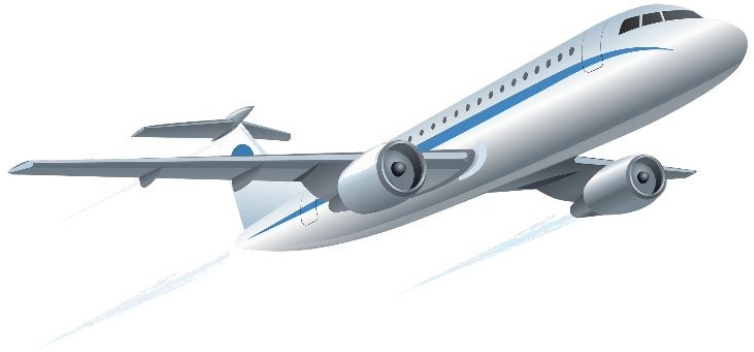
E6893 Big Data Analytics:

Flight Route

Final Presentation



Guy Farkash

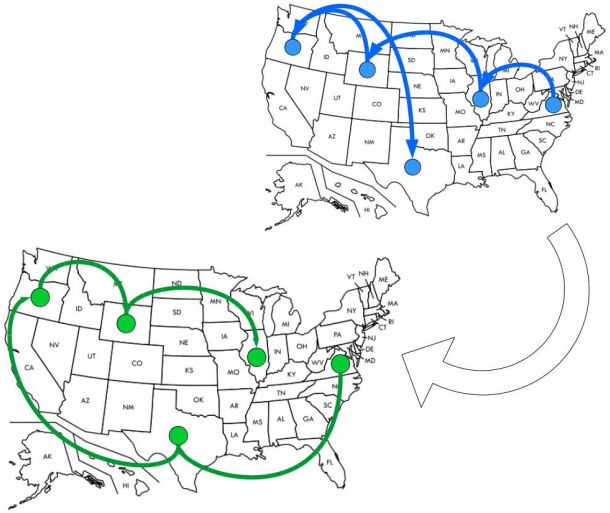
Motivation

The number of business flights in the US was
488M in 2016, with average of **1.3M** each day
(By the Global Business Travel Association)

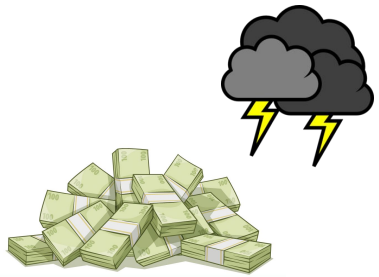
~6% of the flights, delayed → **bad weather**
(By the Bureau Of Transportation Statistics)

Avoid bad weather flights → **Save time**
Saving **5 min** each trip → Saves **10 months** of work each day
(1.3M x 0.06 x 5) / (60 x 24 x 7 x 4) ~ 9.7 (for all trips combined)

For **multi-destination trips**
Can choose a cheaper route → **Save money**



Goal



Best flight route:

Minimum predicted weather delay

Break even by choosing minimum cost

Input:

[Origin City, City 1, City 2, …, City N]

[City 1 days, City 2 days, …, City N days]

Starting Date

Return Date

Output:

Origin City→City 3	[Starting Date, Delay, Fare]
City 3→City 2	[Date 1, Delay, Fare]
…..	
City N→City 5	[Date K, Delay, Fare]
City 5→Origin City	[Return Date, Delay, Fare]

The Process

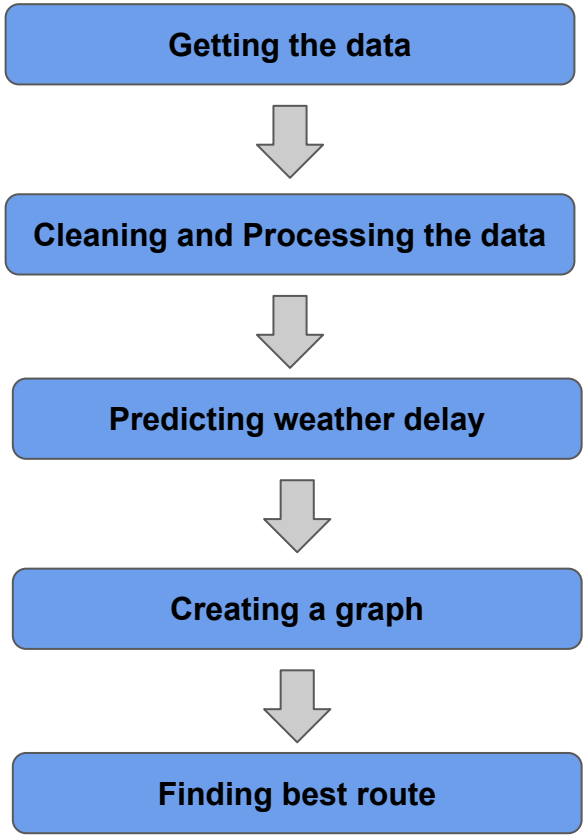
1. **Getting the data**
   Flight reports with weather delay for years 2012 – 2017
   Flight fares for 2017

2. **Cleaning and Processing the data**
   Fixing cities names
   Creating cities IDs
   Creating the database

3. **Predicting weather delay**
   Calculating the delay for each flight in each date

4. **Creating a graph**
   Building the vertices and nodes files

5. **Finding best route**
   Using the graph database



Getting The Data

On-Time Performance database
from Bureau of Transportation Statistics

Years 2012 - 2017 **3.2GB** of data

Consumer Airfare report
from US department of transportation

Flights average fare for every quarter of 2017

Delays Data

	Field Name	Description
1	Year	Year
2	Month	Month
3	DayOfMonth	Day
4	OriginCityName	Origin City
5	DestCityName	Destination City
6	WeatherDelay	Weather Delay, in Minutes.

Fares Data

	Field Name	Description
1	city1	Origin city
2	city2	Destination city
3	fare	Average fare of all flights and airlines

Cleaning and Processing The Data

Removing records with no delay information

Renaming city names to match for all records

Removing $ signs from the fare column

Removing unnecessary columns

Adding unique city ID number

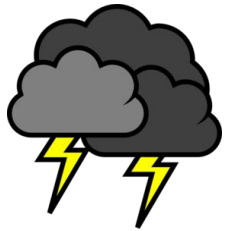
Adding fare

Combining all the the files to one database

Processed Data

	Field Name	Description
1	YEAR	The year → [2012, 2014, 2015, 2016, 2017]
2	MONTH	The month → integer number [1, 2, …, 11, 12]
3	DAY_OF_MONTH	The day of month → integer number [1, 2, …, 30, 31]
4	ORIGIN_CITY_ID	Origin city name → string
5	ORIGIN_CITY_NAME	Origin city ID → unique integer number
6	DEST_CITY_ID	Destination city name → string
7	DEST_CITY_NAME	Destination city ID → unique integer number
8	WEATHER_DELAY	Weather Delay, in Minutes → integer number
9	FARE	Fare in Dollars → floating point number

Predicting Weather Delay



Several delay records for each flight:

YEAR	MONTH	DAY	ORIGIN CITY NAME	DEST CITY NAME	WEATHER DELAY
2012	1	22	New York, NY	Boston, MA	6
2014	1	22	New York, NY	Boston, MA	25
2014	1	22	New York, NY	Boston, MA	75
2016	1	22	New York, NY	Boston, MA	59

Number of records can be 1 - 45

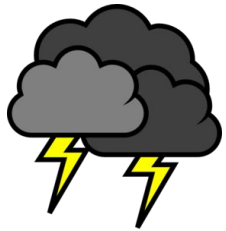
Using ML predictions:

1. Naive Bayes
2. Random Forest
3. Multilayer Perceptron
4. One-vs-Rest
5. Decision Tree

The information is too scarce to train a good model

All the ML models produced accuracy < 30%

Predicting Weather Delay



Creating a predictor of the average delay with confident value

Combining records for each flight to calculate average delay:

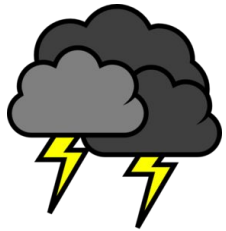
MONTH	DAY	ORIGIN CITY NAME	DEST CITY NAME	**AVG WEATHER DELAY**	**RECORDS**
1	22	New York, NY	Boston, MA	**41.25**	**4**

Adding records from +-5 days of current date: (increase the confidence in the result)

MONTH	DAY	ORIGIN CITY NAME	DEST CITY NAME	**AVG WEATHER DELAY**	**RECORDS**
1	22	New York, NY	Boston, MA	**40.13**	**31**

Assuming that the weather is similar in a 10 days window

Predicting Weather Delay



Examples:

Low Confidence:

MONTH	DAY	ORIGIN CITY NAME	DEST CITY NAME	**AVG WEATHER DELAY**	**RECORDS**
1	5	New York, NY	Dallas, TX	**16**	**1**

High Confidence:

MONTH	DAY	ORIGIN CITY NAME	DEST CITY NAME	**AVG WEATHER DELAY**	**RECORDS**
1	6	New York, NY	Los Angeles, CA	**63**	**79**

Testing The Predictions

P = **Predicted** Delay

A = **Actual** Delay

"False Alarm" prediction $P > A$

"Miss Detect" prediction $P < A$

Predictor error [min] $Avg\ Err = \frac{\sum A - P}{N}$

A Good predictor

Low **"**Miss Detect" and "False Alarm" error rate

"Miss Detect" error rate < "False Alarm" error rate

Splitting the data

Training Data (2012 - 2016)
Testing Data (2017)

Using the training data to build the database
Using the testing data to test the predictor

"Miss Detect" average error = **~9.5 [min]**

"False Alarm" average error = **~20 [min]**

Total average delay is 46 [min]

"Miss Detect" accuracy = ~79%
"False Alarm" accuracy = ~56%

Creating a Graph

Origin Vertices File Contains:
- Origin cities name
- Origin cities ID

Destination Vertices File Contains:
- Destination cities name
- Destination cities ID

Nodes File Contains:
- Year, Month, Day
- Origin cities name
- Origin cities ID
- Destination cities name
- Destination cities ID
- Predicted weather delay
- Number of records
- Fares

Loading the graph to GrapheneDB

Origin Vertices

	Field Name	Description
1	ORIGIN_CITY_NAME	Origin city name → string
2	ORIGIN_CITY_ID	Origin city ID → unique integer number

Destination Vertices

	Field Name	Description
1	DEST_CITY_NAME	Destination city name → string
2	DEST_CITY_ID	Destination city ID → unique integer number

Nodes

	Field Name	Description
1	YEAR	The year → [2012, 2014, 2015, 2016, 2017]
2	MONTH	The month → integer number [1, 2, …, 11, 12]
3	DAY_OF_MONTH	The day of month → integer number [1, 2, …, 30, 31]
4	ORIGIN_CITY_ID	Origin city name → string
5	ORIGIN_CITY_NAME	Origin city ID → unique integer number
6	DEST_CITY_ID	Destination city name → string
7	DEST_CITY_NAME	Destination city ID → unique integer number
8	AVG_WEATHER_DELAY	Weather Delay, in Minutes → integer number
8	DELAY_RECORDS	Number of records → integer number
9	FARE	Fare in Dollars → floating point number

Finding The Best Route

Best Route Algorithm:

1) Find all routes possibilities

   All cities - dates combinations

2) Get delay and fare data for each route

3) Choose the best route with:
   a) Less delay
   b) High confidence (large records number)
   c) Less fare

Start...Date1...Date2...Date3……..**End**
Start……..Date1...Date2…..Date3....**End**
Start....Date1……..Date2...Date3……..**End**
Start....Date1....Date2……..Date3……..**End**

Start	Date 1	Date 2	Date 3	End
Ori	City 1	City 2	City 3	Ori
Ori	City 1	City 3	City 2	Ori
Ori	City 2	City 1	City 3	Ori
Ori	City 2	City 3	City 1	Ori
Ori	City 3	City 1	City 2	Ori
Ori	City 3	City 2	City 1	Ori

GUI

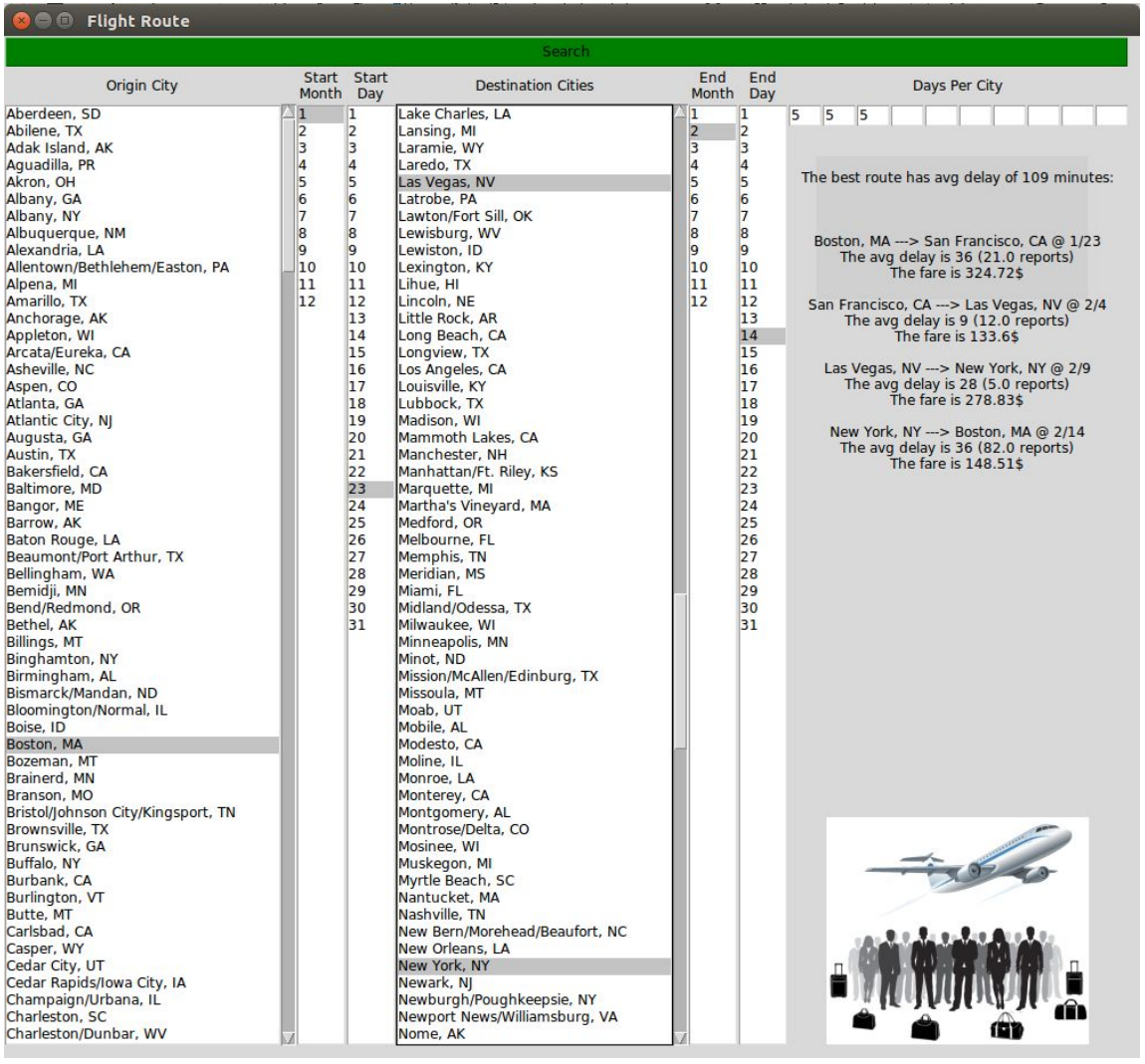
A convenient user interface makes it easy to use

Origin city = **Boston**

Destination 1 = **New York**

Destination 2 = **Las Vegas**

Destination 3 = **San Francisco**



Example Results

Input: Origin city = **Boston**

Destination 1 = **New York** (**5 days**)
Destination 2 = **Las Vegas** (**5 days**)
Destination 3 = **San Francisco** (**5 days**)

Starting date: **Jan. 23th**
Ending date: **Feb. 14th**

Output:

The best route has avg **delay of 109** minutes:

Boston, MA ---> **San Francisco, CA** @ 1/23
The avg delay is 36 (21.0 reports)
The fare is 324.72 $

San Francisco, CA ---> **Las Vegas, NV** @ 2/4
The avg delay is 9 (12.0 reports)
The fare is 133.67 $

Las Vegas, NV ---> **New York, NY** @ 2/9
The avg delay is 28 (5.0 reports)
The fare is 278.83 $

New York, NY ---> **Boston, MA** @ 2/14
The avg delay is 36 (82.0 reports)
The fare is 148.51 $

Example Results

Best Route <u>Predicted</u> Delay: **109** minutes

Boston, MA ---> **San Francisco, CA** @ 1/23
The avg delay is 36 (21.0 reports)

San Francisco, CA ---> **Las Vegas, NV** @ 2/4
The avg delay is 9 (12.0 reports)

Las Vegas, NV ---> **New York, NY** @ 2/9
The avg delay is 28 (5.0 reports)

New York, NY ---> **Boston, MA** @ 2/14
The avg delay is 36 (82.0 reports)

<u>Real World</u> Delay: **99** minutes

Boston, MA ---> **San Francisco, CA** @ 1/23
The delay was 23

San Francisco, CA ---> **Las Vegas, NV** @ 2/4
The delay was 0

Las Vegas, NV ---> **New York, NY** @ 2/9
The delay was 0

New York, NY ---> **Boston, MA** @ 2/14
The avg delay is 76

Other Route Predicted Delay: **208** minutes

Boston, MA ---> **New York, NY** ---> **Las Vegas, NV** ---> **San Francisco, CA** ---> **Boston, MA** (different order)

Thank You