Tonight - An iOS app for event aggregation

Final Report for CS39440 Major Project

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Consent to share this work

In signing below, I hereby agree to this dissertation being made available to other students and academic staff of the Aberystwyth Computer Science Department.

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Acknowledgements

I would like to thank my dissertation tutor Richard Jensen for helping throughout the project.

I would also like to thank my family for their continued support throughout my time at university!

Last but not least I would like to thank all of my friends, mainly the `Harvington household' and the `Orchard Banter House' for the support and telling me when my app `looked rubbish' and the usual `that dont work'. Cheers guys!

Abstract

This report describes a project for helping users discover events around them. When visiting a new area trying to find out what's going on can be difficult even for the most adept regular. Tonight tries to solve that problem by providing a mobile application that allows you to discover events that are going on around you. It does this by presenting the user with events that may be of interest to them via a `My Feed' section. A user also has the ability to explore events by selecting a city/area then drilling down to a particular venue or category. The users is then able to view all of the details on a particular event, with the option to follow the event. By following an event the system can learn about the user and present them with suggestions of events, based on what similar users are also following. To do this I developed a Ruby on Rails server application that provided a REST based API to access the information that a user needed, as part of this I also developed a data mining module to be able to pull in information from various data sources. Using this in conjunction with an iOS application to present the data and add in functionality to the user on a mobile device.

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Chapter 1

Background & Objectives

1.1 Background

The UK music events and festival industry was estimated at 3.5 billion in 2010 and expected to raise to 4.2 billion in 2015. With roughly 530,000 full time equivalent jobs employed by 25,000 employers. [6] The industry itself is very diverse with a huge range of events going on every night, from intimate acoustic sets to all night raves, many people find themselves going to the same venue over and over again not aware of other events happening around them. Currently the promotion of events is limited to the users of certain social media sites, or purpose built websites for promotion of events. The tools that a promoter currently has at their disposal is limited and sporadic at the best, for an example The Rainbow Venues [17] use a mixture of their own site, social media (Facebook/Twitter) and the ticket masters. This brings to the core problem for a potential customer to discover the venue, they must be aware of the venue first to be able to find the information that they want. Even with use of social media the reach of a promoted event will only reach those that know of the venue or by those that 'share' the promotion to their friends.

With the cost of living going down people are looking further afield for evening entertainment, by not being from around the area they are at an immediate dis-advantage. With the increase of popularity of smart phones many people will pick up their smart phones, and immediately search for an application to help them find events on the go. The current selection of applications are very limited to the style of events and the area they are based, which means a new application for each time they go away this is not ideal and will quickly fill up a smart phone.

At this time there is a wide selection of similar applications available to download from the Apple AppStore. Each of these applications differ slightly be it the way the information is presented or the key functionality they provide. Many of the applications are only suited towards a particular city or specific headlining artists, by doing this they are somewhat limiting the scope of their audience. Many of the solutions out there also currently only utilise data that's being input by employees, this means that only a representative of all the events happening are selected and presented by the application.

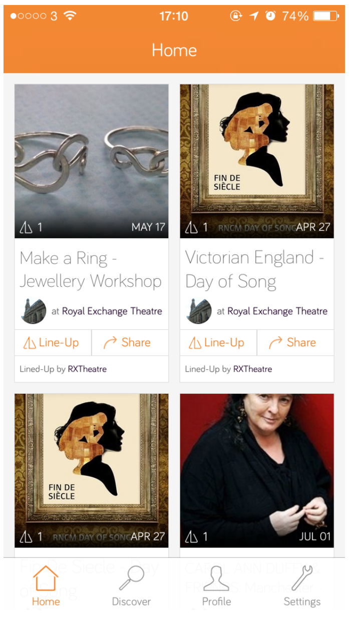
1.1.1 Current Solutions

Here are some of the current applications that are available to download from the Apple AppStore. All of the applications are free downloads, along with free registration to use the features. All of the applications as standard provide a feed of events (in a relevant order), and the ability to filter them in various ways.

1.1.1.1 Line Up

Line Up [9] shows a wide variety of events in the Manchester area, it gives you the ability to add events to their `Line Up' which is essentially a list of events that they are planning to go to or going to. It also gives you the opportunity to share the event via popular social network sites, increasing there own reach and allowing the users friends to see what they are attending/interested in. To discover events you are able to browse events by type of place, People, and all events. The application also allows you to follow other users that use the application, allowing a user to see what other users are attending. When viewing an individual event you can see a title, description, dates of the event, and the location.

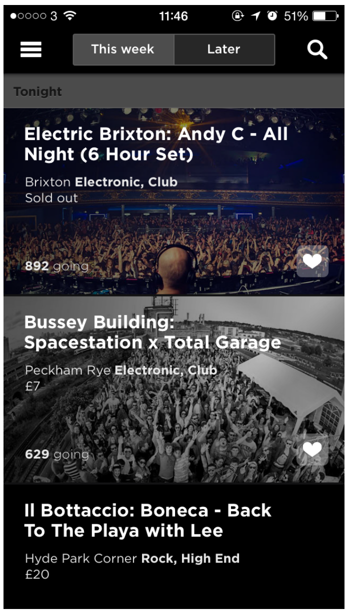
Figure 1.1: Image showing the home screen for the Line Up application


17:10
74%
Home
MAY 17
APR 27
Make a Ring - Jewellery Workshop
Victorian England - Day of Song
at Royal Exchange Theatre
at Royal Exchange Theatre
Line-Up
Share
Lined-Up by RXTheatre
FIN DE SIÈCLE
JUL 01
Home
Discover
Profile
Settings

1.1.1.2 Spotnight

Spotnight [15] shows selected events happening in the London area, it gives you the ability to purchase tickets for the events available through a 3rd party service. You can view the events that are happening either this week or later on, however you are able to apply filters for specific areas, style of music, and genres. The application allows you to like events, however this does not seem to have any particular effect to the ordering of the events or any other aesthetic/functional item of the application. When viewing an individual event, you are able to view the location, description, price, images, people attending, and venue contact details. You are also able to share particular events through social networking sites; Facebook and Twitter.

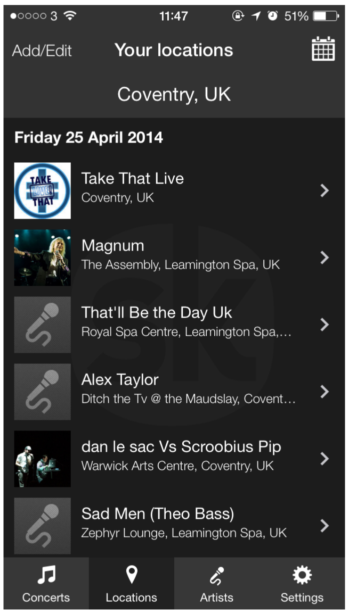
Figure 1.2: Image showing the home screen for the Spotnight application


●○○○○ 3
11:46
51%
This week
Later
Tonight
Electric Brixton: Andy C - All Night (6 Hour Set)
Brixton Electronic, Club
Sold out
892 going
Bussey Building: Spacestation x Total Garage
Peckham Rye Electronic, Club
£7
629 going
Il Bottaccio: Boneca - Back To The Playa with Lee
Hyde Park Corner Rock, High End
£20

1.1.1.3 Songkick

Songlick [14] offers a selection of artist specific events, Songkick allows you to see events happening in your area, and by artist. From here you are presented with the details of the event including the line up, location and an option to purchase tickets via a 3rd party service. Songkick also allows you to track an event and mark an event as attending, to use these functions you are required to sign up however casual use of the application does not require signing up. The application also allows you to follow artists and will suggest events that are happening near you within the artists you are following.

Figure 1.3: Image showing the home screen for the Songkick application



Coventry, UK

Friday 25 April 2014

Take That Live
Coventry, UK

Magnum
The Assembly, Leamington Spa, UK

That'll Be the Day Uk
Royal Spa Centre, Leamington Spa,...

Alex Taylor
Ditch the Tv @ the Maudslay, Covent...

dan le sac Vs Scroobius Pip
Warwick Arts Centre, Coventry, UK

Sad Men (Theo Bass)
Zephyr Lounge, Leamington Spa, UK

1.2 Analysis

With the main problem being users not knowing an area there is a prevalent set of key features that is required by the application for it to help solve the issue at hand. The most prominent being be able to grab the users current location and to be able to filter out the events that are happening near to their current location. However many people may not want to travel to the area only to find out that nothing that interests them is happening, so ideally the events should be categorised by area and then a user should be able to browse the areas they are visiting. Bearing this in mind, as the user is visiting a potentially new area they may require directions or some sort of map indicating the location of the event.

Another issue is that many of the previous systems require human interaction to find out about events and manually input these into to the system. Whilst this allows for a human based data validation it can be slow and time consuming to conduct, and result in only key events being selected and not provide a large enough range for their users. By use of data mining techniques we are able to pull in a must larger variety of events and therefore cater for a wider audience, thus allowing the user to actually discover new events that they may not have thought about. This relates to the first issue, by pulling in the details automatically from various API's we are able to half the work required by us and the promotions companies. Making the use of this service much more attractive to both parties, ultimately widening the stakeholders and potential audience.

1.2.1 Primary objectives

There a number of primary objectives for this task, these are listed below

Personalised feed
The application must produce a feed that's personalised to the currently logged in user

Registration/Authentication
The system must provide the ability to create a new user, and to login a previously registered user. They should also stay logged in until the have logged out of the account.

Ability to follow events
The application should provide functionality to follow an event to help facilitate the personalised feed.

Categorise the events
The application should allow the events to be presented in multiple ways including categories and areas.

Show individual events
The application must provide all of the relevant details of each event

Connect to various API's
The server must be able to pull in information from a number of different API's and

Application - Server interoperability
The application and server need to be able to pass information to each using some form of interoperability.

Interoperability authentication
The implementation of the interoperability must utilise some form of authentication for access.

1.2.2 Secondary objectives

These objectives are not critical to the running of the application but provides extra functionality to the service.

Location awareness
The application should be of the location of the user, and only use the nearest events.

Notifications
The user should receive notifications then events have been updated based off the data mining application.

User profile
The application should show a users profile, showing the events they are following and their personal details.

Link to purchase the events
The application should provide some sort of back link to enable a user to purchase tickets through a 3rd party service.

Ability to administer data from an administration panel
The server application must give the ability to administer the data stored from an administration panel.

Ability to administer jobs from an administration panel
The server application must be able to administer data mining jobs from an administration panel

1.2.3 Non-Functional requirements

Application needs to training to be used
The user should not need any training to use the application

1.2.4 Hardware requirements

Application must run on > iPhone 4
The iOS application must run on all iPhones that run the latest version of the iOS firmware.

Server should run on cloud computing provider
The server element should run on a cloud computer to allow for high demand with ease.

1.3 iOS and Ruby on Rails

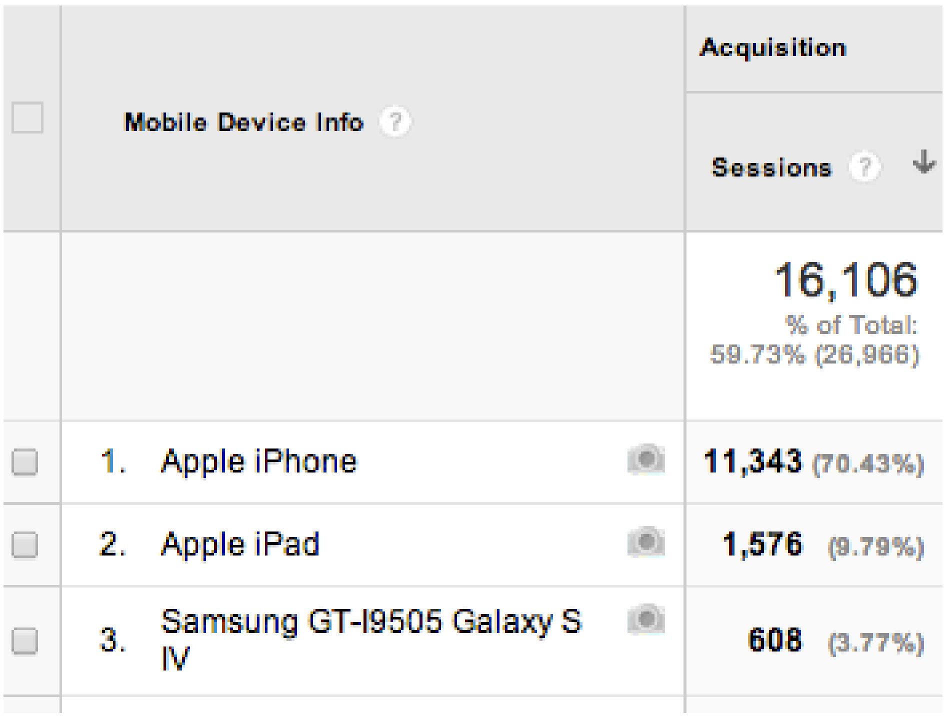
1.3.1 iOS Development

The application itself will be based on the iOS platform for Apple iPhones, being programmed using Apples Objective C language. This decision was made based on some Google Analytics information, which was provided by a popular events company in Birmingham. Figure 1.4 shows us the statistics that's been produced by Google Analytics showing that over 70% of their traffic was coming from Apple iPhones. The programmer also had readily available access to an iPhone to assist with the development process underlined.

To develop iOS applications you are required to use Apples own IDE XCode 5 packaged into this is the iOS simulator, this allows me to test applications developed locally on the machine without needing to make a payment to the developers network. The simulator allows for all parts of the application to be tested, however I will need to manually set up locations to test the location awareness of the application. I will also be utilising a package manager called CocoaPods [2] which allows me to pull in various libraries with ease and make sure I'm using the latest versions with future updates. To get used to the new IDE and we will utilise the resources from Ray Wenderlichs sites [11], Ray gives many resources including sample projects that can be analysed and tutorials.

iOS has 2 main design patterns that are usually followed, the first being model view controller (MVC) this is implemented by having 3 main sections of code; a place where the

Figure 1.4: This image shows within a month their main traffic is through Apple iPhones, with secondary traffic of Android being a much smaller percentage.



	Mobile Device Info	Acquisition
		Sessions
		16,106 % of Total: 59.73% (26,966)
	1. Apple iPhone	11,343 (70.43%)
	2. Apple iPad	1,576 (9.79%)
	3. Samsung GT-I9505 Galaxy S IV	608 (3.77%)

data is defined/stored(model), a place where any business logic is performed(controller), and a place where the data is outputted(view). Typically you can find multiple instances of the MVC pattern inside of one project. However it also utilises a delegation & target/action delegation is used to pass data between the multiple MVC's you will find inside a project, and target/action which is used by iOS to link buttons with methods to be called upon that button being selected.

1.3.2 Server Development

The project will also require a server side element to be able to mine the data and provide the data to the application, this will be written in Ruby using the Ruby on Rails framework. Using the framework gives access to lots of functionality not built into the core of Ruby and provides a production ready environment. Due to the explosive nature of applications, it's been decided to use cloud computing to be able to effectively manage the demand of resources used by the application. For this it was decided the best cloud platform is Heroku [7] this was mainly due to the ease of deployment, which involved a git push to their remote server, Heroku also provided a free service to be used during development and for small scale applications.

1.3.3 API Interoperability

To get the data to be used throughout the system, it will need to communicate to a number of API's and store the outputted data to to be processed and outputted through the server element of the project. The main API to communicate with is the Facebook Graph API [3], the key event and venue details that have been provided from Facebook have been listed in Table 1.1.

Table 1.1: Data retrieved on events and venues from Facebook API

Table 1.2: Event data

Property Name	Type
id	numeric string
cover	CoverPhoto
description	string
end_time	datetime
is_date_only	bool
location	string
name	string
owner	User|Page|Group
parent_group	Group
privacy	string
start_time	datetime
ticket_uri	string
timezone	string
updated_time	datetime
venue	Page

Table 1.3: Venue data

Property Name	Type
id	string
about[1]	string
checkins	int32
company_overview[1]	string
cover[1]	CoverPhoto
current_location	string
description[1]	string
general_info[1]	string
hometown	string
likes	int32
link	string
location	object
country	string
city	string
longitude	float
zip	string
state	string
street	string
latitude	float
name[1]	string
parking[1]	object
street	int32
lot	int32
phone[1]	string
username	string
website[1]	string

1.4 Process

Mostly the methodology followed was a cut down version of agile, optimised for a single developer. This decision was made to allow the programmer to add in extra functionality as seen fit throughout the project, and to allow the design to flex with these requirements. To develop the bulk of the application feature driven development (FDD) was used as there were 3 main logical aspects to the project those being; Interoperability, iOS Application, and Data mining. Due to the nature of each of these sub sections, there will a slightly different sub-methodology for each. Each feature relies on one already being present bar the data mining feature, this is key to the order of features. The first feature developed was the data mining, which received information and input it into a database, the interoperability feature of the server element (REST API) and then the iOS application itself to use the server element of the project. Agile was also chosen as whilst we know the scope of the project currently, looking to the future it may be required to add in extra functionality based off the reception received. Inside of each feature was a set of iterations, these were primarily individual requirements for each feature.

1.4.1 Server application

The development of the server application will be following the test driven development (TDD) methodology, utilising the red, green, re-factor ideology. This was chosen as it will allow for flexibility in the overall design of the application, and will also ensure tests are being written for the functionality of the software. By following TDD it will also ensure that the code is the most efficient, as no more code is written except for what's required to pass the various tests.

1.4.2 iOS Application

The development of the iOS application was a lot more conventional, a feature was programmed with relevant unit testing implemented to ensure the functionality produced the correct output. A form of TDD was used as sometimes a test failed so it was required to go back and fix the code to ensure the test passed. After each feature was added, device testing was undertaken ensuring it all ties together well and works on the device.

1.4.3 GitHub

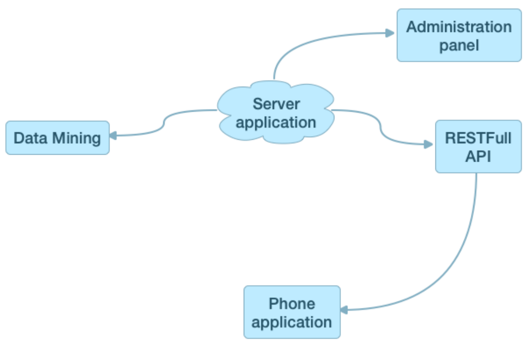
1.4.4 Trello

Chapter 2

Design

There are 2 main parts of the project the first being the server element and the second the mobile application itself. The mobile application will be connecting to the server applications through a RESTFull API to retrieve all of the data that's required. The server element will be composed of 3 main parts the RESTFull API, Administration panel, and the data mining part.

Figure 2.1: This diagram shows the main areas of the project and how the interact with each other.



2.1 Database

To full fill the requirement of utilising a cloud server solution the database will be using PostgresSQL which the server element will interface with it using the ActiveRecord gem bundled with Ruby on Rails. Because the server element was designed using TDD and each the overall design, was moulded during the process Figure 2.2 shows the resultant entity relationship diagram at the end of the project. There is also a set of definite fields that was worked from the Facebook API schema listed in Table 1.1, schema.org [13] was also used to help build the list of relevant information on an event.

2.2 Server Application

The server application, will be composed of 3 components these will be the Data mining module, the RESTFull API for interfacing with the mobile application, and the administration panel. These components whilst being separate, will all interact with the same database and will reside within the same code base to be uploaded and ran on the cloud application platform (CAP).

2.2.1 Development tools

The server application will be written in Ruby utilising the Ruby on Rails (RoR) framework, there were other options to use such as; Node, Clojure, Java, Python. However the RoR framework provided great native support for developing API's and database integration. Rails also gives us the ability to run code using the rails environment via the command line by use of rake tasks. The CAP will call the task hourly using a cron job to pull in new events and venues, these jobs will be specified by the administration panel and then ran by the rake task.

To develop the server side code the programmer will be using the Sublime Text 2 text editor [8] with the following packages installed; RSpec [5], Ruby Test [10], and Rails Developer Snippets [16]. These packages will assist the programmer by allowing them to run tests within the editor and provide key snippets to be used by them. The use of a text editor with the packages noted installed allowed a cleaner interface for the programmer to deal with and was a tool they where familiar with.

As stated above, the programmer will be following a test driven development approach as such it will be required to use some form of test framework. For this the programmer will be using RSpec for RoR gem [12], this gem provides the user with the RSpec suite correctly optimised and set-up to be used within a RoR environment. The programmer will also be using FactoryGirl [18] a higher grain of control over mock models, and WebMock [1] to be able to mock API connections with test data.

2.2.2 OAuth

The application will use the OAuth standard for authentication to the application, OAuth is an open protocol that offers `secure client delegation'. By delegating a different user token for each user the server can serve user specific data to each user, whilst ensuring statelessness. The use of OAuth will also restrict server resources to defined applications, allowing a higher level of control to the applications that utilise the API.

2.2.3 Routes

Ruby on Rails allows for a series of URL routes to be defined, to ensure the project follows REST principles the API the interface is required to be uniform, for this all requests will be responded in JSON and will be in the format similar to snippet 1. The API URI structure should also be representational of the data being served and how the data is structured in the database. Table 2.1 shows the endpoints and accessors for the data that's available through the API. The returned data will also be paginated using the gem api-pagination [**?**] the pagination URIs will be formed as part of the header information of the response to keep the returned body easy to parse.

Example Code 1 Example JSON output for REST requests

```
{
`code' => `201',
`errors' => `',
`body' => [ ]
}
```

Table 2.1: API Routes

Verb	URI Pattern	Controller#Action
GET	/api/v1/events(.:format)	api/v1/events#index
GET	/api/v1/events/:id(.:format)	api/v1/events#eventByID
GET	/api/v1/venues(.:format)	api/v1/venues#index
GET	/api/v1/venues/:id(.:format)	api/v1/venues#show
GET	/api/v1/venues/:id/events(.:format)	api/v1/events#eventsByVenue
POST	/api/v1/register(.:format)	api/v1/user#register
GET	/api/v1/user(.:format)	api/v1/user#index
POST	/api/v1/user(.:format)	api/v1/user#update
GET	/api/v1/user/feed(.:format)	api/v1/user#feed
GET	/api/v1/user/following(.:format)	api/v1/following#index
POST	/api/v1/user/follow(.:format)	api/v1/following#followEvent
POST	/api/v1/user/unfollow(.:format)	api/v1/following#unfollowEvent
GET	/api/v1/categories(.:format)	api/v1/categories#index
GET	/api/v1/categories/:id(.:format)	api/v1/categories#show
GET	/api/v1/categories/:id/events(.:format)	api/v1/events#eventsByCategory
GET	/api/v1/cities(.:format)	api/v1/cities#index
GET	/api/v1/cities/:id(.:format)	api/v1/cities#show
GET	/api/v1/cities/:id/events(.:format)	api/v1/events#eventsByCity
GET	/api/v1/cities/:city_id/venues(.:format)	api/v1/venues#venuesByCity
GET	/api/v1/cities/:city_id/categories(.:format)	api/v1/categories#catsByCity

2.2.4 Data mining element

The data mining element is broken up into a 2 different parts these being the interfaces to the external data sources, and the second being the job scheduler. Figure 2.4 shows how these parts will work together to input data from the various API's that's needed. To allow for any number of API's to be added to the system, a base class called `Resources' will be needed with any inherited functions needed Figure 2.3 shows the class diagram for this part of the project. Then another class that inherited from `Resources' will be used to define each individual API connection. By doing this the API is easy to extend simply by working as a interpreter to the different names for data fields and layout for each API response. The scheduler RAKE task will then read in the jobs defined by the administration panel and pull in the relevant information and insert this into the database.

2.2.5 Class diagram

Following on from the MVC design pattern and the fact the API needs to be representational, each controller is representational for each table stored in the database. However in some cases there are filters such as being able to get the events via the venue, since this will return a list of events rather than venues the method to do this is inside the events controller. Figure 2.5 shows the structure of the controllers, and the methods inside of them.

2.3 iOS Application

2.3.1 Development tools

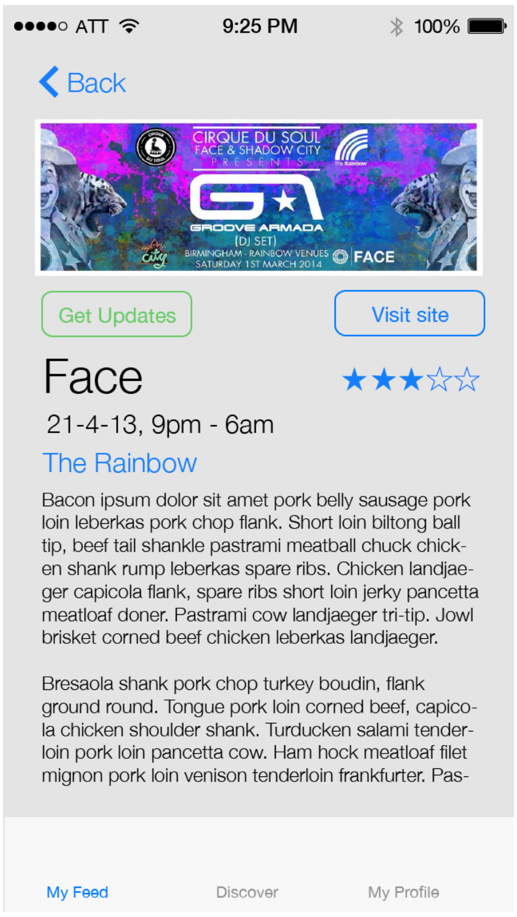
To develop in iOS you are required to use Apples own IDE XCode, version 5 is the latest and supports the latest version of iOS. XCode 5 includes a number of tools bundled with the IDE including the iOS Simulator and GIT Integration. Cocoa pods will also be used for package management and pulling in various libraries that will be used throughout the project. XCode 5 itself is a purpose built IDE for iOS applications and everything that was required came as standard and was used as a one stop solution for the development of the mobile application.

2.3.2 Wireframes

The main application will consist of 2 main views these being a list of events with some filter applied and the event details themselves. Figure 2.6 depicts a rough outline of where elements will be positioned and the possible interactions a user can undertake. Figure 2.8 shows the various different ways I could present the data using the iOS' table view to show list events happening, the list of events screen will be re-usable and able to show a list of events with a wide range of filters applied to it. The filters applied will be dependant on how the user access the list view be it through the `Discover' tab or the `My Feed' tab.

The wireframes show the 3 key different screens, the first being the `My Feed' tab this tab is used to show the users personalised feed, this will utilise the list view for the events and then when an event is selected it will show the user the selected event using the individual event view. The second is the `Discover' tab this will be used to be able to select events from a particular city, it will then give you the option to select a particular category or venue to see relevant events to the selector chosen. The third is the `My Profile' tab this will be where you can see your information potentially change it and view the events you are following, this will also present you with the option to `unfollow' these events as well.

Figure 2.6: Basic wireframes and design choices for the mobile application



Bacon ipsum dolor sit amet pork belly sausage pork loin leberkas pork chop flank. Short loin biltong ball tip, beef tail shankle pastrami meatball chuck chicken shank rump leberkas spare ribs. Chicken landjaeger capicola flank, spare ribs short loin jerky pancetta meatloaf doner. Pastrami cow landjaeger tri-tip. Jowl brisket corned beef chicken leberkas landjaeger.

Bresaola shank pork chop turkey boudin, flank ground round. Tongue pork loin corned beef, capicola chicken shoulder shank. Turducken salami tenderloin pork loin pancetta cow. Ham hock meatloaf filet mignon pork loin venison tenderloin frankfurter. Pas-

Figure 2.7: Individual event wireframe

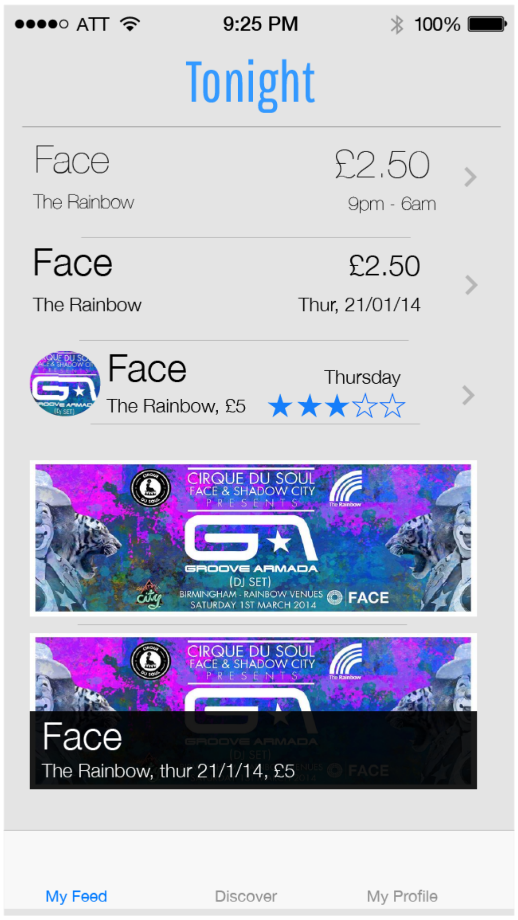


Figure 2.8: List of events wireframe

2.3.3 Class diagrams

The majority of the application design was based on the delegation design pattern where actions and data are linked with the UI elements, and so the mobile application is a series of controllers where it retrieves information and outputs this into the UI. There will be a different controller for each screen that can be viewed as part of the application. Including this I will be using data classes to store and use the data pulled in from the server. Figure 2.9 shows the 2 classes I will be using to keep the data retrieved from the API, these classes are simple data classes that have some functionality applied to them and allow for scope as the project develops.

Figure 2.2: This diagram depicts the various entities, and their interactions with each other.

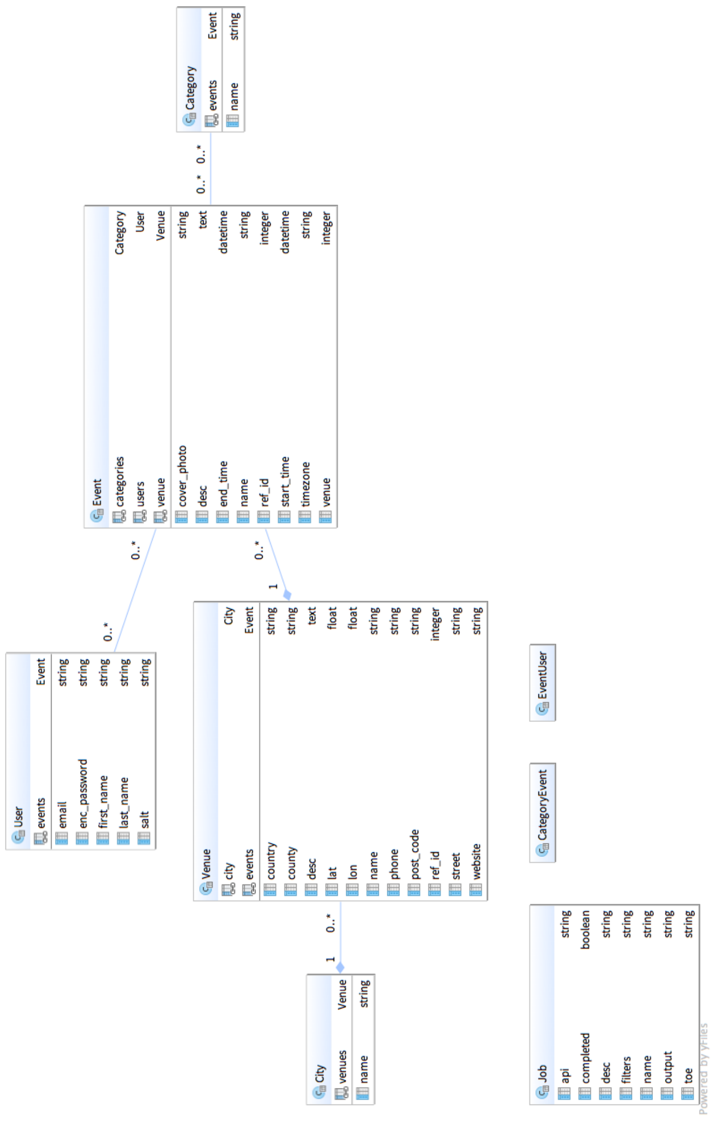


Figure 2.3: This diagram describes the functions and inheritance used for the library that connects to the APIs

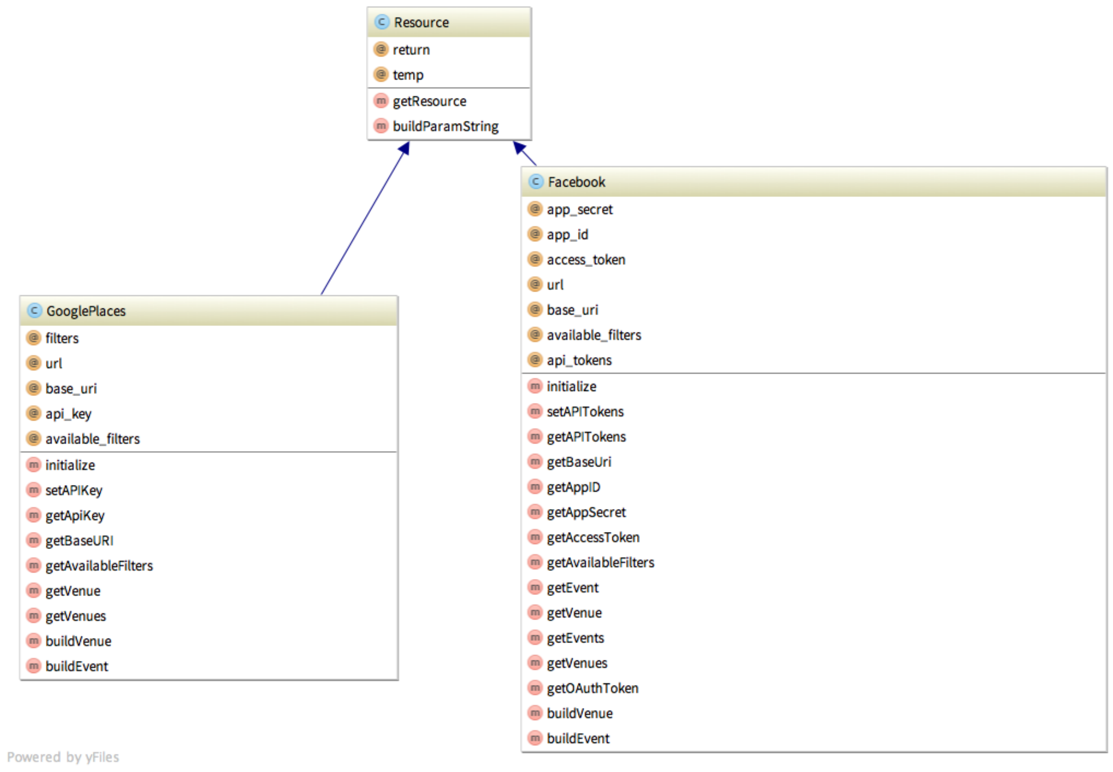


Figure 2.4: This diagram shows an overview of how the different data mining module is composed.

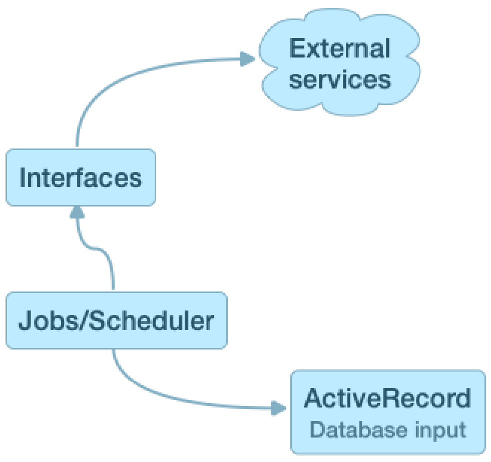


Figure 2.5: This diagram shows the classes along with the methods and class variables

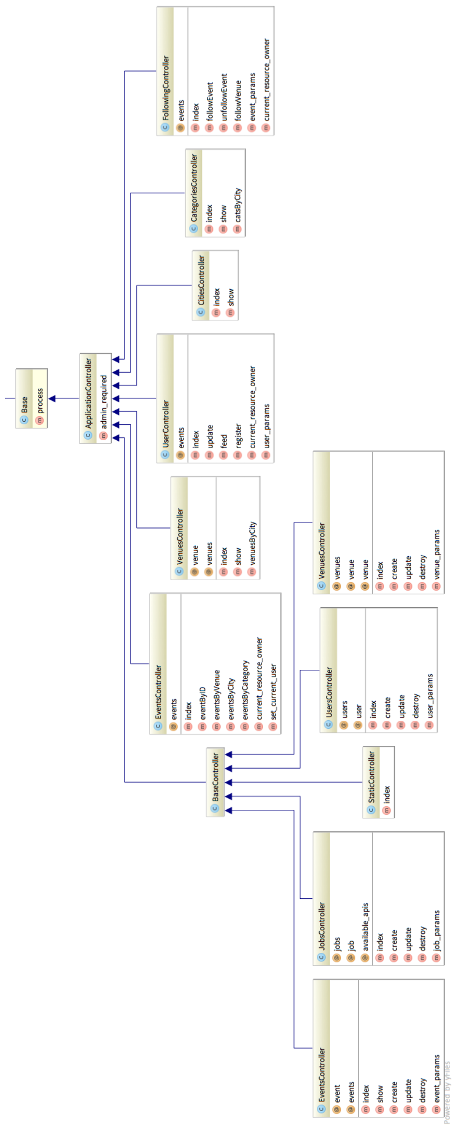
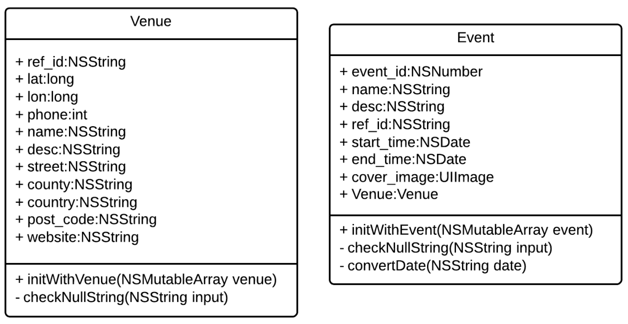


Figure 2.9: Class diagram for the iOS data classes



Chapter 3

Implementation

The implementation should look at any issues you encountered as you tried to implement your design. During the work, you might have found that elements of your design were unnecessary or overly complex; perhaps third party libraries were available that simplified some of the functions that you intended to implement. If things were easier in some areas, then how did you adapt your project to take account of your findings?

It is more likely that things were more complex than you first thought. In particular, were there any problems or difficulties that you found during implementation that you had to address? Did such problems simply delay you or were they more significant?

You can conclude this section by reviewing the end of the implementation stage against the planned requirements.

Chapter 4

Testing

Detailed descriptions of every test case are definitely not what is required here. What is important is to show that you adopted a sensible strategy that was, in principle, capable of testing the system adequately even if you did not have the time to test the system fully.

Have you tested your system on □real users□? For example, if your system is supposed to solve a problem for a business, then it would be appropriate to present your approach to involve the users in the testing process and to record the results that you obtained. Depending on the level of detail, it is likely that you would put any detailed results in an appendix.

The following sections indicate some areas you might include. Other sections may be more appropriate to your project.

4.1 Overall Approach to Testing

4.2 Automated Testing

4.2.1 Unit Tests

4.2.2 User Interface Testing

4.2.3 Stress Testing

4.2.4 Other types of testing

4.3 Integration Testing

4.4 User Testing

Chapter 5

Evaluation

Examiners expect to find in your dissertation a section addressing such questions as:

- Were the requirements correctly identified?
- Were the design decisions correct?
- Could a more suitable set of tools have been chosen?
- How well did the software meet the needs of those who were expecting to use it?
- How well were any other project aims achieved?
- If you were starting again, what would you do differently?

Such material is regarded as an important part of the dissertation; it should demonstrate that you are capable not only of carrying out a piece of work but also of thinking critically about how you did it and how you might have done it better. This is seen as an important part of an honours degree.

There will be good things and room for improvement with any project. As you write this section, identify and discuss the parts of the work that went well and also consider ways in which the work could be improved.

Review the discussion on the Evaluation section from the lectures. A recording is available on Blackboard.

Appendices

Appendix A

Third-Party Code and Libraries

If you have made use of any third party code or software libraries, i.e. any code that you have not designed and written yourself, then you must include this appendix.

As has been said in lectures, it is acceptable and likely that you will make use of third-party code and software libraries. The key requirement is that we understand what is your original work and what work is based on that of other people.

Therefore, you need to clearly state what you have used and where the original material can be found. Also, if you have made any changes to the original versions, you must explain what you have changed.

As an example, you might include a definition such as:

Apache POI library □ The project has been used to read and write Microsoft Excel files (XLS) as part of the interaction with the client□s existing system for processing data. Version 3.10-FINAL was used. The library is open source and it is available from the Apache Software Foundation [**?**]. The library is released using the Apache License [**?**]. This library was used without modification.

Appendix B

Code samples

2.1 Random Number Generator

The Bayes Durham Shuffle ensures that the psuedo random numbers used in the simulation are further shuffled, ensuring minimal correlation between subsequent random outputs [**?**].

```
#define IM1 2147483563
#define IM2 2147483399
#define AM (1.0/IM1)
#define IMM1 (IM1-1)
#define IA1 40014
#define IA2 40692
#define IQ1 53668
#define IQ2 52774
#define IR1 12211
#define IR2 3791
#define NTAB 32
#define NDIV (1+IMM1/NTAB)
#define EPS 1.2e-7
#define RNMX (1.0 - EPS)

double ran2(long *idum)
{
  /*--------------------------------------------------*/
  /* Minimum Standard Random Number Generator         */
  /* Taken from Numerical recipies in C               */
  /* Based on Park and Miller with Bays Durham Shuffle */
  /* Coupled Schrage methods for extra periodicity     */
  /* Always call with negative number to initialise    */
  /*--------------------------------------------------*/

  int j;
  long k;
  static long idum2=123456789;
  static long iy=0;
  static long iv[NTAB];
  double temp;

  if (*idum <=0)
  {
    if (-(*idum) < 1)
    {
      *idum = 1;
    }else
    {
      *idum = -(*idum);
    }
    idum2=(*idum);
    for (j=NTAB+7;j>=0;j--)
    {
      k = (*idum)/IQ1;
      *idum = IA1 *(*idum-k*IQ1) - IR1*k;
      if (*idum < 0)
      {
        *idum += IM1;
      }
      if (j < NTAB)
      {
        iv[j] = *idum;
      }
    }
    iy = iv[0];
  }
  k = (*idum)/IQ1;
  *idum = IA1*(*idum-k*IQ1) - IR1*k;
  if (*idum < 0)
  {
    *idum += IM1;
  }
  k = (idum2)/IQ2;
  idum2 = IA2*(idum2-k*IQ2) - IR2*k;
  if (idum2 < 0)
  {
    idum2 += IM2;
  }
  j = iy/NDIV;
  iy=iv[j] - idum2;
  iv[j] = *idum;
  if (iy < 1)
  {
    iy += IMM1;
  }
```

```
  if ((temp=AM*iy) > RNMX)
  {
    return RNMX;
  }else
  {
    return temp;
  }
}
```

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