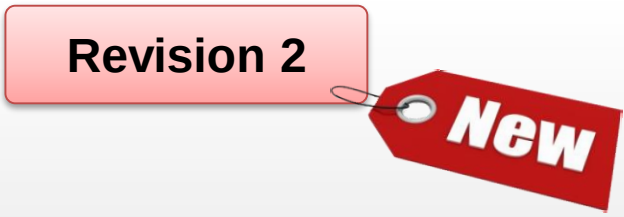
Revision 2



EWSN 2018 Dependability Competition

Logistics Information

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Institut für Technische Informatik
Graz University of Technology, Austria

16.12.2017

3rd EWSN Dependability Competition

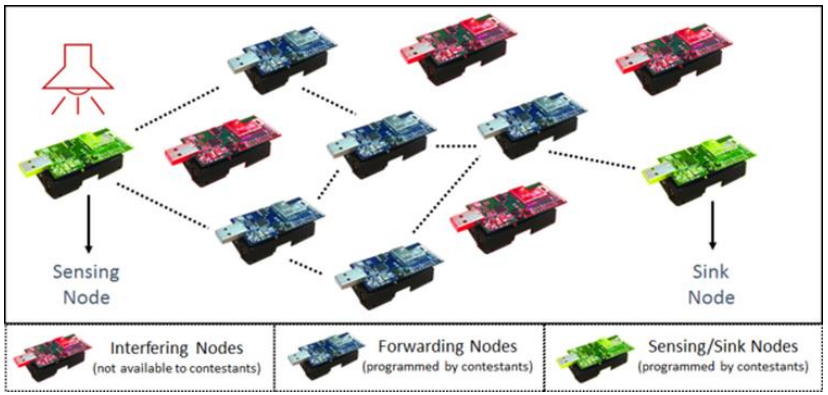
- Following the success of the past two editions, the International Conference on Embedded Wireless Systems and Networks (EWSN) hosts also this year a dependability competition comparing the performance of IoT communication protocols in harsh RF environments
  - 1st edition (2016): Graz, Austria [link]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

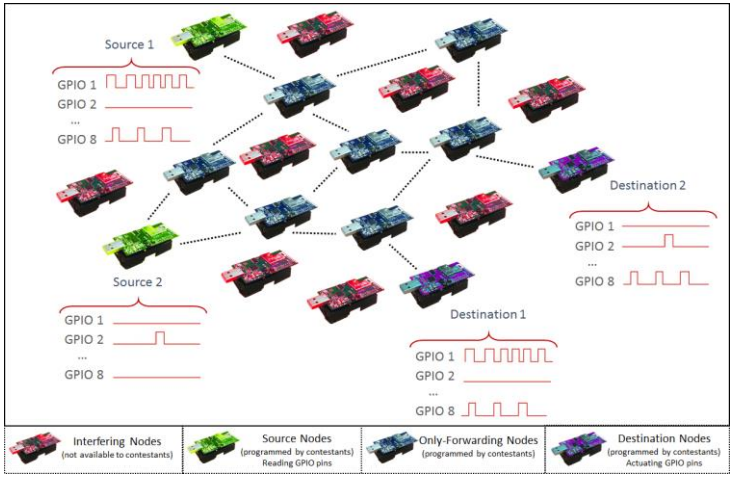
New Format

- 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 multiple events from/to several 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

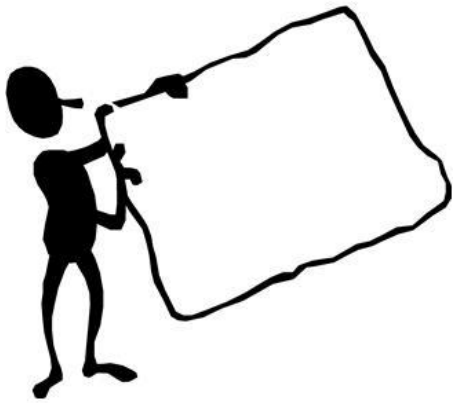




New Format

- 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 evening of the first day of the main EWSN conference, there will be a dedicated poster session for all competitors

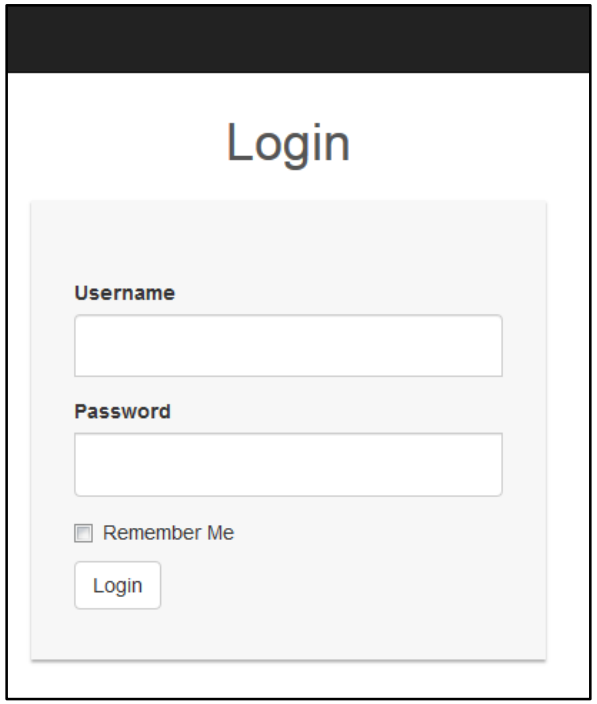
    → All competing teams must present their solution in the poster session and will have the possibility to engage in lively discussions with the other conference attendees



Competition's Testbed Facility

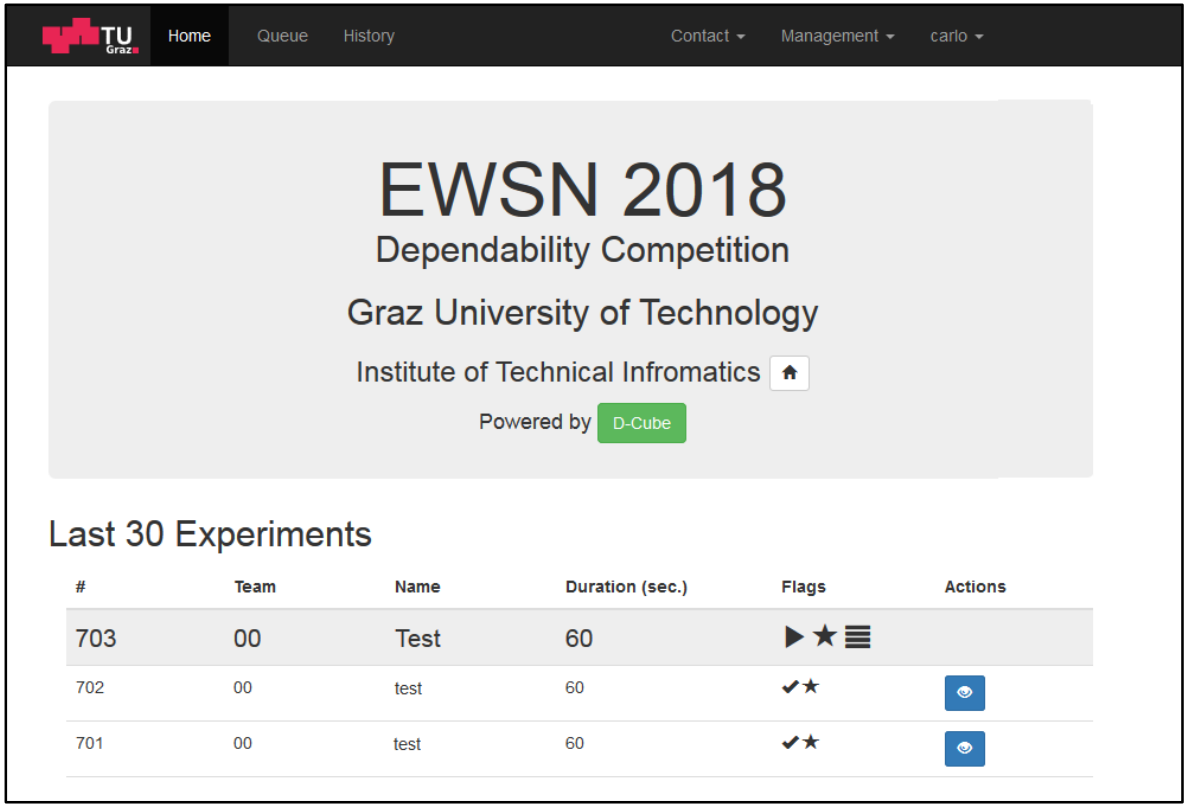
Competition's Testbed Facility

- 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

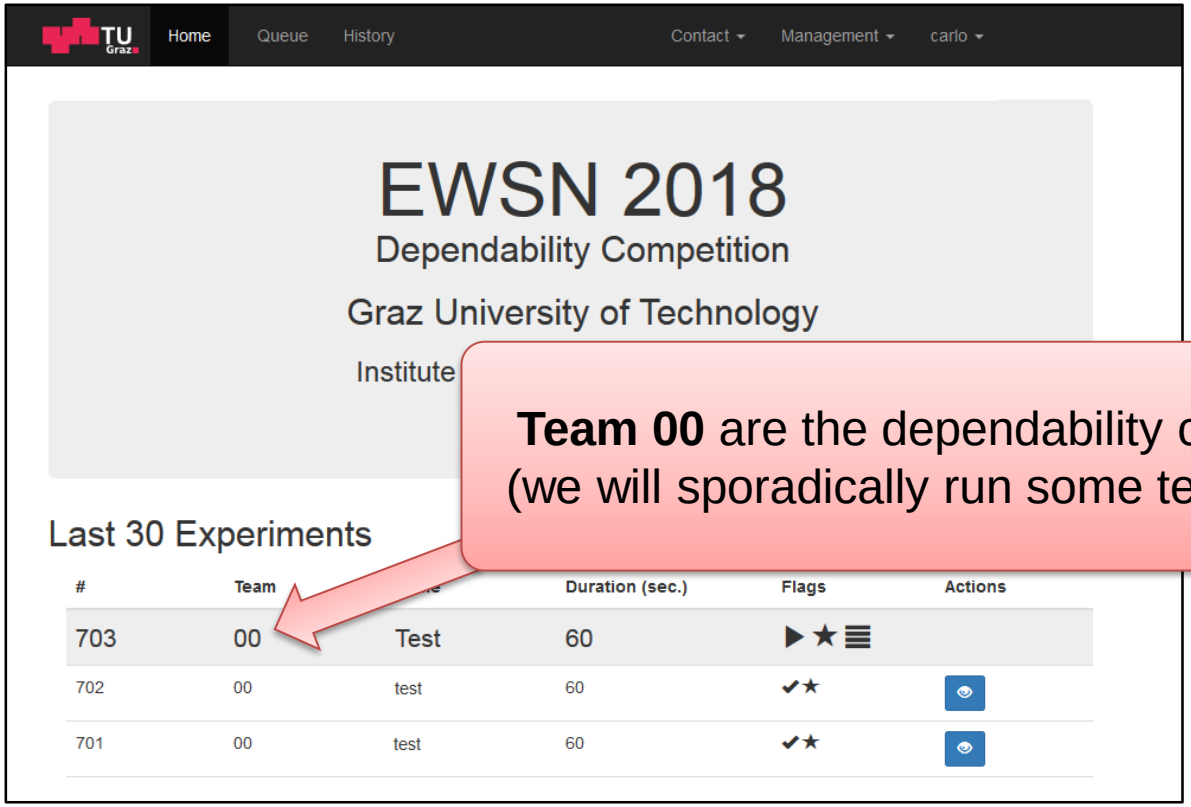
- At a glance
  - Home tab shows the list of all experiments of all teams (completed, running, or queued for execution)



- 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)



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

▶ Currently running

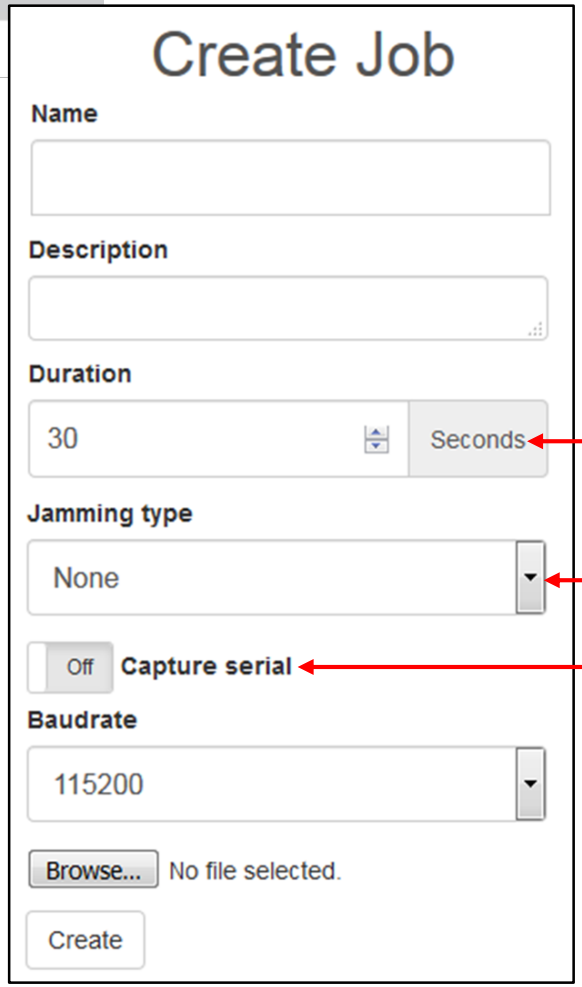
✔ Successfully completed

✖ Aborted or failed

(traces only seen by team)

Visualize results
(anyone can see those!)

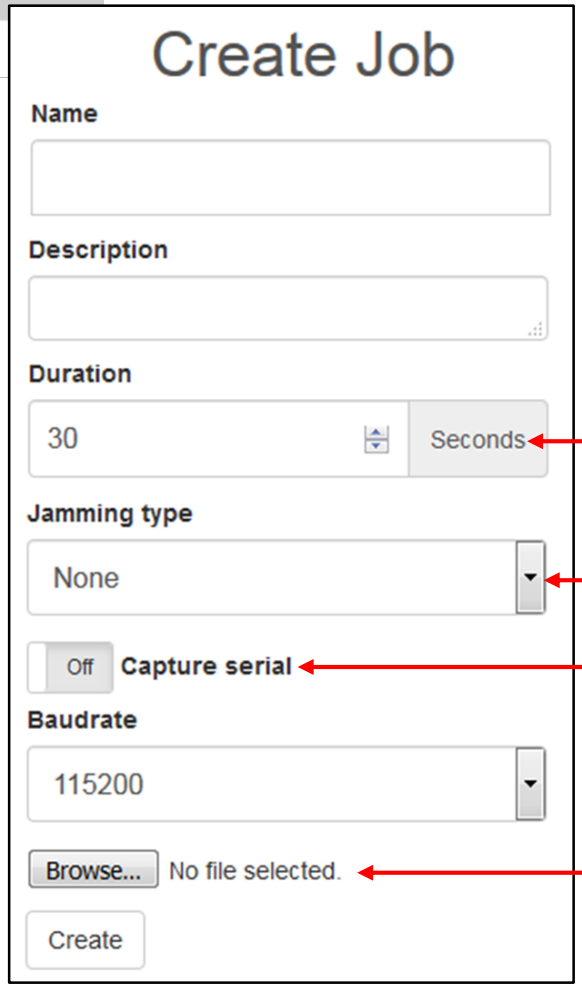
Firmware Upload



- 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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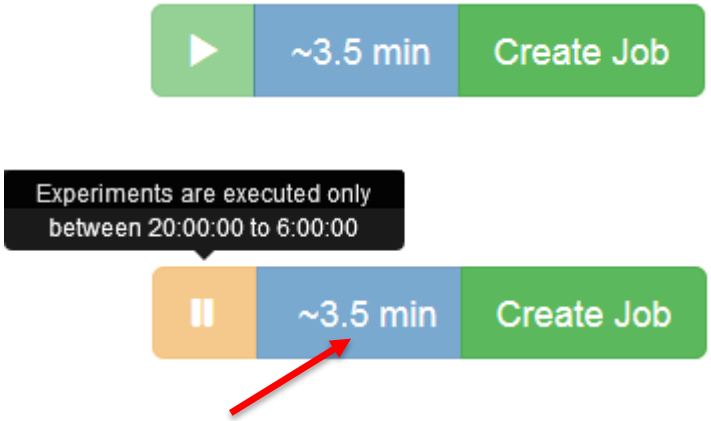
  Please note: the jamming pattern in the final evaluation is subject to change to avoid engineered solutions
- Contestants can capture serial output
  Please note: turning FTDI on/off severely affects the overall energy consumption!
- Contestants can upload a single binary `ihex` file: this will be uploaded 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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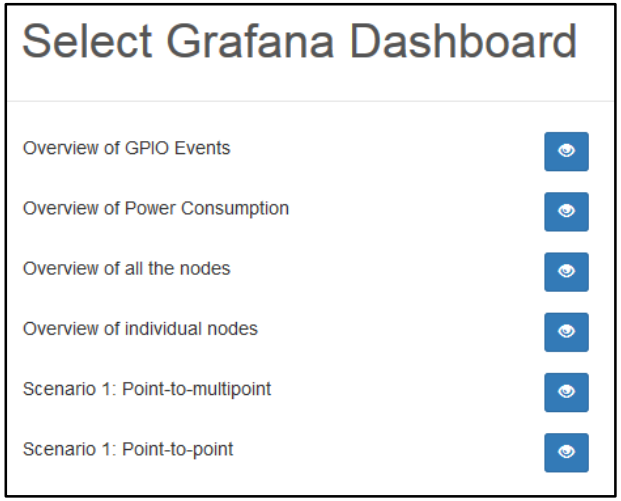
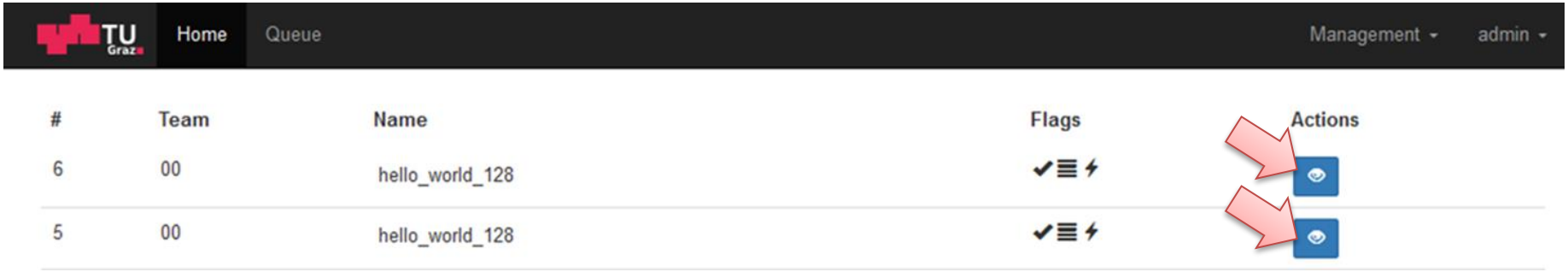
- Why this limitation?
  - During the experiments, a harsh RF environment is created by making use of (among others) Raspberry Pi3 nodes to generate a significant amount of Wi-Fi traffic
  - When heavy Wi-Fi traffic is generated, the University's Wi-Fi infrastructure is severely affected any can be disrupted
  - Therefore, we have agreed with TU Graz to carry out experiments only outside the official working hours

Results of an Experiment

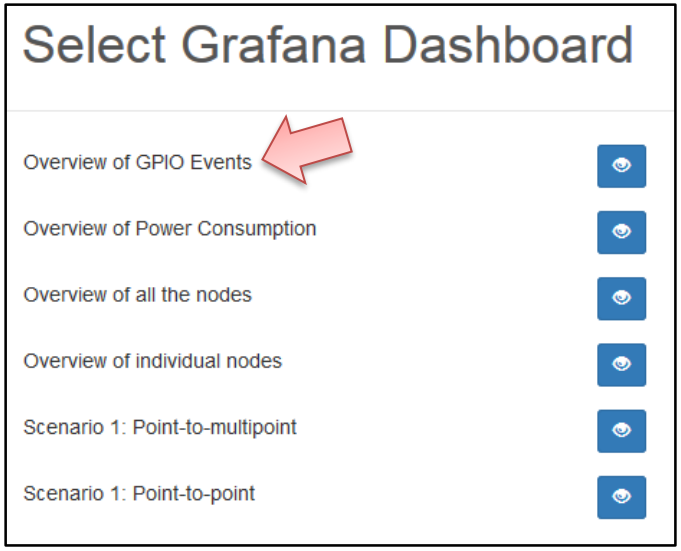
- After the execution of an experiment, graphical results can be checked by anyone by clicking on the blue button on the right side
  - Results displayed using Grafana
  - Power consumption and GPIO status is tracked for each node
  - Additional features will be activated in the next weeks
- The team owning a job can also see the program log

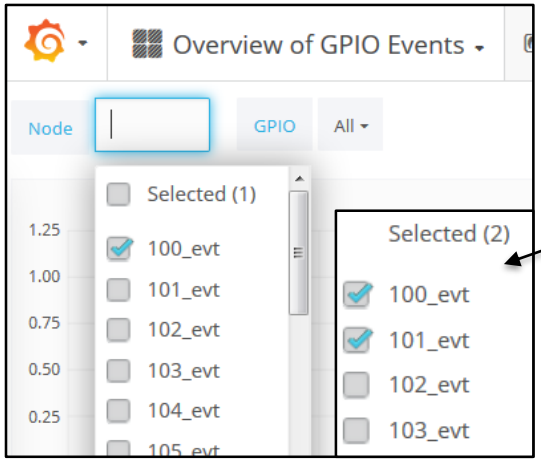




Results of an Experiment

- 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

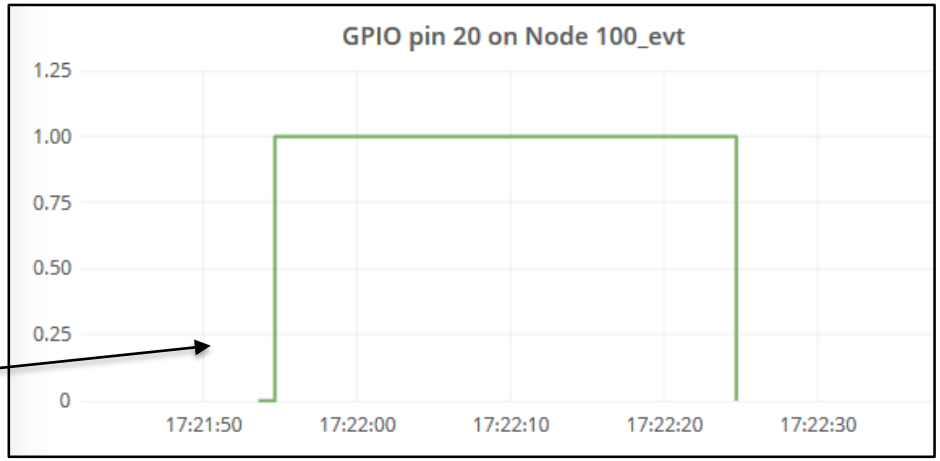




Monitoring the GPIO of multiple nodes at the same time

Monitoring individual GPIO pins

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



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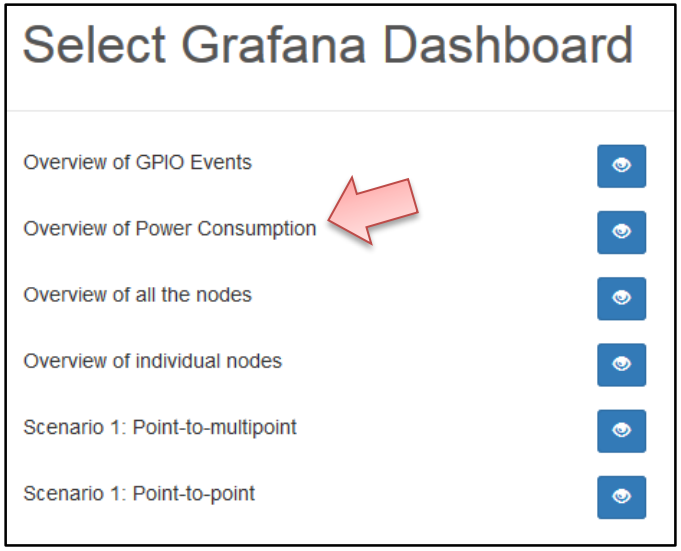
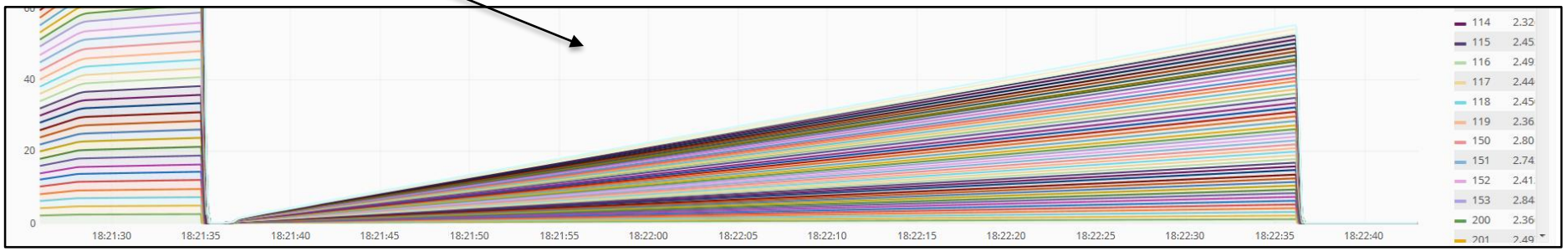


Stacked energy consumption:
Shows the total energy consumed by all nodes in the testbed

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



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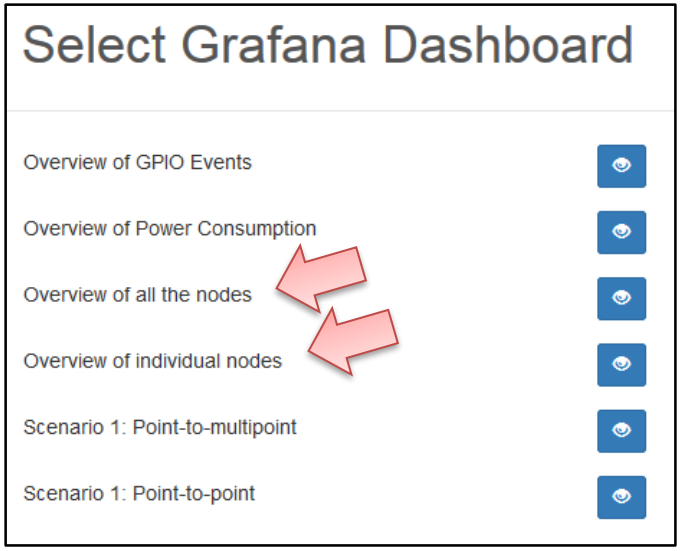

Individual statistics on **voltage, current, power,** and **cumulative energy** for each node in the network

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)
```

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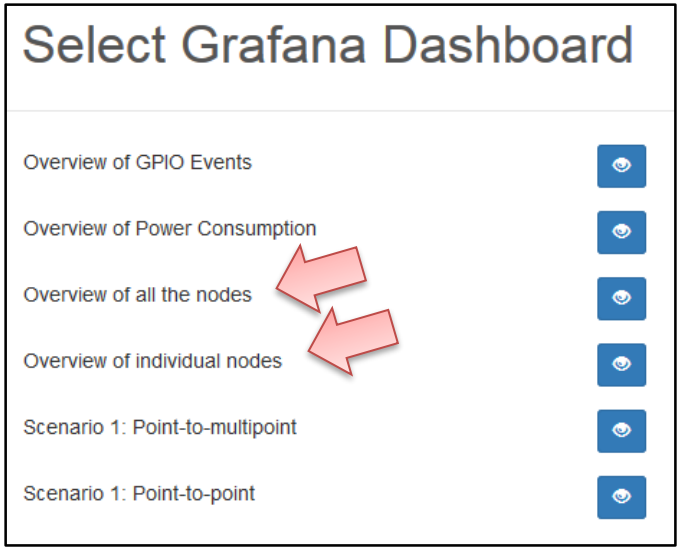
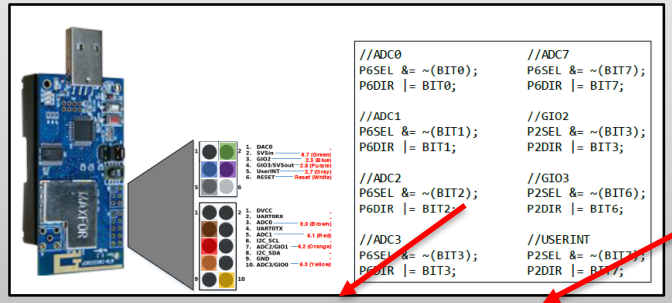


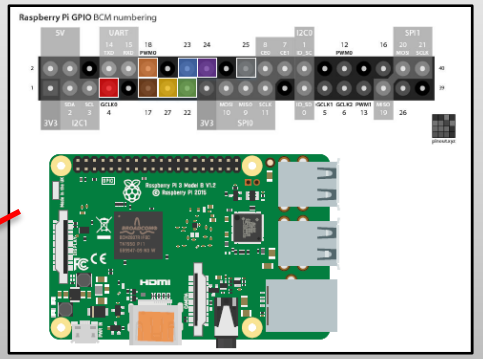
GPIO pins (Information is encoded in a special way – for individual values, use "Overview of GPIO events")

The value is computed as follows:

```
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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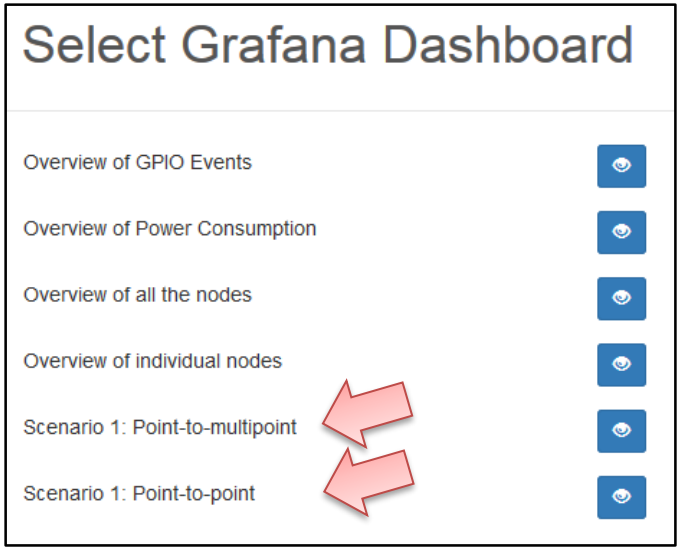
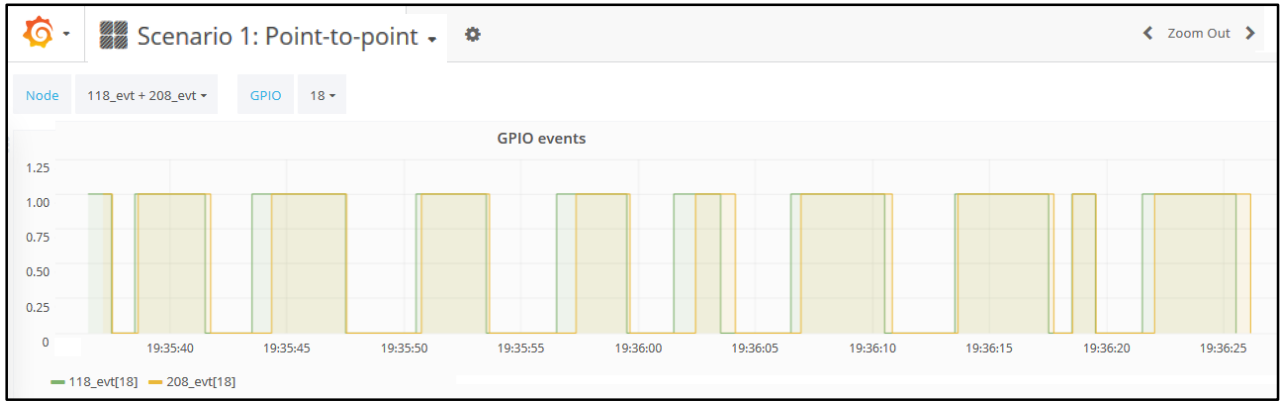
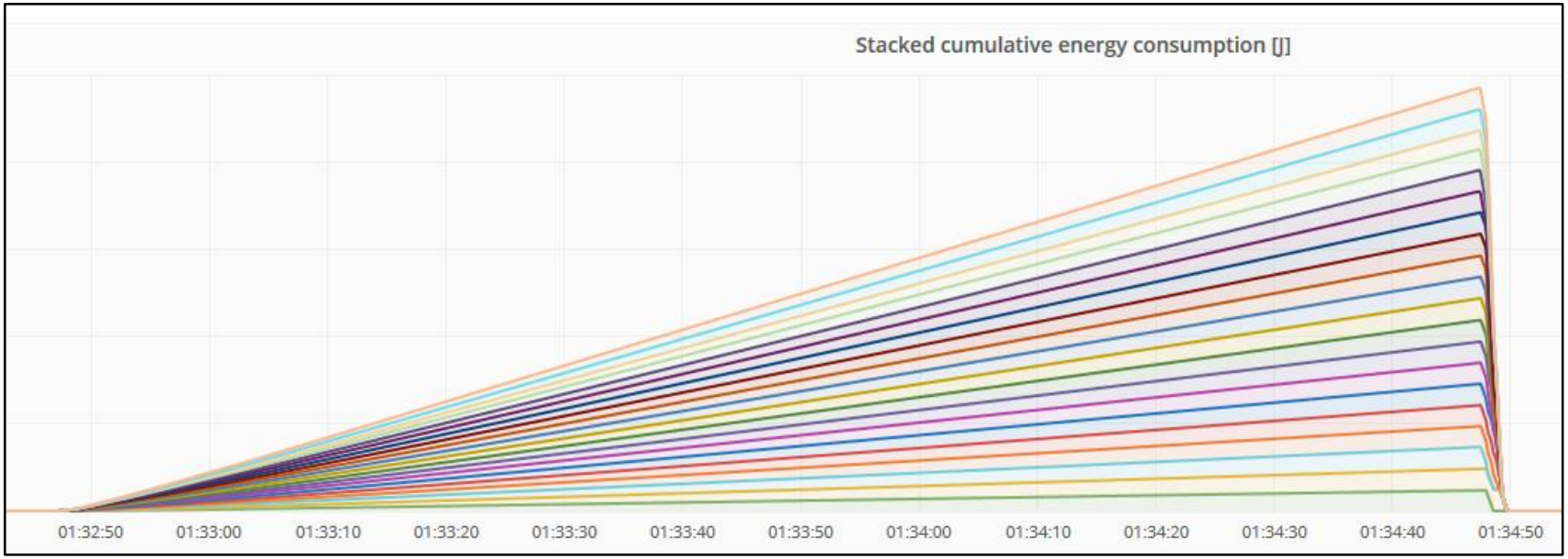




Plots specific to the current evalation scenario
(see "Evaluation Scenario scetion" of these slides)

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, …)

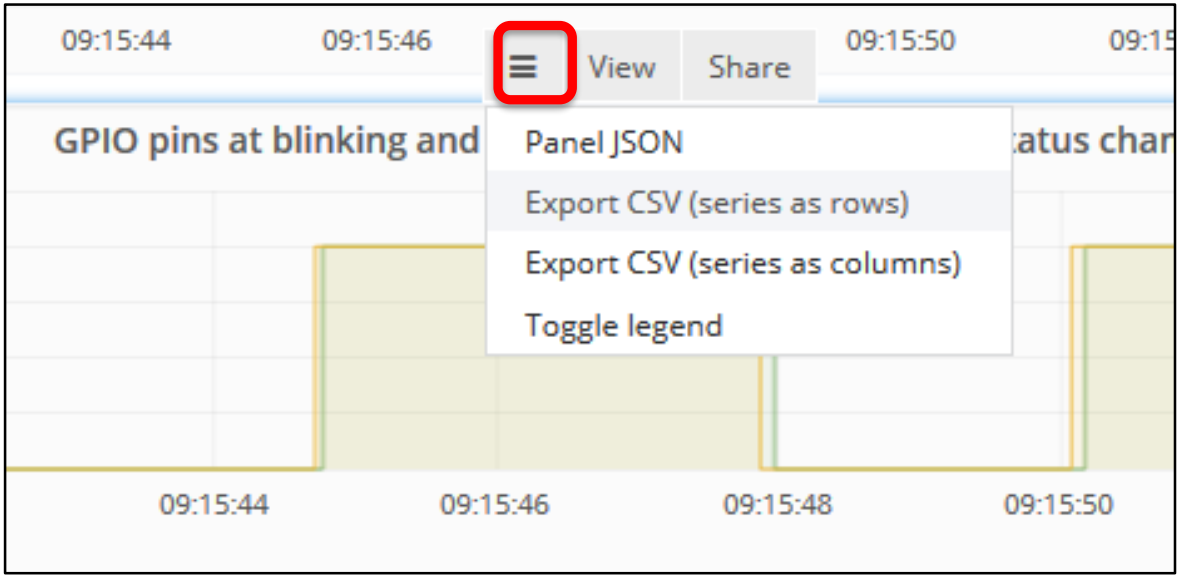


Visualization in Grafana – FAQ

- 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"

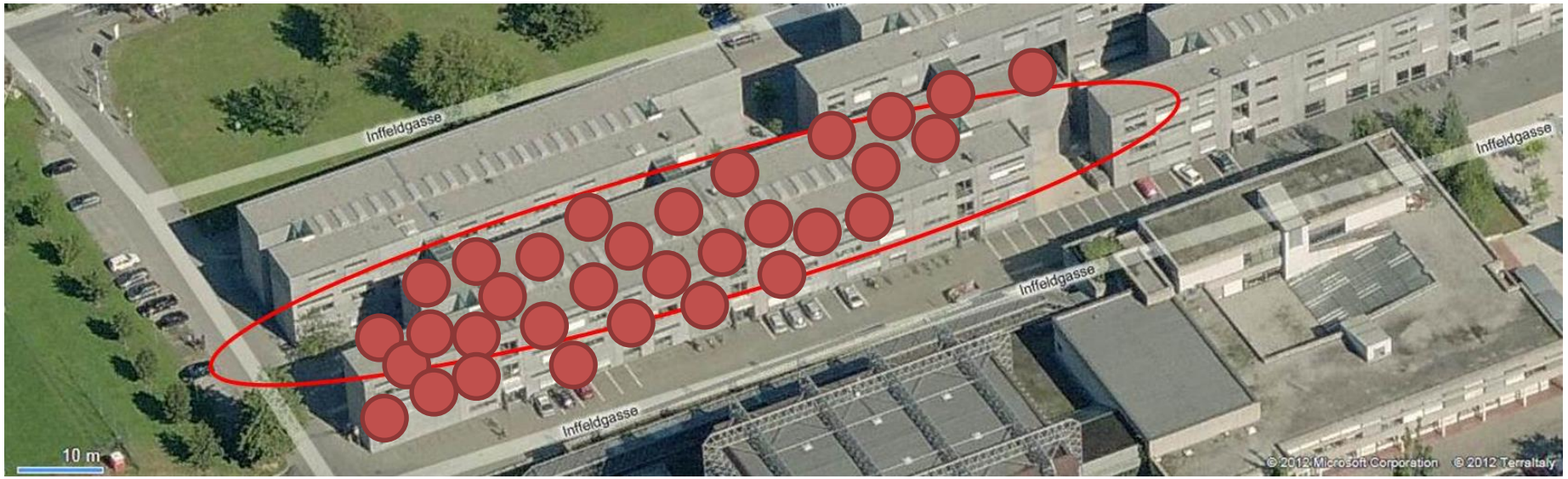


	A	B	C
1	Time	1	2
2	2017-02-16T09:43:46.876Z	0.0840805771962	0.1951102
3	2017-02-16T09:43:47.501Z	0.152616695366	0.2566677
4	2017-02-16T09:43:48.126Z	0.221115444991	0.2613602
5	2017-02-16T09:43:48.751Z	0.289725498238	0.2663699
6	2017-02-16T09:43:49.376Z	0.336447792086	0.2709752

	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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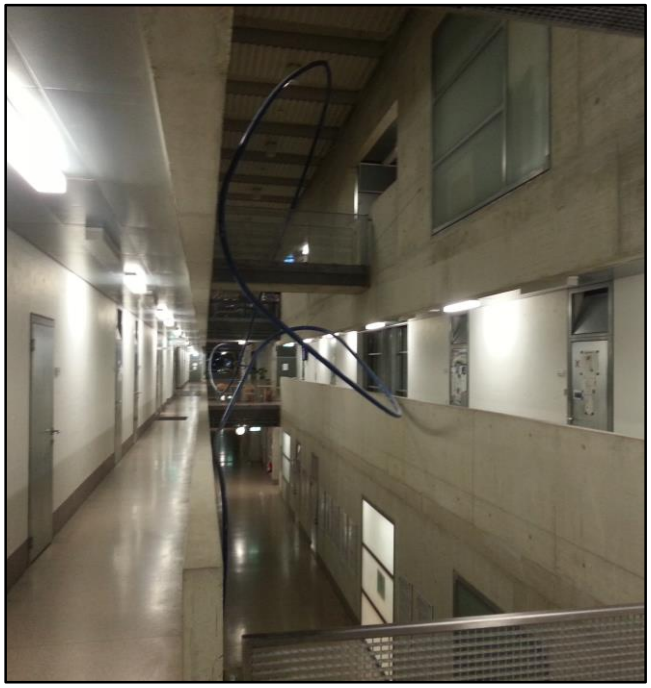
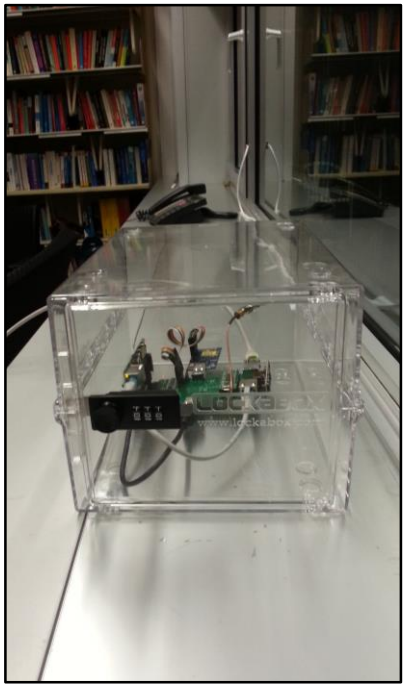




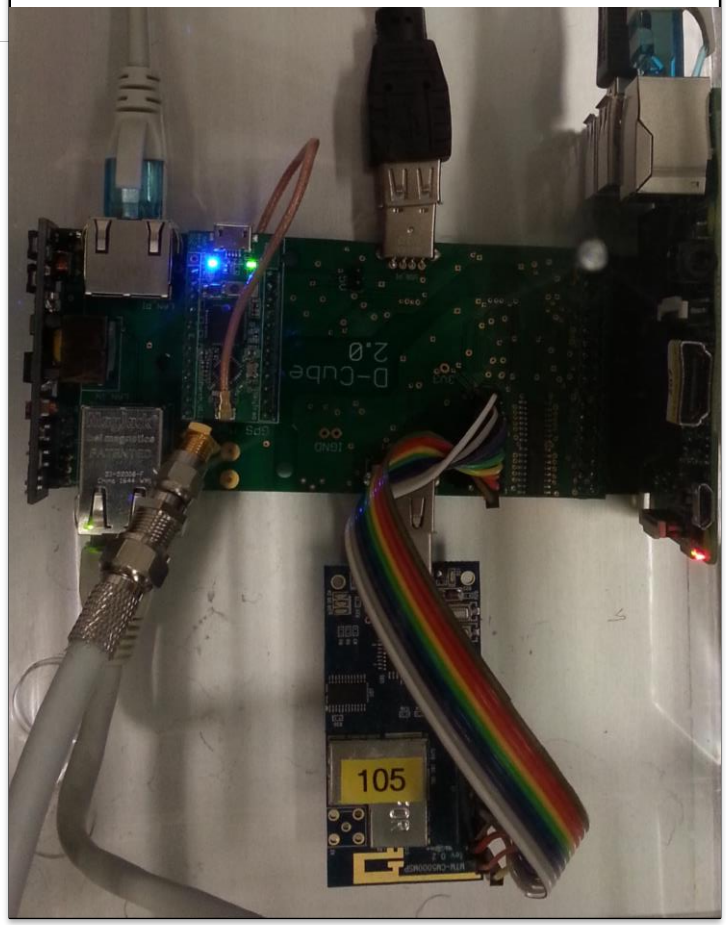
Testbed Hardware

- 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

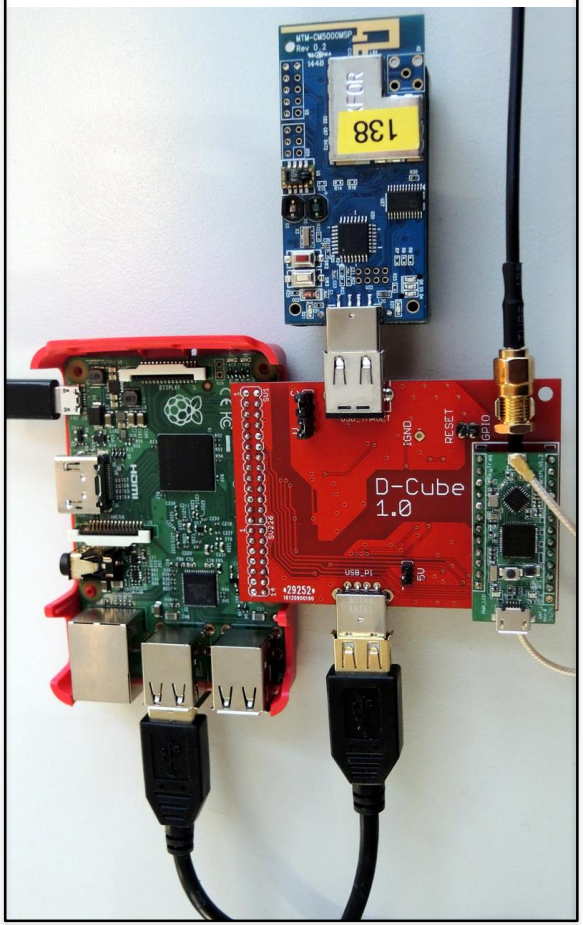
Testbed Hardware: D-Cube

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

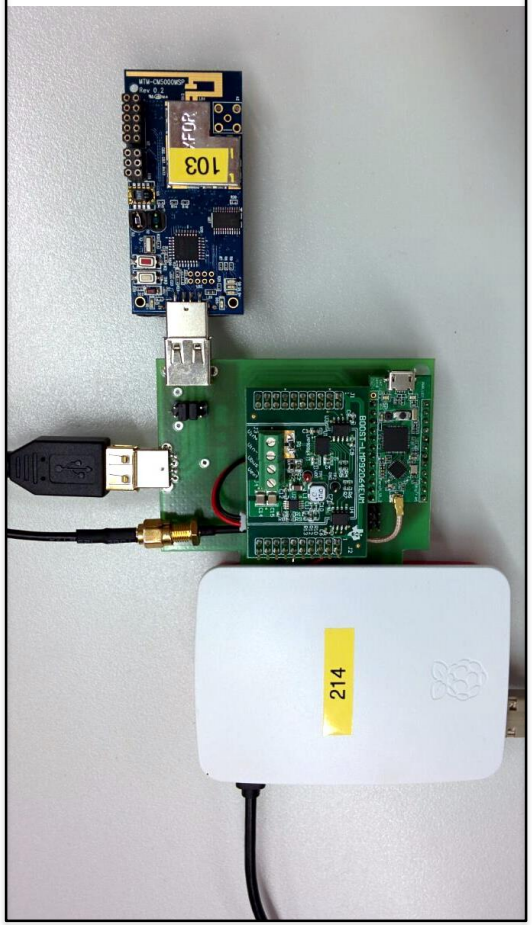
This year's prototype (EWSN'18)



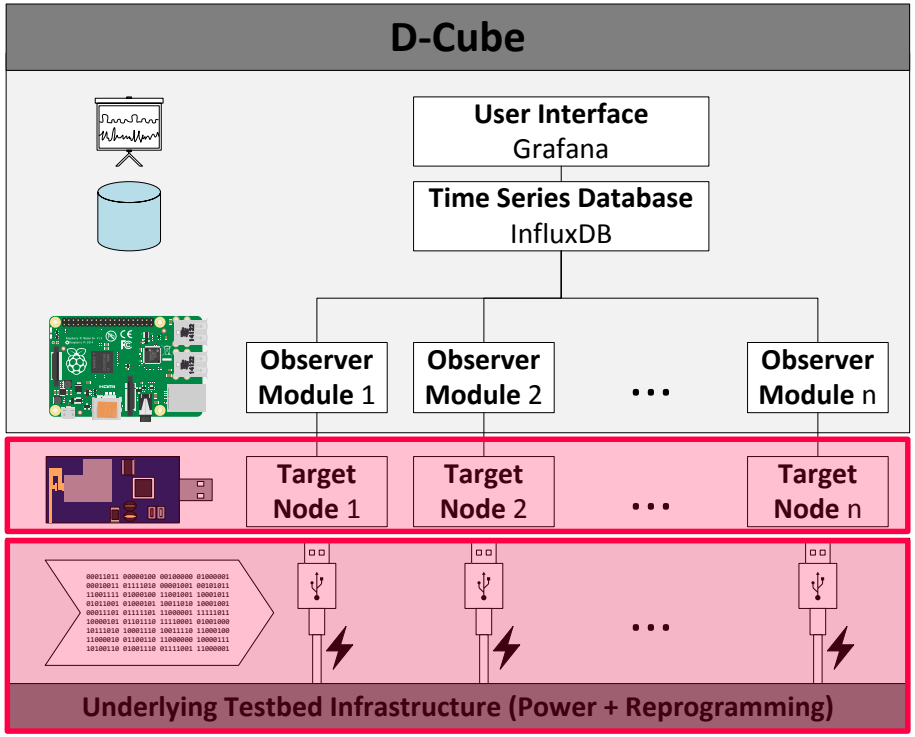
EWSN'17 version



EWSN'16 version



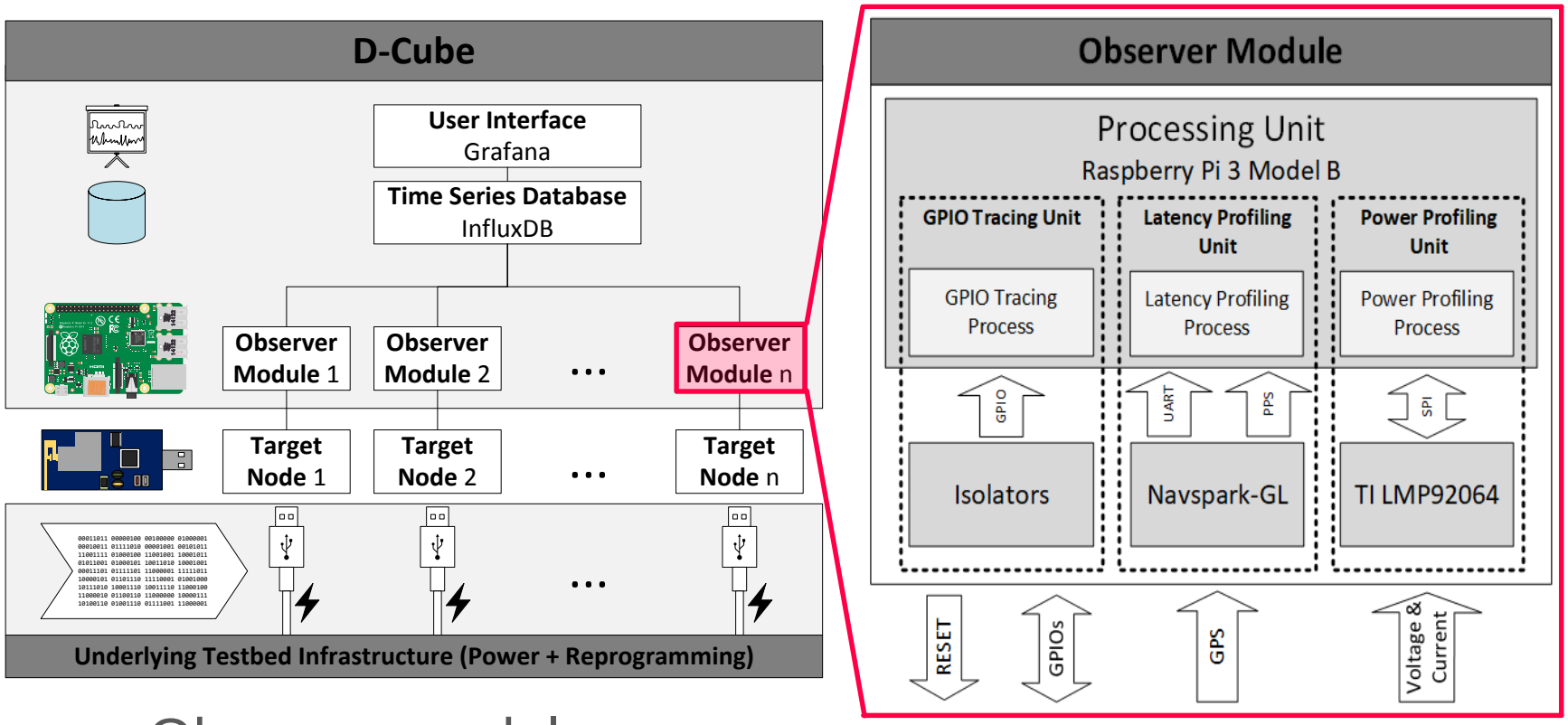
Testbed Hardware: D-Cube



- 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)

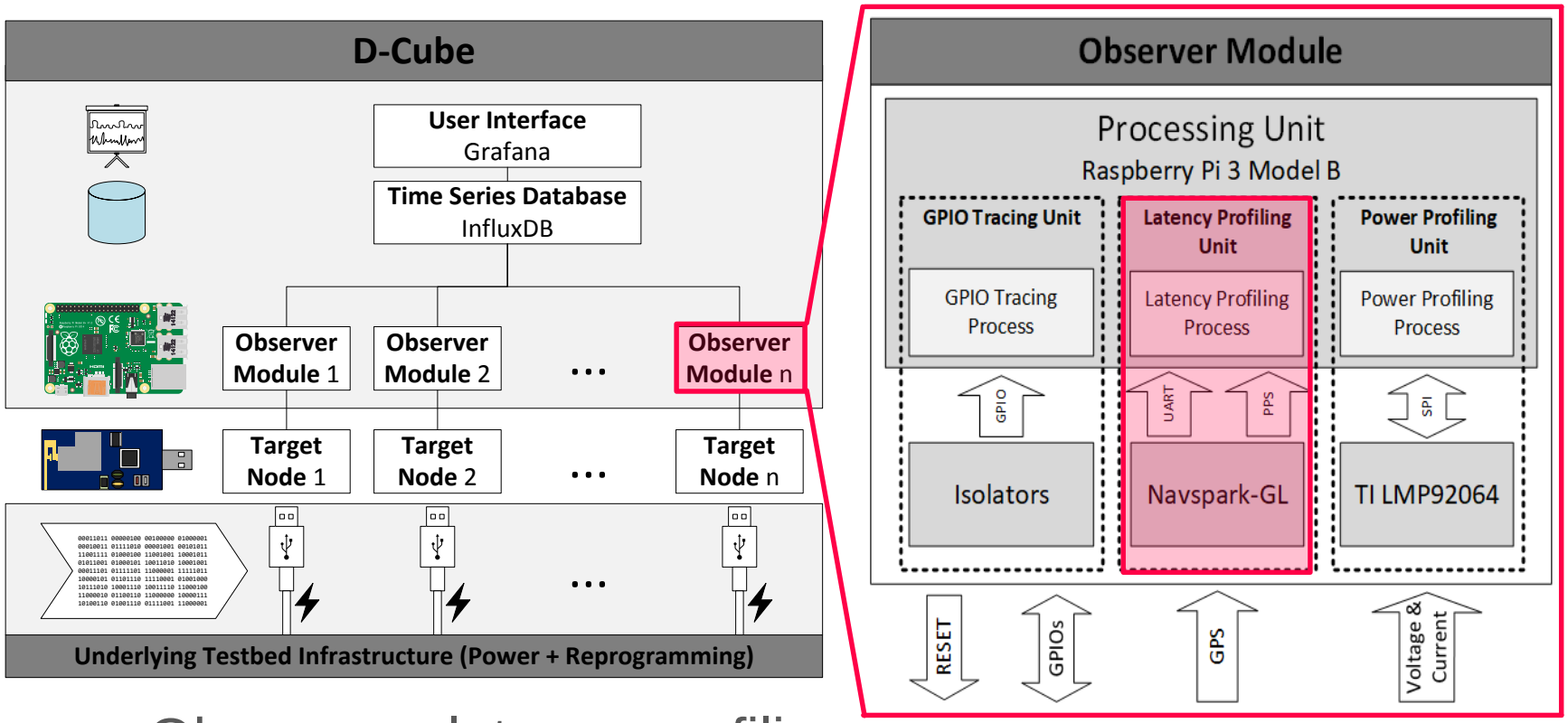
- Underlying infrastructure
  - → Power + reprogramming of the target nodes
  - → Allows to disable the UART interface

Testbed Hardware: D-Cube



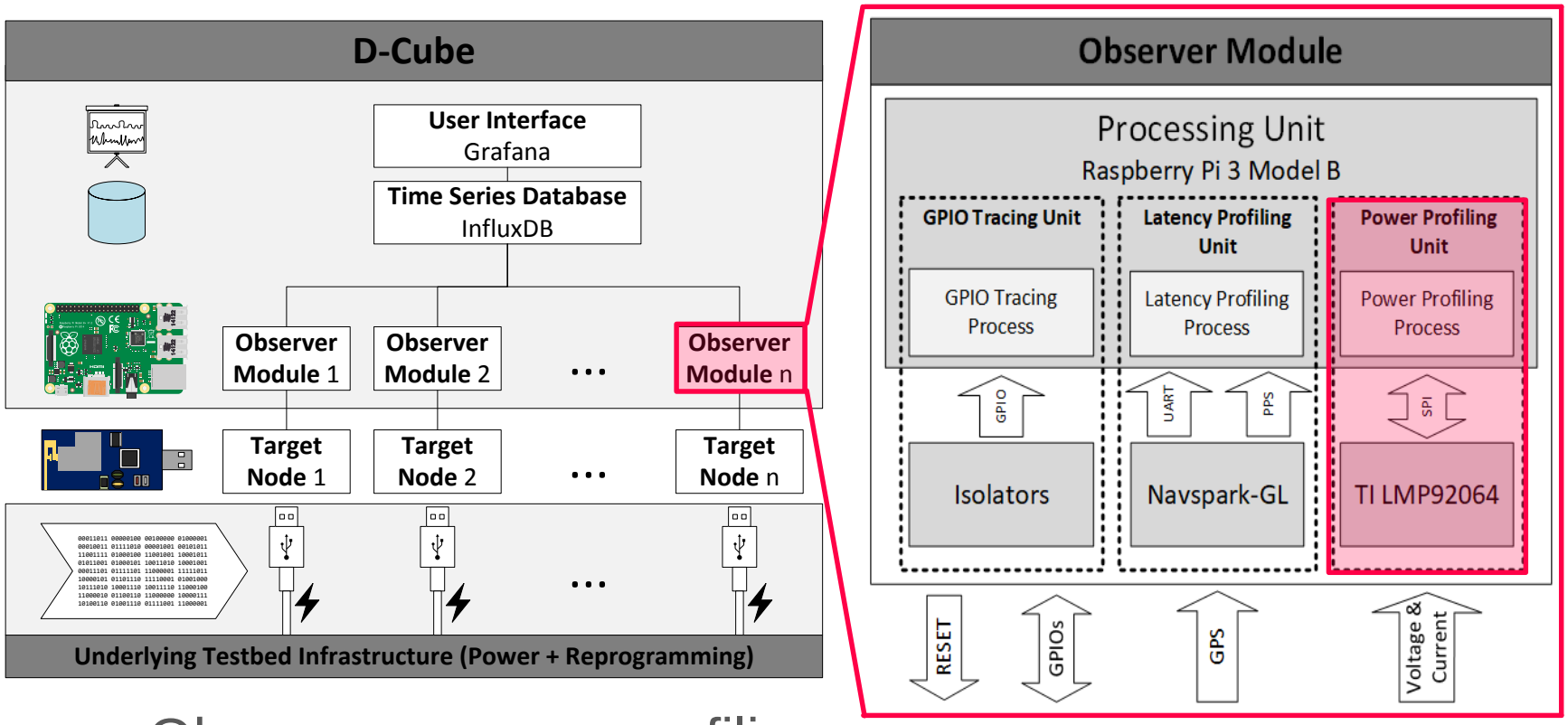
- Observer modules
  - → Each module monitors exactly one target node
  - → Raspberry Pi 3 + custom-made add-on card (ADC+GPS)

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

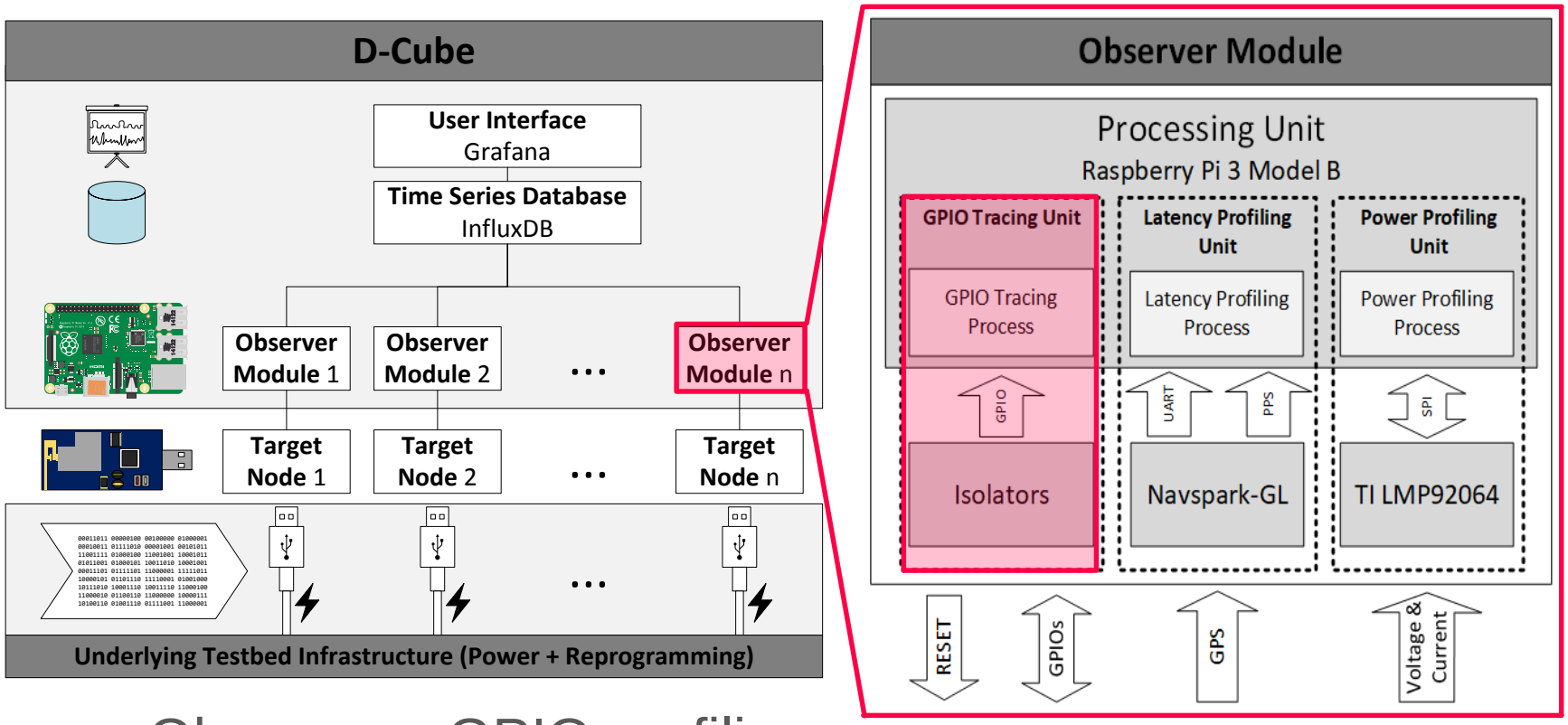


- Observers: power profiling

→ Simultaneous sampling ADC (TI LMP92064) read via SPI @ 62.5 kHz using a real-time process

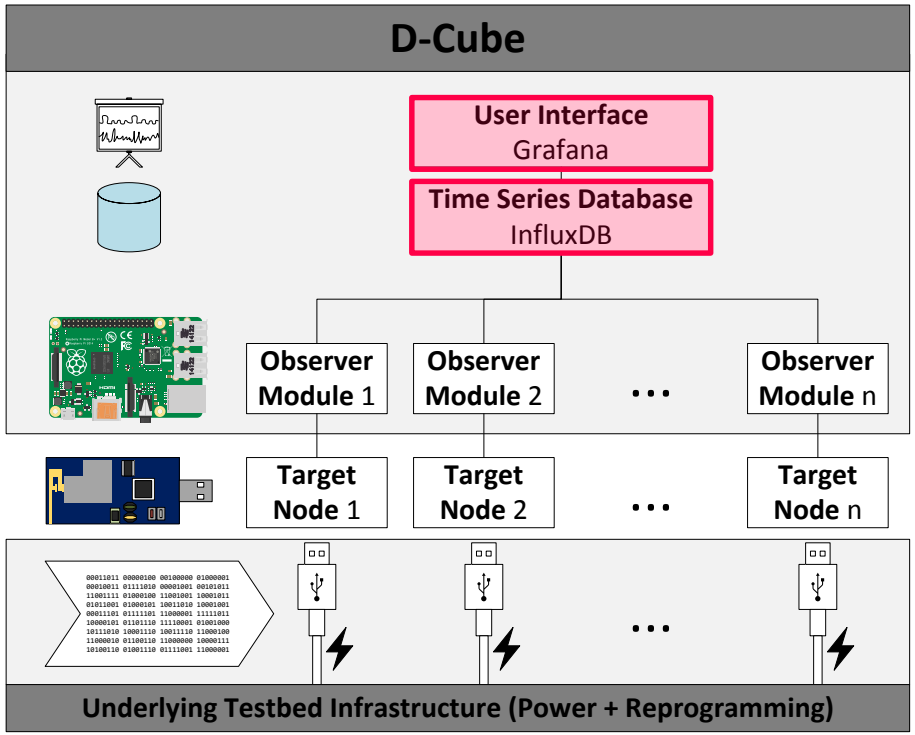
- Voltage channel: up to 10.82V with 2.82mV resolution
- Current channel: up to 150.59mA with 39.22µA resolution

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

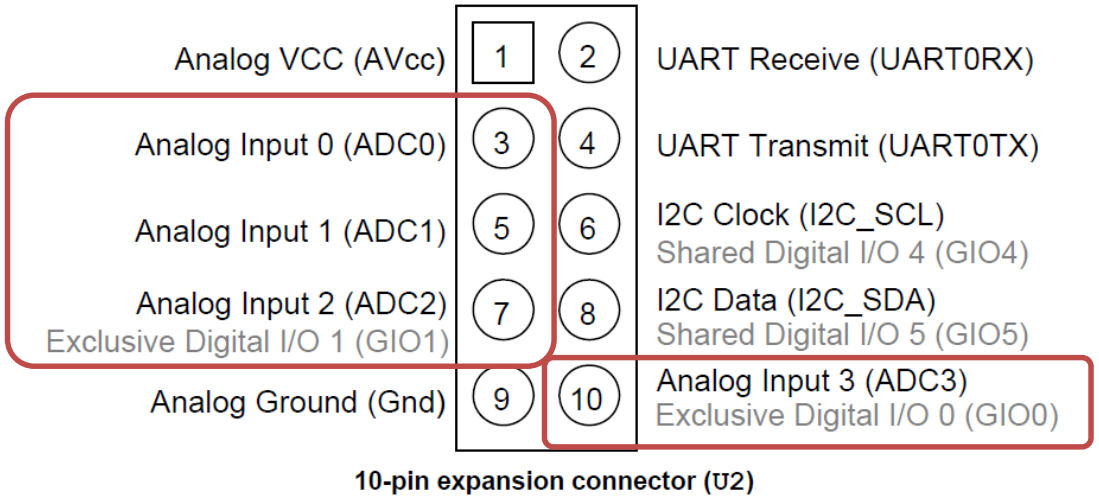


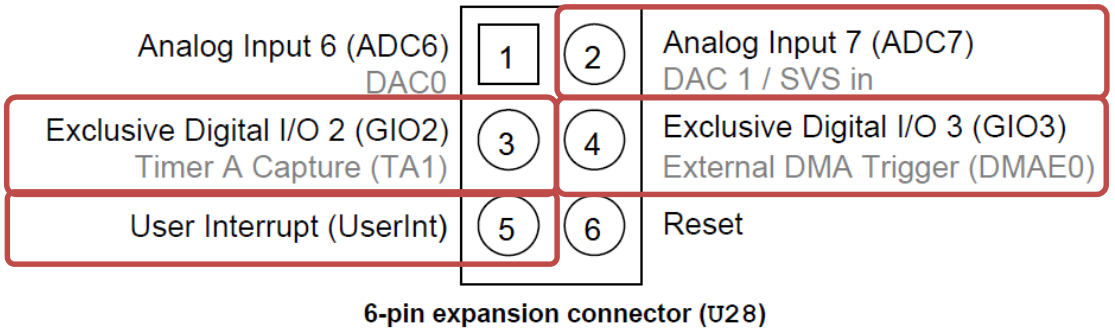
- Time Series database
  - → Collects and persistently stores the data from all observers
  - → InfluxDB (open-source)
  - → Nanosecond precision timestamps
- User Interface
  - → Acts as proxy to the database and gives real-time feedback
  - → Grafana (open-source)

GPIO Pins

GPIO Pins

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

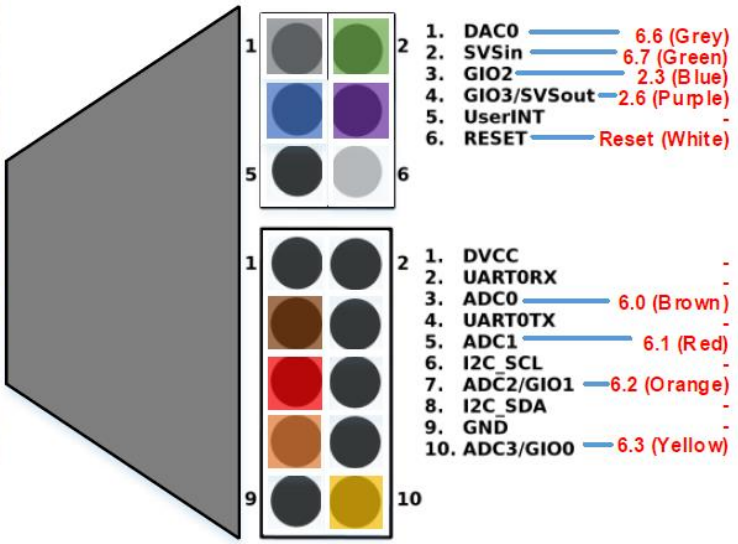




GPIO Pins

- 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

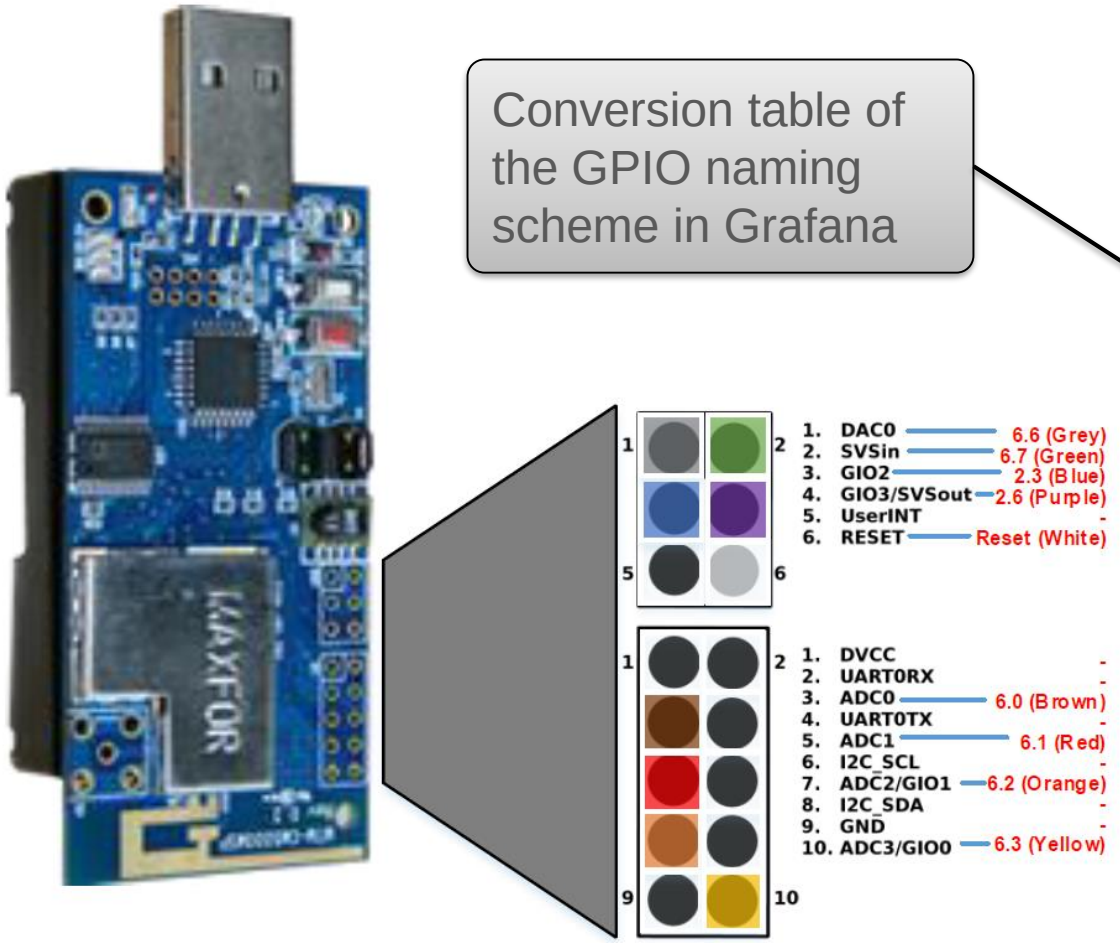



```
//ADC0                          //ADC7
P6SEL &= ~(BIT0);               P6SEL &= ~(BIT7);
P6DIR |= BIT0;                  P6DIR |= BIT7;

//ADC1                          //GIO2
P6SEL &= ~(BIT1);               P2SEL &= ~(BIT3);
P6DIR |= BIT1;                  P2DIR |= BIT3;

//ADC2                          //GIO3
P6SEL &= ~(BIT2);               P2SEL &= ~(BIT6);
P6DIR |= BIT2;                  P2DIR |= BIT6;

//ADC3                          //ADC6 / DAC0
P6SEL &= ~(BIT3);               P6SEL &= ~(BIT6);
P6DIR |= BIT3;                  P6DIR |= BIT6;
```

Pin **UserINT** has been replaced with **DAC0/ADC6**!

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

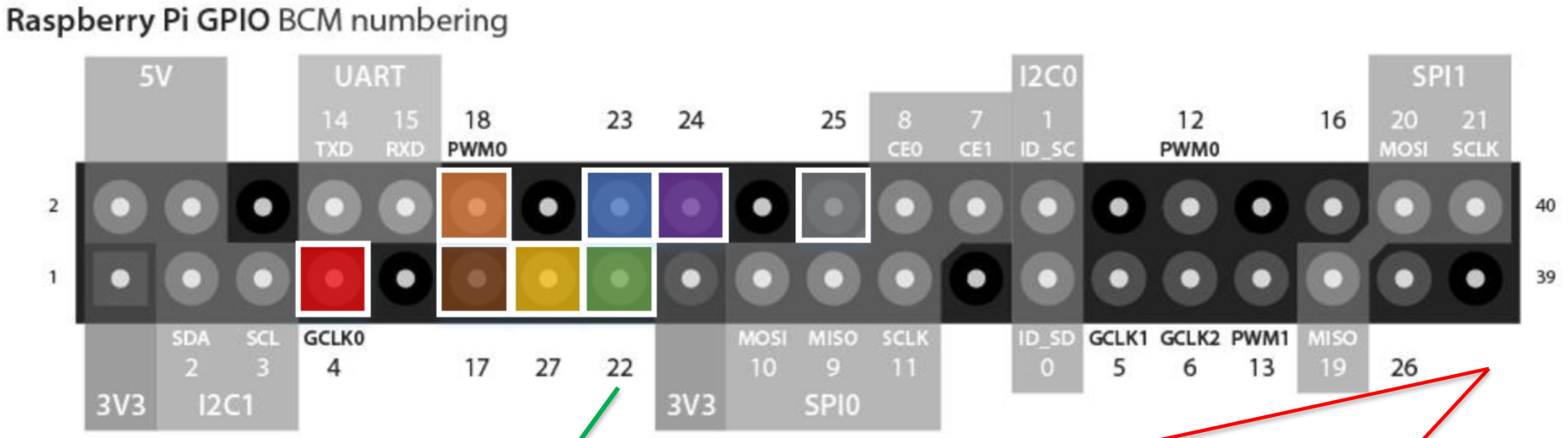
Sensor Node	Grafana
ADC0	GPIO 17
ADC1	GPIO 4
ADC2/GIO1	GPIO 18
ADC3/GIO0	GPIO 27
ADC7/SVSin	GPIO 22
GIO2	GPIO 23
GIO3/SVSout	GPIO 24
DAC0/ADC6	GPIO 25

Pin **UserINT** has been replaced with **DAC0/ADC6**!

New

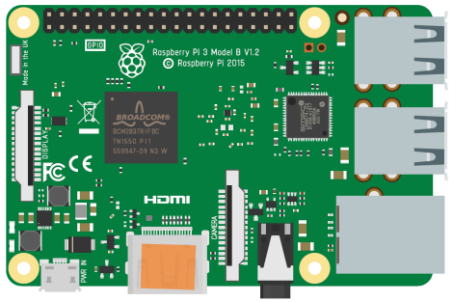
Numbering of GPIO Pins in Grafana

- 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)



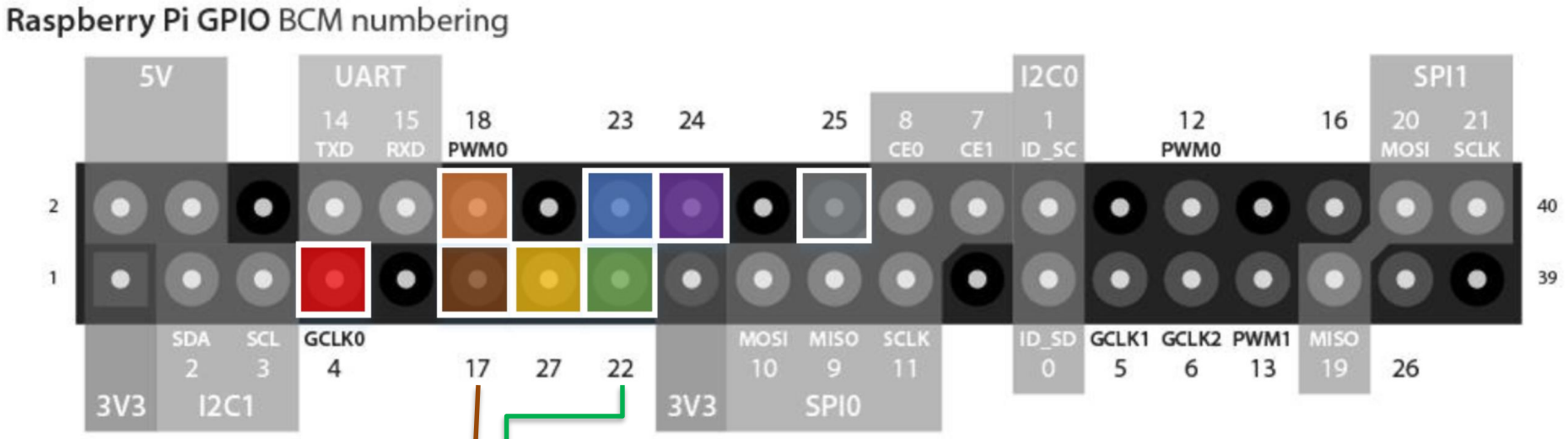
(Pin 22 on Raspberry Pi3)

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)



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

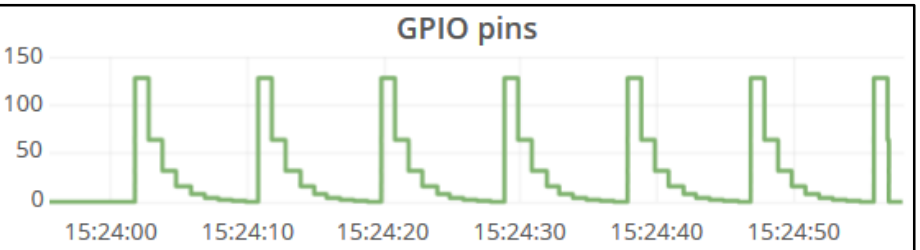
"GPIO Pins" Tab in Grafana

- 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
  - 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 – 29.01.2018)

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 – 07.01.2018
   → A more advanced scenario added (details follow)
   → Harsh RF environment can be generated

NOW!

3. Third preparation phase: Large-scale tests
   08.01.2018 – 29.01.2018
   → Large-scale scenario with harsh RF environment

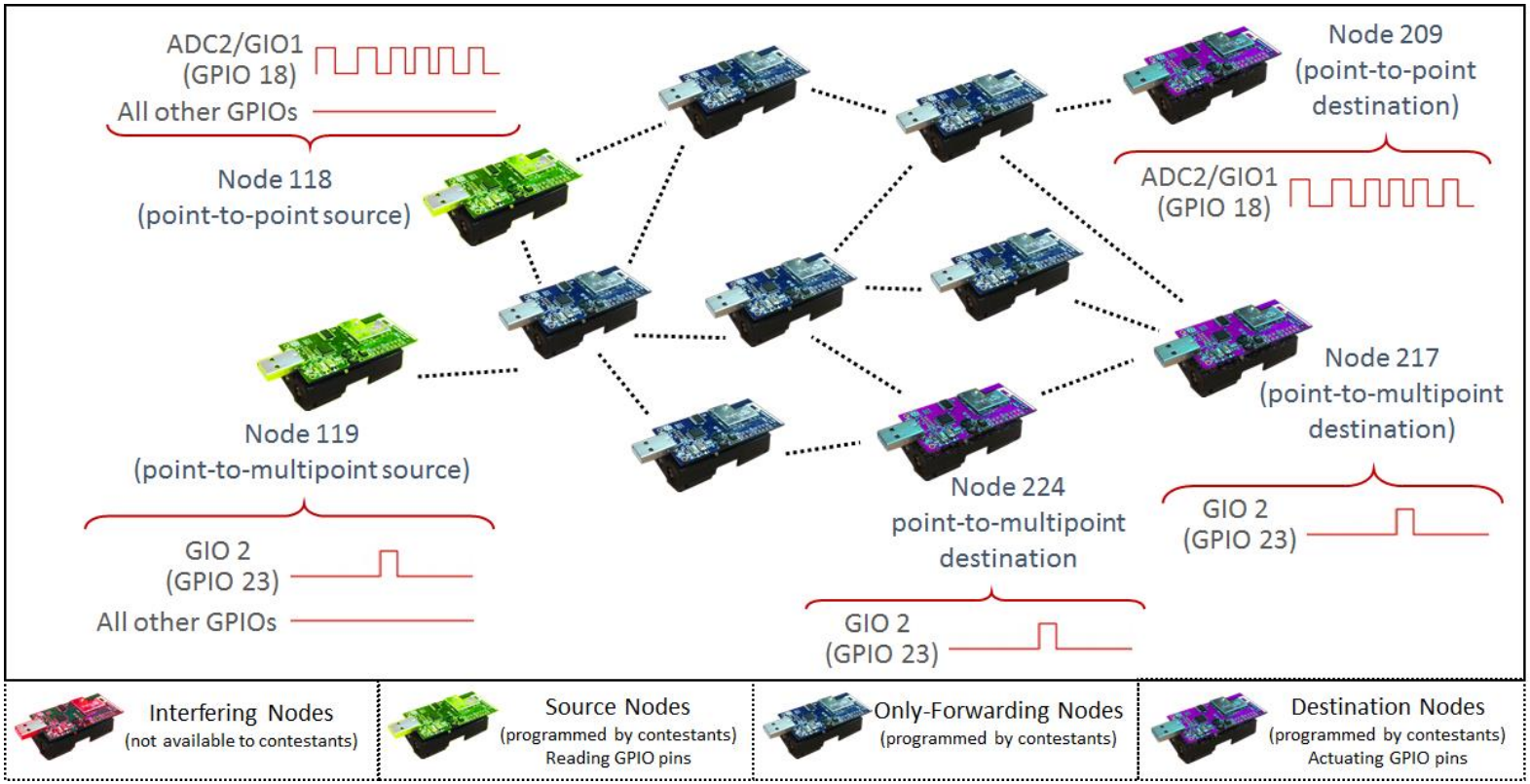
Tentative Agenda

- Evaluation phase (30.01.2018 – 09.02.2018)
  - Submission of final software: January 29, 2018 at 23:59 (AoE)
    → One single `.ihex` file per competing team
  - The code of each team will be run several times by the organizers during the evaluation phase
    → Large-scale scenario
    → Harsh RF environmental conditions varying over time
- EWSN Conference in Madrid (15.02.2018)
  - Afternoon: Competition awards & winners' presentations
  - Evening: poster session (one poster / team)

Evaluation Scenarios

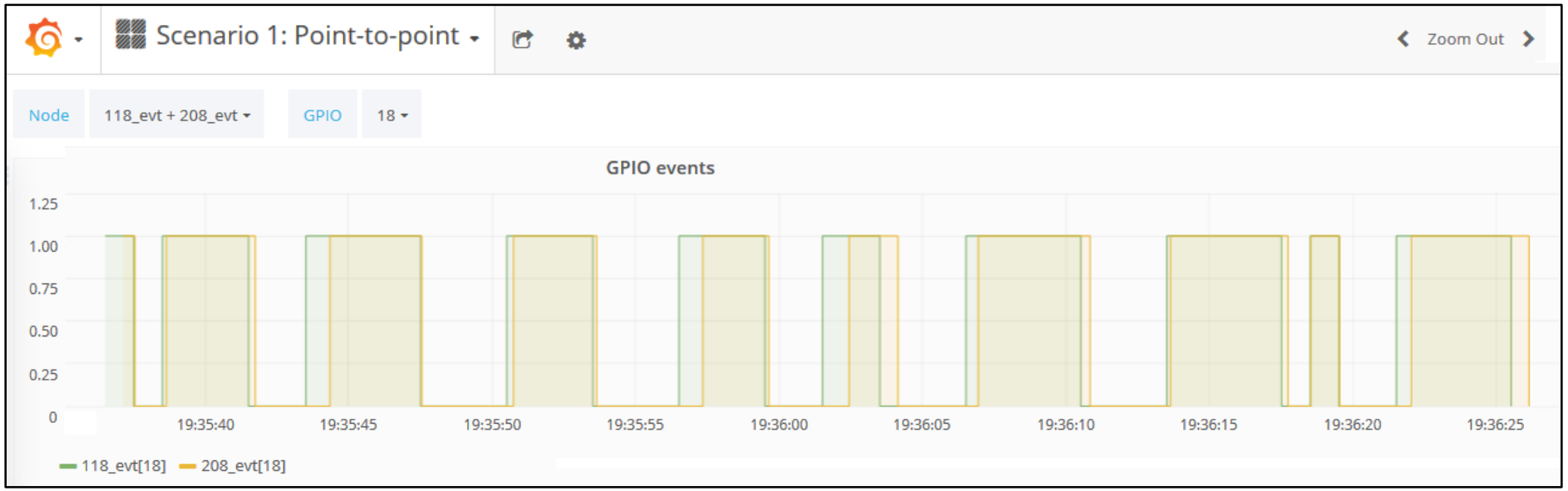
1st Preparation Phase

- 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

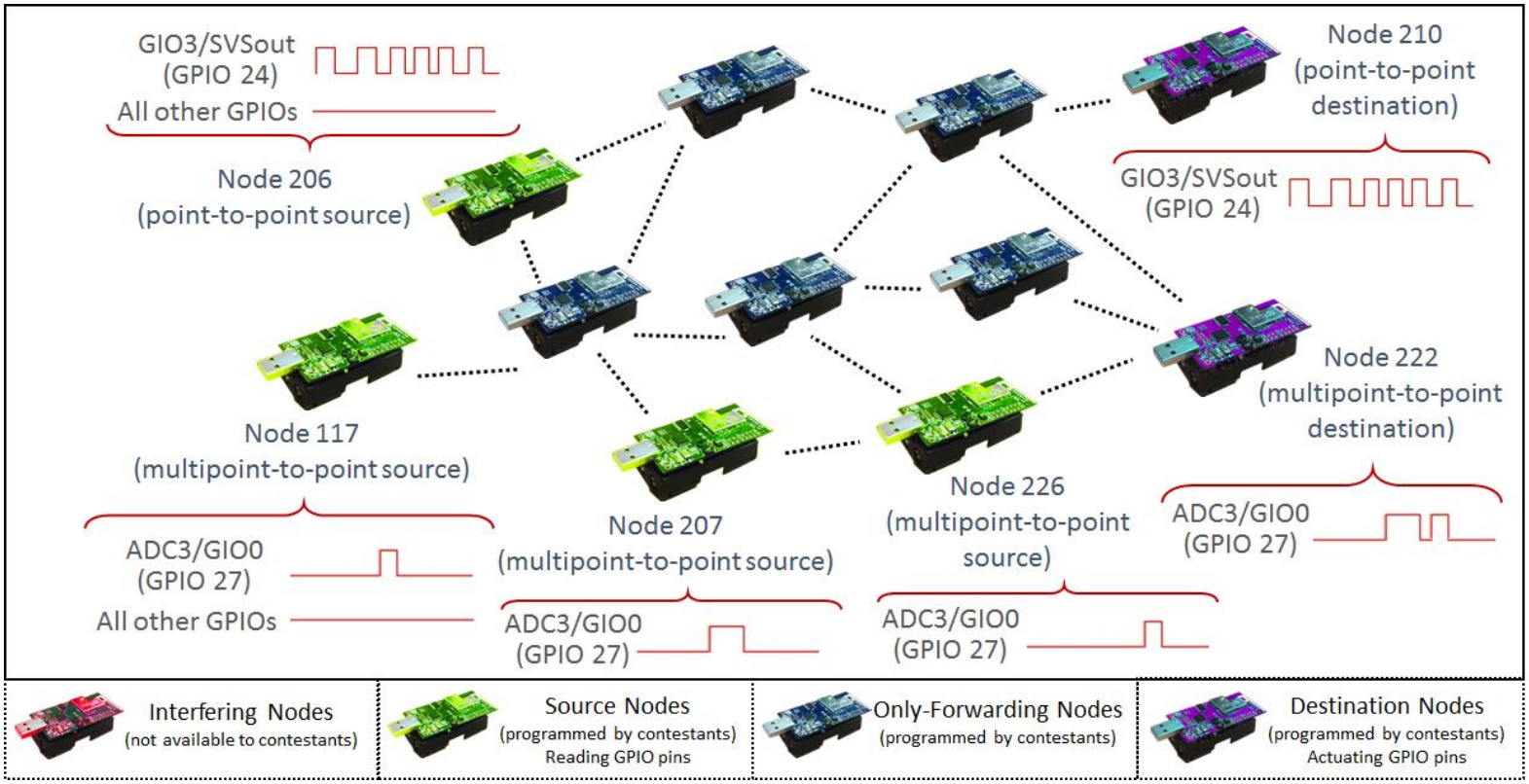
- Specific "Scenario" tabs available on the Grafana Dashboard
  - Showing if the GPIO of the nodes employed on a specific scenario have been toggled correctly



Additional scenarios will be added regularly over time

2nd Preparation Phase

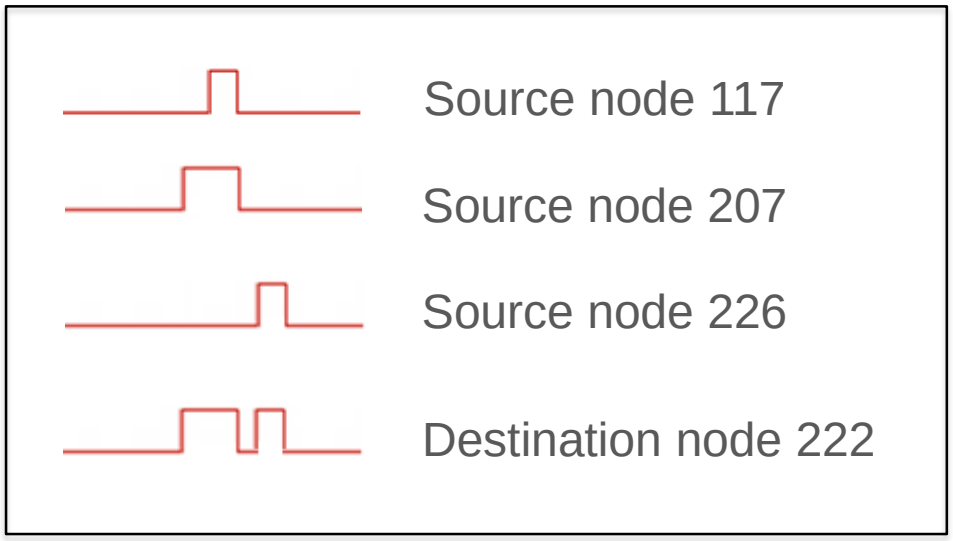
- Two additional scenarios are available
  - Point-to-point communication from node 206 to 210 (GPIO24)
  - Multipoint-to-point communication from nodes 117 & 207 & 226 to 222 (GPIO27)



2nd Preparation Phase

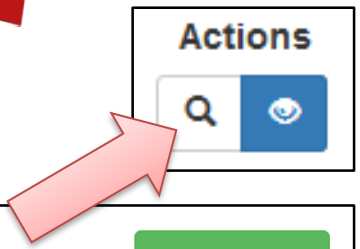
- Two additional scenarios are available
  - Point-to-point communication from node 206 to 210 (GPIO24)
  - Multipoint-to-point communication from nodes 117 & 207 & 226 to 222 (GPIO27)

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



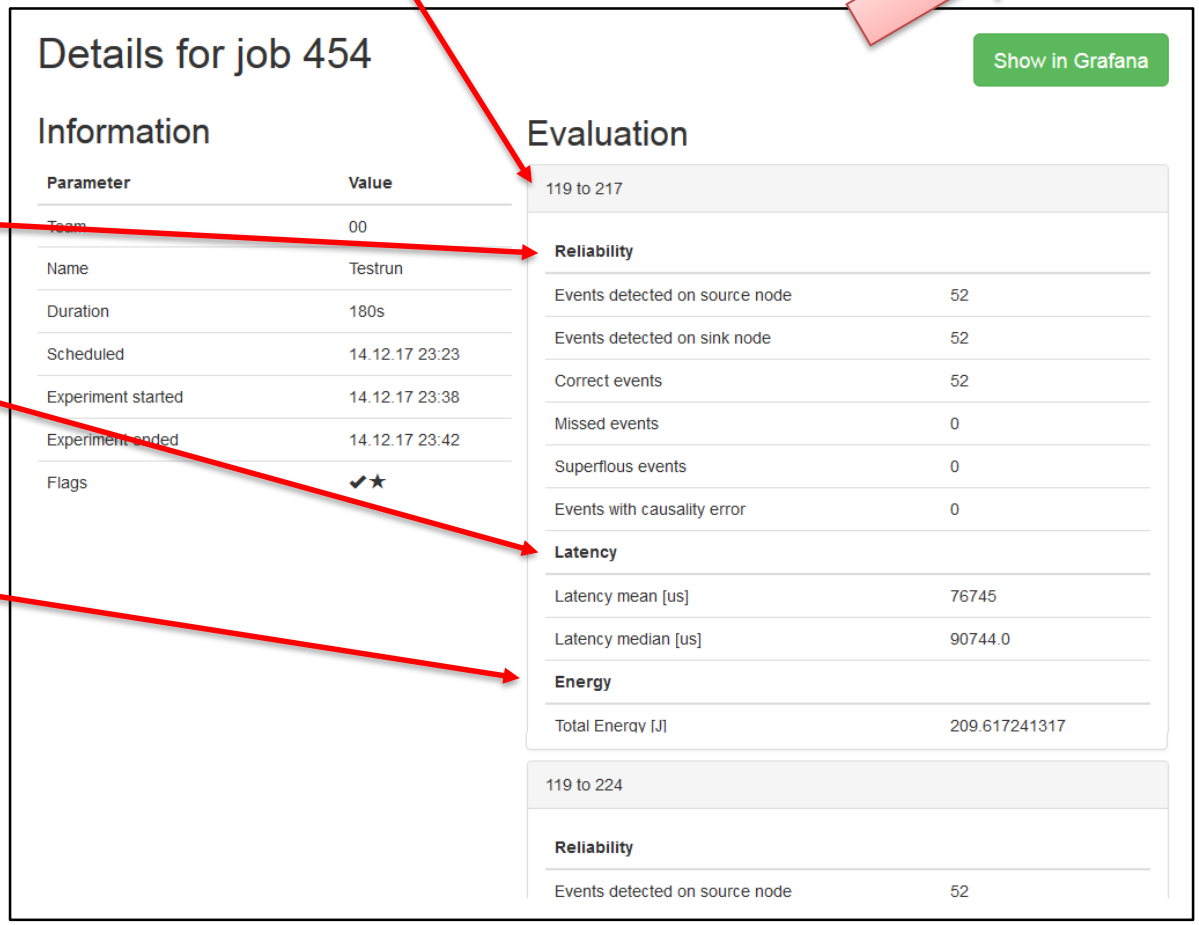
Evaluation of Experiments

- 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)

The evaluation for the other scenarios will be added in the next days!

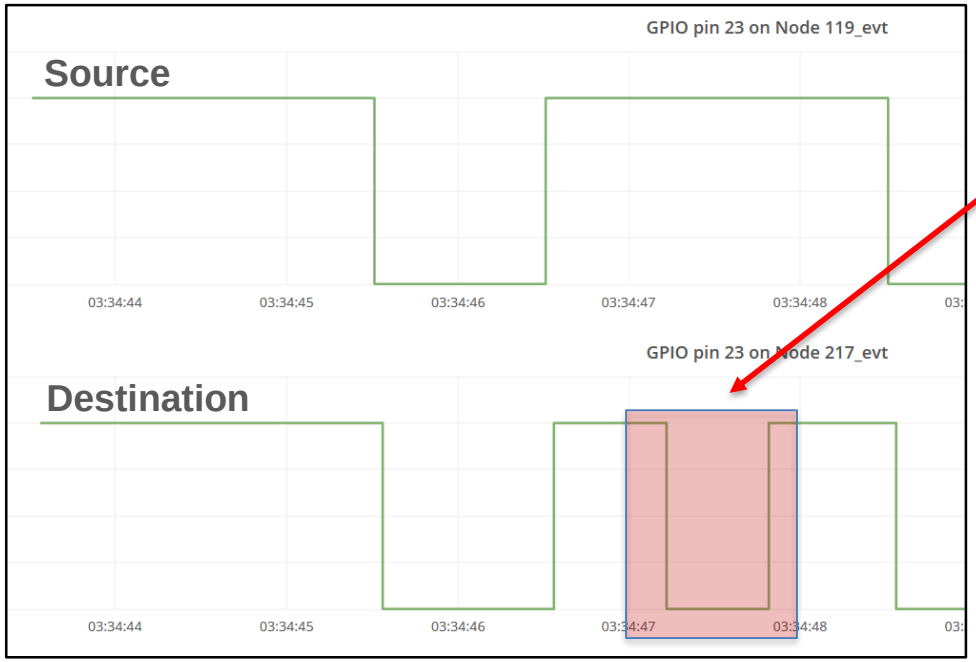


Evaluation of Experiments

- 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

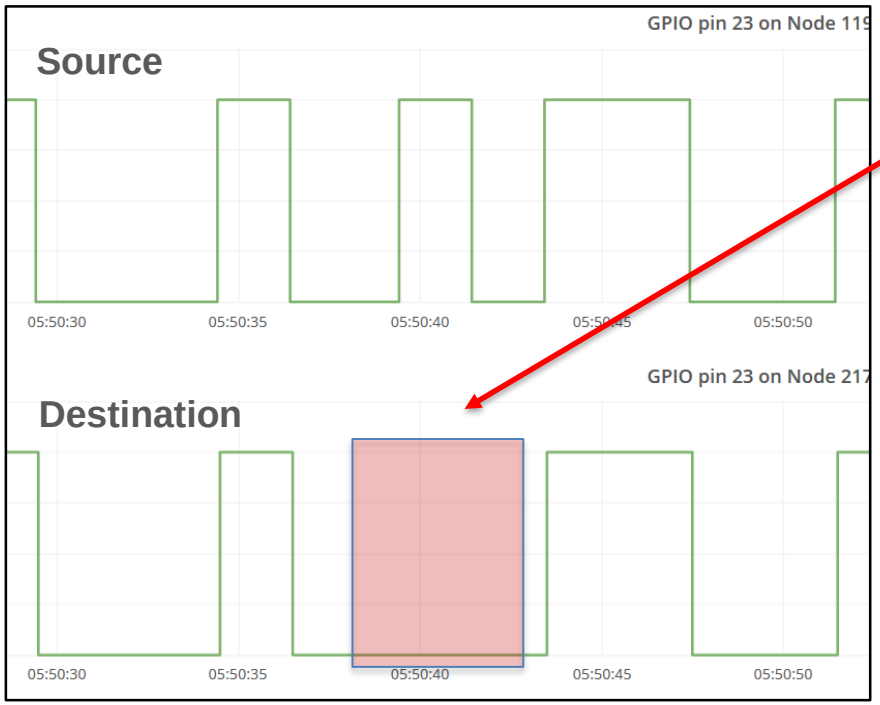


Evaluation of Experiments

- 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?

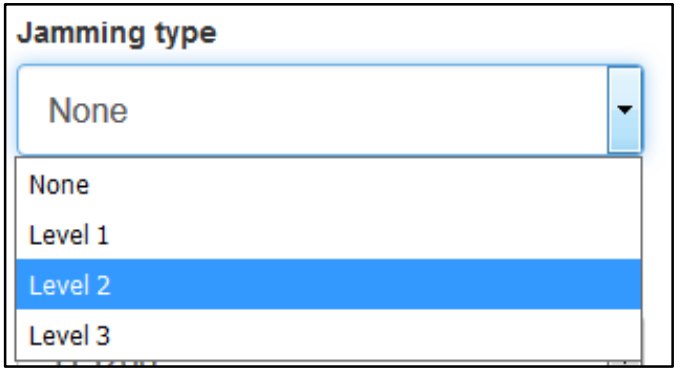
    Cases in which the destination reported a pin change at the source before it has actually happened

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

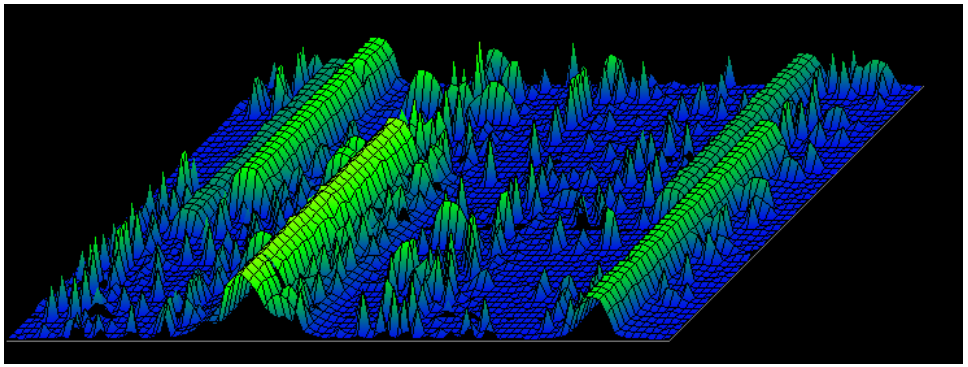
Challenging RF Environment

- 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)



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)

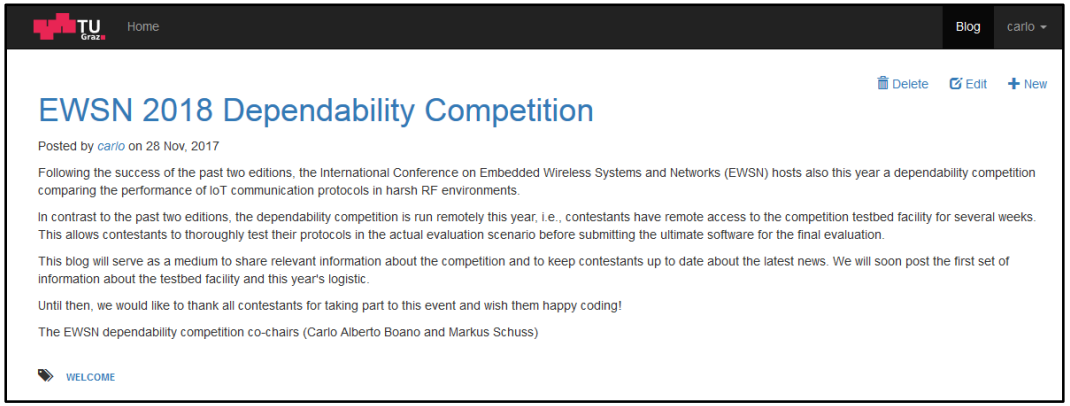
  - The use of frequencies below 2400 and above 2483.5 MHz is strictly forbidden!

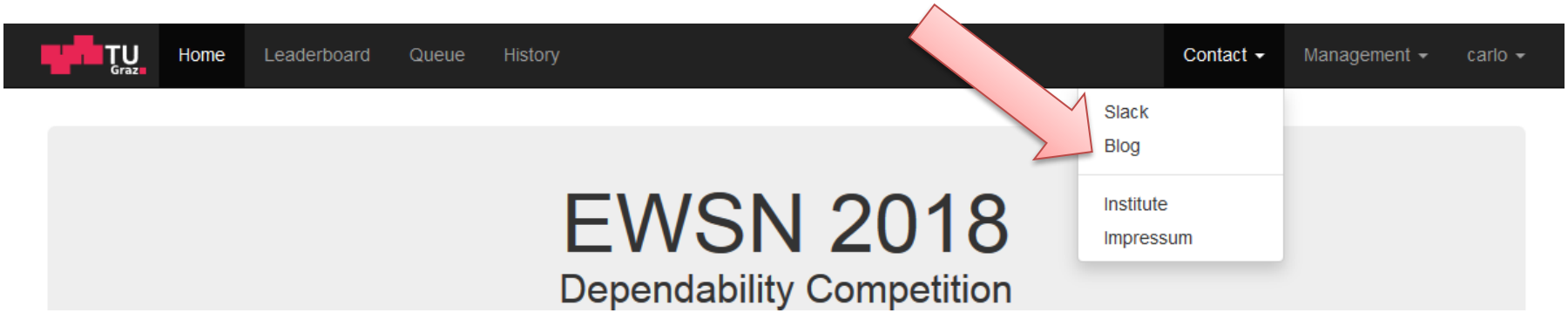
    → Any detected violation will lead to a disqualification

Communication with Organizers

Official Blog

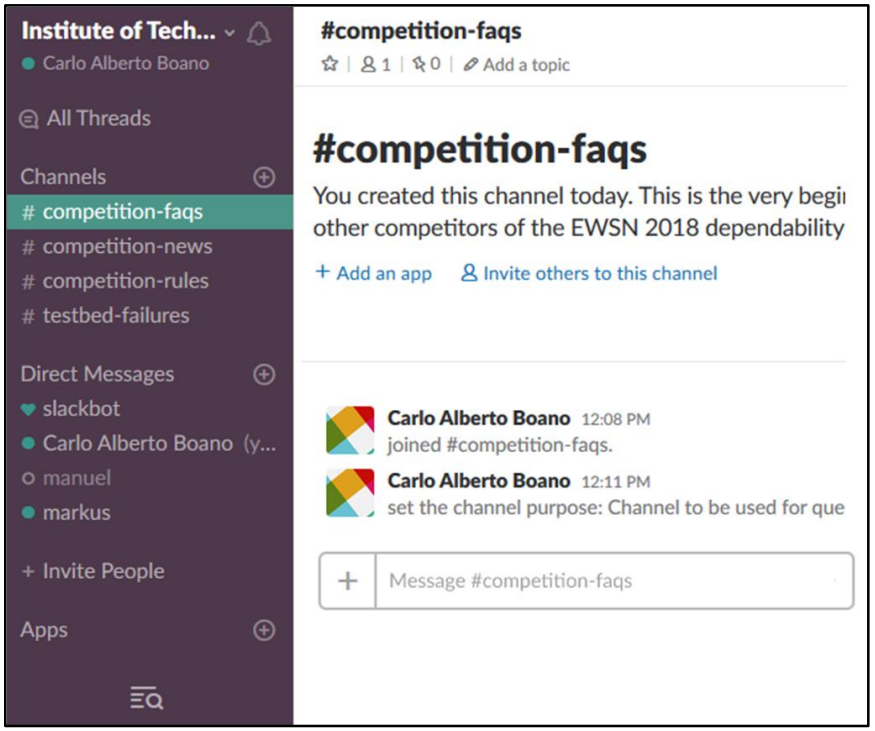
- The organizers have created a blog to keep contestants up to date about the logistics and any important news
  - Please check it regularly!
  - Answers to FAQs will be posted here

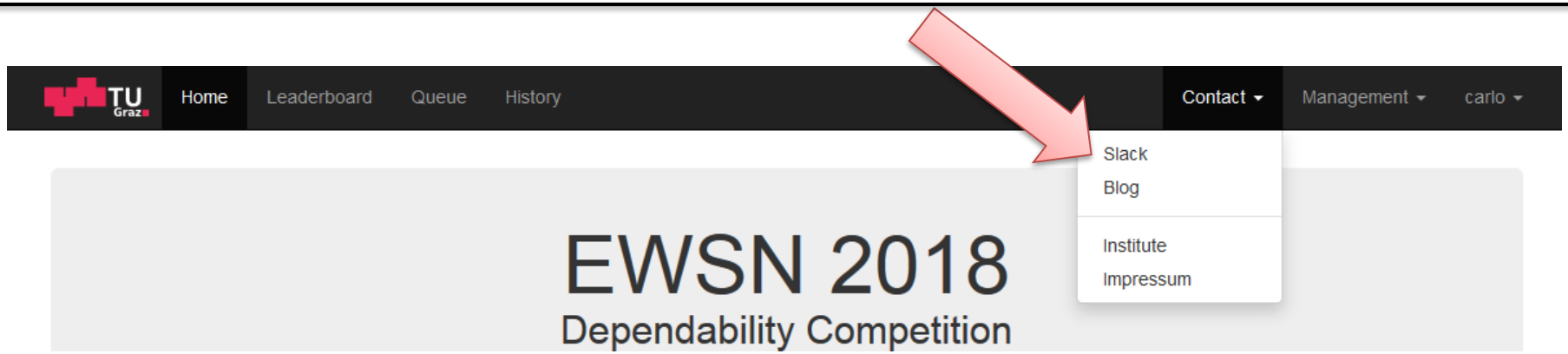




Slack Group

- 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





Contacts

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