Revision 4

New

EWSN 2018 Dependability Competition

Logistics Information

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3rd EWSN Dependability Competition

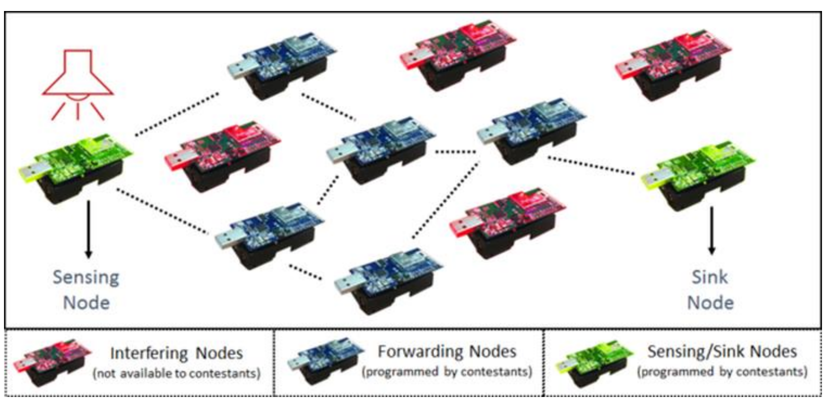
- Following the success of the past two editions, the International Conference on Embedded Wireless Systems and Networks (EWSN) hosts also this year a dependability competition comparing the performance of IoT communication protocols in harsh RF environments
  - 1st edition (2016): Graz, Austria [link]
  - 2nd edition (2017): Uppsala, Sweden [link]
  - 3rd edition (2018): Madrid, Spain [link]

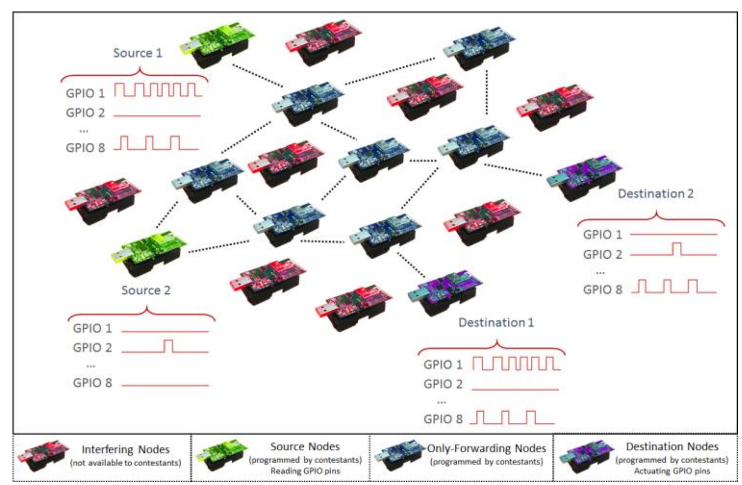
New Format

- This year's dependability competition is run remotely over a longer time window
  - The competition organizers have built a testbed facility that is available remotely to all contestants
    - → Contestants can thoroughly test their code on the actual evaluation scenario
    - → Roughly two months time to test a solution before submitting the code used for the final evaluation
  - The testbed facility can be used exclusively for research purposes and for testing the solution submitted to the competition
    - → It is prohibited to upload malware trying to gain unauthorized access to or disrupt any service, data, account or network (see terms and conditions)

New Format

- This year’s evaluation scenario includes the reporting of <u>multiple</u> events from/to <u>several</u> nodes
  - The scenario used in the past two editions focused on a *single* source node monitoring *one* event and forwarding this information to a *single* destination node over a multi-hop network
  - In this year’s scenario, *many* source nodes monitor *several* events and need to forward this information to *one or more* destinations over a multi-hop network

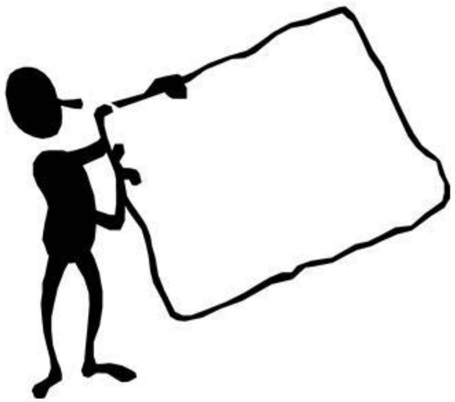




New Format

- Dedicated poster session during the main conference
  - During the first day of the main EWSN conference, the winners of the dependability competition will be awarded
  - The top-three teams will hold a 10-minutes presentation about their solution, followed by a short discussion session
  - In the afternoon of the first day of the main EWSN conference, there will be a dedicated poster session for all competitors

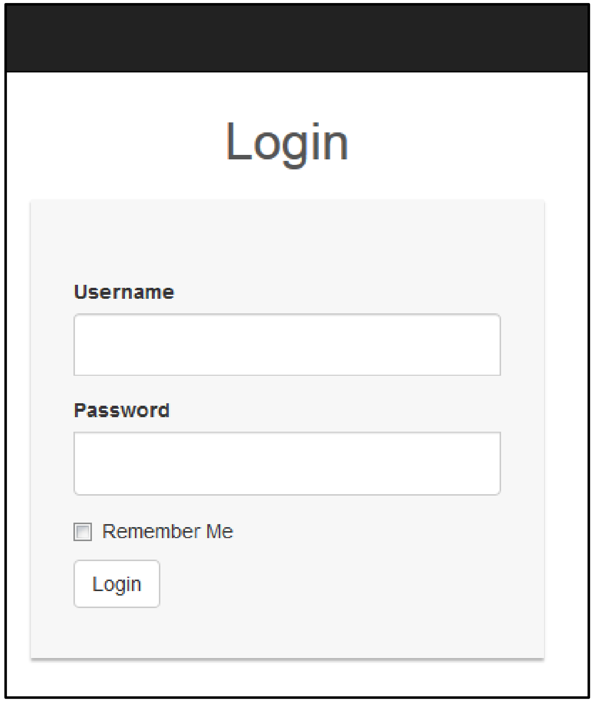
    → All competing teams must present their solution in the poster session and will have the possibility to engage in lively discussions with the other conference attendees



Competition's Testbed Facility

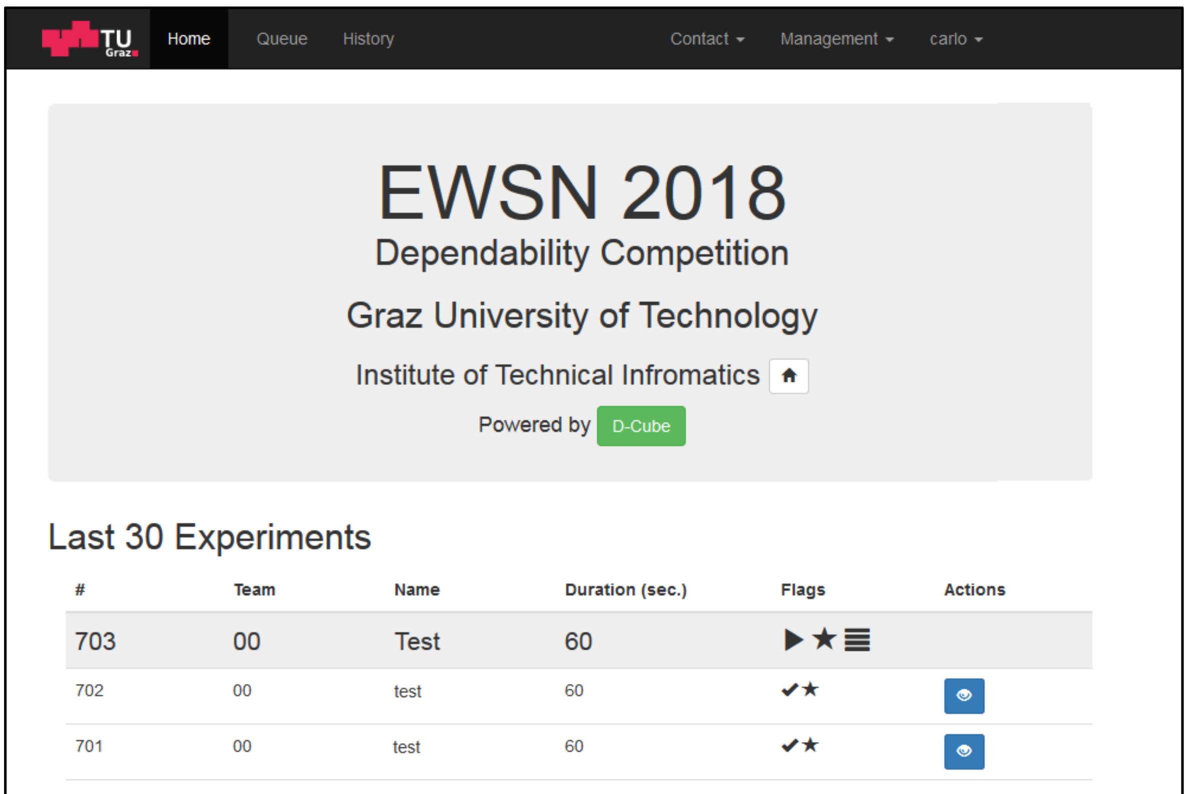
Competition’s Testbed Facility

- The testbed facility is available at: https://iti-testbed.tugraz.at/
- Login credentials
  - Each team will receive the login credentials to access the testbed facility via e-mail as soon as:
    - → At least one team member has registered to EWSN 2018
    - → A signed scanned copy of the terms and conditions for the use of the competition’s testbed has been sent to the organizers
    - → One username and password shared for the whole team



Competition’s Testbed Facility

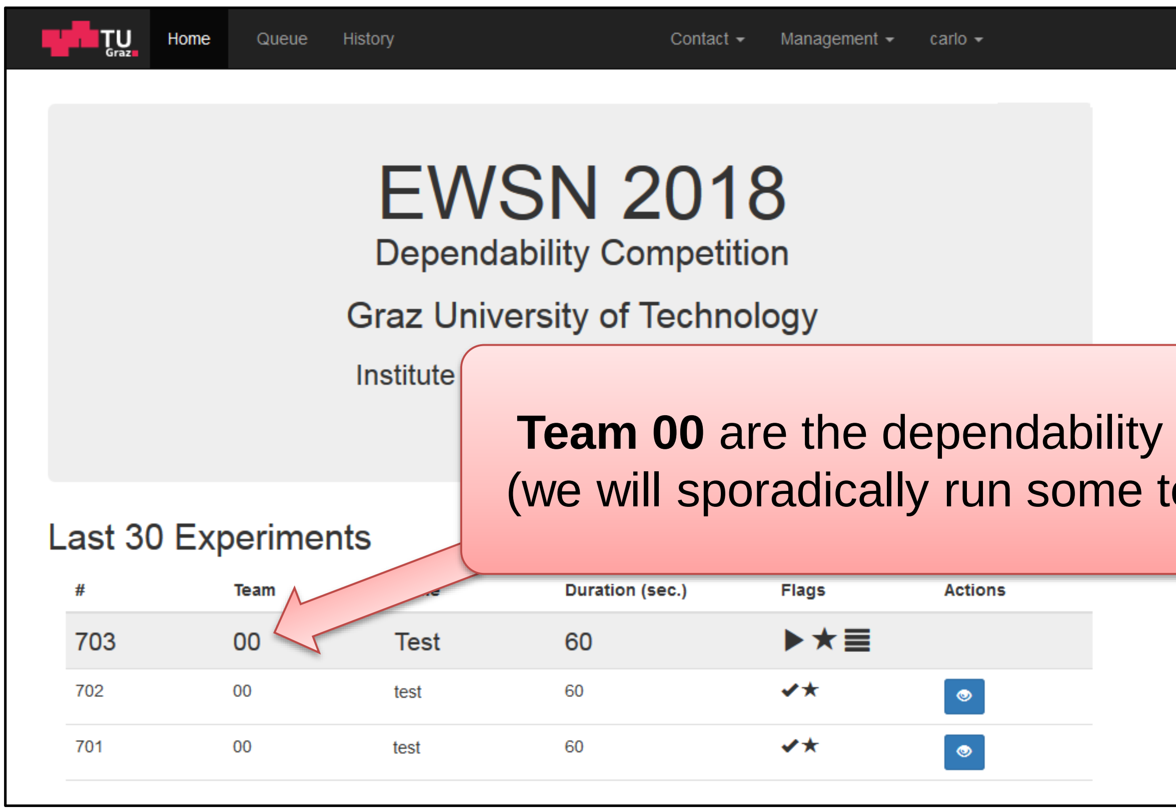
- At a glance
  - Home tab shows the list of all experiments of all teams (completed, running, or queued for execution)



- Currently running
- Successfully completed
- Aborted or failed
- Higher priority job (organizers only)
- Log output enabled (traces only seen by team)
- Visualize results (anyone can see those!)

Competition's Testbed Facility

- At a glance
  - Home tab shows the list of all experiments of all teams (completed, running, or queued for execution)



Currently running

Successfully completed

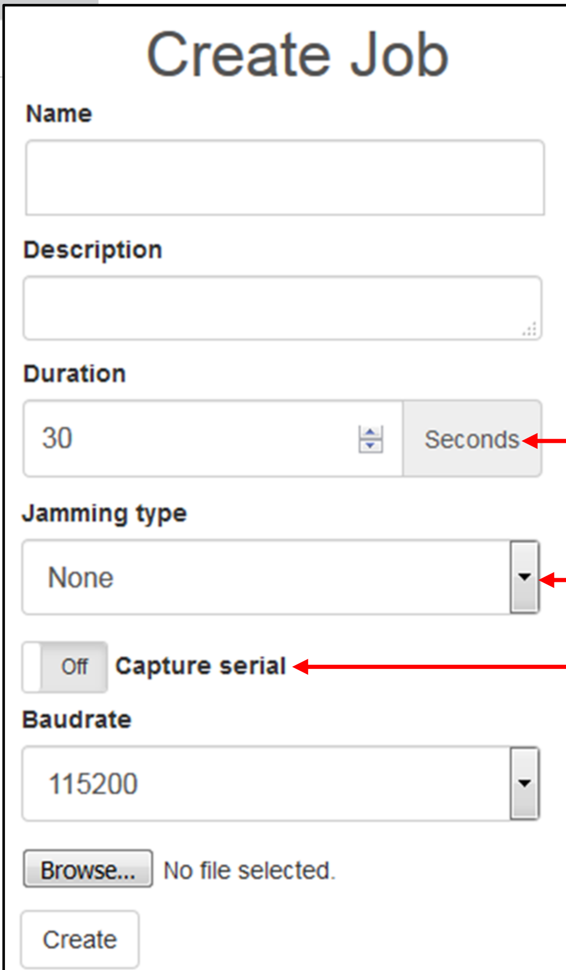
Aborted or failed

(traces only seen by team)

Visualize results (anyone can see those!)

Team 00 are the dependability competition organizers! ☺
(we will sporadically run some testruns and sanity checks)

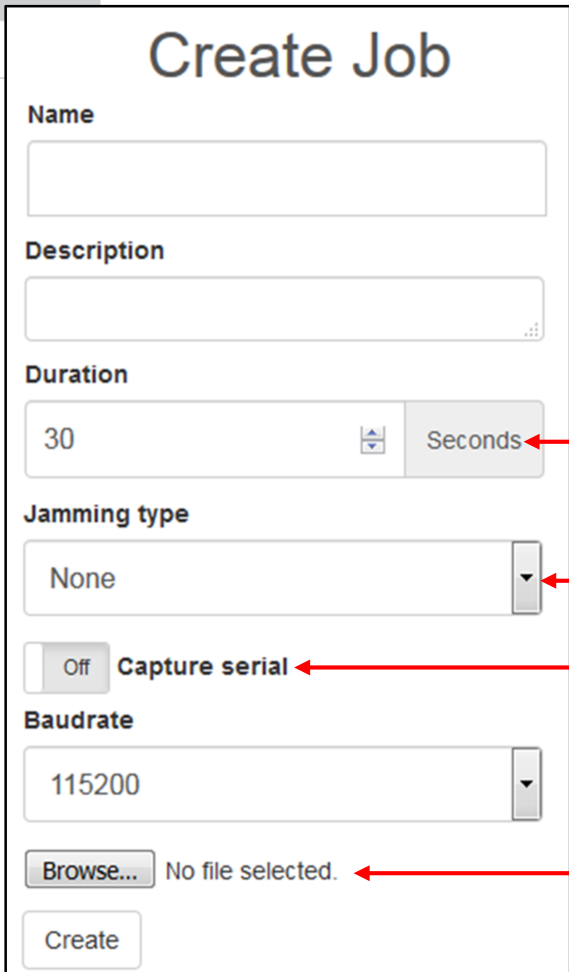
Firmware Upload



- Contestants can select an experiment duration
  Please note: this will be initially limited to max. **300** seconds
- Contestants can enable interference in the surroundings of the nodes and specify its level
  Please note: this feature will be initially disabled
  Please note: the jamming pattern in the final evaluation is subject to change to avoid engineered solutions
- Contestants can capture serial output
  Please note: turning FTDI on/off severely affects the overall energy consumption!

Important note: the captured serial output may have gaps due to the nature of the USB isolation (for accurate power measurements)

Firmware Upload



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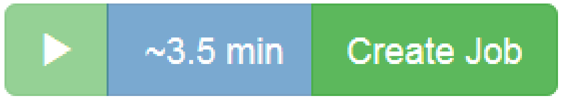
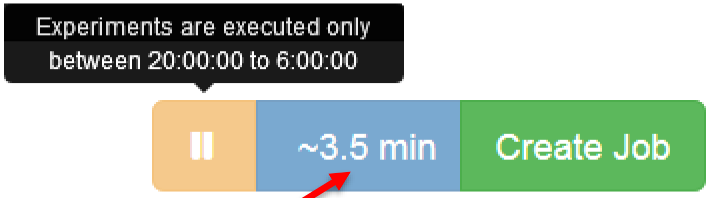
- Contestants can capture serial output
  Please note: turning FTDI on/off severely affects the overall energy consumption!
- Contestants can upload a single binary `ihex` file: this will be uploaded to all nodes in the network using a common MSP430 Bootstrap Loader

Testbed's Scheduler

- Jobs execution policy: first come, first served
- Jobs are executed **between 7:00 and 17:00 AoE only!**
  - Between 20:00 and 6:00 (Central Europe time)
  - Between 4:00 and 14:00 (Tokyo time)
  - Between 4:00 and 13:00 (Bejing time)



The scheduler is currently active and processing jobs



The scheduler activity will be resumed at 20:00 CET

Amount of time required by the jobs currently queued

Experiments can be queued anytime!

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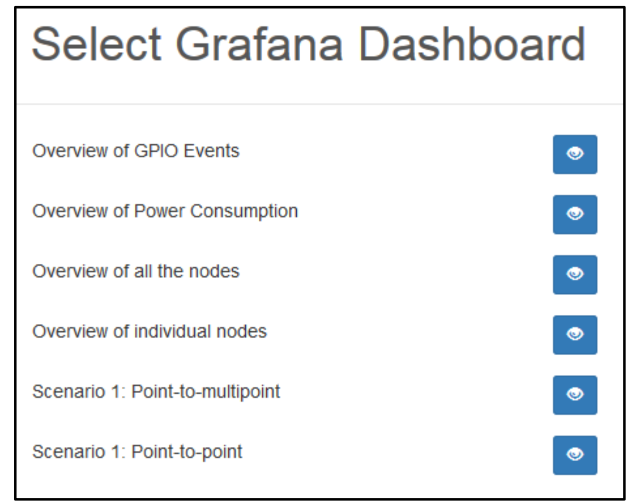
- Why this limitation?
  - During the experiments, a harsh RF environment is created by making use of (among others) Raspberry Pi3 nodes to generate a significant amount of Wi-Fi traffic
  - When heavy Wi-Fi traffic is generated, the University’s Wi-Fi infrastructure is severely affected any can be disrupted
  - Therefore, we have agreed with TU Graz to carry out experiments only outside the official working hours

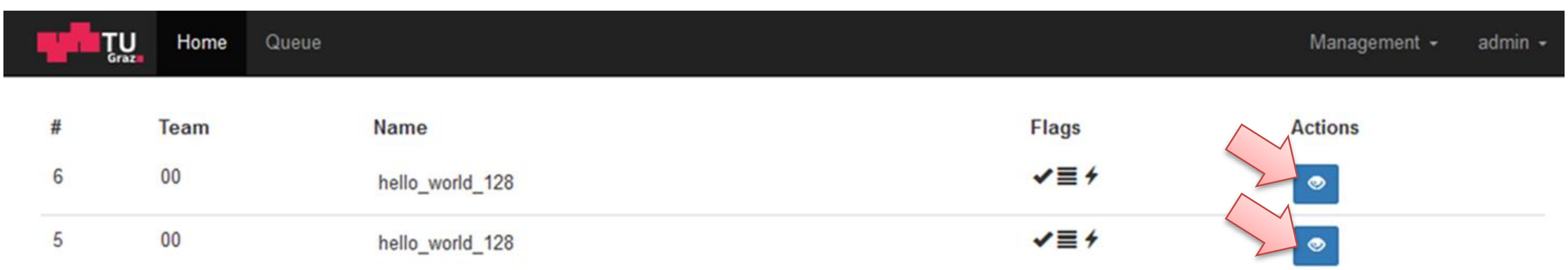
Results of an Experiment

- After the execution of an experiment, graphical results can be checked by anyone by clicking on the blue button on the right side

  - Results displayed using Grafana
  - Power consumption and GPIO status is tracked for each node
  - Additional features will be activated in the next weeks

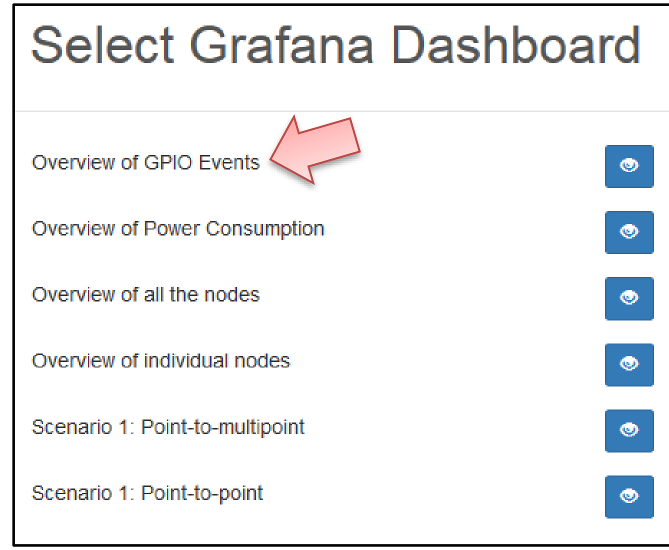


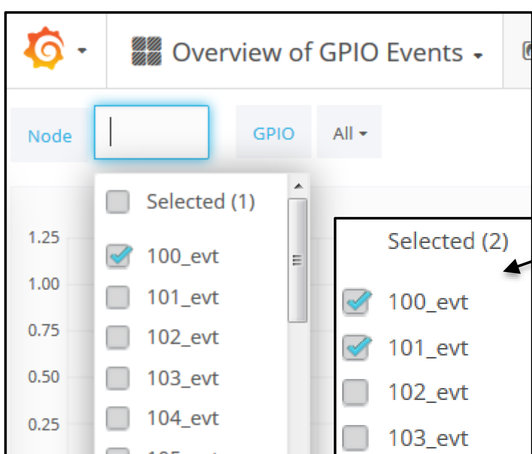
- The team owning a job can also see the program log



Results of an Experiment

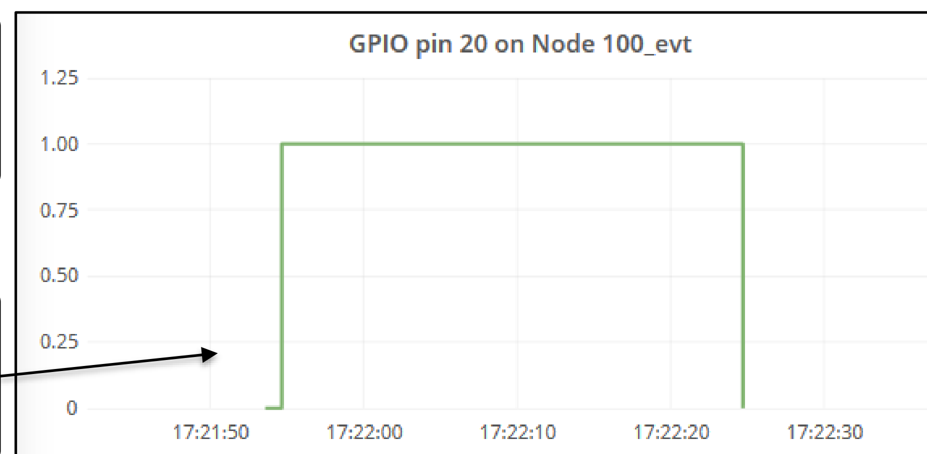
- Grafana dashboards
  - Overview of GPIO events
  - Overview of power consumption
  - Overview of all the nodes
  - Overview of individual nodes
  - Scenario 1: Point-to-multipoint
  - Scenario 1: Point-to-point
  - Additional features will be activated in the next weeks





Monitoring the GPIO of multiple nodes at the same time

Monitoring individual GPIO pins
(for the numbering explanation check the "GPIO pins" section)



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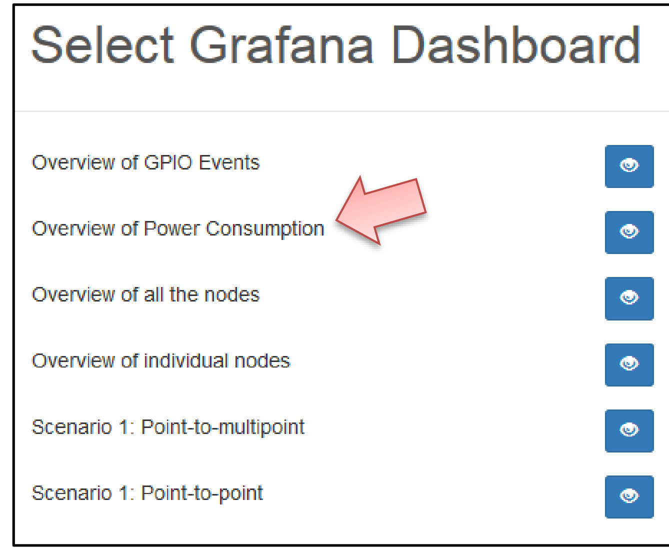
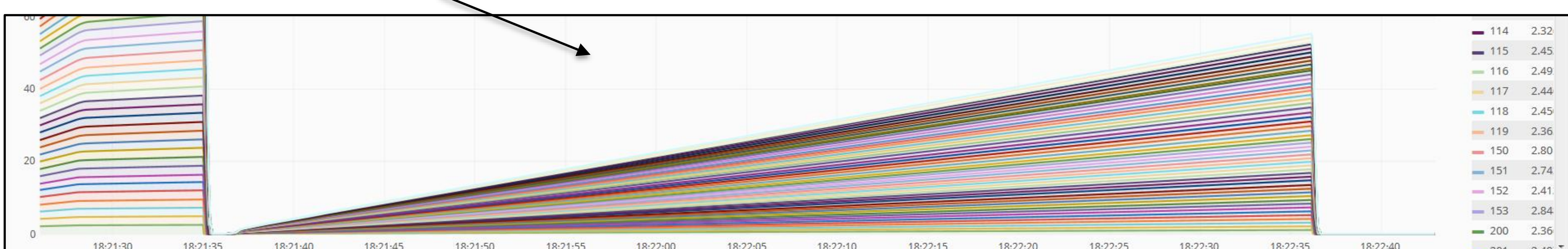


Stacked energy consumption:
Shows the total energy consumed by all nodes in the testbed

Experiment state:
Shows if a sensor node is active (1) or not (0)



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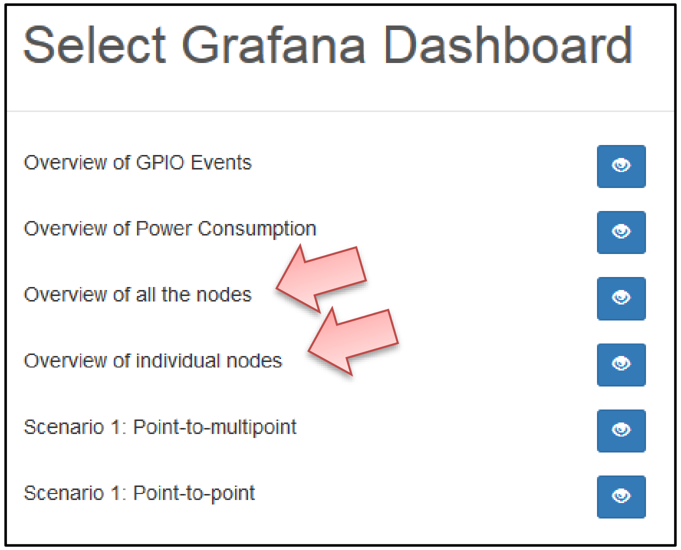

Individual statistics on **voltage, current, power,** and **cumulative energy** for each node in the network

Node status information (serves as a sanity check for contestants and organizers)

See "GPIO pins" section for details

The value is computed as follows:

```
control=0;
control=gpioRead(21);                  // GPIO 21 = TelosB has power? (1 = yes, 0 = no)
control=(control<<1) | gpioRead(20); // GPIO 20 = reset pin of TelosB node (1 = running, 0 = not running)
control=(control<<1) | gpioRead(16); // GPIO 16 = The GPIOs ADC0, ADC1, ADC2, and ADC3 are all configured
                                        as input (0) or as output (1)
control=(control<<1) | gpioRead(12); // GPIO 12 = The GPIOs ADC7, GIO2, GIO3, and USERINT are all
                                        configured as input (0) or as output (1)
```

Results of an Experiment

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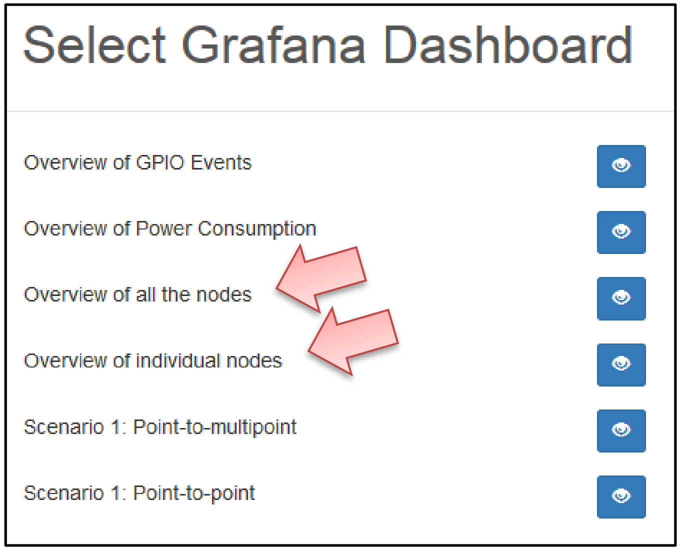
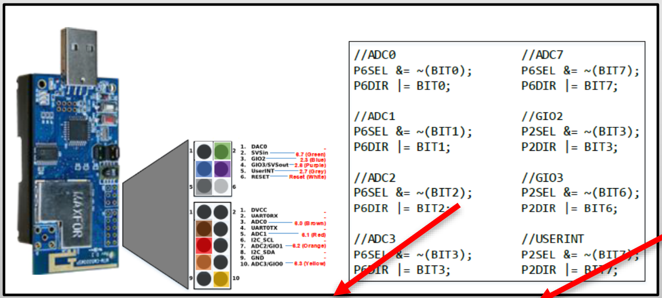
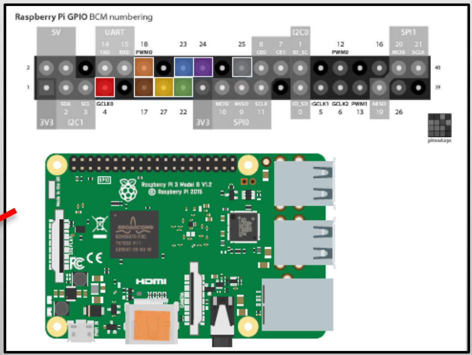


GPIO pins (Information is encoded in a special way – for individual values, use "Overview of GPIO events")

<u>The value is computed as follows:</u>

```
gpio=0;
gpio=gpioRead(17);
gpio=(gpio<<1) | gpioRead(4);
gpio=(gpio<<1) | gpioRead(18);
gpio=(gpio<<1) | gpioRead(27);
gpio=(gpio<<1) | gpioRead(22);
gpio=(gpio<<1) | gpioRead(23);
gpio=(gpio<<1) | gpioRead(24);
gpio=(gpio<<1) | gpioRead(25);
```





(See "GPIO pins" section for details)

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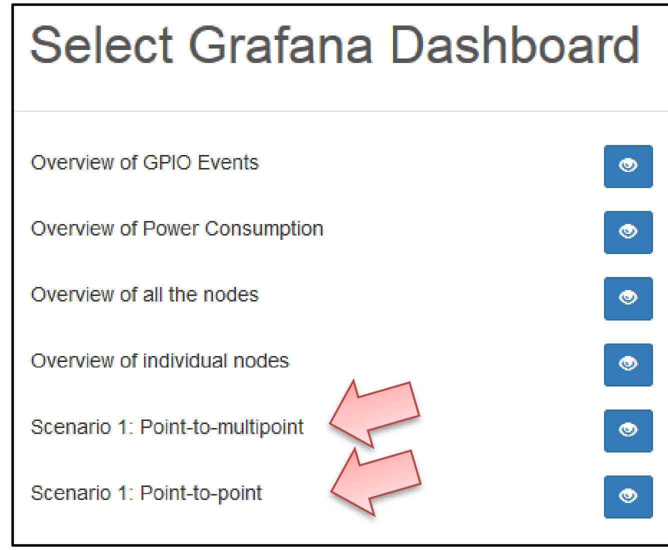
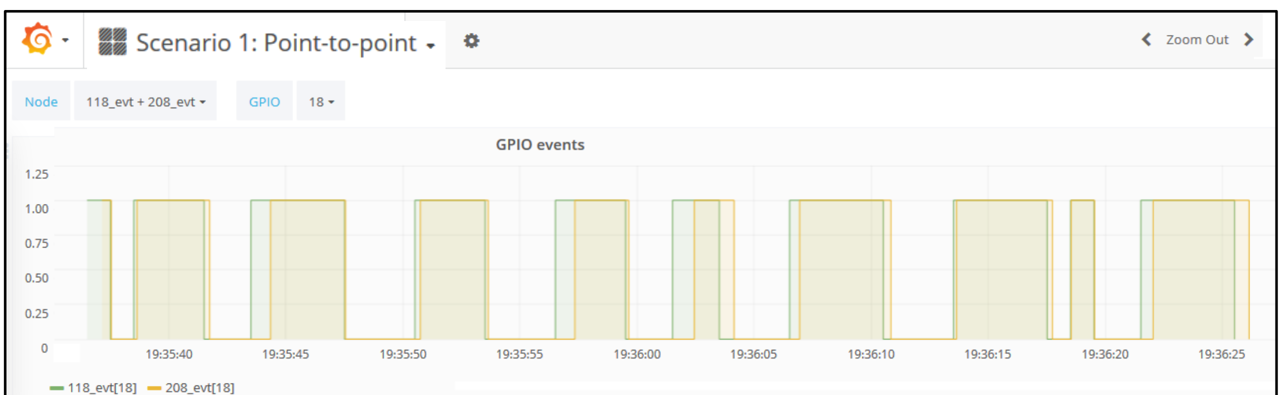


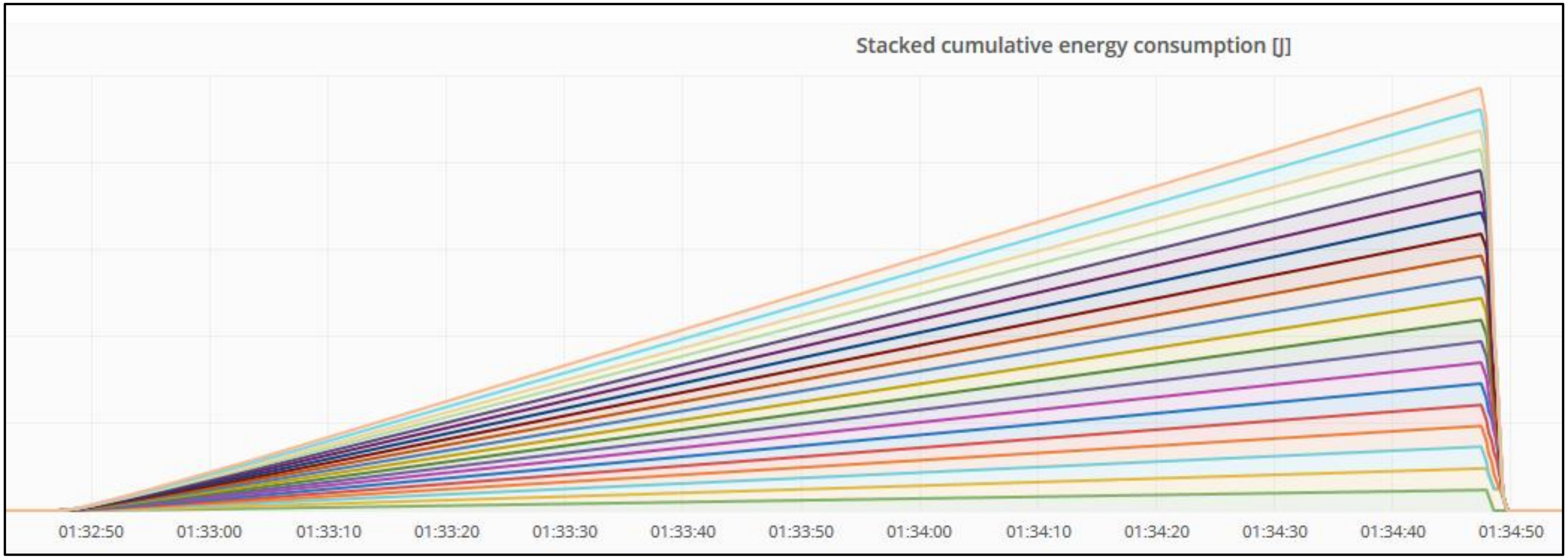


Plots specific to the current evalation scenario
(see "Evaluation Scenario scetion" of these slides)

Visualization in Grafana – FAQ

- What is the meaning of the "Stacked cumulative energy consumption" plot?
  - The plots shows the consumption in Joules of each TelosB node

    → Note that the consumption of the whole sensor node is measured (this includes USB circuitry, DC-DC converter, …)

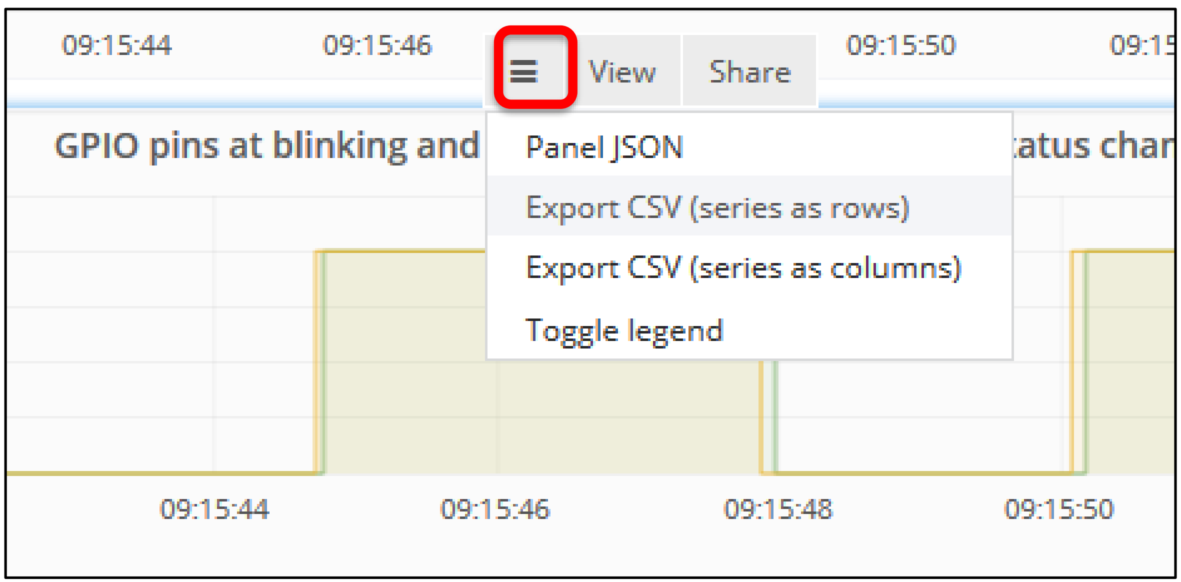


Visualization in Grafana – FAQ

- Why is Grafana not displaying any point when I zoom in?
  - Grafana uses second resolution for the zoom
  - When zooming too much, the averaging may lead to a situation in which Grafana uses the same timestamp as startpoint and endpoint and cannot hence visualize a line

Visualization in Grafana – FAQ

- Can we export the data seen in Grafana?
  - Yes, CSV files can be exported by clicking on the title of the plot
  - Click on the menu icon and select "Export CSV"

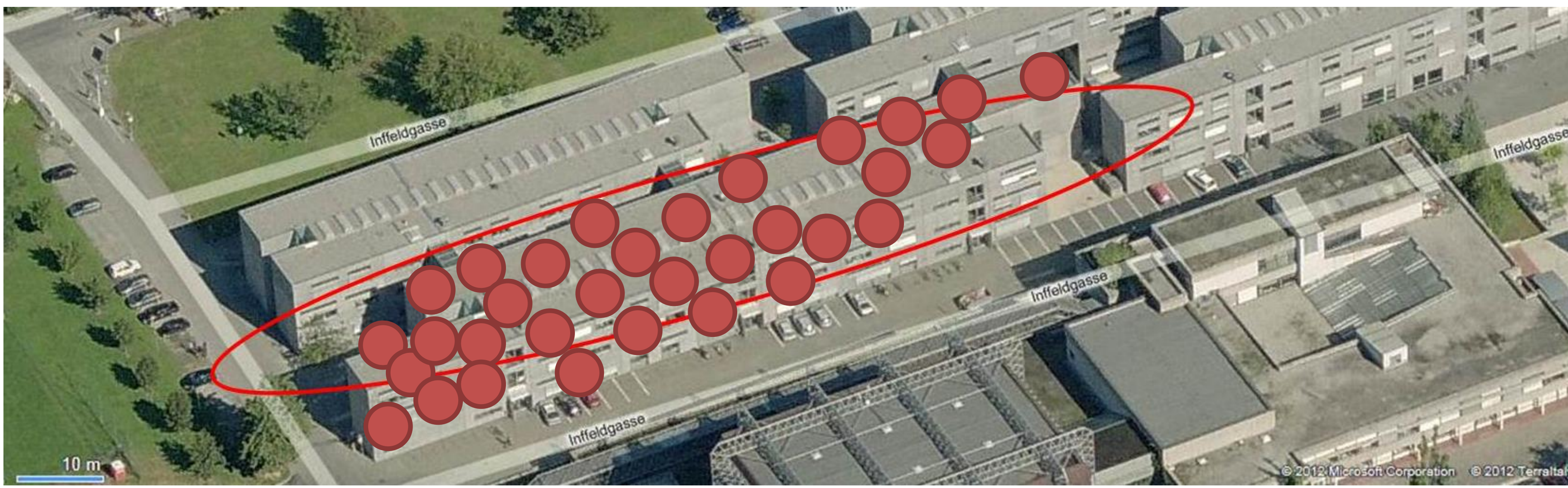


	A	B	C
1	Time	1	2
2	2017-02-16T09:43:46.876Z	0.0840805771962	0.1951102
3	2017-02-16T09:43:47.501Z	0.152616695366	0.2566677
4	2017-02-16T09:43:48.126Z	0.221115444991	0.2613602
5	2017-02-16T09:43:48.751Z	0.289725498238	0.2663699
6	2017-02-16T09:43:49.376Z	0.336447792086	0.2709752

	A	B	C
1	Series	Time	Value
2	Sink node	2017-02-16T09:49:06.669Z	1
3	Sink node	2017-02-16T09:49:08.868Z	0
4	Sink node	2017-02-16T09:49:13.570Z	1
5	Sink node	2017-02-16T09:49:16.571Z	0
6	Sink node	2017-02-16T09:49:25.068Z	1
7	Sink node	2017-02-16T09:49:28.674Z	0

Testbed Location

- Nodes are deployed in Inffeldgasse 16 (Graz, Austria)
  - University offices, seminar rooms, and laboratories (belonging to the Institute for Technical Informatics of TU Graz)
  - 51 testbed nodes currently active over multiple floors
  - Density of nodes varies across the building



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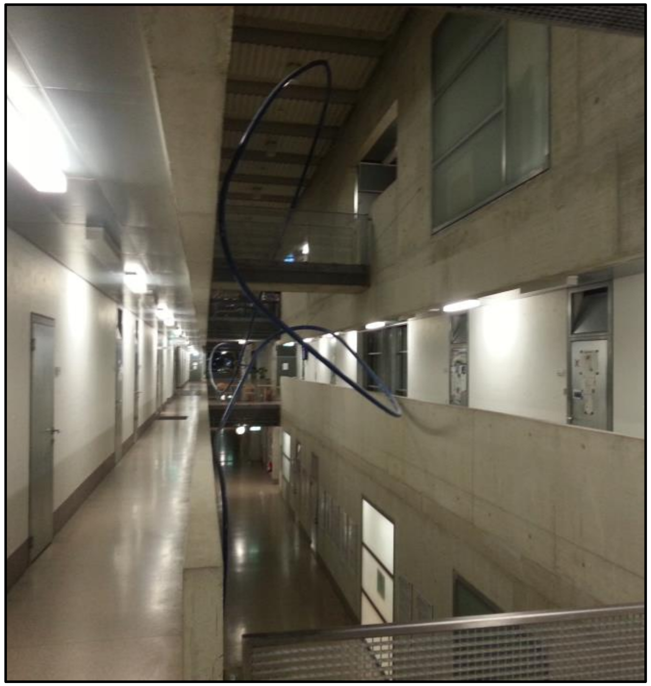
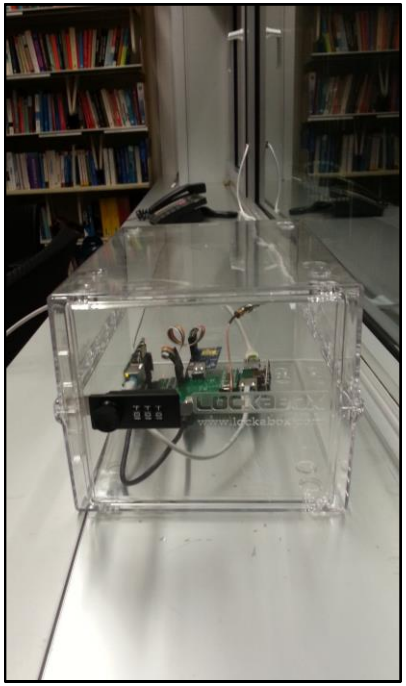




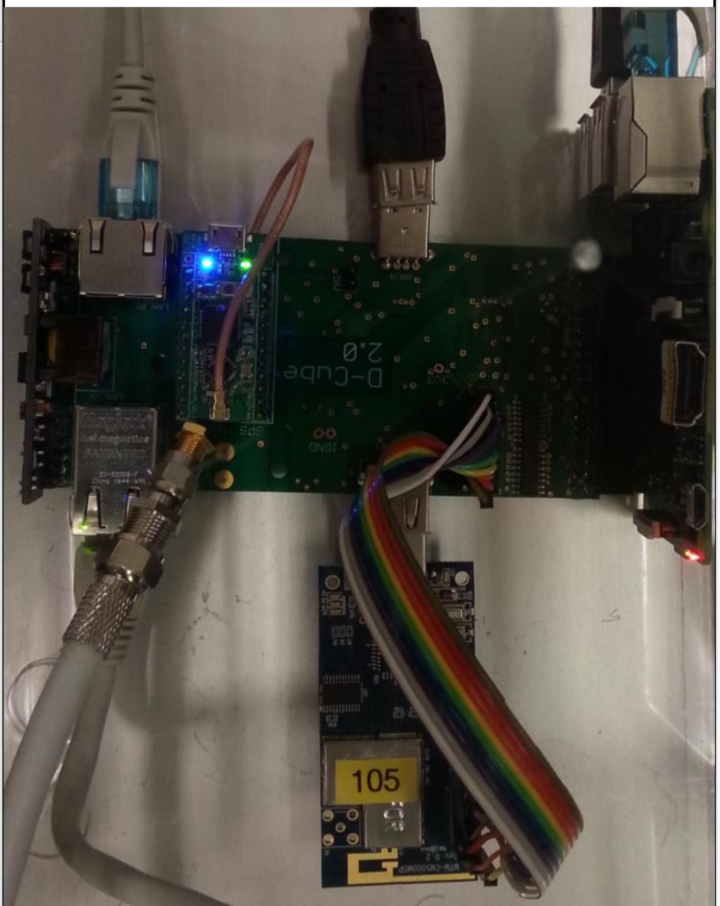
Testbed Hardware

- The testbed allows contestants to program several Maxfor/Advanticsys MTM-CM5000-MSP nodes (replicas of TelosB/Tmote Sky nodes)
  - With and without SMA antenna
  - All powered via USB
  - 10 kB of RAM
  - Attached to D-Cube

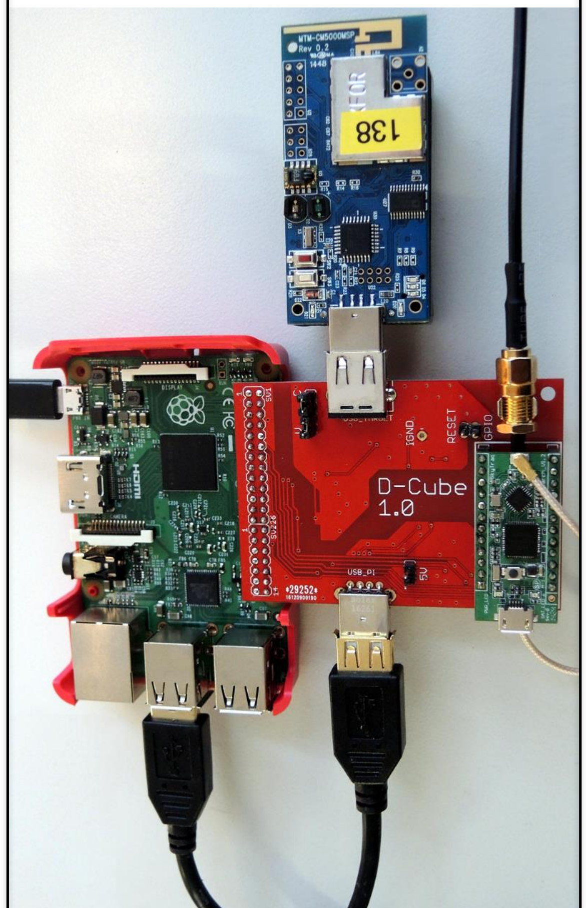
Testbed Hardware: D-Cube

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

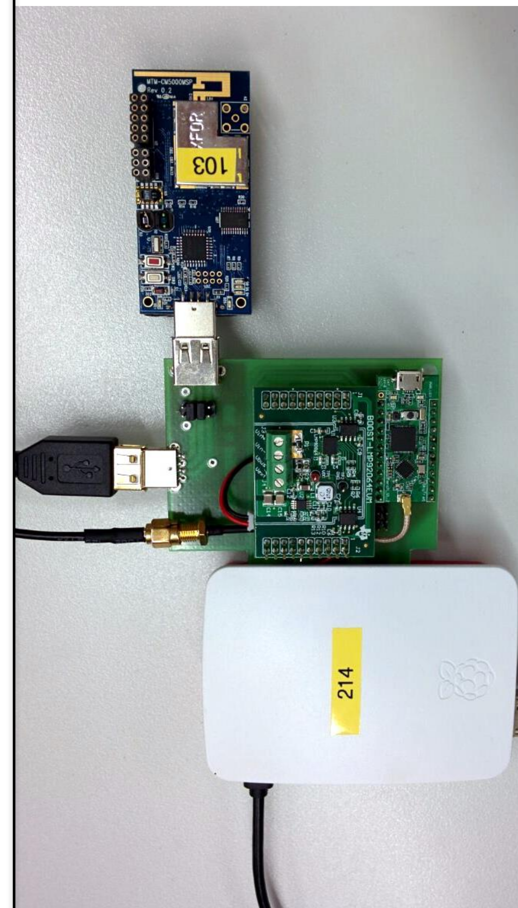
This year’s prototype (EWSN’18)



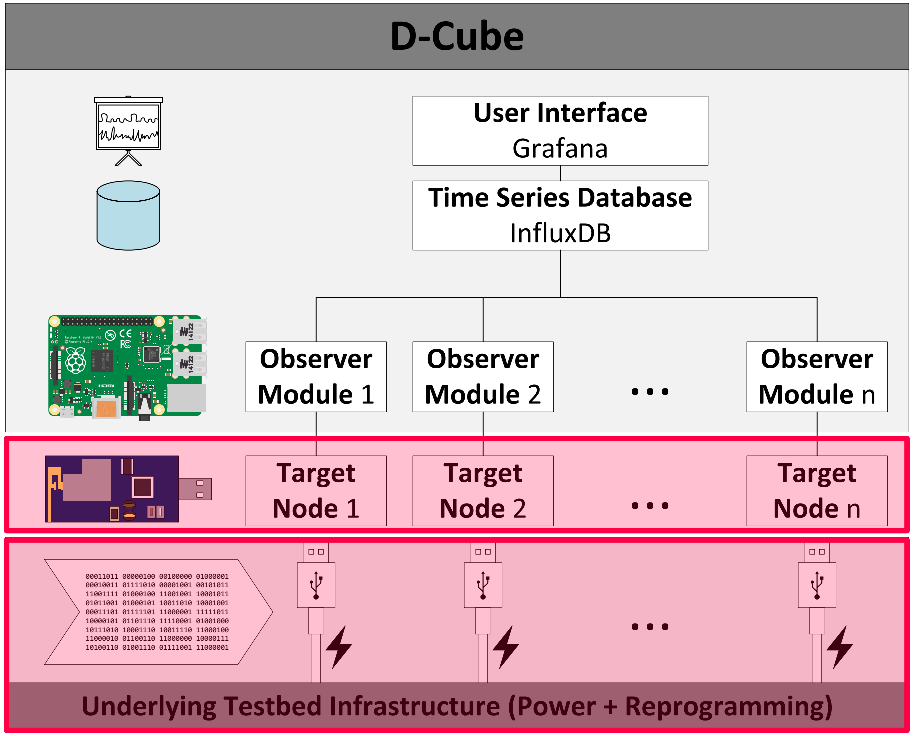
EWSN’17 version



EWSN’16 version



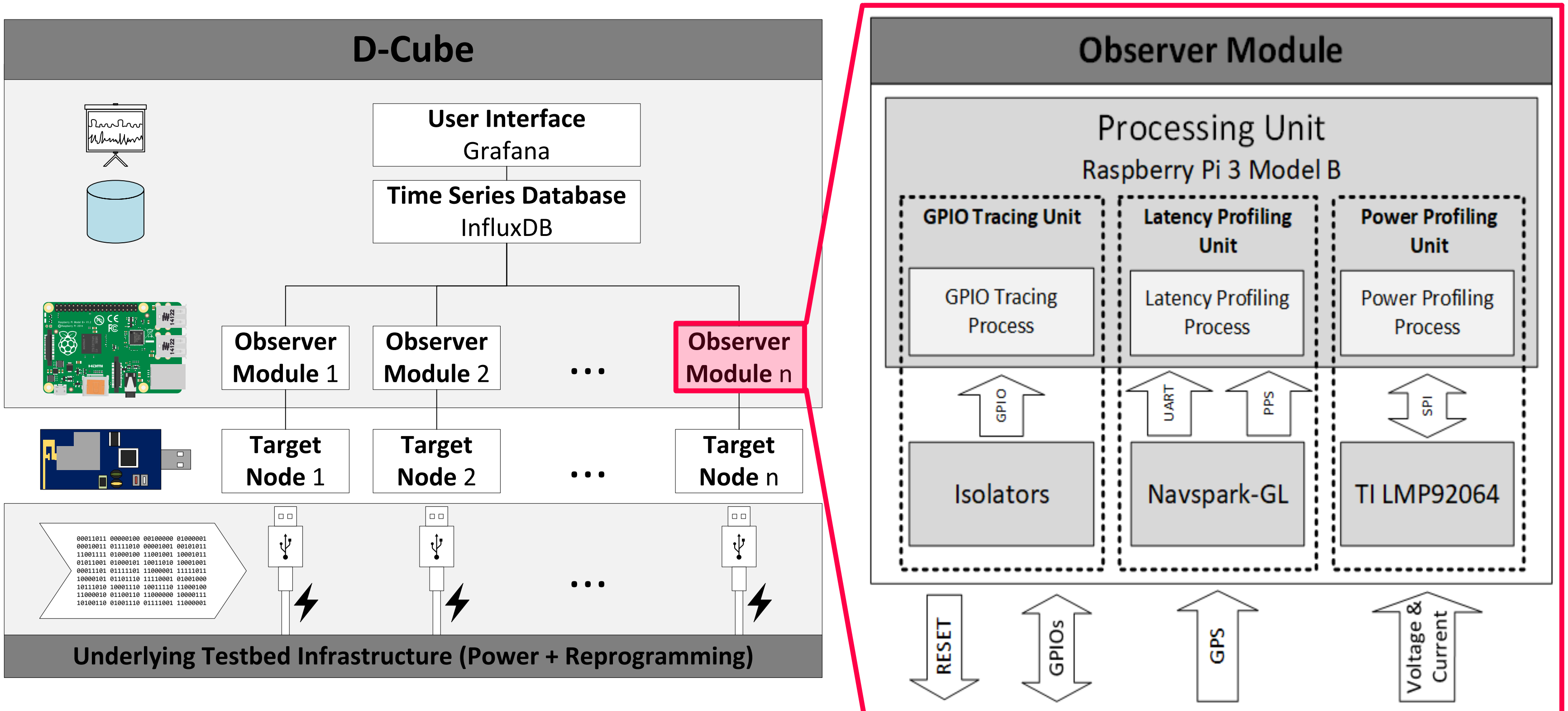
Testbed Hardware: D-Cube



- Target nodes
  - → Devices running the code/system under test
  - → D-Cube agnostic to HW platform chosen as target
  - → MTM-CM5000-MSP nodes (TelosB replicas - 10 kB RAM)

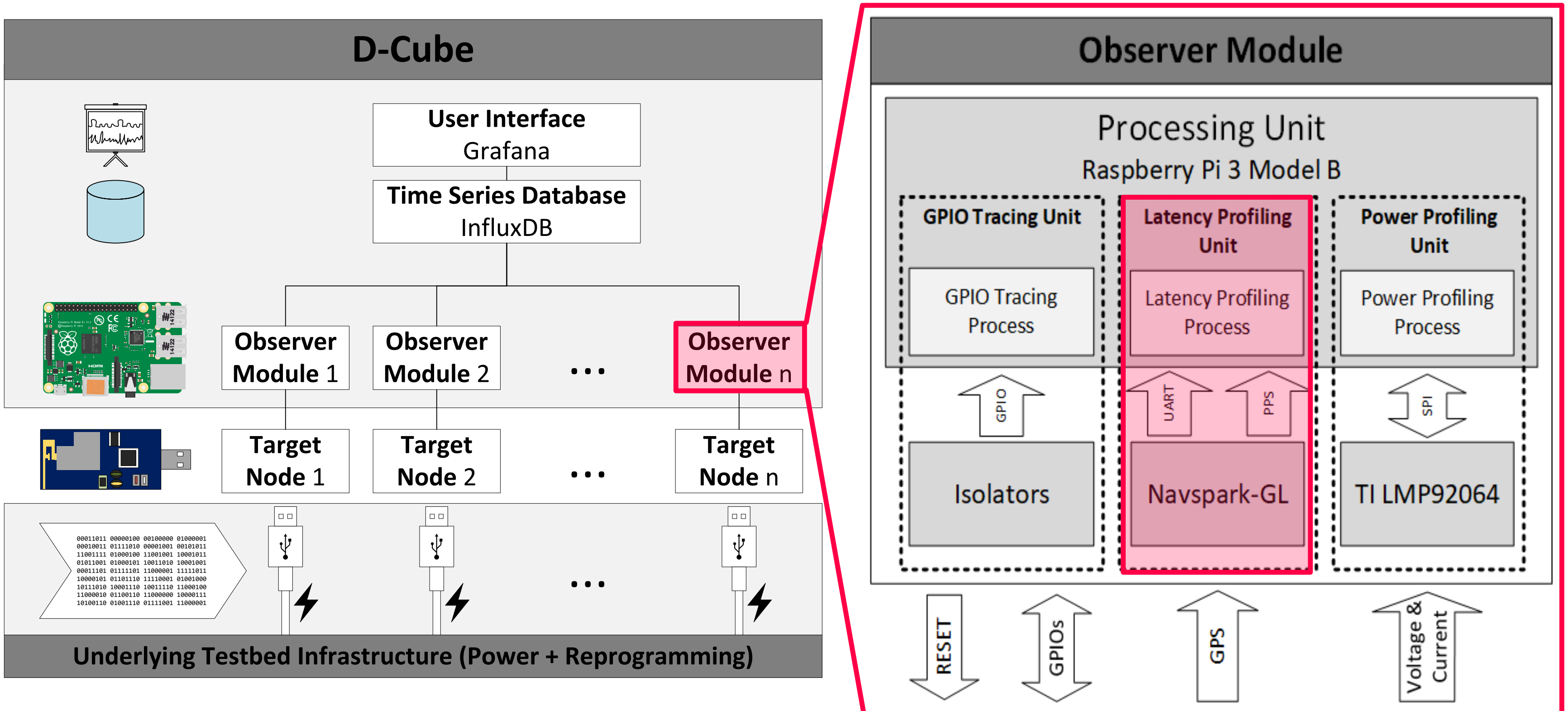
- Underlying infrastructure
  - → Power + reprogramming of the target nodes
  - → Allows to disable the UART interface

Testbed Hardware: D-Cube

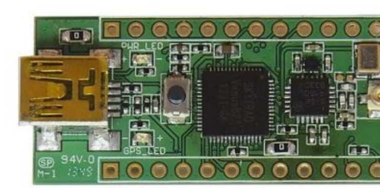


- Observer modules
  - → Each module monitors exactly one target node
  - → Raspberry Pi 3 + custom-made add-on card (ADC+GPS)

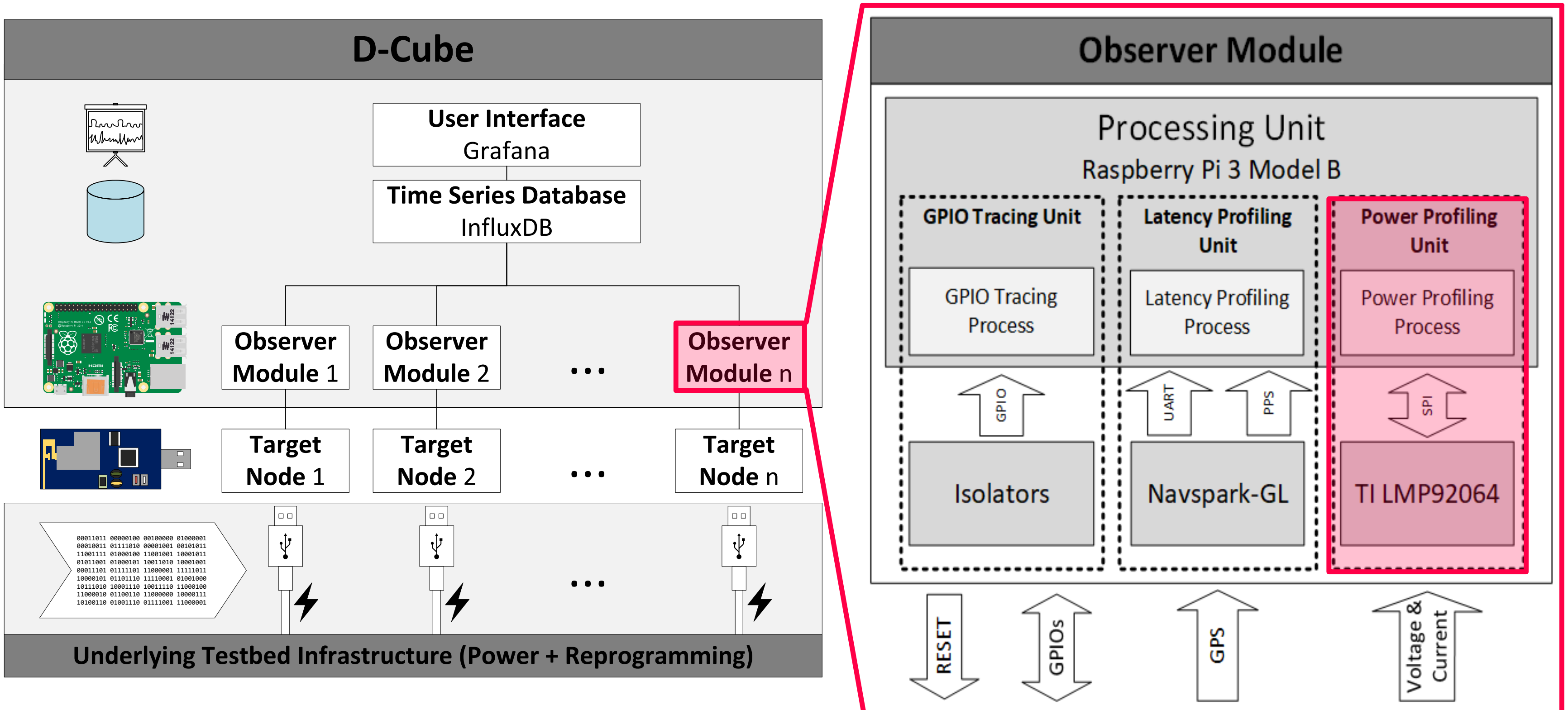
Testbed Hardware: D-Cube



- Observers: latency profiling
  - → GPS module to synchronize system clock (NavSpark-GL: Arduino DevBoard with GPS/GLONASS) http://navspark.mybigcommerce.com/navspark-gl-arduino-compatible-development-board-with-gps-glonass/
  - → Ensures accurate time measurements across the nodes in the testbed

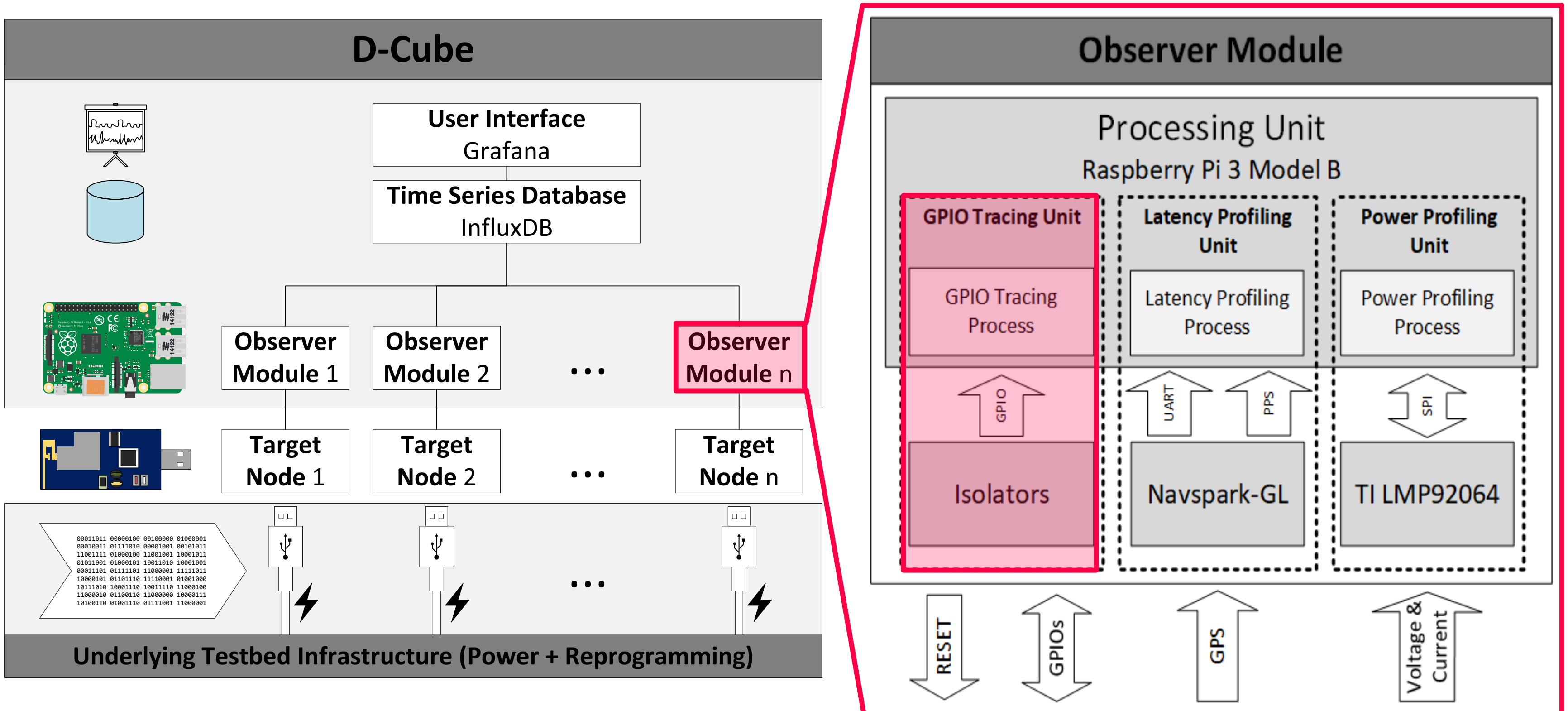


Testbed Hardware: D-Cube



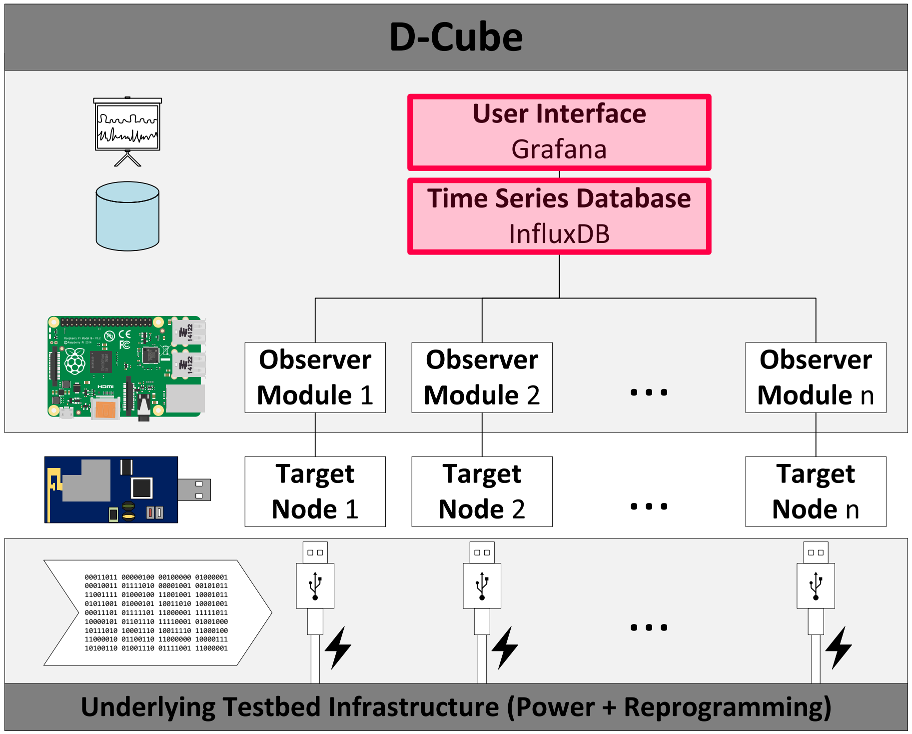
- Observers: power profiling
  - → Simultaneous sampling ADC (TI LMP92064) read via SPI @ 62.5 kHz using a real-time process
    - Voltage channel: up to 10.82V with 2.82mV resolution
    - Current channel: up to 150.59mA with 39.22µA resolution

Testbed Hardware: D-Cube



- Observers: GPIO profiling
  - → GPIO changes are monitored using the same real-time process sampling the ADC
  - → System clock accuracy is ensured by the GPS module (NTP for nodes where GPS is unavailable)

Testbed Hardware: D-Cube

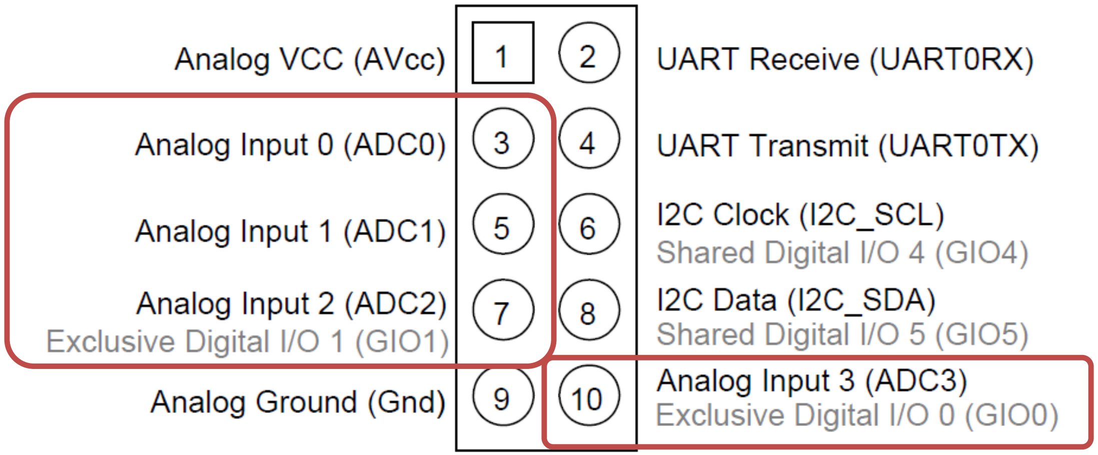


- Time Series database
  - → Collects and persistently stores the data from all observers
  - → InfluxDB (open-source)
  - → Nanosecond precision timestamps
- User Interface
  - → Acts as proxy to the database and gives real-time feedback
  - → Grafana (open-source)

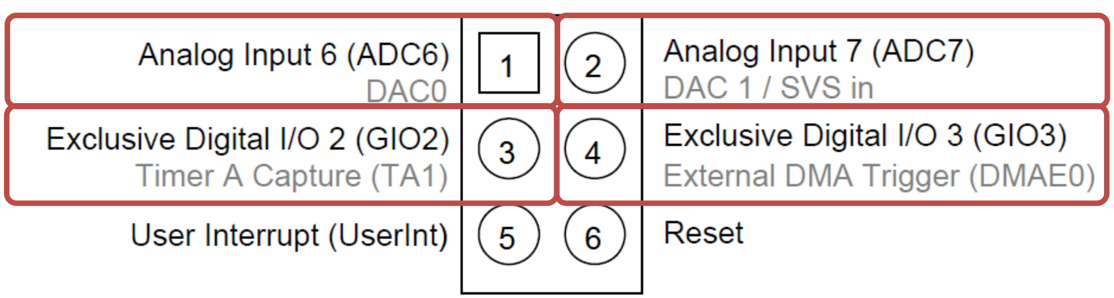
GPIO Pins

GPIO Pins

- The testbed facility is connected to eight of the pins available in the 10-pin and 6-pin expansion connector



10-pin expansion connector (U2)



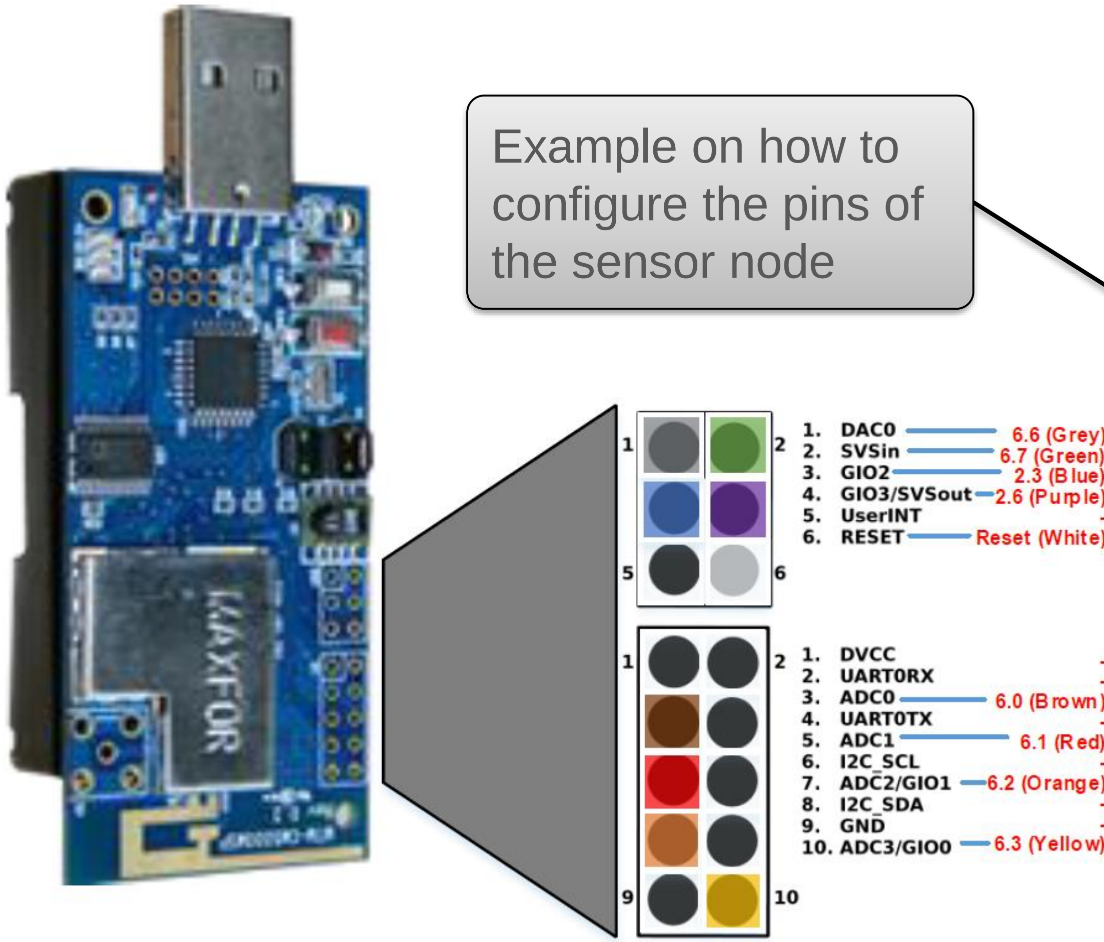
6-pin expansion connector (U28)

GPIO Pins

- The testbed facility is connected to eight of the pins available in the 10-pin and 6-pin expansion connector

Example on how to configure the pins of the sensor node

```
//ADC0
P6SEL &= ~(BIT0);
P6DIR |= BIT0;

//ADC1
P6SEL &= ~(BIT1);
P6DIR |= BIT1;

//ADC2
P6SEL &= ~(BIT2);
P6DIR |= BIT2;

//ADC3
P6SEL &= ~(BIT3);
P6DIR |= BIT3;

//ADC7
P6SEL &= ~(BIT7);
P6DIR |= BIT7;

//GIO2
P2SEL &= ~(BIT3);
P2DIR |= BIT3;

//GIO3
P2SEL &= ~(BIT6);
P2DIR |= BIT6;

//ADC6 / DAC0
P6SEL &= ~(BIT6);
P6DIR |= BIT6;
```

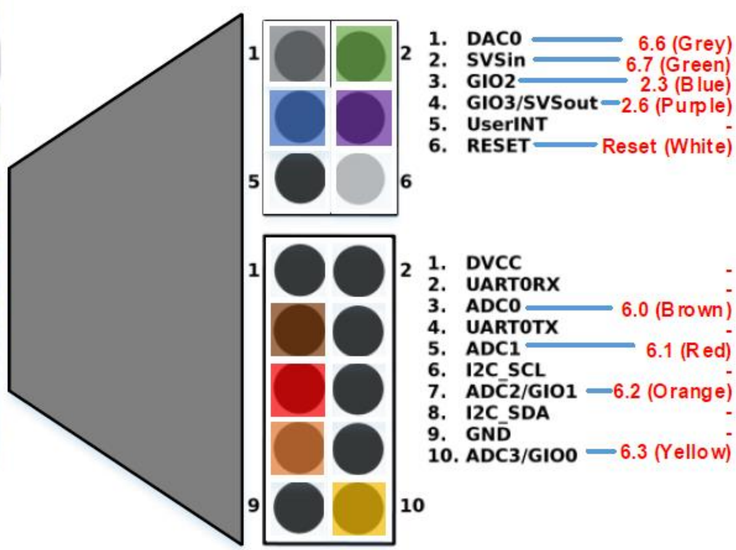


GPIO Pins

- The testbed facility is connected to eight of the pins available in the 10-pin and 6-pin expansion connector

Conversion table of the GPIO naming scheme in Grafana

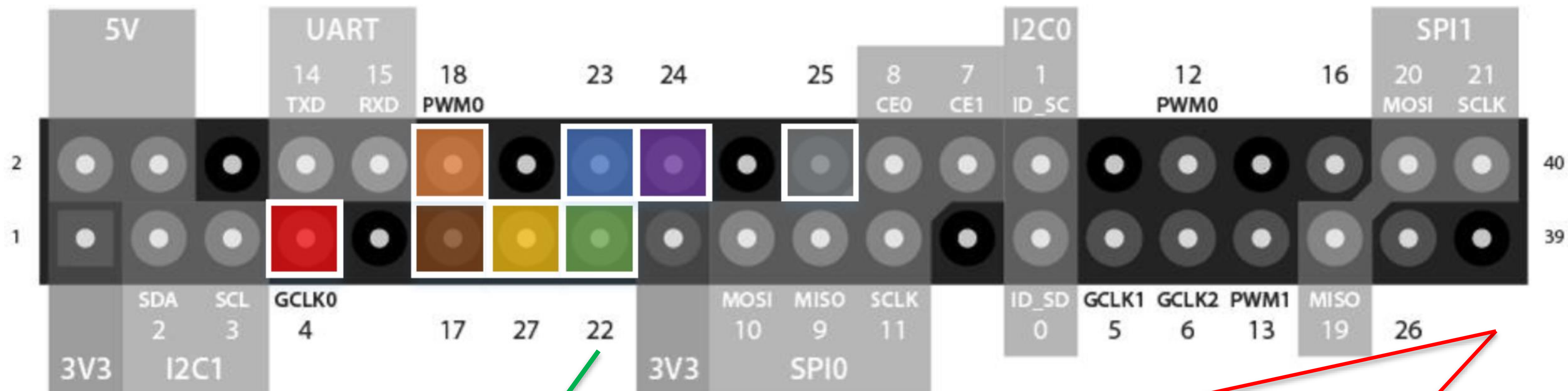
Sensor Node	Grafana
ADC0	GPIO 17
ADC1	GPIO 4
ADC2/GIO1	GPIO 18
ADC3/GIO0	GPIO 27
ADC7/SVSin	GPIO 22
GIO2	GPIO 23
GIO3/SVSout	GPIO 24
DAC0/ADC6	GPIO 25



Numbering of GPIO Pins in Grafana

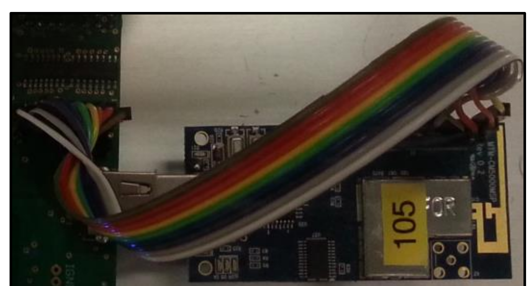
- The GPIO numbers in Grafana correspond to the GPIO pin number to which the sensor node testbed is attached on D-Cube's Observer (Raspberry Pi3)

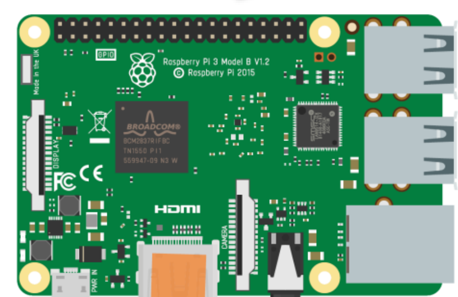
Raspberry Pi GPIO BCM numbering



(Pin 22 on Raspberry Pi3)

ADC7/SVSin	GPIO 22

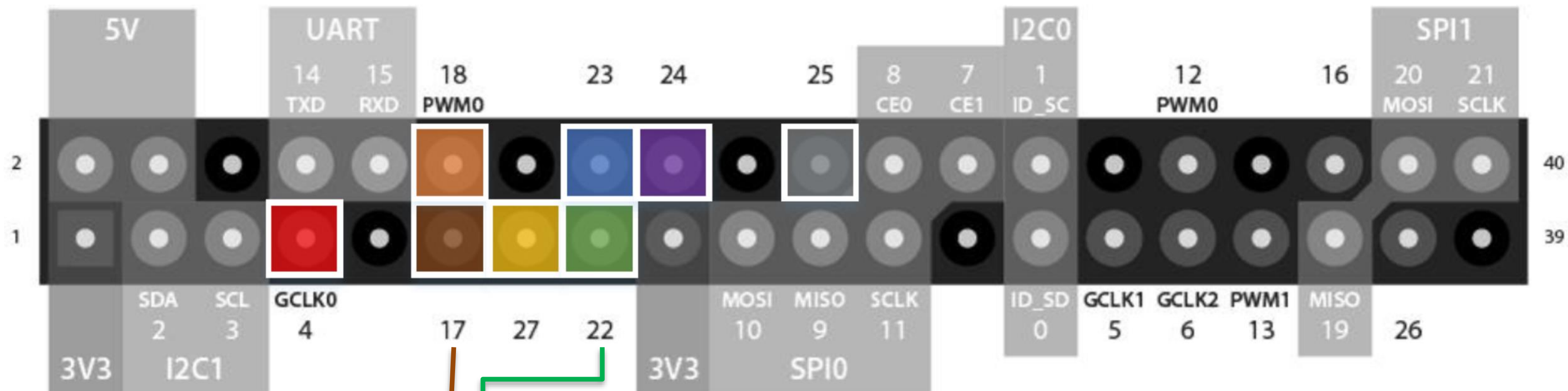




Numbering of GPIO Pins in Grafana

- The GPIO numbers in Grafana correspond to the GPIO pin number to which the sensor node testbed is attached on D-Cube’s Observer (Raspberry Pi3)

Raspberry Pi GPIO BCM numbering



Sensor Node	Grafana
ADC0	GPIO 17
ADC1	GPIO 4
ADC2/GIO1	GPIO 18

Sensor Node	Grafana
ADC3/GIO0	GPIO 27
ADC7/SVSin	GPIO 22
GIO2	GPIO 23

Sensor Node	Grafana
GIO3/SVSout	GPIO 24
DAC0/ADC6	GPIO 25

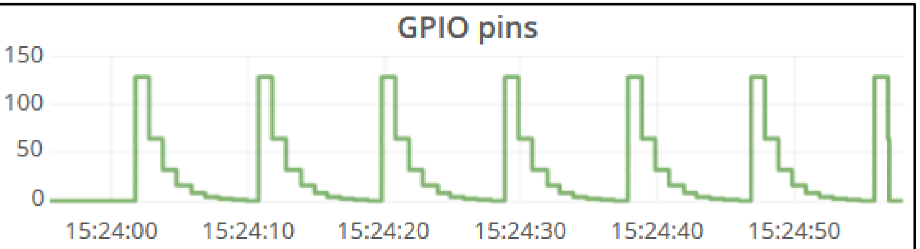
"GPIO Pins" Tab in Grafana

- In the “Overview of individual nodes” tab, the displayed “GPIO pins” numbers in Grafana is derived with the following mapping:

- Example: “GPIO pins” value of 18
  - 18 = 0001 0010 in binary
  - Using Grafana’s mapping:
  - ADC0=0; ADC1=0; ADC2=0; ADC3=1
  - SVSin=0; GIO2=0; GIO3=1; ADC6=0

```
gpio=0;
gpio=gpioRead(17);
gpio=(gpio<<1) | gpioRead(4);
gpio=(gpio<<1) | gpioRead(18);
gpio=(gpio<<1) | gpioRead(27);
gpio=(gpio<<1) | gpioRead(22);
gpio=(gpio<<1) | gpioRead(23);
gpio=(gpio<<1) | gpioRead(24);
gpio=(gpio<<1) | gpioRead(25);
```

Mapping in Grafana



GPIO Pins: Frequently Asked Questions

- How often do GPIO pins change?
  - Changes in the GPIOs of a source node can happen anytime
    - → This implies that there could be events in the multipoint-to-point scenario that may last a few milliseconds only
    - → We will not consider (punish) missing events that are shorter than 100ms in these settings
  - The minimum time between changes in the **same** GPIO pin of a source node is one second

Node Types & Identities

Node Identities

- Node address of all nodes is known beforehand
  - Provided text file in the blog:
    List of node addresses.txt
  - The file contains: Node ID in flash, FTDI Serial ID, DS2411 ID
- Node ID in flash
  - 16-bit unsigned short value (e.g., 100, 101)
    stored by Contiki in the 1 MB external flash → Contiki example
- DS2411 ID
  - Provided by the on-board DS2411 chip
  - Important: Contiki changes the ds2411_id byte 0 such that it is not an odd number, e.g.,
    119 → 00:12:75:00:13:b7:71:6d → 00:12.74:00:13:b7:71:6d

The node list may be updated during the next weeks
depending on failures and/or testbed updates!

Node Type: Frequently Asked Questions

- How many source and destinations nodes there will be in the network?
  - There will not be more than 60 nodes (currently 51 deployed)
  - There will not be more than 32 source/destination nodes (e.g., 20 sources, 12 destinations): the remaining nodes will be only-forwarding nodes
  - Each source node monitors up to 8 events (i.e., up to 8 GPIOs) in parallel
  - Each destination node reports up to 8 events (i.e., up to 8 GPIOs) in parallel

Tentative Agenda

Tentative Agenda

- Preparation phase (29.11.2017 – 31.01.2018)
  1. First preparation phase: Testing of infrastructure
     29.11.2017 – 14.12.2017
     → Simplified scenario
     → No harsh RF environment
  2. Second preparation phase: Introducing jamming
     15.12.2017 – 14.01.2018
     → A more advanced scenario added (details follow)
     → Harsh RF environment can be generated
  3. Third preparation phase: Large-scale tests
     15.01.2018 – 31.01.2018
     → Additional scenarios added (details follow)
     → Leaderboard and detailed evaluations (details follow)

NOW!

Tentative Agenda

- Submission of final software
  - January 31, 2018 at 23:59 (AoE)
    - → One single `.ihex` file per competing team
    - → Deadline has been extended of 48 hours!

  - Send this file via e-mail to:
    - → cboano@tugraz.at
    - → markus.schuss@tugraz.at

Tentative Agenda

- Evaluation phase
  (01.02.2018 – 12.02.2018)
  - The final code submitted by each team will be run multiple times by the organizers during the evaluation phase
    - → Harsh RF environmental conditions will vary over time, i.e., the intensity of interference will vary between 0 and ⚡$_3$
    - → Differently from the previous editions of the competition, contestants cannot assume the absence of harsh RF conditions at the startup of the experiment
    - → If two or more teams have an optimal performance (i.e., 100% reliability) and similar scores, an interference intensity higher than ⚡$_3$ may be used to find the winner
  - The network architecture will not change between the preparation phase and the final evaluation, but nodes will be shuffled to avoid that teams hardcode optimal routes learnt during the preparation

Tentative Agenda

- EWSN Conference in Madrid (15.02.2018)
  - Preliminary program:

    …

    12:50 - 14:00: Lunch

    14:00 - 15:00: Awards and winners' presentations
    (three best teams will present their solutions on-stage)

    15:00 - 15:30: Discussion and future directions

    15:30 - 16:30: Poster session
    (each team will have one dedicated poster in this session)

    16:30 - 18:00: Session 3: Emerging Networking Paradigms

    …

List of Accepted Contestants

Nine teams from both academia and industry

- 44 researchers and practitioners from China, France, Germany, Italy, Japan, Sweden, Switzerland, and United Kingdom

Accepted Contestants

- Team 01
  - "Aggressive Synchronous Transmissions with In-network Processing for Dependable All-to-All Communication"
  - Beshr Al Nahas and Olaf Landsiedel
    Chalmers University of Technology, Sweden

- Team 02
  - "Using Enhanced OFPCOIN to Monitor Multiple Concurrent Events under Adverse Conditions"
  - Xiaoyuan Ma[1,3], Peilin Zhang[4], Weisheng Tang[1,3], Xin Li[1,2], Wangji He[1,2,3], Fuping Zhang[1], Jianming Wei[1], and 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

Accepted Contestants

- Team 03
  - “BigBangBus”
  - Antonio Escobar[1,2], Fernando Moreno[1], Antonio J. Cabrera[1], Javier Garcia-Jimenez[3], Francisco J. Cruz[4], Jirka Klaue[5], Angel Corona[5], Divya Tati[5], and Thomas Meyerhoff[5]

    [1]Infineon Technologies AG, Germany
    [2]RWTH Aachen University, Germany
    [3]BMW AG, Germany
    [4]eesy-innovation GmbH, Germany
    [5]Airbus Group Innovations, Germany

- Team 04
  - “Synchronous Transmissions + Channel Sampling = Energy Efficient Event-Triggered Wireless Sensing Systems”
  - Camilo Rojas and Jean-Dominique Decotignie

    Swiss Center for Electronics and Microtechnology (CSEM), Switzerland

Accepted Contestants

- Team 05
  - “CRYSTAL Clear: Making Interference Transparent”
  - Matteo Trobinger[1], Timofei Istomin[1], Amy L. Murphy[2], and Gian Pietro Picco[1]

    [1]University of Trento, Italy

    [2]Bruno Kessler Foundation, Italy

- Team 06
  - “Smart flooding with multichannel for industrial wireless sensor networks”
  - Jinpeng Wang, Hamadoun Tall, and Gérard Chalhoub

    University of Clermont-Auvergne / LIMOS CNRS, France

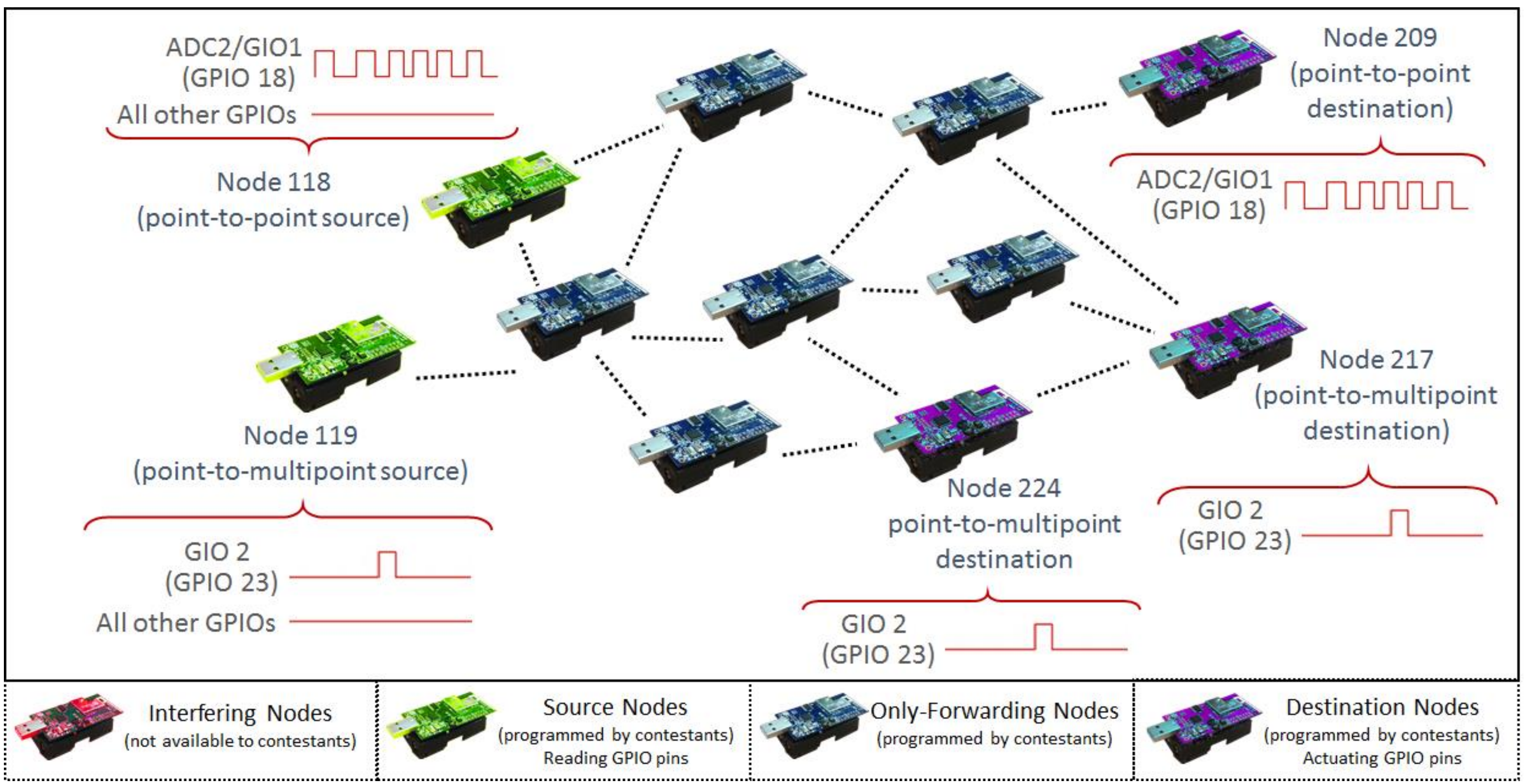
Accepted Contestants

- Team 07
  - "Wireless-Transparent Sensing Platform"
  - Chun-Hao Liao, Theerat Sakdejayont, Makoto Suzuki, Yoshiaki Narusue, and Hiroyuki Morikawa
    School of Engineering, The University of Tokyo, Japan
- Team 08
  - "CROWN: Concurrent ReceptiOns in Wireless Sensor and Actuator Networks"
  - Usman Raza, Yichao Jin, Aleksandar Stanoev, and Mahesh Sooryiabandara
    Toshiba Research Europe Limited, Bristol, United Kingdom
- Team 09
  - "Energy-Efficient Many-to-Many Communication with Channel-Hopping"
  - Philipp Sommer, Yvonne-Anne Pignolet, Stevan Marinkovic, Aurelien Monot, Maelle Kabir-Querrec, and Robert Birke
    ABB Corporate Research, Baden-Daettwil, Switzerland

Evaluation Scenarios

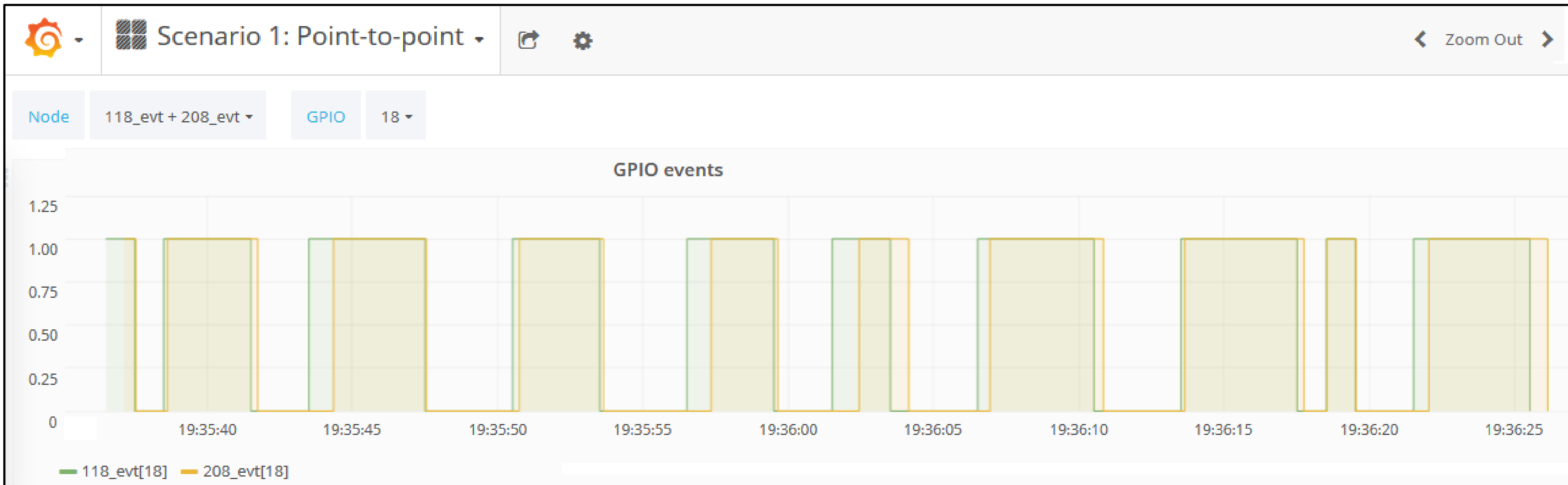
1st Preparation Phase

- To get the contestants acquainted with the testbed facility, a simple evaluation scenario is initially available
  - Point-to-point communication from node 118 to 209 (GPIO18)
  - Point-to-multipoint communication from 119 to 217 & 224 (GPIO23)



Grafana Visualization of Eval. Scenarios

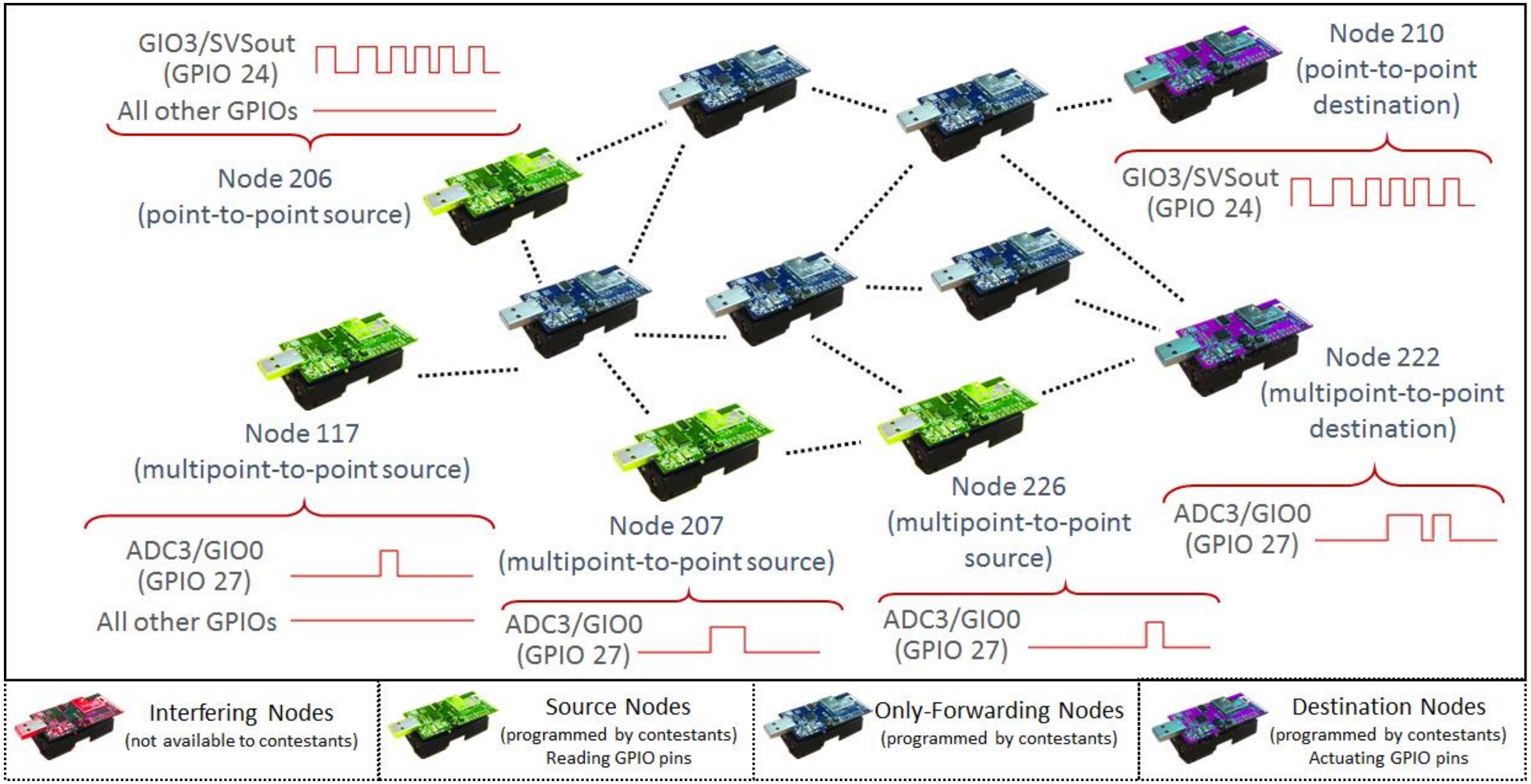
- Specific "Scenario" tabs available on the Grafana Dashboard
  - Showing if the GPIO of the nodes employed on a specific scenario have been toggled correctly



Additional scenarios will be added regularly over time

2nd Preparation Phase

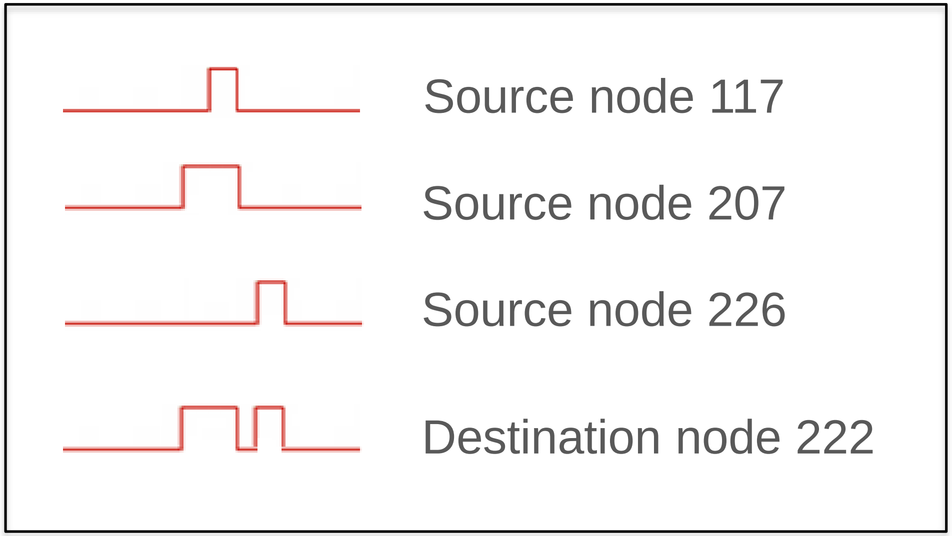
- Two additional scenarios are available
  - Point-to-point communication from node 206 to 210 (GPIO24)
  - Multipoint-to-point communication from nodes 117 & 207 & 226 to 222 (GPIO27)



2^{nd} Preparation Phase

- Two additional scenarios are available
  - Point-to-point communication from node 206 to 210 (GPIO24)
  - Multipoint-to-point communication from nodes 117 & 207 & 226 to 222 (GPIO27)

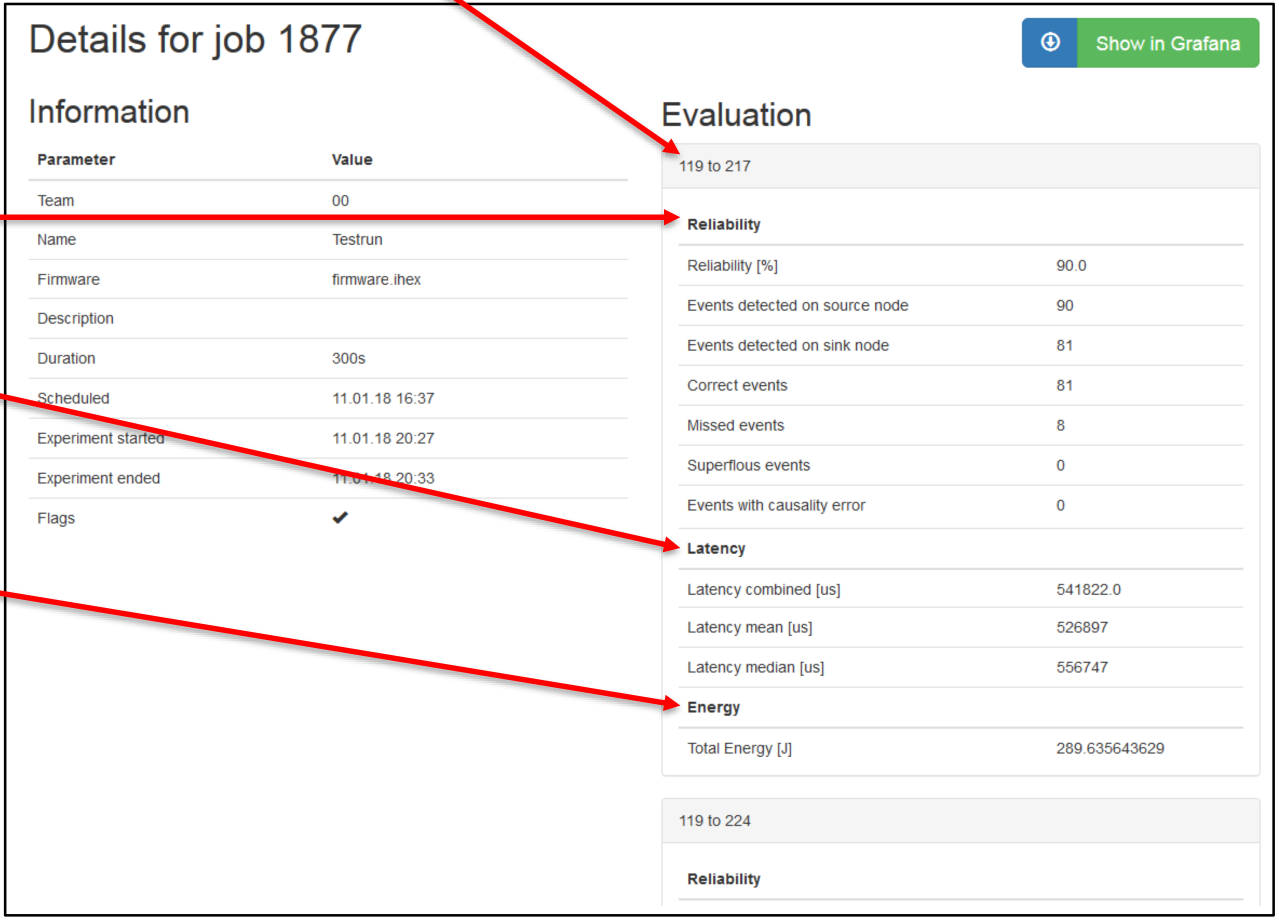
    → Node 222 ORs the information obtained by the three source nodes on GPIO27 (ADC3/GIO0 pin)



Evaluation of Experiments

- Available for the first set of scenarios
  - Example: node 119 to 217

- Evaluation of reliability (# of events detected)
- Evaluation of latency (mean & median)
- Evaluation of energy consumption (∑ of all nodes in Joule)



Details for job 1877

Show in Grafana

Information

Parameter	Value
Team	00
Name	Testrun
Firmware	firmware.ihex
Description	
Duration	300s
Scheduled	11.01.18 16:37
Experiment started	11.01.18 20:27
Experiment ended	11.01.18 20:33
Flags	✔

Evaluation

119 to 217

Reliability	
Reliability [%]	90.0
Events detected on source node	90
Events detected on sink node	81
Correct events	81
Missed events	8
Superflous events	0
Events with causality error	0
Latency	
Latency combined [us]	541822.0
Latency mean [us]	526897
Latency median [us]	556747
Energy	
Total Energy [J]	289.635643629

119 to 224

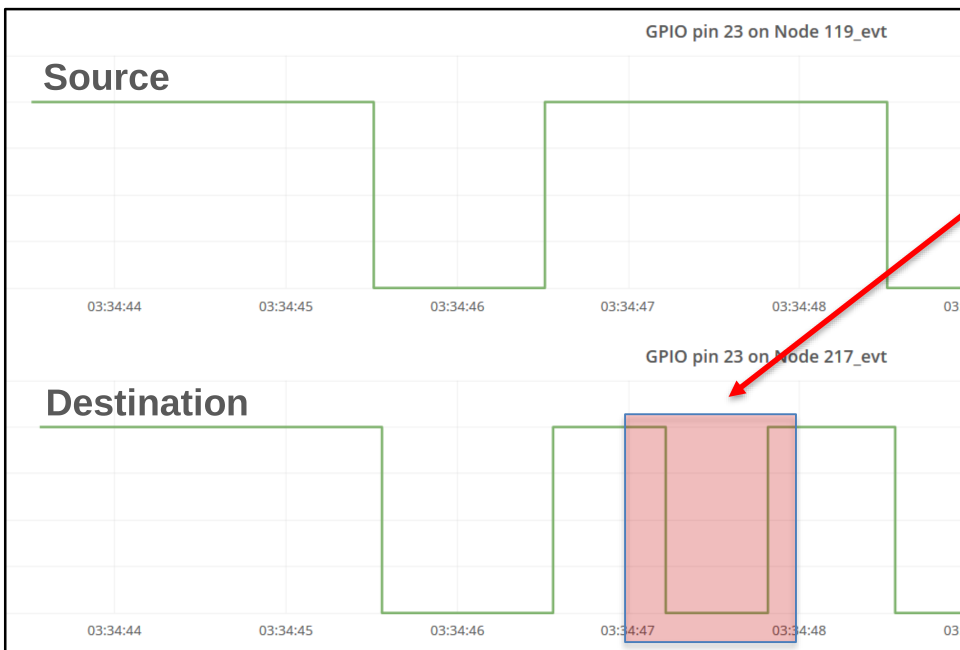
Reliability

Evaluation of Experiments

- Reliability (# of events detected)
  - What are superfluous events?

    Extra events reported by the destination node

Reliability	
Events detected on source node	52
Events detected on sink node	52
Correct events	52
Missed events	0
Superflous events	0
Events with causality error	0

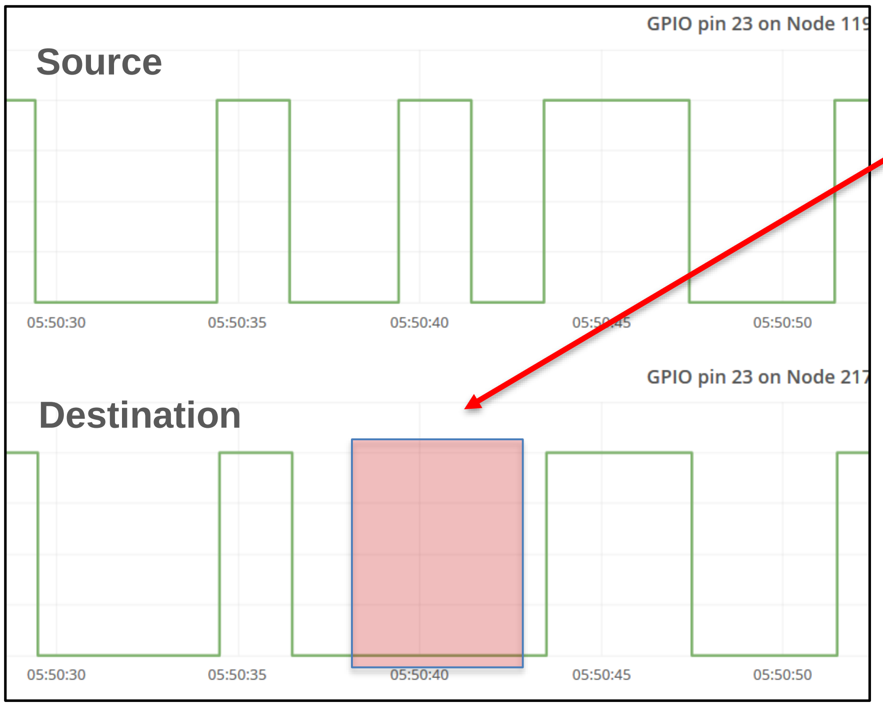


Evaluation of Experiments

- Reliability (# of events detected)
  - What are missed events?

    Cases in which the destination did not report a pin change in the source before the next pin change actually occurred

Reliability	
Events detected on source node	52
Events detected on sink node	52
Correct events	52
Missed events	0
Superflous events	0
Events with causality error	0



Evaluation of Experiments

- Reliability (# of events detected)
  - What are events with a causality error?

Cases in which the destination reported a pin change at the source before it has actually happened

Reliability	
Events detected on source node	52
Events detected on sink node	52
Correct events	52
Missed events	0
Superflous events	0
Events with causality error	0

Evaluation of Experiments

- How is the reliability score computed?

$$R = \frac{C}{E_S} \cdot \left(1 - \frac{K_S \cdot S}{E_S}\right) \cdot \left(1 - \frac{K_C \cdot C}{E_S}\right)$$

- R = Reliability
- E_S is the number of events detected on source node
- S is the number of superfluous events
- C is the number of causality events
- $K_S = K_C = 2$

Reliability	
Reliability [%]	93.43
Events detected on source node	90
Events detected on sink node	90
Correct events	88
Missed events	2
Superflous events	2
Events with causality error	0

Evaluation of Experiments

- How is the latency combined score computed?

$$L_C = \frac{L_{mean} + L_{median}}{2}$$

- L_C = Latency combined
- L_{mean} = Mean latency
- L_{median} = Median latency

Latency	
Latency combined [us]	541822.0
Latency mean [us]	526897
Latency median [us]	556747

Evaluation of Experiments

- In point-to-multipoint scenarios, also the evaluation statistics for each individual [source-destination] pairs are shown
  - Example:
    Scenario: 119 → [217,224] (GPIO 23)

119 to 217

Reliability	
Reliability [%]	93.43
Events detected on source node	90
Events detected on sink node	90
Correct events	88

119 to 224

Reliability	
Reliability [%]	93.43
Events detected on source node	90
Events detected on sink node	90
Correct events	88

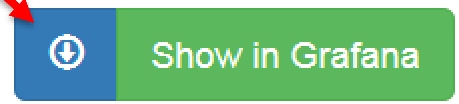
119 to [217*224]

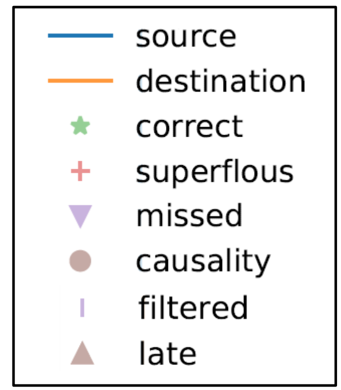
Reliability	
Reliability [%]	93.43
Events detected on source node	90
Events detected on sink node	90
Correct events	88

- Only the aggregate evaluation will be considered in the computation of the final score

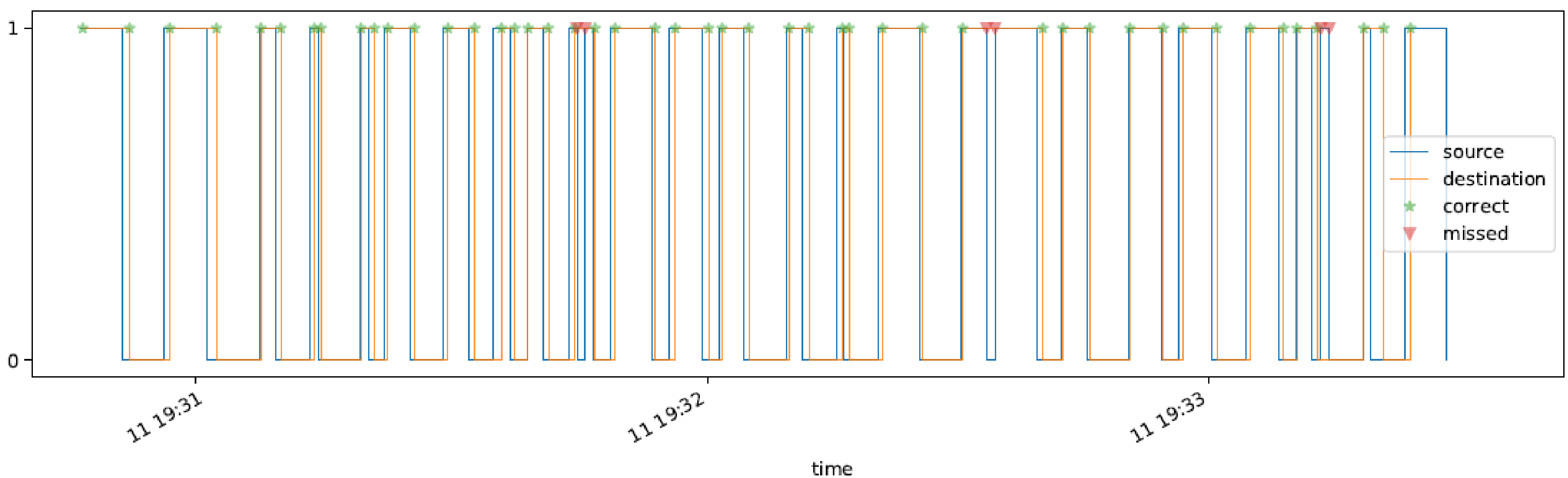
Evaluation of Experiments

- Detailed analysis
  - Can be downloaded from the "job details" page
    (new experiments only!)



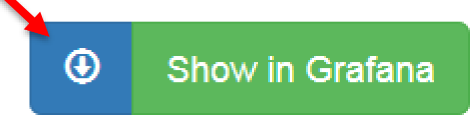


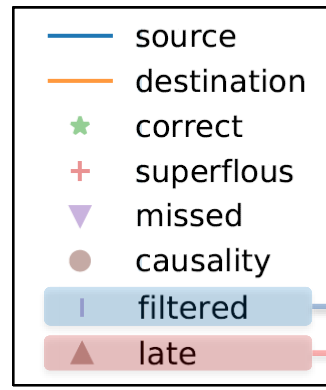
  - Events are marked graphically (correct, missed, …)



Evaluation of Experiments

- Detailed analysis
  - Can be downloaded from the "job details" page (new experiments only!)

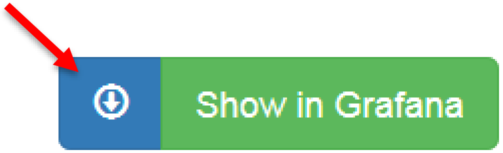


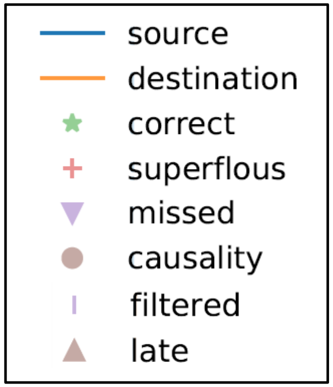


  - Events are marked graphically (correct, missed, …)
  - Filtered events in the multipoint-to-point scenario are those shorter than 100ms (see slide 40)
  - Late events are events that have been reported after other events have occurred, but still within one-second time (and hence considered as correct)

Evaluation of Experiments

- Detailed analysis
  - Can be downloaded from the "job details" page
    (new experiments only!)





  - Events are marked graphically (correct, missed, …)

- Please note that when running with log output enabled the accuracy of the GPIO tracing decreases significantly

  → May lead to causality errors, for example

  → We recommend disabling the log output if you are interested in the actual protocol performance

3rd Preparation Phase

- Three additional scenarios are available
  - Point-to-point communication from node 213 to 225 (GPIO4)
  - Point-to-multipoint communication from node 213 to nodes 108 & 200 (GPIO17)
  - Multipoint-to-point communication from nodes 219 & 110 to 220 (GPIO25)
- Latest addition (18.01.2018):
  - Point-to-multipoint communication from node 201 to nodes 209 & 211 & 224 & 225 (GPIO22)

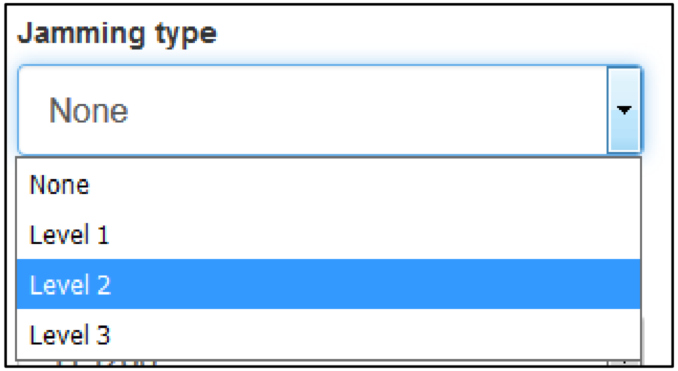
Summary of Scenarios

- These scenarios will be used in the final evaluation
  - 118 → 209 (GPIO 18)
  - 119 → [217,224] (GPIO 23)
  - 206 → 210 (GPIO 24)
  - [117,207,226] → 222 (GPIO 27)
  - 213 → 225 (GPIO 4)
  - 213 → [108,200] (GPIO 17)
  - [219,110] → 220 (GPIO 25)
  - 201 → [209,211,224,225] (GPIO 22)
- Important remarks:
  - The random seed used for the generation of GPIO events and of challenging RF environments will be changed in the final evaluation (this won't affect the intensity of interference, but the time distribution)
  - The position of forwarding nodes (i.e., nodes that are neither destinations nor sources) will be shuffled in the testbed, the source and destinations nodes will not be moved

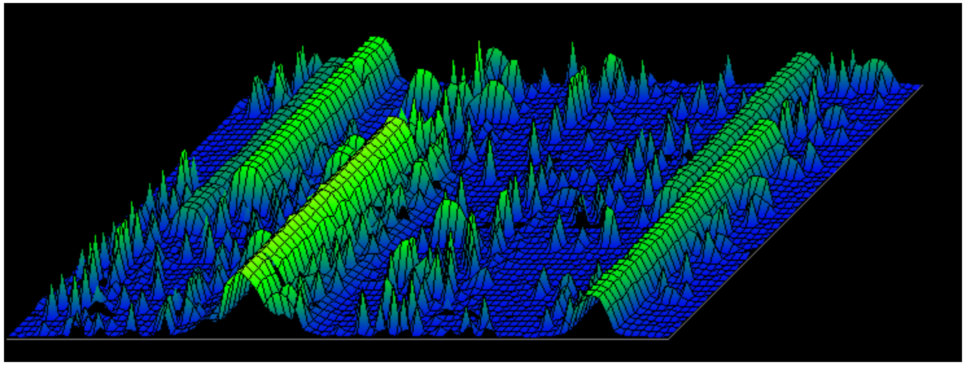
Challenging RF Environment

- The testbed infrastructure provides the ability to create a challenging RF environment on specific experiments
  - Contestants can select the rate at which Raspberry Pi3 nodes generate Wi-Fi traffic

    Please note: the jamming pattern is probabilistic in order to avoid engineered solutions



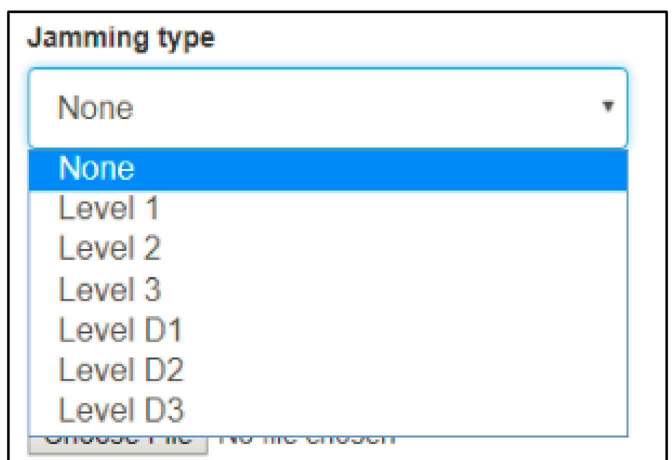
- Jamming Type 1: only on a single frequency
- Jamming Type 2: on multiple frequencies (mild)
- Jamming Type 3: on multiple frequencies (stronger)



Challenging RF Environment

- Due to numerous requests, three new interfering patterns (D1, D2, and D3) have been added to the testbed infrastructure
  - These patterns are not constant over the whole duration of the experiments (as the previous three), but they dynamically become more challenging over time (every 30 seconds)
  - Enabling this feature allows teams to check how well they can mitigate interference compared to the other contestants

Levels D1-D3 dynamically vary between interference levels that are selected between level 0 (no jamming) and level 3 (stronger jamming)



Challenging RF Environment

New

- Due to numerous requests, three new interfering patterns (D1, D2, and D3) have been added to the testbed infrastructure
  - Jamming Type D1:
    - The interference amount (density) remains the same over time
    - The affected frequencies remain the same over time
    - The TX power of the jammers is increased over time
  - Jamming Type D2:
    - The interference amount (density) is increased over time
    - The affected frequencies remain the same over time
    - The TX power of the jammers remains the same over time
  - Jamming Type D3:
    - The interference amount (density) remains the same over time
    - The affected frequencies vary over time
    - The TX power of the jammers remains the same over time

Challenging RF Environment

- Due to numerous requests, three new interfering patterns (D1, D2, and D3) have been added to the testbed infrastructure
  - Jamming Type D1:
    - The interference amount (density) remains the same over time

Please note that the new interference types are meant to let contenstants quickly check their solution against varying (dynamic) interference patterns!
(i.e., it is meant to challenge your solution in a very harsh way to show you if and how it breaks)

The final evaluation scenario will contain milder interference settings!

  - Jamming Type D3:
    - The interference amount (density) remains the same over time
    - The affected frequencies vary over time
    - The TX power of the jammers remains the same over time

Limitations on Frequency Usage

- The TI CC2420 radio allows to send and receive packets also outside the 2.4 GHz band (roughly between 2230 MHz and 2730 MHz)
  - No limitation about the usage of frequencies between 2400 and 2483.5 MHz

    → You can use any IEEE 802.15.4 channel (11 to 26)

  - The use of frequencies below 2400 and above 2483.5 MHz is strictly forbidden!

    → Any detected violation will lead to a disqualification

Performance Metrics

- A summary of the performance for each experiment is now available under “Job details”
  - The reliability, latency, and energy for each of the scenarios is averaged with equal weight

Performance Metrics

Metric	Result
Latency [ms]	506.5
Reliability [%]	87.5
Energy [J]	291.3

Leaderboard

- The results of the experiments of all teams are summarized on a public leaderboard
  - As shown in the previous editions, knowledge of each other's performance is one of the salient aspects of the competition (to push each other's performance)

Contestants comparing the results from the leaderboard during EWSN'17 in Uppsala

Leaderboard

- The results of the experiments of all teams are summarized on a public leaderboard
  - The leaderboard shows the X best experiments of each team for each performance metric (reliability, latency, energy)

Leaderboard

Showing first 3 results for jobs with id>1872, with no jamming, duration 300s and with reliability between 75 and 100%

Energy

#	T	E[J]	R[%]	L[ms]
1877	00	289.6	81.7	552.6
1881	00	291.3	89.4	497.4
1873	00	296.3	86.3	480.9

Reliability

#	T	E[J]	R[%]	L[ms]
1881	00	291.3	89.4	497.4
1873	00	296.3	86.3	480.9
1877	00	289.6	81.7	552.6

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1873	00	296.3	86.3	480.9
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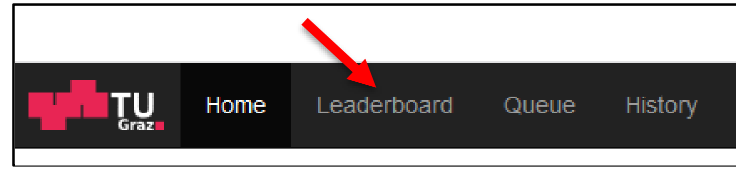
Leaderboard



- The results of the experiments of all teams are summarized on a public leaderboard
  - The leaderboard shows the X best experiments of each team for each performance metric (reliability, latency, energy)
  - The leaderboard refers to the average of all scenarios (the reliability, latency, and energy for each of the scenarios is averaged with equal weight)

Duration 300 | Jamming None | Count 3

Leaderboard

Showing first 3 results for jobs with id>1872, with no jamming, duration 300s and with reliability between 75 and 100%

Energy

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Leaderboard

- The results of the experiments of all teams are summarized on a public leaderboard
  - The leaderboard is filtered by experiment duration and interference setting (Duration, Jamming combo-boxes)

Duration 300 | Jamming None | Count 3

Leaderboard

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Leaderboard

- The results of the experiments of all teams are summarized on a public leaderboard
  - The leaderboard is filtered by experiment duration and interference setting (Duration, Jamming combo-boxes)
  - One can also consider only at most X experiments per team (with X being selected through the Count combo-box)

Duration 300 | Jamming None | Count 3

Leaderboard

Showing first 3 results for jobs with id>1872, with no jamming, duration 300s and with reliability between 75 and 100%

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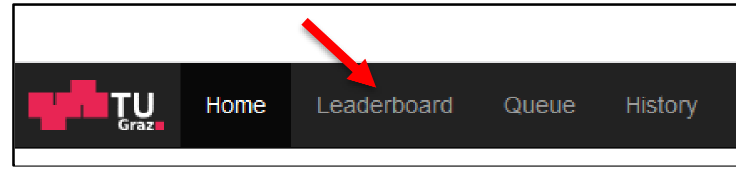
Leaderboard



- The results of the experiments of all teams are summarized on a public leaderboard
  - The leaderboard is filtered by experiment duration and interference setting (Duration, Jamming combo-boxes)
  - One can also consider only at most X experiment per team (with X being selected through the Count combo-box)
  - Only results of the experiments run without log output enabled are considered in the leaderboard

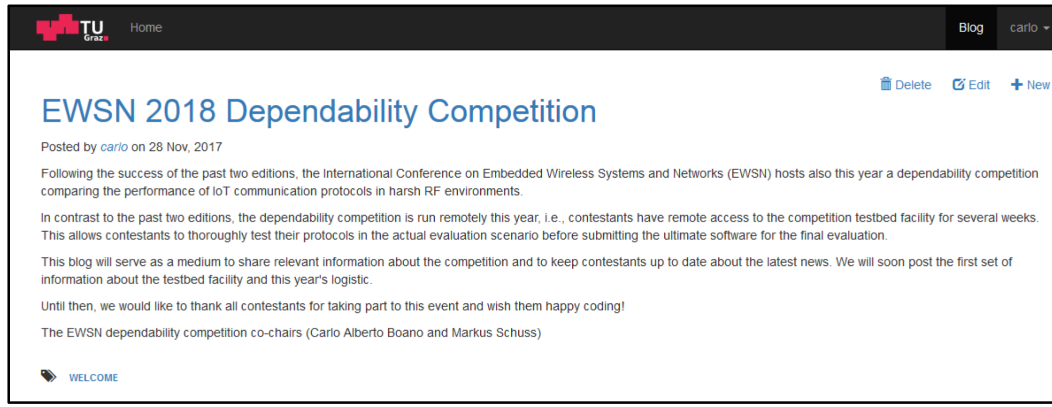
→ Logging significantly increases energy consumption

→ Logging decreases the precision of GPIO tracing

Communication with the Organizers

Official Blog

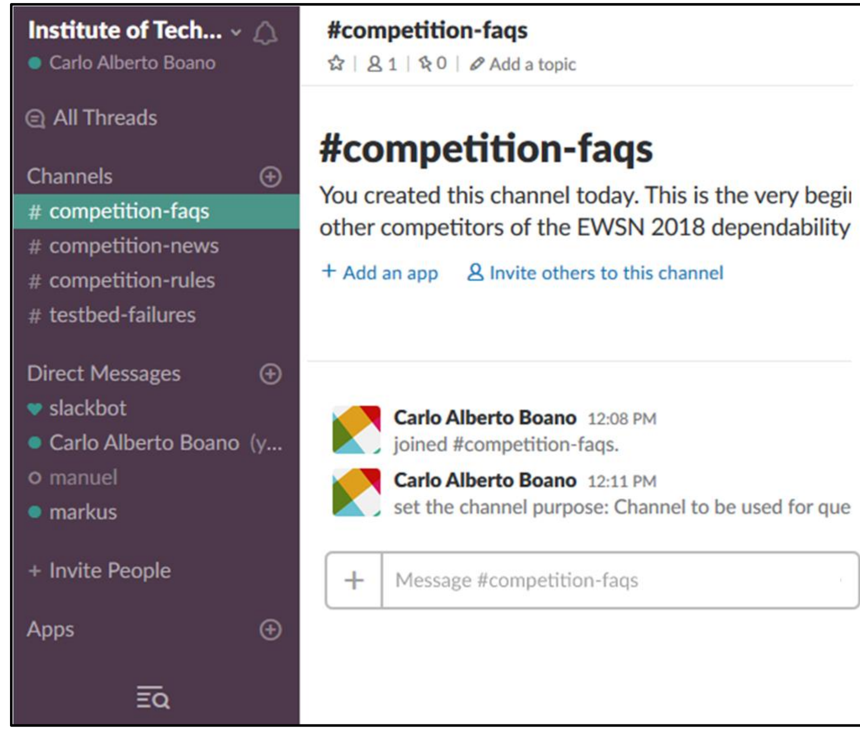
- The organizers have created a blog to keep contestants up to date about the logistics and any important news
  - Please check it regularly!
  - Answers to FAQs will be posted here

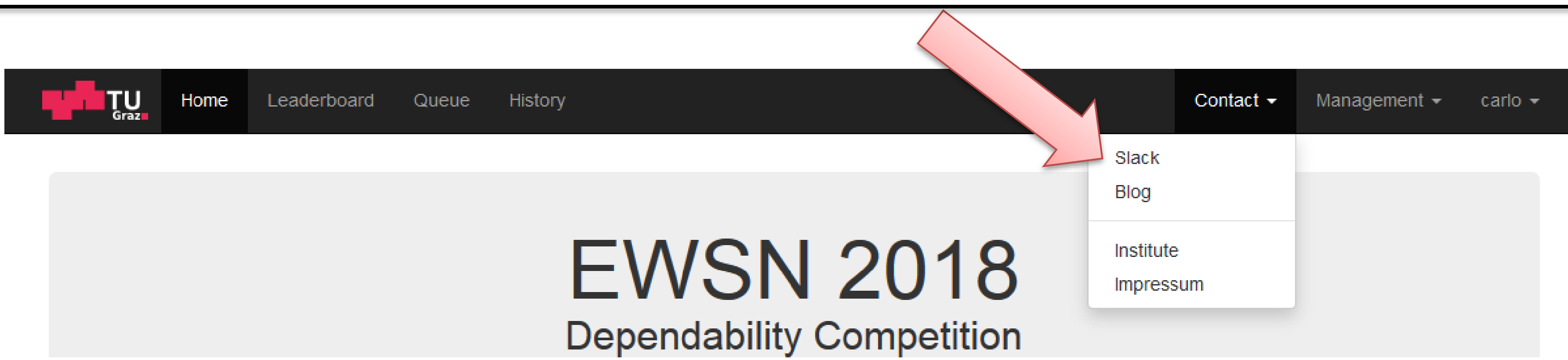


Slack Group

- The organizers have also created a slack group to let contestants easily post questions and interact with the organizers as well as with the other teams

- To join slack, click here





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