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Statement of Originality

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Abstract

This project involves implementing a web application used to plan a holiday abroad with a number of people. The goal is to develop a self-contained application with features that allow a user to rent out apartments, add attractions, find the directions to these attractions and the way an end user should visit these attractions once and only once utilizing a genetic algorithm utilizing crossover and mutation methods. The genetic algorithm gave positive results when compared to existing algorithms available for different applications.

Upon completion of all these objectives, it becomes clear from the evaluation techniques that users prefer having an application by which planning could be done in a simpler way. The participants walked away from the program with a sense of hope that they will be able to utilize this program in the near future.

Acknowledgements

I would never have been able to finish my theses without the guidance of my work mates, help from friends, the participants who helped me with the evaluation of this project and the support from my family.

I am grateful to Mr. Steven Camilleri, lecturer at Middlesex University Malta and my thesis adviser. I am extremely thankful and indebted to him for sharing expertise, and sincere and valuable guidance and encouragement extended to me throughout this scholastic year.

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List of Abbreviations and Notation

API	Application Program Interface
GA	Genetic Algorithm
GTSP	Generalized Travelling Salesman Problem
TSP	Travelling Salesman Problem
TRP	Travelling Repairmen Problem
SA	Simulated Annealing
NN	Nearest Neighbor
PSO	Particle Swarm Optimization
IPN	Instant Payment Notification
F(X)	Function of X
JSON	JavaScript Object Notation
XML	Extensible Markup Language

Chapter 1 - Introduction

1.1 - Project Description

The proposed project is a web application that will allow a person or group of people to better plan their holiday abroad. It will mainly consist of a self-contained website that will work similarly to a Social Networking site.

The user will be able to register for an account which will allow him to create a holiday. Checking what flights are available for said holiday will also be available, together with searches for any attractions that he would like to visit using the Google Places API. These attractions are stored in a database together with the location.

Using the Google Directions API, the user will be able to get data on how to arrive from their apartment/hotel to any of the attractions stored in the database. A choice will be offered for the preferred method of transportation. That is, whether one would prefer public transportation, walking, cycling or driving. In the case of public transportation, the times of the next ferry together with the train station name and approximation of time for arrival will also be given. An algorithm will then take into consideration which attractions should be divided in the days of stay of the holiday using the travelling salesman problem which will give the best route to visit the attractions, in a way of minimizing travel.

The web application will also have a business portal for hotel/apartment owners where an end user can directly book an accommodation through what's called 'business affiliation'.

The social networking aspect of the project allows the creator of the holiday to invite other end users to the holiday. This will allow for better planning and the possibility to make suggestions and discuss as to what attraction should be visited.

1.2 - Problem Definition

As stated by Michael Hrenka (2015), many people are not capable of using online sources. This is due to the fact that many of the sites don't have a centralized method of solving problems. In such a case, this would lead an end user who wants to visit a country visiting multiple websites just to book accommodation and attractions (Abraham, Hassanien, and Snazel, 2012).

Although the TSP (Travel Salesman Problem), which was defined as a mathematical problem in the 1930s, is NP-hard, it has become very popular due to its potential applications in many real-world problems. This will in turn lead to better time management when it comes to visiting and planning the attractions to be visited (Camci, 2014).

1.3 - Aims

This project aims to analyze the requirements and design and implement a solution built around them, i.e. a centralized holiday planner web application that allows the user or group of users to manage their holiday planning through the Cloud. It also aims to provide these users with the shortest route to visit the stored attractions utilizing a genetic algorithm and the traveling salesman problem.

1.4 - Objectives

1. Research how to apply a genetic algorithm to the traveling salesman problem and to understand why it's so problematic.
2. Develop a web application that allows a user to login to his account where he/she is able to start planning his/her holiday.
3. Develop a section in the website which will allow interaction with other users. Users have the possibility to introduce their ideas as to what attractions could be visited.
4. Develop a backend portal for hotel/apartment owners to sign up and offer accommodation to the users.

5. Apply the genetic algorithm in objective one to allow the users to take the best possible route from one attraction to another.
6. Testing the whole system and each of the implemented functions mentioned above.

1.5 - Deliverables

- Genetic Algorithm for Travelling Salesman Problem
- Web Application

1.6 - Outcome / Product Evaluation / Testing Approach

To gauge the project's output, a number of evaluation tests will be carried out, divided in two main categories: Designer Tests and User Tests. The former involves iterative tests and dry-runs by the system implementer before the product is released, in order to possibly rectify any software bugs and/or integration issues. User tests will be carried out by the end-users of the system in order to evaluate the usability of the system (how user-friendly and responsive it is). These tests together with Qualitative data collection will evaluate if the system reaches its intended requirements and will gather feedback that can be used for further improvement.

Other tests include white box and black box testing to be done on the website and a test plan will be included showing all my test case results at this report within the appendix.

1.7 - Resources Required

Microsoft Visual Studio is needed for all the front and back-end of the system. I will also need to purchase a domain by amazon where to host my website and database server.

Google APIs such as Google Places, Google Distance Matrix and the Google Maps API for JavaScript will be needed to visualize and use certain data regarding location and attraction data.

Also I will be needing people to test the web site whilst abroad as to have an indication if the genetic algorithm is in fact working correctly.

1.8 - Schedule

The following is a Gantt chart of how the objectives of this project proposal will be divided throughout the 7 months of this final scholastic year.

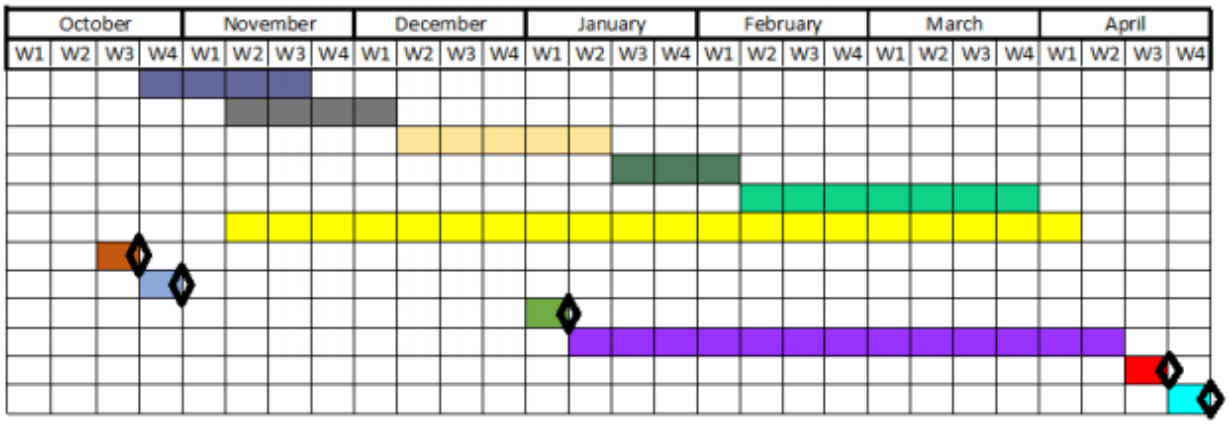

Figure 1 - Gantt chart

Legend

Objective 1	Research of Genetic Algorithms
Objective 2	Login / Register of Website
Objective 3	Apply Social Networking Ideas
Objective 4	Back End Affiliation Portal
Objective 5	Apply Genetic Algorithm for TSP
Objective 6	Testing
Acceptance of Submission	
Submission of IPP	
Submission of Literature Review	
Write up of the Report	
Final Report Submission	
Viva Voce	

Figure 2 - Gantt chart Legend

Chapter 2 - Background and Literature Review

The following chapter will be spent on researching relevant information about the algorithms available to solve the travelling salesman problem for this particular application.

2.1 – Research on the Travelling Salesman Problem

A lot of time was spent in research. From visiting website, to watching videos related to the project and also viewing existing solutions to the problem at hand. After a visit to London this Christmas, it was noticed that just pinpointing the places of interest to visit was not enough. A centralized software such as the one proposed in this project was needed to sort the attractions to be visited by distance using an algorithm similar to the travelling salesman problem because it's one of the most problematic problems when implemented in its very large number of applications in every days world, from Postal delivery, to an applications for which this project is being implemented, to search for the optimal route to view attractions on holiday.

M of the variants of the TSP consider total distance travelled. The presented problem will aim to find the best route among attractions and minimizing the sum of travel distance and consequential non-linear cost of the latencies to the attractions. Latency is the travel time spend to reach the attractions from a given starting point, which in the case of this project, will be the apartment location for the people travelling to visit the country.

The TSP in its simplest form is algorithm to find in which order to travel to a number of cities to be visited that will eventually give the shortest travelling distance. There can also be a limitation that each city will have to be visited only once and no value is associated with the service.

There are many different variations of the TSP, namely –

- TSP with Profits, developed and researched by Feillet et al (2005)
- The Generalized TSP (GTSP)
- Travelling Repairman Problem (TRP) or also known as the delivery-man problem, developed and researched by Fischetti et al (1993)

2.1.1 – TSP with Profits

The TSP with profits is a generalization of the normal travelling salesman problem but it is not necessary to visit all the vertices that would be included for the final solution. This is why a profit is associated with each vertex. Hence the overall goal is the simultaneous optimization of the collected profit and the travel costs. There are in total two criteria to this problem, the distance that is travelled and the gain that is gained by visiting the city. The first case gives the aim to find a tour that will minimize the total distance. This is known as the Profitable Tour Problem. (Dell'Amico et al, 1995.) For the second case, the aim is to get a higher gain rather than minimizing the distance but still keeping the total traveled distance into consideration. (Vansteenwegen et al, 2009). One could also minimize the distance as to achieve a given profit. This is called the Prize Collecting TSP (Balas, 1995).

2.1.2 – The Generalized TSP (GTSP)

The Generalized Travelling Salesman Problem is a modification of the algorithm in which nodes are divided into clusters. Each and every node from each cluster is marked and visited in a cycle. This is one of the most widely used algorithm. It is used for airplane routing (Fischetti, Gonzalez, and Toth, 1997), parcel delivery (Labordere, 1969), welfare agency routing (Reinelt, 1996) and computer file sequencing (Laporte, 1996). The core modification to this algorithm was produced using a genetic algorithm (GA) heuristic mimicking natural selection. This will take many different parameters such as the isolated initial population and a new reproduction mechanism.

The set of nodes is partitioned into sets, or clusters. The objective as stated before is to find a minimum-length for the whole tour containing exactly one node from each set. The GTSP is NP-hard (Non-deterministic polynomial hard). According to Garey, M. R. and Johnson, NP hard represents the set of all decision problems for which the instances where the answer is "yes" have proofs that can be verified in polynomial time (Garey, M.R, 1983).

2.1.3 – Travelling Repairman Problem (TRP)

This is also known as the Delivery Man problem or the Minimum Latency Problem (Luo, Qin, Lim 2014 and Sitters, 2014). In this problem, the pure delivery or pickup tour of a single vehicle has to be planned in order to minimize the total customer waiting time. The repairman (server) visits a subset of nodes in order to collect time-dependent profits. The objective consists of maximizing the total collected revenue. Imagine a single server, travelling at a constant speed. There are locations given, each with a profit.

Some problems which are of particular interest in this type of solution are the linear programming of difficult combinatorial optimization problems. These being -

- There are large number of variable constraints
- Have a complicated characteristic type, but when removed will make it easier to understand.

2.2 – Six Basic Genetic Algorithm Processes

There are in total six basic processes for a genetic algorithm -

- Initialization – This process creates a starting point that is usually randomly generated and of any node weight. Only a few are chosen but this could also number in the thousands.
- Evaluation - Each member of the points are then evaluated and a positive integer number is returned, called a ‘fitness’. This integer is calculated by how good a potential solution is relative with the requirements of the solution. These requirements can be elementary such as ‘the fastest algorithms are required’ or a bit more complicated requirements, such as ‘stronger materials but not heavy’
- Selection - The overall fitness needs to be improved constantly. This process helps by removing all the nodes that do not relate so well with the originals and keep the best nodes within the selection. The most basic selection method is to make the individual more likely to be ‘fitter’ for other generations.

- Crossover - New individuals are created by combining the aspects of the previous individuals that were selected. This can be better understood as to how sex works in nature. When combining two parents with certain genetics and traits, a better offspring will be produced with traits from each of the two.
- Mutation - This is the process that takes care of providing a bit of randomness in the genetics of the individual.
- Repetition - After creating the new generation, the processes start again from evaluation step as to create the next of generation individual. This is repeated up until the termination condition is reached.

2.2.1 – Termination

After running for a few times, it would be best to terminate the genetic algorithm from searching for a solution. This is because after a few runs from the above processes, the algorithm will have likely resolved the problem with a good enough solution that meets the criteria. There might also be constraints on the time and funding that would require for a more speedy termination. (Alves, 2015)

2.2.2 – Constraints

One such limitation of a genetic algorithm is what is known as Local Optimum. A local optimum is the best solution to a problem that include a small number of possible solutions. This has the opposing meaning to global optimum which gives the optimal solution when all the solutions are considered. When developing algorithms to solve a problem, heuristics such as simulated annealing (SA) are used. These minimize the solutions that are optimal locally as opposed to globally. Simulated Annealing is popularly and widely used in search algorithms. It utilizes the principles of statistical mechanics regarding the behavior of a large number of atoms at low temperature, for finding minimal cost solutions to large optimization problems by minimizing the associated energy. An example for the local optimum could be presented as a hill hiker who is situated at the roots of a hill and is told to

find a location that places him at the highest peak of the hill whilst blind folded. The only option that is left for the hiker is to keep on ascending the hill until noticing that he cannot ascend any further. Here he might think that he is at the top of the hill. But there is no way for him to know for certain as he might only be just at the top of a smaller hill which connects to a larger one. A visual representation of this is found below in Figure 3.

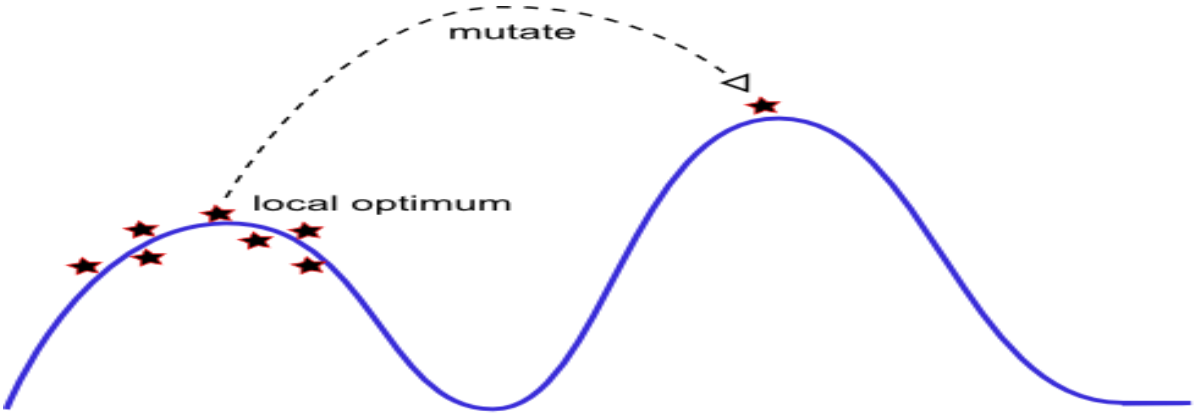

Figure 3 - The Local Optimum

As for genetic algorithms, it could normally terminate if it found a well enough solution to the problem, though like the blindfold problem, still not capable of knowing that the algorithm has indeed found the best solution for the problem. Hence the best thing that could be done is find a close approximation of the optimum solution.

2.3 – Solution using the Genetic Algorithm

Although the best solution is not always practical to give a solution to this problem, certain algorithms help by discovering the close to optimum solutions. Some of which are mentioned below; the Nearest Neighbor Algorithm (NN) and Particle Swarm Optimization (PSO).

2.3.1 – Nearest Neighbor Algorithm

This algorithm is the simplest one, but its performance is lacking. This algorithm mimics the traveler whose rule of thumb is always to visit the nearest unvisited node/location. Attractions are constructed and ordered a1, ... aN, with the first city c1 chosen randomly and in general ai+1 chosen to be the city closest ak. The corresponding tour travels all cities in the order given, and then returns to a1 (initial) attraction after visiting city aN (final city).

2.3.2 – Particle Swarm Optimization

The swarm optimization was developed and inspired from the behavior of bird flocks, fish schools and human communities which means that this algorithm has a high convergence speed. This technology was first presented in 1995 by Eberhart and Kennedy which state that they are all maneuvered on the basis of population operated. Infarct they do not rely on genetic operators, like the previously stated, natural selection operators, mutation and crossover operators but optimizes the population through the information exchanged among the individuals (Eberhard, Kennedy, 1995).

It finds the optimum solution by having swarms of individuals following the best particle. Compared to other GAs, the Particle Swarm Optimization holds a better intelligent background which allows it to perform easier than others. This algorithm has in fact attracted a lot of attention not only in the scientific research division, but also for engineering applications.

2.4 – Continuation to Section 2.3

To find a good enough solution to solve the travelling salesman problem, the genetic algorithm needs to be set up in a particular and specially designed way. For example, one good result would be to create a route where the attraction is included only once in the solution. If a location/attraction is contained more than once in the route or not included at all, then the route would be invalid and therefore gain more computational time by not calculating its weight.

Certain special types of Crossover and mutational methods are therefore used to make sure that the genetic algorithms meets all the requirements that need to be set out beforehand.

2.4.1 – The Mutation Method

The mutation process will only take care of modifying the route randomly. It will not insert or delete and of the locations from the route as this would create an invalid or not possible to solve solution. The type of mutation to be used in such a situation is the swap mutation.

With swap location, two location will be chosen and swapped at random. If this kind of mutation was to be applied on a route consisting of [1,2,3,4,5], the result might then be [1,2,5,4,3]. The nodes 3 and 5 were swapped which created a new route with the same weight but in a different form and structure. Since this type of mutation only swaps the existing values, the nodes will never be duplicated or missing, hence never resulting to an invalid solution. A visual representation is shown in Figure 4.

Figure 4 - Swap Mutation

2.4.2 – The Crossover Method

The crossover method that will be used to produce a valid solution to the route is the ordered crossover. This method selects a group from the parent and this is added to new child created. The next step is to take all the missing values and

add them up to the offspring from different parent in the order that was given by the second parent. A visual representation is shown in Figure 5.

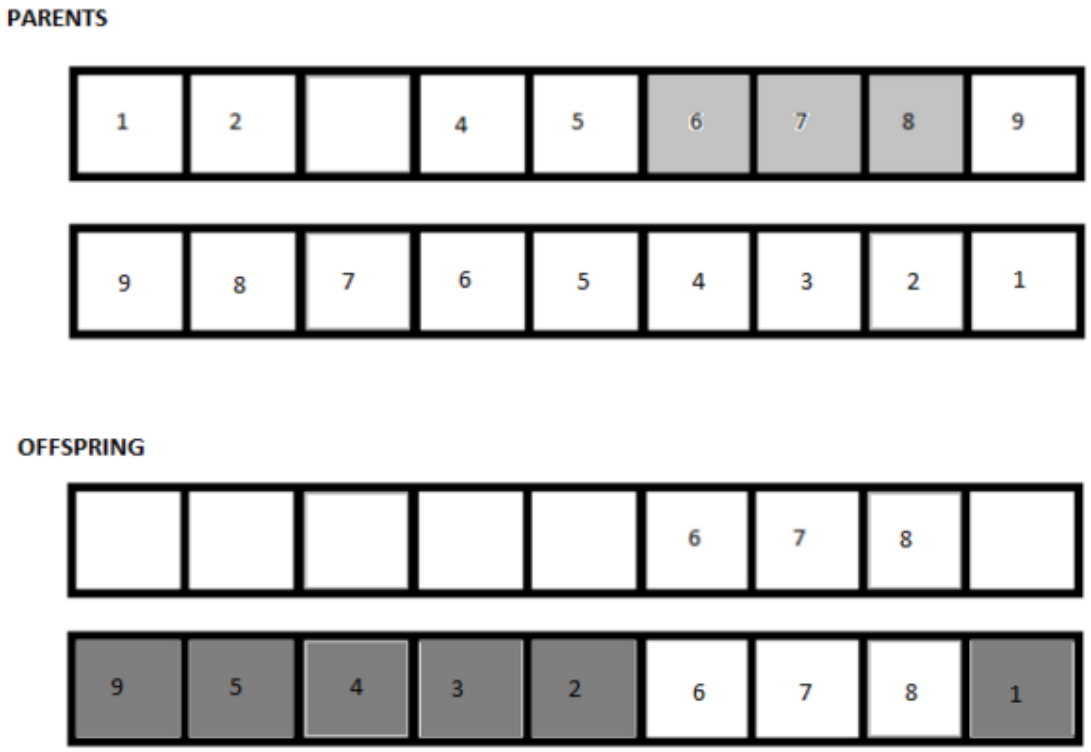

Figure 5 - Crossover Method

As can be seen above in Figure 5, a group from the first parent, 6, 7 and 8 are taken and added to the first offspring. The missing locations are then added from the second parent to the offspring in the same order they are taken. That is, 9, 5, 4, 3, 2 are placed in the offspring after each other which are taken from the second parent. The locations 6, 7 and 8 are taken from the first parent and the last location 1 is taken from the 2nd parent. This will allow the process to be completed successfully without having any missing or duplicate values.

In real life, there are multiple restriction such as road speed and traffic accidents, closed roads and traffic jams which affects the importance of coming up with the best route. The project will be completely built in HTML, JavaScript whilst utilizing the Google Maps API, Direction Matrix API and the JQuery Library.

Chapter 3 - Requirements Specification

3.1 – Genetic Algorithm Implementation

Starting with why this is so problematic, a classic example of the problem will be explained briefly.

A salesman is given a map like in Figure 1 found in Appendix 2. The map contains 20 locations and the salesman is told to visit each of the locations to make a sale. First step before starting the journey is to plan out the route as to minimize the travel time. Fortunately, humans can easily process this and work out a reasonable good route by just glancing at the map. But when finding this solution of what they think is the optimal route, can they really be 100 percent certain that this in fact is the best route? This cannot be done, at least not practically.

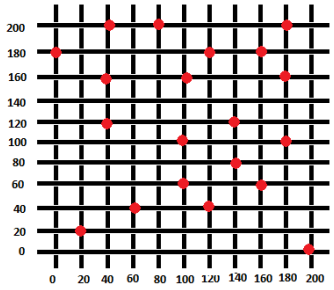

Figure 6 - 20 Location Map

Taking an easier example of 3 locations on a map, to find a single route, and decide from which of the locations will the starting node be. There will then be a choice of 2 locations to visit a second location. Finally only one location will be left to visit and the route will be completed. This is mathematical terms means that there are six different locations that can be chosen. (Factorial of 3 is 3x2x1)

One comes to the conclusion that from the above factorial, there are six different routes that can be chosen. Six routes is a quite trivial to reason out which route must be taken to find the shortest path. Though one should notice by now that the problem with this that having a larger number of locations will result to an even larger number of routes. This means that they will grow in size rather quickly.

Going back to the map in Appendix 2 Figure 1, with 20 locations, an evaluation of 2432902008176640000 different routes.

In this project, a genetic algorithm will be applied to the traveling salesman problem. A Genetic Algorithm is found on the process of natural selection. Meaning that this algorithm process takes the most basic traits of natural selection to apply to any query and problem that needs to be solved.

3.2 – Data Acquisition

Distance data and duration from one attraction to the next will be gained through the use of Google Distance Matrix API which is a service that provides both travel distance and duration for a matrix of origins and destinations. This returns the recommended route between start and end points which is calculated by the default Google Maps API but contains additional rows containing duration and distance values for each pair.

Output returned from this service may be either JavaScript Object Notation (json) or Extensible Markup Language (xml).

The following table shows the parameters that are needed for the request to return this data.

Required Parameters	Parameter Description
origins	This is the location to use as the starting point for calculating travel distance and time
destinations	One or more locations to use as the finishing point for calculating travel and distance time
key	The Application API Key. Not needed if web application is on a local server
mode	Specifies the mode of transport to use

Table 1 - Required Parameters

Chapter 4 - Analysis and Design

4.1 - Use-Case Diagram

Below is a use-case diagram of how the system and users will interact with each other. There are three entities in all –

- The End User – A user that will be attending the holiday. All main functionality is present for all users.
- The Business Affiliate – This is a portal for hotel and apartment owners that would like to rent out to the end users attending a holiday. Payment method is through PayPal.
- The Web Application – The whole web application that will interact with the users.

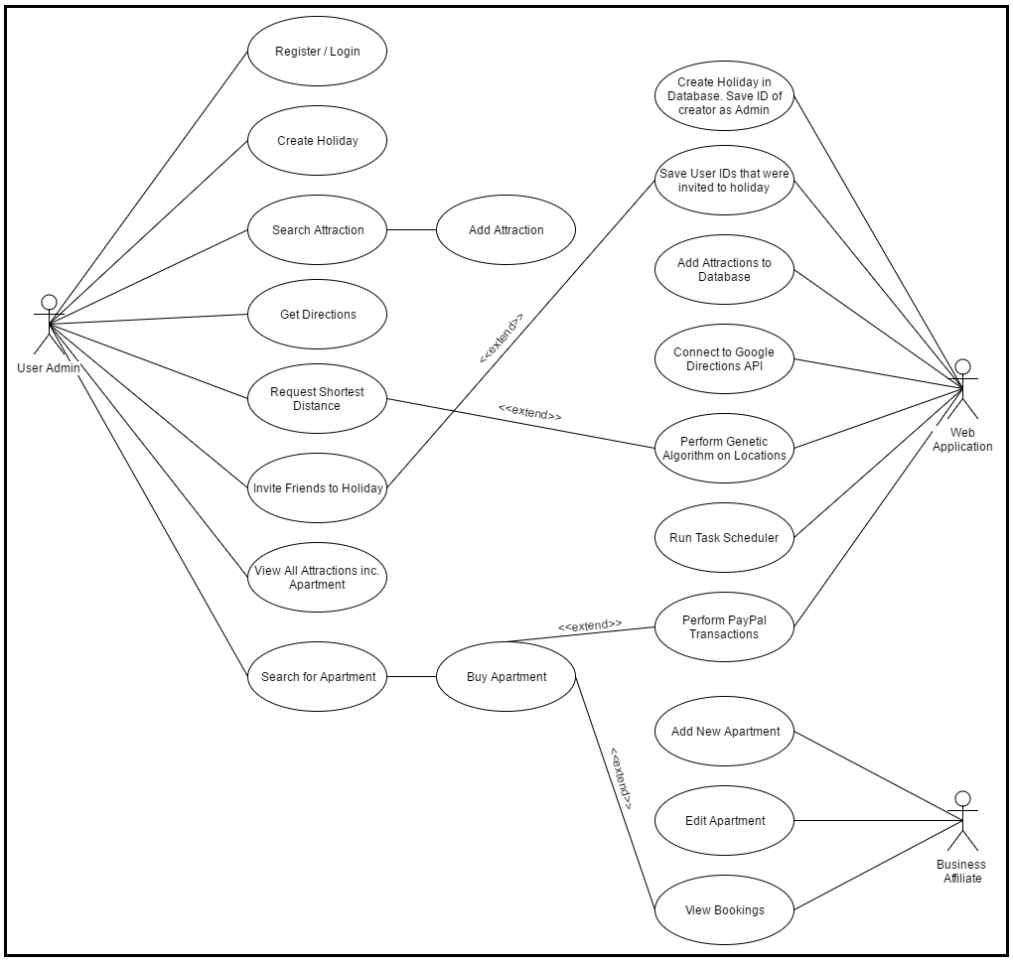

Figure 7 - Use Case Diagram

4.1.1 – End User

The creator of the holiday has all the options available to him. This can be seen by the figure above.

The Register/Login page is available to both the User Admin and the User Invited. Creating a holiday requires the user enter the country and city they will be visiting. By default, when the holiday is created, the creator becomes its administrator. The administrator's power of a normal user are that only he/she can invite other users to the holiday, and for an invited user to add a new attraction, the attraction has to be approved by the administrator. At any point in time, the administrator can accept or deny the attraction.

The apartment is also selected by the administrator.

Searching for an attraction is made by connecting to the Google Places API. This returns the name, opening hours and locations through JavaScript. Upon entering the date to attend and hitting Add Attraction, this is added to the database.

Get Directions connects to the Distance Matrix API. Options are given to the user to choose the mode of transportation. These are walking, cycling, driving or public transportation which will give even more options such as Bus, Rail, Subway, Train and Tram. The last two options given to the users is whether the user prefers fewer transfers or less walking in the case of choosing public transportation.

Request Shortest Distance will call a Genetic Algorithm which was developed in this project to get the shortest travelling distance between attractions on any given day. The methods used were the Crossover Method and the Mutation Method.

4.1.2 – Business Affiliate

A business affiliate is a hotel and/or apartment owner that would like to rent out their property to end users. A PayPal account is requested at registration for the transaction to occur between them.

4.1.3 - Web Application

The web Application was developed using PHP and JavaScript. The JQuery Library was needed to use AJAX calls as well as to connect to the Google APIs which include the Google maps API, Google Directions API and the Distance Matrix API. The Genetic Algorithm will be coded using JavaScript and PHP by utilizing the methods mentioned above.

4.2 - Database Design

The database schema below will be used to collect the data of the web application.

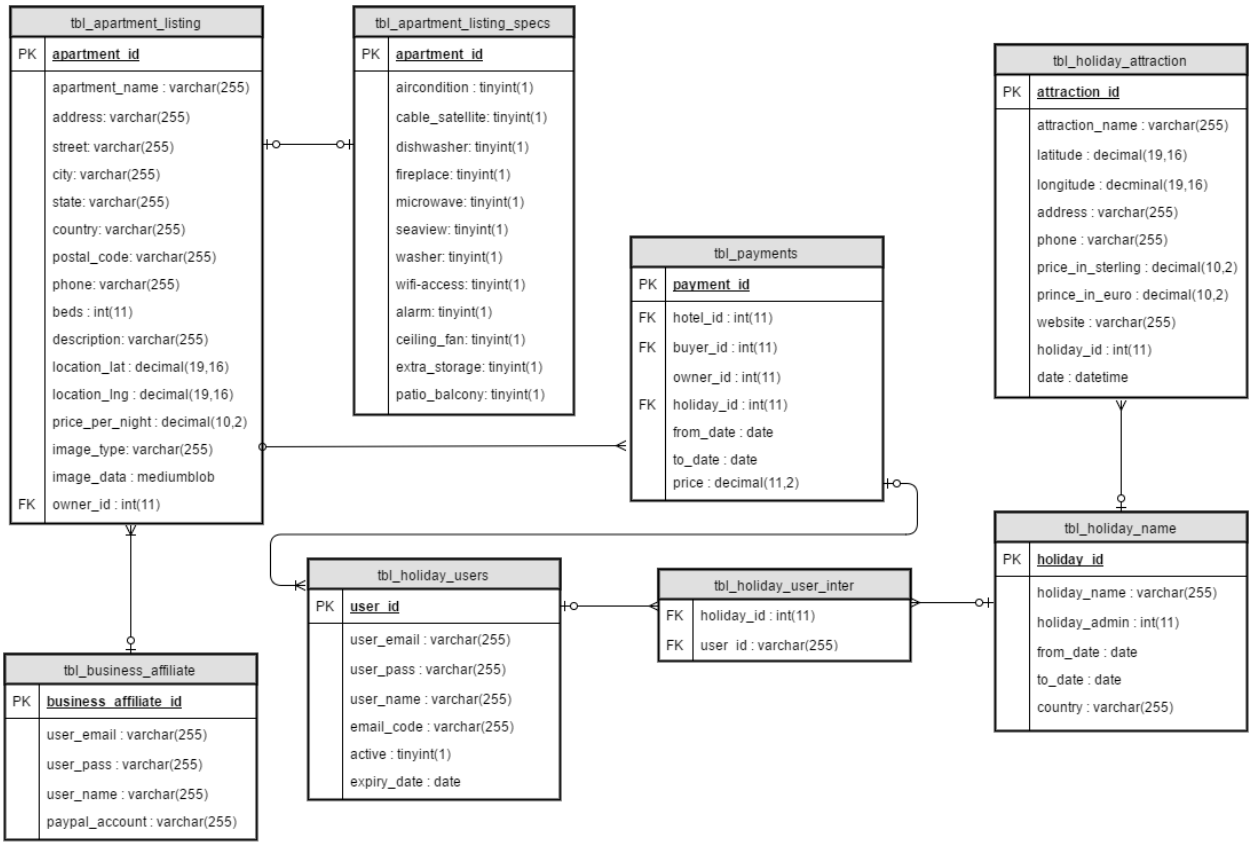

Figure 8 - ERD Diagram

4.2.1 - Holiday_Apartment Table

The primary key of this table is the apartment ID with is an Auto Incremental Value.

Apartment_name holds the name of the apartment you give it.

Latitude is of type decimal (19,16) which will hold the latitude value of the apartment when returned through a search in Google Places API.

Longitude is of type decimal (19,16) which will hold the longitude value of the apartment when returned through a search in Google Places API.

Address holds the full address returned by the Google Places API

Number_of_guests is inputted by the Administrator

From declares the date that the apartment will be used

To declares the date that the people will leave the apartment

4.2.2 - Holiday_Name

The Holiday_ID holds the ID of the holiday being created. This is an Auto Incremental Value.

Holiday_name denotes the name of the holiday. This is to differentiate between more holidays.

Holiday_Creator holds the ID of the User that created this holiday to give him full privileges.

From declares the date that the holiday will be start.

To declares the date that the holiday will end.

4.2.3 - HolidayName_ApartmentID_Inter

This is an intermediate table between the holiday and the apartment. This table is used so the ID of the holiday name can be associated with the ID of the Apartment. The apartment can be used more than once but cannot be used on the same date that another holiday is requesting the apartment.

4.2.4 - Holiday Users

This table holds the data of the users that are registering to the web application.

User_ID is a unique and Auto Incremental Value that holds the ID of the user.
User_Email is also a unique value that holds the email of the user. This is used to log in to the application.
UserPass is the value that is used to securely log in to the application.

4.2.5 - Holiday_Invites

The Holiday invites Intermediate table takes care to associate any user with a holiday when the administrator decides to invite them. The ID from the user is taken and written together with the ID of the holiday. These allows for the user to attend more than one holiday.

4.2.6 - Holiday_Attraction

This table takes care of adding attractions to the holiday. The Administrator can directly write to this table but an invited user has to first write in a different table for approval before writing to this table.

This table gets most of its data from the Google Places API through JavaScript.

Attraction_ID is the ID of the attraction. This is an auto incremental Value and the primary Key
Attraction_Name is the name that the user searches for.
Latitude is of type decimal (19,16) which will hold the latitude value of the attraction when returned through a search in Google Places API.
Longitude is of type decimal (19,16) which will hold the longitude value of the attraction when returned through a search in Google Places API.
Address holds the address of the attraction that is returned by the Google Places API through JavaScript.
Phone holds the phone of the attraction that is returned by the Google Places API through JavaScript.

Website holds the website of the attraction that is returned by the Google Places API through JavaScript.
VisitingDate is inputted by the Administrator to decide when to attend the attraction
HolidayID is the ID of the holiday as to associate the Attraction with the ID as this attraction can be added more than once not with the same holiday but with other holidays.

4.2.7 - Holiday_Attraction_Approval

This table does the same but also holds a status field which is a Boolean. When The Administrator reviews the attraction and approves, the status will turn to 1 and the data is written over to the Holiday_Attraction table. If the administrator denies this attraction, the attraction will be removed from this approval table.

4.3 - Design Mock-up

4.3.1 - Login Screen (End User)

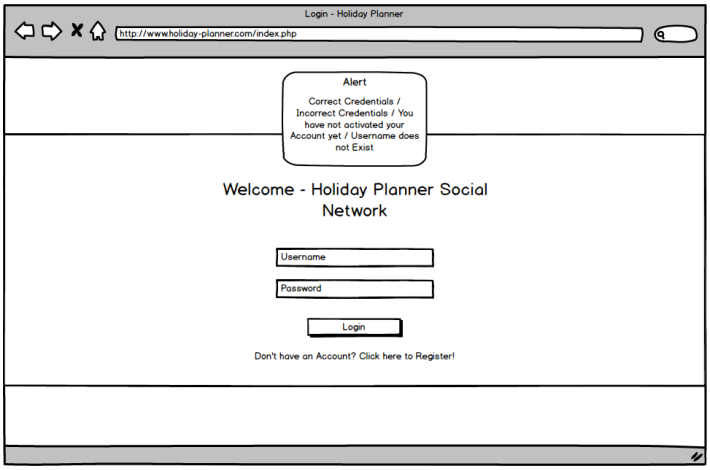

Figure 9 - Login Screen (End User)

4.3.2 – Registration Screen (End User)

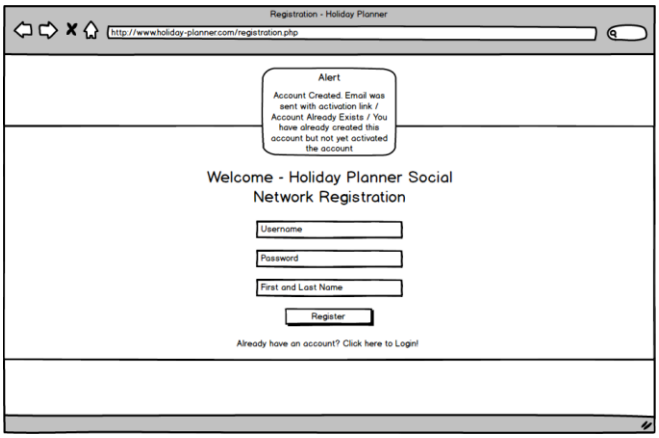

Figure 10 - Registration Screen (End User)

4.3.3 – Home Screen (End User)

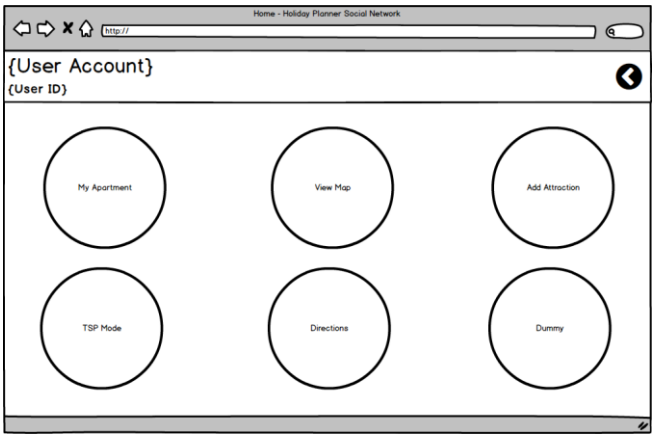

Figure 11 - Home Screen (End User)

4.3.4 – Home Screen (Inviting Users through Slider)

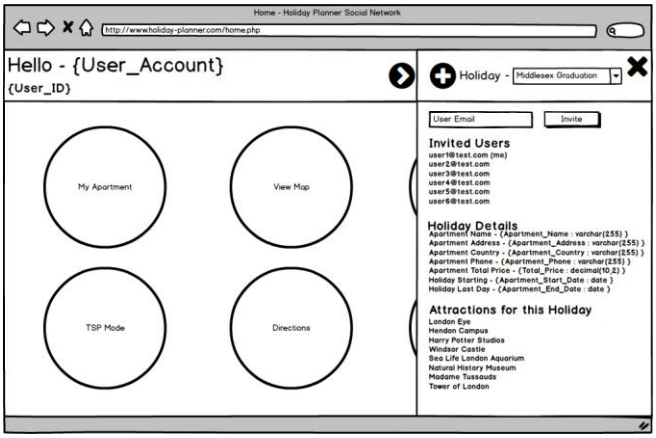

Figure 12 - Home Screen (Inviting Users through Slider)

4.3.5 – My Apartment (Pre-Booking)

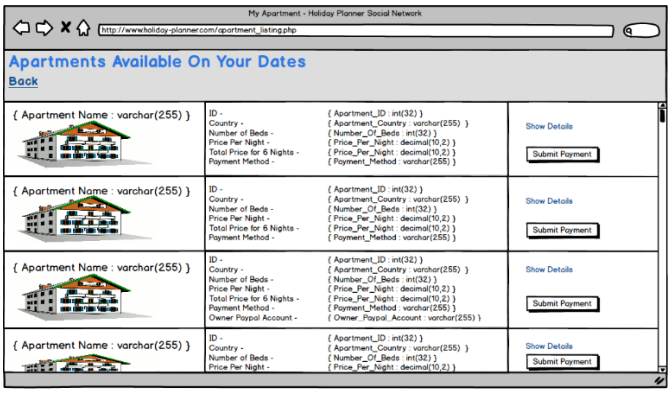

Figure 13 – My Apartment (Pre booking)

4.3.6 – My Apartment (Post Booking)

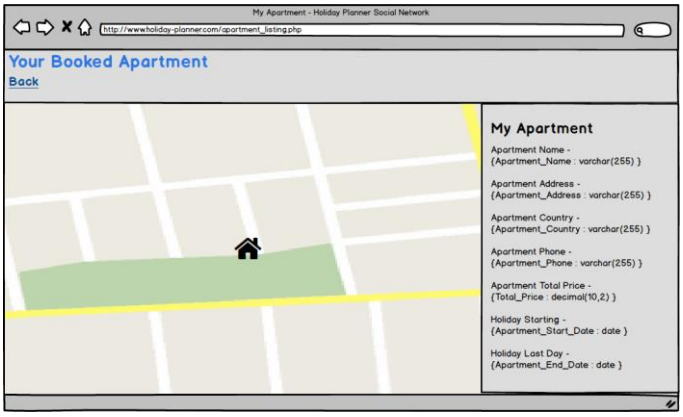

Figure 14 – My Apartment (Post Booking)

4.3.7 – View Map

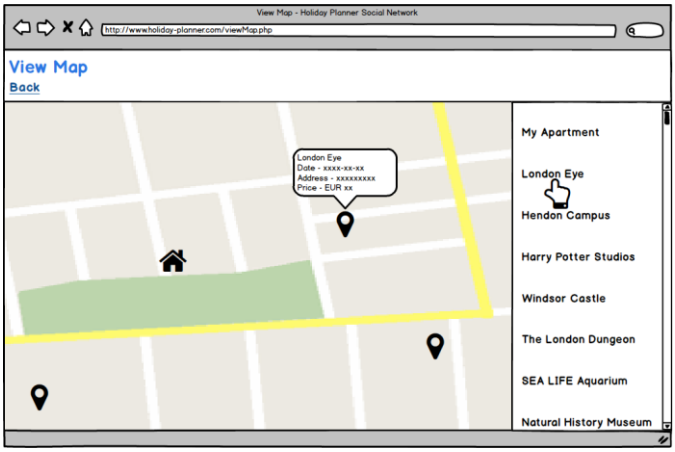

Figure 15 – View Map

4.3.8 – Add Attraction

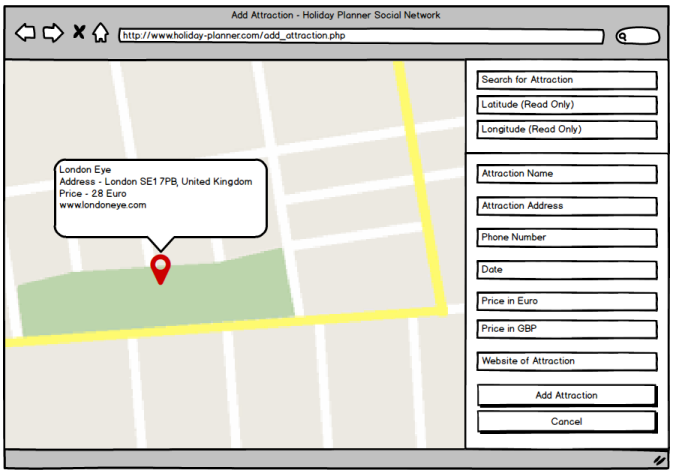

Figure 16- Add Attraction

4.3.9 – TSP Mode

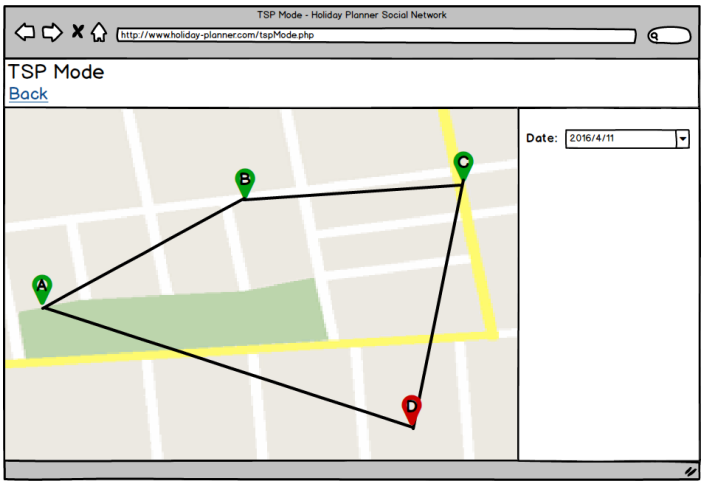

Figure 17- TSP Mode

4.3.10 – Directions

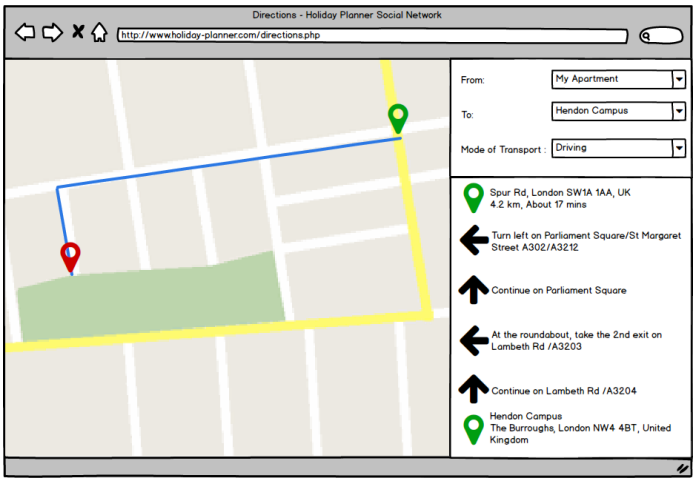

Figure 18 - Directions

4.3.11 – Business Affiliation Registration

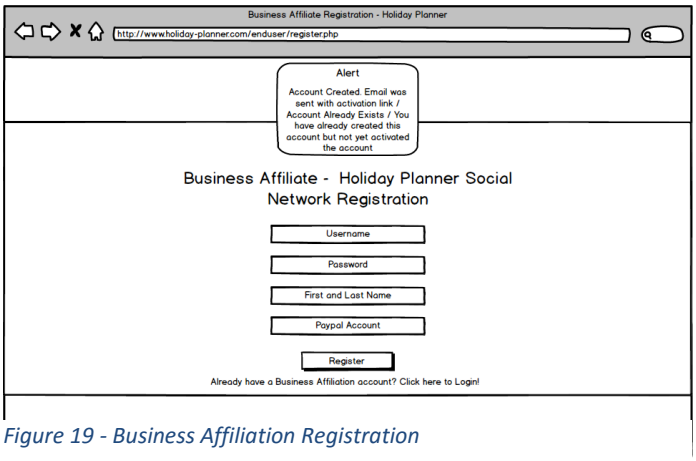

Figure 19 - Business Affiliation Registration

4.3.12 – Business Affiliation Add Apartment

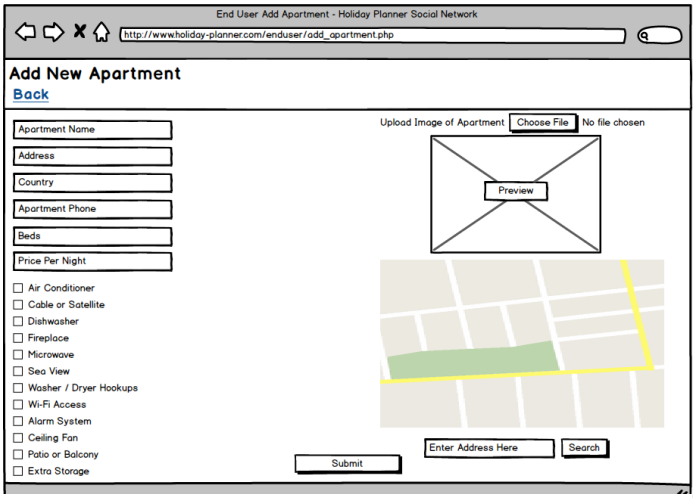

Figure 20 - Business Affiliation Add Apartment

Chapter 5 - Implementation and Testing

5.1 - Implementation

The implementation of the proposed system was built upon the design of the mockups within the Analysis and Design section. This chapter deals with how the project was designed and implemented. Any figures or tables that are in this chapter can also be found enlarged in the appendix section to give a clear picture of what is happening at each stage of developing the project. The project is divided into two sections:

- End User Section
- Business Affiliate Section

An End User are the users that will be utilizing this program to plan their holidays abroad utilizing the following features:

- My Apartment / Renting an Apartment
- View Map
- Add Attractions
- TSP Mode
- Multiple Holidays
- Directions
- Inviting/Sharing the holiday with other end users.

A Business Affiliate is a user that advertises his apartments which an end user can buy for the duration of the holiday within the same country. A business affiliate can add their payment method through a PayPal account and an end user can make the payment to the affiliates account directly when booking the apartment. The following features are available to a business affiliate:

- Add Apartments
- Show Performance
- Show Apartments
- My Details

5.1.1 - TSP Mode

This part of the implementation uses a custom built genetic algorithm from the list of attractions saved in the database through the add attraction functionality mentioned above.

The script is fed a number of locations belonging to the attractions that the user would like to visit and a genetic algorithm is applied.

The Method of a GA for the Travelling salesman problem is started with a set of solutions, chromosomes or individuals which are called populations. The solutions that are recoded from the current population are used and to form a new population. This is done with the hopes that a new a healthier population is produced. The solutions which are used to form a new population is called an offspring. These are selected according to their fitness.

The mutation method is only capable of shuffling the route. It will neither add nor remove any of the locations. A check is always done before start of each generation to make sure that the number of locations are the same as the starting location count. If this check fails, an invalid solution will be shown therefore an exception is raised which exits the algorithm. The mutation method used is the swap method.

The locations are sent as marker objects to an array of markers. Two locations in the route are selected at random and swapped. Each marker object has a longitude and latitude reading which corresponds to the location of the attraction that needs to be visited. No identifier is therefore needed. A swap method can be shown below.

```
// Mutate individual
this.mutate = function() {
    this.fitness = null;

    // Loop over chromosome making random changes
    for (index in this.chromosome) {

            var randomIndex = Math.floor(Math.random() * this.chromosomeLength);
            var tempNode = this.chromosome[randomIndex];
            this.chromosome[randomIndex] = this.chromosome[index];
            this.chromosome[index] = tempNode;

    }
};
```

Figure 21 - Swap Mutation Code Snippet

The above helps to add randomness into the population's genetics so as to avoid having the same combination of solutions the same as the initial population. Therefore five locations in the Array[4] being {0,1,2,3,4} might end up with {0,1,4,3,2}. As can be noticed, locations 2 and 4 were swapped which created a new list with the exact same length of array. Since swap mutation only swaps the locations, no new locations are created, missing or duplicated when compared to the original.

The crossover method used is the ordered crossover. A subset is selected from the first parent which is added to the offspring. The remaining missing values are then added to the offspring from the second parent in the order that they are found. The crossover helps with creating new individuals

```
// Applies crossover to current individual and mate, then adds it's offspring to given population
this.crossover = function(individual, offspringPopulation) {
    var offspringChromosome = [];
    // Add a random amount of this individual's genetic information to offspring
    var startPos = Math.floor(this.chromosome.length * Math.random());
    var endPos = Math.floor(this.chromosome.length * Math.random());
    var i = startPos;
    while (i != endPos) {
        offspringChromosome[i] = individual.chromosome[i];
        i++
        if (i >= this.chromosome.length) {
            i = 0;
        }
    }
```

Figure 22 - Crossover Method Code Snippet

Since the TSP is a minimization problem, the fitness function f(x) = 1/d was considered where d calculates the cost. (distance/length) of the route which is represented by a chromosome. The fitness function that characterizes each chromosome represents the total length of the route from the first to the last gene (attraction) moving according to the order of the genes within the chromosome. In a 2D plane, the distance between an attraction and another which are usually represented with x and y coordinates is calculated with the equation $d = \sqrt{(x^1 - x^2)^2 + (y^1 - y^2)^2}$. This is known as the Euclidean distance. (Riccardo Fabbri, 2008).

```
// Calculates individuals fitness value
this.calcFitness = function() {
    if (this.fitness != null) {
        return this.fitness;
    }

    var totalDistance = this.getDistance();
    this.fitness = 1 / totalDistance;
    return this.fitness;
};
```

Figure 23 - Get Fitness Code Snippet

Since google maps is being used for this implementation, the Google Maps Distance Matrix API was used. This is a service that provides travel distance and time for a matrix of origins and destinations. A recommended route is returned by this service when giving a start and end point. Although this service does not return detailed route information, using the TSP mode in conjunction to the Directions implementation mentioned above, will offer the user a better way of travelling.

A limitation in the current Google Maps API version 3 was encountered where the service limits each directions request to a start point, an end point and 8 waypoints in between. This therefore leaves the user with a maximum of 8 attractions to visit per day, with the last attraction being the starting attraction. A

solution which could be implemented to overcome this limitation is to break the list of attractions into groups, make multiple requests to the Google API, and stich the results together when returned. Another solution is to apply geo-fencing functionality to set up a fence of 1km radius and any number of attractions within that fence is considered to be 1 attraction. This is the least favorable solution since it will give a less precise reading of duration and distance that will be travelled.

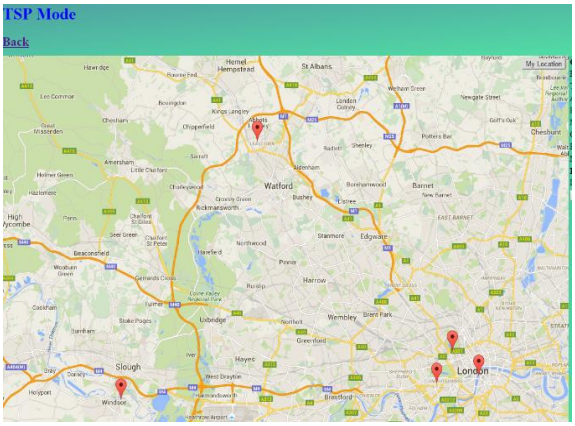

Figure 24 - TSP Mode Pre-GA

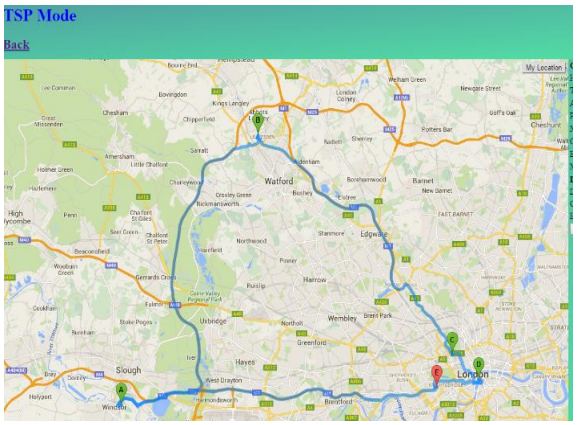

Figure 25 - TSP Mode with GA Results

5.2 - Testing

The following test cases were performed on the website. Any failed cases where fixed throughout the implementation phase of this project. Limitations were also marked as failed.

5.2.1 - Login Test Cases

Test Description	Expected Output	Actual Output	Pass / Fail
Login to Account that does not exist	Login fails showing message {Username does not exist}	Login failed and message shown	Pass
Login with Account not yet activated	Login fails showing message {Account is not yet activated}. Sends email with link to account	Does not send link	Fail
Login with empty fields	Login fails and focuses on first missing text box	Focus on first empty field	Pass
Login with correct credentials	Login is successful and session is created	Session created and redirected to Home Page	Pass
Click on Register here link	Page is redirected to Register Page	Redirects to register.php	Pass
Go to login page when session is active	Page is redirected to Home page	Page redirected to Home Page	Pass

Table 2 - Login Test Cases

5.2.2 - Registration Test Cases

Test Description	Expected Output	Actual Output	Pass / Fail
By Normal Registration			
Register with empty field	Registration fails reporting message {Empty Fields}	Registration failed and message shown	Pass
Register with existing user	Registration fails reporting message {Account Name Taken}	Registration failed and message shown	Pass
Register with existing user that has not yet activated	Registration fails reporting message {Account Exists but not activated. Email Sent}	Registration failed and message shown but email not sent	Fail
Register with correct credentials	Registration Successful and Activation Email sent	Registration succeeded and email sent	Pass
Click on Login here link	Redirects User to index.php	Page redirected to Login Page	Pass

Table 3 - Registration Test Cases

5.2.3 - Registration by Invite Test Cases

By Invite			
User Account Read only	User Account not editable	User account textbox couldn't be changed	Pass
Register with empty field	Registration fails reporting message {Empty Fields}	Registration failed and message shown	Pass
Register with existing user	Registration fails reporting message {Account Name Taken}	Registration failed and message shown	Pass
Register with existing user that has not yet activated	Registration fails reporting message {Account Exists but not activated. Email Sent}	Registration failed and message shown but email not sent	Pass
Register with correct credentials	Registration Successful and Activation Email sent	Registration succeeded and email sent	Pass
Click on Login here link	Redirects User to index.php	Page redirected to Login Page	Pass

Table 4 - Registration by Invite Test Cases

5.2.4 - Home Page Test Cases

Test Description	Expected Output	Actual Output	Pass / Fail
Click on Slide Panel	Panel Slides out	Panel Slides outwards	Pass
Click on Add holiday	Add Holiday Page	Opens up new page to create a holiday	Pass
Click on any Function without any holidays created	Warning shown in each function	Shows an empty page with empty Maps	Fail
Load Users attending this holiday	Attending users should be shown	Data is shown only on change event of combo box	Fail
Load Holiday Details	Holiday Details should be shown	Data is shown only on change event of combo box	Fail
Load Attractions for this holiday	Attractions related to holiday should be shown	Data is shown only on change event of combo box	Fail
Change Holiday - Load Users attending this holiday	Attending users should be shown	Attending users are changed to reflect holiday chosen	Pass
Change Holiday - Load Holiday Details	Holiday Details should be shown	Hotel Details are changed to reflect holiday chosen	Pass
Change Holiday - Load Attractions for this holiday	Attractions related to holiday should be shown	Attraction list are changed to reflect holiday chosen	Pass
Invite User : Empty Field	Warning shown {Field is empty}	Alert message shown	Pass
Invite User Account that does not exist	Partial Account Registration and added to holiday	User Partially registered and activation link sent. Shown in list.	Pass

Invite User Account that exists but not activated	Add User to Holiday. Status Pending Activation	User is added to the holiday and shown as pending activation in the list of invited users	Pass
Invite User Account that is already invited	Warning shown with message {User is already a part of this holiday}	Alert box shown with correct warning	Pass
Invite a valid User Account	Warning with message {malformed email}	Alert box shown with correct warning	Pass
Close Button on Sliding Panel	Closes the Sliding Panel	Closes the Sliding Panel	Pass

Table 5 - Home Page Test Cases

5.2.5 - My Apartment Test Cases

My Apartment			
Click on My Apartment for the first time	List of Apartments are shown with relevant country	List shown if available	Pass
Click on My Apartment after booking an apartment	Map View shown	Map View shown with location of apartment rented	Pass
Select Apartment : Pay Now	Redirect Page to PayPal	Page correctly redirected to PayPal	Pass
Click Back	Back to Home Page	Page redirected to home.php	Pass
Submit Payment	Creates apartment in tbl_payments	Entry created	Pass
PayPal Redirect	After Payment, redirects to Home Page	Known issue due to website hosted locally. Limitation from PayPal	Fail

Table 6 - My Apartment Test Cases

5.2.6 - View Map Test Cases

View Map			
Click View Map without Attractions added	Empty Map Shown with only apartment icon	Empty map is shown without attractions.	Pass
Click View Map without Apartment added	Empty Map Shown	Empty map is shown without apartment.	Pass
Click View Map with both Attractions and Apartments	Map shown with apartment books and attractions added	Map is shown with both attractions and apartment icons	Pass

Table 7 - View Map Test Cases

5.2.7 - Add Attractions Test Cases

Add Attractions			
Enter unknown Place and Click Search	Map results are undefined	Empty map shown	Pass
Click Search Button with empty textbox	Map results are undefined	Empty map shown	Pass
Enter valid place	Map results are shown	Results are shown on the map	Pass
Click Add Attraction without Month	Error shown. Month required	Warning is not shown	Fail
Enter GBP	Automated conversion of EUR	Euro textbox is converted to input of GBP	Pass
Enter EUR	Automated conversion of GBP	GBP textbox is converted to input of EURO	Pass
Click on Add Attraction	Attraction added to tbl_attractions	A new attraction is added to the holiday	Pass
Click on Cancel	Redirected to home Page	Page is redirected to home.php	Pass

Table 8 - Add Attractions Test Cases

5.2.8 - TSP Mode Test Cases

TSP Mode			
Click Start without selecting a day	Error shown with message {At least 3 points are required}	Error shown with correct message	Pass
Click Start when selecting a day without attractions	Error shown with message {At least 3 points are required}	Error shown with correct message	Pass
Click Start when selecting a day with more than 8 attractions	Error shown. More than 8 attractions not supported. Limitation by API	Error shown with correct message	Pass
Click Start when selecting a day with more than 3 and less than 8 attractions	Genetic Algorithm runs and returns results	Shows the results from the genetic algorithm	Pass
Click on Clear	Clears the Map	Map cleared after running GA	Pass
Click Back	Redirect Page to Home Page	Page redirected to home.php	Pass

Table 9 - TSP Mode Test Cases

5.2.9 - Directions Test Cases

Directions			
Click on Calculate with empty From and To Fields	Error shown with message {From and To fields required}	The correct error is shown	Pass
Click on Cancel	Page redirected to Home Page	Page redirected to home.php	Pass
Select From and Calculate	Error shown with message {From and To fields required}	The correct error is shown	Pass
Select To and Calculate	Error shown with message {From and To fields required}	The correct error is shown	Pass
My Apartment in From and To Fields when apartment is added	Book Apartment > From and To Fields contain My Apartment selection	My Apartment is present in both From and To combo boxes	Pass
My Apartment not in From and To Fields when apartment is not added	Apartment not Booked > From and To Fields don't contain My Apartment selection	My Apartment is not present in both From and To combo boxes	Pass
Select Mode of Transport : Driving	Runs directions with car results	Show directions for car	Pass
Select Mode of Transport : Walking	Runs directions with walking results	Show directions for walking	Pass
Select Mode of Transport : Public Transport	Runs directions with public transport results	Shows directions and details for public transport	Pass
Select Mode of Transport : Bicycle	Runs directions with bicycle results	Show directions for bicycle	Pass

Table 10 - Directions Test Cases

5.2.10 - Other Test Cases

OTHER			
Click on activation link	Account is registered	Account registered and login is possible	Pass
Click on activation link after activating	Message shown that account is already activated	Message not shown, goes through activation processes normally	Fail
Click on activation link 30 days after registering	User cannot be activated. User was deleted	The user was deleted therefore no activation process	Pass
Business Affiliate : Add new Apartment	Add new apartment with owner id being business affiliate id	New apartment added in tbl_apartment_listing	Pass
Business Affiliate : Edit new Apartment	Edit a particular apartment	Apartment details updated in database	
Go to login page when session is active	Redirect to Home.php	Session still exists therefore got redirected to home page	Pass

Table 11 - Other Test Cases

Chapter 6 - Demonstration / Evaluation

This section entails the demonstration as well as an evaluation of the study that was worked upon during this year. The program will be explained as well as showing how the requirements specification were fulfilled.

6.1 - End User Portal

Using the End User Portal requires the user to first register for their account and activate it which results to a user having full functionality of the functions discussed in the previous section.

The registration page asks the user for a username which is their email address, a password and their first and last name. Checks are done for all those fields such as malformed email address and empty fields. After that first level of validation, a second level of validation is done using Ajax requests which sends post request to the database. This will return the following states,

- Account Created, an email was sent to you with an activation link.
- Username is already taken. Please try a different username
- Account is not yet activated. Please visit your email to activate this account

Upon registering, an expiration date of thirty days is given to the link from the day of registration. This is to decrease contention of the database. A scheduled task is run every day indefinitely on the server which selects all the non-activated accounts and checks their expiration date with respect to the date on the server. If both dates are the same, this will permanently delete this account.

Upon activating his/her account, the user is allowed to login into the website and is presented with a home page containing his/her name together with the following options: My Apartment, View Map, Add Attractions, TSP Mode and Directions. The user is allowed to select any of these functions as well as create a holiday and invited friends to the currently selected holiday.

6.1.1 - My Apartment

This section comprises of two different views. The system checks whether or not the user has purchased a rented apartment from the list of apartments within the country where the holiday is taking place which is provided by the business affiliates. Details such as Price per night, total price for the holiday duration and method of payment is shown. Upon clicking on show details, more details are shown about the apartment together with a map with the location. When the user hits Submit payment, the page will be redirected to PayPal pointing at business affiliates account for payment. Upon payment, the user will be redirected from the PayPal account and back to his Holiday Planner account. To do this a sandbox PayPal account had to be created and in the Instant Payment Notification (IPN) section, the holiday planner URL had to be added for the redirect to occur. But since this project was tested on a local server, this is not possible to demonstrate as the IPN does not accept local URLs. When the user visits the 'My Apartment' function again, rather than being presented with a list of apartments, he is shown a map on the side with the apartment marker on it together with the details of the apartment that was purchased. The apartment listing window is shown below in Figure 26.

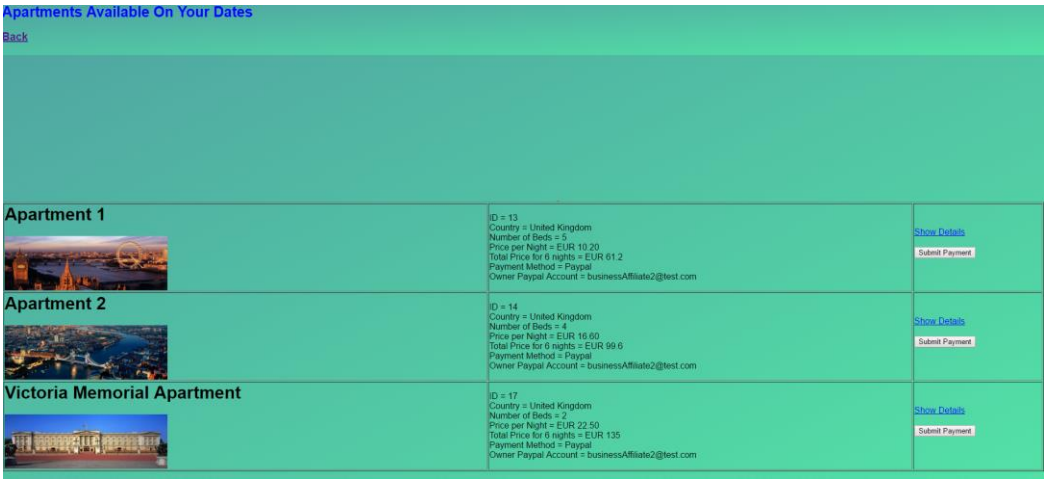

Figure 26 – Apartment Listing

6.1.2 - Add Attraction

The add attraction functionality allows the end user to search out a particular attraction or place within the country of the holiday using the Google Places API. Once the user enters a name of a place, for example the below Figure 27 shows that the user entered ‘The Tower of London’, this will make a request to Google Places which will return a JSON object. This object contains a number of fields which I will be using. The latitude and longitude which are placed within the textboxes as read only. The json object also contains other fields if available such as a formatted address, the true name, telephone number the website and the prices. These are all entered automatically upon search complete within their respective textboxes which the user can edit if needed. The attraction is also shown on the map for visual purposes. Upon hitting add attraction, this is saved inside the database. Purchases for the actual ticket is not possible through the holiday planner because of certain limitations from the ticketing services API. Trip advisor offers an API whereby which tickets can be purchased but there is no sandbox version that could have been implemented with this project.

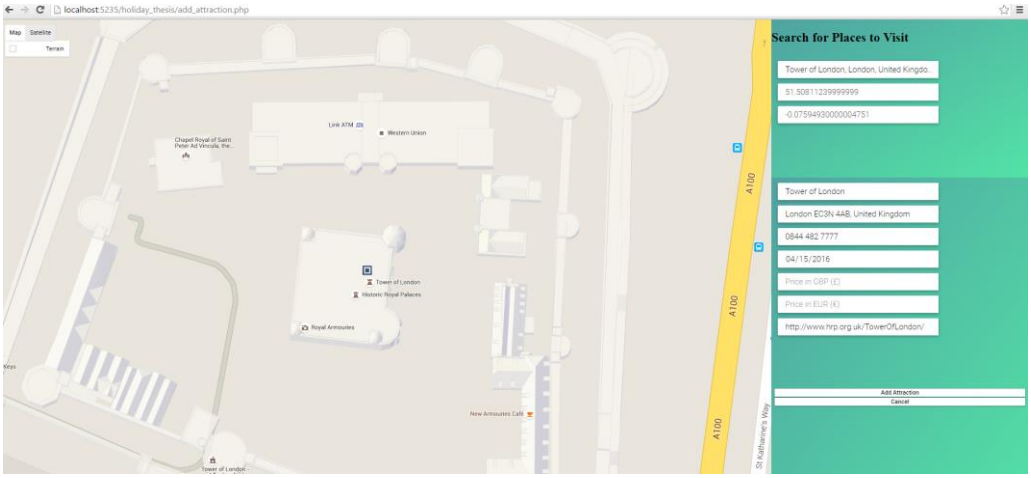

Figure 27 – Add Attraction

6.1.3 - View Map

The View Map functionality shows a map on the left hand side of the page with markers showing the attractions that were added from the previous section. If an apartment was booked, this is also shown with a custom marker to differentiate between the attractions and the apartment. This page helps the user to see where

and how the attractions are structured on the map. A list of the attractions are also listed on the right hand side of the page with a clickable element. This allows the user to click on the text of an attraction and the same map zooms into the attraction that was clicked. The below Figure 28 shows an example of a holiday in London with attractions that will be visited during the duration of the holiday. As can be seen, an apartment was booked therefore a custom icon is shown for the apartment. On the right hand side, the list of attractions are shown in black and the user is able to click on each and every one of them which then calls a function within the code to set the center of the map with that attraction's latitude and longitude as well as zoom into it.

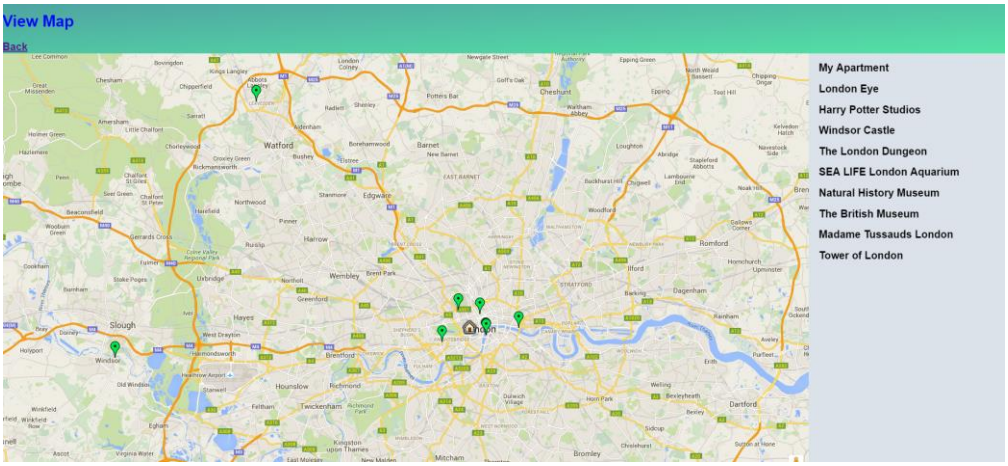

Figure 28 – View Map

6.1.4 - Directions

Directions allows the user to plan how to arrive from one location to another using the locations that were saved in the database by the user. This functionality selects all the attractions and apartment within the database and adds them as options within 2 combo boxes named From and To. The use will first choose from where he would like to calculate the distance and then the destination. A third combo box allows the user to select the mode of transport that he/she will be using, be it by driving, walking, and public transport or cycling. Whichever is chosen, the result by Google Directions API will return the fastest destination. Driving, cycling and walking modes will also give the steps needed to be arrive from the starting to destination points whereas public transport mode will show

details as to which subway station and train lines are needed to arrive to the destination. Figure 29 below shows an example of the directions from the apartment to London Eye through public transport. Notice that the subway lines are also stated together with the duration as well as the number of stops required aboard the metro.

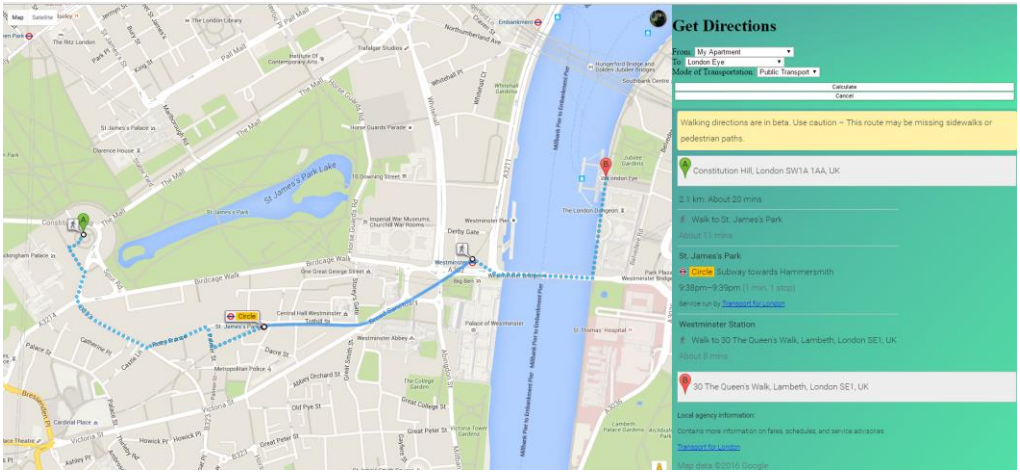

Figure 29 - Directions

6.1.5 - Inviting Friends to the Holiday

The creator of the holiday has the possibility of inviting other users to the holiday which is done from the home page by typing in the email address of a user. If the user exists within the holiday planner social planner, the invited user is automatically added to the holiday. If the user does not exist in the system, an email is sent to that user stating that he has been invited to a holiday but must first register by clicking on the link provided within the email. When this link is clicked, the registration page shows up with the user account text input being read only. The user must then enter his password together with the first and last name. Upon clicking register, the user does not need to activate his account since when accepting the invite, it is automatically assumed that the account needs to be created. All users that were invited to the holiday can be seen underneath the invite button which is located on a sliding panel in the home screen. The sliding panel, apart from giving the user the possibility to change holiday selections, invite and see the invited users, also gives a breakdown of all the attractions that were

added to this holiday as well as basic information about the apartment and holiday details as can be seen below in Figure 30.

Figure 30 - Sliding Panel / Invite Users

6.2 - Business Affiliation Portal

The Business Affiliation portal allows apartment and hotel owners to advertise their property in the holiday planner social network. The registration and login portal have the same logic as the end user portal but on separate tables within the database. In the registration stage, a business affiliate is also required to provide their personal business PayPal account. All payments from end users for the rental of an apartment are done through PayPal. For testing purposes, the endpoint in this project is pointing at the URL *sandbox.paypal.com* and a sandbox account was also created so as to not make real transactions.

A business affiliate can add multiple apartments by inputting the necessary details such as name of the apartment, number of beds, and the address as well as placing a marker on google maps by searching for the address in a search box. Another requirement is to add an image of the apartment as well as other details regarding the apartment by ticking the checkbox. This can be seen in Figure 31 below.

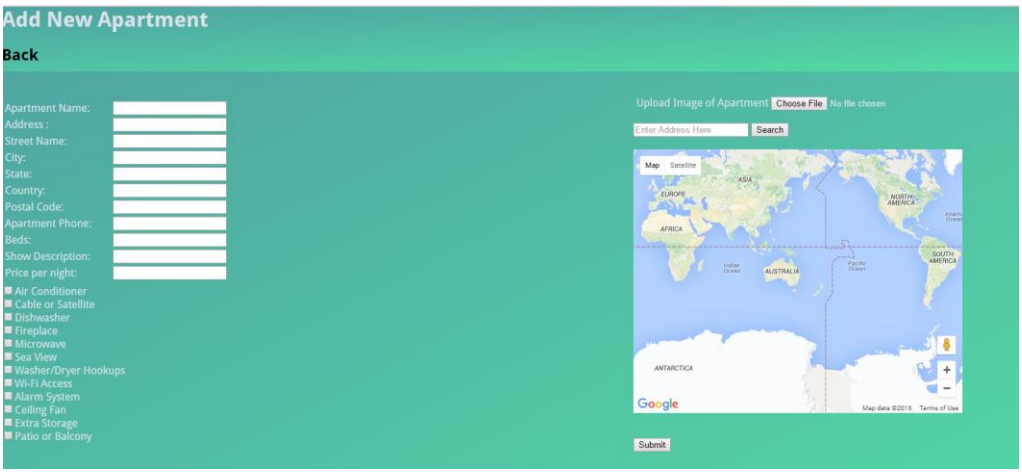

Figure 31 - Business Affiliate, Adding a new Apartment

6.3 - Evaluation

The method for evaluating this project was taken through observation. This is the most common method used for getting information. According to Oxford Concise Dictionary, observation means 'accurate watching, noting the phenomenon by which they occur in the nature with regard to the cause and effect of mutual relations.' They are useful to researchers in a variety of ways since they provide researchers with ways to check for nonverbal expression of feelings, and grasp how the participants interact with the task assigned to them as well as check for the time spent to accomplish a task or activity (SCHMUCH, 1997).

Schensul and LeCompte (1999) list the following as some advantages with utilizing an observation method which are as follows:

- Best direct method to collect information, especially for the study of human behavior.
- Data collected is very reliable.
- Improves prevision of the obtained results.
- Is less demanding in nature, which therefore tends to make it less bias in working abilities.

Four participants were offered to undergo an evaluation and all four accepted. The following is the list of tasks that each participant had to undergo.

Evaluation Tasks

1. Register an Account with Holiday Planner using this email – test@holidayplanner.com
2. Activate your account through an activation link sent to you after step 1. (Ask researcher for assistant with opening this email)
3. Try Login to your new account using the user account and password assigned at step 1.
4. After Logging in, create a holiday. Input country as United Kingdom.
5. Invite the following users to this holiday.
    a. test2@holidayplanner.com
    b. test3@holidayplanner.com
    c. test4@holidayplanner.com
6. In My Apartments, select an apartment of your choice and purchase it. Use thomasborg.mdx@gmail.com as your PayPal account. (Do not worry, this is a test account therefore no payment will be processed)
7. See Apartment Location after payment.
8. Add Multiple Attractions to your holiday.
9. Get Directions from your Apartment to one of the attractions by Car, Walking and Public Transport.
10. Use TSP Mode to get the order of viewing attractions based on the day.

These tasks were carried out by each participant and time as well as certain details were taken note of. Where possible, participants were encouraged to "Think Aloud". By listening to users think and plan, this enables the researcher to examine the participant's expectation of the project as well as their intentions and their problem solving strategies.

6.3.1 – First Participant

The first participant had a great affinity and understand in software development and therefore produced the best results out of all the participant. Some of the naming conventions were suggested to be changed such as Directions into 'Tours'. Functionality to the TSP mode could have been largely improved also by integrating the Directions API together with the Genetic Algorithm. The Genetic algorithm uses the Distance Matrix API which returns the distances and duration of a matrix of attractions. After running the genetic algorithm and returning the positions of attractions as to how they were to be visited, it was suggested that once getting these results, another request is made to the Google Maps API to return the directions needed to go about this tour.

This would therefore integrate the TSP Mode functionality with the Directions method into one function. Reusability of code would be possible since the results of the genetic algorithm is returned in an array. Each array index refers to a particular attraction. A request would then be sent to the Google API with the origin of the object within index zero of the array and destination of the object within index one. Once this is completed, a recursive function would be needed to make the same request but using origin of the object within index one and destination of the object within index two. This goes on recursively until the last object within the array is covered.

6.3.2 – Second Participant

The second participant, although not a technical person, gave a very interesting points as to how to improve this project for future functionality. This functionality involves giving users the possibility to import attractions from other past users who attended the same holiday within the same country. For example last year, a group of eight users attended a holiday in London for five days which included a total of thirty attractions. Once a new user creates a new holiday within the same country or state, the administrator of this holiday could have the ability to import the attractions of the holiday that the eight users from last year attended. This would need to be set as a permission by the 'owners' of that previous holiday. This would allow the new users attending the similar holiday to have some idea of

interesting attractions and places that other user before them have visited. Participant was also happy with the warning presented when taking mistakes as they helped him/her to correct his/her own mistakes on his/her own without any help from the researcher. Saw a lot of potential with allowing a user to invite a person who does not have an account. A partial registration for that user will be created. The Partial user would only have to add the password and submit the activation link. This was explained to the participant.

6.3.3 – Third Participant

The third participant gave a lot of insight on how certain function could work better within the project. All messages and warning were self-explanatory and although errors were made by this participant, all were immediately corrected after reading the warnings that showed up. After the second participant, the UI functions were set in order of functionality. From left to right – My Apartment, Add Attractions, View Map, TSP Mode and Directions. This gave better insight as to how a holiday should be planned the correct way. This participant suggested to change the input box when adding an attraction to a combo box which holds each day of the holiday which is similar to the date combo box in TSP Mode. This reduces the possibility of the user giving an incorrect date or an out of bounds date from the holiday. This change is shown in Figure 32 below.

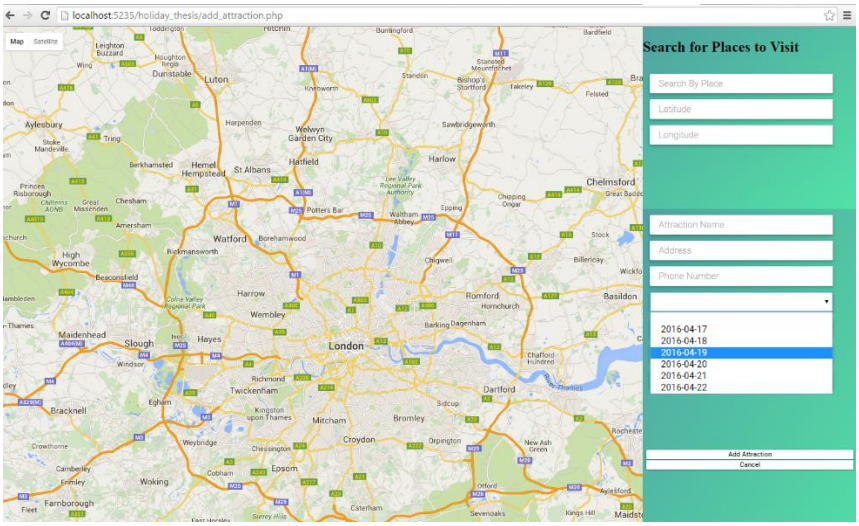

Figure 32 – View Map Evaluation

6.3.4 – Fourth Participant

This participant enjoyed the on the whole functionality that the project offered. Certain suggestions were given toward making the system more aesthetically pleasing as well as smartphone functionality for users. Another suggestion which was included in this version of implementation was to add the names of the attractions in the View Map screen on a panel to the right. The user could click on each and any one of these links and the map would automatically zoom in to that attraction clicked.

6.4 – Evaluation Results

The results from this evaluation was important for the final conclusion and amendments in the source code. Almost all participants agreed and appreciated with the amount of time dedicated to the customization of the errors that are given to the user. This helped with trial and error occurrences. Below is a chart for the timings of how much time each task take to conclude.

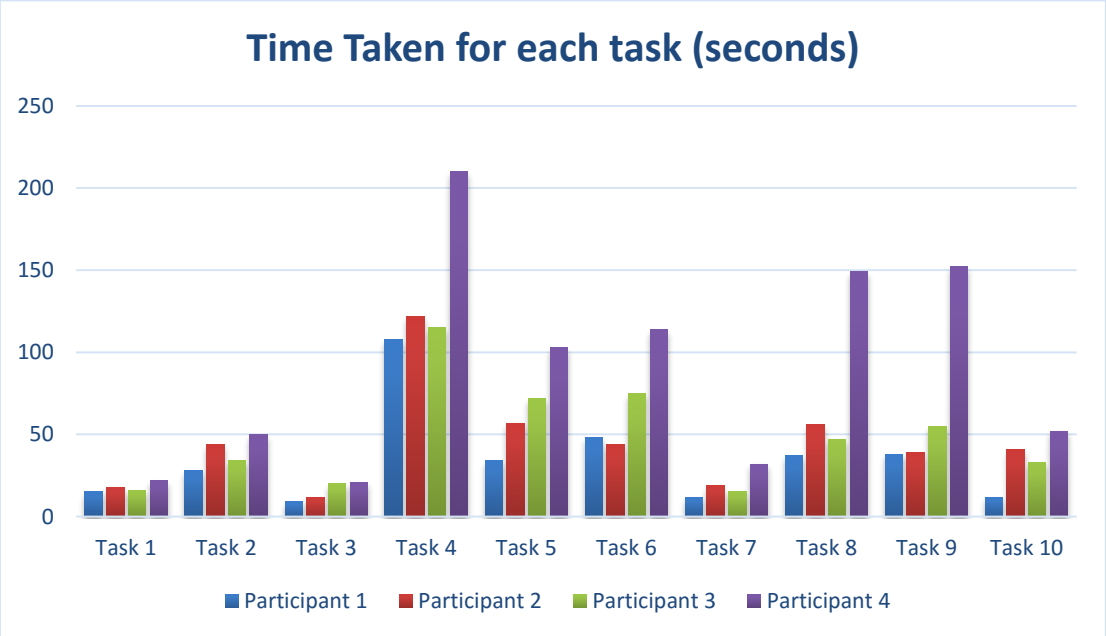

Figure 33 – Time taken for each task

Chapter 7 - Conclusion

After concluding the project, a thoroughly analysis was made of the various implementation steps, including:

- The planning
- Implementation
- Genetic Algorithm
- Testing
- Troubleshooting
- Evaluation

Through the above steps and evaluation process, the participants enjoyed the integration of the functions offered in this project and content with having all of these function centralized into one program. And thus, all the objectives listed were reached and the genetic algorithm offers some insight to other researches who are keen to learn more about this algorithm developed for this particular use case.

Chapter 8 - Suggestions for Further Work

The work performed in this project provided basis for future research in several areas. At least four such areas can be identified. These areas include:

- Building a smart phone application that connects to the same web server.
- Using HTML5 Web Workers
- Airline API Implementation
- More Social Networking Functionality

The following sections discuss each of these areas in more details.

8.1 – Smart Phone Application

The use of mobile web applications has dropped by almost a quarter, from an average of 31 minutes daily in March 2013 to 22 minutes a year later as stated by Charles Arthur (2015). The APIs made by Google are offered on both the mainstream OS for smartphones, Android and iOS. Implementation of the GA would have to be implemented in both languages Java and Objective C although distance measured through the Distance Matrix API and getting locations from Google Places would basically include re-usability of the same code from the web application developed.

8.2 – HTML Web Workers

HTML5 introduces the ability to perform multi-threading in the browser using JavaScript through Web Workers. Whilst scripts are being executed in an HTML page, the page is unresponsive until the script is fully executed. This technology run independently of other script in the background. This does not hinder the performance of the page. This could therefore be implemented and applied to the travelling salesman problem. This would result to multi-threaded implementation of the TSP which converges on a solution for up to 200 cities with a zero footprint.

8.3 – Airline API Implementation

Certain Airline APIs are available such as the one Sky Scanner offers. This would allow the web application to make airline bookings. This would keep all functionality of the holiday in a centralized application.

8.4 – Social Networking Functionality

Chat services could be implemented as well as approvals of attractions by an administrator. The administrator could be the holiday creator or a number of users within the holiday can take the role of administrator.

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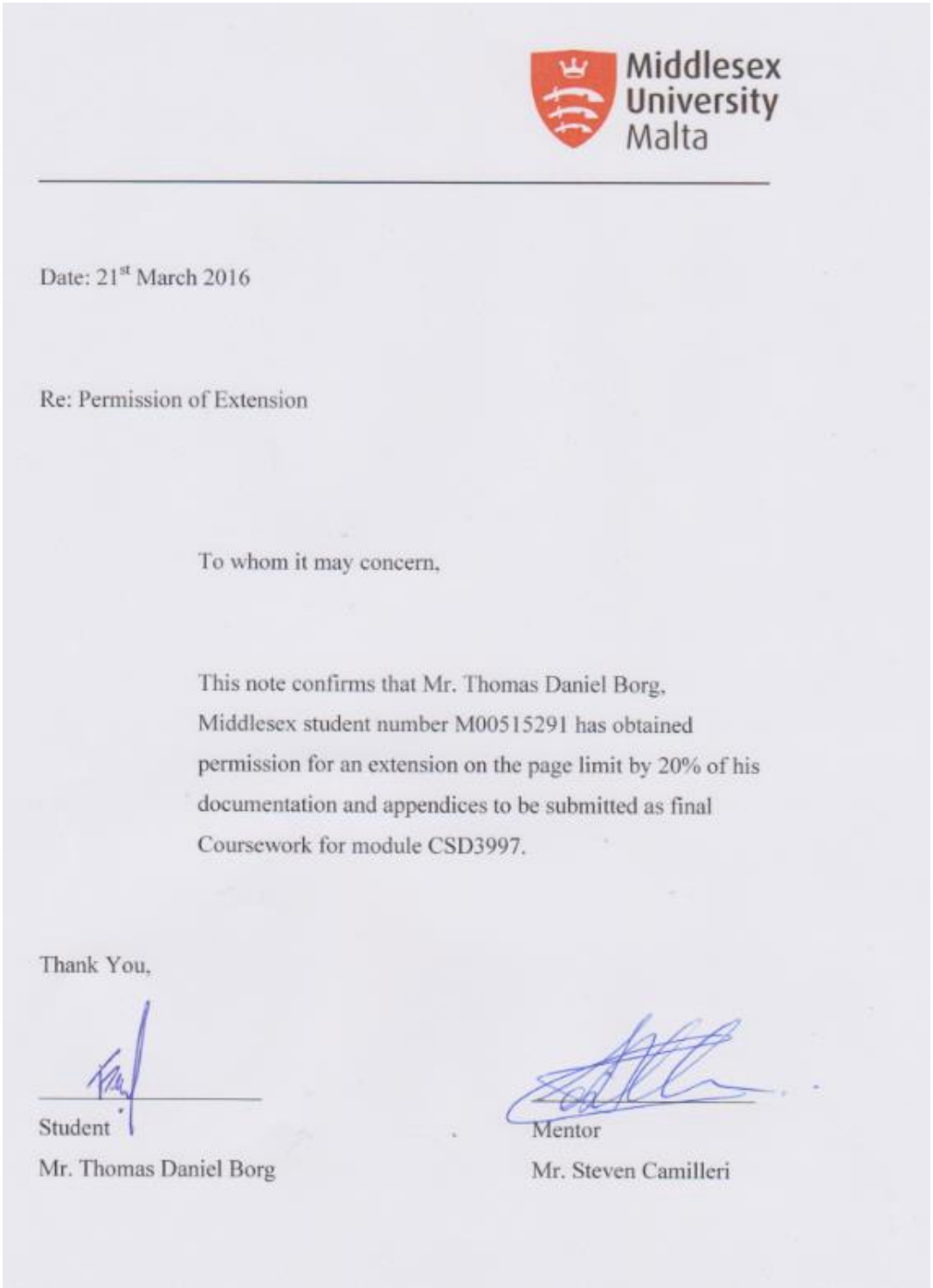
Appendices

Permission of Extension



Middlesex University Malta

Date: 21st March 2016

Re: Permission of Extension

To whom it may concern,

This note confirms that Mr. Thomas Daniel Borg, Middlesex student number M00515291 has obtained permission for an extension on the page limit by 20% of his documentation and appendices to be submitted as final Coursework for module CSD3997.

Thank You,

Student
Mr. Thomas Daniel Borg

Mentor
Mr. Steven Camilleri

Instruction Manual

Requirements

Install Xampp from the following link : http://www.apachefriends.org/index.html

Setting up Files and Folders

1. Unzip holiday_thesis.zip from CD inside CSD1993_M00515291_ThomasDanielBorg/Source Code Folder
2. Copy holiday_thesis folder to C:\xampp\htdocs
3. Open Browser. Surf to http://localhost/phpmyadmin
4. Create a database named holiday
5. Select the database and import the sql file found in C:\xampp\htdocs\holiday_thesis
6. Go to C:\xampp\htdocs\holiday_thesis and open up db.php in notepad
7. Change the credentials of the database within method mysql_connect() Example– mysql_connect('localhost' , 'your_username' , 'your_password')

Setting up the Task Scheduler

This can be either done manually or by importing the xml file found in holiday_thesis/scheduled_tasks folder.

1. Click the Start button
2. Click on Command Prompt
3. At the command prompt, type Taskschd.msc
4. At Task Scheduler Window, Click on Action and Create Task
5. Enter the name Auto Account Removal
6. Choose radio button 'Run whether user is logged on or not'
7. Tick checkbox 'Run with highest privileges'
8. Click on Actions and New Button
9. Select 'Start a program' in the Action combo box
10. Type in the location of the php executable in the Program Script field. Usually in C:\xampp\php\php.exe
11. Add the following to the Add Arguments text box –f {Path\to\phpscript.php} Therefore type in : C:\xampp\htdocs\holiday_thesis\ remove_expired_registrations.php See Figure 34 below
12. Click OK

13. Go to Triggers
14. Click on New Button
15. Select ‘On a schedule’ from the Begin the task combo box
16. Click on the Repeat task every check box and select every *5 minutes* for a duration of *indefinitely.*
    See Figure 35 below
17. Click Ok

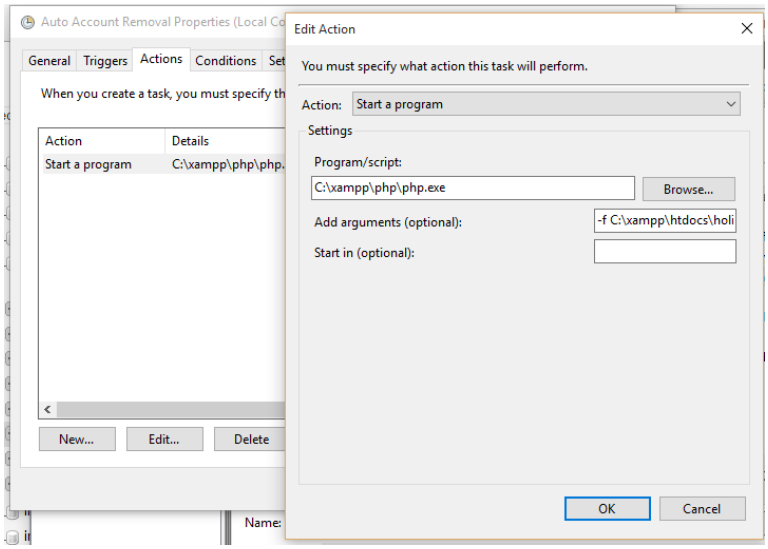


Figure 34 – Task Scheduler Action

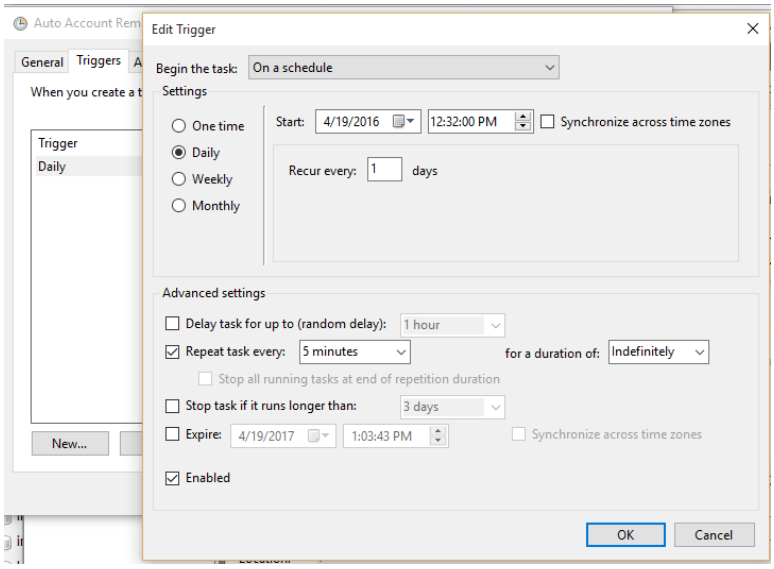


Figure 35 – Task Scheduler Trigger

Form C – Consent Form

Middlesex University Department of Computer Science

Research Consent Form

This consent form gives you, the research participant, information about the research study in which you have been asked to participate and what your participation will involve. Please take time to read it and any accompanying information.

Research Project Title: Holiday Planner Social Network

Name of Researcher: Thomas-Daniel Borg

Purpose of Study:

This evaluation is an integral part of the program. Designing a program with evaluation in mind together with collecting data on an on-going basis helps to improve the design and development.

Participant Recruitment and Selection

You were chosen to take part in this study because of the frequent visits abroad that you participate in, both on a social and working basis. The results obtained by this test should prove to be very relevant to this project since such a project should be able to solve problems that are met without the necessary research being done beforehand.

Procedure

The method of this research is through observation. You will be provided with a website and dummy email address. You will be asked to register an account with the software being provided and use the email address provided to complete this registration. You are then presented with a home screen where you will be asked to make the necessary tasks like booking an apartment online, adding new holidays, attractions as well as getting

directions from one attraction to another. You will be assessed on how your experience was and at any point in time, you make ask me questions.

Data Collection

The information that is collected from this test is you overall user experience of the system. You will be graded from 1 to 5 on certain events within the system. Any comments and remarks are very much appreciated and this will also be documented.

Confidentiality

Data collection will not contain information that could readily identify the participants. The use of study codes on data documents will be used instead of recording identifying information. Identifiable data will also be encrypted as well as the removal of face sheets containing identifiers such as names and addresses from survey instruments.

Likelihood of Discomfort

During the research study, you will not experience discomfort of any sort, and if for any reason you do, please note that you can withdraw from the experiment without any penalty.

Further information about the Researcher and the Project

This project was thought of during the planning of a personal vacation together with ten of my friends. As can be expected, a group vacation could result to many misunderstandings within the group itself. Misunderstandings such as where to visit, which attractions should we visit and when, as well as complications of how to arrive at these attractions and a way to minimize the travelling distances and durations. I therefore decided to create this project to minimize this conflict and allow groups to have their say as well as better plan their holiday.

Finding out about Results

Should you be interested to know the results of the study that you are taking part in, I would be happy to provide you with my personal email address listed below and will forward you all the necessary information.

Agreement

Please sign below if you agree to participate in the study. Your signature does not waive any legal rights or release the researcher/investigator, sponsors, or involved institutions from their legal and professional responsibilities. You can withdraw from all or part of the study at any time without penalty. Your continued participation should be as informed as your initial consent, so please feel free to ask for clarifications or new information at any time.

The researcher agrees to comply with the Malta Data Protection Act and all other relevant legal obligations.

Participant: _____

Date: _____

Researcher/Investigator: _____

Date: _____

Turn it in Digital Receipt

Turn it in Digital Receipt – Interim Submission

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

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Form D: Declaration Form

Middlesex University Malta

Student Project: Ethical Approval Request

Name:	Student ID:	Date:
Thomas-Daniel Borg	M00515291	7/04/2016

Supervisor:
Mr Steven Camilleri

Title
Holiday Planner Social Network

Ethical Approval Statement:

Declaration A

(i) I have studied the Ethical Approval section.
(ii) I have established that my study does not require additional human participation.
(iii) I agree to re-apply for approval if the nature or goals of my project change.

☐

Declaration B

Project Goals involving human participation:

Evaluate Usability of Program Developed

Increase Positive Perceptions

Increasing Quality of Program

(i) I have studied the Ethical Approval section.
(ii) My study involves human participation through
- observation
- questioning.

(iii) Participants will be selected without coercion (see Chart 1).
(iv) I will obtain informed consent (see Chart 2) from each participant using Form C.
(v) I have arrangements in place for the protection of personal data (see Chart 3).
(vi) I agree to re-apply for approval if the nature or goals of my project change.

☐

Declaration C

My project does not fulfil the conditions for fast track Ethical Approval and I am applying separately to the Ethics Committee

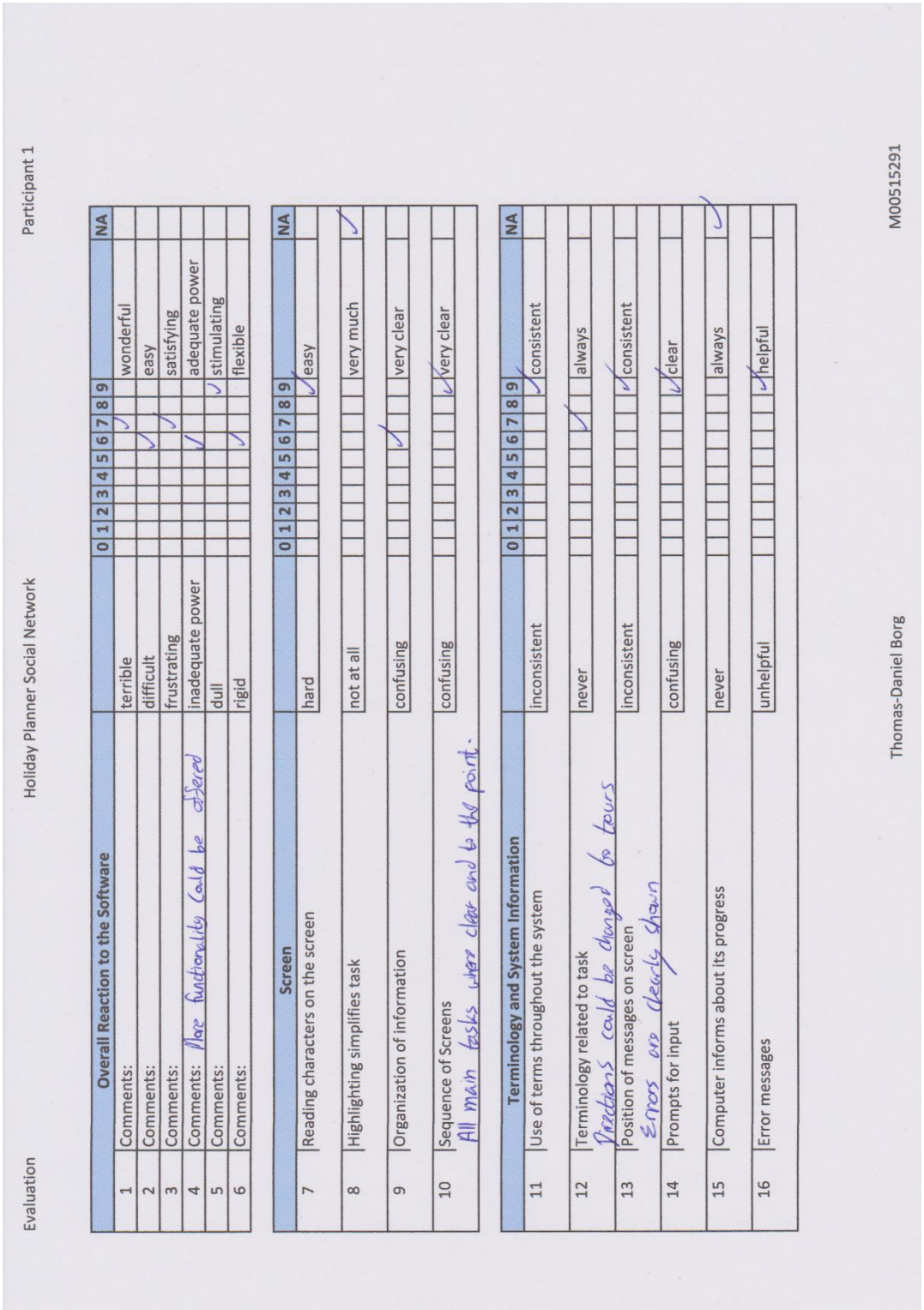
☐

Note: to make an application to the Ethics Committee, you need to complete
Form E - Application for Ethical Approval & **Form C** – Informed Consent Form
(Download from: **http://tinyurl.com/mdx-ethics**)

Student Signature..... Date.....

Supervisor's Signature..... Date.....

Participant 1 Results



Evaluation — Holiday Planner Social Network — Participant 1

	Overall Reaction to the Software		0	1	2	3	4	5	6	7	8	9		NA
1	Comments:	terrible										✓	wonderful	
2	Comments:	difficult								✓			easy	
3	Comments:	frustrating								✓			satisfying	
4	Comments: More functionality could be offered	inadequate power							✓				adequate power	
5	Comments:	dull										✓	stimulating	
6	Comments:	rigid								✓			flexible	

	Screen		0	1	2	3	4	5	6	7	8	9		NA
7	Reading characters on the screen	hard										✓	easy	
8	Highlighting simplifies task	not at all											very much	✓
9	Organization of information	confusing							✓				very clear	
10	Sequence of Screens All main tasks were clear and to the point.	confusing										✓	very clear	

	Terminology and System Information		0	1	2	3	4	5	6	7	8	9		NA
11	Use of terms throughout the system	inconsistent										✓	consistent	
12	Terminology related to task Functions could be changed to tours	never								✓			always	
13	Position of messages on screen Errors are clearly shown	inconsistent										✓	consistent	
14	Prompts for input	confusing										✓	clear	
15	Computer informs about its progress	never											always	✓
16	Error messages	unhelpful										✓	helpful	

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	Learning		0	1	2	3	4	5	6	7	8	9		NA
17	Learning to operate the system	difficult							✓				easy	
	Needs to follow certain structure													
18	Exploring new features by trial and error	difficult								✓			easy	
19	Remembering names and use of commands	difficult										✓	easy	
20	Performing tasks is straightforward	never								✓			always	
	In home page, circles need to be in chronological order of use													
21	Help messages on the screen	unhelpful											helpful	✓
22	Supplemental reference materials	confusing										✓	clear	

	System Capabilities		0	1	2	3	4	5	6	7	8	9		NA
23	System Speed	too slow										✓	fast	
	Quite content with the speed with which the results are returned.													
24	System Reliability	unreliable										✓	reliable	
25	Correcting your mistakes	difficult								✓			easy	
26	Designed for all levels of users	never				✓							always	
	I would categorize this website for users of the age 18 and over													

	Most Negative Aspects
1	Main functions need to be in chronological order.
2	Warning Conversions. Tours rather than Directions
3	

First Add Attraction, then View Map options

	Most Positive Aspects
1	Found No difficulty using the functions ~~Hotel~~
2	
3	

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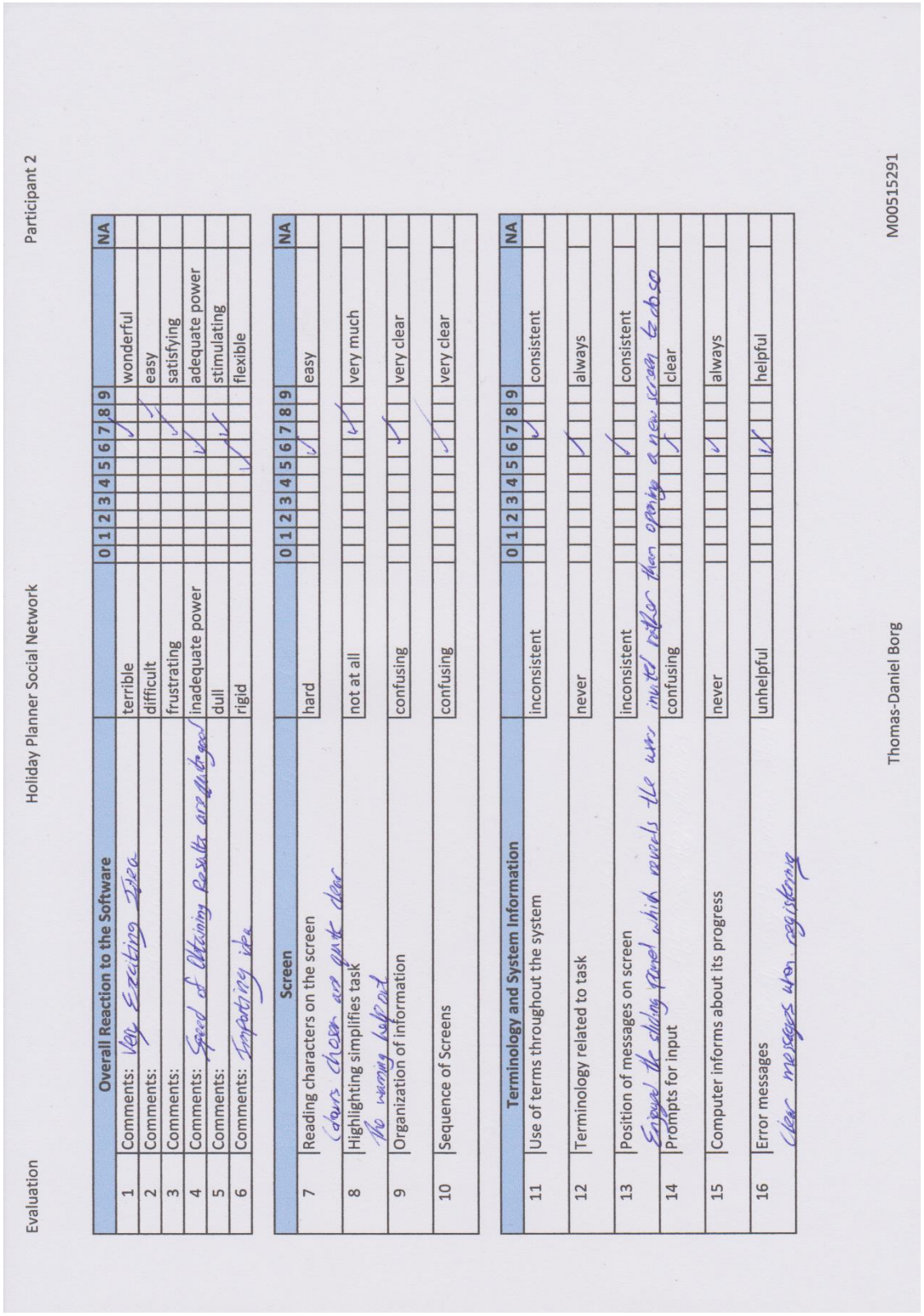
Participant 2 Results



Evaluation — Holiday Planner Social Network — Participant 2

	Overall Reaction to the Software		0	1	2	3	4	5	6	7	8	9		NA
1	Comments: Very Exciting Idea	terrible									✓		wonderful	
2	Comments:	difficult									✓		easy	
3	Comments:	frustrating									✓		satisfying	
4	Comments: Speed of Viewing Results are quite good	inadequate power							✓				adequate power	
5	Comments:	dull									✓		stimulating	
6	Comments: Supporting idea	rigid							✓				flexible	

	Screen		0	1	2	3	4	5	6	7	8	9		NA
7	Reading characters on the screen Colours chosen are quite clear	hard							✓				easy	
8	Highlighting simplifies task The wording helped	not at all									✓		very much	
9	Organization of information	confusing								✓			very clear	
10	Sequence of Screens	confusing								✓			very clear	

	Terminology and System Information		0	1	2	3	4	5	6	7	8	9		NA
11	Use of terms throughout the system	inconsistent									✓		consistent	
12	Terminology related to task	never								✓			always	
13	Position of messages on screen Enjoyed the sliding panel which reveals the user invited rather than opening a new screen to choose	inconsistent								✓			consistent	
14	Prompts for input	confusing								✓			clear	
15	Computer informs about its progress	never								✓			always	
16	Error messages Clear messages when registering	unhelpful								✓			helpful	

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Evaluation | Holiday Planner Social Network | Participant 2

	Learning		0	1	2	3	4	5	6	7	8	9		NA
17	Learning to operate the system	difficult								✓			easy	
18	Exploring new features by trial and error	difficult								✓			easy	
19	Remembering names and use of commands	difficult							✓				easy	
20	Performing tasks is straightforward	never								✓			always	
21	Help messages on the screen	unhelpful											helpful	✓
22	Supplemental reference materials	confusing											clear	✓

	System Capabilities		0	1	2	3	4	5	6	7	8	9		NA
23	System Speed	too slow									✓		fast	
24	System Reliability	unreliable								✓			reliable	
25	Correcting your mistakes Gives opportunity to correct mistakes	difficult								✓			easy	
26	Designed for all levels of users	never								✓			always	

	Most Negative Aspects
1	Importing holiday by previous users
2	
3	

	Most Positive Aspects
1	Like the fact that even a user who hasn't
2	invited doesn't have an account can be
3	invited

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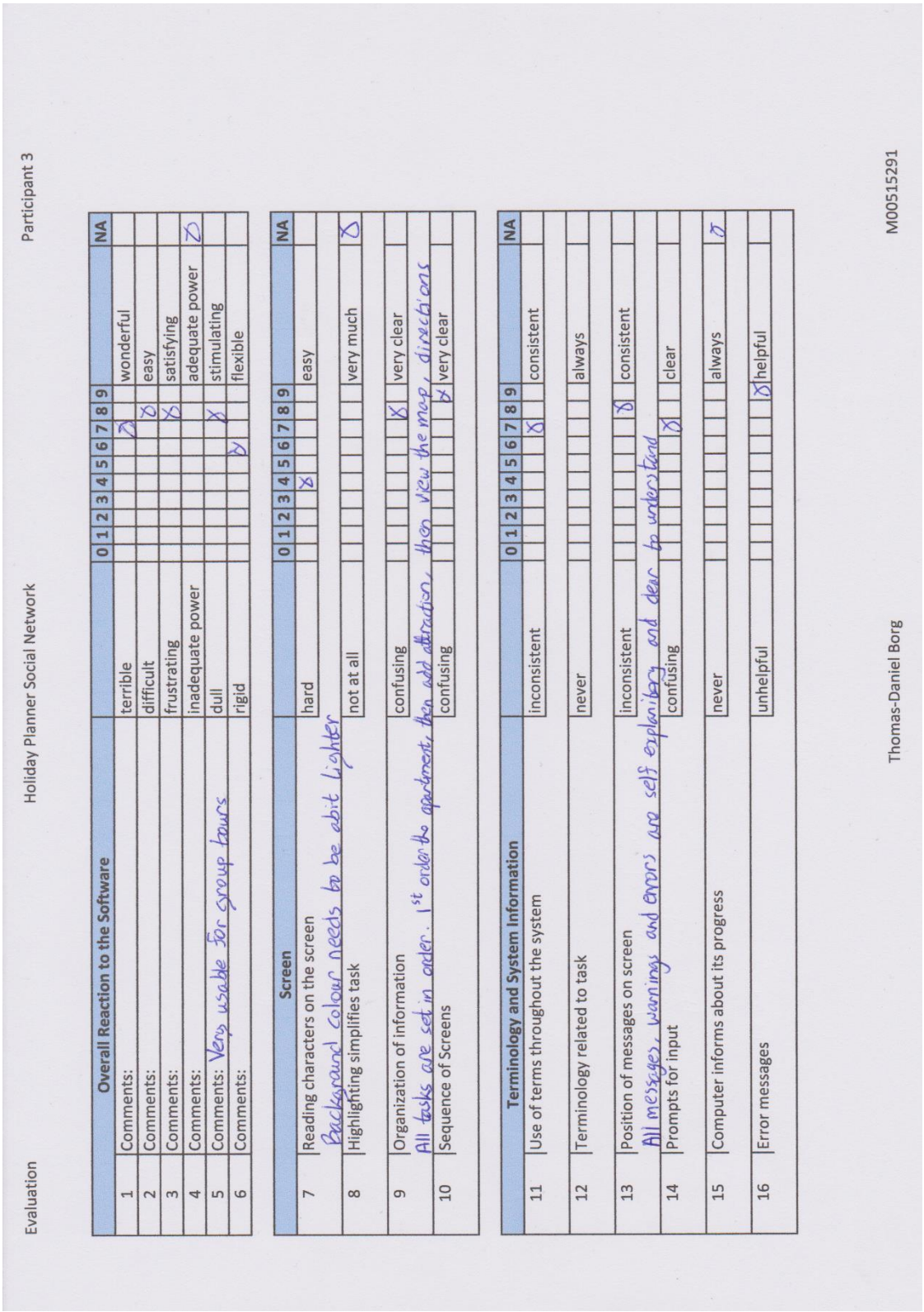
Participant 3 Results



Evaluation — Holiday Planner Social Network — Participant 3

	Overall Reaction to the Software		0	1	2	3	4	5	6	7	8	9		NA
1	Comments:	terrible								X			wonderful	
2	Comments:	difficult									X		easy	
3	Comments:	frustrating									X		satisfying	
4	Comments:	inadequate power											adequate power	X
5	Comments: Very usable for group tours	dull									X		stimulating	
6	Comments:	rigid							X				flexible	

	Screen		0	1	2	3	4	5	6	7	8	9		NA
7	Reading characters on the screen Background colour needs to be abit lighter	hard					X						easy	
8	Highlighting simplifies task	not at all											very much	X
9	Organization of information All tasks are set in order. 1st order the apartment, then add attraction, then view the map, directions	confusing									X		very clear	
10	Sequence of Screens	confusing										X	very clear	

	Terminology and System Information		0	1	2	3	4	5	6	7	8	9		NA
11	Use of terms throughout the system	inconsistent								X			consistent	
12	Terminology related to task	never											always	
13	Position of messages on screen All messages, warnings and errors are self explanitory and clear to understand	inconsistent										X	consistent	
14	Prompts for input	confusing								X			clear	
15	Computer informs about its progress	never											always	X
16	Error messages	unhelpful										X	helpful	

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	Learning		0	1	2	3	4	5	6	7	8	9		NA
17	Learning to operate the system	difficult								✓			easy	
18	Exploring new features by trial and error	difficult							✓				easy	
19	Remembering names and use of commands	difficult						✓					easy	
20	Performing tasks is straightforward	never											always	
	When adding an attraction, use the dropdown boxes for the date. This can be taken from dates specified when creating the holiday													
21	Help messages on the screen	unhelpful										✓	helpful	
22	Supplemental reference materials	confusing											clear	✓

	System Capabilities		0	1	2	3	4	5	6	7	8	9		NA
23	System Speed	too slow											fast	✓
24	System Reliability	unreliable								✓			reliable	
25	Correcting your mistakes	difficult								✓			easy	
26	Designed for all levels of users	never								✓			always	

	Most Negative Aspects
1	Resizing window of browser not correct
2	Automated functionality such as the drop down
3	feature in #20

	Most Positive Aspects
1	Very fun to use
2	
3	

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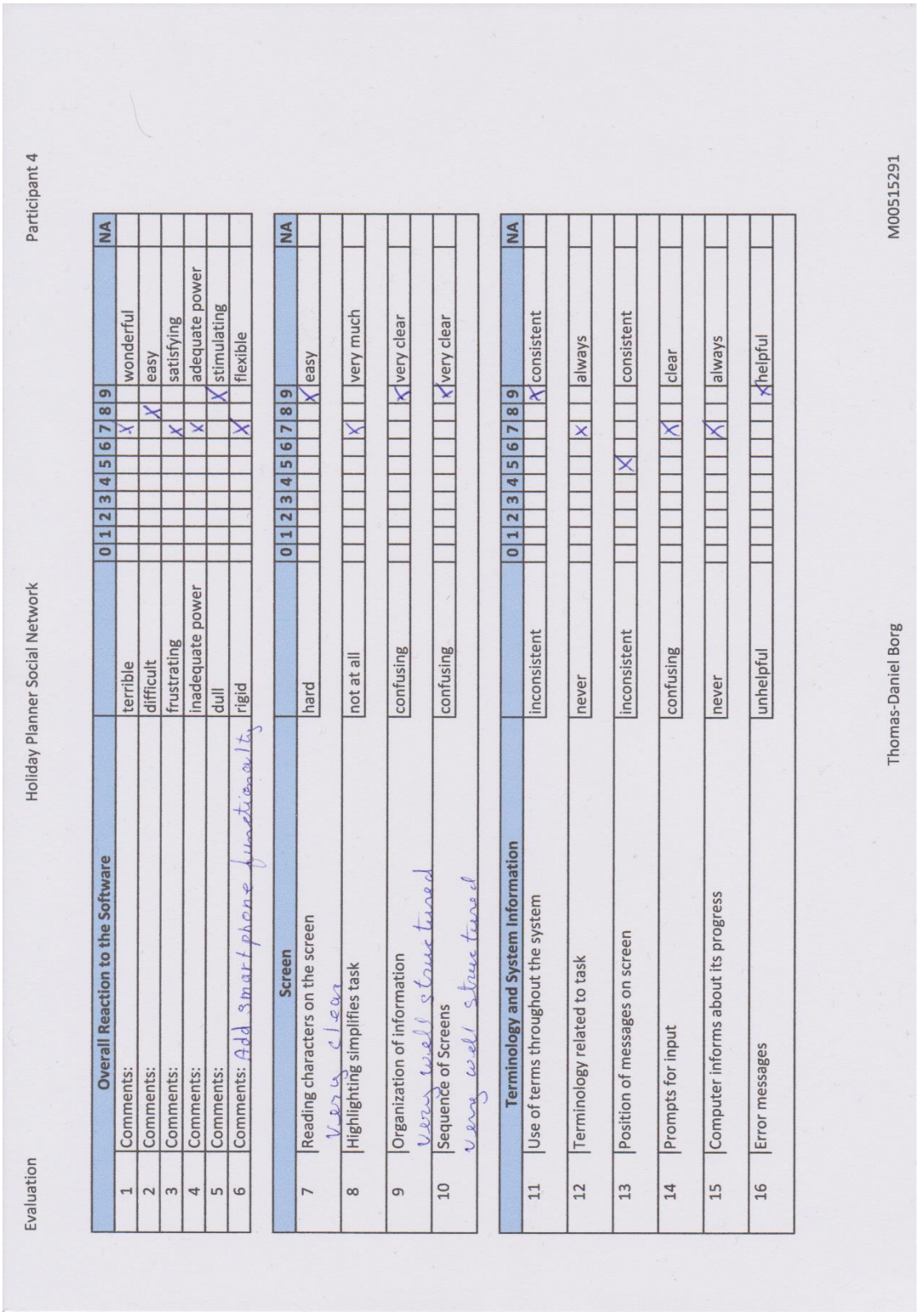
Participant 4 Results



Evaluation — Holiday Planner Social Network — Participant 4

	Overall Reaction to the Software		0	1	2	3	4	5	6	7	8	9		NA
1	Comments:	terrible								X			wonderful	
2	Comments:	difficult									X		easy	
3	Comments:	frustrating								X			satisfying	
4	Comments:	inadequate power								X			adequate power	
5	Comments:	dull										X	stimulating	
6	Comments: Add smartphone functionalities	rigid								X			flexible	

	Screen		0	1	2	3	4	5	6	7	8	9		NA
7	Reading characters on the screen Very clear	hard										X	easy	
8	Highlighting simplifies task	not at all								X			very much	
9	Organization of information Very well structured	confusing										X	very clear	
10	Sequence of Screens Very well structured	confusing										X	very clear	

	Terminology and System Information		0	1	2	3	4	5	6	7	8	9		NA
11	Use of terms throughout the system	inconsistent										X	consistent	
12	Terminology related to task	never								X			always	
13	Position of messages on screen	inconsistent						X					consistent	
14	Prompts for input	confusing								X			clear	
15	Computer informs about its progress	never								X			always	
16	Error messages	unhelpful										X	helpful	

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Evaluation | Holiday Planner Social Network | Participant 4

	Learning		0	1	2	3	4	5	6	7	8	9		NA
17	Learning to operate the system	difficult								X			easy	
18	Exploring new features by trial and error	difficult								X			easy	
19	Remembering names and use of commands	difficult										X	easy	
20	Performing tasks is straightforward	never								X			always	
	Add in view map screen functionality of hyper-links.													
21	Help messages on the screen	unhelpful										X	helpful	
22	Supplemental reference materials	confusing											clear	X

	System Capabilities		0	1	2	3	4	5	6	7	8	9		NA
23	System Speed	too slow											fast	X
24	System Reliability	unreliable											reliable	X
25	Correcting your mistakes	difficult									X		easy	
26	Designed for all levels of users	never									X		always	

	Most Negative Aspects
1	Add view map functionality
2	Smart phone functionality
3	

	Most Positive Aspects
1	Enjoyed booking integration
2	
3	

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