myTaxiService

Design **D**ocument

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Contents

1 Introduction

1.1 Purpose

This document represents the Design Document, which main goal is to describe the overall system architecture and to show the technical design decisions made, with the support of schema and diagrams.
It delineates how the software system will be structured in order to satisfy the requirements defined in the Requirement Analysis and Specification Document (RASD), each one translated into a representation of components, interfaces, and data necessary in the implementation phase.
This document is addressed to the project development teams, technical architects, database designers and testers, as long as it has useful guidelines and a specific description of the design implementation of the system.

1.2 Scope

The system aims at simplifying the access of the passengers and guaranteeing a fair management of taxi queues.
The server listens for the requests of the clients, which can be taxi drivers or users and access to their GPS position.
The user clients are able to request a taxi and, if logged into the system, they can also make reservations and choose the payment method they prefer. On the other hand, taxi driver clients can change their status from available to unavailable, accept or decline the requests of the users and see their position in the queue of the area they are in.
The server manages the notifications to forward to the clients, for example the arrival of a taxi for a user or the requests of the users for the taxi drivers.

1.3 Definitions, Acronyms, Abbreviations

- **Definitions**

- **User**: a person who requests a service from the system. It can be a visitor or a passenger.

- **Visitor**: a person who is not registered in the application.

- **Passenger**: a person who is registered in the application.

- **Taxi driver**: a taxi driver who access the application with a specific ID.

- **Request**: the request of a taxi in a certain area and position in the city made by a user.

- **Reservation**: the reservation of a taxi in a certain area, place and time that can be made only by passengers.

- **Acronyms and abbreviations**

- **RASD**: Requirement Analysis and Specification Document

- **DBMS**: Database Management System

- **JEE**: Java Enterprise Edition

- **API**: Application Programming Interface

- **UML**: Unified Modeling Language

- **HTML**: HyperText Markup Language

- **HTTP**: HyperText Transfer Protocol

- **MVC**: Model View Controller

1.4 Reference documents

- myTaxiService Requirement Analysis and Specification Document (RASD)

1.5 Document structure

This document is divided in six main parts:

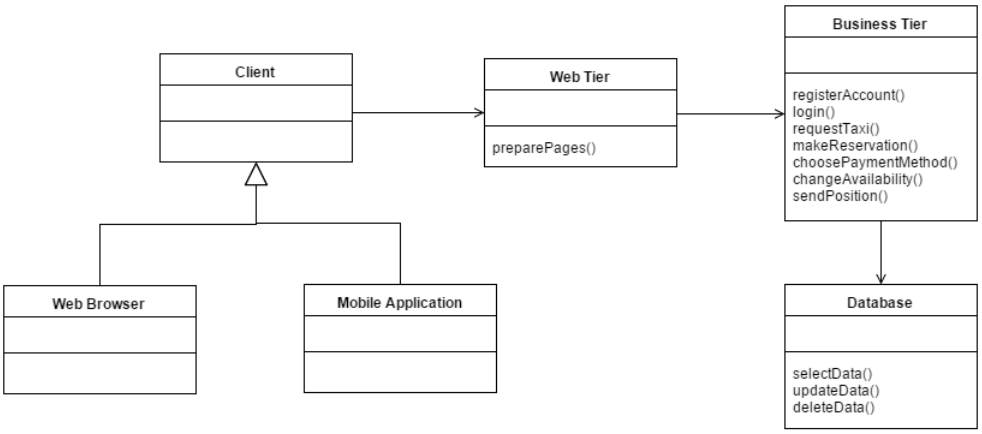
- **Introduction**: this section describes the document in general and its purpose.
- **Architectural Design**: this section specifies the architectural design part, giving information about the components involved.
- **Algorithm Design**: this section provides a general description of the main algorithms used during implementation.
- **User Interface Design**: this section outlines an overview on how the user interfaces of the system will look like.
- **Requirements Traceability**: this section explains the connection between the requirements already defined in the RASD and the design elements introduced in this document.
- **References**: this section contains the references to external documents used to redact this document.
- **Appendix**: this section provides information about the tools used to redact this document and how many hours of work each author has spent.

2 Architectural Design

2.1 Overview

It has been adopted a four-tier architectural model, composed by thin client, web server, application server and database.
This architecture is the best choice for our system, even if it has some cons, such as the complexity of the structure and the difficulty of set up and maintenance, it still has several pros. For example, it guarantees increased performance, great flexibility, useful if there will be any future change concerning the architecture, and great security for each level, as there is no direct route from the web server to the database, with the introduction of a middle tier, which is essential as the application deals with several personal data.

2.2 High level components and their interaction



- **Client tier**: this part runs on the client devices via a Web browser or the mobile application. It allows the users to insert and submit the data in the input forms, that are sent to the web tier. On the other hand, the taxi drivers can send information about their availability to the server and the application client monitors their GPS position in order to move the taxi drivers to another queue if they change their area.
- **Web tier**: this part runs on the JEE server. It always listens to all the clients requests and forwards them to the business tier, if they need to be processed. It is the responsible for the creation of the faces and pages of the client interfaces with the data fetched from the business application.
- **Business tier**: this part runs on the JEE server, too. It contains the logical part of the application, collecting and managing the information of the other tiers. It analyses the data coming from the web tier and, according to the request, it modifies or asks for the required information stored in the database, then it is able to send the result to the web tier.
- **EIS tier**: this part contains the database where all the application data are stored. It is not only accessed by the business tier, but also by the administrators, who can directly add a taxi driver account to the database.

2.3 Component view

2.4 Deployment view

2.5 Runtime view

2.6 Component interfaces

2.7 Selected architectural styles and patterns

2.8 Other design decisions

3 Algorithm Design

The most relevant algorithm of the myTaxiService application is the one implementing the queue management. It is important to optimize its implementation as long as it is the most complex and the one that distinguishes the system.
Another significant algorithm is the one that manages the forwarding of the requests of the users to the taxi drivers.

- **Initialization.** The class which manages the areas distribution and the queues of the taxi driver also deals with the initialization of the queues of the taxis. It starts assigning to every area as many taxi as the average number of the requests expected in that area, based on the statistics. Once all the areas have been filled with their optimal number of taxis, the remaining taxi drivers are sent to the areas that are most needy.
  The "needyArea" function, in fact, returns the index of the most needy area at the moment, calculating the area that has the maximum difference between the maximum number of requests recorded and the average of requests.

  COMPLEXITY: O(T) with T = number of taxis.

Algorithm 1 Initialization

```
1:  procedure INITQUEUES(TaxiDriver[] taxiDrivers, Area[] areas)
2:      i ← 0
3:      j ← 0
4:      for i < areas.size() do
5:          k ← 0
6:          for k < areas[i].getAverage() do
7:              areas[i].addToQueue(taxiDrivers[j])
8:              j ← j + 1.
9:          end for
10:     end for
11:     if j < taxiDrivers.size() then
12:         for j < taxiDrivers.size() do
13:             areas[needyArea(areas)].addInQueue(taxiDrivers[j])
14:         end for
15:     end if
16: end procedure
```

- **Manage requests.** After the initialization, the taxi drivers are able to take requests. If they accept the request, the function sets their availability to false and stops monitoring their position. It is also possible that a taxi driver declines the request or is not able to give an answer to the server. In this case, the first taxi driver is moved to the last position of the queue and forwards the request to the second of the queue, who is now moved to the first position. This action is iterated in the queue of that area until a taxi accept the request. After accepting the call, the taxi driver is set unavailable and he is deleted from the queue, as it is likely that he will end up in another area.

  COMPLEXITY: O(A+Q) with A = number of areas and Q = number of taxi enqueued in that area.

Algorithm 2 Manage requests

```
1:  procedure MANAGEREQUEST(Position pos, Area area)
2:      answer ← "no"
3:      timer ← new Timer(60)
4:      while answer = "no" || answer = "timeOut" do
5:          sendRequest(area.getFirstOfQueue(), pos)
6:          answer ← waitAnswer(timer)
7:          if answer = "no" || answer = "timeOut" then
8:              area.moveToEndOfQueue()
9:          end if
10:     end while
11:     area.getFirstOfQueue().setUnavailable()
12:     area.deleteFirstFromQueue()
13: end procedure
```

- **Manage queues.** The areas of the city are represented by a graph with an array of adjacencies, which is a useful representation in order to decide how to distribute and move the taxi drivers within the areas.
  In the first place the function search for the area where the taxi is in and sets the "startingArea" variable to the index of that area, then adds the taxi driver to the queue of the area if it has not reached the maximum number of taxi. If the area is completely full it is necessary to iterate on the areas, exploiting a breadth-first search algorithm.
  The function searches for adjacent areas with the number of taxi lower than the average of the requests and, if it does not find any, it looks for adjacent areas with the number of taxi lower than the maximum allowed for that area.
  If these two conditions are not supplied, the function assign this taxi driver to the first adjacent area visited and takes from that area the last taxi of the queue. This "rejectedTaxi" is moved to an adjacent needy area, repeating the iterations done before, searching needy areas and moving taxi drivers, until it is possible to reach an equilibrium state.
  It is always feasible to exit the while cycle because the number of taxi driver can not be the maximum for all the areas, as it is not cost efficient. The system only ensures that the minimum number of taxi drivers per area is guaranteed.

  COMPLEXITY: O(A) with A = number of areas.

Algorithm 3 Manage queues

```
1: procedure MANAGEQUEUE(Area[] area, TaxiDriver taxiDriver)
2:     for i < area.size() do
3:         if taxiDriver.position is in area[i] then
4:             startingArea ← i
5:         end if
6:     end for
7:     if area[startingArea].getNumOfTaxi() < max[i] then
8:         area[startingArea].addToQueue(taxiDriver)
9:     else
10:        for i < area.size() do
11:            area[i].distance ← INFINITY
12:        end for
13:        area[startingArea].distance ← 0
14:        unvisitedQueue.enqueue(area[startingArea])
15:        rejectedTaxi ← taxiDriver
16:        while !unvisitedQueue.isEmpty() do
17:            tmpArea ← unvisitedQueue.dequeue()
18:            for i < tmpArea.adjacencies.size() do
19:                if tmpArea.adjacencies[i].getNumOfTaxi() < avg[i] then
20:                    tmpArea.adjacencies[i].addToQueue(rejectedTaxi)
21:                    return
22:                end if
23:            end for
24:            for i < tmpArea.adjacencies.size() do
25:                if tmpArea.adjacencies[i].getNumOfTaxi() < max[i] then
26:                    tmpArea.adjacencies[i].addToQueue(rejectedTaxi)
27:                    return
28:                end if
29:                if tmpArea.adjacencies[i].distance = INFINITY then
30:                    tmpArea.adjacencies[i].distance ← tmpArea.distance+1
31:                    unvisitedQueue.enqueue(tmpArea.adjacencies[i])
32:                end if
33:            end for
34:            firstUnvisited ← unvisitedQueue.getFirstOfQueue()
35:            rejectedTaxi ← firstUnvisited.addToFullQueue(rejectedTaxi)
36:        end while
37:    end if
38: end procedure
```

4 User Interface Design

The user interface design has been already specified in the section 3.1.1 of the RASD, where all the user interfaces are described with the support of mockups.

5 Requirements Traceability

- **Registration of the visitor.** This requirement is specified in the section 2.3 in the Access interface and in the AccessManager component.
- **E-mail confirmation.**
- **Look up information about the system.**
- **Log in as a passenger.** This requirement is specified in the section 2.3 in the Access interface and in the AccessManager component.
- **Log in as a taxi driver.** This requirement is specified in the section 2.3 in the AccessManager component.
- **Log in with social networks.** This requirement is specified in the section 2.3 in the Access interface and in the AccessManager component.
- **Retrieve password.** This requirement is specified in the section 2.3 in the AccessManager component.
- **Request a taxi.** This requirement is specified in the section 2.3 in the RequestTaxi interface and in the RequestManager component.
- **Reserve a taxi.** This requirement is specified in the section 2.3 in the MakeReservation interface and in the RequestManager component.
- **Choose payment method.** This requirement is specified in the section 2.3 in the ChoosePaymentMethod interface and in the PaymentManager component.
- **View profile.** This requirement is specified in the section 2.3 in the PassengerArea and TaxiDriverArea interfaces.
- **Edit profile.** This requirement is specified in the section 2.3 in the PassengerArea and TaxiDriverArea interfaces and in the PassengerAreaManager and TaxiDriverAreaManager components.
- **See waiting time.**
- **Change availability.** This requirement is specified in the section 2.3 in the TaxiDriverArea interface and in the TaxiDriverAreaManager component.
- **Notification of the requests.** This requirement is specified in the section 2.3 in the TaxiDriverArea interface and in the TaxiDriverAreaManager component.
- **See position in the queue.** This requirement is specified in the section 2.3 in the TaxiDriverArea interface and in the TaxiDriverAreaManager component.

6 References

- ISO/IEC/IEEE 42010:2011, Systems and software engineering - Architecture description
- `http://www.uml-diagrams.org/component-diagrams.html`

7 Appendix

7.1 Software and tools used

- TeXstudio (`http://www.texstudio.org/`): to redact and to format this document.
- draw.io (`https://www.draw.io/`): to create all the diagrams.

7.2 Hours of work

Time spent redacting this document:

- Cattaneo Michela Gaia: ~1 hours of work.
- Barlocco Mattia: ~1 hours of work.