

Final Project Report

Flights Route Analysis

Link Prediction and Optimization

Group 26

M11015018 陳彥家

M11015080 湯傑堯

M11015064 何昆霖

Introduction

Air travel has become a very important mode of transportation in this century. Hundreds of thousands of routes have been planned in the sky, both for travel and for transporting cargo. In order to be more competitive among airlines, airline alliances have been created. Airline alliances are partnerships between or among airlines. Within these collaborations, airlines can share resources, pick up or extend partner routes and even offer the ability to earn and redeem miles through each others' rewards programs. There are three major airline alliances: SkyTeam, Star Alliance and Oneworld, Each have different partner airlines. We will target these three airline alliances and analyze how to optimize their airline alliance composition through social networking technologies in order to become more competitive and explain the reasons for this optimization.

Dataset

We use *OpenFlight* dataset, which includes 67663 routes, 14110 airport and 6162 airlines. In airport dataset, it will includes following data :

- Name
- City
- Country
- IATA
- ICAO
- Lat
- Long
- Alt
- Timezone
- DST
- Tz DTZ
- Type
- Source

In routes dataset, it will includes following data :

- Airline
- Airline ID
- S.Airport
- S.Airport ID
- D.Airport
- D.airport ID
- Codeshare
- Stops
- Equipment

Method

Airline Metric

- Number of edges in the airline

$$E(A)$$

- Change in effective diameter

$$\Delta g = g(G \cup A) - g(G)$$

- Change in the clustering coefficient

$$\Delta Cl = Cl(G \cup A) - Cl(A)$$

- Modularity

$$Q = Q(y)$$

- Change in the average closeness centrality

$$\Delta CC = CC(G \cup A) - CC(A)$$

- Change in the nodes

$$\Delta V = V(G \cup A) - V(G)$$

Cost Function

$$c(G, A) = \sum_{i=1}^5 c_i X_i$$

X_i is one of the 6 features in airline metric, and c_i are constants. We will find the top five most significant features of three air alliance. And use the difference of these features between each air alliance to analyze them.

Algorithm

Algorithm 1 Feature Weighting

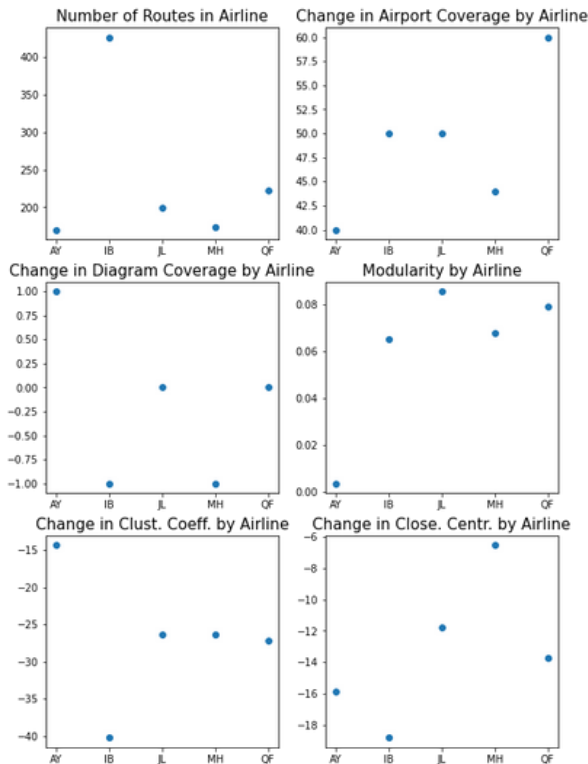
Input: $A = \{A_1, \dots, A_N\}$ a set of airline graph
 G an alliance graph

```
for  $i = 1$  to  $N$  do
    Remove  $A_i$  from  $G$ 
end for
 $F = N \times 6$  zero matrix
for  $i = 1$  to  $N$  do
    for  $j = 1$  to 6 do
         $F_{ij}$  = value of the  $j^{th}$  metric with current  $G$  and  $A_i$ 
    end for
     $G = G \cup A_i$ 
end for
for  $j = 1$  to 6 do
    Normalize the  $j^{th}$  column of  $F$  by its column standard deviation  $\sigma_j$ 
end for
Solve in CVX:
    Let  $c = (c_1, \dots, c_6)$ 
    Solve:  $F_C > 0$ 
    Subject to:  $\sum_{i=1}^6 c_i = 1$ 
```

Result

One World

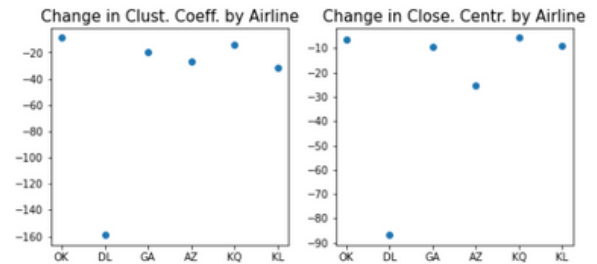
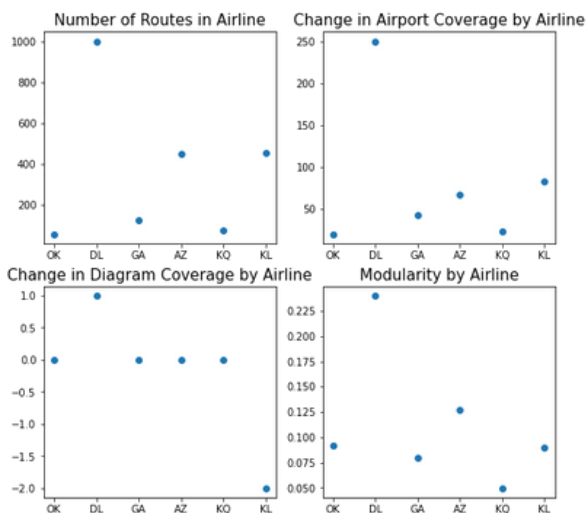
$$C_1, C_2, C_3, C_4, C_5 = (-0.001, -0.002, -0.133, 1.161, 0.005, -0.029)$$



According to our algorithm, 'BRA-Transportes Aereos' 'Flybe' 'Meridiana' 'Pinnacle Airlines' 'SATENA', these five airlines have similar features as One World but not join the One World air alliance yet.

Skyteam

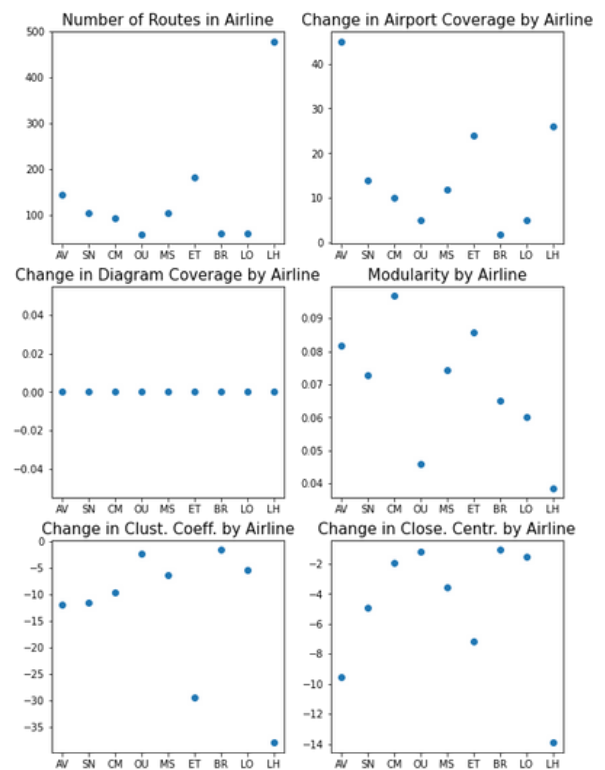
$$C_1, C_2, C_3, C_4, C_5 = (0.001, -0.003, 0.148, 0.842, -0.005, 0.018)$$



According to our algorithm, 'American Airlines' 'Ryanair' 'US Airways' 'United Airlines' 'China Southern Airlines', these five airlines have similar features as One World but not join the Skyteam air alliance yet.

Star Alliance

$$C_1, C_2, C_3, C_4, C_5 = (0.000, 0.000, 1.000, 0.000, -0.000, 0.000)$$



According to our algorithm, 'Air Berlin' 'Big Sky Airlines' 'Cielos Airlines' 'Azul' 'Ryanair', these five airlines have similar features as One World but not join the Star Alliance air alliance yet.

Conclusion

Most of the smaller airline alliances have similar feature values, probably because the smaller market alliances have specific customer attraction methods, given the size of their capitalization. For example, they sell tickets at low prices, have frequent fixed regional routes, etc.

At least half of the airlines in each airline alliance do not meet the best interests of the algorithm. We believe that this is because determining the best interests of an airline alliance based on routes alone is only a secondary factor, and that in reality, routes may be more politically driven, with flexibility to change at the will of national leaders, resulting in less accuracy in the algorithm's calculations. The algorithm we use only takes into account the benefits of combining similar routes for airline alliances.

Reference

- Open Flight Dataset
(<https://openflights.org/data.html>)
- What Is An Airline Alliance? – Forbes Advisor
(<https://www.forbes.com/advisor/travel-rewards/what-is-an-airline-alliance/>)
- The Route Analysis Based On Flight Plan
(<https://iopscience.iop.org/article/10.1088/1757-899X/114/1/012147/pdf>)
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(<https://www.routesonline.com/news/tagged/7211/route-analysis/>)