Result Analysis

September 7, 2023

1 AethraDB All Query Result Analysis Overview

This file contains the result analysis for the filter query aggregation and join queries at the current stage of development in the AethraDB engine. Additionally, it contains a comparison against a single-threaded run of the same queries on the same data on DuckDB version 0.8.1 using PyArrow 13.0.0.

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

plt.style.use('tableau-colorblind10')
plt_patterns = ('-', 'x','/','\\','O','o','//','\\\\')
```

[2]:
```
# Load the data from AethraDB
aethra_results_full = pd.read_csv("./jmh-result.csv", dtype = {
    'Benchmark': str,
    'Mode': str,
    'Threads': int,
    'Samples': int,
    'Score': float,
    'Score Error (99.9%)': float,
    'Unit': str,
    'Param: tableFilePath': str,
    'Param: tpchInstance': str
})

# Discard all non-aggregated results
aethra_results = aethra_results_full[~aethra_results_full['Benchmark'].str.
 ↪contains('executeFilterQuery:executeFilterQuery')]
aethra_results = aethra_results[~aethra_results['Benchmark'].str.
 ↪contains('executeQuery:executeQuery')].copy(deep=True)

# Round the running-times to 1 decimal
aethra_results["Running-Time"] = aethra_results["Score"].round(1)

# Introduce the scale-factor column
```

```
aethra_results["Scale-Factor"] = aethra_results.apply(
    lambda x: 20 if 'sf20' in str(x['Param: tableFilePath']) or 'sf-20' in␣
 ↪str(x['Param: tpchInstance'])
       else (10 if 'sf10' in str(x['Param: tableFilePath']) or 'sf-10' in␣
 ↪str(x['Param: tpchInstance'])
             else 1), axis=1)

# Discard useless columns
aethra_results.drop(columns=["Mode", "Threads", "Samples", "Score", "Score␣
 ↪Error (99.9%)", "Unit"], inplace=True)

aethra_results.head()
```

[2]:

```
                                                Benchmark
0   benchmarks.aggregation_query.NonVectorisedNonS…  \
9   benchmarks.aggregation_query.NonVectorisedNonS…
18  benchmarks.aggregation_query.NonVectorisedNonS…
27  benchmarks.aggregation_query.NonVectorisedNonS…
36  benchmarks.aggregation_query.NonVectorisedNonS…

                              Param: tableFilePath Param: tpchInstance
0   /nvtmp/AethraTestData/aggregation_query_int/ar…                 NaN  \
9   /nvtmp/AethraTestData/aggregation_query_int/ar…                 NaN
18  /nvtmp/AethraTestData/aggregation_query_int/ar…                 NaN
27  /nvtmp/AethraTestData/aggregation_query_int/ar…                 NaN
36  /nvtmp/AethraTestData/aggregation_query_int/ar…                 NaN

    Running-Time  Scale-Factor
0          334.5             1
9          475.8             1
18         633.8             1
27        1973.4             1
36        4906.5             1
```

2 Analysis of the Filter Query at different Scale Factors

[3]:

```
# Get the data of the filter query
filter_query = aethra_results[aethra_results['Benchmark'].str.
 ↪contains('filter_query')].copy(deep=True)

# Introduce the "Engine" column
filter_query["Engine"] = filter_query.apply(
    lambda x: "NV-NS" if 'NonVectorisedNonSimd' in x['Benchmark']
    else ("NV-S" if 'NonVectorisedSimd' in x['Benchmark']
          else ("V-NS" if 'VectorisedNonSimd' in x['Benchmark']
                else "V-S")), axis=1)
```

```
# Extract the restrictive column
filter_query["Restrictive-Column"] = filter_query.apply(lambda x: 1 if␣
 ↪'col1_002' in x['Param: tableFilePath'] else (2 if 'col2_002' in x['Param:␣
 ↪tableFilePath'] else 3), axis=1)

# Drop irrelevant columns
filter_query.drop(columns=["Benchmark", "Param: tableFilePath", "Param:␣
 ↪tpchInstance"], inplace=True)

filter_query.head()
```

[3]:

	Running-Time	Scale-Factor	Engine	Restrictive-Column
540	77.9	1	NV-NS	1
549	78.8	1	NV-NS	2
558	79.4	1	NV-NS	3
567	742.2	10	NV-NS	1
576	741.7	10	NV-NS	2

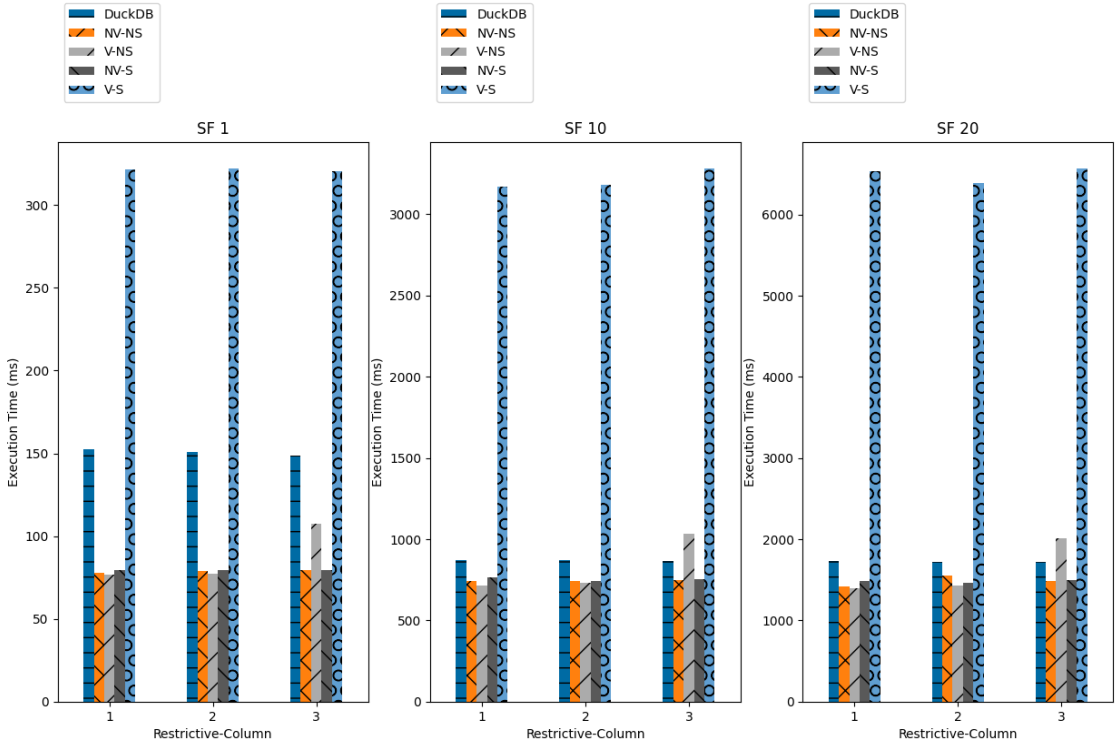
[4]:
```
# Load duckdb reference data
filter_query_duck = pd.read_csv("duckdb_filter_query_result.csv")
filter_query_duck.head()
```

[4]:

	Running-Time	Scale-Factor	Engine	Restrictive-Column
0	152.6	1	DuckDB	1
1	151.1	1	DuckDB	2
2	148.9	1	DuckDB	3
3	872.9	10	DuckDB	1
4	868.9	10	DuckDB	2

[5]:
```
index_column = "Restrictive-Column"
scale_factors = [1, 10, 20]

fig, ax = plt.subplots(nrows=1, ncols=len(scale_factors), figsize=(15,8))

for i, sf in enumerate(scale_factors):
    duckdb_data = filter_query_duck[filter_query_duck["Scale-Factor"] == sf].
 ↪sort_values(index_column)
    index = duckdb_data[index_column]

    aethra_data = filter_query[filter_query["Scale-Factor"] == sf].
 ↪sort_values(index_column)
    aethra_nv_ns_data = aethra_data[aethra_data["Engine"] == "NV-NS"]
    aethra_nv_s_data = aethra_data[aethra_data["Engine"] == "NV-S"]
    aethra_v_ns_data = aethra_data[aethra_data["Engine"] == "V-NS"]
    aethra_v_s_data = aethra_data[aethra_data["Engine"] == "V-S"]
```

```
    df = pd.DataFrame({
        'DuckDB': duckdb_data["Running-Time"].tolist(),
        'NV-NS': aethra_nv_ns_data["Running-Time"].tolist(),
        'V-NS': aethra_v_ns_data["Running-Time"].tolist(),
        'NV-S': aethra_nv_s_data["Running-Time"].tolist(),
        'V-S': aethra_v_s_data["Running-Time"].tolist(),
    }, index = index)

    df.plot.bar(rot=0, ax=ax[i])
    ax[i].set_ylabel("Execution Time (ms)")
    ax[i].set_title("SF " + str(sf))

    bars = ax[i].patches
    hatches = [p for p in plt_patterns for j in range(len(df))]
    for bar, hatch in zip(bars, hatches):
        bar.set_hatch(hatch)

    ax[i].legend(loc=3, bbox_to_anchor=(0., 1.06, 1., .102))
```



3 Analysis of the Aggregation Query at different Scale Factors

[6]:
```
# Get the data of the aggregation query
aggregation_query = aethra_results[aethra_results['Benchmark'].str.
 ↪contains('aggregation_query')].copy(deep=True)

# Introduce the "Engine" column
aggregation_query["Engine"] = aggregation_query.apply(
    lambda x: "NV-NS" if 'NonVectorisedNonSimd' in x['Benchmark']
    else ("NV-S" if 'NonVectorisedSimd' in x['Benchmark']
          else ("V-NS" if 'VectorisedNonSimd' in x['Benchmark']
                else "V-S")), axis=1)

# Extract the number of keys in the result
aggregation_query["Keys"] = aggregation_query.apply(lambda x: x['Param:␣
 ↪tableFilePath'].split('keys_')[1], axis=1)
aggregation_query["Keys"] = aggregation_query["Keys"].str.extract('(\d+)').
 ↪astype(int)

# Drop irrelevant columns
aggregation_query.drop(columns=["Benchmark", "Param: tableFilePath", "Param:␣
 ↪tpchInstance"], inplace=True)

aggregation_query.head()
```

[6]:

	Running-Time	Scale-Factor	Engine	Keys
0	334.5	1	NV-NS	2
9	475.8	1	NV-NS	16
18	633.8	1	NV-NS	8192
27	1973.4	1	NV-NS	262144
36	4906.5	1	NV-NS	524288

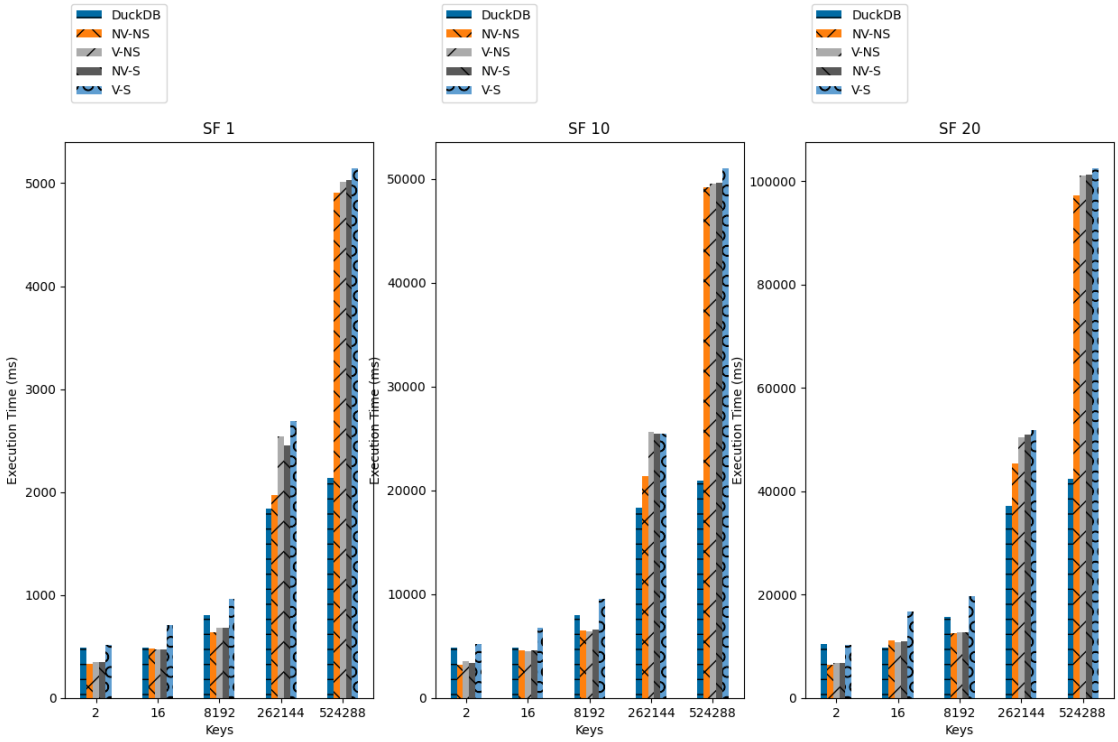
[7]:
```
# Load duckdb reference data
aggregation_query_duck = pd.read_csv("duckdb_aggregation_query_result.csv")
aggregation_query_duck.head()
```

[7]:

	Running-Time	Scale-Factor	Engine	Keys
0	2138.2	1	DuckDB	524288
1	1843.1	1	DuckDB	262144
2	487.3	1	DuckDB	16
3	805.0	1	DuckDB	8192
4	487.0	1	DuckDB	2

[8]:
```
index_column = "Keys"
scale_factors = [1, 10, 20]

fig, ax = plt.subplots(nrows=1, ncols=len(scale_factors), figsize=(15,8))
```

```
for i, sf in enumerate(scale_factors):
    duckdb_data = aggregation_query_duck[aggregation_query_duck["Scale-Factor"]␣
 ↪== sf].sort_values(index_column)
    index = duckdb_data[index_column]

    aethra_data = aggregation_query[aggregation_query["Scale-Factor"] == sf].
 ↪sort_values(index_column)
    aethra_nv_ns_data = aethra_data[aethra_data["Engine"] == "NV-NS"]
    aethra_nv_s_data = aethra_data[aethra_data["Engine"] == "NV-S"]
    aethra_v_ns_data = aethra_data[aethra_data["Engine"] == "V-NS"]
    aethra_v_s_data = aethra_data[aethra_data["Engine"] == "V-S"]

    df = pd.DataFrame({
        'DuckDB': duckdb_data["Running-Time"].tolist(),
        'NV-NS': aethra_nv_ns_data["Running-Time"].tolist(),
        'V-NS': aethra_v_ns_data["Running-Time"].tolist(),
        'NV-S': aethra_nv_s_data["Running-Time"].tolist(),
        'V-S': aethra_v_s_data["Running-Time"].tolist(),
    }, index = index)

    df.plot.bar(rot=0, ax=ax[i])
    ax[i].set_ylabel("Execution Time (ms)")
    ax[i].set_title("SF " + str(sf))

    bars = ax[i].patches
    hatches = [p for p in plt_patterns for j in range(len(df))]
    for bar, hatch in zip(bars, hatches):
        bar.set_hatch(hatch)

    ax[i].legend(loc=3, bbox_to_anchor=(0., 1.06, 1., .102))
```



4 Analysis of the Join Query at different Scale Factors

For this experiment, we only ran the query at selectivity instance A-B 0.6, A-C 0.8

[9]:
```
# Get the data of the join query
join_query = aethra_results[aethra_results['Benchmark'].str.
 ↪contains('join_query')].copy(deep=True)

# Introduce the "Engine" column
join_query["Engine"] = join_query.apply(
    lambda x: "NV-NS" if 'NonVectorisedNonSimd' in x['Benchmark']
    else ("NV-S" if 'NonVectorisedSimd' in x['Benchmark']
          else ("V-NS" if 'VectorisedNonSimd' in x['Benchmark']
                else "V-S")), axis=1)

# No need to get the selectivity of each join, since the experiment was only␣
 ↪run at A-B 0.6, A-C 0.8

# Introduce the hard-coded column
join_query['Hard-Coded'] = join_query['Benchmark'].str.contains('hard_coded')

# Drop irrelevant columns
```

```
join_query.drop(columns=["Benchmark", "Param: tableFilePath", "Param:␣
 ↪tpchInstance"], inplace=True)

join_query.head()
```

[9]:

	Running-Time	Scale-Factor	Engine	Hard-Coded
864	4742.4	1	NV-NS	False
873	54505.8	10	NV-NS	False
882	5321.7	1	NV-S	False
891	60955.0	10	NV-S	False
900	4946.8	1	V-NS	False

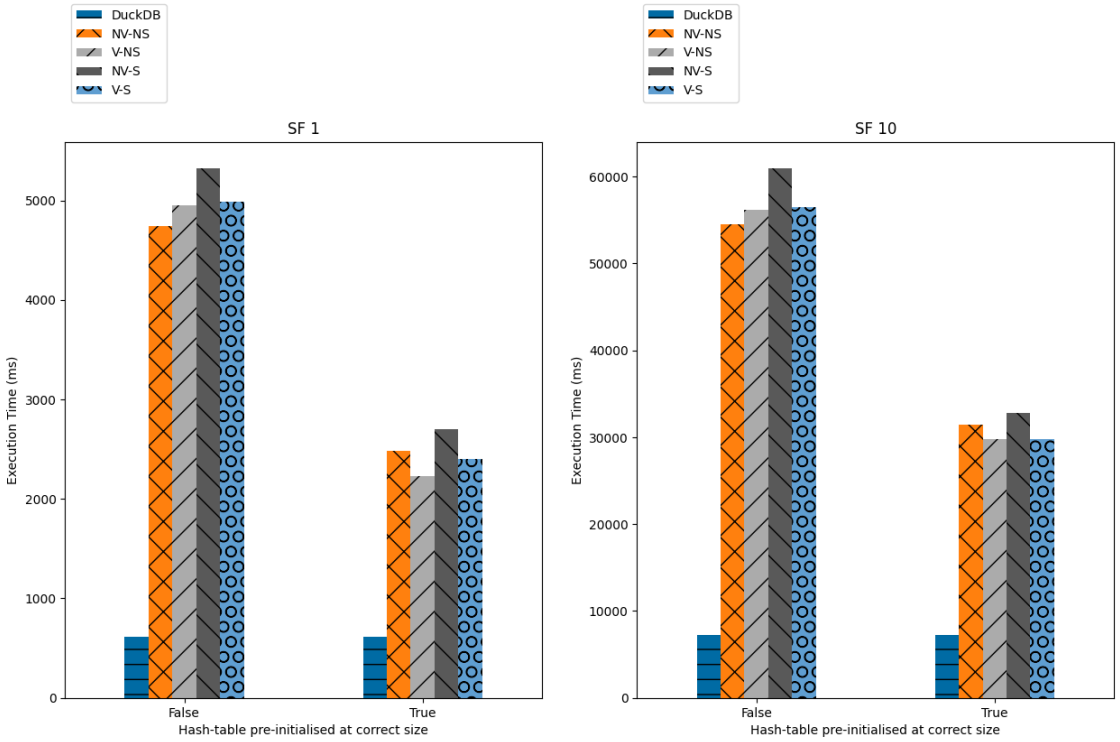
[10]:
```
# Load duckdb reference data
join_query_duck = pd.read_csv("duckdb_join_query_result.csv")
join_query_duck.head()
```

[10]:

	Running-Time	Scale-Factor	Engine	Hard-Coded
0	617.0	1	DuckDB	False
1	617.0	1	DuckDB	True
2	7290.9	10	DuckDB	False
3	7290.9	10	DuckDB	True

[11]:
```
index_column = "Hard-Coded"
scale_factors = [1, 10]

fig, ax = plt.subplots(nrows=1, ncols=len(scale_factors), figsize=(15,8))

for i, sf in enumerate(scale_factors):
    duckdb_data = join_query_duck[join_query_duck["Scale-Factor"] == sf].
 ↪sort_values(index_column)
    index = duckdb_data[index_column]

    aethra_data = join_query[join_query["Scale-Factor"] == sf].
 ↪sort_values(index_column)
    aethra_nv_ns_data = aethra_data[aethra_data["Engine"] == "NV-NS"]
    aethra_nv_s_data = aethra_data[aethra_data["Engine"] == "NV-S"]
    aethra_v_ns_data = aethra_data[aethra_data["Engine"] == "V-NS"]
    aethra_v_s_data = aethra_data[aethra_data["Engine"] == "V-S"]

    df = pd.DataFrame({
        'DuckDB': duckdb_data["Running-Time"].tolist(),
        'NV-NS': aethra_nv_ns_data["Running-Time"].tolist(),
        'V-NS': aethra_v_ns_data["Running-Time"].tolist(),
        'NV-S': aethra_nv_s_data["Running-Time"].tolist(),
        'V-S': aethra_v_s_data["Running-Time"].tolist(),
    }, index = index)
```

```
    df.plot.bar(rot=0, ax=ax[i])
    ax[i].set_ylabel("Execution Time (ms)")
    ax[i].set_xlabel("Hash-table pre-initialised at correct size")
    ax[i].set_title("SF " + str(sf))

    bars = ax[i].patches
    hatches = [p for p in plt_patterns for j in range(len(df))]
    for bar, hatch in zip(bars, hatches):
        bar.set_hatch(hatch)

    ax[i].legend(loc=3, bbox_to_anchor=(0., 1.06, 1., .102))
```

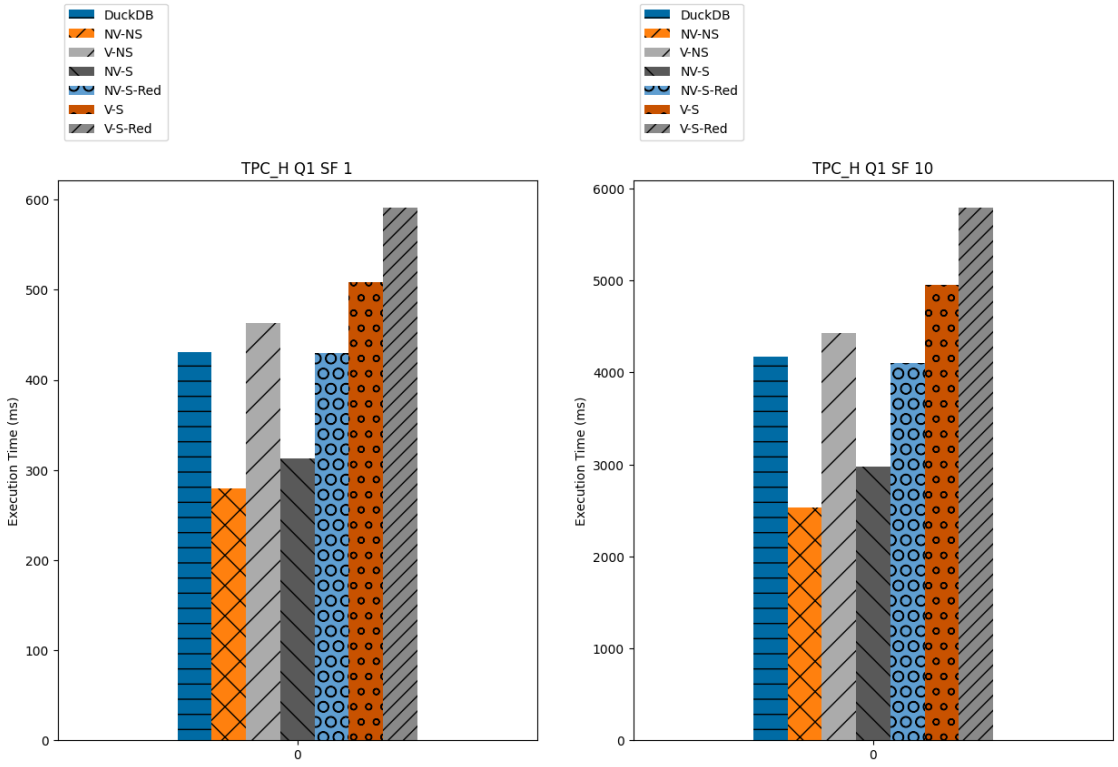


5 Analysis of TPC-H Q1 at different Scale Factors

[12]:
```
def plot_tpch_data(query_number):
    # Get the data of the query
    tpch_data = aethra_results[aethra_results['Benchmark'].str.
 ↪contains('tpch')].copy(deep=True)
    tpch_query_data = tpch_data[tpch_data['Benchmark'].str.contains('q' +␣
 ↪str(query_number) + '_')].copy(deep=True)

    # Introduce the "Engine" column
```

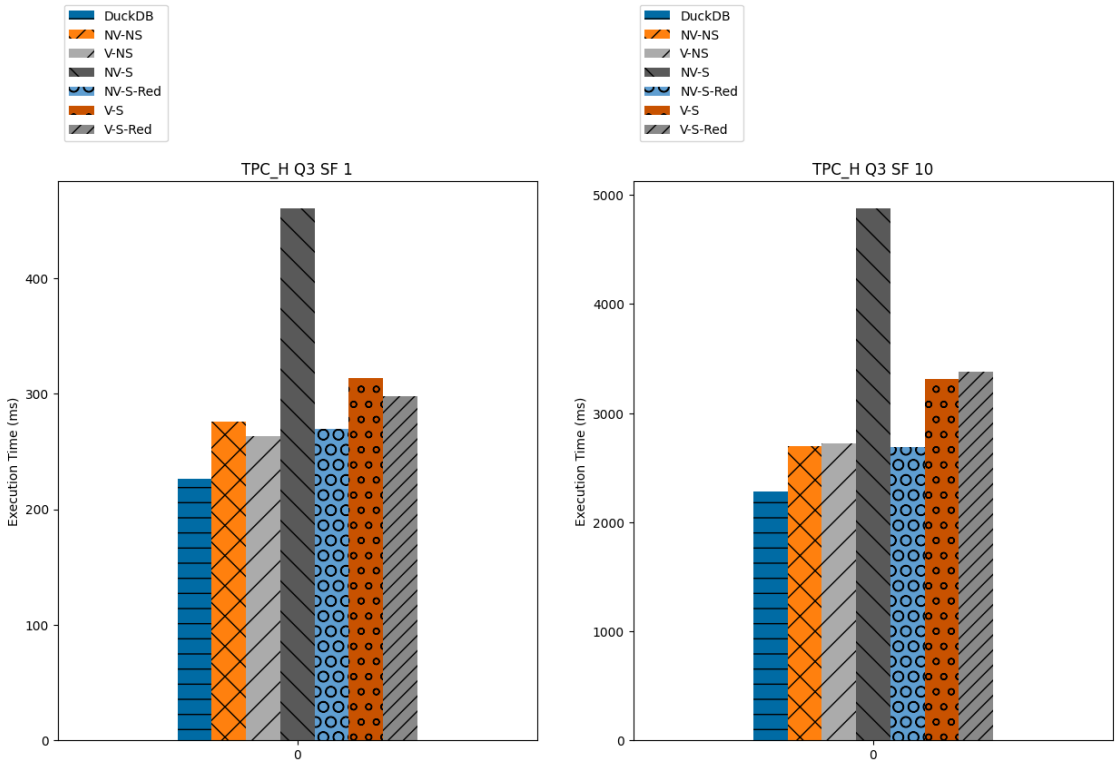
```
    tpch_query_data["Engine"] = tpch_query_data.apply(
        lambda x: "NV-NS" if 'NonVectorisedNonSimd' in x['Benchmark']
            else ("NV-S" if 'NonVectorisedSimd' in x['Benchmark']
                  else ("V-NS" if 'VectorisedNonSimd' in x['Benchmark'] and "Red" not in x['Benchmark']
                        else ("V-NS-Red" if 'VectorisedNonSimd' in x['Benchmark']
                              else ("V-S" if 'VectorisedSimd' in x['Benchmark'] and "Red" not in x['Benchmark']
                                    else "V-S-Red")))), axis=1)

    # Drop irrelevant columns
    tpch_query_data.drop(columns=["Benchmark", "Param: tableFilePath", "Param: tpchInstance"], inplace=True)

    # Load duckdb reference data
    tpch_query_duck = pd.read_csv("duckdb_tpch_q" + str(query_number) + "_query_result.csv")

    # Obtain the different scale factors
    sf_vals = tpch_query_data["Scale-Factor"].unique()
    sf_vals.sort()
    scale_factors = list(sf_vals)

    # Plot the data
    fig, ax = plt.subplots(nrows=1, ncols=len(scale_factors), figsize=(15,8))

    for i, sf in enumerate(scale_factors):
        duckdb_data = tpch_query_duck[tpch_query_duck["Scale-Factor"] == sf]

        aethra_data = tpch_query_data[tpch_query_data["Scale-Factor"] == sf]
        aethra_nv_ns_data = aethra_data[aethra_data["Engine"] == "NV-NS"]
        aethra_nv_s_data = aethra_data[aethra_data["Engine"] == "NV-S"]
        aethra_v_ns_data = aethra_data[aethra_data["Engine"] == "V-NS"]
        aethra_v_ns_red_data = aethra_data[aethra_data["Engine"] == "V-NS-Red"]
        aethra_v_s_data = aethra_data[aethra_data["Engine"] == "V-S"]
        aethra_v_s_red_data = aethra_data[aethra_data["Engine"] == "V-S-Red"]

        df = pd.DataFrame({
            'DuckDB': duckdb_data["Running-Time"].tolist(),
            'NV-NS': aethra_nv_ns_data["Running-Time"].tolist(),
            'V-NS': aethra_v_ns_data["Running-Time"].tolist(),
            'NV-S': aethra_nv_s_data["Running-Time"].tolist(),
            'NV-S-Red': aethra_v_ns_red_data["Running-Time"].tolist(),
            'V-S': aethra_v_s_data["Running-Time"].tolist(),
            'V-S-Red': aethra_v_s_red_data["Running-Time"].tolist(),
        })
```

```
        df.plot.bar(rot=0, ax=ax[i])
        ax[i].set_ylabel("Execution Time (ms)")
        ax[i].set_title("TPC_H Q" + str(query_number) + " SF " + str(sf))

        bars = ax[i].patches
        hatches = [p for p in plt_patterns for j in range(len(df))]
        for bar, hatch in zip(bars, hatches):
            bar.set_hatch(hatch)

        ax[i].legend(loc=3, bbox_to_anchor=(0., 1.06, 1., .102))


plot_tpch_data(1)
```



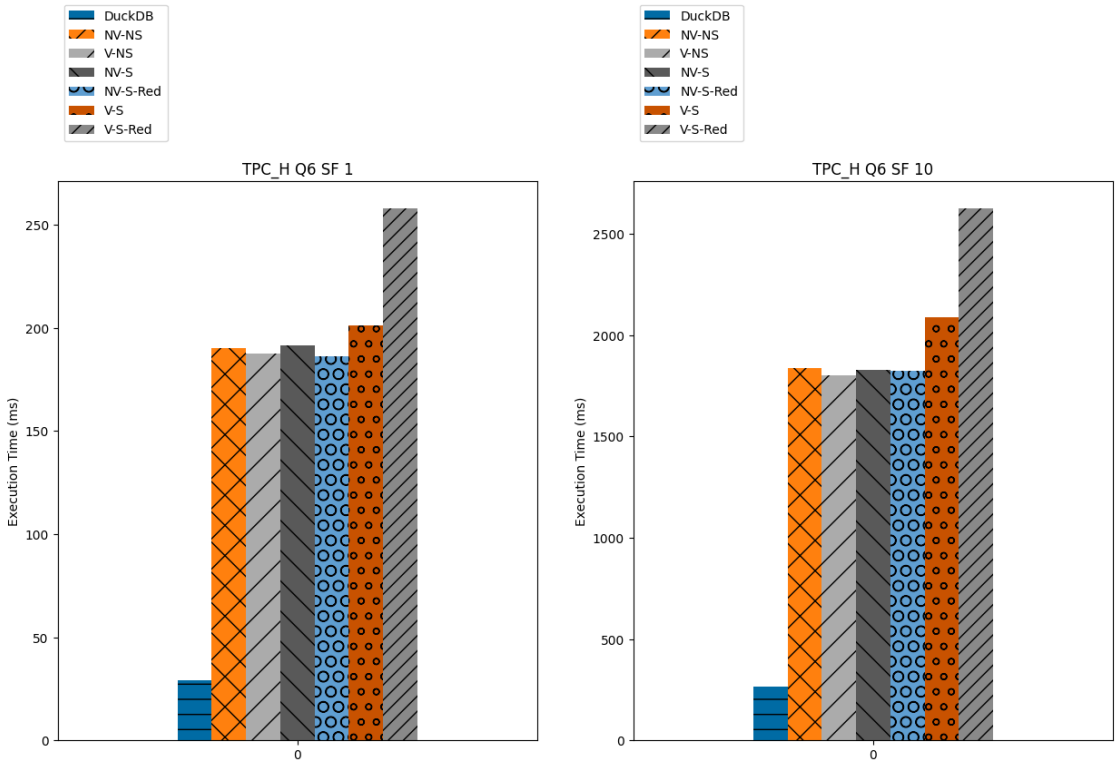
6 Analysis of TPC-H Q3 at different Scale Factors

[13]:
```
plot_tpch_data(3)
```



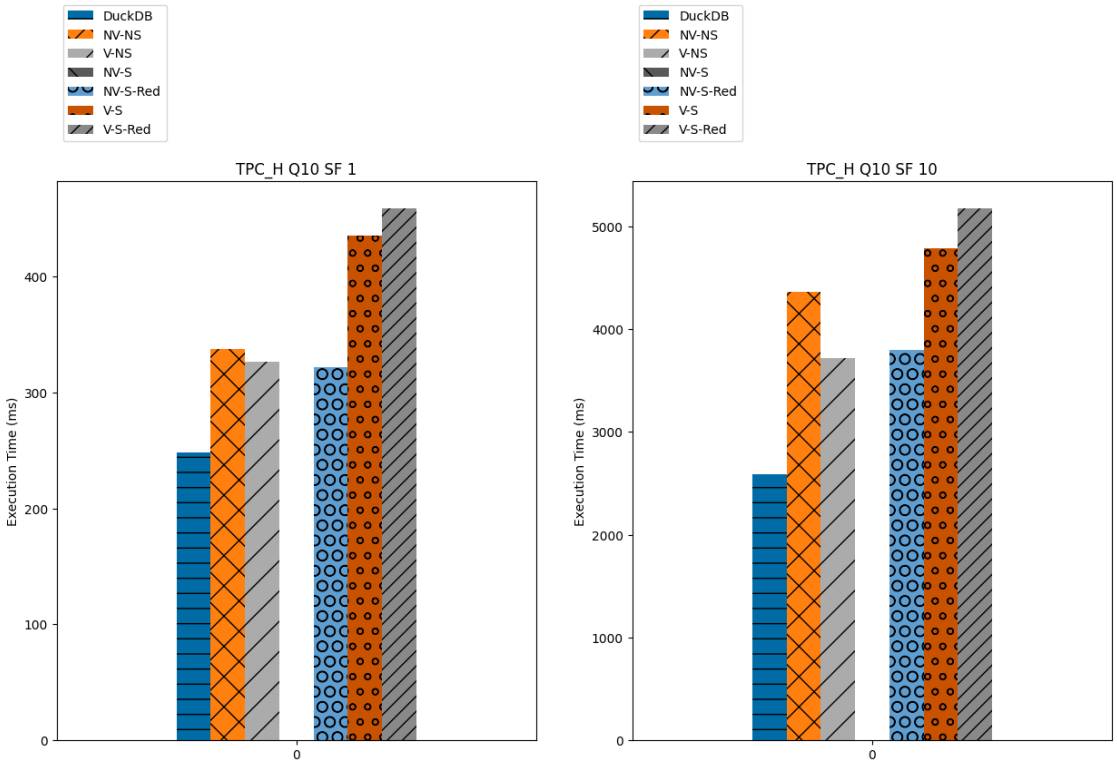
7 Analysis of TPC-H Q6 at different Scale Factors

[14]:
```
plot_tpch_data(6)
```



8 Analysis of TPC-H Q10 at different Scale Factors

[15]:
```
plot_tpch_data(10)
```


DuckDB
NV-NS
V-NS
NV-S
NV-S-Red
V-S
V-S-Red
TPC_H Q10 SF 1
Execution Time (ms)
0
100
200
300
400
0
DuckDB
NV-NS
V-NS
NV-S
NV-S-Red
V-S
V-S-Red
TPC_H Q10 SF 10
Execution Time (ms)
0
1000
2000
3000
4000
5000
0