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AUTOMATED BIKE SHARING SYSTEM FOR UNIVERSITIES

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INTRODUCTION

Chapter 1

1.0 PROJECT BACKGROUND

Bike-share has taken many forms over the course of its development, from free bikes left for a community to use at will to more technologically advanced and secure systems. In every iteration, the essence of bike-share remains simple: anyone can pick up a bike in one place and return it to another, making point-to-point, human powered transportation feasible.Today, more than 600 cities and more than 200 universities around the globe have their own bike-share systems, and more programs are starting every year. The largest systems are in China, in cities such as Hangzhou and Shanghai. In Paris, London, and Washington, D.C. highly successful systems have helped to promote cycling as a viable and valued transport option.

As the most of the universities have wide area of land, transportation within the university causes time waste, accidents, congestion because of using the private vehicles, parking problems and the energy consumption related to the mobility of workers and students of the universities. The bicycle sharing programs have received increasing attention in recent years with initiatives to increase bike usage,better meet the demand of a more mobile public and lessen the environmental impacts of our transportation activities. So the project aims to introduce automated bike sharing system to minimize above impacts while evaluating the mobility patterns of academic campuses and assessing the energy consumption and pollutant emissions produced by the universities. This system provides the users to unlock the chosen bicycle in the substations via a mobile app and start riding, check the availability of bicycles and authorized people to track the path of rides of all users.

1.1 OBJECTIVES

As the most of the universities have wide area of land, transportation within the university causes time waste, accidents, congestion because of using the private vehicles, parking problems and the energy consumption related to the mobility of workers and students of the universities.

- **Mobility** for employees – providing transportation options that assist University employees to conduct their duties and responsibilities in an efficient, environmentally-friendly manner
- **Safety** through reduced motor vehicle traffic – reducing the amount of motor vehicle traffic in areas with complicated infrastructure or high pedestrian volumes
- **Health** through increased physical activity – providing methods for employees and students to add more movement into their daily routine, thus impacting alertness, health, longevity, and more
- **Environmental** benefits of reduced motor vehicle traffic – reducing greenhouse-gas emissions, decreasing impervious surfaces for parking lots, decreasing need for road maintenance
- **Social** benefits through enhancement of bicycling culture – supporting a culture that sees cycling as a preferred transportation mode choice, and a community that respects and works with the different transportation options
- **Convenience** factor – providing efficient transportation choices to aid users in arriving at destinations quickly and safely by reducing the need to always be in search of a bicycle or car parking area as well as the need to have to do own maintenance on bicycles

- **Economically** self-sustaining – implement a system that will pay for itself and reduce transportation costs for the campus community

- **Research** opportunities – provide the potential for research in urban planning, kinesiology and community health, marketing, environment, engineering, and more, with opportunities to publicize findings internationally

- **Education** campaign – participate with the campus-wide bicycle education campaign, by creating a platform for information sharing

- **Enhanced Image** of the Campus – Implementing a bicycle sharing program would improve the campus' standing as a preferred employer and be an attractive feature for prospective students. This could positively impact recruitment and retention.

Chapter 2

2.0 EMBEDDED SYSTEM DESIGNING

1. Measuring and Controlling

- RFID reader and tags/stickers - To identify each bicycle is in the exact position and to identify the bicycle when returning to the dock station.
- Electric lock - To lock the bicycle

2. Embedded Platform

- Arduino

  Arduino is an open source computer hardware and software platform which is very easy to use. There are enough libraries and compatible modules which can connect to the arduino board. For serial communication we can have hardware serial ports or software serial ports. To control the locking mechanism there are digital I/O pins and ICSP pins.

3. Connecting the system to the network

- Whole locking system will connect to internet using a GSM module
- Users will connect to the system using a Mobile App

4. Peripheral devices

- RFID reader
  RFID reader use to read the RFID stickers in the bicycle. These stickers have a unique id which we use as the identification of bicycle. It is a 5V device, so you don’t need a external power source. ICSP pins are going to use for the communication between the reader and the arduino board.

- GSM module
  A GSM module will use to connect with central server. TTL pins in GSM module will use to connect the module to Arduino board.

- A linear actuator
  A linear actuator is use in locking mechanism of the bikes. Digital I/O pins will be used to send control signals to the actuator.

5. Limitations of peripheral devices

- There are various security problems with locking mechanism. Additional sensors have to use in order to make more secure.

2.1 WEB AND NETWORK APPLICATION DESIGNING

1. Protocols and Middle-ware

- HTTP

  HTTP protocol will be use to maintain the communication between dock stations and central server.

- I2C protocol

  This protocol will be use to communicate between locks and the relay node.

- A central server

  Central server is use to control the locks. A user scan the QR code in the lock and send the information with his login details to the server. Then the server will unlock the relevant lock and start to track the bicycle using the GPS system of the mobile using the given mobile app. It maintains a database of users and bicycles.

- MQTT Protocol

  MQTT protocol is a Machine to Machine (M2M) protocol widely used in Internet of things. The MQTT protocol is a message based protocol, extremely light-weight and for this reason, it is adopted in IoT ecosystem. Almost all IoT platforms support MQTT protocol to send and receive data from smart objects. There are several implementations for different IoT boards like Arduino, Raspberry and so on

2. Back End and Front End

- Back end

  Will use Node.js as the server side language

  Mongodb as database management system

  Server, MQTT broker and database are hosted in the Docker Cloud

  SMS Gateway- Twilio is used as the SMS API

- Front end

  - Web interface for administrational usage

  - HTML, CSS, Javascript(React), Redux

  - Mobile Application

  - Android studio

3. Connecting components through APIs

- REST API

  Use to exchange information among components (lock and mobile app)

- Google Maps API

  Will use to show to location of the bicycle

- Bar-code API

  Will use to parse the QR code with different format

2.2 NETWORK SECURITY

- Sensitive data

  Detail of users are stored in central server. Mobile app is used to login to the system. These login requests need to be secure.

  Passwords of users need to be stored in hash representation.

  Controlling responses from server should be secured

- Security features

  Encrypting the requests and responses.

  Encouraging users to use a strong password.

- Making MQTT secure with SSL

  MQTT brokers may require username and password authentication from clients to connect. To ensure privacy, the TCP connection may be encrypted with SSL. SSL (Secure Socket Layer) is the accepted standard for encrypted communication between a server and a client ensuring that all data passed between the server and client remain private and integral.

METHODOLOGY

Chapter 3

3.0 INTRODUCTION

This chapter describes the method which will be used to implement this project.

3.1 ANDROID APPLICATION AND WEB APPLICATION DESIGN

For the riders' side, an mobile application is going to be implemented using Android studio. The client can check the map of the dock stations around the University and he/she can unlock by reading the QR code via this mobile application at the desired dock station.

Here android volley is used to make HTTP requests. Google map API is used to get the locations of the dock stations and Google Bar-code API is used to scan the QR code.

A web application will be developed for
the administrational purposes such as to register the riders and monitor the bike usage. HTML, CSS, Javascript, React, Redux will be used as the front end technologies.

3.1.1 Mobile Application UI Design

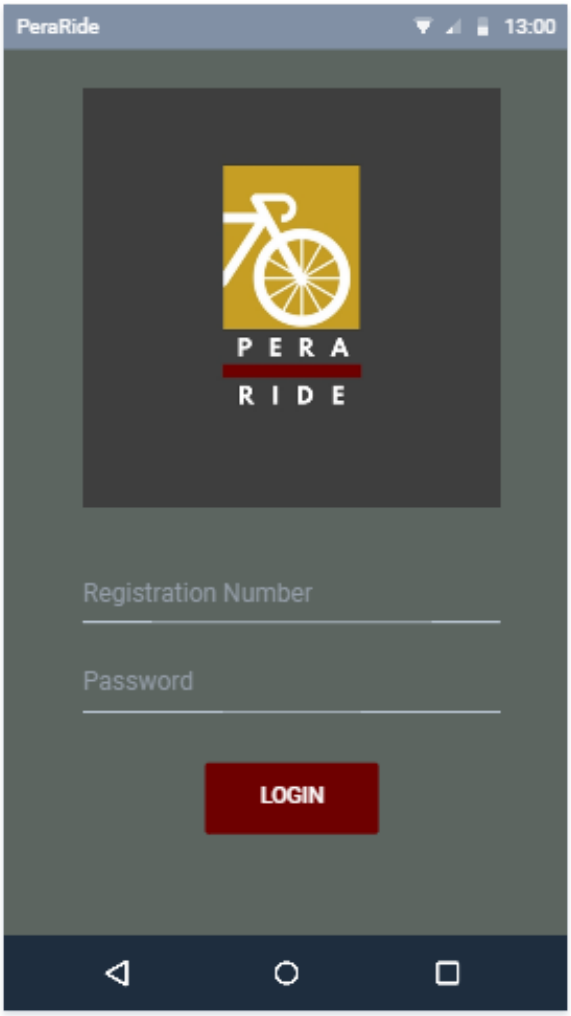


Figure 3.6.1 - Login Interface For Rider

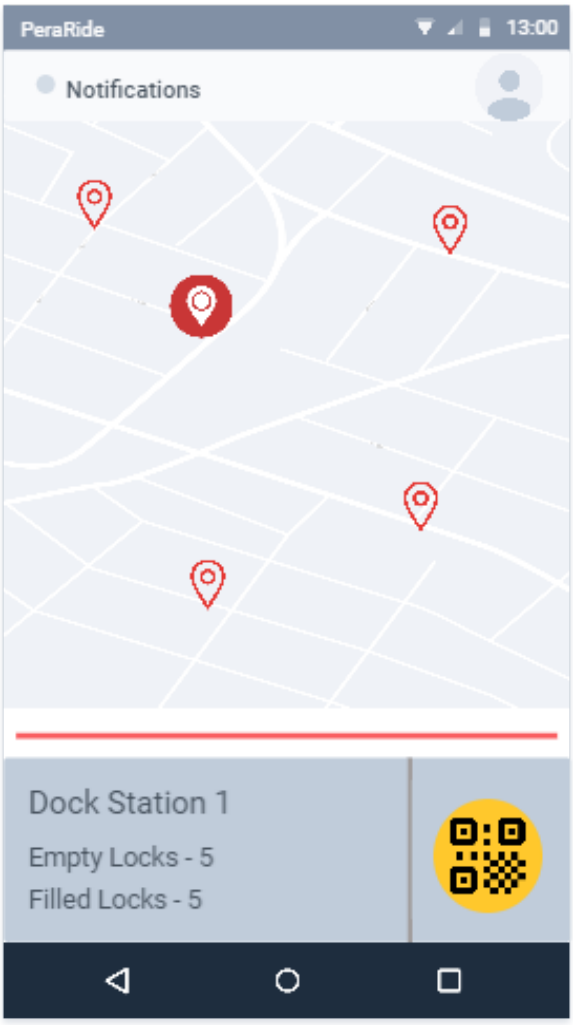


Figure 3.6.2 - Map of the Dock Stations and QR code Scanner

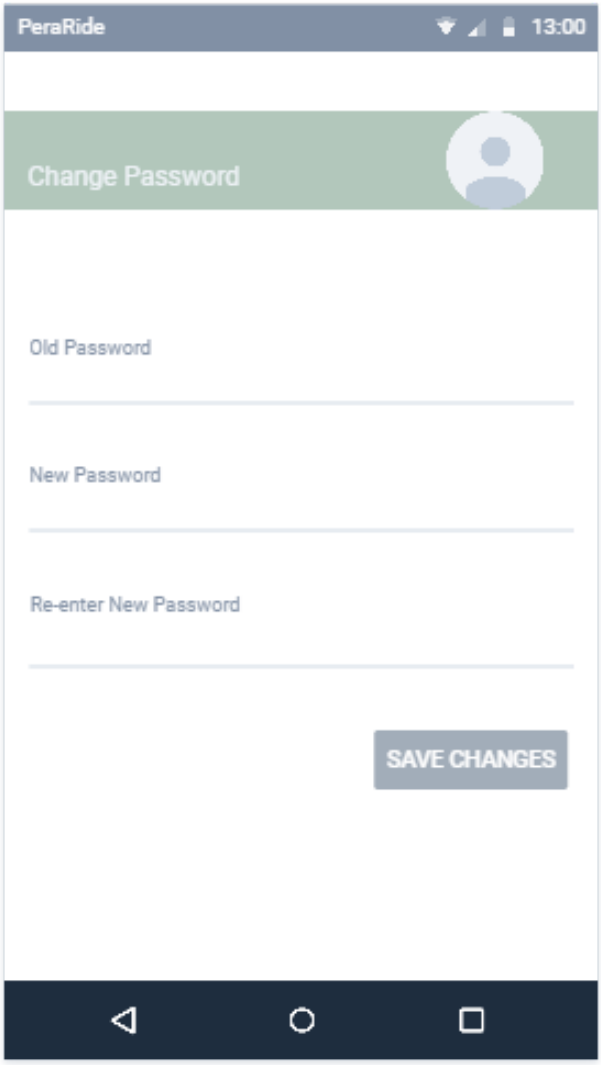


Figure 3.6.3 - Password Changing Interface

3.1.1 Web Application UI Design

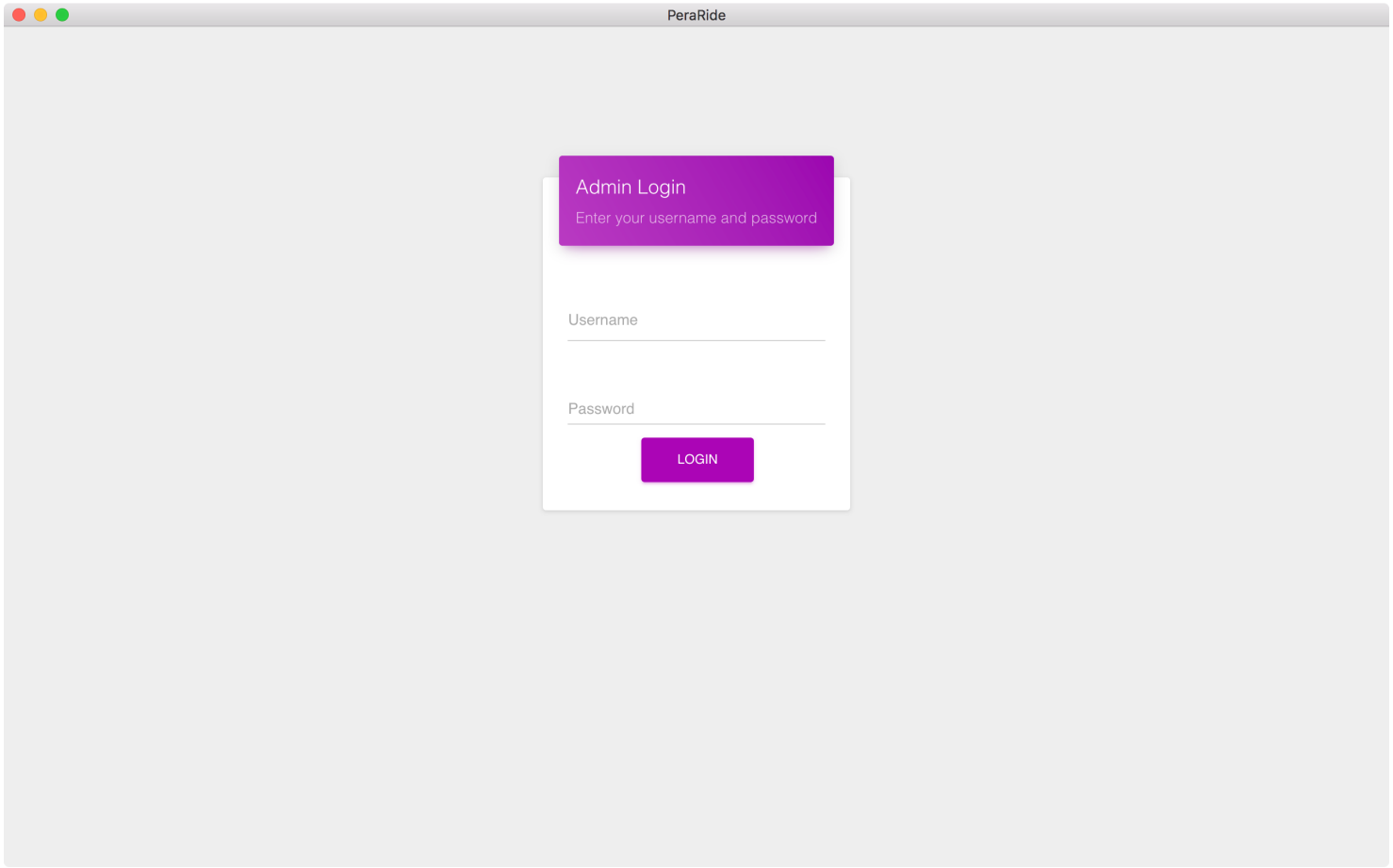


Figure 3.1.1 - Login Interface

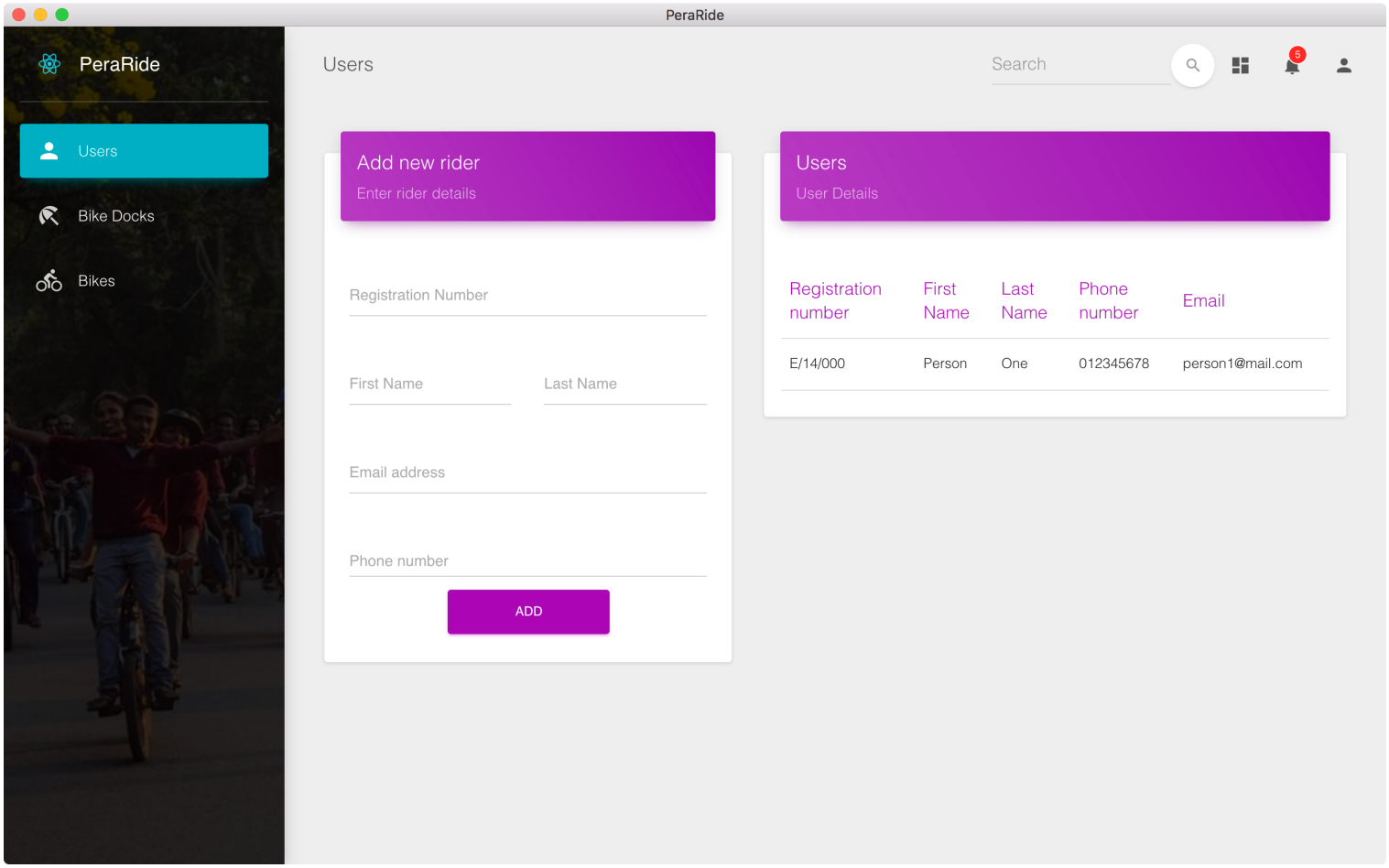
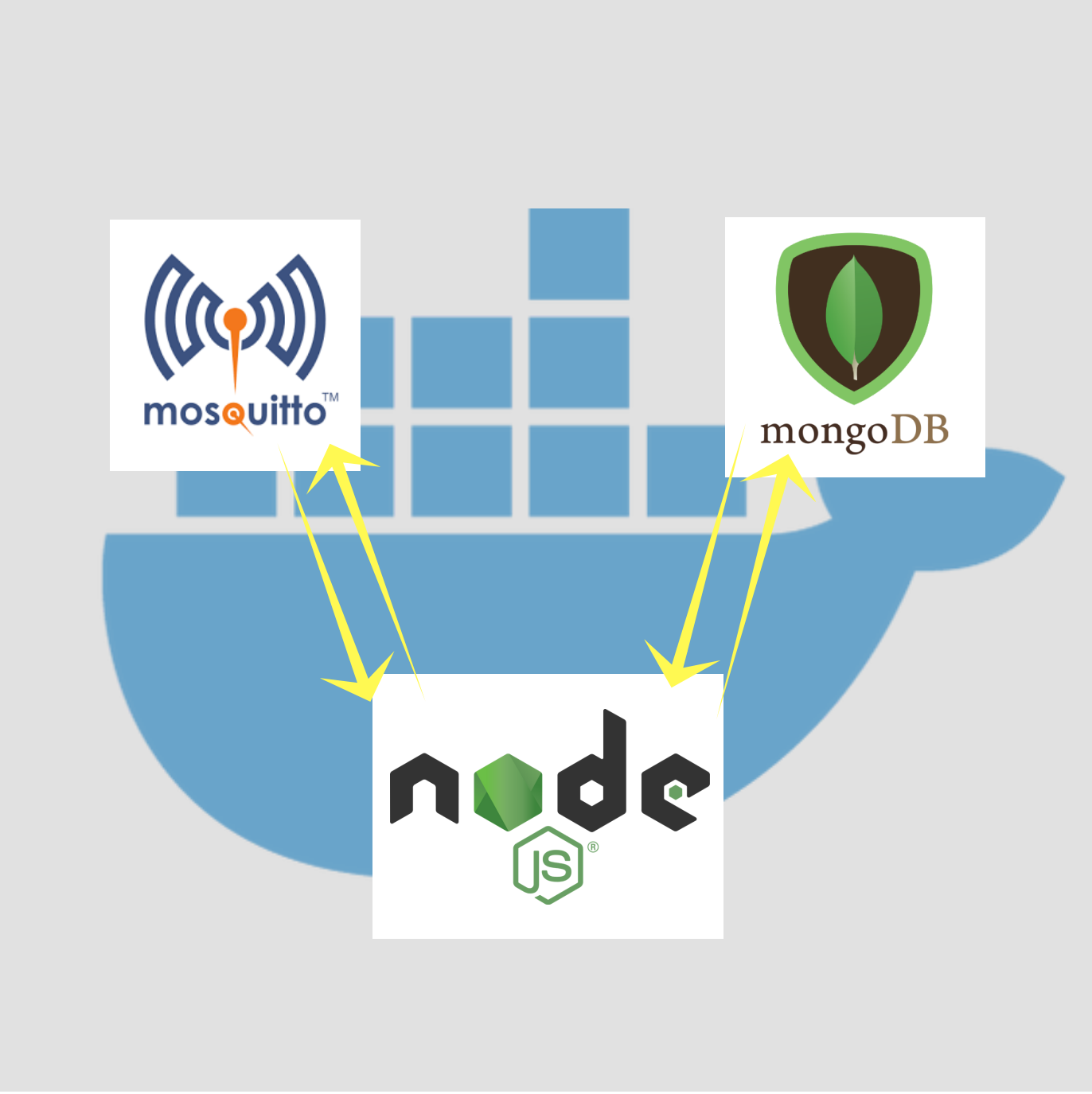


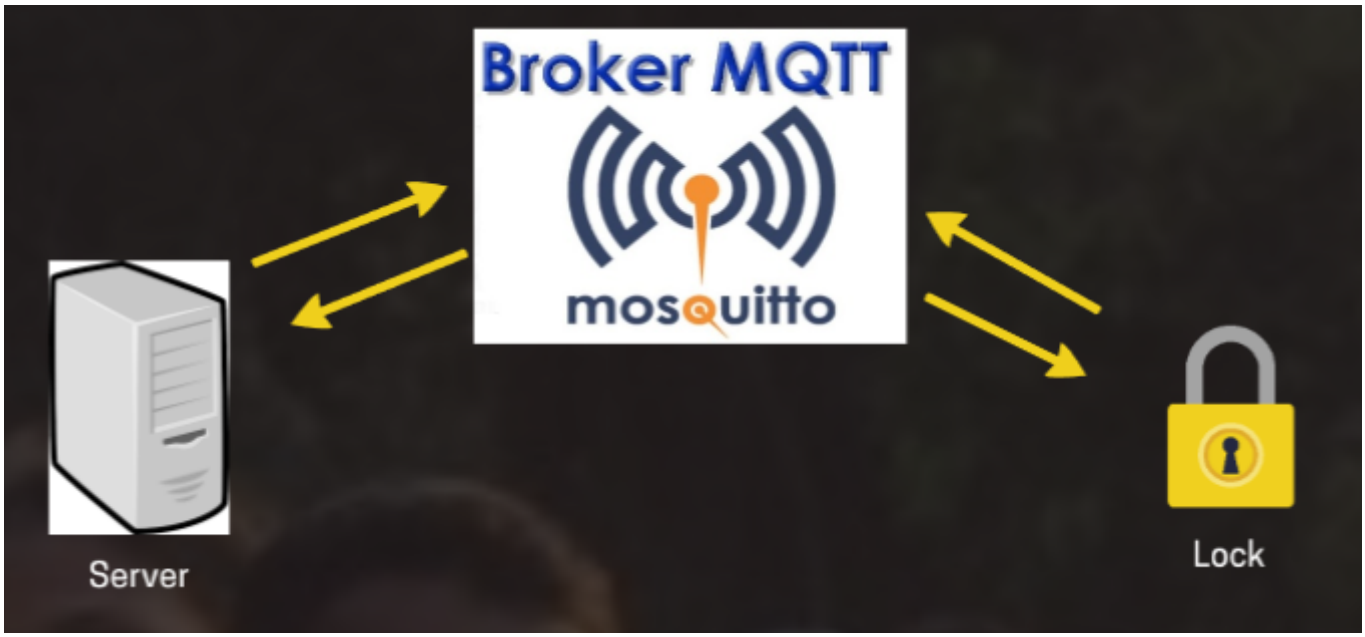
Figure 3.1.2 - User registration interface

3.2 BACKEND DESIGN



3.2.1 MQTT Broker

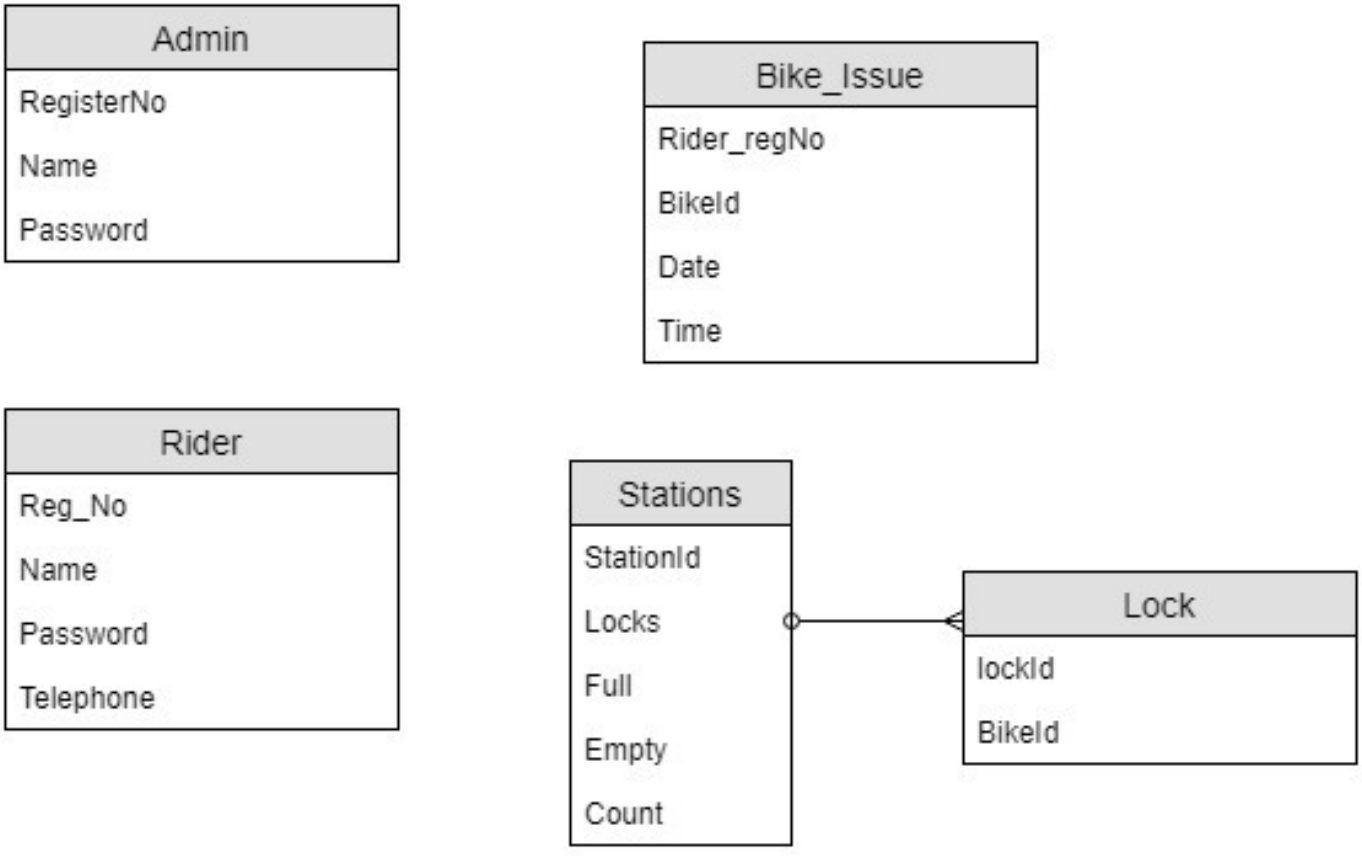
We use Mosquito as our MQTT message broker. It is an open source message broker. Both server and the station subscribe to the relevant topics and publish the message. TLS/SSL will be used to provide a secure communication channel between broker and the client.



3.2.2 MongoDB

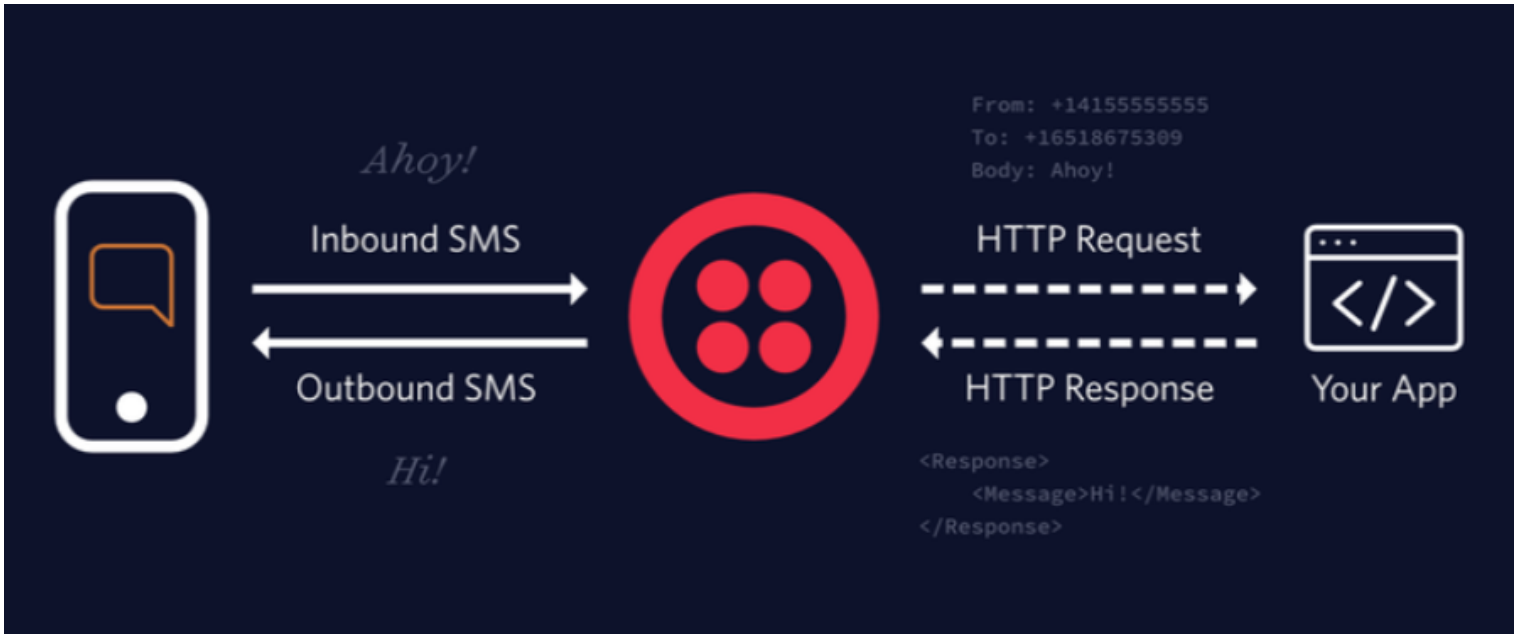
MongoDB is an object oriented, simple, dynamic and scalable no SQL database. The data objects are stored as separated documents inside the a collection. The motivation of the MongoDB language is to implement a data store that provides high performance, high availability, and automatic scaling. MongoDB use s JSON or BSON documents to store data.

Database Schema



3.2.2 SMS Gateway

This system is used when the mobile app cannot be used to unlock the bicycle. It is simply sending a sms with the bike number to unlock the bike. Twilio SMS API is used to send the http request to the server to unlock the bicycle.



3.3 HARDWARE DESIGN

Implementation of smart locks for bike dock stations is the main task under hardware design. Smart lock is going to be designed using a linear actuator (solenoid) which triggered when the current flows. The smart lock unlocks when the rider reads the QR code and locks when the rider returns the bike, RFID reader reads the RFID tag in the bike and then the smart lock works.

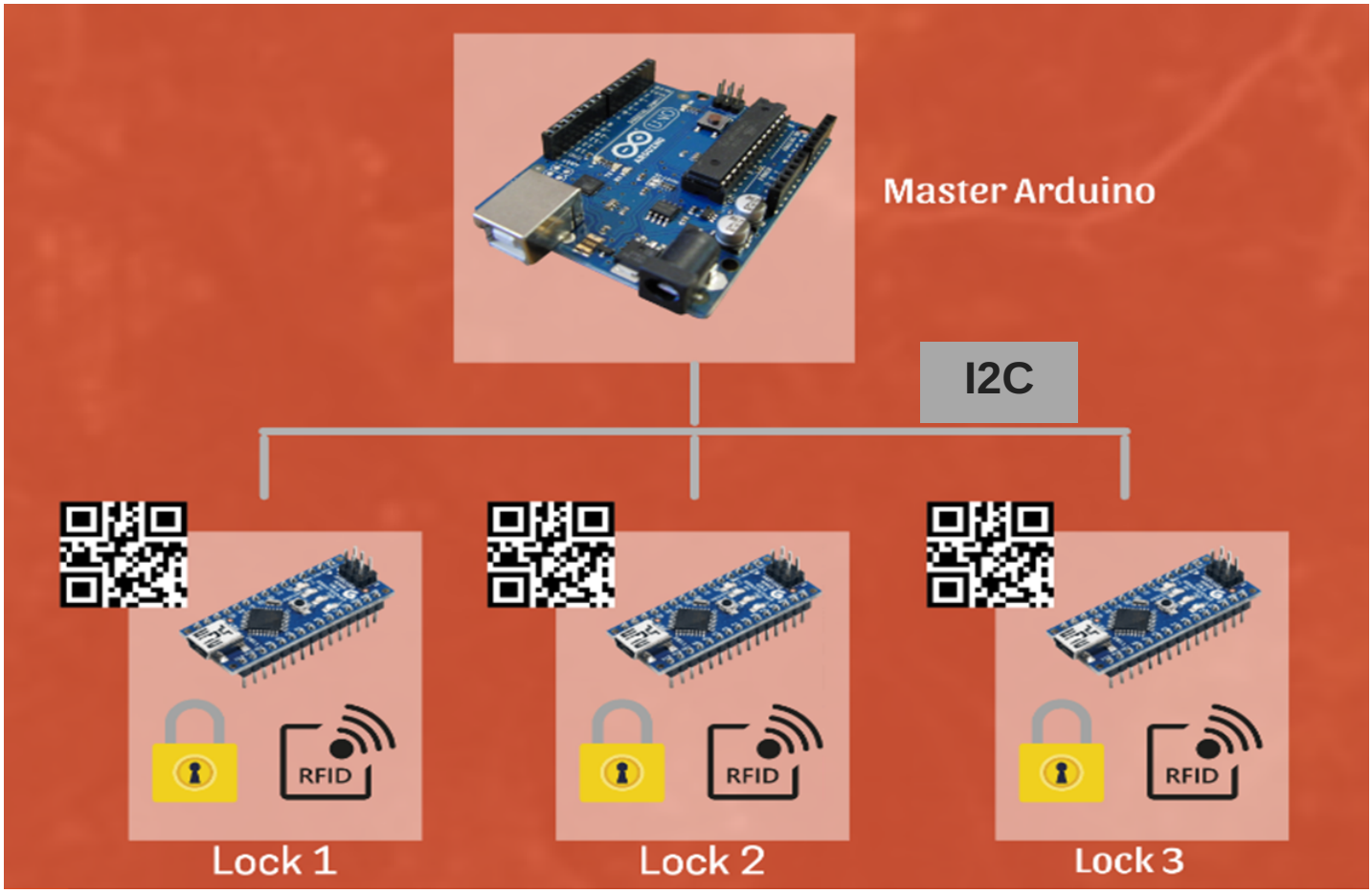
Each lock in dock station contains RFID reader and lock components which are connected to an Arduino nano board. Those Arduino nano boards are connected to an Ardiuno mega board using I2C communication bus. GSM/GPRS module is used for the wireless communication between the hardware components and the server. In between the server and the hardware components, there is a MQTT broker which is primarily responsible for receiving all messages, filtering them, decide who is interested in it and then sending the message to all subscribed clients.

Figure 3.1.0 - RFID Reader

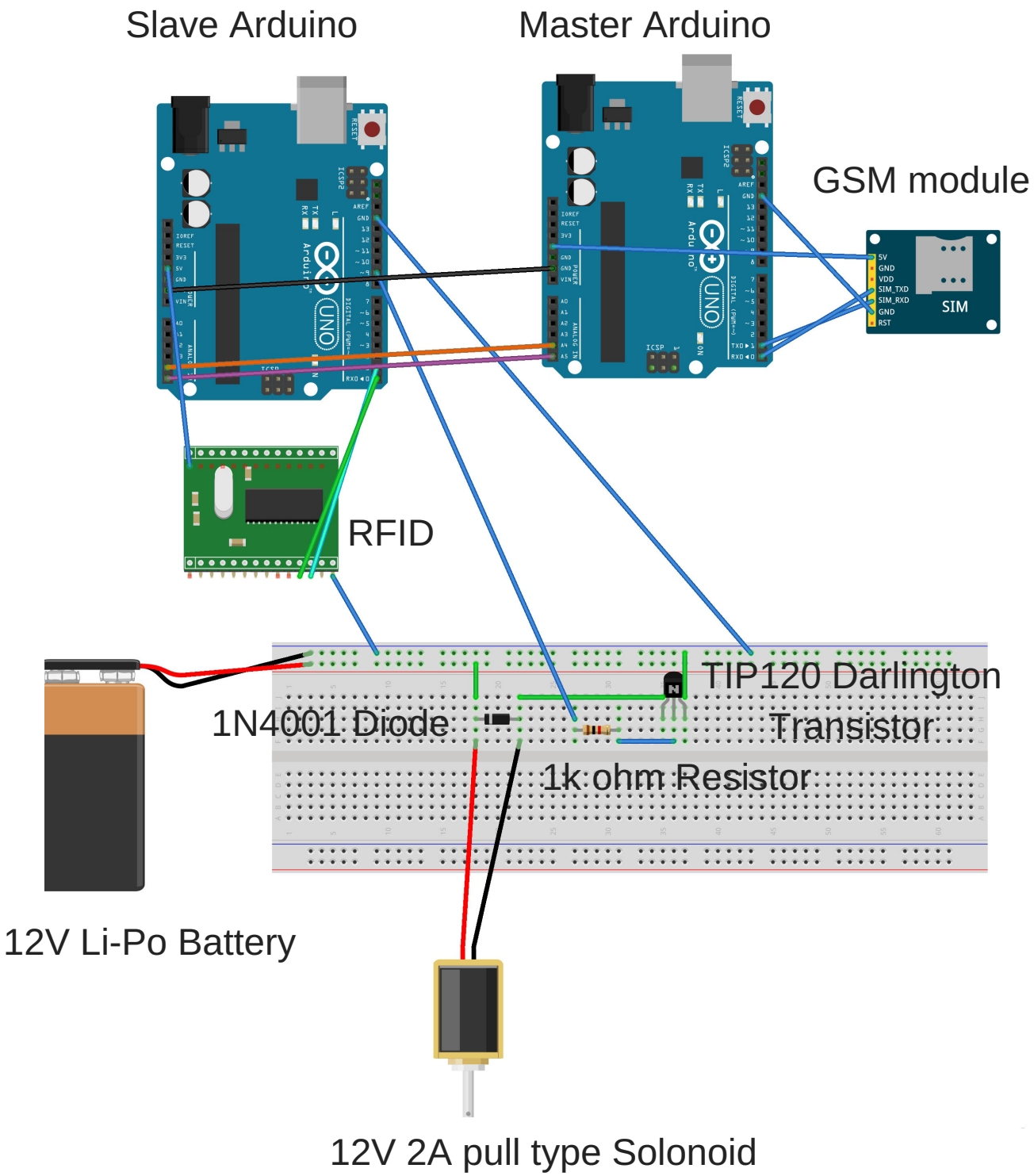
Figure 3.1.1 - GSM/GPRS module

Figure 3.1.2 - Linear actuator

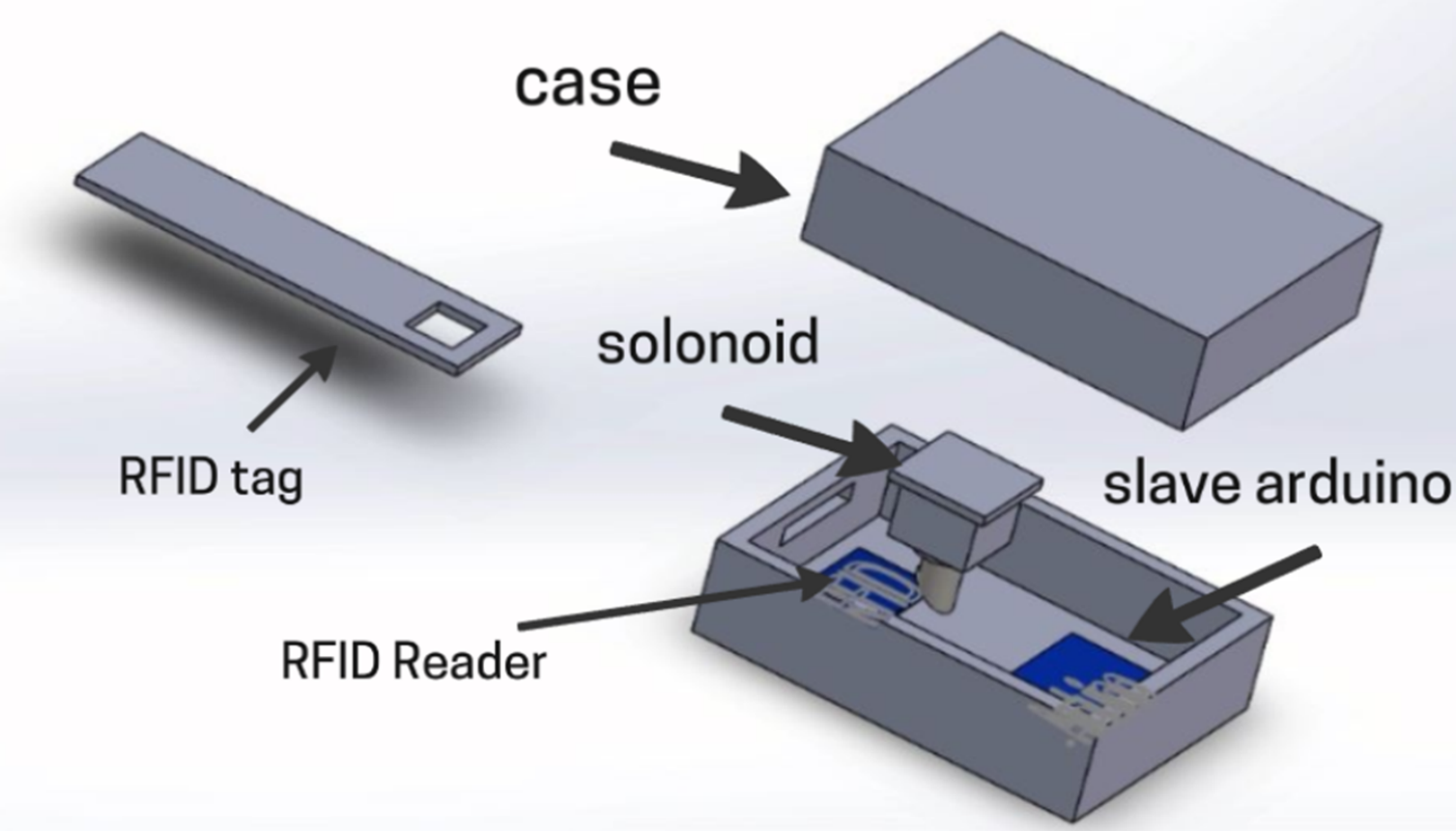
3.3.1 Design of the dock station



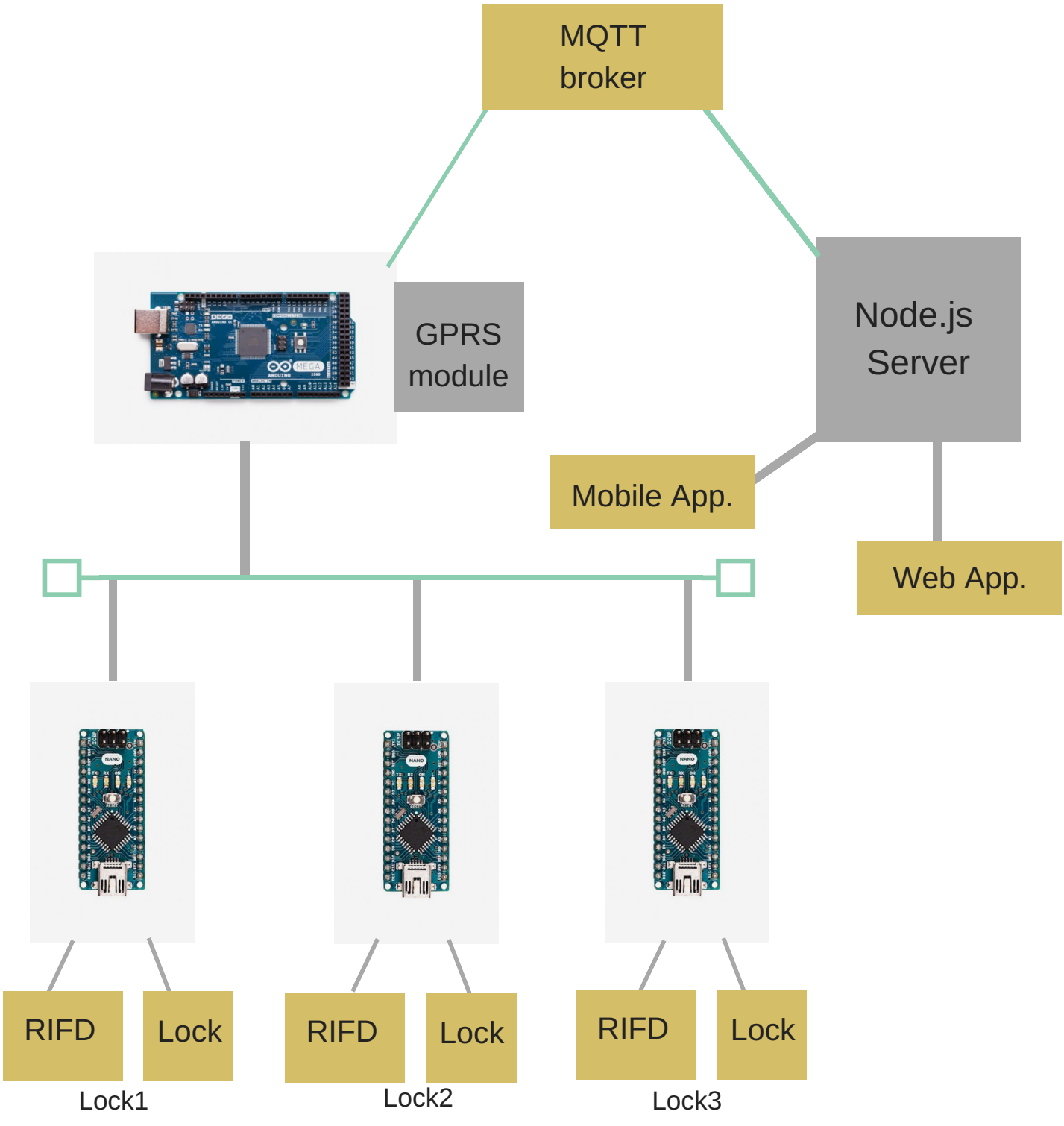
3.3.2 Circuit Diagram



3.3.3 Design of the bicycle lock



3.4 OVERALL SYSTEM DESIGN



MILESTONE PLAN

Chapter 4

Tasks	Feb				Mar				Apr				May				Jun
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
Milestone 1																	
Finishing the design of the lock																	
Setting up the GSM module with the Arduino																	
Checking the RFID reader																	
Creating the Server and a suitable API																	
Database designing																	
Milestone 2																	
Implementing the locking system																	
Checking the communication with the server																	
Setting up the database and connecting it with the server																	
Creating a user interface in Mobile app																	
Creating a login system																	
Milestone 3																	
Implementing the locking system and connecting with the Arduino																	
Controlling the lock using Arduino																	
Creating a sms authentication																	
Identifying the bicycle and update the database accordingly																	
Getting the QR code and other user information and send them to server																	
Milestone 4																	
Connecting all components together and checking																	
Overall testing and finishing																	