UNIVERSITY OF SINDH

M.Phil. Thesis

IMPROVING CHOICE SELECTION SYSTEM: A CASE STUDY OF PUBLIC SECTOR GENERAL UNIVERSITY

THESIS SUBMITTED TOWARDS THE PARTIAL FULFILMENT OF THE REQUIREMENT OF THE UNIVERSITY OF SINDH, FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN COMPUTER SCIENCE

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Dedicated to

To my beloved mother

To my beloved father

To my beloved brother

Declaration

I hereby declare that this dissertation is the presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly with due reference to the literature and acknowledgment of collaborative research and discussions.

This work was done under the guidance of Dr. Hyder Ali Nizamani and Dr.Yasir Arfat Malkani Institute of Mathematics and Computer Science, University of Sindh, Jamshoro (Pakistan).

All the materials submitted is the result of my own research except as cited in the references. Preliminary versions of some results related to those presented in this submission have been published in the following paper:

- Tharwani R.K., Nizamani H.A., Nizamani Q.U.A., Khatri Y, Chandio F.H. and Abbasi M.S., "*Modelling Choice Selection System of a Public Sector General University in Pakistan*". In Sindh University Research Journal, 2016.

Date:

Rajesh Kumar

CERTIFICATE

This is to certify that the work present in this thesis entitled **"Analysis of a computerized choice selection system: A Case Study of Public Sector General University"** has been carried out by **Dr. Hyder Ali Nizamani** and **Dr. Yasir Arfat Malkani** under our supervision. The work is genuine, original and, in our opinion, suitable for submission to the University of Sindh for the award of degree of MPhil in Computer Science.

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Rajesh Kumar

Abstract

Choice selection in large public sector universities has always remained a critical matter when it comes to distributing the seats against the designated categories of the prospective students. In these universities, thousands of prospective students compete for a limited number of seats allocated for specific undergraduate and postgraduate courses. Many universities aim at distributing candidates of different categories and quotas across various departments. Due to various conditions for selection of candidates, appropriate seat allocation has always been an issue. We have studied the existing choice selection system of one of the public sector general universities in Pakistan and have identified its strengths and weaknesses. This research designed a model for the said choice selection system to represent both its structure and behavior. More specifically, the purpose of this research is multiple folds: i) to model the structure of the choice selection system using object modeling technique, ii) to design a suitable algorithm to generate the merit list, and iii) Prototype Design for Maximum Seat Utilization . This research used UML class diagram notations to represent the structural model (i.e., class diagram). In this way, the underlying model of the system resembles the real situations that are exploited while the algorithm generates the selection list. Also this research analyzed how the seats had been utilized during the previous years and their effects on the results.

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Abbreviations

CPDA College Proposing Deferred Acceptance

CPN composite percentage number

MUET Mehran University of Engineering and Technology

RSAU Recommended System for Admission to Universities

SPDA Student Proposing Deferred Acceptance

UML Unified Modeling Language

UoS University of Sindh

Chapter 1

Introduction

In the realm of automation, people are trying to automate every task that is either time or cost consuming. Many manual processes have been automated to save both time and cost for better utilization of resources. Universities or Institutes around the globe contains a different number of seats for students in every offered degree program. As every university or academic institute has its own policies and criteria for students to consume seats of the degree program. For each offered degree program there are certain pre-requisites for previous academic background of student. Requisites are the eligibility criteria for taking admission in particular degree program. The requisites of every degree program may differ from university to university. Seat distribution of each degree program may also differ from university to university. It is a time and cost consuming task to manually filter the student applications and verify the fulfillment of criteria for admission. Therefore, the process student selection (filter the student applications and verify the fulfillment of criteria) needs to be automatic to reduce the chance of human error and save cost and time related to the process.

Automatic assigning the seats to student became a challenging task for the public sector universities. The reason is that thousands of students apply annually for seeking admission in degree program. It is very difficult to manually check the application and academic background each student application and the preferences for admission. With the passage of time, number of applying students in general public universities is increasing each year. The task of student selection process becoming more difficult and time consuming. Keeping in mind this problem, we conducted a deep study on selection problem on academic domain to propose an appropriate solution to the selection problem.

This chapter gives an introduction about our study on student selection problem. This research discusses the process of admission and seat allocation in general public sector university of Pakistan. In addition, the problem statement of selection process in admission is discussed. Furthermore, the motivation behind our research work along with the research objectives are also described.

1.1 Seat Allocation in Admission Process of University

Hundreds of educational fields / areas are open in the world. The education is divided into many fields of study and these fields are under exploration (e.g. Arts, Science, Medical, etc). Each field of study is divided into sub-fields (e.g. Fine Arts, Software engineering, Chemistry, Physics, etc). In terms of academic institution, a sub-field are also called '*Discipline*'. Many students have more than one area of interest from which one has to be their career field. Often, there must a top priority area of interest, a student want to choose for his or her career. But in many cases, students want to choose the field that is high in demand. Choosing the field having vast scope is the top priority by many students. However, competition in every demanded degree program is increasing and due to this situation less competent student has to take another field for their career. This is the reason that most of universities allows students to apply for more than one degree programs. There are limited number of seats in each offered degree programs in every field. Every university or academic institute declare fixed number of seats approved either by higher education commission of the state or educational policy maker of the state.

The process of taking admission include the filling of application form for admission. Students are instructed to prioritize area of interest while applying for admission in university. However depending on admission policy, student can list fixed number of programs (as choices) when applying for admission. On the basis of ordinal list of areas, universities prepare merit list of each offered degree program of every academic field. Every public sector university in Pakistan receives thousands of applications for admission and university has to prepare merit list of students on limited seats among thousands of applications. This problem of selecting the applications and preparing the merit list is referred as “Seat Allocation Problem”. From another perspective, offering degree program to the student from his/her list of selected choices is referred as “Choice Selection Problem”.

Choice selection in large public sector universities has always remained a critical problem, especially, when it comes to distributing the seats against the designated categories of the prospective students. In these universities, thousands of prospective students compete for a limited number of seats allocated for specific undergraduate and postgraduate courses. Many universities aim at distributing candidates of different categories and quotas across various departments. Due to various constraints on the selection of candidates, seat allocation in an appropriate way has always been an issue. University admission is a process through which candidates enter into tertiary education at universities. Each university has its own polices and eligibility criteria (i.e., academic background, country, religion, disabled quota, etc.) to select the candidates. Each university has a fixed quota for selecting candidates in different courses. Recently, such efforts include Brazil’s racial and income-based seat allocation algorithm [1] attempt to increase religious diversity in British schools [2]. In [3], seats are distributed according to racial population, and income. In [4] 50% seats are allocated on neighborhood school priority and 50% seats on choice priority. In [1], seats are distributed according to school’s criteria and religious status. Many universities aim at distributing seats in different categories and quotas for various courses.

Many proposed research work including [3, 1, 5, 6, 4] discuss their own specific criteria for distribution of the seats which do not fit in our setting as selections are done under different factors. There is a need to design algorithm for our special purpose to tackle the choice selection problem. In these studies admission algorithms have been designed for special purpose and thus lack the feature of general seat allocation criteria (i.e., district, cut of list, realm of the university, various quota oriented, waiting list process). The proposed choice selection system will provide a suitable solution which may enable better seats' utilization for public sector universities in Pakistan.

In this study, this research select a public sector general university (i.e, University of Sindh, Jasmhoro, Pakistan) as a case study. It is one of the largest universities of Pakistan. This university offers 140 courses in various shifts (i.e., Morning, Evening, and Noon). Each course has its own admission eligibility criteria for accepting candidates. The number of seats is distributed in each course according to general merit, district-wise quota, self-finance quota, female quota, and special quota (e.g., sports, disable, nomination). There are similar constraints in other countries as well. For instance, Boston city schools distribute seats according to district quota [3]. In United Kingdom, city colleges are required to admit a group of candidates from the ability range [5]. The approaches in literature are based on mathematical formulation but none of them adopted an object oriented model.

This research developed the structural model and algorithm to address the choice selection for the public sector general universities. Also, two factors are discussed which include: i) maximum seat utilization, and ii) how to improve the choice selection system. To the best of our knowledge, the choice selection problem was first studied by Gale and Shapley [7] in their seminal paper in which they proposed a new well-known deferred-acceptance algorithm. Although the existing literature max important contributions from a mechanism design perspective, as in [3, 1, 8], none of these studies are able to fulfill the requirements of the public sector general universities of Pakistan. I have studied the existing choice selection system of one of the public sector general universities in Pakistan and have identified its strengths and weaknesses. I have designed a model for the said choice selection system to represent both its structure and behavior. More specifically, the purpose of this research is multiple folds: i) to model the structure of the choice selection system using object modeling technique, ii) to design a suitable algorithm to generate the merit list, and iii) Prototype Design for Maximum Seat Utilization. This research used UML (Fowler. M., 2004), class diagram notations to represent the structural model. In this way, the underlying model of the system resembles the real situations that are exploited while the algorithm generates the selection list (Cormen et al., 2001). Also analyzed how the seats have been utilized during the previous years and their effects on the results.

1.2 Scope of Proposed Research

The seat allocation algorithm is most important factor for admission to public sector general universities. Different universities have their different ways to distribute seats. So, many universities are wasting seats in terms of finance and seat allocation. This research intend to design seat allocation algorithm, which will result in efficient seat utilization and time-efficient solution (automatically selects the candidates). This seat allocation algorithm can also be used in health care center for the distribution of doctors in urban and rural areas, which will result in benefiting the hospitals in rural areas that suffer due to limited number of available doctors. Various universities admission algorithms are designed for special purpose seat distribution lacking the feature of general seat allocation criteria (district [urban / rural], cut of list, realm of the university, various quota oriented, waiting list process). The proposed algorithm will be general and it will be useful for any general public sector university.

1.3 Objectives of The Research

There are several research objectives related to the problem of selection. The research objectives of this study can be summarized as follows:

- Analyze the existing seat allocation algorithms with respect to efficiency and seat utilization.
- Identify the problem in choice selection process.

- Study of the existing computerized choice selection system of selected public sector general university.
- Identify the strengths and weaknesses of the selected system.
- Modify the existing algorithm to overcome the weaknesses.
- Implement the new / modified system as a prototype.
- Providing implementation guidelines.
- Presenting the results and discussions.

1.4 Significance of The Study

The importance of this study can be summarized in accordance with different factors. The proposed system will improve the choice selection system for general public sector universities in Pakistan, and it can be mapped for selection problem in other countries and different domains. The goal of utilizing maximum seats can also be achieved.

1.5 Limitation of Study

There are two limitation of this study related to case study for resolving selection problem in public sector general universities. Both limitations are discussed as follows:

1. Spatial limits: The study will be applied on public sector universities of Pakistan.
2. Humanity limits: The study is limited in it's applied implementation in University of Sindh.

1.6 Methodology

In order to achieve the objectives of this research will study some steps as follows:

1. Analyze the requirement of the admission system

2. Access to the literature and previous research that dealt with the field of study and related problems in other domains.
3. Use a set of criteria that will be used in evaluating the efficiency of seat utilization
4. Testing and evaluation of the implemented algorithm for university choice selection in the admission process.
5. Design a prototype in one of the programming languages to evaluate the seat utilization.
6. Show this site on a group of experts to evaluate and modify it according to their views.
7. Record the results and begin to analyze and statistically treated.
8. Results of the study and discussion.
9. Make recommendations and proposals in the light of the results of the study.

1.7 Thesis Structure

The thesis comprises of six chapters, rest of organized chapters are described as follows:

Chapter 2 This chapter discusses case study of University of Sindh with admission policies for seat allocation problem.

Chapter 3 This chapter discusses related work related to the problem of seat allocation in different domains. It also include few concepts necessary to understand this work.

Chapter 4 This chapter focuses on structural modeling of the problem which discuss the class diagram of the proposed system. Furthermore, it also discusses proposed algorithm, implemented to solve the choice selection problem.

In last, prototype used for generating best possible outcome of maximum vacant seat utilization is discussed.

Chapter 5 This chapter discuss the factors of maximum seat utilization and measure time and memory of choice selection algorithm. Furthermore, it also discusses the seat allocation and consumption of 2015, 2016 and 2017.

Chapter 6 This chapter discusses a brief summary of this research work and gives future research direction. It contains the conclusion drawn on analyzing the selection system and major contribution of proposing a solution for all public sector universities in Pakistan.

Chapter 2

Problem Statement

This chapter gives detailed description about a public sector university of Pakistan named University of Sindh, chosen as our case study for analyzing the problem and selection system. It also gives the problem statement of seat allocation in selection system regarding the selected case study which can be mapped to any public university in Pakistan.

2.1 Case Study

University of Sindh Jamshoro is selected as a case study for seat allocation problem. The University of Sindh Jamshoro is one of the largest university in Pakistan Public Sector Universities. The University's jurisdiction (or realm) includes two divisions of the "Sindh" province: *Hyderabad* and *Mirpukhas*. However, the University some how also covers two other divisions named *Larkana* and *Sukkur* divisions. The University has total ten campuses located at different cities across the province "Sindh" as listed in Table 2.1. Allama I. I. Kazi Campus (main campus) is at Jamshoro, Sindh. Currently, there are eight faculties comprising several academic departments that can be seen in Table 2.2. The table shows all faculties and offer number of undergraduate courses and allocated number of seats in each faculty at main campus. Here, faculty of natural sciences and social sciences contains the highest number of students and degree programs. The university offers both undergraduate and postgraduate courses.

S.No	Campus Name	Location
1	Allama I.I. Qazi Campus	Jamshoro
2	Elsa Qazi Campus	Hyderabad
3	Larkana Campus	Larkana
4	Noushehro Campus	Noushehro Feroz
5	Thatta Campus	Thatta
6	Dadu Campus	Dadu
7	Mirpurkhas Campus	Mirpukhas
8	Laar Campus	Badin
9	Thar Campus	Mithi
10	University of Sufism and Modern Sciences	Bhit Shah

Table 2.1: *Campus List of University of Sindh*

However, admission system in undergraduate courses is considered in this study.

Faculty	Inst./Dept	Undergraduate Courses	Seat Allocation
Arts	06	10	1037
Commerce and Business	02	02	377
Education	04	01	111
Islamic Studies	03	03	308
Law	01	01	183
Natural Sciences	19	25	3403
Pharmacy	04	01	111
Social Sciences	14	13	1665
Total	**51**	**69**	**6901**

Table 2.2: *Faculties and morning undergraduate courses*

Every year the University announces admissions into these courses to enroll fresh students for the new academic session (i.e., Jan to December). To this purpose, the directorate of admissions (admission department of university) at the main campus receives thousands of applications for the admissions against various categories (Gen-Merit, Female, Employee, Sports, Disabled, Self-Finance, etc.) as seen in Table 2.3. The University offers various courses in two shifts (Morning and Evening). For the morning courses, there were 12708 and 15175 candidates who applied for the academic sessions 2015 and 2016, respectively. The total number of seats for the morning courses are 6901 (see Table 2.2) excluding international and other nomination seats.

University of Sindh contains many departments and institutes of different disciplines. Each applicant is allowed to mark choices from one to fifteen disciplines.

DISCIPLINE	Quota/General Merit (Jurisdiction)	Upper Sindh (Out of Jurisdiction)	Female Quota (Jurisdiction)	Female Quota (Out of Jurisdiction)	Disabled Quota	Sports Quota	Commerce Quota	Sindh University Employees Quota	Affiliated College Quota	Total Merit Seats	Sindh Province (Self Finance)	Other Province (Self Finance)	Total Self-Finance Seats	Total Merit Seats
FACULTY OF NATURAL SCIENCES														
Anthropology & Archeology (BS)	50	10	10	1	1	1	0	10	2	**85**	21	5	**26**	**111**
Biochemistry (BS)	60	10	10	1	1	1	0	10	2	**95**	24	5	**29**	**124**
Biotechnology (BS)	60	5	10	1	1	1	0	10	2	**90**	23	5	**28**	**118**
Botany (BS)	85	5	10	1	1	2	0	10	2	**116**	29	5	**34**	**150**
Chemistry (BS)	90	5	10	1	1	2	0	10	2	**121**	30	5	**35**	**156**
Computer Science (BS) – PE	41	20	10	2	1	1	0	10	2	**87**	22	5	**27**	**114**
Electronics (BS)	41	20	10	0	1	1	0	10	2	**85**	21	5	**26**	**111**
Environmental Science (BS)	50	10	10	1	1	1	0	10	2	**85**	21	5	**26**	**111**
Fresh Water Biology & Fisheries (BS)	50	10	10	1	1	1	0	10	2	**85**	21	5	**26**	**111**
Genetics (BS)	41	20	10	0	1	1	0	10	2	**85**	21	5	**26**	**111**
Geography (BS)	120	10	10	1	1	2	0	10	2	**156**	39	5	**44**	**201**
Geology (BS)	41	20	10	0	1	1	0	10	2	**85**	21	5	**26**	**111**
Health & Physical Education (BS)	41	20	10	0	1	1	0	10	2	**85**	21	5	**26**	**111**
Information Technology (BS)	41	20	10	2	1	1	0	10	2	**87**	22	5	**27**	**114**
Mathematics (BS)	120	5	10	1	1	2	0	10	2	**151**	38	5	**43**	**194**
Medical & Laboratory Technology (BS)	60	10	10	1	1	1	0	10	2	**95**	24	5	**29**	**124**
Microbiology (BS)	55	5	10	1	1	1	0	10	2	**85**	21	5	**26**	**111**
Nutrition & Food Technology (BS)	20	5	10	0	1	0	0	10	2	**48**	12	0	**12**	**61**
Physics (BS)	90	10	10	1	1	2	0	10	2	**126**	31	5	**36**	**162**
Physiology (BS)	60	10	10	1	1	1	0	10	2	**95**	24	5	**29**	**124**
Psychology (BS)	30	10	10	1	1	1	0	10	2	**65**	16	5	**21**	**86**
Software Engineering (BS)	41	20	10	0	1	1	0	10	2	**85**	21	5	**26**	**111**
Statistics (BS)	90	5	10	1	1	2	0	10	2	**121**	30	5	**35**	**156**
Telecommunication (BS)	41	20	10	0	1	1	0	10	2	**85**	21	5	**26**	**111**
Zoology (BS)	85	25	10	1	1	2	0	10	2	**136**	34	5	**39**	**175**

Table 2.3: *Seat Distribution of University of Sindh, Jamshoro*

According to the choice selection rules, these choices of the applicant are ordered in a way that the applicant will be offered one or more courses in higher preference. For instance, a candidate might be offered one course from the first choice on self-finance and the other from the third choice on merit. Many scenarios are described in next section 2.2. In this way, the choice selection system is relatively complex.

Figure 2.1 illustrates the high-level activities of the directorate to deal with the admissions for the new academic session. The potential candidates submit their respective applications at the concerned section in the directorate within the due date. The officials receiving the applications check the eligibility of the choices marked. After few days from the closing date, all applications are thoroughly checked before placing them for the admission process. The officials generate the initial merit lists of admissions. These lists are published to receive any objections by the competitor candidates. After resolving the valid objections on the list, the final list (first merit list) is published to receive confirmation within specific time period. If there are any candidates who do not confirm their choices in this list, their left-over seats will be assigned to the next candidates who are waiting for their selection. As a result, another list (second merit list) is published. Similarly, the final updated (third merit list) list is published to mark the end of the admission process for a particular academic session. Such updated merit lists are dispatched to the concerned academic departments so as to start with the new semester for the fresh students.

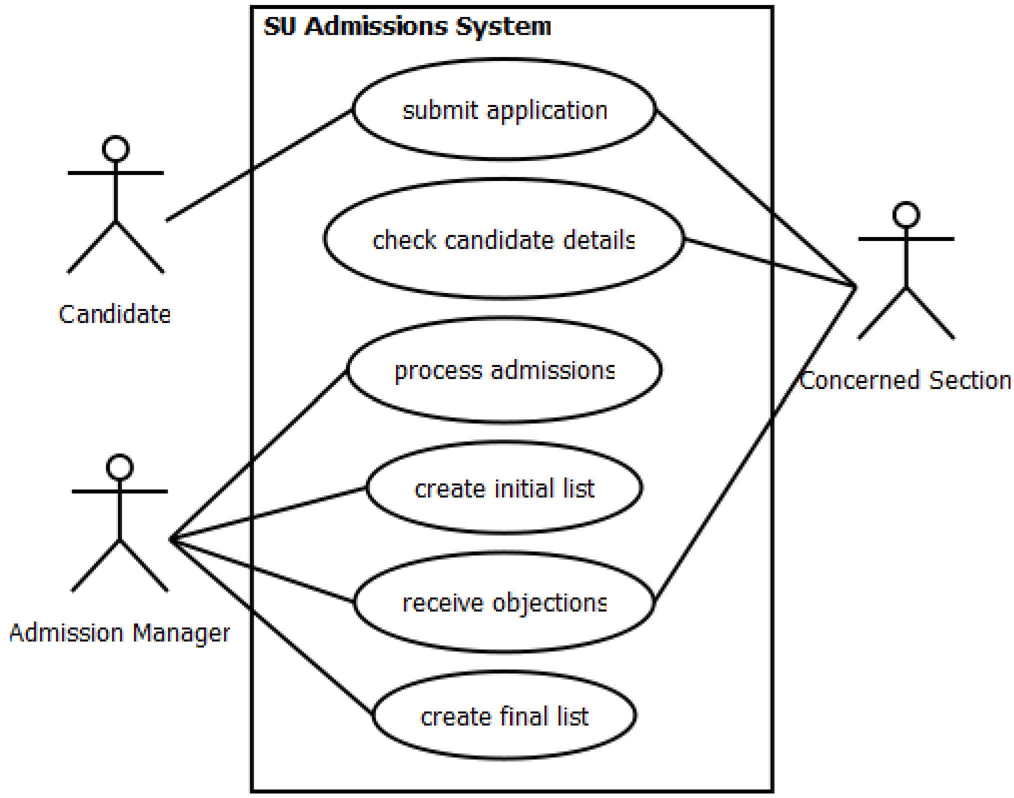


Figure 2.1: *High-level admissions management use cases*

Table 2.3 shows that seats are distributed category-wise (General Merit Jurisdiction, General Merit out of Jurisdiction, Female Quota Jurisdiction, Sport Quota, Disabled Quota, etc.). In each discipline seats are reserved on sports quota, which is 2%, and also 1% for disabled quota and so on. The marked disciplines are further distributed in Table 2.4 and Table 2.5. The number of seats are distributed in highlighted degree program according to district-wise quota and other is open merit according to realm of university. In University of Sindh each campus has own districts in Jurisdiction and here Table 2.4 shows district under jurisdiction of main campus of University of Sindh. The District-wise seat allocation for the Rural and Urban areas for admission to the above highlighted courses of study is shown in Table 2.4 and Table 2.5.

sno	District	Urban	Rural	Total
1	Hyderabad	3	1	4
2	Tando Allahyar	1	1	2
3	Tando Mohd Khan	1	2	3
4	Matari	1	2	3
5	Badin	1	1	2
6	Thatta	1	2	3
7	Thar	0	3	3
8	Mirpurkhas	2	3	5
9	Umerkot	0	2	2
10	Sanghar	1	1	2
11	Dadu	2	3	5
12	Jamshoro	1	3	4
13	NawabShah	1	2	3
	Total	15	26	41

Table 2.4: *District Wise Seat Allocation Under Jurisdiction*

sno	District	Urban	Rural	Total
1	Sukur	2	2	4
2	Ghotki	1	1	2
3	Shaikarpur	1	1	2
4	Jacobabad	1	1	2
5	Larkana	1	1	2
6	Kambar	1	1	2
7	Kashmore	1	1	2
8	KhairPur	1	1	2
9	Noushahrofero:	1	1	2
	Total	10	10	20

Table 2.5: *District Wise Seat Allocation Out of Jurisdiction*

2.2 Problem of Seat Allocation

Thousands of students apply every year in University of Sindh for admission from every city of Sindh. Steps followed in admission process can be seen in Figure 2.2. In the first stage, student have to fill application form for admission where the student has to put name of ten disciplines in which he / she wants to take admission. The order of selected discipline by student represent the intensity of interest (can be said as priority) for taking the degree in that particular discipline. The activities performed by an applicant can be visualized in given usecase in Figure 2.3. The next stage is to validate the given information of student with their provided academic documents by the concerned section as shown in Figure 2.4. After clearing the discussed steps, university conduct an aptitude test for students for assessing the able students. A commutative score is calculated on the basis of the score of aptitude test and previous academic report. On the basis of the attained score, generation of "merit list" is needed. A "merit list" contains list of students who have applied for admission in university. Before merit list, a temporary list is published so that any applicant can could not raise any objection against the given details of applicant. Applicants confirms their names in merit list and pay admission fee for the desired program. This generating of merit list progress ends on third merit list of applicants.

The task of generating merit list is very hard and time consuming for a human that is why this need to be automate. The reason behind this problem is different criteria, eligibility and seat distribution of degree program disciplines.

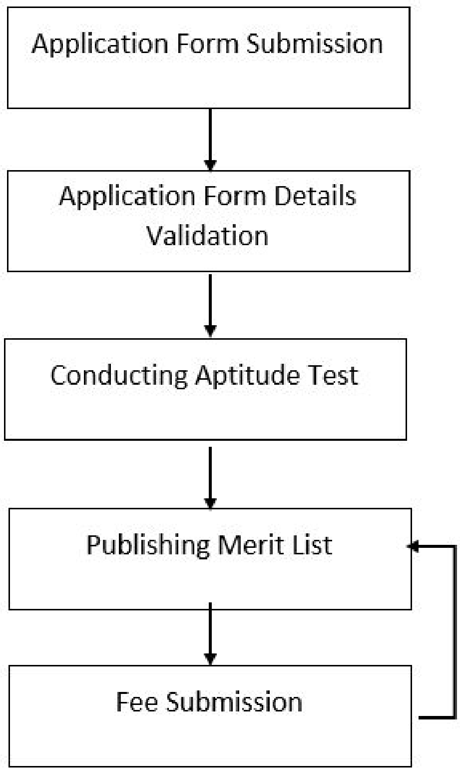


Figure 2.2: *Admission Process*

Many programs (disciplines) Each discipline contain vacant seats for admission on which applicants have to compete. However, there are two types of disciplines on the basis of distribution of seats. The first type of disciplines contain fixed number of seats

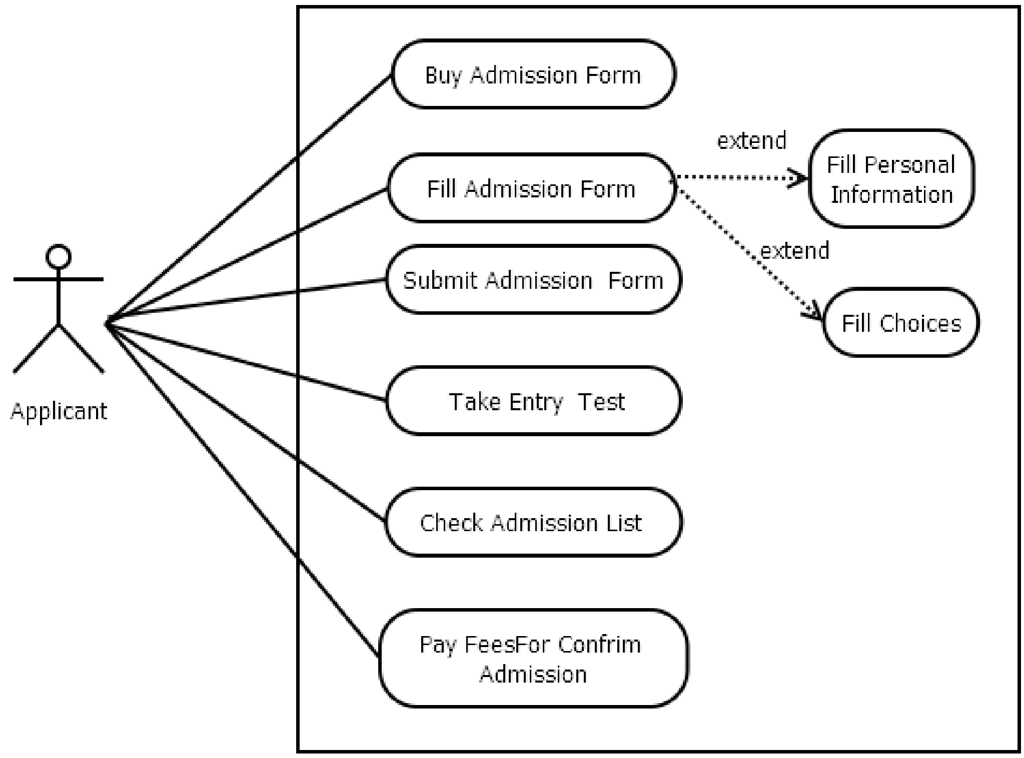


Figure 2.3: *Usecase of Applicant*

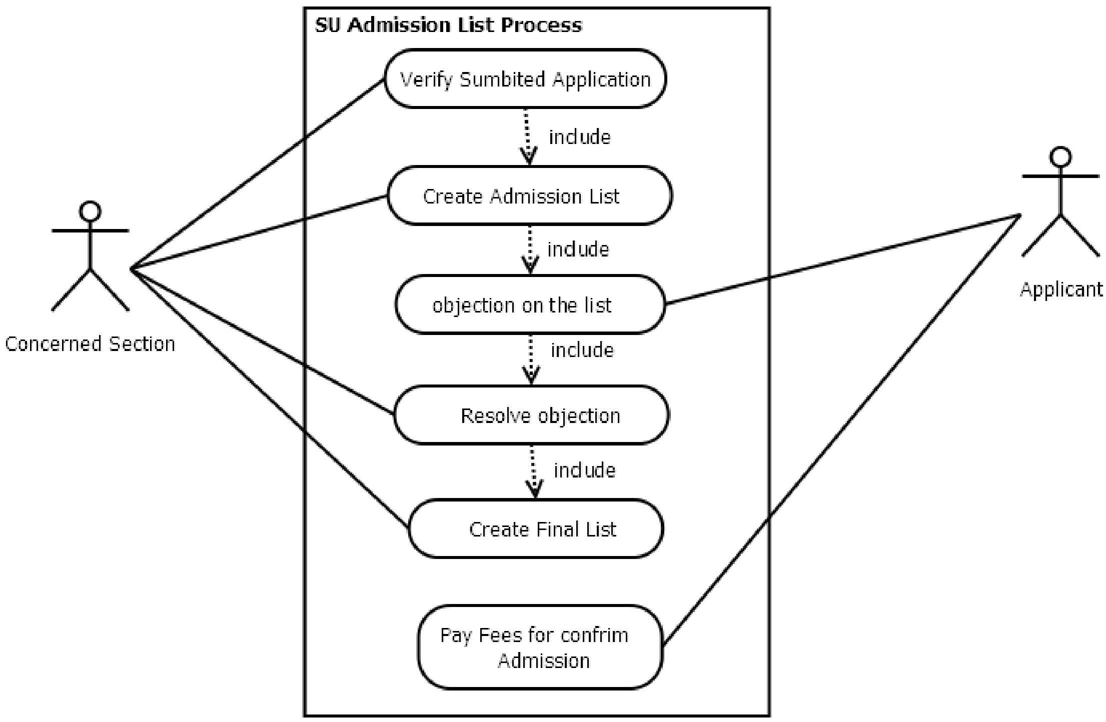


Figure 2.4: *Detailed Admission Process*

for students of each district in Sindh province. The second type of disciplines contain seats for students of area under jurisdiction and other seats for out of jurisdiction area. Therefore, the first thing under consideration for generating merit list is two types of seat distribution. However, beside two types of distribution, there are fixed number of seats fall under each quota (listed in Table 2.6). University also offers degree program of some disciplines in evening shift. However, offered degree programs in evening shift contains seats in “Self Finance Quota”. None of other quotas are available in evening shift.

S.No	Quota
1	Sports Quota
2	Female Quota
3	Disable Person Quota
4	Employee Quota
5	Affiliated College Employee Quota
6	Army Personal Quota
7	Shuhda Waris Nomination Quota
8	FATA Nomination Quota
9	Foriegn Nationals Quota
10	Northern Areas Quota
11	Self Finance Quota
12	AJK Quota
13	Pharmaceutical Industry Quota
14	NCEAC Quota

Table 2.6: *List of Quota*

The problem for generating merit list of student includes some points under consideration. The first point is that student with the high commutative score is preferred for taking admission in the chosen discipline than student having low score. The second point is that a student can apply disciplines in morning as well as in the disciplines in evening shift. This point drag us to that the student who applied for both shift, university have to give chance to take admission in either of the shift in initial merit list. The third point is that the order of selected disciplines (choices) by students have to be considered while generating merit list. University has to publish three merit list of students for admission. The fourth point is that those students who were selected in first merit list and did not paid the admission fee will not be considered in next merit lists. In addition, those student will not be the part of next merit list who got their highest priority (first choice) discipline in previous merit list.

For better understanding of this problem we describe some possible scenarios.

Scenario 1: An applicant who belongs to either of four divisions of province Sindh apply for admission. The gender of applicant is male and attempt to apply in self finance. The choices of the applicant are filled only for morning shift. The residence of student in either of four divisions approve applicant to compete for vacant seats of general merit. In the basis of commutative score of student, a degree program (from his given choices) is offered. If the offered degree program is the first choice of applicant then their will be no other program offered in current list and applicant will not be considered in future lists. The second part of this scenario is that if student is offered a degree program which is not his/her first choice or commutative score is not sufficient to compete for general merit seats of any of choices then seats of self-finance will be checked for offering. If the commutative score of applicant is able to compete for seat of self-finance in any program then both seats of programs (if applicable one for general merit and one for self-finance) are offered in the current merit list. The seat of self-finance of a program is offered when either: i) applicant is not offered any choice in general merit or ii) the priority of offered self-finance program seat (marked by applicant) is greater than offered program of general merit. If applicant accept (pay the admission fee) the program seat of general merit then applicant will be not applicable to compete for self-finance seats of program in future merit lists. If applicant accept the program seat of self-finance then applicant will be applicable to compete for self-finance as well as general merit in future merit list. If applicant do not show the interest by not paying admission fees then applicant will not be able to compete for any program in future list. The applicant cannot avail or consume the offered seat after expiry of the current merit list.

Scenario 2: An applicant who belongs to either of four divisions of province Sindh apply for admission in morning as well as in evening. The gender of applicant is male and attempt to apply in self-finance. Apparently applicant will compete for morning choices as well as evening choices. The applicant is able to compete for general merit seats due to his/her residence in area of either of four divisions. All possible situations are applicable here which are described in Scenario 1. Additionally, applicant will also compete for evening programs if applicant is not offered his/her first priority program in morning shift either in seat of general merit of self-finance category. The seat in evening program is offered when either the priority of that evening program (by applicant) is greater then the priority of offered morning seat of general merit or self-finance. Lets assume that applicant is offered a program (not first choice) in general merit category, a program in self-finance category and a program in evening then: i) if applicant pays the admission fee for seat of general merit then the applicant will not considered to compete for seats of self-finance and evening programs in future merit lists, ii) if applicant pays the admission fee for seat of self-finance category then applicant can only compete for self-finance and general merit seats, iii) however, if applicant pays the admission fee for seat of evening program then applicant will be able to compete for general merit, self-finance category and evening programs.

Scenario 3: An female applicant who belongs to either of four divisions of province Sindh apply for admission in morning as well as evening. The applicant does not apply for seats of self-finance category. The University of Sindh offers a special seat for females in each discipline. This female applicant can compete for seat of general merit as well as seat of female quota. Here, the applicant is offered either first choice. If offered choice is not her first choice then there will be process to check the seats in evening choices. Suppose, the applicant is offered a choice from morning and choice from evening (apparently the priority of offered evening choice must greater than offered morning), if applicant pays admission fee for evening choice then the applicant can compete for merit and female quota seats as well as for evening in future merit lists. However, if the applicant chose to move for merit seat then the applicant will lose for compete in evening shift program in future merit list.

Likewise in Scenario 3, the applicant can also apply for other quota seats i.e. Sports Quota, Employee Quota, Disable Quota etc. From above discussed scenarios it is been clarified that an applicant can apply for more than one category of seats in each applied discipline. This makes harder to manually validate each applicant to fill the vacant seats. Along with validating the educational background of applicant the score the applied categories are also been focused while generating merit list.

The above discussed points build a complicated situation for generating lists. In literature, none of the provided solution works in the given complicated problem of seat allocation. The next chapter will discuss some related work in literature which covers problems under different domains.

Chapter 3

Related Work

The literature suggests that the process of choice selection system, This chapter discussed different types of choice selection systems and also discussed different polices to select the students.

3.1 Background of Choice Selection System

The concept of choice selection was first introduced by Gale and Shapley [7]. Inspired by the problem of college admissions, the authors present two mechanisms i) the Student Proposing Deferred Acceptance (SPDA) ii) College Proposing Deferred Acceptance (CPDA). They showed that the different outcomes of the both mechanisms. Furthermore, [9] use the both mechanisms for the college admission system. In their model, colleges are not considered but their seats to be consumed by the students. And also they show the collage priorities (i.e., exam score). [8] introduces the quota system it used the SPDA mechanism. After Kojima, [10] showed that quotas of every minority student, the focus shifted to minority reserves. These papers focuses on school choice based mechanism but these mechanisms not proper fit on the Pakistan Public Sector Universities. Previous work focusing on choice selection system can be broadly divided into two categories: (i) seats are distributed according to district where each district has its own fixed quota [8], and (ii) seats are distributed according to their realms [4]. Some existing work falls in the first category and some works falls on second category. This work falls in the both category

3.2 Choice Selection Algorithms

A set of mathematical model have been developed for choice selection system such as Marriage stability [11, 12, 13, 14, 15, 16, 17, 18, 19, 20], doctor distribution[6], school based choice selection system [9, 8, 21]. This work aims is two fold i) to model the structure of the choice selection system using object modeling technique ii) to design a suitable algorithm to generate the merit list. Now a days, object-oriented languages dominate the programming paradigm, therefore, This research use UML class diagram notations to represent the structural model (class diagram).

3.3 Models of Choice Selection Systems

Little work has been done to address the general problem of choice selection system for the selection of 8th 9th grade applicants in new York city collage where seats are divided into two portions shows in table 3.1. It divided 50% depends on academic performance (i.e., inter and metric marks) and 50 % depends on his test score. The first 50 % score divided into three parts 16% for lowest marks , 68% for middle score and 16 % for top students. Furthermore, they proposed the stable matching mechanism rules of seat distribution and school criteria. Also, seats of colleges were divided into two portions; i) the first half of seats were allocated to top, middle, and lower performers in the previous academics, ii) second half of seats were divided by test score lottery scheme (i.e., those applicants having greater score than 50% of the lottery scheme). Different factors have been preferred in school's criteria for admissions. For instance, some of the schools prefer higher score in previous academics. Similarly, some schools prefer good attendance.

50% Academic Performance			50% Test Score
16 % lower	68 % Middle	16% Top	Percentage

Table 3.1: *Seat distribution of the New York City colleges*

3.4 Choice Based Seat Distribution

In previous work many authors seats are distributed on the choice based for example seats are divided on the priority of courses shows in table 1 but in this work we divided seats based on score based which show on section 2.2

Table 3.1 shows the Student (sn) different students have different score and different preferences of the courses and table 3.2 shows the results of the student. In table 3.3 Course 1 (C1) has 2 seats and couuse 2 and 3 (C2, C3) has one seat

Table 3.2: *Choice Based Seat Distribution*

Students (Sn)	Percentage	Preferences Cources(Ci) order (>)
S1	71	C3,C1,C2
S2	72	C1,C3,C2
S3	73	C2,C1,C3
S4	75	C2,C1,C3
S5	76	C1,C3,C2

Table 3.3: *Results of Choice Based Seat Distribution*

C1 (2 seats)	C2 (1 seats)	C2 (1 seats)
S5	S4	S1
S2		

3.5 Score Based Seat Distribution

In this section seats are distributed score based priority show on below:

Table 3.4: *Score Based Seat Distribution*

Students (Sn)	Percentage	Preferences Cources(Ci) order (>)
S1	71	C3,C1,C2
S2	72	C1,C3,C2
S3	73	C2,C1,C3
S4	75	C2,C1,C3
S5	76	C1,C3,C2

Table 3.1 shows the Student (Sn) different students have different score and different preferences of the courses and table 3.2 shows the results of the student. In table 3.3

Course 1 (C1) has 2 seats and couuse 2 and 3 (C2, C3) has one seat

Table 3.5: *Results of Score Based Seat Distribution*

C1 (2 seats)	C2 (1 seats)	C2 (1 seats)
S5	S4	S1
S2		

3.6 Marriage Stability Selection System

A marriage problem in [11] is considered. A marriages held in two groups of couples (one group of boys and one group of girls) where they were required to select partners of their choice from the designated group. The problem was to match the wishes of boys and girls to marry with a suitable person. In other words each side each desire to be matched with one other side. In the marriage model there are two disjoint sets of agents, $M = m1, ..., mn$ and $W = w1, ..., wp$, Men and Women, each of whom has complete and transitive preferences over the individuals on the other side. The Table 3.6 shows the preferences of the marriage couple and Figure shows the propose model for marriage stability.

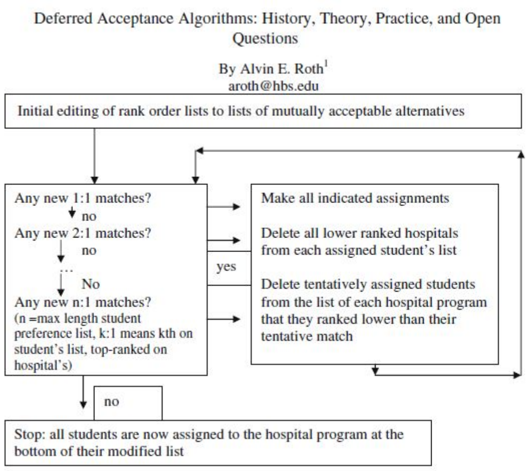


Figure 3.1: *The 1952 deferred acceptance algorithm (from Roth 1984)*

Table 3.6: *Marriage Stability Selection System*

Boys Group	Boy Preferences for Girls	Girls Group	Grils Preferences for Boys
B1	G1, G2, G3	G1	B2, B1
B2	G4, G5	G2	B5, B2
B3	G3	G3	B3
B4	G2, G1	G4	B2, B1
B5	G1, G3, G5	G5	B4, B5

3.7 Doctor Distribution

In the doctor distribution model are proposed for divided doctors in the urban and rural areas because many doctors do not want to go rural areas. The study in Kamada. et al., [10] focuses on a problem similar to the admissions into colleges and schools where the doctors have been assigned duties in regions of Japan. In practice, however, this is implemented by simply reducing the individual capacities of the hospitals by some fixed percentage. Many governments are concerned about access to health care in rural communities and trying to implement policies to balance the distribution of doctors in urban and rural areas[6].

3.8 Other Models Related to Choice Selection System

Abdulkadiroglu and Sonmez [8] introduced matching theory as a tool in school choice and noted the problem with diversity concerns.

The last two years have seen multiple explorations into controlled school choice and diversity concerns. Kojima [10]shows that armative action policies based on majority quotas may hurt minority students. To overcome this difficulty, Hafalir, Yenmez, and Yildirim (2013) propose alternative action based on minority reserves. More generally, Ehlers, Hafalir, [22], and Yildirim study armative action policies when there are both upper and lower type-specific bounds. They propose solutions based on whether the bounds are hard or soft. In contrast, this paper seeks to homogenize the rules and consider (possibly) all of them. Other papers consider specific choice rules, including some that are close to our reserves rule [3, 1, 23].

Dur. et al [5]., discussed a scheme for the seat distribution, where 50% seats are assigned to neighborhood school on priority and remaining 50% are on choice-base priority. A function of reserved seat allocation is developed in [3]where seats are distributed according to racial population and income. Furthermore, an individual applicant can be a part of one or more categories where seats are distributed in more than one category and vacant seats can be filled with applicants having other categories. Bo. et al [1], focuses on a mechanism for allocating seats to applicants in which seats are distributed according to school's criteria and religious status of applicant. Bhatia et al [4], proposes a solution of same type of two problems; i) limited seats and academic score threshold in colleges for applying applicants ii) choice preference, age and some other criteria for the applicants claiming seats in desired colleges.

Fong. et al. [24], have designed a prototype system called Recommended System for Admission to Universities (RSAU). Such a system provides a solution based on the test scores. In RSAU, applicant's academic background and other factors play a major role in their admissions. Furthermore, they used a hybrid model of neural network, which takes applicant's academic merits, academic background, and the university admission criteria into account. Similarly, in [25] neural network model is proposed for the admissions of undergraduates in the universities of Nigeria. They mention few problems that exist in the current system. For instance, such a system considers other courses for candidate admission if candidate do not meet the criteria for his courses of choice. Prior to their proposed solution, the admission process was not transparent to the candidates. In a study conducted in Kenya by Wabwoba. et al. [23], the selection carried out against the candidate's choice where the candidates have chosen the irrelevant subjects. This is because of minimum prerequisites of each course with the prescribed grades in specific subjects. In this model, candidates can regular on the courses at their own choices. In the previous research, I have analyzed two problem situation regarding selection; i) first, considering higher priority to choice preference and lower to academic score, ii) second, considering inverse of the first. This research problem resembles with later one. Also, this research analyzed that the problem subsumes previous problems discussed in the literature. In addition to this, This research used the object modeling approach to structure the system that dominates the programming paradigm. To the best of our knowledge, such an approach has not been used for the said purpose.

Niederle and Rose [26, 27, 28, 29] point out that according to experience, there is no difference between the medical profession of salaries and the concentration-less matching. An interesting game theory aspect of the suit itself is that this is the dual suit is intended to represent not only the class of all previous medical residents, but it seeks to sue a class of defendants, including residents employed by all hospitals, including dozens of defendants. This makes legal defense costs very high because many defendant's lawyers have to coordinate with each other in many preliminary actions and hearings that are expected to extend for several years. Therefore, the plaintiff's strategy seems to be to try to force a financial solution before the long-term process reaches the trial. However, the same strategy makes the cost of legal defense high, so that the defendant can seek legislative remedies from the lawsuit, because almost every senator and members of the National Assembly have a hospital in their area. Niederle demonstrates how the model changes, as proposed by the applicant, the difference between hospital and deferred acceptance algorithms may differ from that in a simple matching market [30, 31, 32, 33].

Chapter 4

Design and Implementation

This chapter focuses on structural modeling of the problem which discuss the class diagram of the proposed system. Furthermore, it also discusses proposed algorithm, implemented to solve the choice selection problem. In last, prototype used for generating best possible outcome of maximum vacant seat utilization is discussed.

4.1 Structural Modeling of Choice Selection System

It is important step to construct a structural model [34, 35, 36] of the system to depict the main objects or entities of the system. Classes of the choice selection system related to university are illustrated in Figure 4.1. For simplicity, necessary classes are included at this level. However, a detail design can be obtained by going deep detail in each entity. The classes in Figure 4.1, $Candidate$, $CandProfile$, and $Student$ represent the characteristics of a particular prospective student. The important attributes are session , gender , test score , and composite percentage number (CPN). Attribute CPN is the sum of the applicant's scores in Matriculation, Intermediate, and Entry-Test. The attributes CPN, gender, group, domicile, category, choices which are used by the admissions process.

Since each of these courses has a specific number of seats allocated for particular category and jurisdiction, the class $SeatAllocation$ represents such information associated with a particular course. For instance, the undergraduate course in

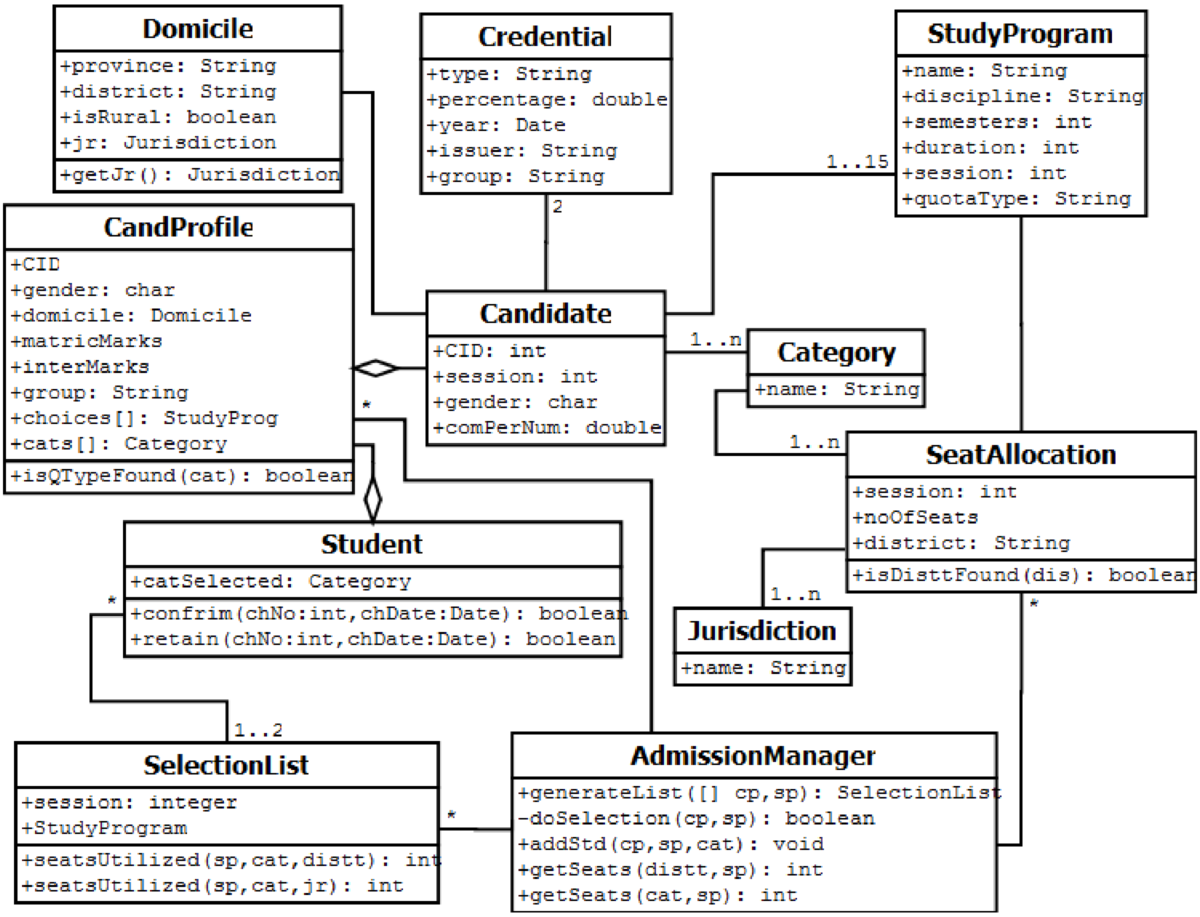


Figure 4.1: *Meta model of the choice selection system*

English Language has 80 seats for the General Merit category under the University's jurisdiction.

Figure 4.1 illustrates the classes of the choice selection system of the University. For simplicity, this research include the classes that are necessary at this level. However, a detail design can be obtained. In this diagram, classes *Candidate*, *CandProfile*, and *Student* represent the characteristics of a particular prospective student. The important attributes are *session*,*gender*, *testscore*, and composite percentage number (CPN). Attribute *CPN* is the sum of the applicant's scores in Matriculation, Intermediate, and Entry-Test. The attributes *CPN*, *gender*, *group*, *domicile*, *catagory*, *choices* which are used by the admissions process.

Class *StudyProgram* models undergraduate courses offered by the University. Since each of these courses has a specific number of seats allocated for particular category and jurisdiction, the class *SeatAllocation* represents such information associated with a particular course. For instance, the undergraduate course in English Language has 80 seats for the General Merit category under the University's jurisdiction.

Class *AdmissionManager* models an artificial entity that is responsible for generating the selection lists. Its operation namely *generateList*, *doSelection*, and *addStd* are defined to process the admissions. Given all applicants data and a particular course, method *generateList* will create the final merit list of a particular course. This method repeatedly calls *doSelection* by passing individual applicant for a particular course. Similarly, in response, the *doSelect* method calls *addStd* method to add the selected applicants into the final merit list against a particular category (e.g., General Merit). For a specific course in a particular academic session, class *SelectionList* represents a merit list of the applicants selected against a particular category. In the final merit lists, a student can be offered different courses from his/her choices against one or two different categories. For instance, a applicant might be offered two different courses such as Sindhi Language on General Merit against the second choice and English Language on Self-Finance against the first choice. Therefore, the type of relationship between classes *SelectionList* and *Student* is many to many. The multiplicity constraints on the association between these classes represents such type of relationship.

4.2 Algorithm Design and Implementation

This section describe the algorithm [37, 38] that generates the selection list. Also, This research present the results achieved through the proposed choice selection system. Furthermore, it provide the discussion over such results.

As described in Chapter 2, the case of the Sindh University choice selection system is a complex system owing to different rules and eligibility criteria for admission in the university. Algorithm 4.1 and Algorithm 4.2 represent the solution that has been implemented at the university. The flow diagram of Algorithm 1 can be seen in Figure 4.2.

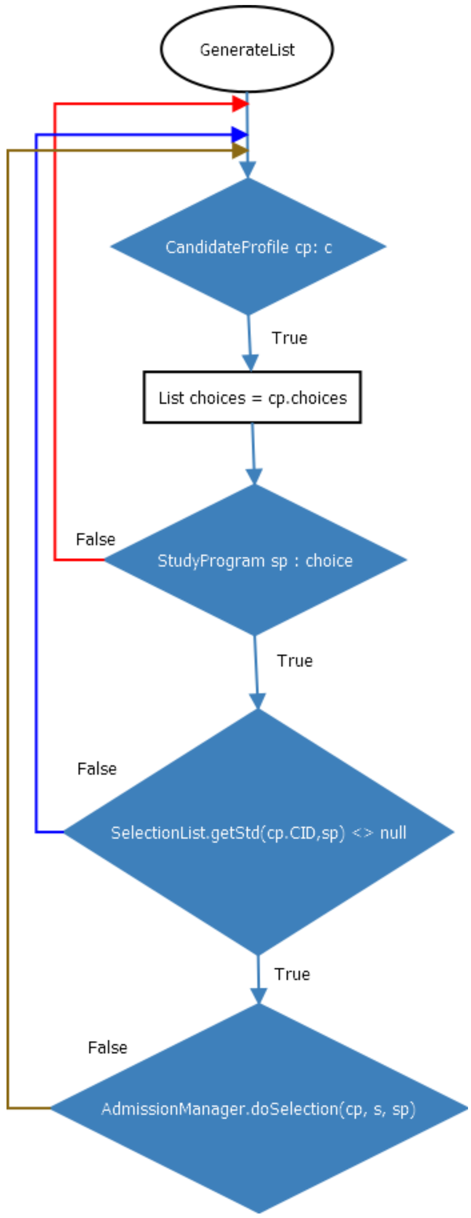


Figure 4.2: *Flow Diagram of Algorithm 1*

Algorithm 4.1 List Generation

```
function GENERATELIST(CandidateProfile[] c, SeatAllocation s )
    for CandidateProfile cp: c do
        List choices = cp.choices
        for StudyProgram sp : choices do
            if SelectionList.getStd(cp.CID,sp) <> null then
                Break
            end if
            if AdmissionManager.doSelection(cp, s, sp) then
                Break
            end if
        end for
    end for
end function
```

Algorithm 4.1 is the "List Generation" algorithm, which generates merit list for every course, according to different categories (e.g., general merit, female quota, sports quota etc.). The algorithm accepts *CandidateProfile* and *SeatAllocation* as inputs. *CandidateProfile* is an array of candidate records who have applied for various courses in the university. *SeatAllocation* is a multidimensional array specifying total number of seats available for each course in various categories. The details of these two data structures can be found in section 4.1 (see Figure 4.1)

The array of *CandiadteProfile* is sorted on CPN in descending order. For every candidate in *CandidateProfile*, the algorithm checks the candidate's specified choices for admission which again are sorted on preference in descending order. For each choice, the algorithm checks if the candidate has already been allocated a seat in the said course ($SelectionList.getSTD(cp.CID, sp) \neq null$) because if we are generating second or higher list it will check from previous *SelectionList* for not allocating same course in current admission list. If so is the case, the loop breaks, and next candidate is considered for the same procedure. Otherwise, Algorithm 4.1 calls *doSelection* procedure specified in Algorithm4.2 to proceed towards candidate seat allocation. The flow diagram of Algorithm 2 can be seen in Figure 4.3.

Algorithm 4.2 accepts the parameters, *CandidateProfile*, *SeatAllocation* and *StudyProgram*. Recall from Section 2.1 that a student can apply under various categories and under different quotas. This research present here pseudo-code for only one category and two quotas for the better understanding of the reader. The algorithm starts off by extracting candidate's district of domicile from his profile and assign it

Algorithm 4.2 Do Selection

```
function DOSELECTION(CandidateProfile cp, SeatAllocation sa, StudyProgram sp)
    boolean status = false
    String canDist = cp.domicile.district
    String catApplied = "GM"
    String stdCatSelected = SelList.getStd(cp.CID).catSelected.name
    boolean stdCat = cp.isQTypeFound(catApplied)
    if stdCat AND stdCatSelected <> catApplied then
        int seats = sa.getSeats(catApplied, sp)
        if sp.qoutaType == "DISTRICT" then
            if sa.isDisttFound(canDist) then
                int disttSeats = AdmissionManager.getSeats(cp.district, sp)
                int seatsUtilized = SelectionList.seatsUtlized(sp, catApplied, canDist)
                if seatsUtilized < disttSeats then
                    AdmissionManager.addStd(cp, sp, catApplied)
                    status = true
                end if
            end if
        end if
        if sp.qoutaType == "JURISDICTION" then
            if sa.jr.name == cp.domicile.jr.name then
                int jrSeats == sa.getSeats(cp.district.jr.name,sp)
                int seatsUtilized = SelectionList.seatsUtlized(sp, catApplied, cp.district.jr)
                if seatsUtilized < jrSeats then
                    AdmissionManager.addStd(cp, sp, catApplied)
                    status = true
                end if
            end if
        end if
    end if
    return status
end function
```

to *canDist*. *CatApplied* can be used for specifying various categories under which candidate can apply. Here, this research have taken only one category, i.e., general merit (GM). *StdCatSelected* gets the category under which student has already been selected in the previous list. *StdCat* returns true if the the category under which a candidate has applied is same for which code is checking his eligibility. The algorithm then proceeds by checking the condition that if student has applied for GM and and his previous selection is not under the same category ($StdCat\ AND\ StdCatSelected <> CatApplied$) then algorithm proceeds with checking if he can be allocated a seat under the applied category. Otherwise, his eligibility for the next choice is checked.

For allocating a seat, the algorithm first checks the quotas under which program is run and checks candidate's eligibility for each quota. Here, I only explain the procedure for one quota, i.e., District quota. The algorithm first checks if the current seat allocation has any seats of district as the candidate has domicile for ($sa.isDisttFound(canDist)$). If this condition results in false, then student is checked for his eligibility under next category. On the other hand, if this condition results in true, then algorithm checks

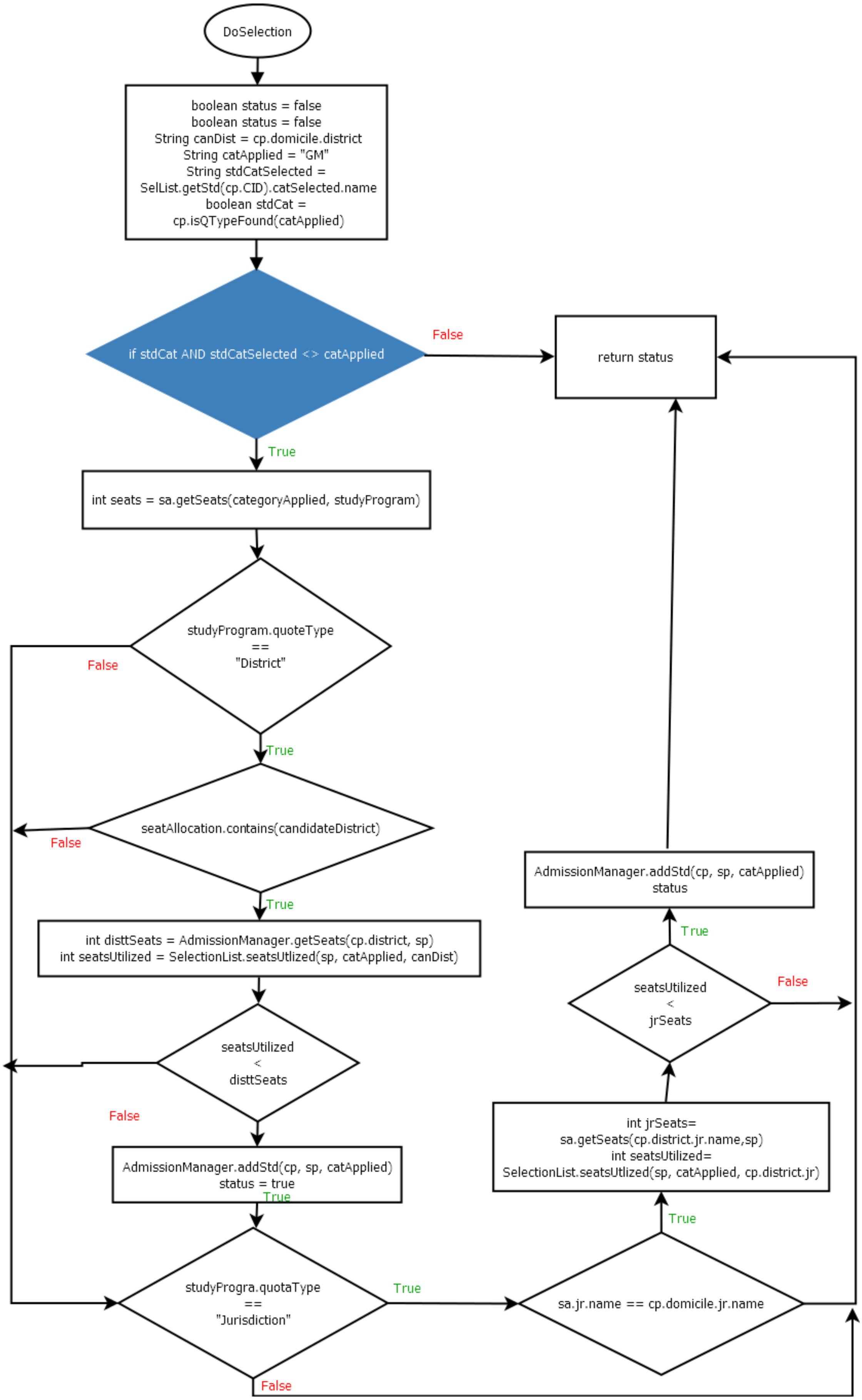


Figure 4.3: *Flow Diagram of Algorithm 3*

if the utilized number of districts for which seat allocation is being done is less then the total number of seats for the said district ($if\, seatsUtilized < disttSeats$). If so, then the student is allocated a seat ($AdmissionManager.addStd(cp, sp, catApplied)$). Otherwise, again the student is checked for the next choice. The process continues for each student in the list of $CandidiateProfile$.

4.3 Prototype Design for Maximum Seat Utilization

This section develop a prototype for the maximum seat utilization, This research develop two types of prototypes; one before the list and other after the list. Every year seats are going t wastage due to certain reasons for example:

- Students drop his program.
- Students do not know what score is needed to the discipline so that is the reason many student has not selected.
- After the selection student wants to change his choice because he / she wants to take admission in other disciplines.

Online open-house based process to utilize the left-over seats:

The first prototype is: after the test score this research provide option for selection of Program of study so that the seats are utilized efficiently because students already know the score so they made choice carefully. In this way seats may be utilized effectively.

Another protocol seats are wasted every year after selection so this research provide another interface for fill the choices again and after that system generate another list for the students. In Figure 4.4 student login his account and enter the user name and password which is given by university.

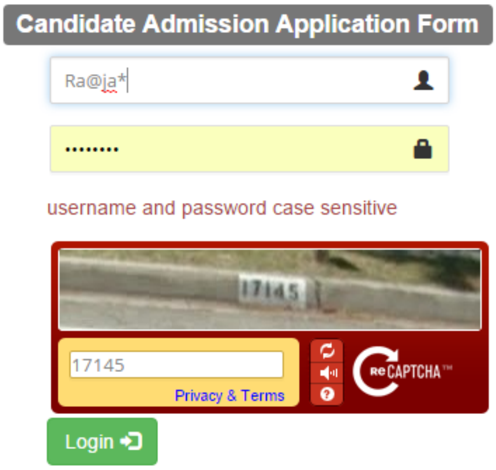


Figure 4.4: *Login Form*

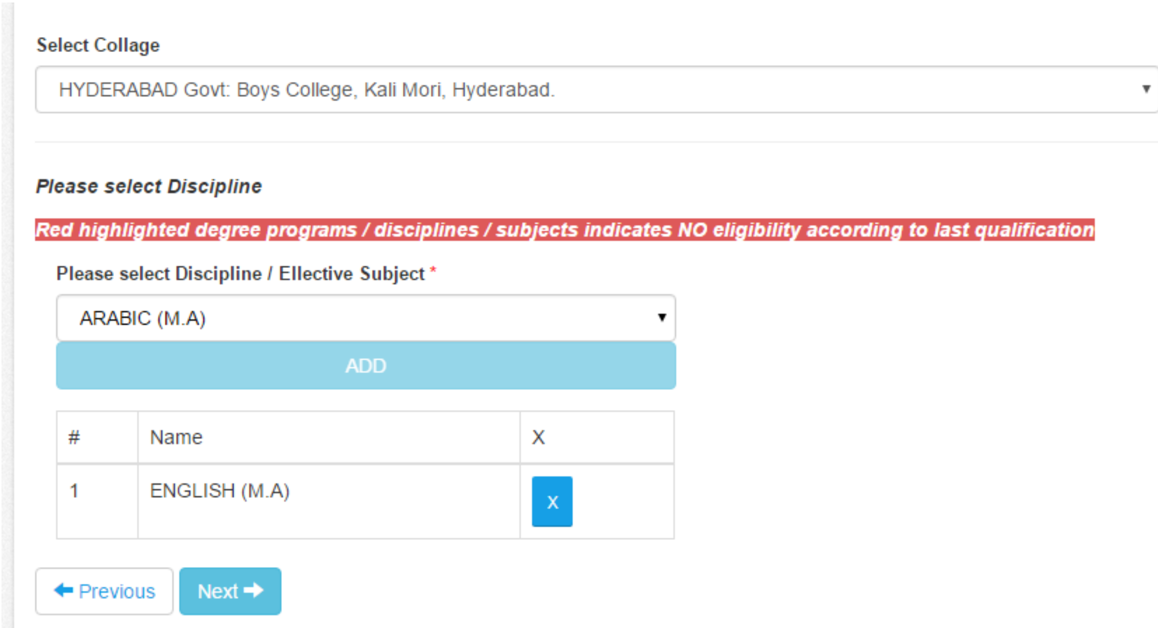
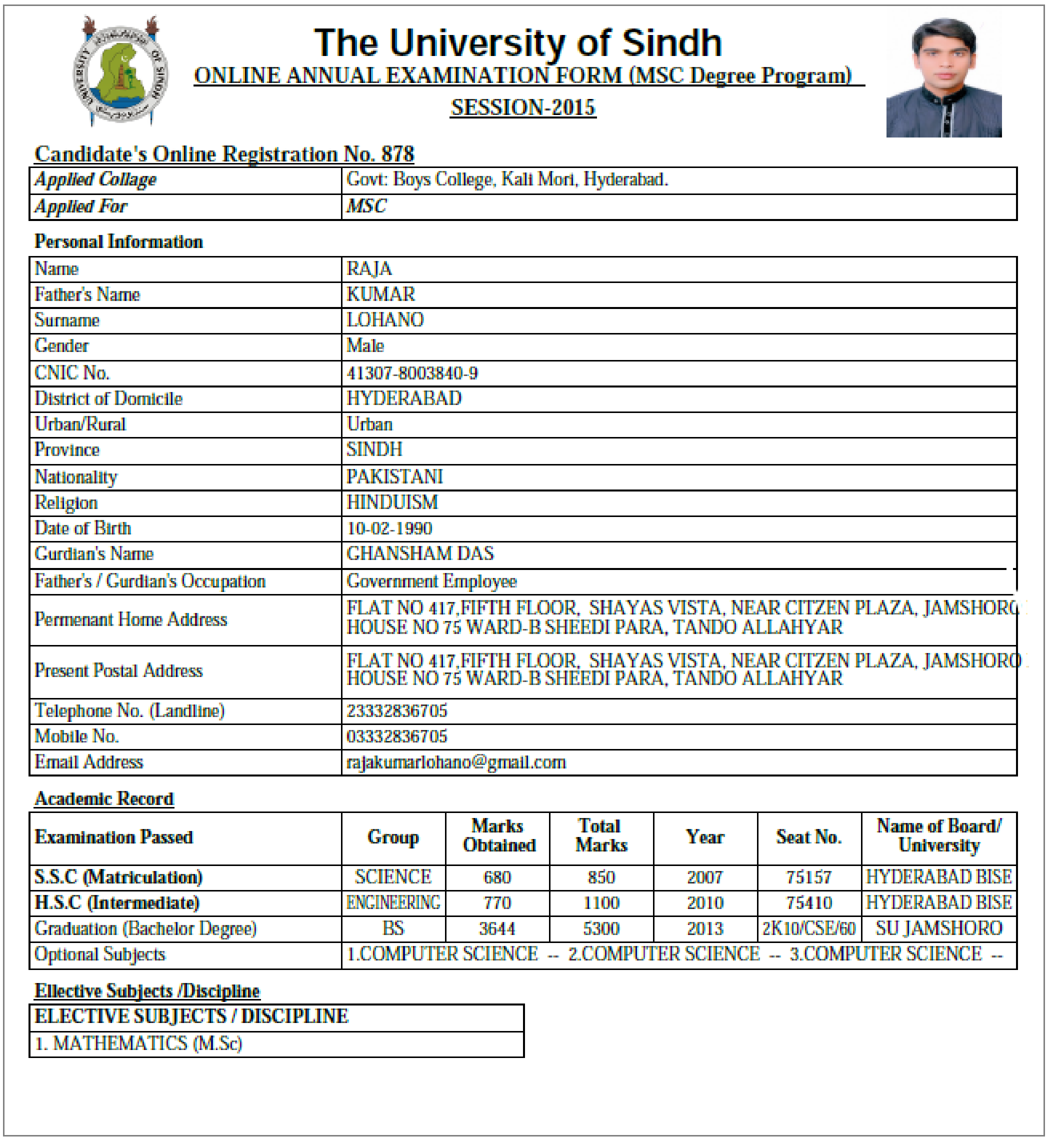


Figure 4.5: *Choice Selection Form*

The Figure 4.5 shows the filling choices procedure. This research use this graphic user interface after the test candidate login his form and fill the choices again and also this interface is useful for after 3rd list. The university announced the left over seats again and candidate fill the choices again that's why is graphic user interface is useful. The Figure 4.6 shows the print preview, candidate verify his details, if the details are wrong then go back correct again.



The University of Sindh
ONLINE ANNUAL EXAMINATION FORM (MSC Degree Program)
SESSION-2015

Candidate's Online Registration No. 878

Applied Collage	Govt: Boys College, Kali Mori, Hyderabad.
Applied For	*MSC*

Personal Information

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Surname	LOHANO
Gender	Male
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District of Domicile	HYDERABAD
Urban/Rural	Urban
Province	SINDH
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Date of Birth	10-02-1990
Gurdian's Name	GHANSHAM DAS
Father's / Gurdian's Occupation	Government Employee
Permenant Home Address	FLAT NO 417,FIFTH FLOOR, SHAYAS VISTA, NEAR CITZEN PLAZA, JAMSHORO HOUSE NO 75 WARD-B SHEEDI PARA, TANDO ALLAHYAR
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Academic Record

Examination Passed	Group	Marks Obtained	Total Marks	Year	Seat No.	Name of Board/ University
S.S.C (Matriculation)	SCIENCE	680	850	2007	75157	HYDERABAD BISE
H.S.C (Intermediate)	ENGINEERING	770	1100	2010	75410	HYDERABAD BISE
Graduation (Bachelor Degree)	BS	3644	5300	2013	2K10/CSE/60	SU JAMSHORO
Optional Subjects	1.COMPUTER SCIENCE -- 2.COMPUTER SCIENCE -- 3.COMPUTER SCIENCE --					

Ellective Subjects /Discipline

ELECTIVE SUBJECTS / DISCIPLINE
1. MATHEMATICS (M.Sc)

Figure 4.6: *Report Generated System*

4.4 Comparison between Other Admission Systems

The admission system of selected case study University of Sindh (UoS) for general public sector university is more complex than other universities. We compare admission system of "Mehran University of Engineering and Technology" (MUET) with our admission system in terms of complexity in admission procedure and policies. We cover multiple points to discuss the comparison between both systems. The beginning point to compare is that UoS offers degree programs in different disciplines for students having different type of educational background (such as, pre-medical, pre-engineering, pre-commerce, etc). However, MUET accepts students for applying who belong to pre-engineering in intermediate (or FSc). Along with students having variety of educational background, UoS offer more degree programs than MUET. Each degree program of every discipline have different pre-requisites in terms of educational background and previous academic score of the student. The second point worth pondering in UoS admission system is the complex structure of seat distribution in each degree of every discipline. In MUET admission system, seat in each discipline is distributed by the district/area of student. Additionally, special quotas seats are also available but comparatively, a student in UoS can compete more than one category of seats distribution. Whereas, there are two types of seat distribution observed with respect to each discipline in UoS admission system. UoS admission system enable student to apply in morning shift as well as evening shift. The choices of both shift is considered in admission list generation, however MUET does not offer evening degree programs (Undergraduate programs). The admission procedure of UoS covers at least three merit list (one after another) of student for admission. Another perspective to focus in UoS admission is that the seats allocation of some disciplines to students is prioritize on the basis of specific educational background. For example, student having intermediate in commerce group have high priority on seats of BS(Commerce).

Chapter 5

Experiment Results and Analysis

This chapter discuss the factors of maximum seat utilization and measure time and memory of choice selection algorithm. Furthermore, it also discusses the seat allocation and consumption of 2015, 2016 and 2017.

5.1 Time of Algorithm

Figure Time is based upon the choice selection algorithm time. It shows that if the number of candidates and choices increase, then the running time increase proportionally. For example, if the number of candidates and choices is 50,000, the algorithm take four minutes generating the selection list. Similarly, if the number increases to 100,000 and 150,000, then it takes eight, and twelve minutes respectively. This reseach conjecture from these experiments that the running time of the algorithm is linear.

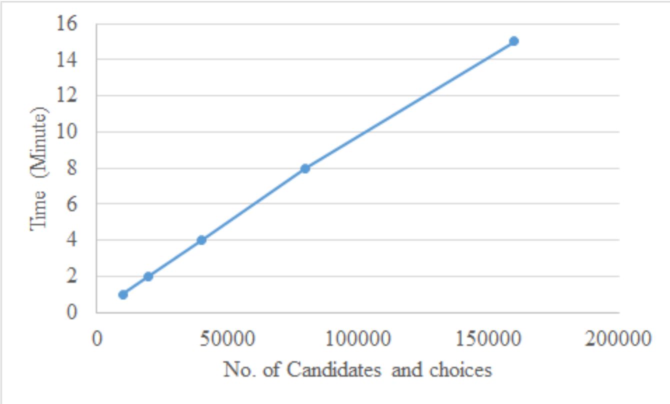

Figure 5.1: *Algorithm Time*

5.2 Memory of Algorithm

Figure 5.2 is based upon the choice selection algorithm memory. It shows that running time is directly proportional to number of applying candidates and choices. For the process of generating selection list algorithm occupied 1 mega bite memory in 5000 candidates and choices, 2 mega bite occupy in 10000 candidates and choices.

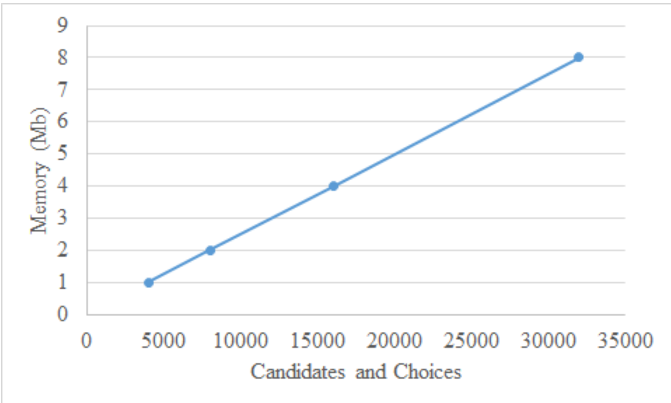

Figure 5.2: *Algorithm Memory*

5.3 Seat Utilization 2015

Figure 5.3 shows total and consumed seats in academic year 2015. The data preparation and selection process involves a dataset of 12708 student records from 2015 academic years. Thus, it was observed that 61% seats are consumed in Arts faculty, 93% seats in Commerce and Business, 26% in Education, 61% in Islamic Studies, 46 % in Law, 80% in Natural Sciences, 99% Pharmacy and 73% in Social Sciences.

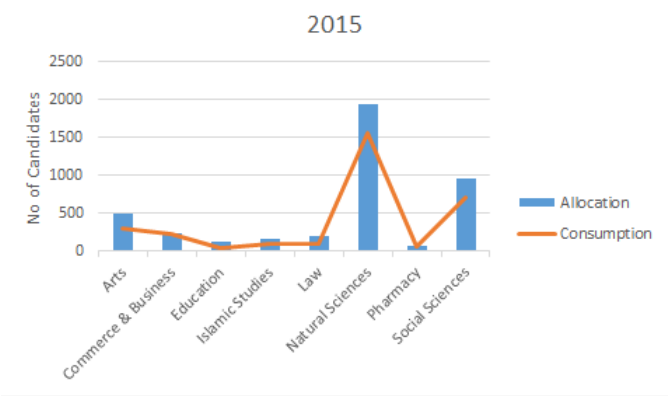

Figure 5.3: *Seat Allocation and Consumption*

Figure 5.4 shows total and consumed seats of each program in 2015. The results show in the aforementioned charts suggests that a substantial number of seats remain un-utilized every year. The scenario given in next paragraph help to understand the reasons for such un-utilized seats.

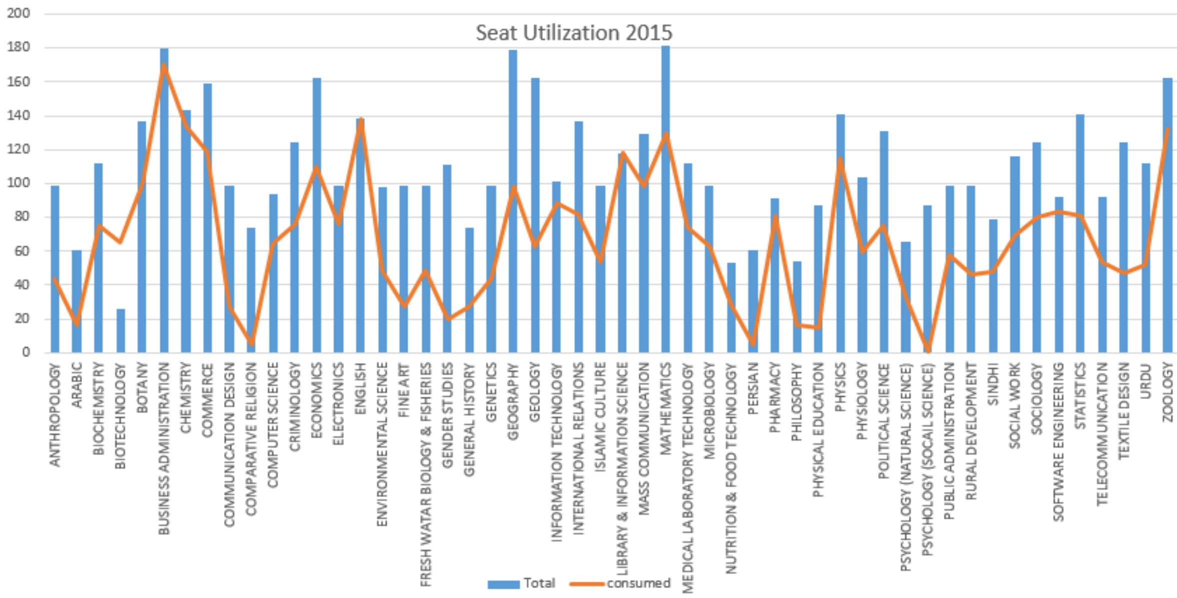

Figure 5.4: *Seat Allocation and Consumption Program Wise*

5.4 Seat Utilization 2016:

Figure 5.5 shows total and consumed seats in academic year 2016. The data preparation and selection process involves a dataset of 15175 student records from 2016 academic years. Thus, from the experiment it was observed that 60% seats are consumed in Arts faculty, 89% seats in Commerce and Business, 51% in education, 44% in Islamic Studies, 76 % in Law, 74% in Natural Sciences, 99% Pharmacy and 70% in Social Sciences.

The results show in the aforementioned charts suggests that a substantial number of seats remain un-utilized every year. The scenario given in next paragraph help to understand the reasons for such un-utilized seats.

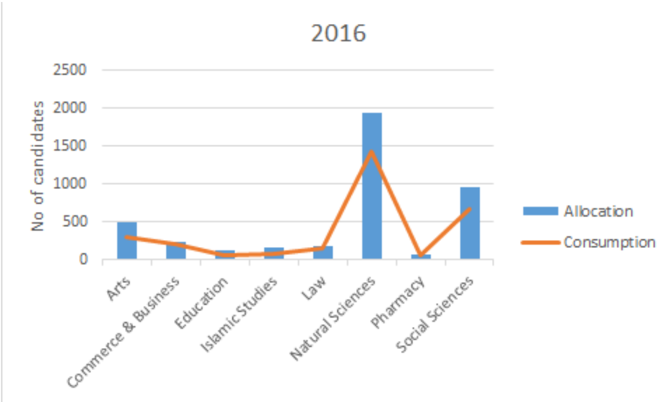

Figure 5.5: *Seat Allocation and Consumption 2016*

Figure 5.6 shows total and consumed seats of each program in 2016. The results show in the aforementioned charts suggests that a substantial number of seats remain unutilized every year. The scenario given in next paragraph help to understand the reasons for such unutilized seats.

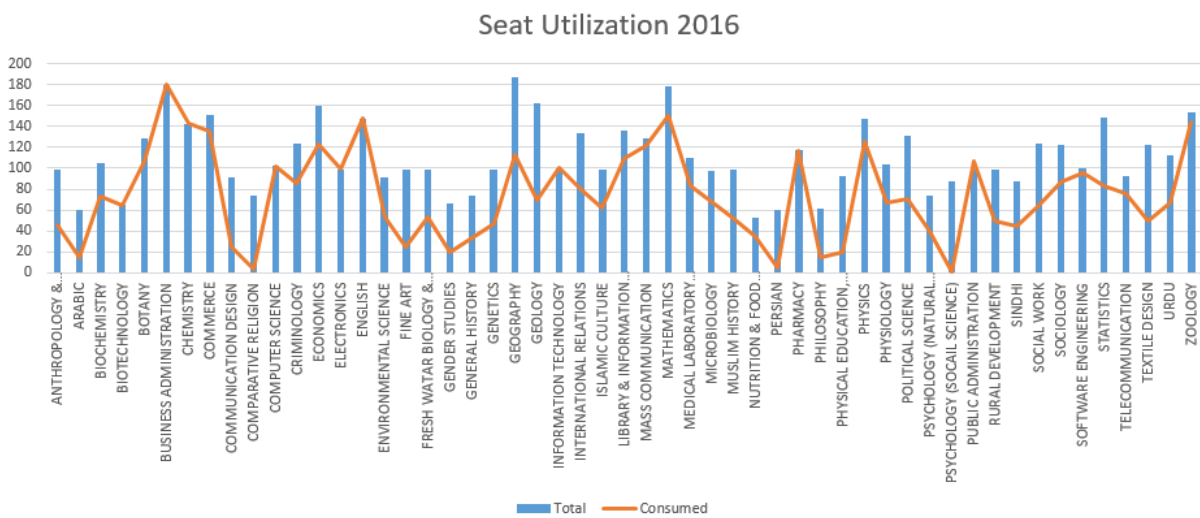

Figure 5.6: *Seat Allocation and Consumption Program Wise*

5.5 Seat Utilization 2017:

Figure 5.7 shows total and consumed seats in academic year 2017. The data preparation and selection process involves a dataset of 18251 student records from 2017 academic years. Thus, from the experiment it was observed that 58% seats are consumed in Arts faculty, 76% seats in Commerce and Business, 65% in education, 56% in Islamic Studies, 90 % in Law, 76% in Natural Sciences, 93% Pharmacy and 72% in Social Sciences.

The results show in the aforementioned charts suggests that a substantial number of seats remain un-utilized every year. The scenario given in next paragraph help to understand the reasons for such un-utilized seats.

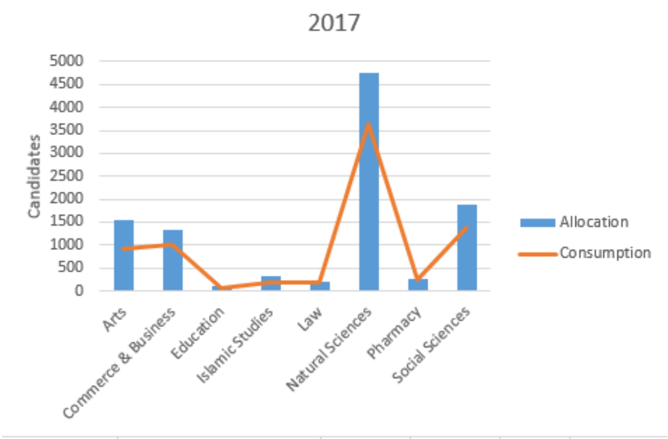

Figure 5.7: *Seat Allocation and Consumption2017*

5.6 Analysis of Choice Selection of the Market Oriented Courses:

The results show in the aforementioned charts suggests that a substantial number of seats remain not utilized every year. The scenario given in next paragraph help to understand the reasons for such non-utilized seats.

University of Sindh offered 69 courses in 2015/16. A large number of students applied in market-oriented courses (i.e., English, Business Administration, Pharmacy) which are shown in figure choices. The University allowed each candidate to specify

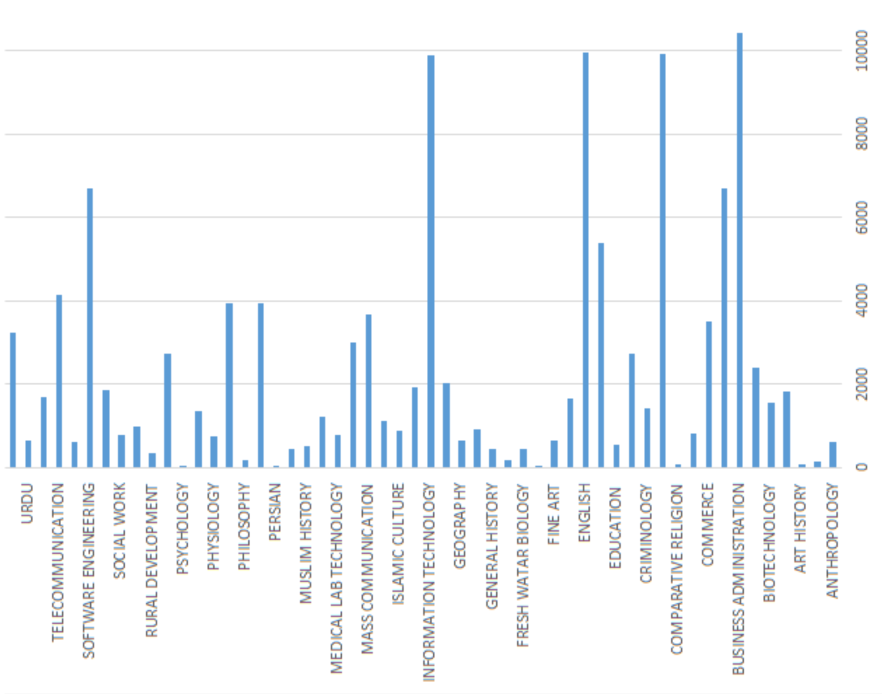

Figure 5.8: *Seat Consumption Course*

maximum of 10 choices. The results of academic sessions 2015 and 2016 show that on average students specified maximum of 8 and 9 choices. This suggests, that if we increase maximum number of choices to be specified by the candidates, we will have a probability of getting the good results in seat utilization.

5.7 Analysis of the Candidate Apply for Admission

Figure 5.9 shows candidates apply for admission in academic year 2015, 2016 and 2017. The data preparation and selection process involves a dataset of Jamshoro Campus 12708, 15175 and 18251 student records from 2015, 2016 and 2017 academic years. Thus, it was observed that the ratio of applying in entry test is increased.

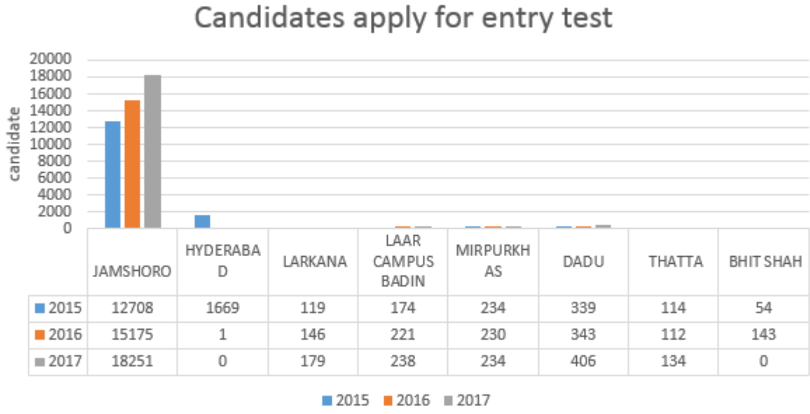

Figure 5.9: *Candidate apply for entry test*

5.8 Analysis of the Number of Choices that Effect on Seat Utilization

Figure 5.10 , 5.11 and 5.12 shows candidates select the program of study in academic year 2015, 2016 and 2017. The data preparation and selection process involves a dataset of Jamshoro Campus 12708, 15175 and 18251 student records from 2015, 2016 and 2017 academic years. Thus, it was observed 2015 and 2016 that the 10 is the maximum selection of program of study but in 2017 the policy was changed. Admission office offerd 15 choices of program of study. In Figure 5.12 shows the 2017 choices , we observed that to increase the3 choices not effective as much for seat utlization.

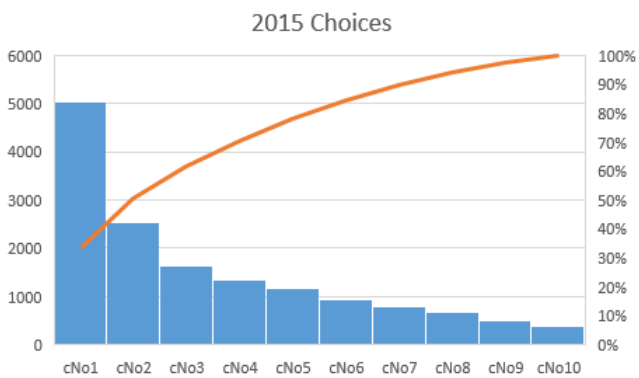

Figure 5.10: *Candidate select the choices in 2015*

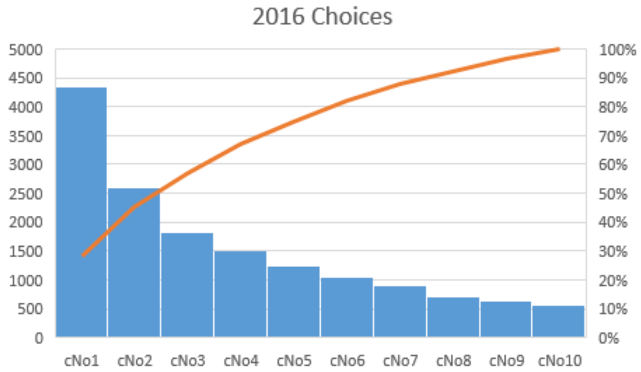

Figure 5.11: *Candidate select the choices in 2016*

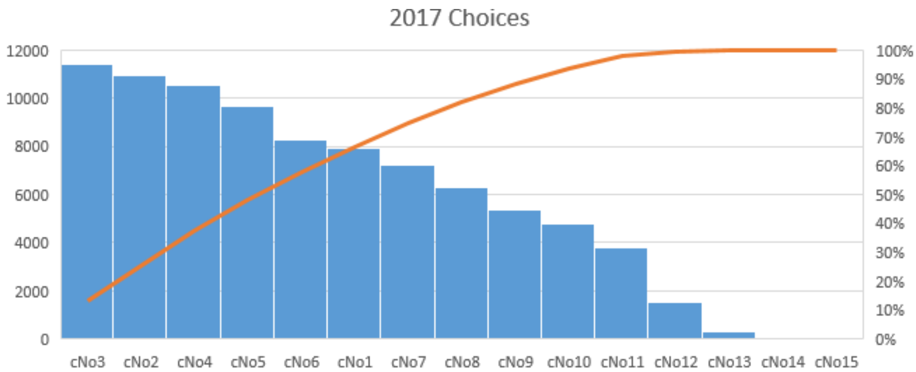

Figure 5.12: *Candidate select the choices in 2017*

5.9 Distribution of Left Over Seats

In Figure5.13 shows the results of 2016 , we make a prototype for left-over seats which is describe in the Chapter 4 Section 4.3 that achieve better results compare to 2015 which is shown in Figure 5.13. Thus, from the experiment it was observed that 14% seats are more consumed in Arts faculty, 6% seats are more increase Commerce and Business, 30% increase in education, 10% in Islamic Studies, 2 % in Law, 16% in Natural Sciences, 8% Pharmacy and 15% in Social Sciences.

In Figure5.14 shows the results of 2017, that achieve better results compare to 2016. Thus, from the experiment it was observed that 8% seats are more consumed in Arts faculty, 8% seats are more increase Commerce and Business, 10% increase in education, 10% in Islamic Studies, 2 % in Law, 15% in Natural Sciences, 3% Pharmacy and 5% in Social Sciences. same prototype used in 2017 the results is was improved.

In summary, our designed prototype utilized more seats but it has some issues so may be need to change some policies for seat utilization. For the maximum seat utilization, we suggested the another policy that is more effective which is mentioned in Chapter 4.

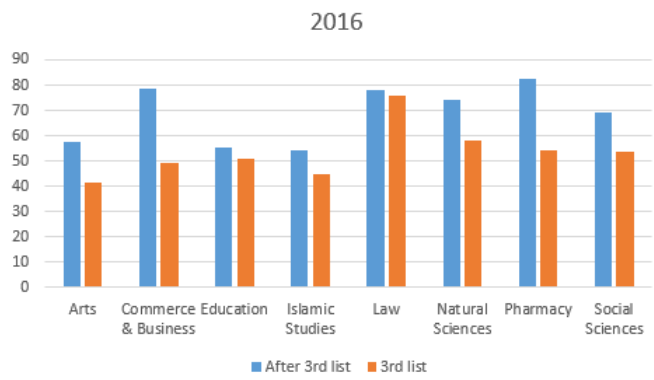

Figure 5.13: *Distribution of left over seats in 2016*

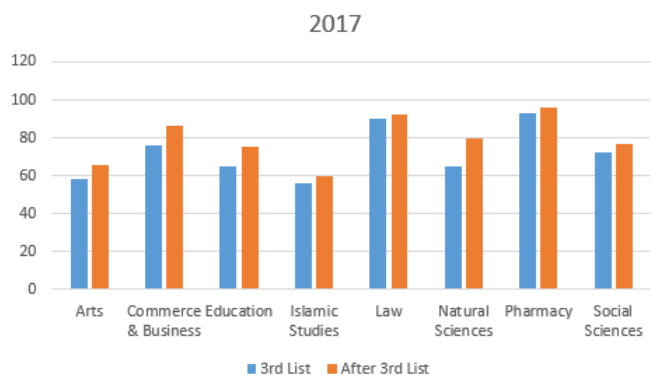

Figure 5.14: *Distribution of left over seats in 2017*

Chapter 6

Summary and Future Directions

This chapter discusses a brief summary of this research work and gives future research direction. It contains the conclusion drawn on analyzing the selection system and major contribution of proposing a solution for all public sector universities in Pakistan.

6.1 Conclusion

Thousands of students apply in each general public sector university of Pakistan. Each university is offering many degree programs every each in different disciplines. The admission process in every general public sector university is same. It is very difficult to filter out eligible and valid student application from thousands. In addition, each student can apply for admission in multiple disciplines. The task of creating merit list of students became very important due to complicated criteria and different seat distribution for student of each discipline. This research proposed a model based solution with general purpose algorithm for this problem. This research model a choice selection system for public sector universities in Pakistan. Specifically, this research chose the *University of Sindh Jamshoro* as a case study in this thesis, where thousands of applicants seek admissions to various undergraduate and postgraduate courses every year. This research describe the case study by considering scenarios of managing admissions for the undergraduate courses against various categories (e.g., General Merit, Self-Finance, etc). The underlying model of the system is represented as a meta-model using UML class diagram notations. Such a model is exploited while designing the algorithm that generates the selection list. Also, discuss the results with respect to seat utilization in two years of admission after implementation of this system in University of Sindh Jamshoro. A prototype of admission system is also proposed for left-over seats. This prototype leads the admission process towards maximum utilization of the seats.

6.2 Future Work

The proposed choice selection system has a room for the improvement in terms of seats' utilization and usability. Based on the results, we intend to place certain more constraints (e.g., increasing the minimum number of choices for courses) on the system to improve seat utilization. Also, a more interactive model for the users can be considered. Such as adopting an on-line open-house based process to utilize the left-over seats for the prospective students.

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