helyOS

Software framework for mobile machine orchestration

Fraunhofer IVI

DIY - Deployment of Autonomous Driving Applications

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Fraunhofer-Institute for Transportation and Infrastructure Systems IVI
Dresden, Germany

Autonomous Driving in Delimited Areas

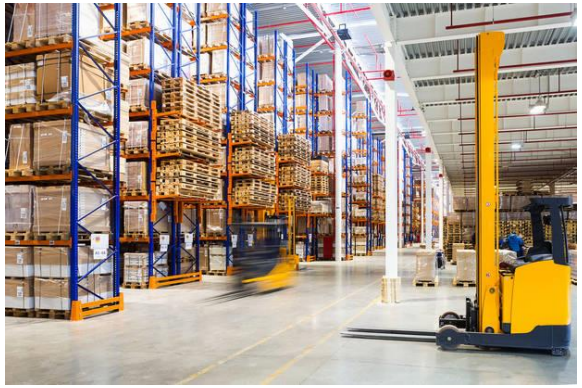
Logistic centers

Smart farms

Ports

Factories

Warehouses



Mowers

helyOS solves the Orchestration of Assignments for You

Mission A

Mission B

Mission C

Assignment 1

Assignment 3

Assignment 2

Assignment 1

Assignment 1

Assignment 3

Assignment 2

Assignment 2

Assignment 3

time

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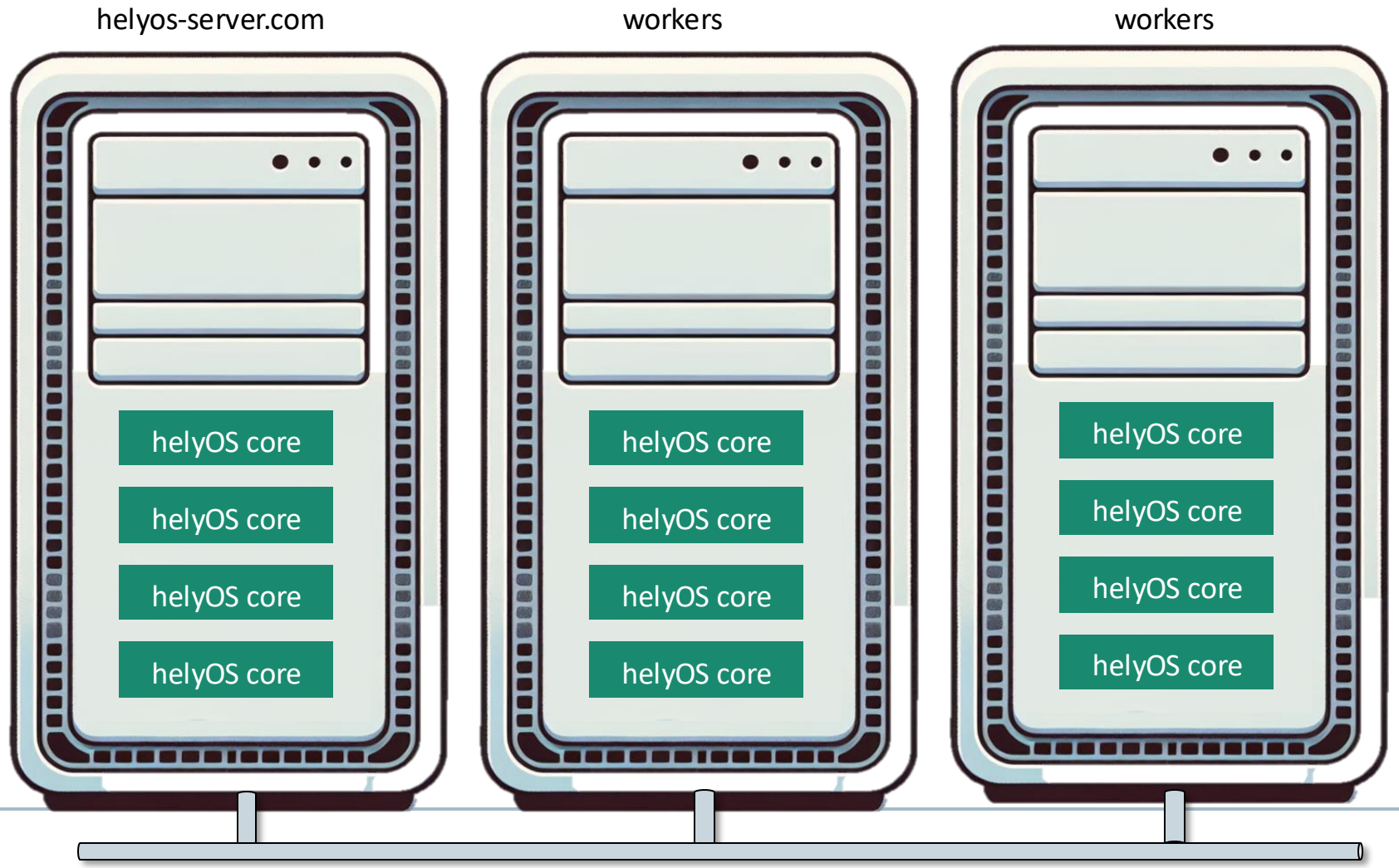
helyOS is Designed for Commercial Use

Vertically and Horizontally Scalable (version > 2.2.0)



Resource Optimization
Cost savings.

Reliability
Allow management tools like Kubernetes.

Future-Proofing
Growth with seamless scaling.

Outline

- **helyOS Framework Components**
- **Deploy Demo Applications**
- **Advancing Demo Applications Towards Real-World Scenarios.**

https://github.com/FraunhoferIVI/diy-helyos-deployment

Can’t memorize everything?

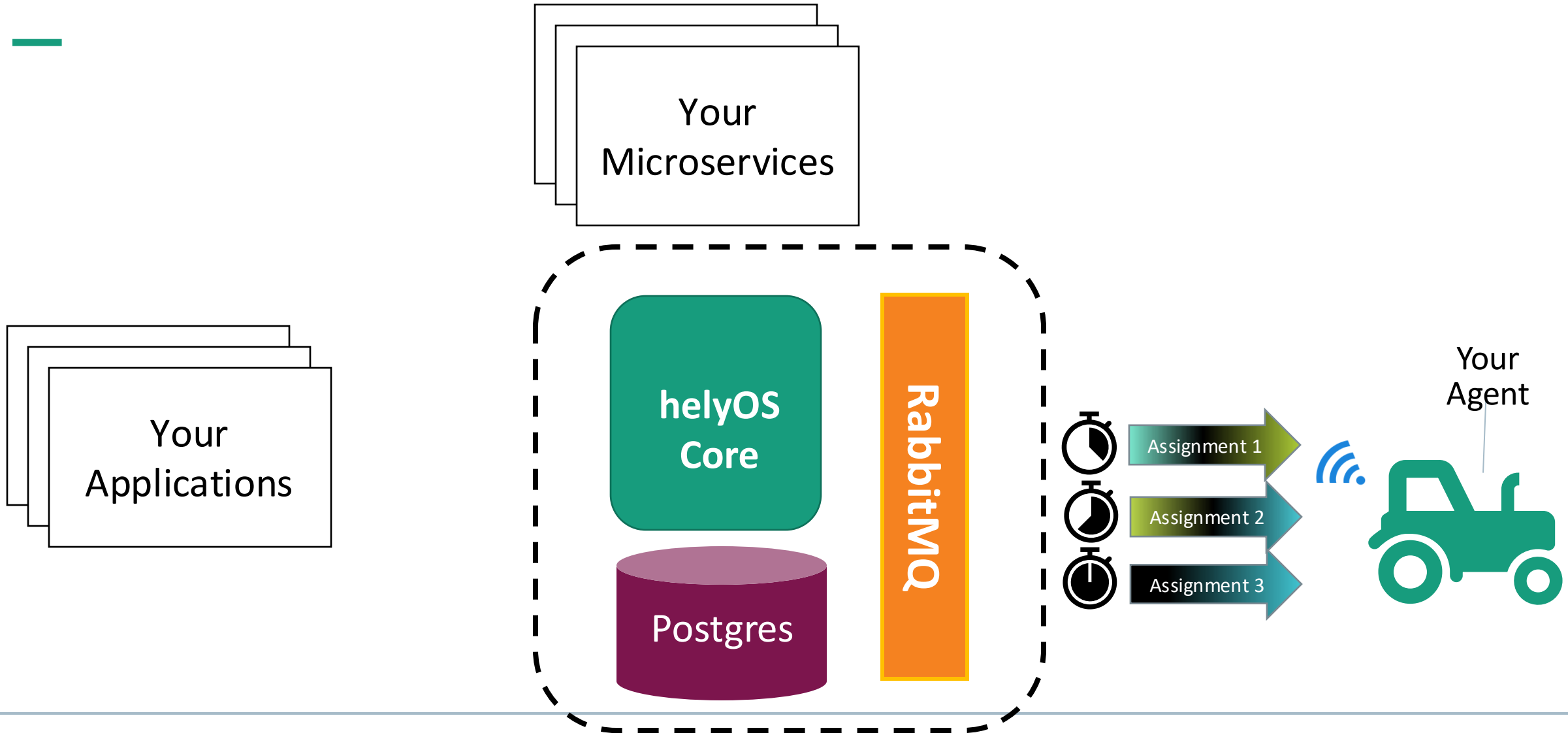
No worries, no need to.

These slides will be your cheat-sheet later!

https://github.com/FraunhoferIVI/diy-helyos-deployment

helyOS Framework Components

The helyOS framework components



The helyOS framework components

Your Applications

Agriculture platforms,
Logistic management

users

Auth &
Permissions

Web app
(visualization &
prototypes)

Your
Microservices

Add the features to your application

helyOS
Core

Postgres

RabbitMQ

Assignment 1

Assignment 2

Assignment 3

Agent

BACKEND

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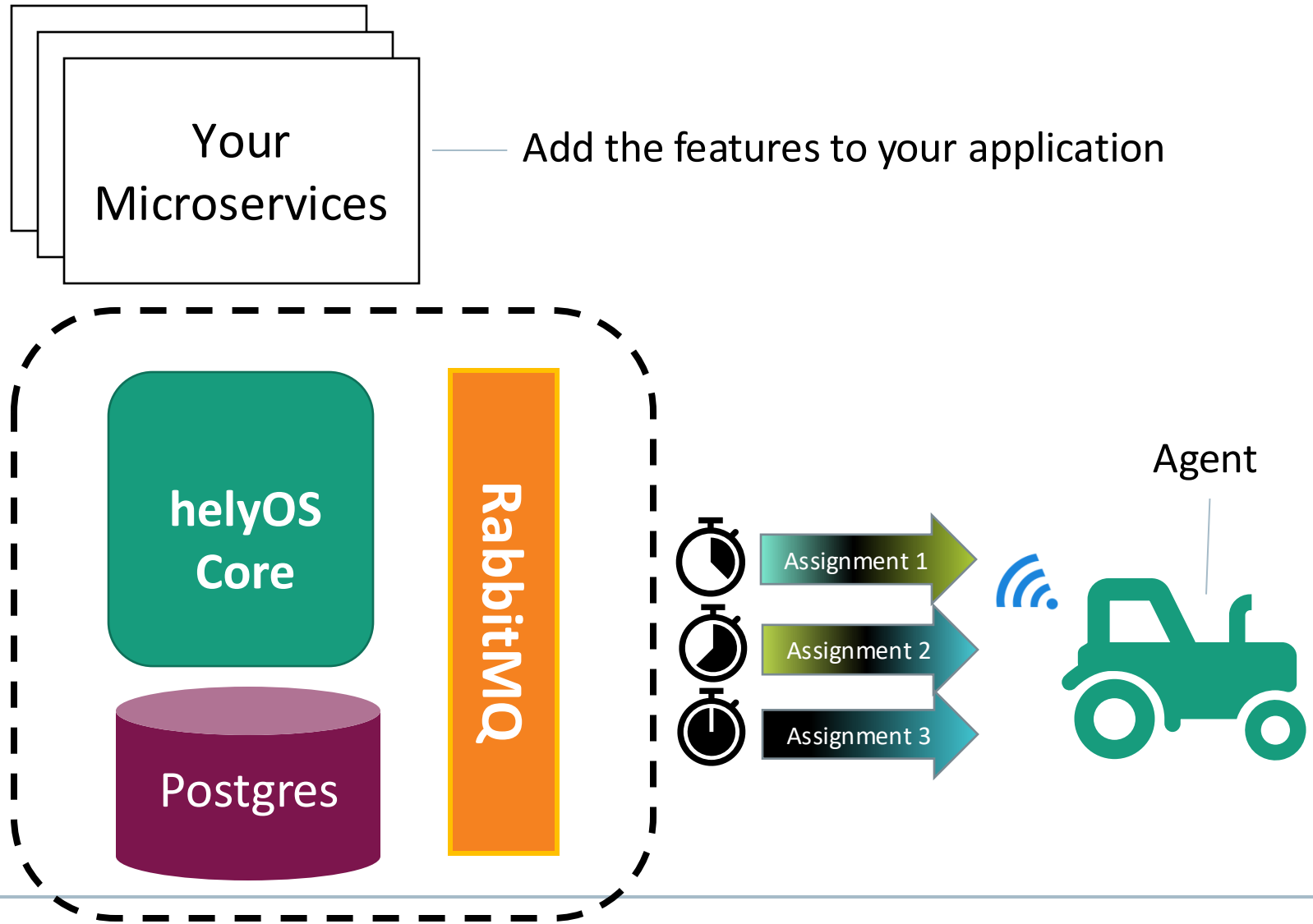
The helyOS framework components

Microservices



The main problem helyOS core is solving for you.

Microservices

Mission

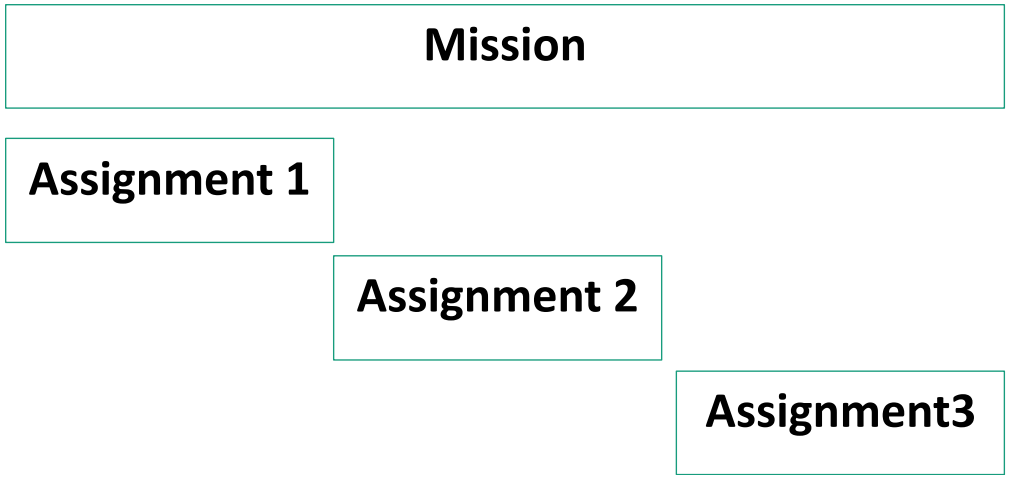
Assignment 1

Assignment 2

Assignment3

The problem we are solving with helyOS

Microservices




```python
from caculations import assigment_calculation

def my_mission(input_data):
    assignment1 = assigment_calculation(input_data, 'excavator')
    assignment2 = assigment_calculation(input_data, 'truck')
    assignment3 = assigment_calculation(input_data, 'tractor')

    results = [ {
                  "uuid": 'excavator',
                  "assignment": assignment1,
                  "assignment_order": 1},
                {
                  "uuid": 'truck',
                  "assignment": assignment2,
                  "assignment_order": 2},
                {
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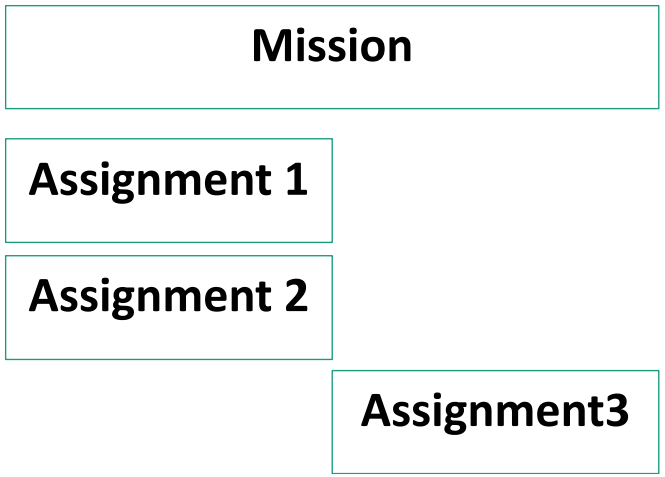
                  "assignment": assignment3,
                  "assignment_order": 3}

                 ]

    return results
```

The problem we are solving with helyOS

Microservices

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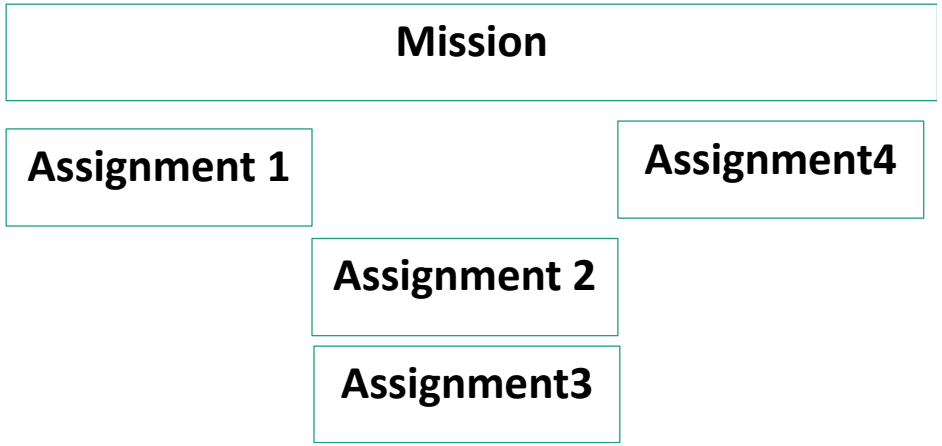
    return results
```

The problem we are solving with helyOS

Microservices

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    assignment4 = assigment_calculation(input_data, 'excavator')


    results = [ {
                  "uuid": 'excavator',
                  "assignment": assignment1,
                  "assignment_order": 1},
                {
                  "uuid": 'truck',
                  "assignment": assignment2,
                  "assignment_order": 2},
                {
                  "uuid": 'tractor',
                  "assignment": assignment3,
                  "assignment_order": 2},
                              {
                  "uuid": 'escavator',
                  "assignment": assignment4,
                  "assignment_order": 3}

                ]

    return results
```

The problem we are solving with helyOS

Microservices

Function in a Module

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                  "uuid": 'tractor',
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                  "assignment_order": 3}

                 ]

    return results
```


Function Wrapped as a service

```python
from flask import Flask, request, jsonify
from caculations import assigment_calculation

app = Flask(__name__)

@app.route('/plan_job', methods=['POST'])
def my_mission():
    input_data = request.json.get('input_data')
    assignment1 = assigment_calculation(input_data, 'excavator')
    assignment2 = assigment_calculation(input_data, 'truck')
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            "assignment_order": 1
        },
        {
            "uuid": 'tractor',
            "assignment": assignment3,
            "assignment_order": 2
        }
    ]

    return jsonify(results)

if __name__ == '__main__':
    app.run(debug=True)
```
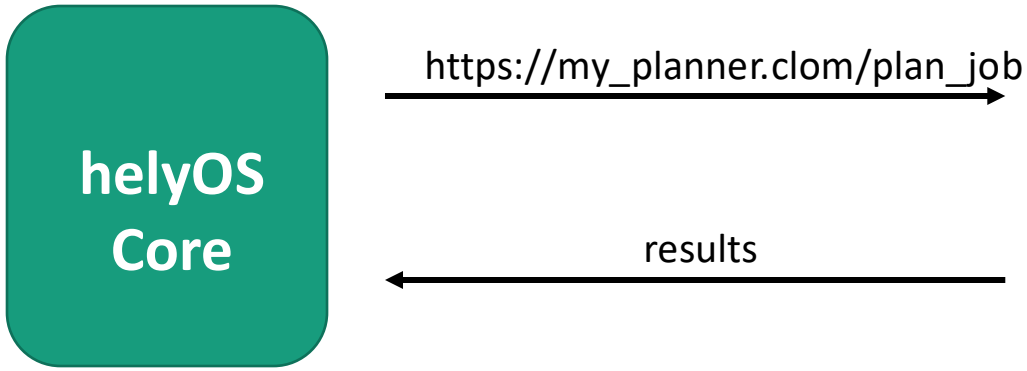

The problem we are solving with helyOS

Microservices



Microservice

```python
from flask import Flask, request, jsonify
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@app.route('/plan_job', methods=['POST'])
def my_mission():
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    ]

    return jsonify(results)


if __name__ == '__main__':
    app.run(debug=True)
```

The helyOS framework components

Your Applications

Agriculture platforms,
Logistic management

users

Auth &
Permissions

Web app
(visualization &
prototypes)

Your
Microservices

Add the features to your application

helyOS
Core

Postgres

RabbitMQ

Assignment 1

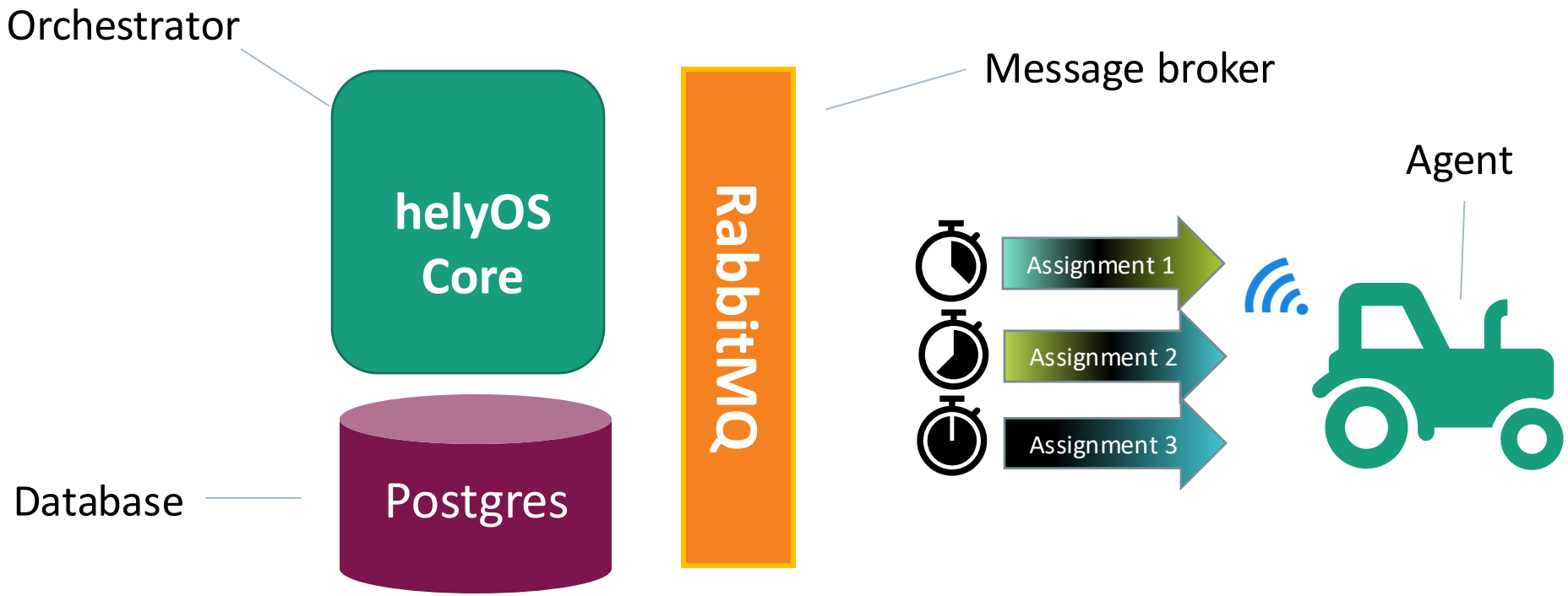
Assignment 2

Assignment 3

Agent

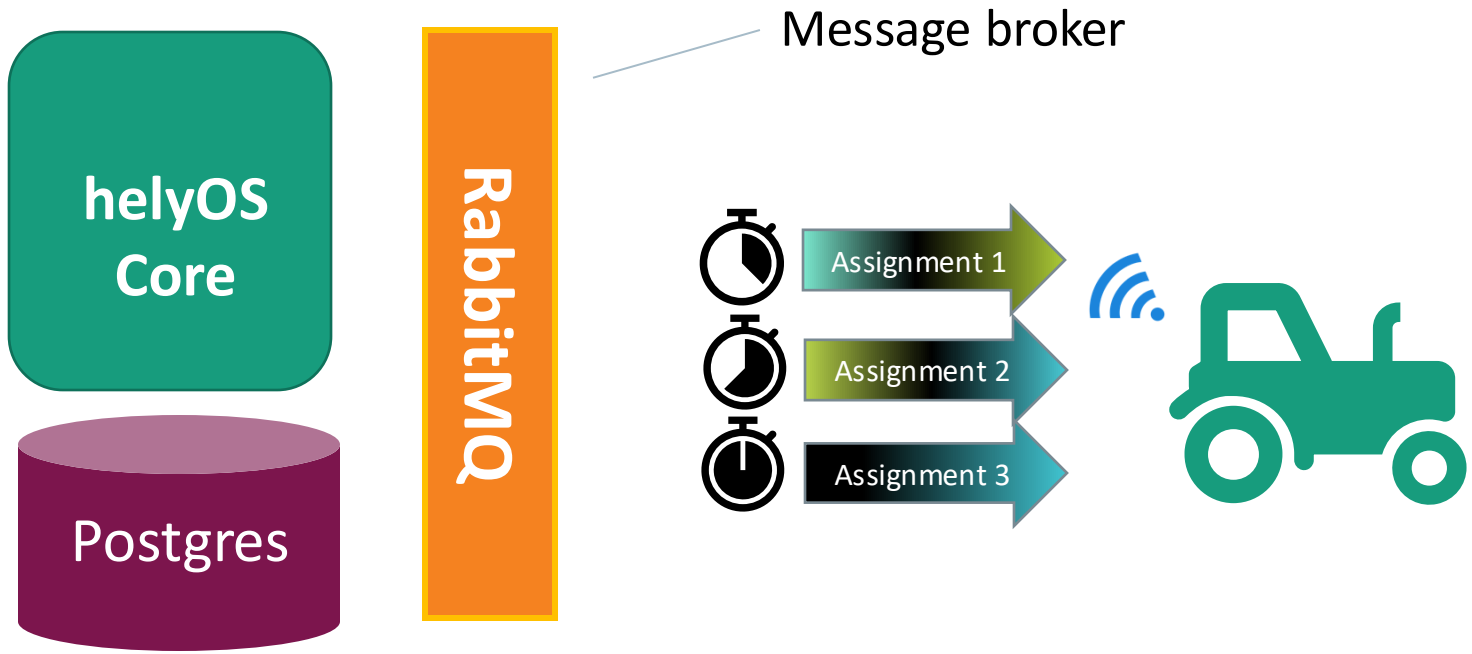
BACKEND

The helyOS framework components



The helyOS framework components

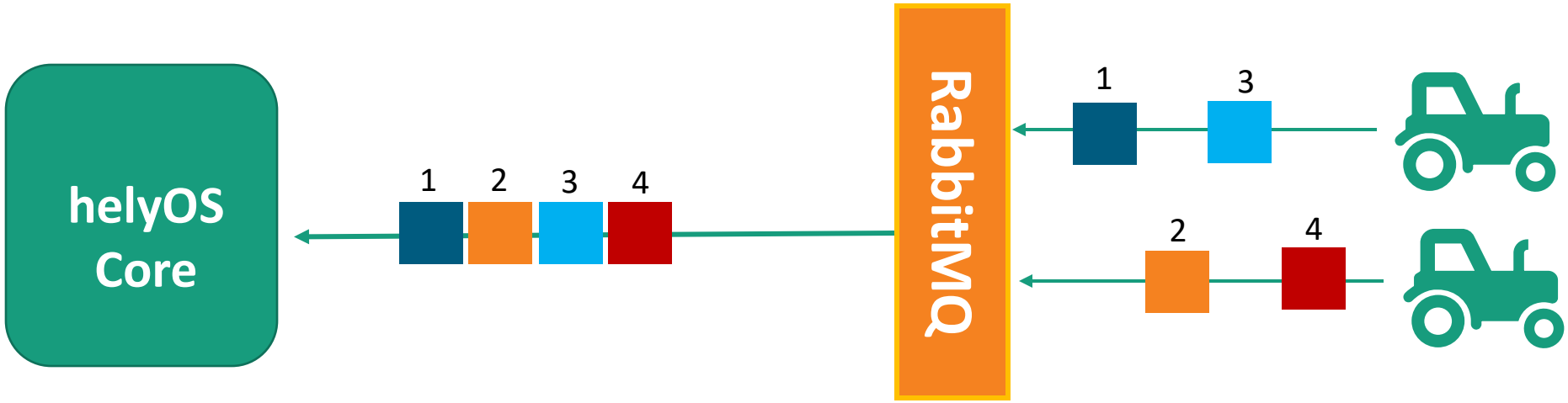
Message Broker



The helyOS framework components

Why RabbitMQ ?

- **Queueing is crucial for the correct orchestration**.
- Multiple Protocols including AMQP, MQTT, and STOMP
- Robust security features, which help prevent message forging.



Deploying Demo Application

- Blazing-Fast Course on Docker
- Install helyOS Backend on Your Computer
- Creating a Microservice
- Running Your Application
- Migrate Your Installation to the Cloud

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The helyOS framework components

Your Applications

Agriculture platforms,
Logistic management

users

Auth &
Permissions

Web app
(visualization &
prototypes)

microservices

Tailor the application by adding features

helyOS
Core

Postgres

RabbitMQ

Assignment 1

Assignment 2

Assignment 3

BACKEND

The helyOS framework components

Our Application

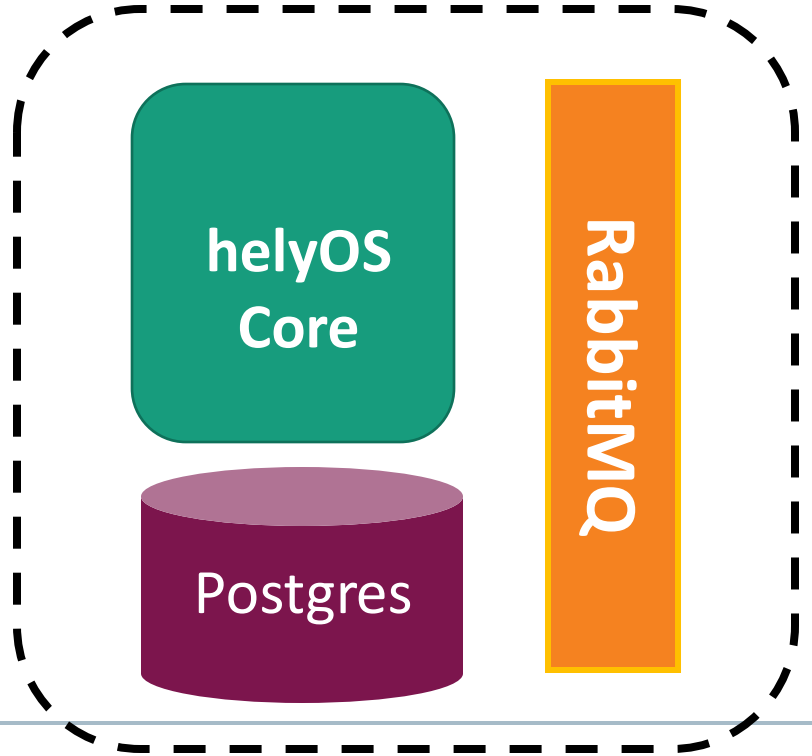
Your Applications

Python Script

Web app

microservice
Clothoid planner

Drivable paths for vehicles



BACKEND

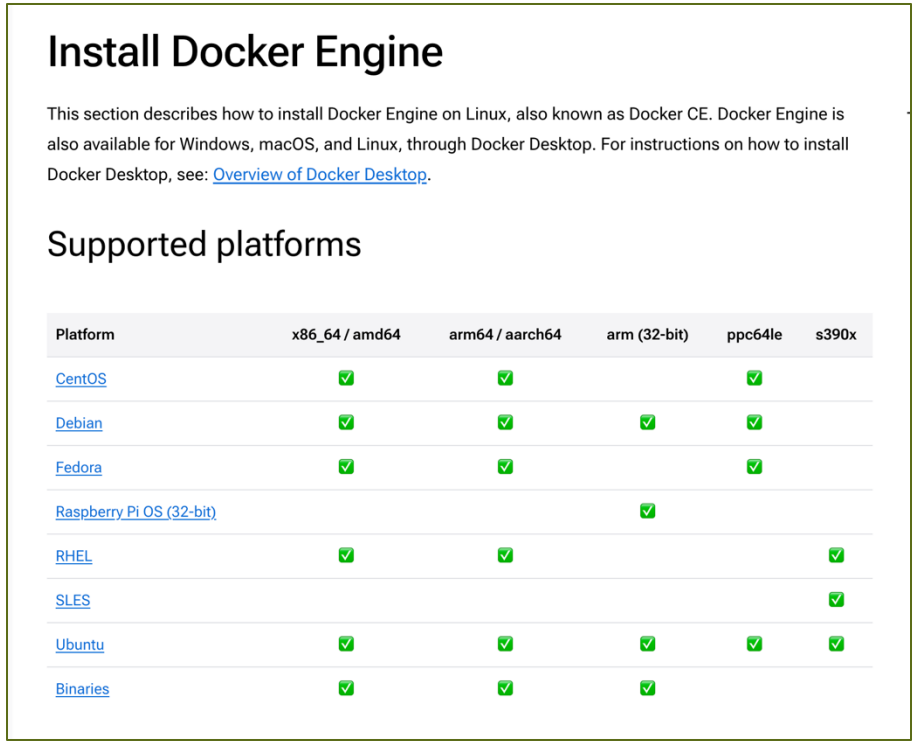
Assignment 1

Blazing-Fast Course on Docker

Install

https://www.docker.com/

https://docs.docker.com/engine/install/



- Docker **containers** are like a **super-light virtual machine**; they have their own “disk”, OS and network.
- **Host machine**: It is where you installed the Docker, where the containers run.
- The docker **image** encloses the base data of the container.
- **docker-compose.yml** is a file that describes which and how the containers run.

Blazing-Fast Course on Docker

docker-compose.yml

```yaml
services:

    local_rabbitmq:
        image: rabbitmq:3-management
        hostname: local_rabbitmq
        volumes:
            - rbmq_data:/var/lib/rabbitmq/

        networks:
            - my-docker-net
        ports:
            - 15672:15672


networks:
    my-docker-net:
        external: true


volumes: # For persistent data
    rbmq_data:
        external: false
```

Image name

Define a hostname for this container

Mapping internal folder into host file system

Open port to the host machine

Name of network

Storing the mapped folder on the host disk.

Blazing-Fast Course on Docker

Interacting with docker-compose.yml

We will be using four docker commands:

docker network create my-docker-net	Creates a virtual network.
docker compose up -d	Starts the containers.
docker compose down	Stops and removes all containers from the RAM.
docker compose down -v	Stops and removes all containers from the RAM and remove all volumes (permanent data).

Optional parameter: -f my_docker-compose.yml

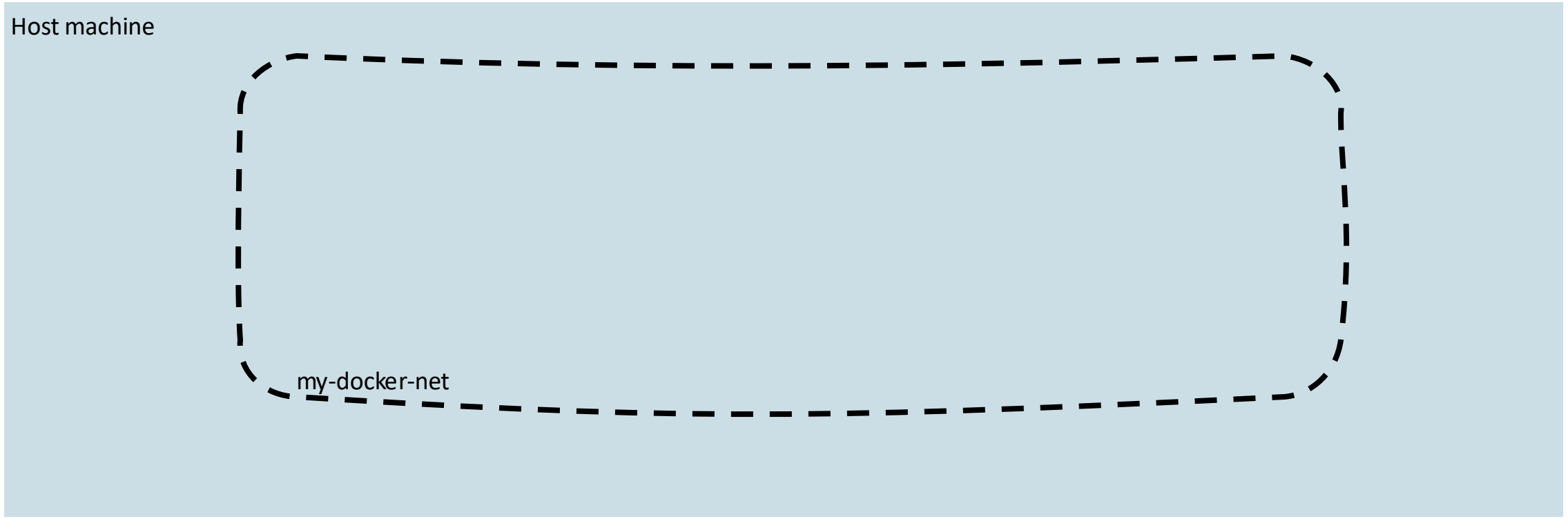
Blazing-Fast Course on Docker

Interacting with docker-compose.yml

```yaml
services:


    local_rabbitmq:
        image: rabbitmq:3-management
        hostname: local_rabbitmq
        volumes:
            - rbmq_data:/var/lib/rabbitmq/

        networks:
            - my-docker-net
        ports:
            - 15672:15672


    local_postgres:
        image: postgres:13
        hostname: local_postgres
        volumes:
            - postgres_data:/var/lib/postgresql/data/
        environment:
            POSTGRES_USER: helyos_db_admin
            POSTGRES_PASSWORD: helyos_secret
        networks:
            - my-docker-net


networks:
    my-docker-net:
        external: true


volumes: # For persistent data
    postgres_data:
        external: false
    rbmq_data:
        external: false
```

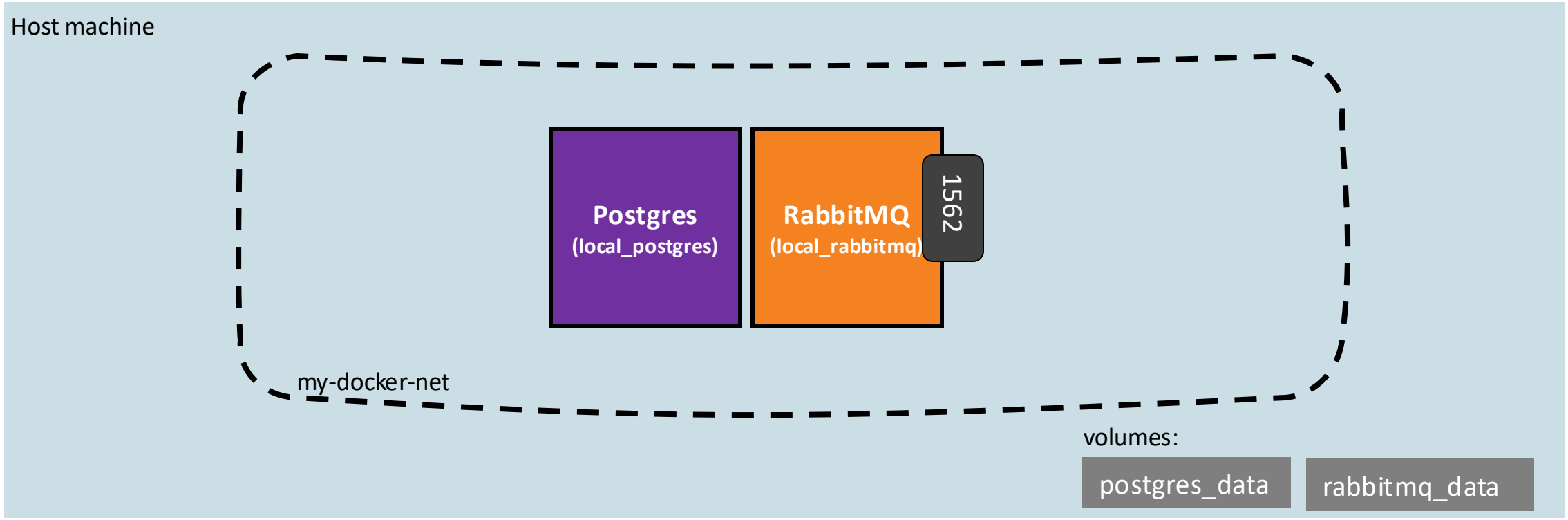
Parameter: -f my_docker-compose-pg-rmbq.yml

Blazing-Fast Course on Docker



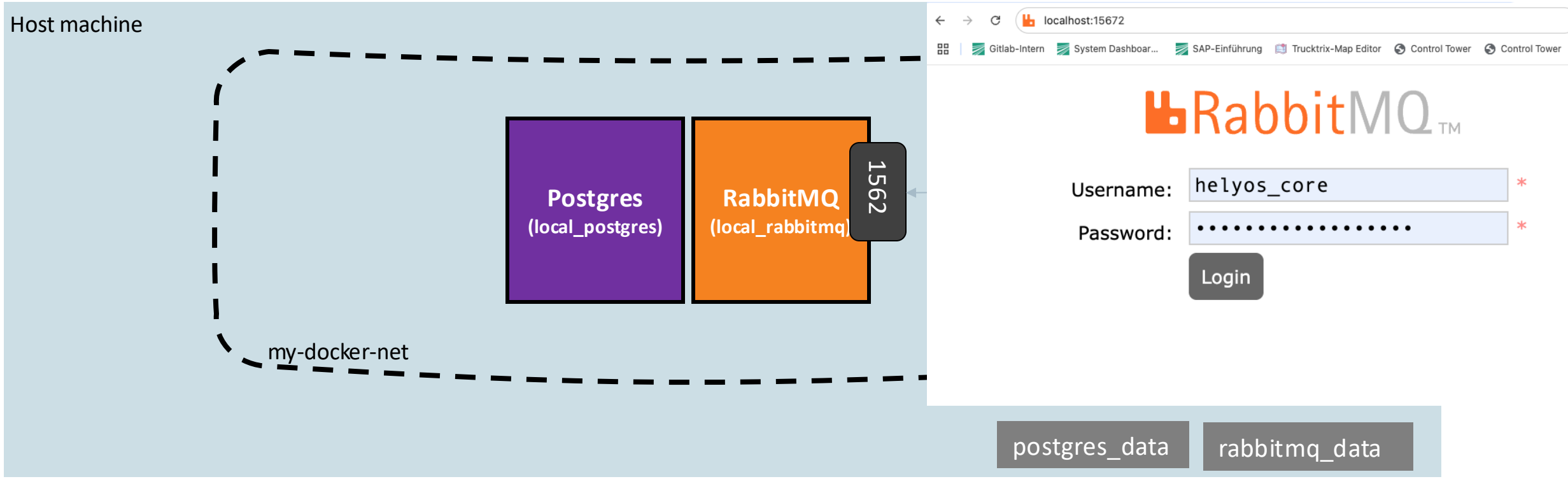

```
$ docker network create my-docker-net
```

Blazing-Fast Course on Docker



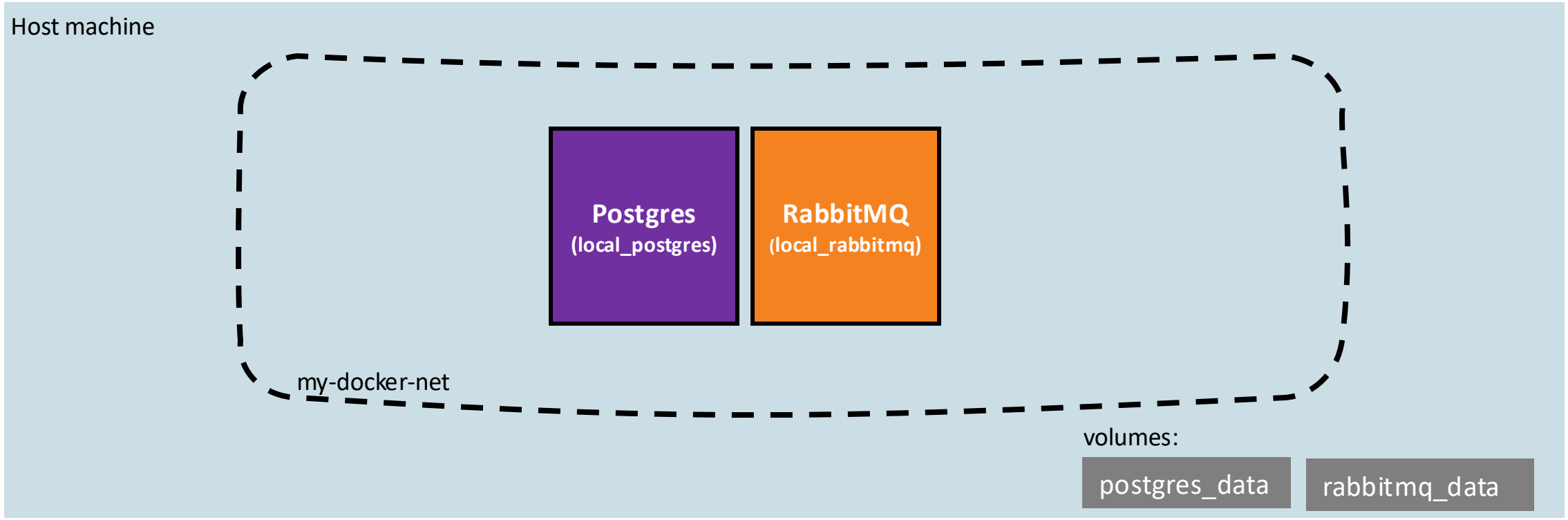

```
$ docker compose –f docker-compose-pg-rbmq.yml up -d
```

Blazing-Fast Course on Docker



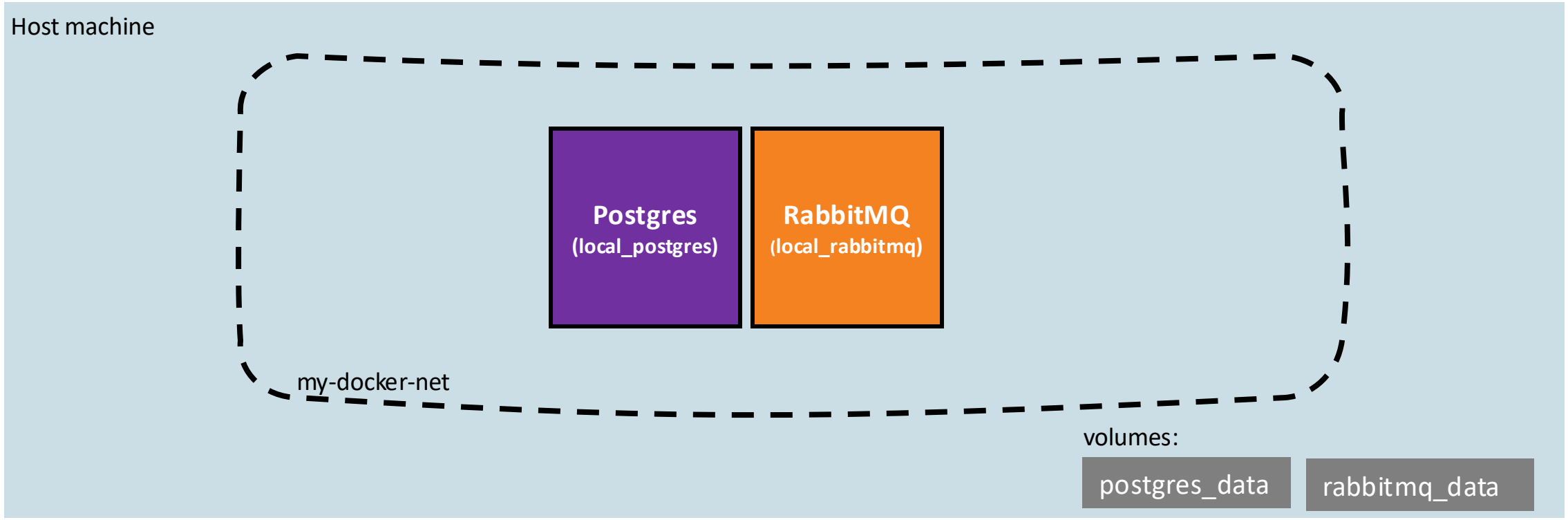

```
$ docker compose –f docker-compose-pg-rbmq.yml up -d
```

Blazing-Fast Course on Docker




```
$ docker compose –f docker-compose-pg-rbmq.yml down
```

Blazing-Fast Course on Docker




```
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```
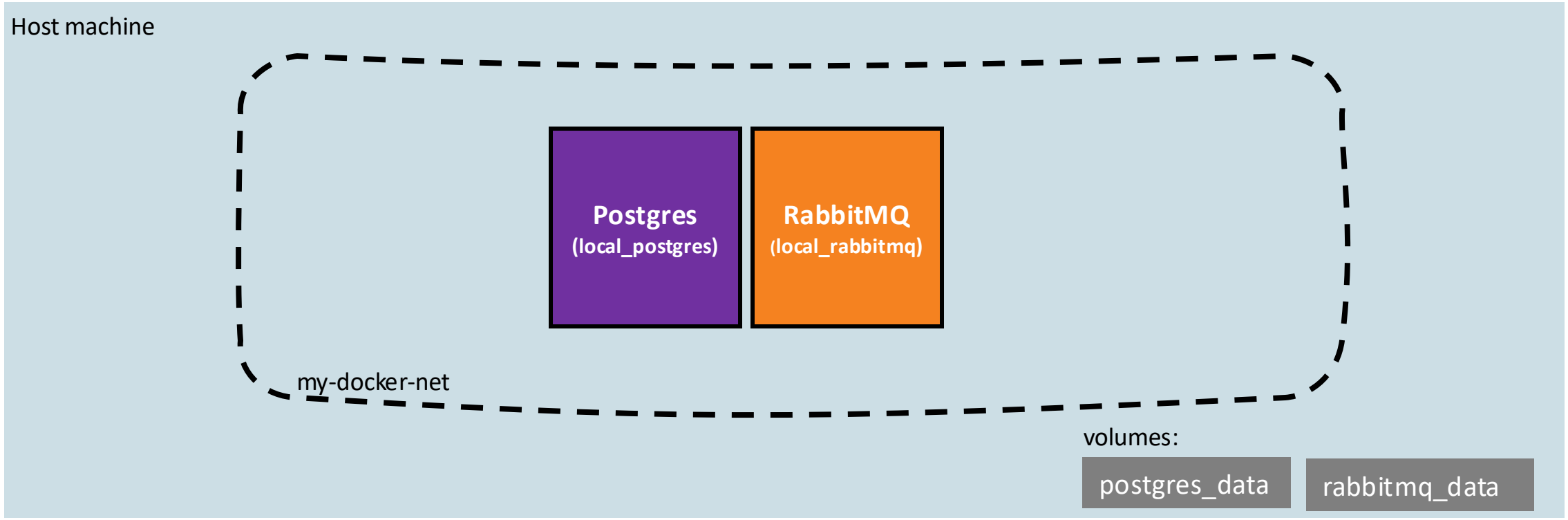

Blazing-Fast Course on Docker




```
$ docker compose –f docker-compose-pg-rbmq.yml down -v
```

Blazing-Fast Course on Docker

Other useful commands

docker ps

List running containers.

docker system prune

Unexpected issues, it clean up unused containers, networks, images, and build cache.

docker compose –f my_docker-compose.yml logs

See the logs of all containers listed in the docker compose file.

Install helyOS Backend on Your Computer

Now that you are an expert in Docker ;)

let’s start our helyOS project !

Install helyOS Backend on Your Computer

```yaml
services:

    helyos_core:
        image: helyosframework/helyos_core:2.2.0-rc1

        ports:
            - 5002:5002 # Websocket: Push Notifications.
            - 5000:5000 # GraphQL: Communicate with External Applications
            - 8080:8080 # HelyOS Dashboard: Settings and Monitoring for Developers

        volumes:
            - ./etc_helyos/:/etc/helyos/:ro

        environment:
            # DATABASE
            - PGUSER=helyos_db_admin
            - PGPASSWORD=helyos_secret
            - JWT_SECRET=keyboard_kitten
            - PGHOST=local_postgres
            - PGDATABASE=smartfarm_db
            - PGPORT=5432
            - GQLPORT=5000

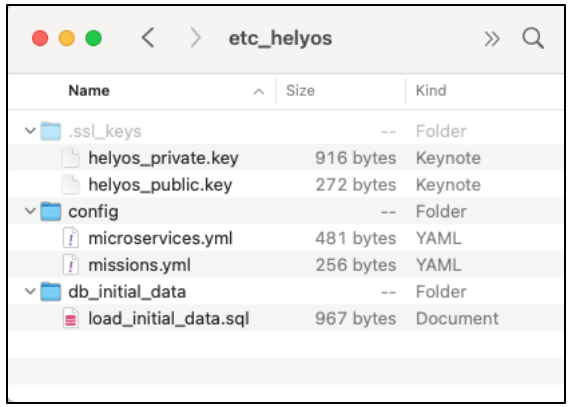
            # RABBITMQ
            - RBMQ_HOST=local_rabbitmq
            - RBMQ_PORT=5672
            - RBMQ_API_PORT=15672
            - RBMQ_SSL=False      # For TLS support
            - RBMQ_API_SSL=False # For TLS support

            # RBMQ ACCOUNTS
            - CREATE_RBMQ_ACCOUNTS=True
            - RBMQ_ADMIN_USERNAME=helyos_rbmq_admin # Set it if CREATE_RBMQ_ACCOUNTS is True
            - RBMQ_ADMIN_PASSWORD=helyos_secret     # Set it if CREATE_RBMQ_ACCOUNTS is True
            - AGENT_AUTO_REGISTER_TOKEN=0001-0002-0003-0000-0004 # Delete it for production

        networks:
            - my-docker-net


networks:
    my-docker-net:
        external: true
```

helyOS official image



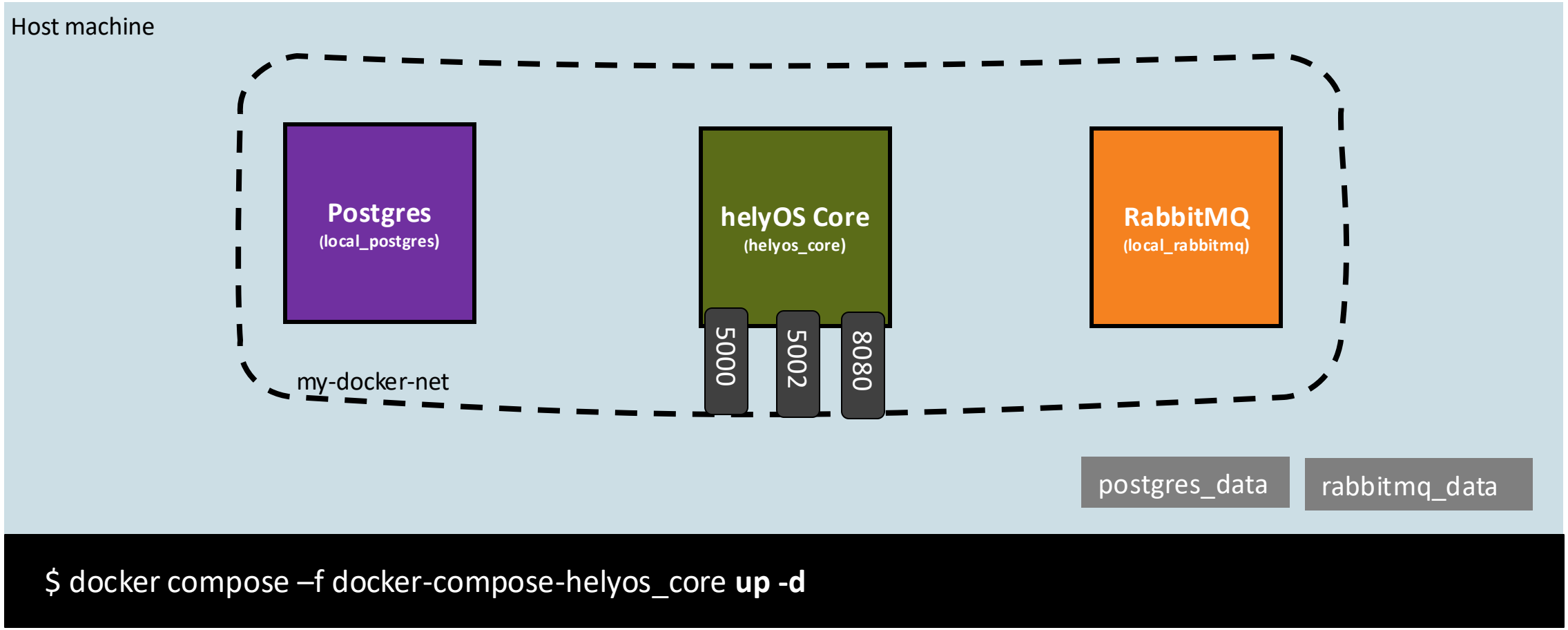
RabbitMQ hostname

Postgres hostname

Only for development: any agent with this token can access helyOS.

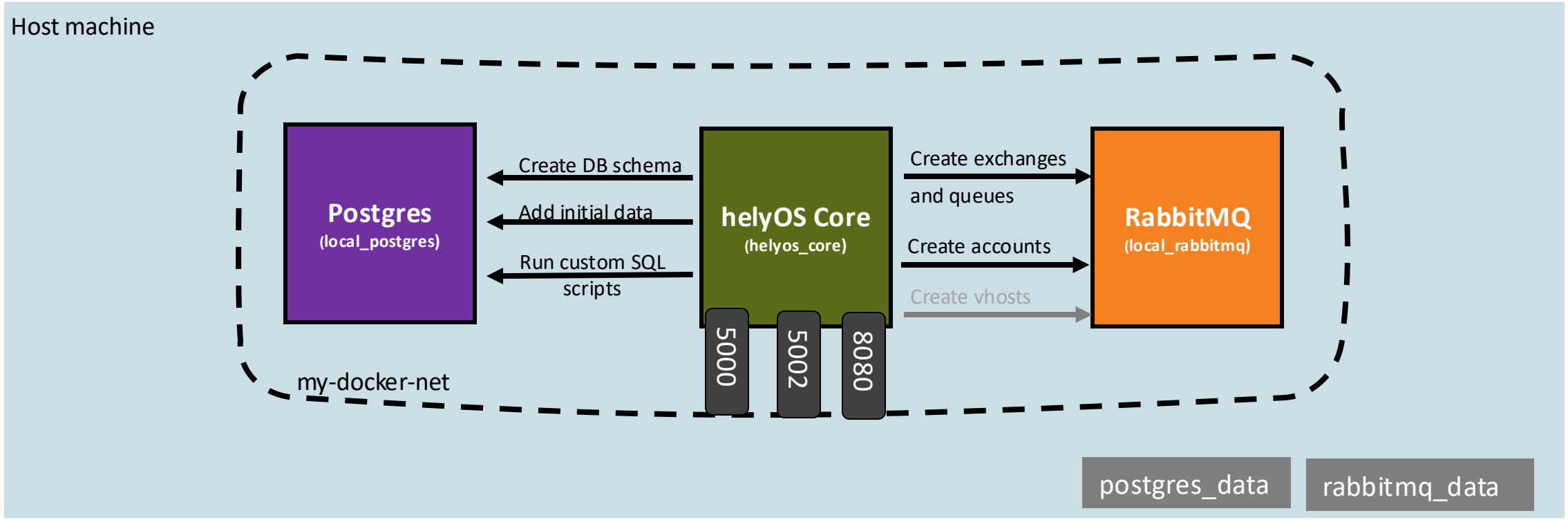
https://helyos-manual.readthedocs.io/en/latest/2-helyos-configuration/getting-started.html#helyos-setting

Install helyOS Backend on Your Computer




```
$ docker compose –f docker-compose-helyos_core up -d
```

Install helyOS Backend on Your Computer

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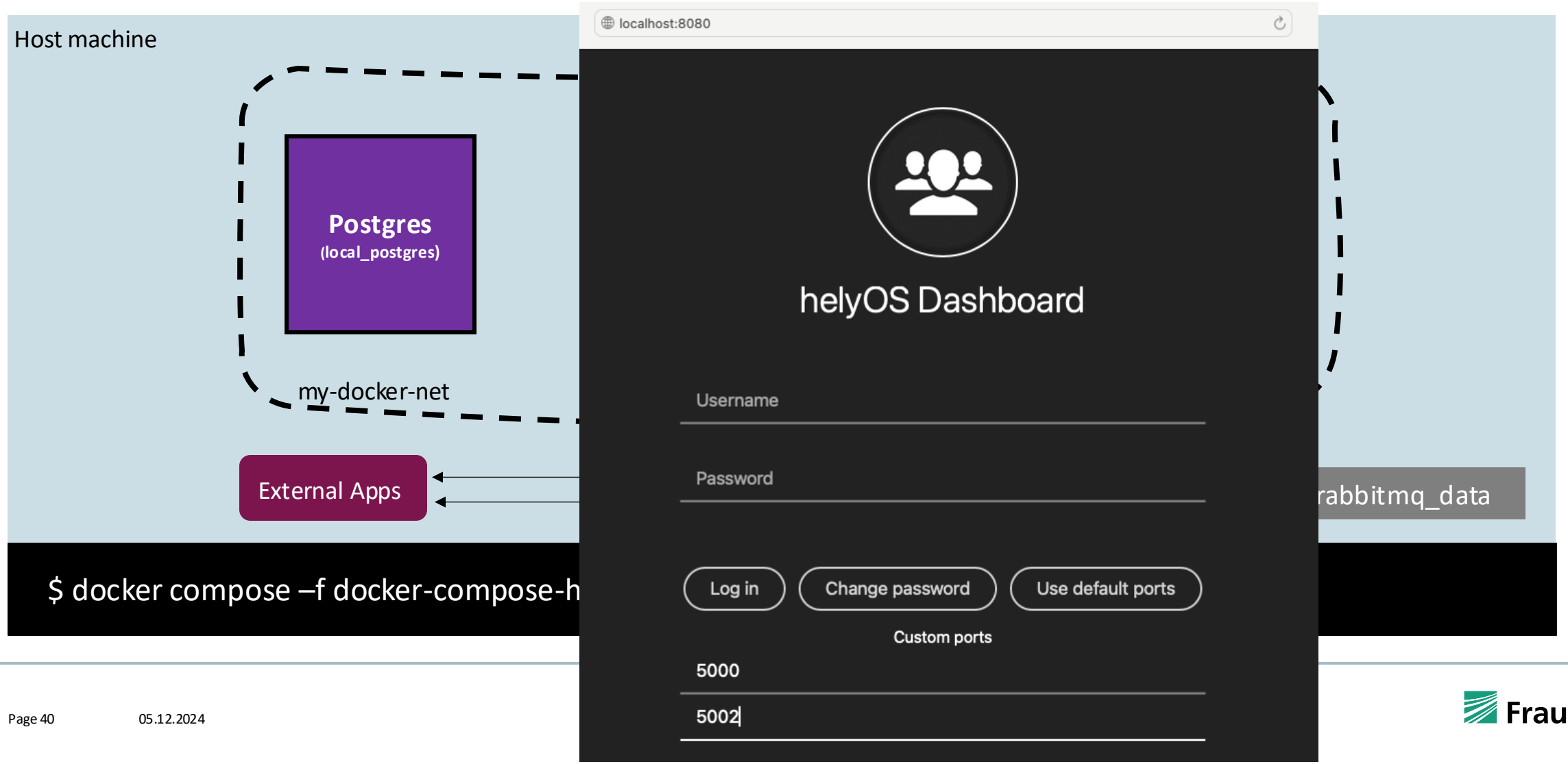
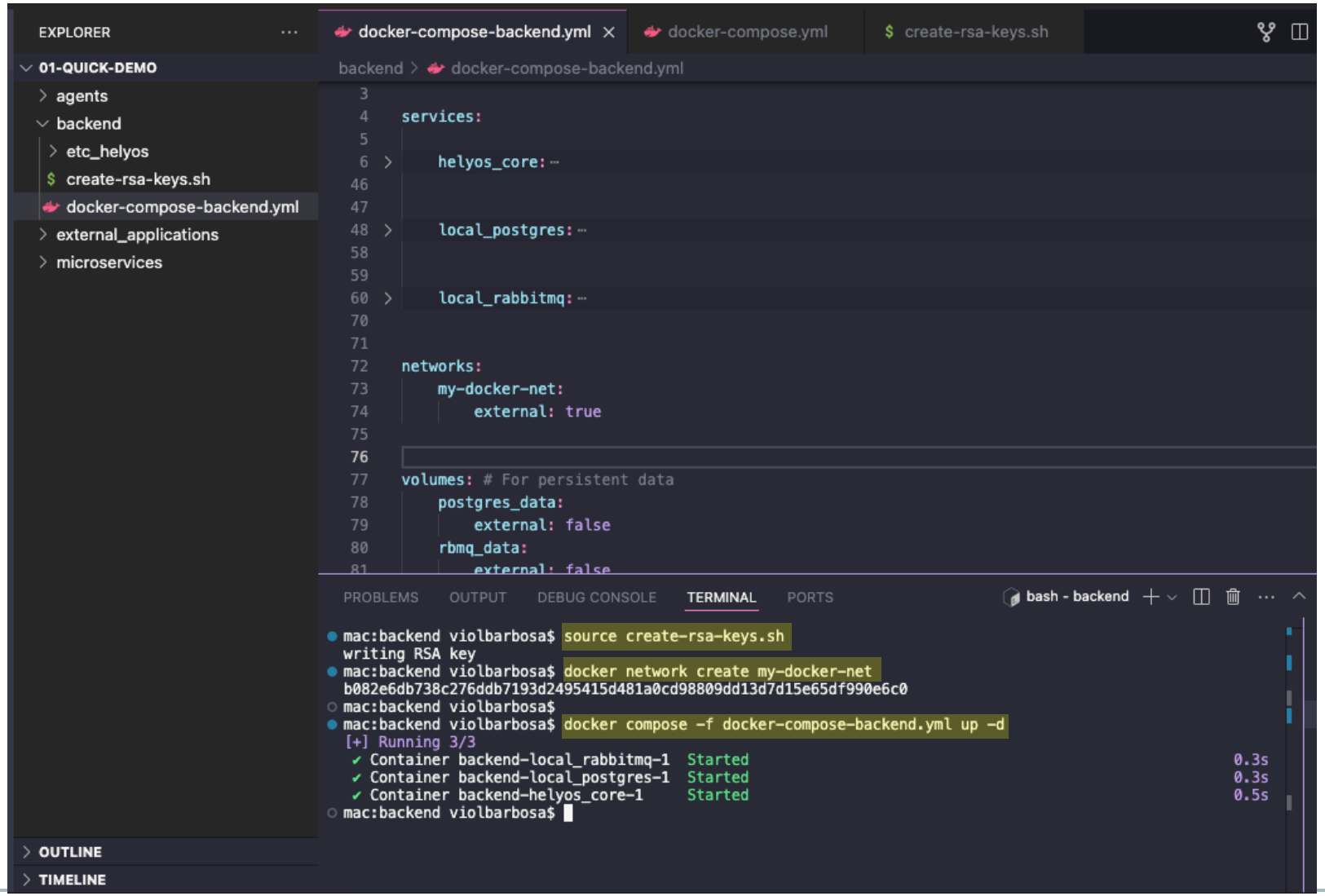
```

Install helyOS Backend on Your Computer



Install helyOS Backend on Your Computer

Wrapping up



The helyOS framework components

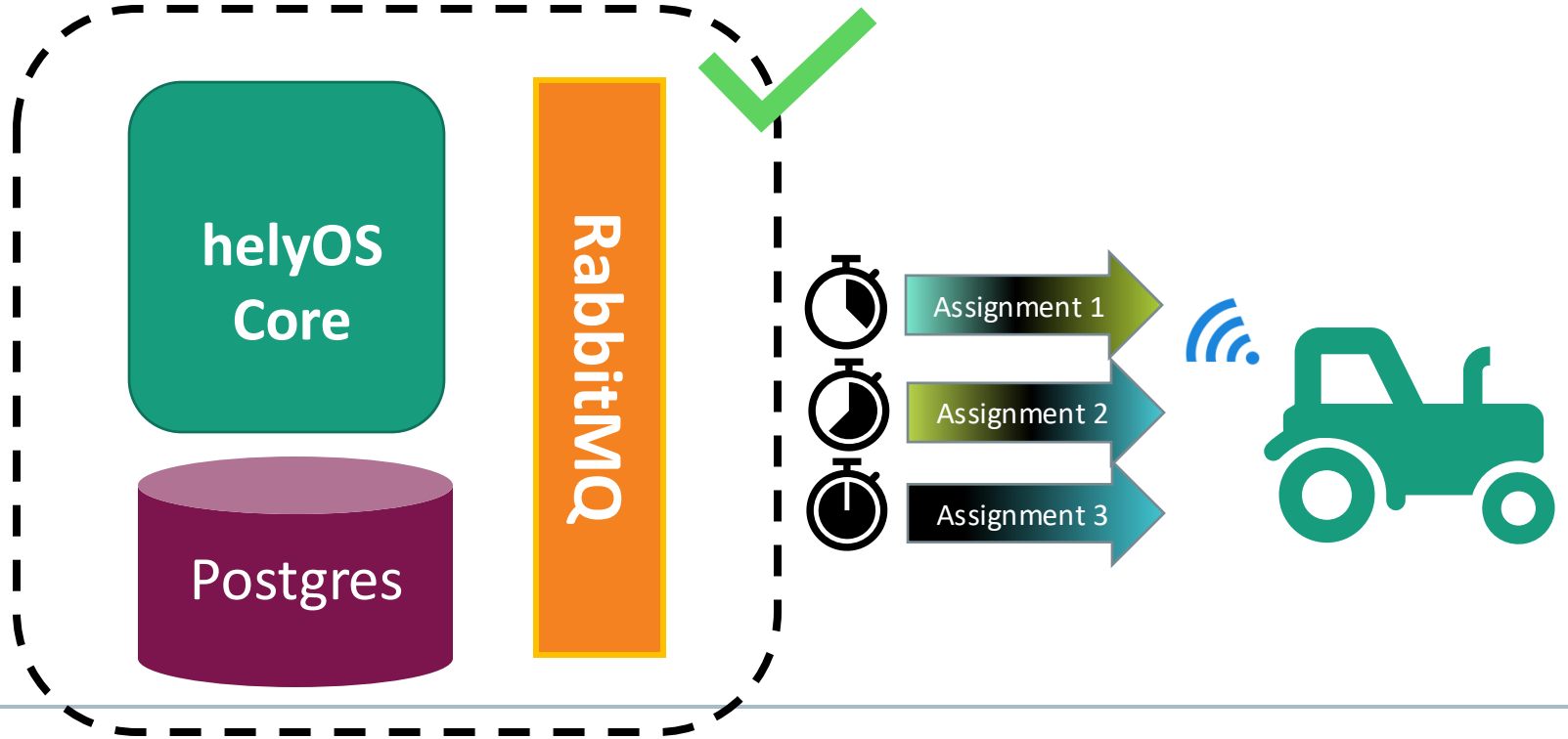
Your Applications.

Python Script

Web app

microservice
Clothoid planner

Drivable paths for vehicles



BACKEND

Creating a Microservice

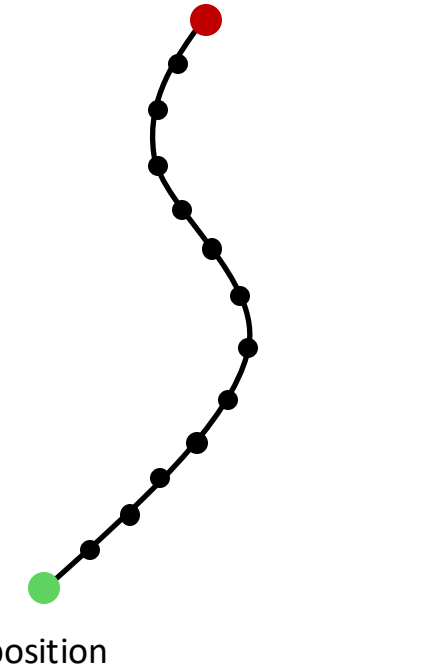
Code: service.py

```python
from flask import Flask, jsonify,  request
from path_calculation import calculate_path

app = Flask(__name__)

@app.post("/plan_job/")
def getPath():
    """
    Calculate path using a data format COMPATIBLE with the AGENT.
    """
    request_body = request.get_json()
    request_data = request_body['request']   # Input from external application.
    helyos_context = request_body['context'] # Snapshot from helyos database.

    # Parse input data
    agent_uuid = request_data.get('agent_uuid',  None)
    initial_position = request_data.get('initial_position', None)
    destination = request_data.get('destination', initial_position)

    # Calculate path
    assignment = calculate_path(initial_position, destination)

    # Return response
    response =     {
                    "results":[{
                                    "agent_uuid": agent_uuid,
                                    "assignment": assignment
                                }]
                }


    return jsonify(response)

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=9002, debug=True)
```

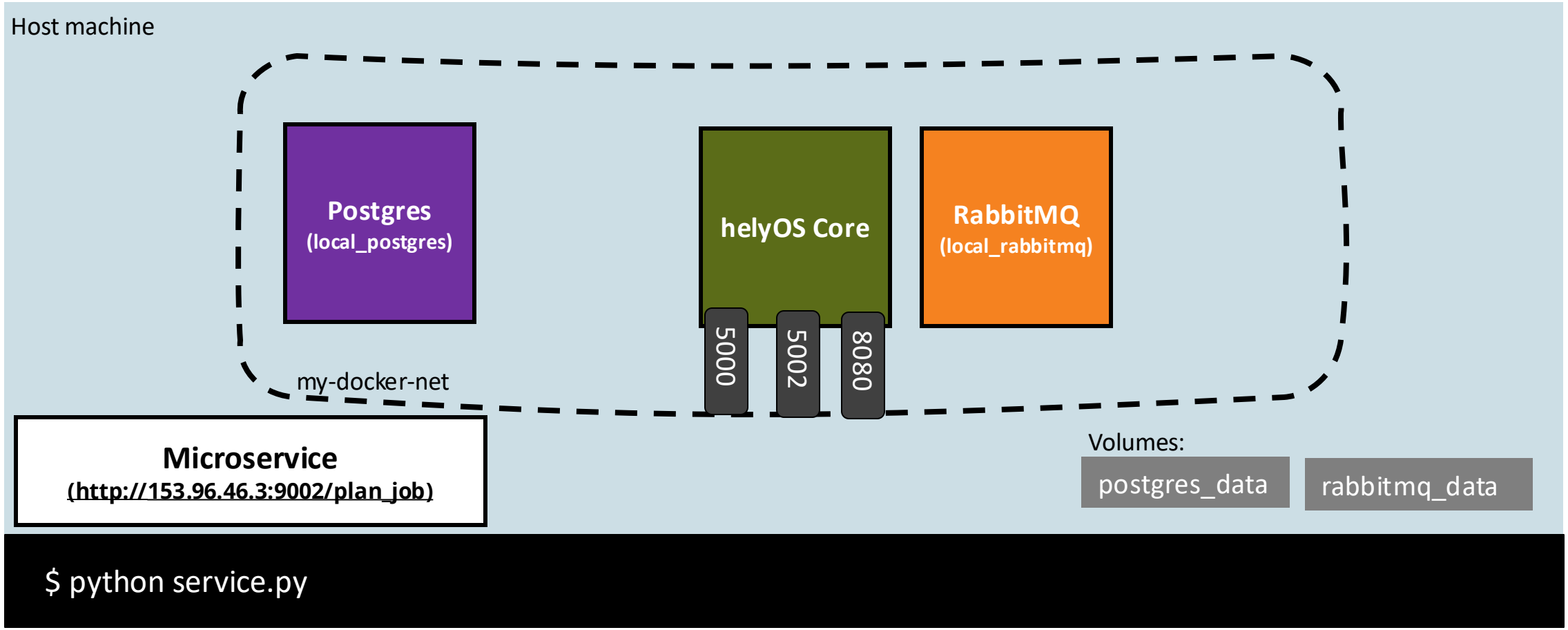
Example of request_data:

```
{
    "initial_position": {
        "x": 23234,
        "y": 54653,
        "orientations": [
            0
        ]
    },
    "destination": {
        "x": 11234,
        "y": 64653,
        "orientations": [
            1570.7
        ]
    }
}
```

Data format compatible with the vehicle that will receive this assignment.



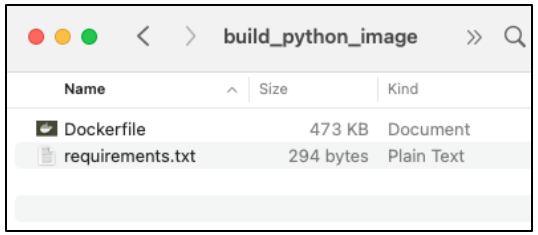
Running microservice
On the host machine

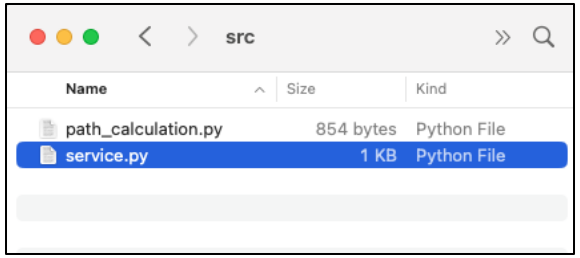


Creating microservice

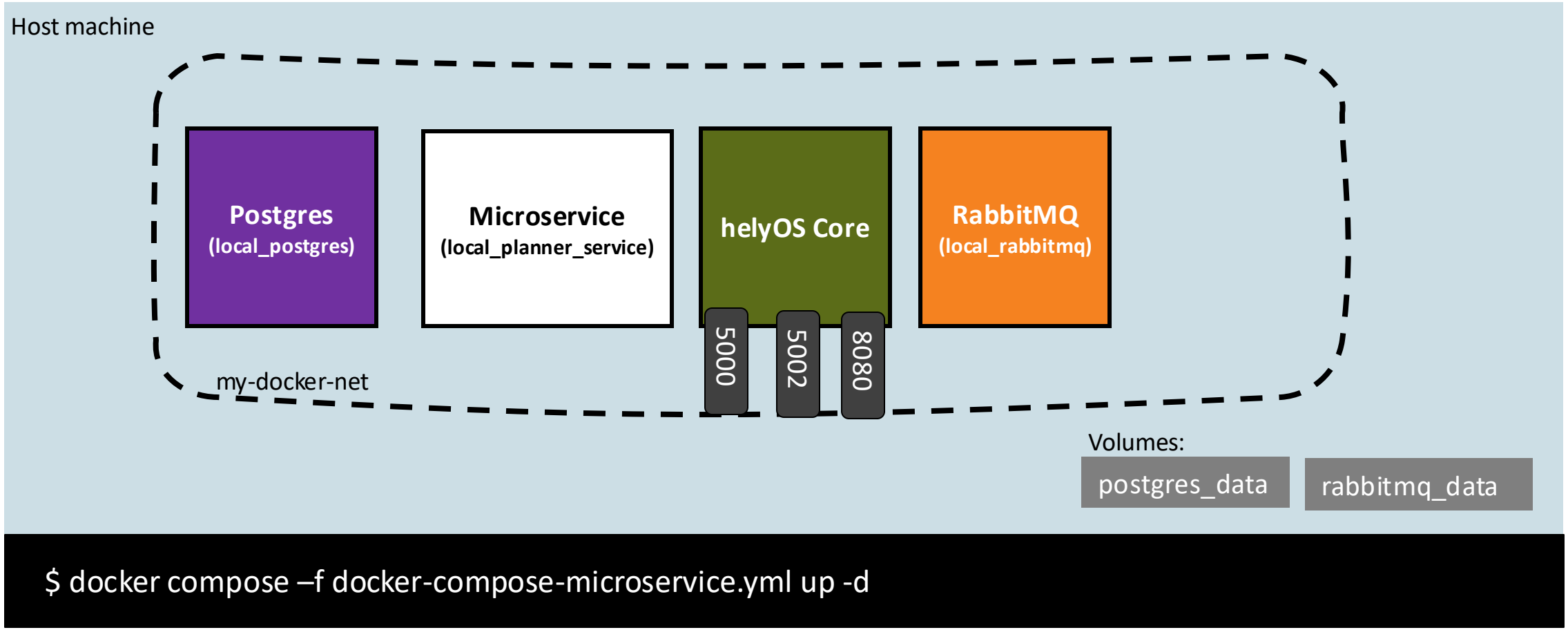
Set the service in a container

```yaml
services:

  local_planner_service:
    restart: always
    container_name: local_planner_service

    build:
      dockerfile: ./build_python_image/Dockerfile

    volumes:
      - ./src/:/app/src

    networks:
      - my-docker-net

    ports:
      - "9002:9002"  # optional


networks:
    my-docker-net:
        external: true
```





Running microservice
As a Docker container




```
$ docker compose –f docker-compose-microservice.yml up -d
```

The helyOS framework components

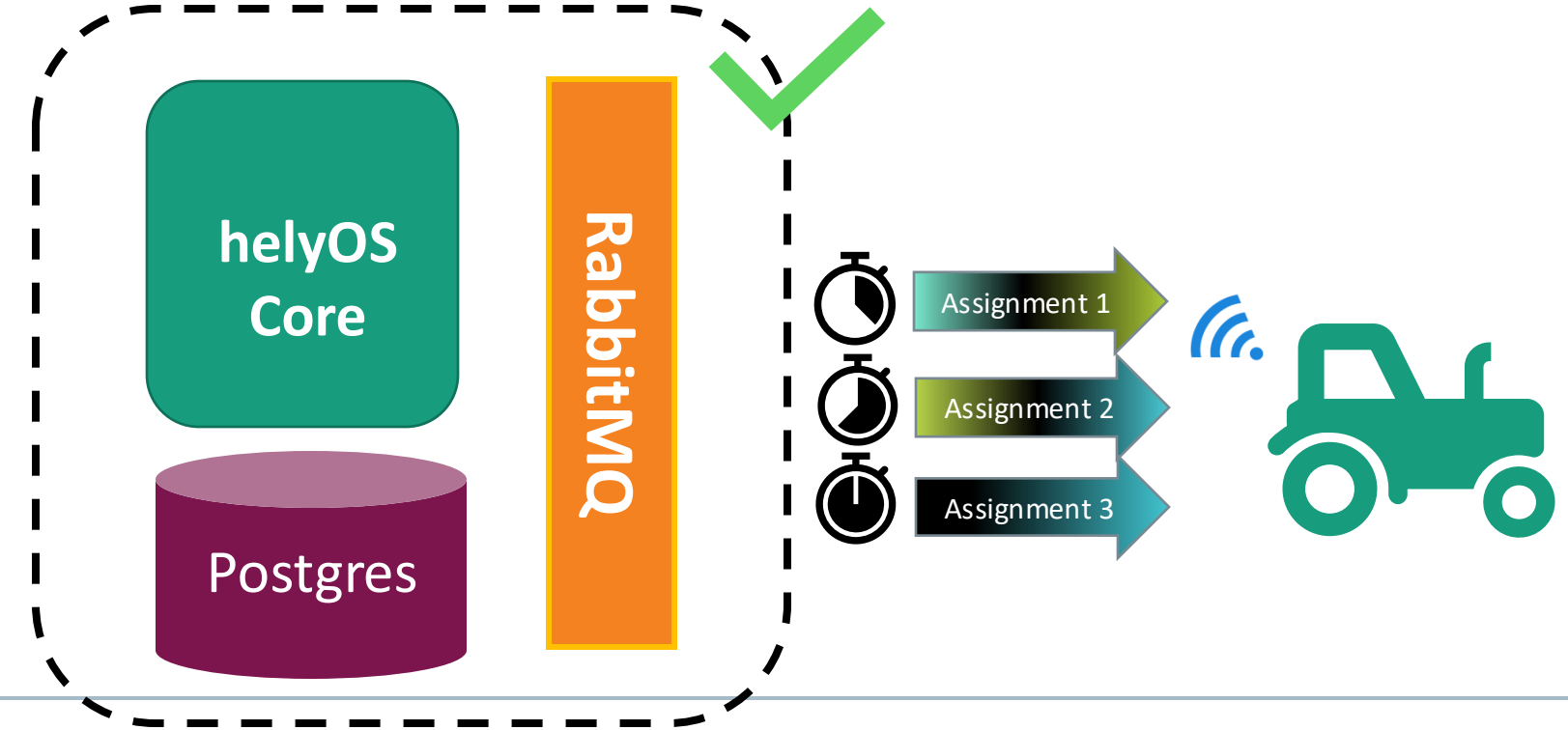
Your Applications.

Python Script

Web app

microservice
Clothoid planner

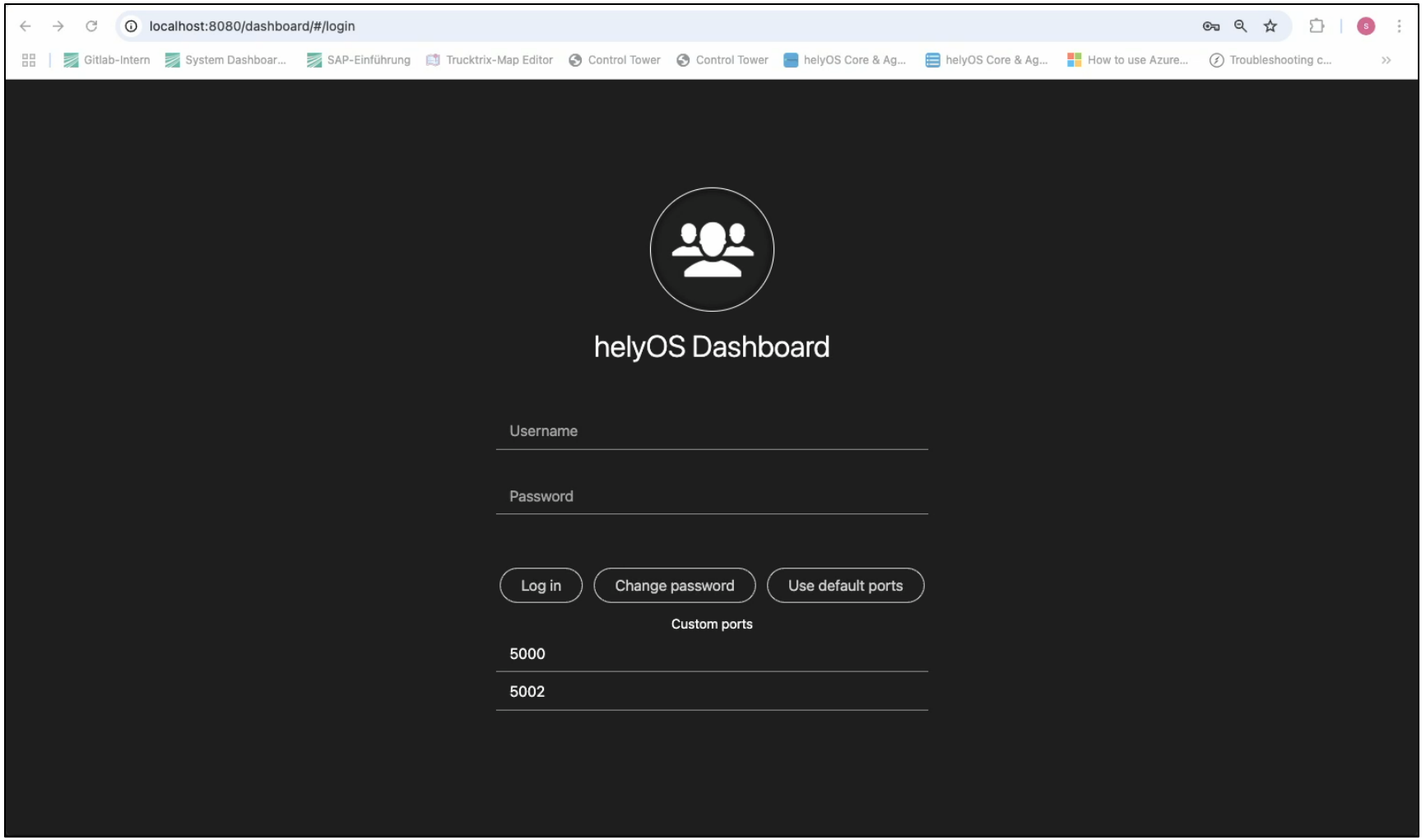
Drivable paths for vehicles



BACKEND

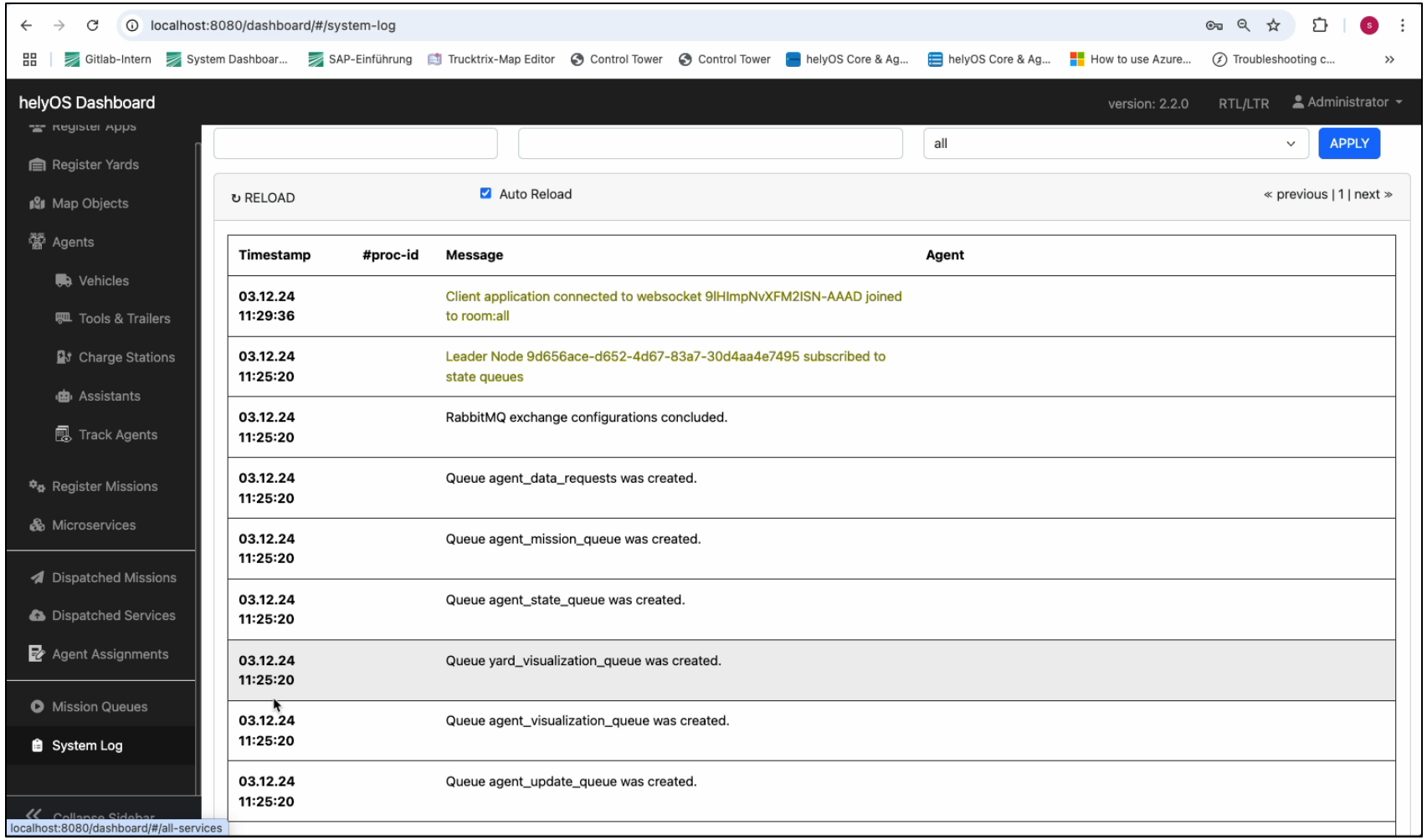
A look into helyOS Dashboard

Logs



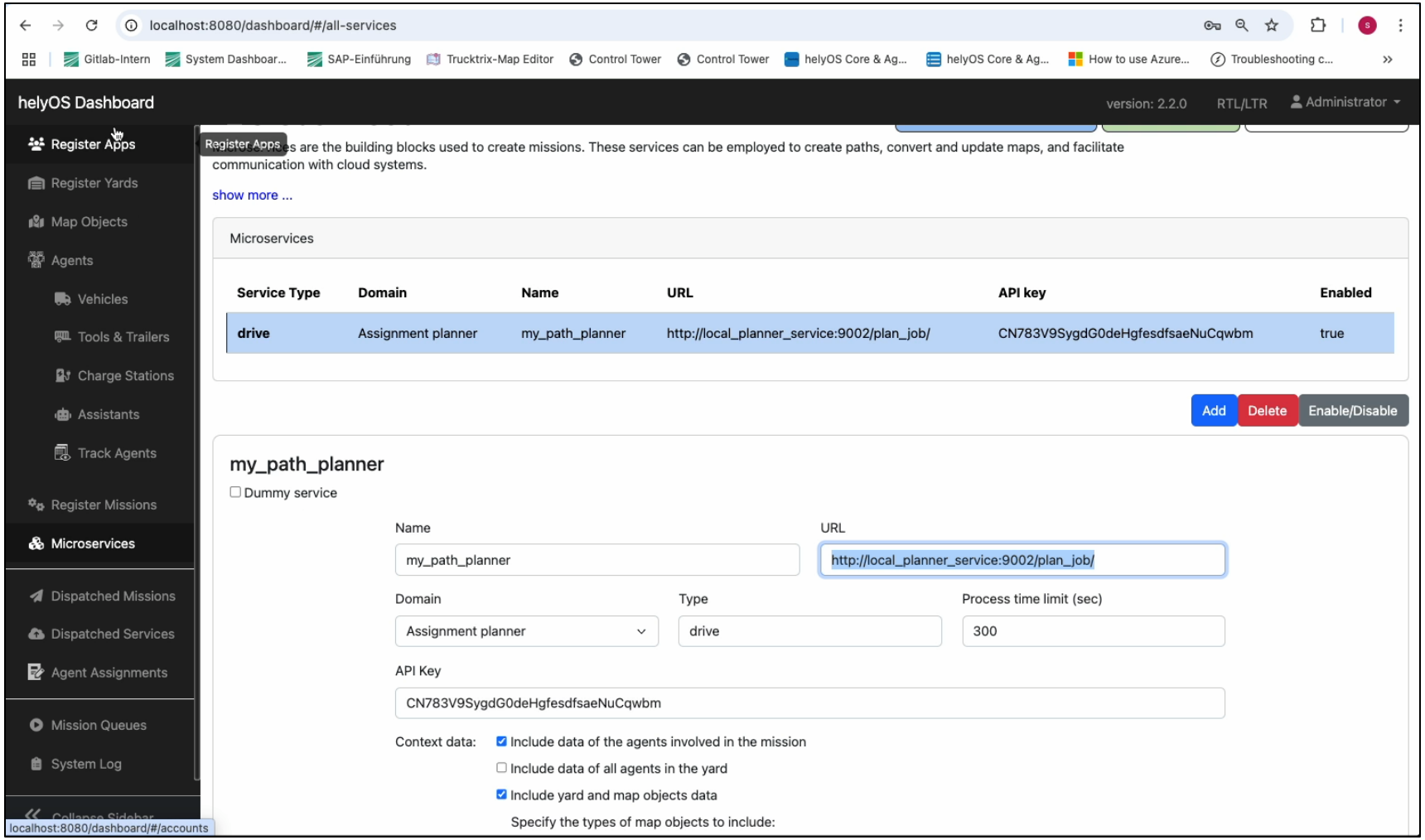
A look into helyOS Dashboard

Microservices



A look into helyOS Dashboard

External Applications



Creating Application

Python script run on the host machine

helyos_core url

Application token

See Python code examples in the documentation

https://helyos-manual.readthedocs.io/en/latest/3-helyos-and-client-apps/examples.html

```python
import random, time
from helyos_requests import get_free_agents, create_work_process

# Define the GraphQL endpoint and headers
hostname = "http://localhost"
port = 5000
headers = {
    "Content-Type": "application/json; charset=utf-8",
    "Authorization": "Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJyb2xlIjoicm9sZV9hcHBsaWNhdGlvbiIsI
}
graphql_conf = { 'url': f"{hostname}:{port}/graphql", 'headers': headers }

# Main function to request a random mission for a random free agent
def request_random_mission():
    free_agents = get_free_agents(graphql_conf)
    if not free_agents:
        return

    # Randomly select a free agent
    for selected_agent in free_agents:
        agent_uuid = selected_agent['uuid']
        agent_yard_id = selected_agent['yardId']
        current_pos =  {'x':selected_agent['x'],
                        'y':selected_agent['y'],
                        'orientations':selected_agent['orientations']}

        random_destination = { 'x':random.randint(-10000, 10000),
                        'y':random.randint(-20000, 20000),
                        'orientations':[random.randint(-6000, 6000)]}

        request_data = {'agent_uuid': agent_uuid,
                        'initial_position': current_pos,
                        'destination': random_destination}

        # Create a work process (mission) for the selected agent
        mission = create_work_process(graphql_conf,agent_uuid, agent_yard_id, "driving", request_data)
        print(f"Mission created with ID: {mission['id']} for Agent UUID: {agent_uuid}")

# Execute the main function
try:
    print("This command will repeat until you press Control + C")
    while True:
        time.sleep(2)
        request_random_mission()
except KeyboardInterrupt:
    print("Loop interrupted by user.")
```

Creating Application

Index.html run on the host machine

helyos_core url

Application token

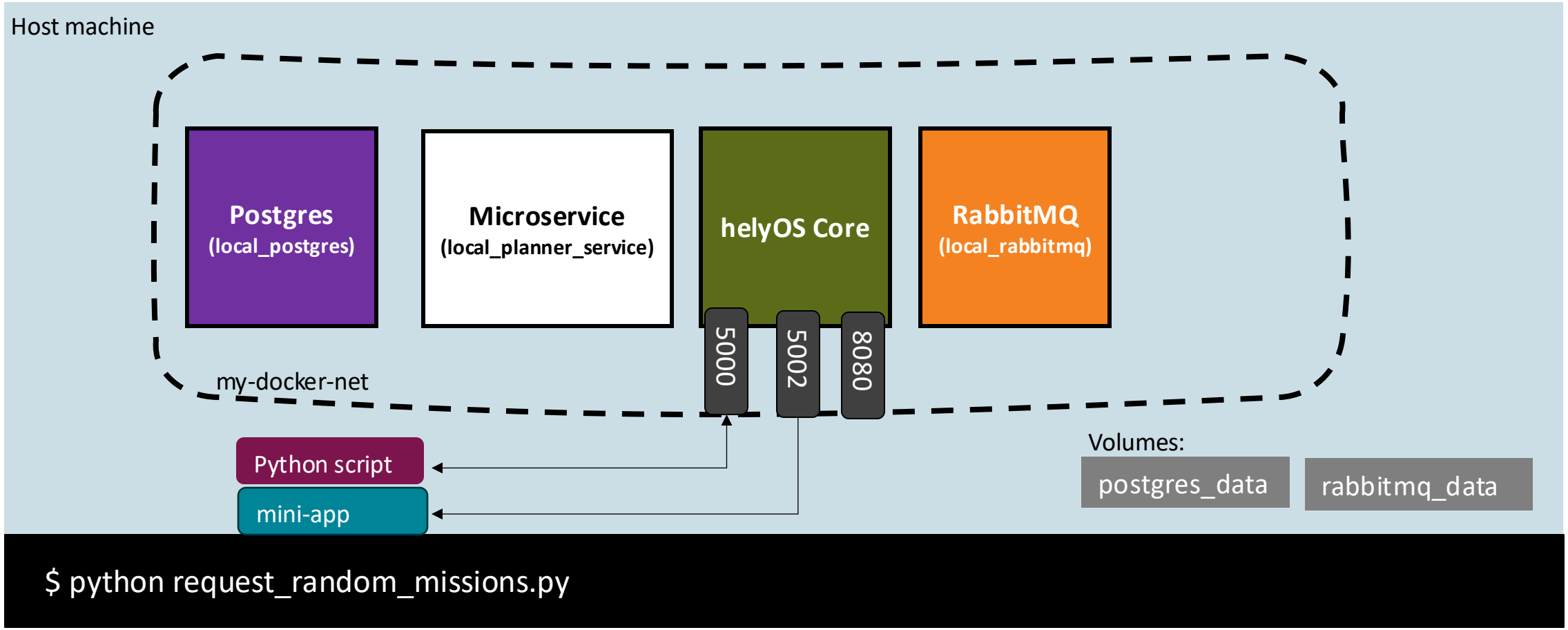
```
<!DOCTYPE html>
<html>
<head>
    <title>Minimalistic Map with Floating Images - Leaflet</title>
    <meta charset="utf-8" />
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <link rel="stylesheet" href="https://unpkg.com/leaflet@1.7.1/dist/leaflet.css" />
    <style>
        #map { height: 100vh; }
        /* Set the rotation origin to the center of the icon */
        .leaflet-rotated-icon { transform-origin: 50% 50%; }
    </style>
</head>
<body>

<div id="map"></div>

<script src="https://unpkg.com/leaflet@1.7.1/dist/leaflet.js"></script>
<script src="Leaflet.Marker.SlideTo.js"></script>
<script src="leaflet.rotatedMarker.js"></script>
<script src="https://cdn.socket.io/4.0.0/socket.io.min.js"></script>
<script>

    ///////  HELYOS CLIENT  SETTINGS /////////
    const socket = io('http://localhost:5002', {
        path: '/socket.io/',
        transports: ['websocket'],
        auth: {
            token: 'eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJyb2xlIjoicm9sZV9hcHBsaWNhdGlvbiIsInBlcnNvbl9pZCI6bnVsbCwiZXhwIjoxNzY0NzYxNDU3LCJpYXQiOjE3MzM
        }
    });


    ///////  LEAFLET MAP SETTINGS /////////
    const refPoint = [48.11398, 11.542205];
    const goalBlue = [-2013, 51588]
    const goalRed = [2499, -50177];
    const blueIcon = './tractor_blue.png';
    const redIcon = './tractor_red.png';
    const vehicleIconOption = (iconUrl, text) => ({
        iconUrl: iconUrl,
        iconSize: [15, 24   ], // size of the icon,
        className: 'leaflet-rotated-icon' // custom class for CSS rotation
    });
    // Create a label using L.divIcon
    var createLabelIcon = function(value) {
        return L.divIcon({
            className: 'label-icon',
            html: '<div style="position: relative; text-align: center;">' +
            '<div style="position: absolute; top: -25px; left: 50%; transform: translateX(-50%); font-size: 12px; color: black;">' + value + '</div>' +
            '</div>',
            iconSize: [0, 0] // Size of the icon, set to 0,0 to make it invisible
        });
    };

    const ballIconOption = {
        iconUrl: './ball_transp.png',
        iconSize: [20, 20], // size of the icon,
        className: 'leaflet-rotated-icon' // custom class for CSS rotation
    };
    const ballIcon = L.icon(ballIconOption);
    const vehicleRedIcon = L.icon(vehicleIconOption(redIcon));
    const vehicleBlueIcon = L.icon(vehicleIconOption(blueIcon));
```

To learn how to make a complete web app able to send requests and Visualize agents, visit the tutorial by Jiapang Wang:

https://fraunhofer-ivi-helyos-frontend-example.readthedocs.io/en/latest/index.html

Running the Application

As a Docker container



The helyOS framework components

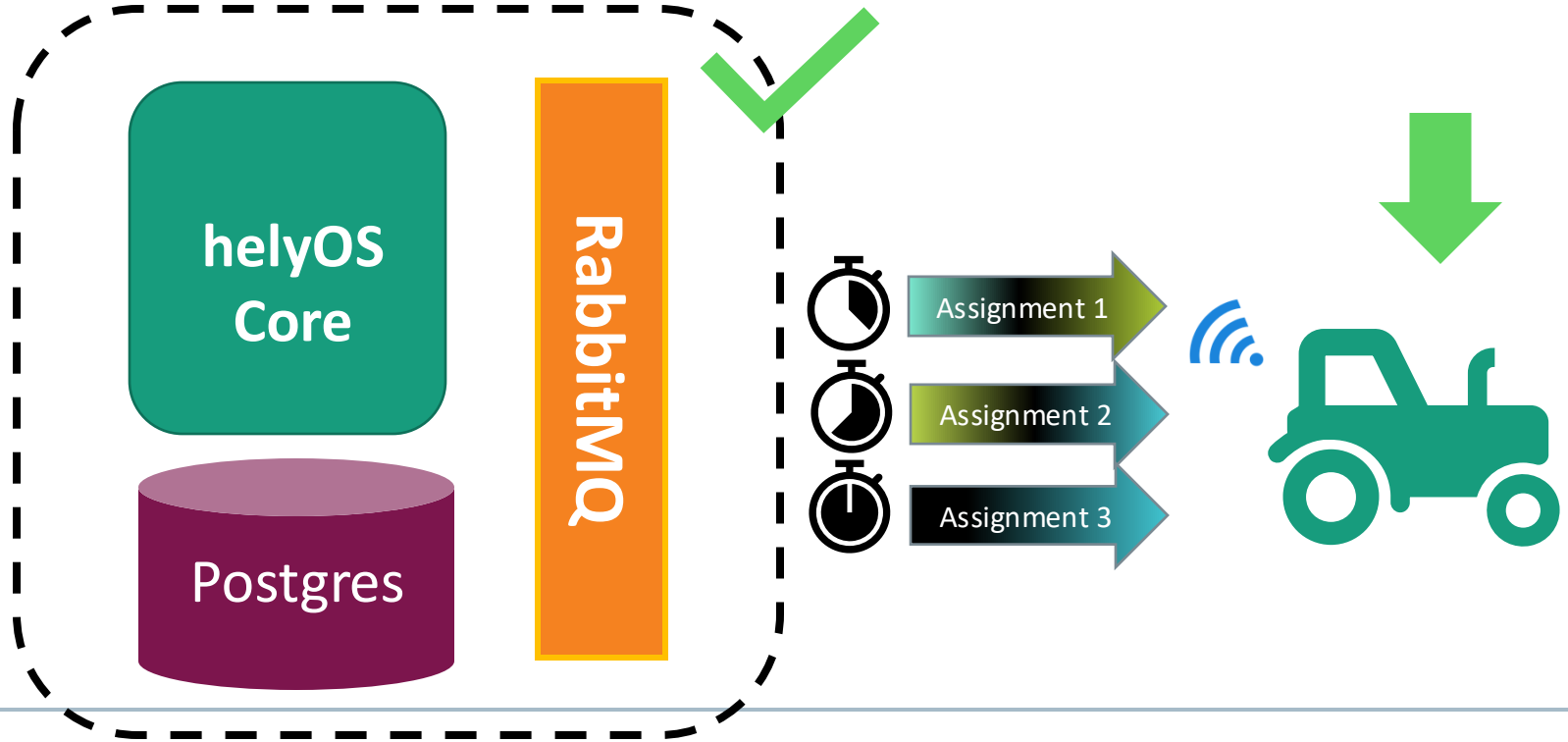
Your Applications.

Python Script

Web app

microservice
Clothoid planner

Drivable paths for vehicles



BACKEND

Prepare an agent simulator

Use helyOS slim simulator!

```yaml
services:

    agent_simulator_1:
        image: helyosframework/helyos_agent_slim_simulator:0.8.2
        platform: linux/amd64
        environment:

            # AGENT ID
            - UUID=6b22b670-b185-11ef-8952-0242ac130008
            - ASSIGNMENT_FORMAT=trajectory
            - NAME=MY_TRUCK1
            - X0=-28000
            - Y0= 0
            - ORIENTATION=0.329
            - VELOCITY=10
            - YARD_UID=FTB
            - UPDATE_RATE=10

            # RABBITMQ
            - RBMQ_HOST=local_rabbitmq
            - RBMQ_PORT=5672
            - REGISTRATION_TOKEN=0001-0002-0003-0000-0004

        networks:
            - my-docker-net

        command: ["python", "-u", "main.py"]


networks:
    my-docker-net:
        external: true
```

helyOS Agent Slim Simulator

- Uses the *helyos_agent_sdk*
- Easy to customize.
- For development and tests.
- Run as docker container.

https://github.com/helyOSFramework/helyos_agent_slim_simulator

Prepare an agent simulator

Use helyOS slim simulator!

```yaml
services:

    agent_simulator:
    image: helyosframework/helyos_agent_slim_simulator:0.8.2
    platform: linux/amd64
    environment:

        # AGENT ID
        - UUID=RANDOM_UUID
        - ASSIGNMENT_FORMAT=trajectory
        - NAME=MY_TRUCK2
        - X0=28000
        - Y0=0
        - ORIENTATION=0.329
        - VELOCITY=10
        - YARD_UID=FTB
        - UPDATE_RATE=10

        # RABBITMQ
        - RBMQ_HOST=local_rabbitmq
        - RBMQ_PORT=5672
        - REGISTRATION_TOKEN=0001-0002-0003-0000-0004

    networks:
        - my-docker-net

    command: ["python", "-u", "main.py"]
    deploy:
        replicas: 11

networks:
    my-docker-net:
        external: true
```

Each container will create a random indentifier.

Attention: Every time you start this docker, you will have more 11 agents registered in helyOS

Docker automatically creates replicas for you.

Running the Application

Index.html run on the host machine

```python
import random, time
from helyos_requests import get_free_agents, create_work_process

# Define the GraphQL endpoint and headers
hostname = "http://localhost"
port = 5000
headers = {
    "Content-Type": "application/json; charset=utf-8",
    "Authorization": "Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJyb2xlIjoicm9sZV9hcHBsaWNhdGlvbiIsInBlcnNvbl9pZCI6bnVsbCwiZXhwIjoxNzY0NzYxNDU3LCJpYXQiOj
}
graphql_conf = { 'url': f"{hostname}:{port}/graphql", 'headers': headers }

# Main function to request a random mission for a random free agent
def request_random_mission():
    free_agents = get_free_agents(graphql_conf)
    if not free_agents:
        return

    # Randomly select a free agent
    for selected_agent in free_agents:
        agent_uuid = selected_agent['uuid']
        agent_yard_id = selected_agent['yardId']
        current_pos =  {'x':selected_agent['x'],
                        'y':selected_agent['y'],
                        'orientations':selected_agent['orientations']}

        random_destination = { 'x':random.randint(-10000, 10000),
                        'y':random.randint(-20000, 20000),
                        'orientations':[random.randint(-6000, 6000)]}

        request_data = {'agent_uuid': agent_uuid,
                        'initial_position': current_pos,
                        'destination': random_destination}
```

```
PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS
(myenvs) mac:python_script violbarbosa$
```

The helyOS framework components

Your Applications.

Python Script

Web app

microservice
Clothoid planner

Drivable paths for vehicles

helyOS Core

Postgres

RabbitMQ

Assignment 1

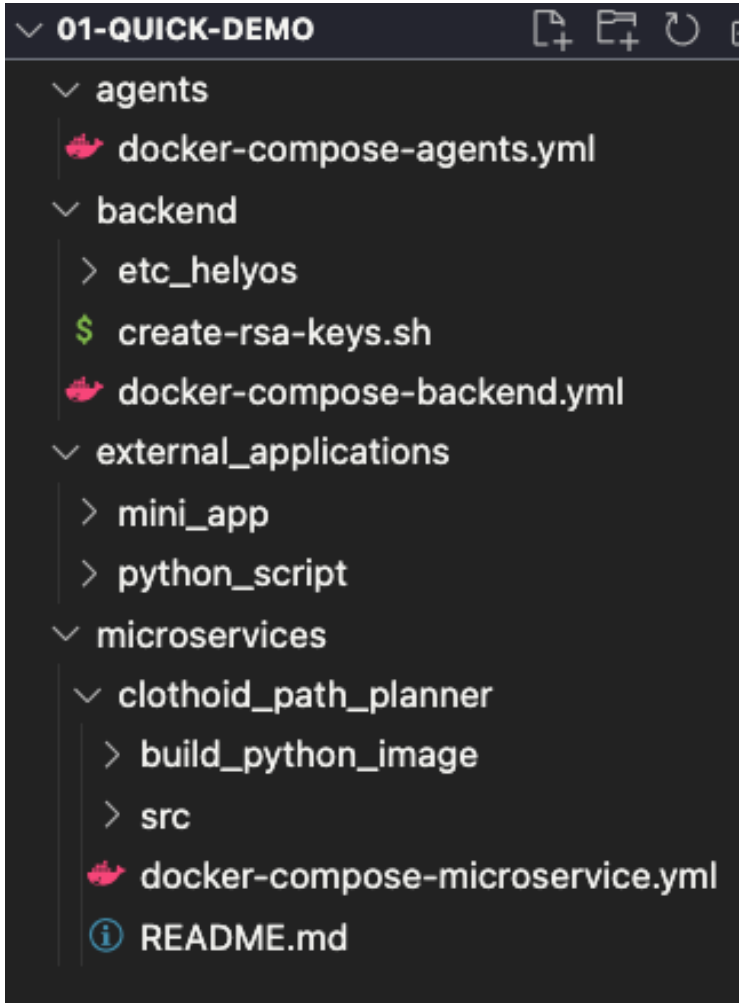
Assignment 2

Assignment 3

BACKEND

Migrate Your Installation to the Cloud

Prepare files



Let's run this application in the computer *helyos-server.ivi.fraunhofer.de*.

What should we change?

- ✓ In the **external_applications** and in the **agents**

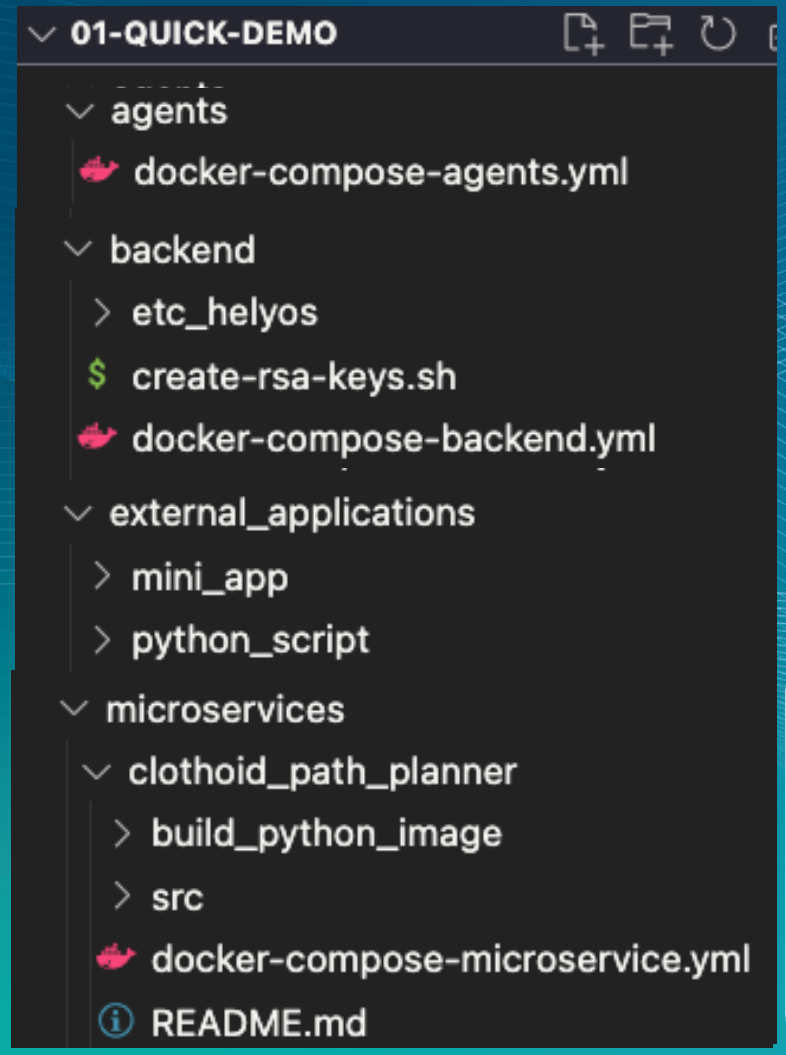
  HOSTNAME = "helyos-server.ivi.fraunhofer.de"
  RBMQ_HOST = "helyos-server.ivi.fraunhofer.de"

- ✓ In the **docker-compose-backend.yml**

```
local_rabbitmq:
    image: rabbitmq:3-management
    hostname: local_rabbitmq
    volumes:
        - rbmq_data:/var/lib/rabbitmq/
    networks:
        - my-docker-net
    ports:
        - 15672:15672
        - 5672:5672
```

Accessible to external agents

Dev computer



Private Cloud computer

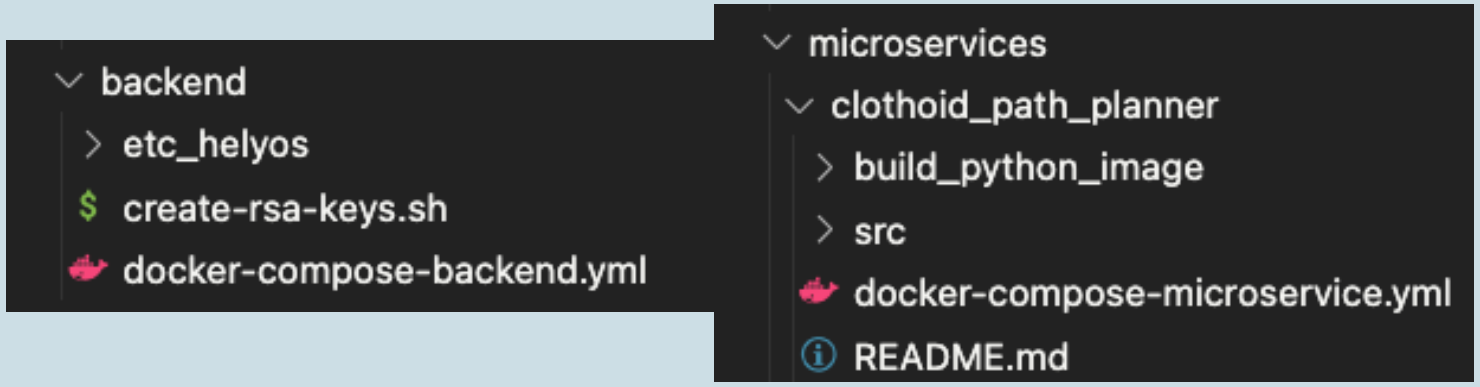
helyos-server.ivi.fraunhofer.de

User computer

Vehicle computer unit

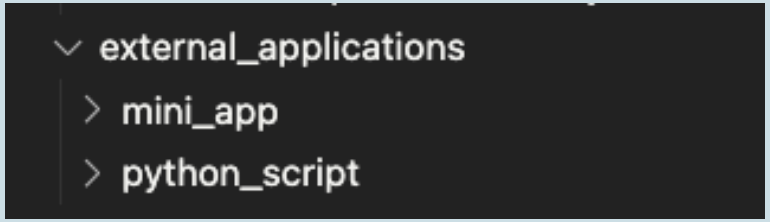
Private Cloud computer

helyos-server.ivi.fraunhofer.de



5000 5002 8080 15672 5672

User computer



Vehicle computer unit

Advancing Demo Applications Towards Real-World Scenarios

- Improving security
- Improving robustness

Improving security

Secure Dashboard and External Applications Connections

- Change the *admin* password.
- Use Nginx as a proxy to enable secure HTTPS connection

```yaml
nginx_server:
    image: nginx:stable-alpine
    container_name: nginx_server
    ports:
        - "443:443"
    volumes:
        - ./etc_nginx/nginx.conf:/etc/nginx/nginx.conf:ro
        - ./certificates:/etc/ssl:ro
    networks:
        - my-docker-net

    depends_on:
        - helyos_core
```

```
events {}
http {
    server {
        listen 443 ssl;
        server_name helyos-server.ivi.fraunhofer.de;

        ssl_certificate  /etc/ssl/server_certificate.pem;
        ssl_certificate_key /etc/ssl/server_key.pem;

        location /socket.io/ {
            proxy_pass http://helyos_core:5002;
            proxy_http_version 1.1;
            proxy_set_header Upgrade $http_upgrade;
            proxy_set_header Connection "Upgrade";
            proxy_set_header Host $host;
            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;
        }

        location /graphiql {
            proxy_pass http://helyos_core:5000/graphiql;
            proxy_set_header Host $host;
            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;
        }

        location /graphql {
            proxy_pass http://helyos_core:5000/graphql;
            proxy_set_header Host $host;
            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;
        }

        location / {
            proxy_pass http://helyos_core:8080;
            proxy_set_header Host $host;
            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;
        }
    }
}
```

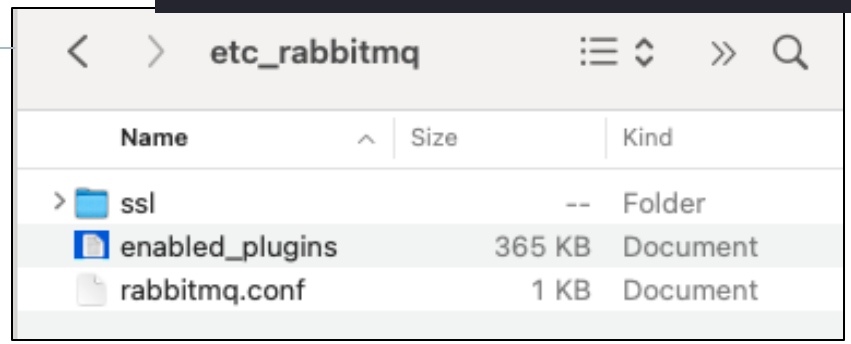
Improving security

Secure Agents Connections

- Delete the RabbitMQ *guest* account.
- Delete the *AUTO-AGENT-REGISTRATION-TOKEN* in **helyos_core** environment variable
- Configure RabbitMQ to use TSL and use the port 15671 and 5673

```yaml
local_rabbitmq:
    # image: rabbitmq:3-management
    build:
        context: .
        dockerfile: Dockerfile_RBMQ_with_certs
    hostname: local_rabbitmq
    volumes:
        - ./etc_rabbitmq/enabled_plugins:/etc/rabbitmq/enabled_plugins:ro
        - ./etc_rabbitmq/rabbitmq.conf:/etc/rabbitmq/rabbitmq.conf:ro
        - rbmq_data:/var/lib/rabbitmq/
    networks:
        - my-docker-net
    ports:
        # - 15672:15672
        # - 5672:5672
        - 15671:15671
        - 5673:5673
```

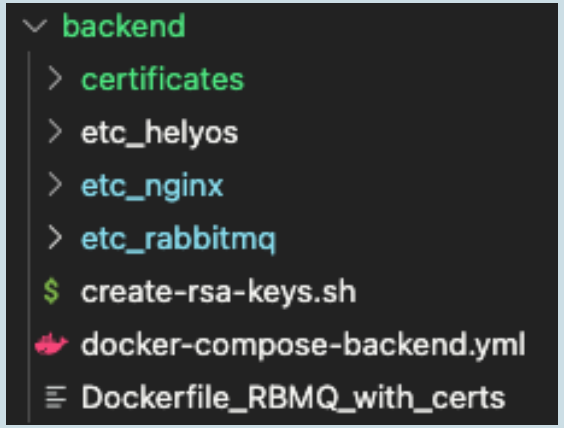
```
FROM rabbitmq:3-management
# we cannot simply map the certificates in the docker-compose volumes
# because rabbitmq is strict with the permissions.
ADD ./certificates /etc/ssl/certs/
RUN chown rabbitmq:rabbitmq /etc/ssl/certs \
    && chown rabbitmq:rabbitmq /etc/ssl/certs/* \
    && chmod 710 /etc/ssl/certs \
    && chmod 610 /etc/ssl/certs/*
```

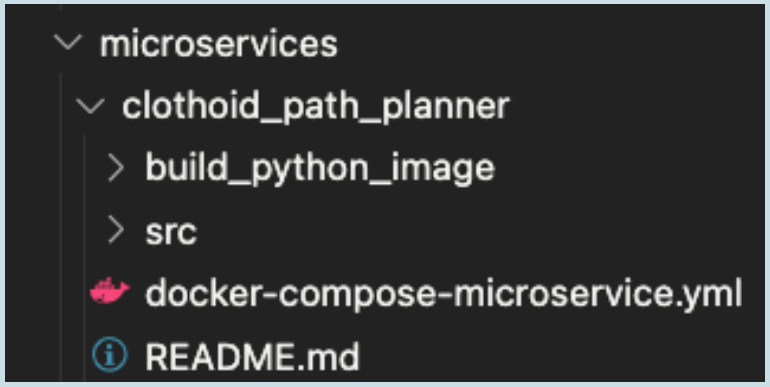


Private Cloud computer

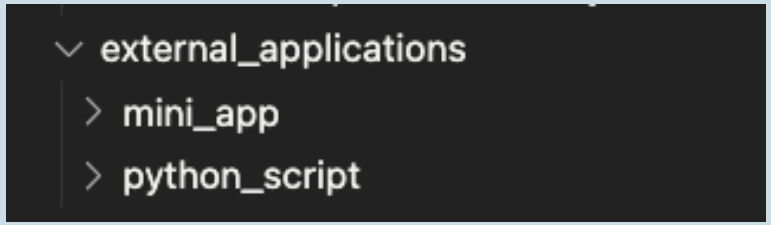
helyos-server.ivi.fraunhofer.de

15673





443 5000 5002 8080 15672 5672 5673



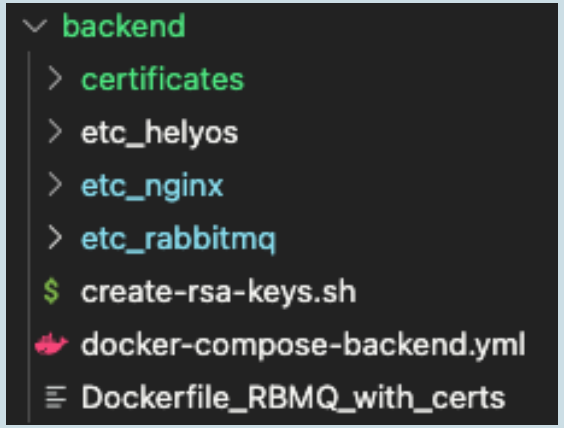
User computer

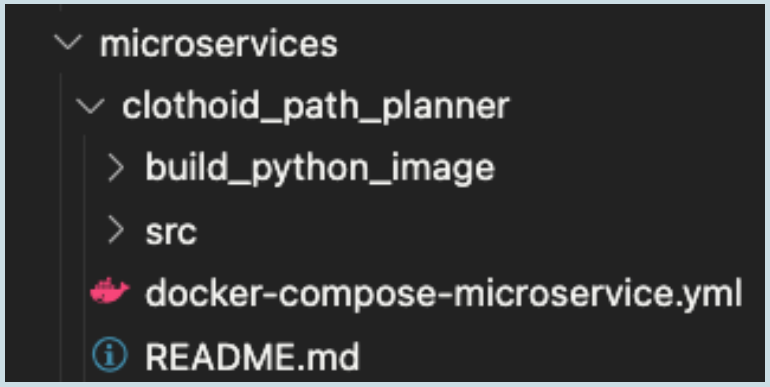
Vehicle computer unit

Private Cloud computer

helyos-server.ivi.fraunhofer.de

15673

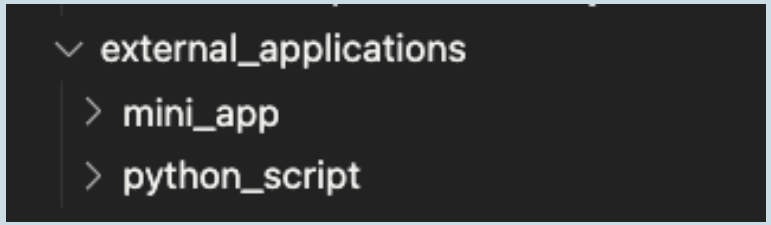




443

5673

https://helyos-server.ivi.fraunhofer.de
wss://helyos-server.ivi.fraunhofer.de



User computer

amqps://helyos-server.ivi.fraunhofer.de

Vehicle computer unit

Improving robustness

Microservices

- Use a WSGI server and not the *development server*. I like *gunicorn* ☺

```
FROM python:3.8
WORKDIR /app
COPY ./build_python_image/requirements.txt .
RUN pip install -r requirements.txt
COPY src src
EXPOSE 9002:9002
CMD ["python", "./src/service.py"]
```



```
FROM python:3.8

WORKDIR /app
COPY ./build_python_image/requirements.txt .
RUN pip install -r requirements.txt
RUN pip install gunicorn
COPY src/ src/
EXPOSE 9002:9002

# Run the application using Gunicorn
WORKDIR /app/src
CMD ["gunicorn","-w","4","-b","0.0.0.0:9002", "service:app"]
```

Improving robustness

Microservices

- Do not build your microservice in the server. Just pull its image from a docker registry.

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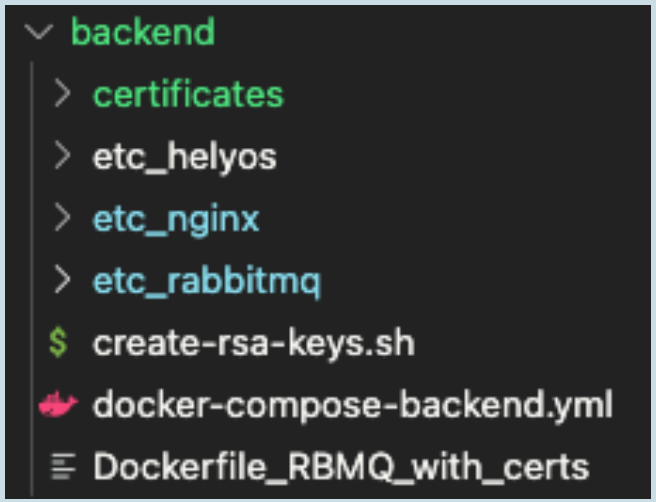

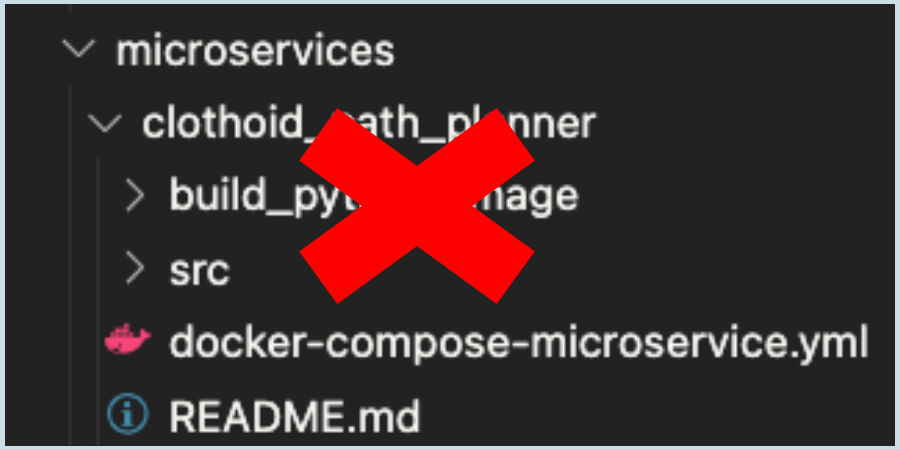

Improving robustness

Microservices

- Do not build your microservice in the server. Just pull its image from a docker registry.

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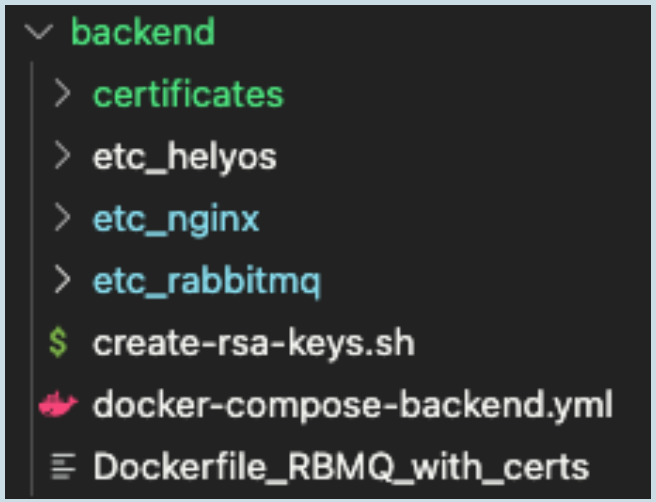
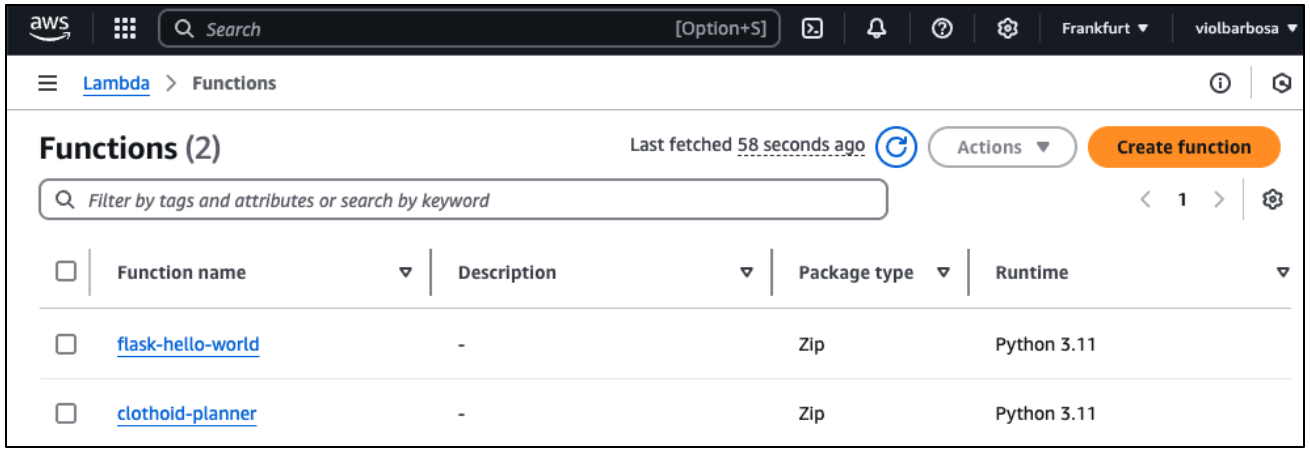


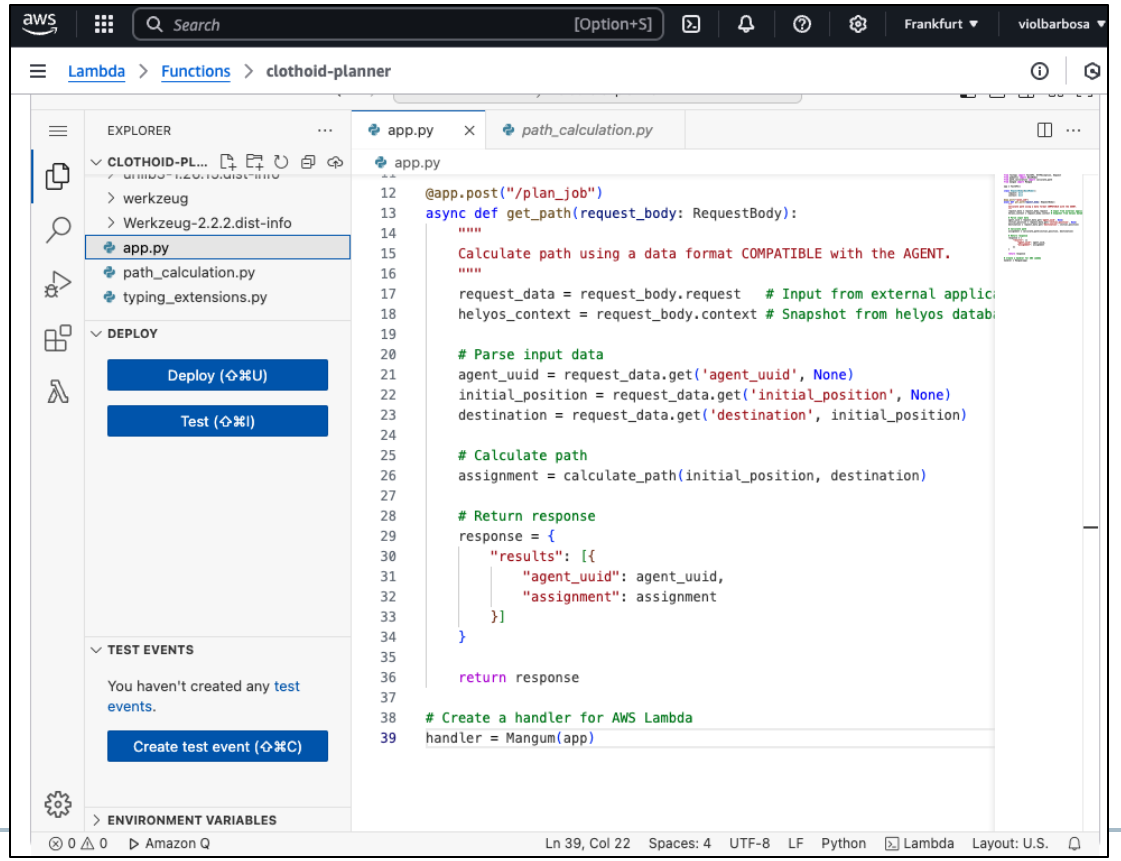

```yaml
services:

  local_planner_service:
    image: my_registry/my_clotoid_planner:vs1.0
    restart: always
    container_name: local_planner_service
    networks:
      - my-docker-net
    # ports:
      # - "9002:9002"  # optional

networks:
    my-docker-net:
        external: true
```

Improving robustness

Microservices

- Create an extra server to host collections of shared microservices. If you do not want to host them, you can use a service like the AWS Lambda.





Improving robustness

helyOS core

- Use Multi-threads to provide redundancy in case of failure.

```
helyos_core:
    image: helyosframework/helyos_core:2.2.0-rc1

    ports:
        - 5002:5002 # Websocket: Push Notifications.
        - 5000:5000 # GraphQL: Communicate with External Applic
        - 8080:8080 # HelyOS Dashboard: Settings and Monitoring

    volumes:
        - ./etc_helyos/:/etc/helyos/:ro

    environment:
        # MULTI-THREADING
        - NUM_THREADS=4
        - REDIS_HOST=redis.com
        - REDIS_PORT=6379
        - REDIS_PASSWORD=myp@ss,
        # # #

        # DATABASE
        - PGUSER=helyos_db_admin
```

Extra TO DOs

Configuration files

- Remove all passwords from the Docker Compose files and use .env files or other secure methods, such as secret management tools, to store and manage passwords.

```yaml
helyos_core:
    image: helyosframework/helyos_core:2.2.0-rc1

    ports:
        - 5002:5002 # Websocket: Push Notifications.
        - 5000:5000 # GraphQL: Communicate with External Applications
        - 8080:8080 # HelyOS Dashboard: Settings and Monitoring for Developers

    volumes:
        - ./etc_helyos/:/etc/helyos/:ro

    environment:
        # DATABASE
        - PGUSER=helyos_db_admin
        - PGPASSWORD=${PGPASSWORD}
        - JWT_SECRET=${PGPASSWORD}
        - PGHOST=local_postgres
        - PGDATABASE=smartfarm_db
        - PGPORT=5432
        - GQLPORT=5000

        # RABBITMQ
        - RBMQ_HOST=local_rabbitmq
        - RBMQ_PORT=5672
        - RBMQ_API_PORT=15672
        - RBMQ_SSL=False     # For TLS support
        - RBMQ_API_SSL=False # For TLS support

        # RBMQ ACCOUNTS
        - CREATE_RBMQ_ACCOUNTS=True
        - RBMQ_ADMIN_USERNAME=helyos_rbmq_admin # Set it if CREATE_RBMQ_ACCOUNTS is True
        - RBMQ_ADMIN_PASSWORD=${RBMQ_PASSWORD}     # Set it if CREATE_RBMQ_ACCOUNTS is True
        # - AGENT_AUTO_REGISTER_TOKEN=0001-0002-0003-0000-0004 # Deleted for production

    networks:
        - my-docker-net
```

02-single-tenant > backend > .env

```
1   PGPASSWORD=helyos_secret
2   RBMQ_PASSWORD=helyos_rb_secret
3
```

Extra TO DOs

Configuration files

- Export save and version the configuration files *microservice.yml* and *mission.yml* every time you modify it in the dashboard.

microservice.yml

```yaml
version: '2.0'

services:

    my_path_planner:
      is_dummy: false
      domain: "Assignment planner"  # Assignment planner
      type: "drive"
      url: http://local_planner_service:9002/plan_job/
      enable: true
      apikey: "CN783V9SygdG0deHgfesdfsaeNuCqwbm"
      timeout: 300
      description: "Simple clothoid path pallaner"

      context:
        map_data: true
        all_agents_data: false
        mission_agents_data: true
```

mission.yml

```yaml
version: '2.0'

missions:

    driving:
      maxagents: 1
      description: "drive from a to b"

      recipe:
        steps:
          - step: "microservice1"
            service_type: "drive"
            request_order: 1
            apply_result: true
```

Conclusion

- We learned how to install helyOS and develop Demo Applications.
- We learned how to transfer our Demo Application to the cloud.
- We learned the steps to improve our application for a real-world scenario.

Useful links

- Official page: https://www.helyosframework.org
- helyOS Manual: https://helyos-manual.readthedocs.io
- helyOS WebApp Tutorial: https://fraunhofer-ivi-helyos-frontend-example.readthedocs.io
- helyOS AWS Deployment: https://github.com/cviolbarbosa/aws-logistics-center-demo
- Questions: https://github.com/helyOSFramework/helyos_core/discussions

Thank you.

violbarbosa@ivi.fraunhofer.de