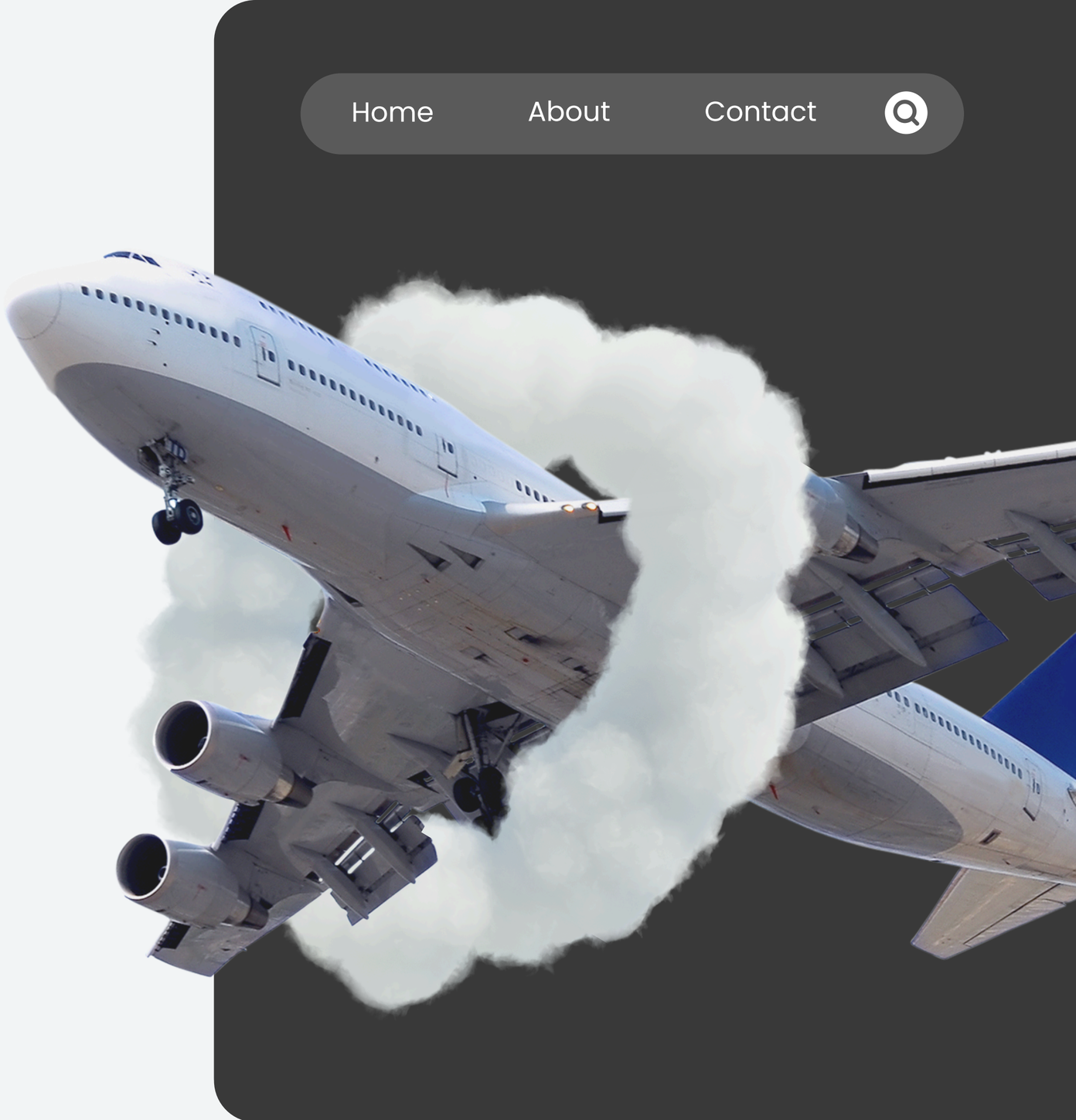
FLIGHT ROUTE ADVISOR

Group 2

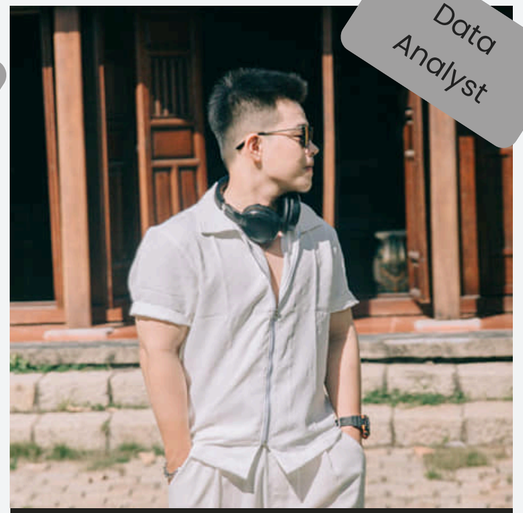
CS5433.Q12.CTTT

Social Network Analysis



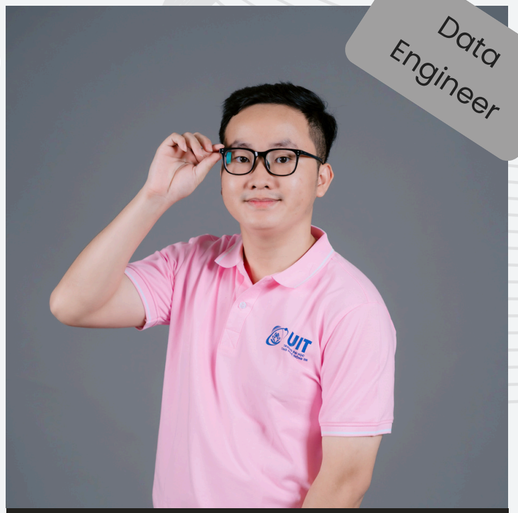
OUR TEAM

Phạm Duy Tuấn
22521609



Hồ Tấn Lộc
22520786

Ngô Thành Trung
22521561



Tăng Kim Sơn
22521258

Overview

PROBLEM BACKGROUND

Global aviation forms a large-scale, complex network

Thousands of airports and tens of thousands of flight routes

Travelers and airlines face challenges

PROBLEM STATEMENT

How to efficiently find routes between any two airports worldwide?

Statement 1

Which airports are critical hubs in the global flight network?

Statement 2

What happens to the network if a major hub is disrupted or removed?

Statement 3

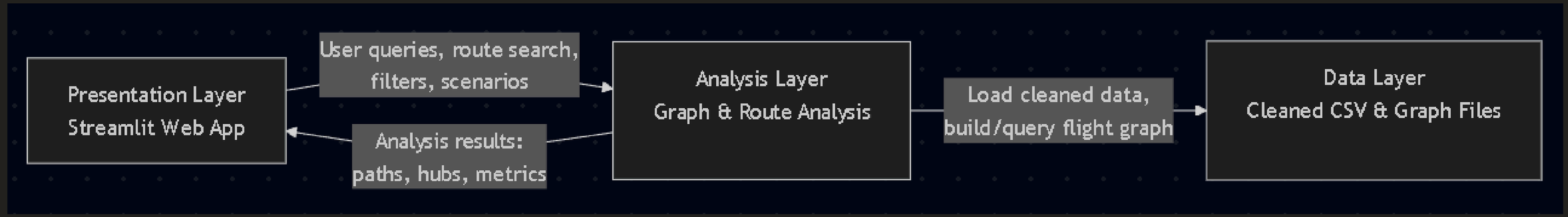
SYSTEM OVERVIEW

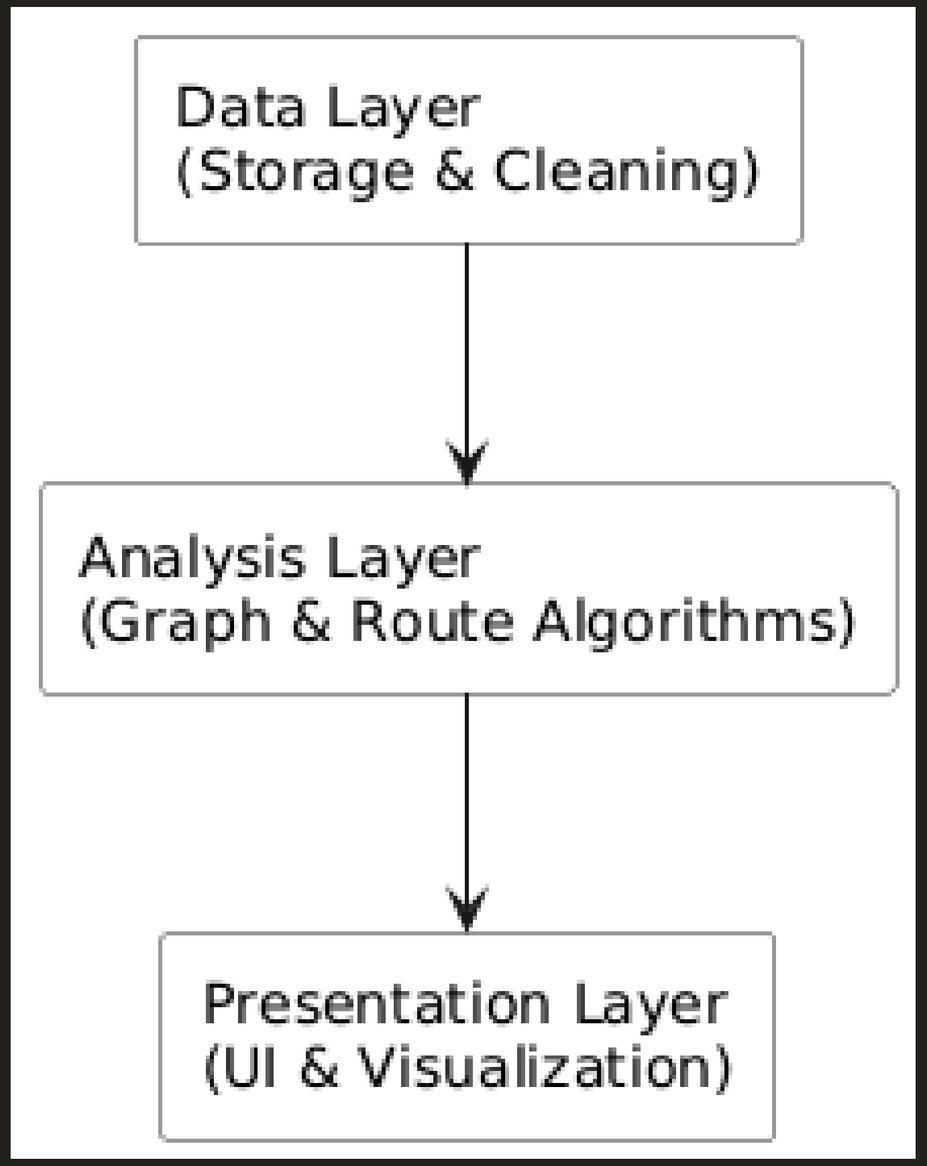
System Overview

- Interactive system for global flight network analysis
- Built on graph-based modeling

Three main layers:

- Data Layer
- Analysis Layer
- Presentation Layer





ARCHITECTURE TYPE

Clear Separation

- Data: storage & cleaning
- Analysis: algorithms
- Presentation: UI & charts

Independent Testing

- Test algorithms without UI
- Mock analysis for UI testing

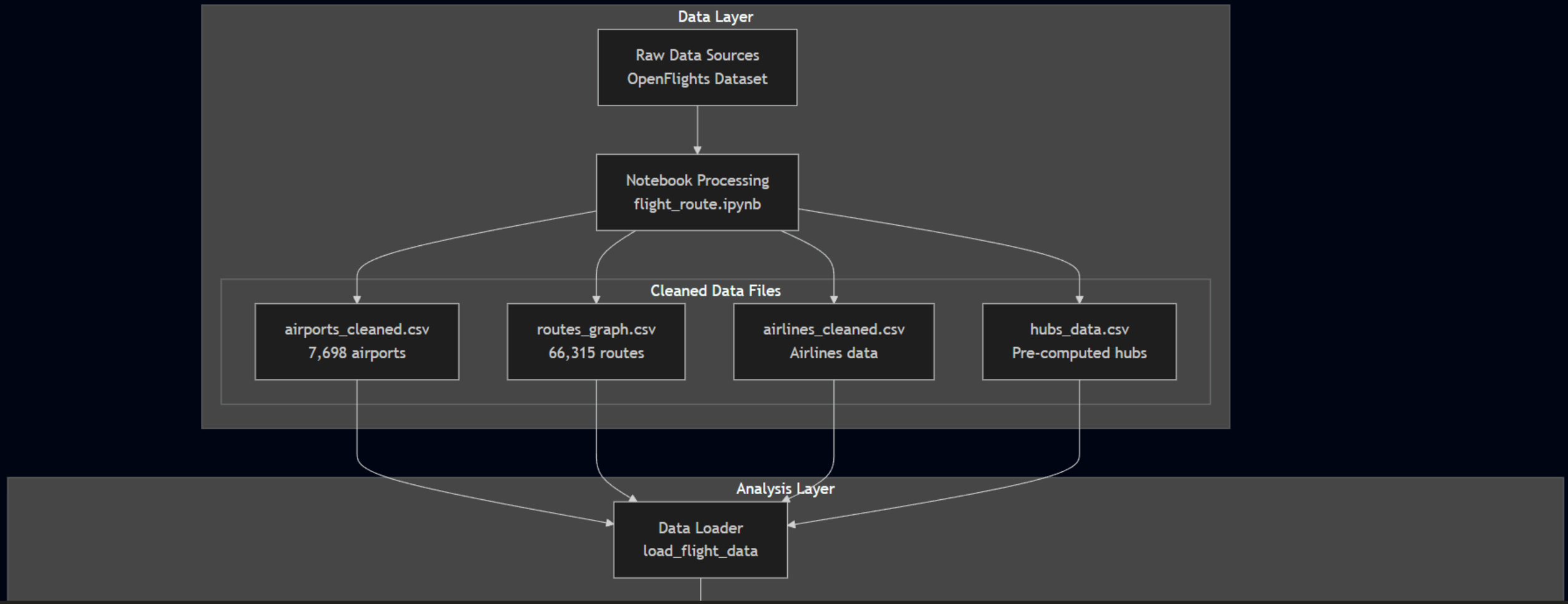
Flexible & Extensible

- Swap UI without touching logic
- Change data source easily

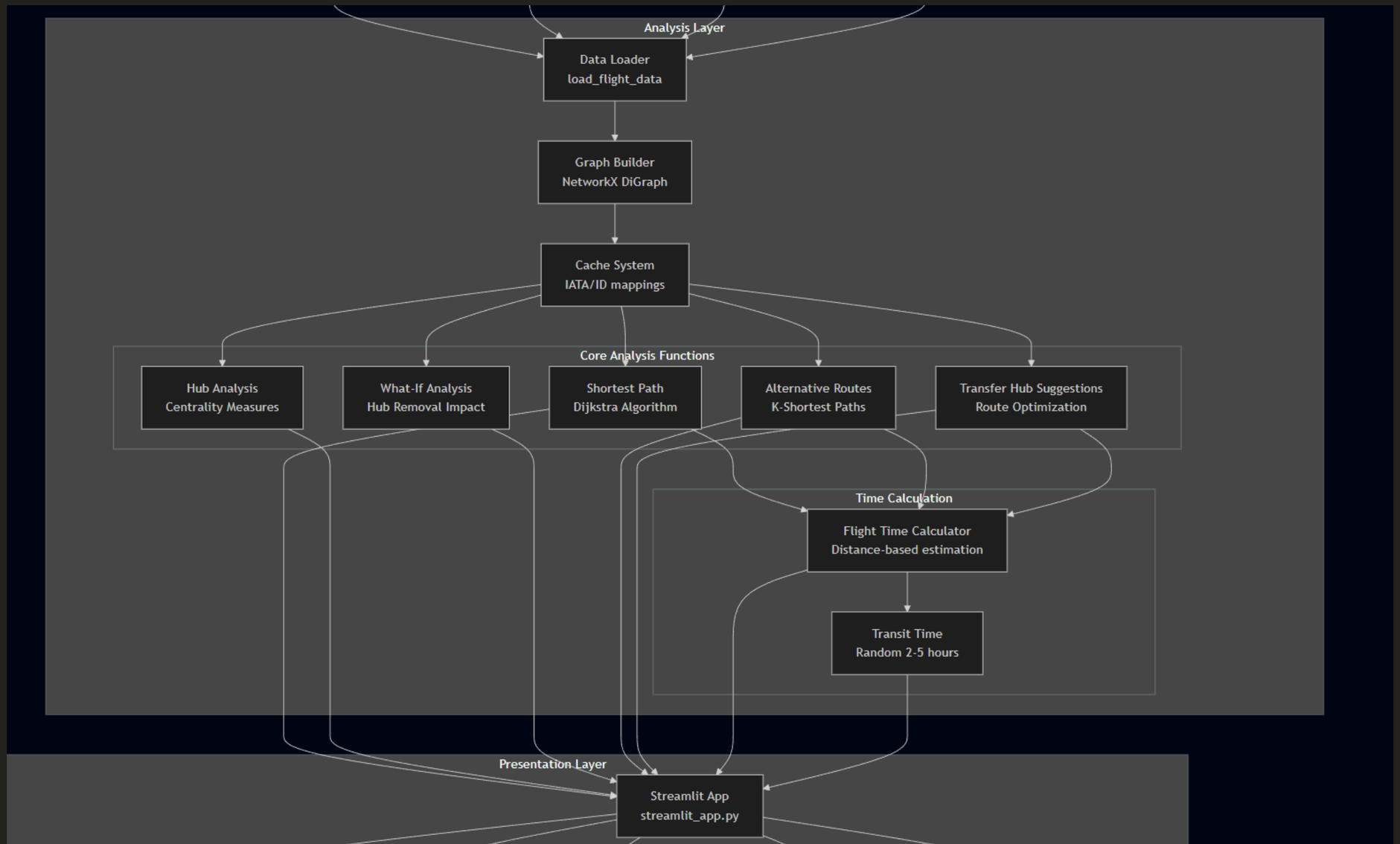
Academic & Analytical Fit

- Reusable analysis layer
- Easy to explain & document

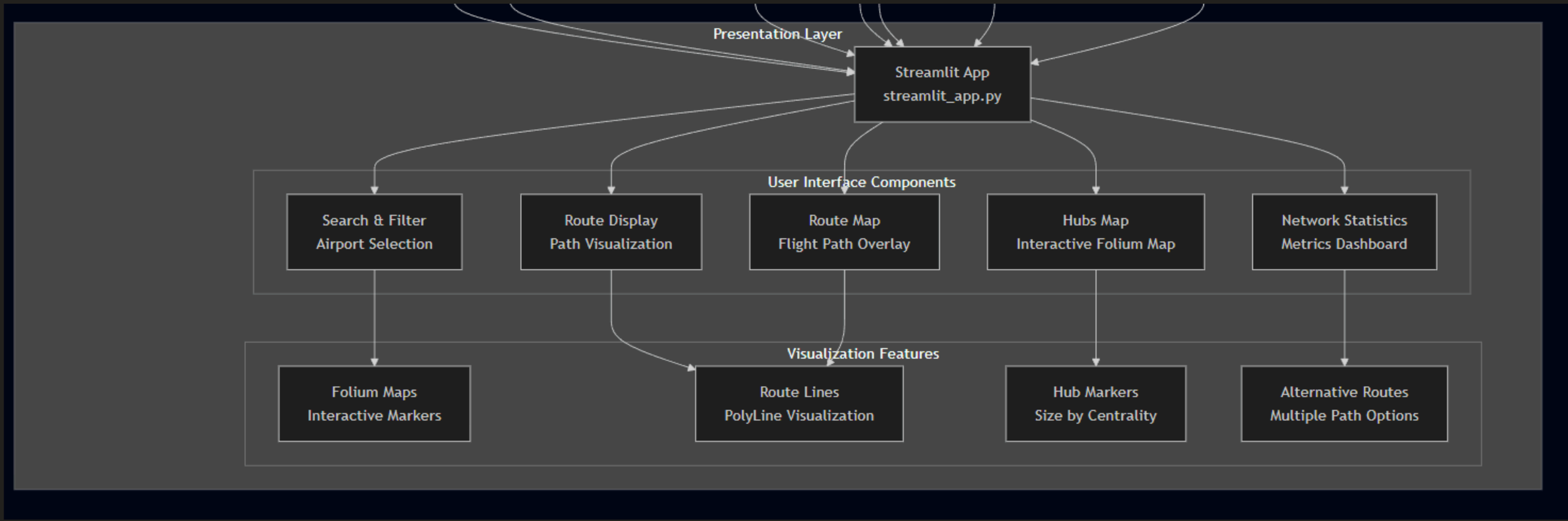
DATA LAYER DESIGN



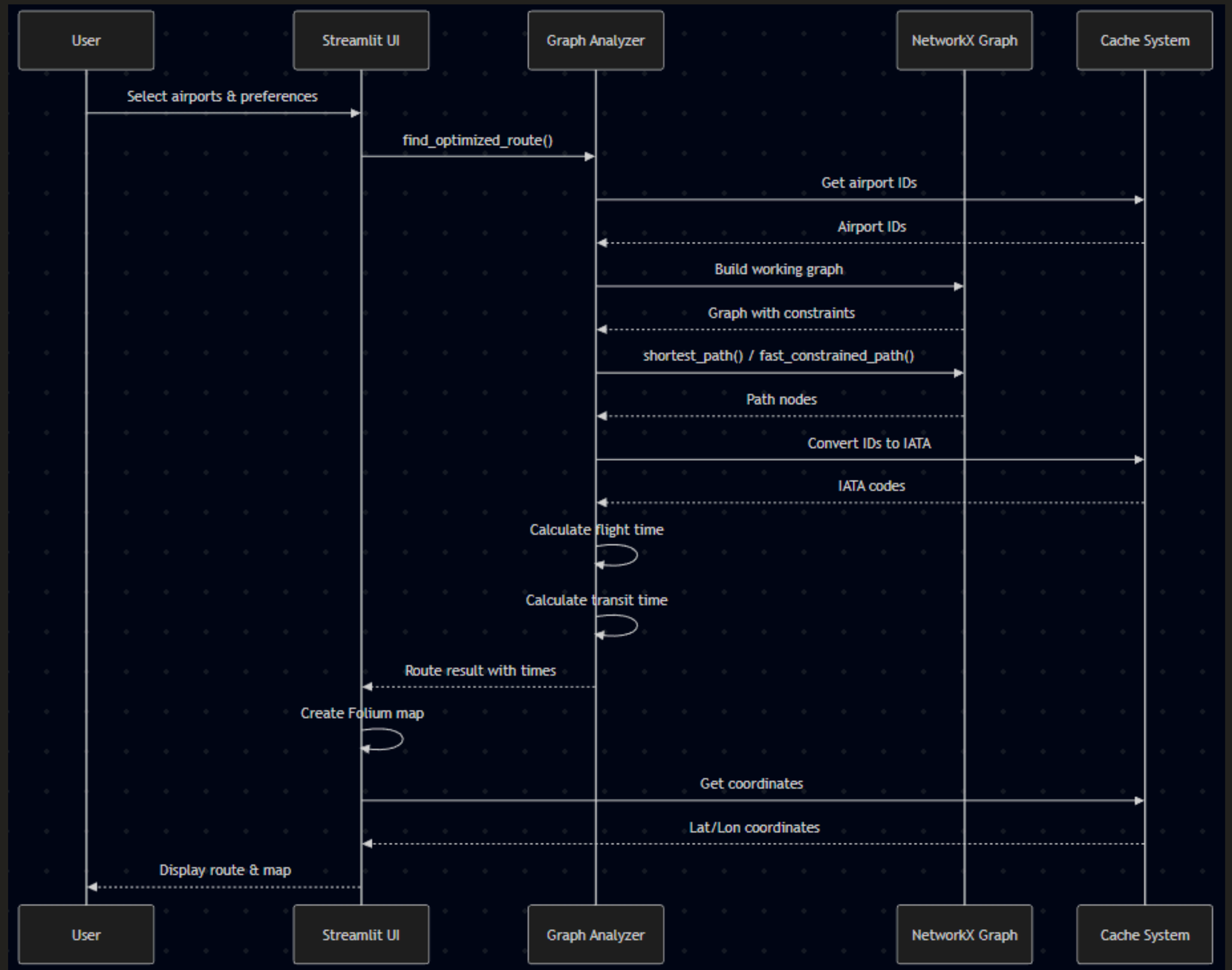
ANALYSIS LAYER DESIGN



PRESENTATION LAYER DESIGN



DATA FLOW


User
Streamlit UI
Graph Analyzer
NetworkX Graph
Cache System
Select airports & preferences
find_optimized_route()
Get airport IDs
Airport IDs
Build working graph
Graph with constraints
shortest_path() / fast_constrained_path()
Path nodes
Convert IDs to IATA
IATA codes
Calculate flight time
Calculate transit time
Route result with times
Create Folium map
Get coordinates
Lat/Lon coordinates
Display route & map
User
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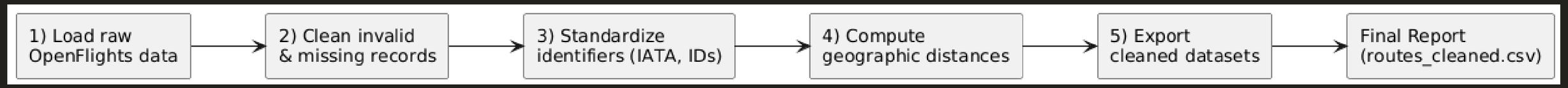
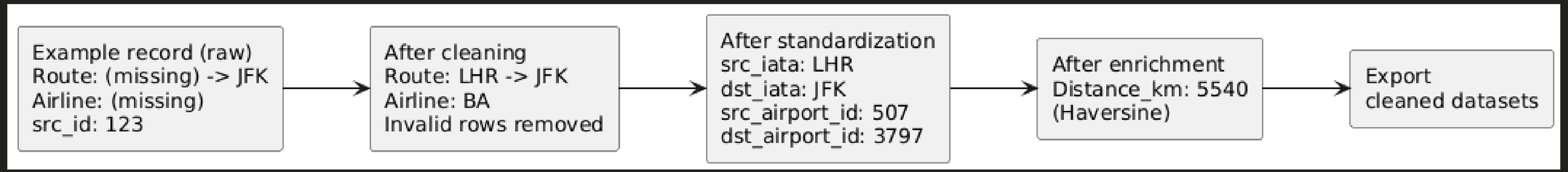
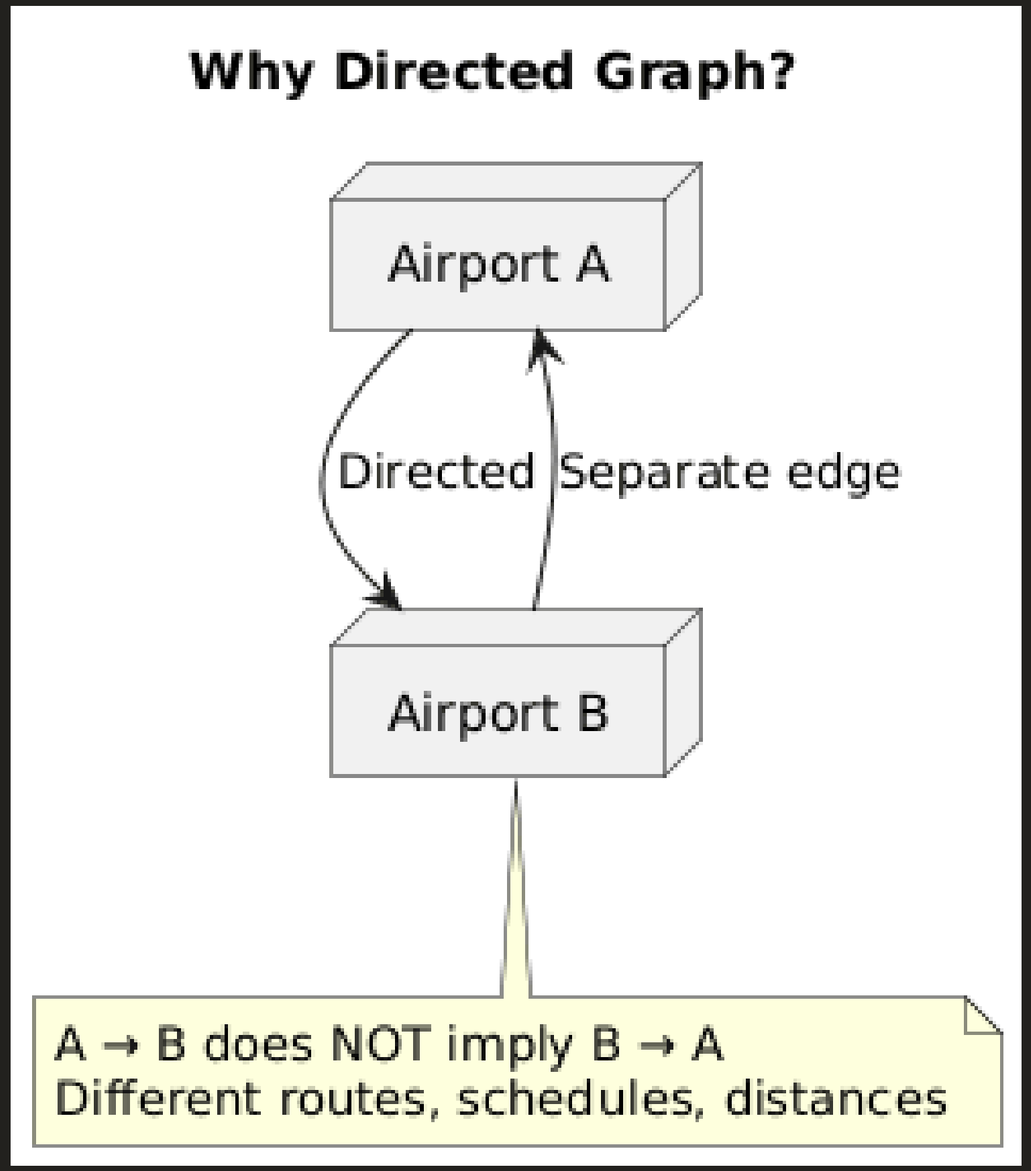
DATA PREPROCESSING PIPELINE



EXAMPLE



SYSTEM DESIGN

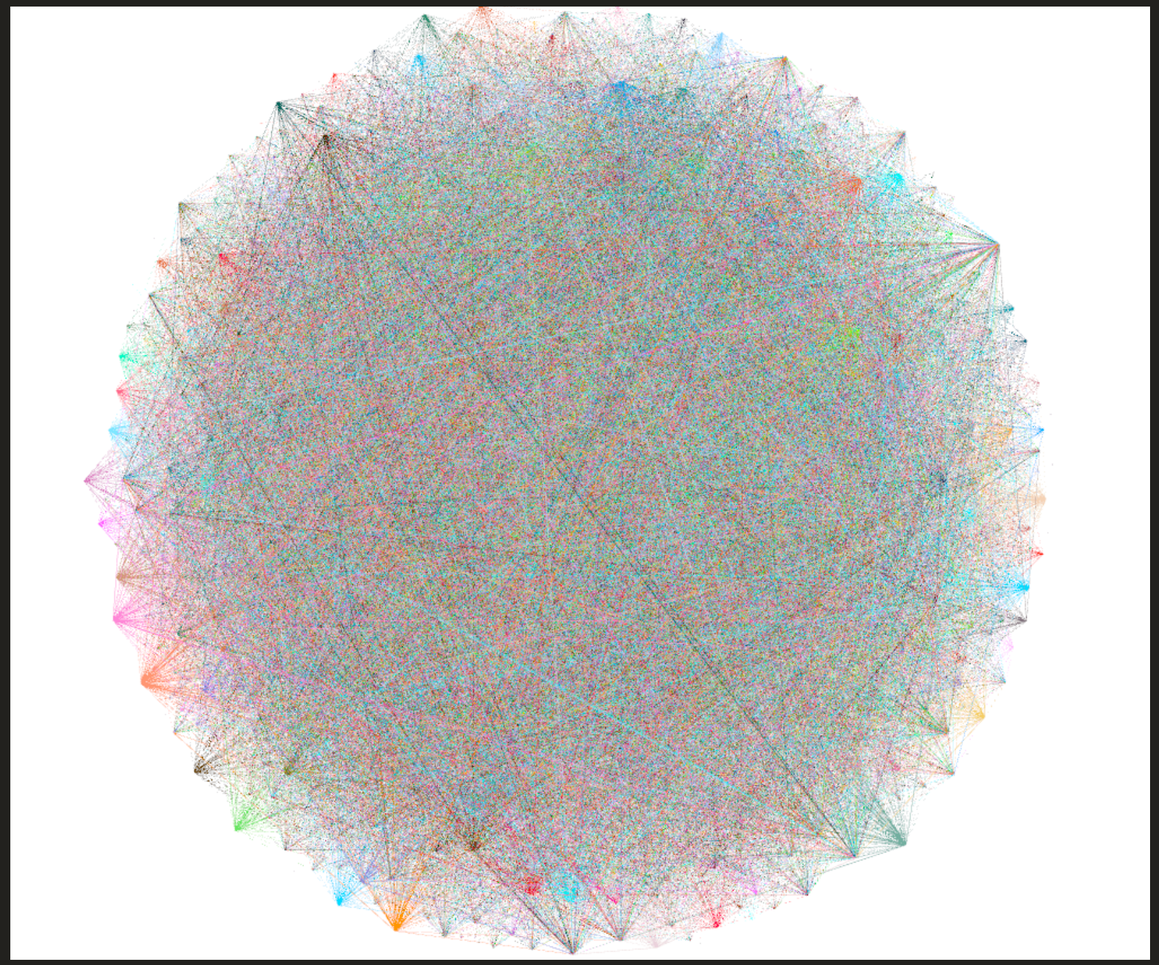


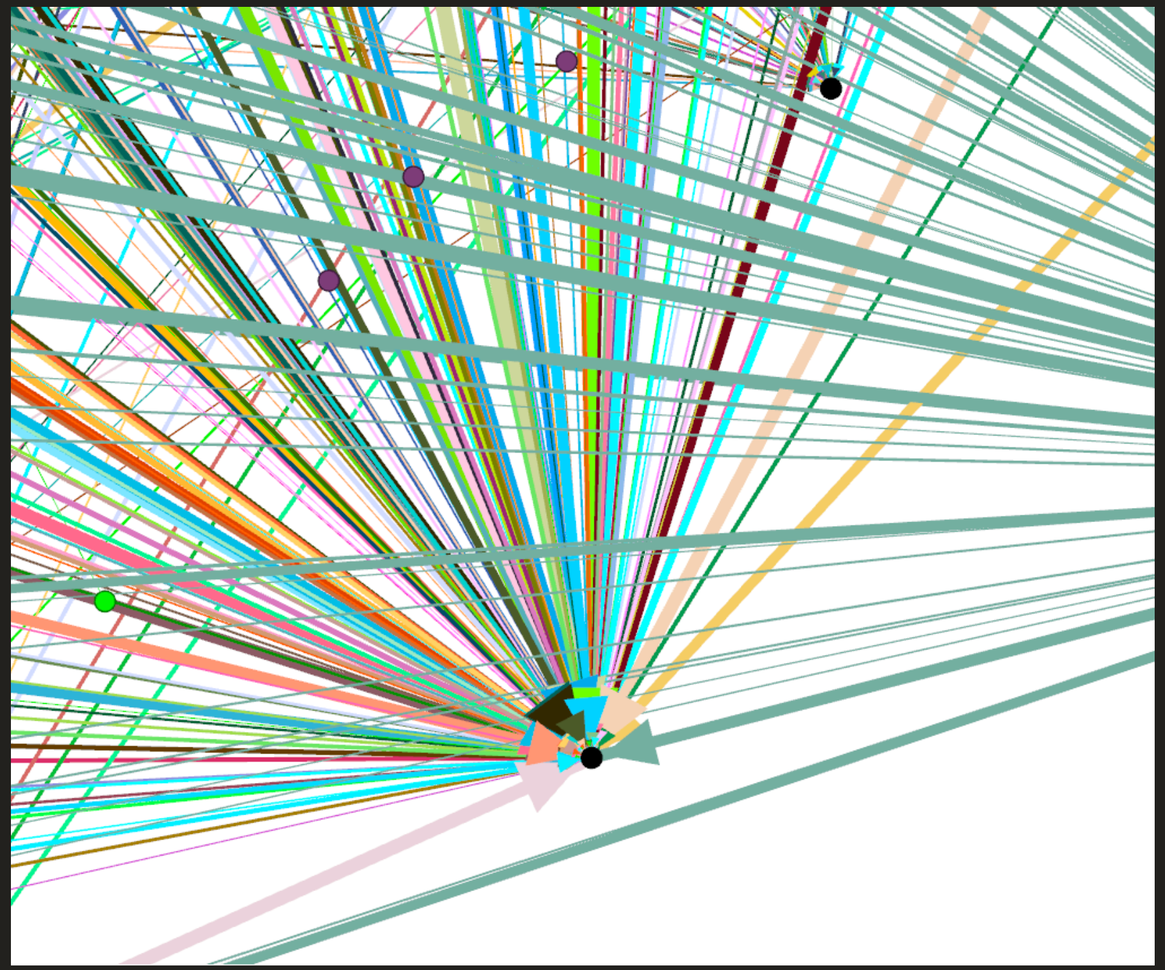
GRAPH MODELING DESIGN

Graph Representation

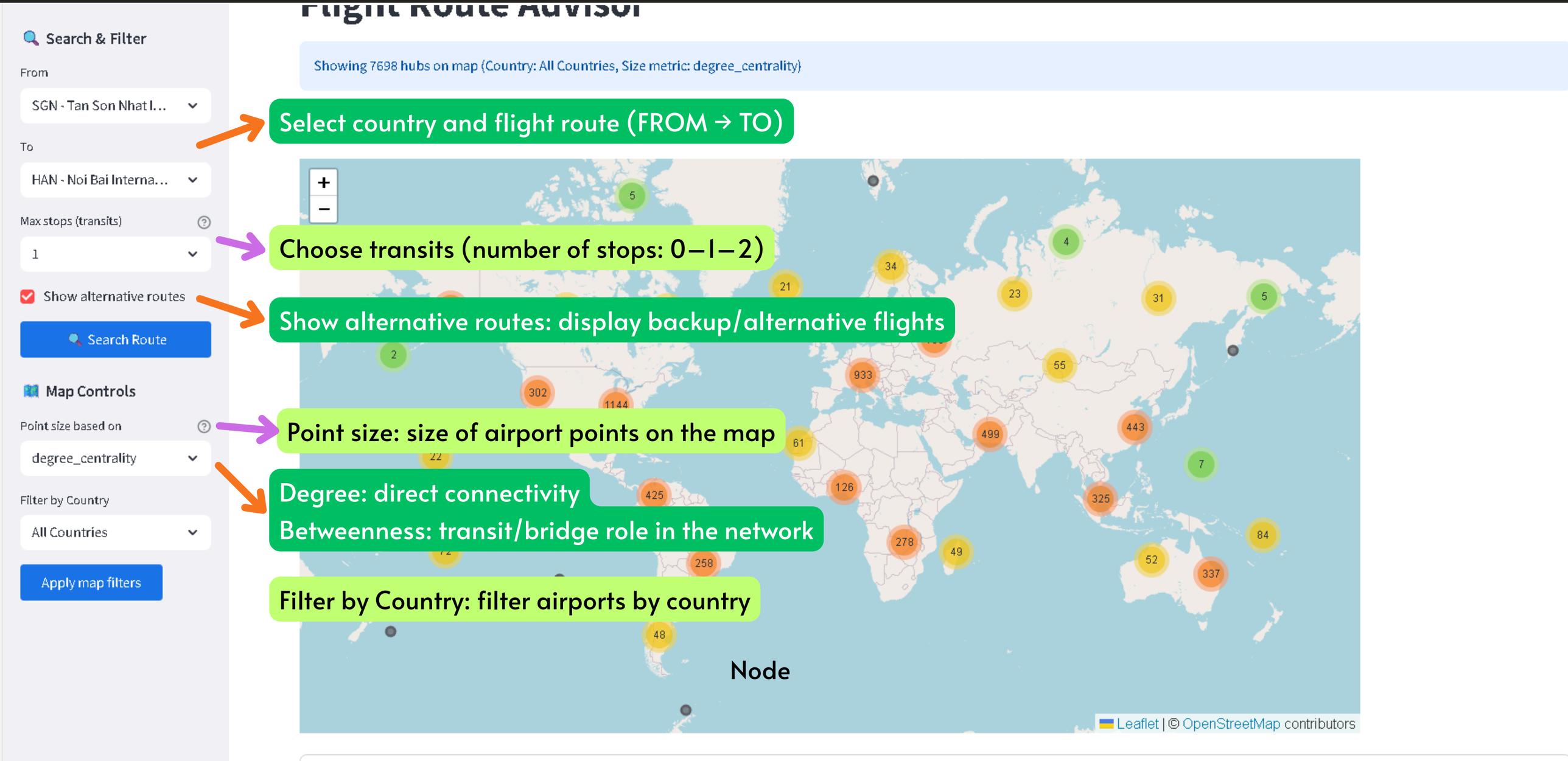
- Type: Directed Graph
- Nodes: Airports
- Edges: Flight routes
- Weight: Distance (km)

GRAPH MODELING DESIGN

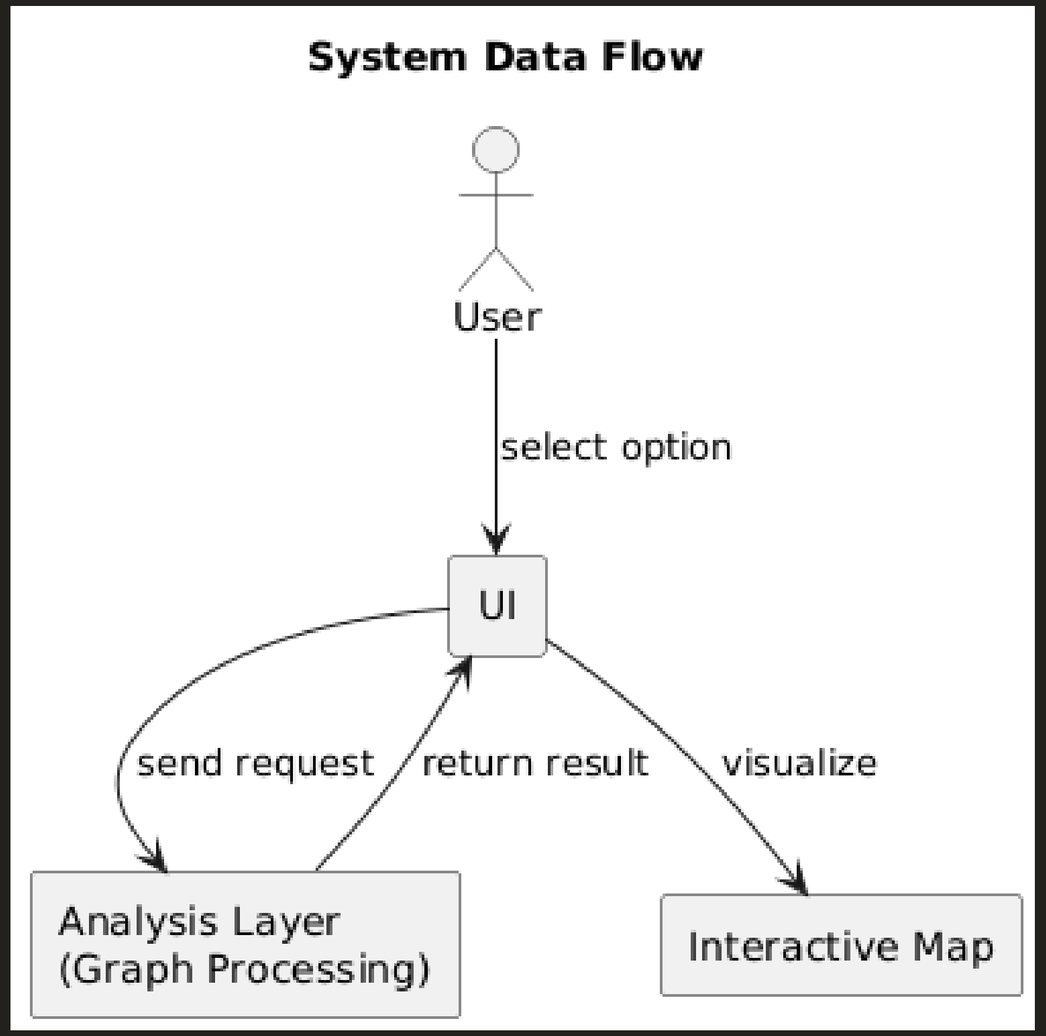




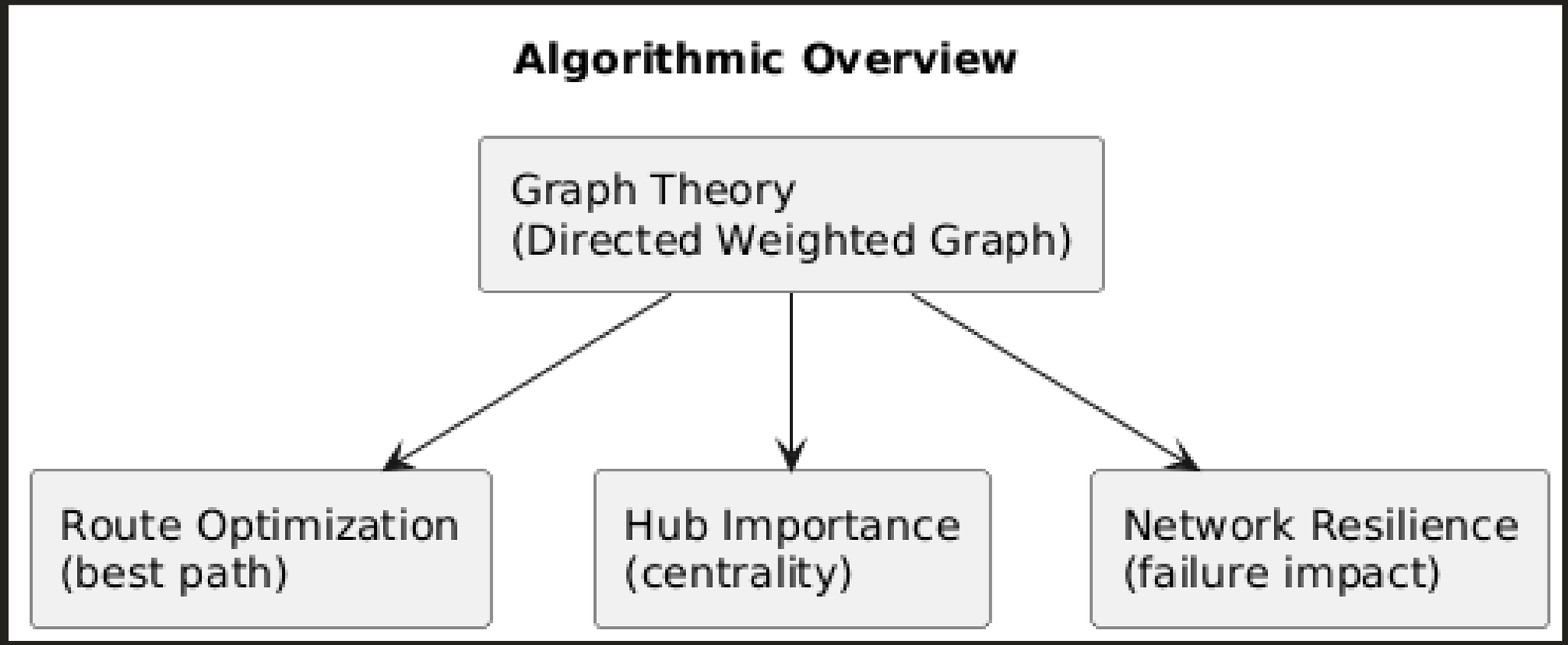
PRESENTATION LAYER DESIGN



SYSTEM DATA FLOW



ALGORITHMIC OVERVIEW



Why Graph Algorithms?

Flight networks naturally form a directed weighted graph
Efficient algorithms exist for:

Shortest path

Centrality

Connectivity analysis

ROUTE OPTIMIZATION ALGORITHM

Problem Definition

- Find best route From → To
- With objectives + constraints

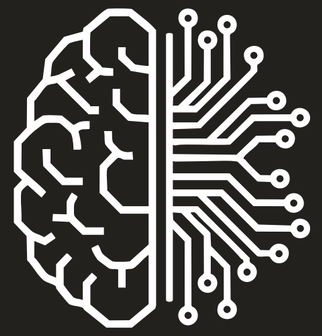
Supported Objectives

- Min transfers -> fewest hops
- Min distance -> shortest (km)

Algorithm Selection Strategy

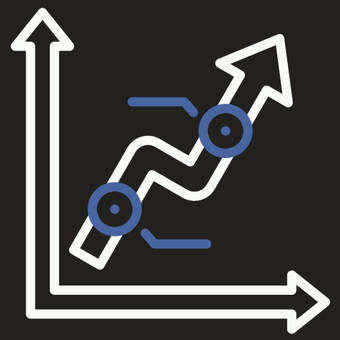
- BFS → fewest transfers (unweighted)
- Dijkstra → minimum distance (weighted)

FAST CONSTRAINED PATH STRATEGY



Optimization Insight

- Most real routes ≤ 2 transfers



Fast Constrained Path

- 0 stop → direct edge
- 1 stop → enumerate 1-hop paths
- 2 stops → enumerate 2-hop paths
- Select min distance

Why not Dijkstra / k-Shortest?

- k-shortest paths → expensive
- Enumeration → faster (small k)

HUB ANALYSIS ALGORITHMS

Objective

- Identify critical airports in the global network

Centrality Measures Used

Degree Centrality
→ Local connectivity
Betweenness Centrality
→ Bridge on shortest paths
Closeness Centrality
→ Avg distance to all airports
PageRank
→ Network influence

Why Multiple Metrics?

- No single metric is sufficient
- Different roles, different hubs

KEY FINDINGS & INSIGHTS

KEY FINDINGS

Sparse but hub-dependent network

Few airports dominate connectivity & robustness

Optimized routes match real-world major hubs

INSIGHTS FROM ANALYSIS

Distance-optimal routes rely on international hubs

Min transfers ≠ min distance

Resilience differs by region

DISCUSSION

Current Limitations

Equal airline importance

Expensive hub computation

Static flight data

Approximate flight time

No pricing / availability

Impact & Scope

Analytical, not operational

Not for real-time booking

Suitable for:

- Network analysis
- Education

FUTURE WORK & RESEARCH DIRECTIONS

SHORT-TERM

Integrate real-time flight APIs

Improve caching and performance

Use actual schedules and transit times

MEDIUM-TERM

Multi-objective optimization (time + distance)

Advanced alternative route generation

API layer for external systems

LONG-TERM / RESEARCH

Machine learning for delay prediction

Environmental impact (CO_2 emission analysis)

Distributed graph processing

Real-time network resilience monitoring

Thank You

for listening!

Gerente General