Linux on zSeries Performance Update

Session 9390

Steffen Thoss
thoss@de.ibm.com

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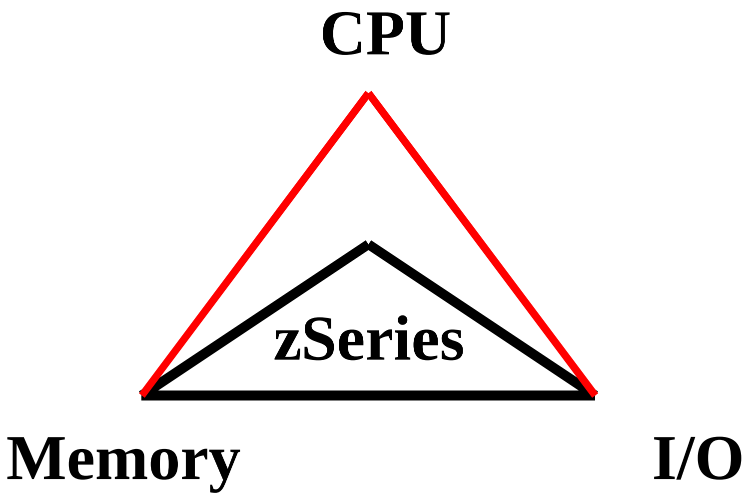
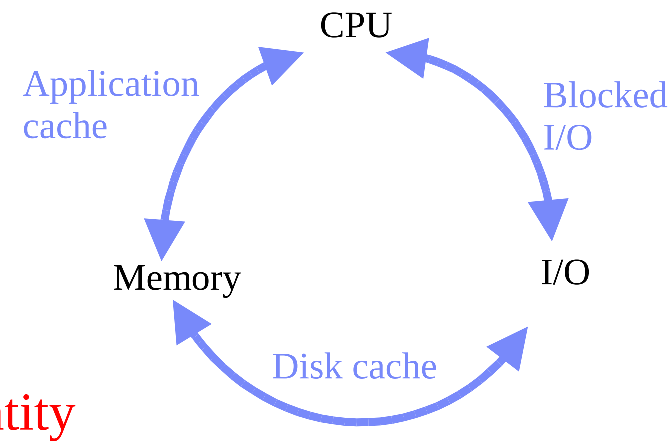
Agenda

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

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 ...)

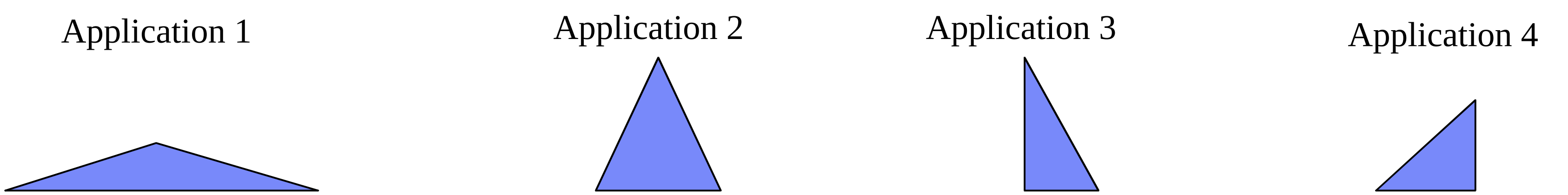




The ideal platform requires a mix of resources in right quantity

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.

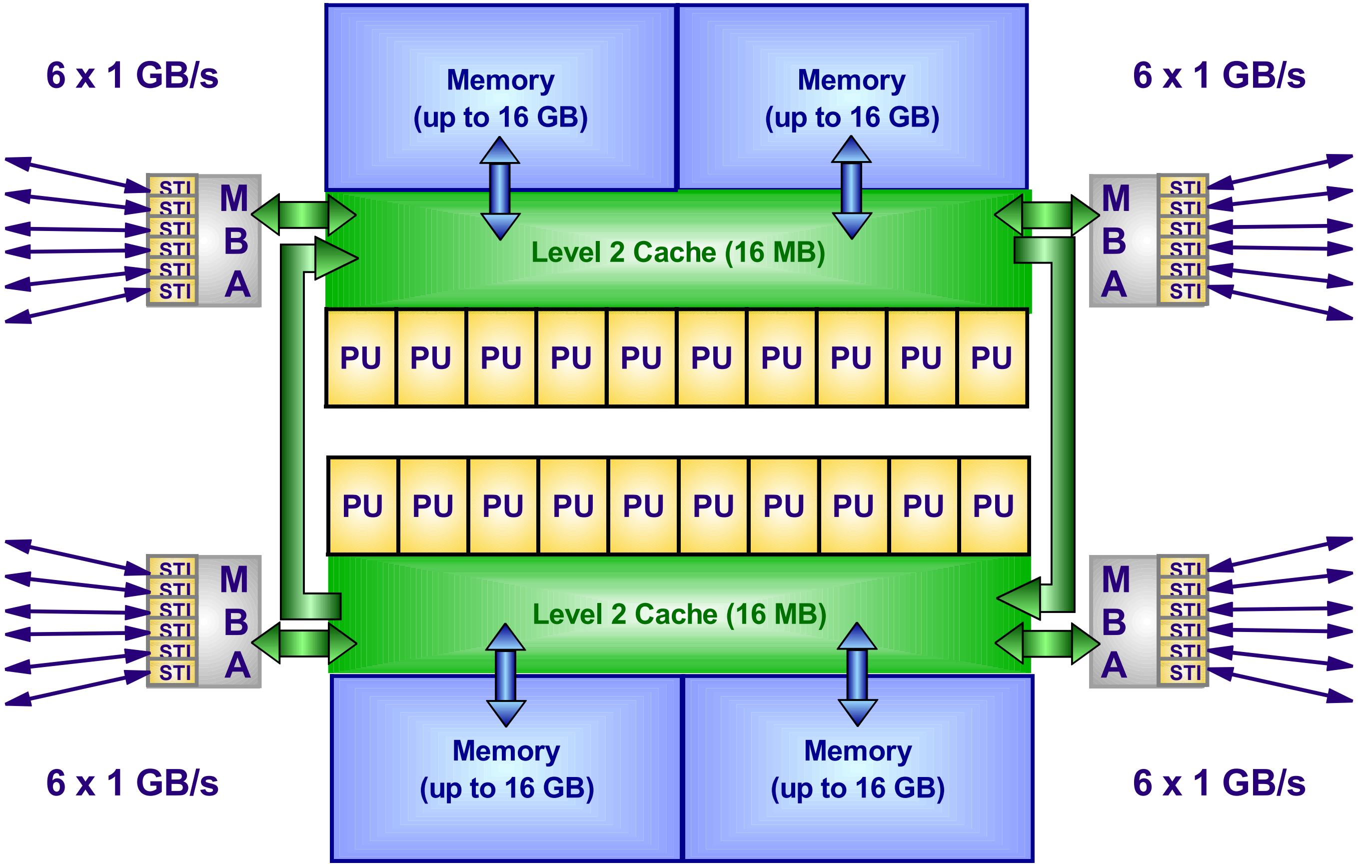


zSeries Hardware

z800/z900

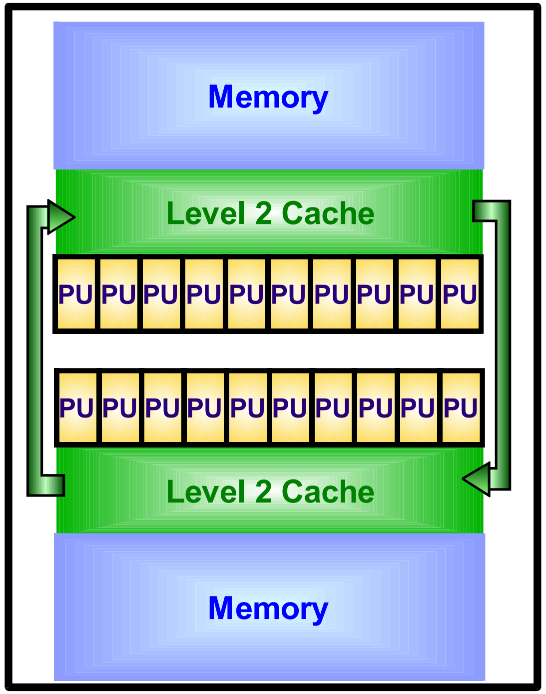
z990

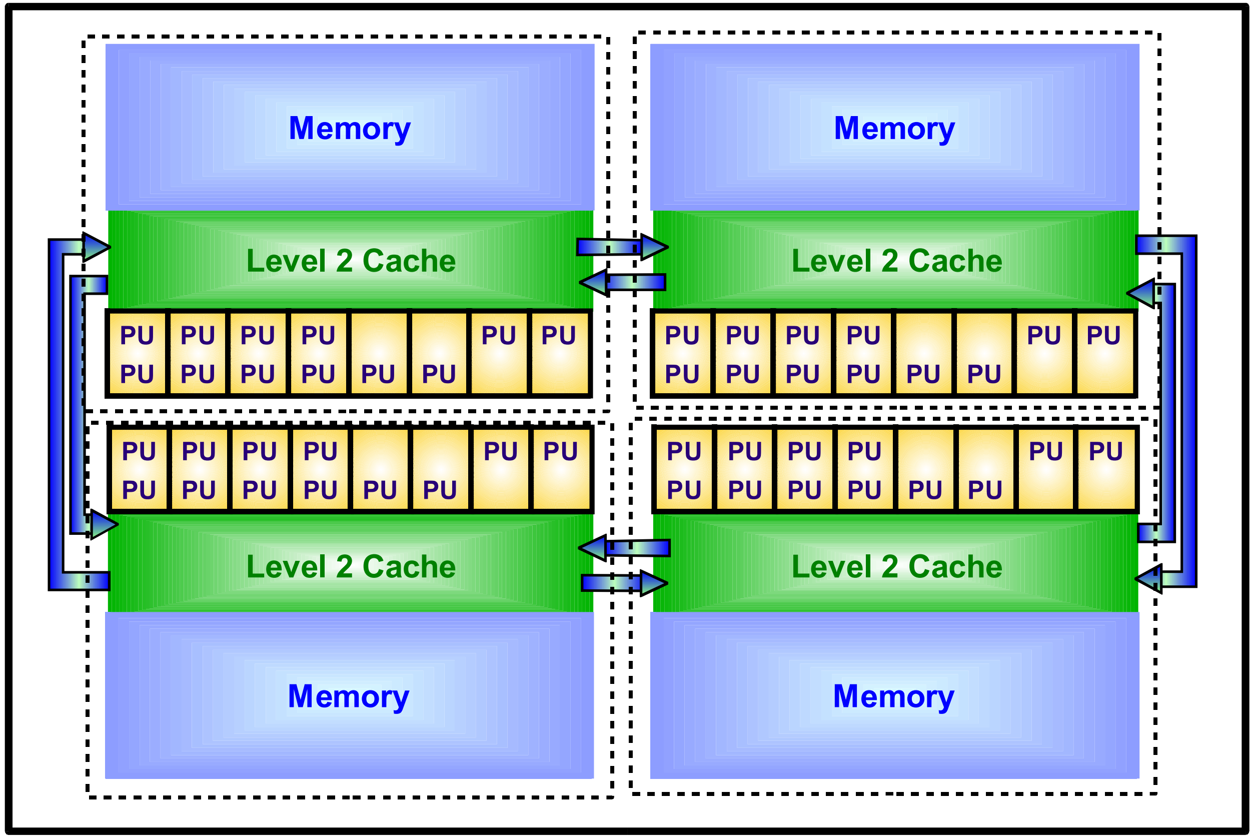
z900 System structure: Optimized for maximum external bandwidth



- 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

zSeries 2003: Extended Multi-Node(Book)-Structures:



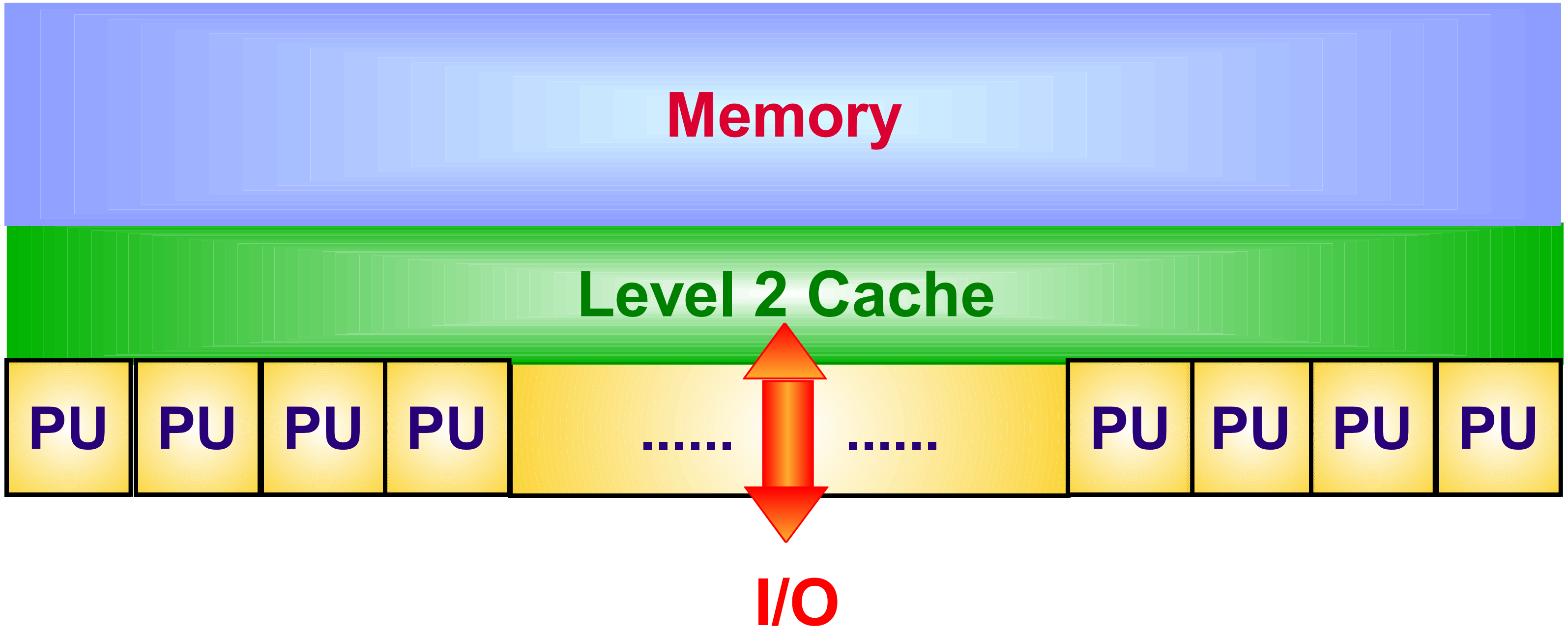


From z900 ...

... to next generation modular zSeries systems with x-fold capacity

- 0.8x nsec CPU-Cycle
- Superscalar Design
- ..50..60.. % more UP-Performance vs 2C1

zSeries 2003: 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)

z990 – 4 New Models

- Machine Type: 2084
- 4 Models:
  - A08 & B16 (GA1 = 6/16/2003) maximum 2 Books
  - C24 & D32 (GA2 = 4Q2003) maximum 4 Books
- Each Processor-Book has:
  - 12 PUs
  - 8 PUs available for characterization as CPs, IFLs, ICFs or additional SAPs
  - 2 PUs standard as SAPs
  - 2 PUs standard as spares
- Memory:
  - Up to 64 GB per Book
  - System minimum of 8 GB
  - 8 GB increments
- I/O:
  - Each Book has up to 12 STIs @ 2 GB/s
  - Up to 96 GB System bandwidth
  - Up to 512 channels/CEC - dependent on Channel types

Our Hardware for Measurements

2064-216 (z900)

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

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)

2 Books each with 8 PU
64 GB
OSA Express GbE
FICON
Hipersocket
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

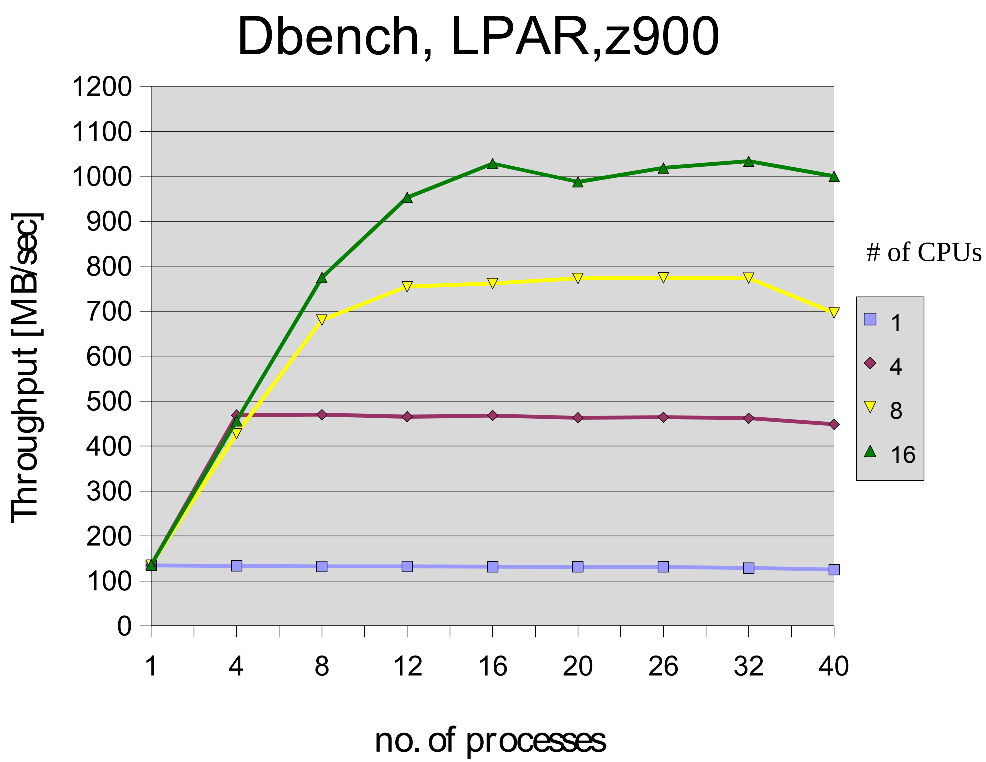
SuSE SLES7 versus SuSE SLES8

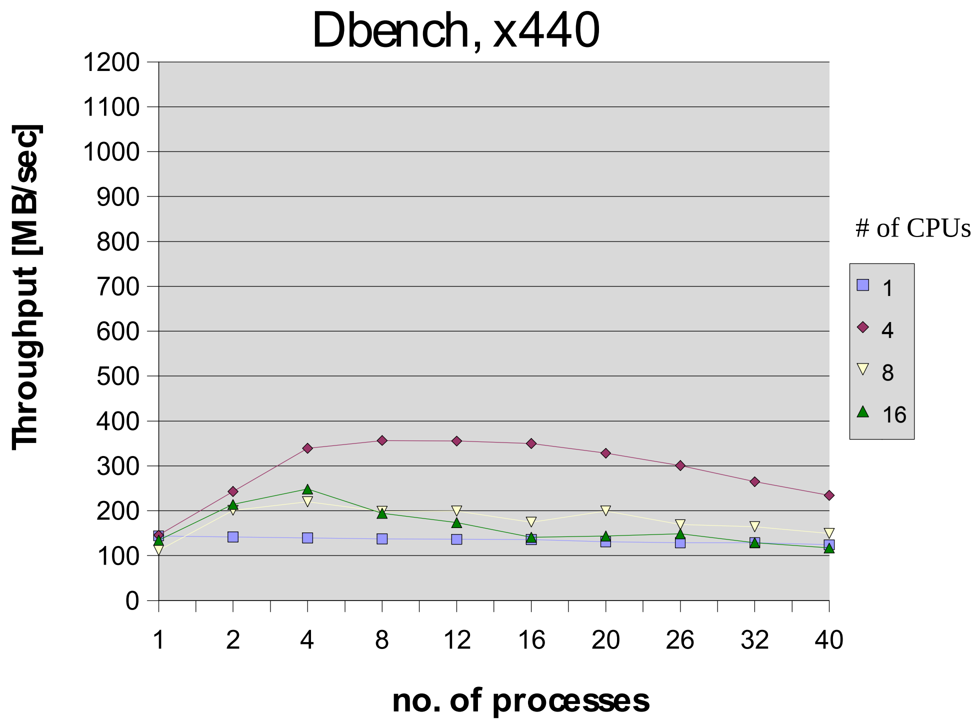
- From Kernel version 2.4.7 / 2.4.17 to version 2.4.19
- From glibc version 2.2.4-31 to version 2.2.5-84
- From gcc version 2.95.3 to version 3.2-31
- Huge number of United Linux patches
- 1.3 MLOC (including x,p,i changes)
- New Linux scheduler
- Async I/O
- SLES8 SP2 available

Scalability – Dbench File I/O

- Emulation of Netbench benchmark, rates windows fileservers
- Mixed file operations workload for each process: create, write, read, append, delete
  - Scaling for Linux with 1, 4, 8, 16 PUs
  - Scaling for 1, 4, 8, 12, 16, 20, 26, 32, 40 clients (processes) simultaneously
- Runs completely in main memory/buffercache in our scenario (2 GB main memory)

Scalability - z900 vs Intel, ext2, 31/32Bit

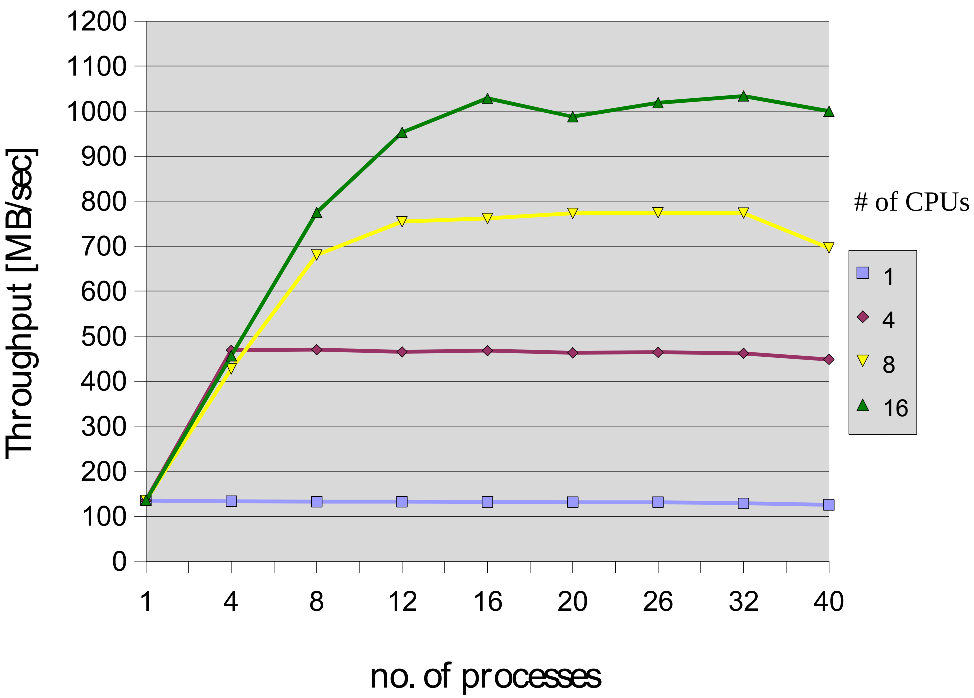




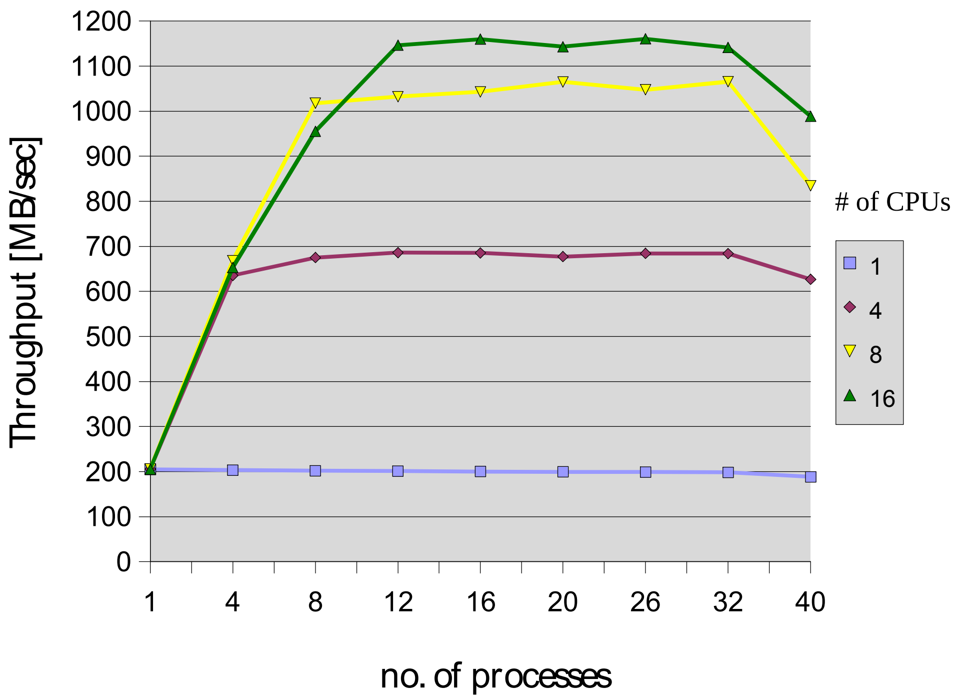
- z900 shows good scaling behavior
- x440 shows best throughput with 4 CPU, strong throughput degradation with more than 4 CPUs

Scalability - z900 vs z990, ext2, 31 Bit

Dbench, LPAR, z900



Dbench, LPAR, z990

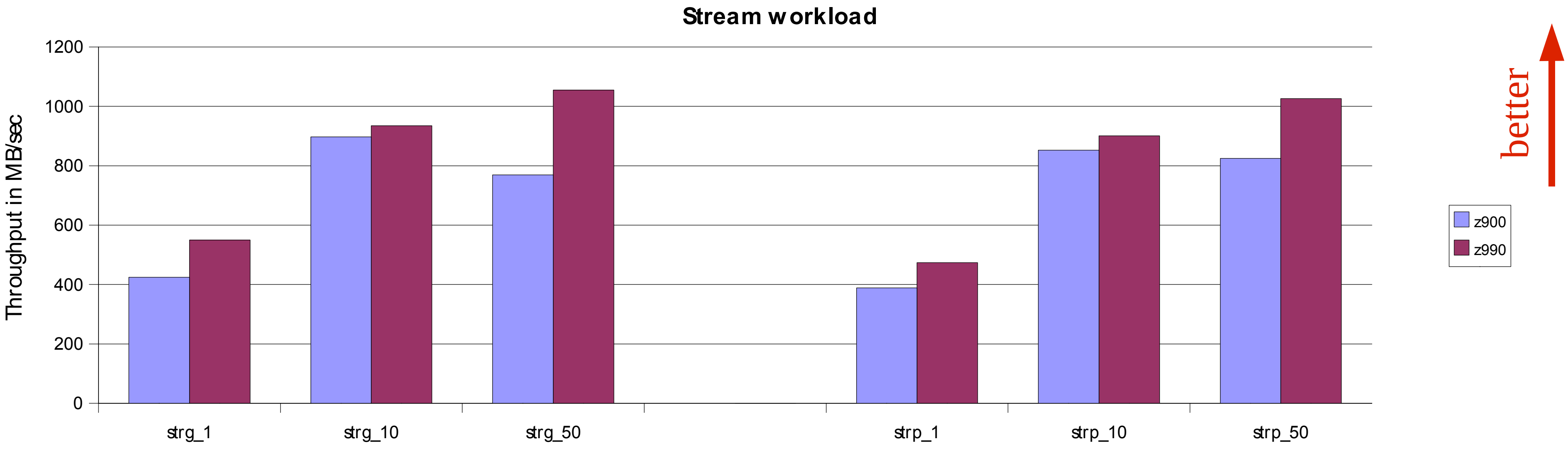


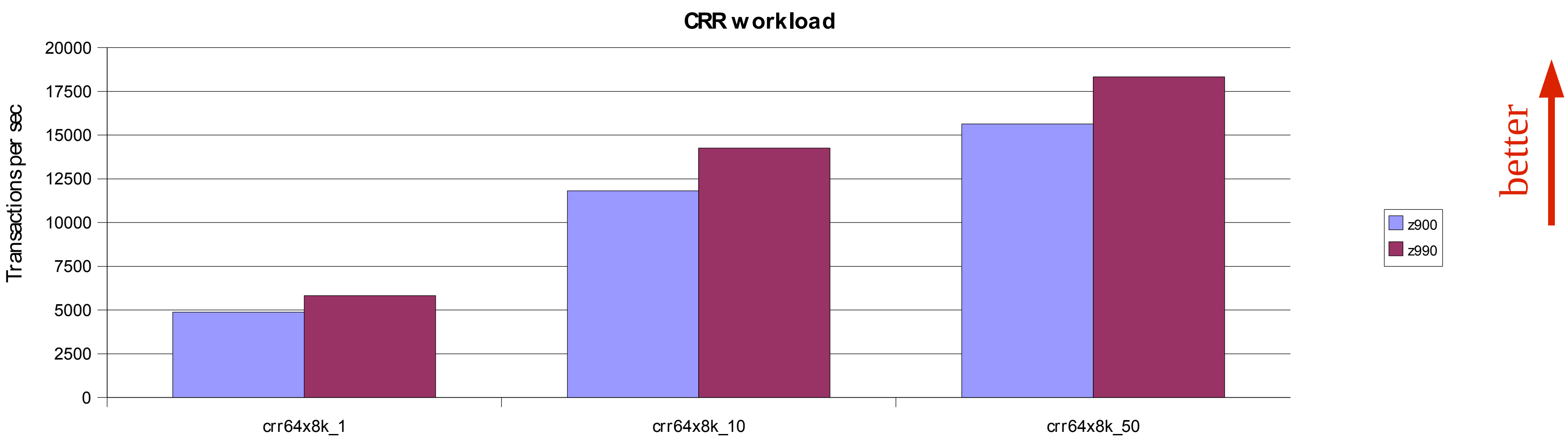
- z990 takes advantage of higher memory bandwidth
- small improvement with 16 PUs because PUs are spread over 2 books

Networking

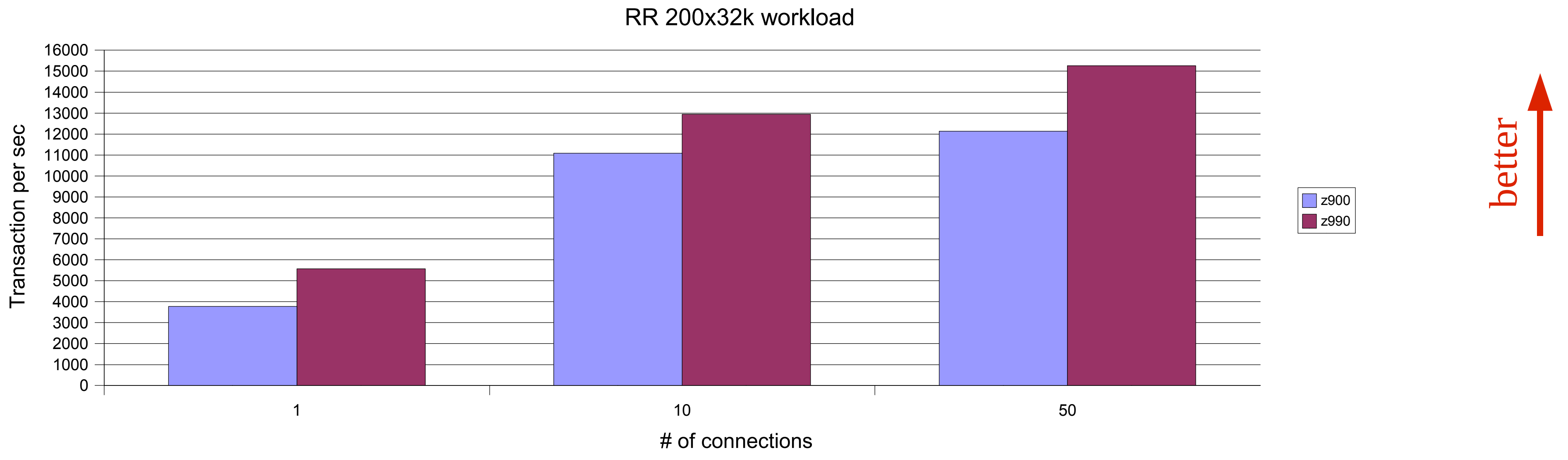
- IBM internal benchmark Netmark 2
- Based on netperf
- Simulates network traffic
- Adjustable parameters
  - runtime
  - packet size
  - number of connections
  - ...
- Huge results file with much statistical information
- Numbers measured on z900 and z990

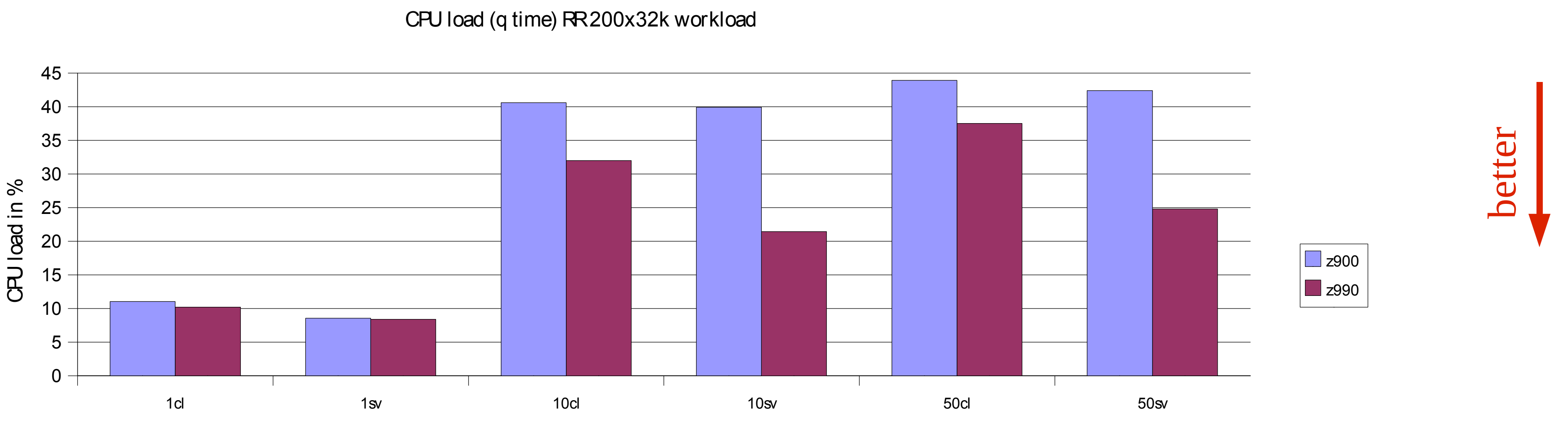
Hipersocket MTU 32k – LPAR





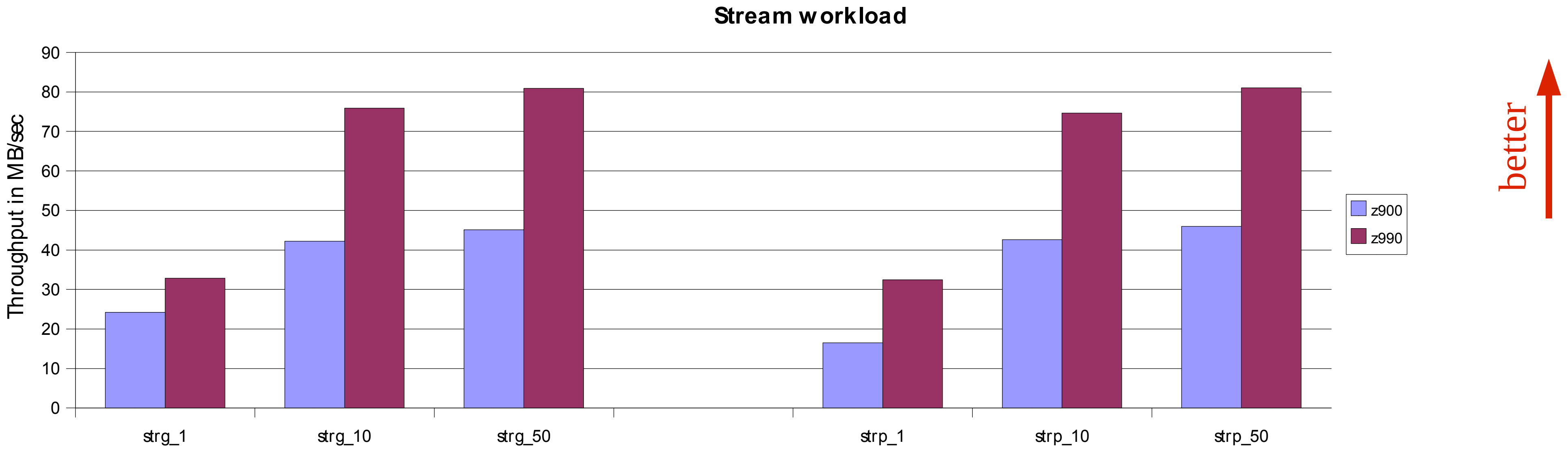
GuestLAN type Hipersocket MTU 32k – z/VM

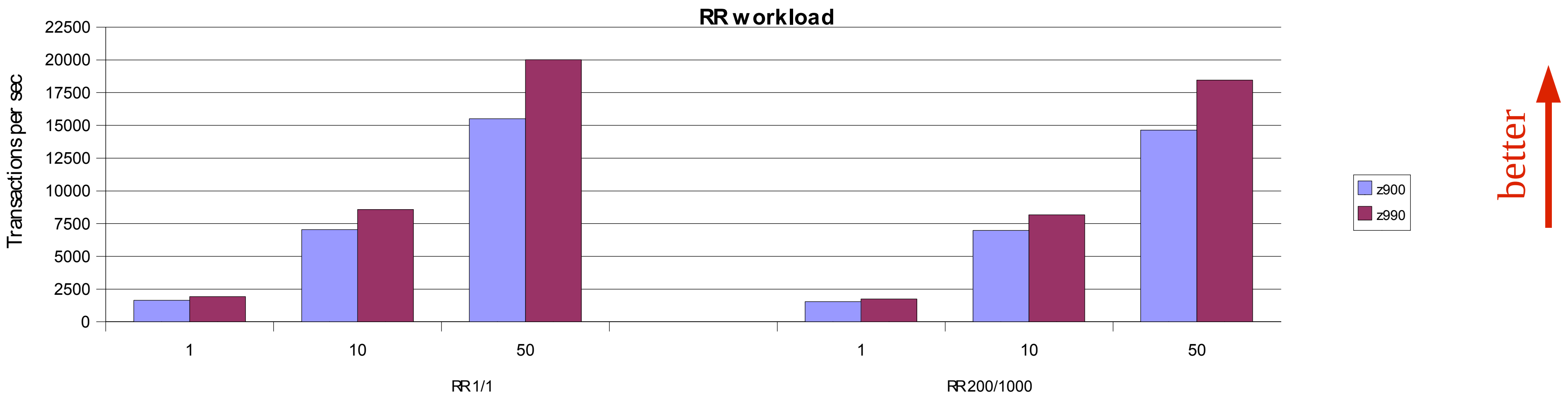




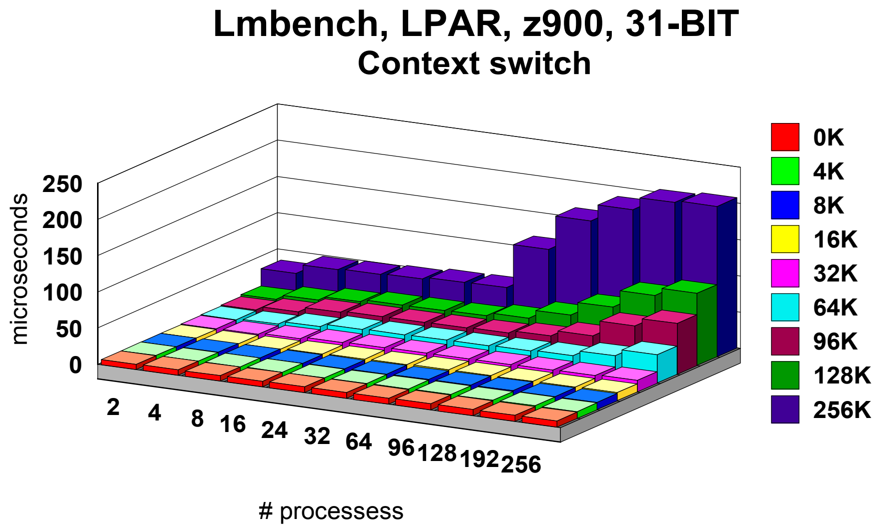
1cl = 1 connection client side (sv=server)

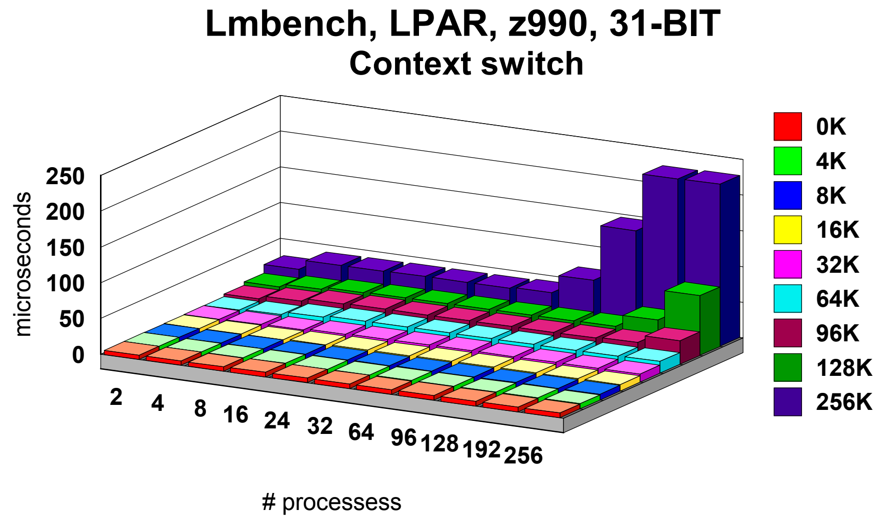
Gigabit Ethernet MTU 1500 – z/VM

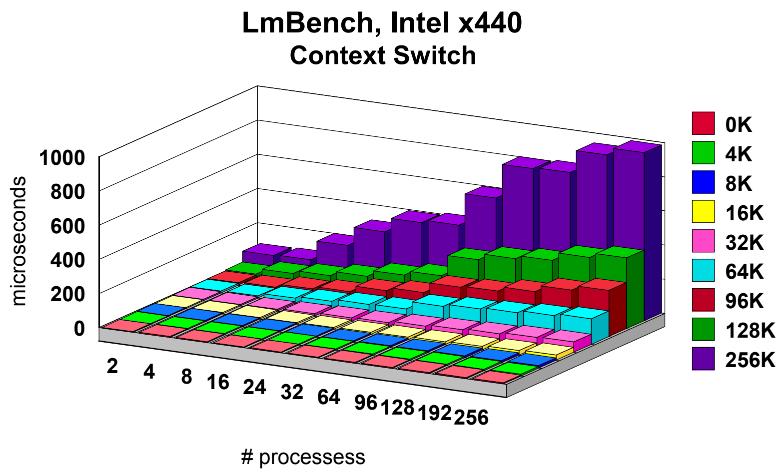




Kernel – Context Switches

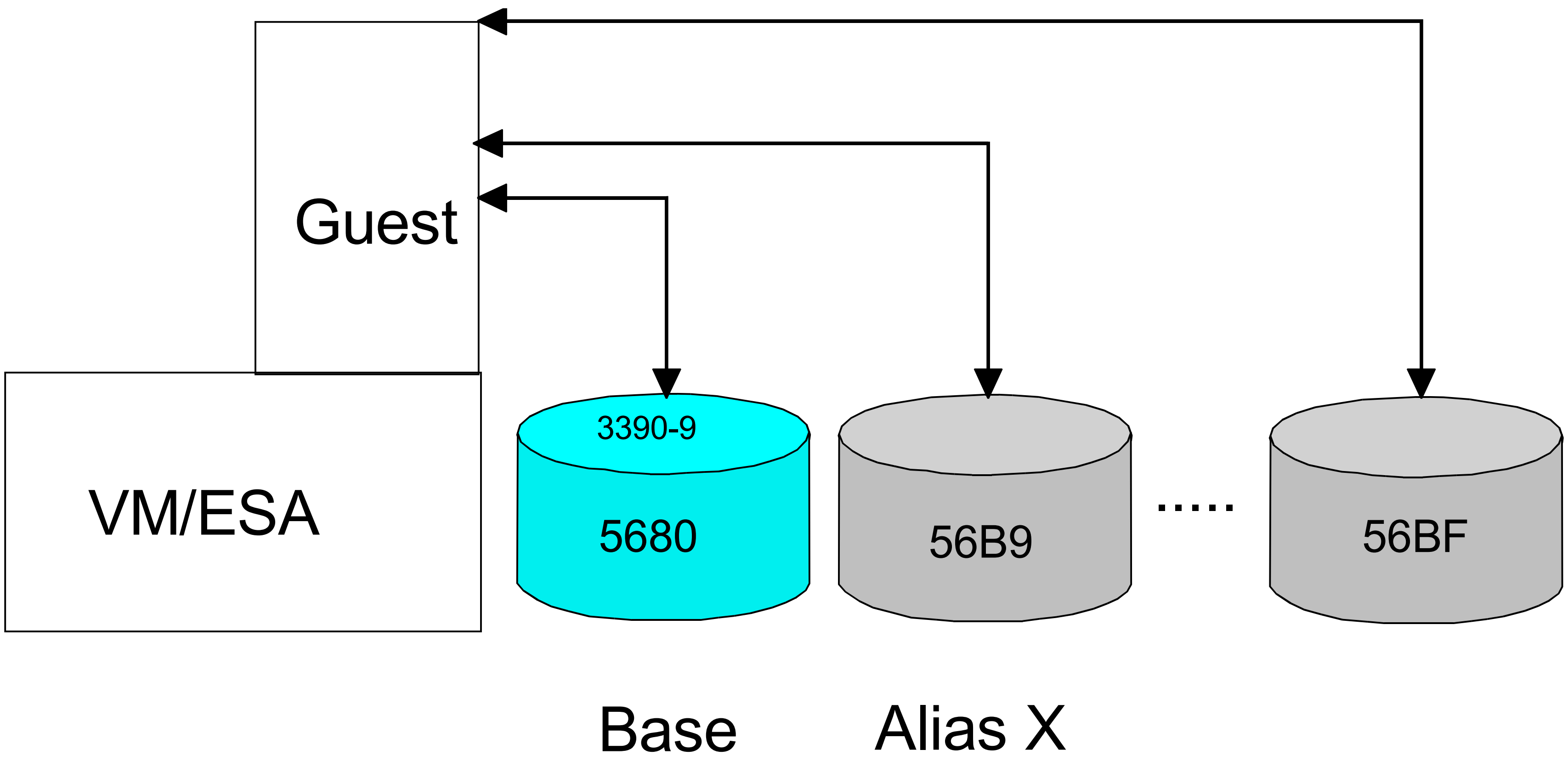






- Context Switches much faster on zSeries because of large shared caches
- Be aware of different Y-axis scale

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
```

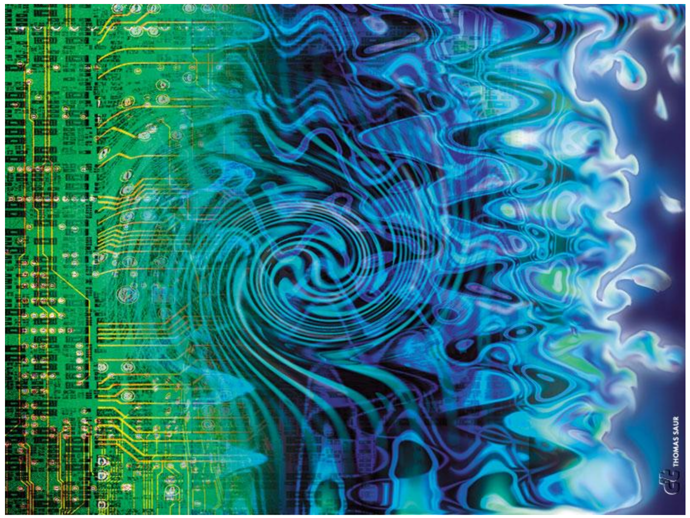
cat /proc/subchannels | egrep "5680|56BF"

```
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
- pvcreate /dev/dasdc1
- vgcreate vg_kb /dev/dasdc1
- 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 -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

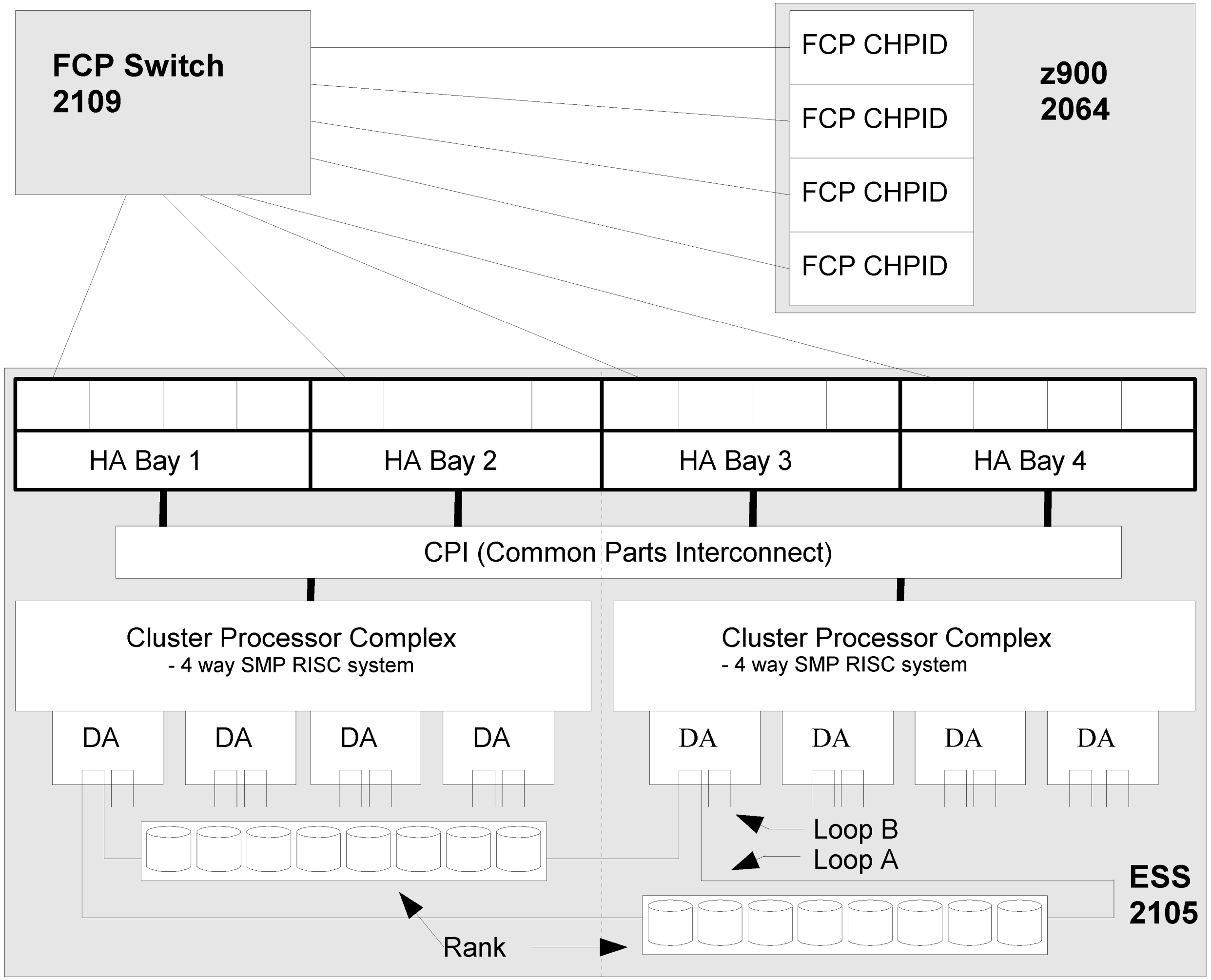
These are preliminary results in a controlled environment.
PAV is not yet officially supported with Linux on zSeries!

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

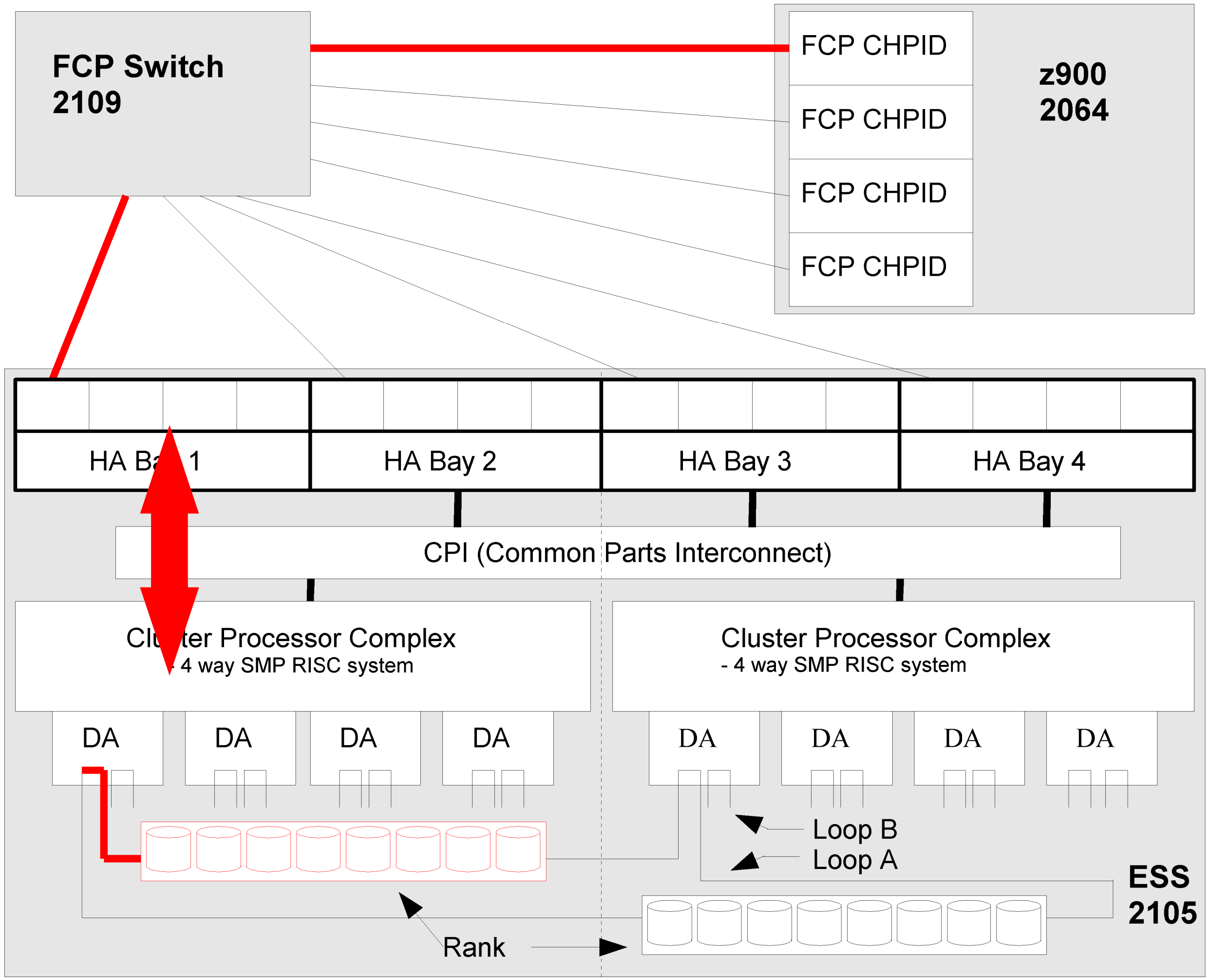
Let's have a deeper look to the elements of the scenario:



- **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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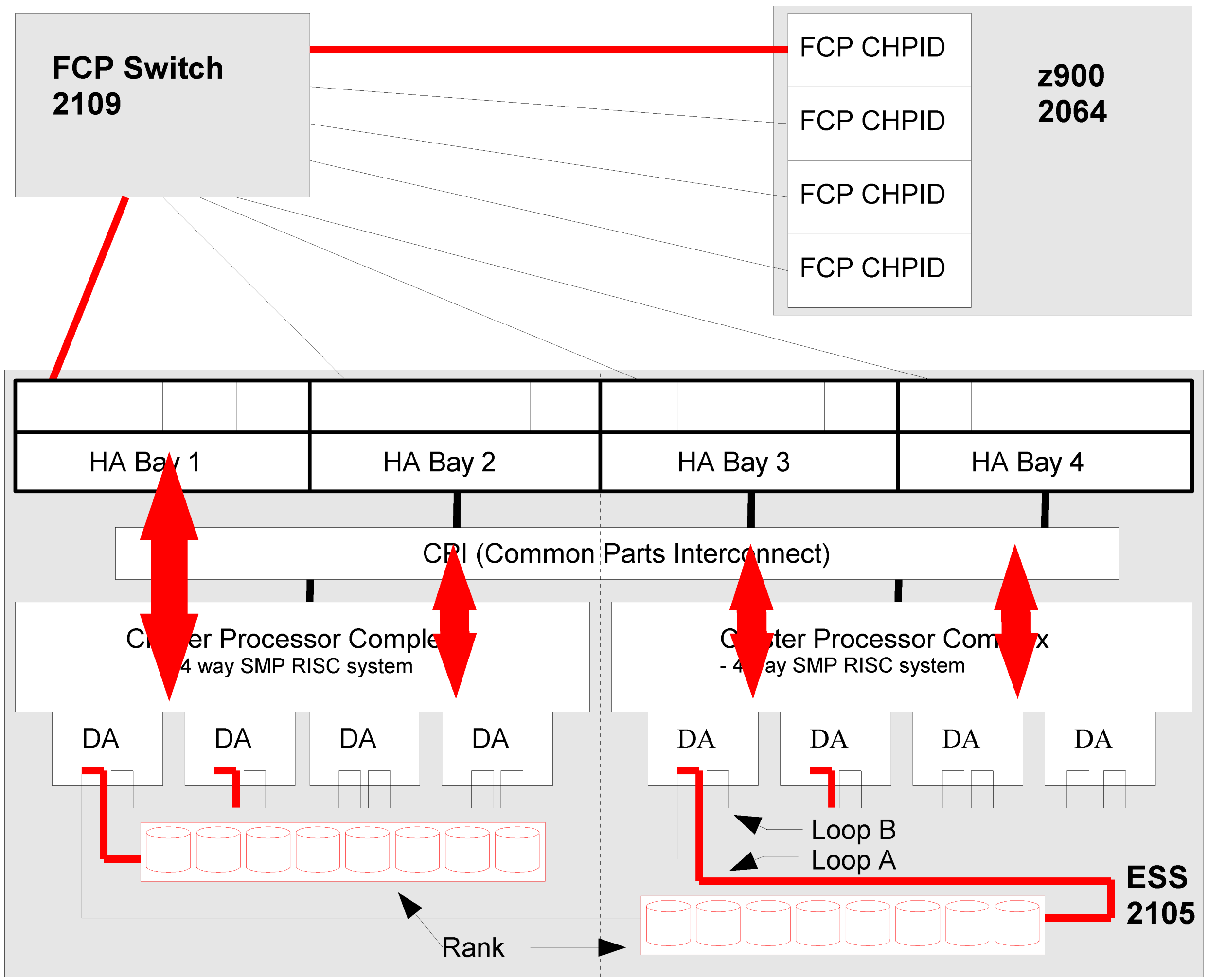
ESS Architecture

Scenario: single host adapter



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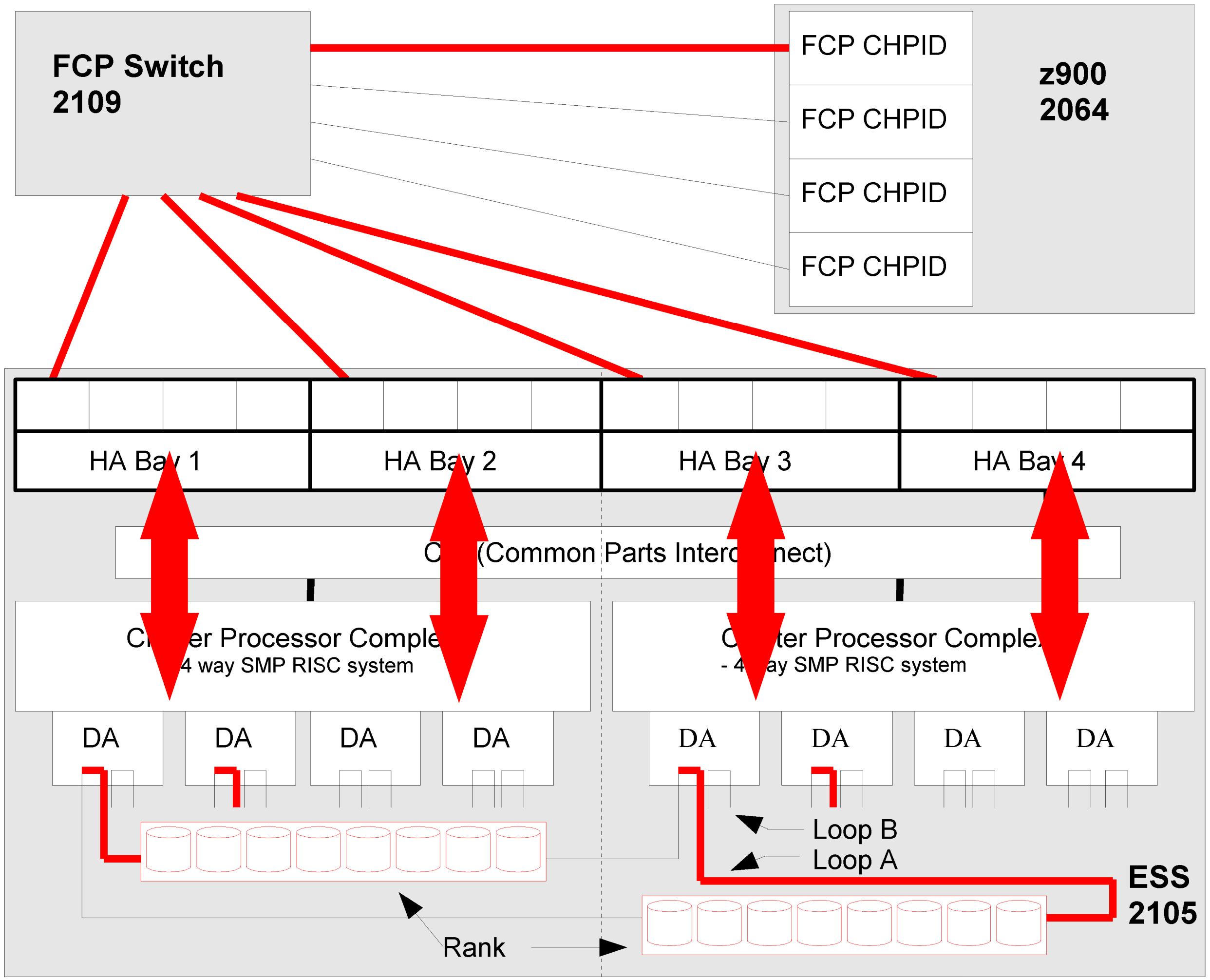
ESS Architecture

Scenario: single CHPID



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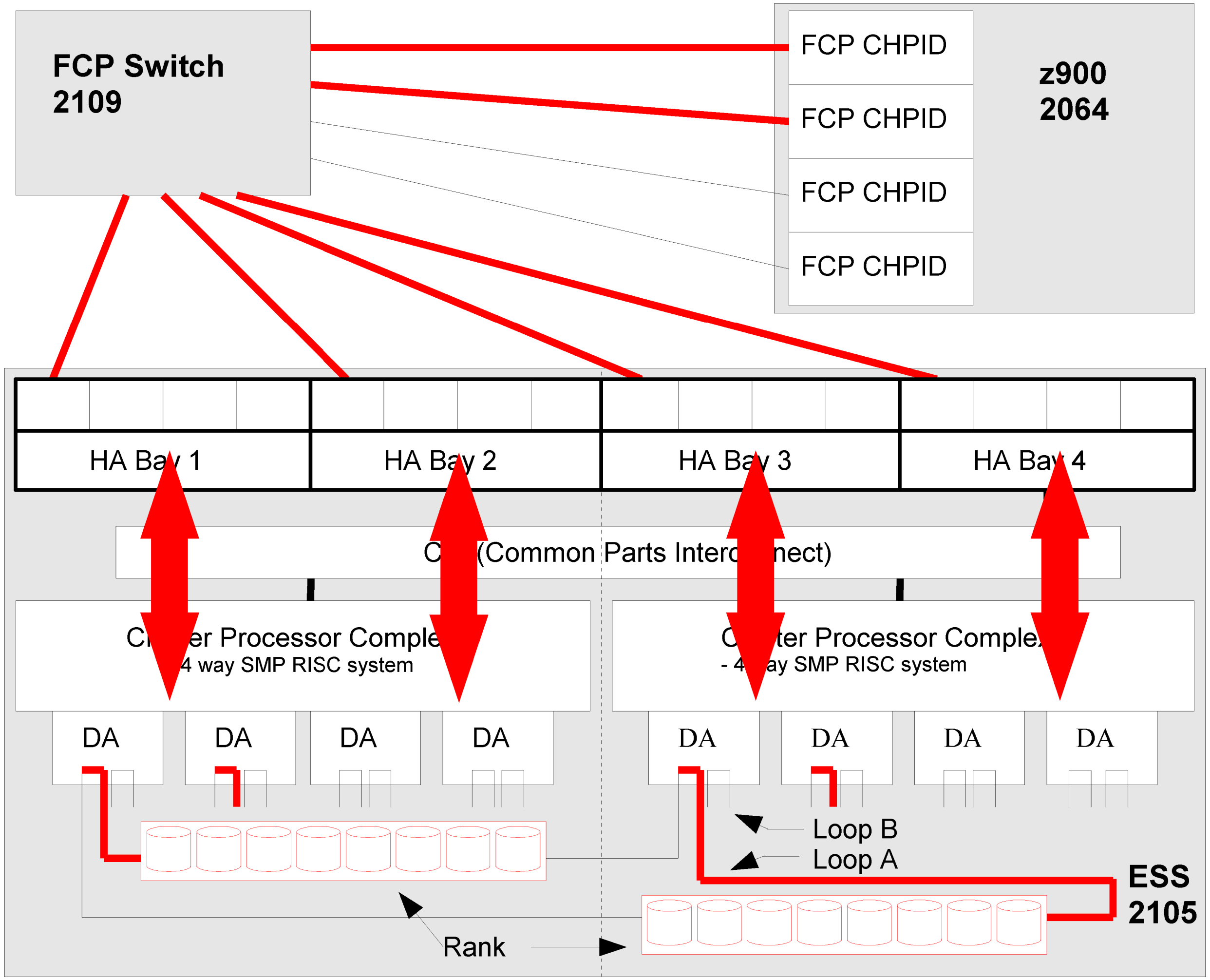
ESS Architecture

Scenario: two CHPIDs



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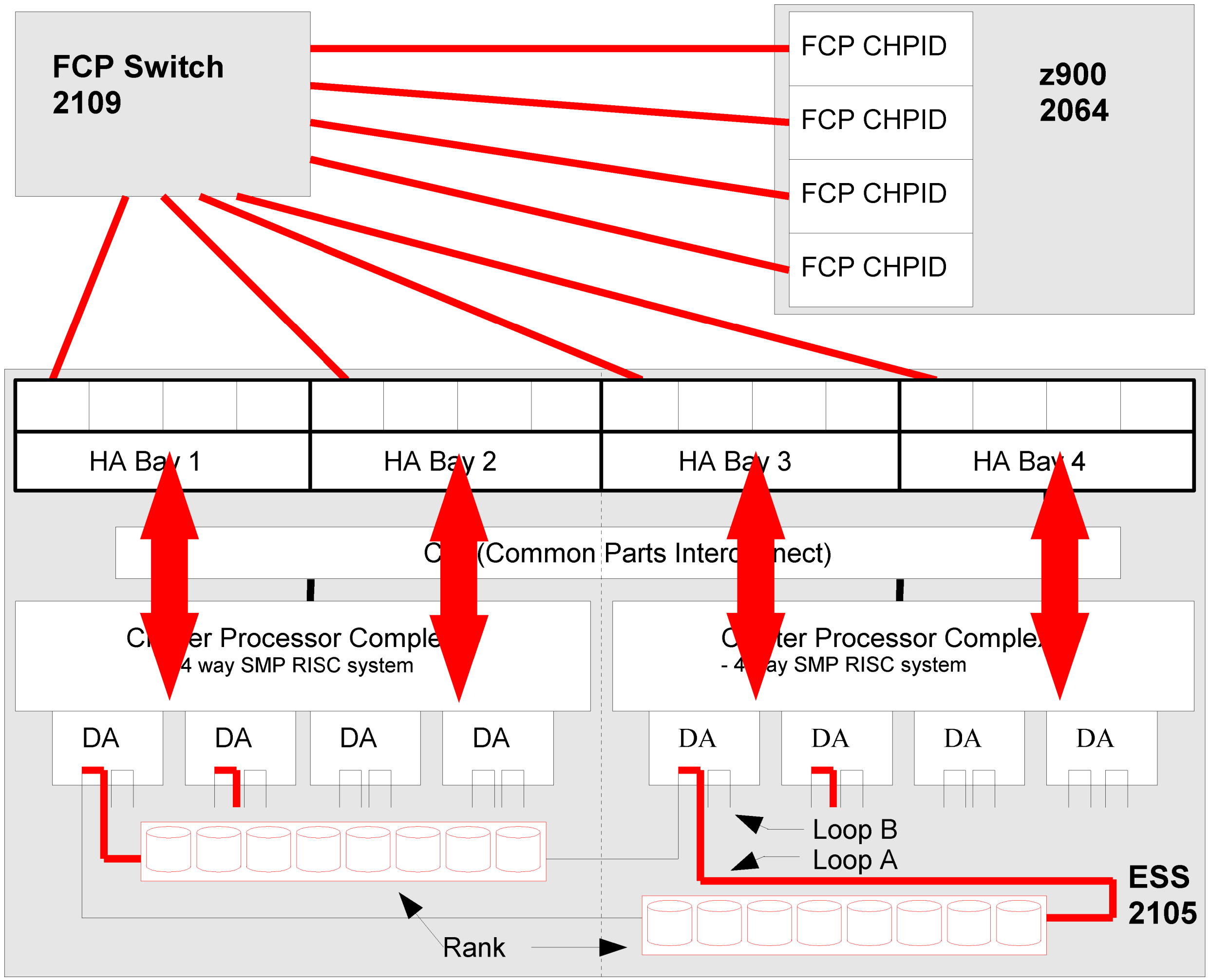
- **Disks are organized in ranks**
  - each rank (8 physical disks) implements one RAID 5 array (with logical disks)

ESS Architecture

Scenario: four CHPIDs (4C4H4R ESS 2105)



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

FCP Measurement

- Summary of the Scenarios:

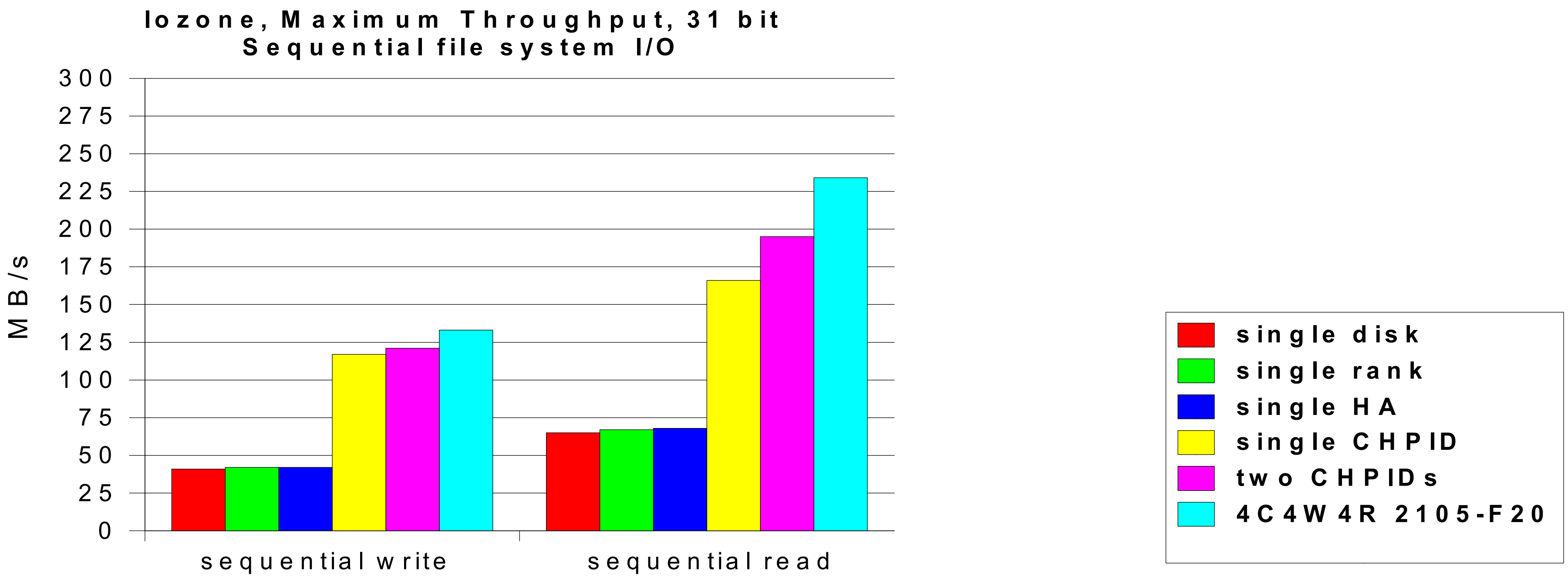
Scenario	used resources				limiting resource
	CHPIDs	HA	Ranks	Disks	
single Disk	1	1	1	1	1 host adapter
single Rank	1	1	1	8	1 host adapter
single Host Adapter	1	1	4	8	1 host adapter
single CHPID	1	4	4	16	1 CHPID
two CHPIDs	2	4	4	16	2 CHPIDs
maximum available = 4C4H4R ESS 2105	4	4	4	16	4 host adapters

- 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

Hardware Setup

- 2064-216, 917 Mhz, 256MB LPAR
- 4 FICON Express channels used for FCP (IOCDS: type FCP)
- 6 FICON Express Channels used for FICON (IOCDS: type FC)
- 2109-F16 FCP switch
- ESS 2105-F20:
  - 16GB cache, 4 FCP host adapters, 6 FICON host adapters
  - 4 device adapter pairs
  - only A-loops contain disks (36.4 GB, 10,000 RPM):
    - - 4 ranks for FB (fixed block) disks used for FCP
    - - 8 ranks ECKD disks used for FICON measurements

Results – Maximum Throughput



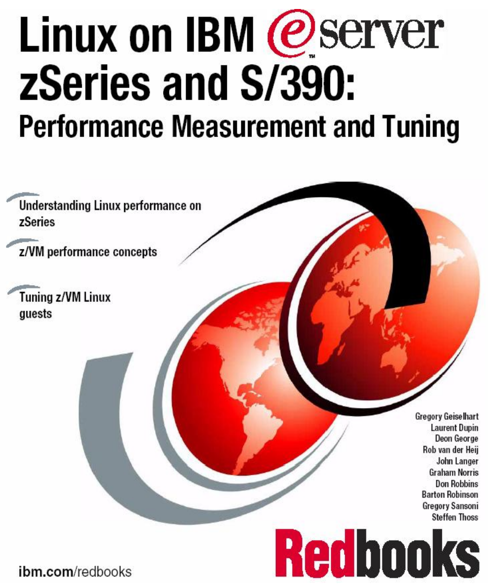
- 1 HA limits to 40MB/s write and 65 MB/s read, regardless of the number of ranks
- 4 HA are limiting to 125 MB/s write and 240 MB/s read,but 4 CHPIDs are required to make use of it
- 31 bit and 64 bit difference is small
- it is expected that the values further increase using more ranks, HA, CHPIDs

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)
  - don't use more than two HAs per CHPID
  - spread the disks used over all ranks equally
  - avoid using the same resources (CHPID, host adapter, rank) as long as possible
- 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



Questions