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AN INTEGER PROGRAMMING MODEL FOR THE CONFERENCE TIMETABLING PROBLEM

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Abstract: This study proposes a generic integer programming (IP) model to prepare the timetable of a custom conference. The proposed model not only allocates the conference topics to the sessions but also assigns presentations to the sessions in consistent with session topics. Beside, the number of presentations assigned to different sessions with the same topic (e.g., Logistics 1, Logistics 2 etc.) is balanced. The IP model is solved with two objective functions. The first is to minimize the number of cases in which more than one session with the same topic is assigned to the same time period within a day. The second one is to minimize the number of cases in which the number of presentations assigned to each parallel session is different from each other. A case study has been presented and discussed to show the applicability of the proposed IP model. The results indicate the same conference topic is not assigned to more than one parallel session and when the second objective function goes into the scheme, the number of periods, in which the number of presentations in parallel sessions is not the same, is reduced from eight to one.

Keywords: *Conference Timetabling, Integer Programming, Modeling*

KONFERANS ÇİZELGELEME PROBLEMİ İÇİN BİR TAMSAYILI PROGRAMLAMA MODELİ

Özet: Bu çalışma, bir konferansa ait oturumların ve sunumların zaman çizelgesinin hazırlanması için genel bir tamsayılı programlama modeli sunmaktadır. Önerilen model, hem konferans konu başlıklarını oturumlara atamakta hem de sunumları konu başlıkları açısından tutarlı oturumlara yerleştirmektedir. Bunların dışında aynı konu başlıklı farklı oturumlara (örn. Lojistik-1, Lojistik-2 vb.) atanan sunum sayılarının dengesini sağlamaktadır. Tamsayılı programlama modeli, iki amaç fonksiyonu ile çözülmektedir. Birincisi, her bir gün için aynı zaman aralığında, aynı konferans başlığına sahip birden fazla oturumun olduğu durumların sayısını en küçüklemektir. İkincisi ise, her bir gün için aynı zaman aralığına düşen oturumlara ait sunum sayılarının birbirinden farklı olduğu durumların sayısını en küçüklemektir. Önerilen modelin uygulanabilirliğini göstermek üzere örnek bir problem sunulmuş ve tartışılmıştır. Sayısal sonuçlar, herhangi bir konferans başlığının aynı zaman aralığındaki birden fazla paralel oturuma atanmadığını ve ikinci amaç fonksiyonu dikkate alındığında, aynı zaman aralığına düşen oturumlara ait sunum sayılarının birbirinden farklı olduğu durumların sayısının sekizden bire düştüğünü göstermiştir.

Anahtar Kelimeler: *Konferans Çizelgeleme, Tamsayılı Programlama, Modelleme*

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1. INTRODUCTION

A significant step of scientific conferences is the construction of the conference timetable. In a custom conference timetable, two issues have to be solved: assigning all presentations to the sessions within pre-determined conference time interval and disallowing the time conflicts of the presentations belonging to the same author [1]. Also, each conference may have its specific constraints, e.g., the preferences of the organizing committee and/or the participants [1]. In a custom conference, generally, the authors are asked for the coverage topic or the keywords of their presentations. The main problem is the assignment of these topics to the available conference days and time periods. Another important problem is the assignment of papers (presentations) to the sessions in consistent with their topics. Therefore, conference timetabling mainly involves the assignment of topics and presentations to the time periods.

The solution approaches for the conference timetabling problem can be classified into mathematical models and heuristics. If the satisfaction of the constraints is only the case, the heuristic approaches may be used instead of mathematical models. On the other hand, if an objective function is in order, mathematical programming models are usually preferred.

In this study, for a custom conference timetabling problem, a generic IP model is developed with two different objective functions emphasizing on a balanced allocation of presentations among the sessions. An earlier version of this paper is presented by Edis and Edis [2]. A brief review of the literature on the conference timetabling problem is given in the next section. In section 3, the IP model with the required notation is given and some extensions on the IP model are proposed. In Section 4, a case study is presented and solved with the proposed IP model. The last section summarizes the study and gives some remarks for the further studies.

2. LITERATURE REVIEW

Although the conference timetabling problem has a wide application area, e.g., all conference organizers face with this problem, it has rarely been studied in the literature [3]. In the early studies, Eglese and Rand [4] and Sampson and Weiss [5] developed heuristic approaches by considering the session preferences of the participants. Sampson and Weiss [6] also proposed a heuristic method with the aim of maximizing the ratio of satisfying the session preferences of the audiences. Sampson [3] took into account the preferences of the speakers as well as the audiences and proposed an IP model which incorporates strategic decisions such as the flexibility of the timetable and the details of the preferences. Nicholls [7] considered the preferences of the program chair as well as the speakers and audiences and developed a heuristic approach without an objective function. Tanaka et al. [8] used self organizing map to cluster the keywords into sessions. They assigned papers to sessions according to keyword compatibility and named the sessions with regarding to the keywords of the assigned papers. As a similar paper to our study, Potthoff and Munger [9] proposed an IP model which includes a balanced allocation of the conference topics in addition to the basic constraints of the conference timetabling problem. Potthoff and Brams [10] applied the proposed IP model of Potthoff and Munger [9] to construct the timetables of two meetings established in 2005 and 2006. Edis et al. [1] proposed a two-step constraint programming approach for assigning conference topics to sessions and presentations to sessions accordingly, for constructing the timetable of a national conference. In a recent study, Zulkipli et al. [11] developed a goal programming model by considering the preferences of the participants and aim to minimize the deviation between the sum of the weights of the presentations assigned to each session and the calculated overall average weight.

Our study differs from the above papers, since it focuses on constructing more balanced schedules in terms of the number of presentations assigned to the conference sessions.

3. THE PROPOSED INTEGER PROGRAMMING MODEL AND EXTENSIONS

The notation used in the proposed IP model is given below.

Sets and Indices

D	the set of conference days	d	the index of days, $d \in D$
P	the set of presentations	p	the index of presentations, $p \in P$
T	the set of time periods in a day	j	the index of time periods
PS	the set of parallel sessions in a time period	k	the index of parallel sessions
S	the set of conference topics	s	the index of conference topics
C	the set of cases each of which indicates a situation involving a set of presentations that should not be assigned to the parallel sessions in same day and the same time period (e.g., the presentations of the same author)	c	the index of cases
B_s	the set of presentations belonging to conference topic s, $B_s \in P$		
$CASE_c$	the set of presentations of belonging to case c, $CASE_c \subset P$		

Parameters

L the maximum number of presentations that can be assigned to each session

M a very big number

Decision Variables

x_{pdjk} 1, if presentation p is assigned to parallel session k at the time period j of day d, 0, otherwise.

y_{sdjk} 1, if topic s is assigned to parallel session at the time period j of day d, 0, otherwise.

u_{sdj} 1, if topic s is assigned to more than one parallel session at time period j of day d, 0, otherwise.

3.1 The Proposed IP Model

The proposed IP model is as follows.

$$\text{Minimize} \quad \sum_{s\in S}\sum_{d\in D}\sum_{j\in T} u_{sdj} \qquad (1)$$

subject to:

$$\sum_{k\in PS} y_{sdjk} \le 1 + u_{sdj} \times M \qquad \forall s, \forall d, \forall j \qquad (2)$$

$$\sum_{d\in D}\sum_{j\in T}\sum_{k\in PS} x_{pdjk} = 1, \qquad \forall p \qquad (3)$$

$$\sum_{s\in S} y_{sdjk} \le 1 \qquad \forall d, \forall j, \forall k \qquad (4)$$

$$\sum_{i \in B_s} x_{idjk} \leq L \times y_{sdjk} \qquad \forall d, \forall j, \forall k, \forall s \qquad (5)$$

$$\sum_{i \in B_s} x_{idjk} - \sum_{i' \in B_s} x_{i'd'j'k'} \leq 1 + (2 - y_{sdjk} - y_{s'd'j'k'})M$$
$$\forall d, \forall d', \forall j, \forall j', \forall k, \forall k', \forall s \qquad (6)$$

$$\sum_{p \in CASE_c} \sum_{k \in PS} x_{pdjk} \leq 1 \qquad \forall c, \forall d, \forall j \qquad (7)$$

$$x_{pdjk} \in \{0, 1\}, \qquad \forall p, \forall d, \forall j, \forall k \qquad (8)$$

$$y_{sdjk} \in \{0, 1\}, \qquad \forall s, \forall d, \forall j, \forall k \qquad (9)$$

$$u_{sdj} \in \{0, 1\}, \quad \forall s, \forall d, \forall j \qquad (10)$$

The objective function, given in (1), minimizes the number of cases in which more than one session with the same or similar topic is assigned to the same time period within a day. A similar objective is considered by Potthoff and Munger (2003). However, they aimed to minimize the total deviation from a desired objective value while we minimize the number of these cases occurred. Constraint set (2) determines if a time period in a day includes more than one parallel session with the same topic. Constraint set (3) ensures that each presentation should exactly be assigned to a session at a time period of a day. Constraint set (4) indicates that at most one conference topic can be assigned to each session at a time period of a day. Constraint set (5) guarantees that at most *L* presentations, all of which are in the same topic, can be assigned to a particular session at a time period of a day. Constraint set (6) states that the difference among the number of presentations belonging to the same conference topic (in different sessions) should be equal to or less than one. This constraint set balances the number of presentations among the conference sessions.

For each case *c* defined, constraint set (7) ensures that at most one of the presentations belonging to a case can be assigned to any session in a day. Finally, constraint set (8)-(10) indicates that all the decision variables are binary.

3.2 Extensions to the IP Model

Some extensions to the proposed IP model may be considered. Other than the above constraints, special constraints regarding the preferences and non-preferences of program chairs and participants may be required such as:

(a) Assign the presentation of a participant to one of his/her preferred days.

(b) Do not assign the presentation of a participant to his/her non-preferred days.

(c) Assign the special sessions to the program chair's preferred time periods and days.

To formulate such constraints, the required notation is given below:

a	the index of preference cases
b	the index of non-preference cases
PRF_D_a	the set of presentations belonging to day preference case *a*.
PDS_a	the set of preferred days regarding the case *a*.
PT_a	the set of preferred time periods regarding the case *a*.
$NPRF\_D_b$	the set of presentations belonging to day non-preference case *b*.
$NPDS_b$	the set of non-preferred days regarding the case *b*.
NPT_b	the set of non-preferred days regarding the case *b*.

Below, constraint set (11) indicates that a particular set of presentations belonging to a preference case should exactly be assigned to their preferred days and time periods. Constraint set (12), on the other hand, ensures that another set of presentations belonging to a non-preference case should not be assigned to a non-preferred day and time period.

$$\sum_{p \in PRF_{D_a}} \sum_{d \in PDS_a} \sum_{j \in PT_a} \sum_{k \in PS} x_{pdjk} = 1 \quad \forall a \quad (11)$$

$$\sum_{p \in NPRF_{D_b}} \sum_{d \in NPDS_b} \sum_{j \in NPT_b} \sum_{k \in PS} x_{pdjk} = 0 \quad \forall b \quad (12)$$

Assuming that the objective function of the IP model (Eq.1) is valued zero in the optimal solution, the model may be extended by a secondary objective function regarding to the balanced allocation of presentations among the time periods of the same day. In other words, the second objective is to minimize the number of cases in which the number of presentations assigned to each parallel session is different from each other. Such an objective provides easier adjustment of session lengths for the organization committee. For the second objective function, the additional decision variable set is defined as follows:

v_{dj} 1, if the number of presentations assigned to each parallel session at time period j of day d is not the same,
0, otherwise.

Constraint sets (13) search time periods of each day and find out the periods where the number of presentations in all parallel sessions is not the same, i.e., v_{dj} gets equal to 1.

$$\sum_{p \in P} x_{pdjk} \le \sum_{p' \in P} x_{p'djk'} + (v_{dj} \times M)$$

$$\sum_{p' \in P} x_{p'djk'} \le \sum_{p \in P} x_{pdjk} + (v_{dj} \times M)$$

$$\forall d, \forall j, \forall k, \forall k', k \neq k' \quad (13)$$

As stated earlier, the objective function (14) minimizes the number of cases in which the number of presentations assigned to each parallel session is different from each other. We refer to the IP model with extensions as IP-Ext.

$$\text{Minimize} \quad \sum_{d \in D} \sum_{j \in T} v_{dj} \quad (14)$$

4. CASE STUDY

A hypothetical problem is used to evaluate the proposed IP model. In our case, 170 presentations (indexed from 1 to 170) belonging to 10 conference topics should be scheduled. The conference takes three days with four time periods per day. Each time period has approximately three parallel sessions. At most five presentations can be assigned to each session. Table 1 presents the corresponding topics of the presentations.

Table 1. Presentations and Their Topics

Presentations	Conference Topic
1, 2, …, 24	1
25, 26, …, 44	2
45, 46, …, 73	3
74, 75, …, 78	4
79, 80, ….,98	5
99, 100, …, 112	6
113, 114, …, 134	7
135, 136, …, 157	8
158, 159, …, 165	9
166, 167, …, 170	10

Surely, the feasibility of the problem should be checked first, such that the number of presentations to be assigned, 170, is less than the available number of sessions (i.e., 36 = 3 days × 4 time periods/day × 3 sessions/time period) multiplied by the maximum number of presentations (i.e., 5) per session.

There are three cases that a participant will present more than one study, therefore none of these presentations should be assigned to the parallel sessions in the same time period. The set of presentations {1, 15, 33}, {36, 48}, {45, 55} should not be assigned to the same time period.

Although there may exist some constraints with respect to the preferences/non-preferences of the program chair and/or participants, we do not contain any of such constraint in our case study. With the data given above, the proposed IP model (without extensions) produced the assignment of topics and presentations as given in Table 2. As seen from Table 2, all the presentations have been scheduled and none of the parallel sessions in the same time period contains the same conference topic. Therefore, the objective function value is zero. We have also observed that none of the presentations in three pre-defined sets of {1, 15, 33}, {36, 48}, {45, 55} have been scheduled to the same time period of a day.

In Table 2, we observed that in time period 1 of Day 1, in time periods 1, 2 and 3 of Day 2 as well as in all the time periods of Day 3 (eight time periods in total), the number of presentations assigned to each parallel session is not same. To reduce the number of these cases, we run the IP-Ext model. The results of IP-Ext are given in Table 3. In Table 3, we observed that, the number of periods, in which the corresponding number of presentations in parallel sessions is not the same, is reduced from eight to one, i.e., only the last period of day 2. This is the optimal solution. Therefore, presentations are distributed more evenly among the parallel sessions in a day.

Table 2. Assignment of topics and presentations to the time periods (IP Model)

		Paralel Session 1	Paralel Session 2	Paralel Session 3
Day 1	Time Period 1	Topic 4 {74 75 76 77 78}	Topic 1 {16 20 21 22 24}	Topic 2 {36 39 41 43 44}
	Time Period 2	Topic 3 {52 59 60 64 72}	Topic 2 {25 33 34 35 40}	Topic 9 {158 159 160 164}
	Time Period 3	Topic 3 {49 65 66 67 70}	Topic 5 {89 90 91 92 94}	Topic 7 {113 123 125 131 132}
	Time Period 4	Topic 1 {5 7 13 14 15}	Topic 3 {46 53 54 69 71}	Topic 6 {100 101 107 109 112}
Day 2	Time Period 1	Topic 7 {115 121 124 127}	Topic 5 {82 83 88 96 97}	Topic 3 {45 48 63 68 73}
	Time Period 2	Topic 8 {140 143 149 153 157}	Topic 3 {55 57 58 61 62}	Topic 1 {9 10 12 17}
	Time Period 3	Topic 6 {104 108 110 111}	Topic 3 {47 50 51 56}	Topic 5 {80 81 84 87 95}
	Time Period 4	Topic 7 {114 116 117 119 133}	Topic 8 {138 141 146 147 150}	Topic 1 {1 2 3 4 23}
Day 3	Time Period 1	Topic 10 {166 167 168 169 170}	Topic 7 {122 126 130 134}	Topic 2 {27 31 32 37 42}
	Time Period 2	Topic 2 {26 28 29 30 38}	Topic 6 {99 102 103 105 106}	Topic 8 {137 139 151 155}
	Time Period 3	Topic 9 {161 162 163 165}	Topic 8 {142 144 145 156}	Topic 5 {79 85 86 93 98}
	Time Period 4	Topic 1 {6 8 11 18 19}	Topic 7 {118 120 128 129}	Topic 8 {135 136 148 152 154}

Table 3. Assignment of topics and presentations to the time periods (IP-Ext Model)

		Paralel Session 1	Paralel Session 2	Paralel Session 3
Day 1	**Time Period 1**	Topic 5 {82 83 92 93 96}	Topic 8 {135 139 144 145 146}	Topic 6 {105 106 107 110 112}
	Time Period 2	Topic 4 {74 75 76 77 78}	Topic 5 {84 86 88 89 91}	Topic 10 {166 167 168 169 170}
	Time Period 3	Topic 5 {79 81 85 90 94}	Topic 6 {99 100 103 104 108}	Topic 3 {56 58 61 62 70}
	Time Period 4	Topic 1 {1 2 7 17 20}	Topic 3 {50 59 60 67 72}	Topic 2 {28 32 35 37 39}
Day 2	**Time Period 1**	Topic 6 {101 102 109 111}	Topic 7 {123 126 127 128}	Topic 3 {51 54 64 73}
	Time Period 2	Topic 5 {80 87 95 97 98}	Topic 7 {117 124 125 130 133}	Topic 3 {45 46 47 48 49}
	Time Period 3	Topic 2 {26 27 29 34 43}	Topic 3 {63 66 68 69 71}	Topic 1 {3 6 9 12 13}
	Time Period 4	Topic 2 {25 31 36 40 44}	Topic 7 {114 115 118 122}	Topic 1 {16 18 19 22 23}
Day 3	**Time Period 1**	Topic 9 {158 159 161 162}	Topic 1 {11 14 21 24}	Topic 8 {141 142 143 155}
	Time Period 2	Topic 2 {30 33 38 41 42}	Topic 8 {140 150 154 156 157}	Topic 3 {52 53 55 57 65}
	Time Period 3	Topic 7 {120 129 132 134}	Topic 8 {136 137 138 152}	Topic 9 {160 163 164 165}
	Time Period 4	Topic 8 {147 148 149 151 153}	Topic 1 {4 5 8 10 15}	Topic 7 {113 116 119 121 131}

5. CONCLUDING REMARKS

This study presented an IP model to construct a general conference timetable. The IP model emphasizes on the balanced allocation of presentations among the parallel sessions in addition to the basic requirements of a conference timetable. The applicability of the model has also been showed via a case study. The results can be summarized in two aspects. Firstly, in any time period, none of the parallel sessions include the same conference topic. Secondly, when the IP model is solved with the second objective function, the number of periods, in which the corresponding number of presentations in parallel sessions is not the same, is reduced from eight to one.

In the further studies, the IP model may be extended such that the conference topics are automatically constructed with respect to keywords given in the individual presentations, as studied by Tanaka et al. [8]. The IP model can also be integrated into a spreadsheet-based user-friendly interface to ease the implementation.

References

[1] Edis, E.B., Ozfirat, P.M., and Ozkarahan, I., “A Constraint Programming Approach for a Conference Timetabling Problem”, Proceedings of the 37th Annual Meeting of the Western Decision Sciences Institute, San Diego, USA, 603-605, (2008).

[2] Edis, E.B., and Edis, R., “Konferans Çizelgeleme Problemi için Bir Tamsayılı Programlama Modeli” Yöneylem Araştırması ve Endüstri Mühendisliği 33. Ulusal Kongresi, 26-28 Haziran, İstanbul, Turkey, (2013).

[3] Sampson, S. E., “Practical Implications of Preference-Based Conference Scheduling”, Production and Operations Management, 13(3), 205-215, (2004).

[4] Eglese, R. W., and Rand, G. K., “Conference seminar timetabling”. Journal of the Operational Research *Society*, 591-598, (1987).

[5] Sampson, S. E., and Weiss, E. N., “Increasing service levels in conference and educational scheduling: A heuristic approach”, Management Science, 41(11), 1816-1825, (1995).

[6] Sampson, S. E., and Weiss, E. N., “Designing conferences to improve resource utilization and participant satisfaction”, Journal of the Operational Research Society, 297-314, (1996).

[7] Nicholls, M. G., “A small-to-medium-sized conference scheduling heuristic incorporating presenter and limited attendee preferences”, Journal of the Operational Research Society, 58(3), 301-308, (2007).

[8] Tanaka, M., Mori, Y., and Bargiela, A., “Granulation of Keywords into Sessions for Timetabling Conferences”, Proceedings of SCIS & ISIS 2002, Tsukuba, Japan, 1-5, (2002).

[9] Potthoff, R. F., and Munger, M. C., “Use of integer programming to optimize the scheduling of panels at annual meetings of the Public Choice Society”, Public Choice, 117(1-2), 163-175, (2003).

[10] Potthoff, R. F., and Brams, S. J. “Scheduling of panels by integer programming: Results for the 2005 and 2006 New Orleans meetings”, Public Choice, 131(3-4), 465-468, (2007).

[11] Zulkipli, F., Ibrahim, H., and Benjamin, A.M.. "Optimization capacity planning problem on conference scheduling." Business Engineering and Industrial Applications Colloquium (BEIAC), IEEE (2013)

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