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IBM System z Technical University

Enabling the infrastructure for smarter computing

# SLES11 SP2 performance evaluation

**zLG15**

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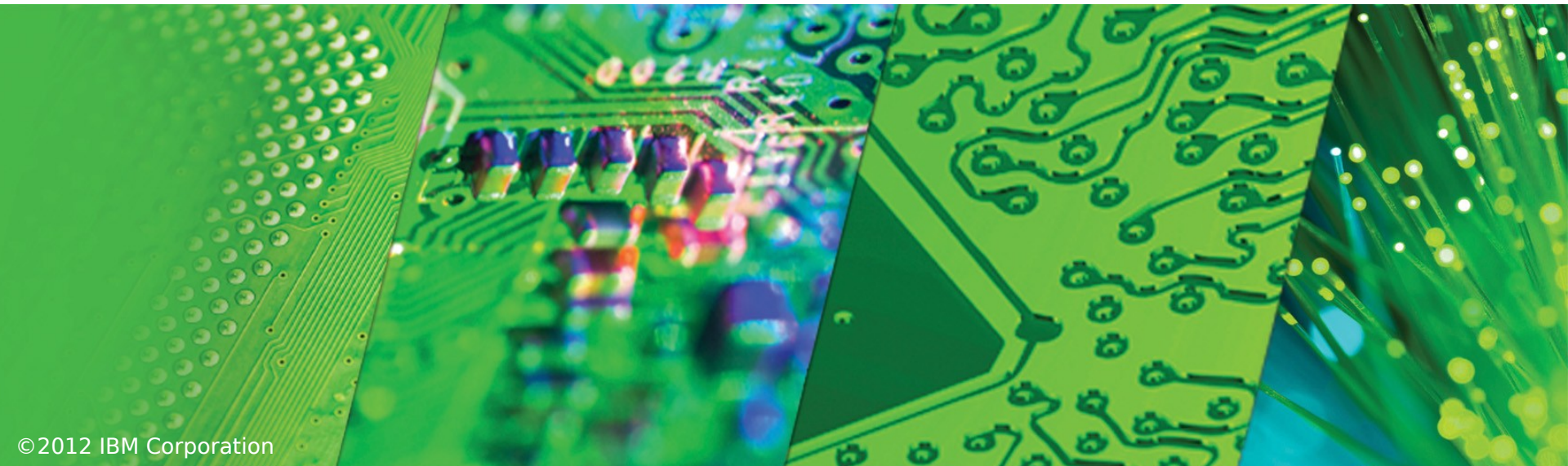

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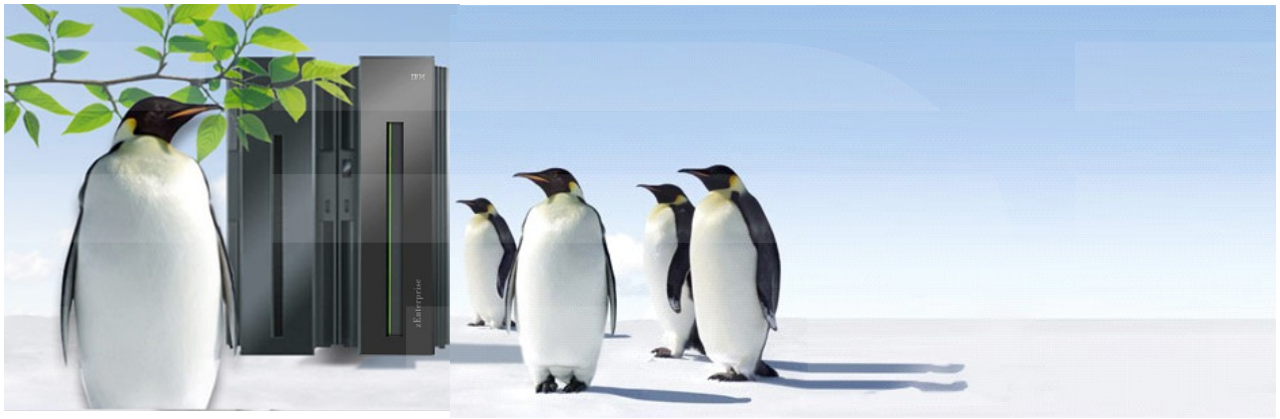
# Agenda

- Performance evaluation
  - ✓ System under test (SUT) description
  - ✓ Changes one should be aware of
- Performance evaluation summary
  - ✓ Improvements and degradations per area
  - ✓ Summarized comparison

# System under test (SUT)

- Hardware platform – System z10
  - ✓ FICON 8 Gbps
  - ✓ FCP 8 Gbps
  - ✓ HiperSockets
  - ✓ OSA Express 3 1GbE + 10GbE
- Software platform
  - ✓ z/VM 5.4
  - ✓ LPAR
- Storage – DS8300 (2107-922 )
  - ✓ FICON 8 Gbps
  - ✓ FCP 8 Gbps

- Hardware platform – System z196
  - ✓ FICON 8 Gbps
  - ✓ FCP 8 Gbps
  - ✓ HiperSockets
  - ✓ OSA Express 3 1GbE + 10GbE
- Software platform
  - ✓ z/VM 6.1
  - ✓ LPAR
- Storage – DS8800
  - ✓ FICON 8 Gbps
  - ✓ FCP 8 Gbps



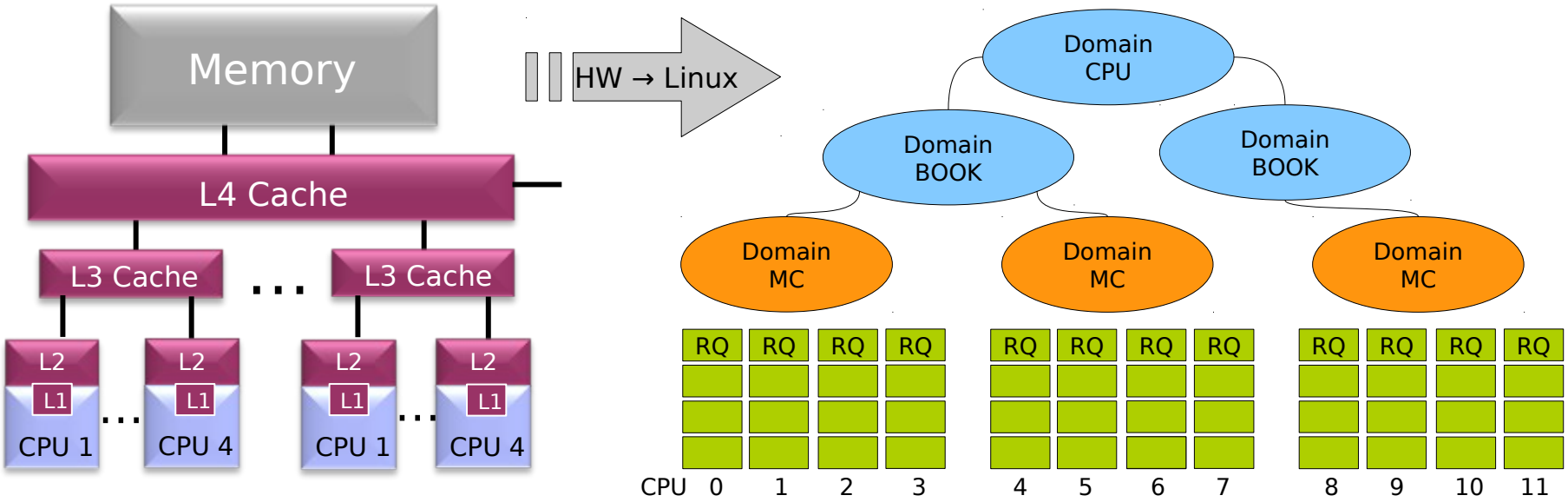
# Compared Distribution Levels

- Compared Distribution Levels
  - ✓ SLES 11 SP1 (2.6.32.12-0.6-default)
  - ✓ SLES 11 SP2 (3.0.13-0.27-default)
- Measurements
  - ✓ Base regression set covering most customer use cases as good as possible
  - ✓ Focus on areas where performance issues are more likely
  - ✓ Just the top level summary, based on thousands of comparisons
  - ✓ Special case studies for non-common features and setups
- Terminology
  - ✓ Throughput – “How much could I transfer once?”
  - ✓ Latency – “How long do I have to wait for event X?”
  - ✓ Normalized cpu consumption - “How much cpu per byte do I need?”

# Completely Fair Scheduler (CFS)

- Goals of CFS
  - ✓ Models “ideal, precise multi-tasking CPU”
  - ✓ Fair scheduling based on virtual runtime
- Changes you might notice when switching from O(1) to CFS
  - \+ Lower response times for I/O, signals, …
  - \+ Balanced distribution of process time-slices
  - \+ Improved distribution across processors
  - \- Shorter consecutive time-slices
  - \- More context switches
- Improved balancing
  - ✓ Topology support is now on by default
    - ▫ Can be switched via the topology=on|off kernel parameter
  - ✓ This makes the scheduler aware of the cpu hierarchy
- You really get something from fairness as well
  - ✓ Improved worst case latency and throughput
  - ✓ By that CFS can ease QoS commitments

# Topology of a zEnterprise System

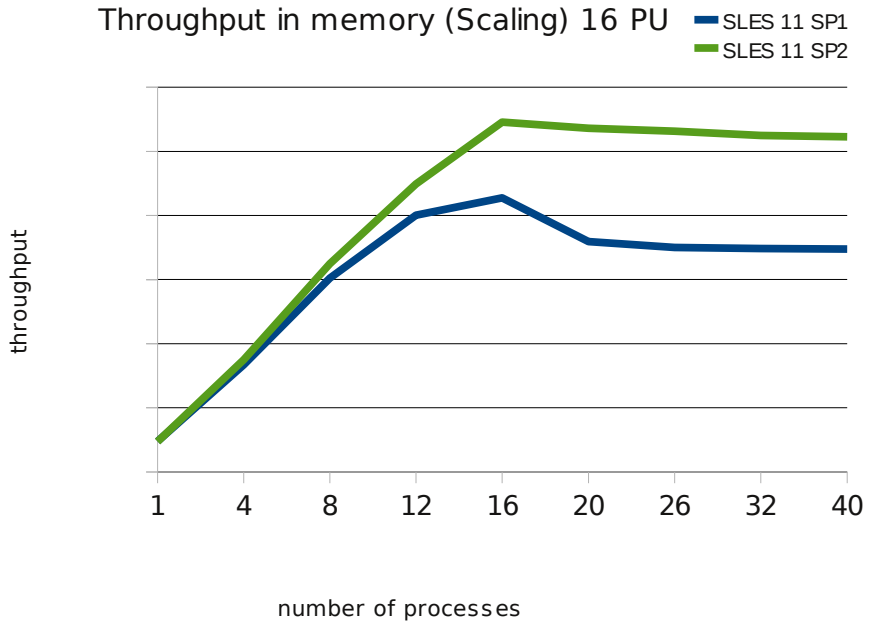



- Topology feature
  - ✓ Ability to group (rec. ipc heavy loads) or spread (rec. cache hungry) loads
  - ✓ Unintended asymmetries now known to the system
  - ✓ **Off in z/VM Guests, since there is no virtual topology information**
- Tunable, but complex
  - ✓ /proc/sys/kernel/sched_* files contains tunables for decisions regarding request queues (▮)
  - ✓ /proc/sys/kernel/sched_domain/... provides options for the scheduling domains (▮/▮)

# Benchmark description - File system / LVM / Scaling

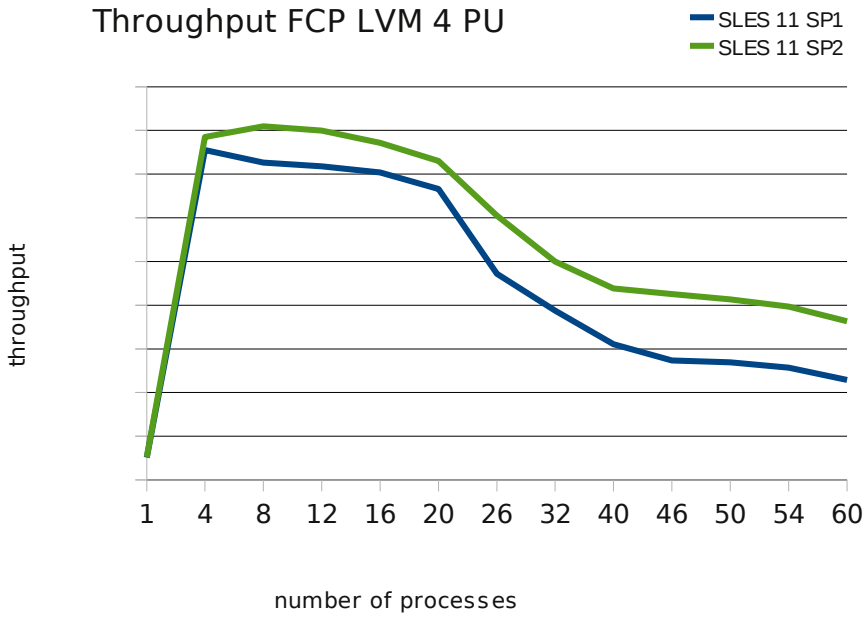
- Filesystem benchmark Dbench 3.0
  - ✓ Emulation of Netbench benchmark
  - ✓ Generates file system load on the Linux VFS
  - ✓ Does the same I/O calls like smbd server in Samba (without networking calls)
- Simulation
  - ✓ Workload simulates client and server (Emulation of Netbench benchmark)
  - ✓ Mixed file operations workload for each process: create, write, read, append, delete
  - ✓ Measures throughput of transferred data
  - ✓ Two setup scenarios
    - Scaling – Loads fits in cache, so mainly memory operations for scaling 2,4,8,16 CPUs, 8Gib Memory and scaling from 1 to 40 processes
    - Low main memory and LVM setup for mixed I/O LVM performance 8 CPUs, 2 GiB memory and scaling from 4 to 62 processes

# File System benchmark – Scaling Scenario




- Improved scalability for page cache operations
  - ✓ Especially improves large workloads
    - Saves cache misses of the load that runs primarily in memory
    - Lower cross process deviation improves QoS

# File system benchmark – LVM Scenario

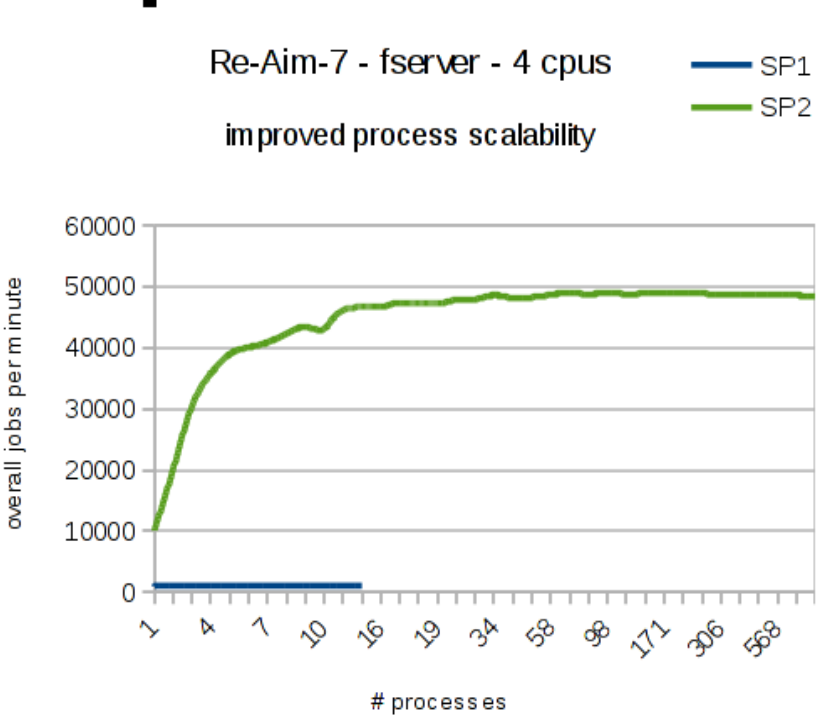


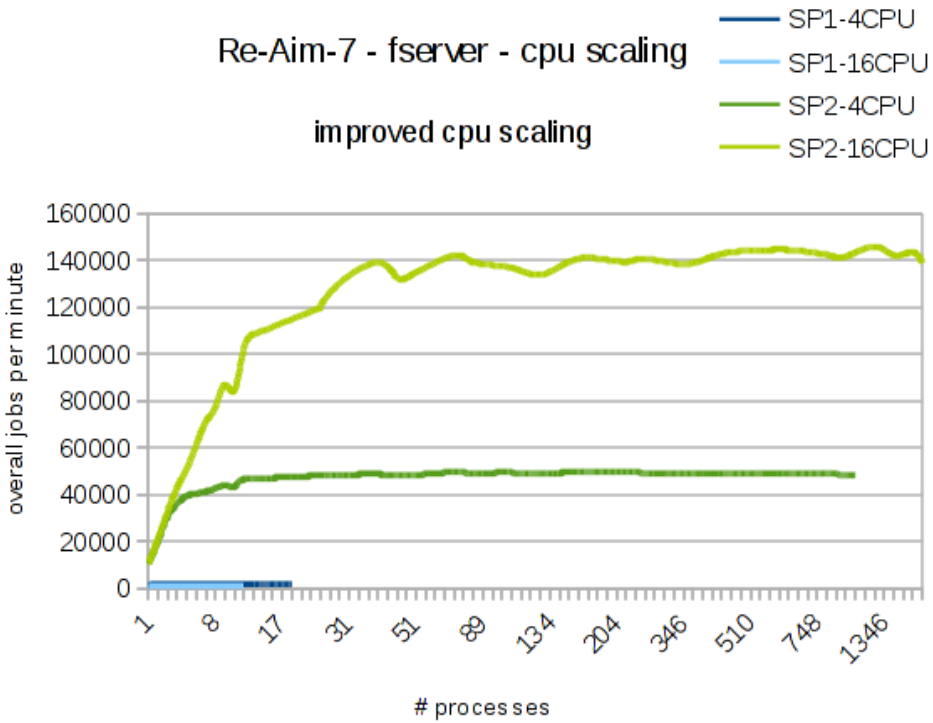

- Improved throughput for disk bound LVM setups as well
  - ✓ Especially improves heavily concurrent workloads
    - Fix in device mapper included which especially helps workloads with small I/Os
    - Saves a lot of CPU costs

# Benchmark description – Re-Aim-7

- Scalability benchmark Re-Aim-7
  - ✓ Open Source equivalent to the AIM Multiuser benchmark
  - ✓ Workload patterns describe system call ratios (patterns can be more ipc, disk or calculation intensive)
  - ✓ The benchmark then scales concurrent jobs until the overall throughput drops
    - Starts with one job, continuously increases that number
    - Overall throughput usually increases until #threads ≈ #CPUs
    - Then threads are further increased until a drop in throughput occurs
    - Scales up to thousands of concurrent threads stressing the same components
  - ✓ Often a good check for non-scaling interfaces
    - Some interfaces don't scale at all (1 Job throughput ≈ multiple jobs throughput, despite >1 CPUs)
    - Some interfaces only scale in certain ranges (throughput suddenly drops earlier as expected)
  - ✓ Measures the amount of jobs per minute a single thread and all the threads can achieve
- Our Setup
  - ✓ 2, 8, 16 CPUs, 4 GiB memory, scaling until overall performance drops
  - ✓ Using a journaled file system on an xpram device (stress FS code, but not be I/O bound)
  - ✓ Using fserver, new-db and compute workload patterns

# Improvements to file-system sync



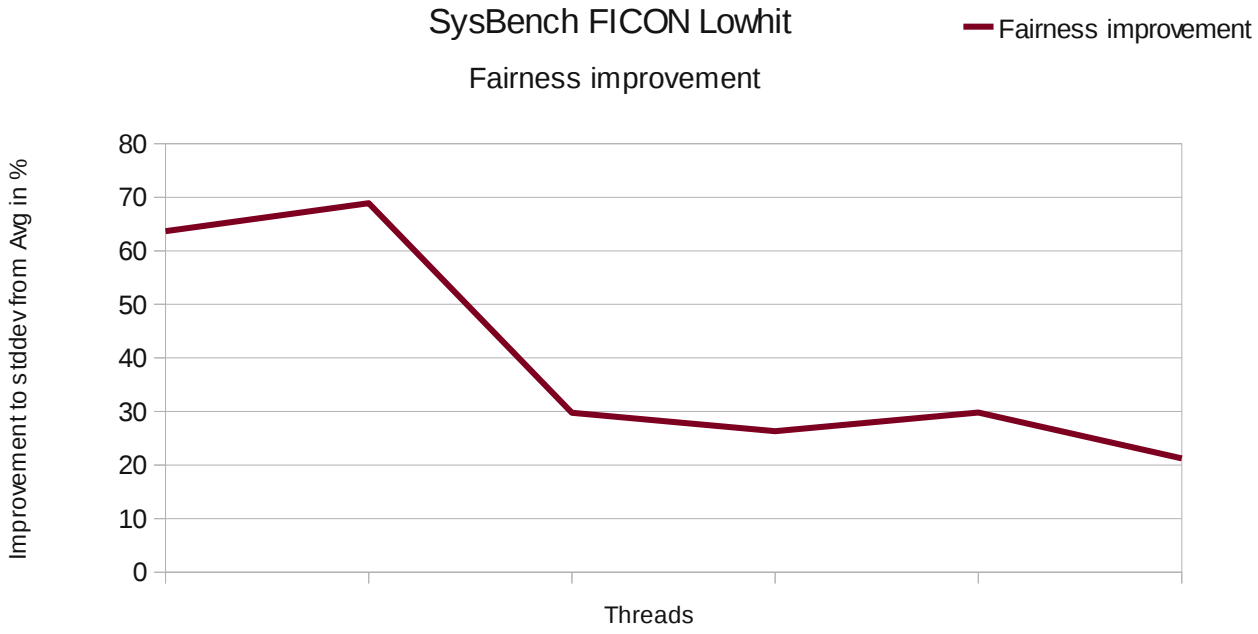




- The issue blocked process scaling (left) and CPU scaling (right)
- The sync call was broken, so scaling relying on it was almost non existent
  - ✓ Scales well in SP2 now with increasing number of processes
  - ✓ Fortunately for SP1 this system call is not one of the most frequently called ones

# Benchmark description – SysBench

- Scalability benchmark SysBench
  - ✓ SysBench is a multi-threaded benchmark tool for (among others) OLTP- database loads
  - ✓ Can be run read-only and read-write
  - ✓ Clients can connect locally or via network to the database
  - ✓ Database level and tuning is important
    - We use Postgres 9.0.4 with configuration tuned for this workload in our test
  - ✓ High/Low Hit cases resemble different real world setup cases with high or low cache hit ratios
- Our List of Setups
  - ✓ Scaling – read-only load with 2, 8, 16 CPUs, 8 GiB memory, 4GiB DB (High-Hit)
  - ✓ Scaling Net – read-only load with 2, 8, 16 CPUs, 8 GiB memory, 4GiB DB (High-Hit)
  - ✓ Scaling FCP/FICON High Hit ratio – read-write load with 8 CPUs, 8 GiB memory, 4GiB DB
    - RW loads still need to maintain the transaction log, so I/O is still important despite DB<MEM
  - ✓ Scaling FCP/FICON Low Hit ratio – read-write load with 8 CPUs, 4 GiB memory, 64GiB DB
    - This is also I/O bound to get the Data into cache TODO
  - ✓ All setups use
    - HyperPAV (FICON) / Mulitpathing (FCP)
    - Disk spread over the Storage Server as recommended + Storage Pool Striping
    - Extra Set of disks for the WAL (Transaction Protocol)

# SysBench – improved thread fairness

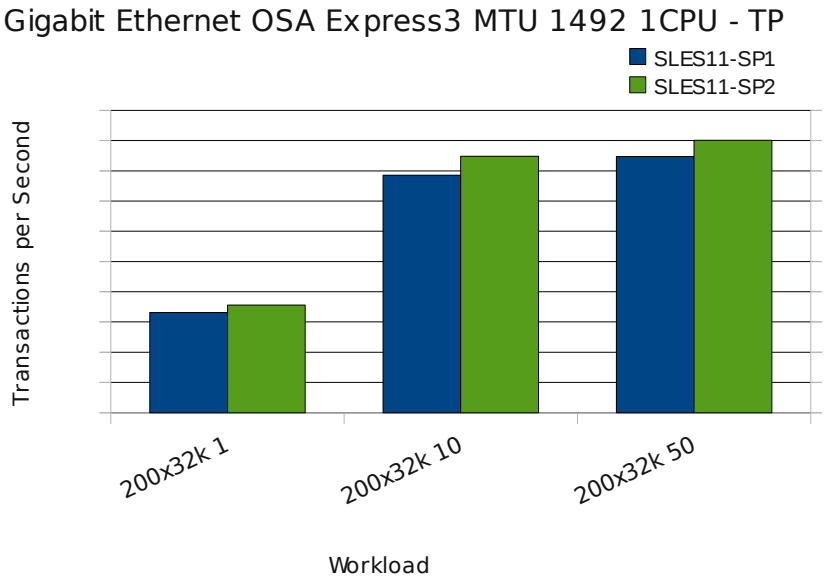


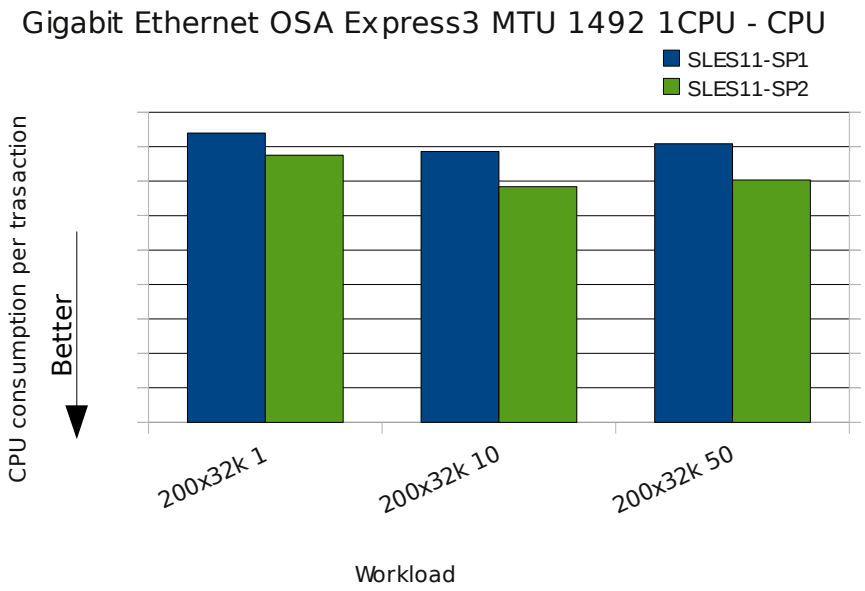

- Overall throughput stayed comparable
- But the fairness across the concurrent threads improved
  - ✓ Good to improve fair resource sharing without enforced limits in shared environments
  - ✓ Effect especially visible when the Database really has to go to disk (low hit scenario)
  - ✓ Can ease fulfilling QoS commitments

# Benchmark description – Network

- Network Benchmark which simulates several workloads
- Transactional Workloads
  - ✓ 2 types
    - RR – A connection to the server is opened once for a 5 minute time frame
    - CRR – A connection is opened and closed for every request/response
  - ✓ 4 sizes
    - RR 1x1 – Simulating low latency keepalives
    - RR 200x1000 – Simulating online transactions
    - RR 200x32k – Simulating database query
    - CRR 64x8k – Simulating website access
- Streaming Workloads – 2 types
  - ✓ STRP/STRG – Simulating incoming/outgoing large file transfers (20mx20)
- All tests are done with 1, 10 and 50 simultaneous connections
- All that across on multiple connection types (different cards and MTU configurations)

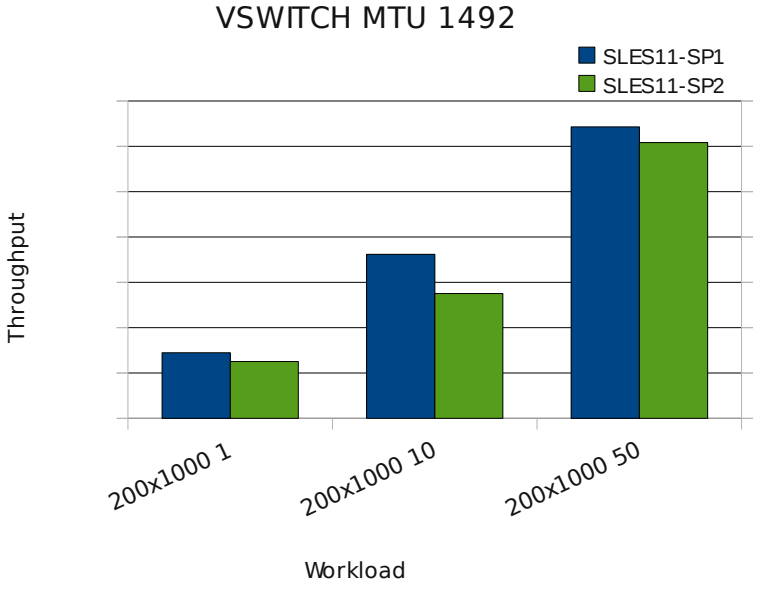
# Network I

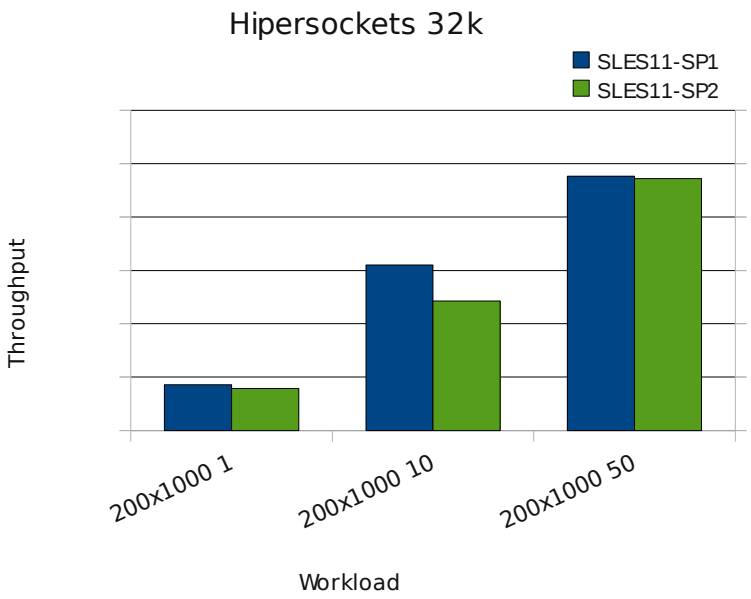



- Small systems gain an improvement in streaming throughput and cpu consumption
  - ✓ Systems being cpu-oversized always had to pay a price in terms of cpu consumption
  - ✓ Sometimes dynamic adjustment of your sizing can be an option, check out cpuplugd
    - A soon published paper about that can be found at http://www.ibm.com/developerworks/linux/linux390/perf/index.html
- Generic receive offload is now on by default
  - ✓ Further improves cpu consumption, especially for streaming workloads

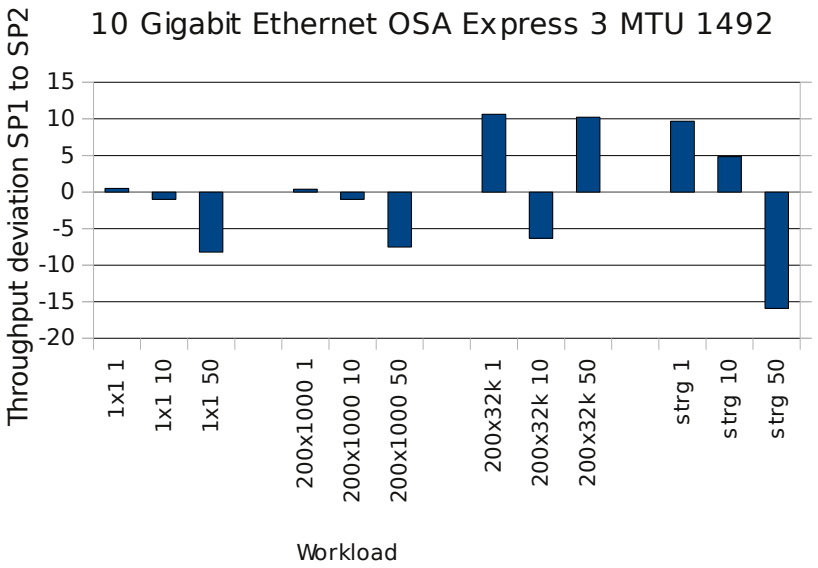
# Network II

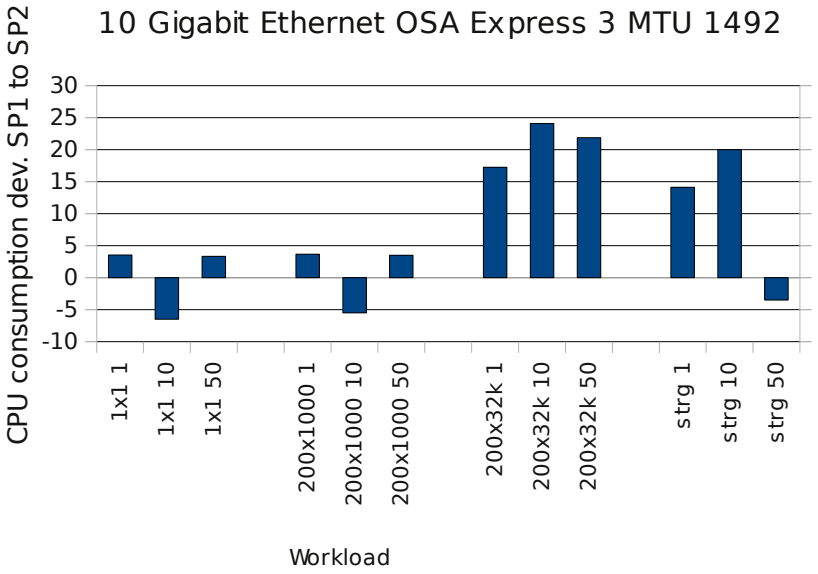



- Pure virtual connections degraded by 5 to 20%
  - ✓ Affects approximately half of the workload scenarios (smaller payloads are more in trouble)
  - ✓ Affects virtual VSWITCH and Hipersocket connections
- Some good messages mitigating that degradations
  - ✓ The reported overhead caused in the virtualization layers improved, so scaling will be better
  - ✓ Smaller degradations with larger mtu sizes
  - ✓ Effect smaller on z196 than on z10

# Network III



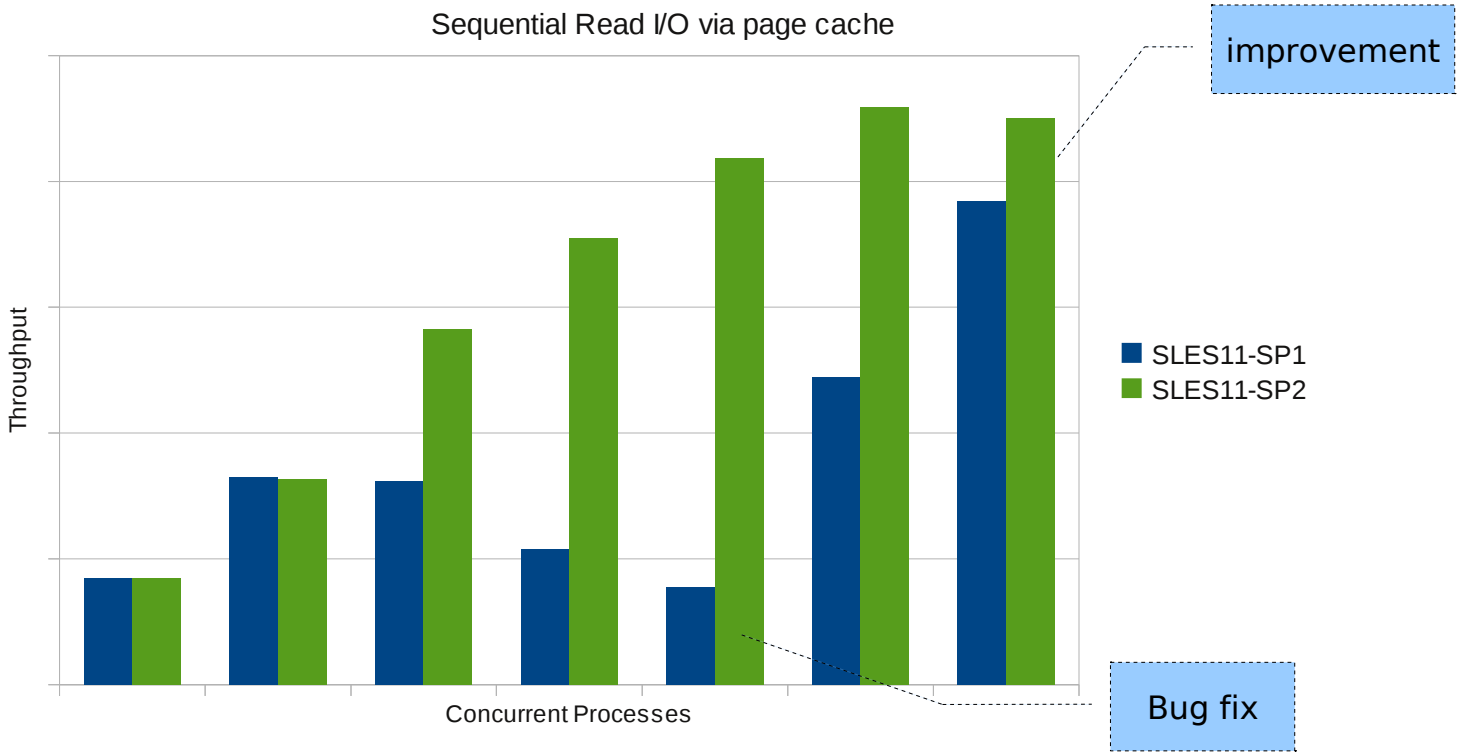

- Degradations and Improvements often show no clear line to stay away from
  - ✓ Overall we rated most of the network changes as acceptable tradeoff
    - If your workload matches exactly one of the degrading spots it might be not acceptable for you
    - On the other hand if your load is in one of the sweets spots your load can improve a lot
  - ✓ No solid recommendations what will surely improve or degrade in a migration
    - While visible in pure network benchmarks, our Application benchmarks didn't show TODO
    - Streaming like workloads improve in most, but not all cases

# Benchmark description - Disk I/O

- Workload
  - ✓ Threaded I/O benchmark
  - ✓ Each process writes or reads to a single file, volume or disk
  - ✓ Can be configured to run with and without page cache (direct I/O)
  - ✓ Operating modes: Sequential write/rewrite/read + Random write/read
- Setup
  - ✓ Main memory was restricted to 256 MiB
  - ✓ File size (overall): 2 GiB, Record size: 64KiB
  - ✓ Scaling over 1, 2, 4, 8, 16, 32, 64 processes
  - ✓ Sequential run: write, rewrite, read
  - ✓ Random run: write, read (with previous sequential write)
  - ✓ Once using bypassing the page cache
  - ✓ Sync and Drop Caches prior to every invocation

# Page cache based read

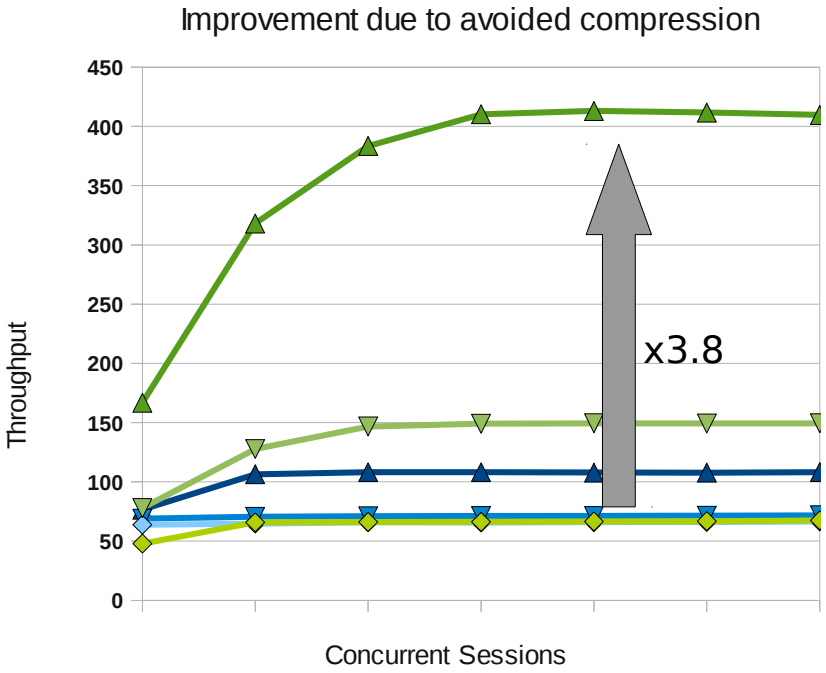
- Huge improvement for read throughput
  - ✓ Most of the impressive numbers are caused by a fixed bug included in older releases
  - ✓ Occurred if a lot of concurrent read streams ran on a small (memory) system
    - Last Distribution releases only had a partial mitigation of the issue
  - ✓ The improvements for other loads are within a range from 0 to 15%

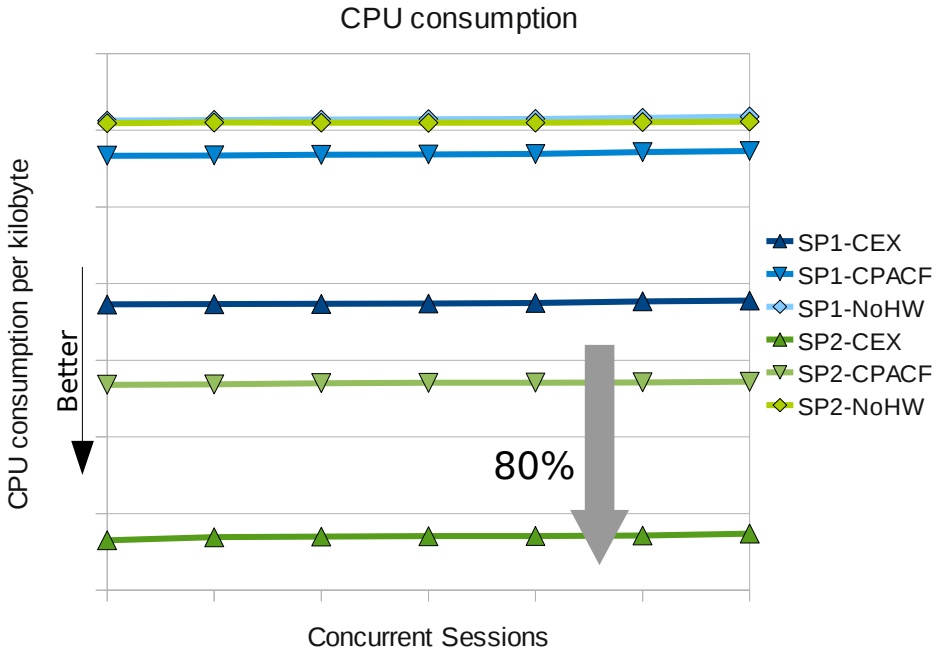


# OpenSSL based cryptography

- OpenSSL test suite
  - ✓ Part of the openssl suite
  - ✓ Able to compare different Ciphers
  - ✓ Able to compare different payload sizes
  - ✓ contains a local and distributed (via network) test tools
  - ✓ Can pass handshaking to crypto cards using the ibmca openssl engine
  - ✓ Can pass en-/decryption to accelerated CPACF commands using the ibmca openssl engine
- Our Setups
  - ✓ Scale concurrent connections to find bottlenecks
  - ✓ Iterate over different Ciphers like AES, DES
  - ✓ Run the workload with different payload sizes
  - ✓ Run SW only, CPACF assisted and CPACF + CEX3 Card assisted modes
    - CEX cards in accelerator and co-processor mode
  - ✓ We use distributed clients as workload driver
    - Evaluate overall throughput and fairness of throughput distribution
    - Evaluate the CPU consumption caused by the load

# OpenSSL based cryptography




- Compressing the data to save cryptographic effort was the default for a while
  - ✓ Counter-productive on System z as CPACF/CEX is so fast (and CEX account as off-loaded)
- Now it is possible to deactivate compression via an Environment variable `OPENSSL_NO_DEFAULT_ZLIB=Y`
  - ✓ 1000k payload cases with CPACF and cards x3.8 times faster now, still x2.3 without CEX cards
  - ✓ Even 40b payload cases still show 15% throughput improvement
  - ✓ At the same time depending on the setup 50% to 80% less cpu per transferred kilobyte

# Agenda

- Performance Evaluation
  - ✓ System under test (SUT) description
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- Performance evaluation Summary
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# SLES 11 SP2 Improvements & Degradations per area

**SLES 11 SP2 vs. SLES 11 SP1**

| Improvements/Degradations | Especially affects, but not limited to the following workloads |
|---|---|
| Process scaling | Websphere Family, large scale Databases |
| Filesystem Scaling | File serving |
| Network Streaming | TSM, replication tasks (DB2 HADR, Domino) |
| Disk I/O via page cache | Clearcase, DB2 on ECKD disks, File serving, Datastage |
| Disk I/O | TSM, Databases |
| Cryptography | Secure Serving/Communication in general |
| Pure Virtual Networks (vswitch G2G, HS) | Common Hipersocket setups: SAP enqueue server, Websphere to z/OS, Cognos to z/OS |

# Summary for SLES 11 SP2 vs. SP1

- SLES 11 SP2 performance is good
  - ✓ Improved compared to the already good SP1 release
    - Beneficial effects slightly bigger on newer System zEnterprise systems
  - ✓ Generally recommendable
    - Except environments focusing on pure virtual networks
- Improvements and degradations

| Level | On HW | Improved | No difference or Trade-off | Degraded |
|---|---|---|---|---|
| SLES 11 SP2 | z10 | 30 | 67 | 8 |
| SLES 11 SP2 | z196 | 33 | 64 | 3 |

# Questions

- Further information is located at
  - ✓ Linux on System z – Tuning hints and tips
    http://www.ibm.com/developerworks/linux/linux390/perf/index.html
  - ✓ Live Virtual Classes for z/VM and Linux
    http://www.vm.ibm.com/education/lvc/

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