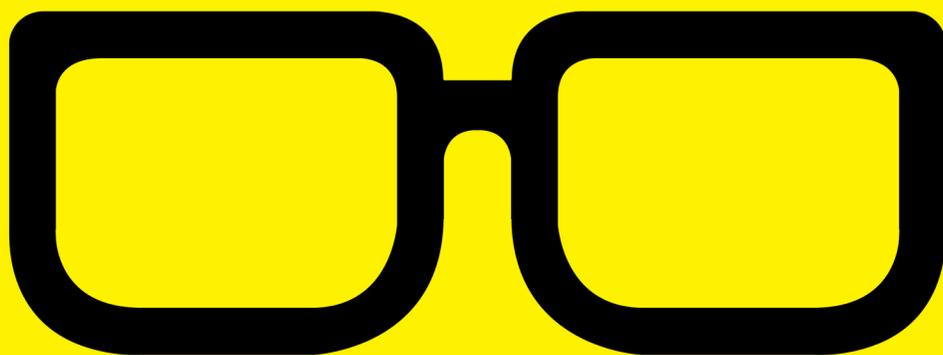


GEEK GUIDE



LinuxONE: the Ubuntu Monster

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About the Sponsor

IBM

IBM is a globally integrated technology and consulting company headquartered in Armonk, New York. With operations in more than 170 countries, IBM attracts and retains some of the world's most talented people to help solve problems and provide an edge for businesses, governments and non-profits.

Innovation is at the core of IBM's strategy. The company develops and sells software and systems hardware and a broad range of infrastructure, cloud and consulting services.

Hybrid Cloud is helping businesses deliver unprecedented levels of agility for quicker time to market and richer customer experiences. But not all cloud infrastructures are equal. IBM z Systems and LinuxONE are the world's leading cloud platforms for enterprise transactions, systems of record and application workloads.

Today, IBM is focused on four growth initiatives—business analytics, cloud computing, growth markets and Smarter Planet. IBMers are working with customers around the world to apply the company's business consulting, technology and R&D expertise to build systems that enable dynamic and efficient organizations, better transportation, safer food, cleaner water and healthier populations.

LinuxONE: the Ubuntu Monster

JOHN S. TONELLO

Introduction

When the first Linux kernel was released 25 years ago, it became the go-to platform for hobbyists and developers looking to build systems and develop software on the cheap. Since it was designed for x86 machines, the Linux operating system could be deployed on just about any old hardware lying around.

Of course, a lot has changed since then, and Linux has

Unlike any other mainframes in history, these machines were designed from the ground up to run Linux and only Linux, and for the first time, to run Canonical's Ubuntu along with Red Hat and SUSE.

become a viable and widely used OS for every platform, including mission-critical IT infrastructure, thanks in part to IBM's early adoption and investment in Linux and the Open Source community.

Still, unless you've had the opportunity to work someplace that needs the mainframe-class computing power of IBM z Systems and their predecessors, you probably rely on cabinets filled with x86 blades outfitted with the flavor of Linux that best suits your needs and go on your merry way. When virtualization came along, the x86 architecture proved adaptable, and you were content with boosting your CPU and memory utilization from 15% on bare-metal servers to 35% on virtual ones.

IBM is challenging that paradigm with the launch of its new IBM LinuxONE Emperor and Rockhopper, appropriately named for two breeds of penguins. Unlike any other mainframes in history, these machines were designed from the ground up to run Linux and only Linux and, for the first time, to run Canonical's Ubuntu along with Red Hat and SUSE.



Emperor

Rockhopper

FIGURE 1. LinuxONE Emperor and Rockhopper (Image courtesy of IBM.)

For those who've built their shops around clusters of x86 blades and Ubuntu (which edged out Debian as the most popular Web server platform in May 2016), there's now a reason to take a look at alternate hardware—particularly if data-center space is becoming limited or you're hitting a bit of a hardware wall as you spin up and manage more than 200 clustered VMs. Given Ubuntu's popularity, the abundance of developers who prefer it and the massive base of developed software available for Ubuntu, it's pretty hard not to see real opportunity.

What Is LinuxONE?

Launched in August 2015, IBM's LinuxONE machines are Linux-only z Systems that accommodate up to 10TB of memory and IBM's industry-leading 5GHz CPUs that, depending on your needs and budget, can scale to 141 cores. If you're used to thinking in x86 blade terms, these machines are monsters that provide drool-worthy speeds—for both raw processing power and application deployment.

The LinuxONE Emperor has 24 CPU cores dedicated to I/O and up to 320 Power-based I/O co-processors, depending on how many cards you install. All that power given to I/O dwarfs x86 systems, giving the LinuxONE mind-boggling abilities to make high-speed connections to your network and SAN, and move data among VMs with very low latency.

IBM bills the systems as "Linux without limits", an all-in-one platform that allows you to deploy just about any open-source app and service you can think of. Its real strength is the LinuxONE's ability to tackle huge data sets and gobble up analytics that would be more cumbersome and costly—and slower—on traditional x86 platforms.

According to IBM, LinuxONE offers an "enterprise-grade platform for Linux technology as a trustful, reliable and highly secure system to confidently deploy business-essential applications, optimize operating costs and achieve seamless infrastructure growth". What that means for the rest of us is that IBM has bundled together some of the speediest hardware—designed for 100% uptime over decades—with some of the most popular and widely used open-source software to offer

a system that makes sense for enterprises that may have considered this hardware out of reach.

The Hardware: The LinuxONE Emperor comes in five models, starting with the L30, which offers 1 to 30 cores and 64GB to 2.5TB of memory. The top-end LE1 offers 1 to 141 cores and up to 10TB of memory.

The LinuxONE Rockhopper—what IBM calls its entry-level system in the category—offers more modest horsepower, yet it can be upgraded as your needs grow into full Emperor-like capabilities. The two Rockhopper models offer 1 to 10 cores (running on 4.3GHz IBM processors) with a maximum 1TB of memory for the L10 model, and a total of 20 cores and 4TB of memory for the L20.

TABLE 1. IBM LinuxONE Emperor at a Glance

Emperor Models	Cores: Minimum–Maximum	Memory: Minimum–Maximum
L30	1–30	64GB–2.5TB
L63	1–63	64GB–5.0TB
L96	1–96	64GB–7.5TB
LC9	1–129	64GB–10.0TB
LE1	1–141	64GB–10.0TB

TABLE 2. IBM LinuxONE Rockhopper at a Glance

Rockhopper Models	Cores: Minimum–Maximum	Memory: Minimum–Maximum
L10	1–10	64GB–1.0TB
L20	1–20	64GB–4.0TB

The capacity of these systems is, frankly, a bit jaw-dropping. For example, the LinuxONE Emperor supports 85 logical partitions for secure workload isolation. Partitions built atop those partitions using the Linux-based hypervisor, KVM or IBM's z/VM can support up to 8,000 virtual machines and 1 million Docker containers, although tens of thousands are more realistic for particular applications. Because its transactional architecture scales quickly, the systems offer high availability with built-in component redundancy and "smart" features that detect problems before they happen, along with concurrent maintenance and repair.

IBM outfitted the LinuxONE family with its z13 processor that has extra microcode to optimize its Linux performance and simultaneous multithreading, making it the fastest commercially available processor on the market.

To make sure these powerful systems can connect to your SAN at speeds that don't get in the way of all that processing power, the LinuxONE Emperor and Rockhopper offer FICON Express16S/FICON Express8S (320 ports max) that can operate at up to 8Gbps using single or multimode fiber. Connecting to your network is similarly fast with IBM's OSA-Express5S (96 ports max) that can operate at up to 10Gbps.

All that horsepower doesn't come small, but the LinuxONE systems won't overwhelm your machine room. The Emperor is about four times the size of a standard 42-U cabinet. The Rockhopper has a footprint about half that. Weight varies largely on whether you include built-in batteries.

Because it's built on a broad-based open-source philosophy, the LinuxONE systems are a virtual playground for Linux developers.

The Software: Because it's built on a broad-based open-source philosophy, the LinuxONE systems are a virtual playground for Linux developers. Perhaps best of all, if you and your team have experience with open-source languages and tools, you'll be able to use them in the IBM environment without skipping a beat.

The system starts with a choice of hypervisors: KVM based on SUSE, IBM's z/VM and an Ubuntu option that's under development. The KVM offers an open-standards option that will be familiar to the growing number of shops looking for non-proprietary hypervisor options; z/VM offers a robust platform from which to spawn both Linux virtual machines and z/OS. You also can get the best of both worlds: KVM and z/VM can be mixed in a single LinuxONE system.

Either choice will provide a solid foundation for managing VMs, particularly since they have baked-in support for OpenStack, the IaaS platform. Both hypervisors enable easy migration, good scalability and low-overhead performance.

The LinuxONE systems introduce several popular tools to the IBM platform, including Apache Spark, MongoDB, MariaDB, Chef and Docker.

In real-world examples, Spark running on the LinuxONE

Emperor proves to be a bit of a mind-blowing tool for managing ever-more disparate apps and data science. As a fast, general-purpose cluster computing system, Spark offers a single interface for managing large data sets with R, Python, Java and Scala.

Chef allows IT shops to manage servers across data centers—even a mix of LinuxONE and x86 systems that live on-site and off. That means you can begin to erase the line between private and public clouds, and manage system resources from a central system. MariaDB, the pure open-source database created by the original makers of MySQL, is now fully supported along with MongoDB and other NoSQL databases.

The combination of these tools plus the addition of Docker (and LXD) makes things really interesting. Sure, the LinuxONE can handle 1 million containers, but what does that mean, exactly? Well, with its real-time scalability, Docker running on LinuxONE with Spark and Spawn enables you to create clusters of micro-VMs that add Web servers, databases and any number of apps and services to your deployment as real-time demand increases (and automatically scale back and free resources as demand wanes).

The architecture pays off in speed: MariaDB, MongoDB and PostgreSQL are twice as fast on LinuxONE compared with x86 systems; Docker is four times faster.

VMs on Steroids: Before virtualization and the onset of commercial products, such as VMware and Hyper-V, IT shops generally followed the paradigm of one physical machine for each service. Need a Web server? Spin up a new blade. Need a new database? Spin up a blade.

Of course, virtualization has changed that paradigm forever, allowing enterprises of all sizes to make far better use of the computing power they have, to speed up server deployments and to better prepare for disasters and business continuity.

Yet, this approach has a limit to its flexibility that IBM seeks to exploit—namely the ever-increasing need to buy and add new hardware. A single ESXi host running VMware, for example, easily might handle 30 lightweight Linux VMs, but the next 30 will require new hardware, time for delivery and setup, and time to cluster and deploy.

LinuxONE looks to make all that a thing of the past by allowing you to scale quickly with dynamically managed clustering, load-balancing, and CPU and memory allocation. The LinuxONE Emperor can host more than 8,000 VMs—a phenomenal capacity that means rapid deployment—without adding hardware and the clustering tasks that go with it.

Comparison with x86: For those looking at one-to-one comparisons of cost and performance between x86 and LinuxONE, there are a range of metrics to consider. Generally speaking, the speed and low-latency/low-overhead of the IBM cores mean that the LinuxONE is particularly good (and fast) at parallel processing. For example, a typical Java-based Web service might consume eight cores on an x86 system, but just a single core on the z System.

According to IBM's benchmarks, the LinuxONE outperforms x86 systems in a number of areas, particularly in Web and database transactions. For example, it handles 2.1 times as many Node.js Web transactions as x86 when the systems each utilize four

cores. The advantage tapers a bit as the number of cores grows to 16 on each system, but LinuxONE maintains a healthy advantage, serving up 5,500 transactions per second while comparable x86 hardware handles just 3,100.

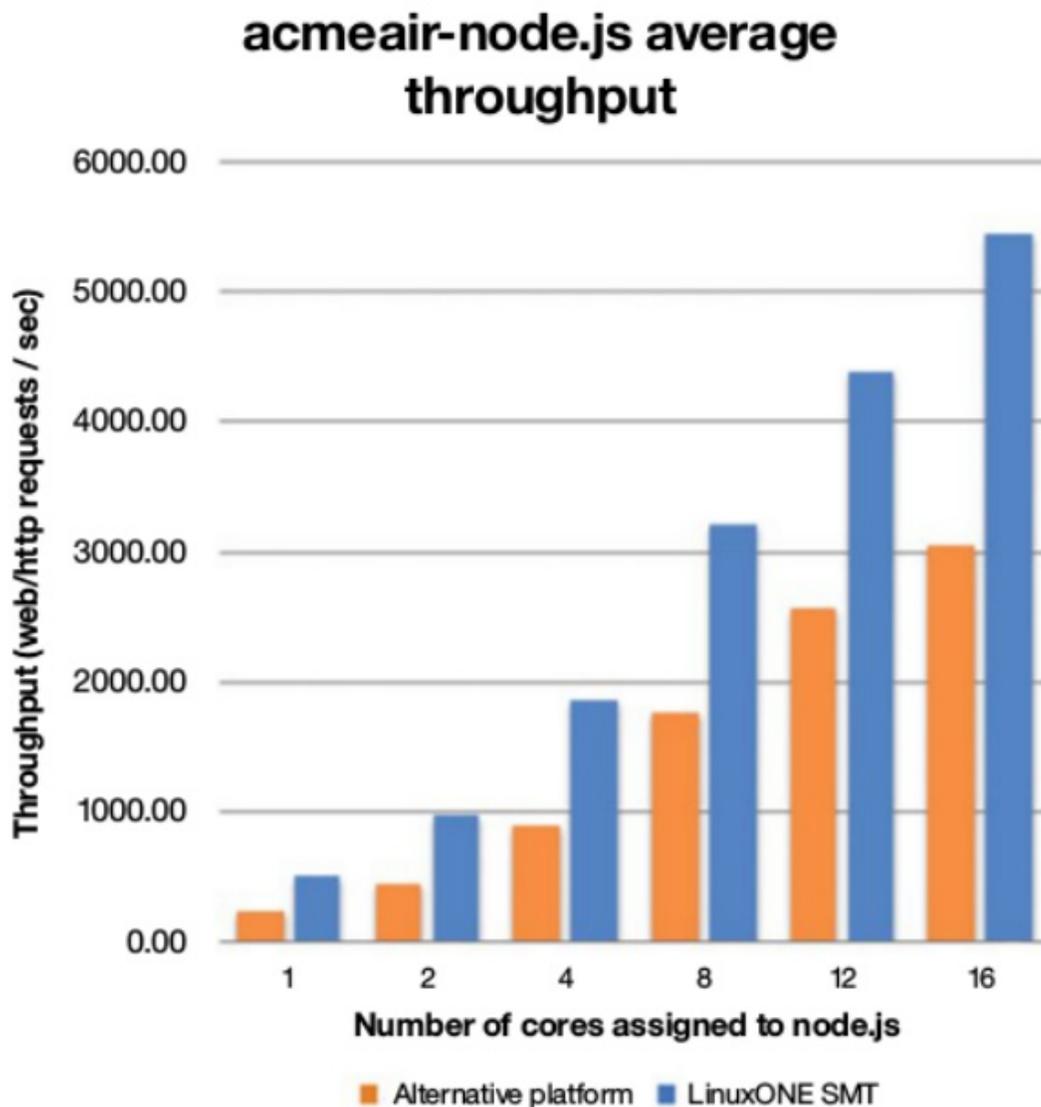


FIGURE 2. With its massive I/O capabilities, LinuxONE can handle about 1.5 times as much Node.js Web throughput as alternative systems. (Image courtesy of IBM.)

On the database side, an independent performance test conducted by 2ndQuadrant that analyzed read-only, write-only and in-memory workloads showed that the LinuxONE is capable of handling 1.6 to 2.2 times as many transactions as competing hardware. A similar test with MongoDB showed that LinuxONE could handle 1.9 to 2.1 times more operations than competing hardware, thanks in part to its ability to scale database transactions without sharding.

CPU utilization rates also can be maintained at high levels on the LinuxONE, because system capacity can be increased as needed. That means if you start with a “base”

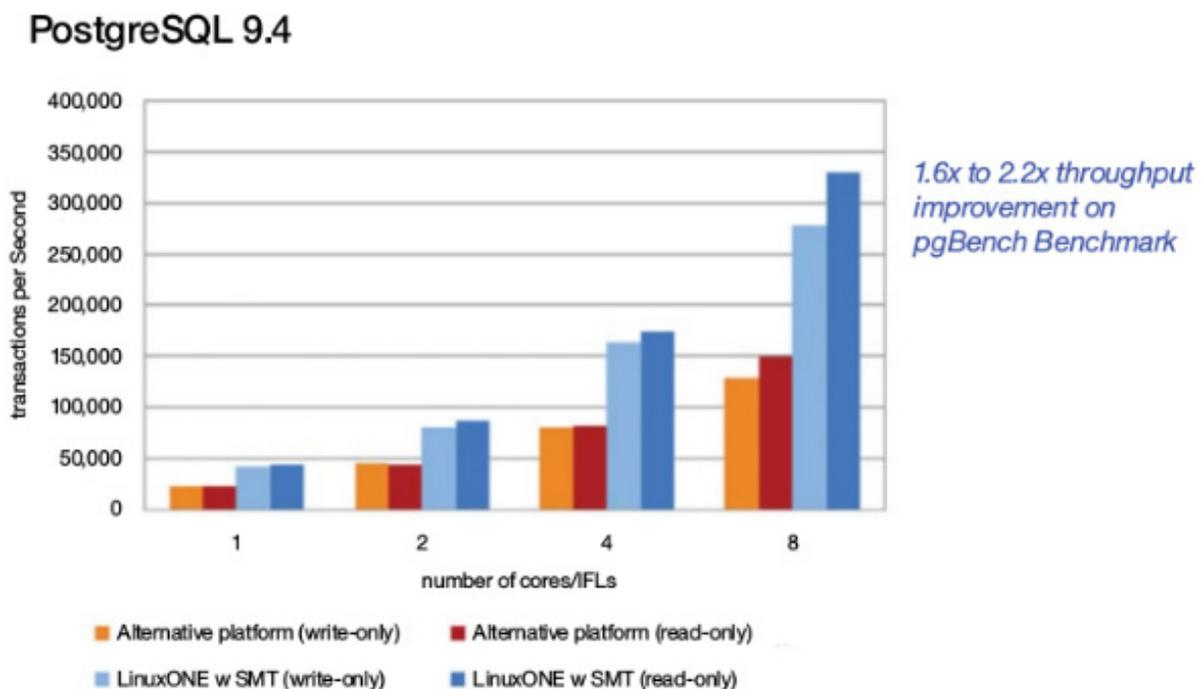


FIGURE 3. PGBench results (read-only and write-only, in-memory workloads) on IBM LinuxONE as compared to distributed systems. LinuxONE can handle twice as many PostgreSQL transactions per second than x86 systems. (Image courtesy of IBM.)

Hardware Compression

Up to **7.5x** reduction in elapsed-time to compress database: MongoDB, containing large documents

Up to **4.5x** reduction in elapsed time when using MongoDB GridFS to put files (>16M document or binary file) – zEDC vs. SW gzip compression

- Up to **4.9x** better throughput archiving Spark RDD on LinuxONE with zEDC vs. software gzip compression
- Up to **4x** reduction in elapsed time to compress Docker containers on LinuxONE with zEDC vs. SW gzip

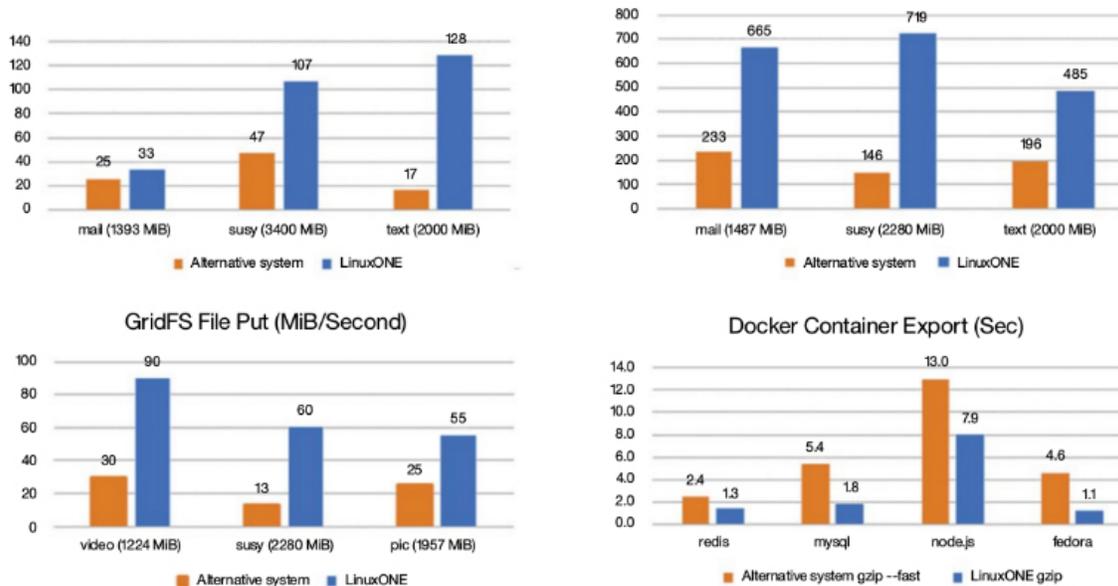


FIGURE 4. LinuxONE can compress and archive video, text, images, mail and other data four to seven times faster than alternative systems. (Image courtesy of IBM.)

\$150,000 Rockhopper system, you can scale up and out, closely matching resources to the hardware.

Where LinuxONE Fits

With OpenStack front and center, the LinuxONE systems are poised for on- or off-premises cloud deployments and hybrid environments. That appears to be IBM's target sweet spot, and the company argues that these systems begin to compete well on price for shops that run 50 to 100 VMs

What Ubuntu developers wouldn't want to test their apps on a monster like LinuxONE? And, what IT manager wouldn't want to keep everything aligned on a single, familiar OS?

or more—or as few as ten physical Oracle servers. Below these totals, IBM admits it has trouble competing with x86 solutions on price alone.

However, for organizations that are quickly expanding their off-premises or hybrid cloud solutions—where the total number of VMs is larger than many care to acknowledge—hitting the cost threshold is in reach for many.

Leverage Your Existing Linux Infrastructure: But as anyone who has deployed hardware knows, deploying IT infrastructure has more to it than simply the price of hardware, although price considerations surely have kept many Linux developers comfortably rooted in x86 hardware and on the mainframe sidelines.

Total cost of ownership has as much to do with the human talent available to manage the hardware, software and services. If you're an Ubuntu shop, the idea of having everyone learn Red Hat or SUSE may foster thoughts of costly man hours, slowed development, lost productivity and the dread of having to deploy apps and services on a production platform that's different from your development platform.

By teaming up with Canonical for Ubuntu 16.04, IBM is taking that challenge head on. What Ubuntu developers

wouldn't want to test their apps on a monster like LinuxONE? And, what IT manager wouldn't want to keep everything aligned on a single, familiar OS? By embracing Ubuntu, IBM recognizes it's the platform of choice for a growing number of developers and IT shops, and an opportunity for those IT shops to deploy big iron without a learning curve—and that means lower cost.

At the same time, adding a LinuxONE Emperor or Rockhopper to your x86 cluster and using tools like Chef to manage them all means you can add resources seamlessly that you and your team already know. Next to Linux itself, that's sure to be enticing for some.

Leverage Your Existing Software: It's hard to overstate the broad support these IBM LinuxONE servers represent for the Open Source community. In the 15 years since IBM first embraced Linux, it also has embraced the development community, adding expertise that has helped it flourish. Its involvement with the Linux Foundation's Open Mainframe Project is a good example of those efforts. With LinuxONE Emperor and Rockhopper, IBM understands that open source isn't just nice to have, it's must-have for anyone looking to compete.

According to a 2015 Black Duck survey, 65% of companies are contributing to open-source projects, and 59% participate in open-source projects to gain a competitive edge.

Clearly, organizations of all sizes are investing in open-source development, and they want to hold on to the value they gain from that work—and leverage it. Being able to reuse apps—and the human-resource capital behind it, IBM argues—makes open standards good for business.

As a result, IBM isn't holding anything back with the LinuxONE. In addition to providing full support for Red Hat (RHEL 6 and 7), SUSE (SLES 11 and 12) and Ubuntu 16.04, the systems provide full support for core packages that drive a lot of today's development, including the following development languages, runtimes and databases:

- Ansible
- Docker
- Java
- JavaScript
- MariaDB
- MySQL
- nginx
- Node.js
- Ruby
- Rails
- Erlang
- OpenJDK
- Puppet
- Python
- PostgreSQL
- WordPress

Some of these tools are still in development for the Ubuntu 16.04 platform, but new ports and packages are being released regularly. You can follow that progress in the community forum, a link to which is listed in the Resources section at the end of this ebook.

Cluster Performance without the Cluster Overhead:

The challenge of any environment where x86 clusters are deployed is the overhead of managing multiple physical or virtual machines across an enterprise. Take the example of MySQL or MariaDB.

In a traditional multi-server environment, you might deploy five physical or virtual servers, install your favorite flavor of Linux on each, assign network addresses and attach some storage. Of the five servers, two might be assigned to do the actual database work, two might be load balancers, and one might be the cluster management server. All of that is necessary to make sure the servers stay in sync and continue to perform in case of an outage.

This approach also requires a floating (or virtual) IP that points to the servers in the cluster. From there, you can configure the load balancers, set up the storage nodes, configure the databases to talk to each other, run some tests and move the cluster into production. If you want to add more capability, you can spin up more database servers, modify your load balancers and heartbeat configurations, run more tests, and expand your capacity and capabilities.

There's certainly nothing wrong with that approach, and a variety of management tools work well with MySQL (and other packages), but there's no denying it's a time-consuming task. The investment isn't the hardware or

software so much as it's the labor. For your uninitiated staff, you pay for them to learn. For the experts, you pay upfront for their skill. Neither comes cheap.

Of course, there are a variety of open-source tools for managing and deploying clusters (Puppet, for example), but LinuxONE seeks to go one better by enabling you to spawn new database nodes quickly, including CPU and storage resources, without having to load-balance, shard your databases or scale your hardware. Sharding is a good way to chunk a database across a cluster to speed the processing, but the raw power of the IBM machines makes it unnecessary. Combining that simplicity with the benefit of 2x performance makes the platform even more appealing. If you add Docker containers to the mix—perhaps spawning still more micro-VM databases—you can begin to envision ways to take advantage of that raw scaling power.

On-Premises and Hybrid Clouds: As more and more IT shops explore and deploy cloud strategies to meet ever-increasing customer demands, the scale of the LinuxONE Emperor or Rockhopper may be able to help reduce “cloud sprawl”—the worrisome spread of on- and off-site VMs and SaaS solutions. Today, end users are increasingly emboldened to sign up for what they believe to be easy-to-use third-party SaaS solutions that leave IT out of the loop and put the organization—and its data—at risk.

The sheer scale of the LinuxONE Emperor, with its 8,000 VM capacity, makes it easy for any enterprise to spin up standardized systems quickly for developers and users alike. IBM is betting on the growth of next-generation

apps and the Next-Thing-as-a-Service to help drive interest not just in on- and off-premises cloud capabilities, but also in the centralized management of it all. IBM has made sure popular open-source tools like Spark and Chef are available on the LinuxONE for all of its Linux flavors and has shown them to outperform x86.

This leads to a new opportunity to regain control of the technology behind critical business functions—and save money doing it. In fact, IBM estimates the total cost of ownership over three years with the LinuxONE is 32% lower than an on-premises x86 cloud and 60% lower than a public cloud.

Why You Might Use LinuxONE

By now, you probably have a few ideas about how you might take advantage of the IBM LinuxONE and perhaps mix it with your existing x86 infrastructure. At the very least, there are probably a couple things you'd like to try. At the end of this ebook are resources to show you how to create your own account on a LinuxONE Community Cloud. In the meantime, the following are some scenarios IBM has promoted for LinuxONE.

Mobile Apps: According to a recent Pew Research Center study, nearly two-thirds of Americans use smartphones as a primary tool for accessing the Internet and on-line resources. Whether they're banking, looking for a house or job, or just browsing Facebook, smartphone users are creating billions of transactions each day. Some 85% of young people use smartphones, which means mobile devices will drive demand for mobile data, which will

continue to be critical for every type of organization.

LinuxONE has some advantages when it comes to serving up apps and data for those users—particularly apps and analysis that utilize both structured and unstructured data.

In one example, IBM Fellow Donna Dillenberger uses the LinuxONE to analyze billions of social-media events related to an in-progress snowstorm that's wreaking havoc on East-coast airports. By analyzing that unstructured data, and real-time weather information and aviation travel alerts (structured data), her app can show travelers which flights to avoid, when to transfer to ground transportation, how to find vacant hotel rooms near their favorite kinds of restaurants and attractions, and update their calendars based on their new travel itineraries.

By using Apache Spark as the analytics layer, this app demonstrates how the LinuxONE can be a smart, fast gatekeeper of critical information and easily manage and respond to new data and changing user criteria. It's the kind of information delivered to a mobile app that could save millions of travelers time and headaches.

Despite the fact that the app is tracking data from 15,000 US airports and 87,000 daily flights, the LinuxONE scales nicely to handle it. The Emperor can handle 30 billion Web events per day, and in this example, it can keep up with the influx of data and the demands of millions of travelers and their smartphones. The system's massive I/O is part of the key, along with IBM's creative use of Docker containers that spawn and evaporate as user demand grows and ebbs.

Real-Time Analytics of Financial Data: This transactional

model—lots of data in, useful data out—is the LinuxONE’s sweet spot. In another example, developers use the LinuxONE Emperor to process real-time stock transactions (structured data) and comb through news, Tweets and other social media to see how the Greek financial crisis influenced trades around the world.

By using MariaDB, MongoDB, Spark Analytics, Chef, Docker and PostgreSQL to analyze data from a variety of sources, the LinuxONE easily handled millions of events per second. As CPU use spiked to 90%, the responsiveness of the services remained moderate and constant. The LinuxONE Emperor spawned Docker containers and capacity to meet the demand, and thanks to something IBM calls Hyper Swap, it seamlessly migrated those containers—and the processing—to another LinuxONE server when the first was shut down intentionally to simulate an outage.

Getting a Taste

If you want to get your hands on a LinuxONE system, you can sign up to be part of IBM’s LinuxONE Community Cloud, which operates LinuxONE Emperor systems at Marist College and Syracuse University. Other European-based systems are in development as well.

You can use your free account to create Red Hat-, SUSE- and (soon) Ubuntu-based images, and then deploy a LAMP stack or install Webmin (or any number of services and apps) and take a flight around the system. You can test your apps and services freely and begin to get a feel for how your developers might use a LinuxONE.

Your 90-day trial VM image includes up to two CPUs,

2GB of memory and 40GB of storage. You can create new instances (VMs), but just one at a time. Sign up for an account at <http://www.ibm.com/linuxone/try>. The site also offers a gateway to IBM's extensive Linux community, LinuxONE product spec sheets, videos and resources. ■

Resources

LinuxONE Emperor Datasheets: <http://www-03.ibm.com/systems/linuxone/enterprise-linux-systems/emperor.html>

LinuxONE Rockhopper Datasheets: <http://www-03.ibm.com/systems/linuxone/enterprise-linux-systems/rockhopper.html>

LinuxONE Developer Community:
<http://www.ibm.com/developerworks/community/forums/html/topic?id=5dee144a-7c64-4bfe-884f-751d6308dbdf>

Open-Source Software on LinuxONE:
<http://www-03.ibm.com/systems/z/os/linux/open-source-software.html>

LinuxONE Open-Source Demo:
<http://www.youtube.com/watch?v=VWBNolwGEjo>

Install Ubuntu on LinuxONE:
<http://wiki.ubuntu.com/S390X/InstallationGuide>

Tested Linux Environments on IBM Platforms:
<http://www-03.ibm.com/systems/z/os/linux/resources/testedplatforms.html>

The Open Mainframe Project: <http://www.openmainframeproject.org>