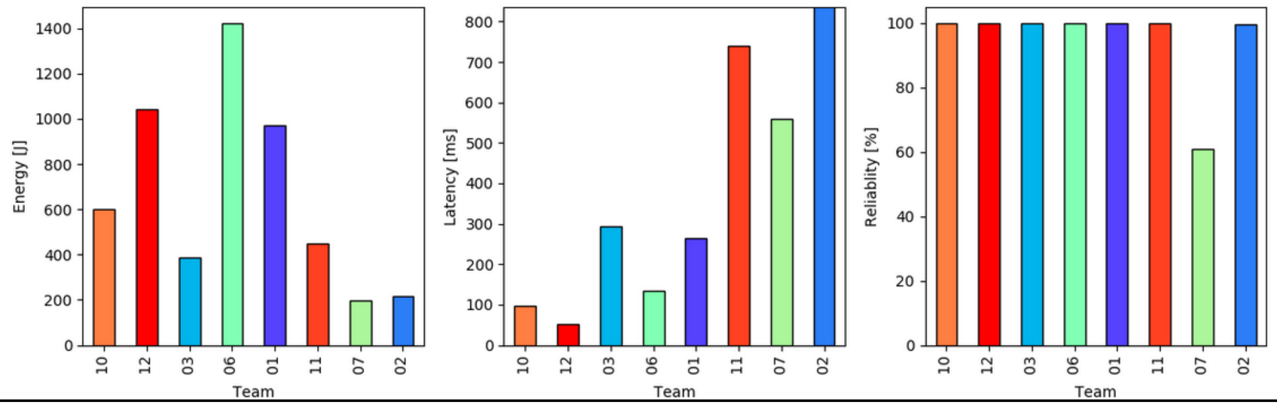
Jamming	Count	Category	Layout	Periodicity	Message length
None	Median	1	3	Aperiodic	8

Home Leaderboard Queue History Contact Management carlo

Jamming	Count	Category	Layout	Periodicity	Message length
None	Median	1	3	Aperiodic	8

EWSN 2019 Leaderboard

Team	Energy[J]	Reliablity [%]	Latency [ms]
10	599.62	100.00	98.35
12	1040.69	100.00	51.34
03	388.83	100.00	293.43
06	1424.41	100.00	135.54
01	971.51	100.00	264.46
11	451.11	100.00	741.17
07	195.28	60.87	559.16
02	215.91	99.44	18368.10



https://iti-testbed.tugraz.at/ewsn2019/leaderboard/

All results are publicly available!

Stay Tuned!

- All results will be publicly available after the banquet!
  - https://iti-testbed.tugraz.at/ewsn2019/summary/
  - https://iti-testbed.tugraz.at/ewsn2019/leaderboard/

Final results

Detailed results

CPS-IoTBench 2019: The 2nd Workshop on Benchmarking Cyber-Physical Systems and Internet of Things

Workshop @ CPS-IoT Week in Montreal, Canada - April 15, 2019