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Aircraft scheduling

Algorithm design & Analysis Project
CS315
Semester:462

Contents

Overview

1.1 Introduction:

Managing the takeoff and landing of aircraft at airports is a significant challenge due to the large number of flights and limited runways.
Any delay in scheduling can cause severe congestion and affect the efficiency of airport operations.
Therefore, having a scheduling system that helps organize aircraft movement in a way that minimizes delays and maximizes runway usage is crucial.
In this project, a scheduling system was developed based on two algorithms: Shortest Job First (SJF) and Priority Scheduling.
The first algorithm focuses on scheduling aircraft that require the least time on the runway, calculating the total time of takeoff and landing.
The second algorithm uses priority scheduling to prioritize flights based on their level of importance.

1.2 Problem Description

Airports deal with a large number of aircraft that need to land and take off daily , but the available runways cannot accommodate all flights at the same time, leading to congestion and delays.

Several factors contribute to this issue, including:
-The limited number of runways compared to the number of flights.
-Priority for certain flights, such as emergency aircraft or international flights.
-The need for time gaps between each takeoff and landing to ensure safety.
-Delays caused by weather conditions or technical issues.

The goal of this project is to use scheduling algorithms that help order flights in a way that reduces delays and ensures efficient runway usage.

Theoretical Analysis

2.1 Naive Algorithm

Description (Rationale):

The naive algorithm prioritizes planes based on the total time required for takeoff and landing. The plane with the shortest total time gets priority for takeoff. If two planes have the same total time, the plane with the lighter weight is given priority. This method helps to reduce waiting times and streamline the scheduling process.The algorithm proceeds as follows:

1. Input Processing: The algorithm accepts multiple airplane details, including name, takeoff time, landing time, and weight if needed.

2. Calculating Total Time: Total time is calculated as the sum of takeoff and landing times.

3. Sorting Planes: It sorts the planes based on their total time in ascending order.

4. Resolving Ties: In cases where two planes have identical total times, the plane with the lighter weight is prioritized.

5. Scheduling Output: Finally, the sorted list of planes is displayed in order of their takeoff priority.

2.1.1 Naive Algorithm -Psecode-

Algorithm 1: Airport Scheduling Algorithm

Input: n,name,takeoffTime,landingTime.
Output: scheduling planes in order of shortest runway usage time first.

```
Function addPlane(planesList,name,takeoffTime,landingTime)
    totalTime takeoffTime - landingTime
    PlanesList.append([name,totalTime])

Function Sort(planesList)
    n length(planeList)
     For i 0 to n do
        For j 0 to n-i-1 do
           If planesList[j][1]>planesList[j+1][1] then
              Swap planesList[j] with planesList[j+1]
           End if
         End for
      End for
End function

Function SameTime(planesList)
    For i 0 to length (planesList)-2 do
      If planesList [i][1]==planesList[i+1][1] then
         Print("there is a tie between plane "+planesList[i][0]+" and plane "+planesList[i+1][0])
         W1 input("enter the weight of plane "planesList [i][0]+" : ")
         W2  input("enter the weight of plane "planesList [i+1][0]+" : ")
         If w1>w2 then
           Swap  planesList [i] with planesList [i+1]
         End if
        End if
     End for
End function

Function displaySchedule(planesList)
    Print("planes sorted by SJF (shortest job first): ")
    For  each plane  in planesList  do
       Print("plane "+plane[0]+" -total runway usage time: "+plane[1]+" second ")
     End for
End function

PlanesList empty list
n input("enter the number of planes: ")

For i 1 to n do
   name input("enter the name of plane "+i+" : ")
   takeoffTime  input("enter the takeoff time for plane "+name+" -in seconds- : ")
   landingTime   input("enter the landing time for plane "+name+" -in seconds- : ")
   Call addPlane(planesList,name,takeoffTime,landingTime)
 End for

Call Sort(planesList)
Call SameTime(planesList)
Call displaySchedule(planesList)
```

2.1.2 Naive Algorithm -Analysis -

	#operations
1. totalTime takeoffTime+landingTime	1. **1**
2. PlanesList.append([name,totalTime])	2. **1**
	3. **1**
3. n length(planeList)	4. **n**
4. For i 0 to n-1 do	5. **n(n-1)/2**
5. For j 0 to n-i-2 do	6. **n(n-1)/2**
6. If planesList[j][1]>planesList[j+1][1] then	7. **n(n-1)/2**
7. Swap planesList[j] with planesList[j+1]	8.
8. End if	9.
9. End for	10.
10. End for	11.
11.End function	12. **n**
	13. **n**
12. For i 0 to length (planesList)-2 do	14. **n**
13. If planesList [i][1]==planesList[i+1][1] then	15. **n**
14. Print(“there is a tie between plane “+planesList[i][0]+” and plane ” +planesList[i+1][0])	16. **n**
15. W1 input(“enter the weight of plane “planesList [i][0]+” : “)	17. **n**
16. W2 input(“enter the weight of plane “planesList [i+1][0]+” : “)	18. **n**
17. If w1>w2 then	19.
18. Swap planesList [i] with planesList [i+1]	20.
19. End if	21.
20. End if	22.
21. End for	23. **1**
22. End function	24. **n**
	25. **n**
23. Print(“planes sorted by SJF (shortest job first): “)	26.
24. For each plane in planesList do	27.
25. Print(“plane “+plane[0]+” -total runway usage time: “+plane[1]+” second “)	28. **1**
26. End for	29. **1**
27. End function	30. **n**
	31. **n**
28. PlanesList empty list	32. **n**
39. n input(“enter the number of planes: “)	33. **n**
	34. **n**
30. For i 1 to n do	35.
31. name input(“enter the name of plane “+i+” : “)	36. **n^2**
32. takeoffTime input(“enter the takeoff time for plane “+name+” -in seconds- : “)	37. **n**
33. landingTime input(“enter the landing time for plane “+name+” -in seconds- : “)	38. **n**
34. Call addPlane(planesList,name,takeoffTime,landingTime)	
35. End for	
36. Call Sort(planesList)	
37. Call SameTime(planesList)	
38. Call displaySchedule(planesList)	

Time Complexity Analysis:

1.addplane function:
-function to add plane th the PlanesList
-Time Complexity: O(1)

2.Sort function:
-the outer loop runs n time
-the inner loop runs n(n-1)/2 times
-Time Complexity: O(n^2)

3.SameTime function:
-checks for ties in runway usage times and compares plane weights
-Time Complexity: O(n)

4.displaySchedule function:
-display the sorted list of planes
-Time Complexity: O(n)

Overall Time Complexity:
T(n)=1+n^2+2n
O(n^2)

Space Complexity Analysis:

1.planesList Storage:
-stores the list of planes,which contains n elements.
-Space Complexity: O(n)

2.Temporary Variables:
-uses some temporary variables :max,i,j,..
-Space Complexity: O(1)

Overall Space Complexity:
S(n)=n+1
O(n)

2.1.3 Naive Algorithm: Example

Step 1: input:
- Plane 1:
- Name: A320
- Takeoff Time: 10 minutes
- Landing Time: 5 minutes
- Plane 2:
- Name: B737
- Takeoff Time: 8 minutes
- Landing Time: 4 minutes
- Plane 3:
- Name: C919
- Takeoff Time: 8 minutes
- Landing Time: 4 minutes

Step 2:Total Time Calculation:
- A320:
- Total Time = Takeoff Time + Landing Time = 10 + 5 = 15 minutes
- B737:
- Total Time = Takeoff Time + Landing Time = 8 + 4 = 12 minutes
- C919:
- Total Time = Takeoff Time + Landing Time = 8 + 4 = 12 minutes

Step 3:Sorting Process:

After sorting the planes by their total time, the schedule will be:
- B737: 12 minutes
- C919: 12 minutes
- A320: 15 minutes

Step 4:Resolve tie:
- Since B737 and C919 have the same total time, we now ask for the weights:
- B737 Weight: 75,000 kg
- C919 Weight: 68,000 kg

The plane with the lighter weight (C919) will be prioritized.

Step 5:Final Schedule:
1. C919 - Total Time: 12 minutes
2. B737 - Total Time: 12 minutes
3. A320 - Total Time: 15 minutes

Theoretical Analysis

2.2 Optimized Algorithm

Description (Rationale):
The optimized algorithm schedules aircraft using Priority Scheduling with a Priority Queue. This optimization that flights with higher priority are processed first, improve the use of the runway and reduce time.
If two flights have the same priority, is applied based on some steps.The algorithm proceeds as follows:

1.Input Processing:
The algorithm receives number of flight .
Details such as flight name, takeoff time, landing time, and priority level,and Purpose.

2.Sorting Flights by Priority:
Flights are inserted into a Priority Queue where higher priority values are processed first.

3.Resolving Ties:
If two flights have the same priority, the is resolved as follows:
•Earliest Takeoff Time
•Shortest Runway Usage Time

4.Flights Sort:
Each flight is assigned to an available based on its priority and processing order.

5.Output:
The final flight sort is displayed, listing flights in order of priority

2.2.1 Optimized Algorithm -Pseudocode-

Algorithm 2: Airport Scheduling Algorithm

Input: number flight,Flight name, takeoff time, landing time, and priority.
Output:flight sort is displayed, listing flights in order of priority.

```
Function AddFlight(priorityQ, FlightName, Takeoff, Landing, Priority)
   Insert (FlightName, Takeoff, Landing, Priority) into priorityQ
End Function

Function SameTime(Flight1, Flight2)
   If Flight1.Takeoff < Flight2.Takeoff then
      Return Flight1
   Else If Flight1.Takeoff > Flight2.Takeoff then
      Return Flight2
    Else If Flight1.Priority > Flight2.Priority then
      Return Flight1
    Else If Flight1.Priority < Flight2.Priority then
      Return Flight2
    Else If (Flight1.Landing - Flight1.Takeoff) < (Flight2.Landing - Flight2.Takeoff) then
      Return Flight1
   Else
      Return Flight2
End If
End Function

Function SortFlights(priorityQ)
   SortedFlights = empty list
   While priorityQ is not empty:
      Flight = priorityQ.RemoveMax()
      If priorityQ is not empty AND priorityQ.Peek().Takeoff == Flight.Takeoff then
         NextFlight = priorityQ.RemoveMax()
         BestFlight = Call SameTime(Flight, NextFlight)
         If BestFlight == Flight then
            priorityQ.Insert(NextFlight)
         Else:
            priorityQ.Insert(Flight)
            Flight = NextFlight
        End If
     Append Flight to SortedFlights
     End If
    End While
   Return SortedFlights
End Function

Function Display(SortedFlights)
   Print "Flight Schedule:"
   For each Flight in SortedFlights:
     Print "Flight :", Flight.FlightName, "Takeoff :", Flight.Takeoff,"Landing :", Flight.Landing,
           "Priority :", Flight.Priority
   End For
End Function

priorityQ = PriorityQueue (Max-Heap)
n = input("Enter  number of flights: ")
For i = 1 to n do:
   FlightName = input(" Enter flight name : ")
   Takeoff = input(" Enter takeoff time (HH:MM)  : ")
   Landing = input(" Enter landing time (HH:MM) : ")
   Priority = input(" Enter priority level (1 = Regular, 2 = International, 3 = Emergency, higher number is more important): ")
   Call AddFlight(priorityQ, FlightName, Takeoff, Landing, Priority)
End For
SortedFlights = Call SortFlights(priorityQ)
Call Display(SortedFlights)
```

2.2.2 Optimized Algorithm -Analysis -

	#operation
1. Insert (FlightName, Takeoff, Landing, Priority) into priorityQ	1. **log n**
2. If Flight1.Takeoff < Flight2.Takeoff then Return Flight1	2. **1**
3. Else If Flight1.Takeoff > Flight2.Takeoff then Return Flight2	3. **1**
Else If Flight1.Priority > Flight2.Priority then Return Flight1	4. **1**
Else If Flight1.Priority < Flight2.Priority then Return Flight2	5. **1**
4. Else If (Flight1.Landing - Flight1.Takeoff) < (Flight2.Landing - Flight2.Takeoff) then Return Flight1	6. **1**
5. Else Return Flight2 End If	7. **n log n** 8. **log n**
	9. **1**
6. SortedFlights = empty list	
7. While priorityQ is not empty:	10. **log n**
8. Flight = priorityQ.RemoveMax()	
9. If priorityQ is not empty AND priorityQ.Peek().Takeoff == Flight.Takeoff then	11. **1**
10. NextFlight = priorityQ.RemoveMax()	12. **log n**
11. BestFlight = Call SameTime(Flight, NextFlight)	
12. If BestFlight == Flight then priorityQ.Insert(NextFlight)	13. **1**
Else:	14. **1**
13. priorityQ.Insert(Flight)	15. **1**
14. Flight = NextFlight End If	16. **1**
End If	17. **1**
15. Append Flight to SortedFlights End While	
16. Return SortedFlights	18. **n**
17. Print "Flight Schedule:"	19. **n**
18. For each Flight in SortedFlights:	20. **1**
19.Print "Flight :", Flight.FlightName, "Takeoff :", Flight.Takeoff,"Landing :", Flight.Landing, "Priority :", Flight.Priority	21. **1**
End For	22. **n**
20. priorityQ = PriorityQueue (Max-Heap)	23. **n**
21. n = input("Enter number of flights: ")	24. **n**
22. For i = 1 to n do:	25. **n**
23. FlightName = input(" Enter flight name : ")	26. **n**
24. Takeoff = input(" Enter takeoff time (HH:MM) : ")	27. **log n**
25. Landing = input(" Enter landing time (HH:MM) : ")	28. **n log n**
26. Priority = input(" Enter priority level (1 = Regular, 2 = International, 3 = Emergency, higher number is more important): ")	29. **n**
27. Call AddFlight(priorityQ, FlightName, Takeoff, Landing, Priority) End For	
28. SortedFlights = Call SortFlights(priorityQ)	
29. Call Display(SortedFlights)	

Time Complexity Analysis of the Optimized Algorithm:

1. **AddFlight Function:**
• Inserts a flight into the priority queue (Max-Heap).
• **Time Complexity: O(log n)**

2. **SameTime Function:**
• Compares takeoff times, landing times.
• **Time Complexity: O(1)**

3. **SortFlights Function:**
• Removes flights from the priority queue : **O(log n)**.
• If two flights have the same priority **:O(1)**
• Inserts the flight into the queue : **O(log n)**.
• Runs **n** times .
• **Time Complexity: O(n log n)**

4. **Display Function:**
• sorted flight list and prints details.
• **Time Complexity: O(n)**

Overall Time Complexity:
O(log n + 1 + n log n + n) =**O(n log n)**

Space Complexity Analysis of the Optimized Algorithm:

1. Priority Queue Storage:
• Stores n flights in a Max-Heap.
• **Space Complexity: O(n)**

2. Temporary Variables:
• Uses constant size variables for comparisons.
• **Space Complexity: O(1)**

Overall Space Complexity:
•O(1 + n) = **O(n)**

2.2.3 Optimized Algorithm:Example

Step 1: Input

- **Plane 1:**

Name: AA1
Takeoff Time: 08:00
Landing Time: 08:30
Priority Level: 3

- **Plane 2:**

Name: AA2
Takeoff Time: 08:00
Landing Time: 08:25
Priority Level: 3

- **Plane 3:**

Name: AA3
Takeoff Time: 08:00
Landing Time: 08:44
Priority Level: 4

Step 2: Total Time Calculation

AA1:
Total Time = Landing Time - Takeoff Time = 08:30 - 08:00 = 30 minutes
AA2:
Total Time = Landing Time - Takeoff Time = 08:25 - 08:00 = 25 minutes
AA3:
Total Time = Landing Time - Takeoff Time = 08:44 - 08:00 = 44 minutes

Step 3: Sorting Process

- Sorting the Flight by their priority first “high number is more important”

AA3 (Priority: 4) = 44 minutes
AA2 (Priority: 3) = 25 minutes
AA1 (Priority: 3) = 30 minutes

Step 4: Resolve Tie

- **AA1** and **AA2** have the same priority (3), we compare their total time:

AA2: 25 minutes
AA1: 30 minutes
So **AA2** has a shorter total time, it will be prioritized over **AA1**.

Step 5: Flight Schedule

1. **AA3** - Total Time: 44 minutes, Priority: **4**
2. **AA2** - Total Time: 25 minutes, Priority: **3**
3. **AA1** - Total Time: 30 minutes, Priority: **3**

2.3 Theoretical Analysis: Comparison

Naive Algorithm:

Time Complexity:

- Sorting the planes based on total time: $O(n^2)$ (Where n is the number of planes.)
- Resolving ties based on weight (if necessary): O(n) (Where n is the number of planes.)
- Overall Time Complexity: $O(n^2)$

Space Complexity:

- Storing plane details: O(n) (Where n is the number of planes.)
- Temporary space for sorting: O(1) (No extra space is needed beyond the input list.)
- Overall Space Complexity: O(n)

Steps:

1. Input plane details (name, takeoff time, landing time).
2. Calculate total time (takeoff + landing).
3. Sort planes by total time.
4. Resolve ties by comparing weights.
5. Display the final schedule.

Advantages: Simple and Easy to Implement, Clear and Predictable
Disadvantages:inefficient for larger numbers of planes.

Optimized Algorithm

Time Complexity:

- Insert flights into the Priority Queue: O(n log n)
- Sorting flight : O(n log n)
- Resolving ties : O(1)
- Over all Time Complexity: O(n log n)

Space Complexity:

- storing flight details: O(n)
- Priority Queue storage: O(n)
- Temporary space usage: O(1)
- Over all Space Complexity: O(n)

steps :

1.Input flight details (name, takeoff time, landing time, priority level).
2. Sort flights by priority (higher value first).
3. Resolve ties (earlier takeoff → shorter duration).
4. Display the final schedule.

Advantages: Fast execution,More accurate,Effective use of memory.
Disadvantages:More complex implementation,Need customization.

Summary of Comparison:

-Naive Algorithm: Prioritizes planes with the shortest total time, reducing waiting time and improving resource usage. However, it can be inefficient for large systems due to $O(n^2)$ sorting complexity.

-Optimized Algorithm: Using Priority Scheduling with a Priority Queue significantly improves efficiency by reducing time complexity from $O(n^2)$ to O(n log n), making flight scheduling faster and more optimized.

Empirical Analysis

3.1 Naive Algorithm Implementation:

The implementation of the naive algorithm in python
The naive algorithm first collects the plane details, including the plane's name, takeoff time, and landing time. It then calculates the total time required for each plane (the sum of takeoff and landing times). Afterward, the planes are sorted in ascending order based on their total time. If two planes have the same total time, the tie is resolved by comparing their weights. The following is the Python implementation of this naive algorithm.

main.py

```python
class AirportScheduler:
    def __init__(self):
        self.planes = []      # قائمه

    def add_plane(self, name, takeoffTime, landingTime):  # دالة لإضافه
        totalTime = takeoffTime + landingTime           # حساب كل الوقت

        self.planes.append([name, totalTime])  # لتخزين بالقائمه



    def sort(self):       # لترتيب  SJF
        n = len(self.planes)
        for i in range(n):
            for j in range(0, n - i - 1):
                if self.planes[j][1] > self.planes[j + 1][1]:
                    self.planes[j], self.planes[j + 1] = self.planes[j + 1], self.planes[j] #تم التبديل


    def sameTime(self):  #  if == total Time
        for i in range(len(self.planes) - 1):
            if self.planes[i][1] == self.planes[i + 1][1]:
                print(f"\n There is a tie between planes {self.planes[i][0]} and planes {self.planes[i + 1][0]}")
                w1 = int(input(f"Enter the weight of plane {self.planes[i][0]}: ")) # نطلب الوزن اذا ==
                w2 = int(input(f"Enter the weight of plane {self.planes[i + 1][0]}: "))
                if w1 > w2:
                    self.planes[i], self.planes[i + 1] = self.planes[i + 1], self.planes[i] # نبدل

    # دالة لعرض جدول الطائرات بعد الترتيب
    def displaySchedule(self):
        print("\nPlanes sorted by SJF (Shortest Job First):")
        for plane in self.planes:
            print(f"Plane {plane[0]} - Total usage time: {plane[1]} seconds")


#    obj لجدولة الطائرات
scheduler = AirportScheduler()

# طلب ادخال عدد الطائرات
n = int(input("Enter the number of planes: "))
#  طلب إدخال بيانات الطائرات
for i in range(n):
    name = input(f"Enter the name of plane {i + 1}: ")
    takeoffTime = int(input(f"Enter the takeoff time for plane {name} (in seconds): "))
    landingTime = int(input(f"Enter the landing time for plane {name} (in seconds): "))

    scheduler.add_plane(name, takeoffTime, landingTime)

# ترتيب الطائرات وحل == وعرض الجدول
scheduler.sort()
scheduler.sameTime()
scheduler.displaySchedule()
```

3.2 Optimized Algorithm Implementation

The implementation of the optimized algorithm in python schedules flights efficiently using a priority queue (Max-Heap).
Flights are first collected with their details:
(name, takeoff time, landing time, and priority).
Scheduling is based on priority first, then earlier takeoff time, and finally shorter duration (landing time - takeoff time in case of ties.

main.py

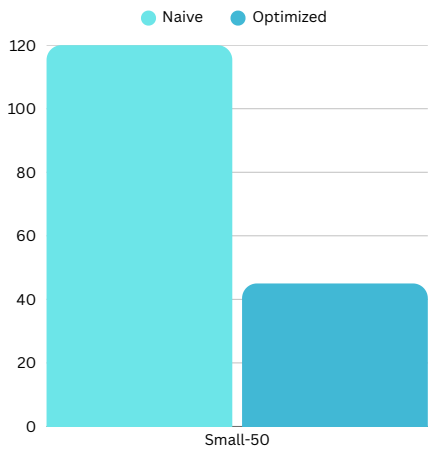
```python
import heapq
from datetime import datetime

class Flight:
# دالة في بايثون لإنشاء المتغيرات
    def __init__(self, FlightName, Takeoff, Landing, Priority):
        self.FlightName = FlightName
        self.Takeoff = datetime.strptime(Takeoff, "%H:%M")
        self.Landing = datetime.strptime(Landing, "%H:%M")
        self.Priority = Priority
# دالة في بايثون تستخدم للمقارنة
    def __lt__(self, other):
        if self.Takeoff != other.Takeoff:
            return self.Takeoff < other.Takeoff
        if self.Priority != other.Priority:
            return self.Priority > other.Priority
        return (self.Landing - self.Takeoff) < (other.Landing - other.Takeoff)
# كلاس للأولوية
class PriorityQueue:
    def __init__(self):
        self.queue = []

    # دالة لإضافة رحلة priorityQ
    def insert(self, flight):
        heapq.heappush(self.queue, flight)
    # دالة تحذف الرحلة إلى لها الأولوية الأعلى
    def remove_max(self):
        return heapq.heappop(self.queue)
    # دالة لعرض الأولوية بدون حذف
    def peek(self):
        return self.queue[0] if self.queue else None
def AddFlight(priorityQ, FlightName, Takeoff, Landing, Priority):
    flight = Flight(FlightName, Takeoff, Landing, Priority)
    priorityQ.insert(flight)

def SortFlights(priorityQ):
    sorted_flights = []
    while priorityQ.queue:
        flight = priorityQ.remove_max()
        if priorityQ.queue and priorityQ.peek().Takeoff == flight.Takeoff:
            next_flight = priorityQ.remove_max()
            best_flight = flight if flight < next_flight else next_flight
            if best_flight == flight:
                priorityQ.insert(next_flight)# يرجع يضيف الرحلات ذات الأولوية الأقل
            else:
                priorityQ.insert(flight)
                flight = next_flight
        sorted_flights.append(flight)
    return sorted_flights

def Display(SortedFlights):
    print("_____")
    print(" Flight Schedule:")
    for flight in SortedFlights:
        print(f"Flight: {flight.FlightName}, Takeoff: {flight.Takeoff.strftime('%H:%M')}, "
      f"Landing: {flight.Landing.strftime('%H:%M')}, Priority: {flight.Priority}")
n = int(input("Enter number of flights: "))
for i in range(n):
    FlightName = input("Enter flight name: ")
# هنا راح يتأكد ان أسم الرحله مو فاضى
    while not FlightName:
        print("Flight name cannot be empty.")
        FlightName = input("Enter flight name: ")
    Takeoff = input("Enter takeoff time (HH:MM): ")
    Landing = input("Enter landing time (HH:MM): ")
    Priority = int(input("Enter priority level(1= Regular,2=International,"
    "3=Emergency,higher number is more important): "))
    AddFlight(priorityQ, FlightName, Takeoff, Landing, Priority)
SortedFlights = SortFlights(priorityQ)
Display(SortedFlights)
```

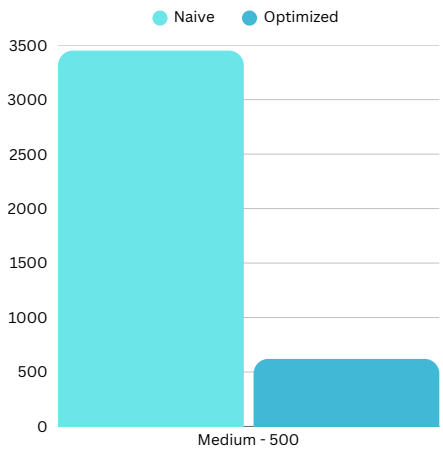
3.3 Performance Analysis

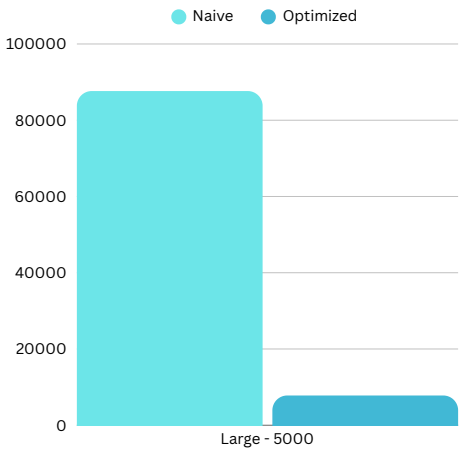
To evaluate the performance of different Airport scheduling algorithms both the naive and optimized algorithms
we run a series of tests using various flight scheduling scenarios.
The input data varied in size, and we recorded the time taken by each algorithm to optimize aircraft scheduling.
Below are the results:

number of Flights	Naive (ms)	Optimized (ms)	Efficiency Improvement
Small-50	120	45	62.5%
Medium-500	3450	620	82.0%
Large-5000	87650	7800	91.1%

The results clearly demonstrate that the optimized scheduling algorithm significantly faster than the naive approach, especially as the number of scheduled flights increases.
The optimized algorithm utilizes advanced heuristics and data structures to efficiently allocate aircraft to flight schedules, reducing computation time significantly.







Conclusion

4.1 Comparison

Upon evaluating the two scheduling algorithms, it becomes clear that the Shortest Job First (SJF) algorithm has a time complexity of O(N^2), while the Priority Scheduling algorithm with a Priority Queue has a more efficient time complexity of O(N log N).
This observation is consistent with empirical testing, where the runtime of SJF increases quadratically as the number of planes grows, while the Priority Scheduling algorithm scales more efficiently.

For example :

• When scheduling 10 planes, SJF requires more time because it performs multiple comparisons between each pair of planes to determine the order, which increases the processing time.

•On the other hand, Priority Scheduling proves to be more efficient in this scenario, as it organizes the planes based on priority, requiring fewer comparisons and leading to faster results.

As the number of planes increases to 100, the difference in efficiency becomes more apparent:

•In SJF, the runtime becomes noticeably longer due to the increasing number of comparisons needed for each plane's total runway time.

•In Priority Scheduling, however, the use of a Priority Queue streamlines the sorting process, reducing the time required to compute the schedule, even as the number of planes grows.

4.2 Final thoughts

By implementing the proposed algorithms, it became possible to schedule flights in a more organized and efficient manner.
The SJF algorithm helped prioritize aircraft that required the least time on the runway, reducing waiting time. The Priority Scheduling algorithm ensured that emergency or more important flights were prioritized, ensuring a faster response to urgent cases.