Uebung3

Benötigte Pakete:

```
- Oracle-Pandas: 'pip install pandas-oracle',
https://github.com/cwade/pandas_oracle
- cx_Oracle: siehe unten
- Seaborn, Pandas, Numpy, etc
```

Anleitung:

- Installiert `cx_Oracle`
- Ladet den Oracle Instant Client herunter:
  https://www.oracle.com/database/technologies/instant-client/downloads.html
- Führt die entsprechenden Installationsanweisungen durch

In [1]:
```
# Bei Bedarf auskommentieren
!python -m pip install cx_Oracle --upgrade
!python -m pip install pandas-oracle
```

```
Requirement already satisfied: cx_Oracle in /opt/anaconda3/envs/data/lib/python3.1
1/site-packages (8.3.0)
Requirement already satisfied: pandas-oracle in /opt/anaconda3/envs/data/lib/python
3.11/site-packages (2.1.4)
Requirement already satisfied: pandas in /opt/anaconda3/envs/data/lib/python3.11/si
te-packages (from pandas-oracle) (2.2.3)
Requirement already satisfied: cx-Oracle in /opt/anaconda3/envs/data/lib/python3.1
1/site-packages (from pandas-oracle) (8.3.0)
Requirement already satisfied: pyaml in /opt/anaconda3/envs/data/lib/python3.11/sit
e-packages (from pandas-oracle) (24.12.1)
Requirement already satisfied: numpy>=1.23.2 in /opt/anaconda3/envs/data/lib/python
3.11/site-packages (from pandas->pandas-oracle) (1.26.4)
Requirement already satisfied: python-dateutil>=2.8.2 in /opt/anaconda3/envs/data/l
ib/python3.11/site-packages (from pandas->pandas-oracle) (2.9.0)
Requirement already satisfied: pytz>=2020.1 in /opt/anaconda3/envs/data/lib/python
3.11/site-packages (from pandas->pandas-oracle) (2024.1)
Requirement already satisfied: tzdata>=2022.7 in /opt/anaconda3/envs/data/lib/pytho
n3.11/site-packages (from pandas->pandas-oracle) (2023.3)
Requirement already satisfied: PyYAML in /opt/anaconda3/envs/data/lib/python3.11/si
te-packages (from pyaml->pandas-oracle) (6.0.2)
Requirement already satisfied: six>=1.5 in /opt/anaconda3/envs/data/lib/python3.11/
site-packages (from python-dateutil>=2.8.2->pandas->pandas-oracle) (1.16.0)
```

Pfad setzen

In [2]:
```
import cx_Oracle

# Pfad anpassen!!
path_to_instant_client = "/Users/luhangfang/Documents/Software/instantclient_23_3"
try:
    cx_Oracle.init_oracle_client(lib_dir=path_to_instant_client)
except cx_Oracle.ProgrammingError as e:
    if "already been initialized" not in str(e):
        raise
```

HU-VPN aktivieren oder in HU-Netzwerk (WLAN) einloggen.

Anleitungen: https://www.cms.hu-berlin.de/de/dl/netze/vpn

Verbindungsdaten:

Die Verbindungsdaten werden in `config.yml` gespeichert. Die Datein *muss* im gleichen Ordner liegen.

In [3]:
```
import cx_Oracle

import pandas_oracle.tools as pt
import numpy as np
import pandas as pd

# visualization
import seaborn as sns
import matplotlib.pyplot as plt
import folium
from folium import plugins
```

Verbindungsaufbau:

In [4]:
```
def run_query(query) :
    ## opening conn
    conn = pt.open_connection("config.yml")

    try:
        ## passing the conn object to the query_to_df
        df1 = pt.query_to_df(query, conn, 10000)
        return df1
    except Exception as e:
        print("An exception occurred")
        print(str(e))
    finally:
        ## close connection
        pt.close_connection(conn)
```

Wichtig: die Verbindungs zur DB muss geschlossen werden, wenn ein Fehler auftritt.

EXPLAIN PLAN

In [5]:
```
def explain_plan_query(query) :
    ## opening conn
    conn = pt.open_connection("config.yml")
    try:
        # There is small change
        #  ("+query+")" => " + query
        # query_explain = "EXPLAIN PLAN FOR ("+query+")"
        query_explain = "EXPLAIN PLAN FOR " + query
        pt.execute(query_explain, conn)
        query2 = "SELECT PLAN_TABLE_OUTPUT FROM TABLE(DBMS_XPLAN.DISPLAY())"

        df = pt.query_to_df(query2, conn, 10000)
        return df
    except Exception as e:
        print("An exception occurred:", str(e))
```

```
    finally:
        ## close connection
        pt.close_connection(conn)
```

In [6]:
```
query = "SELECT * FROM delays"
df = explain_plan_query(query)

print(df.to_string())
```

```
                                                                                PLAN_TABLE_OUTPUT
0                                                                     Plan hash value: 3893133417
1
2   ------------------------------------------------------------------------------------------
3   | Id  | Operation          | Name   | Rows  | Bytes | Cost (%CPU)| Time     |
4   ------------------------------------------------------------------------------------------
5   |   0 | SELECT STATEMENT   |        |  5332K|   472M| 22662   (2)| 00:00:01 |
6   |   1 |  TABLE ACCESS FULL| DELAYS |  5332K|   472M| 22662   (2)| 00:00:01 |
7   ------------------------------------------------------------------------------------------
```

1.Ursache der Verspätung

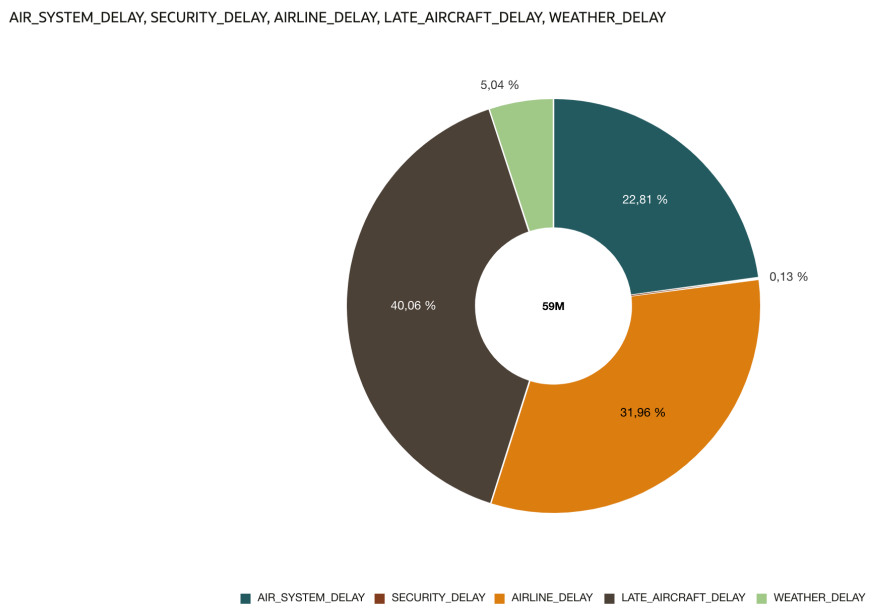
SQL

In [ ]:
```
# Old Query
#
# query1_1 = """
# SELECT
#     CASE
#         WHEN delay_type = 'air_system_delay' THEN 'Air System Delay'
#         WHEN delay_type = 'security_delay' THEN 'Security Delay'
#         WHEN delay_type = 'airline_delay' THEN 'Airline Delay'
#         WHEN delay_type = 'late_aircraft_delay' THEN 'Late Aircraft Delay'
#         WHEN delay_type = 'weather_delay' THEN 'Weather Delay'
#     END as delay_category,
#     SUM(delay_minutes) as total_minutes,
#     ROUND(SUM(delay_minutes) * 100.0 / SUM(SUM(delay_minutes)) OVER (), 2) as per
# FROM (
#     SELECT 'air_system_delay' as delay_type, COALESCE(air_system_delay, 0) as del
#     UNION ALL
#     SELECT 'security_delay', COALESCE(security_delay, 0) FROM delays
#     UNION ALL
#     SELECT 'airline_delay', COALESCE(airline_delay, 0) FROM delays
#     UNION ALL
#     SELECT 'late_aircraft_delay', COALESCE(late_aircraft_delay, 0) FROM delays
#     UNION ALL
#     SELECT 'weather_delay', COALESCE(weather_delay, 0) FROM delays
# ) unpivoted
# GROUP BY delay_type
# HAVING SUM(delay_minutes) > 0
# ORDER BY total_minutes DESC
# """

# New Query
query1_1 = """
SELECT
SUM(air_system_delay) AS air_system_delay,
SUM(security_delay) AS security_delay,
SUM(airline_delay) AS airline_delay,
SUM(late_aircraft_delay) AS late_aircraft_delay,
SUM(weather_delay) AS weather_delay
FROM delays d
WHERE d.arrival_delay > 0
"""
df1_1 = run_query(query1_1)
df1_1
```

Out[ ]:

	AIR_SYSTEM_DELAY	SECURITY_DELAY	AIRLINE_DELAY	LATE_AIRCRAFT_DELAY	WEATHER
0	13533065	77945	18966945	23767674	

Visualisierung



EXPLAIN PLAN und Indices

In [ ]:

```
# Index Vorschlag
query1_2 = """
CREATE INDEX idx_delay_delays ON delays (
    air_system_delay,
    security_delay,
    airline_delay,
    late_aircraft_delay,
    weather_delay
)
"""

# Explain Plan
df1_3 = explain_plan_query(query1_1)
print(df1_3.to_string())
```

```
                                                                                PLAN_TABLE_OUTPUT
0                                                                     Plan hash value: 2933321896
1
2   ------------------------------------------------------------------------------------------
3   | Id  | Operation          | Name    | Rows  | Bytes | Cost (%CPU)| Time     |
4   ------------------------------------------------------------------------------------------
5   |   0 | SELECT STATEMENT   |         |     1 |    14 | 22650   (2)| 00:00:01 |
6   |   1 |  SORT AGGREGATE    |         |     1 |    14 |            |          |
7   |*  2 |   TABLE ACCESS FULL| DELAYS  |  1899K|    25M| 22650   (2)| 00:00:01 |
8   ------------------------------------------------------------------------------------------
9
10                                Predicate Information (identified by operation id):
11                                ---------------------------------------------------
12
13                                                    2 - filter("D"."ARRIVAL_DELAY">0)
```

3.2 Analyse:Region

3.2.1 SQL

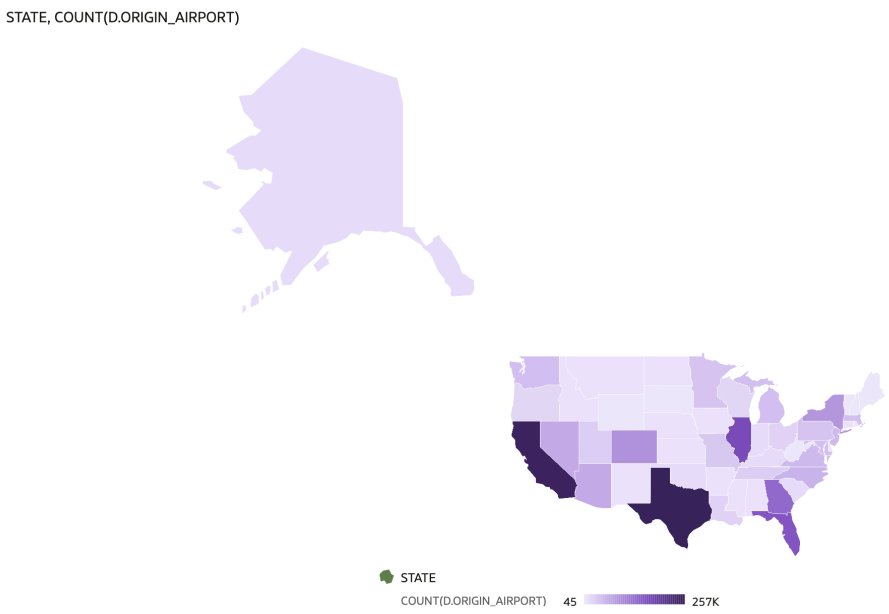
In [ ]:
```
# Old Query
#
# query2_1 ="""
# SELECT
#     f.origin_state as STATE,
#     f.origin_airport as AIRPORT,
#     f.origin_city as City,
#     f.origin_latitude/100000.0 as LATITUDE,
#     f.origin_longitude/100000.0 as LONGITUDE,
#     COUNT(*) as TOTAL_FLIGHTS,
#     SUM(CASE WHEN d.departure_delay > 0 THEN 1 ELSE 0 END) as DELAYED_FLIGHTS,
#     ROUND(SUM(CASE WHEN d.departure_delay > 0 THEN 1 ELSE 0 END) * 100.0 / COUNT(
#     ROUND(AVG(CASE WHEN d.departure_delay > 0 THEN d.departure_delay ELSE NULL EN
# FROM Flight f
# JOIN Delays d ON f.flight_id = d.flight_id
# GROUP BY
#     f.origin_state,
#     f.origin_airport,
#     f.origin_city,
#     f.origin_latitude,
#     f.origin_longitude
# HAVING COUNT(*) > 100
# """


# New Query
query2_1 ="""
select count(d.origin_airport),a.airport, a.state
from delays d
join airport a
on d.origin_airport = a.iata_code
where d.departure_delay > 0
group by a.state, a.airport
order by a.state
"""
df2_1 = run_query(query2_1)
df2_1
```

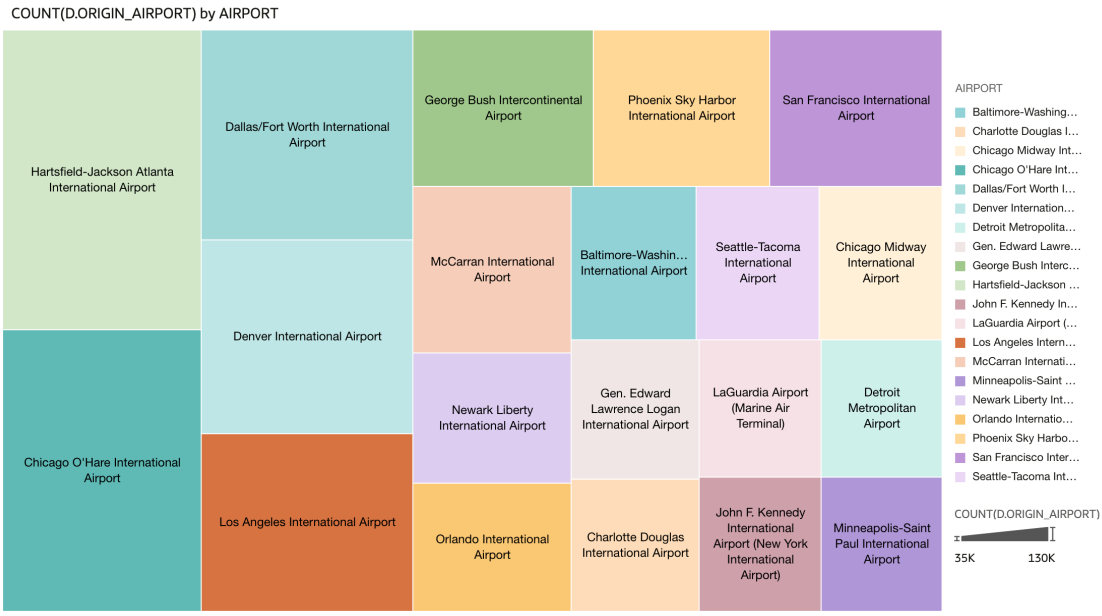
Out[ ]:

	COUNT(D.ORIGIN_AIRPORT)	AIRPORT	STATE
0	55	Adak Airport	AK
1	257	Bethel Airport	AK
2	230	Deadhorse Airport (Prudhoe Bay Airport)	AK
3	25	Dillingham Airport	AK
4	563	Fairbanks International Airport	AK
...	...	...	...
317	903	Jackson Hole Airport	WY
318	110	Laramie Regional Airport	WY
319	319	Natrona County International Airport	WY
320	114	Rock Springs-Sweetwater County Airport	WY
321	207	Yellowstone Regional Airport	WY

322 rows × 3 columns

Visualisierung





EXPLAIN PLAN und Indices

In [ ]:
```
# Index Vorschlag
query2_2 = """
-- Create Index: airport name and state
CREATE INDEX idx_state_airport ON airport (state, airport);
"""

# Explain Plan
df2_3 = explain_plan_query(query2_1)
print(df2_3.to_string())
```

```
                                                                    PLAN_TABLE_OUT
PUT
0                                                                Plan hash value: 3775427
858
1
2   ------------------------------------------------------------------------------------
---
3   | Id  | Operation             | Name     | Rows  | Bytes | Cost (%CPU)| Time
|
4   ------------------------------------------------------------------------------------
---
5   |   0 | SELECT STATEMENT      |          |   322 | 18676 | 22696   (2)| 00:00:0
1 |
6   |   1 |  SORT GROUP BY        |          |   322 | 18676 | 22696   (2)| 00:00:0
1 |
7   |*  2 |   HASH JOIN           |          |   322 | 18676 | 22695   (2)| 00:00:0
1 |
8   |   3 |    VIEW               | VW_GBC_5 |   322 |  5474 | 22692   (2)| 00:00:0
1 |
9   |   4 |     HASH GROUP BY     |          |   322 |  2576 | 22692   (2)| 00:00:0
1 |
10  |*  5 |      TABLE ACCESS FULL| DELAYS   |  2002K|    15M| 22550   (1)| 00:00:0
1 |
11  |   6 |    TABLE ACCESS FULL  | AIRPORT  |   322 | 13202 |     3   (0)| 00:00:0
1 |
12  ------------------------------------------------------------------------------------
---
13
14                                 Predicate Information (identified by operation i
d):
15                                 ---------------------------------------------------
---
16
17                                              2 - access("ITEM_1"="A"."IATA_COD
E")
18                                               5 - filter("D"."DEPARTURE_DELA
Y">0)
```

3.Analyse:Weather

3.1 10 Tage meisten Stornierungen wegen Wetter

SQL

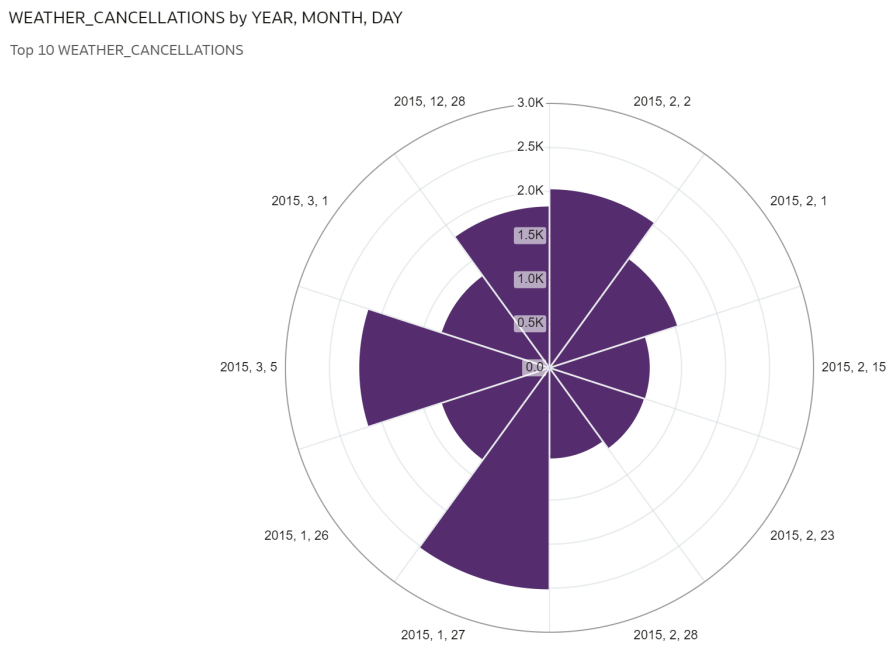
In [14]:
```sql
# Query 1: Top 10 days with most weather-related cancellations
query3_1 = """
SELECT
    f.year,
    f.month,
    f.day,
    COUNT(*) as WEATHER_CANCELLATIONS,
    ROUND(COUNT(*) * 100.0 / (SELECT COUNT(*)
                              FROM Delays
                              WHERE cancelled = 1
                              AND cancellation_reason = 'B'), 2) as PERCENTAGE_OF_T
FROM Delays f
WHERE f.cancelled = 1
AND f.cancellation_reason = 'B'
GROUP BY f.year, f.month, f.day
"""
df3_1 = run_query(query3_1)
df3_1
```

Out[14]:

	YEAR	MONTH	DAY	WEATHER_CANCELLATIONS	PERCENTAGE_OF_TOTAL
0	2015	1	9	136	0.28
1	2015	1	14	81	0.17
2	2015	1	15	27	0.06
3	2015	1	16	19	0.04
4	2015	2	6	135	0.28
...	...	...	...	...	...
326	2015	11	30	30	0.06
327	2015	12	8	34	0.07
328	2015	12	11	14	0.03
329	2015	12	10	22	0.05
330	2015	12	18	72	0.15

331 rows × 5 columns

Visualisierung



EXPLAIN PLAN und Indices

In [15]:
```
# Index Vorschlag
query3_2 = """
-- Index for cancelled reason
CREATE INDEX idx_delays_cancel ON Delays(cancelled, cancellation_reason);

-- special for date
CREATE INDEX idx_delays_date ON Delays(year, month, day);
"""

# Explain Plan
df3_3 = explain_plan_query(query3_1)
print(df3_3.to_string())
```

```
                                                                    PLAN_TABLE_OUTPUT
0                                                                 Plan hash value: 1046980958
1
2   ----------------------------------------------------------------------------------------
3   | Id  | Operation          | Name   | Rows  | Bytes | Cost (%CPU)| Time     |
4   ----------------------------------------------------------------------------------------
5   |   0 | SELECT STATEMENT   |        |   331 |  4965 | 45240   (2)| 00:00:02 |
6   |   1 |  SORT AGGREGATE    |        |     1 |     5 |            |          |
7   |*  2 |   TABLE ACCESS FULL| DELAYS | 47874 |   233K| 22618   (2)| 00:00:01 |
8   |   3 |  HASH GROUP BY     |        |   331 |  4965 | 45240   (2)| 00:00:02 |
9   |*  4 |   TABLE ACCESS FULL| DELAYS | 47874 |   701K| 22618   (2)| 00:00:01 |
10  ----------------------------------------------------------------------------------------
11
12                            Predicate Information (identified by operation id):
13                            ---------------------------------------------------
14
15                         2 - filter("CANCELLED"=1 AND "CANCELLATION_REASON"='B')
16                 4 - filter("F"."CANCELLED"=1 AND "F"."CANCELLATION_REASON"='B')
17
18                                                                          Note
19                                                                          -----
20                           - dynamic statistics used: dynamic sampling (level=2)
21                                  - 1 Sql Plan Directive used for this statement
```

3.2 An welchen Flughafen

SQL

In [16]:

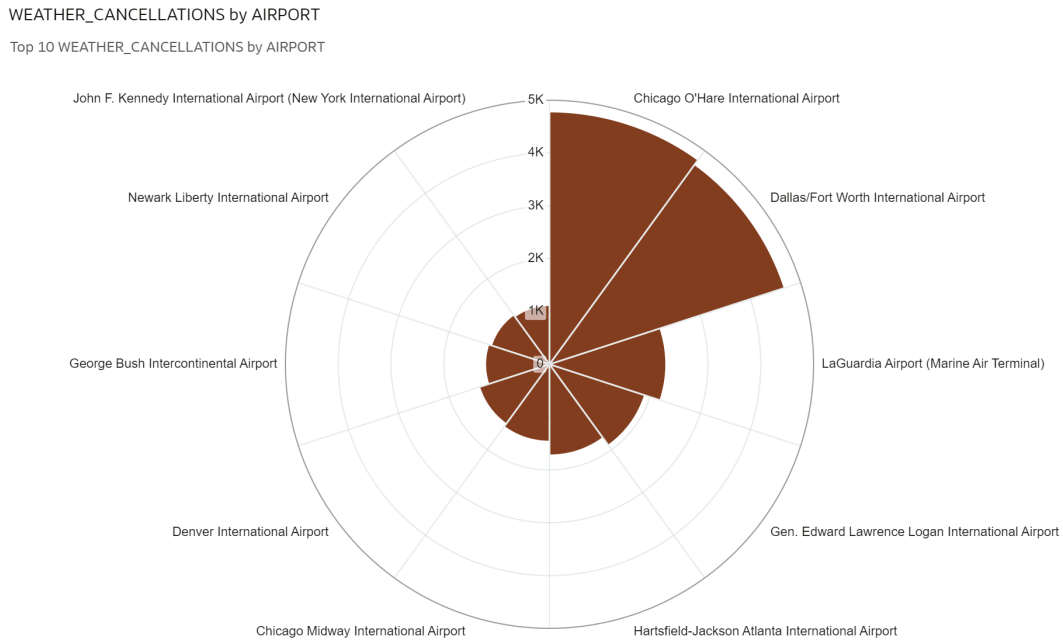
```
query3_4 = """
SELECT
    f.origin_state as STATE,
    f.origin_airport as AIRPORT,
    COUNT(*) as TOTAL_CANCELLATIONS,
    SUM(CASE WHEN d.cancellation_reason = 'B' THEN 1 ELSE 0 END) as WEATHER_CANCELL
    ROUND(
        (SUM(CASE WHEN d.cancellation_reason = 'B' THEN 1 ELSE 0 END) * 100.0) /
        NULLIF(COUNT(*), 0),
        2
    ) as CANCELLATION_PERCENTAGE,
    COUNT(DISTINCT TRUNC(f.scheduled_departure)) as AFFECTED_DAYS
FROM Flight f
JOIN Delays d ON f.flight_id = d.flight_id
WHERE d.cancelled = 1
GROUP BY
    f.origin_state,
    f.origin_airport
HAVING SUM(CASE WHEN d.cancellation_reason = 'B' THEN 1 ELSE 0 END) > 0
ORDER BY WEATHER_CANCELLATIONS DESC
"""
df3_4 = run_query(query3_4)
df3_4
```

Out[16]:

	STATE	AIRPORT	TOTAL_CANCELLATIONS	WEATHER_CANCELLATIONS	CANCELLATIO
0	IL	Chicago O'Hare International Airport	8547	4769	
1	TX	Dallas/Fort Worth International Airport	6254	4664	
2	NY	LaGuardia Airport (Marine Air Terminal)	4531	2191	
3	MA	Gen. Edward Lawrence Logan International Airport	2654	1882	
4	GA	Hartsfield-Jackson Atlanta International Airport	2557	1707	
...	...	...	...	...	
306	UT	Canyonlands Field	1	1	
307	NY	Plattsburgh International Airport	2	1	
308	HI	Lihue Airport	44	1	
309	NY	Ithaca Tompkins Regional Airport	4	1	
310	ME	Bangor International Airport	3	1	

311 rows × 6 columns

Visualisierung



EXPLAIN PLAN und Indices

In [17]:

```
# Index Vorschlag
query3_5 = """
-- Index for flight_id and cancelled
CREATE INDEX idx_delays_cancel ON Delays(
    cancelled,
    cancellation_reason,
    flight_id
);

-- Composite index for grouping columns on Flight table
CREATE INDEX idx_flight_origin ON Flight(
    origin_state,
    origin_airport,
    scheduled_departure,
    xxx
);
"""

# Explain Plan
df3_5 = explain_plan_query(query3_4)
print(df3_5.to_string())
```

```
                                                                                PLAN
_TABLE_OUTPUT
0                                                                             Plan hash valu
e: 2411417394
1
2   ------------------------------------------------------------------------------------
-------------
3   | Id  | Operation               | Name     | Rows  | Bytes |TempSpc| Cost (%CP
U)| Time     |
4   ------------------------------------------------------------------------------------
-------------
5   |   0 | SELECT STATEMENT        |          |   615 | 57195 |       | 26620
(2)| 00:00:02 |
6   |   1 |  SORT ORDER BY          |          |   615 | 57195 |       | 26620
(2)| 00:00:02 |
7   |*  2 |   FILTER                |          |       |       |       |
|          |
8   |   3 |    HASH GROUP BY        |          |   615 | 57195 |       | 26620
(2)| 00:00:02 |
9   |   4 |     VIEW                | VW_DAG_0 | 23655 |  2148K|       | 26616
(2)| 00:00:02 |
10  |   5 |      HASH GROUP BY      |          | 23655 |  1409K|  6552K| 26616
(2)| 00:00:02 |
11  |*  6 |       HASH JOIN         |          | 87429 |  5208K|       | 25929
(2)| 00:00:02 |
12  |*  7 |        TABLE ACCESS FULL| DELAYS   | 87430 |   853K|       | 22602
(2)| 00:00:01 |
13  |   8 |        TABLE ACCESS FULL| FLIGHT   |   493K|    24M|       |  3322
(1)| 00:00:01 |
14  ------------------------------------------------------------------------------------
-------------
15
16                                          Predicate Information (identified by o
peration id):
17                                          ---------------------------------------
-------------
18
19                                                                  2 - filter(SUM
("ITEM_4")>0)
20                                                 6 - access("F"."FLIGHT_I
D"="D"."FLIGHT_ID")
21                                                               7 - filter
("D"."CANCELLED"=1)
22
23
Note
24
-----
25                                        - dynamic statistics used: dynamic sampl
ing (level=2)
26                                               - 1 Sql Plan Directive used for t
his statement
```

4. Beste Zeit

4.1 Wochentage

SQL

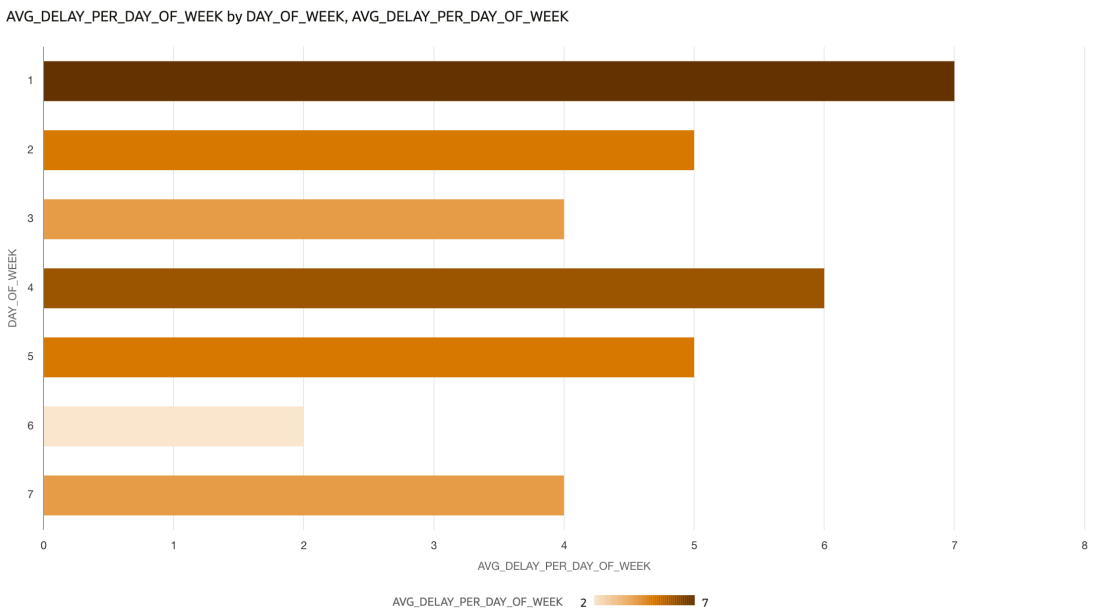
In [10]:
```
# query4_1 = """
# SELECT
#     t.DAY_OF_WEEK AS DAY_OF_WEEK,
#     ROUND(AVG(f.DEPARTURE_DELAY +
#         NVL(f.TAXI_OUT, 0) +
#         NVL(f.SECURITY_DELAY, 0) +
```

```
#         NVL(f.AIRLINE_DELAY, 0) +
#         NVL(f.WEATHER_DELAY, 0) +
#         NVL(f.AIR_SYSTEM_DELAY, 0)
#     ), 2) AS AVERAGE_DELAY_MINUTES,
#     COUNT(*) AS TOTAL_FLIGHTS
# FROM DELAYS f
# JOIN TIME t ON
#     f.DAY = t.DAY AND
#     f.MONTH = t.MONTH AND
#     f.YEAR = t.YEAR
# WHERE f.CANCELLED = 0
# GROUP BY t.DAY_OF_WEEK
# ORDER BY AVERAGE_DELAY_MINUTES ASC
# """
query4_1 = """
select
cast(sum(d.arrival_delay) / count(t.day_of_week) as int) as avg_delay_per_day_of_we
t.day_of_week
from delays d
join time t
on d.day=t.day and d.month=t.month
group by t.day_of_week
order by t.day_of_week
"""
df4_1 = run_query(query4_1)
df4_1
```

Out[10]:

	AVG_DELAY_PER_DAY_OF_WEEK	DAY_OF_WEEK
0	7	1
1	5	2
2	4	3
3	6	4
4	5	5
5	2	6
6	4	7

Visualisierung



EXPLAIN PLAN und Indices

In [17]:
```
# Index Vorschlag
query4_2 = """
-- Index for time table with day of week
CREATE INDEX idx_time_day_month_dow ON time (day, month, day_of_week);
"""

# Explain Plan
df4_3 = explain_plan_query(query4_1)
print(df4_3.to_string())
```

```
                                                                                PLAN_TABLE_OUTPUT
0                                                                     Plan hash value: 3015434639
1
2   ------------------------------------------------------------------------------------------
3   | Id  | Operation           | Name    | Rows  | Bytes | Cost (%CPU)| Time     |
4   ------------------------------------------------------------------------------------------
5   |   0 | SELECT STATEMENT    |         |     7 |   133 | 23076   (4)| 00:00:01 |
6   |   1 |  SORT GROUP BY      |         |     7 |   133 | 23076   (4)| 00:00:01 |
7   |*  2 |   HASH JOIN         |         |  5332K|    96M| 22673   (2)| 00:00:01 |
8   |   3 |    TABLE ACCESS FULL| TIME    |   365 |  3285 |     3   (0)| 00:00:01 |
9   |   4 |    TABLE ACCESS FULL| DELAYS  |  5332K|    50M| 22630   (2)| 00:00:01 |
10  ------------------------------------------------------------------------------------------
11
12                              Predicate Information (identified by operation id):
13                              ---------------------------------------------------
14
15                    2 - access("D"."DAY"="T"."DAY" AND "D"."MONTH"="T"."MONTH")
```

4.2 Sationale Unterschiede

SQL

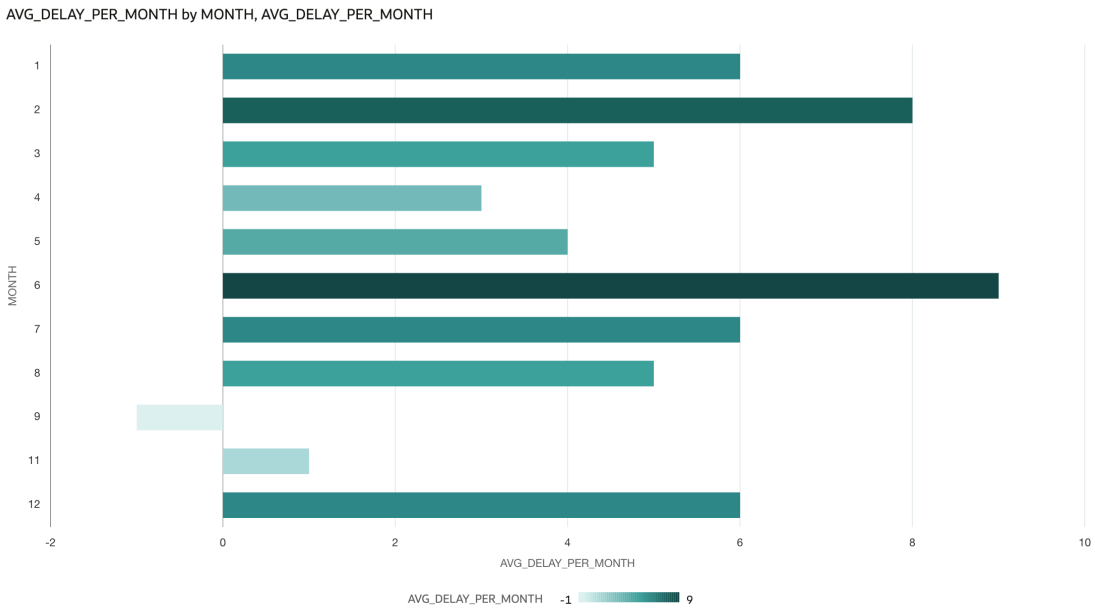
In [13]:
```
# query4_4 = """
# SELECT
#     t.MONTH AS MONTH,
#     ROUND(AVG(
#         NVL(f.DEPARTURE_DELAY, 0) +
#         NVL(f.TAXI_OUT, 0) +
#         NVL(f.SECURITY_DELAY, 0) +
#         NVL(f.AIRLINE_DELAY, 0) +
#         NVL(f.WEATHER_DELAY, 0) +
#         NVL(f.AIR_SYSTEM_DELAY, 0)
#     ), 2) AS AVERAGE_DELAY_MINUTES,
#     COUNT(*) AS TOTAL_FLIGHTS
# FROM DELAYS f
# JOIN TIME t ON
#     f.DAY = t.DAY AND
#     f.MONTH = t.MONTH AND
#     f.YEAR = t.YEAR
# WHERE f.CANCELLED = 0
# GROUP BY t.MONTH
# ORDER BY t.MONTH ASC
# """

query4_4 = """
select
cast(sum(d.arrival_delay) / count(d.month) as int)as avg_delay_per_month,
d.month
from delays d
join time t
on d.day=t.day and d.month=t.month
```

```
group by d.month
order by d.month
"""
df4_4 = run_query(query4_4)
df4_4
```

Out[13]:

	AVG_DELAY_PER_MONTH	MONTH
0	6	1
1	8	2
2	5	3
3	3	4
4	4	5
5	9	6
6	6	7
7	5	8
8	-1	9
9	1	11
10	6	12

Visualisierung



EXPLAIN PLAN und Indices

In [18]:

```
# Index Vorschlag
query4_5 = """
--Index Date and arrival delay
CREATE INDEX idx_delays_day_month_year_arrival ON delays (day, month, year, arrival
"""

# Explain Plan
df4_5 = explain_plan_query(query4_4)
print(df4_5.to_string())
```

```
                                                                    PLAN_TABLE_OUTPUT
0                                                                 Plan hash value: 2036356653
1
2   ------------------------------------------------------------------------------------------
3   | Id  | Operation           | Name    | Rows  | Bytes | Cost (%CPU)| Time     |
4   ------------------------------------------------------------------------------------------
5   |   0 | SELECT STATEMENT    |         |    11 |   176 | 23074   (4)| 00:00:01 |
6   |   1 |  SORT GROUP BY      |         |    11 |   176 | 23074   (4)| 00:00:01 |
7   |*  2 |   HASH JOIN         |         |  5332K|    81M| 22671   (2)| 00:00:01 |
8   |   3 |    INDEX FULL SCAN  | PK_TIME |   365 |  2190 |     1   (0)| 00:00:01 |
9   |   4 |    TABLE ACCESS FULL| DELAYS  |  5332K|    50M| 22630   (2)| 00:00:01 |
10  ------------------------------------------------------------------------------------------
11
12                              Predicate Information (identified by operation id):
13                              ---------------------------------------------------
14
15                    2 - access("D"."DAY"="T"."DAY" AND "D"."MONTH"="T"."MONTH")
```

5. Analyse: Fluglinien

5.1 Fluglinien mit meisten Flügen

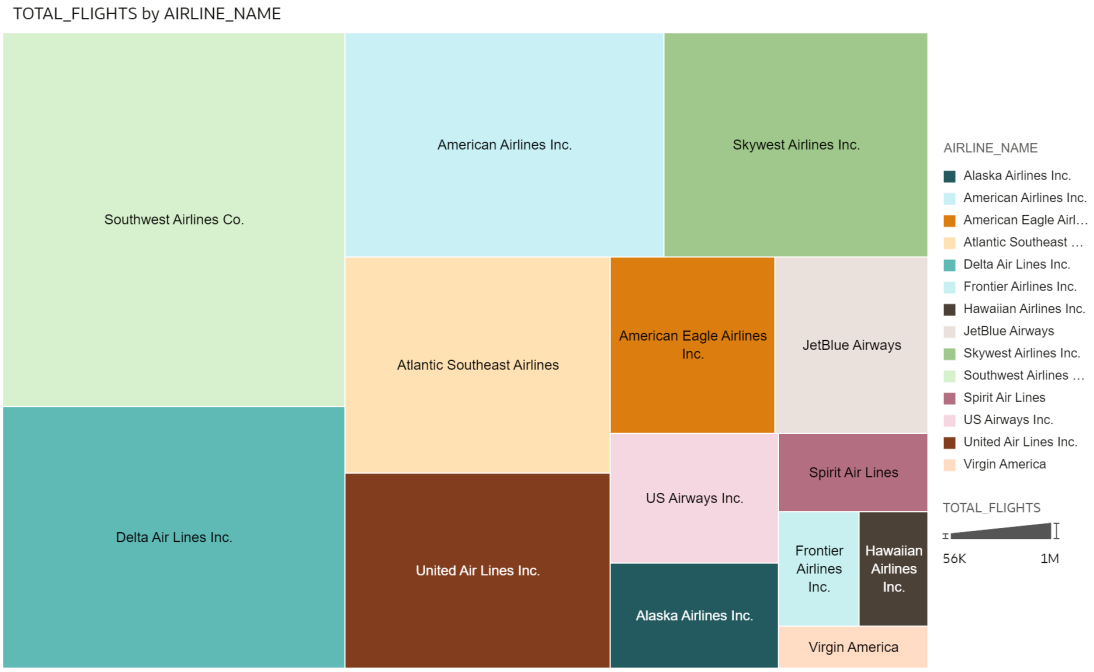
SQL

In [23]:
```
query5_1 ="""
SELECT
    a.AIRLINE AS AIRLINE_NAME,
    COUNT(*) AS TOTAL_FLIGHTS
FROM DELAYS f
JOIN AIRLINE a ON f.AIRLINE_IATA = a.IATA_CODE
WHERE f.CANCELLED = 0
GROUP BY a.AIRLINE
ORDER BY TOTAL_FLIGHTS DESC
"""
df5_1 = run_query(query5_1)
df5_1
```

Out[23]:

	AIRLINE_NAME	TOTAL_FLIGHTS
0	Southwest Airlines Co.	1141618
1	Delta Air Lines Inc.	796522
2	American Airlines Inc.	638500
3	Skywest Airlines Inc.	529826
4	Atlantic Southeast Airlines	511495
5	United Air Lines Inc.	463384
6	American Eagle Airlines Inc.	257898
7	JetBlue Airways	240989
8	US Airways Inc.	194648
9	Alaska Airlines Inc.	157418
10	Spirit Air Lines	105228
11	Frontier Airlines Inc.	82159
12	Hawaiian Airlines Inc.	69871
13	Virgin America	55928

Visualisierung



EXPLAIN PLAN und Indices

In [24]:
```
# Index Vorschlag
query5_2 = """
-- Index for the JOIN condition on Delays table
CREATE INDEX idx_delays_airline ON Delays(
    airline_iata,
    cancelled
);

-- Index for airline lookup
CREATE INDEX idx_airline_iata ON Airline(
    iata_code,
    airline
);
"""

# Explain Plan
df5_3 = explain_plan_query(query5_1)
print(df5_3.to_string())
```

```
                                                                    PLAN_TABLE_OUTPU
T
0                                                                 Plan hash value: 79856489
2
1
2   ------------------------------------------------------------------------------------
-
3   | Id  | Operation            | Name    | Rows  | Bytes | Cost (%CPU)| Time
|
4   ------------------------------------------------------------------------------------
-
5   |   0 | SELECT STATEMENT     |         |    14 |   434 | 23483   (5)| 00:00:01
|
6   |   1 |  SORT ORDER BY       |         |    14 |   434 | 23483   (5)| 00:00:01
|
7   |   2 |   HASH GROUP BY      |         |    14 |   434 | 23483   (5)| 00:00:01
|
8   |*  3 |    HASH JOIN         |         |  5245K|   155M| 22691   (2)| 00:00:01
|
9   |   4 |     TABLE ACCESS FULL| AIRLINE |    14 |   350 |     3   (0)| 00:00:01
|
10  |*  5 |     TABLE ACCESS FULL| DELAYS  |  5245K|    30M| 22649   (2)| 00:00:01
|
11  ------------------------------------------------------------------------------------
-
12
13                              Predicate Information (identified by operation i
d):
14                              ---------------------------------------------------
-
15
16                                   3 - access("F"."AIRLINE_IATA"="A"."IATA_COD
E")
17                                                 5 - filter("F"."CANCELLED"=
0)
```

5.2 Fluglinien mit höchste Verspätungen

SQL

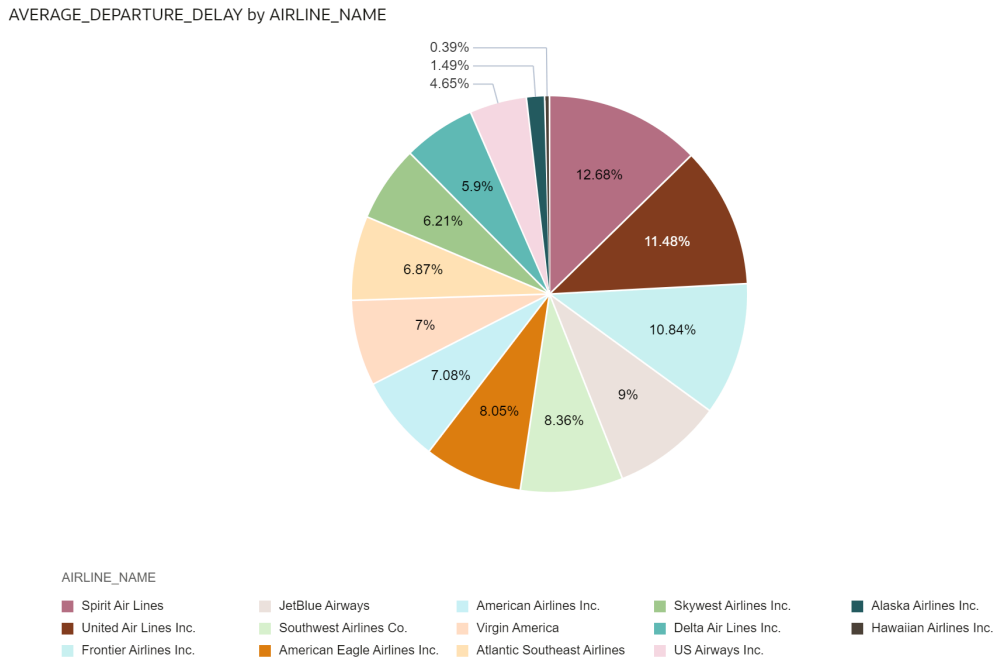
In [25]:

```
query5_4 = """
SELECT
    a.AIRLINE AS AIRLINE_NAME,
    ROUND(AVG(f.DEPARTURE_DELAY), 2) AS AVERAGE_DEPARTURE_DELAY
FROM DELAYS f
JOIN AIRLINE a ON f.AIRLINE_IATA = a.IATA_CODE
WHERE f.CANCELLED = 0
  AND f.DEPARTURE_DELAY IS NOT NULL
GROUP BY a.AIRLINE
ORDER BY AVERAGE_DEPARTURE_DELAY DESC
"""
df5_4 = run_query(query5_4)
df5_4
```

Out[25]:

	AIRLINE_NAME	AVERAGE_DEPARTURE_DELAY
0	Spirit Air Lines	16.65
1	United Air Lines Inc.	15.07
2	Frontier Airlines Inc.	14.23
3	JetBlue Airways	11.81
4	Southwest Airlines Co.	10.98
5	American Eagle Airlines Inc.	10.57
6	American Airlines Inc.	9.29
7	Virgin America	9.19
8	Atlantic Southeast Airlines	9.02
9	Skywest Airlines Inc.	8.15
10	Delta Air Lines Inc.	7.75
11	US Airways Inc.	6.11
12	Alaska Airlines Inc.	1.95
13	Hawaiian Airlines Inc.	0.51

Visualisierung



EXPLAIN PLAN und Indices

In [26]:

```
# Index Vorschlag
query5_5 = """
-- maybe as same as before
"""

# Explain Plan
df5_5 = explain_plan_query(query5_4)
print(df5_5.to_string())
```

```
                                                                    PLAN_TABLE_OUTPU
T
0                                                                  Plan hash value: 79856489
2
1
2   ------------------------------------------------------------------------------------
-
3   | Id  | Operation            | Name    | Rows  | Bytes | Cost (%CPU)| Time
|
4   ------------------------------------------------------------------------------------
-
5   |   0 | SELECT STATEMENT     |         |    14 |   490 | 23476   (5)| 00:00:01
|
6   |   1 |  SORT ORDER BY       |         |    14 |   490 | 23476   (5)| 00:00:01
|
7   |   2 |   HASH GROUP BY      |         |    14 |   490 | 23476   (5)| 00:00:01
|
8   |*  3 |    HASH JOIN         |         |  5163K|   172M| 22697   (2)| 00:00:01
|
9   |   4 |     TABLE ACCESS FULL| AIRLINE |    14 |   350 |     3   (0)| 00:00:01
|
10  |*  5 |     TABLE ACCESS FULL| DELAYS  |  5163K|    49M| 22656   (2)| 00:00:01
|
11  ------------------------------------------------------------------------------------
-
12
13                                Predicate Information (identified by operation i
d):
14                                ---------------------------------------------------
-
15
16                                     3 - access("F"."AIRLINE_IATA"="A"."IATA_COD
E")
17                5 - filter("F"."DEPARTURE_DELAY" IS NOT NULL AND "F"."CANCELLED"=
0)
```

6.Beliebte Flüge

6.1 Beliebteste Flüge

SQL

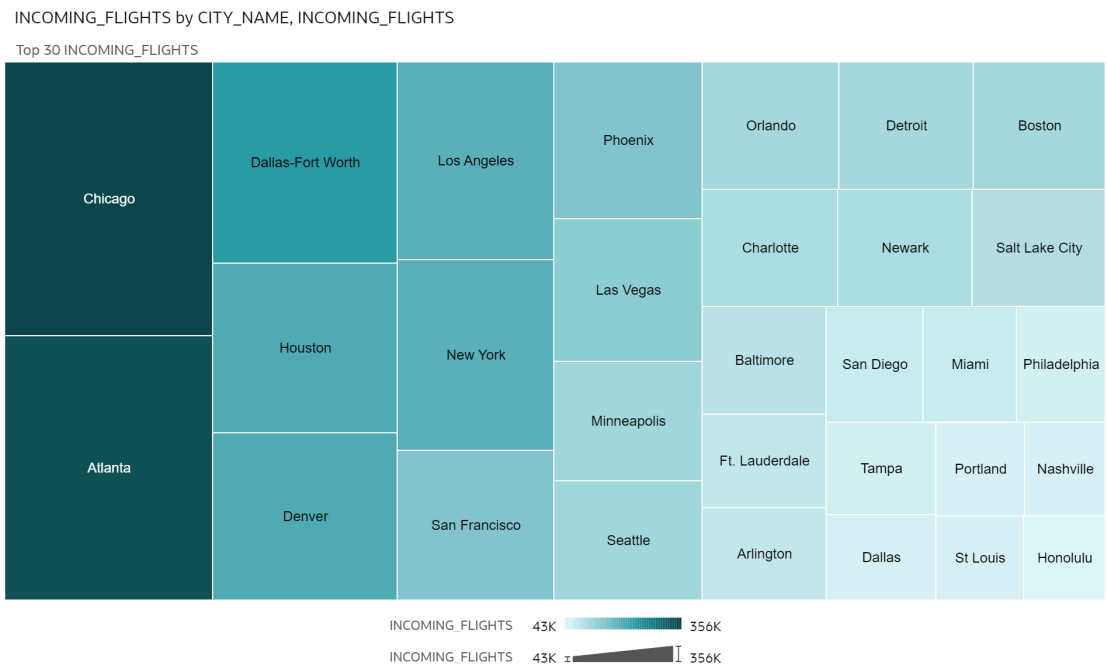
In [27]:
```
query6_1 = """
SELECT
    f.destination_city AS CITY_NAME,
    f.destination_state AS STATE,
    COUNT(*) AS INCOMING_FLIGHTS
FROM FLIGHT f
JOIN DELAYS d ON f.flight_id = d.flight_id
WHERE d.CANCELLED = 0
GROUP BY
    f.destination_city,
    f.destination_state
ORDER BY INCOMING_FLIGHTS DESC
"""
df6_1 = run_query(query6_1)
df6_1
```

Out[27]:

	CITY_NAME	STATE	INCOMING_FLIGHTS
0	Chicago	IL	355664
1	Atlanta	GA	344189
2	Dallas-Fort Worth	TX	232833
3	Houston	TX	195516
4	Denver	CO	193700
...	...	...	...
313	St Cloud	MN	77
314	Dillingham	AK	77
315	Gustavus	AK	76
316	King Salmon	AK	63
317	Ithaca	NY	31

318 rows × 3 columns

Visulaisierung



EXPLAIN PLAN und Indices

In [28]:

```
# Index Vorschlag
query6_2 = """
-- Index for flight_id and cancelled as before
CREATE INDEX idx_delays_flight_id ON Delays(
    flight_id,
    cancelled
);

-- Index for destination name ans state grouping
CREATE INDEX idx_flight_destination ON Flight(
    destination_city,
    destination_state
);
```

```
"""

# Explain Plan
df6_3 = explain_plan_query(query6_1)
print(df6_3.to_string())
```

```
                                                                                PLAN_TABL
E_OUTPUT
0                                                                    Plan hash value: 6
73129677
1
2   ------------------------------------------------------------------------------------
--------
3   | Id  | Operation            | Name    | Rows  | Bytes |TempSpc| Cost (%CPU)| Ti
me     |
4   ------------------------------------------------------------------------------------
--------
5   |   0 | SELECT STATEMENT     |         |   318 |  8268 |       | 32498   (4)| 0
0:00:02 |
6   |   1 |  SORT ORDER BY       |         |   318 |  8268 |       | 32498   (4)| 0
0:00:02 |
7   |   2 |   HASH GROUP BY      |         |   318 |  8268 |       | 32498   (4)| 0
0:00:02 |
8   |*  3 |    HASH JOIN         |         |  5177K|   128M|    14M| 31717   (2)| 0
0:00:02 |
9   |   4 |     TABLE ACCESS FULL| FLIGHT  |   493K|  8678K|       |  3322   (1)| 0
0:00:01 |
10  |*  5 |     TABLE ACCESS FULL| DELAYS  |  5245K|    40M|       | 22649   (2)| 0
0:00:01 |
11  ------------------------------------------------------------------------------------
--------
12
13                                        Predicate Information (identified by operat
ion id):
14                                        ------------------------------------------
--------
15
16                                               3 - access("F"."FLIGHT_ID"="D"."FLI
GHT_ID")
17                                                    5 - filter("D"."CANCE
LLED"=0)
```

6.2 Beliebsteste Abflughafen

SQL

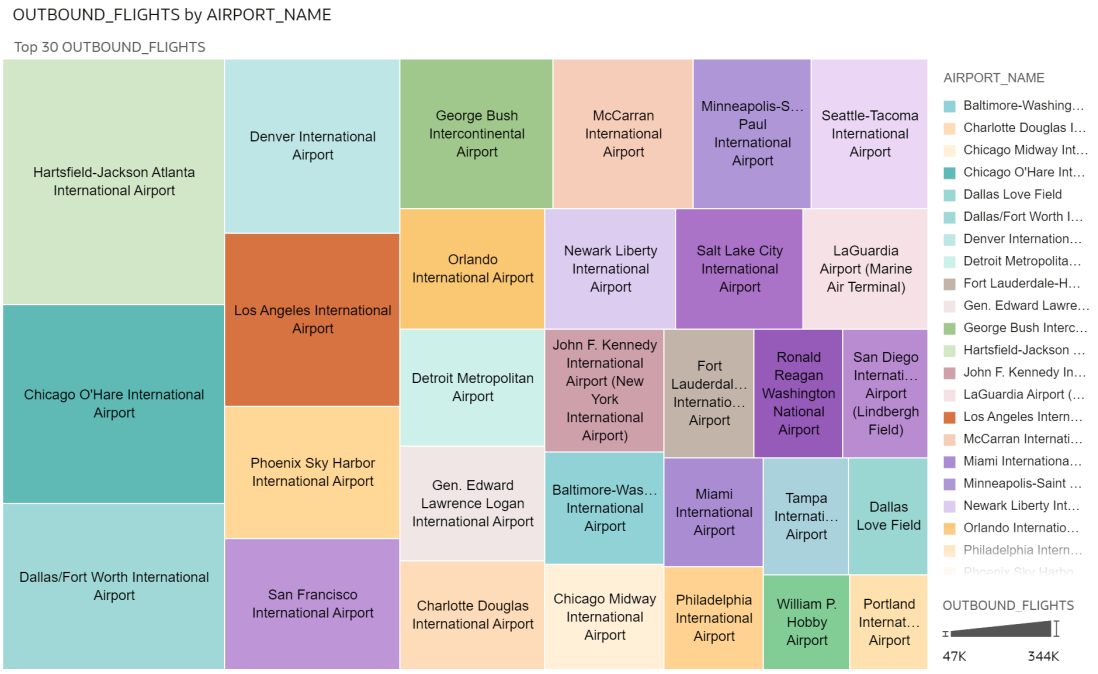
In [30]:
```
query6_4 = """
SELECT
    f.ORIGIN_AIRPORT AS AIRPORT_NAME,
    f.ORIGIN_CITY AS CITY,
    f.ORIGIN_STATE AS STATE,
    COUNT(*) AS OUTBOUND_FLIGHTS
FROM FLIGHT f, DELAYS d
WHERE d.FLIGHT_ID = f.FLIGHT_ID
    AND d.CANCELLED = 0
GROUP BY
    f.ORIGIN_AIRPORT,
    f.ORIGIN_CITY,
    f.ORIGIN_STATE
ORDER BY OUTBOUND_FLIGHTS DESC
"""
df6_4 = run_query(query6_4)
df6_4
```

Out[30]:

	AIRPORT_NAME	CITY	STATE	OUTBOUND_FLIGHTS
0	Hartsfield-Jackson Atlanta International Airport	Atlanta	GA	344279
1	Chicago O'Hare International Airport	Chicago	IL	277336
2	Dallas/Fort Worth International Airport	Dallas-Fort Worth	TX	233297
3	Denver International Airport	Denver	CO	193932
4	Los Angeles International Airport	Los Angeles	CA	192509
...	...	...	...	...
317	St. Cloud Regional Airport	St Cloud	MN	78
318	Dillingham Airport	Dillingham	AK	77
319	Gustavus Airport	Gustavus	AK	76
320	King Salmon Airport	King Salmon	AK	63
321	Ithaca Tompkins Regional Airport	Ithaca	NY	30

322 rows × 4 columns

Visualisierung



EXPLAIN PLAN und Indices

In [31]:

```
# Index Vorschlag
query6_5 = """
-- Index for origin grouping
CREATE INDEX idx_flight_origin ON Flight(
    origin_airport,
    origin_city,
    origin_state
);
"""

# Explain Plan
```

```
df6_5 = explain_plan_query(query6_4)
print(df6_5.to_string())
```

```
                                                                                    PLAN_TABL
E_OUTPUT
0                                                                          Plan hash value: 6
73129677
1
2   -------------------------------------------------------------------------------
--------
3   | Id  | Operation            | Name    | Rows   | Bytes |TempSpc| Cost (%CPU)| Ti
me     |
4   -------------------------------------------------------------------------------
--------
5   |   0 | SELECT STATEMENT     |         | 12296 |   768K|       | 33386   (4)| 0
0:00:02 |
6   |   1 |  SORT ORDER BY       |         | 12296 |   768K|       | 33386   (4)| 0
0:00:02 |
7   |   2 |   HASH GROUP BY      |         | 12296 |   768K|       | 33386   (4)| 0
0:00:02 |
8   |*  3 |    HASH JOIN         |         |  5177K|   316M|    32M| 32605   (2)| 0
0:00:02 |
9   |   4 |     TABLE ACCESS FULL| FLIGHT |   493K|    26M|       |  3322   (1)| 0
0:00:01 |
10  |*  5 |     TABLE ACCESS FULL| DELAYS |  5245K|    40M|       | 22649   (2)| 0
0:00:01 |
11  -------------------------------------------------------------------------------
--------
12
13                                        Predicate Information (identified by operat
ion id):
14                                        -------------------------------------------
--------
15
16                                                3 - access("D"."FLIGHT_ID"="F"."FLI
GHT_ID")
17                                                              5 - filter("D"."CANCE
LLED"=0)
```