

SENSEMAKERS IOT PLATFORM

David Šálek
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SURF SARA

Website

- **WordPress**
- <https://www.sensemakersams.org>

MQTT

- MQTT stands for Message Queuing Telemetry Transport
- extremely simple and lightweight messaging protocol designed for constrained devices and low-bandwidth, high-latency or unreliable networks
- became a standard for the Internet of Things
- **Mosquitto** is an open-source MQTT broker and serves as a backbone of the Sensemakers IoT platform. <https://mosquitto.org/>
- publish/subscribe to topics
- TLS encryption, user authentication, access control lists



Automated data pipeline

- Messages sent to the **pipeline/<app_id>/<dev_id>** topic are automatically:
 - stored in InfluxDB database
 - appended in JSON format to files in a shared volume
 - sent to a serverless function (if in place) to enable event-driven actions

https://openfaas.sensemakersams.org/async-function/<app_id>

Automated data pipeline – Message format

- Messages sent to the **pipeline/<app_id>/<dev_id>** topic have to comply with this JSON format.
- Time (in milliseconds) is optional.
In case it is not provided, the server time upon message arrival will be used.
- Additional fields are allowed.
- Examples:

```
{"app_id": "test_project", "dev_id": "test_device",  
 "payload_fields": {"temperature": 42},  
 "time": 1557244616000}
```

```
{"app_id": "test_project", "dev_id": "test_device",  
 "payload_fields": {"temperature": 42, "foo": "bar"},  
 "foo": "bar"}
```

```
{  
  "type": "object",  
  "properties": {  
    "app_id": {  
      "type": "string"  
    },  
    "dev_id": {  
      "type": "string"  
    },  
    "payload_fields": {  
      "type": "object"  
    },  
    "time": {  
      "type": "integer"  
    }  
  "required": [  
    "app_id",  
    "dev_id",  
    "payload_fields"  
  ]  
}
```

Automated data pipeline – Ingesting data

■ Publish to MQTT

- Username and password are required.
- port 9999 with encryption, port 9998 without encryption

```
mosquitto_pub -t pipeline/test_project/test_device -m \  
'{"app_id": "test_project", "dev_id": "test_device", "payload_fields": {"temperature": 42}}' \  
--cafile ca.crt \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9999 \  
-u test_project -P 1234
```

■ HTTP endpoint

- Password needs to be passed in a header, TLS encryption is in place.
- Works well with The Things Network HTTP integration.

```
curl -XPOST https://openfaas.sensemakersams.org/function/faas-mqtt --data \  
'{"app_id": "test_project", "dev_id": "test_device", "payload_fields": {"temperature": 42}}' \  
-H "X-Api-Key:1234"
```

Publishing to MQTT topics with encryption

- Automated pipeline

```
mosquitto_pub -t pipeline/test_project/test_device -m \  
'{"app_id": "test_project", "dev_id": "test_device", "payload_fields": {"temperature": 42}}' \  
--cafile ca.crt \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9999 \  
-u test_project -P 1234
```

- Project-specific topic

```
mosquitto_pub -t test_project/test_device -m 42 --cafile ca.crt \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9999 -u test_project -P 1234
```

- Public topic

```
mosquitto_pub -t public -m 42 --cafile ca.crt \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9999 -u public -P 1234
```

Publishing to MQTT topics without encryption

- Automated pipeline

```
mosquitto_pub -t pipeline/test_project/test_device -m \  
'{"app_id": "test_project", "dev_id": "test_device", "payload_fields": {"temperature": 42}}' \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9998 \  
-u test_project -P 1234
```

- Project-specific topic

```
mosquitto_pub -t test_project/test_device -m 42 \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9998 -u test_project -P 1234
```

- Public topic

```
mosquitto_pub -t public -m 42 \  
-h lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9998 -u public -P 1234
```

Data storage

- **Shared volume**

- Every message is appended to a file specific to a device and a calendar day.
- The filename and path is defined in the following way:
app_id/dev_id-YYYY-mm-dd.json

- **InfluxDB** <https://docs.influxdata.com/influxdb/>



- InfluxDB is an open-source time series database.
- Every message is written as a point to InfluxDB measurement **dev_id** in database **add_id**.
- Each point consists of the fields from **payload_fields**.
- All numeric values are converted into floats.

InfluxDB example queries

- Access InfluxDB from command line:

```
influx -host influxdb.sensemakersams.org -port 443 -ssl \
        -username test_project -password 1234
```

- Example queries:

```
SHOW DATABASES
USE test_project
SHOW MEASUREMENTS
SHOW SERIES

precision rfc3339
SELECT * FROM test_device
SELECT * FROM test_device WHERE time > now() - 1h
```

Download data from InfluxDB

- Download data in the csv format:

```
influx -host influxdb.sensemakersams.org -port 443 -ssl \
--username test_project --password 1234 --database test_project \
--execute 'SELECT * FROM test_device' --format 'csv'

curl -XPOST \
"https://influxdb.sensemakersams.org/query?u=test_project&p=1234" \
--data-urlencode "db=test_project" \
--data-urlencode "q=SELECT * FROM test_device" | jq -r \
"(.results[0].series[0].columns), (.results[0].series[0].values[]) | @csv"
```

Data storage

■ Object store

- Minio is an open-source object store compatible with Amazon S3
<https://min.io/>
- used for periodic backups
- can be used for uploading larger files, e.g. images
- <https://minio.sensemakersams.org>
- command-line interface:

```
mc config host add sensemakers https://minio.sensemakersams.org/ \
sensemakers 1234
```

```
mc ls sensemakers
mc cp --recursive sensemakers/backup .
```



Periodic backups and SQL queries in the object store

- All data files from the shared volume from the previous day are automatically copied to the object store every night.
- Every project gets its own folder in the bucket called **backup**.
- SQL queries of the data in the object store are possible.

```
mc sql sensemakers/backup/test_project/ \
--query "SELECT time,payload_fields FROM S3Object WHERE dev_id='test_device'"
```

Metadata for the files in the object store

- Metadata for every data file in the object store is written to the bucket called **metadata**.

```
mc sql --recursive --query "SELECT * FROM S3Object" sensemakers/metadata/
```

```
{  
  "filename": "test_project/test_device-2019-05-12.json",  
  "date": "2019-05-21",  
  "app_id": "test_project",  
  "dev_id": "test_device",  
  "keys": [  
    "conductivity",  
    "light",  
    "moisture",  
    "temperature"  
  ],  
  "num_events": 3  
}
```

Public access and data sharing

- Minio supports multiple users and setting policies at the bucket/folder/object level.
- <https://docs.min.io/docs/minio-multi-user-quickstart-guide.html>
- Public access to the files in a particular project folder can be defined by a policy.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Action": [  
                "s3:GetObject"  
            ],  
            "Effect": "Allow",  
            "Resource": [  
                "arn:aws:s3:::backup/test_project/*"  
            ],  
            "Sid": ""  
        },  
        {  
            "Action": [  
                "s3>ListBucket"  
            ],  
            "Effect": "Allow",  
            "Resource": [  
                "arn:aws:s3:::backup"  
            ],  
            "Condition": {  
                "StringLike": {  
                    "s3:prefix": [  
                        "test_project/*",  
                        "test_project"  
                    ]  
                }  
            },  
            "Sid": ""  
        }  
    ]  
}
```

Public access and data sharing

- Add the policy and define a new user with that policy.

```
mc admin policy add sensemakers public policy.json  
mc admin user add sensemakers public public1234 public
```

- The public user can access the shared data.

```
mc config host add sensemakers-public https://minio.sensemakersams.org/ \  
public public1234  
  
mc ls sensemakers-public/backup/test_project  
mc cp --recursive sensemakers-public/backup/test_project .  
  
mc sql sensemakers-public/backup/test_project/ \  
--query "SELECT time,payload_fields FROM S3Object WHERE dev_id='test_device'"
```

Dashboards

- **Grafana** is available for visualizing data from InfluxDB and alerting.
- <http://docs.grafana.org/>
- <https://grafana.sensemakersams.org>



Serverless functions

- OpenFaaS framework is available to deploy serverless functions.

- <https://www.openfaas.com/>



OPENFAAS

- <https://openfaas.sensemakersams.org>

- Functions can be deployed by a platform administrator using **faas-cli**.
- The HTTP endpoint for ingesting data to the platform is an OpenFaaS function that publishes the received message over MQTT to the pipeline topic for the corresponding project.

The Things Network HTTP integration

- In case **app_id** in TTN does not correspond to the one in the Sensemakers IoT platform, it can be overwritten in a URL query.
- In case the MQTT user is not identical to **app_id**, it can be specified in URL query variable **mqtt_user**.
- The MQTT password is passed as a custom **X-Api-Key** header.

URL The URL of the endpoint	<input type="text" value="https://openfaas.sensemakersams.org/function/faas-mqtt?app_id=test_project"/>
Method The HTTP method to use	<input type="text" value="POST"/>
Authorization The value of the Authorization header	<input type="text"/>
Custom Header Name An optional custom HTTP header that you would like to add to the request	<input type="text" value="X-Api-Key"/>
Custom Header Value The value of the custom Header	<input type="text" value="1234"/>

Jupyter notebooks

- Jupyter notebooks are available for data analytics purposes.
- <https://jupyter.org/hub>
- <https://jupyter.sensemakersams.org>
- Every project gets its own Jupyter server with private storage space and access to the shared storage under /home/shared



Linux machine

- Linux machine running **Ubuntu** is available.
- Shared volume is mounted under **/data**
- SSH access

```
ssh root@lb.cluster-meetup-demo.aws.surfsaralabs.nl -p 9997
```

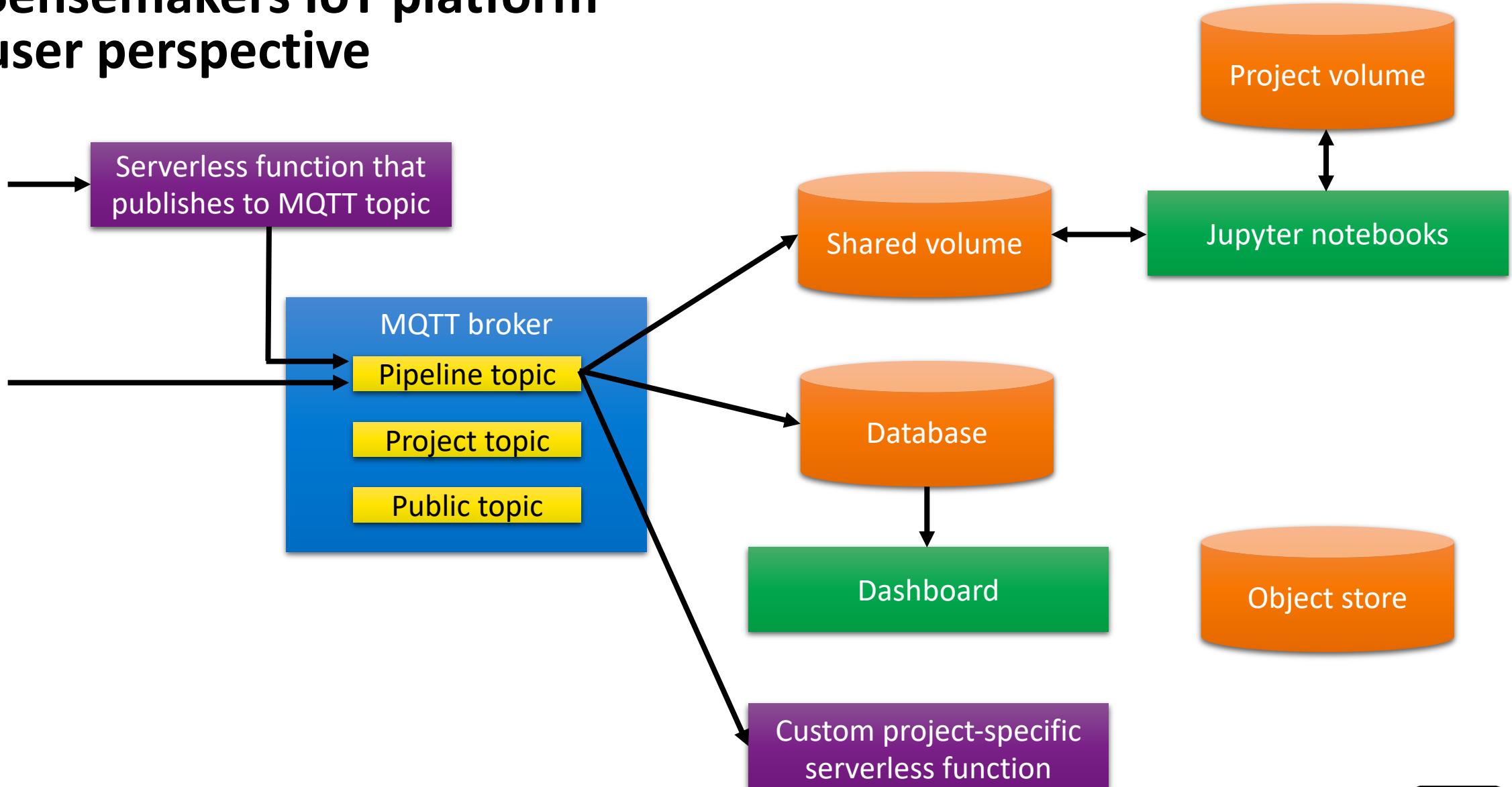
Event-driven actions/talking back to devices

- Event-driven actions (i.e. executing code triggered by an incoming message) can be implemented in the following ways:
 - Run code that subscribes to an MQTT topic on your own machine.
 - Run code that subscribes to an MQTT topic on the Linux machine in the Sensemakers IoT platform.
 - Deploy a serverless function.

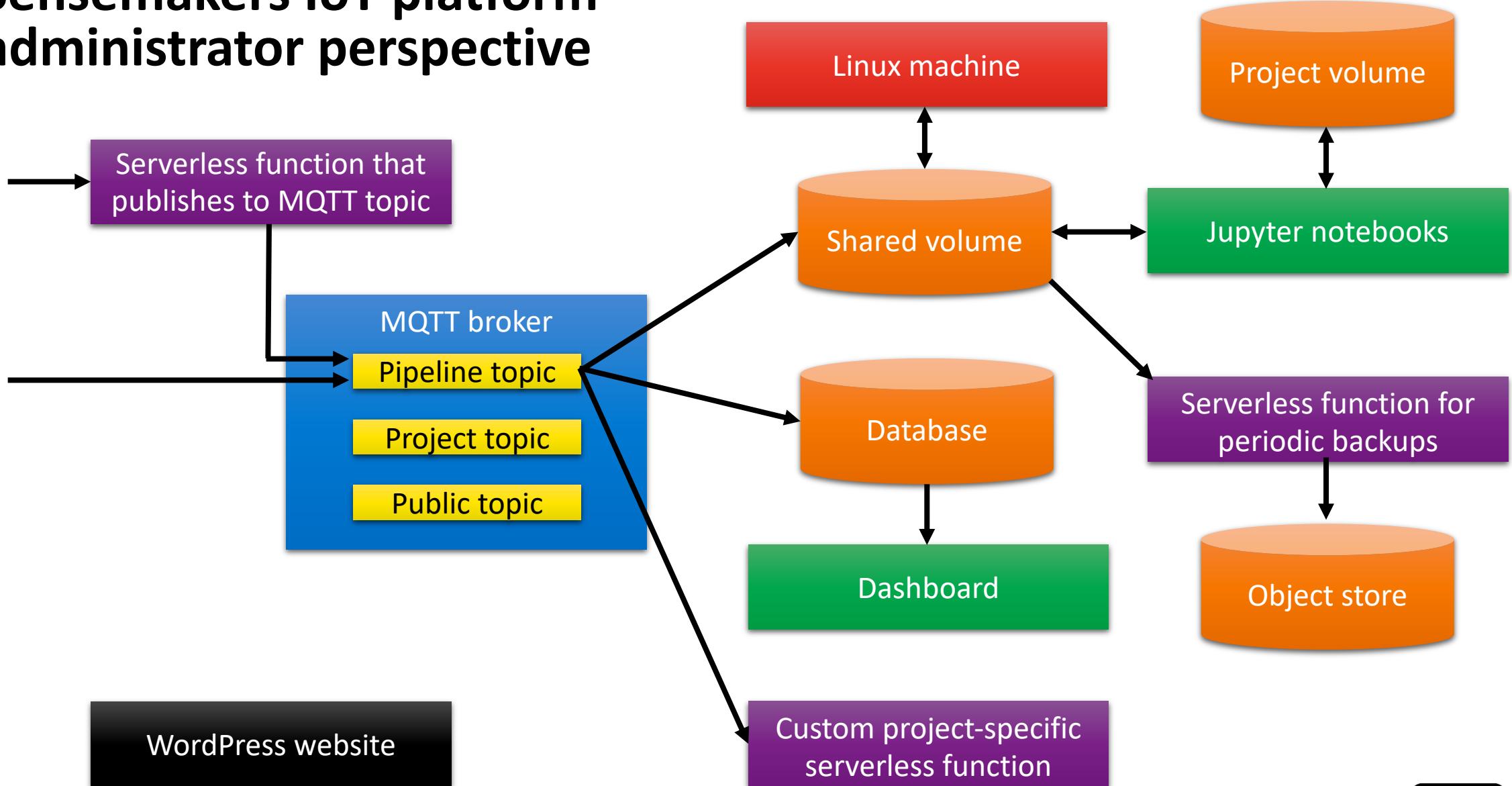
https://openfaas.sensemakersams.org/async-function/<app_id>

- The MQTT broker can be used to send messages back to devices. (provided the devices are capable of subscribing to MQTT topics)

Sensemakers IoT platform user perspective



Sensemakers IoT platform administrator perspective



SENSEMAKERS IOT PLATFORM

 David Šálek

 E-mail: david.salek@surfsara.nl

 <https://www.linkedin.com/in/davidsalek/>

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