Linux on System z - What’s New?

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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
- Filesystem
- 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

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* 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](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
- Native PCI feature cards (kernel 3.8)
  - Support for native PCIe adapters visible to the operating system
PCI Express

- Native PCIe feature cards introduced on zEC12 and zBC12
  - 10GbE RoCE Express, network card for SMC-R
  - zEDC Express, data compression/decompression card
- Native PCIe adapter concept
  - Plugged into an PCIe I/O drawer
  - Managed by an internal firmware processor (IFP)
  - Device driver for the PCIe function is located in the operating system
- Uses standard Linux PCI support and drivers with some constraints
  - Only MSIX, no port I/O, memory mapped I/O by use of PCI load/store instructions
  - Provides ability to assign individual functions of an adapter to an LPAR
  - Converted System z architecture code to use generic hardirqs
  - Only selected PCIe adapters are known to the IFP and surfaced to the OS
10GbE RoCE Express

- Native PCIe networking card
  - 10 Gigabit remote direct memory access (RDMA) capable network card
  - Uses Infiniband RDMA over Converged Ethernet (RoCE) specification
  - Up to 16 10GbE RoCE Express adapters per machine
  - Reduced latency and lower CPU overhead
  - Supports point-to-point connections and switch connection with an enterprise-class 10 GbE switch

- Software support
  - z/OS V2R1 with PTFs supports SMC-R with RoCE
  - z/VM support planned
  - Linux support in principle available but not available in any distribution yet
**zEDC Express**

- Native PCIe data compression / decompression card
  - Up to 8 adapters can be installed into a single machine
  - With large blocks, it can compress data at more than 1 GB per second
  - Implements compression as defined by RFC1951 (DEFLATE)
  - Comparable to gzip -1
- Software support
  - z/OS V2R1, V1R13 and V1R12 with PTFs
  - The zlib open source library is a C implementation commonly used to provide compression and decompression services
System z Linux Features - Network

- Improved QDIO performance statistics (2.6.33)
  - Converts global statistics to per-device statistics and adds a new counter for the input queue full condition

- QDIO outbound scan algorithm (2.6.38)
  - Improve scheduling of QDIO tasklets
  - OSA, HiperSockets and zfcp need different thresholds

- Offload outbound checksumming (2.6.35)
  - Move calculation of checksum for non-TSO packets from the driver to the OSA network card

- IPv6 support for the qetharp tool
  - 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
  [11.3]

- Add OSA concurrent hardware trap
  [6.3] [11.2]
  - 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)
  [6.2] [11.2]
  - Use HiperSockets completion queues to control traffic

- Multiple 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 getting a table of physical and logical device information
System z Linux Features - Crypto

- 4096 bit RSA fast path (kernel 2.6.38)
  - Make use of 4096 bit RSA acceleration available with Crypto Express3 GA2 cards

- CPACF exploitation of z196
  - 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
  - Programmatic way to query for supported crypto ciphers, modes and key sizes
  - Information wether cryptographic features are implemented in hardware or software

- CPACF Support

- Crypto Express4S Support

- Support the SHA-256 in the opencryptoki CCA token
System z Linux Features - Tools

- Fuzzy live dump
  - Dump live system without stopping
  - Possibly some data structures are inconsistent
    - But still useful in most cases

- Extend lscpu and add new chcpu tool
  - 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)
  - Tool analog to chccwdev to enable or disable SCSI LUNs addressed by HBA/target port/LUN

- CMSFS user space filesystem support
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

\[
\begin{align*}
\text{LG GR15, MEM} & \quad \text{LGFI GR5, 5} \\
\text{LG GR14, 0(GR5,GR15)} & \\
\end{align*}
\]

Out of Order Execution

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\end{align*}
\]
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

z196 Out-of-order core execution

zEC12 Out-of-order core execution

- Shorter L1 Miss latency
- Faster millicode execution
- Better Instruction Delivery
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

- Runtime instrumentation support
System z Linux Features - zEC12 support

- Transactional Execution Facility
  - Also known as hardware transactional memory
  - CPU features that allows to execute a group of instructions atomically
  - Optimistic execution, if a transaction conflicts a rollback to a saved state is done
**Transactional Execution**

- **Typical pattern**
  1. Lock
  2. Short operation
  3. Unlock

- **Use case**
  - Speculative execution
  - Avoid locks for code segments
  - Kernel support required for control register setup

- **Transaction abort is expensive**

```c
spin_lock(&list_lock, 0, 1);
list_add(new, &list_head);
spin_unlock(&list_lock, 1, 0);
```
### Transactional Execution

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

#### Traditional Code

```c
# spin_lock
larl %r3, list_lock
lhi %r1, 1
lock: lhi %r0, 0
cs %r0, %r1, 0(%r3)
lt %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

```c
# 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
```
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
- Feedback: linux390@de.ibm.com
### s390-tools

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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 ls-css (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
- Query 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
Common Kernel News

- **btrfs**
  - Reduce CPU contention while waiting for delayed extent operations (3.9)
  - Reduce lock contention on extent buffer locks (3.9)
  - Smaller, more space-efficient extent tree (3.10)
  - Offline data deduplication support in btrfs (3.12)

- **ext4**
  - Add punching hole support for non-extent-mapped files (3.9)

- **NFS**
  - Parallel NFS (pNFS)
  - NFS Server Side Copy (SSC)
Common Kernel News

- **Locking**
  - Implement writer lock-stealing for better scalability (3.9)
  - Add support for wound/wait style locks (3.10)
  - Mutex locking scalability improvements (3.10)
  - Improved locking performance for virtualized guests (3.12)
  - New lockref locking scheme, VFS locking improvements (3.12)
  - Improved tty layer locking (3.12)
  - IPC locking improvements (3.12)

- **Multiprocessor and Virtualization**
  - Add a tuning knob to allow changing SCHED_RR timeslice (3.9)
  - Implement NUMA affinity for unbound workqueues (3.10)
  - Timerless multitasking (3.10)
Common Kernel News

- TCP optimization: Tail loss probe (3.10)
- Better Out-Of-Memory handling (3.12)
- Device mapper target dm-cache allows to use SSD as cache for spinning disk (3.9)
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 Schwiebelsky
- Einar Lueck
Questions?

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