Processor Analysis and Tuning

Processor Topics

- What is CPU utilization
- Theory of processor speed
- Common problems
- LPAR, HiperDispatch, Horizontal
- Overview of Processors
- Processor measurements
- Steal time
- Master Processor
- PLDV, Dispatch rates
- MFC, SMT

Processor Performance Concepts - Utilization

What is important?

- TOTAL IFL Utilization
- LPAR Utilization
- “My” share

CPU Utilization used for:

- Performance Analysis
- Capacity Planning
- Accounting/Chargeback

Utilization measured in many ways

- Virtual Linux measures what? Percent of something.
- z/VM under LPAR measures what? CPU Seconds
- Hardware measurement only valid method of measuring CPU

Processor Performance Concepts - Utilization

What is “CPU Utilization”?

Percent of Percent misleading

- Can not be used directly for capacity planning
- Can not be used directly for accounting/chargeback
- Often misleading for performance analysis

All zVPS numbers are measured in CPU Seconds

- Percent is always based on CPU seconds divided by wall clock

Impacts measurements of

- LPAR
- z/VM Virtual Machines
- Linux processes
- zVSE Jobs/Partitions

Processor CAPACITY Concepts – Adding IFLs

Adding processors in MP environment reduces MSU / CP in z/OS

Adding processors in z/VM MP environment

- Reduces queuing time
- increases CPU available
- Cost money

Service levels comparison at 50% CPU Queue time

- One CPU: 50% busy, queue time = cpu time
- Two CPUs: 70% busy, queue time = cpu time
- Three CPUS: 79% busy, queue time = cpu time
- Four CPUs: 84% busy, queue time = cpu time

The 2nd CPU almost triples the capacity at target service level

The 3rd CPU adds 70% to capacity

More processors operate at higher utilization with good performance

Processor speed

- **Many expensive mistakes based on mis-understanding**
- **More hardware costs money, financial choices**
- **Understand Impacts (common mistakes)**
  - Number of vcpu in LPAR (impact on relative weight?)
  - Number of vcpu in virtual machine (impact on relative share)?
  - ALL single threaded large CPU Consumers! MP doesn't help?
  - ALL CPU intensive applications

- **CPU response time is a function of processor speed and CPUs.**
  - Faster processors mean shorter service time.
  - More processors means lowering queuing time.

- **Which provides better response time,**
  - 2 x 20 MIP engines, or 1 x 40 MIP engine?
  - at what percent utilization?

Processor Performance Concepts

- **Which provides better response time multi-process workload,**
  - 2 x 20 MIP engines, (LESS QUEUEING)
  - 1 40 MIP engine? (SMALLER SERVICE TIME)
- **at what percent utilization? ("x" is cpu requirement)**
  - MM1: 2x20: resp(50%) = 2x/(1-(.5*.5)) = 2.66x
  - MM1: 1x40: resp(50%) = x / (1-.5) = 2x
  - MM1: 2x20: resp(90%) = 2x/(1-.9*.9) = 10.52x
  - MM1: 1x40: resp(90%) = x/(1-.9) = 10x
  - MM1: 2x20: resp(95%) = 2x/(1-.95*.95) = 20.51*x
  - MM1: 1x40: resp(95%) = x/(1-.95) = 20x

Processor Performance Concepts

- **Which provides better response time for SINGLE THREAD?**
  - 2 x 20 MIP engines, (LESS QUEUEING)
  - 1 40 MIP engine? (SMALLER SERVICE TIME)

- **at what percent utilization? ("x" is cpu requirement)**
  - MM1: 2x20: resp = 2x
  - MM1: 1x40: resp = x

- **Common error made by sales people and financial people**
- **The 2x20 is less expensive in hardware and software**
  - Fine for high multitasking,
  - bad for single thread or batch
- **What problem is to be resolved?**

Common Reported CPU Performance Problems

Problems:

- Workload timing out,
- Application running slow
- Workload/Server in CPU Wait

Causes - Tuning

- LPAR Weights vs utilization
- LPAR VCPU vs SHARE
- Share settings poor
- Operating on GP, not IFL
- Processor Utilization high

Causes - Workload

- Master processor
- Cron jobs synchronized
- Spin locks (DIAG 9C)

Processor Distribution Management

Objective: operate at high utilization

- **Requires management decisions, prioritization**
- **Alternative to management is more hardware/licensing**

Managing distribution:

- **z/VM LPAR share of IFLs**
  - **Based on weight of LPAR**
  - **Based on number of IFLs (1 40 mip vs 2 20 mip)**
- **Linux server's share is**
  - **Share of z/VM LPAR (relative/absolute)**
  - **Based on number of vcpu**
- **Process "niced", "priority"**

LPAR Configuration

z/VM share of IFLs

```
Report: ESALPARS     Logical Partition Summary
-------------------------------------------------------------------------
          <--Complex--> <--------Logical Partition-------->  <-Assigned
          Phys Dispatch                 Virt CPU  <%Assigned>  <---LPAR-->
Time      CPUs    Slice Name     Nbr CPUs Type Total   Ovhd   Weight  Pct
--------  ---- -------- -------- --- ---- ---- -----  ----   ------ ----
00:15:00    23  Dynamic Totals:    0   22  CP  506.0   4.5      999  100
                        Totals:    0   23 IFL  903.1   8.6     1000  100
                        ZVMQA     11    6 IFL  374.8   0.9      150 15.0
                        MVSPRD     7   10  CP  320.1   3.2      860 86.1
                        MVSQA      1    6  CP  181.8   1.1       71  7.1
                        ZVMDEQ     9    4 IFL  131.6   2.0      100 10.0
                        ZVMPRD     8   10 IFL  333.7   4.9      650 65.0
                        ZVMSHR    12    3 IFL   63.0   0.8       80  8.0
                        MVSTST    17    3  CP    5.1   0.1        8  0.8
Totals by Processor type:
<---------CPU-------> <-Shared Processor busy->
Type Count Ded shared  Total  Logical Ovhd Mgmt
---- ----- --- ------ ------ -------- ---- ----
CP       7   0      7  511.9    501.5  4.5  5.9
IFL     10   0     10  915.6    894.5  8.6 12.5
ZIIP     3   0      3   23.9     22.3  0.4  1.2
```

Processor Utilization Components

LPAR Physical Overhead

LPAR Assigned Logical Partition

- Logical Partition Logical Overhead
- LPAR logical time

z/VM (LPAR logical time)

- System Time (z/VM Control Program)
- Emulation (z/VM Guest time)
- User Overhead (allocated system time)

Linux (Emulation time)

- System time (kernel time)
- IRQ Time
- User time

IDLE

LPAR Configuration

z/VM share of IFLs

```
Report: ESALPARS     Logical Partition Summary
-------------------------------------------------------------------------
          <--Complex--> <--------Logical Partition-------->  <-Assigned
          Phys Dispatch                Virt CPU  <%Assigned>  <---LPAR-->
Time      CPUs    Slice Name     Nbr CPUs Type Total   Ovhd   Weight  Pct
--------  ---- -------- -------- --- ---- ---- -----  ----   ------ ----
00:15:00    23  Dynamic Totals:    0   22   CP 506.0    4.5      999  100
                        Totals:    0   23  IFL 903.1    8.6     1000  100
                        ZVMQA     11    6  IFL 374.8    0.9      150 15.0
                        ZVMDEQ     9    4  IFL 131.6    2.0      100 10.0
                        ZVMPRD     8   10  IFL 333.7    4.9      650 65.0
                        ZVMSHR    12    3  IFL  63.0    0.8       80  8.0
Totals by Processor type:
<---------CPU-------> <-Shared Processor busy->
Type Count Ded shared  Total  Logical Ovhd Mgmt
---- ----- --- ------ ------ -------- ---- ----
IFL     10   0     10  915.6    894.5  8.6 12.5
```

- ZVMQA is allocated 150/1000 of 10 SHARED IFLs
- ZVMQA is using 37.5% of 10 SHARED IFLs
- IFLs running 91.6% busy

LPAR Weights

Each LPAR gets a weight

LPAR's share:

- (LPAR Weight) / SUM(LPAR Weights)

Processor share of system:

- (LPAR Share) / (Number CPUs in LPAR)

Processor share of a CPU is

- (Processor share of system) * (Number physical processors)

LPAR Weights Example

- **ESALPAR (Partial report)**
- **Note each vcpu running at 10%?**
- **z/VM can dispatch 8 concurrent virtual machines**
  - Less queueing, slower service
  - But, each single vcpu runs “slow”

	<--Complex-->		<--Logical->		<--------Logical Processor--------				
	Phys	Dispatch	<-Partition>	VCPU	<%Assigned>			Cap-	Wait
Time	CPUs	Slice	Name No.	Addr	Total	Ovhd	Weight	ped	Comp
Average:	8	Dynamic	ZVM 6	0	8.3	0.2	10	No	No
				1	10.2	0.2	10	No	No
				2	11.0	0.2	10	No	No
				3	11.1	0.2	10	No	No
				4	10.5	0.2	10	No	No
				5	10.5	0.2	10	No	No
				6	10.5	0.2	10	No	No
				7	10.6	0.2	10	No	No
					-----	----			
				LPAR	82.8	1.4			

LPAR Share Example

Processor Details

- 30 LPARs configured
- 4 LPARs active
- Total of all active lpar shares: 60
- z/VM Weight: 10 (out of 60)
- z/VM Logical Processors: 8
- Physical processors online: 8

Guaranteed processor share (speed)

- (Share of system / nbr logical processors) * nbr phys
- ((10 / 60) / 8) * 8 = .16

Each virtual cpu at peak runs at 16% rated spead

- **(go back to processor performance concepts)**

LPAR Share Example

Processor Details: If change to 4 logical processors:

- 4 LPARs active
- Total of all shares: 60
- z/VM Weight: 10 (out of 60)
- z/VM Logical Processors: 4
- Physical processors online: 8

Guaranteed processor share (speed)

- **((10 / 60) / 4) * 8 = .32**
- **Real problem in many installations**

Too many logical processors will slow you down!

- Specifically the master processor….
- The same concept applies to Linux virtual processors
- SEE DISCUSSION ON HIPERDISPATCH!!!

LPAR Summary Report

```
Report: ESALPARS     Logical Partition Summary                          TEST MAP
Monitor initialized: 08/04/03 at 18:52:10 on 2084 serial 4B54A          First recor
-------------------------------------------------------------------------------
         <--Complex--> <-------Logical Partition--->  <-Assigned Shares---->
         Phys Dispatch                Virt <%Assigned>  <---LPAR--> <VCPU Pct>
Time     CPUs    Slice Name     Nbr CPUs Total  Ovhd  Weight  Pct /SYS /CPU
-------- ---- -------- -------- --- ---- -----  ----  ------ ---- ---- ----
Average:    8  Dynamic Totals:    0   22 188.7   2.1      60  100
                     ZVM          6    8  82.8   1.4      10 16.0 2.00 16.0
                     CF01         1    1  99.9   0.0      10 16.0 16.0  128
                     LINUXSW      2    2     0     0      10 16.0 8.00 64.0
                     S01          3    4   4.6   0.4      10 16.0 4.00 32.0
                     S02          4    0
                     VMTPC        5    5   1.2   0.2      10 16.0 3.00 24.0
                     ZVMCSS1     16    2   0.2   0.0      10 16.0 8.00 64.0
```

"ZVM" Allocated 16% of 8 CPUs

Each virtual cpu allocated 2% of system (8 CPUs)

Each processor rated at 16% speed of real processor

LPAR with HiperDispatch

Stated Purpose of HiperDispatch and vertical scheduler:

- Localize work to L1/L2 cache
- Reduce impact of installation configuration errors

Impact

- Virtual CPUs disabled, share redistributed
- Faster master processor
- L1/L2 cache impact negligible

```
ESAOPER:
07:00:41 CPU Park from 15 to  13 CPUUtil= "12.9",
07:00:43 CPU Unpark from  13 to  15 CPUUtil= "12.5
07:05:35 CPU Park from 15 to  13 CPUUtil= "12.2",
07:05:37 CPU Unpark from  13 to  15 CPUUtil= "12.0
07:05:53 CPU Park from 15 to  12 CPUUtil= "12.0",
07:05:55 CPU Unpark from  12 to  15 CPUUtil= "10.4
07:07:13 CPU Park from 15 to  13 CPUUtil= "12.5",
07:07:15 CPU Unpark from  13 to  15 CPUUtil= "11.9
07:07:19 CPU Park from 15 to  13 CPUUtil= "12.1",
07:07:21 CPU Unpark from  13 to  15 CPUUtil= "11.8
07:07:29 CPU Park from 15 to  13 CPUUtil= "12.1",
```

LPAR with HiperDispatch

HiperDispatch requires Vertical scheduling

```
Report: ESALPAR      Logical Partition Analysis
Monitor initialized: 05/31/16 at 00:00:00 on 2827 serial 2F5A7
-------------------------------------------------------------------
         <--Complex--> <--Logical-> <----------Logical Processor-
         Phys Dispatch <-Partition> VCPU <%Assigned> VCPU
Time     CPUs    Slice Name     No. Addr Total  Ovhd TYPE Weight
-------- ---- -------- -------- --- ---- -----  ---- ---- ------
07:15:00   19  Dynamic R3SYSG     2    0  87.9   0.8 IFL      400
                                    1  89.3   0.7 IFL      400
.....
                                   11  81.9   0.8 IFL      400
                                   12  77.5   1.0 IFL      400
                                   13  75.5   0.9 IFL      400
                                   14  60.9   0.7 IFL      400
                                       -----  ----
                                 LPAR  1245  11.8

                           R3SYS1  3    0  48.6   2.1 IFL      500
                                    1  35.5   1.6 IFL      500
                                    2  40.4   1.7 IFL      500
                                    3  38.9   1.5 IFL      500
                                    4  36.8   1.7 IFL      500
                                    5  38.8   1.7 IFL      500
                                    6  40.1   1.3 IFL      500
                                    7  32.5   1.3 IFL      500
                                    8  30.0   1.2 IFL      500
                                    9  18.6   0.9 IFL      500
                                   10  17.8   1.4 IFL      500
                                   11   0.0   0.0 IFL      500
                                   12   0.0   0.0 IFL      500
                                   13   0.0   0.0 IFL      500
                                   14   0.0   0.0 IFL      500
                                       -----  ----
                                 LPAR 378.1  16.4
```

LPAR Options

Time Slice: Dynamic, used exclusively

Weights: Sets priority between Logical Partitions

Virtual processors

Capping

- Limits Assigned time to LPAR
- Useful for outsourcing, fixed contracts

Wait Completion

- “no” gives up processor if idle (default)
- “yes”, Partition keeps processor even if idle (rarely/never used)

LPAR Dispatching

CEC Processor Utilization:

- Physical overhead
- Assigned time (physical cpu assigned to logical cpu)
  - Logical overhead
  - Assigned time (work)

Each LPAR gets a “Share”

LPAR was based on CP, much of LPAR has the same concepts as CP

Physical overhead is cost of dispatching lpar vcpus

LPAR Overconfigure worst Case Study

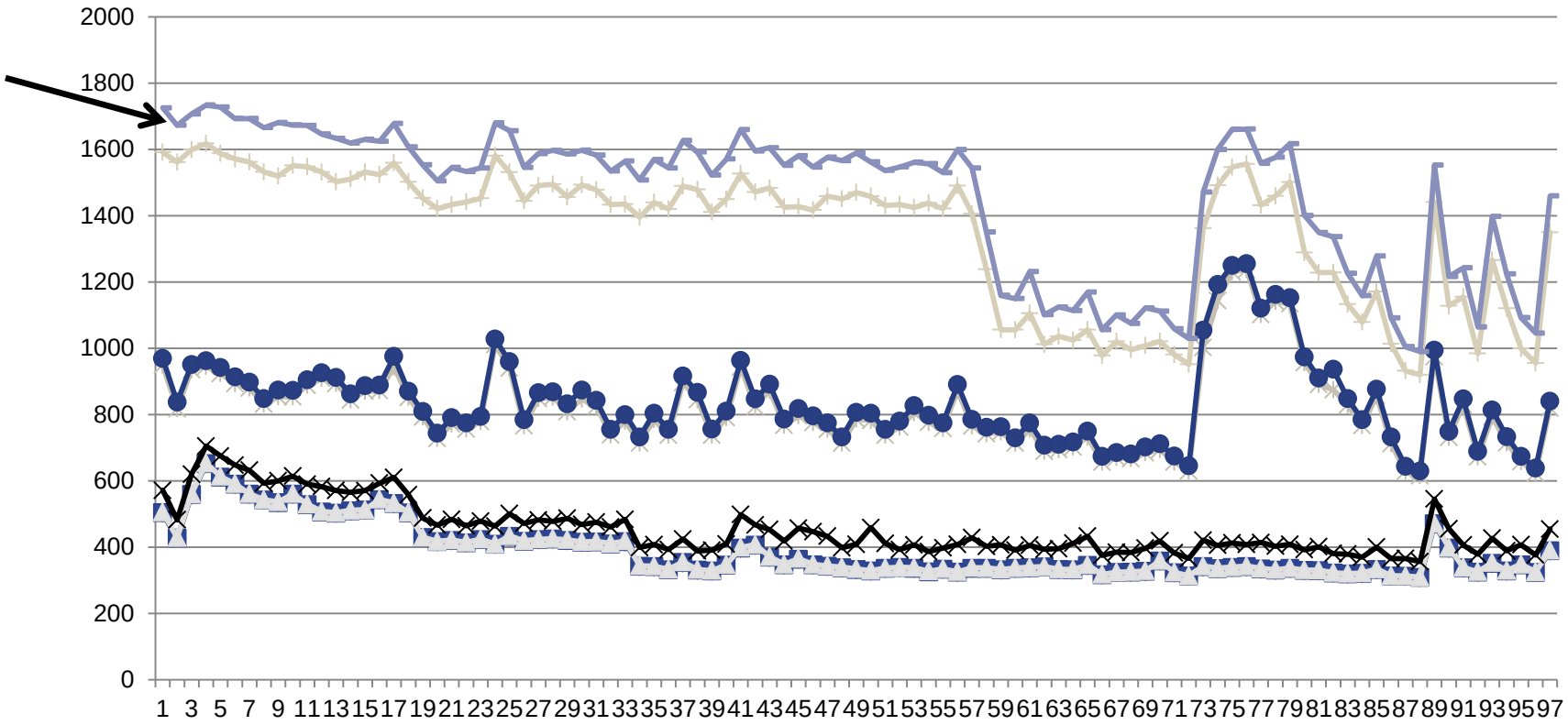
Linux Servers

- 120 servers total (Big, ORACLE)
  - 4gb-40gb
    - (1 / 2 size from original SUN servers)

Hardware

- 17 IFLs
  - 7 servers per IFL
  - 395 vcpus (23:1 overcommit)
- 7 LPARs, each with 17 VCPU
  - Worst case possible for overhead

LPAR Configuration Overhead



17 IFLs, 7 lpars, 17 vcpus each, 7:1 overcommit

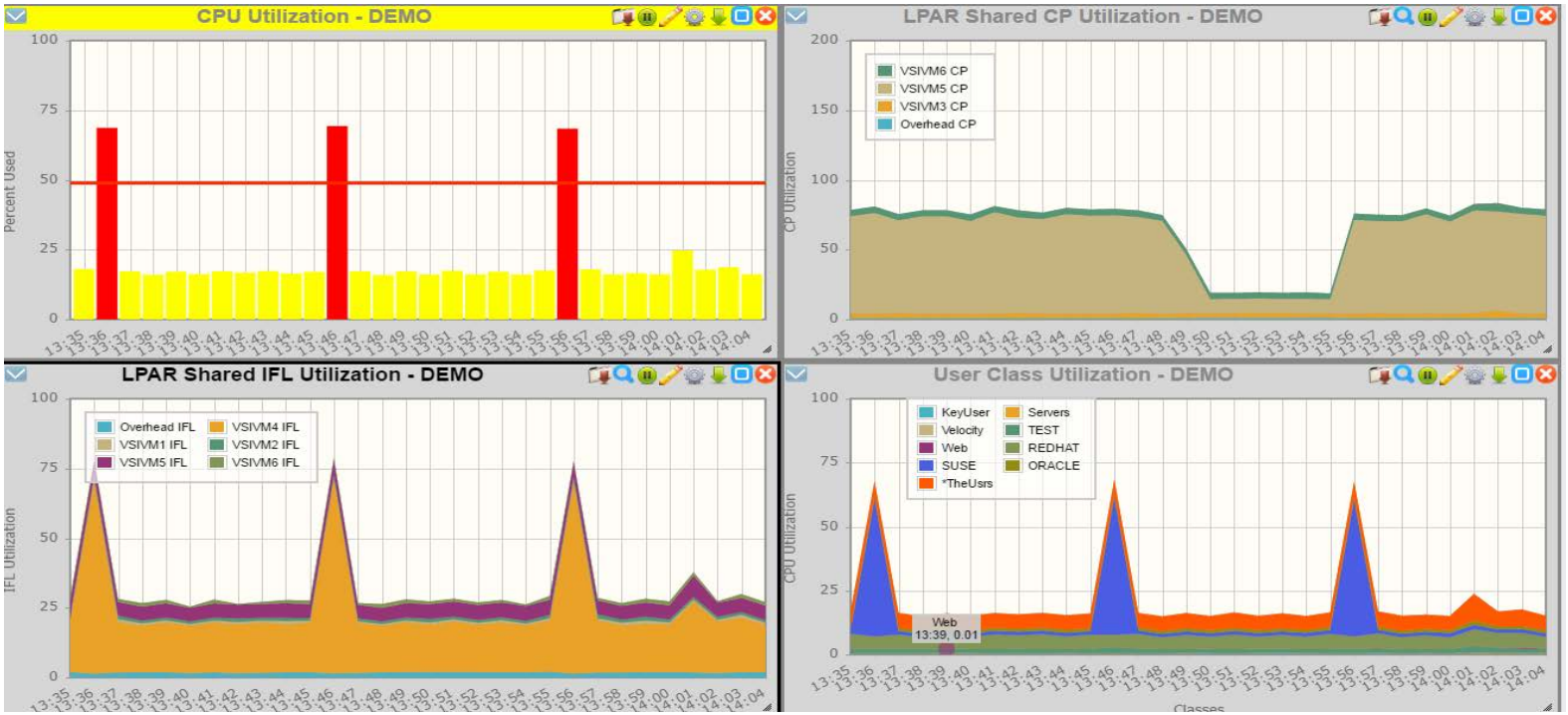
Physical Overhead significant from real processor overcommit

VELOCITY SOFTWARE

PROVEN PERFORMANCE

Analyzing IFL Consumption

- zVIEW, 4 charts (default subset)
- IFL utilization, CP utilization
- z/VM LPAR utilization, by workload (classes)



Managing Distribution - What is my share?

CPU distribution depends on

- LPAR Weight (and impact of other LPARs)
- Share within z/VM LPAR
- Impact of other virtual servers

Share analysis:

- ESALPARS for LPAR / IFL utilization
- ESALPARS for LPAR allocation
- ESACPUU / ESACPUA for z/VM perspective
- ESAUSRC for share settings
- ESAUSP2 for how much am I getting out of used

“z” Processor Overview (ESAHDR)

```
Machine Model/Type                    z9EC:2094/707
System Sequence Code                 000000000006EA7D
Processor  0 model/serial           2094-707  /0AEA7D Master
Processor  1 model/serial           2094-707  /0AEA7D
Processor  2 model/serial           2094-707  /0AEA7D
Processor  3 model/serial           2094-707  /0AEA7D

 ESAME (Memory Extension) Nucleus in use
 Power of processor in terms of service Units: 25000
 ESA/370 hardware installed
 Operating on IFL Processor(s)
 Channel Path Measurement Facility(CPMF) Extended is installed
```

Service units from table

Understand the

- CEC (two books)
- z/VM (IFLs)

Processor Measurement

```
Report: ESACPUU      CPU Utilization Report                          Linux Test
Monitor initialized: 05/06/08 at 12:00:00 on 2094 serial AEA7D     First record analyzed:
-------------------------------------------------------------------------------------
         <----Load---->     <-----CPU (percentages)-----> <------External (per second)---
         <-Users-> Tran     Total  Emul  User   Sys  Idle <--Page---> <--Spool-->  RSCH+
Time     Actv In Q /sec CPU  util  time ovrhd ovrhd  time  Read Write  Read Write  SSCH
-------- ---- ---- ---- -  ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
12:01:00  103  118  9.1  0   92.8  88.6   2.3   1.9   7.2    11    52     0     0   220
                          1   93.8  90.5   2.2   1.0   6.2    14     0     0     0   182
                          2   94.4  90.9   2.2   1.2   5.6    17     0     0     0   196
                          3   94.5  90.9   2.1   1.5   5.5    13     0     0     0   179
                             ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
System:                     375.4 361.0   8.9   5.5  24.4    55    52     0     0   778
```

- **Processor utilization has three components:**
  - Emulation time – running users in Interpretive Execution
  - User overhead – CP time performing services for a user
  - System overhead – CP “housekeeping”
  - Note master processor – only problem if architecturally constrained

Processor Measurements User View

ESAUSP2:

CPU Consumption in percent

- Total all user
- By user
- By Class

Note

- one server dominates CPU
- Capture ratio

T:V Ratio is Total to Virtual, 1.0 is good

```
Report: ESAUSP2      User Resource Rate Report
Monitor initialized: 05/06/08 at 12:00:00 on 2094 serial
-------------------------------------------------------
         <---CPU time--> <----Main Storage (pages)----->
UserID   <(Percent)> T:V <Resident> Lock <-----WSS----->
/Class    Total  Virt Rat Totl Activ  -ed Totl Activ  Avg
-------- ----- ----- --- ---- ----- ---- ---- ----- ----
12:01:00 369.9 361.0 1.0  17M   17M  417  17M   17M 129K
 ***User Class Analysis***
*Servers  1.95  1.72 1.1 7566  7555   49 8674  7444  207
*CMSUser  0.00  0.00  23    0     0    0   63    63   63
*Linux   184.0 180.6 1.0  15M   15M  305  15M   15M 185K
*Misc    183.7 178.5 1.0   2M 1642K   11   2M 1642K 328K
 ***Top User Analysis***
LXPWK001 183.5 178.4 1.0   2M 1641K    3   2M 1641K   2M
LXWKB215 37.63 37.01 1.0 782K  782K    1 782K  782K 782K
LXWKB211 33.97 33.88 1.0 514K  514K    0 514K  514K 514K
LXWKB210 17.64 17.55 1.0 298K  298K    2 298K  298K 298K
LXWKB214 16.86 16.68 1.0   1M 1188K    0   1M 1254K   1M
LXWKB228  6.01  5.98 1.0 731K  731K    3 731K  731K 731K
LXWKB222  5.06  4.94 1.0 621K  621K    5 621K  621K 621K
LXWKB183  4.70  4.57 1.0 231K  231K    0 230K  230K 230K
LXWKB220  3.69  3.66 1.0 125K  125K    8 124K  124K 124K
LXWKB225  3.65  3.52 1.0 780K  780K    0 780K  780K 780K
ESATCP    0.45  0.35 1.3 1038  1038    1 1037  1037 1037
TCPIP2    0.02  0.01 2.0 1142  1142   48  198   198  198
```

Master Processor Overview

Much system code NOT re-entrant

- Must be single threaded
- Can not update one control block by multiple processors simultaneously

Implementation

- hardware locks: TS, CS, CDS instructions
- software locks: “ownership” of resources
  - (such as in database)
- running on the Master Processor

SPIN Locks

- Test for lock, if fail, test for lock
- Linux uses “spin lock”, replaced with Diag44 -> DIAG9C
- Linux spin locks an issue, cost in CPU

Resource Serialization Master Processor

Many CP processes run "master only" to ensure the integrity of the system

- Spooling
- some IUCV services (*MSG, *RPI, *ACCOUNT from CP)
- Page migration
- execution of ALL CP commands
- Line mode console I/O

Master processor utilization shows up as higher System Overhead and User Overhead on the Master Processor.

Higher Master CPU busy is worse on a system with more processors.

- Master calls is measured
- Simulation wait is measured
- Processor imbalance can be a problem

Master Processor Problem

CPU Example

- User overhead high on master
- System overhead high on master
- Master processor can be a limiter

```
Report: ESACPUU      CPU Utilization
-------------------------------------------------------------------------------------------------
         <----Load---->     <-----CPU (percentages)-----> <------External (per second)------->
         <-Users-> Tran     Total  Emul  User   Sys  Idle <--Page---> <--Spool-->  RSCH+
Time     Actv In Q /sec CPU  util  time ovrhd ovrhd  time  Read Write  Read Write  SSCH  ExInt
-------- ---- ---- ---- --- ----- ----- ----- ----- ----- ----- ----- ----- ----- -----  -----
09:19:12    7  5.0  0.1   1  99.4  20.9  58.8  19.8     0     0     0     0     0     3    140
                       2   84.7  43.6  30.7  10.3  15.0     0     0     0     0     0    154
                       3   84.2  43.2  30.9  10.1  15.5     0     0     0     0     0    153
                       4   84.5  43.6  31.1   9.7  15.2     0     0     0     0     0    155
                           ----- ----- ----- ----- ----- ----- ----- ----- ----- -----  -----
System:                    352.7 151.3 151.6  49.9  45.7     0     0     0     0     3    602
```

Would adding another processor help this system?

MASTER Processor Analysis

- **Investigating Master Overhead**
  - User overhead high on master
  - System overhead high on master
  - All spool I/O performed by master Note I/O lower on master?
- **ESAIUCV: RPI, MSG IUCV**
- **ESACPUA: Page migration, Spool I/O**

```
          <----Load--->     <-----CPU (percentages)-----> . <---External (per second)->
         <-Users> Tran     Total  Emul  User   Sys  Idle . <--Page--> <-Spool--> RSCH+
Time     Actv InQ /sec CPU  util  time ovrhd ovrhd  time . Read Write Read Write SSCH
-------- ---- --- ---- -  ----- ----- ----- ----- ----- . ---- ----- ---- ----- ----
10:21:09  255  20 23.9  0   86.4  16.7  53.6  16.2  13.4 .   60    71    9     4   86
                      1   67.9  35.9  23.7   8.4  31.9 .   82    56    0     0  135
                      2   69.5  36.4  24.5   8.7  30.3 .   89    58    0     0  140
                      3   67.0  35.4  23.2   8.4  32.8 .   76    71    0     0  134
                         ----- ----- ----- ----- ----- . ---- ----- ---- ----- ----
System                   290.9 124.3 124.9  41.7 108.4 .  307   256    9     4  496
```

Processor Local Dispatch Vectors

- **Users are selected for dispatch from a PLDV.**
- **Each processor has a local PLDV.**

- **Master ONLY PLDV**
  - Some work for users
  - Some System work
  - The System VMDBK

- **The System VMDBK and users on the Master Only PLDV are dispatched on the Master Processor.**

Dispatch Vector Activity

Report: ESAPLDV Processor Local Dispatch Vector Activity Linux Test ESAMAP 3.7.4

	<----Users----->			Tran		<VMDBK Moves/sec>		<--------PLDV Lengths------>					Dispatcher
Time	Logged	Actv	In Q	/sec	CPU	Steals	To Master	Avg	Max	Mstr	MstrMa	%Empty	Long Paths
12:01:00	129	103	118	9.1	0	0	2.5	3.2	4.0	0.0	1.	8.3	4497.1
					1	0	0	2.1	4.0	.		38.3	3942.1
					2	0	0	2.0	4.0	.		41.7	3942.7
					3	0	0	1.8	3.0	.		38.3	3741.7
System:						0	2.5	9.2	15.0	0.0	1.	126.7	16123.5

- **The Dispatcher selects users from the CPU's Processor Local Dispatch Vector (PLDV).**
- **Each processor has a Local PLDV.**
- **The Master Processor has a special PLDV from which "master only" work for users is selected.**

Processor Utilization (Is it correct?)

- **Why is the Linux LPAR always 100% busy? (RMF)**
  - Dedicated processors show up as 100%
- **Processor utilization measurements are NOT consistent between products/commands**
  - This matters when running second level, or in an LPAR
  - CP Indicate shows percent of what is available
  - CP Does NOT KNOW what is available
- **ESAMON/ESAMAP show absolute utilization**
  - LPAR information is available
- **Measuring Linux under VM or LPAR had same issue**

  Linux reported a percent of a percent busy

Effects of Logical Partitioning

```
Report: ESASSUM Subsystem Activity Velocity Software, Inc.
-------------------------------------------------------------------------------------------------------------
         <---Users----> Transactions <Processor> Storage (MB) <-Paging--> <-----I/O-----> <MiniDisk> Spool
         <-avg number->    Per  Avg. Utilization Fixed Active <pages/sec> <-DASD--> Other <-Cache--> Page
Time       On Actv In Q Minute  Resp Total Virt.  User Resid. XStore DASD Rate Resp  Rate  Rate %Hit Rate
-------- ---- ---- ---- ------ ----- ----- ----- ----- ------ ------ ---- ---- ---- ----- ----- ---- -----
08:00:08 1479  244 34.3 1310.1 0.603   124    87  36.9  192.0    888  451  641 15.4    40 687.9 49.3    36
08:01:08 1500  248 46.0 1260.9 0.543   147   110  37.3  192.7    904  494  732 20.1    37 881.6 53.9    32
*************************************************Summary*************************************************
Average: 1483  245 37.3 1297.8 0.589   130    93  37.0  192.1    892  461  664 16.7    39 736.4 50.7    35
```

- **A high-level view of processor utilization shows a system with some capacity to spare.**
- **Next step, look at processor configuration**

Effects of Logical Partitioning

Report: ESACPUU CPU Interval Analysis Velocity Software, Inc.

	<----Load---->				<-----CPU (percentages)----->					<---Internal (per second)---->				
	<-Users->		Tran		Total	Emul	User	Sys	Idle	Diag-	Inst.	SIE	Fast	Page
Time	Actv	In	Q /sec	CPU	util	time	ovrhd	ovrhd	time	nose	sim.	intrcp	path	fault
08:00:08	244	34.3	24.6	0	48.5	27.3	16.7	4.5	9.9	1449	1478	1753	0	18
				1	35.9	28.8	5.2	1.9	11.8	818	599	716	0	9
				2	39.5	31.4	5.9	2.2	13.5	902	682	815	0	11
System:					124.0	87.4	27.9	8.7	35.3	3170	2758	3284	0	37
08:01:08	248	46.0	24.0	0	53.6	32.5	16.7	4.4	7.1	1557	1588	1806	0	24
				1	44.6	37.2	5.4	1.9	6.5	843	594	685	0	11
				2	48.8	40.2	6.4	2.2	7.4	903	704	817	0	12
System:					147.0	109.9	28.5	8.6	21.0	3303	2886	3308	0	48

- **A more detailed view of processor utilization seems to confirm this hypothesis. CPU to spare.**

Effects of Logical Partitioning

```
Report: ESAXACT Transaction Analysis Velocity Software, Inc.
-------------------------------------------------------------------------------
                    <--------------Percent non-dormant------------------>
UserID    <-Samples->                     E-  D-  T-     Tst             Lim Pct
/Class    Total  In Q Run Sim CPU SIO Pg SVM SVM SVM CF Idl I/O Ldg Oth Lst Elig
--------  ----- ----- --- --- --- --- -- --- --- --- -- --- --- --- --- --- ----
System:    5936   149 5.4  34 8.7   0  3   0   0 6.0  2  36 4.7   .   0   .    0
Hi-Freq: 176K   7057 2.0  17 2.8   0  1   0 3.8 4.2 49  17 3.1   0   0   .    0
***Resource use by User Class
*Servers 3720    568 3.0  29 4.2   0  0   0  21 6.9  1  28 7.6   0   0   .    0
*Keys    1080    490 1.6 0.6 6.7   0  0   0  16  19  1  43  13   0   0   .    0
*TheUsrs 172K   6108 1.9  16 2.6   0  1   0 1.2 3.0 57  14 2.5   0   0   .    0
```

- **User state sampling shows significant amount of CPU wait as compared to “Running”, Simulation wait even greater.**

Effects of Logical Partitioning

```
Report: ESALPAR Logical Partition Analysis Velocity Software, Inc.
-------------------------------------------------------------------------------------------------
         <----Load----> <--Complex--> <--Logical-> <--------Logical Processor---------->
         <-Users-> Tran Phys Dispatch <-Partition> VCPU <%Assigned>       Cap- Wait
                          Slice    Name     No. Addr Total Ovhd Weight  ped Comp      e
-------- ---- ---- ---- ---- -------- -------- --- ---- ----- ---- ------ ---- ----
08:00:08  244 34.3 24.6    3  Dynamic CMS2       1    0  58.7  0.2    155   No  Yes
                                                    1  47.8  0.1    155   No  Yes
                                                    2  53.2  0.1    155   No  Yes
                                                       ----- ----
                                                  LPAR 159.7  0.4

                                    SWCF       2    0  36.6  0.1    130   No  Yes
                                                    1  43.0  0.1    130   No  Yes
                                                    2  46.7  0.1    130   No  Yes
                                                       ----- ----
                                                  LPAR 126.3  0.3

                                    CMS8       3    0   9.1  0.1     15   No  Yes
                                                    1   4.6  0.2     15   No  Yes
                                                       ----- ----
                                                  LPAR  13.7  0.3

Total Logical Partition busy:                          299.6
Total Physical Management time: 0.366
```

- **This system does not have access to 100% of each processor.**
- **Reducing CMS2 LPAR to 2 processors will perform better.**

Processor Capture Ratio

```
Report: ESASSUM      Subsystem Activity
-------------------------------------------------------
         <---Users----> Transactions <Processor>  Captur
         <-avg number->    Per  Avg. Utilization   Ratio
Time       On Actv In Q Minute  Resp Total Virt.  (pct)
-------- ---- ---- ---- ------ ----- ----- -----  ------
16:26:00  741  154 27.0  765.0 0.521   799   678   99.96
16:27:00  738  136 41.0  602.0 0.356   693   585   99.99
16:28:00  740  131 31.0  695.0 0.318   688   589   99.99
16:29:00  739  159 32.0  665.0 0.437   858   735  100.09
16:30:00  738  154 34.0  783.0 0.435   656   558  100.04
***********************************************
Average:  738  157 35.9  793.6 0.416   740   632   99.50
```

Capture ratio is CPU accounted for / CPU used

Capture ratio critical for capacity planning, chargeback

Unique methodology

Managing the delivery of CPU Resource

Options for tuning processor

- **Reducing overhead**
  - Application tuning to reduce processor demand
  - Reducing system overhead
- **Reallocating resources**
  - Adjust SHARE values
  - Limit DSPBUF occupancy
  - Dedicate processors
  - Interactive BIAS (SET SRM IABIAS)

Limiting Shares

```
Q  share vmservu
USER VMSERVU :RELATIVE SHARE= 100 MAXIMUM SHARE= NOLIMIT
Ready; T=0.01/0.01 16:58:54
```

LIMITs

- LIMITHARD caps resource consumption regardless of other user demands
- LIMITSOFT caps resource consumption unless all users have received their target minimum, and there are no unlimited users who can consume resources

```
set share vmservu relative 200 500 limitsoft
USER VMSERVU : RELATIVE SHARE= 200 MAXIMUM SHARE=LIMITSOFT
RELATIVE 500
Ready; T=0.01/0.01 17:01:12
```

```
set share mvsys1 abs 5% abs 20% limithard
USER MVSYS1 : ABSOLUTE SHARE = 5%
MAXIMUM SHARE = LIMITHARD ABSOLUTE 20%
Ready; T=0.01/0.01 14:40:49
```

Adjusting DSPBUF values

- **The purpose of the Dispatch Buffer (DSPBUF) is the limit on the number of users of each Scheduler class allowed in the Dispatch List – thereby controlling CPU utilization**
- **If CPU is 100% busy, try lowering the Q3 value.**
  - Watch CPU busy very carefully.
- **What happens if DSPBUF is lowered too far for Q3?**
  - (Hint: How is Elapsed Time Slice determined?)
- **Experimenting with DSPBUF is not for the casual tuner or the faint of heart.**

I/O Processor - SAP

I/O Processor is another type of processor

If I/O processor overloaded, determine why.

- Is I/O Slow with no explanation?
- Could be iop….
- ESCON and Ficon mixed channels?
- DASD Cache performing poorly?

```
Report: Report: ESAIOP        I/O Processor Analysis
-------------------------------------------------------------------
          I/O  <-----------------I/O Processor-------------------->
          Proc <Pct Util> <Rate/Second>  <-Percent of Strts busy->
Time      Nmbr Busy  Idle  SSCH Intrpts  chan switch CtlUnit Device
--------  ---- ---- ----- ----- -------  ---- ------ ------- ------
21:22:00    0  65.8  34.2  2690    2402  1488   12.7     0.3    1.5
            1  55.6  44.4  2939    3686   837    4.3     0.3    0.1
            2  54.2  45.8  1684    2979  1756    0.6     0.5    0.4
21:27:00    0  50.6  49.4  2227    2190  1374   12.6     0.4    0.9
            1  39.8  60.2  2540    2997   648    3.6     0.4    0.2
            2  41.2  58.8  1711    2691  1334    0.7     0.4    0.5
```

I/O Processor is another type of processor

If I/O processor overloaded, determine why.

- Is I/O Slow with no explanation?
- Could be iop….
- ESCON and Ficon mixed channels?
- DASD Cache performing poorly?

```
Report: Report: ESAIOP       I/O Processor Analysis
Report: ESAUSRQ      User Queue and Load Analysis                    Veloc
Monitor initialized: 05/22/08 at 14:00:00 on 2084 serial 15BAF       First
-------------------------------------------------------------------------
         <-----------User Load------------>      <-----------Average Num
UserID   Logged  Non-          Disc- Total  Tran <-------Dispatch List--
/Class       on  Idle  Active  conn  InQue  /min    Q0    Q1    Q2    Q3
-------- ------ ----- ------- ------ -----  ---- ----- ----- ----- -----
14:01:00 1061.0     .   156.0      .  20.0  1175   5.0   6.0   2.0   7.0
14:02:00 1063.0     .   157.0      .  25.0  1184  10.0   5.0   4.0   6.0
14:03:00 1064.0     .   188.0      .  52.0  1423   3.0   2.0   8.0  39.0
14:04:00 1062.0     .   203.0      .  38.0  1245   3.0   1.0   6.0  28.0
14:05:00 1061.0     .   193.0      .  46.0  1228   5.0   8.0   4.0  29.0
…….
14:18:00 1064.0     .   154.0      .  31.0  1185  10.0   5.0   6.0  10.0
14:19:00 1065.0     .   161.0      .  36.0  1130   6.0   4.0   3.0  23.0
```

User's complain, InQueue skyrockets, why?

- Impact really is quickdsp and Q3 –Really long running transactions.

```
Report: ESAUSRQ      User Queue and Load Analysis                    Veloc
-------------------------------------------------------------------------
         <-----------User Load------------>     <-----------Average Num
UserID   Logged  Non-           Disc- Total  Tran <-------Dispatch List--
/Class       on  Idle  Active  conn  InQue  /min    Q0    Q1    Q2    Q3
-------- ------ ----- ------- ------ -----  ---- ----- ----- ----- -----
14:01:00 1061.0     .   156.0      .  20.0  1175   5.0   6.0   2.0   7.0
14:02:00 1063.0     .   157.0      .  25.0  1184  10.0   5.0   4.0   6.0
14:03:00 1064.0     .   188.0      .  52.0  1423   3.0   2.0   8.0  39.0
…….
14:18:00 1064.0     .   154.0      .  31.0  1185  10.0   5.0   6.0  10.0
14:19:00 1065.0     .   161.0      .  36.0  1130   6.0   4.0   3.0  23.0
14:20:00 1065.0     .   186.0      .  47.0  1143  13.0   3.0   1.0  30.0
14:21:00 1066.0     .   190.0      .  72.0  1140  25.0  15.0   8.0  24.0
14:22:00 1065.0     .   213.0      .  73.0  1189  35.0   3.0   1.0  34.0
14:23:00 1067.0     .   243.0      .  88.0  1157  31.0   3.0   1.0  53.0
14:24:00 1067.0     .   259.0      .  81.0  1105  11.0   2.0   5.0  63.0
14:25:00 1067.0     .   215.0      .  46.0   932  12.0   6.0   3.0  25.0
…..
14:30:00 1069.0     .   266.0      . 108.0  1227  34.0   6.0   7.0  61.0
14:31:00 1069.0     .   274.0      . 116.0  1183  30.0   2.0   2.0  82.0
14:32:00 1067.0     .   266.0      . 126.0   960  47.0   4.0   5.0  70.0
14:33:00 1067.0     .   257.0      . 105.0  1230  43.0   7.0  13.0  42.0
```

Check processor, cpu is a constant, I/O is constant

Report: ESASSUM Subsystem Activity Velocity Software

	<---Users---->			Transactions	<Processor>		Storage (MB)		<-Paging-->		<-----I/O----->		
	<-avg number->			Per	Avg.	Utilization			Fixed	Active	<pages/sec>	<-DASD-->		Other
Time	On	Actv	In Q	Minute	Resp	Total	Virt.	User	Resid.	XStore	DASD	Rate	Resp	Rate
14:01:00	1061	156	20.0	763.0	0.733	41	35	18.5	999.5	5	5	536	1.0	27.5
14:02:00	1063	157	25.0	803.0	0.594	41	35	18.5	1022.0	7	4	634	1.0	27.8
14:03:00	1064	188	52.0	981.0	1.112	41	35	18.5	1162.0	7	5	318	1.0	33.4
14:18:00	1064	154	31.0	729.0	1.055	41	36	18.5	986.5	0	3	277	1.0	26.3
14:19:00	1065	161	36.0	727.0	0.704	41	34	18.5	1061.1	226	3	303	1.3	35.3
14:20:00	1065	186	47.0	773.0	1.954	41	35	18.5	1315.9	432	2	377	1.1	30.8
14:21:00	1066	190	72.0	843.0	2.160	41	34	18.7	1308.9	1	2	769	0.8	38.9
14:22:00	1065	213	73.0	833.0	2.367	41	35	18.7	1394.9	1	3	548	0.9	31.1
14:23:00	1067	243	88.0	830.0	2.824	41	35	18.9	1537.0	1	3	858	0.8	29.8
14:24:00	1067	259	81.0	775.0	2.389	41	34	18.7	1660.4	13	3	683	0.8	18.2
14:25:00	1067	215	46.0	509.0	1.095	41	34	18.7	1452.4	8	2	583	0.8	28.5
14:30:00	1069	266	108	838.0	1.623	41	35	19.2	1618.2	5	3	511	0.8	28.8
14:31:00	1069	274	116	787.0	0.655	41	35	19.2	1630.7	8	3	569	0.8	29.0
14:32:00	1067	266	126	650.0	1.191	41	34	19.2	1580.9	4	3	774	0.8	30.7

Check LPAR Configuration

- Check weights
- VM shares with MVS and TEST, share is 179 / (179+260+5) = 40%
- (Only one CP defined)
- VM LPAR is capped!!!! At 40% of one CPU. VM running 100%

```
Report: ESALPARS     Logical Partition Summary   Velocity Software
-------------------------------------------------------------------------------------------
          <--Complex--> <-------Logical Partition--->  <-Assigned Shares---->             Proce
          Phys Dispatch              Virt <%Assigned>  <---LPAR--> <VCPU Pct> Cap-  Wait Type
Time      CPUs    Slice Name     Nbr CPUs Total  Ovhd  Weight  Pct /SYS /CPU  ped   Comp
--------  ---- -------- -------- --- ---- -----  ----  ------ ---- ---- ----  ----  ---- ----
14:01:00     1  Dynamic Totals:    0    3  80.4   0.5     444  100                          
                        VM         1    1  41.2   0.1     179 40.0 40.0 40.0   Yes    No CP
                        MVS        2    1  39.2   0.4     260 59.1 59.1 59.1    No    No CP
                        TEST       3    1     0     0       5  1.0 0.96 0.96    No    No CP
                        TESTTEST   5    0
```

Processor Case Study

Check User Wait States

- Running went down as percent of non-dormant, inqueue time.
- CPU wait stayed the same
- Asynchronous I/O wait is bottleneck – but DASD I/O was constant?
- Clue – something was on the Limit List – this is result of SHARE CAP
- Wait state sampling tests I/O Wait before testing Limit. If I/O wait, stops.

```
Report: ESAXACT      Transaction Delay Analysis                    Velocity Software
-------------------------------------------------------------------------------------
                     <---------------Percent non-dormant---------------------->        Times
UserID   <-Samples->                        E-  D-  T-     Tst <Asynch>        Lim  Pct     I/O
/Class   Total  In Q Run Sim CPU SIO Pag SVM SVM SVM  CF Idl I/O Pag Ldg Oth Lst Elig  Throttl
-------- ----- ----- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ----  -------
14:01:00  1061    20 5.0 5.0  40   0   0   0   0  10   0  35   0       .   0   0    0        .
Hi-Freq: 62599  1880 3.1 1.5  39 2.8   0   0  23 4.3 3.3  22 0.8   0   0   0 3.0    0        0
-------------------------------------------------------------------------------------
14:31:00  1069   116 0.9 0.9  34   0   0   0   0 1.7   0 3.4  59       .   0   0    0        .
Hi-Freq: 64140  7755 0.7 1.2  39 1.0   0   0 9.1 2.1 0.3 4.0  42   0   0 0.5   0    0        0
-------------------------------------------------------------------------------------
14:32:00  1067   125   0 4.0  46   0   0   0   0 2.4   0 5.6  42       .   0   0    0        .
Hi-Freq: 64020  7508 0.8 1.2  42 1.0   0   0 8.7 2.1 0.3 3.7  40   0   0 0.5   0    0        0
```

Processor Case Study

Check User Share settings

- Cap on the database servers
- CPU consumption reaches point where database servers are limited
- Fall over the cliff
- Solution: Remove all caps. z/VM does a better job

```
Report: ESAUSRC      User Configuration
-------------------------------------------------------------
                                    <---------SHARE--------->
                 Account  ACI Grp  <Normal> <-Maximum>
UserID   ClassID Code     Name      Rel Abs Type Share Limit
-------- -------- -------- -------- ---- --- ---- ----- -----
TIFSHRE  *BMAdmn  SYSTEMS          .  200   .  Abs  10.0  Soft
TIFSHRE2 *BMAdmn  SYSTEM           .  200   .  Abs  10.0  Soft
TIFSHRE3 *BMAdmn  SYSTEMS          .  200   .  Abs  10.0  Soft
TIFSHRE4 *BMAdmn  SYSTEM           .  200   .  Abs  10.0  Soft
```