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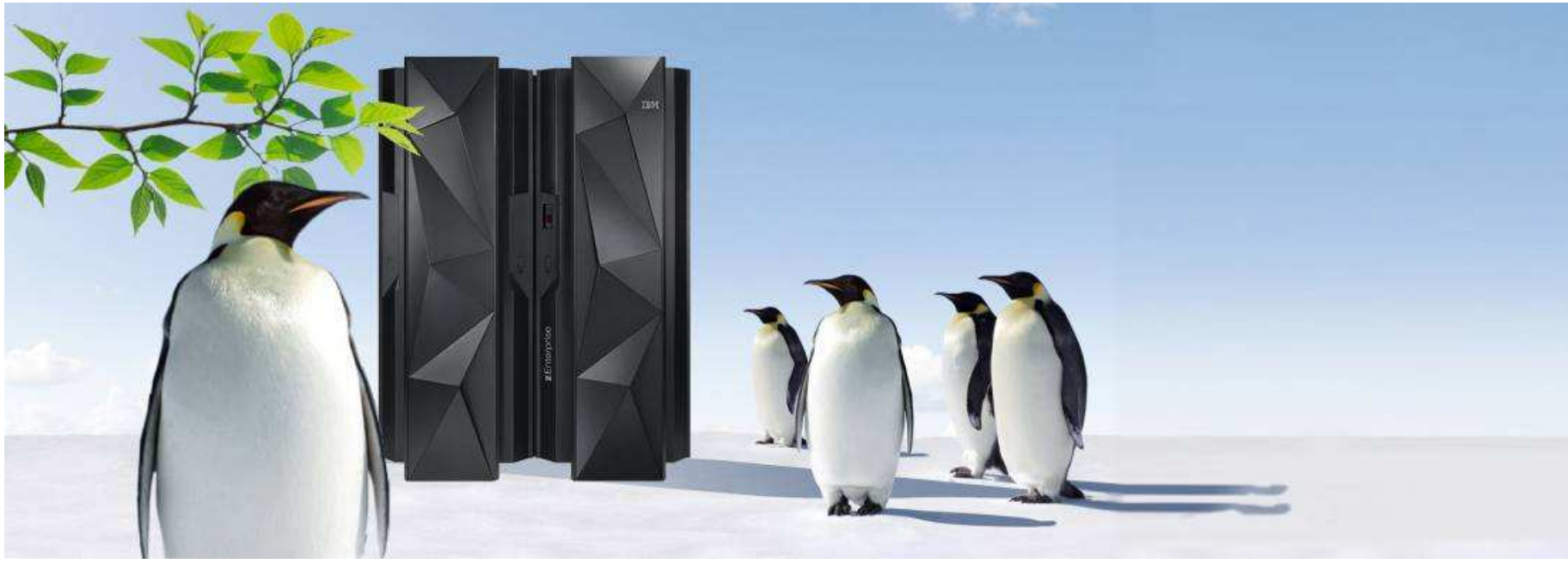
Linux on System z - What's New ?



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Notes:

Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.

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Agenda

- Linux Development
- Distributions
- System z Code News
- Tool-Chain

Linux Trivia

- Kernel 1.0.0 176,250 lines of code
- Kernel 3.3 15,000,000 lines of code in 2012
- 3/4 is driver code
- 3 Billion USD estimated development costs
- 30 CPU architectures with many machine architectures
- 476 of the Top500 systems running Linux (performance 97.4%)
  - and growing
- 1.91% of desktop clients (browser stats)

source: http://en.wikipedia.org/wiki/Linux_kernel
http://www.top500.org
www.w3counter.com

IBM Integration with Linux Community

- Since 1999
- One of the leading contributors
- > 600 full-time developers in Linux and Open Source

Linux Kernel & Subsystem Development

- Kernel Base
- Security
- Systems Mgmt
- Virtualization
- Filesystems
- and more . . .

Expanding the OpenSource Ecosystem

- Apache
- Eclipse
- Firefox
- OpenOffice
- and more . . .

Promoting Open Standards & Community Collaboration

- The Linux Foundation
- Linux Standards Base
- Common Criteria Certification
- and more . . .

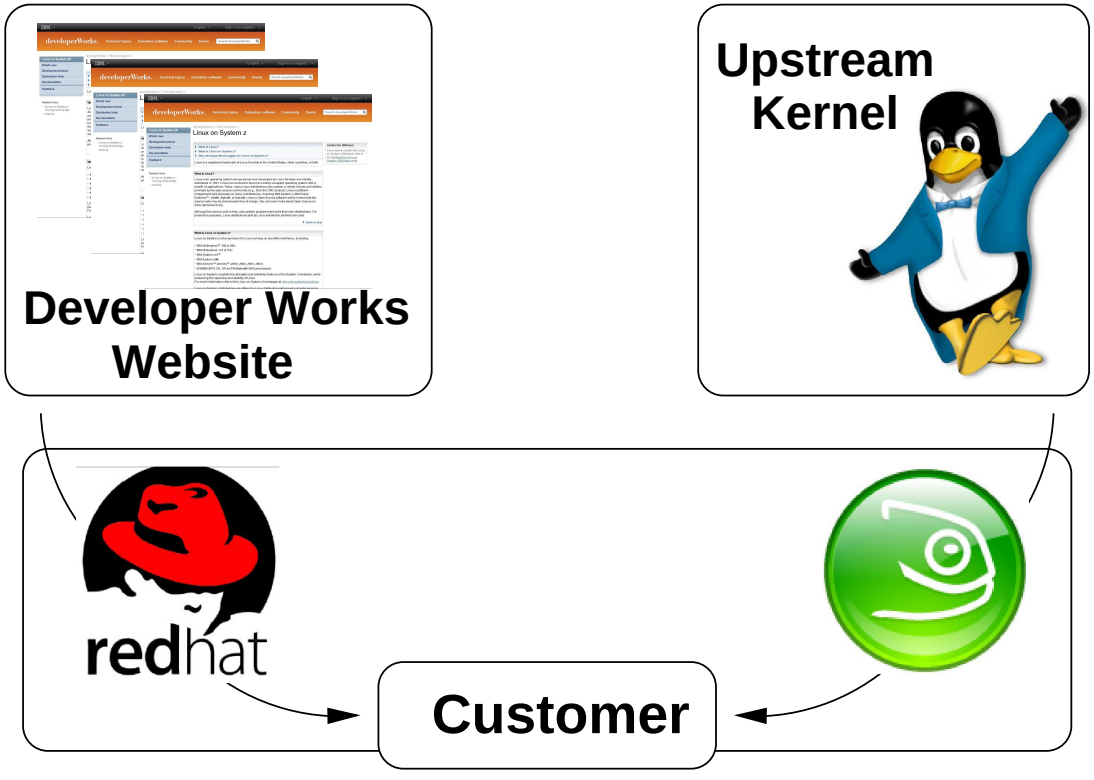
Foster and Protect the Ecosystem

- Software Freedom Law Center
- Free Software Foundation (FSF)
- and more . . .

IBM Linux Development Process

IBM Linux on System z development contributes in the following areas

- kernel
- s390-tools
- Open source tools (e.g. eclipse)
- gcc and glibc
- binutils



Distributions

- SUSE Linux Enterprise Server
  - SLES 10 Service Pack 4 (GA 05/2011) end of regular life cycle
  - SLES 11 (GA 03/2009) kernel 2.6.32 gcc 4.3.3
    - Service Pack 3 (GA 07/2013) kernel 3.0.93
- Red Hat Enterprise Linux
  - RHEL 4 Update 9 (GA 02/2011) end of regular life cycle
  - RHEL 5 Update 9 (GA 01/2013)
  - RHEL 6 (GA 11/2010) kernel 2.6.32 gcc 4.4.7
    - Update 4 (GA 02/2013)
- Others
  - Debian
  - Slackware

Supported Linux Distributions

	zEnterprise EC12 & BC12	zEnterprise z196 & z114	System z10	System z9	zSeries
RHEL 6	✓*	✓	✓	✓	X
RHEL 5	✓*	✓	✓	✓	✓
RHEL 4	X	✓*	✓	✓	✓
SLES 11	✓*	✓	✓	✓	X
SLES 10	✓*	✓	✓	✓	✓
SLES 9	X	✓*	✓	✓	✓

* specific release level recommended or required, some new functions may not be available
see http://www-03.ibm.com/systems/z/os/linux/resources/testedplatforms.html

System z Linux Features - Core

- Enable spinning mutex —  
  - Make use of new common code for adaptive mutexes
  - Add new architecture primitive arch_mutex_cpu_relay to exploit sigp sense running to avoid mutex lock retries if hypervisor has not scheduled the CPU holding the mutex
- Jump label support (3.0) — 
  - Branch optimization for conditions that are rarely toggled e.g. tracepoints
- Two stage dumper - kdump support —  
  - Uses Preloaded crash kernel
  - Either panic triggered or stand-alone
  - Can reduce dump size
  - Can't dump z/VM Named Saved System (NSS)

System z Linux Features - Core

- Allow to compare dump system with boot system
  - z/VM 6.2 allows relocation of guests to other z/VM host systems
  - Provide log of live-guest-relocations in runtime system and dump system for debugging

- Physical memory > 4 TB (kernel 3.3)

- libhugetlbfs support
  - Enables the transparent use of large pages in C/C++ programs
  - Provide large pages of anonymous data

- Transparent huge page support (kernel 3.7)
  - Improve performance in memory intensive applications
  - Reduce number of TLB entries and Page Faults
  - Waste more memory when using

System z Linux Features - Core

- System z hardware counters (kernel 3.4)
  - Counters for running in LPAR
    - basic counter set
    - problem-state counter set
    - crypto-activity
    - counter set,
    - extended counter set with System z10
    - System zEC12 counter (kernel 3.7)
- Compile & disassemble support for zEC12 (kernel 3.8)
  - Add new instructions to the kernel disassembler and allow compiling with -march=zEC12

System z Linux Features - I/O

- End-To-End data consistency checking
  

- Support for hardware data router
  

  - FCP on FICON Express8S
  - Improve performance by reducing path length for data
- Extended DASD statistics
  

  - Add detailed per-device debugging of DASD I/Os via debugfs
  - Useful to analyze problems in particular for PAV and HPF
- Store I/O and initiate logging - SIOSL
  

  - Enhance debug capability for FCP attached devices
  - Enables operating system to detect unusual conditions on a FCP channel

System z Linux Features - I/O

- Safe offline interface for DASD devices (kernel 3.8)
  - Gracefully complete all outstanding I/O requests before a DASD is set offline
- DASD enhancements (kernel 3.11)
  - Add 'timeout' attribute
  - Implement block timeout handling
  - Number of retries configurable

System z Linux Features - Network

- Improved QDIO performance statistics (2.6.33) — 11.2
  - Converts global statistics to per-device statistics and adds adds new counter for the input queue full condition
- QDIO outbound scan algorithm (2.6.38) — 11.2
  - Improve scheduling of QDIO tasklets
  - OSA, HiperSockets and zfcp need different thresholds
- Offload outbound checksumming (2.6.35) — 6.1 — 11.2
  - Move calculation of checksum for non-TSO packets from the driver to the OSA network card
- IPv6 support for the qetharp tool — 6.3 — 11.2
  - Extend the qetharp tool to provide IPv6 information in case of a layer 3 setup
  - Required for communication with z/OS via HiperSockets using IPv6

System z Linux Features - Network

- Support Virtual Ethernet Port Aggregator (VEPA) mode 

  - Send all packages to networking switch to enable external routing
  - Reduce CPU overhead in virtual machine
  - Ensure isolation mode never falls back to non-isolated
  - Check switch supports required configuration modes
- Toleration of optimized latency mode (2.6.35) 

  - OSA devices in optimized latency mode can only serve a small number of stacks / users print a helpful error message if the user limit is reached
  - Linux does not exploit the optimized latency mode
- QETH debugging per single card (2.6.36) 

  - Split some of the global QETH debug areas into separate per-device areas
  - Simplifies debugging for complex multi-homed configurations

System z Linux Features - Network

- Change default standard blkt settings for OSA Express
  

- Add OSA concurrent hardware trap
  

  - For better problem determination the qeth driver requests a hardware trace when the device driver or the hardware detect an error
  - Allows correlation between OSA and Linux traces
- AF_IUCV HiperSockets transport (kernel 3.2)
  

  - Use HiperSockets completion queues to control traffic
- Muliple paths with netiucv between z/VM guests (kernel 3.3)
  - Performance improvement with parallel IUCV paths
- Query OSA address table (kernel 3.4)
  - Diagnostic option by gettting a table of physical and logical device information

System z Linux Features - Crypto

- 4096 bit RSA fast path (kernel 2.6.38) — 11.2
  - Make use of 4096 bit RSA acceleration available with Crypto Express3 GA2 cards
- CPACF exploitation of z196 — 6.2 — 11.2
  - Add support for new crypto modes
    - Cipher feedback mode (CFB)
    - Output feedback mode (OFB)
    - Counter mode (CTR)
    - Galois counter mode (GCM)
    - XEX based Tweaked Code Book with Cipher Text Stealing (XTS),
    - Cipher based message authentication mode (CMAC)
    - Counter with cipher block chaining message authentication (CCM)

System z Linux Features - Crypto

- libica APIs for supported crypto modes — RHEL 6.2, SLES 11.2
  - Programmatic way to query for supported crypto ciphers, modes and key sizes
  - Information wether cryptographic features are implemented in hardware or software
- CPACF Support — RHEL 6.4, SLES 11.3
- Crypto Express4S Support — RHEL 6.4, SLES 11.3
- Support the SHA-256 in the opencryptoki CCA token — SLES 11.3

System z Linux Features - Tools

- Fuzzy live dump — 11.3
  - Dump live system without stopping
  - Possibly some data structures are inconsisent
    - But still useful in most cases
- Extend lscpu and add new chcpu tool — 6.4 — 11.3
  - Display CPU topology and CPU state
  - chcpu can change rescan, change state and dispatching mode of CPUs
- SCSI device management tool (s390-tools 1.14.0) — 11.3
  - Tool analog to chccwdev to enable or disable SCSI LUNs addressed by HBA/target port/LUN
- CMSFS user space filesystem support — 6.1 — 11.2

System z Linux Features - Compiler

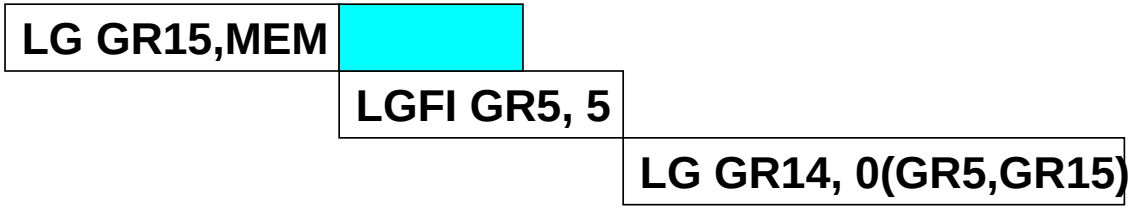
- z196 exploitation
  - gcc 4.6
  - Use new instructions -march=z196
  - Use -mtune=z196 to use out-of-order execution
  - Performance improvements with new instructions - needs recompile
  - Use -mtune=z196 to use out-of-order execution

Out of Order Execution

- Change order of instructions that have no dependencies
  - Use wait time to execute other instructions
- Improves instructions with long latencies, like memory access
- Faster Millicode execution

In Order Execution

Out of Order Execution

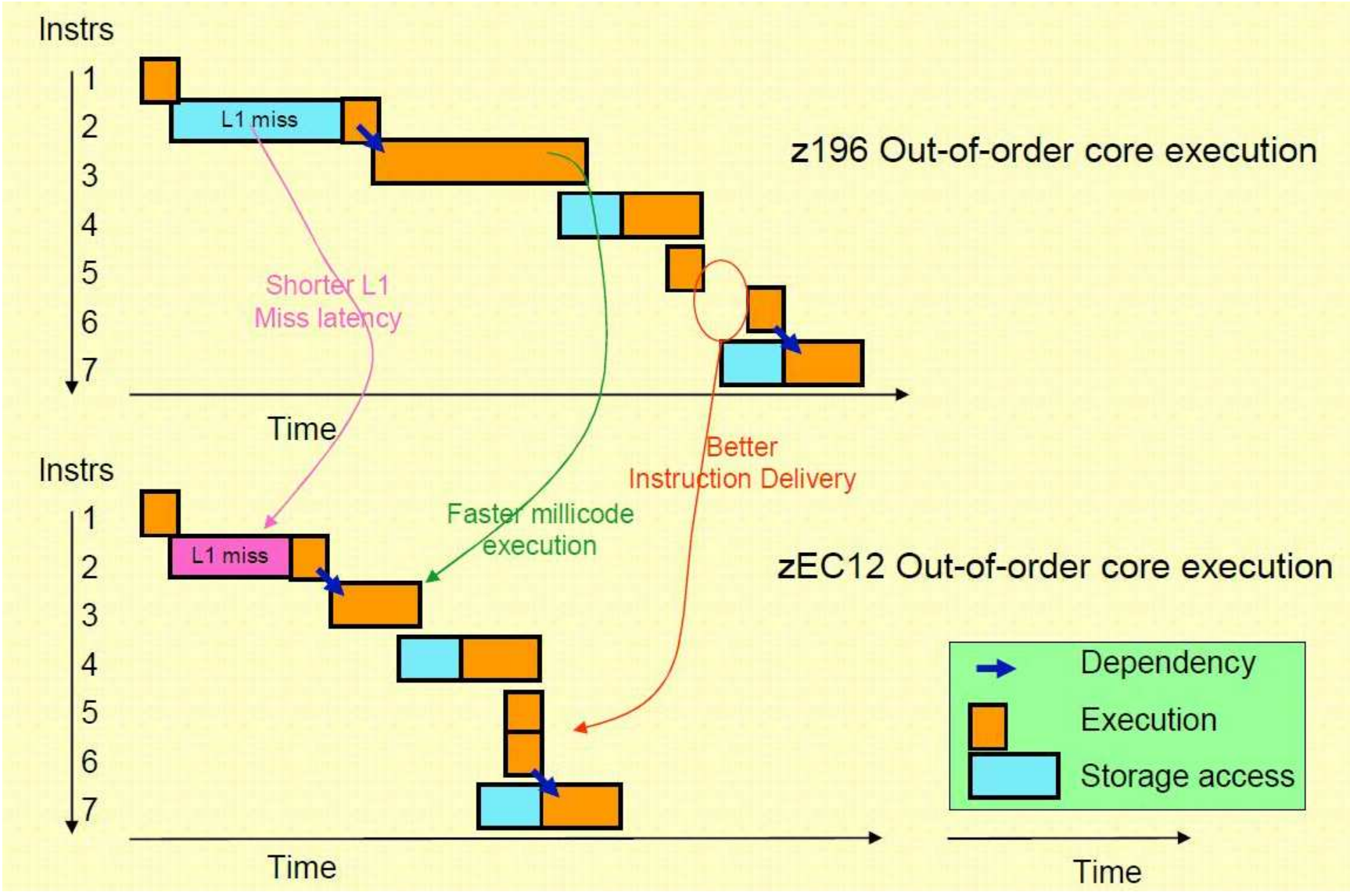


Out of Order Execution

- Instruction Fetch
- Wait for operands
- Dispatch to functional unit
- Execute instruction
- Write back results to register file

- Instruction Fetch
- Dispatch to Instruction Queue
- Wait for operands
- Dispatch to functional unit
- Execute instruction
- Queue Results
- Write back results to register file

Out of Order Execution



System z Linux Features - zEC12 support

- Flash Express  
  - Internal Solid State Disk
  - Up to 4 pairs of cards with max 6.4 TB
  - Concurrent update (kernel 3.8)
- Crypto Express4S  
  - Indicates capabilities through bit field
- Compiler (gcc 4.8)
  - New instructions
  - Optimization for instruction pipeline
- Transactional Execution Facility  
- Runtime instrumentation support  

Transactional Execution

- Also known as transactional memory
- Allows to execute a group of instructions atomically
- Typical pattern
  1. Lock
  2. Short operation
  3. Unlock

```
spin_lock(&list_lock, 0, 1);
list_add(new, &list_head);
spin_unlock(&list_lock, 1, 0);
```

- Use case
  - Speculative execution
  - Avoid locks for code segments
  - Kernel support required for control register setup
- Transaction abort is expensive

Transactional Execution

```
spin_lock(&list_lock, 0, 1);
list_add(new, &list_head);
spin_unlock(&list_lock, 1, 0);
```

Traditional Code

```
# spin_lock
larl %r3,list_lock
lhi %r1,1
lock: lhi %r0,0
cs %r0,%r1,0(%r3)
ltr %r0,%r0
jne lock
# list_add
larl %r4,list_head
lg %r5,0(%r4)
stg %r4,0(%r2)
stg %r5,8(%r2)
stg %r2,0(%r5)
stg %r2,8(%r4)
# spin_unlock
cs %r1,%r0,0(%r3)
br %r14 br %r14
```

Transaction Execution Code

```
# begin transaction
tbeginc 0,0




# list_add
larl %r4,list_head
lg %r5,0(%r4)
stg %r4,0(%r2)
stg %r5,8(%r2)
stg %r2,0(%r5)
stg %r2,8(%r4)
# end transaction
tend
br %r14
```

Changes Kernel 3.8

- Automatic NUMA balancing
  - New NUMA foundation
  - Allows for different NUMA placement policies
- ext4
  - Embed very small files in the inode
- btrfs
  - Fast device replacement
- Remove support for i386 processors

Changes Kernel 3.9

- SSD cache devices
  - Device mapper target dm-cache allows to use SSD as cache for spinning disk
- rwsem-spinlock
  - Implement writer lock-stealing for better scalability
- sched
  - Add a tuning knob to allow changing SCHED_RR timeslice
- softirq
  - Reduce latencies

Changes Kernel 3.9

- btrfs
  - Add a new ioctl to get the label of a mounted file system (commit) and set/change it
  - Add cancellation points to defrag
  - Implement unlocked direct-io write
  - Reduce CPU contention while waiting for delayed extent operations
  - Reduce lock contention on extent buffer locks
- ext4
  - Add punching hole support for non-extent-mapped files
  - Track the delay between when we first request that the commit begin and when it actually begins, so we can see how much of a gap exists

Changes Kernel 3.10

- Timerless multitasking
- Btrfs
  - smaller, more space-efficient extent tree
- mutex locking scalability improvements
  - reduce cache line contention
- TCP optimization: Tail loss probe
  - Reduce latency of short transactions
  - Use fast recovery instead of waiting for retransmission timeout
- Implement NUMA affinity for unbound workqueues

Changes Kernel 3.11

- Preliminary support for NFS 4.2 and SELinux Labeled NFS
  - Parallel NFS (pNFS)
  - Server Side Copy (SSC)
- Detailed tracking of which pages a task writes
  - For checkpoint-restore
  - Could be used for statistics and profiling
- Low latency network polling
  - A socket can request a shorter polling interval
- Add support for wound/wait style locks
  - Release a group of locks to avoid lock contention

s390-tools

- A package with a set of user space utilities to be used with the Linux on System z distributions.
- THE essential tool chain for Linux on System z
- Contains everything from the boot loader to dump related tools for a system crash analysis .
- Contained in all major (and IBM supported) Enterprise Linux distributions which support s390
- RedHat Enterprise Linux
- SUSE Linux Enterprise Server
- Website: http://www.ibm.com/developerworks/linux/linux390/s390-tools.html
- Feedback: linux390@de.ibm.com

s390-tools

chccwdev chchp chreipl chshut chcrypt chmem	CHANGE
lscss lschp lsdasd lsluns lsqeth lsreipl lsshut lstape lszcrypt lszfcp lsmem	DISPLAY
dasdfmt dasdinfo dasdstat dasdview fdasd tunedasd	DASD
mon_fsstatd mon_procd ziomon hyptop	MONITOR
ip_watcher osasnmpd qetharp qethconf	NETWORK
tape390_display tape390_crypt	TAPE
dbginfo dumpconf zfcpdump zfcpdbf zgetdump scsi_logging_level	DEBUG
vmconvert vmcp vmur cms-fuse	z/VM
cpuplugd iucvconn iucvtty ts-shell ttyrun	MISC
zipl	BOOT

s390-tools

- Dump on panic - prevent reIPL loop (1.8.4)
  - Delay arming of automatic reIPL after dump
  - Avoids dump loops where the restarted system crashes immediately
- Automatic menu support in zipl (1.11.0)
  - zipl option to create a boot menu for all eligible non-menu sections in zipl.conf
- re-IPL from device-mapper devices (1.12.0)
  - Automatic reIPL function only works with a physical device
  - Enhance the zipl support for device-mapper devices to provide the name of the physical device if the zipl target is located on a logical device
- Configuration tool for System z network devices (1.8.4)
  - Provide a shell script to ease configuration of System z network devices

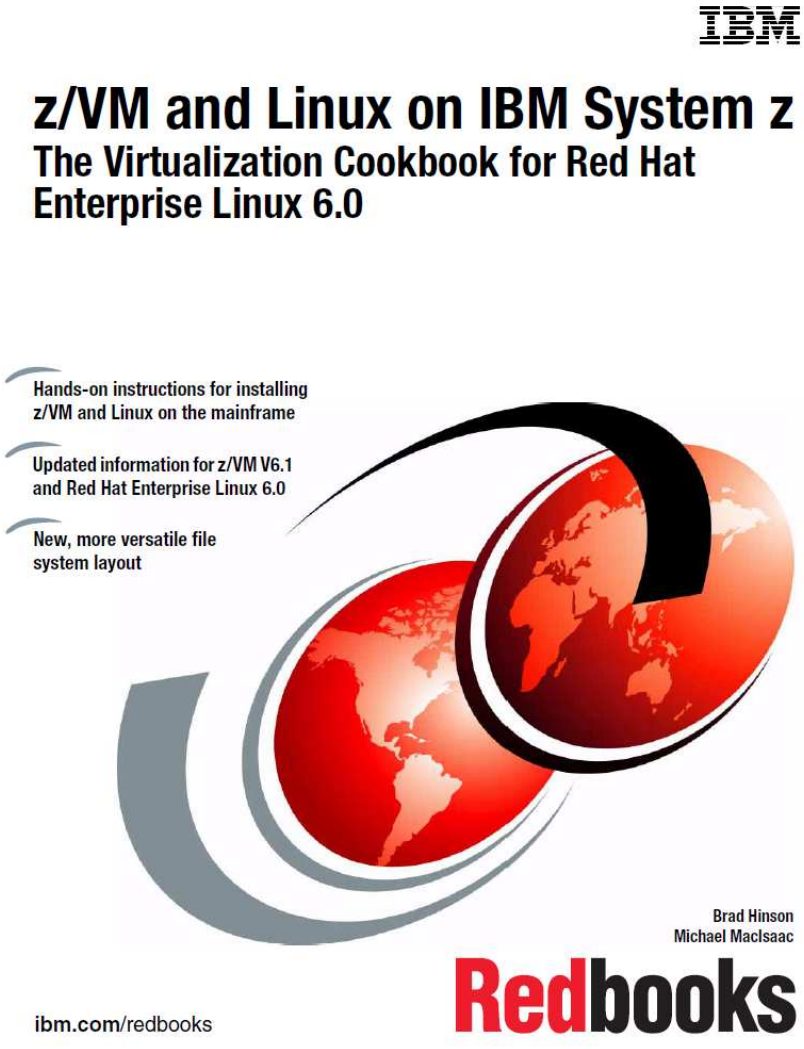
s390-tools

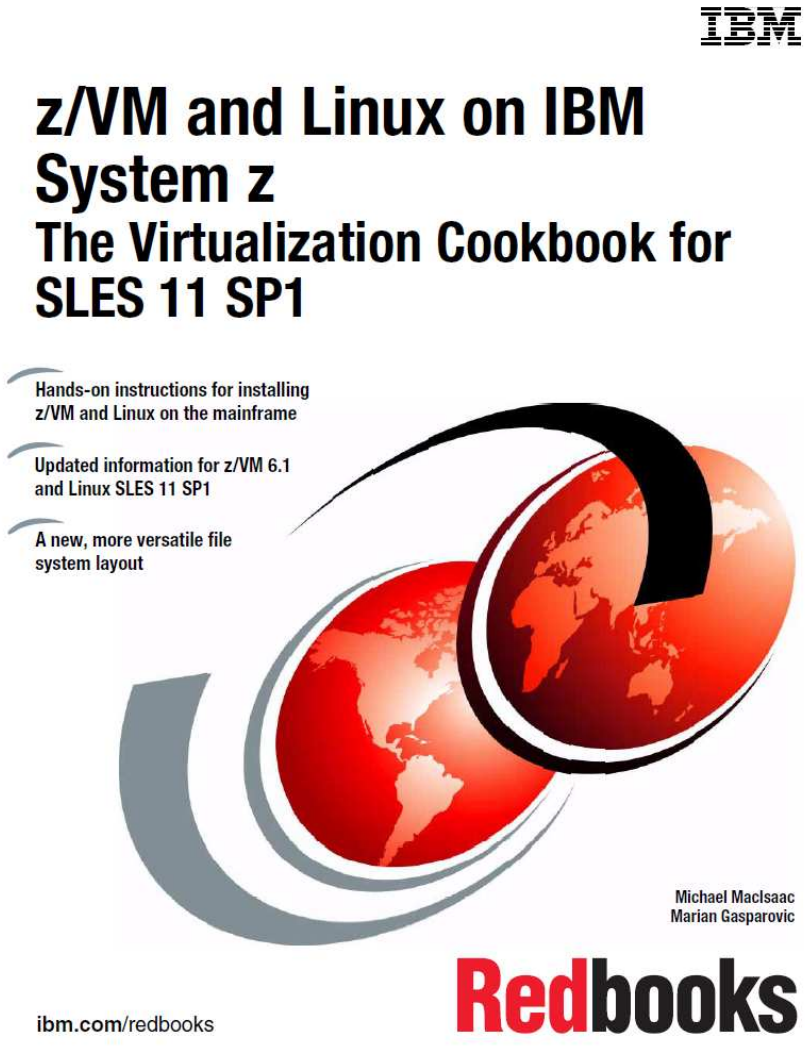
- Safe offline feature for DASD devices (1.21.0)
- Add Flash Express support to lscss (1.20.0)
- Live Dump support for zgetdump (1.19.0)
  - Use /dev/mem as source dump
  - creation of live dumps in all supported target formats
- Queury OSA address table with qethqoat (1.18.0)
  - Display physical and logical device information
- Support for stand-alone kdump (1.18.0)
- Support for AF_IUCV Completion Queue (1.17.0)
  - New hsuid attribute for lsqeth

LNXHC - Linux Health Checker

- Command line tool for Linux.
- To identify potential problems before they impact your system performance, availability or cause outages.
- Collect and compare the active Linux settings and system status with the values provided by health-check authors or defined by the customer
- Produces detailed messages, which describe potential problems and the suggests solutions
- Can be easily extended by writing new health check plug-ins
- The Linux Health Checker is an open source project sponsored by IBM. It is released under the Eclipse Public License v1.0. http://lnxhc.sourceforge.net
- **BUT:** it's not a one size fits all tool ! to be really useful it needs configuration using a system profile

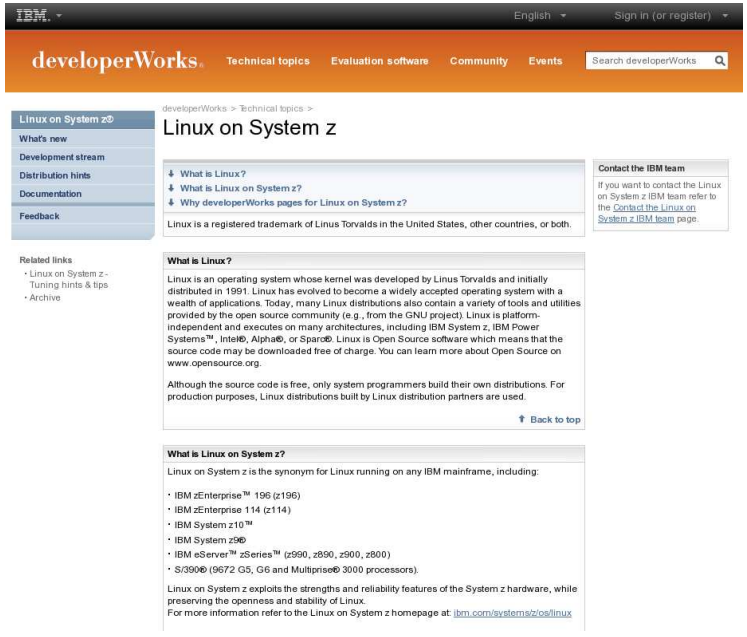
RedBooks





Links

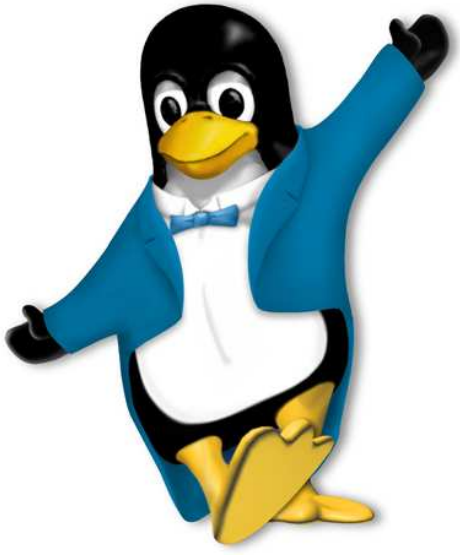
- developerWorks
  `http://www.ibm.com/developerworks/linux/linux390`
- Resources for Linux on System z
  `http://www-03.ibm.com/systems/z/os/linux/resources/index.html`
- IBM Redbooks
  `http://www.redbooks.ibm.com`



Thank You !

- Martin Schwidefsky
- Einar Lueck

Questions ?



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