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IBM LinuxONE

for dummies®

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Secure your data and protect digital assets

Build an open hybrid cloud environment

Realize the cost benefits of consolidation

Judith Hurwitz

Daniel Kirsch

2nd Limited Edition

IBM LinuxONE

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by Judith Hurwitz and Daniel Kirsch

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Introduction

As more companies transform their IT infrastructures with hybrid cloud services, they require environments that protect the safety of their intellectual property, such as data and business rules. In addition, businesses need a set of hybrid cloud services that combines the security and integrity of their enterprise computing environment with the economic viability of the hybrid computing environment. Welcome to IBM LinuxONE.

LinuxONE is a hardware system designed to support and exploit the Linux operating system based on the value of its unique underlying architecture. We are in an era where openness is paramount to support the needs of corporations. At the same time, in the era of cloud computing, businesses need scalability and security to support increasingly complex workloads. The business value of LinuxONE is that it can be used within a multicloud environment to support a range of workloads and a variety of customer scalability requirements.

LinuxONE supports open APIs and Red Hat OpenShift. The openness of the platform means your business can create a hybrid environment that can include both on-premises environments and public cloud services.

About This Book

IBM LinuxONE For Dummies, 2nd Limited Edition, is designed to help you understand LinuxONE as an integrated hardware and software environment that supports a hybrid cloud environment. This book provides you with an overview of the value of LinuxONE when compared to other platforms.

Foolish Assumptions

The information in this book is useful to many people, but we have to admit that we did make a few assumptions about who we think you are:

- You're already familiar with enterprise and cloud computing and need to understand how to enable your company to scale in the era of the hybrid cloud.
- You're planning a long-term cloud strategy and want to understand the value of the private cloud and how it can be used to support your business goals.
- You need to ensure that data is managed in a secure manner.
- You're a business leader who wants to ensure that you have a predictable, secure, and resilient computing infrastructure.

Icons Used in This Book

The following icons are used throughout the book.

REMEMBER

This icon highlights important information that you should remember.

TIP

Tips help identify information that needs special attention. You may save money, time, or resources.

WARNING

This icon points out content that you should pay attention to in order to avoid problems.

TECHNICAL STUFF

This icon is reserved for more technical information.

IN THIS CHAPTER

- Examining the history and evolution of LinuxONE
- Understanding the hardware of LinuxONE
- Making sure to protect data
- Looking at scalability, performance, and reliability
- Grasping the LinuxONE ecosystem
- Seeing LinuxONE in action: Workload performance
- Cashing in on the business benefits of LinuxONE

Chapter 1
Explaining IBM LinuxONE

Linux adoption has grown dramatically over recent years, expanding from initial use by startups for web servers, into its use today for a vast range of enterprise computing workloads. These mission-critical applications have in turn placed greater requirements on the underlying server hardware for security, scalability, and resilience. As more enterprises move to a cloud-native architecture, Linux combined with containers and Kubernetes has become an invaluable platform to support cloud-native development and deployment. IBM LinuxONE is an important platform to support this DevOps and continuous delivery process. Because LinuxONE is based on open source Linux, developers can use the same tools they're familiar with in any on-premises or cloud environment; because of LinuxONE's capabilities, it can safely run development alongside production workloads.

LinuxONE is an enterprise-grade Linux server with a unique architecture designed to meet the needs of mission-critical workloads. It brings together IBM's experience in building secure, resilient, and scalable systems with the openness of the Linux operating system. LinuxONE is a Linux-only platform intended to support customers interested in leveraging the open source ecosystem combined with highly secure and highly scalable servers.

Linux has been available on supercomputers for more than a decade, so it's no novice at being the operating system for powerful machines. However, LinuxONE is focused squarely at enterprise computing in the era of the cloud. After you understand the hardware and software platform of LinuxONE, you can understand the business opportunities and benefits of LinuxONE.

In this chapter, we provide an overview of what LinuxONE is and how it can be used to support growing requirements in the enterprise.

The Evolution of LinuxONE

Over the years, centralized enterprise computers and their workloads have taken on many new roles, such as hosting servers in client-server applications or hosting the Internet. In the late 1990s, IBM made the strategic decision to support the Linux operating system on its enterprise server architecture.

In 2014, IBM saw a shift in how clients were deploying Linux and open source. This was driven by the use and maturity of open source software for enterprise application deployments. Clients were increasingly looking for scale, performance, availability, and security in their Linux servers. Observing this shift, IBM decided to build a system to address these requirements.

IBM decided to take existing components from across its Systems portfolio and fashion a platform that's designed to deliver on these new expectations for enterprise Linux servers. The LinuxONE system was launched in August 2015. With IBM's acquisition of Red Hat in 2019, the LinuxONE platform gained support for additional foundational components such as Red Hat OpenShift. In parallel, LinuxONE continues to work closely with its other Linux Distribution Partners, SUSE and Canonical (Ubuntu).

The result is a platform that can run cloud-native applications, provide enterprise class-leading security, has high enterprise server reliability, and can consolidate workloads from many smaller servers onto a single integrated LinuxONE machine.

Looking at the LinuxONE Hardware

LinuxONE is currently in its third generation. Named IBM LinuxONE III, the platform can be delivered in two models: Model LT1 and LT2. Both models are designed to support cloud-native development and deployment. They support pervasive encryption and IBM Data Privacy Passports to protect data at rest and in transit:

- LT1 can be configured in one to four frames. It supports up to 190 processor cores, running at 5.2 gigahertz (GHz), up to 32 terabytes (TB) of RAM, and 640 dedicated Input/Output (I/O) processors. It supports tens of thousands of sessions and millions of containers.
- LT2 is designed for midsized businesses and is therefore an entry point into the LinuxONE III family. This model is delivered as a single 19-inch frame so that it can easily fit into existing data centers. It is based on the same technology foundation as Model LT1 and is available with up to 16TB of memory and up to 64 processor cores, running at 4.5 GHz, instead of 5.2 GHz, to support hundreds of production and development virtual machines (VMs) in a single frame footprint.

REMEMBER

LinuxONE processor cores are designed to be more powerful than x86 processor cores, through a combination of processor architecture, clock speed, cache, optimization, and I/O offloading. While security and scalability are the key differentiators of these platforms, the hardware also provides reliability and performance benefits for many important cloud workloads.

Architecting Security into LinuxONE

Security is architected into LinuxONE for both the hardware and software. For example, pervasive encryption is designed to encrypt all data associated with an application, database, or cloud

service — whether at rest or in transit. This level of protection is achieved through hardware-accelerated encryption of data, delivered with little overhead by the on-chip Central Processor Assist for Cryptographic Function (CPACF) and the dedicated Crypto Express adapter. The availability of this level of encryption at scale can make it easier for organizations to meet compliance mandates for regulations such as Health Insurance Portability and Accountability Act (HIPAA) and Payment Card Industry Data Security Standard (PCI DSS).

Security is further promoted by protecting cryptographic keys by using a Hardware Security Module (HSM). Protected key encryption is processed in the CPACF for high speed and stored in an HSM. This key encryption enables fast encrypting and decrypting of complete disks (volumes) or selected partitions. Logical partition (LPAR) isolation, standard on all LinuxONE processors for generations, isolates workloads running in partitions to help ensure the integrity of applications and data and minimize security breaches and their damaging impact both financially and to an organization's credibility.

IBM Hyper Protect Virtual Servers, formerly known as IBM Secure Service Containers, adds further security capabilities at a logical partition level. Hyper Protect Virtual Servers provides workload isolation, restricted administrator access, and tamper protection against internal threats, including from systems administrators.

Linux itself provides a comprehensive set of security technologies, including firewalls, VPNs, auditing tools to support regulatory compliance, and SELinux, a kernel-based security subsystem. For more details on security of LinuxONE, check out Chapter 2.

Protecting Data

In order to maximize data protection, LinuxONE offers two services: IBM Secure Execution and IBM Data Privacy Passports. Both these offerings help provide a comprehensive way to protect data in a distributed environment that spans from LinuxONE to a multicloud environment.

Secure Execution

Secure Execution for LinuxONE III is a hardware-based approach to security that's intended to protect sensitive data in use. To achieve this objective, it isolates individual on-premises and cloud workloads from both internal and external attacks. To accomplish data protection, Secure Execution uses a hardware-based Trusted Execution Environment that isolates workloads in order to restrict access to data. It can process unencrypted memory securely without exposing the data to the hosted or other external environments. Secure Execution also provides isolation between KVM hypervisor hosts and guests in the VMs.

Chapter 2 provides more detail on Secure Execution.

Data Privacy Passports

Data Privacy Passports is designed to support encryption everywhere through a secure service container appliance. To achieve this objective, an organization's security policy can remain active and operate on eligible data regardless of where the data resides in the enterprise. Check out Chapter 2 for more information.

Scalability and Performance

LinuxONE is designed to be a high-performance machine. With its processors, clock speed, I/O bandwidth, and more, LinuxONE is designed to operate at near 100 percent utilization. In contrast, x86 machines often operate at relatively low utilization levels (typically near 50 percent, although case studies show that number is often lower in practice). In addition, because encryption is built into the processor cores in hardware, encryption processing doesn't add high overhead and can also reduce the need for the customer to add third-party encryption tools.

LinuxONE systems can scale vertically or horizontally without disruptions to running applications. The scalability of LinuxONE is efficient because you can scale up within the same machine. This scalability is ideal for "systems of record" workloads, such as databases and transaction processing, and reduces the costs of scaling workloads. In comparison, to scale out with an x86 system, you're required to add more servers and dedicate more floor space, management tools, and networking — anything associated with adding new systems to your environment.

Reliability

Reliability is a well-known capability of IBM's unique enterprise server architecture — for example, the fact that its design has no single points of failure. LinuxONE inherits these capabilities, including component redundancy to allow the machine to continue when a single component fails. This feat is possible because maintenance and repairs can be performed concurrently while the machine is still running workloads.

The LinuxONE Ecosystem

The LinuxONE environment is designed as a unified system based on the Linux operating system combined with the most important open source services, ranging from databases to management tools. Therefore, IBM has marshaled key open source and industry software for LinuxONE systems, including Python, Go, Swift, Java, and other languages; MongoDB, PostgreSQL, Apache Spark, Node.js, Hadoop, and other tools, including Linux containers, Chef, and Puppet. A critical part of the LinuxONE ecosystem is support for Red Hat's Kubernetes platform, OpenShift. Red Hat OpenShift helps to accelerate DevOps and transformation efforts across Linux-based on-premises and cloud environments. This support for Red Hat OpenShift means that workloads can be managed and moved across LinuxONE III and cloud environments — connecting on-premises and cloud ecosystems.

These technologies work seamlessly on LinuxONE, just as they do on other hardware platforms, requiring no special skills. Because of its open source heritage, LinuxONE can operate both in the traditional data center or as a private cloud platform. LinuxONE runs the enterprise Linux distributions — Red Hat, SUSE, and Ubuntu — as well as community editions, including CentOS, Debian, Fedora, and OpenSUSE.

For more information on the LinuxONE ecosystem, flip to Chapter 7.

Workload Performance of LinuxONE

The unified platform of LinuxONE is designed to support demanding performance requirements in the enterprise. While we could give you countless examples of the benefits of this level of performance, in this section, we describe four use cases where customers benefit from the workload performance.

Support for large high-performance databases

Many databases use sharding or other scale-out mechanisms because the data is too large to fit on a single machine. Because of the scalability and performance of LinuxONE, a massive database can often fit on a single LinuxONE machine. Performance is often improved because everything is in the same server — avoiding the overhead of additional communications and coordination, the latency from gathering results, and the application changes required with a scale-out approach.

Support for large number of containers

LinuxONE systems have been enabled for Linux containers, Kubernetes, and Red Hat OpenShift with integrated management. Supporting high numbers of containers is key for businesses that service a large number of enterprise customers in areas such as telecommunications, cloud service providers (CSPs), and financial institutions.

Support for blockchain

REMEMBER

Blockchain is a technology for creating distributed, secure ledgers that represent the history of transactions and life cycle of things (Bitcoin is the best-known application of blockchain). Blockchain is an ideal technology to run on LinuxONE. It relies on data encryption and decryption, and LinuxONE's hardware cryptography is designed for superior performance at scale. When the size of a blockchain network or the size of the ledger gets huge, LinuxONE's massive available RAM still allows verification of the ledger to occur in memory for optimal performance. Check out Chapter 5 for more information on blockchain.

Support for DevOps

LinuxONE is an important platform to support the DevOps process. Because LinuxONE is based on open source Linux, developers can use the same tools they're familiar with in any on-premises or cloud environment and can safely run development alongside production workloads.

The Customer Benefit of LinuxONE

One of the consequences of the movement to hybrid cloud is the need to have performance, resilience, scalability, security, and manageability as the foundation. The cloud has brought the imperative of elasticity and security to the forefront of how businesses are supporting their customers, suppliers, and partners. You can no longer assume that you can estimate the capacity you'll need a year in the future. While you can continue to add individual servers, management and security concerns are holding back businesses from achieving their goals. Ironically, LinuxONE — based on one of the longest lasting architectures in the industry — has emerged as one of the most forward-focused platforms to support change.

IN THIS CHAPTER

- Knowing why you need a secure platform to protect your data
- Seeing the LinuxONE approach to security
- Understanding the ability to encrypt all your data
- Using Secure Execution for Linux

Chapter 2
IBM LinuxONE as a Secure Platform

Security must be at the center of any IT platform. If critical business data is compromised or customer data is leaked, your business's reputation may be damaged, and you may face regulatory and legal consequences. Likewise, if corporate data is exposed, you risk the chance of losing significant intellectual property.

When you're considering an infrastructure platform, you need to understand the security features inherent to the platform, both in the cloud and on premises. In this chapter, we discuss how the IBM LinuxONE system incorporates many security capabilities.

UNDERSTANDING CONFIDENTIAL COMPUTING

A new movement in the industry has introduced the concept of confidential computing. The term *confidential computing* refers to protection of data in use and is a key pillar of data protection. It uses hardware-based techniques to isolate data, specific functions, or an entire application from the operating system, hypervisor, or virtual machine (VM) manager, and other privileged processes. The Linux Foundation hosts the Confidential Computing Consortium, of which IBM is a member, to define industry-wide standards for confidential computing and to promote the development of open-source confidential computing tools. The focus of confidential computing is to store data in a trusted environment. LinuxONE supports protection of data in use, as well as data at rest and data in motion within the system.

Why You Need a Secure Platform

Initially, corporate management assumed that regulatory compliance and audits would be enough to protect your company's data. However, many security risks come from third-party malicious attacks. Management now understands that with the advent of cloud computing many of the risks may be out of their direct control.

Businesses are concerned about cybersecurity threats to the information that is the lifeblood of their relationships with their customers and partners. More and more data resides in a hybrid cloud environment, and applications are designed to manage data and provide collaboration between customers and partners.

REMEMBER

We are not just talking about data stores here. Instead, data is embedded in spreadsheets, documents, applications, and databases on premises and in the cloud. At one point, the Chief Security Officer (CSO) may have had direct control over how security was handled. However, increasingly, distributed data and applications make it difficult for the CSO to control this complex set of services. At the same time, security is now a major concern of business management. Management needs to report to shareholders that security is being managed at the highest level.

A common misconception exists that when a business entrusts its data and applications to a cloud provider it is no longer responsible for security. But in fact, the business remains responsible for keeping track of this highly distributed data, including who's allowed to access the data and whether regulations are adhered to. To be successful at protecting your assets, there needs to be a partnership between the cloud vendor and the security management team.

IBM's Approach to Security with LinuxONE

In Chapter 1, we discuss how LinuxONE is designed to support industry-standard Linux. LinuxONE provides customers with a combination of a highly scalable standards-based platform designed with security at the core. Security is built in at the lowest levels of the platform for LinuxONE. Security is at the heart of helping businesses to protect their assets at the most sophisticated level possible. This approach requires a sophisticated technique of protecting the integrity of data at rest, in motion, or in use called Cloud Hyper Protect Services. This service can be deployed either on LinuxONE or in the cloud as a service (see Chapter 4 for more details about IBM Cloud Hyper Protect Services). Important technologies for ensuring this level of protection are delivered through IBM Hyper Protect Services, which employs pervasive encryption, Hardware Security Module (HSM), and IBM Secure Service Container as underlying technologies for data protection.

Pervasive encryption

Pervasive encryption can automatically encrypt data both at rest and in flight and doesn't require application changes. This approach enables companies to encrypt all their data by default with little compute overhead.


TIP

One of the benefits of the LinuxONE system is the extent of the security services. Because of the architecture of LinuxONE, security is pre-integrated at every level of the hardware and software stack. LinuxONE-based security is designed to encrypt data in bulk. Therefore, it is possible to encrypt all the data associated with an application or a database at one time.

Providing encryption of everything and at every level is in stark contrast to the way encryption is typically approached. Most companies only encrypt a small amount of data, leaving the vast majority of data completely unencrypted. All the unencrypted data is at risk of being leaked by mistake or stolen by a criminal. On the other hand, when all the data is encrypted, even if it's exposed to people outside of your organization, it will be meaningless without the encryption key.

Traditionally, encrypting all your data required a large amount of compute and time overhead; however, the LinuxONE platform has dedicated hardware specifically tuned for encryption. The on-chip encryption co-processor is on every compute chip next to the main processor.

Hardware Security Module (HSM)

LinuxONE can also include CryptoExpress adapters, which support high-speed encryption as well as provide an HSM for securely storing and protecting encryption keys. These CryptoExpress adapters are protected using a tamper-responsive hardware environment that self-destructs encryption keys if it senses an attack.

Explaining Data Privacy Passports

IBM Data Privacy Passports is a capability available on LinuxONE III service that's deployed on IBM Hyper Protect Virtual Servers. It's designed to protect eligible data after it leaves its source and travels throughout the enterprise and into distributed and hybrid cloud environments. This solution focuses on the security of data itself rather than the security of networks, hardware, or software, in order to reduce vulnerabilities that exist with point-to-point data protection.

Before data leaves the system of record, the Data Privacy Passports component known as the Passport Controller provides protection, enforcement, policy, and key management. The goal of Data Privacy Passports is to ensure that privacy is maintained and managed based on policy as eligible data is moved from its source such as a system of record to other systems, including a variety of clouds. The objective is to provide transparent end-to-end data level protection and privacy. It achieves this goal by encrypting

eligible data based on corporate rules and compliance requirements. Data Privacy Passports is designed so data access can be either granted or revoked in order to maintain control, and you can do so even after the data has left its source. This is especially important when data moves from the system of origin in order to conduct sophisticated analysis of data.

To execute on this process, Data Privacy Passports secures SQL-based structured data sources that are accessed via Java Database Connectivity (JDBC) APIs. The policy governed by the Passport Controller allows each persona to have a different view of the same table, based on its need to know. And policies can be set accordingly. Data owners may see all data in the clear, whereas others will see it either enforced, like masked value or encrypted as a Trusted Data Object.

Setting up Data Privacy Passports has two critical stages:

1. **The system administrator installs and configures the Hyper Protect Virtual Server hardware and software.**

   At this stage, the data owners identify which data needs to be protected.

2. **Once identified, the security administrator sets up the policy for Data Privacy Passports based on which users have authorization to access the data under what conditions.**

   At this stage, the system administrator activates the approval policy and connects the policy to the source and target databases.

Seeing the Value of Secure Execution for Linux

While existing techniques can provide extensive protection of data in flight and data at rest, protecting the third state — data in use — is the new frontier. Protecting data while in use has been a challenge so far because applications need to have data that's unencrypted, or not protected, in order to run computations. This poses a significant security issue because this type of data remains exposed in memory and can be exploited by malware or

other threat vectors to steal information. The Confidential Computing Consortium is an industry-wide movement to help protect data while it is in use through the implementation of hardware-based techniques such as Trusted Execution Environments (TEE).

IBM Secure Execution for Linux is a LinuxONE exclusive TEE technology that's built into the hardware and firmware of the system. It is designed to protect the confidentiality and integrity of data and code in use (during runtime). Unencrypted data and memory while in use can now be securely processed in a protected execution environment, often termed an enclave. Secure Execution offers workload isolation and access restrictions to help ensure that other compromised guests or malicious administrators don't have access to your sensitive workloads. Secure Execution can help provide a highly secure and trustworthy hosting solution for enterprise ready multi-tenant workloads on premises or in the cloud and hybrid environments.

REMEMBER

The value of Secure Execution is that it can help mitigate some of the data exposure concerns that many organizations have expressed when approached with the idea of moving their most sensitive workloads to the cloud. Secure Execution can maintain confidentiality and integrity for data in use, regardless of who may own or have access to the machine on which the software is running. By protecting data in use, the last pillar of data security, Secure Execution makes it possible to run sensitive workloads more securely even on untrusted or malicious infrastructure and help you move one step closer to realizing a Zero-Trust environment.

IN THIS CHAPTER

- Scaling approaches for LinuxONE and databases
- Choosing LinuxONE for running databases
- Looking at IBM Cloud Hyper Protect DBaaS

Chapter 3
Scalable Databases for IBM LinuxONE

The key difference between IBM LinuxONE and other Linux systems is that LinuxONE's hardware is engineered to offer dramatic improvements in performance, security, and reliability. In particular, LinuxONE can scale up to handle large databases when compared to other approaches. The platform also enables the consolidation of multiple database servers onto a single system. These hardware advantages create the opportunity to run databases on a single scale-up LinuxONE machine rather than multiple scale-out servers. Transitioning from a scale-out to a scale-up strategy helps organizations increase performance, achieve higher utilization, and reduce costs.

In this chapter, we provide an overview of LinuxONE and why it's well suited to running large databases. We also discuss an IBM product designed to deploy and monitor secure databases in the cloud.

Scaling LinuxONE and Databases

Organizations have coped with large volumes of data for decades, but the challenge is exacerbated by the ever-increasing volume of big data that's applied to advanced analytics problems at a massive scale. This rapid data increase requires significant processing power and computing resources that can scale performance quickly as demands change.

Scalable processing power can be achieved in various ways. The cloud has demonstrated the ability to scale massively by scaling out — using many independent, cooperating virtual machines (VMs), running on commodity servers. While this scale-out approach can work for systems of insight and systems of collaboration, there are challenges for systems of record because of the need to achieve immediate consistency in data across multiple VMs — and managing a sprawling network of distributed servers can quickly become difficult. In addition, as you continue to scale out, you'll likely introduce latency and increase costs.

Scale up, not out

Instead of scaling out, you can scale up. Scaling up allows you to get more compute and storage resources from a single machine. With the scale-up model, you begin with a small VM and add processors and memory as your workloads expand.


TECHNICAL STUFF

LinuxONE uses a fast commercially available processor running at 4.5 or 5.2 gigahertz (GHz). Input/Output (I/O) is offloaded up to 640 dedicated co-processors, speeding access to data. And LinuxONE can run many workloads that otherwise require multiple x86 machines. For example, a single IBM LinuxONE III system is designed to scale up to billions of transactions per day, support up to 8 terabytes (TB) of main memory, contain 30 CPUs, and provide extreme I/O bandwidth with a 16 gigabit (Gb) channel — all while designed for 99.999 percent availability. However, you can start by provisioning and paying for a much smaller workload and scale up as your requirements expand.

Database scalability

There's no shortage of databases in the world. Each platform has its strengths and weaknesses depending on its use and constraints. For example, some databases are designed to run as

clusters of cooperating servers in the cloud. This scaled-out configuration can manage larger quantities of data than a single machine and can continue to scale out with even more servers to meet additional demands.

Other on-premises databases are designed to operate on a single machine. If a business needs to deploy a workload larger than the machine's capacity, it may need to use a strategy like *sharding* — another form of scaling out.


TECHNICAL STUFF

When the data is complex or has many interconnections, sharding (partitioning a large database into smaller units) will also introduce latency to data access when it is retrieved and reassembled from multiple partitions. Add in the extra communication required between the scaled-out servers as well as the management overhead of a cluster of servers, and the performance cost of the scaled-out solution can become significant. Therefore, as a general solution, sharding can cause as many (or more) problems as it solves. In contrast, a single LinuxONE machine, with its high capacity and performance, can handle large databases in a single system without requiring sharding.

Consolidating databases

One common use case for LinuxONE is to host the consolidation of commercial databases onto a single system. The benefits include increased performance, better throughput of data, and more efficient sharing of resources. Customers have reported consolidation ratios of 10:1 cores or more, which can lead to the opportunity for significant savings in software license fees where these are calculated on a per-core basis. See Chapter 6 for a more detailed discussion of LinuxONE and total cost of ownership (TCO).

LinuxONE as a Database Platform

The Linux operating system has enjoyed success in the enterprise and has a broad and deep ecosystem for databases and applications. One of the benefits of LinuxONE is that it supports many of the popular SQL and NoSQL databases. Many databases are available on LinuxONE. Two of the commercial databases, Oracle and IBM Db2, are among the most popular. Two others, PostgreSQL and MongoDB, are prominent open source databases that can also benefit from LinuxONE's scalability.

The Linux operating system can be tuned to optimize performance of applications and databases. For example, administrators can configure swapping conditions, RAM page size, choice of filesystem to use (ext4, XFS, ZFS), filesystem parameters, as well as many other system features. The scale-up capacity and performance allow many large database workloads to be handled by a single LinuxONE server. Also, multiple databases and applications can be consolidated on a single LinuxONE server for cost savings without a performance penalty. In addition, a database running on LinuxONE can exploit the large memory to hold data.

IBM Cloud Hyper Protect DBaaS

One of the issues keeping many highly regulated businesses from moving to the cloud is the fear of putting sensitive customer data at risk. To address this issue, IBM created the service IBM Cloud Hyper Protect Database as a Service (DBaaS) to provide high levels of data confidentiality. This cloud-based platform provisions and manages cloud databases with strong security features and is built on IBM LinuxONE and delivered through IBM Cloud. The data owner maintains complete control over the data. IBM Cloud Hyper Protect DBaaS includes built-in workload isolation that restricts administrative access so it incorporates tamper protection. In fact, IBM can't access the data within your database service.

Where databases used to be installed and configured by hand, IBM Cloud Hyper Protect DBaaS presents a visual, graphical user interface where you can select a database type (currently, MongoDB or PostgreSQL), a processor class, and security features to apply. One click then creates a cluster of three databases for you, one primary and two secondary, in a controller/follower/follower configuration.

Databases are protected by security features like hardware protected encryption keys (via a Hardware Security Module [HSM]), and IBM Secure Service Container technology. The cluster of three databases provides not only scale-out performance but also redundancy for extra protection of data. Users can monitor their running databases from the IBM Cloud Hyper Protect DBaaS Graphical User Interface (GUI) or use their favorite database-specific management tools. With IBM Cloud Hyper Protect DBaaS, you don't have to be a database administrator (DBA) or database expert to provision highly secure databases quickly and easily.

IN THIS CHAPTER

- Understanding the role of Red Hat OpenShift
- Explaining IBM Cloud Paks
- Introducing IBM Cloud Hyper Protect Services

Chapter 4
IBM LinuxONE as a Cloud Platform

Businesses are turning to hybrid cloud as a way to manage their workloads to support customers and partners. One solution to support all workloads and business situations doesn't exist. Both corporations and cloud service providers (CSPs) are evaluating a new generation of cloud offerings as a solution. In this chapter, you explore IBM Cloud Pak Solutions and Red Hat OpenShift in combination with IBM LinuxONE in a hybrid cloud environment. LinuxONE can be deployed in a variety of cloud use cases, including in the IBM Cloud as the foundation for IBM Cloud Hyper Protect Services or IBM Blockchain Platform.

The Role of Red Hat OpenShift Container Platform

The foundational layer of the IBM hybrid cloud platform is provided by Red Hat OpenShift. Red Hat OpenShift is platform agnostic, runs on multiple clouds and architectures, and has been available for IBM LinuxONE since early 2020. Red Hat OpenShift Container Platform is built on Kubernetes and enables new

cloud-native applications to be developed and existing applications to be modernized. These new and modernized applications are designed for high performance and for the flexibility to respond to customer and market changes. Applications built on Red Hat OpenShift and deployed on LinuxONE inherit the enterprise qualities of LinuxONE, with high levels of security and fast performance through co-location with core data.

Understanding IBM Cloud Paks

IBM Cloud Pak Solutions are an integrated set of solutions infused with artificial intelligence (AI) designed for the hybrid cloud. Cloud Pak offerings are built on Red Hat OpenShift and can run on public clouds, private clouds, and on-premises infrastructure. Cloud Pak Solutions are designed so they can sit on top of any public or private cloud. The benefit of this software abstraction layer is that LinuxONE can become the high-end hybrid cloud platform. For LinuxONE, four Cloud Pak offerings are currently available:

- **Cloud Pak for Applications:** An enterprise-ready containerized software solution that modernizes existing applications and develops new cloud-native applications
- **Cloud Pak for Integration:** A pre-integrated API-based platform to support data integration, messaging and events, high-speed transfer, and integration security
- **Cloud Pak for Data:** Designed to unify data services through an integrated data catalog, open source, and third-party microservices
- **Cloud Pak for Multicloud Management:** A solution that provides consistent visibility, automation, and governance across a range of hybrid multicloud management capabilities, such as infrastructure management and application management.

Additional Cloud Paks will be made available on LinuxONE, including Cloud Pak for Security and Cloud Pak for Automation.

Cloud-optimized software and services

Because Cloud Pak Solutions are based on Red Hat's OpenShift container architecture, several optimized services are part of

the platform. Cloud Pak offerings give you a common catalog of services that increases developer productivity. The catalog helps manage microservices so they can scale both horizontally and vertically. The structure of the catalog makes it easier to govern, deploy, and maintain software and services to support rapid development, test, and deployment. Services that are managed in the catalog include Helm charts, Terraform templates, and Cloud Foundry buildpacks.

Red Hat OpenShift serves as the foundation for Cloud Pak Solutions and incorporates a broad range of managed middleware, data, and analytics services, supporting both cloud-native and existing applications. New Kubernetes services included are Microservices Builder, IBM Watson Studio, security services, and IBM API Connect. Developers can leverage existing application development skills such as Java, Spring, and Open Liberty through the Red Hat Runtimes and IBM middleware. API connectivity and management services make it possible to integrate services across public, private, and existing enterprise environments.

Infrastructure flexibility

The IBM Cloud Pak Solutions environment can operate on any existing hardware environment that supports Red Hat OpenShift, including IBM LinuxONE, IBM Z, IBM Power Systems, IBM Storage, IBM Hyperconverged Systems, and x86-based systems. It also supports a variety of clouds, including VMware, Amazon Web Services, Microsoft Azure, Google Cloud Platform, and IBM Cloud.

IBM Cloud Hyper Protect Services

IBM Cloud Hyper Protect Services is a portfolio of IBM Cloud services deployed on LinuxONE. The portfolio provides advanced security, database, and virtual servers offerings that use the enterprise-grade capabilities of LinuxONE but are available to everyone through the IBM Cloud catalog. These include

- **IBM Cloud Hyper Protect Crypto Services:** This is a fully managed, dedicated key management and cloud Hardware Security Module (HSM) service. The HSM is the only one among several popular compared cloud providers based on FIPS 140-2 level 4-evaluated technology offered by a public

cloud provider. Through this, enterprises can fully manage their encryption keys in the cloud and have exclusive control of the HSMs that protect those keys, which enables a Keep Your Own Key (KYOK) functionality to help achieve more authority over your data.

Multiple IBM Cloud services integrate with Hyper Protect Crypto Services for key management. Additionally, the service can be used as a cloud HSM for application-driven data integrity and to protect data in transit (such as SSL offloading).

- **IBM Cloud Hyper Protect Database as a Service (DBaaS):** This is a cloud service designed to provide highly secure databases on demand, such as PostgreSQL and MongoDB Enterprise Edition. It's designed to provide data confidentiality, security, performance, and reliability for moving highly sensitive confidential data and workloads to the IBM Cloud. Clients can quickly provision, manage, and protect sensitive data workloads.


REMEMBER

The service leverages LinuxONE encryption capabilities, allowing clients to retain their data in an encrypted client database without needing specialized skills. It uses IBM Secure Service Container to provide workload isolation, restricted administrator access, and tamper protection against internal threats. The Docker-based stack inherits security without any code changes. With IBM Cloud Hyper Protect DBaaS, clients can deploy integrated database clusters in the IBM Cloud, manage database instances using APIs, Command Line Interfaces (CLIs) or User Interfaces (UIs), administer database content, and monitor their database environments.

- **IBM Cloud Hyper Protect Virtual Servers:** IBM Cloud Hyper Protect Virtual Servers are the industry's first customer-managed LinuxONE-based virtual servers offering in the public cloud. The offering gives customers complete authority over their workloads and confidentiality of code, data, and business Internet protocol (IP) within a secure environment. Workloads are protected from both internal and external threats, and not even privileged users, such as cloud administrators, can access client data. Finally, a client can easily provision, manage, maintain, and monitor instances in the IBM Cloud using a standard UI.

IN THIS CHAPTER

- Understanding the fundamentals of digital assets and blockchain
- Introducing digital assets
- Enabling blockchain and digital assets with LinuxONE security
- Looking at the deployment patterns behind blockchain and digital assets

Chapter 5
IBM LinuxONE as the Digital Assets and Blockchain Platform

Business leaders are beginning to understand that blockchain is much more than just the technology that underlies Bitcoin and other cryptocurrencies. The core architecture of blockchain allows a means of conducting secure transactions among many participants. The blockchain architecture ensures that the transactions are secure, auditable, and transparent to all stakeholders. Digital assets are blockchain-native assets that are secured using cryptography.

The IBM LinuxONE platform is engineered to provide a broad array of security capabilities, ranging from pervasive encryption to IBM Data Privacy Passports and IBM Hyper Protect Virtual Servers (for more details on LinuxONE security, check out Chapter 2). LinuxONE's depth of security helps applications that are using blockchain perform faster and more efficiently while delivering the highly rated common criteria levels of security through logical partitions rated at EAL 5 level.

This chapter explains how digital assets housed in a private blockchain provide the required security to protect the privacy and security of corporate and customer information. The value of digital assets and blockchain are explained in the context of the hybrid cloud.

Understanding Digital Assets and Blockchain

A blockchain is a digital database containing information (such as records of financial transactions) that can be simultaneously used and shared within a large decentralized, publicly accessible network for public blockchains, or within a private network for enterprise blockchains. In public blockchains (for example, Bitcoin or Ethereum) participation is unrestricted and anonymous. Therefore, nodes don't have a legal identity, are geographically dispersed, and tend to be large networks with low throughput. These properties are in contrast to enterprise blockchains where only selected parties (such as a consortium of banks) can participate. These enterprise nodes are legal entities and tend to be slim networks designed to drive much higher throughput compared to public blockchains.

Before blockchains were developed, a central clearinghouse was responsible for verifying the identity of participants, managing inventory of the product (for example, currency), conducting transactions (purchases), and providing security and transparency. Each party kept its own records of transactions, resulting in delays and expense to reconcile the discrepancies. A security breach of the central authority could be catastrophic, risking the financial underpinning of the marketplace and possibly destroying trust in the business.

The breakthrough for blockchain was to replace a central authority with a distributed consensus model that transformed the centralized database into a "distributed, shared ledger" available to all members of the network.

REMEMBER

To ensure the highest level of security, the system or platform must be separated from endpoint security for both users and devices.

Introduction to Digital Assets

An asset is simply anything of value, meaning that somebody is willing to trade something else for the asset or wants to steal it. An asset can be physical, such as a box of chocolates. Most people think of assets as durable, that they don't expire, but assets are often perishable at least to some degree. Because assets have value, their owners, custodians, and managers want to handle them with care and defend them against thieves. For example, they keep chocolates refrigerated, in locked warehouses, and sell them (trade them for Swiss francs, for example) to chocolate lovers before the chocolate starts growing mold.

Digital assets are non-physical assets ultimately represented as sequences of binary digits (1s and 0s). Because it's technically possible to preserve binary data indefinitely with extreme fidelity, digital assets are nonperishable in a literal sense. However, digital assets can certainly depreciate in value even to zero. Binary data is also technically easy to copy, which results in a significant protection challenge when digital assets are private secrets. Some examples of digital assets include video game software code, digital photographs of celebrities, missile launch codes, as well as codes captured in hotel room key cards that allow time-limited access to hotel rooms, and cryptocurrencies such as Bitcoin.

LinuxONE Security Enables Blockchain and Digital Assets

Both LinuxONE and blockchain emphasize the importance of security to ensure that the business solutions built or running on their platforms are robust and secure from security threats. The threats to digital assets are broad. Threats range from simple carelessness on the part of administrators or operators to sophisticated threats from external players. One of the biggest challenges to protecting digital assets is securing the private key. Additionally, threats occur when code is compiled to build an image that's stored in memory. A common error is for this code to be left displayed, leaving this information open to intruders.

LinuxONE provides a solution to this common problem by providing a secure memory enclave. Rather than leave code to be clear text, LinuxONE builds an image in a secure memory enclave. This secure container service creates a protected memory. Known as *confidential computing,* this approach to securing data stored in memory is critical for creating safe blockchain and digital assets.

While LinuxONE's hardware and software have security benefits for all applications, there are features that particularly benefit blockchain. In this section, we discuss the primary benefits of LinuxONE security in protecting your digital assets.

Built-in encryption

Encryption and decryption have a performance cost, and LinuxONE has dedicated on-chip co-processors for hardware encryption and decryption of data without the typical processing overhead associated with software encryption. The low overhead of LinuxONE hardware encryption enables pervasive encryption to be practical, automatically protecting all data.

Key management

LinuxONE has a security hardware module (the Hardware Security Module, HSM) that supports the storage of private keys required for cryptographic signing in a tamper-resistant module. This is another feature that improves performance and security. These HSMs hold the root wrapping key material that in turn encrypts the user's private keys. The private keys are never presented in clear text within the system, and the root wrapping key material never leaves the HSM.

Workload isolation

Workloads are also isolated on LinuxONE, using the firmware virtualization of logical partitions (LPARs). These ensure near air-gap separation between workloads and have enabled LinuxONE to be common criteria certified at EAL5+, one of the highest commercially available certifications.

IBM Secure Service Container technology

Building on logical partitions is the IBM Secure Service Container technology, which takes workload isolation to the next level by providing a secure computing environment for Linux applications. IBM Hyper Protect Virtual Servers (on premises) and IBM Cloud Hyper Protect Virtual Servers (in the IBM cloud) use this technology to protect data and applications from each other and from systems administrators. We discuss security in more detail in Chapter 2 and IBM Cloud Hyper Protect Services in Chapter 4.

Performance

One of the requirements for blockchain is a sophisticated level of security. Therefore, it's imperative that the deployment platform has the best possible performance so the system performs at the speed demanded by complex blockchains and digital asset management environments. These deployment models require a significant amount of encryption as well as support for hashing algorithms.

REMEMBER

Blockchain workloads use a lot of encryption and hashing in blockchain. LinuxONE handles this level of performance through a number of capabilities, including an on-chip cryptographic accelerator. LinuxONE also provides a high-capacity scale-up environment, with large memory, a dedicated Input/Output (I/O) subsystem, and a large cache available.

Blockchain and Digital Asset Deployment Patterns

Clients are selecting the deployment pattern that best matches their business requirements for blockchain. Some customers are deploying their entire blockchain network on premises while other businesses are selecting a hybrid pattern. Still other companies are operating the blockchain in a public cloud.

TIP

Because of its distributed architecture, blockchain is well suited for the hybrid cloud model and can be deployed both in the public cloud and on premises. The decision on where to deploy blockchain could, for example, depend on if a managed service is preferred for ease of use, or whether government, industry, or corporate regulations mean that data needs to be held locally.

For both cases, blockchain, running on LinuxONE, benefits from the LinuxONE security capabilities, including pervasive encryption, workload isolation, and the additional protection of IBM Secure Service Container technology.

LinuxONE is an open platform for blockchain technologies. Therefore, customers have a choice of deployment models. For example, popular deployments include hyperledger fabric (managed by the Linux Foundation) and the IBM Blockchain Platform. More recently LinuxONE now supports R3, Ltd.'s distributed permissioned blockchain ledger protocol called Corda Enterprise.

There are a number of patterns available for customers protecting digital assets in a blockchain. Digital assets can be managed in a blockchain custody solution. Independent software vendors offer a variety of solutions that leverage LinuxONE and IBM Hyper Protect Virtual Servers. For example, a fintech startup created a smart contract and digital asset offering in order to help businesses store and transfer assets securely. Fintechs may leverage the LinuxONE platform to build and host their digital asset custody solutions, recognizing the security value proposition offered through Hyper Protect Virtual Servers and the Crypto Express HSM.

IN THIS CHAPTER

- Consolidating workloads onto LinuxONE
- Examining higher utilization
- Reducing cost with open source software
- Saving money in additional areas

Chapter 6
The Economics of IBM LinuxONE

You may assume the total cost of ownership (TCO) of the enterprise-grade IBM LinuxONE platform is much higher than commodity servers. However, customers are surprised at the economic advantage of the LinuxONE platform compared to a similarly complex set of applications running in an x86 environment. The economics of LinuxONE become clear when you begin to compare the TCO of a LinuxONE machine versus other servers. x86-based infrastructures tend to have workloads distributed over many individual servers while LinuxONE-based infrastructures consolidate workloads onto fewer LinuxONE cores. The primary reason for software savings is due to per-core licensing. LinuxONE requires fewer cores to run an equivalent x86 workload; therefore, fewer licenses are required. Secondary and indirect costs also have a significant impact on TCO.

In this chapter, we explain how LinuxONE provides cost savings by consolidating workloads, supporting higher utilization, using open source software, and more. We also discuss two business cases where organizations replaced x86-based environments with LinuxONE servers.

Consolidating Workloads

Workload consolidation gathers workloads from multiple servers and runs them on a single, larger server. LinuxONE servers can run many workloads simultaneously and consolidate workloads from x86 servers. The result is fewer LinuxONE servers than the number of x86 servers they replace.


TIP

Consolidation has many advantages. Removing the servers whose workloads are consolidated onto a larger server can reduce hardware costs. Having fewer physical machines to run and maintain can reduce operations costs. Additional savings are gained by the reduction in data center infrastructure resources required, including less networking (because of fewer servers to connect), freed-up floor space, reduced power requirements, and redeployment of staff from administration to innovation. The largest savings typically comes from fewer software licenses due to dramatically fewer processor cores required to run the same work.

Supporting Higher Utilization

Because LinuxONE servers have higher processing, storage, and Input/Output (I/O) capacities than x86 servers, a LinuxONE server will generally support many more active applications than an x86 server. However, that's not the whole story. LinuxONE and x86 machines support fundamentally different levels of CPU utilization.

Understanding the utilization capacities of servers is critical when comparing hardware platforms. Utilization is the percentage of overall processor performance consumed by a computer when running workloads. After a processor reaches 100 percent of processor utilization, no additional processing power is available. Remember that you must plan for application spikes. For example, an application's load might average just 20 percent of the server's utilization, but during brief high-demand periods that 20 percent could spike to nearly 100 percent.


WARNING

When workloads exceed 100 percent of processor capacity, even if from temporary spikes, overall performance decreases as the machine struggles to manage the workloads it can't service. x86 servers rarely sustain high levels of utilization, further limiting available performance. Because exceeding the available processing

capacity is counterproductive, organizations usually over-provision compute resources and limit the number of workloads on machines to avoid bottlenecks.

LinuxONE cores run at high speed and high utilization and contain other performance features that support demanding workloads. LinuxONE cores are also designed to provide sustained high utilization. Therefore, LinuxONE machines have the capacity to handle spikes that near 100 percent utilization without over-provisioning. Further, LinuxONE machines are designed to reach higher average utilization levels, while x86 machines often reserve a large portion of their capacity simply to handle spikes.

THE COST BENEFIT OF MIGRATING TO LinuxONE

A mid-sized financial services organization stood at a crossroads. As it grew, it added more and more servers to its data center to support its database workload. The company had forty-two x86 servers with 1,512 cores. Expenses began to exponentially increase. For example, its software licensing costs increased because the licenses were based on the number of cores. Likewise, networking costs between all the machines ran high. The company knew it had to look at alternatives. It considered the cloud but determined the costs to be similar to, if not more than, the current environment.

The company learned more about the LinuxONE platform and discovered that it could begin consolidating database workloads. To run the database workload, the company needed two IBM LinuxONE Emperor II platforms with 135 cores — close to 1,400 fewer cores than was needed with their forty-two x86 servers. After implementing the LinuxONE the company realized the following savings:

- **Migration:** 50 percent savings
- **Energy:** 86 percent savings
- **Networking:** 98 percent savings
- **Staffing:** 28 percent savings
- **Software:** 89 percent savings

(continued)

(continued)

Although the company spent more on hardware and system software, switching to LinuxONE resulted in a TCO savings of 41 percent, or $12 million, over five years. The company realized savings within the first year, and the difference in annual run rate was approximately $2.5 million.

Using Open Source Software

The accelerating growth of data from mobile devices, social media, and big data activities is exerting pressure on data storage, communications bandwidth, and processor power resources. Using open source operating system and tools on LinuxONE can offer economic advantages over proprietary offerings and a more manageable path to handle the continuing rapid growth of data that organizations handle. There is also a large ecosystem of open source partners and tools. LinuxONE customers can take advantage of a wide variety of free open source tools or lower priced tools, many of which aren't available on proprietary platforms.

LOOKING AT THE VALUE OF SUSTAINABILITY

Understanding the value of a sustainability is tightly linked to the economics of the LinuxONE platform. The single- and multi-frame models are designed with TCO in mind. The design is intended to fit the systems into the cloud data centers to coexist with other platforms in the hybrid cloud environment.

One of the most important characteristics of sustainability requires limiting the amount of greenhouse gas emissions in order to address the impact of human activity on the environment. Many nations have laws requiring compliance with environmental directives that can result in financial penalties. In addition, businesses view minimizing greenhouse gas emission as a way to satisfy expectations of customers. The typical data center can consume as much as 50 times the energy per floor space of a commercial building. Therefore, reducing energy consumption can have a dramatic impact on costs and sustainability.

For example, a global insurance company's data center costs and database and application server workloads were increasing. The insurance company selected a LinuxONE system and decreased costs significantly. The company moved from fifty-five x86 servers to one LinuxONE system. This resulted in an 86 percent reduction in required floor space and a 62 percent reduction in energy consumption. Administration efforts were also dramatically reduced. Overall the company significantly reduced its carbon footprint.

How can your business achieve the objectives of reducing energy consumption? It can invest in an energy-efficient data center design that focuses on addressing the carbon footprint of the hardware, heating, ventilation, and air-conditioning systems in order to reduce electricity consumption. This may be accomplished through better sharing of resources, lowering overall power consumption, and reducing floor space requirements.

Looking at Additional Savings

The robustness, resiliency, and security of LinuxONE have potential to save customers money in other ways by reducing costs associated with downtime, repairs, and security breaches. LinuxONE customers can realize savings in these two areas as well:

- **Achieving high availability (HA):** Enterprise applications require high uptime and use HA to achieve it. HA is provided by maintaining redundant hardware and software environments, often with constant data mirroring. Providing HA can be a costly and difficult process. However, fault tolerance is built into the LinuxONE server, and redundant parts take over seamlessly without staff intervention. Mean time between failures (MTBF) of the underlying technology is measured in decades.
- **Planning for disaster recovery:** In a traditional scale-out environment with potentially hundreds of servers, each server must be replicated in another physical region with constant data mirroring from the active servers to achieve a reliable DR plan. DR is easier in a LinuxONE environment because of the greatly reduced number of servers and associated infrastructure that must be replicated to handle failovers. In fact, with LinuxONE there may be only one or two physical servers that must be maintained along with accompanying failover systems.

LinuxONE DEPLOYMENT AT A BANK

A banking enterprise was experiencing 30 percent year-to-year growth in new accounts and also for transactions from different applications, credit cards, core bank accounts, and peripheral accounts. The company faced frequent server upgrades and additions, which led to a sprawling infrastructure. The easiest approach was to keep doing what it had always been doing, but that created a complex environment that required more people and more processes. DR was another growing concern. If a move to DR was needed, could the business do it confidently? Would all data be accessible at the right speed and within the right amount of time?

After learning about the LinuxONE platform, the company contacted IBM for help. The Chief Information Officer (CIO) explained that the company needed a platform that could scale to avoid frequent upgrades. Key objectives and issues for the client were

- **Achieving scalability:** The company needed an environment that would scale up as demand increased.
- **Increased security:** Data protection was one of the key requirements for everything the company did.
- **Reducing database costs:** With the company's existing scale-out strategy, software licenses for the increasing numbers of cores were becoming expensive.

The client decided to use a phased LinuxONE approach. It started small, moving a few workloads at a time and increased capacity over time to minimize costs. Unlike other architectures, LinuxONE growth can happen without disruption so moving the workloads was simple. The phase-one migration of 20 applications was complete in less than 90 days.

The business was convinced of the technical merits of the LinuxONE solution, but the financial benefits convinced its board. In phase one, the company saw reduced TCO of 40 percent, or $10 million over five years. The largest savings came from reduced application and database license pricing due to a core reduction of ten times for the workloads. The business case also showed that fewer staff members were required, freeing up resources to work on new projects. In the data center, floor space, networking, and cabling were also areas for savings, and those savings were realized in the first year.

IN THIS CHAPTER

- Introducing LinuxONE's open source background
- Delivering innovation and agility
- Recognizing the breadth of software available with LinuxONE
- Using LinuxONE for software development and DevOps

Chapter 7
The IBM LinuxONE Open Ecosystem

Linux is a dominant operating system in the overall computing landscape for both on premises and cloud environments. The IBM LinuxONE open ecosystem includes the broader set of Linux software developed and used by the Linux community. Although many different Linux distributions exist, the vast majority of Linux software can run on any Linux distribution.

In this chapter, you focus on the LinuxONE ecosystem for partners and customers. You explore how open models foster innovative software and how software stability is maintained in the context of constant innovation. You also see how these traits have attracted innovative developers who are creating new offerings on top of the LinuxONE platform.

Open Source

Linux is an established platform for business. Many software developers build applications and tools on top of Linux because the operating system is open source and ubiquitous. By using the open source model, developers from many different companies

around the world have formed a community to continue the evolution and innovation of Linux. For example, Google's Android operating system, used in many smartphones, is based on a modified version of Linux.

Communities work at their own schedules to build open source code. These experts work in collaboration to innovate whenever they can to produce new features and capabilities. Keeping up with the rapid pace of open source software development needs to be balanced with the enterprise need for reliable and stable software that is fully tested and secured.

This need for production-ready, open source software is why many businesses choose open source software with enterprise support. For example, three enterprise Linux distributions that have been certified and tested to run on the LinuxONE platform are Red Hat Enterprise Linux (RHEL), SUSE Linux Enterprise Server (SLES), and Canonical's Ubuntu LTS. In addition, community versions of Linux are available for LinuxONE, including CentOS, Debian, Fedora, and OpenSUSE. By supporting a variety of Linux distributions, the LinuxONE platform gives customers and developers choice.

The Breadth and Depth of Linux

Linux offers the same operating system features one would expect from other platforms, including everything from productivity tools to web and mail servers. Firewalls and other security features are all standard. Because so many organizations are running Linux, the vast majority of software vendors selling significant business applications release versions that run on Linux.

Further, many open source applications and tools are built on, and for, Linux. These tools include hypervisors, languages, runtimes, management, and analytics platform. The Linux distributions that are certified for LinuxONE include graphical tools that make it easy for administrators to add various development tools and software.

REMEMBER

Open source software is free (although there may be a charge for support and service), so you can try a variety of tools to see which works best for your business. In addition, like Linux, many of the open source tools have enterprise versions. LinuxONE offers support for a variety of the key Linux distributions, including Red Hat Linux, Open SUSE, and Ubuntu.

LinuxONE as a Development and Deployment Platform

LinuxONE supports a broad ecosystem of third-party tools and languages. Linux has always offered many tools for developers, and the quantity and quality of these tools have grown over the years.

Today, a developer can install Linux with its development options and have everything needed to code, test, and package software. Linux also includes other tools needed to design, develop, and deploy software. Organizations that are creating a development, security, and operations (DevSecOps) process will find a wide variety of tools designed to support their practice. LinuxONE also supports a broad set of enterprise programming languages such as Python, Ruby, C and C++, Go, Swift, Java, and Lisp. Scripting and other interpreted languages are also available, including shells, PHP, perl, awk, and others.

Beyond programming languages and integrated development environments (IDEs), LinuxONE supports open-source relational databases (PostgreSQL, MySQL, and MariaDB) and NoSQL databases (MongoDB, Cassandra, Redis, Apache Hadoop). Databases such as these are able to take advantage of the scalability and performance of LinuxONE and avoid the need for sharding (we discuss this in Chapter 3).

Because of LinuxONE's enterprise architecture, some applications may need to be recompiled for LinuxONE. Other applications, such as those written using interpretive languages (for example, Java or Python), should be able to run on LinuxONE without needing to be ported. Most recently, Linux containers and Kubernetes have become popular with both developers and IT operators, and these are also supported on LinuxONE — including through Red Hat OpenShift.

Focusing on development processes, Linux also includes source control systems and bug tracking/issue management software. Finally, many commercial software products are also available for LinuxONE, including Oracle database, Temenos T24 core banking, IBM Financial Transaction Manager, IBM middleware such as Db2 and WebSphere, and Jira, one of the top tools used for agile product management.

LinuxONE as a DevSecOps Platform

Many organizations are moving to using a development, security, and operations (DevSecOps) approach. Rather than keeping development, operations, and security separate, DevSecOps combines them into a single practice. Many companies have already developed DevOps practices, and DevSecOps is the next step. DevSecOps begins with a change in culture founded in ongoing learning (to raise security awareness with developers who may already be entrenched in DevOps processes) and the empowerment of security experts to determine the best ways to embed security into applications.


TIP

The benefit of DevSecOps is that you have higher-quality, fully tested code that's more secure and released more quickly than traditional development methods. LinuxONE is a good platform for DevSecOps because the platform is designed to be secure, and development and production systems can safely be run on the same server through workload isolation and container support.

Although DevSecOps is largely about changing your corporate culture and processes, a successful implementation does require technology and tools. Because many independent organizations are creating tools for Linux, you are able to take advantage of best-of-breed tools and software. DevSecOps depends on the ability to quickly and conveniently create new virtual servers for test and staging areas, deploy test instances with secure containers, and scale up production instances to handle changing loads. These tasks are routine for LinuxONE, making it an ideal platform as part of a DevSecOps practice.

LinuxONE for Solution Providers and Cloud Service Providers

LinuxONE is gaining a growing foothold as a platform for solution providers (SPs) and cloud hosts who deliver cloud and application services and provide data center management for clients. SPs can leverage this highly optimized open Linux platform to quickly build and deploy environments clients need to run their businesses. By using familiar applications, the IT specialists can design systems in secure containers assigned for one or multiple individual clients, providing privacy and security that clients demand, while simplifying life for developers and satisfying ongoing service level agreements (SLAs) from a single LinuxONE system. In turn, the system provides a platform that supports cloud-based usage reporting so SPs can leverage monthly pricing models and easily increase customers' IT resources as needed through planned business growth or routine computing spikes.

SPs also look to LinuxONE as a preferred platform for consolidation — for Linux application environments, managed growth, and optimized utilization for x86 distributed server farms and to manage large open databases like Oracle with intelligence and improved total cost of ownership (TCO) in mind. The inherent benefits of the platform and built-in security allow the SPs to start their work on a proven, trusted cloud-ready infrastructure, which increases speed to market and quality of IT overall.

IN THIS CHAPTER

- Meeting your organization's computing requirements
- Securing all your data and applications
- Supporting the LinuxONE platform

Chapter 8
Ten Reasons to Consider IBM LinuxONE

Selecting a platform that protects your business and customer data and supports innovation can be difficult. You need to consider many issues when making a decision. The IBM LinuxONE platform may be a good choice for the following reasons:

- **Hybrid cloud:** The availability of Red Hat OpenShift and IBM Cloud Pak Solutions on IBM LinuxONE brings together the world of cloud-native applications and services with that of enterprise data center IT. Red Hat OpenShift applications can be developed once and deployed anywhere, including on LinuxONE where they inherit the system's underlying security, scalability, and resilience.
- **Security:** Having security at the application layer or infrastructure level is no longer enough — you need protection at *every* level of your environment. Security needs to range from securing your cloud assets to data at rest and data in transit to your container platforms.

- **Scalability:** Meeting increasing customer demands and creating new services mean that the size and complexity of your workloads is likely expanding. LinuxONE's scale-up approach allows you to meet expanding needs without adding additional hardware and complexity.
- **Capacity:** You can't always anticipate how much computing power you need. Adopting a system that can support compute-heavy workloads is an important step in protecting your infrastructure investments.
- **Manageability:** The centralized approach of LinuxONE can be much easier to manage than complex distributed systems.

  
  WARNING

  You can experience performance problems if you have too many systems trying to communicate across the network. Management can be impacted if critical operations aren't effectively coordinated.
- **Costs:** Your existing IT infrastructure servers are likely underutilized, and your staff costs are high. If you can reduce costs, budget can be allocated toward innovation.

  
  TIP

  The LinuxONE platform dramatically supports sustainability and cost reduction by reducing power usage.
- **Blockchain distributed ledger and digital asset applications:** In order to protect your intellectual property and customer data, you need a highly secure approach that supports a transparent, trusted chain of custody.
- **Innovation:** To compete in fast-moving markets, you need to innovate and leverage new technologies, including containers, analytics, and artificial intelligence (AI). Get a platform that combines the latest innovation in software with secure and scalable systems of record.
- **Linux and open source:** Open source and the Linux operating system drive innovation and efficiency for your organization. The LinuxONE platform supports the three most common Linux distributions.
- **Differentiating your cloud services:** As a service provider, you need a platform that's scalable and secure enough to differentiate your services from those of competitors. You want your teams to focus on innovation and customer needs, not the underlying platforms.

IBM LinuxONE: A secure open platform

To be successful, businesses must select a secure, scalable, and reliable computing platform. At the same time, they also demand openness so development teams can select the tools and technologies that they're skilled in using. The LinuxONE system provides security at every layer of the computing stack, while giving developers the flexibility that they demand. In this book, you discover how the IBM LinuxONE platform can play a critical role in your enterprise computing and open hybrid cloud.

Inside...

- Digitally transform with LinuxONE
- Deploying a cloud on LinuxONE
- Maximize your IT budget with LinuxONE
- LinuxONE as the blockchain platform
- Securing digital assets with LinuxONE
- Scale up design to meet business needs

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