МОДЕЛЮВАННЯ ПОШИРЕННЯ ЗАТРИМКИ В ПРОЦЕСІ ПЛАНУВАННЯ РЕЙСІВ В АЕРОПОРТУ

(SIMULATION OF THE DELAY PROPAGATION IN THE AIRPORT FLIGHT SCHEDULING PROCESS)

Презентація Кудякової Анни ІПЗ-4

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Departures
Terminal Flight Destination Time Gate Remark
Terminal D BA117 Edinburgh 06:45 40
Terminal B CX1347 Bucharest 06:50 22
Terminal A BA165 Brussels 06:55 10
Terminal D BA3925 Amsterdam 07:05 41 CHECK-IN
Terminal D BA872 Istanbul 07:05 42 CHECK-IN
Terminal Z BA6706 Copenhagen 07:10 02 CHECK-IN
Terminal B AY6559 Glasgow 07:15 23 CHECK-IN
Terminal D AF7651BY Zurich 07:15 43 CHECK-IN
Terminal A QL861ICO Rome 07:25 11 CHECK-IN
Terminal A RZ 300MF Newcastle 07:35 12 CHECK-IN
Terminal D AF1007DL Dusseldorf 07:35 45 CHECK-IN
Terminal C AF1765KL Berlin 07:40 31 ON-TIME
Terminal Z RZ3635 Aberdeen 07:45 09 ON-TIME
Terminal B QL7793 Kyiv 07:50 29 DELAYED
Arrivals
Terminal Flight Destination Time Gate Remark
Terminal A AX1225CO Basel 06:40 11a ARRIVED
Terminal B RC 566 Manchester 06:40 22a LANDING
Terminal C RO1258E Tel Aviv 06:45 31a
Terminal C KP 102CO Brussels 07:00 32a EXPECTED 07:06
Terminal A AN 800 Kyiv 07:05 12a
Terminal D DV9501 Vancouver 07:05 41a EXPECTED 07:12
Terminal A TY1125CO Munich 07:10 14a EXPECTED 07:17
Terminal D RY 105 Charlotte 07:15 42a EXPECTED 07:
Terminal C KBP302 Beisin 07:15 33a EXPECTED 07:21
Terminal A AY7815 Shanghai 07:20 15a EXPECTED 07:28
Terminal Z T10 Taipei 07:25 23a DELAYED
Terminal C AY751Z Dubai 07:40 34a EXP
Terminal A BE 780 Paris 07:50 16a EXPECTED 07:53
Terminal B AF5680FE Singapore 07:50 24a EXPECTED 07:52

Optimized Flight Schedules

- an optimization model for flight rescheduling at a schedule coordinated airport
- to minimize congestion and flight delays at peak hours
- considering airport resource constraints and safety of operation

Simulation of Airport Operations

- a simulation of delay propagation to **mimic the real-time ad hoc airport flight scheduling process**
- to **validate the optimization results and compare them** with the results from simulation
- adheres to the first come first served protocol while enforcing runway capacity constraints, safety restriction and minimum turnaround times

Publications

- The simulation algorithm became the part of the paper “An Optimization Model for Flight Rescheduling from an Airport’s Centralized Perspective for Better Management of Demand and Capacity Utilization” published in Computation Journal
  Link: https://www.mdpi.com/2079-3197/12/5/98

- Press-paper “Modeling delay propagation within a network of outbound flights at a hub airport” specifically about the simulation algorithm has been accepted into the AMMCS 2023 Conference Proceedings.
  (Not yet published)

Data source

- Work with **Airline On-Time Statistics** from United States Department of Transportation official website https://www.transtats.bts.gov/ontime/ : departure and arrival datasets (working primarily with Airline Code, Date, Flight Number, Aircraft Number, Origin\Destination Airport, Scheduled Arrival/Departure Time, Actual Arrival/Departure Time)
- Analyze data from Hartsfield-Jackson Atlanta International Airport **(ATL)**
- Data collection period: **Jan. 1st - April 1st , 2023.**
- Collect, process and visualize data from dataset for analysis and simulation

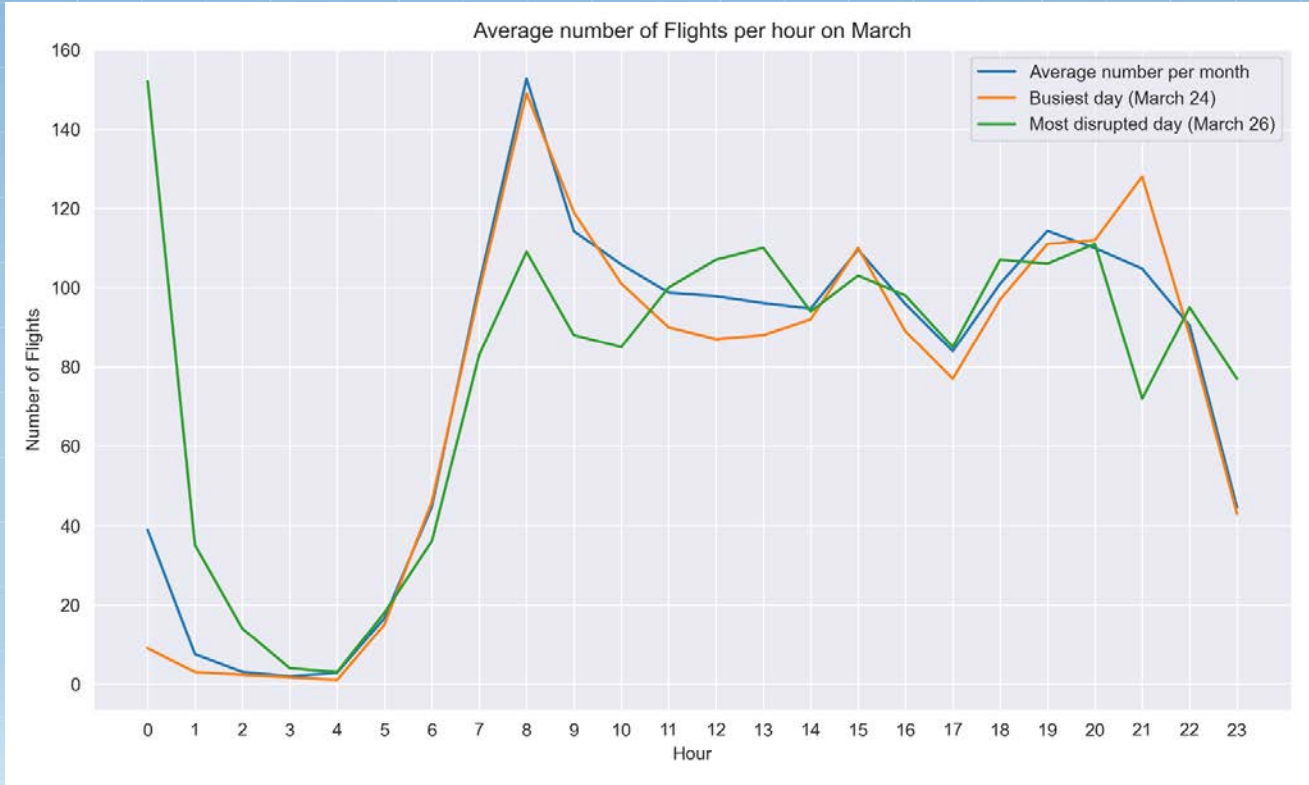
Displaying Items 1 - 100 of 50762

Excel | CSV

Carrier Code	Date (MM/DD/YYYY)	Flight Number	Tail Number	Origin Airport	Scheduled Arrival Time	Actual Arrival Time	Scheduled Elapsed Time (Minutes)	Actual Elapsed Time (Minutes)	Arrival Delay (Minutes)	Wheels-on Time	Taxi-In time (Minutes)
DL	01/01/2023	0032	N359DN	DFW	21:01	20:54	122	116	-7	20:46	8
DL	01/01/2023	0302	N945AT	MYR	12:25	12:12	84	78	-13	12:04	8
DL	01/01/2023	0306	N366NW	DCA	14:17	14:09	117	112	-8	14:05	4
DL	01/01/2023	0309	N194DN	LAX	06:40	06:27	251	236	-13	06:19	8
DL	01/01/2023	0345	N375NC	MCI	19:51	20:11	116	110	20	20:03	8
DL	01/01/2023	0356	N548US	SMF	21:18	21:31	258	252	13	21:23	8
DL	01/01/2023	0357	N327DN	BOS	15:17	14:45	184	161	-32	14:41	4

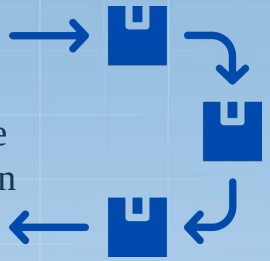
Data Analysis

- **Busiest day - March 24** with the biggest number of flights **1940**
- **The most disrupted day in March - March 26** with the highest total delay time - **83006 min**



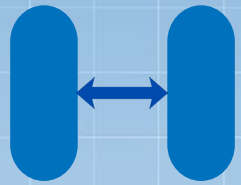
Brute-Force Simulation algorithm

FCFS (FIFO)



Reschedule the flights in a **queuing system** on first-come first served basis (FCFS) within each **15-min time intervals**

Safety Constraints



For safe operation, **3 min separation time** between two consecutive arrivals, and **2 min** between departures

Airport capacity

ATL has **3 runways for arrivals** and **2 for departures** that operate independently from each other (single runway cannot serve both arrivals and departures)

GroUND Operations

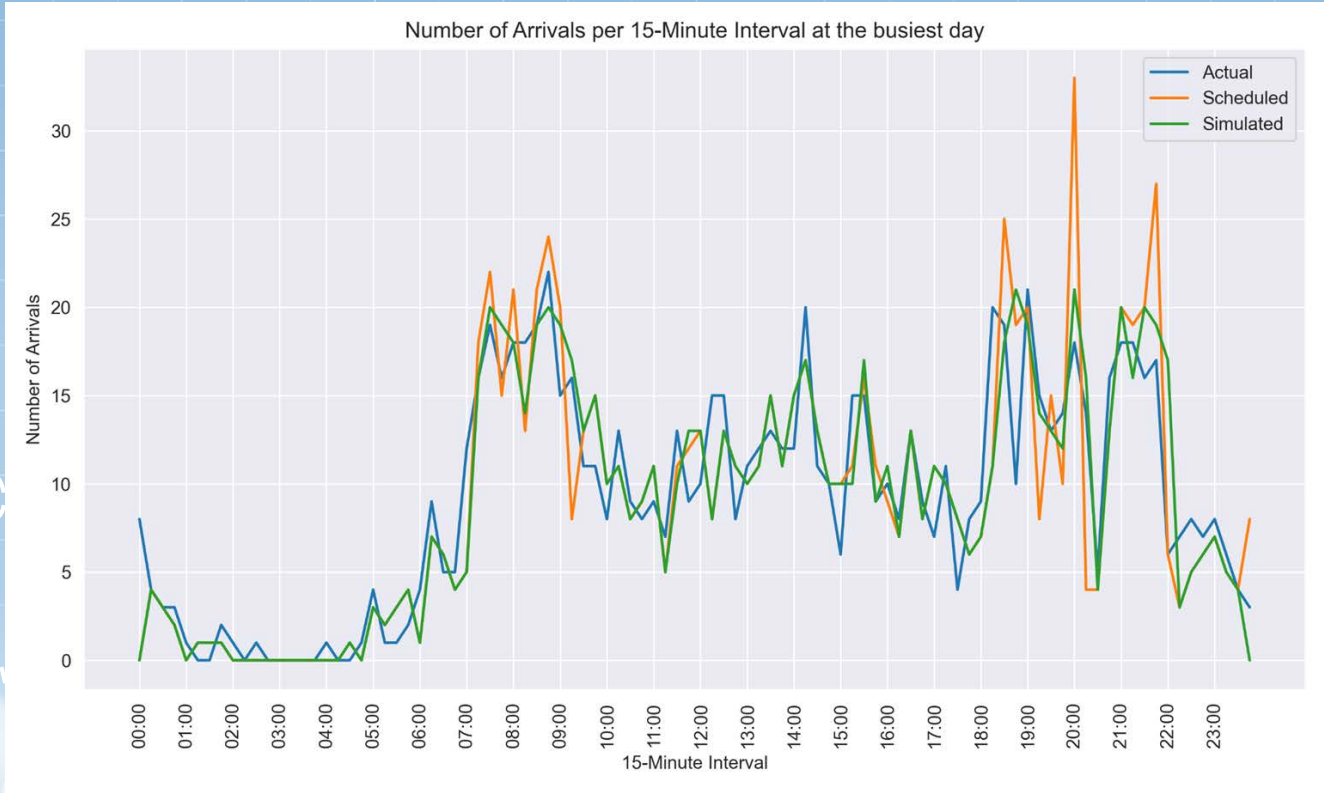
Considering ground operation services, **minimum ready time in connecting flights** 35 minutes for departure flights are computed in the simulation

Technology Stack

- Programming language: **Python**
- Development environment: **PyCharm**
- Data Handling and Analysis Libraries: **Pandas, NumPy**
- Visualization Libraries: **Matplotlib, Seaborn**

Comparison of actual, scheduled and simulated arrivals on March 24

With no safety restrictions

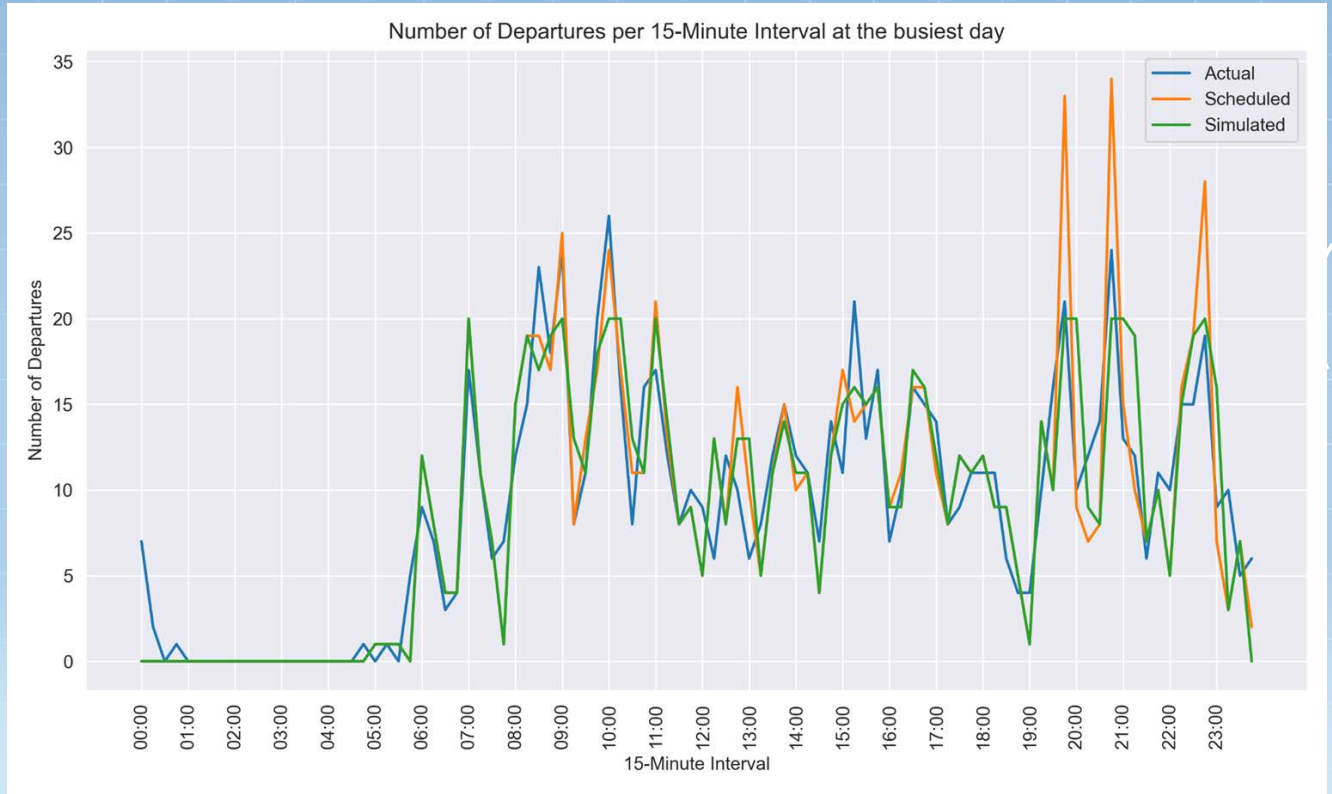


- Max. **capacity of 20 flights** in each 15-minute interval.
- **2.25 minutes separation time**
- **3 runways for arrivals**

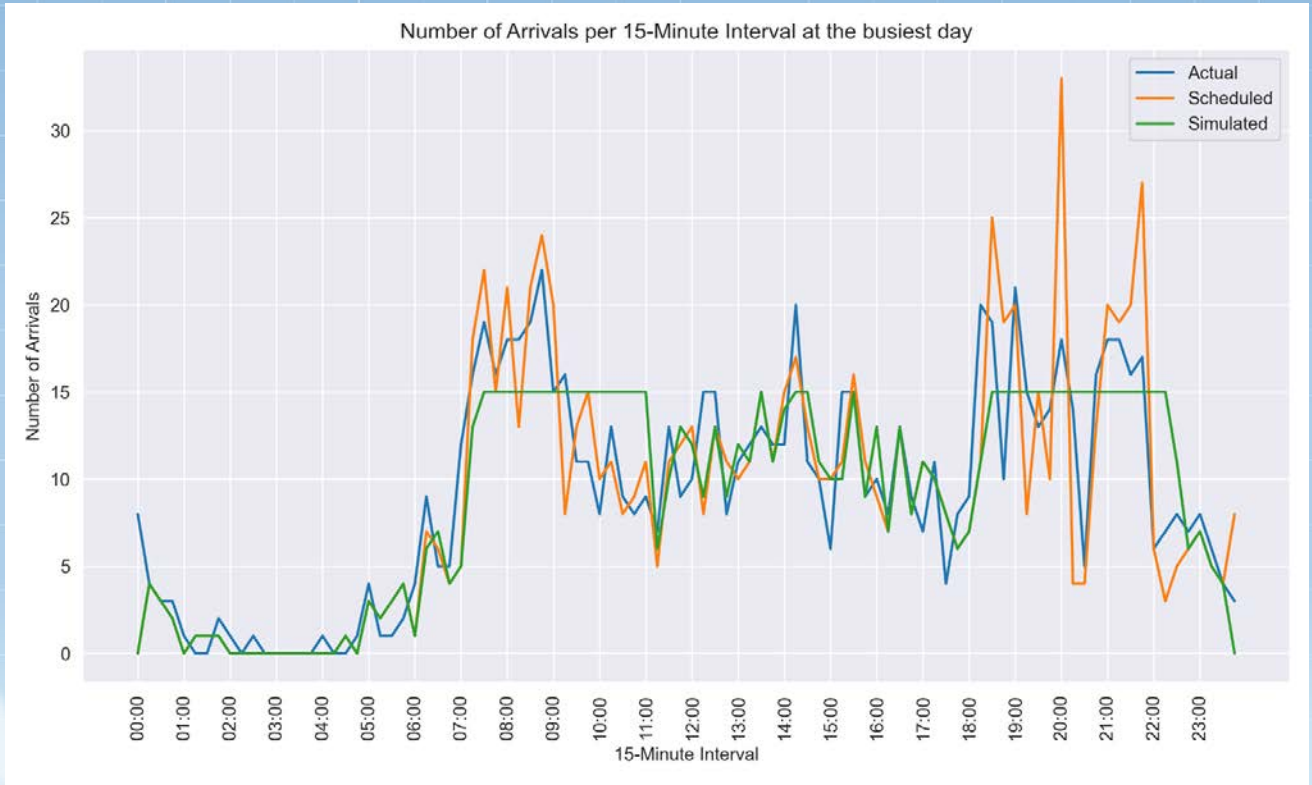
Comparison of actual, scheduled and simulated Departures on March 24

With no safety restrictions

- Max. **capacity of 20 flights** in each 15-minute interval
- **1.5 minutes separation time**
- **2 runways for departures**



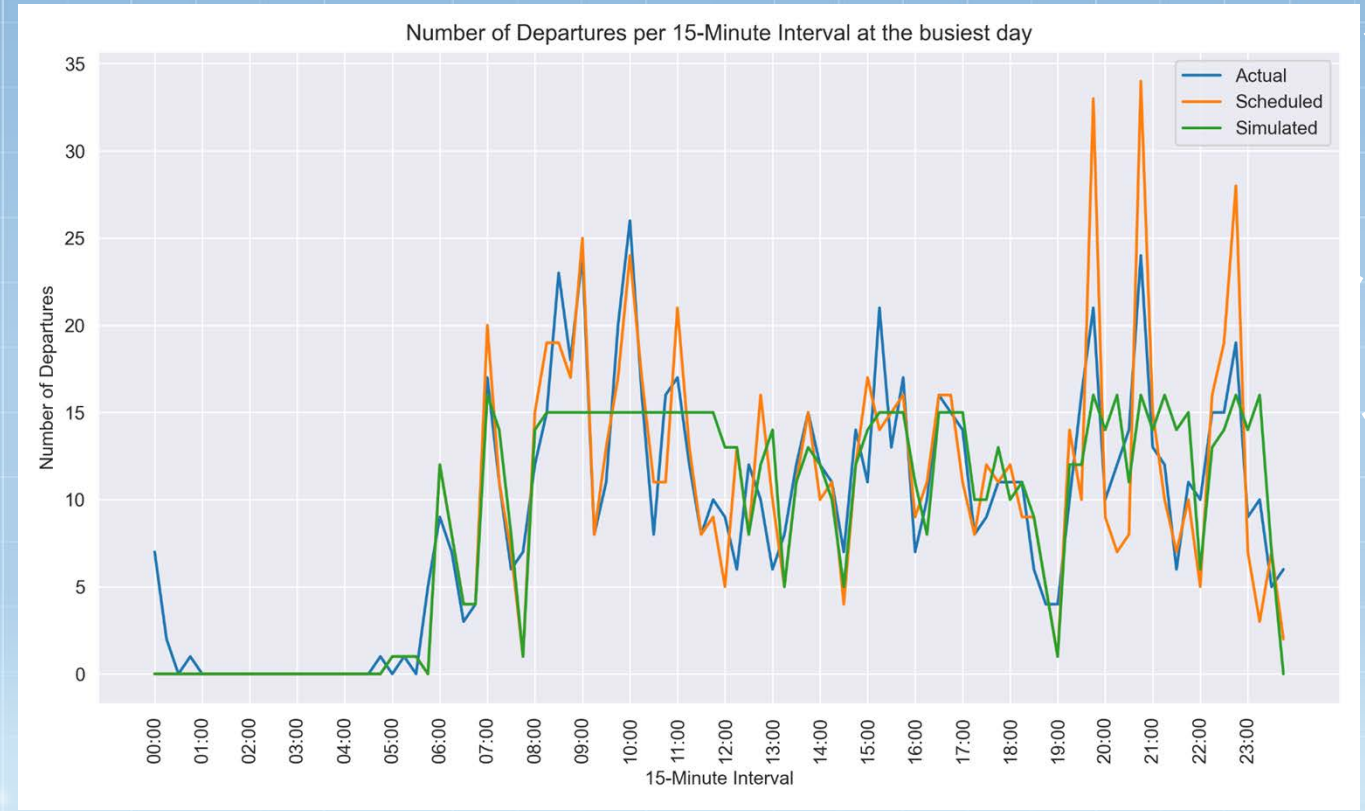
Comparison of actual, scheduled and simulated arrivals on March 24



- Safe operational **capacity of 15 flights** per 15-minute
- **3 minutes separation time**
- **3 runways for arrivals**

Comparison of actual, scheduled and simulated Departures on March 24

- Safe operational **capacity of 15 flights** per 15-minute
- **2 minutes separation time**
- **2 runways for departures**



Results

- Developed a simulation algorithm that mimics the real-time scheduling and delay propagation processes of an airport.
- **Confirmed the accuracy of the simulation model**, by running the algorithm with 20 arrivals/ departures capacity per 15-minute interval
  - Run the simulation with **15 flights per 15-minute interval** capacity, respecting 3-minute separation time for arrivals and 2 minutes for departures

Demonstrated that real airport operations achieve lower overall delays **at the expense of safety standards** during peak times.