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The Many CPU Fields Of SMF

Cheryl Watson

Watson & Walker, Inc.

www.watsonwalker.com - home of Cheryl Watson's Tuning Letter, CPU Charts, BoxScore and GoalTender

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Agenda

- Sources of SMF CPU Usage
- What is a CPU Second?
- CPU Field Precision
- Normalization
- Address Space CPU Usage
- Service Class CPU Usage
- LPAR Usage
- CEC Usage
- CPU Variability
- References

Sources of CPU Information in SMF

- RMF CPU Records (Type 70)
  - CEC CPU usage, LPAR usage, zIIP usage, zAAP usage, IFL usage, CF usage
- RMF Workload Activity Records (Type 72)
  - CPU usage by service class period
- SMF Address Space Activity (Type 30)
  - CPU usage by address spaces, including cross-address space, and cross-system usage

Additional Sources of CPU Information

- DB2 Records (Type 102)
- CICS Records (Type 110)
- MQ Records (Type 115)
- WAS Records (Type 120)
- WebSphere Message Broker (Type 117)
- HTTP Server (Type 103)
- Hardware (Type 113)
- RMF Monitor II (Type 79)
  - CPU usage by address spaces and enclaves
- TSO/E (Type 32)

CPU Time Precision

- CPU fields
  - .01 – most fields are in hundredths of seconds
  - .001 – milliseconds
  - .001024 – 1024-microseconds units (and 1.024-millisecond units)
  - .000128 - 128-microsecond units
  - .000001 – TOD field, where bit 51 is one microsecond
  - .000000625 – one service unit (a sixteenth of a microsecond)

What is a Second?

- A CPU second is defined as one clock second
- Theoretically, a job that takes one second of CPU time on a machine will take two seconds of CPU time on a machine that is half as fast, or one-half second on a machine that is twice as fast. Does this happen?
- For chargeback or capacity planning, how do you measure the speed of a machine?

Normalization

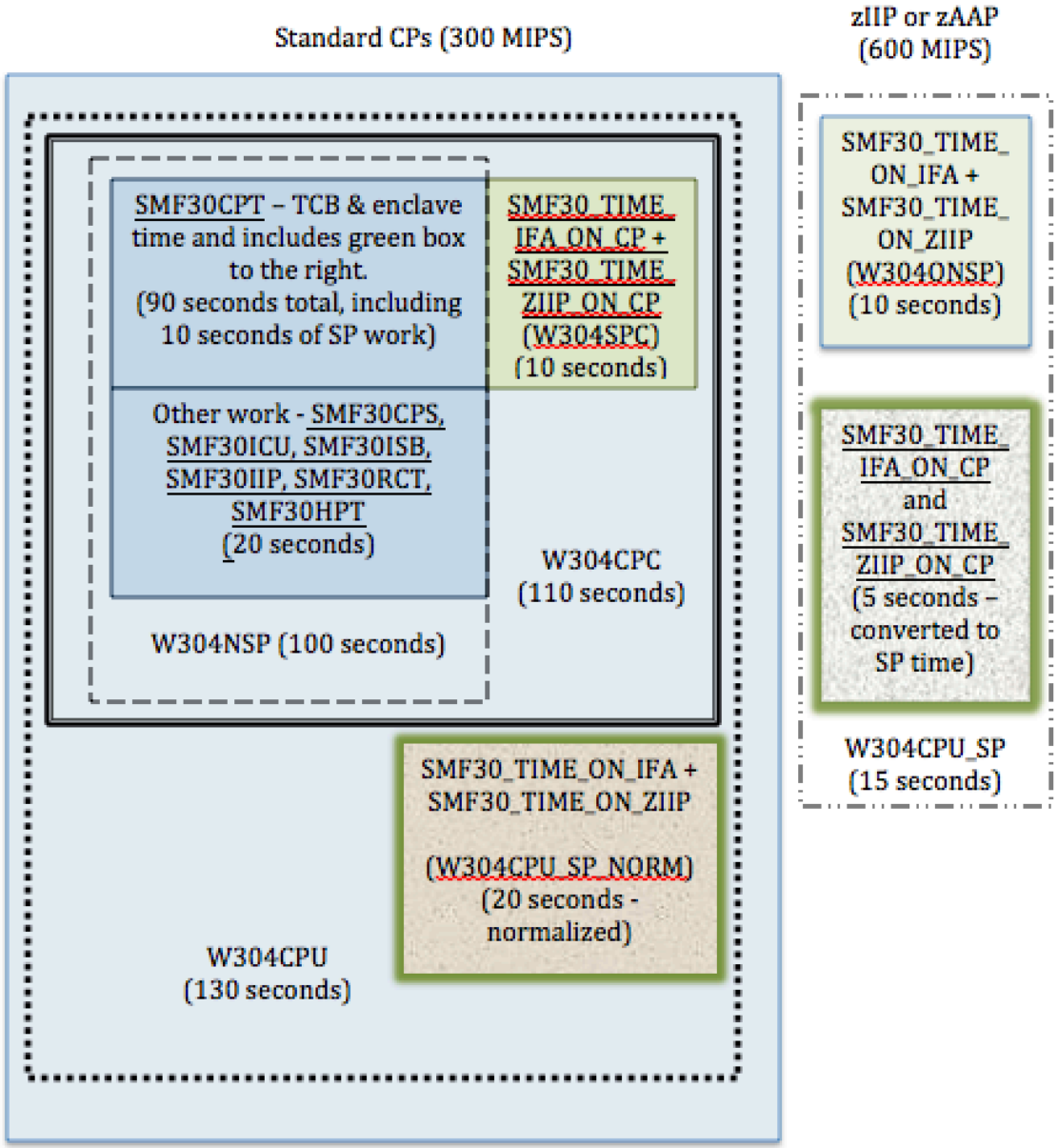
- Different Speed CECs
  - What is the normalization factor for chargeback or capacity planning?
  - Most sites use LSPR ratios, MIPS from CPU charts, or service units
  - Example:
    - z196 2817-501 1-way has an LSPR ratio of 1.05, is 588 MIPS, and has a published service unit/second (su/sec) rate of 30888.0309
    - z196 2817-701 1-way has an LSPR ratio of 2.15, is 1202 MIPS, and has a published su/sec rate of 61776.0618
    - Notice ratios: 1202/588 = 2.04; 61776.0618/30888.0309 = 2.0;
      2.15 / 1.05 = 2.05

Normalization

- "Knee-capped" CPUs
  - Base CPs run at a slower (degraded) speed, while zIIPs and zAAPs run at base speed
  - For example, the zIIP and zAAP on a 2817-501 1-way are the same speed as the 2817-701, which is twice as fast.
  - SMF records include normalization factor
  - Much of the session deals with handling the situations where specialty processors are not the same speed as the general CPs.
  - From Harv Emery's presentation in Atlanta (see references), the z196 has three series of machines that are knee-capped. The 4xx series is about 20% of a 7xx; the 5xx is about 49%; and the 6xx is about 64%

Address Space CPU Usage

- SMF Type 30 Records
  - 30.2 & 30.3 – Written at end of interval
  - 30.4 – Written at end of step
  - 30.5 – Written at end of job
  - CPU times are in hundredths of seconds (.01 seconds)
  - Some of the CPU time can be from CPs, some from zIIPs, some from zAAPs, and some from other LPARs or CECs



SMF Type 30

- Work that ran on the standard CPs (1 of 2)
  - SMF30CPT – TCB time, enclave time, preemptable SRB time, client SRB time and CPU time for work that was eligible for zIIPs & zAAPs, but that ran on the CP (last 2 fields on next page)
  - SMF30CPS – SRB CPU time that ran on the CP
  - SMF30ICU – TCB CPU time for initiator work; sum of SMF30ICU_STEP_INIT for this step and SMF30ICU_STEP_TERM from the previous step
  - SMF30ISB – SRB CPU time for initiator work; sum of SMF30ISB_STEP_INIT for this step and SMF30ISB_STEP_TERM from the previous step

SMF Type 30

- Work that ran on the standard CPs (2 of 2)
  - SMF30IIP – CPU time processing I/O interrupts (SLIH)
  - SMF30RCT – Region control task CPU time (startup and swapping)
  - SMF30HPT – CPU time spent moving Hiperspace data

  - SMF30_TIME_IFA_ON_CP – Work that is eligible for a zAAP, but that ran on the CP
  - SMF30_TIME_ZIIP_ON_CP – Work that is eligible for a zIIP, but that ran on the CP

SMF Type 30

- Work that ran on a zAAP or zIIP
  - SMF30_TIME_ON_IFA – Work that ran on a zAAP
  - SMF30_TIME_ON_ZIIP – Work that ran on a zIIP
- Potential work for zAAP
  - (SMF30_TIME_IFA_ON_CP * 256 / SMF30ZNF) + SMF30_TIME_ON_IFA
- Potential work for zIIP
  - (SMF30_TIME_ZIIP_ON_CP * 256 / SMF30SNF) + SMF30_TIME_ON_ZIIP

SMF Type 30

- Total work that ran on a CP
  - SMF30CPT + SMF30CPS + SMF30ICU + SMF30ISB + SMF30ICU + SMF30IIP + SMF30RCT + SMF30HPT

- Potential work for the CP
  - Total of above + (SMF30_TIME_ON_IFA * SMF30ZNF / 256) + (SMF30_TIME_ON_ZIIP * SMF30SNF / 256)

- SMF30ZNF and SMF30SNF = 256 if SPs are same speed as CPs

SMF Type 30

- Obtaining CPU time from service units:
  - SMF30SUS – Copy of RmctAdjC – number of sixteenths of one CPU microsecond per CPU service unit
  - SMF30CPC – CPU service definition coefficient, scaled by 10
  - SMF30SRC – SRB service definition coefficient, scaled by 10
  - SMF30CSU_L – CPU service units; this is equivalent to SMF30CPT plus normalized SMF30_TIME_ON_IFA plus normalized SMF30_TIME_ON_ZIIP; new in z/OS 1.11
  - SMF30SRB_L – SRB service units; this is equivalent to SMF30CPS; new in z/OS 1.11
  - SMF30ESU_L – Independent enclave CPU service units; new in z/OS 1.11

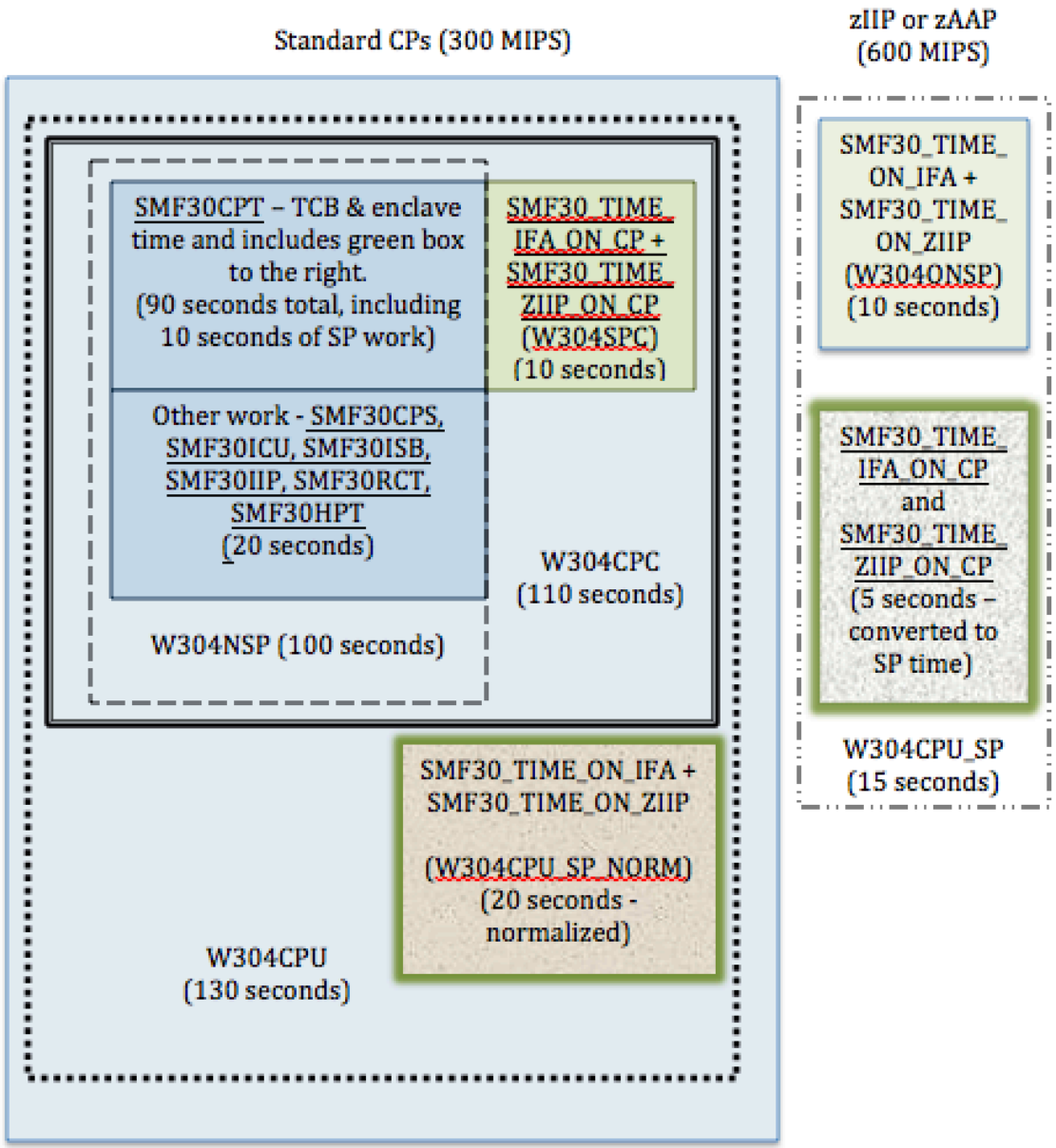
SMF Type 30

- Obtaining CPU time from service units:
  - To convert service units to CPU time in microseconds (.000001 seconds):

    TCB time = (SMF30CSU_L * (SMF30SUS / 16))
    / (SMF30CPC / 10)

    SRB time = (SMF30SRB_L * (SMF30SUS / 16))
    / (SMF30SRC / 10)

    Independent enclave time = (SMF30ESU_L * (SMF30SUS / 16))
    / (SMF30CPC / 10)
  - Why?
    - Use when precision of .01 is not sufficient
    - For TCB time from service units, remember to back out the zIIP and zAAP normalized times



SMF Type 30

- Consistency?
  - Most consistent is to normalize everything back to a CP and charge on that time (from diagram, that would be W304CPU of 130 seconds of 300 MIPS processor)
  - Also consistent is to have two values and charge different rates, so one is non-specialty work that can only run on a CP and the other is specialty work that would prefer to run on an SP (from diagram, that would be W304NSP of 100 seconds and W304CPU_SP of 15 seconds of 600 MIPS processor)
  - Actual time spent on each isn't consistent because it depends on parameter settings and the current load on the CPs and SPs

SMF Type 30

- Other CPU times if you want to get down and dirty:
  - SMF30ASR – CPU time used by preemptable SRBs and client SRBs; this is included in SMF30CPT
  - SMF30ENC – CPU time used by independent enclaves when in a WLM enclave; this is included in SMF30CPT
  - SMF30DET – Similar field for dependent enclaves
  - SMF30_ENCLAVE_TIME_ON_IFA – Independent enclave time spent on zAAP; this is included in SMF30_TIME_ON_IFA
  - SMF30_DEP_ENCLAVE_TIME_ON_IFA – Similar field for dependent enclaves

SMF Type 30

- More CPU times if you want to get down and dirty:
  - SMF30_ENCLAVE_TIME_IFA_ON_CP – CPU time used by independent enclaves on a CP that are eligible for zAAPs; this is included in SMF30_TIME_IFA_ON_CP
  - SMF30_DEP_ENCLAVE_TIME_IFA_ON_CP – Similar field for dependent enclaves
  - SMF30_ENCLAVE_TIME_ON_ZIIP – Independent enclave time spent on zIIP; this is included in SMF30_TIME_ON_ZIIP
  - SMF30_DEPENC_TIME_ON_ZIIP – Similar field for dependent enclaves

SMF Type 30

- More CPU times if you want to get down and dirty:
  - SMF30_ENCLAVE_TIME_ZIIP_ON_CP – CPU time used by independent enclaves on a CP that are eligible for zIIPs; this is included in SMF30_TIME_ZIIP_ON_CP
  - SMF30_DEPENC_TIME_ZIIP_ON_CP – Similar field for dependent enclaves
  - SMF30_ENCLAVE_TIME_ZIIP_QUAL – Normalized independent enclave time qualified to be on a zIIP; the eligible time achieved is in SMF30_TIME_ON_ZIIP and SMF30_TIME_ZIIP_ON_CP
  - SMF30_DEPENC_TIME_ZIIP_QUAL – Similar field for dependent enclaves

SMF Type 30

- Even more CPU times if you want to get down and dirty:
  - SMF30ICU_STEP_TERM – Initiator TCB time for step termination of the previous step; included in the SMF30ICU field of that step; new in z/OS 1.12
  - SMF30ISB_STEP_TERM – Similar field for SRB time; included in the SMF30ISB field of that step; new in z/OS 1.12
  - SMF30ICU_STEP_INIT – Initiator TCB time for step initiation of this step; is included in the SMF30ICU; new in z/OS 1.12
  - SMF30ISB_STEP_INIT – Similar field for SRB time; included in the SMF30ISB field; new in z/OS 1.12
  - SMF30OST – z/OS UNIX services requested by APPC/MVS work; included in SMF30CPT or SMF30CPS

SMF Type 30

- And even more:
  - SMF30UCT – TCB time for registered product; included in other fields; also recorded in Type 89 record
  - SMF30UCS – SRB time for registered product; included in other fields; also recorded in Type 89 record
  - SMF30_Highest_Task_CPU_Percent – Largest percent of TCB time used by any task in this address space; new with APAR OA39629 (13Jul2012) for z/OS 1.12/1.13
  - SMF30_HIGHEST_Task_CPU_Program – Program name associated with previous field; new with APAR OA39629

SMF Type 30

- Work that executes on another system:
  - Enclaves may run on other systems (other LPARs, and even other CECs)
  - SMF type 30 record can have multiple segments to show that work (each system is identified by field SMF30MRS)
  - SMF30MRA – CPU rate adjustment factor (the number of sixteenths of one microsecond per CPU service unit)
  - SMF30MRD – CPU time used by dependent enclaves on another system
- SMF Type 97
  - Contains CPU time for work run on this system, but sent by another system

Service Class Period CPU Usage

- RMF Type 72.3 Records
  - 72 – Written at end of RMF interval
  - CPU times are in service units and microseconds

RMF Type 72.3

- CPU Usage
  - R723CCPU – TCB service units including zAAP & zIIP time on CP, client SRBs, and enclaves
  - R723CSRB – SRB service units
  - R723RCT – RCT in microseconds
  - R723IIT – I/O interrupt time in microseconds
  - R723HST – Hiperspace time in microseconds
  - R723IFAT – zAAP time in microseconds
  - R723IFCT – zAAP time spent on CPs in microseconds
  - R723CSUP – zIIP time in microseconds
  - R723CSUC – zIIP service units spent on CPs; included in R723CCPU
  - R723CIFA – zAAP service units
  - R723CIFC – zAAP service units spent on CPs; included in R723CCPU

RMF Type 72.3

- Fields used for normalization:
  - R723MCPU – CPU (TCB) service definition coefficient * 10,000
  - R723MSRB – SRB service definition coefficient * 10,000
  - R723MADJ – Adjustment factor for CPU rate
  - R723NFFI – Normalization factor for zAAP; calculate normalized time on CP by multiplying with this value and dividing by 256
  - R723NFFS – Normalization factor for zIIP; use same calculation
  - R723NADJ – Nominal adjustment factor for CPU rate (see note)
  - R723CECA – CEC adjustment factor (see note)
  - Note: z196 capacity change supported with APAR OA30968 in z/OS 1.12/1.13

RMF Type 72.3

- Obtaining CPU time from service units:
  - To convert service units to CPU time in microseconds (.000001 seconds):

    TCB_time = (R723CCPU * (R723MADJ / 16))
    / (R723MCPU / 10000)

    SRB time = (R723CSRB * (R723MADJ / 16))
    / (R723MSRB / 10000)
  - Total CPU time on CPs =

    TCB_time + SRB_time + R723RCT + R723IIT +
    R723HST
  - Total zIIP and zAAP time = R723IFAT + R723CSUP

RMF Type 72.3

- Relating RMF type 72.3 CPU total usage with SMF type 30 data:
  - RMF does not contain initiator time
  - RMF does not contain eligible zIIP/zAAP time
  - SMF precision of .01 is not very accurate
  - It's sometimes difficult to get good times for comparison (SMF and RMF would need to have similar intervals, with the same SYNC, and SMF would need to be creating interval records)

RMF Type 72.3

- RMF Workload Activity Report

```
                                        . . .  INTERVAL 29.59.998
REPORT BY: POLICY=DAYTIME
                          DAYTIME WLM SERVICE POLICY
---SERVICE---    SERVICE TIME  ---APPL %---
IOC     156748K  CPU 18505.31  CP     1079.1
CPU       6609M  SRB 3388.175  AAPCP    1.48
MSO          0   RCT    6.049  IIPCP    3.19
SRB       1210M  IIT  171.501
                 HST   13.059  AAP     60.34
                 AAP 1086.112  IIP     87.50
                 IIP 1575.015

Service time is in seconds; APPL % is in percent of a single CP
```

RMF Type 72.3

- RMF Workload Activity Report

```
                                        . . .  INTERVAL 29.59.998
 . . .  INTERVAL 29.59.998
                SERVICE POLICY PAGE
                                  -SERVICE DEFINITION COEFFICIENTS-
                                     IOC      CPU      SRB      MSO
                                      6.0     10.0     10.0   0.0000
SYSTEMS
  ---ID---   OPT   SU/SEC   CAP% --TIME--   INTERVAL
  SYS1        00   35714.3   100 10.00.00   00.29.59
```

RMF Type 72.3

- Sample calculations:
  - CPU SUs (6609M) + SRB SUs (1210M) = 7819M
  - CPU time = (7,819,000,000 / 10) / 35714.3 = 21893.20 seconds
  - From RMF report, CPU time = 18505.31 + 3388.175 = 21893.5 (COOL – it matches!)
  - Total CPU time is 21893.20 + 6.049 +171.501 +13.059 = 22083.809
  - zAAP CPU time on zAAP = 1086.112 seconds; and from AAP % - .6034 * 1800 – 1086.12 (COOL!)
  - zIIP CPU time on zIIP = 1575.015 seconds; and from IIP% - .8750 * 1800 = 1575.0 (COOL!)
  - CP % = 1079.1%, and from (22083.809 – 1086.112 – 1575.015) / 1800 = 10.79% (This just gives me goosebumps!)

LPAR CPU Usage

- Source is RMF Type 70 CPU Record

---CPU---		---------- TIME % ----------				LOG PROC		--I/O INTERRUPTS--	
NUM	TYPE	ONLINE	LPAR BUSY	MVS BUSY	PARKED	SHARE %		RATE	% VIA TPI
0	CP	100.00	68.61	68.51	0.00	100.0	HIGH	331.3	33.30
1	CP	100.00	70.04	69.97	0.00	100.0	HIGH	228.2	33.38
2	CP	100.00	64.05	63.99	0.00	100.0	HIGH	177.9	33.86
3	CP	100.00	69.16	69.09	0.00	100.0	HIGH	405.8	31.88
4	CP	100.00	68.57	68.49	0.00	100.0	HIGH	280.0	31.94
5	CP	100.00	62.20	62.14	0.00	100.0	HIGH	203.5	32.82
6	CP	100.00	68.69	68.58	0.00	100.0	HIGH	376.8	32.03
7	CP	100.00	68.25	68.18	0.00	100.0	HIGH	243.9	31.87
8	CP	100.00	62.86	62.81	0.00	100.0	HIGH	182.4	32.92
9	CP	100.00	68.40	68.31	0.00	100.0	HIGH	329.1	31.85
A	CP	100.00	81.74	81.39	0.00	100.0	HIGH	1319	28.34
B	CP	100.00	60.66	60.60	0.00	100.0	HIGH	208.3	33.54
C	CP	100.00	72.18	74.15	0.00	100.0	HIGH	296.2	33.13
D	CP	100.00	78.85	84.13	0.00	100.0	HIGH	1196	30.66
E	CP	100.00	66.20	66.16	0.00	100.0	HIGH	12018	14.35
F	CP	100.00	66.64	66.59	0.00	100.0	HIGH	151.8	34.25
10	CP	100.00	65.29	65.22	0.00	95.0	MED	182.1	34.65
11	CP	100.00	0.00	-----	100.00	0.0	LOW	0.00	0.00

LPAR CPU Usage

- More of RMF Type 70 Record:

```
 ---CPU---    ---------------- TIME % ----------------     LOG PROC      --I/O INTERRUPTS--
 NUM  TYPE    ONLINE    LPAR BUSY    MVS BUSY   PARKED     SHARE %       RATE     % VIA TPI

. . .
 3B    CP     100.00     0.00        -----      100.00       0.0  LOW     0.00      0.00
 TOTAL/AVERAGE          19.37        68.73                   1695         18130     20.10

My calculation:                    1168.31 (same as 17 * 68.73)

 40    AAP    100.00    43.69        43.58        0.00      100.0  HIGH
 41    AAP    100.00    20.78        20.75        0.00       50.0  MED
 TOTAL/AVERAGE          16.12        32.17                   150.0

 My calculation:                    64.33

 3C    IIP    100.00    56.56        56.34        0.00      100.0  HIGH
 3D    IIP    100.00    36.94        36.91        0.00       50.0  MED
 TOTAL/AVERAGE          23.37        46.62                   150.0

 My calculation:                    93.25
```

LPAR CPU Usage

- Capture Ratios
  - CPs from LPAR view – 1168.31%
  - CPs from Workload view – 1079.1%
  - CP capture ratio = (100 * 1079.1) / 1168.31 = 92.4%

  - zAAPs from LPAR view – 64.33%
  - zAAPs from workload view – 60.34%
  - zAAP capture ratio = (100 * 60.34) / 64.33 = 93.8%

  - zIIPs from LPAR view – 93.25%
  - zIIPs from workload view – 87.50%
  - zIIP capture ratio = (100 * 87.5) / 93.25 = 93.8%

CEC CPU Usage

- RMF Type 70 Record

```
MVS PARTITION NAME                    SYS1        NUMBER OF PHYSICAL PROCESSORS          80
IMAGE CAPACITY                        5001                CP                             60
NUMBER OF CONFIGURED PARTITIONS         16                AAP                             4
WAIT COMPLETION                         NO                IFL                             4
DISPATCH INTERVAL                    DYNAMIC              ICF                             8
                                                          IIP                             4

--------- PARTITION DATA -----------------        -- AVERAGE PROCESSOR UTILIZATION PERCENTAGES --

                    ----MSU----  PROCESSOR-  . . . LOGICAL PROCESSORS  --- PHYSICAL PROCESSORS ---
NAME       S   WGT  DEF    ACT  NUM   TYPE        EFFECTIVE    TOTAL  LPAR MGMT  EFFECTIVE  TOTAL

SYS1       A   339    0    969 60.0   CP              19.15    19.37       0.22      19.15  19.37
. . .
*PHYSICAL*                                                                 0.85                1.21
                                                                          -----      -----  -----
  TOTAL                                                                    1.52      51.19  53.07
```

- LPAR usage here is 19.37% of 60 CPs, which is 1162% compared to LPAR view of 1168%
- 60 CPs of CEC are 53.07% busy or 3184.2% (only 32 CPs needed)

CEC CPU Usage

- RMF Type 70 Record

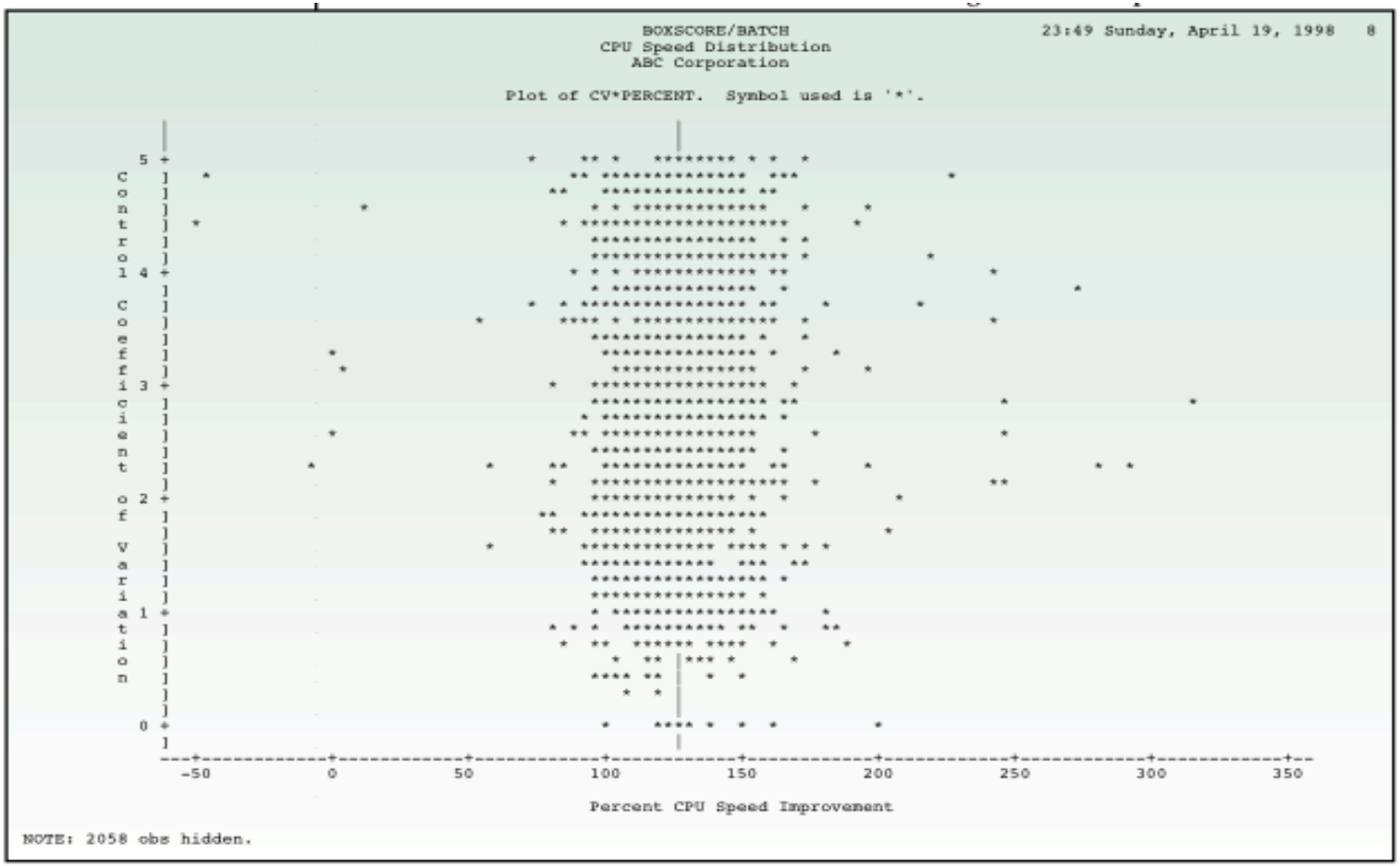
```
--------- PARTITION DATA -----------------        -- AVERAGE PROCESSOR UTILIZATION PERCENTAGES --

                    ----MSU----  PROCESSOR-  . . . LOGICAL PROCESSORS  --- PHYSICAL PROCESSORS ---
 NAME       S   WGT  DEF    ACT  NUM   TYPE        EFFECTIVE    TOTAL  LPAR MGMT  EFFECTIVE  TOTAL

 SYS1       A   375    0          4   AAP             15.95    16.12       0.17       15.95  16.12
. . .
 *PHYSICAL*                                                                1.05                1.05
                                                                          -----      -----  -----
   TOTAL                                                                  1.51       98.01  99.52

 SYS1       A   375    0          4   IIP             22.93    23.37       0.44       22.93  23.37
. . .
 *PHYSICAL*                                                                2.50                2.50
                                                                          -----      -----  -----
   TOTAL                                                                  3.46       45.64  49.10
```

- zAAP usage is 16.12% of 4 zAAPs or 64.48% compared to LPAR view of 64.33%
- zIIP usage is 23.37% of 4 zIIPs or 93.48% compared to LPAR view of
- 93.25%

CPU Variability

- Now that you are comfortable with the CPU fields and their precision, consider the variability of a CPU second.
- In my last Hot Flashes presentation, I included the following slide. It shows how jobs behaved after an upgrade. The average improvement was 127%, but some steps saw no improvement and others saw 300% improvement.
- Conclusion – there is NO golden normalization factor!

CPU Variability



References

- IBM MVS System Management Facilities (SMF) – SA22-7630
- SHARE in Anaheim #11264 – *SMF 101 – Everything You Should Know About SMF and More*, Thu, 3 pm, Cheryl Watson
- SHARE in Anaheim #11609 – z/OS *WLM Update for z/OS 1.13 & 1.12*, Horst Sinram
- RMF Performance Management Guide – SC33-7992
- RMF Report Analysis – SC33-7990
- Redbook – Effective zSeries Performance Monitoring using Resource Measurement Facility (RMF) – SG24-6645
- Cheryl Watson's Tuning Letter 2004 No. 3 & 2012 No. 4 – SMF CPU fields
- SHARE in Atlanta #10606 – *IBM z196 & z114 Hardware Overview & Update*, Harv Emery

Introduction

- Currently
  - Author of *Cheryl Watson's Tuning Letter* (40-60 pages six times a year) and *Cheryl Watson's CPU Charts*
  - Author of free email – *Cheryl's List* (sign up on website)
  - Developer of two Watson & Walker's software products, *BoxScore* and *GoalTender*
  - Long-time SHARE member/contributor (ribbon wearer since 1978)
  - CMG past director/contributor
  - CMG A. A. Michelson Award winner
  - zJournal Mainframe Hall of Fame
  - Presenter of "Hot Flashes" at every SHARE to talk about the things I'm passionate about

Introduction

- History
  - 1965 – Math & physics major at Portland State; worked at Consolidated Freightways, wrote Autocoder on 1401 and 7010; installed MFT in 1966; wrote Assembler & COBOL
  - 1967-1982 – Several software companies, Amdahl, and EDS (training, CICS admin, performance and capacity)
  - 1982-1986 – Morino Associates (England, Germany, Virginia)
  - 1986 – Met Tom Walker, partner and future husband, started Watson & Walker, Inc. as a training company (taught SMF, RMF, performance, WLM, capacity planning until 1999)
  - 1991 – Started *Cheryl Watson's Tuning Letter*
  - 1995 – Created WLM QuickStart Policy
  - Never met an SMF record I didn't like!

See You in San Francisco!

Cheryl Watson Walker with partner, husband, and best friend Tom Walker in the Galapagos (www.tomandcheryltravels.me)

- **Email: technical@watsonwalker.com**
- **Website: www.watsonwalker.com**