Coupling Facility Disruptions and the DB2 Reorg Utility

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A few DB2 data sharing users have experienced disruptions in their parallel sysplexes caused by extreme write stress on the coupling facilities. They have observed paths to the coupling facility (CF) being taken offline, loss of CF connectivity, and in one extreme case, even a sysplex outage. The common factor was that all users affected were running the DB2 Reorg utility at the time of the incident. In addition the group buffer pool (GBP) structures affected were configured to allow z/OS System-Initiated Alter (AutoAlter) processing. This flash provides the technical background for the Coupling Facility Control Code (CFCC) scenario, as well as an explanation from the DB2 perspective.

The Problem and The Fix

A problem was found in the Coupling Facility Control Code (CFCC) internal latching protocol that permitted ongoing CF background processes (resulting from the DB2 Reorg and AutoAlter activity) to monopolize the entire CF image, effectively preventing new CF commands arriving from z/OS from executing for a period of time. If this situation continued for a short period of time, no impact would be observed; if it continued for a longer period of time, loss of CF links or loss of the entire CF image could result. A change was made to the CFCC internal latching protocol to mitigate the latching sequence such that foreground requests received from z/OS will continue to be serviced, as well as the background processes. The following changes are for CFCC levels 15 and 16:

- For processor models 2097 / 2098, the following code changes have been/will be released:
  - D73G (CFCC 15): EC F85900 MCL005 not yet available at time of this flash.
- For processor models 2094 / 2096, the following code change has been released:
  - Note: CFCC 16 is not applicable to 2094 / 2096 machines.

The fixes can be applied concurrently. Please see your IBM Customer Engineer to request application of this service.

Even after this fix is applied, note that it is still possible to over commit the use of CF resources during the intensive write activity triggered by a DB2 Reorg. The best practices described in this flash are strongly recommended until the user has migrated to DB2 9.
How DB2 Reorg plays in this scenario

The source of heavy write activity focuses on the index group buffer pool (GBP) when REORG PART is run. This activity occurs during the BUILD2 phase of REORG PARTITION. **It occurs only when a subset of the partitions of a partitioned table space is Reorged and there is an non-partitioning index (NPI) over the table space.**

**BUILD2 phase issues:**

Following the RELOAD phase of Reorg, the keys for the partition that has been Reorged must be updated in the NPI. That is called the “logical partition” or LPART and access to it is denied while its keys are being updated. All other logical partitions of that NPI can be accessed during the BUILD2 phase by transactions from any DB2. If the NPI is GBP-dependent, then the updates to its logical partition must be written to the GBP (and subsequently cast out by DB2). The BUILD2 phase writes pages out very fast to the GBP and can cause AutoAlter processing to attempt to increase the size of the GBP. (If AutoAlter has not been implemented for the GBP, it can cause pages to be set to LPL if writes to the GBP fail due to lack of storage.) The pages written to the GBP are cast out, but sometimes not as fast as they are written to the GBP. This can cause slowdowns for all requesters to the CF, and in severe cases, can affect the sysplex.

*The situation cannot occur for DB2 for z/OS Version 9.1 users because there IS no BUILD2 phase.*

The view from the coupling facility

One of the pieces of information in the CF cache structure directory is a user data field (UDF), which DB2 uses to denote the time at which the data item was written changed to the CF. The CF maintains an internal queue (the UDF Order Queue) of cache directory entries which is ordered based on the contents of the UDF field. (DB2 stores the LRSN when the page was changed in the UDF). When an entry is created or has the user data field updated, it needs to get inserted in the UDF Order Queue in the appropriate spot. In most cases, newly-written entries will be positioned at or near the end of the UDF Order Queue, so inserting the entry on the queue in the proper sequence is normally fast. When the proper insertion point on the ordered queue is not found within a small set of entries, the coupling facility control code (CFCC) puts the entry on a deferred queue that gets ordered asynchronously via a background process. It was this background process that was key to exposing the CF problem.

In the identifying incident, the Reorg was causing entries to be written with user data values that required UDF Order Queue background processing to occur. Since there were a lot of these entries, there ended up being many entries on the queue for UDF background processing to run in the CF. The CFCC dispatcher had a problem where it was incorrectly servicing the background work to the exclusion of either new incoming CF requests or other suspended foreground CF requests. Thus, even with the low incoming request rate, the CF was only doing the background work instead. A delay / timeout occurred for the incoming work and directly lead to the CFCC deciding to take the paths offline to the CF.

OPERLOG / SYSLOG will contain IXL158I messages indicating paths to the CF were taken offline. Example:
When the CF loses connectivity as a result of becoming unresponsive to incoming z/OS commands, there may also be structure rebuild messages and/or duplexing failover messages issued at this point. The CF may even abort and reboot itself, if the unresponsiveness persists long enough to trigger that processing.

In one case, the paths to both CFs were taken offline at the same time. Since there was no other CF available, the GRS lock structure could not be rebuilt and GRS terminated. All systems in the sysplex entered a WAIT0A3-CC. These messages were issued:

*ISG309W GRS PROCESSING TERMINATED. 018
UNRECOVERABLE FAILURE DURING LOCK STRUCTURE REBUILD PROCESSING.
09:00:54.84
*ISG309W GRS PROCESSING TERMINATED.

The AutoAlter Factor

System-initiated Alter (AutoAlter) is activated for particular CF structures by specification of ALLOWAUTOALT(YES) on the STRUCTURE statement of the CFRM Policy. It allows for autonomic tuning for structures that have it enabled. You can find more information on AutoAlter in Setting up a Sysplex, SA22-7625, section 4.2.2.5, titled “Allowing a Structure to Be Altered Automatically” and “AutoAlter Improved! Tuning DB2 GBPs the Couch Potato Way” at http://www-03.ibm.com/support/techdocs/atmastr.nsf/WebIndex/PRS1956.

While AutoAlter provides many advantages for the DB2 user, in this case it exacerbated the situation.

Local buffer pools have two thresholds that affect the GBP

1. Vertical deferred write threshold (VDWQT) – when the percentage (or number) of pages for a data set have been updated, they are written to the GBP
2. Horizontal deferred write threshold (DWTH) – when the percentage of pages in the BP have been updated, they are written to the GBP

When a local buffer pool (BP) with a VDWQT default threshold such as 10%, writes bursts of pages to a GBP with similar default threshold (CLASST=5%), castout processing may not be able to keep up with the demand. The CFRM policy FULLTHRESHOLD (the threshold for attempting to increase the structure size) can then be more easily reached and AutoAlter will attempt to increase the structure size. If the z/OS systems staff keeps increasing the structure size, as is generally recommended, the size of the structure can
increase forever, consuming excessive CF storage.

- In one case a GBP housing an index GBP had grown to 11GB with a directory to
data ratio of 1:1. That 4-way data sharing group had the local BP sized at 240,000
pages each for a total size of 960,000 buffers (4K). CFSizer (http://www.ibm.com/systems/support/z/cfsizer/) had calculated its INITSIZE much
lower, as 922,000K.

- There were about 3M pages. A local buffer pool of 240,000 and a VDWQT=5% would write 12,000 pages to the GBP. The GBP with a CLASST=5% would initiate
castout at almost 150,000 pages at once. Castout is a long running process and with these volumes, cannot keep up.

To summarize, AutoAlter increased the GBP allocated size and increased the number of
pages to be cast out at once.

Additionally, AutoAlter processing itself performs much of its activity through background
processes in the CFCC, which also exposes and exacerbates the CFCC dispatcher
problem described above, which was causing these background units of work to
monopolize the CF image, preventing new incoming requests from receiving service.

Best Practice DB2 Recommendations

Those DB2 data sharing users who may be exposed to this problem

1. Are not yet on DB2 9 (CM) and
2. Use the IBM DB2 Reorg utility.

The goal of the recommendations is to reduce the write intensity to the GBP even after the
application of the CFCC fix, which reduce exposure to the problem.

While the customers who have experienced disruptions were executing Reorg, it is
possible that LOAD PART might be similarly affected.

1. Isolate all NPIs to a separate BP/GBP so that their behavior during Reorg does not
adversely affect other objects in the same GBP (let us use GBP42 as an example, though clearly any unused GBP number will suffice)

2. Size GBP42 generously. For the above condition, INITSIZE=2,000,000K, SIZE=3,000,000K may be reasonable.(Commas are shown for the parameters here for readability, though the actual specification does not contain them). For smaller GBPs, INITSIZE=1,000,000K and SIZE=2,000,000K may be sufficient. Note: If there is not enough storage in the GBP, pages can be put in the logical page list (LPL).

3. Use the DB2 command to –ALTER GBPOOL (GBP42) RATIO (5) to reset the
directory to data ratio at 5:1.You can set a different ratio if you wish.

The next structure allocation will implement the ratio. The ratio will then not change
without manual intervention. Note that the ratio is stored in the DB2 BSDS and not
in the CFRM policy.

4. Turn off AutoAlter only for the NPI index GBP42
- Set ALLOWAUTOALT(NO) in the STRUCTURE statement of the CFRM policy for this specific structure only.
- Activate the CFRM policy
- Issue XCF START, REALLOCATE to ensure that structures are in their preferred locations and that all pending actions are resolved.
  Note that it is not necessary to reallocate the structures in order for the change in the ALLOWATOALT specification to take effect.

5. Thresholds:
- Use the DB2 command to –ALTER GBPOOL(GBP42) CLASST=1
  As the goal is to pace writes to the GBP, use CLASST of 1%. The GBPOOLT does not need to be reduced, since it should never be hit
- Use the DB2 command to –ALTER BPOOL(BP42) VDWQT(1) DWTH(1) for all members
- If Reorgs are usually run over the weekend, a Reorg-friendly option is to set thresholds on Friday and reset them on Sunday evening. In that case, set all thresholds to 0 (zero). This will write pages from BP to the GBP every 40 pages and will cast out every 40 pages, achieving a goal of casting out continuously a small number of pages

6. Stopping and starting the NPI before the Reorg to eliminate GBP dependency may help, but at the cost of an outage. In addition there is no sure way to keep it out of GBP dependency, as transactions may later arrive on other members for a different logical partition.

7. Before and after the Reorg job step, add a job step with
- DIS GBPOOL (GBP42) GDETAIL
  The “after” command will show if there were any “writes failed due to lack of storage”. If there are many of these, pages can be placed in LPL. It means that the GBP should be enlarged, which will have to be done manually. The GDETAIL option reports statistics since the last time the command was issued from the same DB2 member.

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