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Final Thesis

"Smart Cafeteria" Adaptive And Interactive Mobile Application

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Abstract

Mobile Human-Computer Interaction is the relationship (interaction) between people and their handheld mobile systems and the applications which we use in our everyday life. In a word, mobile applications are interactive products to support users in their day to day life no matter where they are. Since technology is moving fast and changing rapidly, it is very important to understand the mobile interaction techniques and the impact of possible mobile technologies on human life. Mobile HCI concerns about the mobile applications and PDA which discusses the different possible interaction techniques with those applications. In the university cafeteria provides services manually to the students which cause different kinds of problems such as losing time in cafeteria queue, unable to browse and choose meal in advance, does not provides any kind of dieting advices to students which help them to keep proper dieting. In this thesis, I have proposed an adaptive, interactive mobile application which is called "Smart Cafeteria" that will provide services to the university students and faculties for managing their meal in the universities' cafeterias which in consequence makes their life more easy and comfortable. In this work from beginning to end, I have followed HCI interaction design methodology in every step such as problem define, data gathering, requirement analysis, prototype development and usability evaluation for "Smart Cafeteria" application.

Keywords: Mobile Human-Computer Interaction, Adaptive HCI, Interactive Mobile Application, Smart Cafeteria.

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Dedication

This work is dedicated to my Family Members who are been long waiting for my return back to home with success.

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Chapter 1

Introduction

One of the most common and fundamental necessity of life is food. It is not only about the joy of eating, it also has an intimate relationship with the important factors of human life such as health, dietary, entertainment. Many people who are busy in their work place, have to take their breakfast and lunch at cafeteria or Restaurant. In that case, time, quality of food and appropriate food are very important fact. Those people needs some extra facilities for planning their menu and save their time for searching food and also spend less time in the queue for food. It is obvious that, good and enjoyable food in a short time would improve the quality of life[1].

"Smart Cafeteria" is a part of Smart Campus project[2] funded by Trento RISE. The goal of the project is to provide advanced Information and Communication Technology (ICT) solutions to all people involved in a University campus; namely to provide innovative services to support their lives.

1.1 Problem Statement

In this section, I will discuss two real life scenarios which happens quite often students and professors.

1.1.1 Scenario 1: Hungry Student

XXX is a second year student, he has a lot of friend, he spends most of his day at the University. His classes usually ends at 13.00 then he always have to wait for his friends. Eventually when he reaches the canteen to eat with his friends, he always finds long queue of students waiting to take food.

[1] Some ideas & contents have taken from Silvia Torsi, Researcher, University of Trento.
[2] This work is a part of Smart Campus project funded by Trento RISE.

Furthermore he would prefer to know the menu of the canteen before standing in the queue but he has to wait because of the huge gathering of students in queue. Even when he reaches the food counter it takes a long time to prepare the food he ordered. He is also not happy with the decreasing quality of the food in the canteen. He also finds the canteen a boring place to sit and chat with friends as there is always huge gathering of students during the lunch break.

1.1.2 Scenario 2: Busy Professor

Mr. YYY is a professor of Computer Science who is busy with a lot of things like research work, teaching in class, presentation talk, meetings. He does not have enough time to choose food standing in the queue of the canteen. So he is thinking if there will be a system where user can choose and order their lunch even before going to the canteen, it would be even better if the system can suggest dietary as well. If he can access the system through his mobile phone from anywhere around the university it would make him a really happy professor.

1.1.3 Real Life Problem

In the previous section [1.1.1,1.1.2], I have discussed two real life scenarios where technological service will make our life more easy. Providing good facilities for eating can be a simple way to improve campus life by the university cafeteria. Standing in long queues in cafeteria for food takes out a good amount of time from student's and staff's daily working routine. Additionally waiting in the queue without knowing the menu for a particular day can be time killing if someone finds nothing satisfactory to eat. The facility of knowing the menus in advance is a recurring request. The canteen is a space for students to pass some quality time eating and discussing with their friends similar for that university staff's with their colleague's.

Daily and weekly menu are not available at cafeteria in advance and there is no way to know cafeteria is open or not before going to the cafeteria physically. It is always important to maintain proper diet from dieting suggestions to keep healthy life. Healthy and happy life always has a great impact on daily works such as study, research, job.

In this research, I have tried to figure out the possible answeres and solutions of following questions:

(I) How to skip the long queue of cafeteria such that no waiting more than 5 minutes to take food.

(II) How to know the menu of the cafeteria before standing in the queue; namely from any another places.

(III) How technology can help us in selecting meal from cafeteria more comfortably.

(IV) How to know the most appropriate menu for me in terms of calorie contains and price.

(V) How to collaborate and share my feeling with others when I am in cafeteria.

1.2 Objectives

In this thesis work, I have applied user centered design methodology and found some possible services of Smart Cafeteria. First of all, I have applied PACT[3] analysis on Smart cafeteria and figured out the following factors through this analysis.

Places: Meeting places for students, researchers and professors; the canteen, the queue.

Activities: Finding food menu to eat, avoid queue, choosing the meals, eating, choose diet menu.

Context: The university life, The activity of eating.

Technologies: Web 2.0, SmartPhone.

Finally there are some services which should be considered in case of smart cafeteria. In the thesis work, I will try to emphasize and develop such an interactive, adaptive system to provide the following services:

1. ***Mensa Queue Skipper:*** A system of booking food menu from the canteen that makes the students wait no more than 5 minutes. Queues in the canteen and at the administration services results loosing time. Students often feel that the University cafeteria system is not enough to provide them good supports for their daily lunch activities. This is due to large number of students with respect to the number of personnel's providing services in cafeteria. Technology could easily help them avoid queue. If all member of the university could be able to access everydays food menu as a list or search for their preferable menu with the help of an application as well as ordering food and paying for the food through the application, It could be a solution to skip queue in the cafeteria.

[3]PACT Analysis

2. ***Menu Finder:*** Daily and weekly menus of the University of Trento cafeteria' are available on the website which is offered by cafeteria's stuff in a specific format. But most of university's members do not notice that information and the system does not notify them. So it is obvious that university's cafeteria must need a menu finder to help them to search their appropriate food menu which is offered by the cafeteria.

3. ***Menu Suggester and Dieting Adviser:*** Students' dieting is a very important issue that should not be left to chance. Some research [3] shows that the students' recurrent lack of information about dieting, proper food combining meal plans, balance dieting and this could be an obstacle to improve their general health and well being. So indications of dieting measures in a cafeteria system such as Menu Suggester and Dieting adviser depend on users' choice and how much calories they consumed in the last couple of weeks could be a very good solution for Smart Cafeteria.

4. ***Create Customized Menu:*** People can order food and make their own menu in the restaurant according to their own choice and as much as food they need. In the system application point of view, giving the user freedom to create their own menu from different food could be a very smart thinking.

5. ***Lunch with Friend:*** Create a collaborative application where user can follow their friends; can see the activities of friends and share the activity of meals. This may give newcomers and foreign students the possibility to exchange language or psychological peer supporting.

The goal of the thesis is to develop just in time service where students, professors, rersearchers do not need to wait too long to order food, we will imposed such a system where students and staffs will be able to order their food online even before going to the cafeteria physically. Daily and weekly menu will be made available in the system which will also give suggestions of dieting measures. The system will also suggest food according for their choice and the calorie requirement. So the main objectives of this thesis are to:

(I) Create "Smart Cafeteria" which will be supported by web 2.0 system and Smartphone application.

(II) The application should be adaptive and interactive.

There is also couple of sub goals which overlap with the main objectives of this thesis. The sub goals are:

(i) Provide online cafeteria services.

(ii) Provide dieting services to the students.

(iii) Provide social collaboration services in the application.

1.3 Structure of Thesis

The thesis is organized as follows:

Chapter 2, *State of Art*, highlights Human Computer Interaction (HCI), its goals and adaptive HCI. It is also described Interaction Design and its Process, Goals, Principles and Usability Heuristics. In the last two sections of this chapter are discussed Interactive Mobile HCI and Benchmark Analysis using some related mobile applications.

Chapter 3, *Analysis of Smart Cafeteria*, discusses Requirements and Data Gathering techniques and processes of "Smart Cafeteria" which help to find Stakeholders, initial Functional Requirements and Non Functional Requirements as well as stable requirement using Studying Document, Focus Group and Questionnaires. Finally Data Analysis has been done using UML 2.0 such as use cases, class diagram and activity diagrams.

Chapter 4, *Smart Cafeteria Design*, presents Conceptual Architecture and Design, Mid-fadelity UI for both desktop and Mobile version of Smart Cafeteria; and finally discusses Key Features of the application as a mobile application.

Chapter 5, *Usability Evaluation of Smart Cafeteria*, reports Evaluation Methodology and Evaluation Result such as user observation and Questionnaire for usability evaluation for both desktop and mobile prototype. Finally Suggestions for Improvement has been presented.

Chapter 6, *Conclusion*, concludes the overall achievements of the thesis work and possible extensions of the work are being presented.

Chapter 2

State of Art

In this chapter, first section [2.1] is dedicated for discussion related to HCI, its goal and adaptive HCI. In the second section [2.2], I have discussed interaction design, its processes, goals, principles and usability heuristics. In the following sections [2.3, 2.4], I have discussed interactive mobile application and some related mobile applications from google play store, which offers some similar feature as like our proposed "Smart Cafeteria" application respectively.

2.1 Human Computer Interaction

Human Computer Interaction is a area of research and study which deal with analysis, design of interactive application by involving its users in the design process; and focuses on the interaction between Human and computer application. In some cases, HCI is also known as man-machine interaction (MMI) or computer-human interaction (CHI). In recent years, there was a great progress in the field of Mobile human interaction which invloves interaction between users and mobile applications.

According to Love [1], HCI is concerned with looking into the relationship between human and computer systems and applications that people use on their everyday life. Since HCI or Mobile Human Interaction is concerned with investigating the relationship between people and systems or applications, we are always concerned with understanding the users as well as their various capabilities and expectations and how these can be taken place into the mobile system or application design. In the any HCI design process or Interactive mobile system design, User should be emphasized first and then the other key aspects are firstly what tasks users want to perform when using the system; secondly which characteristics of the user could have a significant

effect on their performance with the system; thirdly developing the system which meet the users needs and finally the evaluation of the developed system should check if it meets users' needs as well as satisfying to use and getting users' feedback which helps to develop updated version of the system. So this includes the factors such as an understanding of the user and their task what they want to perform in the system, the design tools and software packages that are needed to achieve usability of the system.

Yang and Chen [4] state that the ultimate goal of Human-Computer Interaction research is exploring how to design the computer or system application to help people to complete the necessary tasks more safely and efficiently. However the computer is still a tool and in that case, people and the computer communicate with each other through the system interface consisting hardware and software. To achieve that communication effectively and efficiently is called interactive system design methodology. The main thing is that are those communication really efficient and effective or enjoyable during usage? All these questions and answers we will figure out in HCI research work.

2.1.1 HCI Goals

The basic goal of Human-Computer Interaction is to improve interaction between users and computer by making applications and computers more usable and receptive to the user's needs. That means that we want to make the system easy, safe, effective and enjoyable and to decrease barrier as much as possible between human's cognitive model and user tasks [5]. The principle aim of Human Computer Interaction is to design interactive and safe functional software system with good usability.

Basically Human Computer Interaction concerns about:

- **Process of design interfaces, prototypes and their methodologies:** HCI concerns about designing the best possible interface, prototype and development considering user needs and optimizing the design to achieve desired functionality in term of learnability ,efficiency of use, effectiveness of use, enjoyable to use.

- **Methods for implementing interfaces and prototype:** HCI also concerns about methods of software developments, software toolkits and libraries, efficient algorithms for developing inferface, prototypes and implementing in real products.

- **Methods of evaluating and comparing interfaces and prototypes:** This is one of the most important part in HCI and interactive

product design which involves user interview, review of application that ensure usability of application.

- **Developing new interfaces, prototypes and interaction techniques:** This part involves in re-design and evaluating the design of the application.

2.1.2 Adaptive HCI

Even the most sophisticated machines will be worthless if user cannot use them. With time HCI has travelled a long way forward from the start of the concept. Intelligent and Adaptive HCI is a part of HCI with the goal of research to improve HCI by using smarter and newer technology. HCI has been influenced a lot by all the researches of AI technology as AI addresses to topics important for HCI like adaptability and problem solving.

The main aim of the Intelligent HCI is to enhance the flexibility, usability and the human-computer interaction. This interaction between men and machine is not limited to computers only but also with all other machine used in our day to day life like, television, refrigerator, mobile phones, cars. Nowadays most of the Intelligent HCIs have the ability to learn from the environment and work accordingly to reach its goal. Intelligent technologies are used to achieve the intelligent and adaptive HCI but the goal always remains the same which is to improve the communication between users and machines. Several techniques are used to achieve this goal like intelligent input technology, user modeling, user adaptivity, explanation generation.

An adaptive HCI might be a website using regular GUI for selling various products. This website would be adaptive -to some extent- if it has the ability to recognize the user and remembers his searches and purchases and intelligently search, find, and suggest products on sale that it thinks user might need. Most of these kind of adaptation are the ones that deal with cognitive and affective levels of user activity [6].

Jia-Jiunn Lo [7] discussed in his paper that identifying the user's characteristics is the key for developing adaptive Web-based systems. He also proposed an adaptive architecture [Figure- 2.1] according to that architecture, adaptation decision in an adaptive web-based system depends on user characteristics which is represented in the user model. An adaptive Web-based system is helpful to deliver information to users more efficiently and effectively.

According to his architecture, there are three components in the server: Product Data Repository, User Model Constructor, and Adaptive Product Recommender. The Product Data Repository stores the product into

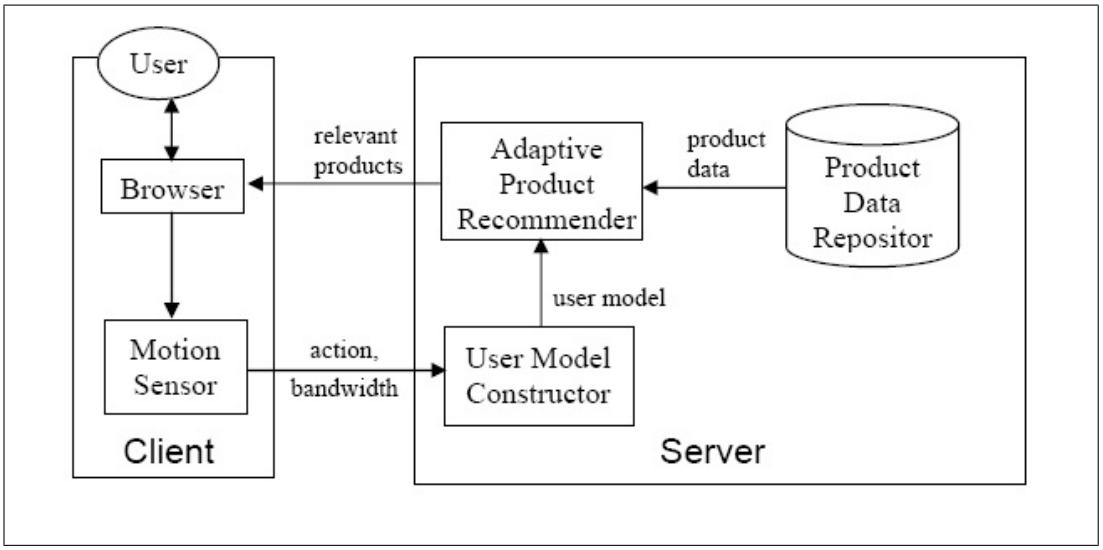

Figure 2.1: Adaptive Application Architecture

database. The User Model Constructor, together with the observed user browsing behavior, are responsible for building and updating the temporary user model for incremental learning of the user's interests. The Adaptive Product Recommender is responsible for determining the recommendation sequence and the presentation of products in the user interface based on Product Data Repository and the user model.

2.2 Interaction Design

A main goal of interaction design is to develop interactive software products that are usable which means the software should be easy to learn, effective to use, and should provide an enjoyable experience from the user's perspective [2]. Designing usable interactive products requires consideration of the users of software product and the context; means who is going to use the product and where they are going to be used. Another important aspect is understands the type of activities performed by users when they try to interact with the products. The perfectness of different kind of interfaces and arrangements of input and output factors depends on different type of activities need to be supported. The aim of interaction design is to provide redress this concern by bringing usability into the design process. Through interaction design process, we design interactive products to support people in their everyday lives. The main key view of Interactive design is easy, effortless, and enjoyable.

Interactive system design being a part of Human Computer Interaction is a multidisciplinary area where various subjects and disciplines such as Psychology, Computer Science, Sociology, Design contribute its knowledge and research works supporting on both the machine and the human factors such as computer user satisfaction. Interactive system design involves several disciplines and some of them are shown in Figure 2.2.

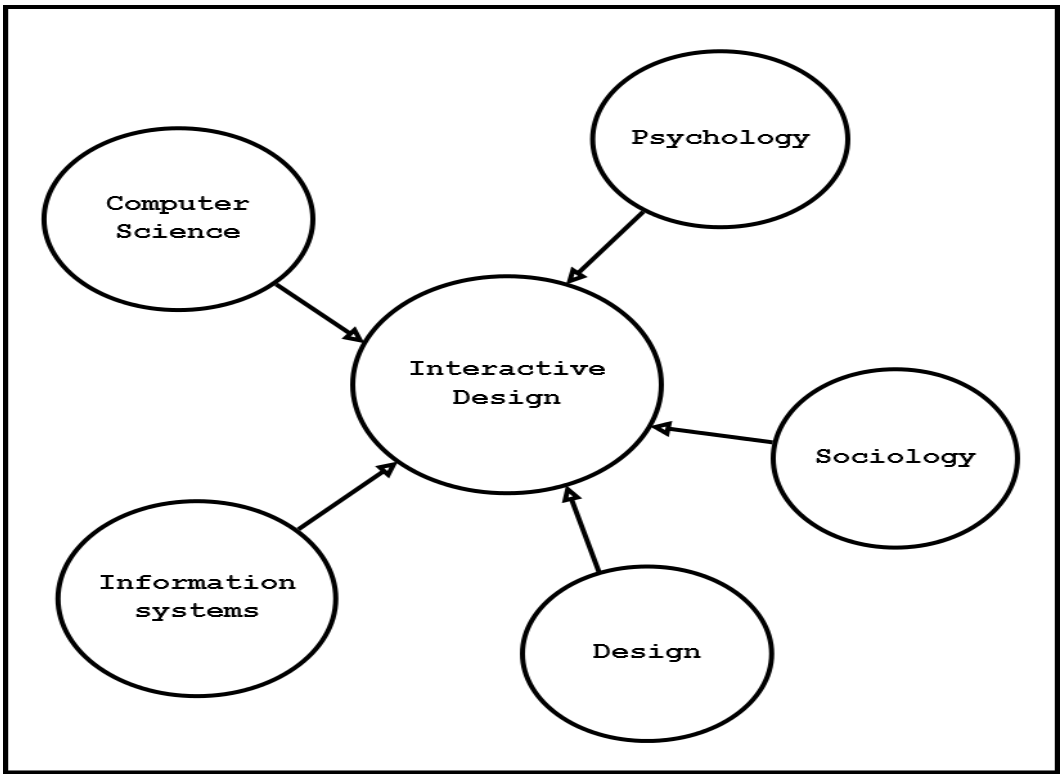

Figure 2.2: Disciplines involved in Interactive system design [adapted from [1, 2]]

2.2.1 Interactive Design Process

According to Yang and Chen [4], there has not any unique standard for interactive design in theory, and there's still mainly concept and model from the software industry. In the field of product design, many new subjects and situations could happen and the industrial designers need to keep in practice and study to use the old theory of interaction design principles and should do more research to sum up interactive principle and theory which can suit for target product design and planning. There are three key characteristics

of the interaction design process [2] which should be kept in mind when we are going to develop any interactive product:

- Users need to be involved in the development process.
- Specify usability and user experience goals, identify them clearly and document them properly at the beginning of the project.
- Iteration through the basic four interaction design activities.

Fundamentally, the process of interaction design [2] involves four basic activities:

1. **Identifying needs and establishing requirements:** In order to design some interactive system, we must know about target users and what kind of services an interactive product could usefully provide. We should always find out goals and needs of product from the point of view users. And finally establish a set of requirements which will help to design and develop product.
2. **Developing alternative designs that meet those requirements:** This is the core activity of designing an interactive product which basically suggesting ideas to meet the requirements. This could be divided into two sub parts: conceptual design that means developing a conceptual model of the product which describes what the product should do, behave and seems like; and physical design considers the detail of the product including the colors, sounds, and images of the product template namely menu design, icon and interface design.
3. **Building interactive versions of the designs:** There are sensible ways for users to evaluate interactive versions of the designs which should be built, but that does not mean that the final version of the software is required. There are several techniques to achieve interactive version of product; namely prototyping, but it does not require a complete software. There are different prototyping techniques; among them paper-based prototypes are very quick and cheap for building demo and those are very effective for identifying problems at the very beginning stages of software design, and through that users can get a real sense of the product to interact with.
4. **Evaluating the designs:** Evaluation is the way to determine the usability and acceptability of product design, which means it is measured variety of criteria namely the number of errors user make when they

are using it, how attracting it is, how well it matches the requirements, and so on. Interaction design need user involvement throughout the development and this increases quality of the product and confirm final product's quality.

These four steps in interaction design model contains iteration and involves user in evaluation. From these steps, perhaps some alternative designs could be generated in some attempts that meet the needs and requirements of the application. Then interactive design versions of application are developed and evaluated iteratively. Based on the feedback of the evaluations namely interviews, users group; it could return to the step for identifying needs or refining the previous requirements. In the figure 2.3 a simple lifecycle model of interaction design has been shown[1].

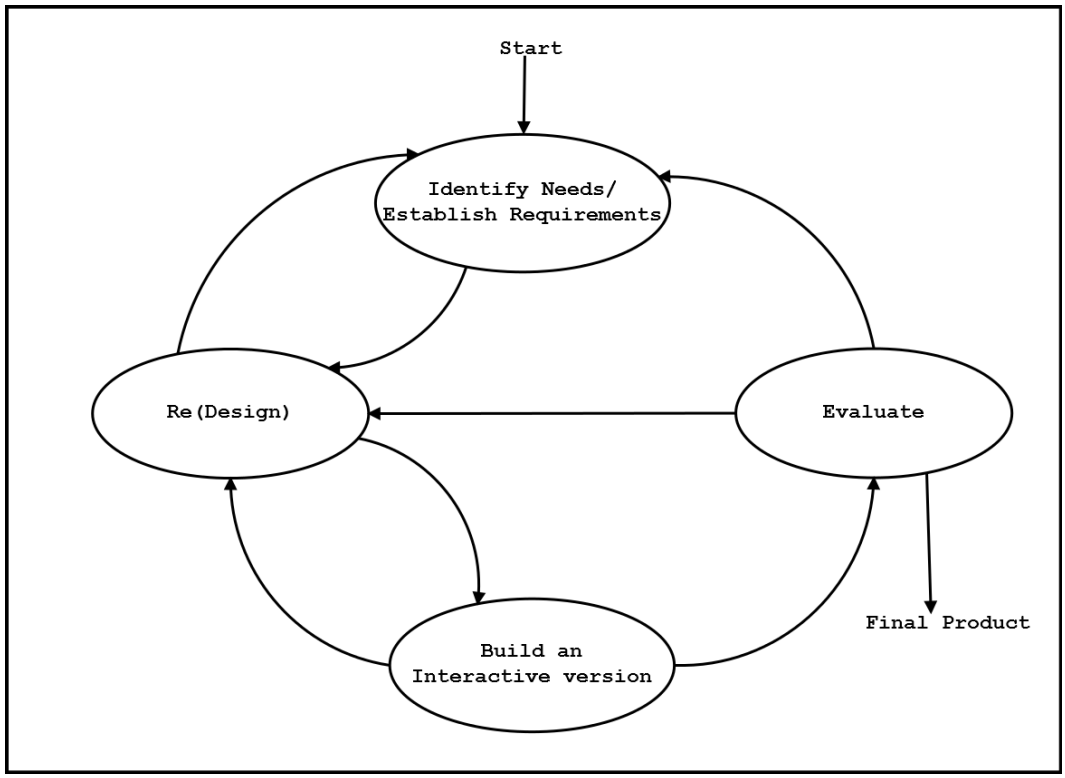

Figure 2.3: A Simple Life Cycle of Interaction Design Process.

[1]This image is adapted from Interaction design: beyond human-computer interaction.

2.2.2 Goals and Principles

The goals of interactive software design mainly concentrates on usability goals which ensure that developed applications are easy to learn, efficient to use, safe to use, effective to use, easy to remember and enjoyable from users' perspective [2]. Optimizing alternative connection of people and products are the main objective of interactive product design. It requires the designers to consider the great anticipations of the users. Satisfying users' expectation and extending them to potential needs. Here are the basic principles [4] of Interactive product design:

1. **Visibility:** In the implementation of application's controls and functions should follow user perception of the application's operation and the user's mental model of that application as much as possible. To be compatible with psychological needs of the users, functions of the product should be developed in a way so that users can understand and control it properly.

2. **Correct and clear feedback:** Somehow correct and clear feedback is related with Visibility. Application receives command from different functions, for execution it should follow a variety of sensory feedback in the right manner to make access and control of the system pleasurable, efficient and canonical.

3. **Constraints:** It can be put to practice through physical, logical and common sense of cultural aspects of interactive product design. Users must take the correct actions of cross-function to control the enter into the system forcefully to avoid human errors. To enhance the interaction easy to learn, the design can be created with safe and reliable use of the environment.

4. **Mapping and Matching:** Control of information and feedback should be able to establish a direct relationship efficiently and accurately. This is the assurance of user's interactive behavior.

5. **Consistency:** The psychological vulnerability and memory of user has a direct impact on the efficiency of the control of the application. All the above principles should be followed by the designers in successful interactive system designs. The designers have to take the psychological feeling into account and should make the product in a way so that it have a positive effect in the day-to-day use when they executes the functions.

2.2.3 Usability Heuristics

Interactive Design principles incline to be used mainly for developing a new design, whereas usability principles known as Usability Heuristics are used mostly as the basis for evaluating prototypes and existing applications. Below ten usability principles are described which were developed by Nielsen [8]. Observe that some of them overlap with the interactive design principles.

1. **Visibility of system status:** The system should always inform users about what is going on in the system and should also provide appropriate feedback within reasonable time.

2. **Match between system and the real world:** The system should provide services using the users' language, rather than system oriented terms and should follow real world conventions, making information appear in a natural and logical order.

3. **User control and freedom:** The system should provide the ways such as control and freedom to users; if somehow they are stuck somewhere within system, they could easily escape from that unexpected situation themselves using clearly marked emergency exits.

4. **Consistency and standards:** The system should avoid making users wonder where different words, actions and situations mean the same thing and should follow standard conventions.

5. **Help users recognize, diagnose, and recover from errors:** The system should use plain and easy language to describe the nature of the problem and suggest a way to solve it.

6. **Error prevention:** The system should show relavent error messages but it is always better to prevent occurrence of errors as much as possible.

7. **Recognition rather than recall:** The system should minimize the user's memory load by making objects, actions, and options visible.

8. **Flexibility and efficiency of use:** The system should provide accelerators and flexibility that are invisible to novice users, but allow more experienced users to carry out tasks more quickly.

9. **Aesthetic and minimalist design:** The system should avoid using information which are irrelevant or rarely needed.

10. **Help and documentation:** The system should provide information that can be easily searched and help in a set of concrete steps that can easily be followed.

2.3 Interactive Mobile HCI

Mobile Human-Computer Interaction is the relationship (interaction) between people and their handheld computer systems and the applications which we use in our everyday life. In a word, mobile applications are interactive products to support users in their day to day life no matter where they are [1]. Since we know from the definition of interactive system that if a system maintains and follows usability heuristics and interactive design principles then we can call that system interactive. So most of the mobile applications are more or less interactive because of their effectiveness, efficiency, usability and also for their portability.

Mobile applications commonly known as mobile apps are applications developed for small handheld devices, such as mobile phones, Smartphone's, tablets, PDA and so on.

Generally mobile application provides the users with similar services which can be acquired from PCs. Apps are generally small, individual software units with limited function. They offer limited and confined functionality such as a game, calculator or even a mobile web browser [9].

The use of mobile application is rapidly growing now a days because of its portability and usability. In the last couple of year many company and vendor launched their mobile OS and software platforms to support their PDA. Among them, Android OS from Google Inc. to support for Android-based devices, iOS from Apple Inc. to support the iPhone, iPad and iTouch; and Windows Phone from Microsoft are mostly popular in the market. According to The Telegraph [10], in 2011 an average of 701 apps were launched in the UK version of Apple's App Store every day. According to The New York Times [11], in 2011 an average of 543 apps were released each day for Android-based devices.

In the Figure 2.4 has shown basic interaction between human and mobile application; and its communication flows.

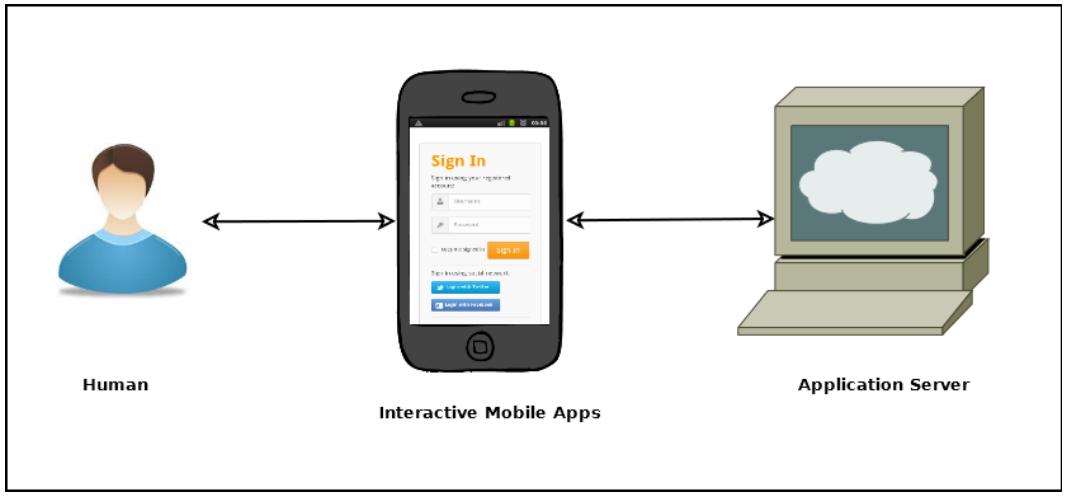

Figure 2.4: Interactive Mobile Application

2.4 Benchmark Analysis

In order to get the idea about smart cafeteria, I have found some android applications from Google play store which are similar to my targeted application. Most of the applications are very light. Although I have not found all functionalities in single application, so I have chosen couple of applications to find more requirements and functionalities. In the following paragraphs I will discuss about some applications which were really helpful for smart cafeteria.

1. Calorie Counter-MyFitnessPal[2] : This is an Android app that has largest food database and exercise entry by analyzing those, a fastest and easiest app to use calorie counter to diet . It takes input your basic information such as height, weight, age, gender, your daily activities type and durations; and your daily food consumptions and exercises; gives you perfect diet suggestions and generates different reports such as charts of progress over time and daily nutrition. This application also support social networking such as friends request and friend invitation.

[2] Google Play Store Application-Calorie Counter-MyFitnessPal.

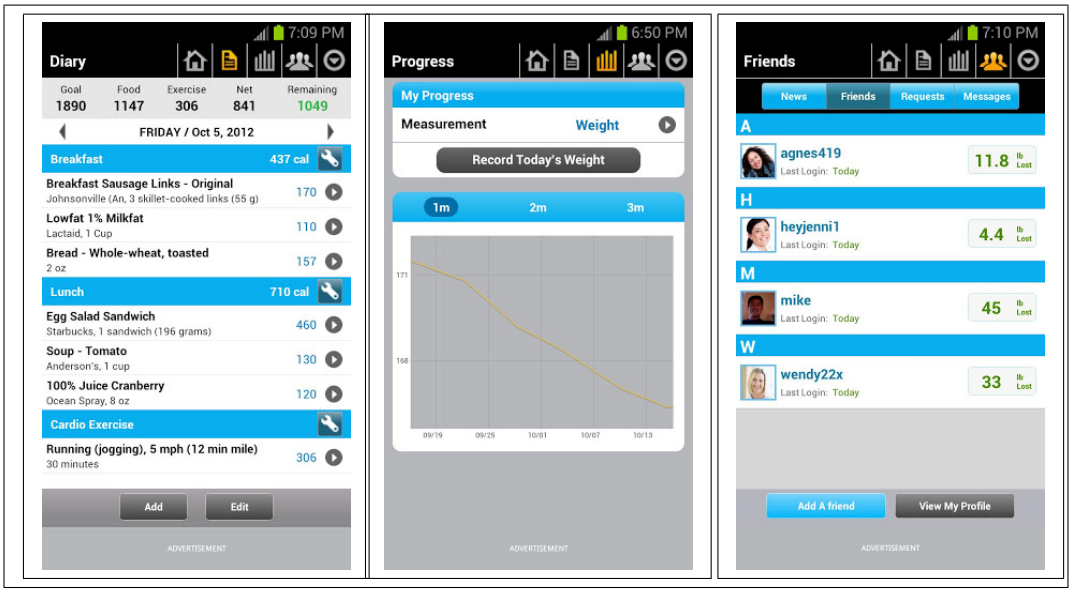

Figure 2.5: Users' Food Diary (left). Users' Progress Report(middle). Users' friends activities (right).

2. My Food Circle[3] : This is a social [12] app that helps you instantly share pictures of what you are eating with your friends. Through this you can connect with people and friends or you can maintain private food diary. This app is not only great fun but also can be a big help to stay healthy, lose weight, eat for fitness, or just enjoy tasty nutritious food. This has also functionalities like rate one another's meals and share comments, ideas, encouragement and advice.

3. Restaurant System[4] : Restaurant System is a demo android application where customers could order foods before going to restaurent and also can reserve a table. Waiters also can use application to check orders from customers' and Chefs receives orders directly, which are displayed in the monitors placed in the kitchen.

[3]Google Play Store Application-My Food Circle.
[4]Google Play Store Application-Restaurant System.

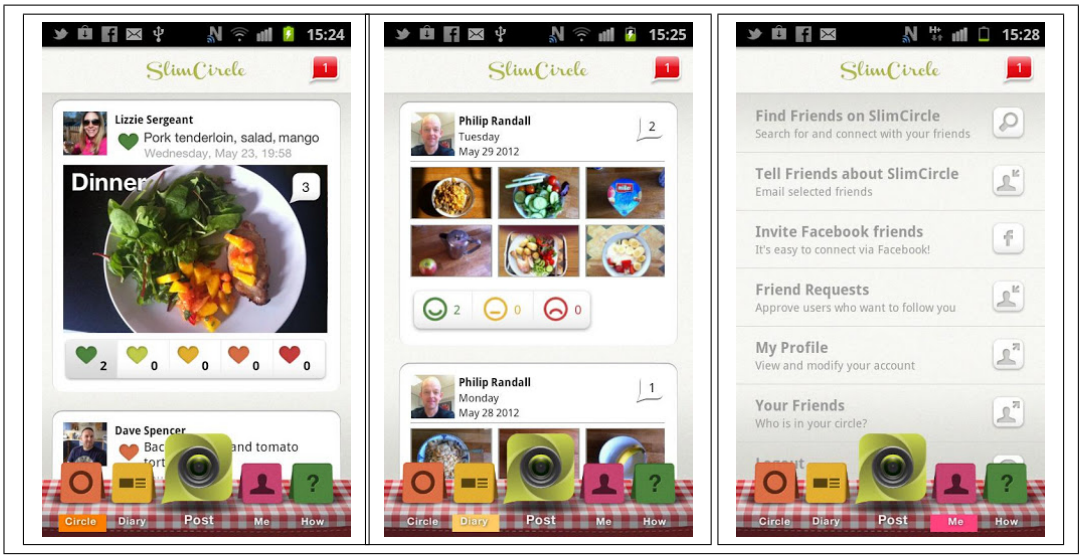

Figure 2.6: Users' wall of My Food Circle (left). User's Food Diary (middle). Users' functionalities of My Food Circle (right).

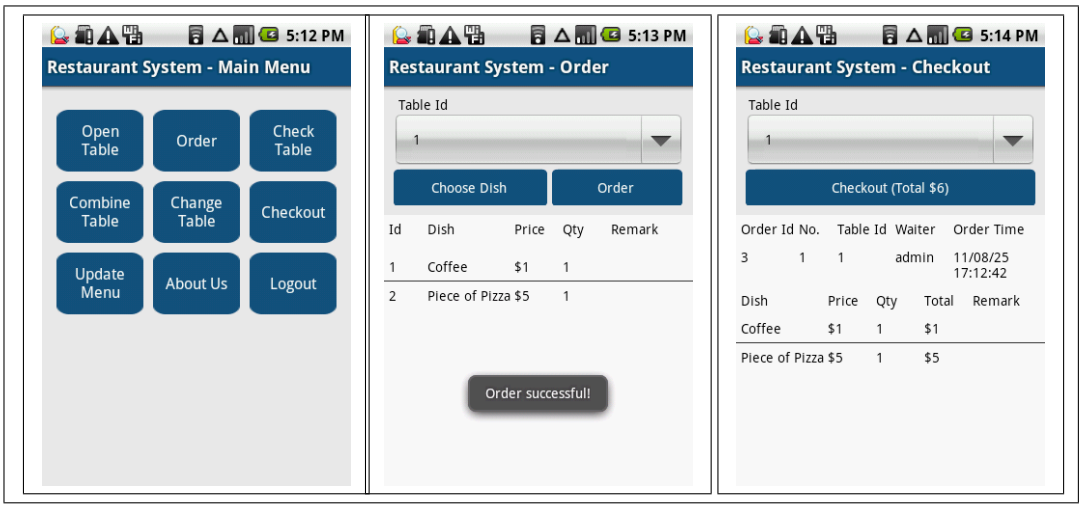

Figure 2.7: Users' Dashboard of Restaurant System(left). Restaurant System Order Dish(middle). Restaurant System checkout Dish(right).

Chapter 3

Analysis of Smart Cafeteria

In this chapter, I will explain the methodology [3.1] and the result of analysis phase [3.2] of "Smart Cafeteria". In the first section, I have provided the definition of Requirements and Data Gathering techniques; and also mentioned different data gathering techniques which were required to collect requirements for "Smart Cafeteria". I have used some data gathering techniques that are used to find and clarify the users' needs and requirements for "Smart Cafeteria".

At the very beginning of analysis, I have started to study documents and researched about "Smart Cafeteria" and found a set of stakeholders [3.1.1], initial functional requirements [3.1.2] and non functional requirements [3.1.3]. Then I have studied Opera universitaria's documents related to Mensa and found a few new requirements [3.1.4]. To find out more requirements for "Smart Cafeteria" I have made a focus group discussion [3.1.5] and finally went through questionnaire [3.1.6].

In the second section [3.2], I have presented data analysis and result using previous set of requirements. The result was presented using UML 2.0 e.g. Use Case diagram [3.2.1], Class Diagram [3.2.2] and Activity Diagram [3.2.3].

3.1 Requirements and Data Gathering

A Requirement [2] is a statement about a proposed system that specifies what it should do or how it should perform it's activities. One of the aim of the requirement activity is to make them as specific, unambiguous, and clear as possible. Traditionally, there exists two different kind of requirement; **functional requirements** which concerns about what the system should do, and **non functional requirements** which states about the constraints of the system and its development. The main reason of the requirement analysis

is to understand about the users, their work, and the context , so that the system can be developed such a way which could satisfy the requirements of the users. This is called identifying needs. On the other hand, second aim is to produce a set of stable requirements that drive to next phase which is design phase. Identifying needs and establishing requirements is itself an iterative activity in which the sub activities inform and refine one another. It does not last for a precise number of weeks or months, it lasts until it achieves usability goals.

The purpose of **data gathering** is to find a set of stable requirements even though a set of initial requirement exists, data accumulation will help to expand, clarify, and confirm those initial requirements. Data accumulation needs to cover a wide spectrum of issues because the different kind of requirements needed to be established [2].

There are very few number of basic techniques to gather data, but they are very important and flexible which could be combined and extended in many ways. These will give scope to understand the variety of requirements and these techniques are commonly studying documentation, questionnaires, interviews, focus groups and workshops, users' observation.

3.1.1 Stakeholders

Stakeholders are the people from whom all requirements will be gathered, the people who has the most influence on design and the people who will get benefited from the completed project. Here is the list of all stakeholders of the smart cafeteria.

1. **System Users:** System user is those who are going to use and get services from our system "smart cafeteria". They are usually students, professors, researchers, University administration officers and University technical staffs who are closely involved with our system. Their main goal is to search food menu in online system application and order menu through online to reduce mensa queue time.

2. **Students:** Students are one of the most important stakeholder who belongs to system users. Basically most of the students are busy with their classes, examinations and they stay at the university almost entire day and generally take their breakfast, lunch and some cases even their dinner in cafeteria.

3. **Professors:** Professors are one of the most important stakeholder who will be system users. They are mostly busy with their classes, seminars, projects in all day long at the university.

4. **Researchers:** Researchers are another kind of stakeholder and system users who are going to use this system to get services.

5. **Administrative Officer & Technical Staff:** University administrative officers & technical staffs are system users and stakeholder. They stays busy with their work all day long and also take their lunch at university cafeteria. So they will also get services and facilities from this system.

6. **System Administrator:** System administrator is a kind of stakeholder of this system who is going to manage the system, update menu in the system, check the order and add all kind of information related to cafeteria in the system. Cafeteria staffs are the mainly system administrator and their main goal is to spread food menu information through online.

7. **Cafeteria Staff:** They are one kind of stakeholder and a kind of system administrator who is going to check the order and serve the menu for the other stakeholders.

3.1.2 Initial Functional Requirements

As a cafeteria user I have done initial analysis and found some initial functional requirements from my previous experience and knowledge which is discussed in this section. To find out more requirements and make the system stable, I have studied cafeteria's food menu and related documents [3.1.4], built focus group [3.1.5] and conducted interview with questionnaires [3.1.6].

In software engineering, a functional requirement defines the functions of a software system and its component [13]. A function is described as a set of input, it's behavior, and outputs. Functional requirements may be calculations, technical details, data manipulation, processing and other specific functionality that describes what a system will do. The system uses the functional requirements that are captured in use cases. All functional requirements are supported by non functional requirements which impose some constraints such as security, reliability, portability on the design and implementation of the system. Functional requirement catches the proposed behavior as services, tasks or functions of the system that is required to achieve goals.

The functional requirements of "Smart Cafeteria" as follows which is categorized by different roles and tasks in the application.

(I) **System Users:** System users have the principle role in the system application. They are basically students, professors, researchers, university administration officers and university technical staffs who are going to use the system. After research, I have found the following functionalities of the system users into the "Smart Cafeteria" which has been shown in table 3.1.

Serial No.	Functional Requirements
F1	User should register in the system to get services.
F2	Registration confirmation through email.
F3	Forgot user name or password.
F4	Login into the system.
F5	Login into system through application login function.
F6	Login into system through university's login service.
F7	Check users own dashboard after login.
F8	User can update user's own information and credential (change profile information, password).
F9	follow users.
F10	view User's activities.
F11	View list of food menu.
F12	Search food menu.
F13	View menu details.
F14	Place oder menu.
F15	Payment for order.
F16	View order statistics.
F17	View dieting report and calorie consumption per day.
F18	Generate dieting report.
F19	Rating in food menu .
F20	Give comments in individual food menu.
F21	Generate report.
F22	Take food menu receipt after placing order by punching student card into the POS terminal.

Table 3.1: Functional Requirements of System Users.

(II) **System Administrator:** System administrators who are basically cafeteria's staffs have the following functionalities that has been shown in the table 3.2.

(III) **System Application:** System application itself has some functionality which has to be performed to make the system more interactive.

Serial No.	Functional Requirements
F23	Login in admin panel.
F24	Add food menu in the system.
F25	Edit food menu.
F26	Delete food menu.
F27	Manage order.
F28	View order.
F29	View order statistic per day (Total order).
F30	View order statistic per week.
F31	View order statistic by menu.
F32	view User's activities.
F33	Search order by food menu.
F34	Search food menu by name and key word.
F35	Generate report.

Table 3.2: Functional Requirements of System Administrator.

The functionalities of system application has been shown in table 3.3.

Serial No.	Functional Requirements
F36	Generate daily food menu notification through email or sms.
F37	Generate weekly food menu notification to users.
F38	Suggesting list of food menu to users based on their choice rating and which food menu they have took daily and how much calorie they have took in the last couple of weeks.
F39	Order status will be kept pending until user takes the receipt from POS terminal.
F40	Order status confirm after users take food menu receipts by punching student card.

Table 3.3: Functional Requirements of System Application.

(IV) **POS Terminal:** POS terminal is used for payment through master card in most of shops or supper market. But in "Smart cafeteria" it could be used to pay or print order receipt after order food and successfully paying online. The POS terminal has some functionalities which has shown in the table 3.4.

Serial No.	Functional Requirements
F41	Print food menu order receipt after punching card into the POS terminal machine.
F42	Send a notification to the system that user got the receipt after order.

Table 3.4: Functional Requirements of POS Terminal.

3.1.3 Non Functional Requirements

Non functional requirement defines sometimes as system qualities and properties of the system such as performance, security, maintainability in order to support functional requirements. In other words, how well some behavioral or structural view of the system could be accomplished. The "IEEE-Std 830 - 1998"[1] has discussed some non-functional requirements [14] in a Software Requirements Specification and after research, I have found the following non functional requirements for "Smart Cafeteria":

1. **Usability:** Usability is the most important non functional requirement in smart cafeteria project and our main focus is on system usability from non functional requirements along with the functional requirements of the system. Usability is the activities with which a user can learn to operate, easily understand inputs for and outputs of the system or component. From previous discussion 2.2.3, usability is generally regarded as ensuring that interactive systems are effective to use, easy to learn and enjoyable from user's perspective. Our system should also hold the usability heuristics principles which is discussed earlier.

2. **Internationalization:** Since students in the University of Trento are from various cultures and speakes different languages, our proposed system should support multi language interfaces and functionalities.

3. **Portability:** The proposed system will be portable since the system application will be accesable from Desktop PC, Laptop, Tablet as well as Smart phone. This application will definitely support the non functional requirement "portability".

4. **Adaptability:** According to Subramanian and Chung [15], adaptation of software systems is an unavoidable process which needs faster development of new or maintenance of existing software systems due

[1] IEEE Std 830-1998, Recommended Practice for Software Requirements Specifications IEEE Recommended Practice for Software Requirements Specifications

to the change in customer requirements. There are also several definitions of adaptability which are taken from several papers; some of those definitions are described bellow:

(i) According to Oreizy et al. [16], "Self-adaptive software modifies its own behavior in response to changes in its operating environment".

(ii) "Adaptability is defined as the ease with which a system or parts of the system may be adapted to the changing requirements [15, 17]."

(iii) "A program is called adaptable if it can be easily changed. A program is called adaptive if it changes its behavior automatically according to its context [15, 18]".

There are several things of software adaptation in our proposed smart cafeteria system and one of them is the system capable of accepting http/https request from different clients such as desktop, tablet as well as different versions OS of smart phone and respond to them as well.

5. **Safety and security:** Safety and security is heighly important non functional requirements of a system. There are some safety and security non functional requirements propose in our smart campus project and those are as follows:

   (i) Our proposed system ensures authorized access to the system data as well as user information.

   (ii) The communication between the application server and client must be encrypted and use https protocol.

   (iii) Backup of all the system data should be taken every 24 hours and it should be saved in a secure location.

   (iv) System makes sure to stop if there is a any probability of security attacks.

6. **Reliability:** In the software requirements specification (SRS)[2], Reliability is the most common non functional requirement. There are some proposed non functional requirement for reliability in our smart campus project and those are as follows:

   (i) System should be available 24 hours.

   (ii) System should not have any failure during operation.

   (iii) Good reputation towards user.

[2] IEEE Std 830-1998, Recommended Practice for Software Requirements Specifications.

(iv) Deliver such services and functionalities that user can trust.

7. **Performance:** Performance is a common non functional requirement for a system. The following things should be available in our system as non functional requirements:

   (i) Speed should be good in the operation of the system.

   (ii) Response time of the operation should be good in any platform e.g. in desktop, tablet, smart phone.

8. **Documentation Requirements:** According to Software Requirement Specification, "Smart Cafeteria" will specify and maintain proper documentation before the start of development. The document should contain Title and Author, scope, stakeholder, functional requirements, usability requirements, technical requirements accordingly IEEE Std.

3.1.4 Studying Cafeteria's Food Menu and Documents

Studying documentation is an important part of data gathering technique. Procedures and rules are written down sometimes in manuals or papers and these are a good source of data. In the requirement activity, studying documentation is good for understanding legislation and getting some background information about the work as well as the system [2]. Since studying documents is essential, I have researched and studied about Mensa's food menu [Figure 3.1] and Mensa's other documents [Appendix A.1] of Opera Universitaria di Trento [19](university of Trento). From this research, I have found

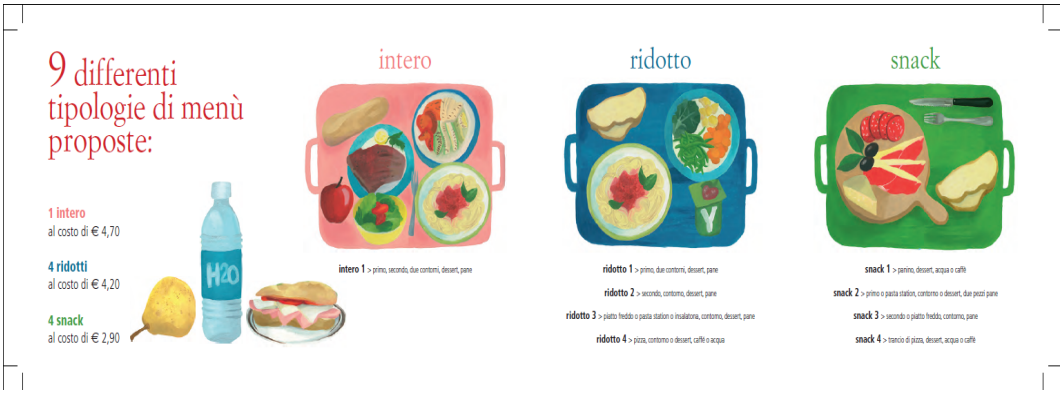

Figure 3.1: different menu of Mensa in University of Trento.

the following facts:

- Since university of Trento has several departments in the several places, university has a lot of cafeteria branch in different place as well.
- I have also found that all cafeteria branches have a monthly opening time schedule in the website as a pdf document.
- I have also found each cafeteria offers different food menu such as full menu, reduce menu and snack charging of different prices and where each menu contains different food items and calories as well.

From those of facts, I have come down into a decision and added some more functional requirements into the system. The additional functional requirements as follows:

System administrator

1. System administrator can add, edit and delete operation into the system for cafeteria branch.
2. System administrator can add, edit and delete monthly operating time schedule of each branch into the system; for example, povo1 is closed January 1 to January 6, 2013 and others working days of the month January 2013 will be opened.
3. System administrator can add, edit and delete food item which contains food item status e.g. first course, second course, dessert, side dishes, cold drinks, etc. and their respective Kilo calories per 100gm and other information's.

System users

1. System users can see and browse the cafeteria branches and monthly operating time schedule of each branch respectively.
2. System user can create own menu using menu wizard from different food items depending on their choice which may have different cost depending on food items.

3.1.5 Focus Group

Focus group and workshop is a very good technique to gather data and set of requirements. Interview is a such kind of thing which tends to be one on one perspective where as focus group and workshop is a very effective, alternative and collaborative technique to get a group of stakeholders together to discuss

about the system and find out set of requirements. This activity sessions should be very structured with predefined set topics for discussion and I was as a facilitator in that focus group session and I have discussed and asked several questions[Appendix A.3] about our smart cafeteria system and its facilities and functionalities. The participants took part in open discussions as well as gave answers to the questionnaires [2].

There were 7 participants in this session, all of them are the student of University of Trento who used to take their lunch in University's cafeteria. In the Table 3.5 [Appendix A.2] , the summary of the focus group meeting are shown.

Agenda Item	Discussion	Decision
Smart Cafeteria Functional Requirements	We discussed all functional requirements that I have found earlier.	They agree with all functional requirements and they suggested one extra functional requirements which is mobile application should support QR BARCODE.
Smart Cafeteria Non Functional Requirements	We have discussed all non functional requirements from IEEE-Std 830 - 1993'.	All participants strongly supported Internationalization, Usability and Portability.
Smart Cafeteria in mobile and Tablet apps	Now we are in the age of informational technology, especially in mobile computing phase where all applications drive to support in mobile and tablet in smartly.	All participants strongly supported smart cafeteria mobile applications.
Adaptive mobile application	Adaptive application will observe user behavior, test, and user's psychology and conclude a result with the help of machine learning techniques and finally suggests a list of solutions.	All participants strongly supported smart cafeteria mobile applications which must be adaptive application.

Table 3.5: Focus Group Discussion Summary.

From the discussion, I have found requirements that, since the application also supports mobile plateform, so the application could scan QR BARCODE [Figure- 3.2] which along with food menu automatically it forces to order menu phase. In the [Appendix A.3], the questions asked to participants is shown.

Figure 3.2: QR BARCODE

3.1.6 Questionnaires

Adams and Cox [20] have defined that Questionnaires are usually paper based or delivered online and consist of a set of questions which all participants are asked to complete. Questionnaire is a kind tool that should be easily understandable, interpretable; and should avoid complex words. Questionnaires should hold reliability and validity; to increase the effectiveness of questionnaires it is important that how it is structured and it's unambiguity. Questionnaires should preserve interviewers' trust, privacy and ethics; so interviewer should ensure confidentiality. They also found that if a large number of users are participating, there always have a chance to get a large amount of data which need to be coded and analysed. They also suggested

that focus group is better than conducting single interview since interviews are usually conducted on a one-to-one basis. It requires a large amount of the investigator's time during the interviews as well as transcribing and analyzing the data.

There were seven questions whose scale was based upon the Likert scale Effective or not Effective and yes or no. On the other hand, two questions were for open suggestions to improve the system's functionalities. The Table 3.6 [Appendix A.3] has shown the questionnaire which have asked to participants in focus group meeting and the number of participants agreed or disagreed with the facts from total 7 participants.

Questions/Answer	Yes or Effective	No or Not Effective
Do you support if an application which will provide mensa system where avoiding a long queues and saving time?	7	0
If there will be an application where you could browse food menu, search food menu, order and pay online, then how effective the system will be ?	7	0
If the application let you create your own food menu as real scenario, how effective the system will be for you?	5	2
how effective the system will be if the application supports mobile plateform?	6	1
If the application could suggest you food menu depending on your choice, test, your dieting preferences, then how effective the system will be?	7	0
If the application provides support in different languages, then how effective the system will be?	7	0
Do you think that this application may help you or make your university life easier?	6	1

Table 3.6: Data Gathering Questionnaire & Result.

3.2 Data Analysis

Data interpretation and analysis is a very important part in the interactive system development life-cycle. When Data-gathering session has been almost finished, data interpretation and analysis phase could start and it is an iterative step between data gathering and data analysis.

In data analysis [2], different techniques and notations were followed to find different aspects of the system that will give different requirements. Traditionally, functional requirements have been analyzed and expressed using data-flow diagrams, state charts diagram, work-flow charts. Since our system development is using object-oriented approach, functional and data requirements are combined in class diagrams and behavior of the system being expressed using sequence diagrams. Use case focuses on goals of users which were introduced through the object-oriented community . Use case focuses specifically on the interaction between the user and a software system. The term scenario is also used in the context of use cases.

In the following Subsections 3.2.1, 3.2.2 and 3.2.3 , I will describe and discuss about Use case diagrams, Class diagram and Activity diagrams of "Smart Cafeteria" respectively.

3.2.1 Use Case Diagram

According to UML 2.0 specification [21], a use case diagram represents the relationship between actors and use cases within a system. The use cases represent functionality of a system or a classifier as like a subsystem or a class, as manifested to external integrator with the system or the classifier. A use case diagram contains a set of actors, set of use cases, some interfaces; and shows the relationships between these elements. The relationships are mainly associations between the actors and the use cases; generalizations, extend and includes among use cases; and generalizations between the actors.

Since I have discovered some stakeholders and their goals in this system after analysis, depending on those I have found four use cases scenarios. Bellow I will describe those use case scenario one by one.

3.2.1.1 Use case of System users

In this use case, students, professors, researchers, university staffs all are generalized as system user basically who are going to use the system to get some service from "Smart Cafeteria" system. System user can perform basic operation like registration, confirm registration, forgot password, login and logout. Login could be performed through university's authentication service

and its own application login. After login into the system users could access their own dashboard from where they could perform search food menu, view list of food menu, view individual food menu, rating in food menu, comments on food menu, place order food menu, change user's profile, view dieting report. Through this system, users could also make their own food menu using create menu wizard. System user could also see information about cafeteria branches and their time schedule through the system. After order and payments, system users must take a menu receipt after punching their card in the POS terminal.

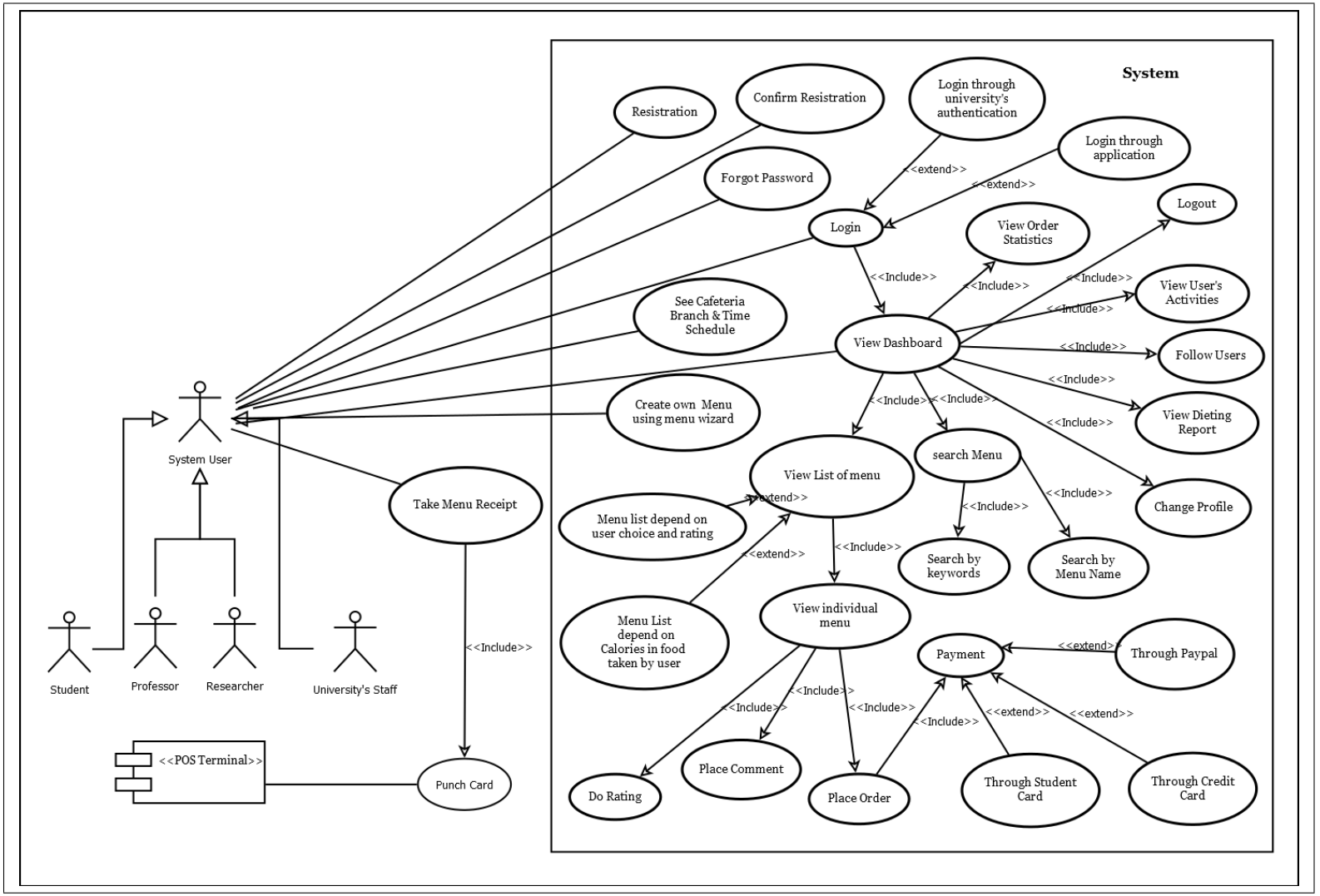

Figure 3.3: Use Case Diagram of System User

3.2.1.2 Use case of System Administrator

In the use case of system administrator, cafeteria staff's are generalized as system administrator. System administrator can perform their operation after login into the system. After login, system administrator can access administrator dashboard. And from administrator dashboard, system administrator can manage cafeteria branch which means add, edit, delete and view operation on cafeteria branch and their respected time schedule. System administrator can add, edit, delete and view operation on food item and menu. They also can make food menu from food item and menu. System user can view order statistics, view total order, view order pending, generate various kind of report.

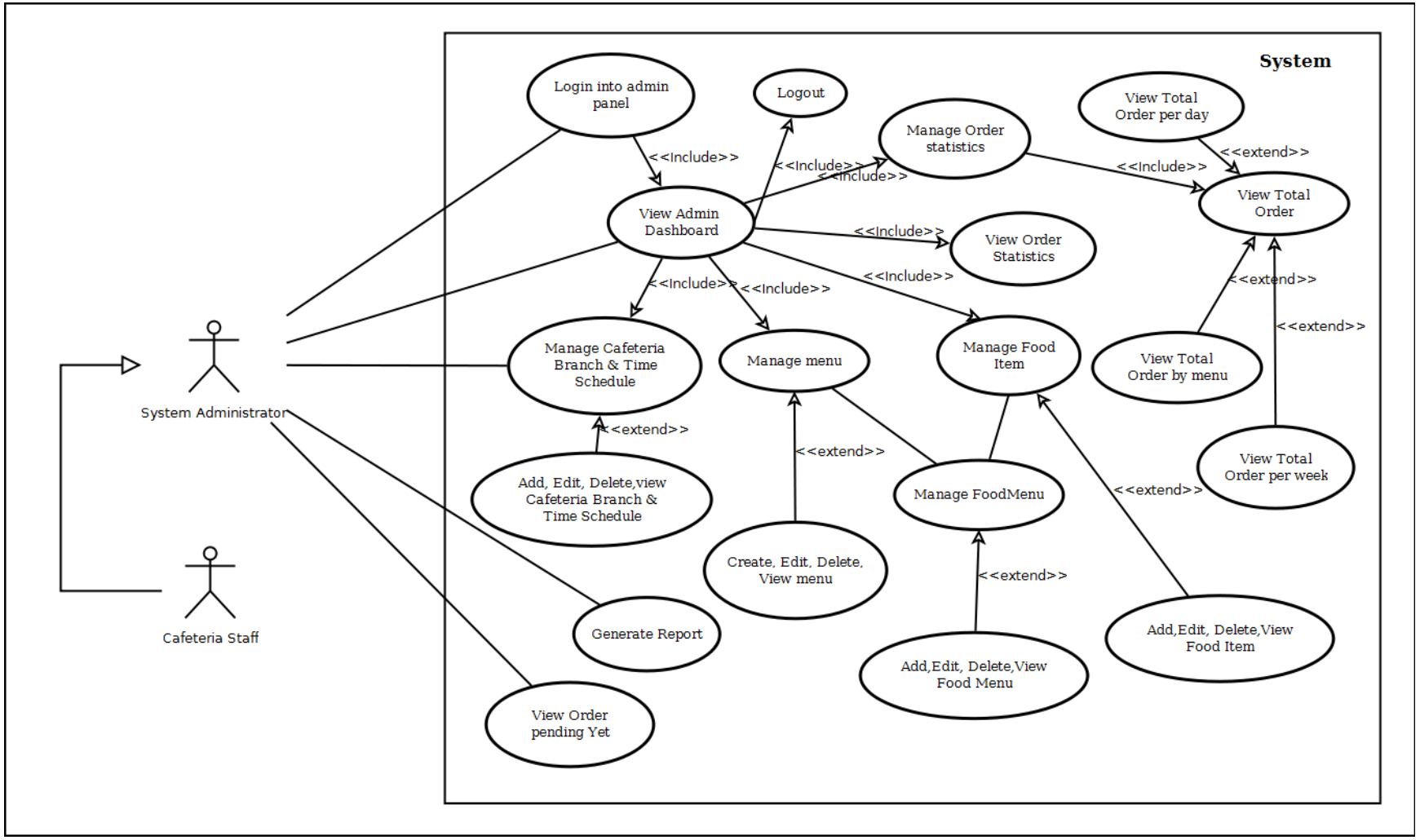

Figure 3.4: Use Case Diagram of System Administrator

3.2.1.3 Use case of System Application

System application itself is a use case where generates various notifications and sends to the system users either through using sms or email depends on user preferences. System application also generates different list of food menu for different user depending on their choices and calorie consumption of the last couple of days. System application also make the order status pending until user takes receipt from POS terminal and also make the order status confirm when user prints invoice from POS terminal punching the card.

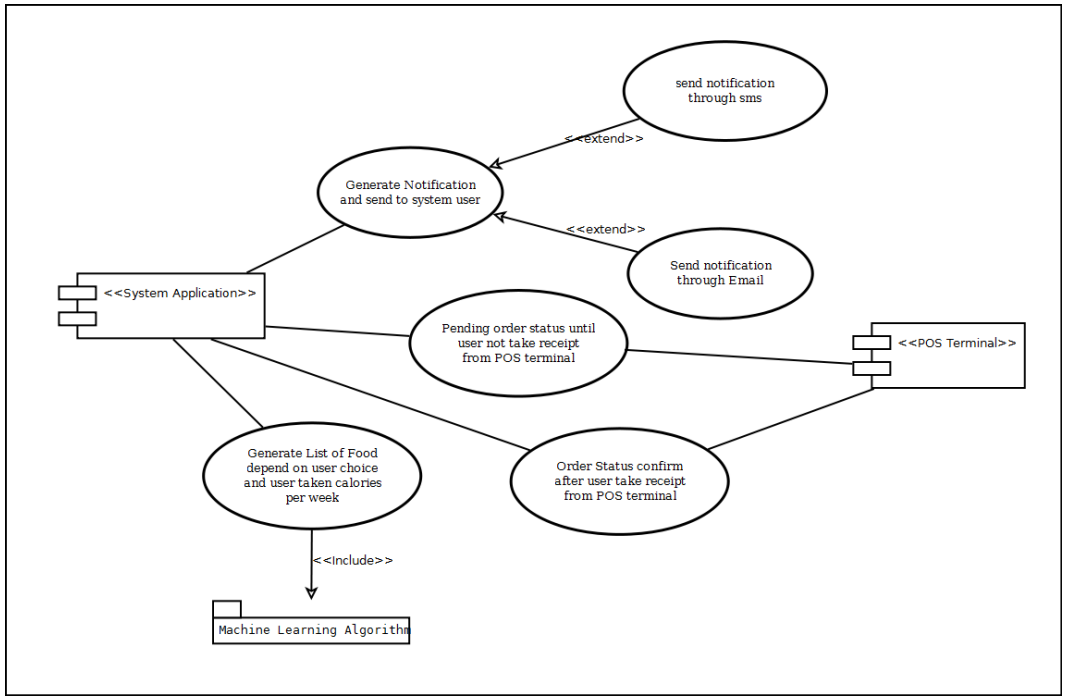

Figure 3.5: Use Case Diagram of System Application

3.2.1.4 Use case of POS terminal

In the use case of POS terminal, POS terminal prints menu invoice for the system user after he punches the card into the pos terminal after placing order for food menu. When system user prints food menu receipt, POS terminal sends a confirmation message to system application.

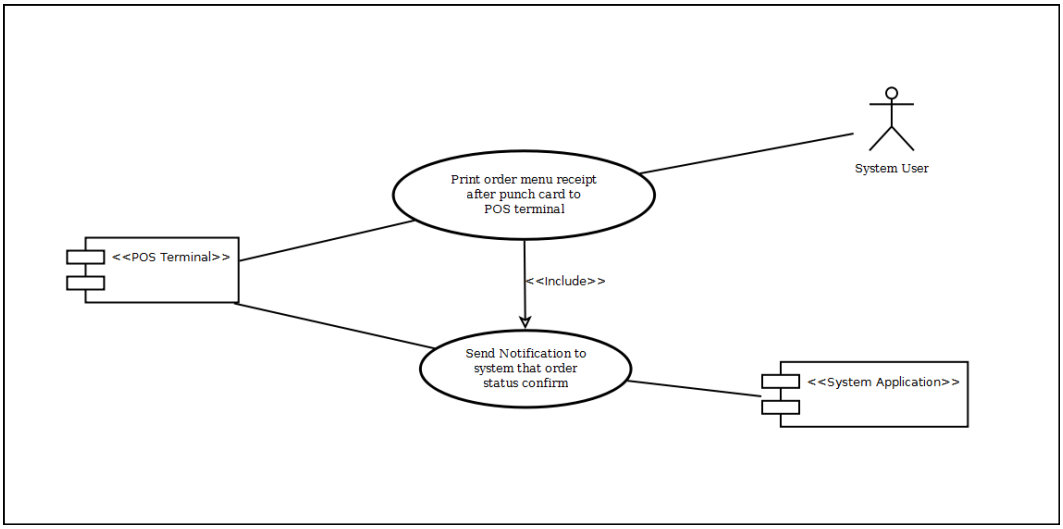

Figure 3.6: Use Case Diagram of Pos Terminal

3.2.2 Class Diagram

In UML 2.0 [22] there are two basic categories of diagrams: structure diagrams and behavior diagrams. Class diagram belongs to structure diagrams which shows the static structure of the system which is going to be modeled. In an object oriented application development, class diagram is very important in initial stage to model a system. Each class consist attributes, operations and relationships with other classes. In the following figure 3.7, I have modeled the class diagram of Smart cafeteria and provided some description of each class.

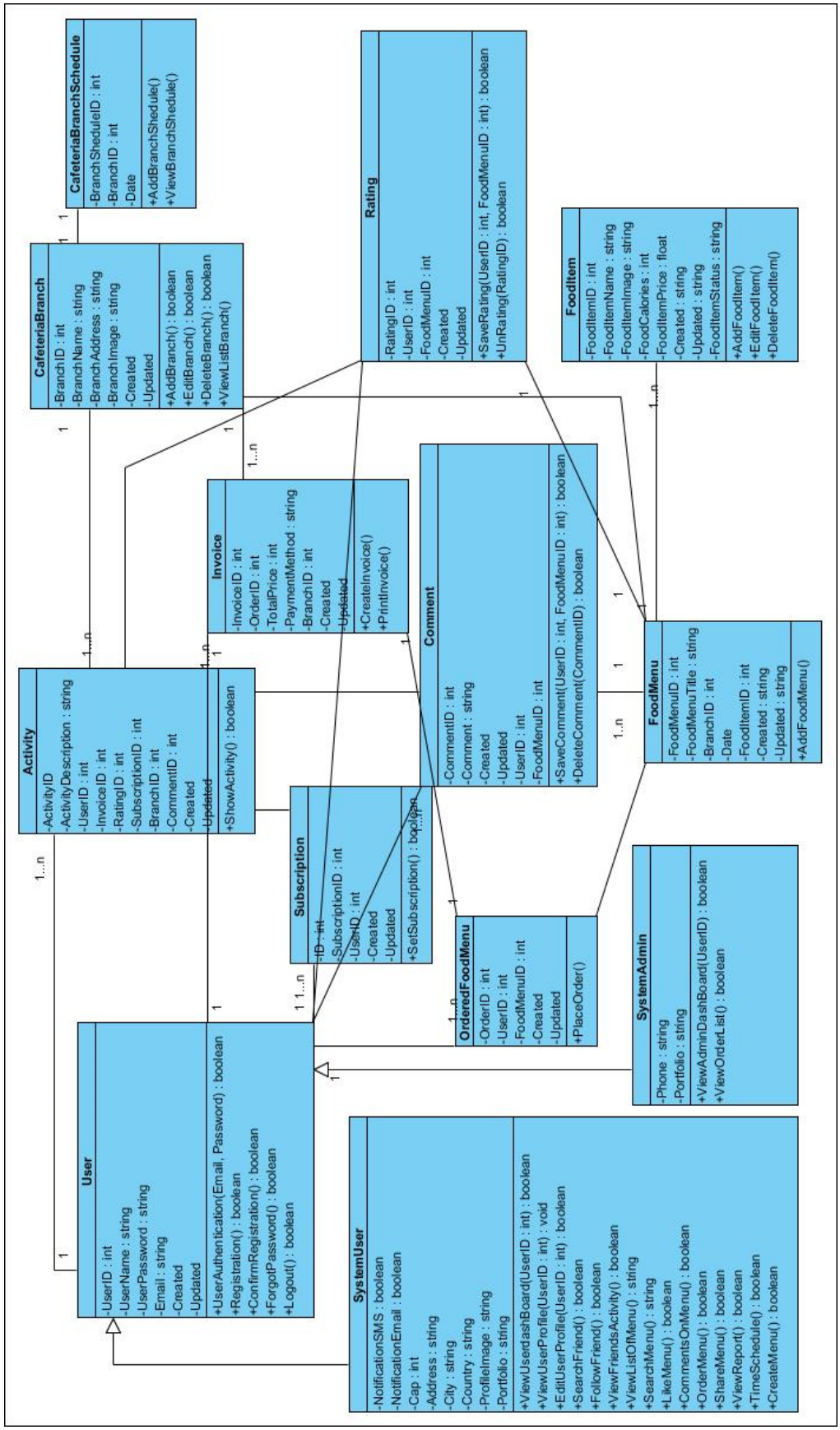

Figure 3.7: Class Diagram of Smart Cafeteria

User: This class contains information about a user in the smart cafeteria. The user class has a UserID as a primary key which will be unique, UserName, UserPassword as credential information, Email address and created and updated properties. This User class also has some functionality UserAuthentication which will take arguments as Email and Password, Registration, ConfirmRegistration, ForgotPassword and Logout. The user class is associated with Activity, Subscriptions, Comments, Rating and OrderedFoodMenu classes.

System User: The class System User will be inherited from User class which means all properties and methods from User class will be included into System User class. This class also contains some attributes such as NotificationSMS that is a flag which gives notification users through SMS, NotificationEmail that also gives notifications users through email, Cap, Address, City, Country; and created and updated properties. This class also has some functionalities such as ViewUserDashboard, ViewUserProfile, EditUserProfile, SearchFriend, FollowFriends, Viewfriendsactivity, ViewListofMenu, SearchMenu, Likemenu, CommentOnMenu, OrderMenu, ShareMenu, ViewReport, TimeSchedule, CreateMenu.

System Administrator: The System User class also will be inherited from User class; means all properties and methods from user class will be included into system admin class. This class also contains some attributes such as phone and portfolio. This class contains some functionalities such as ViewAdminDashboard, ViewListofOrder.

Food Item: Food Item class has FoodItemID, FoodItemName, FoodItemImage, FoodCalories, FoodItemPrice, FoodItemStatus, cretaed and updated attributes. This class contains AddFoodItem, EditFoodItem and DeleteFoodtem methods. This class is associated with FoodMenu and FoodItemID is the foreign key of FoodMenu class.

Food Menu: Food Menu class contains FoodMenuID, FoodMenuTitle, BranchID, FoodItemID, cretaed and updated properties. This class has a method named AddFoodMenu and is associated with Comments, Rating, FoodItem and OrderFoodMenu.

Oder Food Menu: The OrderedFoodMenu class contains OrderID, UserID, FoodMenuID, cretaed and updated properties and OrderPlace function. This class is associated with FoodMenu, Invoice and User classes.

Invoice: The Invoice class contains InvoiceID, OrderID, TotalPrice, PaymentMethod, BranchID , cretaed and updated attributes. This class also has CreateInvoice and PrintInvoice methods and associated with Activity.

Comment: Class Comment contains CommentID, Comment, UserID, FoodMenuID, cretaed and updated properties and SaveComment and DeleteComment methods. This class is associated with User and FoodMenu classes.

Rating: The class Rating contains RatingID, UserID, FoodMenuID, cretaed and updated properties and SaveRating and UnRating methods. This class is associated with User and FoodMenu classes. This class is associated with User and FoodMenu classes.

Subscription: The class Subscription contains ID, SubscriptionID, UserID, cretaed and updated properties and Subscription method. This class is associated with User and Activity classes.

Activity: The class Activity has ActivityID, ActivityDescription, UserID, InvoiceID, CommentID, RatingID, SubscriptionID, BranchID, cretaed and updated properties and ShowActivity method. This class is associated with User, Invoice, Comment, Rating, Subscription and Branch classes.

CafeteriaBranch: The class CafeteriaBranch contains BranchID, BranchName, BranchAddress, BranchImage, cretaed and updated properties and AddBranch, EditBranch, DeleteBranch and ViewListBranch methods. The class Cafeteriabranch is associated with Invoice, Activity and CafeteriaBranchShedule classes.

CafeteriaBranchSchedule: The class CafeteiraBranchSchedule contains BranchScheduleID, BranchID and Date properties and AddBranchSchedule, ViewBranchSchedule methods. This class is associated with CafeteriaBranch class.

3.2.3 Activity Diagram

Activity diagram [23] describes dynamic aspects of any system and basically represents the flow of activity form one to another activity. The activity could be described as an operation of the system and this diagram captures the dynamic behavior of the system. So it is important to visualize dynamic nature of a system. In this analysis, I have found some activity diagram of Smart Cafeteria system and shown in figure[3.8, 3.9, 3.10, 3.11] and described step by step.

3.2.3.1 System User

When a user browses the system, he or she can navigate to search food menu, see time schedule, see today's top menu into the slideshow and browse today's food menus. Users also can register in the system and login into the system. After successfully login into the system, user as a registered user could navigate previous basic activities search food menu, see time schedule as well as could browse User Dashboard from where user could search friends, follow friends, see friend's activities, see dieting reports, create food menu from foods, comment on food menus, like food menus, share food menus

and order food menus. Users also could change profiles and logout from this stage. The system will do some activities alone with user such as suggest daily different food menus for different users based on users interest and previous food consumed and dieting history. System will also save registration information of user after registration and check account credential before login action. After all actions, system saves preferences as well. In the figure 3.8, shows the activity of users as simultaneously with system.

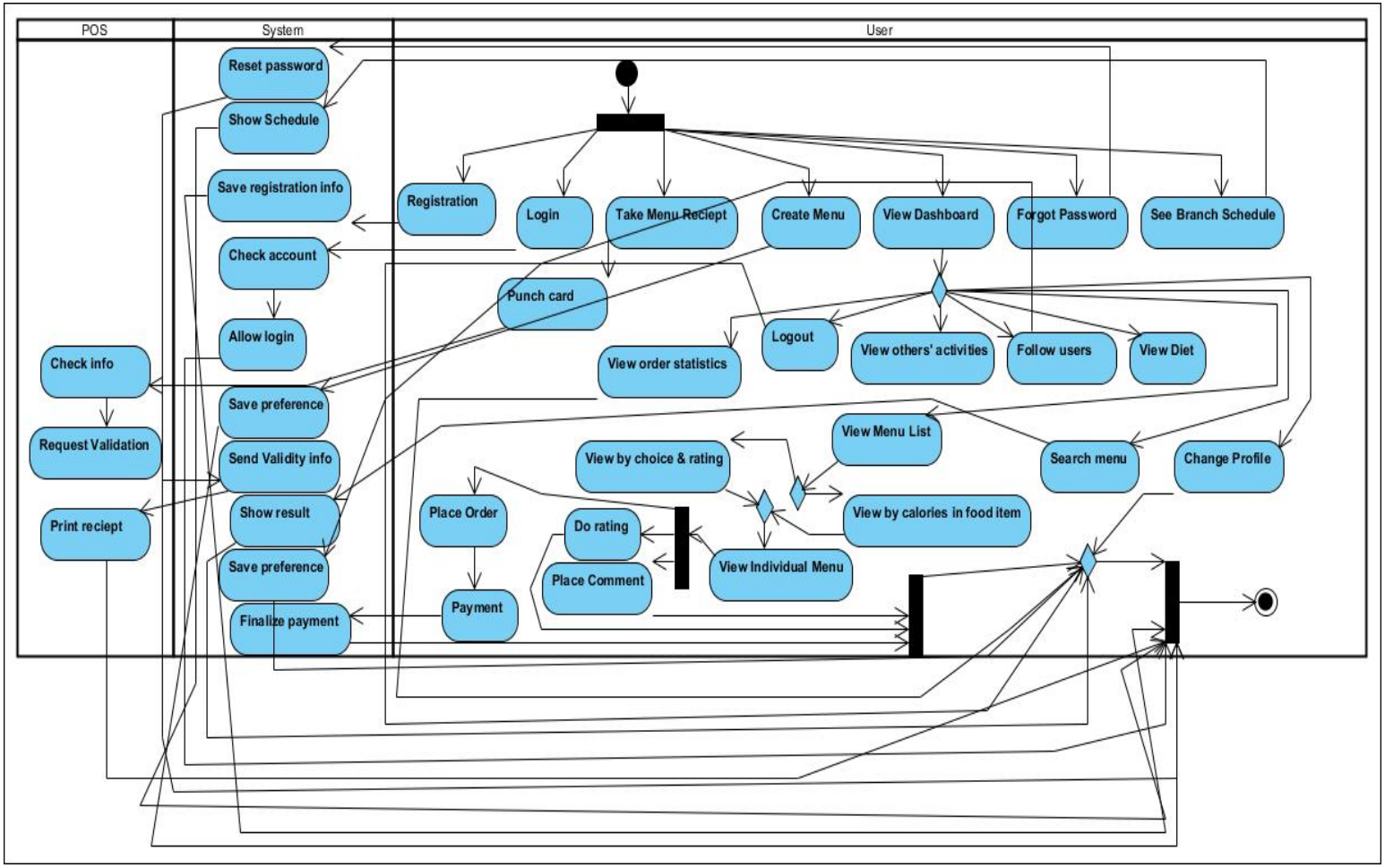

Figure 3.8: System User Activity Diagram of Smart Cafeteria

3.2.3.2 System Administrator

System administrator has some flow of activity after login into the system using administrator panel. System Administrator could view order pending from user's order and can confirm the order; and search report and system show report as well. From dashboard, system administrator can do different activity; manage food item, food menu, view order statistics and manage order statistics into different request such as view order by day, view order by month or view order by menu; and system response as well in the every activity.In the figure 3.9, shows the activity of System Administrator.

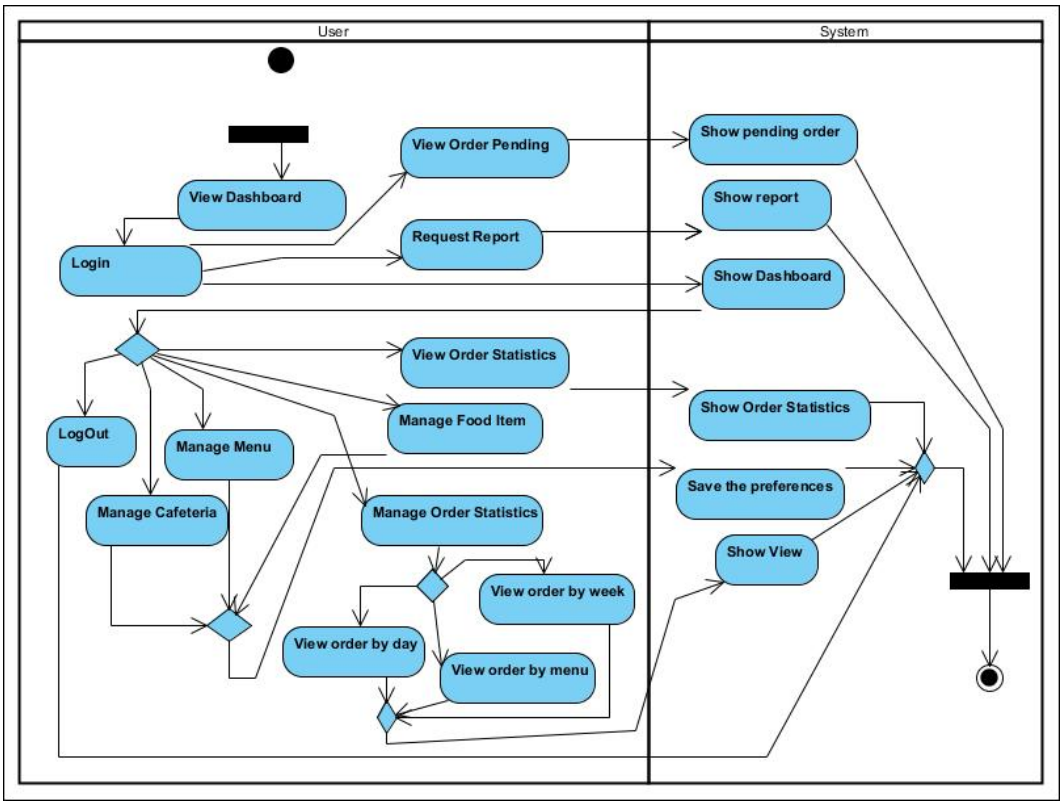

Figure 3.9: System Administrator Activity Diagram

3.2.3.3 System

In the system, there are some very important activities such as receive order confirmation from users, generate diet reports, create food suggestions, generate different kinds of notifications and send to users. The system looks after both type of user's; system users and system administrators, session and credentials as well. In the figure 3.10 shows the activity of System.

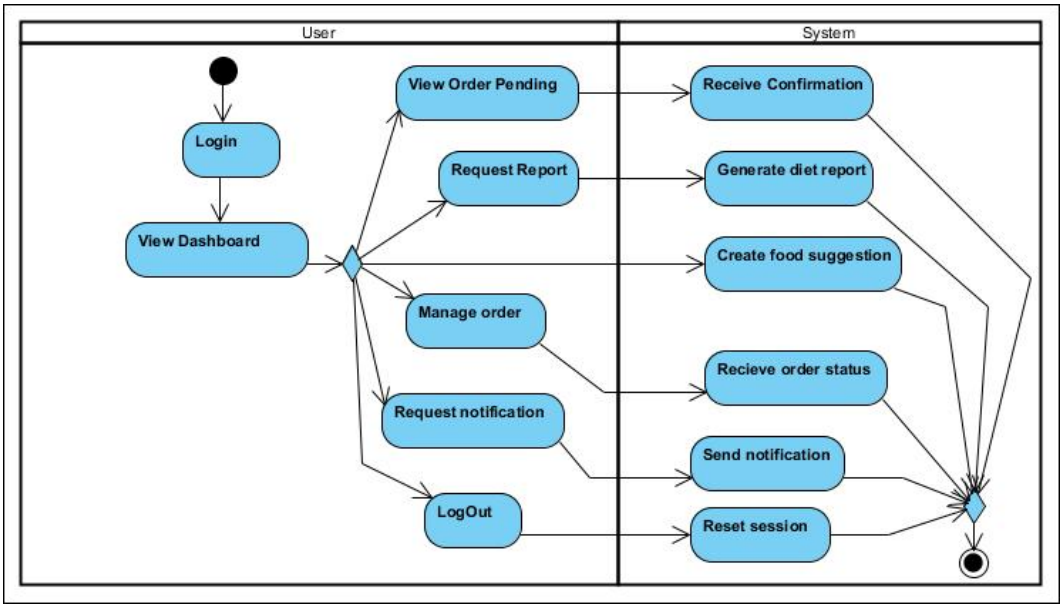

Figure 3.10: System Activity Diagram

3.2.3.4 Point of Sale

After confirmation of order, users punch card into POS terminal and those POS terminations are responsible to print order receipt for users and send a notification to the system application to update that the food menu is being served. In the figure 3.11 shows the activity of Point of Sale.

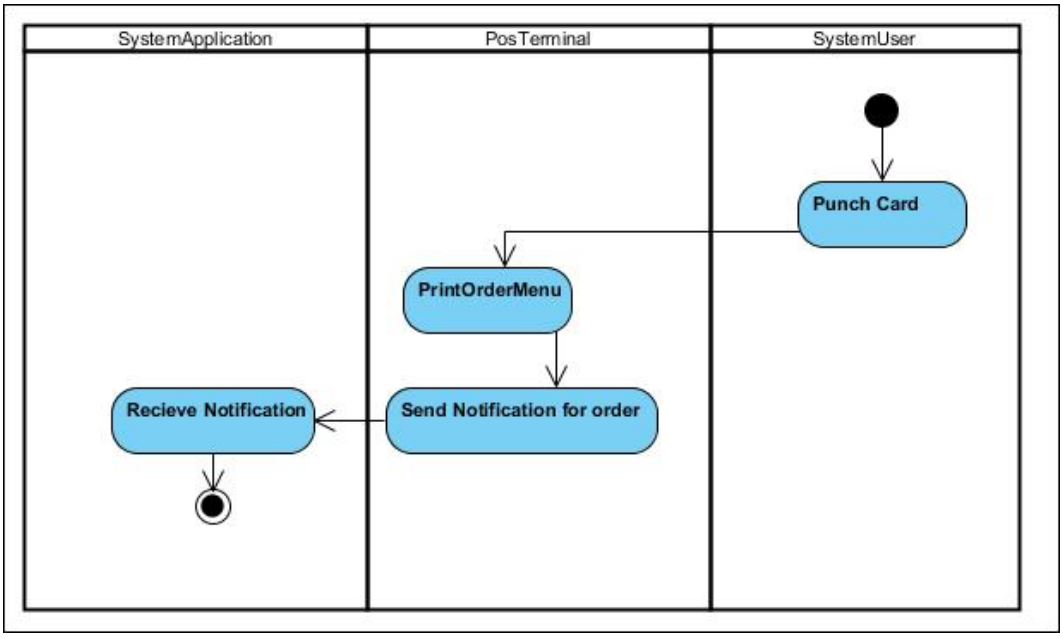

Figure 3.11: Point of Sale Activity Diagram

Chapter 4

Smart Cafeteria Design

In this chapter, I have discussed the design of "Smart Cafeteria". In first [4.1] and second [4.2] section, conceptual architecture and design and service oriented architecture (SOA) was discussed respectively. These are the top level architecture and design of the system. In the next section [4.3] prototype of "Smart Cafeteria" is discussed; a mid fidelity prototype of all functionalities of the system; some of them was covered in desktop prototype [4.3.1] and the rest was covered in mobile prototype [4.3.2]. And the final section [4.4] was discussed about the key features of the system.

4.1 Conceptual Architecture And Design

A conceptual architecture [24] describes essential and top level features of a system and identifies the main processes and their flows taking place in the system. It provides a definition of the phenomenon in terms of features recognizable by analysis and observations; and describes the abstract life cycle of the system.

Conceptual design [25] is the process of gathering, analyzing, and prioritizing business and user perspectives of the problem and the solution, and then creating a high-level representation of the solution. Conceptual design should follow three principle steps in any system development life cycle; research, analysis and optimization by system designer.

In the figure 4.1 a top level architecture of "Smart Cafeteria" application is shown. The mobile appplication users interact with the system through interface of the mobile application and desktop users interact with the system through browser.

In the figure 4.2, server level conceptual design has been shown where application fuctionalities and web services/SOA intergrates together to support

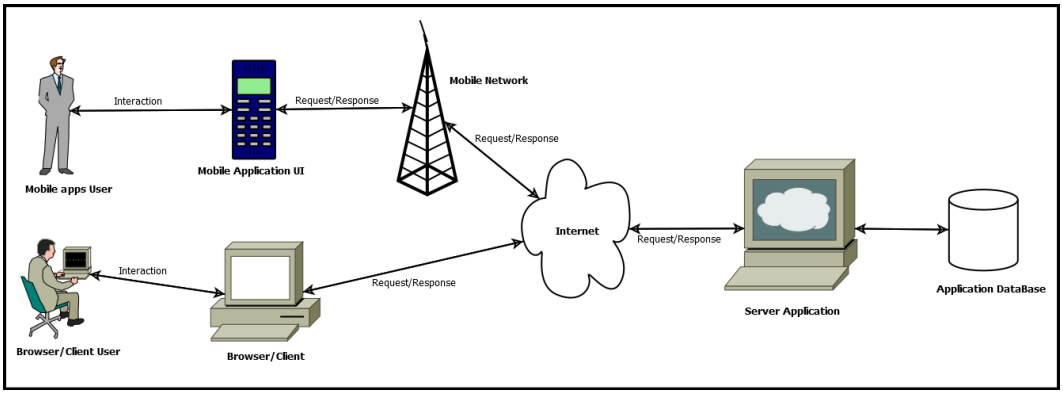

Figure 4.1: Conceptual Architecture of Smart Cafeteria[Top Level]

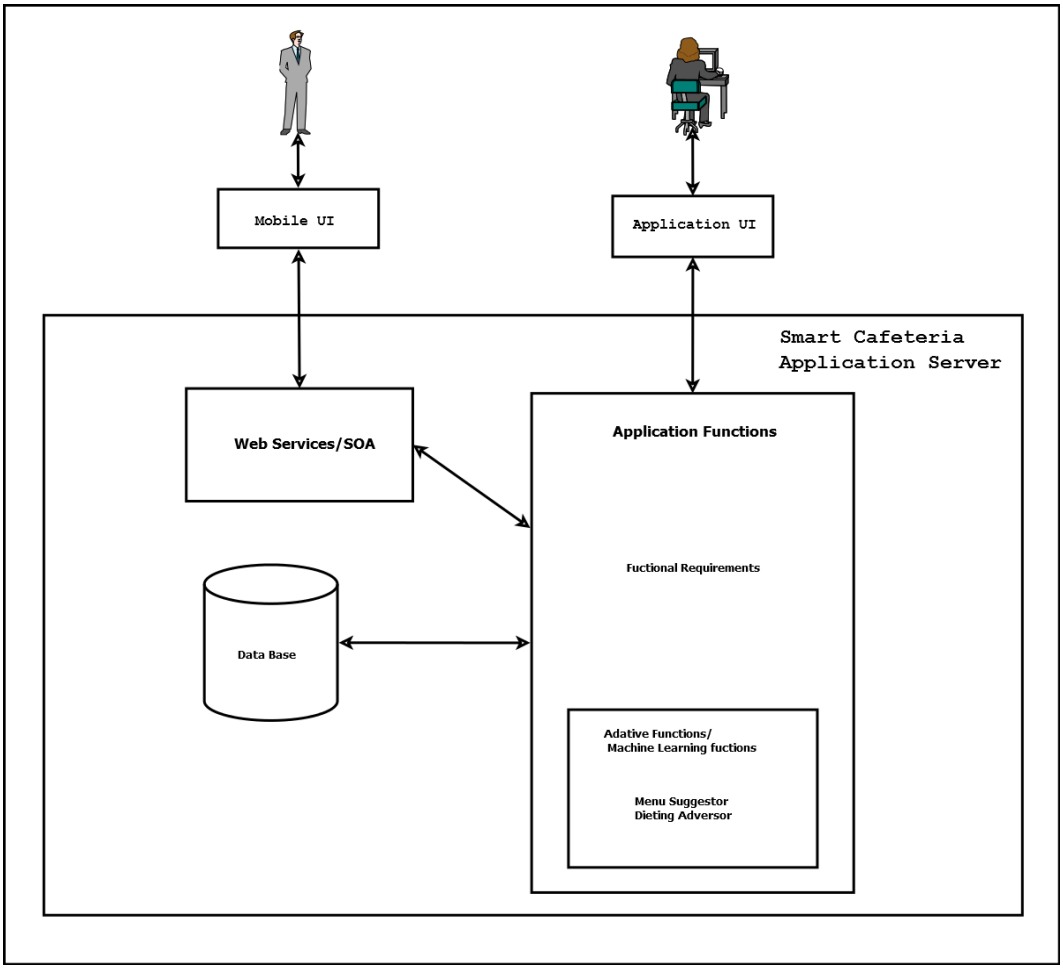

Figure 4.2: Conceptual Design of Smart Cafeteria[Server Level]

mobile apps as well as desktop application. Most of the process of conceptual design has been discussed in Chapter 3.

Within the application architecture, some fuctions of our application are adaptive which support adaptivity features such as menu suggestor, dieting advisor. Since smart cafeteria appplication will also support as a mobile application, Service Oriented Architecture(SOA) is very important to implement mobile application functionalities which is discussed in section 4.2.

4.2 Service Oriented Architecture(SOA)

In recent years, the information technology has moved towards service oriented architectures, especially in mobile computing and distributed computing. Since the number of different clients such as mobile applications, tablet applications are increasing rapidly; an emerging need of using SOA and Web services are also increasing to support those applications. The Service Oriented Architecture (SOA) recognizes and tries to construct a distributed, dynamic, flexible, and reconfigurable service system over Internet [26].

The key feature of service orientation architecture is loose coupling that is using resources only published but not accessable directly implementation behind application. So the change in implementation by the service provider should not affect the service consumer, for instance, weather service consumer and provider have the same technologies for the implementation application, interface. SOA is itself stateless which means it does not depend on the state of other services and also support reuse of software components because of loose coupling. The key component in SOA is web services that are well defined set of actions [27, 28].

Akinci [29] discussed about properties of web services; firstly, web services are for application-to-application communication. Secondly, web services are accessed over Internet. And finally, web services are XML based open standards, such as WSDL, SOAP to support interoperable machine to machine interaction over a network.

Richer UI could be the client side web service technologies such as Java Applets, Flash, Flex, Silverlight, iOS application, Android Application, HTML5 that must has quick response. Services Layer are Stateless Services and most of cases XML, REST or JSON that will get from Object oriented program function such as java, Ruby, Python, etc.

The following figure[4.3] shows Service Oriented Architecture of smart cafeteria.

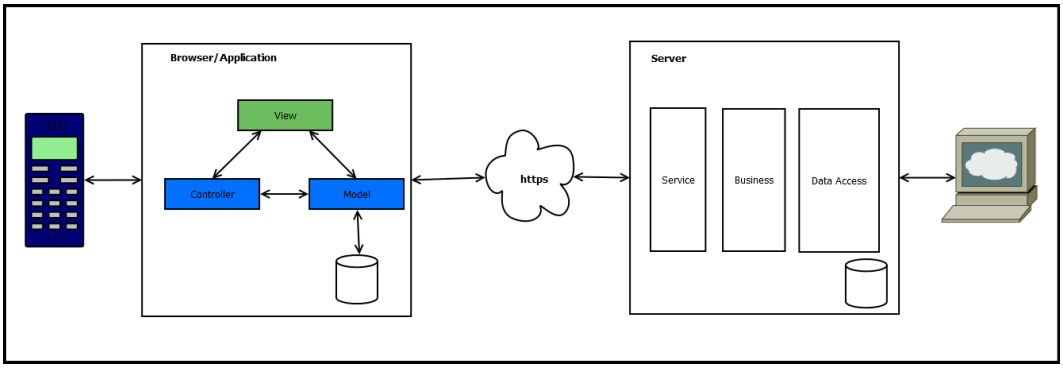

Figure 4.3: SOA Architecture of Smart Cafeteria

4.3 Prototype of Smart Cafeteria

Prototyping [30, 31], the process of developing prototypes, is a method used by designers to get feedback from users about future designs. Prototypes are experimental and incomplete designs of system which are cheap; can be developed quickly and it is an essential part of iterative user-centered design.

The main purpose of prototyping is to involve the users in testing design ideas and get their feedback in the early stage of development, to reduce cost and save time. It provides an efficient and effective way to optimize interfaces through interactive discussion and testing. The prototypes can be changed multiple time until a stable version of user interface that has been accomplished with efforts both from designers and users.

Prototyping can be divided into three categories; low-fidelity prototyping, medium-fidelity prototyping and high-fidelity prototyping. In some literature, it is simply classified as low-fidelity prototyping and high-fidelity prototyping, where low-fidelity prototyping is mainly about paper-based mock-up such as Sketches, Storyboard and high-fidelity is mainly about computer-based simulation. High-fidelity prototypes are fully interactive, simulating most of the functionality of the final product whereas medium-fidelity prototypes are computer-based simulation too but it simulates the system interaction and functionality partially; not all features of the intended system.

I have designed and demonstrate most of the functionalities and requirements which I have gathered in previous chapter 3. According to structural diagram (Class Diagram 3.2.2) and dynamic diagram (Activity Diagram 3.2.3) in UML 2, I have come to a stage from where I have proposed a medium fidelity prototype which meets and shows initial visualization of most fundamental functionalities and requirements.

To demonstrate and discuss full design template, I will discuss some func-

tionalities in desktop prototype section 4.3.1 and rest of them will be discussed in mobile prototype section 4.3.2.

4.3.1 Desktop Prototype

In this thesis work, I have designed a medium fidelity prototype of smart cafeteria.

The prototype of smart cafeteria has been designed by HTML5[1], CSS3[2] and Twitter Bootstrap[3] jQuery plugins. To design the template, I have used Eclipse IDE Juno[4] and run that on Apache Tomcat server v7.0[5].

There are two basic main part in the prototype; index 4.3.1.1 which will come after starting the application or browsing the application and dashboard 4.3.1.2 will be accessible after user logs into the system.

4.3.1.1 Index

In the index page, there are a couple of functionalities; among them search food menu, signup, login, todays hot food menu slider and today's all food menus are most common. Using user information such as user name and password, user could go into user dashboard page. There are two steps in signup activity; the first step is for basic information of user and the last step will ask user's additional information which will help to calculate user's dieting information and suggesting food menu by some adaptive mechanism such as machine learning methods. The functionality of user's password recovery also exists there. There exists two navigation shortcuts link such as search more menu and time schedule of cafeteria and branches. This page also contains a list of today's food menu supported by pagination functionality that are divided into three subcategory; full menu, half menu and snacks. In full menu, there are three types of menu courses such as first course (pasta or rice and sauce), second course (fish or meat and vegetable soup) and desert. Since the proposed system would support as dynamic content management so we should not concentrate about number of foods and food menus. In the figure 4.4, demonstrate a medium fidelity prototype of index page of Smart cafeteria system.

[1] HTML 5
[2] Cascading Style Sheets (CSS3)
[3] Twitter Bootstrap
[4] Eclipse IDE
[5] Apache Tomcat server v7.0

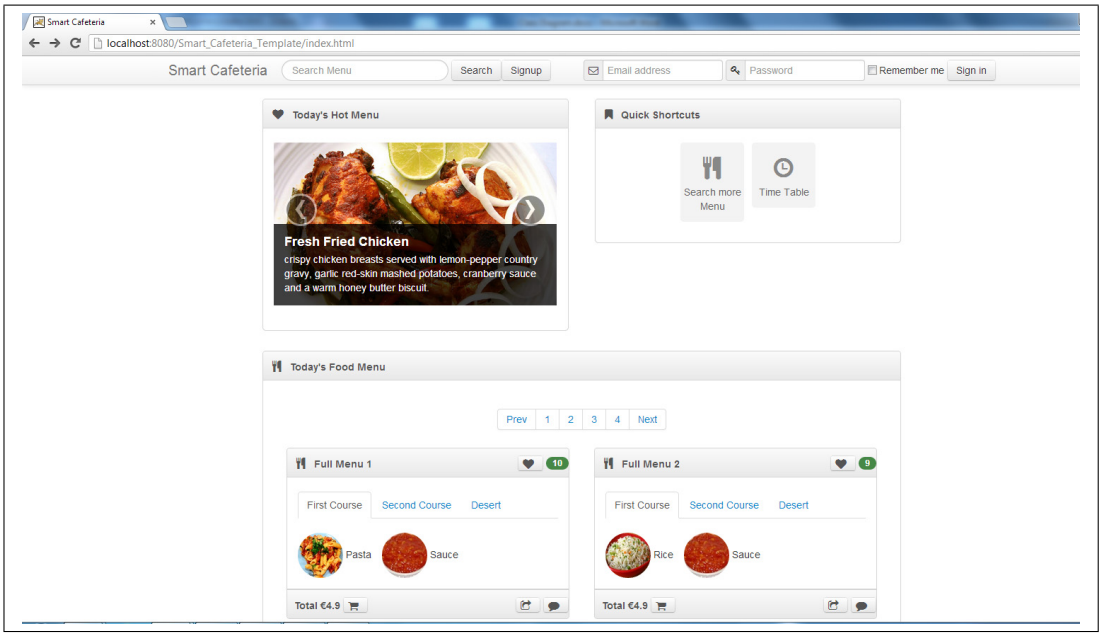

Figure 4.4: Index of Smart Cafeteria

4.3.1.2 Dashboard

This is the most important page in the system where credentials are required to get access. In this page, there are two sides; upper side of the page [Figure 4.5] consist navigation shortcuts and a short report of food consumption by user and lower side of the page [Figure 4.6] consists suggested food menu by the system using adaptive mechanism (Machine learning approach). The navigation shortcuts [Figure 4.5] consists different functionalities such as search menu, search friends, see follower, friend's activities, show dieting reports, create custom menu, show time table and branches.

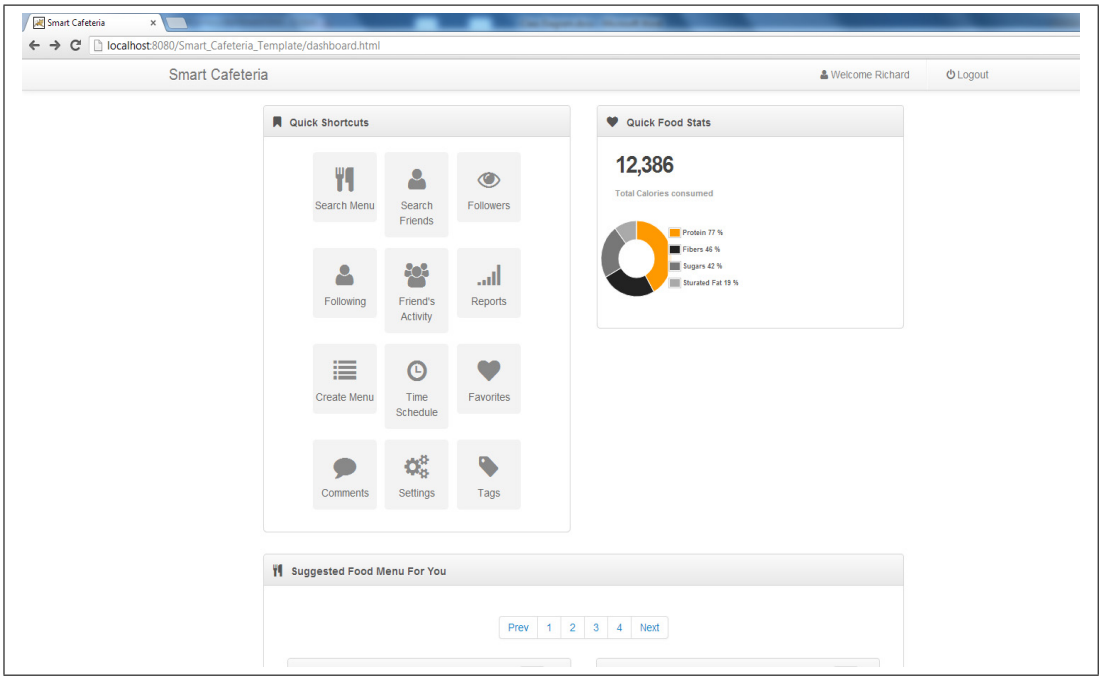

Figure 4.5: Dashboard of Smart Cafeteria [Navigation]

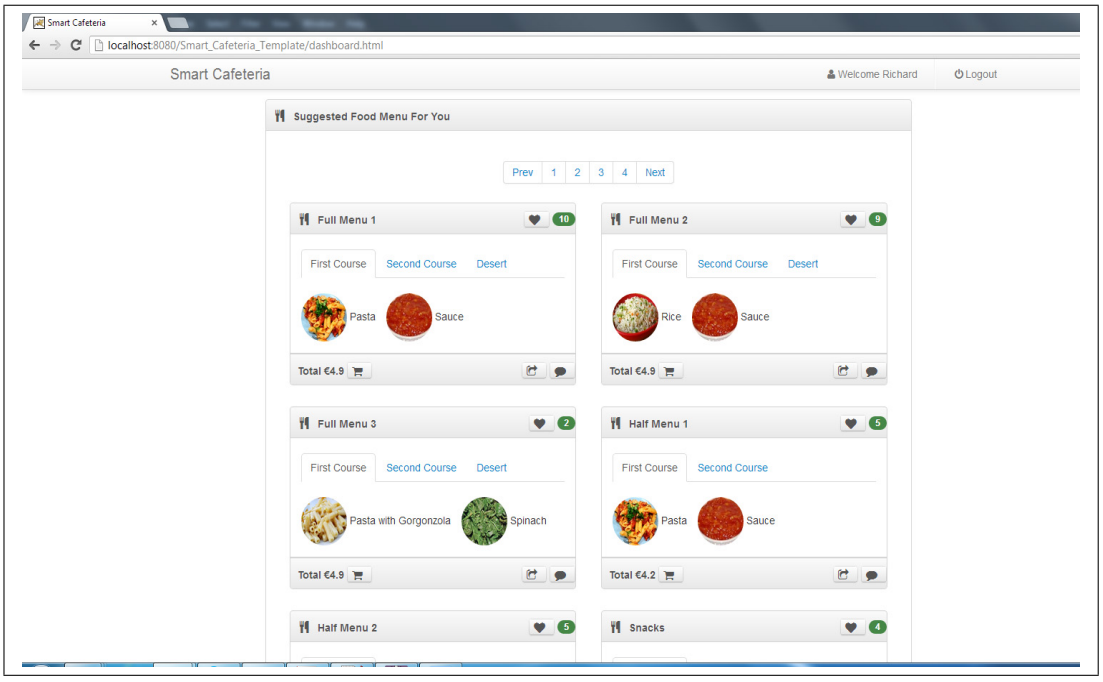

Figure 4.6: Dashboard of Smart Cafeteria [Today's & Suggested food menu]

4.3.2 Mobile Prototype

The prototype of smart cafeteria for mobile plateform was designed with HTML5, CSS3 and Twitter Bootstrap jQuery plugins. To design and demonstrate the template, I have used phonegap[6] tools for implemention as it supports most of mobile OS such as android, iOS. I have described some functionalities in the previous section 4.3.1 and the rest of the functionalities of smart cafeteria I will be demonstrated in this section.

4.3.2.1 Index

The index page contains search food menu, signup, login, today's hot food menu slider and today's all food menus offered by cafeteria. In the figure 4.7, left shows installed smart cafeteria apps and the right shows index page of smart cafeteria.

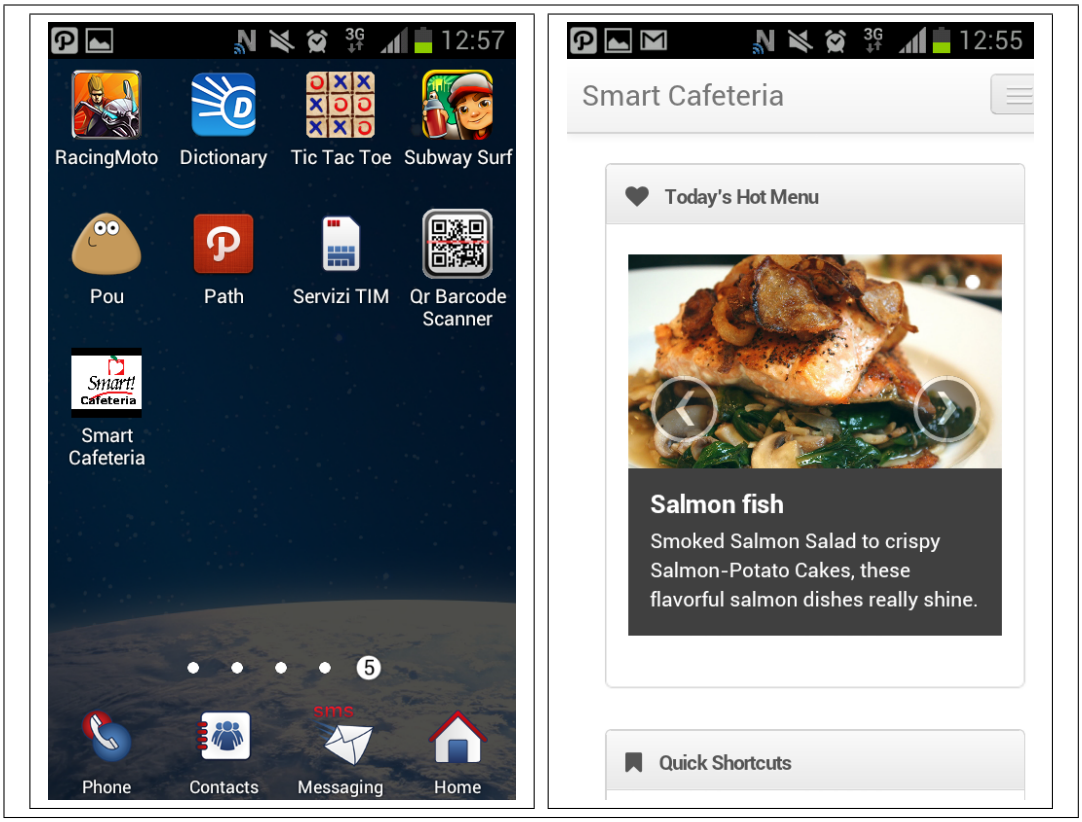

Figure 4.7: Installed Smart Cafeteria Apps(Left). Index page of Smart Cafeteria (Right).

[6]Phonegap

4.3.2.2 User Registration

The registration has two steps; step one needs the basic information of users such as User Name, Email, password which is shown in left of the figure 4.8 and on the right of the figure 4.8 step two which asks users' physical information which will help to calculate dieting report and suggest appropriate food menu is shown.

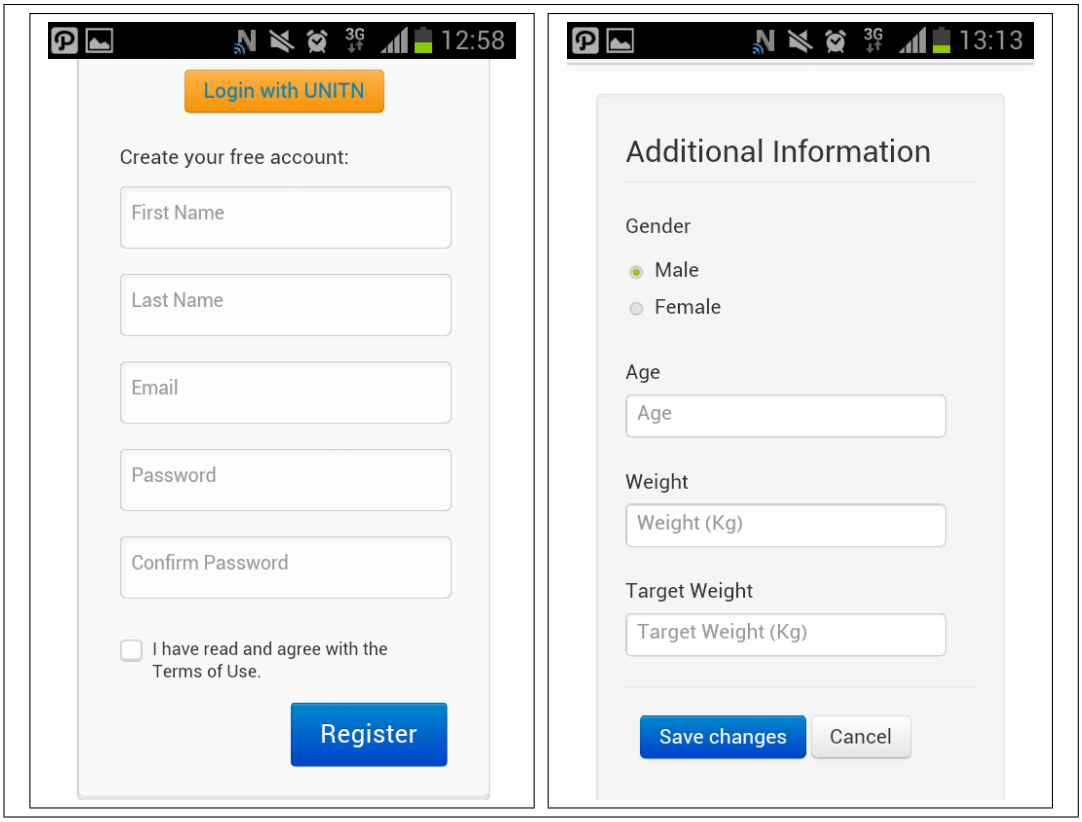

Figure 4.8: User Registration step one of smart cafeteria (Left). User Registration step two of smart cafeteria (Right).

4.3.2.3 User Login and Password Recovery

To use full functionalities of the system such as order food menu, follow friends, share lunch item with friends; it is very important to login into the system. Since sometimes it is essential to recover password in any system, password recovery also an important function in the smart cafeteria. In the left of the figure 4.9 shows user Login of smart cafeteria and in the right of the figure 4.9 shows user Password Recovery of smart cafeteria.

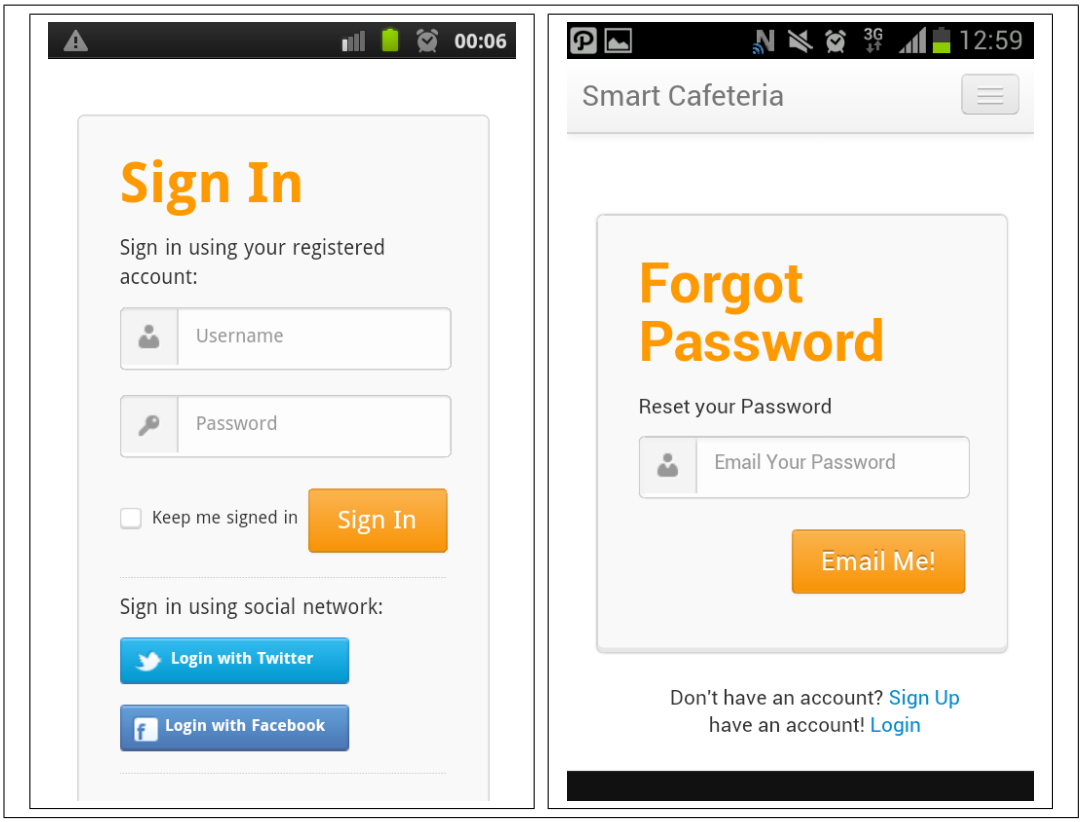

Figure 4.9: User Login of smart cafeteria (Left). User Password Recovery of smart cafeteria (Right).

4.3.2.4 Generate dieting report

Since the system will store the basic information of users as well as their physical information; using these information through some machine learning approach, system will generate dieting report, menu suggestion as an adaptive system. In the left of the figure 4.10 shows users dieting report of smart cafeteria and in the right of the figure 4.10 shows Nutrition Suggestion for user of smart cafeteria.

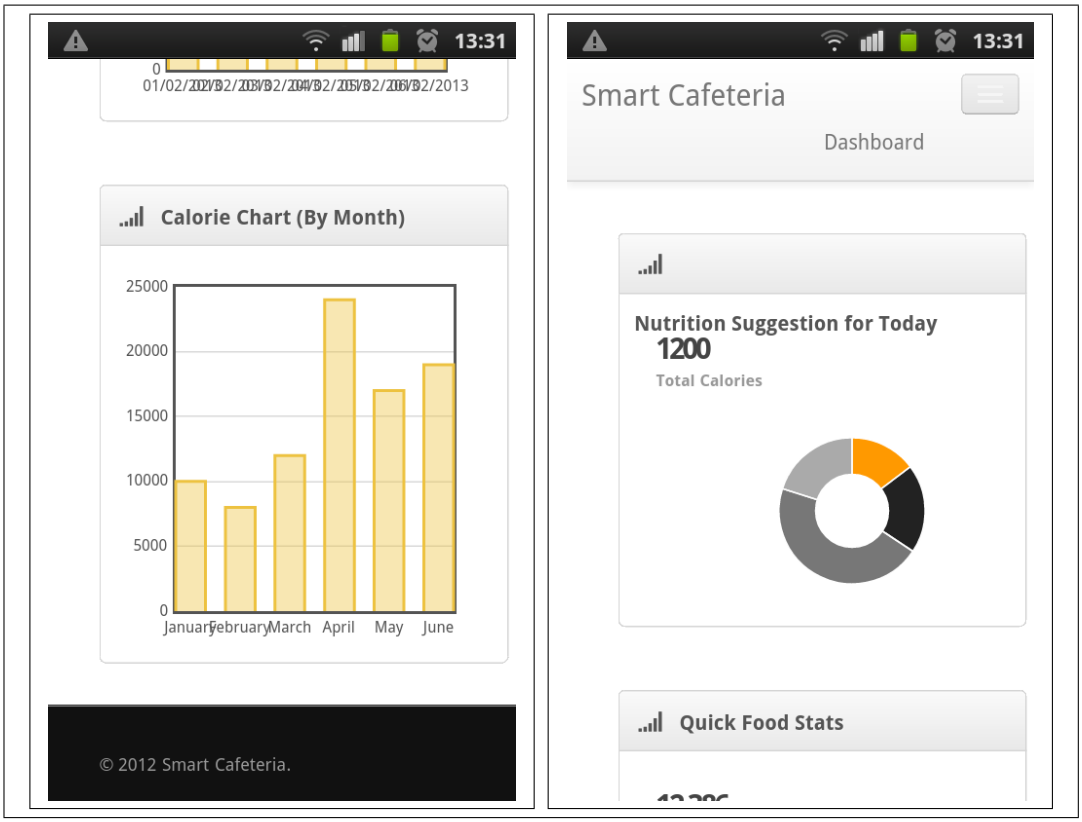

Figure 4.10: Dieting Report for User of smart cafeteria (Left). Nutrition Suggestion of smart cafeteria (Right).

4.3.2.5 Collaborative and Sharing Activities

Since Smart cafeteria support collaborative activities, the design template consists those functionalities: search friends, follow friends and sharing their activities which will make the system more interactive and usable in user prospective. In the left of the figure 4.11 shows following friends functionality of smart cafeteria and in the right of the figure 4.11 shows friends activity of smart cafeteria.

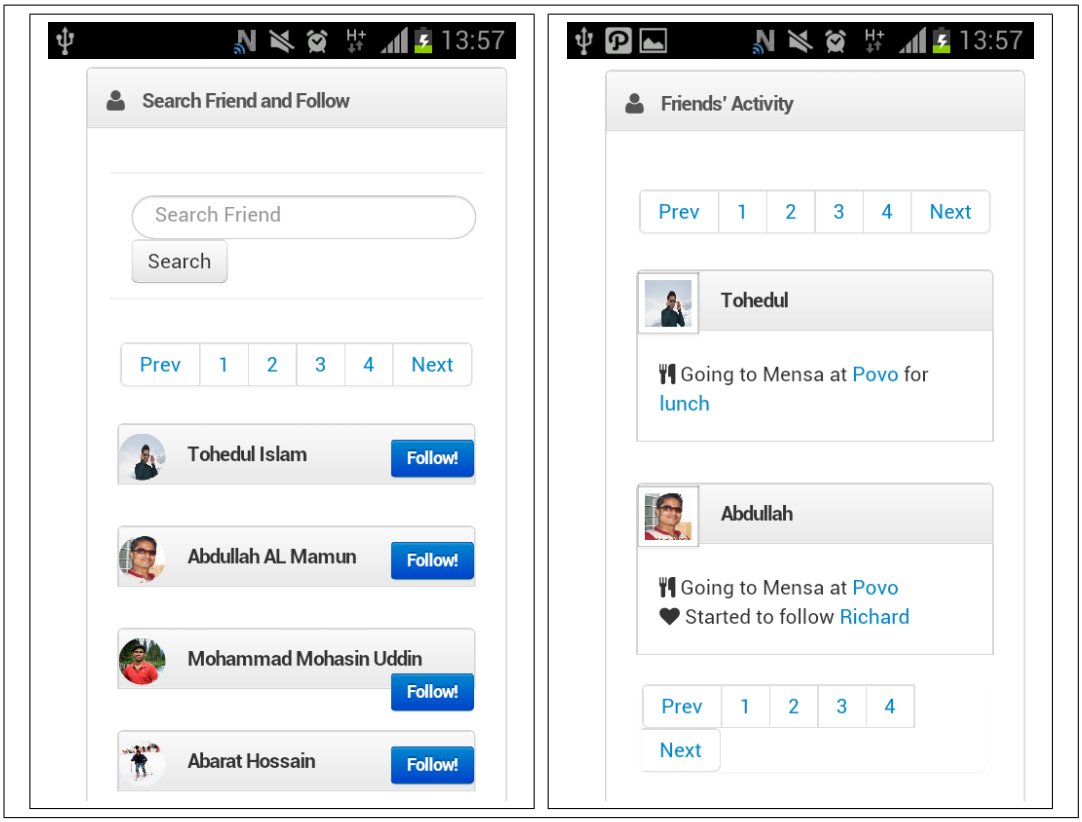

Figure 4.11: : Following Friends for User of smart cafeteria (Left). Friends activity of smart cafeteria (Right).

4.4 Key Features of Smart Cafeteria

There are three key feature in proposed smart cafeteria system which will support this system's analysis as a research work. The features are listed and describing bellow:

4.4.1 Online Cafeteria services

The application will provide online cafeteria services where user could search food menu, order online food menu, pay online that will support university's cafeteria queue skipper; namely users could browse and choose their food menu before entering cafeteria. Thus user could easily skip long queue that seems to be very annoying task in every day lunch time at university. At the same time, through this application, user could get knowledge about every day food menu in different branch and acknowledge about time schedule of all branches of cafeteria. This is very important services now days in university

to make life easy and enjoyable.

4.4.2 Adaptive services

The application will provide online adaptability services such as daily menu suggestion based on users' previous choice and calorie consumption of the users in the last couple of weeks. The system will also provide dieting report of every user which makes the life of the people more comfortable, more enjoyable and happier. This is very important issue especially for students so these adaptive services will have a great significance in university life without any doubt.

4.4.3 Social collaboration services

The application will provide such an environment where user could interact in social collaboration such as follow friends, share food menu with friends, share activities of social eating as well as can see friend's activities. These services will help students to increase collaboration between domestic students with international students due to exchange food culture, language or psychological peer supporting.

4.4.4 Mobile Interaction

Now a days, only web 2.0 applications are not sufficient to provide services to users; a huge number of users want to get the application's services using Smart phone. People are now used to get portable services to ensure maximum level of satisfaction and enjoyable experience from application. Since Smart cafeteria will provide services to university students, so all services and functionalities of Smart Cafeteria should be supported by mobile apps and tablet apps. So the plan is to make the application services portable, enjoyable, usable using smart phone application to help students.

Chapter 5

Usability Evaluation of Smart Cafeteria

In interactive system design, usability evaluation appears to be very vital issue in the design life cycle and development process. Sometimes, usability evaluation is performed in user-centric design at the very beginning stage with low fidelity prototype such as paper based prototype; or at requirements gathering stage using focus group and survey questionnaire to get users' feedback which helps to find out more requirements to make a system stable; and the modification process continues until the final version of the product.

The usability evaluation goals of "Smart Cafeteria" is to test usefulness of the system, how easy the system to use, Satisfaction, learnability and find out more requirements to improve the design. To know and figure out best evaluation methods for "Smart Cafeteria", I have studied a couple of article, paper and book which is discussed here.

Nielsen [32] define five usability components to assesses how easy user interfaces are to use. These are Learnability, Efficiency, Memorability, Errors and Satisfaction.

Dix et al. [33] defines usability as quality attribute of a system that ensure the efficiency, effectiveness and satisfaction of specified users to achieve specified goals in particular environment. They suggested making a distinction between evaluation by the users at early design stage using focus groups, survey questionnaires and the evaluation by the designer or a usability expert at completed system or functional prototype design stage as a cheap and quick usability assessment. According to their consideration, there are four approaches for expert analysis: cognitive walkthrough, heuristic evaluation, the use of models and use of previous work.

In the cognitive walkthrough, the sequence of actions will be performed in order to accomplish some known task by the users in the system and the

principle focus of the cognitive walkthrough methodology is to establish how easy a system is to learn.

Heuristic evaluation, developed by Jakob Nielsen and Rolf Molich, is performed in design specification stage or early design evaluation stage but could also be used on prototypes, fully functioning systems.

There are four approaches for user analysis too: empirical or experimental methods, observational methods, query techniques, and methods that use physiological monitoring.

Query techniques are a kind of evaluation techniques that is asking the user about the interface directly and these could be useful in drawing out detail about the user's view of a system and collect information about user requirements and tasks. The main query techniques approaches are interview and questionnaires.

Interviewing users with an interactive system about their experience is a direct and structured way of collecting feedbacks and gathering information or requirements.

Questionnaire is an alternative method of querying the user with different question styles such as general opens ended, scalar, multiple choice and ranked questions.

M. Ivory [34] has shown in his thesis work that the activities that may occur during the usability evaluation process.

1. Specify usability evaluation goals.
2. Determine UI aspects to evaluate.
3. Identify target users.
4. Select usability metrics.
5. Select evaluation method(s).
6. Select tasks.
7. Design experiments.
8. Capture usability data.
9. Analyze and interpret usability data.
10. Critique UI to suggest improvements.
11. Iterate the process if necessary.
12. Present results.

5.1 Evaluation Methodology

From above definition and discussion of usability evaluation techniques, this work has followed **user studies methodology and questionnaire** techniques for evaluation. In the beginning of evaluation, the goal of evaluations are defined; **(i) to test usefulness of the system, (ii) how easy the system is to use, (iii) learnability and (iv) Satisfaction** to improve the design.

Then I have identified the **target users (students of University of Trento)** for evaluation who are used to have lunch in cafeteria in the working days. I have chosen ten (10) students; all of them takes lunch at cafeteria more than three times in a week. In each session, I have discussed with them the main goals and key features [section 4.4] of the "Smart Cafeteria" and given them some specific tasks to perform. The users had no previous experience about the system and UI. The tasks were as follows:

- **T1:** Perform Login.
- **T2:** Search Food Menu.
- **T3:** Create A Food Menu.
- **T4:** Search Friends.
- **T5:** Check Your Diet Report.
- **T6:** Check Followers.
- **T7:** Check Time Schedule.
- **T8:** Check who are Following you.
- **T9:** Check friend's activities.

I have given to users simple tasks to perform, as I had mid-fidelity prototype for both desktop and mobile application with the most important navigation control and basic functionalities at that time. The reason for giving tasks was because I wanted the users to browse the whole system at once and those tasks would cover the present version of prototype. The task analysis and user observation has done only for desktop prototype[subsection 5.2.1].

After performing the tasks, I have presented some questionnaire to the users and requested them to answer which covered the goal of usability evaluation of this work. The questionnaire was built based upon the Likert scale

and the users were allowed to indicate their agreement or disagreement with a 7 point scale.

The usability evaluation has done for both desktop prototype[subsection 5.2.2] and mobile prototype[subsection 5.2.3] followed by the same questionnaire.

5.2 Evaluation Result

5.2.1 User Observation

In the user observation phase, most of users were able to perform the task correctly. There was one iteration conducted for testing the performance of the users on using the user interfaces of Smart Cafeteria initially; but in future there will be more iteration to conduct for making the system more usable. In this phase, no bench mark time would be fixed, only observe users how many attempts they need to perform the task. The scale of observation was from one attempt to three attempts which indicate best case to worst case. There was also a case unsuccessful which was meant user didn't find the option.

The outcome of the study of the user observation test for the tasks is presented in details here.

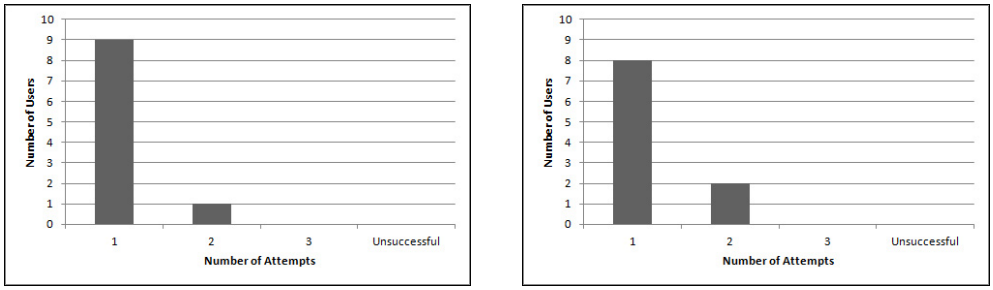

Figure 5.1: Perform Login(Left).Search Food Menu(Right).

It is found that nine (9) users [figure 5.1] were able to perform login in first attempt and only one (1) user needed two attempts. And Eight (8) users were able to Search Food Menu in the first attempt without any error and two (2) users took two attempts. In those tasks 100% users are successful.

From the figure 5.2 we can see that 40% of the users were unsuccessfully in create food menu tasks and 30% users were unable to search their friends.

In the figure 5.3 shows that 60% of the users were able to perform these two tasks successfully in the first attempt and 100% was successful.

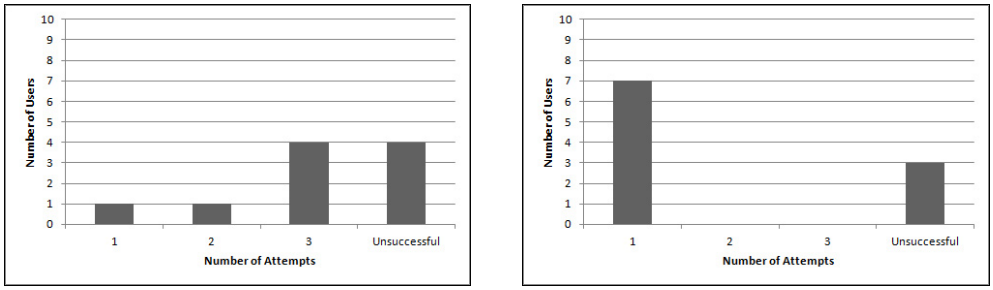

Figure 5.2: Create Food Menu(Left). Search friend(Right).

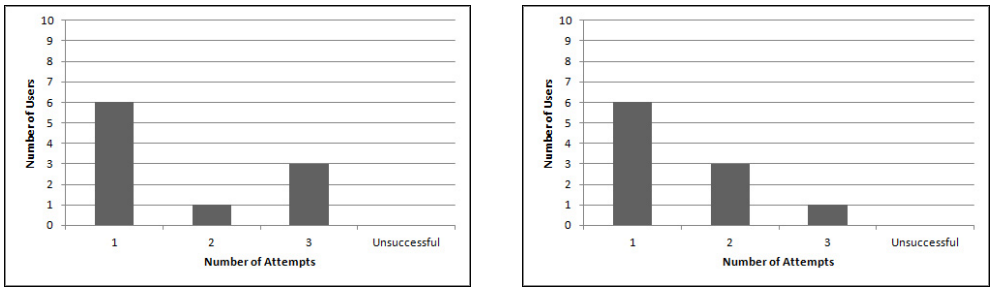

Figure 5.3: Check your Diet Report(Left). Check followers(Right).

In case of checking time schedule [figure 5.4] and "who are following you" [figure 5.4], 80% and 70% users were able to perform the tasks successfully with only one attempt respectively.

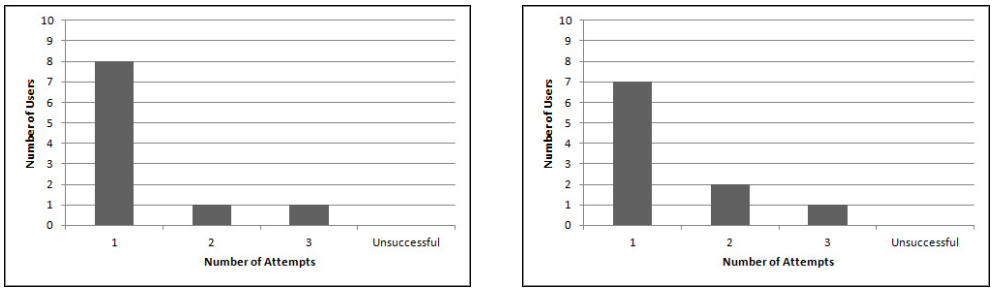

Figure 5.4: Check Time Schedule(Left). Check who are Following you (Right).

From the figure [5.5] we can see that 90% of the users successfully done the task to check friend's activities successfully in the first attempt.

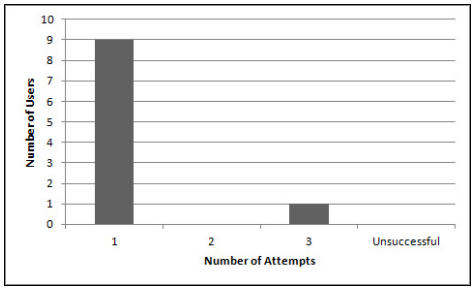

Figure 5.5: Check friend's activities

In the figure [5.6], we can see the comparison of the tasks performance of the users where create food menu and search friends only had 40% and 30% unsuccessful rate, otherwise the other task had satisfactory performance rate.

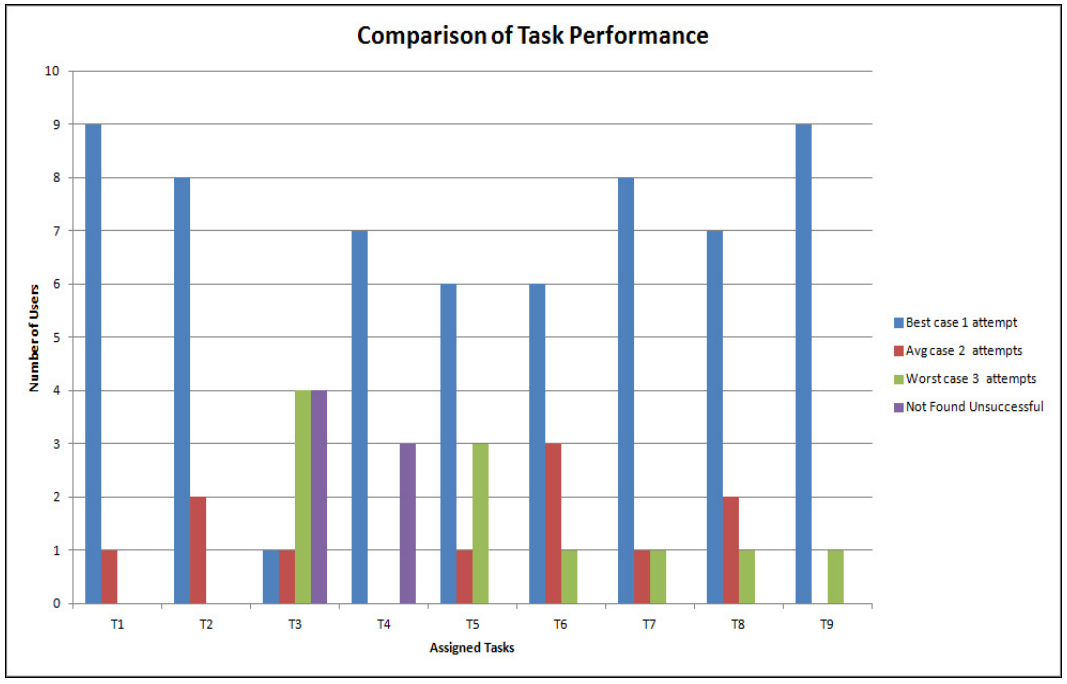

Figure 5.6: Comparison of Tasks Performance.

5.2.2 Desktop Prototype Evaluation

The study of the collected responses from the users through the questionnaire has been presented in the tables bellow. In the appendix[B], questionnaire to measure usability created in accordance with the USE questionnaire are provided [35]. There was two part of questionnaire; firstly the general information about the users and last part was for usability testing. The scale of the questionnaire was based upon the Likert scale agreement or disagreement within 7 point scale. The scale is as follows:

Likert Scale	Point
Strongly disagree	1
Disagree	2
More disagree than agree	3
Neutral	4
More agree than disagree	5
Agree	6
Strongly agree	7

Table 5.1: Likert scale for Evaluation.

Ten users participated in the evaluation session. They have answered 14 usability questions which were labeled as Q1, Q2,... and so on. Finally the result was analyzed calculating Mean(μ) and Standard deviation(σ).

Standard Deviation, $\sigma = \sqrt{\frac{1}{N}\sum_i^N (x_i - \mu^2)}$ where Mean, $\mu = \frac{1}{N}\sum_i^N x_i$.

The reason of using Standard Deviation is to measure how spread feedback score from Mean. Mean measures usability acceptance value; namely it belongs to below neutral(scale 4)[not accepted] or upper regions from neutral(scale 4)[accepted][figure 5.7].

5.2.2.1 Usefulness

In the first section of the questionnaire it was requested to the users for providing their valuable feedback about the usefulness of smart cafeteria to improve the system design.

From users' feedback result sheet [Appendix B.2], Usefulness of desktop prototype has been calculated [Table 5.2]. The result sheet has shown that "Smart Cafeteria" system makes life easy at university and most of the users agreed with usefulness of the new system. A significant number of users agreed that by using this system they could find out their lunch menu easily. Half of the user agreed that the system could make life comfortable and give more control over activities of life; specially time at university.

Questions	Mean (μ)	Standard Deviation (σ)
Q1. The smart cafeteria will help me to schedule my meal easily.	4.9	1.663329993
Q2. This system will make my life more comfortable.	4.3	1.766981104
Q3. This system will give me more control over the activities of my life.	3.8	1.686548085
Q4. This system does everything I would expect it to do.	4.3	1.636391694

Table 5.2: Usefulness[Desktop Prototype].

5.2.2.2 Ease of Use

In second section of questionnaire, the feedback about ease of use of the "Smart Cafeteria" was provided.

Questions	Mean (μ)	Standard Deviation (σ)
Q5. The system is easy to use.	4.9	1.33749351
Q6. The system requires fewest steps to accomplish what I want to do with it.	5.1	1.370320319
Q7. I can use it without any written instruction.	4.4	1.95505044
Q8. The system is user friendly.	5.4	1.429840706

Table 5.3: Ease of Use [Desktop Prototype].

Table "Ease of Use [Desktop Prototype]" [5.3] has been generated from users' feedback result sheet for evaluating desktop prototype of "Smart Cafeteria" [Appendix B.2]. The feedback result has indicated that most users feel the software is easy to use and user friendly but they have strong suggestion to include any written or visual instruction of how to use the system.

5.2.2.3 Ease of Learning

In the third section of questionnaire, users were asked to provide their opinion about the system complexity of learnability.

Table "Ease of Learning [Desktop Prototype]" [5.4] has been calculated from users' feedback result sheet to evaluate desktop prototype [Appendix

Questions	Mean (μ)	Standard Deviation (σ)
Q9. I learned to use it quickly.	4.9	1.054092553
Q10. I easily remember how to use it.	5.4	1.264911064

Table 5.4: Ease of Learning [Desktop Prototype].

B.2]. In the feedback, more than half of the users agreed that the desktop prototype is ease to learn.

5.2.2.4 Satisfaction

In the forth section of the questionnaire, users were asked to provide their feedback about level of satisfaction after using the system.

Questions	Mean (μ)	Standard Deviation (σ)
Q11. I am satisfied with it.	4.9	1.888562063
Q12. It is fun to use.	4.4	1.429840706
Q13. I feel I have to need it.	4.9	1.286683938
Q14. I would recommend this to my friend.	5.8	1.398411798

Table 5.5: Satisfaction [Desktop Prototype].

The table “Satisfaction [Desktop Prototype]" [5.5] has been deduced from users' feedback result sheet to evaluate desktop prototype [Appendix B.2]. The result sheet has shown that more than half of the users were satisfied with the system and recommended the system to their friends. Besides, to make the system more fun and enjoyable, it needs more research to find out how we could make the system more fun and attractable.

5.2.2.5 Evaluation Statistics

The figure 5.7 has shown that Q1, Q2 and Q4 feedback scores are more than neutral(scale 4) which deduces that Smart cafeteria is usefull application in univesity. The feedback scores of questions Q5, Q6, Q7 and Q8 are more than neutral(scale 4) which has proved that the desktop prototype [4.3.1] of the application is easy to use. The mean value of Q9, Q10 are more than neutral(scale 4) which ensured that the desktop prototype [4.3.1] of the application is easy to learn. The mean value of Q11, Q12, Q13 and Q14 are more than neutral(scale 4) which make sure users' satisfaction when they use the system in desktop's browser.

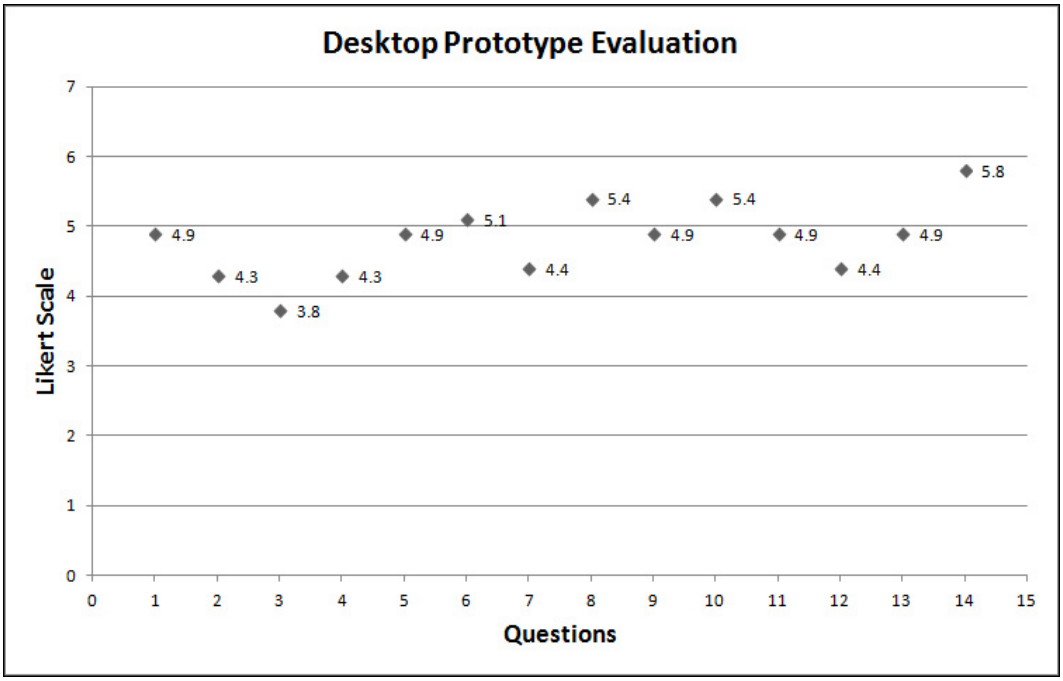

Figure 5.7: Desktop Evaluation Statistics.

5.2.3 Mobile Prototype Evaluation

Mobile prototype usability evaluation has followed similar procedure as desktop prototype evaluation [5.2.2]; same amount of users(10) have participated and same questionnaire was provided. The same techniques has been followed or analyzing the result [5.2.3.5]. In the following section I have analyzed the result of mobile prototype usability evaluation [Appendix B.3].

5.2.3.1 Usefulness

Table 5.6 has concluded that "Smart Cafeteria" will be more usefull; specially when it will be accessible through mobile. Above 70% users agreed to the usefullness of "Smart Cafeteria" mobile application [Appendix B.3].

5.2.3.2 Ease of Use

Table 5.7 has drawn a conclusion that mobile "Smart Cafeteria" is easy to use. Above 80% of users agreed with the fact that it is easy to use [Appendix B.3].

Questions	Mean (μ)	Standard Deviation (σ)
Q1. The smart cafeteria will help me to schedule my meal easily.	5.9	1.100504935
Q2. This system will make my life more comfortable.	5.5	1.178511302
Q3. This system will give me more control over the activities of my life.	4.6	1.577621275
Q4. This system does everything I would expect it to do.	5.4	0.966091783

Table 5.6: Usefulness of Smart cafeteria.

Questions	Mean (μ)	Standard Deviation (σ)
Q5. The system is easy to use.	6.1	0.737864787
Q6. The system requires fewest steps to accomplish what I want to do with it.	6	0.816496581
Q7. I can use it without any written instruction.	5.8	1.135292424
Q8. The system is user friendly.	5.6	0.966091783

Table 5.7: Ease of Use of Smart cafeteria.

5.2.3.3 Ease of Learning

Questions	Mean (μ)	Standard Deviation (σ)
Q9. I learned to use it quickly.	6	1.054092553
Q10. I easily remember how to use it.	6.1	0.567646212

Table 5.8: Ease of Learning of Smart cafeteria.

Table 5.8 has concluded that users were agreed that the mobile application is ease to learn.

5.2.3.4 Satisfaction

The table 5.9 has deduced the average satisfactory level which are more than neutral opinion of using “Smart Cafeteria” mobile application.

Questions	Mean (μ)	Standard Deviation (σ)
Q11. I am satisfied with it.	5.2	1.135292424
Q12. It is fun to use.	4.6	1.429840706
Q13. I feel I have to need it.	5.3	1.766981104
Q14. I would recommend this to my friend.	5.8	1.475729575

Table 5.9: Satisfaction of Smart cafeteria.

5.2.3.5 Evaluation Statistics

The figure 5.8 has shown that Q1, Q2, Q3 and Q4 feedback scores are more than scale 5 which deduces that “Smart Cafeteria" mobile application is usefull. The feedback scores of questions Q5, Q6, Q7 and Q8 are more than scale 5 which has proved that the mobile prototype[4.3.2] of the application is easy to use. The mean value of Q9, Q10 are more than scale 5 which ensured that the mobile prototype[4.3.2] is easy to learn. The mean value of Q11, Q12, Q13 and Q14 are more than neutral(scale 4) which make sure users' satisfaction when they use “Smart Cafeteria" in mobile.

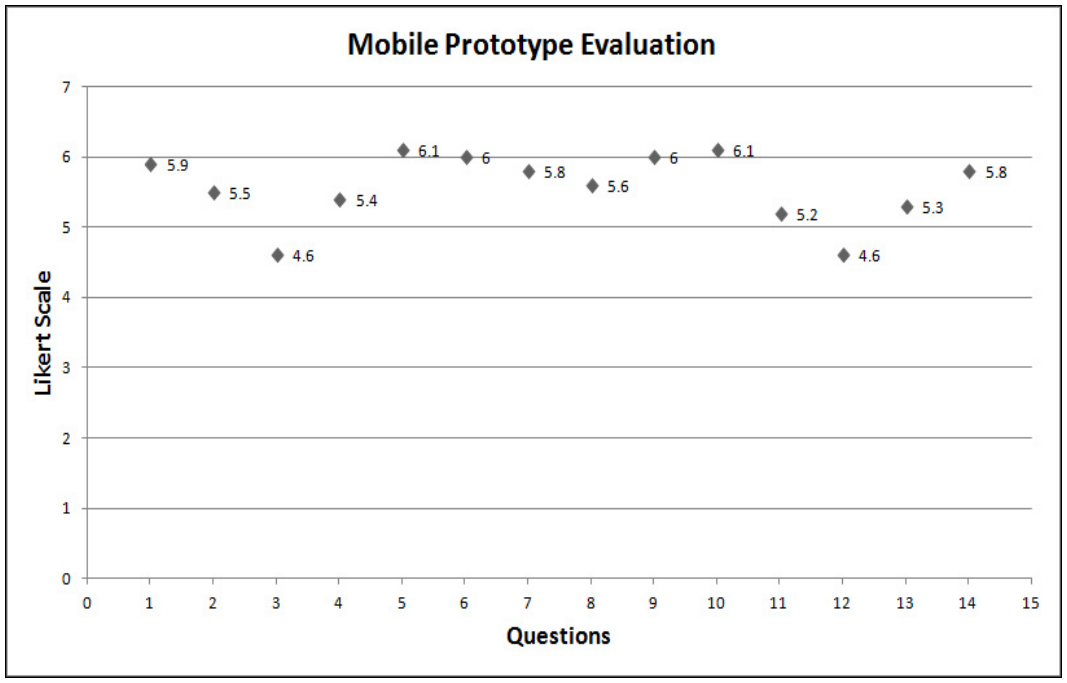

Figure 5.8: Mobile Evaluation Statistics.

5.3 Suggestions for Improvement

The last three questions were open question to users about their suggestions, comments about the system and which part they like most. Finally analysis of the qualitative data we have found the following facts.

- Users mostly liked parts in the system are they could know about the updates of food menu everyday, time schedule of cafeteria, serve menu on time means no queue time, dieting suggestion e.g. suggest food menu, dieting report e.g. calorie consumptions per month. Users also like adaptability of the system which is responsible for generating automatic menu suggestions and create customized menu functionality. Users like social collaboration activities such as food menu's pictures, url and real time odrer activity with friends.
- This part is open suggestions and comments from users. They want to see the following things:
  - Help instruction should be provided using short video.
  - Advanced customized food menu booking system and that should be clearly define with drag and drop action.
  - Provide waiting time notification after booking the lunch. Time of delivery can be included with time flexibilities (In case of emergency user can postponed the delivery time).
  - Inviting friends from other social media or let them know about this application.
  - Brief summary of monthly calorie consumption in front page.
  - Want to know which cafeteria is less crowded at lunch time.
  - Should indicate which food menus are Halal(for Muslim people).
  - Should clarify that different prices for different stakeholder; e.g. Students will pay at discount rate.
  - Should have users flexibility in cancel order or delay order option.

Since this was the first time evaluation and user study, UI navigation and control should be improved such that user will not face difficulties and could understand what's going on in the system. It should include all the new requirements of the system and conducted more survey and evaluation.

Chapter 6

Conclusion

In this thesis, it has been proposed an adaptive and interactive mobile application for Smart cafeteria which gives very essential services to students at everyday life in university. The main objectives were (I) Create "Smart Cafeteria" which will be supported by web 2.0 systems and Smartphone application. (II) The application should be adaptive and interactive. These objectives has been achieved by finding stakeholders, functional requirements; developing desktop, mobile prototype and usability evaluation using HCI interaction design methodology for "Smart Cafeteria".

In depth, there was some sub goals of "Smart Cafeteria" which overlapped with the main objectives and those were (i) Provide online cafeteria services, (ii) Provide dieting services to the students, and (iii) Provide social collaboration services into the system application. To achieve those objectives and sub goals, I have analyzed requirements, developed prototypes for desktop and mobile related to proposed services (i) Mensa Queue Skipper, (ii) Menu Finder, (iii) Menu Suggester and Dieting Adviser, (iv) Create Customized Menu and (v) Lunch with Friend.

The online cafeteria services are able to skip long queue in the cafeteria and users' are able to browse, choose and order meal in advance before entering cafeteria. In addition, users also able to know time schedule of cafeteria using this application. Dieting services provides some functionalities such as generate dieting report for users, suggesting food menu based on users choice and having calories everyday at cafeteria, generates offers and notification through email and sms which will help student keep happy and healthy life. In the social collaboration, users shares meal activities, status with friends.

In this thesis, "Smart Cafeteria" has been analyzed, proposed the application, designed both UI prototype for desktop and mobile, and finally usability evaluation has been performed by through users' study. From the users' evaluation, it is proven that it is essential providing quality services in

cafeteria for achieving the goal of a smart campus. By this proposed cafeteria application's ideas and functionalities, the goals of "Smart Cafeteria" have been achieved.

6.1 Further Work

Since this is the first time analysis and designs such an application in cafeteria domain to provide services through mobile as well as browser to the university students, it is very important to design high fidelity prototype, programming model such as ORM model, controller, view and service oriented architecture (SOA) to provide real services to users.

This moment, I have developed UML model and UI of application to demonstrate "Smart Cafeteria" and evaluated user experience following interactive design methodology. In future I will extend the work and build high fidelity prototype, develop mobile services and perform users study to evaluate the system again until maximum level of usability. I will do also more work with application's adaptation using various machines learning approaches and figure out which will be the best for "Smart Cafeteria". Finally I will develop rest of the parts as full functional application of "Smart Cafeteria" which will ensure more interactive, adaptability and usability.

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Appendix A

Data and Requirements Gathering

A.1 Studying Documents and Research

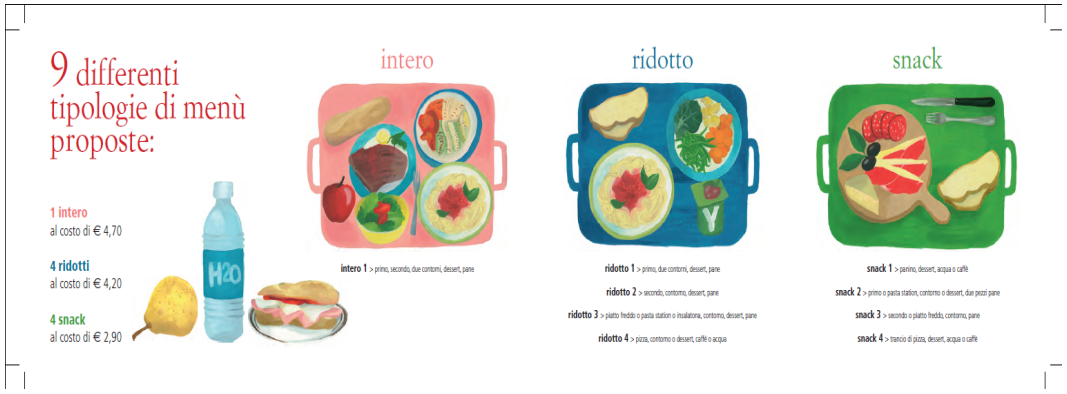


Figure A.1: different menu of Mensa in University of Trento.

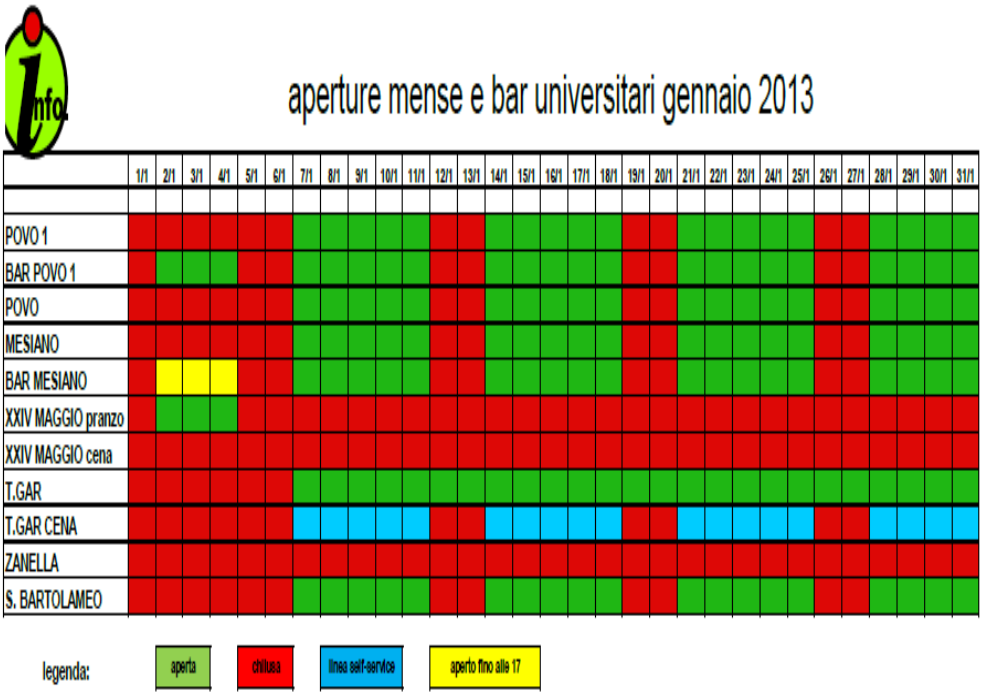


Figure A.2: Time Schedule of Mensa in University of Trento.

Menù settimanale pranzo

LUNEDI' 4 FEBBRAIO	KCAL	MARTEDI' 5 FEBBRAIO	KCAL	MERCOLEDI' 6 FEBBRAIO	KCAL	GIOVEDI' 7 FEBBRAIO	KCAL	VENERDI' 8 FEBBRAIO	KCAL	SABATO 9 FEBBRAIO	KCAL	DOMENICA 10 FEBBRAIO	KCAL
Zuppa di verdura	186	Crema di Porri	168	Zuppa farro e fagioli	485	Stracciatella	185	Vellutata di peperoni	260	Gnocchi pomodoro e ricotta	670	Zuppa alla contatina (misto verdure con orzo)	466
Pasta al gorgonzola	527	Pasta ricotta e zucchine	424	Risotto allo zafferano	478	Pasta all'ortolana	470	Lasagna al pesto e patate	738	Vellutata ai peperoni		Pasta aglio olio e peperoncino	382
Pasta all'arrabbiata (pomodoro, aglio, cipolla peperoncino e prezzemolo)	468	Pasta cacio e pepe	582	Pasta agli aromi	434	Pasta bella napoli	570	Pasta alle vongole	555				
Arrosto di maiale	370	Scaloppina alla boscaiola	134	Salsiccia al forno con aromi	263	Pollo alla diavola (con paprika dolce)	298	Filetto di trota	129	Scaloppine alla valdostana (vino bianco, cipolla farina, formaggio e funghi)	255	Petto di pollo al rosmarino	249
Spezzatino di manzo	247	Bocconcini di tacchino alle spezie	152	Scaloppine aromatizzate	125	Porchetta ai ferri	337	Arrotolato di Tacchino ripieno	292	Piadina all'emiliana	440	Cordon bleu	435
Polenta	298	Patate fritte/al forno	246	Finocchi gratinati	202	Patate gratinate/fritte	292	Patate con erba cipollina	250	Finocchi gratinati	202	Patate fritte	586
Carote al prezzemolo	140	Tegoline all'olio	142	Patate prezzemolate	219	Tegoline al pomodoro	97	Carote prezzemolate	140	Crocchette di patate	350	Broccoletti saltati	160
Spinaci al vapore	65	Cavolfiori al prezzemolo	120	Verza Stufata	85	Carote all'olio	135	Fagioli cannellini al sugo	97				

ALTERNATIVE AL MENU' GIORNALIERO

PRIMI PIATTI	KCAL	SECONDI PIATTI	KCAL	PIATTI FREDDI	KCAL	CONTORNI	KCAL	Menù Cucina Tirolese
Pasta/Riso burro - pomodoro	582/532	Bistecca di tacchino (1)	104	Tagliere misto di salumi e formaggi		Insalata mista di stagione	114	Menù Cucina del Benessere
Pasta al ragù	624	Bistecca di manzo (1)	190	Prosciutto crudo di Parma	202	Verdure grigliate (1)	48	Menù Cucina Emiliana
Riso all'inglese	532	Pesce ai ferri (2)	109	Speck dell'Alto Adige	255			

Le preparazioni gastronomiche potrebbero contenere tracce di: cereali contenenti glutine, crostacei, uova, pesci, arachidi, soia, latte e lattosio, frutta con guscio, semi di sesamo, sedano, senape e solfiti.
The gastronomical products may contain traces of: gluten cereals, crustaceans, shellfish, egg, fish, peanuts, soy, milk and lactose, sesame seeds, celery, mustard and sulphites.

Si precisa che il calcolo delle KCAL si basa su 100 gr di prodotto

(1) Questa pietanza non è disponibile nelle mense: T. Gar e via Zanella
(2) Questa pietanza non è disponibile nelle mense: T. Gar, via Zanella e Povo 0

RISTORAZIONE SMA

Figure A.3: Weekly lunch menu of Mensa in University of Trento.

A.2 Focus Group and Workshop

Smart Cafeteria Focus Group Summary / Minutes
December 15, 2012

Attendees

- Total Participants: 7(Seven), Students are from University of Trento.
- Documents

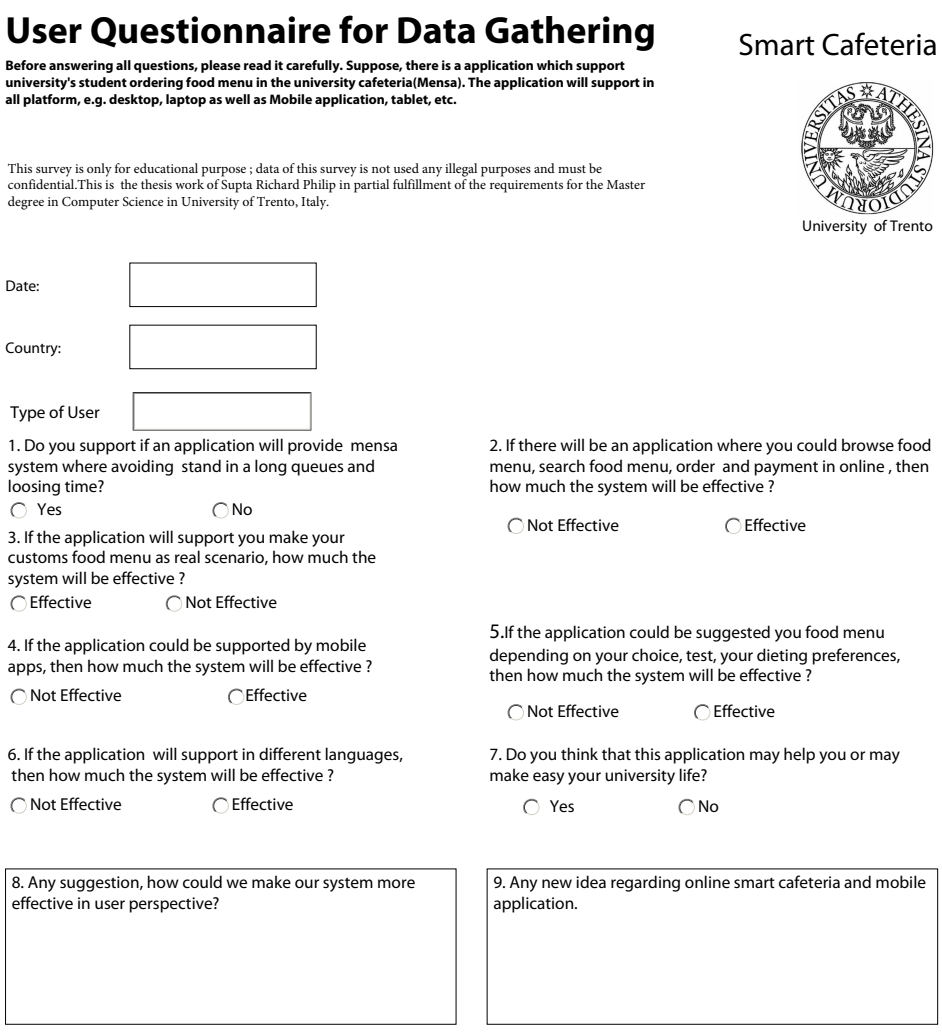
This document is a Focus Group meeting minutes about discussion of Smart Cafeteria application which is the thesis work of Supta Richard Philip in partial fulfillment of the requirements for the Master degree in Computer Science in University of Trento, Italy.

Agenda Item	Discussion	Action / Decision / Proposal
1. Smart Cafeteria Functional Requirements	We discussed all functional requirements that I have found earlier.	They are agree with all functional requirements and they suggested one extra functional requirements which is mobile application should support QR BARCODE.
2. Smart Cafeteria Non Functional Requirements	We have discussed all non functional requirements from IEEE-Std 830 - 1993'.	All participants strongly supported Internationalization, Usability and Portability.
3. Smart Cafeteria in mobile and Tablet apps	Now we are in age of informational technology era, especially in mobile computing phase where all applications drive to support in mobile and tablet in smartly.	All participants strongly supported smart cafeteria mobile applications.
4. Adaptive and Intelligent mobile application	Content was discussed to be as follows: Adaptive application will observe user behavior, test, and user's psychology and conclude a result with the help of machine learning techniques and finally suggests a list of solutions. Intelligence interface could be implemented in the application if possible this stage.	All participants strongly supported smart cafeteria mobile applications which must be adapted application.

Next Meeting Scheduled: **N/A**

Figure A.4: FocusGroup

A.3 Data Gathering Questionnaire & Result



User Questionnaire for Data Gathering

Smart Cafeteria

University of Trento

Before answering all questions, please read it carefully. Suppose, there is a application which support university's student ordering food menu in the university cafeteria(Mensa). The application will support in all platform, e.g. desktop, laptop as well as Mobile application, tablet, etc.

This survey is only for educational purpose ; data of this survey is not used any illegal purposes and must be confidential.This is the thesis work of Supta Richard Philip in partial fulfillment of the requirements for the Master degree in Computer Science in University of Trento, Italy.

Date:

Country:

Type of User

1. Do you support if an application will provide mensa system where avoiding stand in a long queues and loosing time?
Yes No

2. If there will be an application where you could browse food menu, search food menu, order and payment in online , then how much the system will be effective ?
Not Effective Effective

3. If the application will support you make your customs food menu as real scenario, how much the system will be effective ?
Effective Not Effective

4. If the application could be supported by mobile apps, then how much the system will be effective ?
Not Effective Effective

5.If the application could be suggested you food menu depending on your choice, test, your dieting preferences, then how much the system will be effective ?
Not Effective Effective

6. If the application will support in different languages, then how much the system will be effective ?
Not Effective Effective

7. Do you think that this application may help you or may make easy your university life?
Yes No

8. Any suggestion, how could we make our system more effective in user perspective?

9. Any new idea regarding online smart cafeteria and mobile application.

N.P.- Please save the pdf form and Email me @ supta.philip@gmail.com

Figure A.5: Questionnaire

Appendix B

Usability Evaluation

B.1 Usability Evaluation Questionnaire

Questionnaire for Smart Cafeteria

This survey is only for educational purpose; data of this survey is not used any illegal purposes and must be confidential. This is the thesis work of Supta Richard Philip in partial fulfillment of the requirements for the Master degree in Computer Science in University of Trento, Italy.

Part I - General Questions

1. How old are you?
   - ☐ 18-23
   - ☐ 24-29
   - ☐ 30-35
   - ☐ Above 35
2. What is your gender?
   - ☐ Male
   - ☐ Female
3. Where are you from?
4. What is your profession?
5. Do you eat at cafeteria during your working days?
   - ☐ Yes
   - ☐ No
6. How frequently do you go to cafeteria for lunch?
   - ☐ Every day
   - ☐ Twice in a day
   - ☐ Twice a week
   - ☐ Frequently in a week
   - ☐ Some times in a week
7. Do you use any online meal booking system?

- ☐ Yes
- ☐ No

8. Do you want any system where you could book your meal before going cafeteria?
   - ☐ Yes
   - ☐ No

9. Why do you want such a system? Write more reasons.

Part II – Usability Testing

10. Usefulness

Please choose your opinion about the following issues.

	1 Strongly disagree	2 Disagree	3 More disagree than agree	4 Neutral	5 More agree than disagree	6 Agree	7 Strongly agree
The smart cafeteria will help me to schedule my meal easily?							
This system will make my life more comfortable?							
This system will give me more control over the activities of my life?							
This system does everything I would expect it to do?							

11. Ease of Use

Please choose your opinion about the following issues.

	1 Strongly disagree	2 Disagree	3 More disagree than agree	4 Neutral	5 More agree than disagree	6 Agree	7 Strongly agree
The system is easy to use?							
The system requires fewest steps to accomplish what I want to do with it?							
I can use it without any written instruction?							
The system is user friendly?							

12. Ease of Learning

Please choose your opinion about the following issues.

	1 Strongly disagree	2 Disagree	3 More disagree than agree	4 Neutral	5 More agree than disagree	6 Agree	7 Strongly agree
I learned to use it quickly?							
I easily remember how to use it?							

13. Satisfaction

Please choose your opinion about the following issues.

	1 Strongly disagree	2 Disagree	3 More disagree than agree	4 Neutral	5 More agree than disagree	6 Agree	7 Strongly agree
I am satisfied with it?							
It is fun to use.							
I feel I have to need it?							
I would recommend this to my friend?							

14. Which part of the system you like most?

15. Open suggestions to improve the system.

16. You’re Comments about the system.

B.2 Result of Desktop Prototype Evaluation

Usefullness

User\Questions	Q1	Q2	Q3	Q4
U1	2	2	2	2
U2	3	2	2	3
U3	4	2	2	3
U4	4	4	2	3
U5	5	4	4	4
U6	5	5	4	4
U7	6	6	5	5
U8	6	6	5	6
U9	7	6	6	6
U10	7	6	6	7
Mean	4.9	4.3	3.8	4.3
Standard Deviation	1.66333	1.766981	1.686548	1.636392

Ease of Learning

User\Questions	Q9	Q10
U1	3	3
U2	4	4
U3	5	5
U4	5	5
U5	6	6
U6	6	6
U7	6	6
U8	6	7
U9	5	7
U10	4	5
Mean	4.9	5.4
Standard Deviation	1.054093	1.264911

Ease of Use

User\Questions	Q5	Q6	Q7	Q8
U1	2	4	1	6
U2	3	2	3	3
U3	5	5	4	3
U4	5	5	2	5
U5	5	5	5	6
U6	5	6	4	7
U7	6	6	7	5
U8	6	6	6	6
U9	6	7	6	6
U10	4	5	6	7
Mean	4.9	5.1	4.4	5.4
Standard Deviation	1.337494	1.37032	1.95505	1.429841

Satisfaction

User\Questions	Q11	Q12	Q13	Q14
U1	2	2	4	4
U2	2	3	4	4
U3	3	4	4	4
U4	4	4	4	5
U5	5	4	3	6
U6	5	4	5	7
U7	6	5	6	7
U8	6	5	6	7
U9	7	7	6	7
U10	7	6	7	7
Mean	4.9	4.4	4.9	5.8
Standard Deviation	1.888562	1.429841	1.286684	1.398412

Result Analysis

Question	Mean
Q1	4.9
Q2	4.3
Q3	3.8
Q4	4.3
Q5	4.9
Q6	5.1
Q7	4.4
Q8	5.4
Q9	4.9
Q10	5.4
Q11	4.9
Q12	4.4
Q13	4.9
Q14	5.8

B.3 Result of Mobile Prototype Evaluation

Usefullness

User\Questions	Q1	Q2	Q3	Q4
U1	7	6	6	5
U2	7	7	4	5
U3	7	6	6	7
U4	5	4	3	4
U5	5	5	5	6
U6	4	3	1	4
U7	7	6	5	6
U8	5	6	6	5
U9	6	6	5	6
U10	6	6	5	6
Mean	5.9	5.5	4.6	5.4
Standard Deviation	1.100505	1.178511	1.577621	0.966092

Ease of Learning

User\Questions	Q9	Q10
U1	7	7
U2	7	7
U3	4	6
U4	5	5
U5	6	6
U6	5	6
U7	6	6
U8	7	6
U9	6	6
U10	7	6
Mean	6	6.1
Standard Deviation	1.054093	0.567646

Ease of Use

User\Questions	Q5	Q6	Q7	Q8
U1	6	6	7	6
U2	7	7	7	7
U3	6	7	4	5
U4	5	5	5	4
U5	6	6	6	6
U6	6	5	7	5
U7	6	6	4	5
U8	7	7	6	6
U9	7	5	6	7
U10	5	6	6	5
Mean	6.1	6	5.8	5.6
Standard Deviation	0.737865	0.816497	1.135292	0.966092

Satisfaction

User\Questions	Q11	Q12	Q13	Q14
U1	6	5	7	6
U2	5	6	6	7
U3	6	3	7	7
U4	4	4	5	6
U5	6	4	4	6
U6	3	2	1	2
U7	5	5	6	7
U8	5	5	5	5
U9	7	7	6	6
U10	5	5	6	6
Mean	5.2	4.6	5.3	5.8
Standard Deviation	1.135292	1.429841	1.766981	1.47573

Result Analysis

Question	Mean
Q1	5.9
Q2	5.5
Q3	4.6
Q4	5.4
Q5	6.1
Q6	6
Q7	5.8
Q8	5.6
Q9	6
Q10	6.1
Q11	5.2
Q12	4.6
Q13	5.3
Q14	5.8