Intro to z/VM Performance and Configuration Guidelines

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"If you can't Measure it,

I am Just Not Interested ™"

VELOCITY SOFTWARE

PROVEN PERFORMANCE

Topics

Introducing Performance Analysis

- Basic concepts
- Where to start

z/VM CPU Analysis and Configuration

- Linux Guidelines

z/VM Storage Analysis and Configuration

- Linux on z Configuration Guidelines
- Virtual CPU
- Storage size

Note that zmap is used for all analysis examples

Configuration Objectives

The “performance” Objective:

- Configure a system to avoid performance problems
- Run well at higher utilization

If there are problems (and there will be problems):

- Understand the problem and correct

Visibility is required. Black boxes are not managed

zVPS: Performance Management is a Process

Performance Analysis

- Understanding system, application performance
- Resolving current performance issues (z/VM, Linux, network)

Operational Alerts

- Supporting 100’s/1000’s of servers/containers in many locations
- Defining and automating operational support

Capacity Planning

- Providing input to the financial acquisition process

Accounting / Charge back

- Building a financial model for resource billing
- Who is consuming the resource?

Performance Management: Performance Analysis

Why Performance Analysis: Service Level Mgmt

- Diagnose problems real time (ONE MINUTE GRANULARITY….)
- PLATFORM SPECIFIC….
- Analyze all z/VM subsystems in detail, real time
  - (DASD, Cache, Storage, Paging, Processor, TCPIP)
- Analyze Linux
  - (applications, processes, processor, storage, swap)
- Analyze z/OS
  - Subsystems (disk, CPU), jobs, CICS, DB2

- **Historical view of same data important**
  - Why are things worse today than yesterday?
  - Did adding new workload affect overall throughput?
  - Know who/what is using resource and how to re-allocate

Enterprise Performance Management Requirements

Why Capacity Planning: Future Service Levels (15 minute granularity)

- How many more servers / workload can you support with existing z16(s)?
- What is capacity requirements for an application?
- Avoid crisis ***in advance***

Why Chargeback?

- Distributed chargeback model is by server (does NOT port to Z!)
- Shared chargeback model is by resource consumption
- Encourages efficient/effective resource use
- Align IT to your business model

Operational Requirements

- Operations will manage 100's (1000's) of servers
- Requires automated performance management
- Alerts for processes in loops, disks 90% full, missing processes
- zALERT always needed (One Minute Granularity)
- zOPERATOR, if no enterprise monitor, or do it anyway

Performance Management Additional Requirements

Correct data (Virtual Linux CPU, SMT - data wrong)

Capture ratios

- When numbers from different sources do not agree
- Which data is valid?

Performance management can NOT be the performance problem

Black boxes are not managed by definition

- **Depend on “sales” to decide requirements?**
- **How to tune if no feedback?**

High Level Analysis

- **Capacity Planning – Plan by “production”, “Test/Dev”**
- **Server Grouping**
  - Critical servers
  - Production vs Test/Dev
  - Group by Application (10-15 groups / classes)
  - Virtual Machines / Linux Nodes
- **Linux Instrumentation (visibility) really helps….**

Performance Problem “Opportunities”

The user says “Performance is bad, must be VM”

- From the “top” user who can’t see anything

So is it z/VM? To start, “visibility” is required.

“visibility” is what Velocity Software provides…

Must understand the metrics from:

- **z/VM Subsystems (intro)**
  - Processor, Storage, Paging, DASD I/O
- **Linux Subsystems (basics)**
  - Processor, RAM, file systems, network
- **Network (advanced)**
- **Applications (more advanced)**
  - Java, WAS, Oracle, MQ, DB2, postgres, gpfs

The Performance Analysis Flow Chart

Analysis starts with “Define the problem?”

- Describe the problem (what user(s) impacted, what time)

System Configuration

- Processor model, CPU type, SMT support
- Number of processors, storage size

Wait states for those impacted

Loads on the system and subsystems

Subsystem Analysis based on wait states

- DASD, Storage, Paging, Processor, Network

Know the configuration: ESAHDR

```
Monitor file created:                11/21/22  22:00:00

z/VM Version:  7                  Release 2.0 SLU 2201
TOD clock at last IPL:              09/26/22  06:08:25

System Identifier                                VMXXX3
Machine Model/Type                            Z15:8561/704
Multithreading Status(SMT): Enabled
  Core Thread count:        2
  Enabled Count:            2

System Sequence Code                  000000000002F81F
Processor  0 model/serial             8561-704  /xxxx1F Master
Processor  1 model/serial             8561-704  /xxxx1F
........
Processor 28 model/serial             8561-704  /xxxx1F
Processor 29 model/serial             8561-704  /xxxx1F

CPU Cycles/ns:                  5200
CPU Cycles/ns (GP):             5200
 Operating on IFL Processor(s)      <----------------
Totals by Processor type:
<---------CPU-------> <-Shared Processor busy>
Type Count Ded shared total assigned Ovhd Mgmt
---- ----- --- ------ ----- -------- ---- ----
CP       4   0      4  35.2     33.4  1.0  1.9
IFL     60  48     12 263.0    258.9  4.0  4.1
ICF      2   1      1   2.9      0.6  0.0  2.3
ZIIP     1   0      1   1.1      1.1  0.0  0.0

Number of logical partitions defined:           23

Main Storage installed (MB):                2867199
Main Storage Generated (MB):                2867199
```

Common configuration problems

- IFLs? SMT
- Real Storage (2.7TB)
- Release significant
- Master processor significant

Know the configuration: ESAHDR

```
z/VM Version:  7               Release 3.0 SLU 2201          (65
TOD clock at termination                     01:00:00
Abend code of last termination
TOD clock at last IPL:             06/18/23  09:59:24
System Operator:                             OPERATOR
Time zone adjustment from GMT:                1 hours

Machine Model/Type                        Z16:3931/400
Multithreading Status(SMT): Enabled
  Core Thread count:        2
  Enabled Count:            2


System Sequence Code                 000000000008C9C8
Processor  0 model/serial            3931-400  /11C9C8 Master
Processor  1 model/serial            3931-400  /11C9C8
Processor  6 model/serial            3931-400  /11C9C8
…
Processor  7 model/serial            3931-400  /11C9C8

 CPU(GP) Capability Factor:     3002
 CPU Cycles/ns:                5200
 Operating on IFL Processor(s)

Totals by Processor type:
<---------CPU-------> <-Shared Processor busy>
Type Count Ded shared total assigned Ovhd Mgmt
---- ----- --- ------ ----- -------- ---- ----
IFL     70   0     70  1655   1603.7 32.8 51.7
Number of logical partitions defined:            22

Main Storage installed (MB):                 151552
Main Storage Generated (MB):                 151552
```

Common configuration problems

- LinuxOne, IFL Only
- IFLs? SMT
- Real Storage (148GB)
- Release significant
- Master processor significant

Wait State Analysis

CP Monitor provides user Wait states

- State Sampling – once per minute per user
- Hi-Frequency State Sampling – once per second per vCPU
  - (900 samples per vCPU per 15 minute period)

All virtual cpus have a “state” at all times

Determine if problem is for a user or system

Waits reported by server, class, top user

- System: What impacts the whole system?
- User classes: Does one class stand out? (database vs WAS?)
- Users: Is there something specific?
- Recognize “running” to wait comparison

Wait state (queue) analysis -> where to focus

- Running / CPU Wait -> CPU Subsystem
- Simulation wait (master processor) -> CPU Subsystem
- Page wait -> Paging/Storage subsystems
- Asynchronous I/O, SIO -> DASD subsystem
- ~~Eligible –~~ SRM Settings – has no value after 6.3

Normal idle wait states

- TCPIP, Linux: test idle
- Traditional servers: SVM (service machine wait)
- Traditional users: idle (not in queue)

Wait States: ESAXACT

Report: **ESAXACT** Transaction Delay Analysis Veloc
Monitor initialized: 04/15/11 at 10:00:00 on 2097 serial 726xx First

UserID /Class	<-Samples-> Total	In Q	<-----Percent non-dormant (Wait states)----------> Run	Sim	CPU	SIO	Pag	E- SVM	D- SVM	T- SVM	CF	Tst Idl	<Asynch> I/O	Pag	Ldg	Pct Elig
11:00:00	1335	1011	4.0	0.2	0.6	0	0.5	0	0	0.1	0	91	0.1	.	.	0
Hi-Freq:	116K	59208	4.2	0.0	**1.9**	0.0	**0.3**	0	7.9	0.1	0.0	89	**0.4**	0.1	0.2	0
***Key User Analysis ***																
TCPIP	893	285	0.4	0	2.5	0	0	0	0	0	0	97	0	0	0	0
User Class Analysis																
*Servers	12502	822	0.7	0.1	1.0	0.2	0	0	17	4.5	0	93	0	0	0	0
*SOA	35720	31695	7.0	0.0	2.2	0	0.3	0	0	0	0.1	88	0.6	0.0	0.1	0
*ITM	36613	23570	1.1	0.0	1.7	0	0.3	0	0	0	0	91	0.1	0.2	0.4	0
*TheUsrs	24111	480	0.2	0.8	1.3	0	0.6	0	26	5.2	0	91	0.2	0	0.2	0
Top User Analysis																
LNXUWA01	**893**	**893**	**71**	**0**	**2.8**	0	0.1	0	0	0	0	24	1.7	0.4	0	0
LNXUWA03	**1786**	**1786**	**28**	**0.2**	**5.5**	0	1.2	0	0	0	0.6	57	7.2	0.1	0.1	0
LNXUWA02	**1786**	**1786**	**27**	**0.1**	**3.6**	0	0.1	0	0	0	0.4	69	0.1	0	0.1	0

Wait state (queue) analysis -> where to focus

- Running / CPU Wait -> CPU Subsystem
- Simulation wait (master processor) -> CPU Subsystem
- Page wait -> Paging/Storage subsystems

Wait State "RUN": ESAXACT

```
Report: ESAXACT       Transaction Delay Analysis                      Veloc
Monitor initialized: 04/15/11 at 10:00:00 on 2097 serial 726xx        First
-------------------------------------------------------------------------
                      <-----Percent non-dormant (Wait states)------------
UserID   <-Samples->                          E-   D-   T-      Tst <Asynch>     Pct
/Class   Total  In Q Run Sim CPU SIO Pag SVM SVM SVM  CF Idl I/O Pag Ldg Elig
-------- ----- ----- --- --- --- --- --- --- --- --- --- --- --- --- --- ----
11:00:00  1335  1011 4.0 0.2 0.6   0 0.5   0   0 0.1   0  91 0.1   .   .    0
Hi-Freq:  116K 59208 4.2 0.0 1.9 0.0 0.3   0 7.9 0.1 0.0  89 0.4 0.1 0.2    0
***Top User Analysis***
LNXUWA01   893   893  71   0 2.8   0 0.1   0   0   0   0  24 1.7 0.4   0    0
LNXUWA03  1786  1786  28 0.2 5.5   0 1.2   0   0   0 0.6  57 7.2 0.1 0.1    0
LNXUWA02  1786  1786  27 0.1 3.6   0 0.1   0   0   0 0.4  69 0.1   0 0.1    0
```

Run is "high" – Not waiting for anything

- Need more cycles in shorter amount of time
- Faster engine
- Split workload into multiple virtual CPUs

Why CPU Wait State

CPU Wait – Waiting for CPU

SIM Wait – Waiting for master processor CPU

Reasons for wait:

- Total IFLs on CEC Utilization
- LPAR Entitlement
- LPAR Utilization
- SMT Not Enabled for 2 threads
- Shares (usually only needed at high utilization)
- And…. Something else

Wait States: ESAXACT

```
Report: ESAXACT       Transaction Delay Analysis
Monitor initialized: 01/12/21 at 14:00:00 on 3906 serial 35B
-------------------------------------------------------------
                      <-----Percent non-dormant (Wait states)
UserID   <-Samples->                              E-  D-  T-     Tst
/Class   Total  In Q Run Sim CPU SIO Pag SVM SVM SVM  CF Idl
-------- ----- ----- --- --- --- --- --- --- --- --- --- ---
01/12/21
14:01:00   140   126   0  56   0   0   0   0   0   0 0.8  44
Hi-Freq: 11400  7780 1.4  40  20  10 0.9   0 1.6 0.1 4.3  21
 ***User Class Analysis***
LTCUST     342   342 3.8  35  27   0   0   0   0   0 4.1  29
LTDEVL     342   342 2.6  15  31 3.2 1.2   0   0   0  16  24
LTVPARS    855   842 1.5  26  23  12 0.6   0   0   0  14  21
zRTF      2280  2165 1.0  33  19  16 0.1   0   0   0 0.5  27
VPWSPapp  2451  2450 0.7  56  13  10 0.9   0   0   0 1.1  16
LTT4*      969   918 2.1  30  31 8.2 3.3   0   0   0 4.4  18
*TheUsrs  3477   541 2.4  40  28 0.4 0.6   0 5.3 0.9 7.8  19
 ***Top User Analysis***
VMMONIT     57    35 5.7  66  17 2.9   0   0   0   0 5.7 2.9
LTDEVLB    171   171 2.9  12  24   0 2.3   0   0   0  33  25
U1PC       114   114 4.4  25  50 1.8   0   0   0   0   0  19
VPWSP38    114   114 4.4  20  35 0.9  18   0   0   0   0  18
```

Wait state (queue) analysis -> focus on CPU!

- CPU Wait very high for system, for top users
- Sim wait VERY high

CPU Utiliaztion

```
Report: ESALPARS     Logical Partition Summary                          V
Monitor initialized: 01/12/21 at 14:00:00 on 3906 serial 35B158         F
-------------------------------------------------------------------------
           <--------Logical Partition-------->  <-Assigned> Entitled
                        Virt CPU  <%Assigned>  <---LPAR-->  CPU Cnt
Time       Name     Nbr CPUs Type Total  Ovhd  Weight  Pct
--------   -------- --- ---- ---- -----  ----  ------ ----  ------
01/12/21

14:01:00   Totals:   00   25  CP  682.1  25.9    1001  100
           VM3       35    5  CP  362.2   0.3     156 15.6   4.99


Totals by Processor type:
<---------CPU-------> <-Shared Processor busy->
Type Count Ded shared  Total  Logical Ovhd Mgmt
---- ----- --- ------ ------ -------- ---- ----
CP      32   0     32  716.9    656.3 25.9 34.8
```

Wait state (queue) analysis -> focus on CPU!

- CPU Wait very high for system, for top users

32 CPUs shared,

VM3 has access to 5, Entitled to 5, using 3.6

CPU Utiliaztion

```
Report: ESACPUU      CPU Utilization Report
Monitor initialized: 01/12/21 at 14:00:00 on 3906 serial 35B158
-------------------------------------------------------------------
         <----Load---->           <--------CPU (percentages)---
         <-Users-> Tran     CPU   Total  Emul  User   Sys  Idle
Time     Actv In Q /sec CPU Type   util  time ovrhd ovrhd  time
-------- ---- ---- ---- -  ----  ----- ----- ----- ----- -----
01/12/21
14:01:00   95  126  2.0  0  CP     75.6   0.5  51.3  23.8  24.2
                         1  CP     72.4   1.2  69.1   2.0  27.5
                         2  CP     71.5   1.3  67.0   3.2  28.2
                         3  CP     70.4   1.4  66.5   2.5  29.4
                         4  CP     72.1   1.9  69.0   1.2  27.8
                                   ----- ----- ----- ----- -----
System:                            361.9   6.2 322.9  32.8 137.1
```

Wait state (queue) analysis -> focus on CPU!

- CPU Wait very high for system, for top users
- **Why is there CPU wait when not that busy?**
- Linux: Too many virtual cpus waiting for each other
- The secret command….

Wait States: ESAXACT

```
Report: ESAXACT      Transaction Delay Analysis
Monitor initialized: 11/06/23 at 17:00:00 on 3931 serial 11C9
-------------------------------------------------------------
                     <-----Percent non-dormant (Wait states)-
UserID   <-Samples->                          E-  D-  T-     Tst
/Class   Total  In Q Run Sim CPU SIO Pag SVM SVM SVM  CF Idl
-------- ----- ----- --- --- --- --- --- --- --- --- --- ---
11/06/23
17:01:00    36    27  22   0 7.4   0   0   0   0   0   0  70
Hi-Freq:  3480  1682  18 0.2  21 0.1   0   0  12 1.0   0  60
 ***Key User Analysis ***
TCPIP       60    13   0   0   0   0   0   0   0   0   0 100
 ***User Class Analysis***
Servers    420    19   0   0   0   0   0   0   0   0   0 100
Velocity   660    30   0   0   0 3.3   0   0  44  40   0  57
TheUsrs    780    13  23   0   0   0   0   0  16  31   0  46
RHEL        60    60 6.7   0  10   0   0   0   0   0   0  83
COREOS    1560  1560  19 0.3  22   0   0   0   0   0   0  59
 ***Top User Analysis***
LIMEDW2    480   480  42 0.2  20   0   0   0   0   0   0  38
LIMEDW1    480   480 8.3   0  26   0   0   0   0   0   0  66
LIMEDM1    240   240  15 1.3  36   0   0   0   0   0   0  47
LIMEDI1    360   360 5.3   0 8.9   0   0   0   0   0   0  86
LIMEDL1     60    60 6.7   0  10   0   0   0   0   0   0  83
```

Wait state (queue) analysis -> focus on CPU!

- CPU Wait very high for system, for top users
- Sim wait low

CPU Utiliaztion

```
Report: ESALPARS     Logical Partition Summary                          V
Monitor initialized: 11/06/23 at 17:00:00 on 3931 serial 11C
-------------------------------------------------------------------------
 <--------Logical Partition-------->                                Entitle
                          Virt CPU  <%Assigned>  <-Thread->    CPU Cnt
Time        Name      Nbr CPUs Type Total  Ovhd  Idle   cnt
--------    --------  --- ---- ---- -----  ----  ------ ----  ------
11/06/23

17:01:00    Totals:    00   91 IFL   1659  30.1
            RHOSVMD5   11    4 IFL  279.3   2.2  113.3    2    3.52

Totals by Processor type:
<---------CPU-------> <-Shared Processor busy->
Type Count Ded shared  Total  Logical Ovhd Mgmt
---- ----- --- ------ ------ -------- ---- ----
IFL     70   0     70 1706.9   1628.8 30.1 48.0
```

Wait state (queue) analysis -> focus on CPU!

- CPU Wait very high for system, for top users

70 CPUs shared,

VMD5 has access to 4, Entitled to 3.5, using 2.8

CPU Utiliaztion

```
Report: ESACPUU      CPU Utilization Report
Monitor initialized: 11/06/23 at 17:00:00 on 3931 serial 11C9C8
-------------------------------------------------------------------
         <----Load---->                <--------CPU (percentages)----
         <-Users-> Tran      CPU      Total   Emul   User    Sys   Idle
Time     Actv In Q /sec CPU Type       util   time ovrhd ovrhd   time
-------- ---- ---- ---- -  ----      ----- ----- ----- ----- -----
11/06/23
17:01:00   26 27.0  0.6  0   IFL       55.1  53.3   0.8   1.0  44.0
                         1   IFL       58.4  57.0   0.7   0.8  40.6
                         2   IFL       56.2  54.7   0.7   0.8  42.9
                         3   IFL       54.8  53.4   0.7   0.8  44.2
                         4   IFL       51.8  50.3   0.7   0.8  47.2
                         5   IFL       51.5  50.0   0.7   0.8  47.5
                         6   IFL       54.8  53.2   0.7   0.8  44.2
                         7   IFL       54.5  53.0   0.7   0.8  44.5
                                      ----- ----- ----- ----- -----
System:                               437.2 425.0   5.6   6.6 355.1
```

Wait state (queue) analysis -> focus on CPU!

- CPU Wait very high for system, for top users
- **Why is there CPU wait when not that busy?**
- Too many linux virtual cpus waiting for each other
- The secret command….

Configuration issues

- Linux guideline, minimize vcpu
- Linux guideline – SET SHARE REL 100/vcpu

Capacity Issues - visibility

Linux configuration - Number of vCPUs?

- Spin locks?
- Linux overhead of managing vCPUs?
- z/VM overhead of managing vCPUs?
- Very small time slices, each waits for it’s turn
- Hardware cache pollution?

Linux: How many Virtual Processors?

Linux is multiprocessor capable, thus requiring LOCKs

Global SPIN lock is large issue

- One virtual processor acquires lock
- Other virtual processors attempt to spin
- On 390 – spin converted to Diagnose 44 (now 9C)

Problem easily detected

- High Diagnose -> Instruction Simulation -> SIE
- High TV ratio
- Guideline: Minimize virtual processors

CASE STUDIES>>>>

Linux vCPU – Why does it hurt?

Too many vCPUs hurt because:

- DIAG 9C overhead
- Linux balances across all vCPUs
- Pollutes Hardware cache
- vCPUs will wait for each other
- vCPUs will wait to be dispatched, but do little work

Customer Critsit:

- Customer has excess processor capacity
- Bad performance, “CPU WAIT” (ESAXACT)
- Totals by Processor type on box (25% utilization (ESALPARS)

```
Totals by Processor type:
<---------CPU-------> <-Shared Processor busy->
Type Count Ded shared  Total  Logical Ovhd Mgmt
---- ----- --- ------ ------ -------- ---- ----
IFL     70   0     70 1706.9   1628.8 30.1 48.0c
```

Linux “Peculiarities”

LINUXM1:

- Polling at 15,000 times / second (each “poll” has cpu wait)
- Using 60% of one CPU
- 36 CPU seconds / 15,000 = 2.4ms / dispatch

```
Report: ESAUSR3
----------------------
           <Dispatch>
UserID     <Rate/Sec>
/Class     Disp Waits
--------   ---- -----
17:01:00    45K 45271
LIMEDM1     15K 14578
LIMEDI1    6261  6261
```

Linux vCPU – Why does it hurt?

Report: **ESAUSCP** Virtual Machine VCPU Analysis

UserID / CPUvadd	<---CPU time--> Cnt	<-Percent-> TOT	Virt	<-SHARE--> Type	Value	CPU TYPE	<-Samples-> Total	In Q	<---Percent **Run**	**Sim**	**CPU**
17:01:00	0	430.6	425.0	.	.	.	3480	1682	18	0.2	21
LINUXM1	4	**61.53**	59.64	REL	400	IFL	240	240	**15**	**1.3**	**36**
CPU-00		15.89	15.26	REL	100	IFL	60	60	17	1.7	35
CPU-01		13.77	13.41	REL	100	IFL	60	60	8.3	3.3	38
CPU-02		17.69	17.19	REL	100	IFL	60	60	15	0	32
CPU-03		14.18	13.78	REL	100	IFL	60	60	18	0	38
LIMEDI1	6	**49.66**	48.93	REL	600	IFL	360	360	5.3	0	8.9
CPU-00		8.85	8.67	REL	100	IFL	60	60	10	0	10
CPU-01		8.25	8.13	REL	100	IFL	60	60	6.7	0	6.7
CPU-02		7.24	7.11	REL	100	IFL	60	60	1.7	0	10
CPU-03		8.47	8.36	REL	100	IFL	60	60	1.7	0	8.3
CPU-04		10.13	10.04	REL	100	IFL	60	60	8.3	0	10
CPU-05		6.73	6.61	REL	100	IFL	60	60	3.3	0	8.3

Linux balances small tasks across vCPUs

Each vCPU waits and then does a small task

Having more vcpu just means the number of delays increases

Linux vCPU – Why does it hurt?

```
Report: ESAUSCP      Virtual Machine VCPU                re Corporate
Monitor initialized: 11/07/24 at 13:02:24rial 00FBF8  alyzed: 11/07
-------------------------------------------------------------------
UserID   <---CPU time-->                      <---Percent <Dispatch>
 CPUvadd      <-Percent-> <-SHARE--> CPU                  <Rate   MS/
          Cnt TOT   Virt  Type Value TYPE  Run Sim CPU /Second Disp
-------- --- ----- ----- ---- ----- ----  --- --- --- -------
13:04:00   0  4092  4020    .     .   .    24 0.3  16  193K 0.212
LX1140    18  1074  1060  REL   100 IFL    58 0.6  19 20502 0.524
 CPU-00      68.33 64.83  REL     6 IFL    70 1.7  18  2453 0.279
 CPU-01      69.89 69.17  REL     6 IFL    62   0  22  1156 0.605
 CPU-02      48.68 48.16  REL     6 IFL    43 1.7  23  1042 0.467
 CPU-03      56.03 55.48  REL     6 IFL    57   0  15  1136 0.493
 CPU-04      51.00 50.40  REL     6 IFL    47   0  27  1363 0.374
 CPU-05      54.53 54.00  REL     6 IFL    52   0  25   938 0.582
 CPU-06      70.10 69.42  REL     6 IFL    65   0  15  1062 0.660
 CPU-07      62.87 62.31  REL     6 IFL    63   0  18   904 0.695
 CPU-08      64.73 64.18  REL     6 IFL    63   0  23   876 0.739
 CPU-09      48.21 47.72  REL     6 IFL    53 1.7  23   923 0.522
 CPU-10      53.52 52.95  REL     5 IFL    50   0  23  1045 0.512
 CPU-11      51.09 50.54  REL     5 IFL    47   0  18  1092 0.468
 CPU-12      62.50 61.87  REL     5 IFL    67   0  15  1088 0.574
 CPU-13      76.12 75.45  REL     5 IFL    70 1.7  15   932 0.817
 CPU-14      73.40 72.71  REL     5 IFL    75   0  10  1137 0.645
 CPU-15      50.87 50.18  REL     5 IFL    53   0  15  1378 0.369
 CPU-16      51.32 50.81  REL     5 IFL    50 1.7  17   909 0.565
 CPU-17      60.47 59.79  REL     5 IFL    63 1.7  20  1066 0.567
```

- New column MS/DISP
- Server busy 60%
- Share setting a problem
- Very small dispatches
- Each one waits

z/VM uses “deadline scheduler”

- Each vcpu gets “target deadline” based on share
- Total inque 3000
- Deadline = 3000 / share * DSPSLICE / nCPU
- Rel share of 6, deadline = 5 seconds / nCPU = 70ms
- Any work that comes in with lower deadline goes first
- So 70 ms target for sub millisecond work

Correct Chargeback, accounting for CPU

CPU: What are you measuring? Do you know?

- CPU "thread" numbers are traditional, measured by Linux
- **VSI Prorated** based on HMC data
  - Shows SMT is significantly better

Report: ESAUSP5 User SMT CPU Consumption Analysis

	<------CPU Percent Consumed		(Total)---->		<-TOTAL CPU-->	
UserID	<Traditional>	<MT-Equivalent>	<IBM Prorate>		<VSI Prorated>	
/Class	Total Virt	Total Virtual	Total	Virtual	Total	Virtual
17:01:00	430.6 425.0	341.9 337.4	271.0	267.6	216.7	213.9
User Class Analysis						
Servers	0.12 0.06	0.09 0.05	0.07	0.03	0.06	0.03
Velocity	0.58 0.55	0.45 0.42	0.35	0.33	0.29	0.28
TheUsrs	3.53 3.53	3.44 3.44	3.12	3.12	1.78	1.78
RHEL	4.55 4.31	3.59 3.40	2.85	2.71	2.29	2.17
COREOS	421.8 416.5	334.3 330.1	264.6	261.4	212.3	209.6
Top User Analysis						
LIMEDW2	194.6 193.1	154.7 153.6	122.5	121.6	97.92	97.18
LIMEDW1	116.0 114.9	91.64 90.69	73.77	73.05	58.39	57.80
LIMEDM1	61.53 59.64	48.63 47.12	38.21	37.05	30.96	30.01
LIMEDI1	49.66 48.93	39.32 38.73	30.12	29.68	24.99	24.62

CPU Guidelines

Linux: Minimize vCPU to meet requirements
Set and maintain REL share to 100 per vcpu

z/VM: Avoid CPU Wait (default dspslice 10ms)

- Reduce vcpu count and increase work per dispatch best
- Or, Reduce wait time: SET SRM DSPSLICE 3 (default 10)
- Calculate CPU consumed / dispatch rate

Each vCPU waits, and then does a small task

- .4ms average CPU
- (But waits 5ms – 10ms if SMT2)

But wait, there is more…

If 8 threads (4 cores) at 60% busy, queueing theory says:

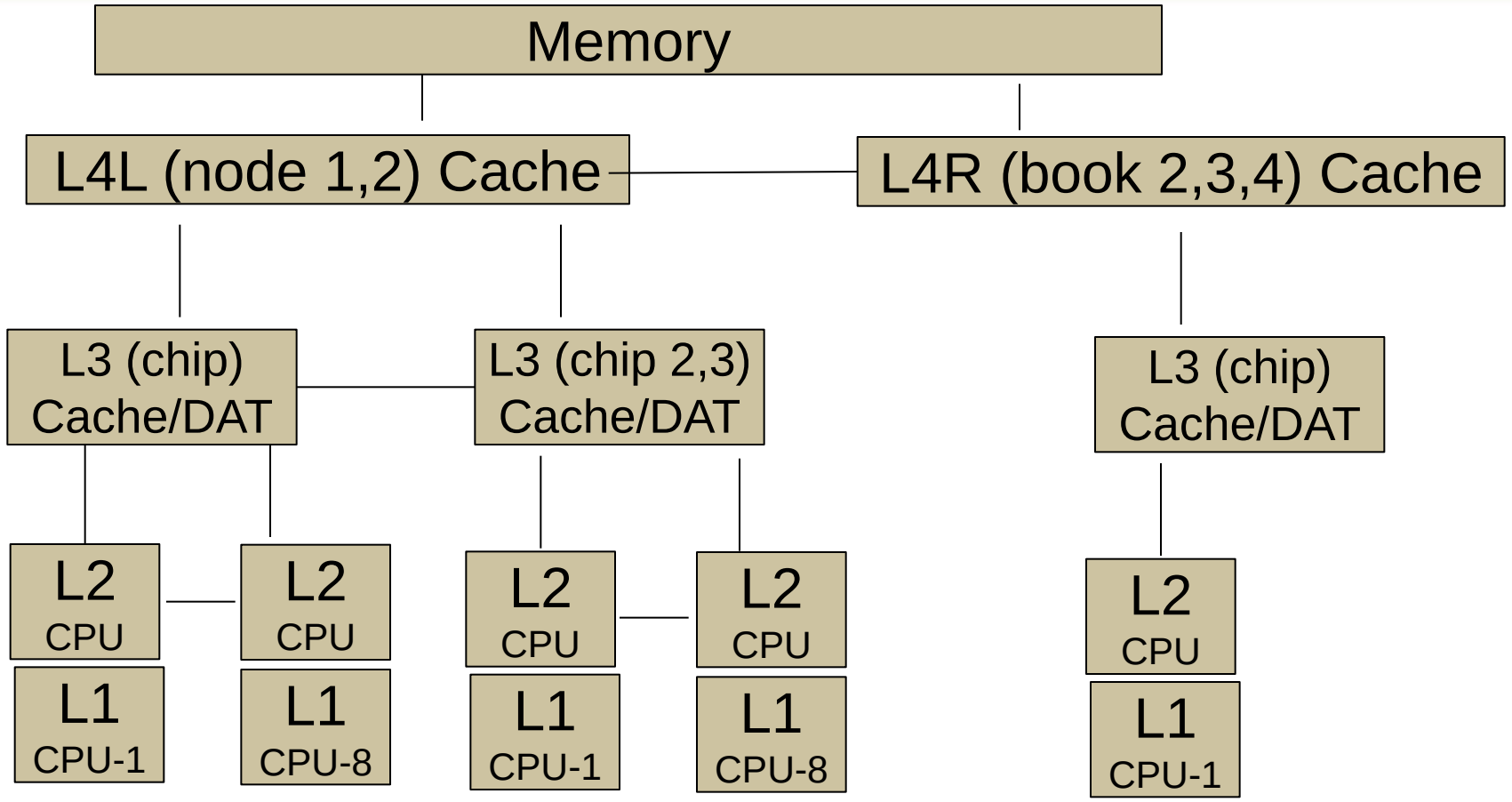
- CPU Queue time should be: .017 time running
- Why is it 2 times running?

Problem: CPU Affinity processing delays 50ms before steal

- 85% of the time there is at least 1 available CPU

The secret command undocumented (yet), used often

- Measured to triple dispatch rate
- Increases capacity



Affinity was meant to better utilize z caching structure

Modlevels Secret Command... – Turn off affinity

```
q syscontrol
DISPATCH THDAFFINITY ON
DISPATCH PREEMPTLOCAL OFF
DISPATCH TSEARLY  50
DISPATCH INCHIPBUSY     50000      ←Delay for steal on chip 50ms
DISPATCH INCHIPDELAY    50000
DISPATCH INNODEBUSY    100000      ←Delay for steal on NODE 100ms
DISPATCH INNODEDELAY   100000
DISPATCH INSYSBUSY      20000      ←Delay for steal on Book 100ms
DISPATCH INSYSDELAY    200000
Ready; T=0.01/0.01 11:24:20
CP SET SYSCONTROL DISPATCH MODLEVEL 0
Ready; T=0.01/0.01 11:24:24
q syscontrol
DISPATCH THDAFFINITY OFF
DISPATCH PREEMPTLOCAL ON
DISPATCH TSEARLY   0
DISPATCH INCHIPBUSY         0
DISPATCH INCHIPDELAY        0
DISPATCH INNODEBUSY     50000
DISPATCH INNODEDELAY    50000
DISPATCH INSYSBUSY     200000
DISPATCH INSYSDELAY    200000
Ready; T=0.01/0.01 11:24:27
 CP SET SYSCONTROL DISPATCH MODLEVEL 1…
```

Storage is expensive, overcommit reduces costs

Paging objective: Page out idle / unused pages

- **Inactive storage? Linux storage is not idle**
  - Extra storage used to cache data and programs
  - Linux “dirties” all storage, that z/VM must back
- **Inactive servers? Linux servers are not idle**
  - Linux applications poll at 200 times per second
  - Which servers are actually doing work if all are “active”?

Real Storage (RAM)

z/VM Paging

- Over commitment of storage causes paging
- **Over commitment of storage reduces cost**
- Paging is common **(manageable)** performance problem

Linux Swapping

- Swapping result of over commitment of Linux storage
- Swapping to VDISK very fast, uses storage when it happens
- Swapping to DASD very slow, always noticeable

Understanding Linux ram (real storage) will save gigabytes real storage

Storage Map, ESASTR1

- **Storage Map to show storage (14GB) use**
  - User resident should be major use
  - Control MDC, Understand vdisk
- **Capture ratio shows accuracy**

```
Report: ESASTR1      Main Storage Analysis                          Velocity Software Corporate   ZMAP 5.1.2 04/16/21   Pg   2
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78     First record analyzed: 04/15/21 00:00:00
-------------------------------------------------------------------------------------------------------------------------
         Users <-----------------------------Pages-------------------------------------------------------------> Over
         Loggd System  Fixed Non-  Free Frame <Available> Systm  User  NSS/DCSS  <-AddSpace> VDISK <MDC> Diag Commit    Capt-
Time        On Storage Store Pgble Stor Table <2gb  >2gb  ExSpc Resdnt Resident  Systm User  Rsdnt Rsdnt  98  Ratio     Ratio
-------- ----- ------- ----- ----- ---- ----- ----- ----- ----- ------ --------  ----- ----- ----- ----- ---- -----     -----

04/15/21
17:00:00   111 3670016  2878 20879 1153 28672  3170  2501 52291  3387K    35061  75702     0  4729 15418  16K 3.653     0.988
17:15:00   111 3670016  2878 20882 1152 28672  3099  2421 52296  3384K    35078  75713     0  4441 18566  16K 3.653     0.988
17:30:00   111 3670016  2878 20883 1166 28672  3164  2669 52296  3383K    35077  75714     0  4307 19741  16K 3.653     0.988
17:45:00   111 3670016  2878 20872 1147 28672  3195  2389 52298  3381K    35074  75716     0  4270 21989  16K 3.653     0.988
18:00:00   111 3670016  2878 20889 1146 28672  3128  2851 52306  3383K    35079  75722     0  4103 19648  16K 3.653     0.988
18:15:00   113 3670016  2878 20876 1141 28672  3077  2508 52316  3384K    35099  75776     0  4028 19283  16K 4.609     0.988
18:30:00   116 3670016  2878 20880 1075 28672  3137  2544 52360  3349K    32071   122K     0  2118 12337  16K 7.354     0.988
18:45:00   116 3670016  2878 20808 1038 28672  3051  2234 52407  3293K    29914   196K     0     0    47  16K 8.227     0.988
19:00:00   116 3670016  2878 20765 1028 28672  3056  2245 52414  3293K    29082   196K     0     0   127  16K 8.227     0.988
19:15:00   115 3670016  2878 20797 1040 28672  3063  2232 52409  3297K    29522   192K     0    22    73  16K 8.754     0.988
19:30:00   116 3670016  2878 20809 1031 28672  3069  2235 52450  3293K    29065   196K     0     0     6  16K 9.363     0.988
```

Understanding Virtual Machine Storage

```
Report: ESAUSP2      User Resource Rate Report                          Velocit
-------------------------------------------------------------------------------
         <---CPU time--> <----Main Storage (pages)-----> <-Paging (pages)-
UserID   <(Percent)> T:V <Resident> Lock <-----WSS-----> Paged <Pgs/Second
/Class   Total  Virt Rat Totl Activ  -ed Totl Activ  Avg 2Disk  Read Write
-------- ----- ----- --- ---- ----- ---- ---- ----- ---- -----   ---- ----
18:30:00 145.3 133.9 1.1 3.3M 3348K 7048 3.9M 3909K  34K 9147K 27057 15496
 ***Key User Analysis ***
TCPIP     0.15  0.05 3.0 1422  1422  601  817 817.3  817  7750  43.4   8.6
***User Class Analysis***
Velocity  5.82  5.43 1.1 3763  3598    5 4593  4271  534 14472 137.4  57.0
SUSE     20.17 19.28 1.0 112K  112K 1534 193K  193K  32K 1048K  2754 828.5
ORACLE    4.66  3.84 1.2 195K  195K  734 381K  381K 190K  473K  2895 936.7
GPFS     12.51 11.68 1.1 195K  195K  975 439K  439K 146K 1332K  4008  1383
TheUsrs  95.37 89.07 1.1 2.6M 2615K 1145 2.5M 2472K  80K 5017K 12958 11022
 ***Top User Analysis***
RHOSBOOT 39.91 38.51 1.0 727K  727K   30  99K 98642  99K  454K  1175  2346
RHOSCP2   8.92  8.20 1.1 250K  250K   19 116K  116K 174K  201K 997.0  1965
RHOSCP1   8.78  8.05 1.1 252K  252K   19 126K  126K 189K  205K 967.6  2005
RHOSCP3   7.83  7.04 1.1 161K  161K   28  48K 47842  80K  125K  1230  1157
```

- **Virtual Machine Storage analysis – ESAUSP2 (percent/rate)**
  - Analyze by user – Large consumers?
  - RHOS* users paging too much to get work done
  - RHOS* is OpenShift installation

Understanding Linux Storage Critical

Linux admins oversize

Linux data shows

- Real storage
- Available storage
- Swap storage
- "cache"

Some Swapping is "good"

- If not swapping,
  - reduce vm size
  - Use CMM to reduce

Watch for opportunities

- HIGH available
- No swap

```
Report: ESAUCD2      LINUX UCD Memory Analysis   Velocity Software Corpo
Monitor initialized: 10/03/14 at 07:22:27 on 2   First record analyzed:
-------------------------------------------------------------------------
Node/    <-------------------Storage Size (MB)------------------------->
Time/    <--Real Storage--> <-----SWAP Storage--Storage in Use--------->
Date     Total  Avail Used  Total Avail Used   Buffer Cache Ovrhd Shared
-------- ------ ----- ----- ----- ----- -----  ------ ----- ----- ------
07:24:00
ORAap042 8041.5 475.9  7566  1130  1130   0.1   183.5  1512  5870      0
ORAap044  13069  7131  5939  6888  6888     0   233.0  3913  1793      0
ORAap046 8041.5  2091  5951  1130  1130   0.1   260.9  3423  2267      0
ORAap048 8041.5  2291  5751  1130  1130     0   224.8  3347  2179      0
ORAap050 8041.5 529.3  7512  1130  1130   0.1   186.9  1577  5749      0
ORAap052  10046 642.8  9403  8172  8172     0   226.5  3958  5218      0
ORAap054 8041.5  1235  6807  3036  2878 158.3   139.9 319.3  6348      0
ORAap056 8041.5 818.5  7223  5604  5592  12.2   156.4 968.3  6098      0
ORA1101b  12062  64.0 11997  4942  4758 183.6   727.5 10024  1246      0
ORA1201a  12062 218.9 11843  4942  4438 503.7   152.4  7170  4520      0
ORA1202a  12062  1668 10394  4942  4399 543.3   137.3  6435  3822      0
ORA1203a  12062  94.0 11968  4942  4443 498.5   168.6  7582  4216      0
ORA1204a  12062  90.9 11971  4942  3754  1188    70.9  8088  3811      0
ORA1403a  12062 462.1 11599  4942  4420 521.8   180.6  6783  4636      0
ORA1404a  12062 439.3 11622  4942  4442 499.9   103.4  6853  4666      0
ORA1405a  12062 442.5 11619  4942  4471 471.1   127.0  6593  4899      0
WAS2a016 2502.6  89.6  2413  1130  1106  24.2   203.0 243.0  1967   48.0
WAS2a020 2502.6  29.9  2473  1130  1106  24.1   254.3 238.8  1980   47.9
WAS2a024 5520.4  2635  2885  1130  1130     0   776.4 613.3  1496   50.3
WAS2a054 2502.6  22.0  2481  1130  1106  23.4   247.9 274.1  1959   48.5
WAS2a058 2502.6  22.4  2480  1130  1106  23.5   244.5 254.9  1981   48.5
WAS2a062 6528.3  3687  2841  1130  1130     0   762.0 591.8  1487   50.3
WAS2a114 2502.6  17.7  2485  1130  1106  23.6   219.6 267.6  1998   48.4
WAS2a118 2502.6  17.6  2485  1130  1106  23.6   260.5 264.1  1960   48.2
```

z/VM STORAGE and Paging Architecture Moving Target

z/VM shared storage / Overcommit

- Objective: Page unused pages out to allow re-use
- Need optimal test before paging to slow disk
- Optimize page-in when needed (block paging)

The problem? Which servers, pages are truly idle

Architectures to choose from:

- Excessive Storage – enough so no paging (expensive)
- Solid State paging device – sort of fast
- Disk paging devices – not fast

Strategy / best practices in past if overcommit high

- Need high speed page recovery

~~Expanded Storage was used for "30 second test case"~~

- Pages migrated to disk after 30 seconds
- Minimum 20% of storage reconfigured to Expanded Storage
- Page-in from expanded storage was synchronous, FAST
- Pages migratable to disk after 30 seconds unreferenced

"New" strategy is IBR (z/VM 6.3)

- Invalid But Resident
- VERY LIMITED. 5% is the max
- 2% is the default, Go the max!

z/VM Storage Management Options

- **System Age List**
  - Maximum 5%,
  - recommend 5% always
  - SET AGELIST SIZE 5% EARLYWRITES YES KEEPSLOT YES

```
-Set--AGELIST---.-SIZE--.-n.n--PERCent-.-.
                |       |-n.n%---------| |
                |       '-storsize-----' |
                |-EARLYWrites--.-Yes-.---|
                |              '-No--'   |
                '-KEEPSlot--.-Yes-.------'
                            '-No--'
```

  - CP QUERY AGELIST (default)

```
Target size    =          280576K (274M)      2.0% of pageable
storage
In use         =          271712K
Pending writes =          120296K
Early writes   = Yes
Sizing         = Variable
```

Linux Cache

- Linux avoids I/O by using cache
- Linux will cache gigabytes of data if allowed
- Oracle SGA MUST fit in Linux page cache
- Swap historically was slow SCSI device so storage oversized

Reduce size of Linux Virtual Machine MAJOR Knob.

- Reducing virtual machine size reduces caching of old data
- Define virtual disk for swap
- Virtual Disk paged out when not in use
- Swapping is ok if configured correctly

Linux Swapping

Reducing virtual storage size may cause swap

- Linux does not swap until out of storage

Swapping to disk

- VERY VERY SLOW
- Other platforms increase storage size because disk is slow
- **Swap to disk if you want to penalize a server**
- Max swap rate maybe 200 on a very good day

Linux Swapping to VDISK

- Not a performance degradation
- 40,000 / second is FAST

Swap Guideline:

- **Define 2 virtual disks, prioritized swap**
- **First one "smaller", 2nd on 2GB (Insurance)**
- More swap devices for SAP as needed (they are essentially free)
- Use DIAG driver instead of FBA - Reduces I/O by factor of 8

VDISK Case Study

VDISK for swap best practice: Two disks, prioritized – DOUBLE CHECK!

- Two disks per server, goodness
- Should be 1 small swap disk, plus 2nd large disk, goodness
- Prioritized backward though, badness….
- (Address space names have server, virtual address and index)

```
<--Size--->  <--pages--> ----->  DASD    X-
                                 AddSpc VDSK  Resi- Lock-  Stg->  Page Store
Owner    Space Name              Pages  Blks   dent    ed T Migr Slots  Blks
-------- ---------------------- ----- -----  ----- ----- - ---- ----- -----
Average:
LINUX1   VDISK$LINUX1$$$0101$0041 65791  8738   3.0     0      0   568     0
LINUX1   VDISK$LINUX1$$$0112$0042  524K 69905   170     0    0.0 61212    11
LINUX2   VDISK$LINUX2$$$0101$0043 65791  8738   3.0     0      0   571     0
LINUX2   VDISK$LINUX2$$$0112$0044  524K 69905   85K     0    0.4  346K  2047
LINUX3   VDISK$LINUX3$$$0101$0045 65791  8738   3.0     0      0   571     0
LINUX3   VDISK$LINUX3$$$0112$0046  524K 69905   2.0     0      0  5767     0
LINUX4   VDISK$LINUX4$$$0101$0047 65791  8738   3.0     0      0   571     0
LINUX4   VDISK$LINUX4$$$0112$0048  524K 69905  147K     0    0.3  223K 35967
LINUX5   VDISK$LINUX5$$$0101$0049 65791  8738   3.0     0      0   568     0
LINUX5   VDISK$LINUX5$$$0112$004A  524K 69905   2.0     0      0  4321     0
-----  -----  -----  -----  - ----  -----  -----
System Totals:                   5901K 39321  233K     0    0.7  669K 38631
```

Summary: Configuration Guidelines

- **Virtual Machines**
  - Relative 100 per virtual CPU
  - Shares are a bigger hammer than would appear
- **z/VM System settings**
  - SET SRM DSPSLICE 3ms (Validate)
  - SET SYSCONTROL DISPATCH MODLEVEL 0
- **z/VM Real Storage Guidelines**
  - SET MDC MIN 128m MAX 128m
  - Ensure accounting is disabled
  - Validate page space
- **Linux**
  - Minimize vCPU
  - Minimize RAM
  - Use VDISK (two) for swap