SENSEMAKERS IOT PLATFORM

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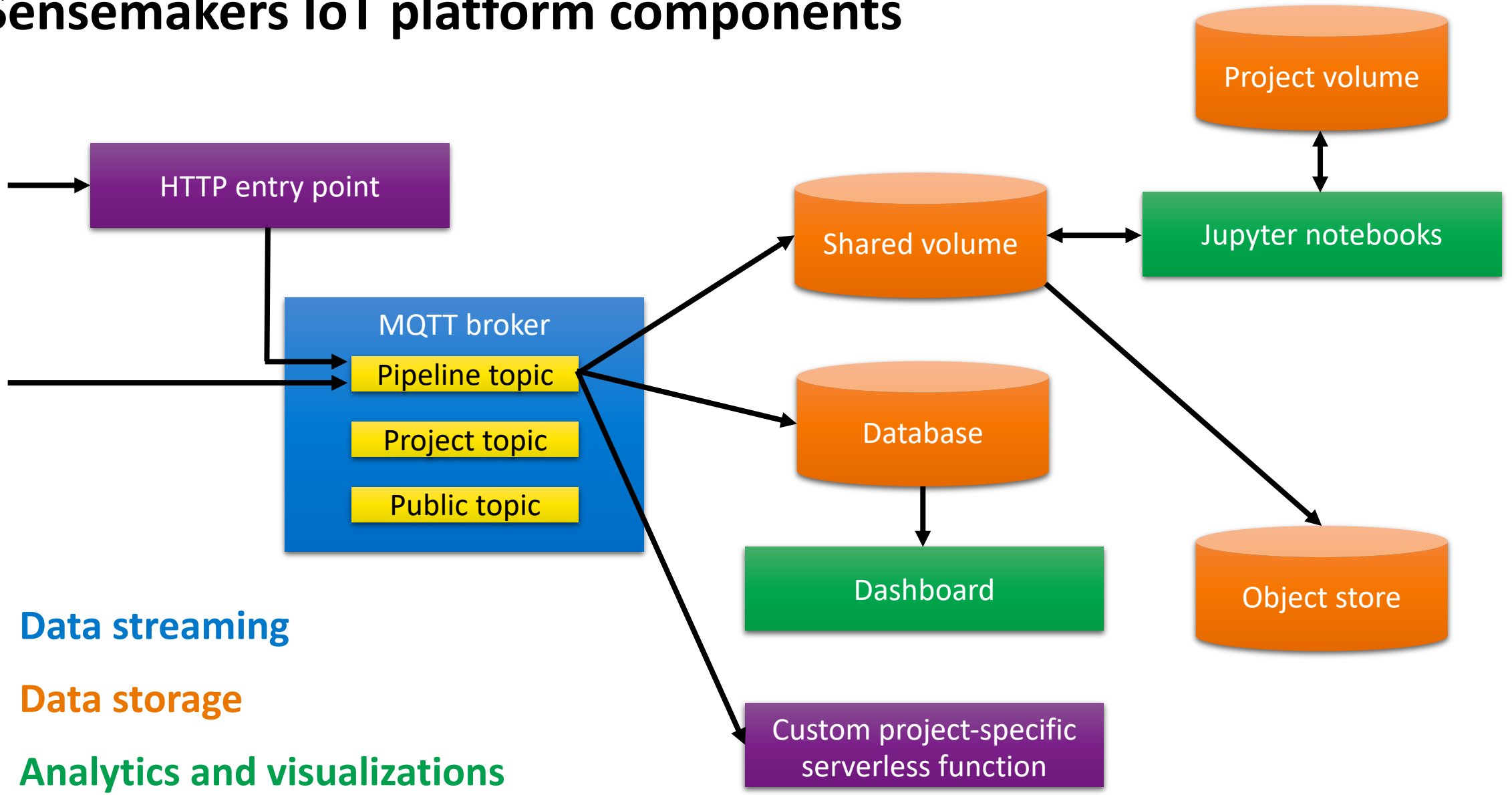
12/06/2019

Sensemakers IoT platform components



- Data streaming
- Data storage
- Analytics and visualizations
- Event-driven actions

Documentation, examples and dashboard backups

- https://github.com/sensemakersamsterdam/sensemakers-iot-platform

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
- 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" },
"tag_fields": {"foo": "bar"}, "foo": "bar"}
```

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

Automated data pipeline – Ingesting data

- **Publish to MQTT**
  - Username and password are required.

```
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
```

- **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

- 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**.
  - **dev_id** and **tag_fields** are used as tags.
  - All numeric values are converted into floats.

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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"
```


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Using tags to select time series in InfluxDB

- Tags can be used to select particular time series from measurements.
- For example, human readable name for each device can be used as a tag.

```
SHOW TAG VALUES WITH KEY = "foo"
SELECT * FROM /.*/ WHERE "foo"::tag =~ /bar/'
```

```
influx -host influxdb.sensemakersams.org -port 443 -ssl \
  -username test_project -password 1234 -database test_project \
  -execute 'SELECT * FROM /.*/ WHERE ”foo"::tag =~ /bar/' -format 'csv'
```


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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

  - web interface: 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 .
```


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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/
```

- Metadata give a summary of available sensor readings in the data file.

```
{
  "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
}
```


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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

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Serverless functions

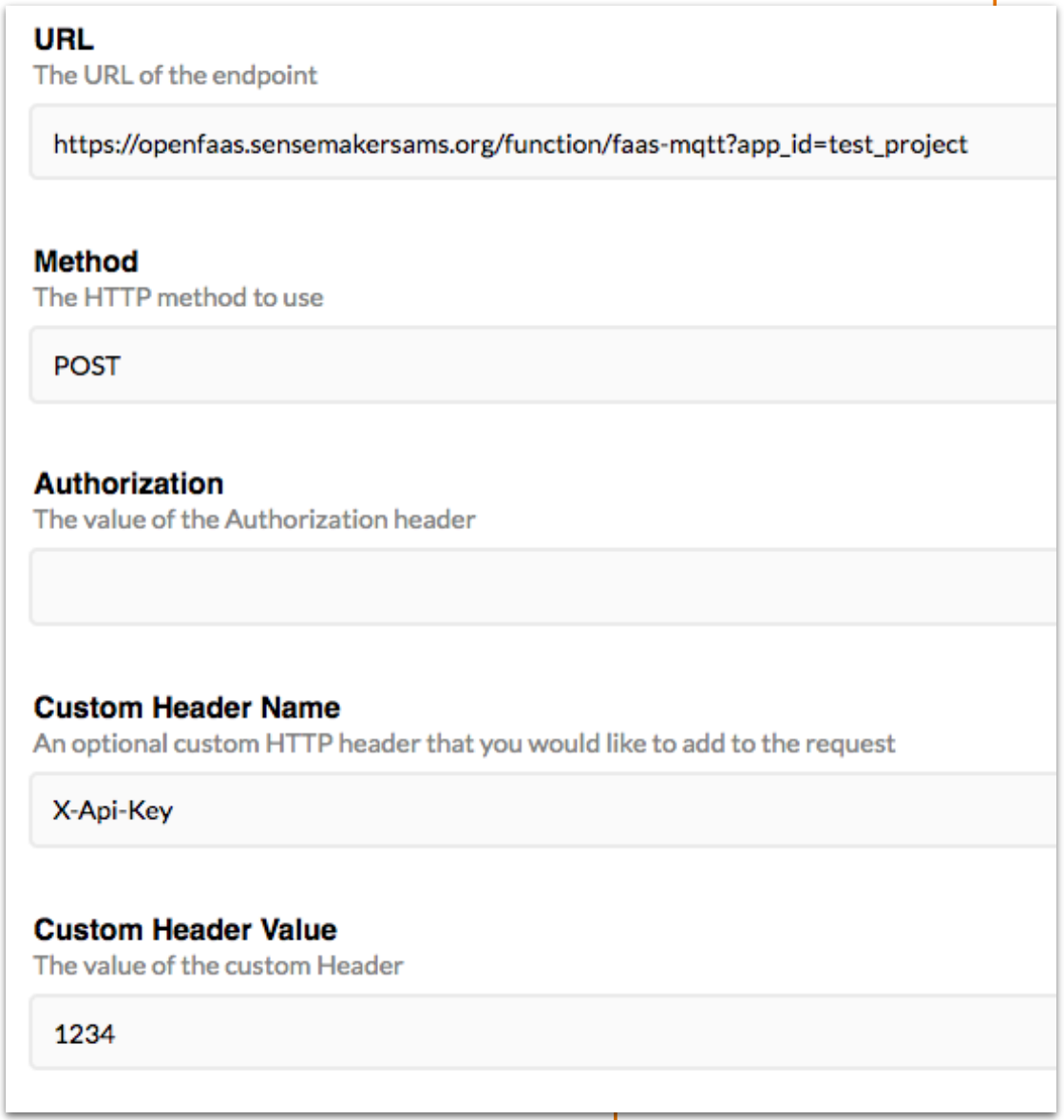
- **OpenFaaS** framework is available to deploy serverless functions.
- https://www.openfaas.com/

- 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.



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
```

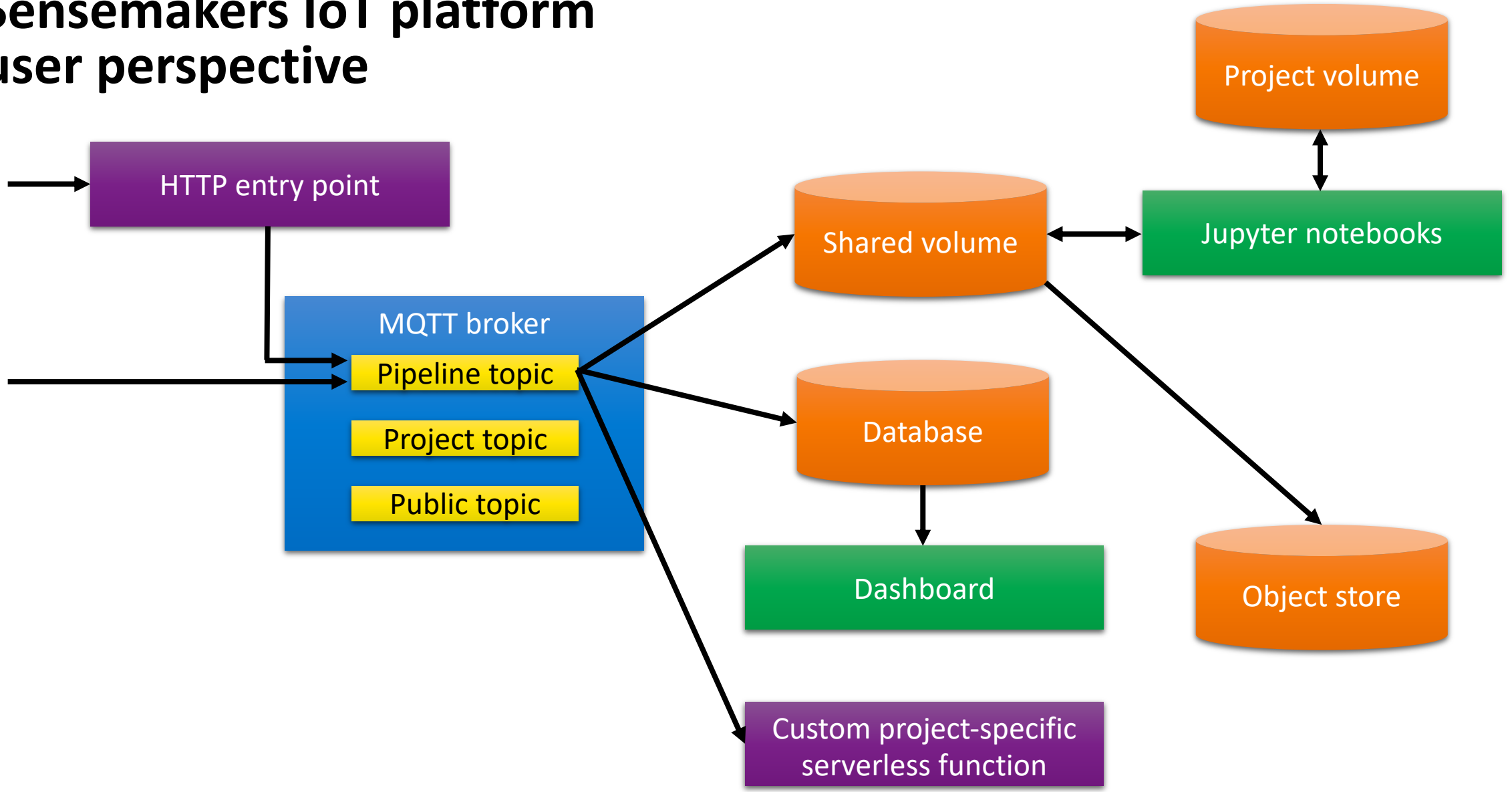
Event-driven actions/talking back to devices

- 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.

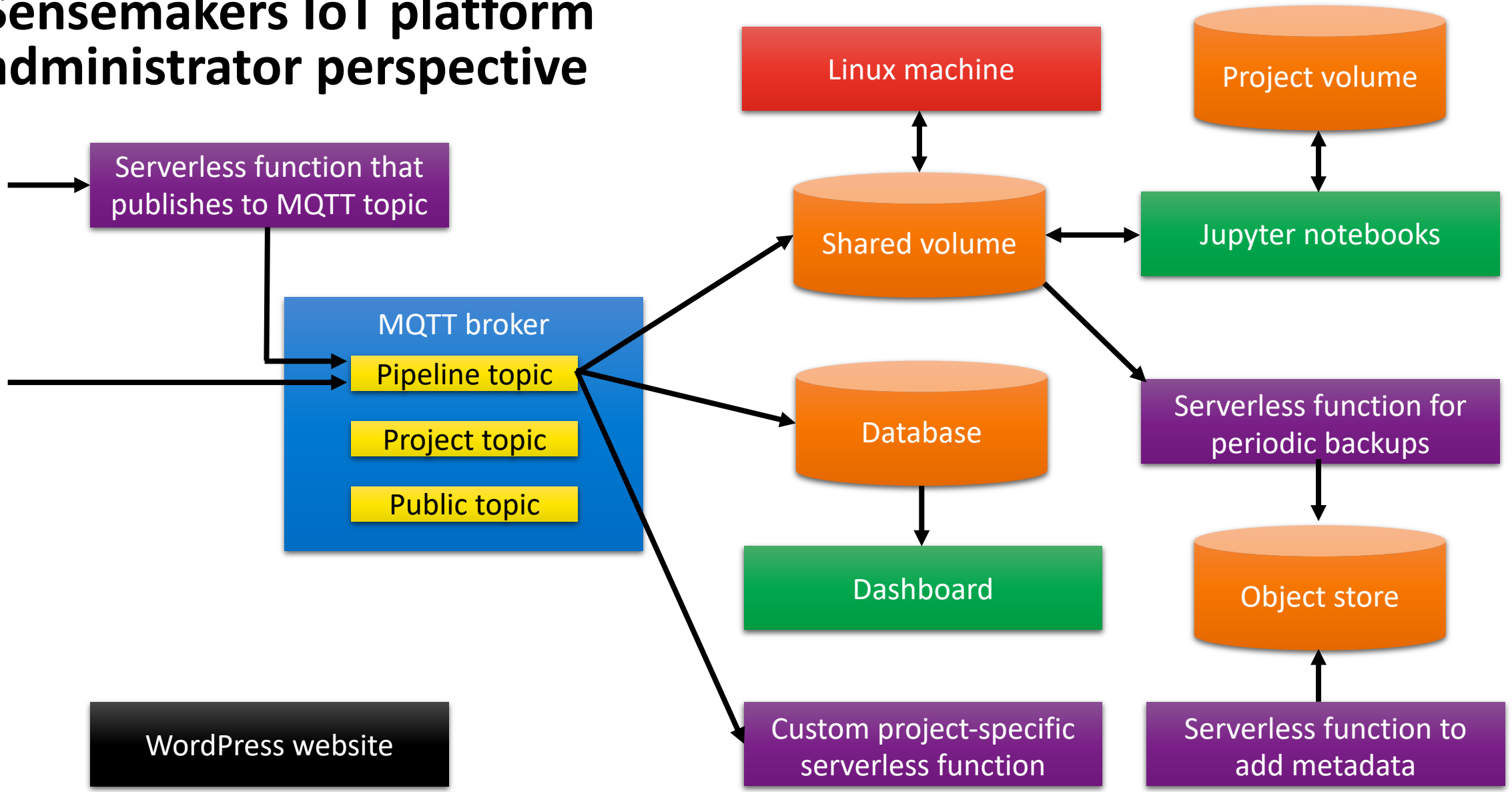
```
https://openfaas.sensemakersams.org/async-function/<app_id>
```

- 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



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