The Many CPU Fields Of SMF

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Enterprise2013

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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
- z/OS 2.1
- References

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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

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Additional Sources of CPU Info

- 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)

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CPU Time Precision

- CPU fields
  - .01 – most fields are in hundredths of seconds
  - .001 – milliseconds
  - .000001 – microseconds
  - .001024 – 1024-microseconds units (and 1.024-millisecond units)
  - .000128 - 128-microsecond units
  - .000001 – TOD field, where bit 51 is one microsecond
  - .0000000625 – one raw CPU or SRB service unit (a sixteenth of a microsecond) – not multiplied by service definition coefficient

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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?

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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

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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
  - The zEC12 has three series of machines that are knee-capped. The 4xx series is about 16% of a 7xx; the 5xx is about 42%; and the 6xx is about 63%

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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

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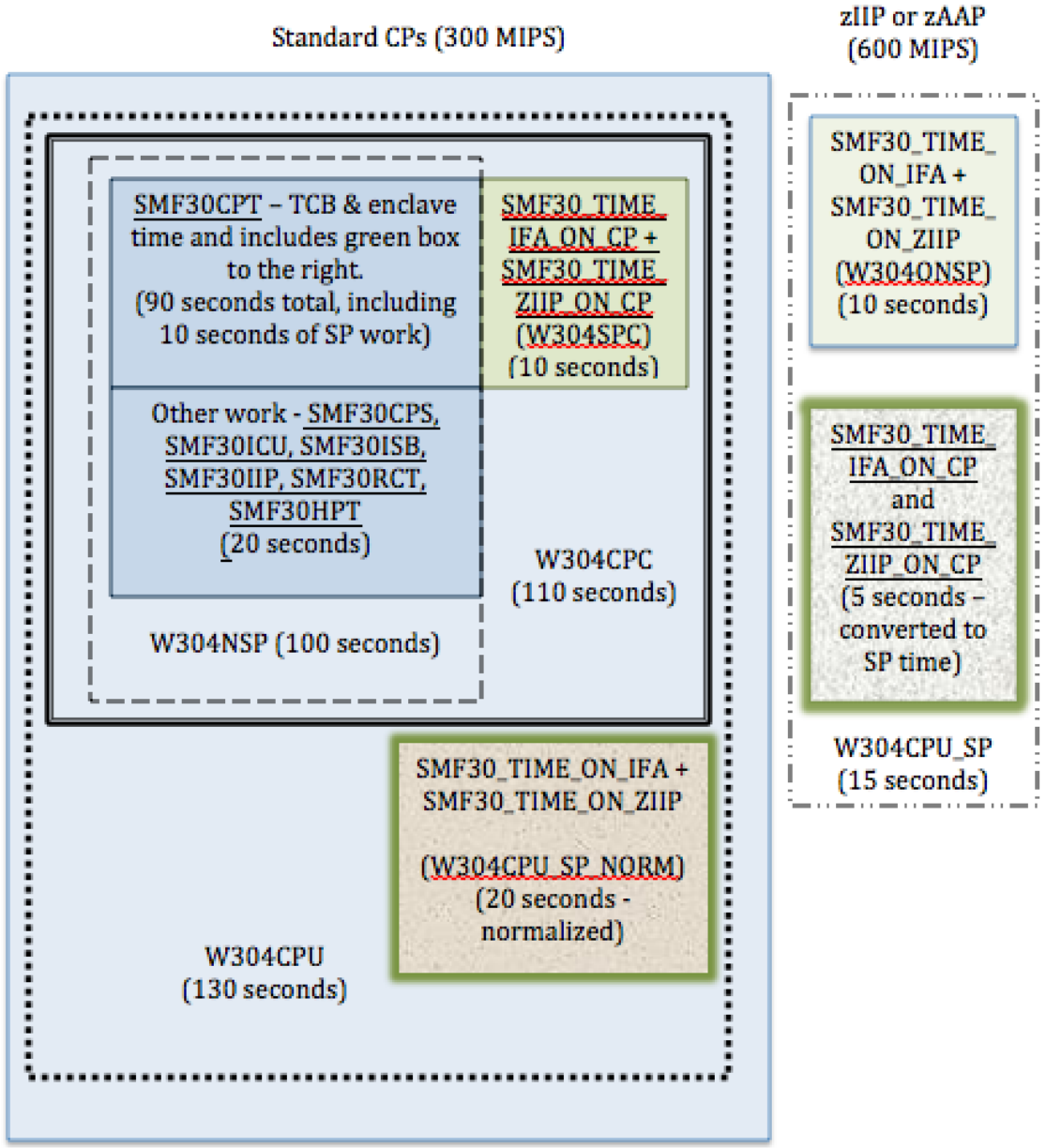

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SMF Type 30

- 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

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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

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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

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

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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
```


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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

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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

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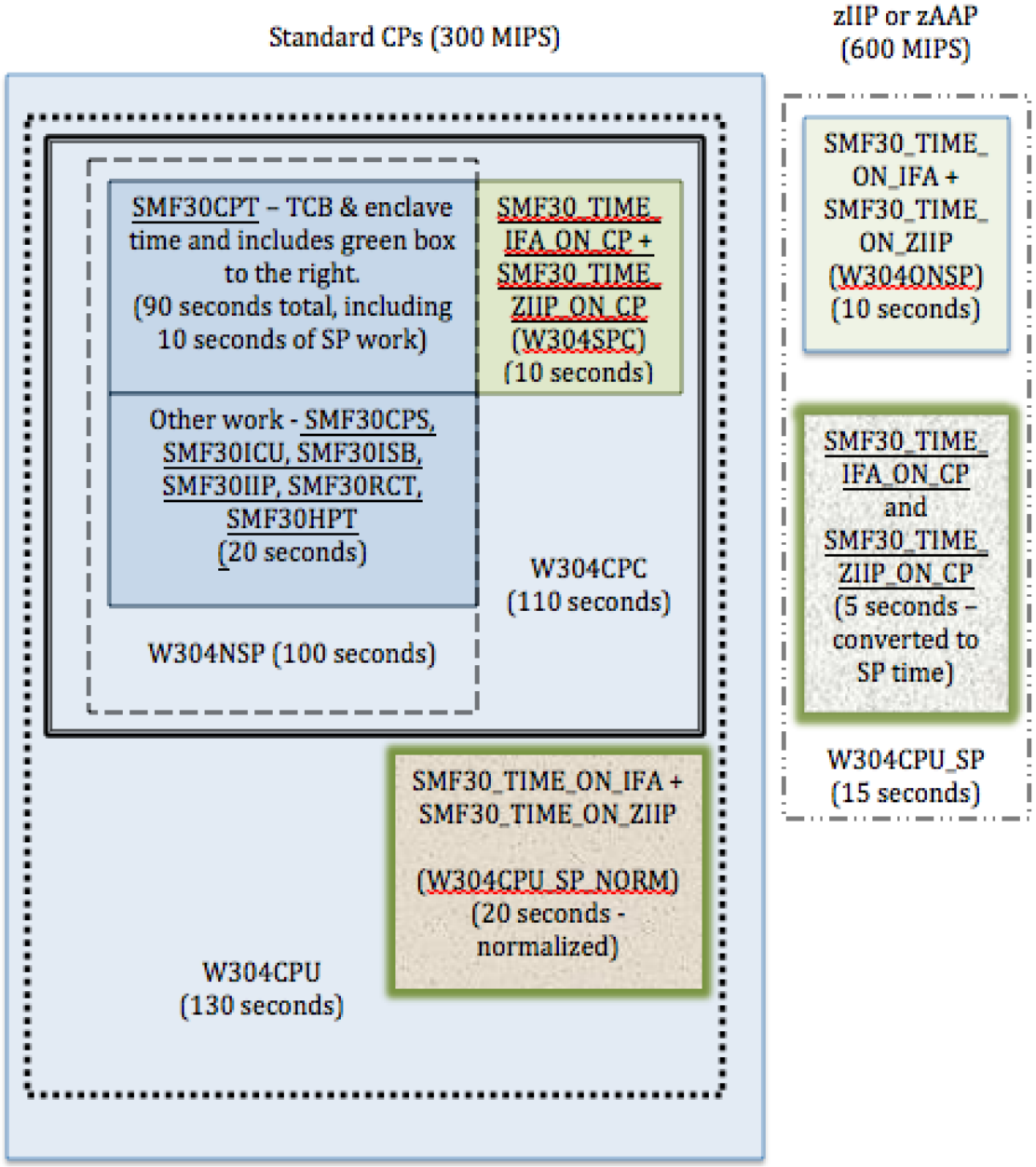
Standard CPs (300 MIPS)
zIIP or zAAP
(600 MIPS)
SMF30CPT – TCB & enclave time and includes green box to the right.
(90 seconds total, including 10 seconds of SP work)
SMF30_TIME_IFA_ON_CP + SMF30_TIME_ZIIP_ON_CP
(W304SPC)
(10 seconds)
Other work - SMF30CPS, SMF30ICU, SMF30ISB, SMF30IIP, SMF30RCT, SMF30HPT
(20 seconds)
W304NSP (100 seconds)
W304CPC
(110 seconds)
SMF30_TIME_ON_IFA + SMF30_TIME_ON_ZIIP
(W304CPU_SP_NORM)
(20 seconds - normalized)
W304CPU
(130 seconds)
SMF30_TIME_ON_IFA + SMF30_TIME_ON_ZIIP
(W304ONSP)
(10 seconds)
SMF30_TIME_IFA_ON_CP and SMF30_TIME_ZIIP_ON_CP
(5 seconds – converted to SP time)
W304CPU_SP
(15 seconds)

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

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SMF Type 30

- Other CPU times for the obsessives (like me):
  - 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

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SMF Type 30

- Other CPU times for the obsessives:
  - 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

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SMF Type 30

- Other CPU times for the obsessives:
  - 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

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SMF Type 30

- Other CPU times for the obsessives:
  - 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

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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

  - To learn more about how to use the last two fields, send your name, company, and address to marketing@watsonwalker.com for a free issue of our last Tuning Letter.

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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

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SMF Type 30

- SMF Type 97
  - Contains CPU time for work run on this system, but sent by another system

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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

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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

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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

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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

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RMF Type 72.3

- Relating RMF type 72.3 CPU total usage with SMF type 30 data:
  - RMF does not contain initiator 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)

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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
```


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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
```


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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!)

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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

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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
```


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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%

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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)

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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%

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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!

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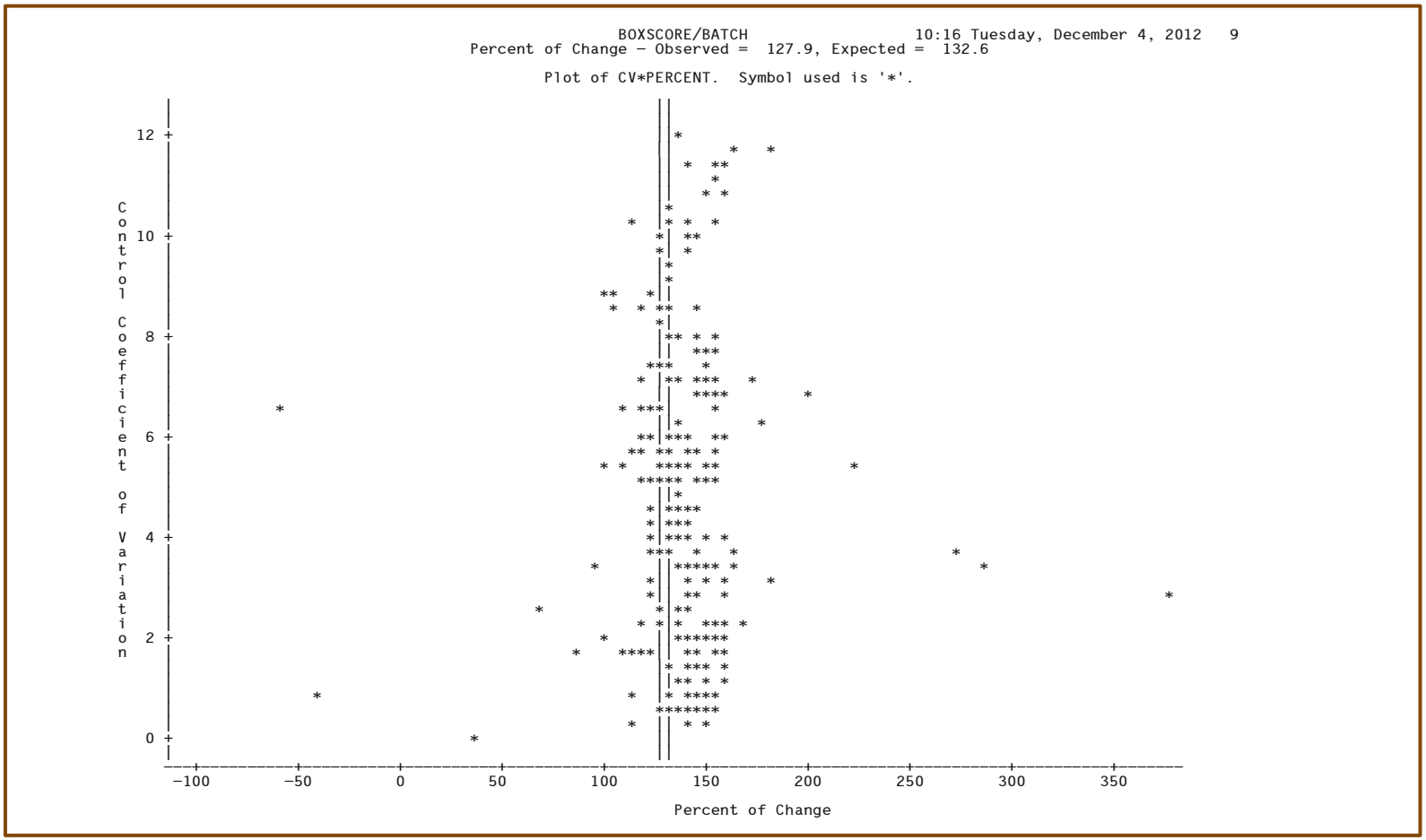
CPU Variability



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New in z/OS 2.1

- SMF Type 30, Counter Section
  - Activated when SMFCOUNT is specified in SMFPRMxx (or set with SETSMF command) and Hardware Instrumentation Services (HIS) is enabled for the Basic Counter Set
  - Records number of instructions executed on:
    - CP as TCB (non-enclave)
    - CP as SRB (non-enclave)
    - CP as preemptable or client SRB (non-enclave)
    - zIIP/zAAP (non-enclave)
    - CP but eligible for zIIP/zAAP (non-enclave)
    - CP as independent enclave
    - zIIP/zAAP as independent enclave
    - CP but eligible for zIIP/zAAP as independent enclave
    - CP as dependent enclave
    - zIIP/zAAP as dependent enclave
    - CP but eligible for zIIP/zAAP as dependent enclave

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New z/OS 2.1 - **WOW!**

- RMF XP (RMF Distributed Platform Performance)
  - RMF XP can collect performance data from:
    - AIX on System p (12 subtypes)
    - Linux on System x (9 subtypes)
    - Linux on System z (11 subtypes)
    - Windows on System x (5 subtypes)
  - In z/OS 2.1, RMF XP records type 104 records to SMF
    - Obtain CPU usage, memory, I/O, configuration (e.g. number of CPUs)
  - NOW – you can report on your entire complex in a single report for management
  - See **Harald Bender's** session on RMF XP at 9 am Friday, zST011

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Thank you!

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