EWSN 2018 Dependability Competition

Logistics Information

Carlo Alberto Boano and **Markus Schuß**
Institut für Technische Informatik
Graz University of Technology, Austria

01.12.2017

3rd EWSN Dependability Competition

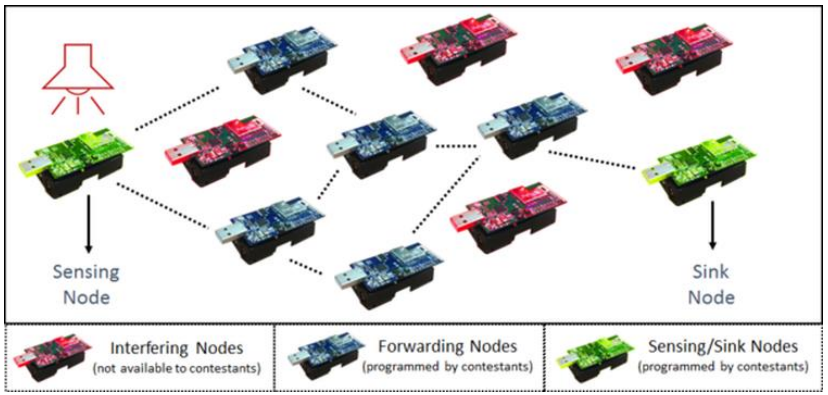
- Following the success of the past two editions, the International Conference on Embedded Wireless Systems and Networks (EWSN) hosts also this year a dependability competition comparing the performance of IoT communication protocols in harsh RF environments
  - 1st edition (2016): Graz, Austria [link]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

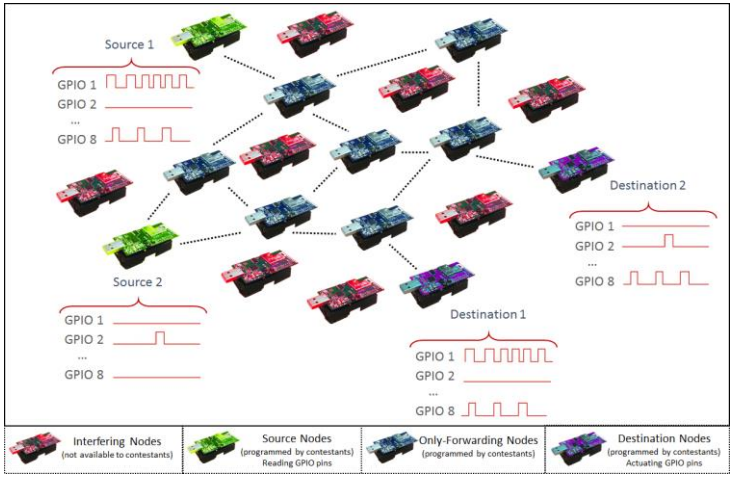
New Format

- 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

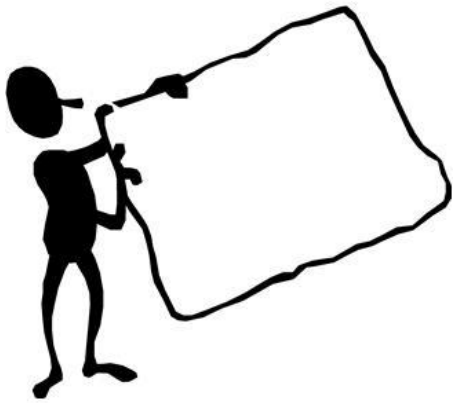




New Format

- 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

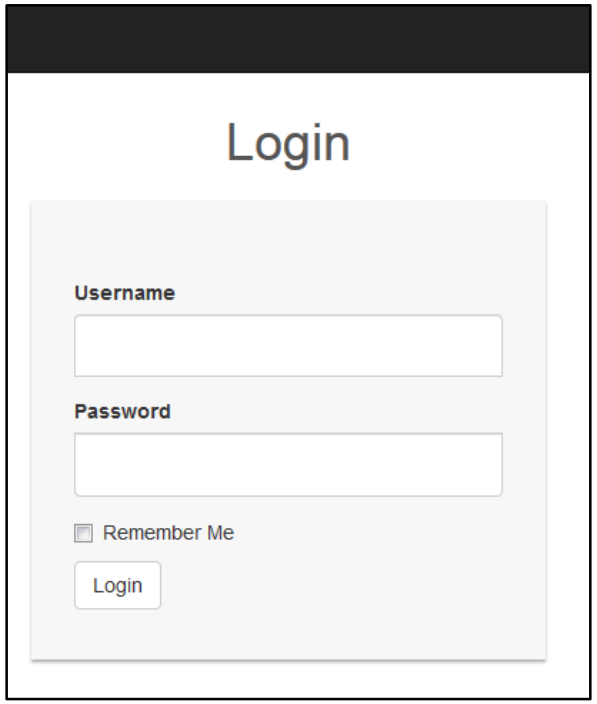
    → All competing teams must present their solution in the poster session and will have the possibility to engage in lively discussions with the other conference attendees



Competition's Testbed Facility

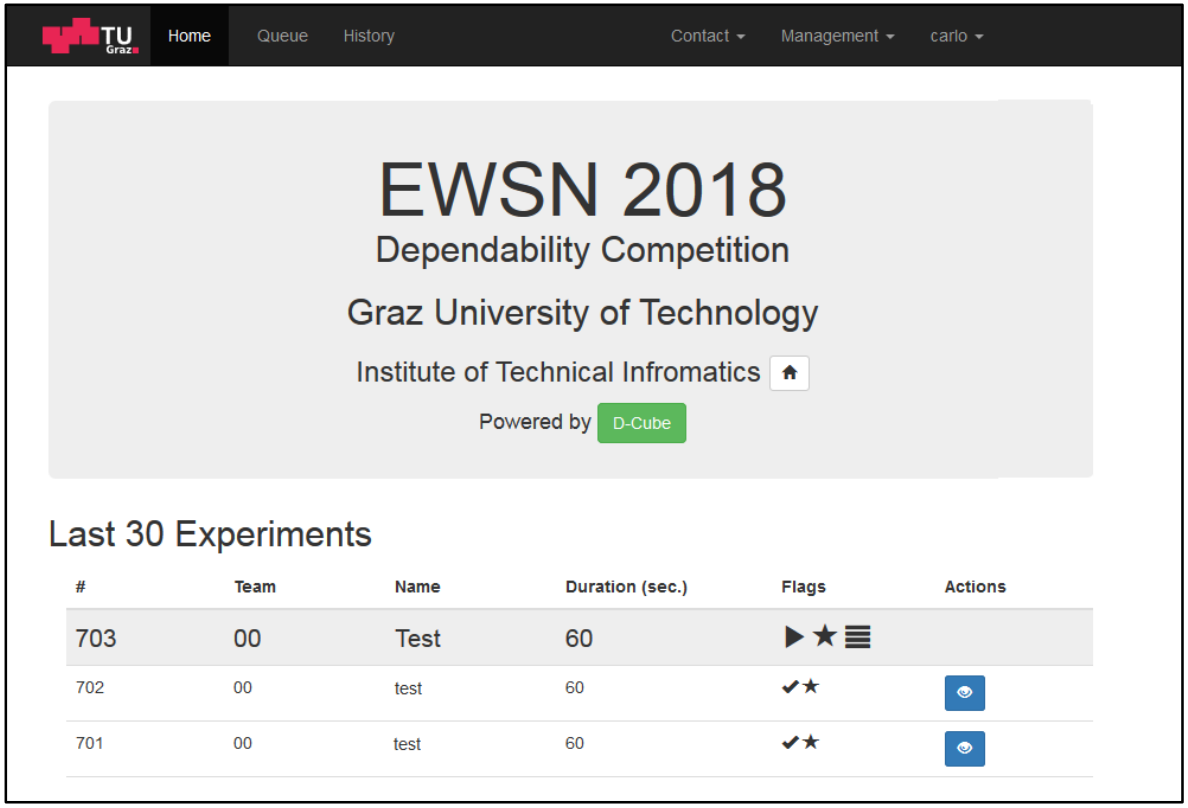
Competition's Testbed Facility

- 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

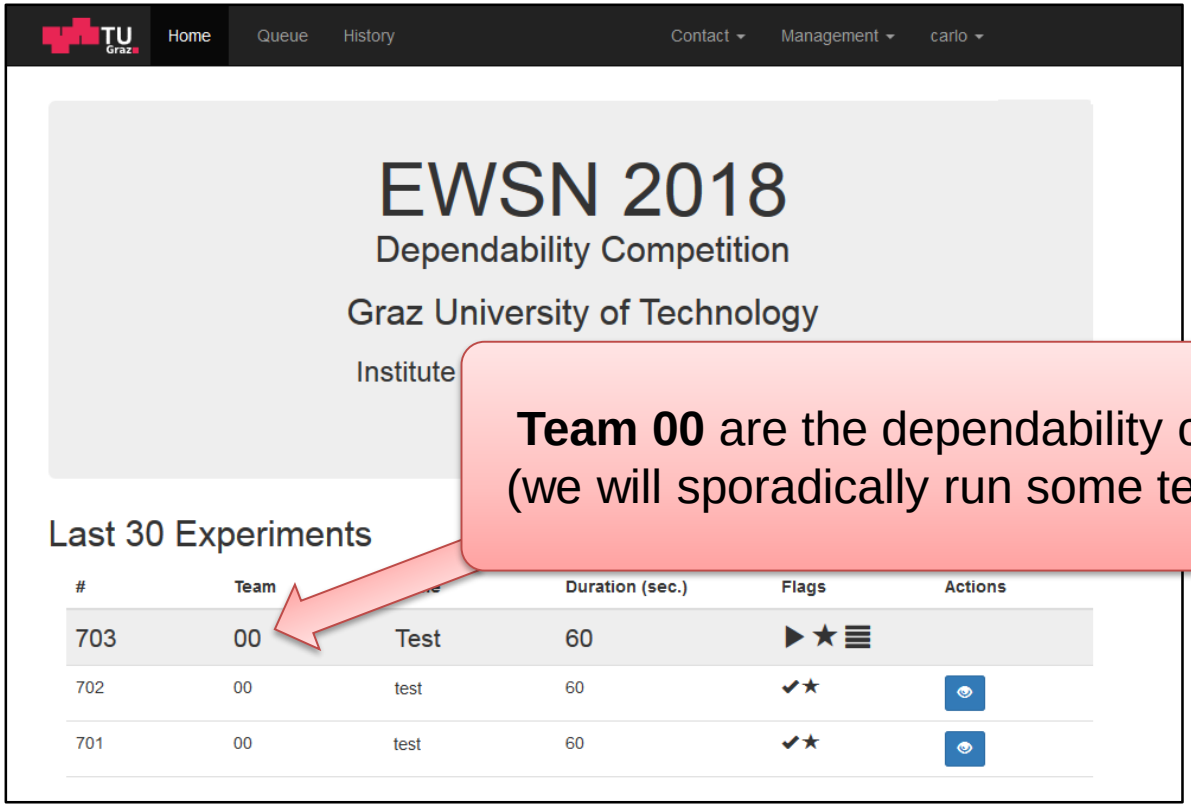
- At a glance
  - Home tab shows the list of all experiments of all teams (completed, running, or queued for execution)



- 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

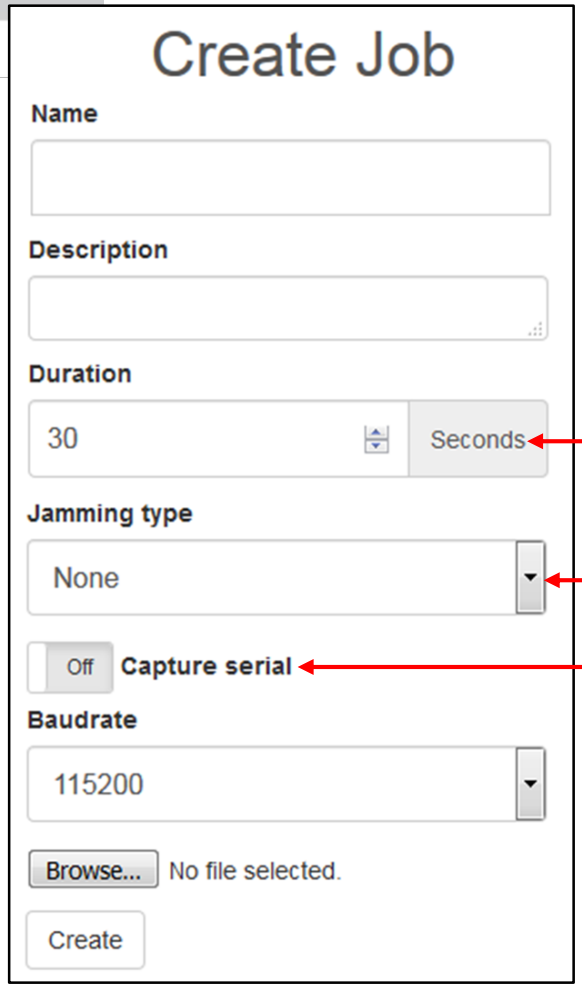
✔ Successfully completed

✖ Aborted or failed

(traces only seen by team)

Visualize results
(anyone can see those!)

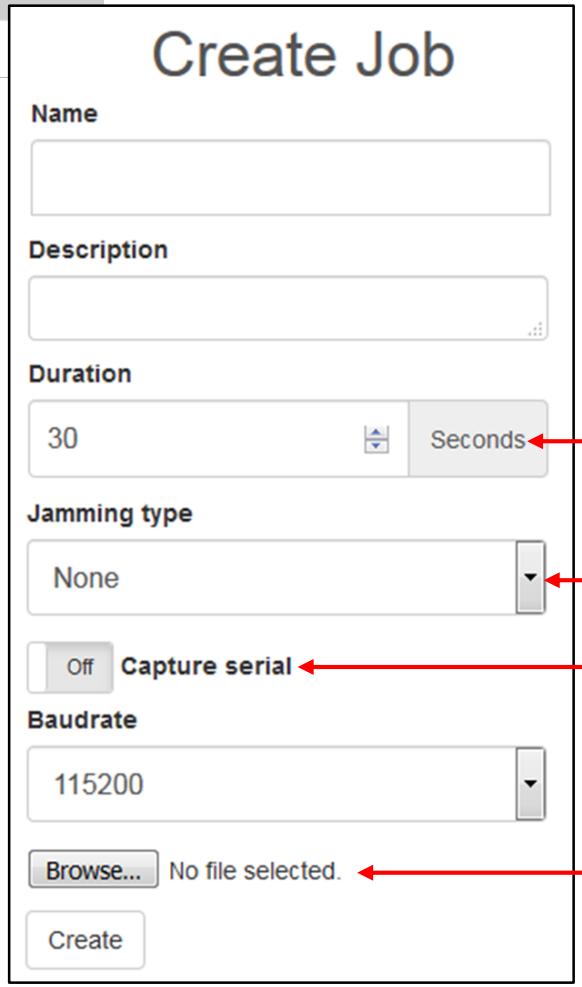
Firmware Upload



- 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)

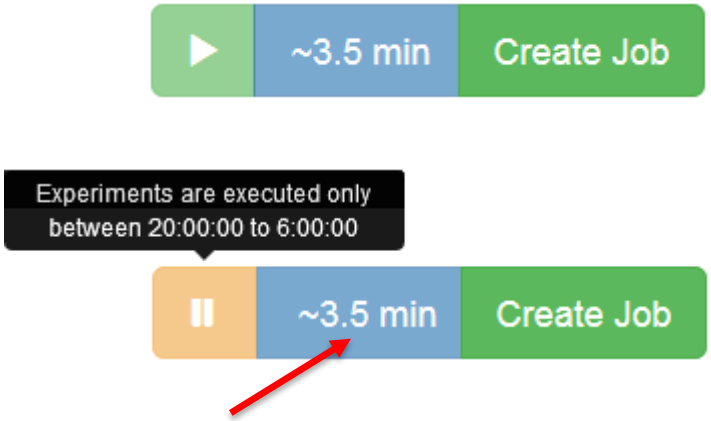
Firmware Upload



- 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!
- 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!

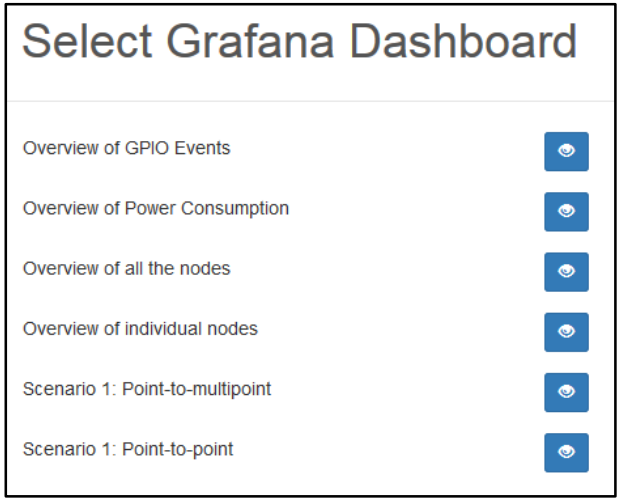
Testbed's Scheduler

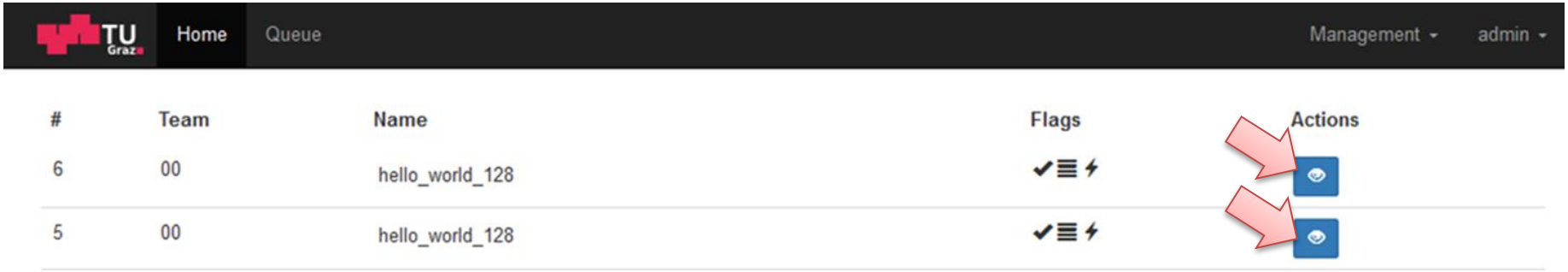
- Jobs execution policy: first come, first served
- Jobs are executed between 7:00 and 17:00 AoE only!
  - Between 20:00 and 6:00 (Central Europe time)
  - Between 4:00 and 14:00 (Tokyo time)
  - Between 4:00 and 13:00 (Bejing time)

- 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

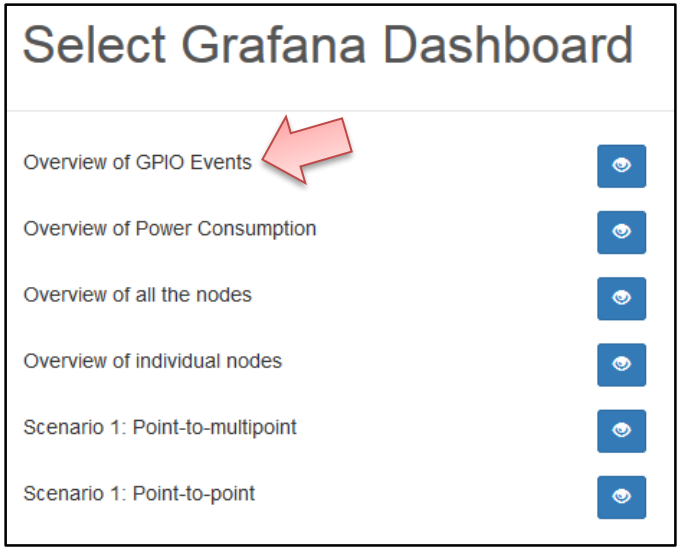
- After the execution of an experiment, graphical results can be checked by anyone by clicking on the blue button on the right side
  - Results displayed using Grafana
  - Power consumption and GPIO status is tracked for each node
  - Additional features will be activated in the next weeks
- The team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

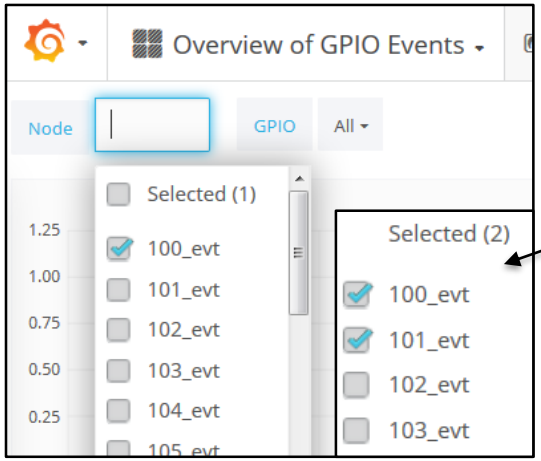




Results of an Experiment

- 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

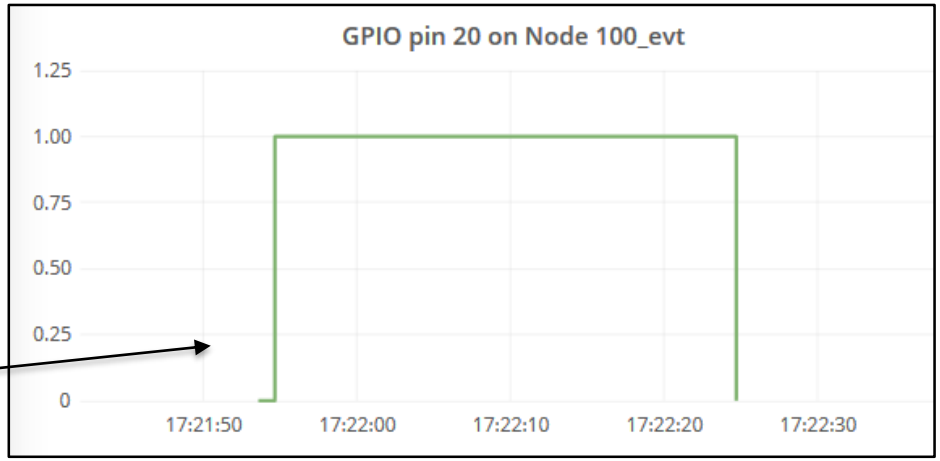




Monitoring the GPIO of multiple nodes at the same time

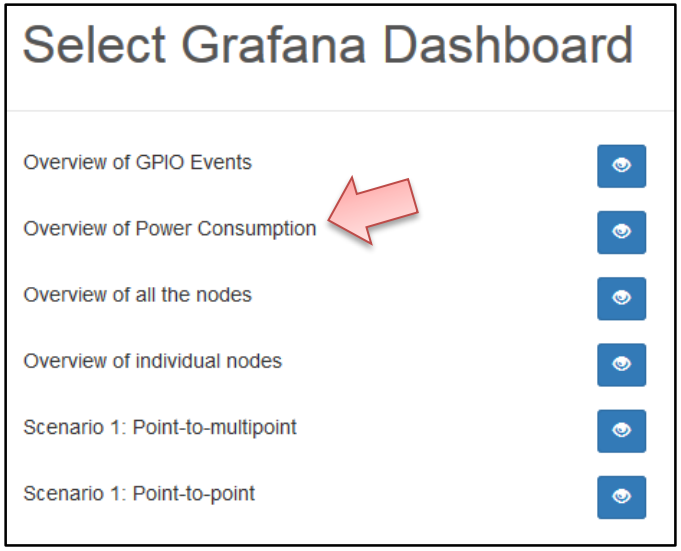
Monitoring individual GPIO pins

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



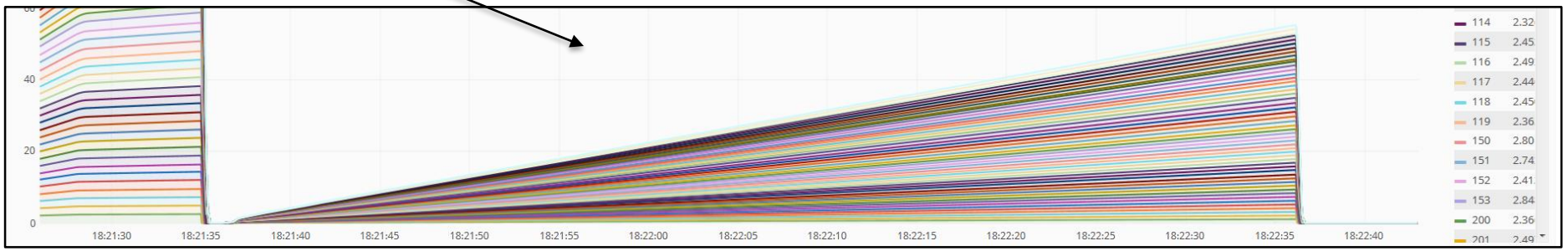
Results of an Experiment

- 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



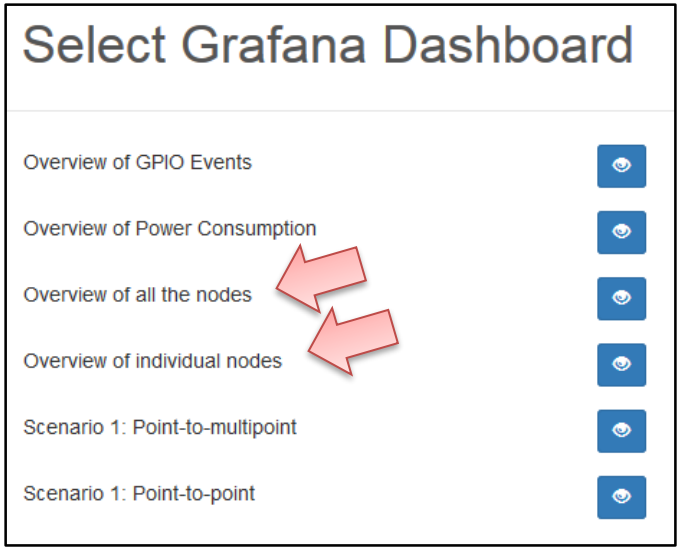
Stacked energy consumption:
Shows the total energy consumed by all nodes in the testbed

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



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



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)

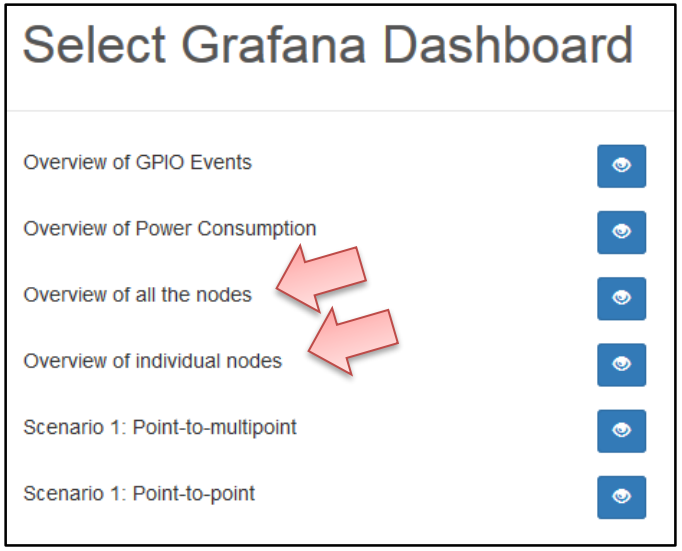
See "GPIO pins" section for details

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

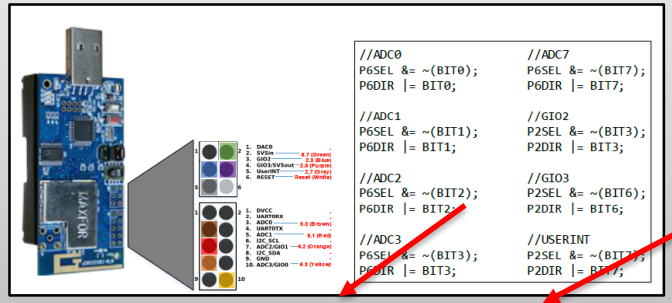
- Grafana dashboards
  - Overview of GPIO events
  - Overview of power consumption
  - Overview of all the nodes
  - Overview of individual nodes
  - Scenario 1: Point-to-multipoint
  - Scenario 1: Point-to-point
  - Additional features will be activated in the next weeks



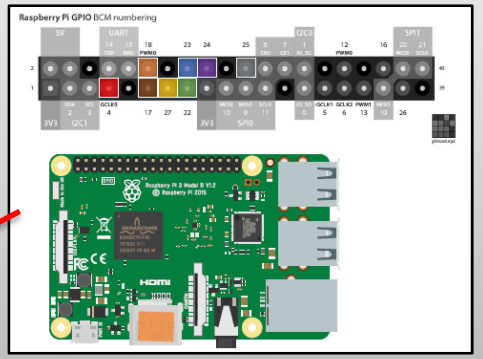
GPIO pins (Information is encoded in a special way – for individual values, use "Overview of GPIO events")

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);
```

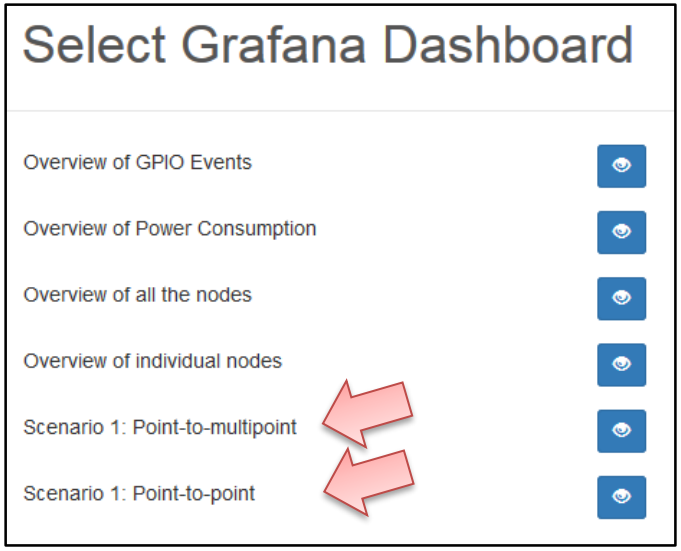


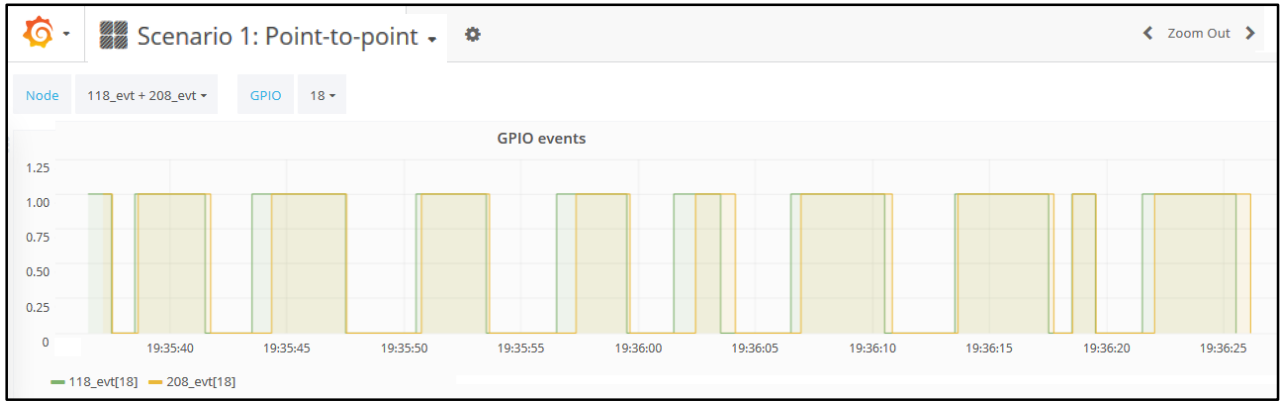
(See "GPIO pins" section for details)



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

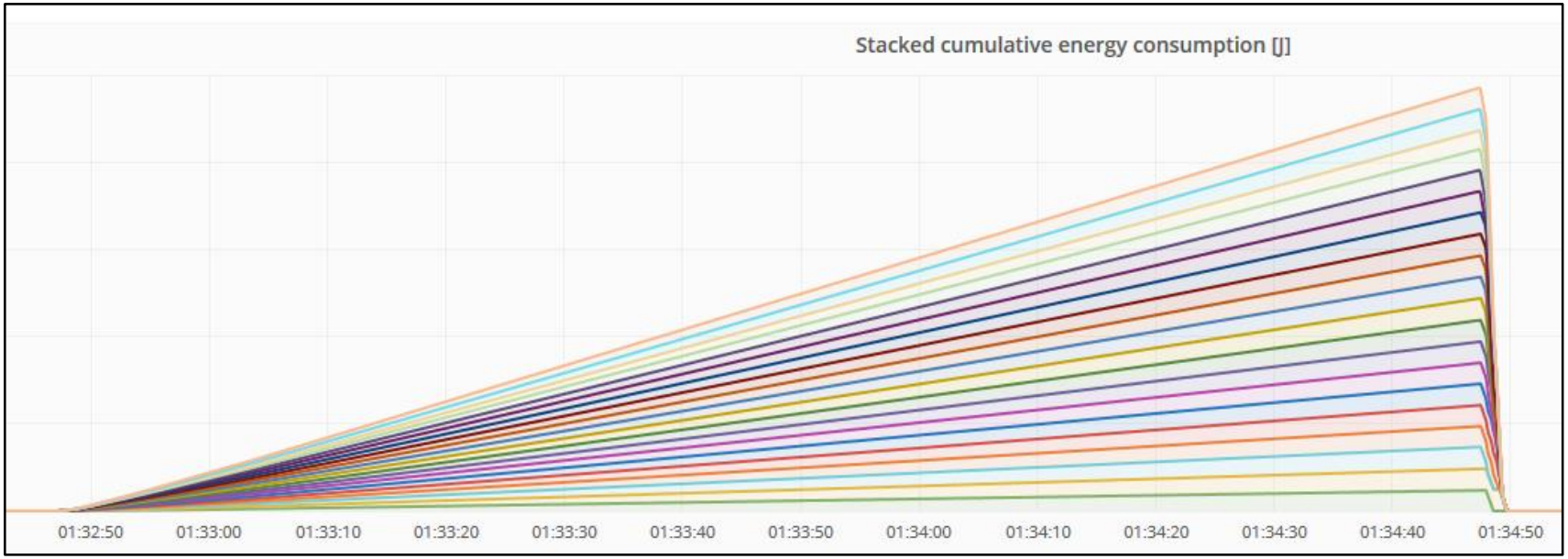




Plots specific to the current evalation scenario
(see "Evaluation Scenario scetion" of these slides)

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, …)

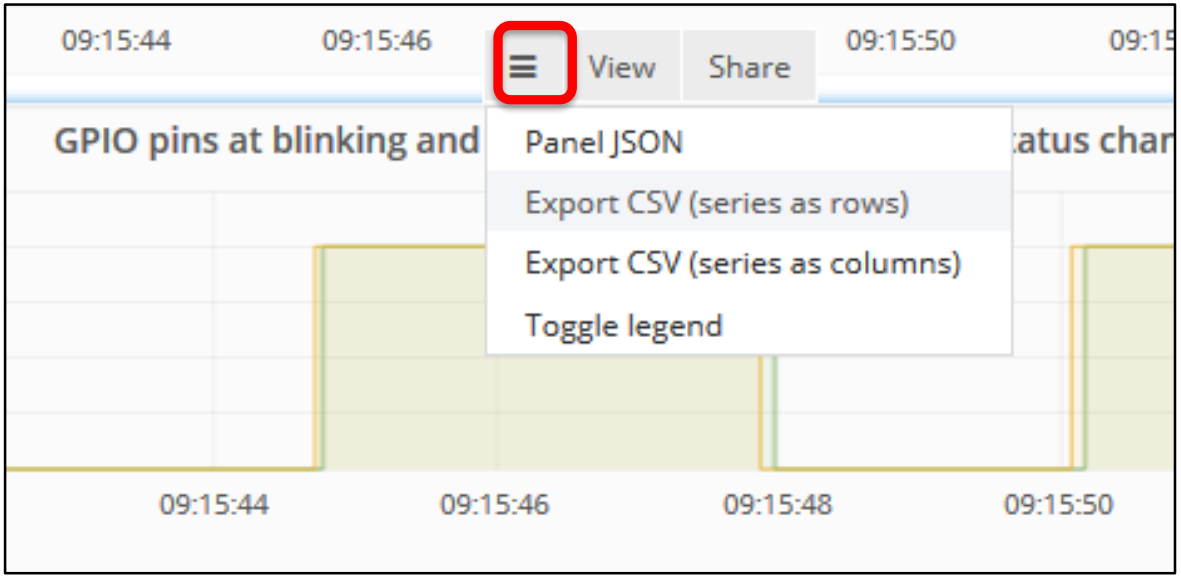


Visualization in Grafana – FAQ

- 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"

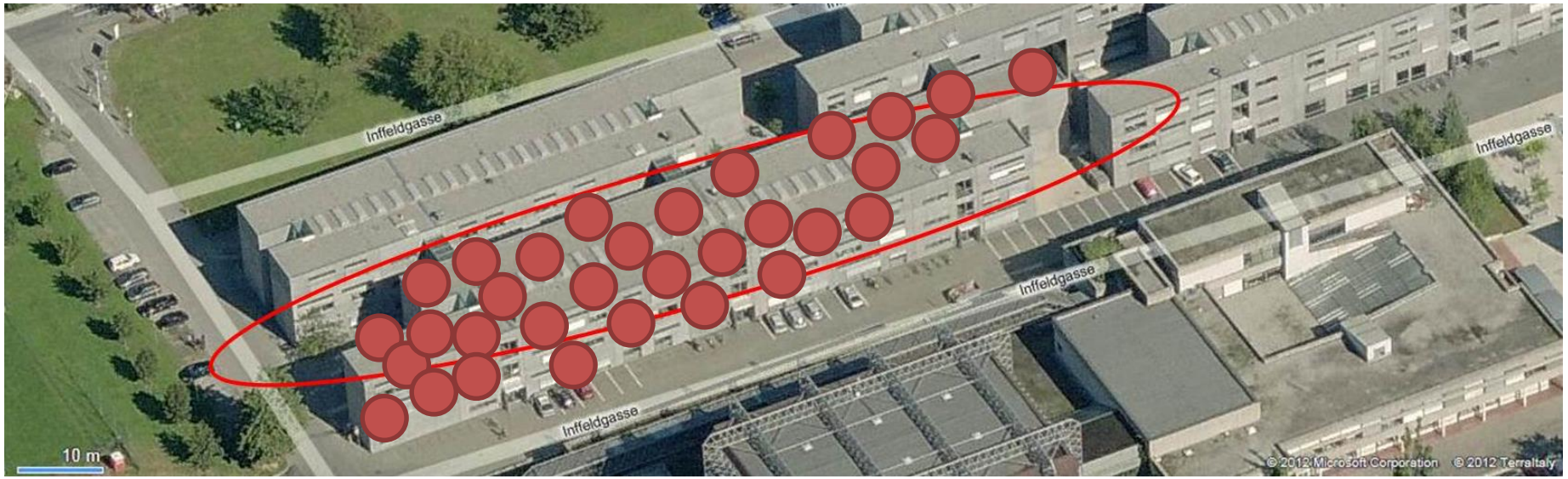


	A	B	C
1	Time	1	2
2	2017-02-16T09:43:46.876Z	0.0840805771962	0.1951102
3	2017-02-16T09:43:47.501Z	0.152616695366	0.2566677
4	2017-02-16T09:43:48.126Z	0.221115444991	0.2613602
5	2017-02-16T09:43:48.751Z	0.289725498238	0.2663699
6	2017-02-16T09:43:49.376Z	0.336447792086	0.2709752

	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

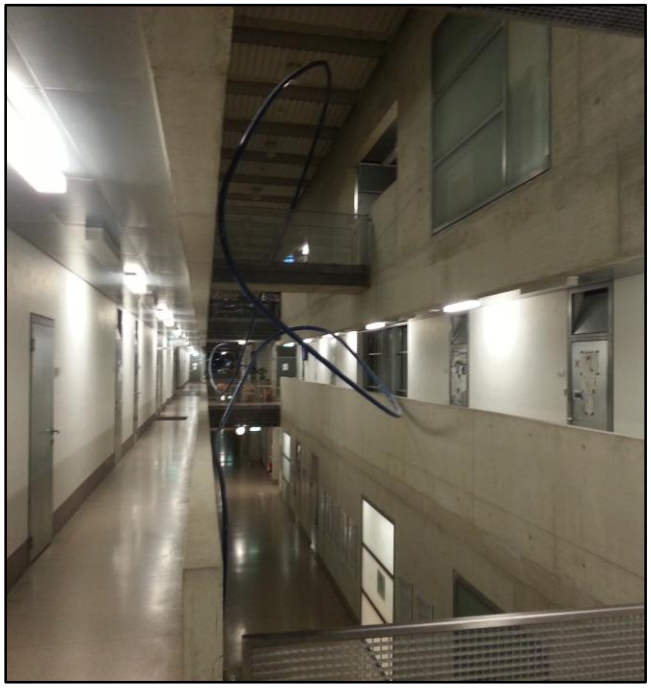
Testbed Location

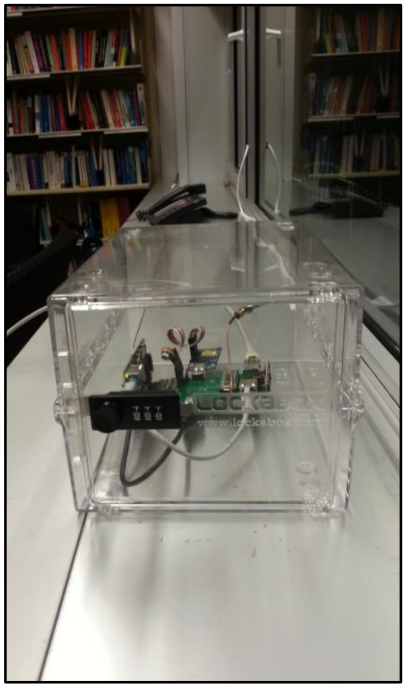
- Nodes are deployed in Inffeldgasse 16 (Graz, Austria)
  - University offices, seminar rooms, and laboratories (belonging to the Institute for Technical Informatics of TU Graz)
  - 51 testbed nodes currently active over multiple floors
  - Density of nodes varies across the building



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





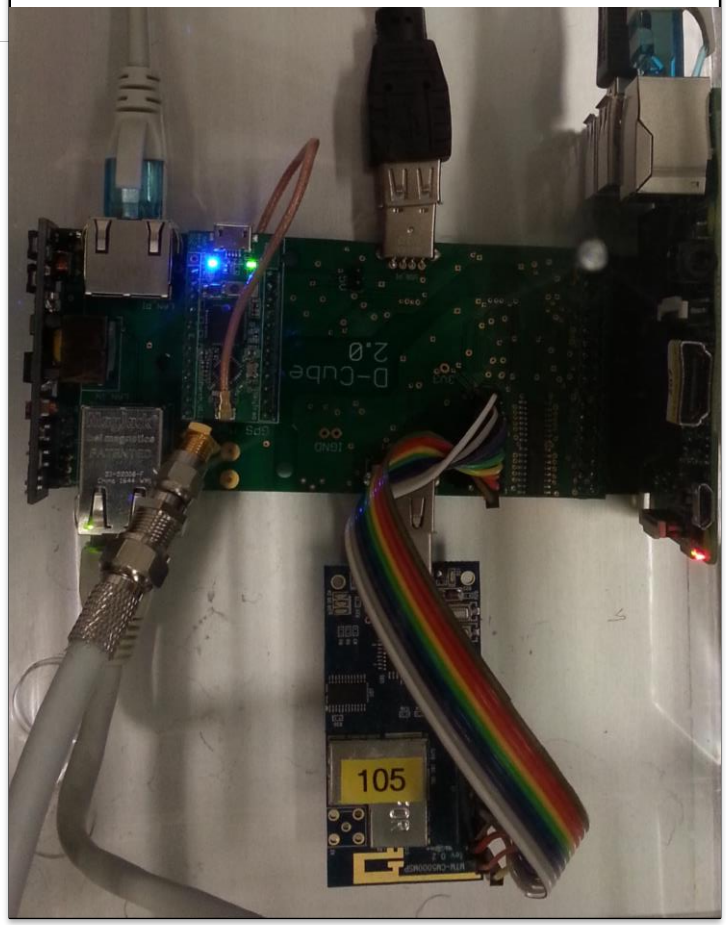
Testbed Hardware

- 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

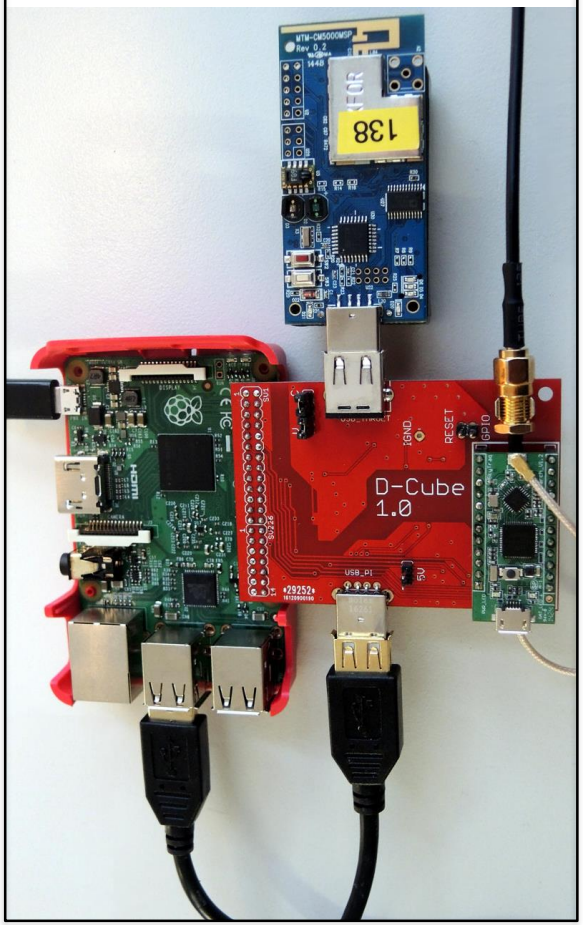
Testbed Hardware: D-Cube

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

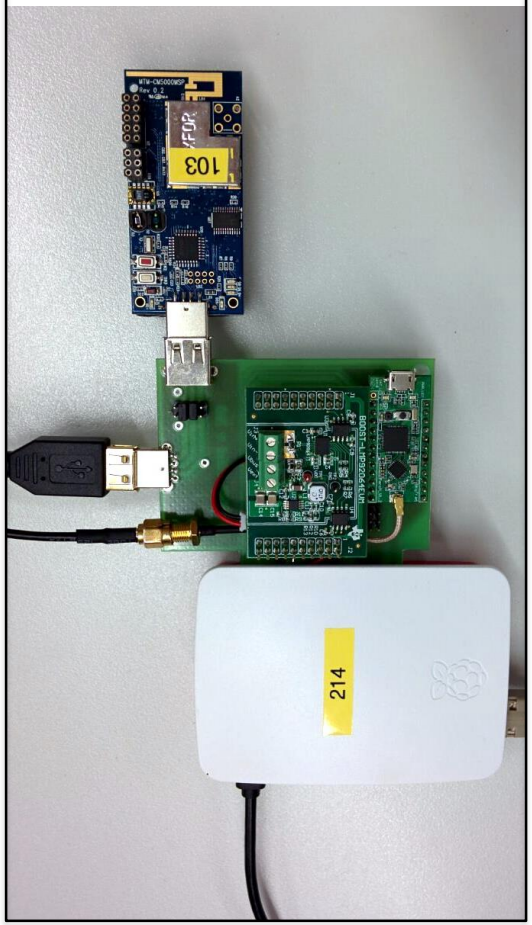
This year's prototype (EWSN'18)



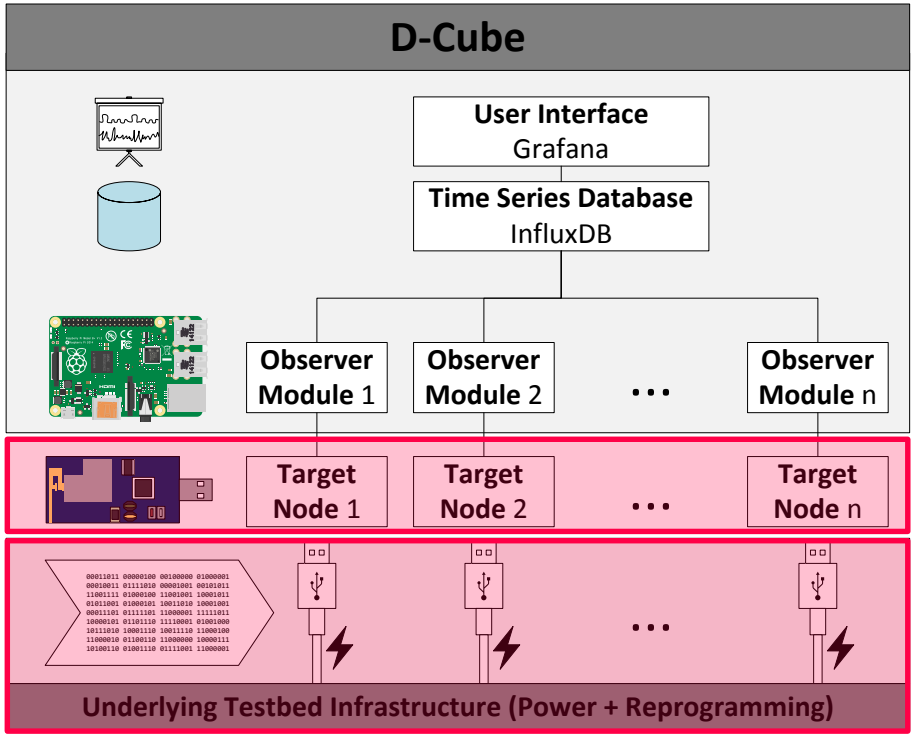
EWSN'17 version



EWSN'16 version



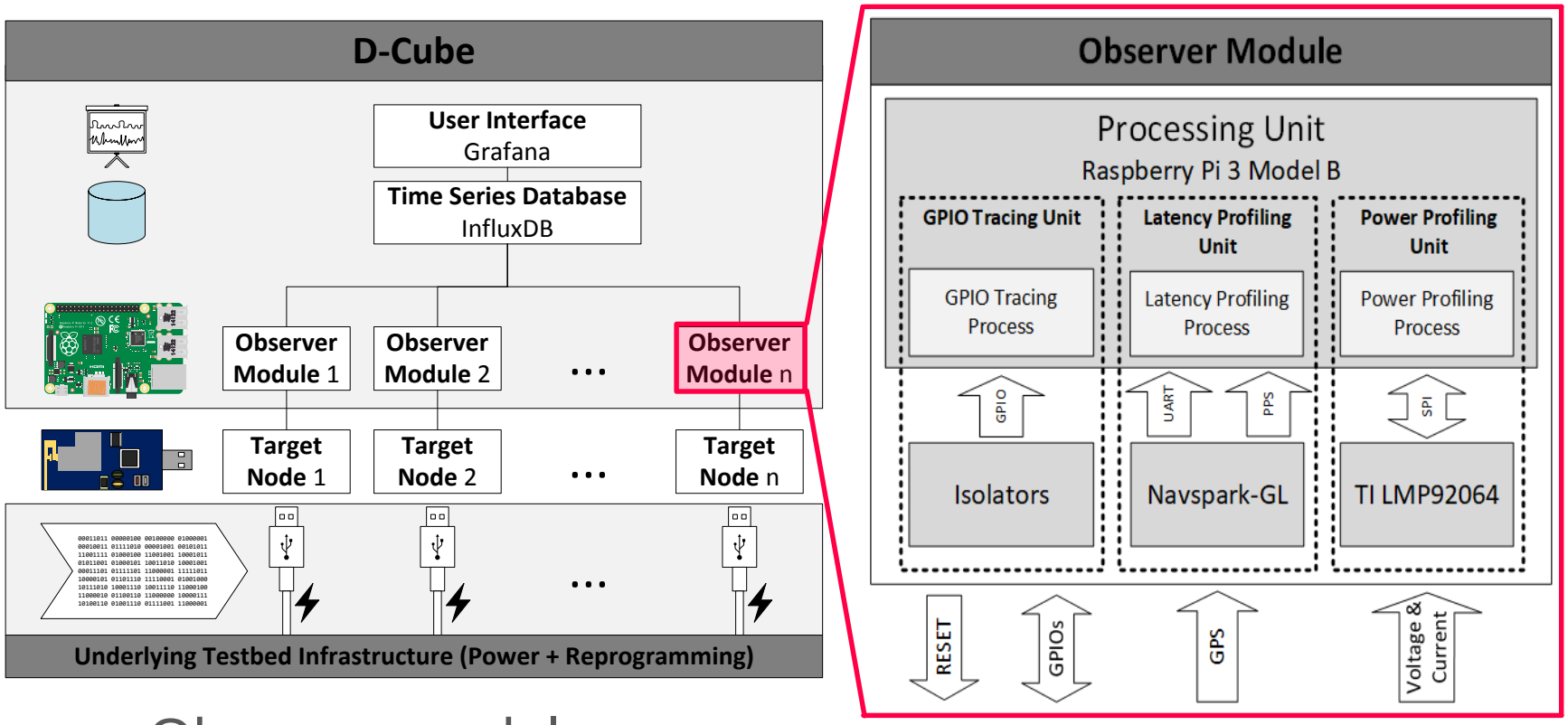
Testbed Hardware: D-Cube



- 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)

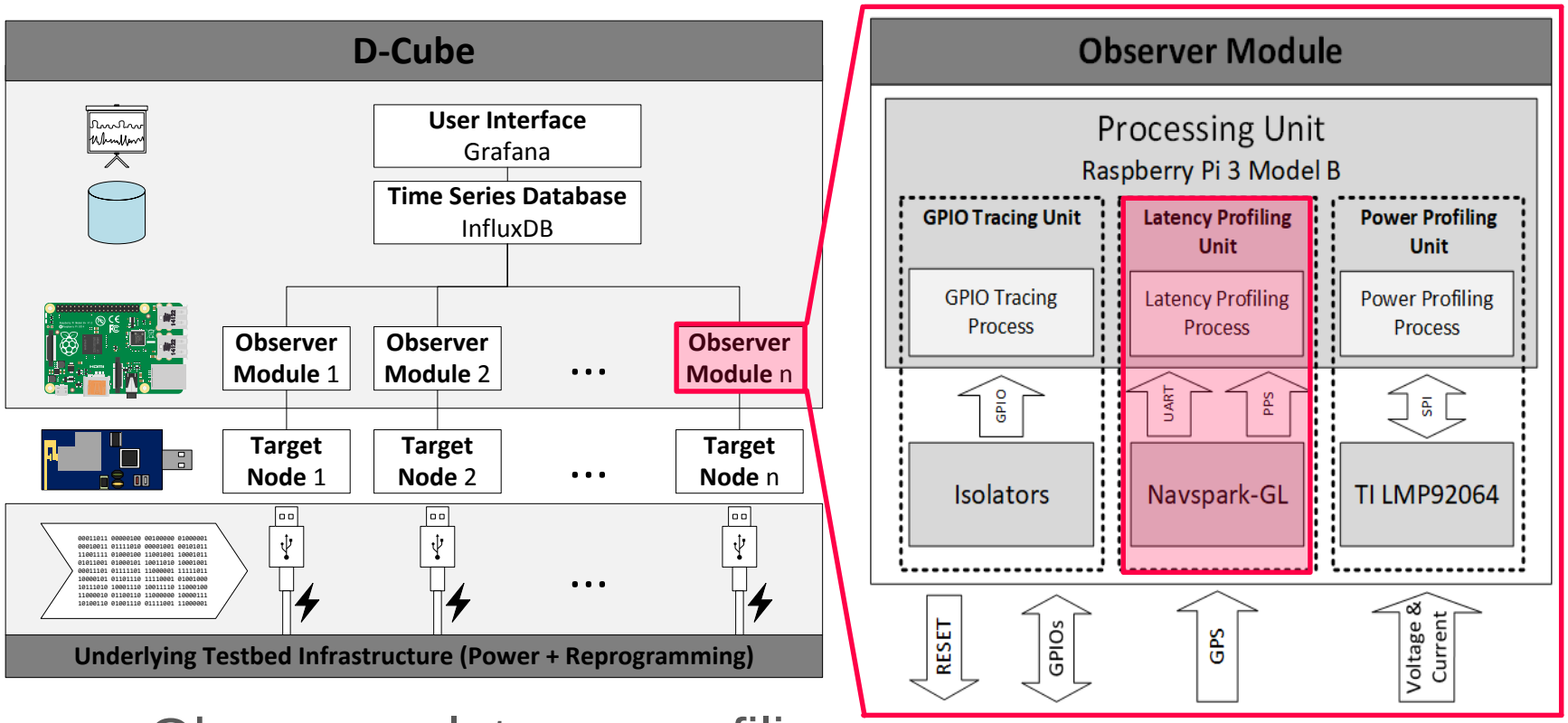
- Underlying infrastructure
  - → Power + reprogramming of the target nodes
  - → Allows to disable the UART interface

Testbed Hardware: D-Cube



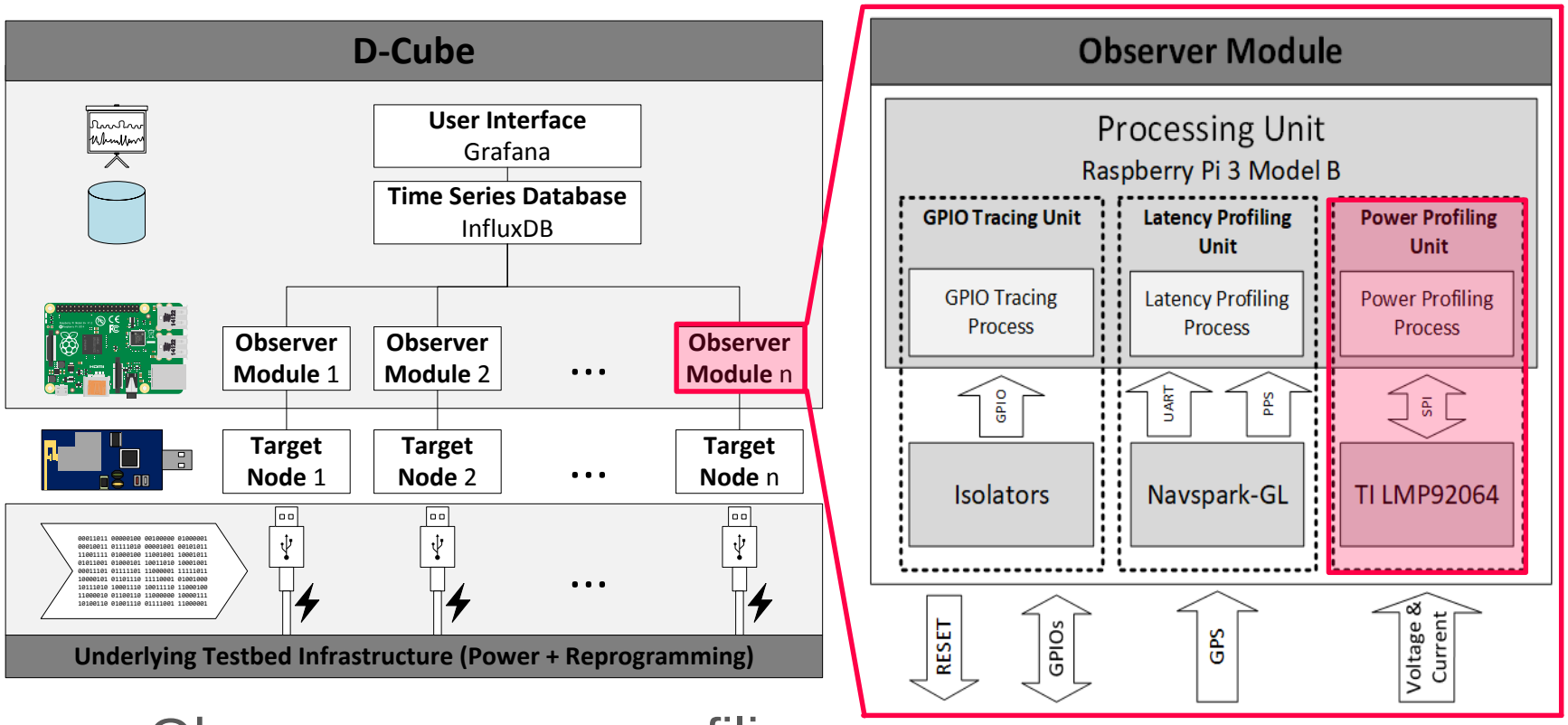
- Observer modules
  - → Each module monitors exactly one target node
  - → Raspberry Pi 3 + custom-made add-on card (ADC+GPS)

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

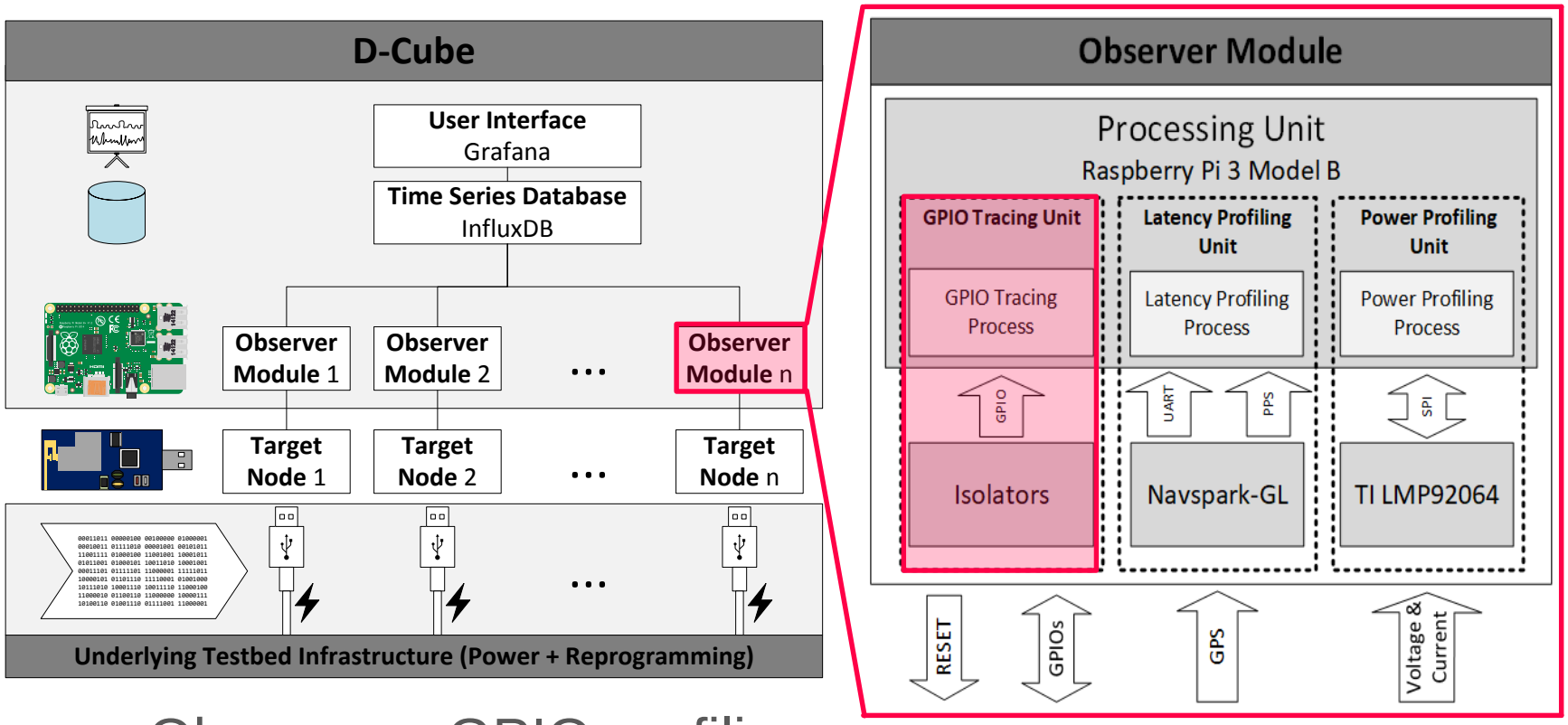


- Observers: power profiling

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

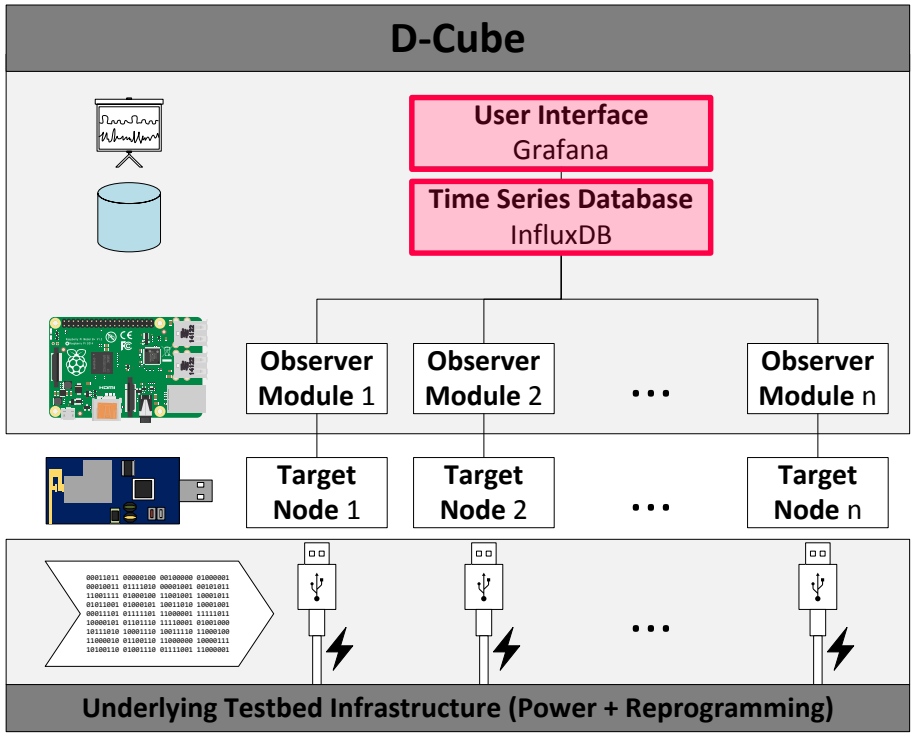
- Voltage channel: up to 10.82V with 2.82mV resolution
- Current channel: up to 150.59mA with 39.22µA resolution

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)

Tentative Agenda

Tentative Agenda

- Preparation phase (29.11.2017 – 29.01.2018)

1. First preparation phase: Testing of infrastructure 29.11.2017 – 13.12.2017
   → Simplified scenario (details follow)
   → No harsh RF environment

NOW!

2. Second preparation phase: Introducing jamming 14.12.2017 – 07.01.2018
   → A more advanced scenario added
   → Harsh RF environment can be generated

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)

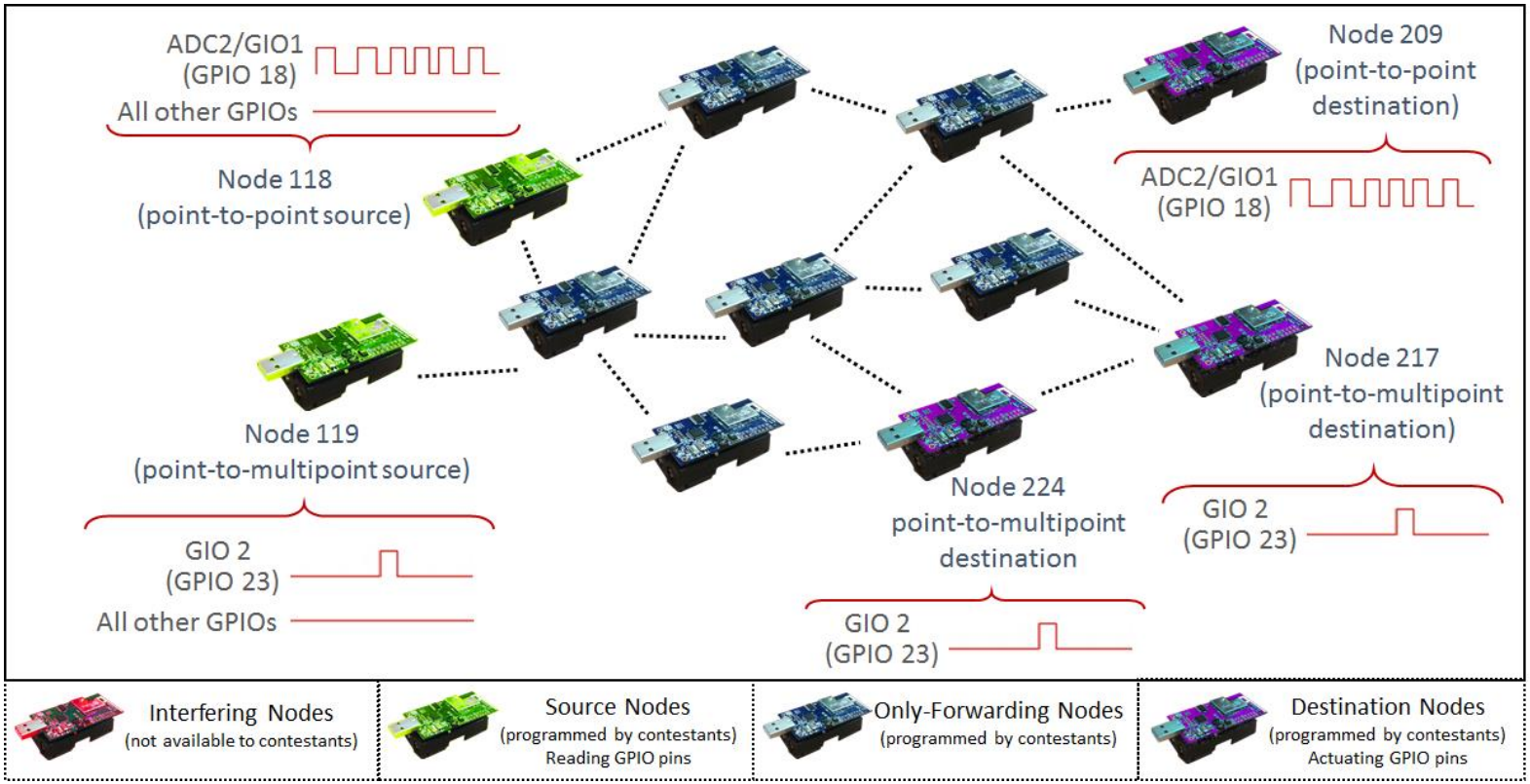
Evaluation Scenario

(1st preparation phase)

aka getting acquainted with the testbed facility

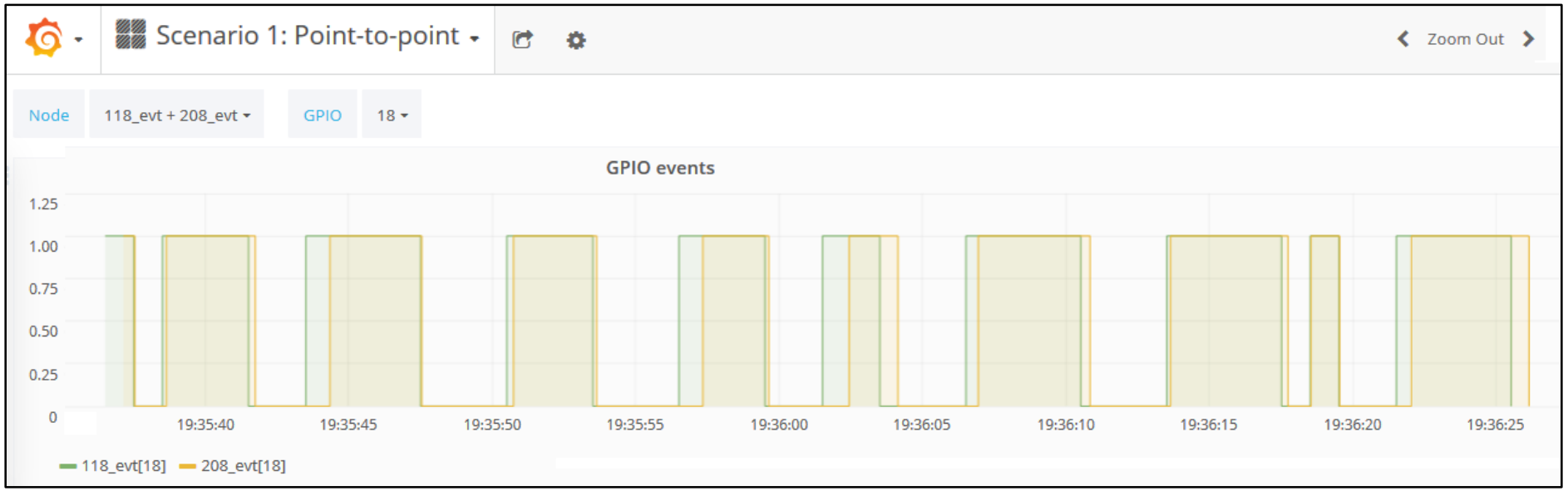
Evaluation Scenario

- For the 1st preparation phase, a simplified evaluation scenario is implemented
  - Point-to-point communication from node 118 to 209 (GPIO18)
  - Point-to-multipoint communication from 119 to 217 & 224 (GPIO23)



Visualizing in Grafana the Eval. Scenario

- Specific "Scenario" tabs available on the Grafana Dashboard
  - Showing if the GPIO of nodes 118, 119, 209, 217 and 224 have been toggled correctly

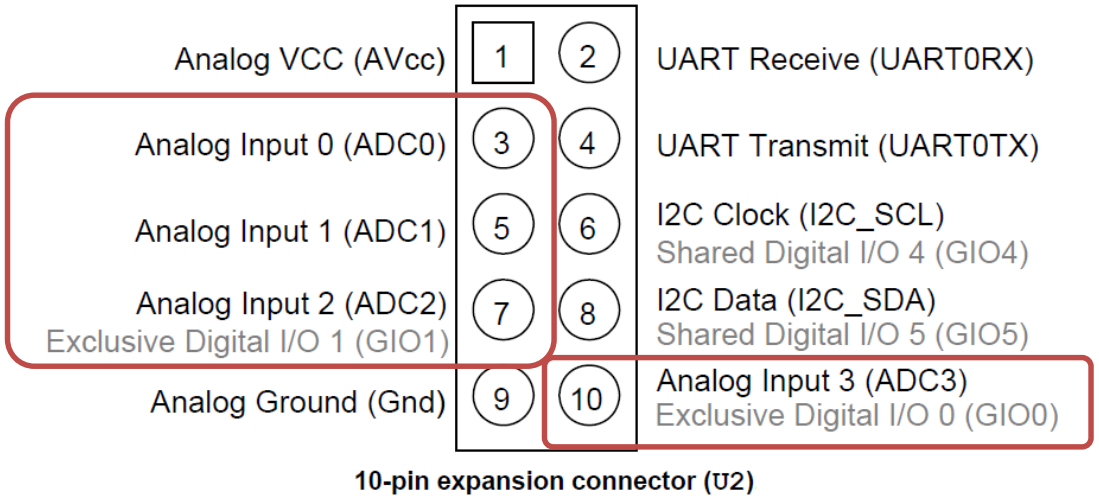


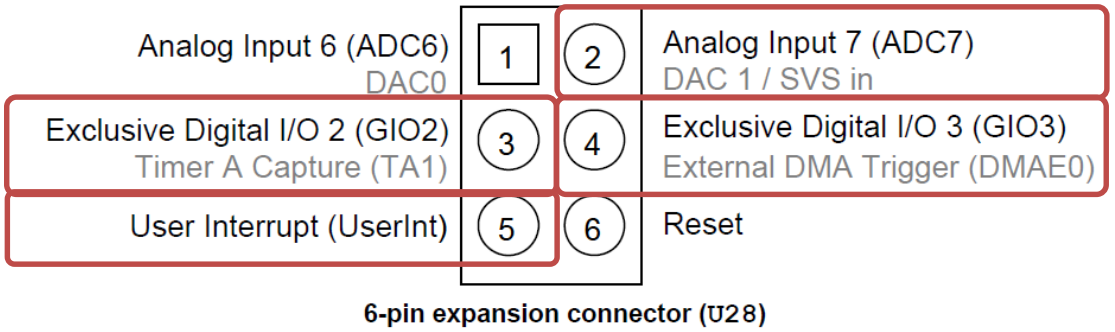
In the first week, Scenario 1 will be active to allow contestants to get acquainted with the testbed facility

Additional scenarios will be added in the next days!

GPIO Pins

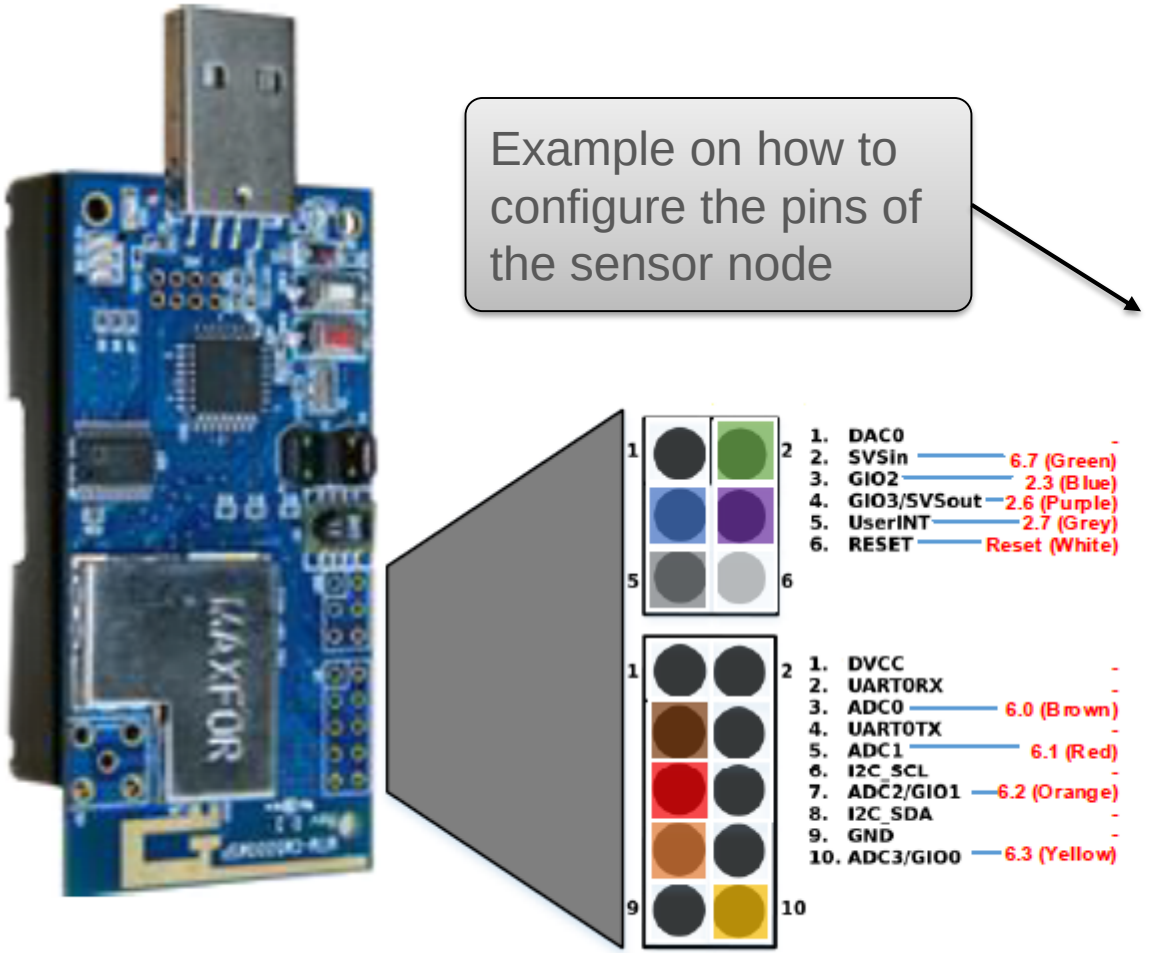
- The testbed facility is connected to eight of the pins available in the 10-pin and 6-pin expansion connector





GPIO Pins

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

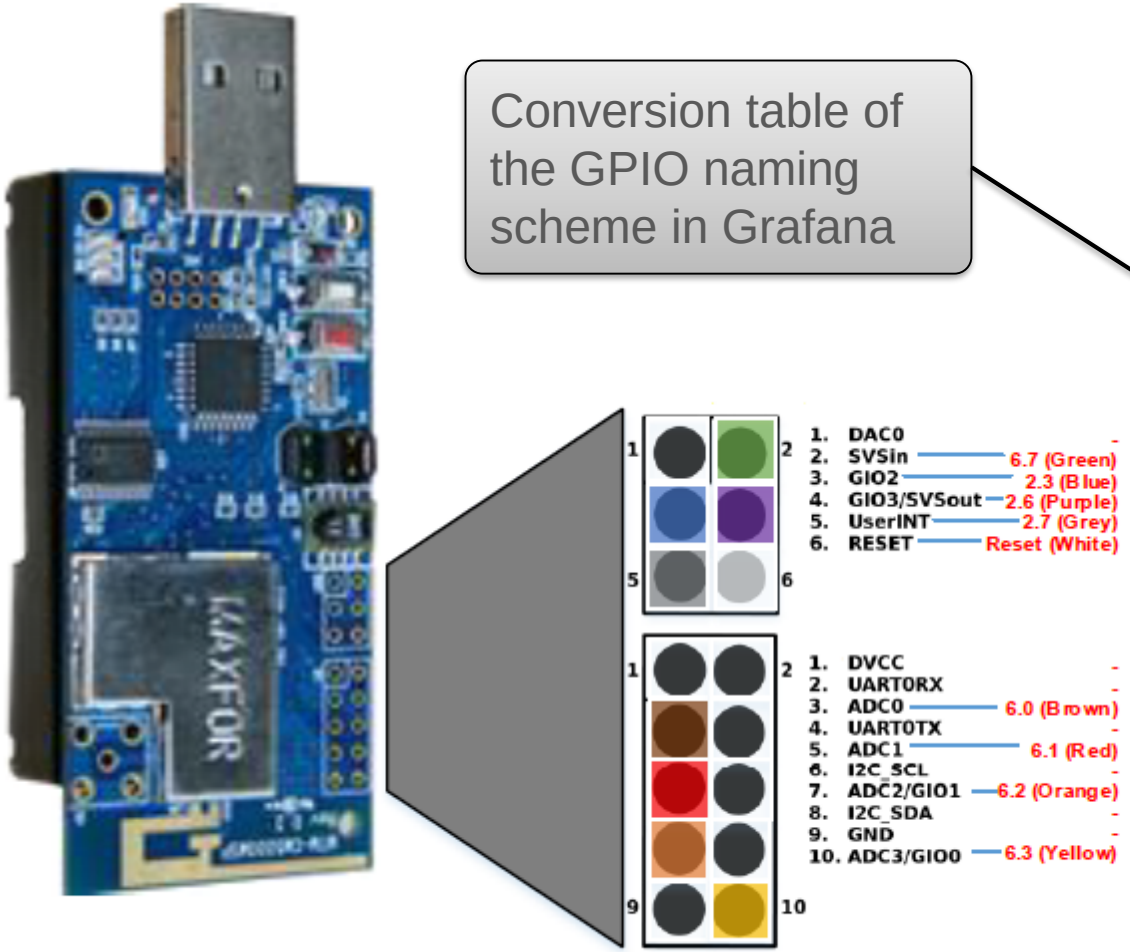


Example on how to configure the pins of the sensor node

```
//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                          //USERINT
P6SEL &= ~(BIT3);               P2SEL &= ~(BIT7);
P6DIR |= BIT3;                  P2DIR |= BIT7;
```

GPIO Pins

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

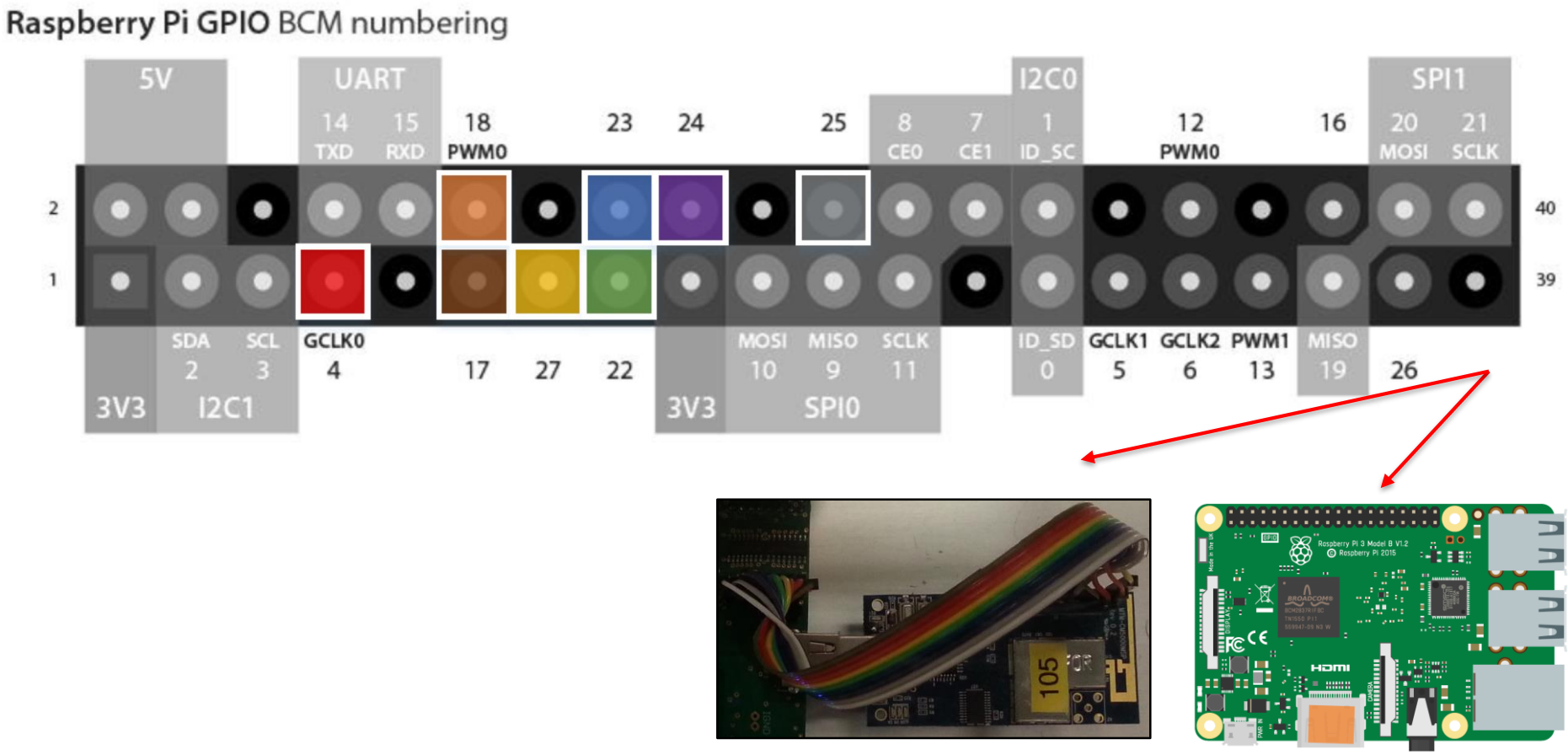


Conversion table of the GPIO naming scheme in Grafana

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
UserINT	GPIO 25

GPIO Pins

- 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)



GPIO Pins

- 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)

- Example: GPIO 18 in Grafana
  - 18 = 0001 0010 in binary
  - Using Grafana's mapping:
  - ADC0=0; ADC1=0; ADC2=0; ADC3=1
  - SVSin=0; GIO2=0; GIO3=1; UserINT=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

Node Identities

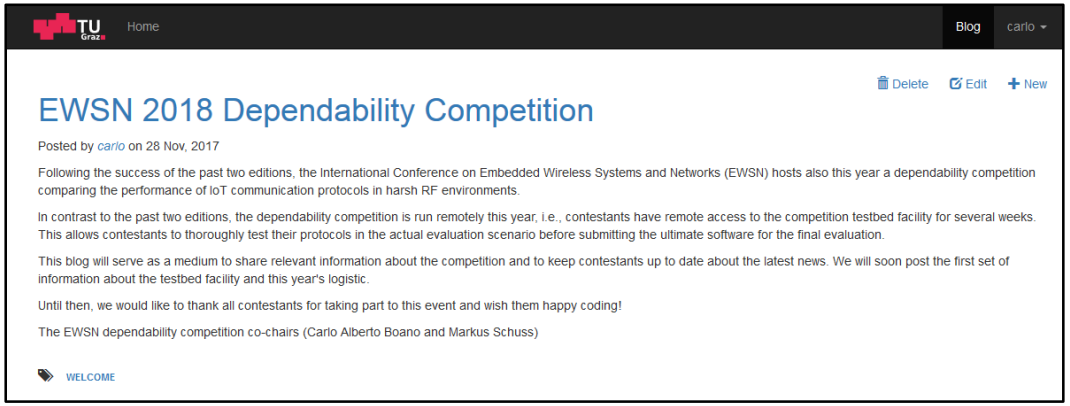
- Node address of all nodes is known beforehand
  - Provided text file in the blog:
    `List of node addresses.txt`
  - The file contains: Node ID in flash, FTDI Serial ID, DS2411 ID
- Node ID in flash
  - 16-bit unsigned short value (e.g., 100, 101)
    stored by Contiki in the 1 MB external flash → 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

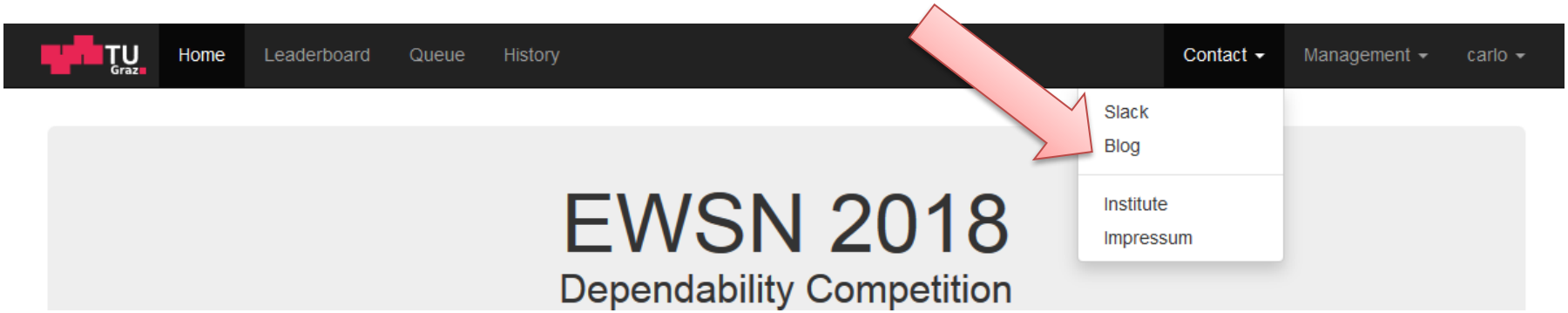
The node list may be updated during the next weeks depending on failures and/or testbed updates!

Communication with Organizers

Official Blog

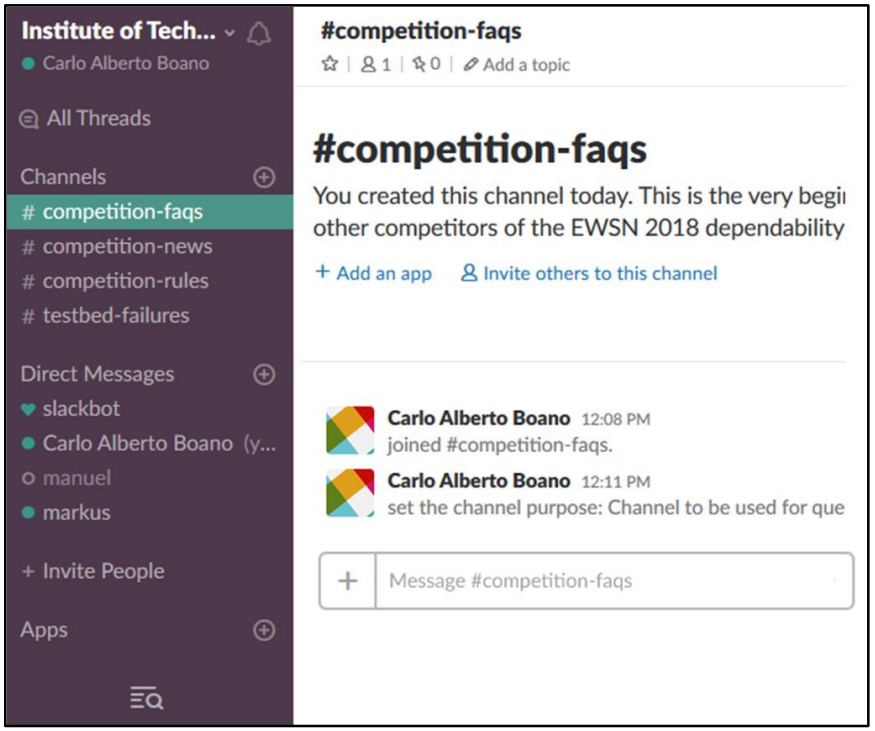
- The organizers have created a blog to keep contestants up to date about the logistics and any important news
  - Please check it regularly!
  - Answers to FAQs will be posted here

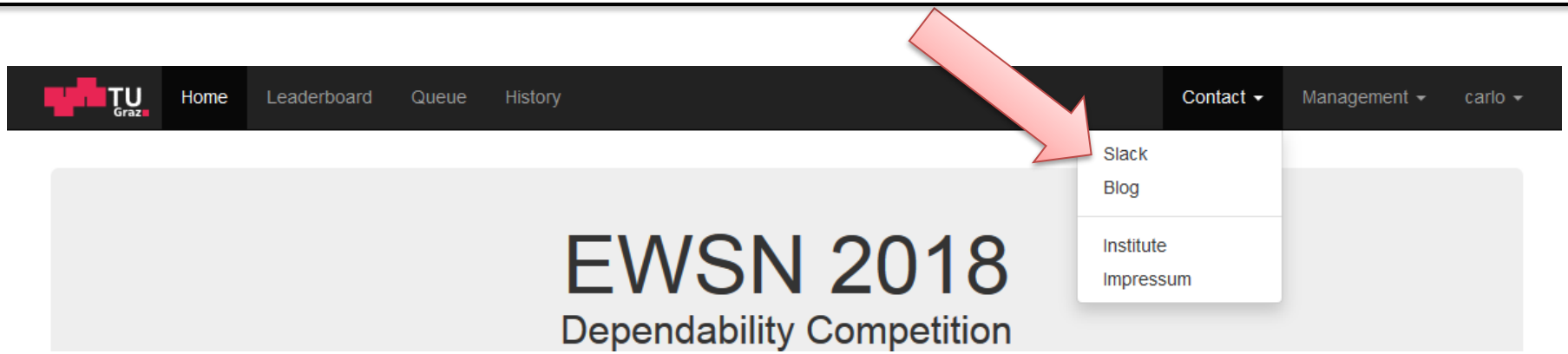




Slack Group

- 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

- Carlo Alberto Boano
  - E-mail: cboano@tugraz.at
  - Tel.: +43 316 873 6413
- Markus Schuss
  - E-mail: markus.schuss@tugraz.at
  - Tel.: +43 316 873 6403