Better Batch: Exploiting New Functions to Improve Batch Processing

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Notes:
Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user’s job stream, the I/O configuration, the storage configuration, and the workload processed.

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Agenda

- Blocked Workload Support
- JES2 WLM Initiator Enhancements
- Initiator Dispatching
- Improved Reporting of Ready Work
- z/OS Capture Ratio and Batch Workloads
- Discretionary Batch Enhancements
- Benchmark results
z/OS 1.9 Performance Items

1. Provide automatic CPU promotion for canceled jobs
   - Canceled job may be holding resources needed elsewhere, (storage, ENQ, latch), but if dispatch priority is not high enough Cancel processing cannot run

2. Provide throughput to blocked workloads
   - Dispatch low priority workloads from time to time
   - Helps resolve resource contention for workloads without resource management implemented

High Priority work is now blocked by lower priority work
Blocked Workloads

- New IEAOPTxx parameters
  - BLWLTRPCT
    - Percentage of the CPU capacity of the LPAR to be used for promotion
    - In tenths of a percent (0.1%)
    - Range: 0 to 200 (0.1% to 20%)
    - Default: 5
  
  - BLWLINTHD
    - Starvation threshold in seconds. Amount of time when an address space or enclave has not received CPU service within this time and is considered blocked
    - Range: 5 seconds to 65535 seconds (18+ hours)
    - Default: 20 seconds
  
- Recommended for the IEAOPTxx member of SYS1.PARMLIB to not code parameters specifying default values
WSC FLASH10609 - Blocked Workload Support

- Information Contained in RMF reports
  - CPU Activity
  - Workload Activity

CPU Activity Report

<table>
<thead>
<tr>
<th>BLOCKED WORKLOAD ANALYSIS</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OPT PARAMETERS:</td>
<td>BLWLTRPCT (%)</td>
<td>0.5</td>
<td>PROMOTE RATE:</td>
<td>DEFINED</td>
<td>76</td>
<td>WAITERS FOR PROMOTE:</td>
</tr>
<tr>
<td></td>
<td>BLWLINTHD</td>
<td>20</td>
<td>USED (%)</td>
<td>0</td>
<td></td>
<td>PEAK</td>
</tr>
</tbody>
</table>

- PROMOTE RATE: DEFINED - Number of blocked work units which may be promoted in their dispatching priority per second

- PROMOTE RATE: USED (%) - The utilization of the defined promote rate during the reporting interval
  - It demonstrates how many trickles were actually given away (in percent of the allowed maximum) for the RMF interval
Workload Promotion

- CPU time in seconds transactions in a service class were running at a promoted dispatching priority
  - BLK - Blocked workloads
  - ENQ - Enqueue promotion
  - CRM - Chronic resource contention
  - LCK - In HiperDispatch mode used to shorten the lock hold time of a local suspend lock – set to x’FF’
  - SUP - Raised by the z/OS supervisor to a higher dispatching priority

- Should be tracked over time and, if possible, corrected
  - Indicator of resource contention and potential latent demand
  - Growth inhibitor

<table>
<thead>
<tr>
<th>Workload Activity Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>--PROMOTED--</td>
</tr>
<tr>
<td>BLK 0.000</td>
</tr>
<tr>
<td>ENQ 0.000</td>
</tr>
<tr>
<td>CRM 0.000</td>
</tr>
<tr>
<td>LCK 0.275</td>
</tr>
<tr>
<td>SUP 0.000</td>
</tr>
</tbody>
</table>
JES2 Improvements - Better Balance for Batch Work

- JES2 tends to favor job execution on the system where the work goes through conversion (submitting system)
  - No concept of spreading the load among the members
  - Load could be controlled via the management of JES2 initiators, job class structure, system affinity or scheduling environments

- WLM managed inits don't provide this level of control
  - Work is managed to service class goals not CPU utilization or Initiator balance
  - Result is more WLM initiators on the submitting system
  - WLM will re-balance WLM Inits at 95% busy

**Issue:** Use of VWLC and defined capacity pricing models makes this unattractive behavior
z/OS JES2 1.8 WLM Initiator Balance Improvements

- Support requires all members of the JESPlex to be at z/OS 1.8
- JES2 will defer job selection for newly arriving work until it determines which member is most in need of work in terms of idle initiators
- **NO WLM changes** to take advantage of the support
- General Approach:
  - Determine how many WLM managed batch jobs *could be running* in the MAS
    - Could be running = currently executing and awaiting execution
  - If more initiators are available than jobs to run then the percentage of busy initiators is determined and is called the "goal" for WLM Inits on each system

<table>
<thead>
<tr>
<th>JOB Q</th>
<th>JOB Submit</th>
<th>Service Class = BLUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serv Class</td>
<td>Serv Class</td>
<td>Total Inits = 50</td>
</tr>
<tr>
<td>Blue</td>
<td>Green</td>
<td>Goal = 20 / 50 = 40%</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>10 INITS</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>20 INITS</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>10 INITS</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>10 INITS</td>
</tr>
<tr>
<td>8 Inits to run</td>
<td>4 Inits to run</td>
<td>4 Inits to run</td>
</tr>
</tbody>
</table>
z/OS JES2 1.8 WLM Initiator ShutDown Improvements

- OS/390 R4 provided basic controls for managing WLM service classes
  - `$PXEQ` - stop selection of all batch work
  - `JOBCLASS XEQCOUNT=MAX=nnn` controls maximum number of jobs which can run in a given jobclass across the JESplex

**Issue:** No method to specify a jobclass should no longer be selected on a given member and still be selectable on the remaining members

**New Support**
- New `JOBCLASS` specification called QAFF (Queue Affinity)
  - Members will select from a given jobclass only if the member is part of the QAFF affinity mask
    - `$TJOBCLASS(X),QAFF=-SYS2`
  - `JOBCLASS` can also be assigned a maximum execution value on a member basis
    - `$TJOBCLASS(X),XEQMEMBER(SYS1)=MAX=3`
      - QAFF setting override execution values
  - Service classes can also be controlled via QAFF
    - `$T SRVCLASS(BLUE),QAFF=(-SYS2,-SYS3)`
z/OS 1.12 Enhanced Reporting of Work Units

- New in-ready distribution of work units provides a more detailed view of the CPU demand than the in-ready distribution of address spaces

- Number of work units is presented per processor type (CP, zAAP, zIIP)

- Data is added to the SMF 70 records

---

**Number of Address Spaces**

<table>
<thead>
<tr>
<th>QUEUE TYPES</th>
<th>MIN</th>
<th>MAX</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN</td>
<td>73</td>
<td>74</td>
<td>73.4</td>
</tr>
<tr>
<td>IN READY</td>
<td>6</td>
<td>9</td>
<td>8.8</td>
</tr>
<tr>
<td>OUT READY</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>OUT WAIT</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>LOGICAL OUT RDY</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>LOGICAL OUT WAIT</td>
<td>24</td>
<td>25</td>
<td>24.6</td>
</tr>
</tbody>
</table>

**Address Space Types**

<table>
<thead>
<tr>
<th>ADDRESS SPACE TYPES</th>
<th>MIN</th>
<th>MAX</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATCH</td>
<td>10</td>
<td>10</td>
<td>10.0</td>
</tr>
<tr>
<td>STC</td>
<td>85</td>
<td>85</td>
<td>85.0</td>
</tr>
<tr>
<td>TSO</td>
<td>1</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>ASCH</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>OMVS</td>
<td>2</td>
<td>2</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Number of Work Units**

<table>
<thead>
<tr>
<th>CPU TYPES</th>
<th>MIN</th>
<th>MAX</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>5</td>
<td>60</td>
<td>9.3</td>
</tr>
<tr>
<td>AAP</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>IIP</td>
<td>0</td>
<td>2</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Initiator Importance

- INITIMP=0 | 1 | 2 | 3 | E
  - Specified in the IEAOPTxx
  - Specifies the dispatching priority for JES, APPC, and OMVS initiators
    - 0 - DP x'254' (SYSSTC)
    - E - calculated in the same way as the enqueue promotion dispatching priority
      - The DP is calculated dynamically to ensure access to the processor and at a point where it should not impact high importance work
      - No guarantee CPU critical work will always have a higher dispatching priority.
    - 1,2,3 - Lower than the dispatching priority for CPU critical work with the same or higher importance level
      - If no service class with the CPU critical attribute and a corresponding or higher importance level is defined in the WLM policy, the DP is calculated in the same way as INITIMP=E.

- Very important for small nway LPARs with lots of batch work
  - Onlines can be disrupted if lots of batch starts
- May want to reduce the importance
  - Recommend: E
## Displaying Initiator Importance

- Use RMF Monitor 2 Library function
- New in z/OS 1.11

### RMF - OPT Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Value</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABNORMALTERM</td>
<td>Yes</td>
<td>Yes Y/N</td>
<td></td>
<td>Abnormal terminations in routing</td>
</tr>
<tr>
<td>BLWLINTHD</td>
<td>20</td>
<td>20 sec</td>
<td></td>
<td>Time blocked work waits for help</td>
</tr>
<tr>
<td>BLWLTRPCT</td>
<td>5</td>
<td>5 0/00</td>
<td>CPU cap. to promote blocked work</td>
<td></td>
</tr>
<tr>
<td>CCCAWMT</td>
<td>12000</td>
<td>3200 usec</td>
<td></td>
<td>Alternate wait management time</td>
</tr>
<tr>
<td>ZAAPAWMT</td>
<td>12000</td>
<td>3200 usec</td>
<td></td>
<td>AWM time value for zAAPs</td>
</tr>
<tr>
<td>ZIIPAWMT</td>
<td>12000</td>
<td>3200 usec</td>
<td></td>
<td>AWM time value for zIIPs</td>
</tr>
<tr>
<td>CNTCLIST</td>
<td>No</td>
<td>No Y/N</td>
<td></td>
<td>Clist commands count</td>
</tr>
<tr>
<td>COPENABLE</td>
<td>10,30</td>
<td>10,30 %</td>
<td></td>
<td>Threshold for TPI (low,high)</td>
</tr>
<tr>
<td>DVIO</td>
<td>Yes</td>
<td>Yes Y/N</td>
<td></td>
<td>Directed VIO is active</td>
</tr>
<tr>
<td>ERV</td>
<td>500</td>
<td>50000/F2</td>
<td>SU</td>
<td>Enqueue residency CPU Service/DP</td>
</tr>
<tr>
<td>HIPERDISPATCH</td>
<td>No</td>
<td>Yes Y/N</td>
<td></td>
<td>Hiperdispatch is desired/active</td>
</tr>
<tr>
<td>IFAHONORPRIORITY</td>
<td>Yes</td>
<td>Yes Y/N</td>
<td></td>
<td>Allows CPs to help zAAPs</td>
</tr>
<tr>
<td>IIIPHONORPRIORITY</td>
<td>Yes</td>
<td>Yes Y/N</td>
<td></td>
<td>Allows CPs to help zIIPs</td>
</tr>
<tr>
<td>INITIMP</td>
<td>0</td>
<td>9/F2 #</td>
<td>INITIMP value/DP for initiators</td>
<td></td>
</tr>
</tbody>
</table>
z/OS Capture Ratio

- CPU time used by the system to do processing which cannot be related to a specific user
  - Capture ratios in z/OS have improved over time
  - 88-95% capture ratios are "common"
  - Indicator of overall system health

- Calculation

\[
\text{Capture Ratio} = \frac{\sum \text{Service Class APPL\%}}{\# \text{Logical CPs} \text{ LPAR Busy}}
\]

- Should be a concern if capture ratio varies widely across time
- Review White Paper:
  - z/OS Performance: Capture Ratio Considerations for z/OS and IBM System z Processors V2
    http://www-03.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/FLASH10526
Capture Ratio Data Sources

- RMF Monitor 1
  - RMF CPU Activity Report and use LPAR Busy from CPU Activity
  - Use RMF Workload Activity with control card SYSRPT5(WLMGL(POLICY)) and get a single report per interval

Capture Ratio = 7.38 / 7.72 = 96%
Capture Ratio Data Sources

- **RMF Monitor 3**
  - Use the SYSINFO screen

<table>
<thead>
<tr>
<th>Partition: TOSP2</th>
<th>CPs Online: 2.0</th>
<th>AAPs Online: -</th>
<th>IIPs Online: 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2817 Model 764</td>
<td>Avg CPU Util%: 82</td>
<td>Avg MVS Util%: 87</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>EAppl%: 78</td>
<td>Appl% AAP: -</td>
<td>Appl% IIP: 30</td>
</tr>
</tbody>
</table>

RMF V1R12 System Information

<table>
<thead>
<tr>
<th>Command ===&gt;</th>
<th>Samples: 100</th>
<th>System: SYSD</th>
<th>Date: 09/20/10</th>
<th>Time: 14.53.20</th>
<th>Range: 100 Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scroll ===&gt; CSR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appl% / Avg CPU Util %

\[
\frac{78}{82} = 95\%
\]
Common Causes of Uncaptured CPU Time

- High page fault rates
- Full preemption
- Suspend lock contention
- Spin lock contention
- GETMAIN/FREMAIN being done in interrupt handlers or the dispatcher
- Branch Tracing

- IRB queuing with a large subtask tree
- Inability to queue IRBs to a task
- SLIP processing
- Long internal queues
- Affinity processing
- Account code verification
- Fragmented storage pools
- Inefficient ACS routines
- Symbolic Substitution

★ Generally look for a capture ratio in the 88-95% range
★ Use SMF 30, subtype 4,5 to get information on CPU time spent in the initiator to determine if there are areas for improvement
★ New z/OS 1.12 SMF 30 fields to characterize batch times
Likely Cause of Uncaptured Time

System Capture Ratio

MIPS Used
RMF 72 records

INITTIME (SMF30ICU)
More Granularity and Greater Precision in CPU Timing

- SMF30ICU and SMF30ISB includes time:
  - Time spent in previous job's termination
  - Time spent during current job's step initialization

- New fields added to the CPU accounting section of the z/OS 1.12 SMF type 30:
  - SMF30ICU_STEP_INIT
  - SMF30ICU_STEP_TERM
  - SMF30ISB_STEP_INIT
  - SMF30ISB_STEP_TERM
Performance Enhancements in DFSMS

- Large storage groups take up more CPU time when storage pools have 5000+ volumes
  - This CPU time is uncaptured in the SMF72 records
  - Recorded in SMF30 records in field SMF30ICU

- In z/OS 1.8 new support called 'fast' volume selection is provided
  - See SMS Volume Selection for Data Set Allocation in the DFSMS Storage Administration Reference
  - For non-best-fit allocations using fast volume selection, SMS will perform volume selection from the prioritized list until 100 volumes have been rejected by DADSM for insufficient space
  - When that occurs, SMS will exclude, based on the volume statistics in the SMS configuration, all volumes with insufficient free space

- Fast volume selection can greatly reduce the number of candidate volumes, and thus the number of retries

- Activate fast volume selection by using the FAST_VOLSEL(ON) parameter in IGDSMSxx or SETSMS FAST_VOLSEL( ON) command
New z/OS 1.12 Discretionary Batch Improvements

- TIMESLICES=1-255

Specifies number of timeslices a CPU-intensive address space or enclave with a discretionary goal should be given before a dispatchable unit of equal importance is dispatched.

- Increasing this parameter might:
  - Increase processor delay for some CPU-intensive work
  - Decrease the number of context switches between equal priority work and therefore increase the throughput of the system

- Parameter only affects discretionary work that is CPU-intensive as determined by significant mean time to wait (MTTW)
  - As controlled by the CCCSIGUR parameter

- Default: 1
z/OS 1.12 New Discretionary Batch Enhancements

- **CCCSIGUR=0-32767**

- Specifies the minimum mean-time-to-wait (MTTW) threshold value in milliseconds for heavy CPU users
  - Used to determine the range of MTTW values which are assigned to each of the ten MTTW dispatching priorities - x'C0' to x'C9'
  - Specified real time value is adjusted by relative processor speed to become SRM time to give consistent SRM control across various processors
  - Default Value: 45

- Used to differentiate Dispatch Priority of discretionary work
  - Work clumps at x'C9'
    - Appears all address spaces have short MTTW
    - CCCSIGUR is too large and should be decreased
  - Work clumps at x'C0'
    - Appears all work has large MTTW
    - CCCSIGUR is too small and should be increased

- Recommendation: start by doubling or halving the value
Performance Costs to Over Initiation of Work

- Blocked Workloads
- Hiperdispatch (park/unpark)
- IRD
- Workload Promotion
- Discretionary Goal Management
- WLM Managed Initiators
z196 versus z10 Hardware Comparison

- **z10 EC**
  - **CPU**
    - 4.4 GHz
  - **Caches**
    - L1 private 64k i, 128k d
    - L1.5 private 3 MB
    - L2 shared 48 MB / book
  - **Book interconnect: star**

- **z196**
  - **CPU**
    - 5.2 GHz
    - Out-Of-Order execution
  - **Caches**
    - L1 private 64k i, 128k d
    - L2 private 1.5 MB
    - L3 shared 24 MB / chip
    - L4 shared 192 MB / book
  - **Book interconnect: star**
Better Batch Benchmarks

- **System**
  - 2817 (z196) M66 - 766 with 2 zIIPS
  - LPAR
    - 4 GCP and 2 zIIPs
- **Compare z/OS 1.11 to z/OS 1.12**

- **Environment**
  - **Workloads**
    - **Base Workload**
      - High importance DDF-like workload using the zIIPs
      - Medium importance batch workload, vel 30/31, imp 3
    - **Batch Workload**
      - CPU intensive batch workload
      - 50 jobs in the execution queue
      - Single period - Discretionary Goal
      - Multiple periods
      - P1 - Velocity goal of 35, importance 3
      - P2 - Discretionary goal
  - **Test Environment**
    - 4 JES2 initiators - just enough to make LPAR 98-100% busy (JES4)
    - 10 JES2 initiators - over-initiated environment (JES10)
    - WLM managed initiators (WLM)

- **Test Cases**
  - **z/OS 1.11**
    - JES4
    - JES10
    - WLM
    - WLM Multi-Period
  - **z/OS 1.12**
    - Timeslices=1, CCCSIGUR=45
      - JES4
      - JES10
      - WLM
      - WLM Multi-Period
    - Timeslices=50, CCCSIGUR=45
      - JES4
      - JES10
      - WLM
    - Timeslices=100, CCCSIGUR=45
      - JES4
      - JES10
      - WLM
Impacts of Running Work at High Utilization

- CPU times are impacted but not as much as elapsed times
  - May be very reasonable for lower importance batch work

![Graph showing the impact of LPAR Utilization on CPU and Elapsed Times]
Discretionary Goal Management

- Applies to a velocity goal of 30 or less, or a response time goal of 1 minute

**CPU Busy by Workload**

**BAT_MED Capping and PI**
**Circumvention:** Use a resource group with a NULL Min and MAX value
Set velocity goal >30

Modify a Resource Group
Enter or change the following information:
Resource Group Name . . . . : NOCAPP
Description . . . . . . . . . Eliminate capping of work

Minimum Capacity . . . . .
Maximum Capacity . . . . .

**Before**
Bat_LO Perf Index = 0.1 / No resource group specified/ BAT_LO is capped

<table>
<thead>
<tr>
<th>NP</th>
<th>JOBNAME</th>
<th>SrvClass</th>
<th>Workload</th>
<th>DP</th>
<th>SysName</th>
<th>Pos</th>
<th>ASID</th>
<th>ASIDX</th>
<th>JobID</th>
<th>CPU%</th>
<th>ResG</th>
</tr>
</thead>
<tbody>
<tr>
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**After**
Bat_LO Perf Index = 0.1 / NOCAPP resource group set/ BAT_DISC doesn't run

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Timeslices Testing- CPU Profile

- CPU per tran dropped in z/OS 1.12 over 1.11
  - Better hardware cache reuse
  - More slices helped
- Helps the over-initiation case (JES8)

**CPU per Tran**

![CPU per Tran chart]

- Y-axis: seconds
- X-axis: 1.11, 1.12 TS=1, 1.12 TS=50
- Legend: WLM, JES10, JES4
Timeslices Testing - Elapsed Time

- Greater elapsed time in z/OS 1.12 due to higher LPAR utilization
- Helps the over-initiation case (JES8)
- WLM struggled with initiators (OA33359)
  - TS = 1 ran with 3-4 inits
  - TS = 50 ran with 4-5 inits

Average Response Time
Multi-Period WLM Managed Initiators

- Be careful with Multi-Period Service Classes when using WLM Managed Initiators
  - Impacts of QMPL delay may influence WLM to start too many inits
- 1st period needs to be a reasonable goal
  - i.e. achievable

50* - Limited by only having 50 jobs on the execution queue
Summary

- Track workload promotions
- Evaluate capture ratios and track SMF30ICU
- Over-initiation of batch can cause reduced throughput and increased CPU time
- WLM Managed Initiators
  - Be careful with multi-period batch service classes
    - Ensure 1st period is reasonable or avoid them when possible
  - Need to review number of started initiators when CPU capacity is available
    - May not be enough inits started
    - Stay current on maintenance - OA33359, OA31416, OA31814
  - Use new JES2 controls to limit WLM Initiators
- Discretionary batch enhancements tend to help over-initiated environments more