rsensor Documentation

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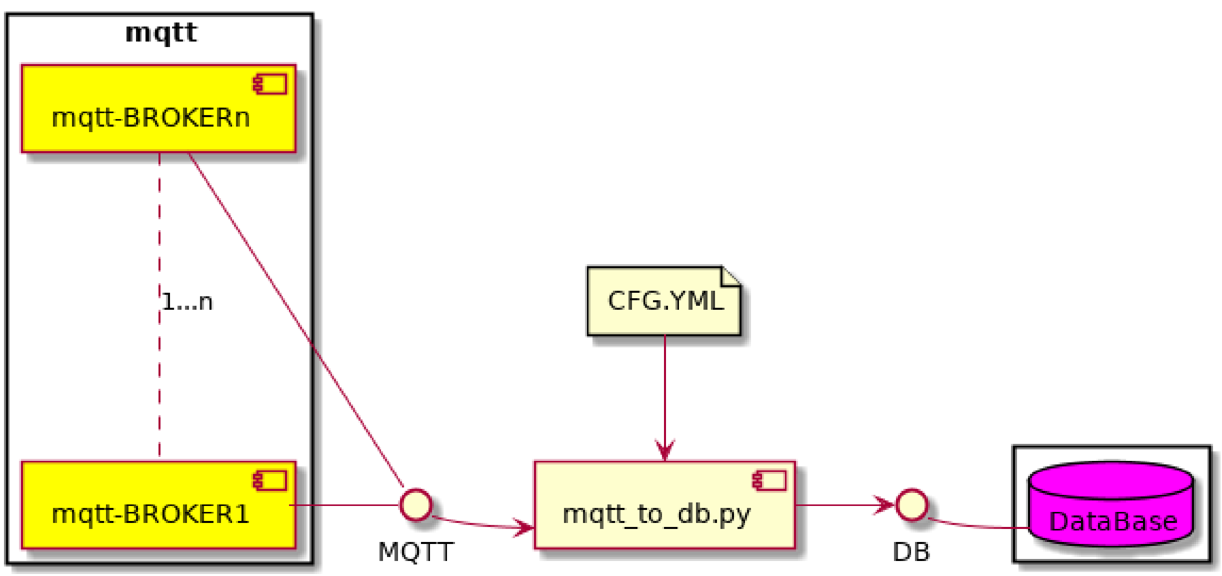
Contents:

The uracoli-rsensor project stores sensor data, received from a MQTT broker in a database.

CHAPTER 1

Introduction

The script `mqtt_to_db.py` reads sensor data from one ore more MQTT brokers and stores it together with additional meta information in a database.



Sensor values are characterized by their meaning, e.g. the physical quantity a value represents. Beside their basic meaning (numeric value and physical unit), a sensor value can also have meta information attached.

The following information shall be stored in the database:

- What was measured? (numeric value and physical unit)
- When? (the timestamp of the measurement)
- Where? (the location of the sensor)
- How? (the type of the sensor, system information, software version, . . .)

CHAPTER 2

Usage

2.1 Installation

The installation of the latest version can be done with:

```
pip install git+https://gitlab.com/uracoli-project/uracoli-rsensor.git
```

2.2 Getting Started

After successfull installation run:

```
mqtt_to_db -h
```

to see the available command line options of the script.

Create now the initial configuration file `myrsensor.cfg`:

```
mqtt:
 - host: test.mosquitto.org
   port: 1883
   prefix: rsensor-test

database:
    dbtype: sqlite
    dbname:  /tmp/rsensor/rsensor.sqlitedb
```

This configuration connects to the public available MQTT broker `test.mosquitto.org` and stores the received data in a SQlite database file `/tmp/rsensor/rsensor.sqlitedb`.

Run the script and see the messages on the console:

```
mqtt_to_db -C myrsensor.cfg
```

The file /tmp/rsensor/rsensor.sqlitedb is created and can be accessed with the SQLite tool:

```
sqlite3 /tmp/rsensor/rsensor.sqlitedb
```

The next section describes how to receive test data from MQTT, that are stored in the database

2.3 Generating Test Data

The package contains also a script rs_testgen that generates appropriate formatted test data.

The script uses per default the MQTT broker on localhost:1883.

After start you will see an output:

```
$ rs_testgen -H test.mosquitto.org
INFO:MqttRandomGenerator:create generator class
using default sensor config: /opt/esp/ve_esp/local/lib/python2.7/site-packages/
↪rsensor/data/test_node.yml
INFO:MqttRandomGenerator:connected to test.mosquitto.org:1883, prefix=rsensor-test
INFO:MqttRandomGenerator:info message on: rsensor-test/s_1111_0001/info
INFO:MqttRandomGenerator:info message on: rsensor-test/s_1111_0002/info
INFO:MqttRandomGenerator:info message on: rsensor-test/s_1111_0003b/info
INFO:MqttRandomGenerator:data message on: rsensor-test/s_1111_0001/data
INFO:MqttRandomGenerator:data message on: rsensor-test/s_1111_0002/data
INFO:MqttRandomGenerator:data message on: rsensor-test/s_1111_0002/data
INFO:MqttRandomGenerator:data message on: rsensor-test/s_1111_0003b/data
INFO:MqttRandomGenerator:data message on: rsensor-test/s_1111_0001/data
INFO:MqttRandomGenerator:data message on: rsensor-test/s_1111_0002/data
```

With the command mosquitto_sub -h localhost -t "rsensor-test/#" -v you can watch the generated messages.

See rs_testgen -h for available configuration options.

2.4 Writing a SystemD-Daemon Script

To collect sensor data over a long time, the script mqtt_to_db can run as Daemon-service on a Linux server, e.g.on a Raspberry-Pi.

Create a file /etc/systemd/system/rsensor.service with the following contents:

```
[Unit]
Description=MqttToDb Service
After=network-online.target

[Service]
Type=simple
User=pi
Group=pi
WorkingDirectory=/home/pi/rsensor
ExecStart=/home/pi/ve_py2_rsensor/bin/mqtt_to_db -C /home/pi/rsensor/rsensor.cfg -L␣
↪ERROR
SyslogIdentifier=rsensor
StandardOutput=syslog
StandardError=syslog
```

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```
Restart=always
RestartSec=3

[Install]
WantedBy=multi-user.target
```

In the file above adapt the path to the script `/home/pi/ve_py2_rsensor/bin/` and the location of the configuration file `/home/pi/rsensor/rsensor.cfg` to your system (see also section *Python Virtual Environment*) . Also note the option `-L ERROR`, which reduces the amount of messages written to the system-log.

The script `rsensor.service` is activated with the following commands:

```
systemctl daemon-reload
systemctl enable rsensor.service
systemctl start rsensor.service
```

The status of the script can be verified with these commands:

```
# see if the script is running or it is crashed.
systemctl status rsensor.service

# see all log messages from the beginning of the log.
journalctl -u rsensor.service

# see actual incoming messages
journalctl -u rsensor.service -f
```

The script can be stopped with:

```
systemctl stop rsensor.service
```

CHAPTER 3

Config File Format

3.1 Format

The config file is written in YAML syntax.

The file contains a YAML-dictionary with two predefined keywords:

- mqtt
- database

3.2 MQTT Section

This section starts with the YAML-key `mqtt` and contains a list of MQTT-Brokers:

```yaml
mqtt:
 - host: iot.eclipse.org
   port: 1883
   prefix: 'clt2020/thlog'
   info_topic: 'clt2020/thlog/+/info'
   data_topic: 'clt2020/thlog/+/data'
 - host: test.mosquitto.org
   port: 1883
   prefix: 'aw/thlog'
   info_topic: 'aw/thlog/+/info'
   data_topic: 'aw/thlog/+/data'
```

Each configured MQTT broker requires a YAML structure with the following keys:

host hostname or IP address of the broker

port portnumber of the mqtt service (1883 unencrypted, 3883 TLS secured)

info_topic the topic where the nodes publish their description information

data_topic the topic where the nodes publish their sensor data

prefix

Todo: check if still used.

3.3 Database section

This section starts with the YAML-key `database` and requires the `dbtype` key:

```
database:
    dbtype: {sqlite|mysql}
```

The rest of the data-structure depends on the database type used.

3.3.1 SQLITE Database

The SQLITE DB is configured as follows:

```
database:
    dbtype: sqlite
    dbname:  /tmp/rsensor/rsensor.sqlitedb
```

dbtype *sqlite*

dbname the path and name of the SQLITE-file

If `dbname` refers to a file that not exists, the file, including a none existing directory, is created and initialized as sqlite database.

The data in the sqlite database can be accessed with the command:

```
sqlite3  /tmp/rsensor/rsensor.sqlitedb
sqlite> .tables
locations   nodes        sensors     timeseries
```

More details about how to work with this DB refer to section *SQlite Commands*.

3.3.2 MySQL Database

CHAPTER 4

MQTT Interface

4.1 Info Topic rsensor/node/+/info[r]

The =node_info= topuc is a retained topic that contains information about the sensors and actors that it contains. An example of the JSON-data is given here:


```
{
    "actors": [],
    "node": {
        "id": "51fe4a00",
        "name": "thlog-51fe4a00",
        "board": "esp8266+bm280",
        "firmware": "TempHumLogger.py",
        "version": "1.02"
        "geoloc": [ 1, 2],
        "loctag": "WH.KG.K2",
    },
    "sensors": [
        {
            "id": "temp",
            "name": "temp",
            "type": "float",
            "unit": "\u00b0C"
        },
        {
            "id": "rh",
            "name": "rh",
            "type": "float",
            "unit": "%"
        }           ]
}
```

4.1.1 Data Structure

The data in the info topic is a dictionary with three keywords:

```
{
        "node": {<node_description>}
        "sensors": [{<sensor_description>}, {...}, ...]
        "actors": [{<actor_description>}, {}, ...]
}
```

4.1.2 Node Information <node_description>

name	description
id	unique id of the sensor node
name	symbolic name
board	type of the board
firmware	name of the firmware image
version	version of the firmware image
loctag	location description
geoloc	geographic location of the node (optional)

4.1.3 Sensor Information <sensor_description>

name	description
id	identifier of the sensor, e.g. 'temp'
name	long name of the sensor, e.g. 'Temperature'
type	data type, e.g. float, int, bool, ...
unit	name of the measurment unit

4.1.4 Actor Information <actor_description>

name	description
id	identifier of the sensor, e.g. 'coil1'
...	...

4.2 Data Topic rsensor/node/+/sensor/data

In this topic data from sensors are published.

```
{ '<sensor_id>' : value,
  '<sensor_id1>' : value
}
```

Note: A published sensor_data message need not to contain all data defined in node_info.sensors. This is because of, that the sensors might have different update rates.

CHAPTER 5

Database Interface

5.1 Supported Databases

- SQlite
- MySQL

5.2 Tables, Views and Indexes

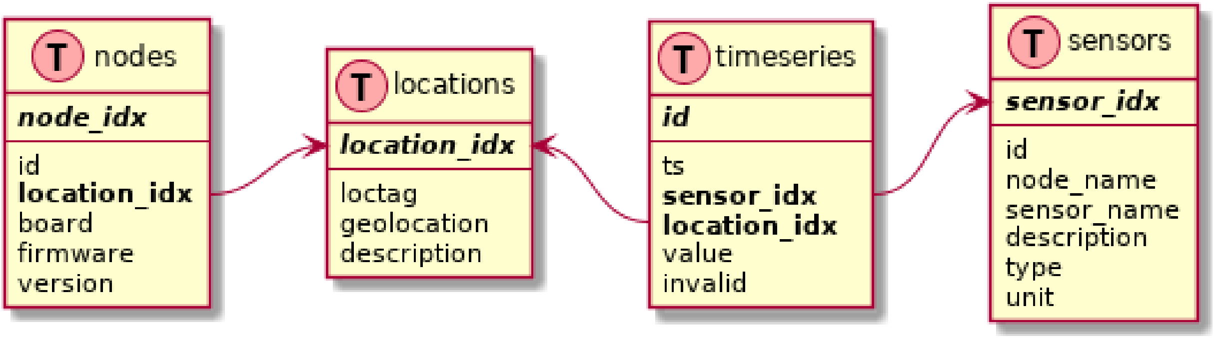
The database definition is stored in the YAML-file `data/schema.yml`.

5.2.1 Tables

The rsensor-database consists of four tables:

- nodes
- locations
- sensors
- timeseries

The following diagram shows the relations between the table fields.



The table *nodes* stores node specific information (see MQTT-info topic):

```
mysql> select * from nodes;
+----------+----------+--------------+----------------+------------------+---------+
| node_idx | id       | location_idx | board          | firmware         | version |
+----------+----------+--------------+----------------+------------------+---------+
|        1 | 36004b00 |            1 | esp8266+bm280  | TempHumLogger.py | 1.00    |
+----------+----------+--------------+----------------+------------------+---------+
1 row in set (0.00 sec)
```

The field *location_idx* references to the table *locations*.

The table *locations* stores a list of all seen locations, based on the field *loctag*:

```
mysql> select * from locations;
+--------------+----------+-------------+-------------+
| location_idx | loctag   | geolocation | description |
+--------------+----------+-------------+-------------+
|            1 | WH.KG.K2 | NULL        | NULL        |
+--------------+----------+-------------+-------------+
1 row in set (0.00 sec)
```

Each node serves one or sensors, all of these are stored in the table *sensors*:

```
mysql> select * from sensors;
+------------+---------------+-----------+-------------+-------------+-------+-------+
| sensor_idx | id            | node_name | sensor_name | description | type  | unit  |
+------------+---------------+-----------+-------------+-------------+-------+-------+
|          1 | 36004b00_temp | 36004b00  | temp        | NULL        | float | C    |
|          2 | 36004b00_rh   | 36004b00  | rh          | NULL        | float | %     |
|          3 | 36004b00_p    | 36004b00  | p           | NULL        | float | hPa   |
|          4 | 36004b00_ah   | 36004b00  | ah          | NULL        | float | g/m^3 |
|          5 | 36004b00_svp  | 36004b00  | svp         | NULL        | float | hPa   |
+------------+---------------+-----------+-------------+-------------+-------+-------+
5 rows in set (0.00 sec)
```

The individual measurement values are stored in table *timeseries*:

```
mysql> select * from timeseries;
+-----+------------+------------+--------------+---------+---------+
| idx | ts         | sensor_idx | location_idx | value   | invalid |
+-----+------------+------------+--------------+---------+---------+
|   1 | 1586237223 |          4 |            1 | 6.21505 |       0 |
|   2 | 1586237223 |          2 |            1 |      34 |       0 |
|   3 | 1586237223 |          5 |            1 | 24.8118 |       0 |
```

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```
|   4 | 1586237223 |           1 |             1 |    20.97 |         0 |
|   5 | 1586237223 |           3 |             1 |     1019 |         0 |
|   6 | 1586237258 |           4 |             1 |  6.21867 |         0 |
|   7 | 1586237258 |           2 |             1 |       34 |         0 |
|   8 | 1586237258 |           5 |             1 |  24.8271 |         0 |
|   9 | 1586237258 |           1 |             1 |    20.98 |         0 |
|  10 | 1586237258 |           3 |             1 |     1019 |         0 |
+-----+------------+-------------+---------------+----------+-----------+
10 rows in set (0.00 sec)
```

5.2.2 Views

Todo: add support views in schema.yml

5.2.3 Indexes

Todo: describe indexes

5.3 SQlite Commands

The initial content of the SQLite database can be explored with the commands `.tables` and `.schema <tablename>`:

```
sqlite> .tables
locations   nodes       sensors     timeseries
sqlite> .schema nodes
CREATE TABLE `nodes`
(
   node_idx INTEGER PRIMARY KEY NOT NULL  /*!40101 AUTO_INCREMENT */,
   id VARCHAR(64) DEFAULT NULL,
   location_idx INTEGER DEFAULT -1,
   board VARCHAR(64) DEFAULT NULL,
   firmware VARCHAR(64) DEFAULT NULL,
   version VARCHAR(64) DEFAULT NULL
);
sqlite>
```

If data was received, the table `timeseries` contains data:

```
sqlite> select * from timeseries

idx         ts          sensor_idx  location_idx  value       invalid
----------  ----------  ----------  ------------  ----------  ----------
1           1586844220  4           1             5.68866     FALSE
2           1586844220  2           1             29.0        FALSE
3           1586844220  5           1             26.7363     FALSE
4           1586844220  1           1             22.19       FALSE
```

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```
5           1586844220  3           1             1010.0      FALSE
6           1586844352  4           1             5.46655     FALSE
7           1586844352  2           1             29.0        FALSE
8           1586844352  5           1             25.6324     FALSE
9           1586844352  1           1             21.5        FALSE
10          1586844352  3           1             1011.0      FALSE
```

More about the representation of the data in the `timeseries` table can be found in section *Database Interface*.

5.4 MySQL Commands

Query a specific sensor value:

```
select from_unixtime(t.ts), s.id, t.value, s.unit from timeseries as t join sensors␣
↪as s on t.sensor_idx = s.sensor_idx where s.id like "%ah";
```

```
SELECT
    FROM_UNIXTIME(t.ts), s.id, t.value, s.unit
FROM
    timeseries AS t
        JOIN
    sensors AS s ON t.sensor_idx = s.sensor_idx
WHERE
    s.id LIKE '%ah';
```

CHAPTER 6

Using the Sensor Data

6.1 Dashboards with Grafana

A Dashboard displays the collected sensor data in a graphical user interface (GUI). They are used to monitor the current and past state of a technical system. The data are repesented by widgets like graphs, bar-charts, gauges and heat-maps. An easy to use and powerful application is Grafana, https://grafana.com.

Install and start a standard grafana container:

```
docker pull grafana/grafana
docker run -d -p 3000:3000 grafana/grafana
```

Open the URL http://172.17.0.1:3000 in the Web-Browser (usually the docker container runs on this address). Follow the instructions to set a new password, initial login is done with user: admin, password: admin.

Setup a Data Source

At first Configure the MySQL-DB used by rsensor as data source in grafana. After all parameters are entered, press “Save and Test”.

Setup a Dashboard with a Panel

If the test was succesful, the next step is to configure a dashboard. Select “Create Dashboard” and “Add Panel”.

In the “Query” tab press “Edit SQL” and enter the following query:

```
select t.ts as time_sec,
       s.id as metric,
       t.value
  from timeseries as t
  join sensors as s on t.sensor_idx = s.sensor_idx
  where s.id like "%temp"
```

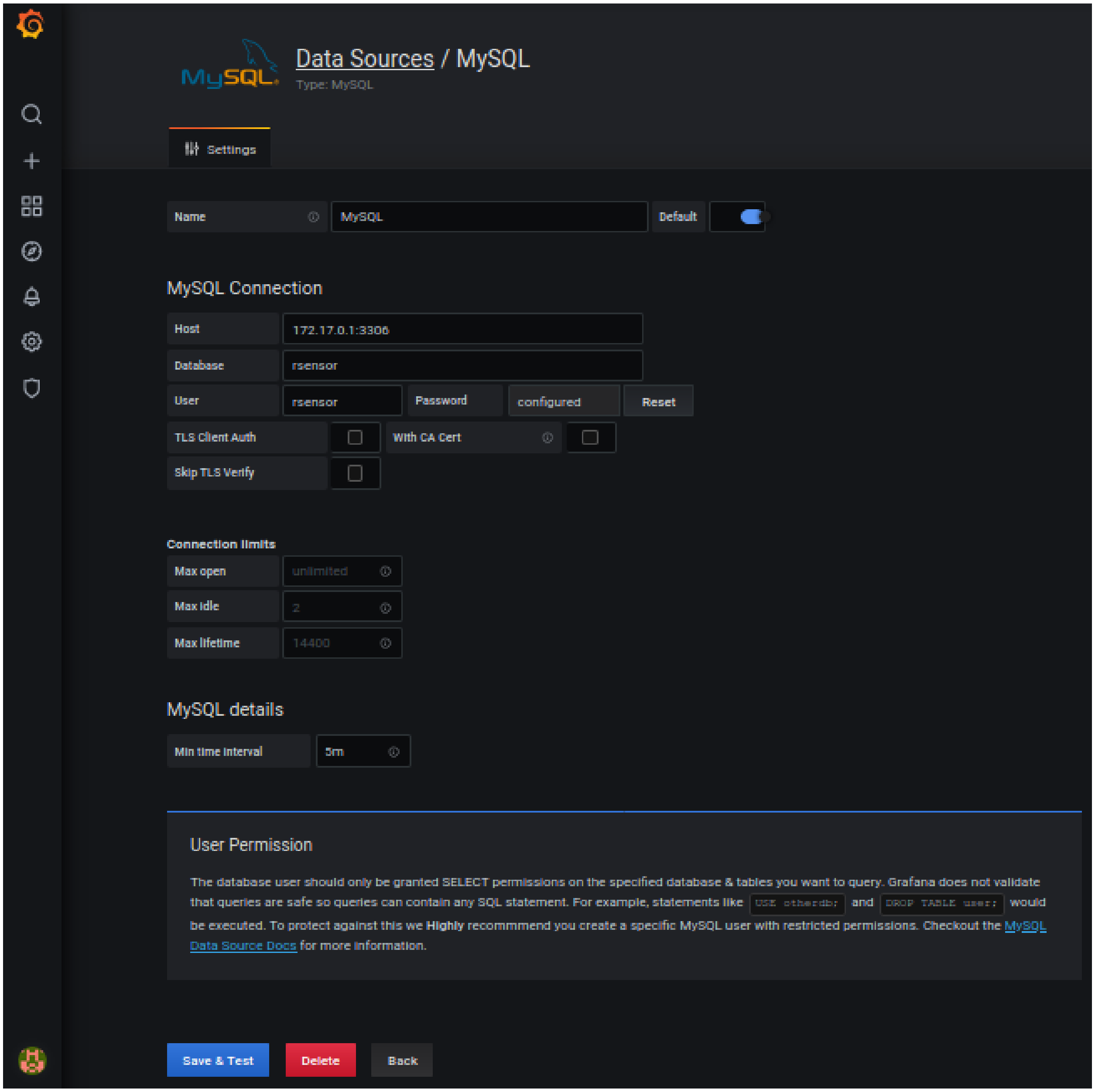

Fig. 1: Configure dialog of the data source

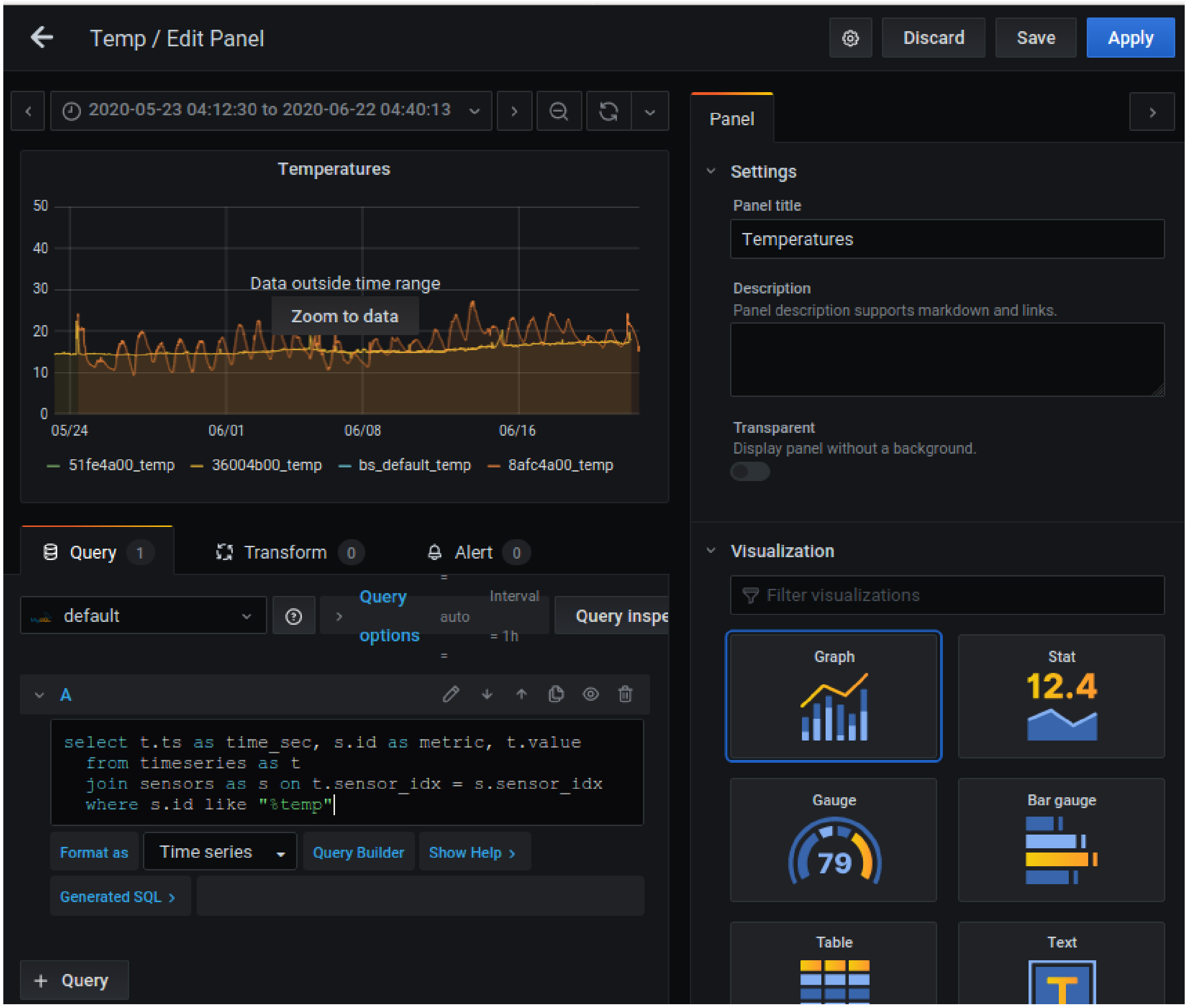

Fig. 2: Configure dialog of a panel

Use and fine tune the Dashboard

Finally press “Apply” and watch the result.

By entering the “Edit” submenue, the dashboard can be further optimized and fine tuned.

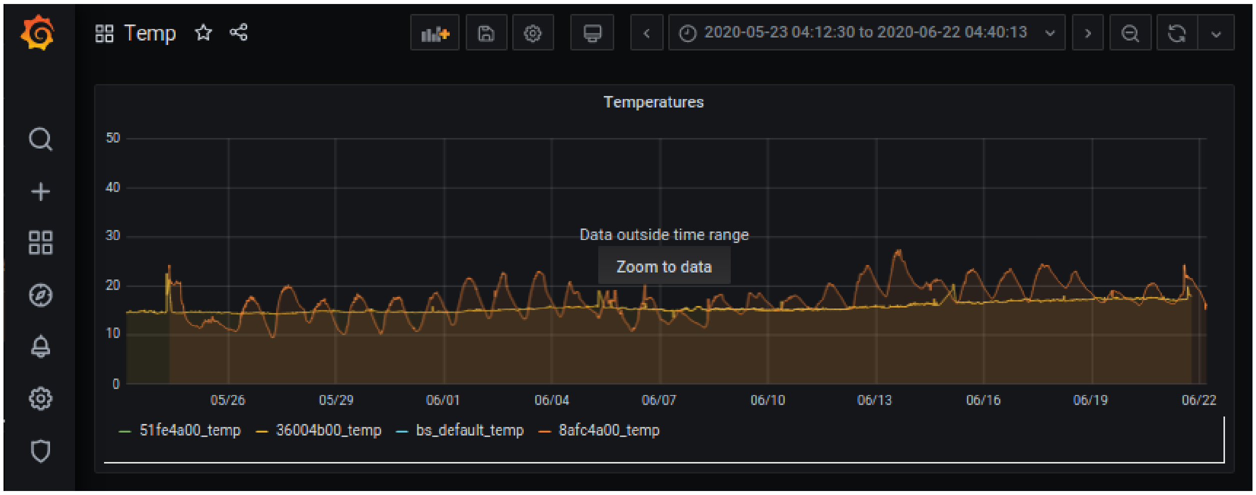

Fig. 3: Dashboard from the above example

6.2 Data Analysis with JupyterLab

. . . coming soon

CHAPTER 7

Development Information

7.1 Makefile

The important command lines for development are collected in the *Makefile*.

7.2 Docker Environment

The rsensor-Docker-Container contains the following components:

- **Mysql Server**
    - the database is initialized with the script `test/init_db.sql`
- sqlite3
- Python
- the latest rsensor package (todo: really needed?)
- (todo: maybe add mosquitto)

The Container is created with the command:

```
cd test
docker build -t rsensor .
```

The container is started with:

```
cd test
docker run --rm --name rsensordb --hostname rsensordb -v $(pwd):/test -p 5555:5000 -p 3306:3306 -t -i rsensor
```

Options:

–rm delete container at exit

–name .... set container name

–hostname .... set hostname of the container

-v ... map local directory as volume

-p ... map ports to host system

-t ???

-i ???

rsensor name of the container (see docker build)

At the docker-prompt you can testwise access the database:

```
mysql -u root
```

The script `prepare_mysql.sql` creates the user rsensor and the database rsensor:

```
mysql -u root < prepare_mysql.sql
```

7.3 Using the MySQL Docker DB from extern

Acess the container via its IP address with:

```
mysql -u rsensor -h 172.17.0.1  rsensor -p
```

The password is "rsensor" (see prepare_mysql.sql)

Todo: check how to add docker-container to DNS automatically

7.4 Python Virtual Environment

In the example *Writing a SystemD-Daemon Script* it is assumed that `uracoli-rsensor` is installed in a virtual environment in directory `/home/pi/ve_py2`. This virtual environment is created with the commands:

```
python -m virtualenv /home/pi/ve_py2
/home/pi/ve_py2/bin/pip install -e git+https://gitlab.com/uracoli-project/uracoli-
↪rsensor.git
```

7.5 Raspi AP Setup

Follow the article How to use your Raspberry Pi as a wireless access point (https://thepi.io) and skip the bridge settings in this article, they are not needed for the sensor network. (alternativly see also Raspberry Pi als WLAN-Router einrichten)

Here are the current used configuration files.

`/etc/dhcpcd.conf`:

```
hostname
clientid
persistent
option rapid_commit
option domain_name_servers, domain_name, domain_search, host_name
option classless_static_routes
option interface_mtu
require dhcp_server_identifier
slaac private
interface wlan0
static ip_address=10.65.87.1/24
denyinterfaces eth0
denyinterfaces wlan0
```

`/etc/dnsmasq.conf`:

```
interface=wlan0
  dhcp-range=10.65.87.100,10.65.87.200,255.255.255.0,24h
```

`/etc/hostapd/hostapd.conf`:

```
interface=wlan0
#bridge=br0
hw_mode=g
channel=7
wmm_enabled=0
macaddr_acl=0
auth_algs=1
ignore_broadcast_ssid=0
wpa=2
wpa_key_mgmt=WPA-PSK
wpa_pairwise=TKIP
rsn_pairwise=CCMP
ssid=MyRsensorAP
wpa_passphrase=sovershennosekretno
```

`/etc/default/hostapd`:

```
DAEMON_CONF="/etc/hostapd/hostapd.conf"
```

`/etc/sysctl.conf`:

```
net.ipv4.ip_forward=1
```

`/etc/rc.local`:

```
#!/bin/sh -e
_IP=$(hostname -I) || true
if [ "$_IP" ]; then
  printf "My IP address is %s\n" "$_IP"
fi
# appended iptables-restore for AP, generated by:
#       sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
#       sudo sh -c "iptables-save > /etc/iptables.ipv4.nat"
iptables-restore < /etc/iptables.ipv4.nat
exit 0
```

Note: Also check the permissions of /etc/rc.local. It needs to be executable. `-rwxr-xr-x 1 root root 306 Apr 4 2017 /etc/rc.local`

7.5.1 Wifi Issues

In case of an error message from `hostapd`:

```
>> journalctl -u hostapd.service
-- Logs begin at Sat 2020-06-06 12:17:01 CEST, end at Sat 2020-06-06 13:16:17 CEST. --
Jun 06 12:46:06 gretel systemd[1]: Starting Advanced IEEE 802.11 AP and IEEE 802.1X/
↪WPA/WPA2/EAP Authenticator...
Jun 06 12:46:07 gretel hostapd[379]: Configuration file: /etc/hostapd/hostapd.conf
Jun 06 12:46:07 gretel hostapd[379]: nl80211: Driver does not support authentication/
↪association or connect commands
Jun 06 12:46:07 gretel hostapd[379]: nl80211: deinit ifname=wlan0 disabled_11b_rates=0
```

If a Wifi-USB stick like TP-LINK TL-WN722N is used, you need to install new drivers. Easy way is using MrEngmans precompiled modules. (https://www.raspberrypi.org/forums/viewtopic.php?f=28&t=62371&sid=97f79dbe9f8ac40727b1c4ba236c9454)

Do this steps on Raspberry:

```
sudo wget http://downloads.fars-robotics.net/wifi-drivers/install-wifi -O /usr/bin/
↪install-wifi
sudo chmod +x /usr/bin/install-wifi
sudo /usr/bin/install-wifi -h
sudo /usr/bin/install-wifi
```

After reboot the error should have been gone.

CHAPTER 8

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```
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```

CHAPTER 9

Indices and tables

- genindex
- modindex
- search