FLIGHT SCHEDULING BASED ON CONNECTIVITY INDEX MODEL

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Sibel ALİM // Canan Aslı ALTIOK // Enes Sedat ÇAĞLAR
Academic Supervisor: Prof. Dr. İbrahim AKGÜN // Assistant Advisor: Betül KAYIŞOĞLU
ABDULLAH GÜL UNIVERSITY
DEPARTMENT OF INDUSTRIAL ENGINEERING

Introduction

Ever since the beginning of civil aviation, the structures and strategies of aviation networks have undergone fundamental change. Today, to adapt these changes, airlines create strategies to stabilize or improve their place in the market. Some airline strategies emphasize local traffic while others focus on transfer traffic.

Hubs are airports with a high volume and proportion of transfer traffic. The more an airline depends on transfer traffic, the more important high performance is to connectivity.

In times of expanding markets, airlines emphasize connectivity; but during times of traffic congestion, productivity becomes a more prominent issue. As a general trend, however, the pureplay connectivity network structures increasingly were replaced by structures that take a more balanced approach between connectivity and productivity.

Motivation

Turkey is strategically positioned astride three continents with a fast-growing population, rapid urbanization, booming tourism industry, an increasing regional commercial base, and a need of developed civil aviation and airport infrastructure. The company which is studied with in this project is one of the biggest airline companies in Turkey.

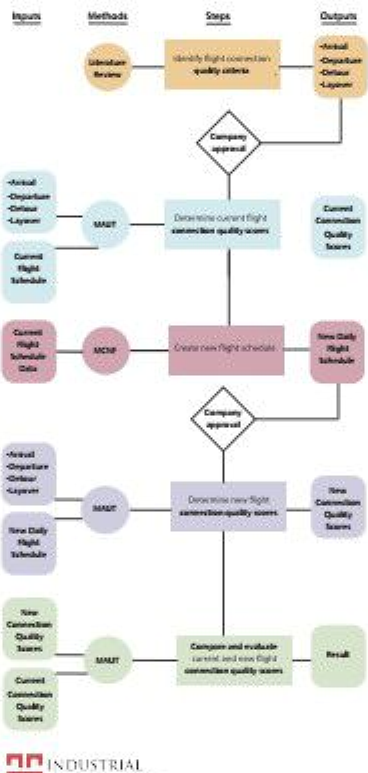
The company's business model is built upon high volumes of transfer traffic. The company must understand its performance in relation to its competitors to attract as much valuable transfer traffic as possible. Assessing and comparing the company's performance is invaluable in optimizing the given network.

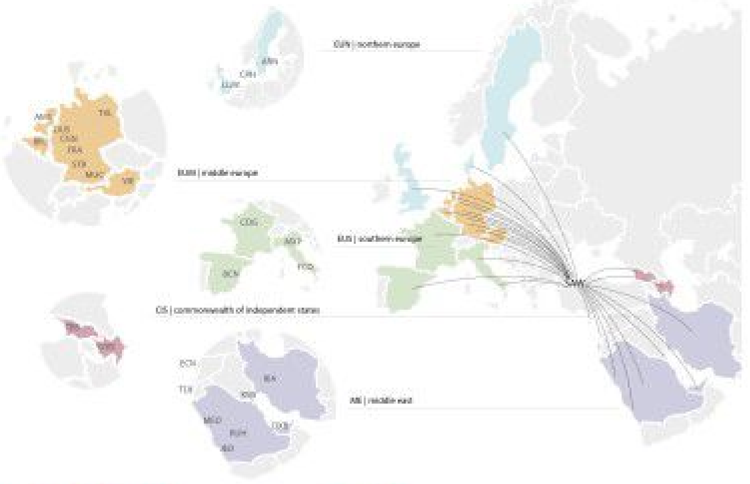
Current System

The company manages its flight network by accurately analyzing the demands from different destinations. When the existing system is analyzed, it is seen that its flight network structure is based on the Hub and Spoke model and adopts the daily two-wave form. Hub and Spoke is the network model where at least one flight point is received at the center and other flight points are generated by the arrival/departure traffic.

The wave is the connection of arrival flights to the hub and departure flights from the hub within a certain time period. Synchronization of the waves is an important operation in terms of reducing the waiting time in the flight network center of the transfer passengers. For this purpose, the network planning department generates new flight schedules each winter and summer.

Methodology





Problem Definition

The company structures current flight schedule intuitively without relying on connection quality factors. The intuitive scheduling and the lack of consideration of the passenger criteria lead to a decrease in the preferability of connected flights and a decrease in customer satisfaction.

According to the assessments, this situation allows the airline company to use only 70% of the volume of the transfer traffic. In order to increase the transfer volume and improve the connection quality due to the specified criteria, it is considered that the need for improvement of the current flight schedule is needed.

The aim of this study is to increase the quality of connections of the flights.

Mathematical Model

Sets

i : set of nodes in the network
s_i: set of supply nodes
d_j: set of demand nodes
η_j: set of hub time periods
k : set of commodities in the network

Parameters

$Supply_{ik}$: The amount of supply of commodity k of node i
$Demand_{jk}$: The amount of demand of commodity k of node j
W_{ij}: The waiting time between node i and node j
F_{ij}: Flight permission given from node i to node j
C : Maximum capacity of a flight that is gone from node i to node j
P: Number of flight that is coming from the airport or going to the airport in a time period
A_{ij}: { 1 if there is an arc between node i and node j, 0 otherwise

Decision Variables

X_{ijk}: The amount of flow of commodity k between node i and node j
Y_{ij}: { 1 if there is a flow between node i and node j, 0 otherwise

Objective Function

$$\text{Minimize } Z = \sum_{i \in s_i} \sum_{j \in \eta_j} \sum_k W_{ij\eta_j} X_{ijk} \quad (1)$$

Subject to

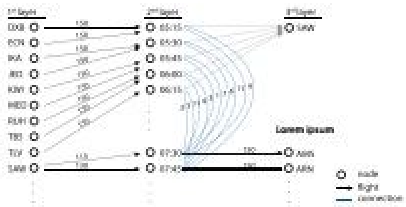
$\sum_{j \in \eta_j, n \in \eta_j} X_{ijk} = Supply_{ik}$	$\forall i \in s_i$ and $\forall k$	(2)
$\sum_{i \in \eta_j, n \in \eta_j} X_{ijk} = Demand_{jk}$	$\forall j \in d_j$ and $\forall k$	(3)
$\sum_{j \in \eta_j, n \in \eta_j} X_{ijk} = \sum_{j \in s_i} X_{ijk}$	$\forall i \in \eta_j$ and $\forall k$	(4)
$\sum_{j \in \eta_j, n \in \eta_j} X_{ijk} = \sum_{j \in d_j} X_{ijk}$	$\forall i \in \eta_j$ and $\forall k$	(5)
$\sum_{j \in \eta_j, n \in \eta_j} Y_{ij} < F_{ij}$	$\forall i \in s_i$	(6)
$\sum_{i \in \eta_j, n \in \eta_j} Y_{ij} < F_{ij}$	$\forall i \in d_j$	(7)
$\sum_k X_{ijk} < Y_{ij} C$	$\forall i \in s_i, j \in \eta_j$ and $(i,j) \in A_{ij}$	(8)
$\sum_k X_{ijk} < Y_{ij} C$	$\forall i \in \eta_j, j \in d_j$ and $(i,j) \in A_{ij}$	(9)
$\sum_{i \in s_i, n \in \eta_j} Y_{ij} < P$	$\forall j \in \eta_j$	(10)
$\sum_{j \in d_j, n \in \eta_j} Y_{ij} < P$	$\forall i \in \eta_j$	(11)
$X_{ijk} \geq 0$	$\forall i,j$ and k	(12)
$Y_{ij} \in \{0,1\}$	$\forall i,j$ and k	(13)

The objective (1) of the model is to minimize total waited time in İstanbul hub. Constraint (2) and constraint (3) provide all demand and supply of the nodes are satisfied. Constraint (4) and constraint (5) provide all flow that comes to hub nodes to go demand nodes. Constraint (6) and constraint (7) provide the flight limits from supply nodes and to demand nodes are satisfied. Constraint (8) and constraint (9) limits the capacity of each arc. Constraints (10) and (11) are the constraints which limit the hub arrival and departure flight numbers. Constraint (12) and (13) define the decision variables.

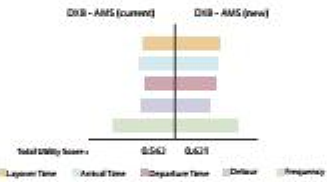
Results

As a result, the mathematical model generated similar flight frequencies for each connection. On the other hand, overall waiting times are decreased. In addition, it is found out that the new flight schedule provides connection quality scores to improve as a result of the re-made MAUT.

Illustrative example of new flight schedule is shown below.



Illustrative example of MAUT results that compare a new and current connection quality index scores for an origin-destination pair is shown below.



DXB - AMS connection quality increases after new scheduling. As it can be seen from the graph, even the detour and frequency remain the same, the reduction in layover time provide higher utility score for the connection.

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