RabbitMQ Infrastructure Prototype

Documentation

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Contents

1 Introduction

1.1 Abstract

Message brokers have always been a critical part of many infrastructures. This architectural pattern allows for easy to horizontally scale and reliable networks. The goal of this project is to make a network infrastructure which uses a messaging system through a message broker (RabbitMQ[1]). My additional personal requirement is to use the Rust programming language[2] as much as possible and bleeding edge technology.

1.2 Information

This is a project of the Scuola Arti e Mestieri di Trevano (SAMT) under the following circumstances

- **Section**: Computer Science
- **Year:** Fourth
- **Class:** Progetti Individuali
- **Supervisor:** Geo Petrini
- **Title:** RabbitMQ based web app prototype
- **Start date**: 2022-09-29
- **Deadline**: 2022-12-07

and the following requirements

- **Documentation**: a full documentation of the work done
- **Diary**: constant changelog for each working session
- **Source code**: source code of the project

All the source code and documents can be found at https://github.com/paolobettelini/rabbitmq-rs-app [3].

1.3 Structure

This document is structured as follows:

1. **Introduction:** General information, requirements and scope of the project
2. **Analysis:** Analysis of the requirements and functionality
3. **Planning:** Waterfall planning
4. **Infrastructure:** Analysis of the infrastructure and network topology
5. **Technology:** List of main technologies used
6. **Implementation:** Applied logic and technologies to solve the task
7. **Structure:** Structure of the project folders
8. **Compilation and usage:** Compilation and usage of the executables
9. **Testing:** Test results
10. **Conclusion:** Personal conclusion and possible future development

2 Analysis

2.1 Requirements

Req-00	
Name	Login & Register
Priority	1
Version	1.0
Notes	none
Description	The user must be able to create an account and log in.
Subrequirements	
Req-00_0	The authentication must be kept alive by a cookie.
Req-00_1	The keep-alive cookie must contain a randomly generated token.
Req-00_2	The password must be hashed client-side.

Req-01	
Name	Functionality
Priority	1
Version	1.0
Notes	none
Description	The website must contain a file dropzone. The user must be able to upload an image which will be converted into a 200x200 px webp.
Subrequirements	
Req-01_0	During the conversion an async progress status must be displayed.

Req-02	
Name	Message Queues
Priority	1
Version	1.0
Notes	none
Description	Every message sent between webserver and backend must be through a message queue on the message broker.

Req-03	
Name	Gallery
Priority	1
Version	1.0
Notes	none
Description	When the users logs in a list of the previously converted images must be display.
Subrequirements	
Req-03_0	Only the last N images are loaded. Another chunk of images is loaded if requested by the user.

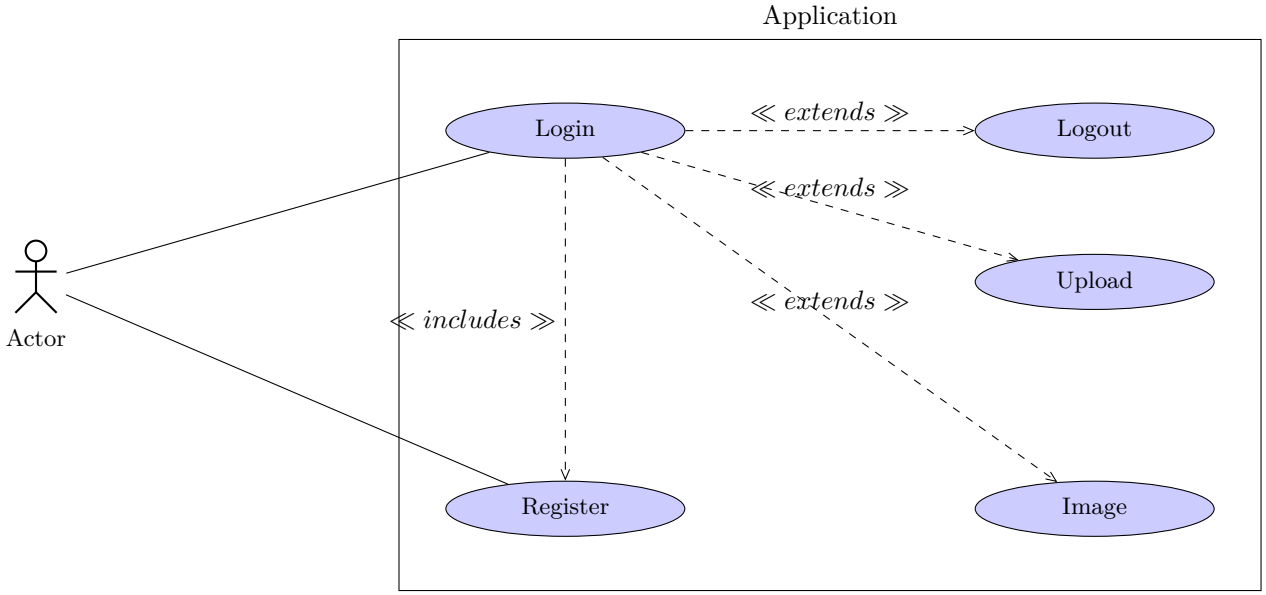
Req-04	
Name	Network Structure
Priority	1
Version	1.1
Notes	none
Description	A loadbalancer (Round Robin) is the entry point for N web-servers. There are M backend workers. Workers and web-servers communicate by connecting to a RabbitMQ server or a RabbitMQ Cluster. Each worker stores data on the same database.

Req-05	
Name	Scalability
Priority	1
Version	1.0
Notes	none
Description	The network must scale horizontally with multiple servers.

2.2 Use Cases

The user can log in only if it has registered. Once logged the user has access to the application features:

- **Logout** (Logout)
- **Upload** (Upload an image)
- **Image** (Retrieve an image)



3 Planning

3.1 Initial Gantt chart

I chose the waterfall Gantt chart to plan the actions throughout the project.

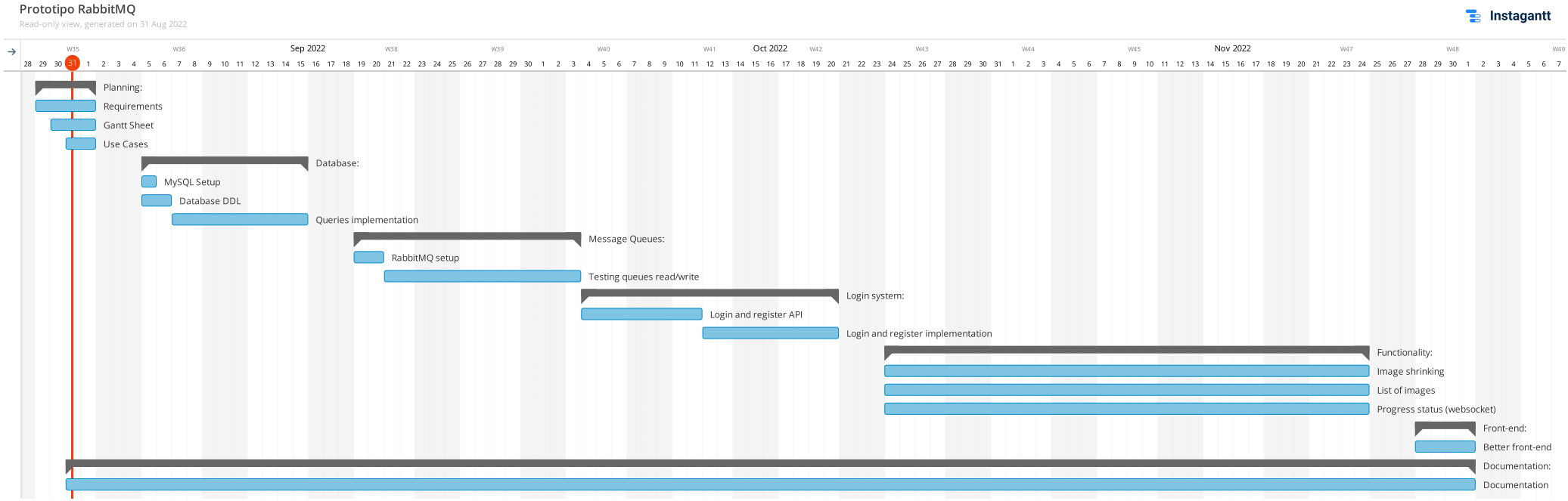


Figure 1: Initial Gantt chart

3.2 Final Gantt chart

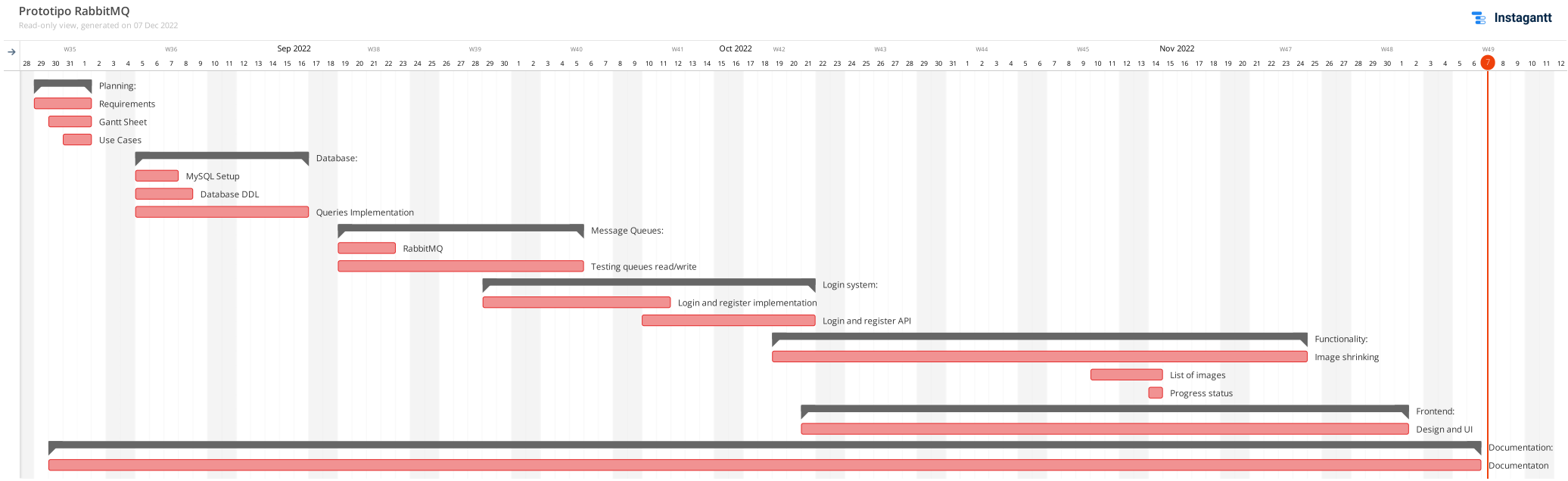


Figure 2: Final Gantt chart

The left side of the initial Gantt chart has been left as is, whilst in the second half many tasks have taken longer than expected.

4 Infrastructure

The following diagram illustrates the network topology of the application.

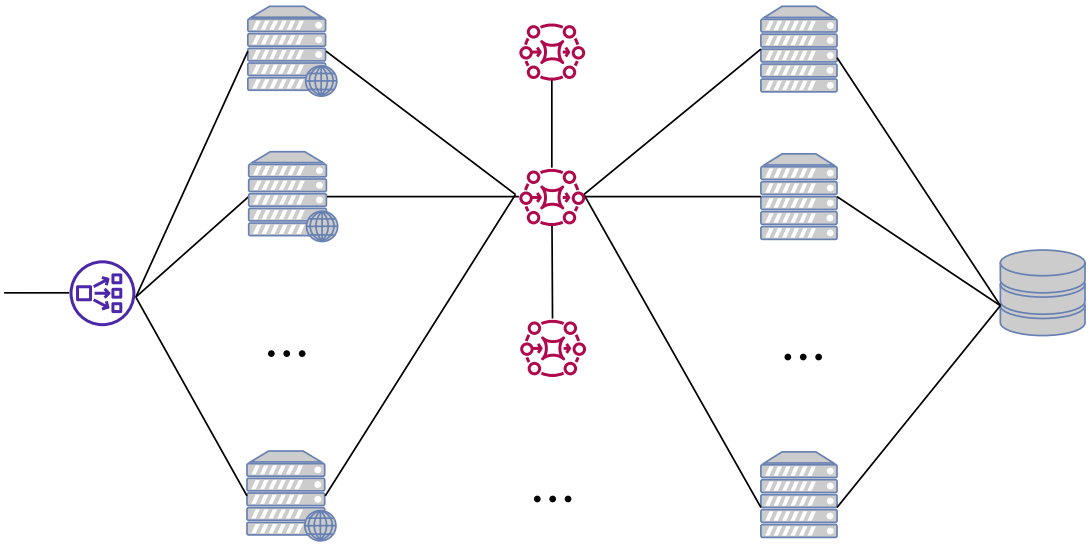


Figure 3: Network Infrastructure

The entry point is a load balancer which redirects the stream into one of the webservers. The webservers send and receive data from the RabbitMQ cluster which they are connected to. Likewise, the workers consume data from the same cluster and send message back. Every backend server is connected to the same database.

5 Technologies

5.1 WebAssembly

WebAssembly[4] (wasm) is a portable low-level language supported by all majors browsers. It can be used for a variety of things within the browser and can be mixed with HTML and JavaScript. WebAssembly does not need to be parsed by the browser since it is already in a binary format.
At the time of writing, WebAssembly is not widely used and it is not always faster than JavaScript based applications. However, is it my opinion and hope that it will better in the future and that it will become a standard in web development. There are many uses cases for WeAassembly such as image/video editing, videogames, image recognition, encryption and many more[5]

5.2 Rust

Rust[2] is a generic compiled programming language. The code is compiled using LLVM to machine code and its speed is comparable to C and C++. Rust is the first programming language to guarantee memory safety; memory is not manually freed nor garbage collected. It is not possible to dereference a null pointer, cause memory segfaults, core dumps and memory leaks. Code that could cause undefined behavior can still be written, but it is strictly bounded in blocks where the compiler is relaxed. This relaxation implies that the language is also low-level. Another key feature to the performance of Rust is zero cost abstraction, which means that generic types and function abstractions are resolved at compile-time. Conditional compilation and compile-time computations are also extensively used.
There are also many features concerning the programming experience, such as advanced metaprogramming and code generation using macros, intelligent compiler, dependency system (Cargo), modern syntax and many tools to ease development.

Note: a Rust *crate* refers to a library. A *feature* is an optional component of library. A *module* is a logical section of a program or library.

5.3 RabbitMQ

RabbitMQ[1] is a popoular message broker implementing many messaging protocols. Message brokers such as RabbitMQ can make an infrastructure to route messages, validate them and transform them. Messages queue are used to store messages. Multiple consumers may consume messages from a queue.
RabbitMQ servers can also form a cluster. All the nodes in a cluster communicate between eachother and share the same state. A client may connect to just one rabbit node.

6 Implementation

6.1 Frontend

6.1.1 Generating WebAssembly

WebAssembly code is compiled from Rust code using the `wasm-pack` tool. The rust code uses the `wasm_bindgen` crate to bind to WebAssembly. A function to export into the module might be written as

```
#[wasm_bindgen]
pub fn hash(value: String) -> String {
    let data = value.as_bytes().to_vec();

    let digest = sha256(&data);

    to_base64(digest)
}
```

Compiling using

```
wasm-pack build
```

will produce a folder named `pkg/` which contains the wasm module.

6.1.2 Importing the module

I used `webpack` to integrate the wasm module in the website and be able to call wasm function from JavaScript. `npm` is used to handle the dependencies.

package.json

```
{
    "name": "webapp-frontend",
    "version": "0.1.0",
    "description": "Frontend",
    "main": "index.js",
    "scripts": {
        "build": "webpack --config webpack.config.js"
    },
    "author": "Paolo Bettelini",
    "devDependencies": {
        "webpack": "^5.74.0",
        "webpack-cli": "^4.10.0",
        "copy-webpack-plugin": "^11.0.0"
    },
    "dependencies": {
        "frontend": "file:../pkg"
    }
}
```

webpack.config.js

```
const CopyWebpackPlugin = require("copy-webpack-plugin");
const path = require('path');

module.exports = {
entry: {
    login: "./www/login.js",
    register: "./www/register.js",
    upload: "./www/upload.js",
    gallery: "./www/gallery.js"
```

```
},
output: {
    path: path.resolve(__dirname, "dist"),
    filename: "[name].bundle.js",
},
mode: "development",
plugins: [
    new CopyWebpackPlugin({
    patterns: [ "www" ],
    })
],
experiments: {
    asyncWebAssembly: true
}
};
```

To compile the website to static files run

```
npm run build
```

To call a wasm function within the file `login.js` we can do the following.

```
import { hash } from 'frontend'

console.log(hash('Hello World'));
```

The compiled file is called `login.bundle.js` which is what the HTML page will need to include (see webpack config).

6.1.3 Module contents

The wasm module `frontend` contains the following functions:

- validate_email(**String**) −> **bool**
- validate_password(**String**) −> **bool**
- validate_username(**String**) −> **bool**
- hash(**String**) −> **String**

Note: the validation functions are defined in the `protocol::validation` Rust module. These functions are also used by the webserver to validate requests. This means that by modifying the validation logic in one point both the frontend and webserver are automatically updated since they share the same codebase.

6.1.4 Website

The following image shows the index page when the user is logged in.

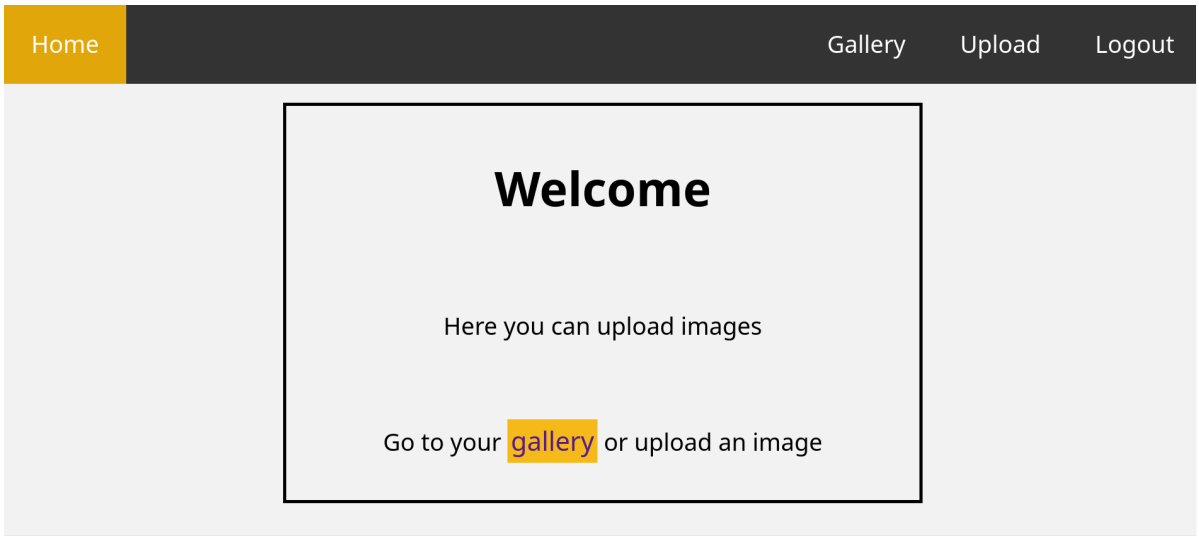


Figure 4: Index page - user logged in

The following image shows the index page when the user is not logged in.

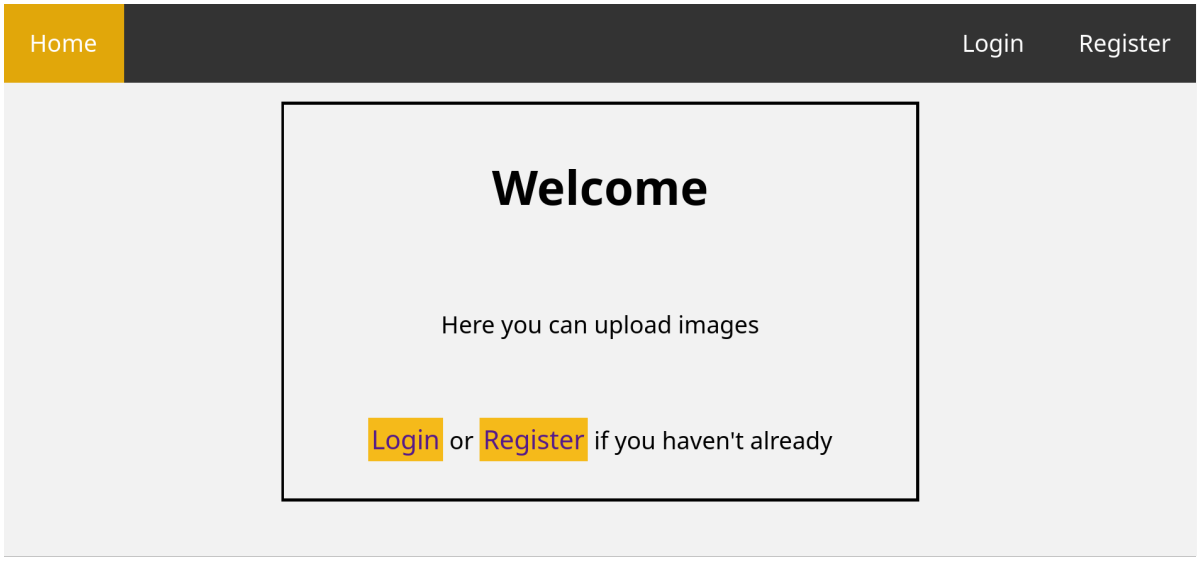


Figure 5: Index page - user not logged in

The following image shows the logout page.

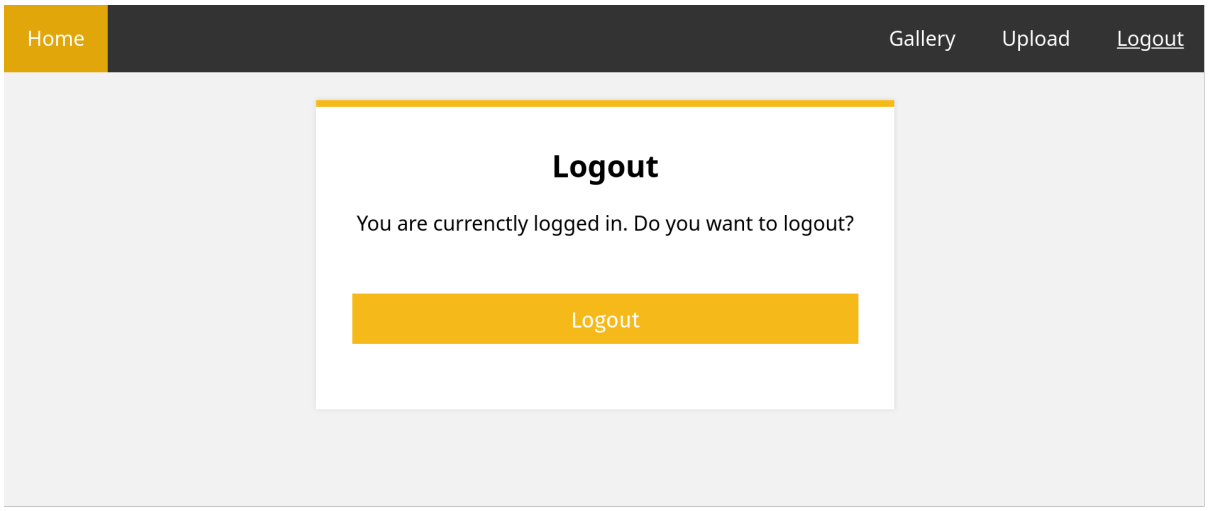


Figure 6: Logout page

The following image shows the login page.

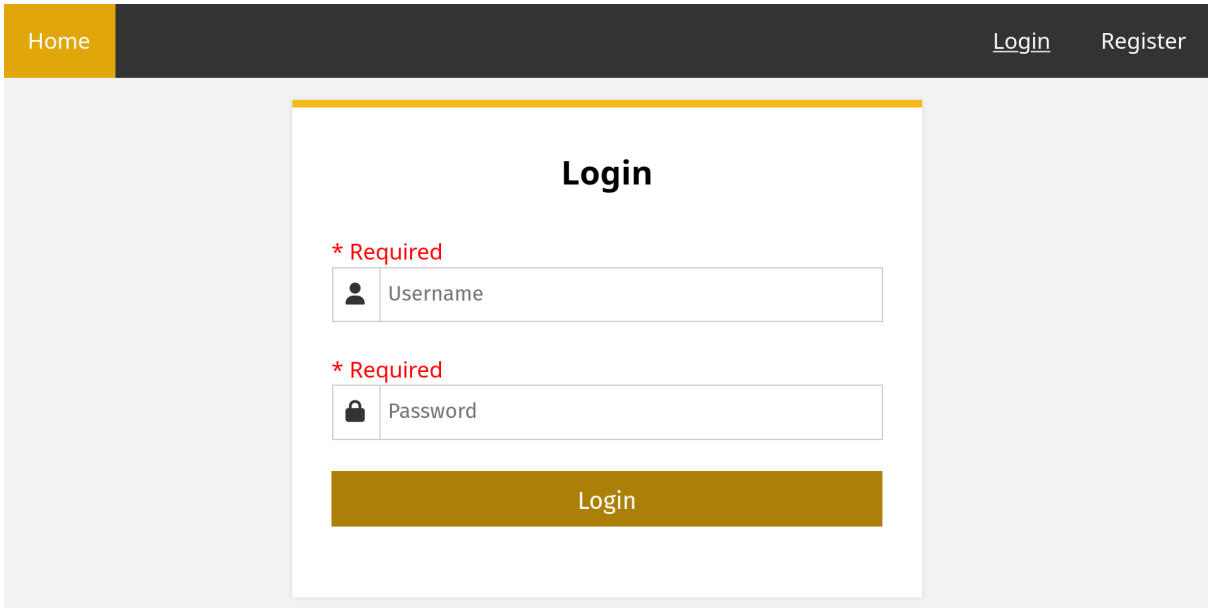


Figure 7: Login page

The following image shows the register page.

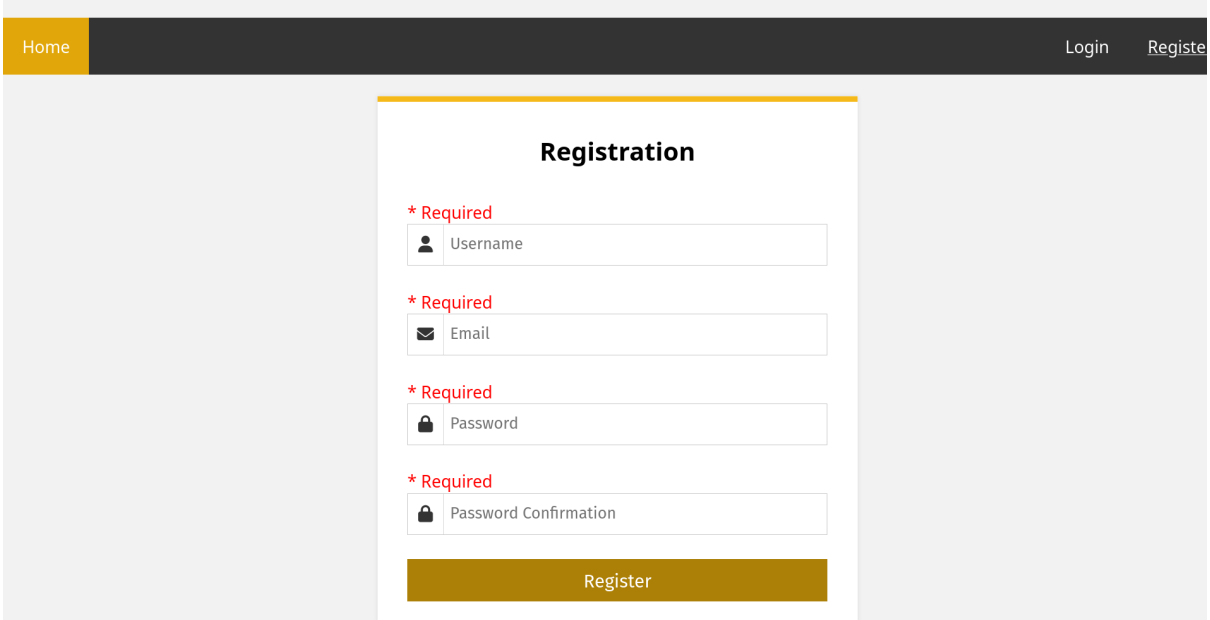


Figure 8: Register page

The following image shows the upload page. No images have been uploaded.

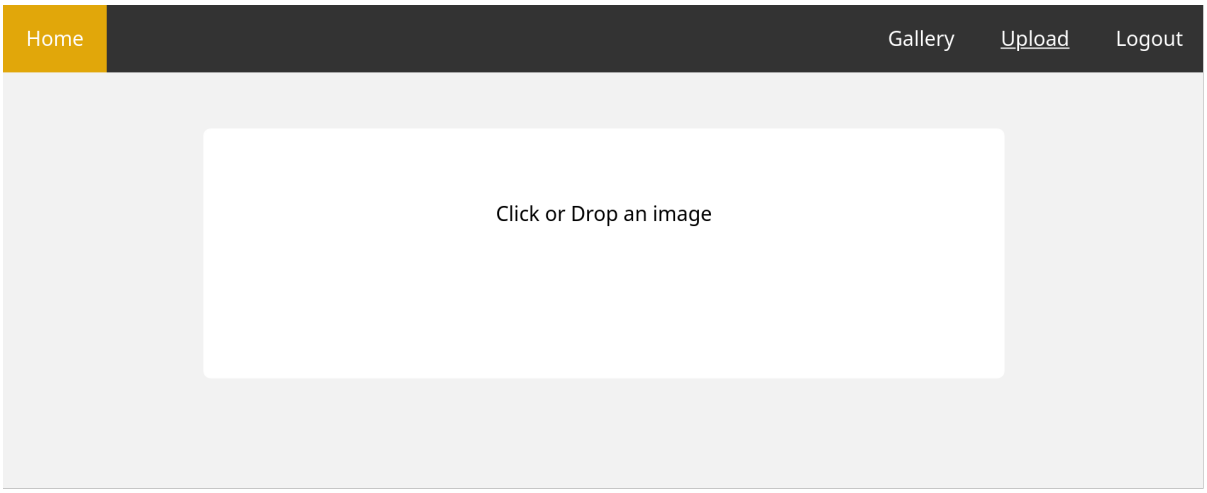


Figure 9: Upload page - empty

The following image shows the upload page. Three images have been uploaded.

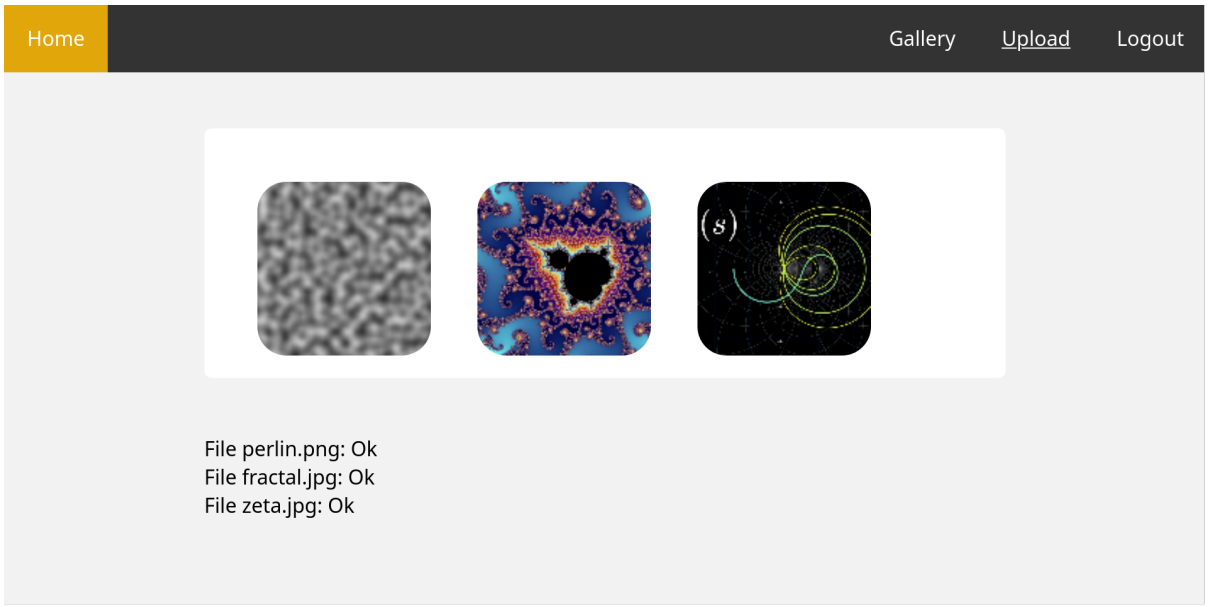


Figure 10: Upload page - full

The following image shows the gallery page. 6 images are loaded at a time. There is a button to load more images. If the are no images remaining the button disappears.

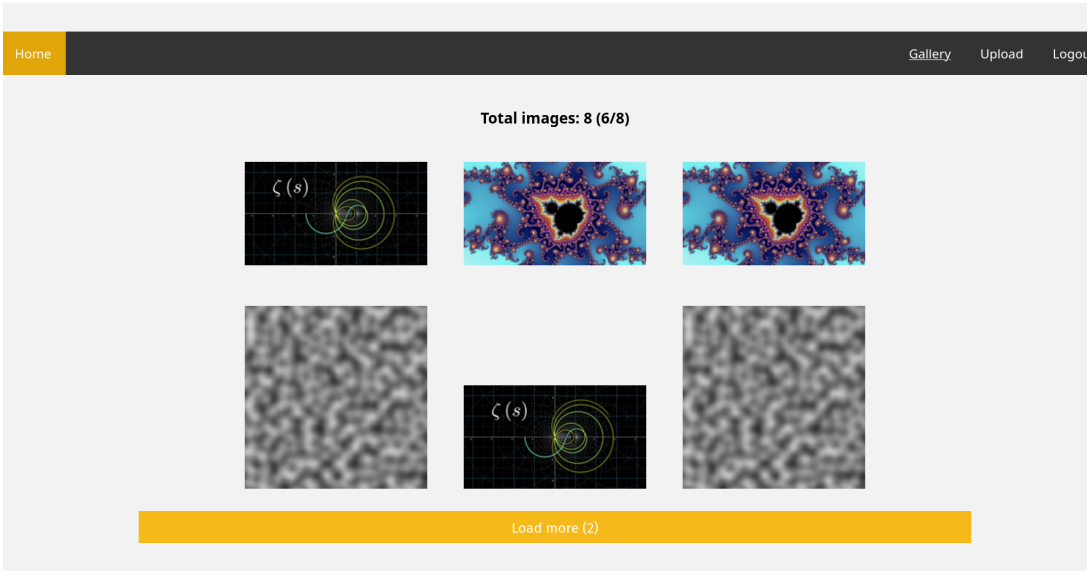


Figure 11: Gallery page

6.2 Webserver

6.2.1 Templating

Templating is used to programmatically serve HTML content based on some logic. To do so a template engine is needed. The template engine renders the HTML content when needed.

I used a template engine library for Rust called tera. Logic blocks can be integrated in the HTML file like so

```
<ul>
{% for user in users %}
    <li><a href="{{ user.url}}">{{ user.url }}</li>
{% endfor %}
</ul>
```

HTML files containing templating code need to be stored in RAM. When the webservers starts it loads from the `www` folder every file containing templating code.

6.2.2 Routing using warp

The webserver needs to respond to different routes. I used a composable Rust framework called warp [6].

The routes are the following:

- **/** → Serve index page
- **/register** → Serve register page
- **/login** → Serve login page
- **/logout** → Serve logout page
- **/upload** → Serve upload page
- **/gallery** → Serve gallery page
- **/api/register** → Register action
- **/api/login** → Login action
- **/api/logout** → Logout action
- **/api/image/<id>** → Get image action
- **/<file>** → Serve static file
- **/index.html** → Block action
- **/register.html** → Block action
- **/login.html** → Block action
- **/logout.html** → Block action
- **/upload.html** → Block action
- **/gallery.html** → Block action

6.3 Database

The database is an instance of `MariaDB`.

6.3.1 Diesel

`diesel` is an ORM library for the Rust programming language. It supports MySQL, Postgres and SQLite and can manage migrations.

Diesel comes with a CLI tool to manage migrations. A configuration file (`diesel.toml`) may be placed in the cargo project.

```
[migrations_directory]
dir = "migrations" # folder containing the migrations
```

A table with the name `__diesel_schema_migrations` is automatically created on the database to keep track of all the migrations run.

Creating a migration

```
diesel migration generate <name>
```

This command will generate a migration in the migration folder with the current timestamp. The files `up.sql` and `down.sql` created.

Executing migrations

```
diesel migration <run|redo|revert>
```

This command will run, redo or revert the migration on the database. The database service address must be passed using the `--database-url` parameter or by setting the `DATBASE_URL` enviroment variable.

Generating schema file

```
diesel print-schema > src/schema.rs
```

This command will generate the `schema.rs` file. This file is produced from the databased and is used to perform compiled-time checked queries. The database service address must be passed using the `--database-url` parameter or by setting the `DATBASE_URL` enviroment variable.

up.sql

```
CREATE TABLE user (
    id INT PRIMARY KEY AUTO_INCREMENT,
    mail VARCHAR(50) NOT NULL,
    username VARCHAR(25) NOT NULL,
    password BINARY(32) NOT NULL,
    token BINARY(32) NOT NULL,
    created_at TIMESTAMP NOT NULL DEFAULT CURRENT_TIMESTAMP
);

CREATE TABLE image (
    id INT NOT NULL,
    user_id INT NOT NULL,
    PRIMARY KEY (id, user_id),
    uploaded_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    data BLOB NOT NULL,
    FOREIGN KEY (user_id)
        REFERENCES user(id)
            ON UPDATE CASCADE
            ON DELETE CASCADE
);

CREATE TABLE log (
    id INT PRIMARY KEY AUTO_INCREMENT,
    log_date TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    message VARCHAR(50) NOT NULL
);
```

down.sql

```
DROP TABLE image;
DROP TABLE user;
DROP TABLE log;
```

The migration can be included in the code at compile-time using a macro and run at the start of the program, like so

```
fn run_embedded_migrations(connection: &mut MysqlConnection) {
    const MIGRATIONS: EmbeddedMigrations = embed_migrations!();

    connection.run_pending_migrations(MIGRATIONS).unwrap();
}
```

The traits `Queryable` and `Insertable` can be automatically derived for structures, such that diesel can execute queries and inserts directly with the structures themselves.

```rust
#[derive(Queryable, Debug)]
#[diesel(table_name = user)]
pub struct User {
    pub id: i32,
    pub mail: String,
    pub username: String,
    pub password: Vec<u8>,
    pub token: Vec<u8>,
    pub created_at: NaiveDateTime,
}

#[derive(Insertable)]
#[diesel(table_name = user)]
pub struct NewUser<'a> {
    pub mail: &'a str,
    pub username: &'a str,
    pub password: &'a Vec<u8>,
    pub token: &'a Vec<u8>,
}

#[derive(Queryable, Debug)]
#[diesel(belongs_to(User))]
#[diesel(table_name = image)]
pub struct Image {
    pub id: i32,
    pub user_id: i32,
    pub uploaded_at: NaiveDateTime,
    pub data: Vec<u8>,
}

#[derive(Insertable)]
#[diesel(belongs_to(User))]
#[diesel(table_name = image)]
pub struct NewImage<'a> {
    pub id: i32,
    pub user_id: i32,
    pub data: &'a Vec<u8>,
}
```

Queries and inserts are executed using the schema file.

```rust
use crate::schema::user::{username, token, dsl::user};
use diesel::select;

// select token of user with a given username
let result = user
    .select(token)
    .filter(username.eq(name))
    .first::<Vec<u8>>(connection) // retrieve first element
    .ok(); // convert Result<Vec<u8>, _> into Option<Vec<u8>>
```

6.4 Messaging

6.4.1 Request/Reply Pattern

A common requirement within a messaging system is a request/reply pattern. A client must be able to publish a message in a queue and *await* a response from a consumer.

Method 1 The most intuitive method is to generate a temporary queue for each request. A client will declare a queue with a random name. Before publishing the message to the main queue, it will set the `reply_to` field. When a consumer consumes this message it will also read the `reply_to` field and send the reply to the specified queue. After publishing the client will start consume from the temporary queue. Upon arrival of the message it will stop consuming and delete the queue. This approach is rather inefficient since we need to declare a new queue for each request.

Method 2 Instead of generating a new queue per request we might create a long-lived queue just for this purpose. Like before, the client sets the `reply_to` field and the consumer replies to this queue. The client awaits the message in the reply queue. However, if multiple clients are await a response from some consumer, the reply messages may overlap in the reply queue and cause a malfunction. This can be resolved by settings the `correlation_id` field in the message (UUID). This value is copied over by the consumer to the `correlation_id` field of the response. The awaiting clients will start to sequentially receive the replies, they will check the `correlation_id` field and if it is not theirs their will ignore it. If the message is the one they have been awaiting the will consume it and send an acknowledgment.

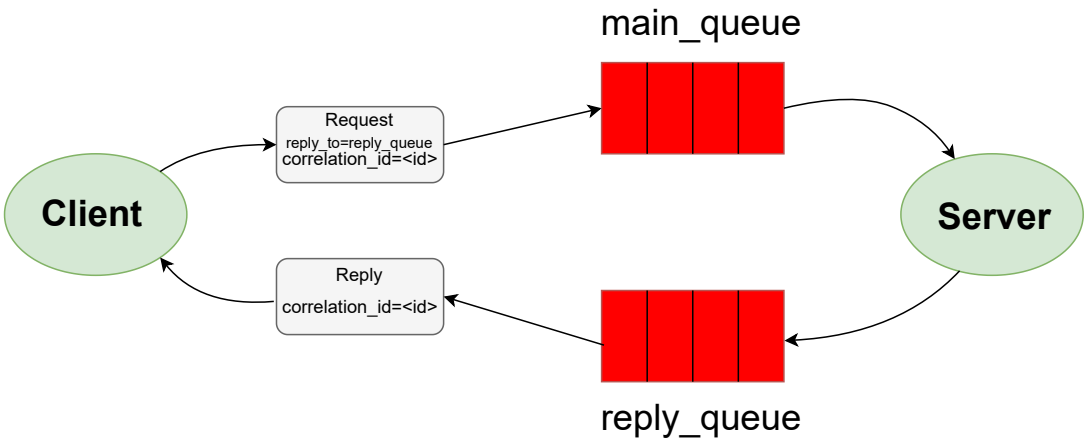


Figure 12: Request Reply Infastructure

Method 3 RabbitMQ has a *built-in* request/reply pattern which is easier to implement and more efficient. The client will set the `reply_to` field to **amq.rabbitmq.reply-to**. This is a pseudo-queue known by the RabbitMQ server. When the server processes the message it will change the `reply_to` field to **amq.rabbitmq.reply-to.<token>** where **<token>** is a randomly generated token. The consumer will consume the message and publish the response to the **amq.rabbitmq.reply-to.<token>** pseudo-queue. The client will await the reply in no-ACK mode by consuming from the **amq.rabbitmq.reply-to** pseudo-queue. This method does not require the client to send an acknowledgment for the reply and the reply is directly sent back to the client.

6.4.2 Binding

The binding to RabbitMQ is done via the `lapin` crate.
Every message is published through the default exchange ("") in a queue named "queue". Consumers take the name of "consumer".

The (own-made) `messaging` crate mainly exports the following functions:

```
    pub async fn publish(
        &self,
        queue_name: &str,
        payload: &[u8],
    ) -> Result<PublisherConfirm, Box<dyn Error>>

    pub async fn publish_and_await_reply(
        &self,
        publish_queue: &str,
        consumer_name: &str,
        payload: &[u8],
    ) -> Result<Vec<u8>, Box<dyn Error>>

    pub async fn consume_messages<D: lapin::ConsumerDelegate + 'static>(
        &self,
        queue_name: &str,
        consumer_name: &str,
        delegate: D,
    )
```

The **publish_and_await_reply** implements the `Request/Reply` pattern. It is important to note that when the publisher consumes from the pseudo-queue it cannot ack, so the following settings need to be set to the consumer:

```
    let consume_properties = BasicConsumeOptions {
        no_local: false,
        no_ack: true, // Important. Reply consumer cannot ACK
        exclusive: false,
        nowait: false,
    };
```

6.4.3 Messages

The following tables show the structures of every message in the protocol.

Note: these messages are converted to bytes using serialization functions which are automatically generated at compile-time.

The type **Image ≡ Vec<u8>**.

RabbitMessage (enum)

Field	Content	Description
LoginRequest	LoginRequestData	Login request packet
LoginResponse	LoginResponseData	Login response packet
RegisterRequest	RegisterRequestData	Register request packet
RegisterResponse	RegisterResponseData	Register response packet
GetImage	GetImageData	Get image data packet
GetImageResponse	GetImageResponseData	Get image response packet
ShrinkAndUpload	ShrinkAndUploadData	Shrink and upload image packet
ShrinkAndUploadResponse	ShrinkAndUploadResponseData	Shrink and upload response
GetTotalImages	GetTotalImagesData	Get total images packet
GetTotalImagesResponse	GetTotalImagesResponseData	Get total images response
Log	LogData	Log to database packet

LoginRequestData (struct)

Field	Type	Description
username	String	The username
password	Vec<u8>	The password

LoginResponseData (enum)

Field	Content	Description
Ok	LoginResponseDataOk	Positive login response
Err	LoginResponseDataErr	Negative login response

LoginResponseDataOk (struct)

Field	Type	Description
token	Vec<u8>	The authentication token

LoginResponseDataErr (enum)

Field	Content	Description
NotFound	()	User was not not
WrongPassword	()	Password was incorrect

RegisterRequestData (struct)

Field	Type	Description
mail	String	The mail
username	String	The username
password	Vec<u8>	The password

RegisterResponseData (enum)

Field	Content	Description
Ok	(RegisterResponseDataOk)	Positive register response
Err	(RegisterResponseDataErr)	Negative register response

RegisterResponseDataOk (struct)

Field	Type	Description
token	Vec<u8>	The authentication token

RegisterResponseDataErr (enum)

Field	Content	Description
MailAlreadyExists	()	mail already used
UsernameAlreadyExists	()	Username already exists

GetImageData (struct)

Field	Type	Description
token	Vec<u8>	The auth token
index	u16	The image index

ShrinkAndUploadData (struct)

Field	Type	Description
token	Vec<u8>	The auth token
image	Image	The image

GetTotalImagesData (struct)

Field	Type	Description
token	Vec<u8>	The auth token

GetTotalImagesResponseData (enum)

Field	Content	Description
Ok	GetTotalImagesResponseDataOk	Positive response
Err	GetTotalImagesResponseDataErr	Negative response

GetTotalImagesResponseDataOk (struct)

Field	Type	Description
amount	u32	The amount of images

GetTotalImagesResponseDataErr (enum)

Field	Content	Description
AuthenticationRequired	()	Authentication error

ShrinkAndUploadResponseData (enum)

Field	Content	Description
Ok	()	Positive response
Err	ShrinkAndUploadResponseDataErr	Negative response

ShrinkAndUploadResponseDataErr (enum)

Field	Content	Description
InvalidImage	()	Invalid image response
AuthenticationRequired	()	Authentication error

GetImageResponseData (enum)

Field	Content	Description
Ok	(GetImageResponseDataOk)	Positive response
Err	(GetImageResponseDataErr)	Negative response

GetImageResponseDataOk (struct)

Field	Type	Description
data	Image	The image data

GetImageResponseDataErr (enum)

Field	Content	Description
InvalidIndex	()	Invalid index error
AuthenticationRequired	()	Authentication error

LogData (struct)

Field	Type	Description
message	String	The message to log

6.5 Backend

The backend is a software that endlessly consumes messages on every core.
The main part of the logic is the action matching. When a message is consumed, it is converted into a `RabbitMessage` struct. The structure is then matched and an action is chosen. The generated answer (if any) it is converted to bytes and sent back.

```
    fn consume(&self, delivery: &Delivery) -> Option<Vec<u8>> {
        info!("Received Delivery");

        // Convert bytes to `RabbitMessage` structure
        let message = {
            let settings = &Settings::default();
            let res = RabbitMessage::from_raw_bytes(&delivery.data, settings);
            if let Ok(data) = res {
                data
            } else {
                return None;
            }
        };

        // Match action
        let response = match message {
            LoginRequest(ref data) => self.on_login_request(&data),
            RegisterRequest(ref data) => self.on_register_request(&data),
            GetImage(ref data) => self.on_get_image(&data),
            ShrinkAndUpload(ref data) => self.on_shrink_and_upload(&data),
            GetTotalImages(ref data) => self.on_get_total_images(&data),
            Log(ref data) => {
                // No response for log
                self.on_log(&data);
                return None;
            }
            _ => return None,
        };

        // Convert `RabbitMessage` response to bytes
        let res = response.raw_bytes(&Settings::default());

        res.ok()
    }
```

6.6 Dependencies

Here's a list of all the libraries used within the project

Dependency table (worker)			
Name	**Description**	**Vesion**	**Features**
clap	CLI Parser	3.2.20	derive
tokio	Asynchronous runtime	1	full
log	Logging inerface	0.4	
env_logger	Logging implementation	0.9.0	
sha2	SHA-2 hash function family	0.10.5	
image	Imaging library	0.24.5	
webp	WebP format	0.2.2	
futures	Future and streams	0.3.17	
rand	Random number generators	0.8.5	
database	(Own) database library	-	
messaging	(Own) messaging library	-	
config	(Own) config library	-	
protocol	(Own) protocol library	-	

Dependency table (webserver)			
Name	**Description**	**Vesion**	**Features**
log	Logging inerface	0.4	
env_logger	Logging implementation	0.9.0	
clap	CLI Parser	3.2.20	derive
tokio	Asynchronous runtime	1	full
warp	Web server framework	0.3.3	
serde	Serialization/deserialization framework	1.0	derive
tower	client and server components	0.4	
tower-http	HTTP middleware	0.3	full
futures	Future and streams	0.3.25	-
bytes	Bytes utilities	1.2.1	
tera	Template engine	1.17.1	
lazy_static	Lazily evaluated statics	1.4.0	
once_cell	Single assignment cells	1.16.0	
base64	Base64 encoder/decoder	0.13.1	

Dependency table (frontend)			
Name	**Description**	**Vesion**	**Features**
wasm-bindgen	JS and Rust interaction	0.2.83	
console_error_panic_hook	Logs panics to wasm32	0.1.7	
wee_alloc	Allocator	0.4.5	
js_sys	JS objects binding	0.3.60	
base64	Base64 encoder/decoder	0.13.1	
web-sys	Binding to Web APIs	0.3.60	
protocol	(Own) protocol library	-	

Dependency table (config)			
Name	**Description**	**Vesion**	**Features**
serde	Serialization/deserialization framework	1	derive
toml	TOML parser	0.5.9	

Dependency table (database)			
Name	**Description**	**Vesion**	**Features**
serde	Serialization/deserialization framework	1	derive
diesel	Database ORM	2.0.0	mysql, chrono, r2d2
chrono	Datetimes	0.4.19	
diesel_migrations	Diesel migrations	2.0.0	

Dependency table (protocol)			
Name	**Description**	**Vesion**	**Features**
protocol	Protocol definitions	3.4.0	
protocol-derive	Protocol definitions	3.4.0	
lazy_regex	Lazily evaluated regex	2.3.1	

Dependency table (messaging)			
Name	**Description**	**Vesion**	**Features**
lapin	AMQP client	2.1.1	
amq-protocol-types	AMQP specifications	7.0.1	
tokio	Asynchronous runtime	1	full
tokio-amqp	lapin integration with tokio	2.0.0	
deadpool	Connection pool	0.9.5	
deadpool-lapin	Connection pool for lapin	0.10.0	
futures	Future and streams	0.3.17	
uuid	UUID utils	1.1.2	v4, fast-rng, macro-diagnostics
threadpool	Thread pools	1.8.1	

6.7 Config files

The *worker* and *worker* require a configuration file which is passed through a CLI argument. The configuration files look as follows:

worker `config.toml`

```
# Alternately, comment the [database] section and
# set the enviroment variable
#
# DATABASE_URL="mysql://worker:root@192.168.1.10:3306/service"
[database]
address = "192.168.1.10"
port = 3306
username = "worker"
password = "root"
name = "service"

# Alternately, comment the [rabbit] section and
# set the enviroment variable
#
# AMQP_URL=amqp://worker:root@192.168.1.11:5672/vhost
[rabbit]
address = "192.168.1.11"
port = 5672
username = "worker"
password = "root"
vhost = "vhost"

# Alternately, comment the [log] section and
# set the enviroment variables (only RUST_LOG is fine)
#
# RUST_LOG="info"
# RUST_LOG_STYLE="auto"
#
# See https://doc.servo.org/env_logger/index.html
[log]
log = "debug"
style = "auto"
```

webserver `config.toml`

```toml
[http]
www = "/path/to/dist"
ip = "0.0.0.0"
port = 8080

# Alternately, comment the [rabbit] section and
# set the enviroment variable
#
# AMQP_URL=amqp://worker:root@192.168.1.11:5672/vhost
[rabbit]
address = "192.168.1.11"
port = 5672
username = "worker"
password = "root"
vhost = "vhost"

# Alternately, comment the [log] section and
# set the enviroment variables (only RUST_LOG is fine)
#
# RUST_LOG="info"
# RUST_LOG_STYLE="auto"
#
# See https://doc.servo.org/env_logger/index.html
[log]
log = "info"
style = "auto"
```

6.8 Load balancer

The load balancer is implemented via a simple `nginx`[7] reverse proxy.

```
events {}

http {
    upstream backend {
        server 192.168.56.15;
        server 192.168.56.16;
        server 192.168.56.17;
    }

    server {
        listen 80;

        location / {
            proxy_pass http://backend;
        }
    }
}
```

7 Structure

7.1 mandate

The `mandate` folder contains all the documents regarding the project (documentation and diary).

7.2 worker

`worker/` is the Rust project for the backend service. The worker consumes messages from the AMQP server and processes them by interacting with the database.

7.3 webapp

`webapp/` contais the softwre regarding the webserver and frontend.

7.3.1 webserver

webserver is the Rust project for the webserver. This program serves the web page and handles the API routes. It send messages to the AMQP server and awaits the responses once the requests are processed by a backend server.

7.3.2 frontend

frontend is the program containing Rust code which is compiled to WebAssembly. This project be compield to a WASM module and interacted with with JavaScript on the frontend.

7.4 common

`common/` is a collection of own Rust libraries shared accross the programs.

7.4.1 config

common is a library to help parse the TOML configuration files. This library is used by the webserver and worker programs.

7.4.2 database

database is a library wrapper around the database structure of this project. It is only used by the worker server.

7.4.3 messaging

messaging is a library to publish and consume messages to an AMQP server. The request/reply pattern is also available. This library is used both by the websever and worker.

8 Compilation and usage

8.1 Frontend

8.1.1 Compilation

The frontend project is compiled into WASM and then static files for the website are generated.

```
cd webapp/frontend/website
wasm-pack build --release
npm install
npm run build
```

The `wasm-pack` commands compiles the Rust code into a WASM module in the folder `./pkg`. The npm script *build* generates the static website files from the files of the website (*www* folder) and the WASM module (*pkg* folder). The static files are placed in `./dist`.

8.2 Webserver

8.2.1 Compilation

The compilation is done using cargo.

```
cd webapp/webserver
cargo build --release
```

The executable is now at `./target/release/webserver`.

8.2.2 Usage

```
    USAGE:
    webserver --config <CONFIG>

    OPTIONS:
        -c, --config <CONFIG>    Configuration file
        -h, --help               Print help information
```

8.3 Worker

8.3.1 Compilation

The compilation is done using cargo.
Note that you need to have the *diesel* command installed.

```
cd worker
cargo build --release
```

The executable is now at `./target/release/worker`.

8.3.2 Usage

```
    USAGE:
    worker --config <CONFIG>

    OPTIONS:
        -c, --config <CONFIG>    Configuration file
        -h, --help               Print help information
```

9 Testing

9.1 Test protocol

Test-00	
Name	Sign in
Reference	Req-00
Prerequisites	Description
Description	• Go to the page and click register • Fill the form and submit it • Press logout to log out • Press login, fill the form and submit it

Test-01	
Name	Persistent authentication
Reference	Req-00_0, Req-00_1
Prerequisites	Description
Description	• Go to the page and log in or register • Close the browser and reopen the page • The user should still be logged in

Test-02	
Name	Client-side hash
Reference	Req-00_2
Prerequisites	Description
Description	• Go to the page • Whilst executing the log in or register sniff the HTTP packet • The packet should contain $\text{base}_{64}(\text{SHA}_{256}(\text{password}))$

Test-03	
Name	Functionality
Reference	Req-01, Req-01_0
Prerequisites	Description
Description	• Go to the page, log in and go to upload • Drop an image in the dropzone • The image should upload and an async progress should appear

Test-04	
Name	Message queues
Reference	Req-02
Prerequisites	Description
Description	• This requirement cannot be checked functionally • Check the code to ensure queues are used

Test-05	
Name	Gallery
Reference	Req-03, Req-01
Prerequisites	Description
Description	• Go to the page and log in or register • Go to the gallery. The uploaded images should be rendered. • Download the image at `/api/image/1` and check its properties. • The size should be 200x200 pixels and the format WebP.

Test-06	
Name	Gallery chunks
Reference	Req-03_0
Prerequisites	Description
Description	• Go to the page and log in or register • Go to upload and upload at least 10 images • Go to the gallery. Only the last N images should be rendered • Use the button to render more images

Test-07	
Name	Network structure
Reference	Req-04
Prerequisites	Description
Description	• This cannot be checked funcationally • Check the code and topology of the instance to ensure the requirement.

9.2 Test results

ID	Result	Note
Test-00	Passed	-
Test-01	Passed	-
Test-02	Passed	-
Test-03	Passed	-
Test-04	Passed	-
Test-05	Passed	Images are not displayed right away after login
Test-06	Passed	-
Test-07	Passed	-

10 Conclusion

10.1 Future development

There are lots of features that could be added to the application and improvements:

1. Deleting images, giving names to images, changing email, changing password and forgot password features.
2. Source code could be more organized, readable, optimized and documented
3. The webserver could prevent CSRF attacks
4. The frontend design could be improved
5. The infrastructure lacks a cache system
6. Exhaustive error handling

10.2 Personal conclusions

This project was exhausting but overall I am happy about it. The project gave me the opportunity to gain a more deep understanding of the Rust programming language. I am kind of unhappy with how the project itself turned out; there are lots of things that I could have done better. I hated that fact that the infrastructure is, by design, inherently suboptimal, though still desirable to learn about message brokers and such designs. The application itself is not especially "exciting" but rather kind of boring and trivial, but I managed to make it more interesting by using bleeding edge technologies. `8/10` experience.

List of Figures

References

Sitography

[1] Pivotal Software. *RabbitMQ*. 2007. URL: https://www.rabbitmq.com/.

[2] Mozilla Research. *Rust*. 2010. URL: https://www.rust-lang.org/.

[3] Paolo Bettelini. *rabbitmq-rs-app*. 2022. URL: https://github.com/paolobettelini/rabbitmq-rs-app.

[4] World Wide Web Consortium. *WebAssembly*. 2015. URL: https://webassembly.org/.

[5] World Wide Web Consortium. *WebAssembly Use Cases*. 2015. URL: https://webassembly.org/docs/use-cases.

[6] seanmonstar. *warp*. 2018. URL: https://github.com/seanmonstar/warp.

[7] Igor Sysoev. *NginX*. 2004. URL: https://www.nginx.com/.

[8] crates.io. *The Rust community's crate registry*. URL: https://crates.io.