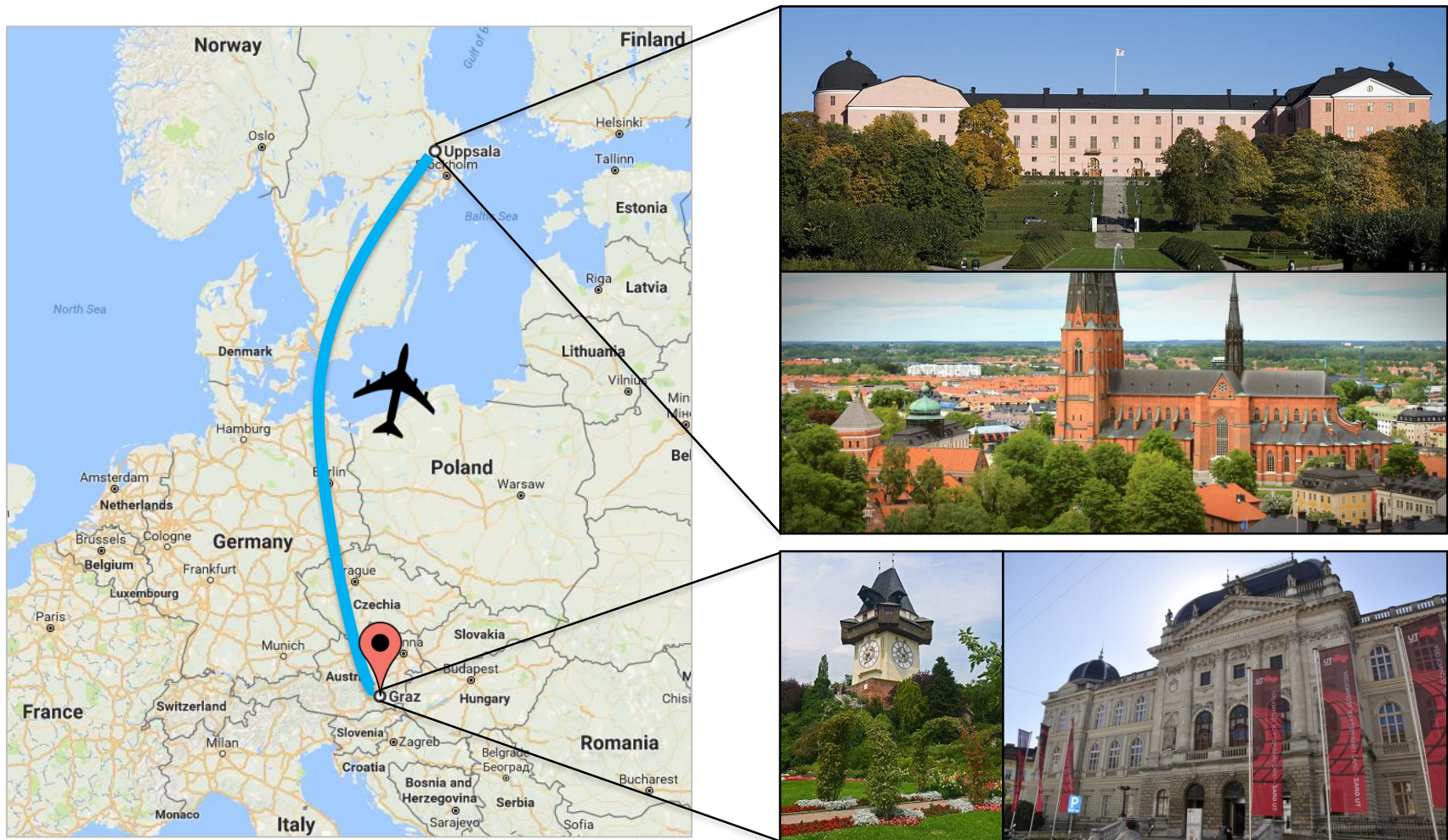1

EWSN 2017 Dependability Competition

Awards and Presentations

Carlo Alberto Boano
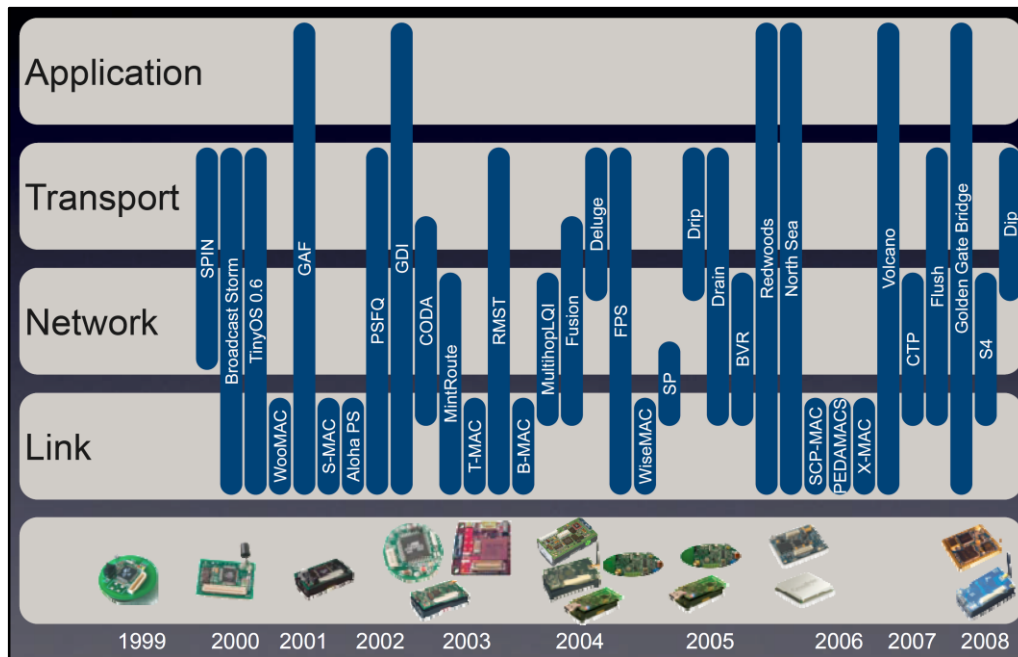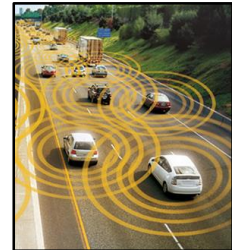Graz University of Technology, Austria

Dependability Competition: 2nd Edition!

→ EWSN dependability competition 2016 (Graz, Austria)

→ EWSN dependability competition 2017 (Uppsala, Sweden)

Competition: Motivation

- Increasing need for dependable networked embedded systems

- A large number of solutions were proposed by academia & industry in the last decade

→ **Hard to know** which of those perform(s) best in a given application scenario

→ Performance has rarely been benchmarked under the **exact same settings**

→ Focus has rarely been on **end-to-end** performance

J. Hui & D. Culler, IP is Dead, Long Live IP for Wireless Sensor Networks, SenSys'08.

"Let chaos reign"

A-MAC, Glossy, LWB, Orchestra, TSCH, EM-MAC, Chaos, Oppcast, …

Evaluation Scenario
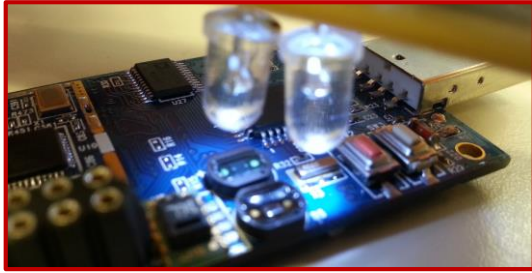
- **Sensor network monitoring discrete events**
  - Sensing node in proximity of a light source detecting status changes (on/off)
  - Events are immediately reported to a sink node

Sensing
Node

Evaluation Scenario

- **Sensor network monitoring discrete events**

  - Sensing node in proximity of a light source detecting status changes (on/off)
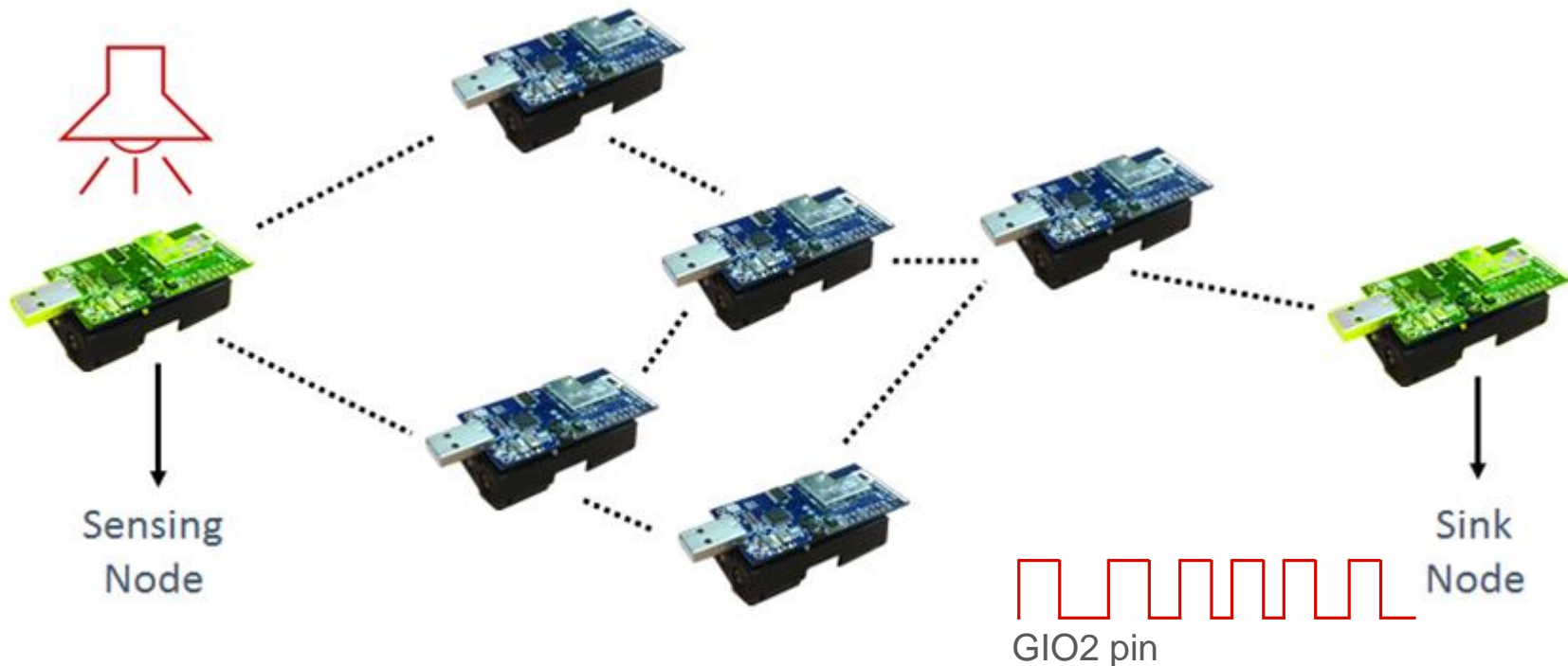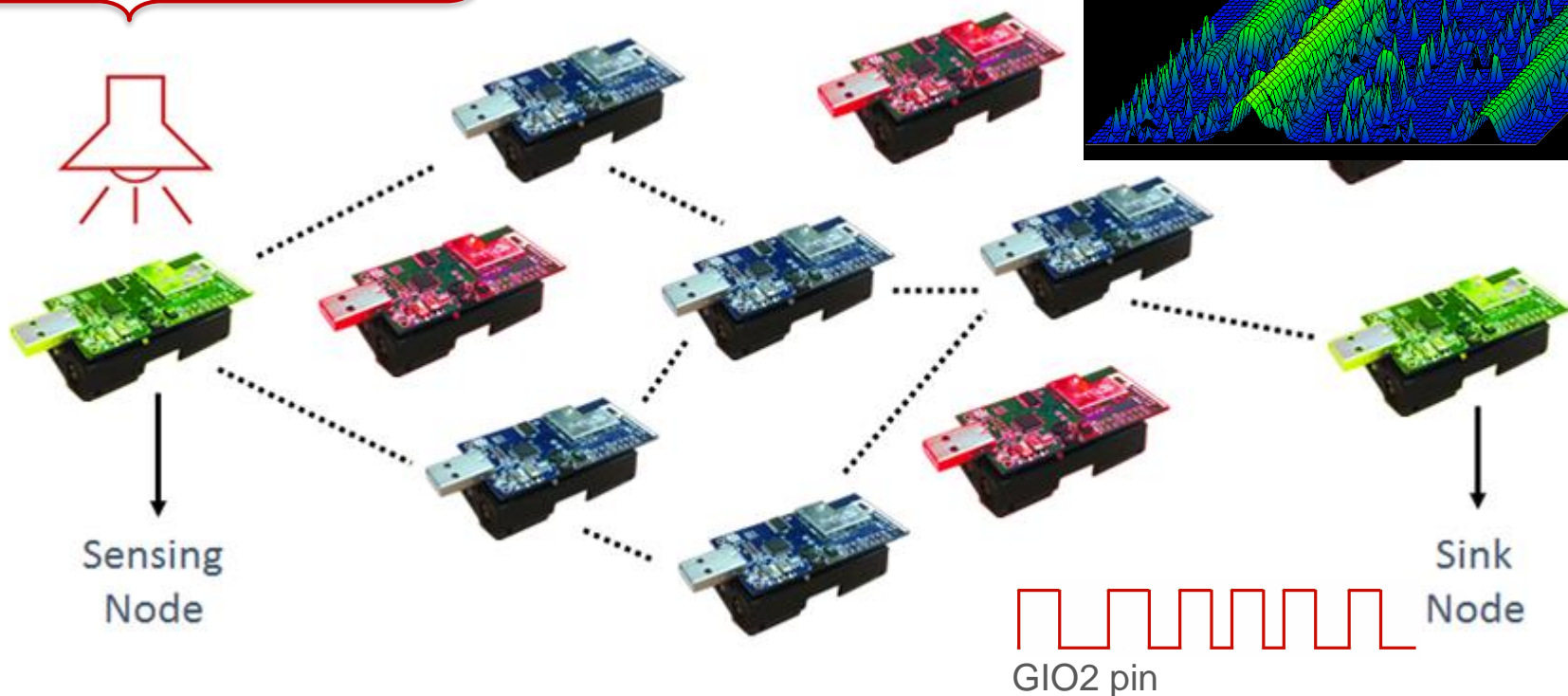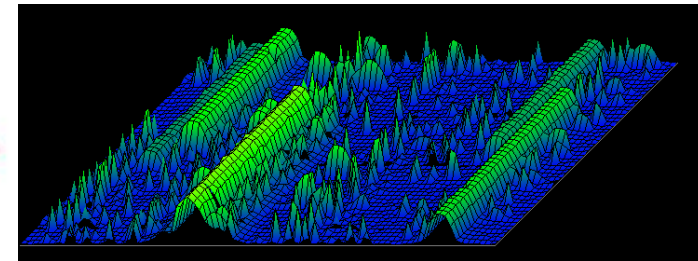 - Events are immediately reported to a sink node
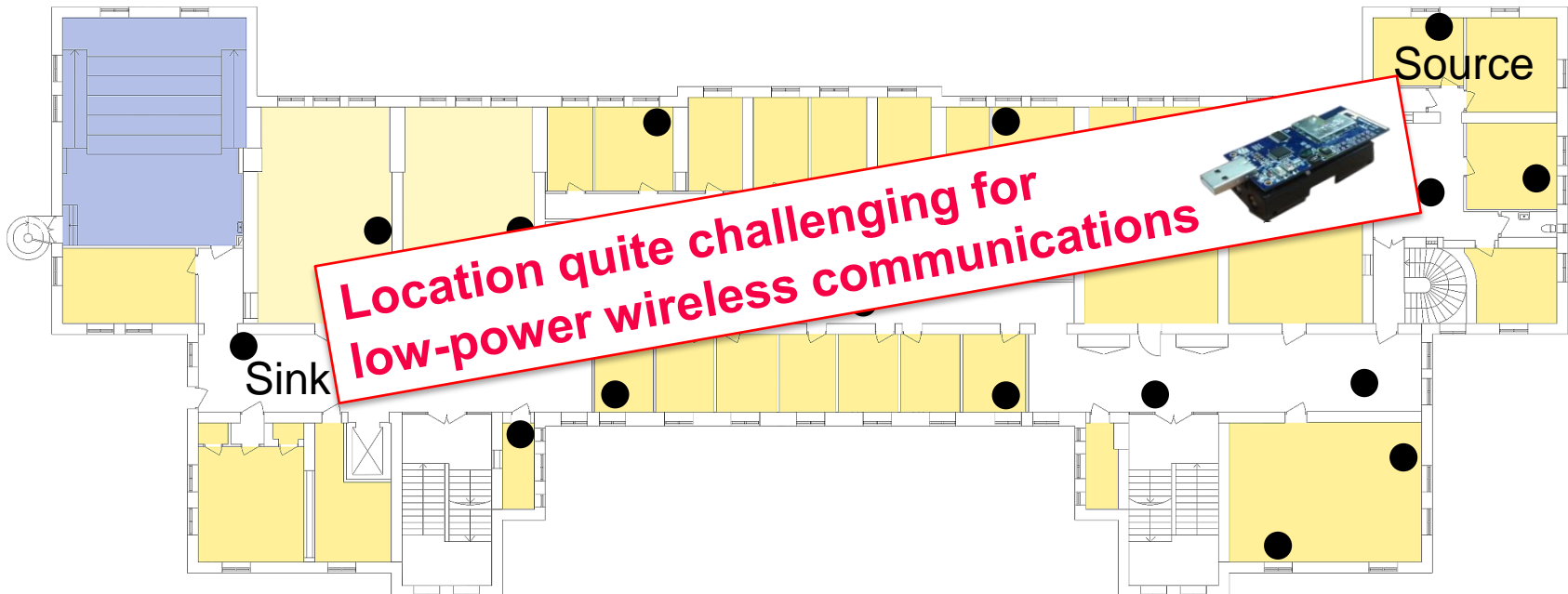 - Multi-hop wireless network

Sensing Node

Sink Node

GIO2 pin

Evaluation Scenario

- **Sensor network monitoring discrete events**
  - Crowded RF spectrum
 - RF interference generated using JamLab in the 2.4 GHz band
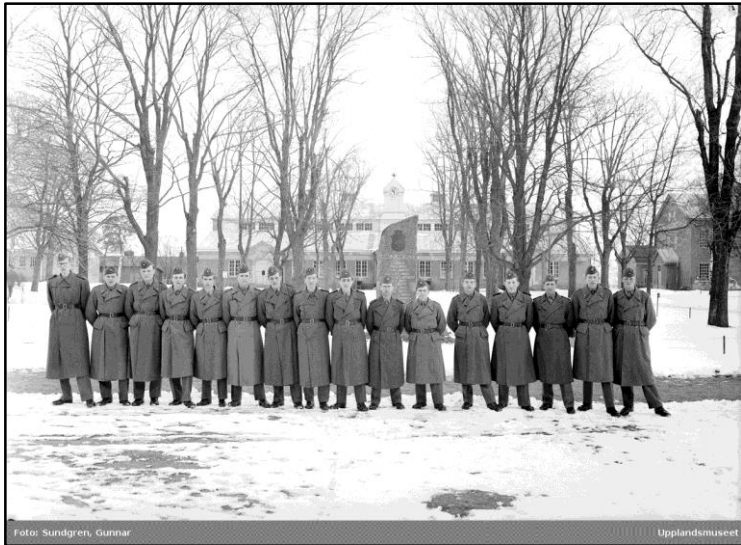

Sensing Node

Sink Node

GIO2 pin

Location

- Uppsala University campus in Polacksbacken
  - 3rd floor of Lägerhyddsvägen 2, Hus 1

Source

Sink

Location quite challenging for low-power wireless communications

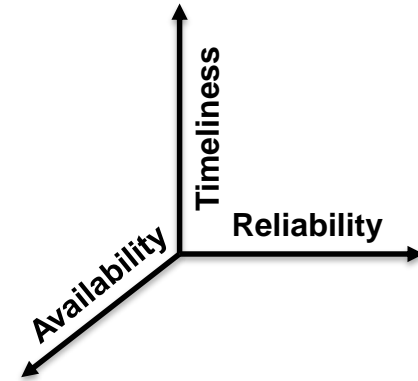# Location

- Uppsala University campus in Polacksbacken
  - Old military building, very thick walls (≈ 350-400 m^2 area)
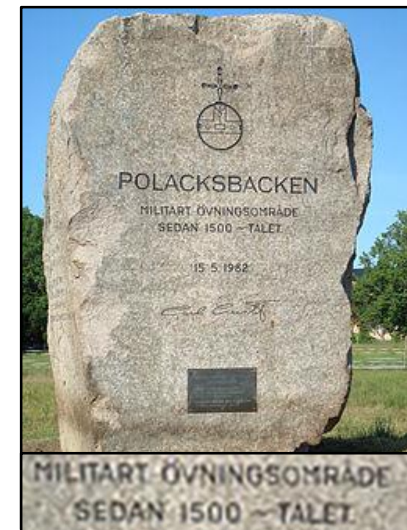
Evaluation Metrics

- Solutions have been evaluated according to three criteria:

  1. Reliability of transmissions
     → Number of changes in the LED status that were missed (i.e., that were not correctly reported to the sink)

  2. End-to-end latency
     → Time necessary to communicate a change in the LED status to the sink node
     → Measured with microseconds precision using GPS timestamps

  3. Energy-efficiency
     → Power consumed by all nodes in the network (measured in hardware every every 16 µs)

- For each criterion, a separate ranking is derived
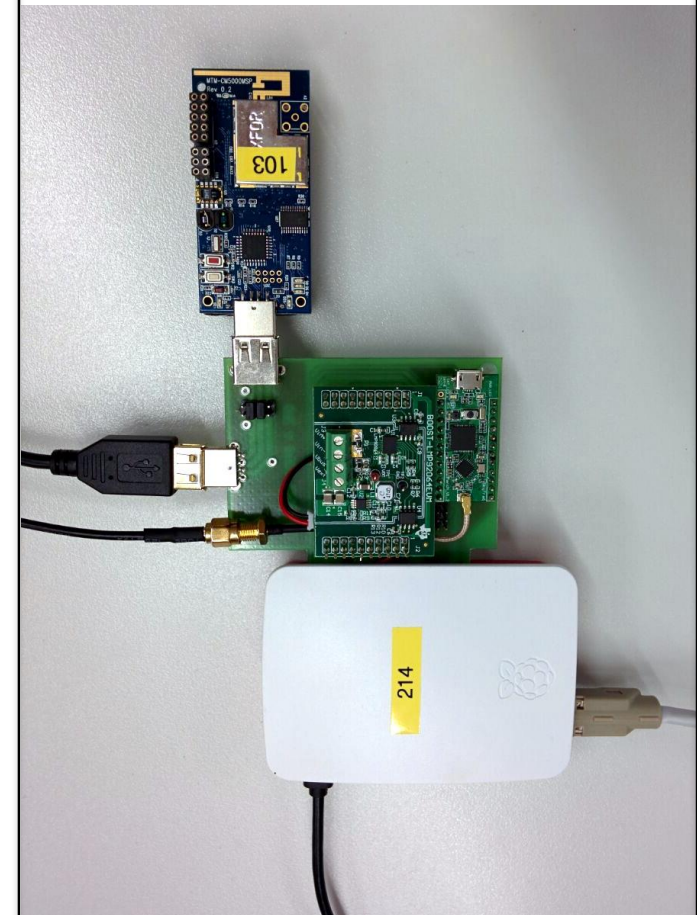 - The team with <u>the best rankings across all three metrics</u> wins!
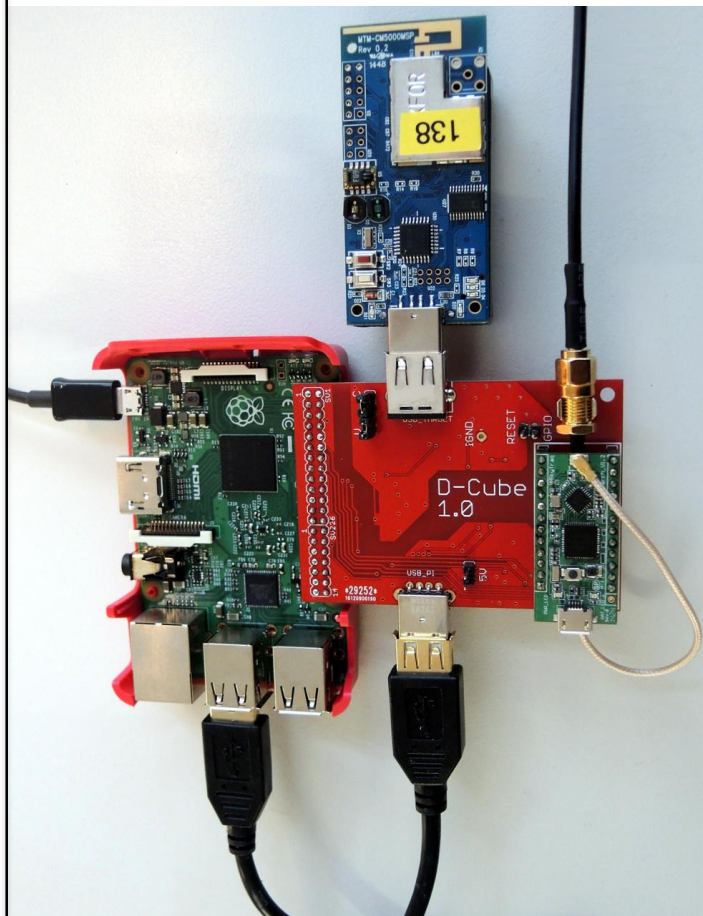
Benchmarking Tool: D-Cube

- GitHub: https://github.com/TuGraz-ITI/D-Cube

This year's prototype (EWSN'17)
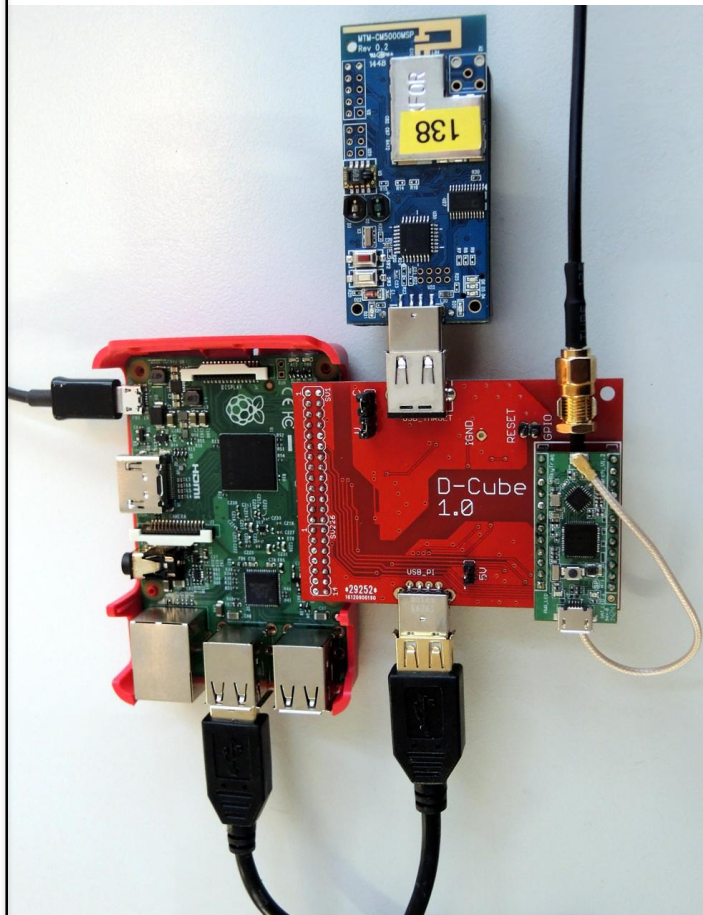
Last year's prototype (EWSN'16)

Benchmarking Tool: D-Cube

- GitHub: https://github.com/TuGraz-ITI/D-Cube

This year's prototype (EWSN'17)

- Raspberry Pi3 with custom made add-on card
  - → Latency profiling: GPS module with timestamping support
  - → Energy profiling: simultaneous sampling ADC @62.5 kHz
  - → Target platform: MTM-CM5000-MSP nodes (TelosB replicas - 10 kB RAM)

More info this afternoon at 15:10!

Execution

- 10 teams answered to the call for competitors
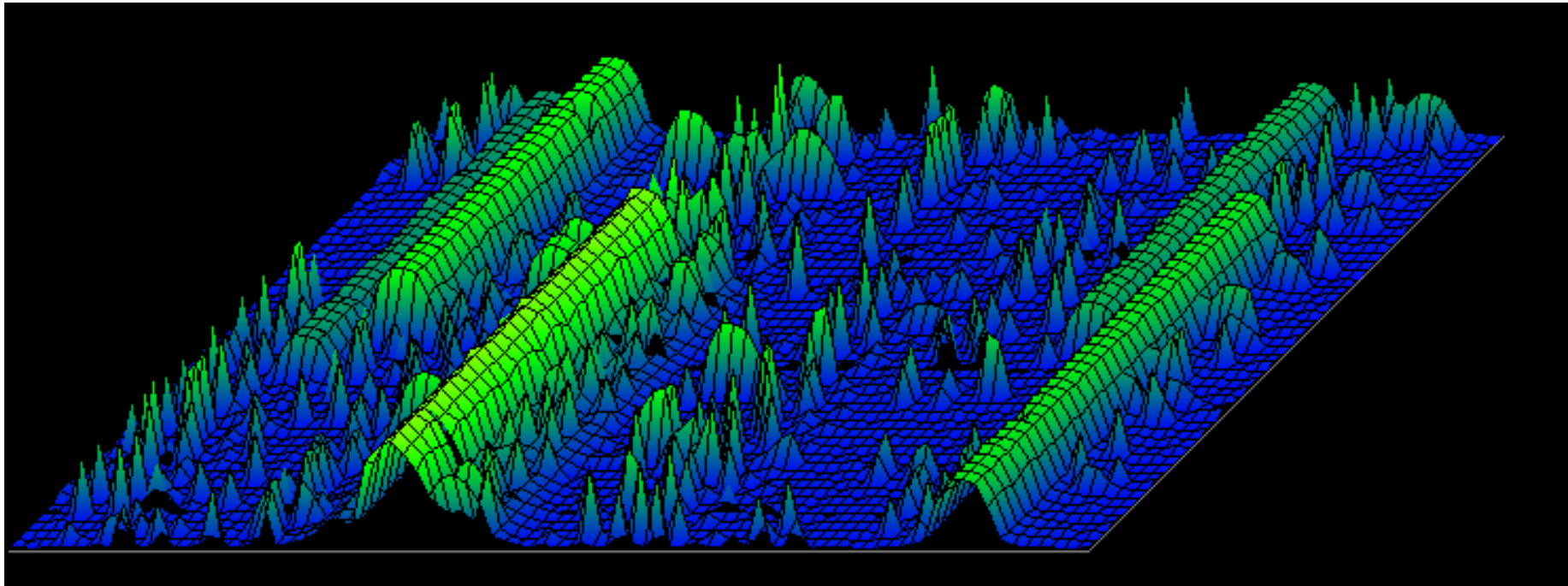
- Step 1: Remote preparation

- Step 2: on-site preparation day (Saturday)

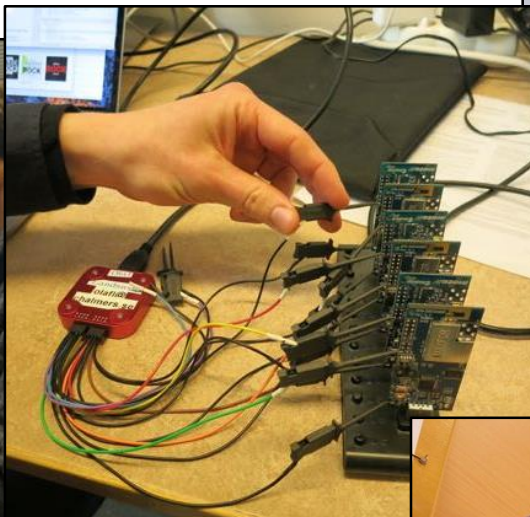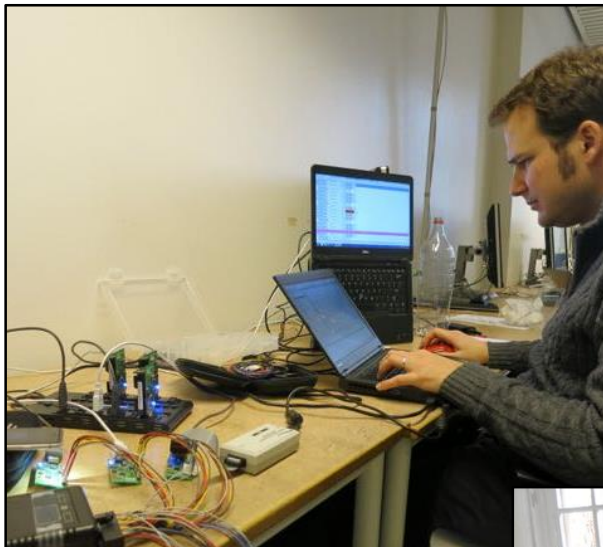- Step 3: on-site evaluation day (Sunday)

Generated Interference

- Two separate evaluations
  1. 45 minutes under varying interference patterns resembling Wi-Fi video streaming, file transfer, and malicious nodes
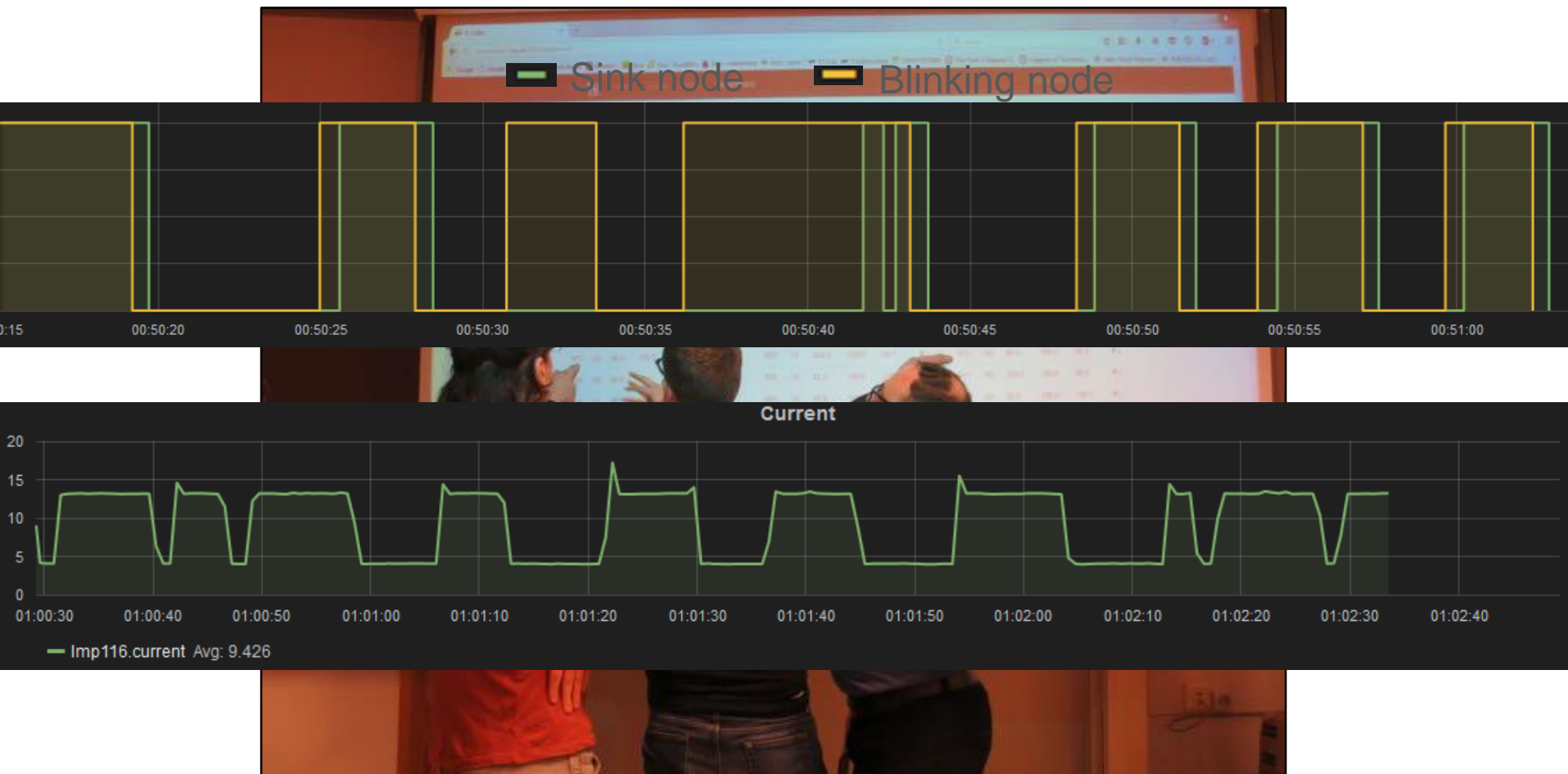 2. 5 minutes "extreme" scenario with very high interference
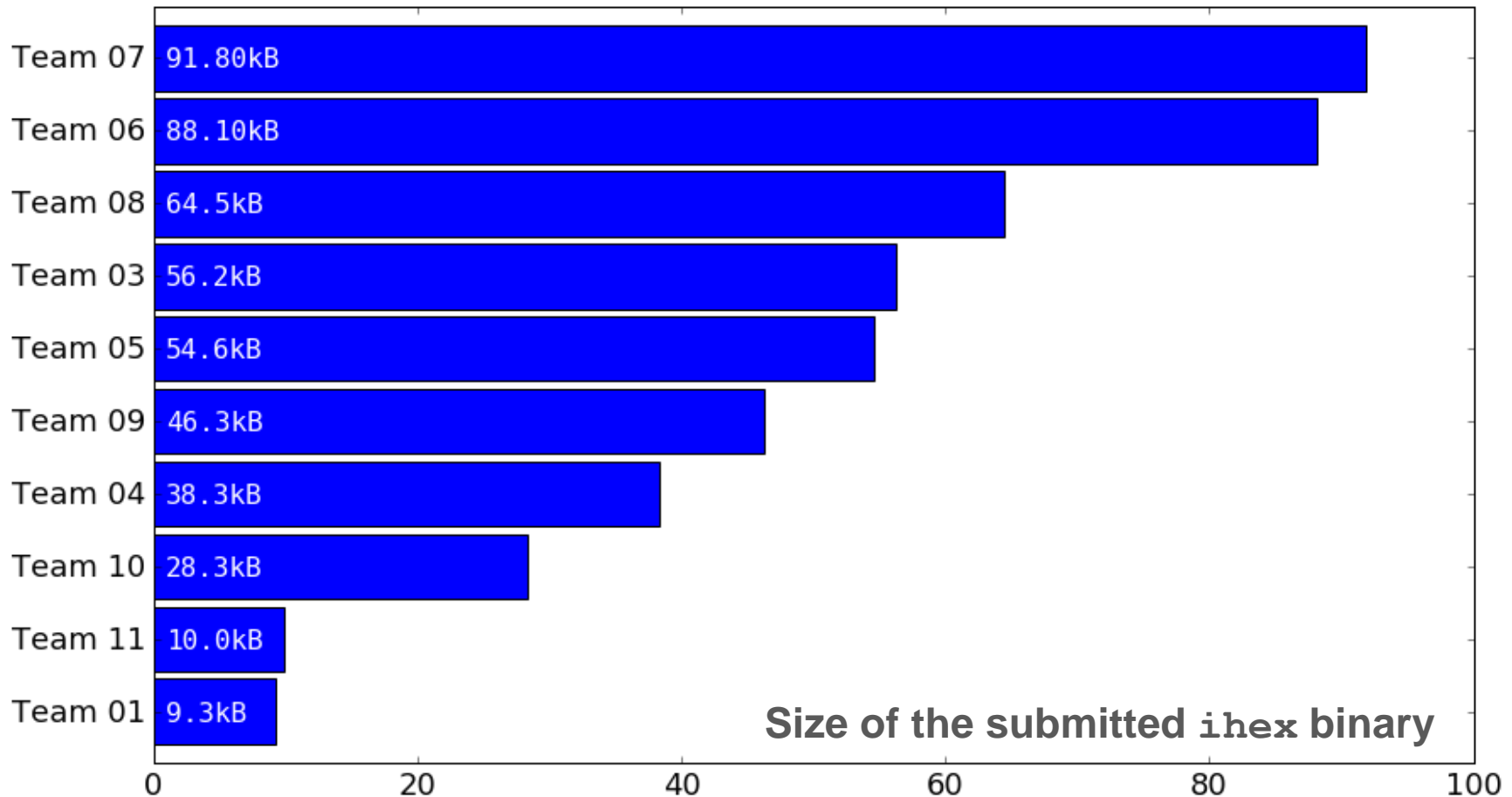
Fun Times

Comparing Results **Live**!

- Every team knew how the other teams were performing and had to adjust / parametrize their solutions accordingly!

Comparing Results **Live**!

- Every team knew how the other teams were performing and had to adjust / parametrize their solutions accordingly!
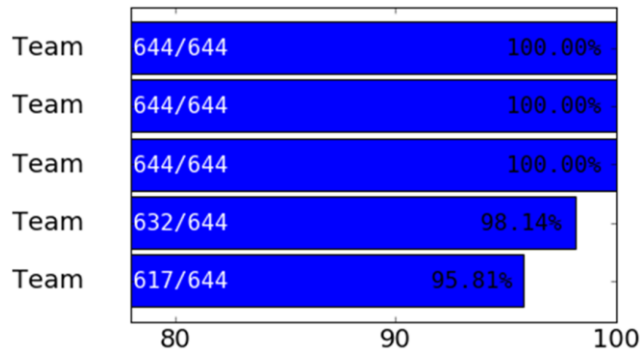

Team	Size
Team 07	91.80kB
Team 06	88.10kB
Team 08	64.5kB
Team 03	56.2kB
Team 05	54.6kB
Team 09	46.3kB
Team 04	38.3kB
Team 10	28.3kB
Team 11	10.0kB
Team 01	9.3kB

Size of the submitted `ihex` binary

And the winners are…
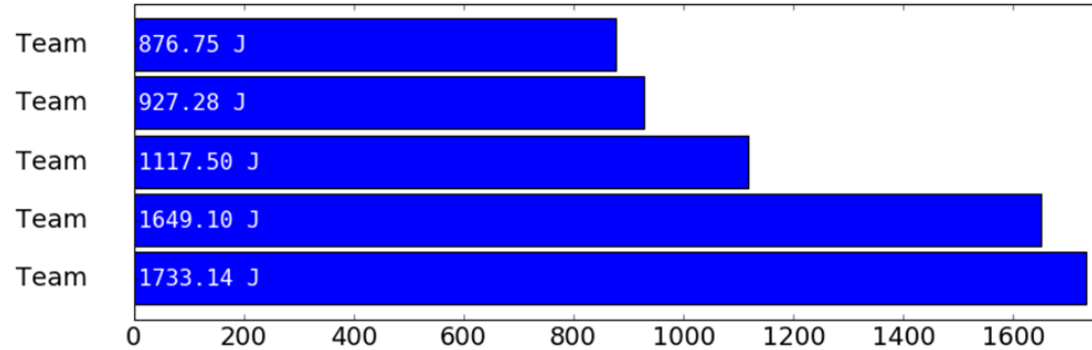## (announcing the top five teams)

Official Results – 1ˢᵗ Evaluation

- Top five solutions achieved > 95% reliability!

- Latency was often kept below 100 ms

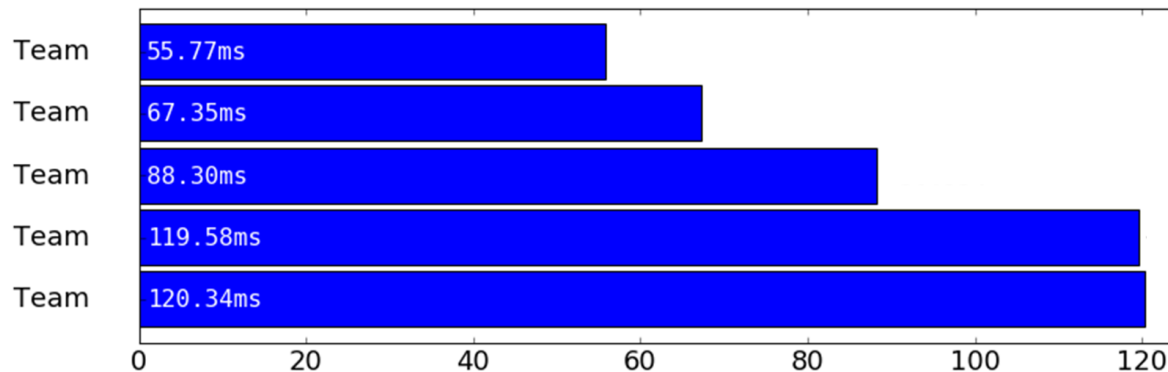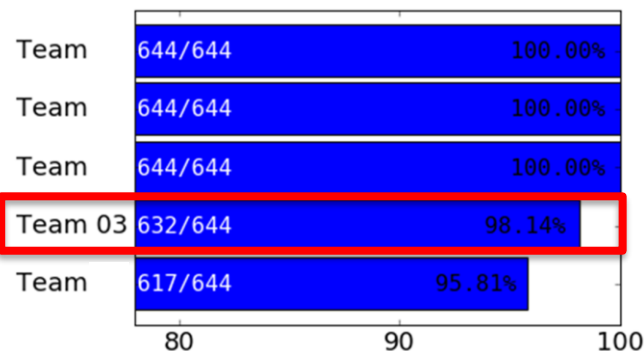- Very low energy consumption (0.01 - 0.03 J/s for each node)

RELIABILITY

Team	644/644	100.00%
Team	644/644	100.00%
Team	644/644	100.00%
Team	632/644	98.14%
Team	617/644	95.81%

ENERGY

Team	876.75 J
Team	927.28 J
Team	1117.50 J
Team	1649.10 J
Team	1733.14 J

LATENCY

Team	55.77ms
Team	67.35ms
Team	88.30ms
Team	119.58ms
Team	120.34ms

Official Results – 1ˢᵗ Evaluation
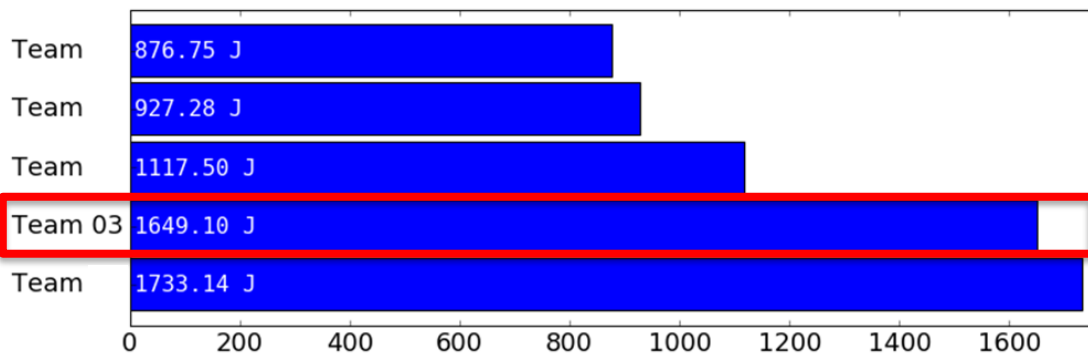
- **4ᵗʰ place** (ex-aequo):

  Team #03: Using OFPCOIN under Interference

  Xiaoyuan Ma, Weisheng Tang, Wangji He, Fuping Zhang, and Jianming Wei
  (Shanghai Advanced Research Institute, China; Chinese Academy of Sciences, China)
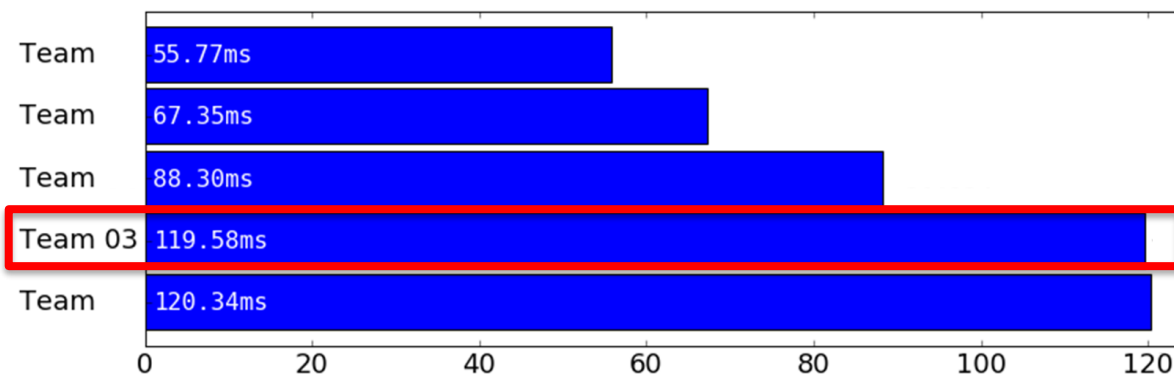

RELIABILITY

Team	644/644	100.00%
Team	644/644	100.00%
Team	644/644	100.00%
Team 03	632/644	98.14%
Team	617/644	95.81%

ENERGY

Team	876.75 J
Team	927.28 J
Team	1117.50 J
Team 03	1649.10 J
Team	1733.14 J

LATENCY

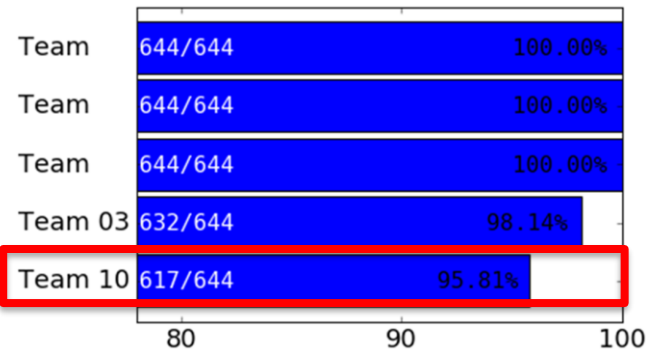| Team | 55.77ms |
Team	67.35ms
Team	88.30ms
Team 03	119.58ms
Team	120.34ms

Official Results – 1ˢᵗ Evaluation

- **4ᵗʰ place** (ex-aequo):

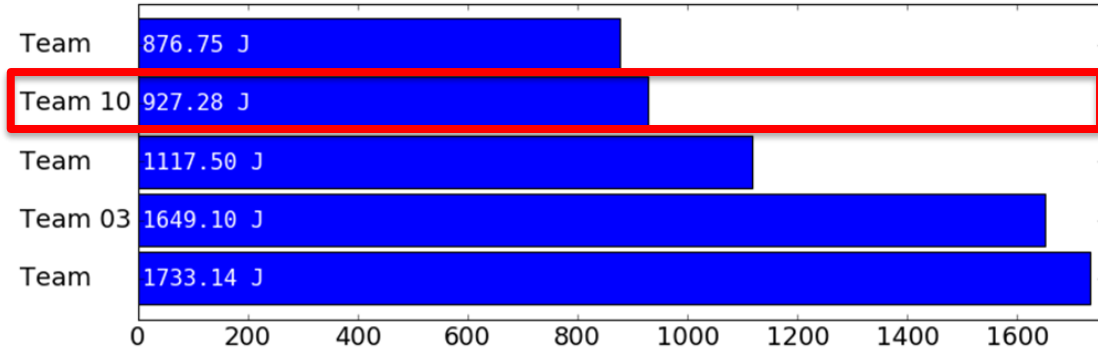Team #10: Energy-Efficient Network Flooding with Channel-Hopping

Philipp Sommer and Yvonne-Anne Pignolet
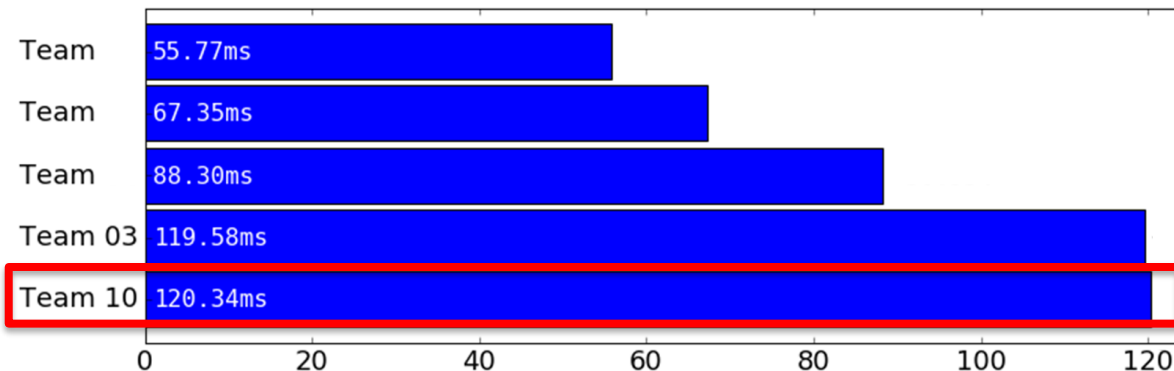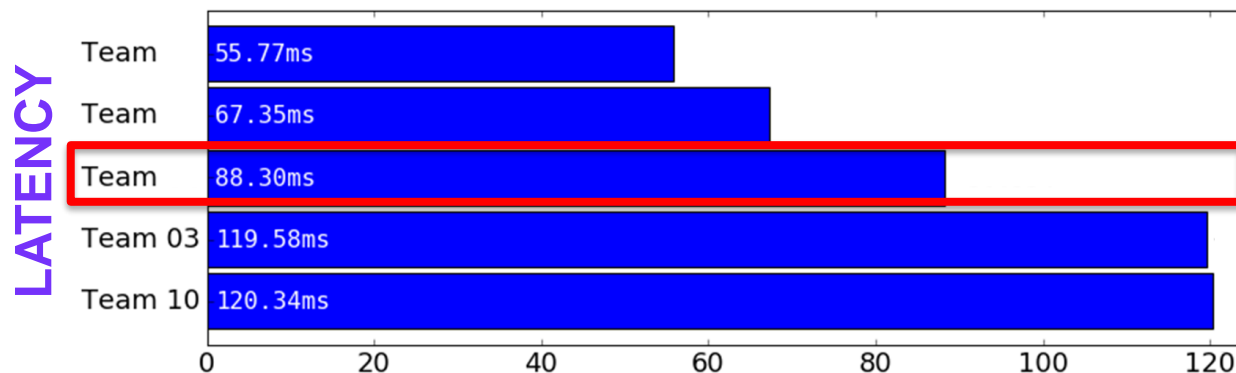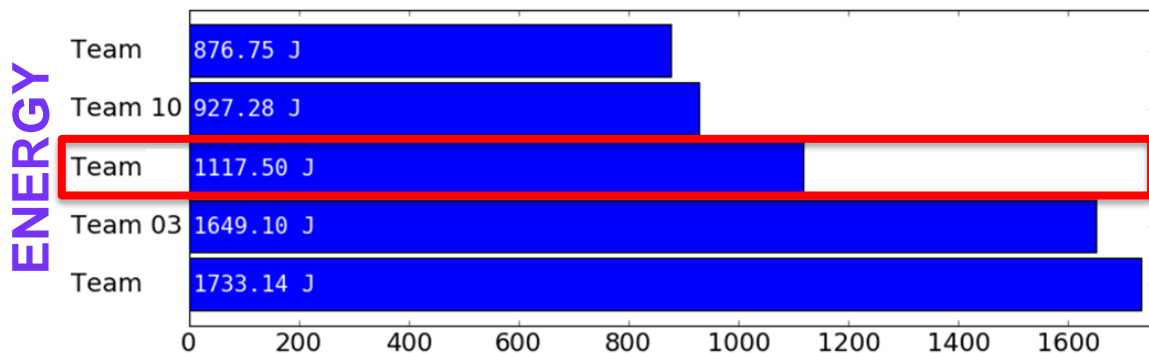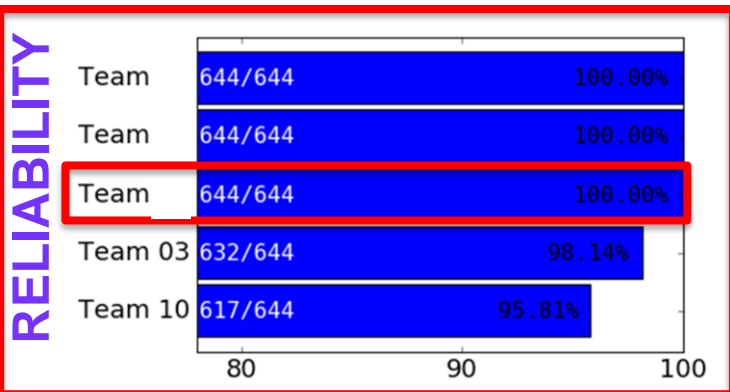(ABB Corporate Research, Switzerland)

Official Results – 1ˢᵗ Evaluation

- **3ʳᵈ place**:

Team #04: Towards Low-Power Wireless Networking that Survives
Interference with Minimal Latency
Beshr Al Nahas and Olaf Landsiedel
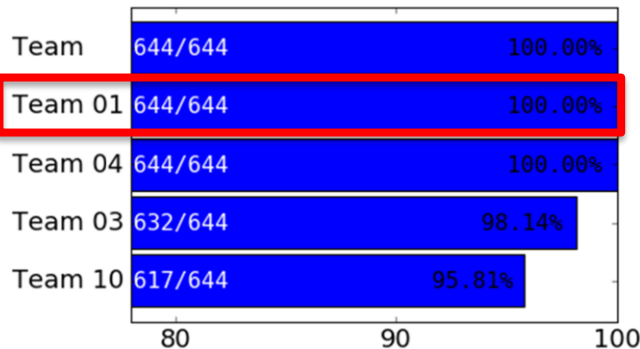(Chalmers University of Technology, Sweden)

Official Results – 1st Evaluation
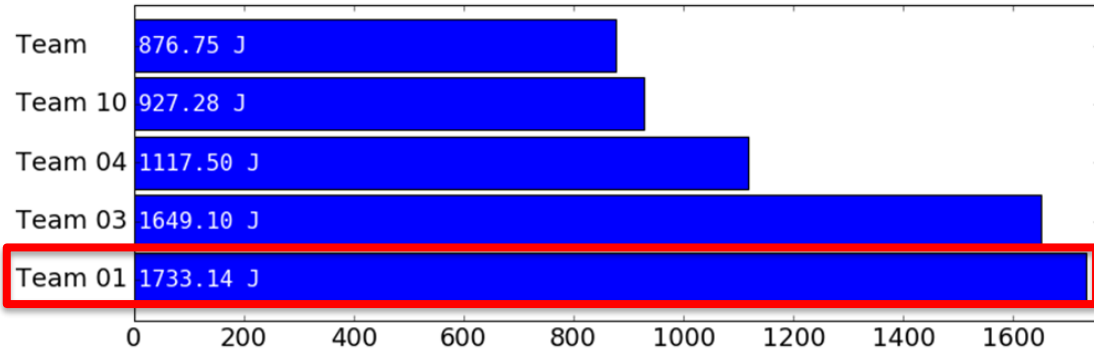
- **2nd place**:

Team #01: RedFixHop with Channel Hopping

Antonio Escobar, Javier Garcia, Francisco Cruz, Jirka Klaue, Angel Corona, Divya Tati
(Infineon Technologies AG, Germany; RWTH Aachen University, Germany; Kinexon GmbH, Germany;
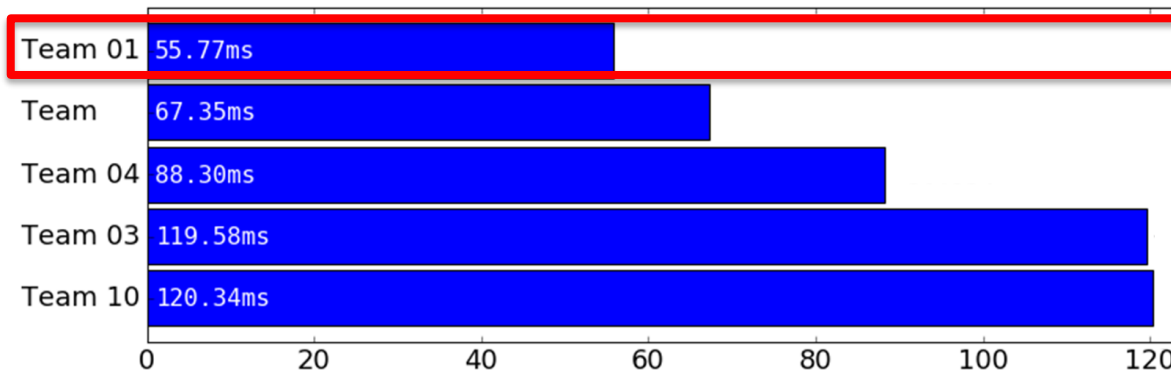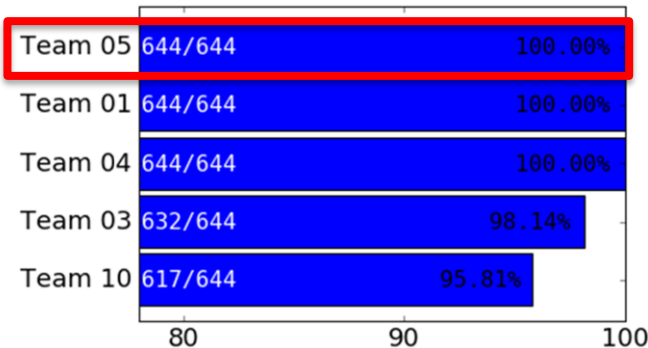eesy-innovation GmbH, Germany; Airbus Group Innovations, Germany)

RELIABILITY

Team	644/644	100.00%
Team 01	644/644	100.00%
Team 04	644/644	100.00%
Team 03	632/644	98.14%
Team 10	617/644	95.81%

ENERGY

Team	876.75 J
Team 10	927.28 J
Team 04	1117.50 J
Team 03	1649.10 J
Team 01	1733.14 J

LATENCY

Team 01	55.77ms
Team	67.35ms
Team 04	88.30ms
Team 03	119.58ms
Team 10	120.34ms

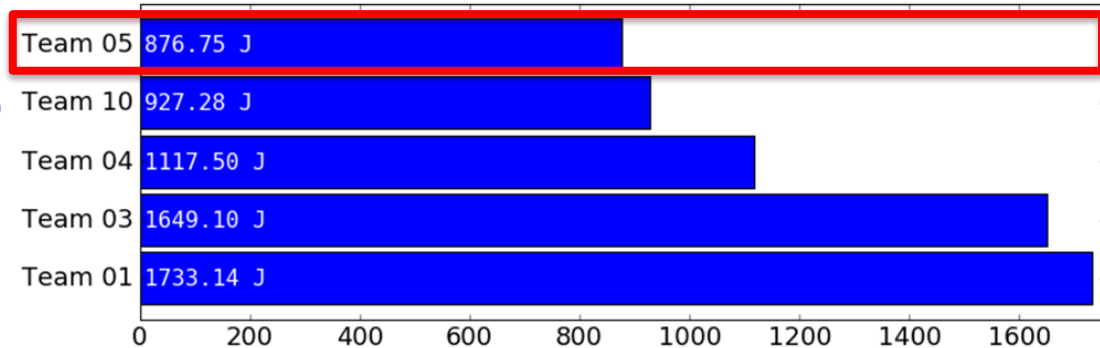# Official Results – 1ˢᵗ Evaluation

- **1ˢᵗ place**:

Team #05: Robust Flooding using Back-to-Back Synchronous
Transmissions with Channel-Hopping
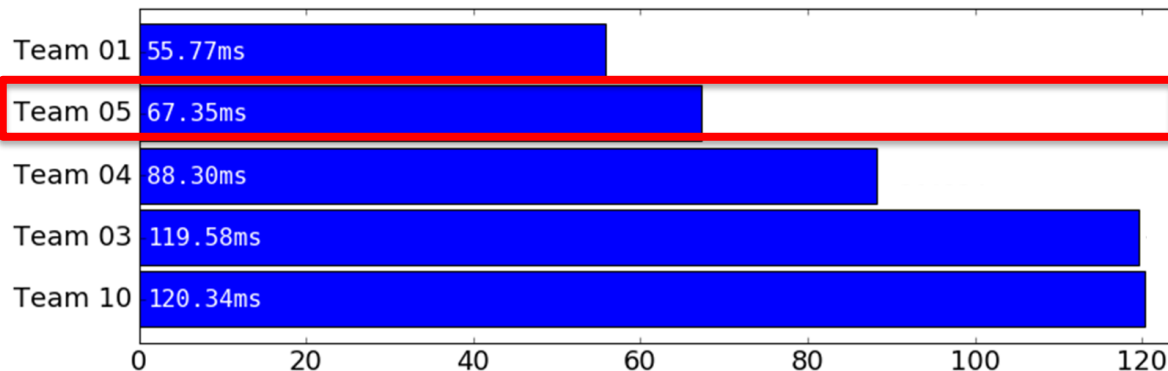Roman Lim, Reto Da Forno, Felix Sutton, and Lothar Thiele
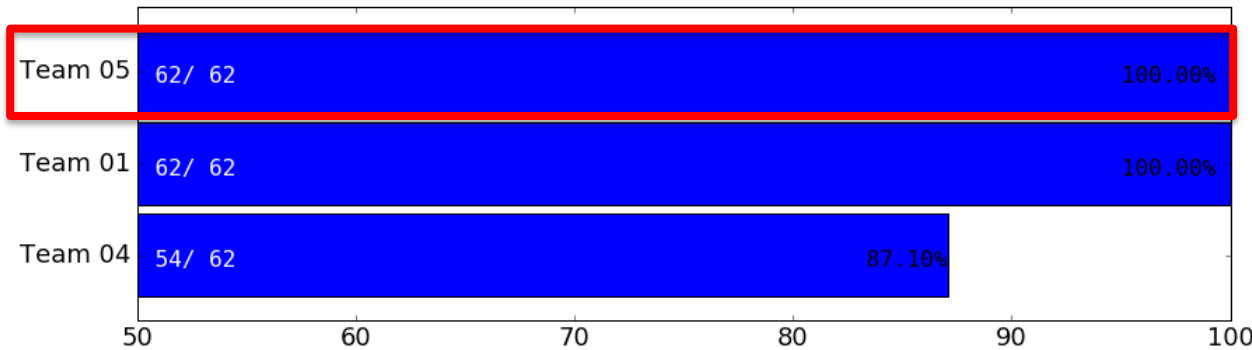(ETH Zurich, Switzerland)

RELIABILITY

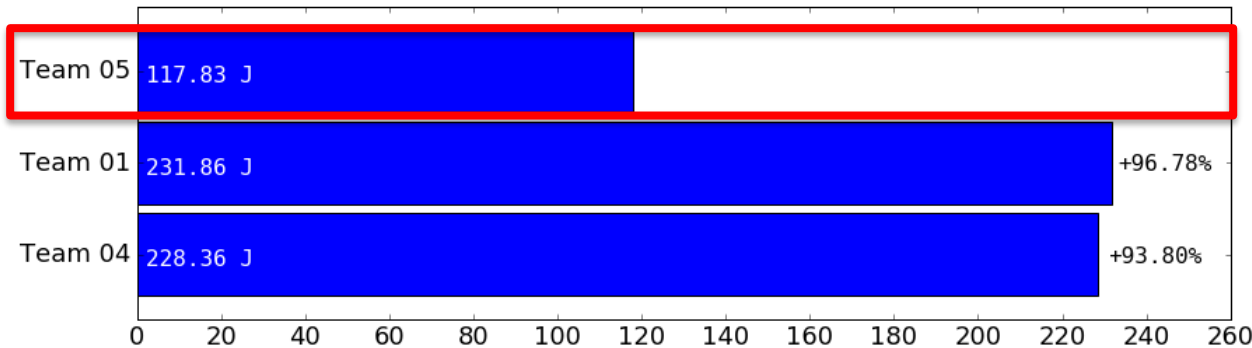|	
Team 05	644/644 — 100.00%
Team 01	644/644 — 100.00%
Team 04	644/644 — 100.00%
Team 03	632/644 — 98.14%
Team 10	617/644 — 95.81%

ENERGY

Team 05	876.75 J
Team 10	927.28 J
Team 04	1117.50 J
Team 03	1649.10 J
Team 01	1733.14 J

LATENCY

Team 01	55.77ms
Team 05	67.35ms
Team 04	88.30ms
Team 03	119.58ms
Team 10	120.34ms
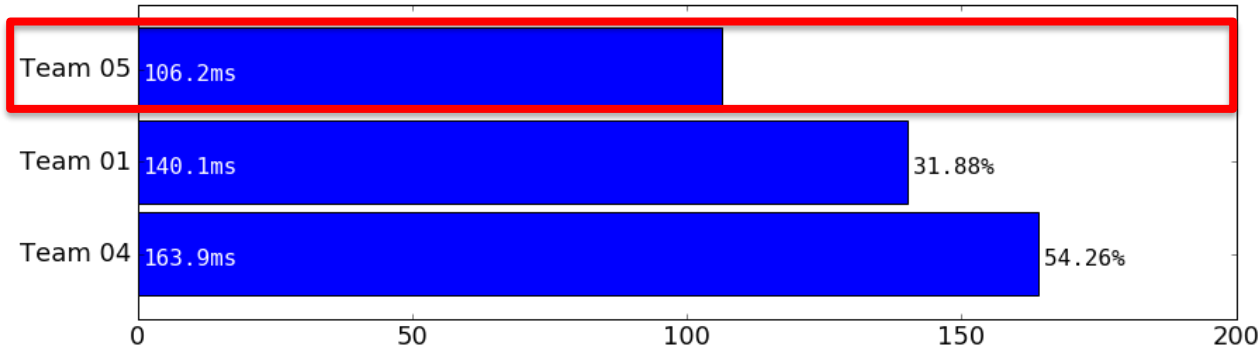
Official Results – 2nd Evaluation
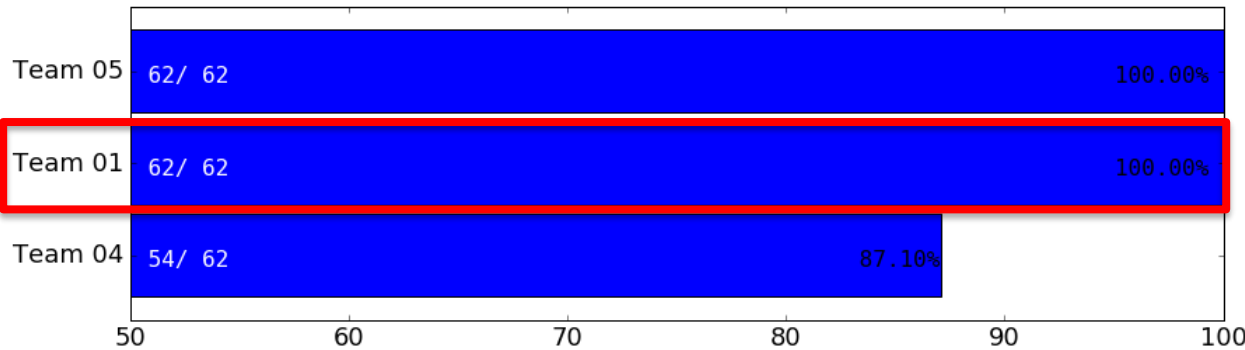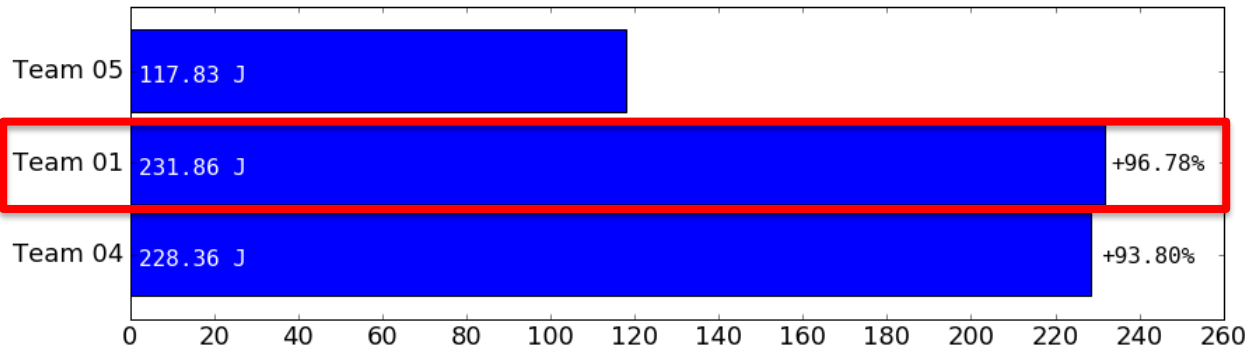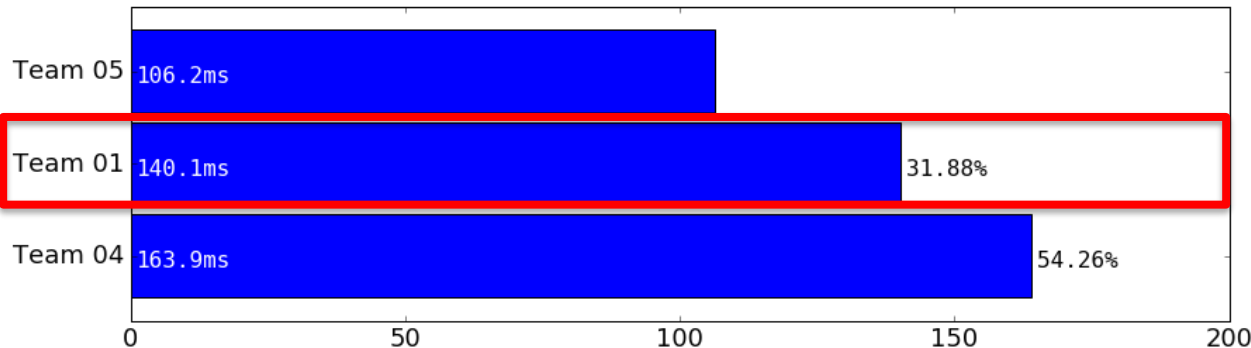
Official Results – 2nd Evaluation

Official Results – 2nd Evaluation
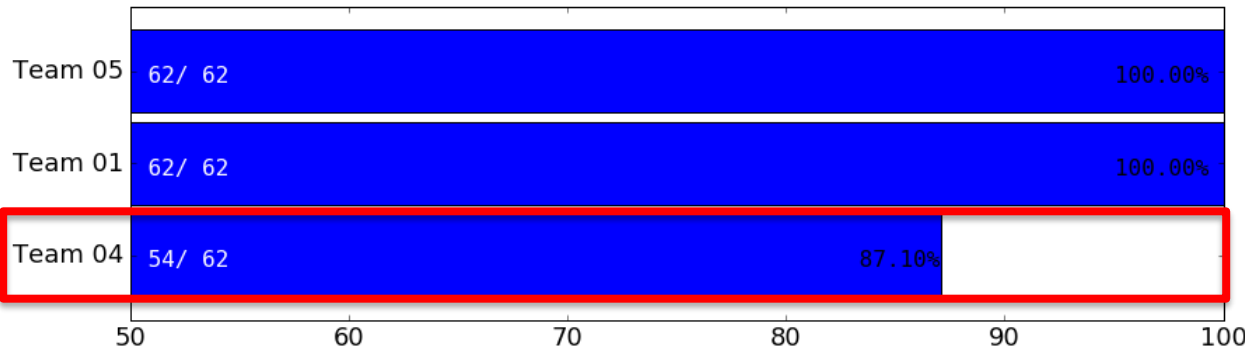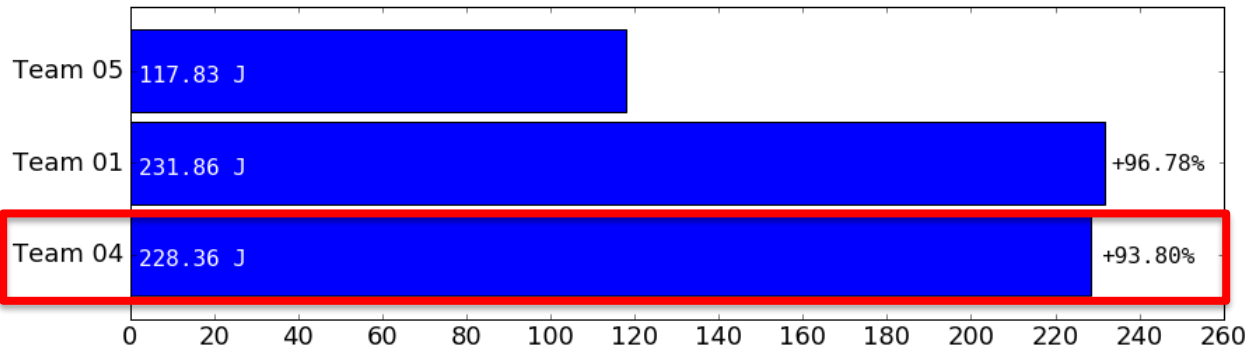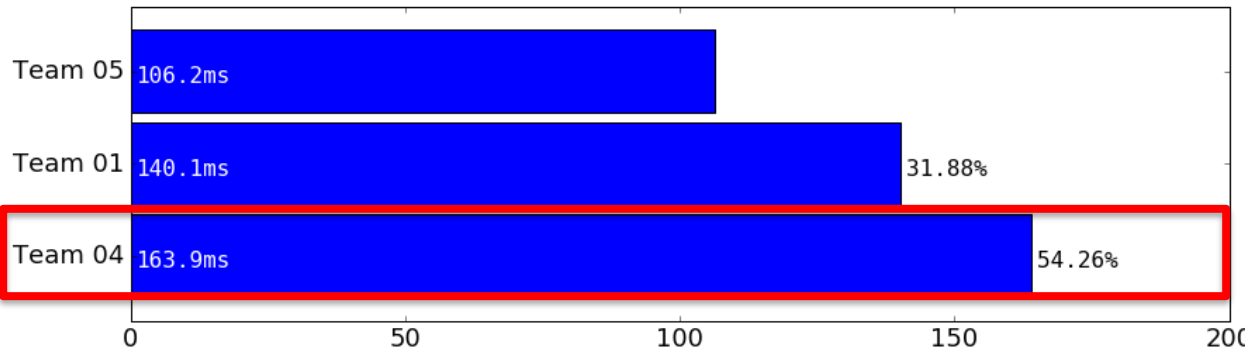
Congratulations to the Winners!

- **1st place (Team #05)**
  - Robust Flooding using Back-to-Back Synchronous Transmissions with Channel-Hopping
    Roman Lim, Reto Da Forno, Felix Sutton, and Lothar Thiele
    (ETH Zurich, Switzerland)

- **2nd place (Team #01)**
  - RedFixHop with Channel Hopping
    Antonio Escobar, Javier Garcia, Francisco Cruz, Jirka Klaue, Angel Corona, Divya Tati
    (Infineon Technologies AG, Germany; RWTH Aachen University, Germany; Kinexon GmbH, Germany; eesy-innovation GmbH, Germany; Airbus Group Innovations, Germany)

- **3rd place (Team #04)**
  - Towards Low-Power Wireless Networking that Survives Interference with Minimal Latency
    Beshr Al Nahas and Olaf Landsiedel
    (Chalmers University of Technology, Sweden)

- **Coming up next: presentations of the three best teams**

Thanks to Everyone supporting the Competition

- Thiemo, Christian, Ambuj, Haris, Kasun, Joel, Georgios, TU Graz, …

- But especially one person:

Markus Schuß

- Coming up next: presentations of the three best teams