Overview and Update

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Agenda

The business challenges
Introducing IBM LinuxONE
How LinuxONE helps
Use cases
Next steps
45% more security incidents due to unauthorized access

your data is at risk

external data protection is not enough

customers are quick to switch when services, including response time and uptime, don’t meet their expectations

downtime costs brand image, loyalty, and revenue

the always on culture means customers expect 24x365 service (or as close as possible)

of the 9 Billion records breached since 2013, only 4% were encrypted

average cost of downtime is an estimated $1-5M/hour
Highest levels of security & privacy

Highly engineered for data & cloud serving

foundation for next-generation apps and data
IBM LinuxONE Generation III portfolio – differ in performance and scale

IBM LinuxONE III Model LT2
Mono-frame

IBM LinuxONE III Model LT1
Multi-Frame

A LinuxONE for everyone

“Right-sized” to fit your needs

Designed for highly secure
data and cloud serving

Engineered for performance and scale

Foundation for data serving
and next generation applications

Built on decades of proven and trusted
IBM technology

Built for cloud
with standardization
and simplicity

Lower total cost of ownership than x86

Right-sized for your business needs
# The IBM LinuxONE Generation III (LinuxONE III) portfolio

<table>
<thead>
<tr>
<th>LT2 Mono-Frame</th>
<th>LT1 Single-Frame</th>
<th>LT1 Dual-Frame</th>
<th>LT1 Triple-Frame</th>
<th>LT1 Quad-Frame</th>
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<tbody>
<tr>
<td>1–2 Processor drawers</td>
<td>1–3 Processor drawers</td>
<td>1–5 Processor drawers</td>
<td>1–5 Processor drawers</td>
<td>1–5 Processor drawers</td>
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<td>1–4 I/O drawers</td>
<td>1–3 I/O drawers</td>
<td>1–8 I/O drawers</td>
<td>1–12 I/O drawers</td>
<td>1–12 I/O drawers</td>
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<tr>
<td>1–65 cores @ 4.5 GHz</td>
<td>1–108 cores @ 5.2 GHz</td>
<td>1–190 cores @ 5.2 GHz</td>
<td>1–190 cores @ 5.2 GHz</td>
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<tr>
<td>64 GB–16 TB memory</td>
<td>512 GB–24 TB</td>
<td>512 GB–40 TB</td>
<td>512 GB–40 TB</td>
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<tr>
<td>Up to 40 logical partitions</td>
<td>Up to 85 logical partitions (LPARs, classified as “hard partitions” for software licensing purposes)</td>
<td>Up to 85 logical partitions</td>
<td>Up to 85 logical partitions</td>
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<tr>
<td>Up to 40 secure enclaves</td>
<td>Up to 85 Hyper Protect Virtual Server secure hosting appliance enclaves</td>
<td>Up to 85 Hyper Protect Virtual Server secure hosting appliance enclaves</td>
<td>Up to 85 Hyper Protect Virtual Server secure hosting appliance enclaves</td>
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<tr>
<td>Up to 2,880 TEE guests</td>
<td>Up to 72 KVM guests per Trusted Execution Environment (TEE) LPAR x up to 85 LPARs = up to 6,120 TEE guests per LT1</td>
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<tr>
<td>iPDU</td>
<td>Choice of either Intelligent Power Distribution Unit (iPDU) or Bulk Power Assembly (BPA)</td>
<td>Choice of either Intelligent Power Distribution Unit (iPDU) or Bulk Power Assembly (BPA)</td>
<td>Choice of either Intelligent Power Distribution Unit (iPDU) or Bulk Power Assembly (BPA)</td>
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<tr>
<td>Air-cooled</td>
<td>Liquid-cooled, choice of radiator or customer-supplied water source</td>
<td>Liquid-cooled, choice of radiator or customer-supplied water source</td>
<td>Liquid-cooled, choice of radiator or customer-supplied water source</td>
<td></td>
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<tr>
<td>Up to 16 slots for SSDs</td>
<td>Up to 16 IBM Adapter for NVMe carrier cards, each of which can house 1 solid state drive (SSD)</td>
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</tr>
<tr>
<td>8U Reserved Space</td>
<td>No option for reserving rack space for storage</td>
<td>No option for reserving rack space for storage</td>
<td>No option for reserving rack space for storage</td>
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</tbody>
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* The max number of drawer will vary based on the configuration
IBM Hyper Protect Virtual Servers on-premises

A secure virtualization platform that protects your critical Linux® applications throughout the DevSecOps lifecycle

**Build applications with integrity**
Leverage the secure build process to sign images, validate code, and integrate into your CI/CD pipeline.

**Deploy workloads with trust**
Validate the provenance of your applications before deployment.

**Manage applications with simplicity**
Manage your infrastructure without visibility to sensitive code or data – RESTful API deployment.

**Encrypt & Sign critical solution components**
Give your images access to the industry leading FIPS 140-2 level 4 Hardware Security Module for signing and encryption needs.
Where it matters

**A Secure Infrastructure Foundation**

IBM Hyper Protect Virtual Servers serves as both a solution for external clients to securely build Docker based applications on IBM Z and LinuxONE and a foundational component of other IBM solutions.

- **Hyper Protect Digital Assets Platform**
  Enables custodians, exchanges, & Distributed Ledger Technology i.e. DLT ecosystem partners to protect tokenized assets and validate participants for transactions

- **Data Privacy Passports**
  Provides a secure host environment to deploy the Passport Controller used for policy enforcement and data transformation in Data Privacy Passports

- **Reduce Regulatory Compliance Scope**
  Host sensitive workloads that require a high degree of isolation and data protection to meet security & compliance needs for your organization, industry, or geography

- **Secure the application build pipeline**
  Automate security into the software application build pipeline – from the start
Unrivaled economics through engineering

Consolidate 100s of x86 cores onto a single LinuxONE III LT1 server

Reduce costs by up to 40% over a 3-year period compared to x86
Putting technology to use

Performance, scale, and simplicity for lower operational costs

- Scale your business, with confidence, at a lower cost
  - SCALE a single MongoDB database to 17TB with less than 1ms response times at large scale
  - SAVE up to 37% vs. x86

- SCALE private cloud by running up to 6.6x more containers under KVM on a LinuxONE III Model LT2 system vs. x86
Linux on Z
Distributions
Linux Distributions & Hardware Certification

<table>
<thead>
<tr>
<th></th>
<th>z15</th>
<th>z14 (all models)</th>
<th>z13</th>
<th>z13s</th>
<th>zEnterprise – zEC12, zBC12</th>
<th>zEnterprise – z196, z114</th>
<th>System z10, System z9</th>
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<tbody>
<tr>
<td></td>
<td>LinuxONE III</td>
<td>Emperor II</td>
<td>Rockhopper II</td>
<td>Emperor</td>
<td>Rockhopper</td>
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<td>RHEL 8</td>
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<td>RHEL 7</td>
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<td>SLES 12</td>
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<td>SLES 11</td>
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<td>Ubuntu 20.04</td>
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<td>Ubuntu 18.04</td>
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<td>Ubuntu 16.04</td>
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See [www.ibm.com/systems/z/os/linux/resources/testedplatforms.html](http://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

- **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

- For further details on SLES lifecycles, see [https://www.suse.com/en-en/lifecycle/](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
  - 11/2020 RHEL 8.3
  - 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 Jun. 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

- For further details on RHEL lifecycles, see [https://access.redhat.com/support/policy/updates/errata](https://access.redhat.com/support/policy/updates/errata)
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 20.10 (Groovy Gorilla)**
  - 10/2020 GA: Kernel 5.9, GCC 10.2.0
  - EOS: July 2021

- **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: Apr 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: Apr 2024

- **Lifecycle**
  - Regular releases every 6 months and supported for 9 months
  - LTS releases every 2 years and supported for 5 years
  - LTS enablement stack will provide newer kernels within LTS releases
OpenShift 4.6 available on LinuxONE same day as on x86

Red Hat® OpenShift®
Multi-Cluster, Full Stack, Autonomous, Secure

Cloud.redhat.com
- Install new clusters
- View capacity

OpenShift (Kubernetes)
- Full-stack auto-install (Master & Nodes)
- Zero-downtime full-stack updates
- Full-stack configuration of Kubernetes and CoreOS
- Auto-scale cluster nodes

Red Hat Enterprise Linux (RHEL) CoreOS
- Secure, immutable container operating system
- RHEL 8 kernel and core libraries
- Autonomous updates & config

Bare Metal, Virtual Machine, IBM Z and Power plus x86, Public Cloud
OCP 4.6 Release

- In lockstep with other platforms
- Minimum configuration:
  - z/VM hypervisor
  - OCP cluster nodes run in z/VM guests
- LPAR/KVM support subject to future releases
- Try for yourself:
  - https://try.openshift.com/
  - https://docs.openshift.com/container-platform/4.6/installing/installing_ibm_z/installing-ibm-z.html
IBM Cloud Pak solutions – Enterprise-ready cloud software

A faster, more secure way to move your core business applications to any cloud through enterprise-ready containerized software solutions

IBM containerized software
Packaged with open-source components, pre-integrated with the common operational services, and secure by design

Container platform and operational services
Logging, monitoring, security, identity access management

Complete, yet simple
Application, data and AI services
Fully modular and easy to consume

IBM certified
Full software stack support, and ongoing security, compliance and version compatibility

Run anywhere – on-premises, on private and public clouds, and in pre-integrated systems

Amazon Web Services
Google Cloud Platform
Microsoft Azure
IBM Cloud
IBM Z and Power, x86 servers
IBM Cloud Paks 2021

IBM delivers hybrid cloud software that **predict**, **secure**, and **automate** their businesses. They are packaged as **Cloud Paks** that include: Containerized software, foundational services and Red Hat OpenShift.

**2020**
- IBM Cloud Pak for Data
- IBM Cloud Pak for Automation
- IBM Cloud Pak for Integration
- IBM Cloud Pak for Applications

**Embedded inside each Cloud Pak:**
- Containerized software
- Foundational services
- Red Hat OpenShift

**2021**

**Predict**
- IBM Cloud Pak for Data
- IBM Cloud Pak for Multicloud Management

**Secure**
- IBM Cloud Pak for Security
- IBM Cloud Pak for Business Automation
- IBM Cloud Pak for Watson AIOps

**Automate**
- IBM Cloud Pak for Integration
- IBM Cloud Pak for Network Automation

**New**
- Automation platform
- WebSphere Hybrid Edition

**Modernize**
- IBM Cloud Pak for Data
- IBM Cloud Pak for Integration
- IBM Cloud Pak for Applications

**Embedded inside each Cloud Pak:**
- Containerized software
- Foundational services
- Red Hat OpenShift
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
- 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

E.coli=entire genome, bible.txt=KJV text, world192.txt=CIA Fact Book, Canterbury.tar=Canterbury Corpus
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)
- Supported curves:
  - ECDSA (sign/verify) P256, P384, P521, Ed25519, 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"
  1 disable secure boot
  2 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

- **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**
  - Uses standard Linux NVMe driver
  - Always apply latest service levels!
SMC-Dv2

• Recap:
  - **SMC-Dv1** provides intra-CEC communication 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
SMC-R / smc-tools

SMC-R Link Group Support

- 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
  - 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
Without secure execution: Guest memory and state at risk of inside attacks
With secure execution:
Guest *memory* protected and *state* shielded by ultravisor
IBM z15 Support: Secure Execution (continued)

- Allows users to run their Linux workloads with maximum privacy by protecting system memory.
- Not even the system administrator can access customer data
  ⇒ Protection against insider attacks
- Allows customers to run sensitive workloads on and off premise with the same level of data protection
- Reduces the efforts of a cloud service provider to establish and document procedures for compliance and certification

- What is IBM Secure Execution for Linux?
  - Orderable feature of IBM z15 or LinuxONE III (feature code 115)
  - End-to-end memory protection realized in hardware
  - Trusted firmware controlling the separation and isolation of virtual machines
  - CA-certified public private keys to form a chain of trust

- What else is needed?
  - By the machine owner: a Linux operating system with KVM supporting IBM Secure Execution (RHEL 8.3, SLES 15 SP2, Ubuntu 20.04)
  - By the workload owner: a Linux operating system which supports running as KVM guest in an IBM Secure Execution virtual machine (RHEL 7.8, RHEL 8.2, SLES 12 SP5, SLES 15 SP2, Ubuntu 20.04)
Ensuring timely delivery of essential weather data to millions of customers

The UK Meteorological Office migrated its meteorological databases from x86 systems to a resilient, high-performance and scalable IBM® LinuxONE platform—ensuring it can handle massive peaks in requests.

A single team supports a large number of core Linux apps
Cuts operational costs through database consolidation
Ensures millions of customers can access critical weather data 24x7

“We can bet the business on LinuxONE—and I can sleep easily in the knowledge that we can absolutely rely on our data delivery systems.”

Graham Mallin, Executive Head of Technology at the Met Office
Origins of the LinuxONE Community Cloud

• Mission:
  • The public cloud exists to provide access to IBM z based Linux servers for developers, testers and enthusiasts to try and experience.
  • Individuals can sign up for 120 days at a time and get the ability to deploy Linux server of their choice, or experience IBM OpenShift Container Platform (OCP) based services.
    • A valid email address is required, plus affirm standards of use agreement
  • The L1CC has been used by many academic programs, special events (hackathons) and the 2020 IBM Master the Mainframe Contest.

• Beginnings:
  • Developed as a joint project between IBM and Marist College, starting in 2015.
LinuxONE Community Cloud - Today

- Current L1CC resides on LinuxONE Emperor III (z15 technology)
  - Three hypervisors running z/VM 7.1
    - Two in SSI cluster, one in 4-way SSI cluster
  - IBM Cloud Infrastructure Center level 1.1.1
    - One controller, three host nodes (compute nodes)
    - All running on RHEL 7.8 servers
  - First L1CC to use it for cloud technology
  - Went production in August 2020
- OCP (Red Hat OpenShift Container Platform) option was added to registration in September 2020
  - Allows people to try out environment for a short time
Staying Up-To-Date

Blogs

- Very latest news from the development team
  - KVM on Z: http://kvmonz.blogspot.com/
  - 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 Knowledgecenter
  https://www.ibm.com/support/knowledgecenter/linuxonibm/liaaf/lnz_r_main.html

- Videos 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/
  - KVM on Z: http://kvmonz.blogspot.com/
Next Steps

Discuss your options

- Schedule an Expert Consultation or on-site workshop

Learn more

- Read "10 Reasons Why LinuxONE" paper by the Robert Frances Group
- Watch LinuxONE provides a more secure Blockchain (3:43)
- Read the “Scaling the Digital Mountain: A Path to a Secure, Agile, and Efficient Organization” paper by Solitaire Interglobal, Ltd
- Review the labor and resource usage savings in LinuxONE environments paper
- Calculate the TCO savings of LinuxONE vs. x86

Try before you buy on the LinuxONE Community Cloud
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