STEVENS
INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY

Flight Scheduling Optimization for American Airlines — based on Deficit Function and Network Flow Model

Author

Jinghao Wang, Han Zhu, Kun Liu,

Nithin Das, Swithin Ruskin Roy

Instructor

Edward A Stohr

Introduction

- Solve two problems:

    1) find the minimal number of aircrafts needed to carry out the flights

    2) maximize profits by removing several uneconomic flights

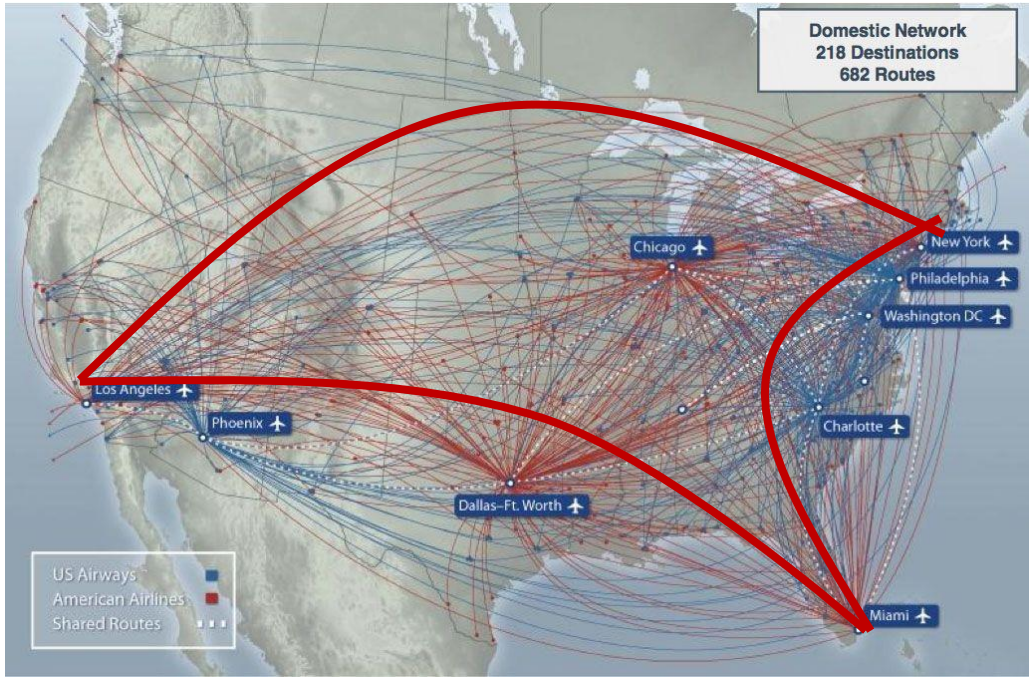
Introduction

The function and the model we used:

- Deficit function (DF)
- Network flow model

Data Source

- All data are captured from www.aa.com
- American Airlines has over 1,000 domestic flight routes across the country.
- As a sample, select 3 major airports, JFK, LAX and MIA, and 30 flights that connect them.
- Ignore the midnight flight (flight past 0:00)



Data Preprocessing

Adjust data format.

- Uniform time to EST.
- Transform time formats to number formats.

[=ROUND((HOUR(F2)+MINUTE(F2)/60),2)]

- Merge airport and time

[=C2&G2]

Flight Number	Origin	Destination	Departs	Arrives
1	JFK	LAX	08:00	11:15:00

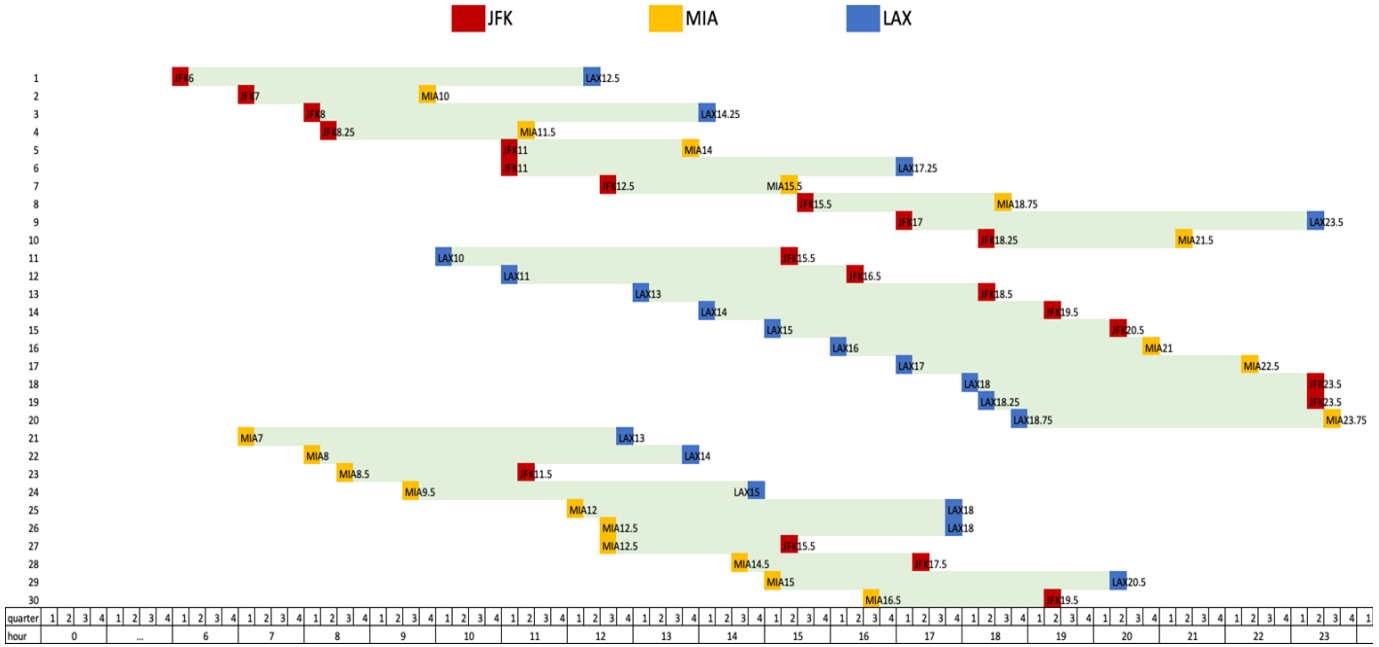
Flight Number	Origin+Time	Des+Time	Duration
1	JFK8	LAX14.25	06:15:00

For a flight schedule like this:

Flight No.	Departure + Time	Destination + Time
1	JFK6	LAX12.5
2	JFK7	MIA10
3	JFK8	LAX14.25
...	...	...
28	JFK17.5	MIA14.5

how to draw the graph

- Endpoints → airport departure/arrival time
- Length → duration of flight



Deficit Function

A function for estimating an optimal fleet size required for a fixed schedule.

DF of Airport A = Number of aircrafts departing from airport, "A" - Number of aircrafts arriving at airport "A" at a particular time period

DF can be calculated at any instance between time period [0,T]

Minimum Fleet Size

Minimum number of flights required to service **= ∑ max(DF(i))**

where i = airport A, airport B etc.

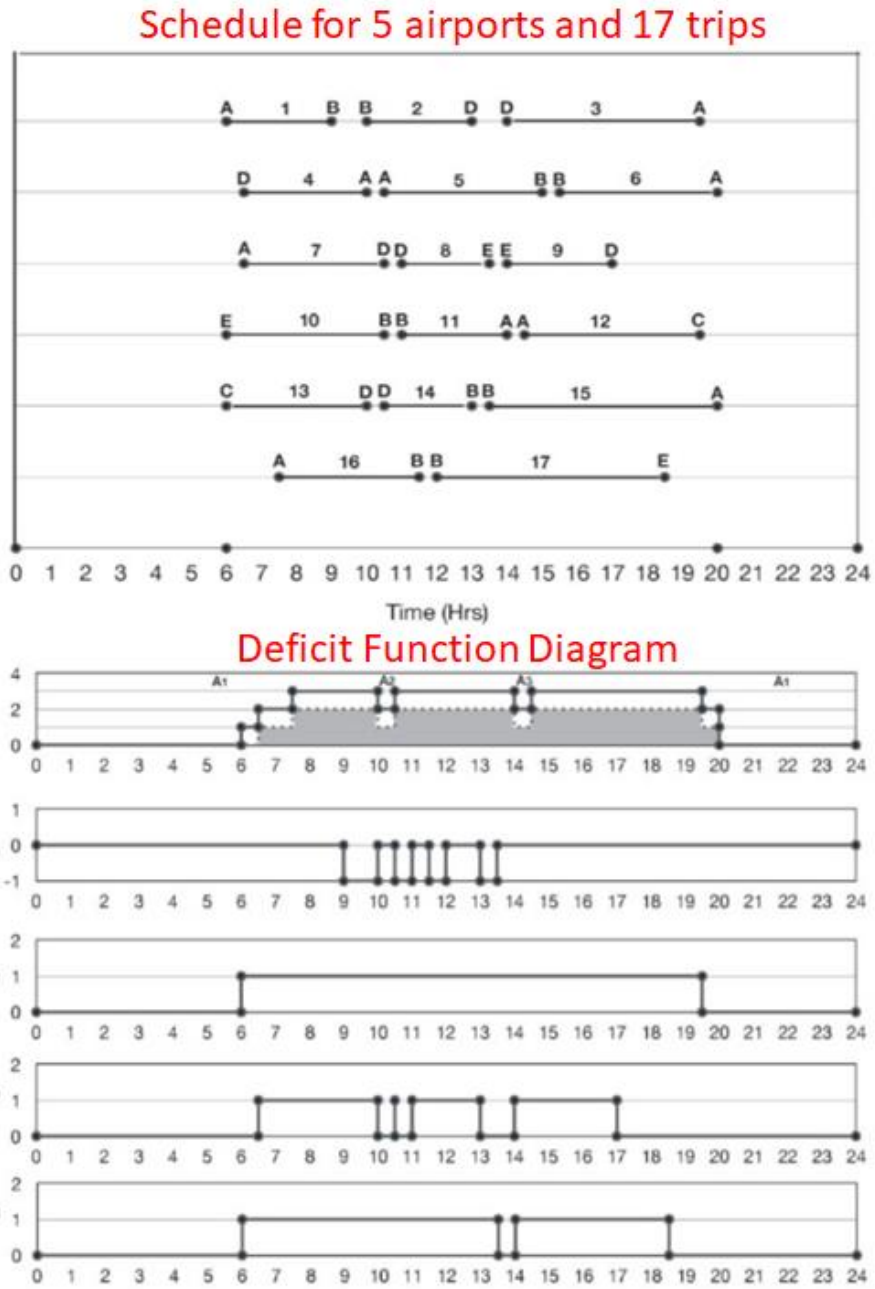
Assumption

1.The trip schedule are repeated on each period [T(k-1),TK] k=2,3

~~For this example,~~

max(DF(A))=3, max(DF(B))=0, max(DF(C))=1, max(DF(D))=1, max(DF(E))=1,

minimum number of flights required= 3+0+1+1+1 => 6

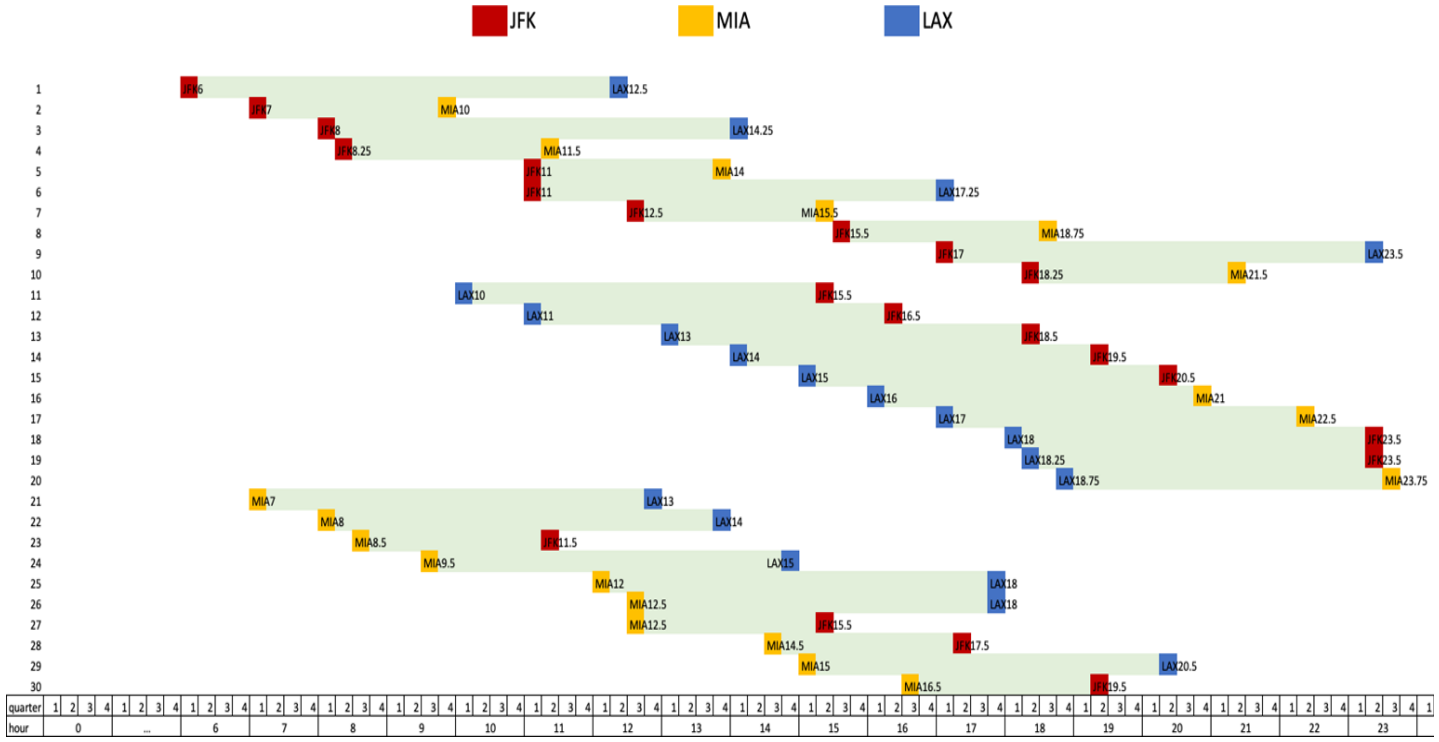


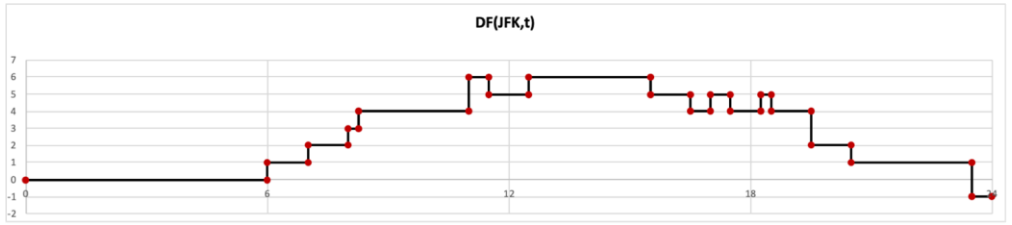
Flight Schedule & Fleet Size

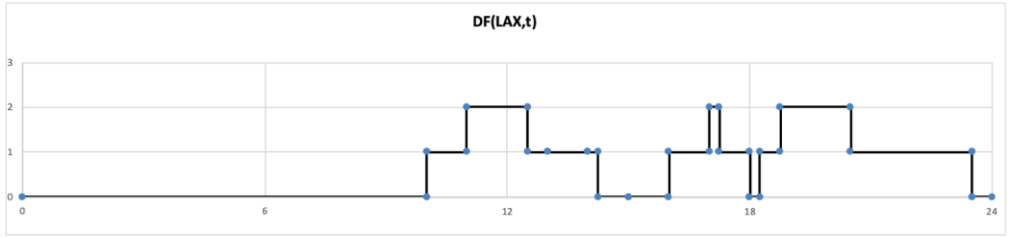
- We have a total of 30 possible flights between JFK, MIA and LAX
- Entire time period is divided into quarter hour intervals
- Our first objective is to find out the minimum number of aircraft (FS) required to serve this schedule.
- We make use of Deficit function to calculate this.
- FS = Maxima of DF(JFK) + Maxima of DF(MIA) + Maxima of DF(LAX)

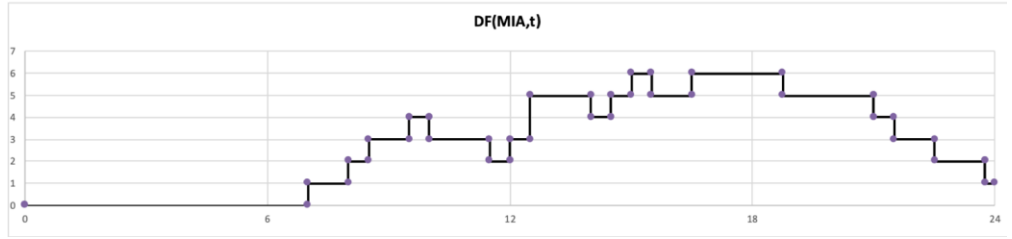
Deficit Function – For JFK, LAX and MIA

Reduced model: 3 airport, 30 flights

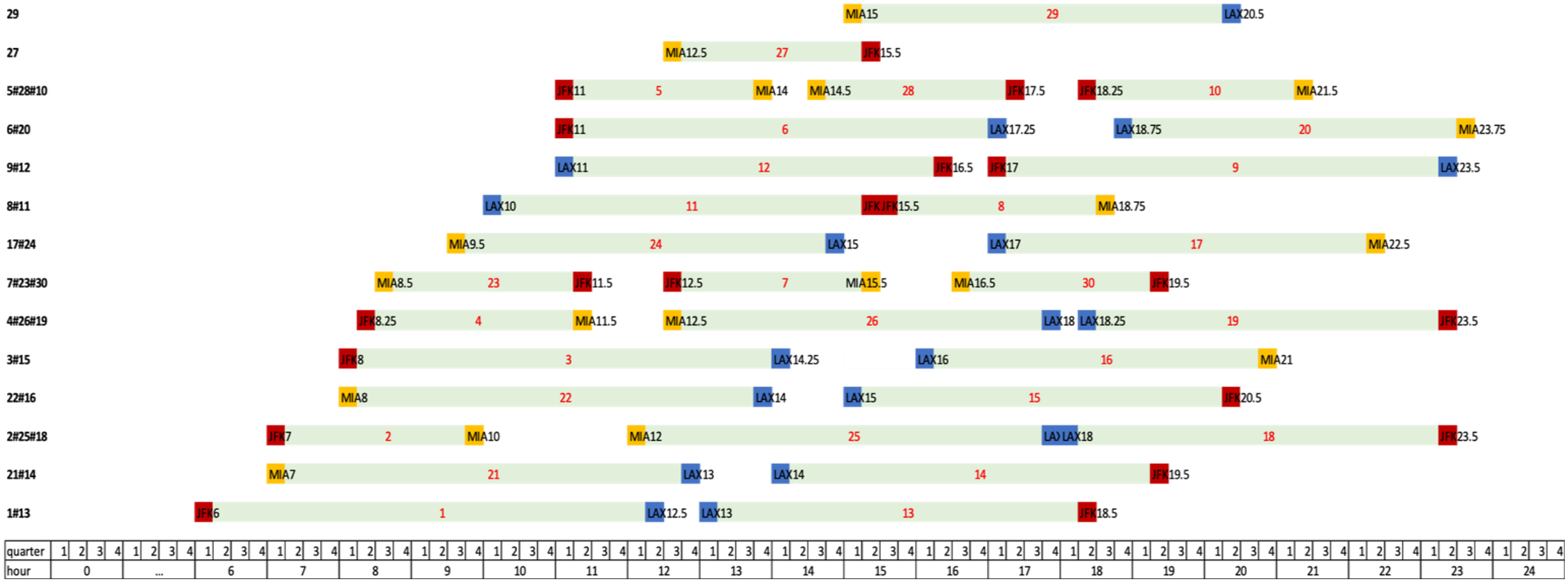








Flight Schedule Graph – For JFK, LAX, MIA

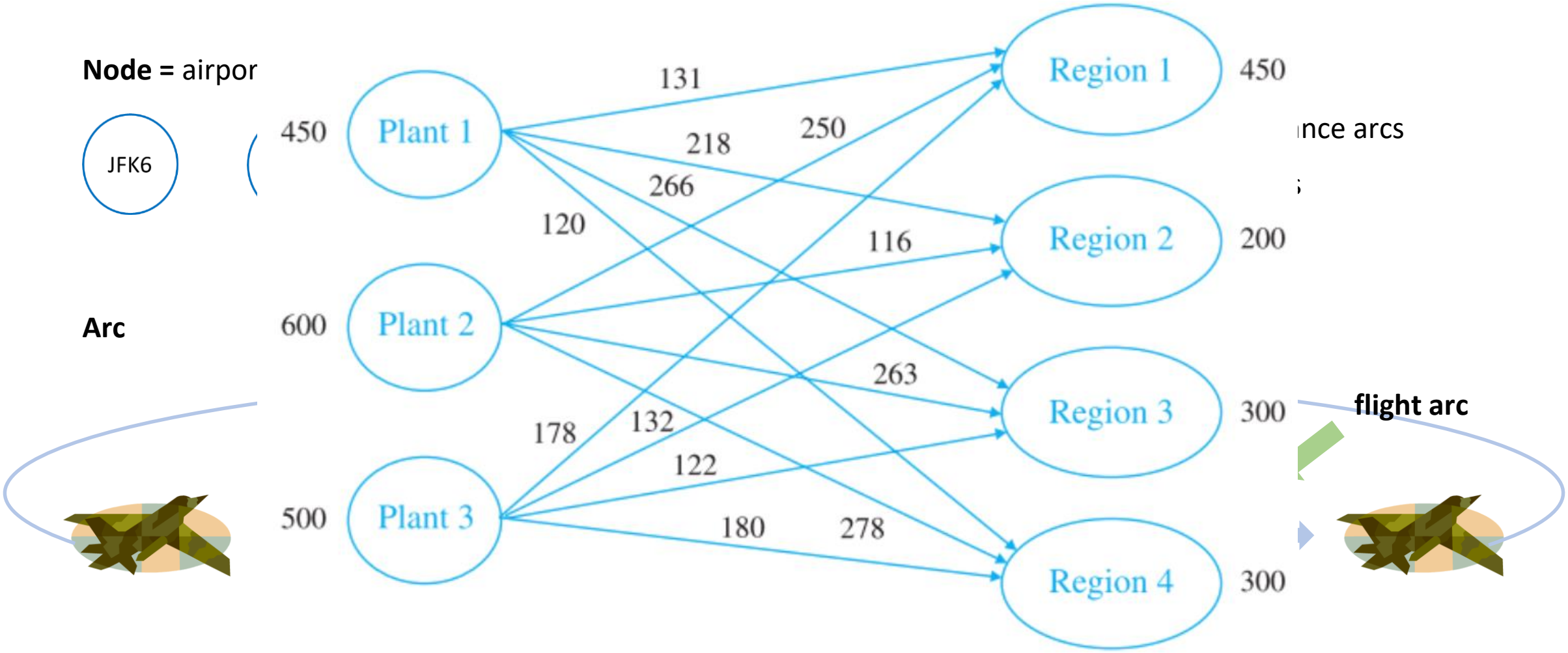


Transform flight schedule into a Network flow model

Node = airpor

JFK6

Arc



nce arcs

flight arc

Build model in Excel

What's our objective?

Remove uneconomic flights

Maximize profit or minimize cost

Flight arc

Flight origin	Flight destination	Revenue	Cost	Flight flow		Flow capacity
JFK11	LAX17	94	90	0	<=	1
JFK13	MIA16	98	87	1	<=	1
LAX10	JFK16	96	93	0	<=	1
LAX13	MIA19	97	83	1	<=	1
MIA8	LAX14	99	85	1	<=	1
MIA12	JFK15	95	89	1	<=	1

Ground arc

Ground origin	Ground destinatio	Ground cost	Ground flo
MIA0	MIA1	0	0
MIA1	MIA2	0	0
MIA2	MIA3	0	0
...			
LAX21	LAX22	0	0
LAX22	LAX23	0	0
LAX23	LAX0	0	0

Maintenance arc

Maintanance ori	Maintanance desti	Fixed cost	Maintanance flow	Constraints
LAX17	LAX5	5	1	4
LAX17	MIA5	10	0	
LAX17	JFK5	10	0	
MIA16	MIA4	5	1	
MIA16	LAX4	10	0	
MIA16	JFK4	10	0	
JFK16	JFK4	5	1	
JFK16	MIA4	10	0	
JFK16	LAX4	10	0	
MIA19	MIA7	5	1	
MIA19	JFK7	10	0	
MIA19	LAX7	10	0	
LAX14	LAX2	5	0	
LAX14	JFK2	10	0	
LAX14	MIA2	10	0	
JFK15	JFK3	5	0	
JFK15	LAX3	10	0	
JFK15	MIA3	10	0	

Flow balance

Node	Net flow		Required
MIA0	0	=	0
MIA1	=SUMIF(Flight_origin,J245,Flight_flow)+SUMIF(Ground_origin,J245,Ground_flow) +SUMIF(Maintanance_origin,J245,Maintanance_flow)		0
LAX22	-(SUMIF(Flight_destination,J245,Flight_flow)		0
LAX23	+SUMIF(Ground_destination,J245,Ground_flow)		0
	+SUMIF(Maintanance_destination,J245,Maintanance_flow))		

Objective

maximized profit	25

Conclusion

Challenges we met:

- Solver cannot take more than 200 adjustables
- It occurs sometimes that a loop is without flight arc

Future work

- Extend the period from 24 hours to a week
- Incorporate more inputs into the model

Thanks!