

Nested Repetitive Structure Techniques in Examination Seating Number Allocation Process at UiTM Pulau Pinang Branch

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ABSTRACT

Preparation of examination seating numbers during the final examination at UiTM Pulau Pinang branch is manually drafted and written by the examination unit staff on the class lists printed through the Student Integrated Managements Systems (SIMs). Process of assigning the seating number for each student takes couple of weeks and this task has become a challenging part for examination unit. Since the students' enrolments are linearly increasing every semester, the workloads among Examination Unit staffs become very burdensome in assigning the seating number. To automate the process of assigning the seating numbers, an algorithm was designed and constructed using the nested repetitive or looping structure techniques with JAVA programming language. Two tasks were identified in assigning the seating numbers; the first task was to set the examination seating number range with start and end numbers for each group of courses registered by the students and the subsequent task was to assign the seating number for each student accordingly by group seating number range as specified during the prior task without the violation or overlapping of seating numbers. The algorithm was tested using real data enrolments taken from SIMs for two semesters and resulted in positive effect especially on the reduction of stressfulness and zero erroneous allocation of the seating numbers.

Keywords: *Nested Repetitive, Seating Numbers, SIMs, SDLC, EMS*

INTRODUCTION

Generally, the Academic Affairs Department at UiTM Pulau Pinang branch is divided into three main units namely general administration, students' records and examination units. Examination unit is the most crucial unit in which its key functions involve the preparation of question paper, printing and packaging of question paper, handling examination operations and management of the overall students' marks (Quality, 2010; UiTM, 2016).

Handling examination operations involves several sub modules including the preparation of final examination schedules for each course, placement of examination venue process, printing and packaging of the question papers and the process of assigning invigilators at the examination halls (UiTM, 2016). Whenever the Department of Academic Evaluation from UiTM Shah Alam, Malaysia announce the examination schedules for each subject, staff at the examination unit will start preparing final examination operations. The earliest task is to allocate the venue of examination for each course. Once the venue is allocated and verified by the Assistant Registrar (Examination), the subsequent process is to arrange the examination seating number. The arrangement or allocation of the seating numbers is prepared manually for all courses and links to students' enrollment downloaded from the Student Integrated Management Systems (SIMs). This process is employed by two staff of Examination Unit assisted by the examination committee at UiTM Pulau Pinang Branch for 20 days of examination duration. This preparation continues until the examination ends. The examination seating number for each student is written manually one by one on the class list printed from SIMs by referring the range of seating numbers, which is also manually calculated during the prior task.

The process of allocating the seating number is very cumbersome. For the staff who involved in the seating number allocation, it is tiring and exhausting. Quite a number of cases have been reported in the pass examinations whereby two students clashed in the same seat number. The seating numbers written on the class lists were different from the examination hall plan on seating number range sheets. As a result, it became very tough for the invigilators to control the examination halls and ensure proper examination environment under the standard operating procedure (SOP) or ISO 9001:2008. All these lead to examination defects and surely the credibility or integrity in handling of examination operations will be queried by the top management and more importantly, creates negative perceptions among students.

On average, the total numbers of students' enrolment at UiTM Pulau Pinang Branch are approximately 32,000 to 35,000 per semester. Imagine if the allocation of students' seating numbers with that total of enrolment need to be done manually by only two staffs for three week of examination duration, surely erroneous examination cannot be avoided. More time is required to prepare the examination timetable whenever the total enrollments of students are very large besides the diversified courses offered at the faculty or department levels (Bloomfield and McSharry, 1997). The task of examination seating number allocation in the examination halls cannot be excluded as it helps the students to determine the seat number for each course easily. Hence, this task needs to be done automatically to improve the smoothness and efficiency of the examination operations and create positive satisfaction among examination unit staff and examination committees.

Therefore, one technique or approach was introduced to automate the process of examination seating number allocation for each course taken by students. This process can be performed in less than a minute with a powerful coding. This way, the manual allocation of seating numbers for three weeks will be replaced by a powerful application and processed without the overlapping of similar seating numbers. With this enhancement, the staff will be able to avoid defects on examination operations and their credibility or integrity will not questionable. Techniques or algorithms of examination seating number allocation were traced, evaluated and customized according to the situation of Universiti Teknologi MARA at Pulau Pinang Branch.

The paper is organized as follows. The next section explores related works on allocation of examination seating numbers at present. The following section discusses on the proposed work that could contribute to the efficiency of the examination seating number allocation. Finally, the paper is concluded with several recommendations for the future work.

RELATED WORKS

The primary concern of well-prepared examination halls depends on the comprehensive distribution of examination seats. Allocation of the examination seats with unique number will ensure the distance among students can be controlled to avoid cheating by copying answers from their close friends (Chaki & Anirban, 2016). The process of examination seat allocation starts as soon as the examination timetable of the courses is released. The tasks of examination timetabling and the seat allocation process are two different things (Burke, McCollum & McMullan, 2006).

There are few solutions or techniques that have been proposed for examination seating number allocation. Kahar and Kendal (2010) provided a solution for the venue allocation or assignment at Universiti Malaysia Pahang, Malaysia They considered only one examination will take place in one room at a time. Nevertheless, this solution may create an opportunity to cheat in exam hall like copying from nearby students, which requires many examination venues and more invigilators. Furthermore, it will incur additional costs for such invigilation duty wages and utility such as electricity usage and light beverages for invigilators during the examination periods. Ayob and Malik (2011) done the same thing about the room assignment, but considered only special examination. This type of examination environment is easy

to maintain, but cannot be tested with large numbers of enrolment, which requires more examination halls, courses and invigilators. The system should be able to cover and mostly focus on optimum uses of examination seats, having a standard distance of students getting the same set of question paper, avoiding the overlapping of seats and finally comprehensive seating arrangement that is comfortable for the students and invigilators (Chaki & Anirban, 2016).

Who is responsible for the arrangement of examination seating number? This issue has been discussed either the seating numbers will be prepared using centralized or decentralized approach. Centralized examination seating number arrangement is prepared by the main department authority and this responsibility refers to Examination Department at the university level, while the decentralized examination seating number arrangement is arranged accordingly by the faculty or college (Wobmann, 2002). Most universities are unwilling to handle the centralized examination seating number arrangement because of increasing number of students, variety nature of the courses and special requirements from departments. It is quite difficult to properly allocate the seats among a large number of students whenever the students are from different courses and faculties. Majority of the education institutions practice the decentralized examination to avoid the hassles of seating number allocation preparation (Poala & Scoppa, 2004).

The first pilot system for efficient seat allocation process has been proposed by Muhammad & Elyas (2018). They created a preliminary plan for students from various fields or disciplines. Objectives of the project were to optimize a minimum number of chairs in the examination halls, provide a standard distance of seating plan in the examination halls to avoid cheating or copying answers from the nearby students as well as to avoid two or more students having the same seat numbers or overlapping during the examination. This way, students are able to check their seat numbers and examination venue before the examination day through online system. This really helps the students to plan earlier before they go to the examination halls. Before this, most of the students faced many problems finding examination venues as they knew their seating number 30 minutes before the examination starts. The class lists with complete seating numbers are pasted at the entrance of examination halls. With an innovative system, the class lists do not need to be pasted at the examination hall anymore. The system features allow the students to print the examination slips, which contain comprehensive examination information such as the date and time, venue and seating number for each course enrolled by each student. In addition, the system will navigate the student location of the seating number in the examination halls through their smart phone. The seating numbers are arranged according to students' name in alphabetical order and grouped by different types of course or subject.

The second project has been proposed and developed by group of students at A.V.C College of Engineering, Tamil Nadu, India (Ezhilarasi et. al, 2018). The objective of the system was to automate the process of assigning the examination venue and generate the seating numbers for each student. The system was developed using Visual Basic programming language and the database in Microsoft Access. Basically, the system runs as an offline platform. The system administration needs to distribute the printed examination slips from the system to each student, which contain complete information such as the examination date and time, venues and the seat numbers for each course.

The third similar project named Examination Seating Arrangement System (AU, 2014) has also been developed at Eden High School, Hong Kong, to arrange internal examinations automatically. The system was able to automate the seating arrangement and generate comprehensive examination slips similar to the first and second projects above.

PROPOSED WORK

This section discusses the methodology applied in the development of automated examination seating number allocation and further clarifies the software and hardware requirements for this project. Detailed technique or approach required for this project is further explained at the end of this section.

The following Figure 1 below shows the proposed research methodology framework with six phases namely requirement analysis, system design, coding or implementation, integration and testing, system deployment and finally the maintenance. This framework was adapted from the Waterfall Model of System Development Life Cycle (SDLC) (Kenneth and Julie, 2014).

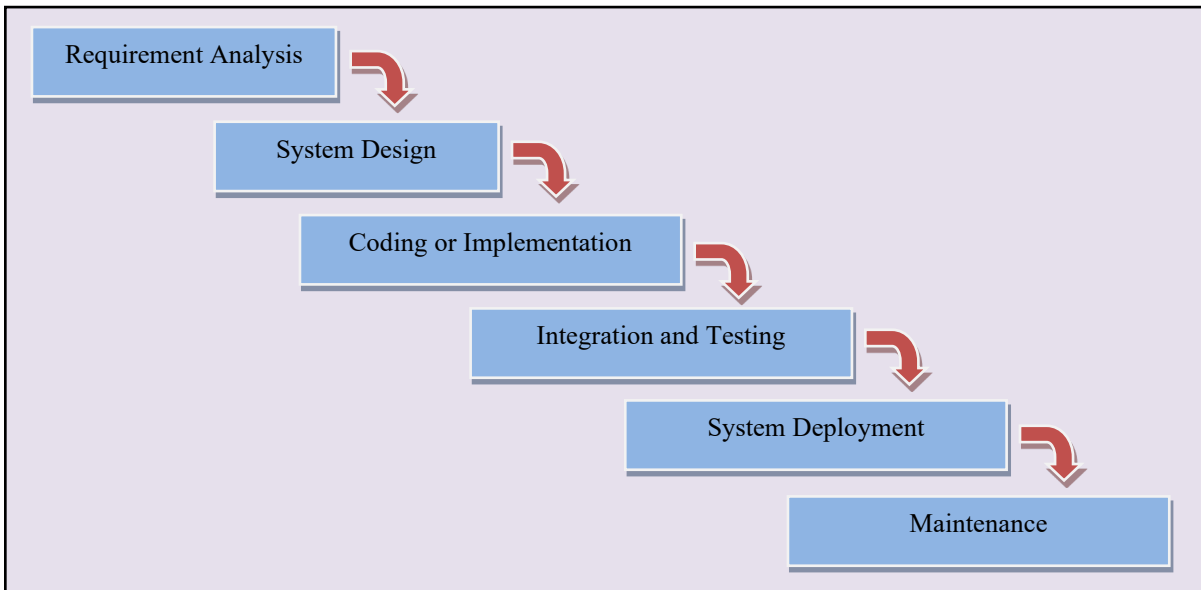


Figure 1: Research Methodology Framework, Waterfall Model of System Development Life Cycle (SDLC)

The waterfall model of SDLC is a sequential process in which its progress is seen as flowing steadily downwards like a waterfall through the phases. The first phase involves analysing and understanding the current systems. The system's specifications such as input, process and output (IPO) are also among the main focus in this phase. The purposes, scopes, objectives and functional requirements of the systems are needed to be proposed and confirmed before the systems design phase is started. The requirement specifications from the first phase are analyzed and studied during the system design. Activities involved are designing the algorithm and content ideas by reviewing the pseudo-code or flowchart to automate the allocation of seating numbers. System Design helps in specifying hardware and system requirements and in defining overall system architecture.

The third phase is implementation or coding whereby the documented design specifications from the second phase are coded using specified programming language and database management systems. The system is first developed in small programs called units, which are integrated into the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing. Integrating testing is the fourth phase in which all the units developed during the implementation phase are integrated into a system. The software needs to go through thorough software testing to find out any conscious and unconscious errors. The functional and non-functional testing are done by the users and developers so that they do not face any problem during the software deployment. Functional testing mainly refers to the system requirements confirmed by the users, while the non-functional requirement is related to technical requirements such as the hardware, network and security aspects.

Once the functional and non-functional testing is successfully done, the product is deployed in the client environment or released into the market. System deployment is the phase prior to system maintenance. The maintenance phase involves making modifications to the system or an individual component to alter attributes or improve performance. These modifications arise either due to changed requests initiated by the users, or defects uncovered during live use of the system. The user is provided with regular maintenance and support for the software. Maintenance is also the activity of improvising the system to sustain the users' acceptance, meet the goals of the project and fulfils the ad hoc requirements raised by the users.

The task of seating number allocation started whenever the Academic Evaluation Department at UiTM Shah Alam releases the finalized examination schedules to all campuses and faculties. Examination Unit staff at each campus and faculty downloads the students' enrolments from the Student Integrated Managements Systems (SIMs). Once the enrolments are downloaded, the records are crossed linked with the records of examination schedules through the Examination Management Systems (EMS). Next, the crossed linked records are auto assigned with examination venues before the seating number allocation process is started. The following Figure 2 shows the framework of Examination Management System (EMS) operations.

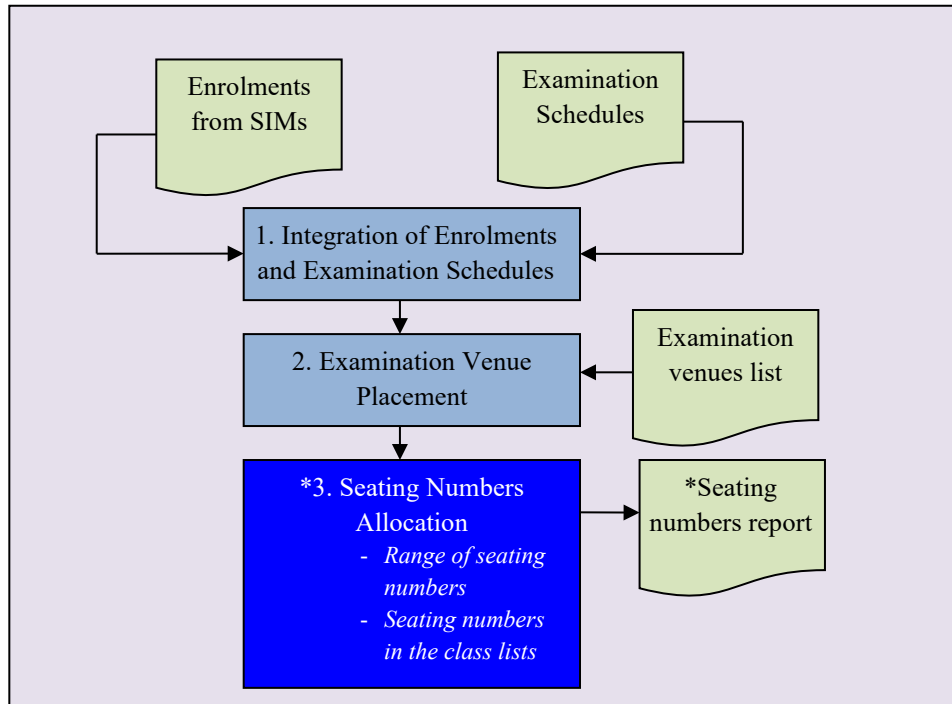


Figure 2: Framework of Examination Management System (EMS) with Seating Number Allocation Module (*new module)

The first and second tasks of Figure 2 are auto generated by EMS. The third task is the new module embedded as part of EMS module. This new module encompasses two sub modules; the first sub module generates the range of seating numbers according to the groups of each course in the examination hall. The second sub module sequentially assigns the seat number in the class lists of the group for each student according to the seating number range allocated and generated in the first sub module.

Special techniques including nested repetitive structures were applied for both sub modules. To test and verify the effectiveness of this technique, real data of students' enrolments and examination schedules were taken from the Student Information Integrated System (SIMs). The data were taken from two

consecutive examination sessions; June 2019 and December 2019 academic semester. The following figures are the sample of enrolments (Figure 3), examination schedules (Figure 4) and the examination venues list records (Figure 5) taken during December 2019 examination.

ID	Program	Year	Seat No
S	HM110	ACC106	PHM1102A1/2 31
S	HM110	ACC106	PHM1102B1/2 32
S	HM110	ACC106	PHM1102C1/2 31
S	HM110	ACC106	PHM1102D1/2 30
S	HM110(29)/HM115(3)/	ACC106	PHM1102E1/2 32
S	HM110	ACC106	PHM1102F1/2 29
S	HM111(22)/HM115(3)/	ACC106	PHM1112A1/2 25
S	HM111	ACC106	PHM1112B1/2 20
S	HM111	ACC106	PHM1112C1/2 20
S	HM111	ACC106	PHM1112D1/2 20
S	HM111	ACC106	PHM1112E1/2 21
S	HM111	ACC106	PHM1112F1/2 21
S	HM111	ACC106	PHM1112G1/2 19
S	HM111	ACC106	PHM1112H1/2 22
S	HM112	ACC106	PHM1122A1/2 23
S/SML/	HM111(1)/HM112(28)/	ACC106	PHM1122B1/2 29

Figure 3: Enrolments Records

ID	Date	Day	Time	Room
1	30/12/2019	ISNIN	PAGI	CEM443 9:00 AM 12:00 PM
1	30/12/2019	ISNIN	PAGI	CE5422 9:00 AM 12:00 PM
1	30/12/2019	ISNIN	PAGI	MGT162 9:00 AM 12:00 PM
3	31/12/2019	SELASA	PAGI	ACC030 9:00 AM 12:00 PM
4	31/12/2019	SELASA	PETANG	CEM571 2:15 PM 4:15 PM
4	31/12/2019	SELASA	PETANG	CM0083 2:15 PM 4:15 PM
4	31/12/2019	SELASA	PETANG	CTU095 2:15 PM 5:15 PM
7	02/01/2020	KHAMIS	PAGI	CE6451 9:00 AM 12:00 PM
7	02/01/2020	KHAMIS	PAGI	MEC412 9:00 AM 12:00 PM
8	02/01/2020	KHAMIS	PETANG	EPO514 2:15 PM 5:15 PM
8	02/01/2020	KHAMIS	PETANG	MAT133 2:15 PM 5:15 PM
9	03/01/2020	JUMAAH	PAGI	CEV415 8:30 AM 11:30 AM
9	03/01/2020	JUMAAH	PAGI	MEC411 8:30 AM 11:30 AM
10	03/01/2020	JUMAAH	PETANG	ECM413 2:45 PM 5:45 PM
10	03/01/2020	JUMAAH	PETANG	MAT183 2:45 PM 5:45 PM
11	04/01/2020	SABTU	PAGI	CEM483 9:00 AM 12:00 PM

Figure 4: Examination Schedules Records

Venue Name	Capacity
DEWAN_BESAR	640
DEWAN_KRISTAL	258
DEWAN_DELIMA	223
BKBA2A	139
BKBA2B	139
BKBA3A	139
BKBA3B	139
BKH_3_1	40
BKH_3_2	40
BKH_3_3	40
BKH_3_4	40
BKH_3_5	40
BKH_3_6	40

Figure 5: Examination Venues Records

Figure 6 show the cross link of enrolments and examination schedules records while Figure 7 is the cross linked records (from Figure 6) that have been allotted with the examination venues.

ID	Date	Day	Time	Room	Program	Year	Seat No
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110(31)/HM115(2)/	MGT162 PHM1101A1/2 33
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101B1/2 33
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110(31)/HM111(1)/	MGT162 PHM1101C1/2 32
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101D1/2 32
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101E1/2 31
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101F1/2 31
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111A1/2 22
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111(22)/HM115(1)/	MGT162 PHM1111B1/2 23
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111C1/2 21
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111D1/2 21
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111E1/2 21
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111F1/2 21
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111(20)/HM115(1)/	MGT162 PHM1111G1/2 21
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121A1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121B1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	HM112(29)/HM115(3)/	MGT162 PHM1121B1/2 32
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121C1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121D1/2 25
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM115	MGT162 PHM1152A1/2 25
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM115	MGT162 PHM1152B1/2 27
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM116	MGT162 PHM1161A1/2 23
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM116	MGT162 PHM1161B1/2 18
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415A1/2 25
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415B1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415C1/2 24
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415D1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415E1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415E1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415F1/2 25
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415G1/2 26
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415H1/2 26

Figure 6 : Cross Linked of Enrolments & Examination Schedules

ID	Date	Day	Time	Room	Program	Year	Seat No	Venue
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110(31)/HM115(2)/	MGT162 PHM1101A1/2 33	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101B1/2 33	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110(31)/HM111(1)/	MGT162 PHM1101C1/2 32	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101D1/2 32	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101E1/2 31	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM110	MGT162 PHM1101F1/2 31	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111A1/2 22	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111(22)/HM115(1)/	MGT162 PHM1111B1/2 23	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111C1/2 21	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111D1/2 21	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111E1/2 21	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111	MGT162 PHM1111F1/2 21	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM111(20)/HM115(1)/	MGT162 PHM1111G1/2 21	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121A1/2 26	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121B1/2 26	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	HM112(29)/HM115(3)/	MGT162 PHM1121B1/2 32	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121C1/2 26	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM112	MGT162 PHM1121D1/2 25	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM115	MGT162 PHM1152A1/2 25	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM115	MGT162 PHM1152B1/2 27	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM116	MGT162 PHM1161A1/2 23	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	HM116	MGT162 PHM1161B1/2 18	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415A1/2 25	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415B1/2 26	DEWAN_BESAR
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415C1/2 24	DEWAN_KRISTAL
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S	EN041	NECS21 PEN0415D1/2 26	DEWAN_KRISTAL
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415E1/2 26	DEWAN_KRISTAL
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415F1/2 25	DEWAN_KRISTAL
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415G1/2 26	DEWAN_KRISTAL
1	30/12/2019	ISNIN	PAGI	9:00 AM 12:00 PM	S/SML/	EN041	NECS21 PEN0415H1/2 26	DEWAN_KRISTAL

Figure 7 : Records with Examination Venue

An algorithm of Nested Repetitive Techniques was designed and coded using JAVA programming language and operated under Windows 7 or higher version of windows operating system. Normal personal computer or laptop can be used to operate this application program. The algorithm considers no issues of overlapping seat numbers among the students, no cases of overloaded problem in the examination halls and extra seats are always available if there is a case of special students without the seat numbers are allocated to him. Figure 8 shows the algorithm of nested repetitive technique to generate the range of seating numbers.

```
void RangeSeatingNumbers(ExamPlacement[] examPlace, int totRec)
{
    int x = 0, sNum = 0, eNum = 0;

    while (x<totRec) {

        if (x==0)
        {
            sNum = 1;
            examPlace[x].setStartNum(sNum);

            eNum = examPlace[x].getStartNum() +
                    examPlace[x].getTotStud() - 1;
            examPlace[x].setEndNum(eNum);
            x++;
        }

        while((examPlace[x].getIndexSession() == examPlace[x-1].getIndexSession())
            && (x<totRec))
        {
            while ((examPlace[x].getVenue() == examPlace[x-1].getVenue()) && (x<totRec))
            {
                sNum = examPlace[x-1].getEndNum() + 1;
                examPlace[x].setStartNum(sNum);

                eNum = examPlace[x].getStartNum() +
                        examPlace[x].getTotStud() - 1;
                examPlace[x].setEndNum(eNum);
                x++;
            }//close second level inner loop

            if (x == totRec)
                break;

            if (((examPlace[x].getVenue() != examPlace[x-1].getVenue()) && (x != 0))
                ||
                ((examPlace[x].getIndexSession() != examPlace[x-1].getIndexSession())
                 && (x != 0)))
            {
                sNum = 1;
                examPlace[x].setStartNum(sNum);

                eNum = examPlace[x].getStartNum() +
                        examPlace[x].getTotStud() - 1;
                examPlace[x].setEndNum(eNum);
            }
            x++;
        }//close first level inner loop

        x++;
    }//close outer loop

    return;
} //close void RangeSeatingNumbers
```

Figure 8: An Algorithm of Nested Repetitive Techniques for the Range of Seating Numbers

The following Figure 9 shows the nested repetitive technique for assigning seat numbers to each student based on the seating number range allocated by algorithm in Figure 8.

```
void StudentSeatingNumbers(ExamPlacement[] examPlace, int totRec, Enrolment[] enroll,
                           int totEnrol)
{
    for (int x=0;x<totRec;x++)//reads the ExamPlacement records
    {

        int sNum = examPlace[x].startNum();
        int eNum = examPlace[x].endNum();
```



```

//continued from the previous page
for (int y=0;y<totEnrol;y++)//read the Enrolment records
{
    if (examPlace[x].getCourseCode().equals(enroll[y].getCourseCode()))
    {
        if (examPlace[x].getCourseGroup().equals(enroll[y].getCourseGroup()))
        {
            if (!(sNum > eNum))
            {
                enroll[y].setSeatNumber(sNum);
                sNum++;

            }//close if third level
        }//close if second level
    }//close if first level

} //close inner loop
} //close outer loop
return;
} //close void StudentSeatingNumbers
    
```

Figure 9: An Algorithm of Nested Repetitive Techniques for Assigning the Seat Number to Each Student

The algorithm from Figure 8 was used to generate the range of seating numbers before the algorithm of Figure 9 was applied to allocate the seat numbers for each student. Both algorithms were developed using JAVA programming language and embedded in the Examination Management Systems (EMS). These two algorithms are related to each other because the records processed in the first algorithm (Figure 8) were further processed in the second algorithm (Figure 9).

RESULTS AND FINDINGS

The students' enrolments and examination schedules records in Jun 2019 and Dec 2019 sessions were used to test the effectiveness of both algorithms. The following Figure 10 shows the last two columns of each record that has successfully assigned the start and end numbers of seating number range. The following is the standard report generated from Examination Management System (EMS).

UNIVERSITI TEKNOLOGI MARA
PEP. AKHIR DIS 2019
PELAN KEDUDUKAN NOMBOR MEJA
TEMPAT : DEWAN_BESAR
TARIKH : 30/12/2019 (ISNIN)
MASA : PAGI

MASA MULA	MASA TAMAT	PENGAJIAN	KURSUS	KUMPULAN	PROGRAM	BIL. PELAJAR	NOMBOR MEJA	CATATAN
9:00 AM	12:00 PM	SSML/	MECS21	PEM1104CU	EM110	30	1 hingga 30	
9:00 AM	12:00 PM	SSML/	MECS21	PEM1104CU	EM110	24	31 hingga 54	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM11031/H	33	55 hingga 87	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM110	33	88 hingga 120	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM11031/H	32	121 hingga 152	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM110	32	153 hingga 184	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM110	31	185 hingga 215	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM110	31	216 hingga 246	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM111	22	247 hingga 268	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM111(22)/H	23	269 hingga 291	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM111	21	292 hingga 312	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM111	21	313 hingga 333	
9:00 AM	12:00 PM	S	MGT162	PEM11031U	HM111	21	334 hingga 354	

UNIVERSITI TEKNOLOGI MARA
PEP. AKHIR DIS 2019
PELAN KEDUDUKAN NOMBOR MEJA
TEMPAT : BKB42A
TARIKH : 30/12/2019 (ISNIN)
MASA : PAGI

MASA MULA	MASA TAMAT	PENGAJIAN	KURSUS	KUMPULAN	PROGRAM	BIL. PELAJAR	NOMBOR MEJA	CATATAN
9:00 AM	12:00 PM	S	MECS21	PEM2445AU	EM241	25	1 hingga 25	
9:00 AM	12:00 PM	S	MECS21	PEM2445BU	EM241	26	26 hingga 51	
9:00 AM	12:00 PM	S	MECS21	PEM2445CU	EM241	24	52 hingga 75	
9:00 AM	12:00 PM	S	MECS21	PEM2445DU	EM241	26	76 hingga 101	
9:00 AM	12:00 PM	SSML/	MECS21	PEM2445EU	EM241	26	102 hingga 127	

Jumlah Pelajar : 127

Figure 10: Range of Seating Numbers were Successfully Assigned at Two Different Venues in the Morning session for the First Day of Examination

The algorithm has also successfully assigned the range of seating numbers to all slots of examination for three weeks of examination including the location of examination, courses and the students' groups. The following Figure 11 illustrates the next slots of examination, which are in the afternoon session.

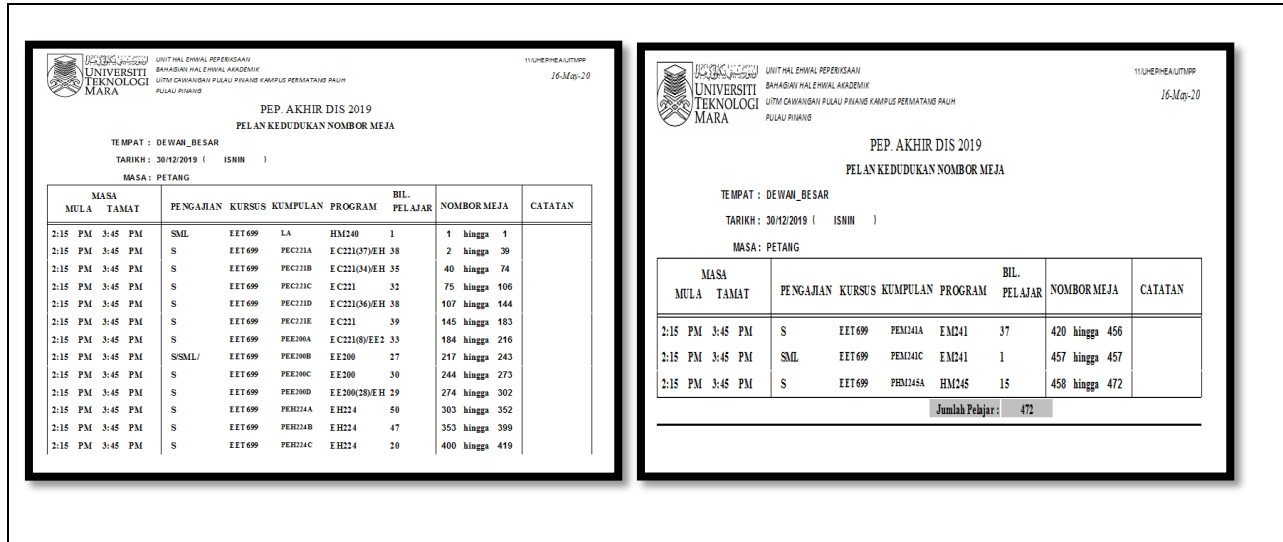


Figure 11: Range of Seating Numbers in Afternoon Session for the First Day of Examination at Dewan Besar

The second algorithm was used to assign the seat number for each student by group of the course. The following Figure 12 displays the report generated from the Examination Management Systems (EMS) after the second algorithm was executed. The following report showed that the seat numbers were assigned sequentially from the start number until end number of the range where the names of the students were sorted in alphabetical order.

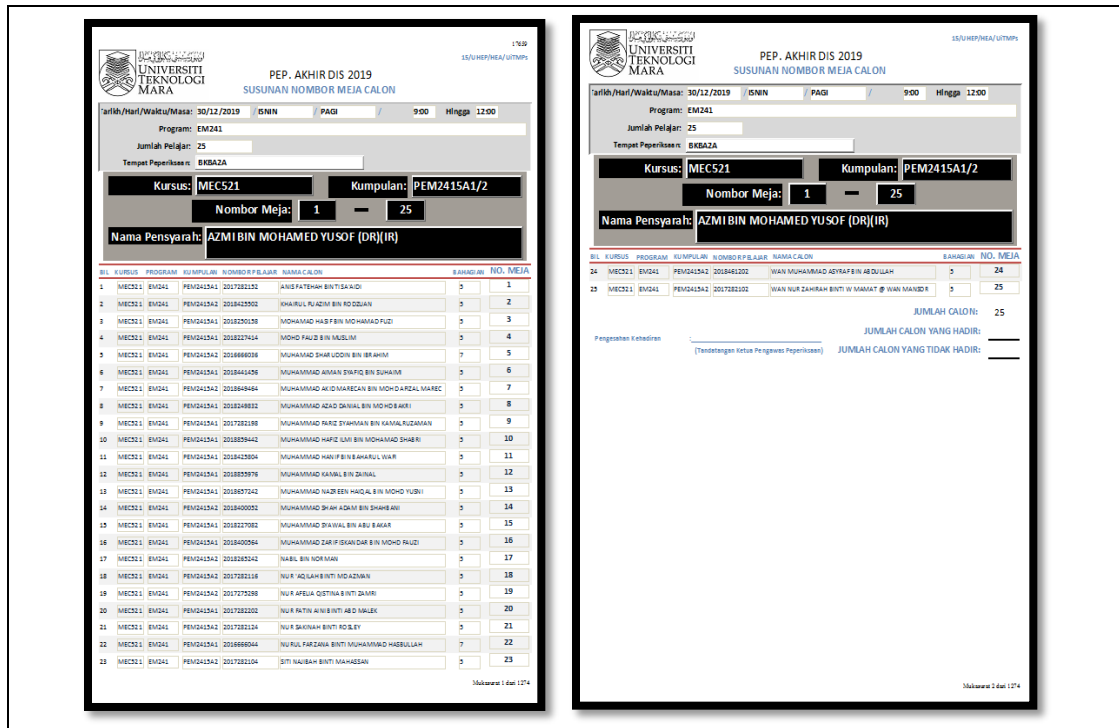


Figure 12: Each Student is Assigned with the Seat Numbers Sequentially

The techniques used to test the functionality of both algorithms were unit testing and integration testing. Unit testing is a practical approach to increase the correctness and quality of a software (Cheon & Leavens, 2001). Unit testing is based on the structural view into the implementation code. Code coverage tools can be used to provide the programmer with insight into which part of the code structure has been tested (Runeson, 2006). Meanwhile, integration testing is used to uncover errors in the interactions between system units or modules. It focuses on testing the connections presumed to be more error-prone (Banitaan et al., 2017). The testing techniques applied to both algorithms showed no errors in the report generated in Examination Management Systems (EMS). The following Table 1 shows the testing results of execution for seating numbers range algorithms using the real data of two sessions of final examination academic sessions.

Table 1: Testing Results of Execution for Seating Numbers Range Algorithms

Examination Academic Sessions	Total Records	Total Records Assigned the Table Seating Range	Successfully	Total Error	Records Detected
December 2019	730	730		None	
June 2019	641	641		None	

The same testing techniques have been done to the second algorithm to examine effectiveness of assigning the seat numbers to each student. The following Table 2 shows the results of the execution using the same real data of two sessions of final examination academic sessions.

Table 2: Testing Results of Execution for Assigning Seat Numbers Algorithms

Examination Academic Sessions	Total Records of Enrolment	Total Records Assigned the Seating Numbers	Successfully	Total Error	Records Detected
December 2019	17659	17659		None	
June 2019	15487	15487		None	

Both algorithms have successfully assigned the range of seating number at the examination venues and seat numbers to each student, respectively. The algorithms have solved issues such as overloaded students after assigning the seat numbers, clashes of the same seat numbers, mistakenly unassigned seat numbers and unstructured order of the students' sequence in the examination halls. The Examination Unit staff and examination committee members responded positively to the new application system since it has solved a lot of their workloads. Their job specifications were reviewed and currently, their only tasks left were to examine and verify the report of seating numbers generated through the Examination Management Systems (EMS). Once the report is verified and approved by the Executive Officer, it will be released to the students. The students will be able to check their seat numbers for each course through the online system earlier before the examination. The following Figure 13 shows an example of student's examination profile complete with the examination venue and the seat numbers for each course.

#	Kod Kursus	Kumpulan	Tarikh Peperiksaan	Hari	Sesi	Masa	Tempat	Nombor Meja
1	CES422	PEC2213G2	30/12/2019	ISNIN	PAGI	9:00	DEWAN_KRISTAL	107
2	CEM571	PEC2213G1	31/12/2019	SELASA	PETANG	2:15	DEWAN_BESAR	339
3	MAT435	PEC2213G2	06/01/2020	ISNIN	PETANG	2:15	DEWAN_BESAR	166
4	CEG461	PEC2213G2	09/01/2020	KHAMIS	PETANG	2:15	DEWAN_BESAR	99
5	CEW441	PEC2213G2	12/01/2020	AHAD	PAGI	9:00	DEWAN_BESAR	102
6	CES420	PEC2213G1	15/01/2020	RABU	PAGI	9:00	DEWAN_BESAR	144

*Silalah klik pada hyperlink tempat peperiksaan untuk menyemak kedudukan nombor meja peperiksaan di dalam dewan.

Figure 13: Student's Examination Profile

Through the hyperlinks of examination venue as shown in Figure 13, the student will be self-guided through their smart phones to the location of the seat number in the examination hall as shown the Figure 14. This feature will improve examination operation efficiency especially at venues with a large capacity.

100	147	154	22	62	24	26	7
185	148	133	96	81	52	37	8
199	184	149	132	97	80	53	36
200	183	150	131	98	79	54	35
243	232	201	182	151	130	99	78
244	231	202	181	152	129	100	77
245	230	203	180	153	128	101	76
246	229	204	179	154	127	102	75
247	228	205	178	155	126	103	74
248	227	206	177	156	125	104	73
249	226	207	176	157	124	105	72
250	225	208	175	158	123	106	71
251	224	209	174	159	122	107	70
252	223	210	173	160	121	108	69
253	222	211	172	161	120	109	68
254	221	212	171	162	119	110	67
255	220	213	170	163	118	111	
256	219	214	169	164	117	112	

Figure 14: Examination Venue Plan with the Highlighted Location of the Seat Number

CONCLUSION AND FUTURE WORK

Examination Management Systems (EMS) has been able to improve the efficiency and effectiveness of examination administration. The application had decreased the resources needed to accomplish the task (Bhardwaj & Singh, 2011). The Examination Unit staff and examination committee members were proudly satisfied with the application system because the burden of manual preparation of the examination seating numbers arrangement have been took over by the application system. Their job specifications have been reviewed and they were able to focus much more on the efficiency and integrity aspects of examination operations. This will reduce the risk of mismanagement during examination operations (Muhammad & Elyas, 2018). In addition, the system has reduced the duration of seating number manual preparation from three weeks to less than 1 minute. Consequently, the reduction of overtime claimed among staff is expected once the system is implemented. In addition, the students praised the website of Examination Management System (EMS) for helping them in knowing the examination schedules earlier, which is also accessible anywhere and anytime. The students responded that the web provides comprehensive examination information.

Planning for the future work, the algorithms as introduced in this paper will be tested at other campuses of Universiti Teknologi MARA (UiTM). The algorithms will be enhanced and improvised repeatedly until it achieves the optimized standard of algorithm that can be flexibly applied at any situation and condition. The enhancement of EMS is an on-going process whenever there are suggestions or positive comments given by the users or Examination Unit staff as well as through benchmarking platforms by other UiTM campuses, faculties and local or private universities. Thus, for the improvement of EMS, the Examination Unit will continuously support the operation of EMS and ensure the good rapport. Nested Repetitive Technique is just the beginning of the journey. In the future, it is hoped that there will be more innovative

ideas to further improvise the algorithm to become an outstanding approach in the process of examination seating number arrangement.

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