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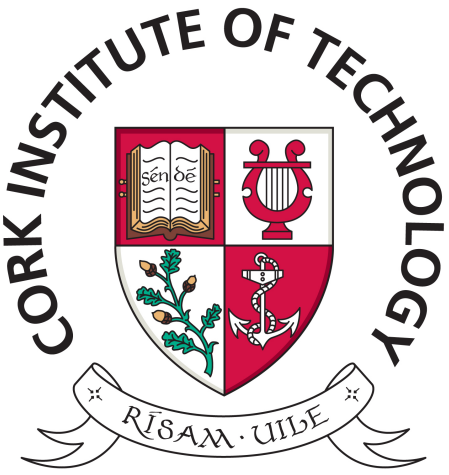

School attendance management system

by

Pavel Vasilev

This thesis has been submitted in partial fulfillment for the degree of Bachelor of Science in Software Development

in the
Faculty of Engineering and Science
Department of Computer Science

January 2017

Declaration of Authorship

I, Pavel Vasilev, declare that this thesis titled, 'School attendance management system' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for an undergraduate degree at Cork Institute of Technology.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at Cork Institiute of Technology or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this project report is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

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CORK INSTITUTE OF TECHNOLOGY

Abstract

Faculty of Engineering and Science
Department of Computer Science

Bachelor of Science

by Pavel Vasilev

Research project report based on fully automated school attendance system focused on the use of beacons.

Acknowledgements

I would like to express my special thanks of gratitude to my project supervisor Sean Mc Sweeney who gave me the golden opportunity to do this wonderful project, which also helped me in doing a lot of Research and I came to know about so many new things I am really thankful to him.

Contents

Declaration of Authorship i

Abstract ii

Acknowledgements iii

List of Figures vii

List of Tables ix

Abbreviations x

1 Introduction 1
- 1.1 Motivation . . . 1
- 1.2 Executive Summary . . . 1
- 1.3 Project Goal . . . 2
- 1.4 Project Objectives . . . 2

2 Background research 3
- 2.1 Overview . . . 3
- 2.2 School Attendance Management System . . . 3
  - 2.2.1 Why is attendance important? . . . 3
    - 2.2.1.1 Advantages . . . 3
    - 2.2.1.2 Disadvantages . . . 4
- 2.3 Project Scope . . . 5
  - 2.3.1 Components . . . 5
  - 2.3.2 Overview . . . 5
    - 2.3.2.1 Requirements . . . 6
    - 2.3.2.2 Advantages . . . 6
    - 2.3.2.3 Disadvantages . . . 7
  - 2.3.3 How SAMS works? . . . 7
- 2.4 A Review of the Thematic Area . . . 8
  - 2.4.1 What is Bluetooth? . . . 8
    - 2.4.1.1 Application . . . 9
  - 2.4.2 What is BLE - Bluetooth Low Energy? . . . 9

2.4.2.1 Why use it? . . . 9
2.4.3 What are BLE beacons? . . . 10
2.4.4 Types of BLE beacons . . . 10
2.4.4.1 Overview . . . 10
2.4.4.2 iBeacon . . . 11
2.4.4.3 AltBeacon . . . 11
2.4.4.4 Eddystone . . . 12
2.4.5 Beacon manufacturers . . . 13
2.4.5.1 Estimote . . . 13
2.4.5.2 Glimworm . . . 14
2.4.6 What is cloud database? . . . 16
2.4.7 Which platform to choose? . . . 16
2.4.7.1 Firebase . . . 16
2.5 Existing Attendance systems . . . 17
2.5.1 Paper-based solutions . . . 18
2.5.2 All Hours . . . 18
2.5.3 Anseo Time and Attendance . . . 18

3 School Attendance Management System 19
3.1 Overview . . . 19
3.2 Naming Conventions and Definitions . . . 19
3.3 Objectives . . . 20
3.4 Functional Requirements . . . 20
3.5 Non-Functional Requirements . . . 21

4 Implementation Approach 22
4.1 Overview . . . 22
4.2 Architecture . . . 22
4.2.1 Technologies . . . 23
4.2.1.1 Data tier . . . 23
4.2.1.2 Logic tier . . . 24
4.3 Business Use Cases . . . 25
4.3.1 Register student . . . 25
4.3.2 Remove student . . . 27
4.3.3 Monitor student . . . 28
4.3.4 View attendance sheet . . . 29
4.3.5 Print attendance sheet . . . 30
4.3.6 Add teacher . . . 31
4.3.7 Message Service . . . 33
4.3.8 Add student to class . . . 34
4.4 Risk Assessment . . . 35
4.5 Methodology . . . 36
4.5.1 Scrum . . . 36
4.6 Implementation Plan Schedule . . . 37
4.6.1 Goals and Objectives . . . 37
4.6.2 Expected Project Goals . . . 38
4.6.3 Project constraints . . . 39

4.6.4 Project Schedule 39
4.7 Evaluation 40
4.8 Prototype 40

5 Discussion and Future Work **43**
5.1 Discussion 43
5.2 Future Work 43

6 Conclusions **44**

Bibliography **45**

List of Figures

2.1 Benefits of SAMS 7

2.2 SAMS 7

2.3 SAMS 8

2.4 iBeacon Data Spec 11

2.5 AltBeacon Data Spec 12

2.6 Estimote's different products 14

2.7 Glimworm beacon 15

2.8 Glimworm beacon specifications 15

2.9 Glimworm beacon specifications 15

2.10 Firebase 17

2.11 Firebase 17

4.1 Architecture Design 23

4.2 Database model 24

4.3 Student Register Flow Diagram 27

4.4 Student Remove Flow Diagram 28

4.5 Monitor Student Flow Diagram 29

4.6 View attendance sheet Flow Diagram 30

4.7 Print attendance sheet Flow Diagram 31

4.8 Add teacher Flow Diagram 32

4.9 Message Service Flow Diagram 33

4.10 Add student to class Flow Diagram 35

4.11 Phone Mockup 41

4.12 Website - Teacher 41

4.13 Website - Admin 42

List of Tables

4.1 Initial risk matrix 36

4.2 Project Schedule 40

Abbreviations

SAMS **S**chool **A**ttendance **M**Management **S**ystem

Chapter 1

Introduction

This report contains the result of my background research and the requirements for a software to aid the school facility in the very time consuming task of taking attendance of students as main goal, while still adding a few extra features to the project. Chapter 2 covers the research of why attendance is important, what are the advantages and disadvantages, what can be improved. Chapter 3 and 4 are covering the system requirements and the design of the software. The rest of this chapter provides some background information on what motivated me to create the project, what are the objectives and goals of the software.

1.1 Motivation

During the summer of 2016 I was supposed to come up with a project idea for my final year project. Even though I had a few interesting idea, one day I was off work and was walking in the city centre and saw a few students around 12:00 walking with no purpose. I overheard talking that they skipped class that day. I finished my walk and that same night I decided to do some research on the attendance rate, and how to properly keep track of students and properly notify their parents if their behaviour is inappropriate.

1.2 Executive Summary

School facilities rely on their teachers to keep track of the attendance rate of the students, pass the information to the administration so that it can contact the parents of the given student.

The main feature of the project is to manage a fully automated attendance sheet. Teachers can put a better use of their time by interacting with the students in a higher educational level. Each teacher would have it's own attendance sheet fully provided with real time data.

Another feature is interaction with the parents. Parents would be immediately notified if the student hasn't entered into the school premises. Earlier measures can be taken to help the given student.

1.3 Project Goal

The goal of the project is to create a fully automated attendance system to improve the education and to minimize the consequences by being able to identify student problems at the early stage.

1.4 Project Objectives

The project consist of 3 main objectives. First is research on the problem, technologies, competitors and the current state of similar software. The next objectives consist of implementation. The final one is mainly focused on testing as part of a research to make sure that software delivers the expected behavior. The project will consist of 3 components(database, dashboard, and monitoring device). In our case the monitoring device will be an Mobile Phone application. Dashboard will be represented using a website to easy the use for each school facility. Cloud database is the only option here, because it provides real time data collection which is the essence of the project. Extensive research needs to be made on the proper database required.

Chapter 2

Background research

2.1 Overview

What is fully automated attendance system? Why is it needed? What are the advantages and disadvantages of the software? Who does it help? These are the questions that are going to be covered in this chapter based on research of the existing literature, results from survey and a comparison of existing solutions and how they differentiate from this project.

2.2 School Attendance Management System

2.2.1 Why is attendance important?

The main purpose of any school facility is to ensure that children are save within the premises. To reach this goal many schools have hired security officer to maintain proper behaviour within the school. Multiple cameras have been installed to monitor in case of emergency, unfortunately most education facilities are on a tight budget and can't afford people to monitor cameras all the time. That is why teachers are required to spend few minutes (2 to 5 minutes) in each class to confirm whether every student is within the class. For educational class to improve on its quality first we need to increase the quantity as well. These 2 to 5 minutes wasted at the beginning of each class is critical to be implemented using today's technology.

2.2.1.1 Advantages

What are the advantages of teachers taking attendance ?

1. Students are more likely to succeed in academics.
2. Less likely to get into trouble.
3. Easier to address a problem if the student is frequently missing.
4. More interaction with the students.
5. Teachers can notify parents if the child is not attending school on given day.

2.2.1.2 Disadvantages

What are disadvantages ? Eliminating the disadvantages would it be possible to keep the advantages?

1. Time consuming.
2. Teacher negligence.
3. Human error.

A report titled "School Attendance Data from Primary and Post-Primary Schools" for 2013/14 provides us with a table in contrast to Annual Attendance Report conducted in 2012/13 and 2013/14.[1]

Response rate of schools to the Annual Attendance Report		
	2012/13	2013/14
Primary	99.3%	99.8%
Post-primary	98.4%	99.9%

Percentage of student/days lost		
	2012/13	2013/14
Primary	5.9%	5.4%
Post-primary	7.7%	7.5%

Percentage of twenty-day absences		
	2012/13	2013/14
Primary	11.6%	10.4%
Post-primary	15.5%	15.4%

Number and percentage of expulsions		
	2012/13	2013/14
Primary	0.004%	0.004%
Post-primary	0.066%	0.044%

Number and percentage of suspensions		
	2012/13	2013/14
Primary	0.2%	0.2%
Post-primary	4.5%	4.1%

The tables above gives us information on the attendance rate of the students, how many days have they been absent. The information includes absent from sickness or family matters, but still some of the numbers are way too high. All of the categories above are connected, by confronting one of them, a change is going to occur in the rest as well.

The Annual Attendance Report provides us with all the critical information required to prove that taking attendance is important task of the teachers.

2.3 Project Scope

2.3.1 Components

The project consist of 3 major components:

1. Cloud Database - The database have to be connected to the monitoring device(in our case that would be the Android device) and to the Dashboard. Important requirement, which database is applicable to this project, is real time data collection. This is the major factor to have constant communication protocol between the three components. The data will constantly be looked up by the device and the website to register any changes.

2. Dashboard -The main function of the dashboard is to provide a workspace for teachers to view the attendance sheet. Add and remove students from their classes. Overall the function of the dashboard is to provide an interface of the database that has been collected.

3. Monitoring device(IPhone, Android) - The device would act as a sensor. Whenever a students passes into the premises of the school, it would get detected and that information will be sent to the Cloud database.

2.3.2 Overview

As we all know taking attendance in class is time consuming activity. There are plenty of implementations for attendance systems using fingerprints, magnetic cards or some PIN number, but all of these require manual input in the system. My project removes the

limitations set by the previous technology used. Combining the 3 components specified above and adding BLE beacons a project can be made that allows school facility to use fully automated attendance sheet. Let's look at how the project works, the requirements, and his advantages.

2.3.2.1 Requirements

- PC/Tablet/Mobile Device is required for the teacher to see the attendance sheet.
- Students are required to wear Beacons(they are small and can be put in a jewelry/accessory - necklace/bracelet).
- Monitoring device installed on the gates of the school.

2.3.2.2 Advantages

- Real time data for students in the school premises.
- Notifications for parents to be relieved that their child has arrived safely to school.
- Teachers can login to the system to see the attendance sheet.
- Removes the time consuming task of teachers taking attendance.
- Provides extra time for more productive activities.
- Manual change of beacon ID.
- Manual configuration of each beacon.
- Reduce paperwork and save time and money with mobile and cloud-based attendance management system.
- Eliminate duplicate data entry and errors in time and attendance.
- Real-time status tracking of leave requests.
- Keep the parents informed about the student's performance via Email or SMS alerts.
- Automated report generation.
- Increased security and confidentiality.

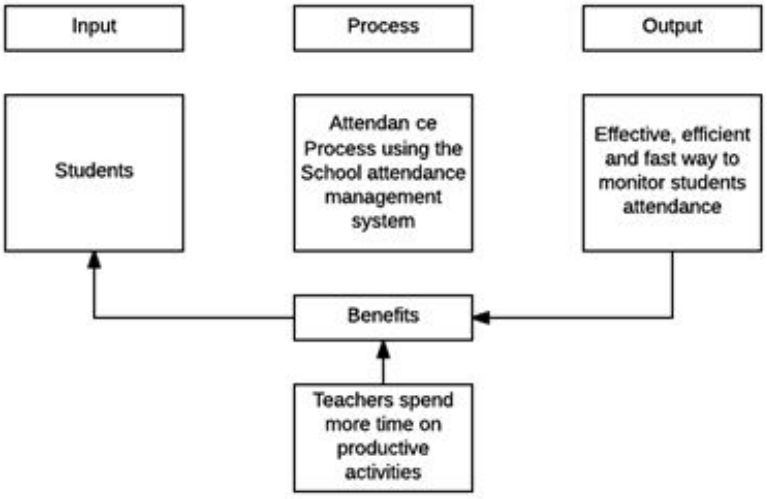


FIGURE 2.1: Benefits of SAMS[]

2.3.2.3 Disadvantages

- Price of Beacons - approximately 15-25$ (last 2 to 3 years based on manufacturer).
- Small manual configuration is required of each at the beginning of the year.

The price of the beacon is not high, but it shouldn't be ignored as well. Most likely parents would be given the choice if they want their child to be recored using SAMS. However every parent would be more than welcome to spend this amount every 2-3 years to make sure that his child is under proper supervision.

2.3.3 How SAMS works?

SAMS - School attendance management system is a fully automated software providing real time data on location based sensors. The monitoring device works as a checkpoint. Whenever a student passes through that checkpoint, the data gets send to the database and updated on the website as well.

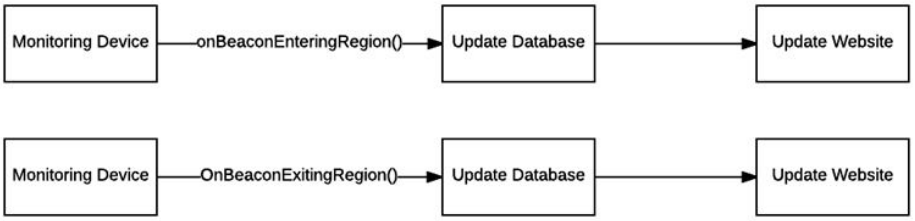


FIGURE 2.2: SAMS system[]

One of the main features included in the software is that it sends notifications to parents. When the student passes through the checkpoint, a SMS service is activated that sends message to the parent that his child has entered the premises of the school allowing him to relax. If the child doesn't arrive by the start of the period a message will be send as well to parents to be able to take early measures in case of accident, student skipping classes, and to ensure that the school cares for each kid.

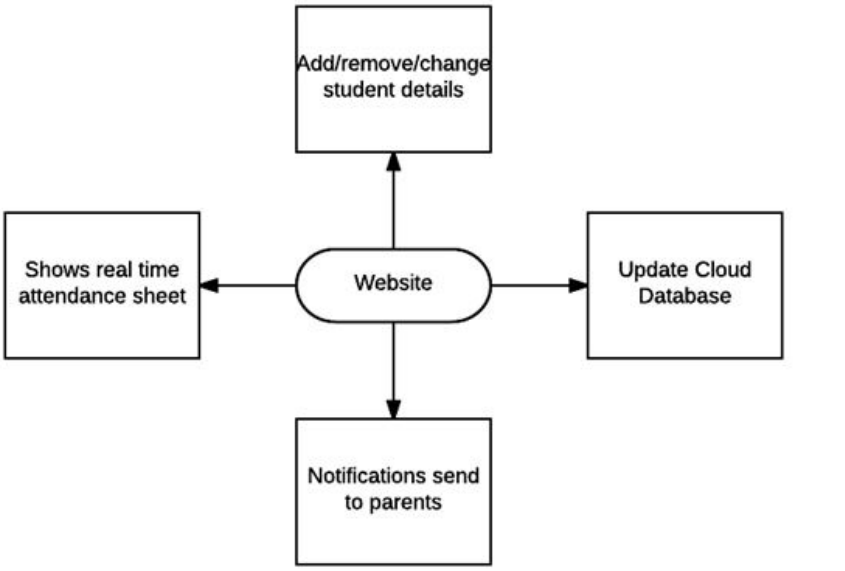


FIGURE 2.3: SAMS features[]

2.4 A Review of the Thematic Area

2.4.1 What is Bluetooth?

"A Bluetooth® device uses radio waves instead of wires or cables to connect to a phone or computer. A Bluetooth product, like a headset or watch, contains a tiny computer chip with a Bluetooth radio and software that makes it easy to connect. When two Bluetooth devices want to talk to each other, they need to pair. Communication between Bluetooth devices happens over short-range, ad hoc networks known as piconets. A piconet is a network of devices connected using Bluetooth technology. When a network is established, one device takes the role of the master while all the other devices act as slaves. Piconets are established dynamically and automatically as Bluetooth devices enter and leave radio proximity."[2]

2.4.1.1 Application

"One of the most popular applications for Bluetooth historically has been wireless audio—headsets and hands-free connectivity in cars to wireless speakers and headphones that stream music from your phone or tablet. This uses a version of Bluetooth called BR/EDR (basic rate/enhanced data rate) that is optimized for sending a steady stream of high quality data (i.e. music) in a power efficient way."[2]

2.4.2 What is BLE - Bluetooth Low Energy?

"Bluetooth low energy (LE) is the power- version of Bluetooth that was built for the Internet of Things (IoT). The power-efficiency of Bluetooth® with low energy functionality makes it perfect for devices that run for long periods on power sources, such as coin cell batteries or energy-harvesting devices. Native support for Bluetooth technology on every major operating system enables development for a broad range of connected devices, from home appliances and security systems to fitness monitors and proximity sensors."[3]

2.4.2.1 Why use it?

"Bluetooth makes it easy for developers and OEMs to create innovative new products that communicate with the billions of Bluetooth enabled devices already in the market. Bluetooth with low energy is inexpensive and developer-friendly, with a flexible development architecture that means you're only limited by your imagination. And as a Bluetooth SIG member, you can tap into a network of tens of thousands of application developers, device makers and service providers."[3]

Key features of Bluetooth with low energy include:

- Industry-standard wireless protocol that allows for interoperability across platforms
- Ultra-low peak, average and idle mode power consumption
- Standardized application development architecture eases development and deployment time and cost
- Allows for some of the government-grade security with 128-bit AES data encryption

2.4.3 What are BLE beacons?

"A new generation of low-cost devices is allowing marketers to track the exact location of consumers via their mobile devices. This article explains how the technology works and proposes a number of ways in which marketers might leverage the proximity and triggers that beacons will make possible."[4]

In this section of the document we will discuss what are advantages and disadvantages of using BLE beacons? What is their current state at the moment. We are going to look into journals, articles and/or books on what their thoughts are on beacons, analyse whether it is the right choice, and what companies would be interested in the project. We are also going to look at the state of the school attendance rate and analyse the consequences of it, and how the project can be efficient in this area.

The current advancement on BLE beacons is beyond compare and multiple companies have started integrating them into their projects, current projects and even into their own life. The BLE beacons acts as an identification protocol allowing the system to identify who you are and what are your needs. It can act as marketing promotion based on your location and allowing the company to market their product, it can act as map guide to show you where you are. Overall the implementation are beyond counting.

The manufacturers of BLE beacons offer different features to accommodate the needs of many. The beacon can have multiple sensors integrated (temperature, whether, location, pulse, etc.). We are going to look at the 3 biggest manufacturers and research which is the best option in topic with this project.

2.4.4 Types of BLE beacons

Bluetooth Low Energy (BLE) Beacons - there are several different types available(iBeacon, AltBeacon, Eddystone), each of those has their own pros and cons. Some of them are open source, some are closed and cost money. This section covers will cover the 2 main types available, their advantages and disadvantages

2.4.4.1 Overview

Bluetooth Low Energy (BLE) can transfer information in one of two states: connected and advertising modes. Connected mode transfers data in one-to-one connection and uses the Generic Attribute (GATT) layer. Advertising mode broadcasts data to anyone who is listening and uses the Generic Access Profile (GAP) layer

Most common use of the beacons is throughout the advertising mode by broadcasting advertisements, vouchers, navigation. Each type of beacon uses custom specification to create the advertisement.

2.4.4.2 iBeacon

Apple's iBeacon was the BLE Beacon to be released, the rest of the beacons take inspiration from the iBeacon structure. iBeacons are enabled in most of the Apple SDKs and are compatible with any BLE-enabled device. iBeacon offers a large ecosystem and resources around it for the developers needs, however you need to be part of the Apple's community to use it's benefits.

iBeacons sent four pieces of information:

1. A UUID that identifies the beacon.
2. A Major number identifying a subset of beacons within a large group.
3. A Minor number identifying a specific beacon.
4. A TX power level in 2's compliment, indicating the signal strength one meter from the device. This number must be calibrated for each device by the user or manufacturer.

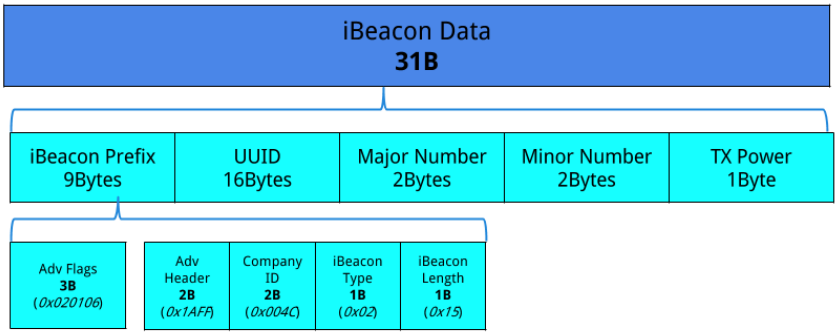


FIGURE 2.4: iBeacon Data Spec[5]

2.4.4.3 AltBeacon

AltBeacon is free beacon design given by the Radius Networks[6]. It's gaining popularity in terms of usage. In terms of functionality it has the same specification like the iBeacon, but is not company specific. However it is not as widely supported as the iBeacon yet.

Data spec for AltBeacon:

1. AltBeacon has 28 bytes (only 26B are modifiable).
2. First 2 bytes are set by the BLE stack.
3. AD Lenght - specify lenght of the advertising data packet.
4. AD Type - specify manufacturing data.
5. MFG ID - user modifiable (2 Byte).
6. Beacon Code - user modifiable (2 Byte).
7. Beacon ID - user modifiable (20 Byte).
8. Ref RSSI - user modifiable (1 Byte).
9. MFG RSVD - user modifiable (1 Byte).

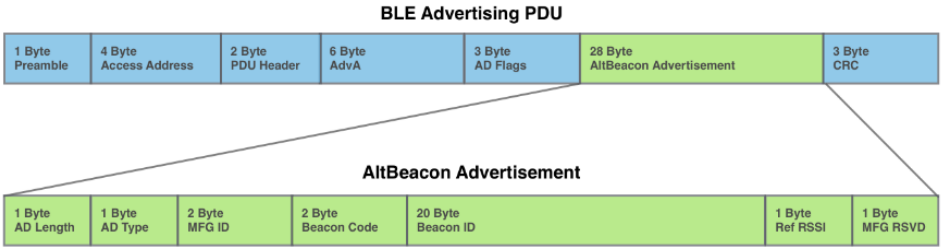


FIGURE 2.5: AltBeacon Data Spec[5]

2.4.4.4 Eddystone

Eddystone is open beacon format developed by Google. Eddystone is compatible by both iOS and Android devices. The format is build based on long collaboration with industry partners in existing developments as well as the beacon community. Google Beacon platform provides a dashboard to manage all of the beacons.[7]

Data Spec of the Eddystone[7]:

1. Eddystone-UID
   A unique, static ID with a 10-byte Namespace component and a 6-byte Instance component.
2. Eddystone-URL
   A compressed URL that, once parsed and decompressed, is directly usable by the client.

3. Eddystone-TLM
   Beacon status data that is useful for beacon fleet maintenance, and powers Google Proximity Beacon API's diagnostics endpoint. -TLM should be interleaved with an identifying frame such as Eddystone-UID or Eddystone-EID (for which the encrypted eTLM version preserves security).

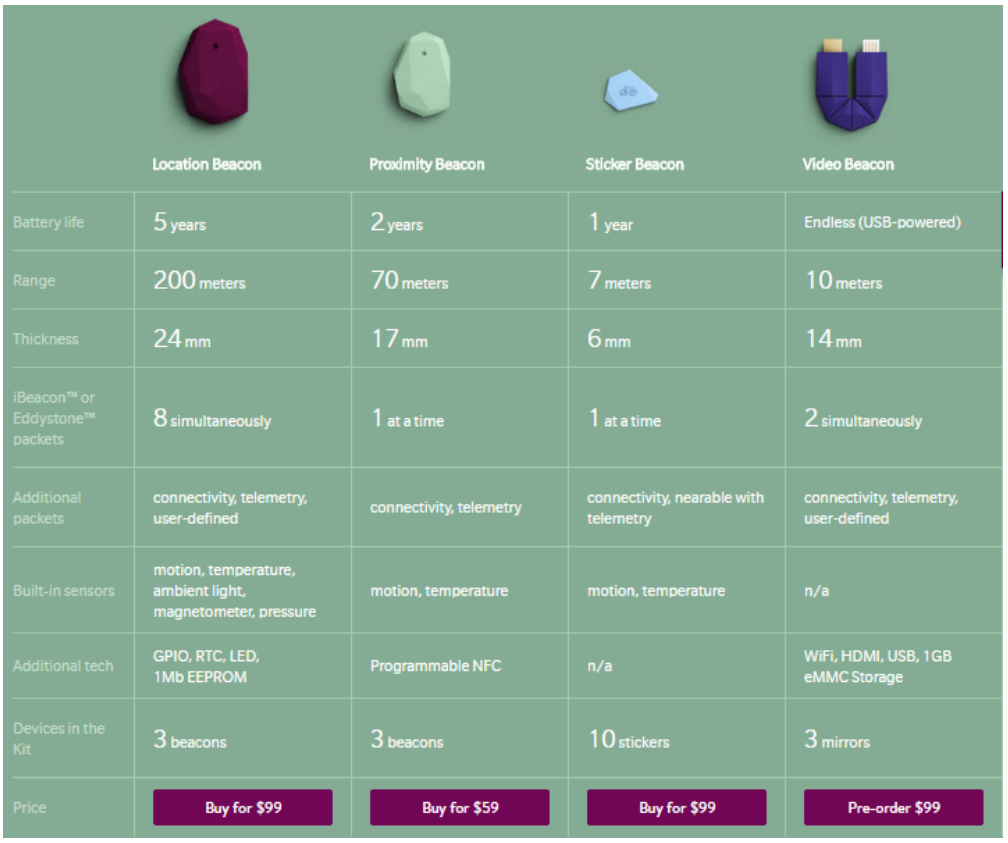
4. Eddystone-EID
   A time-varying beacon frame that can be resolved to a stable identifier by a linked resolver, such as Proximity Beacon API.

Additionally, Eddystone includes a configuration service and branding materials. To ensure that your deployment fully supports the Google beacon platform, you should set up your beacons with Eddystone-UID or -EID, and optionally add -URL and -TLM.

2.4.5 Beacon manufacturers

2.4.5.1 Estimote

Estimote is by far the largest manufacturers in terms of distribution. Below is a diagram with the current beacons offered by Estimote. They differ in terms of application, price, and features[8].



	Location Beacon	Proximity Beacon	Sticker Beacon	Video Beacon
Battery life	5 years	2 years	1 year	Endless (USB-powered)
Range	200 meters	70 meters	7 meters	10 meters
Thickness	24 mm	17 mm	6 mm	14 mm
iBeacon™ or Eddystone™ packets	8 simultaneously	1 at a time	1 at a time	2 simultaneously
Additional packets	connectivity, telemetry, user-defined	connectivity, telemetry	connectivity, nearable with telemetry	connectivity, telemetry, user-defined
Built-in sensors	motion, temperature, ambient light, magnetometer, pressure	motion, temperature	motion, temperature	n/a
Additional tech	GPIO, RTC, LED, 1Mb EEPROM	Programmable NFC	n/a	WiFi, HDMI, USB, 1GB eMMC Storage
Devices in the Kit	3 beacons	3 beacons	10 stickers	3 mirrors
Price	Buy for $99	Buy for $59	Buy for $99	Pre-order $99

FIGURE 2.6: Estimote's different product[8]

In terms of features "Location Beacon" and "Proximity Beacon" are applicable to this project. However the difference in battery life is noticeable and highly based on usage, but for the developing part either of those beacons can provide the required functionality to meet the requirements of the project. The price is significant factor as well, based on the features it provides as you can see prices can differ a lot.

Estimote also offers their own dashboard to provide easier management of their beacons. It provides you the functions to modify the beacon, insert data into it and view the analytics of their behaviour.

2.4.5.2 Glimworm

What is a Glimworm beacon ?

Glimworm manufacturers have decided to conquer one of the main limitations of the beacon industry and that is it's battery life. The battery has a significant importance when deciding for appropriate beacon and also critical factor when considered its lifetime in terms of financial segment[9].

The picture below shows the specifications of the beacon.

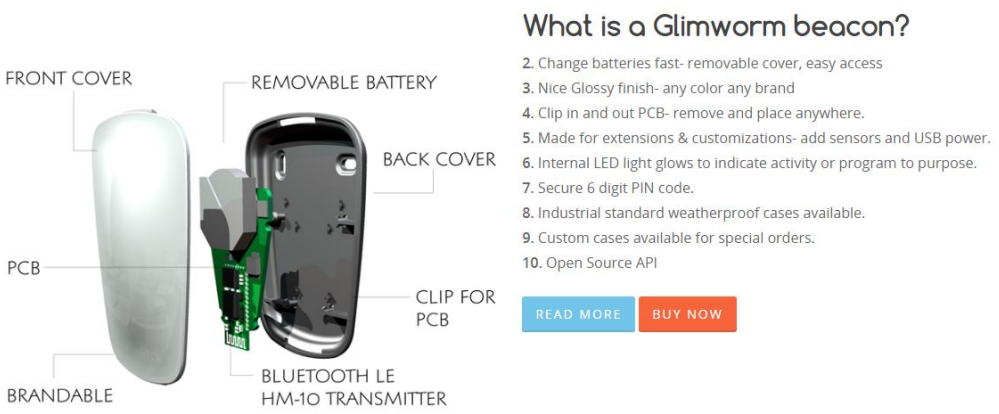


FIGURE 2.7: Glimworm beacon[9]

Format: PCUSB
Battery: CR2450
Battery Life: 1 yr @ 1285ms
Battery Level Display: user selectable ON/OFF
USB Power: YES
iBeacon Compatible: YES
UUID: User Configurable
Major: User Configurable 1-65535
Minor: User Configurable 1-65535

Advertisement rate: 100ms or 1285ms (selectable)
Advertisement Interval: 100ms to 7s in 15 steps (selectable)
Range: 2m, 20m, 50m (selectable)
Bluetooth chip: Texas Instruments CC2450
Compatible configuration apps: iOS- Github v2.1 and above, osX – not compatible, Android – current Github

FIGURE 2.8: Glimworm beacon specifications[9]

In terms of features the product has very basic functionality limiting the implementation of creative ideas. However their have focused on the developer part of the project allowing him to implement his own configuration. Another great aspect of this company is that it is that the platform that configures the beacon is Open Source which is a major factor in the current technology.

Below is a picture of another set of specifications that have to be considered.

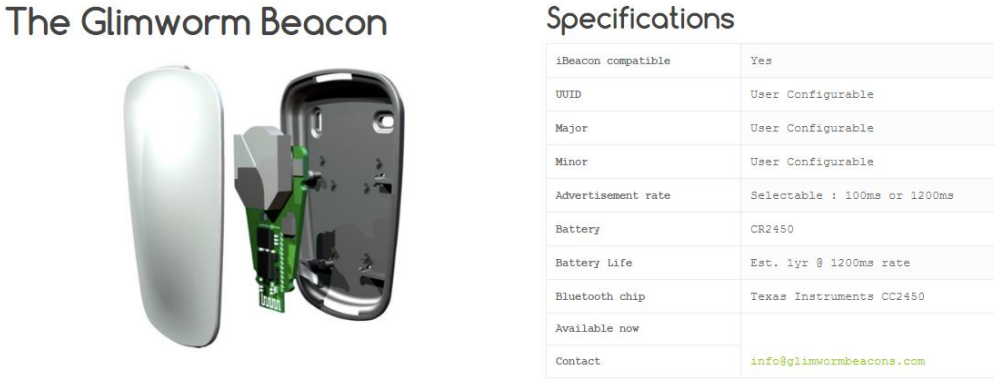


FIGURE 2.9: Glimworm beacon specifications[9]

2.4.6 What is cloud database?

"With a database as a service model, application owners do not have to install and maintain the database themselves. Instead, the database service provider takes responsibility for installing and maintaining the database, and application owners are charged according to their usage of the service. For example, Amazon Web Services provides three database as a service offerings as part of its cloud portfolio: SimpleDB, a NoSQL key-value store; Amazon RDS, a relational database service that includes support for MySQL, Oracle, and more ; and DynamoDB. Microsoft offers its SQL Database service[3]third-party source needed on its Azure cloud service platform. Cloud computing platform Rackspace offers database as a service for MySQL and MongoDB. Database as a service providers are not limited to cloud computing platforms. For example, MongoDB as a service provider mLab allows their customers to host their databases on AWS, Azure, or Google Cloud Platform. Database vendors have also launched their own services under this model. Oracle provides its own database as a service, allowing users to access Oracle Database 11g and 12c as cloud services. MongoDB recently launched its own hosted MongoDB as a service, MongoDB Atlas."[10]

2.4.7 Which platform to choose?

When deciding on which cloud database platform best fills up the missing pieces of your project. The market for cloud based solutions is huge. The main cloud providers that offer a scalable solution for small/medium/huge applications are: Amazon Web Services, Microsoft Azure, Google Cloud SQL, MongoLab, EnterpriseDB, Garantia Data, Rackspace, SAP, StormDB, Xeround).

Each of those providers has its own unique features to maintain a cloud solution. However in this case, every company can accommodate the requirements of the project. In depth look is required to pick the most developer friendly services.

2.4.7.1 Firebase

"Firebase is a mobile platform that helps you quickly develop high-quality apps, grow your user base, and earn more money. Firebase is made up of complementary features that you can mix-and-match to fit your needs."[11]

Firebase is owned by a major company, which provides provides assurance to the user that the services will be probably maintained and is very unlikely to be acquired by a

FIGURE 2.10: Firebase specifications[11]

competitor. Important advantages is that the platform provides SDKs for the different components(Android SDK, iOS SDK, Web SDK), which covers all of the project requirements. The services provides full real time data collection, meaning that if the Monitoring detects devices and uploads it to the database, immediate change will occur in the website with the change.

With the use of NOSQL queries implementation of features is significantly easier with just a simple RESTfull API's. Also it provides hosting for your website, which in our case it will be the dashboard.

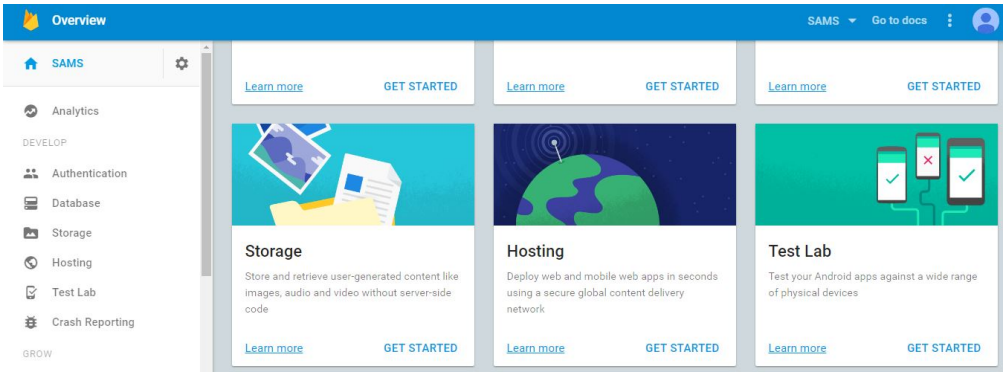


FIGURE 2.11: Firebase console[11]

2.5 Existing Attendance systems

Many schools are using different software to manage students, but most of them don't accommodate the needs of the teacher. The software is mainly used for administration

and doesn't provide real-time data. Traditional solutions require teacher to manually input attendance sheet and deliver it to the administration of the school.

2.5.1 Paper-based solutions

Paper-based solutions are still used in many schools today. A common practice is for the teacher to take attendance in the beginning of the class. And if the student is not present to pass it to the administration for the child's parents to be notified of his absence.

2.5.2 All Hours

All Hours is software built by the Slovenian company "SPICA INTERNATIONAL" for the purpose of collecting and recording real-time data of the employee's location in the premises. This product has been commonly used in many small/medium sized companies. It provides the required information to ease the task of the administrative part of the company. Overall the project uses the same technologies as mine, but in a different way. It uses beacons set up around the firm premises and whenever the employee enters it, the information is uploaded in real time data to the database. The company is allowed to set up their own rules, on what is allowed(kitchen, sport room, etc.), so whenever the employee goes for e.g a walk it doesn't count as his working hours. The software is very user friendly and can accommodate the needs of most of the medium sized companies[12].

2.5.3 Anseo Time and Attendance

Anseo time Attendance is a software developed by the Irish company "Ivertec". Students are required to have a magnetic card with integrated with their details. The software definitely provides most of the crucial information that school is requires. However the need of the student to manually check himself in is bound to be a critical part of the current stage of the technology[13].

Chapter 3

School Attendance Management System

3.1 Overview

In this chapter we will be describing the problem, emphasize on the objectives that needs to be achieved. The chapter only shows the objectives without their any specific implementation details, which will be discussed more thoroughly in the next chapter. We will also take a look at the requirements of the project, both functional and non-functional and elaborate briefly on each.

3.2 Naming Conventions and Definitions

Throughout the requirements chapter the following terms are defined as follows:

Front-End: This refers to all components of the website and the server hosting it.

Monitor device: This refers to the Mobile application responsible for monitoring the area for beacons.

Database: This refers to the data that the system will be constantly using.

Teacher: Refers to the party that interfaces with the front-end of the system. It only has limited access(read.)

School administration: Refers to any party of the school that has complete access to the database(CRUD options) of the system.

3.3 Objectives

In order to achieve success in the project, 4 specific objectives are required.

1. Create a database for the project - should be made to become as scalable as possible.
2. Develop a Mobile application to monitor around it's area for beacons.
3. Develop a Front-End for the database, which allows us to create, update, delete, read from it.
4. Final objective is to create a communication protocol between the rest of the objectives and is automatic. It can be categorized in 2 different objectives.
   (a) Bi-directional communication between Front-End and Database.
   (b) Bi-directional communication between Mobile Application and Database.

3.4 Functional Requirements

1. **Register student**
   Register student to the system.
2. **Remove student**
   Remove student from the system and all sensitive information.
3. **Monitor student**
   Monitor student presence in the premises of the school.
4. **View attendance sheet**
   View attendance sheet from the system.
5. **Print attendance sheet**
   Print attendance sheet from the system.
6. **Add teacher**
   Add teacher to the system.
7. **Message Service**
   Activate the messaging service to notify parents.
8. **Add student to class**
   Add student to class.

3.5 Non-Functional Requirements

1. **Accuracy and Precision**
   Monitoring device requires full accuracy and precision in order to be successful. Missing even a single student, could cause worries and troubles for parents and staff.

2. **Operating constraints**
   Monitoring devices are required to be plugged in into electricity constantly and is required to be on Android platform.
   System needs to be managed(adding, deleting, updating) by the school administration.
   Monitoring devices are required internet connection.

3. **Security**
   No sensitive information regarding the student will be contained in the beacon.

4. **Usability**
   Software is to be easily usable by all the teachers.

5. **Portability**
   Mobile application is to be portable, to be easily implemented in iOS version.

6. **Performance requirements**
   Testing and monitoring the software throughout the implementation stage to ensure proper behaviour without extensive delays.

Chapter 4

Implementation Approach

4.1 Overview

This chapter will illustrate and explain the architecture design, database design and briefly elaborate on the reason they are chosen. Different aspect that we are going to take a look at is different use cases, implementation plan and scheduling required and analyse the possible risk involved in the overall project to determine if project could be a success.

4.2 Architecture

Each architecture design has its own advantages and disadvantages, however the project is mostly based on the collection of data. The different components in the project are not directly communicating between each other, they are rather using the database as a communication path, an appropriate design is the data-centered architecture. Data-centered architecture allows implementation of additional clients without the need to change the database itself. This can increase scalability in terms of incrementing the amount of monitoring devices.

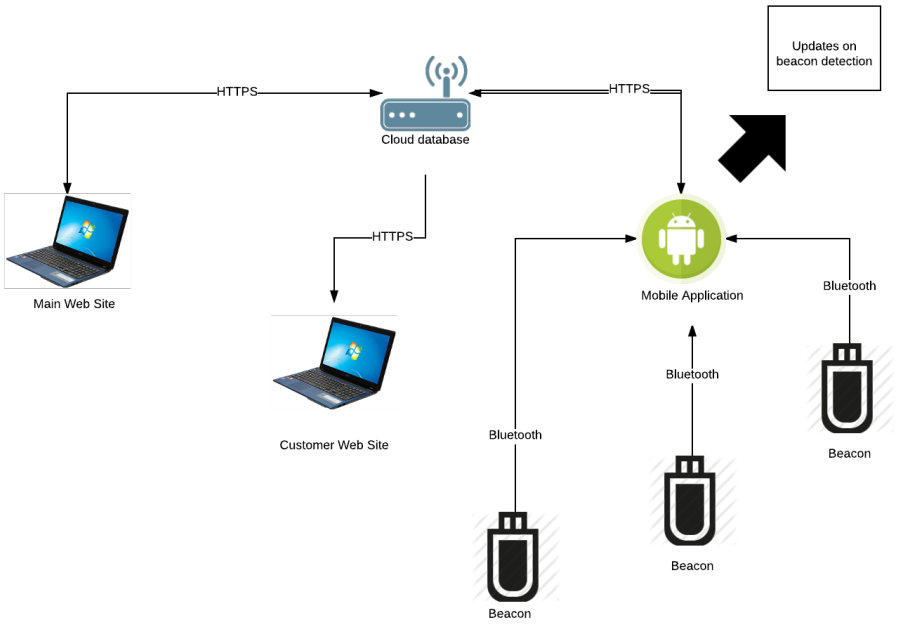


FIGURE 4.1:
Architecture Design

4.2.1 Technologies

4.2.1.1 Data tier

Picking the best possible solution for creating the database is crucial part of the project. Safest possible choice is to create your database server, however that solution takes a lot of resources and time. For the database we are going to pick 'Firebase'[11]. Database is responsible for storing and retrieving information from the components of the system. The goal of the project is to to have fully automation

Below is an illustration of how the database will look like:

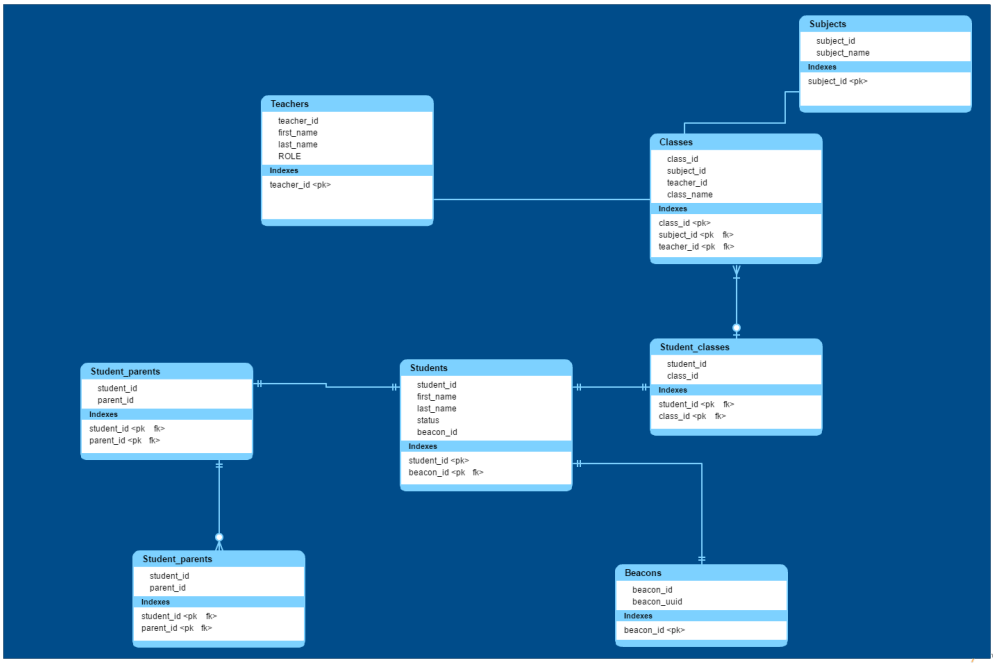


FIGURE 4.2:
Database Schema Design

4.2.1.2 Logic tier

Logic tier can be divided in 2 separate parts - Android for the mobile application/monitoring device and the front-end.

The front-end is the client of the project and it acts as a controller. It provides the users with their specific features represented by the database and managed by the school administration. The front-end has 2 different interfaces, one of them is for the teachers that let's them see/print the attendance sheet, while the other is specifically made for the management of the students, teachers and their roles. It's also the place where teachers and students can be assigned to classes.

Technologies to be used in the developing of the Front-end:

- HTML5
- CSS
- Javascript
- Firebase library

Firebase is a platform that helps manage every aspect of the developing to deployment. Website can be hosted on the platform, which also allows us to easily implement authentication and authorization for the people trying to access the system.

The second part is the Android application which will act as a listener when someone enters the area around it. There are hardware requirements needed for the device itself.

- It needs to be connected to electricity all the time.
- It needs to have internet connection all the time.

In terms of the application itself, it will be required the usage of 2 specific libraries.

- Beacon library (AltBeacon) - used for management of the beacons.
- Firebase - used to get access to the database.

The core technology in the project are beacons. They are small BLE devices, that can be put into medallion or bracelet(depending on the beacon).

When looking at Figure 4.1:

- This is the initial design for the database. It is likely to change a bit during the implementation.
- The database model uses Crow Foot annotations.
- The beacons table is a real-time data collecting through the monitoring device.

4.3 Business Use Cases

4.3.1 Register student

Business Event New student

Business Use Case Register student

Trigger New student joins the system

Outcome Student is added to the system and given a beacon.

Interested stakeholders Teacher, Parents, Student, School administration

Active stakeholders Teacher, Parents, Student

Preconditions Parents have agreed to enter their child into the system.

Flow

1. Parents are informed of the system's benefits.
2. The parents agrees that they want to enter the child into the system.
3. The parents provide the details for the child.
4. Child has been entered into the system and is given a beacon.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

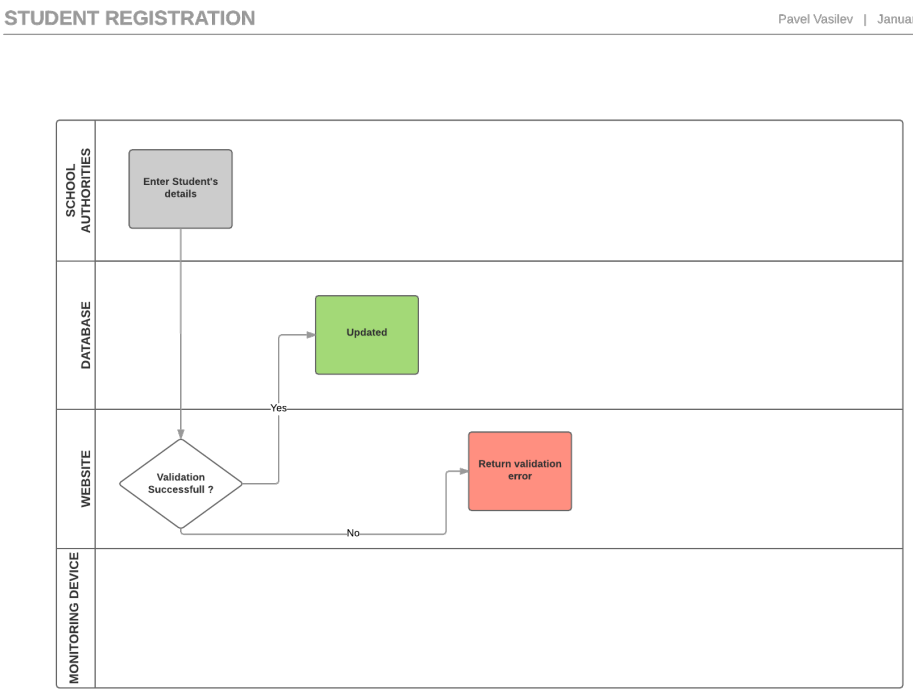


FIGURE 4.3:
Student Register Flow Diagram

4.3.2 Remove student

Business Event Student leaves the school

Business Use Case Remove student

Trigger Student is leaving school(graduation, change of school, or any other reason)

Outcome Student details has been removed from the system and is no longer used

Interested stakeholders Teacher, Parents, Student, School administration

Active stakeholders Teacher, Parents, Student

Preconditions Notification from the administration

Flow

1. Notification have been received for student leaving the school.
2. Details of student have been removed from the system.
3. SMS is send to parents notifying them of the removal.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

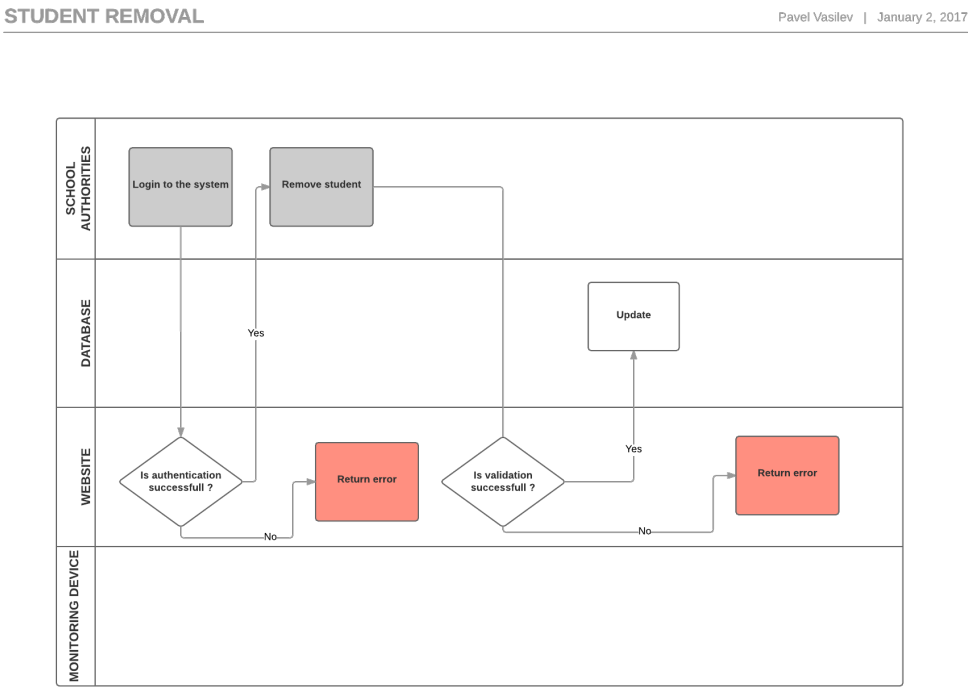


FIGURE 4.4:
Student Removal Flow Diagram

4.3.3 Monitor student

Business Event Monitor student

Business Use Case Monitor student

Trigger Student enters the building and is detected by the monitoring device

Outcome Student information is updated in the database.

Interested stakeholders Teacher, Parents, Student, School administration

Active stakeholders Parents, Student

Preconditions Student is wearing the beacon device.

Flow

1. Student enters the premises of the school.
2. Monitoring device detects the beacon.

3. Monitor device extracts information about the student from the database and updates it based on the configuration of the database.

4. Messaging service is activated and send to the parents(notifying them of the arrival of the child to the school premises).

5. Front-End service is synchronized with the database.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

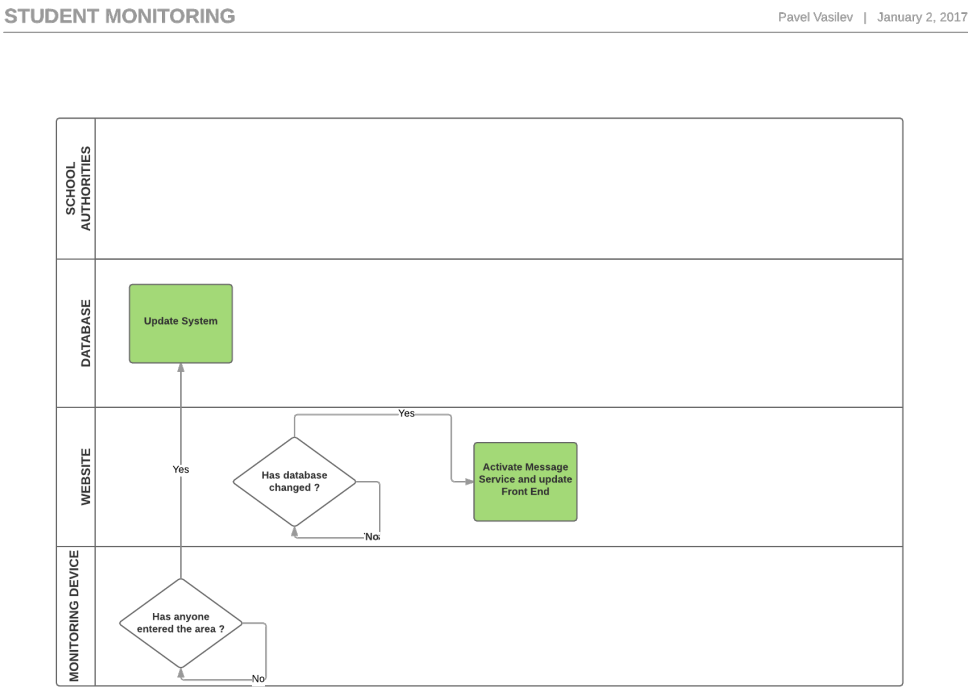


FIGURE 4.5:
Monitor student flow diagram

4.3.4 View attendance sheet

Business Event View attendance sheet

Business Use Case View attendance sheet

Trigger Teacher or school administration wants to see the attendance sheet.

Outcome Teacher or school administration is given attendance sheet. Teachers can only access attendance sheet only for their classes.

Interested stakeholders Teacher, Student, School administration

Active stakeholders Teacher, Student, School administration

Preconditions None

Flow

1. Teacher chooses attendance sheet for her classes.
2. System returns attendance sheet.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

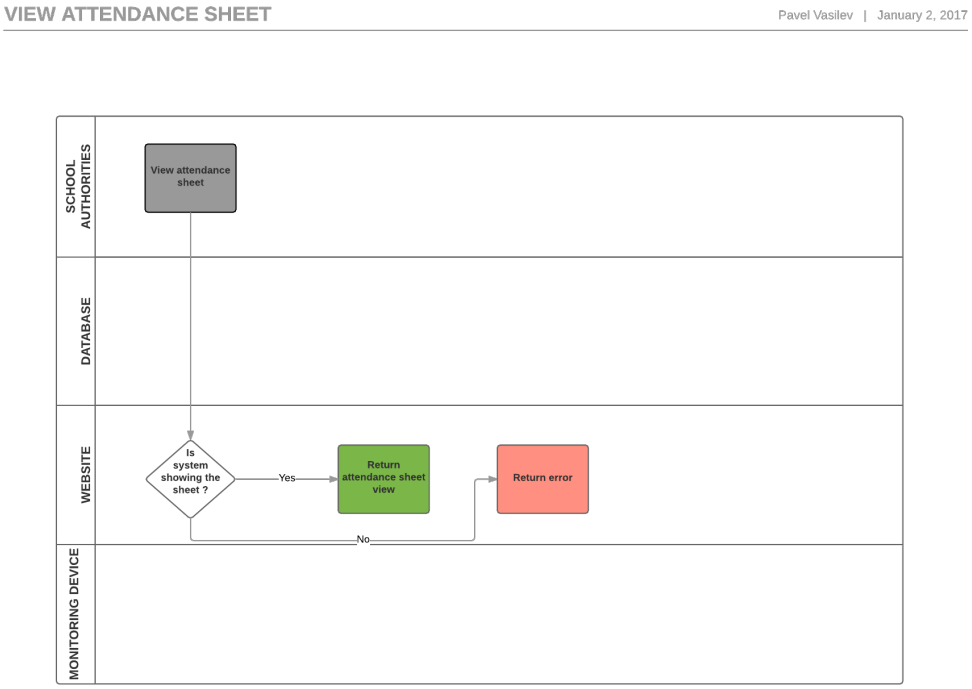


FIGURE 4.6:
View attendance sheet diagram

4.3.5 Print attendance sheet

Business Event Print attendance sheet

Business Use Case Print attendance sheet

Trigger Teacher or school administration wants to print the attendance sheet.

Outcome Teacher or school administration is given printed form of the attendance sheet. Teachers can only access attendance sheet only for their classes.

Interested stakeholders Teacher, Student, School administration

Active stakeholders Teacher, Student, School administration

Preconditions None

Flow

1. Teacher chooses attendance sheet for her classes
2. System returns attendance sheet
3. Teacher chooses to print the attendance sheet
4. Attendance sheet is printed

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

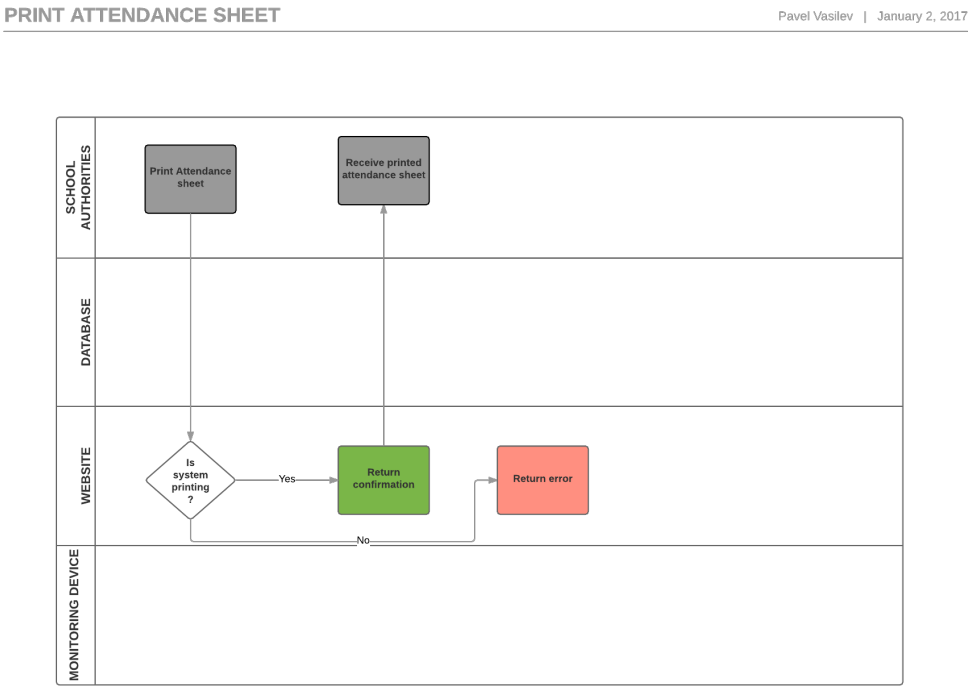


FIGURE 4.7:
Print Attendance Sheet Flow Diagram

4.3.6 Add teacher

Business Event Add teacher to the system

Business Use Case Add teacher

Trigger Teacher wants to use the system

Outcome Teacher is granted access to the system and their classes.

Interested stakeholders Teacher, Student, School administration

Active stakeholders Teacher, Parents, Student

Preconditions Teacher has been shown the system features, how to use it.

Flow

1. School administration adds teacher to the system.
2. School administration assigns teacher to their classes.
3. System returns logging details of the teacher.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

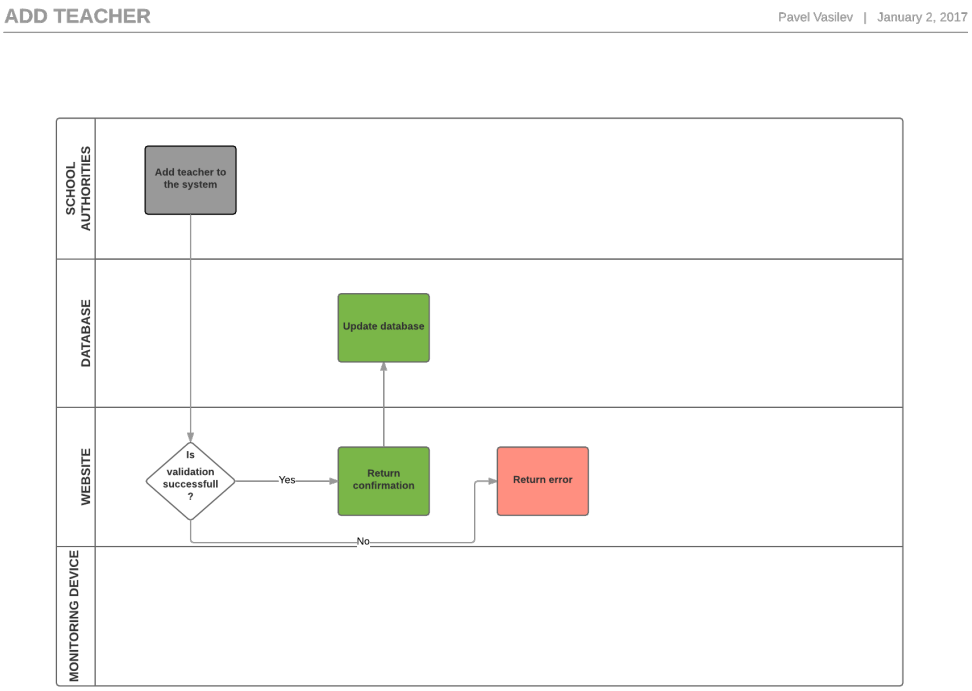


FIGURE 4.8:
Add teacher Flow Diagram

4.3.7 Message Service

Business Event Use message service to notify parents

Business Use Case Message service

Trigger Student hasn't been detected from the monitoring device after the given hour.

Outcome Parents receive message stating that their child is not in school yet.

Interested stakeholders Teacher, Parents, Student, School administration

Active stakeholders Teacher, Parents, Student,

Preconditions Parent has registered their child with the system.

Flow

1. Student doesn't arrive by the stated hour.
2. System automatically sends messages to parents.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

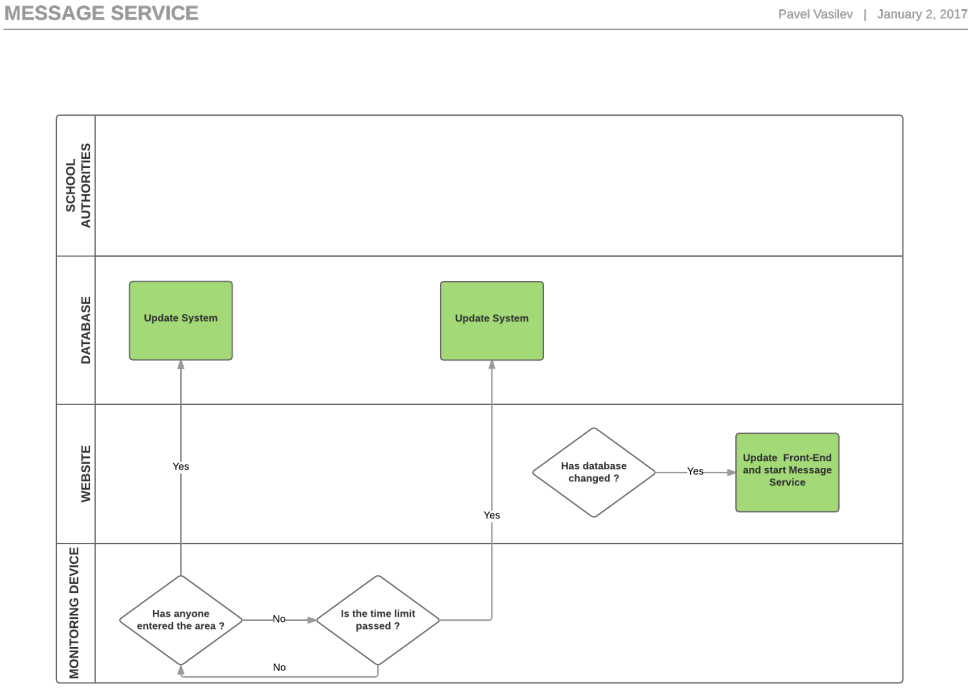


FIGURE 4.9:
Message Service Flow Diagram

4.3.8 Add student to class

Business Event Add student to class

Business Use Case Add student to class

Trigger School administration adds student to class.

Outcome Student has been added to the appropriate class.

Interested stakeholders Teacher, Student, School administration

Active stakeholders Teacher, School administration, Student

Preconditions Student has been added to the system.

Flow

1. School administrator assigns student to his class.
2. System confirms that student is assigned.
3. System updates database.

Below figure represents the flow in terms of technologies and their interaction between each other for the use case.

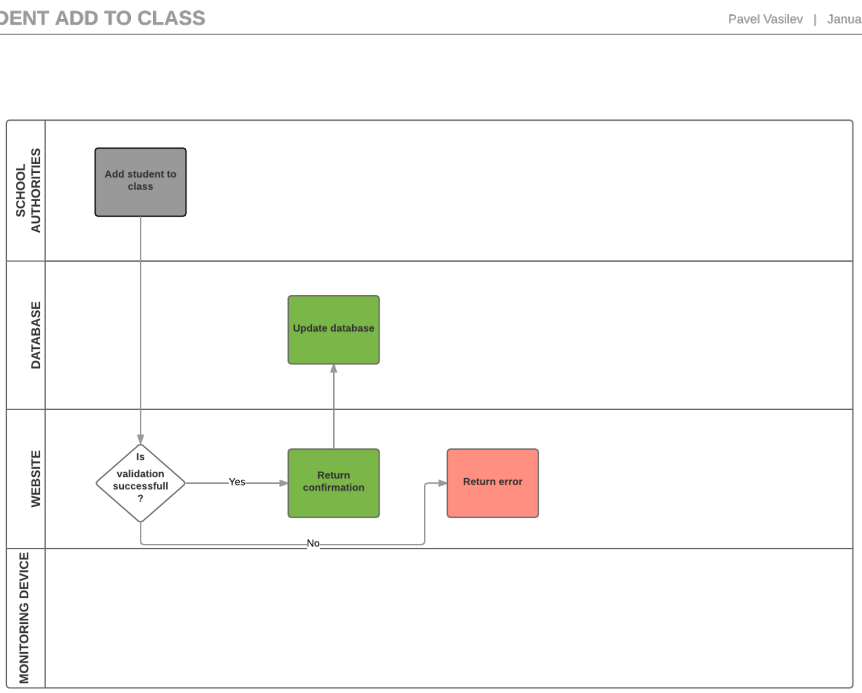


FIGURE 4.10:
Add student to class Flow Diagram

4.4 Risk Assessment

This section is responsible for identifying a potential risk preventing you to complete the project. Risk below are classified in terms of most likely to occur and a possible solution.

- Difference in beacons. Due to the huge market of beacons, there are differences between them. In order to choose the most suitable beacon, a testing strategy is required to test all of them, however this out of the reach in terms of resources. In case that the current beacons do not behave properly, the next most suitable will be bought to prevent failure.
- There is a huge risk in choosing the proper beacon library for detection. The current library is called AltBeacon, in case that this library doesn't meet the requirements of the project, we will swap for another one.

The table below shows a risk matrix that will be used during the implementation process to properly categorize the risks involved.

TABLE 4.1: Initial risk matrix

Frequency/ Consequence	**1-Rare**	**2-Remote**	**3-Occasional**	**4-Probable**	**5-Frequent**
4-Fatal					
3-Critical					
2-Major					
1-Minor					

4.5 Methodology

The project involves various of technologies involved, some of which I'm unfamiliar with. A huge factor in selecting the current technologies is the amount of documentation and examples presented to the developer.

Technologies that I need to get familiar with:

- Beacon libraries - my knowledge is very limited and this is my first time actually using beacons, however due to their uniqueness I have stopped on them. I intend to follow a few tutorials at first and get the feel of how the whole thing works.
- Cloud database - there is a huge market for cloud database at the moment. I have chosen Firebase because of the documentation and examples offered in their website.
- Beacon management - I have no prior experience in using beacons.

4.5.1 Scrum

For this project I think Scrum is very appropriate because of the testing required. A new version of the project will be available every 2-3 weeks(depending on the Sprint time).

"Scrum is an Agile framework for completing complex projects. Scrum originally was formalized for software development projects, but it works well for any complex, innovative scope of work. The possibilities are endless. The Scrum framework is deceptively simple."[14]

4.6 Implementation Plan Schedule

The project will be undertaken using Scrum. Scrum projects are carried out in small Sprints, usually 2-3 weeks, where the project is developed iteratively. This allows the development of a system that is very relative to the stated requirements in the beginning. At the end and beginning of the Sprint the project is measured against the requirements to determine what the status of the project is.

4.6.1 Goals and Objectives

1. Develop simple Mobile Application
2. Develop simple Front-End
3. Configure Beacons
4. Testing
5. Develop database
6. Integrate database with the mobile application
7. Testing
8. Integrate database with the front-end
9. Testing
10. Documentation
11. Demonstration

1. **Develop simple Mobile Application** The first stage of the project is to get familiar with beacons in order to create a small application to be able to detect a beacons in the area. It only needs to detect them, any other features will be implemented during the integration with the database.
2. **Develop simple Front-end** The Front-end is acting as the interface for the customer(e.g School administration, Teacher). The requirements at this stage are entirely focused on establishing the graphics design, and the overall look of the website.
3. **Configure Beacons** Beacons consist of a small data package that contains really small amount of data. The goal in this task is to establish a sequence number to ease up the process in the future when adding multiple beacons.

4. **Testing** In this stage testing is required to confirm the status of the project. Is the application detecting the beacons? Is the Front-end in good condition?

5. **Develop database** At this stage a database will be create from the Database Schema in the report. However it's very likely that it might change during the integration phases.

6. **Integrate database with the mobile application** At this stage the mobile application is required to use the Firebase library in order to communicate with the database. So this stage is almost entirely focused on the mobile application and it's features.

7. **Testing** This stage will focus on testing the previous goal and if any changes are required.

8. **Integrate Database with the front-end** This goal follows the same principles as with the previous task. Turn the front-end graphics into functional website.

9. **Testing** This testing phase will be longer than the previous ones. There will be enough time allocated for it in case that anything goes wrong somewhere. It also requires a bit more testing to confirm that the whole project is behaving properly.

10. **Documentation** Any documentation that is due for submission will be completed.

11. **Demonstration** The last phase involves the demonstration of the project features and any additional activity required at the end.

4.6.2 Expected Project Goals

The expected project goals are outlined below:

1. Database

2. Database-driven website

3. Mobile application

4. Demonstration of the above

5. Documentation

4.6.3 Project constraints

In order to create the implementation plan, first we need to look at the constraints:

- Time - 12 weeks
- Limited resources
- Limited testing area

4.6.4 Project Schedule

Project schedule is a listing of project milestones and the duration it takes for the goals to be completed. In my schedule I have given extra time for most of the tasks due to risk management, in case any problem arises.

Any extra time that is left will be entirely focused on testing. Beacons are very sensitive technology and miscalculations will probably arises early in the project. However something might be missed at early stage and this extra time will provide us with a way to confront it.

TABLE 4.2: Project Schedule

ID	Objective	Duration(weeks)	Predcessor
1	Develop Mobile Application	1 week	None
2	Develop Front-End	0.5 week	None
3	Configure Beacons	0.5 week	None
4	Testing	0.5 week	1
5	Develop database	1 week	None
6	Integrate database with Mobile Application	1 week	1, 5
7	Testing	0.5 week	1, 5, 6
8	Integrate database with Front-end	1 week	2, 5
9	Testing	3 weeks	All
10	Documentation	2 week	All
11	Demonstration	1 week	All

4.7 Evaluation

An evaluation plan is like a map that shows the goals and ways that data will be collected and analyzed. This include selective information, in terms of how, when, where it is collected. It identifies the research methods responsible for carrying out the plan, budget and timeline.

4.8 Prototype

Prototype consist of basic draw mock up just to clarify the basic interface of the website and the mobile application.

Since the mobile application is only used for monitoring, it is only going to be working on the background of the phone without ever turning off except in case of emergency.

Below are 2 Figures that represent the website interface - one is used by the teacher the other one is used by the school administration.

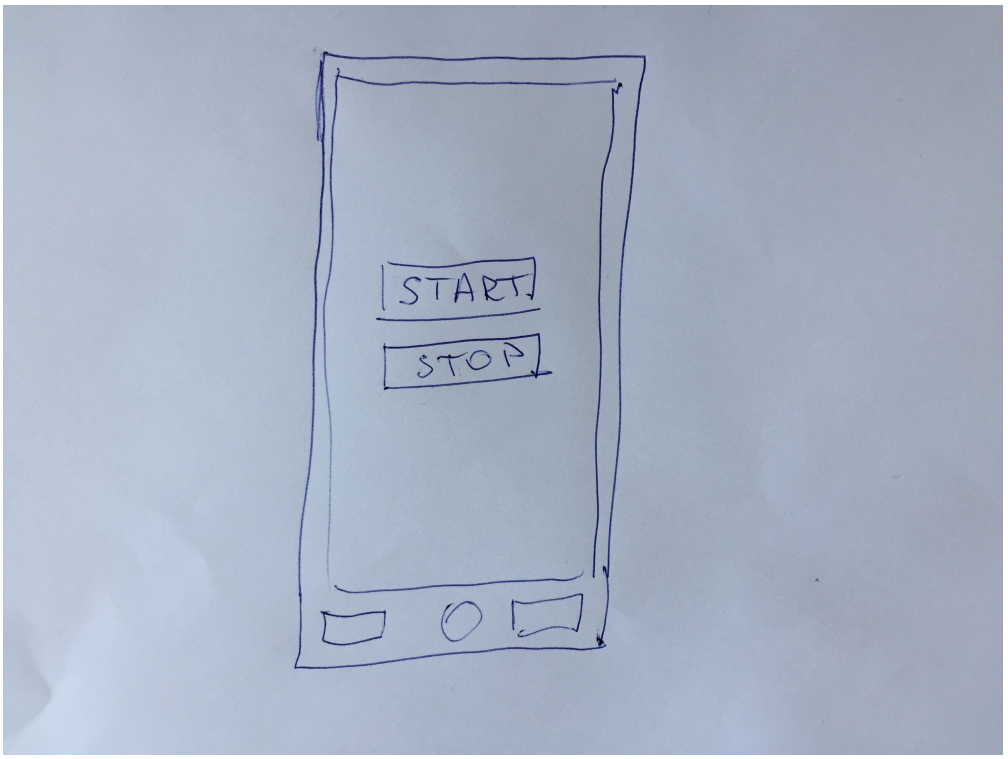


FIGURE 4.11:
Phone Mockup

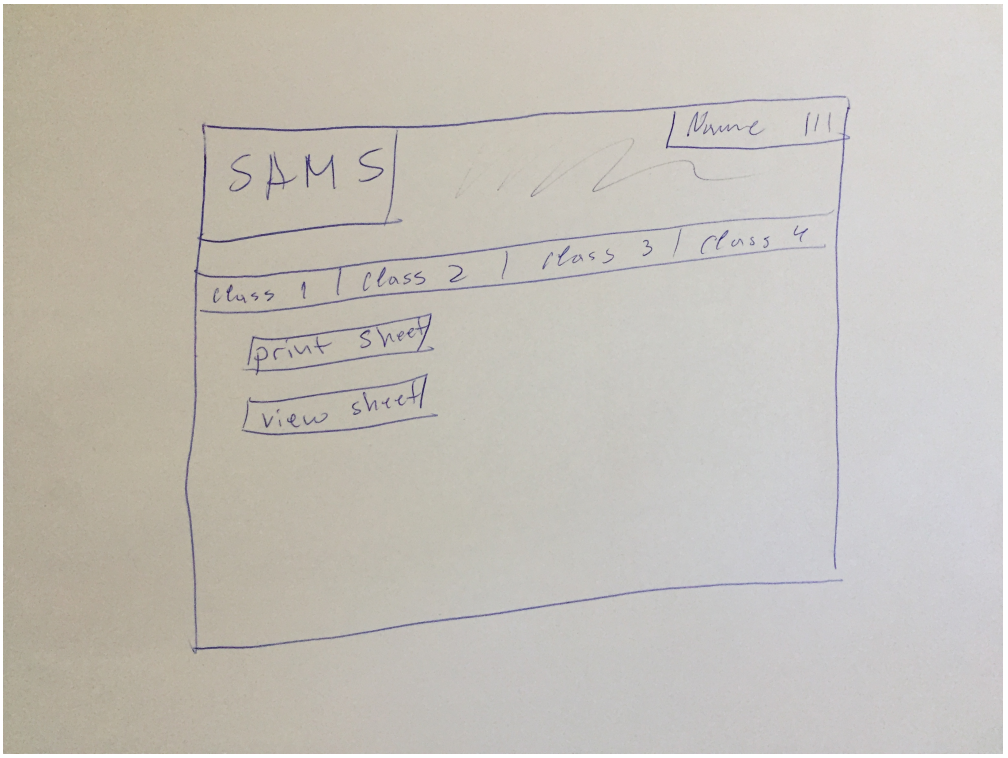


FIGURE 4.12:
Website - Teacher

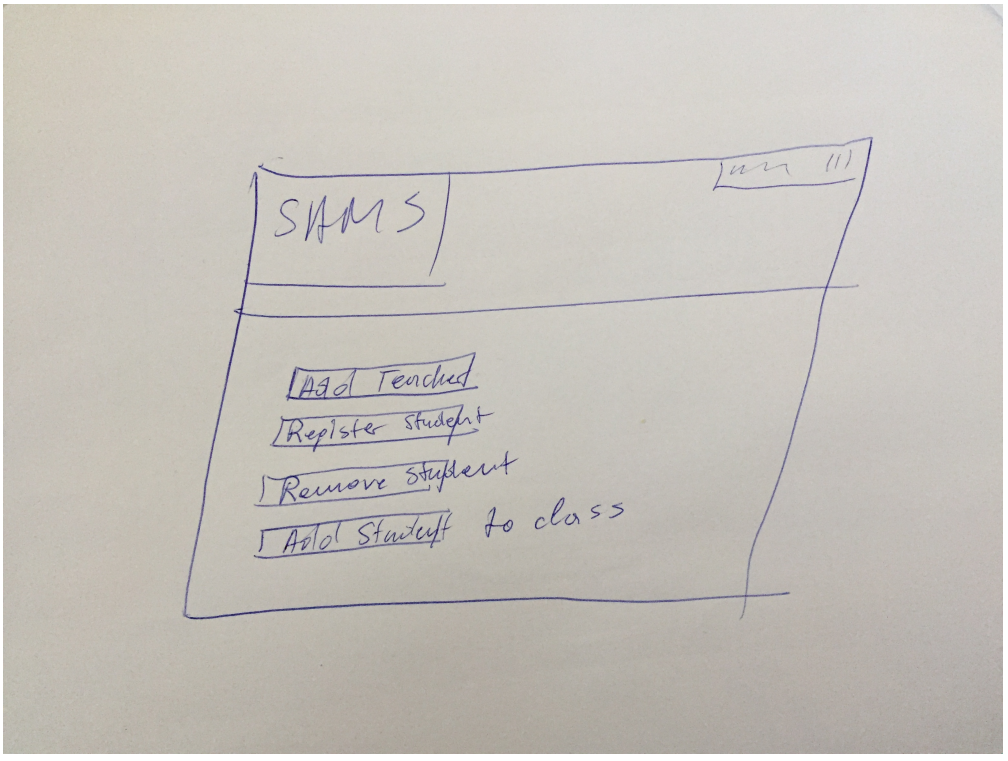


FIGURE 4.13:
Website - Admin

Chapter 5

Discussion and Future Work

5.1 Discussion

Assuming that the current project requirements are met during the implementation phase of the project. A few problems might arise in case the application decides to expand further. One of the main thing is the database model.In case the system is to be expanded, a complete restructure of the database model will have to be made to meet the requirements.

The current design of the application is very specific to the requirements of attendance management, rather than management of the school itself. Intense testing is required during the implementation phase to analyse the gathered data.

Another problem that will arise during the implementation phase is insufficient testing, caused by the lack of resources. The system will have to be tested against multiple brand's of Beacons to collect different test data for complete analysis of the results.

5.2 Future Work

Assuming that the requirements of the project are met during the implementation phase, what would be the next step in the projects? It will involve implementing different levels of monitoring devices inside the school itself, which can allow to pinpoint each student into which classroom he is in. Adding a searching protocol to search for students and returns the exact premises of the school.

Chapter 6

Conclusions

The author must thank his project supervisor, Sean Mc Sweeney, for helping with interesting ideas and suggestions in regards to features and implementation. With the conclusion of the research phase and establishment of the requirements, project plan, initial design, a clear outline of the overall project path can be seen.

The author is very much looking forward to the implementation phase of the project and demonstrating it as well. The project will be demonstrated using 3-5 beacons at the same time to sufficiently demo the full potential of the system.

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