

UNIVERSITY OF LEEDS

FINAL YEAR PROJECT

---

# User Adaptive System to Support Automated Medical Appointment Scheduling of Outpatients

---

*Author:*

Andrew MUNRO

*Supervisor:*

Dr. Raymond KWAN

*A report submitted in fulfilment of the requirements  
for the degree of Computer Science*

*in the*

School of Computing

February 2014

# 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.

Signed:

---

Date:

---

*“Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism.”*

Dave Barry

UNIVERSITY OF LEEDS

# *Abstract*

Faculty of Engineering

School of Computing

Computer Science

## **User Adaptive System to Support Automated Medical Appointment Scheduling of Outpatients**

by Andrew MUNRO

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

# *Acknowledgements*

The acknowledgements and the people to thank go here, don't forget to include your project advisor. . .

# Contents

<b>Declaration of Authorship</b>	<b>i</b>
<b>Abstract</b>	<b>iii</b>
<b>Acknowledgements</b>	<b>iv</b>
<b>Contents</b>	<b>v</b>
<b>List of Figures</b>	<b>vii</b>
<b>List of Tables</b>	<b>viii</b>
<b>Abbreviations</b>	<b>ix</b>
<b>Physical Constants</b>	<b>x</b>
<b>Symbols</b>	<b>xi</b>
<b>1 Project Overview</b>	<b>1</b>
1.1 Project Aim . . . . .	1
1.2 Objectives . . . . .	1
1.3 Minimum Requirements . . . . .	2
1.4 Extensions . . . . .	2
1.5 Deliverables . . . . .	3
1.6 Relevance to Degree Modules . . . . .	3
<b>2 Problem Description and Background Research</b>	<b>4</b>
2.1 Problem Description . . . . .	4
2.1.1 Wasted Resources . . . . .	5
2.1.1.1 Patient No-Shows . . . . .	6
2.1.1.2 Cancellations . . . . .	6
2.1.1.3 Managing Appointments . . . . .	7
2.1.2 Patient Satisfaction and Experience . . . . .	8
2.1.2.1 Patient Requirements . . . . .	8
2.1.2.2 Waiting times . . . . .	9

---

2.2	Choose and Book - An existing online medical appointment service . . . . .	9
2.3	Mobile Applications and Smart Devices . . . . .	10
2.4	Conclusion . . . . .	10
<b>3</b>	<b>Project Management</b>	<b>11</b>
3.1	Schedule . . . . .	11
3.2	Research . . . . .	11
3.3	Design . . . . .	11
3.4	Implementation . . . . .	11
3.5	Evaluation . . . . .	11
<b>4</b>	<b>Design and Development</b>	<b>12</b>
<b>5</b>	<b>Implementation</b>	<b>13</b>
<b>6</b>	<b>Testing and Evaluation</b>	<b>14</b>
<b>7</b>	<b>Project Conclusion</b>	<b>15</b>
<b>A</b>	<b>Appendix Title Here</b>	<b>16</b>
	<b>Bibliography</b>	<b>17</b>

# List of Figures

2.1	Factors contributing to non-attendance according to a patient questionnaire - [1]	5
-----	---	---



# List of Tables

# Abbreviations

**LAH** List Abbreviations **Here**

# Physical Constants

Speed of Light  $c = 2.997\,924\,58 \times 10^8 \text{ ms}^{-\text{s}}$  (exact)

# Symbols

$a$	distance	m
$P$	power	W ( $\text{Js}^{-1}$ )
$\omega$	angular frequency	$\text{rads}^{-1}$

*For/Dedicated to/To my...*

# 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:

- TODO Put some of tasks from min requirements here

## 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

# Problem Description and Background Research

### 2.1 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.

### 2.1.1 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.

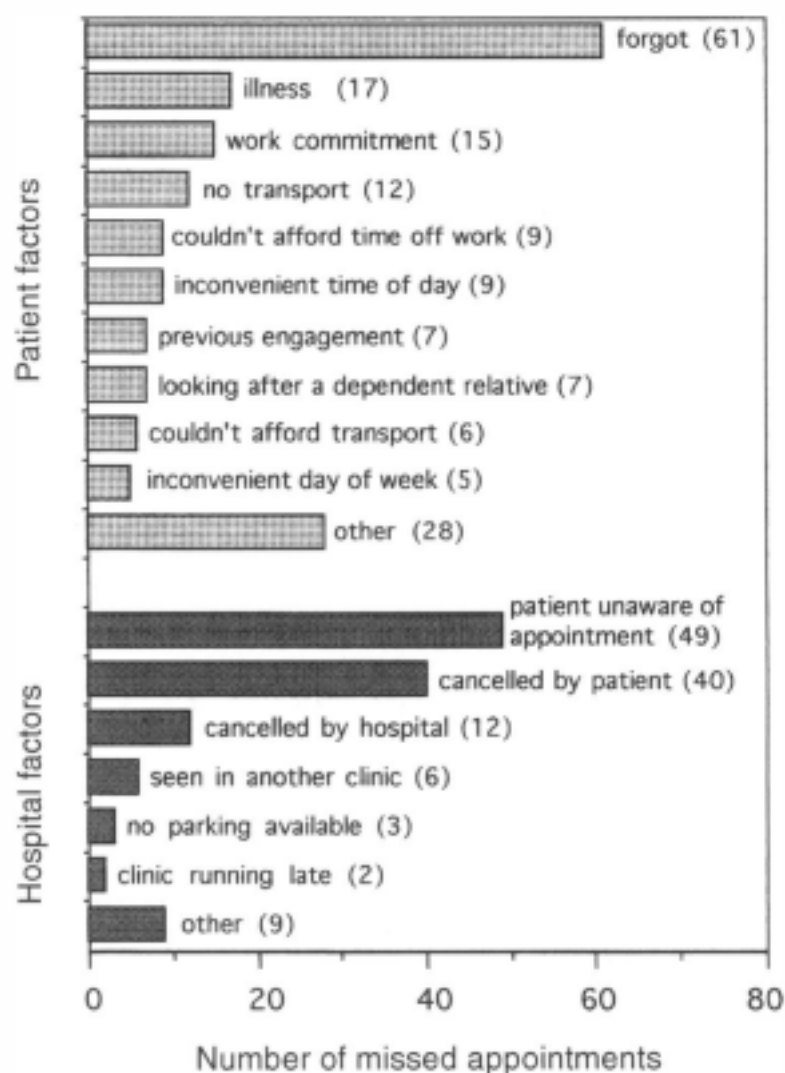


FIGURE 2.1: Factors contributing to non-attendance according to a patient questionnaire - [1]

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

### **2.1.1.1 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.

### **2.1.1.2 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.

### **2.1.1.3 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

### **2.1.2 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.

#### **2.1.2.1 Patient Requirements**

Patients are given a level of responsibility that some may not be used to. For a general out-patient 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.

### **2.1.2.2 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 can also provide transport information, reminders on when they have to leave and any prerequisite requirements that the patient must undertake before leaving for their appointment (such as take medication or bring test results).

## **2.2 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[11].

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[12]. 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.

## **2.3 Mobile Applications and Smart Devices**

Emerging 'smart' technology allows service providers to remain connected to users with almost no down time.

## **2.4 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 3

# Project Management

3.1 Schedule

3.2 Research

3.3 Design

3.4 Implementation

3.5 Evaluation



## Chapter 4

# Design and Development

## Chapter 5

# Implementation

## Chapter 6

# Testing and Evaluation

## Chapter 7

# Project Conclusion

## Appendix A

# Appendix Title Here

Write your Appendix content here.

# Bibliography

- [1] Peter J Saxby Christopher A Stone, John H Palmer and Vikram S Devaraj. Reducing non-attendance at outpatient clinics. *Journal of the Royal Society of Medicine*, 92:114–118, March 1999. URL <http://jrs.sagepub.com/content/92/3/114.full.pdf+html>.
- [2] Gerard Gallucci, Wayne Swartz, and Florence Hackerman. Brief reports: Impact of the wait for an initial appointment on the rate of kept appointments at a mental health center. *Psychiatric Services*, 56(3):344–346, 2005.
- [3] McWhinnie DL Mann DV. A simple extended-cavity diode laser. *Appointment Reminders*, 303:1526, December 1991. URL <http://dx.doi.org/10.1136/bmj.303.6816.1526>.
- [4] Stephen Frankel, Alexandra Farrow, and Robert West. Non-attendance or non-invitation? a case-control study of failed outpatient appointments. *BMJ: British Medical Journal*, 298(6684):1343, 1989.
- [5] Naomi L Lacy, Audrey Paulman, Matthew D Reuter, and Bruce Lovejoy. Why we don’t come: patient perceptions on no-shows. *The Annals of Family Medicine*, 2(6):541–545, 2004.
- [6] NHS. Productive general practice: Plannning and scheduling, Febuary 2014. URL [http://www.institute.nhs.uk/productive\\_general\\_practice/general/planning\\_and\\_scheduling.html](http://www.institute.nhs.uk/productive_general_practice/general/planning_and_scheduling.html).
- [7] NHS. Choose and book, Febuary 2014. URL <http://www.chooseandbook.nhs.uk/patients/whatiscab>.
- [8] NHS. Choose and book use drops further, Febuary 2014. URL <http://www.ehi.co.uk/news/ehi/7835/choose-and-book-use-drops-further>.
- [9] NHS. Your hospital outpatient appointment, February 2014. URL <http://www.nhs.uk/NHSEngland/AboutNHSservices/NHShospitals/Pages/hospital-outpatient-appointment.aspx>.
- [10] Alison J Macarthur, Colin Macarthur, and Joan C Bevan. Determinants of pediatric day surgery cancellation. *Journal of clinical epidemiology*, 48(4):485–489, 1995.

- 
- [11] Simon Walford. Choose and book. *Clinical medicine*, 6(5):473–476, 2006.
  - [12] Judith Green, Zoe McDowall, and Henry WW Potts. Does choose & book fail to deliver the expected choice to patients? a survey of patients’ experience of outpatient appointment booking. *BMC medical informatics and decision making*, 8(1):36, 2008.