Advanced RAC troubleshooting

By

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Who am I?

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- 17 years using Oracle products/DBA
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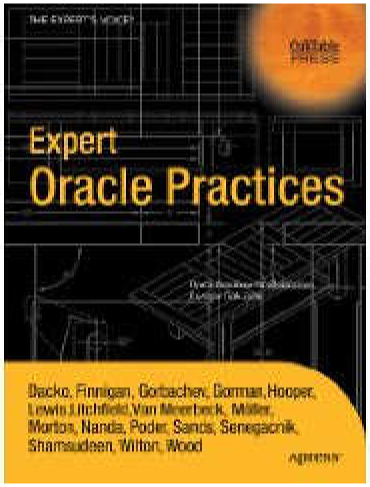

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Agenda

- Global cache performance
- Few important RAC wait events
- RAC background process tuning
- Interconnect issues, lost packets and network layer
- Network layer tuning
- Effective use of parallel query
- Troubleshooting locking issues
- Object re-mastering

Types of packets

- Block oriented packets
  - Consistent Read blocks
  - Current Read blocks
- Message oriented packets
  - Single block grants
  - Multi block grants
- Service oriented packets
  - SCN generation
  - Row cache updates
  - GES layer packets

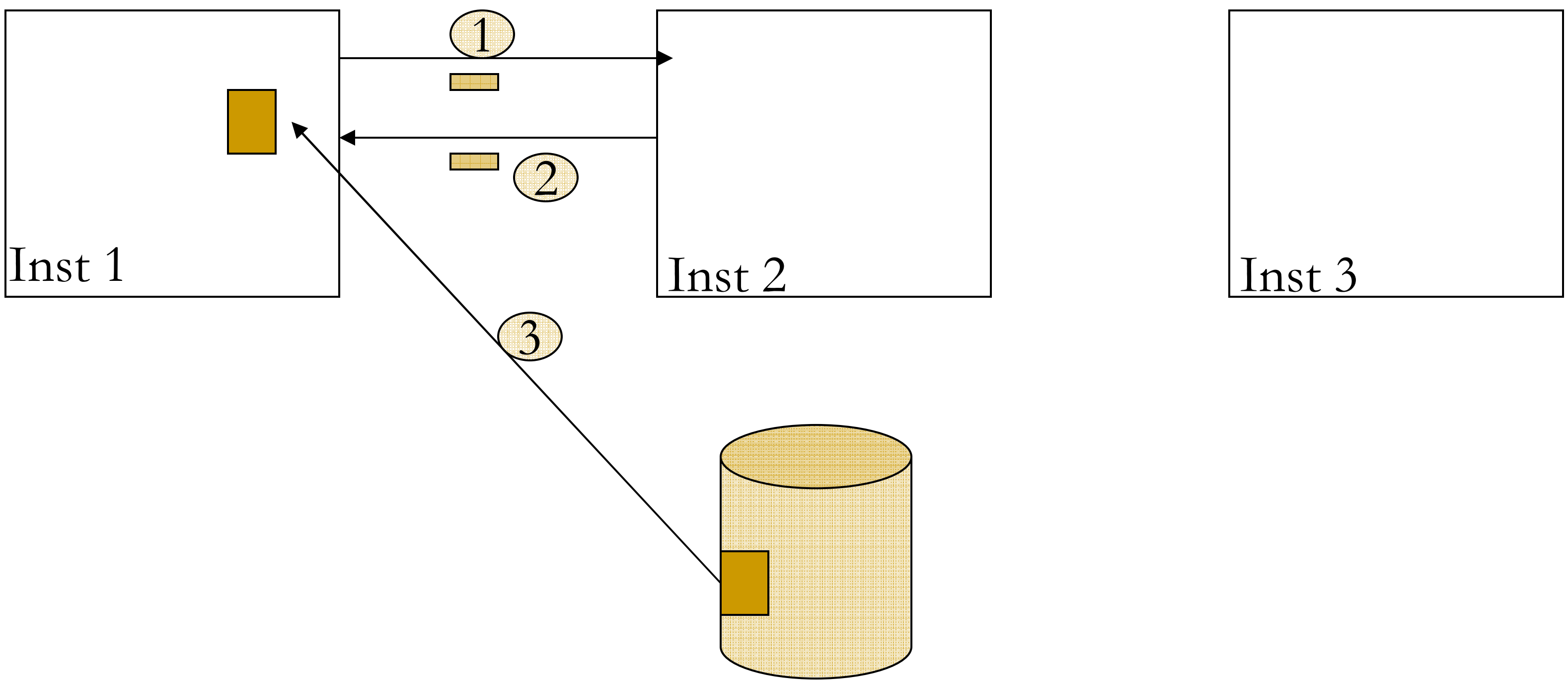
Block oriented packets

- Consistent Read (CR) blocks
  - Blocks requested by other nodes for mostly read operations.
  - User processes running in local node requests LMS processes running in the remote nodes for a block or set of blocks.
  - LMS might need to apply undo blocks to reconstruct requested version of the blocks.

CR – disk read

Select c1 from t1 where n1 =:b1;

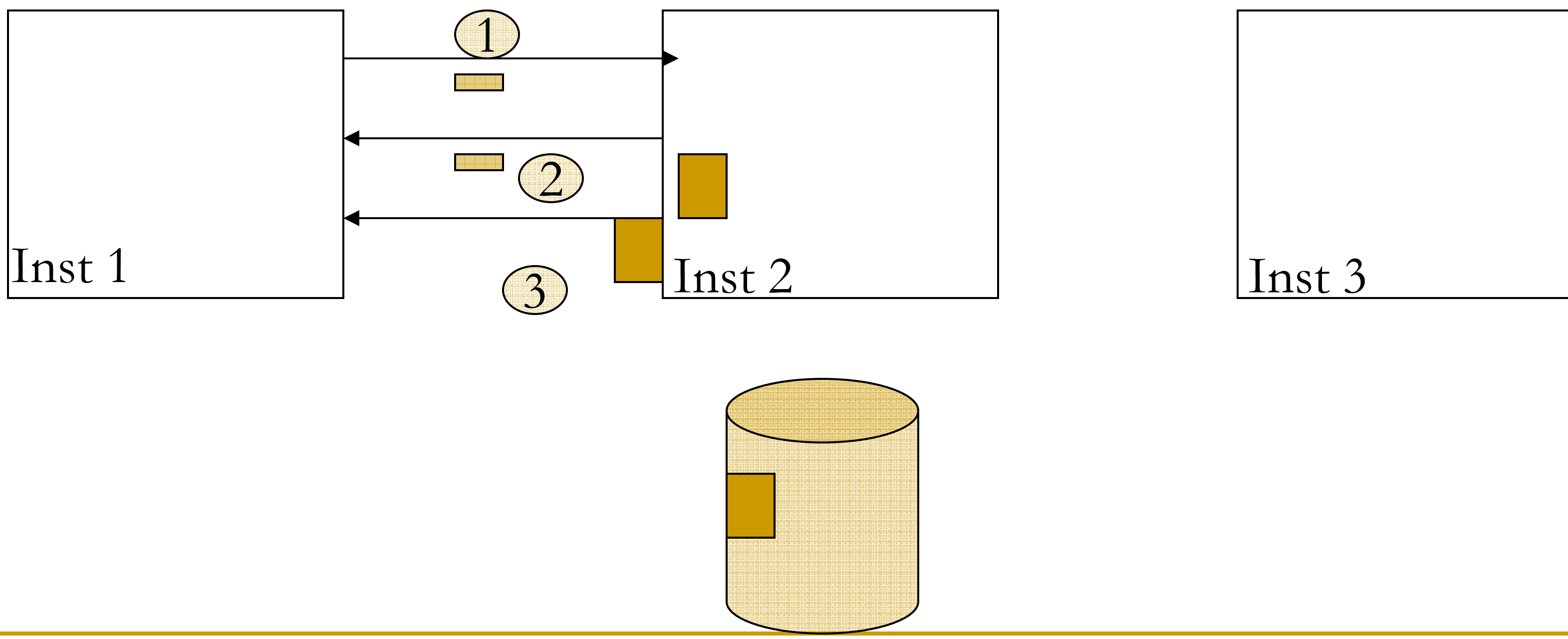
1. User process in instance 1 requests master for a PR mode block.
2. Assuming no current owner, master node grants the lock to inst 1.
3. User process in instance 1 reads the block from the disk and holds PR.



CR immediate 2-way

Select c1 from t1 where n1=:b1;

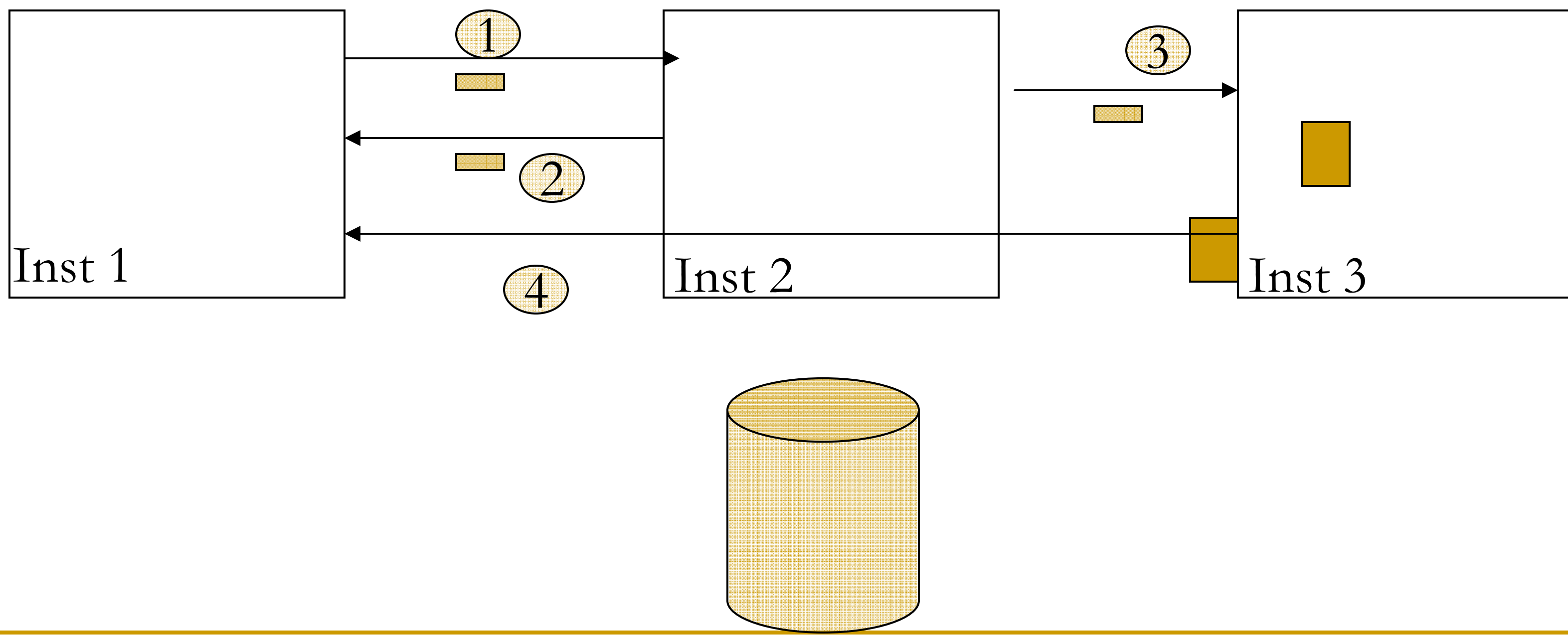
1. User process in instance 1 requests master for the block in PR mode.
2. Current owner (2) holds the block Protected Read (PR) and so master grants a PR to instance 1.
3. In this case master instance and owner instance are the same. Owner instance LMS process serves the block to the user process in instance1.



CR immediate 3-way

Select c1 from t1 where N1 =:b1;

1. User process in instance 1 requests master for the block.
2. Current owner holds Protected Read (PR) and so master grants a PR to instance 1.
3. Master sends the owner to send the block to instance1.
4. Owner instance LMS process serves the block to the user process in instance1



CR complications

- There are lot more complications then I covered here:
  - gcs log flush
  - What if the block has uncommitted transaction?
  - What if the block SCN is ahead the query environment SCN?
  - What if the block is undergoing changes and the buffer is pinned by another process?
  - What if the block is transaction table, undo block?
  - What if the block is index branch block that was just split?

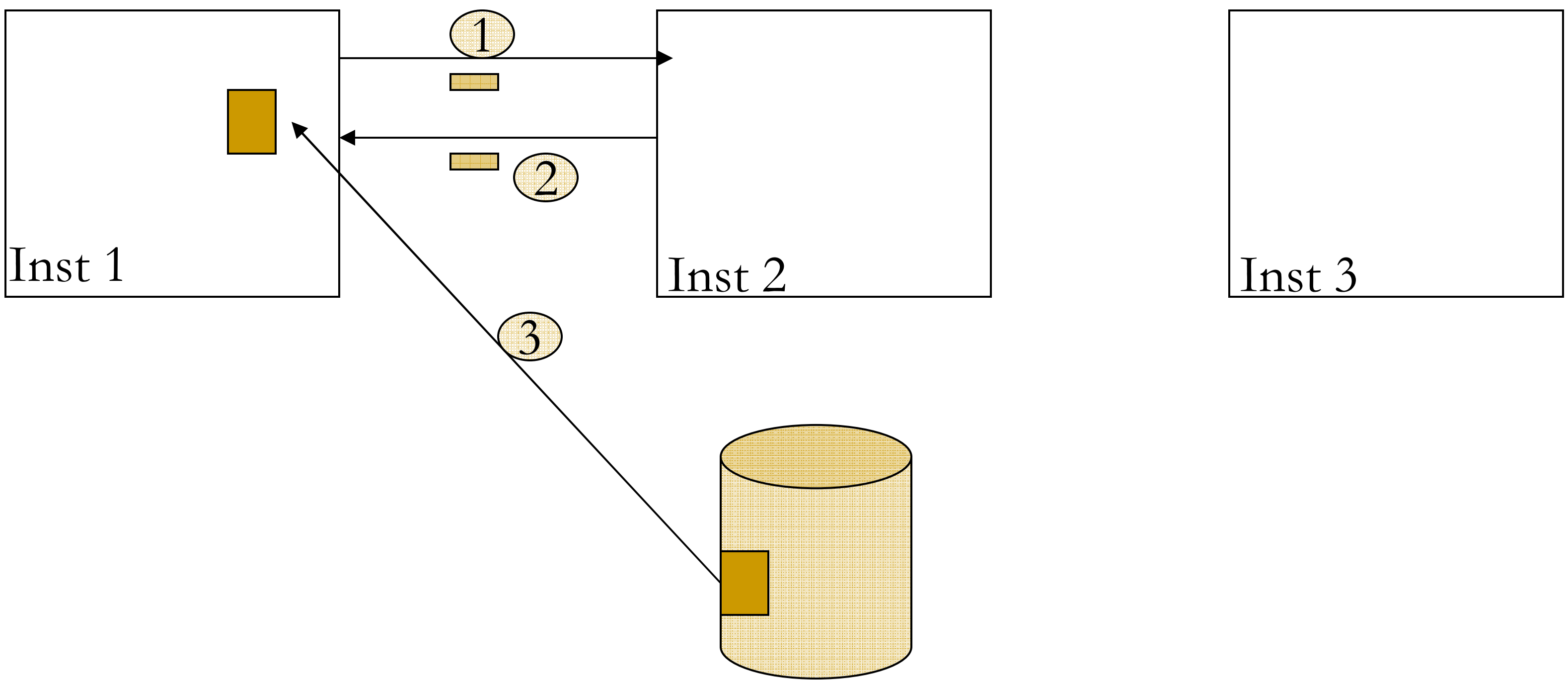
Block oriented packets

- CURRENT mode blocks
  - Blocks requested by other nodes to modify the blocks.
  - LMS will send the current mode block to the requesting process.
  - Converts the existing block to Past Image.

CUR – disk read

Update t1 set c1=:b1 where T1 =:b2;

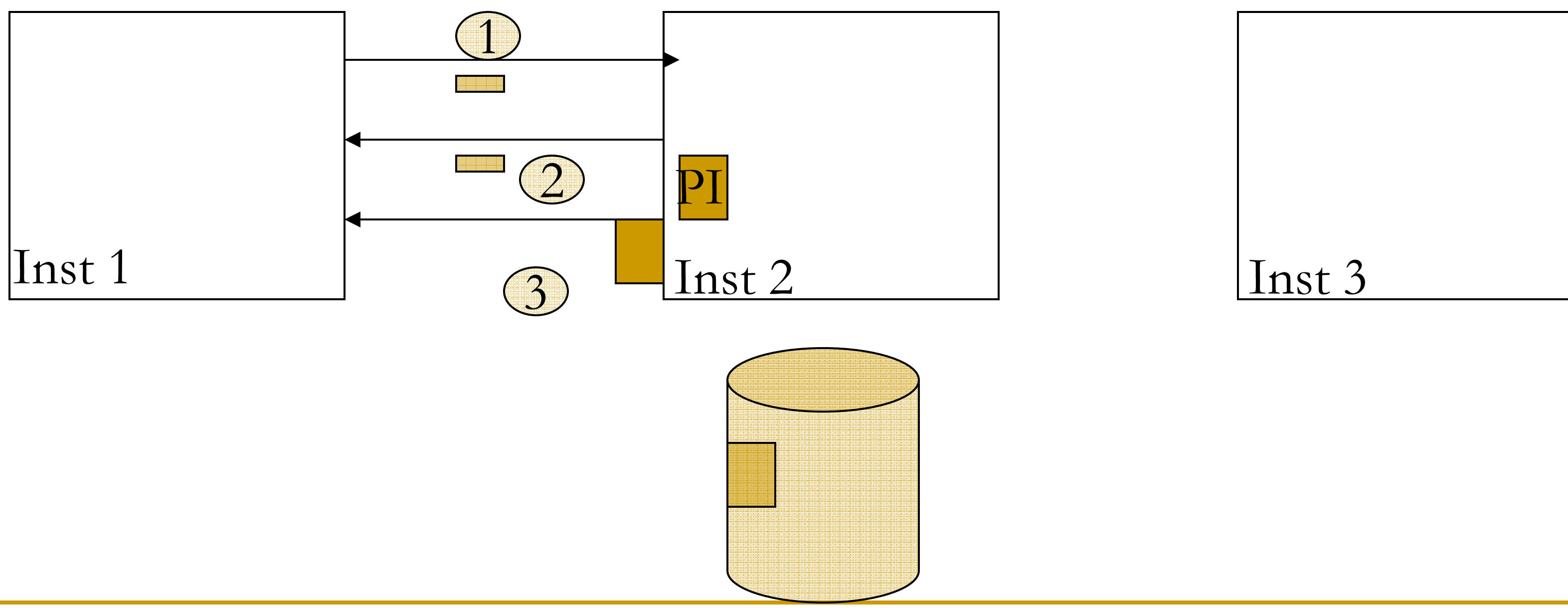
1. User process in instance 1 requests master for a Exclusive grant.
2. Assuming no current owner, master node grants the request.
3. User process in instance 1 reads the block from the disk.



CUR immediate 2-way

Update t1 set c1=:b1 where T1 =:b2;

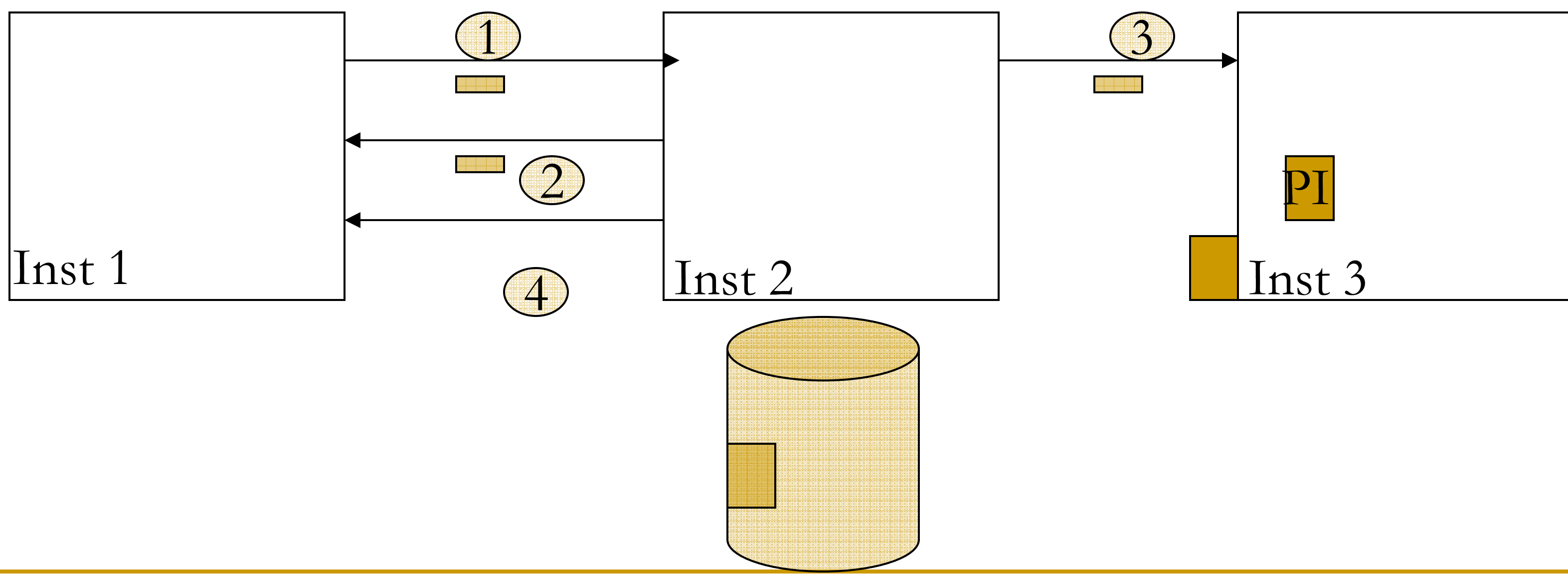
1. User process in instance 1 requests master for Exclusive grant on the block.
2. Current owner (2) holds Exclusive mode lock on that block.
3. In this case master instance and owner instance are the same. Owner instance LMS process serves the block to the user process in instance1. Block in instance 2 is marked as PI (Past Image).



CUR immediate 3-way

Update t1 set c1=:b1 where T1 =:b2;

1. User process in instance 1 requests master for Exclusive grant on the block.
2. Current owner (3) holds Exclusive mode lock on that block.
3. Master (instance 2) requests instance 3 to ship the block to instance 1.
4. In this case master instance and owner instance are the same. Owner instance LMS process serves the block to the user process in instance1. Block in instance 2 is marked as PI (Past Image).



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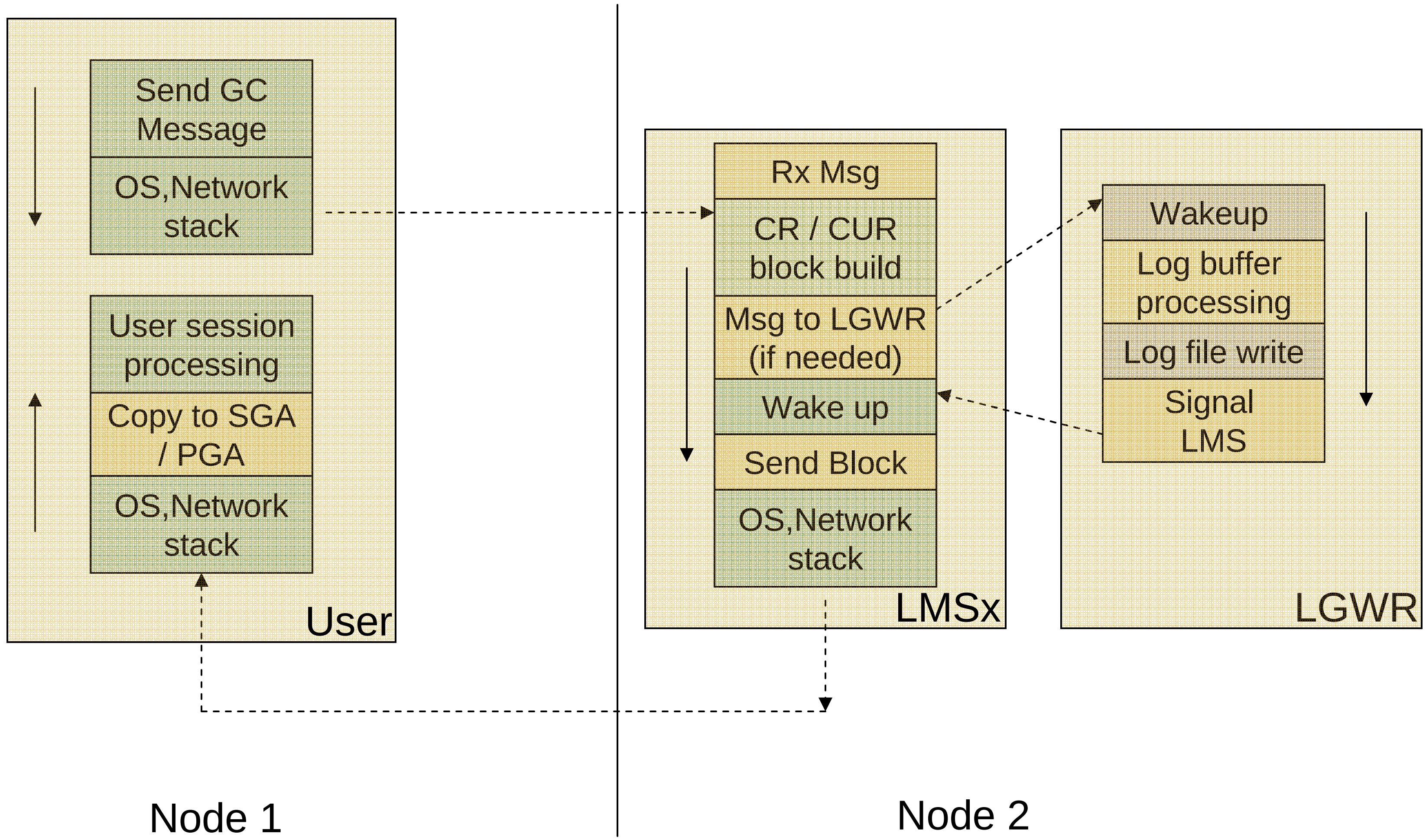
Gcs log flush sync

- But, if the instances crash right after the block is transferred to other node, how does RAC maintain consistency?
- Actually, before sending a current mode block LMS process will request LGWR for a log flush.
- Until LGWR sends a signal back to LMS process, LMS process will wait on ‘gcs log flush’ event.
- CR block transfer might need log flush if the block was considered “busy”.
- One of the busy condition is that if the block was constructed by applying undo records.

LMS Processing (over simplified)



GC CR latency

- GC CR latency ~=

  Time spent in sending message to LMS +

  LMS processing (building blocks etc) +

  LGWR latency (if any) +

  LMS send time +

  Wire latency

> Averages can be misleading. Always review both total time and average to understand the issue.

Breakdown latency

In this case, LGWR flush time
Need to be reduced to tune latency.

```
Avg global cache cr block receive time (ms):      6.2
```

Wait time	Node 1	Node 2	Node 3	Node 4	Total
gc cr block build time	402	199	100	227	1679
Gc cr block flush time	3016	870	978	2247	7111
Gc cr block send time	375	188	87	265	1290

GC CURRENT latency

- GC CUR latency ~=

  Time spent in sending message to LMS +

  LMS processing : (Pin and build block) +

  LGWR latency: Log flush +

  Wire latency

Statistics : gc current block flush time

gc current block pin time

gc current block send time

Caution

- Don't use gv$views to find averages. Use AWR reports or custom scripts.
- gv$views are aggregated data and persistent from the instance restart.
- For example this query can be misleading:

```
select b1.inst_id, b2.value "RECEIVED",
b1.value "RECEIVE TIME",
((b1.value / b2.value) * 10) "AVG RECEIVE TIME (ms)"
from gv$sysstat b1, gv$sysstat b2
where b1.name = ‘gc cr block receive time' and
b2.name = 'gc cr blocks received' and b1.inst_id = b2.inst_id
```

gc_traffic_print.sql

- You can use my script to print global cache performance data for the past minute. Download from scripts archive:

  http://www.orainternals.com/scripts_rac1.php

```
---------|--------------|---------|----------------|----------|---------------|---------------|-------------|
Inst     | CR blocks Rx | CR time |  CUR blocks Rx | CUR time |  CR blocks Tx | CUR blocks Tx |Tot blocks   |
---------|--------------|---------|----------------|----------|---------------|---------------|-------------|
1        |         40999|    13.82|            7827|      4.82|          25070|          17855|        91751|
2        |         12471|     5.85|            8389|      5.28|          31269|           9772|        61901|
3        |         28795|     4.11|           18065|      3.97|          28946|           4248|        80054|
4        |         33105|     4.54|           12136|      4.68|          29517|          13645|        88403|
---------|--------------|---------|----------------|----------|---------------|---------------|-------------|
```

- During the same time frame, output of the script from prior slide:

```
 INST_ID    RECEIVED RECEIVE TIME AVG RECEIVE TIME (ms)
---------- ---------- ------------ ---------------------
         4  165602481    104243160             6.2947825
         2  123971820     82993393            6.69453695
         3  215681074    103170166             4.7834594
         1  134814176     66663093             4.9448133
```

Very misleading!

Review all nodes.

- It is important to review performance data from all the nodes.

- It is easy to create AWR reports from all nodes using my script: Refer awrrpt_all_gen.sql.
  - [Don't forget that access to AWR report needs license]

- Or use my script gc_traffic_processing.sql from my script archive.

```
Default collection period is 60 seconds.... Please wait for at least 60 seconds...
---------|-----------|---------|-----------|----------|------------|------------|------------|----------|
Inst     | CR blk Tx | CR bld  | CR fls tm | CR snd tm| CUR blk TX | CUR pin tm | CUR fls tm |CUR blk TX|
---------|-----------|---------|-----------|----------|------------|------------|------------|----------|
2        |      67061|      .08|        .88|       .23|       34909|        1.62|          .2|       .23|
3        |      38207|      .17|       2.19|       .26|       28303|         .61|         .08|       .26|
4        |      72820|      .06|       1.76|        .2|       40578|        1.76|         .24|       .19|
5        |      84355|      .09|       2.42|       .23|       30717|        2.69|         .44|       .25|
----------------------------------------------------------------------------------------------------------
```

Place holder events

- Few events are place holder events such as:
  - gc cr request
  - gc cr multiblock request
  - gc current request

  …
- Sessions can be seen waiting for these wait events, but will not show up in AWR / ADDM reports.
- After sending the global cache block request, foreground process waits on these events.
- On receipt of the response, time is accounted for correct wait event.

2-way/3-way events

- As we saw in the prior section, there are 2-way and 3-way block transfer.
  - GC CR block 2-way
  - GC CR block 3-way
  - GC CUR block 2-way
  - GC CUR block 3-way
- Even if there are many instances, only three instances participate in a block transfer.
- But, flush messages can be sent to all instances in few cases.

Gc grants

- Wait events ‘gc cr grant 2-way’ and ‘gc current grant 2-way’ indicates
  - Block is not in any cache
  - Permission granted to read from the disk.

```
WAIT #6: nam='gc cr grant 2-way' ela= 567 p1=295 p2=770871 p3=1
   obj#=5153800 tim=817052932927

WAIT #6: nam='db file sequential read' ela= 11003 file#=295 block#=770871
   blocks=1 obj#=5153800 tim=817052943998
```

Congested..

- Congestion indicates that LMS processes were not able to service fast enough:
  - gc cr grant congested, gc current grant congested
  - gc cr block congested, gc current block congested

- Focus on LMS processes and usual culprits are load, SQL performance or longer CPU queue etc.

Histogram

89.4% of these waits are Under 4ms.

- Averages can be misleading. Use v$event_histogram to understand true performance metrics.
- It is better to take snapshots of this data and compare the differences.

INST_ID	EVENT	WAIT_TIME_MILLI	WAIT_COUNT	THIS_PER	TOTAL_PER
1	gc cr block 2-way	1	466345	.92	.92
1	gc cr block 2-way	2	23863264	47.58	48.51
1	gc cr block 2-way	4	20543430	40.96	89.47
1	gc cr block 2-way	8	4921880	9.81	99.29
1	gc cr block 2-way	16	329769	.65	99.95
1	gc cr block 2-way	32	17267	.03	99.98
1	gc cr block 2-way	64	2876	0	99.99
1	gc cr block 2-way	128	1914	0	99.99
1	gc cr block 2-way	256	1483	0	99.99
1	gc cr block 2-way	512	618	0	99.99
1	gc cr block 2-way	1024	83	0	99.99
1	gc cr block 2-way	2048	4	0	99.99
1	gc cr block 2-way	4096	3	0	99.99
1	gc cr block 2-way	8192	5	0	99.99
1	gc cr block 2-way	16384	3	0	100

GC event histograms

- Better yet, use my script gc_event_histogram.sql to understand current performance metrics.

```
Default collection period is sleep seconds. Please wait..
Enter value for event: gc cr block 2-way
Enter value for sleep: 60
---------|-----------------------|----------------|----------|
Inst id  | Event                 |wait time milli |wait cnt  |
---------|-----------------------|----------------|----------|
1        |gc cr block 2-way      |               1|        37|
1        |gc cr block 2-way      |               2|      4277|
1        |gc cr block 2-way      |               4|      5074|
1        |gc cr block 2-way      |               8|      1410|
1        |gc cr block 2-way      |              16|        89|
1        |gc cr block 2-way      |              32|         1|
1        |gc cr block 2-way      |              64|         0|
1        |gc cr block 2-way      |             128|         0|
1        |gc cr block 2-way      |             256|         0|
```

Gc buffer busy waits

- GC buffer busy waits are usually symptoms. In many instances, this event can show up the top most waited event.
- GC Buffer busy simply means that buffer is pinned by another process and waiting for a different global cache event.
- Understand why that 'buffer pin holder' is waiting. Resolving that will resolve global cache buffer busy waits.
- Segment header changes dues to insufficient freelist groups also can lead to longer 'gc buffer busy' waits.

Example analysis

Client had high Global Cache response time waits.

```
Global Cache and Enqueue Services - Workload Characteristics
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
                     Avg global enqueue get time (ms):      2.5

           Avg global cache cr block receive time (ms):     18.2
      Avg global cache current block receive time (ms):     14.6

             Avg global cache cr block build time (ms):      0.3
              Avg global cache cr block send time (ms):      0.2
      Global cache log flushes for cr blocks served %:     25.1
             Avg global cache cr block flush time (ms):      5.2

          Avg global cache current block pin time (ms):      0.4
         Avg global cache current block send time (ms):      0.2
 Global cache log flushes for current blocks served %:      1.7
        Avg global cache current block flush time (ms):      5.2
```

GC CR latency

- GC CR latency ~=

  Time spent in sending message to LMS +

  LMS processing (building blocks etc) +

  LGWR latency (if any) +

  LMS send time +

  Wire latency

Statistics : gc cr block flush time
gc cr block build time
gc cr block send time

CR latency

- Three instances are suffering from CR latency, except instance 2!

Wait time	Node 1	Node 2	Node 3	Node 4
Avg. CR block receive time	18.2	6.7	20.0	17.3
Avg CUR block receive time	14.6	5.0	11.6	17.3

- In RAC, node suffering from chronic issues causes GC performance issues in other nodes. With that logic in mind, node 2 should be suffering from chronic issues.

Breakdown of latency

- Sum of flush time is higher, but it is comparable across the cluster.

But, notice the build time in node 2.

Statistics	Node 1	Node 2	Node 3	Node 4	Total
gc cr block build time	11,392	148,666	5,267	6,632	171,957
Gc cr block flush time	56,634	75,751	34,406	53,031	219,822
Gc cr block send time	9,153	7,779	4,018	7,905	28,855

Consistent reads

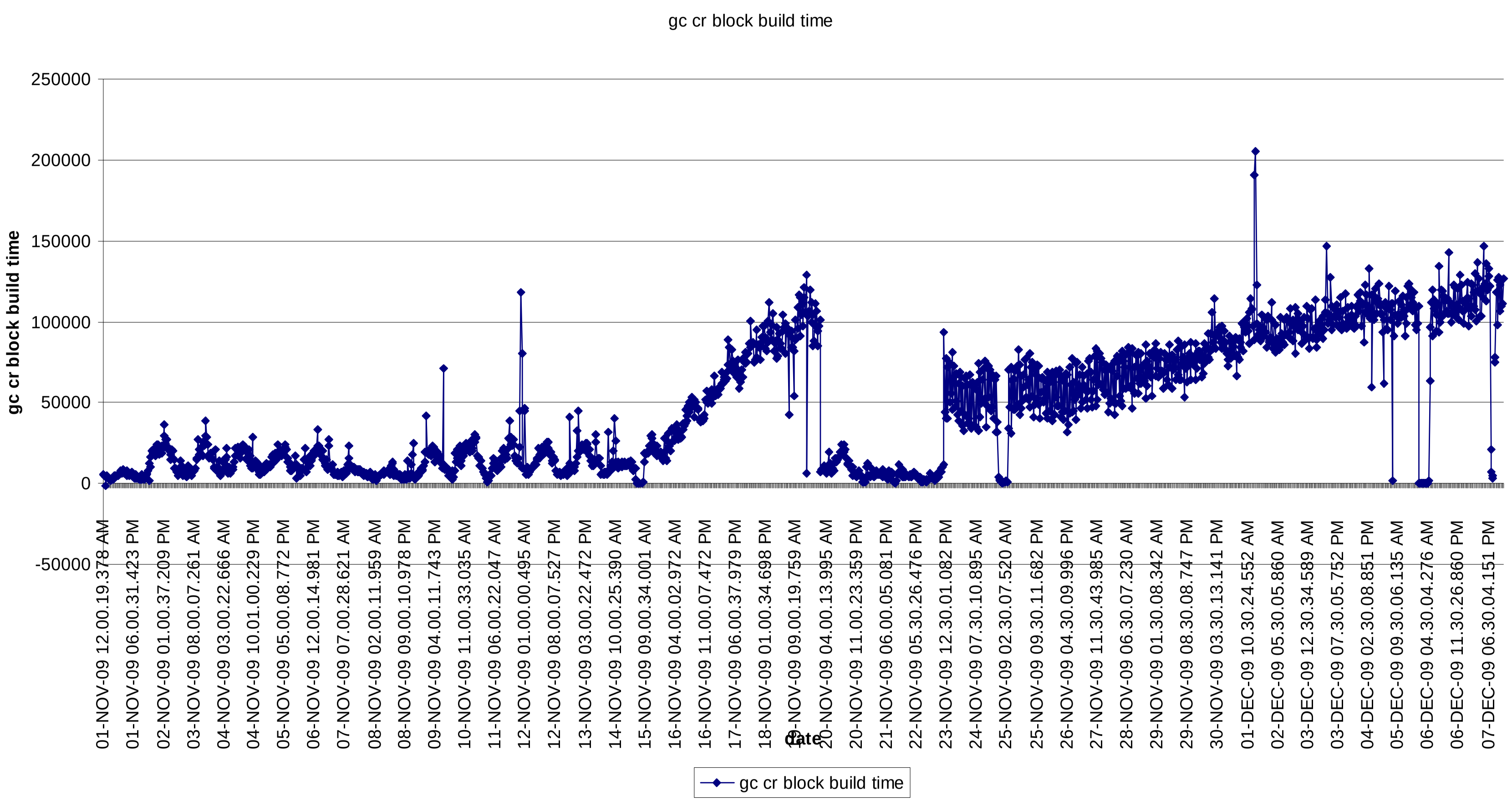
- For CR blocks, time is spent in building blocks, which indicates consistent block generation.

Very high value compared to other nodes.

Statistics	Node 1	Node 2	Node 3	Node 4
data blocks consistent Reads – undo records applied	2,493,242	86,988,512	3,090,308	7,208,575
db block changes	6,276,149	43,898,418	20,698,189	14,259,340

Time line

- We wanted to see when this problem started. Surprisingly, instance 2 had a pattern of increasing flush time.



Db block changes

Unfortunately, AWR report does not capture segments with high 'db block changes'.

```
with  segstats as (
       select * from (
         select inst_id, owner, object_name, object_type , value ,
                rank() over (partition by  inst_id, statistic_name order by value desc
   ) rnk , statistic_name
                 from gv$segment_statistics
          where value >0
        ) where rnk <11
       )  ,
sumstats as ( select inst_id, statistic_name, sum(value) sum_value from
   gv$segment_statistics group by statistic_name, inst_id)
 select a.inst_id, a.statistic_name, a.owner, a.object_name,
   a.object_type,a.value,(a.value/b.sum_value)*100 perc
    from segstats a ,   sumstats b
where a.statistic_name = b.statistic_name
and a.inst_id=b.inst_id
and a.statistic_name ='db block changes'
order by a.statistic_name, a.value desc
/

INST_ID STATISTIC_NAME     OWNER OBJECT_NAME                    TYPE  VALUE        PERC
------- ------------------ ----- ------------------------------ ----- ------------ ------
      2 db block changes   AR    CUSTOM_TABLE                   TABLE 122949282400  81.39
      4                    INV   MTL_MATERIAL_TRANS_TEMP_N1     INDEX   1348827648  16.59
      3                    AR    RA_INTERFACE_LINES_N2          INDEX    791733296   9.77
      3                    AR    RA_CUSTOMER_TRX_LINES_N2       INDEX    715855840   8.83
      1                    INV   MTL_MATERIAL_TRANS_TEMP_N1     INDEX    652495808  12.44
...
```

Solution

- Finally, it boiled down to a custom code bug which was updating almost all rows in a table unnecessarily.

- Unfortunately, number of rows that fall in to that criteria was slowly increasing.

- So, GC CR response time was slowly creeping up and it wasn't easy to identify the root cause.

- After the code fix, GC CR time came down to normal range.

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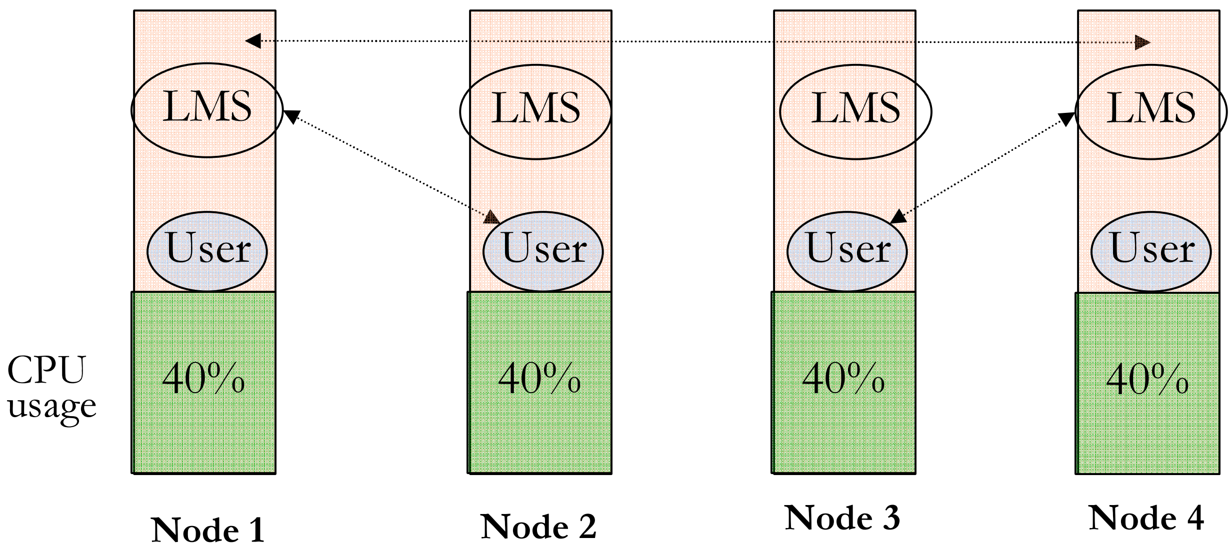
LMS processes – normal state

- During normal conditions, LMS processes are operating with no CPU latency.

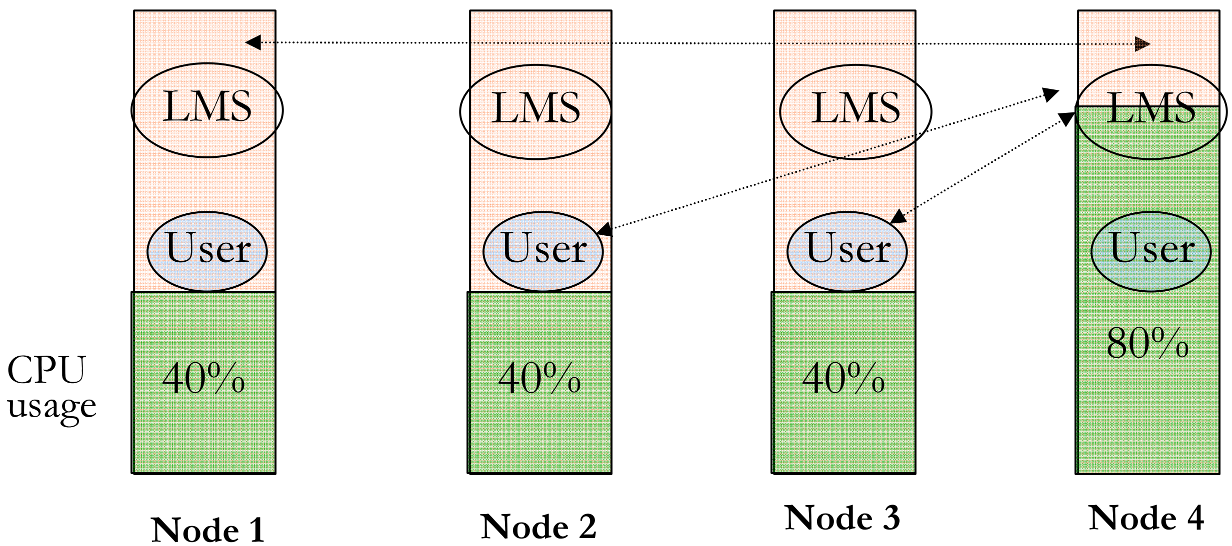
- So, there is no Global cache latency either.



CPU latency

- If one node is suffering from CPU starvation then LMS process running in that node will suffer from CPU latency.

- This will result in Global cache latency in other nodes.



Global Cache waits

- Global Cache waits increases due to increase in LMS latency in the CPU starved node.
- Much of these GC waits are blamed on interconnect interface and hardware.
- In many cases, interconnect is performing fine, it is that GCS server processes are introducing latencies.

LMS & 10.2.0.3

- In 9i, increasing priority of LMS processes to RT helps (more covered later).

- From Oracle release 10.2.0.3 LMS processes run in Real Time priority by default.

- Two parameters control this behaviour:
  - _high_priority_processes
  - _os_sched_high_priority

Parameters in 10gR2

- _high_priority_processes:

  Default value: LMS*|VKTM*

  This parameter controls what background processes should get Real time priority. Default is all LMS processes and VKTM process.

- _os_sched_high_priority :

  Default value: 1

  This is a switch. If set to 0, no background process will run in high priority.

oradism

- Of course, bumping priority needs higher privileges such as root in UNIX.
- Oradism utility is used to increase the priority class of these critical background process in UNIX.
- Verify that LMS processes are using Real time priority in UNIX and if not, oradism might not have been configured properly.
- In Windows, oradism service is used to increase the priority.

More LMS processes?

- Typical response is to increase number of LMS processes adjusting _lm_lms (9i) or gcs_server_processes(10g).

- Increase in LMS processes without enough need increases xcalls/migrates/tlb-misses in massive servers.

- Further, LMS process runs in RT CPU priority and so, CPU usage will increase.

LMS & CPU usage

- In huge servers, by default, number of LMS processes might be quite high. It is possible to get up to 26 LMS processes by default.
- Typically, same number of LMS processes as interconnect or remote nodes is a good starting point.
- If there is enormous amount of interconnect traffic, then configure LMS processes to be twice the interconnect.

LGWR and CPU priority

- LGWR performance is akin to Global cache performance.
- If LGWR suffers from performance issues, it will reflect on Global cache performance.
- For example, If LGWR suffers from CPU latency issues, then LMS will have longer waits for ‘gcs log flush sync’ event
- This leads to poor GC performance in <u>other nodes</u>.

LGWR priority

- Method to increase priority for LGWR and LMS in 9i (Example for Solaris). If you don't want to increase priority to RT for LGWR, at least, consider FX priority.

priocntl -e -c class -m userlimit -p priority

priocntl -e -c RT -p 59 `pgrep -f ora_lgwr_${ORACLE_SID}`

priocntl -e -c FX -m 60 -p 60 `pgrep -f ora_lms[0-9]*_${ORACLE_SID}`

- In 10g, parameter _high_priority_processes can be used (needs database restart though)

alter system set "_high_priority_processes"="LMS*|LGWR*" scope=spfile sid='*';

alter system set "_high_priority_processes"="LMS*|VKTM*|LGWR*" scope=spfile sid='*'; (11g)

Pitfalls of RT mode

- Of course, there are few!
- LMS process can continuously consume CPU and can introduce CPU starvation in servers with few CPUs.
- A bug was opened to make LMS process sleep intermittently, but that causes LMS to be less active and can cause GC latency.
- Another undocumented parameter _high_priority_process_num_yields_before_sleep was introduced as a tunable. But, hardly a need to alter this parameter.
- Hyper-active LGWR can lead to latch contention issues.

Binding..

- Another option is to bind LGWR/LMS to specific processors or processor sets.
- Still, interrupts can pre-empt LMS processors and LGWR. So, binding LMS to processor set without interrupts helps (see psradm in solaris).
- But, of course, processor binding is useful in servers with higher number of CPUs such as E25K platforms.

CSSD/CRSD

- CSSD is a critical process. Few CSSD processes must be running with RT priority.
- CPU starvation in the server can lead to missed network or disk heart beat. This can lead to node reboots.
- It is important to have good and consistent I/O performance to ORA_CRS_HOME directories.
- If CSSD can't access those directories efficiently (i.e. due to NFS or other file system issues), then that can lead to node reboots too.

Summary

- In summary,
  - • Use optimal # of LMS processes
  - • Use RT or FX high priority for LMS and LGWR processes.
  - • Configure decent hardware for online redo log files.
  - • Tune LGWR writes and Of course, avoid double buffering and double copy using optimal file systems.
  - • Of course, tune SQL statement to reduce logical reads and reduce redo size.

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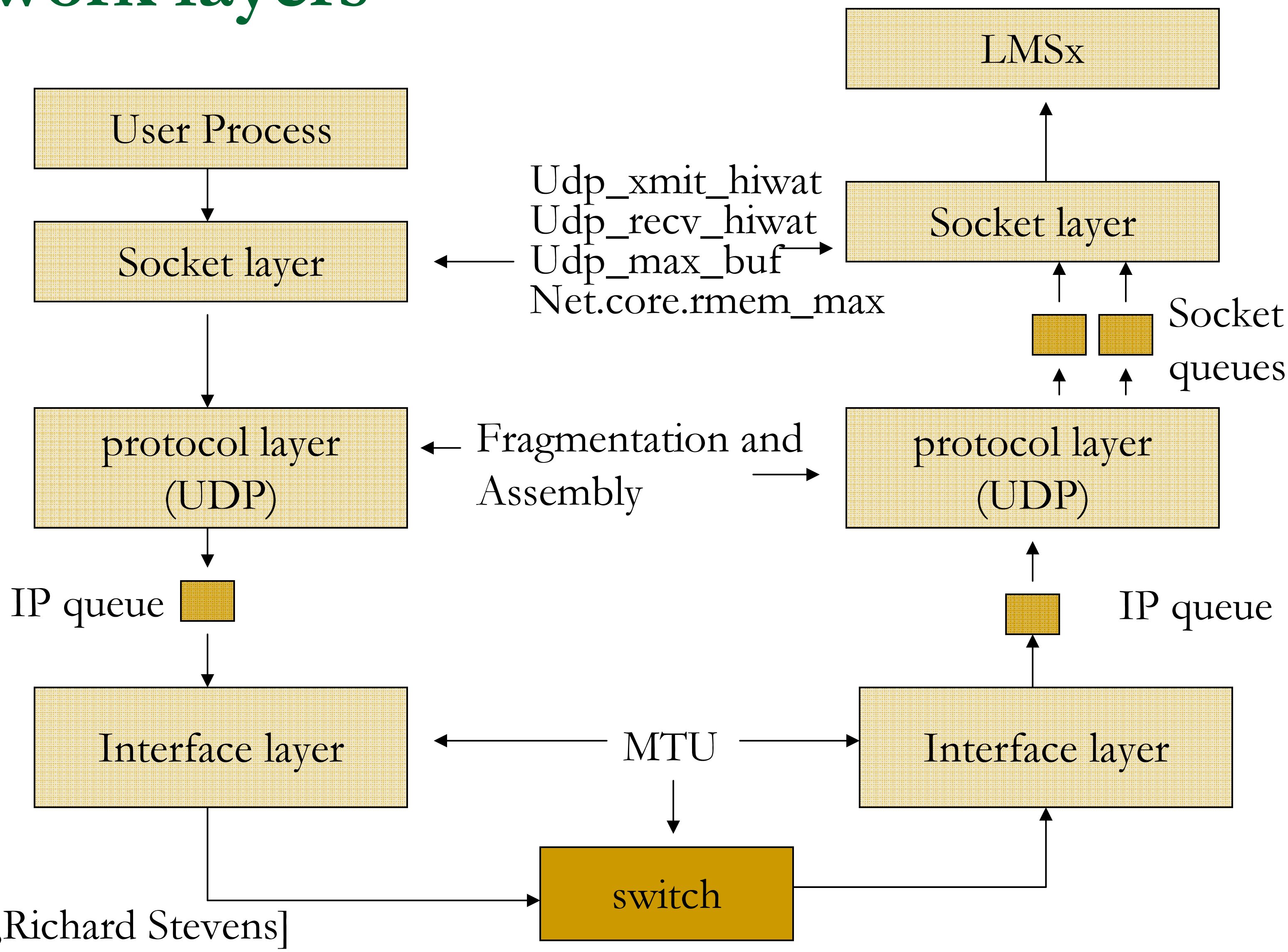
gc blocks lost

- Probably, the most critical statistics for interconnect issues.
- Consistent high amount of 'gc blocks lost' is an indication of problem with underlying network infrastructure. (Hardware, firmware etc).
- Need to understand which specific component is an issue. Usually, this is an inter-disciplinary analysis.
- Ideal value is near zero. But, only worry about this, if there are consistently higher values.

Effects of lost blocks

- Higher number of block loss can lead to timeouts in GC traffic wait events. Many processes will be waiting for place-holder events.
- Use total_timeouts column in v$system_event to see if the timeouts are increasing.
- Percent of total_timeouts should be very small.

Network layers



Source: [8,Richard Stevens]

UDP buffer space

- UDP is a "send-and-forget" type protocol. Sending process does not get any acknowledgement.
- UDP Tx/Rx buffers are allocated per process.
- When the process executes CPU, it drains the UDP buffers. If the buffer is full, then incoming packets to that process are dropped.
- Default values for the UDP buffers are small for the bursty nature of interconnect traffic. Increase UDP buffer space to 128KB or 256KB.

CPU latency and UDP

- Due to CPU latency, process might not be able to acquire CPU quick enough.
- This can lead to buffer full conditions and lost packets.
- It is essential to keep CPU usage under 80% to avoid latencies and lost packets.

Agenda

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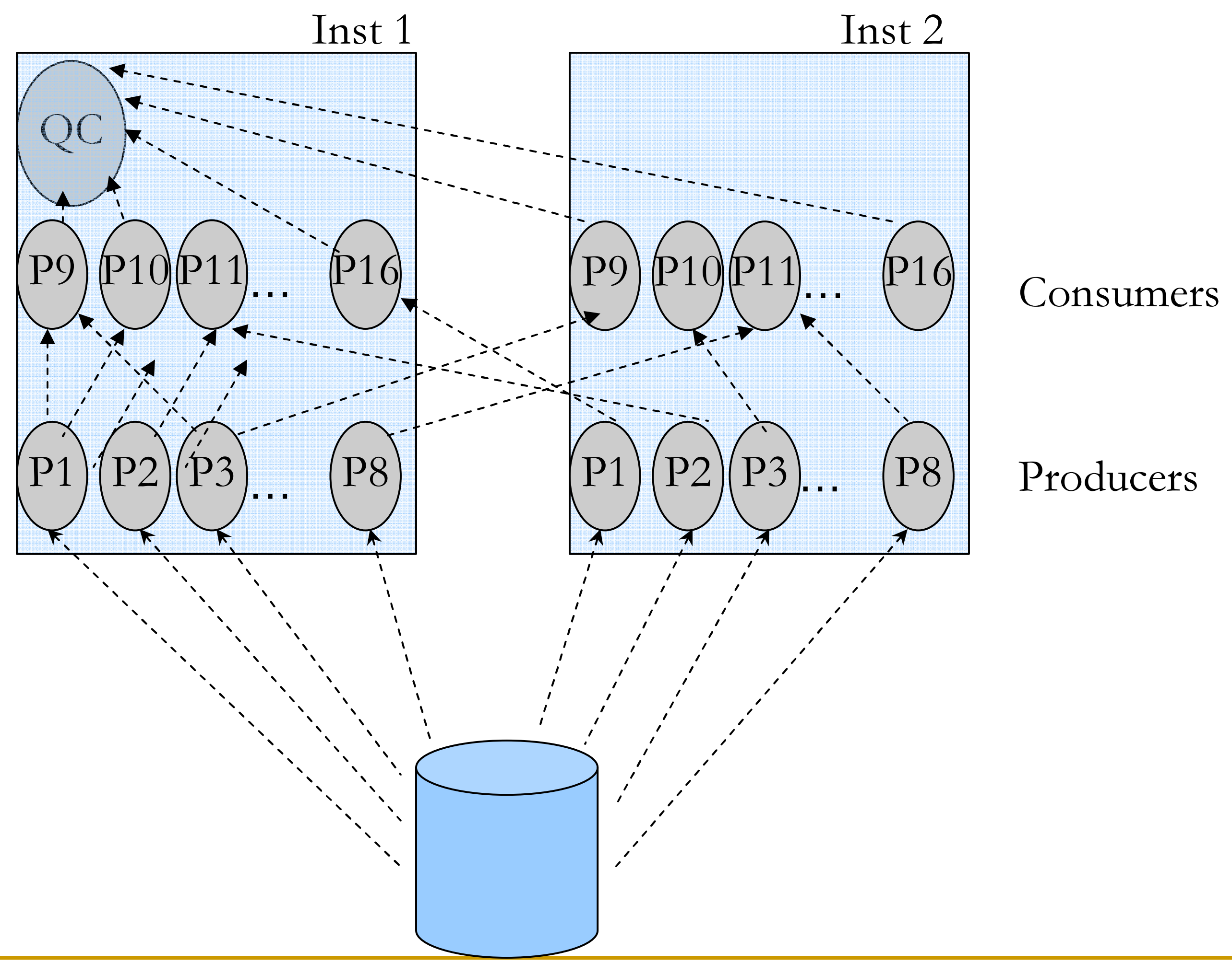
- Troubleshooting locking issues
- Object re-mastering

Parallel Query Setup

- Parallel Query slaves can be allocated from multiple instances for a query.
- It is imperative that PQ messages are transmitted between producers and consumers.
- Insufficient network bandwidth with PQ storm can cause higher GC latency and possible packet loss.

PQ Optimization

Communication between producers/consumers are
Not limited to one node. Gigabytes of data flew
Between node 1 and node 2.



Optimizations in 10g/11g

- PQ algorithms are optimized in Oracle versions 10g and 11g. Only few discussed here.
- In 11g, interconnect traffic due to PQ is also reported in the AWR reports.
- Oracle code tries to allocate all PQ slaves in one node, if possible. This minimizes PQ induced interconnect traffic.
- If it not possible to allocate all slaves from a node, then the least loaded node(s) are chosen for PQ slave allocation.

PQ and partitioning

- For partition-wise joins, PQ traffic is further minimized.
- Partitions are joined within the same node further reducing PQ induced interconnect traffic.
- Of course, partitioning strategy plays critical role in this localized partition-wise joins.
- Full partition-wise join can use all instance effectively, akin to shared-nothing systems. Full partition-wise joins does not induce spurious interconnect traffic.

PQ-Summary

- Inter instance parallelism need to be carefully considered and measured.

- For partition based processing, when processing for a set of partitions is contained within a node, performance will be better.

- Excessive inter instance parallelism will increase interconnect traffic leading to performance issues.
- http://www.oracle.com/technology/products/bi/db/11g/pdf/twp_bidw_parallel_execution_11gr1.pdf

"..inter-node parallel execution will not scale with an undersized interconnect"

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GES layer

- In RAC, Global Enqueue Services handles all global locks requests, converts.
- Almost many resources are globally co-ordinated.
- For example, in a single instance, library cache locks are not implemented as “enqueues”. But, In RAC, library cache locks are externalized as enqueues (LA-LZ) and globally co-ordinated.
- This means that DDL statement on an object in one node need to be globally co-ordinated so that parse locks can be invalidated in all instances.

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Object re-mastering

- Before reading the block, an user process must request master node of the block to access that block.
- Typically, a batch process will access few objects aggressively.
- If an object is accessed excessively from a node then re-mastering the object to that node reduces Global cache grants.
- Local grants (affinity locks) are very efficient compared to remote grants avoiding global cache messaging traffic.

Object based in 10gR2

- Dynamic remastering is file based in 10gR1. If a block need to be remastered, then every block in that data file must be remastered to an instance.

- In 10gR2, remastering is object based. If a block to be remastered, then all blocks associated with that object is remastered to an instance.

- Three background processes work together to implement dynamic remastering functionality.

High level overview 10gR2

- LCK0 process maintains object level statistics and determines if remastering must be triggered.
- If an object is chosen, a request is queued. LMD0 reads the request queue and initiates GES freeze. LMD0 trace file

```
*** 2010-01-08 19:41:26.726
* kjdrchkdrm: found an RM request in the request queue
  Dissolve pkey 6984390
*** 2010-01-08 19:41:26.727
Begin DRM(189) - dissolve pkey 6984390 from 2 oscan 1.1
 ftd received from node 1 (8/0.30.0)
 ftd received from node 0 (8/0.30.0)
 ftd received from node 3 (8/0.30.0)
 all ftds received
```

- LMON performs reconfiguration.

```
*** 2010-01-08 19:41:26.793
Begin DRM(189)
 sent syncr inc 8 lvl 5577 to 0 (8,0/31/0)
 synca inc 8 lvl 5577 rcvd (8.0)
```

Parameters 10gR2

Three parameters control the behavior:

  - _gc_affinity_limit
  - _gc_affinity_time
  - _gc_affinity_minimum

- _gc_affinity_limit default value is 50. Not documented well, but, it is number of times a node should access an object more than other nodes.
- _gc_affinity_time default value is 10. Frequency in seconds to check if remastering to be triggered or not.
- _gc_affinity_minimum determines number of DRM requests to enqueue and default is 600.

Defaults

- Default for these parameters may be too low in a very busy, high-end instances.

- If your database have higher waits for 'gc remaster' and 'gcs drm server freeze' then don't disable this feature completely. Instead tune it.

- Some good starting points (for a very busy environment) are:

  [YMMV]

  - _gc_affinity_limit to 250
  - _gc_affinity_minimum to 2500.

11g

- In 11g, these three parameters are completely removed.
- Three new parameters are introduced:
  - _gc_affinity_locking
  - _gc_affinity_locks
  - _gc_affinity_ratio
- Sorry, I have not tested these parameters thoroughly yet.

An example

```
Top 5 Timed Events                                         Avg %Total
~~~~~~~~~~~~~~~~~~                                        wait   Call
Event                                 Waits    Time (s)   (ms)   Time Wait Class
------------------------------ ------------ ----------- ------ ------ ----------
gc buffer busy                    1,826,073     152,415     83   62.0    Cluster
CPU time                                         30,192          12.3
enq: TX - index contention           34,332      15,535    453    6.3 Concurrenc

gcs drm freeze in enter server       22,789      11,279    495    4.6      Other

enq: TX - row lock contention        46,926       4,493     96    1.8 Applicatio


Global Cache and Enqueue Services - Workload Characteristics
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
                     Avg global enqueue get time (ms):     16.8

          Avg global cache cr block receive time (ms):     17.1
     Avg global cache current block receive time (ms):     14.9
```

Views

- View v$gcspfmaster_info provides remastering details. For example, you can identify the object with high remastering count.

FILE_ID	OBJECT_ID	CURRENT_MASTER	PREVIOUS_MASTER	REMASTER_CNT
0	6983606	0	32767	1
0	5384799	2	1	2
0	6561032	3	2	2
0	5734002	0	2	2
0	6944892	2	0	2
0	5734007	2	0	4
0	6944891	2	0	5
0	6795604	2	0	5
0	6944894	2	0	5
0	6795648	2	0	6
0	5734006	2	0	6
0	4023250	2	0	6
0	5734003	0	2	7

Views

- View x$object_object_affinity_statistics provides current object affinity statistics.

```
select * from  x$object_affinity_statistics  order by opens
ADDR                   INDX    INST_ID     OBJECT       NODE      OPENS
---------------- ---------- ---------- ---------- ---------- ----------
…
FFFFFFFF7C04CB40          8          3    4740170          1        113
FFFFFFFF7C04CB40        109          3    1297745          1        127
FFFFFFFF7C04CB40         21          3    1341531          1        128
FFFFFFFF7C04CB40          2          3    2177393          1        135
FFFFFFFF7C04CB40        153          3    6942171          2        174
FFFFFFFF7C04CB40        108          3    1297724          1        237
FFFFFFFF7C04CB40          3          3    2177593          1        239
FFFFFFFF7C04CB40        106          3    1297685          1        337
FFFFFFFF7C04CB40         53          3    6984154          3       1162
```

Oradebug

- You can manually remaster an object with oradebug command

oradebug lkdebug -m pkey <object_id>

- This enqueues an object remaster request. LMD0 and LMON completes this request

```
*** 2010-01-08 23:25:54.948
* received DRM start msg from 1 (cnt 1, last 1, rmno 191)
Rcvd DRM(191) Transfer pkey 6984154 from 0 to 1 oscan 0.0
 ftd received from node 1 (8/0.30.0)
 ftd received from node 0 (8/0.30.0)
 ftd received from node 3 (8/0.30.0)
```

Oradebug

- You can manually remaster an object with oradebug command. Current_master starts from 0.

```
 1* select * from v$gcspfmaster_info where object_id=6984154
SQL> /

   FILE_ID  OBJECT_ID CURRENT_MASTER PREVIOUS_MASTER REMASTER_CNT
---------- ---------- -------------- --------------- ------------
         0    6984154              1               0            2

SQL> oradebug lkdebug -m pkey 6984154
Statement processed.
SQL>  select * from v$gcspfmaster_info where object_id=6984154
  2  /

   FILE_ID  OBJECT_ID CURRENT_MASTER PREVIOUS_MASTER REMASTER_CNT
---------- ---------- -------------- --------------- ------------
         0    6984154              2               1            3
```

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