

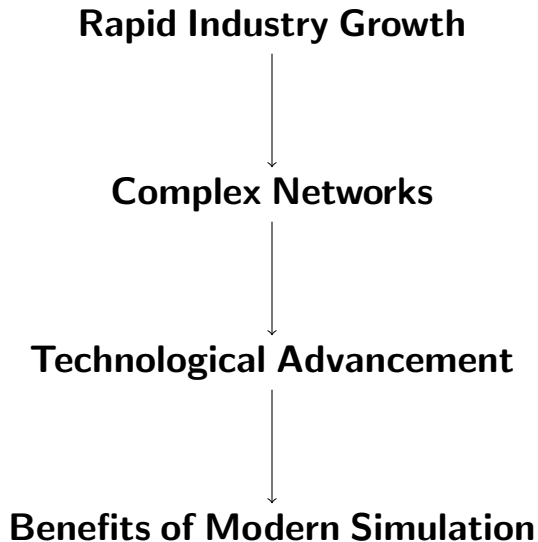
# The Optimization of Flight Routes: Enhancing Connectivity and Reducing Cost

Leveraging Optimization Models for Profitability!

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**What variables can airlines manipulate to optimize flight routes across the continental United States to enhance efficiency and maximize profitability?**

# Flight Route Optimization Problem vs. Standard Optimization

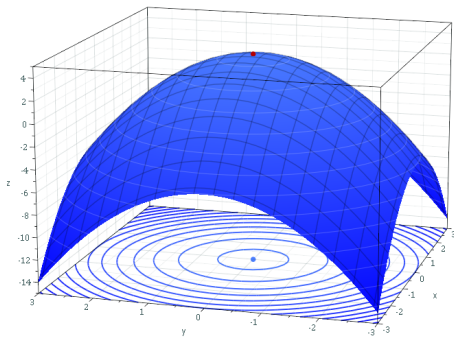
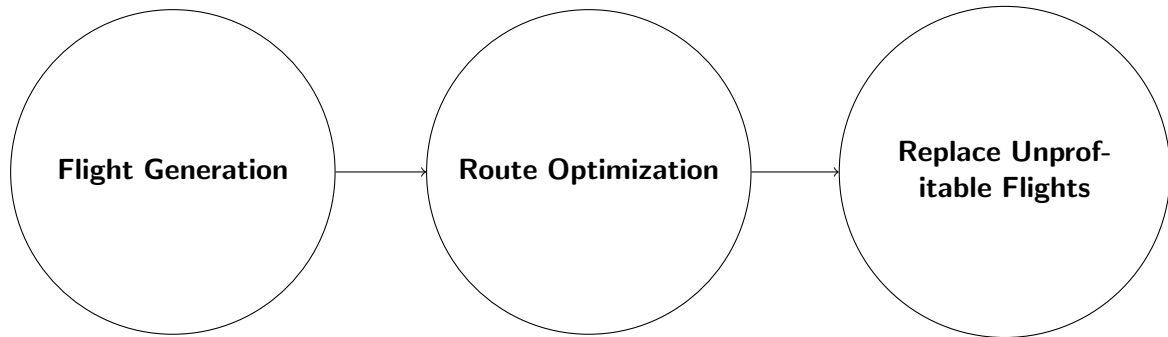


Figure: Example of a Standard Optimized Plot

- **Discrete Decision Making:**
  - All-or-Nothing Routes
  - Incremental Adjustments
- **Strict Operational Constraints:**
  - Fixed vs Dynamic Variables
  - Levels of Flexibility on Constraints
- **Data Integration:**
  - Simulation vs Functions
  - Balanced vs Feasible Solutions

# Strategy of the Three Algorithms



# Flight Generation

```
flight_number: 1
origin: LAX
destination: PHX
passengers: 49
flight_path: LAX, None, None, PHX
n_stops: 0
__FLIGHT_RECORD_SEPARATOR__
flight_number: 2
origin: LAX
destination: DEN
passengers: 64
flight_path: LAX, SEA, None, DEN
n_stops: 1
__FLIGHT_RECORD_SEPARATOR__
flight_number: 3
origin: LAX
destination: DFW
passengers: 57
flight_path: LAX, MIA, MCI, DFW
n_stops: 2
__FLIGHT_RECORD_SEPARATOR__
```

## Overview:

- Generate all possible flights from predefined airports
- Base File Prior for Modification

## Details:

- Produces flights from one airport (origin) to all other listed airports
- Random number of stops and amount of passengers
- IATA codes with an associated latitude and longitude coordinate.

Figure: Output within generated\_flights\_new.txt

# Haversine Formula

## Description:

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1) \cdot \cos(\phi_2) \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$$

$$c = 2 \cdot \operatorname{atan2}\left(\sqrt{a}, \sqrt{1-a}\right)$$

$$d = R \cdot c$$

where  $\phi_1$  and  $\phi_2$  are the latitudes,  $\Delta\phi$  and  $\Delta\lambda$  are the differences in latitudes and longitudes, and  $R$  is the Earth's radius.

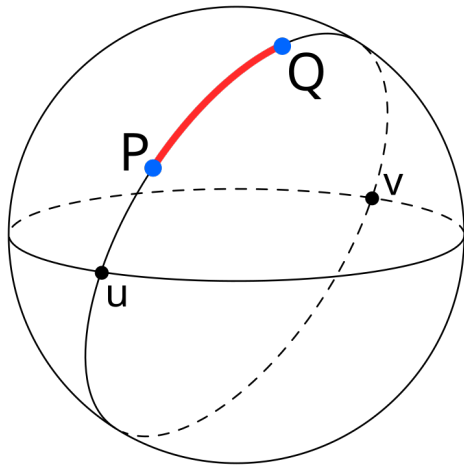


Figure: Haversine Formula Visualization

# Route Optimization

```
REORDER: 1 310.07875842955656 ['LAX', 'PHX'] 310.07875842955656
ORIG: ['LAX', 'SEA', 'DEN']
OPTIMAL: ['LAX', 'DEN', 'SEA']
REORDER: 2 1720.3251381031996 ['LAX', 'DEN', 'SEA'] 1607.0480523143033
ORIG: ['LAX', 'MIA', 'MCI', 'DFW']
OPTIMAL: ['LAX', 'MCI', 'DFW', 'MIA']
REORDER: 3 3522.954323132324 ['LAX', 'MCI', 'DFW', 'MIA'] 2551.50200846393
REORDER: 4 2135.772293104575 ['LAX', 'JFK'] 2135.772293104575
REORDER: 5 2029.5732616512466 ['LAX', 'MIA'] 2029.5732616512466
```

Figure: Trial Error of the sorting algorithm of three flight routes

## Overview:

- Utilizes Airport IATA Codes as coordinate pair.
- Sorts the distance using the Haversine formula

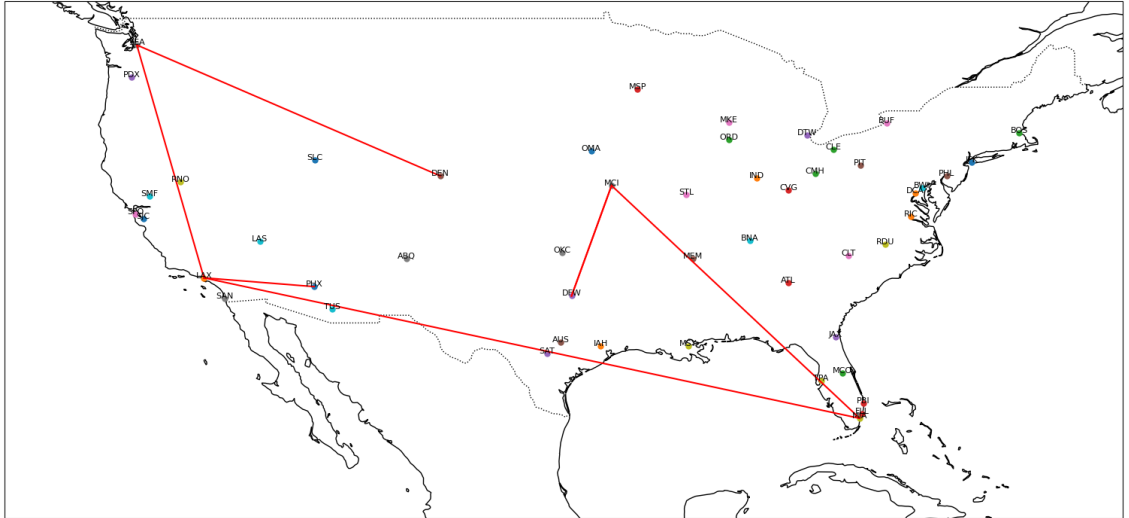
## Details:

- Explains the importance and impact of sorting distances
- Enhances route efficiency by minimizing travel distance



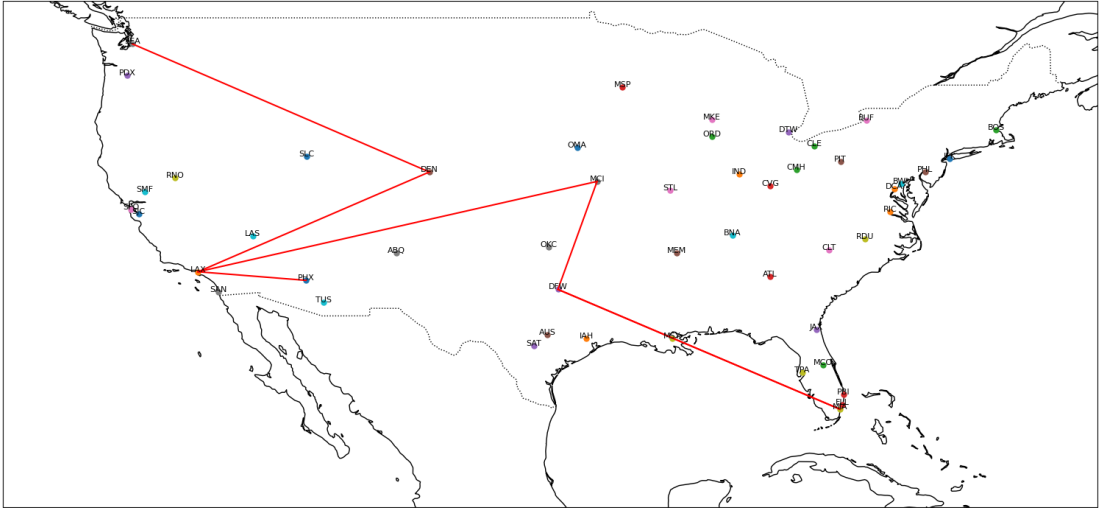
# Visualization of the Sorting Algorithm: Unsorted Flights

Flight 3: LAX to MIA to MCI to DFW - Frame 8



# Visualization of Sorting Algorithm: Sorted Flights

Flight 3: LAX to MCI to DFW to MIA - Frame 8



# Replace Unprofitable Flights

```
REPLACEMENT: Flight 27: DEN, MCI, DFW, MIA -> Flight 76: ABQ, PHX, DFW, MIA
               $ -12471.263962290022    ->    $ 47914.60656796576
REPLACEMENT: Flight 28: DFW, MIA, LAX, SEA -> Flight 46: MIA, DFW, LAX, SEA
               $ -25666.983748255916    ->    $ 26609.28941328331
```

Figure: Bad Profitable Flight to Profitable Flight (Net Profits Below Flight Routes).

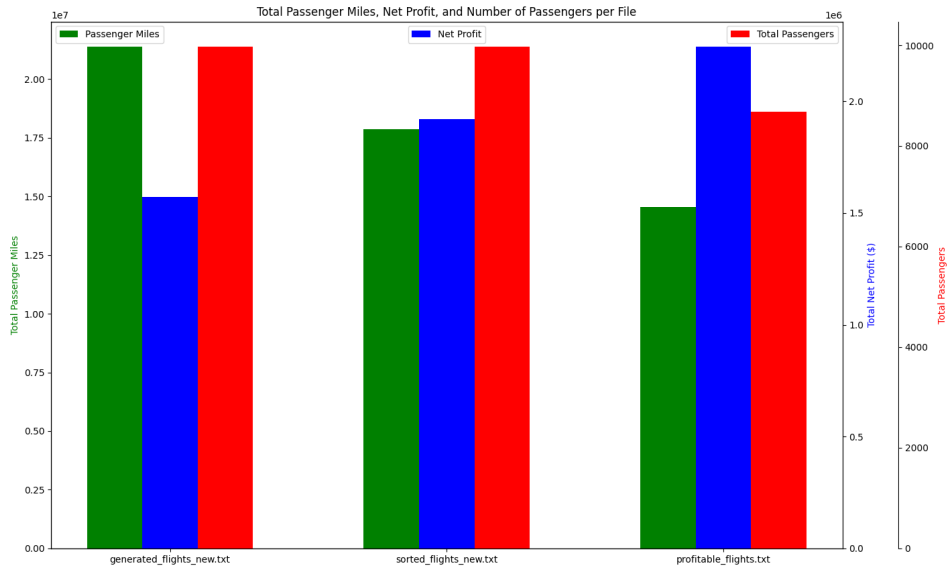
## Overview:

- Remove Unprofitable Routes
- Replace with Nearby Profitable Flights

## Details:

- Matched Closest Profitable Paths
- Adhered to Passenger Capacity Limits

# Results



# Future Work

- Consider passenger boarding and deboarding at intermediate stops.
- Incorporate dynamic ticket pricing based on flight distance.
- Adapt to real-life flight routes with only an origin and a destination, with no intermediate stops.
- Modify Total Passenger Miles also to reflect its contribution to income.
- Integrate weather conditions and no-fly zones into the data analysis.