

## Article 1

### Assigning Examination Invigilator's Schedule Problem: An Approach of Programming Techniques Using Simple Sequential Assignment

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#### **Abstract**

*Preparation of examination invigilation schedule is a tedious and challenging tasks. It is impossible to satisfy all invigilators or proctors with the invigilation schedules prepared. The examination committees have to analyze and thoroughly checks all constraints submitted by the invigilators. Formerly, the process of assignments and deciding the best slot for invigilation will usually take a couple of weeks and all these processes are done manually. This paper proposes a programming technique using simple sequential approach to assign the invigilators on the proper examination slot without any conflicts or clashes aligned with the list of constraints and parameters. This simple tools or systems has been developed to help the examination committee to reduce the time taken for invigilation schedule preparation, avoid erroneous of incorrect assignment of invigilators and increase the satisfaction amongst invigilators with the invigilation schedule assigned. However, this tool is only a supplementary support in invigilation assignment process and the manual changes by considering human touch factors are still considered to produce friendly and empathy worthy invigilation schedules.*

**Keywords:** *Invigilators, Invigilation, Sequential Techniques*

#### **Introduction**

One of the main operations of any university is examination. Most universities setup special unit under the Department of Academic Affairs to manage the examination operations. Universiti Teknologi MARA (UiTM) for example, runs an independent department or section to manage all examination operations, which is connected to all faculties, centers and campuses. Basically, the examination department manages the printing and packaging of question papers, distribution of examination package to faculties, centers or campuses, preparation of examination schedules, determination of examination venues and assignment of invigilators (UiTM, 2016).

Gaspero et al. (2003) has stated that the university timetabling problem includes the preparation of lectures and examination scheduling which allocate to the number of rooms, consisting of lecturers or tutors, administrative staffs and students in a specified duration of time. Furthermore, ahead of the schedule preparations, the constraints as predetermined are filtered and verified as soft and hard constraints to minimize the lecturer's and student's workload. Carter & Laporte (1997) has mentioned, generally, for the preparation of examination scheduling in tertiary education, it involves large number of constraints, highly considered constraints and complex multiple combination of constraints. Several applications have been developed to generate the class and examination scheduling by using special techniques such as mathematical modeling (Sagir & Ozturk, 2010), constructive heuristic approach (Kahar & Kendall, 2010), particle swarm based hyper-heuristic approach (Ahmed, Sajid, Ali, & Bukhari, 2011), bender's partitioning (Sarin, Wang, & Varadarajan, 2010) and graph coloring framework (Mohamed, Mushi, & Mujuni, 2013).

Experts have introduced several approaches to perform an efficient, accurate and establish the best solution to solve complex and large problem of examination or class scheduling(Chunbao & Nu, 2012). Furthermore, the existence of big data evolution has coincidentally influence and increase the complexity of timetabling system. The happiness index of timetable becomes the highest priority of timetabling schedule regardless of the complexity of the system. The systems cannot promise fulfilling 100% of users' satisfactions, nevertheless, complying with 70% of happiness index is considered successful.

This paper will focus on the preparation of invigilation examination schedules amongst invigilators at UiTM Pulau Pinang Branch, Malaysia. The scope of invigilators comprises the lecturers, administrative staff, invigilators assistant and part-timers. The parameters and constraints are determined as required data for the invigilation processing. The hard and soft constraint are determined and prioritized to optimize the complexity of invigilation assignments.

An algorithm has been developed to generate the invigilation assignment reports, taking into consideration all approved parameters and constraints. This algorithm has been tested to several sets of data for testing and it has continuously been applied on real data since January 2016 examination session until the current session of examination. The programming language used is the Java Programming language. Figure 1 illustrates the records extraction process from the text file and automated records generation process subsequently into Microsoft Access.

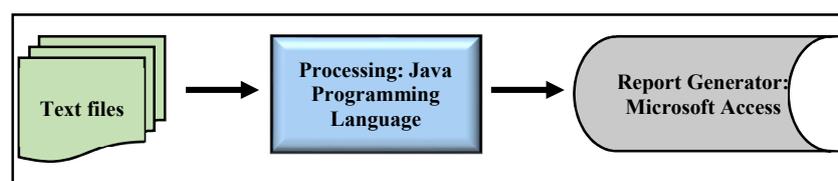


Figure 1: The Framework of Invigilation Timetabling Systems

### **Prior Practices of Invigilation Assignment**

In the past practices, most of the invigilation duties preparation will be managed by the examination committee which approximately consists of 10 members. The committee will be concentrating on the invigilation duties preparation after the examination placement of venue is completed. Once the examination placement is verified and accepted, the committee will be requesting data such as the list of invigilators, ratio of invigilator to the number of candidates or capacity of the examination rooms, records of examination from the first day until the final day of examination together with the examination venue which has been placed and list of constraints. All this data are needed by the committee and the preparation will consume more than 1 week together with the validation and verification processes before the letter of appointment can be distributed to each invigilator.

All these processes are done manually by examination committee. Most of the examination committee members are lecturers that are busy with other commitments besides teaching and doing research work. Furthermore, several members of examination committee are also holding administrative position such as program coordinator or head of department. With the time constraint and workloads, this is one of the reasons for some cases in the invigilation assignment the committees are unable to take into account the hard constraints as requested by the invigilators. Similarly mentioned by Hanum, Romliyah, & Bakhtiar(2015), the manual

system fails to consider the hard constraints and the invigilators are unhappy with the invigilation duties received.

Related paper which has mentioned by Cowling, Kendall and Hussin(2002)from the survey has observed that most of invigilators are not satisfied with their timetables and they requested the scheduler or examination committee to do a thorough work on invigilation assignment duties. Other desirable factor such as the human touch or personal preferences is also considered as one of the element during the assignment of invigilation duties. Most of the examination committee members work accordingly to the standard operating procedure (SOP) as stated, determined and standardized by the committee. We believe that the personal preferences will be look over thoroughly if the examination committee has ample time to amend the invigilation assignment duties.

Table 1 shows the total changes or invigilators replacement after the manual assignment of invigilation duties amongst invigilators. This data has been collected from Examination Unit at Permatang Pauh Campus, UiTM Pulau Pinang Branch.

Table 1: Total Changes of Invigilation Duties according to Examination Session

	Examination Session			
	Jan 2013	Mar 2013	Jun 2013	Dis 2013
<b>Total Invigilation</b>	578	1096	624	1290
<b>Total request to change or amend the invigilation duties</b>	153	245	148	301
<b>Percentages of changes</b>	26.47	22.36	23.72	23.33

Based on the above table, it shows that although the examination committee members have spent almost two weeks to prepare the invigilation duties, however the percentage of changes are still more than 20%. The suggested algorithm is expected to decline the percentage of changes and increase the invigilators satisfaction.

### **Assignment Model for Invigilation Schedule**

Examination Management Systems (EMS) has been developed and consisting of four (4) main modules including the Examination Placement module, Printing & Packaging of Question Papers module, Assignment of Invigilation Duties module and Examination Operation module. This paper will concentrate on the discussion of Assignment of Invigilation Duties amongst invigilators.

The process of assigning of invigilation duties amongst invigilators will be performed after the examination placement is completed. EMS requires the following data for assignment of invigilation duties:

- List of invigilators or proctors. The invigilators including the academic staffs either the permanent staffs, contract staffs, part-timers or part-time full-timers (PTFT). Besides that, the administrative staffs and invigilators assistant (outsiders) will be appointed to assist the invigilation at the examination hall which requires many invigilators.

	KAMPUS	JAWATAN	NAMA	BIDANG	KULTI/JABATAN	LEVEL
5						
12	P	PENSYARAH	MOHD HAPIZ BIN MAHAYADIN (DR)	ACIS	ACIS	0
13	P	PENSYARAH	MOHD MARBAWI BIN TAHA (DR)	ACIS	ACIS	0
14	P	PENSYARAH	ROSHAIMIZAM BIN SUHAIMI	ACIS	ACIS	0
15	P	PENSYARAH	ZAITON BINTI DIN	ACIS	ACIS	0
16	P	PROF. MADYA	HOE FOO TERNG (PM) (DR)	APB	APB	0
17	P	PENSYARAH MUDA (K)	NUR DARINA BINTI IBRAHIM	APB	APB	0

Figure 2: List of Invigilators

- The examination records from the first day until the final day of examination including the venue of examination that has been assigned to each course.

14	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EC110	ELC151	PEC1102A1/2	24 DEWAN BESAR
15	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EC110(27)	ELC151	PEC1102B1/2	28 DEWAN BESAR
16	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EC110	ELC151	PEC1102C1/2	24 DEWAN BESAR
17	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EE110(15)	ELC151	PEE1102A1/2	20 DEWAN BESAR
18	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EE111	ELC151	PEE1112A1/2	29 DEWAN BESAR
19	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EE111(31)	ELC151	PEE1112B1/2	32 DEWAN BESAR
20	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EE111	ELC151	PEE1112C1/2	31 DEWAN BESAR
21	1	27/03/2017	ISNIN	PAGI	9:00 AM	11:00 AM	S	EE111(1)/	ELC151	PEE1122A1/2	30 DEWAN BESAR

Figure 3: Examination Records

Furthermore, EMS requires parameter setting for invigilators either will be appointed as invigilator (represents as index 1) or not invigilating (represent as index 0). Moreover, additional parameter setting such as number of invigilation duties during weekends or weekdays and fairness dissemination of invigilation duties amongst invigilators is manually determined.

KAMPUS	JAWATAN	NAMA	BIDANG	KULTI/JABATAN	LEVEL	WDAYS (K)	WENDS (K)	WDAYS (PK + PwB)	WENDS (PK + PwB)	TOTAL INVIGILATIONS
P	PENSYARAH KANAN	WAN ANISHA BINTI WAN MOHAMMAD	JSKM	JSKM	1	0	0	1	0	1
P	PENSYARAH	MUNIROH BT HAMAT	JSKM	JSKM	1	0	0	1	0	1
P	PENSYARAH	NORSHUHADA BINTI SAMSUDIN	JSKM	JSKM	1	0	0	1	0	1
P	PENSYARAH	SHARIFAH SARIMAH BINTI SYED ABDULLAH	JSKM	JSKM	1	0	0	1	0	1
P	PENSYARAH	SITI BALQIS BINTI MAHLAN	JSKM	JSKM	1	0	0	0	1	1
P	PENSYARAH	WAN NUR SHAZIAYANI BINTI WAN MOHD ROSLI	JSKM	JSKM	1	0	0	0	1	1
P	PENSYARAH	ZURAIRA BINTI LIBASIN	JSKM	JSKM	1	0	0	0	1	1
P	PENSYARAH KANAN	CHE HASLINA BINTI ABDULLAH (DR)	ACIS	ACIS	1	0	0	1	0	1
P	PENSYARAH KANAN	NORHASIDAH BINTI A. BAKAR	ACIS	ACIS	1	1	0	0	0	1

Figure 4: Assignment of total invigilation duties parameter to invigilators

Constraints of invigilators are also needed if there are any exceptions of invigilation duties either constraints on partial duration or full duration of examination week. Besides that, special request to avoid invigilating at certain examination venues are also considered.

	A	B	C
1	Kampus	Nama Staf	Index
2	J4	SITI NOORAIN BINTI ZULKIFLY	2
3	J4	SITI NOORAIN BINTI ZULKIFLY	4
4	J4	SITI NOORAIN BINTI ZULKIFLY	6
5	J4	SITI NOORAIN BINTI ZULKIFLY	8
6	J4	SITI NOORAIN BINTI ZULKIFLY	10
7	J4	SITI NOORAIN BINTI ZULKIFLY	12
8	J4	SITI NOORAIN BINTI ZULKIFLY	14
9	J4	SITI NOORAIN BINTI ZULKIFLY	16
10	J4	SITI NOORAIN BINTI ZULKIFLY	18
11	J4	SITI NOORAIN BINTI ZULKIFLY	20
12	J4	SITI NOORAIN BINTI ZULKIFLY	22
13	J4	SITI NOORAIN BINTI ZULKIFLY	24
14	J4	SITI NOORAIN BINTI ZULKIFLY	26
15	J4	SITI NOORAIN BINTI ZULKIFLY	28
16	J4	SITI NOORAIN BINTI ZULKIFLY	30
17	J4	SITI NOORAIN BINTI ZULKIFLY	32
18	J4	SITI NOORAIN BINTI ZULKIFLY	34
19	J4	SITI NOORAIN BINTI ZULKIFLY	36
20	J4	SITI NOORAIN BINTI ZULKIFLY	38
21	J4	SITI NOORAIN BINTI ZULKIFLY	40
22	J4	SITI NOORAIN BINTI ZULKIFLY	42
23	J4	MOHD HANAFIE BIN YASIN	11
24	J4	MOHD HANAFIE BIN YASIN	12
25	J4	MOHD HANAFIE BIN YASIN	13
26	J4	MOHD HANAFIE BIN YASIN	14

Figure 5: Constraints of examination date

	A	B	C
1	Kampus	Nama Pengawas	Tempat Peperiksaan
2	J4	NOOR RAIFANA BINTI AB RAHIM	DP 1/3
3	J4	NOOR RAIFANA BINTI AB RAHIM	DP 2/4
4	J4	DR MAHFUZA MOHAMMED ZABIDI	DP 1/3
5	J4	DR MAHFUZA MOHAMMED ZABIDI	DP 2/4
6	J4	ZURRIATI BINTI MOHD ALI (DR.)	DP 1/3
7	J4	ZURRIATI BINTI MOHD ALI (DR.)	DP 2/4
8	J4	ROHAYA BINTI SULAIMAN	DP 1/3
9	J4	ROHAYA BINTI SULAIMAN	DP 2/4
10	J4		
11	J4		
12	J4		
13	J4		
14	J4		
15	J4		
16	J4		
17	J4		
18	J4		

Figure 6: Constraints of examination venue

The last constraint is the list of courses and the lecturer's name. EMS avoids the invigilators invigilating the course that he or she taught.

9	J4	S	EH110	CHE111	J4EH1102A	25	SHARIFAH IZUUNA BINTI SAYED JAMALUDIN
10	J4	S	EH110	CHE111	J4EH1102B	22	SHARIFAH IZUUNA BINTI SAYED JAMALUDIN
11	J4	S	EH110	CHE111	J4EH1102C	22	SALMI NUR AIN BINTI SANUSI
12	J4	S	EH110	CHE111	J4EH1102D	25	SHARIFAH IZUUNA BINTI SAYED JAMALUDIN
13	J4	S	EH110	CHE121	J4EH1101A	37	NORFADILAH BINTI MOHAMAD / AHMAD RAFIZAN BIN MOHAMAD DAUD (DR)
14	J4	S	EH110	CHE135	J4EH1104A	34	MUHAMMAD IMRAN BIN ISMAIL
15	J4	S/SML/	EH110	CHE135	J4EH1104B	36	MUHAMMAD IMRAN BIN ISMAIL
16	J4	S	EH110	CHE135	J4EH1104C	34	MUHAMMAD IMRAN BIN ISMAIL

Figure 7: List of lecturer's name for each subject or course

Basically, the process of assigning the invigilators will consider the following factors as shown in Figure 8.

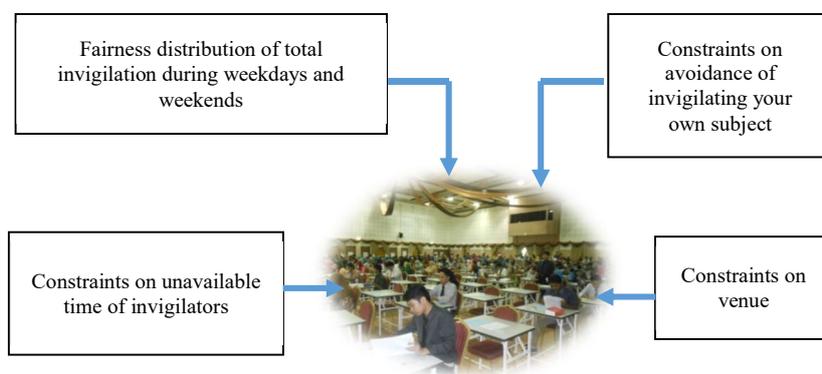


Figure 8: List of constraints considered in the process of assigning the invigilation duties

As shown in Figure 8, the constraints are divided into two types of constraints which the major constraints that are classified as hard constraints and the minor constraints which are categorized as soft constraints. Fairness distribution of invigilation during weekdays or weekends and constraints of unavailable time are considered as hard constraints, while the remaining constraints are categorized as soft constraints. The hard constraints will be the main priority while running the assignment of invigilation duties. The soft constraints will be considered as secondary or optional if the output of invigilation assignment is acceptable and satisfied. Otherwise, the soft constraints will be ignored. In other words, the system will ignore the invigilators request in minor cases such as the invigilator invigilating their own subject or the invigilator is appointed as the chief invigilator for all invigilation or the invigilator has to invigilate in afternoon session only.

An algorithm has been developed to consider the hard and soft constraints as shown in Figure 9. The lists of examination records are extracted from an array list and the invigilators name will be determined sequentially from the array list of invigilators name. Each invigilator has been assigned to the total invigilation during weekdays or weekends and the algorithm will ensure that the total invigilation assigned is aligned to the parameter that has been determined. If the condition is fulfilled, the next step is to determine the assigned invigilators on that particular time slot has the same unavailable slot constraints, invigilating their own subjects and venues that should be omitted. If any of the constraints emerge, the selected invigilator will be rejected, the total number of invigilation assigned will remain the same and the next invigilators from the invigilators name array list will be establish.

This process continues until all examination records are successfully assigned with the invigilators name. The process of assigning the invigilators used the sequential techniques which the name of invigilators are retrieved sequentially from an array list until all invigilators are successfully assigned without any conflicts with the list of constraints. The following figure shows the model of algorithm for assignment of invigilation duties for each invigilator.

```

for (a=0;a<totExamRecords;a++)
{for (b=0; b<totInvigilator;b++)
  {stringtempName = invglatorName[b];
   inttotInvglation = ttlInvglation[b];
   if (totInvglation>ttlAlreadyAssign[b])
   {   assignNamed[a] = tempName;
       ttlAlreadyAssign[b]++;
   }
   for (c=0;c<totConstraintList;c++)
   {   inttempIndex = constraintIndex[c];
if ((tempIndex==examIndex[a]) && (tempName==constraintName[c]))
      {   assignNamed[a] = NIL;
          ttlAlreadyAssign[b]--;
          break; }
   }
   for (d=0;d<totVenueConstraint;d++)
   {   stringtempVenue = constraintVenue[d];
       if((tempVenue == examVenue[a])&&(tempName == lectName[d]))
       {   assignNamed[a] = NIL;
           ttlAlreadyAssign[b]--;
           break; }
   }
   for (e=0;e<totListSubject;e++)
   {stringtempSubject = subjectName[e];
     if ((tempSubject==examSubject[a]) && (tempName==lecturerTeachName[e]))
     {   assignNamed[a] = NIL;
         ttlAlreadyAssign[b]--;
         break; }
   }
}
}
}

```

Figure 9: Algorithm for invigilators assignment of invigilation duties

The following figure shows the list of examination records that successfully assigned the invigilators name.

Line	Date	Time	Subject	Invigilator Name
1	27/03/2017	9:00 AM	ISNIN PEGI	MZLAN BIN SALLEH K
1	27/03/2017	9:00 AM	ISNIN PEGI	SHARMIZAH BINTI ABU HASSAN (DR) PK(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	NUR AINAH NABILAH BINTI MOHD FARIS PP
1	27/03/2017	9:00 AM	ISNIN PEGI	MUHAZZAM BINTI ROSTAM AFFERDIT PP
1	27/03/2017	9:00 AM	ISNIN PEGI	SITI HAMIZAH BINTI BAHAMAN
1	27/03/2017	9:00 AM	ISNIN PEGI	ISMAIL BIN YUSOFF PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	BUSHRA BINTI MOHD ZAKI PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	FARRAH BINTI OTHMAN PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	NOR HALAWAH BINTI AHMAD PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	KHAIRUNNISA BINTI ABD SAMAD PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	NOOR HAFIZA BINTI ISMAIL PwB(PTFT)
1	27/03/2017	9:00 AM	ISNIN PEGI	NANI SHUHADA BINTI SEHAT
1	27/03/2017	9:00 AM	ISNIN PEGI	IRWANIZ HAZLINA BTE ABD. SAMAD
1	27/03/2017	9:00 AM	ISNIN PEGI	SITI NURATSHAH BINTI SCHAHARUM
1	27/03/2017	9:00 AM	ISNIN PEGI	SUZZANA BINTI OTHMAN PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	ROZAITHA BINTI AB MAJID PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	KHAIZIE SAZIMAH BINTI AHMAD PwB(P)
1	27/03/2017	9:00 AM	ISNIN PEGI	NIL V
1	27/03/2017	9:00 AM	ISNIN PEGI	AKMAL BIN ADAMAN K
1	27/03/2017	9:00 AM	ISNIN PEGI	AZHART BIN KHALIP PK(P)

Figure 10: Text file of examination records with invigilators name

### Testing and Findings

The algorithm has been tested for several semester using the real set of examination records. The algorithm has almost 94% successfully assigned the invigilators name on the requested time slots. There are no issues of invigilation clashes which refer to the incidents of the same invigilator is assigned to invigilate at the same time slot but at different places. All constraints

and parameters that have been identified earlier for each invigilator are properly assigned as required. Approximately 5% to 9% of the total examination records found as nil since the algorithm fails to identify the required invigilators. Those nil records will be assigned manually by the members of examination committee. This manual assignment will take less than 1 hour.

A simple survey has been conducted to calculate the total changes of invigilation duties amongst invigilators after the Examination Management Systems (EMS) is implemented. The following table indicates the percentage of invigilation duty changes of four (4) examination sessions in 2016 at UT Pulau Pinang Branch.

Table 2: Total Changes of Invigilation Duties according to Examination Session

	Examination Session			
	Jan 2016	Mar 2016	Jun 2016	Dis 2016
<b>Total Invigilation</b>	625	1287	702	1358
<b>Total request to change or amend the invigilation duties</b>	94	184	86	227
<b>Percentages of changes</b>	15.04	14.30	12.25	16.72

The above table shows the percentage of invigilation duty changes dropped to almost 6% to 7% as compared to Table 1. The changes of invigilation duty are unavoidable because most of the invigilators have other important commitment such as unexpected or ad-hoc responsibility and urgent personal matters. Nevertheless, the examination committee members are happy because they do not need to spend several days to prepare the invigilation duties. Now, EMS helps them to reduce the workloads and amendments process took less than 2 hours. Furthermore, the examination committees have ample time to consider those special preferences and human touch factors. Formerly the assignment of invigilation duties has taken up 3 to 5 days excluding adjustments of invigilators invigilation schedules.

### **Conclusion**

In conclusion, the algorithm as introduced in this paper has improved the satisfaction level of invigilation duties assignment amongst invigilators. The soft constraints as mentioned in this paper require some room for improvement and modification to the algorithm because they are still volatile. The soft constraint is inefficient whenever the situation such as the number of unavailability time slot (hard constraint) is huge. The algorithm fails to identify suitable invigilator if the hard constraint records exceed 300. In order to reduce the number of constraint records, the examination committee needs to filter the application of examination exception.

Furthermore, the algorithm needs to consider other aspects such as avoiding the muslim invigilators invigilating on Fridays afternoon session and preventing the non-muslim invigilators to be on duty on Sunday morning session. Those requests which are considered as personal preferences will only be given as special attention by examination committee after the assignment of invigilation duties are completed by the EMS. The examination committee will try to fulfill all requests from each invigilator with the aims to produce friendly invigilation duties. More soft constraints will be introduced and the existing algorithm will be enhanced continuously to produce a more comprehensive invigilation schedule.

Comparing with the previous manual method of invigilation duties assignments in 2013, it can be observed that the required time for the assignments has declined from a few days to a single day. EMS fulfilled the optimum results as needed by the examination committees and Examination Unit.

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