# Postgres Interface Performance

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Overview
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Intro

## Motivation

- Answer this question:
    - What is relative performance of
      ODBC, JDBC, and libpq?
- Specifically:
    - Connection speed
    - Query result retrieval
    - Alternate retrieval methods
    - Materializing to file
- Secondarily:
    - Connection per query versus persistent
    - Set versus singleton operations
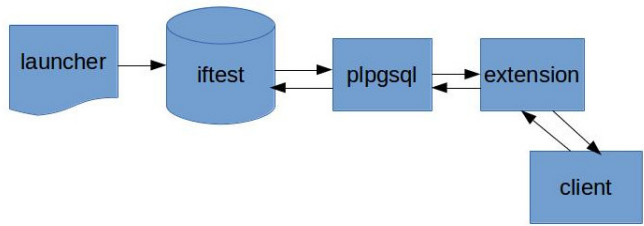    - Local versus remote

# Approach

- Seed database
- Launch command line clients
- Vary conditions
- Collect durations
- Analyze results

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High Level
Approach Detail

# Major Components

- Command line clients
- PG Extension
- Driver, load, and result objects
- Driver function
- Launcher bash script

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# Flow

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## Clients

- Individual command line clients
    - Native language for interface
        - libpq - C
        - ODBC - C
        - JDBC - Java
    - As similar as possible source code structure
    - Identical command line arguments
    - Handle variety of test conditions

## Extension

- C extension for command execution
  - Simple way to execute commands
  - Complete control over string escaping, etc.
  - Allow entire test to be table driven
  - Easy test result (duration) data collection

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# Driver Tables

- interfaces $\Rightarrow$ libpq, ODBC, JDBC
- alternateclientcopy
  - $\Rightarrow$ acc-n: normal interface
  - $\Rightarrow$ acc-a: alternate interface
  - $\Rightarrow$ acc-y: copy interface
- conninfos $\Rightarrow$ lcl:ipc: local connection, BSD socket
  - $\Rightarrow$ lcl:tcp: local connection, TCP/IP
  - $\Rightarrow$ rmt:tcp: remote connection, TCP/IP
- printfracdest
  - $\Rightarrow$ p-none:null: No print to file
  - $\Rightarrow$ p-all:null: Print to /dev/null
  - $\Rightarrow$ p-all:file: Print to file

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## Driver Tables

- sqlstratiter
  - ⇒ sql001:0:50k: 1 row, connect each time, run 50k times
  - ⇒ sql50k:0:001: 50k rows, connect each time, run 1 time
  - ⇒ sql10m:0:001: 10m rows, connect each time, run 1 time
  - ⇒ sql001:1:50k: 1 row, connect once, run 50k times
  - ⇒ sql50k:1:001: 50k rows, connect once, run 1 time
  - ⇒ sql10m:1:001: 10m rows, connect once, run 1 time

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## Driver View

- testcases
    - Generates all testcases from driver tables
    - Uses both JOIN (inner) and CROSS JOIN (Cartesian product)

```
CREATE OR REPLACE VIEW testcases AS
  ...
  FROM interfaces i
  JOIN conninfos c USING (ifname)
  JOIN alternateclientcopy a USING (ifname)
  CROSS JOIN printfracdest
  CROSS JOIN sqlstratiter
  ...;
SELECT * FROM testcases LIMIT 1;
-[ RECORD 1 ]----------------------------------------------------
testcase | ODBC:lcl:ipc:sql001:0:50k:acc-n:p-all:null
testcmd  | odbctest -c DSN=pgsql_ipc \
                     -s "select * from t50k where x1 = 4242" \
                     -p 1 -k 0 -n 50000  > /dev/null 2>&1
```

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## Load Tables

- t50k - 50 thousand rows

```
INSERT INTO t50k
SELECT
 id
 ,'1aaaaaaaaaaaaaaaa[...len = 99...]aaaaaaaaaaaaaaaaaaaaa'
 ,'2bbbbbbbbbbbbbbbb[...len = 99...]bbbbbbbbbbbbbbbbbbbbb'
 ,'3cccccccccccccccc[...len = 99...]ccccccccccccccccccccc'
 ,'4aaaaaaaaaaaaaaaa[...len = 99...]aaaaaaaaaaaaaaaaaaaaa'
 ,'5bbbbbbbbbbbbbbbb[...len = 99...]bbbbbbbbbbbbbbbbbbbbb'
 ,'6cccccccccccccccc[...len = 99...]ccccccccccccccccccccc'
 ,'7aaaaaaaaaaaaaaaa[...len = 99...]aaaaaaaaaaaaaaaaaaaaa'
 ,'8bbbbbbbbbbbbbbbb[...len = 99...]bbbbbbbbbbbbbbbbbbbbb'
 ,'9cccccccccccccccc[...len = 99...]ccccccccccccccccccccc'
FROM generate_series(1,50000) as t(id);
```

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# Load Tables

- t10m - 10 million rows

```
INSERT INTO t10m
SELECT
 id
 ,'1aaaaaaaaaaaaa'
 ,'2bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb'
 ,'3cccccccccccc'
 ,'4aaaaaaaaaaaaa'
 ,'5bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb'
 ,'6cccccccccccc'
 ,'7aaaaaaaaaaaaa'
 ,'8bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb'
 ,'9cccccccccccc'
FROM generate_series(1,10000000) as t(id);
```

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# Results Table

- testresults - aggregate test case representation

```
SELECT * FROM testresults LIMIT 1;
-[ RECORD 1 ]----------------------------------------
testcase | ODBC:lcl:ipc:sql001:0:50k:acc-n:p-all:null
iter     | 1
ts       | 2014-09-06 17:27:11.585011-07
duration | 238.23702
```

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# Results View

- vtestresults - expanded test case representation

```
SELECT * FROM vtestresults LIMIT 1;
-[ RECORD 1 ]--------------------------
iface     | JDBC
loc       | lcl
comm      | tcp
sql       | sql001
connstrat | 0
numiter   | 50k
extra     | acc-n
prnt      | p-all
dest      | file
iter      | 3
ts        | 2014-09-06 17:27:11.585011-07
duration  | 206.280236
```

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# Driver Function

- exectestcases()
- Arguments
  - path - client binary location (command line clients)
  - ldlibpath - linked library location (libpq.so)
  - classpath - Java class location (JDBC and getopt jar files)
  - outeriter - how many times to execute all test cases
- Returns SETOF RECORD
  - iter - current outeriter
  - tcase - aggregate form test case identifier
  - dur - duration of test case run

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# Launcher script

- Kicks off the entire automated test
    - Sets variables for exectestcases() arguments
    - Calls exectestcases() using psql
    - Currently executes 288 test cases per run
    - Runs for many hours and produces many GB output files

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# libpq Client

See libpqtest.c

# ODBC Client

See odbctest.c, odbc.ini, odbcinst.ini

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# JDBC Client

See jdbctest.java

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# Extension Code

See pgiftest.*, Makefile.ext, Makefile

```
-- make the extension available
CREATE EXTENSION pgiftest;
```

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# Object Creation SQL

See test-plan.sql

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# Driver Function SQL

See test-plan.sql

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# bash Script

See runtests.sh

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# Interface Variations

```
SELECT * FROM interfaces;
 ifname |    testprog
--------+---------------
 ODBC   | odbctest
 libpq  | libpqtest
 JDBC   | java jdbctest
(3 rows)
```

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## Connection Type Variations

```
SELECT * FROM conninfos;
 conndesc | ifname |                    conninfo
----------+--------+-----------------------------------------------------
 lcl:ipc  | ODBC   | -c DSN=pgsql_ipc
 lcl:tcp  | ODBC   | -c DSN=pgsql_lcl
 rmt:tcp  | ODBC   | -c DSN=pgsql_rmt
 lcl:ipc  | libpq  | -c postgresql://%2Ftmp/iftest?user=postgres
 lcl:tcp  | libpq  | -c postgresql://localhost/iftest?user=postgres
 rmt:tcp  | libpq  | -c postgresql://192.168.1.3/iftest?user=postgres
 lcl:tcp  | JDBC   | -c jdbc:postgresql://localhost/iftest?user=postgres
 rmt:tcp  | JDBC   | -c jdbc:postgresql://192.168.1.3/iftest?user=postgres
(8 rows)
```

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# Result Size, Conn Count, Num Executions

```
SELECT sqlstratiterdesc as desc,
       sql,
       connstrat as strat,
       numiter
FROM sqlstratiter;
     desc    |                  sql                  | strat | numiter
-------------+---------------------------------------+-------+---------
 sql001:0:50k | -s "select * from t50k where id = 4242" | -k 0  | -n 50000
 sql50k:0:001 | -s "select * from t50k"                 | -k 0  | -n 1
 sql10m:0:001 | -s "select * from t10m"                 | -k 0  | -n 1
 sql001:1:50k | -s "select * from t50k where id = 4242" | -k 1  | -n 50000
 sql50k:1:001 | -s "select * from t50k"                 | -k 1  | -n 1
 sql10m:1:001 | -s "select * from t10m"                 | -k 1  | -n 1
(6 rows)
```

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# Materialize (Y/N) and Destination

```
SELECT * FROM printfracdest;
   pfddesc   |   printfrac   |      dest
-------------+---------------+------------------
 p-all:null  | -p 1          | /dev/null
 p-all:file  | -p 1          | /tmp/iftest.out
 p-none:null | -p 0          | /dev/null
(3 rows)
```

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# Use Alternate Fetch or COPY Interface

```
SELECT * FROM alternateclientcopy;
 accdesc | ifname | sw
---------+--------+----
 acc-n   | ODBC   |
 acc-n   | libpq  |
 acc-a   | libpq  | -a
 acc-y   | libpq  | -y
 acc-n   | JDBC   |
 acc-y   | JDBC   | -y
(6 rows)
```

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## Results - Interface/Method

```
CREATE OR REPLACE VIEW ifmeth_cat_results AS
SELECT sql  || $$:$$ || numiter  || $$:$$ || loc  || $$:$$ || comm ||
       $$:$$ || connstrat  || $$:$$ || prnt || $$:$$ || dest AS testcase
      ,iface || $$:$$ || extra AS candidate
      ,round(duration::numeric, 5) AS duration
      ,round(drange::numeric, 5) AS drange, grpsz
      ,round(((duration - min(duration) OVER w) /
             (max(duration) OVER w - min(duration) OVER w)
            )::numeric, 5) AS nml_dur
      ,round(((drange - min(drange) OVER w) /
             (max(drange) OVER w - min(drange) OVER w)
            )::numeric, 5) AS nml_drng
FROM (SELECT iface,loc,comm,connstrat,sql,numiter,extra,prnt,dest
           ,count(1) as grpsz, avg(duration) AS duration
           ,max(duration) - min(duration) AS drange
      FROM vtestresults GROUP BY 1,2,3,4,5,6,7,8,9) as t
WINDOW w AS (PARTITION BY sql,numiter,loc,comm,connstrat,prnt,dest
            ORDER BY duration
            ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING);
```

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# Results - Interface/Method Summarized

```
SELECT candidate
      ,round(AVG(grpsz),1) AS avg_grpsz
      ,round(AVG(nml_dur),3) AS avg_nml_dur
      ,round(AVG(nml_drng),3) AS avg_nml_drng
FROM ifmeth_cat_results
GROUP BY candidate
ORDER BY 3,4,1;
  candidate  | avg_grpsz | avg_nml_dur | avg_nml_drng
-------------+-----------+-------------+--------------
 libpq:acc-a |       9.0 |       0.008 |        0.285
 libpq:acc-n |       9.0 |       0.055 |        0.224
 libpq:acc-y |       9.0 |       0.097 |        0.416
 JDBC:acc-y  |       9.0 |       0.231 |        0.279
 ODBC:acc-n  |       9.0 |       0.748 |        0.523
 JDBC:acc-n  |       9.0 |       0.851 |        0.600
(6 rows)
```

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# Results - Location/Transport

```
CREATE OR REPLACE VIEW loccomm_cat_results AS
SELECT iface || $$:$$ || extra || $$:$$ || sql || $$:$$ || numiter ||
       $$:$$ || connstrat  || $$:$$ || prnt || $$:$$ || dest AS testcase
      ,loc || $$:$$ || comm AS candidate
      ,round(duration::numeric, 5) AS duration
      ,round(drange::numeric, 5) AS drange, grpsz
      ,round(((duration - min(duration) OVER w) /
             (max(duration) OVER w - min(duration) OVER w)
            )::numeric, 5) AS nml_dur
      ,round(((drange - min(drange) OVER w) /
             (max(drange) OVER w - min(drange) OVER w)
            )::numeric, 5) AS nml_drng
FROM (SELECT iface,loc,comm,connstrat,sql,numiter,extra,prnt,dest
           ,count(1) as grpsz, avg(duration) AS duration
           ,max(duration) - min(duration) AS drange
      FROM vtestresults GROUP BY 1,2,3,4,5,6,7,8,9) as t
WINDOW w AS (PARTITION BY sql,numiter,iface,extra,connstrat,prnt,dest
            ORDER BY duration
            ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING);
```

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# Results - Location/Transport Summarized

```
SELECT candidate
      ,round(AVG(grpsz),1) AS avg_grpsz
      ,round(AVG(nml_dur),3) AS avg_nml_dur
      ,round(AVG(nml_drng),3) AS avg_nml_drng
FROM loccomm_cat_results
GROUP BY candidate
ORDER BY 3,4,1;
 candidate | avg_grpsz | avg_nml_dur | avg_nml_drng
-----------+-----------+-------------+--------------
 lcl:ipc   |       9.0 |       0.001 |        0.398
 lcl:tcp   |       9.0 |       0.108 |        0.484
 rmt:tcp   |       9.0 |       1.000 |        0.538
(3 rows)
```

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## Results - Query/Connect Strategy Summarized

```
SELECT testcase, round(avg(duration),3) AS avg_dur
FROM ifmeth_cat_results
WHERE testcase IN (
    'sql50k:001:lcl:ipc:0:p-all:file'
   ,'sql50k:001:lcl:ipc:1:p-all:file'
   ,'sql50k:001:lcl:tcp:0:p-all:file'
   ,'sql50k:001:lcl:tcp:1:p-all:file'
   ,'sql50k:001:rmt:tcp:0:p-all:file'
   ,'sql50k:001:rmt:tcp:1:p-all:file'
   ,'sql001:50k:lcl:ipc:0:p-all:file'
   ,'sql001:50k:lcl:ipc:1:p-all:file'
   ,'sql001:50k:lcl:tcp:0:p-all:file'
   ,'sql001:50k:lcl:tcp:1:p-all:file'
   ,'sql001:50k:rmt:tcp:0:p-all:file'
   ,'sql001:50k:rmt:tcp:1:p-all:file'
)
GROUP BY testcase
ORDER BY 2;
```

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# Results - Query/Connect Strategy Summarized

```
        testcase             | avg_dur
------------------------------+---------
 sql50k:001:lcl:ipc:0:p-all:file |   0.293
 sql50k:001:lcl:ipc:1:p-all:file |   0.299
 sql50k:001:lcl:tcp:0:p-all:file |   0.758
 sql50k:001:lcl:tcp:1:p-all:file |   0.784
 sql50k:001:rmt:tcp:0:p-all:file |   1.036
 sql50k:001:rmt:tcp:1:p-all:file |   1.038
 sql001:50k:lcl:ipc:1:p-all:file |  10.245
 sql001:50k:lcl:tcp:1:p-all:file |  15.586
 sql001:50k:rmt:tcp:1:p-all:file |  40.944
 sql001:50k:lcl:ipc:0:p-all:file | 186.176
 sql001:50k:lcl:tcp:0:p-all:file | 203.528
 sql001:50k:rmt:tcp:0:p-all:file | 428.544
(12 rows)
```

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## sql001:50k:lcl:ipc:0:p-all:file

- sql001:50k $\Rightarrow$ Query 1 row, 50k times
- lcl:ipc $\Rightarrow$ Local host via IPC connection
- 0 $\Rightarrow$ Connect every query
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql001:50k:lcl:ipc:0:p-all:file';
  candidate  | duration
-------------+-----------
 libpq:acc-n | 167.08301
 libpq:acc-a | 168.08354
 libpq:acc-y | 169.53112
 ODBC:acc-n  | 240.00766
(4 rows)
```

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## sql001:50k:lcl:ipc:1:p-all:file

- sql001:50k $\Rightarrow$ Query 1 row, 50k times
- lcl:ipc $\Rightarrow$ Local host via IPC connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql001:50k:lcl:ipc:1:p-all:file';
  candidate  | duration
-------------+----------
 libpq:acc-n |  7.72111
 libpq:acc-a |  8.30801
 libpq:acc-y |  8.44191
 ODBC:acc-n  | 16.50867
(4 rows)
```

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## sql001:50k:lcl:tcp:0:p-all:file

- sql001:50k $\Rightarrow$ Query 1 row, 50k times
- lcl:tcp $\Rightarrow$ Local host via TCP/IP connection
- 0 $\Rightarrow$ Connect every query
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql001:50k:lcl:tcp:0:p-all:file';
  candidate  | duration
-------------+-----------
 libpq:acc-n | 184.76682
 libpq:acc-a | 185.10930
 libpq:acc-y | 187.35046
 JDBC:acc-y  | 200.94066
 JDBC:acc-n  | 206.43863
 ODBC:acc-n  | 256.56118
(6 rows)
```

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## sql001:50k:lcl:tcp:1:p-all:file

- sql001:50k $\Rightarrow$ Query 1 row, 50k times
- lcl:tcp $\Rightarrow$ Local host via TCP/IP connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql001:50k:lcl:tcp:1:p-all:file';
  candidate  | duration
-------------+----------
 libpq:acc-a | 11.40072
 libpq:acc-n | 11.62985
 libpq:acc-y | 12.67647
 JDBC:acc-y  | 15.00848
 JDBC:acc-n  | 20.46275
 ODBC:acc-n  | 22.33883
(6 rows)
```

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## sql001:50k:rmt:tcp:0:p-all:file

- sql001:50k ⇒ Query 1 row, 50k times
- rmt:tcp ⇒ Remote host via TCP/IP connection
- 0 ⇒ Connect every query
- p-all:file ⇒ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql001:50k:rmt:tcp:0:p-all:file';
  candidate  | duration
-------------+-----------
 libpq:acc-n | 380.87894
 libpq:acc-a | 381.20051
 libpq:acc-y | 398.77627
 JDBC:acc-y  | 437.91512
 JDBC:acc-n  | 443.36177
 ODBC:acc-n  | 529.13435
(6 rows)
```

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## sql001:50k:rmt:tcp:1:p-all:file

- sql001:50k $\Rightarrow$ Query 1 row, 50k times
- rmt:tcp $\Rightarrow$ Remote host via TCP/IP connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql001:50k:rmt:tcp:1:p-all:file';
  candidate  | duration
-------------+----------
 libpq:acc-n | 26.79044
 libpq:acc-a | 26.95195
 libpq:acc-y | 41.10257
 JDBC:acc-y  | 44.27100
 ODBC:acc-n  | 52.93944
 JDBC:acc-n  | 53.60791
(6 rows)
```

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## sql50k:001:rmt:tcp:1:p-all:file

- sql50k:001 $\Rightarrow$ Query 50k rows, 1 time
- rmt:tcp $\Rightarrow$ Remote host via TCP/IP connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql50k:001:rmt:tcp:1:p-all:file';
  candidate  | duration
-------------+----------
 libpq:acc-a |  0.44083
 libpq:acc-y |  0.55278
 libpq:acc-n |  0.60207
 JDBC:acc-y  |  0.67728
 ODBC:acc-n  |  0.94350
 JDBC:acc-n  |  3.00985
(6 rows)
```

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## sql10m:001:rmt:tcp:1:p-all:file

- sql10m:001 $\Rightarrow$ Query 10m rows, 1 time
- rmt:tcp $\Rightarrow$ Remote host via TCP/IP connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql10m:001:rmt:tcp:1:p-all:file';
  candidate  | duration
-------------+-----------
 libpq:acc-a |  36.10610
 libpq:acc-y |  41.68094
 JDBC:acc-y  |  41.85082
 libpq:acc-n |  52.39856
 ODBC:acc-n  |  90.92070
 JDBC:acc-n  | 416.97683
(6 rows)
```

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## sql10m:001:lcl:tcp:1:p-all:file

- sql10m:001 $\Rightarrow$ Query 10m rows, 1 time
- lcl:tcp $\Rightarrow$ Local host via TCP/IP connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql10m:001:lcl:tcp:1:p-all:file';
  candidate  | duration
-------------+-----------
 libpq:acc-y |  29.37412
 libpq:acc-a |  31.62445
 JDBC:acc-y  |  31.87552
 libpq:acc-n |  40.85718
 ODBC:acc-n  |  77.09062
 JDBC:acc-n  | 396.85311
(6 rows)
```

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## sql10m:001:lcl:ipc:1:p-all:file

- sql10m:001 $\Rightarrow$ Query 10m rows, 1 time
- lcl:ipc $\Rightarrow$ Local host via IPC connection
- 1 $\Rightarrow$ Connect once
- p-all:file $\Rightarrow$ print every row to file

```
SELECT candidate, duration
FROM ifmeth_cat_results
WHERE testcase = 'sql10m:001:lcl:ipc:1:p-all:file';
  candidate  | duration
-------------+----------
 libpq:acc-y | 27.45592
 libpq:acc-a | 30.03265
 libpq:acc-n | 36.35336
 ODBC:acc-n  | 69.42425
(4 rows)
```

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## all:acc-n:sql50k:001:all:p-all:file

- all:acc-n $\Rightarrow$ All interfaces, normal method
- sql50k:001 $\Rightarrow$ 50k rows, one time
- p-all:file $\Rightarrow$ print every row to file

```
SELECT testcase, candidate, duration
FROM loccomm_cat_results
WHERE testcase LIKE '%:acc-n:sql50k:001:1:p-all:file'
ORDER BY 1, 3, 2;
            testcase              | candidate | duration
----------------------------------+-----------+----------
 libpq:acc-n:sql50k:001:1:p-all:file | lcl:ipc |  0.21962
 libpq:acc-n:sql50k:001:1:p-all:file | lcl:tcp |  0.32501
 libpq:acc-n:sql50k:001:1:p-all:file | rmt:tcp |  0.60207
 ODBC:acc-n:sql50k:001:1:p-all:file  | lcl:ipc |  0.56753
 ODBC:acc-n:sql50k:001:1:p-all:file  | lcl:tcp |  0.70518
 ODBC:acc-n:sql50k:001:1:p-all:file  | rmt:tcp |  0.94350
 JDBC:acc-n:sql50k:001:1:p-all:file  | lcl:tcp |  2.72273
 JDBC:acc-n:sql50k:001:1:p-all:file  | rmt:tcp |  3.00985
(8 rows)
```

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# Future Work

- Additional interfaces
  - Different versions of JDBC library
  - Alternate JDBC library
  - npgsql (.Net data provider)
  - py-postgresql (native python interface)
- Additional alternate fetch strategies
  - Prepared statements
  - Server-side COPY with client-side file fetch
- Cost of SSL connection

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# Questions?

Thank You!
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