Better Batch: Exploiting New Functions to Improve Batch Processing

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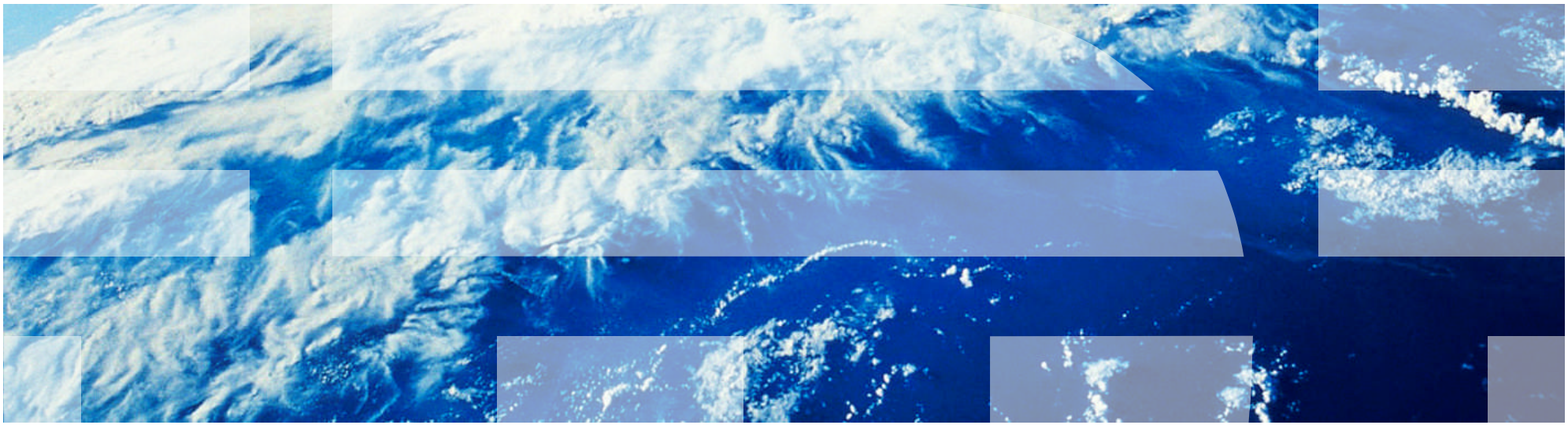

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Notes:
Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.
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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

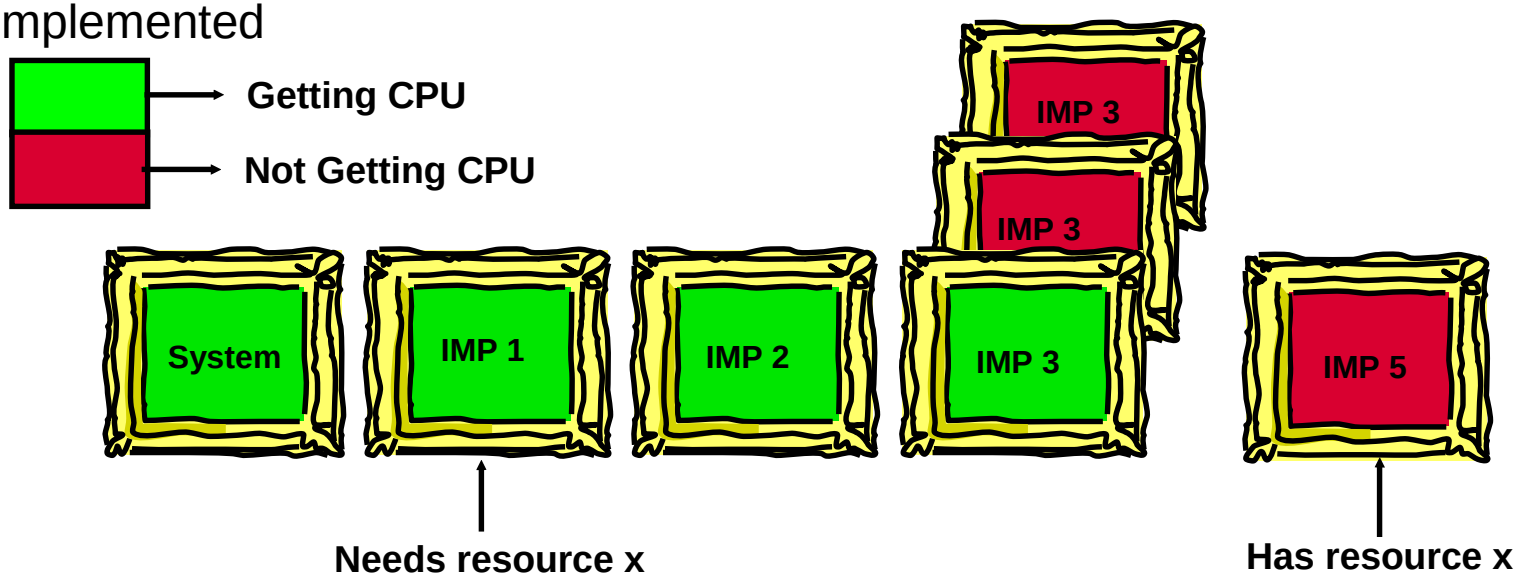
z/OS 1.9 Performance Items

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

```
BLOCKED WORKLOAD ANALYSIS
  OPT PARAMETERS: BLWLTRPCT (%) 0.5  PROMOTE RATE:  DEFINED   76   WAITERS FOR PROMOTE:  AVG     0.000
                  BLWLINTHD      20                 USED (%)   0                         PEAK        0
```

- 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

Workload Activity Report

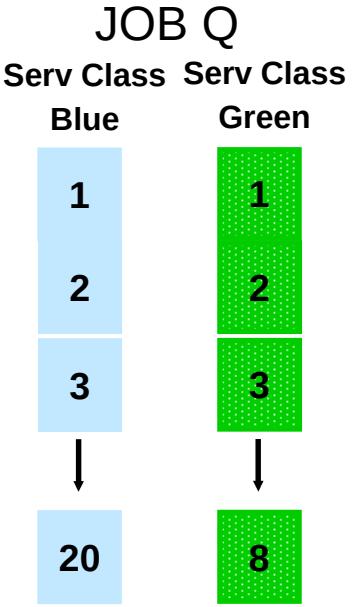
--PROMOTED--	
BLK	0.000
ENQ	0.000
CRM	0.000
LCK	0.275
SUP	0.000

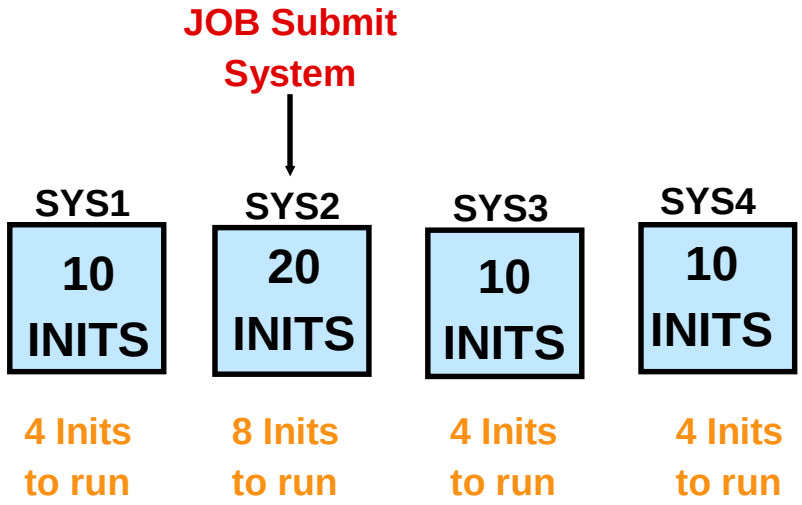
JES2 Improvements - Better Balance for Batch Work

- 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





Service Class = BLUE
Total Inits = 50
Goal = 20 / 50 = 40%

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

```
                                RPT VERSION V1R12 RMF
SYSTEM ADDRESS SPACE AND WORK UNIT ANALYSIS
  ---------NUMBER OF ADDRESS SPACES---------
  QUEUE TYPES              MIN       MAX       AVG

  IN                        73        74      73.4
  IN READY                   6         9       8.8

  OUT READY                  0         0       0.0
  OUT WAIT                   0         0       0.0

  LOGICAL OUT RDY            0         0       0.0
  LOGICAL OUT WAIT          24        25      24.6

  ADDRESS SPACE TYPES

  BATCH                     10        10      10.0
  STC                       85        85      85.0
  TSO                        1         1       1.0
  ASCH                       0         0       0.0
  OMVS                       2         2       2.0
---------NUMBER OF WORK UNITS-------------
CPU TYPES                MIN       MAX       AVG
CP                         5        60       9.3
AAP                        0         0       0.0
IIP                        0         2       0.6
```

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                    Line 1 of 29
                      CPU= 84/ 84 UIC= 65K PR=   0         System= SYSD
Total
OPT: KW            Time: 07/31/10 15:17:47
-- Parameter --   - Default - -- Value -- Unit ---------- Description ---------
-

ABNORMALTERM             Yes          Yes Y/N  Abnormal terminations in routing
BLWLINTHD                 20           20 sec  Time blocked work waits for help
BLWLTRPCT                  5            5 0/00 CPU cap. to promote blocked work
CCCAWMT                12000         3200 usec Alternate wait management time
ZAAPAWMT               12000         3200 usec AWM time value for zAAPs
ZIIPAWMT               12000         3200 usec AWM time value for zIIPs
CNTCLIST                  No           No Y/N  Clist commands count
individually
CPENABLE           10,30|0,0        10,30 %    Threshold for TPI (low,high)
DVIO                     Yes          Yes Y/N  Directed VIO is active
ERV                      500     50000/F2 SU   Enqueue residency CPU Service/DP
HIPERDISPATCH             No      Yes/Yes Y/N  Hiperdispatch is desired/active
IFAHONORPRIORITY         Yes          Yes Y/N  Allows CPs to help zAAPs
IIPHONORPRIORITY         Yes          Yes Y/N  Allows CPs to help zIIPs
INITIMP                    0          9/F2 #    INITIMP value/DP for initiators
```

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

$$\textbf{Capture Ratio} = \frac{\textbf{(}\Sigma\textbf{ Service Class APPL\%) / \# Logical CPs}}{\textbf{LPAR Busy}}$$

- 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

```
-------------------------------------------------------------------------------------------------------------- SERVICE POLICY
-TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---  --PROMOTED--  ----STORAGE----
AVG     287.47  ACTUAL            17.054  SSCHRT  8208  IOC     38141K  CPU 8257.462  CP     738.41  BLK     0.000  AVG    23729.95
MPL     287.42  EXECUTION         13.090  RESP     8.8  CPU    186346K  SRB  943.551  AAPCP    0.00  ENQ     0.527  TOTAL   3701667
ENDED    10357  QUEUED               867  CONN     6.4  MSO         0  RCT    1.011  IIPCP  13.49  CRM     0.000  SHARED   877.88
END/S    11.51  R/S AFFIN           2.897  DISC     0.1  SRB     21293K  IIT   59.980                LCK     0.000
#SWAPS    2796  INELIGIBLE            198  Q+PEND   2.3  TOT    245781K  HST    0.179  AAP      N/A                -PAGE-IN RATES-
EXCTD        0  CONVERSION              1  IOSQ     0.0  /SEC   273191   AAP      N/A  IIP      0                  SINGLE      0.0
AVG ENC 131.43  STD DEV         2.28.422                                 IIP    0.00                                 BLOCK       0.0
REM ENC   0.00                                           ABSRPTN   950                                            SHARED      0.0
MS ENC    0.00                                           TRX SERV  950                                            HSP         0.0
```

```
CPU         2094   CPC CAPACITY   N/A
MODEL       712    CHANGE REASON=N/A
H/W MODEL   S38
---CPU---    ---------------- TIME % -----
NUM  TYPE    ONLINE    LPAR BUSY    MVS BU
 0    CP     100.00    64.37        99.82
 1    CP     100.00    64.37        99.83
 2    CP     100.00    64.36        99.84
 3    CP     100.00    64.37        99.84
 4    CP     100.00    64.38        99.84
 5    CP     100.00    64.37        99.83
 6    CP     100.00    64.37        99.82
 7    CP     100.00    64.36        99.82
 8    CP     100.00    64.38        99.81
 9    CP     100.00    64.36        99.82
 A    CP     100.00    64.33        99.81
 B    CP     100.00    64.35        99.80
TOTAL/AVERAGE         64.36        99.82
```

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

738.41 /100 = 7.38 CPs
64.36 /100 * 12 CPs = 7.72 CPs

Capture Ratio = 7.38 / 7.72 = 96%

Capture Ratio Data Sources

- RMF Monitor 3
  - Use the SYSINFO screen

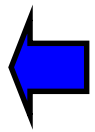
```
                        RMF V1R12  System Information            Line 1 of 31
Command ===>                                                 Scroll ===> CSR

Samples: 100     System: SYSD  Date: 09/20/10  Time: 14.53.20  Range: 100   Sec

Partition:   TOSP2    2817 Model 764          Appl%:      57  Policy: WLMPOL
CPs Online:   2.0     Avg CPU Util%:   82     EAppl%:     78  Date:   09/08/10
AAPs Online:    -     Avg MVS Util%:   87     Appl% AAP:   -  Time:   15.58.05
IIPs Online:  2.0                            Appl% IIP:  30
```

EAPPL% / Avg CPU Util %

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



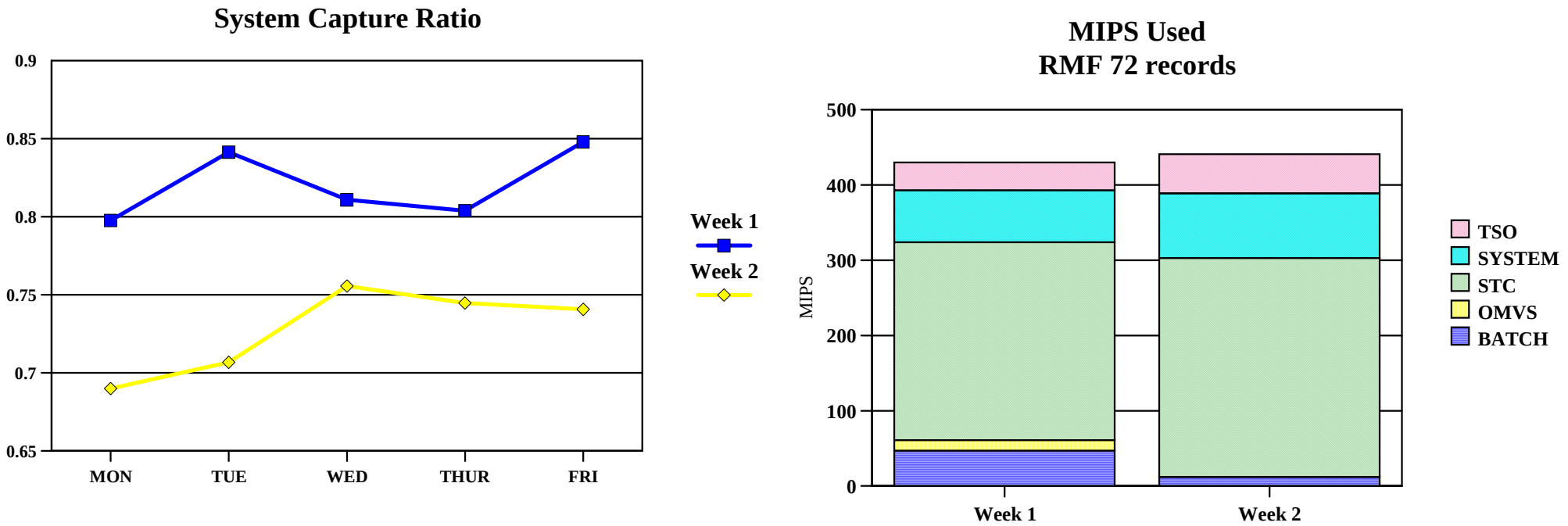
Most Common

★ 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

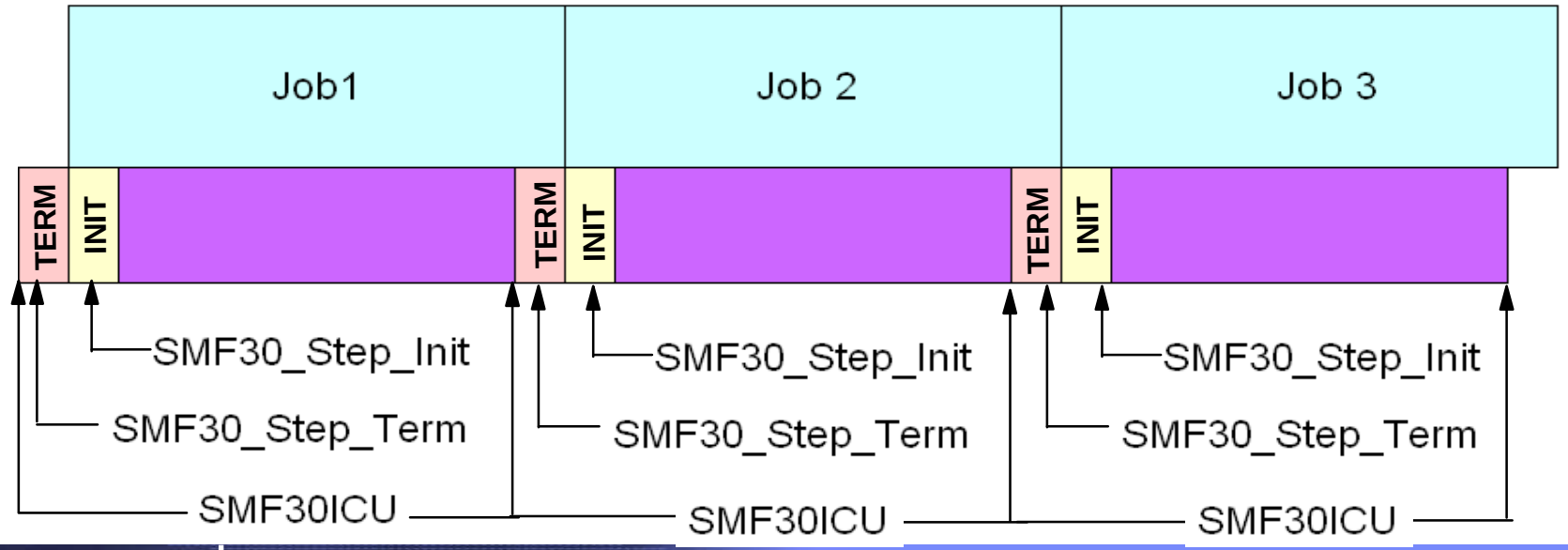
Likely Cause of Uncaptured Time



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

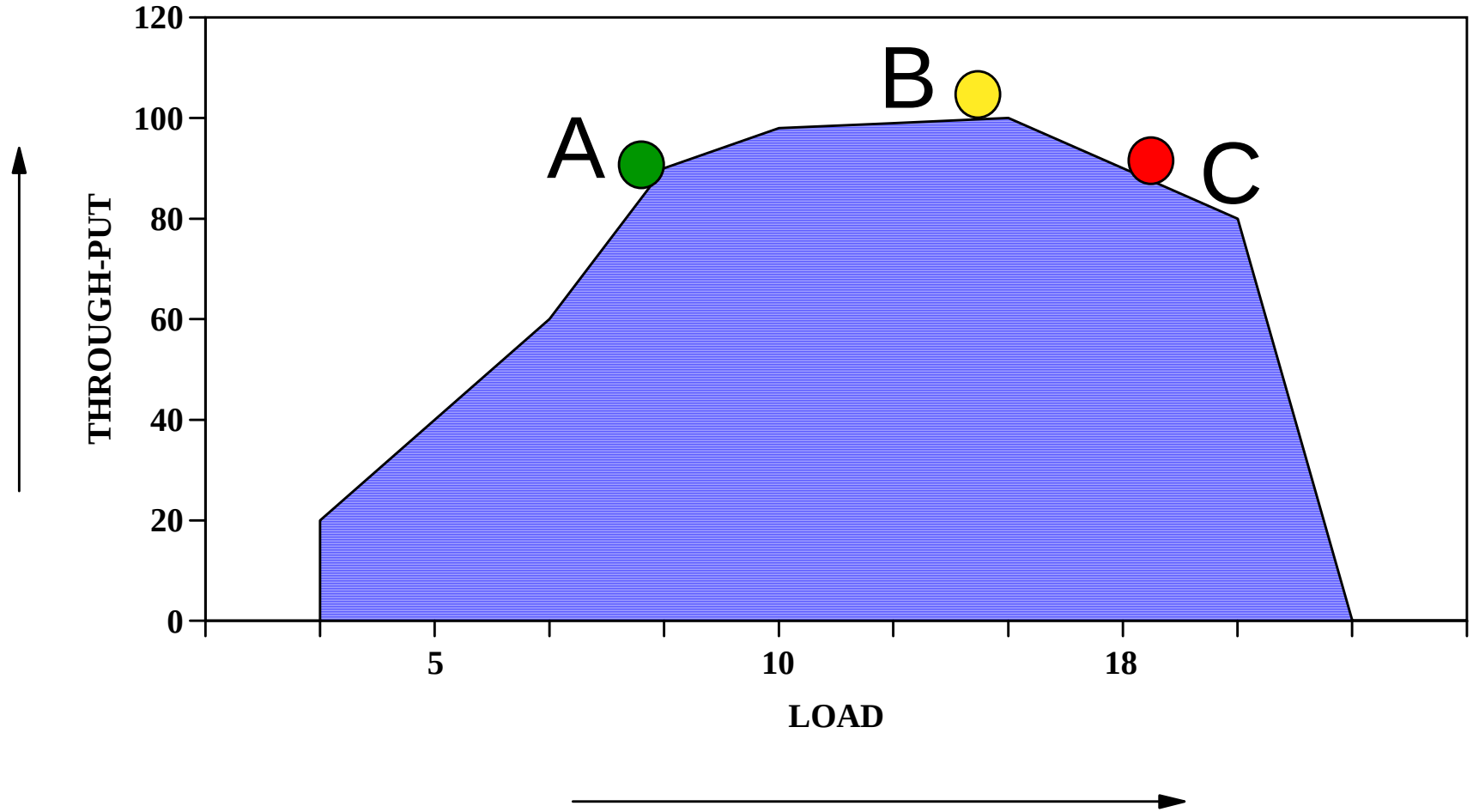
- CCCSIGUR=0-32767

- 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

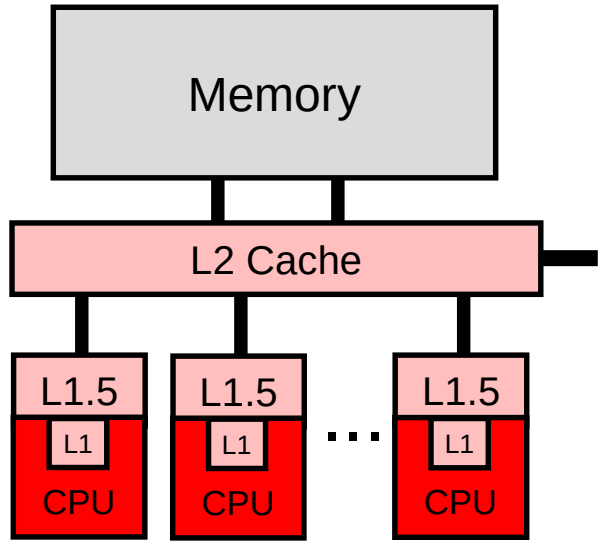


- Blocked Workloads
- Hiperdispatch (park/unpark)
- IRD

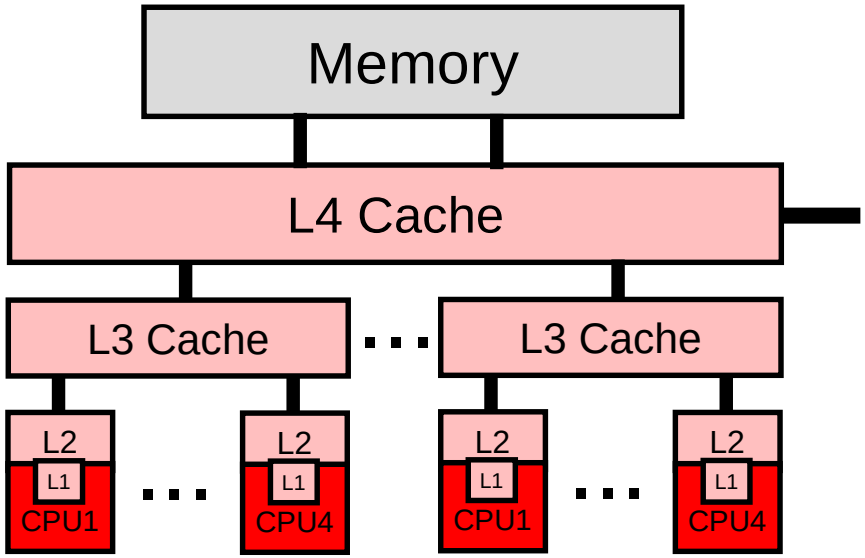
- Workload Promotion
- Discretionary Goal Management
- WLM Managed Initiators

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

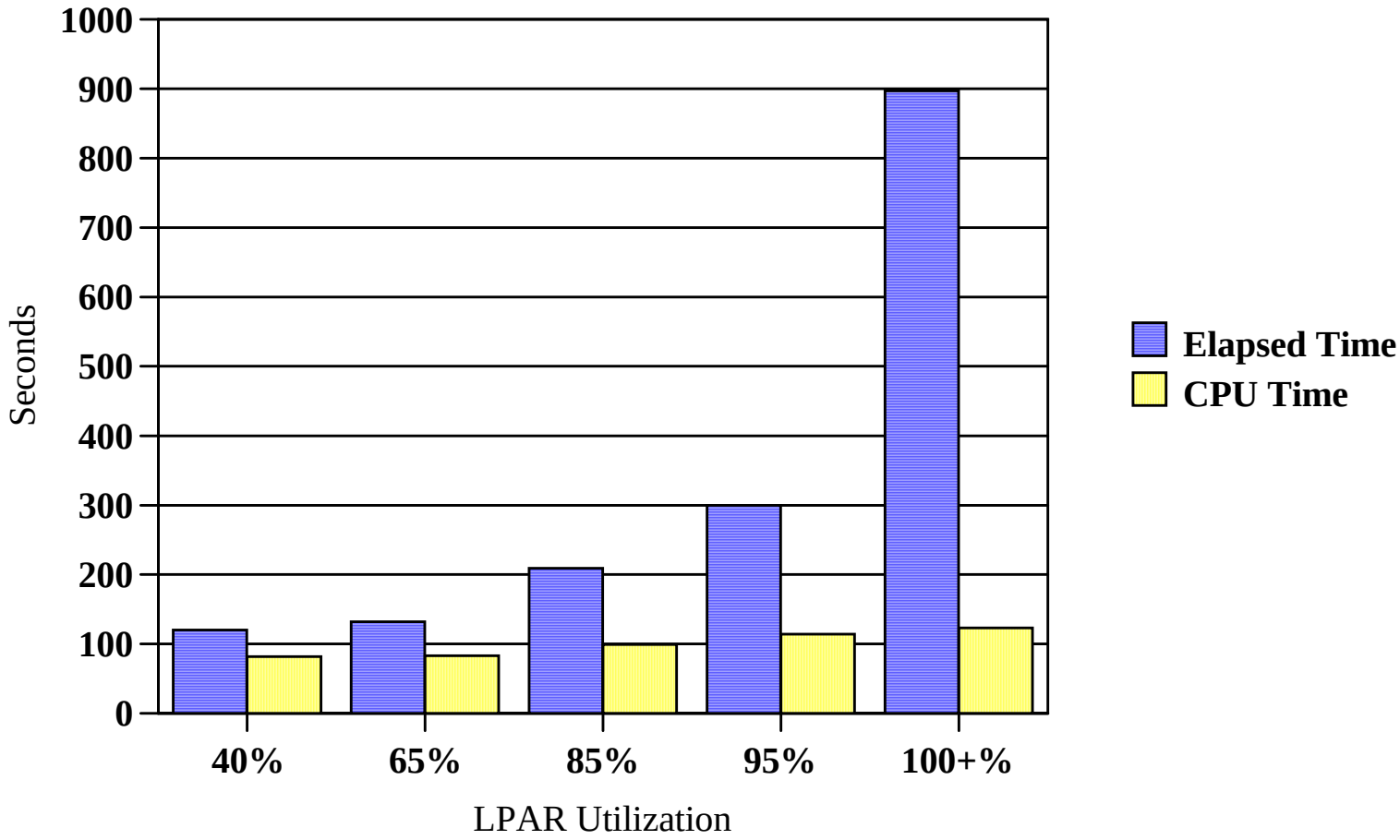


Better Batch Benchmarks

- 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

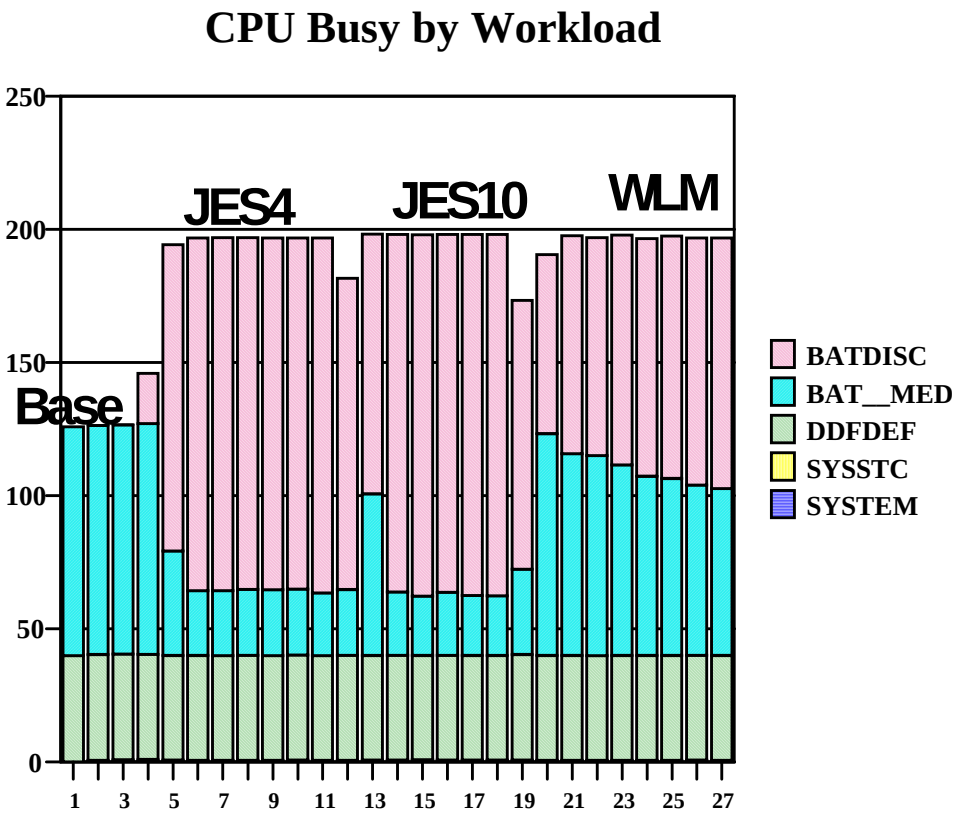
Impacts of Running Work at High Utilization

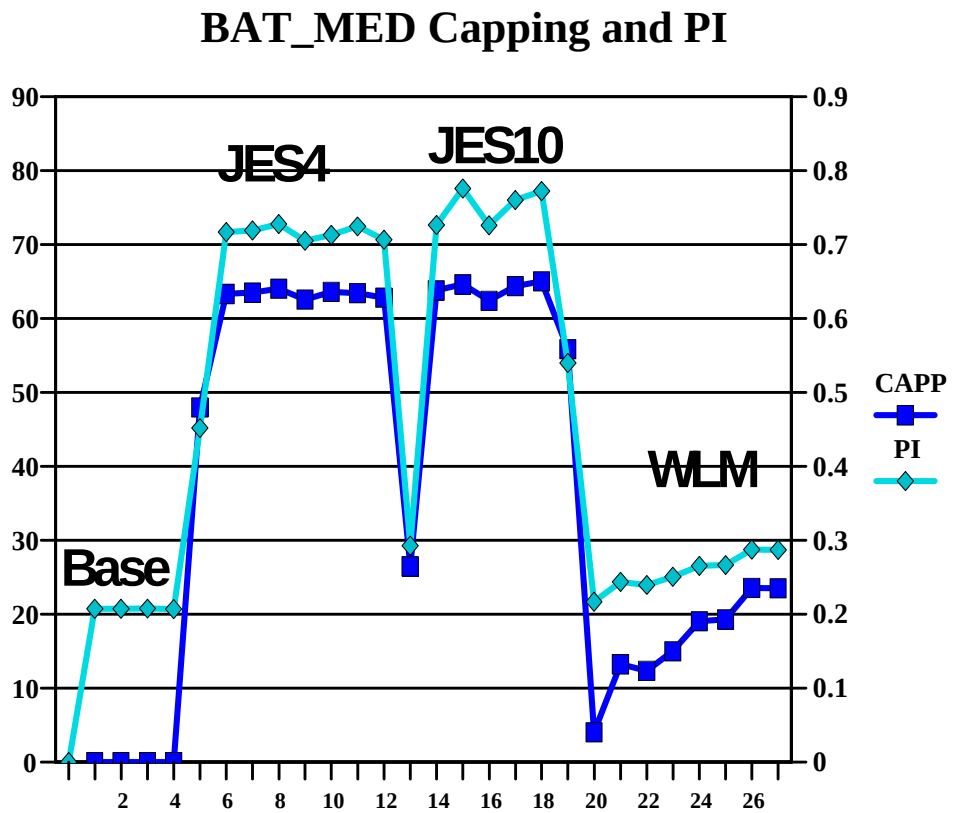
- CPU times are impacted but not as much as elapsed times
  - May be very reasonable for lower importance batch work



Discretionary Goal Management

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





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

```
NP   JOBNAME  SrvClass Workload DP SysName  Pos ASID ASIDX JobID      CPU% ResG
     KMWSOAK2 BAT_DISC BAT_WKL  C1 SYSC     IN    45  002D JOB32642  42.18
     KMWSOAK3 BAT_LO   BAT_WKL  F5 SYSC     IN    46  002E JOB32643  24.78
     KMWSOAK1 BAT_LO   BAT_WKL  F5 SYSC     IN    25  0019 JOB32646  24.84
```

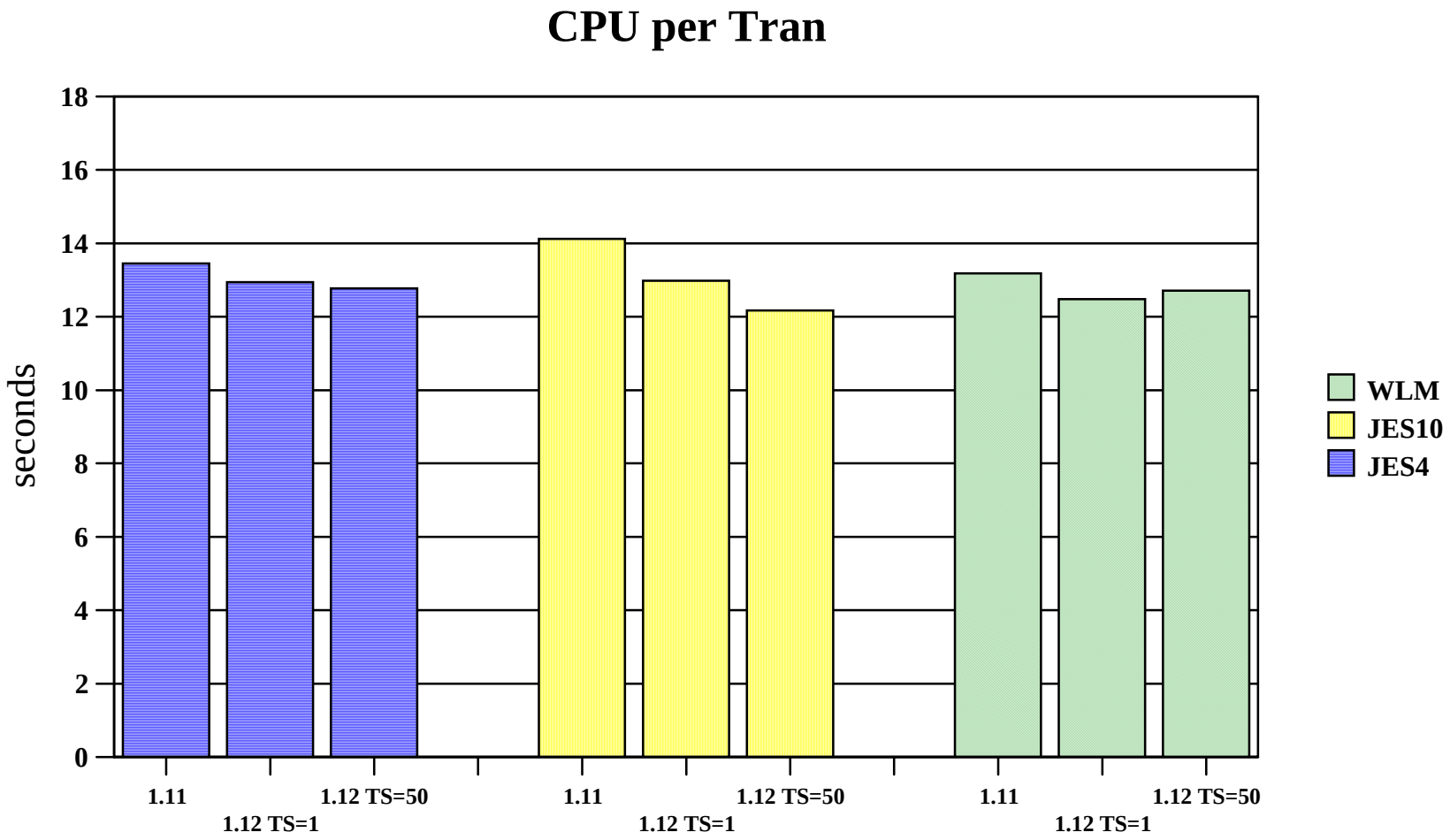
After

Bat_LO Perf Index = 0.1 / NOCAPP resource group set/ BAT_DISC doesn't run

```
 NP   JOBNAME  SrvClass Workload DP SysName  Pos ASID ASIDX JobID      CPU% ResG
      KMWSOAK2 BAT_DISC BAT_WKL  C1 SYSC     IN    45  002D JOB32642   0.00 NOCAPP
      KMWSOAK3 BAT_LO   BAT_WKL  F5 SYSC     IN    46  002E JOB32643  46.78
      KMWSOAK1 BAT_LO   BAT_WKL  F5 SYSC     IN    25  0019 JOB32646  46.84
```

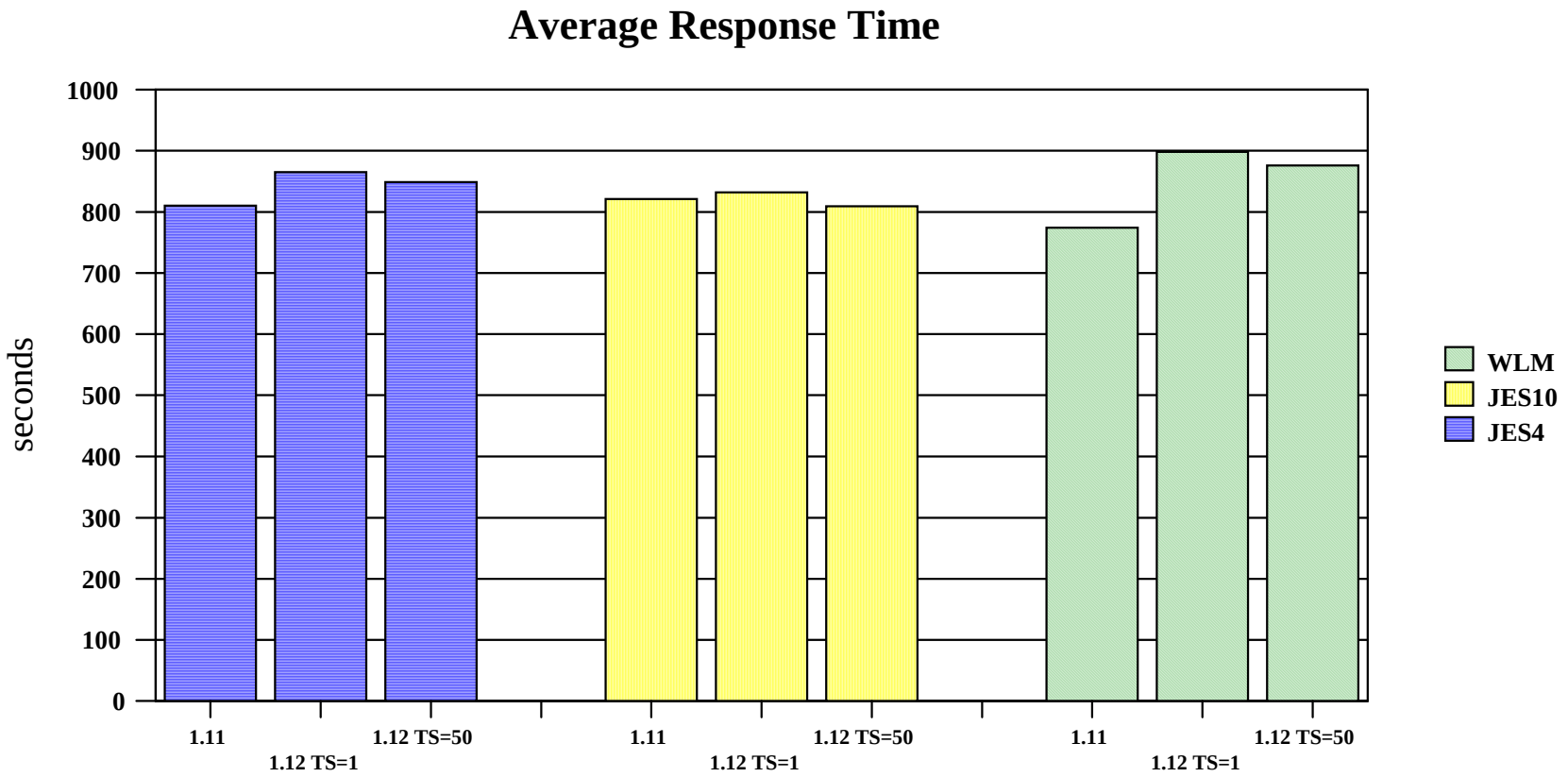
Timeslices Testing- CPU Profile

- 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)



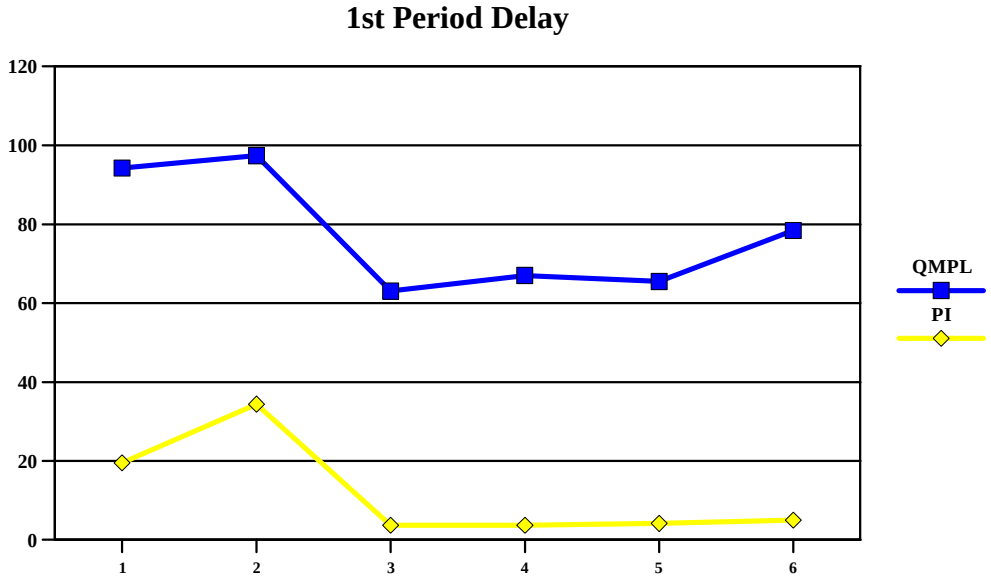
Timeslices Testing - Elapsed Time

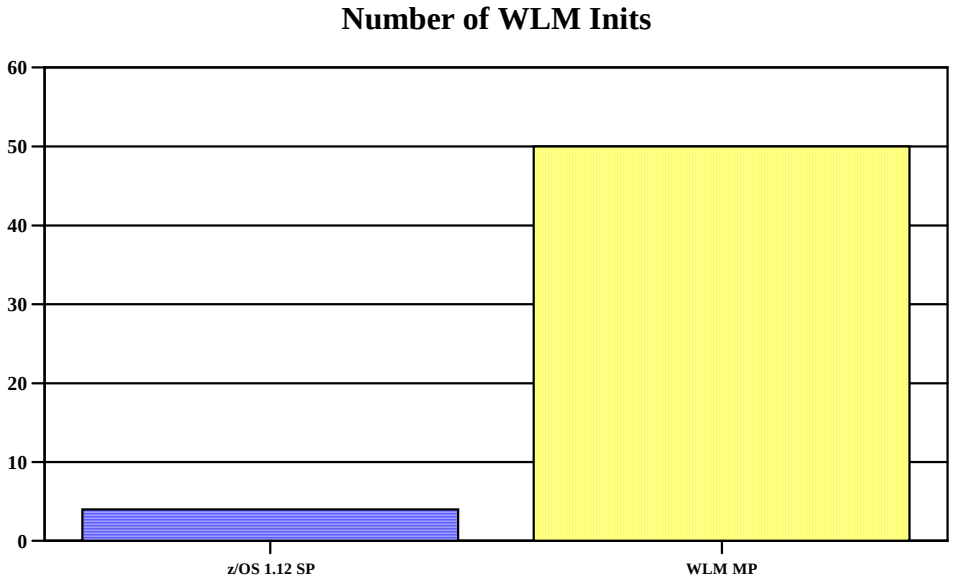
- Greater elapsed time in z/OS 1.12 due to higher LPAR utilization
- Helps the over-initiation case (JES8)
- WLM struggled with initiators (OA33359)
  - TS = 1 ran with 3-4 inits
  - TS = 50 ran with 4-5 inits

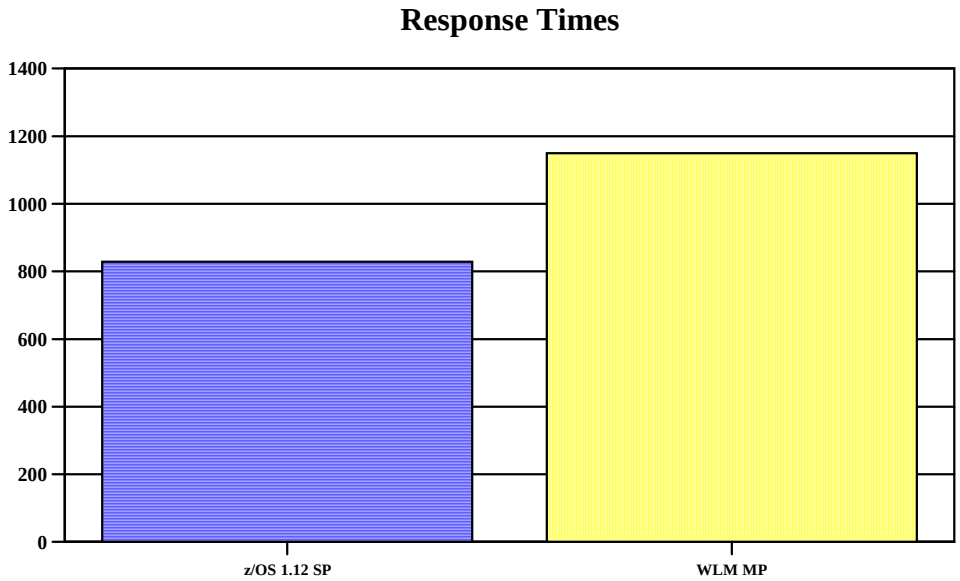


Multi-Period WLM Managed Initiators

- 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 reaonable goal
  - i.e. acheivable







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 maintenace - OA33359, OA31416, OA31814
  - Use new JES2 controls to limit WLM Initiators
- Discretionary batch enhancements tend to help over-initiated environments more