Scheduling and Allocation of Airport Service Manpower by considering Time and Work Constraints using M-MAPTWTC Method: a case study

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Abstract. Airport Service workforce scheduling and allocation is important because the handling of ground handling jobs is also increasing. The system and allocation of workforce scheduling in the company that is currently being carried out is based on trials only (trial and error), this causes frequent shortages or excess labor. This can happen because in scheduling and allocating workforce has not considered the time span between the preparation time and flight time, as well as the work team constraints. To overcome the weaknesses of the system of scheduling and allocation of labor previously in this thesis, scheduling and allocation of labor is done by considering the time span between preparation time and flight time. The method used is using the m-MAPTWTC method. The results of a case study in a company using the m-MAPTWTC method show that the number of jobs done in the period 04.00 - 12.00 WIB as many as 80 flights can be done by 20 teams whereas previously the same number of jobs required 24 teams. With the m-MAPTWTC method it is also obtained the team allocation and work order for each job by each team.

Keywords: Scheduling and allocation of labor, job-teaming constraints, time span, m-MAPTWTC method.

1. Introduction

The growth of air transportation facilities users in Indonesia is so rapid every year, the average increase every year is 10%. Indonesia as an archipelagic country has limitations in the use of land transportation modes (cars and trains) and sea transportation modes causing the shift of consumers to use fast and cheap transportation facilities from land and sea transportation modes to air transportation modes. The rapid use of the aviation service industry in Indonesia is an opportunity for airlines. Airlines in Indonesia are competing to add consumers and strengthen their fleets and increase destinations. Three major airlines, namely Garuda Indonesia Group (Garuda Indonesia Airways and Citilink) with a total fleet of 200 aircraft, Lion Air (400 aircraft), and Air Asia (100 aircraft). In the flight system there are four interested parties, namely: Regulators (Government), Airport Managers (Angkasa Pura), Airlines (Airlines), and Ground Handling (PT. Gapura Angkasa and PT. JAS). PT. Gapura Angkasa is a company engaged in the field of Ground Handling (GH or Airport Services). The role of Ground Handling may not be seen directly for users of air transportation modes but for airlines it is very important because the punctuality of the aircraft to be ready to fly (ready take-off), passenger handling and cargo handling (letters, packages, etc.) is largely determined by the role of Ground Handling [1].
Business partners of PT. Gapura Angkasa namely domestic: Garuda Indonesia airlines and Citilink (Garuda Group), Batavia Air, Air Asia, Kalstar, Kartika Airlines, Lion Air and Wings Air (Lion Group), Sriwijaya Air, Sky Aviation International: China Airlines, Royal Brunei, Japan Airlines/All Nippon, Vietnam Airlines, Korean Airlines, Cathay Pacific, Airfrance (KLM). The problem faced by PT Gapura Angkasa is the scheduling and allocation of airport services workers in handling Garuda Indonesia aircraft. PT. Gapura Angkasa is currently not optimal in workforce scheduling and allocation system, where 80 flights are handled by 24 teams, and the allocation and scheduling of work teams is uneven with the number and growth of the Garuda Indonesia fleet. The purpose of this study is to provide suggestions regarding the scheduling and allocation of airport service workers.

Ground Handling (GH) comes from the word ground and handling. Ground means (on) land, in this case related to the airport. Handling means handling. In terms of (etymology) ground handling or ground service is an activity of an airline company which is related to the handling of passengers and their luggage, cargo, mail, auxiliary equipment for aircraft movement on the ground and the aircraft itself while at the airport, both for departure (departure) or arrival.

The scope of ground handling is in preflight services and post flight services. The scope of GH at the airport includes: handling passengers at the terminal, handling aircraft in the parking area called the Apron Area and cargo handling called Cargo Handling.

The Manpower Allocation Method with Time Windows and Job Teaming Constraints and a Limited number of teams was developed by Anders Dohn, Esben Kolind and Jens Clausen (Tecnical University of Denmark) [2]. The focus of research on this method (m-MAPTWTC) is carried out at ground handling companies at major airports in Europe regarding scheduling, focusing on the work team (group) of technicians involved in doing a job in this case the team from Ramp Handling, baggage handling, Catering Services, Fuel Services, Technical Services and Cleaning Services [3].

The m-MAPTWTC method is a refinement of the Manpower Allocation with Time Windows and Job Teaming Constraints (MAPTWTC) method developed first by Yanzhi Li, Andrew Lim, Brian Rodrigues Hongkong University in 2004 with a metaheuristic approach. The study of MAPTWTC, carried out in the port of Singapore, focuses on minimizing the number of workers needed in doing existing work [4].

2. Methods

The research begins by observing the main tasks and functions of the Ramp Coordinator in the field; during preparation to passenger embarkation and aircraft closing doors. From these observations note the time required to handle one aircraft (Loading - Unloading Baggage, Embarkation - Passenger Debarkation, Cleaning, and Other Preparations) ([4], [5]).

Notation

The notation used in the process of calculating this method are:

\[ K \] = Number of available teams \((K = 20)\)

\[ V \] = The set of all existing teams \((K_1, K_2, K_3, \ldots, K_{20})\)

Service center = 0

\[ C \] = The set of all tasks \((A_1, A_2, \ldots, A_{80})\)

\[ a_i \] = Preparation Time

\[ b_i \] = Actual Time Departure (ATD)

\[ e_k, f_k \] = start time and end time of each team (time span)

\[ t_{ij} \] = Travel time from task -I to task-j

\[ a, b, e, f, \] = non-negative integers

\[ s_i \] = integer variable and is defined as the start time of task -i

\[ M \] = a very large positive number

\[ N \] = the set of all tasks and service centers \(= C \cup \{0\}\)

Decision variable:

\[ x_{ijk} \] = binary number
\( x_{ijk} = \begin{cases} 
1, & \text{if team } k \text{ is doing task } i \text{ and I can directly do task } j \\
0, & \text{if other} 
\end{cases} \)

**Model Manpower Allocation Problem with Time Windows and Job-Teaming Constraints (m-MAPTWTC)**

The formulation of the m-MAPTWTC model is as follows:

\[
\text{max} \sum_{i \in C} \sum_{j \in N} \sum_{k \in V} x_{ijk} \tag{1}
\]

Subject to:

1. \( \sum_{k \in V} \sum_{j \in N} x_{ijk} \leq r_i \quad \forall i \in C \)
2. \( \sum_{j \in N} x_{0,jk} = 1 \quad \forall k \in V \)
3. \( \sum_{i \in C} \sum_{j \in N} x_{ijk} - \sum_{j \in N} x_{hjk} \geq 0 \quad \forall h \in N, \forall k \in V \)
4. \( e_i + t_{0j} - M(1 - x_{0jk}) \leq s_j \quad \forall j \in C, \forall k \in V \)
5. \( s_j + t_{0j} - M(1 - x_{i0k}) \leq f_k \quad \forall i \in C, \forall k \in V \)
6. \( s_j + t_{0j} - M(1 - x_{ijk}) \leq s_j \quad \forall i \in C, \forall j \in C, \forall k \in V \)
7. \( a_i \leq s_j \leq b_i \quad \forall i \in C \)
8. \( x_{ijk} \in \{0, 1\} \quad \forall i \in N, \forall j \in N, \forall k \in V \)
9. \( s_j \in \mathbb{Z}^+ \cup \{0\} \quad \forall i \in C \)

The objective function (1) is to maximize the number of tasks assigned. An assignment is calculated multiples of time divided by team \( (r_i \geq 2) \). Constraints / limitations (2) It is ensured that each job is carried out by a number of teams that are appropriate or may be lacking (only done by two teams), if some parts of the work are separate then the work is not done. Make sure each team starts work from the service center (3). Constraint (4) make sure the shift is not segmented (fragmented). Every work done by it must be completed. The next four constraints / constraints relate to time span. Ensure that each team must do its work during the available working hours (5) - (6). Check whether travel time is needed between one work and another (7). If the i-th plane is not visited, M large scalars make the related constraints non-binding. Constraint (8) make sure the job is within a certain time frame. Constraint (9) says that the decision variable is binary value. Constraint (10) is a non-negative integer \((\mathbb{Z}_+ \cup \{0\})\).

### 3. Results and Discussion

The following data is needed in data processing which includes the number of available teams, Task (aircraft handled), handling time, ATD time, windows time, start and finish time for each team, travel time

The following are the results of plotting the allocation of labor needed in one shift using the help of the Ip Solve 5.5.2.0 Software and the computer specifications for Intel Core 2 Duo CPU (2 Gzh), Memory (3 GB). By using the collected data, the number of decision variables \( (x_{ijk}) \) is 128000, the number of constraints is 261060. The time required to execute the model is 4 hours.
Table 1. Work Allocation and Scheduling Table

| Work team (K) | Task (A) (Airlines)                                                                 |
|---------------|-----------------------------------------------------------------------------------|
| K1            | A2, A4, A5, A6, A7, A21, A41, A64, & A65                                         |
| K2            | A3, A4, A6, A7, A22, A46, & A62                                                  |
| K3            | A3, A5, A7, A23, A27, A43, & A63                                                 |
| K4            | A6, A7, A24, A26, A44, & A66                                                     |
| K5            | A4, A6, A25, A27, A45, & A64                                                     |
| K6            | A3, A5, A6, A47, & A66                                                           |
| K7            | A1, A4, A5, A7, A21, A22, A23, A27, A46, A47, A61, A62, A66, & A67               |
| K8            | A8, A28, A48, & A68                                                              |
| K9            | A9, A29, A53, A54, & A69                                                         |
| K10           | A10, A30, A49, A54, & A73                                                        |
| K11           | A11, A33, & A74                                                                  |
| K12           | A34, A70, & A73                                                                  |
| K13           | A12, A31, A34, A54, & A73                                                        |
| K14           | A8, A10, A11, A13, A14, A28, A32, A34, A50, A51, A52, A55, A69, A71, A72, & A64 |
| K15           | A17, A35, A75, & A77                                                             |
| K16           | A16, A17, A40, A56, A60, A76, & A78                                               |
| K17           | A18, A40, A58, A60, & A77                                                        |
| K18           | A19, A37, A57, A59, & A78                                                        |
| K19           | A20, A39, A40, A60, & A79                                                        |
| K20           | A15, A16, A18, A20, A36, A38, A56, A57, A58, A59, A60, A77, A79, & A80          |

The number of tasks completed amounted to 80 flights but only used 20 work teams. The previous workforce scheduling and allocation system requires 24 work teams to do 80 flights, with the team allocation and work order for each job by each team.

4. Conclusions

From these calculations conclusions can be drawn regarding the division of tasks of each team:

- Team K1 handled 9 aircraft, namely: 2, 4, 5, 6, 7, 21, 41, 64, and 65.
- Team K2 handled 8 aircraft, namely: 3, 4, 6, 7, 22, 42, 46 and 62
• Team K3 handles 7 aircraft, namely: 3, 5, 7, 23, 27, 43 and 63
• Team K4 handled 6 aircraft, namely: 6, 7, 24, 26, 44, and 66
• Team K5 handled 6 aircraft, namely: 4, 6, 25, 27, 45 and 64
• Team K6 handled 5 aircraft, namely: 3, 5, 6, 47 and 66
• Team K7 handled 14 aircraft, namely: 1, 4, 5, 7, 21, 22, 23, 27, 46, 47, 61, 62, 66 and 67
• Team K8 handled 4 aircraft, namely: 8, 28, 48 and 68
• Team K9 handled 5 aircraft, namely: 9, 29, 53, 54 and 69
• Team K10 handled 6 aircraft, namely: 10, 30, 49, 54, 72 and 74
• Team K11 handled 3 aircraft, namely: 11, 33 and 74
• Team K12 handled 3 aircraft, namely: 34, 70 and 73
• Team K13 handled 5 aircraft, namely: 12, 31, 34, 54 and 73
• Team K14 handled 16 aircraft, namely: 8, 10, 11, 13, 14, 28, 32, 34, 50, 51, 52, 55, 69, 71, 72 and 64
• The K15 team handled 4 aircraft, namely: 17, 35, 75 and 77
• The K16 team handled 7 aircraft, namely: 16, 17, 40, 56, 60, 76 and 78
• The K17 team handled 5 aircraft, namely: 18, 40, 58, 60 and 77
• The K18 team handled 5 aircraft, namely: 19, 37, 57, 59, and 78
• The K19 team handled 5 aircraft, namely: 20, 39, 40, 60 and 79
• The K20 team handled 15 aircraft namely: 15, 16, 18, 20, 36, 38, 56, 57, 58, 59, 60, 77, 79, and 80.

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