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Category (Enter the category in which the project was done. E.g. Operations Research, Simulation, Logistics…)	Operations Research, Database Handling, Programming
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Optimisation of the Virgin Active Group Exercise Communication System

by

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Submitted in partial fulfilment of the requirements for
the degree of

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Optimisation of the Virgin Active Group Exercise Communication System

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Executive Summary

Every Virgin Active health club has several independent instructors that teach group exercise classes at the facility. The current method of communicating with staff is very archaic and can be greatly improved upon. Not only in speed, but also potentially saving large amounts of money. Currently, there is no proper communication channel apart from SMS, IM, phone calls or the occasional email. The aim of this project is to write and trial a mobile application running on the iOS platform to accommodate most instructors. This will allow the club to easily communicate with a large number of instructors without the need to phone them one at a time or have the possibility of double bookings occurring. With the majority of clubs scheduled to get Apple iPads, using the iOS platform to write an application is an excellent way for managers to communicate with their respective instructors when the latter cannot teach their class.

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Chapter 1

Introduction and Background

Virgin Active SA forms part of Richard Branson's larger Virgin Group. The company bought the assets of the Health and Racquet Club chain after the latter's parent company, Leisurenet, had been placed in liquidation in October 2000 (Mathews, 2002). The 100th club opened its doors in August 2012, making Virgin Active SA by far the largest chain of health clubs in the country. It should be noted that the facilities provided by Virgin Active are referred to as health clubs and not "gymnasiums" or "gyms" and this will also be the terminology used throughout the entire project.

Every club has a hierarchy of management positions with various heads of department (HOD) each responsible for certain aspects of the club. This hierarchy is demonstrated in Figure 1.
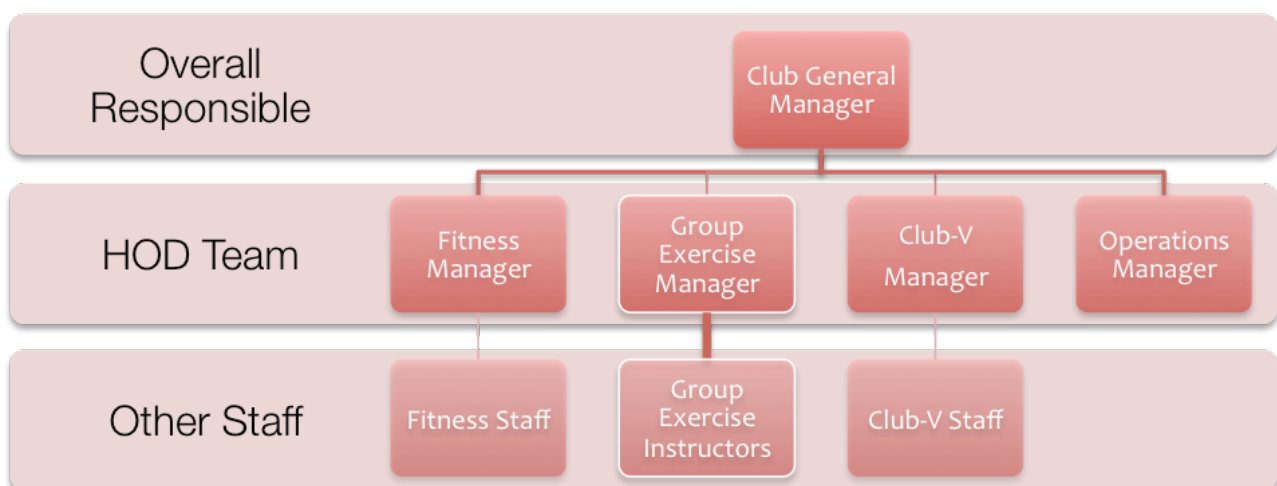
Figure 1 - Club Staff Hierarchy

The Group Exercise Department

Special attention should be devoted to Group Exercise Instructors (GEI) – staff who are subcontracted by Virgin Active to teach a variety of classes at each health club – including, but not limited to Spinning, Step, Yoga and Pilates. GEIs are not all qualified in all different class types and many teach at more than one health club – with each club generally having between 10-50 instructors. Thus,

some GEIs focus on teaching only one or two class types with a higher specialty in their field of expertise. Experience, qualifications and performance all affect a GEI's salary. The responsibility concerning the governing of classes, completing timetables, communication with GEIs and finding GEIs called "fill-ins" (to cover a particular GEI if they are unable to teach the specific class) rests solely on the Group Exercise Manager (GEM).

In contrast to regular staff that have certain daily shifts, GEIs only work at a club during the hours they teach classes. Traffic conditions and illness are two of the largest factors than can cause an instructor to miss their class without managing to find a replacement instructor. This event is known as a "no-show".

General employment benefits do not extend to GEI as they are seen as Independent Group Exercise instructors. However, the term GEI will be used for the entire project when referring to instructors that teach classes at health clubs.

It is critical that the reader fully grasps the idea of GEI and GEM to ensure proper comprehension of the entire project.

As seen by the bold link in Figure 1 on page 1, the communication between GEM and GEI is seen as the main target for improvement and what the project focuses on.

Finding a Fill-in

When a GEI cannot teach one of their classes due to whatever reason, they are required to inform the GEM as soon as possible. Through consulting a list of GEIs with all the necessary qualifications to cover the class, the GEM must then phone or email the GEIs about the available class. Once the GEM finds a suitable fill-in, they can update the online timetable to ensure members know who will be teaching the class – this process in shown through a FFBD in Figure 2. Due to the importance of classes starting on time and GEMs being informed of unavailable GEIs with inadequate notice, time is a prominent element in the process. Thus, in the majority of cases GEMs need to find fill-ins very quickly to avoid a no-show.
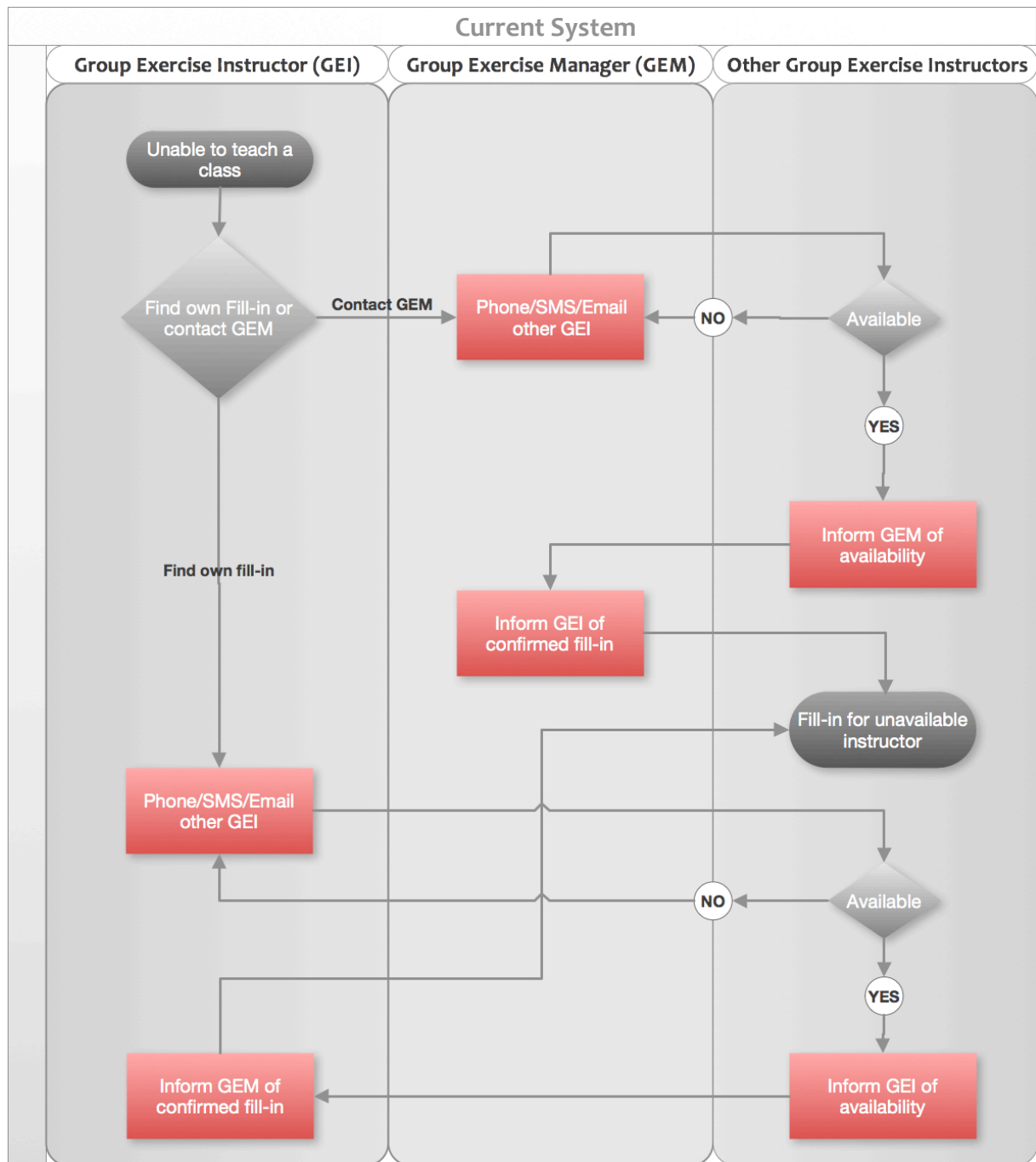
Figure 2 - The Process of finding a Fill-in

Project Aim and Initial Requirements

Currently, there is no proper communication channel apart from SMS, Instant Messaging (IM), phone calls or email for a GEM to contact their GEIs. This project aims to simplify the entire process.

Initially the project will be concerned with determining communication capabilities of current GEIs in order to establish how advanced the system can be on the user end and whether the system can

also be used to directly communicate with the GEIs. The feasibility of an application for the iPad and iPhone that runs on iOS operating system will then be determined.

Through Operations Research, Database Management and Programming, a solution should utilise a platform on which GEIs and GEMs can communicate easier, in bulk and faster. As a result of this, it will be necessary to gain an in-depth understanding of the programming language Objective-C, as the iOS operating system for both the iPad and iPhone is written in this language. Only after mastering Objective-C ideas and methods for determining the best fill-in for the right class can ideas be put into code, tested and simulated. The application will need to calculate, based on a number of constraints, which GEI to contact about the available fill-in position. Although described easily, this will make up a critical component of the application, as both the speed, accuracy and efficiency will be the main driving force to implement the application.

After writing the application, designing a GUI (Graphic User Interface) can be seen as an added feature to the project, although the original scope does not include this. Because of time being a massive constraint, the full implementation of the application cannot be included in the scope of this project. Although the later implementation seems rather definite, the finalising and branding of a product may take an excess amount of time for which the project does not allow.

A trial phase plan at a small number of health clubs is included as the final part of the project in order to test the practicality of the new system in the future. The system can be expanded to automatically update online timetables on the Virgin Active website. The project scope does not include the synchronisation with any of the current databases the company employs; information relating to qualifications and other personal information of Virgin Active staff.

Proposed System

Where the current system mainly uses phone calls and a GEM's best guess for the right fill-in, the proposed system will use optimisation techniques to best fit the scenario. Apart from saving money, through eliminating many unnecessary phone calls, the system is aimed at saving time and being generic in order to be applied to different database without requiring any programming effort. This proposed system is graphically depicted in Figure 3. When more than one instructor responds to an available fill in position, it is awarded on a first come, first serve basis.

The focus for the project is highlighted in Figure 3 by a light square. Although the rest of the system is important, there is no need to include explanations of this in the project.

The dashed lines and dimmed process steps show a possible future expansion to the application. Because this expansion of the project mainly falls under programming, it is not as applicable to the Industrial and Systems engineering aspects of the project requirements. Other reasons for excluding these steps are discussed in the literature review in the chapter 2.
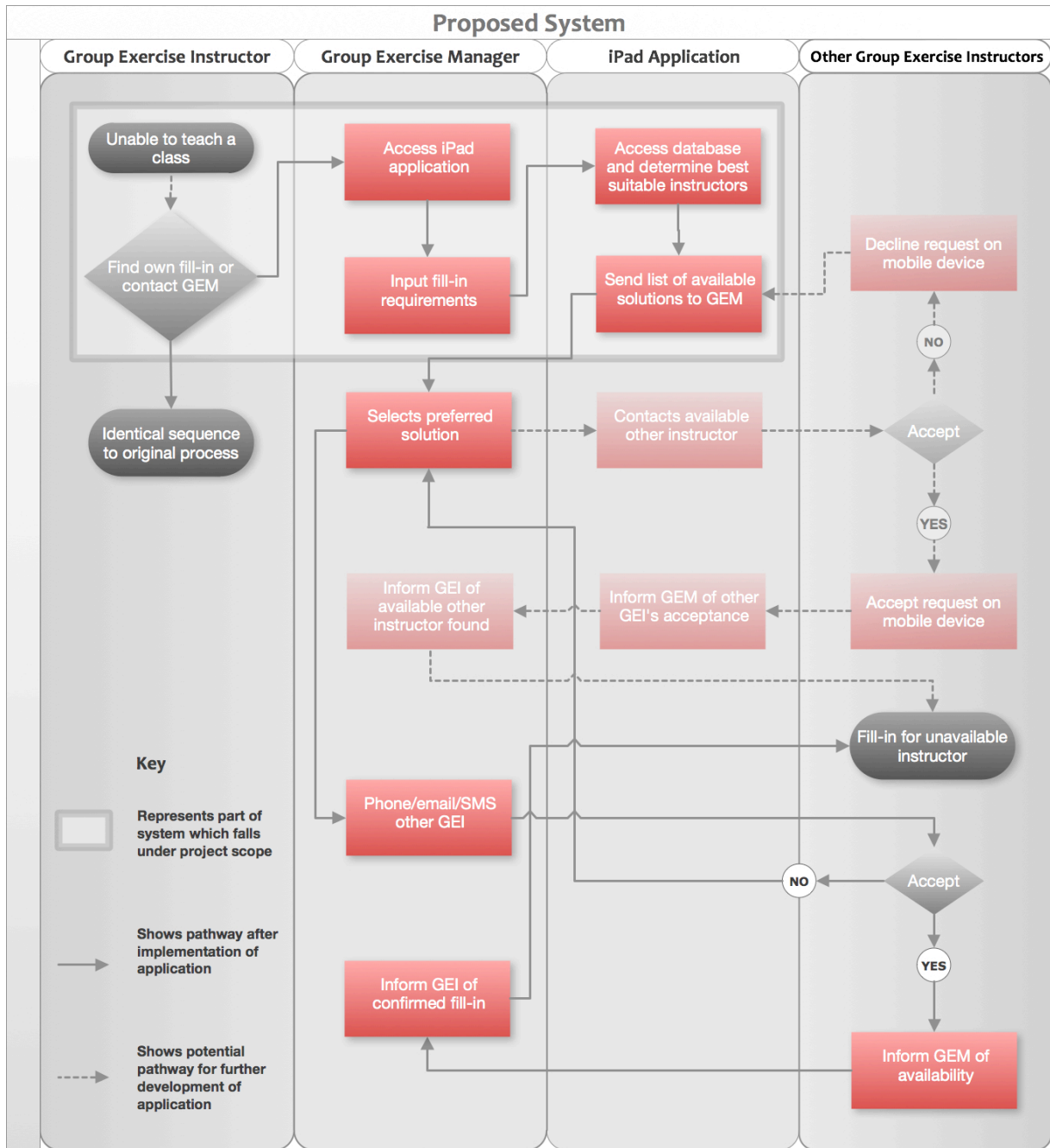
Figure 3 - The Proposed System

Project Plan

Activities and Resources

Consultation by the supervising lecturer and mentorship by Virgin Active staff will be on-going.

Mentorship will be provided by both the regional level (Gauteng North Product Manager) and national level (Head of Innovation and Talent).

Both Devoe (2011) and Brant (2010) provide incredible insight to the development of iOS based applications. These books will be the main source of information relating to the programming and database aspects of the application.

Chapter 2

Literature Review

The aim of this review is to introduce the necessary requirements for writing and implementing the mobile application. Fundamental aspects of the health club and group exercise environment are addressed first. Because programming and associated database requirements are not specific to the group exercise environment and follow a much more generic approach, they are therefor discussed separately.

Operating System Support

Feasibility is the main concern for failure of the application. Issues relating to the practicality are addressed and described by information gathered by Virgin Active Gauteng North Regional Office (Oosthuisen, 2012). As seen in Figure 5, 100% of instructors have access to a mobile phone. Although only 9% will have access to the iOS application through an iPhone handset, the trend in phone adoption as well as a multi-phased approach is considered.

Considering international adoption trends, the large percentage of Blackberry smartphones in South Africa is somewhat of an anomaly. This can largely be attributed to the associated inexpensive data bundles and mobile service providers' subsidies through contracts. Research In Motion (RIM) (the company producing Blackberry devices) has seen their handset shipments drop by 21% in the last quarter of 2011. Information relating to iPhone adoption shows a gradual increase over the last few years in both the local and international market. Following international trend, iOS adoption in South Africa should continue to steadily increase over the next number of years (Tarrant, 2012). Although the handset adoption should be a strong indicator to what operating system the application should be written for and because only one can be accommodated at first, more elements are considered.

Using the Java platform to accommodate Blackberries is not chosen due to a number of reasons:

- Virgin Active is due to introduce an iPad at every club in the near future. This enables all GEMs to use the same platform for communication, whereas they do not all currently have Blackberry handsets.

- The statistics obtained from the Instructor Communication Research data does not include iPads. This can have a significant impact on users' iOS accessibility.

- A Blackberry application can be developed at a later stage to accommodate a larger share of the phone demographics, but currently the complexity of such a system falls outside the scope of this project.
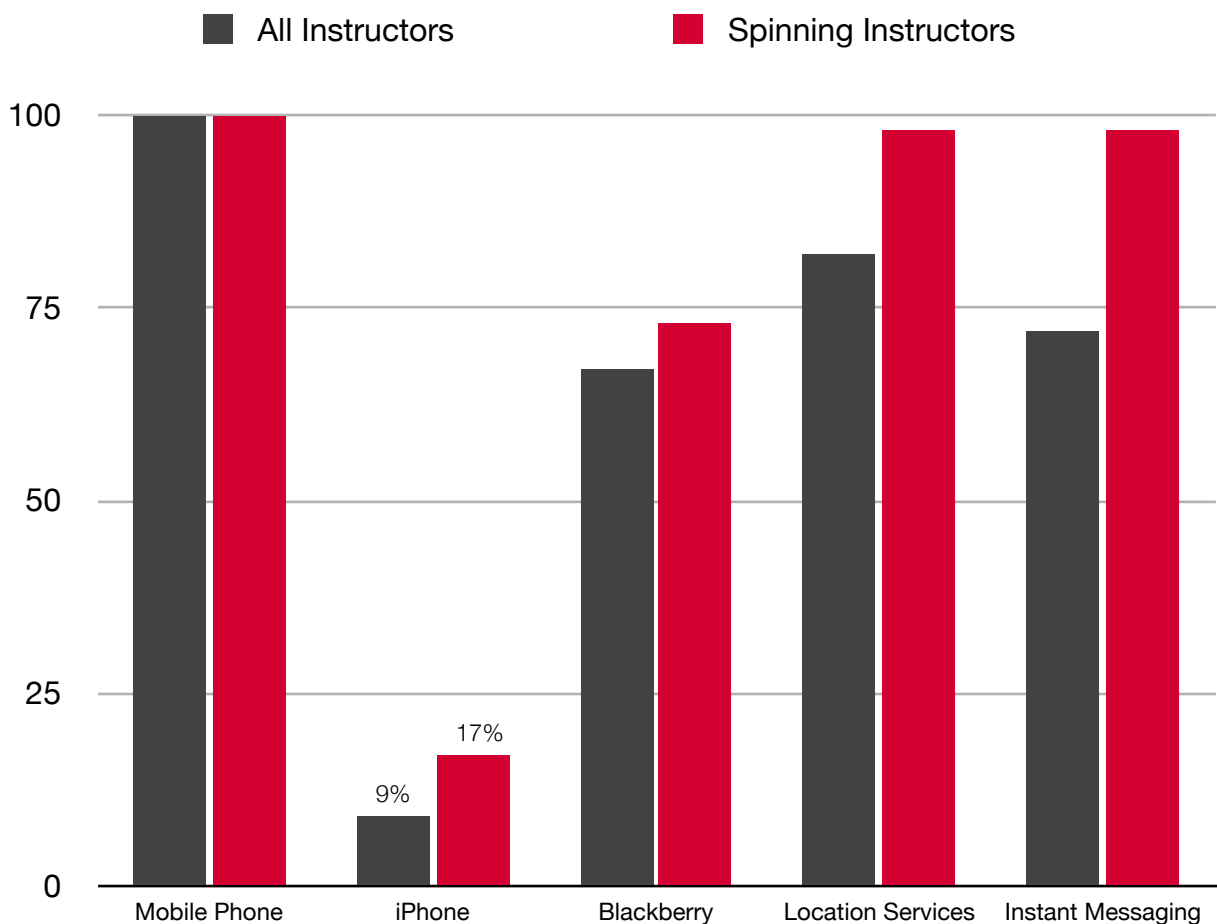
Figure 4 - Instructor Handset Research

Due to the low number of GEIs that can be contacted through their iPhones, it is decided that the application will be written for the iPad that is used at each club. The GEM can then contact the instructor manually based on the application's recommended solutions. Refer to Figure 3 on page 5 to see the part of the system (dimmed out) that can be added at a later stage if more GEIs can be reached.

Programming and the Database Requirements

Software changes a lot. One of the best approaches when coding is to keep the code easily changeable. This is very applicable to live databases (Stevenson, 2010).

In his tutorial on Creating an iOS 5 Database Application, software architect Kevin Languedoc recommends the use of SQLite. iOS 5 and SQLite make a powerful combination for building data persistent to iPad, iPhone or iPod Touch mobile applications. The iOS 5 Software Developer Kit provides native support for SQLite through the use of the C programming language.

Implementation

The implementation of a system that increases efficiency is very dependant on a thorough adoption in order to be successful. The system will therefore only promote increased response and fill-in finding times when used by the majority of health clubs. Due to the natural human resistance to change, attention will have to be awarded to each GM in order to ensure their respective GEM is using the application (Freivalds, 2009).

When regarding the low iOS adoption among instructors, it appears to be a hurdle for the proper functioning of the application. However, a larger view of the group exercise instructors shows how this can be overcome. The number of classes by class type for the average health club on a weekday can be seen in Table 1.

Class Type	Kick	Indoor Cycle	Dance Based	Yoga	Shape
No. Of Classes	1.6	6.2	1.8	2	2.2

Table 1 - Average number of Classes by Class Type

The majority of instructors are qualified to teach an indoor cycle class. This class type is also the leading type of class at most health clubs with more than three times the number of classes than any other type. Considering this, focus for a trial application will only be made based on indoor cycle classes, as this makes up the largest share of instructors as well as classes on the average group exercise timetable.

A second reason for focusing mainly on Indoor Cycle for the application trial run, is the handset adoption for this instructor demographic group. Indoor Cycle GEIs have an iOS accessibility through iPhones of 17% compared to the overall average of 9%. Wider adoption can thus be ensured for the trial.

The application's reliability will ensure it's continued use. Only after getting very comfortable with the use of it will instructors refrain from reverting to their old methods of communication.

Instructors can download the finalised application to their mobile phones only after the application has been submitted to the Apple Online App Store and been approved by Apple (Brant, 2010). A number of guidelines and rules are presented by Apple to which all application behaviour must adhere. Should these rules be broken, the application cannot be run on iOS devices. Approval by Apple can take up to 3 weeks from date of submission (Apple Inc., 2010). Applicable App Store guidelines can be found in Appendix A. Only the relative guidelines have been included from the extensive list.

Scheduling and Optimisation

Following work scheduling examples from Winston et al (2003), LP (linear programming) can be used to schedule GEIs to certain classes. LP allows for an unambiguous way of stating the problem. An objective function must be designed to not only run off a number of constraints or rules, but must also incorporate a form of optimisation.

To accommodate the whole day's classes (starting at 5h00 and finishing at 20h00), 30 minute time slots can be used. Class lengths are typically 30, 60 or 90 minutes.

A penalising strategy can be used in order for the objective function to choose a more ideal GEI over a less ideal GEI. Implementation of this concept can be achieved through an instructor rating system. There are a number of ways to determine when an GEI is a good candidate as a fill-in:

- Location - Distance from a club means that GEIs take longer to get there and are less likely to accept a proposal as fill-in. It also makes them less reliable as the more road they are exposed to, the larger their chances of hitting traffic congestion gets.

- Fatigue - If a GEI has taught in the previous time slot(s), they are likely to be tired and will be unable to teach at their full potential.

- Arrival Reliability - Should a GEI have a record of no-shows, they would be deemed unreliable and bad candidate as fill-in.

Due to the frequent (dynamic) change of the problem, it is seen as a control problem (Talbi, 2009). The optimisation is not used for a single once-off solution, but instead it may be used as frequently as a number of times daily.

Due to the algorithm not knowing if the "best" solution is the proven most efficient solution it is considered to be a combinatorial NP-hard problem.

Technical and Financial Feasibility

The proposed design is deemed very feasible due to the availability of devices at clubs, as well as the ability to create a database to house the required information required for the optimisation.

In terms of the cost of design, trial and implementation, the project is rather inexpensive as very few extra costs need to be added. The company will buy iPads regardless of this project. At the same time it is putting together an online database of GEIs' details as it was stored in physical files up to now.

Conclusion

The iOS platform is selected as operating system for the application. A straight forward LP will be set up which attains some of its values though a genetic algorithm finding the best solution for instructors with their current rating.

For the trial phase, only Indoor Cycling classes will be used.

The project is deemed both technically and financially feasible.

Chapter 3

Problem Solving

Requirements for the programming of the database revolve around a standard SQlite database for which an Entity Relationship Diagram can be found in the Appendix. It is believed that SQLite is the most widely used SQL database engine due to its capability to be used as an embedded database. Other database engines, such as MySQL or Oracle are typically found running on a server. One server is able to serve a large number of users. SQLite differs in that a single user will generally have exclusive use of multiple copies of SQLite (SQLite, 2010)

A LP is written with a maximising objective function which is subject to a number of constraints which are explained in the next section.

Declarations

$$\bar{I}$$
Each instructor is given a unique number.

$$\bar{J}$$
Due to the large number of class time, location and type combinations available, each unique instance is created and assigned a number j. It should be noted that consecutive numbers of j do not necessarily follow chronologically or indicate the same location.

$$x_{ij}$$ Instructor i teaching class j

Where i,j = {1,2,3,…,n}

= { 1 when instructor i teaches class j

0 otherwise

$$v_{ij}$$ Value of instructor i teaching class j.

Where i,j = {1,2,3,…,n}

$$j_{max}$$ This is the total number of classes that will be taught on a specific day.

An instructor that is allocated to their permanent slot is allocated a the maximum value of 100, as this is the preferred instructor to class combination. Several conditions determine the value of a fill-in candidate.

Because the time and location of two classes will need to be compared, an explanation is discussed in relating to which sequence pairs of classes are undesirable, or simply not allowed. For the time being, sequence pairs will fall under:

$$\overline{L}$$ This includes pairs of classes that are not allowed to follow consecutively due to their location relative to each other. Eg. {(8,15); (2,3); (13,8)}

$$\overline{S}$$ This includes pairs of instructors with classes that are not allowed due to the instructor not having the necessary skills to teach the class.

$$\overline{T}$$ This includes pairs of classes that are not allowed to follow consecutively due to the combination being impossible in terms of time. Such as a 17h00 class followed by a 15h00 class.

Objective Function

$$\max z = \sum_{i \in \bar{I}} \sum_{j \in \bar{J}} (x_{ij} v_{ij} + ny)$$

The n element will hold a large negative number to multiply by y the number on no-shows. The reason being that solutions with no-shows are still possible solutions albeit the most undesirable. This ensures that any solutions with a no-show has a very low z value.

Subject to

$$x_{ij} = 0 \quad \forall \ (i,j) \in \bar{L}$$

$$x_{ij} = 0 \quad \forall \ (i,j) \in \bar{S}$$

$$x_{ij} = 0 \quad \forall \ (i,j) \in \bar{T}$$

$$x_{ij} + x_{ik} \leq 1 \quad \forall \ (i,j,k) \in \bar{L}$$

$$n = j_{\max} - \sum_{i \in \bar{I}} \sum_{j \in \bar{J}} (x_{ij})$$

Chapter 4

Metaheuristic

With reference to (Talbi, 2009) the following template can be used for the genetic algorithm to put together the different types of sequence pairs if they are not manually drawn up for each region. However, when trailing the application, the sequence pairs will be added manually as there are only a small number of combinations.

```
Initialise the population of q individuals;

Evaluate the q individuals;

Repeat

    Generate p offspring from q parents;

    Evaluate the p offspring;

    Replace the population with q individuals from parents and
    offspring;

Until Stopping criteria

Output Best individual or population found
```

Chapter 5

Interface Design

A red, orange and yellow interface theme is selected to symbolize aerobic, conditioning and relaxation class types respectively. This falls in line with the current standard of representation on the Virgin Active time tables. The application icon is an instructor doing a familiar yoga pose.


When the application is launched, the welcome screen asks for the GEM to input their login details. They also have the option of registering a new user should they be using the application for the first time. Their staff number is used as username as this is a unique identifier for each GEM.
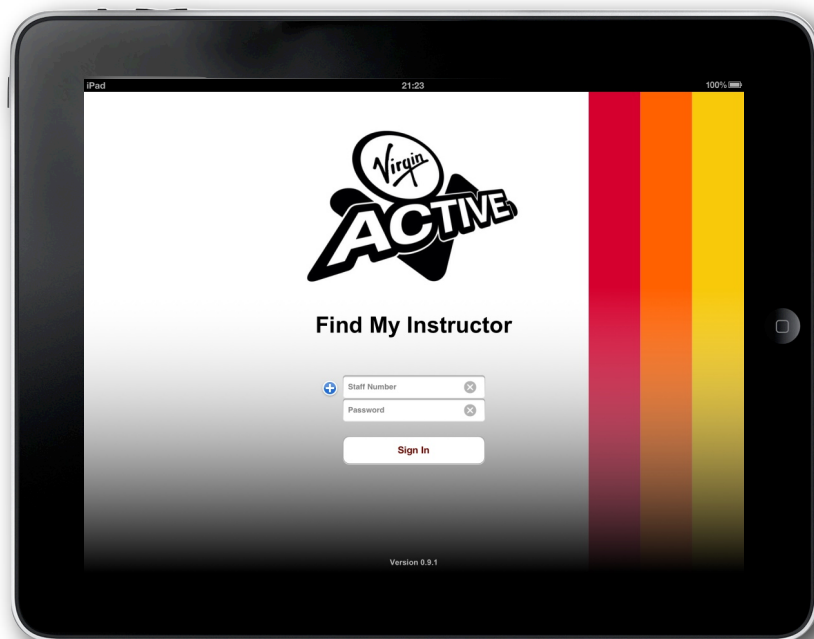
After signing in, the first screen to appear allows the user a number of options on the left hand side column. They can select *Instructors* to get information on what home club an instructor has. Gain contact details on instructors and review their qualifications.
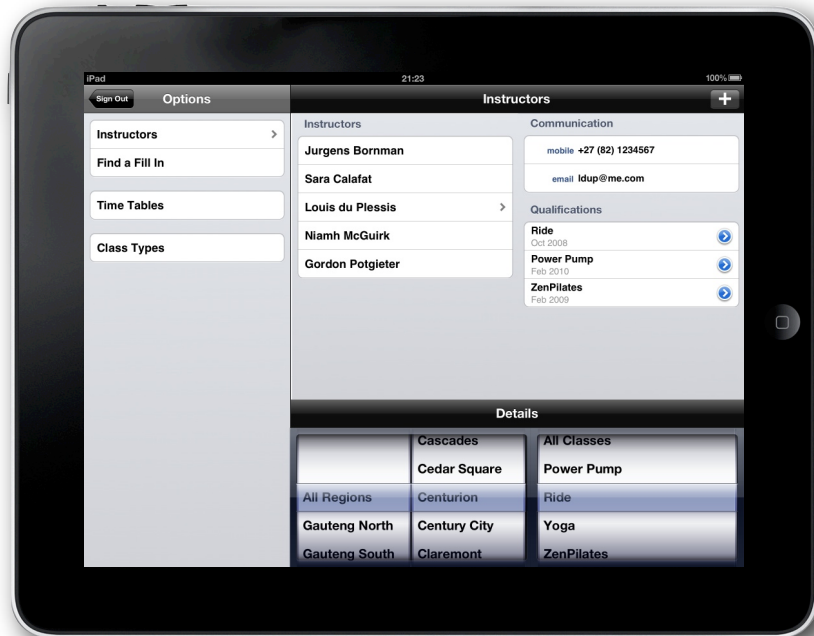

The most important option is *Find a Fill In*. The GEM's home club is automatically selected, as this is their workplace. They are not expected to find a fill in for other clubs. They must first enter the date, time and type of class they need a fill in for.
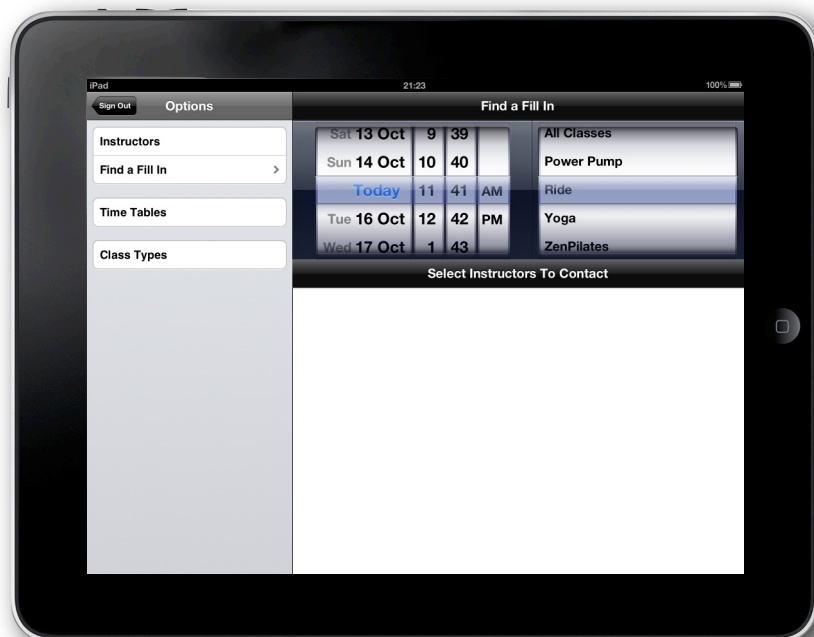
Once the details concerning the class are all selected, the application will request whether the user is certain about the input details. This step is necessary as it may take some time to when more than one instructor is shifted across multiple time tables. Selecting *Search* will start the process.


In the next step. The application shows possible fill ins for the required class. It also lists *Multiple Fill in Solutions* which are solutions where more than one instructor will be shifted across time tables. The GEM can then select all the single fill instructors they want to contact by tapping on their names. A tick will appear next to their names to show they have been selected. The *Send Request* button is the pressed.
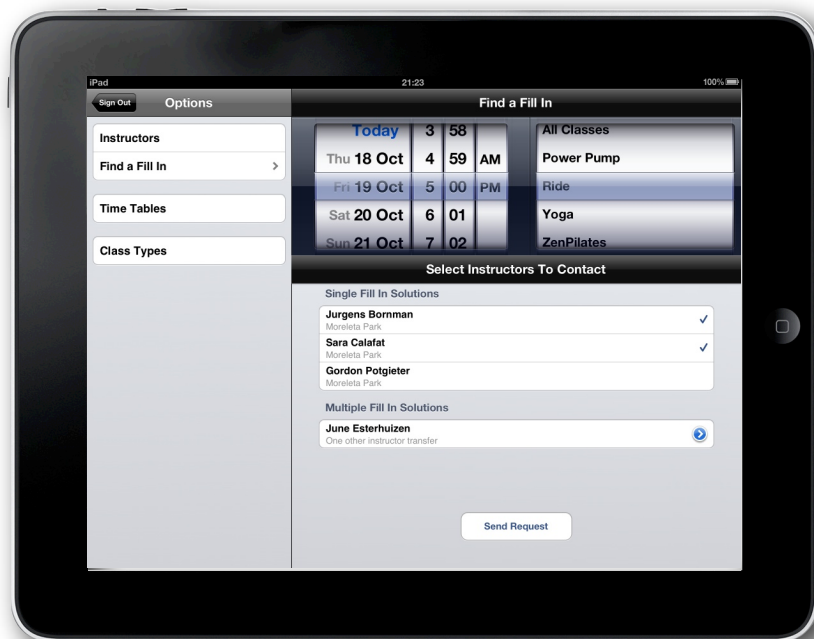
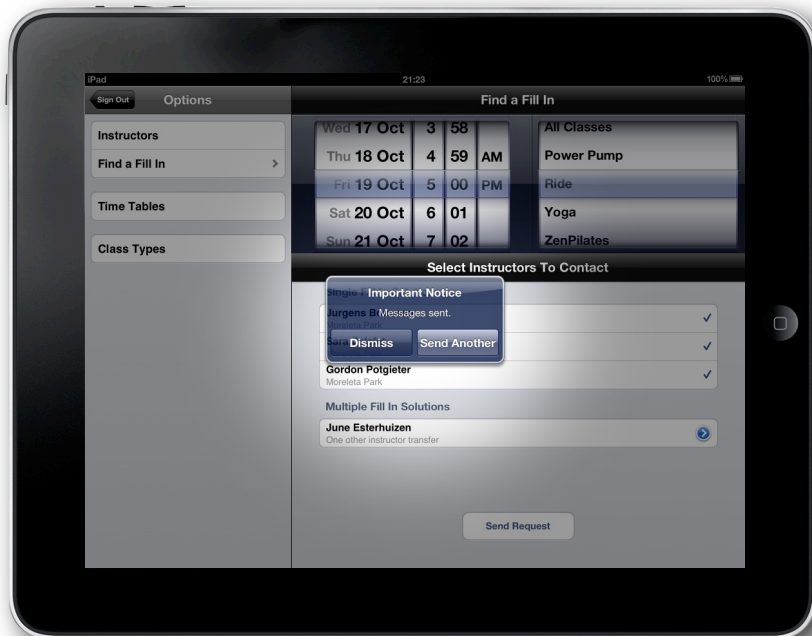Before the instructors are contacted through the system, the GEM must confirm the details and number of instructors about to be contacted.
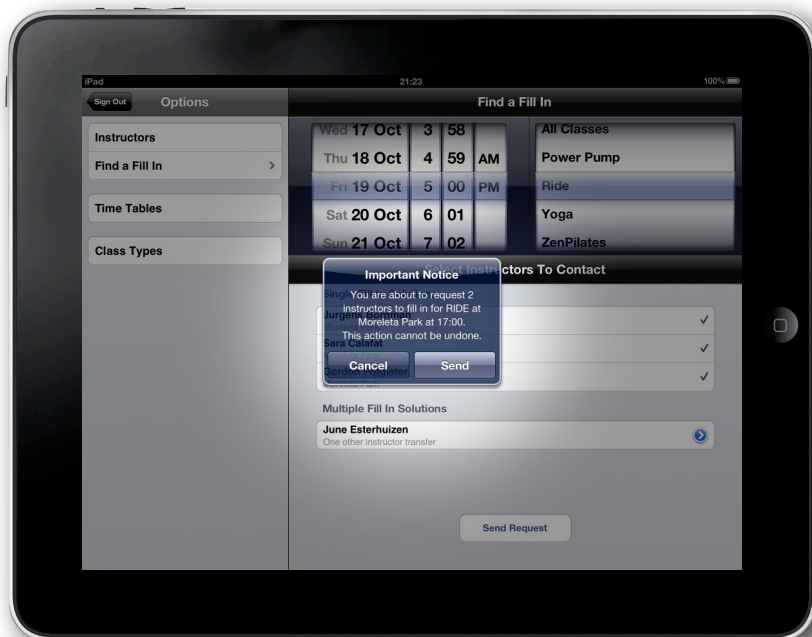
The GEM then has the option of contacting more instructors or returning to the starting *Find A Fill In* page.

More features such as viewing club time tables, or gathering more information about class types can be added to make the application more functional in future.

Chapter 6

Application Trial

Virgin Active does not allow for the trialling of new services at any of its flagship health clubs. Considering the number of instructors and their iOS access, as well as the proximity to each other, 3 clubs have been selected for the trial phase of the application.

Figure 6 - Trial Club Locations
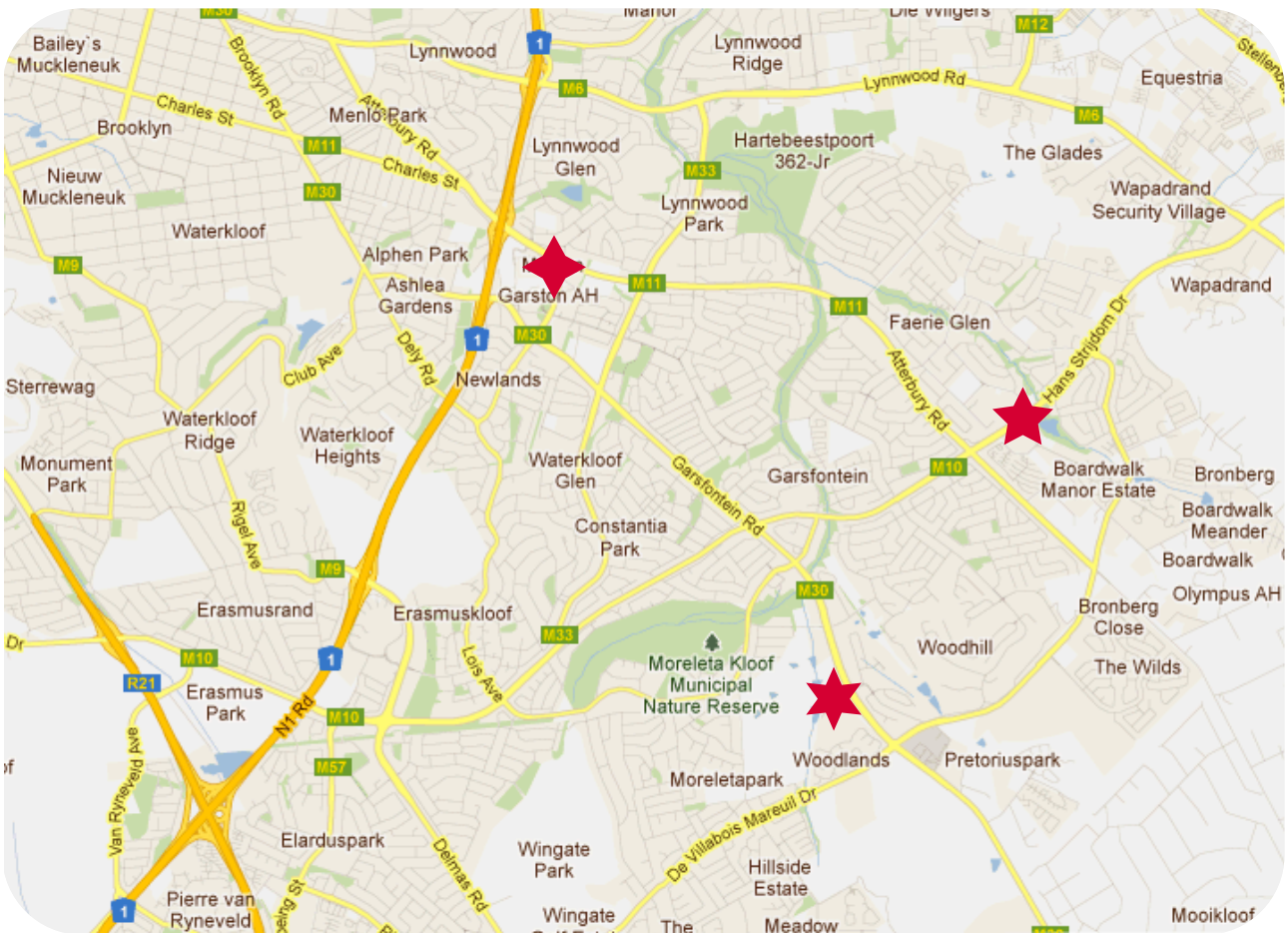
All three clubs have Spinning studios and fall within a 5km radius of each other. This ensures that instructors are always in close proximity to each of the clubs if they live in the surrounding areas.

Club Name	Instructors	Symbol
Menlyn	26	◆
Faerie Glen	19	★
Moreleta Park	32	✶

Table 2 - Trial Club Details

Appendix

Application Requirements set out by Apple

2. Functionality

2.1 Apps that crash will be rejected

2.2 Apps that exhibit bugs will be rejected

2.4 Apps that include undocumented or hidden features inconsistent with the description of the app will be rejected

2.9 Apps that are "beta", "demo", "trial", or "test" versions will be rejected

2.10 iPhone apps must also run on iPad without modification, at iPhone resolution, and at 2X iPhone 3GS resolution

2.15 Apps larger than 20MB in size will not download over cellular networks (this is automatically prohibited by the App Store)

2.16 Multitasking apps may only use background services for their intended purposes: VoIP, audio playback, location, task completion, local notifications, etc

4. Location

4.1 Apps that do not notify and obtain user consent before collecting, transmitting, or using location data will be rejected

4.2 Apps that use location-based APIs for automatic or autonomous control of vehicles, aircraft, or other devices will be rejected

4.3 Apps that use location-based APIs for dispatch, fleet management, or emergency services will be rejected

5. Push notifications

5.1 Apps that provide Push Notifications without using the Apple Push Notification (APN) API will be rejected

5.2 Apps that use the APN service without obtaining a Push Application ID from Apple will be rejected

5.3 Apps that send Push Notifications without first obtaining user consent will be rejected

5.4 Apps that send sensitive personal or confidential information using Push Notifications will be rejected

5.7 Apps cannot charge users for use of Push Notifications

8. Trademarks and trade dress

8.5 Use of protected 3rd party material (trademarks, copyrights, trade secrets, otherwise proprietary content) requires a documented rights check which must be provided upon request

8.6 Google Maps and Google Earth images obtained via the Google Maps API can be used within an application if all brand features of the original content remain unaltered and fully visible. Apps that cover up or modify the Google logo or copyright holders identification will be rejected

10. User interface

10.3 Apps that do not use system provided items, such as buttons and icons, correctly and as described in the Apple iPhone Human Interface Guidelines and the Apple iPad Human Interface Guidelines may be rejected

10.6 Apple and our customers place a high value on simple, refined, creative, well thought through interfaces. They take more work but are worth it. Apple sets a high bar. If your user interface is complex or less than very good it may be rejected

17. Privacy

17.1 Apps cannot transmit data about a user without obtaining the user's prior permission and providing the user with access to information about how and where the data will be used

17.2 Apps that require users to share personal information, such as email address and date of birth, in order to function will be rejected
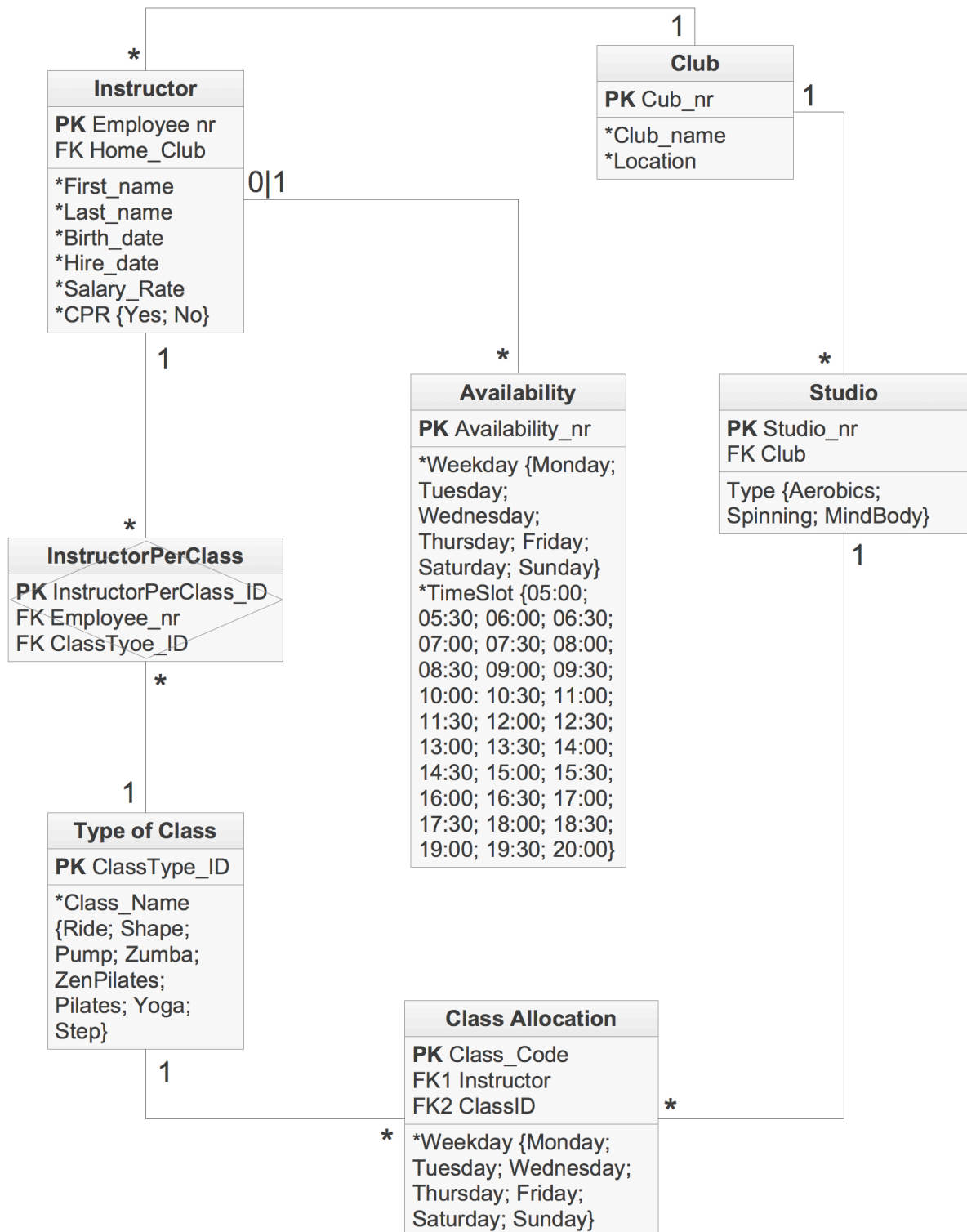
17.3 Apps that target minors for data collection will be rejected

22. Legal requirements

22.1 Apps must comply with all legal requirements in any location where they are made available to users. It is the developer's obligation to understand and conform to all local laws

22.6 Apps that enable anonymous or prank phone calls or SMS/MMS messaging will be rejected

Database Entity Relationship Diagram

Club
PK Cub_nr

*Club_name
*Location

Instructor
PK Employee nr
FK Home_Club

*First_name
*Last_name
*Birth_date
*Hire_date
*Salary_Rate
*CPR {Yes; No}

1

*

0|1

1

1

1

*

*

1

Availability
PK Availability_nr

*Weekday {Monday;
Tuesday;
Wednesday;
Thursday; Friday;
Saturday; Sunday}
*TimeSlot {05:00;
05:30; 06:00; 06:30;
07:00; 07:30; 08:00;
08:30; 09:00; 09:30;
10:00; 10:30; 11:00;
11:30; 12:00; 12:30;
13:00; 13:30; 14:00;
14:30; 15:00; 15:30;
16:00; 16:30; 17:00;
17:30; 18:00; 18:30;
19:00; 19:30; 20:00}

Studio
PK Studio_nr
FK Club

Type {Aerobics;
Spinning; MindBody}

1

InstructorPerClass
PK InstructorPerClass_ID
FK Employee_nr
FK ClassTyoe_ID

*

*

1

Type of Class
PK ClassType_ID

*Class_Name
{Ride; Shape;
Pump; Zumba;
ZenPilates;
Pilates; Yoga;
Step}

1

Class Allocation
PK Class_Code
FK1 Instructor
FK2 ClassID

*

*Weekday {Monday;
Tuesday; Wednesday;
Thursday; Friday;
Saturday; Sunday}

*

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