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Linux on System z Distribution Performance Update

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Session 10015

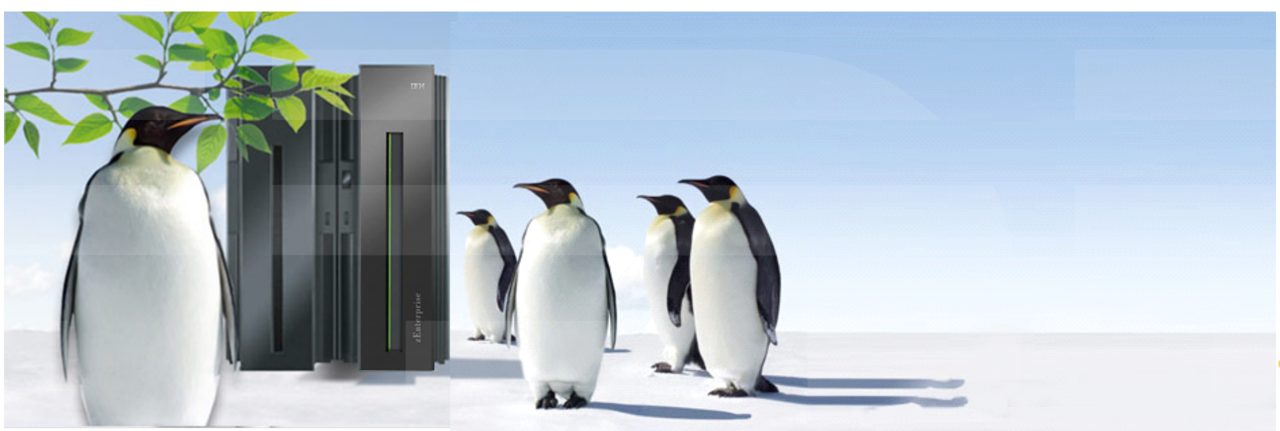
Agenda

- Performance Evaluation Results
  - Environment
  - Improvements
  - Changes one should be aware of

- Performance evaluation Summary
  - Improvements and degradations per area
  - Summarized comparison

Environment

- Host – System z10
  - FICON 4 Gbps
  - FCP 4 Gbps
  - HiperSockets
  - OSA Express 3 1GbE + 10GbE
- Storage – DS8300 (2107-922)
  - FICON 4 Gbps
  - FCP 4 Gbps
- HW-Platform
  - Linux on LPAR
  - Linux in z/VM 5.4 guest
- Verified on
  - System z Enterprise
  - DS8800 with 8 Gbps connectivity
  - Linux in z/VM 6.1



Compared Versions

- Compared Set 1
  - RHEL5 U4 (2.6.18-194.el5)
  - RHEL6-GA (2.6.32-71.el6)
  - RHEL6-GA + tuning
    - our recommended tuning (in RH Tech Notes)
    - workarounds for known issues
- Compared Set 2
  - SLES10-SP3 (2.6.16.60-0.54.5-default)
  - SLES11-GMC (2.6.27.19-5-default)
  - SLES11-SP1-GMC (2.6.32.12-0.6-default)
    - workarounds for known issues
- 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?”

New process scheduler (CFS)

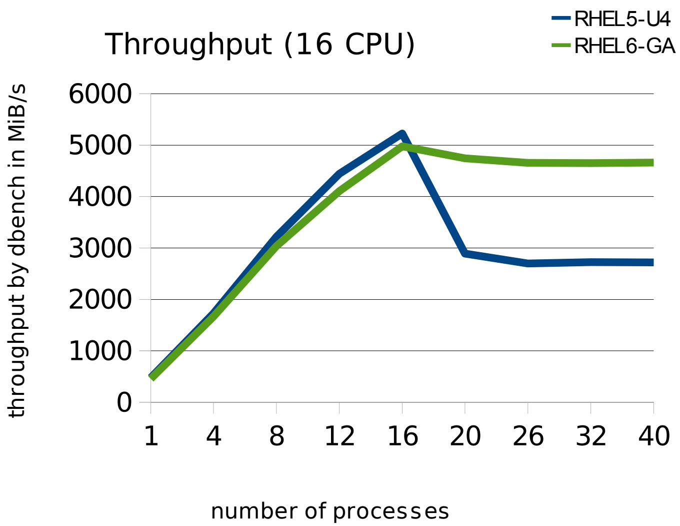
- Goals of CFS
  - Models “ideal, precise multi-tasking CPU”
  - Fair scheduling based on virtual runtime
- Changes you might notice when switching from O(1) to CFS
  - Lower response times for I/O, signals, …
  - Balanced distribution of process time-slices
  - Improved distribution across processors
  - 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

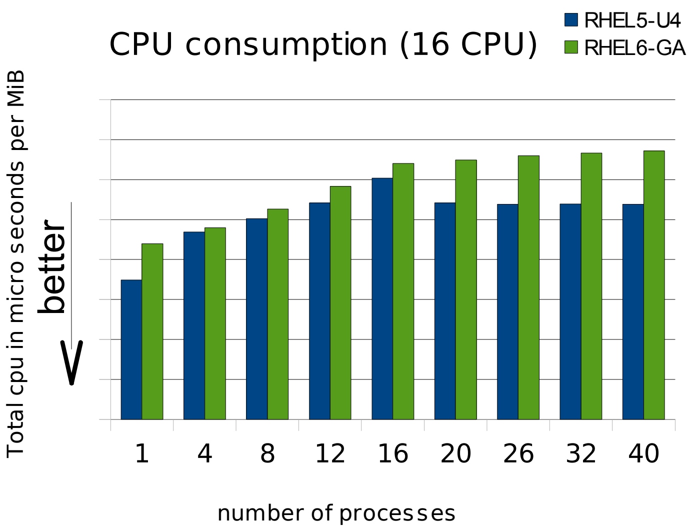
Benchmark descriptions
File system / LVM / Scaling

- 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)
  - Mainly memory operations for scaling
  - Low main memory and LVM setup for mixed I/O and LVM performance
  - Mixed file operations workload for each process: create, write, read, append, delete
  - 8 CPUs, 2 GiB memory and scaling from 4 to 62 processes (clients)
  - Measures throughput of transferred data

File system benchmark – process scaling



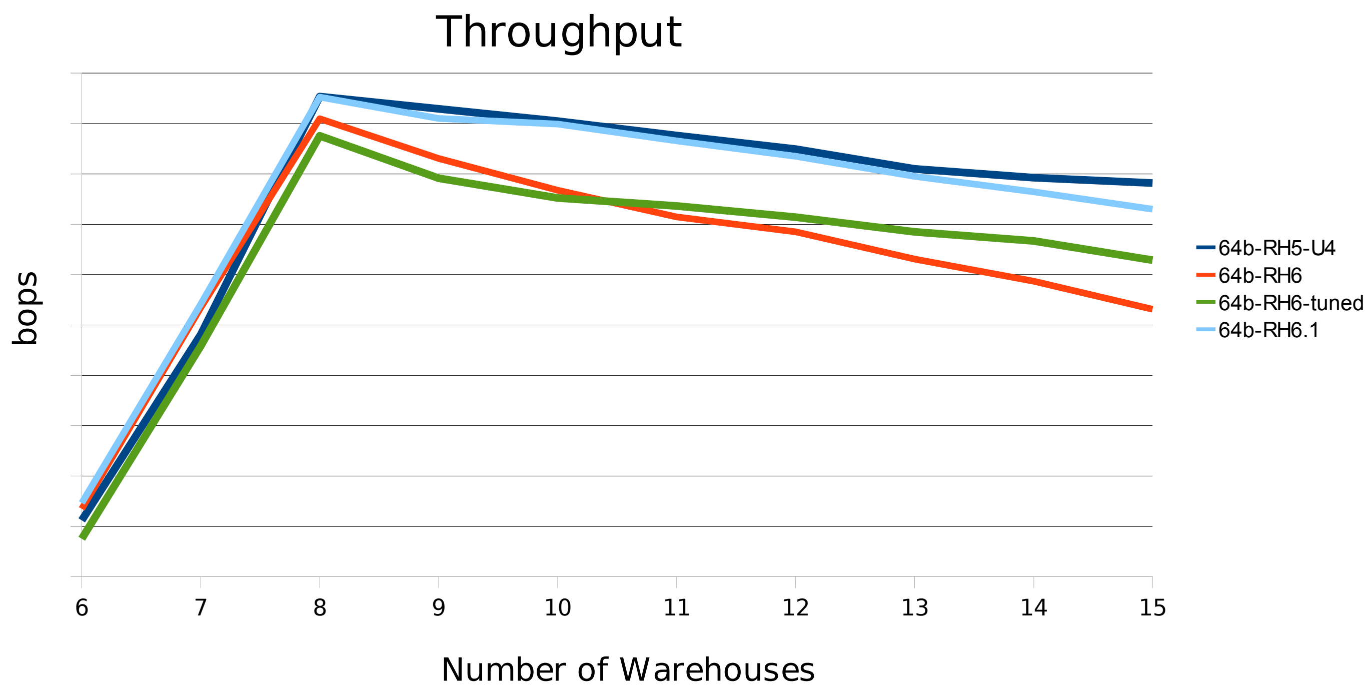


- Improved scalability
  - Especially improves large workloads
  - Lower cross process deviation improves QoS
- Increased CPU consumption due to
  - CFS is striving for better interactivity and fairness
  - Changes affecting the writeback of dirty pages
    - Rule of thumb – now about twice as aggressive
    - One might want to tune dirty ratios in `/proc/sys/vm/dirty_*`
- Comparison between SLES10 SP3 and SLES11 SP1 looks similar

Benchmark descriptions - Java

- evaluates server side Java
  - 3-tier system
    - Random input from user
    - Middle tier business logic implemented in Java
    - No explicit database --> emulated by Java objects
    - Scales warehouses
- stressed components
  - Java
    - Virtual Machine (VM)
    - Just-In-Time compiler (JIT)
    - Garbage Collection (GC)
  - Linux operating system
    - Threads
    - Scheduler
    - Caches and Memory

Java

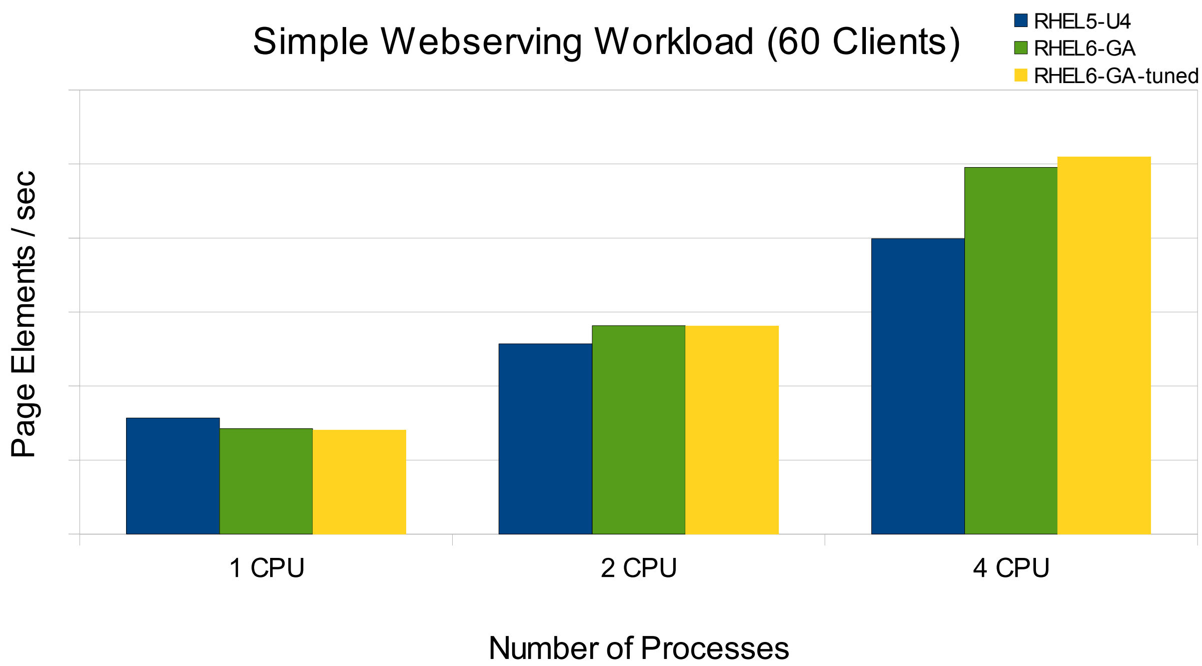


- 64b – RHEL6-GA -4.8% vs RHEL5-U4; tuned at least only -3.8%
- This is caused by a bit of over-optimization for desktop latency in the new scheduler
- System z recommended tunables are not set by default in RHEL6, but part of the tech notes
- RHEL6.1 had our recommendation by default and CFS fixes, now almost equal to RHEL5-U4
- SLES11 SP1 showed always slightly better throughput versus SLES10 SP3

Benchmark descriptions - Webserving

- Webserver Benchmark
  - Static website content read
  - Variable number of connections
  - Measures throughput via network connection
- Server side
  - Apache
  - HTML content
- Client side
  - 3 clients connected to webserver
  - Number of active requests scaled from 1 to 20 connections per client

Webserving – example for improved CPU scaling

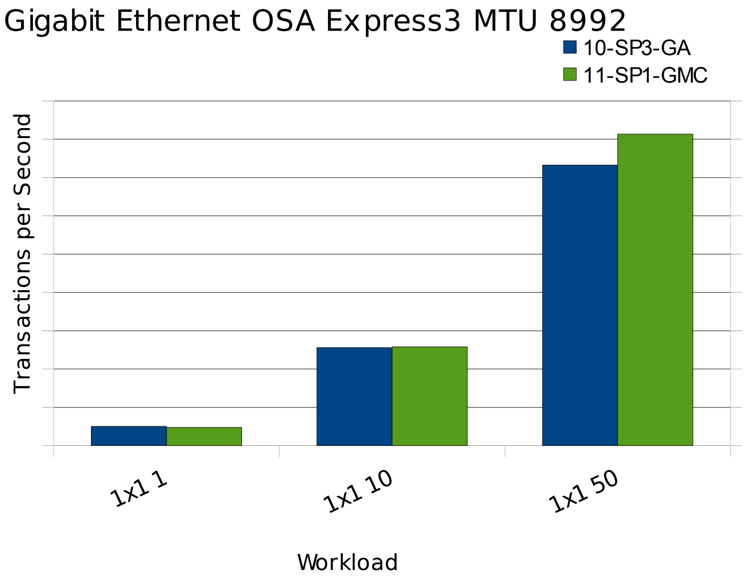


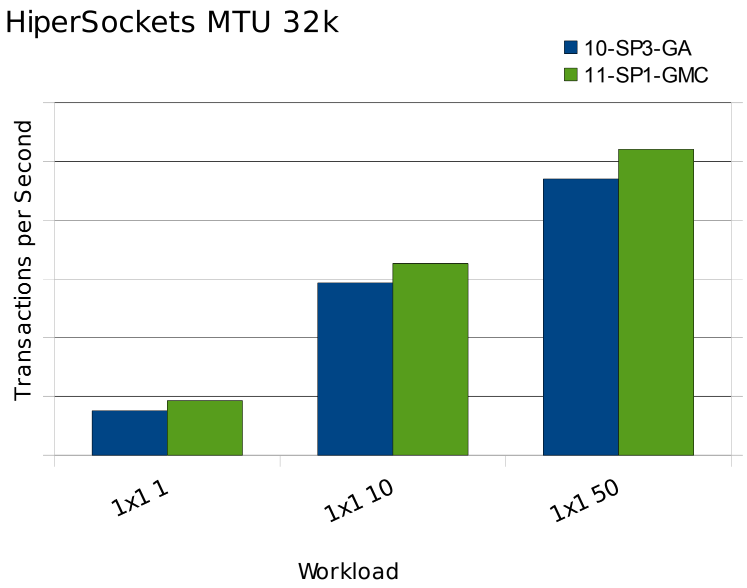
- Improved CPU scalability compared to RHEL5-U4
  - The recommended scheduler tuning adds further improvements
- Additional CFS effect
  - Lower worst-case response time

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)

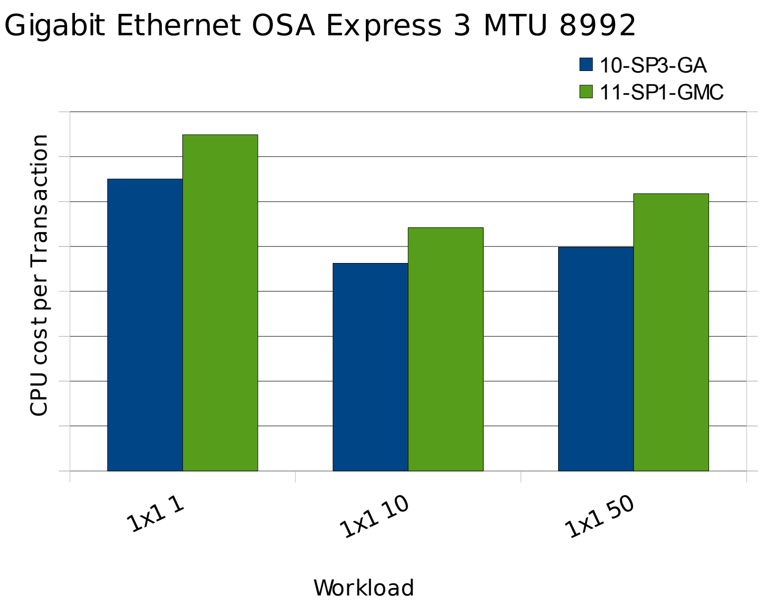
Network Throughput

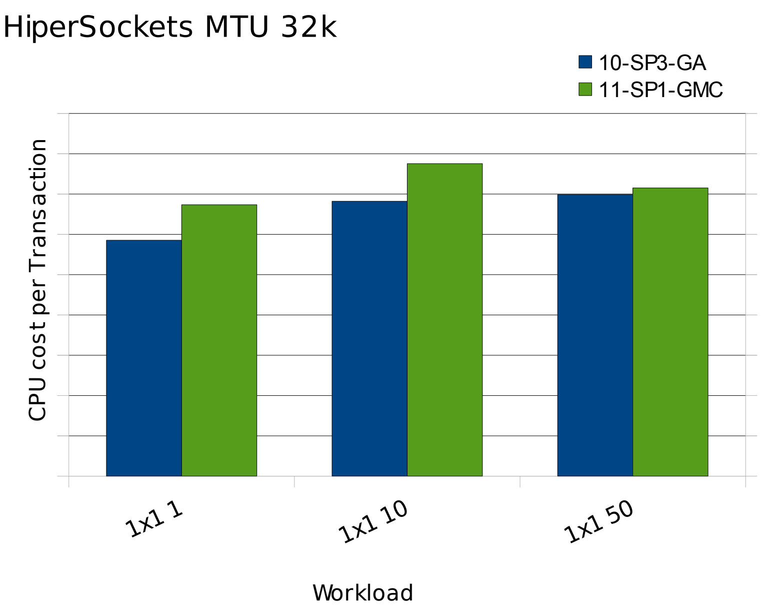




- Single connection Latency can be an issue, but it is much better than in SLES11
  - 1x1 is shown here as it forces max overhead and latency per transferred byte
- Connection scaling is good - parallel scenarios improved a lot
  - Workloads with larger transferred sizes benefit a bit more
- For HiperSockets even latency improved

Network CPU consumption



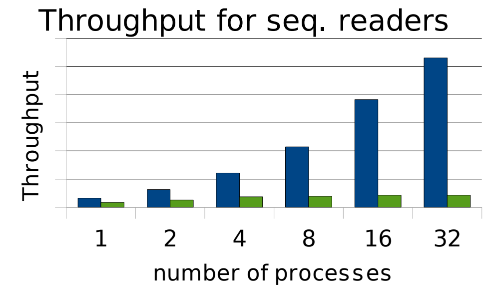


- CPU consumption increased for a lot of workloads
  - roughly 2/3 of the connection types we distinguish are affected
  - Part of the trade-offs for better performance
  - Also partially a scheduler/caching effect
- Some improvements for loads with large mtu's
  - Usually seen on the sender side
  - That implies it is beneficial for data sources not for data sinks

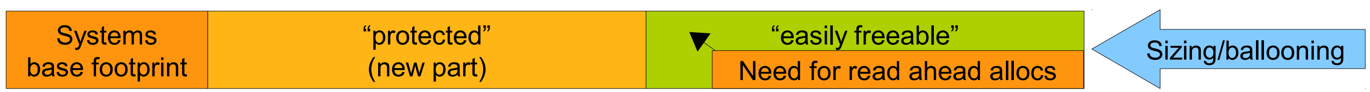
Benchmark descriptions - Disk I/O

- 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 disk I/O read issue



- Caused as corner case by memory management “improvements”
- Real World - Backups
  - It can hold a lot of data to scan by the backup software (→ a lot of seq. read)
  - A lot of data is usually split across many discs on s390 (→ concurrent access)
  - Overcommitment/ballooning effects or sized too small (→ memory constraint)

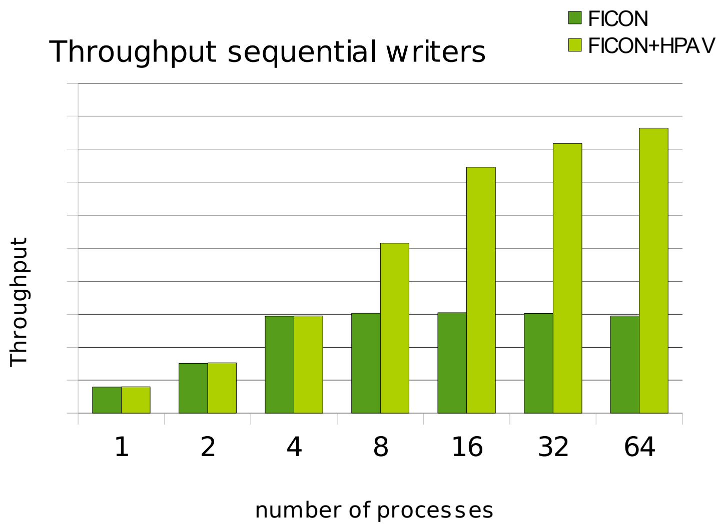


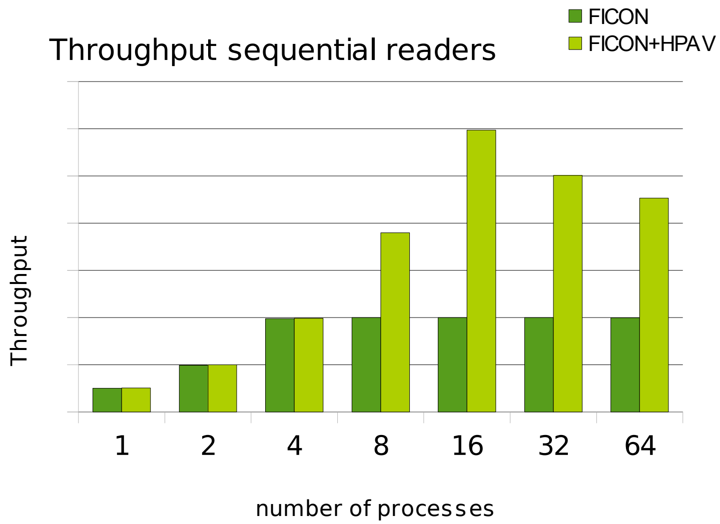
- Detection
  - Most workloads won't see the impact or more than that benefit from these changes
  - Check sysstat which should report a huge amount of pgscand/s
  - Run “sync; echo 3 > /proc/sys/vm/drop_caches”
    - Should hurt throughput, huge improvements mean you are probably affected
- Workarounds other than “more memory”
  - Drop caches if there is a single time this happens (e.g. on nightly backup)
  - Use direct I/O or shrink read ahead if applicable
  - Fix got upstream accepted in 2.6.37-rc1
    - will appear in both distributions next service update

Disk I/O – New FICON features

- HyperPAV
  - Avoid subchannel busy
  - Automatic management of subchannel assignment/usage
  - No need of multipath daemon
  - Especially useful for concurrent disk accesses
- Read-Write Track Data
  - Allows to read/write up to a full track in one command word
  - Especially useful for huge requests and streaming sequential loads
- High Performance Ficon
  - New metadata format reduces overhead
  - Especially useful for small requests

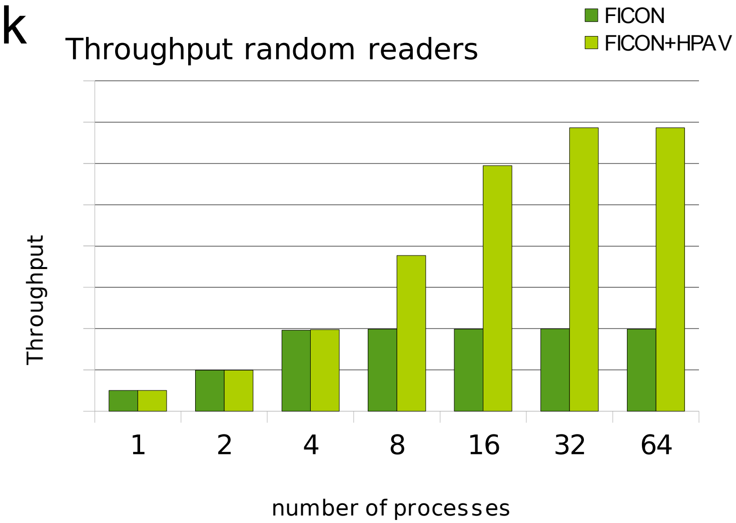
Disk I/O – FICON – HyperPAV



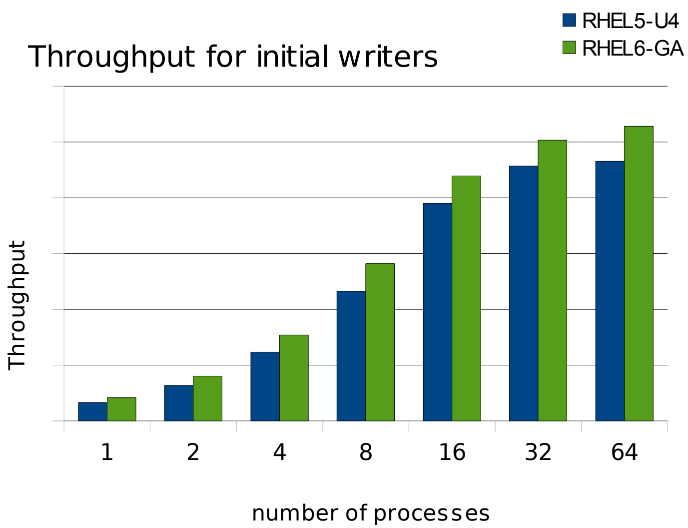


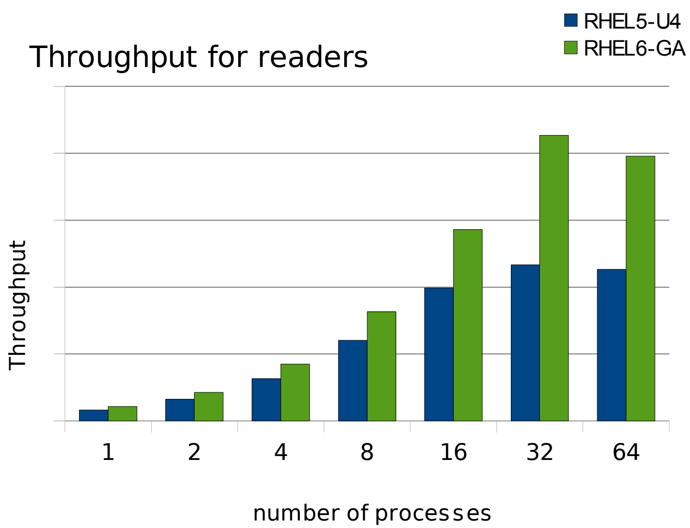
- Using 4 disks (4 ranks) with 3 aliases per rank
- Without PAV/HyperPAV
  - Access could become contented (subchannel busy)
  - Throughput stays constant >1 proc per disk
- Solution: multiple subchannels per device
  - PAV: Aliases for devices
  - HyperPAV: Pool of aliases defined per rank
  - Throughput increased up to 3.5 x in our scenario

→ Usage of HyperPAV can be highly recommended



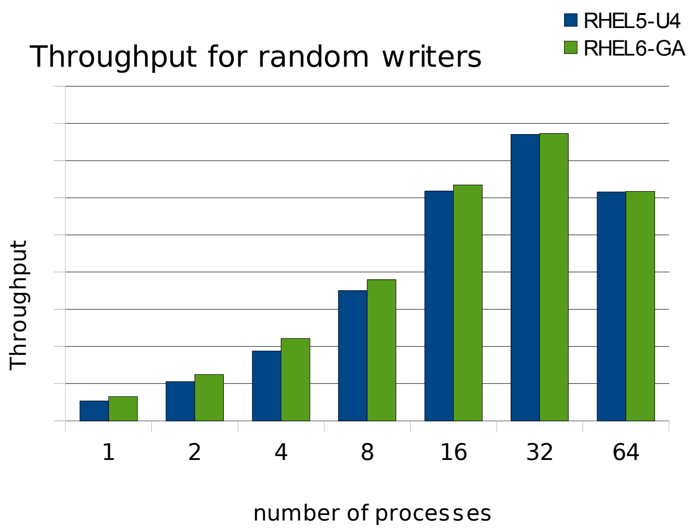
Disk I/O – FICON – effect of RWTD/HPF – Throughput

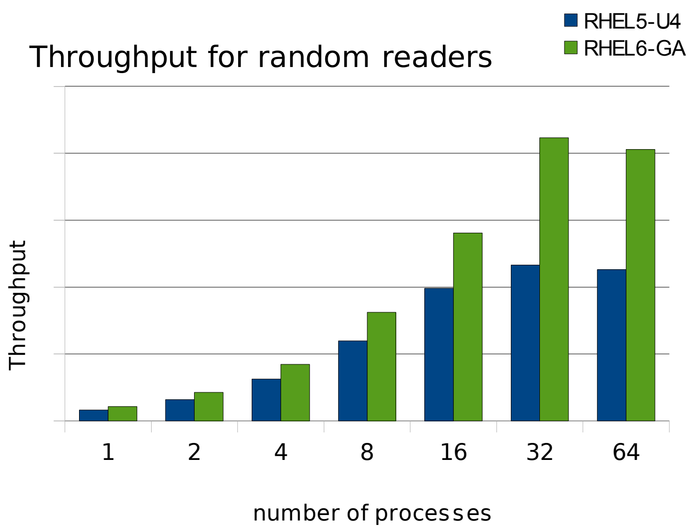




- IOzone sequential write/read using direct I/O
  - Huge throughput improvements
    - Write throughput up to 26%
    - Read throughput up to 82%
  - Normalized I/O consumption stays about the same
    - despite the much larger throughput
- SLES11 SP1 to SLES10 SP3 comparison looks similar

Disk I/O – FICON – effect of RWTD/HPF – random workloads





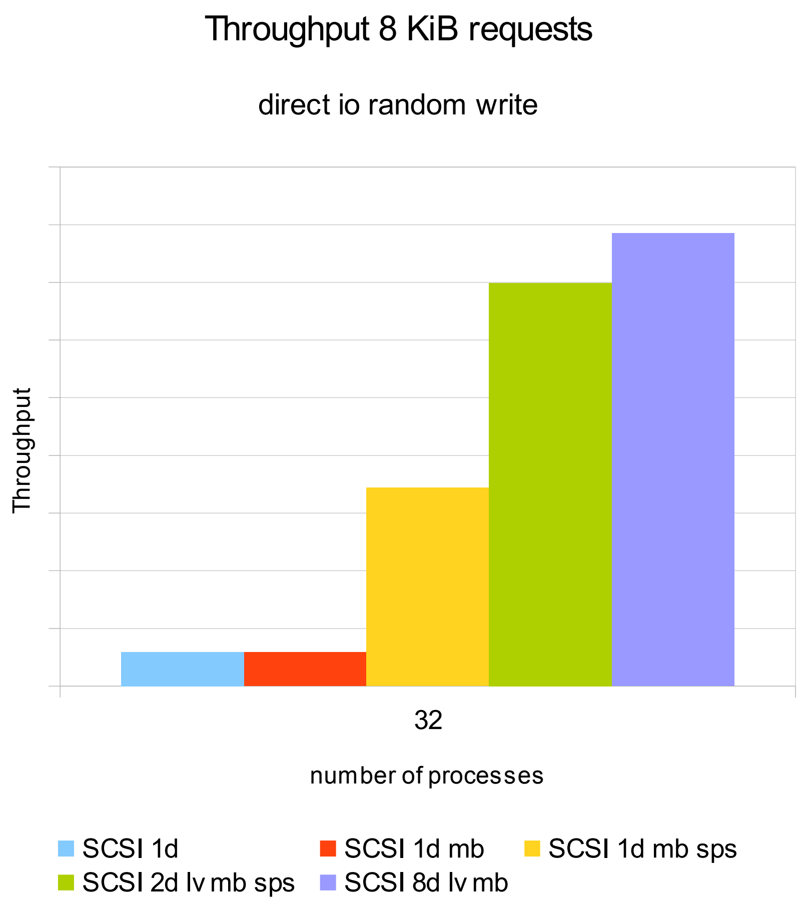
- IOzone random write/read using direct I/O
  - Huge throughput improvements
    - Read throughput up to +81%
    - Write throughput up to +23%
- Where throughput isn't improved usually cpu consumption drops
- SLES11 SP1 to SLES10 SP3 comparison looks similar

Disk I/O – Multipathing

- In the Past: Required for RAS (failover)
- Now: recommendable for RAS+Perf (multibus)
  - Throughput
  - Lower latency
  - Utilize multiple Adapters
  - Cpu consumption sane

- Example of a single Database I/O case
  - 32 processes doing random 8KiB writes
  - From worst to best setup throughput 13 times faster

- Huge topic
  - two presentations just about these setups
  - check out our webcasts



Hints - General

- Cgroup memory support
  - This is a feature coming with newer kernels
  - Recommended by some management tools to enforce very customizable memory constraints
  - Has a rather large footprint by consuming 1% of the memory
  - Activated by default
  - In a consolidation environment it is actually 1% multiplied by your virtual/real ratio
  - Not pageable by linux, but fortunately by z/VM
  - This can be overridden with a kernel parameter (reboot):

```
cgroup_disable=memory
```

Improvements and Degradations of RHEL6 per area

vs. RHEL5-U4

Improvements	Degradations
FICON I/O	CPU consumption*
Process scaling	OSA single C. Latency
CPU scaling	I/O corner cases via page cache*
Compiler	
Multiconn. Networking	
Disk I/O via page cache	

- Improvements in almost every area
  - Especially for large workloads
- Degradations for corner cases and cpu consumption
  - * = Partially or completely avoidable due to tunings/workarounds

Summary for RHEL6

- RHEL 6 performance is good
  - With some trade-offs roughly equal to RHEL5-U4
    - A common trade-off is increased cpu consumption for better scalability
  - Our recommended tunings/workarounds help in some known cases
    - Upcoming RHEL6.1 will further reduce the amount of manual tuning needed
  - Almost generally recommendable
    - An exception are very cpu consumption sensitive environments
      - *Here upgrades have to be considered carefully*

- Improvements and degradations

Base	New	Improved	No difference or Trade-off	Degraded
RH5U4	RH6	27	22	33
RH5U4	RH6 tune & w.	34	48	0

Improvements and Degradations of SLES11 SP1 per area

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vs. SLES10SP3

Improvements	Degradations
FICON I/O	CPU consumption*
Process scaling	OSA single C. Latency
CPU scaling	I/O corner cases via page cache*
Compiler	
Multiconn. Networking	
Disk I/O via page cache	

vs. SLES11

Improvements	Degradations
Disk I/O	Only corner cases
Process scaling	
Compiler	
Latency	
CPU consumption	
Multiconn. Networking	

- Improvements in almost every area
  - Especially for large workloads
- Degradations for corner cases and cpu consumption
  - * = Partially or completely avoidable due to tunings/workarounds

Summary for SLES11 SP1

- SLES11-SP1 performance is good
  - With some trade-offs roughly equal to SLES10-SP3
    - A common trade-off is increased cpu consumption for better scalability
  - Almost generally recommendable
    - Especially Systems with SLES11 or with heavy FICON I/O
    - An exception are very cpu consumption sensitive environments
      - *Here upgrades have to be considered carefully*
- Improvements and degradations

Base	New	Improved	No difference or Trade-off	Degraded
SLES10	SLES11	5	31	46
SLES10	SLES11-SP1	33	37	12
SLES10	SLES11-SP1 tune + w	36	46	0
SLES11	SLES11-SP1	53	29	0

Questions

- Further information is 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/
  - Red Hat Enterprise Linux 6 Tech Notes
    http://docs.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/6/html-single/Technical_Notes/index.html

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