Raising the fetch size, good or bad?

Exploring Memory Management in Oracle JDBC 12c

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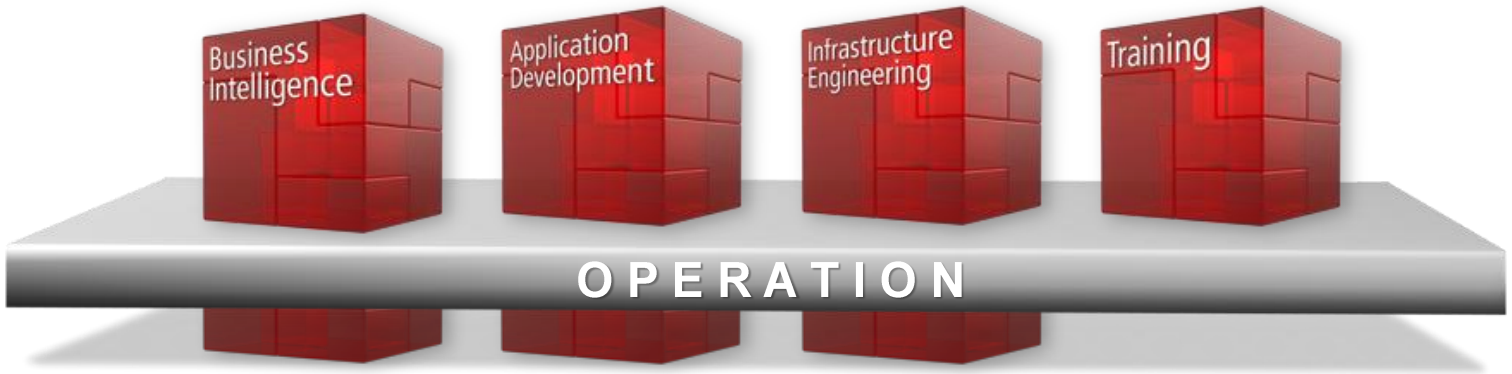

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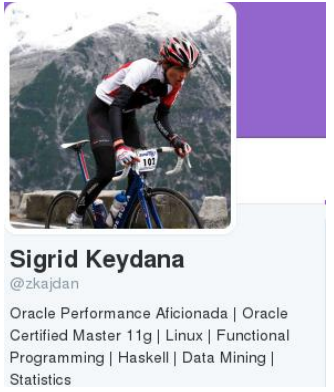
About me

- Oracle Database Administrator since 2010
- Former Java Developer (up & including Java SE 5)
- Certifications including
  - Oracle Certified Master 11g
  - Red Hat Certified Systems Administrator RHEL 6
  - Sun Certified Developer for the Java 2 Platform
- Blog: http://recurrentnull.wordpress.com
- Twitter: @zkajdan



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Agenda

- What is meant by fetch size, and why should you care?
- Memory allocation for result buffers: 11g vs. 12c
- Test Setup
- Results
- Conclusion / Recommendations

What is Meant by Fetch Size, and Why Should You Care?

Fetch Size - in a Nutshell

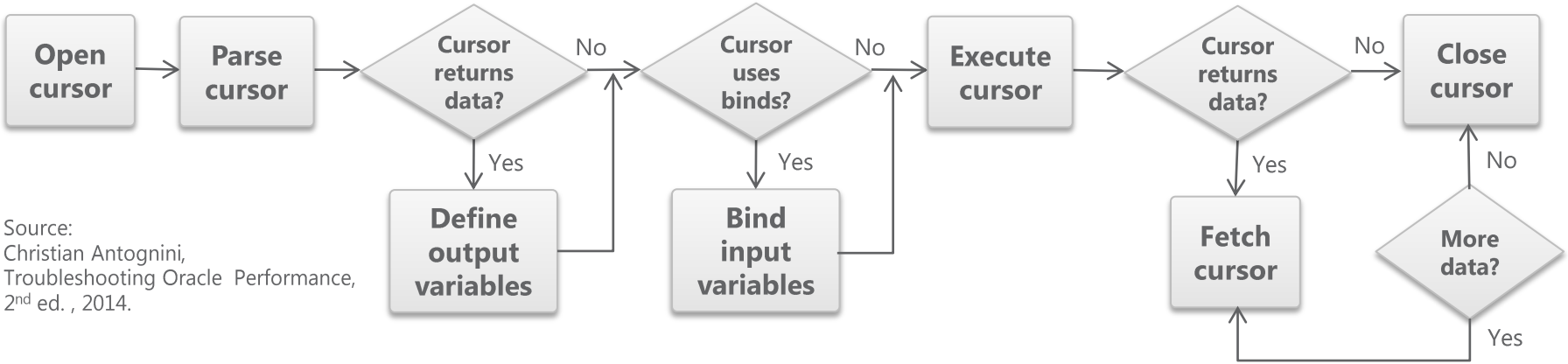
- Fetch size determines the number of rows retrieved from the database server in one network round trip
- Default in Oracle JDBC is 10
- Set on a *(Prepared)Statement*: `stmt.setFetchSize(n);`
- Depending on network latency, increasing fetch size could (should!) allow for substantial performance gains

A True Story

Fetch Size – Digging Deeper: Under The Hood

```
CDB1.PDB1 SQL> select employee_id, first_name, last_name from employees;

EMPLOYEE_ID FIRST_NAME           LAST_NAME
----------- -------------------- ------------------------
        100 Steven               King
        101 Neena                Kochhar
        102 Lex                  De Haan
        103 Alexander            Hunold
        104 Bruce                Ernst
        105 David                Austin
```



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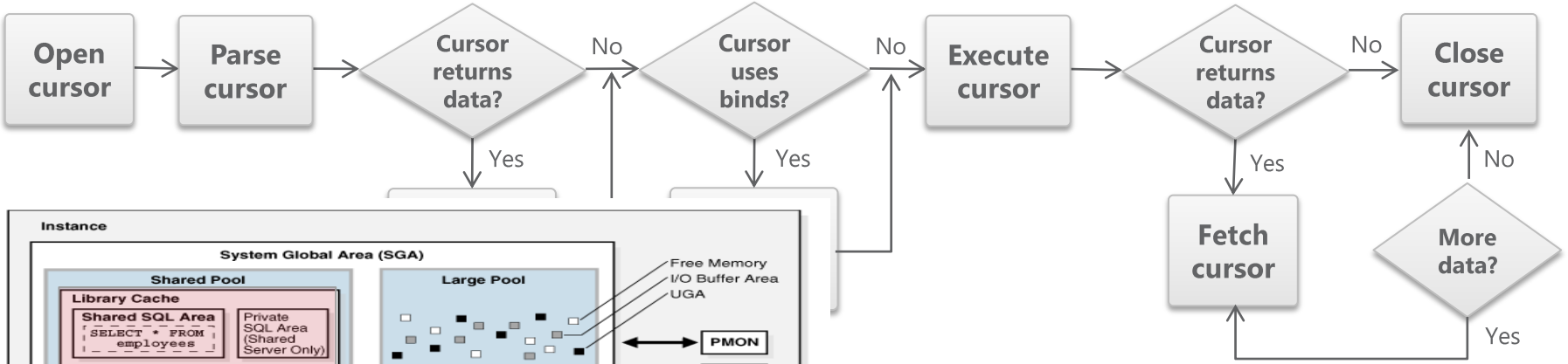
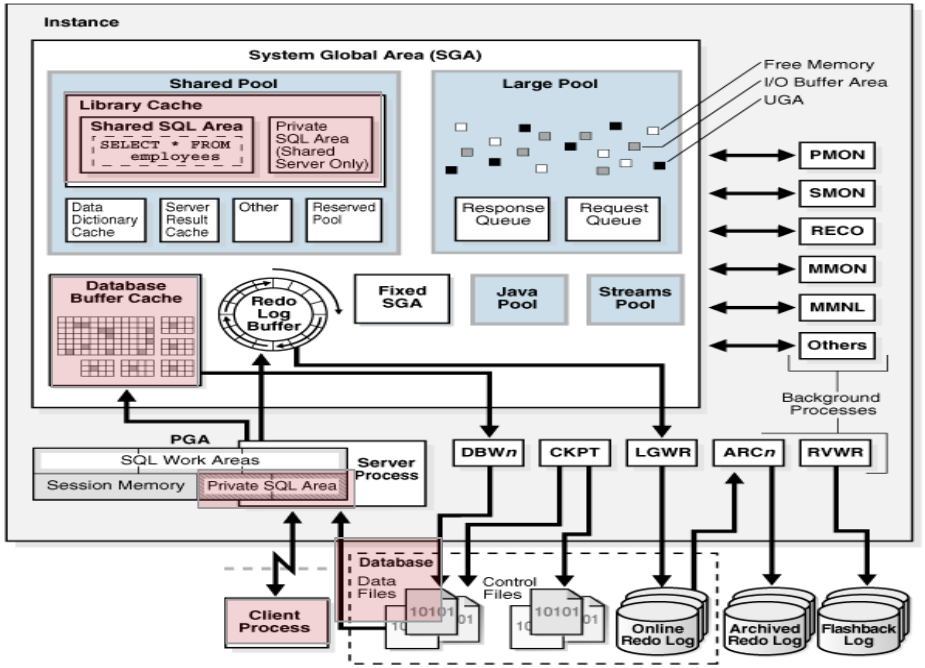
Christian Antognini,
Troubleshooting Oracle Performance,
2nd ed. , 2014.

Fetch Size – Digging Deeper: Under The Hood





Source:
Christian Antognini,
Troubleshooting Oracle Performance,
2nd ed. , 2014.

Source:
Oracle Database Concepts
12.1, October 2014

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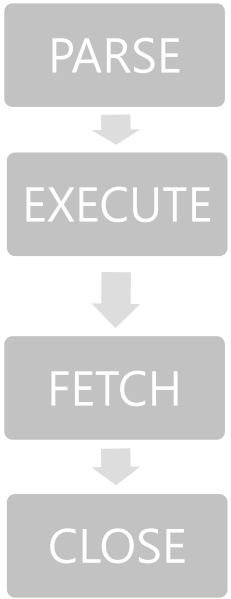
Fetch Size – Digging Deeper: DBMS_SQL

```
DECLARE
  l_ename emp.ename%TYPE := 'SCOTT';
  l_empno emp.empno%TYPE;
  l_cursor INTEGER;
  l_retval INTEGER;
BEGIN
  l_cursor := dbms_sql. open_cursor ;
  dbms_sql. parse(l_cursor, 'SELECT empno FROM emp WHERE
ename = :ename', 1);
  dbms_sql. define_column(l_cursor, 1, l_empno);
  dbms_sql. bind_variable(l_cursor, ':ename', l_ename);
  l_retval := dbms_sql. execute(l_cursor);
  IF dbms_sql. fetch_rows(l_cursor) > 0
  THEN
    dbms_sql. column_value(l_cursor, 1, l_empno);
    dbms_output.put_line(l_empno);
  END IF;
  dbms_sql. close_cursor(l_cursor);
END;
```

Source:
Christian Antognini,
Troubleshooting Oracle Performance,,
2nd ed. , 2014.

Fetch Size – Digging Deeper: JDBC




```
String getEmployees = "select firstname, lastname from employee";
PreparedStatement stmt = conn.prepareStatement(getEmployees);

List<Employee> employees = new ArrayList<>();
ResultSet rset = stmt.executeQuery();

while (rset.next()) {
    Employee employee = new Employee();
    employee.setFirstname(rset.getString(1));
    employee.setLastname(rset.getString(2));
    employees.add(employee);

}
rset.close();
stmt.close();
```

Where does the fetch size come in?

Fetch Size – Digging Deeper: Two meanings

- By fetching, we may mean two things:
  - Fetching rows from a cursor (requires server round trip)
  - Fetching rows from a result set (client side)
- This is easier so see with OCI.

Fetch Size – Digging Deeper: OCI

- In OCI, the number of rows to be fetched from a cursor is set on the statement handle as its *OCI_ATTR_PREFETCH_ROWS* attribute:

```
OCIAttrSet (stm, OCI_HTYPE_STMT, &rows, sizeof(rows),
OCI_ATTR_PREFETCH_ROWS, err);
```

- When the statement is executed, it may be told how many rows to fetch from this result set into a defined output variable using the *iters* parameter (position 4). The output variable has to be an array if *iters* > 0:

```
OCIStmtExecute(svc, stm, err, iters, 0, 0, 0, OCI_DEFAULT);
```

Fetch Size – Digging Deeper: OCI

- In case more results have been pre-fetched than are stored in the output variable, the rows are buffered during calls to *OCIStmtFetch2.*
- The above JDBC code is equivalent to having defined a scalar output variable and having set *iters* to 0 in *OCIStmtExecute*:

```
while (ret = OCIStmtFetch2(stm, err, 1, OCI_FETCH_NEXT, 0, OCI_DEFAULT) ==
OCI_SUCCESS) {
    //do something
}
```

- It will pre-fetch rows from the cursor as configured on the Statement and fetch from the result set one row at a time, buffering the rest in memory.

Fetch Size – Digging Deeper: OCI

- This is where CLIENT SIDE MEMORY comes in.
- Which makes setting fetch size basically a tradeoff between PERFORMANCE and RESOURCE USAGE.

Memory Allocation for Result Buffers: 11g vs. 12c

Memory Allocation – 11g

- Each *Statement* object has two buffers:
  - One char[] : for (N)CHAR and (N)VARCHAR2 columns
  - One byte[] : for all other column types (NUMBER, DATE,
  - …)
- Buffer sizes are determined at PARSE TIME, depending on column definition
- The actual size of the data returned does not matter!

Memory Allocation – 11g

- Example:

```
CDB1.PDB1 SQL> CREATE TABLE allocs (id NUMBER, created DATE,
  2  short_desc VARCHAR2(30), long_desc VARCHAR2(4000));
```

- To retrieve 1 row from this table, the driver will allocate:
  - 22 bytes for the NUMBER column (in the byte[])
  - 22 bytes for the DATE column (in the byte[])
  - 60 bytes for the VARCHAR2(30) column (in the char[])
  - 8000 bytes for the VARCHAR2(4000) column (in the char[])

Memory Allocation – 11g

- Now imagine a table with 255 columns defined as VARCHAR2(4000):
- You would need to allocate 255 * 8000 bytes = ~ 2 MB per row
- Independent of whether actual values are shorter or even absent (null)!
- These ~2 MB are for 1 row only
- – they need to be multiplied by the fetch size!
  - – If fetch size = 10: ~ 20 MB
  - – If fetch size = 100: ~ 200 MB
  - – If fetch size = 1000: ~ 2 GB

Memory Allocation – 12c

- *Statement* objects have one byte[] buffer only (for all column types)
- Bytes are allocated based on actual column *values* (plus a fixed 15 bytes per column)
- Imagine same table with 255 VARCHAR2(4000) columns again
- Imagine 170/255 columns are not null, with an average length of 30 characters
- Now we need just ~5 kb of buffers to store one result row in the *Statement*
- And to retrieve several rows, now we need
  - If fetch size = 10: ~ 50 kb
  - If fetch size = 100: ~ 500 kb
  - If fetch size = 1000: ~ 5 MB

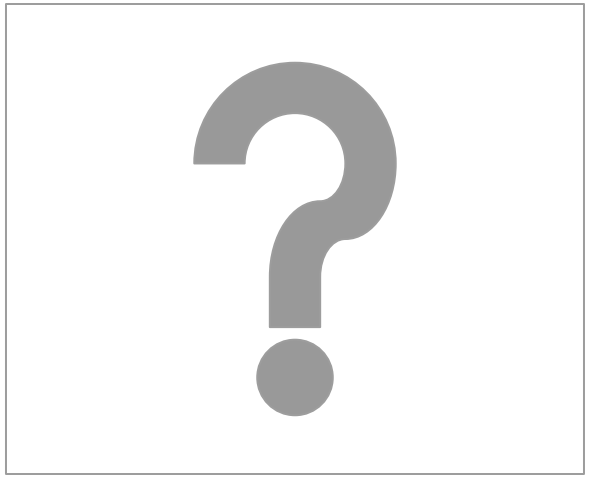
Aside: Why Did They Change It?

- Optional new maximum VARCHAR2 size in 12c: 32k (with max_string_size=extended)
- Internally stored as LOBs
- But formally defined as e.g. VARCHAR2(32767)
- Determining required buffer size at parse time, based on *column definitions*, is no longer feasible!

So

...

DOES IT WORK



Test Setup

Test Setup

- Load tests using Swingbench (http://www.dominicgiles.com/swingbench.html)
- Custom Java transaction selects from big table with LARGE character columns (200 VARCHAR2(4000) columns, with an average length of 160 bytes each)
- Each transaction selects ~ 1000 rows, to allow for meaningful variations in fetch size
- Test run duration 20 minutes, 4 concurrent users
- DB version 12.1.0.2, client java version 1.8.0_45
- Maximum client heap size 1G
- Independent variable: JDBC driver version - 11.2.0.4 (ojdbc6.jar) vs. 12.1.0.2 (ojdbc6.jar)

Dependent Variables: Swingbench

- Number of completed transactions

```
<TimeOfRun>Jun 14, 2015 8:27:25 AM</TimeOfRun>
<TotalRunTime>0:15:00</TotalRunTime>
<TotalLogonTime>0:00:03</TotalLogonTime>
<TotalCompletedTransactions>79</TotalCompletedTransactions>
<TotalFailedTransactions>0</TotalFailedTransactions>
<AverageTransactionsPerSecond>0.09</AverageTransactionsPerSecond>
<MaximumTransactionRate>8</MaximumTransactionRate>
<AverageResponse>45418.759493670885</AverageResponse>
<MinimumResponse>41665</MinimumResponse>
<MaximumResponse>48357</MaximumResponse>
<GeometricMean>45381.87265448191</GeometricMean>
<Skewness>-0.6101485966611743</Skewness>
<Kurtosis>-0.6940221560736153</Kurtosis>
<StdDeviation>1826.3569048735317</StdDeviation>
```

Dependent Variables: Java Flight Recorder

- Maximum and average heap sizes

Avg 413 MiB Max 648 MiB

- Memory allocated for char[] and byte[] buffers

Class	Instances	Size	Percentage of He
char[]	12,023	342.24 MB	99.75%
byte[]	537	231.34 kB	0.07%

Dependent variables: OS memory

- */usr/bin/time:* OS level maximum memory usage (max resident size)

```
10.06user 14.16system 20:02.02elapsed 2%CPU (0avgtext+0avgdata 128676maxresident)k
32936inputs+592outputs (6major+78356minor)pagefaults 0swaps
```

Dependent variables: SQL Trace

- Raw trace file

```
PARSING IN CURSOR #139782612022088 len=63 dep=0 uid=113 oct=3 lid=113 tim=2643223245 hv=1959287399 ad='fbf37a30' sqlid='ahuqtjjuchqm7'
select * from mining_info where customer_id between :1  and :2
END OF STMT
PARSE #139782612022088:c=0,e=95,p=0,cr=0,cu=0,mis=0,r=0,dep=0,og=1,plh=584152139,tim=2643223244
EXEC #139782612022088:c=1000,e=2759,p=0,cr=0,cu=0,mis=0,r=0,dep=0,og=1,plh=584152139,tim=2643226090
WAIT #139782612022088: nam='SQL*Net message to client' ela= 4 driver id=675562835 #bytes=1 p3=0 obj#=-1 tim=2643226224
WAIT #139782612022088: nam='Disk file operations I/O' ela= 117 FileOperation=2 fileno=18 filetype=2 obj#=96222 tim=2643229263
WAIT #139782612022088: nam='Disk file operations I/O' ela= 2499 FileOperation=2 fileno=0 filetype=15 obj#=96222 tim=2643231852
WAIT #139782612022088: nam='Disk file operations I/O' ela= 18 FileOperation=2 fileno=0 filetype=15 obj#=96222 tim=2643233052
WAIT #139782612022088: nam='direct path read' ela= 6817 file number=18 first dba=484228 block cnt=124 obj#=96222 tim=2643240321
WAIT #139782612022088: nam='Disk file operations I/O' ela= 23 FileOperation=2 fileno=0 filetype=15 obj#=96222 tim=2643240579
WAIT #139782612022088: nam='Disk file operations I/O' ela= 12 FileOperation=2 fileno=0 filetype=15 obj#=96222 tim=2643240820
WAIT #139782612022088: nam='direct path read' ela= 6507 file number=18 first dba=484482 block cnt=126 obj#=96222 tim=2643247428
```

<snip>

```
WAIT #139782612022088: nam='SQL*Net more data to client' ela= 4 driver id=675562835 #bytes=8171 p3=0 obj#=96222 tim=2647881093
WAIT #139782612022088: nam='SQL*Net more data to client' ela= 4 driver id=675562835 #bytes=8081 p3=0 obj#=96222 tim=2647881108
WAIT #139782612022088: nam='SQL*Net more data to client' ela= 5 driver id=675562835 #bytes=8042 p3=0 obj#=96222 tim=2647881135
FETCH #139782612022088:c=1000,e=1055765,p=0,cr=91,cu=0,mis=0,r=10,dep=0,og=1,plh=584152139,tim=2647881148
```

Dependent variables: SQL Trace

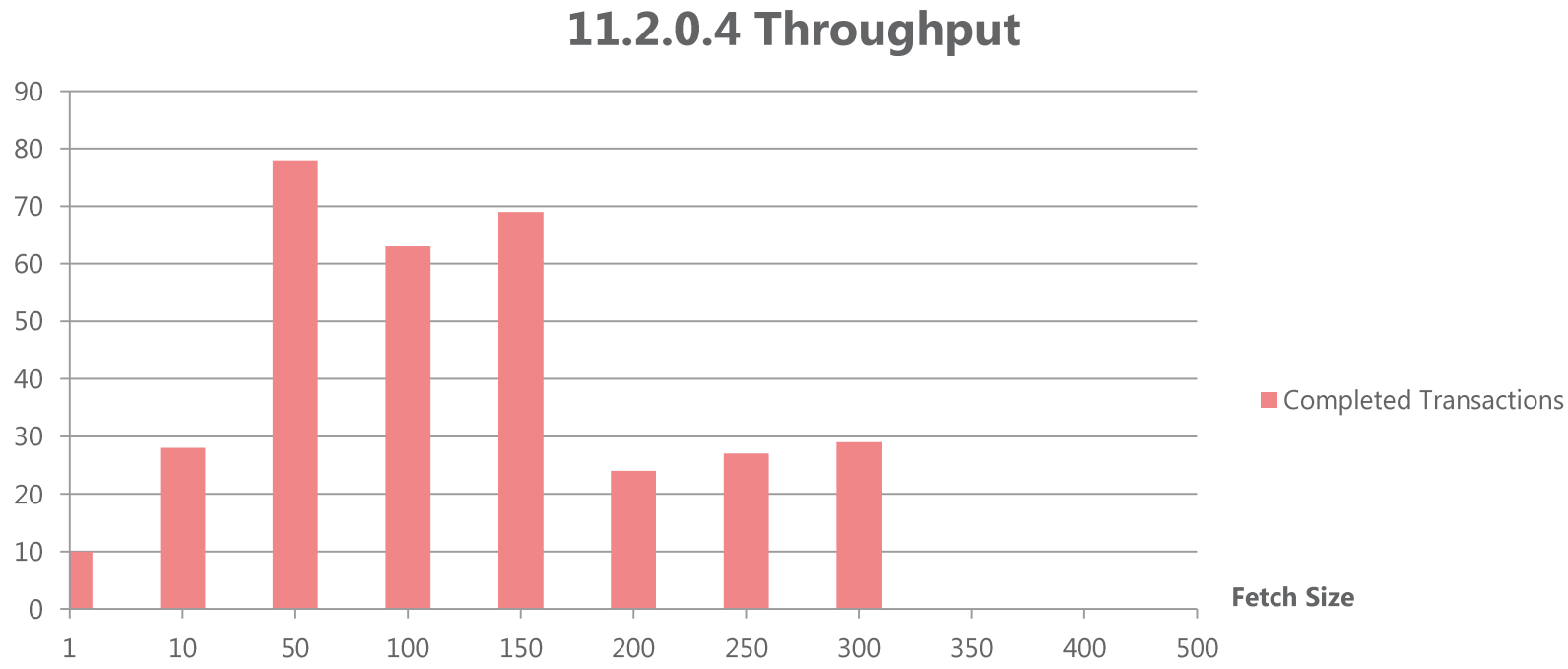
- TKPROF output

call	count	cpu	elapsed	disk	query	current	rows
Parse	40	0.00	0.00	0	0	0	0
Execute	40	0.00	0.01	0	0	0	0
Fetch	3917	27.01	2973.19	2022034	1890904	0	38810
total	3997	27.02	2973.20	2022034	1890904	0	38810

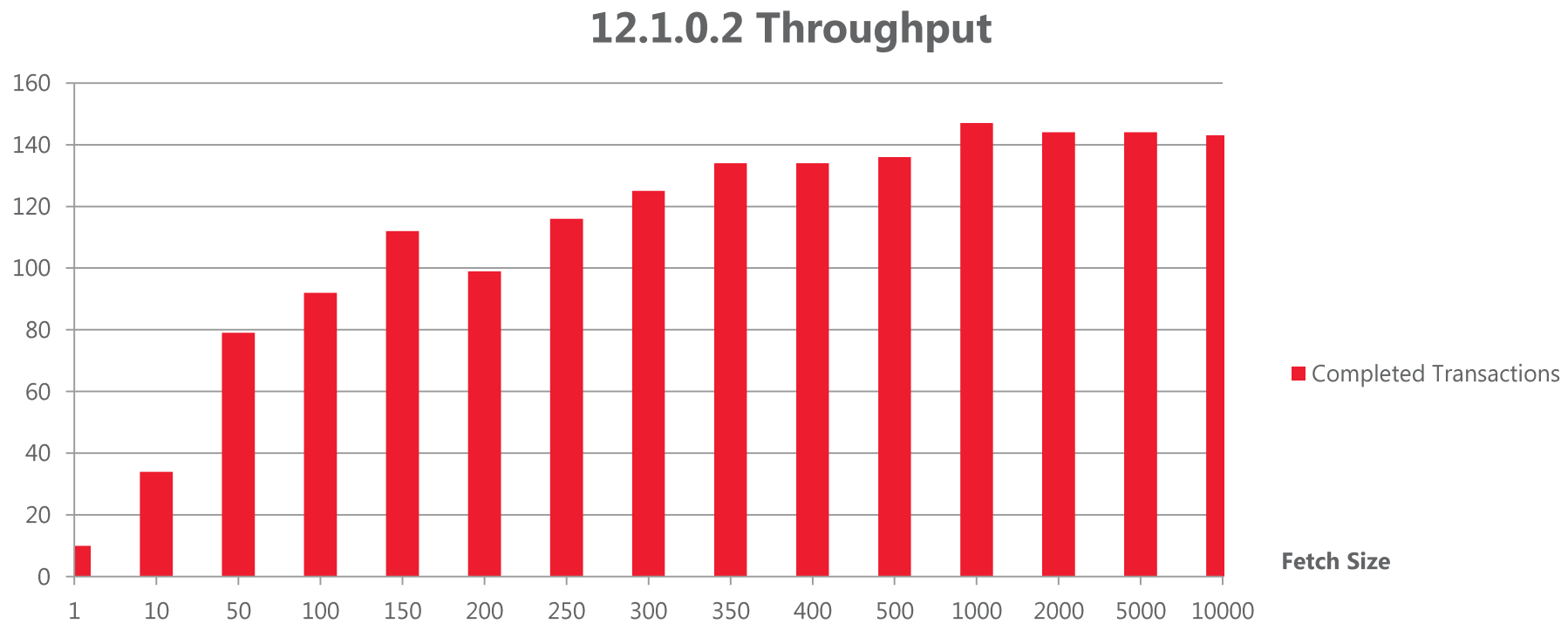
SQL*Net message to client	3917	0.00	0.01
Disk file operations I/O	20	0.00	0.01
direct path read	6925	0.03	33.40
SQL*Net more data to client	152113	1.17	2845.25
SQL*Net message from client	3917	0.75	1818.13
db file sequential read	302142	0.03	79.81
resmgr:cpu quantum	5	0.01	0.05

Results

11g : Completed Transactions

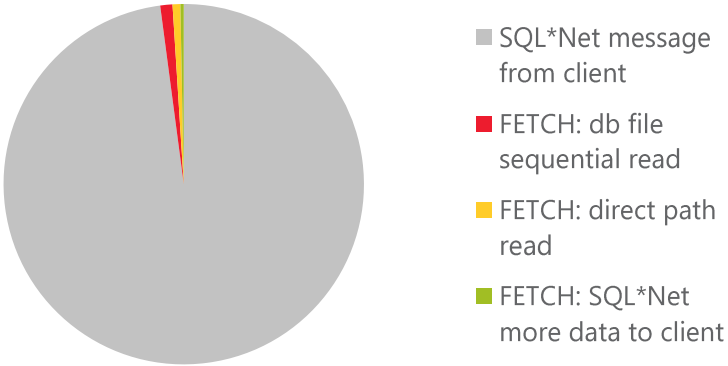


12c : Completed Transactions

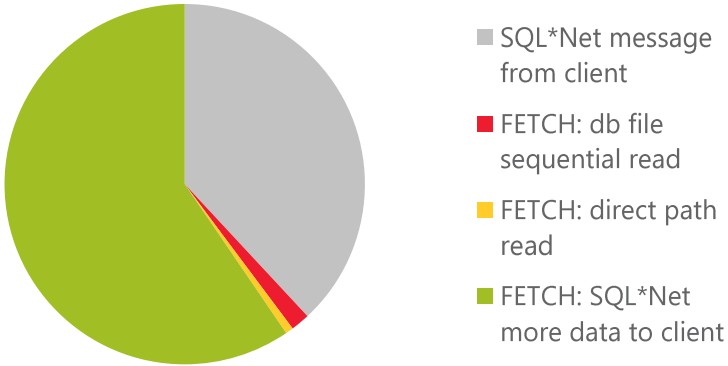


Database Time

11.2.0.4, fetch size 1

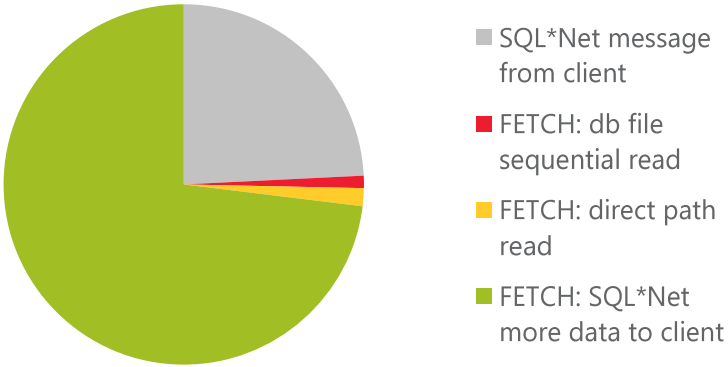


11.2.0.4, fetch size 10

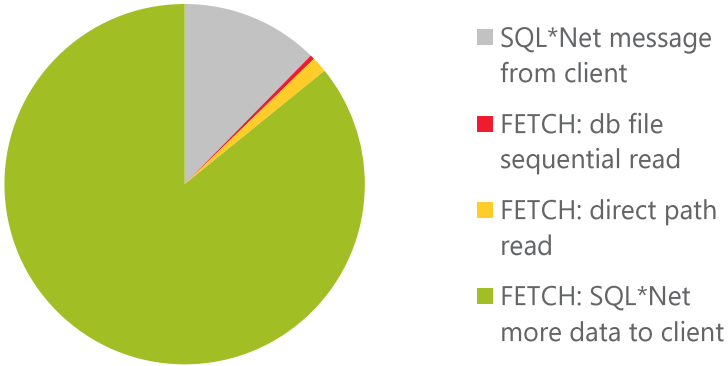


Database Time

11.2.0.4, fetch size 50

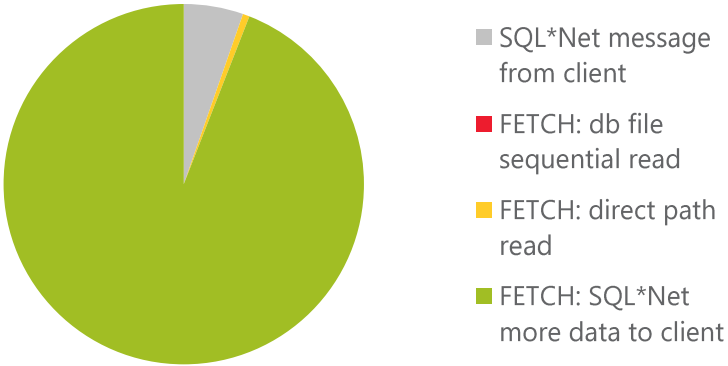


11.2.0.4, fetch size 100

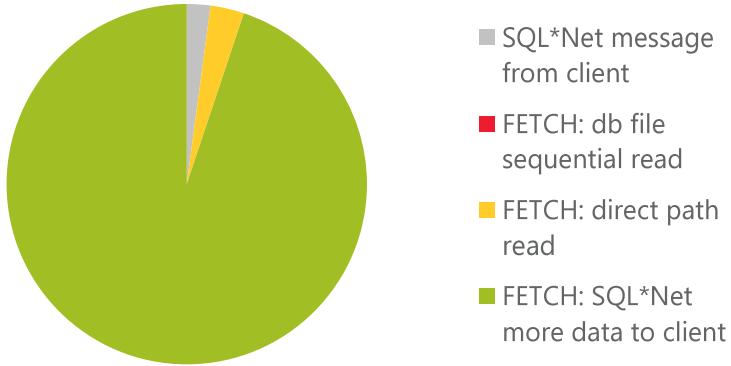


Database Time

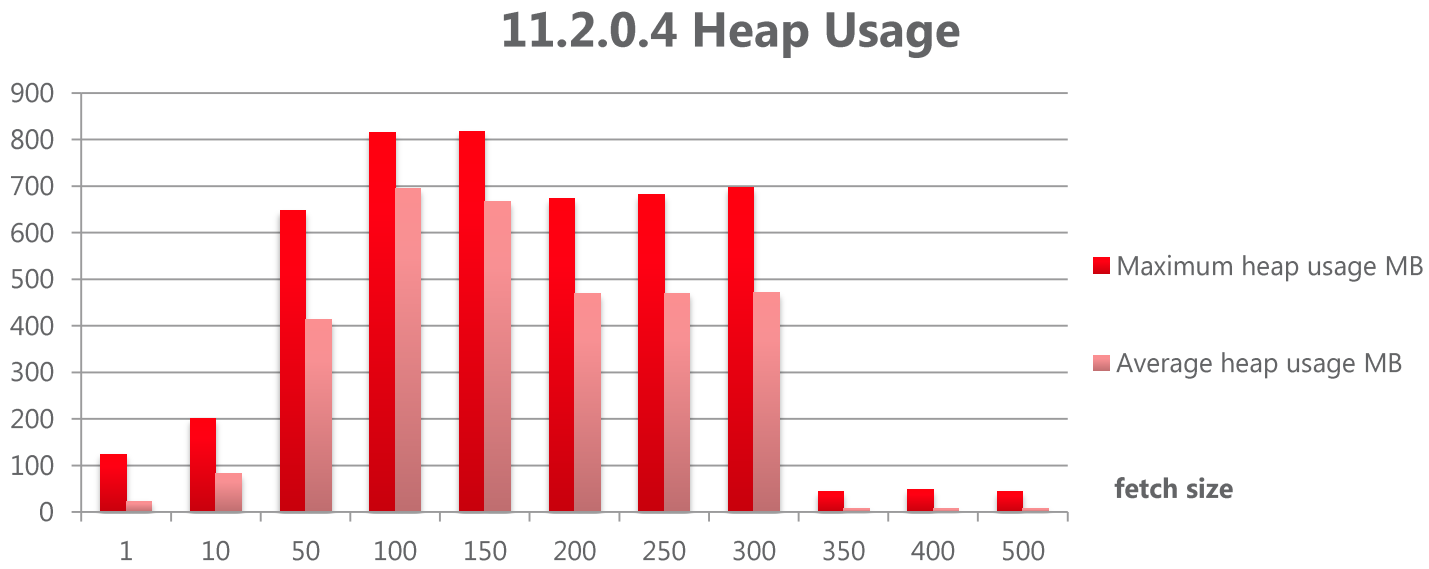
12.1.0.2, fetch size 1000



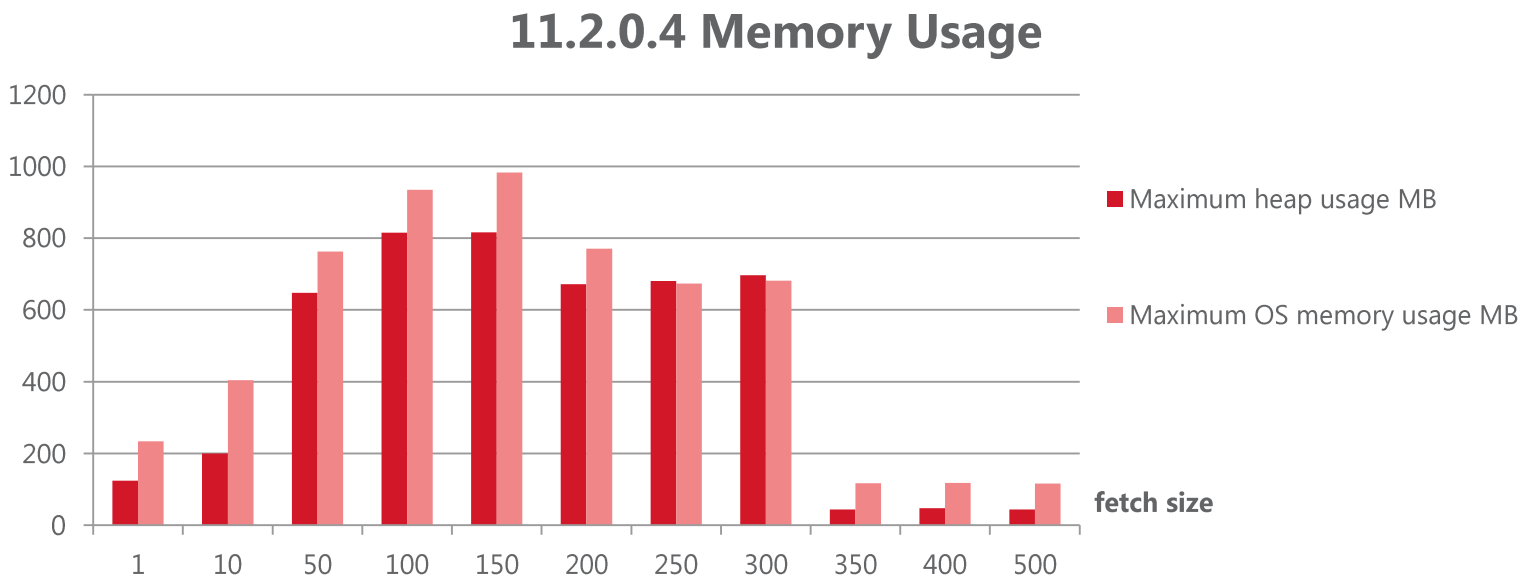
12.1.0.2, fetch size 10000



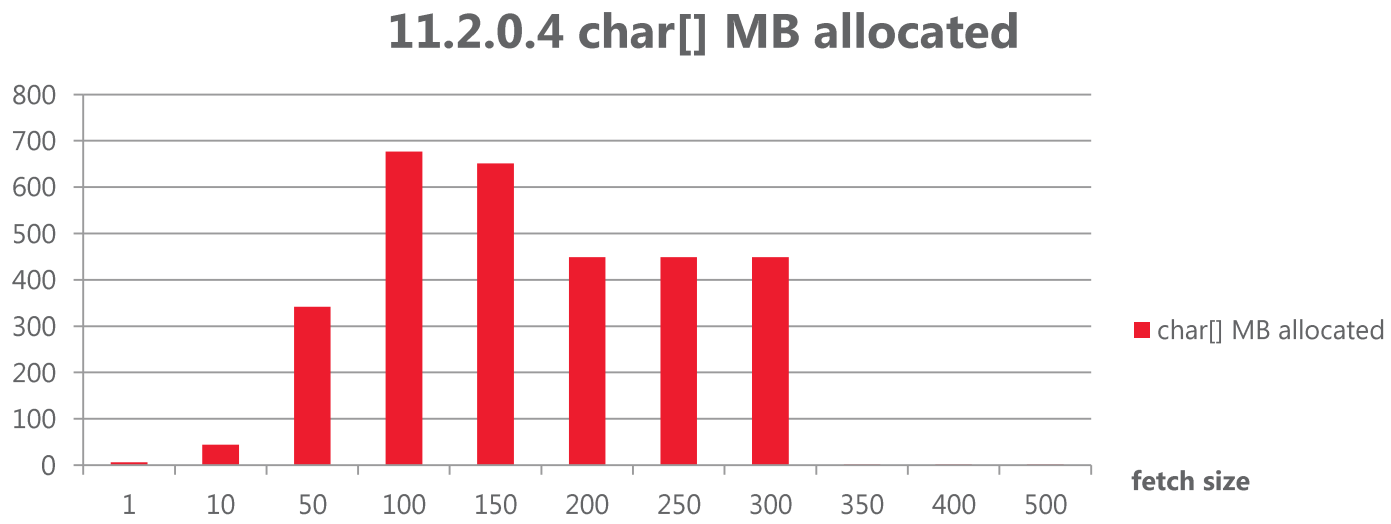
11g : Memory Usage



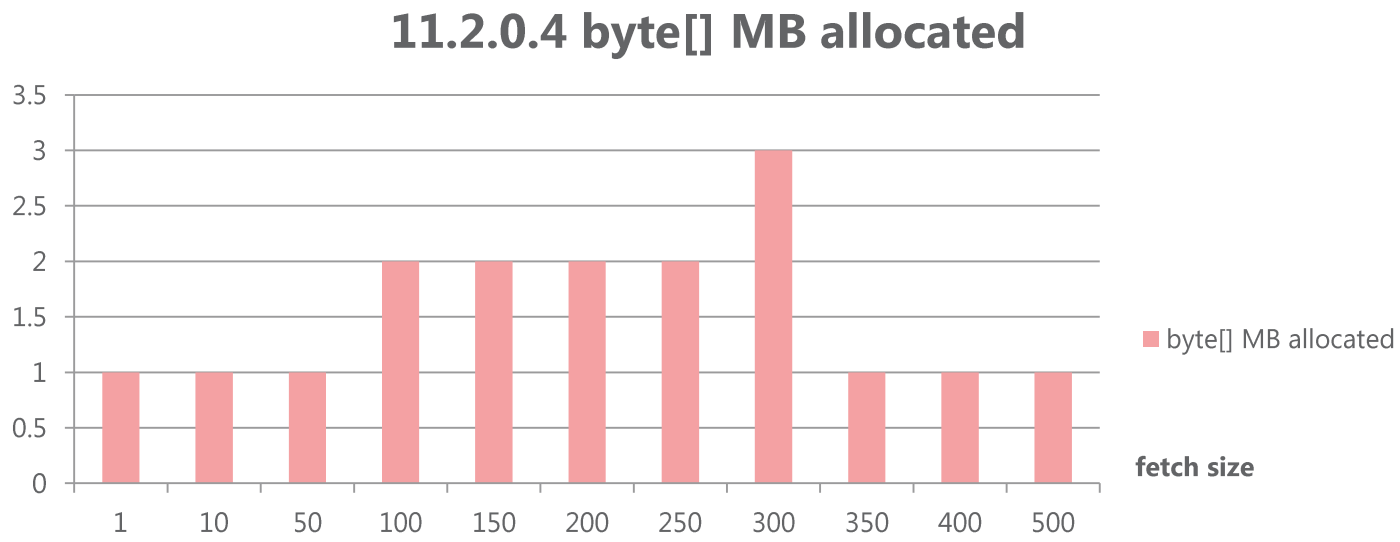
11g : Memory Usage



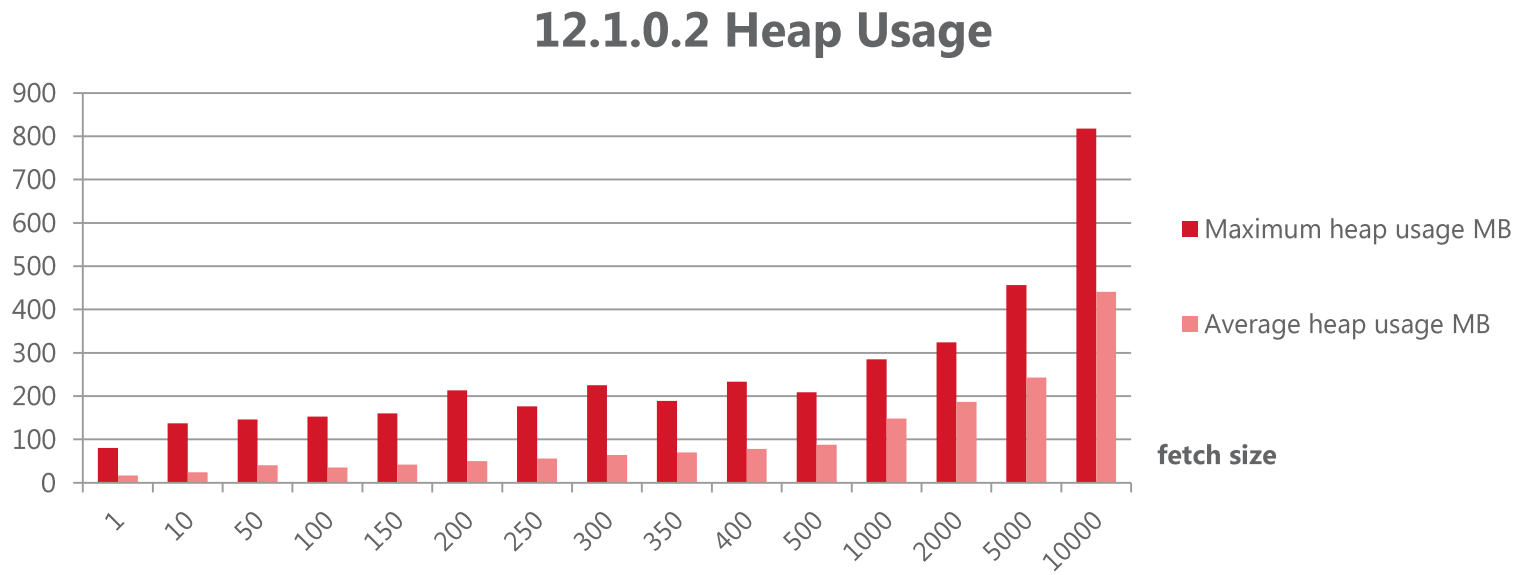
11g : Buffers



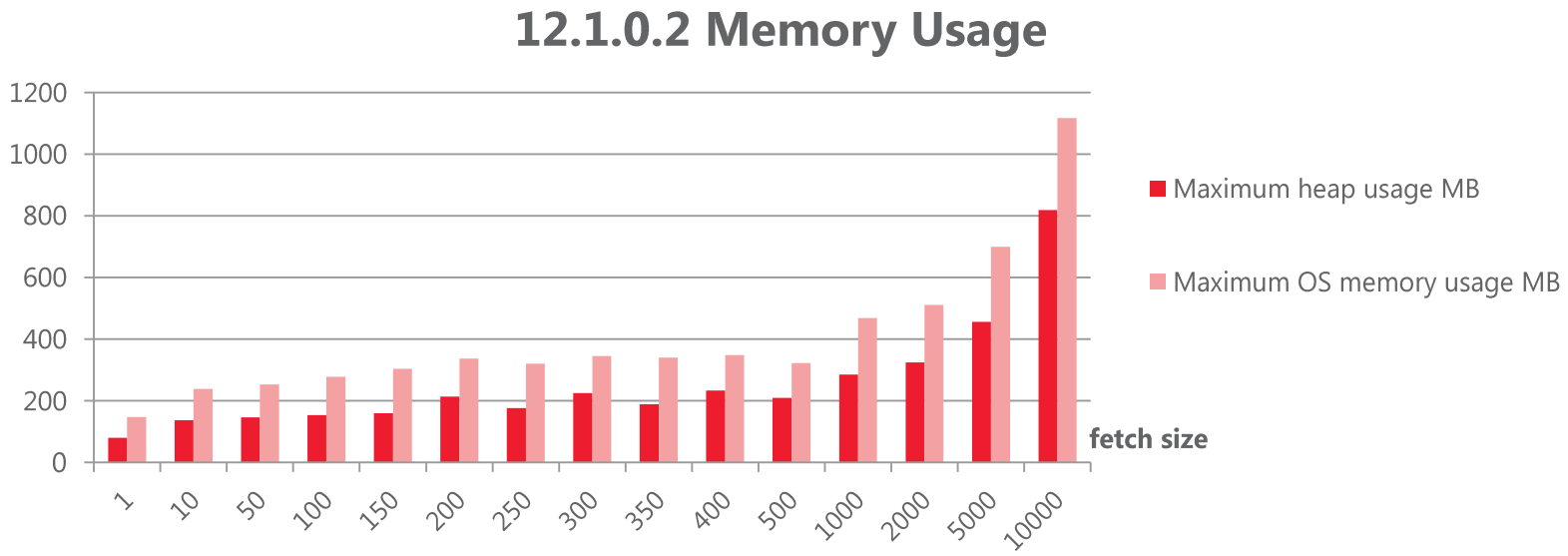
11g : Buffers



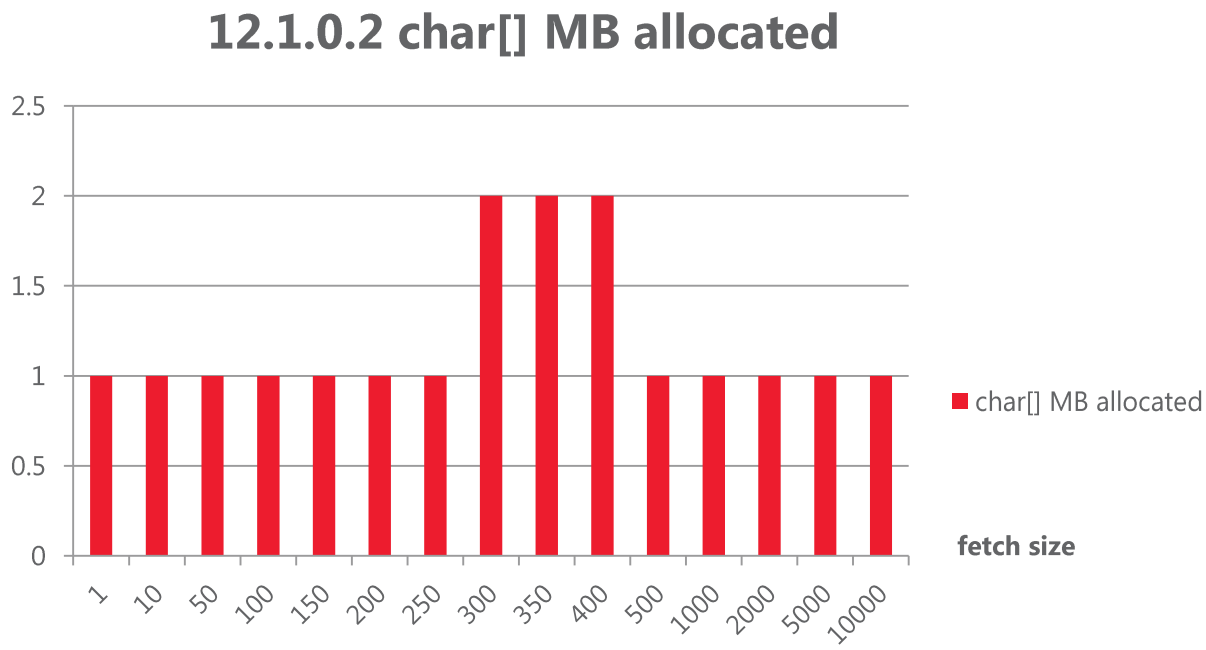
12 c : Memory Usage



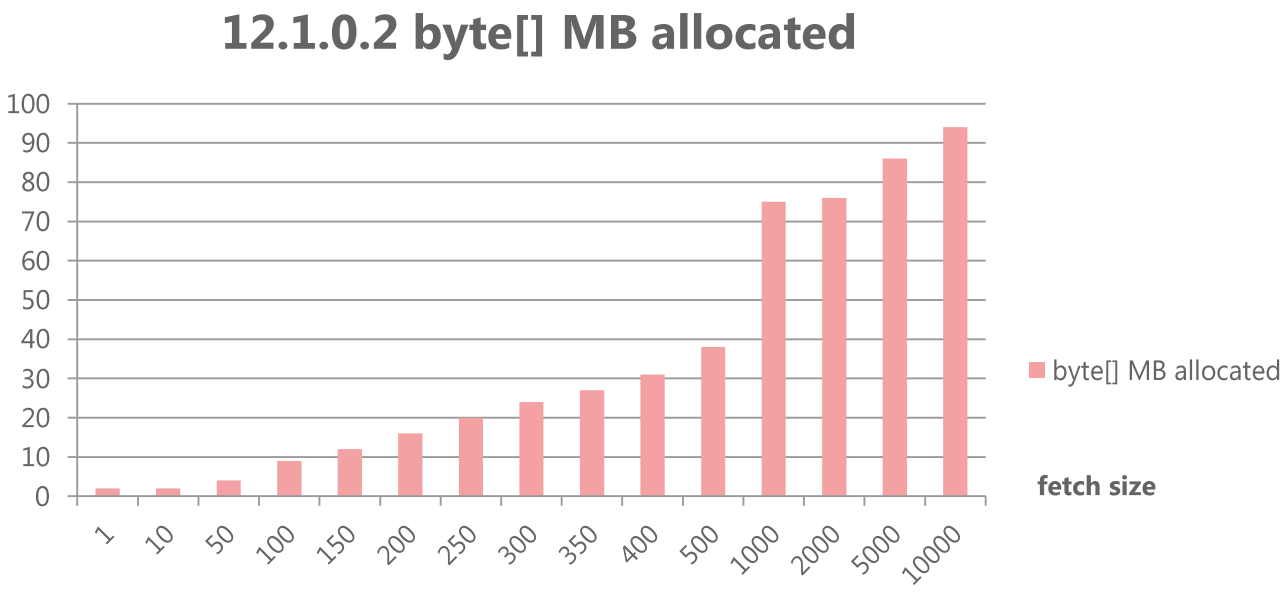
12 c : Memory Usage



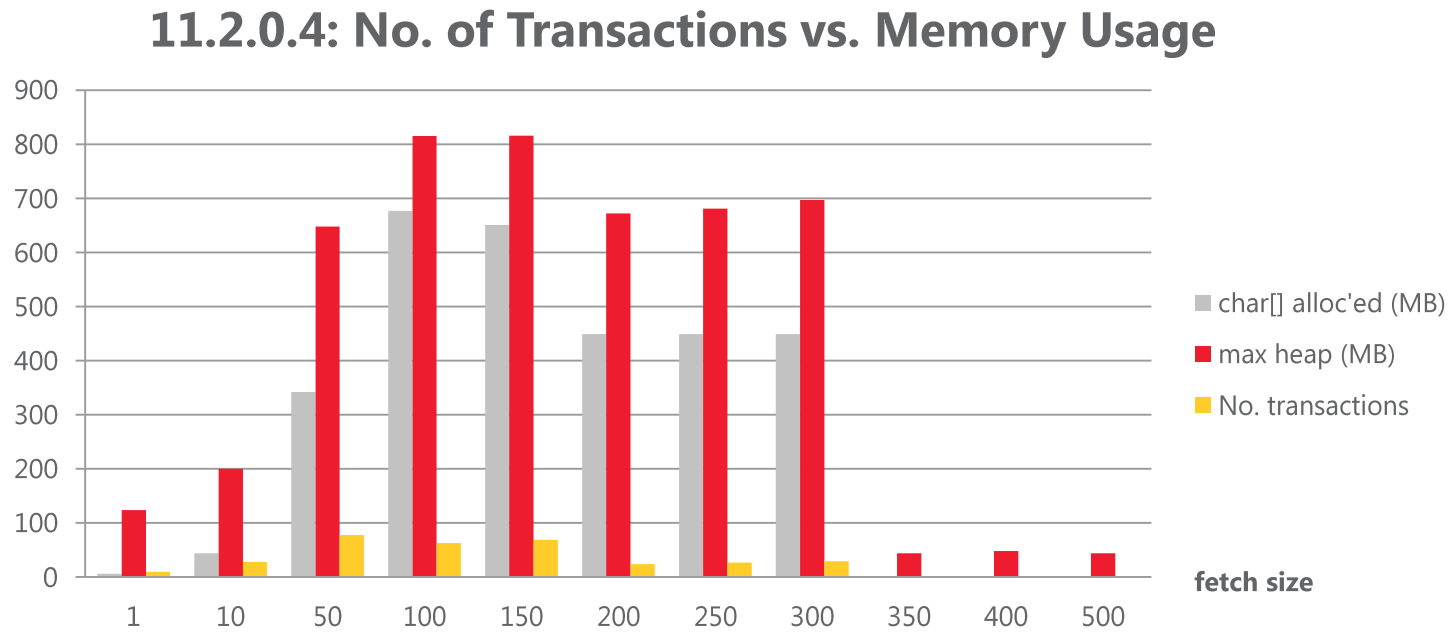
12c : Buffers



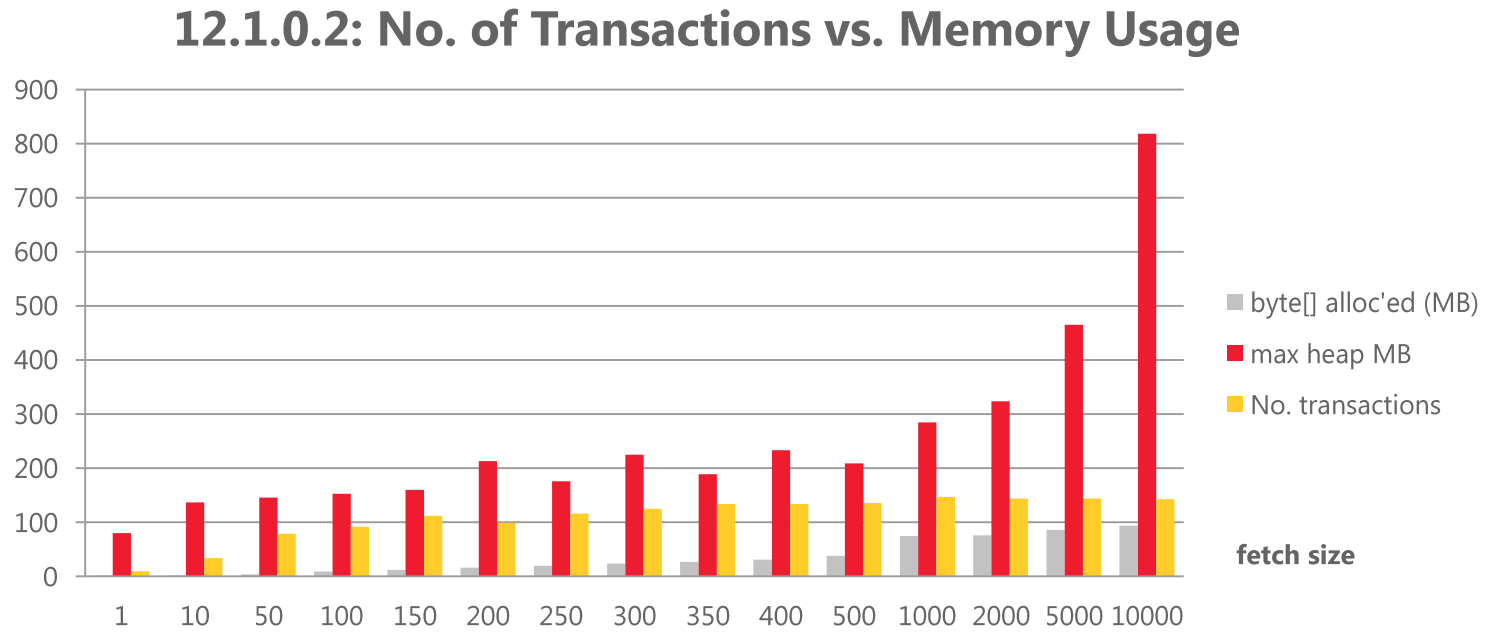
12c : Buffers



Relating Throughput and Memory Usage: 11g



Relating Throughput and Memory Usage: 12c



Conclusion / Recommendations

Conclusion

- Yes, new memory management in the 12c driver has a clear impact on possible throughput
- Chances are much bigger now that the optimal fetch size for a statement may be used
- Still, avoid configuring overly large fetch sizes (which anyway could not possibly do any good for most applications)

Recommendations – Version Independent

- Don’t fetch all columns (SELECT *) when only a few are needed
  - Especially not in combination with multiple joins
  - If you use an O/R Mapper check out if this is an option
- Find and configure the optimal fetch size for your application - possibly even for different statements / statement types
- Take into account your application’s display behavior – no need for a high fetch size if application pages through result in sets of 20 rows …
- Also keep in mind response time (in addition to throughput) – again, avoid excessive fetch sizes

And whereto from here?

- If you still need to economise on memory:
- Look into other memory and throughput related topics such as batching and statement caching
- But these already are topics for another time

Questions?

Thank You!

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