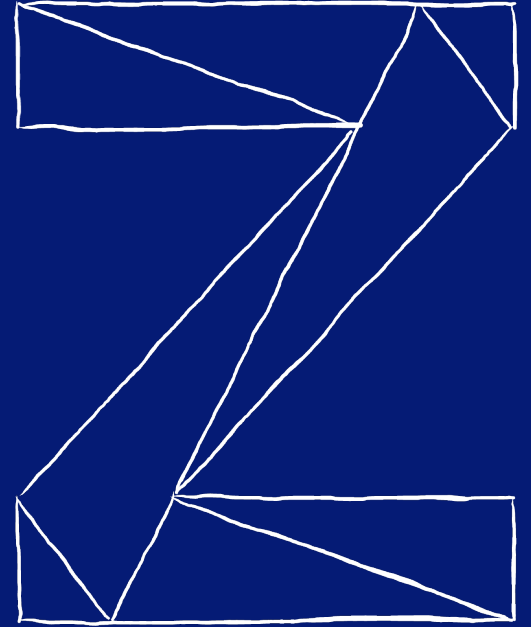# Linux on IBM Z and LinuxONE: What's New

—

Stefan Raspl
IBM Research & Development Germany

VM Workshop, June 2021

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CICS*	EASY Tier	IMS	OMEGAMON*	PureSystems	Storwize*	Tivoli*	z10 EC	
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Agenda

- Linux on Z Distributions

- IBM z15 and LinuxONE III

- Latest Linux on Z Features & Packages

Linux on Z Distributions

Linux Distributions & Hardware Certification

	z15	z14 (all models)	z13	z13s	zEnterprise – zEC12, zBC12	zEnterprise – z196, z114
	LinuxONE III	Emperor II Rockhopper II	Emperor	Rockhopper		
RHEL 8	●	●	●	●		
RHEL 7	●	●	●	●	●	●
RHEL 6	●	●	●	●	●	●
RHEL 5			●		●	●
SLES 15	●	●		●	●	
SLES 12	●	●	●	●	●	●
SLES 11		●	●	●	●	●
Ubuntu 20.04	●	●	●	●		
Ubuntu 18.04	●	●	●	●	●	
Ubuntu 16.04	●	●	●	●	●	

Last update 22/03/2021

See www.ibm.com/systems/z/os/linux/resources/testedplatforms.html for latest updates and details, including **certified Linux distributions by machine**.

Linux on IBM Z Distributions: SUSE

- **SUSE Linux Enterprise Server 15**

  - 07/2018 SLES 15 GA: Kernel 4.12, GCC 7.1 / 7.3

  - 07/2020 SLES 15 SP2: Kernel 5.3. GCC 7.5 / 9.3

    - EOS 31 July 2028; LTSS: 31 July 2031

But don't forget:
**Keep it current,
apply maintweb
updates!!!**

- **SUSE Linux Enterprise Server 12**

  - 10/2014 SLES 12 GA: Kernel 3.12, GCC 4.8

  - 12/2019 SLES 12 SP5: Kernel 4.12, GCC 4.8

    - EOS 31 Oct. 2024; LTSS: 31 Oct 2027

- **SUSE Linux Enterprise Server 11**

  - 03/2009 SLES 11 GA: Kernel 2.6.27, GCC 4.3.3

  - 07/2015 SLES 11 SP4: Kernel 3.0, GCC 4.3.4

    - ~~EOS 31 Mar. 2019~~; LTSS: 31 March 2022

- **Lifecycle Details**
  https://www.suse.com/en-en/lifecycle/

Linux on IBM Z Distributions: Red Hat

- **Red Hat Enterprise Linux 8**

    - 05/2019 RHEL 8 GA: Kernel 4.18, GCC 8.2.1

    - 05/2021 RHEL 8.4

    - EOS: May 2029; ELS: tbd

- **Red Hat Enterprise Linux 7**

    - 06/2014 RHEL 7 GA: Kernel 3.10, GCC 4.8

    - 09/2020 RHEL 7.9

    - EOS 30 June 2024; ELS: tbd

- **Red Hat Enterprise Linux 6**

    - 11/2010 RHEL 6 GA: Kernel 2.6.32, GCC 4.4.0

    - 06/2018 RHEL 6.10

    - ~~EOS 30 Nov. 2020~~; ELS: 30 June 2024

- **Lifecycle Details**
  https://access.redhat.com/support/policy/updates/errata

But don't forget:
**Keep it current,
apply z-Stream
updates!!!**

Linux on IBM Z Distributions: Canonical

- **Ubuntu 20.04 (Focal Fossa)**

  – 04/2020 GA: Kernel 5.4, GCC 9.3.0, LTS-Release

  – 08/2020 Ubuntu 20.04.1:

  – EOS: April 2025; ESM: Apr 2030

- Ubuntu 21.04 (Hirsute Hippo)

  – 04/2021 GA: Kernel 5.11, GCC 10.3

  – EOS: January 2022

But don't forget:
**Keep it current,
apply SRU
updates!!!**

- **Ubuntu 18.04 (Bionic Beaver)**

  – 04/2018 GA: Kernel 4.15, GCC 7.2.0, LTS-Release

  – 08/2019 Ubuntu 18.04.3
    Kernel 4.15/4.18 GCC 7.2.0

  – EOS: April 2023; ESM: April 2028

- **Ubuntu 16.04 (Xenial Xerus)**

  – 04/2016 GA: Kernel 4.4, GCC 5.3.0+, LTS-Release

  – 02/2019 Ubuntu 16.04.06 LTS

  – ~~EOS: April 2021~~; ESM: April 2024

- **Lifecycle**

  – Regular releases every 6 months, supported for 9 months

  – LTS releases every 2 years, supported for 5 years

  – LTS enablement stack provides newer kernels

  – http://www.ubuntu.com/info/release-end-of-life

IBM z15 & LinuxONE III

IBM z15
Machine Type: 8561
Model T01

IBM LinuxONE III
Machine Type: 8561
Model LT1

IBM z15
IBM LinuxONE III

IBM z15 Overview

- 19" industry standard form factor
- New on-chip compression acceleration

1 core

- 14nm SOI technology
- 17 layers of metal
- 5.2 GHz

as IBM z14

- **12 cores per CP-chip**
- **Increased cache sizes:**
  - **2x L2 on-chip**
  - **1.4x L4**
- **14% single thread performance improvement**
- **40TB max memory**
- **190 usable cores**

NEW

IBM z15 Single Frame Offerings

IBM z15
Machine Type: 8562
Model T02

IBM LinuxONE III
Machine Type: 8562
Model LT2

Processor
- Up to 6 cores for CP and up to 65 IFLs
- **14%** Single Thread Performance Improvement
- **14%** maximum system capacity growth over z14 ZR1
- 19" frame with 8U or 16U Reserved Space
- New on-chip functions – Integrated Accelerator for zEDC – for more efficient storage of data

Memory
- Up to 2X more RAIM Memory - 16 TB Max Per System

To the Data
- **Faster** SSL/TLS handshake performance on T02 with Crypto Express7S compared to z14 ZR1 with Crypto Express6S

IBM z15 Toleration Support:
Linux Distros and z/VM (Minimum Versions)

- **Linux Distributions**
  - Red Hat Enterprise Linux 8.0 (z stream if needed)
  - Red Hat Enterprise Linux 7.7.z
  - Red Hat Enterprise Linux 6.10.z

  - SUSE Linux Enterprise Server 15 SP1
    (maintweb if needed)
  - SUSE Linux Enterprise Server 12 SP4 maintweb

  - Canonical Ubuntu 18.04 LTS
  - Canonical Ubuntu16.04 LTS

- **z/VM Hypervisor**
  - z/VM 7.1

Install z15 with the Linux environment you use today!

Latest Linux on Z Features & Packages

IBM z15 Support: New Vector Instructions

- Reported with new feature flags in `/proc/cpuinfo`
  - `vxp`
  - `vxe2`

- Examples for use of new vector instructions:
  - Vector alignment hints
  - Vector Byte and element swaps
  - Vector substring search in `strstr()` and `memmem()`

- Exploited (among others) in
  - GCC 9.1
  - glibc 2.30
  - LLVM 9.0.0

IBM z15 Support: Deflate

- Data compress and uncompress through new instruction

- Compression equivalent to `gzip -1`

  `-1` is fastest, `-9` slowest, default is `-6`

- Can be exploited e.g. by `zlib`, `gzip`, Java et al

- Compress data with zlib on IBM z15 with
  4 processors up to 42x faster as compared to
  software compression

- Enabled for the **default compression level** starting with
  RHEL 8.4, SLES 15 SP3, and Ubuntu 20.10

- Linux enablement:

  - Java: Use Java 8 SR6 FP16 on any Linux distribution

  - Reported with new feature flag in `/proc/cpuinfo`: `dflt`

  - Use env variable `DFLTCC_LEVEL_MASK` to enable for arbitrary compression levels

  - See here for further details on usage

Compression Time w/ 4 IFLs

E.coli	bible.txt	world192.txt	Canterbury.tar
33.9x	30.3x	24x	42x

Source data file

■ minigzip -1 w/ software compression
■ minigzip -1 w/ Integrated Accelerator for zEDC
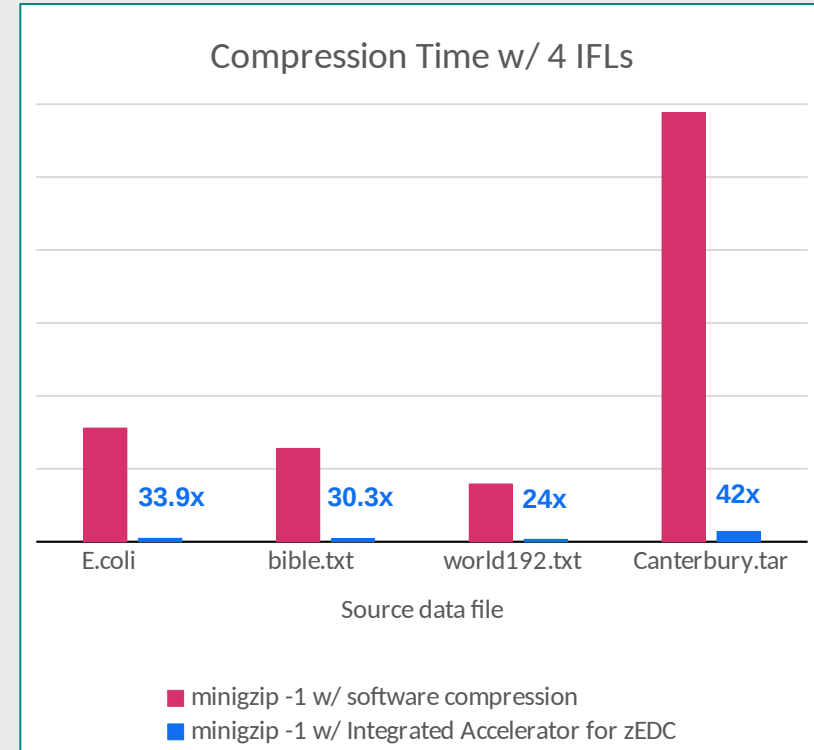
IBM z15 Support: CPACF

- New Message Security Assist MSA9 for *Elliptic Curve Cryptography* (ECC)
- Supports
  - message authentication
  - generation of elliptic curve keys
  - scalar multiplication
- Used with SSL/TLS protocol
  - securing client-server network connection
  - handshake establishes the secure connection
- TLS v1.2 and v1.3 support ECDH (key exchange) and ECDSA (signature)
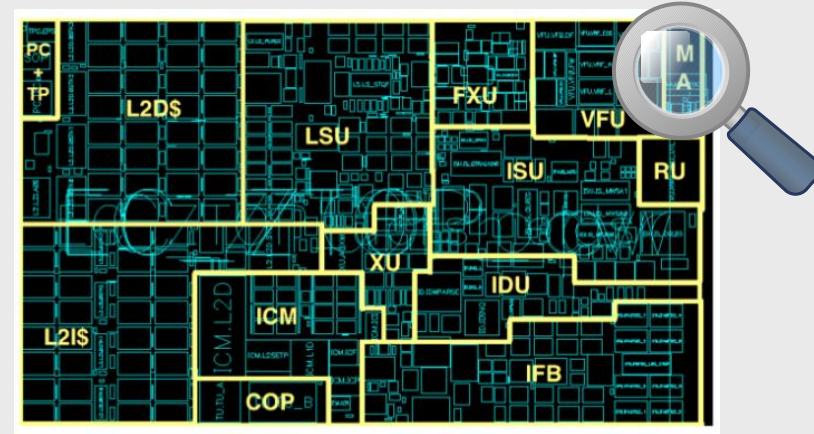
z15 Processor Unit

- Supported curves:
  - ECDSA (sign/verify) P256, P384, P521 Ed 25519, Ed448
  - ECDH (key exchange) P256, P384, P521, X25519, X448
- **Performance**
  - Up to **20x key exchange** operations
  - Up to **38x sign** operations
  - Up to **10x verify** operations

IBM z15 Support: Secure Boot for SCSI IPL

- Ensure that only code is loaded during IPL that is
  - signed by a trusted distribution vendor (currently: Red Hat, SUSE or Canonical)
  - unmodified

- Kernel image and `zipl` boot record must be signed

- `zipl` tool creates signature entries for SCSI IPL

- New switch on HMC enables secure boot

- Firmware checks signatures and stops IPL on mismatch

- `/sys/firmware/ipl/has_secure` indicates support

- `/sys/firmware/ipl/secure` indicates IPL using secure boot

- zipl option `secure="auto/0/1"`
  - `0`   disable secure boot
  - `1`   enforce secure boot
  - `auto`   enable secure boot if system supports it and image/stage3 signed

- Support available in
  - Linux kernel 5.3

IBM LinuxONE support for NVMe drives

- **IBM Adapter for NVMe**
  - Carrier card for industry standard U.2 NVMe drives
    - Common capacities up to 16 TB per drive
    - 1 drive per carrier, up to 16 cards per CEC
  - Available for IBM LinuxONE starting with Emperor II and Rockhopper II

FC 0435
IBM Adapter for NVMe

adapter card — NVMe SSD
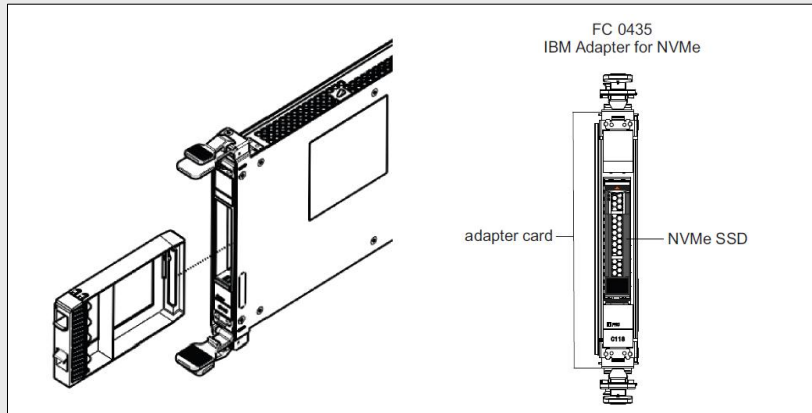
- **NVMe drive characteristics**
  - Low-cost, low-latency, high-throughput storage
  - PCI direct-attached (no SAN)
    - No cabling, switches, etc. required
  - No virtualization or shared access: can use one drive only in one LPAR/VM

- **Linux on Z support for NVMe** (18.04) (7.8) (8.0) (12 SP4) (15)
  - Uses standard Linux NVMe driver
  - Always apply latest service levels!

Working with NVMe drives in Linux

- **Listing available devices**

  - Use `lspci` to show PCI device information

  - Use `lsblk` to list NVMe block devices:

  ```
  $ lsblk
  NAME          MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
  nvme0n1       259:0    0  3.6T  0 disk
  ├─nvme0n1p1 259:1    0  300M  0 part
  ├─nvme0n1p2 259:2    0   40G  0 part
  ├─nvme0n1p3 259:3    0  3.6T  0 part
  └─nvme0n1p4 259:4    0    2G  0 part
  ```

- **Storing data**

  - Use NVMe for swap, root, boot* and data file systems (*=requires IPL support)

  - Use of software RAID recommended

- **Management tools**

  - `nvme-cli`: query and manage NVMe device functions

  - `zpcictl`: recovery and service actions

- **IPL support**   20.04 8.3 LPAR

  - Available on LinuxONE III with latest firmware

    - LPAR only

  - NVMe IPL support added with

    - Linux kernel v5.8

    - s390-tools v2.14

  - Distribution installer support available

- **What it does**: Provides read-only access to z/OS data sets on DASD

- **Why you should care**:
  - Transfer speed closer to FICON limits
  - No CPU cycles spent in z/OS during data transfer

- **Latest Improvements**

  - **Robustness**
    - Use storage mechanisms to prevent concurrent access
    - Get an updated dataset list without need to unmount/mount DASDs

  - **Coordinated read access**   20.04 8.4
    - Establish authorization checking and audit capabilities
    - DASD no longer required offline in z/OS during Linux access

  - **Transparent dataset conversion (*upcoming*)**
    - Read EBCDIC encoded datasets as ASCII without any add'l codepage conversion required
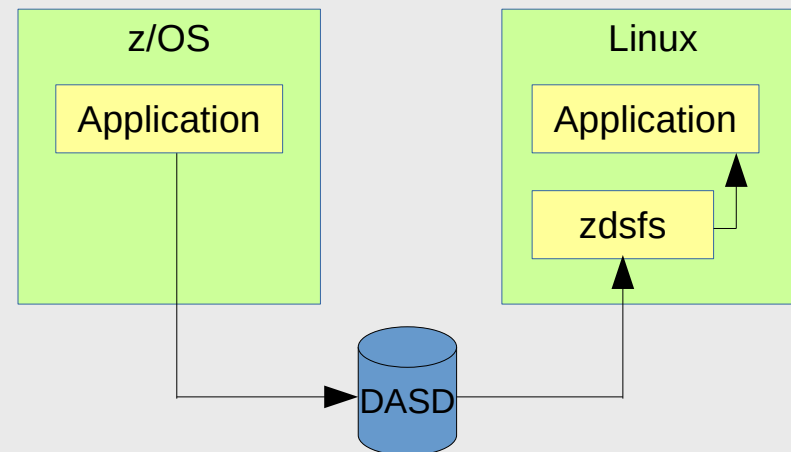
Fig.1: *Architecture overview*

z/OS — Application
Linux — Application — zdsfs
DASD

```
$ zdsfs /dev/disk/by-path/ccw-0.0.edc0 /mnt/
Using z/OSMF REST services on https://192.168.1.1/zosmf/

$ cat /mnt/HABERL.ZDSFSDV.LARGE.TEST2
[...]

$ fusermount -u /mnt
```

Fig.1: *Usage example*

SMC-Dv2

- **Recap:**
  - **SMC-Dv1** provides intra-CEC acceleration for TCP traffic using Internal Shared Memory (ISM) devices
  - Superior performance (low latency, high throughput) at reduced CPU consumption
  - *However*:
    - Peers must be in **same IP subnet**
    - Devices need to be **paired using PNET IDs**

- **SMC-Dv2**
  - Peers can be in *any* IP subnet
  - **No PNET IDs required**
   ⇒ Simplified configuration
  - Requires z15 or LinuxONE III
  - Support available in Linux kernel 5.10

Peer A — SMC-Dv1
Peer B — SMC-Dv1
178.17.0.0/16
Peer C
192.168.0.0/16

Peer A — SMC-Dv2
Peer B — SMC-Dv2
178.17.0.0/16
Peer C — SMC-Dv2
192.168.0.0/16
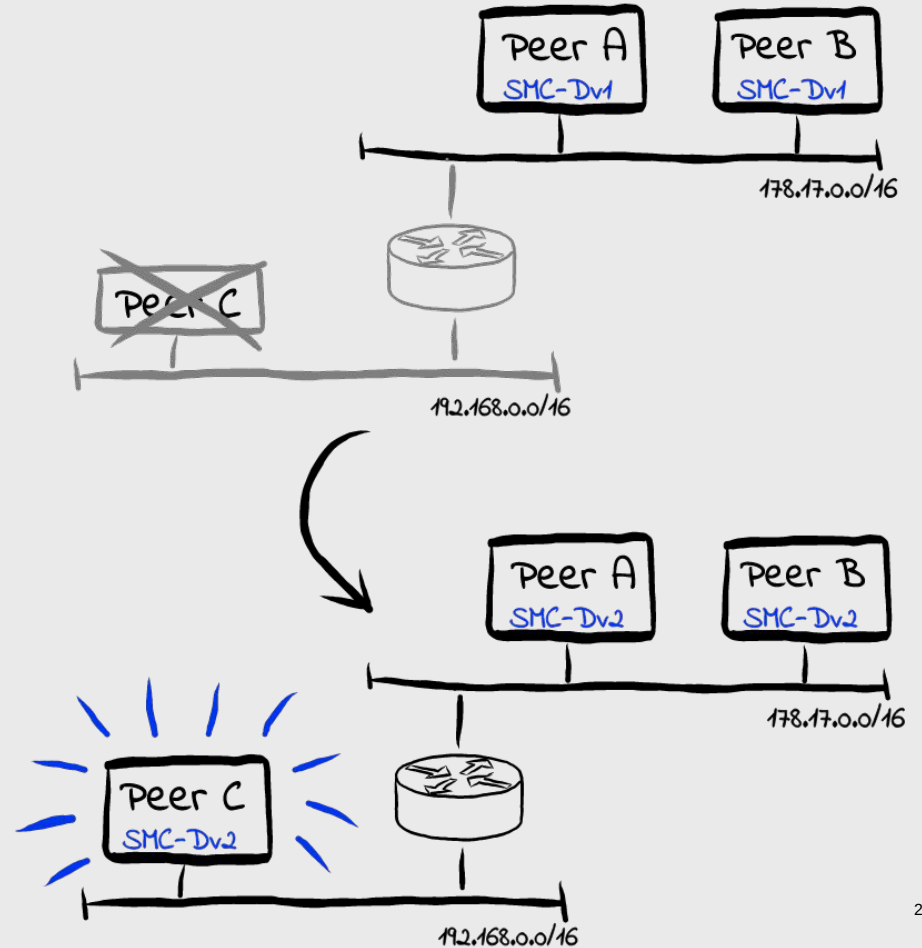
SMC-R / smc-tools

SMC-R Link Group Support

(LPAR) (z/VM) (20.10) (8.3)

- Transparently moves connections between links in link group upon link failure - think channel bonding for SMC-R
- Compatible to z/OS
- Reference Architecture:
  - 2x OSA for IP connectivity
  - 2x RoCE for RDMA
- Support available in Linux kernel 5.8
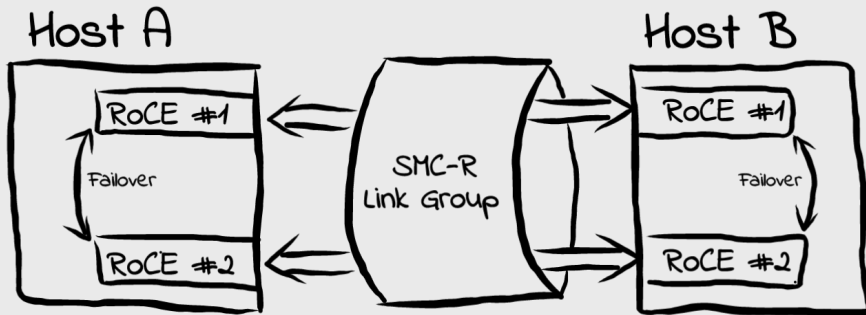
smc-tools v1.5

- Utilities in support of SMC-R and SMC-D
- Latest additions:
  - New tools `smcd`/`smcr`, e.g

```
$ smcd info
  Kernel Capabilities
  SMC Version:       2.0
  SMC Hostname:      tux
  SMC-D Features:    v1 v2
  SMC-R Features:    v1

  Hardware Capabilities
  SEID:                IBM-SYSZ-ISMSEID0000...
  ISM:                 v1 v2
  RoCE:                v1
```

  - New tool `smc_chk` to verify setup/peer capabilities

```
$ smc_chk -C 192.168.2.95 -p 23
  Live test (SMC-D and SMC-R)
    Failed  (TCP fallback), reasons:
      Client:  0x03010000  Peer does
                            not support SMC
```

HiperSockets Converged Interface

- Forms a **single logical LAN segment** across
  - external LAN, and
  - HiperSockets
- I.e. one IP to rule them all!
- **The best of both worlds**: Prefer HiperSockets over external LAN, taking advantage of the low latencies of HiperSockets in a simple setup
- Can register a *single* **MAC only per Linux instance for now** – i.e. not usable with Open vSwitch
- **Requirements/compatibility**:
  - z15 or LinuxONE III
  - HiperSockets VCHID with External Bridge option set
  - All participants accessing the same HiperSockets channel need to setup HSCI, too
  - In z/VM, use VSWITCH Bridgeport
  - Compatible with z/OS, providing layer 2 connectivity to z/OS over HiperSockets
- Support available in Linux kernel 5.10 and s390-tools v2.16
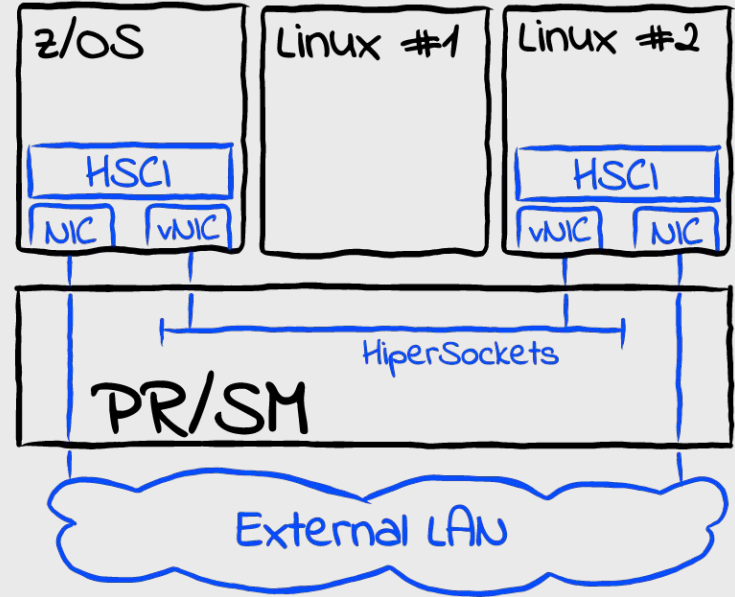
```
$ hsci add enc8410 encb040
Verifying net dev encb040 and HiperSockets dev enc8410
Adding hsci8410 with a HiperSockets dev enc8410 and an external dev encb040
Set enc8410 MAC fe:c2:f4:35:00:12 on encb040 and hsci8410
Successfully added HSCI interface hsci8410

$ ip addr add 192.1.2.3/16 dev hsci8410

$ hsci show
HSCI      PNET_ID   HiperSockets   External
-------------------------------------------------
hsci8410  NET1      enc8410        encb040
```

Other Packages

- **s390-tools** v2.16 (02/2021)
  - Userspace tools for use with the Linux kernel and its device drivers on IBM Z
  - Homepage: https://github.com/ibm-s390-linux/s390-tools
  - v2.16 supports Linux kernel 5.11
    - New tool: `hsci`, manages HiperSockets Converged Interfaces
    - See CHANGELOG for further details

- **Open Cryptoki** v3.15 (10/2020)
  - Implements Cryptoki API as defined by the PKCS#11 specification
  - Homepage: https://github.com/opencryptoki/opencryptoki/
  - Latest Changes:
    - Conform to PKCS#11 3.0 Baseline Provider profile
    - p11sak tool: add remove-key command version
    - CCA: Support key wrapping
    - SOFT: Support ECC

- **qclib** v2.3 (04/2021)
  - C library providing information on system, capacity, and virtualization layers
  - Latest changes (as of 2.2.1):
    - Support for zCX environment
    - Added new commands `zname` and `zhypinfo`

```
$ zname
IBM z15
$ zhypinfo
#  Layer_Type       Categ   Name       IFLs  CPs  Tot
-----------------------------------------------------
3  z/VM-guest       GUEST   R3545038     3    0    3
2  z/VM-hypervisor  HOST    BOER3545     2    1    3
1  LPAR             GUEST   R35LP45      2    1    3
0  CEC              HOST    P35         60    3   63
```

- **smc-tools** v1.5 (01/2021)
  - Utilities in support of SMC-R and SMC-D
  - Latest changes:
    - New tools `smcd`/`smcr` for link group and device information
    - New tool `smc_chk` to verify setup/peer capabilities

Compilers

- Development focus on **GCC** and **LLVM**

- **IBM z15 support** available in GCC 9.1 and LLVM 9.0.0 or later as follows:

  - `–march=arch13` enables GCC and LLVM z15 instruction set exploitation
    - New bit operations
    - 2 way conditional register moves (select)
    - Vector byte and element swaps

  - `–mtune=arch13` for z15 specific instruction scheduling
    - No new instructions used (does not require a z15 to run)
  - Alias `–march`/`–mtune=`**z15** available in GCC 9.3 and LLVM 10.0.0 or later

Libraries & Debuggers

- **GNU C Library Support**
  - Hardware capability flags indicate z15 facilities
  - New instruction MVCRL (move right to left), provides 1.5x speedup for `memmove` when used for array insert operations
  - New instruction Vector Substring Search, providing 2.5x speedup for `strstr` and `memmem` functions
  - Included in glibc 2.30
  - RHEL 8.1, SLES 12 SP5, SLES 15 SP2, Ubuntu 19.10, or later

- **GNU Debugger GDB**
  - z15 instruction set support for record and replay (reverse debugging)
    - Upstream in GDB 9.1
    - Available via TCM 2019 for SLES, Ubuntu 20.04

- **Valgrind - Memory Debugger**
  - Full instruction set translation to and from intermediate language required
  - z13 support available with RHEL 8.0, SLES 12 SP5, SLES 15 SP1, Ubuntu 19.04
  - z14 support available as of Valgrind v3.17

- **Perf – Performance Profiling**
  - Includes support for IBM Z hardware sampling and counter facilities
  - z15 support available with RHEL8.0, RHEL7, SLES15, SLES12 & Ubuntu19
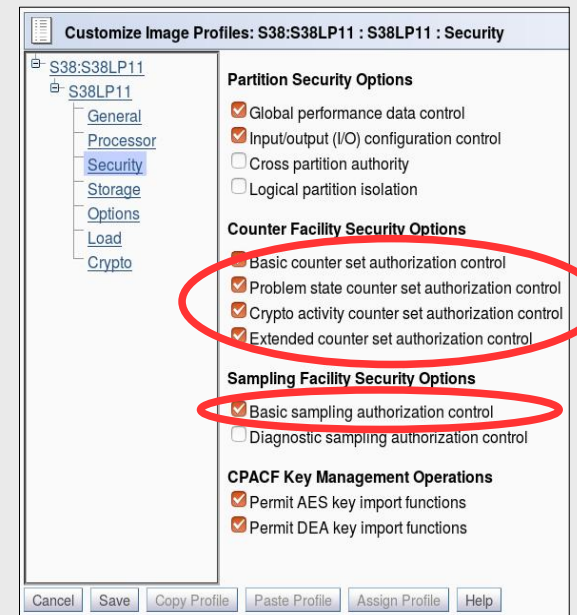
Activation profile settings for HW sampling and counter support

Libraries with IBM Z Optimizations

- **Algebra libraries** serve as back-ends for various math frameworks like *Numpy*, *R*, and *Octave*.

  - *OpenBlas*
    - z13 double precision support (dgemm) upstream since 0.2.20
      ⇒ RHEL 7/8, SLES 12/15, Ubuntu 18.04
    - z14 single precision support (sgemm) upstream in 0.3.10
      ⇒ future distros

  - *libAtlas*
    - z13 and z14 support in Ubuntu 19.10

  Note: *OpenBlas* and *libAtlas* implement the standard *blas* library interface and can be used interchangeably.

- *Eigen*
  - CPU compute back-end for Tensorflow
  - *Source-only* **package**: Recent versions will be pulled in during build
  - IBM z13 full support since 3.3.0
  - IBM z14 support upstream since 2017 will be part of upcoming release
  - z15 alignment hints added by compiler

- *Anaconda*
  - Popular Data-Science platform
  - Enables installation of most popular AI tools and frameworks independent from Linux distribution

(20.10) (8.4) (LPAR) (z/VM)

(19.10) (8.3) (LPAR) (z/VM)

(LPAR) (z/VM)

(18.04) (7) (12) (LPAR) (z/VM)

Miscellaneous

Staying Up-To-Date

Blogs

- Very latest news from the development team

  - Linux on Z & containers:
    http://linux-on-z.blogspot.com/

- Focus primarily on upstream submissions, which will end up in Linux distributions later

- Also features in-depth articles on specific topics

- Provided by Linux on Z development team

References

Documentation

- Linux on Z and LinuxONE on IBM Documentation
  https://www.ibm.com/docs/en/linux-on-systems?topic=linux-z-linuxone

- Videos explainers
  https://www.ibm.com/docs/en/linux-on-systems?topic=linuxone-video-explainers

Webcasts

- In-depth sessions right from the Linux on Z development team

- Recordings available
  http://ibm.biz/Linux-on-IBMZ-LinuxONE-Webcasts

Blogs

- Primary places for news and updates
  - *Linux on Z, including containers: http://linux-on-z.blogspot.com/*

Linux on IBM Z and LinuxONE - Technical Webcast Sessions

Get the latest news about the Linux exploitation and advantages of the IBM Z and LinuxONE platform in these technical webcast sessions presented by IBM experts out of the Labs.

The following videos and accompanying resources will help you get the best performance from your Linux on IB

To be notified about webcasts please contact Stephanie Gherghe at gherghe@de.ibm.com.

Upcoming Sessions

Date & Time	Title	Abstract	Registration Link
November 18 11:00 AM - 12:15 PM EST	IBM Secure Execution for Linux Introduction and Demo	IBM Secure Execution for Linux allows to build a Trusted Execution Environment for IBM Z and LinuxONE that helps protect data in use. This webcast gives an overview of the value and the key concepts of the technology, followed by a hands-on demo, outlining the steps needed to secure Linux workloads.	Register here
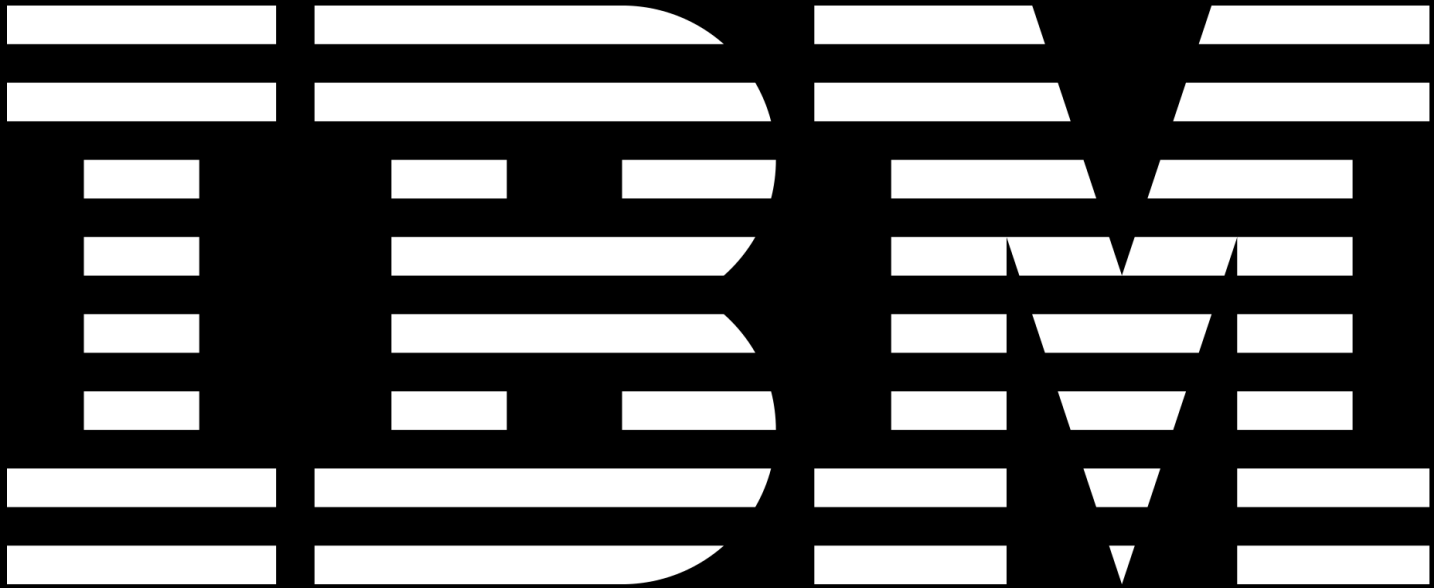
Tag Legend

- Supported distributions

  (x.y) for SUSE SLES \<X\> Service Pack \<Y\>, e.g. (12 SP3) for SLES12 SP3

  (x.y) for RHEL \<x\> Update \<y\>, e.g. (7.4) for RHEL7.4

  (x.y) for Ubuntu x.y, e.g. (16.04) for Ubuntu 16.04 LTS

- Suppored environments

  (LPAR) usable for systems running in LPAR mode

  (z/VM) usable for guests running on z/VM

  (KVM) usable for guests running on KVM