Latch and Mutex Contention Troubleshooting in Oracle

Tanel Põder

http://blog.tanelpoder.com

OakTable.net

ORACLE | CERTIFIED MASTER

If you like this session...

...then you're probably an Oracle geek like me ;)

And you will like my tech-blog:

- http://blog.tanelpoder.com

All my scripts freely downloadable

- http://blog.tanelpoder.com/seminar/seminar-files/
- Look for TPT scripts

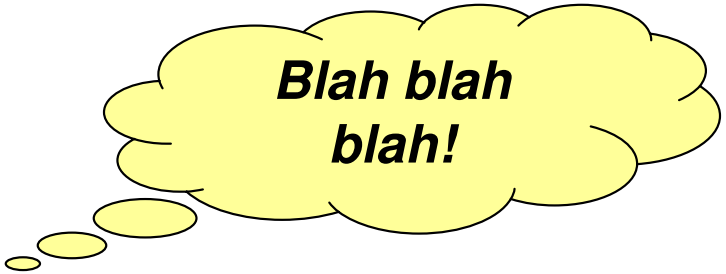
Oh... and I do seminars with much more stuff like this ;-)

- And I also fix these kinds of problems as a consultant
- http://blog.tanelpoder.com/seminar/
- tanel@tanelpoder.com

Intro to latching - 1

What is a latch?

- Oracle's low-level mechanism for serializing concurrent access to very shortly accessed memory structures such as cache buffer headers etc...



Yeah, but what *is* a latch?

- Latch is just a simple memory structure
- Usually around 100-200B in size (dependent on version,platform)
- Is wrapped into a latch state object structure (since v8.0 I think)
- Can reside in fixed SGA (parent latches) or shared pool
- Is set using hardware-atomic *compare-and-swap* (CAS) instructions
  - LOCK CMPXCHG on intel
- Latches are taken and released without any OS interaction
  - Actually the OS doesn't even have a clue that Oracle latches exist!
- Can be shared (since Oracle 8.0)
  - Used for some AQ ops
  - For example, used for *cache buffers chains* latch gets if *examining* a buffer chain

Latch is a lock

period.

What is latch contention?

I want to get a latch...
but someone is already holding it!

To troubleshoot, find out:

1) *Who and why* tries to get the latch (waiter)
2) *Who and why* are holding the latch (blocker)

In other words - find who and why ***is blocking*** us!
Just like with regular enqueue locks...

Remember, latches are locks!

Latch contention troubleshooting

V$SESSION_WAIT / V$ACTIVE_SESSION_HISTORY

- PARAMETER1 = latch address for any latch wait event
- sw, WaitProf to see latch addresses of latch wait events
- Addresses map to v$latch_parent/v$latch_children.ADDR column

SQL Trace

- you need to convert the P1/address number to hex:

```
WAIT #3: nam='latch free' ela= 3749 address=15709454624 number=202 tries=1
  obj#=-1 tim=5650189627

SQL> select to_char(15709454624, 'XXXXXXXXXXXXXXXX') addr_hex from dual;
ADDR_HEX
-----------------
        3A85B4120

SQL> @la 3A85B4120
ADDR                 LATCH#   CHLD NAME                 GETS
---------------- ---------- ------ --------------- -----------
00000003A85B4120        202      2 kks stats           494562
```

Identifying latch holders

V$LATCHHOLDER

- Shows top-level latch holders from process state objects
  - See the ***Session ID*** of latch holder!!!
- Any latch held by a process state object is shown there
- Works in 99.9% of cases - enough for practical troubleshooting
- Additional latches held (while the top-level one is held) are not reported by v$latchholder :-(

- In the 0.01% of cases a fallback to old latch contention troubleshooting method could be used
  - Alternatively its possible to traverse state object trees via direct SGA attach

```
SQL> desc v$latchholder
           Name                                  Null?    Type
           ----------------------------------- -------- -------------
    1      PID                                            NUMBER
    2      SID                                            NUMBER
    3      LADDR                                          RAW(8)
    4      NAME                                           VARCHAR2(64)
    5      GETS                                           NUMBER
```

Latch contention troubleshooting approach

1. Identify the session(s) experiencing problems
   - Remember, databases don't have problems, only users, through database sessions
2. Quantify for which latch that session is waiting for the most
   - ...and whether the wait time is significant enough
3. Identify the child latch involved in contention
   - Is the contention concentrated on a particular child latch or is it spread across many?
4. Identify where in kernel code (why) the latch is held from
   - V$LATCHHOLDER
   - LatchProfX / X$KSUPRLAT / X$KSUPR if problem with some sessions

Latch contention troubleshooting with LatchProfX

Sample V$LATCHHOLDER stats with LatchProfX, fast

- 10-100k samples per second!
- @latchprofx *<columns>* *<sid>* *<latches>* *<#samples>*
- @latchprofx sid,name,func,hmode % % 1000000

```
SQL> @latchprofx sid,name,func,hmode &sid % 100000

-- LatchProfX 1.07 by Tanel Poder ( http://www.tanelpoder.com )

       SID NAME                                FUNC                                     HMODE              Held
---------- ----------------------------------- ---------------------------------------- ------------- ----------
       139 shared pool                         kghalo                                   exclusive          3174
       139 shared pool                         kghalp                                   exclusive          1294
       139 shared pool                         kghupr1                                  exclusive           704
       139 shared pool simulator               kglsim_unpin_simhp                       exclusive           581
       139 kks stats                           kksAllocChildStat                        exclusive           489
       139 shared pool simulator               kglsim_upd_newhp                         exclusive           240
       139 row cache objects                   kqrpre: find obj                         exclusive           158
       139 enqueues                            ksqdel                                   exclusive           116
       139 enqueues                            ksqgel: create enqueue                   exclusive            91
       139 shared pool                         kgh_heap_sizes                           exclusive            90
       139 row cache objects                   kqreqd: reget                            exclusive            58
       139 enqueue hash chains                 ksqgtl3                                  exclusive            57
       139 shared pool simulator               kglsim_scan_lru: scan                    exclusive            53
       139 shared pool                         kghfre                                   exclusive            49
       139 row cache objects                   kqreqd                                   exclusive            41
       139 enqueue hash chains                 ksqrcl                                   exclusive            36
       139 shared pool simulator               kglsim_chg_simhp_free                    exclusive            22
       139 shared pool                         kghasp                                   exclusive            18
       139 MinActiveScn Latch                  ktucloGetGlobalMinScn                    shared               14
```

KGX mutexes

KGX = Kernel Generic muteX module

- Kernel functions managing mutexes start with kgx

Introduced in Oracle 10.2

- Physically like a latch (a piece of memory)
  - only more lightweight
  - and smaller
- Can be embedded inside other structures (lib cache object handle)
- Can have flexible spin/yield/wait strategy defined by "client"
- Do not account SPINGETS,YIELDS, only WAITS
  - GETS are accounted internally, but not externalized in any view

KGX mutexes are *not* OS mutexes!!!

Mutexes for Library Cache

Used for protecting V$SQLSTATS buckets

- `oradebug dump cursor_stats 1`

Used for pinning library cache cursors and parent examination

- If *_kks_use_mutex_pin=true* (default from 10.2.0.2)
- `oradebug dump librarycache level 10`

In 11g+ mutexes are used instead of most library cache latches

- Instead of up to 67 library cache latches there's 131072 mutexes!
- Each library cache mutex protects one library cache hash bucket

Known mutex types in 11g:

- Cursor Parent
- Cursor Pin
- Cursor Stat
- Library Cache
- hash table
- ...

Mutex troubleshooting

V$SESSION_WAIT

- Shows wait events such:
  - cursor: mutex S
  - cursor: mutex X
  - library cache: mutex S
  - library cache: mutex X

The mutex sleeps are well instrumented in wait interface. P1,P2,P3 values show what is the hash value of library cache objects under contention, the session holding the mutex etc. v$event_name and v$session_wait "text" columns document the meaning of P1,P2,P3

V$MUTEX_SLEEP

- Shows the wait time, and the number of sleeps for each combination of mutex type and location. Somewhat useless.

V$MUTEX_SLEEP_HISTORY

- Shows last individual occurrences of mutex sleeps
- Based on a circular buffer, has most detail
- @mutexprof script

Systemstate dumps

- http://el-caro.blogspot.com/2007/10/identifying-mutex-holder.html

Mutex waits and their meaning - 1

cursor: mutex S

- We try to get a mutex on Parent cursor or V$SQLSTAT bucket in shared mode.
- The mutex is "in flux" (someone is in progress of taking it in shared mode) so we have to wait until the holder finishes its shared get.
- Used when:
  - Examining parent cursor, Querying V$SQLSTATS bucket

cursor: mutex X

- We try to get a mutex on Parent cursor or V$SQLSTAT bucket in *exclusive* mode.
- Someone is already holding the mutex in incompatible mode
- ...Either there's someone already holding the mutex in X mode
- ...Or there may be multiple holders in S mode
- Used when:
  - Loading new child cursor under parent, Modifying V$SQLSTATS bucket, Updating bind capture data

Mutex waits and their meaning - 2

cursor: pin S

- We try to pin the cursor in shared mode (for execution for example)
- Mutex for child cursor pinning is "in flux", someone is in process of pinning that same cursor already.
- We have to wait until the other session completes their pin request

cursor: pin X

- We try to pin a cursor in exclusive mode, but someone already has pinned it in a non-compatible mode
- Either one session has pinned it in X mode or multiple sessions in S mode

cursor: pin S wait on X

- We try to pin a cursor in shared mode, but someone already has pinned it in X mode
- Other session is currently loading that child cursor (parsing)

Mutex waits and their meaning - 3

In 11g, most library cache latches have been replaced by mutexes directly on library cache hash buckets

- 131072 KGL hash buckets
- Each is protected by a separate mutex
- Less room for false contention
- http://blog.tanelpoder.com/2008/08/03/library-cache-latches-gone-in-oracle-11g/

library cache: mutex S

- Trying to get a mutex on library cache hash bucket in S mode
- The mutex is already held in incompatible mode or is "in flux"

library cache: mutex X

- Trying to get a mutex on library cache hash bucket in X mode
- The mutex is already held in incompatible mode or is "in flux"

Mutex wait event parameters - 1

```
SQL> @sed mutex  <-- this script queries v$event_name

EVENT_NAME                     PARAMETER1      PARAMETER2      PARAMETER3
------------------------------ --------------- --------------- ------------
cursor: mutex S                idn             value           where|sleeps
cursor: mutex X                idn             value           where|sleeps
cursor: pin S                  idn             value           where|sleeps
cursor: pin S wait on X        idn             value           where|sleeps
cursor: pin X                  idn             value           where|sleeps
library cache: mutex S         idn             value           where
library cache: mutex X         idn             value           where
```

As with any wait event, the parameters (P1,P2,P3) provide additional detail, context info about the wait:

- Parameter1 (idn) can be used for finding the *cursor* related to mutex
- Parameter 2 (value) can be used for finding the *session* holding the mutex in exclusive mode
  - For all shared mode holders a systemstate dump would be needed

Mutex wait event parameters - 2

PARAMETER1 - **idn**:

- cursor:* wait events
  - idn = hash value of the library cache object under protection

- library cache: mutex* wait events
  1) library cache hash bucket number (if idn <= 131072)
  2) idn = hash value of the library cache object under protection (if idn > 131072)

```
Find SQL by hash_value:
    SELECT sql_text FROM v$sql WHERE hash_value = &idn;

Find SQL by library cache hash bucket (idn <= 131072):
    SELECT sql_text FROM v$sql WHERE MOD(hash_value, 131072) = &idn;

Find SQL from AWR by SQL_ID (hash_value is the lower half of SQLID):
    SELECT sql_text FROM dba_hist_sqlstat
    WHERE tpt.sqlid_to_sqlhash( sql_id ) = &idn;

You'll find the TPT package in setup directory in TPT_public.zip
```

Mutex wait event parameters - 3

PARAMETER2 - **value**:

- low bytes of word (2 or 4 bytes) - number of mutex shared references
- high bytes of word (2 or 4 bytes) - SID of exclusive holder

```
SQL> select session_id, event, blocking_session,
  2         to_char(p2, '0XXXXXXX') value_hex
  3  from v$active_session_history
  4  where event like 'library cache: mutex%';

SESSION_ID EVENT                          BLOCKING_SESSION VALUE_HEX
---------- ------------------------------ ---------------- ---------
       157 library cache: mutex X                           00830000
```

PARAMETER 3 - **where:**

- where = maps to x$mutex_sleep.location_id
- Useful for understanding from which kernel function the mutex get operation was done. Used for advanced diagnostics.

Questions?

Thank you !!!

Further questions are welcome:

- tanel@tanelpoder.com

Slides, scripts and my blog:

- http://blog.tanelpoder.com

If you liked this session, you will also like my ***Advanced Oracle Troubleshooting*** seminar!

- I do both public and private corporate seminars
- http://blog.tanelpoder.com/seminar/