Politecnico di Milano

Software Engineering 2 Project
a.y. 2015-16

MyTaxiService
Project Plan Document
Version 1.0

Casati Fabrizio, 853195
Castelli Valerio, 853992

Referent professor: Di Nitto Elisabetta

January 30, 2016

Contents

1 Introduction **1**
1.1 Revision History . . . 1
1.2 Purpose and scope . . . 1
1.3 Definitions, Acronyms, Abbreviations . . . 2
1.3.1 Definitions . . . 2
1.3.2 Acronyms . . . 2
1.3.3 Abbreviations . . . 2
1.4 Reference Documents . . . 2

2 Project size, cost and effort estimation **3**
2.1 Size estimation: function points . . . 3
2.1.1 Internal Logic Files (ILFs) . . . 4
2.1.2 External Logic Files (ELFs) . . . 6
2.1.3 External Inputs (EIs) . . . 6
2.1.4 External Inquiries (EQs) . . . 8
2.1.5 External Outputs (EOs) . . . 9
2.1.6 Overall estimation . . . 9
2.2 Cost and effort estimation: COCOMO II . . . 10
2.2.1 Scale Drivers . . . 10
2.2.2 Cost Drivers . . . 12
2.2.3 Effort equation . . . 19
2.2.4 Schedule estimation . . . 19

3 Schedule **21**

4 Resource allocation **24**

5 Risk management **29**

Appendix A Hours of work **32**

Chapter 1

Introduction

1.1 Revision History

Version	Date	Author(s)	Summary
1.0	26/01/16	Valerio Castelli & Fabrizio Casati	Initial release

1.2 Purpose and scope

This document represents the Project Plan Document for myTaxiService.

Its main purpose is to analyze the expected complexity of myTaxiService and assist the project leader in the delicate phase of cost and effort estimation. This information can be subsequently used as a guidance to define the required budget, the resources allocation and the schedule of the activities.

In the first section, we're going to use the Function Points and COCOMO approaches together to provide an estimate of the expected size of myTaxiService in terms of lines of code and of the cost/effort required to actually develop it.

In the second section, we'll reuse these figures to propose a possible schedule for the project that covers all activities from the requirements identification to the implementation and testing activities.

In the third section we're going to assign the different members of our development group to the various tasks.

Finally, we're going to elaborate on the possible risks that myTaxiService could face during the various phase of the project and provide some general conclusions.

1.3 Definitions, Acronyms, Abbreviations

1.3.1 Definitions

1.3.2 Acronyms

- FP: Function Points.
- ILF: Internal logic file
- ELF: External logic file.
- EI: External Input.
- EO: External Output.
- EQ: External Inquiries.
- DBMS: Database Management System.
- API: Application Programming Interface.
- ETA: Estimated Time of Arrival.
- UI: User Interface.
- GPS: Global Positioning System.

1.3.3 Abbreviations

1.4 Reference Documents

- Assignment document: Assignment 5 - Project Plan.pdf
- myTaxiService Requirement Analysis and Specification Document: RASD.pdf
- The Project Plan Example documents: Example of usage of FP and COCOMO for Assignment 5.pdf and Second example of usage of FP and COCOMO for Assignment 5.pdf
- The Function Points complexity evaluation tables.
- The COCOMO II Model Definition Manual (version 2.1, 1995 – 2000 Center for Software Engineering, USC).

Chapter 2

Project size, cost and effort estimation

This section is specifically focused on providing some estimations of the expected size, cost and required effort of myTaxiService.

For the size estimation part we will essentially use the Function Points approach, taking into account all the main functionalities of myTaxiService and estimating the correspondent amount of lines of code to be written in Java. This estimation will only take into account the parts of the project that concur to the implementation of the business logic and will disregard the aspects concerning the user interface.

For the cost and effort estimation we will instead rely on the COCOMO approach, using as in initial guidance the amount of lines of code computed with the FP approach.

2.1 Size estimation: function points

The Function Points approach provides an estimation of the size of a project taking as inputs the amount of functionalities to be developed and their complexity.

The estimation is based on the usage of figures obtained through statistical analysis of real projects, which have been properly normalized and condensed in the following tables:

For Internal Logic Files and External Logic Files

	Data Elements		
Record Elements	*1-19*	*20-50*	*51+*
1	Low	Low	Avg
2-5	Low	Avg	High
6+	Avg	High	High

For External Output and External Inquiry

	Data Elements		
File Types	*1-5*	*6-19*	*20+*
0-1	Low	Low	Avg
2-3	Low	Avg	High
4+	Avg	High	High

For External Input

	Data Elements		
File Types	*1-4*	*5-15*	*16+*
0-1	Low	Low	Avg
2-3	Low	Avg	High
4+	Avg	High	High

UFP Complexity Weights

	Complexity Weight		
Function Type	*Low*	*Average*	*High*
Internal Logic Files	7	10	15
External Logic Files	5	7	10
External Inputs	3	4	6
External Outputs	4	5	7
External Inquiries	3	4	6

2.1.1 Internal Logic Files (ILFs)

myTaxiService relies on a number of ILFs to store the information it needs to offer the required functionalities. In the next few paragraphs, we'll analyze in detail the various ILFs we have identified.

First of all, the system has to store information about taxis and taxi drivers. These data are condensed in a single table that holds the first name, last name and birthdate of a taxi driver as Strings, together with his home address, SSN, email address and mobile phone number as contact information. It also stores the taxi driver's driving license, his taxi license, the taxi plate number and the taxi status (available, unavailable, on a ride, outside city) for convenience.

As for the zones, they are stores using a two-level structure. The first level of the structure holds the identifiers of all the zones, while a secondary table contains all the location coordinates (as <latitude, longitude> pairs) necessary to identify the vertices of the zone polygon.

The system furthermore needs a queue for each zone in which it can store the identifiers of the taxi drivers waiting in that zone and their relative position in the queue, and similar structures to store the lists of taxi drivers who are unavailable, outside the city or currently on a ride. These data are stored on disk primarily to facilitate a fast recovery of the system in case of failure.

Reservations are stored in a dedicated table that holds all the information about the identifier of the passenger who booked them, the timestamp of the moment when the tuple is created, the date and time of the pickup, the origin and destination locations as addresses and the status (pending, being served, completed, cancelled).

Requests are also stored in a dedicated table with a similar structure, the only difference being the absence of the destination field and the presence of an extra field for the secret code.

The system has a dedicated table to store the passenger data. Each passenger is associated with an identifier, a name, surname and birthdate, the username, an email address and a mobile phone number. The passenger identifier is used as foreign key in a secondary table that stores his the personal settings.

Passengers and taxi drivers login information, that is username, password, identifier and user type are stored in a dedicated user table. Admin accounts are not stored in this table to achieve a greater level of security.

To keep track of who can access the administration services, information on the admin accounts is stored in a dedicated table. The main fields are name, surname, username, password and the id of the privilege level of the account, which is referencing a correspondent entry in a dedicated privileges table.

Finally, the system keeps a list of application and plugin identifiers that have access to the privileged API. Each identifier is associated with the contact information of the developer, a description of what the application or plugin does and the exhaustive list of methods that can be called.

Using the previously defined tables, this is the count we obtain:

ILF	Complexity	FPs
Login data	Low	7
Passenger data	Low	7
Taxi drivers	Low	7
Zones	Low	7
Queues	Average	10
Reservations and requests	Low	7
API permissions	Average	10
Total		55

2.1.2 External Logic Files (ELFs)

The only external data source myTaxiService relies on is represented by the Mapping Service.

The interaction between the core system and the remote service provider happens through a RESTful API and data can be returned in JSON or XML format. The results have then to be processed before they can be used as part of our computation.

There are two main kind of interactions:

- Given the coordinates of two locations, get an estimate of the time that is necessary to drive from one to the other

- Given an address, get the correspondent pair of coordinates (reverse geocoding)

On the client side, the mapping service is also used to retrieve the graphical representation of the city map to be displayed on the smartphone of the taxi driver.

Given the complexity of the interaction and the amount of data that is retrieved, it is reasonable to classify this logic file as a complex one.

ELF	Complexity	FPs
ETA computation	Low	10
Reverse geocoding	Low	10
Map data retrieval	Low	10
Total		30

2.1.3 External Inputs (EIs)

myTaxiService supports many kind of interactions with different categories of users.

We are now going to summarize the impact of the offered features, grouping them by user category. All users:

- Login/Logout: these are simple operations that involve only the account manager. They contribute 3 FPs each.

Passengers:

- Password retrieval: this operation has an average complexity, as it involves a number of steps in order to be sure the user is really entitled to retrieve his password. For this reason, it contributes 4 FPs.

- Change settings: this operation also has an average complexity, as the number of settings to be managed can be quite high. As such, it contributes 4 FPs.
- Request or reserve a taxi: these are both very complex operations that involve a large number of components. For this reason they account 6 FPs each.
- Delete a reservation: since this is straightforward operation, it yields 3 FPs.
- Register a new account: this operation also has an average complexity, as it involves a number of checks on the validity of the fields. As such, it contributes 4 FPs.
- View reservation history: since this is straightforward operation, it yields 3 FPs.

Administrators:

- Insert, delete and update zones: these are very complex operations that involve a great number of components. For this reason they account 6 FPs each.
- Insert, delete and update taxi drivers: as for the zones, the complexity of these operations is high, so they account another 6 FPs each.
- Request service statistics: as this operation involves some fairly complicated aggregate queries on the database, it can be considered complex and thus contributes 6FPs to the total amount.
- Grant and revoke privileges to an application or plugin: while these two specular operations involve a large number of fields that can be set, the impact on the database is quite limited. For this reason we think they have an average complexity and they should contribute 4 FPs each.

Taxi drivers:

- Accept, refuse and end ride: even though from a client point of view these operations seem trivial, the steps required to properly rearrange the taxi queues are quite complex. For this reason they account 6 FPs each.
- Set availability: this operation also involves a few rearrangements of the taxi queues, but has a smaller impact on the overall behavior of the system. For this reason it can be though as having an average complexity and it contributes 4 FPs.

The final results are shown in the following table:

EI	Complexity	FPs
Login/Logout	Low	2x3
Password retrieval	Average	4
Change settings	Average	4
Request or reserve a taxi	High	2x4
Delete a reservation	Low	3
Register a new passenger account	Average	4
View reservation history	Low	3
Insert, delete and update zones	High	3x6
Insert, delete and update taxi drivers	High	3x6
Request service statistics	High	6
Grant and revoke app privileges	Average	2x4
Grant and revoke plugin privileges	Average	2x4
Accept, refuse and end ride	High	3x6
Set taxi availability	Average	4
Total		112

2.1.4 External Inquiries (EQs)

As specified by the FP guidelines, an inquiry is essentially a data retrieval request performed by an user.

myTaxiService supports a few interactions of this type that don't require complex computations:

- A taxi driver can retrieve his position in the queue of his current zone.
- A passenger can retrieve his reservation history.
- An administrator can retrieve the full list of taxi drivers, zones, passengers or approved applications and plugins that are making usage of the APIs.

All these operations can be though as fairly simple. The resulting table is the following:

EQ	Complexity	FPs
Retrieve taxi position in queue	Low	3
Retrieve passenger reservation history	Low	3
Retrieve list of taxi drivers	Low	3
Retrieve list of zones	Low	3
Retrieve list of passengers	Low	3
Retrieve list of approved applications	Low	3
Retrieve list of approved plugins	Low	3
Total		21

2.1.5 External Outputs (EOs)

As part of its normal behavior, myTaxiService occasionally needs to communicate with the user outside the context of an inquiry. These occasions are:

- Notify a taxi driver that he has been assigned to a request.
- Notify a passenger that his request has been accepted.
- Notify a passenger that his request has been dropped.
- Notify a taxi driver that his zone has changed.
- Notify a taxi driver that his position in the zone queue has changed.

All these operations can be though as fairly simple. The resulting table is the following:

EQ	Complexity	FPs
Taxi request assignment notification	Low	4
Request accepted notification	Low	4
Request dropped notification	Low	4
Zone changed notification	Low	4
Position in the queue changed notification	Low	4
Total		20

2.1.6 Overall estimation

The following table summarizes the results of our estimation activity:

Function Type	Value
Internal Logic Files	55
External Logic Files	30
External Inputs	112
External Inquiries	21
External Outputs	20
Total	238

Considering Java Enterprise Edition as a development platform and disregarding the aspects concerning the implementation of the mobile applications (which can be thought as pure presentation with no business logic), we can estimate the total number of lines of code.

Depending on the conversion rate, we have a lower bound of:

```
SLOC = 238 * 46 = 10948
```

and an upper bound of

```
SLOC = 238 * 67 = 15946
```

2.2 Cost and effort estimation: COCOMO II

In this section we're going to use the COCOMO II approach to estimate the cost and effort needed to develop myTaxiService.

2.2.1 Scale Drivers

In order to evaluate the values of the scale drivers, we refer to the following official COCOMO II table:

Scale Factor values, SF_j, for COCOMO II Models

Scale Factors	Very Low	Low	Nominal	High	Very High	Extra High
PREC	thoroughly unprecedented	largely unprecedented	somewhat unprecedented	generally familiar	largely familiar	thoroughly familiar
SF_j	6.20	4.96	3.72	2.48	1.24	0.00
FLEX	rigorous	occasional relaxation	some relaxation	general conformity	some conformity	general goals
SF_j	5.07	4.05	3.04	2.03	1.01	0.00

RESL	little (20%)	some (40%)	often (60%)	generally (75%)	mostly (90%)	full (100%)
SF_j	7.07	5.65	4.24	2.83	1.41	0.00
TEAM	very difficult interactions	some difficult interactions	basically cooperative interactions	largely cooperative	highly cooperative	seamless interactions
SF_j	5.48	4.38	3.29	2.19	1.10	0.00
PMAT	Level 1 Lower	Level 1 Upper	Level 2	Level 3	Level 4	Level 5
SF_j	7.80	6.24	4.68	3.12	1.56	0.00

A brief description for each scale driver:

- Precedentedness: it reflects the previous experience of our team with the development of large scale projects. Since we are not expert in the field, this value will be low.
- Development flexibility: it reflects the degree of flexibility in the development process with respect to the external specification and requirements. Since there are very strict requirements on the functionalities but nothing specific is stated as for the technology to be used, this value will be low.
- Risk resolution: reflects the level of awareness and reactiveness with respect to risks. The risk analysis we performed is quite extensive, so the value will be set to very high.
- Team cohesion: it's an indicator of how well the team members know each other and work together in a cooperative way. For our team, the value is very high.
- Process maturity: although we had some problems during the development of the project, the goals have been successfully achieved, so this value is set to high.

The results of our evaluation is the following:

Scale Driver	Factor	Value
Precedented (PREC)	Low	4.96
Development flexibility (FLEX)	Low	4.05
Risk resolution (RESL)	Very high	1.41
Team cohesion (TEAM)	Very high	1.10
Process maturity (PMAT)	Very high	3.12
Total		14.64

2.2.2 Cost Drivers

- Required Software Reliability:

  Since the system represents the only way to get taxis in the city, a malfunctioning could lead to important financial losses. For this reason, the RELY cost driver is set to high.

RELY Cost Drivers						
RELY Descriptors	slightly inconvenience	easily recoverable losses	moderate recoverable losses	high financial loss	risk to human life	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	0.82	0.92	1.00	1.10	1.26	n/a

- Database size:

  This measure considers the effective dimension of our database. We don't have the ultimate answer, but our estimation given the tables and fields we have is to reach a 3GB database. Since it is distributed over 10.000-15.000 SLOC, the ratio D/P (measured as testing DB bytes/program SLOC) is between 209 and 314, resulting in the DATA cost driver being high.

DATA Cost Drivers						
DATA Descriptors		$\frac{D}{P} < 10$	$10 \leq \frac{D}{P} \leq 100$	$100 \leq \frac{D}{P} \leq 1000$	$\frac{D}{P} > 1000$	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	n/a	0.90	1.00	1.14	1.28	n/a

- Product complexity:

  Set to very high according to the COCOMO II rating scale.

CPLX Cost Driver						
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	0.73	0.87	1.00	1.17	1.34	1.74

- Required reusability:

  In our case, the reusability requirements are limited in scope to the project itself, so the RUSE cost driver is set to nominal.

RUSE Cost Driver						
RUSE Descriptors		None	Across project	Across program	Across product line	Across multiple product lines
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	n/a	0.95	1.00	1.07	1.15	1.24

- Documentation match to life-cycle needs:

  This parameter describes the relationship between the documentation and the application requirements. In our case, every need of the product life-cycle is already foreseen in the documentation, so the DOCU cost driver is set to nominal.

DOCU Cost Driver						
DOCU Descriptors	Many life-cycle needs uncovered	Some life-cycle needs uncovered	Right-sized to life-cycle needs	Excessive for life-cycle needs	Very excessive for life-cycle needs	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	0.81	0.91	1.00	1.11	1.23	n/a

- Execution time constraint:

  This parameter describes the expected amount of CPU usage with respect to the computational capabilities of the hardware. As myTaxiService is a quite complex software, our expectance is that its CPU usage will be very high.

TIME Cost Driver						
TIME Descriptors			$\leq$ 50% use of available execution time	70% use of available execution time	85% use of available execution time	95% use of available execution time
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	n/a	n/a	1.00	1.11	1.29	1.63

- Storage constraint:

  This parameter describes the expected amount of storage usage with respect to the availability of the hardware. As current disk drives can easily contain several terabytes of storage, this value is set to nominal.

STOR Cost Driver						
STOR Descriptors			$\leq$ 50% use of available storage	70% use of available storage	85% use of available storage	95% use of available storage
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	n/a	n/a	1.00	1.05	1.17	1.46

- Platform Volatility:

  For what concerns the core system, we don't expect our fundamental platforms to change very often. However, the client applications may require at least a major release once every six months to be aligned with the development cycle of the main mobile operating systems. For this reason, this parameter is set to nominal.

PVOL Cost Driver						
PVOL Descriptors		Major change every 12 mo., minor change every 1 mo.	Major: 6mo; minor: 2wk.	Major: 2mo, minor: 1wk	Major: 2wk; minor: 2 days	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	n/a	0.87	1.00	1.15	1.30	n/a

- Analyst Capability:

  We think the analysis of the problem has been conducted in a thorough and complete way with respect to a potential real world implementation. For this reason, this parameter is set to high.

ACAP Cost Driver						
ACAP Descriptors	15th percentile	35th percentile	55th percentile	75th percentile	90th percentile	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.42	1.19	1.00	0.85	0.71	n/a

- Programmer Capability:

  We have not implemented the project, so this parameter is just an estimation; however we are fairly in our programming abilities, so we'll set this parameter to high.

PCAP Cost Driver						
PCAP Descriptors	15th percentile	35th percentile	55th percentile	75th percentile	90th percentile	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.34	1.15	1.00	0.88	0.76	n/a

- Application Experience:

We have some experience in the development of Java applications, but we never tackled a Java EE system of this kind. For this reason we're going to set this parameter to low.

APEX Cost Driver						
APEX Descriptors	≤ 2 months	6 months	1 year	3 years	6 years	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.22	1.10	1.00	0.88	0.81	n/a

- Platform Experience:

  We don't have any experience with the Java EE platform, but we have some previous experience with databases, user interfaces and server side development. For this reason, we're going to set this parameter to nominal.

PLEX Cost Driver						
PLEX Descriptors	≤ 2 months	6 months	1 year	3 years	6 years	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.19	1.09	1.00	0.91	0.85	n/a

- Language and Tool Experience:

  We don't have any experience with the Java EE platform, but we have some previous experience with databases, user interfaces and server side development. We are also knowledgable of the development environment, so we're going to set this parameter to nominal.

LTEX Cost Driver						
LTEX Descriptors	≤ 2 months	6 months	1 year	3 years	6 years	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.20	1.09	1.00	0.91	0.84	n/a

- Personnel continuity:

This parameter is quite relevant in our case, since the time we can spend on this project is limited. For this reason, this parameter is set to very low.

PCON Cost Driver						
PCON Descriptors	48% / year	24% / year	12% / year	6% / year	3% / year	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.29	1.12	1.00	0.90	0.81	n/a

- Usage of Software Tools:

  Our application environment is complete and well integrated, so we'll set this parameter as high.

TOOL Cost Driver						
TOOL Descriptors	edit, code, debug	simple, frontend, backend CASE, little integration	basic life-cycle tools, moderately integrated	strong, mature life-cycle tools, moderately integrated	strong, mature, proactive life-cycle tools, well integrated with processes, methods, reuse	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.17	1.09	1.00	0.90	0.78	n/a

- Multisite development:

  Although we live in two different cities, we have collaborated relying hugely on wideband Internet services including social networks and emails. For this reason, we're going to set this parameter to very high.

SITE Cost Driver						
SITE Collocation Descriptors SITE Communications Descriptors	International Some phone, mail	Multi-city and multi-company Individual phone, fax	Multi-city or multi-company Narrow band email	Same city or metro area Wideband electronic communication	Same building or complex Wideband elect. comm., occasional video conf.	Fully collocated Interactive multimedia
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.22	1.09	1.00	0.93	0.86	0.80

- Required development schedule:

  Although our efforts were well distributed over the available development time, the definition of all the required documentation took a consistent amount of time, especially for the requirement analysis and the design phases. For this reason, this parameter is set to high.

SCED Cost Driver						
SCED Descriptors	75% of nominal	85% of nominal	100% of nominal	130% of nominal	160% of nominal	
Rating level	Very low	Low	Nominal	High	Very High	Extra High
Effort multipliers	1.43	1.14	1.00	1.00	1.00	n/a

Overall, our results are expressed by the following table:

Cost Driver	Factor	Value
Required Software Reliability (RELY)	High	1.10
Database size (DATA)	High	1.14
Product complexity (CPLX)	Very high	1.34
Required Reusability (RUSE)	Nominal	1.00
Documentation match to life-cycle needs (DOCU)	Nominal	1.00
Execution Time Constraint (TIME)	Very high	1.29
Main storage constraint (STOR)	Nominal	1.00

Platform volatility (PVOL)	Nominal	1.00
Analyst capability (ACAP)	High	0.85
Programmer capability (PCAP)	High	0.88
Application Experience (APEX)	Low	1.10
Platform Experience (PLEX)	Nominal	1.00
Language and Tool Experience (LTEX)	Nominal	1.00
Personnel continuity (PCON)	Very low	1.12
Usage of Software Tools (TOOL)	High	0.90
Multisite development (SITE)	Very high	0.86
Required development schedule (SCED)	High	1.00
Total		1.54613

2.2.3 Effort equation

This final equation gives us the effort estimation measured in Person-Months (PM):

```
Effort = A * EAF * KSLOC^E
```

where:

```
A = 2.94 (for COCOMO II)
EAF = product of all cost drivers (1.54613)
E = exponent derived from the scale drivers. It is computed a
  s:
  B + 0.01 * ∑_i SF[i] = B + 0.01 * 14.64 = 0.91 + 0.1464 =
  1.0564
   in which B is equal to: 0.91 for COCOMO II.
```

With this parameters we can compute the effort value, which has a lower bound of:

```
Effort = A * EAF * KSLOC^E = 2.94 * 1.54613 * 10.948^1.0564 =
  56.957 PM ≈ 57 PM
```

and an upper bound of:

```
Effort = A * EAF * KSLOC^E = 2.94 * 1.54613 * 15.946^1.0564 =
  84.737 PM ≈ 85 PM
```

2.2.4 Schedule estimation

Regarding the final schedule, we are going to use the following formula:

```
Duration = 3.67 * Effort^E
```

As a lower bound, we consider

```
F = 0.28 + 0.2 ∗ (E − B) = 0.28 + 0.2 ∗ 0.1464 = 0.30928
Effort = 56.957 PM
Duration = 3.67 ∗ (56.957)^0.30928 = 12.81 months
```

while as an upper bound, we consider

```
F = 0.28 + 0.2 ∗ (E − B) = 0.28 + 0.2 ∗ 0.1464 = 0.30928
Effort = 84.737 PM
Duration = 3.67 ∗ (56.957)^0.30928 = 14.49 months
```

which seem to be both reasonable estimates.

Chapter 3

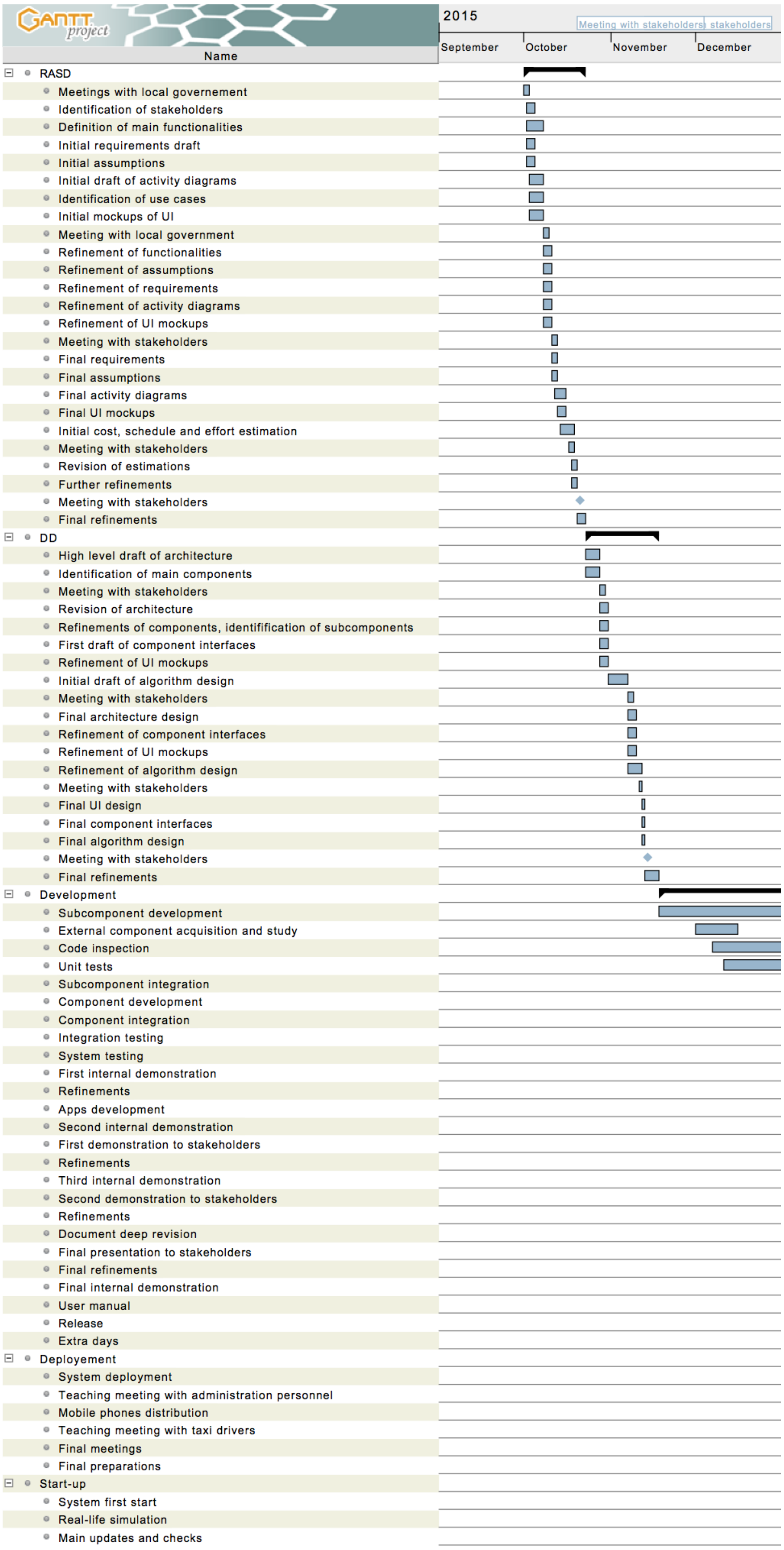
Schedule

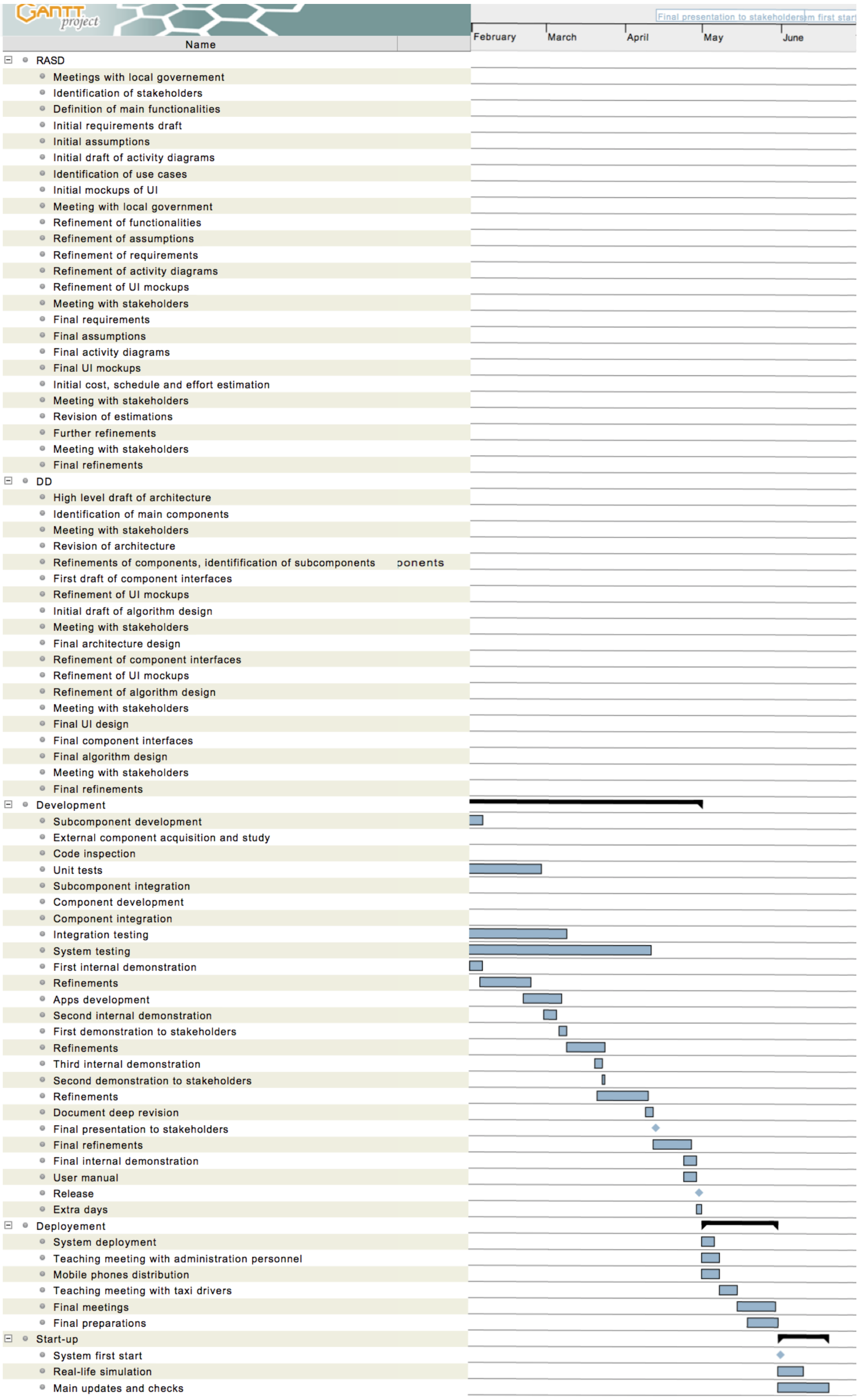
In this chapter we're going to provide a general, high-level project schedule. More refined schedules will be defined during the project to manage the internal organization of the single development phases.

It is important to notice that, while this project is made for didactic purposes and no implementation and testing will be performed, we have nevertheless considered these steps as part of our schedule. This is to try to take into account what could be the full development of this project, should it continue.

In order to maintain readability, we have split the schedule in two halves, the first one covering the period from September to January and the second going from February to June.

Furthermore, given the size of the document, it is included in separate pages.


GANTT project
Name
2015
Meeting with stakeholders
stakeholders
September
October
November
December
RASD
Meetings with local governement
Identification of stakeholders
Definition of main functionalities
Initial requirements draft
Initial assumptions
Initial draft of activity diagrams
Identification of use cases
Initial mockups of UI
Meeting with local government
Refinement of functionalities
Refinement of assumptions
Refinement of requirements
Refinement of activity diagrams
Refinement of UI mockups
Meeting with stakeholders
Final requirements
Final assumptions
Final activity diagrams
Final UI mockups
Initial cost, schedule and effort estimation
Meeting with stakeholders
Revision of estimations
Further refinements
Meeting with stakeholders
Final refinements
DD
High level draft of architecture
Identification of main components
Meeting with stakeholders
Revision of architecture
Refinements of components, identifification of subcomponents
First draft of component interfaces
Refinement of UI mockups
Initial draft of algorithm design
Meeting with stakeholders
Final architecture design
Refinement of component interfaces
Refinement of UI mockups
Refinement of algorithm design
Meeting with stakeholders
Final UI design
Final component interfaces
Final algorithm design
Meeting with stakeholders
Final refinements
Development
Subcomponent development
External component acquisition and study
Code inspection
Unit tests
Subcomponent integration
Component development
Component integration
Integration testing
System testing
First internal demonstration
Refinements
Apps development
Second internal demonstration
First demonstration to stakeholders
Refinements
Third internal demonstration
Second demonstration to stakeholders
Refinements
Document deep revision
Final presentation to stakeholders
Final refinements
Final internal demonstration
User manual
Release
Extra days
Deployement
System deployment
Teaching meeting with administration personnel
Mobile phones distribution
Teaching meeting with taxi drivers
Final meetings
Final preparations
Start-up
System first start
Real-life simulation
Main updates and checks


Name
February
March
April
May
June
RASD
Meetings with local governement
Identification of stakeholders
Definition of main functionalities
Initial requirements draft
Initial assumptions
Initial draft of activity diagrams
Identification of use cases
Initial mockups of UI
Meeting with local government
Refinement of functionalities
Refinement of assumptions
Refinement of requirements
Refinement of activity diagrams
Refinement of UI mockups
Meeting with stakeholders
Final requirements
Final assumptions
Final activity diagrams
Final UI mockups
Initial cost, schedule and effort estimation
Meeting with stakeholders
Revision of estimations
Further refinements
Meeting with stakeholders
Final refinements
DD
High level draft of architecture
Identification of main components
Meeting with stakeholders
Revision of architecture
Refinements of components, identifification of subcomponents
First draft of component interfaces
Refinement of UI mockups
Initial draft of algorithm design
Meeting with stakeholders
Final architecture design
Refinement of component interfaces
Refinement of UI mockups
Refinement of algorithm design
Meeting with stakeholders
Final UI design
Final component interfaces
Final algorithm design
Meeting with stakeholders
Final refinements
Development
Subcomponent development
External component acquisition and study
Code inspection
Unit tests
Subcomponent integration
Component development
Component integration
Integration testing
System testing
First internal demonstration
Refinements
Apps development
Second internal demonstration
First demonstration to stakeholders
Refinements
Third internal demonstration
Second demonstration to stakeholders
Refinements
Document deep revision
Final presentation to stakeholders
Final refinements
Final internal demonstration
User manual
Release
Extra days
Deployement
System deployment
Teaching meeting with administration personnel
Mobile phones distribution
Teaching meeting with taxi drivers
Final meetings
Final preparations
Start-up
System first start
Real-life simulation
Main updates and checks

Chapter 4

Resource allocation

In this chapter we're going to provide a general overview of how the tasks defined by the schedule in the previous section will be divided between the two members of the development team. More refined schedules will be defined during the project to manage the internal organization of the single development phases.

As we already mentioned in the previous section, we have also included activities in the requirement analysis and design phases that won't actually take place, like the stakeholders meetings, as well as the full implementation phase. This has been purposefully done to have a more realistic depiction of how the development process could go.

In order to maintain readability, we have split the document in four parts. There are two parts for each team member, each one furthermore divided in two halves: the first one covering the period from September to January and the second going from February to June.

Furthermore, given the size of the document, it is included in separate pages.


GANTT project
Name
2015
2016
Meeting with stakeholders
stakeholders
September
October
November
December
January
Fabrizio Casati
300%
400%
Meetings with local governement
Identification of stakeholders
Definition of main functionalities
Initial requirements draft
Initial assumptions
Initial draft of activity diagrams
Initial mockups of UI
Meeting with local government
Refinement of activity diagrams
Refinement of UI mockups
Meeting with stakeholders
Final activity diagrams
Final UI mockups
Initial cost, schedule and effort esti...
Meeting with stakeholders
Revision of estimations
Further refinements
Meeting with stakeholders
Final refinements
High level draft of architecture
Identification of main components
Meeting with stakeholders
Revision of architecture
Refinements of components, identif...
First draft of component interfaces
Refinement of UI mockups
Initial draft of algorithm design
Meeting with stakeholders
Final architecture design
Refinement of component interfaces
Refinement of UI mockups
Meeting with stakeholders
Final UI design
Final component interfaces
Final algorithm design
Meeting with stakeholders
Final refinements
Subcomponent development
External component acquisition an...
Code inspection
Unit tests
Subcomponent integration
Component development
Component integration
Integration testing
System testing
First internal demonstration
Refinements
Apps development
Second internal demonstration
First demonstration to stakeholders
Third internal demonstration
Second demonstration to stakehold...
Refinements
Document deep revision
Final presentation to stakeholders
Final refinements
Final internal demonstration
User manual
Release
Extra days
System deployment
Teaching meeting with administrati...
Mobile phones distribution
Final preparations


GANTT project
Name
Final presentation to stakeholders
m first start
February
March
April
May
June
Fabrizio Casati
400%
200%
Meetings with local governement
Identification of stakeholders
Definition of main functionalities
Initial requirements draft
Initial assumptions
Initial draft of activity diagrams
Initial mockups of UI
Meeting with local government
Refinement of activity diagrams
Refinement of UI mockups
Meeting with stakeholders
Final activity diagrams
Final UI mockups
Initial cost, schedule and effort esti...
Meeting with stakeholders
Revision of estimations
Further refinements
Meeting with stakeholders
Final refinements
High level draft of architecture
Identification of main components
Meeting with stakeholders
Revision of architecture
Refinements of components, identif...
First draft of component interfaces
Refinement of UI mockups
Initial draft of algorithm design
Meeting with stakeholders
Final architecture design
Refinement of component interfaces
Refinement of UI mockups
Meeting with stakeholders
Final UI design
Final component interfaces
Final algorithm design
Meeting with stakeholders
Final refinements
Subcomponent development
External component acquisition an...
Code inspection
Unit tests
Subcomponent integration
Component development
Component integration
Integration testing
System testing
First internal demonstration
Refinements
Apps development
Second internal demonstration
First demonstration to stakeholders
Third internal demonstration
Second demonstration to stakehold...
Refinements
Document deep revision
Final presentation to stakeholders
Final refinements
Final internal demonstration
User manual
Release
Extra days
System deployment
Teaching meeting with administrati...
Mobile phones distribution
Final preparations


GANTT project
Name
2015
2016
Meeting with stakeholders
stakeholders
September
October
November
December
January
Valerio Castelli
300%
400%
Meetings with local governement
Identification of stakeholders
Definition of main functionalities
Initial requirements draft
Initial assumptions
Initial mockups of UI
Identification of use cases
Meeting with local government
Refinement of assumptions
Refinement of requirements
Refinement of UI mockups
Refinement of functionalities
Meeting with stakeholders
Final requirements
Final assumptions
Initial cost, schedule and effort esti...
Meeting with stakeholders
Revision of estimations
Further refinements
Meeting with stakeholders
Final refinements
High level draft of architecture
Identification of main components
Meeting with stakeholders
Revision of architecture
Refinements of components, identif...
First draft of component interfaces
Refinement of UI mockups
Initial draft of algorithm design
Meeting with stakeholders
Final architecture design
Refinement of component interfaces
Refinement of UI mockups
Meeting with stakeholders
Final UI design
Final component interfaces
Final algorithm design
Meeting with stakeholders
Final refinements
Subcomponent development
External component acquisition an...
Code inspection
Unit tests
Subcomponent integration
Component development
Component integration
Integration testing
System testing
First internal demonstration
Refinements
Apps development
Second internal demonstration
First demonstration to stakeholders
Refinements
Third internal demonstration
Second demonstration to stakehold...
Refinements
Document deep revision
Final presentation to stakeholders
Final refinements
Final internal demonstration
User manual
Release
Extra days
System deployment

GANTT project
Name
Final presentation to stakeholders m first start
February
March
April
May
June
Valerio Castelli
400%
200%
200%
200%
Meetings with local governement
Identification of stakeholders
Definition of main functionalities
Initial requirements draft
Initial assumptions
Initial mockups of UI
Identification of use cases
Meeting with local government
Refinement of assumptions
Refinement of requirements
Refinement of UI mockups
Refinement of functionalities
Meeting with stakeholders
Final requirements
Final assumptions
Initial cost, schedule and effort esti...
Meeting with stakeholders
Revision of estimations
Further refinements
Meeting with stakeholders
Final refinements
High level draft of architecture
Identification of main components
Meeting with stakeholders
Revision of architecture
Refinements of components, identif...
First draft of component interfaces
Refinement of UI mockups
Initial draft of algorithm design
Meeting with stakeholders
Final architecture design
Refinement of component interfaces
Refinement of UI mockups
Meeting with stakeholders
Final UI design
Final component interfaces
Final algorithm design
Meeting with stakeholders
Final refinements
Subcomponent development
External component acquisition an...
Code inspection
Unit tests
Subcomponent integration
Component development
Component integration
Integration testing
System testing
First internal demonstration
Refinements
Apps development
Second internal demonstration
First demonstration to stakeholders
Refinements
Third internal demonstration
Second demonstration to stakehold...
Refinements
Document deep revision
Final presentation to stakeholders
Final refinements
Final internal demonstration
User manual
Release
Extra days
System deployment

Chapter 5

Risk management

In this section we're going to assess the main risks that the project development may face. Some of them could pose technical issues, while others are related with political or financial challenges.

A first threat belonging to this last category comes from taxi drivers' worker unions, as they are among the main stakeholders of the project and have a strong influence on the acceptance or refusal of myTaxiService by taxi drivers themselves.

A strongly related issue may arise from the other major political stakeholder of the project, that is the city administration itself. Potential issues can include a change of the city government, a budget crisis (possibly as a secondary effect of some nationwide policy of spending review) or other shifts in the local government priorities.

In principle, both risks can be mitigated by letting the stakeholders have an active role in the development of the project, in the requirement analysis and design phases as well as in the implementation phase. Activities in this direction may include periodical reviews and meetings, demonstrations, discussions on the interface design and so on. We have to be conscious that putting together the requirements and desires of the different stakeholders may not be an easy task and that some negotiations are certainly going to be there.

Another related political issue concerns the possible changes in the national legislation. In particular, we are mainly concerned with modifications to the way taxi service is operated in general (for instance revisions of the driving license format or other restrictions) and to the possibility of using a smartphone while driving. There are already some limitations to this, but today they are overcome by avoiding to actively interact with the device and by keeping it fixed in a position that doesn't interfere with the vision of the road. Stricter laws could be enacted in the future that forbid this possibility and require, for instance, that only voice interactions are allowed. The only countermeasure we can put in place is to keep an eye on discussions of these laws, which typically take months to be approved, and be ready to move fast before the legislation is actually enacted.

Other issues might arise regarding the acceptance of the system from its intended users, both taxi drivers and passengers. As this system is going to completely replace the previous taxi management service, it is reasonable to assume that it's going to face some initial opposition from people unwilling to change their habits. To make the transition easier, we suggest to consider a few marketing strategies aimed at winning the support of the majority of the users. These can include acceptance tests, special offers and discounts for an initial period of time or other kinds of incentives.

We also have to consider issues arising from people management inside our company. Key members of the team may be ill just prior to important milestones or meetings, or may be ill for prolonged periods of time, causing delays. Also, we have to consider the possibility of people quitting the company, as the IT job market is quite flexible. A possible solution for this problem is to split duties and responsibilities across multiple people, so that no single person is in charge of a specific task.

Another risk might come from underestimating the knowledge of a specific matter or programming technique that our programmers and engineers have. Adding people to the project should not be seen as the primary solution here, unless the task is extremely specific. A good antidote is to hire knowledgable and flexible people beforehand.

Obviously, a loss of the whole source code, or significant parts thereof, would be a disaster. This issues is quite easy to tackle, though, by implementing appropriate versioning systems and backup techniques distributed over multiple, redundant locations.

Another issue that must not be underestimated is related to our dependency on external services and components. A change in the terms and conditions of the Mapping Service, or even just a modification of the API itself, could pose serious financial or technical problems. We are somewhat more protected as for database and message broker technology, as there is a greater number of vendors and the access methods are more or less standardized. Also, a change in the pricing plans of the cloud infrastructure could lead to significant issues on the financial and business side, but they could be quite easily tackled at least if they happen while the project is still in the development phase. The cost of putting a remedy to these issues would be, of course, much greater if they happen in production. A possible countermeasure is to design the code to be as portable as possible and with a great modularity and independence between components, exploiting the information hiding principle to the fullest.

We could also have troubles making arrangements with the mobile phone vendors and the telecommunication services providers to find appropriate hardware solutions and data plans for the taxi drivers. While the hardware side of the problem shouldn't create any major problem as there are plenty of smartphone vendors on the market, finding a suitable data plan could prove trickier to solve. Given the consistent number of involved taxi drivers, though, we expect economies of scale to give us some strategic and contractual power to find a suitable agreement.

A final problem may also derive by issues with the project scheduling. Even though an initial overall schedule is provided in this document, it can't obviously take into account all the possible issues that may arise down the road. For this reason, some extra time has been allocated at the expected end of each major activity to allow for adjustments.

Appendix A

Hours of work

To redact this document, we spent 15 hours per person. We also report here the overall amount of hours required by the project.

Document	*Hours of work*
Requirements Analysis and Specifications Document (RASD)	40
Design Document (DD)	55
Inspection Document (ID)	25
Integration Test Plan Document (ITPD)	30
Project Plan Document (PPD)	15
Total	**165**