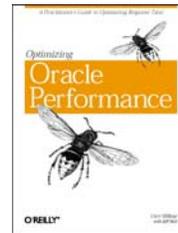Profiling Oracle: How it Works

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NoCOUG Spring Conference / Sunnyvale CA
11:00am–12:00n Thursday 19 May 2005

Agenda

- Introduction
- The role of profilers
- Profiling Oracle
- Case study
- Discussion

About Hotsos

- Thought leadership
  - *Optimizing Oracle Performance*
  - *Oracle Insights*
  - Method R

- Products
  - Hotsos Profiler
  - Laredo
  - Interceptor technologies

- Services
  - 1-week performance assessment
  - On-site consulting and education
  - Remote consulting

- Education
  - Oracle performance curriculum
  - Hotsos Symposium

So there will be no confusion...

- This presentation <u>does</u> describe
  - <u>Why</u> you use a profiler
  - <u>How</u> you use profile data

- This presentation does <u>not</u> describe
  - How to create a profile from raw trace data

- We can do that…
  - But it takes more than an hour
  - Visit www.hotsos.com for more information

The role of profilers

Performance analysis is the study of how long something takes.

- Imagine…
  - Q: "How long does it take to fly on AA from DFW to SFO?"
  - A: "Mean fuel consumption in 2004 was F lbs/flight"
- This isn't an answer!
  - Wrong unit of measure
  - Includes stuff you don't want (LAX-SIN, HNL-OGG, …)
  - Different aircraft types with different consumption rates

What you need is "How long does it take to fly on AA from DFW to SFO?!"

In Oracle, performance analysis has become the study of just about everything <u>but</u> response time.

- From everyday life in Oracle…
  - Q: "Why does *P* take so long?"
  - A: "Here are your hit ratios, your utilization rates, …"
- How long? Why?
  - You <u>cannot</u> tell from these reports

Oracle analysis tools are medieval compared to the tools and methods that software <u>developers</u> use

---

A <u>profiler</u> is a tool that reports a useful decomposition of a computer program's response time.

- Nothing new
  - Knuth described a FORTRAN profiler in 1971
  - The GNU *gprof* profiler has been around since 1988
  - …
- Profilers are indispensable application development tools
  - Diagnosis
  - Instruction
  - Debugging

The simplest profile is the <u>flat profile</u>, which shows response time decomposed by subroutine call.

```
$ gprof
Flat profile:

Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls  us/call  us/call  name
60.37     0.49      0.49 62135400     0.01     0.01  step
39.63     0.82      0.33   499999     0.65     1.64  nseq
```

- Response time is 0.82 seconds
- 60.37% is consumed by 62,135,400 calls to *step*
- *nseq* takes longer per call, but contributes less total time
- …

Another type of profile is the <u>call graph</u>, which shows hierarchical interactions between subroutines.

```
                Call graph (explanation follows)
…

index % time    self  children    called     name
                0.33    0.49  499999/499999      main [2]
[1]    100.0    0.33    0.49  499999          nseq [1]
                0.49    0.00 62135400/62135400     step [3]
-----------------------------------------------
                                                <spontaneous>
[2]    100.0    0.00    0.82                    main [2]
                0.33    0.49  499999/499999      nseq [1]
-----------------------------------------------
                0.49    0.00 62135400/62135400     nseq [1]
[3]     60.4    0.49    0.00 62135400          step [3]
-----------------------------------------------
```

Profiling Oracle

You can use *gprof* on <u>your</u> code, but not Oracle's.

- To use *gprof*
  ```
  $ gcc -pg myprogram.c
  $ a.out
  $ gprof
  ```
- Works great for application code you're writing
- The problem…
  - You can't compile *oracle.c*

The Oracle kernel has a feature built in that allows you to profile its internal operations as well.

- Extended SQL trace
  - The event formerly known as "10046 level 12"
  - Works great with versions 7, 8, and 9; even better in 10
- Gives you everything you need to create…
  - Flat profile
    - …by Oracle subroutine (timed events $\cup$ dbcalls $\cup$ …)
    - …by database call
  - Call graph
    - …by statement (SQL or PL/SQL)
  - Lots more

This is a huge capability

Version 10 example: Using extended SQL trace…

```
$ sqlplus
…
SQL> show parameter…
NAME                          TYPE        VALUE
---------------------------- ----------- -------------------------------
timed_statistics              boolean     TRUE
max_dump_file_size            string      UNLIMITED
user_dump_dest                string      /u01/app/oracle/admin/v10/udump
…
SQL> exec dbms_monitor.session_trace_enable(null,null,true,true);
SQL> select 'hello' from dual;
SQL> exec dbms_monitor.session_trace_disable(null,null);
…

$ ls -lt $UDUMP
total 248
-rw-r-----  1 oracle   oinstall     2396 Jan 17 11:18 v10_ora_5286.trc
…
```

Version 9 example: Using extended SQL trace…

```
$ sqlplus
…
SQL> show parameter…
NAME                        TYPE        VALUE
--------------------------- ----------- -------------------------------
timed_statistics            boolean     TRUE
max_dump_file_size          string      UNLIMITED
user_dump_dest              string      c:\Oracle\admin\v92\udump
…
SQL> exec dbms_support.start_trace(true,true);
SQL> select 'hello' from dual;
SQL> exec dbms_support.stop_trace;
…

$ ls -lt %udump%
total 44
-rw-rw-rw- 1 user      group          4083 Jan 17 02:29 v92_ora_2272.trc
…
```

The trace file contains everything you need to create a flat profile by Oracle subroutine.

```
Oracle subroutine              Duration (secs)    # Calls    Dur/call
--------------------------- ----------------- --------- -----------
SQL*Net message from client   984.010   49.6%    95,161     0.010340
SQL*Net more data from client 418.820   21.1%     3,345     0.125208
db file sequential read       279.340   14.1%    45,084     0.006196
CPU service, EXEC             136.880    6.9%    67,888     0.002016
CPU service, PARSE            74.490     3.8%    10,098     0.007377
CPU service, FETCH           37.320     1.9%    57,217     0.000652
unaccounted-for               27.720     1.4%         1    27.720000
latch free                    23.690     1.2%    34,695     0.000683
log file sync                 1.090      0.1%       506     0.002154
SQL*Net more data to client   0.830      0.0%    15,982     0.000052
log file switch completion    0.280      0.0%         3     0.093333
enqueue                       0.250      0.0%       106     0.002358
…
--------------------------- ----------------- --------- -----------
Total response time          1,985.190  100.0%
```

The trace file contains everything you need to create a call graph by SQL or PL/SQL statement.

Cursor statement	Duration of self (secs)		Duration incl. children (secs)	
/* REGULAR_PAY*/DECLARE LERMT VA…	6.620	0.3%	67.270	3.4%
| SELECT 'Y' FROM PAY_ELEMENT_ENTR…	35.020	1.8%	35.020	1.8%
| SELECT DECODE(COUNT(PRR.RUN_RESU…	14.740	0.7%	14.740	0.7%
| SELECT DECODE(COUNT(RRS.RUN_RESU…	9.090	0.5%	9.090	0.5%
| SELECT DECODE(NVL(TO_CHAR(PDS.AC…	1.110	0.1%	1.110	0.1%
| SELECT START_DATE,END_DATE FROM …	0.690	0.0%	0.690	0.0%
update pay_person_latest_balance…	66.650	3.4%	66.650	3.4%
select ASSBAL.defined_balance_id…	64.580	3.3%	64.580	3.3%
update pay_assignment_latest_bal…	61.140	3.1%	61.140	3.1%
select 1 into :b0 from sys.dual …	36.470	1.8%	36.470	1.8%
/* REGULAR_EARNINGS*/DECLAREL_ER…	8.080	0.4%	35.670	1.8%
| SELECT DECODE(COUNT(PRR.RUN_RESU…	26.280	1.3%	26.280	1.3%
…				
Total response time	1,985.190	100.0%		

Case study

Baseline case: inserting is too slow.

- Each process inserts 5,000 rows
- 2 concurrent processes
- 1-CPU Windows XP
- Oracle 9.2.0.4
- Connection configuration

```
v92 =
  (DESCRIPTION =
    (ADDRESS_LIST =
      (ADDRESS = (PROTOCOL = TCP)(HOST = CVM-LAP02)(PORT = 1521))
    )
    (CONNECT_DATA =
      (SERVER = DEDICATED)
      (SERVICE_NAME = v92.hotsos)
    )
  )
```

Baseline response time profile…

```
v92_ora_2020.trc

Oracle subroutine              Duration (secs)    # Calls    Dur/call
---------------------------    ---------------    -------    -----------
unaccounted-for                 7.292   60.4%      10,255    0.000711
SQL*Net message from client     2.371   19.6%      20,007    0.000119
CPU service, PARSE calls        1.843   15.3%       5,040    0.000366
CPU service, EXEC calls         0.411    3.4%       5,061    0.000081
SQL*Net message to client       0.066    0.5%      20,007    0.000003
db file sequential read         0.055    0.5%           2    0.027650
log file sync                   0.017    0.1%           3    0.005714
CPU service, FETCH calls        0.010    0.1%         152    0.000066
latch free                      0.006    0.0%          19    0.000315
---------------------------    ---------------    -------    -----------
Total                          12.071  100.0%
```

Typical first questions about the profile…

- What is "unaccounted-for"?
- Isn't *SQL*Net message from client* supposed to be "idle" time?
- Why does this thing parse almost 4.5× longer than it inserts?

If the point is to insert 5,000 rows, then why does inserting consume only 3.5% of total response time?

The call graph shows that almost all the time is consumed by one statement.

Cursor statement	Duration of self (secs)		Duration incl. children (secs)	
insert into t values (1, lpad('1…	11.309	93.7%	11.392	94.4%
| select u.name,o.name, t.update$,…	0.063	0.5%	0.063	0.5%
| select file# from file$ where ts…	0.017	0.1%	0.017	0.1%
| update tsq$ set blocks=:3,maxblo…	0.002	0.0%	0.002	0.0%
[[synthetic parent]]	0.000	0.0%	0.582	4.8%
| select u.name, o.name, trigger$.…	0.472	3.9%	0.493	4.1%
| | select ts#,file#,block#,nvl(bobj…	0.015	0.1%	0.015	0.1%
| | select i.obj#,i.ts#,i.file#,i.bl…	0.002	0.0%	0.002	0.0%
| | select name,intcol#,segcol#,type…	0.002	0.0%	0.002	0.0%
| | select pos#,intcol#,col#,spare1,…	0.001	0.0%	0.001	0.0%
| | select type#,blocks,extents,mine…	0.001	0.0%	0.001	0.0%
| select order#,columns,types from…	0.002	0.0%	0.040	0.3%
… (35 other statements have been elided)				
Total	12.071	100.0%		

The database call profile shows that the preponderance
of the response time is spent <u>between</u> db calls.

```
insert into t values (1, lpad('1',20))

Oracle hash value: 2581399381
 Statement re-use: 5,000 similar but distinct texts
     Response time: 11.309 seconds (93.7% of task total 12.071 seconds)

                     -----Duration (seconds)-----
Database call          Elapsed      CPU    Other   Calls   Rows
--------------------  ------------- -----  ------  ------  -----
Between-calls          6.518  57.6% 0.000  6.518       0      0
PARSE                  3.801  33.6% 1.843  1.958   5,000      0
EXEC                   0.991   8.8% 0.411  0.580   5,000  5,000
--------------------  ------------- -----  ------  ------  -----
Total                 11.309 100.0% 2.253  9.056  10,000  5,000
--------------------  ------------- -----  ------  ------  -----
Total per EXEC         0.002   0.0% 0.000  0.002       2      1
Total per row          0.002   0.0% 0.000  0.002       2      1
```

The baseline program executed far too many parse
calls.

- Old code behavior…
```
for each row {
    $sql = "insert into t values ($v1, lpad('$v2',20))";
    $c = parse($sql);
    exec($c);
}
```

- New code…
```
❶$c = parse("insert into t values (❷?, lpad(❷?,20))");
for each row {
    exec($c, ❸$v1, ❸$v2);
}
```

The rewrite should eliminate 4,999 parse calls

The results are spectacular (before).

```
v92_ora_2020.trc

Oracle subroutine              Duration (secs)    # Calls     Dur/call
----------------------------   -----------------  ---------   -----------
unaccounted-for                   7.292   60.4%     10,255     0.000711
SQL*Net message from client       2.371   19.6%     20,007     0.000119
CPU service, PARSE calls          1.843   15.3%      5,040     0.000366
CPU service, EXEC calls           0.411    3.4%      5,061     0.000081
SQL*Net message to client         0.066    0.5%     20,007     0.000003
db file sequential read           0.055    0.5%          2     0.027650
log file sync                     0.017    0.1%          3     0.005714
CPU service, FETCH calls          0.010    0.1%        152     0.000066
latch free                        0.006    0.0%         19     0.000315
----------------------------   -----------------  ---------   -----------
Total                            12.071  100.0%
```

The results are spectacular (after).

```
v92_ora_2588.trc

Oracle subroutine              Duration (secs)    # Calls     Dur/call
----------------------------   -----------------  ---------   -----------
unaccounted-for                   0.631   41.2%      5,032     0.000125
SQL*Net message from client       0.393   25.7%      5,010     0.000078
CPU service, PARSE calls          0.090    5.9%         11     0.008194
CPU service, EXEC calls           0.381   24.9%      5,011     0.000076
SQL*Net message to client         0.008    0.5%      5,010     0.000002

log file sync                     0.027    1.8%          1     0.027396
CPU service, FETCH calls          0.000    0.0%          9     0.000002

----------------------------   -----------------  ---------   -----------
Total                             1.530  100.0%
```

Why are the results so much better than we expected?

- Eliminating dbcalls has several better-than-linear positive effects
  - We got the CPU `service, PARSE` estimate right
  - Eliminating ~5,000 parse calls eliminated ~15,000 SQL*Net `message from client` calls
  - Preemption time decreased better than linearly!

Eliminating unnecessary workload often result in better-than-linear performance improvement.

- Eliminating work…
  - Saves top-line response time
  - Eliminates dependant work
  - Reduces queue lengths
    - Makes remaining calls faster
    - Helps everyone

Eliminating unnecessary work <u>reverses</u> exponential performance degradation
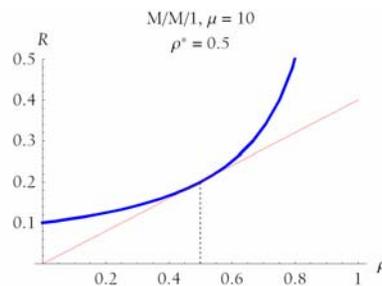
Recap

- A profiler tells you exactly where a task's time has gone
- Oracle emits everything you need to begin profiling
- Profilers give two capabilities you're not accustomed to having
  - "What happened?" becomes very easy
  - "What if?" becomes very easy

**Once you have these capabilities,
it's hard to imagine life without them**

References

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    2004. *Oracle Insights: Tales of the Oak Table*. Berkeley CA: Apress.
    I wrote Chapter 5 of this book, which details the history and evolution of Oracle's extended SQL trace feature.
Oracle Corporation. Various technical resources:
    DBMS_MONITOR package: http://download-west.oracle.com/docs/cd/B14117_01/appdev.101/b10802/d_monito.htm#ARPLS091.
    DBMS_SUPPORT package: Oracle Metalink doc id Note:62294.1.
    New version 10 OCI attributes: http://download-west.oracle.com/docs/cd/B14117_01/appdev.101/b10779/oci08sca.htm#452699

A game…

- How would each problem show up in a profile?
    1. Program parsed inside a loop
    2. Program is efficient but can't get enough CPU to run fast
    3. SQL used an inefficient execution plan
    4. Other program's SQL used an inefficient execution plan
    5. Table had too many extents
    6. Disk subsystem was too busy
    7. Client code path consumed too much time
    8. Other program locked my table
    9. Too many programs update same block
    10. Shared pool was too small