z/VM Tuning Revisited with Specialty Engines for z/OS
Session 9122

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Agenda

- Some general z/VM Scheduling and Dispatching Discussion
- Some general z/OS Guest Tuning Discussion
- Background on Specialty Engine support in z/VM
- Tuning of Specialty Engines
- Miscellaneous z/OS Tuning
z/VM Scheduling & Dispatching at the High Level

- **Objectives of the z/VM Scheduler**
  - Protect the system from over committing resources to where the system thrashes
  - Prioritize access to system resources

- **Objectives of the z/VM Dispatcher**
  - Effectively run virtual processors based on their priorities
Scheduler Protection from Thrashing

- **Run**
- **Dispatch List**
  - **Limit List**
- **Ready to Run**
- **ETS**
- **Dormant List**
- **Eligible List**
Three Main Controls to Entering Dispatch List

```plaintext
cp q srn
IABIAS : INTENSITY=90%; DURATION=2
LDUBUF : Q1=100% Q2=75% Q3=60%
STORBUF: Q1=125% Q2=105% Q3=95%
DSPBUF : Q1=32767 Q2=32767 Q3=32767
DISPATCHING MINOR TIMESLICE = 5 MS
MAXWSS : LIMIT=9999%
...... : PAGES=999999
XSTORE : 0%
Ready;
```

LDUBUF: protects from thrashing DASD Paging

STORBUF: protects from general thrashing of real memory

DSPBUF: Absolute number allowed in dispatch list for each scheduling class
Comments on SRM Value for z/OS Systems

- Defaults were determined based on traditional workload with mix of interactive CMS and Guest work.

- **Potential benefit from changing SRM values.**
  - If having problems, investigate STORBUF first
  - Second, look at LDUBUF
  - Keep your hands off DSPBUF unless you really know what you are doing.
  - Avoid temptation to increase/change several values at once

- **Increasing DSPSPLICE was considered clever at one time.** The overhead from dispatching these days probably isn’t worth the downside of increasing it. Leave it alone.
Deadline Scheduling – Prioritizing Work

- Each virtual processor has a priority computed as a ‘deadline’ for when a unit of work should be completed.
- This ‘deadline’ is a time value on an artificial TOD often referred to as ATOD
- The ‘deadline’ is computed based on several factors, but the most significant is the normalized Share value
- Therefore the share setting is a big knob
- Virtual processors get ordered for dispatching based on their deadlines
ATOD and Deadline

ATOD

Current ATOD  Offset for larger share value  Offset for smaller share value

Simplified offset formula used to set deadline ‘offset’ from current ATOD:

\[
OFFSET = \frac{\text{Minor\_TimeSlice} + \text{Previous\_TimeSlice Overrun}}{\text{Normalized\_Share} \times \text{Number\_PUs}}
\]
A Word About QUICKDSP

- Quick Dispatch (SET QUICKDSP) for a virtual machine allows it to pass from eligible list to dispatch list without going through the system resource checks.

- Does NOT turn off the scheduler completely.

- Should be set on for:
  - Mission Critical Virtual Machines
  - Virtual Machines that are extensions of Operating System (e.g. RACF, TCP/IP)
  - A virtual machine you have access to for tuning and problem determination.
z/VM and Specialty Engine Support

**February 2001**
- z/OS running on z/VM V3
- Standard (CP) engines
- MLC pricing for z/VM V3

**June 2007**
- z/OS running on z/VM V5.3
- Using CPs, zAAPs, zIIPs
- OTC pricing for z/VM V5
- Sub-cap pricing for z/OS

**July 2001**
- Linux running on z/VM V4
- Integrated Facility for Linux
- OTC pricing for z/VM V4

**September 2008**
- Add Linux on IFLs on System z10
- LPAR

**February 2001**
- Linux running on z/VM V3
- Standard (CP) engines
- MLC pricing for z/VM V3

**July 2001**
- z/OS running on z/VM V3
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**September 2008**
- Add z/OS on CPs on System z10
- LPAR
z/VM 5.3.0 Support for Specialty Processors

- **z/VM V5.3 introduces support for zAAP and zIIP specialty processors**
  - System z Application Assist Processors (zAAPs) – provide an economical Java execution environment for z/OS and z/OS.e
  - System z9 Integrated Information Processors (zIIPs) – designed to help improve resource optimization and lower the cost for eligible z/OS and z/OS.e workloads by offloading software system overhead from standard Central Processors (CPs); this includes certain DB2 processing

- **z/VM support is provided for z/OS guest exploitation**
  - Offers additional hardware support for z/OS-on-z/VM development and test support

- **Two levels of z/VM support:**
  - **Simulation support**
    - z/VM dispatches virtual zAAPs and zIIPs on real CP engines
    - Only possible if the underlying hardware is capable of supporting the real engine type
    - Does not require activation of real specialty engine(s) within the mainframe server
  - **Virtualization support**
    - z/VM dispatches virtual zAAPs and zIIPs on corresponding real specialty engines

- **Consistent with z/OS, there are no z/VM license fees associated with real zAAP or zIIP processors**
z/VM 5.3.0 Specialty Processor Support Example

Simulating Specialty Engines in Virtual Machines

- Allows users to discover the operational aspects of using zAAPs and zIIPs in a z/OS environment without having to purchase real specialty processors
- May help users assess specialty-processor eligible workloads in a z/OS environment
- Provides a function test environment for z/OS workloads that use specialty processors
- Consumes CP processor capacity to host virtual zAAP and zIIP processor cycles
z/VM 5.3.0 Specialty Processor Support Example

*Using Real Specialty Engines in Virtual Machines*

- Allows users to test and verify z/OS specialty processor support on the real hardware
- Users can maximize real specialty processor utilization by sharing processors among production and test LPARs
- Consumes specialty processor capacity to host virtual zAAP and zIIP processor cycles
New LPAR type for IBM System z10: *z/VM-mode*
- Allows z/VM V5.4 users to configure all CPU types in a z10 LPAR

**Offers added flexibility for hosting mainframe workloads**
- Add IFLs to an existing standard-engine z/VM LPAR to host Linux workloads
- Add CPs to an existing IFL z/VM LPAR to host z/OS, z/VSE, or traditional CMS workloads
- Add zAAPs and zIIPs to host eligible z/OS specialty-engine processing
- Test integrated Linux and z/OS solutions in the same LPAR

**No change to software licensing**
- Software continues to be licensed according to CPU type
Some Additional Background

- **CPU Affinity**
  - Setting to control whether virtualized Specialty Engines must be dispatched on real processors of that type
  - ON means virtual type must equal real type
  - Suppressed: you have asked for ON, but we don’t have processors of that type to use

- **Processor Type Pools**
  - Scheduling is done within a pool for CPUAFFINITY ON
  - Capacity Planning of each type
  - ATOD, ATOD2, etc. for each Processor Type Pool

- **Primary vs. Secondary Processor**
  - Primary: CP or IFL
  - Secondary: zAAP, zIIP, and sometimes IFL (secondary to CPs)

- **Different Speed Processors**
  - Specialty engines are full-speed on all z9 and z10 machines, while some general purpose run at a fractional speed.

- **The z/VM Scheduler is a deadline scheduler, not a consumption scheduler**
Considerations for z/VM-mode LPARs

- **Merging IFL only and CP only partitions in a z/VM-mode partition requires planning**
  - First step, make virtual machines on IFL LPAR have virtual IFLs
  - For duplicated work (RACF, TCP/IP, etc.), need to determine which to use or in some cases which to duplicate
  - Remember that in some environments, the IFLs may be faster than the CPs.
  - Determine any changes you want to make to the charge back model.
Output from INDICATE USER EXPanded

CPU 00: Ctime=0 00:00:53  Vtime=0 00:00:00  Ttime=0 00:00:00
  Rdr=0  Prt=0  Pch=0  IO=332
  Type=CP  CPUAffinity=ON
  VtimePrimary=0 00:00:00  TtimePrimary=0 00:00:00
  VtimeSecondary=0 00:00:00  TtimeSecondary=0 00:00:00

CPU 01: Ctime=0 00:00:30  Vtime=0 00:00:00  Ttime=0 00:00:00
  Rdr=0  Prt=0  Pch=0  IO=0
  Type=ZAAP  CPUAffinity=SUPP
  VtimePrimary=0 00:00:00  TtimePrimary=0 00:00:00
  VtimeSecondary=0 00:00:00  TtimeSecondary=0 00:00:00

CPU 02: Ctime=0 00:00:20  Vtime=0 00:00:00  Ttime=0 00:00:00
  Rdr=0  Prt=0  Pch=0  IO=0
  Type=ZIIP  CPUAffinity=SUPP
  VtimePrimary=0 00:00:00  TtimePrimary=0 00:00:00
  VtimeSecondary=0 00:00:00  TtimeSecondary=0 00:00:00
Specialty Engines and Share Settings

- The Share setting for a virtual machine applies to each pool of the processor types
  - CP, IFL, zIIP, zAAP, etc.
- z/VM 5.3.0 one share setting for all types
- z/VM 5.4.0 added support to set a separate share setting for each processor type pool
  - Default is TYPE ALL and results in one setting for all types, effectively like z/VM 5.3.0
- Normalized to the sum of shares of virtual machines in dispatch list for each pool of the processor types
- Absolute (and normalized) is percentage of resources of a given processor type.
NN% = (IPW) In Perfect World percentage of real processor
NN% = split of share per virtual processor

SERVERA
Abs 20%

100%
20%

CP

SERVERB
Abs 10%

25%
5%
25%
5%

CP
CP

SERVERC
Abs 15%

25%
5%
25%
5%
25%
5%

CP
CP
CP

CPs: 5 x 100 = 500%
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

100%
20%

CP
SERVERA
Abs 20%

25%
5%

25%
5%

25%
5%

CP
CP
SERVERB
Abs 10%

CP
CP
SERVERC
Abs 15%

CPs: 5 x 100 = 500%; zAAP: 2 x 100=200%; zIIP: 1 x 100 = 100%
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

SERVERA
Abs 20%
CP
100%
20%

SERVERB
Abs 10%
CP
25%
25%

SERVERC
Abs 15%
CP
75%
30%
15%

CP
100%
NN% = split of share per virtual processor
25% 75% 30% 15% 15% 15%

CP: 5 x 100 = 500%;
zAAP: 2 x 100 = 200%; zIIP: 1 x 100 = 100%
NN% = IPW percentage of real processor  
NN% = split of share per virtual processor

The dedicated processor changes what gets split up by shares.
NN% = IPW percentage of real processor
NN% = split of share per virtual processor
NN = relative split of share per virtual processor

CP
SERVERA
Rel 100

50%
12.5%
100

CP
SERVERB
Rel 200

50%
12.5%
100
50%
12.5%
100
83.3%
20.9%
167
83.3%
20.9%
167
83.3%
20.8%
167

CP
SERVERC
Rel 500

Sum of Relative Shares = 800

CPS: 4 x 100 = 400%

Same concept with relative shares, except it is relative to all users wanting to run. Therefore need to add up all relative shares.
NN% = IPW percentage of real processor
NN% = split of share per virtual processor
NN = relative split of share per virtual processor

<table>
<thead>
<tr>
<th>Server</th>
<th>CP</th>
<th>zAAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ServerA Rel 100</td>
<td>50%</td>
<td>33.3%</td>
</tr>
<tr>
<td>ServerB Rel 200</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>ServerC Rel 500</td>
<td>83.3%</td>
<td>83.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CP</th>
<th>zAAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

CPs: 4 x 100 = 400% ; zAAPs: 1 x 100 = 100%

Sum of CP Relative Shares = 800
Sum of zAAP Relative Shares = 300
NN% = IPW percentage of real processor
NN% = split of share per virtual processor
NN = relative split of share per virtual processor

CP | zAAP
---|-----
100 | 100
100 | 100
100 | 200

SERVERA Rel 100
SERVERB Rel 200
SERVERC Rel 500

Sum of CP Relative Shares = 700
Sum of zAAP Relative Shares = 200

CPs: 4 x 100 = 400% ; zAAPs: 1 x 100 = 100%
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

Total Processor for SERVERB is 15+15+15+15+20 = 80%

Total Processor for SERVERC is 21+21+21 = 63%

CPs: 3 x 100 = 300%; zAAP: 3 x 100 = 300%; zIIP: 2 x 100 = 200%
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

z/VM-Mode LPAR

15% 15% 15% 15% 20%
5% 5% 5% 5% 10%

SERVERB
Abs 10%

CP CP zAAP zAAP zIIP

14% 14% 14%
7% 7% 7%

SERVERC
Abs 21%

IFL IFL IFL

CP CP zAAP zAAP zIIP zIIP IFL IFL

CPs: 2 x 100 = 200%; zAAP: 2 x 100 = 200%; zIIP: 2 x 100 = 200%; IFL: 2 x 100 = 200%
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

z/VM-Mode LPAR

15% 21%
5%  7%

CP  CP  zAAP  zAAP

SERVERB
SET SHARE TYPE CP ABS 10% TYPE ZAAP 50%

21% 14% 14%
7%  7%  7%

IFL  IFL  IFL

SERVERC
SET SHARE ABS 21%

CPs: 2 x 100 = 200%;
zAAP: 2 x 100 = 200%;
zIIP: 2 x 100 = 200%;
IFL: 3 x 100 = 300%
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

15% 15% 50% 50%
5% 5% 25% 25%

CP CP zAAP zAAP

SERVERC
SET SHARE ABS 21%

CPs: 2 x 100 = 200%;  zAAP: 2 x 100 = 200%;
zIIP: 2 x 100 = 200%;  IFL: 3 x 100 = 300%

z/VM-Mode LPAR

14% 14% 14%
7% 7% 7%

IFL IFL IFL

SERVERB
SET SHARE TYPE CP ABS 10% TYPE ZAAP 50%

SET CPUAFFINITY OFF
NN% = IPW percentage of real processor
NN% = split of share per virtual processor

CP  CP  zAAP  zAAP

SERVERB
SET SHARE TYPE CP ABS 10% TYPE ZAAP 50%

CPs: 2 x 100 = 200%;  zAAP: 2 x 100 = 200%;
zIIP: 2 x 100 = 200%;  IFL: 3 x 100 = 300%

z/VM-Mode LPAR

IFL  IFL  IFL

SERVERC
SET SHARE ABS 21%

21%  21%  21%

5%  7%  5%  7%  5%  7%

SET CPUAFFINITY OFF
### Logical Partition Activity

<table>
<thead>
<tr>
<th>Partition Nr.</th>
<th>Upid</th>
<th>#Proc</th>
<th>Weight</th>
<th>Wait-C</th>
<th>Cap</th>
<th>%Load</th>
<th>CPU</th>
<th>%Busy</th>
<th>%Ovhd</th>
<th>%Susp</th>
<th>%VMld</th>
<th>%Logld</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>KST1</td>
<td>4</td>
<td>04</td>
<td>5</td>
<td>20</td>
<td>NO</td>
<td>NO</td>
<td>51.5</td>
<td>0</td>
<td>99.9</td>
<td>0</td>
<td>1</td>
<td>99.9</td>
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<td>20</td>
<td>NO</td>
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<td>99.9</td>
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<td>20</td>
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<td>99.9</td>
<td>.1</td>
<td>.1</td>
<td>99.8</td>
<td>99.9</td>
<td>99.9</td>
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<td>80</td>
<td>NO</td>
<td>3</td>
<td>.0</td>
<td>.0</td>
<td>.4</td>
<td>.0</td>
<td>.4</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>ZAAP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>NO</td>
<td>4</td>
<td>9.3</td>
<td>.2</td>
<td>.3</td>
<td>9.0</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
<td>ZIIP</td>
<td></td>
</tr>
</tbody>
</table>

#### Summary of physical processors:

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Weight</th>
<th>Dedicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>3</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>ZAAP</td>
<td>1</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>IFL</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ZIIP</td>
<td>1</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

- New Type for each processor
- Totals for Processor types
- One IFL on machine, but no active partitions using it.
### FCX202 LPARLOG – updated

<table>
<thead>
<tr>
<th>Interval &lt;Partition-&gt;</th>
<th>End Time</th>
<th>Name</th>
<th>Nr.</th>
<th>Upid</th>
<th>#Proc</th>
<th>Weight</th>
<th>Wait-C</th>
<th>Cap</th>
<th>%Load</th>
<th>%Busy</th>
<th>%Ovhd</th>
<th>%Susp</th>
<th>%VMld</th>
<th>%Logld</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>KST1</td>
<td>4</td>
<td>04</td>
<td>5</td>
<td>80</td>
<td>NO</td>
<td>NO</td>
<td>...</td>
<td>61.8</td>
<td>.1</td>
<td>.2</td>
<td>61.7</td>
<td>61.7</td>
<td>MIX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>..</td>
<td>..</td>
<td>6</td>
<td>100</td>
<td>..</td>
<td>..</td>
<td>.1</td>
<td>30.9</td>
<td>.0</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

FCX202  Run 2007/06/20 09:55:12  LPARLOG
Logical Partition Activity Log
With new Specialty Engine support, your z/VM system may include processors that are different speeds.

Smaller “Cap” number indicates faster Processor.
## FCX144 PROCLOG – updated

**FCX144 Run 2007/06/20 09:53:49**

**PROCLOG**

Processor Activity, by Time

---

<table>
<thead>
<tr>
<th>Interval</th>
<th>P</th>
<th>End Time</th>
<th>U Type</th>
<th>Total</th>
<th>User</th>
<th>Syst</th>
<th>Emul</th>
<th>Vect</th>
<th>Siml</th>
<th>DIAG</th>
<th>SIGP</th>
<th>SSCH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|   | Mean | CP | 99.8 | 99.5 | .3   | 97.9 | .... | 125.0 | 12.6 | .7   | 71.6 |
|   | Mean | 1 CP | 99.8 | 99.5 | .2   | 98.0 | .... | 120.9 | 4.5  | .8   | 58.4 |
|   | Mean | 2 CP | 99.8 | 99.5 | .3   | 98.0 | .... | 123.4 | 3.2  | .7   | 59.5 |
|   | Mean | 3 ZAAP | 96.0 | 96.0 | .1   | 95.8 | .... | 1.1   | .0   | 36.6 | 1.4  |
|   | Mean | 4 ZIIP | 8.8  | 8.4  | .4   | 8.1  | .... | 1.0   | .0   | 289.9 | 7.5  |
|   | Mean | . CP | 99.7 | 99.5 | .2   | 98.0 | .... | 123.0 | 6.7  | .7   | 63.1 |
|   | Mean | . ZAAP | 96.0 | 96.0 | .1   | 95.8 | .... | 1.1   | .0   | 36.6 | 1.4  |
|   | Mean | . ZIIP | 8.8  | 8.4  | .4   | 8.1  | .... | 1.0   | .0   | 289.9 | 7.5  |
Virtual Sysplex Environments

- **Key is tuning effectively for the virtual coupling machines**
  - QUICKDSP ON
  - Sufficiently High Share setting
  - Using real ICFs in z/VM-mode LPARs in z/VM 5.4.0 where appropriate

- **Beware of scenarios with both a large number of systems in a virtual sysplex and the systems join and leave the sysplex frequently.**
  - High CP CPU overhead as the z/OS systems that are not changing state issue large number of messages while the coupling machine is busy making updates for the system that is leaving/joining.
  - Privileged Operations count will be very high (>10,000s/second)
Miscellaneous Tuning Thoughts

- Disable IRD for z/OS virtual machines
- PAV Usage & Trade-offs
  - Dedicating volumes to z/OS guests and letting them use PAV can be the best performance
  - More flexibility in sharing volumes and using PAV volumes through the minidisk support
  - Analysis of where the I/Os are queued up may require looking at both z/VM data and z/OS data
- HiperDispatch
  - Does not apply in z/VM guests
Summary

- Specialty Engines enhance z/VM’s virtualization capabilities
- A few things to keep in mind…
  - Share for virtual machine applies to each processor type pool
  - There are scenarios where processors can be different speeds
  - Looking at averages takes on new meaning
  - CPU Affinity Setting is important
- Monitor and Accounting records updated to provide needed information
- For more on scheduling, see VM Scheduler Made Simple
- For more on Specialty Engine Performance, see Performance Report