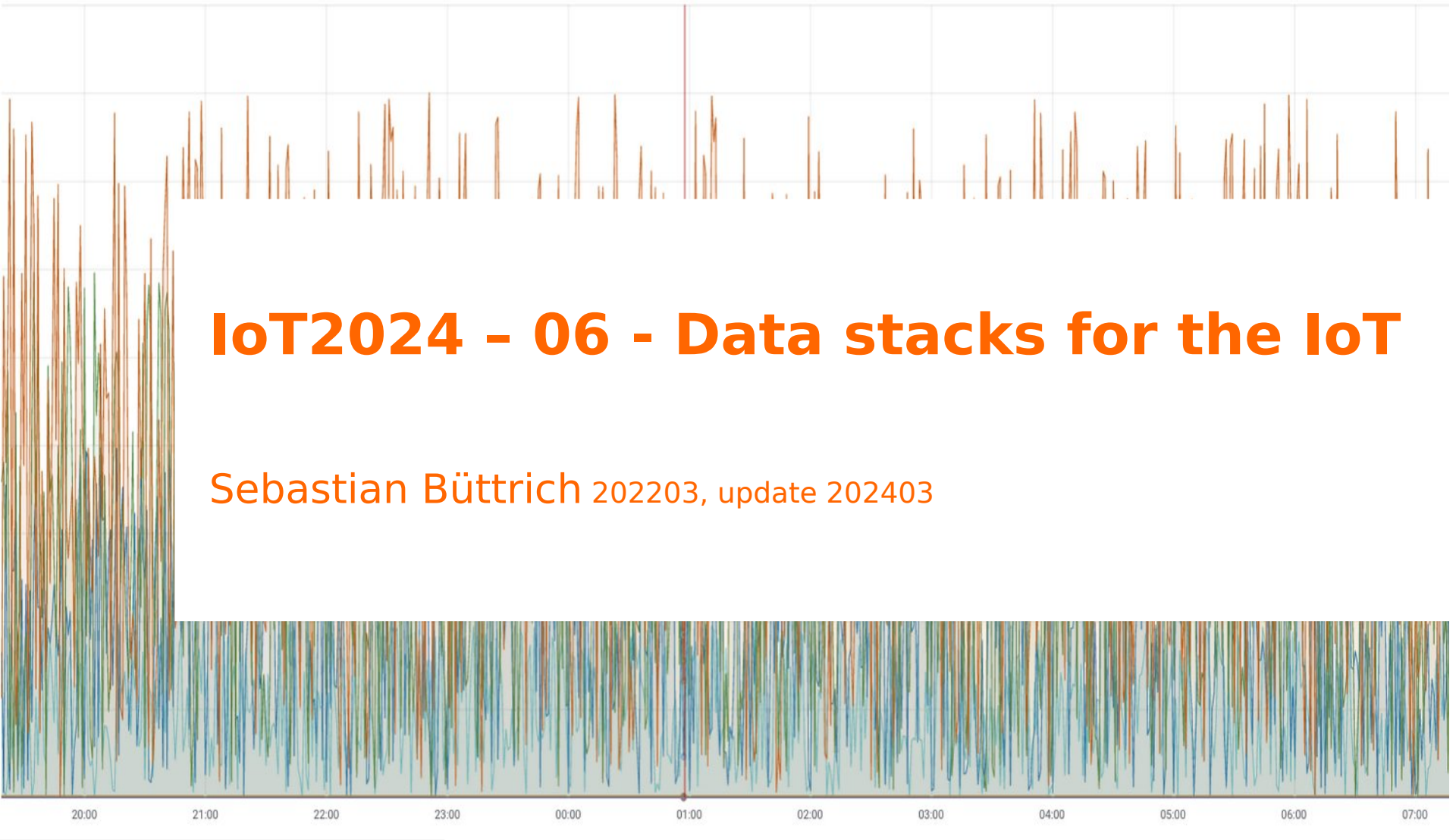
IoT2024 – 06 - Data stacks for the IoT

Sebastian Büttrich 202203, update 202403



Agenda

Data stacks: transport, storage, presentation

Ingesting data

We know how to generate data and we know the physical network layers (and a bit of higher layers, e.g. MQTT) – now we need to complete the data flow

Storing data

(Timeseries) Databases for IoT Data, e.g. InfluxDB

Showing (and (pre-)processing) data

e.g. Grafana

Example

Ingesting data

THE THINGS NETWORK

Node-RED

influxdb

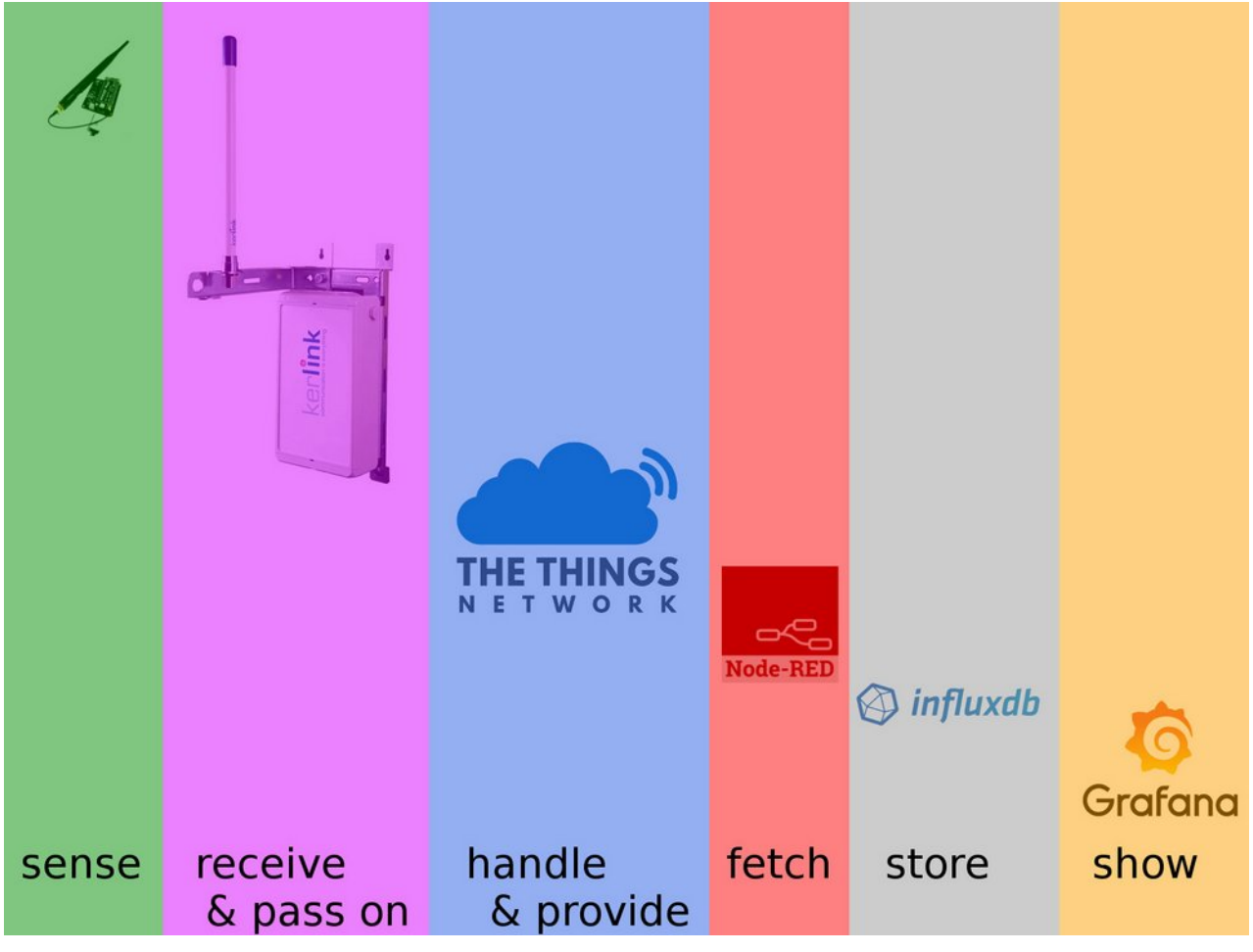
Grafana

Storing data

Showing (and processing) data

Overview /2

Roles

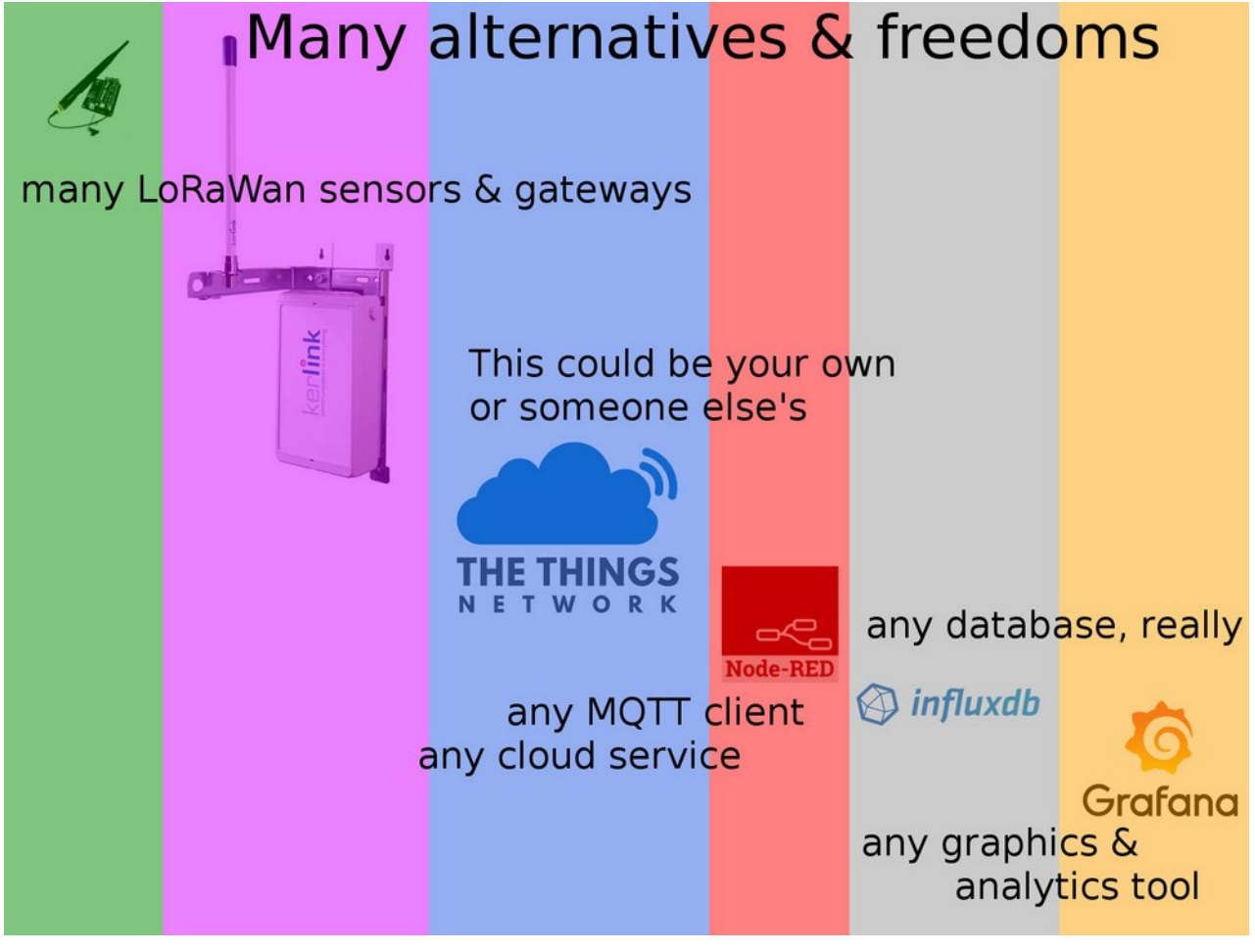


Overview /5

Freedom

Of

Choice



Our current setup(s)

LoRaWAN

THE THINGS NETWORK

Wi Fi™

Ingesting data

python™

Storing data

influxdb

Grafana

Showing (and processing) data

Options & freedoms

Though standardization in the IoT is still a big challenge,

the vast majority of IoT stacks agree on some open technologies

For connectivity and communication -

e.g. LoRaWAN, … http APIs, MQTT, json,

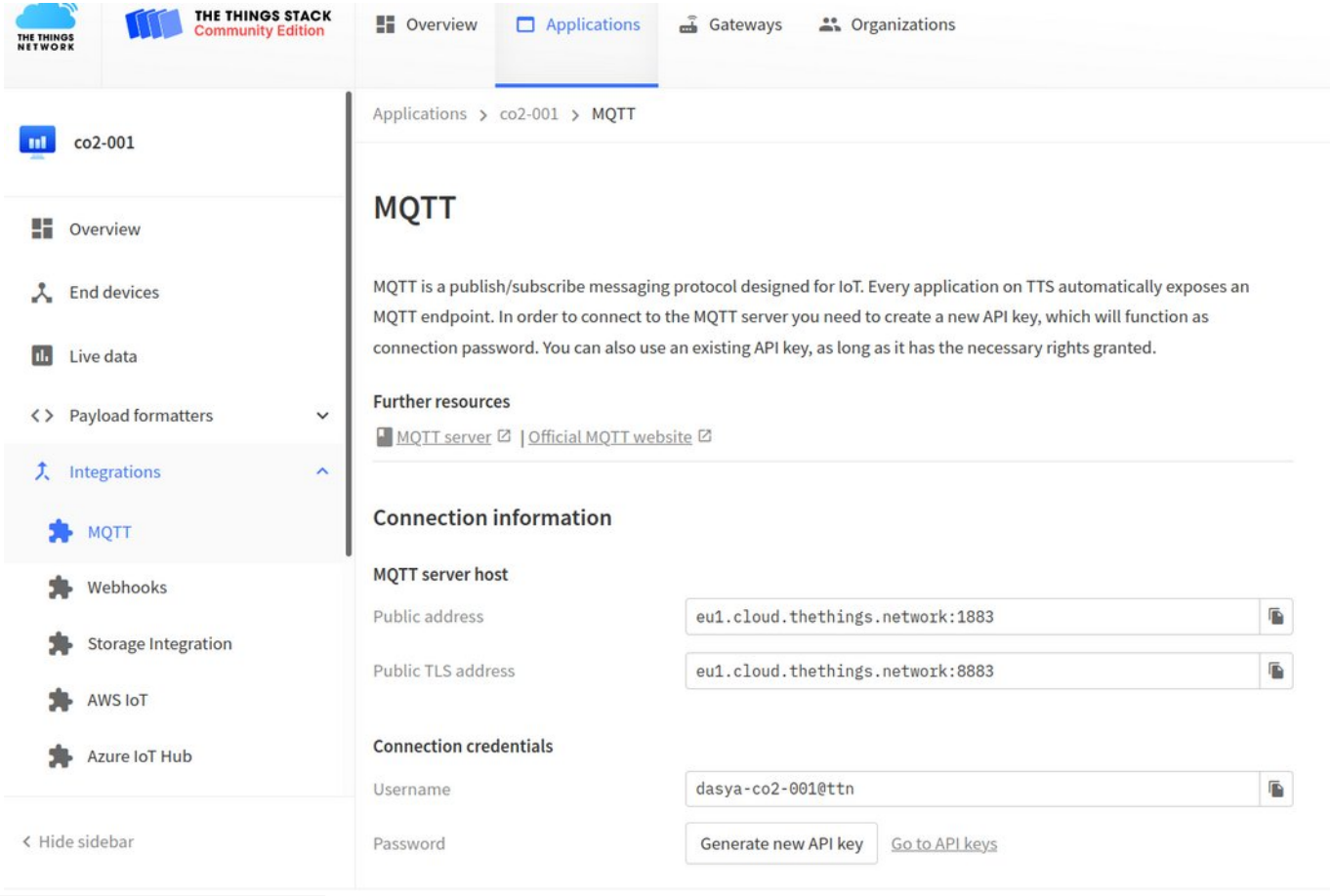
allowing us to combine and exchange systems quite freely.

MQTT is everywhere – e.g. TTN

The Things Network's Application server, openly available in the community version, makes data availabale via MQTT.
It implements a 'tenant' structure which you find in many commercial IoT systems.

You can subscribe to the data feeds provided you have the right credentials for a given application.

MQTT is everywhere – e.g. TTN



MQTT is everywhere – e.g. TTN

MQTT broker	**eu1.cloud.thethings.network:8883**
user	**application@ttn ttn = tenant**
password	**API key generated by application server**

topics:

v3/{application id}@{tenant id}/devices/{device id}/join
v3/{application id}@{tenant id}/devices/{device id}/up
v3/{application id}@{tenant id}/devices/{device id}/down/queued
v3/{application id}@{tenant id}/devices/{device id}/down/sent
v3/{application id}@{tenant id}/devices/{device id}/down/ack
v3/{application id}@{tenant id}/devices/{device id}/down/nack
v3/{application id}@{tenant id}/devices/{device id}/down/failed
v3/{application id}@{tenant id}/devices/{device id}/service/data
v3/{application id}@{tenant id}/devices/{device id}/location/solved

MQTT is everywhere – e.g. TTN

```
^Csebastian@x2021:~$ mosquitto_sub -u dasya-co2-001@ttn -P NNSXS.MJIIGGBMBOTBYPFH4WKKAGYC2GOMTF3JNMRGJWQ.FCV46DXUDW2V4CCXV3
IRI6LUGOVSJVT2BYIJVJHLZLSPNI3FKQEQ -v --capath /etc/ssl/certs  -h eu1.cloud.thethings.network -p 8883  -t "#"
v3/dasya-co2-001@ttn/devices/eui-70b3d54990564b35/up {"end_device_ids":{"device_id":"eui-70b3d54990564b35","application_ids
":{"application_id":"dasya-co2-001"},"dev_eui":"70B3D54990564B35","join_eui":"70B3D57ED003CEC0","dev_addr":"260B0DB0"},"cor
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NM","gs:uplink:01FXMZ90502333RMD72XCC5B0Q","ns:uplink:01FXMZ9050E720JXQP2HKVDEEE","rpc:/ttn.lorawan.v3.GsNs/HandleUplink:01
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d":"000013","tenant_id":"ttn","cluster_id":"ttn-eu1"}}}
v3/dasya-co2-001@ttn/devices/eui-70b3d54990564b35/up {"end_device_ids":{"device_id":"eui-70b3d54990564b35","application_ids
":{"application_id":"dasya-co2-001"},"dev_eui":"70B3D54990564B35","join_eui":"70B3D57ED003CEC0","dev_addr":"260B0DB0"},"cor
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NM","gs:uplink:01FXMZCW6SKVM0BXQ4ZP6741KH","ns:uplink:01FXMZCW6S9ZS3GZ6V69W57XPR","rpc:/ttn.lorawan.v3.GsNs/HandleUplink:01
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rk_ids":{"net_id":"000013","tenant_id":"ttn","cluster_id":"ttn-eu1"}}}
```

Integrations, webhooks, endpoints

We know how to move payloads around –

either big ones on non-constrained networks (e.g. Wi-Fi, LTE, 5G),

or minimized ones on constrained ones (LPWAN, LowPAN).

We still need the mechanism to parse and store those payloads.

A json from the LoRaWAN app server

v3/dasya-co2-001@ttn/devices/eui-70b3d54990564b35/up {"end_device_ids":{"device_id":"eui-70b3d54990564b35","application_ids":{"application_id":"dasya-co2-001"},"dev_eui":"70B3D54990564B35","join_eui":"70B3D57ED003CEC0","dev_addr":"260B0DB0"},"correlation_ids":["as:up:01FXQ33WZPWNGQ26QHZGACKK92","gs:conn:01FXHXCX0EC5EZKBMTC7FZB585","gs:up:host:01FXHXCY5T0N5R7J863FFH9MNM","gs:uplink:01FXQ33WS1ZK5X8B2Z0AQ6XFN4","ns:uplink:01FXQ33WS2C870ZNAZ5BA08QB3","rpc:/ttn.lorawan.v3.GsNs/HandleUplink:01FXQ33WS26TVAH4X618ZEM0ZR","rpc:/ttn.lorawan.v3.NsAs/HandleUplink:01FXQ33WZPMR92PX4SZRE46QX7"],"received_at":"2022-03-09T10:20:41.846775520Z","uplink_message":{"session_key_id":"AX7d4KdO0GgGq7h2+290/Q==","f_port":2,"f_cnt":19061,"frm_payload":"AgdkUBMU","rx_metadata":[{"gateway_ids":{"gateway_id":"dasya-purple-01","eui":"B827EBFFFE51B07E"},"timestamp":2786380707,"rssi":-22,"channel_rssi":-22,"snr":9.8,"location":{"latitude":55.65971490666779,"longitude":12.591437101364138,"altitude":30,"source":"SOURCE_REGISTRY"},"uplink_token":"Ch0KGwoPZGFzeWEtcHVycGxlLTAxEgi4J+v//lGwfhCjl9OwChoMCPn+oZEGEKi+ga4CILjp7YmM2Sc="}],"settings":{"data_rate":{"lora":{"bandwidth":125000,"spreading_factor":7}},"coding_rate":"4/5","frequency":"868100000","timestamp":2786380707},"received_at":"2022-03-09T10:20:41.634389195Z","consumed_airtime":"0.051456s","locations":{"user":{"latitude":55.659605433634624,"longitude":12.591425404814808,"altitude":30,"source":"SOURCE_REGISTRY"}},"network_ids":{"net_id":"000013","tenant_id":"ttn","cluster_id":"ttn-eu1"}}}

A json from the LoRaWAN app server


```
"received_at": "2022-03-09T11:43:14.310905856Z",
"uplink_message": {
  "session_key_id": "AX7d4KdO0GgGq7h2+290/Q==",
  "f_port": 2,
  "f_cnt": 19100,
  "frm_payload": "AepkThLr",
  "rx_metadata": [
    {
      "gateway_ids": {
        "gateway_id": "dasya-purple-01",
        "eui": "B827EBFFFE51B07E"
      },
      "timestamp": 3443866836,
      "rssi": -20,
      "channel_rssi": -20,
      "snr": 8.8,
      "location": {
        "latitude": 55.65971490666779,
        "longitude": 12.591437101364138,
        "altitude": 30,
        "source": "SOURCE_REGISTRY"
      },
      "uplink_token": "Ch0KGwoPZGFzeWEtcHVycGxlLTAxEgi4J+v//lGw
      "channel_index": 7
    }
  ],
  "settings": {
    "data_rate": {
      "lora": {
        "bandwidth": 125000,
```

Integrations, webhooks, endpoints

= lots of metadata &

a tiny payload: AgdkUBMU

which is base64 encoded (not encrypted!).

use script or tool to

decode to hex: 02 07 64 50 13 14

online tool: https://v2.cryptii.com/base64/hexadecimal

Integrations, webhooks, endpoints

Once we have the hex bytes

02 07 64 50 13 14

we of course need to understand

what these bytes meant.

Decoders

Decoders may reside on the application server or on a receiving **endpoint**.

Webhooks are **URLs** to such **endpoints**.

Decoders by sensor companies, e.g. decentlab

master ▾ **decentlab-decoders** / **DL-CTD10** /

decentlab JavaScript, Docksters: do not add unit if not available (pub)

..

DL-CTD10.Docksters.json	JavaScript, Docksters: do not add unit if not available (pub)
DL-CTD10.ELEMENT-IoT.ex	remove empty unit defs (pub)
DL-CTD10.cs	remove empty unit defs (pub)
DL-CTD10.erl	erlang: fix typo (pub)
DL-CTD10.ex	remove empty unit defs (pub)
DL-CTD10.js	JavaScript, Docksters: do not add unit if not available (pub)
DL-CTD10.lua	Improve display names (pub)
DL-CTD10.php	remove empty unit defs (pub)
DL-CTD10.py	remove empty unit defs (pub)

source: https://github.com/decentlab/decentlab-decoders/tree/master/DL-CTD10

Summary: Integrations

A vast choice of integrations, connectors, decoders, libraries, APIs ...

Main challenge is to keep the overview :)

TIG stack

One possible and popular option – the TIG Stack

	with alternatives
Telegraf	Node-Red, any scripting language
InfluxDB	SQL Dbs (any) Timeseries DBs: Timescale, Prometheus, ElasticSearch
Grafana	plain text, custom formats Kibana, Tableau, Power BI, ...

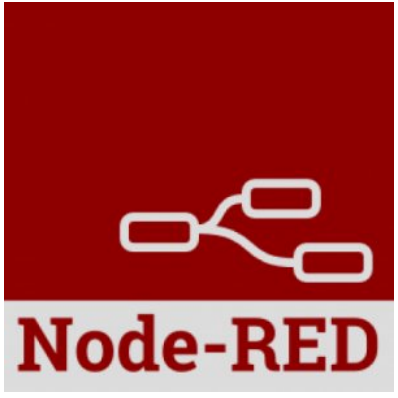
Node-RED /1

Node-RED is a

graphical tool for wiring together

hardware devices, APIs and online services

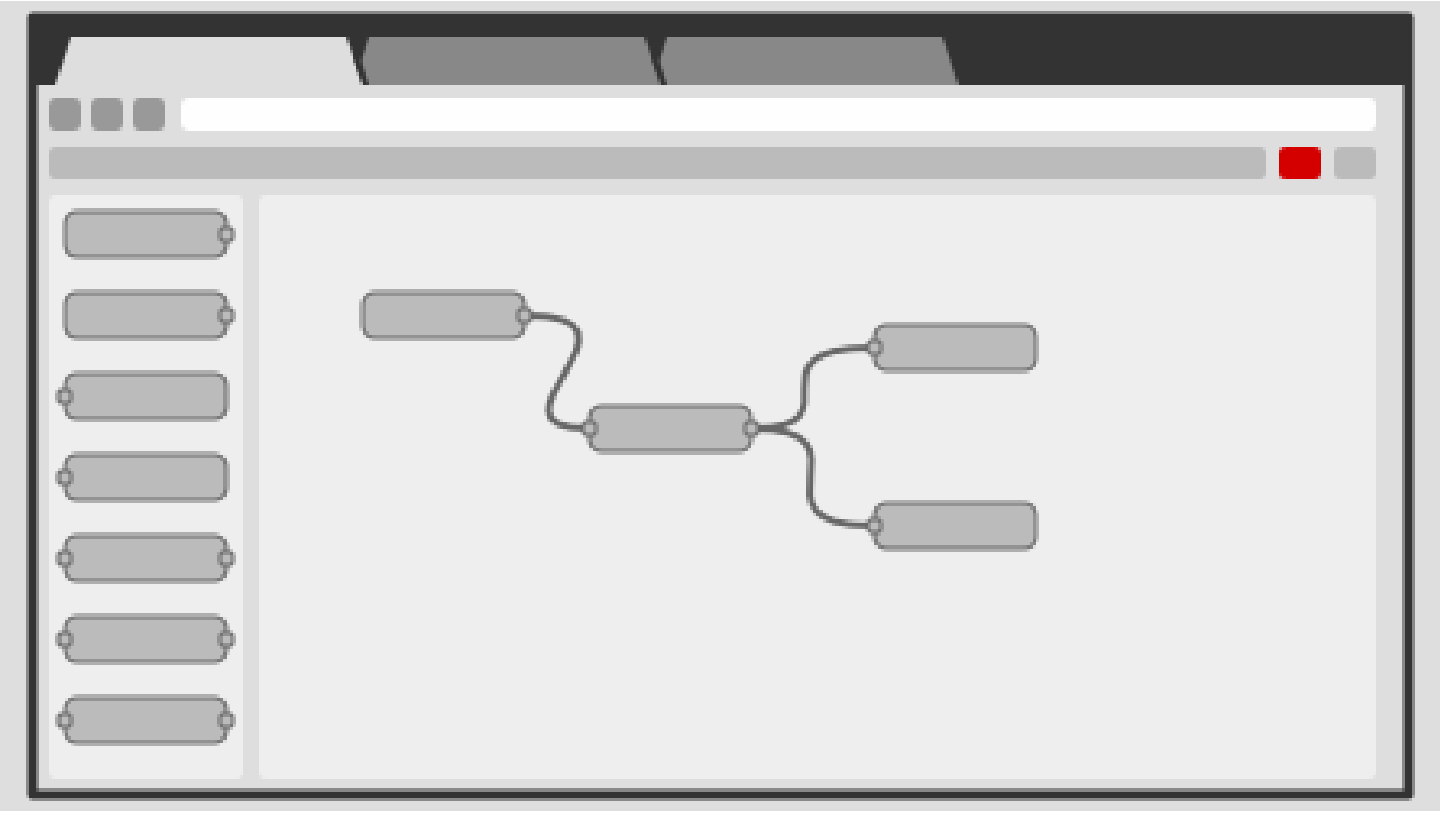
in new and interesting ways.



It provides a **browser-based editor** that makes it easy to wire together **flows** using the wide range of **nodes** in the **palette** that can be deployed to its runtime in a single-click.

Built on **Node.js**

Node-RED /2 principle



nodes ..... **flows**

Node-RED /3 nodes

Examples of existing nodes:

Input/Output: tcp, udp, http, mqtt, ttn, ...

debug, status, inject, link, trigger

Functions: logic, analytics

Storage: e.g. databases

Social: e.g. tweet, mail

You can write your own nodes!

It is a bit like a DJs patchbay.

Node-RED /4 node config

Nodes are configured by double-clicking and editing the necessary info,

e.g.

MQTT topics,

http URLs,

TheThingsNetwork applications and security keys

Node-RED /5 adding nodes

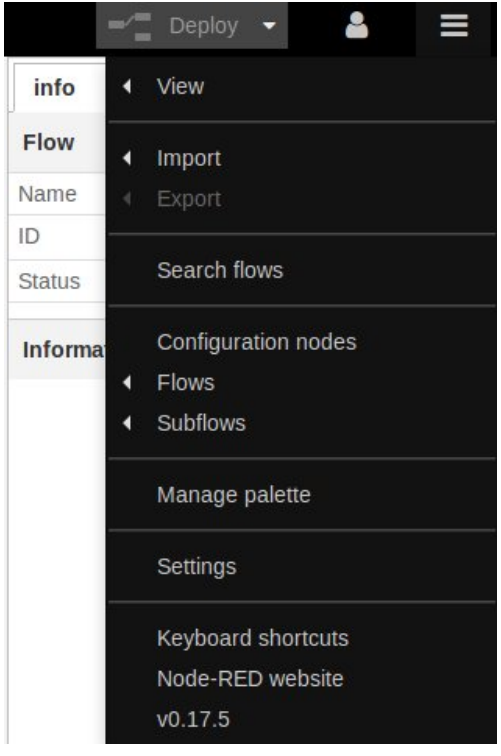
You may add nodes, e.g. the ttn node,

https://flows.nodered.org/node/node-red-contrib-ttn

via the command line, like so:

$ npm install node-red-contrib-ttn

Or you can go to the node-RED menu ==>

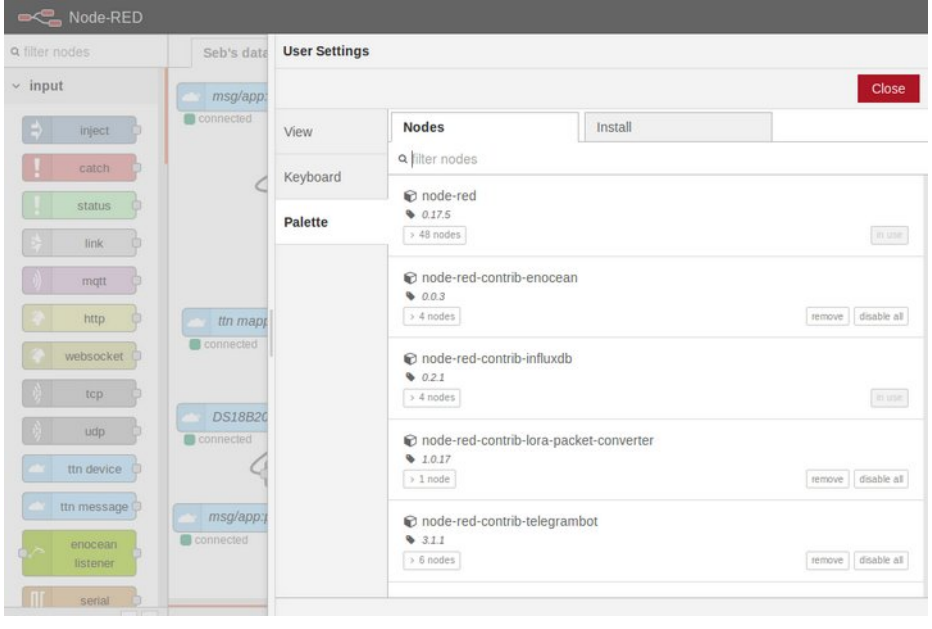


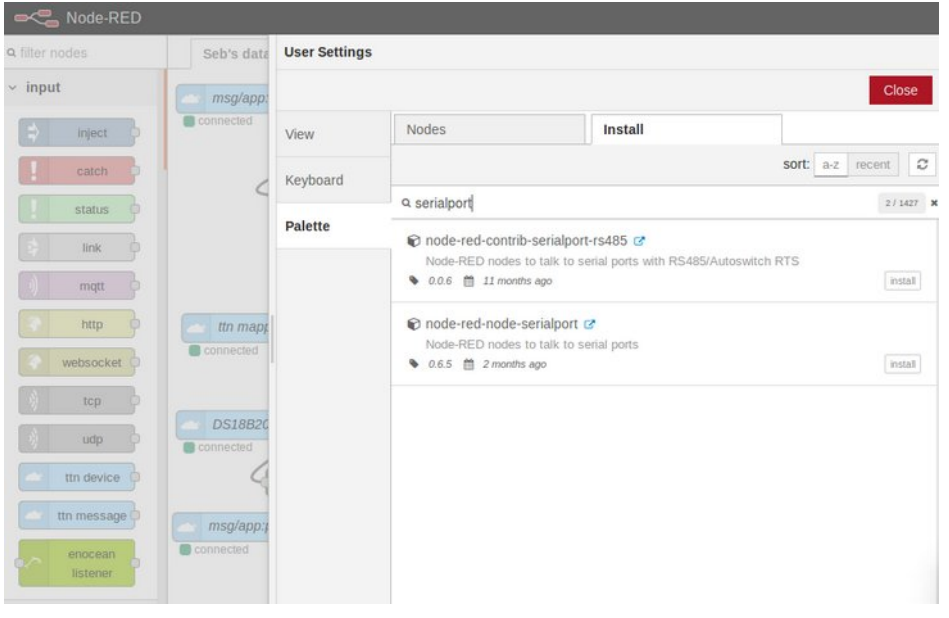
and then ...

Node-RED /6 adding nodes

Use the palette manager to find and install new nodes, in this example,

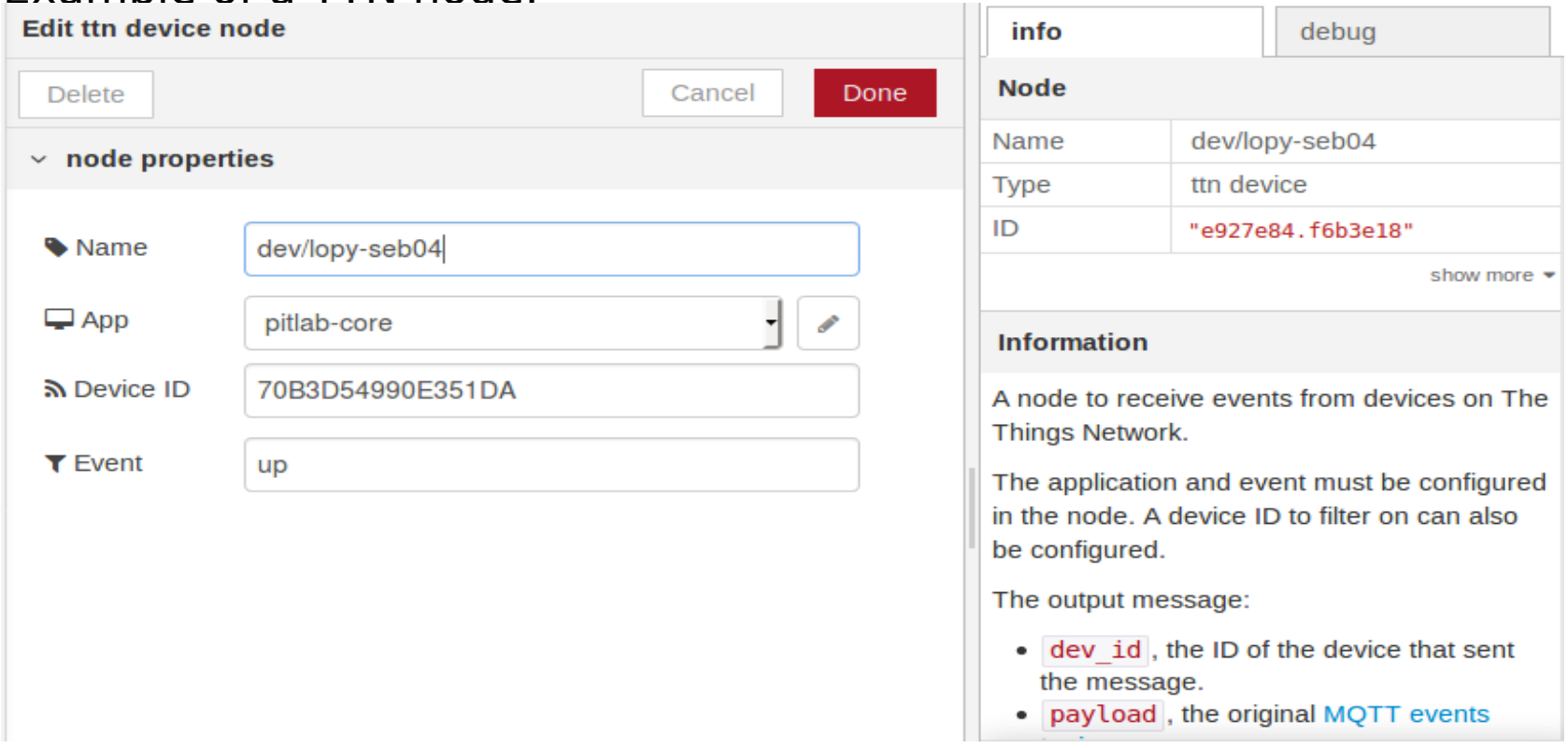
A serial port node to read direct input over USB serial





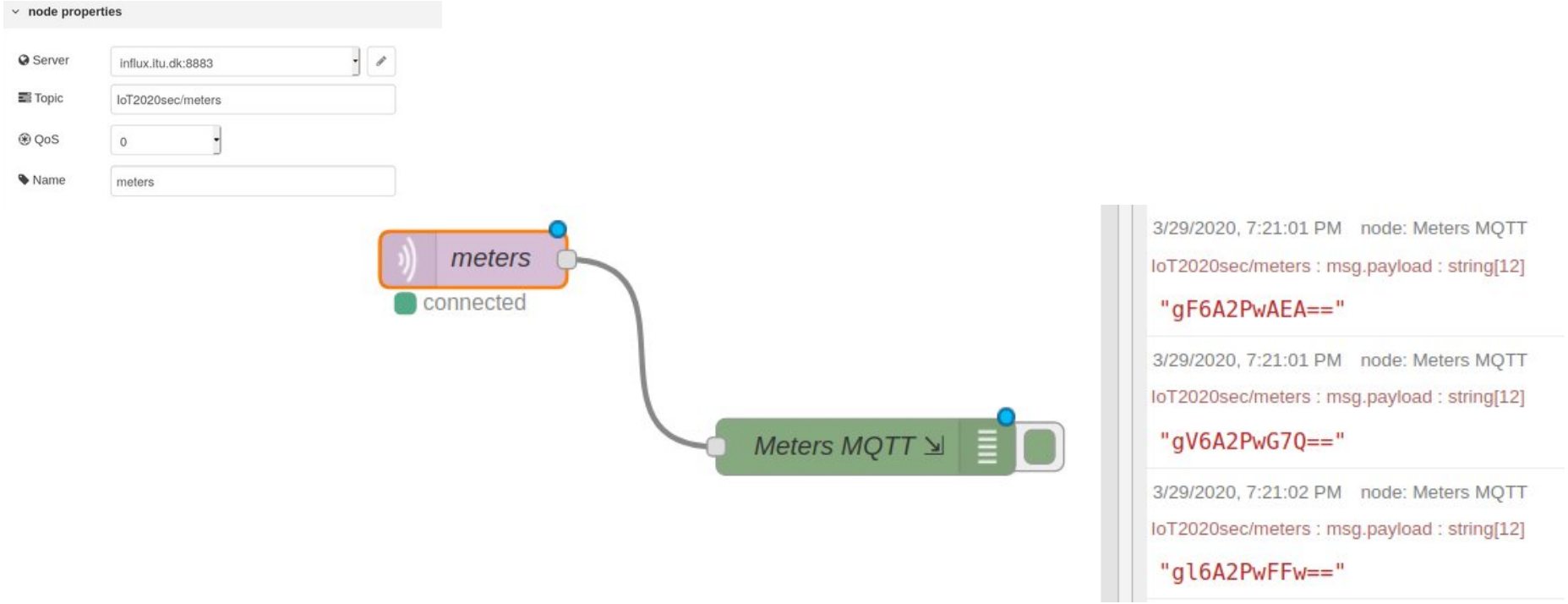
Node-RED /7 node config ttn

Example of a TTN node:

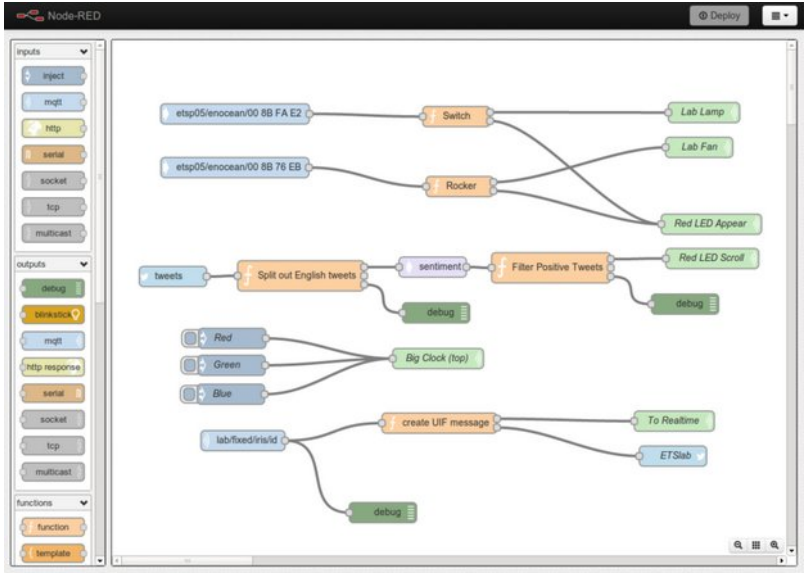


Node-RED /8 node config MQTT

Example of a MQTT node



Node-RED /9 flows



Flows are combinations of

inputs, outputs, connections,

Actions, etc

which you can share and reuse.

e.g. receive sensor messages,

do calculations on the values, keep averages or deltas, put them in a database, trigger an actuator,

and inform the owner via messages.

Node-RED /10 text

While this is a graphical tool,

behind the scenes it s all text files

which you can access via shell, edit, export, import, ...

Node-RED /11 Try it!

Local install (best! requires nodejs)

or

free IBM instance

or

training.itu.dk (ask for access!)

Telegraf /1

Alternative to Node-Red:

Telegraf “is a popular open-source agent for collecting, processing, aggregating, and sending metrics and events to various monitoring systems. Telegraf is widely used and highly configurable.”

`[ChatGPT, https://chat.openai.com/c/31d15754-ed89-4e81-8b74-324cbf0af5be prompt: “what are alternatives to telegraf?” 20240306`

Large library of plugins (100+) for data collection.

Telegraf /2 Configuration

```
[agent]
hostname = "localhost"
flush_interval = "15s"
interval = "15s"
[[inputs.mqtt_consumer]]
servers = ["tcp://eu.thethings.network:1883"]
qos = 0
connection_timeout = "30s"
topics = [ "+/devices/+/up" ]
client_id = ""
username = "your application name"
password = "ha! not gonna tell you"
data_format = "json"
[[outputs.influxdb]]
database = "your database"
urls = [ "http://localhost:8086" ]
```

Ingestion, custom /1

Any modern scripting or programming language

has the integrations, libraries etc

needed to connect -

e.g.

In: http, MQTT in

Out: to database.

python:

- MQTT paho-mqtt **https://pypi.org/project/paho-mqtt/**
- influxdb **https://github.com/influxdata/influxdb-client-python**

Time Series Databases (TSDB) /0

Time Series Databases are a form of NoSQL databases, non-relational databases

though in fact many are very near-SQL

Time Series Databases (TSDB) /1

Time series databases are different from relational databases -

Note the benefits, but also fundamental trade-offs!

- Schema-less: no definition of "table" schemes - just write! Any *write* creates a “table”
- Like an SQL database table where the primary key is pre-set by the system and is always time.
- Time stores timestamps, in RFC3339 UTC, precision might vary
- Time is assumed to be ascending – and only ascending!
- Time series data is predominantly new data that is never updated. UPDATE and DELETE are very limited / impossible.

Time Series Databases (TSDB) /1

How time series databases are different from relational databases:

- To simplify conflict resolution and increase write performance, data sent multiple times is seen as duplicate data. Identical points aren’t stored twice.
  - If temperature at 15:00 is 21 degrees, it s not 23 degrees!
- Provide time specific functions, such as now()
  - SELECT * FROM "meters" WHERE time > now() - 1h

NoSQL – Timeseries - InfluxDB

InfluxDB

- Time Series database
- “time” is a special value, has special meaning
- Applies special logic to “time”

SMART!

MySQL

- Generic relational database
- “time” is a generic data value
- Doesn’t apply special logic

DUMB!

https://www.slideshare.net/PhilipWernersbach/grafana-and-mysql-benefits-and-challenges

InfluxDB

"SELECT count(bar1) FROM foo
WHERE bar1 > 0 AND bar2 > 0 AND
time > now() - 7d GROUP BY time(1h)"

https://www.slideshare.net/PhilipWernersbach/grafana-and-mysql-benefits-and-challenges

MySQL

```
"SELECT time, count(bar1) FROM foo
WHERE bar1 > 0 AND bar2 > 0 AND
time > NOW(6) - INTERVAL 7 DAY
GROUP BY YEAR(time), MONTH(time),
DAY(time), HOUR(time) ORDER BY time
ASC"
```

https://www.slideshare.net/PhilipWernersbach/grafana-and-mysql-benefits-and-challenges

InfluxQL != SQL

- InfluxQL is SQL-like, but different enough that it can't be passed through to MySQL

https://www.slideshare.net/PhilipWernersbach/grafana-and-mysql-benefits-and-challenges

NoSQL – Timeseries - InfluxDB

- “time” is SELECT’d automatically implicitly in InfluxDB
  - “SELECT bar FROM foo” → “SELECT time, bar FROM FOO”
- GROUP’ing on “time” is smart in InfluxDB, and dumb in MySQL
  - See slides 16 and 17
- “time” in epoch format with millisecond precision is a float in MySQL
  - “FROM UNIXTIME(1444667802.145)”

https://www.slideshare.net/PhilipWernersbach/grafana-and-mysql-benefits-and-challenges

NoSQL – Timeseries – InfluxDB: v1 vs v2

Note that the previous comments refer to InfluxQL,

which – while still available in InfluxDB v2 for backwards compatibility – is being replaced by the Flux scripting language for data query, and classical SQL is offered as an alternative.*

https://docs.influxdata.com/influxdb/v2.1/query-data/

~~*At the time of writing (March 2022), ITU InfluxDB instances are still v1.*~~

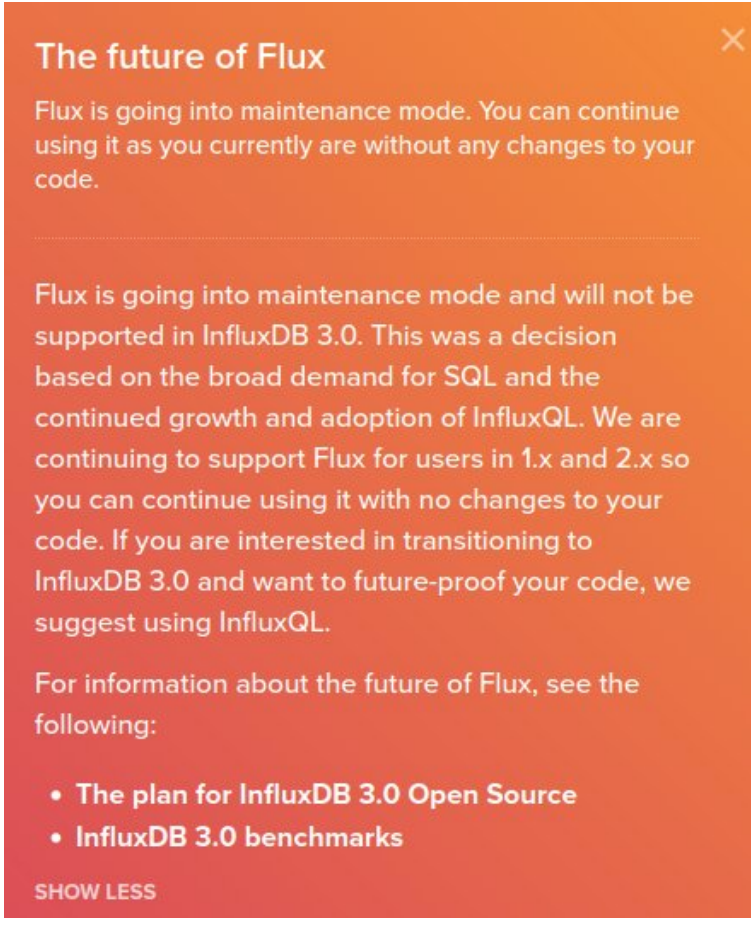
At the time of writing (March 2024), ITU InfluxDB runs v 2.7.

Documentation: https://docs.influxdata.com/influxdb/v2/

NoSQL – Timeseries – InfluxDB: v1 vs v2 vs v3

** … is being replaced by the Flux scripting language*

or so we thought :) … announcement 2023: →



The future of Flux

Flux is going into maintenance mode. You can continue using it as you currently are without any changes to your code.

Flux is going into maintenance mode and will not be supported in InfluxDB 3.0. This was a decision based on the broad demand for SQL and the continued growth and adoption of InfluxQL. We are continuing to support Flux for users in 1.x and 2.x so you can continue using it with no changes to your code. If you are interested in transitioning to InfluxDB 3.0 and want to future-proof your code, we suggest using InfluxQL.

For information about the future of Flux, see the following:

- **The plan for InfluxDB 3.0 Open Source**
- **InfluxDB 3.0 benchmarks**

SHOW LESS

Time Series Databases (TSDB) /2

Popular TSDBs:

- InfluxDB

  near-SQL
- Cassandra

  Mozilla
- Timescale
  - Postgres-based, extension to SQL
- Prometheus

In what follows, we focus on InfluxDB as example.

Time Series Databases (TSDB) /3

Comparison/Choice of TSDBs:

- Often, choices tend to be culturally determined rather than tech-driven
- Depending on choice, you will model data in different ways
    - Example: room booking – how is this best represented?

- Integration with analytics / machine learning concerns may be a determining factor

Time Series Databases (TSDB) /4

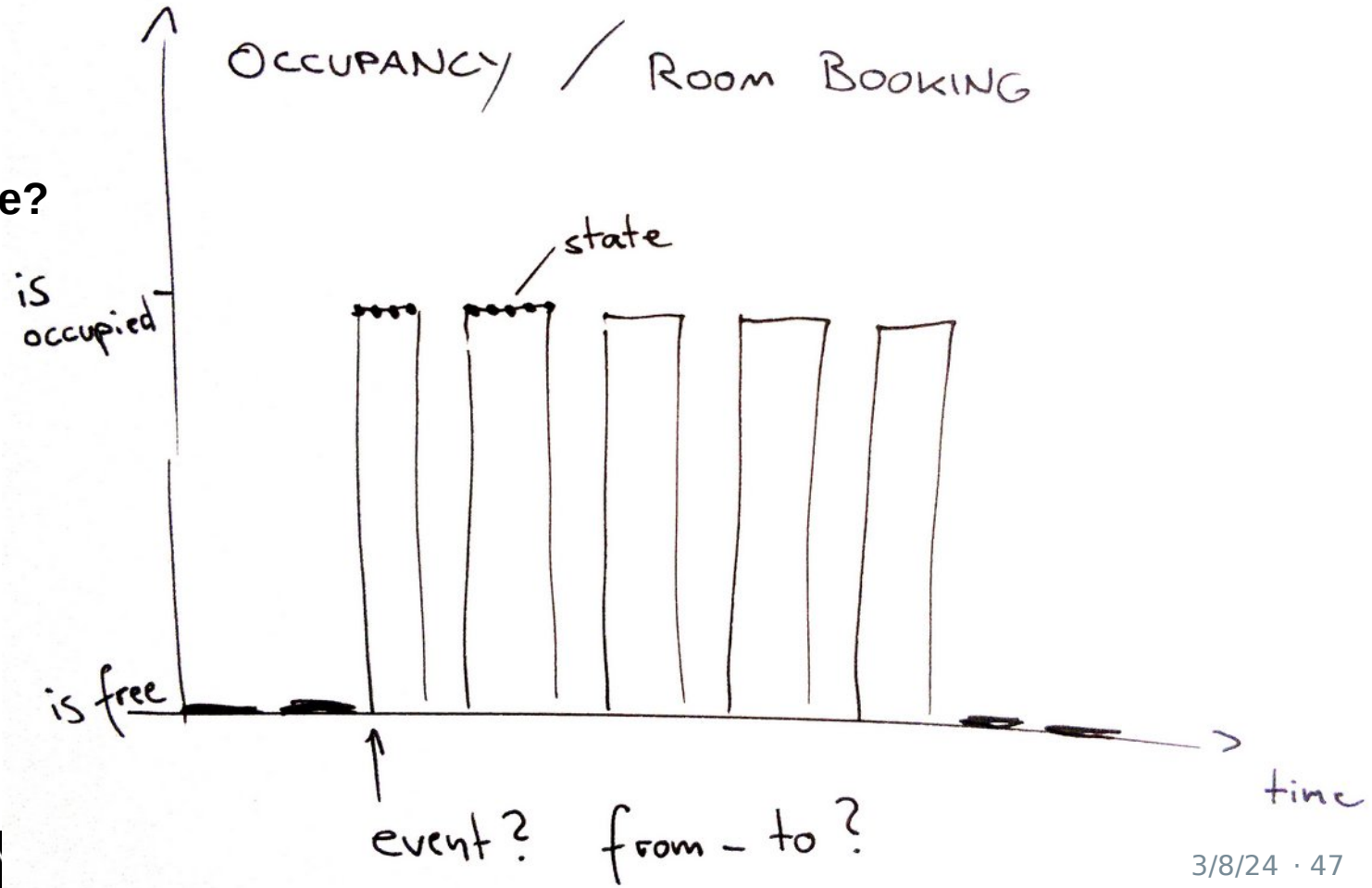
Example:

prioritize

… performance?

… data size?

… structure?



InfluxDB /1

InfluxDB is an **open-source time series database** developed by InfluxData.

It is written in **Go** and optimized for fast, high-availability storage and retrieval of time series data in fields such as operations monitoring, application metrics, **Internet of Things sensor data**, and real-time analytics.

Open Source: Each component (except for some ...) of the InfluxData platform or TIG Stack is on github and available via a simple download.

The company Influxdata is venture funded.

InfluxDB /2

SQL-like language with builtin **time-centric** functions for querying a data structure composed of measurements, series, and points.

Each point consists of several **key-value pairs** called the fieldset and a **timestamp.** When grouped together by a set of key-value pairs called the tagset, these define a series. Finally, series are grouped together by a string identifier to form a **measurement.**

```
measurement(,tag_key=tag_val)* field_key=field_val(,field_key_n=field_value_n)*
(nanoseconds-timestamp)
```

Values can be 64-bit integers, 64-bit floating points, strings, and booleans.

InfluxDB /3

Main differences to a classical SQL database or NoSQL database:

It s for **time series** - nothing else!

A "table" (called measurement here) has 2 “columns”, not more *:

a **timestamp** and the **value** for that point in time.

(You can add optional “tags” to create some structure).

You would not keep an address database or such in InfluxDB.

* it s actually possible, but not advised to do so: https://stackoverflow.com/questions/45368535/influxdb-single-or-multiple-measurement#45545405

InfluxDB /4 terminology in-depth

Relational	vs	TSDB
database		database / “bucket”
table		measurement
index		tag key
column		field key (or tag)
		field key - field value
row		points
		data record = a set of
		timestamp, field key, field tag and values
		series: all data within one measurement
		sharing the same tag set

InfluxDB /5 tags

Tags are optional.

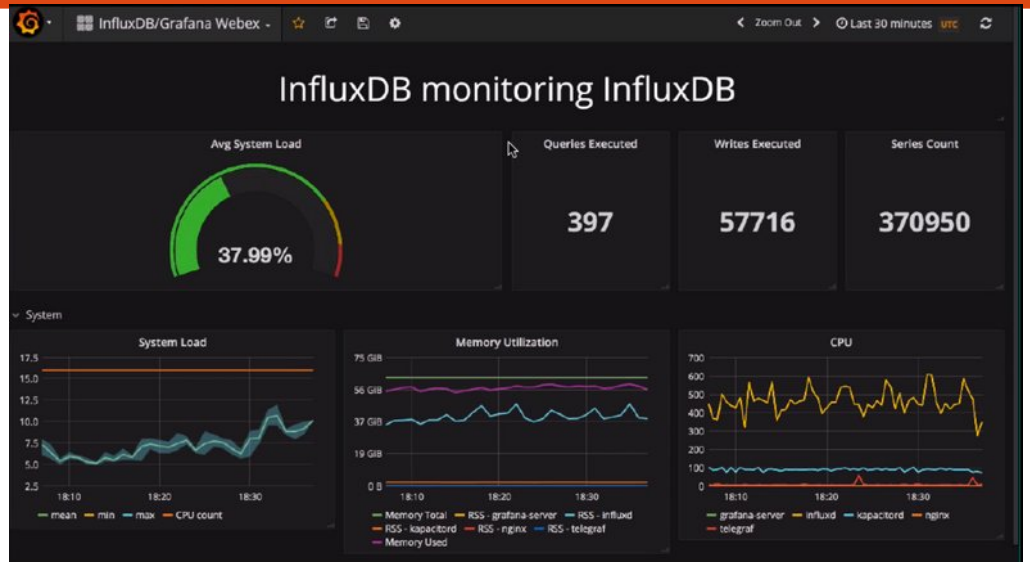
You don’t need to have tags in your data structure, but it’s generally a good idea to make use of them because, unlike fields, tags are indexed.

This means that queries on tags are faster and that tags are ideal for storing commonly-queried metadata.

Properties that you often query for should best be tags:

e.g. all values for meter with ID=3, all sensors from room=3A52

InfluxDB /5.a example




```
adeunis_sb
adeunismapper
> select * from adeunismapper
name: adeunismapper
time                RSSI_DL SF       SNR_DL application   counter geohash   lat              lon               name
----                ------- --       ------ -----------   ------- -------   ---              ---               ----
1567082773119995678 -47     SF7BW125 7      adeunismapper 16      gcmzu7j54 53.410583333333335 -2.9703333333333335 adeunisarf8123aa
1567082775811795699 -54     SF7BW125 7      adeunismapper 17      gcmzu7j54 53.410583333333335 -2.9703333333333335 adeunisarf8123aa
1567082778335478066 -57     SF7BW125 7      adeunismapper 18      gcmzu7j54 53.41056666666667  -2.9703333333333335 adeunisarf8123aa
1567082782067048465 -57     SF7BW125 7      adeunismapper 18      gcmzu7j54 53.41056666666667  -2.9703333333333335 adeunisarf8123aa
1567082785251096765 -55     SF7BW125 8      adeunismapper 19      gcmzu7j5n 53.41055           -2.9701666666666666 adeunisarf8123aa
```

InfluxDB /6 additionals

aggregations	time-specific, such as medians, averages, etc
batches	batches of points, for mass processing
retention	how long we are keeping data
	InfluxDB automatically creates the autogen retention policy with an infinite duration, replication factor = 1

```
> SHOW RETENTION POLICIES
name    duration shardGroupDuration replicaN default
----    -------- ------------------ -------- -------
autogen 0s       168h0m0s           1        true
```

InfluxDB /8 shard

A **shard** contains the actual encoded and compressed data, and is represented by a TSM file on disk.

Every shard belongs to one and only one shard group. Multiple shards may exist in a single shard group. Each shard contains a specific set of series.

The default shard is one week of data.

TSM = Time structures merge tree

Details on TSM, storage:

https://docs.influxdata.com/influxdb/v1.7/concepts/storage_engine/

InfluxDB /9 structure on disk

```
root@influxus:/var/lib/influxdb/data/plantower# tree
.
├── autogen
│   ├── 716
│   │   ├── 000000004-000000002.tsm
│   │   └── fields.idx
│   ├── 725
│   │   ├── 000000001-000000001.tsm
│   │   └── fields.idx
│   ├── 737
│   │   ├── 000000001-000000001.tsm
│   │   └── fields.idx
│   ├── 749
│   │   ├── 000000005-000000002.tsm
│   │   └── fields.idx
│   ├── 762
..
└── _series
    ├── 00
    │   └── 0000
    ├── 01
    │   └── 0000
    ├── 02
    │   └── 0000
    ├── 03
    │   └── 0000
    ├── 04
    │   └── 0000
    ├── 05
    │   └── 0000
```

InfluxDB /10 surprises!

you will encounter surprises! (at least I did …):

“Disappearing” of data

You **can not store more than one point** with the same timestamp in a series! Assumption: if the same data is sent multiple times, it is the exact same data that a client just sent several times.

PRO no conflicts, ever!

CON you ll have to separate (tag) to store multiple

Deleting and updating is hard! only whole series, shards

InfluxDB /11 look inside: v1 shell: show databases

```
InfluxDB shell 0.10.0
> show databases
name: databases
---------------
name
_internal
pit001
pit002
pit003
```

InfluxDB /12 look inside: v1 shell: show measurements

```
> use pit001
Using database pit001
> show measurements
name: measurements
------------------
name
003-01-light
003-01-moist
003-01-temp
003-02-light
```

InfluxDB /13 look inside: v1 shell: select

```
> select * from "004-01-temp"

1525096049108783758 50
1525096124247923458 49
1525096199476486703 49
1525096274435089220 50
1525096349502370874 50
1525096424982100010 50
1525096499794455963 49
```

InfluxDB /14 look inside: v1 shell: create database

```
>   CREATE DATABASE meters
>   CREATE USER smartie WITH PASSWORD 'youWish'
>   GRANT ALL ON meters TO smartie
```

InfluxDB /15 look inside: v1 shell

```
> select * from "meters-script" where "id"='0'
name: meters-script
time                fakeness id reading
----                -------- -- -------
1585471260000000000 8        0  850
1585471320000000000 8        0  845
1585471380000000000 8        0  272
1585471440000000000 8        0  165
1585471500000000000 8        0  302
```

InfluxDB /16 access

Typically, you would access data via network rather than direct -

InfluxDB accepts data via **HTTP, TCP, and UDP**.

For example you could connect from ....

Grafana /1

Visualizing, Monitoring, Analyzing, Querying, Alerting

As of right now, there are

41 data sources, 30 panels, 17 apps and 857 dashboards available. (2021! check now!)

Data sources include: influxDB, MySql, Postgres, Azure, ...

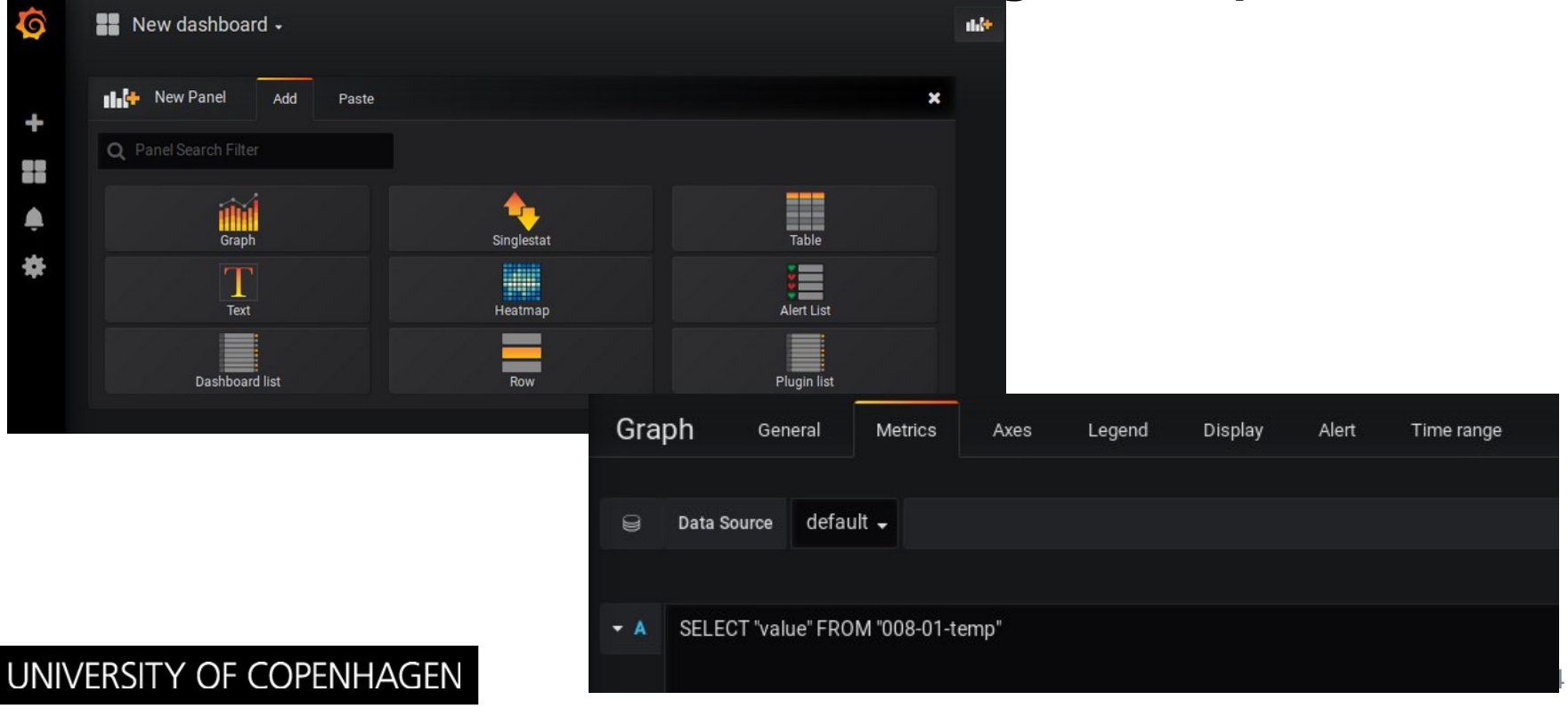
Grafana /2


Graphite
Cloudwatch
Prometheus
Elasticsearch
InfluxDB
Hosted Metrics
2017-3-9-13:13:00
329 °F
249 °F
2017-3-9-13:12:50
315 °F
315 °F
2017-3-9-13:12:40
270 °F
255 °F
2017-3-9-13:12:30
309 °F
232 °F
2017-3-9-13:12:20
228 °F
228 °F
57
78

Grafana /3

Dashboards, Graphs, Queries:

Setting up a new one is mainly click, drag and drop.



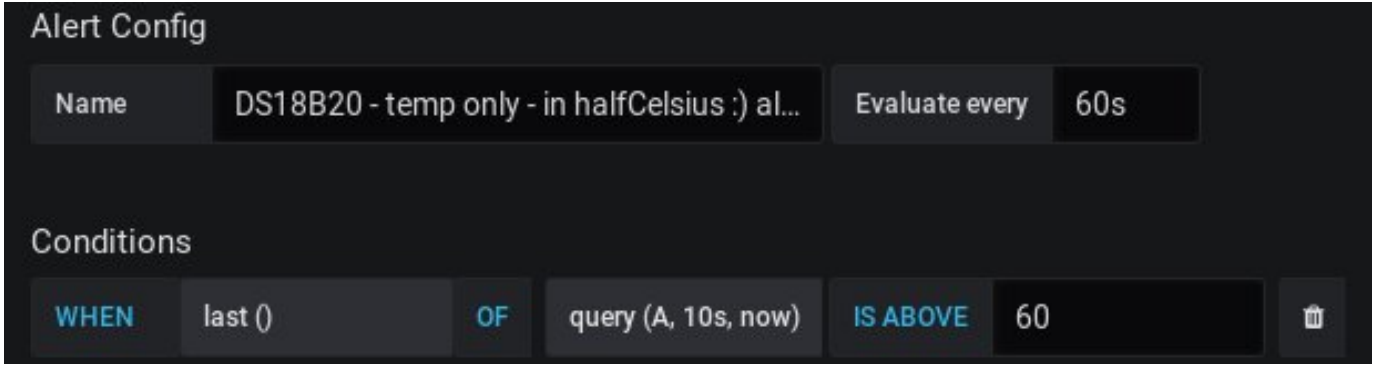
Grafana /4

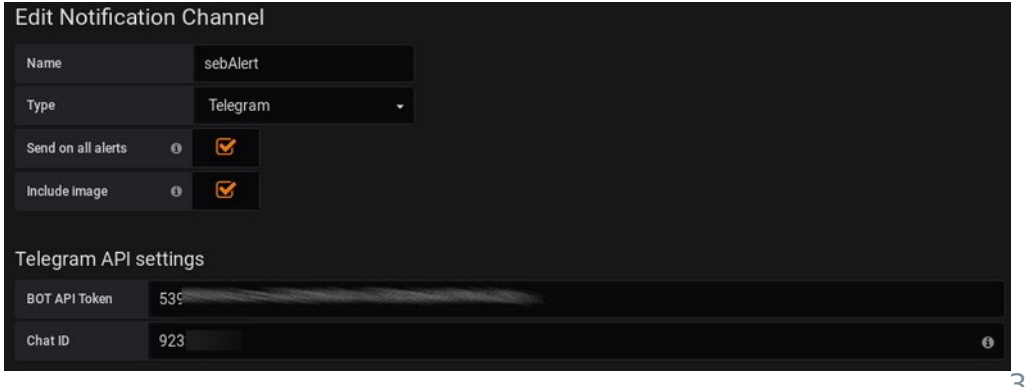
Alerts

let you define flexible alert conditions

and

may trigger



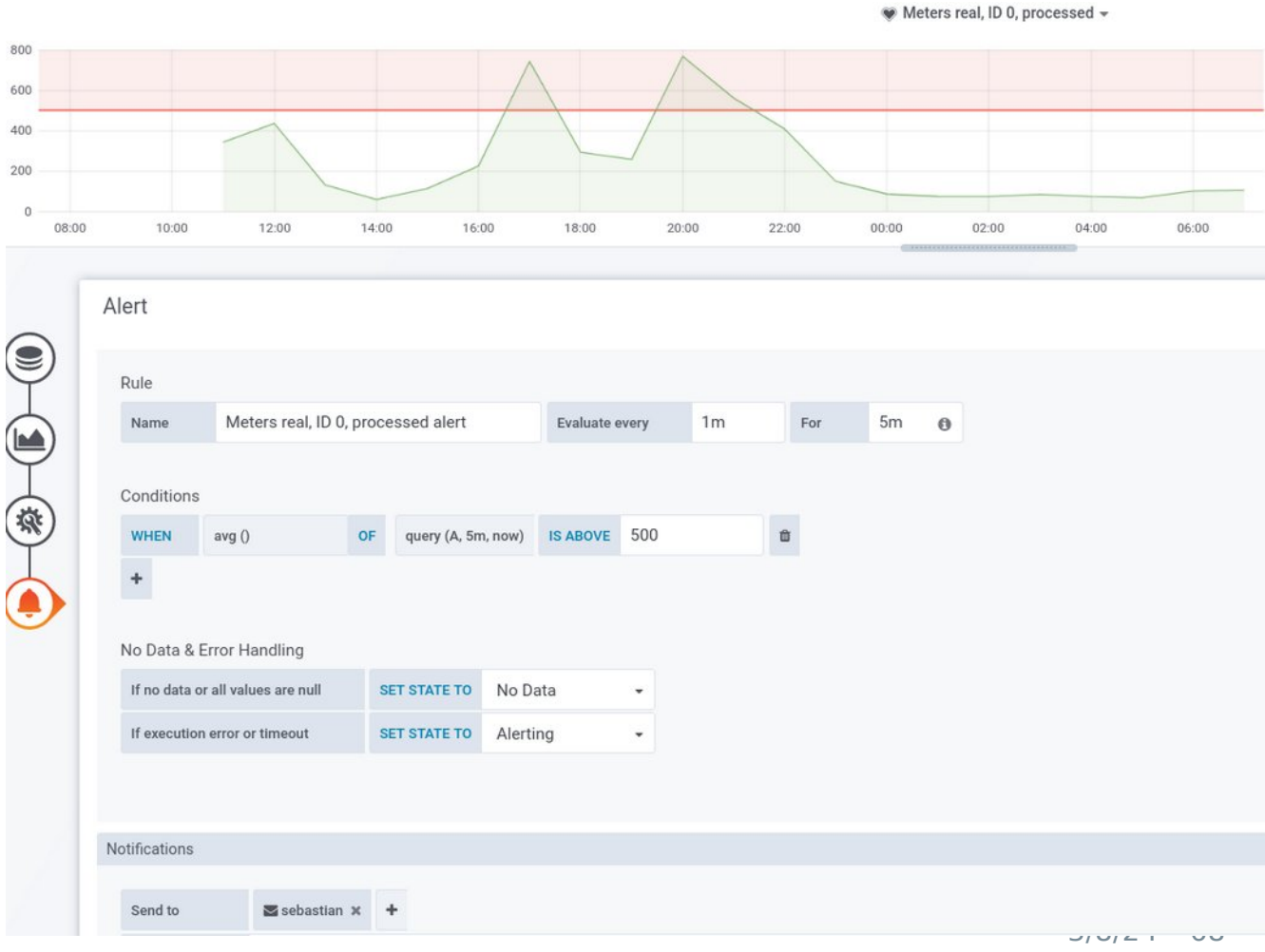


emails,

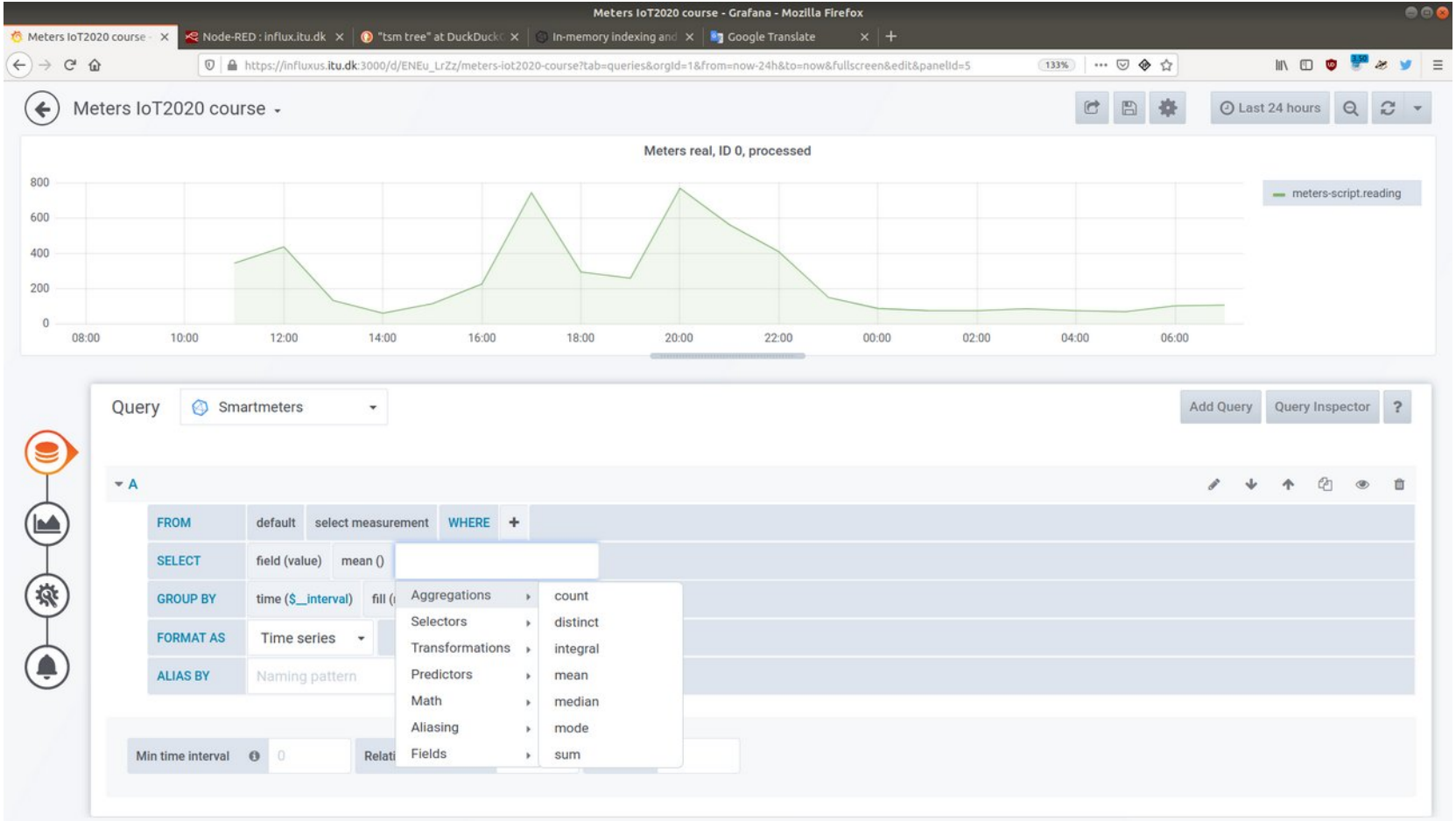
telegram messages,

slack messages, ...

Grafana /5 alerts



Grafana /6 aggregations, maths, predictions



Some concluding remarks

- Choices for interoperability and integrations are many … to the extent of being overwhelming.
- Challenge: long term management
- Practical challenge for this course/exercise:

  to deploy components like scripts/decoders in stable places.
- Your laptop is a great starting point, but likely not on public IP and not 24/7 available → cloud deployment

Take-aways

- Data transport
- Integrations, decoders, webhooks, endpoints
- Tools: TIG stack, node-red, ...
- Timeseries Databases and their special features
  - benefits / trade-offs
- Grafana as Data Visualizer