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Scale up for Linux on LinuxONE

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LinuxONE

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Scale up for Linux on LinuxONE

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First Edition (July 2019)

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Preface

This book was written by IBM® IT specialists who have experience implementing Linux solutions on IBM LinuxONE™ (LinuxONE). The contents of this book follow the guidelines from Linux regarding LinuxONE installations. The preferred practices that are described in this book are gathered from the experiences of those specialists in hundreds of projects at IBM and customer environments.

This IBM Redbooks® publication provides you with the information needed in making a decision on scaling architecture when implementing Linux on LinuxONE. This book has the following goals:

- To inform you about x86 sprawl problems
- To inform you that x86 Vertical Scale out architectures are problematic going forward
- To provide solutions to x86 server sprawl problems
- To inform you about the LinuxONE solution for each x86 server sprawl problem
- To provide virtulization and security options for LinuxOne

The scaling up and scaling out architectures enable you to scale the capacity of an existing system to accommodate sporadic application demands or application workloads. This provides some freedom to operate in the environment. However, if this activity is performed without correct planning and the correct architecture choice, it leads to server sprawl where your environment houses more servers than it should based on its current and predicted requirements. This can potentially cause your enterprise to both waste resources and increase costs.

Although scaling out on x86 systems is a common form of growth because of inexpensive x86 systems, the scale out can easily become a problem in terms of total cost of ownership (TCO) when the environment starts to increase the number of physical servers and the resources needed to maintain them.

LinuxONE servers solve the sprawl problem caused by the scaling out of x86 servers, and are an excellent choice for cloud, mobile, big data, blockchain, analytics, and other workloads that require a robust and flexible environment.

This publication describes the advantages and disadvantages of the LinuxONE scaling option.

The audience for this publication consists of the following groups:

- Customers, IBM Business Partners, IT architects and IT Specialists planning and installing Linux on LinuxONE
- System administrators managing the Linux Systems

If you are looking for solutions using LinuxONE as a platform for your applications (analytics, blockchain, cloud, or other) the following web sites can provide more information about the advantages of server consolidation on LinuxONE:

- IBM LinuxONE solutions
- IBM LinuxONE Redbooks

Authors

This paper was produced by a team of specialists from around the world working at the IBM Redbooks, Poughkeepsie Center.

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Introducing the LinuxONE platform

In the digital era, businesses are demanding optimization of IT resources, focusing on workloads. It is a challenge to scale the environment when the workload increases. Server sprawl is a growing concern in data centers today.

Usually, server sprawl is associated with typical x86 scale-out environments because they had an uncontrolled proliferation in past years, and also because x86 technology was the first choice for many organizations. The x86 architecture is designed to only scale out, which exacerbates the server sprawl problem.

In this chapter, we explain why LinuxONE became the popular choice to deliver more applications and services, and as an important component to support compute-intensive Business Analytics and big data workloads. LinuxONE helps to consolidate hundreds of underutilized systems onto a single machine. It also helps your application use all of the platform benefits.

We also introduce the differences between the scale-out (horizontal) and scale-up (vertical) architectures and discuss the benefits of the IBM LinuxONE platform in both types of scalability.

This chapter includes the following topics:

1.1 Scale-up and scale-out definitions

When a system or an application reaches its maximum capacity, the system administrators have some options to make it scale to improve performance or add capacity for a new application feature. Knowing the strengths and weaknesses of each option enables them to make the best decision to improve a system that is expensive to operate, prone to errors, or difficult to support.

New workloads, such as cloud computing, the Internet of Things (IoT), and mobile applications became common across organizations around the world. The importance of having an agile infrastructure with a faster way to respond to changing demands is a key element for success. Scaling an application to support new functionality or building a new system is not a trivial task. It requires huge efforts to ensure that everything is correctly implemented without a system outage.

Application owners (AO) require less time to create server instances and add new system resources to help them deploy new applications and workloads faster and more frequently, with no need to wait for weeks.

Infrastructure must be flexible and enable the AOs to manage scalability where new workloads are needed, and when they are no longer required. Therefore, one of the biggest features of the infrastructure is the ability to scale. Scaling can be accomplished in two ways: *vertical scaling* and *horizontal scaling*.

Scale up (or vertical scaling) is the method to enlarge the capabilities of a single system and increase the capacity of existing hardware or software by adding resources to the system. Adding processors, memory, or any other resource also are examples of scale up. This type of scalability is limited by the size of the server.

Scale out (or horizontal scaling) is the method of adding more hosts to a tier instead of increasing the capacity of the current system. It is typically the ability to scale larger to deal with a new workload. Usually, the system resources are spread across multiple servers (called *clusters*). Spreading the resources reduces the load on a single system to increase the availability, which avoids a “single point of failure” problem. Therefore, system reliability is improved.

From an architectural perspective, the base environment scale-out essentially is many nodes that work together to provide an aggregated performance that cannot be achieved by making a single large node work on its own.

New application demands, budgets, smartphones, and other digital devices are driving the definition of scale-up and scale-out architectures today. Some “horizontal” applications, such as data analytics, can use f the scale-out approach to increase performance and provide availability. The scale-out is many nodes that work together to provide an aggregated performance that cannot be achieved by making a single large node work on its own.

When a system administrator must grow the infrastructure from two systems to five or more to support a mission-critical workload, they use the scale-out approach, which increases availability even if one of the servers crashes. If a crash occurs, you usually lose only a minor portion of the virtual infrastructure, as opposed to losing the entire cluster.

The main idea is to aggregate enough computing power to support large operations and complex applications by using more than one node. Scale up and scale out require planning and ensuring that the resources are available and the architecture where applications run can handle the scalability.

On the LinuxONE platform, applications can be scaled out or scaled up with superior performance and security by using virtual Linux servers. LinuxONE can use the best of both architectures.

1.1.1 Scaling up (vertical)

Vertical scaling is often used to address the growing demands of an application, where a system administrator can scale an application capacity up or down according to application business needs. The scale-up approaches have been around longer and are more familiar to administrators. They generally offer a good feature set and functionality to meet their purpose. It is commonly used when a server with high load needs more resources or when the application owner must run an extra critical workload in a determined period.

However, on a platform that cannot scale-up, resources cannot be freely added without affecting the overall performance of the server. Another crucial point to consider before scaling up an application is related to the platform on which the application is running.

With the LinuxONE platform, the CPU usage can run at over 90% for sustained periods without fear of failover. Alternatively, x86 typically runs at 40 - 60% utilization, which in turn requires more server cores and memory to meet scaling requirements.

The advantages and disadvantages when the scale up architecture is used are listed in Table 1-1.

Table 1-1 Overview of common pros and cons that are associated with vertical scaling

Pros	Cons
Simplify management-flexible to resize a virtual server	Hardware is more expensive than scaling out (specialized servers)
Reduce energy and cooling consumption	Sometimes hard to upgrade a node (application outage is needed)
Optimize the floor space, which minimizes the number of physical nodes	Need reliable hardware, increasing the hardware complexity
Optimize resource utilization	
Reduce intrusion points (tighter security)	
Reduce license fees	

LinuxONE is designed to run at high CPU and I/O utilization because of the balance between CPU performance, I/O capabilities, and access to memory. It is possible to reach 100% of utilization of CPU in the LinuxONE, but it is not recommended for extended periods because it does not leave room for temporary workload spikes or for any sort of recovery processing that might need to be done if a subsystem failure occurs.

LinuxONE is virtualized and provides tools that increase virtual resources, such as processor and memory, without an outage, which improves the availability of the workload during runtime.

Figure 1-1 shows the scale up architecture with LinuxONE.

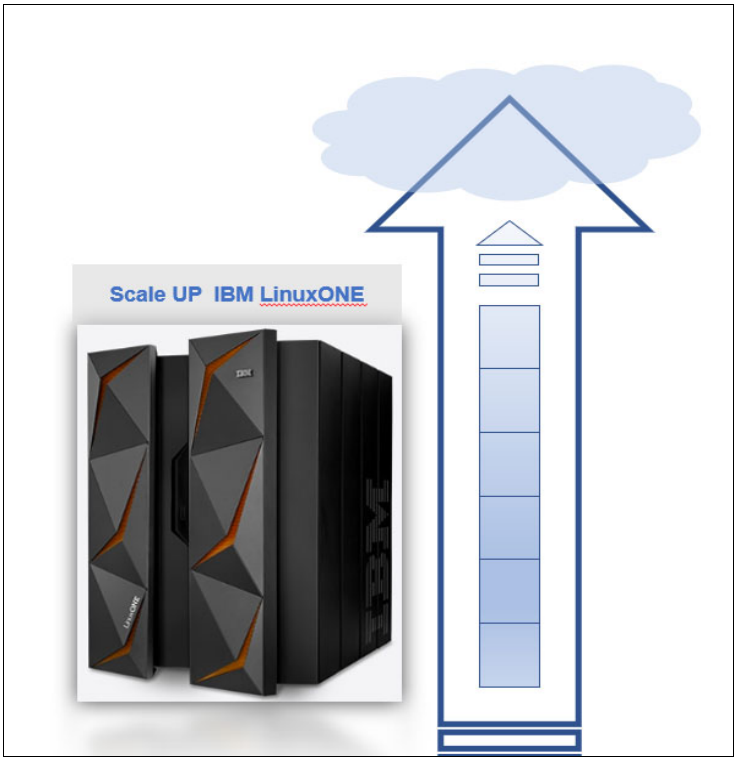

Figure 1-1 Scale up with LinuxONE

1.1.2 Scaling out (horizontal)

Some cloud-based applications require HA, flexibility, scalability, and granularity. The most important and compelling advantage of scaling out is to increase capacity dynamically by adding physical or virtual machines and providing redundancy. If more resources are required to improve performance or provide HA, a system administrator can scale out the system by adding servers into the pool.

The advantages and disadvantages of horizontal scaling are listed in Table 1-2.

Table 1-2 Overview of common pros and cons that are associated with horizontal scaling

Pros	Cons
Typically easy to expand the farm, buy, and add node	Requires more power, cooling, and floor space in the data center
Easy to run fail tolerance	Increases complexity and the points of failures
Safe to perform upgrades on nodes that are in the cluster in high availability environment (no application downtime)	Increase in latency because the high dependency of the network
From a hardware perspective, the nodes often are lower in complexity and cheaper	More license fees
	Generally requires software for clustering to implement high availability
	Increase the intrusion points
	Increase the management

For example, adding inexpensive commodity computers to a cluster might seem to be a cost-effective solution at first glance, but it is important for the decision makers to know the other costs that are associated with those extra servers, such as labor, licensing fees, floor space, network infrastructure, and electricity for power and cooling.

A typical scale-out data center is shown in Figure 1-2.

Figure 1-2 Scale out data center

1.2 LinuxONE versus distributed x86

Linux is an Open Source, multiplatform operating system that is used by businesses around the world for various workloads. Many characteristics make Linux popular in the server market and its use is growing from small to large companies.

Mission-critical applications that are running on Linux placed greater requirements on the underlying server hardware for security, resilience, and scalability. The challenge for the decision makers is to decide which platform is best to run Linux, comparing the benefits and disadvantages of each platform.

LinuxONE is enterprise-grade hardware with a unique architecture that meets the needs of small and large businesses. It brings together IBM's experience in building secure, resilient, and scalable systems with the Linux operating system.

One of the major advantages of LinuxONE is the ability to consolidate hundreds of scaled-out distributed servers onto one machine. Because of LinuxONE's hardware architecture, it is possible to run 8,000 virtual machines (VMs) within a single system (optimally, 350 - 8,000 VMs), which achieves some peaks of 100% system utilization.

With its massive hardware capabilities, LinuxONE can handle 1million Docker containers without slowing down. When Node.js and MongoDB are used, LinuxONE can handle over 30 billion web events.

1.2.1 LinuxONE workload utilization

LinuxONE combines HA with great scalability and resilience. The redundant hardware of Rockhopper II or Emperor II is a high-performance machine with high utilization that combines high clock-speed (5.2 MHz) Integrated Facility for Linux (IFL) processors with dedicated I/O processors that offload I/O from the IF. LinuxONE also is designed to operate at near 100% utilization. In contrast, x86 machines must operate at relatively low utilization levels (less than 50%).

This high utilization makes a difference for mission-critical applications that require resilient hardware to deliver greater performance during peak access times.

1.2.2 x86 sprawl problems

Server sprawl typically refers to the number of underutilized computer systems that are running in a data center. As the number of physical systems increases, the costs to manage it become more expensive and requires more efforts from support staff to keep the environment running and compliant with security standards.

Server sprawl often is associated with typical x86 scale-out environments because the hardware is not designed to scale up.

A typical x86 scale-out environment is shown in Figure 1-3.

Figure 1-3 Typical x86 scaled-out server farm

1.2.3 Reducing costs with LinuxONE

Research that was produced by the Robert Francis Group (RFG) in 2015 provides evidence about how IBM LinuxONE is a better choice than the x86 platform. The information that is presented in this research demonstrated LinuxONE as the most reliable and scalable computing platform available, and is ideal for consolidating hundreds of distributed servers. The reason is because these platforms deliver on the promise of a flexible, secure, and intelligent IT architecture that can be managed seamlessly to meet the business requirements.

LinuxONE hardware is prepared to scale up and scale out, which fits the needs of the business and optimizes the infrastructure costs. It has compelling total cost of ownership (TCO) and total cost of acquisition (TCA) metrics that show considerable cost savings over the x86.

Note: The ability to scale out on an x86 platform can easily become a problem in terms of TCO when the business grows in a way where hundreds or thousands of nodes are running a popular application in Linux. That is, a system administrator can replace these hundred or thousands of x86 servers with a single LinuxONE box. This simple choice can substantially reduce TCO.

IBM LinuxONE reduces costs in the following ways:

- Reduced licensing fees

  Databases, operational systems, application servers, and management software in a current distributed server farm can be licensed more cost effectively by using the powerful IBM LinuxONE processors, which optimize the use of main processors Integrated Facility for Linux (IFL)[1]. The costs savings arise because LinuxONE hardware can use processor time more efficiently compared to x86 and the licensing fees are charged by core (similar to distributed environment).

- Reduced risk of downtime

  The LinuxONE hardware is redundant and provides advanced virtualization features, such as single system image (specific to IBM z/VM® Clustering) and Live Relocation.

- Save energy and be green

  LinuxONE can consolidate hundreds or thousands of servers in a single box. Therefore, the energy and cooling costs can be reduced by 75% in comparison to distributed environment.

- Save labor costs

  The complexity of maintenance of the environment is decreased because many virtual servers are in a single box.

The LinuxONE main processor (IFL) is offloaded by specialized processors, which enable LinuxONE to work more efficiently. From a costs perspective, it is classified by many software vendors as a single core. It generates significant savings by consolidating multiple workloads servers to a single LinuxONE processor.

1.2.4 Total cost ownership versus total cost of acquisition

CIOs have a significant challenge to choose the best infrastructure versus lowest price to run the workloads. For many reasons, mainly budget limitation, they often based the costs in a total cost of acquisition (TCA) study, negating the TCO. This can be out of control and exponentially increase the overall costs.

For a complete study costs, enabling the decision makers to have a big picture of the IT costs through the years, the TCO study must cover all components necessary to run the workload, including the following components:

- Hardware
- Software licensing
- Energy
- Hardware maintenance
- Floor Space
- Asset depreciation
- Labor

The TCA contains the instantaneous costs during assets acquisitions. As part of TCO information, it does not cover the monthly costs and the asset depreciation. Instead, it focuses on only the acquisition of IT components, such hardware and software. It is common to see applications and Linux workloads that are deployed in x86 systems because of their low price, but the hidden costs keep growing. The costs can be considerably higher if you consider other factors, such as system availability, support, licensing, reliability, scalability, and performance.

[1] The IFL is similar to a manager that offloads the workload to specialized processors.

For more information about the best return on investment (ROI) and technical solutions for your workload, see IBM IT Economics - TCO Studies.

Some CIOs and SAs assume that a x86 server is cheaper than other platforms, including LinuxONE, and that the TCA study is enough to assess the overall costs. However, many other costs are discovered after the acquisition. In addition, the x86 architecture disadvantages can become increasingly onerous when the number of physical servers in a data center reaches a point where the system administrator can no longer manage them effectively.

It is possible to receive a personalized TCO estimate and determine how much you can save with the LinuxONE platform. The LinuxONE TCO Calculator tools helps decision makers to compare the TCO of both platforms for 3, 4, and 5 years. The IBM LinuxONE TCO calculator tool is shown in Figure 1-4.

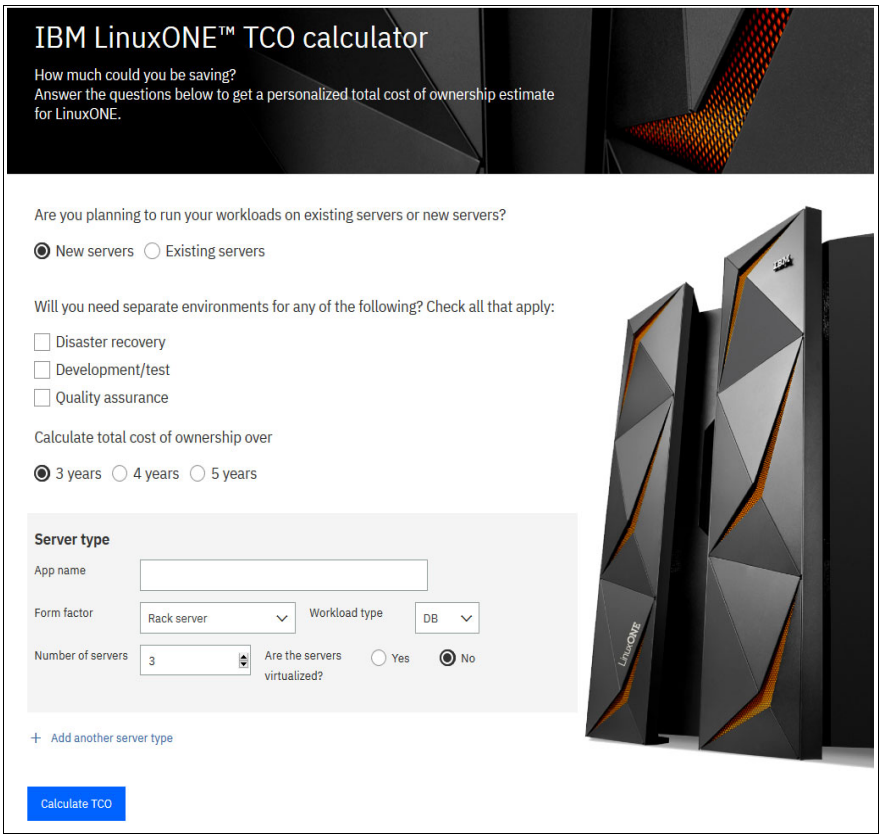

Figure 1-4 IBM LinuxONE TCO calculator

Figure 1-5 on page 13 shows an example of TCO study between the x86 and LinuxONE platform. This study included the following workloads with respective x86 servers:

- Three dedicated database servers (physical)
- Eight dedicated application servers (virtual)
- Five servers mixed workloads (virtual)

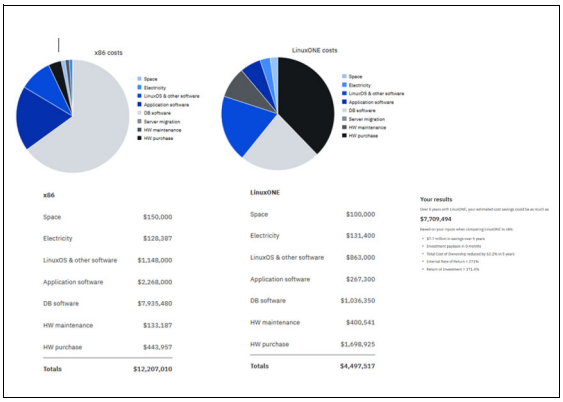

Figure 1-5 TCO sample that is built in the TCO calculator

The 16 x86 servers that are shown in Figure 1-5 were compared with one LinuxONE; that is, enable to consolidate all workload into a single machine.

Linux has been a major factor in IBM for years now, and this new venture for LinuxONE is based on robust computers, which process high-volume transactions with fast I/O. The Linux applications can use the strengths and reliability features of the IBM LinuxONE hardware, and use the I/O speed, security, scalability, and availability. The server consolidation onto the new machines allows the complex applications to use the efficiencies of LinuxONE, and provide the flexibility of a bottom-up provisioning capability.

Also, the platform delivers various tools for systems administrators to help keep the Linux-based services running at the most optimal level, and to use resources efficiently to react quickly to challenges and opportunities. The fact that Linux on LinuxONE runs in a virtual environment does not affect the task of porting an application. IBM chose the LinuxONE platform to centralize and consolidate IT workloads, which significantly reduced costs, improved availability, and achieved better performance and utilization.

1.2.5 Scaling up x86 servers issues

Business innovation is forcing organizations to establish a flexible infrastructure where a server can be quickly built in a few seconds and quickly deleted when it is no longer needed. Following this need further, new applications are demanding resilience and availability,

Although the x86 servers became more efficient and powerful, they faced some architectural design challenges to scale compared with other platforms, such as LinuxONE. The x86 vertical architectures are problematic going forward, and can lead to performance inefficiencies when applied to modern applications, such as analytics, cloud, and big data, because of the following reasons:

- Increase data center space and cooling

  New workloads or capacity means new servers.

- High power demand

  More servers means more power.

- Lack of resilience

  Difficult to upgrade physical servers when production applications demand 24 x 7 availability. It also means application downtimes.

- Short Hardware and software lifecycle

A technical refresh is needed when the end of license (EOL) is near and a replacement is required.

- Increase labor costs

  More system administrators.

- Increase security breaches

  Updating many servers to fix a security exposure can be a difficult and complex task.

- Licensing fees lead to higher costs.

- Lack of redundancy

  Providing HA results in more servers that are concurrently running the same workload (clustering).

The x86 server issues are compounded because each server has licensing, support, security, and compliance issues. The system administrator must know how many servers are running on a network, where their storage is, what software or operating system licenses are associated with them, and who deployed them. Other not obvious costs include increased infrastructure costs (hidden costs).

The number of new servers that is added to the data center directly increases the electrical and cooling costs, in addition to increased requirements for floor space and networking. This phenomenon is commonly known as server sprawl, and is one of the top worries of many businesses and organizations today.

It is common to deploy each application on its own server, but it might result in an inefficient system without financial benefits. The organizations often face issues to keep the operation from running at top performance because of sprawl challenges. The x86 server sprawl caused high maintenance, power, and cooling costs, and more space in the data center.

Large data centers face several major issues. The most critical is their complexity, which requires highly skilled and experienced personnel to manage and control the environment. Other considerations include their power and cooling requirements, and the challenges of managing the lifecycle of so many assets. For example, when old servers are retired, are they turned off and removed from the data center? Alternatively, are they left continually powered-up with nothing running on them because no one is sure if any workloads are running on them?

In general, the number of x86 servers in today's data centers has grown, which in turn leads to enormous challenges in designing an efficient and cost-effective data center infrastructure.

The issue with x86 scalation is shown in Figure 1-6. To scale up the application, an x86 require more servers, which increases complexity and costs.

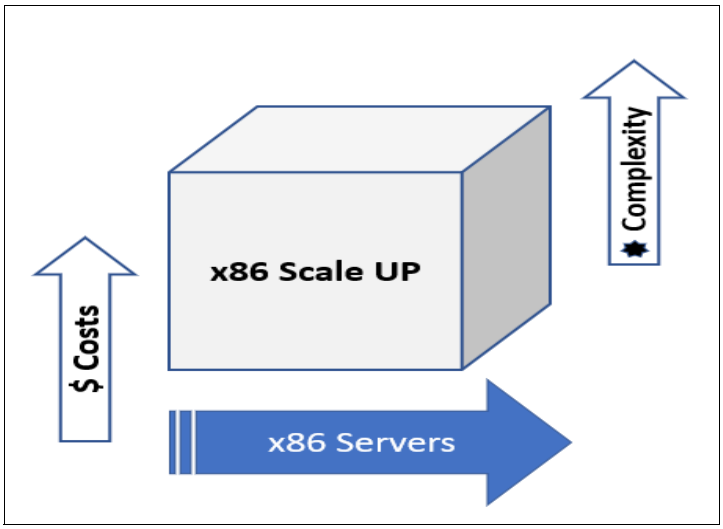

Figure 1-6 x86 Scale up

Server sprawl must be considered because the issue affects many organizations and data centers around the world today. It is time to begin considering a range of increasingly vertically and horizontally converged solutions that vendors are offering for mission-critical applications.

1.2.6 Data center floor space

This issue is a critical factor that must be considered when planning the infrastructure for an application. To respond to a new application or to data growth, most decision makers choose to add a system into the data center by default. As a result, more space is needed to accommodate the new racks, cabling, switches, and servers. These components must be considered when deploying or resizing an application.

The decision makers also must consider all data center functions and space requirements before designing final architecture plans and determining a budget for the data center building space.

Consolidation is the key to resolving data center management challenges and act efficiently to manage the new demands. The LinuxONE adds and delivers services faster and more efficiently to shrink those server farms back to a manageable size.

Organizations also must develop a plan to support the cloud, mobile, and big data applications while freeing up space in the data center. Power and cooling requirements also must be reduced. This issue is the main challenge today.

The migration of the x86 servers onto a LinuxONE platform entails the use of the classic strengths of the IBM LinuxONE solutions, such as high availability (HA) with zero downtime, high I/O bandwidth, the capacity to run diverse concurrent workloads, a high level of security, and a superior disaster recovery environment. Therefore, considering the Linux on LinuxONE as the default choice makes it the ideal platform for Linux consolidation, which reduces the use of space.

Traditionally, applications that are deployed on x86 distributed systems feature hundreds of servers that occupy a large area in the data center. Therefore, managing an environment such as this type of data center can become a nightmare.

The consolidation onto a LinuxONE platform appears to be the long-sought remedy for x86 server sprawl and space problem. So, moving the distributed x86 servers to virtual machines (VMs) decreases the number of physical servers that is required in a data center, which results in significant data center space savings. Also, the number of network connections, network switches, and other connections that are needed for the x86 servers are reduced because an LinuxONE machine can accommodate them by using only a few connections and specialized components.

Scaling out your environment by using distributed servers seems to occupy more space in your data center and increases the sprawl problem. However, consolidating the physical servers and scaling up onto an LinuxONE platform can allow more applications to occupy the same square footage area in your data center, which results in significant cost savings.

1.2.7 Energy on data center

Energy consumption grows substantially in scale-out environments. Although the IT platforms evolve in energy efficiency, the workloads are requiring more capacity, and in the case of x86, more servers. To achieve power efficiency in your data center, the first step is to solve (or minimize) sprawl problem that is caused by many servers in the data center.

The data centers are not immune to power outages. The high number of servers in a data center increases the risk of voltage surge and can result in damage to hardware, including network devices and storage units, which is problematic for users and providers.

By consolidating many servers in a single box, the LinuxONE server can significantly reduce the strain on energy consumption risk and minimize the power issues when compared with distributed systems.

The IBM LinuxONE machines (Rockhopper II and Emperor II) are energy-efficient and save up to 75% on energy costs compared to x86 alternatives. These platforms are a good choice when power efficiency is needed without losing performance and are the strongest platforms to take better control of energy usage in your data center.

Figure 1-7 shows the benefits of consolidating distributed servers onto a single LinuxONE. The gains in space and energy are significantly high compared with the x86 platform, which makes the LinuxONE platforms the best choice for Linux servers and critical workloads.

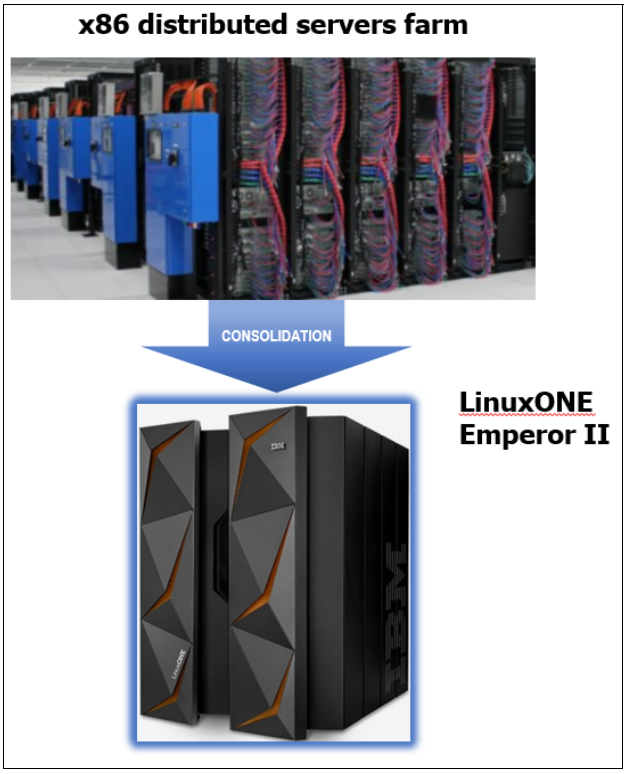

Figure 1-7 x86 scale-out infrastructure consolidated to a single LinuxONE machine

1.2.8 Cooling

Cooling is another important part of a data center's infrastructure that must be considered. Although many people still believe the LinuxONE platforms are more expensive than x86 distributed systems, this assumption is not always accurate. Many studies show that LinuxONE servers can reduce power consumption and cooling costs by up to 40%.

It is essential that data centers measure how much energy they use for non-computing functions, such as cooling. Several factors account for effective data center cost, but the number of servers per square meter (density) and power consumption are responsible for a good part of it. For more effective data center management, the hidden costs must be considered.

Remember that each server takes up space. Although this issue might seem harmless, those systems are added so rapidly that their use of space, power, and cooling becomes a major challenge in a distributed scale-out environment.

Although the servers are well-organized in racks, as shown in Figure 1-2 on page 9, the number of x86 systems is higher when is compared with LinuxONE. Also, you likely need more cooling and more space to cool them.

LinuxONE was developed to be the coolest-running processors, with less power consumption and cooling costs than the distributed scale-out systems. For more information about the LinuxONE machines, see this web page.

1.2.9 Flexibility

At the first sign, the upgrade of an operating system or an application seems a simple and quick task. However, upgrading 100 (or 500) increase exponentially the complexity and spend much time and mostly cause system outages. Thex86 scale-out architecture is the lack of flexibility to perform required updates and changes. Usually major upgrades require restart. It spends time because the support team need to negotiate with the users. One option in x86 environment is to create a HA environment, but this effort requires 2x more machines, increasing the costs and complexity.

Also, some required updates must be applied quickly to close security software exposures and keep the system safe from cyber attacks. Therefore, the number of x86 scale-out servers in your infrastructure can directly increase your security problems and make things even more complex.

The LinuxONE provides a 100% virtualized environment, including the z/VM SSI features that allow it to migrate resources between two LinuxONE machines. During the software update process, the virtual server can be moved to another hardware, which avoids system outages.

1.2.10 Hardware and software lifecycle

As part of this ongoing evolution, the hardware and software is periodically discontinued. This issue provides straightforward product lifecycle policies that help you better design, deploy, and manage your environment.

Whatever your application deployment strategy might be, it is important to decide when your servers and software are obsolete and have a good plan to refresh them. Upgrading your assets too early, or waiting too long for upgrades, might be risky to your business and return on investment (ROI).

Today, hardware and software asset administration is much more complex to track, manage, and support. Without good inventory control, you can face challenges to manage your infrastructure, which can lead you to disorganized workflows, wasted time, and unnecessary delays. That is, these situations can affect the entire organization.

Although the x86 scale-out architecture is common in the distributed world, their high numbers of small servers and difficult inventory control management can create problems. The reason is that you need more time and effort to track your hardware details and software assets, such as version, installation date, latest software updates, purchase date, usage, warranty expiration date, and location for every server. As the number of servers grow, the negative effects grow more rapidly than do the positive effects.

The LinuxONE scale-up architecture can help to simplify your infrastructure, making your asset inventory control and organization much easier and more accurate. Also, server consolidation onto the LinuxONE helps you eliminate the x86 sprawl problems and effectively use your resources to meet growing business needs, without increasing the data center’s footprint.

With adoption of a LinuxONE solution and its virtualization technology, you can expand your services without adding any hardware. Although scaling up can seem expensive, it does make it easier to control your systems. Also, scaling up provides better cost savings when compared to the x86 platform, including costs that are related to cooling, data center space, inventory control, and others.

1.2.11 Support

The administrative labor that is required to support hundreds of x86 scale-out systems is normally significantly high, and usually requires special administrative skills from the technical teams to keep the environment running at top performance. The nature and number of workloads changed the way that system administrators support their environment because they must learn about new technologies quickly, and then try to reduce operational costs by their implementation.

One of the most obvious differences between scale-out and scale-up architectures is the cost perspective. Both depend on the technical support teams to ensure that the system infrastructure works as expected. However, the distributed scale-out approach creates a more complex infrastructure where every server needs to be purchased, configured, and operationally managed. This approach requires more system administrators, which results in higher operational costs and less efficient use of resources.

In fact, creating and maintaining a high-level quality of service from a large collection of distributed components demands significant knowledge and effort. It implies acquiring and installing extra equipment and software to ensure availability and security, monitoring, and managing.

More employees and skills are required to configure, administer, troubleshoot, and tune such a complex distributed environment. Server consolidation can help to reduce the number of physical servers, and the number of staff to maintain those qualities of service or serviceability.

The consolidation and virtualization of x86 scale-out servers onto the LinuxONE platform can eliminate the effects of x86 server sprawl with compelling performance advantages. This reduces labor costs, is more reliable, and can be much less expensive to install and support your critical applications.

1.2.12 Security

Security is the number one business priority for most organizations today. If you do not take measures to secure your environment, you probably spend more money to recover your business than to implement a good security policy.

Although it is technically possible to maintain security on hundreds of physical servers, it is more complicated and expensive to keep the systems safely under your control. As the number of x86 servers increases, it becomes more difficult for system administrators to track everything. Therefore, it is impracticable, cumbersome, and overly expensive to keep this environment compliant with security policies and auditable.

Choosing LinuxONE hardware architecture can reduce x86 server sprawl, power costs, and your data center's footprint by consolidating scale-out servers onto a LinuxONE server is cost saving and helps you control and improve system security.

The LinuxONE platform includes a key feature that is called *IBM Secure Service Container*. This feature represents a significant leap forward in data privacy and security capabilities because it increases security by preventing changes from being made at the command-line level.

Also, the LinuxONE servers have superior security performance, whether generating digital signatures or hashing encryption for the blockchain. The LinuxONE uses hardware accelerators that enable pervasive encryption that is not found on x86 platforms that are common to most public clouds.

For more information about this feature, see *Security and Linux on z Systems*, REDP-5464.

1.2.13 Software licensing

Consider software licensing when you are choosing your scaling platform solution. Scaling up and scaling out are both viable architectures, but significant licensing cost differences exist between them. Therefore, knowing the differences helps you to cut software license costs.

You must consider software pricing for your Linux distribution and middleware. Otherwise, It can be more expensive to run (or deploy) your application in distributed systems than for the LinuxONE platform because software licenses are attached to CPU cores. One of the advantages of this platform is to lower your licensing costs with an Integrated Facility for Linux (IFL) that often is classified as a single core. Significant savings can be achieved by consolidating many distributed servers to an IFL.

Note: The IFL is a processor that is dedicated to Linux workloads on LinuxONE and expressly designed to reduce costs. It is supported by the Linux operating system, IBM z/VM, IBM Wave for z/VM, and KVM virtualization technology.

The IBM LinuxONE Emperor™ II offers massive processing capacity with up to 170 user-configurable IFLs on one server, which can consolidate until 1,000 VMs.

Some critical workloads, such as cloud, big data, and mobile, are gaining more space on the global market. It requires more CPU cycles and more complex software to support these new workloads.

As IBM keeps improving technology and continues its commitment to open solutions, IBM introduced a new way of paying for IBM hardware and software that makes LinuxONE servers cheaper than they have even before. The elastic pricing model is based on how much you use the great capabilities of the LinuxONE system, where distributed systems often are priced per processor core.

With the LinuxONE servers, you often use fewer cores than you use for distributed systems (x86) because of the strengths of these platforms. Therefore, you can save licensing costs by choosing them to run your workloads while having the world's fastest commercially available processor to deliver outstanding processing and response times.

Note: The LinuxONE TCO calculator tool can help to calculate the savings with software licenses and other cost factors.

You can have significant software pricing savings from core consolidation on the IBM LinuxONE platform because it has flexible pricing where you can take advantage of the platform strengths and capabilities while controlling your IT costs. For more information about LinuxONE pricing, contact an IBM representative.

1.2.14 Availability

The cost of your application being down might be too high, and in many cases it brings irreversible losses to your business. The costs of downtime increased over time, so companies are paying more attention to HA solutions today than in the past. Also, the costs of HA software decreased considerably in way that makes much more sense to invest in protecting business continuity than to incur the downtime costs.

The challenge of your availability strategy is making it simpler to manage more data without increasing the complexity of managing it. In essence, the scale-out architecture provides the availability by using more than one node through load-balancing software.

From an x86 scale-out perspective, you must maintain two or more servers with the same resources, which increases the complexity and the hidden costs. You must consider the hidden costs before you decide about which platform to use. As LinuxONE scale up becomes more common, your application can be packaged in a single box to meet your performance and stability goals.

The LinuxONE scale-up architecture provides high reliability through various redundant hardware options, such as transparent CPU sparing and Redundant Array of Independent Memory (RAIM) memory modules to prevent hardware from affecting the availability of your critical workload.

Simultaneously, several HA software programs can run on LinuxONE to improve HA that is based on different application requirements. By using the combination of HA software, LinuxONE is a key customer criteria where HA is required to support your mission-critical workloads.

1.3 LinuxONE platform considerations

Refurbishing data centers can also prove cost-prohibitive, such as installing new cooling units that require reconfigured floors. The cost of power over time must also be considered in data center planning.

With the rising trends in energy costs is an accompanying trend towards high-density distributed servers that stress the power capacity of today's environment. However, this trend was met with rising energy bills, and facilities that do not accommodate new energy requirements. Distributed servers result in power and cooling requirements per square foot that stress current data center power thresholds.

Because these servers have an attractive initial price point, their popularity has increased. At the same time, their heat created a problem for data centers whose total utility usage is consumed entirely by the energy proliferating servers.

The LinuxONE and IBM's virtualization uses the power of many servers by using a small hardware footprint. Today's IBM LinuxONE reduces the effect of energy cost to a near-negligible value when calculated on a per logical server basis because more applications (several hundred of them) can be deployed on a single machine.

With the LinuxONE system, fewer physical servers that are running at a near constant energy level can host multiple virtual software servers. This setup allows a company to optimize the utilization of hardware and consolidate physical server infrastructure by hosting servers on a few powerful servers.

With server consolidation onto a LinuxONE system, companies can achieve better hardware utilization and reduce floor space and power consumption often by using open source software, which drives down costs.

Because of the many benefits are offered by the LinuxONE machine (including low floor space requirements, unmatched virtualization capabilities, energy efficiency, security, and reliability), mission-critical enterprise Linux applications are increasingly being deployed to LinuxONE server, which are arguably the most reliable and available servers on the market.

As in any IT environment, elements, such as sizing, capacity planning, and TCO always were important factors in supporting a decision to run or consolidate new applications onto a platform. These same elements are essential in minimizing the possibility of critical situations, and they are key to enabling IBM to earn from its clients the high levels of satisfaction that we strive to deliver.

Part of the advice that is given in this chapter specifically targets the LinuxONE platform, which is flexible platform that offer alternatives in terms of hardware and software. For example, KVM-hosted Linux images that are running on the LinuxONE is an efficient and cost-effective alternative to distributed servers.

Organizations are realizing that moving their workloads to LinuxONE provides significant advantages to their virtualized Linux infrastructure, with the power and flexibility they need for Linux based workloads.

The movement of applications to the LinuxONE platform can be caused by consolidation initiatives because of any of the following reasons:

- The need to eliminate an island of technology (resources and technology used only for a few applications)
- Standardization of IT operations and development resources
- Applications that are running on antiquated hardware or proprietary software
- Limitations and high cost of supporting proprietary programming languages
- Using existing resources (such as hardware, software, and labor)
- Reduction in IT costs (reduction of data center space, power, cooling, and so on)

From a technical perspective, new applications, such as cloud, big data, blockchain, IoT, and mobile have many characteristics that must be addressed when deciding on the design of the future architecture. From a business perspective, the main criteria is the cost and risk factor. You must determine what the cost is for installing and maintaining an infrastructure to provide the necessary resources for the business.

These decisions are some examples of the decisions that must be made for all levels of the architecture to provide the proper performance and recovery times while factoring in the proper investments that must be made. In fact, virtualization is the key for a successful consolidation, and the LinuxONE is the best choice for that purpose. By using the best platform, you can deliver exceptional services and keep your environment secure, fast, and ready for growth.

From a costs perspective, the most compelling reason for consolidation to increase the nodes in a data center is the costs that are associated with software licensing because most software vendors charge licensing fees for software per core. In a TCO study, software licensing is responsible for the largest piece of the cost. The LinuxONE processors can run more workload with fewer processor cores, which minimizes the number of licenses.

For more information about server consolidation onto LinuxONE, see Chapter 2, “Getting started on the LinuxONE platform” on page 23.

2

Getting started on the LinuxONE platform

IBM LinuxONE is an enterprise-grade platform that combines with the Linux operating system to deliver scalable, secure, quick, and resilient infrastructure. This infrastructure supports various environments that are running within the same hardware footprint.

With IBM LinuxONE Emperor II™ and IBM LinuxONE Rockhopper™ II, customers can expect an efficient and cost-effective system for hosting various Linux workloads that are ready to meet the business requirements of the digital era.

After reading this chapter, the reader understands how the union between the IBM LinuxONE platforms, along with the Linux operating systems, helps to achieve the growing demands within the IT industry.

Terminology: The terms *virtual server*, *guest*, and *virtual machine* are interchangeable. These terms are used throughout this book, depending on the component that is used.

The chapter includes the following topics:

2.1 Platform for Linux workloads

Linux is available on many computing platforms, ranging from set-top boxes and handheld devices to the largest servers and supercomputers. The flexibility of the operating system allows users to run applications without having to worry about being tied to a particular hardware platform. In addition, it is the leading operating system for server workloads within the IT industry, which means that Linux specialized workforce can be found worldwide.

Being an open source operating system, Linux also has a large community and development support from software companies. It features large adoption from developers because of its versatility and ability to quickly scale.

In addition, the Linux operating system commonly supports the latest new technology trends as they are available in the market, such as Docker containers and infrastructure automation tools (including Chef, Puppet, Ansible, and Salt). This feature allows it to use DevOps practices within an organization, and evolving Cloud technologies, such as Node.js, Go, and Rails.

IBM LinuxONE supports the following Linux distributions:

- Red Hat Enterprise Linux (RHEL)
- SUSE Linux Enterprise Server (SLES) and
- Ubuntu

Although other Linux distributions can work within the IBM LinuxONE platform, users of such solutions can rely only on community-driven support now. These choices provide customers with the option to choose the best Linux version that suits their needs and better scales within their own environments without having to worry about vendor lock-in.

This multiplatform approach allows customers to run a common operating system across all computing platforms, which means significantly lower support costs and, with respect of Linux, no incremental license charges. It also offers customers the flexibility of easily moving applications to the most appropriate platform. For example, many IT organizations choose Linux for the ability to scale databases across highly scalable hardware.

2.1.1 Architectural benefits

IBM LinuxONE is a highly engineered system for data serving and premium Cloud services and delivers industry-leading security, faster data throughput for top application performance, and the highest level of scalability to handle the most unpredictable data and transaction growth.

The LinuxONE platform delivers the performance and massive scalability that is needed to address today's business demands. IBM LinuxONE Emperor II can have up to 170 cores that use the fastest commercially available processor (5.2 GHz). It can also support up to 32 TB of memory to tune even the most demanding applications and databases for optimal performance.

The IBM LinuxONE Rockhopper II is an entry model hardware with a lower entry cost. This feature allows for businesses of all sizes to react quickly and address all of the opportunities in the digital era. The IBM LinuxONE Rockhopper II is built by using the same architecture as the IBM LinuxONE Emperor II.

Businesses that are acquiring this machine can expect their Linux workloads to work immediately on one of the two LinuxONE machines. Fitting in an industry-standard, 19-inch frame, the IBM LinuxONE Rockhopper II can quickly be installed on any data centers within the industry.

The LinuxONE family also counts with dedicated I/O processors to process and accelerate data-intensive applications without having to rely on its general processor count. This feature allows for a much higher scalability while assuring data and system integrity. In addition, hitting as much as nearly 100% resource usage without affecting performance, the IBM LinuxONE offers a much better utilization rate when compared to x86 systems.

IBM LinuxONE is built with a security mind set from its foundation. As a result, it can protect data and comply with the most demanding regulatory requirements. With IBM LinuxONE, it can provide data security in the following aspects:

- Whether in flight or at rest
- With low resource consumption
- Without changes to existing applications
- With minimal impact to service level agreements (SLAs)

IBM LinuxONE delivers industry-leading Java performance because of the use of pause-less garbage collection, which enables applications to run up to 50% faster than on x86 alternatives. Also, along with its improved cryptographic acceleration exploitation, the LinuxONE allows for a much greater vertical scalability of Java workloads when compared to its x86 counterpart.

IBM LinuxONE strengths

The strengths of the IBM LinuxONE platform are described in the following sections.

Reliability

LinuxONE is reliable because of its redundant processors, I/O, power and cooling subsystems, and memory architecture. It also includes error detection and correction, which provides the most reliable hardware in this area.

Availability

Designed to work at near 0% downtime, the LinuxONE features fault tolerance, automated failure detection, and nondisruptive hardware and software changes. These features allow for concurrent maintenance operations without disrupting service.

Scalability

With the most scalable platform on the market, IBM LinuxONE offers the performance and scale that is needed to address today's business demands.

IBM LinuxONE Emperor II scales up to 170 physical processors and 32 TB of memory. It also can house thousands of virtual systems and support them all running concurrently without performance hits.

IBM LinuxONE Rockhopper II scales up to 30 physical processors and up to 8 TB of memory. Even the entry level LinuxONE platform can scale up to 330,000 Docker containers in a single system.

2.2 Virtualization on LinuxONE

Virtualization is a common fabric on top the IBM LinuxONE platform. It is built from the ground as a combination of hypervisors that are configured to allow unparalleled flexibility in Linux deployments. Because virtualization is built on its core, IBM LinuxONE uses all of its scalability capabilities in a single hardware footprint.

2.2.1 Benefits of virtualization

Virtualization was around for many years within the IT Industry and became the de-facto standard solution to quickly scale new environments, reduce costs, and save on data center space. Its basic concept is to use a hypervisor, which is the piece of software that is responsible for managing the available hardware resources (such as CPU, memory, storage, and network resources) and make them available to its managed virtual servers.

The concept of virtualization emerged in the late 1960s when IBM released the virtual machine (VM) operating system. VMs allowed administrators to run multiple VMs on top of a single physical machine. Therefore, virtualization technology was developed to address the business need to better use limited resources. In a single hardware footprint, it is possible to run several environments in parallel that securely maintain full isolation one from another while scaling up virtual systems to take the best out of its underlying hardware.

The benefits of the use of IBM LinuxONE over x86 servers in a virtual environment are immense. IT managers are driven by the need to reduce the costs of IT labor. The savings are most pronounced when companies choose LinuxONE systems to run virtualized applications. IBM LinuxONE counts with IBM long expertise to develop powerful systems that can meet all of the business demands on the digital era.

Virtualization became a key solution for simplifying service management and reducing energy costs in Data Centers. The benefits from virtualization can be profound, and good results were realized in virtualization and server consolidation when compared with non-consolidated systems. Even more opportunities are available for efficiency gains and cost savings in an x86 server world.

Introducing virtualization can be a critical first step in managing computing infrastructures in the following ways:

- By lowering the cost of infrastructure
- By reducing the complexity of adding resources to that infrastructure
- By building heterogeneous infrastructure across multiple data centers, which makes those centers more responsive to business needs

The benefits of virtualization vary, depending on the objectives, specific virtualization technologies selected, and IT infrastructure. Not all users obtain the same benefits from implementing a particular virtualization solution. However, users realize many of the benefits to some degree that are described next, even when virtualization is used for server consolidation.

Higher resource usage

Virtualization enables the dynamic sharing of physical resources and resource pools. This sharing results in higher resource usage, especially for variable workloads where the average needs are much less than an entire dedicated resource. Also, the IBM LinuxONE systems are highly engineered to ensure that all of its hardware resources can run at near 100% usage, which ensures optimal performance.

Lower management costs

Virtualization can improve staff productivity in the following ways:

- Reduce the number of physical resources that must be managed
- Hide some of the resource complexity
- Simplify management tasks through automation, better information, and centralization
- Enable workload management automation

Virtualization also enables common tools to be used across multiple platforms.

Usage flexibility

Virtualization enables resources to be deployed and reconfigured dynamically to meet changing business needs.

Improved security and guest isolation

Virtualization enables separation and isolation that is not available with simpler sharing mechanisms, and that provides controlled, secure access to data and devices. Each VM can be isolated from the host machine and other VMs. If one VM crashes, the other VMs are not affected. Also, LinuxONE LPARs are EAL5+ certified, which ensures workload isolation.

Note: Virtualization prevents data from leaking across VMs, and ensures that applications communicate only over configured network connections.

Higher availability

Virtualization enables physical resources to be removed, upgraded, or changed without affecting users.

Increased scalability

Resource partitioning and aggregation enable a virtual resource, depending on the product to be much smaller or much larger than an individual physical resource. Therefore, you can make scale adjustments without changes to the physical resource configuration.

Interoperability and investment protection

Virtual resources can provide compatibility with interfaces and protocols that are unavailable in the underlying physical resources. This feature is increasingly important for supporting existing systems and ensuring compatibility with earlier versions.

Improved provisioning

Virtualization can enable resource allocation to a finer degree of granularity than individual physical units. Because of their abstraction from hardware and operating system issues, virtualized resources often can recover much more quickly after a crash rather than a physical resource.

Consolidation

Virtualization enables multiple applications and operating systems to be supported in one physical system, in addition to consolidating servers into VMs on a scale-up or scale-out architecture, as described in section 1.1, “Scale-up and scale-out definitions” on page 6. It also enables systems to treat computing resources as a uniform pool that can be allocated to VMs in a controlled manner.

Note: The x86 architecture was not designed for virtualization. Therefore, high-performance virtualization is difficult to achieve.

2.2.2 Virtualization synergy in the LinuxONE platform

Virtualization can help reduce the number of footprints by increasing server usage and reallocating resources, which brings value to customer challenges. It also supports diverse workloads with a high degree of isolation and security.

The LinuxONE family is a large-scale, robust consolidation platform. It includes built-in virtualization capability that supports hundreds of virtual Linux servers within its hardware.

IBM is also committed to the architectural development and use of its LinuxONE servers in the Linux upstream code. IBM releases open source code and contributes to the mainstream kernel code to use the Linux operating system to take the most out of the platform.

IBM virtualization solutions address the need to increase the use of information assets, simplify the IT infrastructure, and reduce operating costs across servers, storage, networking, and grid computing. By extracting some administrative costs out of the infrastructure (through increased resource use and improved productivity and flexibility), these virtualized IT assets can help fuel business growth, control costs. In doing so, staff productivity increases.

Factors that make the LinuxONE server compelling for a client

Data volumes, business demands, and the complexity of applications are increasing dramatically. Clients are looking for systems that provide security, speed, and scalability while also running on top of a server that can run today’s leading open source software.

Note: The IBM LinuxONE platforms can deliver all the strength of the architecture in a single server or more, depending on the business requirements.

Organizations seek to improve the effectiveness of the IT infrastructure, consolidating workloads onto a single larger system becomes an attractive proposition. LinuxONE technologies are designed to enable the reduction in overall total cost of ownership (TCO) and increase in business flexibility to meet anticipated and unanticipated processing capacity demands with a more streamlined system infrastructure.

The more components that are in an IT environment, such as servers, cables, switches, and routers, the more difficult it is to manage, maintain, identify potential issues, and ensure that compliance regulations requirements are met. IT complexity can drain budgets and hinder a company’s ability to maximize the business value of its IT investment. For this reason, the LinuxONE servers were designed specifically to maximize resource use, minimize energy consumption, simplify virtualization management, and provide an economically attractive alternative to IT complexity.

Note: Virtualization and consolidation are key for IT simplification.

2.2.3 Levels of virtualization

LinuxONE servers feature unparalleled levels of virtualization at the hardware and software levels. This approach allows IBM LinuxONE customers to use their businesses according to their needs.

In addition, the LinuxONE platform does not lock users with a particular hypervisor in such a way that the learning curve within the platform is reduced to allow customers to quickly scale and deploy their Cloud assets within the platform. The IBM LinuxONE virtualization architecture provides resource optimization and introduces the granularity that is required by many organizations to create and separate environments and resources to provide an outstanding solution.

Hardware virtualization

The hardware hypervisors that are built on top of the LinuxONE platform are used to partition the hardware into logical partitions (LPARs). These LPARs are classified as type 1 hypervisors (see Figure 2-1) and run directly on top of the hardware. Such solutions are known as *native* or *bare metal* hypervisors.

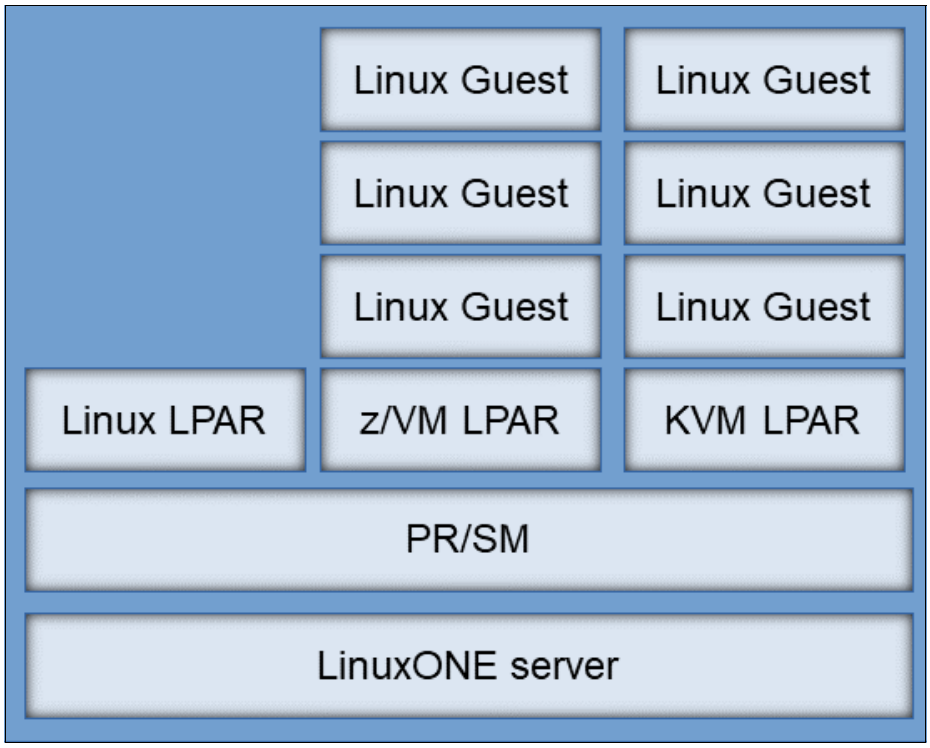

Figure 2-1 IBM LinuxONE virtualization architecture

IBM PR/SM

IBM PR/SM™ is the facility in LinuxONE servers that provides another layer of virtualization. It is a hypervisor that is classified as type 1 and enables multiple LPARs to share physical resources, such as processors, memory, channel paths, and Direct Access Storage Devices (DASDs). It is extensively used in LinuxONE servers, as described in “Virtualization on LinuxONE” on page 26.

IBM DPM

Dynamic Partition Manager (DPM) is an administrative mode that was introduced to LinuxONE servers. A system can be configured in DPM mode or PR/SM mode, as shown in Figure 2-2. This mode is enabled before a system power-on reset (POR).

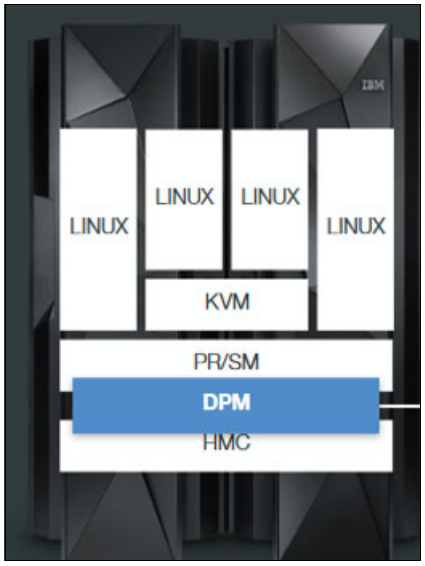

Figure 2-2 Dynamic Partition Manager (DPM) + PR/SM = easy to use

IBM DPM provides a simplified way to configure a LinuxONE server. Similar to PR/SM, it supports Linux, kernel-based virtual machine (KVM), and z/VM systems, which gives administrators the flexibility to set up their LinuxONE systems according to their business requirements. It also removes the need for LinuxONE configuration tools, such as Hardware Configuration Definition (HCD) and Hardware Configuration Manager (HCM).

The entire system configuration is performed from the Hardware Management Console (HMC). It eliminates the need to build a stand-alone IOCP input deck for I/O devices. It also eliminates the need for the second POR to enable dynamic I/O, which is required in non-DPM configurations. DPM provides for fully dynamic reconfiguration of CPU, memory, and I/O resources. Adding and dynamically reconfiguring I/O devices is greatly simplified with DPM.

A simplified vision of DPM

DPM provides the following advantages:

- Speed: Much faster than managing with HCD and HCM. Deployment time is reduced from hours to minutes.
- Ease of use: With an intuitive user interface, DPM dramatically reduces the need for multiple administrators with different skills or tools to configure the hardware. DPM also allows for administrators without previous LinuxONE expertise to quickly get the platform set-up and running.

- Powerful: With the same efficiency as the PR/SM hardware virtualization with a greater abstraction layer, DPM supports dynamic configuration changes with only a few clicks. It also provides a foundation for bare metal Cloud.

Note: For more information about DPM operation and capabilities, see this IBM Resource Link® web page (log in required).

Software virtualization

Also known as type 2 hypervisors, this virtualization are designed to run on top of a host operating system. Its purpose is to control the entire hardware (or only a partition of it) by way of an LPAR that was set up by using PR/SM or DPM. The LinuxONE servers use two main hypervisors for virtualization of Linux workloads.

2.2.4 Kernel-based virtual machine

Delivery of the KVM hypervisor on LinuxONE can be done more efficiently through our Linux distribution partners. This delivery method helps to simplify the delivery of an open source infrastructure and makes it easier to obtain and deploy a Cloud infrastructure by communicating with open source cloud infrastructure components, including OpenStack support. The following minimum Linux distributions levels are supported on the IBM LinuxONE Rockhopper II and IBM LinuxONE Emperor II:

- SUSE Linux Enterprise Server 12 SP2
- Ubuntu 16.04 long-term support (LTS)
- Red Hat Enterprise Server 7.5[1]

Note: All Linux systems that are acting as a KVM hypervisor must be installed in a dedicated LPAR. Running KVM as a z/VM guest is not supported.

KVM hypervisors can manage and administer multiple VMs, which enable many Linux-based workloads to run simultaneously on the IBM LinuxONE servers. Because the hypervisor also is available for multiple architectures, such as x86, KVM administrators also find that their learning curve is dramatically reduced by migrating their workloads from other platforms to LinuxONE.

Advantages of using KVM on LinuxONE servers

KVM offers enterprises a cost-effective alternative to other hypervisors. It has simpler and familiar standard user interfaces that offer easy integration of the LinuxONE servers into any IT infrastructure.

In addition, KVM can help make platform mobility easier. Its live relocation capabilities enable you to move VMs and workloads between multiple instances of LinuxONE systems without incurring downtime.

[1] Red Hat Enterprise Linux (RHEL) 7.5 GA announcement

Main features and benefits of KVM

The major benefits of KVM are listed in Table 2-1.

Table 2-1 KVM main features

Feature	Benefit
KVM hypervisor	Supports running multiple Linux VMs on a single system.
CPU sharing	Enables the sharing of CPU resources by VMs.
I/O sharing	Enables the sharing of I/O resources among VMs.
Memory and CPU overcommitment	Supports the overcommitment of CPU, memory, and swapping of inactive memory.
Live VM relocation	Enables workload migration with minimal impact.
Dynamic addition and deletion of virtual I/O devices	Reduces downtime to modify I/O device configurations for VMs.
Thin-provisioned VMs	Enables copy-on-write virtual disks to save on storage.
Hypervisor performance management	Supports policy-based, goal-oriented management and monitoring of virtual CPU resources.
Installation and configuration tools	Supplies tools to install and configure KVM.
Transactional execution use	Provides improved performance for running multi-threaded applications.
Multiplatform	KVM Administrators from other platforms can use the same hypervisor and tools that they used with for guest provisioning.

2.2.5 z/VM on LinuxONE

Virtualization became a key technology for simplifying service management and reducing energy costs in data centers. z/VM is the most mature solution in the market because it was developed in the late 1960s to make more efficient use of hardware. IBM invests heavily to improve its functionalities whenever a new version is released.

z/VM continues to support more VMs in a single footprint with more excellent service levels than any other solution. It also allows a user to scale up the system capacity without requiring more support personnel.

As a major component of the TCO story, IBM introduced subcapacity pricing for z/VM V6 and its subsequent releases, along with subcapacity terms for select z/VM-based programs that are running in a z/VM system. This feature can help customers to improve alignment between software use and software pricing by realizing the following benefits:

- Add hardware capacity without necessarily increasing software pricing
- Enable greater flexibility with software licensing
- Achieve better price/performance for z/VM products

The merger of z/VM and Linux on LinuxONE is perfect because z/VM can have hundreds of Linux servers that are running harmoniously while z/VM takes care of all of the resources of the LPAR with the benefit of improved price performance as workloads grow.

A fundamental strength of z/VM is the ability for VMs to share system resources with high levels of resource usage. z/VM V7.1 provides even greater levels of extreme scalability, security, and efficiency to create opportunities for cost savings, while providing a robust foundation for cognitive computing on the LinuxONE platform.

When multiple Linux servers run on LinuxONE, each Linux system includes dedicated access to a defined portion of the LinuxONE machine as provided by the hypervisor by using a technique that is known as *timesharing*. Each Linux instance runs in its own VM whose characteristics (for example, memory size and number of CPUs) define the hardware that Linux sees. The allocation and tuning controls in z/VM specify how real hardware resources are allocated to the VM.

Note: The most important z/VM capabilities are rapid deployment of Linux guests and high server consolidation ratio.

Main features and benefits of z/VM

The major benefits of z/VM are listed in Table 2-2.

Table 2-2 Main features of z/VM

Feature	Benefit
z/VM hypervisor	Supports running hundreds of Linux servers with high performance.
Resources sharing	Allows for resource sharing, such as processors, storage, and networking.
I/O support	z/VM is well-integrated with LinuxONE, using the dedicated I/O processors to manipulate the I/O subsystem.
Memory and CPU overcommits	Supports overcommitting of CPU and memory without any service degradation.
Dynamic memory adding	z/VM can change the memory size of Linux servers automatically (defined on the user directory as standby memory).
System Single Image (SSI)	Allows connecting up to four z/VM members to avoid planned outages.
Live Guest Relocation (LGR)	When SSI is used, allows for Linux movement to another z/VM member without any interruption.
Virtual disks	Allows Linux to have real memory access for faster data access.
Performance management	z/VM has several interfaces to monitor performance. It also supports the Performance Toolkit product for increased monitoring and reports about z/VM and overall guests performance.
SMT	Improved performance for running multithread applications. Supports simultaneous multithreading (SMT), enabling up to two threads to be used per IFL core.
NSS and DCSS segments	NSS and DCSS segments allows one to have only one copy of the kernel or product that is loaded in real memory once. Other Linux guests can use the same segments, which improves the use of real memory.
VSWITCH	z/VM supports the use of virtual switches, which enables connectivity to external LAN segments without requiring a router, cabling, and so on.

Feature	Benefit
Real and virtual memory enhancements	z/VM 7.1 supports real memory of 2 TB, and Linux guests at 1 TB.
LinuxONE guest cloning	A Linux guest under z/VM can be quickly cloned to make another Linux image easily in a few minutes.
Upgrade in place	Enables a smoother upgrade of z/VM 6.4 systems to z/VM 7.1.

2.2.6 z/VM 7.1 overview

z/VM V7.1 supports IBM LinuxONE servers and Red Hat, SUSE, and Ubuntu Linux distributions. Support for simultaneous multithreading (SMT) technology extends per-processor, core capacity growth beyond single-thread performance for Linux guests that are running on an IBM Integrated Facility for Linux (IFL) specialty engine on IBM LinuxONE servers.

Its multithreading technology support provides more price and performance benefits over previous hardware generations. It also can meet workload requirements transparently. Improvements that are made in the areas of reliability, availability, and serviceability allow low-end devices, such as IBM Storwize® V7000, V840, and V9000, to be attached to a z/VM host, which removes the need for an IBM SAN Volume Controller.

z/VM V7.1 is a supported environment that uses IBM Dynamic Partition Manager for Linux-only systems. This configuration simplifies system administration tasks for a more positive experience. Also, the use of IBM Wave with z/VM can greatly simplify the task of administering a z/VM environment.

By using z/VM as a hypervisor for Linux workloads, you can extend the business value of IBM LinuxONE technology across the enterprise by integrating applications and data, while providing exceptional levels of availability, scalability, security, and operational ease.

World-class virtualization technology that is offered by z/VM enables you to host many virtual servers that are running different operating systems on LinuxONE servers, as shown in Figure 2-3.

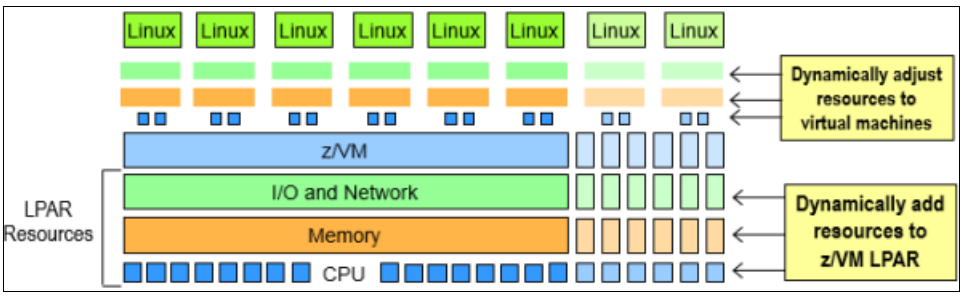

Figure 2-3 LinuxONE hypervisor virtualization

The ability of z/VM to support multiple system images and architectures provides a highly flexible production and test environment for LinuxONE operating systems to realize the following benefits:

- Simplify migration from one release to another
- Facilitate the transition to newer applications
- Provide a test environment whenever one is needed
- Consolidate many systems onto one physical server

For more information, see this IBM z/VM web page.

2.2.7 Single System Image and Live Guest Relocation

Starting with z/VM 7.1, Single System Image (SSI) is included in the base hypervisor at no extra cost. Integrating and making SSI available at no charge helps more clients reduce or shorten planned outages of their Linux workloads as they adopt the z/VM Continuous Delivery model for their z/VM systems.

SSI also allows customers to connect up to four z/VM systems as members of an SSI cluster, as shown in Figure 2-4.

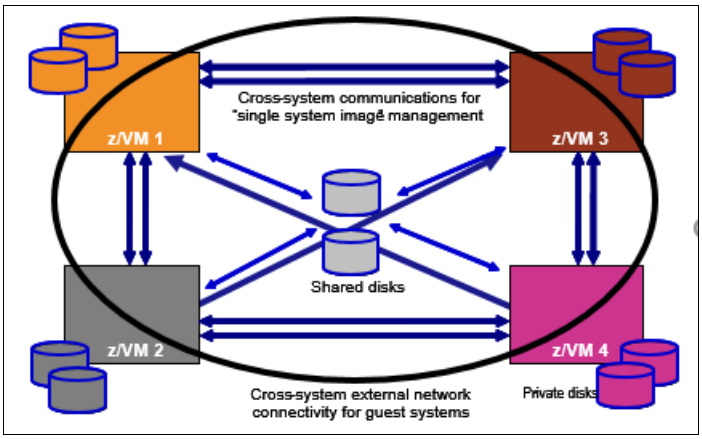

Figure 2-4 z/VM SSI configuration

Each member can run on the same or different LinuxONE servers, which simplifies management of a multi-z/VM environment. Consider the following points:

- Enables live guest relocation (LGR) of running Linux guests among z/VM members
- A single user directory of all VMs is defined
- Cluster management from any member:
  - Apply maintenance to all members in the cluster from one location
  - Issue commands from one member to operate on another
- Built-in cross-member capabilities
- Resource coordination and protection of network and disks

SSI cluster management has greater reliability, including the following benefits:

- Cross-checking of configuration details as members join to the cluster and as resources are used:
  - SSI membership definition and identity
  - Consistent definition of shared spool volumes
  - Compatible virtual network configurations (MAC address ranges, VSwitch definitions, and so on)
- Cluster-wide policing of resource access:
  - Volume ownership marking to prevent dual use
  - Coordinated minidisk link checking
  - Autonomic minidisk cache management
  - Single logon enforcement

Live guest relocation

When SSI is used, a running Linux VM can be relocated from one member system to another. This process is known as *live guest relocation* (LGR), which occurs without disruption to the business. It provides application continuity across planned z/VM and hardware outages and flexible workload balancing that enables work to be moved to available system resources.

Note: As of this writing, Linux is the only operating system that is supported for relocation.

A running virtual server is relocated for the following reasons:

- Increased flexibility for planned outages
- Maintenance of hardware or software
- Fixing performance problems
- Administrative savings
- Increased isolation capability
- Management and balancing of workloads

Relocating virtual servers can be useful for load balancing and moving workload from a physical server or member system that requires maintenance. After maintenance is applied to a member, guests can be relocated back to that member, which allows you to maintain z/VM and keep your Linux virtual servers available.

For more information about SSI cluster and LGR, see the following publications:

- *z/VM CP Planning and Administration version 7 release 1*, SC24-6271
- *An introduction to z/VM Single System Image (SSI) and Live Guest Relocation (LGR)*, SG24-8006
- *Using z/VM 6.2 Single System Image (SSI) and Live Guest Relocation (LGR)*, SG24-8039

2.2.8 IBM HiperSockets

IBM HiperSockets™ is a networking option that is defined in the I/O configuration of LinuxONE servers. This type of network connection provides only an internal connection among LPARs.

The main use for this type of network option is as an internal connection between two IBM LinuxONE LPARs on the same box (CPC). HiperSockets allow for greater scalability for LinuxONE because its communication occurs at the memory level, which allows Linux servers within the same hardware to dramatically increase their throughput without having to rely on the physical network stack.

Characteristics of HiperSockets

HiperSockets have the following characteristics:

- It is used to configure the connection between two LinuxONE LPARs.
- It is a direct memory-to-memory pipeline and operates at memory transfer speed.
- As with an OSA connection, a triplet of devices must be dedicated.
- Unlike an OSA connection, offloading is not possible.

2.2.9 Using LinuxONE with z/VM

By using an infrastructure with LinuxONE with z/VM to virtualize the resources to Linux servers, the following goals can be accomplished:

- Start small and scale up as necessary
- Quickly deploy various workloads
- Consolidate servers and infrastructure components
- Implement cloud services that can rapidly deploy a trusted, scalable, and secure Linux cloud environment with quality of service

z/VM uses and was designed to take advantage of all hardware functionalities of LinuxONE servers. That is, z/VM creates VMs that adhere to the highly engineered architecture of the IBM LinuxONE servers, which allows for a high level of trust. Also, z/VM enables many such VMs to exist and operate simultaneously on one instance of real hardware and in the most interesting cases, z/VM overcommits the real hardware without any extra financial or resource costs.

The heart of z/VM is a multi-programming, multi-processing operating system kernel that is known as the Control Program (CP). CP is the main component of z/VM that creates and dispatches VMs on the real hardware (IBM LinuxONE).

z/VM advantages

The use of z/VM includes the following advantages:

- Infrastructure simplification:
  - Consolidate distributed, discrete servers and their networks
  - LinuxONE quality of service
  - Use built-in z/VM system management
- Speed to Market:
  - Quickly deploy servers, networks, and solutions
  - React quickly to challenges and opportunities
  - Allocate server capacity when needed and dynamically
- Making the most of technology:
  - Total integration with LinuxONE servers, efficiently using its architecture
  - Linux guests with z/VM offer more functionalities and speed to market than Linux servers alone
  - Linux uses unique z/VM technology features
  - Build innovative on-demand solutions

Note: z/VM continues to support more VMs in a single footprint with excellent service levels.

2.2.10 Server consolidation

Server consolidation increases the effective usage of a hardware server by enabling IBM LinuxONE systems to host multiple VMs. This ability can lead to lower power and cooling costs, and to greater computing efficiency and the flexibility to migrate workloads.

Consider the following points:

- Consolidate heterogeneous workloads into a single Linux server as a VM running in z/VM or KVM.
- Consolidate multiple applications into a single physical server, such as IBM LinuxONE.

The most important step is to have the correct strategy to perform consolidation, virtualization, or both. You must conduct a deep analysis of your applications and consider the following points:

- Are the applications I/O or processor intensive?
- Are they heavily accessed?
- Consider other, similar aspects of your application usage.

When this analysis is complete, you can decide to use one or both strategies to address your data center issues, which lowers your costs and decreases server sprawl, as shown in Figure 2-5.

Note: In 2006, IBM consolidated approximately 3,900 distributed internal servers to 30 IBM LinuxONE servers with a consolidation that is called Project Green.

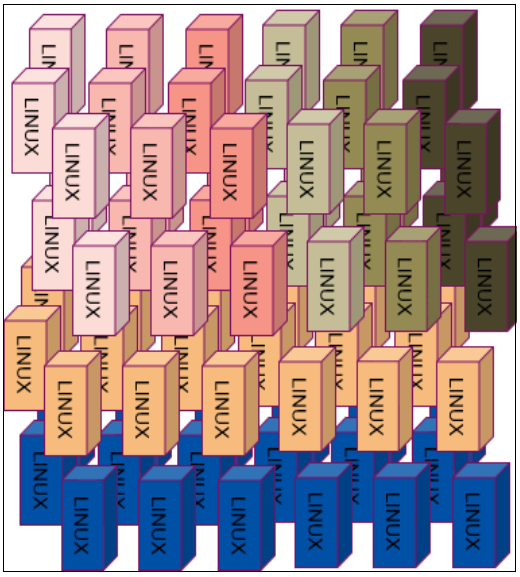

Figure 2-5 Server sprawl in distributed environment

z/VM can help to use consolidation across an infrastructure, as shown in Figure 2-6 on page 39. TCO studies that span more than three years repeatedly show the value of consolidation on z/VM, especially when the following conditions exist:

- A non-trivial number of servers is involved
- All operating expenses are included
- Software licensing is considered

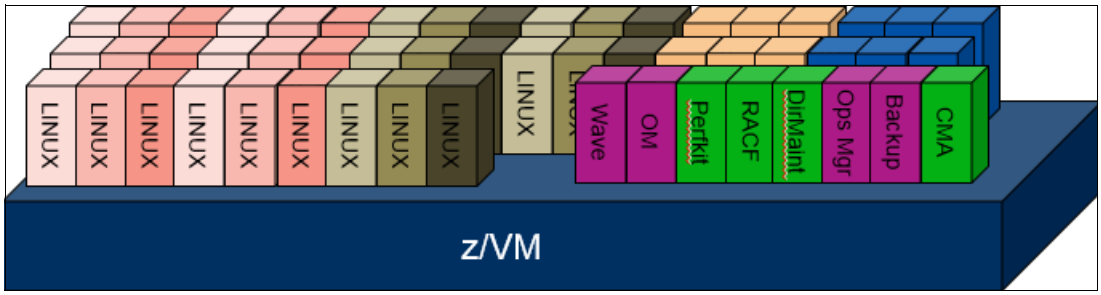

Figure 2-6 z/VM consolidation on the IBM LinuxONE servers

Consolidation is used for a compelling reason. Software (from many vendors) can be expensive, and typically costs more than hardware. It is less expensive (and sometimes much less expensive) to replace multiple software licenses of smaller machines with one or two licenses for larger machines.

Note: Software license costs are often linked to the power of the system, but the pricing curves favor a few large machines, as explained in 1.2.4, “Total cost ownership versus total cost of acquisition” on page 11.

For a complex environment, server consolidation helps reduce power consumption, cooling needs, data center rack space requirements, and server costs. It also helps data centers better manage resources and resiliency. In addition, z/VM has a powerful mechanism to clone servers that enables servers to be cloned in a few minutes. The process leads to increased administration, system controls, and network complexity for your environment.

Lowering TCO is another advantage of using a virtualized environment on the IBM LinuxONE. Consider the following costs:

- Hardware
- Software licensing
- Ongoing support
- Space usage
- Machine room running and cooling

Considering all of these factors, LinuxONE delivers the overall lowest TCO for installations with a large investment that is composed of many distributed servers. The reliability, availability, and serviceability that are proven strengths of LinuxONE servers are other positive factors.

2.3 LinuxONE Cloud capabilities

An enterprise cloud might be composed of various components, depending on its main purpose. Implementing an Infrastructure as a Service (IaaS) cloud in LinuxONE demands the integration of many important components.

The IBM LinuxONE platform is ready to support the Cloud growth demands and speed to market required by most companies today. The LinuxONE platform provides the IBM Cloud™ Automation Manager to provision and scale several Linux guests as required in a short period.

Also, OpenStack based solutions work immediately. That is, that the same components that are used on other platforms can easily be integrated and reused to an organization requirement. This feature speeds up the deployment of new workloads and migration to the LinuxONE platform.

With IBM Cloud Private, customers can further scale their workloads on the LinuxONE platform and use it with rapid container deployment and orchestration by way of Kubernetes. The IBM LinuxONE Emperor II can scale up to 2 million Docker containers in a single system.

Alongside with Kubernetes, application capabilities can further be extended to run in a clustered environment, with self-healing functions, a much easily manageable infrastructure, and quicker speed to market for applications and Cloud-ready applications.

With the LinuxONE virtualization model, the Cloud can further be scaled to satisfy various environments in a single hardware footprint. By creating individual LPARs that meet an organization infrastructure, customers can easily reduce the negative effects of server sprawling to meet a more robust and centralized infrastructure with optimal performance.

One growing concern across many organizations today is how secure are their Cloud services are deployed. The IBM LinuxONE implements the exclusive Pervasive Encryption feature that ensures that all data is encrypted in rest and at flight. IBM Secure Services Container also allows customers to spin-up containers in a secure and robust way.

A Cloud environment might use several components and it is important to protect each of them. It also is important to ensure that the company security policy is clearly defined and its accesses are implemented across the cloud environment.

For more information, see *Securing your Cloud: IBM Security for LinuxONE*, SG24-8447.

2.4 LinuxONE security features

Security is essential in many ways. Although this statement is true for physical security, it is evident that companies also must secure and protect these services because electronic services are more prevalent. Every company that handles customer information or offers services through internet platforms must ensure that processed data is secured against all threats.

All precautions to prevent data leakage and to assure system and data integrity must be taken. It is no longer sufficient to state that data processing is secure today. You also must offer proof to auditors and comply with regulations to establish trust in your services.

Most important, you must prevent a loss of revenue and reputation because of security exposures. Therefore, it is a preferred practice to establish the strongest security mechanisms at all levels of data processing, including the physical security of the machine rooms at your data center (controlling access to the facilities) and implementing appropriate access levels to applications, programs, data, archives, and so on. The principle of least privilege must be met at all levels.

Protecting information from unintended use is one key element of a secure IT environment. The following methods are available to ensure privacy of information:

- Access control
- Encryption methods

Access control mechanisms determine who can access particular information or data. The access control mechanisms then verify who accesses the information (authentication) and whether they can access this information (authorization).

Cases exist in which proper access control cannot be ensured in all situations, especially if data is stored on movable media and also when data is transferred through a network that might not be protected. It is not possible to ensure that no unintended access to data occurs while it is stored or transferred through a network. The only way to protect such information is by using encryption methods.

2.4.1 Hardware security features overview

The hardware security features provide a fundamental part of the security definitions of software techniques and solutions. Each of the operating systems for LinuxONE servers use these hardware features to some degree.

IBM LinuxONE servers have a rich history of delivering a secure infrastructure. It is built on a set of hardware security capabilities that include multi-state operation modes, storage key isolation, high-speed standards-based encryption, logical partitions, and many other features and benefits.

The IBM LinuxONE is designed for Common Criteria Evaluation Assurance Level 5+ (EAL5+) certification for security of logical partitions. Therefore, IBM LinuxONE is designed to prevent an application that is running on one LPAR from accessing unauthorized data that is running on a different LPAR on the same hardware server.

The LinuxONE security features are integrated into the hardware. The following hardware security features are available:

- By using the HMC, LPARs can be defined and isolated from each other. Also, all of the resources (storage, processors, DASD, and tape units) that are needed to run the operating systems are defined by way of LPAR profiles by the HMC.
- Crypto-Express Cards can encrypt session traffic and physical data on DASDs and tape. For better performance, cryptographic coprocessors are used.
- Signed microcode is applied to the hardware to ensure microcode authenticity.

z/VM provides a host of features that isolates VMs (also called *guests*) from one another. This isolation is implemented in the z/VM CP, which can be considered the kernel of the hypervisor. Separation of guest workloads is a vital component of system integrity. It also provides the foundation of the security context on which the IBM Integrity Statement for z/VM is based.

2.4.2 Pervasive encryption

Several organizations recognize the need for data encryption. A common set of best practices involve activities, such as setting up Transport Layer Security (TLS), disk encryption, and safeguarding encryption keys. This approach was typically used by several organizations to secure their assets, reputation, and customers data and comply with most major legal requirements.

However, during the period that is data is moving over across the system components for processing and before it reaches its intended destination, the confidential data can be left exposed and unencrypted. This issue makes it a perfect target for attackers to access the information.

The IBM LinuxONE platform is built on top of a security-oriented architecture. Customers can securely scale their Cloud systems while keeping optimal performance with Pervasive Encryption, which ensures compliance, even with the most restrictive security regulations.

Pervasive Encryption is a technology that encrypts data that is in flight and at rest. It does so by securely storing a master key on top of the CryptoExpress 6S.

The new CryptoExpress 6S is a secure cryptographic card that is designed to never be tampered. That is, the Crypto-Express 6S is a piece of hardware that is made to wipe its contents if any attempt to break into it occurs.

The Linux operating system uses Pervasive Encryption by generating a protected key that is securely wrapped within the CryptoExpress 6S by using its unique master key. The generated protected key can then be used by Linux guests for initializing cryptographic functions, such as Linux Unified Key Setup (LUKS) encrypted volumes and IPSec-related functions.

The Central Processor Assist for Cryptographic Function (CPACF) is a dedicated processor for handling cryptographic workloads on IBM LinuxONE machines. By handling all cryptographic functions, the CPACF offers improved performance when compared with the x86 architecture. Figure 2-7 shows the encryption performance on LinuxONE machines when compared to x86 workloads.

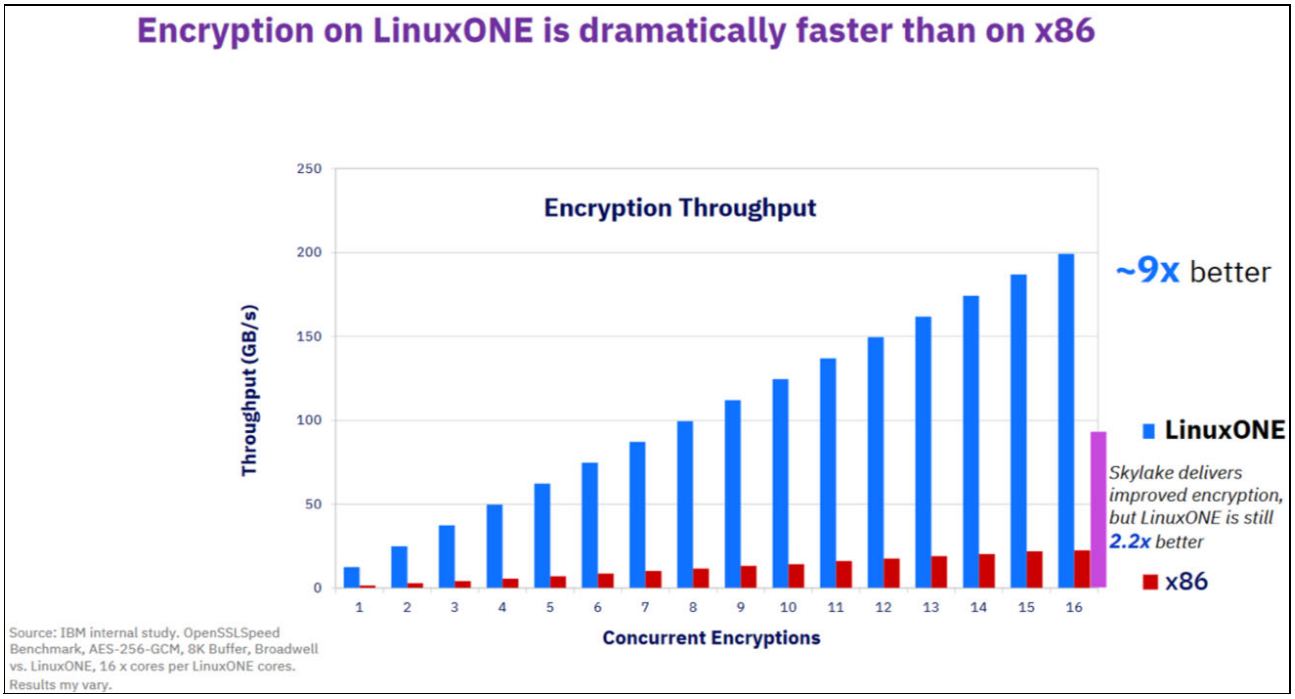

Figure 2-7 LinuxONE encryption performance compared to x86 workloads

For more information about pervasive encryption, see *Getting Started with Linux on Z Encryption for Data At-Rest*, SG24-8436.

2.4.3 Secure Services Container

Docker containers emerged as a technology to quickly scale microservices and cloud-ready applications, and modernize applications, which results in quicker deployment and better system's resource usage. With containers, developers and operations can easily engage in DevOps practices to take the most of their infrastructure.

The use of containers is encouraged across infrastructures because of these reasons. However, it is worth to ask the following questions when a containerized infrastructure is deployed:

- How secure is my container infrastructure?
- What privileges does my operations and development team hold for managing it?
- Which services and APIs are being exposed and what approaches do we take to secure them?

IBM Secure Services Container (SSC) is the LinuxONE approach to securely build and install firmware or software appliances on-premises and off-premises. It can be integrated and communicate with other containers, Kubernetes, and IBM Cloud Private with simplified administration maintenance.

Because LinuxONE partitions are certified for EAL5+, SSC uses this feature by ensuring that no LPARs that are running under the same hardware footprint can access the contents of the secure container. Also, the SSC are enabled with Pervasive Encryption, which ensures that all data and code that is at-rest and in-flight are encrypted.

A Secure Services Container partition contains its own embedded operating system, security mechanisms, and other features that are designed for simplifying the installation of appliances and for securely hosting them. This approach allows for root (privileged) access to be restricted on a deployed SSC LPAR in such a way that unintended access to restricted data is not possible.

For more information, see *IBM Secure Service Container User's Guide*, SC28-6971.

2.5 Summary

IBM LinuxONE is the platform for consolidation, where multiple services are combined on the platform by using its proven virtualization infrastructure. End-to-end solutions that are based on multi-platform workloads can be deployed across the IBM LinuxONE structure and benefit from its qualities of service, including high availability, and simplified and improved management of the virtualized infrastructure.

IBM z/VM uses the architecture of IBM LinuxONE. IBM is investing more each year in new z/VM releases and features to offer the most stable platform for Linux on it. z/VM and KVM provide flexibility, availability, and security capabilities for Linux instances, while creating an isolated and protected environment for critical applications.

Clients can start small with LinuxONE, and non-disruptively grow their environment as business dictates. With features, such as Pervasive Encryption and IBM Secure Services Container, the LinuxONE platform is the industry-leading, security-oriented system.

By using the Linux operating system, LinuxONE customers depend on a versatile platform that can be quickly scaled as required by most organizations.

3

Scaling up on the LinuxONE platform

This chapter describes the options and factors that must be considered to make sound architectural decisions to deploy and scale up services with the LinuxONE platform.

This chapter also describes how and which types of applications can be scaled within the LinuxONE platform to use a reader's businesses to better suit their needs.

This chapter includes the following topics:

3.1 LinuxONE scalability features

The new set of applications, such as analytics, mobile, and social, shows that a better, faster, and easier way is available to build infrastructure for any type of workload.

Applications and data become common and they are increasingly hosted on cloud infrastructure. With an appropriate infrastructure, you can start small and grow within the server, deploy various workloads, consolidate servers, and implement cloud services that can rapidly deploy a trusted, scalable Linux cloud environment with excellent qualities of service.

A key platform for the emerging digital services is the cloud. Many of the emerging digital applications and microservices that provide these innovative new capabilities are built to use the agility of cloud platforms, such as IBM Cloud. However, for the applications and services to function effectively, they must harness the application logic and business data that is held within enterprise systems, such as the LinuxONE platform. The ability to use the LinuxONE platform provides a powerful way to fuel the emerging digital applications by abstracting away the underlying infrastructure complexity.

Every computing platform offers specific areas of strength, and the aim of moving the workloads is to select applications that take advantage of the strengths of the target platform. The classic strengths of the LinuxONE platforms include high availability, high throughput, industry-leading security, the flexibility to run disparate workloads concurrently, and excellent disaster recovery capabilities.

Another critical factor for choosing the LinuxONE platforms is the following aspects of the reduced total cost of ownership (TCO):

- Environmental savings: Single footprint versus hundreds of servers.
- Consolidation savings: Less storage, fewer servers, fewer software licenses, and less server management or support.

These platforms were built to take optimum advantage of open source workloads that need higher levels of scalability, security, and availability from the underlying hardware infrastructure. Combined with these factors, the LinuxONE platform can deliver more than x86 based solutions. In particular, the ability to get your workloads processed at a lower overall cost and less complexity than the x86 scale-out architecture.

Scale in with the LinuxONE platform

The LinuxONE platform is proven to be reliable to handle large amounts of data and mission-critical applications more efficiently than any other platform. These systems were designed to accommodate applications with heavy on storage or heavy on compute while keeping optimal security. They can respond to a sudden surge in demand quickly, which prevents complex applications from experiencing slow responses times.

The architecture is flexible enough to allow applications that are running on cloud services to easily scale up in whatever increments, while offering high performance for applications that require processing power. Also, it addresses application scale-out by adding new virtual servers within a few minutes and make them part of the cluster.

Note: For more information about virtualization, see “Virtualization on LinuxONE” on page 26.

Scale out or scale up alone do not adequately serve today's applications, which are responsive, always available, and can service many users, including cloud, mobile, analytics, and big data. That makes LinuxONE the best platform to meet different demands, from small to complex. In summary, the platform remains the most powerful for tasks that computers performed for decades and technologically redesigned to attend emerging demands.

Note: The performance tests that are described next were performed by IBM on a LinuxONE server.

Scale out

Scale out has the following capabilities:

- Run 1344 concurrent databases that are running a total of 377 billion database transactions per day on a single LinuxONE Emperor II server.
- Run 25% more MongoDB workloads with the same throughput on the LinuxONE Emperor II when compared to the previous LinuxONE Emperor system.
- Scale-out to 2 million Docker containers in a single LinuxONE Emperor II, no application server farms necessary.
- Run 30 billion web transactions per day on a single Emperor II server.

Scale up

Scale up has the following capabilities:

- Scale up a single MongoDB instance to 17 TB in a single system without database sharding and realize 2.4 times more throughput and 2.3 times lower latency on a LinuxONE Emperor II server that uses the extra memory that is available compared to a LinuxONE Emperor server.
- Run MongoDB under on a LinuxONE Emperor II server and realize 4.8 times better performance by using the extra memory that is available per z/VM instance compared to a LinuxONE Emperor server.

The following sections include information about how the LinuxONE systems run more workloads with a consistent approach to improve service levels and meet demands with ease.

3.2 Open source environment on LinuxONE

The IBM LinuxONE platform is deeply engineered to make the most out of the openness of Linux and its related open source software. It is its hardware and software combination that makes the overall solution shine for bringing businesses to the next digital innovation era.

The Linux operating system is known for delivering the best out of several different platforms. As a multiplatform operating system, Linux users can have peace of mind about ensuring that the tools and applications that they used with on their x86 systems are compatible on the LinuxONE with minimal effort.

IBM support of the Linux operating system dates to its announcement in 1999. Since that time, IBM was positioned as one of the top contributors in Linux code with over 100 open source projects engagements.

Also, IBM expertise in building hardware, middleware, and service products for the Linux industry ensures that customers that acquire LinuxONE machines have the best support and solutions available within the industry.

Alongside with the LinuxONE platform, IBM is committed to the development of the Linux operating system and several other open source projects. This commitment make it the best choice for migrating, scaling, and using workloads on top of LinuxONE for top performance and unmatched security.

Note: For more information, see the publication *IBM is Committed to Linux and Open Source*.

IBM contributes to open source projects, including the following examples:

- The Linux Kernel: IBM contributes to the core heart of the operating system to use the LinuxONE platform to its fullest capabilities.
- Hyperledger: The technology that is behind many blockchain systems.
- OpenStack: Being a platinum member of the OpenStack foundation, IBM is committed with Cloud development and improvements.
- Kubernetes: The leading container orchestration technology that is within the market is also backed up by IBM.

IBM LinuxONE platforms can scale several different workloads within its single hardware footprint. By using of its powerful virtualization architecture, the IBM LinuxONE is the leading platform for developers and Application Owners to house their Linux workloads, which greatly reduces the effects of server sprawl while achieving industry-leading security, enhanced performance, and high availability capabilities.

3.3 Docker containers

Containers are an emerging technology for deploying and running workloads by encapsulating several applications to run within the same operating system. From an IT infrastructure perspective, the usage of containers presents a break-through technology for resource optimization and speed to market.

Most container solutions are based on open source software. Docker is the leading container solution in the market because it efficiently implements a complete software solution to run containers.

A Docker *image* is a lightweight, stand-alone, executable package of software that includes everything that is needed to run an application: code, run time, system tools, system libraries, and settings. It was built to make it easier to create, deploy, and run applications by instantiating such images on what are called *containers*. From a system resources perspective, Docker containers are efficient for application granularity.

Docker containers provide several enhancements for applications that allow for portability and simplified security. Because of this feature, some organizations are choosing this technology to bring standardization, reduce costs, and speed up deployments for their environments.

A container can run on many hardware platforms, including LinuxONE, Power, and x86 workloads. It allows for running multiple workloads on a single system, which improves a system's consolidation. On an IBM LinuxONE machine, Linux instances with Docker can run directly in bare metal (LPAR mode) or as a guest virtual machine (z/VM or KVM).

Similarly, as the concept of virtualization provided several efficiencies, capabilities, reduced costs, along with other benefits since it was introduced, containers are significantly improving the way applications are developed and deployed across the IT infrastructure.

The LinuxONE servers are prepared to handle business-critical applications. LinuxONE Emperor II can run up to 2 million Docker containers in a single system, which maintains the highest levels of security and performance. It also can facilitate the transparent use of redundant processor run steps and integrity checking, which are essential for critical workloads.

As a 100% virtualized platform, LinuxONE can scale up resources (processor, disk, and memory) without outages. This ability provides applications an optimized scale architecture and a highly available platform to run and orchestrate Docker containers.

The layers in the LinuxONE machines when Docker containers are used are shown in Figure 3-1. Some servers are running into z/VM, KVM, or in bare-metal (LPAR).

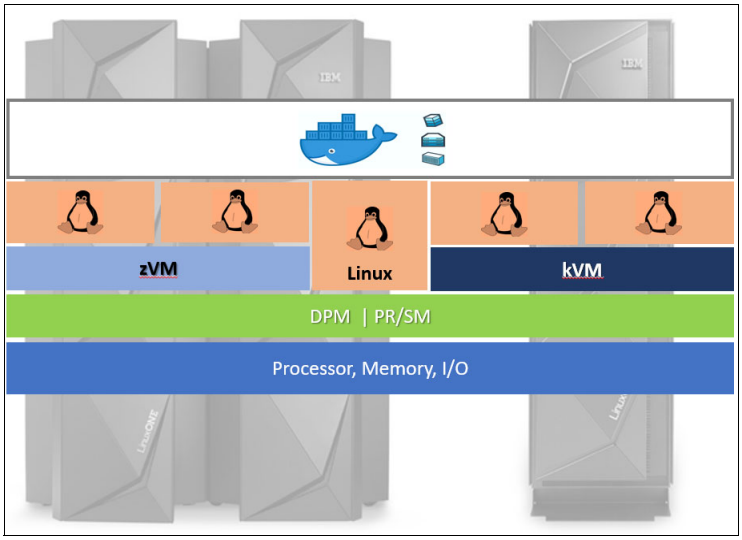

Figure 3-1 Docker containers on LinuxONE

Comparing virtual machines and Containers

A virtual machine (VM) abstracts the underlying hardware, which optimizes the use of hardware resources and reduces costs. The VM stacks include resources, such as memory, CPU, disk, and a network to run the operating system. All of these resources are managed by its hypervisor.

For many years, the massive adherence to virtualization by the companies transformed the IT market in such a way that it became a standard architecture. Containers present an improvement when compared to the traditional virtualization by focusing on the application layer, which facilitates its management.

For many years, the deployment of a new application meant creating a VM (including the base operating system) and customizing it to run the new workload. When compared with a container-based infrastructure, this approach created overhead in the system because all components of the stack must be re-created whenever a new demand occurs.

On x86 systems, the overhead that was caused by VMs was expected because the hardware resources are limited and to scale, the number of physical machines must be increased. These issues lead to the typical server sprawl problem.

Some aspects of containers and VM are compared and contrasted in Table 3-1.

Table 3-1 Comparing some aspects between Containers and VMs

Aspect	Container	Virtual machine
Layers	Run on top of an operating system.	Managed by its hypervisor and provides the operating system layer, which can run containers inside.
Sharing components	Libraries and files can be shared between the containers.	The hardware resources are managed and shared between VMs by the Hypervisor, but each operating system loads its complete stack.
Performance	Lightweight and faster than VM because it contains only the minimum number of libraries and programs that is needed to run an application.	An entire operating system is loaded in the VM, with the full operating stack, which causes overhead.
Isolation	Each container is isolated.	Multiples workloads can run in the same VM.
Scalability	Scale out: The complexity is reduced by orchestrating applications with Kubernetes-based technologies. Scale up: Several containers can be run in a single system, which uses the system resources for better utilization.	Scale out: More VMs are required, which causes environment overhead. Scale up: On LinuxONE, it is easy to add resources to a system without increasing the number of VMs.
Deployment Speed	Container start is swift because only the container context is loaded, not the entire operating system.	Takes longer to start because the entire operating system must be loaded in memory.
Sharing / Density	Allows for sharing of files, such as software libraries and applications.	Duplicate the kernel, software libraries, and applications.

Docker containers can run as VMs run, but without creating the entire operating system layer and its dependencies from scratch. The main difference is that Docker enables applications to use the same Linux kernel and libraries, which share the operating system with different containers.

Lifecycle management is one of the areas in which Docker stands out from server virtualization because of the nature of how Docker rolls out the applications, and the excellent advantage of removing the administrative resources for patching and lifecycle management that are required for every VM.

The structure of the VMs and Docker is shown in Figure 3-2.

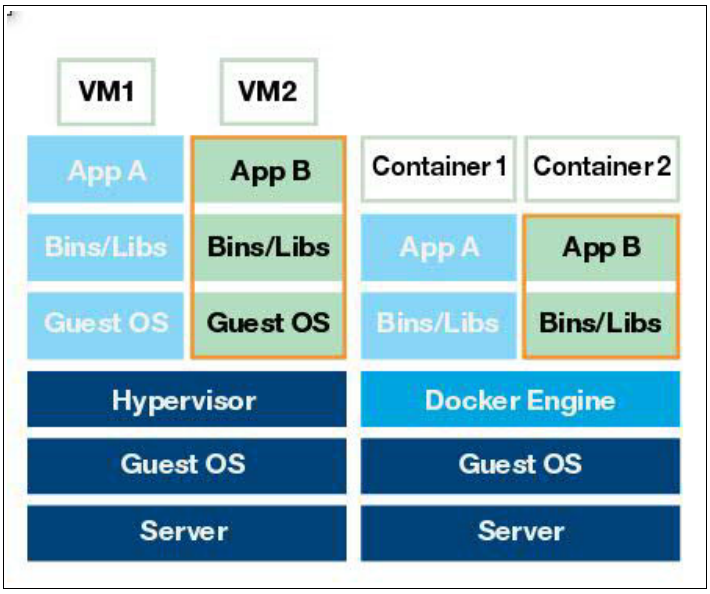

Figure 3-2 VM and Docker structure

Docker Consolidation on LinuxONE

It is widely known that the LinuxONE platform is the best for consolidation, where multiple services are combined on the platform by using its proven virtualization infrastructure. The containers that are used by Docker can accommodate larger density than VMs and enable more applications in one system, which further expands the consolidation capabilities of LinuxONE servers by making it possible to introduce new types of applications.

In a LinuxONE machine, two architectural options are available to run your Docker hosts: LPAR (bare metal) mode and hypervisors (z/VM or KVM).

Running Docker hosts in LPAR mode can be advantageous for workloads that benefit from colocation or high density. You can run multiple containers in a single Linux server in an LPAR, which is called a *host*. Docker can explore the benefits of LinuxONE hardware, such as increasing resources online. The containers that are running in the same LPAR can share resources, such as memory and processor, which avoids communication delays.

By using the VM approach, the improvements that are provided by the virtual environment, such as enhanced security and manageability, can be used, despite a minimal overhead increase caused by adding the hypervisor layer.

On the LinuxONE platform, you can shape your environment with system virtualization and Docker containers according to your landscape and requirements, without performance constraints.

Docker security on LinuxONE

IBM understands the requirements of enterprise organizations with mission-critical environments for security and isolation. LPAR technology provides the highest certification (EAL5+) of virtualization isolation. The z/VM hypervisor also provides a high level of isolation for KVM on IBM LinuxONE. Security and isolation of workloads are often critical concerns to large enterprise clients. IBM is bringing this high level of security with Docker as well.

Note: For more information, see *Getting Started with Docker Enterprise Edition on IBM Z,* SG24-8429.

3.4 Databases

Database *sharding* is defined as a horizontal partition of a database. It is a common practice that was adopted by several organizations to grow their databases on x86 platforms to allow for continuous operations when the underlying infrastructure can no longer support it in a single footprint with the expected performance.

Although splitting the original database into a shard or multiple shards is a solution for exceeding the hardware constraints of the x86 systems, such an approach includes several drawbacks, as listed in Table 3-2.

Table 3-2 Database sharding drawbacks

Cons	Symptoms
Complexity	A shard creates a more complex environment, which is subject to increased maintenance effort.
Increased latency	Because the shards are split among two or more different systems, a higher latency during querying is created.
Cross systems dependency	Because the database is no longer a single entity in a single server, more points of failure are created.
Increased SQL complexity	Can introduce application code bugs or issues with development teams.

The IBM LinuxONE platform can handle several workloads simultaneously while keeping excellent levels of performance to handle even the most demanding databases workloads. LinuxONE users can scale up a single server to circumvent the problems that are involved with database sharding.

By scaling up databases on LinuxONE, the performance is also improved because the platform is tuned for I/O throughput. Also, such an approach leads to an easier maintenance process, which reduces the complexity.

Database scalability is a common technique that is used to enable system administrators to grow systems to handle new business demands or work growth. For more information about scale out and scale up architectures, see 1.1, “Scale-up and scale-out definitions” on page 6.

Traditionally, databases were notorious culprits in hindering scalability. They also were considered incapable of meeting the needs of a high-performance distributed computing design. However, databases rose to the scalability challenge with new advancements in technology, including the following examples:

- Hardware that hosts the databases
- Networks (for example, 10 GigE)
- Disk access technologies (or example, Fibre Channel)
- Advancements in multi-processing database management system (DBMS) technologies

The scale out of a database is shown in Figure 3-3. The database tier is scaled out by including a shadow database that contains log shipping capability to support reports, analysis, and so on. As shown in Figure 3-3, the database complexity increased and poses challenges in keeping the database cluster members synchronized.

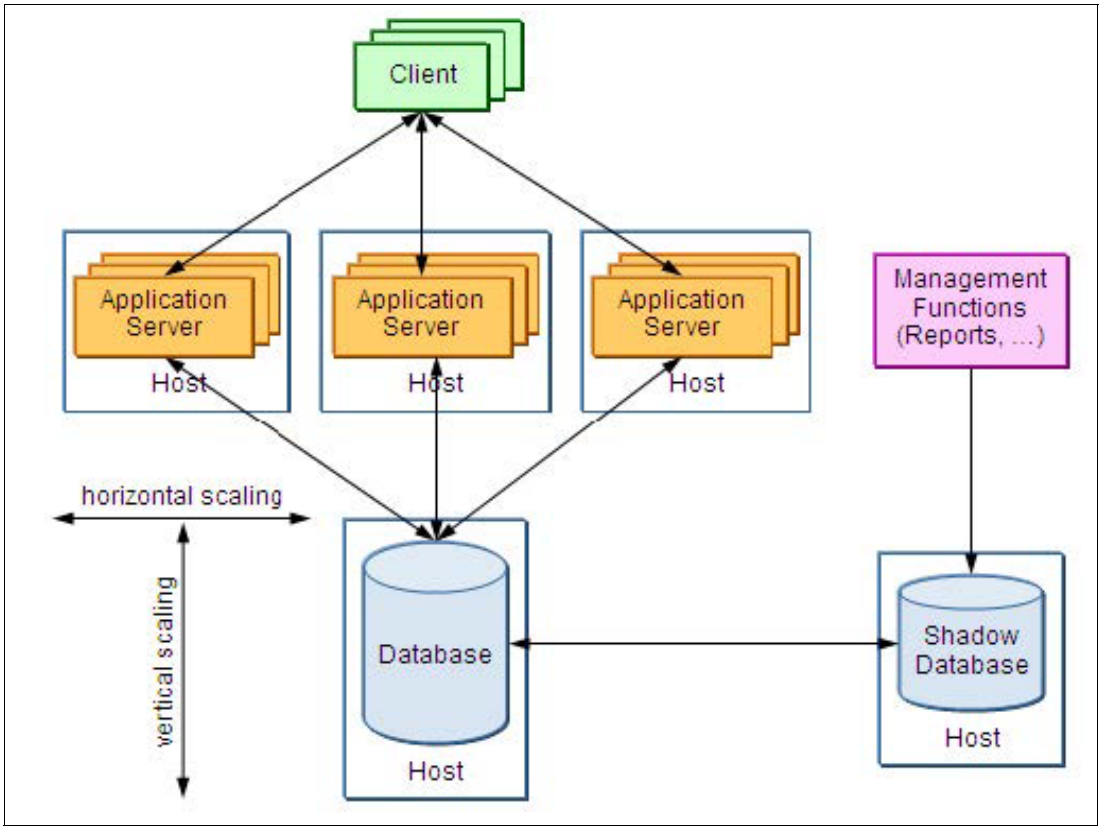

Figure 3-3 Database scalability challenge

Managing hundreds of database instances and a complex architecture are other major challenges of the scale-out architecture. The operational costs and the amount of effort to control this large environment tend to be more expensive and less efficient than the scale up architecture.

From an availability perspective, scaling cannot lead to an application downtime. Otherwise, it can affect application users and sometimes, the image of an organization if the application is critical. This issue is important because of growing demands within the industry, such as mobile and social media solutions, which require 24 x 7 availability.

Cloud-ready applications introduced substantial resource demands, which required larger databases and data throughput. The need for more memory, CPU, and disk I/O to handle the increased load growth keeps increasing with the shift to a world of unstructured data and Analytics Solutions. The fact is that the vertically scaled systems are the most cost-effective and the best-performing platform that is available for large, high-volume, transaction-intensive environments.

The LinuxONE platform enables organizations to keep pace with this growth. Its hardware technology and Open Source support were improved, while also reducing power and data center space needs when infrastructure is built with one or two LinuxONE servers.

To prevent the need to modify applications and increase environment complexity, the scaling up architecture brings the following benefits over the distributed scaling out approach:

- Special Cluster software is not required
- Resources can be instantly available with a simple push of a button (added when needed)
- Less management
- No need for sharding
- No application code changes
- Improved performance
- Lower infrastructure costs
- Eliminate x86 server sprawl

In summary, the operational requirements and complexity of scaling out systems are often far greater than those requirements of the scaling up approach. The use of multiple systems to meet application needs is another major consideration when choosing the scaling out architecture for your database or application.

The use of LinuxONE to scale up has significant advantages over other x86-based solutions, which helps to eliminate performance bottlenecks, environment complexity, and sprawl effects. In fact, database servers are one of the most highly recommended services to be moved to IBM LinuxONE.

The IBM LinuxONE platform capabilities represent some of the most mature and sophisticated virtualization technologies in the industry today. For example, a single LinuxONE system can scale up to millions of transactions per day or scale out to manage tens to hundreds of virtual servers. It can also redistribute system resources dynamically to manage varying server demands on the system resources automatically. The IBM LinuxONE servers can run the toughest workloads quickly and securely.

The following options are available when moving your databases from shared-nothing distributed data servers to a shared environment on top of the LinuxONE platform:

- *Traditional* refers to a database that runs on a virtual machine.
- *Database as a Service* (DaaS) refers to a public or private cloud-based service offering databases on demand. The DaaS solution on LinuxONE offers a flexible and scalable platform that enables you to provision and manage your database of choice quickly and easily.

Because organizations are focusing on keeping capital and operational expenses to a minimum, it is crucial to build a flexible data center infrastructure to accommodate the large databases.

Businesses can reap huge benefits from the LinuxONE platforms scaling up architectures to grow capacity and attend new business demands.

3.4.1 NoSQL databases

Not Only SQL (NoSQL) databases became popular with the new requirements that are driven by the Web 2.0 shift in many sectors, such as analytics and big data. Typically, one of the greatest benefits about such solutions is the simplicity of achieving horizontal scaling across a cluster of systems. Other benefits on the use of NoSQL databases involve the storage of unstructured data and a faster development.

As opposed to traditional relational databases, NoSQL databases are typically key-value pairs that are stored in a document-related model. Also, NoSQL databases do not rely on the Atomicity, Consistency, Isolation, and Durability (ACID) concepts that are present on traditional RDBMS databases.

NoSQL databases present a huge architectural change when compared to SQL-oriented databases. The IBM LinuxONE can meet the scalability needs of NoSQL databases to suit even the most demanding needs.

MongoDB

MongoDB is a popular NoSQL document-oriented database. It stands out from relational databases by using dynamic schemas with which records can be inserted without creating an initial schema to define data structure. Therefore, fields and their values can be easily modified to map application changes without interruption.

Note: MongoDB is just one of many different NoSQL products. Examples of other NoSQL databases include Redis, Cassandra, and IBM Cloudant®.

MongoDB is widely used for mobile apps, real-time analytics, product catalogs, and content management systems. It can also be used for many other use cases, such as storing streams of data from IoT.

MongoDB stores data in a JSON-like documents (aligning data storage formats with modern programming languages that are used by developers) instead of columns and rows that are present in relational databases. Each document can contain different fields, which contain a value that belongs to the same data type, including subdocuments and arrays.

Instead of having related data that is represented by different tables, the cost of joining separate tables is eliminated by storing the linked objects in the same document. This configuration reduces complexity and simplifies data access. Similar documents are organized into collections in the database.

The difference between MongoDB documents and traditional relational data models is shown in Figure 3-4.

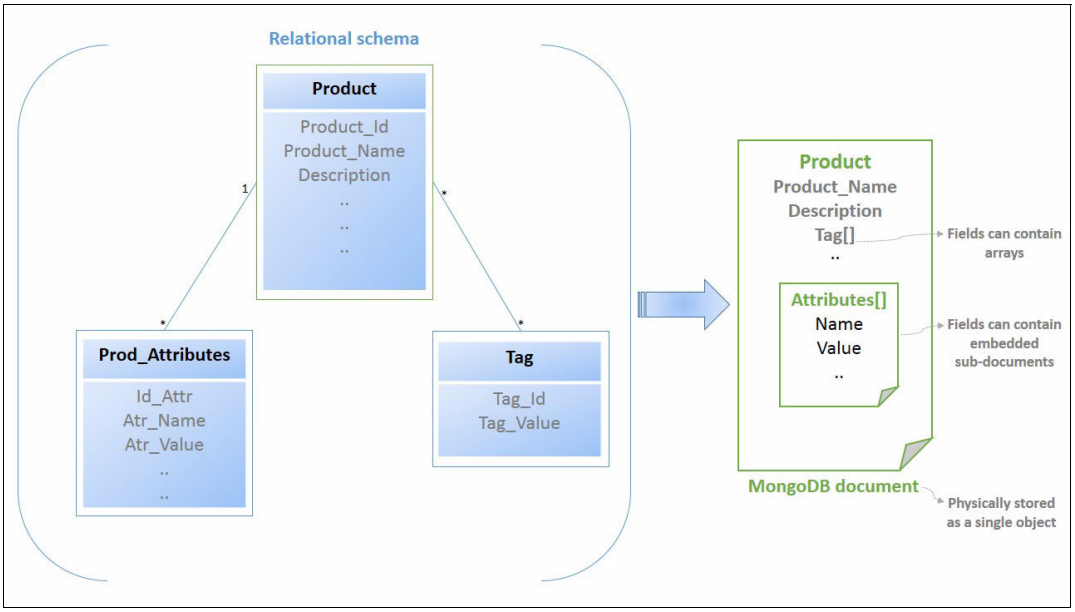

Figure 3-4 MongoDB document model versus relational data model

Some of the concepts that are used in MongoDB and their counterparts in relational databases (for example, IBM Db2® database) are listed in Table 3-3.

Table 3-3 MongoDB versus traditional SQL database

MongoDB	Db2
JSON-like document	Row
Collection	Table
Embedded subdocuments and Linking	Join
Index	Index

The enterprise edition of MongoDB (called MongoDB Enterprise Advanced) is supported on LinuxONE.

Added value of running NoSQL databases on LinuxONE

With the LinuxONE platform, multiple cores can be used (1 - 170 cores on Emperor II), which allows it to scale vertically without scaling out such databases. The network communication between the NoSQL cluster is also drastically reduced (near zero latency) by using IBM HiperSockets technology that is used in LinuxONE to accelerate the communication among different LPARs.

In addition, the capabilities of the LinuxONE platform in terms of security (such as the EAL5+ certification and pervasive encryption), high availability, and resiliency can be used to efficiently enhance MongoDB's capabilities and achieve the most stringent market requirements.

3.5 Cloud

The concept of cloud computing exists for many years now and features many changes and benefits when compared to the previous way of handling an IT Infrastructure. Businesses must react quickly to market changes and use their speed to market while keeping up with a secure, trusted, stable, and available infrastructure.

A proper Cloud infrastructure (public, private, or hybrid) must be carefully planned because several aspects must be considered before its implementation. An incorrect choice of the underlying supporting technology can have disastrous effects on an organization.

The following aspects must be considered when choosing a platform to house Cloud workloads:

- Scalability: The underlying platform must handle future business growth to achieve a better TCO, reduce outages, and prevent maintenance.
- Elasticity: It must allow virtual resource growth or shrinkage as required dynamically, without interruption of services. Maximizing resource use is a fundamental aspect to reduce costs.
- Security: The hardware must be proven secure to prevent customers and business exposures, including affect on reputation.
- Performance and isolation: A problematic workload must not affect other running workloads. Similarly, the hardware footprint must handle all workloads that are running together.

- Availability: The platform must be reliable and redundant to maintain the business operations.
- Maintenance: Infrastructure maintenance must be kept simple.

Other factors include self-service on-demand capabilities along with platform openness to greatly reduce the learning curve from the DevOps teams on managing the infrastructure.

The IBM LinuxONE is the ideal platform to scale and allow customers to run premium Cloud services within a single hardware footprint, as described in 2.3, “LinuxONE Cloud capabilities”. It also meets all of these related aspects to build the most secure, reliable, and top performing cloud infrastructure in the market.

The IBM LinuxONE platform for each layer of the cloud is shown in Figure 3-5.

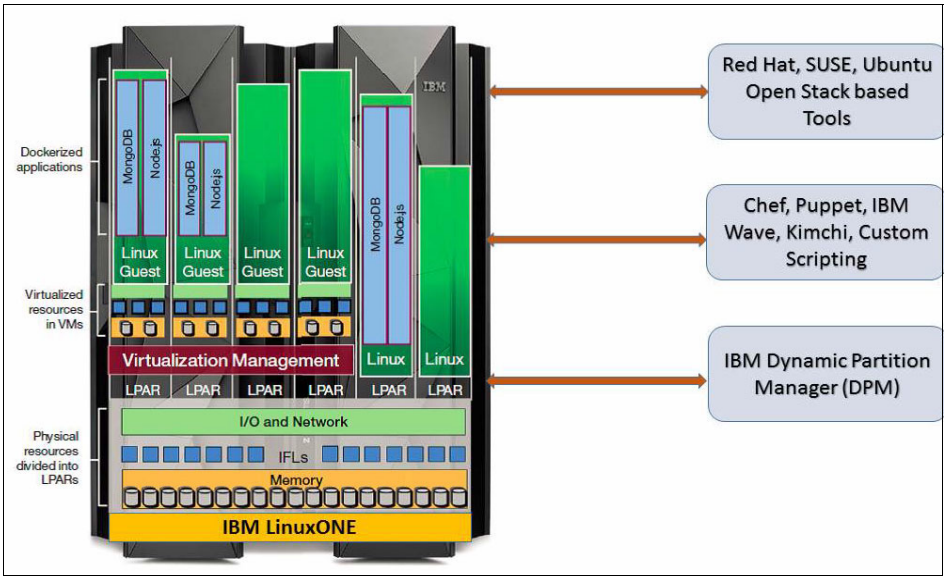

Figure 3-5 IBM LinuxONE is “cloud ready”

IBM also provides several Cloud ready infrastructure services that run on top of the LinuxONE platform, such as the IBM Cloud Hyper Protect Services and IBM Hyper Protect DBaaS on its public cloud. By using these services, customers can expand their cloud portfolio securely and with optimal performance.

IBM Cloud Private also allows customers to quickly scale their infrastructure simply and quickly, which allows them to react quickly to demand changes.

IBM Cloud Private self-service portal that is running on top of IBM LinuxONE is shown in Figure 3-6.

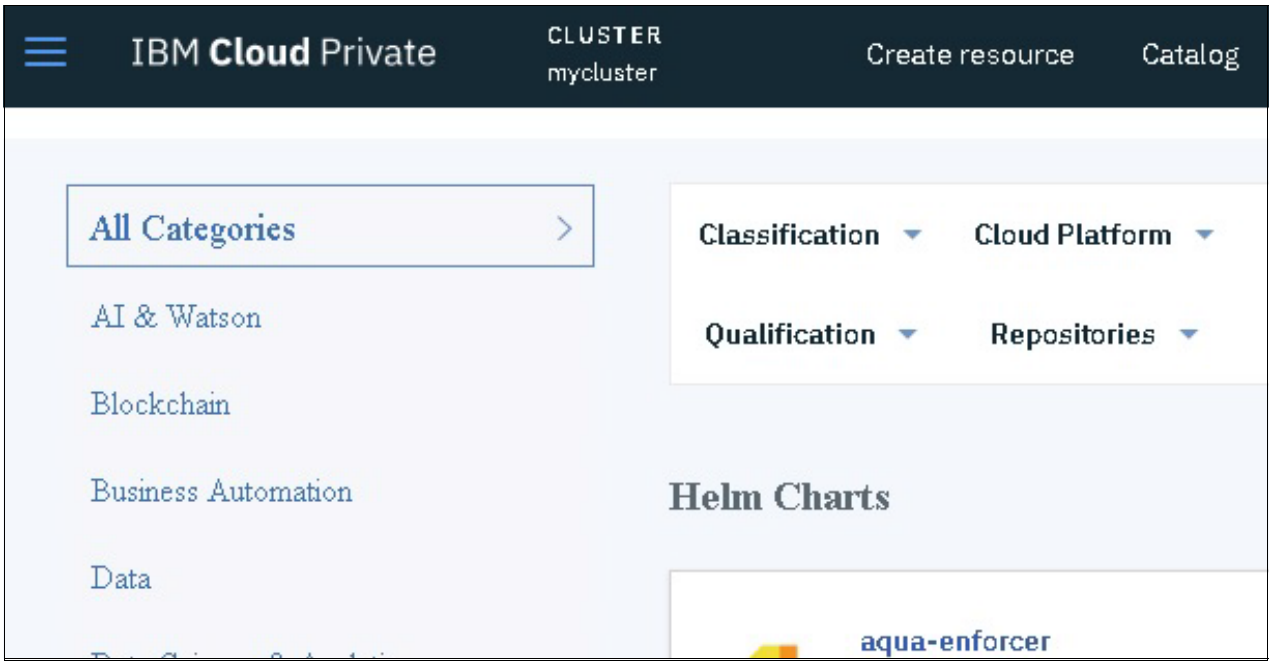

Figure 3-6 IBM Cloud Private provides an easy way to deploy services on IBM LinuxONE

The LinuxONE platform enables users who are delivering cloud services to rapidly deploy a trusted, scalable OpenStack-based Linux cloud environment that can start small and scale up to 8000 VMs in a single footprint on any IBM LinuxONE family.

Note: For more information, see *Practical Migration from x86 to LinuxONE*, SG24-8377.

3.6 Analytics

In the big data era, organizations are searching for critical Analytics Solutions to make better business decisions. They analyze structured and unstructured data to acquire knowledge and keep their competitive advantage.

Business leaders are demanding insights from their data faster than the traditional IT can deliver. The number of companies fully prepared to address big data and analytics challenges and demands are few.

Choosing a big data and analytics platform is a challenge because several factors must be considered to run these types of workloads, including fast performance, security, flexibility, resiliency, and disaster recovery capabilities. This key decision forecasts investments and drives the right business outcomes to improve their competitive advantage.

The LinuxONE platform satisfies these requirements with high performing business analytics and database solutions that reduce cost and complexity. LinuxONE offers a portfolio of hardware, software, and services solutions for housing analytics and big data workloads.

IBM Cognos

IBM Cognos® provides a full range of business intelligence capabilities, such as reporting, analytics, real-time monitoring, dashboards, and Mobile Business Intelligence. By using IBM Cognos Business Intelligence combined with IBM LinuxONE, it is possible to scale up and use data analytics in a single hardware footprint.

With LinuxONE, organizations can scale up and scale out, without performance degradation in application response time, while keeping offering continuous solution availability. The time that is associated with deploying a new business intelligence application, increasing capacity, or both is reduced with the LinuxONE platform for Cognos Business Intelligence deployments.

Apache Spark

Apache Spark is an Open Source engine that is built specifically for data science. It helps simplify algorithm development and accelerate analytics results. With Spark and LinuxONE, analytics leaders can better extract value from big data, conduct deeper analyses, and deliver results faster, all while using the security and virtualization benefits of a centralized infrastructure.

The LinuxONE platform is ideal for hosting the core Spark database and its analytics capabilities because the data is stored in the same hardware footprint. This feature enables high-speed communication that is unmatched by other platforms.

3.7 Mobile and social

The world is becoming more digital and interconnected. Leading companies are seizing the opportunity to build, integrate, and support the next generation of applications. They are using mobile, cloud, and big data analytics in new, more effective ways to drive better business outcomes and competitive differentiation. To support these strategic efforts, companies need a flexible and cost-efficient IT architecture to gain the highest levels of reliability, security, and perform.

These digital applications are not just emerging technologies because their capabilities are disrupting traditional business models. They also provide organizations with new sources of information that can lead to improved decision making and the potential for an increase in business results. Existing core applications on the LinuxONE platform, such as transactional processing or database services, are often characterized as secure, reliable, and highly scalable.

The IBM LinuxONE transaction processing systems were responsible for the control of this huge repository of data for some time. The IBM LinuxONE platform offers the ability to operate continuously, with secure access provided by the latest technological advances in cryptography and digital signatures. Therefore, building a mobile and social solution onto the IBM LinuxONE infrastructure makes perfect sense.

The IBM LinuxONE platform includes a renowned capability to have a linear and automated scalability, and can handle the unpredictable user workload. Also, high availability and disaster recovery are other requirements for every organization that embraces social and mobile applications.

Implementing and maintaining these requirements always is one of the strongest capabilities of an IBM LinuxONE environment. The IBM LinuxONE platform can help you deliver an IT infrastructure that can keep pace with the increased transaction workload that results from mobile and social engagements, while ensuring the highest levels of protection and privacy.

Mobile applications are becoming the primary face of many companies. If an organization's mobile app is unreliable, or the user has a bad experience, it has a direct effect on the overall perception of that company in the customer's mind.

It is crucial for the overall transactional confidentiality, integrity, and auditability of the requests initiated by a mobile device. These applications have a high rate of growth and many active users. Therefore, the system architecture plays an important role to ensure excellent levels of performance and elastic scalability to meet unexpected surges in mobile and social requests.

To fit with social and mobile needs, the LinuxONE platform provides high availability (99.9%), high scalability with over 800 cores (up to 170 IFLs plus 640 processors that are dedicated to I/O), along with up to32 TB of RAM on IBM LinuxONE Emperor II, and pervasive encryption.

For more information, see *Getting Started with Linux on Z Encryption for Data At-Rest*, SG24-8436.

Understanding all of the advantages that are available with the IBM LInuxONE against x86-based platforms can help you to select the best system architecture that can better deal with the challenges of these emerging digital applications.

3.8 Blockchain

Blockchain is a technology for a new generation of transactional applications that fundamentally changed the way businesses created and captured value. Blockchain is a shared, distributed ledger that facilitates the process of recording transactions and tracking assets in a business network. Virtually anything of value can be tracked and traded on a blockchain network, which reduces risk and cuts costs.

IBM Blockchain is based on the Hyperledger project that is led by the Linux Foundation. Hyperledger is an Open Source, collaborative effort that was created to advance and standardize cross-industry blockchain technologies.

Since the project started, IBM supports the Hyperledger and contributes a significant amount of code to the effort and has representatives on the Project's Technical Steering Committee (TSC). IBM has the background and expertise that is needed to implement successful blockchain distributed ledger technologies (DLTs) and numerous customers success cases implementing those solutions.

The LinuxONE is a platform that is prepared for blockchain implementations. By offering customers the most secure platform for blockchain networks, LinuxONE offers features that combine the performance and security of IBM Blockchain networks, including:

- Multi-tenant separation and isolation

  Because systems can host multiple blockchain networks, it is critical that participating entities data and activities are kept separate and secure so they can only see and participate in approved activities. IBM achieves this isolation with logical partitions (LPARs) that support EAL5+ security, which is the highest commercially available security standard.

- Security against external attack

  The IBM Secure Services Container, as described 2.4.3, “Secure Services Container” on page 42, protects blockchain implementations against external attack by encapsulating all software in a secure, signed, trusted appliance-style container. This configuration protects blockchain DLTs against malware, misuse of privileged user credentials, and deliberate or unintentional leakage of information. Because Secure Service Container support is driven all the way into the LinuxONE firmware, it is almost impossible for a malicious individual to break into.

- Cryptographic key safety

  IBM’s LinuxONE further enhances security by encrypting all data in the blockchain container. In addition, encryption keys are stored in dedicated, tamper responsive Crypto-Express cards that prevent privileged users from creating snapshots of blockchain data.

  As a result, IBM LinuxONE blockchain solutions can achieve the highest standard of security compliance**.** Because of the unique functionality and ability to handle the most sensitive data and critical applications, the LinuxONE platform can run blockchain workloads better than any other platform. The LinuxONE is optimized to deal with massive transactions and memory operations, which enables you to scale up the system to accommodate new workloads while maintaining system security.

Blockchain can use the special hardware in the LinuxONE family to deploy this breaking technology at scale, with top performance, high availability, and industry-leading security built-in.

These platforms also can deliver the following benefits:

- Blockchain peer-to-peer nodes realize optimized communication with other IBM solutions, such as z/OS®, which speeds up access to colocated business data
- Isolated partitions (EAL5+) keep ledgers separate and secure
- Availability and scalability of the IBM LinuxONE servers as an environment for both blockchain development and testing and production
- Vertical (scale up) scalability offers unmatched processing power
- Reduced data center footprint, simplified management, and energy savings
- Hardware encryption with built-in accelerators for blockchain hashing, signing, and security
- Faster responses with HiperSockets (in-memory communication)
- Security Standards compliance
- Tamper-proof crypto-keys in firmware/crypto cards
- Unlimited random keys to encode transactions

For organizations that are considering blockchain technologies, the LinuxONE platform can support all blockchain initiatives. Also, customers can review the blockchain technology by downloading and running the blockchain Docker image.

Note: For more information about Hyperledger installation, see *Practical Migration from x86 to LinuxONE*, SG24-8377.

3.9 Performance and capacity

Cost and performance often are the main elements for selecting a scale architecture. Organizations must be ready for today's challenges, and for the bigger challenges of the future, such as ensuring that their infrastructure can handle proper growth.

Systems can be scaled in many ways, but the scale up methodology is capturing the attention of decision-makers that want a solution to solve scaling challenges and performance problems while also reducing costs. The LinuxONE hardware can scale up to have a significant role in today's and tomorrow's data center needs while also having significant advantages over x86-based scale-out systems.

In fact, IBM‘s architecture delivers the flexibility that an organization needs to meet for their business demands and high-performance requirements. It also scales up or scales out later on, as necessary.

Today, the LinuxONE architecture play a central role in the daily operations on most of the world's largest corporations, including many Fortune 1000 companies. Although other forms of computing are used extensively in business in various capacities, its architecture occupies a coveted place in today's e-business environments. In banking, finance, healthcare, insurance, utilities, government, and a multitude of other public and private enterprises, IBM LinuxONE forms the foundation of modern business today.

Much of its popularity and longevity is because of its inherent richness in reliability and stability, which are a result of IBM multiple years of study and technology enhancements. No other computer architecture can claim as much continuous, evolutionary improvement, while maintaining compatibility with existing applications.

In the same way, the evolution of emerging technologies, such as cloud, big data, and blockchain over the past years creates a strong case for organizations looking to deploy open source software running on top of Linux within mission-critical environments.

In terms of hardware, the platform must easily scale up to improve performance and manage large masses of application data.

Organizations across the world are increasing focus on their infrastructure to support these new initiatives. It continues to be a strong focus area in the overall strategic plan of most organizations across the world. Therefore, it is critical to explore the scaling, performance, and management of large databases, complex applications, and the LinuxONE platform.

Its scalability is designed to allow customers to manage more workloads at less cost with increases in capacity per core and increases in single system capacity. IBM LinuxONE delivers exceptionally fast application performance, millisecond response time, and extreme reliability thanks to the recent technological innovations.

Customers expressed a strong interest in understanding how scale up solutions that are built on the LinuxONE platform can be the answer to their growing requirements and performance problems. The configuration, scalability, and management solutions on the IBM LinuxONE create a robust and flexible infrastructure where organizations want see themselves.

Also, LinuxONE systems are equipped with the fastest general-purpose processors in the world that are ideally suited for data processing throughput. The large number of coresthat is available and their high I/O bandwidth means that open source solutions can both scale up and scale out.

They can also bring in an exceptional total cost of ownership (TCO), highest performance, and enormous processor scalability. Indeed, the platform can scale up to 8,000 VMs or thousands of containers, which surpasses the capabilities of any x86-based server.

The concern about availability, performance, scalability, and security is a common one for mission-critical workloads. It also is a major differential factor when deciding the better infrastructure architecture to load vital applications.

The selection criteria between the x86 systems and the LinuxONE platform is in their capabilities to handle data workloads, such as databases, big data, data encryption, and certainly in analytics. Comparing these three platforms by using complex workloads demonstrates a significant advantage for LinuxONE servers.

3.10 Practical LinuxONE hands-on experience

IBM provides a public infrastructure to evaluate the LinuxONE platform called IBM LinuxONE Community Cloud (see Figure 3-7. It enables customers to provision a virtual server image without any charges running on IBM LinuxONE with Red Hat and SUSE Linux distributions.

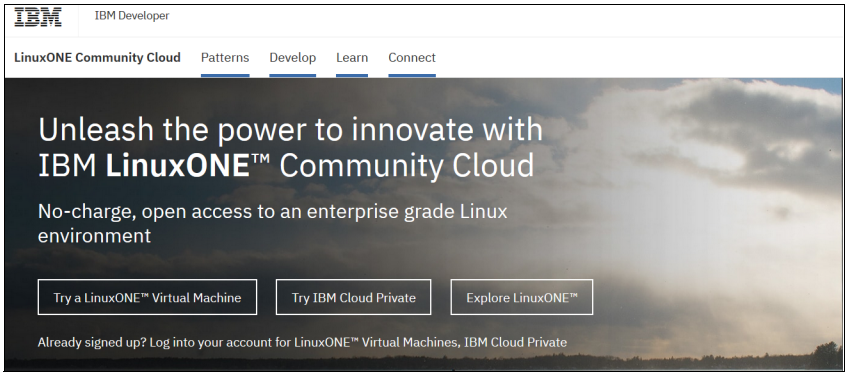

Figure 3-7 Try the LinuxONE platform by creating a VM on LinuxONE Community Cloud

The IBM LinuxONE Community Cloud are ready for the following types of workloads:

- Docker
- Blockchain
- Databases: Db2, MongoDB, and PostgresSQL
- Open source software

You can subscribe to and up to 120-day trial by completing the form on the website. The trial includes a VM that contains up to two virtual CPUs, 4 GB memory, and 50 GB of storage (see Figure 3-8). It is a basic environment to start a Proof of Concept (POC) on IBM LinuxONE and allows customers to evaluate the system functionalities and gain expertise on LinuxONE platform.

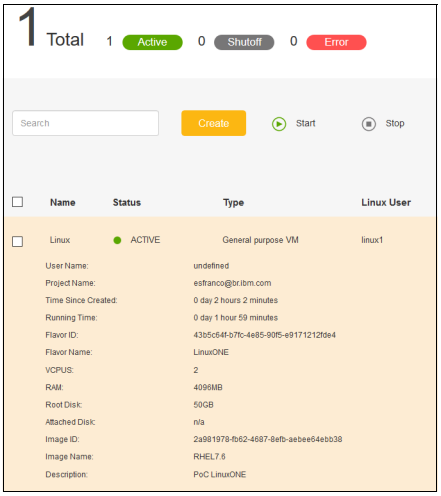

Figure 3-8 Linux VM (instance) running on LinuxONE Community

The LinuxONE VM (instance) creation window is shown in Figure 3-9. You can choose a Red Hat or SUSE operating system and test your workload on top of the LinuxONE hardware.

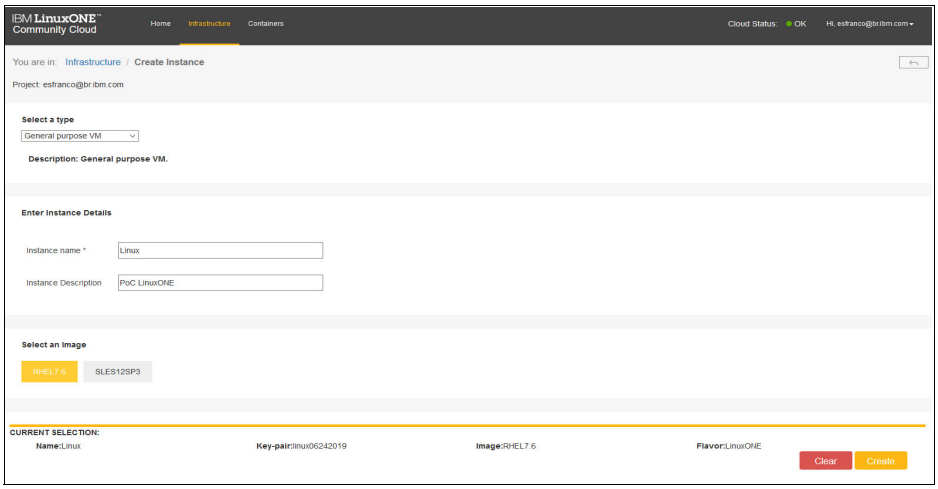

Figure 3-9 Creating a Linux VM in the LinuxONE Community Cloud

Developers can find various documentation about LinuxONE on the website that covers many software platforms and tools.

For more information about creating and starting your VM, see this web page.

For assistance with the site, a Q&A forum also is available to contact with support teams or use the mail address that is available on the page[1].

[1] Suggestion: Discover the potential of your LinuxONE VM and contact IBM about your experience.

3.11 Final considerations

In a data-driven world, your infrastructure needs flexibility and stability to run a wide range of open source products. It also needs to run resource-intensive solutions, such as Db2 and Oracle databases, with optimal performance. Organizations are looking for solutions with constant innovation that stems from open source world and incurs lower costs, while looking forward to the future and how a platform can use their businesses growth across the years.

Most organizations do not accurately calculate the total costs of their server proliferation for many reasons, including the fact that chargeback mechanisms do not exist, because only the incremental IBM LinuxONE investment costs are compared to incremental distributed costs, or because total shadow costs are not included.

Many organizations also fail to recognize the path length delays and context switching of running workloads across many servers, which typically adds up to a performance penalty that is non-existent on the IBM LinuxONE platform. Also, the autonomic capabilities of the LinuxONE platform (reliability, scalability, and self-managing design) might not be considered.

Distributed servers encounter an efficiency barrier where adding incremental servers after a certain point fails to add efficiency. The total diluted cost of the LinuxONE is not used correctly in calculations; rather, the delta costs attributed to an added workload often make the comparisons erroneous. In distributed servers, the cost per unit of work never approximates the incremental cost of a mainframe.

However, over time, it is unlikely that a server farm might achieve the economies of scale that are associated with a fully loaded LinuxONE server, regardless of how many devices are added. In effect, the efficiencies that are realizable in a distributed computing environment are limited. These inefficiencies are because of shadow costs, execution of only one style of workload versus a balanced workload, underutilization of CPUs, people expenses, and real estate costs of a distributed operations management.

Following this idea further, server sprawl and x86 distributed systems can cost you in more ways than one. Cash, complexity, and capacity can all limit your ability to say “yes” to the business. Consolidating your servers to a LinuxONE server gives you the competitive edge so that you do not have to make either choice for your data center.

In particular, the value that the LinuxONE scaling up architecture brings to running Linux applications on a secure and reliable platform makes it the most efficient and economical environment when compared with the x86-based scale-out approach. It means taking advantage of the power of the platform to run multiple workloads and open source application, which gives you a cost-effective alternative to x86 distributed servers.

Scaling up is easier. Most widely used applications, such as MongoDB, analytics, and big data, lend themselves well to that approach. In fact, these applications were designed for scale up to make the system bigger.

Organizations have a preference for open source software, an environment that is flexible, and cost-effective solutions. These aspects help you decide to use LinuxONE that was engineered for the industry’s most secure data serving, with faster throughput to get more from the open source infrastructure, databases, and heavy applications.

The IBM LinuxONE platform delivers the following technical enhancements over its predecessor platforms:

- Vertical scaling up to 170 user-accessible cores that are running at 5.2 GHz.
- A total of 32 TB of shared memory, which enables larger in-memory applications.

- Multi-core, single-chip modules that are running to help improve the running of processor-intensive workloads.
- More real memory per system, which ensures high availability in the memory subsystem by using proven redundant array of independent memory (RAIM) technology.
- Improved cryptographic functions and performance, which is achieved by having one dedicated cryptographic co-processor per processor unit.
- Proven technology (fifth-generation high frequency and third-generation out-of-order design) with a single-instruction, multiple-data (SIMD) processor that increases parallelism to accelerate analytics processing. In addition, simultaneous multithreading (SMT) increases processing efficiency and throughput and raises the number of instructions in flight.
- The channel subsystem is built for I/O resilience. The number of logical channel subsystems (LCSS), subchannel sets, and I/O devices are consistent with its predecessor platform, as is the number of logical partitions (LPARs):
  - Six LCSS
  - 85 LPARs
  - Four subchannel sets
  - 32,000 I/O devices per channel

The latest LinuxONE servers feature a proven architecture to support your digital transformation, create a strong cloud infrastructure, and make back-end services available through secure APIs. They can also streamline your ability to integrate disparate data center systems and create a single, cohesive IT shop.

The infrastructure that is built on the LinuxONE platform provides the following benefits:

- Less data center space
- Less power consumption
- Fewer administrators
- More efficient because it can scale up or scale out
- Fewer servers for reduced complexity
- Fewer software licenses
- Fewer intrusion points for tighter security
- Fewer points of failure for greater availability

By choosing LinuxONE, organizations can benefit from a secure, highly available, and easy-to-manage environment to consolidate their data while optimizing overall costs.

Related publications

The publications that are listed in this section are considered particularly suitable for a more detailed discussion of the topics that are covered in this paper.

IBM Redbooks

The following IBM Redbooks publications provide more information about the topic in this document. Note that some publications that are referenced in this list might be available in softcopy only:

- *Getting Started with KVM for IBM z Systems*, SG24-8332
- *An introduction to z/VM Single System Image (SSI) and Live Guest Relocation (LGR)*, SG24-8006
- *Using z/VM 6.2 Single System Image (SSI) and Live Guest Relocation (LGR)*, SG24-8039
- *Practical Migration from x86 to LinuxONE*, SG24-8377
- *IBM z14 Technical Introduction*, SG24-8450
- *IBM z14 Technical Guide*, SG24-8451
- *Securing your Cloud IBM z/VM Security for IBM Z and LinuxONE*, SG24-8353
- *Security for Linux on System z*, SG24-7728
- *End to End Security with IBM Z*, REDP-5153
- *Security and Linux on z Systems*, REDP-5464

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

The following publications are also relevant as further information sources:

- *Database as a Service*, SC34-2780
- *z/VM CP Planning and Administration version 6 release 4*, SC24-6178

Online resources

The following websites are also relevant as further information sources:

- https://www.ibm.com/linuxone/solutions
- https://www.redbooks.ibm.com/Redbooks.nsf/domains/linuxone?Open&page=trending
- https://www.ibm.com/software/info/eagletco/iteconomics/
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