Journal of Air Transport Management 30 (2013) 10–16

Contents lists available at SciVerse ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Airport gate assignments for airline-specific gates

Ching-Hui Tang [a,*], Wei-Chung Wang [b]

[a] Department of Transportation Science, National Taiwan Ocean University, 2 Pei-Ning Road, Keelung 20224, Taiwan
[b] System Operation Control Division, China Airlines, Taiwan

Keywords:
Airline-specific gate
Gate assignment
Objective
Airline perspective

ABSTRACT

The airline-specific gate, which is exclusively used by a specific airline, has been utilized in many airports. Differing from the traditional gate assignment, allocating flights to airline-specific gates is based on the perspective of the airline rather than that of the airport authority. In this study, we propose a new objective that results from an airline's perspective. Numerical tests, based on the operations of a Taiwanese airline, are carried out to assess the performance of the proposed approach.

1. Introduction

The purpose of flight to gate assignments is to assign a flight to a suitable gate where airlines provide passenger boarding or disembarking services. Currently the airline-specific gate, which is exclusively used by a specific airline, is utilized in many airports. Differing from the traditional gate assignment which is usually performed by the airport authority, the planned assignment of the airline-specific gate is mainly performed by the associated airline. Therefore, assigning flights to airline-specific gates is conducted from the perspective of the airline rather than the airport authority.

In relation to this concept, there is a problem concerning how to find an effective airline-specific gate assignment that considers the airline's perspective. In particular, a recent study by Maharjan and Matis (2011) provides a direction – the objective function. They considered a new objective function which minimizes the total passenger walking distance between the gate shown on the passenger's boarding pass and the actual reassigned gates. This suggests the adoption of a different objective, considered from an airline's perspective, rather than the airport authority's perspective, that can be designed for the airline-specific gate assignment.

To design a new objective from an airline's perspective, past objectives for gate assignments need to be reviewed. These are the passenger walking distance (Maharjan and Matis, 2011), the passenger connection time (Ding et al., 2004), the passenger waiting time (Yan and Tang, 2007), the idle gate times (Bolat, 1999, 2000a, 2000b), the number of conflicting flights (Lim and Wang, 2005), the delay penalties and the total passenger walking distance (Lim et al., 2005), the combination of the total gate preferences, the number of towing activities and the absolute or self-defined deviation from a reference schedule (Yan et al., 2009; Nikulin and Drexl, 2010; Tang. et al., 2010; Tang, 2011). These objectives are primarily focused on the airport authority or both the airport authority and the airline. The divergent considerations that arise between the airport authority and the airline are neglected, for example, the different attention paid to departing and arriving passenger behavior, the different attention paid to economy class passengers, business and first class passengers, the considerations associated with flight connections, and the use of remote gates.

In practice, gates are usually owned by airports, and many airports lease the airline-specific gate to a specific airline on a long term basis. Then the airline may also rent out its airline-specific gates to be used by other airlines. Given the many factors considered by the airlines and the airports, there are two key issues related to the above situation. One is the number and the location of airline-specific gates leased by the airline; the other is the number and the location of the airline-specific gates that the airline rents out. These two issues involve the analysis of gate utilization, the rental charge, the rent policy or rule affecting the rental that will be expended or obtained by the airline, and the extent that the airline will use or rent out its airline-specific gates. Here we focus on the planned gate assignment problem which assigns flights to suitable gates.

The remainder of the paper is organized as follows. Section 2 provides a description of the problem. In Section 3, the objective function is introduced. In Section 4, a numerical test based on the target airline's operations at Taiwan Tao-Yuan Airport (TTY Airport, a major international airport in Taiwan) is conducted. Finally, conclusions are offered in Section 5.

* Corresponding author. Tel.: +886 224622192x7021; fax: +886 224633745.
E-mail address: chtang@mail.ntou.edu.tw (C.-H. Tang).

0969-6997/$ – see front matter
http://dx.doi.org/10.1016/j.jairtraman.2013.02.003

2. Problem description

This section consists of two parts: the pertinent element and the differences between planned assignments and real-time adjustments, which are discussed below.

2.1. The pertinent element

To better understand the problem, we first discuss a number of pertinent elements, which include a buffer time, flight starting and ending times, a flight time window, arriving, departing and transit flights, as well as remote gates.

2.1.1. Buffer time

The buffer time is a minimum amount of time needed at a gate between two consecutive aircraft. In practice, it is used to ensure safety and to absorb any minor delays that might occur in actual operations. For example, TTY airport requires a buffer time of30 min.

2.1.2. Flight starting and ending times

In this study, the flight starting time is the time when the gate first opens for the associated aircraft. The ending time is the time when the associated aircraft releases the gate from use plus the buffer time.

2.1.3. Flight time window

The flight time window is the time period between the starting and ending times (i.e. the time period where a specific gate is assigned to a particular flight). In particular, the flight time window includes the time required for aircraft push back, for jet bridge operations, for fueling, for aircraft checks, for passenger/luggage boarding/deplaning, and so on.

2.1.4. Arriving, departing, and transit flights

We define flights as comprising three parts: arriving, departing, and transit flights. In particular, a transit flight forms a flight pair which usually uses the same aircraft inbound and outbound, with the same flight number. There is a short connection time between a flight pair so the pair needs, in practice, to be assigned to the same gate.

2.1.5. Remote gate

The remote gate is a kind of gate without the jet bridge. In general, airlines do not like to assign flights to remote gates in normal situations because it will increase passenger boarding and waiting time. The number of flights assigned to remote gates should be minimized as much as possible.

2.2. Differences between planned assignments and real-time adjustments

Our problem is a planned assignment problem which is different from a real-time adjustment problem (or reassignment problem). In practice a real-time adjustment is usually performed by adjusting a planned assignment to meet gate assignment perturbations in real-time operations. Such perturbations can be caused by many factors like temporary gate and jet-way malfunctions, temporary airport closures, bad weather conditions, late aircraft arrivals/departures and so on. For airport operations, there are several different characteristics between planned assignment and real-time adjustment problems, which are as follows:

1. Since a planned assignment is performed daily according to the next day's flight schedule in advance, there is usually sufficient time to handle a planned assignment in daily operations. In comparison, a real-time adjustment problem is typically more time constrained because most perturbations that occur in real-time operations are unexpected and need to be dealt with immediately.
2. A real-time adjustment is usually to avoid or lessen cascading downstream impacts on the planned assignment to reduce gate assignment perturbations. That is, a planned assignment is usually used as a basis or measure for a real-time adjustment. This consideration is usually not included in a planned assignment.
3. A planned assignment is made and completed in advance while a real-time adjustment cannot be pre-performed before perturbations occurred in actual operations.

3. The objective function

The objective function is our major representation of the airline's perspective. After consulting with the target airline, we identified four components, which are listed below, that make up our objective.

1. Component 1: Maximization of the number of departing flights assigned to gates with short distances to the target airline's VIP lounge.
2. Component 2: Maximization of the number of arriving flights assigned to gates with short distances to customs.
3. Component 3: Maximization of the number of arriving flights assigned, and the subsequent departing flights assigned, to the same gate, if they are served by the same aircraft.
4. Component 4: Minimization of the number of flights assigned to remote gates.

It is worth noting that the four components are related to two areas: passenger service (Components 1 and 2) and operating efficiency (Components 3 and 4). Since the two areas are fundamental aspects of airline operations, they should be considered by the airline even it has monopoly power at an airport. In addition, the airline may want to retain or gain monopoly power by using its own airline-specific gates. Then the related issues, for example the number of rented out airline-specific gates, could be taken into account. In this case, the airline's action may not be independent of other airlines, as the airline needs to consider other airlines to optimally assign flights to gates. All of this will make the problem more complex.

A detailed discussion for each component is as follows.

1. Component 1

Many past studies use a distance from a specified facility (such as customs) to the gate as a measure to design the objective function. We discussed this with the target airline staff and they also suggested that the distance is a useful criterion to determine the priority of the gate in the assignment. In our consultations, we obtained an interesting finding which differed from past studies and was identified by the target airline. In past studies, the distance from the customs to the gate is usually considered for the departing passengers regardless of the different classes of passengers. However, the behavior of economy class passengers varies after they go through customs. Most economy class passengers will visit the duty free stores, consume food and drink, or use other equipment provided by the airport as they wait for boarding. Only a few of them will go directly to the gate after going through customs. Such behavior means that a short distance from a specified facility to the gate is not essential for the economy class passengers. Therefore, for the departing passengers, the distance factor is not given special consideration for the economy class passengers in this research.

By contrast, the distance issue needs to be considered for passengers in business and first class but with different definitions from the airline's perspective. In practice, most business and first class passengers will go to the airline's VIP lounge to wait for boarding, regardless of whether they go elsewhere after going through the customs or not. In practice, they are concerned more about the distance from the airline's VIP lounge to the gate than the distance from customs to the gate. In particular, the business and first class passengers are usually regarded as important passengers for the airline because they pay higher ticket prices and are potentially regular customers. The airline usually values and thinks highly of these passengers in business terms. The short distance between the gate and the airline's VIP lounge needs to be given more attention in this case where there is a different consideration between the airline and the airport authority. Therefore, we consider the maximization of the number of departing flights assigned to gates with short distances to the airline's VIP lounge, which becomes Component 1 in our objective.

2. Component 2

In addition to the departing passenger, the arriving passenger also needs to be considered in the assignment. However, compared to departing passengers, the behavior of arriving passengers is similar and uncomplicated after they disembark from the aircraft. Most arriving passengers will go directly to customs to perform the arrival process, regardless of whether they are economy class, business class, or first class passengers. That is, the distance from the gate to customs is a considerable factor when the airline assigns arriving flights to gates. A short distance from the gate to customs is desirable and attractive to all arriving passengers. Therefore, our Component 2 is designed to maximize the number of arriving flights assigned to gates with short distances to customs.

3. Component 3

Another different but major consideration between the airline and the airport authority is flight connections involving the same aircraft. In actual operations, an arriving flight and a later departing flight may be served by the same aircraft. The subsequent possibility is that the two flights can then be assigned to the same gate to perform most of their ground services, as shown in Fig. 1. This results in several advantages in airline operations, for example, reducing the charge for towing aircraft, and increasing ground service convenience and efficiency, thereby reducing the shift in the ground service staff for the two flights and the flight delay. All these factors are essential to an airline's cost, its level of service and its competitive capability in the market, which will not necessarily be considered from the airport's perspective. Therefore, we design our component to maximize the number of arriving flights and later departing flights assigned at the same gate, if they are served by the same aircraft.

It should be mentioned that the above combination is not a transit flight pair as introduced in Section 2.1. In Component 3, an arriving flight and a later departing flight have different flight numbers, and the gap between the starting time of the former and the ending time of the latter usually exceeds one hour. In practice, the two flights are not forced (but are encouraged in our objective) to be assigned to the same gate; while a transit flight pair needs to be assigned to the same gate in practice.

4. Component 4

Component 4 is to minimize the number of flights assigned to remote gates. This primarily results from the fact that it is undesirable for the airline to assign flights to remote gates as discussed in Section 2.1. The remote gate undesirability is not significant for the airport authority which is also a difference between the airline's and the airport's perspective. Therefore, less usage of the remote gate is included in our objective.

In addition to the four components, a weighted value for a flight is also considered in the objective to reflect the heterogeneity of each flight. After consultation with the target airline, the number of passengers is used as a reference point when designing the weighted value. The idea is that a flight with more passengers should have a higher weighted value. We consider the flight to be a unit made up of the four components in our objective. A standardized weighted value is designed to maintain the unit after weighting. To do this, we use the minimum number of business and first class passengers or the minimum number of passengers for all flights in daily operations as the standard. As a result, the weighted value for a flight in accordance with each component is designed as follows:

1. Component 1:

Since the business and first class passengers are the particular and major consideration in Component 1, they serve as the reference point for the weighted value for a flight. The weighted value for a flight in Component 1 is designed as the number of business and first class passengers for each flight divided by the minimum number of business and first class passengers for all flights in daily operations.

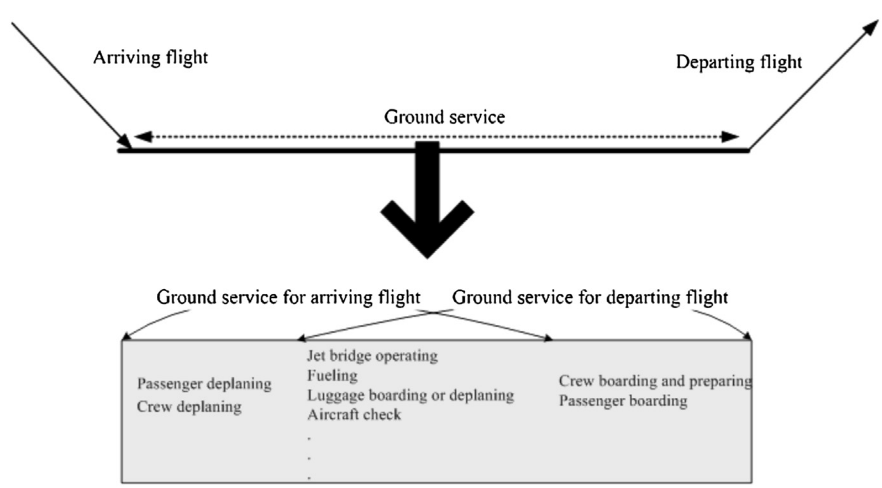

Fig. 1. Ground services of an arriving flight and a later departing flight assigned to the same gate.

2. Components 2, 3, and 4:

For Components 2, 3, and 4, different classes of passengers are not considered and all passengers on a flight are included. Hence, the weighted value for a flight for the three components is designed as the number of passengers for each flight divided by the minimum number of passengers for all flights in daily operations.

4. Numerical tests

The proposed objective function is involved in a gate assignment model for solving the daily gate assignments. The major elements in the model include the gate-flow network and the mathematical formulas which are introduced in Appendix.

4.1. Data analysis

We performed numerical tests based on the target airline in TTY airport operations. Since the airline's timetables are usually the same each week, we used data for just one week for the operating days from September 1–7, 2011. There were between 167 and 186 flights of the target airline during the seven days of operation. As shown in Fig. 2, there were 19specific-gates for the target airline in Zones A and D. Currently, there are 15 remote gates at TTY Airport. Based on the usage practices of remote gates in the target airline's operations, we only considered three remote gates in the numerical tests. In addition, according to the target airline's suggestion and the terminal configuration, the set of gates with the short distance to the target airline's VIP lounge included gates A5–A9 and gates D1–D6 as well as the set of gates with the short distance to the customs included gates A3–A7 and gates D3–D8.

4.2. Test results

In this section, the objective value of each component and the number of flights resulting from each component are presented sequentially in order to analyze the differences among the four components.

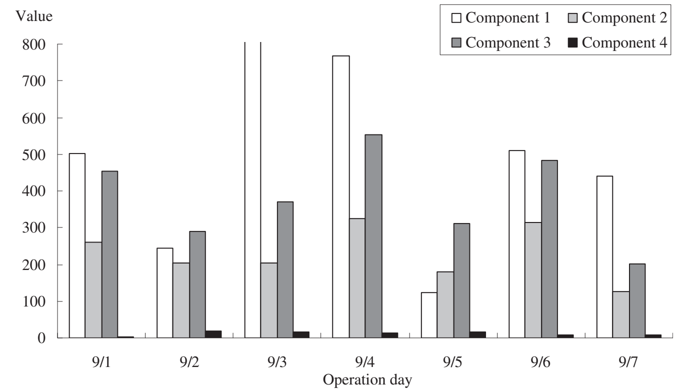

Fig. 3. Objective value of each component.

4.2.1. The objective value of each component

Fig. 3 shows the values of the four components involved in the objective values. We found that Components 1 and 3 have high objective values on most operation days. The result shows the large proportions of the two components and also indicates that the two components are valuable and significant in the gate assignments. By contrast, Component 4 has the smallest objective value. This is reasonable because a minus sign is established for Component 4 in the objective function, and the airline does not like to assign its flights to remote gates.

4.2.2. Number of flights corresponding to each component

The numbers of flights resulting from the four components are shown in Table 1. Clearly, the numbers of flights for Components 1, 2, and 3, which are desirable for the target airline, are significant. The airline's undesirable areas, that is, the numbers of flights assigned to remote gates in Component 4, are minor and range only

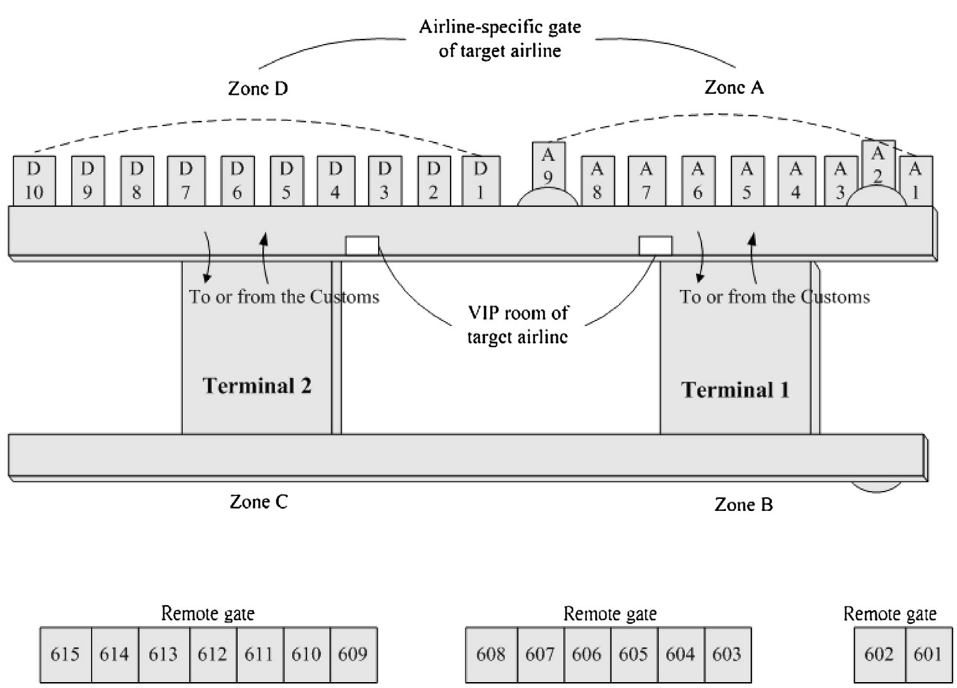

Fig. 2. Terminal and gate configurations at TTY airport.

Table 1
Number of flights corresponding to each component.

Operation days	9/1	9/2	9/3	9/4	9/5	9/6	9/7
Component 1	51	43	54	51	44	52	56
Component 2	48	52	50	50	51	55	55
Component 3	68	62	68	76	72	68	66
Component 4	4	8	10	8	8	8	3

from 3 to 10 flights. The results show that our model can actually plan effective gate assignments to meet the target airline's requirements and considerations.

4.3. Comparison with the practical assignment

We also use the practical assignments, which are performed manually by the target airline staff, to evaluate the performance of our model. We discuss two terms, the objective value and the number of flights corresponding to each component.

4.3.1. The objective value

The objective values of our assignments and practical assignments are shown in Table 2. For all operation days, the objective values of our assignments are better than those of the practical assignments. In particular, on 4 of the 7 operation days the improvements exceed 20%. The comparison demonstrates that our approach can produce better assignments and there will therefore be substantial improvements that will be helpful to enhancing actual operations.

4.3.2. The number of flights corresponding to each component

The numbers of flights corresponding to each component of our assignment and those of the practical assignments are shown for one operation day, namely, 9/1 (Table 3). The results for other operation days are similar. The improvements corresponding to the four components are all positive. The number of flights assigned to remote gates (i.e., corresponding to Component 4) has the largest improvement. This result indicates that our model has the largest contribution to the airline's undesirable term compared with its current assignment. The result also shows that the practical assignment will increase the insufficient gate situation and will thus result in more flights being assigned to the remote gate, which is a useful finding for the airline's planners and operators.

Table 2
Comparison between our assignment and practical assignment.

Operation day	9/1	9/2	9/3	9/4	9/5	9/6	9/7
Objective value							
Our assignment	1210.9	717.8	1494.8	1634.0	599.3	1298.5	757.4
Practical assignment	1067.4	619.3	1301.1	1288.4	481.7	1062.3	620.1
Improvement (%)	13.4	15.9	14.9	26.8	24.4	22.2	22.1

Table 3
Number of flights corresponding to each component of our model and practical assignment.

Component	1	2	3	4
Number of flights				
Our assignment	51	48	34	4
Practical assignment	47	43	32	15
Improvement (%)	8.5	11.6	6.3	73.3

Table 4
Number of flights for Component 3.

Operation days	9/1	9/2	9/3	9/4	9/5	9/6	9/7
Solving only with Component 3	68	64	72	76	72	70	66
Original results (Table 1)	68	62	68	76	72	68	66

4.4. Analyses of Component 3

As discussed above, the number of flights for Component 3 is largest on all operation days (see Table 1). Hence, we only consider Component 3 to solve the assignment problem and analyze the proportion of this specific component. As shown in Table 4, the number of flights associated with Component 3, and for the original results, are similar and high. The result shows that Component 3 actually has a significant effect, regardless of whether there is consideration of just Component 3 or the four components together. In other words, Component 3 will dominate the other three components, and thus the airline should give high importance to Component 3 in the gate assignment.

4.5. Weighted value for each component

We add a parameter of weighted value to each component to understand the variation of the objective value of each component. To do this, four weighted values W1, W2, W3, and W4 are multiplied by Components 1, 2, 3, and 4, respectively. 12 different values are designed for each weighted value, resulting in 48 cases in this test.

The vertical axis in Figs. 4–7 represents the percentage of variation of the objective value compared with the original results

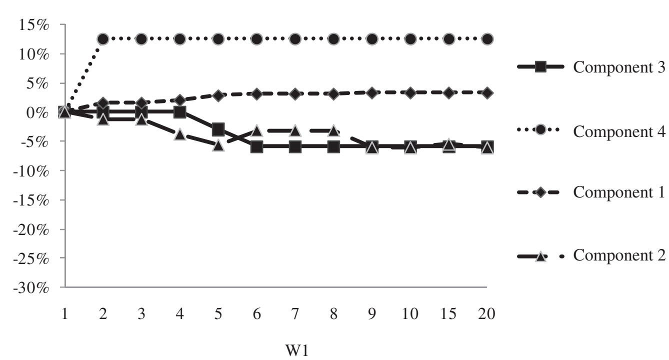

Fig. 4. Variation of the objective value for different W1.

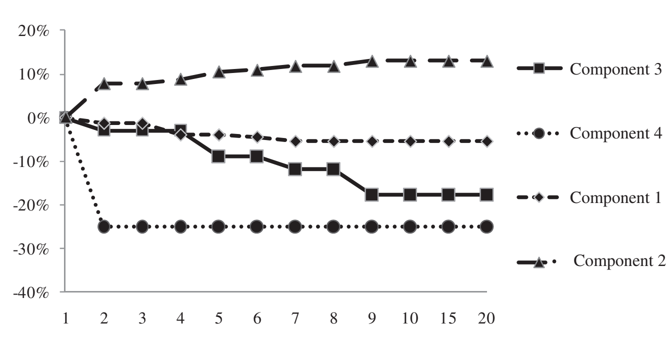

Fig. 5. Variation of the objective value for different W2.

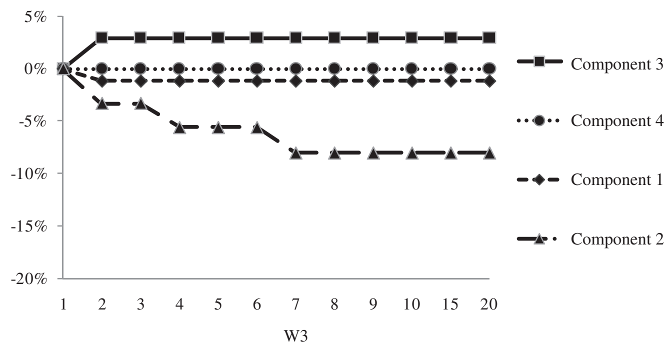

Fig. 6. Variation of the objective value for different W3.

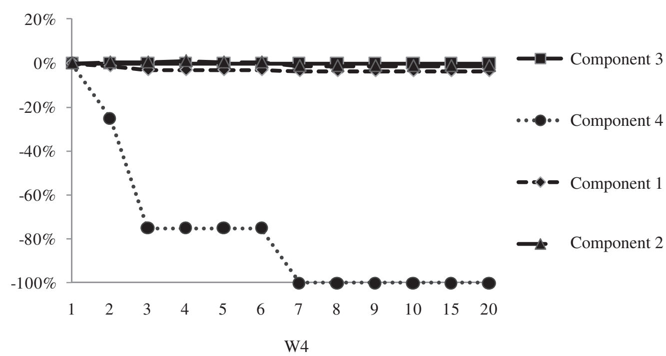

Fig. 7. Variation of the objective value for different W4.

in Fig. 3. We find two interesting results of Components 1 and 4. First, the lines with diamond labels (Component 1) are smooth in the four figures. The variation of the objective value for Component 1 is minor and insensitive to different weighted values. This means that Component 1 will not be affected if the airline decides to pay more attention to other components. Second, an opposite result is that Component 4 is sensitive to different weighted values. As can be seen, the lines with circle labels are varied with different trends in the four figures. This shows that the airline can manage Component 4 by setting different weighted values. For example, if the airline decides to decrease the objective value of Component 4, and then the W2 or W4 could be increased (see Fig. 5 or 7); otherwise W1 could be increased (see Fig. 4).

5. Conclusion

In this research, a new objective including four components from the airline perspective is developed. To the best of the authors' knowledge, there has been a dearth in studies in this area in the past. The proposed objective is one of the first and could serve as a basis for the study of airline-specific gate assignments from both a theoretical and a practical point of view.

The transfer passenger is not a major consideration in our objective. The reason is that most passengers are arriving and departing passengers for the target airline because TTY airport is not a major hub in Asia. Nevertheless, the transfer passenger may be an issue when considering the services provided to passengers. The distances between two gates for transfer passengers may be considerable and could be included in the objective.

Acknowledgments

This research was partially supported by a grant (NSC 100-2410-H-019-024) from the National Science Council of Taiwan. We would like to thank the target airline and TTY airport for providing the test data and for their valuable opinions. We also thank the Editor-in-Chief and the anonymous referees for their helpful comments and suggestions on the presentation of the paper.

Appendix A. The gate-flow network and model formulation

The assignment of each gate is formulated in a gate-flow network, with each gate-flow network corresponding to one gate. We design a flight node to represent a flight in the network that is available for the corresponding type of gate. As shown in Fig. A1, an arc denotes the usages of a gate, including the continuity for a gate serving two different flights (connecting arc), the beginning and end of the daily assignments of a gate (starting and ending arcs), as well as whether agate is used or not (cycle arc).

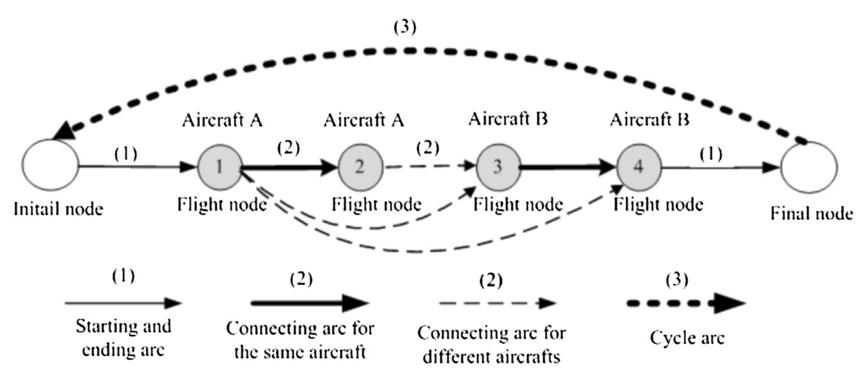

Fig. A1. Examples of the gate-flow network.

The notations and symbols used for the model's formulation are as follows:

Variables:

x_{ij}^{k}: the arc (i,j) flow in the kth gate-flow network (i.e., the kth gate);

Sets:

K, F: the sets of all gate-flow networks and flights, respectively;

B^k: the set of connecting arcs for the same aircraft in the kth gate-flow network;
R: the set of all remote gates;
D^k, A^k: the sets of flight nodes which represent departing and arriving flights in the k^{th} gate-flow network, respectively;
N^k, G^k: the sets of all nodes and arcs in the kth gate-flow network, respectively;
$\mathrm{IC}_i^k, \mathrm{OC}_i^k$: the sets of arcs that connect to and connect from the ith node in the k^{th} gate-flow network, respectively;
OG, IG: the sets of gates with the short distance to the airline's VIP lounge and the Customs, respectively;
AG_f: the set of available gate-flow networks for the fth flight;
FC_f^k: the set of arcs connected to the flight node that represent the fth flight in the k^{th} gate-flow networks;
Q: the set of all adjacent gate pairs;
E_q, T_q: the sets of gates and conflicting flight pairs for the qth adjacent gate pair, respectively;
L_q^t: the set of flights included in the tth conflicting flight pair for the qth adjacent gate pair.

Parameters:
p_i, q_i: the numbers of passengers as well as just business and first class passengers of the flight which is represented by the ith flight node;
t, s: the minimum numbers of passengers as well as business and first class passengers of all flights in daily operations.

The model formulation can now be represented as follows:

$$\text{Max.} \sum_{k\in \mathrm{OG}} \sum_{\forall i\in D^k} \sum_{hi\in \mathrm{IC}_i^k} \frac{q_i}{s} x_{hi}^k + \sum_{k\in \mathrm{IG}} \sum_{\forall i\in A^k} \sum_{hi\in \mathrm{IC}_i^k} \frac{p_i}{t} x_{hi}^k + \sum_{k\in K} \sum_{ij\in B^k} \left(\frac{p_i}{t}+\frac{p_i}{t}\right) x_{ij}^k + \sum_{k\in R} \sum_{hi\in \mathrm{IC}_i^k} \frac{p_i}{t} x_{hi}^k, \tag{1}$$

$$\text{s.t.} \sum_{ij\in \mathrm{OC}_i^k} x_{ij}^k - \sum_{hi\in \mathrm{IC}_i^k} x_{hi}^k = 0, \quad \forall i\in N^k, \quad \forall k\in K, \tag{2}$$

$$\sum_{k\in \mathrm{AG}_f} \sum_{ij\in \mathrm{FC}_f^k} x_{ij}^k = 1, \quad \forall f\in F, \tag{3}$$

$$\sum_{k\in E_q} \sum_{f\in L_q^t} \sum_{ij\in \mathrm{FC}_f^k} x_{ij}^k \le 1 \quad \forall t\in T_q, \quad \forall q\in Q, \tag{4}$$

$$x_{ij}^k = 0,1, \quad \forall (i,j)\in G^k, \quad \forall k\in K. \tag{5}$$

The objective function (3) seeks to maximize the combination of the four components. In particular, a minus is placed before Component 4 for the maximization problem. Constraint (4) ensures flow conservation at every node in each gate-flow network. Constraint (5) ensures that every flight must be assigned to one and only one gate and flight time window. Constraint (6) ensures that a conflicting flight pair cannot be assigned concurrently to two adjacent gates. Constraint (7) ensures that all arc flows are either zero or one.

References

Bolat, A., 1999. Assigning arriving flights at an airport to the available gates. Journal of the Operational Research Society 50, 23–34.

Bolat, A., 2000a. Procedures for providing robust gate assignments for arriving aircrafts. European Journal of Operational Research 120, 63–80.

Bolat, A., 2000b. Models and a genetic algorithm for static aircraft-gate assignment problem. Journal of the Operational Research Society 52, 1107–1120.

Ding, H., Lim, A., Rodrigues, B., 2004. New heuristics for over-constrained flight to gate assignments. Journal of the Operational Research Society 55, 760–768.

Lim, A., Rodrigues, B., Zhu, Y., 2005. Airport gate scheduling with time windows. Artificial Intelligence Review 24, 5–31.

Lim, A., Wang, F., 2005. Robust airport gate assignment. In: Proceedings of the 17th IEEE International Conference on Tools with Artificial Intelligence.

Maharjan, B., Matis, T.I., 2011. An optimization model for gate reassignment in response to flight delays. Journal of Air Transport Management 17, 256–261.

Nikulin, Y., Drexl, A., 2010. Theoretical aspects of multicriteria flight gate scheduling: deterministic and fuzzy models. Journal of Scheduling 13, 261–280.

Tang, C.H., Yan, S., Hou, Y.Z., 2010. A gate reassignment framework for real time flight delays. 4OR 8, 299–318.

Tang, C.H., 2011. A gate reassignment model for the Taiwan Taoyuan Airport under temporary gate shortages and stochastic flight delays. IEEE Transactions on Systems, Man, and Cybernetics Part A 41, 637–650.

Yan, S., Chen, C.Y., Tang, C.H., 2009. Gate reassignment following temporary airport closures. Transportmetrica 5, 25–41.

Yan, S., Tang, C.H., 2007. Aheuristic approach for airport gate assignments for stochastic flight delays. European Journal of Operational Research 180, 547–567.