SLES 11 SP2 Performance Evaluation for Linux on System z

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Agenda

- Performance Evaluation
  - Environment
  - Changes one should be aware of
- Performance evaluation Summary
  - Improvements and degradations per area
  - Summarized comparison

Environment

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

- Hardware Platform – System zEnterprise (z196)
  - FICON 8 Gbps
  - FCP 8 Gbps
  - HiperSockets
  - OSA Express 3 1GbE + 10GbE
- Software Platform
  - VM 6.1
  - LPAR
- Storage – DS8800
  - FICON 8 Gbps
  - FCP 8 Gbps

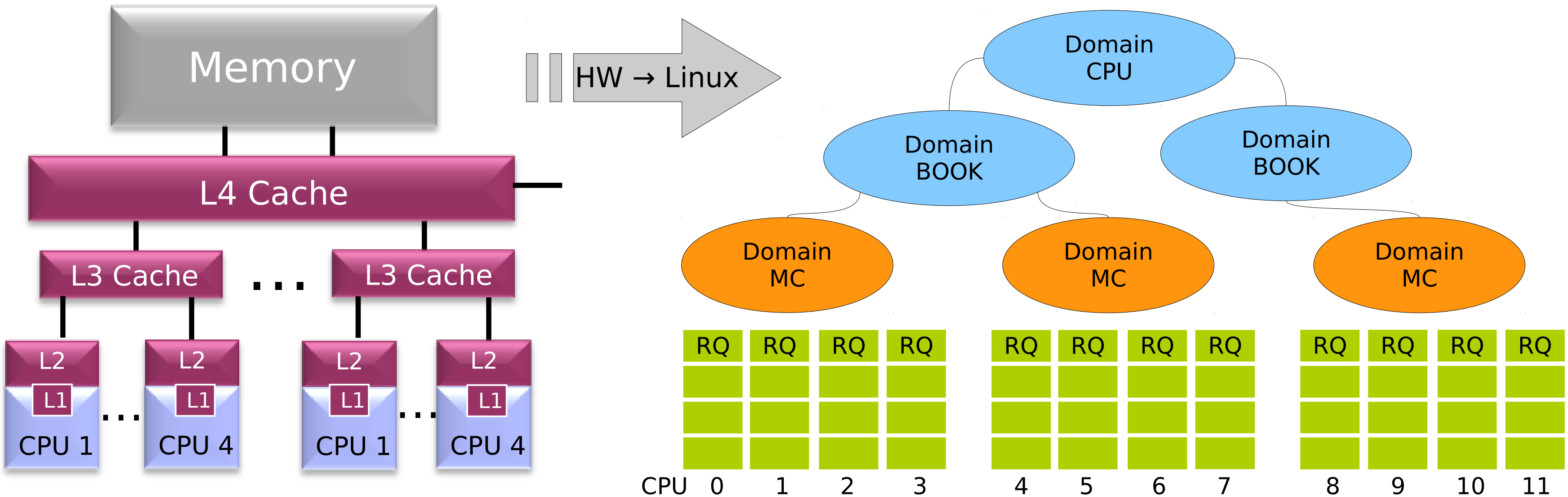
Compared Distribution Levels

- 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 in X seconds?”
  - Latency – “How long do I have to wait for event X?”
  - Normalized cpu consumption - “How much cpu per byte do I need?”

New process 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 can be activated via the topology=on 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



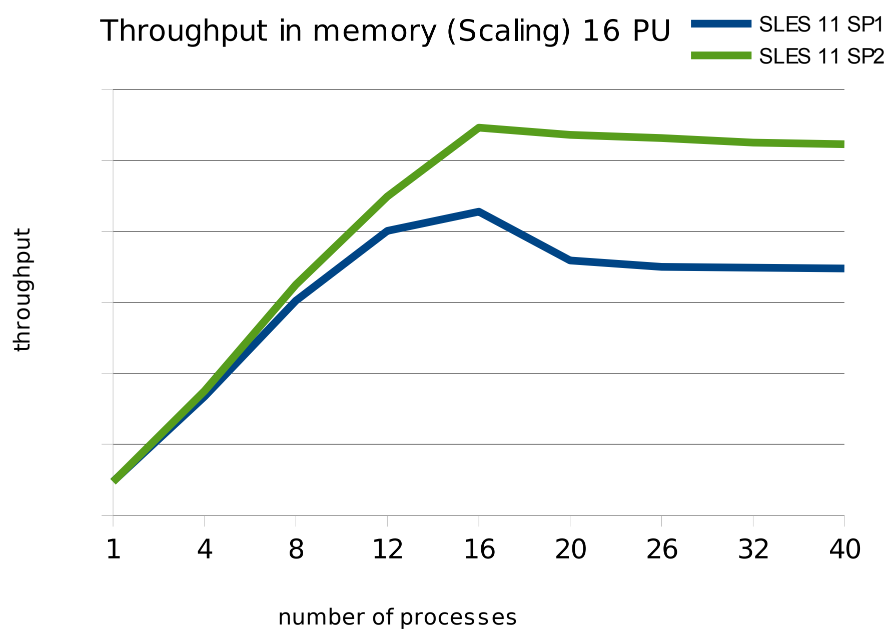
- Recreate the HW layout in the scheduler
  - Off in z/VM Guests, since there is no virtual topology information
  - Ability to group (rec. ipc heavy loads) or spread (rec. cache hungry) loads
  - Unintended asymmetries now known to the system

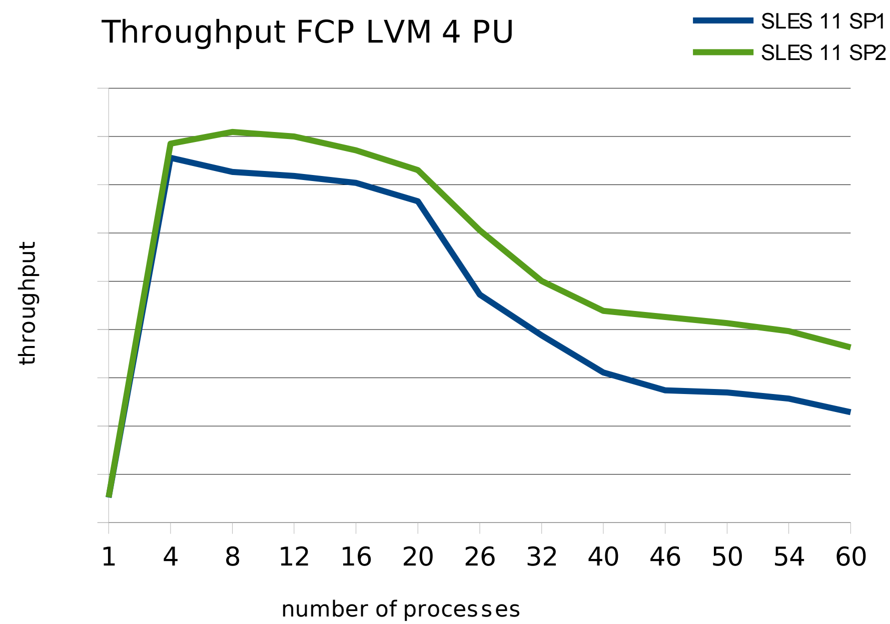
- Tunable, but complex
  - /proc/sys/kernel/sched_* files contains tunables for decisions regarding request queues ( )
  - /proc/sys/kernel/sched_domain/... provides options for the scheduling domains (/)

Benchmark descriptions - File system / LVM / Scaling

- Filesystem benchmark dbench
  - 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





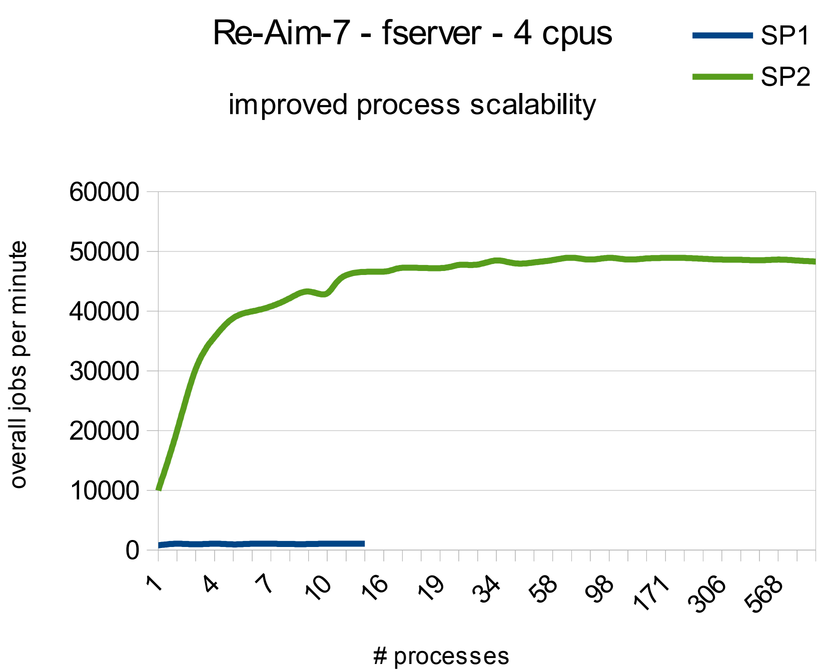
- Improved scalability for page cache operations
  - Especially improves large workloads
    - Saves cache misses of the load that runs primarily in memory
  - At the same time lower cross process deviation improves QoS
- Improved throughput for disk bound LVM setups as well
  - Especially improves heavily concurrent workloads

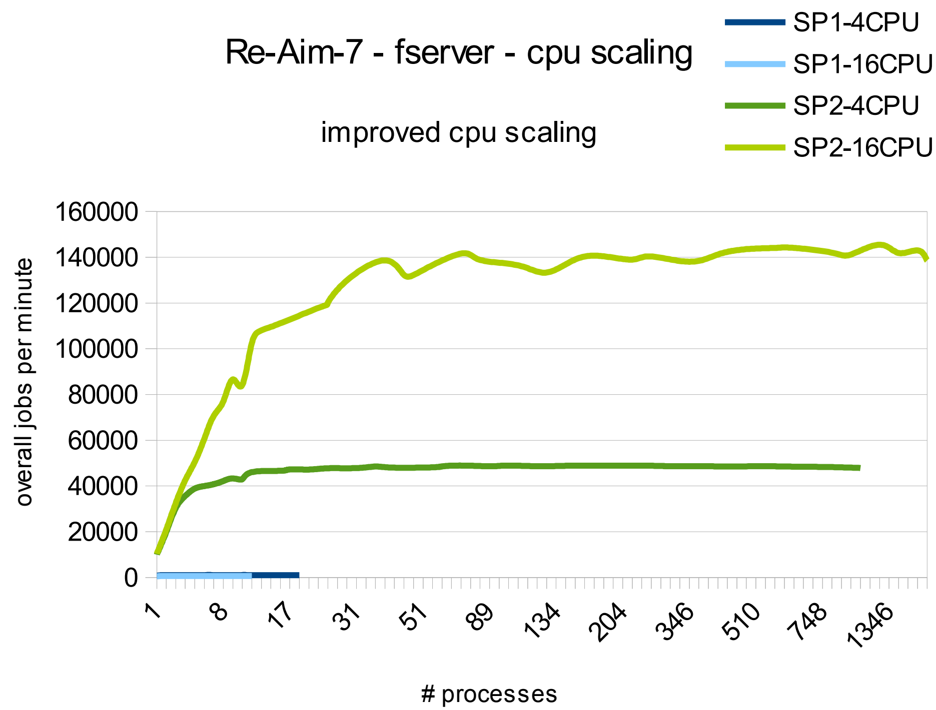
Benchmark descriptions – Re-Aim-7

- Scalability benchmark Re-Aim-7
  - Open Source equivalent to the AIM Multiuser benchmark
  - Workload patterns describe system call ratios (can be 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





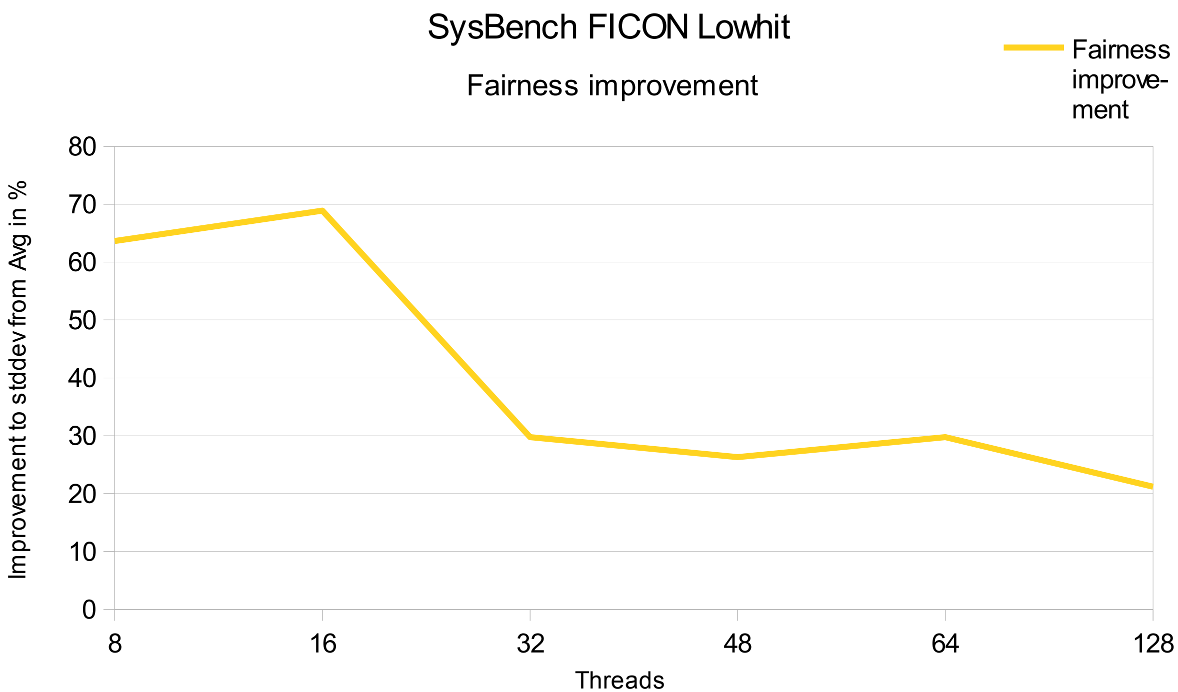
- The issue blocked process scaling (left) and cpu scaling (right)
- The sync call was broken, so scaling relying on it was almost non existent
  - Scales well in SP2 now with increasing number of processes
  - Fortunately for SP1 this system call is not one of the most frequently called ones

Benchmark descriptions – 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

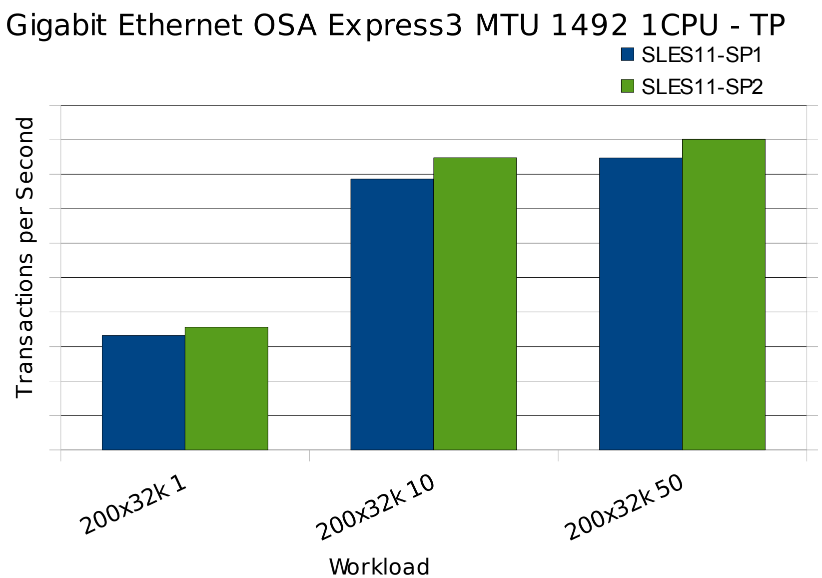


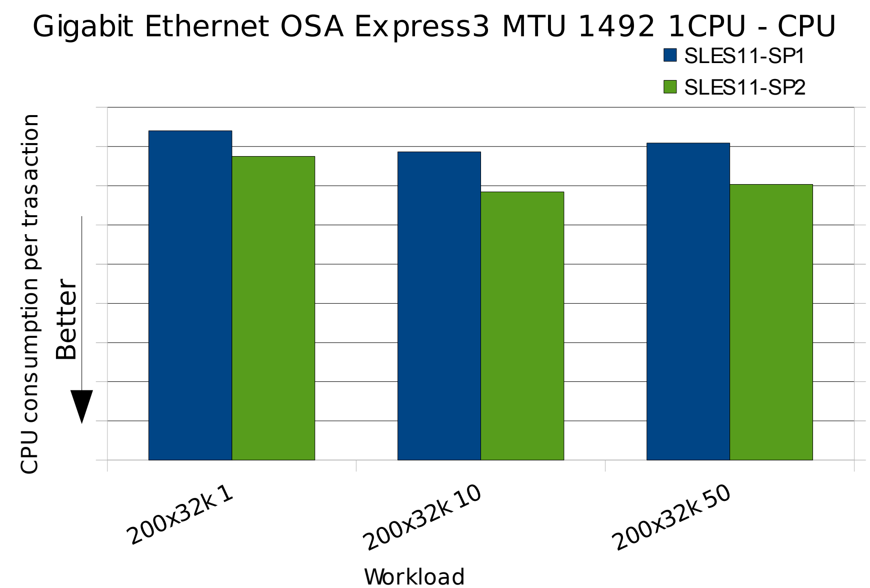
- Overall throughput stayed comparable
- But the fairness across the concurrent threads improved
  - Good to improve fair resource sharing without enforced limits in shared environments
  - Effect especially visible when the Database really has to go to disk (low hit scenario)
  - Can ease fulfilling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

Benchmark descriptions - 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)

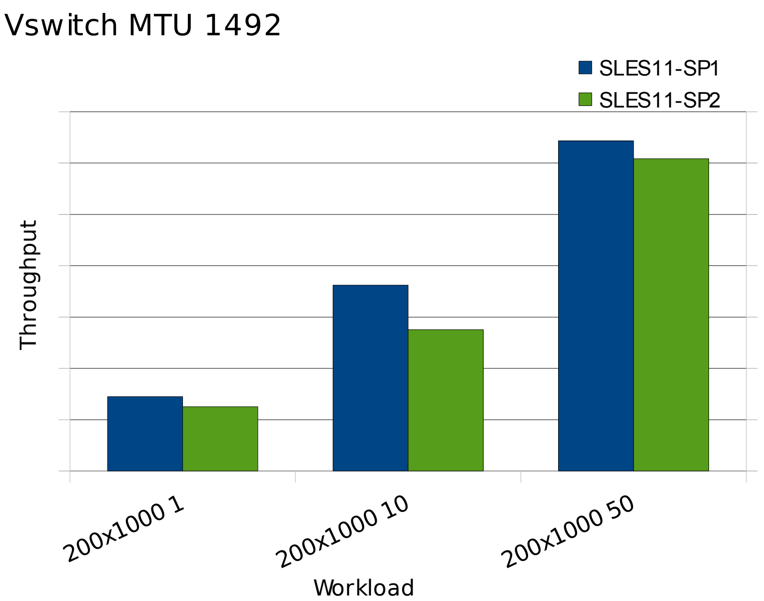
Network I

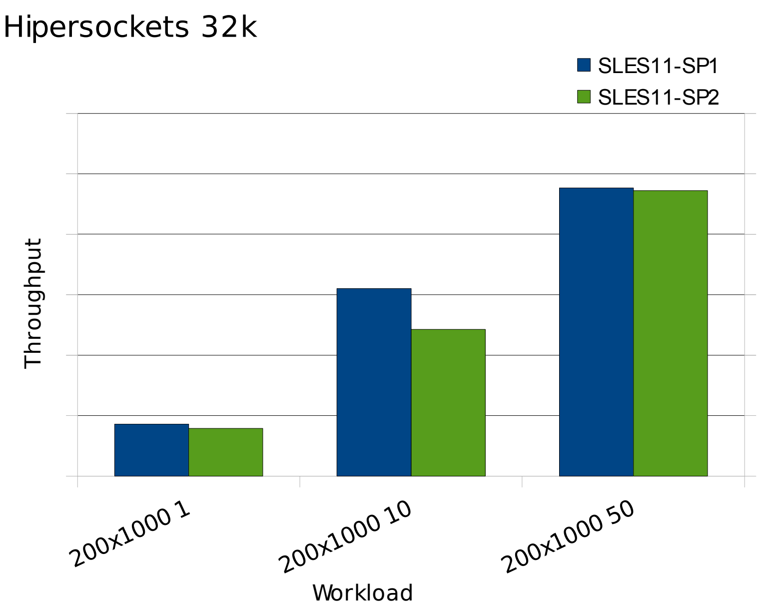




- Small systems gain an improvement in streaming throughput and cpu consumption
  - Systems being cpu-oversized always had to pay a price in terms of cpu consumption
  - Sometimes dynamic adjustment of your sizing can be an option, check out cpuplugd
    - A paper about that can be found at http://www.ibm.com/developerworks/linux/linux390/perf/index.html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

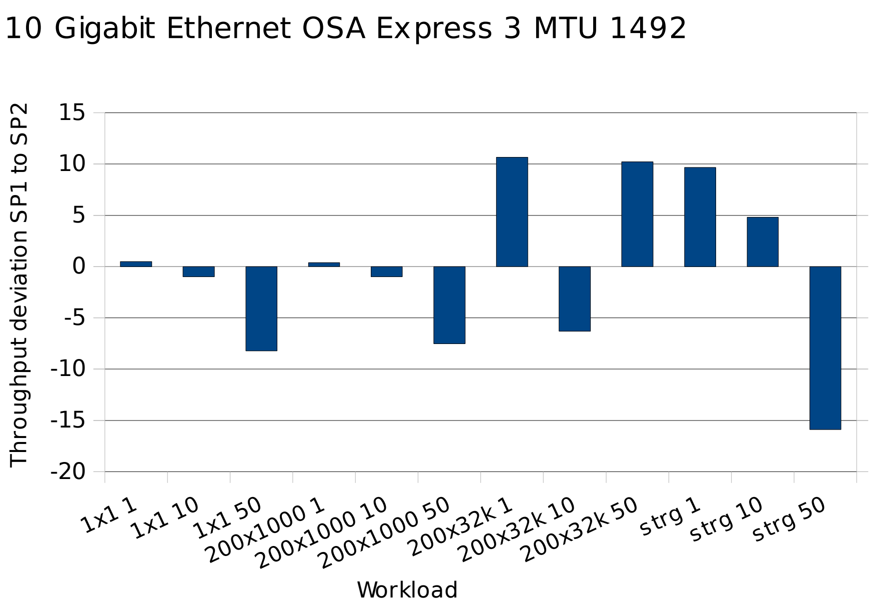
Network II

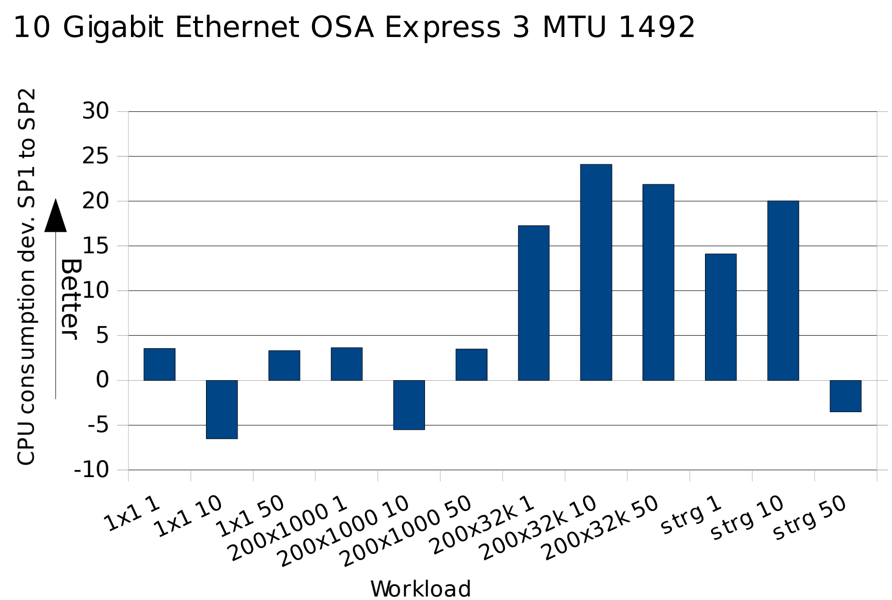




- Pure virtual connections degraded by 5 to 20%
  - Affects approximately half of the workload scenarios (smaller payloads are more in trouble)
  - Affects virtual vswitch and hipersocket connections
- Some good messages mitigating that degradations
  - The reported overhead caused in the virtualization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

Network III



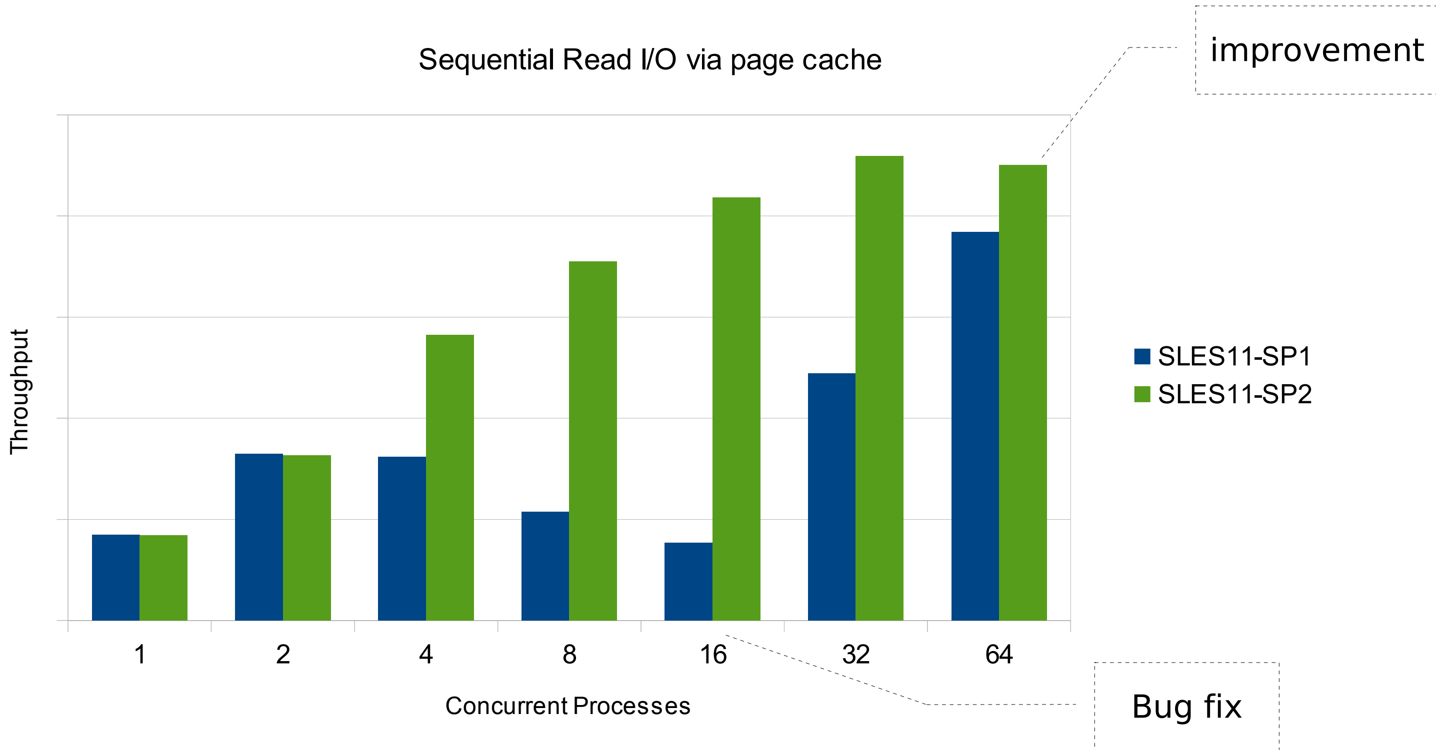


- Degradations and Improvements often show no clear line to stay away from
  - Overall we rated most of the network changes as acceptable tradeoff
    - If your workload matches exactly one of the degrading spots it might be not acceptable for you
    - On the other hand if your load is in one of the 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 net based Application benchmarks didn't show impacts
    - Streaming like workloads improve in most, but not all cases

Benchmark descriptions - 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 - issues fixed and further improved



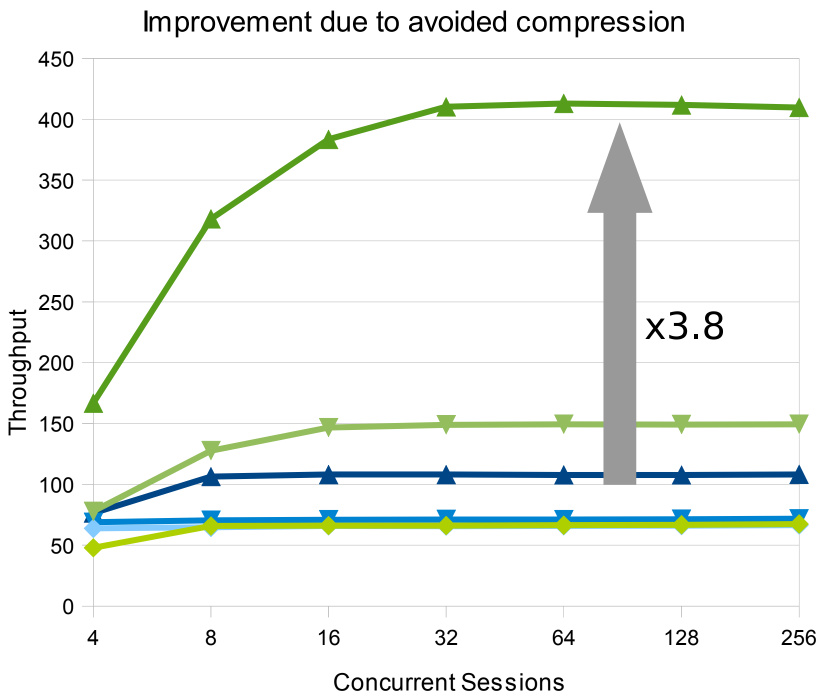
- Huge improvement for read throughput
  - It has improved, but most of the impressive numbers are from a bug in older releases
  - Occurred if a lot of concurrent read streams ran on a small (memory) system
    - Last Distribution releases only had a partial mitigation of the issue, but no fix
  - The improvements for other loads are within a range from 0 to 15%

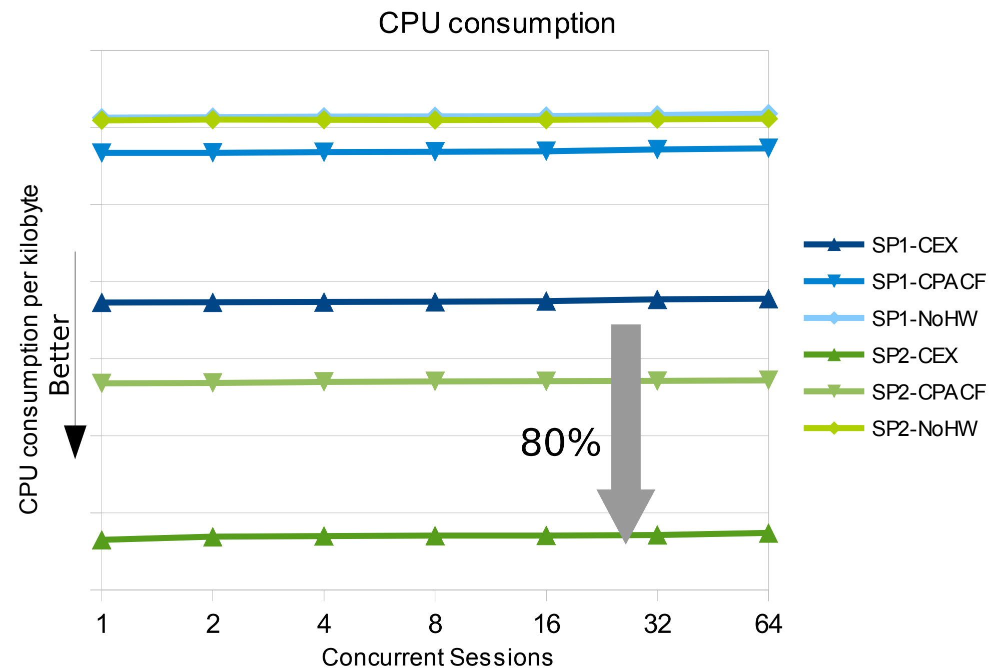
OpenSSL based Cryptography

- 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 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
  - Additionally depending on the setup 50% to 80% less cpu per transferred kilobyte

Agenda

- Performance Evaluation
  - Environment
  - Changes one should be aware of
- Performance evaluation Summary
  - Improvements and degradations per area
  - Summarized comparison

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

- Improvements in almost every area
  - Especially for large workloads/machines (scaling)
- Degradations for virtual networking

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 available 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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Performance Evaluation

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