Linux on zSeries Performance Update

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L74

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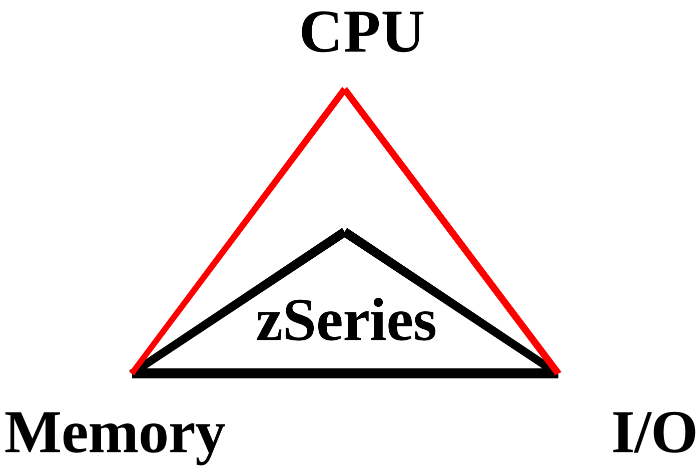
Agenda

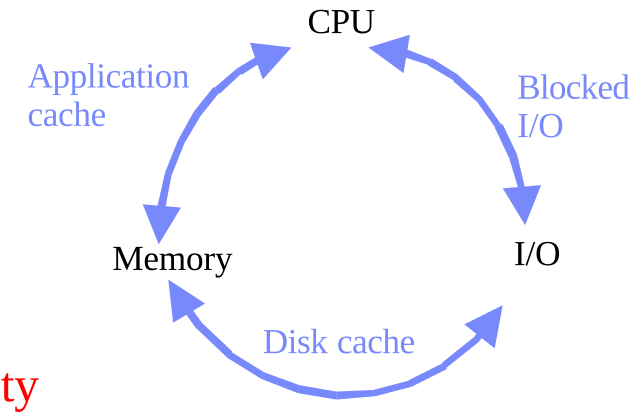
- Relative System Capacity
- zSeries Hardware
- Scalability
- Networking
- Disk I/O
  - Parallel Access Volume (PAV)
  - ESS Architecture

Relative System Capacity

- A system provides different types of resources
- Capacity for each resource type may be different
- The ideal machine provides enough capacity of each type
- Don't forget additional Resources (Network, Skilled staff, Money, availability of software, reliability, time ...)

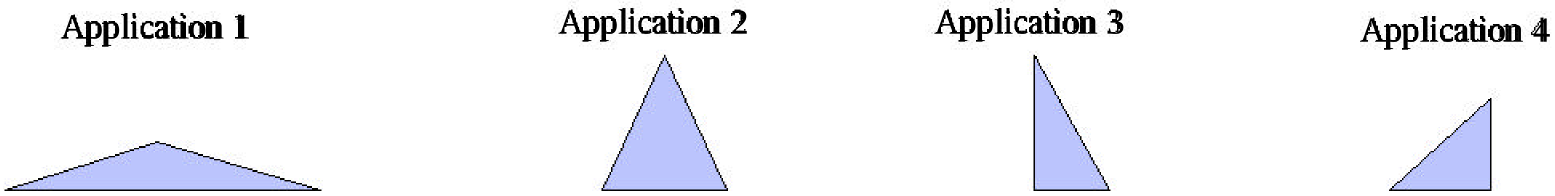


The ideal platform requires a mix of resources in right quantity



Resource Profiles

- Each application has its specific requirements
  - CPU intensive
  - I/O intensive
  - Memory
- Applications can often be tuned to **change the resource profile**
  - Exchange one resource for the other
  - Requires knowledge about available resources
- Some platforms can be extended better than others
  - Not every platform runs every application well
  - It's not easy to determine the resource profile of an appl.



Application 1

Application 2

Application 3

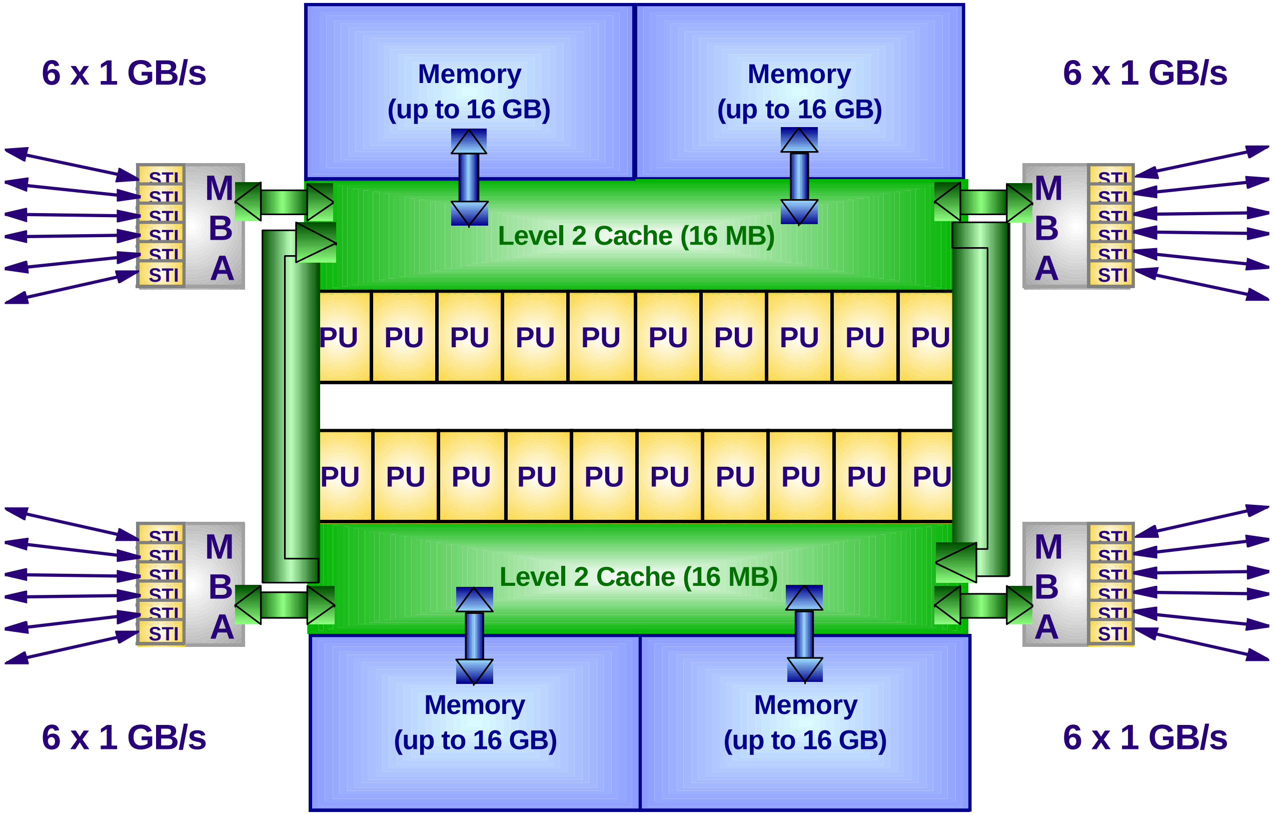
Application 4

zSeries Hardware

z800/z900

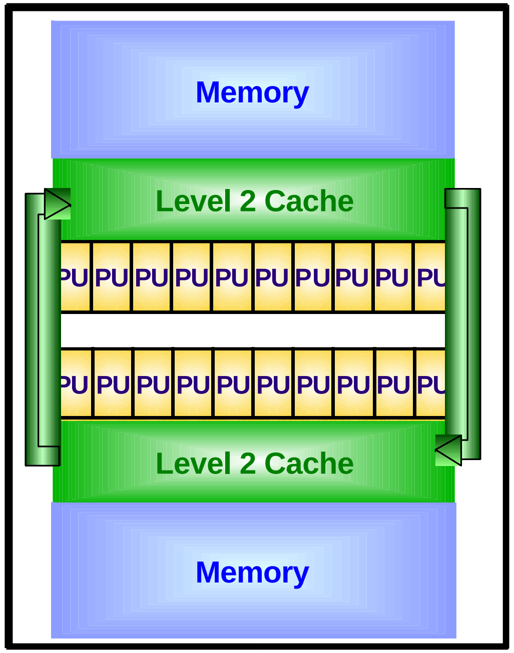
z990

z900 System structure: Optimized for maximum external bandwidth

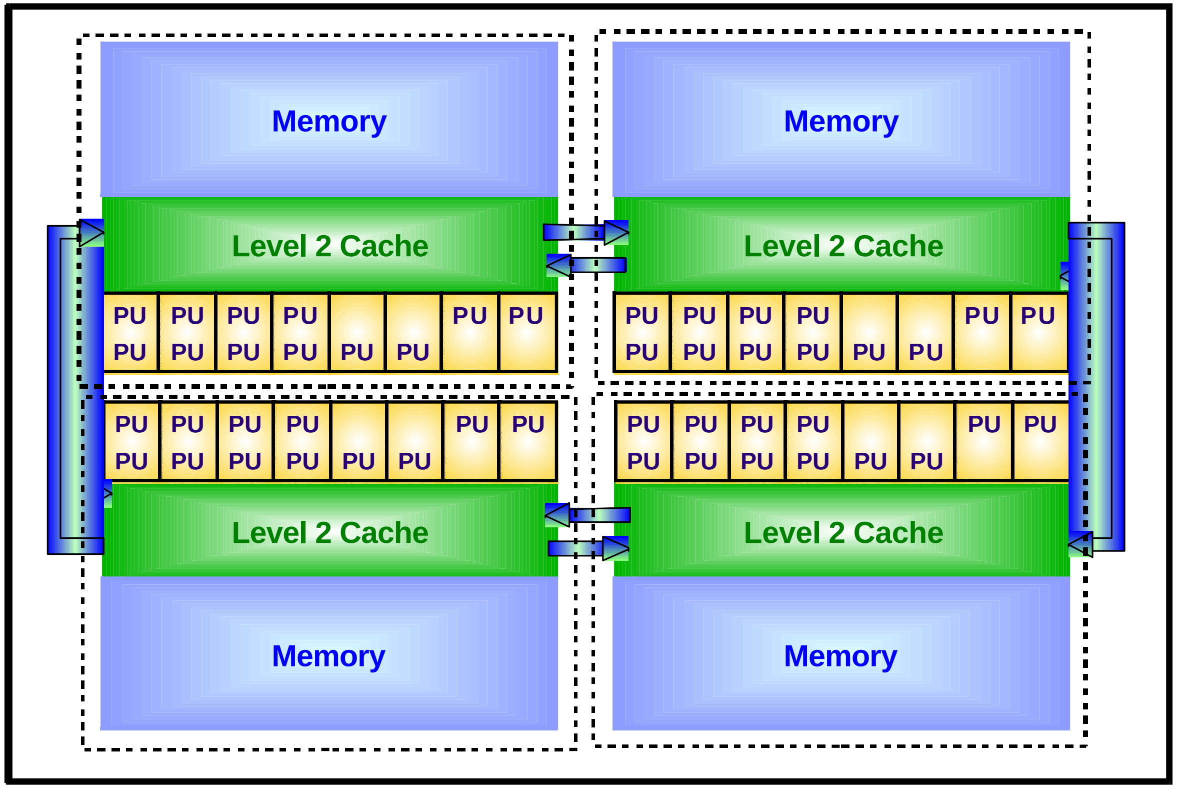


- 20 PU Chips @ 1.3 / 1.09 ns
- 3 SAP's, 1 spare
- up to 16 CP's
- up to 8 ICF's/IFL's

z990: Extended Multi-Node(Book)-Structures:



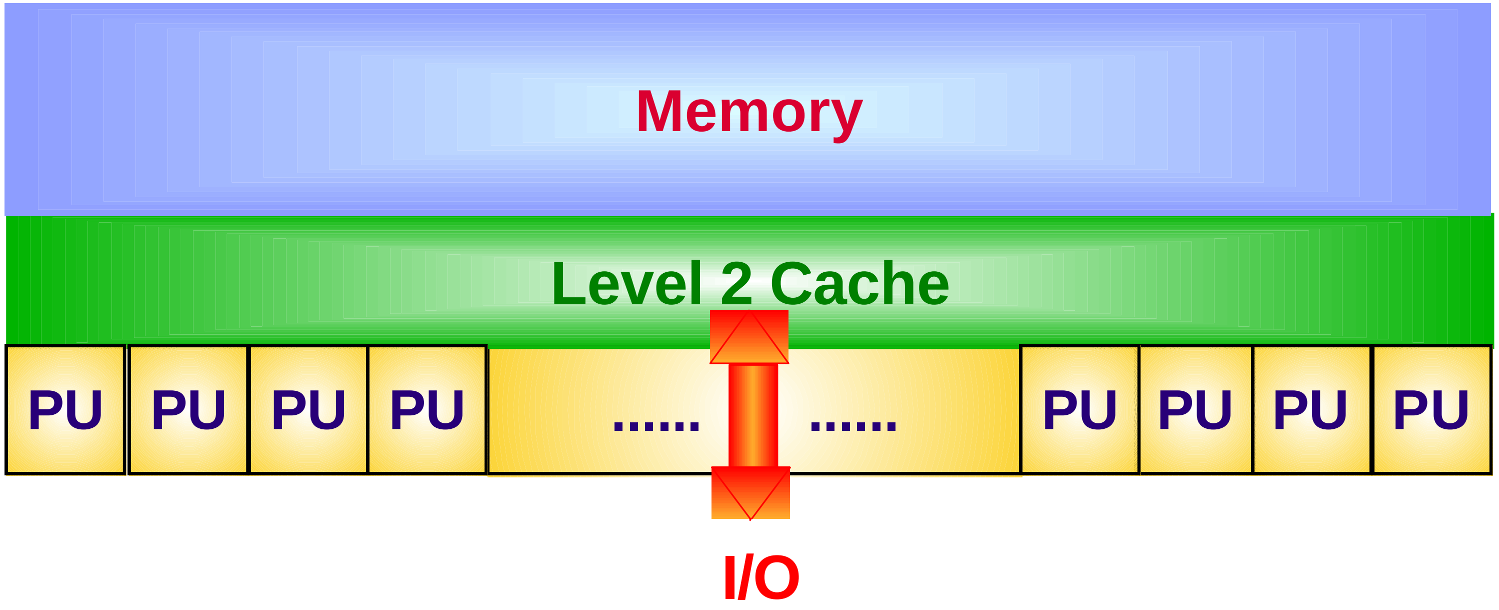
From z900 ...



To z990:

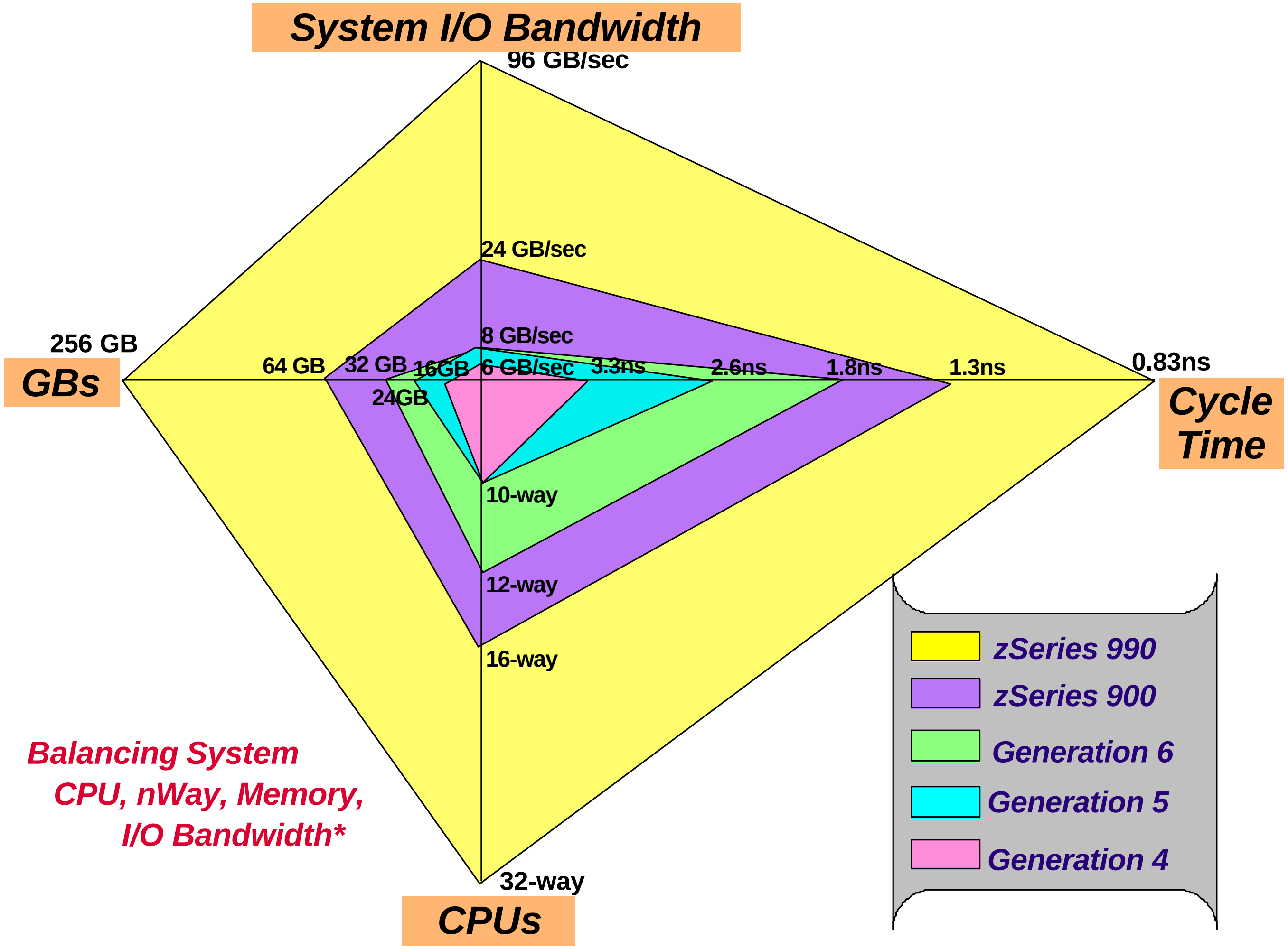
- **0.83ns CPU-Cycle**
- **Superscalar Design**
- **Up to 60% more UP-Performance vs 2C1**

z990: Multi-Book(Node)-Structures (logical view)



- A single pool of physical resources (CPU's, memory, I/O) in modular implementation (n=1/2/3/4 nodes/'books')
- Multiple Channel Subsystems (n x 256 CHPIDs)
- Exploitation through virtual servers: 15, 30, 60 (SOD) LPARs ...100+... (VM)

IBM S390 and zSeries Servers – Balanced Scaling



*Balancing System CPU, nWay, Memory, I/O Bandwidth**

* External I/O or STI bandwidth only (Internal Coupling Channels and HiperSockets not included)
zSeries MCM internal bandwidth is 500 GB/s. Memory bandwidth not included (not a system constraint)

Performance results

Our Hardware for Measurements

2064-216 (z900)

1.09ns (917MHz)
2 * 16 MB L2 Cache (shared)
64 GB
FICON
HiperSockets
OSA Express GbE
z/VM 4.3

2105-F20 (Shark)

384 MB NVS
16 GB Cache
128 * 36 GB disks
10.000 RPM
FCP (2 Gbps)
FICON (1 Gbps)

2084-B16 (z990)

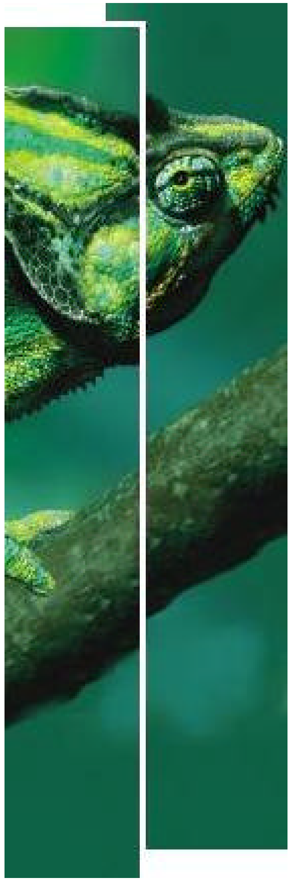
0.83ns (1.2 GHz)
2 Books each with 8 CPUs
64 GB
FICON
HiperSockets
OSA Express GbE
z/VM 4.4

8687-3RX (8-way X440)

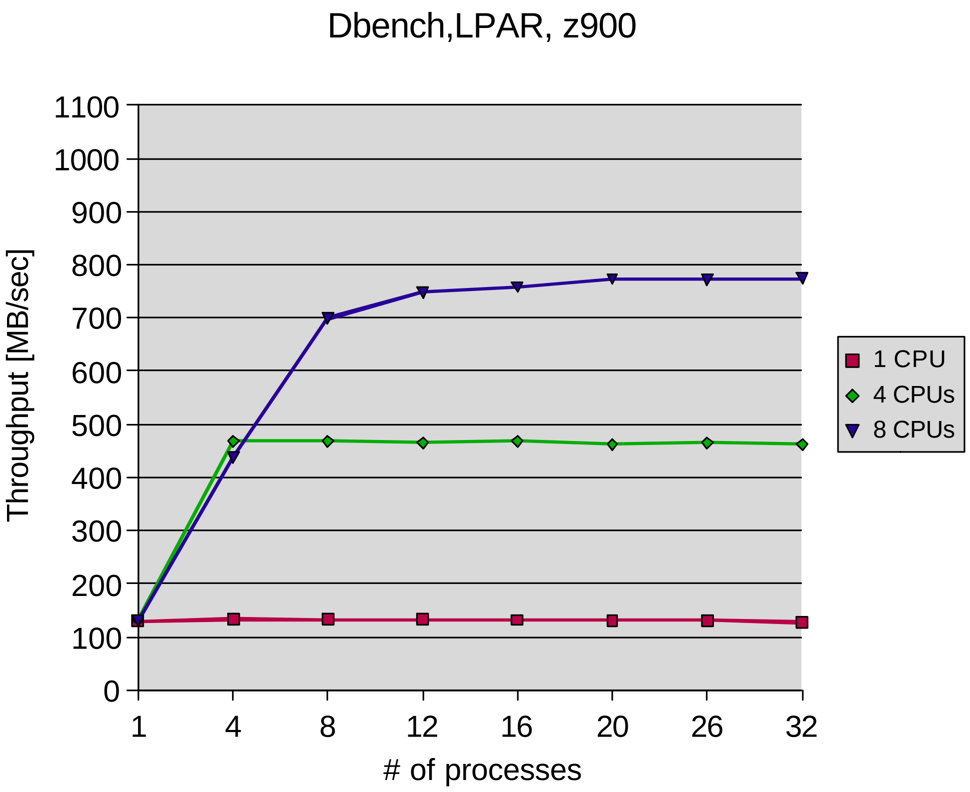
8-way Intel Pentium 3 Xeon
1.6 GHz
8 * 512K L2 Cache (private)
hyperthreading
summit chipset

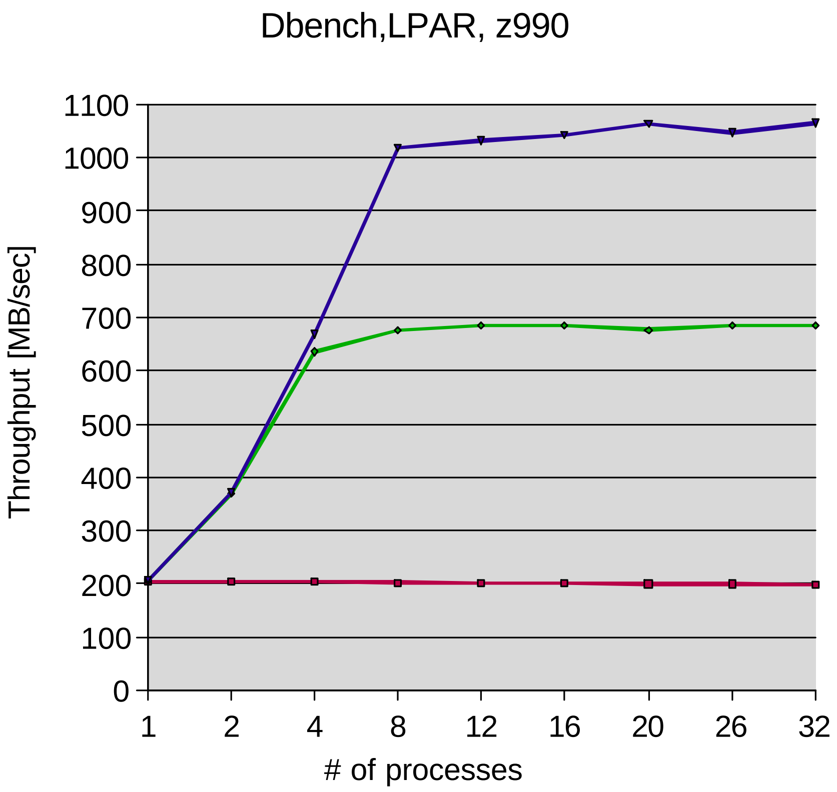
SuSE SLES7 versus SuSE SLES8

- From Kernel version 2.4.7 / 2.4.17 to version 2.4.19
- From glibc version 2.2.4-31 to version 2.2.5-84
- From gcc version 2.95.3 to version 3.2-31
- Huge number of United Linux patches
- 1.3 MLOC (including x,p,i changes)
- New Linux scheduler
- Async I/O
- SLES8 SP2 available



Scalability - z900 vs z990, ext2, 31 Bit

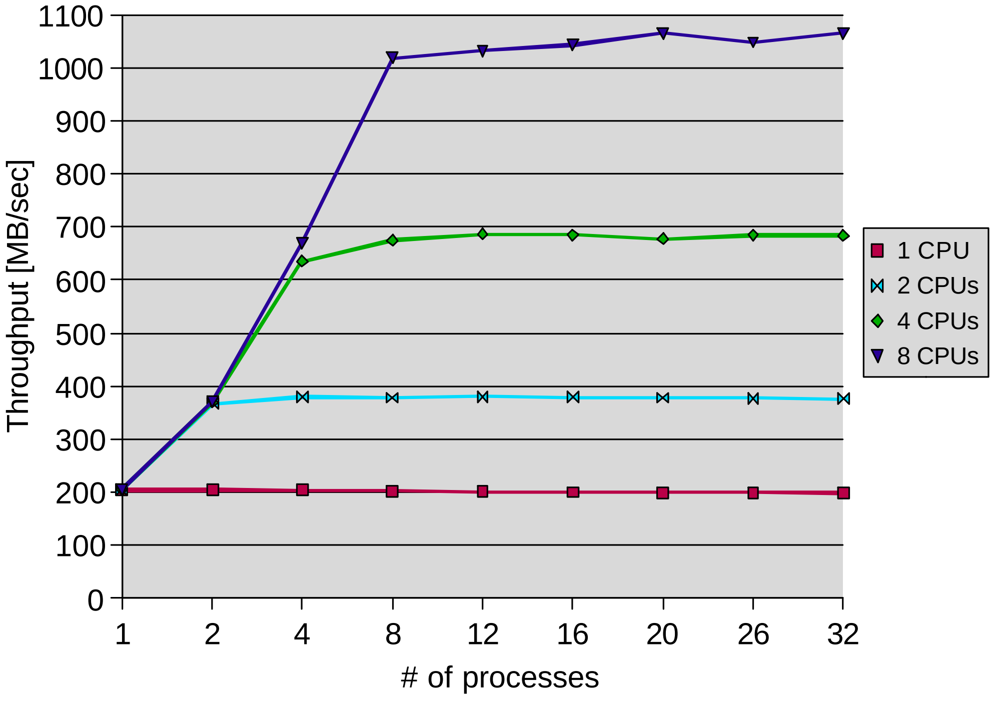




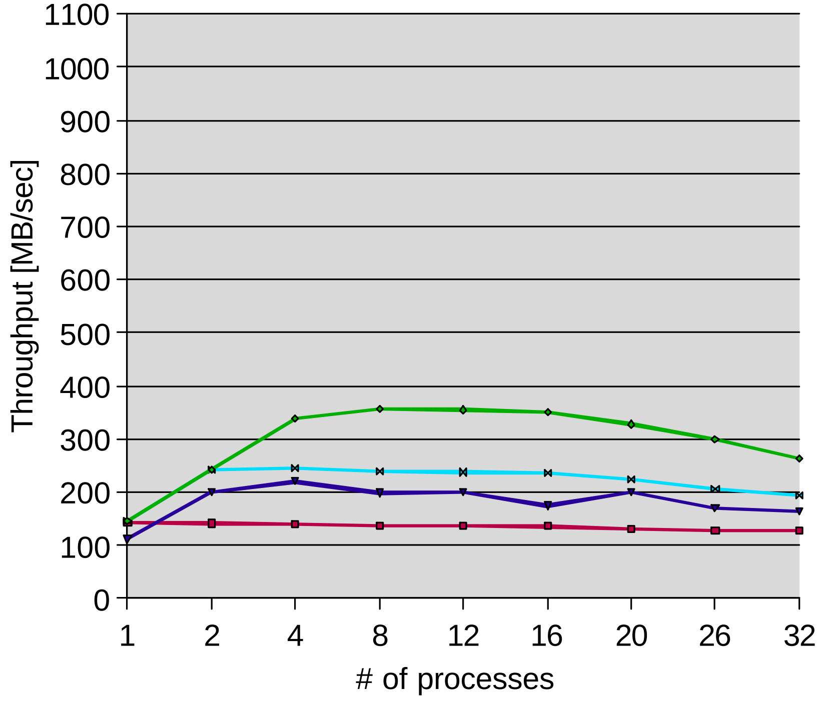
- z990 takes advantage of higher memory bandwidth

Scalability - z990 vs Intel, ext2, 31/32Bit

Dbench,LPAR, z990

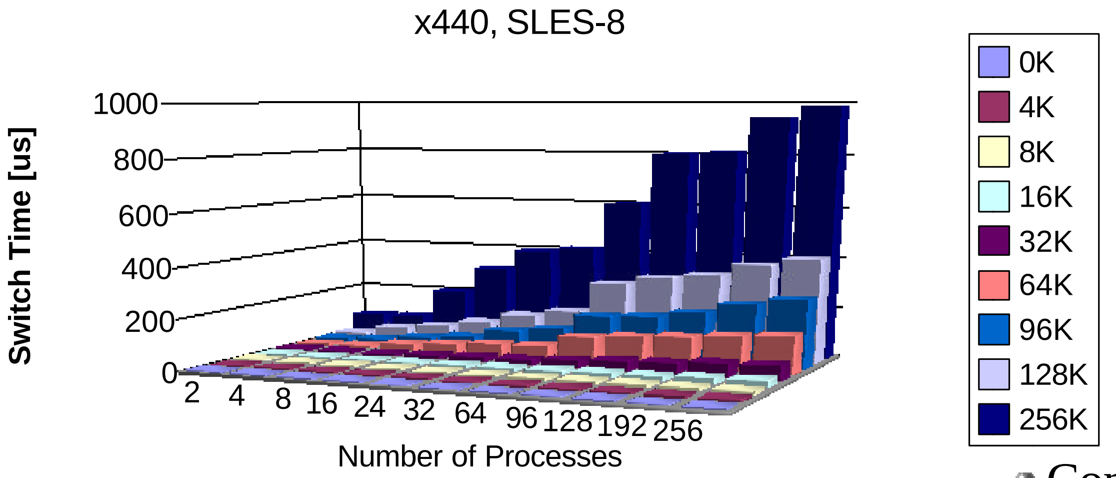


Dbench, x440

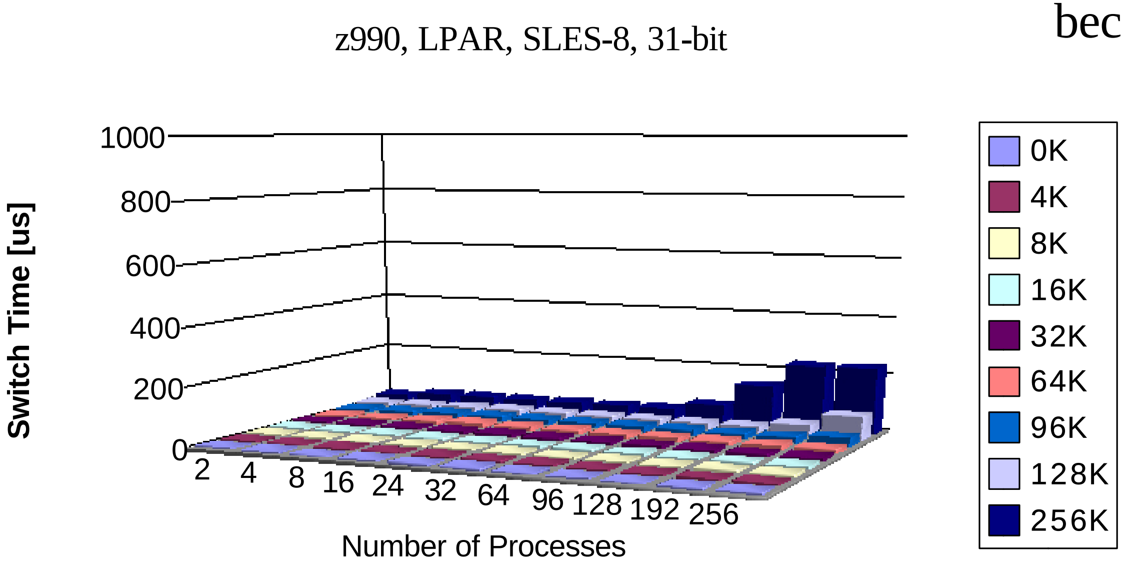


- z990 shows good scaling behavior
- x440 shows best throughput with 4 CPU, strong throughput degradation with more than 4 CPUs

Kernel – Context Switches



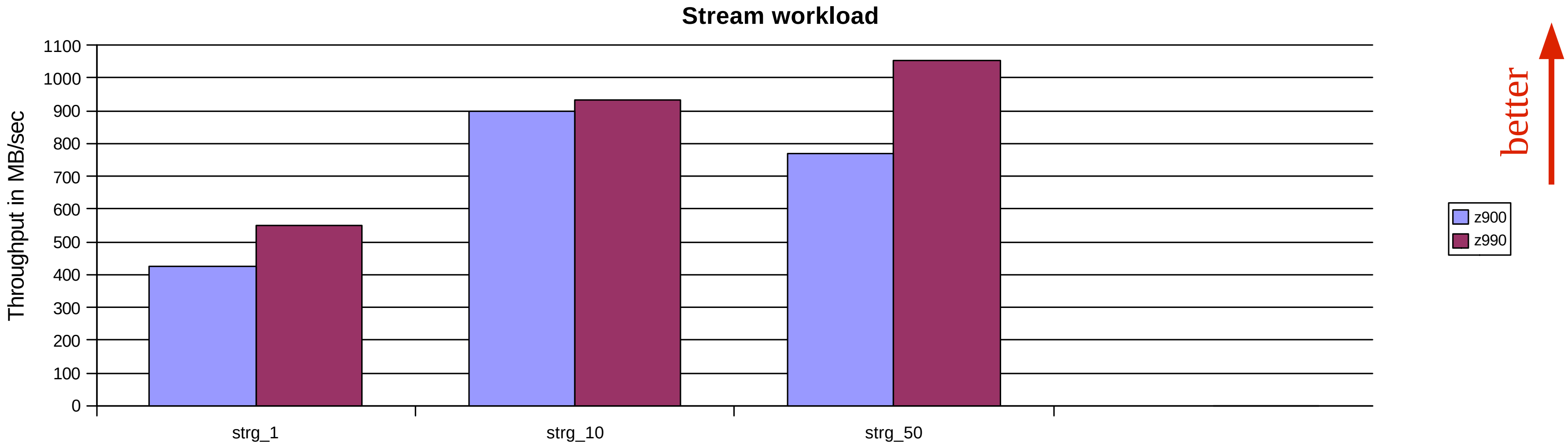
- Context Switches much faster on zSeries because of large shared caches

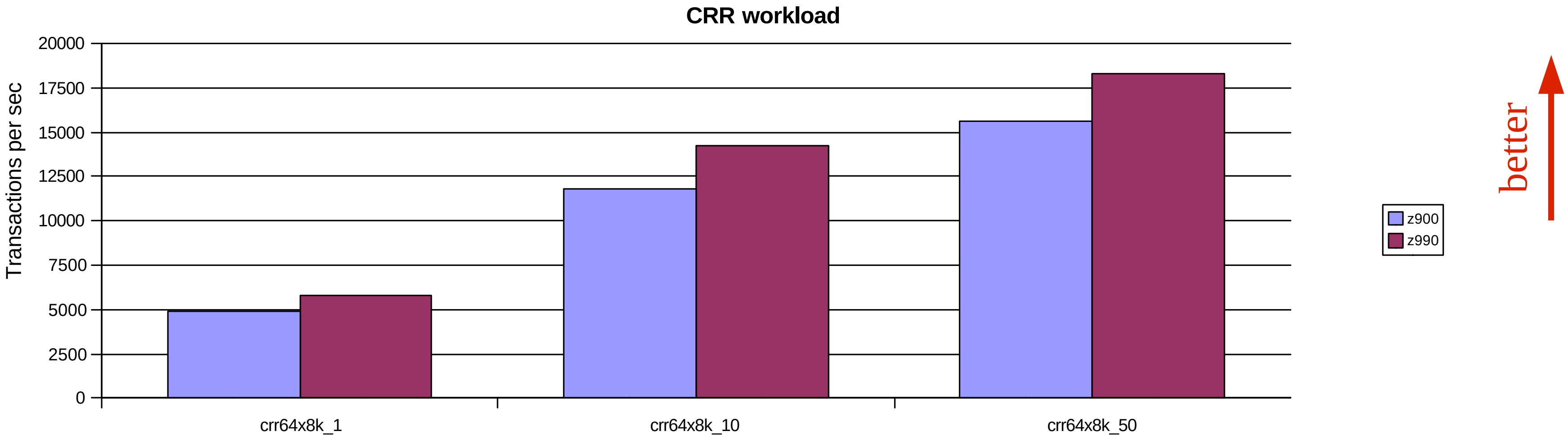


Networking

- IBM internal benchmark Netmark 2
- Available as “IBM Application Workload Modeler”
- Simulates network traffic
- Adjustable parameters
  - runtime
  - packet size
  - number of connections
  - ...
- Huge results file with much statistical information
- Numbers measured on z900 and z990

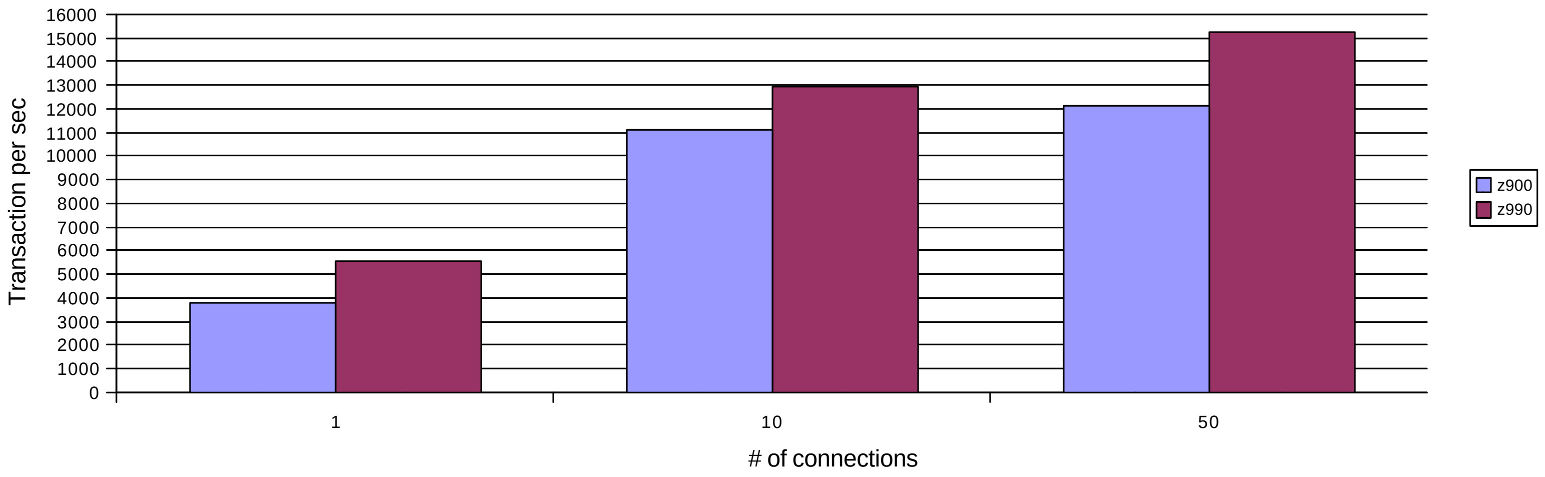
HiperSockets MTU 32K – LPAR





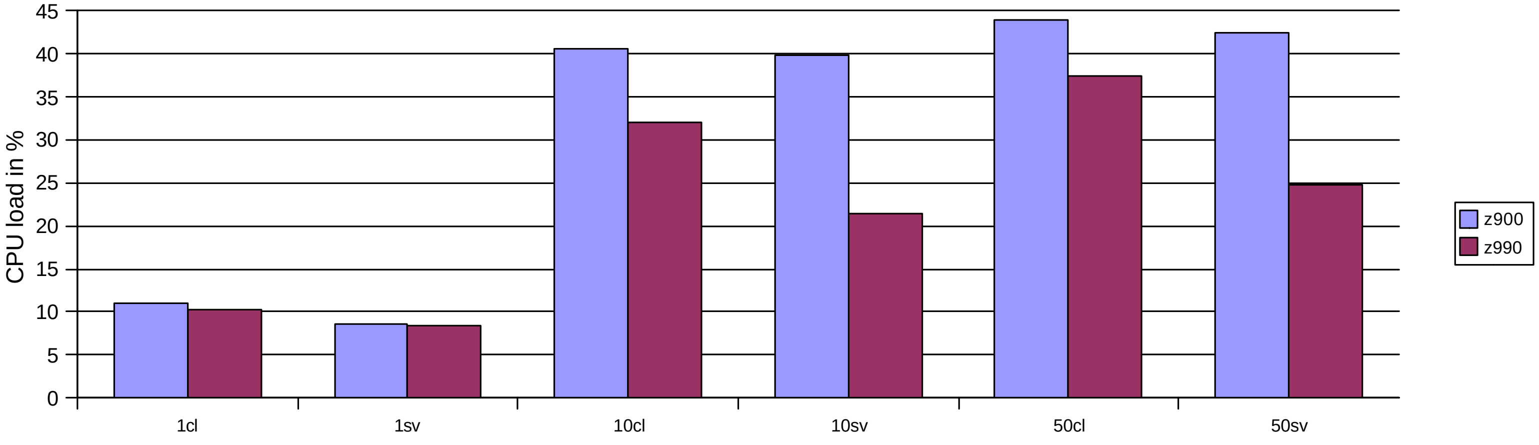
GuestLAN type HiperSockets MTU 32K – z/VM guests

RR 200x32k workload



better

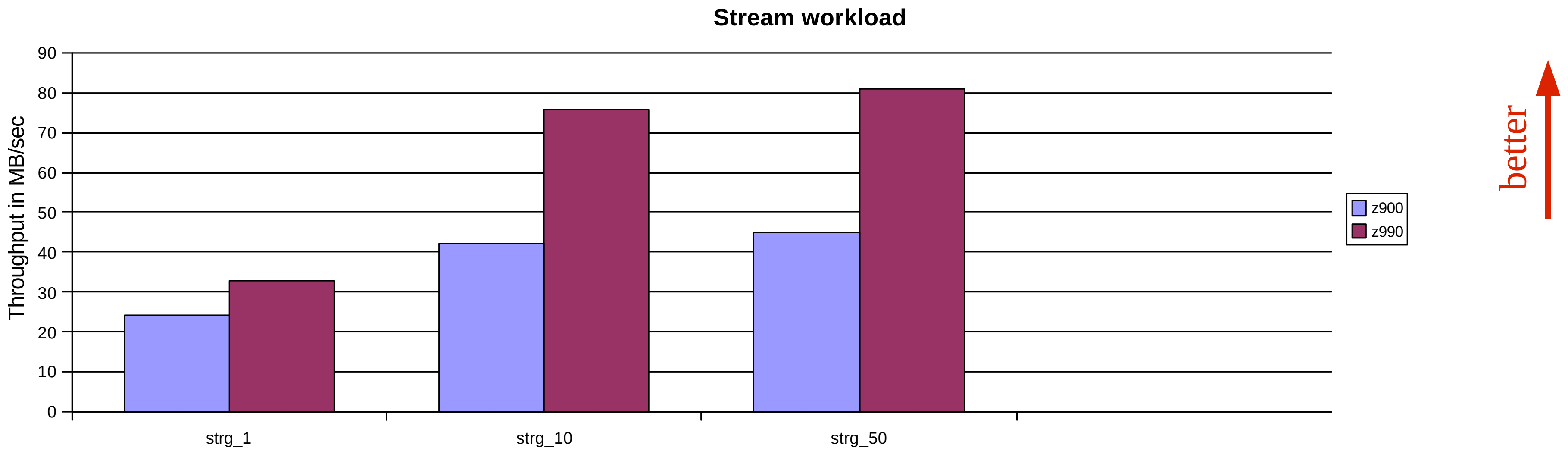
CPU load (q time) RR 200x32k workload

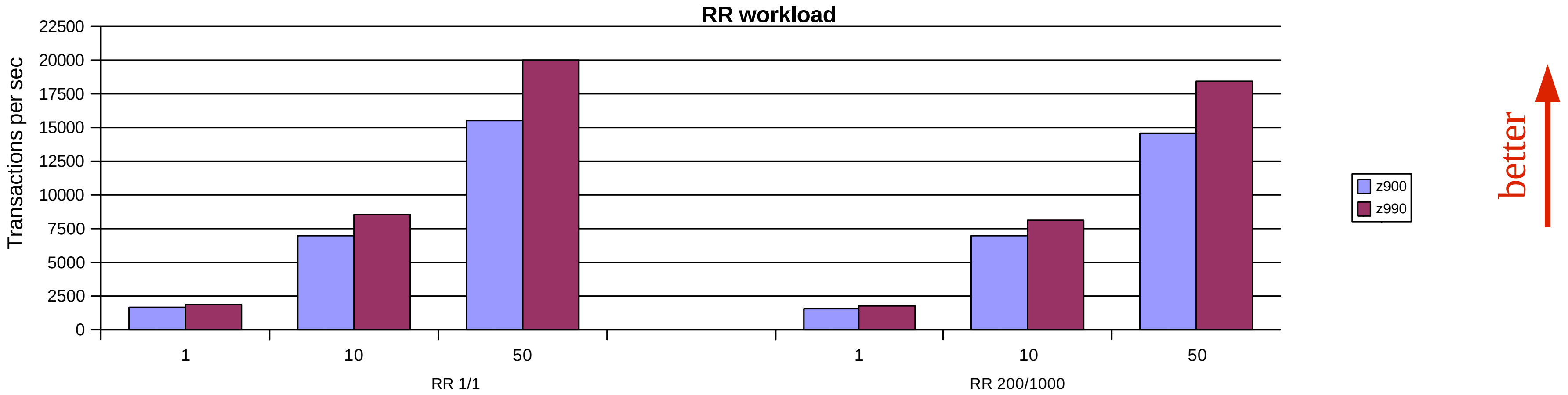


better

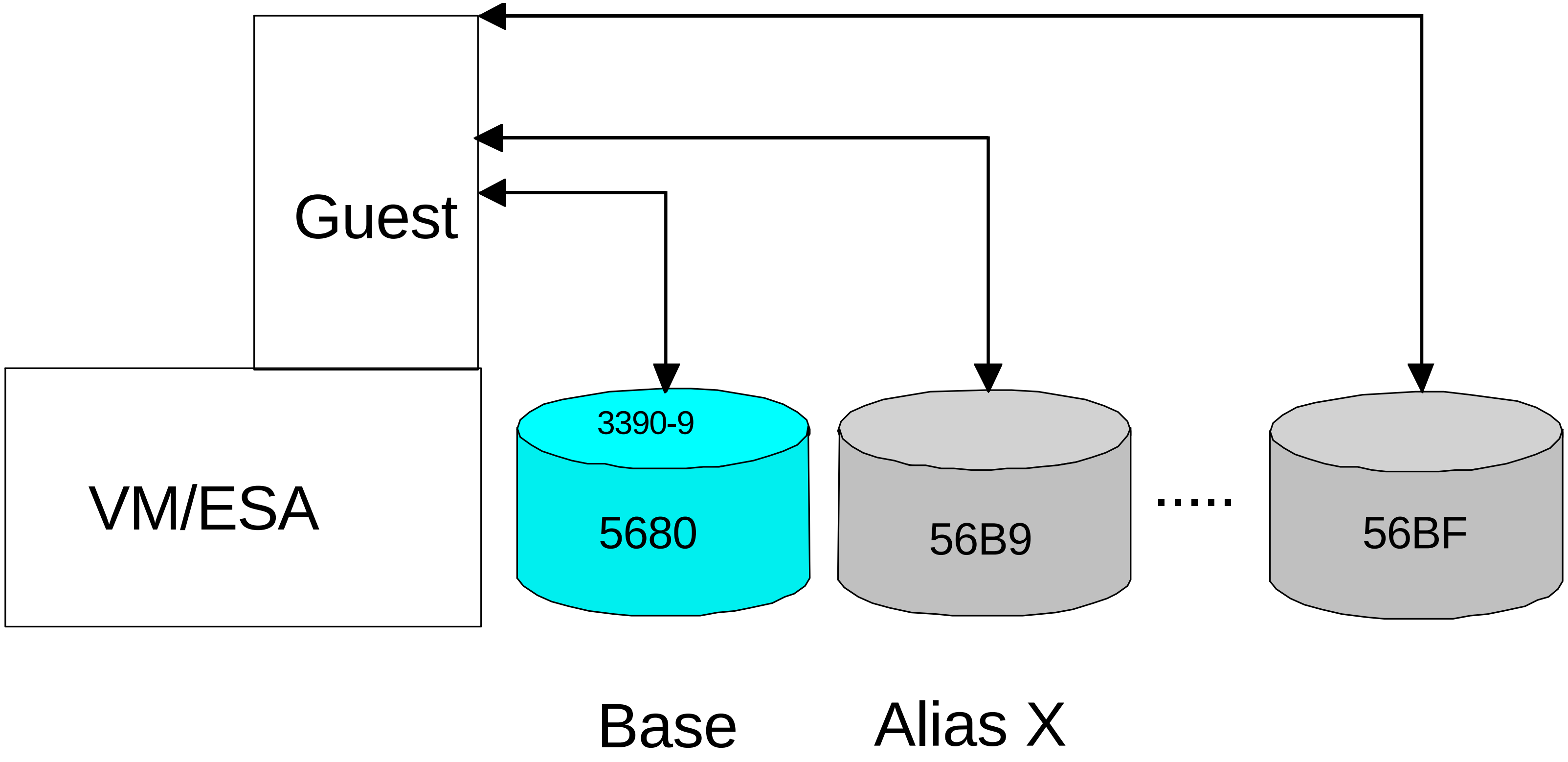
1cl = 1 connection client side (sv=server)

Gigabit Ethernet MTU 1500 – z/VM guests





Parallel Access Volume (PAV)
A Lab experiment



Linux cannot enable PAV on the ESS but can use it under VM

Base and Aliases (PAV Cont.)

- IOCDS changes

```
IODEVICE ADDRESS=(5680,024),UNITADD=00,CUNUMBR=(5680),   *
         STADET=Y,UNIT=3390B
IODEVICE ADDRESS=(5698,040),UNITADD=18,CUNUMBR=(5680),   *
         STADET=Y,UNIT=3390A
```

- ATTACH Base and Aliases to the guest
- QUERY PAV shows base and alias addresses

cat /proc/dasd/devices

```
5794(ECKD) at ( 94:  0) is dasda      : active at blocksize: 4096, 1803060 blocks, 7043 MB
5593(ECKD) at ( 94:  4) is dasdb      : active at blocksize: 4096, 601020 blocks, 2347 MB
5680(ECKD) at ( 94:  8) is dasdc      : active at blocksize: 4096, 1803060 blocks, 7043 MB
56bf(ECKD) at ( 94: 12) is dasdd      : active at blocksize: 4096, 1803060 blocks, 7043 MB
```

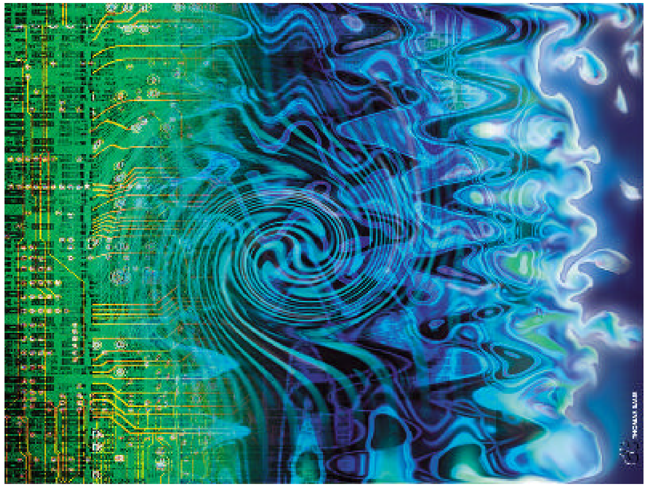
cat /proc/subchannels | egrep "5680|56BF"

```
5680   0030  3390/0C   3990/E9  yes    FC  FC  FF  C6C7C8CA CBC90000
56BF   0031  3390/0C   3990/E9  yes    FC  FC  FF  C6C7C8CA CBC90000
```

This works only with z/VM

LVM commands (PAV Cont.)

- vgscan: create configuration data
  - scans all discs for volume groups
- pvcreate /dev/dasdc1
  - has to be done for each physical volume
- vgcreate vg_kb /dev/dasdc1
  - creates the volume group vg_kb
- vgdisplay



vgdisplay

```
vgdisplay -v vg_kb
--- Volume group ---
VG Name               vg_kb
VG Access             read/write
VG Status             available/resizable
VG #                  0
MAX LV                256
Cur LV                0
Open LV               0
MAX LV Size           255.99 GB
Max PV                256
Cur PV                1
Act PV                1
VG Size               6.87 GB
PE Size               4 MB
Total PE              1759
Alloc PE / Size       0 / 0
Free  PE / Size       1759 / 6.87 GB
VG UUID               3nwJYn-SxW1-gKym-OvZs-TYIf-CrHP-inO5Yp

--- No logical volumes defined in "vg_kb" ---
```

More LVM commands

lvcreate --name lv_kb --extents 1759 vg_kb

cat /proc/lvm/global

```
LVM module LVM version 1.0.5(mp-v6)(15/07/2002)
Total:  1 VG  1 PV  1 LV (0 Lvs open)
Global: 32300 bytes malloced   IOP version: 10   3:18:35 active
VG:  vg_kb  [1 PV, 1 LV/0 open]  PE Size: 4096 KB
  Usage [KB/PE]: 7204864 /1759 total  7204864 /1759 used  0 /0 free
  PV:  [AA] dasdc1                7204864 /1759     7204864 /1759
          0 /0
        +-- dasdd1
    LV:  [AWDL  ] lv_kb                     7204864 /1759     close
```

lvscan

```
lvscan -- ACTIVE            "/dev/vg_kb/lv_kb" [6.87 GB]
lvscan -- 1 logical volumes with 6.87 GB total in 1 volume  group
lvscan -- 1 active logical volumes
```

Enable Paths

pvpath-change or query path attributes of a physical multipathed volume

pvpath -qa

```
Physical volume /dev/dasdc1 of vg_kb has 2 paths:
       Device  Weight Failed Pending State
 #  0:  94:9        0      0       0 enabled
 #  1:  94:13       0      0       0 disabled
```

The second path can be enabled:

pvpath -p1 -ey /dev/dasdc1

```
vg_kb: setting state of path #1 of PV#1 to enabled
```

pvpath -qa

```
Physical volume /dev/dasdc1 of vg_kb has 2 paths:
       Device  Weight Failed Pending State
 #  0:  94:9        0      0       0 enabled
 #  1:  94:13       0      0       0 enabled
```

Now LVM is ready to use both paths to the volume

Results

iozone sequential write/read 1 disk

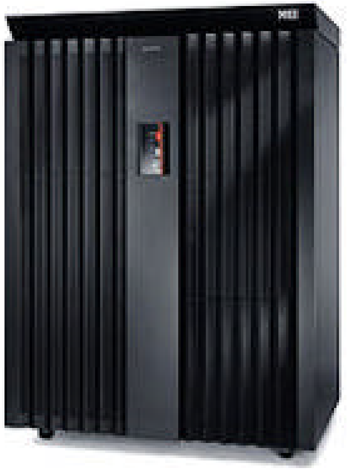
Paths	Write (MB/s)	Read (MB/s)
1	14.9	27.0
2	18.7	46.4
3	22.4	65.9
4	23.4	81.4
5	23.2	96.9
6	22.6	106.7
7	21.2	106.7
8	21.1	119.0

These are preliminary results in a controlled environment.

PAV is not yet officially supported with Linux on zSeries!

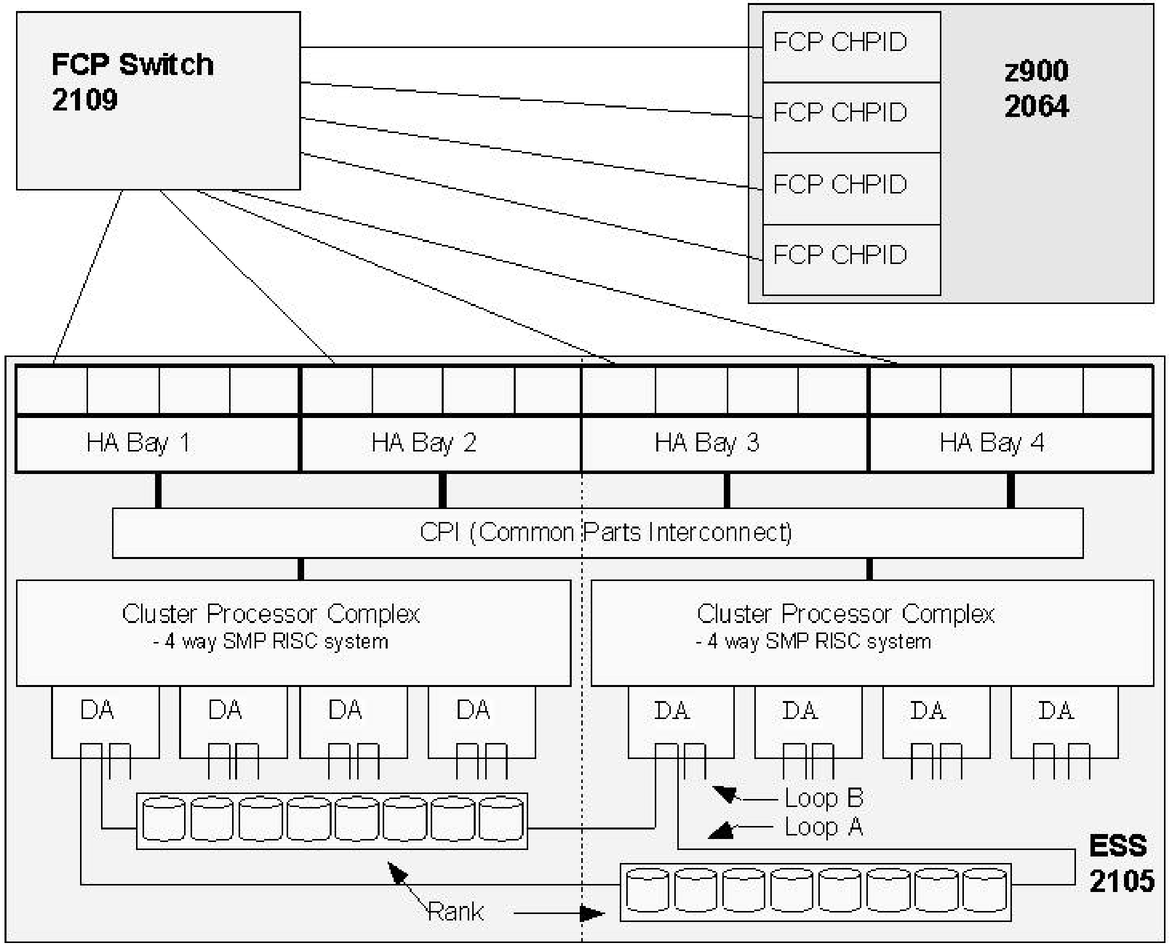
ESS – Disk I/O

- Don't treat ESS as a black box, understand its structure
- The default is close to worst case:
- You ask for 16 disks and your SysAdmin gives you
- addresses 5100-510F
- What's wrong with that?



ESS Architecture

Let's have a deeper look to the elements of the scenario:



- **CHPIDs**

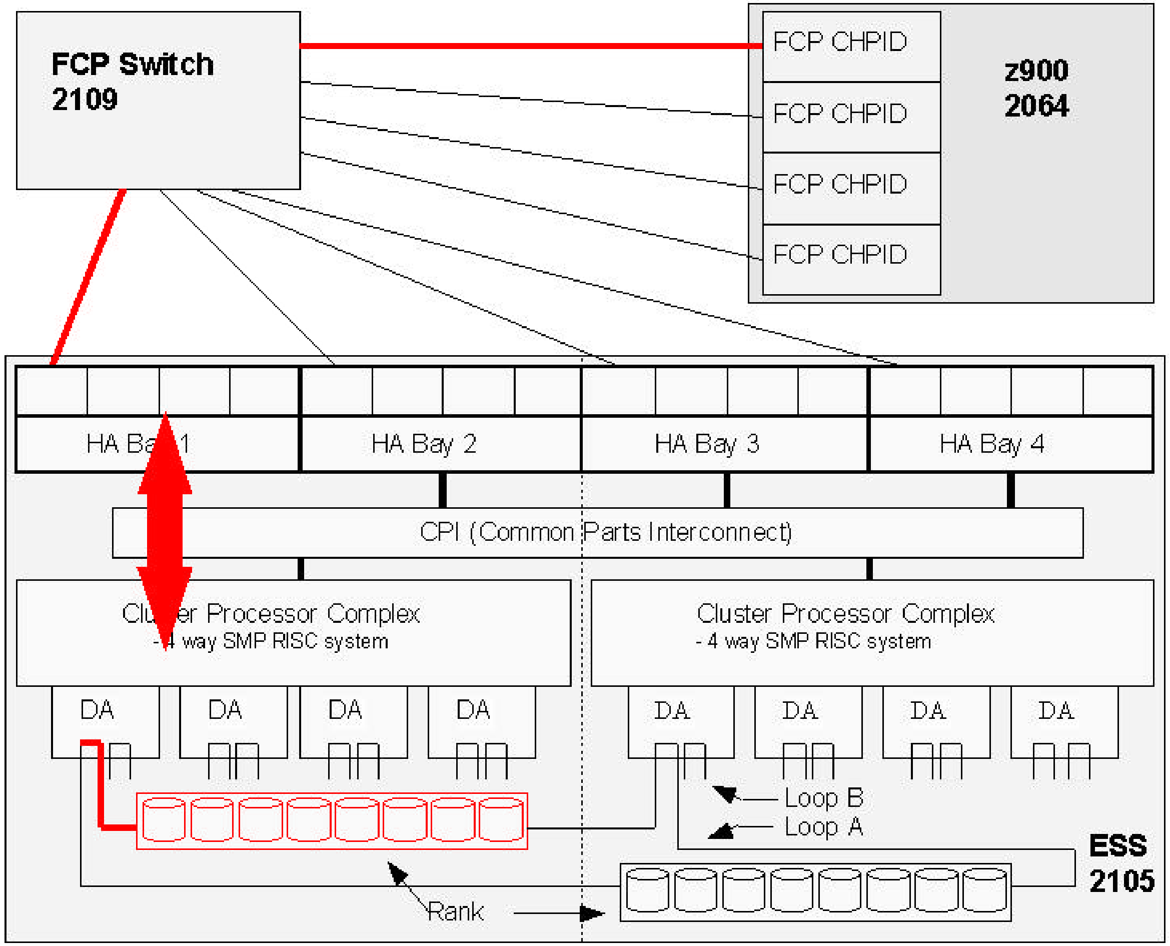
- **Host Adapter (HA) supporting FCP (FCP port)**
  -16 Host Adapters, organized in 4 bays, 4 ports each

- **Device Adapter Pairs (DA)**
  - each one supports two loops

- **Disks are organized in ranks**
  - each rank (8 physical disks) implements one RAID 5 array (with logical disks)

ESS Architecture

Scenarios: single disk, single rank



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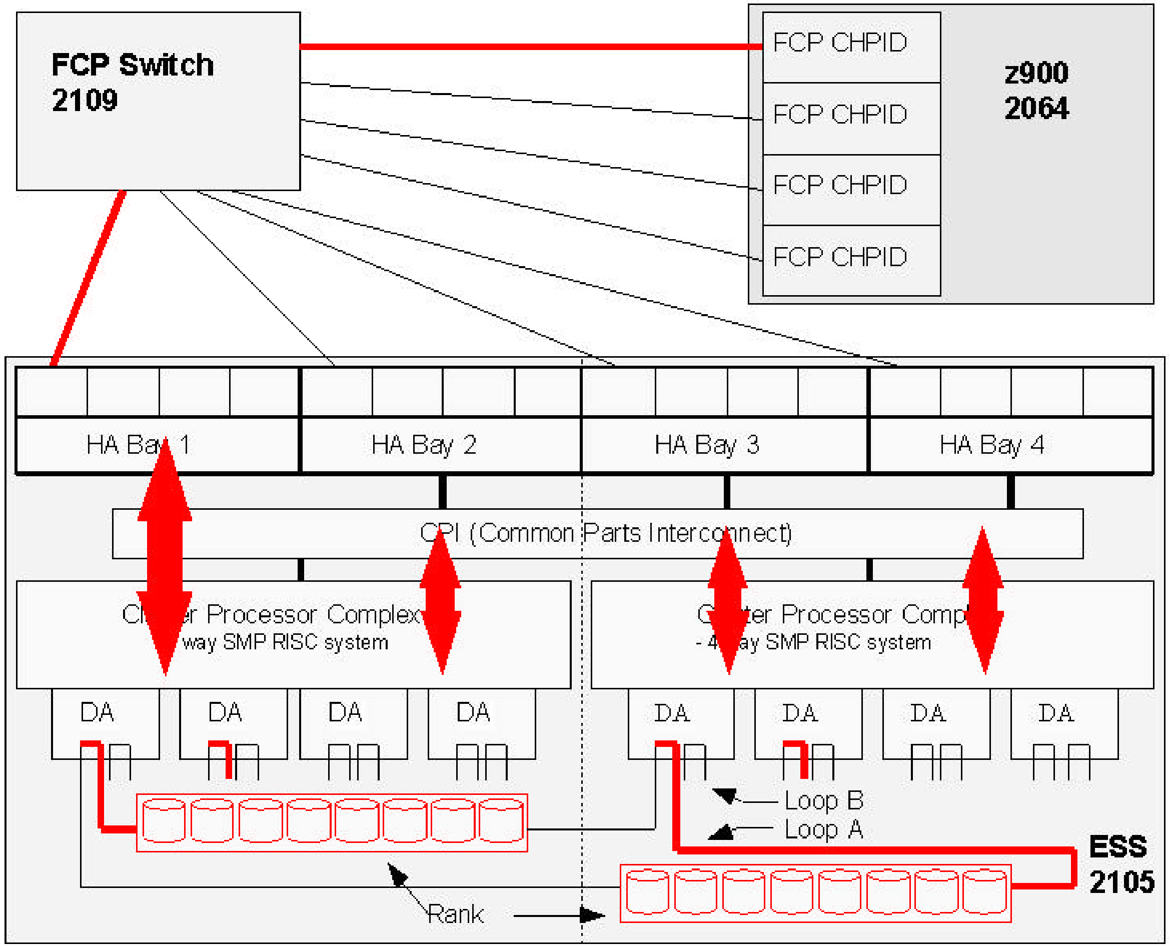
ESS Architecture

Scenario: single host adapter



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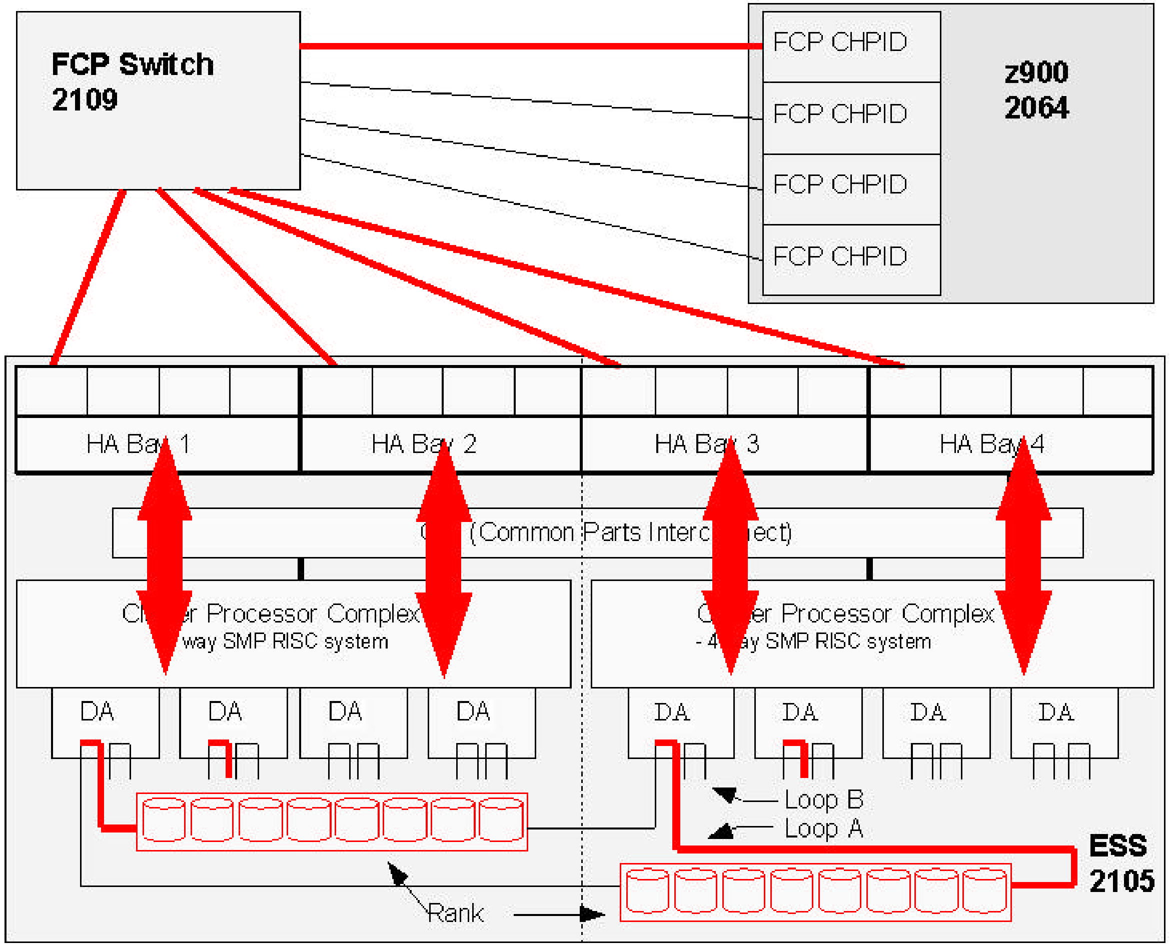
ESS Architecture

Scenario: single CHPID



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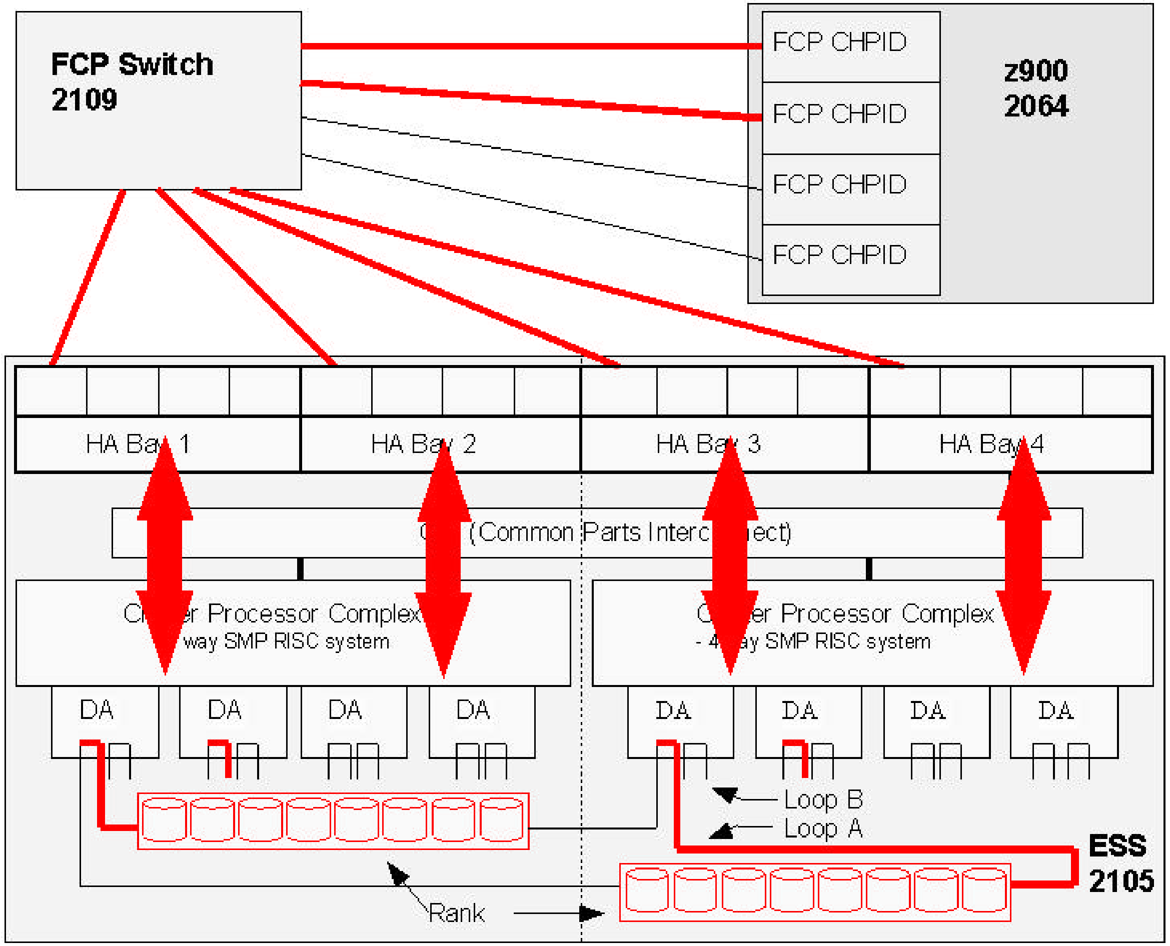
ESS Architecture

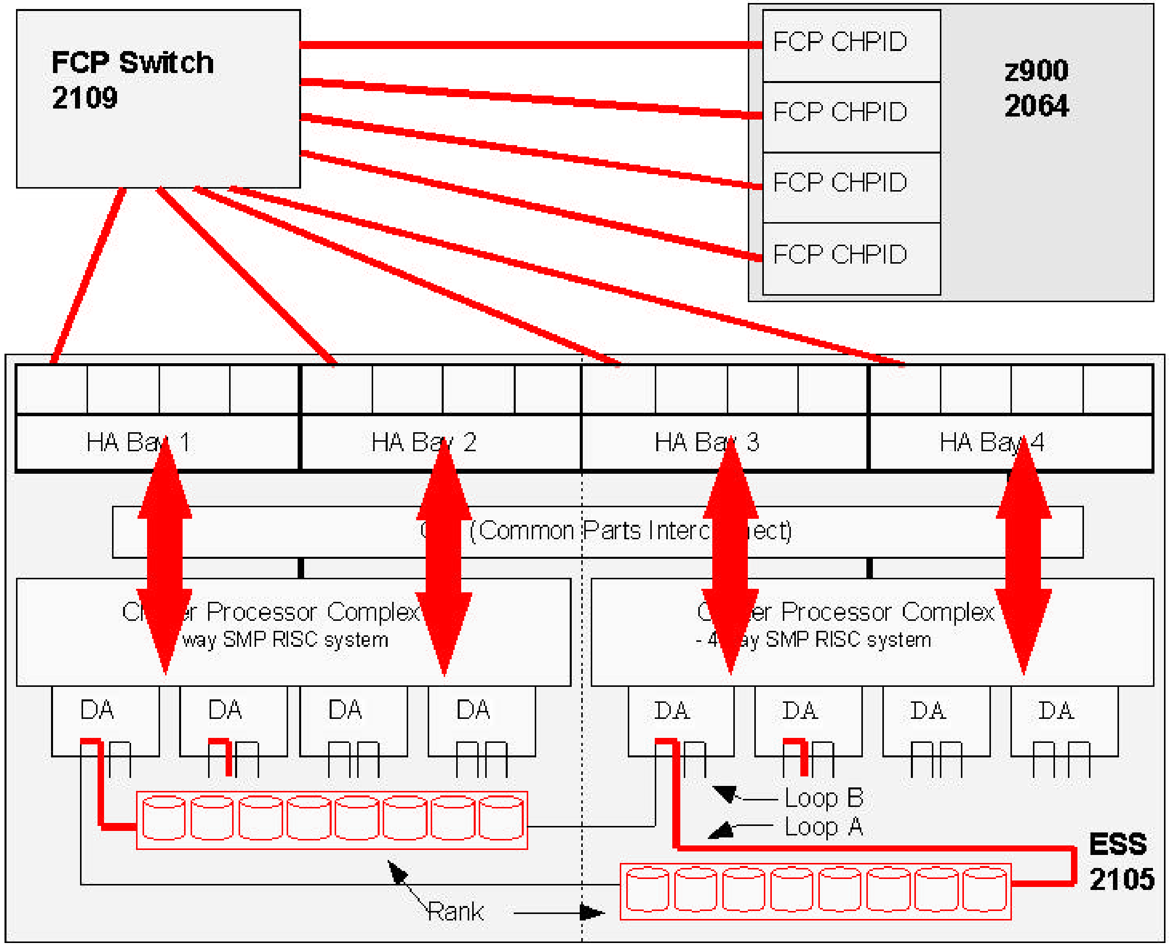
Scenario: two CHPIDs



- **CHPIDs**
- **Host Adapter (HA) supporting FCP (FCP port)**
  - **-16 Host Adapters, organized in 4 bays, 4 ports each**
- **Device Adapter Pairs (DA)**
  - **- each one supports two loops**
- **Disks are organized in ranks**
  - **- each rank (8 physical disks) implements one RAID 5 array (with logical disks)**

ESS Architecture

Scenario: four CHPIDs (4C4H4R ESS 2105)



- **CHPIDs**
- **Host Adapter (HA) supporting FCP (FCP port)**
  - -16 Host Adapters, organized in 4 bays, 4 ports each
- **Device Adapter Pairs (DA)**
  - each one supports two loops
- **Disks are organized in ranks**
  - each rank (8 physical disks) implements one RAID 5 array (with logical disks)

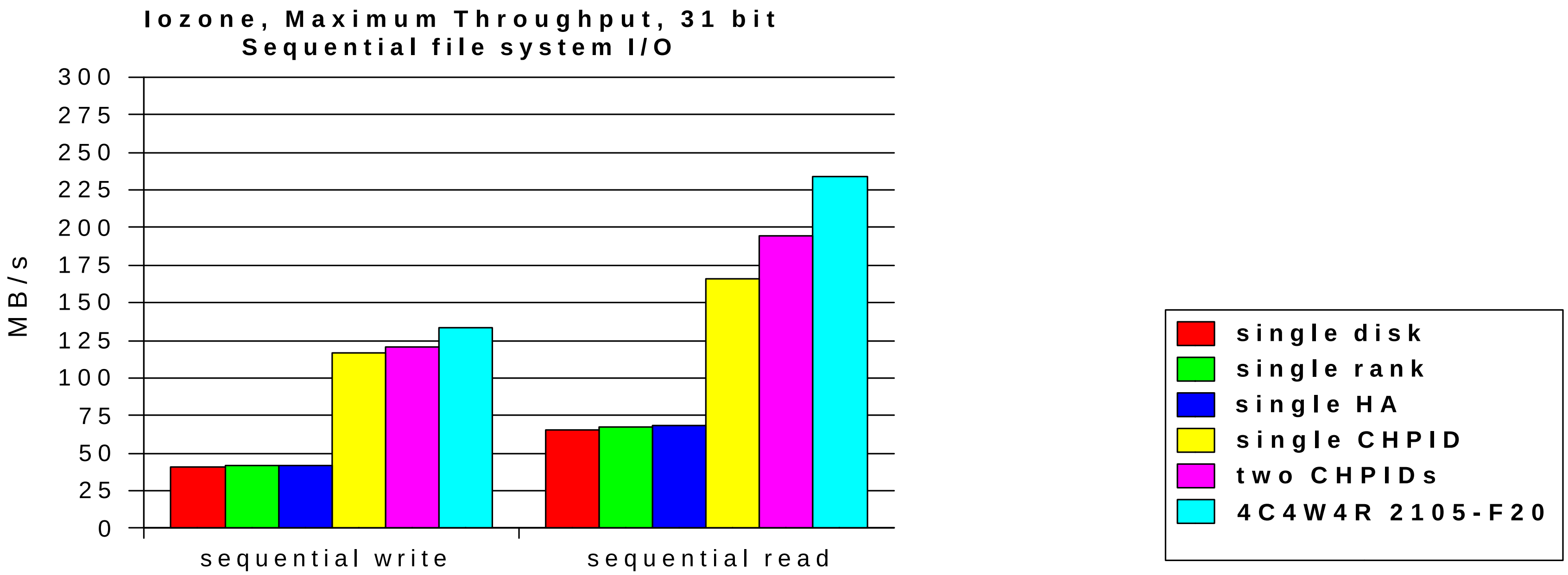
FCP Measurement

- Summary of the Scenarios:

	used resources				limiting resource
Scenario	CHPIDs	HA	Ranks	Disks	
single Disk	1	1	1	1	1 host adapter
single Rank	1	1	1	8	1 host adapter
single Host Adapter	1	1	4	8	1 host adapter
single CHPID	1	4	4	16	1 CHPID
two CHPIDs	2	4	4	16	2 CHPIDs
maximum available = 4C4H4R ESS 2105	4	4	4	16	4 host adapters

- Benchmark used for measuring: **Iozone** (http://www.iozone.org)
  - multi process sequential file system I/O
  - each process writes and reads a 350 MB file on a separate disk
  - System: LPAR, 4 CPUs, 128 MB main memory, Linux 2.4.17 with hz timer off
- scaling was: 1, 2, 4, 8, 16 processes
  the maximum throughput values were taken as result

Results – Maximum Throughput



- 1 HA limits to 40MB/s write and 65 MB/s read, regardless of the number of ranks
- 4 HA are limiting to 125 MB/s write and 240 MB/s read,but 4 CHPIDs are required to make use of it
- 31 bit and 64 bit difference is small
- it is expected that the values further increase using more ranks, HA, CHPIDs

General Rules

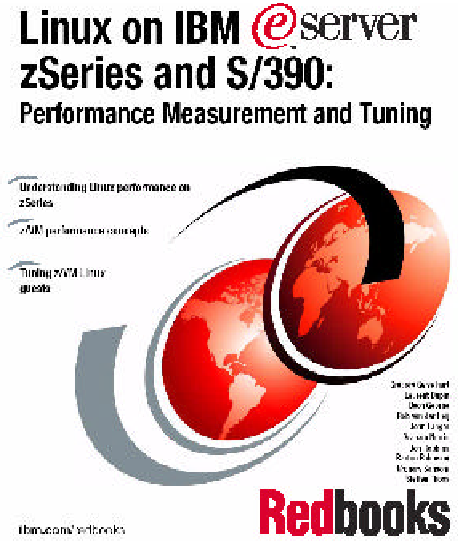
- this makes it **slow**:
    - when all disks are from one rank and accessed via the same path

- this makes it **fast**:
    - use many host adapters
    - spread the host adapters used across all host adapter bays
    - use as much CHPIDs as possible and
      access each disk through all CHPIDs, if possible (FICON, LVM1-mp)
    - spread the disks used over all ranks equally

- this applies to FCP and FICON

Visit us !

- Linux for zSeries Performance Website:
  - http://www10.software.ibm.com/developerworks/opensource/linux390/whatsnew.shtml
- Linux-VM Performance Website:
  - http://www.vm.ibm.com/perf/tips/linuxper.html
- Performance Redbook:
  - SG24-6926-00



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Understanding Linux performance on zSeries

z/VM performance concepts

Tuning z/VM Linux guests

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