Flow Nexus Documentation

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DOCUMENTATION

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Introduction

Welcome to Flow Nexus, your comprehensive solution for small to medium scale IoT deployments. This platform is designed to streamline the setup, configuration, and use of IoT devices, making it easy to manage your IoT ecosystem.

This project aims to provide a minimal and standalone Open Source IoT platform. The focus is on systems with a deployment of up to a few thousand devices; it does not aim to be scalable to millions of devices. The goal is to build a system that receives, for example, regular temperature samples from remote IoT devices. These temperature samples will be sent to a backend and stored in a database. The data is then visualized in a web application.

Our vision for Flow Nexus is to create a user-friendly, efficient, and robust Open Source platform for IoT management. We aim to simplify the complexities of IoT deployments, making them accessible and manageable for businesses of all sizes.

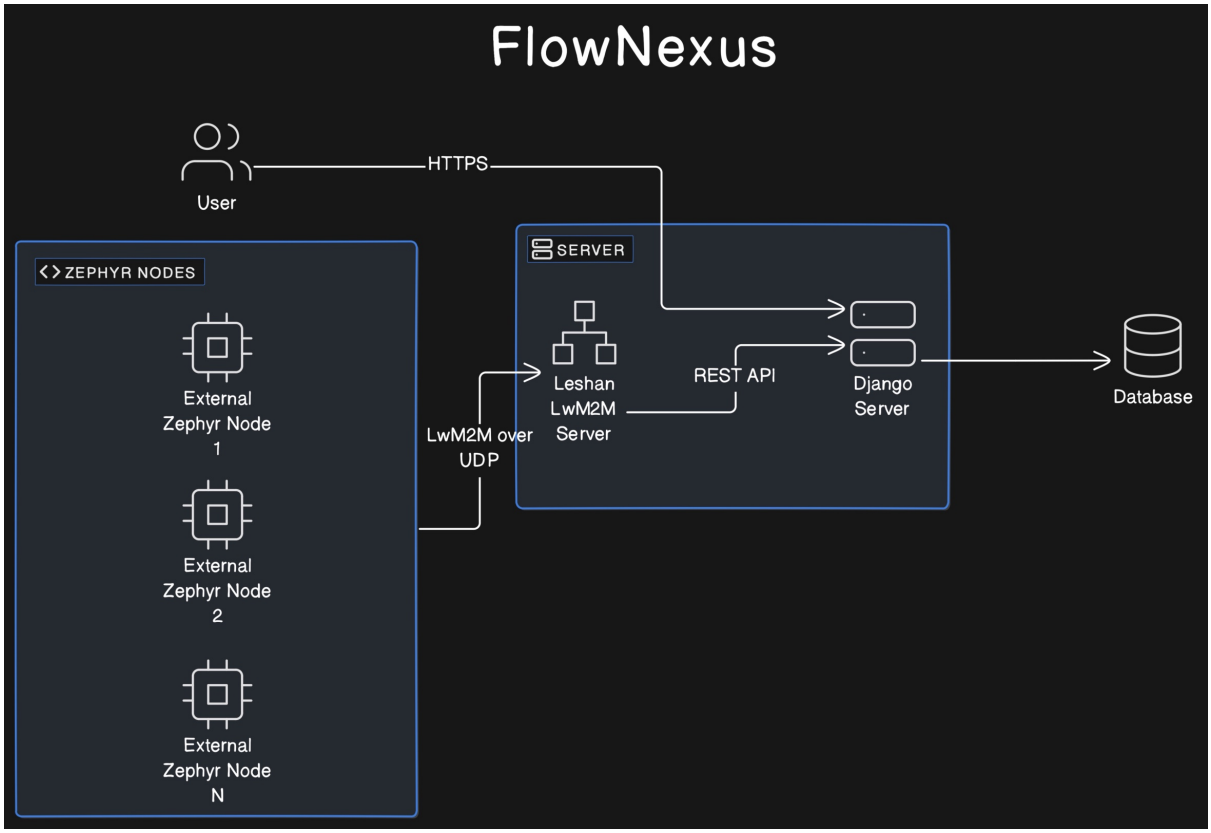
This documentation describes a local server-based IoT system that leverages the Lightweight Machine to Machine (LwM2M) protocol to communicate between IoT devices running Zephyr OS and a backend server using Django. The system does not depend on external cloud services and is designed to operate fully within a local environment.

CHAPTER

ONE

FEATURES

- No dependencies of external services like AWS, MQTT brokers or similar. The system has to be able to run in a local environment.
- The main focus is the LwM2M protocol and the communication between Zephyr and the server.
- The system should show how to add data to a database and visualize it in a web application.
- The web application has to support a secure login and basic user management.
- Certificate based authentication and encryption.
- Server to read and observe resources from IoT Device.
- Server to write resources to IoT Devices.
- OTA Update.
- Receive logs from IoT Devices.



CHAPTER

TWO

KEY COMPONENTS

2.1 IoT Devices

These are typically resource-constrained devices (limited energy and storage capabilities) that run Zephyr OS. They communicate with the server using the UDP protocol to ensure constant connectivity, even in low power states. These devices are programmed to handle tasks like temperature sensing, location tracking, or any other telemetry based on Zephyr applications. They communicate via the UDP protocol to maintain a continuous link without needing frequent reconnections. The IoT device has to support LwM2M. Mainly systems that run Zephyr should be compatible. The application can e.g. be used with a dedicated nRF9160 device or via a simulation like native_sim or in Renode. The nRF9160 is a low power LTE-M and NB-IoT SoC that runs Zephyr OS. UDP is used as transport protocol as it allows to keep devices connected even when the device is sleeping for extended periods (TCP would require a new connection setup typically after a few minutes)

2.2 LwM2M Server

The LwM2M server plays a critical role in managing communications with IoT devices. It handles data transmission, device monitoring, and control commands, ensuring that devices can report their telemetry data, receive configuration updates, and execute commands sent by the server. The server's efficient management of these tasks is essential for maintaining reliable communication with numerous IoT devices, especially those with limited power and processing resources.

CHAPTER

THREE

ARCHITECTURE

This section describes the architecture of individual components and how they interact with each other.

3.1 Django

The Django server hosts the REST API, manages the database, and provides a web interface for data visualization and user management. This server acts as the backend infrastructure that supports the entire IoT ecosystem by:

- **REST API**: Facilitates communication between the IoT devices and the server. The API endpoints handle requests for data uploads from devices, send control commands, and provide access to stored telemetry data.
- **Database Management**: Stores all the telemetry data, device information, user accounts, and configuration settings. The database ensures that data is organized, searchable, and retrievable in an efficient manner.
- **Web Interface**: Offers a user-friendly interface for data visualization and management. Through this interface, users can monitor device status, visualize telemetry data in real-time, manage user accounts, and configure device settings.

3.1.1 Build and Run

The Django server can also run locally, without the need of a docker container. Make sure to create a virtual environment and install the requirements:

```
host:~$ source venv/bin/activate
host:~$ cd flownexus_workspace/lwm2m_server/server/django
host:lwm2m_server/server/django$ pip install -r requirements.txt
host:lwm2m_server/server/django$ ./django_start.sh
```

The Django server should now be up and running under the following URL: `http://localhost:8000/admin`. The admin login is `admin` and the password

Run Unit Tests

There are unit tests, that test the deserializer, which parses the Json payload from the ReST API. You can run the unit tests with the following command:

```
host:~/flownexus_workspace/lwm2m_server/server/django$ python manage.py test␣
↪sensordata
Found 2 test(s).
Creating test database for alias 'default'...
----------------------------------------------------------------------
```

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```
Ran 2 tests in 0.008s

OK
Destroying test database for alias 'default'...
```

3.1.2 Database Model

The database model is the core of the Django server. It aims to store information according to the LwM2M resource model. The advantage is that data can be stored in a generic way and the server can be extended with new resources without changing the database schema.

The server application logic only has to handle higher level events. Those events are situations where multiple resources are associated (e.g. Temperature, Pressure, Humidity, Acceleration). Those multiple resources are linked in the event, together with a timestamp. The event itself is represented by the database model in a generic way, several custom event types can be created by the application logic.

An Entity Relationship Diagram (ERD) is a visual representation of the database schema. It is automatically generated from the Django models. `sensordata` is the Django app that contains the application logic.

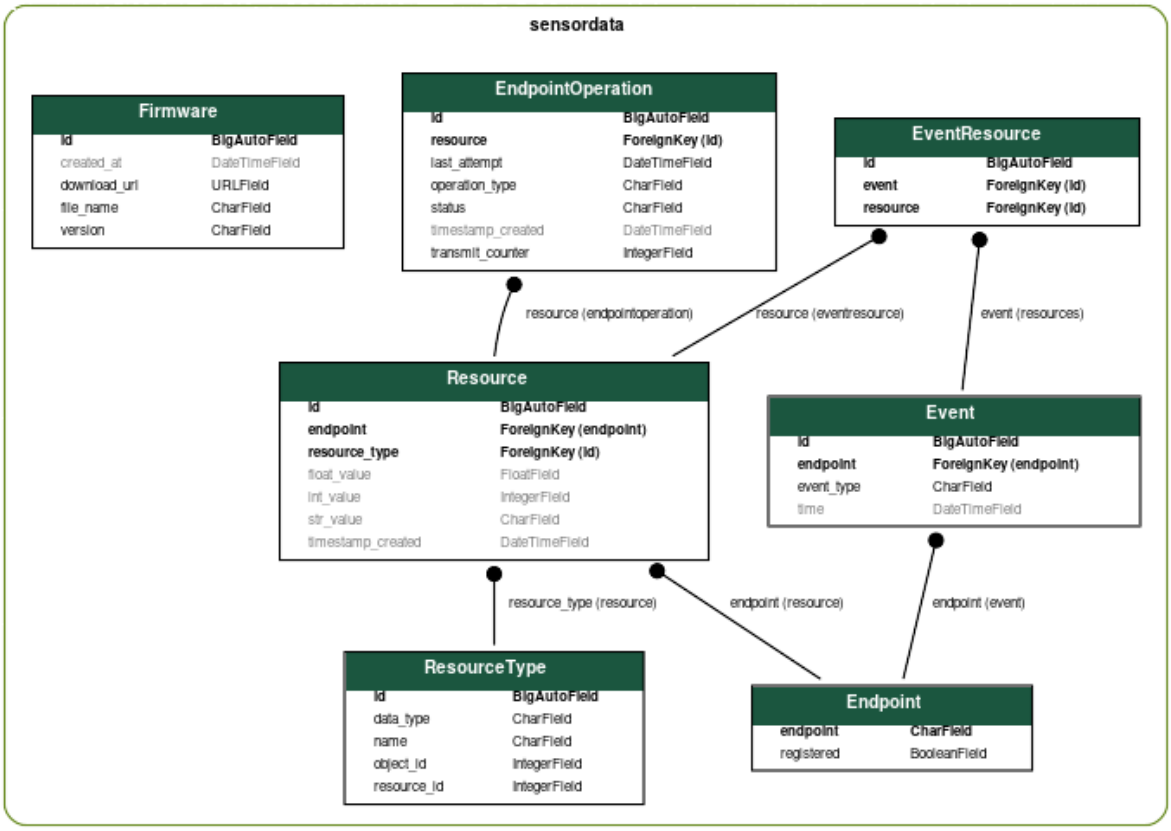

Fig. 1: Entity Relationship Diagram generated from Django models

Endpoint
: IoT devices using the LwM2M protocol in the network, identifiable by a unique name, e.g. `urn:imei:123456789012345`.

ResourceType
: Defines resource data points comprehensively, annotating each with a unique object-resource ID combination, a descriptive name, and specifying the expected data type.

Resource
: A specific piece of data or functionality within an LwM2M Object. Resources represent attributes or actions and are identified by Resource IDs within an Object.

  In the database Model a Resource represents an individual data value from one IoT device, annotated with timestamps, applicable data types, and linked to both the device and resource type for which the data is relevant.

Event
: A collection for significant occurrences reported by endpoints. Events and Resources are linked to each other via EventResource table.

EventResource
: Acts as a junction table forming a many-to-many relationship between events and their constituent resources, enabling flexible association without direct modification to the core events or resources tables.

EndpointOperation
: Represents actionable commands or processes targeted at endpoints, tracking the operation type, status, and scheduling through timestamps, also detailing the transmission attempts and last action.

Firmware
: Stores metadata about firmware binaries that are available for devices to download and install. Each record includes a version identifier, the name of the file, a URL from where the device can retrieve the firmware, and timestamps for tracking when each firmware record was created and last updated.

3.2 Leshan

3.2.1 Build and Run

The Leshan server can also run locally, without the need of a docker container.

```
host:~$ sudo apt update
host:~$ sudo apt install openjdk-17-jdk maven
host:~$ source venv/bin/activate
host:~$ cd flownexus_workspace/lwm2m_server/server/leshan
host:lwm2m_server/server/leshan$ ./leshan_build_run.sh
```

The Leshan server should now be up and running under the following URL: `http://localhost:8080`.

3.2.2 Leshans Role in FlowNexus

Lehsan is considered a production ready LwM2M server and is used in many commercial products. It is used as an LwM2M server in FlowNexus. It is responsible for registering and managing *endpoint*. There is no application specific logic implemented in Leshan related Java code within FlowNexus. The goal is to have all application logic within the Django application.

Leshan can be seen as a proxy between the LwM2M endpoints Django. There is no direct communication between Django and endpoints.

3.2.3 LwM2M Observe

LwM2M observe
The *LwM2M observe* operation allows an LwM2M Server to monitor changes to specific Resources, Resources within an Object Instance, or all Object Instances of an Object on an LwM2M Client. An endpoint must remember these observation requests until re-registration.

Single and CompositeObserve
Leshan supports two types of observe requests: Single and CompositeObserve. SingleObserve is a simple observe request for a single resource. CompositeObserve is a more complex observe request that subscribes to multiple *Resources* of one *Object*.

Once an endpoint registers to Leshan, Leshan will initiate an observe request to selected resources. With every new registration of an endpoint, the observe requests are re-initiated.

Note: The observe initiation will move from Leshan to Django with future versions. Django is informed about new registrations and will then initiate the observe requests. This allows a more centralized approach and better control over the observe requests via the database model.

For testing, the Leshan server currently initiates the following two observe requests:

- SingleObserve (Temperature Sensor Value): `{3303, 0, 5700}`
- CompositeObject (Custom Object Id): `{10300}`

3.3 Communication, Interfaces

The communication between IoT devices and Leshan is specified by the OMA LwM2M standard:

- LwM2M core specification v1.1.1
- LwM2M transport binding v1.1.1

The standard describes how the LwM2M server (Leshan) works, however, it does not describe how to connect a backend server to Leshan. The backend is responsible for storing the data in a database and implementing application logic. A frontend can access the data in the database and visualize outward facing user interfaces. Leshan acts as a gateway between Endpoints and the backend. There should be no application specific logic implemented in Leshan.

In order to communicate and exchange data, both components (Leshan LwM2M Server and Django) post data to each other's ReST APIs. Communication is typically triggered by IoT devices sending data or the user/application requesting data from devices.

3.3.1 Data Flow: Endpoint -> Backend

All communication from Endpoints to the server flows through Leshan. Leshan interprets this data according to the LwM2M protocol and generates a ReST API call to the backend server. The backend server then stores the data in the database.

Django hosts the ReST API that Leshan posts to. Serializers, a part of Django, deserialize the incoming data and store it in the database according to the database model.

Leshan Data Format

There are two types of data that Leshan sends to the backend, single resource and composite resource format. The two ReST API endpoints that Leshan posts to are available under the following URLs:

- `/leshan_api/resource/single`: single resource format.
- `/leshan_api/resource/composite`: composite resource format.

For more details, please theck the `Internal Django` API documentation.

Listing 1: Single Resource Format (3303/0/5700)

```
{
   "ep": "qemu_x86",
   "obj_id": 3303,
   "val": {
       "kind": "singleResource",
       "id": 5700,
       "type": "FLOAT",
       "value": "24.899181214836236"
   }
}
```

Listing 2: Composite Resource Format (3/0/0..17)

```
{
    "ep" : "qemu_x86",
    "val" : {
        "instances" : [ {
            "kind" : "instance",
            "resources" : [ {
                "kind" : "singleResource",
                "id" : 0,
                "type" : "STRING",
                "value" : "Zephyr"
            }, {
                "kind" : "multiResource",
                "values" : {
                    "0" : "1",
                    "1" : "5"
                },
            },
                "kind" : "singleResource",
                "id" : 17,
                "type" : "STRING",
                "value" : "qemu_x86"
            } ],
            "id" : 0
        } ],
        "kind" : "obj",
        "id" : 3
    }
}
```

The marked lines in the composite resource format show where Object ID, Instance ID and Resource ID are located. A composite resource format can consist of multiple Object IDs.

Warning: Currently multiResources are not supported and will be ignored. MultiResource dataypes are e.g. used for Voltage range (min, max).

Registration Updates

Leshan maintains registrations of endpoints. An endpoint can be registered or unregistered. To maintain its registration, an endpoint must send an update to Leshan regularly. If an endpoint does not send an update within the specified duration, it is considered offline and will be unregistered by Leshan.

Those registration events are encapsulated into an LwM2M Object and sent to the backend server. The backend server stores the registration events in the database. This allows to use the generic database model for the registration events as well. All received registration events are stored in the database and can be used for statistics.

All registration events are maintained in the custom LwM2M Object ID `10240`:

- `10240/0/0`: Endpoint **registered** to Leshan.
- `10240/0/1`: Endpoint **unregistered** from Leshan.
- `10240/0/2`: Endpoint **updated** its registration.

3.3.2 Data Flow: Backend -> Endpoint

Endpoints often operate in queue mode, meaning they are not always online. The LwM2M Server is aware of the current status of a device (Online/Offline) and communicates this status to the backend server. Leshan does not queue pending data that should be sent to the device when it comes online. The backend server must handle this by itself so it has to have a representation of the current status of each device as well as the data to be send. The resource table `EndpointOperation` is used to store pending operations that should be sent to the endpoint while it is online.

Once an endpoint updates it's registration (LwM2M Update Operation) Leshan notifies the backend. The backend checks the `EndpointOperation` table for pending operations and sends them to the device by posting to the Leshan hosted ReST API. Leshan keeps the post call open until the device acknowledges the operation or a timeout is generated. Endpoints can be slow to respond (several Seconds), so the backend has to handle the ReST API call in an asynchronous manner. By only sending data to endpoints while they are online, the backend can be sure that the ReST API calls are not open for a long time.

Asynchronous Communication

Given that endpoints are comparably slow to respond, handling communication asynchronously is essential for efficient operation. This can be effectively managed using Celery, a distributed task queue. When Leshan notifies the backend of an endpoint status update, Celery can be used to handle the long-running API calls, ensuring that the backend remains responsive and scalable. As the backend communicates with many endpoints simultaneously, an efficient queing mechanism is essential to ensure that the system remains responsive and scalable.

Before the backend executes the API call, it updates the endpointOperation status to `SENDING`, indicating an ongoing operation.

Once the API call is complete the database will be updated with the result (e.g. `CONFIRMED`, `FAILED`, `QUEUED`) depending on the result of the request. The `FAILED` status is assigned after 3 attempts. Retransmissions are triggered when the endpoint updates it's registration the next time.

Example Communication

The following example shows how the backend server can send a firmware download link resource `Package URI 5/0/1` to an endpoint:

1. User creates new `EndpointOperation`: resource path `5/0/1`, value `https://url.com/fw.bin`.
2. Backend checks endpoint online status.
3. If endpoint is offline, no further action is taken right away.
4. Endoint comes online, Leshan sends update to the backend.
5. Backend checks `EndpointOperation` table for pending operations for the endpoint.
6. Finds pending operation, send resource to endpoint via the Leshan ReST API.
7. Pending operation is marked `completed` if the endpoint acknowledges the operation.

CHAPTER

FOUR

APPLICATION GUIDE

This section explains according to best practises how to develop IoT applications with FlowNexus and Zephyr.

4.1 Endpoint Interactions

FlowNexus can interact with any endpoint via the LwM2M methods `Read`, `Write`, `Execute` and `Observe`.

4.1.1 Read

Note: Currently not supported

4.1.2 Write

See Chapter *Data Flow: Backend -> Endpoint* for more details.

4.1.3 Execute

Note: Currently not supported

4.1.4 Observe

See chapter *Events via Composite Observe* to see events are generated from composite Observe.

Note: Currently Observe interactions are handled in Leshan, check *LwM2M Observe*.

4.2 Events

IoT devices often trigger events. An event is a significant change in the state of a device or its environment. As an example, there could be a machine that is monitored by an IoT device using multiple sensors. An event is triggered by an unusual combination of sensor readings. It is important to aggregate several states into a single event, so an application in the cloud can analyze the event in detail to know the environmental conditions at that moment.

The database model defines the *Events* table that represents events generated by *endpoints*.

4.2.1 Events via Composite Observe

In order to group multiple resources together in an unambiguous way, LwM2M composite resources are used. Once a composite resource is updated in the IoT device (endpoint), Leshan generates a composite event with all values of the composite resource. Django deserializes the event, stores its individual resources in the database and creates a new event. The individual resources within the event may haveindividual timestamps, the event itself has a separate timestamp in addition.

Note: Currently Observe interactions are handled in Leshan at *LwM2M Observe*.

4.3 Queue Mode

When configuring a energy saving endpoint that uses LTE-M or NB-IoT, queue mode must be enabled in Zephyr so the device will sleep between data transmissions. The Zephyr documentation explains the LwM2M Client in Zephyr in detail.

Listing 1: Enable Queue Mode in Zephyr with a registration update interval of 10 minutes

```
CONFIG_LWM2M_QUEUE_MODE_ENABLED=y
CONFIG_LWM2M_QUEUE_MODE_UPTIME=20
CONFIG_LWM2M_RD_CLIENT_STOP_POLLING_AT_IDLE=y

# Default lifetime is 10 minutes
CONFIG_LWM2M_ENGINE_DEFAULT_LIFETIME=600
```

See chapter *Data Flow: Backend -> Endpoint* to know know more about how queue mode is implemented in FlowNexus.

4.3.1 eDRX Settings

eDRX (Extended Discontinuous Reception) is a feature that allows the device to sleep for longer periods of time. The device will wake up periodically to check downlink paging messages. If new messages are available, the device will stay awake to receive them. Otherwise, the device will go back to sleep. - Nordic Devzone Article

Setting the eDRX interval to a value significantly smaller than the timeout value of the LwM2M server would theoretically allow FlowNexus to reach endpoints at any time.

Warning: This approach has not yet been tested! The typical way is to configure endpoints to connect to the server within specific intervals. Inbetween those intervalls, the endpoint will sleep and can't be reached from the server.

4.4 Firmware Setup

4.4.1 LwM2M Version

The used Leshan version uses LwM2M version 1.1. Make sure to enable this version in the Zephyr LwM2M client accordingly.

Listing 2: Enable LwM2M version 1.1 in Zephyr

```
CONFIG_LWM2M_VERSION_1_1=y
```

4.4.2 LwM2M Transport Format

Listing 3: Enable CBOR Format

```
CONFIG_ZCBOR=y
CONFIG_ZCBOR_CANONICAL=y
```

4.4.3 LwM2M SenML Format

Note: Currently not supported in FlowNexus.

Listing 4: Enable LwM2M version 1.1 in Zephyr

```
# SenML CBOR - default
CONFIG_LWM2M_RW_SENML_CBOR_SUPPORT=y
```

CHAPTER

FIVE

BUILD AND DEPLOY

5.1 Build Setup

The build instructions in the documentation are tested for a native Linux Machine. For MacOS or Windows consider creating a docker container build. One of the developers uses the following *devcontainer.json* build environment:

```
{
  "name": "Ubuntu",
  "image": "mcr.microsoft.com/devcontainers/base:jammy",
  "runArgs": [
    "--cap-add=NET_ADMIN",
    "--cap-add=MKNOD",
    "--device=/dev/net/tun",
    "--sysctl=net.ipv6.conf.all.disable_ipv6=0",
    "--sysctl=net.ipv6.conf.default.disable_ipv6=0"
  ],
  "postCreateCommand": "apt-get update && apt-get install -y iproute2 && echo 'IPv6␣
↪is enabled.'",
  "remoteUser": "root"
}
```

Before you we start with any development here are a few things you should get configured:

- Get the Zephyr SDK downloaded and configured in your root directory. You can find the instructions here.
- Setup a virtual environment for the project.

```
host:~$ sudo apt update && sudo apt upgrade
host:~$ sudo apt install python3-pip python3.10-venv
host:~$ python3.10 -m venv venv
host:~$ source venv/bin/activate
host:~$ pip install --upgrade pip && pip install west
host:~$ west init -m https://github.com/jonas-rem/lwm2m_server --mr main flownexus_
↪workspace
host:~$ cd flownexus_workspace
host:~/flownexus_workspace$ west update
```

5.2 Container Environment

Both components run in a Docker container. The Leshan server is running in a `openjdk:17-slim` container and the Django server is running in a `python:3.11-slim` container. This allows for an easy and reproducible setup of the server.

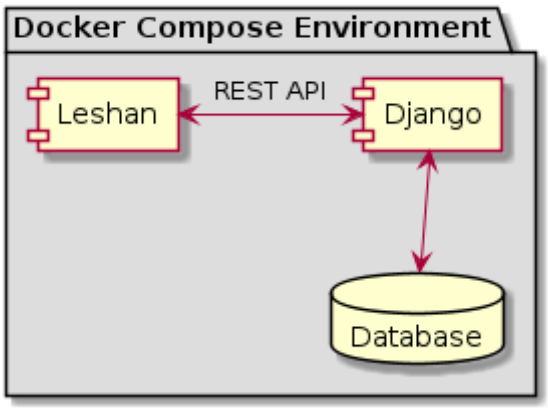

Fig. 1: Both components running in one machine using Docker Compose

The following diagram shows the Docker Compose environment. The file `docker-compose.yml` defines the services and their configuration. The file `Dockerfile.leshan` defines the Leshan container and the file `Dockerfile.django` defines the Django container.

> **Warning:** Make sure to change the password to the admin console as well as other settings like SECRET_KEY, DEBUG flag in a production environment!

The container can be build and started with the following commands:

```
host:~/flownexus_workspace/lwm2m_server/server$ docker compose build
[+] Building 0.5s (20/20) FINISHED                                  docker:default
 => [leshan internal] load build definition from Dockerfile.leshan          0.0s
 => [leshan internal] load metadata for docker.io/library/openjdk:17-slim   0.4s
 => [django internal] load build definition from Dockerfile.django          0.0s
 => [django internal] load metadata for docker.io/library/python:3.11-sli   0.4s
 => [leshan 1/5] FROM docker.io/library/openjdk:17-slim@sha256:aaa3b3cb27   0.0s
 => [django 1/5] FROM docker.io/library/python:3.11-slim@sha256:d11b9bd5e   0.0s
 => CACHED [leshan 2/5] WORKDIR /leshan                                     0.0s
 => CACHED [leshan 3/5] COPY . /leshan/                                     0.0s
 => CACHED [leshan 4/5] RUN apt-get update &&     apt-get install -y mave   0.0s
 => CACHED [leshan 5/5] RUN chmod +x /leshan/leshan_build_run.sh            0.0s
 => => exporting layers                                                     0.0s
 => => writing image sha256:a017577ba2b175374148f5c3f128ac117ba5436ceaeff   0.0s
 => => naming to docker.io/library/server-leshan                            0.0s
 => CACHED [django 2/5] WORKDIR /django                                     0.0s
 => CACHED [django 3/5] COPY . /django/                                     0.0s
 => CACHED [django 4/5] RUN pip install --no-cache-dir -r /django/require   0.0s
 => CACHED [django 5/5] RUN chmod +x /django/django_start.sh                0.0s
 => => writing image sha256:1c88f1227753b08cf994c4e61d5cdcf97d68f260c99ad   0.0s
 => => naming to docker.io/library/server-django                            0.0s
```

```
host:~/flownexus_workspace/lwm2m_server/server$ docker compose up
[+] Running 2/0
 ✓ Container server-leshan-1  Created                                    0.0s
 ✓ Container server-django-1  Created                                    0.0s
Attaching to django-1, leshan-1
[..]
django-1  | Starting development server at http://0.0.0.0:8000/
leshan-1  | [main] INFO org.eclipse.leshan.server.LeshanServer - CoAP over UDP␣
↪endpoint based on Californium library available at coap://0.0.0.0:5683.
leshan-1  | LeshanServer started
^CGracefully stopping... (press Ctrl+C again to force)
[+] Stopping 2/2
 ✓ Container server-django-1  Stopped                                   10.3s
 ✓ Container server-leshan-1  Stopped                                   10.5s
```

5.3 Setup a Virtual Server

flownexus can be deployed to a virtual server. This chapter explains a basic setup of a virtual server with a domain name. A requirement is to have a Linux server and a domain name. The domain name must point to the server, e.g. via a A/AAAA-Record.

The setup has been tested with a Debian 12 server with a 1C/1GB RAM configuration.

Listing 1: Basic setup of a virtual server

```
vserver:~/ apt update
vserver:~/ apt install git docker docker-compose nginx certbot python3-certbot-nginx
# Generate a certificate with letsencrypt:
vserver:~/ certbot --nginx -d flownexus.org -d www.flownexus.org
vserver:~/ Create nginx config at /etc/nginx/sites-available/flownexus (see example␣
↪below)
# Activate the Nginx config:
vserver:~/ sudo ln -s /etc/nginx/sites-available/flownexus /etc/nginx/sites-enabled/
# Test the Nginx config:
vserver:~/ nginx -t
# Restart Nginx:
vserver:~/systemctl restart nginx
```

Listing 2: Example Nginx configuration

```
1  server {
2      listen 443 ssl http2;
3      listen [::]:443 ssl http2;
4      server_name flownexus.org;
5
6      error_log /var/log/nginx/flownexus.org.error.log;
7      access_log /var/log/nginx/flownexus.org.access.log;
8
9      ssl_certificate /etc/letsencrypt/live/flownexus.org/fullchain.pem;
10     ssl_certificate_key /etc/letsencrypt/live/flownexus.org/privkey.pem;
11
12     location / {
13         proxy_pass http://127.0.0.1:8000/;
14         proxy_set_header Host $http_host;
15         proxy_set_header Upgrade $http_upgrade;
```

(continues on next page)

(continued from previous page)

```
        proxy_set_header Connection "upgrade";
        proxy_set_header X-Real-IP $remote_addr;
        proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
        proxy_set_header X-Forwarded-Proto $scheme;
        proxy_set_header X-Frame-Options SAMEORIGIN;
    }
}

server {
    ssl_certificate /etc/letsencrypt/live/flownexus.org/fullchain.pem;
    ssl_certificate_key /etc/letsencrypt/live/flownexus.org/privkey.pem;
    ssl_dhparam /etc/letsencrypt/ssl-dhparams.pem;

    listen 80;
    #listen [::]:80 ipv6only=on;
    listen [::]:80;
    server_name flownexus.org;

    return 301 https://$host$request_uri;
}
```

After the setup, dlownload flownexus and start it with using docker compose in detached mode. Make sure to change the `DEPLOY_SECRET_KEY` and `DEBUG` flag in the `settings.py` file before deploying.:

Listing 3: Start flownexus with docker compose

```
vserver:~/ git clone https://github.com/jonas-rem/flownexus.git
# Change the DEPLOY_SECRET_KEY and DEBUG flag in the settings.py file
vserver:~/flownexus/server$ docker-compose up -d
```

flownexus is now available at https://flownexus.org. The server is running in a Docker container and the Nginx server is used as a reverse proxy. Consider enabling the firewall and only keep required ports open:

- **Port 80, TCP**: HTTP
- **Port 443, TCP**: HTTPS
- **Port 22, TCP**: SSH
- **Port 5683, UDP**: CoAP

Warning: flownexus is not production ready. This server setup is only intended for testing purposes.

The current flownexus configuration uses the default Django `DEPLOY_SECRET_KEY` and enables the `DEBUG` flag. This is a security risk and must be change before deploying.

Currently, the default django inbuild webserver is used. This is not recommended for production use. Consider using a production-ready webserver like Nginx or Apache.

CHAPTER

SIX

SIMULATION

6.1 IoT Devices with Zephyr

As device management protocol LwM2M is used. Zephyr offers a LwM2M client at `subsys/net/lib/lwm2m`. This LwM2M client sample application implements the LwM2M library and establishes a connection to an LwM2M server. The example can be build with the following command:

```
host:~/flownexus_workspace/lwm2m_server$ west build -b nrf9161dk_nrf9160_ns fw_test/
↪lwm2m_client -p
host:~/flownexus_workspace/lwm2m_server$ west flash --recover
```

6.1.1 LwM2M Client Simulation

The Zephyr application can run in simulation mode. This allows to test all components locally. Once leshan and Zephyr are running, the Zephyr application can be started in emulation with the following command:

```
host:~/flownexus_workspace/lwm2m_server$ ./zephyr_build_run_sim.sh
*** Booting nRF Connect SDK zephyr-v3.5.0-3024-g7c3e830729b7 ***
[00:00:00.000,000] <dbg> net_lwm2m_engine: lwm2m_engine_init: LWM2M engine socket␣
↪receive thread started
[00:00:00.000,000] <dbg> net_lwm2m_obj_security: security_create: Create LWM2M␣
↪security instance: 0
[00:00:00.000,000] <dbg> net_lwm2m_obj_server: server_create: Create LWM2M server␣
↪instance: 0
[00:00:00.000,000] <dbg> net_lwm2m_obj_device: device_create: Create LWM2M device␣
↪instance: 0
[00:00:00.010,000] <dbg> net_lwm2m_obj_firmware: firmware_create: Create LWM2M␣
↪firmware instance: 0
[00:00:00.010,000] <inf> net_config: Initializing network
[00:00:00.010,000] <inf> net_config: IPv4 address: 192.0.2.1
```

You should see the following output in the docker console or in the most recent log file in `server/logs/`:

```
host:lwm2m_server/docker_compose$ leshan-1  | LeshanServer started
leshan-1  | new device registered: qemu_x86
leshan-1  | Onboarding qemu_x86
leshan-1  | Resources:
leshan-1  | </3>
leshan-1  | </3/0>
leshan-1  | </3/0/0>
leshan-1  | </3/0/1>
[..]
```

Additionally you can see the device in the Django server under `http://localhost:8000/admin/sensordata/endpoint/`. You should see that the LAST UPDATED field contains a recent timestamp.

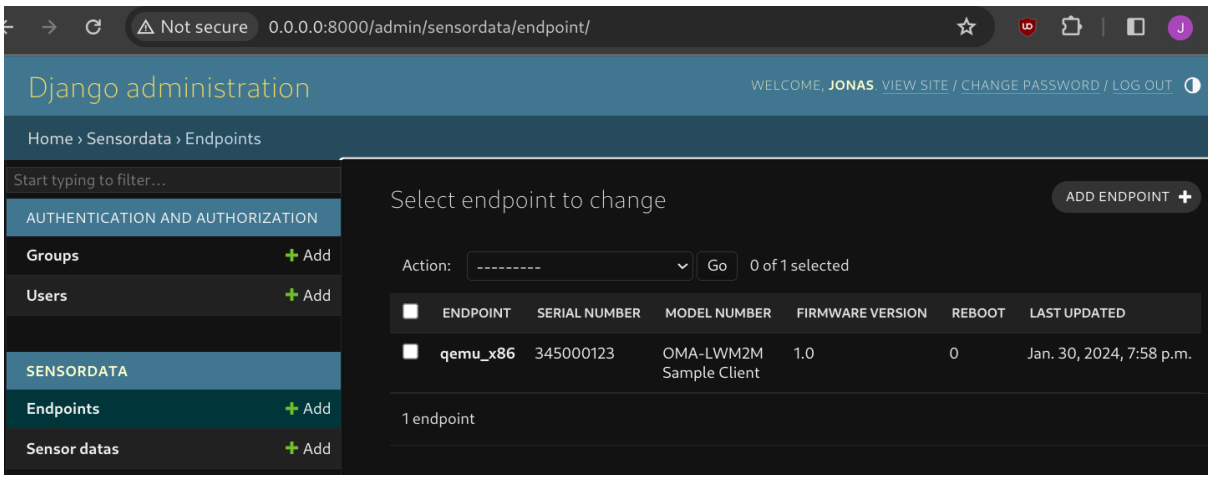

Fig. 1: Endpoints table in Django

CHAPTER

SEVEN

DOCUMENTATION

7.1 Build the documentation

```
host:~$ sudo apt-get install default-jre plantuml graphviz
host:~$ source venv/bin/activate
host:~$ cd flownexus_workspace/lwm2m_server/doc
host:lwm2m_server/doc$ pip install -r requirements.txt
host:lwm2m_server/doc$ tox -e py3-html
```

Open the generated index.html in the doc/build directory in your browser.

CHAPTER

EIGHT

GLOSSARY

Terms are usually explained and indexed directly in the documentation chapters. Additionally, some general terms are defined here to provide a quick reference. The terms defined here, as well as the indexed terms from the documentation chapters can be referenced in the documentation by using the `:term:` role.

8.1 Additional Terms and Definitions

LwM2M
: Lightweight Machine to Machine protocol.

Leshan
: LwM2M server implementation as one main component of the system.

Backend
: Django instance that is responsible for the REST API, database and visualization.

Frontend
: Web application that visualizes the data from the backend, integrated into Django.

Object
: A logical grouping of one or multiple Resources in LwM2M. An Object is identified by an Object ID.

CHAPTER

NINE

INTERNAL DJANGO

The API Documentation is available at https://jonas-rem.github.io/flownexus.

CHAPTER

TEN

WEBLOG

10.1 Update Documentation & Add Weblog

#2

Date
May 15, 2024

Author
https://github.com/Kappuccino111

Tags
Add, Update

- Switched the new documentation to *Sphinx-Book-Theme* for better readability and navigation.
- Added a new section for the weblog to keep track of updates and changes in the project.

10.2 Project Starts

#1

Date
January 1, 2024

Author
https://github.com/jonas-rem

Tags
Update

- The project has started and the initial documentation has been added.

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