University of Leeds

Final Year Project

Mid Project Report

User Adaptive System to Support Automated Medical Appointment Scheduling of Outpatients

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A final year project report submitted in fulfilment of the requirements for the degree of Computer Science

in the

School of Computing

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Declaration of Authorship

I, Andrew Munro, declare that this thesis titled, 'User Adaptive System to Support Automated Medical Appointment Scheduling of Outpatients' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University 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 thesis 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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Abstract

Faculty of Engineering

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Computer Science

User Adaptive System to Support Automated Medical Appointment Scheduling of Outpatients

by Andrew Munro

This project aims to optimise and simplify the medical appointment scheduling process, making it easier and more convenient for both patients and doctors. It also aims to tackle various problems such as attendance, costs and patient satisfaction, by using emerging technology to bridge the current communication gap between patients and the scheduling systems used.

This project is incomplete and submitted as my mid-project report for feedback and advice. Many of these sections are left blank as they are to be completed later, however I have included them for as an overview of the overall structure.

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Abbreviations

NHS	**N**ational **H**ealth **S**ervice
APP	**APP**lication (Computer Program)

Chapter 1

Project Overview

1.1 Project Aim

The aim of this project is to develop a system that allows more communication with outpatients in regards to their appointments, in an attempt to:

- reduce the amount of resources wasted in the event of no-shows and cancellations
- reducing the human cost that is required to manage appointments
- increase the user experience when making and managing an appointment

This project will not aim to implement any scheduling algorithms, but rather create a system that will support current algorithms and possibly shape future algorithms. For this project, I will use a preordained scenario to show off the different features of the system.

It will also not aim to replace the current scheduling system entirely, but act as an alternative to allow willing patients more direct control and easier access to information regarding their appointments.

1.2 Objectives

The objectives of this project is to:

- Collect relevant background data about the problem domain
- Identify requirements necessary to address the problem
- Design a server-client system that implements these requirements
- Prototype a Server that communicates directly with multiple patients and a predetermined scheduling algorithm
- Prototype a Client Application (Smart-phone Application) that allows patients to interface with the server
- Test the systems functionality based on usability and performance
- Evaluate the success of the system in regards to improving user satisfaction, reducing human management resources and reducing appointment wastage

1.3 Minimum Requirements

The minimum requirements of this project is to:

- A working prototype smart-phone application that:
  - Connects to a prototype server
  - Allows the user to view information on their scheduled medical appointments
  - Gives the user information such as location and map instructions, doctor's name, any perquisite tasks the user must undertake prior to the appointment
  - Reminds the user about the appointment
  - Receives appointment updates from the server
- A working prototype server application that:
  - Connects to multiple clients
  - Interfaces with a dumb appointment scheduler
  - Notifies clients of changes to the schedule
  - Uses client information to optimise the scheduling process
  - Offers cancelled appointments to other clients

1.4 Extensions

The possible extensions are:

- Design a website interface for the system
- Investigate and test security issues
- App gives location information and integrates with google maps
- Additional App or website to be used by doctors

1.5 Deliverables

The deliverables are:

- Server application
- Client application
- Report and evaluation results

1.6 Relevance to Degree Modules

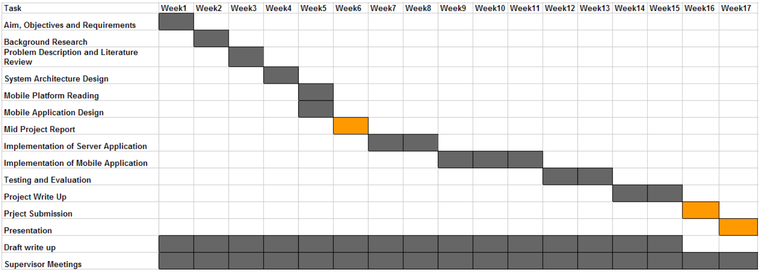
This project uses knowledge and techniques gained in modules studied as part of my Computer Science degree. The most relevant modules are typically 'Software Systems Engineering', 'Distributed Systems', 'User Adaptive Systems' and 'Human Computer Interaction'.

Chapter 2

Project Plan

2.1 Schedule

The schedule was designed as a Gantt chart, in order to highlight key points in the project and ensure that they were completed on time and according to the set deadlines. This schedule is subject to change as the project progresses, as many unforeseen issues may arise. I have tried to estimate tasks based on difficulty, assigning more time to key points where it is likely that problems will occur (such as the implementation phase). Any changes will be shown in an adjusted project schedule.

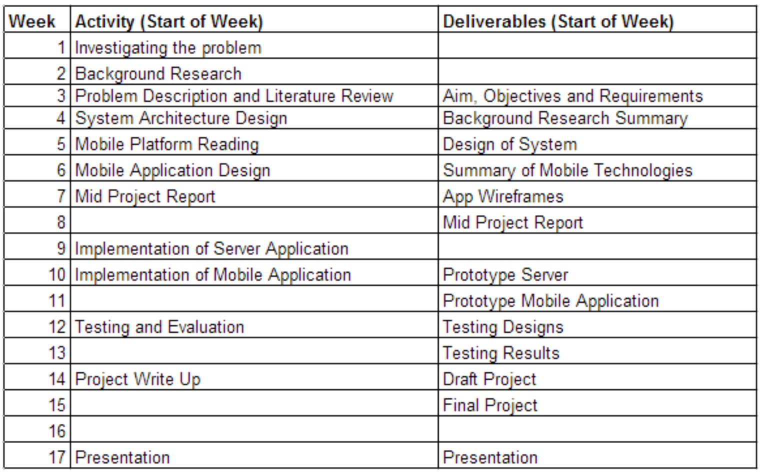


Task	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Week9	Week10	Week11	Week12	Week13	Week14	Week15	Week16	Week17
Aim, Objectives and Requirements	■																
Background Research		■															
Problem Description and Literature Review			■														
System Architecture Design				■													
Mobile Platform Reading					■												
Mobile Application Design					■												
Mid Project Report						🟧											
Implementation of Server Application							■	■									
Implementation of Mobile Application									■	■	■						
Testing and Evaluation												■	■				
Project Write Up														■	■		
Prject Submission																🟧	
Presentation																	🟧
Draft write up	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Supervisor Meetings	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

FIGURE 2.1: Gant Chart showing the schedule of the project

A table was also created to compare objectives with deliverable deadlines.

The project has been split four main components, consisting of research, design, implementation and evaluation. These areas are then sub-divided into appropriate sections, targeting individual parts of the system, individual objectives and individual deliverables.



Week	Activity (Start of Week)	Deliverables (Start of Week)
1	Investigating the problem	
2	Background Research	
3	Problem Description and Literature Review	Aim, Objectives and Requirements
4	System Architecture Design	Background Research Summary
5	Mobile Platform Reading	Design of System
6	Mobile Application Design	Summary of Mobile Technologies
7	Mid Project Report	App Wireframes
8		Mid Project Report
9	Implementation of Server Application	
10	Implementation of Mobile Application	Prototype Server
11		Prototype Mobile Application
12	Testing and Evaluation	Testing Designs
13		Testing Results
14	Project Write Up	Draft Project
15		Final Project
16		
17	Presentation	Presentation

FIGURE 2.2: Table showing the schedule of the project

The following sections will explain these components, what parts of the project they will address and how they will be executed successfully.

2.2 Background Research

The research component will aim to get a better understanding of the problem, how I can address my aims and objectives and highlighting the current research in the field. This research will aid my own project by highlighting areas that need to be addressed, outlining unforeseen problems and finding technologies that I might be useful to my implementation.

2.3 Design

The design component will aim to design the entire system, addressing all objectives whilst making the system both flexible and scalable.

2.3.1 Methodologies

I will choose a software engineering methodology that best fits the development style of the project, explaining how it works and how it is executed successfully. I will also identify the programming languages I will be using, any programming patterns that are useful in the design of the system and Technologies I will use.

2.3.2 Flexibility

Although the system is a prototype, I aim to create it such that it can be adapted in the future. The system will therefore be designed in a way such that additional platforms can be added easily. The system should also be designed in a way that it is feature independent, eliminating dependencies in the code. This will allow more features to be added easily in the future.

2.3.3 Scalability

The system will also be designed to be scalable. It must be able to scale with user demand, be fault tolerant and and appear seamless to the end user, allowing for a smooth service at all times. I will talk about the various problems involved and how I will design the system to overcome them.

2.3.4 Problems

Many problems must be overcome in the implementation phase, such as data security, synchronising data and many more. These problems must be planned in advance, and so I will discuss in detail the problems that the system faces and my proposed solutions to them.

2.4 Implementation

The implementation of the system will occur in two separate platforms, the client and the server. These will sometimes overlap as some code will be shared between the client and the server, however for the most part, I will discuss issues unique to each platform separately.

2.4.1 Server Platform

For the server platform, I will discuss how I implemented the communication and data storage features, and how it can interface with scheduling software.

2.4.2 Client Platform

For the client platform, I will discuss how the user interface is created, how I improve performance and how well it interfaces with the mobile device.

2.5 Evaluation

The evaluation component will show how well my prototype system does in solving my aims and objectives identified in the project. I will analyse the results of user evaluation methods to evaluate the prototype, discussing the results and identifying key parts of my solution that need to be improved. I plan to evaluate on the following questions:

- How good is the User Interface?
- Does the application work?
- Is the application buggy, does it ever fail?
- Is it missing key features?
- How can it be improved?
- Would the user find the application useful?

2.6 Conclusion

From this evaluation, I will formulate a conclusion, reviewing my design choices, how accurate my expectations were and discussing future extensions that this project could inspire.

Chapter 3

Problem Description and Background Research

3.1 Problem Description

Medical appointment scheduling is a complex problem; patients often come with different backgrounds and personal schedules, requiring different treatment and different urgency, some even requiring support in getting to the appointments. Patients sometimes have a need to cancel their appointments or simply do not turn up, which can lead to a waste in resources if the appointment slot is not then assigned to another patient. Often, sessions can overrun, requiring more time per patient than is estimated, and so the following appointments are delayed. Clinics also reschedule appointments regularly, as new patients requiring urgent medical attention become a higher priority. This results in appointments being dynamic, often the time and date of the actual appointment is different from what was originally planned.

Dynamic scheduling leads to many issues. The problem of scheduling appointments becomes far more complex, which in turn requires more staff resources to manage the appointments.

Communication also becomes a problem, as patients need to be informed about all changes to the original schedule. Often, this results in a lower patient satisfaction and a higher chance of appointment cancellations.

These often contribute to longer waiting times and a lack of patient knowledge about their appointments, which can make no-shows and further last-minute cancellations more frequent.

Often the clinic will not find a patient to take the free appointment slot, and these resources are wasted.

3.1.1 Wasted Resources

Many resources are wasted through appointment no-shows and cancellations. Research shows that the longer a patient must wait between making the appointment and the actual appointment date, the more likely it is that they will either cancel or not turn up[2]. Although we can see that there is a relationship between the length of time that a patient must wait for an appointment and the cancellation risk, it is important to understand why.

The most common reasons why patients do not show up was collected through patient questionnaires as can be seen in the figure below.

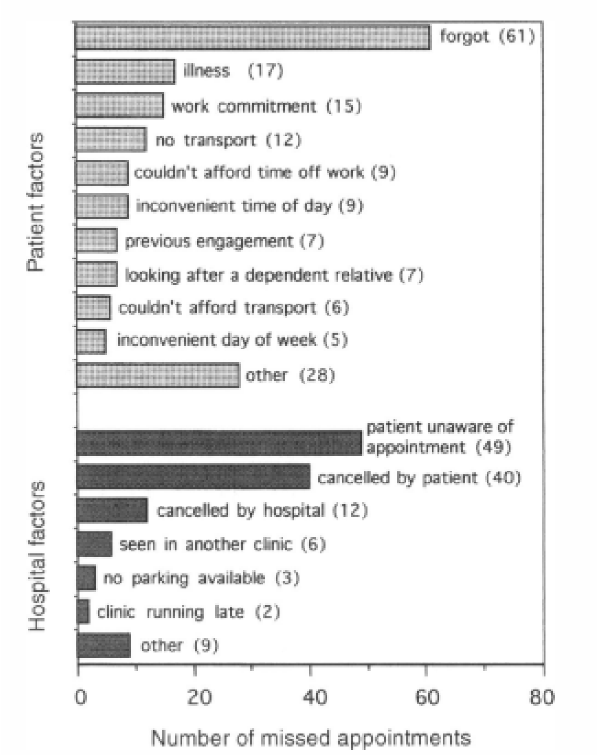


FIGURE 3.1: Factors contributing to non-attendance according to a patient questionaire - [1]

This shows that the most common factor is either that the patient forgot or that they were improperly informed by the clinic.

3.1.1.1 Patient No-Shows

Patient no-shows (or non-attendance at outpatient clinics) are a big problem in appointment scheduling and is one of the largest contributors to wasted resources in the NHS. It is estimated that the financial cost of missed appointments contributes to a loss of £360 million per year[1]. Besides the financial costs, it also increases waiting times as that patient must be rescheduled for another appointment, effectively doubling the required resources per patient.

Because the most common factor contributing to no-shows is the patient forgetting to attend the appointment, it suggests a reminder system could be used effectively to reduce these numbers. Research has shown that telephone and postal reminders can help, but have not proved to be cost effective in the past[3]. However, through recently emerging online devices and 'smart' technology, it is possible to provide a low-cost solution to this problem.

Another factor that can encourage non-attendance can be a lack of information known about the appointment. This can introduce a level of uncertainty within the patient, such as knowledge on how to get to their appointment, or fear about the dangerous/embarrassing factors involved in the appointment[4].

Research shows that the population that miss appointments are increasingly of a young demographic. Often they fail to understand why the appointments are important, and specifically why it is important to cancel the appointment rather than just not turn up.

Patients have given several reasons for no-shows in studies and questionnaires[5]:

- can't get time off work
- child-care
- lack of transportation or cost
- patient felt better or felt too worse to attend the appointment

For all these reasons, the no-show is preventable simply by increasing communication with the patient and allowing them either more information about the appointment or making it easier for them to either cancel/reschedule.

3.1.1.2 Cancellations

Often, clinics are required to cancel an outpatients appointment for a variety of reasons, usually due to a lack of resources such as staff or equipment.

Staff time is then wasted getting contact information for the patient and informing them of the cancellation. Time must also be spent corresponding with the patient and agreeing on a suitable replacement appointment.

If cancellations 'occur at the last minute', often the patient is not informed until they reach the hospital. This is often due to the clinic not wanting to bother wasting resources reaching the patient when it is unlikely that they will get a hold of them (the patient may already be in transit or indisposed). This leads to a lower overall user satisfaction as the patient wastes a trip to the hospital, only to find that they no longer have an appointment.

Although cancellations are not ideal, they are better than no-shows in that it is possible for the appointment to be offered to another patient. In some cases however, this is not attempted due to it being too costly and the additional complexity involved in the scheduling process.

By increasing communication with patients through emerging smart technology, it may be possible for these appointments to be quickly rescheduled whilst avoiding the additional costs, even for 'last-minute' cancellations.

3.1.1.3 Managing Appointments

Managing appointments is costly and a large proportion of the work is carried out by individual staff members, rather than an automated system. Several issues arise with this process:

- Appointments can only be managed within office hours (typically 9am - 5pm), however this depends on the clinic
- Patients can only make appointments over the phone and frequently have to queue to speak to a staff member
- Large proportions of staff members must be allocated to the appointments procedure which could be allocated elsewhere
- State of the system means that it is hard to analyse and therefore adapt to high demand

When making appointments, the patient is required to do so either in person or over the phone. This can only occur within office hours, which can conflict with the patients career or personal schedule, leading to a lower user satisfaction. Often patients will have to queue in order to speak to a staff member. When the patient is finally connected, there isn't time for the patient to explain their personal schedule and discuss conflicts, resulting in less user choice and flexibility.

The appointment system in many areas is also very labour-intensive, carried out by individual receptionists using spreadsheets and paper based systems[6]. This means that it is often very hard to analyse capacity and demand, identifying bottlenecks or methods to improve them and also makes it very hard to integrate with interactive technology such as smart phone devices and online appointments. Whilst some online systems do exist[7], they are time consuming, have poor functionality and tend to be only available on few devices[8].

These problems can be improved by creating an interactive online system that works on many devices. It could not replace the current system entirely, because not all patients will have internet access or smart-devices, but it would provide benefits to patients with internet access such as:

- Easier accessibility to making appointments
- Possibly offer more appointment flexibility to the patient
- More information about the appointment
- Relieve demand on the staff that manage the system
- More analysis of appointment trends and offer insights into improvement

3.1.2 Patient Satisfaction and Experience

Maintaining a high patient satisfaction is the primary goal in appointment scheduling, ultimately because keeping the patients happy leads to less cancellations and less no-shows. This is not an easy task because the demand on the healthcare system is so great, and it is typically faced with many challenges.

3.1.2.1 Patient Requirements

Patients are given a level of responsibility that some may not be used to. For a general outpatient appointment, the NHS requires the patient to do a number of tasks to prepare for the appointment [9]:

- may be required not to eat/drink before the appointment
- may be required to bring samples of urine/stool or medicines
- may need to bring previous test results
- may need to take certain medicines at a certain time period prior to the appointment
- should bring maps and other information required for getting to their appointment

It has been seen that in previous research conducted on day surgery outpatients, the most likely cause of preventable appointment cancellations (5% of day surgery appointments) was due to inadequate preparation [10]. This shows that a large amount of patient cancellations occur simply because patients are expected to find out information about their appointment, transport options and other relevant factors.

3.1.2.2 Waiting times

Another factor that lowers patient satisfaction are waiting times that can occur when the schedule is either running late due to overrunning appointments, or when patients are grouped into time slots.

Patients are frequently grouped together into time slots to simplify the scheduling process (i.e the clinic will expect to have 10 appointments in one hour, so they ask all 10 patients to come at the same time and the appointments occur on a first come first serve basis).

Research suggests that because patients spend increasingly lengthy amounts of time waiting in the clinic for their appointment to start, they feel increasingly amounts of disrespect [5]. This is due to patients being 'left in the dark', with no indication on why their appointment is delayed and why they have to wait.

Through on-line applications and smart devices, we can inform patients about information related to their appointments, any disruptions in the regular service (waiting delays) and a more interactive system that would make the patient feel less disrespect. We will also be able to offer sooner appointments to patients as cancellations occur, which should reduce the waiting times overall.

We can also provide transport information, reminders on when they have to leave and any perquisite requirements that the patient must undertake before leaving for their appointment (such as take medication or bring test results), reducing the likelihood of cancellations and no-shows as the patient is better prepared..

3.1.2.3 Patient Participation

Patient participation is no longer just a goal set by medical commissioners, but a legal obligation. The Health and Social Care Act 2012[11] introduced legislation that enables patients(and carers) to participate in the planning, managing and making decisions about their care and treatment.

The aim of this project targets this participation, engaging patients to have more control and access over their medical care. This system also has the ability to deliver personalised care plans to patients, which will increase the overall patient satisfaction.

Although this system does require patients to have access to the internet and know how to use it, patients without internet in today's world is an increasingly small demographic. The NHS are also launching a program to help disadvantaged people learn how to access the internet and use medical services [12], to try and combat these issues.

3.2 Choose and Book - An existing online medical appointment service

An NHS service 'Choose and Book' was launched in 2006, aimed at providing patients with more choice through online appointments[13].

This system is similar to the project area in that it allows patients to create online outpatient appointments, having a choice over which clinic they go to and when they the appointment is booked for.

However, an independent survey of patient's experience using the service in 2008 showed that patients did not receive the degree of choice that the service was designed to deliver[14]. It has also been widely criticised as being time consuming, over complicated and . An article in 2012[8] shows that the system's popularity is diminishing.

Besides the clear flaws in the system such as ease of use and failing to offer more choice, it also fails to target significant areas of the problem description, such as electronic reminders, recycling unused appointments and general appointment information.

3.3 Conclusion

Attempts have been made in the past to simplify the appointment management process and take it online, however they fail to hit all of the objectives simply because the platforms were not ready. As smart-devices and their many applications are becoming increasingly popular, it opens up a new gateway to communicate directly with patients and receive quick response times. This makes it much easier to create a dynamic appointment schedule whilst maintaining a high user satisfaction level.

This project will therefore focus on improving the communication and interactivity between patients and the appointment scheduling system; so that more information is available to the patient, there is more chance of reusing free appointment slots, and less staff resources are used in managing appointments so they can be allocated to other areas.

The project will also look at making the appointment creation and rescheduling process easier for both patients and staff, requiring less management resources and offering more platform choices and flexibility.

Chapter 4

System Design and Development

4.1 Introduction

This chapter will focus on the requirements that the proposed solution must fulfil, outline the challenges involved and highlight the key technologies that will be used.

4.2 User Requirements

With the research showing areas that could be focused on to improve user satisfaction, a list of proposed user requirements was created to identify specific features that would improve the user experience. The following list shows the final requirements for proposed solution:

4.2.1 Login System

A login system used to hold the patients identity and allow them to easily manage their appointments on multiple devices. This will also act as a security mechanism to ensure that medical information is only revealed to the patient in question.

4.2.2 List of Appointments

A list of the patients appointments which is kept up to date and updated automatically when changes are made. This will display very basic information about each appointment, such as when it occurs and the type of appointment it is.

4.2.3 Appointment Information

Tapping on an appointment in the appointment list will bring up relevant information about that appointment, including the doctor's name, location (using a map) and time. It will also include a short description about the appointment, links to useful information and contact details for emergencies.

4.2.4 Appointment Notifications

The smart device, after the patient has logged in, will listen for notifications from the server, which contain short messages that displays up-to-date information related to appointments.

Use cases for this feature include time-based reminders so that the patient does not forget, or changes to the patients appointment such as a different location or doctor.

4.2.5 Scheduling Appointments

Although appointments are initially set-up by a healthcare professional, patients will have control over the timing of the appointment.

The patient will tap an existing appointment, and choose to schedule or re-schedule it. They will be able to post a time window that they want the appointment to occur within, and the server will respond with 3 choices.

The patient will then be able to either confirm one of the choices, or alter their timing window.

4.3 System Requirements

Alongside the user requirements, a list of system requirements was also created to support the user requirements and ensure the solution is flexible under possible future requirement changes. Here is the finalised list of system requirements:

4.3.1 Cross-Platform

Running on multiple devices is important so that the usability of the service is maximised. Although this project will only target the Android platform, it will be designed such that it can be easily adapted to run on alternate devices such as iOS and web-browsers.

4.3.2 Restful Web Services

Because scheduling is a complex problem, the solution needs to be easily integrable with other systems. Multiple endpoints will be available through restful web services, so that components of the system can be easily utilised by other systems.

For example, many scheduling solutions already exist, written in different programming languages and implemented in different ways. The system should be designed in a way that it can easily 'plug-in' to these scheduling solutions and utilise them fully through web-services.

4.3.3 One Development Language

Very few devices share development languages, which can make it troublesome to offer cross platform support.

For the sake of simplicity and given the time requirements, this project will also aim to implement the server and client in the same programming language, C#.

4.4 Development and Technology Used

To fulfil all user and system requirements, various technologies will be used. Here, I will give a brief description of each technology and what role it will play in the proposed solution.

4.4.1 Mono and Xamarin

Mono is an open source implementation of the C# programming language that is cross-platform. This allows development of C# code that can be compiled and run on Windows, Linux and Mac systems.

Xamarin is a mobile app development framework built on Mono, targeting the Android, iOS and Windows Phone platforms. Also, because Xamarin is written using C#, it can integrate easily with the Windows SDK for the development of Windows Desktop Applications.

Xamarin allows business layer logic to be shared across the different platform implementations, essentially having one main code-base rather than a seperate one for each platform.

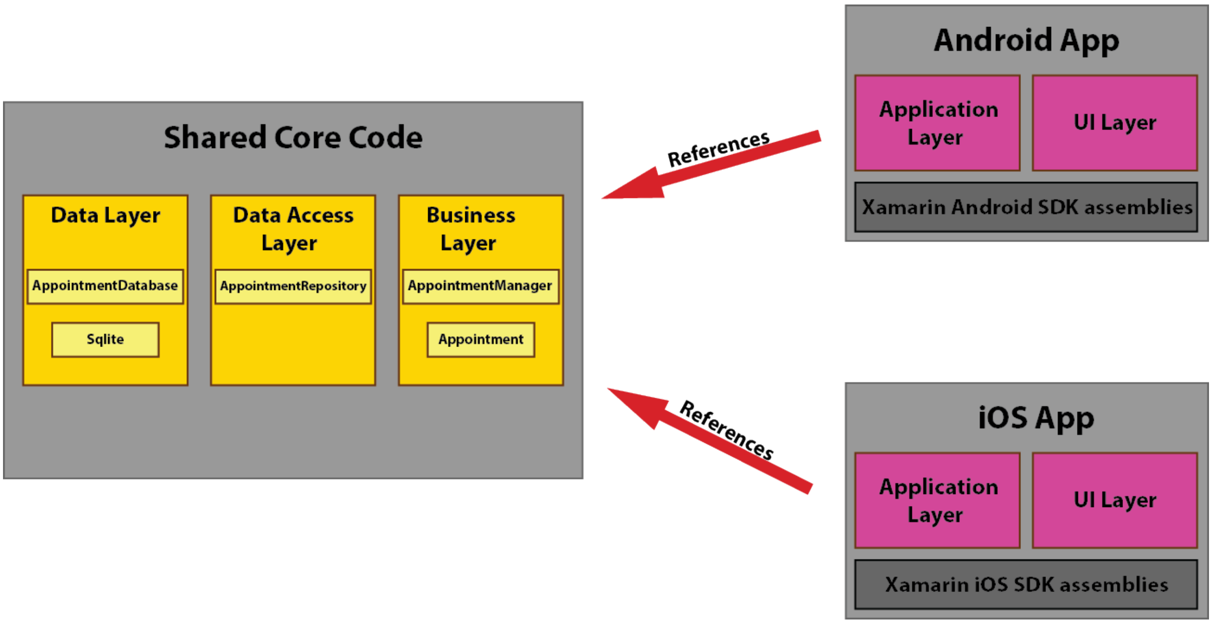


Figure 4.1: Diagram showing client architecture and business logic being reused across multiple platforms

The server application will therefore be written in C# with the possibility of being compiled using Mono, allowing it to run on either Windows or Linux server machines (although this is beyond the scope of this project). The Android App will also be written in C# using the Xamarin framework, allowing the code-base to be easily integrated with future platforms.

4.4.2 Communication

The system requires two types of communication based on the requirements, urgent and direct. It is very important to differentiate between these two when targeting mobile devices, due to the following issues:

- Bandwidth is limited
- Devices aren't always online
- Connections are unreliable
- Constant communication can cause excessive power consumption

Due to these issues, a constant connection to a remote server is not possible for long periods of time. This means that the communication must be separated into two separate components, each being useful for different scenarios.

4.4.2.1 Push Communication

Notification messages, also known as push notifications, are a way of sending a short notification message to a device. This is useful for sending urgent messages when the application is not being used, prompting the user for input.

There are however, limitations of this type of communication:

- Only small messages are allowed to be sent
- The server does not know when the message has been received
- Server to client messages only

Push communication can be seen as a 'answering machine service'. The server leaves a short message for the device to be received at some point in the future. If the device is offline, it will receive the message as soon as it comes online again, making it a good system for unreliable connections.

Push notifications should be kept short and only contain enough data to notify the application that it needs to connect to the server for more information.

Due to these limitations, the system will only use push notifications for the following scenarios:

- A sooner appointment is available for the patient
- An appointment has been cancelled and/or needs rescheduling
- Information about an appointment has been changed

'Google Cloud Messaging (GCM)' is the Android service for sending push notifications which this project will be using. It has a message limit of 4kb and is a free service, however it has a daily fair-usage limitation on how many notifications can be sent from a single application.

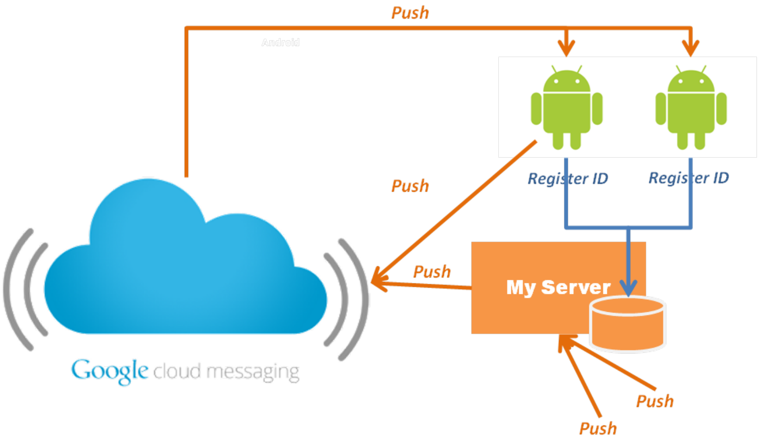


FIGURE 4.2: Google Cloud Messaging - [15]

By using this service, messages are queued and sent to the device as soon as it is available, prompting the user of some kind of notification relating to the application.

4.4.2.2 Direct Communication

After a notification has been received, or simply through using the applications features, the device will require direct communication with the server. It will require communication to:

- Create or Reschedule an appointment.
- Request information about an appointment
- Request reminders about an appointment
- Requesting the database encryption key

All of these direct communication services will be done using restful web-service requests.

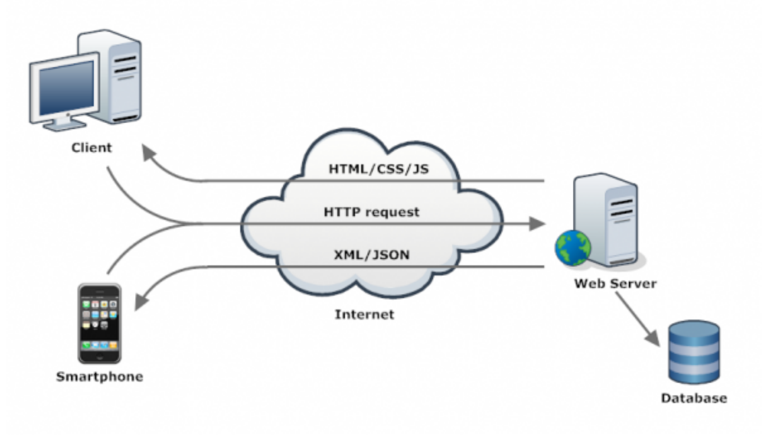


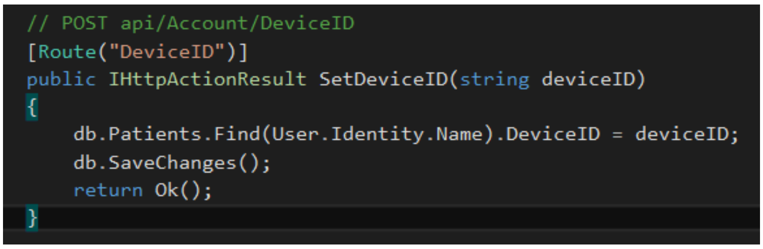
FIGURE 4.3: RESTful Web Services cross-platform communication - [16]

Rest requests can be consumed by almost any programming language and internet accessible device. Data is translated into a mark-up language (JSON will be used for this project), transported via web-services and then reassembled on the target device.

To service these requests, the system will use 'ASP.Net'.

4.4.2.3 Asp.Net

'Asp.Net' is a MVC based web application framework for web development in C#. It allows the binding of restful endpoints to business logic extremely easy, with built in authentication support and custom attributes to define specific restful behaviours.



```
// POST api/Account/DeviceID
[Route("DeviceID")]
public IHttpActionResult SetDeviceID(string deviceID)
{
    db.Patients.Find(User.Identity.Name).DeviceID = deviceID;
    db.SaveChanges();
    return Ok();
}
```

FIGURE 4.4: Example of an Asp.Net web service definition

The figure above shows a method that allows a smart-phone device ID to be registered to a patient's account. This particular method is for use in push notifications, so that the notifications server knows which device to send the patients notifications to. Asp.net will bind this method to the commented url above it by using the 'Route' attribute and the current controller that the method is defined in (the account controller).

4.4.3 Data Storage

Appointment data will be stored in a SQL database, requiring relational models to be created for the solution. The finalised models will be discussed in the implementation chapter.

To create and manage the database, the system will use C#'s 'Entity Framework'

4.4.3.1 Entity Framework

'Entity framework (EF)' is an object-relational mapper that allows developers to work easily with relational data using domain specific objects. This eliminates the need for data access code such as SQL queries, and the database can be easily designed using standard C# code.

Chapter 5

Implementation

5.1 Implementation Process

This chapter will discuss in detail, the implementation of the proposed android client application, and the server application that accompanies it.

5.1.1 Architecture and Design Patterns

Design patterns are reusable solutions to commonly occurring problems in software design. The use of tried and tested design patterns is recommended in software because it stops programmers from making the same mistakes, and also speeds up development time as you no longer need to 'reinvent the wheel' with every software engineering project.

Picking the correct design pattern for the problem can prove troublesome, and choosing the wrong ones can lead to inefficient solutions, such as unnecessary duplication of code.

For this project, MVC was used heavily in both the client and server side application.

5.1.2 Model-View-Controller (MVC)

Model-View-Controller is a well known software design pattern for implementing user interfaces. The design follows three interconnected parts:

- Model - holds the application data, and logic for accessing and manipulating this data.

- View - holds logic that displays the aesthetic view to the user. It can also contain mechanisms of receiving user input and passing that input along to it's controller.
- Controller - holds controller logic that accesses data from a model and passes it to a view. It can also update a models state with new information, and update the view as the model is updated.

Figure 5.1 shows the MVC architecture.

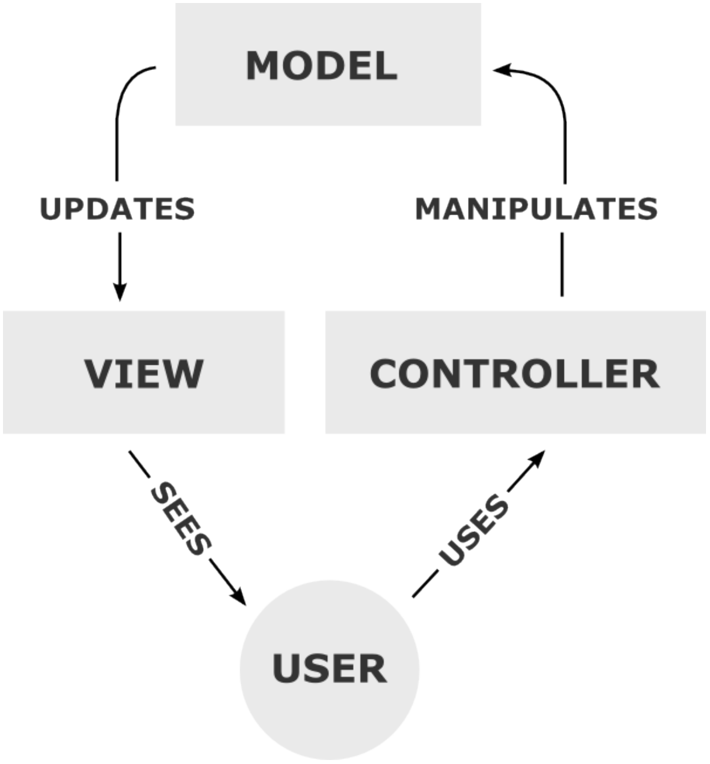


FIGURE 5.1: Model View Controller Diagram - [17]

5.1.3 Communication Methods

5.1.4 User Interface and Storyboards

5.2 Server Implementation

5.2.1 Data Access Layer

5.2.2 Data Layer

5.2.3 Business Layer

5.2.4 Application Layer

5.3 Client Implementation

5.3.1 Data Access Layer

5.3.2 Data Layer

5.3.3 Business Layer

5.3.4 Application Layer

Chapter 6

Testing and Evaluation

To be written

6.1 Testing

6.1.1 Methodology

6.1.2 Result

6.1.3 Conclusion

6.2 Evaluation

6.2.1 User Evaluation

6.2.2 Methodology

6.2.2.1 Controlled Observation

6.2.2.2 Interviews

6.2.3 conclusion

Chapter 7

Project Conclusion

To be written

7.1 Objectives

7.2 Further Extensions

7.3 Future Extensions

7.4 Final Conclusion

Appendix A

How ethical issues are addressed

A.1 Introduction

This section describes the ethical issues involved throughout the project. I also propose techniques for solving and minimising these issues.

A.2 Project background

A few ethical issues arise from the projects aims and objectives. Firstly, personal data will be used and stored in order to optimise the projects aims. Secondly, the project aims to optimise the scheduling process, which could make some employees jobs redundant.

A.2.1 Personal Data

Personal data will be stored and used both locally (on the mobile device) and on an external server to try and optimise scheduling software. It may also be required to transmit this data regularly to keep the system running effectively.

This brings into security issues, as the data could be very valuable to certain individuals for marketing or other purposes. In order to solve this, several areas should considered:

- Patients must be informed about what data is being stored and why

- The system should be as secure as possible with the current technology
- The data should be as anonymous as possible, with no individual besides its owner having access to it.

A.2.2 Employee Downsizing

The system aims to optimise the scheduling process and would replace a lot of the manual labour involved. It is therefore possible that the system would make some employees redundant.

Although this system aims to optimise the current system, it would not be able to replace it entirely, and so not all jobs would be lost. Also, this is only a short term problem, and with more training, employees could be allocated elsewhere.

A.3 Testing and Evaluation

In order to evaluate this project, I plan to perform user based assessments.

A.3.1 User Based Assessments

When performing user based assessments, care must be taken to ensure that participants are well informed of their rights, what the project is about and how their feedback would be stored and used. The participants data would also need to be stored anonymously to preserve confidentiality.

To ensure this is done correctly, the following steps will be taken:

1. The nature of the project will be explained to the user.
2. The user will be informed that their opinions will be used and stored both anonymously and securely.
3. The user will be informed that they can stop the assessment at any time
4. The user will be asked to sign a consent form to confirm that they have agreed to take part and that their data can be used to evaluate the project
5. The data will be collected and stored anonymously

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