Assessor Matching & Assessment Scheduling
An Applications for IQA System

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Abstract

A recommending system plays an important role in daily life, and has become a valuable technology in various industries such as Youtube, Netflix, Facebook, etc. The recommending system, however, has an internal mathematical mechanism and is more alike to Artificial Intelligence. Recommending system learns from patterns or clustering from observations, and recommends a value or a solution. Most of the recommending system is Machine Learning constructs. Thus, the recommending system can support users to decide easier.

In addition, there are specific cases that other algorithms can be suitable used apart from machine learning based. Association rule based classification sometime can overcome specific datasets and business problems.

Presently, there are many business problems which unnecessarily consume cost and time. For example, Internal Quality Assurance (IQA) of KMITL has the problems that cannot be optimized for now. The problems such as lack of suitable committees, poor schedule management, and cluttered and inconsistency database, which must be resolved or mitigated as much as possible.

Ultimately, in this project, we build web application and database system for IQA. Web application consists of three main features which are database management, matching system and scheduling system. Matching system uses various approaches to construct a powerful recommendation system, which popular approaches such as Rule-based and machine learning base will be applied in this part.

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Chapter 1
Introduction

This chapter provides an introduction to the thesis about implementation of the proposed system, an assessor matching & assessment scheduling: an application for IQA system. The motivation and problem description is firstly described, following by the overview of the proposed system. Furthermore, this chapter also includes the objectives, the scope of work, and concludes with an overall outline of this thesis.

1.1 Motivation and Problem Description

First of all, before going through the system. There are few things need to be clarified which are terminology and how the actual basic process is working for Internal Quality Assurance (IQA).

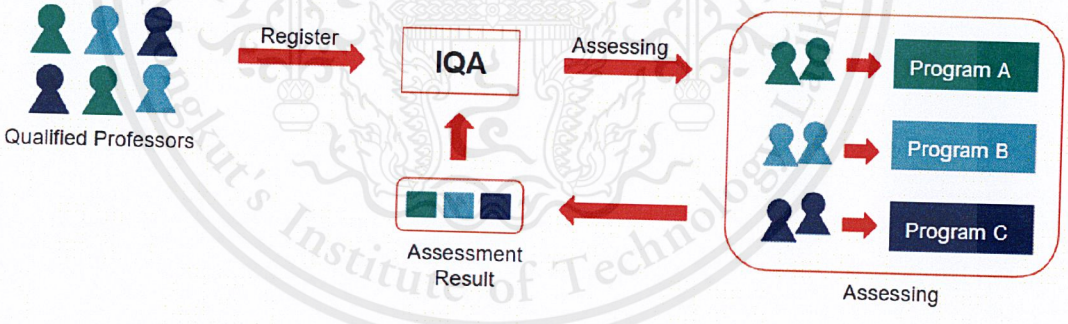


Figure 1.1: Internal quality assurance process

Internal Quality Assurance (IQA), is the department in the college that is responsible for assessing the quality of the programs, faculties, and college. It main job is to send a professors who have been qualified as an IQA committee to assess the programs or faculties. After the assessment, these committee will provide an IQA team a result of the assessment. The result will be used to adjust, develop, and improve the programs, faculties, or the college.

Hence, to do an assessment of every programs, faculties, and college. It requires a huge amount of data collections whether it is an information of the programs, the committee, or the assessment result. Therefore, it is quite exhausting for the IQA team to handle and organize the following information. However, handling and organizing the data are not IQA team's major responsibility, it priority is to make use of an information and prepare an assessment schedule.

As mentioned earlier, three major problems arise, they are caused by inappropriate data handling. First, the data is unorganized. Second, affected from the first problem, it is complicated to retrieve an information from a dislocated data. Last, affected from the first two problems, it is difficult to make use of the data or information which is the final goals of this system.

To be precise on each problem, first, the dislocated data. IQA team itself does not have a database system that collect all of the data. A current way of collecting the data of the IQA team is to store it in an excel file or the paper format. Moreover, each member keeps their own version of the excel file as well. This leads to the problem of lost update.

The second major problem is the complication of an information retrieval. This problem is the consequences from the previous problem. When the other department or IQA team itself are requesting (or requiring) information such as "What is the program A's assessment result in 2016?" or "Can I have the current list of the IQA committee this year?" It is difficult for an IQA team to find an information regarding to the questions. In addition, even if the information has been found, the team has to check whether it is the latest information or not.

The last problem, making use of the data or information. Apart from the data collection issues, IQA committee also faces another problem regarding to the matching of an IQA committees with the programs (or faculties) that they are going to assess. Some of an IQA committees have been matched to assess many programs, however, some of them do not have to assess any program at all. This leads to the problem of bias. For example, if there are two committees who have been assessed ten programs and the college have hundred programs, it means that ten percent of this college's programs are assessed by the perspective of only two people. Despite of that, there also another problem regarding to the recommender system, sometime both of the IQA committees do not have background related to the program they are assessing at all. This might leads to the problem of false judgment as well. However, since there is no database system that collects all the data together, it is almost impossible to make a visualization, prediction, or suggestion out of the data for the IQA committees to match with the suitable programs

to be assessed.

1.2 Proposed System

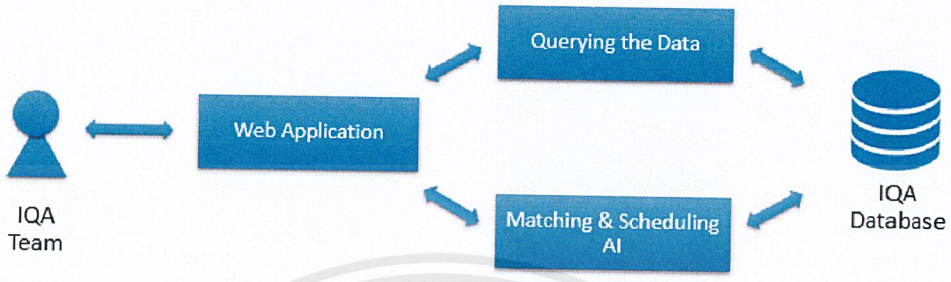


Figure 1.2: Overview of proposed system

Assessor Matching & Assessment Scheduling: An application for IQA System, as it is named, the project aim is to create a system which supports an IQA department's work. However, the system major focus is a matching and scheduling system for IQA committees to assess the suitable program. Hence, to create such a system, it is a must to create a database system which collects necessary information first. Therefore, this project is consisted of three parts where the final goal is to create the matching and scheduling system.

First, the database system for IQA, it will collects all the information necessary for an IQA department. It aims to re-organize and digitalize the data in order to make it more convenient for the future use.

Second, the web application which allows the IQA department to access and interact with the information efficiently. It also allows an IQA department to retrieve an information easily as well.

Third, it is final goal of the project which are matching and scheduling system. It aims is to suggesting the IQA department the best match between IQA committees and the assessed program. It will select the one which yields the most efficient result. It is calculated by several factors such as committee's background, past assessment, or assessment schedules. The system also do it best to spread the IQA committee work (assessing the program) equally and create the most efficient schedule out of it.

1.3 Objectives

An objective of this project is to develop a system that supporting an IQA department with information management and suggesting the schedule for IQA committee assessment. These following goals are set to be achieved, in order to indicate the successfulness of the project:

- IQA database system must be created, it must be usable and contains the necessary information for the IQA department to work with.
- Web Application for IQA must be created, it must be able to access and interact with the IQA database. It should also presenting the necessary information to the user.
- Web Application for IQA must presents only the information that users allowed to access.
- Web Application for IQA must be able to export an information out to other a different file's format.
- The matching and scheduling system must be able to make use of the data from the IQA database and make the suitable suggestion for the IQA committees assessment.

1.4 Scope of Work

The proposed system is designed to work under the scope as follows:

- The system is an isolated system which will be used only within IQA department or staffs related to IQA dapartment.
- The system is not related to any existing system in KMITL.
- The system is currently supporting only the information of the programs neither the faculties nor the college.
- The recommender system will only be able to match the IQA committees with the programs.

Expected benefits of this system is that the system will be used as a prototype web application for IQA in the next academic year. If it is found to be useful, the system will be proposed for further development and will be used as one of the system in KMITL.

1.5 Thesis Structure

The rest of the thesis are organized as follows:

- **Chapter 2** includes literature reviews and related works.
- **Chapter 3** points out the necessary background knowledge to be understood before implementing this system.
- **Chapter 4** illustrates the system architecture design, user interface and interaction with the web application.
- **Chapter 5** describes the system and the proposed methodology in detail, by providing information, methods, and algorithms to develop the system.
- **Chapter 6** shows and discusses the results for the web application.
- **Chapter 7** summarizes the proposed system and the thesis content, along with suggestions for further improvements.

Chapter 2
Literature reviews

This chapter describes the related works of this project and guidelines of the previous work, which can be used to improved this project. The literature reviews and related works part consist of several recommender system's algorithm and other materials that have been used to developed the system.

2.1 Machine Learning Algorithms for Recommender System - a comparative analysis

Satya, Anand, and Mahendra has proposed the comparative analysis of machine learning algorithms for recommender system in[1]. The implementation of the system can be performed by various techniques. In the paper, they have discussed Content Based Filtering, Collaborative Filtering, Hybrid Content-Collaborative Based Filtering, k-mean clustering Based and Naive-Bayes Classifier based techniques.

They have used the MovieLens dataset and applied all the above algorithms to this dataset in order to recommend the movies and calculate the precision along with tackling the cold-start problem Cold-start problem in the recommendation system is also known as the new user problem as it creates problem of generating recommendations for the new user.

The Content Based Filtering considers the items rated by a user to formulate the future recommendations. His ratings determine his inclination and interests in order to form the basis for recommending a new item. The rated items serve as the 'content' in the Content Based Filtering. Therefor, a new item is recommended according to the maximum number of ratings given by the user in a genre.

The Collaborative Based Filtering is the recommendation for a user is governed by other users' profiles. An item is recommended based on the ratings of other users who have similar interests as the user under consideration. This similar pattern of their ratings with the user guides the Collaborative Filtering. The notion behind the Collaborative

Filtering is the recommendation of an item based on the preferences of like-minded users.

A Hybrid Filtering method is used for better precision purpose which can provide the advantages of both the content and the collaborative approaches. Suppose, the user appreciates mostly movies in $g \subset G$ genres, and the collaborating users also give high ratings to the $g \subset G$ genres, then g will be taken as the metric to recommend movies to the user.

The k-mean clustering is a non parametric classification technique, the similarity between the objects is calculated by the means of various distance measures such as Euclidean distance, Pearson Correlation, etc. The value of k determines the number of clusters to be formed. The nearest k objects are the most similar to one another. These clusters of similar objects drive the recommendation of new arriving objects. This proximity is being measured by using the Euclidean distance. In order to calculate the Euclidean distance they set rated and unrated movies as binary. Each cluster possesses the mean of all the items in the cluster as a centroid. All the objects in a cluster move towards the centroid and the centroid is updated in each iteration and keep continues until a saturation point arrives, then the centroid stops altering. By following this approach they are decreasing the search space which results in reduced computational complexity.

The Naive Bayes is based on the Bayes theorem. The probabilistic approach which is conditional probability based classifier followed by Naive Bayes Classifier determines the probability of the classification and helps in finding the uncertainty about the model. It is an efficient learning algorithm which uses the prior knowledge of the observed data. The Naive assumption is that the features are conditionally independent.

They have illustrated the analysis of the experiments performed and provide a comparison of all methods in order to compare their accuracy. They used the MovieLens dataset of 10K, 50K and 100K. The analysis of these algorithms is demonstrated based on precision measure. For each test user, they convert 30% of the user's seen movies into unseen movies and apply the described algorithms. Out of the total number of recommendations(T), the ones which are also present in the converted movies are the correct recommendations(tc).

All approaches described in the paper are compared with respect to their precision rates. The comprehensive analysis depicts the strength and the weakness of each one of them in different versions of the MovieLens dataset. According to their experiment results, Naive Bayes gives the best precision compared all the algorithms.

2.2 A Review Paper on Machine Learning Based Recommendation System

Recommendation system has a lot of approaches that have been used to build a suitable model for the system. Therefore, the paper has been proposed by Bhumika Bhatt, Prof. Premal J Patel and Prof. Hetal Gaudani to determine limitation and performance of popular techniques.

In present, the techniques that are mostly used which are Collaborative Filtering system, Content based system and Hybrid system. Each algorithms use different approach such as rating or content information. Collaborative Filtering system and Content based system, however, are suffered from same limitations. Several researches have been trying to overcome the limitations by combine those two algorithms into Hybrid system that combined rating as well as content information Recommendation system will always remain active search area for researchers[3].

Several recommendation systems have been anticipated are base collaborative filtering, content based filtering and hybrid recommendation methods and so far most of them have been able to resolve the problems while providing improved recommendations. However, due to information explosion, it is required to work on this research area to explore and provide new methods that can provide recommendation in a wide range of applications while considering the quality and privacy aspects. Thus, the current recommendation system needs enhancement for present and future requirements of better recommendation qualities[3].

2.3 Recommendation Systems Based on Association Rule Mining for a Target Object by Evolutionary Algorithms

Online business success highly relies on the ability to present personal goods, services, and information items to the potential customers. This result in willigness toward recommender systems. Through statistical methods and knoweldge discovery, these systems present services to the customers. Collaborating filtering system is one recommender system presents recommendation through detecting similar users based on enter date and previous transactions[6] The paper reviews the previous studies in this area and examines the steps and resulted findings. The Adaptive-Support Association Rule Mining (ASARM) has been proposed, in this algorithm, rule generation has been

done by a CBA-RG algorithm which is the evolutionary version of the Apriori algorithm. Another algorithm proposed based on ASARM is the multi-objective particle swarm optimization association rule mining (MOPSO-ARM). This algorithm tries to remove the shortcomings of ASARM. In Particle swarm optimization each rule is taken as one particle. Another algorithm similar to MOPSO-ARM has been proposed which is the association rules mining algorithm through genetic algorithm. It has been stated that by using a genetic algorithm, the speed and exactness of the MOPSO-ARM were improved. The quality of generated rules is measured through Relation. [6]

In conclusion, the recommender systems and among existing methods are studied, the introduced algorithms were compared focusing on collaborating filtering based on association rules mining. Adaptive-Support Association Rule Mining has low efficiency because it produces the rules many times. Then the evolutionary algorithms and the concept of multi-objective optimization functions are put in this algorithm and Multi-Objective Particle Swarm Optimization Association Rule Mining and Association Rule Mining were analyzed by genetic algorithm.The criterion for choosing ARM and improving the recommender systems are appropriate for further studies. Clearly, there can be more methods to improve accuracy and performance of this systems because the results of prior works show that the accuracy of this system was less than 70% and runtime of them takes a long time yet. [6]

2.4 Application of Content-Based Approach in Research Paper Recommendation System for a Digital Library

Nowadays, information has been growing continuously, Digital library users have faced the obstacle in which difficult getting of finding suitable digital objects (e.g. research papers) from a large collection of digital objects in digital libraries. Thus, a recommender system becomes an important necessity in the design of digital libraries. This would support library users in getting accurate digital objects. Collaborative-filtering technique is ineffective in domains where items (e.g. research papers) are more than users. The paper said that users are not willing to spend time to rate items explicitly. Hence, content-based approach is adopted for the design and implementation of research paper recommender system. This approach does not depend on the ratings of other users but uses the contents describing the items and the users' taste or needs.[7]

In this paper, researchers use several algorithms within content-base approach suchas Keyword-Based Vector-Space Model, Item Representation, and TF-IDF and Cosine Similarity.

The results obtained from the developed system were compared with the results of a digital library without recommendation feature and found to be correct and with even additional features that are not available in the digital library. The results therefore, are in conformity with most of the literatures reviewed. Thus, the research paper recommendation system integrated in the digital library has numerous advantages over the ones without recommendation feature.[7]

2.5 Object-Role Modeling (ORM/NIAM)

Object-Role Modeling (ORM) is a primary method for modeling and querying an information system at the conceptual level. In Europe, the method is frequently called NIAM (Natural language Information Analysis Method).

ORM includes procedures for mapping between conceptual and logical levels. ORM focuses on data modeling, since the data perspective is the most stable and it provides a formal foundation on which operations can be defined. The ORM is termed because it pictures the world in terms of objects (entities or values) that play roles (parts in relationships).

Commonly, ORM is more expressive than ER or OO. Its role-based notation makes it easy to specify a wide various constraints, ORM's object types reveal the semantic domains that bind a schema together. One benefit of this is that conceptual queries may now be formulated in terms of schema paths, where moving from one role though an object type to another role amounts to a conceptual join on which operations can be defined[4].

Ultimately, this article provides a brief history of ORM, summaries of the ORM notation, illustrates the conceptual design and relational mapping procedures, and mentions some recent extensions before concluding.

To sum up, the article has provided only a brief sketch of the ORM method, emphasizing its fundamental features and touching on some of its advantages. Apart from its sound theoretical basis, the method has been used successfully in many countries, on applications from the small to the very large. The recent emergence of intuitive and powerful ORM tools has led to wider adoption of the method, which is now being successfully taught as early as high school level. Perhaps the greatest strengths of ORM are that it lifts the communication between modeler and client to a level where they can readily understand and validate the 12 application model using simple sentences, and that it has been designed from the ground up to facilitate schema evolution. This second advantage is very relevant to today's business world where change is ongoing[4].

Chapter 3
Background Knowledge

3.1 Introduction

As it is mentioned in an introduction that we are creating the website for IQA team which help facilitating their work such as storing data, querying an information, and arranging an IQA committee assessment schedule. However, it would be meaningless if there is no one understanding an idea behind the development of this system. Therefore, throughout this background knowledge section, an information about all of the concepts and knowledge that were used to create such a system will be provided. This section will be mainly splitted into 3 parts which are data handling, applying web technology, and the recommender system.

3.2 Data Handling

First, data, as it is stated in the introduction that we are designing a database system for handling an overwhelming data with a different format and versions of the IQA data. Therefore, it is necessary to know what exactly is the database system and why are we using this technology to store the IQA data.

3.2.1 Database System

Database system[5] is a system that collect a various related data together, in which the system has a clear relationship between each data. In the database system, it consists of many folders that has the data that is related together systematically. It allows the user to make a use of the data and protect it efficiently.

By using database as a substitution for paper and excel files it helps facilitating IQA data management in several ways such as:

- Organizing and collecting the data together in the database system

- Avoiding lost update problem
- Reducing the risk of the data being damaged or lost
- Saving the actual spaces to collect the data

3.2.2 Database Design Technique

Equally as database design technique can be as important as understanding the database technology. It is considered to be one of the hardest parts to create an efficient database system. We have to really understand each and every data that were given to us, as well as its relationship with the other data. One of the popular methods for designing a database is Object Role Modeling or ORM. It is the concept that focusing on finding a unique data, usually called "primary key" or "unique identifier", that represents the object in the real world and connecting it with a related data to create the database object out of this unique data and its related data. However, it is possible that related data can be a unique data for another object as well, in this case, it occurs the relationship between data which can be either one-to-one, one-to-many, or many-to-many relationship. For example:

1) one-to-one relationship: one man can only date one woman at a time, vice versa.
2) one-to-many relationship: one house can have many rooms, but many rooms can be in one house.
3) many-to-many relationship: students can have many teachers, vice versa.

Therefore, during the design process, it is necessary to consider the relationship of the data and the scope of an environment of the system carefully. Note that the relationship of the data can be affected by the system environment as well.

3.2.3 Alternative Methods for handling the data

In addition, there is the other way to design the database system without even touching the database concept too. It is to use the concept of Object Oriented Analysis and Design (OOAD). It is the concept which try to understand the real world application and realize it as an object, then define its relationship. It is similar to Object Role Modeling (ORM), but it is focusing more on the software design aspects.

3.2.4 Why applying the database concept?

The reason behind the database designed is to define a right format to create an excel file for IQA team to fill in an input of the actual data in order to transfer it into the database. Moreover, there also a reason that IQA team cannot fill the data directly into the website for now. It is because of the unstable application design or minor details in the database that might be adjusted later which will definitely affect the system if the actual data has already stored in the database. Hence, it has been decided for all parties that such a risk of data lost or damaged must be avoided as much as possible.

However, to manage a data inside the database, it is requiring a database management system or DBMS which require some amount of knowledge that is intricated to acquire by everyone. Hence, the solution to this problem is to create a website that interact with a user and be able to handle the complicated interaction with a DBMS instead of user. This will be further discussed in the next topic.

3.3 Applying Web Technology

Following from the previous topic, as the data has been handling. Web technology plays the second part, it acts as a medium between users and data. Despite of being a middle man, it also able to provide its own services such as data manipulation, doing the computation, or facilitate the user with its own functionalities as well. However, it is necessary to clarify an overview of web technology first, to ensure that the same understanding with the readers toward web technology are reached.

3.3.1 Web Technology

Web technology is one of many services that is provided by internet, it is the communication between two computers via protocol called "HTTP" or "HyperText transfer protocol", in which this protocol will decide on the rules of communication. We use a type of program called "Browser" as a tool for this communication. As the HTTP protocol process is a client and server, hence there must be at least two computers to create such a communication as it is shown in a diagram below.

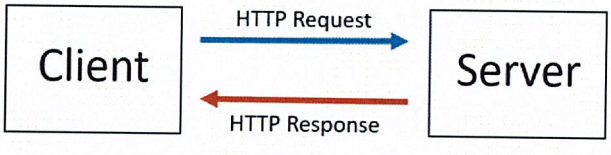


Figure 3.1: The communication between client and server via HTTP protocol

As the diagram shows the communication between client and server via HTTP protocol, to open the webpage using program Browser will have following steps.

1. Client, which currently is a web browser, will connect to the server using socket.
2. When the socket from both sides successfully connected, the client will send the request, or HTTP request to be precise, to the server where server will find the information that client has been requesting no matter it is existed or not. No matter what, the server will always return a client the response, or HTTP response, except when the connect is lost.
3. After the client receive the response, the connection will be terminated.

Therefore, when we are requesting for a web page there might be several requests from the client to the server. It is a consequence after client received a html (hypertext markup language) file from server and browser is translating HTML language, it is possible that the browser found that the web page is requesting for many other information. However, as soon as all the information have been downloaded to the client, the connect will be terminated as it is presented in the diagram below.

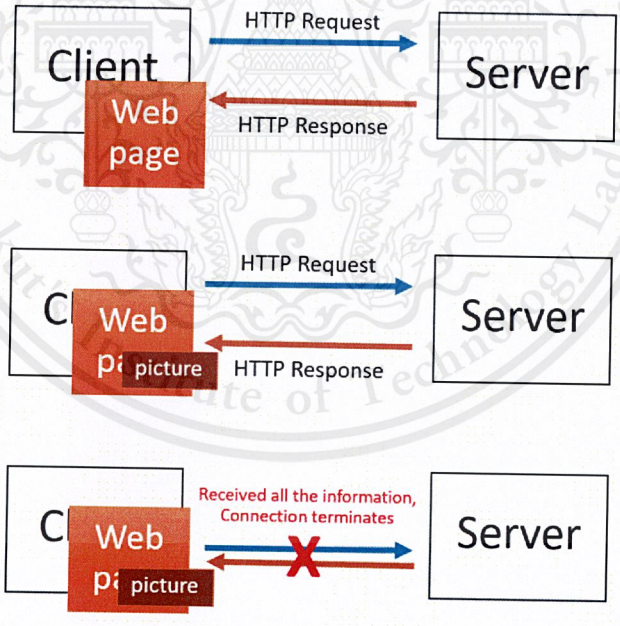


Figure 3.2: Steps to open the webpage using program browser

Hence, it is applicable to apply such a technology to our system, where the IQA database will also be hosted on the server. As a result, the clients can be any computer that have an internet browser to request for a beautiful web page with an information

from the server. Despite of the pros, that the web application can be accessed easily, it also save the memory of the computer and avoid the several problem that might cause during the program installing on computer as well.

3.3.2 Web Framework

However, writing a code in pure html, decorating it in css, and using pure javascript or jquery for doing a computation or rendering the page might give a hard time for developer. Hence, there are a lot of framework out there which are a tools that were used to help facilitating web development. There are the framework that supporting the client side coding (front-end framework), server side coding (back-end framework), web page decoration (css framework) or even web framework that covers all the process of web development as well. Therefore, it is decided that the web framework that will be use to help with the development for this project will be Django. It is the full stack web framework written in python. It will be elaborated more in section 5, the development tools.

3.4 Recommender System

A recommender system or a recommendation system is a system that predicts rating or preference. The system makes a prediction based on several factors such as user's information, item's information, implicit and explicit of user's behaviors and etc. There are several methods or algorithms to create recommender system, difference of approaches create difference of workflows. Nowadays, there are two popular approaches, which are collaborative filtering and content based filtering. These two approaches also contain sub approaches inside of each of them.

Referencing back to this project, the website make uses of the data from the database and rating matrix information to create a recommendation system for the IQA Committee. Four committees that are the most suitable for assessing the study program will be selected by the recommendation system. Note that two of the committees will be the committee that already had the assessment records while the other two are not. This will be further discussed in section 5, the recommender system.

Chapter 4
Requirement Analysis, Design and Architecture

This chapter presents the requirement analysis and the design of a system which provide a broader understanding of details and specifications of the system. It contains a system information ranging from the system analysis which compose of requirement and use cases, following by the system design, and ends with the system architecture.

4.1 Requirement

4.1.1 Requirement Analysis

In this system, users are the IQA team members and the staff who responsible to the issues regarding to the IQA from each faculty. The system is provided the users with an information regarding to the study program and its assessment result. It also assisting the users with the problem regarding to the study program's quality assessment as well. Thus, the following will be the description of what users' are requesting for.

Handling Information Easily

Instead of running around to find the IQA information that collected in the separated places with a difference format, the users can check these information through the website. The user, which is the IQA team members, can visit the website and be able to manipulate the IQA information. Exporting an information out into the excel format also a must for the system, in case of the IQA information is required to make a conference. Therefore, all these IQA information should be stored in the database, where everyone that is relating to IQA can share and use it.

Assisting IQA Task

With the current working process of assessment, IQA team are not able to keep track of the appointment between the faculty and its assessment appointment with the committee. Therefore, there should be a share assessment schedule between both parties. The website should be able to take care of these assessment appointment process for the IQA. Changing in the status of the study program also should be noticed, in case of not enough responsible professor of the study program

Inbox

It might be easier than call or walk across the building to the IQA department for any issues, questions, or reports for IQA department. Therefore, the users should be able to contact each other through the website. The message box would be fine.

IQA Committee Recommendation

For the current process of assessment, the faculty member is the one who making an appointment with the committee. However, with a lack of information or any other reasons, there are a problems of selecting an IQA committee as it is mentioned in the prior sections. Therefore, committee recommendation might be a good alternative and good start to adjust this process of the assessment to be better. Hence, the system should be able to provide some IQA committee recommendation for the study program.

4.1.2 Requirements as FURPS

Requirement ID	Requirement Description
1. Functional	
1.1	The system must be able to present the user an information about the study programs, professors, IQA committee, and assessment results.
1.2	The system must be able to filtering the data and shows the result according to the filter.
1.3	The system must be able to insert and update the information about the study programs, professors, IQA committee, and assessment result.
1.4	The system must be able to export the data out from the database to a different format, especially in csv format.

Table 4.1: Table of requirements set

Requirement ID	Requirement Description
1.5	The system must be able to recommend the IQA committee for the study program.
1.6	The system must be able to notify if there is a change in the status of the study program (i.e. not enough responsible professor, to open the study program).
1.7	The system must be must have an inbox system for the IQA to communicate with the other users.
1.8	The system must allow the faculty members to create an assessment appointment for the study programs.
1.9	The system must provide the schedule that notify all the existed assessment appointment.
1.10	The system must be able to notify if there is any committee conflict within the assessment appointment.
1.11	The system must allow the faculty to edit its own study program.
2. Usability	
2.1	The webpage must be user friendly.
2.2	The webpage must have the navigation.
2.3	The webpage must have a Frequently Asked Question (FAQ).
3. Reliability	
3.1	The system must have the functionalities for backup in case of system failures.
3.2	The system must be able to handle the basic authentication problem.
4. Performance	
4.1	The system must be able to handle multiple users at the same time.
4.2	The information update in the site should be as fast as possible.
5. Supportability	
5.1	The system must be able to support the computer webpage.

Table 4.2: Table of requirements set(cont.)

4.2 Use case

4.2.1 Use Case Diagram

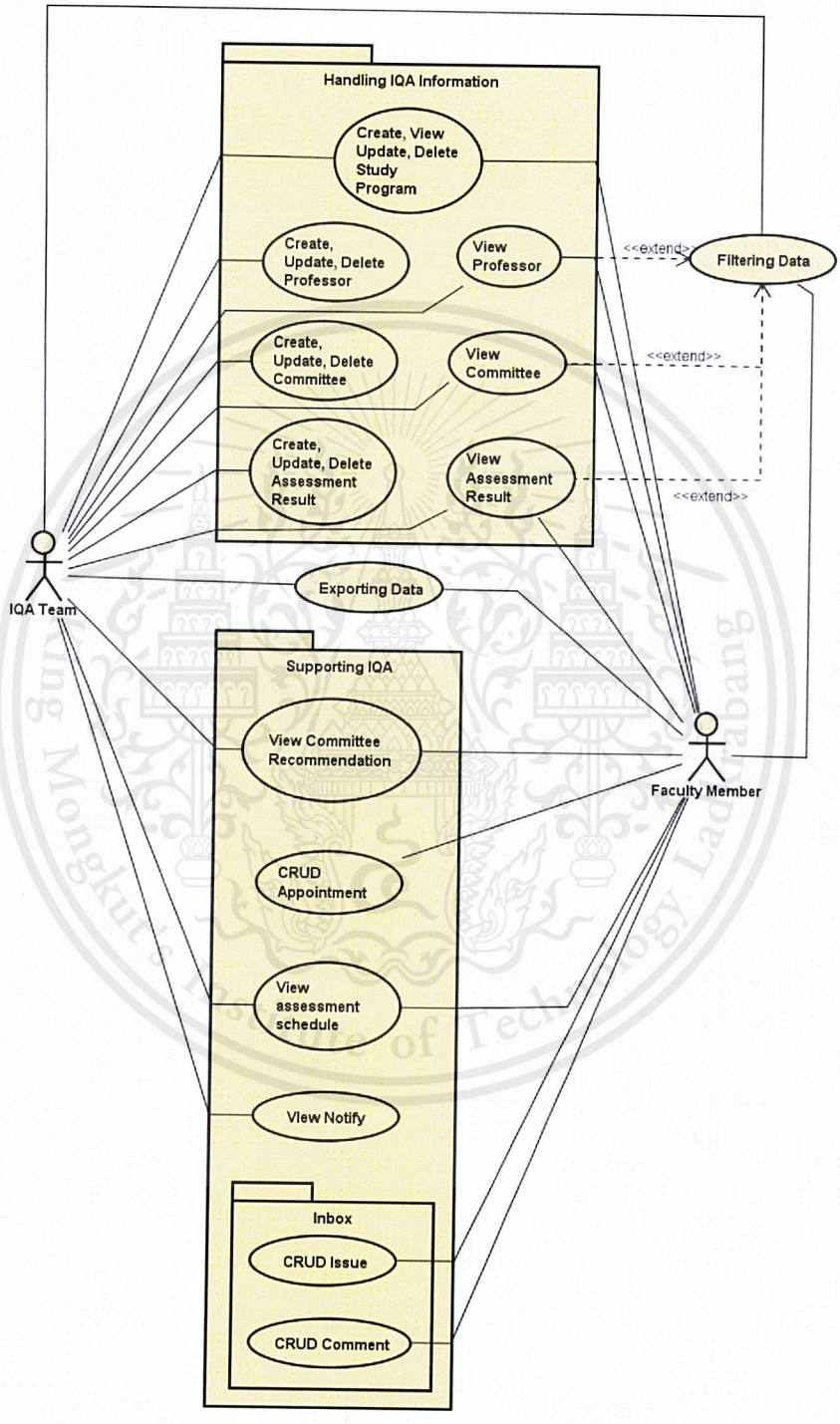


Figure 4.1: Use case

4.2.2 Brief Use Case

1. **View Study Program**: The user (IQA Team, Faculty Member) must be able to see the details of the selected study program.
2. **Update Study Program**: The user (IQA Team) must be able to update the details of the selected study program. As for the user (Faculty Member), the user can only update its own faculties' study programs.
3. **Insert Study Program**: The user (IQA Team, Faculty Member) must be able to add new study program to the system.
4. **Disable Study Program**: The user (IQA Team) must be able to disable a study program that will no longer be used.
5. **View Assessment Result**: The user (IQA Team, Faculty Member) must be see the details of the selected assessment result.
6. **Update Assessment Result**: The user (IQA Team) must be able to update the details of the selected assessment result.
7. **Insert Assessment Result**: The user (IQA Team) must be able to add new assessment result to the system.
8. **Disable Assessment Result**: The user (IQA Team) must be able to disable an assessment that will no longer be used.
9. **View Professor Profile**: The user (IQA Team) must be able to view the selected profile of the professor.
10. **Update Professor Profile**: The user (IQA Team) must be able to update an information about the professor.
11. **Insert Professor Profile**: The user (IQA Team) must be able to add new professor profile into the system.
12. **Deactivate Professor Profile**: The user (IQA Team) must be able to deactivate the profile of the committee that no longer works anymore.
13. **View Committee Profile**: The user (IQA Team) must be able to view the selected profile of the committee.
14. **Update Committee Profile**: The user (IQA Team) must be able to update an information about the committee.

15. **Insert Committee Profile**: The user (IQA Team) must be able to add new committee profile into the system.

16. **Filtering Data**: The user (IQA Team, Faculty Member) must be able to filter the data of study programs, professors, assessment results, or IQA committee according to the filter such as faculties.

17. **Export Data**: The user (IQA Team, Faculty Member) must be able to export the data about the study programs, assessment results, or IQA committee.

18. **IQA Committee Recommendation**: The user (IQA Team, Faculty Member) must be able to view the committee recommendation for each study program.

19. **Create Appointment**: The user (Faculty Member) must be able to create the assessment appointment with the IQA committee.

20. **Edit Appointment**: The user (Faculty Member) must be able to edit the assessment appointment with the IQA committee.

21. **View Appointment**: The user (Faculty Member) must be able to view the assessment appointment with the IQA committee.

22. **Disable Appointment**: The user (IQA Team, Faculty Member) must be able to disable the assessment appointment with the IQA committee.

23. **View Assessment Schedule**: The user (IQA Team, Faculty Member) must be able to view the assessment schedule.

24. **View Assessment Schedule Conflict**: The user (IQA Team, Faculty Member) must be able to view the assessment schedule conflict.

25. **View Notify**: The user (IQA Team) must be able to view to notify if there is any change of the study program status.

4.3 System design

4.3.1 Database Design using Object Role Modeling

A scope of the system will be an information that only used in IQA department. Hence, as a result from the object realization, the database system appears to have 5 objects which are:

- Study Program, which is the database about the study programs in KMITL
- Professor, which is a responsible professor or IQA committee
- Committee, which is the professors that are qualified to be the IQA committee
- Assessment Result, which is the result that has been given by IQA committees assessment once a year
- AUN, which is the assessment criteria for the IQA assessment result

where the ORM is designed result as a following diagram.

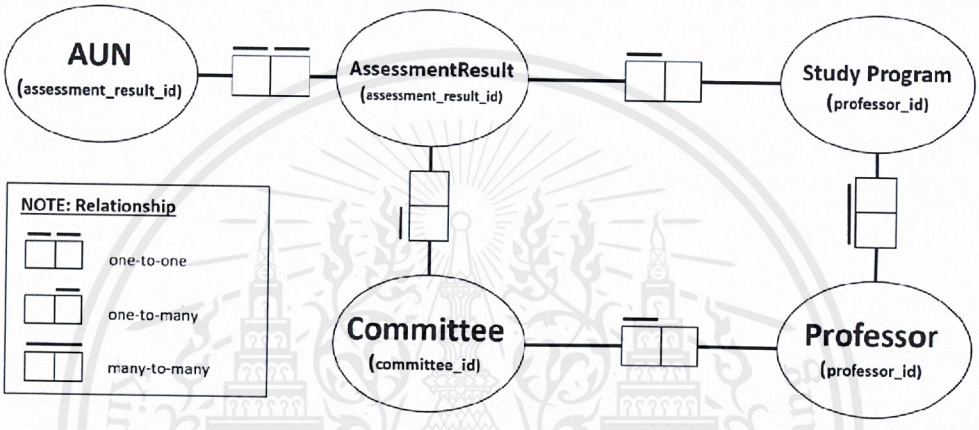


Figure 4.2: Object-role modeling diagram

According to the diagram, it presents several relationship between each object which can be described in a common language as the followings:

- **Study Program:** one study program has many assessment result as there is an assessment every year. Study program also have many responsible professors.
- **Professor:** one professor can be committee for many years. In this environment, it is assumed that each year committee will be reelected. Therefore, it is considered to be a new object. One professor also has many study programs to respond too.
- **Committee:** Many committees, in fact, two committees will be sent to assess the study program and provided an assessment result. Where committee in the different year can be the same professor.
- **Assessment Result:** One assessment result is created from many, in fact, two, committees. Assessment result also be given to study program once a year.
- **AUN:** One AUN criteria will be attached to only one assessment result, vice versa

4.3.2 Business Modeling: Domain Model

The following diagram is the domain model that is used to represent the business concepts and the relationships between them. It shows the type of the users, an actions that can be done by users, and the relationship between the actions and the objects.
Note: the red box is the future work, plus, AUN and CUPT are the assessment criteria.

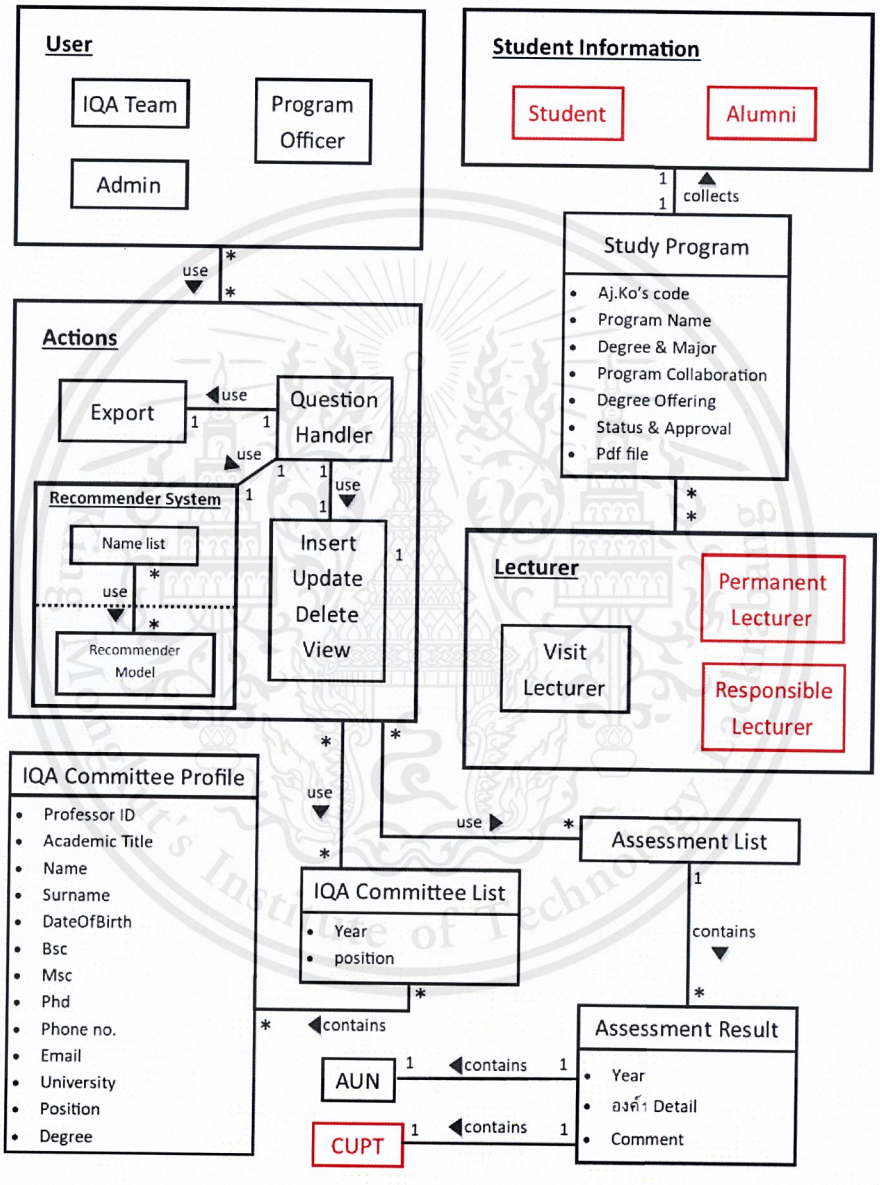


Figure 4.3: Domain model

4.3.3 User Interface Flow

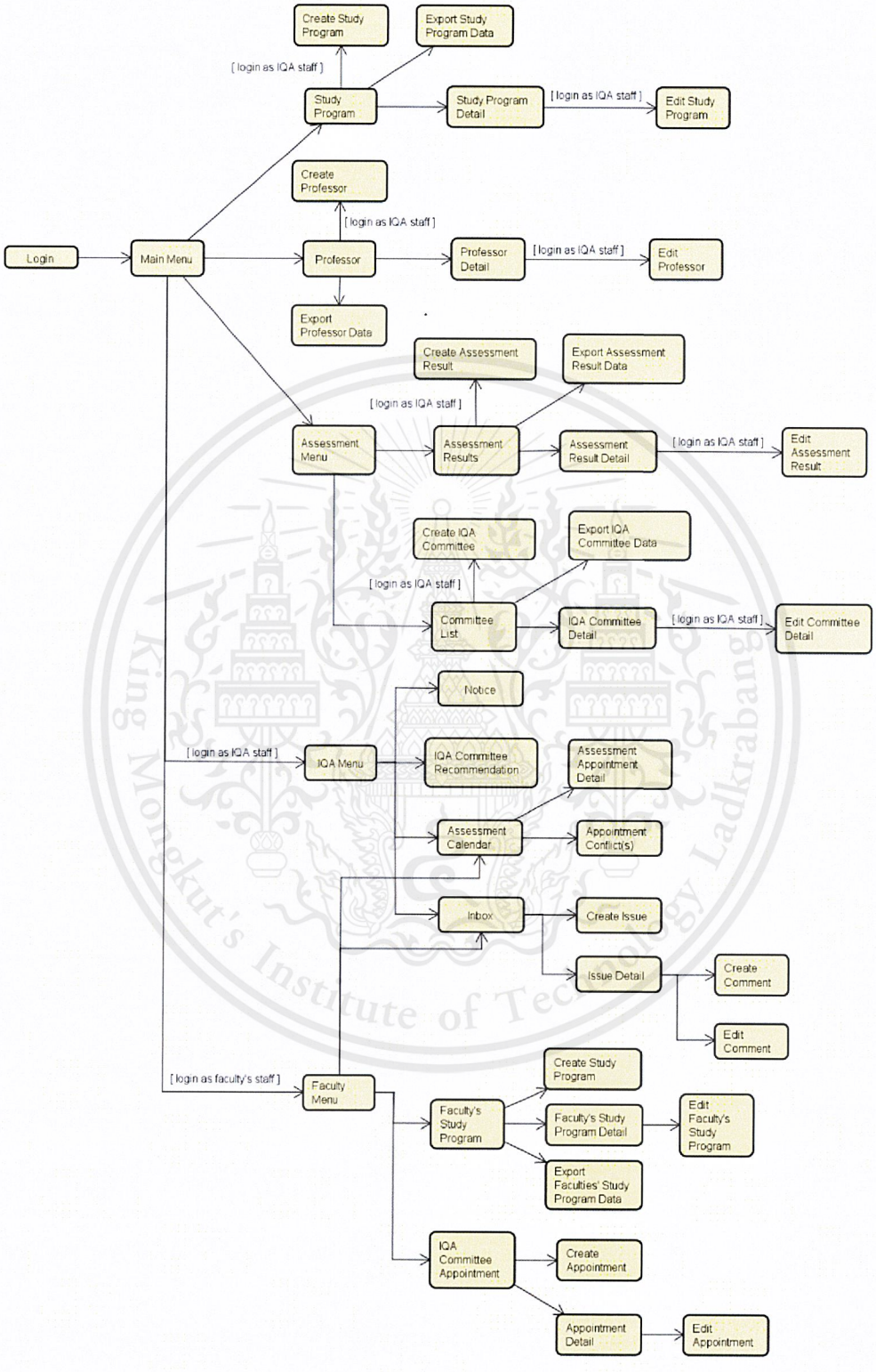


Figure 4.4: Overview of user interface flow

4.3.4 Wireframing

The mockup prototype below was used for a discussion with the client on the first meeting which focusing on the idea of how the website will look like.

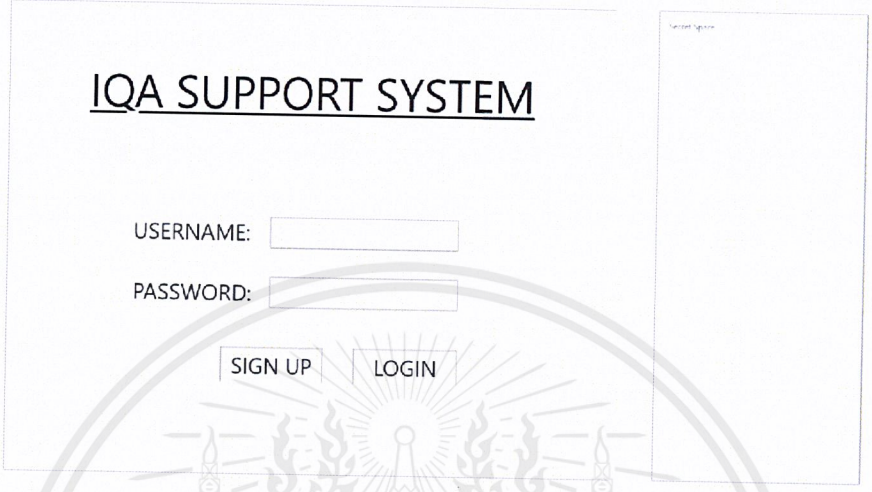


Figure 4.5: Login page

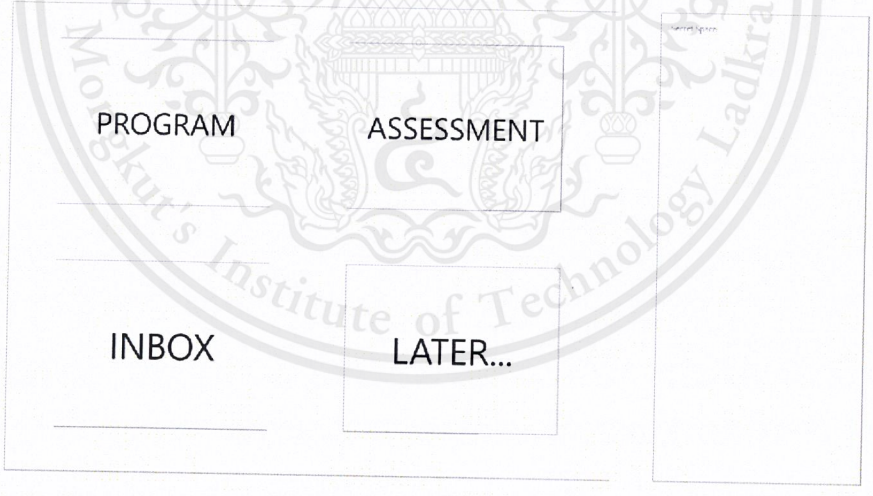


Figure 4.6: Main menu page

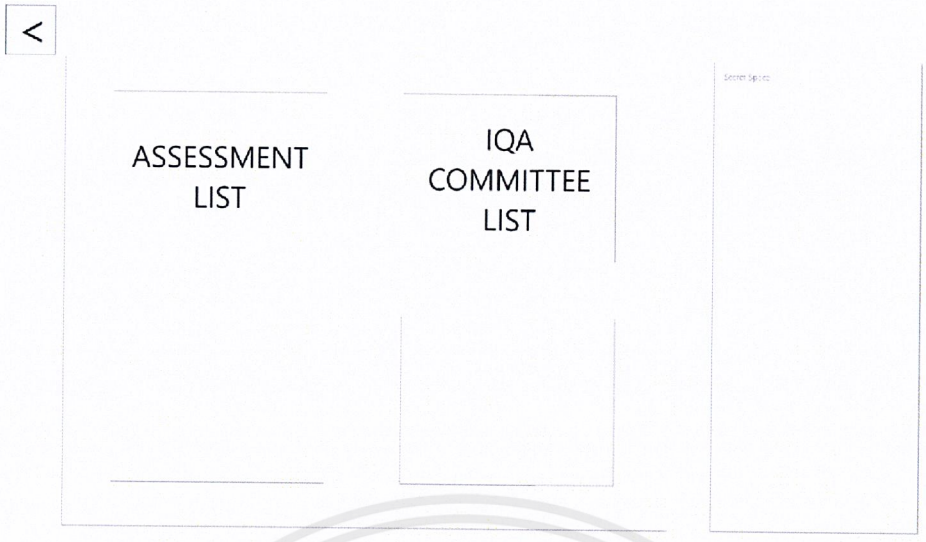


Figure 4.7: Assessment menu page

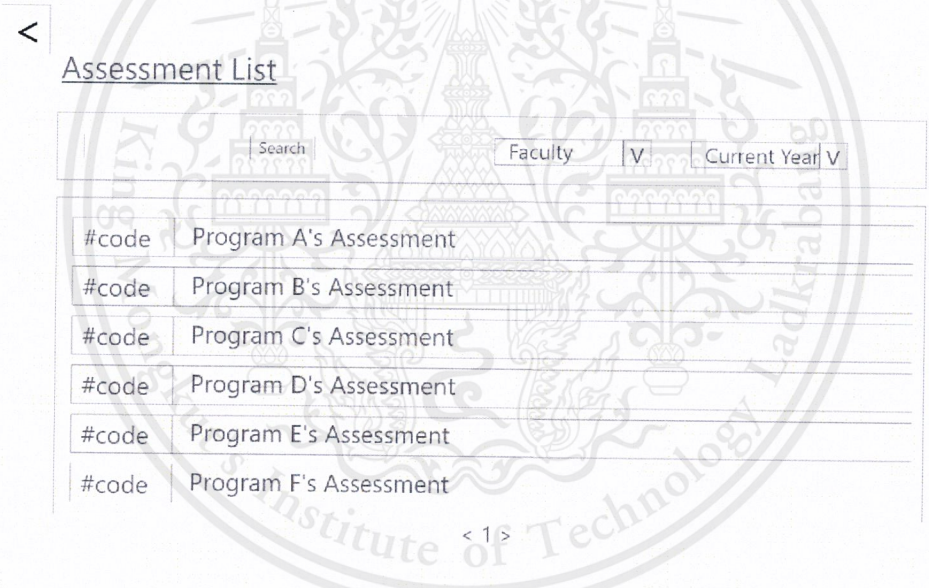


Figure 4.8: All assessment result page

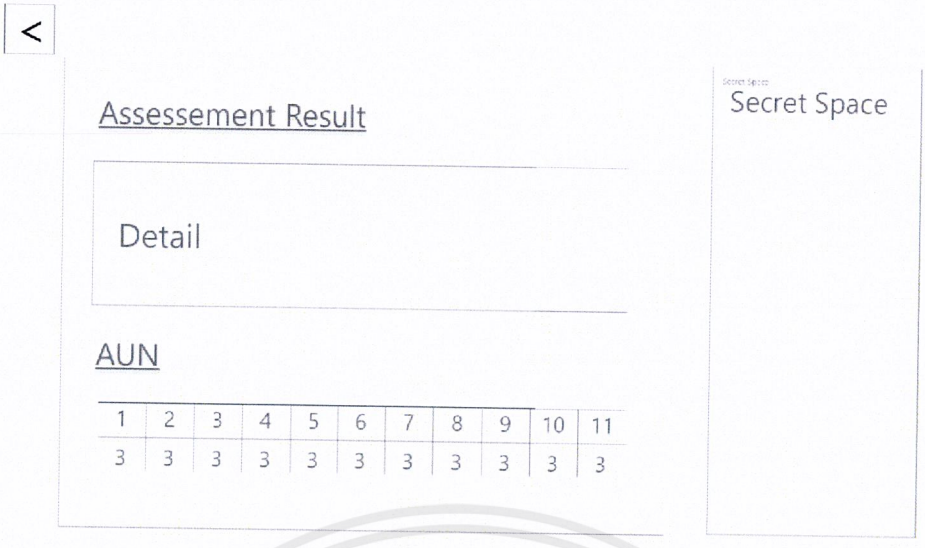


Figure 4.9: Assessment result page

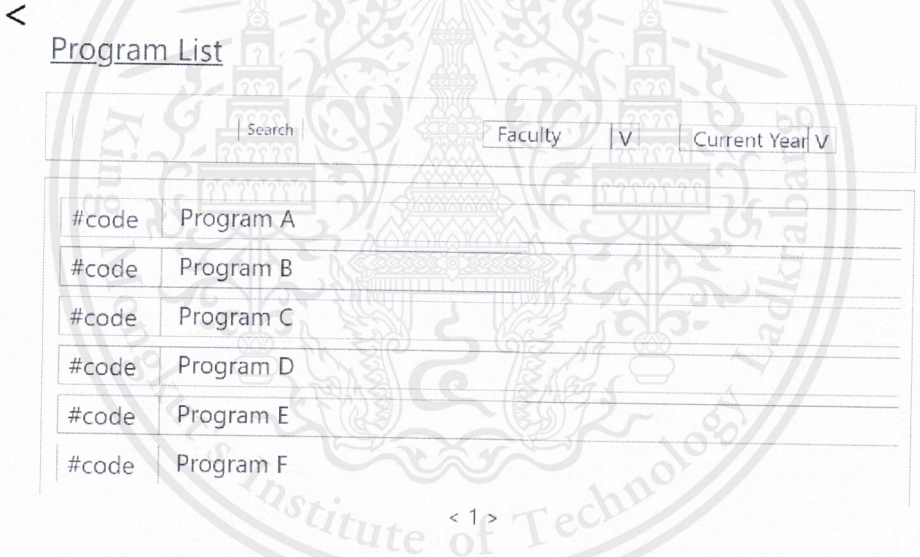


Figure 4.10: All study program page

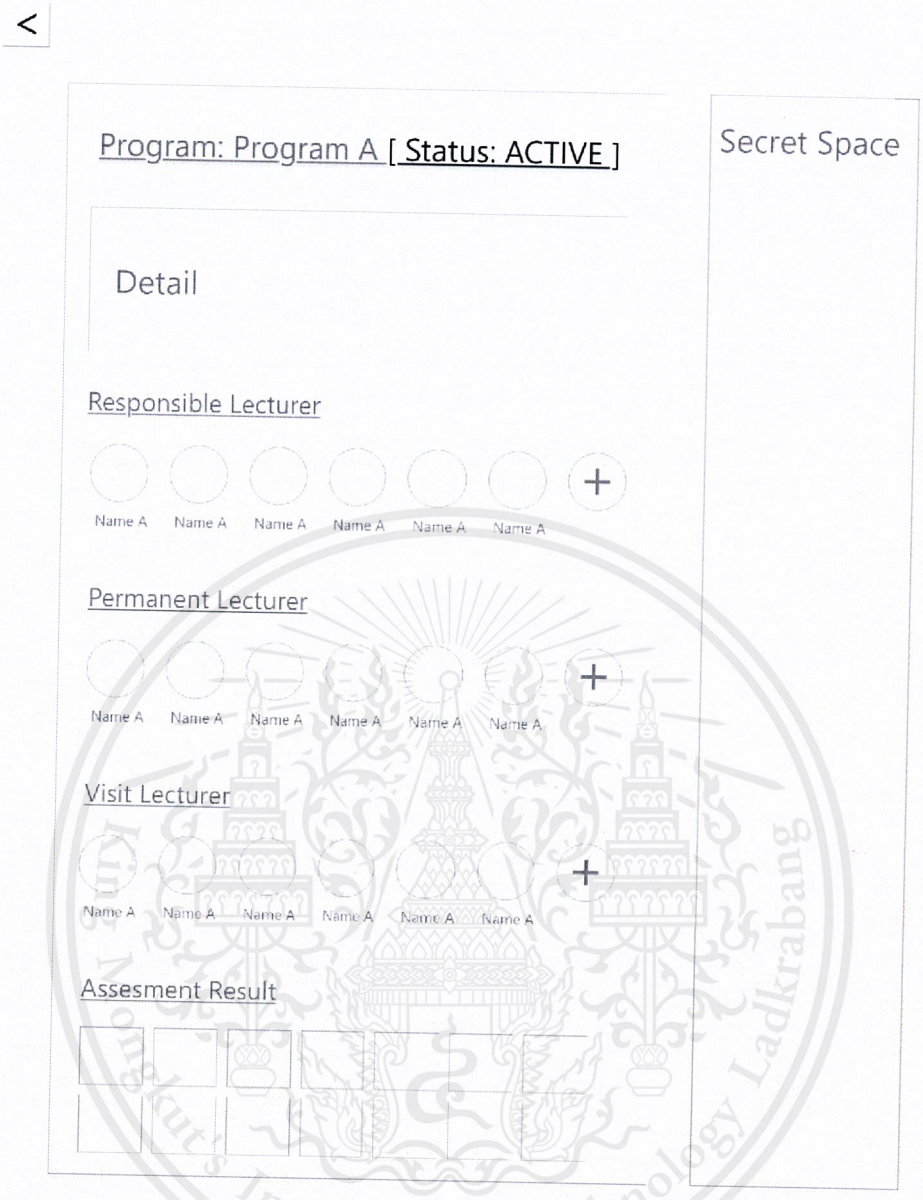


Figure 4.11: Study program page

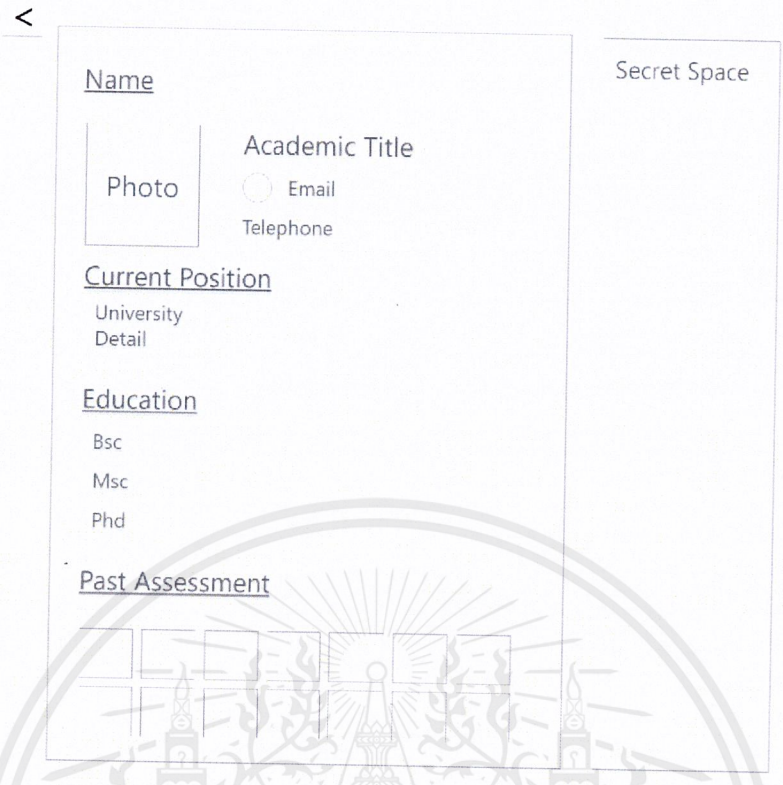


Figure 4.12: Professor profile page

4.3.5 Class diagram

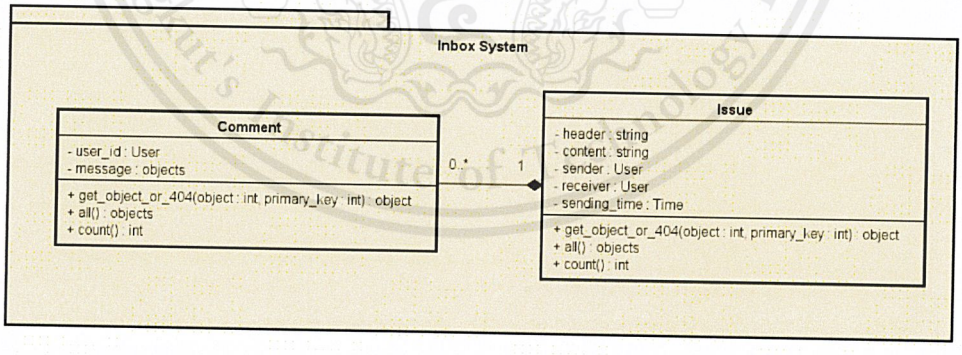


Figure 4.13: Class diagram

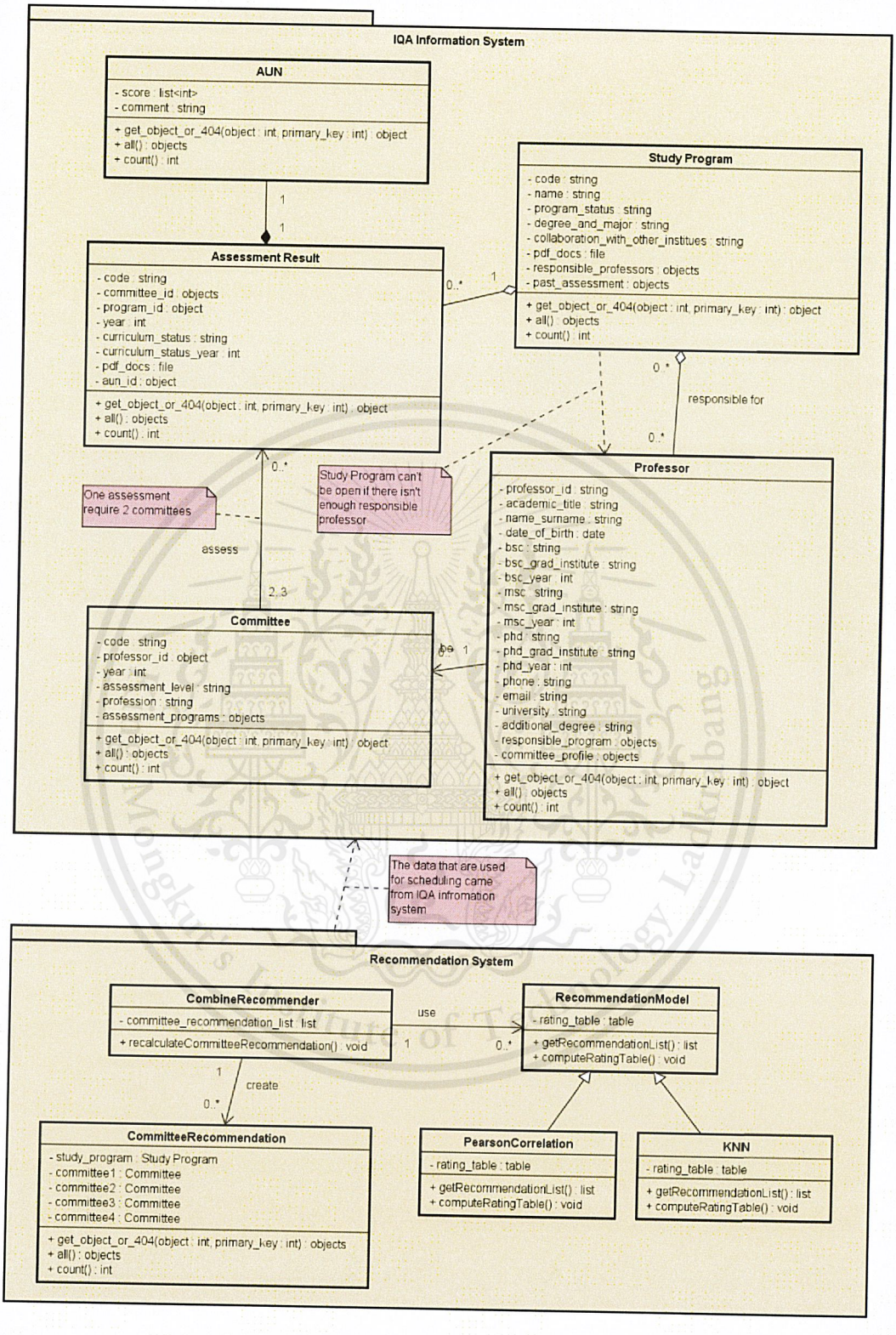


Figure 4.14: Class diagram(cont.)

4.4 System Architecture

As for the system architecture, it is designed using three tiers architecture, or client-server pattern. An idea of this architecture is to separate the system into three tiers, as its name, a presentation tier, a business tier, and the data tier. The presentation tier is responsible for handling the clients. It sends the request from the clients as well as receives the response from the server, and presenting it to the clients. The business tier, it is a logic part of the system, it contains an application server(s). It is used to process an incoming request from the clients and return the response back to the clients as well. Last, the data tier, it is the part of the system that is collected a data for the uses of an entire system.

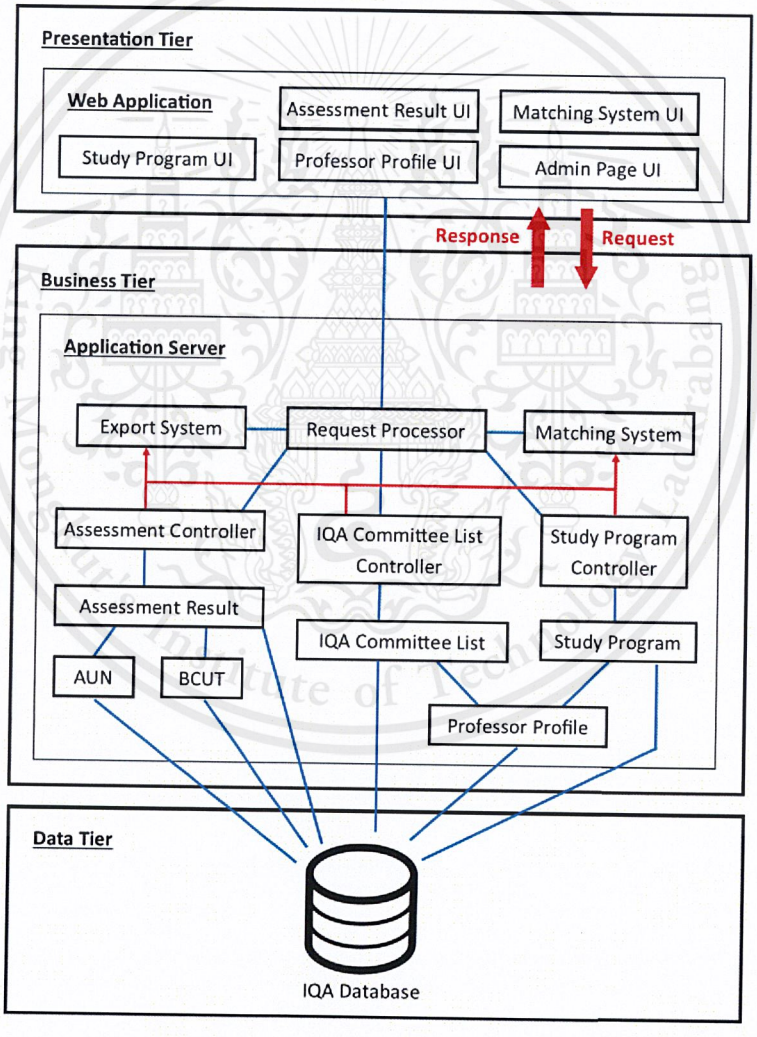


Figure 4.15: System architecture

Chapter 5
Methodology

This chapter describe the development of a system, it describes the proposed methodology in detail as well as the tools and plan for development the system.

5.1 Development Tools

5.1.1 Python

Python is one of the famous and strongest programming language that exist in the world. It has many open source library that can support almost every field of programming such as computer vision, data analysis, machine learning, or even web programming. In addition the syntax of this language itself also considered to be very friendly to the new learners as well.

Tool	Description
NumPy	Fundamental package for scientific computing with Python, that provides a powerful N-dimensional array object , and also provides useful linear algebra, Fourier transform, and random number capabilities
Pandas	Providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language.
scikit-learn	Provides simple and efficient tools for data mining and data analysis

Table 5.1: Library and tools

5.1.2 Django

Django is a popular web development framework that is written in Python. It follows the Model View Template (MVT) architecture ,which has the same idea with Model View Controller (MVC). It can either be used as a full stack web development or as a backend web development. The framework provides several features that helps facilitating the needs of the user such as security, authentication, and content administration. One of the most important feature of that has bee provided by django is object relational mapping (ORM). It helps mapping the object into a relational databases that provided by django. Hence, it cut off the problem of directly dealing with database for the developers.

5.1.3 PostgreSQL

is one of the well-known open source object-relational database system that has been created over 30 years of active development. It also famous for its reliability and its performance too. The most important thing is, it is free to use and provided on the DigitalOcean as well.

5.1.4 Github

In software development industry, working as a team is very important. Thus, the usual problem for coding in team is multi-version control of code. An online repository is one of the solution for this problem. Github, is one of the well-known repository hosting service for Git. It also has a web-base graphical interface. There are several problems that an authors are using Github to overcome and gain maximum advantages for the project. For the major benefits of the Github, The authors list by the following:

- Github provides public and private repository server for git, and using git to perform several tasks.
- Github is made for easier contribution. Mainly, because it is free and includes nifty features like wikis and issue trackers for better documentation and feedback. Github also has a very large community, which users can share experience, troubleshooting and knowledge all the time.
- Github collaborates with various development tools such as Heroku, DigitalOcean, TravisCI, and others. Thus, it is easier to combine different tools to build a stable software system.

5.1.5 Selenium

Selenium is an open source portable software-testing framework for web applications. It provides a playback tool for authoring tests and also provides a test domain-specific language to write the tests in a number of popular programming languages such as C#, Java, Python, and Ruby. The tests can then run in most of the modern web browsers. Selenium is highly flexible because there are many ways to add functionality, both, in Selenium test scripts and Selenium's framework in order to customize the test automation. Selenium WebDriver is one of the component in Selenium which taking a role in aiding the development of web application test automation. Selenium WebDriver was developed to support dynamic web pages where elements of a page may change without the page itself being reloaded. It is also provide a simple and concise programming interface.

5.1.6 DigitalOcean

A well known brand of cloud computing hosting service, DigitalOcean, that offers an Infrastructure as a Service (IaaS) platform. DigitalOcean provides deployment as IaaS environment, to launch a private virtual machine (VM) instance, which DigitalOcean calls a droplet. Developers can choose the droplet's size and data center and geographical region, and which Linux operating system it will be run on. Moreover, DigitalOcean's servers use only high-performance Solid State Disks, to preserve liveness and availability. DigitalOcean manages and monitors droplets with a control panel and an open source API. The control panel allows developers to scale and rebuild droplets based on workload changes and perform backups and redirect network traffic between droplets. In conclusion, DigitalOcean is a powerful primitive distributed system tool that contains a lot of features such as auto scaling, load balancing, and back-up. Therefore, it is very useful when deployment process is performed for the project.

5.1.7 Heroku

Heroku is a Platform as a Service (PaaS) product based on Amazon Web Services (AWS) and scalable administrated web hosting service which support several programming languages such as Ruby. Java, Node.js, Scala, Clojure, Python, PHP, and Go. Heroku provides 'Infrastructure as a Service' and 'Platform as a Service' solutions for deploying, managing, scaling and supporting the application. In addition, Heroku also provides other features. For example these are plenty of Add-on resources such as applications and databases, processes scaling which is an independent scaling for each

component of the app without affecting functionality and performance, Heroku is Isolation means that each process is completely isolated from each other. Also, it is easy access to all logging output from every component of the app and each process.

5.2 Development Plan

As the project duration is one academic year scope, hence, the development plan for this project is splitted into two phrase according to the number of semester in the one academic year. However, in the end of each phrase, there will be a product delivery to the clients. The 1st phrase is focusing on creating a website that handling the information regarding to the IQA, while the 2nd phrase is focusing on developing a new features will help supporting IQA. The development plan of each phrase will be elaborated in details in the following sections.

5.2.1 1st Phrase

In the 1st phrase of the project, it is focusing on clarifying the requirement from the user, identifying the problems, designing the solutions, and creating a well structure of the project for the further development. Therefore, the plan for this phrase is following this Figure5.1 below and will be elaborate more in details.

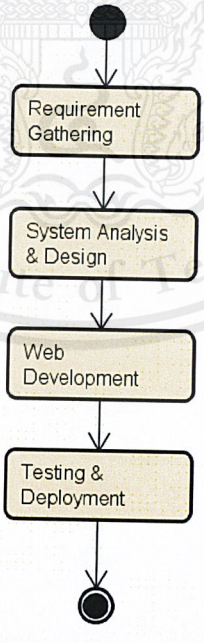


Figure 5.1: Development plan for phrase 1

Requirement Gathering

Most of the understanding about the IQA department's work process and the necessary information (or data) have been clarified in this step. Several meeting has been conducted in this phrase to ensure that every parties will reach the same understanding regarding to the project. Requirement and use cases are developed in this step as well.

System Analysis & Design

In this step, the understanding towards the project idea is clear enough to do the system analysis and design. Therefore, identifying the problem and designing the solutions are the main focus for this step. The IQA information structure design, wireframing, business domain model, system architecture, and class diagram have been created in this phrase. Along the process, there also several discussion with the product owner regarding to the solutions as well. By the end of this step, the target for the product delivery in each phrase has been concluded.

Web Development

As for the result of the system analysis and design, the development step for this phrase is focusing on creating the website that is able to handling an IQA information. These are the following features that has been implemented in this phrase.

- Authorization and Authentication for the website
- Create a base structure for website
- CRUD for every IQA entity object
- Filtering the IQA information

Note that the recommender system research is conducting in parallel and will be discussed in Section 5.3

Testing & Deployment

To ensure the quality of the work in the 1st phrase, the tests have been conducted using selenium to run through every webpage. It will go through the following path given below:

Test Cases

Description	Path
Test Case 1: Login	login, main menu
Test Case 2: View all study program	login, main menu, study program
Test Case 3: View study program detail	login, main menu, study program, study program detail
Test Case 4: Create study program	login, main menu, study program, create study program
Test Case 5: Edit study program	login, main menu, study program, study program detail, edit study program
Test Case 6: View all professor	login, main menu, professor
Test Case 7: View professor detail	login, main menu, professor, professor detail
Test Case 8: Create professor	login, main menu, professor, create professor
Test Case 9: Edit professor	login, main menu, professor, professor detail, edit professor
Test Case 10: View all committee	login, main menu, assessment menu, committee list
Test Case 11: View committee detail	login, main menu, assessment menu, committee list, IQA committee detail
Test Case 12: Create committee	login, main menu, assessment menu, committee list, create IQA committee
Test Case 13: Edit committee	login, main menu, assessment menu, committee list, IQA committee detail, edit committee detail
Test Case 14: View assessment result	login, main menu, assessment menu, assessment results
Test Case 15: View assessment result detail	login, main menu, assessment menu, assessment results, assessment result detail
Test Case 16: Create assessment result	login, main menu, assessment menu, assessment results, create assessment result
Test Case 17: Edit assessment result	login, main menu, assessment menu, assessment results, assessment result detail, edit assessment result

Table 5.2: Testing path of phrase 1

Test Result

Description	Result
Test Case 1: Login	Pass
Test Case 2: View all study program	Pass
Test Case 3: View study program detail	Pass
Test Case 4: Create study program	Pass
Test Case 5: Edit study program	Pass
Test Case 6: View all professor	Pass
Test Case 7: View professor detail	Pass
Test Case 8: Create professor	Pass
Test Case 9: Edit professor	Pass
Test Case 10: View all committee	Pass
Test Case 11: View committee detail	Pass
Test Case 12: Create committee	Pass
Test Case 23: Edit committee	Pass
Test Case 14: View all assessment	Pass
Test Case 15: View assessment result	Pass
Test Case 16: Create assessment result	Pass
Test Case 17: Edit assessment result	Pass

Table 5.3: Summary test result of phrase 1

As for a deployment, it is deployed in Heroku and this is the result.
url: https://iqa-v1.herokuapp.com

5.2.2 2nd Phrase

In the 2nd phrase of the project, the development is focusing more on adding a new features for assisting an IQA with the work process. The works have been conducted in parallel. Committee recommendation and the test also implemented in this phrase as it is presented in the Figure5.2 below.

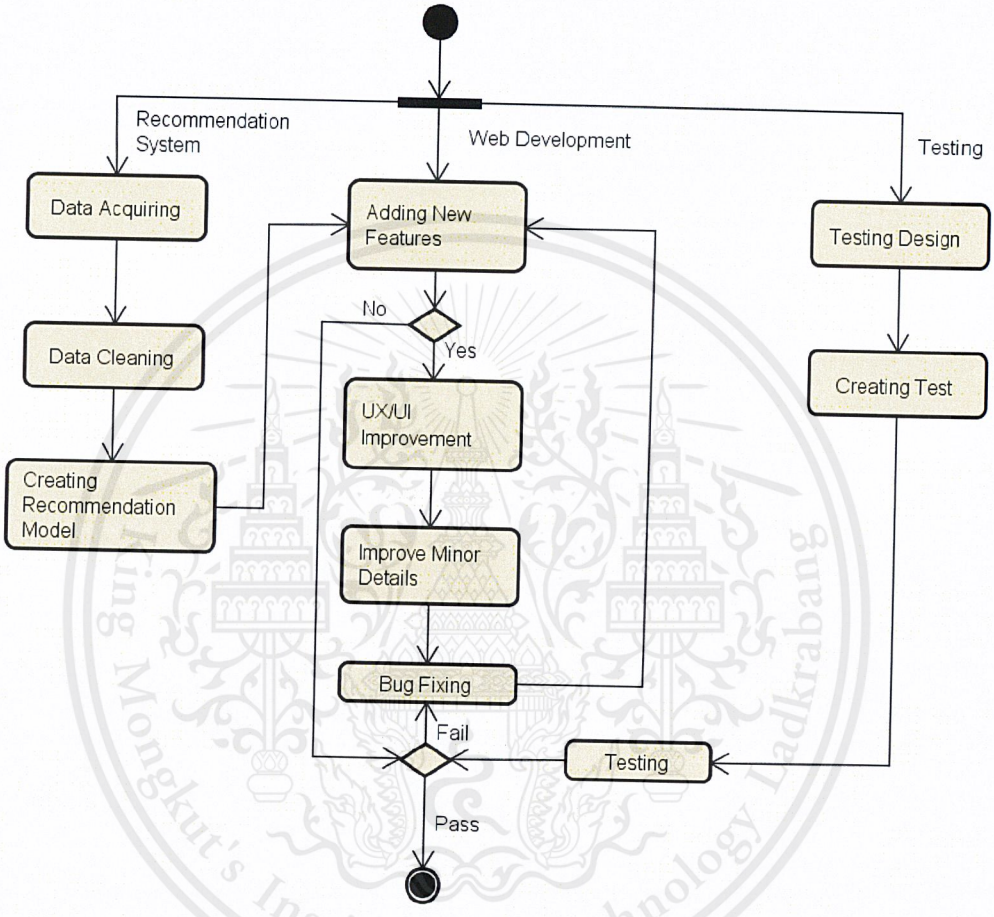


Figure 5.2: Development plan for phrase 2

Web Development

As for the result of the result of web development, several features have been added into the system as the followings:

- Inbox System
- Notifications for IQA
- IQA Committee Recommendation

- CRUD Assessment Appointment
- Assessment Appointment Schedule (in calendar format)
- Assessment Appointment Conflict Detection
- Faculty's study program page
- Exporting the Data

Apart from the new features there also several improvement in user experience and user interface in these following details as well.

- Improve in filtering and searching widget
- Adding Thai language into the webpage
- Sorting an information that presented on the webpage
- Adding a navigations in each webpage
- Adding FAQ page
- Changing the color of the website to make it easier to recognize each page

As the new feature is added, the smoking gun test has always been conducted. A lot of bugs are detected and fixed throughout the development process. By the end of the entire phrase 2, all of features have been added and the committee recommendation models have been integrated into the website. Note that the committee recommendation model development will be discuss in Section 5.3

Testing

As for the testing, user interface flow testing has been conducted to ensure the quality of the program before submitting the product for an acceptance test.

System Testing

As for the system testing, it is done by using the selenium as a tools to run through the flow of UI and create, update, view information according to the test case. By running through the following test cases, it will guarantee the node coverage (reach all the webpage). It also ensure that the main functionalities of the website are working properly.

The followings are the data for test cases and the test cases:

Test Cases Data

Study Program
• Each study program from different faculty • Pairwise test cases for the option fields

Professor
• Some of the professors are an IQA committee • Pairwise test cases for the option fields

Committee
• Committee with the different assessment ranking • Committee with the different profession

Assessment Result
• Assessment Result from each study program • Pairwise test cases for the option fields

Assessment Appointment
• Appointment from each faculty a) Create a conflict on morning, afternoon, and both morning & afternoon b) Appointment on morning, afternoon, and both morning & afternoon • Repeat the process a and b for different month and year

Inbox
• Create Issue from every faculty account • Create the comment for the following issue • Use admin account to comment for every issue • Create Issue from every admin • Create the comment for the following issue • Use faculty account to comment for the issue

UI Flow for following the path

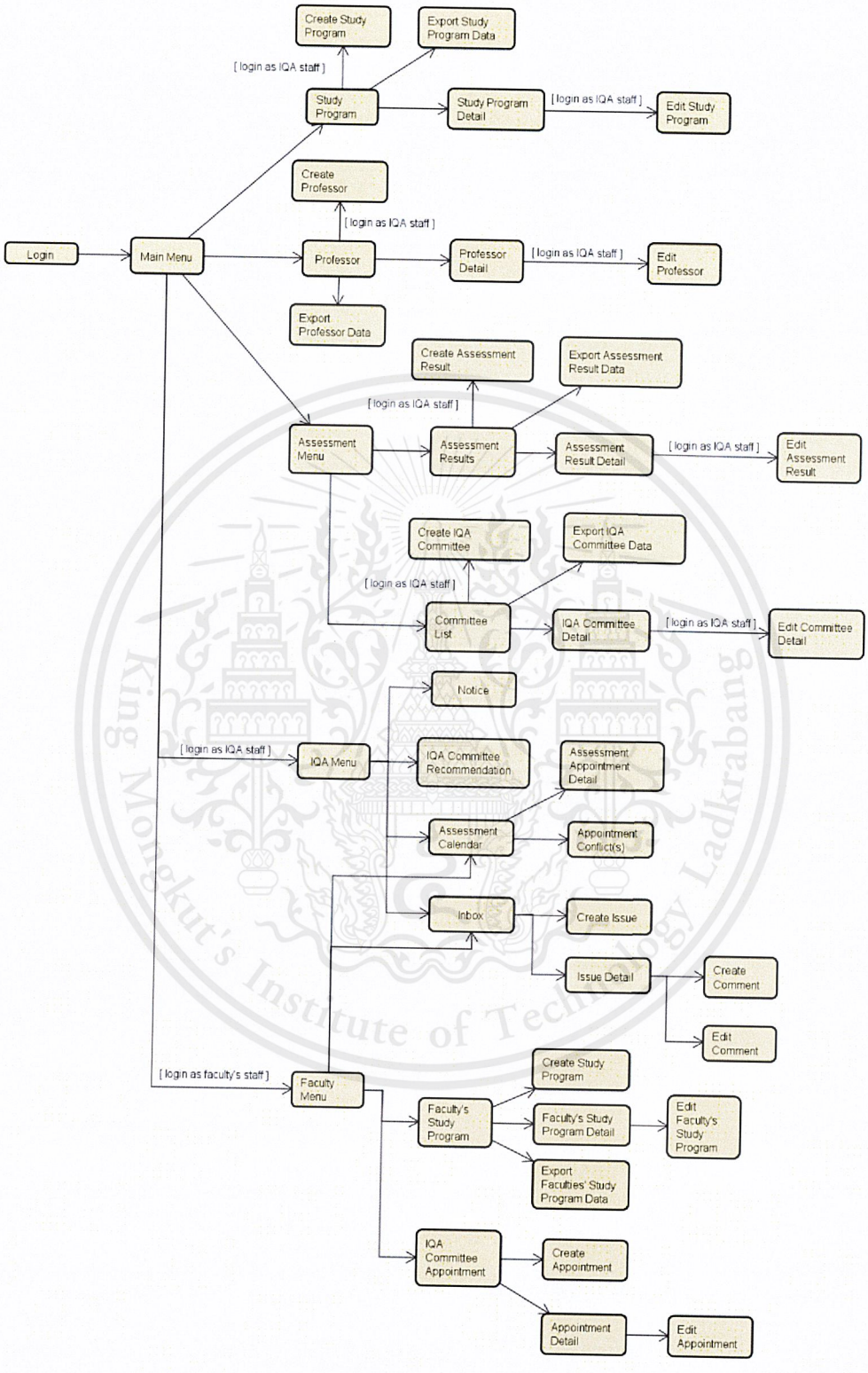


Figure 5.3: Overview of user interface flow

Test Cases

Description	Path
Test Case 1: Main Menu	login, main menu, study program, main menu, professor, main menu, assessment result, committee list, main menu, assessment menu, assessment result
Test Case 2: Study Program	login, main menu, study program, create study program, …. , create study program, export study program data, study program detail, edit study program
Test Case 3: Professor	login, main menu, professor, create professor, …. , create professor, export professor data, professor detail, edit professor
Test Case 4: Committee	login, main menu, assessment menu, committee list, create IQA committee, …. , create IQA committee, export IQA committee data, IQA committee detail, edit committee detail
Test Case 5: Assessment Result	login, main menu, assessment menu, assessment results, create assessment result, …. , create assessment result, export assessment result data, assessment result detail, edit assessment result
Test Case 6: IQA Menu	login, main menu, IQA menu, notice IQA menu, IQA committee recommendation, IQA menu, assessment calendar, IQA menu, Inbox
Test Case 7: Assessment Calendar	login, main menu, IQA menu, assessment calendar, next month, previous month, appointment conflict, assessment calendar, assessment appointment detail
Test Case 8: Inbox	login, main menu, IQA menu, inbox, create issue, issue detail, create comment, edit comment, logout, login main menu, faculty menu, inbox, issue detail, create comment, edit comment, faculty menu, inbox, create issue, issue detail, create comment, edit comment, logout, login, main menu, IQA menu, inbox, issue detail, create comment, edit comment
Test Case 9: Faculty Menu	login, main menu, faculty menu, faculty's study program, faculty menu, IQA committee appointment, faculty menu, assessment calendar, faculty menu, inbox

Table 5.4: Testing path of phrase 2

Description	Path
Test Case 10: Faculty Study Program	login, main menu, faculty menu, study program, create study program, export faculty's study program data, faculty's study program detail, edit faculty's study program
Test Case 11: Committee Appointment	login, main menu, faculty menu, IQA committee appointment, create appointment, create appointment, ... , create appointment, appointment, edit appointment.

Table 5.5: Testing path of phrase 2(cont.)

5.3 Recommender System

As the authors have mentioned beforehand, recommender system is the system that recommends IQA committees to assesses the programs, faculties, and university, but the current scope of the system is focusing on the program assessment. Firstly, the major problem is defined by a number of IQA committees in the system. Hence, it is very difficult to analyze every IQA committees for each program assessments. Therefore, the solution has been proposed by using the same approach as recommender system.

Presently, there are three main approaches in recommender system, namely Content Based Filtering, Collaborative Filtering, and hybrid approaches. All of them have their own advantages and disadvantages. Thus, the data and resource must be considered before choosing the approach. According to the business problem and the IQA data, collaborative filtering seems to be the most suitable approach for this case.

5.3.1 Collaborative Filtering

In recommendation systems, collaborative filtering is the method of making predictions about the interests of the user by analyzing the similarity of the other users and the items. There are two approaches to construct a collaborative filtering model which are memory-based approach and Model based approach. In this project, the authors have chosen the memory-based collaborative filtering (user-item) and the model-based collaborative filtering as the proposed methods, which will be an important part to construct the recommender system.

5.3.2 Memory-Based Collaborative Filtering

Memory-based collaborative filtering approach can divined into two categories which are user-item filtering and item-item filtering. A user-item filtering takes a target user, find users that have similarity to the target user, and recommend items that those similar users liked. On the other hand, item-item filtering will take an target item, find users who liked that target item, and find other items that those users or similar users also liked. It takes items and outputs other items as recommendations.

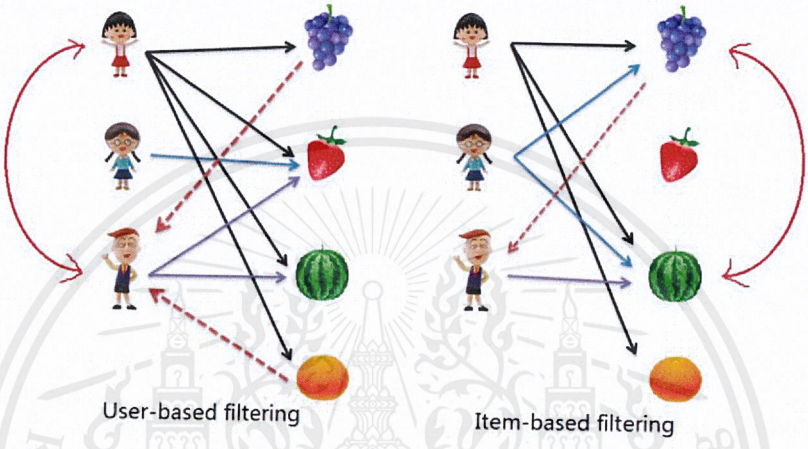


Figure 5.4: User and Item based filtering[9]

Memory-Based Collaborative Filtering approach Worked Example

In this project, the authors have chosen the memory-based collaborative filtering (user-item) as the proposed methods, which will be an important part to construct the recommender system. This section explains about the workflow of the memory-based collaborative filtering (user-item), and the data will be applied in the example below. There are three main steps in the workflow, which are finding similarity between target user and other users, calculating unrated rating, and predicting the items to the target users respectively.

Firstly, the rating matrix must be constructed. Thus, the reliable criteria has been build for the data. The following figure 5.5 and 5.6 are the rating criteria and real example of creating rating respectively.

1.0	0.3	Degree	0.1	0.05	bachelor	match with faculty
				0.05		match with major
			0.1	0.05	master	match with faculty
				0.05		match with major
			0.1	0.05	doctor	match with faculty
				0.05		match with major
	0.1	Affiliation	0.1	match with affiliation		
	0.4	Assessor Rank	0.4	Senior		
			0.3	Junior		
			0.2	Novice		
			0.1	Apprentice		
	0.2	AUN Assessment Frequency	0.067	0-5		
			0.134	6-15		
			0.2	>15		

Figure 5.5: Rating criteria

หลักสูตรวิศวกรรมศาสตรบัณฑิต สาขาวิชาวิศวกรรมการบินและนักบินพาณิชย์				
0.584	0.15	Degree	0.05	วศ.บ. (วิศวกรรมเกษตร)
			0.05	วศ.ม. (เครื่องจักรกลเกษตร)
			0.05	Biological Systems Engineering
	0.1	Affiliation	0.1	คณะวิศวกรรมศาสตร์
	0.2	Assessor Rank	0.2	Novice
	0.134	AUN Assessment Frequency	0.134	10

Figure 5.6: Example creating rating data

Secondly, the similarity of target users with the others must be calculated. There are plenty of ways to calculate similarity, Pearson correlation coefficient that sometimes can be called as centered cosine similarity can find the correlation between the user, and it can overcome the problems of cosine similarity approach. The Pearson correlation coefficient measures correlation of two variables from -1 to +1, Where -1 is a perfect negative correlation which means that the data objects are not correlated, 0.0 is no correlation, and 1.0 is a perfect positive correlation which indicates that the data objects are perfectly correlated. The similarity value can be calculated by equation5.1

$$Similarity(x,y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (5.1)$$

x_i = *value in dimension i of vector x*

$\bar{x}$ = *average value of vector x*

y_i = *value in dimension i of vector y*

$\bar{y}$ = *average value of vector y*

n = *Dimension of vector*

	Professor a	Professor b	Professor c	Professor d
Program a	7.0	3.5	4.0	6.0
Program b	2.0	6.0	7.0	NaN
Program c	6.0	NaN	4.0	7.0
Program d	3.5	7.0	NaN	2.0
Program e	NaN	6.5	6.0	4.0

Figure 5.7: Initial rating matrix

	Professor a	Professor b	Professor c	Professor d
Professor a	1.000000	-0.501844	-0.981981	0.386220
Professor b	-0.501844	1.000000	0.321634	-0.342997
Professor c	-0.981981	0.321634	1.000000	-0.485662
Professor d	0.386220	-0.342997	-0.485662	1.000000

Figure 5.8: Similarity matrix

After similarity values between the users have been gathered (figure 5.8), the predicting unrated rating step then performs by replacing new value to the null value in figure 5.7. The equation that is used in this step is weighted average, the weight is represented by similarity value in this situation.

$$r_{xi} = \frac{\sum_{y \in N}(s_{xy})(r_{yi})}{\sum_{y \in N} s_{xy}} \tag{5.2}$$

r_x = *the vector of user x's rating*

r_{xi} = *the rating of item i which in vector x*

r_y = *the vector of user y's rating*

r_{yi} = *the rating of item i which in vector y*

s_{xy} = *similarity value between target user x and similar user y*

n = set of k users most similar to x who have also rated item i

For the last step, after all of null value has been replaced as figure 5.9, the system can recommend professors to the programs by using condition that rating must exceed the threshold which develop already set beforehand. For example, in this project, the authors attempt to recommend two professors to the programs. Therefore, the condition has been made by set the threshold of the rating that the professor who has rating more than 5 will be recommend to the users. In this case, professor a and d will be assigned to assess program a, and professor b and c will be assigned to assess program b and so on.

	username	Professor a	Professor b	Professor c	Professor d
0	Program a	7.0	3.5	4.0	6.0
1	Program b	2.0	6.0	7.0	2.0
2	Program c	6.0	4.0	4.0	7.0
3	Program d	3.5	7.0	7.0	2.0
4	Program e	4.0	6.5	6.0	4.0

Figure 5.9: Full rating matrix

5.3.3 Model-Based Collaborative Filtering

Model-based collaborative filtering approach provide item recommendation by first developing a model of user ratings. Algorithms in this category take a probabilistic approach and envision the collaborative filtering process as computing the expected value of a user prediction, given his/her ratings on other items. The model building process is performed by different machine learning algorithms such as Bayesian network, clustering, rule-based approaches, and etc.[8]

In this project, the authors also implement the recommender system by using model-based collaborative filtering. K nearest neighbor algorithm has been proposed. K nearest neighbor is also known as instance based learning. The basic idea of the algorithm is to classify a new instance that has been input into the model by finding the nearest number of K instances which developer has to assign the value of K more than or equal to one, and classify the new instance into a class that have the most number out of K. According to the figure 5.10, the new instance is belong to class 2 when k is equal to 3, but it is belong to class 1 when k is equal to 5.

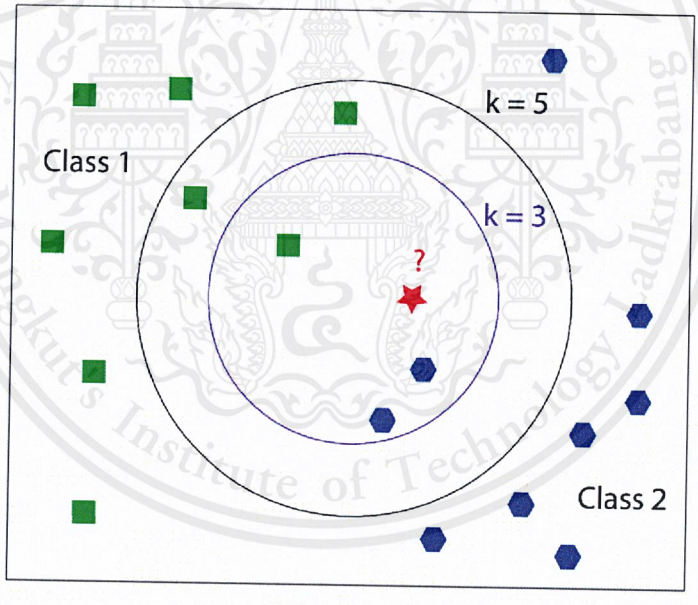


Figure 5.10: KNN[10]

In conclusion, there are three main components to construct this model which are number of "K", metric of distance measurement, and labeled data. Therefore, for the author's model, K is assigned to be 1, and Euclidean distance as a metric of distance measurement. For the labeled data, this topic is the hardest one, because labeled data has to be assigned as a training data, and reliability and representative data must be fulfilled. Therefore, rating matrix from previous section can be used to determine the labeled data. Because K value is equal to 1, which means that the authors must find the most rating value of professor that assesses the programs. To clarify intuitively, the information or data of the professors, who get the most value in each rows will be used as labeled data. For example, according to the dummy data in figure 5.11, data of Prof. A will be used labeled data of class engineer, data of Prof. B will be used labeled data of class Agriculture, and data of Prof. C will be used labeled data of class Business respectively.

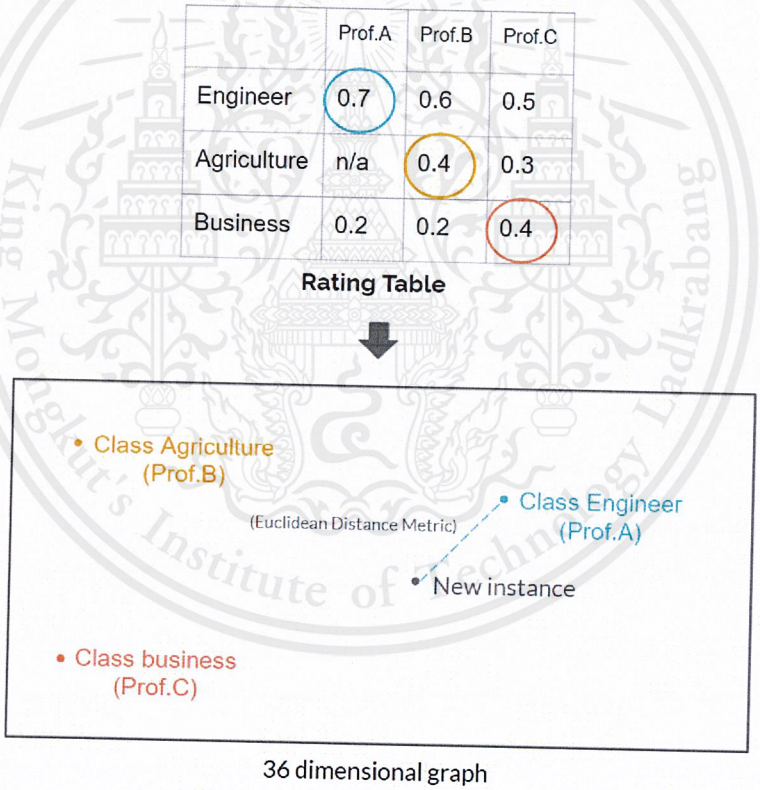


Figure 5.11: Assigning labeled data of the kNN model

The last challenge of this model implementation is the data. The degrees of professors are the most representative data that represent the similarity and difference among the professors, furthermore, those data is the only representative data for now. The challenge is those data are purely string data, and string cannot reliably find the distance between itself. Therefore, feature engineering plays an important role. Thus, the feature extraction approach has been applied, the degrees of professors have been handled by extracting the faculty and major into multiple columns. For example in figure 5.12, there are three features or columns which are bsc (bachelor's degree), msc (Master's Degree), and phd (Doctor of Philosophy) respectively. Those features then have been extracted into 36 columns that cover all of faculty and major that the authors have in hand. The following figure 5.13 is the example of extracting feature data.

Prof_Primary_ID	bsc	msc	phd
VEERPE	วท.บ (วัสดุศาสตร์)	วศ.ม. (วิศวกรรมไฟฟ้า)	วศ.ด. (วิศวกรรมไฟฟ้า)

Figure 5.12: The original degrees data of the professors

Prof_Primary_ID	การเกษตร	นวัตกรรม, วัสดุ, สถาปัตยกรรมศา	เทคโนโลยี	วิทยาศาสตร์	วิศวกรรมศาสตร์
VEERPE	0	1	0	0	1	2

Figure 5.13: The extracting degrees data of the professors

Chapter 6
Results

6.1 Information Organization

6.1.1 Database Design to Spreadsheets

As a result from using Object Role Modeling to understand all the data and its association, it is easier to define a suitable excel format for the IQA department to fill in the required data.

The followings are the list of sheets in the excel file:

1. Program
2. Professor
3. Program-Professor
4. CommitteeList
5. AssessmentResult
6. AUN
7. Committee-AssessmentResult

The followings are the data description in more details:

1. Program: contains information about the programs

Program code	The code that summarize the program detail briefly which consist of 3 letters of faculty's code name 6 letters of the program's name B = Bachelor, M = Master, D = Doctorate M = Modified Program, N = New Program T = Thai, I = International
PDF	The url to the pdf file about the program's information
Program Name	The name of the program
Degree and Major	The name of the degree that is offered by the program
Program Collaborations with other institutes	The type of collaborations that the program is provided where 1 = program issued specifically by KMITL 2 = program supported by others 3 = collaborated program with other institutes
Program Degree Offering	The type of the degree that will be rewarded from the university where 1 = awarded only one degree 2 = awarded more than one degree 3 = other
Program Status	The status of the program where 1 = open 2 = waiting to open 3 = close / stop accepting applicant

2. Professor: contains the information about the professors

Professor ID	The code for professors which consists of 4 letters from first name 2 letters from last name
Academic Title	The academic title of the professor
Name Surname	The first name and last name of the professor separated by a white space
DateOfBirth	The birthdate of the professor
bsc	The bachelor degree of the professor
bsc graduated institution	The institution that professor is graduated his/her bachelor's degree
bsc_year	The year that professor graduated his/her bachelor's degree
msc	The master degree of the professor
msc graduated institution	The institution that professor is graduated his/her master's degree
msc_year	The year that professor graduated his/her master's degree
phd	The doctorate degree of the professor
phd graduated institution	The institution that professor is graduated his/her doctorate's degree
phd_year	The year that professor graduated his/her doctorate's degree
phone no.	The phone number of the professor
email	The email of the professor
university	The university that professor is currently teaching
degree	An additional degree that the professor have

3. Program-Professor

Program code	The code that summarize the program detail briefly which consist of 3 letters of faculty's code name 6 letters of the program's name B = Bachelor, M = Master, D = Doctorate M = Modified Program, N = New Program T = Thai, I = International
Professor ID	The code for professors which consists of 4 letters from first name 2 letters from last name

4. Committee List

Committee ID	The generated id number of the committee
Professor ID	The code for professors which consists of 4 letters from first name 2 letters from last name
Year	The year that the professor is the committee
Assessment Level	The assessment level of the committee / the rank of the committee
Profession	The profession of the committee

5. Assessment Result

Assessment ID	The generated id number of the assessment result
Program	The name of the program that being assessed
Year	The year that the program is being assessed
Curiculum status	The status of the program that being assessed where 1 = new 2 = modified
Year of the curriculum status	The latest year of the program has been modified
Curriculum standard	The standard of the curriculum where 1 = B.E. 2548 2 = B.E. 2558
PDF	The url to pdf file of the assessment result
AUN ID	The id of AUN score

6. AUN

CommitteeID	The generated id number of the committee
AUN ID	The id of AUN score
Score	The AUN score, it consists of 12 columns where 1-11 is a criterion for assessment and 12th column is a total score

7. Committee-AssessmentResult

Committee ID	The generated id number of the committee
Assessment ID	The generated id number of the assessment result

6.2 Web Development

6.2.1 Information Transferring

An information from the excel sheet is successfully transferred into the database by using the script that pull all the data from the excel and transfer it into the database. The script is written in python, it pulls all the information in each and every excel sheet and transform the data each row into a django object then save it into the system.

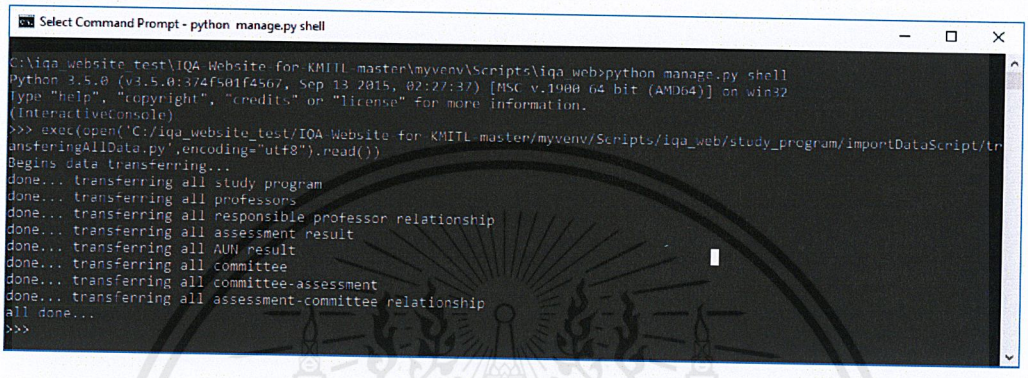


Figure 6.1: Information transferring script

6.2.2 User Interface

User Interface Flow

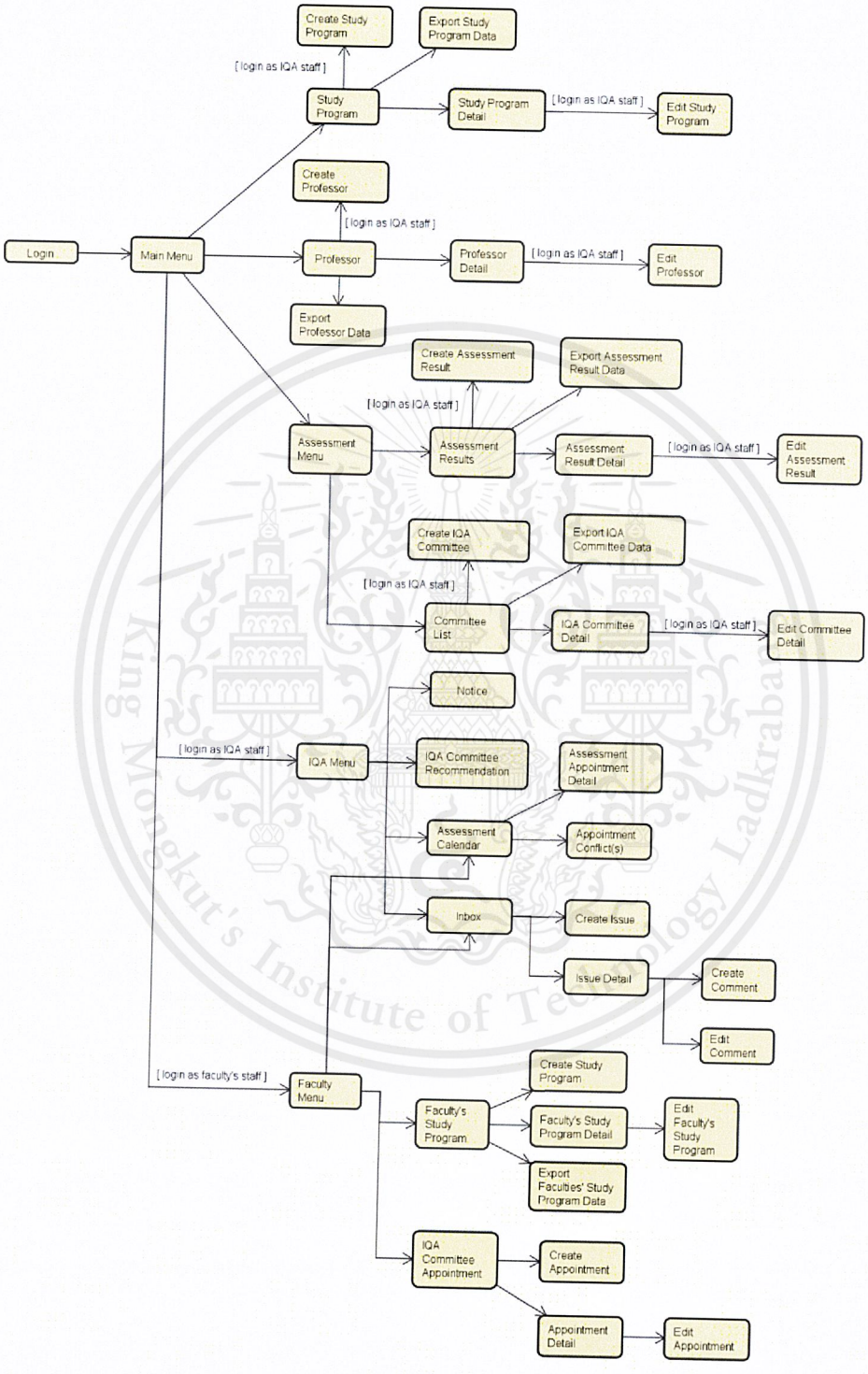


Figure 6.2: Overview of user interface flow

Main Menu

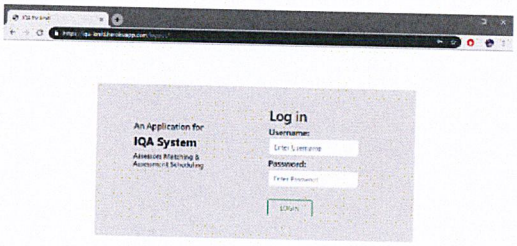


Figure 6.3: Login page

Figure 6.4: Assessment menu page

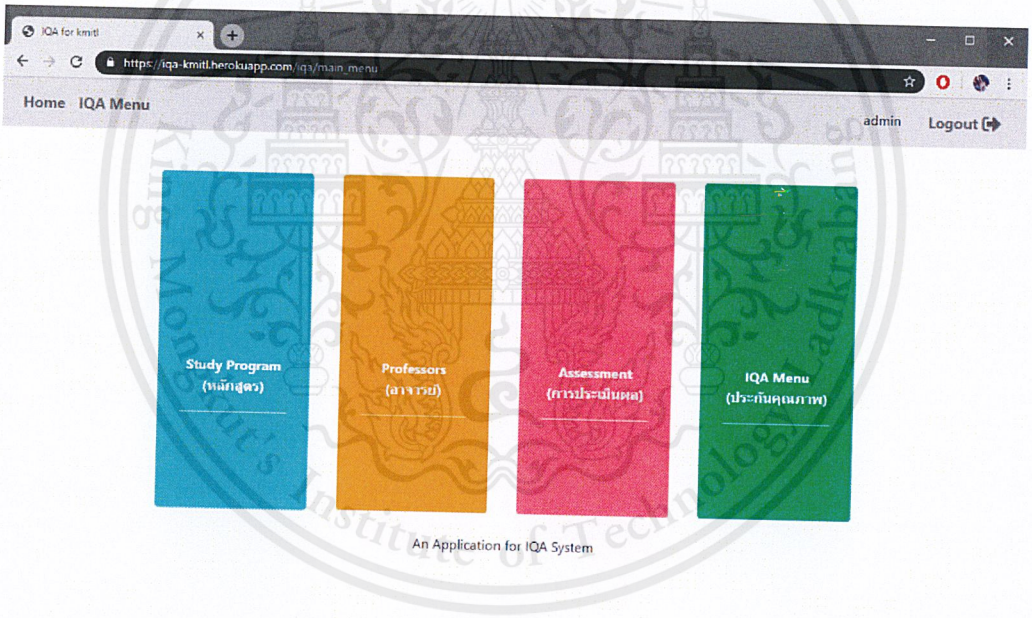


Figure 6.5: Main menu page in case user is admin

Study Program

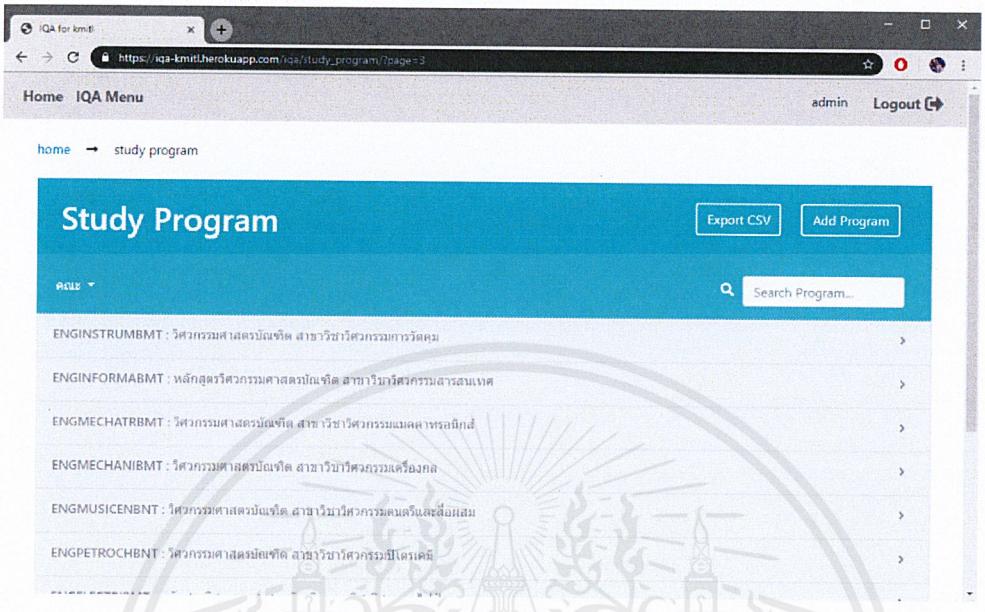


Figure 6.6: Study program page

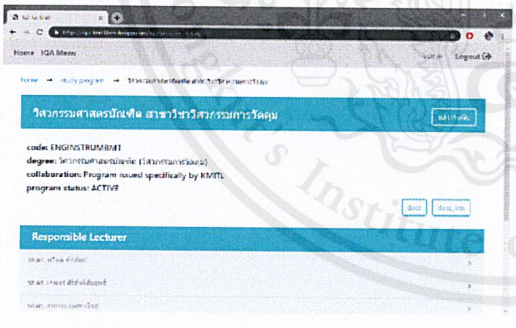


Figure 6.7: Study program detail page

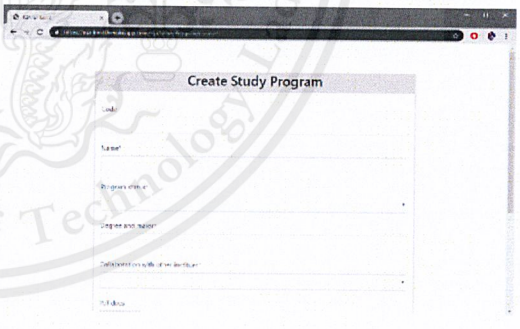


Figure 6.8: Create study program page

Professor

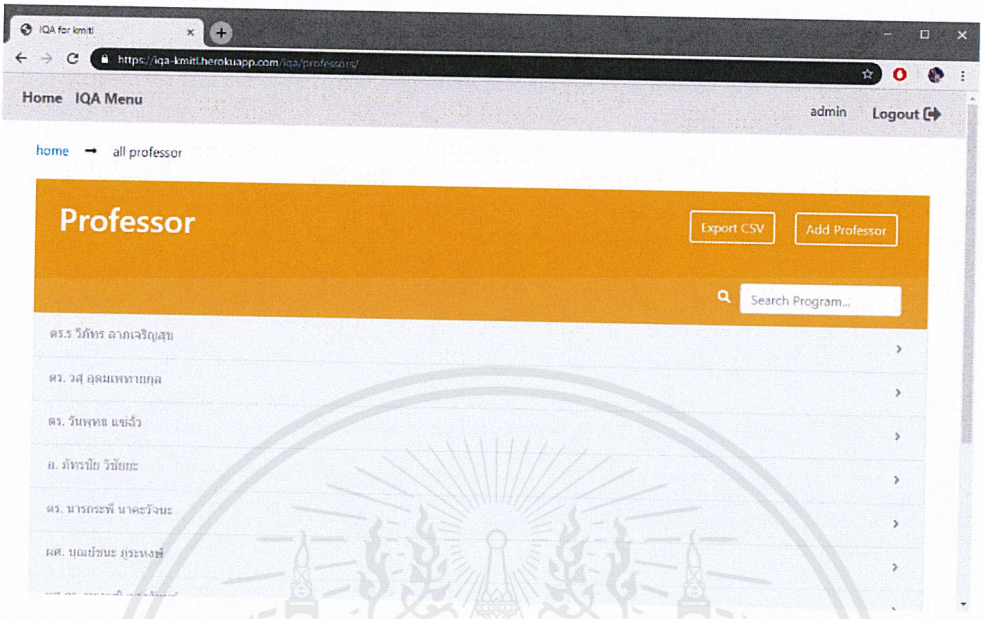


Figure 6.9: All professor page

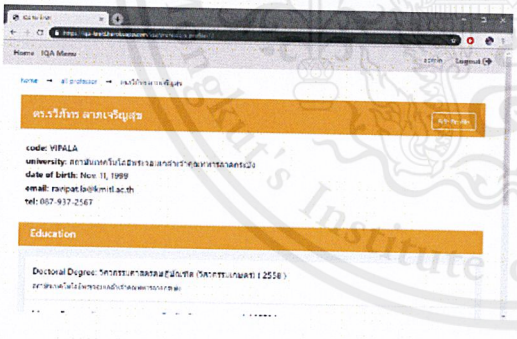


Figure 6.10: Professor profile page

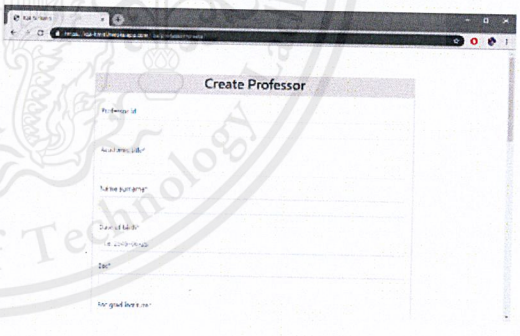


Figure 6.11: Create professor page

Assessment Result

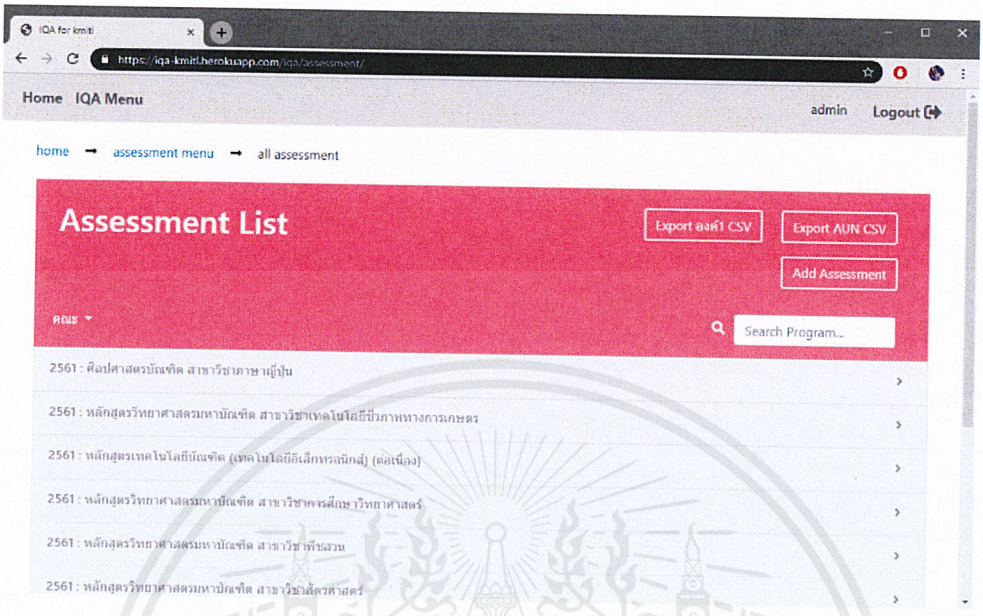


Figure 6.12: Assessment list page

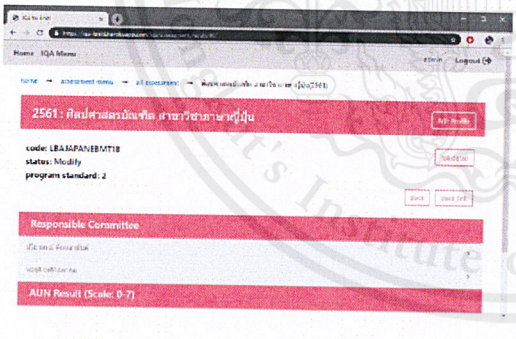


Figure 6.13: Professor profile page

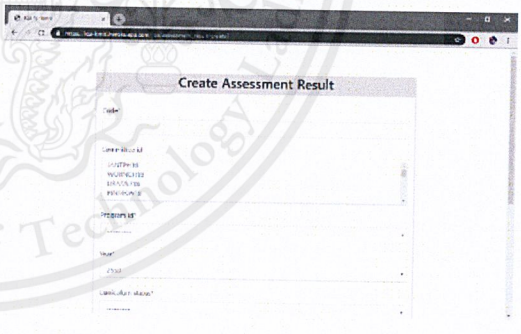


Figure 6.14: Create professor page

Committee

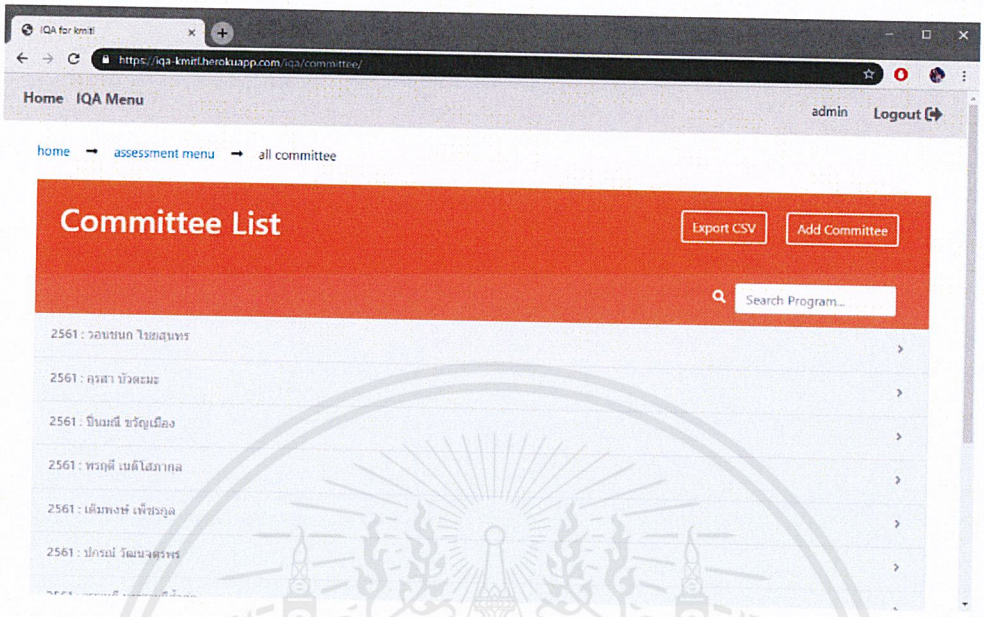


Figure 6.15: Committee list page

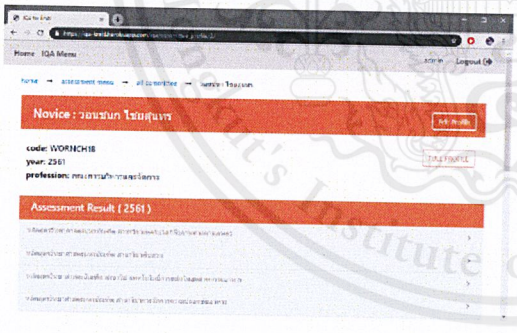


Figure 6.16: Committee profile page

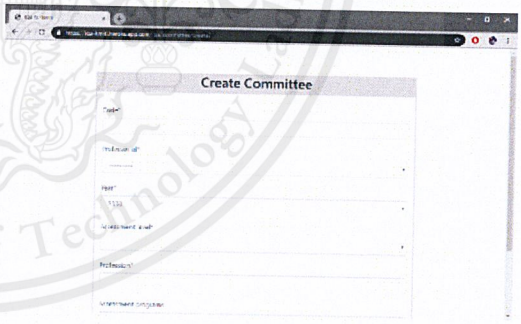


Figure 6.17: Create committee page

Menu for IQA and Faculty

Figure 6.18: IQA menu page

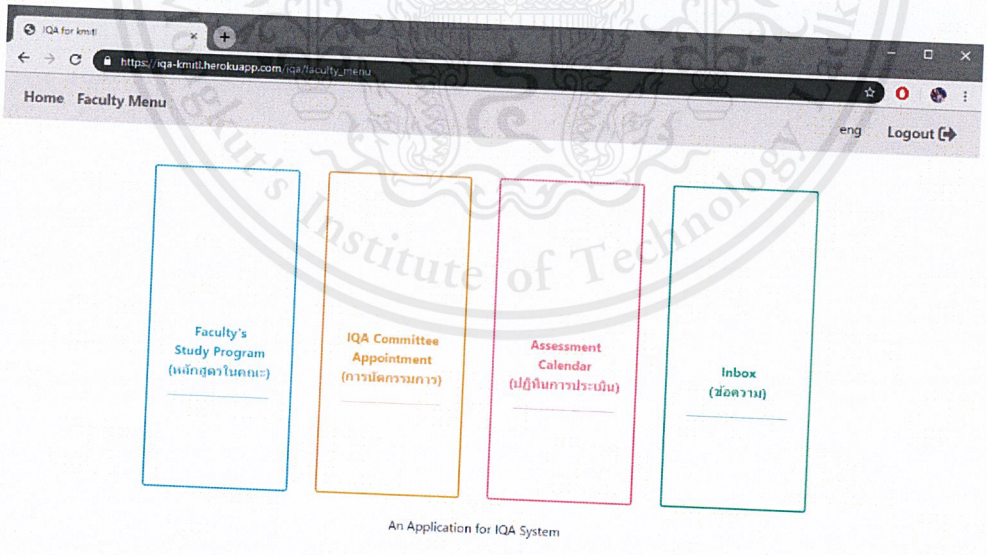


Figure 6.19: Faculty menu page

Notice

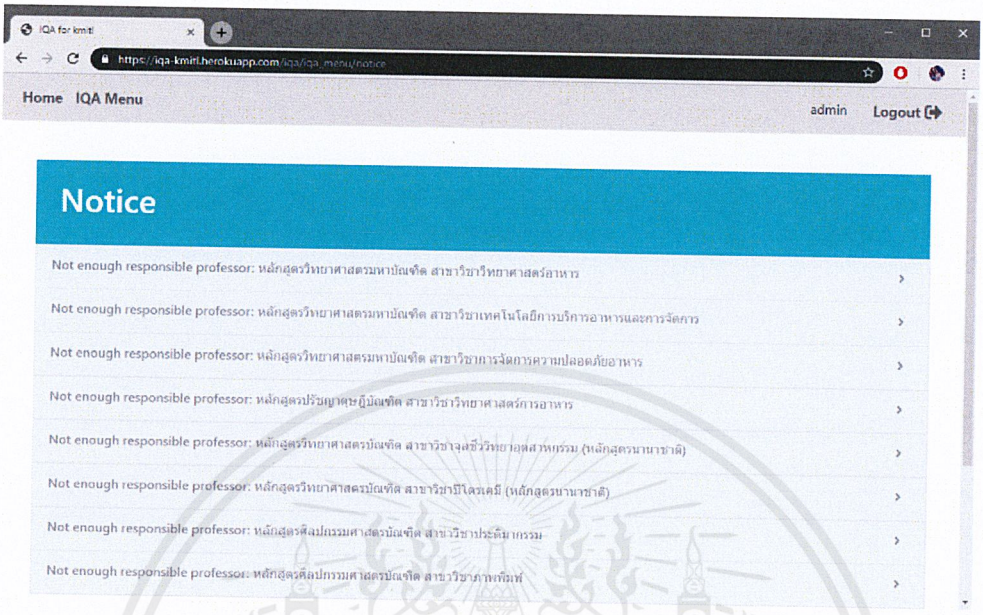


Figure 6.20: Notice page for IQA user

Faculty's Study Program for each faculty user

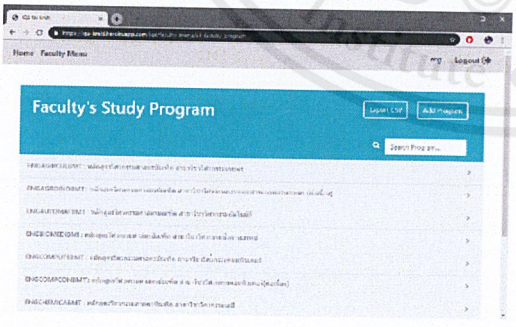


Figure 6.21: Faculty's study program page

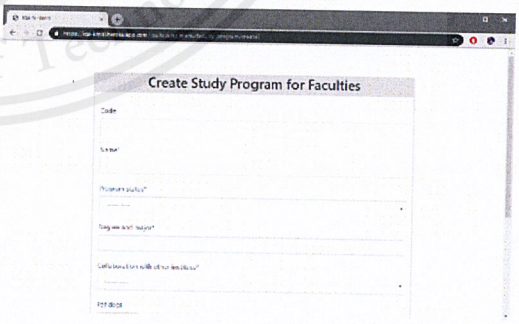


Figure 6.22: Create faculty's study Program page

Committee Appointment

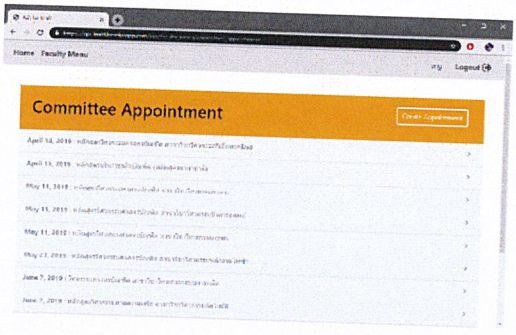


Figure 6.23: Committee appointment page

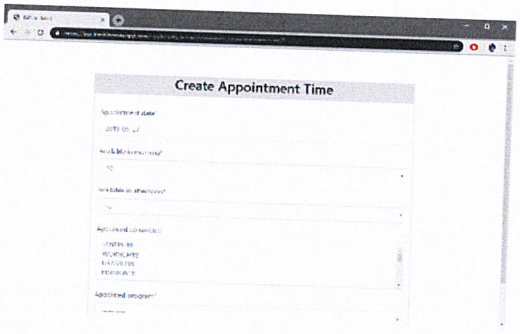


Figure 6.24: Create committee appointment page

Assessment Calendar

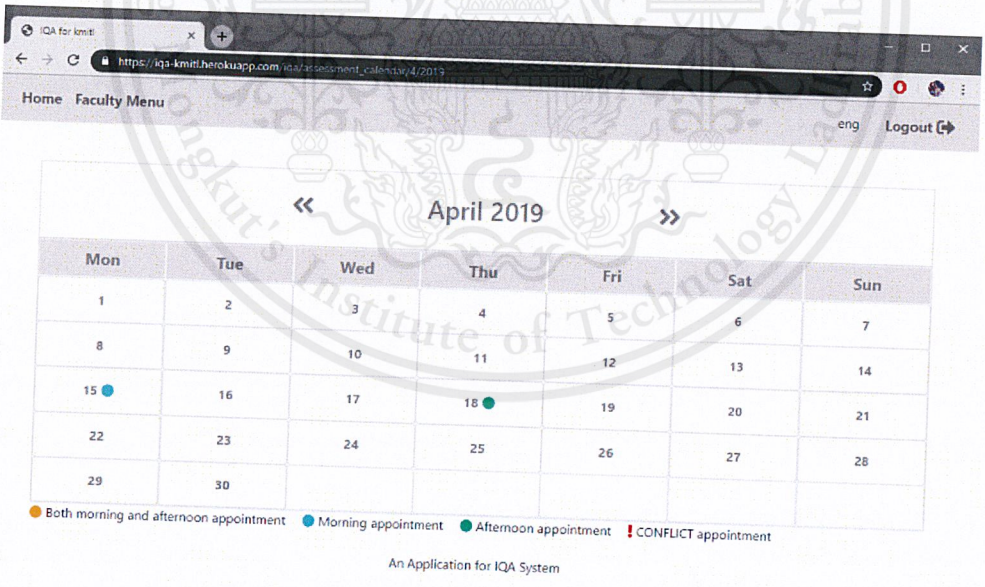


Figure 6.25: Assessment calendar

Assessment Calendar

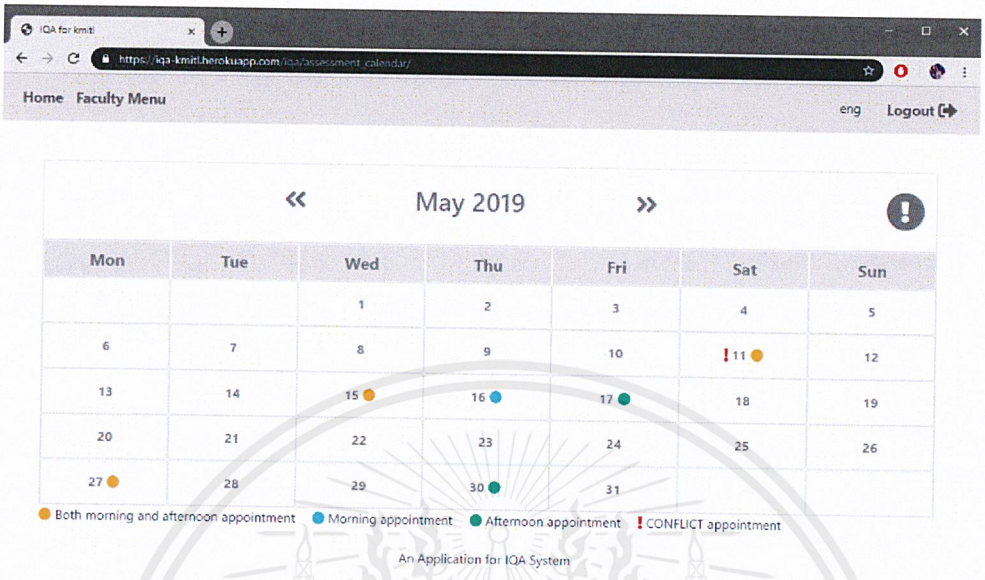


Figure 6.26: Assessment calendar for every user

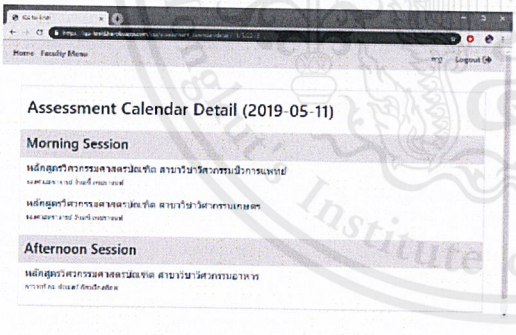


Figure 6.27: Assessment calendar detail page

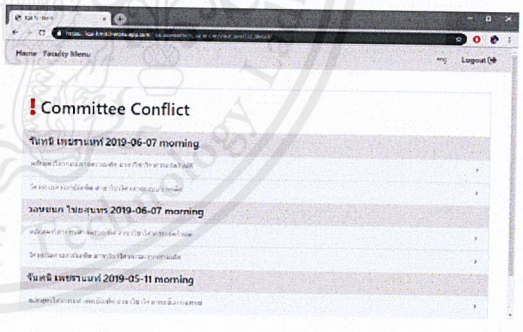


Figure 6.28: Committee conflict detail page

Inbox

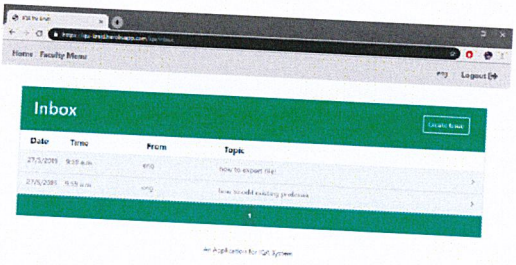


Figure 6.29: Inbox for engineering faculty page

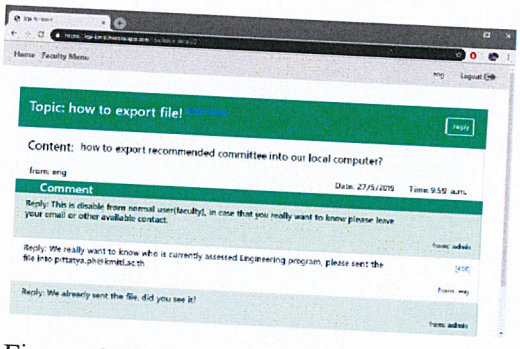


Figure 6.30: Issue detail of engineering faculty page

Figure 6.31: Inbox for IQA team page

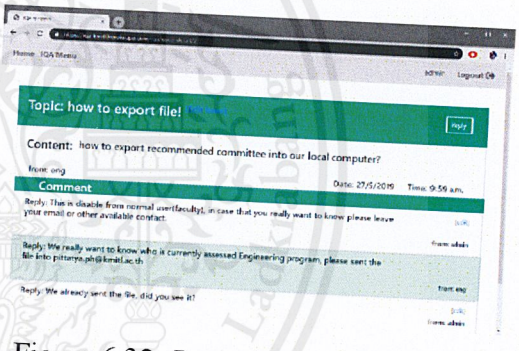


Figure 6.32: Issue detail of IQA team page

6.2.3 Committee Recommendation

As a result from the recommendation system, all the information regarding to the recommended IQA committee has been stored in the Django model. It is presented in following webpage where the information are provided with the faculties name, recommended committee's name, and suitability percentage of that committee.

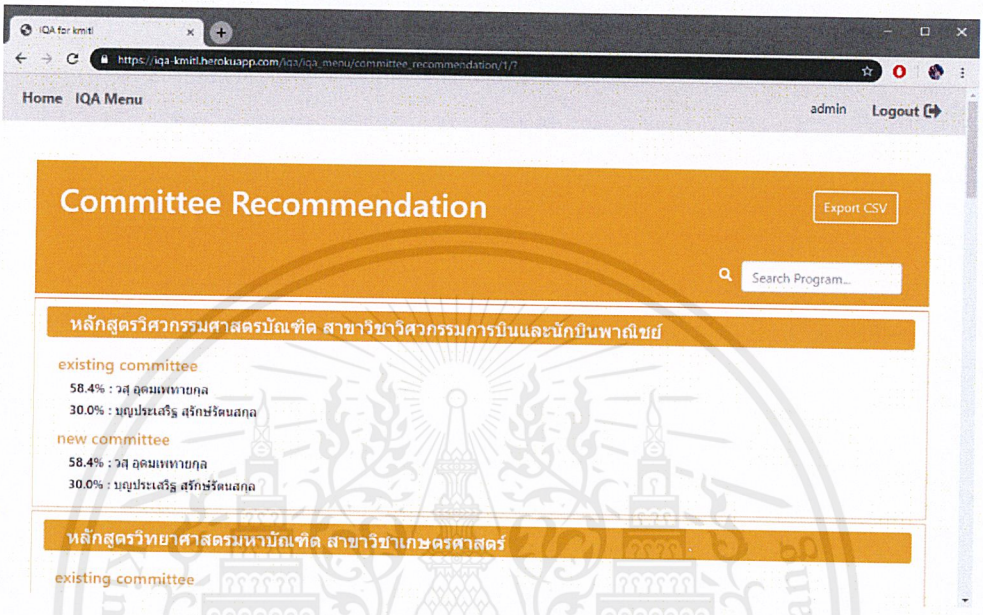
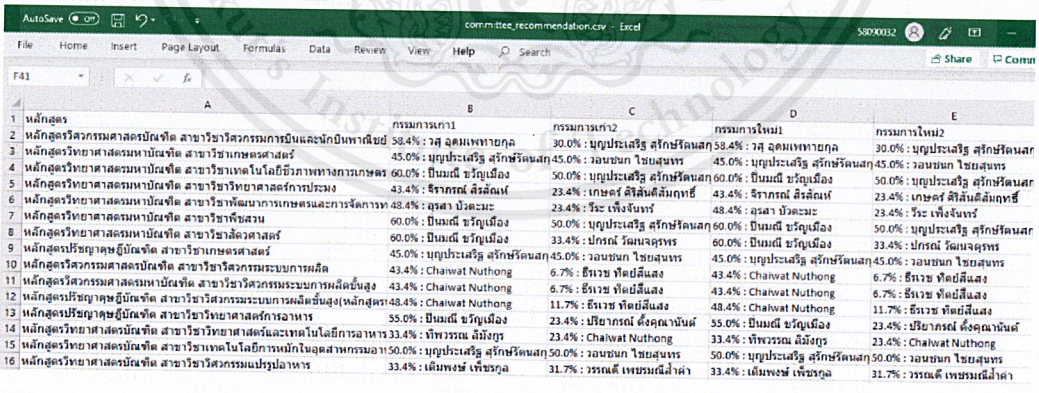


Figure 6.33: Committee recommendation page

The recommended information also be able to export into the excel file as it is presented in the following figure.



	A	B	C	D	E
1	หลักสูตร	กรรมการเก่า1	กรรมการเก่า2	กรรมการใหม่1	กรรมการใหม่2
2	หลักสูตรวิศวกรรมศาสตรบัณฑิต สาขาวิชาวิศวกรรมการบินและนักบินพาณิชย์	58.4% : วสุ อุดมเพทายกุล	30.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	58.4% : วสุ อุดมเพทายกุล	30.0% : บุญประเสริฐ สุรักษ์รัตนสก
3	หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาเกษตรศาสตร์	45.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	45.0% : วอนชนก ไชยสุนทร	45.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	45.0% : วอนชนก ไชยสุนทร
4	หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีชีวภาพทางการเกษตร	60.0% : ปิ่นมณี ขวัญเมือง	50.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	60.0% : ปิ่นมณี ขวัญเมือง	50.0% : บุญประเสริฐ สุรักษ์รัตนสก
5	หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาวิทยาศาสตร์การประมง	43.4% : จิราภรณ์ ศิริสัณห์	23.4% : เกษตร์ ศิริสันติสัมฤทธิ์	43.4% : จิราภรณ์ ศิริสัณห์	23.4% : เกษตร์ ศิริสันติสัมฤทธิ์
6	หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาพัฒนาการเกษตรและการจัดการท	48.4% : อุรสา บัวตะมะ	23.4% : วีระ เพ็งจันทร์	48.4% : อุรสา บัวตะมะ	23.4% : วีระ เพ็งจันทร์
7	หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาพืชสวน	60.0% : ปิ่นมณี ขวัญเมือง	50.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	60.0% : ปิ่นมณี ขวัญเมือง	50.0% : บุญประเสริฐ สุรักษ์รัตนสก
8	หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาสัตวศาสตร์	60.0% : ปิ่นมณี ขวัญเมือง	33.4% : ปกรณ์ วัฒนจตุรพร	60.0% : ปิ่นมณี ขวัญเมือง	33.4% : ปกรณ์ วัฒนจตุรพร
9	หลักสูตรปรัชญาดุษฎีบัณฑิต สาขาวิชาเกษตรศาสตร์	45.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	45.0% : วอนชนก ไชยสุนทร	45.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	45.0% : วอนชนก ไชยสุนทร
10	หลักสูตรวิศวกรรมศาสตรบัณฑิต สาขาวิชาวิศวกรรมระบบการผลิต	43.4% : Chaiwat Nuthong	6.7% : ธีรเวช ทิตย์สืนสง	43.4% : Chaiwat Nuthong	6.7% : ธีรเวช ทิตย์สืนสง
11	หลักสูตรวิศวกรรมศาสตรมหาบัณฑิต สาขาวิชาวิศวกรรมระบบการผลิตขั้นสูง	43.4% : Chaiwat Nuthong	6.7% : ธีรเวช ทิตย์สืนสง	43.4% : Chaiwat Nuthong	6.7% : ธีรเวช ทิตย์สืนสง
12	หลักสูตรปรัชญาดุษฎีบัณฑิต สาขาวิชาวิศวกรรมระบบการผลิตขั้นสูง(หลักสูตรา	48.4% : Chaiwat Nuthong	11.7% : ธีรเวช ทิตย์สืนสง	48.4% : Chaiwat Nuthong	11.7% : ธีรเวช ทิตย์สืนสง
13	หลักสูตรปรัชญาดุษฎีบัณฑิต สาขาวิชาวิทยาศาสตร์การอาหาร	55.0% : ปิ่นมณี ขวัญเมือง	23.4% : ปริยากรณ์ ตั้งคุณานันต์	55.0% : ปิ่นมณี ขวัญเมือง	23.4% : ปริยากรณ์ ตั้งคุณานันต์
14	หลักสูตรวิทยาศาสตรบัณฑิต สาขาวิชาวิทยาศาสตร์และเทคโนโลยีการอาหาร	33.4% : ทิพวรรณ ลิมังกูร	23.4% : Chaiwat Nuthong	33.4% : ทิพวรรณ ลิมังกูร	23.4% : Chaiwat Nuthong
15	หลักสูตรวิทยาศาสตรบัณฑิต สาขาวิชาเทคโนโลยีการหมักในอุตสาหกรรมอา	50.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	50.0% : วอนชนก ไชยสุนทร	50.0% : บุญประเสริฐ สุรักษ์รัตนสกุ	50.0% : วอนชนก ไชยสุนทร
16	หลักสูตรวิทยาศาสตรบัณฑิต สาขาวิชาวิศวกรรมแปรรูปอาหาร	33.4% : เติมพงษ์ เพ็ชรกุล	31.7% : วรรณดี เพชรมณีล้ำค่า	33.4% : เติมพงษ์ เพ็ชรกุล	31.7% : วรรณดี เพชรมณีล้ำค่า

Figure 6.34: Committee recommendation information

6.2.4 Web Directory

https://iqa-kmitl.herokuapp.com

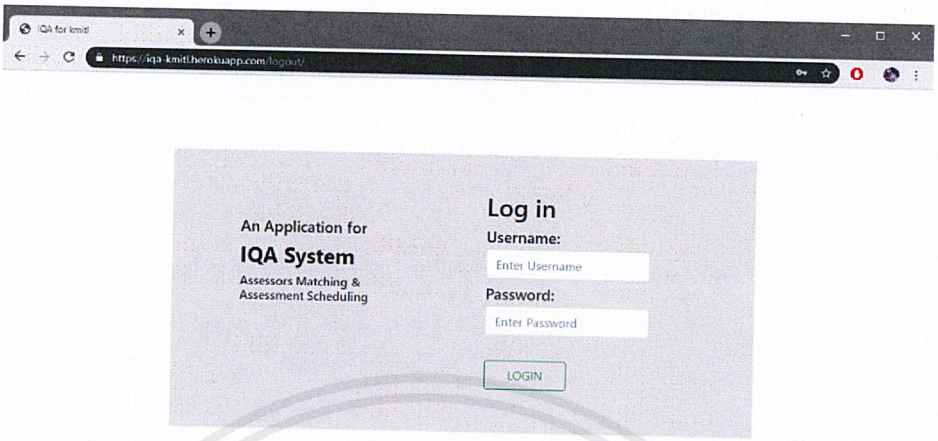


Figure 6.35: Login page

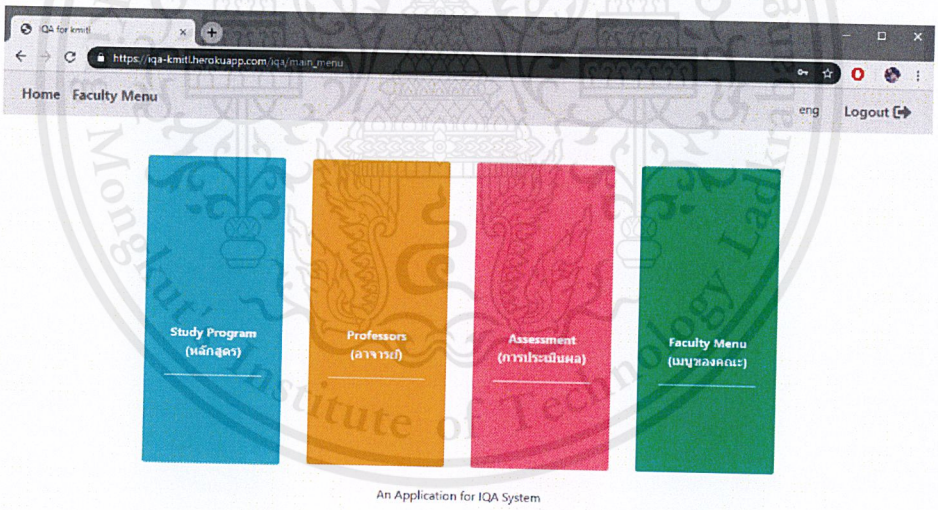


Figure 6.36: Main menu page

6.3 Testing Result

6.3.1 Code Coverage

As for the code coverage testing it is done by the coverage.py and the result is presented in the figure below.

Coverage report: 96%

Module ↓	statements	missing	excluded	coverage
accounts__init__.py	0	0	0	100%
accounts\admin.py	1	0	0	100%
accounts\apps.py	3	0	0	100%
accounts\models.py	1	0	0	100%
iqa_web__init__.py	0	0	0	100%
iqa_web\settings.py	23	0	0	100%
manage.py	9	2	0	78%
study_program__init__.py	0	0	0	100%
study_program\admin.py	13	0	0	100%
study_program\apps.py	3	0	0	100%
study_program\models.py	109	5	0	95%
Total	**162**	**7**	**0**	**96%**

coverage.py v4.5.3, created at 2019-04-01 17:01

Figure 6.37: Overall result of the code coverage

Coverage for **manage.py** : 78%

9 statements | 7 run | 2 missing | 0 excluded

```
1  #!/usr/bin/env python
2  import os
3  import sys
4
5  if __name__ == "__main__":
6      os.environ.setdefault("DJANGO_SETTINGS_MODULE", "iqa_web.settings")
7      try:
8          from django.core.management import execute_from_command_line
9      except ImportError as exc:
10         raise ImportError(
11             "Couldn't import Django. Are you sure it's installed and "
12             "available on your PYTHONPATH environment variable? Did you "
13             "forget to activate a virtual environment?"
14         ) from exc
15     execute_from_command_line(sys.argv)
```

« index coverage.py v4.5.3, created at 2019-04-01 17:01

Figure 6.38: Result of the code coverage for manage.py

Coverage for **study_program\models.py** : 95%

109 statements | 104 run | 5 missing | 0 excluded

```
1  from django import forms
2  from django.db import models
3  import datetime
4  # Create your models here.
5
6  # Handling many to many relationship
7  # https://stackoverflow.com/questions/4881578/django-bi-directional-manytomany-how-to-prevent-table-creation
8
9  class Professor(models.Model):
10     id = models.AutoField(primary_key=True)
11     professor_id = models.CharField(max_length = 200,blank=True)
12     academic_title = models.CharField(max_length = 200)
13     name_surname = models.CharField(max_length = 200)
14     date_of_birth = models.DateField()
15
16     YEAR_CHOICES = []
17     for r in range(1980, (datetime.datetime.now().year+1)):
18         YEAR_CHOICES.append((r,r))
19
20     bsc = models.CharField(max_length = 200)
21     bsc_grad_institute = models.CharField(max_length = 200)
22     bsc_year = models.IntegerField(('year'), choices=YEAR_CHOICES, default=datetime.datetime.now().year)
23     #https://groups.google.com/forum/#!msg/django-users/aL95x1TXFV4/7mCCWQE3jtAJ
24
25     msc = models.CharField(max_length = 200)
26     msc_grad_institute = models.CharField(max_length = 200)
27     msc_year = models.IntegerField(('year'), choices=YEAR_CHOICES, default=datetime.datetime.now().year)
28
29     phd = models.CharField(max_length = 200)
30     phd_grad_institute = models.CharField(max_length = 200)
31     phd_year = models.IntegerField(('year'), choices=YEAR_CHOICES, default=datetime.datetime.now().year)
32
33     phone = models.CharField(max_length = 200)
34     email = models.CharField(max_length = 200)
35     university = models.CharField(max_length = 200)
36     additional_degree = models.CharField(max_length = 200, blank = True)
37
38     responsible_program = models.ManyToManyField('StudyProgram', blank=True)
39     #committee_profile = models.ManyToManyField('Committee', blank=True)
40     def __str__(self):
41         return self.name_surname
42
43
44
45 class StudyProgram(models.Model):
46     id = models.AutoField(primary_key=True)
47     code = models.CharField(max_length=200,blank=True)
48     name = models.CharField(max_length=200)
```

Figure 6.39: Result of the code coverage for study_program\$models.py$

6.3.2 System Test

Description	Result
Test Case 1: Main Menu	Pass
Test Case 2: Study Program	Pass
Test Case 3: Professor	Pass
Test Case 4: Committee	Pass
Test Case 5: Assessment Result	Pass
Test Case 6: IQA Menu	Pass
Test Case 7: Assessment Calendar	Pass
Test Case 8: Inbox	Pass
Test Case 9: Faculty Menu	Pass
Test Case 10: Faculty Study Program	Pass
Test Case 11: Committee Appointment	Pass

Table 6.1: Summary result of the test

Chapter 7
Conclusion

To summarize the main goal of this project in short, the system is created in order to assist and organize the work process of the IQA department. It will serve as a prototype system for IQA department to try using it until the real one is finished. It will help IQA department to learn more about technologies and how it can help improving the quality of its work. By using this system, IQA department will gain more understand about the requirement for the real system as well.

As for the knowledge and experience that the writers have gain throughout this project, it is remarkable. Though, the project itself is not requiring the best of the technical skills, but it requires a lot of details, efforts, and responsibilities because the system will actually be used in the IQA department. Despite of these soft skills, the project itself also required a lot of communication both within the team and the clients, in order to be certain that every parties reach the same understanding regarding to the system. It also the best opportunity to review all the lessons about the software engineering and learn more, as these knowledge will be used in the real work that actually be contributed back to KMITL. Along the way, there also many problems that had occured due to the lack of experiences and knowledge, whether it is about the miscommunication, underestimating the work effort, or technical problems. However, in returns, these problems become a lessons and the new experience for the team to be better.

Hence, wish the readers would understand the vision of this project and gain some knowledge by reading this. The followings topic below will be the area of improvement for the future work. It is open for anyone who wants to be a part of this project or interested in conducting a research that will help improving this IQA supporting system.

7.1 Future Work

As the foundation for organizing the data of this project has been set. It should be more convenience to focus more on conducting the research or developing the features/functionalities that will assisting the IQA support system. These followings below

are some idea for the further improvements the system.

- Create an automate to compute the rating matrix.
- Improve the recommender system.
- Create a general model for committee recommendation, expanding the scale into a national level.
- Create an automated official document generation.
- Create an IQA Chatbot that helps answering a simple question(s) instead of the IQA team. For example, "What is the assessment score for this study program?"
- Create the system that assist IQA department on visualizing and analyzing the data.

Bibliography

[1] Satya, P. S., Anand, N., & Mahendra, P. (2017). *Machine Learning Algorithms for Recommender System - a comparative analysis.* (Volume 6–Issue 2, 97-100) Retrieved from International Journal of Computer Applications Technology and Research.

[2] Rajaram, H. A., & Dinesh, B. H. (2013) *Class Timetable Scheduling with Genetic Algorithm*, IJCST 4(4).

[3] Bhatt, B., Prof. Patel, J. P., & Prof. Gaudani, H. (2014). *A Review Paper on Machine Learning Based Recommendation System.* Department of Computer Engineering, IIET, Dharmaj and Department of Computer Engineering, GCET, Vallabh Vidhyanag.

[4] Halpin, T. (1998). *Object-Role Modeling (ORM/NIAM)* . Microsoft Corporation, USA.

[5] Chittayasothorn, S. (2017). *Relational Database Systems Language, Conceptual Modeling and Design For Engineers.* Thailand: Nutcha Printing Co Ltd. ISBN 978-616-440-143-3.

[6] Varzaneh, H. H., Neysiani S. B., Ziafat, H., Soltani N. (2018). *Recommendation Systems Based on Association Rule Mining for a Target Object by Evolutionary Algorithms.* Emerging Science Journal Vol. 2, No. 2, April, 2018.

[7] Philip, S., Shola, B. P., John, O. A. (2014). *Application of Content-Based Approach in Research Paper Recommendation System for a Digital Library.* (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 5, No. 10, 2014

[8] Sarwar, B., Karypis, G., Konstan, J., Riedl, J. (2014). *Item-based Collaborative Filtering Recommendation Algorithms.* GroupLens Research Group/Army HPC Research Center Department of Computer Science and Engineering University of Minnesota, Minneapolis, MN 55455, GroupLens Research Group/Army HPC

Research Center Department of Computer Science and Engineering University of Minnesota, Minneapolis, MN 55455.

[9] Pinela, C. (2017). *Recommender Systems - User-Based and Item-Based Collaborative Filtering* [Online]. Available: https://medium.com/cfpinela/recommender-systems-user-based-and-item-based-collaborative-filtering-5d5f375a127f/

[10] Mertricks. (2016). *Frome Least Squares to KNN, Statistical Models, Supervised Learning and Function Approximation* [Online]. Available: https://mertricks.com/2016/04/24/from-least-squares-to-knn-statistical-models-supervised-learning-and-function-approximation/