Linux for System z performance update

Session number 2590

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Feb 28, 2008 8:00 - 9:00

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Agenda

- **System z hardware**
- Hardware improvements
  - Processor
  - Networking
  - Disk / Tape
  - Cryptography
- Software improvements
  - Compiler
  - Java
  - WebSEAL
  - Tivoli Storage Manager
- Distribution improvements
  - Red Hat
  - Novell SUSE

Our hardware for measurements

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2084-B16 (z990)
0.83ns (1.2 GHz)
2 Books, 16 CPUs
2 * 32 MB L2 Cache
80 GB
FICON-Express2

2094-S18 (z9-109)
0.58ns (1.7GHz)
2 Books, 18 CPUs
2*40 MB L2 Cache
128 GB
FICON-Express4

HiperSockets
OSA-Express2 (10)GbE

2105-800 (Shark)
32 GB Cache
1 GB NVS
128 * 72 GB disks
15.000 RPM
FCP (2 Gbps)
FICON (2 Gbps)

2107-922 (DS8000)
256 GB Cache
8 GB NVS
256 * 72 GB disks
15.000 RPM
FCP (4 Gbps)
FICON (4 Gbps)

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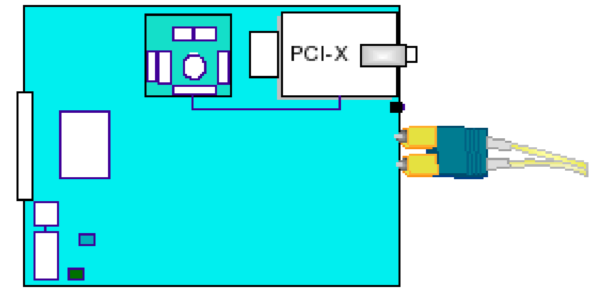
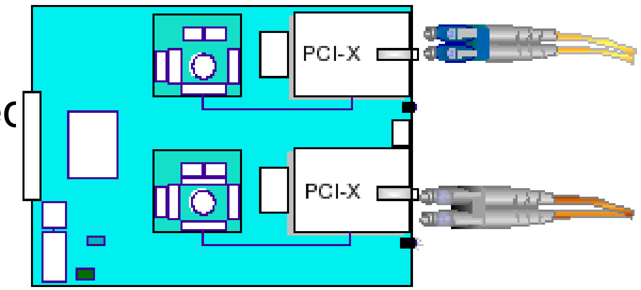
OSA-Express2

- Newest member – 10 Gb Ethernet LR (long reach)
  - One port per feature
- New – Gb Ethernet features
  - Gigabit Ethernet LX (long wavelength)
  - Gigabit Ethernet SX (short wavelength
- Support offered by both 10 GbE and 1 GbE
  - Layer 2 support
  - Up to 1920 TCP/IP stacks for improved virtualization
  - Large send for CPU efficiency

10 Gigabit Ethernet Feature
3368

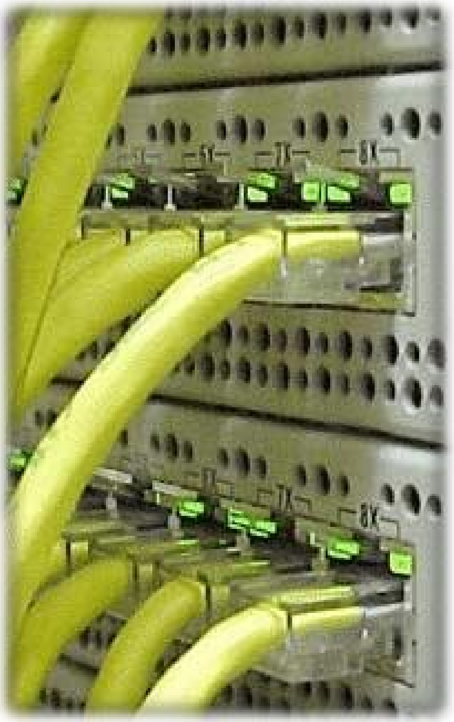


Gigabit Ethernet Features
3364 (LX), 3365 (SX)

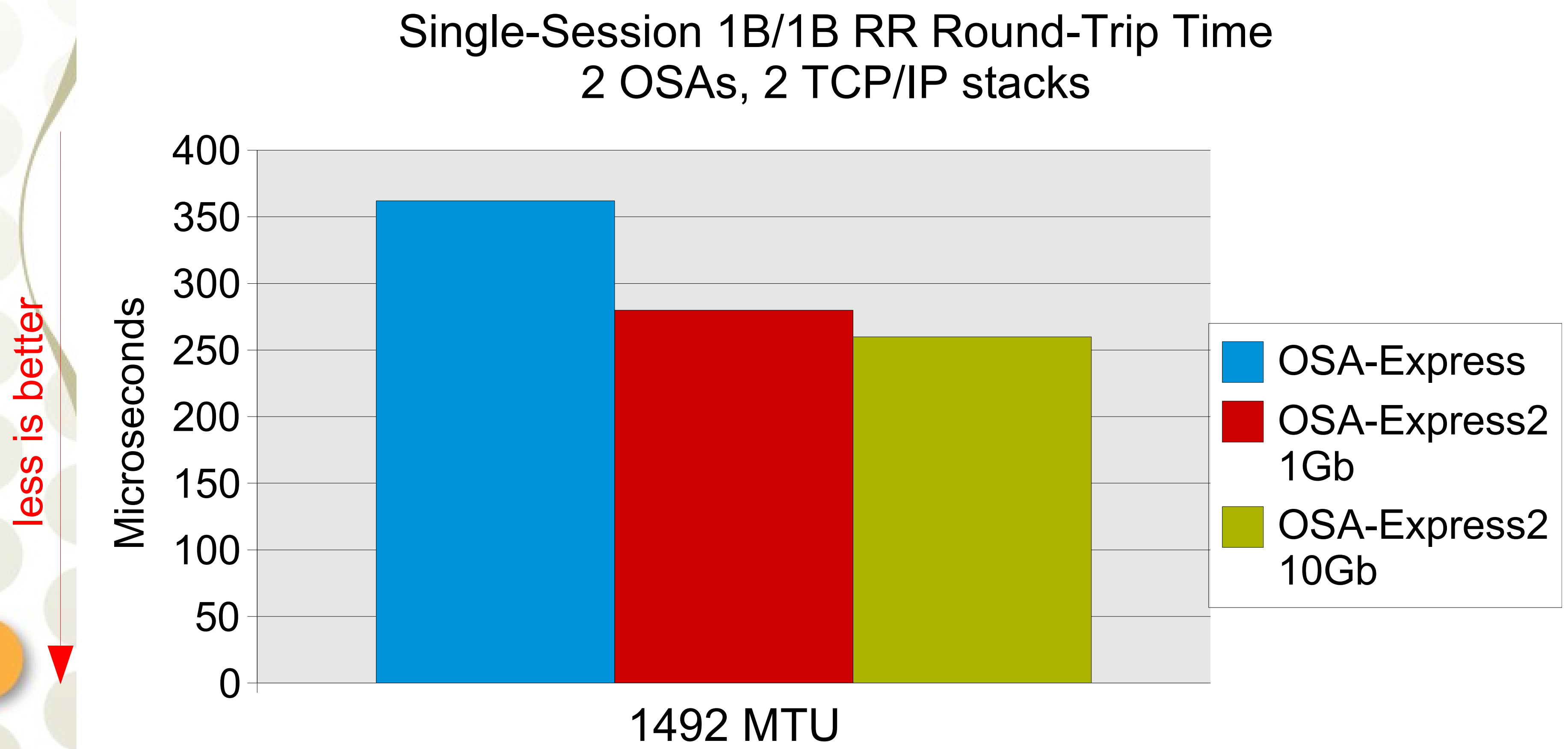


Networking benchmark

- AWM
- Several workload models
  - transactional workload
  - streaming workload
  - mixed workload
- Measured with GbE (QDIO), Hipersockets, and virtual connections in z/VM
- Throughput and cost (CPU) measurements

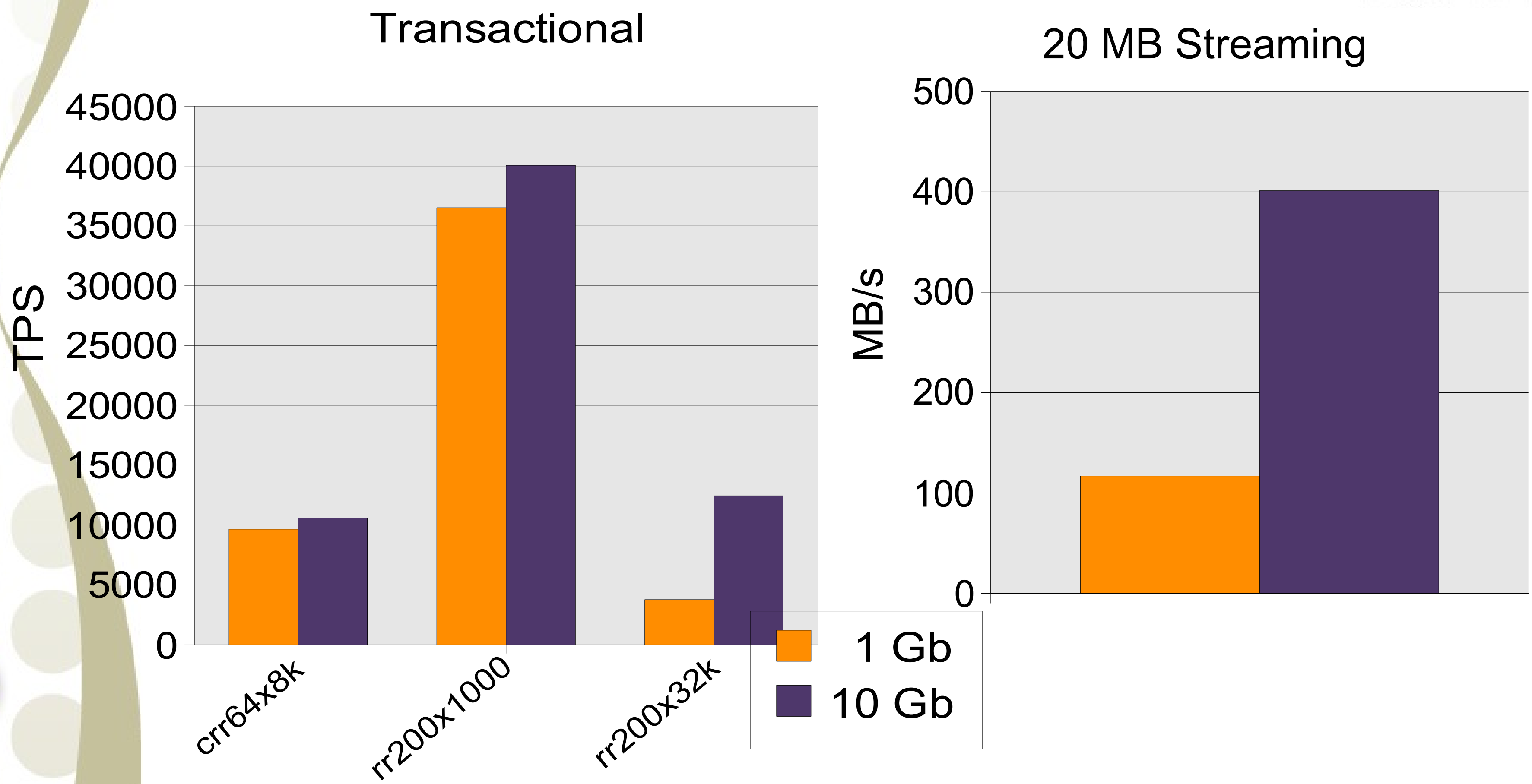


Response times



- More than 20% improvement with OSA-Express2

OSA-Express2, 1Gb / 10Gb, MTU 8992

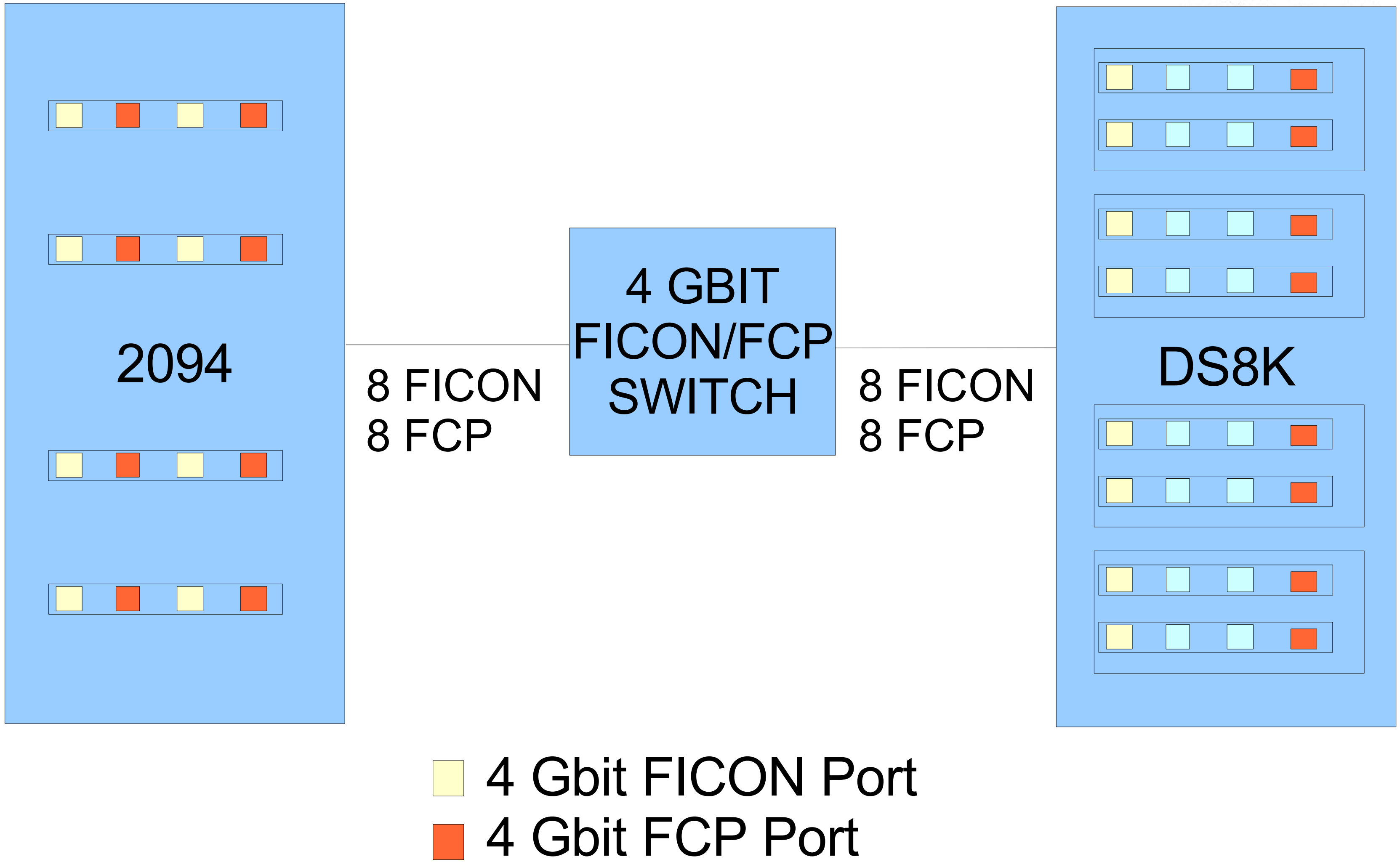


- Advantage for 10 Gb over 1 Gb is increasing with data size
- Improvements up to 3.4x

Disk I/O benchmark

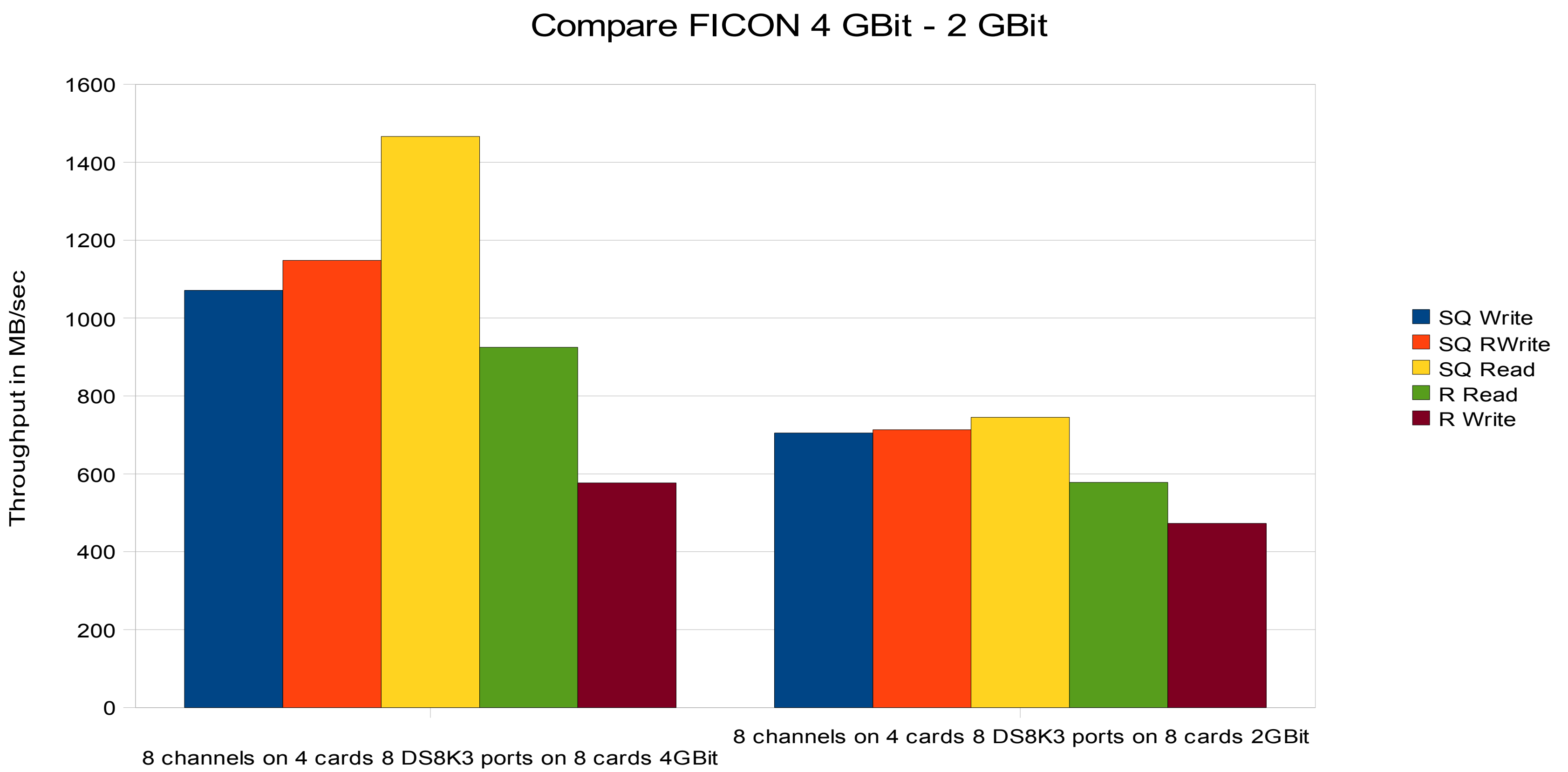
- IOzone
- Threaded file system benchmark used to measure synchronous I/O
- Sequential/random write, rewrite, read of a large enough file (700MB = almost 3x of memory size)
- Main memory was restricted to 256MB
- 1, 2, 4, 8, 16, 32, 64 threads, each operating on its private disk or using a Logical Volume
- Used on FICON and SCSI disks

Configuration for 4Gbps disk I/O measurements



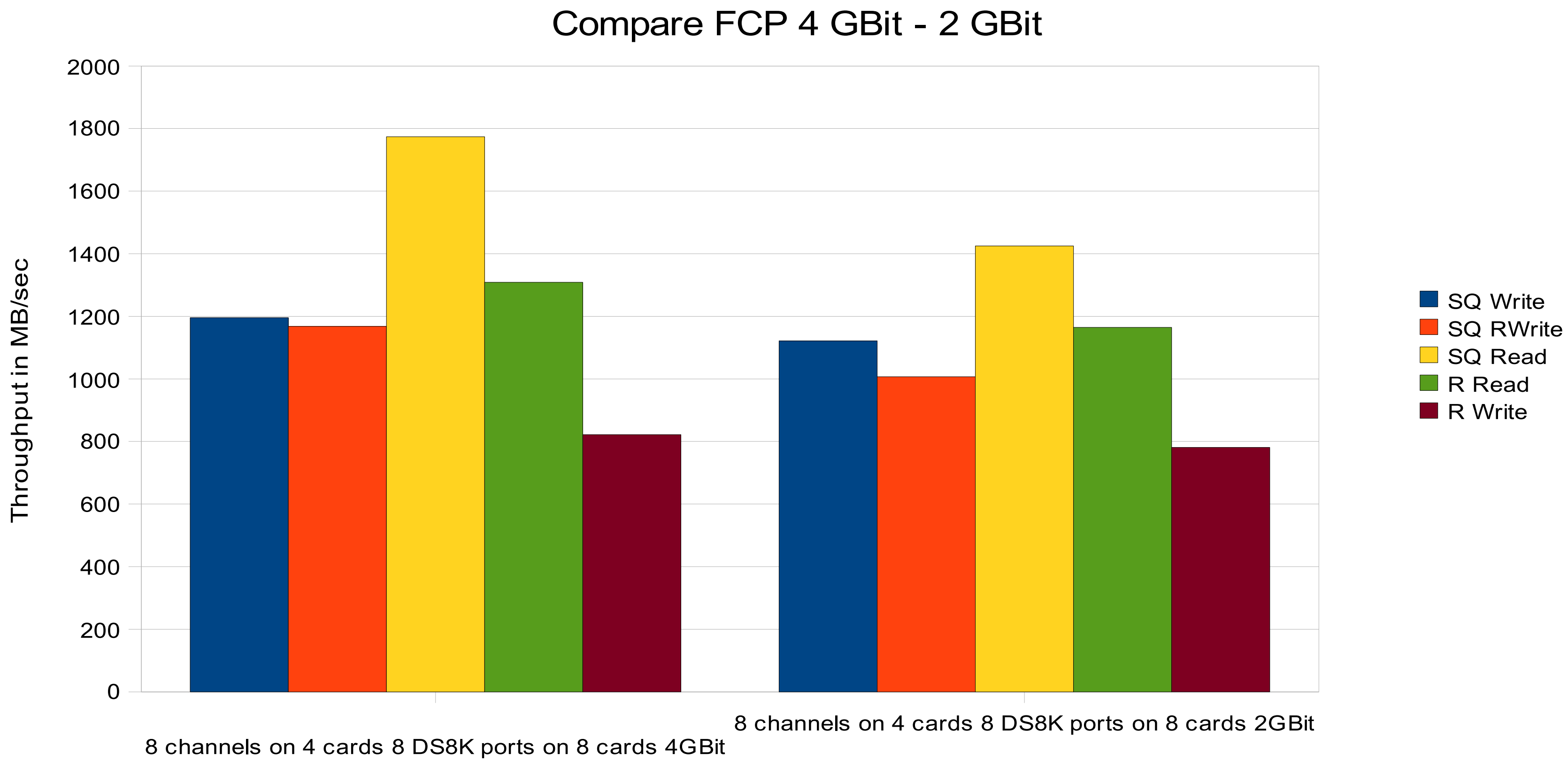
Disk I/O performance with 4Gbps links - FICON

- Strong throughput increase (average 1.6x)
- The best increase is with sequential read at 2x



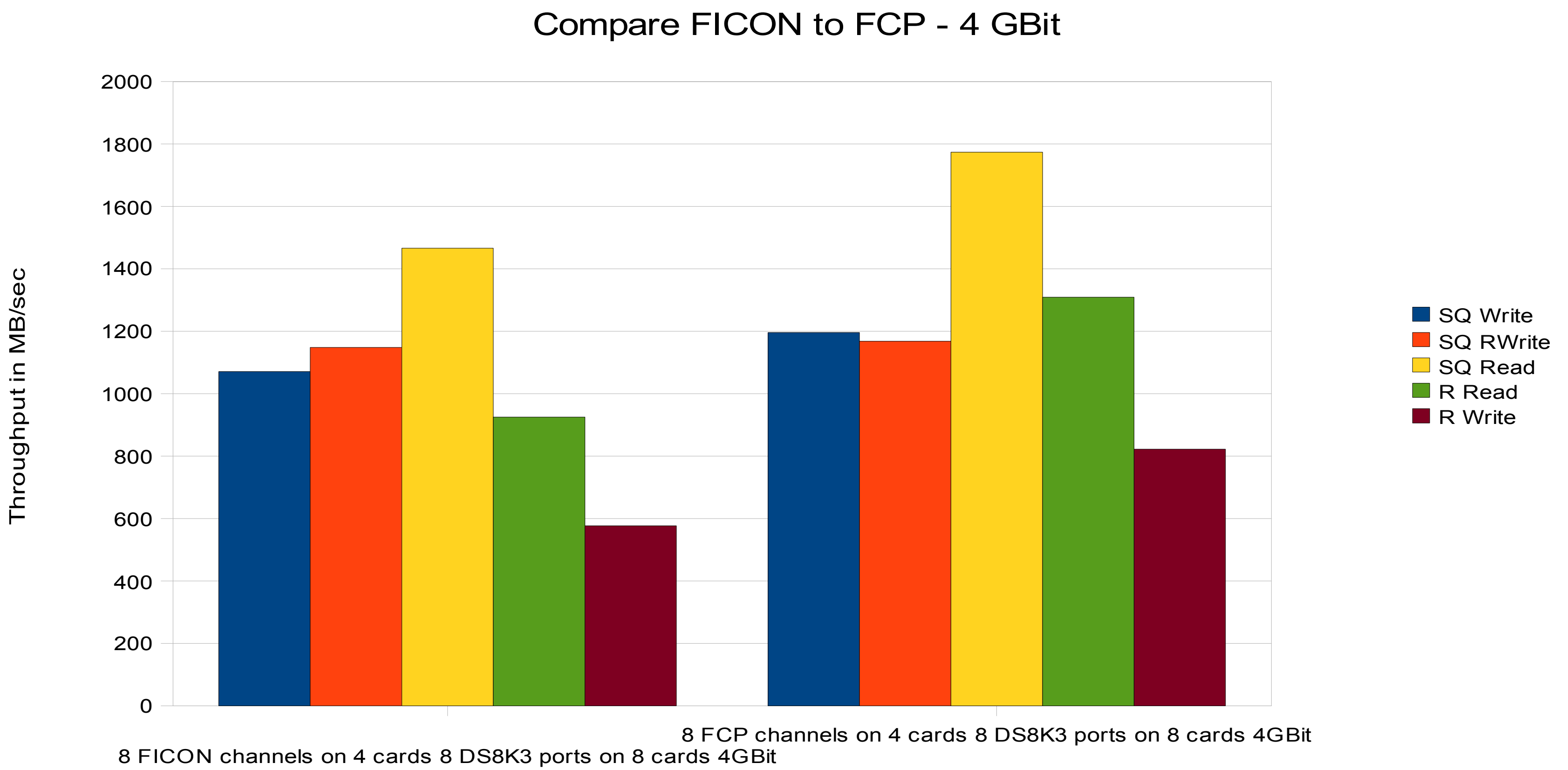
Disk I/O performance with 4Gbps links - FCP

- Moderate throughput increase
- Best improvement with sequential read at 1.25x



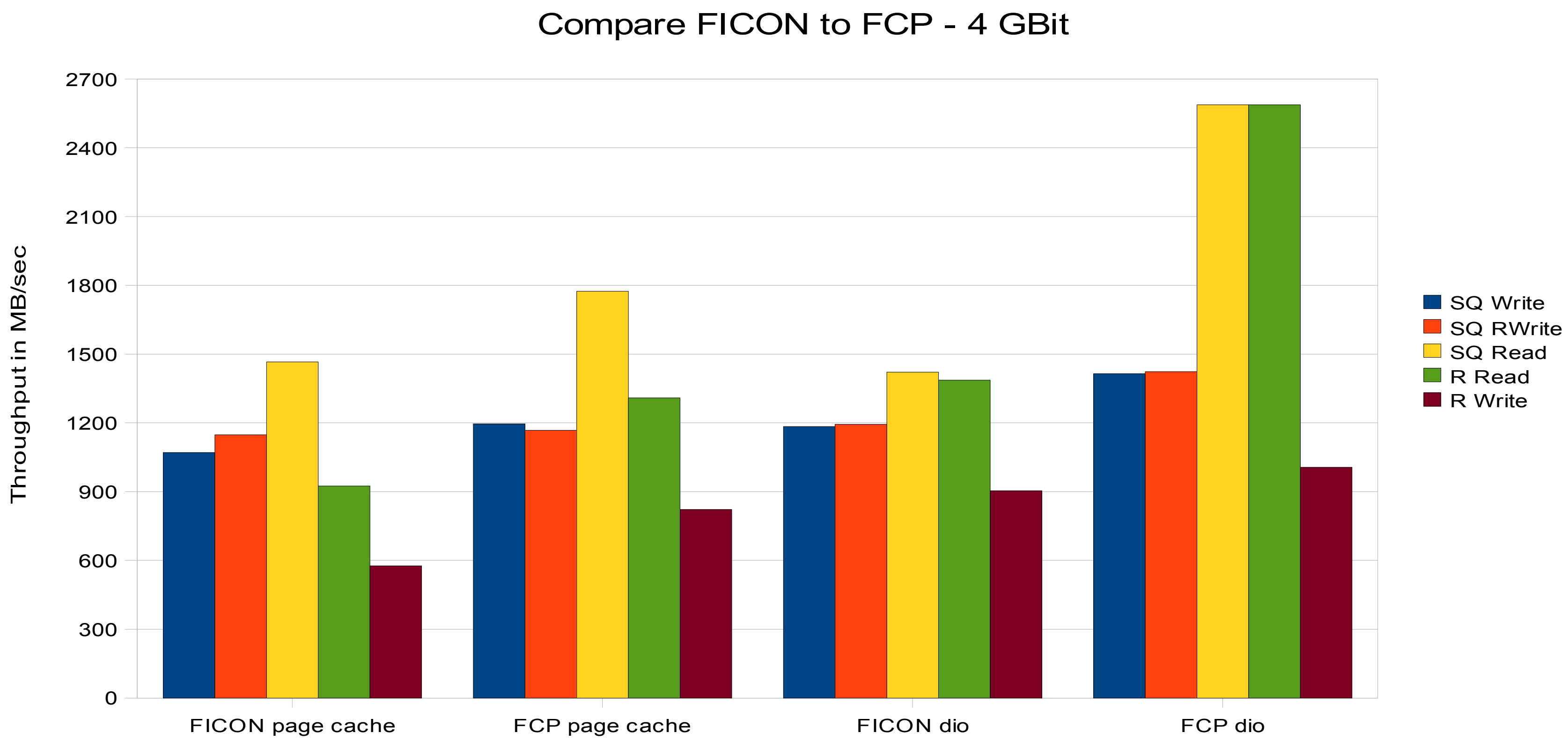
Disk I/O performance with 4Gbps links – FICON versus FCP

- Throughput for sequential write is similar
- FCP throughput for random I/O is 40% higher



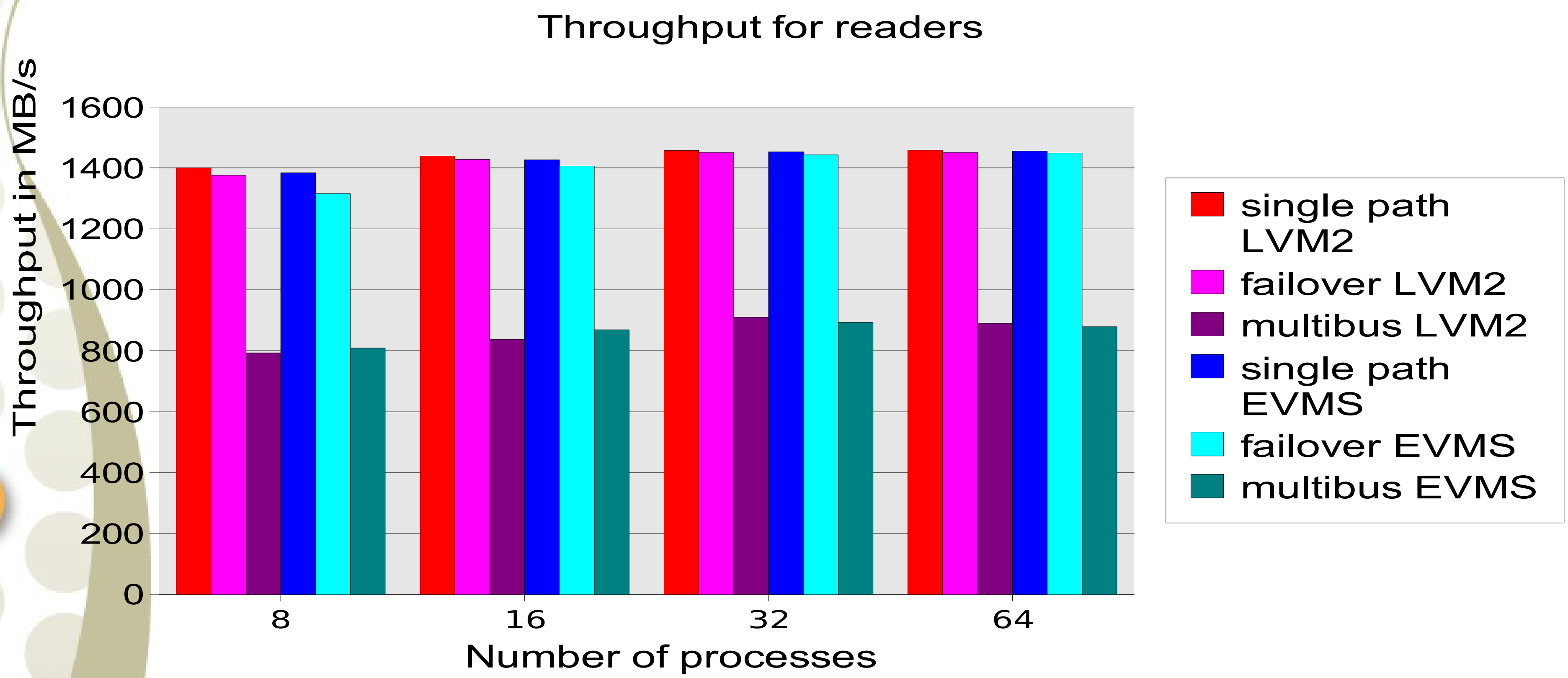
Disk I/O performance with 4Gbps links – FICON versus FCP / direct I/O

- Bypassing the Linux page cache improves throughput for FCP up to 2x, for FICON up to 1.6x.
- Read operations are much faster on FCP



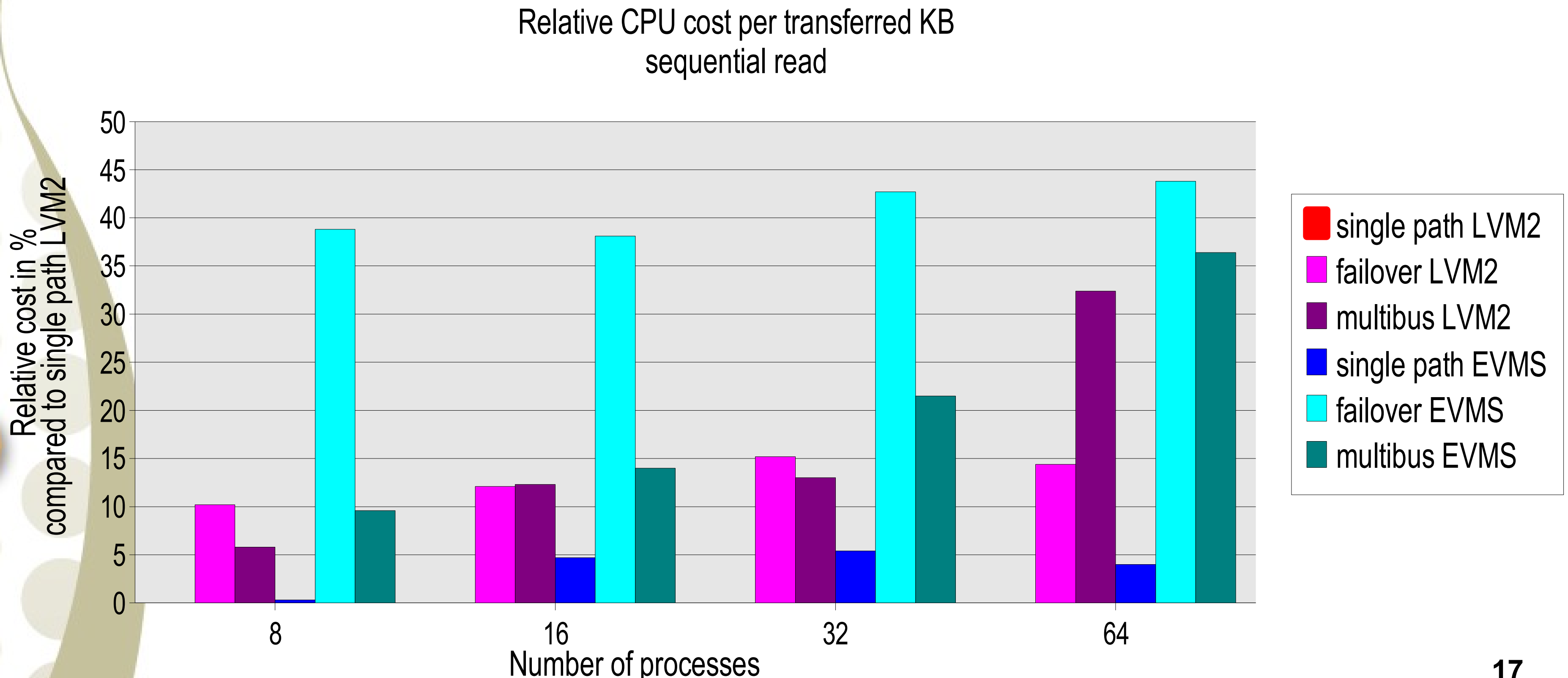
FCP/SCSI single path versus multipath

- Use failover instead of multibus



FCP/SCSI single path versus multipath (2)

- Use LVM2 instead of EVMS
- Costs for multipathing are about 10%

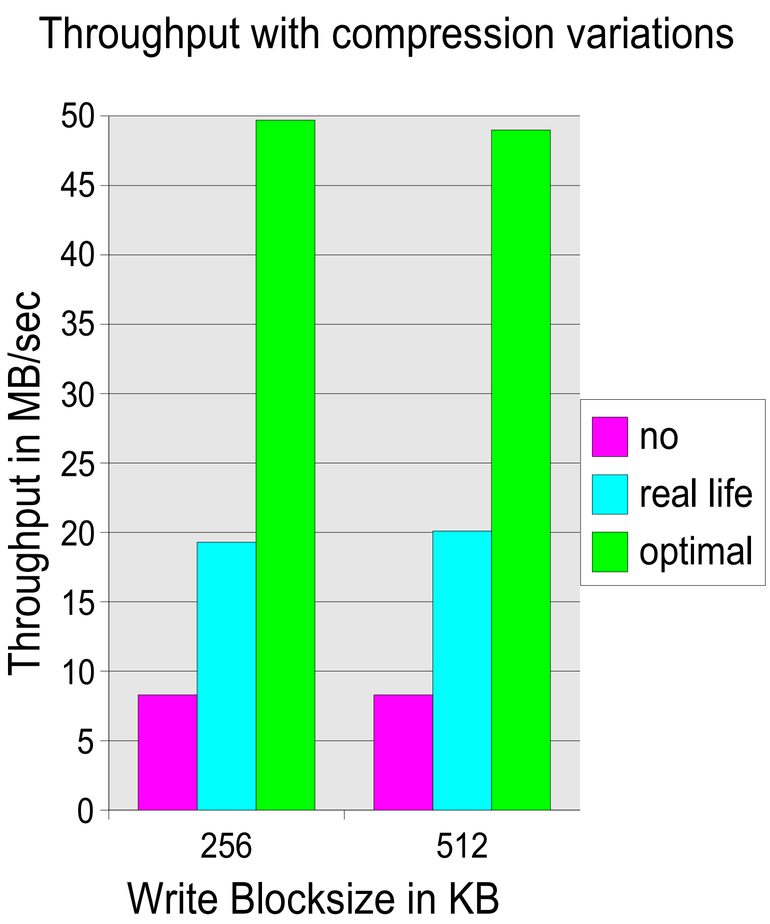


Disk I/O considerations

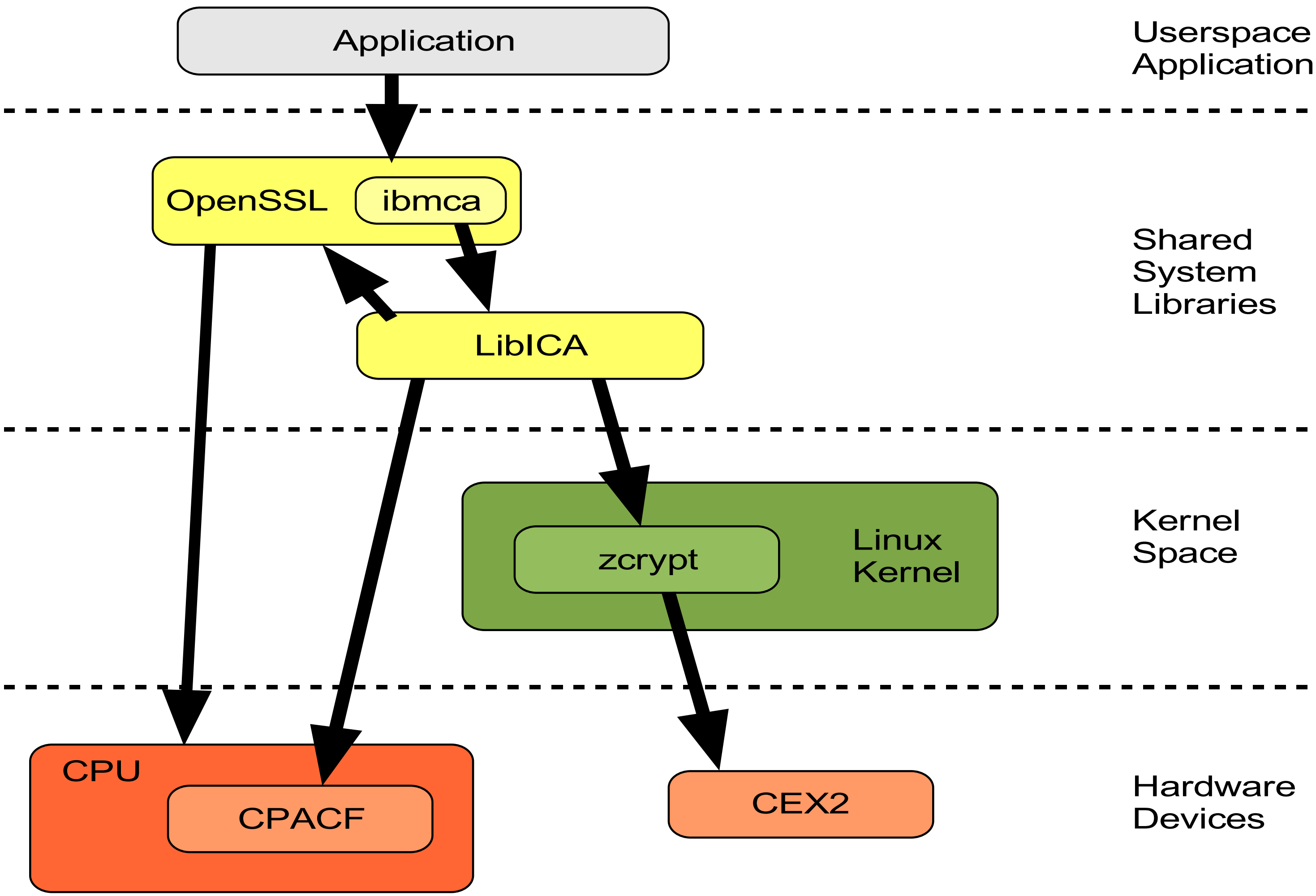
- Higher throughput rates with the new storage server generation require also higher CPU utilization
- This applies also to FCP/SCSI I/O when there is a throughput win versus FICON/ECKD I/O
- Take care that any specific path assignments for FCP/SCSI disks are still valid after re-IPL.
- `http://www.ibm.com/developerworks/linux/linux390/perf/tuning_how_dasd_multipath.html`

SCSI tape performance

- Measurements on IBM 3590 with optimal compression, compression of real life data (Linux source code), without compression
- Tests were done with dd, 1 FCP channel to the tape.
- Select a large blocksize for the tape, e.g. 256 KB

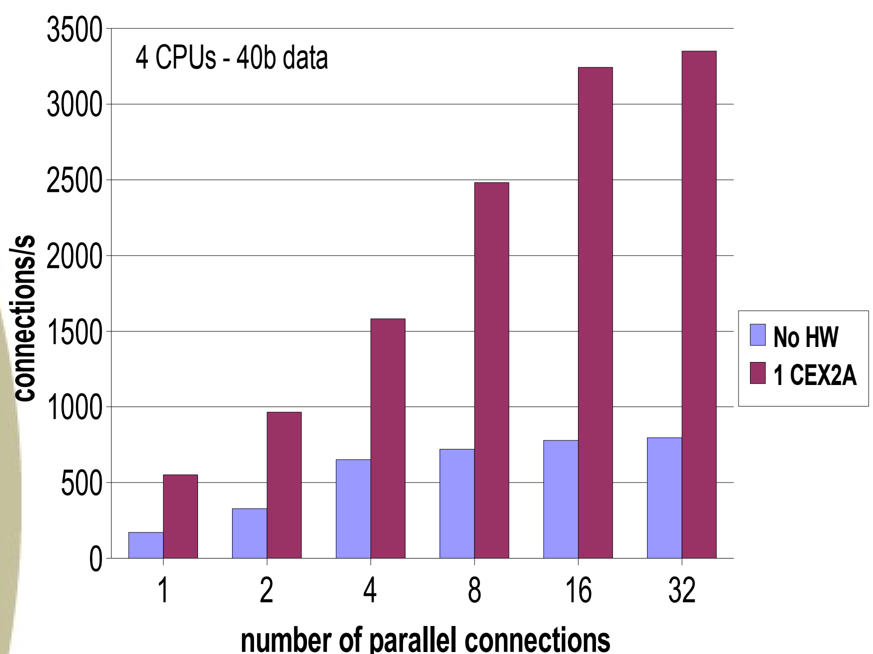


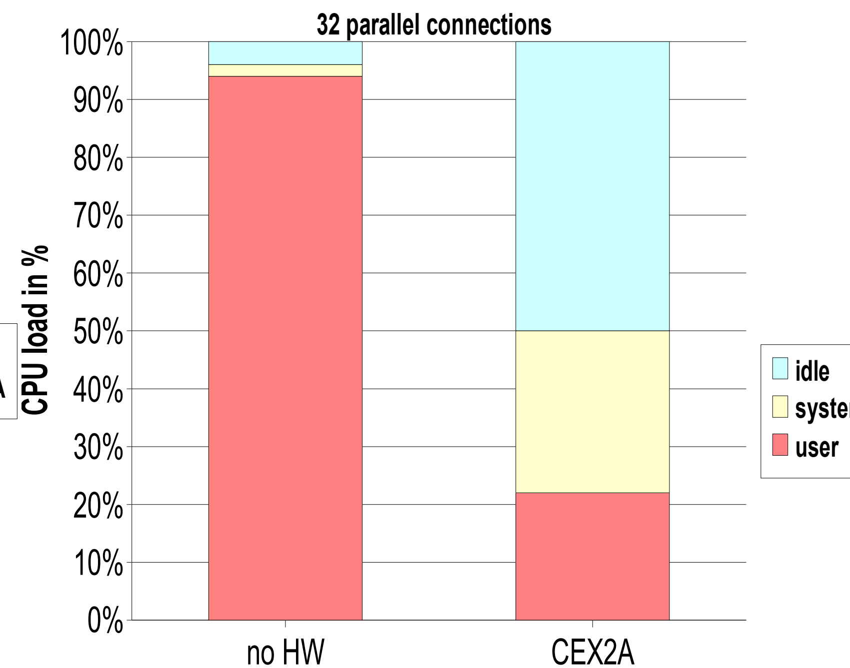
Linux software SSL stack



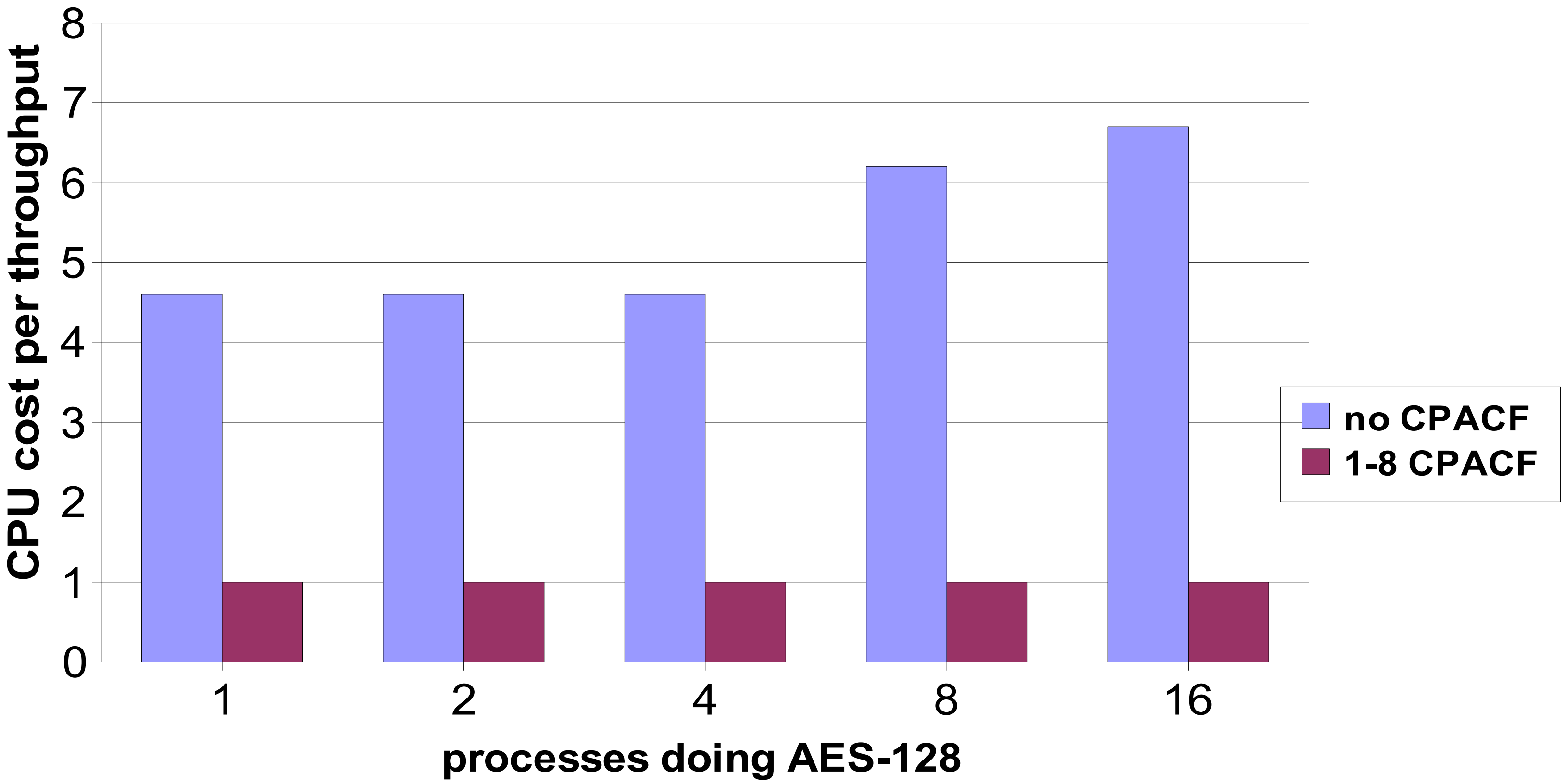
Crypto Express2 - SSL handshakes

- The number of handshakes is up to 4x higher with HW support
- In the 32 connections case we save about 50% of the CPU resources



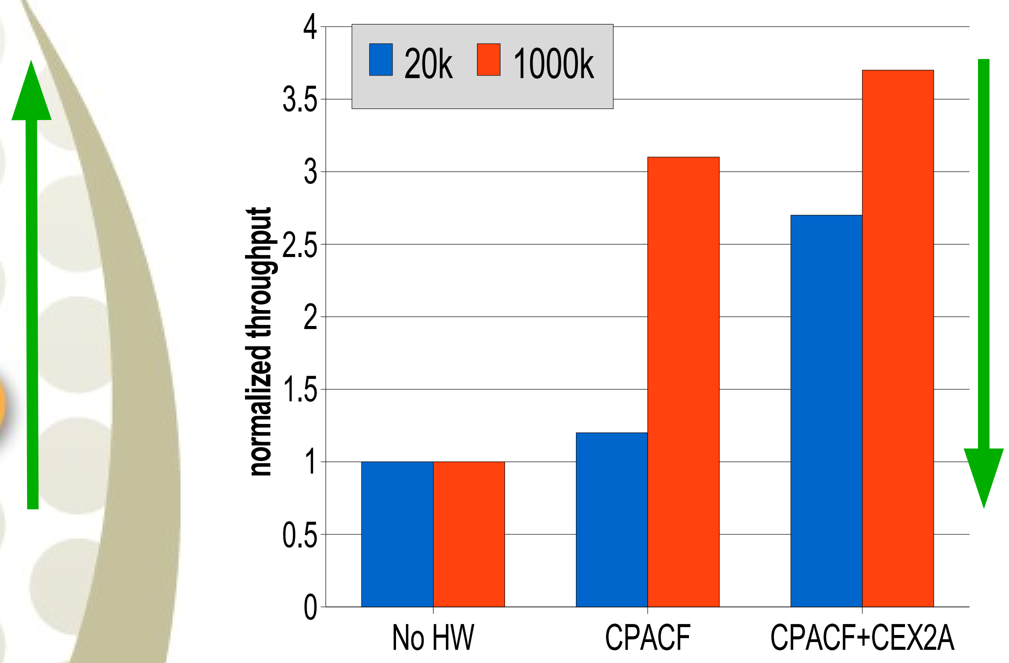


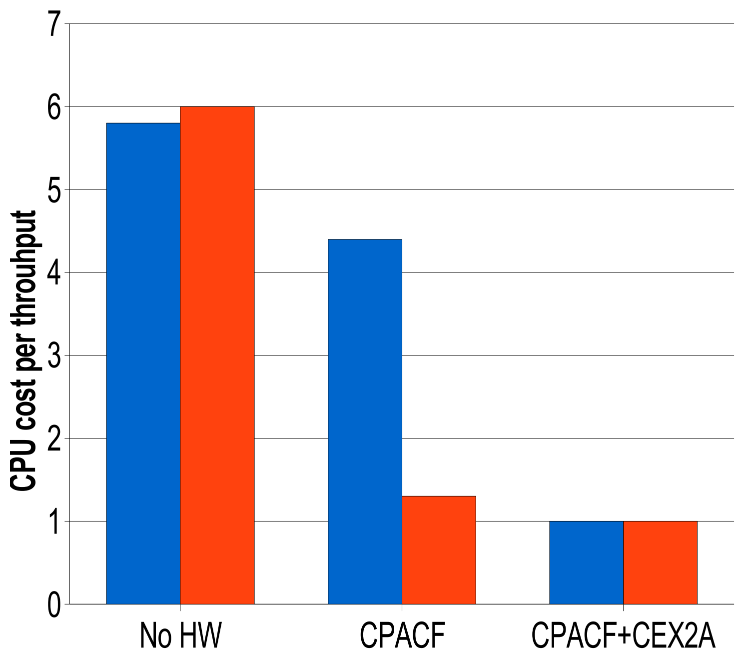
System z9 CPACF feature



Crypto Express2 – CPACF and CEX2

- The use of both hardware features show leads to 3.5x more throughput
- Using software encryption costs about 6x more CPU





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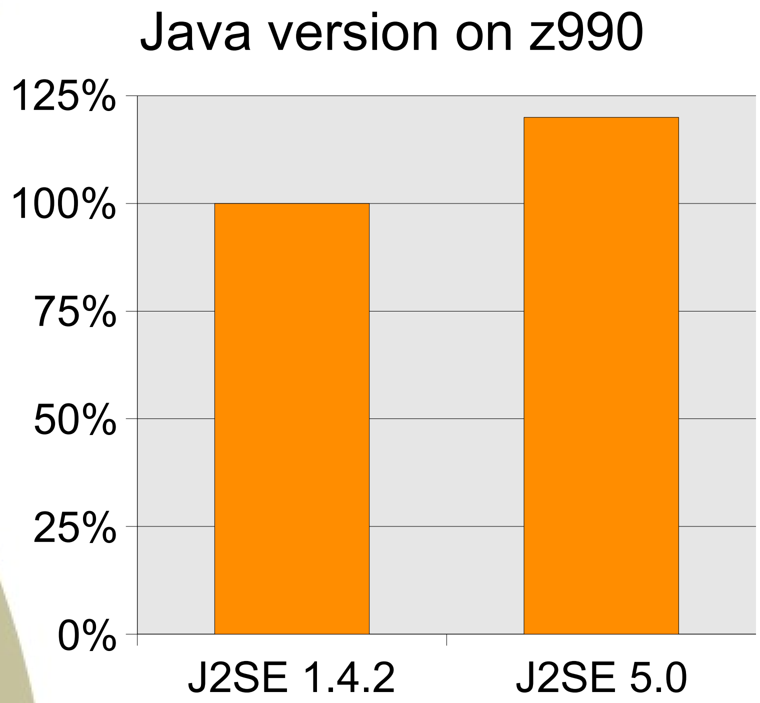
gcc 64bit compiler – SLES9 (gcc-3.3.3) versus SLES10 (gcc-4.1.0)

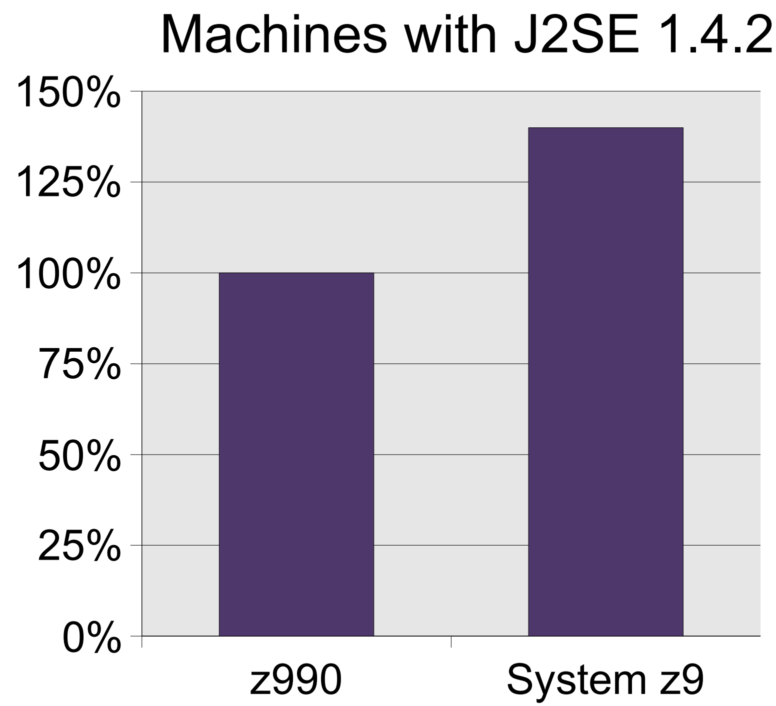
- gcc 4.1 supports -mtune=z9-109 and -march=z9-109

Compiler - why isn't 64-bit for free?

- Hardware effects
  - Primarily D-cache "pressure"
  - z/Architecture supports both 31-bit and 64-bit addressability
    - Data cache is fixed size for machine
    - 64-bit pointers "twice" as large as 31-bit pointers
  - Also impacts I-cache performance
    - 64-bit instructions tend to be 6-byte instead of 2 or 4
- Software effects
  - some 31-bit instructions have no 64-bit equivalent
    - must be implemented with series of 64-bit opcodes
    - = additional pathlength for same function
  - increased cost for entry/exit linkage
    - registers are twice as wide

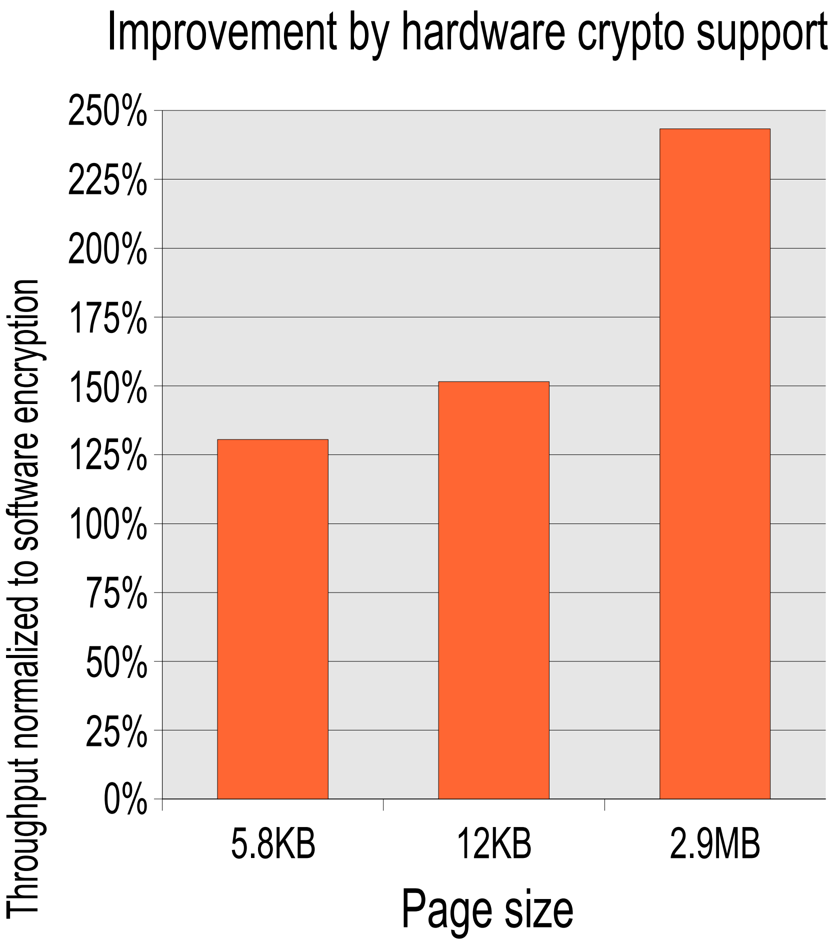
Java Results 64-bit





- Improvements through Java (JVM and JIT)
- Improvements through new hardware
- 64-bit Java is production ready

Crypto performance – WebSEAL SSL access



- The connection from the client to the WebSEAL server runs encrypted using SSL (AES-128)
- Scaling the size of the requested page
- uses mostly CPACF
- Improvement up to factor 2.4 for hardware encryption versus software encryption

Special study with Tivoli Storage Manager

- ECKD versus SCSI
- Configured and measured on our system together with TSM performance specialist
- Entry statement from TSM, based on their tests in 2005 for backing up 70 GB data:
  - *“execution time with SCSI is 25% shorter than with ECKD”*
  - *“average CPU consumption with SCSI is 67% more than with ECKD”*
- Common exit statement from after the tests:
  - *“execution time with SCSI is 50% shorter than with ECKD”*
  - *“costs were almost equal (more CPU resources need to be provided for SCSI)”*

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Comparison SLES10 / RHEL5

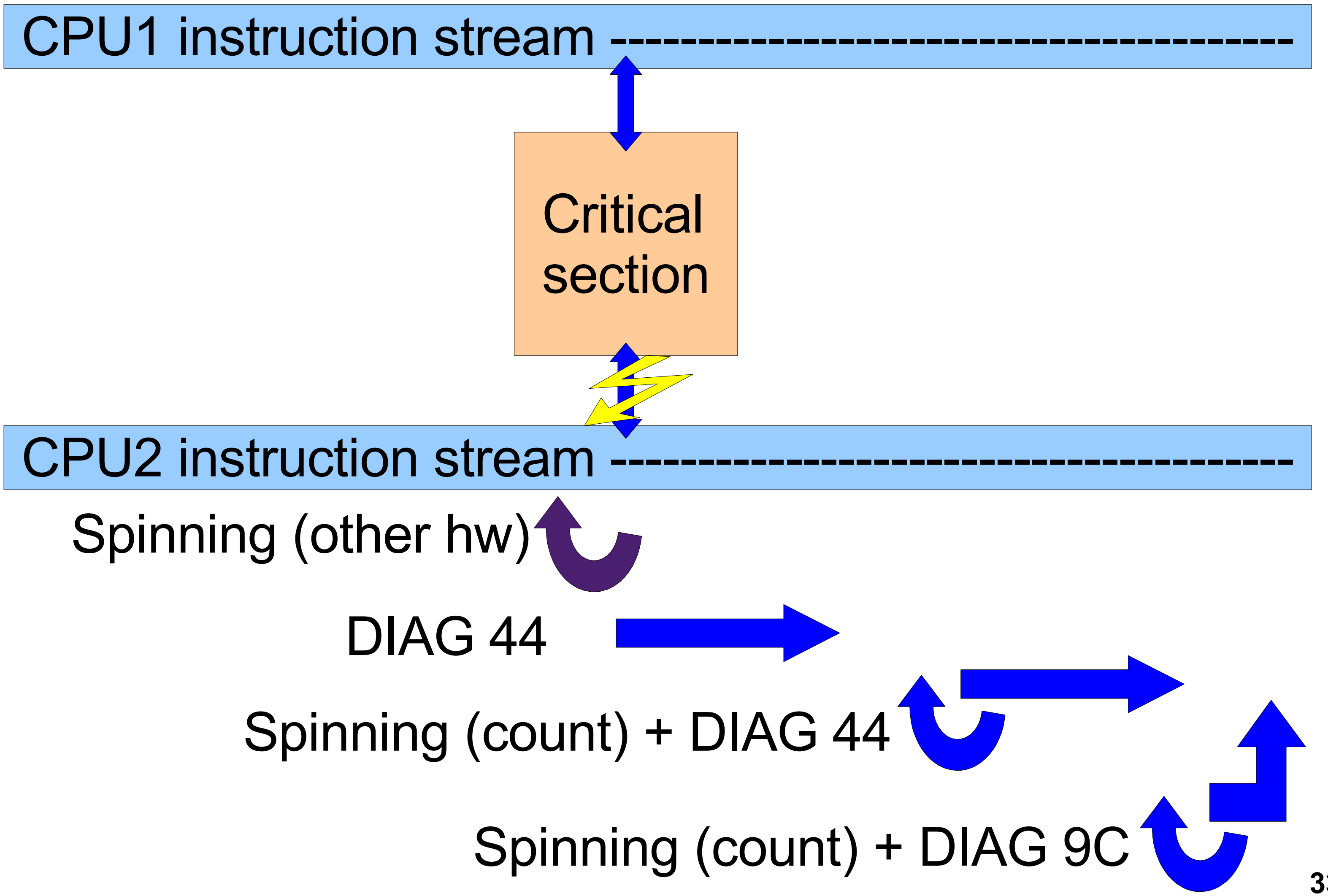
measurement portfolio SLES10 GA versus RHEL5 GA	LPAR 64	LPAR 31 (emu)	z/VM 64	z/VM 31 (emu)
Scaling	equal	n/a	n/a	n/a
Mixed I/O ECKD	worse	n/a	equal	n/a
Mixed I/O SCSI	worse	n/a	worse	n/a
Kernel	equal	n/a	better	better
Compiler INT	equal	n/a	n/a	n/a
Compiler FP	worse	n/a	n/a	n/a
Seq. I/O ECKD	better	n/a	better	n/a
Seq. I/O SCSI	better	n/a	better	n/a
Rnd I/O ECKD	equal	n/a	equal	n/a
Rnd I/O SCSI	equal	n/a	equal	n/a
Network 1000Base-T QDIO	equal	n/a	worse	n/a
Network 1GbE QDIO	equal	n/a	worse	n/a
Network 10GbE QDIO	equal	n/a	worse	n/a
Network HiperSockets	equal	n/a	n/a	n/a
Java	equal	equal	n/a	n/a

Legend	*n/a*	*better*	*equal*	*worse*

SLES9 improved resource usage

- The Linux kernel uses spin locks to wait for exclusive use of kernel resources
- On System z it is not desirable to use processors for active waiting
- The old solution was to issue a DIAG 44 to the LPAR hypervisor or to z/VM to give the CPU back instead of looping on the lock, to allow other more useful work to be done.
- 2 new features:
  - spin_retry counter in Linux to avoid excessive use of diagnose instructions
  - use of DIAG 9C to pass information along with the instruction, who should get the processor

Avoiding spin locks on System z



SLES10 virtual CPU time accounting

- The standard Linux implementation is based on a heuristic model with a 10 ms timer interrupt
  - The complete time slice is accounted to the interrupted context
- On systems with virtual CPUs this approach is too inaccurate
- The new implementation is based on the System z virtual timer
  - CPU times get now accounted whenever the execution context changes
  - A new category of Linux wait state is showing, how often the Linux system is waiting for CPU (current sysstat version required)
  - The feature is enabled by default in SLES10 and RHEL5

Linux command 'top' – the snapshot tool

- Adds new field “CPU steal time”
  - Is time Linux wanted to run, but the hipervisor was not able to schedule CPU
  - Is included in SLES10 and RHEL5

```
top - 09:50:20 up 11 min,  3 users,  load average: 8.94, 7.17, 3.82
Tasks:  78 total,   8 running,  70 sleeping,   0 stopped,   0 zombie
 Cpu0 : 38.7%us,  4.2%sy,  0.0%ni,  0.0%id,  2.4%wa,  1.8%hi,  0.0%si, 53.0%st
 Cpu1 : 38.5%us,  0.6%sy,  0.0%ni,  5.1%id,  1.3%wa,  1.9%hi,  0.0%si, 52.6%st
 Cpu2 : 54.0%us,  0.6%sy,  0.0%ni,  0.6%id,  4.9%wa,  1.2%hi,  0.0%si, 38.7%st
 Cpu3 : 49.1%us,  0.6%sy,  0.0%ni,  1.2%id,  0.0%wa,  0.0%hi,  0.0%si, 49.1%st
 Cpu4 : 35.9%us,  1.2%sy,  0.0%ni, 15.0%id,  0.6%wa,  1.8%hi,  0.0%si, 45.5%st
 Cpu5 : 43.0%us,  2.1%sy,  0.7%ni,  0.0%id,  4.2%wa,  1.4%hi,  0.0%si, 48.6%st
Mem:    251832k total,   155448k used,    96384k free,     1212k buffers
Swap:   524248k total,    17716k used,   506532k free,    18096k cached
```

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