GEQO_SAIO_report

June 8, 2015

In [24]:
```
import matplotlib
matplotlib.use('PS')
%matplotlib inline
```

In [31]:
```
import matplotlib.pyplot as plt # side-stepping mpl backend
from pylab import *
import numpy as np


def plot_geqo_against_average_saio(results_saio, results_geqo, title):
    fig, axes = plt.subplots(nrows=1, ncols=3, figsize=(19,4))

    axes[0].plot(results_geqo[:,0], results_geqo[:,4], label="geqo cost")
    axes[0].plot(results_geqo[:,0],[np.average(results_saio[:,4])]*len(results_geqo[:,4]), labe
    axes[0].set_xlabel('geqo effort')
    axes[0].set_ylabel('cost')
    axes[0].set_title(title)
    axes[0].legend()

    axes[1].plot(results_geqo[:,0], results_geqo[:,5], label="geqo time")
    axes[1].plot(results_geqo[:,0],[np.average(results_saio[:,5])]*len(results_geqo[:,5]), labe
    axes[1].set_xlabel('geqo effort')
    axes[1].set_ylabel('time [s]')
    axes[1].set_title(title)
    axes[1].legend()

    axes[2].plot(results_geqo[:,0], results_geqo[:,6]/1000, label="geqo memory")
    axes[2].plot(results_geqo[:,0],[np.average(results_saio[:,6])/1000]*len(results_geqo[:,6])
    axes[2].set_xlabel('geqo effort')
    axes[2].set_ylabel('memory [MB]')
    axes[2].set_title(title)
    axes[2].legend()
    plt.show()


def plot_comparison(results_saio, results_geqo, title):
    labels = ['GEQO', 'SAIO']
    fig, axes = plt.subplots(nrows=1, ncols=3, figsize=(19,4))
    axes[0].boxplot((results_geqo[:,4], results_saio[:,4]), labels=labels, showmeans=True)
    axes[0].set_ylabel('Cost []')
    axes[0].grid(True)

    axes[1].boxplot((results_geqo[:,5], results_saio[:,5]), labels=labels, showmeans=True)
    axes[1].set_ylabel('Optimizing time [s]')
```

```
    axes[1].grid(True)

    axes[2].boxplot((results_geqo[:,6]/1000, results_saio[:,6]/1000), labels=labels, showmeans=
    axes[2].set_ylabel('Memory usage [MB]')
    axes[2].grid(True)

    fig.suptitle(title, fontsize='15')
    plt.show()

def plot_space(results_saio, results_geqo):
    geqo_avg_cost = np.average(results_geqo[:,4])
    geqo_avg_time = np.average(results_geqo[:,5])
    geqo_avg_memory = np.average(results_geqo[:,6])

    fig, ax = plt.subplots(nrows=1, ncols=3, figsize=(15,5))

    X, Y = results_saio[:,0], results_saio[:,2]
    cost, time, memory = results_saio[:,4], results_saio[:,5], results_saio[:,6]

    plt.subplot(1,3,1)
    cost = cost.reshape(6, 11) / geqo_avg_cost
    im_cost = plt.imshow(cost, extent=(X.min(), X.max(), Y.max(), Y.min()),
           interpolation='nearest', cmap=plt.cm.gray, aspect='auto')
    plt.xlabel('equilibrium factor')
    plt.ylabel('temperature reduction factor')
    plt.colorbar(im_cost)
    plt.title('SAIO cost / avg(GEQO cost)')
    plt.grid(True)

    plt.subplot(1,3,2)
    time = time.reshape(6, 11) / geqo_avg_time
    im_time = plt.imshow(time, extent=(X.min(), X.max(), Y.max(), Y.min()),
           interpolation='nearest', cmap=plt.cm.gray, aspect='auto')
    plt.xlabel('equilibrium factor')
    plt.ylabel('temperature reduction factor')
    plt.colorbar(im_time)
    plt.title('SAIO time / avg(GEQO time) [s/s]')
    plt.grid(True)

    plt.subplot(1,3,3)
    memory = (memory.reshape(6, 11)/1000) / (geqo_avg_memory/1000)
    im_memory = plt.imshow(memory, extent=(X.min(), X.max(), Y.max(), Y.min()),
           interpolation='nearest', cmap=plt.cm.gray, aspect='auto')
    plt.xlabel('equilibrium factor')
    plt.ylabel('temperature reduction factor')
    plt.colorbar(im_memory)
    plt.title('SAIO memory / avg(GEQO memory) [MB/MB]')
    plt.grid(True)
    plt.show()


def display_info_for_test_case(test_case_name):
    with open('benchmarks/'+test_case_name, 'r') as f:
        print f.read()
```

```
#equilibrium_factor, initial_temperature, temperature_reduction_factor, steps_before_froze
results_saio = np.loadtxt('benchmarks/' + test_case_name + '.saio.out')
#geqo_effort, geqo_pool_size, geqo_generations, geqo_selection_bias, cost, time, memory
results_geqo = np.loadtxt('benchmarks/' + test_case_name + '.geqo.out')

plot_comparison(results_saio, results_geqo, test_case_name)
plot_geqo_against_average_saio(results_saio, results_geqo, 'GEQO vs SAIO ' + test_case_name
plot_space(results_saio, results_geqo)
```

1 SAIO vs GEQO comparison - report

1.1 1 Introduction

This is an aggregated report on comparison of two alternative join order optimizers:

- GEQO - Genetic Query Optimizer (current default optimizer in Postgres)
- SAIO - Simulated Annealing based Join Order optimizer (PGXN extension for Postgres)

The tests compare query costs, optimizing time and memory used.

1.2 1.1 Methodology

GEQO and SAIO are tested on many different schemas and queries. To ensure proper representation of each join order optimizer abilities, each query has been tested on a range of parameters:

- GEQO has been tested with GEQO effort in range 0 to 10
- SAIO has been tested with different combinations of:
  - equilibrium factor (explain what is this)
  - temperature reduction (temperature is multiplied by this fraction in each iteration until the system freezes)

Some parameters of SAIO were fixed to reduce testing time:

- initial temperature (explain)
- steps before freeze (explain)

1.3 1.2 Testing data

The testing data (DB schemas and queries) has been divided into following sections:

1.3.1 1.2.1 Provided data

SQL scripts that were written by hand. Mostly for the previous iteration of SAIO.

1.3.2 1.2.2 Programatically generated data

SQL scripts automatically generated by Python scripts
Schemas:

- 20-200 tables without constraints
- 20-200 tables with constraints

Flat queries:

- 15-20 JOINS (JOINS, LEFT JOINS, RIGHT JOINS)

- 20-30 JOINS
- 30-50 JOINS
- 50-70 JOINS
- 70-100 JOINS
- 100+ JOINS

Nested queries:

- 15-20 JOINS
- 20-30 JOINS
- 30-50 JOINS
- 50-70 JOINS
- 70-100 JOINS
- 100+ JOINS

1.3.3 1.2.3 Industrial examples

This would be awesome to include such examples. No examples yet.

2 2 Tests

2.1 2.1 Provided queries

2.1.1 2.1.1 MODERATELY COMPLEX QUERY

//query (toggleable)

```
In [ ]:
```

2.1.2 2.1.2 COMPLEX QUERY

//query

```
In [ ]:
```

Description

2.2 2.2 Programatically generated queries

2.2.1 2.2.1 star query

No constraints, 30 arms
//query

```
In [ ]:
```

No constraints 80 arms
//query

```
In [ ]:
```

No constraints 150 arms

```
In [ ]:
```

LEFT JOINS, RIGHT JOINS, constraints...

```
In [ ]:
```

2.2.2 2.2.2 flat queries

15 JOINS (JOINS, LEFT JOINS, RIGHT JOINS)
20 JOINS
30 JOINS

```
In [32]: display_info_for_test_case('random_query_30_joins_no_constraints')
         display_info_for_test_case('random_query_30_right_joins_no_constraints')
         display_info_for_test_case('random_query_30_left_joins_no_constraints')
         #display_info_for_test_case('random_query_10_right_10_left_10_joins')
```

```
--
DROP SCHEMA IF EXISTS test_view CASCADE;

            CREATE SCHEMA test_view;

            SET SEARCH_PATH = test_view, test_data;
DROP TABLE IF EXISTS table_0;
CREATE TABLE table_0(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_1;
CREATE TABLE table_1(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_2;
CREATE TABLE table_2(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_3;
CREATE TABLE table_3(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
```

```
            );
        DROP TABLE IF EXISTS table_4;
CREATE TABLE table_4(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_5;
CREATE TABLE table_5(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_6;
CREATE TABLE table_6(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_7;
CREATE TABLE table_7(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_8;
CREATE TABLE table_8(
col_0 text,
col_1 text,
col_2 text,
```

```
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_9;
CREATE TABLE table_9(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_10;
CREATE TABLE table_10(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_11;
CREATE TABLE table_11(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_12;
CREATE TABLE table_12(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_13;
CREATE TABLE table_13(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
```

```
col_6 text
            );
        DROP TABLE IF EXISTS table_14;
CREATE TABLE table_14(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_15;
CREATE TABLE table_15(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_16;
CREATE TABLE table_16(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_17;
CREATE TABLE table_17(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_18;
CREATE TABLE table_18(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
```

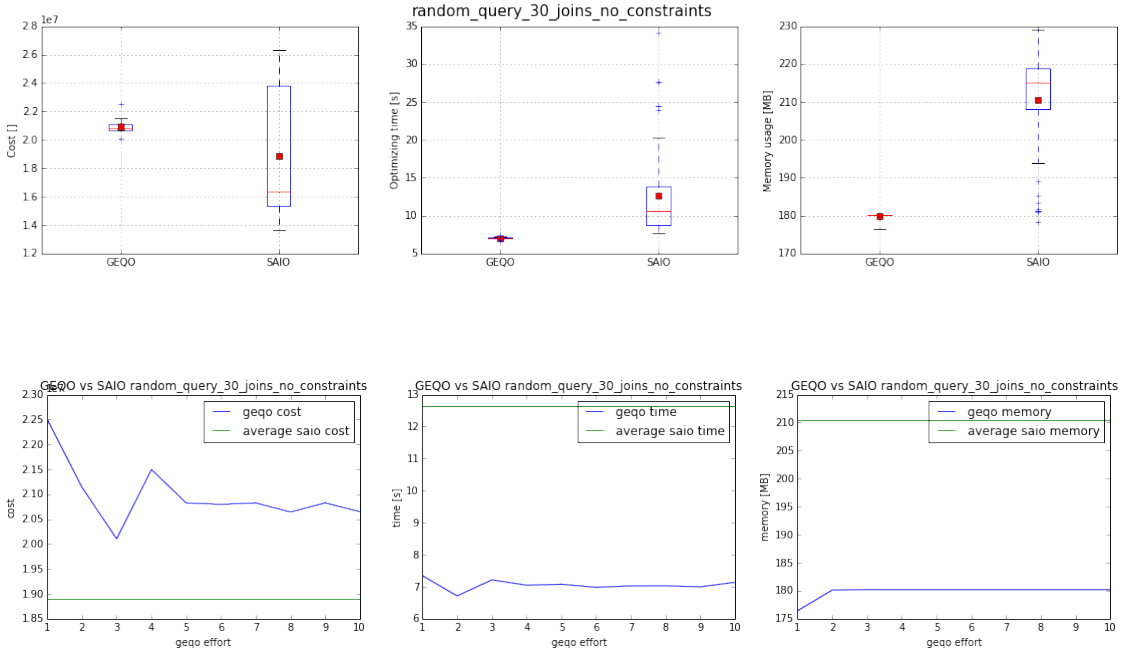
```
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_19;
CREATE TABLE table_19(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_20;
CREATE TABLE table_20(
col_0 text,
col_1 text,
col_2 text,
col_3 text
            );
        DROP TABLE IF EXISTS table_21;
CREATE TABLE table_21(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text
            );
        DROP TABLE IF EXISTS table_22;
CREATE TABLE table_22(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_23;
CREATE TABLE table_23(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text
            );
        DROP TABLE IF EXISTS table_24;
CREATE TABLE table_24(
col_0 text,
```

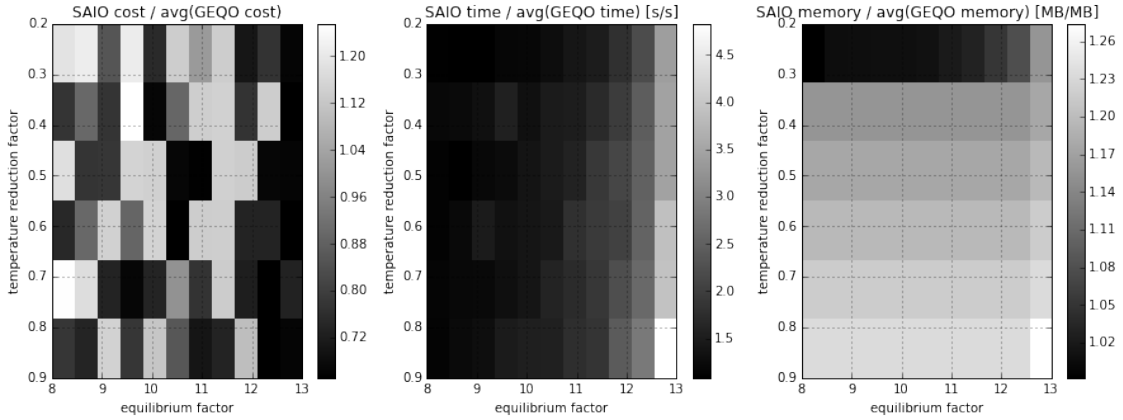
```
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_25;
CREATE TABLE table_25(
col_0 text,
col_1 text,
col_2 text,
col_3 text
            );
        DROP TABLE IF EXISTS table_26;
CREATE TABLE table_26(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_27;
CREATE TABLE table_27(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_28;
CREATE TABLE table_28(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text
            );
        DROP TABLE IF EXISTS table_29;
CREATE TABLE table_29(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
```

```
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_30;
CREATE TABLE table_30(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_31;
CREATE TABLE table_31(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_32;
CREATE TABLE table_32(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_33;
CREATE TABLE table_33(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_34;
CREATE TABLE table_34(
col_0 text,
col_1 text,
col_2 text
            );
```

```
        ANALYZE;
        EXPLAIN (FORMAT JSON)SELECT * FROM table_0 JOIN table_26 ON table_0.col_2 = table_26.col_0
JOIN table_34 ON table_0.col_4 = table_34.col_0
JOIN table_21 ON table_0.col_5 = table_21.col_4
JOIN table_23 ON table_0.col_2 = table_23.col_3
JOIN table_33 ON table_0.col_1 = table_33.col_3
JOIN table_30 ON table_0.col_2 = table_30.col_3
JOIN table_11 ON table_0.col_1 = table_11.col_0
JOIN table_28 ON table_0.col_3 = table_28.col_0
JOIN table_2 ON table_0.col_1 = table_2.col_3
JOIN table_9 ON table_0.col_0 = table_9.col_2
JOIN table_18 ON table_0.col_4 = table_18.col_8
JOIN table_3 ON table_0.col_0 = table_3.col_4
JOIN table_12 ON table_0.col_4 = table_12.col_2
JOIN table_29 ON table_0.col_7 = table_29.col_3
JOIN table_24 ON table_0.col_1 = table_24.col_1
JOIN table_7 ON table_0.col_3 = table_7.col_8
JOIN table_15 ON table_0.col_2 = table_15.col_3
JOIN table_5 ON table_0.col_7 = table_5.col_6
JOIN table_19 ON table_0.col_5 = table_19.col_4
JOIN table_13 ON table_0.col_5 = table_13.col_1
JOIN table_1 ON table_0.col_0 = table_1.col_1
JOIN table_20 ON table_0.col_4 = table_20.col_0
JOIN table_22 ON table_0.col_1 = table_22.col_1
JOIN table_6 ON table_0.col_1 = table_6.col_4
JOIN table_32 ON table_0.col_2 = table_32.col_4
JOIN table_16 ON table_0.col_6 = table_16.col_3
JOIN table_8 ON table_0.col_5 = table_8.col_6
JOIN table_31 ON table_0.col_3 = table_31.col_6
JOIN table_25 ON table_0.col_2 = table_25.col_1
JOIN table_4 ON table_0.col_5 = table_4.col_0

        ;
```






```
--
DROP SCHEMA IF EXISTS test_view CASCADE;

            CREATE SCHEMA test_view;

            SET SEARCH_PATH = test_view, test_data;
DROP TABLE IF EXISTS table_0;
CREATE TABLE table_0(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_1;
CREATE TABLE table_1(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_2;
CREATE TABLE table_2(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
```

```
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_3;
CREATE TABLE table_3(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_4;
CREATE TABLE table_4(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_5;
CREATE TABLE table_5(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_6;
CREATE TABLE table_6(
col_0 text,
col_1 text,
col_2 text
            );
        DROP TABLE IF EXISTS table_7;
CREATE TABLE table_7(
col_0 text,
col_1 text,
col_2 text
            );
```

```
        DROP TABLE IF EXISTS table_8;
CREATE TABLE table_8(
col_0 text,
col_1 text,
col_2 text,
col_3 text
            );
        DROP TABLE IF EXISTS table_9;
CREATE TABLE table_9(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_10;
CREATE TABLE table_10(
col_0 text,
col_1 text,
col_2 text
            );
        DROP TABLE IF EXISTS table_11;
CREATE TABLE table_11(
col_0 text,
col_1 text,
col_2 text,
col_3 text
            );
        DROP TABLE IF EXISTS table_12;
CREATE TABLE table_12(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text
            );
        DROP TABLE IF EXISTS table_13;
CREATE TABLE table_13(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_14;
CREATE TABLE table_14(
col_0 text,
```

```
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_15;
CREATE TABLE table_15(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_16;
CREATE TABLE table_16(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_17;
CREATE TABLE table_17(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_18;
CREATE TABLE table_18(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_19;
CREATE TABLE table_19(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
```

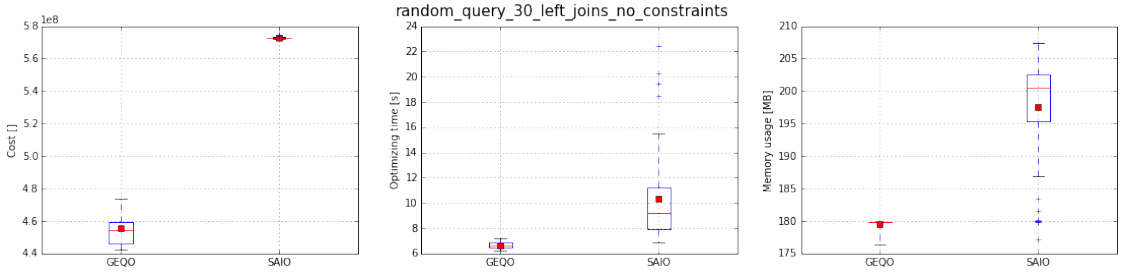
```
            );
        DROP TABLE IF EXISTS table_20;
CREATE TABLE table_20(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_21;
CREATE TABLE table_21(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_22;
CREATE TABLE table_22(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text
            );
        DROP TABLE IF EXISTS table_23;
CREATE TABLE table_23(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_24;
CREATE TABLE table_24(
col_0 text,
col_1 text,
col_2 text,
col_3 text
            );
        DROP TABLE IF EXISTS table_25;
CREATE TABLE table_25(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
```

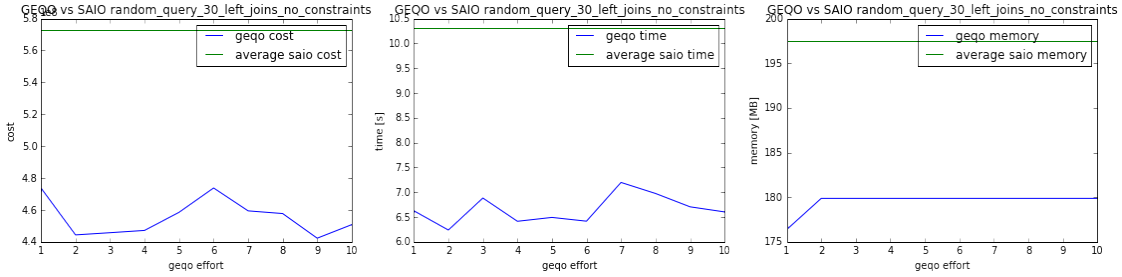
```
            );
        DROP TABLE IF EXISTS table_26;
CREATE TABLE table_26(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text
            );
        DROP TABLE IF EXISTS table_27;
CREATE TABLE table_27(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text
            );
        DROP TABLE IF EXISTS table_28;
CREATE TABLE table_28(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_29;
CREATE TABLE table_29(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_30;
CREATE TABLE table_30(
col_0 text,
col_1 text,
col_2 text,
col_3 text
            );
        DROP TABLE IF EXISTS table_31;
CREATE TABLE table_31(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
```

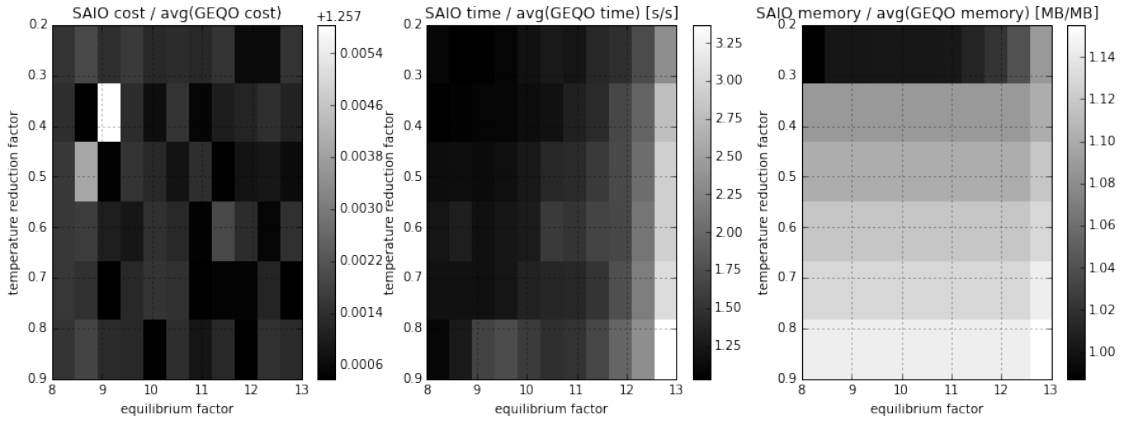
```
col_5 text,
col_6 text
            );
        DROP TABLE IF EXISTS table_32;
CREATE TABLE table_32(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text,
col_9 text
            );
        DROP TABLE IF EXISTS table_33;
CREATE TABLE table_33(
col_0 text,
col_1 text,
col_2 text,
col_3 text,
col_4 text,
col_5 text,
col_6 text,
col_7 text,
col_8 text
            );
        DROP TABLE IF EXISTS table_34;
CREATE TABLE table_34(
col_0 text,
col_1 text,
col_2 text
            );
        ANALYZE;
        EXPLAIN (FORMAT JSON)SELECT * FROM table_0 LEFT JOIN table_2 ON table_0.col_4 = table_2.col_7
 LEFT JOIN table_14 ON table_0.col_2 = table_14.col_1
 LEFT JOIN table_25 ON table_0.col_2 = table_25.col_3
 LEFT JOIN table_30 ON table_0.col_8 = table_30.col_0
 LEFT JOIN table_32 ON table_0.col_4 = table_32.col_6
 LEFT JOIN table_34 ON table_0.col_3 = table_34.col_0
 LEFT JOIN table_8 ON table_0.col_1 = table_8.col_1
 LEFT JOIN table_23 ON table_0.col_7 = table_23.col_5
 LEFT JOIN table_18 ON table_0.col_0 = table_18.col_2
 LEFT JOIN table_5 ON table_0.col_1 = table_5.col_0
 LEFT JOIN table_21 ON table_0.col_7 = table_21.col_1
 LEFT JOIN table_24 ON table_0.col_5 = table_24.col_0
 LEFT JOIN table_22 ON table_0.col_3 = table_22.col_0
 LEFT JOIN table_19 ON table_0.col_0 = table_19.col_2
 LEFT JOIN table_28 ON table_0.col_8 = table_28.col_2
 LEFT JOIN table_26 ON table_0.col_5 = table_26.col_3
 LEFT JOIN table_3 ON table_0.col_2 = table_3.col_1
 LEFT JOIN table_33 ON table_0.col_7 = table_33.col_6
 LEFT JOIN table_1 ON table_0.col_1 = table_1.col_1
```

```
LEFT JOIN table_15 ON table_0.col_7 = table_15.col_2
LEFT JOIN table_13 ON table_0.col_2 = table_13.col_1
LEFT JOIN table_10 ON table_0.col_5 = table_10.col_0
LEFT JOIN table_11 ON table_0.col_5 = table_11.col_1
LEFT JOIN table_9 ON table_0.col_3 = table_9.col_1
LEFT JOIN table_31 ON table_0.col_1 = table_31.col_4
LEFT JOIN table_27 ON table_0.col_8 = table_27.col_0
LEFT JOIN table_12 ON table_0.col_8 = table_12.col_1
LEFT JOIN table_16 ON table_0.col_8 = table_16.col_5
LEFT JOIN table_7 ON table_0.col_6 = table_7.col_0
LEFT JOIN table_17 ON table_0.col_7 = table_17.col_2

    ;
```







50 JOINS
70 JOINS
100 JOINS

In [ ]:

In [ ]:

In [ ]:

2.2.3 2.2.3 nested queries

15 JOINS (JOINS, LEFT JOINS, RIGHT JOINS)
20 JOINS
30 JOINS
50 JOINS
70 JOINS
100 JOINS

In [ ]:

In [ ]:

In [ ]:

2.3 Conclusions

//TODO