# 1. Introduction

This project will be an SMP (Stable-Matching Problem) - Targeting the means by which students are allocated to any given area and supervisor for their Final Year Project (FYP) within the University of Malta. Being an activity, which takes place annually, there already exists a manual system responsible for allocation, however improving upon the existing system by means of implementing automation into the process was deemed appropriate.

In the previous system some inefficiency proved prevalent due to the manual nature of the process. The new system aims to reduce such inefficiencies as much as possible by means through automation. Data will be dynamically stored, in order to be called freely when required. As a result, allocating students to the highest preference available will be simplified by means of replacing manual actions with computational processes.

# 2. Project Definition

The project defined comprised of the process that takes place each scholastic year, being the allocation of students to their respective Final Year Project (FYP). The process consisted of all the steps involved in order to assign students to an area that has been chosen as one of their six preferences. In contrast to previous years, this project strives to eliminate tasks being carried out manually, and instead will introduce automation within the allocation process.

With regards to allocation, three main roles are involved, students, supervisors, and administrators, each having role specific actions distributed amongst them accordingly. Students primarily decide which areas suits them best in order to develop an optimal FYP. Supervisors are responsible for the creation and submission of areas that students may choose as preferences. Administrators serve the purpose of ensuring that following allocation completion, results are published at any time deemed suitable by the appropriate authority.

In relation to the previous process, the submission of areas by supervisors had to be manually compiled, with one form for each area. This meant that if any given supervisor had many areas, each area had to be compiled independently. Moreover, the allocations would be performed manually, demanding significant attention to confirm that all information had been employed without error. This project aims to eliminate any extra processes by means of authentication and validation through automation. As a result, this allows the allocation process to be carried out without having to perform any manual checks on the data provided. It is important to note however, manual checking will still remain available, to be optionally selected. This is to be done as means of providing accountability and auditability to parties that may have doubts as to the accuracy of allocation.

An additional advantage of the automated system will be that all the operations will take place on a single portal. This allows students to submit their preferences, supervisors to create areas for the FYP, and administrators to publish results to all parties involved, all in one place. Data may be appended or removed with proper authorization; however, this is subject to the circumstances at the time of deletion or editing. By this it is mean that supervisors are allowed to edit the areas, while students can only view them. Students are allowed to edit their preferences but cannot change the titles. Also, by circumstances it is to be understood that if students have already begun to choose and submit their preferences, supervisors may not subsequently edit or delete any of their areas, this is to ensure no complications and push the need for confirmation that all data is correct before beginning the submission and allocation process.

# 3. Research done into the Domain

In order to strengthen familiarity with the subject, web-based research was conducted. After the time allocated for research had passed, discussions with regards to research done were held, highlighting key attributes for the allocation process as well as ensuring a global understanding within the capacity of the work to be carried out.

In this instance, allocation is to occur between students and areas proposed by supervisors, dependent on preferences provided by students. Also, allocation is to be dependent on a quantified quota that supervisors have specified by area or as a total quota. Individual preferences are to be submitted through a web form and subsequently passed to an algorithm that serves the purpose of allocating areas to students in an optimally stable manner. Doing such involves the algorithm attempting to appoint the highest available individual preference to each student. Following the completion of allocation, results are compiled and stored with the possibility of later use. Allocation like such may be observed in other instances, including hospitals, where doctors are allocated to particular hospitals based on select criteria.

The allocation results are to be affected by students in the following order:

1. Students submit individual preferences.
2. If two or more students choose the same first preference, the student with the highest average mark is allocated to the area.
3. If students happen to have the same average, the area is allocated to the student with the earliest date of submission.

It is vital that the global quota between all areas and supervisors, is greater than the number of enrolled students. This is to be done as to avoid the eventuality that a student is not allocated at all due to no existing availability, having all areas and supervisors depleted of available places.

As defined by [1] and [2], a properly functioning Student-Area allocation system must ideally consist of:

* Completion in a minimal amount of time, regardless of the size of students, supervisors or areas sets.
* No student is to be allocated to an area not found within the submitted preference list.
* Quotas are not to be exceeded.
* There is no dispersion of resultant data.

Adhering to all the above provided points proves to be imperative. Also, the presentation of a solution that is of higher quality than the currently utilised system is to be done in accordance with best practices from both a User Interface (UI) and functional perspective.

# 4. Overview of Existing / Similar Solutions

A concise overview of the currently available solution consists of:

* Supervisors fill in area forms.
* Students fill in preference forms.
* Compiled data is saved as csv files.
* Allocation is performed.
* Results are once again stored as csv files.
* Final allocations are sent to students.

The current system being utilised by the University of Malta differs in procedure for allocation, in contrast with the proposed system to be developed. The current process begins with manual entry, as each supervisor must fill in the details for each individual area in a form. The form is split into parts, including, the title for the proposed area, primary supervisor as well as any known co-supervisors, followed by all details in relation to the area. To expand on these details, they include, some keywords, a brief description of what is expected, and any resources that may be required. It is important to emphasize that this process must be repeatedly carried out for each individual area offered by any given supervisor.

With regards to students, the preference form is filled manually. The process involves, listing the preferences in order from first to sixth, whilst also associating supervisors to a selected area entered onto the form.

The next step involves manual input of both the area and preference forms into a csv format, a crucial step that demands repeated validation in order to ensure all data gathered is correct before performing the allocation. If this step is not treated with caution, the allocation process may have to be completely restarted upon detecting an error.

The secretaries are the sole individuals responsible for handling the management of allocations. In the case that this role were to be assigned to new parties, proper guidance and training is a must. Moreover, this is a process that must be performed annually, leading to the nonoptimal appropriation of time and resources.

This issue is intended to be tackled through the implementation of authorization segregated by roles within the university, along with optimisation methods to be discussed. As a result of facilitating such processes, and ensuring optimal employment of resources, the primary aim is to ensure a significant improvement in allocation time, as well as eliminating repetitive or redundant tasks.

# 5. Business Requirements

## 5.1 Business Process Description

The current method with regards to assigning students to the appropriate FYP is in working order and has been utilised over a significant amount of years. Despite such, strong evidence suggested the need for a more efficient process, within the capacity of workload and time taken for results to be delivered. The main purpose of allocation is to optimally assign students to their top preferences, with alternately chosen preferences being assigned for those students whose preferred supervisor has had their quota met. Therefore, having an optimal algorithm is necessary, to reduce human-error and the interference possible external factors. There exist three significant external factors in the current system:

1. When entering existing supervisor areas.
2. Recording student details and their preferences.
3. Performing the allocation of students to supervisors.

After the student FYP preferences submission deadline has been met, the allocation is performed and agreed upon by the appropriate authority, with allocations subsequently sent to students to notify them of the area and supervisor to which they have been assigned. This is to be ideally done in a minimal timeframe, with the workload potentially slowing the process, in the case that an error occurs in the aforementioned three stages.

Therefore, the new system must target the alleviation of inefficiencies and the interference of external factors. This to be done by means of presenting a reliable process which is user-friendly, and offers ease of use, whilst more importantly delivering assured accuracy with regards to allocations, in less time and with less effort. This subsequently renders a potential problem faced annually into a job that may be performed with confidence in the results produced.

## 5.2 Process Used to Elicit Requirements

The Initial meeting was the most vital when dealing with familiarization of the FYP allocation system. The supervisors assigned to this project, aided in the understanding of functionality required, along with the clarification of any uncertainties that may have been prevalent. The task to begin with, was the highlighting of areas that would benefit from a change and what work had to be done. Employing the distribution of tasks in a team-based environment, aided with ensuring that decisions were thoroughly discussed and taken with assured quality. This type of environment proved to be an advantage, as a means of ensuring quality injected throughout the process was always up to a certain standard.

After the initial meeting concluded, low-fidelity prototypes were constructed, to be presented during the next meeting with the supervisors. Apart from such, each member was assigned a specific task, along with three forms needing to be collected, each form being part of the current system. These were to be collected from the secretaries being, form A (student FYP preferences form), area submission form (used by supervisors) and form B (Project Definition Form).

Initially, google drive served as the primary storage of resources, containing everything that was to be included in the project, having been made accessible to every member of the team. This allowed for a means of working remotely and sharing resources, in the initial phases of development. It is important to mention stages following the initial phases, saw a shift to version control software as a best practice for development.

The task is uploaded to the drive

Modifications are made

A task is carried out

The task is revised by the team

## 5.3 List of Requirements

The requirements for the FYP Allocation system are as follows:

1. A stand-alone web-based interface
   1. It is to employ a user interface similar to that utilised by the University of Malta.
   2. Sign in is to be restricted to University of Malta email addresses.
   3. After sign-in, users will be redirected to either a student, supervisor, or administrator portal.
2. Student portal is to include tasks relating to FYP preferences.
3. Supervisor portal must include the submission of proposed FYP areas.
4. Each area is to optionally have a quota along with each supervisor having a global quota. It is important to note that if an area quoted is opted for, then each area will have a quota independent of other areas linked to the same supervisor.
5. The administrative portal is to contain the option to import a list of students or supervisors, who are to be involved in the allocation. Also, the portal allows for the performing of allocations, as well as an extensive verification of results, with the option to publish when all allocations are complete.
6. The order of allocation is firstly sorted by average mark, and if two or more students have equal averages, date and time of submission is the deciding factor. Therefore, whoever submitted the preferences earliest is the first to be allocated amongst the students with equal averages.
7. One student can only be allocated to one supervisor and can only choose any given supervisor once when submitting preferences.

For each segregated portal, only the authorised functionality for each user role is visible. This means that in the case that a student logs in, they will not be able to perform supervisor tasks, such as the submission of an area.

In the student preferences form, validation is required to prevent a student from entering the same supervisor for more than one preference.

For supervisors and areas, if the quota for a supervisor is reached, and no area quota is specified, then the areas associated with that supervisor are no longer available. Also, the same may be said for the opposite case, with all area quotas being met rendering a supervisor no longer available.

When allocating, if any given student has a first preference which has not been assigned thus far, then the chosen supervisor and area will be subsequently allocated to that student. If more than one student chooses the same first preference, the average mark and time of submission for each student, will ultimately decide who gets allocated first. It is important to note that, if the chosen supervisor or area quota supports both students, then both will be allocated to that supervisor. For other students, the algorithm will look through each of their preferences until an available preference is found. Lastly, if no preference for any given student is available, then it has been stipulated that an option should be made available to allow for the manual allocation of remaining students to supervisors who are still available.

# 6. Ethics

One important aspect that was to be ascertained from the system was the assurance of widespread understandability, directly resulting in strengthened usability. This was achieved by means of providing users with concise, but informative notifications. Notifications made it possible to inform users of the state of the system and explain all results obtained through the system. As an added benefit, certain academic field may support plenty of jargon that may be misinterpreted, therefore, the employment of such notices proved to be of great benefit to users of the system.

Substantial amounts of personal data will be utilised by the system, including but not limited to, student and supervisor personal details. As a result, GDPR (General Data Protection Regulation) will be followed, as a means of keeping data strictly confidential and extensively protected. During testing, to avoid any breaching of regulations, randomly generated data was utilised in order to carry out tests relating to the performance of allocations.

Each user profession is handled by the system using the aforementioned role authorization, to distribute students, supervisors, and administrators accordingly. Each section, defined by role, has its own functionality dependent on the user logged in. Having an error occur in this section could be harmful to the results of the allocation. For instance, if a student is to log in as an administrator, all the areas, quotas, and other student preferences may be unlawfully manipulated or in the worst case, deleted from the system due to misuse. Therefore, it is of the utmost importance that classification is implemented to separate and restrict user access by role.

To minimize the probability of unwanted manipulation of sensitive data. Administrators are given the sole right to manipulate student and supervisor data, as well as being the only role that is able to perform allocations and publish results.

The algorithm is designed in a way which prioritizes fairness in the allocation of students, by means of conducting all tasks objectively. By this, it is meant that average marks are gathered with no preference being given to students for other factors than individual performances throughout the first year, as well as the time with which they submitted to break any equal averages.

# 7. Proposed Solution

## 7.1 Description including Justifying choice

The first step of the proposed solution was to evaluate the aesthetic design of the system. Draw.io was primarily utilised, as a means of producing detailed diagrams which were later presented as low-fidelity prototypes, with feedback and criticisms subsequently given by supervisors. Upon unanimous agreement as to which design to move forward with, more emphasis was placed on the functionality of the system.

Microsoft SQL was chosen for various reasons. It is a secure database management system, allowing for the efficient maintenance of data. It is also important to note that Microsoft SQL provides support for code first development with Entity Framework Core, being an extension employed with ASP.Net MVC.

To expand upon the aforementioned ASP.Net MVC, it is a technology that utilises web-based strategies whilst providing extensive backend functionality for server-side development. MVC, being the Model View Controller strategy, permits the segregation of the file structure as a means of placing focus on, web page views, server-side models, and controllers to mediate between the two.

The projected solution will be able to identify and allocate, through a one to one relationship, with one student for each supervisor, and vice versa. As has been observed through the discussions in [3], priority will be placed upon ensuring the allocation of a top preference, thus having this prioritization impact the final quality of the project. One of the main focuses will be to preserve the main points made in [3], keeping preferences as the primary allocation factor to the furthest possible extent.

Python and C# were used as programming languages whilst developing the functionality of the system. The use of these server-side languages resulted in the system returning results for allocation in a minimal timespan, usually measured in just a few seconds. Such a result proves to be better than the current system which involves hours of work to successfully perform allocations. Furthermore, having a system which works alongside an administrator may produce better result. As discussed by [4], the collaboration between an algorithm and human by means of a Human-Computer Interface (HCI) may produce more optimal results.

## 7.2 Task Breakdown

The work was divided between each member of the group in the following manner:

1. Connor Sant Fournier was assigned as team leader and was given the task of working with all processes relating to the allocation algorithm and the optimization of these processes. Also, he worked alongside Nicole Cassar with back-end functionality and database management.
2. Nicole Cassar was assigned the role of scribe, whilst also being tasked with back-end development and database management. Nicole Cassar also assisted Caoimhe Camilleri with front-end tasks and data entry.
3. Caoimhe Camilleri was appropriated the front-end tasks and User Interface (UI) related development. Caoimhe also dealt with the majority of data entry involved amidst development.
4. The fourth team member Joshua Spiteri was assigned with the compilation of the documentation. Whilst doing such compilation, Joshua Spiteri also aided in data entry and completion of front-end tasks.

Each group member familiarized themselves with all tasks encapsulating the system in order to provide well revised input during meetings. This was done in order to gather needed information or to be able to tackle problems as a team, irrespective of whether members were assigned to the area of the issue or not.

It is also important to note, meetings with project supervisors proved beneficial as a means of ensuring and maintaining a balanced breakdown of workload.

## 7.3 Project Plan and Methodology of Work

The project was initiated with two meetings, serving as an introduction to help in better understanding the situation that current administrators find themselves in. Such meetings encapsulated the prevalent issues that were to be changed, as well as parts of the system that proved adequate, and should stand unchanged as a result.

Meetings were frequently set up with both Mr. Bonello, the main project supervisor, and Dr. Abela, being the co-supervisor. Any problems faced were discussed during such meetings, with frequent updates being delivered to them with regards to the progress made as a group. When a meeting could not be scheduled, the team leader updated the supervisors by means of email communication.

Good communication proves to be a major factor in having a high-quality solution. A group was created on the Messenger service provided by Facebook where discussions were held. To keep track of progress from each member of the group, Trello was utilised, with both supervisors being added as a means of being updated without having to await an email with information on progress.

Whenever progress was made, draft materials and resources were initially uploaded on Google Drive, enabling every group member to upload or download any material required. This also acted as a backup and prevented loss of data from occurring. With regards to the actual system and resources that proved more vital to the final project composition, a GitHub repository was set up, as a means of keeping each group members system up to date through version control.

During team meetings, each member brought forward any progress made, with suggestions for improvements subsequently discussed. To add to this point, new tasks were assigned after each meeting and a date for when tasks were to be complete and delivered was agreed upon. This allowed for a continuous flow of progress throughout the project life cycle. It is vital to point out that, although the group may have agreed as to the completion of a particular task, supervisors were to be the ultimate approval as to whether any given task was complete or required further refinement.

# References

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