Optimization Capacity Planning Problem on Conference Scheduling

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***Abstract*- Designing a conference scheduling involves various factors that need to be considered in order to fulfill the participants' preferences. Capacity planning problem is a main focus in this study in order to assign the papers that are to be presented into time slots based on paper of interest. All the presentation papers are assigned efficiently to avoid too many participants in a particular session. Goal Programming model has been developed to produce a schedule that maximizes the participants' satisfaction in terms of capacity planning subject to the capacity constraints. The proposed schedule shows that almost 93% of the time slots are fully utilized and fulfill the capacity constraint. Moreover, it could help the conference committee to better understand the preferences of participant prior to construct the schedule in future.**

Keywords-component; Conference Scheduling, Capacity Planning and Goal Programming (GP).

I. INTRODUCTION

Conference is a venue where people gather to exchange ideas and establish mass networking. It usually involves presentations in which presenters put forth or presents their papers to the conference participants. Usually, the conference schedule is expected to maximize the participants' satisfaction in terms of them being able to attend their favorite session [1].

Conference committees need to schedule presentation papers into time slots [2]. This is to ensure that the conference schedule is effectively constructed so that participants are able to attend their sessions of interest [1]. For example, preference for capacity planning, preference for topic of papers and preference for time allocation in the conference timetable.

However, participants often experience frustration with the way the conference is scheduled [3]. They complained that (i) there is not enough seat available (i.e. capacity/space planning), (ii) they would not be able to attend their sessions of interest because those were scheduled simultaneously and (iii) the time allocation for a particular area was not suitable for some of the participants. Subsequently, the task of the committees will become more complex when they would have to consider the preferences of the participants [4] in constructing the schedule.

Another aspect that the conference committees had to grapple with is the capacity constraint in a way that they could increase the efficiency of the conference scheduling [5]. They often use rooms of same size throughout the seminar. Hence, there are participants who could not enter the room due to insufficient seats. Thus, in this study, we include room capacity and presentation time slot as constraints of the conference schedule.

II. METHODOLOGY

A. Goal Programming Approach

There is some research on constructing a schedule using goal programming technique. Researchers applied this technique when multiple objectives and deviational variables were involved. Chu used goal programming to assign shift crew duties for staff in the Hong Kong International Airport [6]. The problem occurred with baggage service at the passenger terminal. He tried to balance the work plan as fairly as possible for each agent.

Zero one goal programming model is used for scheduling the tour of a marketing executive (ME) for a manufacturing company in India [7]. ME had to visit a number of customers in a given planning period. The practice of the company was to assign a ME to make a specific number of visits in a planning period at equal intervals of time depending upon the business transaction with customers and minimize the deviational variables as much as possible so that the schedule would have balanced number of visits.

Much of previous research [2][3][4] and [8] on conference scheduling used integer programming and heuristic technique to solve the problem

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regarding attendees and presenters' preferences. They only emphasized on preferences of the participants in terms of attending their individual choices. However, they did not cater for the constraints capacity as a major factor in order to construct the schedule. Due to the similarity by [6] and [7] we are adopting GP in order to solve the conference scheduling problem for capacity planning. We wanted to assign all the papers into time slots (rooms) so that each time slot would have a balanced number of papers to be presented.

GP attempts to minimize the deviations between the desired goals. The over achievement and under achievement of goals is measured using deviational variables [9]. Furthermore, GP is widely used in allocation problem such as in land use planning as well as in scheduling resources and as well as used in manpower scheduling [7]. GP has been adopted in order to solve the conference scheduling problem for capacity planning.

B. Solution Architecture

In this study, the papers are assigned into time slots with equal number of papers without considering the field of study (Operations Research, Statistics and Mathematics). There are sixty papers presented in the conference, three rooms were available and five sessions with three parallel time slots respectively as in Table 1. Rooms of similar size are used and each time slot would have four papers to be presented. We used a weighted method to get the weight for each paper by adopting a weighted scale algorithm [4]. Participant were asked to rank paper of interest starting from 1 to 10 choices depend on their preferred paper. Each of ranks would have weight from 1 to 10. The weight for each paper is calculated by equation 1 below. The results are shown in Table 2.

$$W_i = \sum_{i=1}^{n} W_i N_r; \quad for\ all\ i, i = 1,2,3,...,60 \quad (1)$$

where :

W_i = *weight for paper i*;

W_r = *weight for rank r* (r = 1,2,3,...,11);

N_r = *number of respondents for rank r*;

R = *number of ranks* (R = 1,2,3,...,11).

After we calculated the weight for each paper, we had to find the average weight for each time slot using the equation 2.

$$\mu_i = \frac{\sum_{i=1}^{n} W_i}{S} \quad (2)$$

where :

μ_i = *average weight for each time slot*;

W_i = *weight for paper i*;

n = *total number of papers*;

S = *total number of time slots*.

This algorithm is used to analyze the weight for each paper and calculate the average weight for time slot. An average weight is used as the right hand side (RHS) value of the time slot balancing constraint.

TABLE 1
SUMMARY OF CONFERENCE SCHEDULING

	Room1	**Room2**	**Room3**
Session1	TS1	TS2	TS3
Session2	TS4	TS5	TS6
Session3	TS7	TS8	TS9
Session4	TS10	TS11	TS12
Session5	TS13	TS14	TS15

*TS: Time Slot

TABLE 2
SUMMARY OF CALCULATED WEIGHT FOR ALL PAPERS

Paper	W*i*	Paper	W*i*	Paper	W*i*
1	273	21	261	41	236
2	275	22	265	42	258
3	257	23	263	43	236
4	276	24	245	44	234
5	252	25	277	45	279
6	275	26	257	46	244
7	259	27	271	47	254
8	255	28	281	48	233
9	244	29	252	49	214
10	261	30	264	50	275
11	225	31	281	51	252
12	213	32	270	52	276
13	261	33	270	53	273
14	284	34	284	54	281
15	247	35	286	55	257
16	275	36	268	56	262
17	273	37	283	57	230
18	274	38	286	58	265
19	271	39	282	59	274
20	274	40	281	60	269

$$Minimize \qquad Z = \sum_{j=1}^{S} d_j^{-} + \sum_{j=1}^{S} d_j^{+}$$

$$subject \quad to$$

$$\sum_{i=1}^{I} W_i X_{ij} - d_j^{+} = \mu; \; for \; all \;\; j(j = 1,2,3,...,15) \qquad (3)$$

$$\sum_{i=1}^{I} W_i X_{ij} + d_j^{-} = \mu; \; for \; all \;\; j(j = 1,2,3,...,15) \qquad (4)$$

$$\sum_{j=1}^{S} X_{ij} = 1; \qquad for \; all \; i \, (i = 1,2,3,...,60) \qquad (5)$$

$$\sum_{i=1}^{I} X_{ij} > a; \qquad for \; all \;\; j(j = 1,2,3,...,15) \qquad (6)$$

$$X_{ij} = 0 \; or \; 1 \qquad (7)$$

$$where:$$

$$the \; decision \; \text{var} \, iable:$$

$$X_{ij} = \begin{cases} 1 \, if \;\; paper \;\, i \, is \;\, presented \;\, in \, time \; slot \;\, j \\ 0 \; otherwise \end{cases}$$

$$and:$$

$$\mu = average \;\; weight \;\; for \; time \; slot;$$

$$W_i = weight \;\; for \;\; paper \;\; i;$$

$$d_j^{+} = over - achievemen \; t \; deviation \;\; \text{var} \, iable \; of \;\; time \; slot \;\; j;$$

$$d_j^{-} = under \; - achievemen \; t \; deviation \;\; \text{var} \, iable \; of \;\; time \; slot \;\; j;$$

$$I = total \;\; number \;\; of \;\; paper;$$

$$a = number \;\; of \;\; paper \;\; in \, each \; time \; slot;$$

$$S = total \;\; number \;\; of \; time \; slot.$$

C. *Mathematical Formulation*

The main objective is maximizing the participants' satisfaction in terms of capacity planning. In doing so, we tried to minimize the undesired deviations in terms of weight for each time slot. There are two undesired deviational variables, which are over-achievement deviation (d_j^+) and under-achievement deviation (d_j^-). We tried to achieve at least one or both deviational variables in a goal constraint which must be equal to zero. The GP model was solved using the ILOG software. The model formulation for this research is shown above:

Constraint (3) specifies that weight for all time slots must be balanced with maximization of under-achievement deviation variables, (4) specifies that weight for all time slots must be balanced with minimization of over-achievement deviation variables, (5) ensures that all papers would be presented once during the conference, (6) ensures that at least *a* papers would be presented in each slot and (7) ensures that the assignment for each paper must have value zero or one.

III. RESULT AND IMPLEMENTATION

We present the proposed schedule for this problem in the format similar of the actual schedule for practical reason. The proposed schedule is as shown in Table 4. As part of the solution, only four papers are assigned to be presented in each time slot, *j*, in order to balance the weight for each time slot due to the capacity of each room. If the weight for paper *i* is small, then it shows that paper *i* was chosen as a preferred paper by many participants. Table 3 show the comparison value of the over-achievement deviation (d_j^+) and under-achievement deviation (d_j^-) between the actual schedule and the proposed schedule. In left hand side, we could see only one time slot which has an undesired deviational variable (d_j^+), which is time slot 5. The undesired deviational value for time slot 5 is 3, where else the rest of the slots have undesired value of zero. Since only one out of 15 time slots do not fulfilled the objective function, the percentage of not fully fulfilled time slots was 7%. This shows that 93% the assignment of papers optimal. In right hand side, the total of all undesired values is 608. The total for under-achievement deviations (d_j^-) is 234 while the total for over-achievement (d_j^+) deviations is 374. It shows that the under-achievement deviation value (d_j^-) is 33% and the over-achievement deviation value (d_j^+) is 67%. It shows that all assigned papers do not fully satisfy in term of space planning. Moreover, all the preferred papers are assigned into each time slot without considering the participants' preferences. The probability of these time slot having an overflow of participants is quite high. That scenario would impact negatively the participants' satisfaction, because they could not sit in the particular time slot for their preferred papers.

IV. CONCLUSION

The proposed schedule gives a marked contribution especially to the conference committees. The proposed schedule has been implemented in order to construct conference scheduling in future to improve services for the participants during the conference. The conference model can increase participants' satisfaction in the sense that they are able to enroll in their preferred time slots. The committee can generate quick schedule by using this computerized model in order to avoid time-consuming planning.

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TABLE 3

COMPARISON BETWEEN THE PROPOSED SCHEDULE AND THE ACTUAL SCHEDULE

Proposed Schedule					Actual Schedule				
Time slots	(d_j^+)		(d_j^-)		Time slots	(d_j^+)		(d_j^-)	
1	d_1^+	0	d_1^-	0	1	d_1^+	20	d_1^-	0
2	d_2^+	0	d_2^-	0	2	d_2^+	0	d_2^-	2
3	d_3^+	0	d_3^-	0	3	d_3^+	70	d_3^-	0
4	d_4^+	0	d_4^-	0	4	d_4^+	0	d_4^-	17
5	d_5^+	3	d_5^-	0	5	d_5^+	11	d_5^-	0
6	d_6^+	0	d_6^-	0	6	d_6^+	0	d_6^-	105
7	d_7^+	0	d_7^-	0	7	d_7^+	0	d_7^-	90
8	d_8^+	0	d_8^-	0	8	d_8^+	35	d_8^-	0
9	d_9^+	0	d_9^-	0	9	d_9^+	26	d_9^-	0
10	d_{10}^+	0	d_{10}^-	0	10	d_{10}^+	29	d_{10}^-	0
11	d_{11}^+	0	d_{11}^-	0	11	d_{11}^+	71	d_{11}^-	0
12	d_{12}^+	0	d_{12}^-	0	12	d_{12}^+	0	d_{12}^-	20
13	d_{13}^+	0	d_{13}^-	0	13	d_{13}^+	31	d_{13}^-	0
14	d_{14}^+	0	d_{14}^-	0	14	d_{14}^+	61	d_{14}^-	0
15	d_{15}^+	0	d_{15}^-	0	15	d_{15}^+	20	d_{15}^-	0
	total	**3**	**total**	**0**		**total**	**374**	**total**	**234**
Z = 3					**Z = 608**				

TABLE 4

THE PROPOSED SCHEDULE

	Room1			**Room2**			**Room3**		
Time Slot	**1**			**2**			**3**		
Session 1	Paper	W_i	Dev	Paper	W_i	Dev	Paper	W_i	Dev
	13	261		9	244		2	275	
	15	247		36	268		22	265	
	21	261		54	281		41	236	
	40	281		55	257		59	274	
	total	1050		total	1050		total	1050	
Time Slot	**4**			**5**			**6**		
Session 2	Paper	W_i	Dev	Paper	W_i	Dev	Paper	W_i	Dev
	1	273		19	271		31	281	
	20	274		25	277		32	270	
	33	270		43	236		44	234	
	48	233		60	269		58	265	
	total	1050		total	**1053**	**$d_5^+ = 3$**	total	1050	
Time Slot	**7**			**8**			**9**		
Session 3	Paper	W_i	Dev	Paper	W_i	Dev	Paper	W_i	Dev
	18	274		10	261		26	257	
	37	283		35	286		30	264	
	45	279		53	273		47	254	
	49	214		57	230		50	275	
	total	1050		total	1050		total	1050	
Time Slot	**10**			**11**			**12**		
Session 4	Paper	W_i	Dev	Paper	W_i	Dev	Paper	W_i	Dev
	3	257		7	259		5	252	
	4	276		28	281		29	252	
	17	273		42	258		34	284	
	46	244		51	252		56	262	
	total	1050		total	1050		total	1050	
Time Slot	**13**			**14**			**15**		
Session 5	Paper	W_i	Dev	Paper	W_i	Dev	Paper	W_i	Dev
	11	225		12	213		6	275	
	23	263		14	284		8	255	
	38	286		27	271		16	275	
	52	276		39	282		24	245	
	total	1050		total	1050		total	1050	