IoT Engineering
9: Dashboards and Apps for Sensor Data

Slides tmb.gr/iot-9

Overview

These slides introduce *sensor dashboards and apps*.

From hosted services and apps to "build your own".

How to move data and integrate with platforms.

Prerequisites

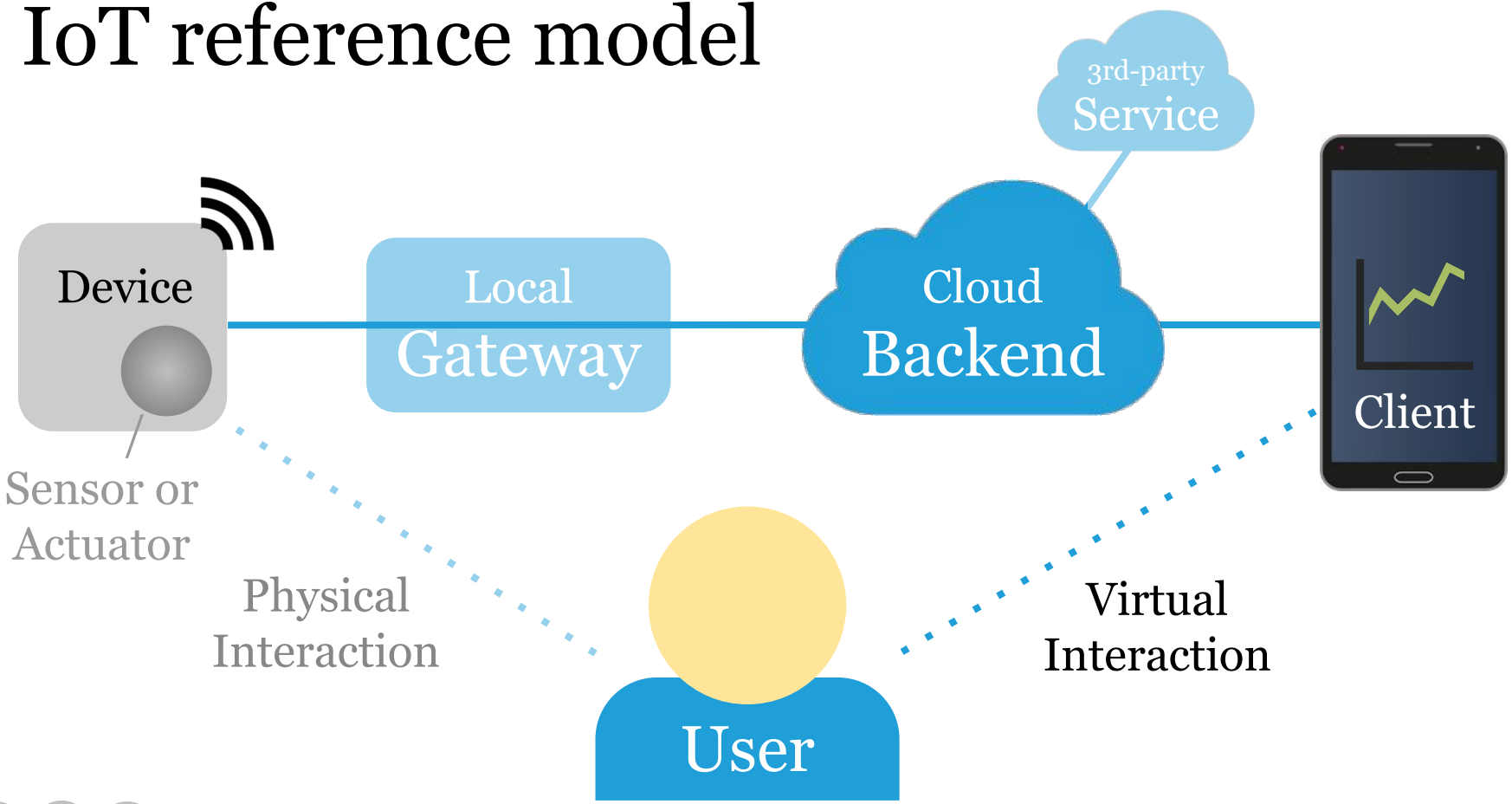
We use curl and the mqtt CLI tool to emulate devices.

The Raspberry Pi with Node.js will be our "backend".

Some examples require Docker on your computer.

Note: Docker part is still in beta, will be updated.

IoT reference model



Dashboards

Dashboard as a service — easy set up, but: dependency.

Self-hosted dashboard — keep control, but: operations.

Graph libraries — re-use, flexible, but: dev & ops work.

Build your own — max. control, but also max. work.

Dashboard as a service

Backend, defining data formats & information model.

Device-side backend API to get data in (HTTP/MQTT).

Data storage or caching functionality (sliding window).

Client-side API to get data out (HTTP or Websocket).

Private or public dashboard Web UI or client app.

Information model

The information model defines how data is structured.

It's the "common denominator" of all involved parties.

Data formats (on the wire) define how it's transported.

The information model is more about data semantics.

E.g. what is a device, what is a sensor measurement?

ThingSpeak

ThingSpeak timestamps, stores and displays data.

It supports per device *channels* with 1-N *fields* each.

Graph controls can be embedded in HTML Web UIs.

ThingSpeak provides HTTP and MQTT endpoints.

ThingSpeak HTTP API

ThingSpeak has a device- and client-side HTTP API.

```
Host: api.thingspeak.com
Port: 80 or 443
```

```
POST /update?key=WRITE_API_KEY&field1=42
```

```
GET /channels/CHANNEL_ID/feed.json?\
key=READ_API_KEY
```

ThingSpeak MQTT API

ThingSpeak has a device- and client-side MQTT API.

```
Host: mqtt.thingspeak.com
Port: 1883 or 8883 (or Websocket: 80, 443)

PUB -t 'channels/CHANNEL_ID/publish/\
WRITE_API_KEY' -m 'field1=42&field2=23'

SUB -t 'channels/CHANNEL_ID/subscribe/\
FORMAT/READ_API_KEY'
```

Uniontown Weather Data - Thi

https://thingspeak.com/channels/3

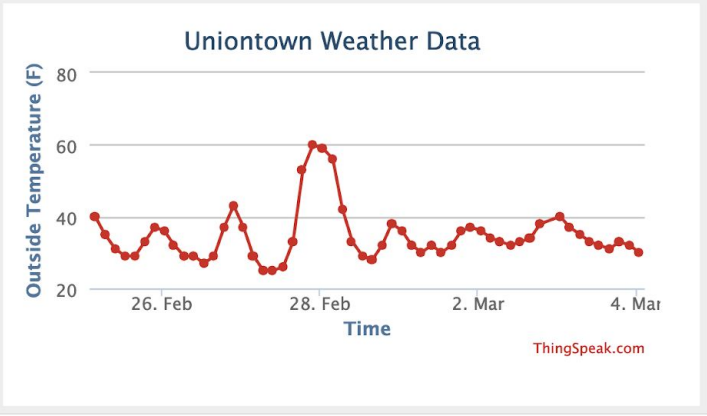
ThingSpeak™ Channels Apps Community Support How to Buy Sign In Sign Up

Uniontown Weather Data

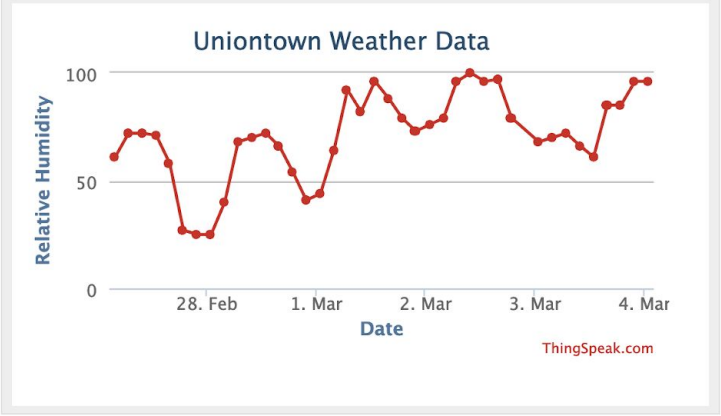
Channel ID: 3
Author: iothans
Access: Public

Weather data from Uniontown, PA
temperature, humidity, weather station, dew point, channel_3

Field 1 Chart



Field 2 Chart



Cayenne

Cayenne apps display data from any MQTT broker.

Per *thing* (device), multiple data *channels* are supported, with *type*, *unit* and *value* fields.

SDKs for ESP8266, Node.js, etc., simplify sending values, e.g. encoded in the CayenneLPP data format.

Cayenne also provides an MQTT broker endpoint.

Cayenne MQTT API

Cayenne specifies a device-side MQTT API and SDKs.

```
Host: mqtt.mydevices.com
Port: 1883 or 8883
```

```
PUB -t 'v1/MQTT_USER/things/DEVICE_ID/\
data/CHANNEL_ID' -m 'TYPE,UNIT=VALUE'
```

For details, see the Cayenne payload documentation, which is wrapped in device specific integrations.

Cayenne HTTP API

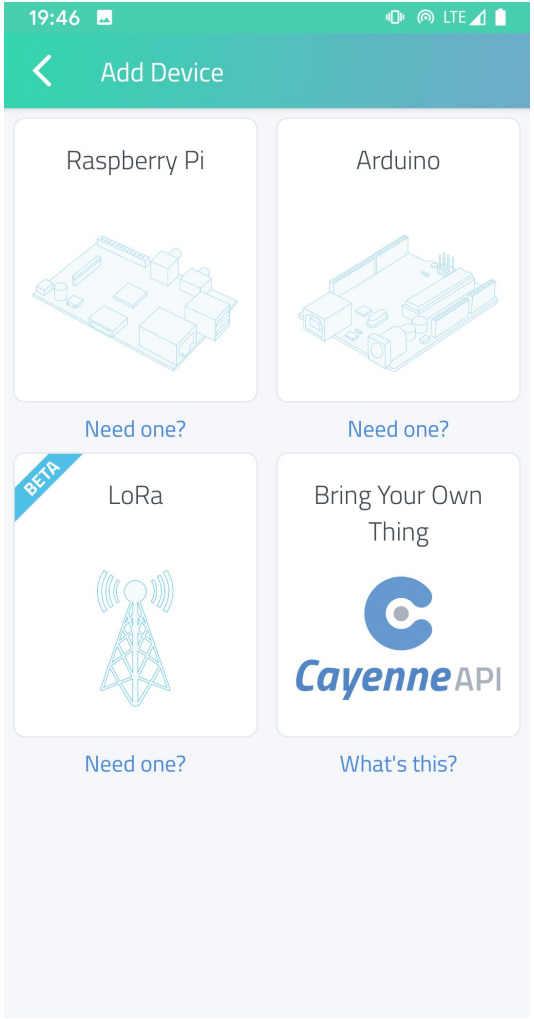
The Cayenne iOS and Android apps use an HTTP API.

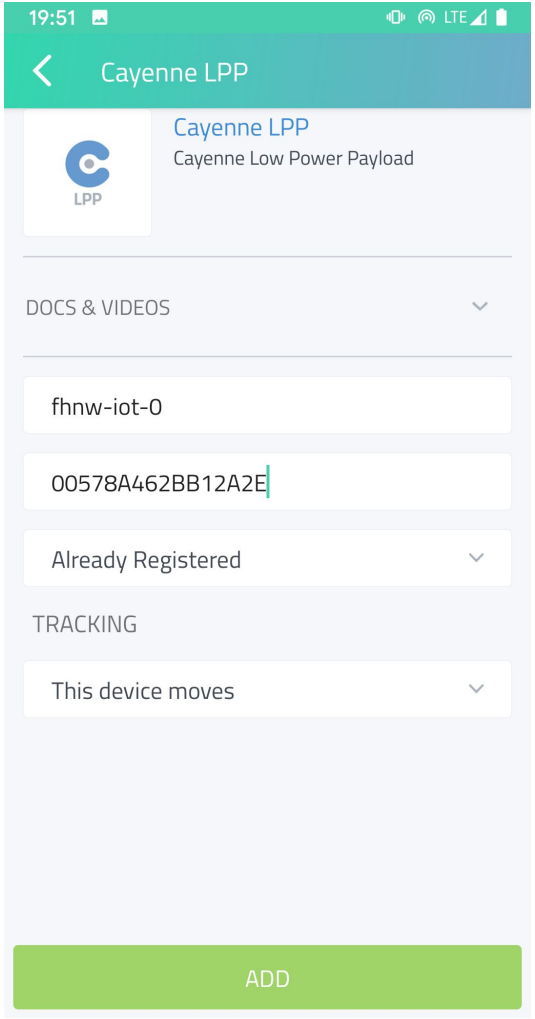
It enables device management, to set up devices/keys.

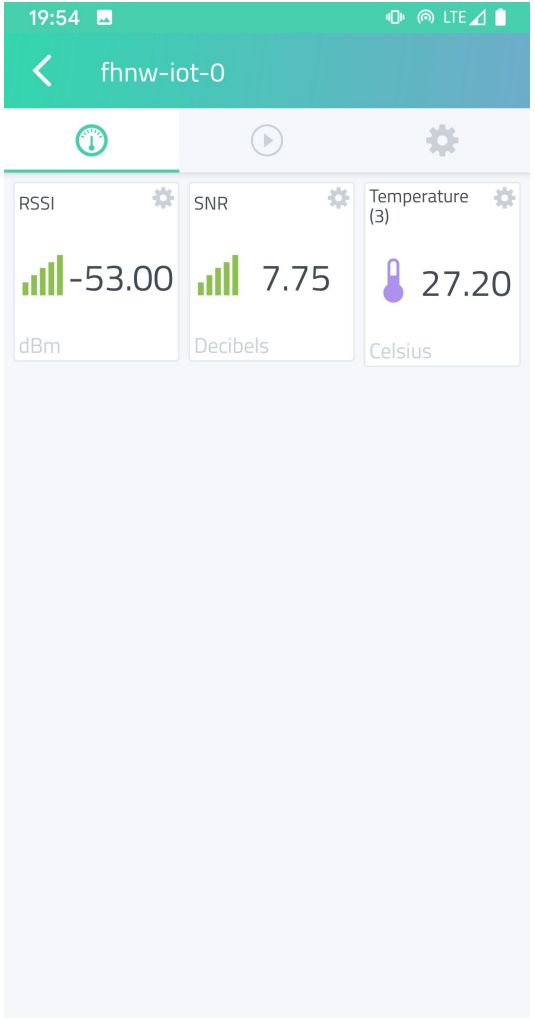
It is client-only, devices connect to the MQTT API.

As soon as data comes in, graphs are generated*.

*The data format includes types, units and values.


19:46
LTE
Add Device
Raspberry Pi
Need one?
Arduino
Need one?
BETA
LoRa
Need one?
Bring Your Own Thing
Cayenne API
What's this?


19:51
LTE
Cayenne LPP
LPP
Cayenne LPP
Cayenne Low Power Payload
DOCS & VIDEOS
fhnw-iot-0
00578A462BB12A2E
Already Registered
TRACKING
This device moves
ADD


19:54
LTE
fhnw-iot-0
RSSI
-53.00
dBm
SNR
7.75
Decibels
Temperature (3)
27.20
Celsius

Integrations

Integrations allow backend services to work together.

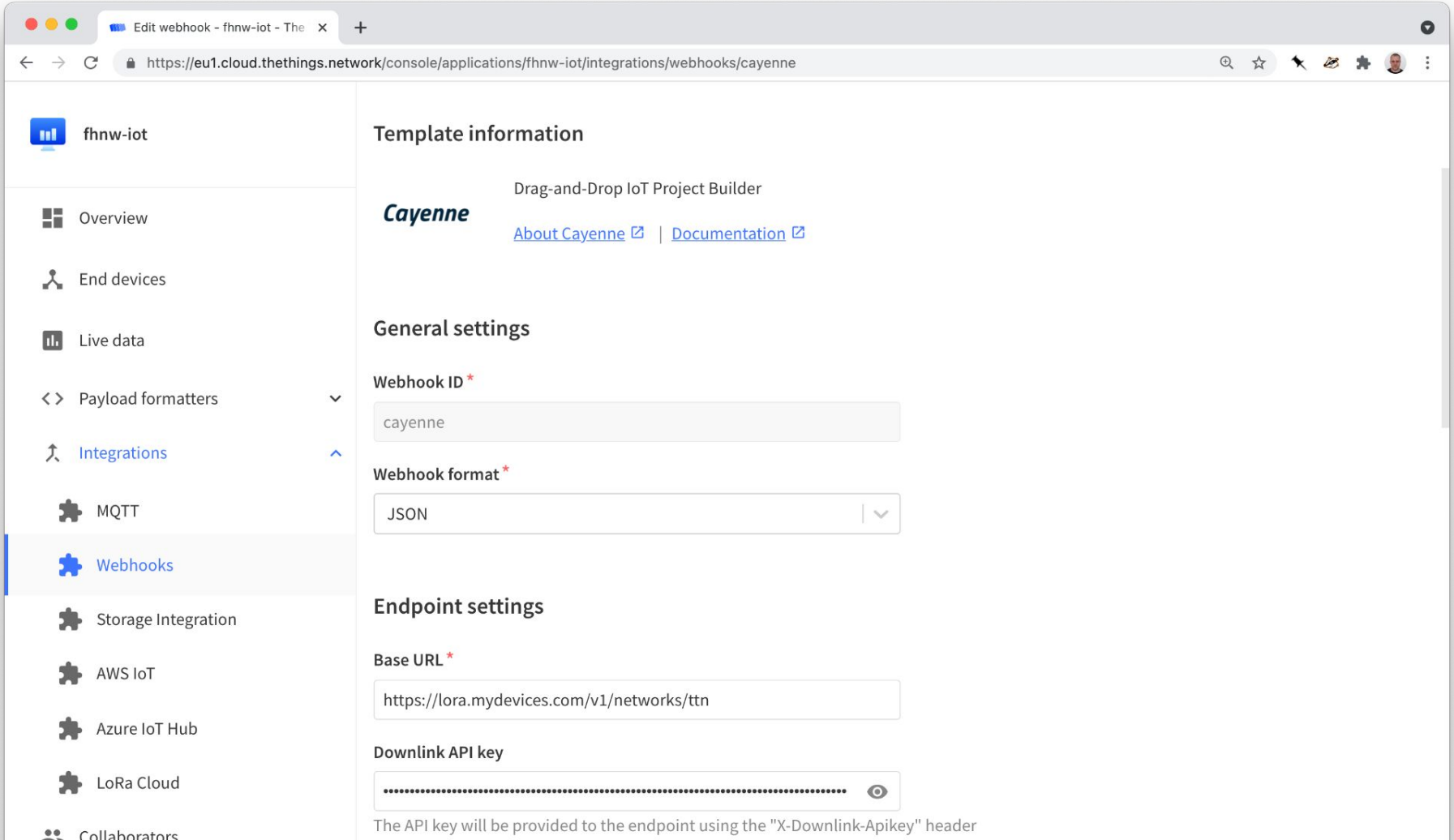
E.g. TTN backend integration w/ Cayenne MyDevices.

Integration adapters can be provided by either party.

The adapter code can be hosted on either backend*.

Settings include endpoint, format and API tokens.

*Or somewhere else, if you use custom glue code.


Edit webhook - fhnw-iot - The
https://eu1.cloud.thethings.network/console/applications/fhnw-iot/integrations/webhooks/cayenne
fhnw-iot
Overview
End devices
Live data
Payload formatters
Integrations
MQTT
Webhooks
Storage Integration
AWS IoT
Azure IoT Hub
LoRa Cloud
Collaborators
Template information
Cayenne
Drag-and-Drop IoT Project Builder
About Cayenne
Documentation
General settings
Webhook ID *
cayenne
Webhook format *
JSON
Endpoint settings
Base URL *
https://lora.mydevices.com/v1/networks/ttn
Downlink API key
The API key will be provided to the endpoint using the "X-Downlink-Apikey" header

Hands-on, 15': Dashboard as a service

Choose a dashboard service* and a transport protocol.

Check the API docs to understand the payload format.

Send data "as a device" with curl or with the mqtt CLI.

The CLI runs on the Raspberry Pi or on your laptop.

*Try ThingSpeak, Cayenne or ThingsBoard.io

Glue code

Glue code is a simple way to integrate service APIs.

A custom adapter acts as a client of both services, e.g. to get data from a LoRaWAN backend to a dashboard.

It converts payload formats, can be hosted anywhere.

Node.js glue code

.js[MQTT], .js[HTTP]

```
…
var client = new ttn.Client('eu', appId, key);
client.on('message', (devId, msg) => {
  var bytes = msg.payload_raw;
  var x = ((bytes[0] << 8) | bytes[1]) / 100.0;
  http.post('http://api.thingspeak.com/update?'
    +'api_key=' + writeApiKeys[msg.dev_id]
    + '&field1=' + x);
});
```

Serverless lambda functions

Serverless lambda functions are cloud hosted handlers.

Conceptually, a server is started for each Web request.

No resources are consumed between Web requests.

This execution model works well for glue code.

E.g. AWS Lambda, Azure Functions or Vercel.

Serverless Node.js with Vercel

Vercel provides hosting for serverless functions.

On you MacOS, Windows or Linux computer:

- Install *vercel* with `$ npm install -g vercel`
- Get examples `$ git clone https://github.com/\ vercel/vercel` then `$ cd /examples`
- Or use examples linked from the following pages
- Deploy with `$ vercel`

Serverless Node.js glue code .js

Creating a Web service in Node.js …

```
let server = http.createServer((req, res) => {
  res.end("200 OK");
};
```

… becomes exporting a handler in Vercel Node.js:

```
module.exports = (req, res) => {
  res.end("200 OK");
};
```

Hands-on, 15': Glue code

Configure the TTN to ThingSpeak adapter glue code.

Host the code serverless or on your laptop via a relay.

Use curl to simulate calls from the TTN backend:

```
$ curl -v http://HOST_OR_IP/ --data
'{"end_device_ids": {"device_id": "fhnw-iot-device-1",},
"uplink_message": {"frm_payload":"CPwQaA=="}}'
```

Self-hosted dashboard

A self-hosted dashboard backend includes:

- A way to run services (and keep them running)
- A service with an API to store or cache data
- A service serving dashboard resources

The backend can be hosted locally or in the cloud, storage or cache can be a database, broker or both.

Docker

Docker provides OS-level virtualisation/containers.

Use it to run services on Windows, MacOS and Linux.

Docker runs on a Pi Zero, but most containers do not*.

*ARMv6 instructions are usually not supported.

InfluxDB

InfluxDB is an open source time-series database.

- To run InfluxDB on Docker, type:

```
$ docker run --name influxdb -p 8086:8086
influxdb:2.5.1
```

- To set it up, open the Web UI or a new terminal:

```
$ docker exec -it influxdb /bin/bash
$ influx setup
```

Getting data into InfluxDB

InfluxDB has a number of mechanisms to get data in:

- Telegraf, a data collection agent, supports MQTT.
- Data formats like Line Protocol, CSV and JSON.
- InfluxDB scrapers can collect data from any HTTP endpoint using the Prometheus data format.
- InfluxDB integrations with systems like Kafka.

Telegraf

Telegraf is a data collection agent with many plugins.

- To run Telegraf on Docker, type:

```
$ docker run --net=container:influxdb
telegraf
```

- To enable the MQTT plugin, use a *telegraf.conf*:

```
$ docker exec -it telegraf /bin/bash
$ nano telegraf.conf #see next page
```

Telegraf MQTT input .conf

The *telegraf.conf* for an MQTT to InfluxDB adapter:

```
[[inputs.mqtt_consumer]]
  servers = ["ssl://MQTT_HOST_OR_IP:8883"]
  topics = ["TOPIC/SUBTOPIC"]
  data_format = "json" …

[[outputs.influxdb]]
  urls = ["http://INFLUXDB_HOST_OR_IP:8086"]
  database = "telegraf"
```

Grafana

Grafana is an open source Web dashboard backend.

It integrates nicely with InfluxDB and other sources.

- To run Grafana on Docker, type:
  ```
  $ docker run -d -p 3000:3000 grafana/grafana
  ```
- Then configure it to connect to InfluxDB:
  `http://127.0.0.1:3000/`
- And create some graph views to display data.

Decentlab Data Access - Indoo

https://demo.decentlab.com/dashboard/db/indoor-air-quality-demo?refresh=15m&orgId=3

Indoor Air Quality Demo

Zoom Out | Last 3 days | Refresh every 15m | Sign in

LoRa WAN demo project by

decentlab

CO2, temperature, and humidity sensor

Node 1404 (CO2)

LoRa infrastructure provided by

THE THINGS NETWORK

CO2 [ppm] (mean of 15m)

Current

625.5

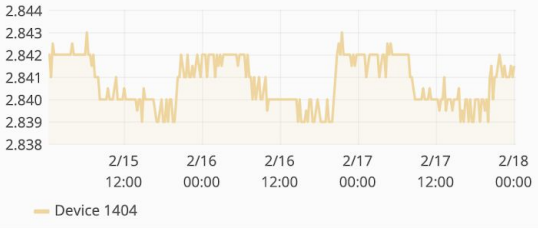
ppm

Humidity [%] (mean of 15m)

Current

38.9 %

Battery [V] (mean of 15m)



Current

2.84 V

Temperature [°C] (mean of 15m)

Current

22.84 °C

Hands-on, 15': Docker hosted dashboard

Install Docker on your computer (not Raspberry Pi).

Run InfluxDB and run/create a Grafana dashboard.

Run Telegraf to get data from test.mosquitto.org.

Send data "as a device" with mqtt, to Mosquitto.

How does the reference model of this setup look?

Graph libraries

For custom dashboards, graph libraries are available:

- Plotly.js is quite easy to get started in Node.js
- CanvasJS has a big collection of React Charts
- Google Charts has been around for a while

There are many other libraries, make sure to check (long term) availability and source code license.

Summary

We created Web dashboards & apps for sensor data.

We saw how data gets to a hosted dashboard service.

We wrote adapter glue code for backend integration.

We set up a self hosted dashboard with Docker.

Next: Rule Based Integration of IoT Devices.

Feedback or questions?

Write me on Teams or email

thomas.amberg@fhnw.ch

Thanks for your time.