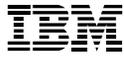


# Jump start next generation applications with IBM LinuxONE



*Leverage open technology solutions to meet the demands of the new application economy*

## Introduction

Meet the demand for a new application economy

Mobile applications are truly becoming the primary face of many companies. If an organization's mobile app is unreliable, or the user has a bad experience, it will have a direct impact on the overall perception of that company in the customer's mind. For example, in 2015, there are more than 7 billion mobile cellular subscriptions worldwide.<sup>1</sup>

Leading companies are seizing the opportunity to build, integrate and support the next generation of applications. They're 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 performance.

Although many organizations have already made large investments in IT systems to meet this demand, they can not afford to continually add new servers and software licenses to keep pace with growth. Right now, C-level IT leaders, infrastructure and operations executives, enterprise and solution architects, developers, and more are exploring better ways to strike the right balance between controlling cost, complexity and risk while ensuring they have the agility to proactively deliver innovative applications and services that drive competitive advantage and marketplace leadership.

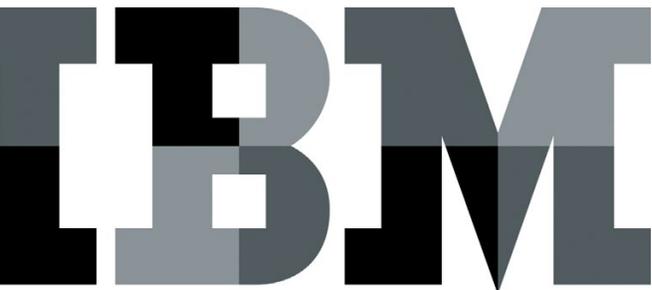




Figure 1. The future of open source, Black Duck, 2015

As seen in Figure 1, many of the world’s most innovative organizations are using Linux and open source technology solutions to deliver customer-facing, revenue-driving applications that serve millions of customers, clients and citizens.

However, as Linux and open source deployments move from niche projects to being more pervasive in the data center to support the business, it is imperative that these applications be fully supported by enterprise-grade capabilities such as nondisruptive scalability, unparalleled availability and continuous data protection. This is especially important for business-critical applications—the solutions that support an entire organization and require 24x7 availability.

For any business, outages impacting a business-critical application or server infrastructure can be costly in terms of lost revenue, missed opportunity and reduced employee productivity. To a client’s customers, when applications become unavailable, that loss of services can diminish the individual experience, causing a negative effect on loyalty, potentially leading to customer attrition. Meeting the demands of customers and service-level agreements (SLAs) hinges on server reliability, uptime and manageability. Having the right infrastructure in place will provide an organization with agility and room for growth.

**Unleash the full potential of Linux with IBM LinuxONE.**

Linux has been the world’s fastest growing server operating systems for a number of years and is now a major player in the global IT market. A Linux infrastructure has to be efficient, secure, adaptive and integrated. It must be designed to handle the explosive growth of mobile clients, be able to leverage vast amounts of data, and provide deep, real-time insights at the point for greatest business impact—all deployed within a secure and resilient cloud-ready environment.

IBM clients rely on the 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. Building on the successful experiences of thousands of customer engagements and deployments, IBM has delivered a new portfolio of systems, solutions and services called IBM LinuxONE.

IBM® LinuxONE™ systems and solutions provide users with a flexible yet powerful infrastructure that helps ensure that a business receives the performance, reliability, security and processing power it needs to address increasingly sophisticated and demanding application requirements.

## IBM Systems

Combining one of the industry's most advanced, trusted and high-performance systems for business-critical applications with Linux technology, IBM LinuxONE offers you a solution that is:

- Open: Choose the tools and applications you love
- Flexible: Meet demand with virtually limitless scale
- Simple: Fewer servers, less complexity lower cost
- Efficient: Get unparalleled utilization and speed
- Trusted: Embedded security and services that never stop

### IBM LinuxONE Emperor

The IBM LinuxONE Emperor™ system offers the necessary capabilities and processing power to be that Linux infrastructure. It can protect sensitive transactions to minimize business risk and client exposure, while providing the performance needed to help deliver on service level agreements (SLAs). IBM LinuxONE Emperor can provide exceptional customer experience.

#### Scalability and performance

The IBM LinuxONE Emperor allows for a simple Linux infrastructure approach. It is available with up to 141 configurable cores for performance and scaling advantages, supporting up to 8,000 virtual Linux servers on a single footprint. That means that the virtualization capabilities in a single IBM LinuxONE Emperor system can result in a less complex Linux infrastructure with fewer components, less management, less space requirements and lower software costs than x86 servers. For compared environments, it is estimated that a cloud environment on a IBM LinuxONE Emperor will have a 32 percent lower total cost of ownership over three years than an x86 Cloud and a 60 percent lower total cost of ownership over three years than a public cloud.<sup>2</sup>



IBM LinuxONE is a responsive service delivery platform capable of provisioning new virtual Linux servers in seconds. The IBM LinuxONE environment allows users to share and over-commit system resources to meet client expectations for unlimited access to existing and new services. IBM LinuxONE supports multiple Linux Distributions such as Red Hat (RHEL), SUSE (SLES) and Canonical (Ubuntu). Virtualization capabilities are delivered by KVM or IBM z/VM® hypervisors. The OpenStack support for KVM and z/VM allows for cloud-like management, with third-party tools such as by VMware vRealize Automation.

Impressive scalability—horizontal and vertical—is provided by the virtualization alternatives to fully exploit the Emperor capabilities to meet mobile and analytic demands. It can run at utilization rates as high as 100 percent for extended periods of time, and users can scale capacity on demand. Having the Linux environment all in one server also means less time is spent on managing the Linux infrastructure.

IBM LinuxONE Emperor is based on the world's fastest commercial processor running at 5.0 GHz, along with its unique cache design allows for massive I/O throughput. It provides high availability in the memory subsystem using IBM's proven Redundant Array of Independent Memory (RAIM) technology.

### **Trustful, reliable and secure for less risk**

Within a single footprint, an IBM LinuxONE Emperor is designed to avoid or recover from failures to minimize business disruptions. High availability is realized through component reliability, redundancy and features that assist in providing fault avoidance and tolerance, as well as permitting concurrent maintenance and repair.

Intrinsic platform security provides privacy for transactions and sensitive data, making the IBM LinuxONE Emperor a securable enterprise application server and data vault. Each IBM LinuxONE core has a dedicated cryptographic coprocessor that provides CP Assist for Cryptographic Function (CPACF) to deliver cryptographic and hashing capabilities in support of clear-key operations. Exclusive to CPACF is the protected key support which provides the speed of processor based cryptography while helping to keep sensitive keys private from applications and the operating system.

The IBM LinuxONE Emperor also offers a cryptographic acceleration feature, the Crypto Express5S, providing a state of the art tamper resistant cryptographic coprocessor for secure-key operations along with new hardware assists for fast data encryption. The IBM LinuxONE Emperor with Crypto Express5S offer asymmetric key support for constrained environments using hardware assisted Elliptic Curve

Cryptography (ECC), providing algorithms with much shorter key lengths than RSA keys for similar cryptographic strength—making ECC cryptography ideal for mobile and smartcards where performance constraints may be a consideration.

The IBM LinuxONE Emperor is a highly securable commercial server,<sup>3</sup> built using groundbreaking technology organizations can trust. An organization can run many Linux virtual servers concurrently, leveraging IBM LinuxONE Emperor capabilities for isolating and protecting each Linux virtual server as if they were running on physically separated servers.

### **Enterprise qualities of service**

The IBM LinuxONE Emperor enables enterprise-grade Linux that is more robust and trusted for critical workloads, and has higher performance and throughput to deliver a lower cost per transaction.

Resiliency analytics for IBM LinuxONE is designed to offer near real-time diagnostics to help identifying potential problems in the Linux environment. It is an analytics solution executed in firmware, which intelligently examines message logs for potential inconsistencies or anomalies. With this capability, organizations can address IT problems quickly, minimize availability lapses and intervene before IT problems become severe.

The IBM GDPS® Virtual Appliance can deliver multiplatform resiliency capability for the IBM LinuxONE Emperor. The solution is targeted to clients, who run the z/VM hypervisor and associated Linux guests, intended to provide high availability and disaster recovery benefits in case of system, application or network failure.

IBM Spectrum Scale™ for IBM LinuxONE Emperor, based on IBM GPFS™ technology, is designed to provide high availability through advanced clustering technologies, dynamic file system management and data replication. IBM Spectrum Scale can continue to provide data access even if the cluster experiences storage or node malfunctions. Its scalability and performance are designed to meet the needs of the most data intensive applications.

When the IT infrastructure needs to be expanded, the efficiency, flexibility and qualities of the IBM LinuxONE Emperor are best demonstrated. Its consolidated design allows organizations to grow capacity inside the server—on the fly—without affecting the running environment. Eliminating the need to constantly buy, configure and manage new services to handle growth.

The IBM LinuxONE Emperor can support exponential growth for Linux with up to 141 cores and up to 85 logical partitions. This, coupled with the utilization of up to 10 TB of memory can provide impressive response time for clients and support the ability to make faster business decisions.

### IBM LinuxONE Rockhopper

---



The IBM LinuxONE Rockhopper™ system is designed as an entry point for IBM LinuxONE portfolio. It embodies the same innovation and value, flexible growth options, industry-leading virtualization, trusted resiliency, secure cloud, enterprise mobility and operational analytics capabilities as the massively scalable IBM LinuxONE Emperor.

IBM LinuxONE is helping to protect sensitive transactions to minimize business risk and client exposure, while helping deliver on SLAs. It is designed for exceptional customer experience with economic efficiencies.

#### Scalability and performance

The IBM LinuxONE Rockhopper allows for a simple Linux infrastructure approach. It is available with up to 20 cores, running at 4.3 GHz, and 4 TBs of memory for performance and scaling advantages. It is capable of supporting hundreds of virtual Linux servers on a single footprint. Its memory hierarchy, execution processing and prefetch instructions are all designed to optimize throughput for many workloads. That means that the virtualization capabilities in a few square meters of one IBM LinuxONE Rockhopper can result in a less complex Linux infrastructure with fewer components, less management efforts and lower software costs, giving it the ability to be a much more economical and flexible solution when compared to x86 servers.

IBM LinuxONE is a responsive service delivery platform capable of provisioning new virtual Linux servers in minutes. The IBM LinuxONE environment allows users to share and over-commit system resources to meet client expectations for unlimited access to existing and new services. IBM LinuxONE supports multiple Linux Distributions such as Red Hat (RHEL), SUSE (SLES) and Canonical (Ubuntu). Virtualization capabilities are delivered by KVM or z/VM hypervisors. The OpenStack support for KVM and z/VM allows for cloud-like management, with third-party tools such as by VMware vRealize Automation.

With the impressive scalability—horizontal and vertical—provided by the virtualization alternatives, users can fully exploit the IBM LinuxONE Rockhopper capabilities to meet mobile and analytics demands. IBM LinuxONE Rockhopper can run at utilization rates as high as 100 percent for extended periods of time, and can scale capacity on demand. Having the Linux environment all in one server also means less time is spent on managing the Linux infrastructure.

The impressive speed of the IBM LinuxONE Rockhopper processor coupled with its unique cache design allows for massive I/O throughput. It provides high availability in the memory subsystem using IBM's proven RAIM technology.

### **Trustful, reliable and secure for less risk**

Within a single footprint, the IBM LinuxONE Rockhopper is designed to avoid or recover from failures to minimize business disruptions. High availability is realized through component reliability, redundancy and features that assist in providing fault avoidance and tolerance, as well as permitting concurrent maintenance and repair.

Intrinsic platform security provides privacy for transactions and sensitive data, making the IBM LinuxONE Rockhopper a highly securable enterprise application server and data vault. Each IBM LinuxONE core has a dedicated cryptographic coprocessor that provides CP Assist for Cryptographic Function (CPACF) to deliver cryptographic and hashing capabilities in support of clear-key operations. Exclusive to CPACF is the protected key support which provides the speed of processor-based cryptography while helping to keep sensitive keys private from applications and the operating system.

The IBM LinuxONE Rockhopper also offers a cryptographic acceleration feature, the Crypto Express5S, providing a state-of-the-art tamper-resistant cryptographic coprocessor for secure-key operations along with new hardware assists for fast data encryption. The IBM LinuxONE Rockhopper with Crypto Express5S offers asymmetric key support for constrained environments using hardware assisted Elliptic Curve Cryptography (ECC), providing algorithms with much shorter

key lengths than RSA keys for similar cryptographic strength - making ECC cryptography ideal for mobile and smartcards where performance constraints may be a consideration.

IBM LinuxONE Rockhopper is a highly securable commercial server<sup>4</sup>, built using groundbreaking technology organizations trust. Users can run many Linux virtual servers concurrently, leveraging IBM LinuxONE Rockhopper ability to isolate and protect each Linux virtual server as if they were running on physically separated servers.

### **Enterprise qualities of service**

The IBM LinuxONE Rockhopper enables enterprise-grade Linux that is more robust and trusted for critical workloads, and has higher performance and throughput to deliver a low cost per transaction.

Resiliency analytics for IBM LinuxONE is designed to offer near-real-time diagnostics to help identify potential problems in the Linux environment. It is an analytics solution executed in firmware which intelligently examines message logs for potential inconsistencies or anomalies. With this capability organizations can address IT problems quickly, minimize availability lapses and intervene before IT problems become severe.

The GDPS Virtual Appliance can deliver multiplatform resiliency capability for IBM LinuxONE Rockhopper. The solution is targeted to clients who run the z/VM hypervisor and associated Linux guests and is intended to provide high availability and disaster recovery benefits in case of system, application or network failure.

IBM Spectrum Scale for IBM LinuxONE Rockhopper, based on GPFS technology, is designed to provide high availability through advanced clustering technologies, dynamic file system management and data replication. IBM Spectrum Scale can continue to provide data access even if the cluster experiences storage or node malfunctions. Its scalability and performance are designed to meet the needs of the most data-intensive applications.

When the IT infrastructure needs to be expanded, the efficiency, flexibility and qualities of the IBM LinuxONE Rockhopper are best demonstrated. Its consolidated design allows organizations to grow capacity inside the server without affecting the running environment. This can eliminate the need to constantly buy, configure and manage new services to handle growth.

### IBM LinuxONE solutions

For organizations that want to deliver solutions designed for the new app economy, IBM LinuxONE solutions offer ultimate flexibility to create applications for mobile, cloud and analytics to improve client and user experiences—on your terms. IBM LinuxONE enables you to choose solutions from IBM software, open source software or independent software vendor (ISVs) products to create, build, customize and deploy solutions unique to your organization's requirements.

### Enterprise capabilities and insights for secure mobile applications

Mobile transactions are generating an unprecedented amount of data, with mobile data traffic predicted to grow globally 10-fold from 2014 to 2019 for a compound annual growth rate of 57 percent.<sup>5</sup> Mobile devices and their ubiquitous access are causing disruptions for employees and consumers alike, with more than 90 percent of mobile users keeping their device within arm's reach 24x7.<sup>6</sup> As users bank, shop, work and manage their lives on mobile devices, they touch each provider's system dozens more times per day than they ever did through websites and laptops, creating a deluge of transactions and requests. In 2004, each user generated less than a single mobile transaction per day. By 2014, that number had hit 37 transactions per day, and continues to spike.<sup>7</sup>

From a business perspective, a mobile channel represents a wealth of opportunity to engage in new and interesting ways to build loyalty, generate revenue and improve enterprise processes. At the same time, users expect instant response times,

100 percent uptime, and completely reliable transactions, or they will switch to a competitor with the touch of a screen. Ask a Chief Marketing Officer what their ultimate goal is for reaching current and potential customers, and the answer will likely be to provide a "demographic of one" experience, personalized to each individual's unique interests and buying behaviors.<sup>8</sup> This presents a seemingly daunting challenge to mobile app and server development teams.

From an IT perspective, multi-channel and device access is driving digital transformation within IT departments. It is estimated that only 30 percent of the value and effort of a mobile application is visible via the mobile app, with 70 percent of the value provided by the infrastructure of software and systems supporting the mobile workloads.<sup>9</sup>

IBM LinuxONE combines the open and industry-leading aspects of Linux with proven qualities of service resulting in the most scalable enterprise-grade Linux environment.

IBM LinuxONE provides an open and highly responsive infrastructure that meets the peaks in mobile workloads, while ensuring the security of mobile device data and enterprise transactions—all without sacrificing response time.

### Key takeaways

- Build and deploy engaging mobile applications that integrate with core business capabilities.
- Secure mobile devices, data and enterprise transactions without sacrificing response time.
- Deliver mobile services on an open and highly responsive infrastructure that scales to meet peaks in mobile workloads.
- Accelerate adoption using best practices and services.

### Flexible, resilient, high performance business and operational analytics

*Analytics requires availability and performance*

IBM LinuxONE delivers high-performance business analytics and database solutions that reduce cost and complexity with unmatched business resiliency, security and flexibility. IBM LinuxONE combined with various software packages—from IBM, the industry or the open community—allows fast analytics capabilities for large volumes of structured and unstructured data, enabling clients to extract faster insights that matter for the business.

Operational analytics allow visualization and analysis of log and event data and performance metrics, and IT analytics capability will bring predictive anomaly detection to Linux enterprise computing.

#### Use cases

- High performance business intelligence and reporting
- Big data insights and next generation database
- IT operational analytics for continuous business availability
- Enabling technologies and services
- IBM Cognos®, Cognos Custom Pattern for Linux, IBM DB2®, DB2 Custom Pattern for Linux, DB2 BLU, IBM InfoSphere® BigInsights®, IBM InfoSphere IBM System z® Connector for Hadoop, IT operational analytics, System z Advanced Workload Analysis Reporter (IBM zAware), Apache Spark
- IBM LinuxONE analytics services

#### Key takeaways

- Provide high performing business intelligence and reporting.
- Gain insights with big data analytics and with next generation database technology.
- Meet the availability expectations of the business with IT operations analytics cost effectively.

### Trusted and agile cloud deployment

*Cloud solutions require always on agility, security and uptime*

As market pressures collapse the cycle of innovation into ever more compressed timeframes, businesses cannot afford to wait for server infrastructure running at traditional speeds, and speed isn't the only constraint. The complexity and scale of the computing problems businesses are attempting to solve are growing at an exponential rate. Driven by a ground up rethinking by many businesses regarding the role of computing in the experience of their customers, business computing is transforming from being a back-office support function to being at the forefront. Today a customer's interaction with, and experience of, a company is often largely (and sometimes completely) defined by interactions with that company's software and services. This is putting unprecedented demands on today's compute infrastructure—not just the need to scale with demand, but also the agility required to keep up with the mandate for change presented by the needs of the business.

Cloud solutions need to provide organization with agility, flexibility and accelerated time-to-value. With IBM LinuxONE cloud solutions, organizations get unparalleled system uptime and data security for business-critical applications, plus massive scalability with high performance that is optimized for efficiency.

#### Key takeaways

- Provides unparalleled enterprise qualities of service.
- Combines exceptional speed and capabilities for supporting business agility and time-to-value for cloud solutions.
- The vertical scale architecture makes IBM LinuxONE the one of the most efficient and cost-effective cloud platform for database workloads.

### Software innovation and accelerated delivery with standard industry DevOps

*Faster time to value*

IBM LinuxONE encompasses the IBM DevOps approach to transforming application development, resulting in faster delivery of software-driven innovation. IBM LinuxONE supports a continuous delivery model through an open, standards-based tooling platform to help bring business, development and quality assurance teams together so they can continuously adjust business goals based on customer feedback.

Use cases

- Develop, test, deploy and operate enterprise-level applications
- Accelerate software delivery by enabling collaborative development and automation across organizational silos.
- Enable developer productivity starting from scratch, open source or IBM Bluemix®, across platforms and languages.

Enabling technologies and services

- IBM Rational collaborative lifecycle management (CLM)
- IBM UrbanCode™ deploy
- IBM Application Performance Manager (APM)
- IBM WebSphere® Liberty
- IBM Bluemix
- IBM LinuxONE DevOps Services

#### Key takeaways

- DevOps solutions for IBM LinuxONE are a win-win combination for the digital enterprise.
- Enable developer productivity across platforms, languages and operating systems.
- Understand the ease and strength of integration capabilities between IBM DevOps solutions and open source technologies.

### Better insights, faster response times, improved business agility

The mobile world and new app economy is driving change with unprecedented speed and scope—impacting the world's most powerful economies and developing nations, changing the game for business, industries and society at large, and creating new requirements and expectations that have to be addressed.

In a world where consumer expectations continue to grow, the ability to keep pace with new opportunities and to differentiate your business through more innovation means, your IT department is key to competing in the immediacy of a digital world. The criterion for success lies in your ability to:

- Deliver at speed with lightning fast response times, all the time.
- Provide access anytime, anywhere, and from any device, no matter how many users or transactions.
- Ensure security for trusted engagements.
- Enable personalization through analytics.
- Achieve new levels of IT efficiency, agility and responsiveness using a cloud model.

The starburst effect on transaction growth rates from mobile can be dramatic, placing even greater pressure on IT. As a result, organizations need to take Linux to the next level where it can fully support the future of high-volume business-critical applications.

The intersection of traditional IT, the new application economy, open technology and community collaboration are central to serving these new requirements, redefining IT operational excellence and ultimately the customer experience.

Open source software applications and programs are bringing a broad set of capabilities and new solutions to IBM LinuxONE—new programming languages and run-time environments, relational and NoSQL databases, more choices in big data analytics, and container technologies are becoming integrated into the core of the enterprise IT toolkit.

When these capabilities are combined with unique IBM LinuxONE performance features—the ability to run up to 141 of the world’s fastest commercially available processors at 5.0 GHz and 10 TB of memory in one system, industry-leading I/O bandwidth and data processing throughput, EAL5+ certified security, and high-speed data compression and cryptography hardware—your business will obtain better insights, faster response times and improved business agility.

With a broad and growing open source ecosystem for IBM LinuxONE, developers are able to use the tools and applications they already know to accelerate new Linux application development and boost performance and reliability.

*Putting it all together—enabled by Open Source running IBM LinuxONE Demo: Scalable Financial Trading Analysis and Insights*

Watch IBM Fellow Donna Dillenberger demonstrate the new IBM LinuxONE system for scalable financial trading. The demo shows multiple data loads (live data from the S&P 500 and Tweets) streaming via Maria DB, MongoDB, Spark Analytics, Chef, Docker and PostgreSQL, Containers. In this IBM LinuxONE demo, even with drastic upticks in CPU utilization during the Greek financial crisis, response times are still lightning fast. [Watch the demo here.](#)

### **IBM LinuxONE allows up to 50 percent better response time in analytics than competing platforms**

*Reduce risk, increase flexibility with diagonal scaling*

Database partitioning or “sharding” is a common technique for scaling out a database that has become too large to fit within a single server. However, sharding is complex in practice, and carries risks such as higher latency for aggregate queries and a lower level of data consistency. Additionally, the size of each shard is limited to the size of the servers.

Using IBM LinuxONE allows you to scale out and scale up—increasing the amount of resources available to each shard server—in an approach termed “diagonal scaling.”<sup>10</sup> Diagonal scaling allows you to adapt to changing workloads with industry-leading performance, increased flexibility and reduced risks, and therefore offers better agility.

*Meet regulatory requirements*

Another example of achieving improved agility using IBM LinuxONE systems is high-performance-secure-logging for auditing in the face of growing regulatory requirements. IBM LinuxONE Enterprise Data Compression (EDC) facility allows IBM LinuxONE to offload main processors while speeding compression by up-to 10x. IBM LinuxONE offers protected-key function which keeps the encryption key out of main memory and storage, keeping data-at-rest secure, while offering 50x better performance than secure-key function. When combining the speed and capability of EDC and protected-key function, IBM LinuxONE offers unmatched agility for quickly, non-intrusively and securely logging snapshots of system states such as Docker instances or Apache Spark Resilient Distributed Dataset (RDDs) for auditing purposes.

*Free valuable computing resources*

Apart from raw computing power, IBM LinuxONE can speed compression and encryption with IBM LinuxONE Enterprise Data Compression and Central Processor Assist for Cryptographic Functions (CPACF) features. Compressing Apache Spark Resilient Distributed Datasets (RDDs) or Docker containers at high speed with little impact on CPU consumption frees CPU cycles that can be used to perform more analytics, or faster, non-disruptive auditing of containerized applications. By using OpenSSL and openCryptoki enhanced with CPACF, encrypted transactions will run faster, and data can be persisted securely and efficiently. This speed allows the computer to do more work, and gives you more agility.

---

*“We believe strongly in the power of open source as the basis to build value for clients, and are fully committed to Spark as a foundational technology platform for accelerating innovation and driving analytics across every business in a fundamental way.”*

—Beth Smith, General Manager, Analytics Platform, IBM Analytics

---

### **Deep innovation and a thriving ecosystem supporting continuous innovation**

IBM has a long history of involvement in open source software development, and continues to contribute to key open source technologies such as the Linux kernel, the Eclipse project, and many Apache projects, including the most recent, Apache Spark. IBM is a member of many open standard organizations and software governance consortia that help shape the future of open source software.<sup>11</sup>

The IBM Linux Technology Center (LTC) is dedicated to enabling Linux adoption on IBM platforms and has been contributing continuously to core technologies such as the Linux kernel, glibc and GCC over the years. But architecture-specific code is only the tip of the iceberg—and represents only a small portion of LTC contributions.

Red Hat and SUSE ship enterprise Linux distributions for IBM LinuxONE systems, and the Ubuntu, Debian and Fedora distributions also support the architecture. The platform is mature and production-ready, and is able to run most applications you would expect to run on a Linux server.

Today, more than 40 commonly used open source products run right out of the box, with more coming on board in future. By listening to clients, working with business partners and ISVs, and engaging the open source development community, IBM is working to bring more foundational open source technologies to IBM LinuxONE and, further enabling and encouraging the most sought after software developers to develop solutions that work on the platform—with a strong emphasis placed on programming languages and run-time technologies.

IBM is investing heavily to create a rich, open source ecosystem to enable IBM LinuxONE as the premier platform for new Linux-based application deployments that exploit emerging technologies such as Node.js, MongoDB, PostgreSQL, MariaDB, Docker, Chef, Puppet and Apache Spark. Additional focus is placed on open source workloads that can benefit from the reliability, availability and serviceability (RAS) of the IBM LinuxONE to bring more business value to users, including database management systems and cloud infrastructure, as well as analytics and big data solutions. Table 1 and Table 2 list some of the key open source technologies that have already been enabled on the platform.<sup>12</sup> Over 40 packages have been enabled on the platform and the list continues to grow with many others in the development pipeline. For an up-to-date-list of available applications, please visit the [Open Source Community on IBM DeveloperWorks](#).

**Table 1: Partial list of foundation open source technologies available on IBM LinuxONE Systems**

<i>Languages and dev environment</i>	<i>Database and messaging</i>	<i>Cloud infrastructure</i>
Node.js	MySQL	Docker
Ruby	PostgreSQL	Chef
Rails	MariaDB	Puppet
Python	MongoDB	Open Stack
LLVM	Cassandra	
OpenJDK	Redis	
GCCGO	CouchDB	
oCaml	Geode	
Erlang	RabbitMQ	
Apache HTTP Web Server		
PHP/Zend		
R language		
Clojure		
Scala		

*Table notes.* Various sources of input (BlueMix, Github stats) and feedback from direct client input, IBM client representatives and ongoing research

**Table 2: Partial list of popular open source tools and applications available on IBM LinuxONE systems**

<i>App development and DevOps</i>	<i>Configuration, monitoring management and tools</i>	<i>Big data and analytics</i>	<i>Web application development</i>	<i>eCommerce and application server</i>
Xerces-c	Fluentd	Hadoop (via Veristorm, BigInsights)	jMeter	jBoss
XMLSec		ELK (Elasticsearch, Logstash, Kibana)	Wordpress	
protobuf		Drupal	Ceilometer	
Doxygen		Hadoop (via Veristorm, BigInsights)	Apache Tomcat	
ANTLR		ELK (Elasticsearch, Logstash, Kibana)	HAProxy	
Maven		Drupal	NGNIX	

### **More speed and choice**

*The flexibility of Linux and open source combined with speed and processing power*

The world's leading organizations are choosing Linux to run mission-critical applications that drive billions of business transactions every day and are leveraging the performance, reliability, security and virtualization capabilities of the enterprise-grade platform for Linux to run databases (such as DB2 and Oracle) and middleware (such as WebSphere).

IBM LinuxONE systems are designed to deliver 100 percent uptime, over decades—they ship with resilient and redundant hardware, which ensures continuous operations even in case of hardware faults. The machines boast higher MTBFs (Mean Time Between Failure), and support hot-swapping of hardware, so they do not typically need to be taken offline for service. The use of IBM GDPS helps automate data replication and speeds recovery from planned or unplanned outages.

IBM LinuxONE systems are equipped with the world's fastest commercially available processor as well as large and efficient memory cache hierarchy, enabling the IBM LinuxONE Emperor system to achieve high single-thread performance, which is ideal for scaling applications to handle the massive volume of transactions that are typical in today's enterprise organizations.

### **Improve application performance, reliability and availability**

IBM LinuxONE is one of the most reliable and available systems in the world. Designed to deliver 100 percent uptime, over decades—they ship with resilient and redundant hardware, which ensures continuous operations even in case of hardware faults. The machines boast higher MTBFs (Mean Time Between Failure), and support hot-swapping of hardware, so they do not typically need to be taken offline for service. The use of IBM GDPS helps automate data replication and speeds recovery from planned or unplanned outages.

IBM LinuxONE systems are equipped with the world's fastest commercially available processor as well as large and efficient memory cache hierarchy, enabling the IBM LinuxONE Emperor system to achieve high single-thread performance, which is ideal for scaling applications to handle the massive volume of transactions that are typical in today's enterprise organizations.

### **A better balance between risk and opportunity**

Every organization is faced with the challenge of building both trust and value amidst uncertainty. Tasked with improving business performance while also reducing risk, business and IT leaders need to feel confident about risk exposures to their data and infrastructure—all while meeting stringent regulatory requirements.

For example, as data and analytics become more critical to the development of business advantage, the need for comprehensive data security escalates. In response, many leaders are implementing stronger security and data privacy measures, in addition to governance policies, to protect their organization from both internal and external threats, proactively identify and manage potential exposure to the risks associated with data breaches, and comply with industry regulations and combat infrastructure vulnerabilities throughout the value chain.

The virtualization technologies in IBM LinuxONE Emperor Systems have been EAL5+ certified. These technologies offer low overhead and higher virtual machine (VM) density compared to other platforms, thanks to the advanced resource over-commit technology in the IBM LinuxONE systems. As a result, applications that run on IBM LinuxONE can scale out to thousands of co-located VMs, as the system essentially becomes a "data center in a box." What's more, they make IBM LinuxONE systems ready for cloud applications with support for rapid provisioning, multi-tenancy and capacity scaling on demand.

The co-location of virtualized Linux guests brings significant benefits to applications that run on IBM LinuxONE systems. Using IBM HiperSockets™, applications can transfer data from one VM to another in-memory instead of sending the data over the network. This type of transfer is more reliable because there is no physical connection to lose, more efficient because there is no network latency, and more secure because there is no wire to tap. Co-location is especially important where system of engagement applications such as mobile and cloud frequently need to access system of record data.

The IBM LinuxONE architecture includes hardware support for cryptography, known as Central Processor Assist for Cryptographic Functions (CPACF). In the presence of a suitable cryptographic co-processor, CPACF supports the use of protected keys, which balances the speed of in-memory clear keys and the high security of hardware-backed, tamper-proof secure keys. The OpenSSL and openCryptoki libraries are able to exploit these IBM LinuxONE system features to speed clear key, protected key and secure key cryptography.<sup>13</sup>

### Speed and performance improvements

The IBM LinuxONE Enterprise Data Compress Express adapter is another feature that distinguishes IBM LinuxONE as a data-processing powerhouse. It allows applications to off-load zLib-compatible compression work to a hardware co-processor, achieving a good compression ratio without consuming CPU cycles. For databases that employ on-the-fly compression, exploitation of the IBM LinuxONE Enterprise Data Compression feature in Linux is expected to improve performance by a factor of five. As shown in Figure 2, users will be able to process more data in the same amount of time and save on storage costs.

- Improve performance by a factor of five,
- Process more data in the same amount of time.
- Lower storage costs.

## 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

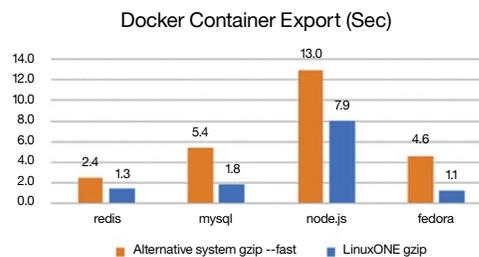
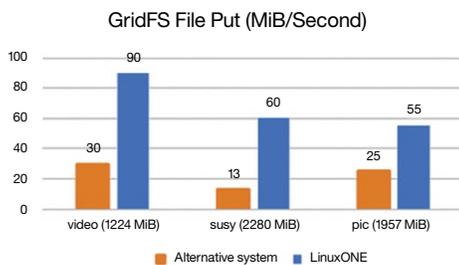
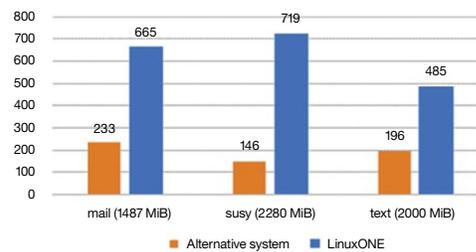
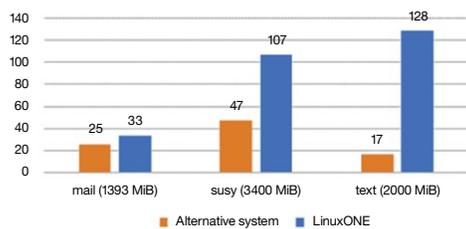


Figure 2. Hardware compression

### Ease of use

You do not need to learn any new codes or commands to log on as a guest with SSH and be productive in a familiar Bash environment. Graphical user interfaces with remote connection capability, such as X11 and Xvnc, are also available if you prefer a graphical desktop environment. Most of the major development tools are available for IBM LinuxONE systems. If some user-space applications are not readily available from distributions, most of them merely need a simple re-compilation to be able to run on IBM LinuxONE. Applications written for modern run-time systems, such as Java, Node.js, and PHP applications, simply run out of the box. Due to the similarity and compatibility with other Linux platforms, you can migrate whole applications stacks from other architectures to IBM LinuxONE simply and easily, often with just a small amount of work, typically in hours.

### More choices and speed with contemporary programming languages

*Contemporary programming languages provide more choice and speed on the platform*

Application developers on IBM LinuxONE systems can choose from a variety of modern, popular programming languages and run-time environments, including Java, Node.js (JavaScript), Python, Ruby-on-Rails, Scala, Erlang, and Go—and the list is growing. This variety allows new, modern applications to be built and run on the IBM LinuxONE platform easily.

Application developers can choose from a variety of modern, popular programming languages and run-time environments including Java, Node.js (JavaScript), Python, Ruby-on-Rails, Scala, Erlang, and Go—and the list is growing. This variety allows modern applications to be built and run on IBM LinuxONE easily.

### *Deploying Node.js on IBM LinuxONE improves performance*

The most notable of these run-time technologies is Node.js. It is the fastest growing ecosystem for application development. Since 2012, Node.js has grown at a rate three times faster than Java with the number of Node.js modules contributed by developers world-wide surpassing other languages.<sup>14</sup> As a high-performance, highly scalable, event-driven, server-side JavaScript solution, Node.js has become popular for web application development—the “N” in the term “MEAN stack” stands for “Node.js.”

To meet the high demand for Node.js functionality on IBM LinuxONE systems, IBM has ported the open source Node.js code to the platform. IBM released IBM SDK for Node.js 1.2 in early 2015. This SDK is fully compatible with Node.js version 0.12.<sup>15</sup> The SDK enables developers to write Node.js code on any platform, and test and deploy their applications on IBM LinuxONE systems. Enterprise users of the SDK will enjoy the performance and security afforded by the platform (on the AcmeAir benchmark, IBM LinuxONE outperforms a comparable distributed server with 2.1 times higher throughput in RESTful transactions<sup>16</sup>), as well as the additional monitoring and debugging tools that ship with the SDK.

---

### Use the same set of tools and skills to diagnose both Node.js and Java applications

- Using IBM Health Center, users can monitor Node.js applications and gain valuable insight into application hot spots, garbage collection activities, memory consumption and much more.
  - The IBM Interactive Diagnostic Data Explorer (IDDE) is now aware of Node.js runtime and JavaScript metadata, giving users the ability to scan the heap for JavaScript objects or walk JavaScript stack frames during postmortem analysis.
  - Both Health Center and IDDE are available at no cost as part of IBM Support Assistant and on the Eclipse Marketplace. Support for IBM SDK for Node.js is also available upon request.
-

High Performance JavaScript for LinuxONE

- Highly scalable, event-driven platform with non-blocking I/O
- Thousands of concurrent connections with minimal overhead
- Improved TLS, TCP and clustering performance over V1.1
- Up to **2.1x** more RESTful web interactions with AcmeAir in node.js with Apache JMeter benchmark setup

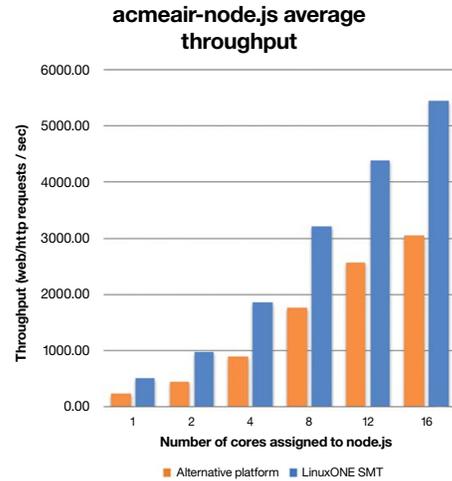


Figure 3. High performance JavaScript for IBM LinuxONE

Enterprise users of the SDK will enjoy the performance and security afforded by the IBM LinuxONE platform (on the AcmeAir benchmark. IBM LinuxONE Emperor out-performs x86 by 52 percent<sup>17</sup>), as well as the additional monitoring and debugging tools that ship with the SDK.

- Improve application throughput by 200 percent.
- Reduce transaction response time by as much as 60 percent.
- Boost database performance for SQL and NoSQL.
- Gain better per core performance and scalability.

One of the most important benefits from deploying Node.js on IBM LinuxONE systems is the ability to bring the processing of web requests to the platform where the data is hosted (co-location of application and data), which can improve application throughput by two times, and reduce transaction response times by 60 percent.<sup>18</sup> The enablement of Node.js on the platform also means that a large number of open source web application frameworks, such as Express and Sails.js, are now available to IBM LinuxONE developers.

By deploying Node.js applications on IBM LinuxONE, you gain all the strengths, security and reliability of IBM LinuxONE. For example, IBM LinuxONE systems fast processors are well suited to the Node.js single-threaded processing model. The large I/O capacity of IBM LinuxONE also complements one strength of Node.js applications: the ability to scale and maintain thousands of concurrent connections.

IBM LinuxONE systems can further provide an advantage to JavaScript applications that need to access enterprise data and transactions. Logical partitions on IBM LinuxONE systems can be linked together by high-speed networking HiperSockets, allowing memory-to-memory communication with drastically improved performance. JavaScript applications can leverage HiperSockets transparently to access data and transactions in other logical machines inside the box.

The IBM SDK for Node.js is 100 percent API compatible with the community version. The IBM SDK was built from the open source community code base with extensions added for support on IBM LinuxONE. Leveraging the strength of monitoring and debugging tools developed for Java, they have been extended to work with the IBM SDK for Node.js.

*NoSQL? No problem.*

NoSQL databases are increasingly being adopted in big data and real-time analytics applications. Some of the most important NoSQL databases include MongoDB (the “M” in “MEAN stack”), MariaDB, Apache Geode, Apache Cassandra, Apache CouchDB and Redis.

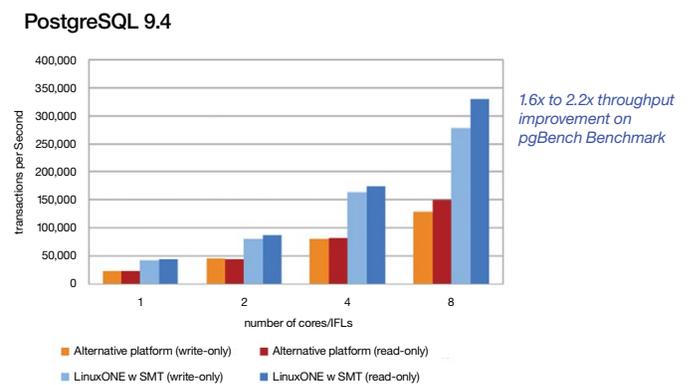
IBM LinuxONE delivers two times the performance for the same SQL and NoSQL databases running on commodity Linux platforms.

### *PostgreSQL achieves up to 2.2x better pgbench throughput over alternative platforms*

Open source relational database management systems such as PostgreSQL serve a great amount of data in many organizations. First released in 1996, PostgreSQL is a well-established enterprise-grade database system that powers many web sites and government agencies.<sup>19</sup> PostgreSQL 9.4 already runs well on IBM LinuxONE Emperor, and it is able to capitalize on the strengths of the system as a data-serving platform.

IBM LinuxONE offers many features that others systems cannot match—including availability, stability, and flexibility—that combine to help PostgreSQL excel as a powerful enterprise database solution. An independent performance test conducted by 2ndQuadrant found that PostgreSQL on the IBM LinuxONE infrastructure provides greater throughput, regardless of the type of workloads, compared to an infrastructure based on a competitive architecture. According to a report by the PostgreSQL consultancy firm 2ndQuadrant,<sup>20</sup> PostgreSQL can offer better per-core performance of 1.6 to 2.2x via pgBench benchmark and scalability on the platform compared to distributed systems, as shown in Figure 4.

*Figure 4 shows, PostgreSQL can offer better per-core performance and scalability on IBM LinuxONE systems compared to distributed systems.*



*Figure 4. PGBench results (read-only and write-only, in-memory workloads) on IBM LinuxONE as compared to distributed systems*

Global PostgreSQL support and consultancy firm, 2ndQuadrant, partners with IBM to support PostgreSQL on IBM LinuxONE. IBM also offers PostgreSQL as a solution on Bluemix. For more information, see Bluemix docs.

PostgreSQL 9.4 has been tested on enterprise Linux distributions (RHEL and SLES) that run on IBM LinuxONE. For more information about the installation instructions, see Building PostgreSQL.

### **Porting, performance measurement and scaling advantages with MongoDB**

MongoDB is a cross-platform document-oriented database. Released under a combination of the GNU Affero General Public License and the Apache License, MongoDB is free and open-source software. Since its initial release in 2009, MongoDB has been adopted as back-end software by a number of major websites and services. Today, MongoDB is one of the fastest-growing database ecosystem, with over 10 million downloads, thousands of customers, and more than 1,000 technology and service partners.

Classified as a NoSQL database, MongoDB eschews the traditional table-based relational database structure in favor of JSON-like documents without fixed schemas. The schema-less nature of MongoDB not only makes it better than relational databases at handling unstructured and sparse data, it also facilitates rapid prototyping and fast evolution of programs without paying the constant costs of updating database schemas and refactoring tables.

By adopting JSON/BSON as the document format, MongoDB allows developers to write data queries in JavaScript, a language with which they are already familiar, so that the need to mix SQL statements into the application code can be eliminated. It also eliminates the cost of ORM (object-relational mapping), because JSON documents can contain complex types and are

by nature JavaScript objects. Because JSON is widely supported as a de-facto standard for information exchange, it is easy to consolidate data from multiple disparate sources into one MongoDB collection.

MongoDB also supports geospatial and time-series analytics, as well as scalability and high availability through sharding and replication, making it a highly capable engine for processing the vast amount of data generated online. All these factors help make programs easier to develop and maintain, boost programmer productivity and improve business agility.

---

### **Advantages of running MongoDB on IBM LinuxONE systems**

By deploying MongoDB on IBM LinuxONE systems, organizations gain all the strength, security and reliability of an enterprise-grade Linux platform. IBM LinuxONE is equipped with the fastest processors in the world, and is an I/O superhero for data and transaction processing throughput.

- The speed of the processors available in an IBM LinuxONE system and its high input/output system, multiple layers of cache mean that MongoDB can scale up, as well as scale out.
  - The enterprise virtualization capabilities of IBM LinuxONE support very high virtual machine density and resource over-commit, which allows MongoDB instances to achieve much better utilization than on other platforms.
  - Co-located MongoDB instances (different shards, or replica set members within the same shard) can leverage HiperSockets (high-speed internal communication pipes) to reduce network communication overhead.
  - Proximity to enterprise data that resides on the IBM LinuxONE allows MongoDB to eliminate extracting, transforming, and loading (ETL) off platform, removing latency and improving data security and governance.
-

Big data is becoming more prevalent as we start to leverage insights from structured and unstructured data together to deliver better business outcomes. MongoDB represents a powerful aggregation point where insights from traditional system-of-record data (such as retail transaction history) can be joined with system-of-engagement data (such as micro-beacon geodesic information) to provide a rich and comprehensive user experience for the shopper. On top of this, MongoDB database aggregation now enables businesses to bring these two worlds together for their own benefit and gain access to insights to all of their data to facilitate critical business decisions.

**Advantages of using MongoDB with IBM LinuxONE**

You can easily build and run MongoDB on IBM LinuxONE. Running MongoDB on IBM LinuxONE enables faster and more secure access to data sources for aggregation purposes and eliminates the need for sharding. The performance and virtualization capabilities of the IBM LinuxONE platform also make it ideal for scaling out as well as scaling up NoSQL applications.

*Up to 2x better throughput on IBM LinuxONE than on alternative platforms.*

MongoDB 3.0.4 (WiredTiger, no sharding)

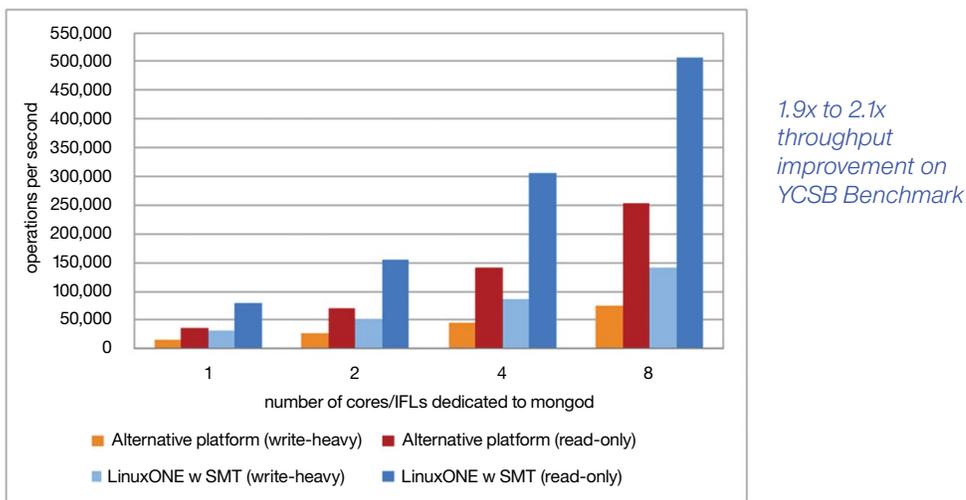
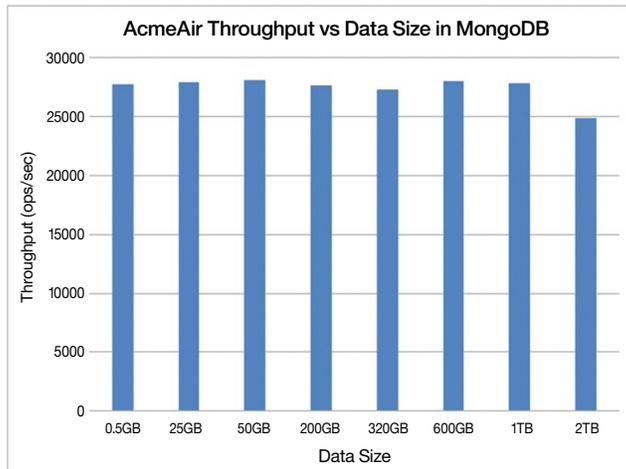


Figure 5. MongoDB running on IBM LinuxONE has 1.9 times to 2.1 times throughput improvement on YCSB Benchmark

Extreme Scale Up Acme Air Throughput vs Data Size



*Consolidate multiple MongoDB servers in one instance*

*— Largest single node of MongoDB with a footprint of +2TB, processing +4B documents with sustained throughput and response time (<5ms).*

*— Avoid the overhead, cost and complexity of distributing DB across many servers*

Figure 6. Extreme scale up of MongoDB on IBM LinuxONE

*No need for sharding*

The superior single-thread performance and large memory capacity of IBM LinuxONE allows MongoDB to scale up very well. On various Yahoo Cloud Service Benchmark (YCSB) workloads, MongoDB running on a IBM LinuxONE Emperor is able to achieve up to two times better throughput than the latest distributed platforms.

Because IBM LinuxONE can support a maximum of 10 TB of memory, a single Linux system can accommodate a larger database that would have required sharding to multiple MongoDB

servers on commodity platforms. This affords users the flexibility to reduce or avoid the risks and costs associated with sharding.

MongoDB drivers for various languages, such as C/C++, Node.js and Ruby, either have been verified to work on IBM LinuxONE or are being ported to the platform. IBM is working to contribute all the changes upstream to the latest version of the product.

*Three simple use cases using MongoDB on IBM LinuxONE*

- Aggregate data from multiple sources into a central repository to create a single 360-degree view of enterprise customers. Complex queries can be performed over the aggregated data efficiently.
- Exploit the flexible data model and multiple options for scaling—including range-based, hash-based and location-aware sharding—to develop applications quickly, and support the constantly changing requirements. Schemas can be radically changed while running in production, with zero impact on the user experience.
- Create a read-forward cache of system of record data for fast viewing or manipulation by a front-end system, such as a web application or a mobile application, which could be in use by a large number of concurrent users.

**Compatible IBM products and services working with MongoDB**

MongoDB is currently available on BlueMix via MongoLab, a fully-managed cloud database service featuring high availability, automated backups, web-based tools, monitoring and support. Since version 10.5, DB2 has provided JSON support.

One way that DB2 users can interact with JSON data is to deploy the MongoDB wire listener, which intercepts the MongoDB wire protocol and acts as a gateway in front of DB2—which allows DB2 to accept and respond to requests from applications written against the MongoDB API. Any modern language with a driver that supports the MongoDB protocol can be used, including Node.js, PHP, Python and Ruby, as well as more traditional languages such as C, C++, Java and Perl.

**Throughput improvements with MariaDB on IBM LinuxONE**

MariaDB is a community-developed fork of the popular MySQL relational database management system, and it is intended to remain free under the GNU GPL. Being a fork of a leading open source software product, it is notable for being led by the original developers of MySQL, who forked the code due to concerns over its acquisition by Oracle. Contributors are required to share their copyright with the MariaDB Foundation.

**MariaDB 10.1.5**

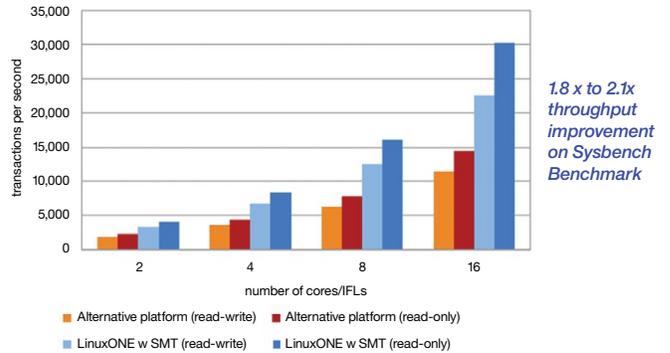


Figure 7. MariaDB running on IBM LinuxONE has 1.8 times to 2.1 times throughput improvement on Sysbench Benchmark

*MariaDB achieves up to 2.1x better Sysbench OLTP throughput on IBM LinuxONE over alternative platforms*

MariaDB delivers value with:

- Backward compatibility with MySQL
- Perpetually open source
- More cutting-edge technologies and more storage engines than MySQL

IBM LinuxONE offers state-of-the-art hardware, world-class security and the capability to scale MariaDB with IBM’s industry-leading virtualization technologies. Clients can easily consolidate clusters with many servers on a single IBM LinuxONE system. IBM LinuxONE can host more servers per core than any other system with high-speed encryption, disaster recovery and continuous availability solutions.

**Common use cases for MariaDB**

Many clients and partners use MariaDB as an alternative to MySQL and Microsoft SQL Server because MariaDB future-proofs their database investment, obtains better value, and developers and IT departments want to leverage the default database from their Linux distributions and simplify deployments. The combination of Linux, Apache, MySQL/MariaDB,

## IBM Systems

and PHP/Python/Perl—together known as LAMP—is perhaps the most commonly used web service solution stack. Common use cases include:

- Web and mobile applications
- Content management systems
- E-commerce and ticketing
- Search and advertising
- Business intelligence and analytics
- Games, entertainment and social media

### Collaboration with the MariaDB community

IBM actively contributes to the MariaDB community to ensure that the latest MariaDB works out of the box on IBM platforms. The effort includes fixing bugs, porting new features and optimizing for the underlying hardware platform. For example, IBM has recently built and validated MariaDB with Galera Cluster capability on IBM LinuxONE. IBM works with MariaDB, Inc. to deliver MariaDB Enterprise for IBM platforms and 24/7 support services to IBM customers with business and mission-critical application needs. This has helped many IBM customers running Linux, and IBM has now extended the partnership to cover IBM LinuxONE systems.

### Compatible IBM products and services working with MariaDB

MariaDB is certified on IBM LinuxONE running Red Hat Enterprise Linux and SUSE Linux Enterprise Server. The MariaDB community version runs out of box on IBM LinuxONE. You can install MariaDB 5.x through Yum on RHEL or Zypper on SLES. See the Installation guide for MariaDB 10.x. MariaDB Inc. and IBM are working together to bring MariaDB Enterprise to IBM LinuxONE. MariaDB Enterprise extends MariaDB 10 with certified binaries and continuous value delivery to optimize MariaDB for the most challenging use cases.

For more information, go to <https://mariadb.org>

### Advances to large-scale data processing New options for analytics

Big data and real-time analytics are the key to success for many enterprises. Apache Spark is an open source cluster computing framework that allows user programs to load data into a cluster's memory and query it repeatedly.

As data and analytics are embedded into the fabric of business and society—from popular applications to the Internet of Things (IoT)—Apache Spark brings essential advances to large-scale data processing. First, it dramatically improves the performance of data dependent applications. Second, it radically simplifies the process of developing intelligent applications, which are fueled by data.

Apache Spark is agile, fast and easy to use, and because it is open source, it is improved continuously by a worldwide community. Apache Spark is designed to perform both batch processing and new workloads, such as streaming, interactive queries and machine learning.

New options for analytics allow data scientists to take advantage of IBM LinuxONE advanced analytic capabilities without having to worry about the specific format of the data.

The enablement of Apache Spark for IBM LinuxONE allows data mining specialists to use Apache Spark's common programming framework to take advantage of IBM LinuxONE advanced analytic capabilities without having to worry about the specific format of the data.

- Apache Spark running on IBM LinuxONE produces 1.5x faster insights for real-time analytics than on alternative platforms.
- Process 54 percent more data

Based on internal IBM testing, the Apache Spark-Perf benchmark suite on IBM LinuxONE can process 54 percent more data (see Figure 2) than distributed systems for model building, leading to real-time insights with higher accuracy.

## Apache Spark Performance Comparisons

- Up to **1.5x** faster insights for real-time analytics using Spark's core primitives
- Up to **1.5x** more data processed for model building leading to real-time insights with higher accuracy within a given batch window
- Co-locate Spark with Competitor Database on LinuxONE outperforms running Spark off-platform up to **3x** for aggregation analytical query
  - e.g. Operational Analytics for a Brokerage running reports on top of OLTP Trading data

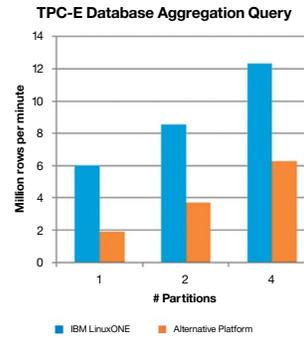
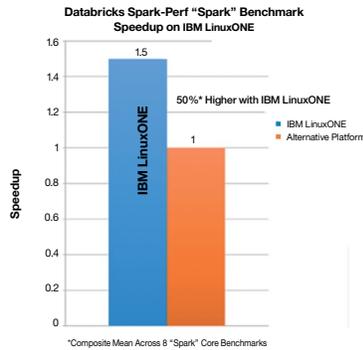


Figure 8. Spark-Perf running on IBM LinuxONE produces 1.5 times faster insights for real-time analytics than on alternative platforms

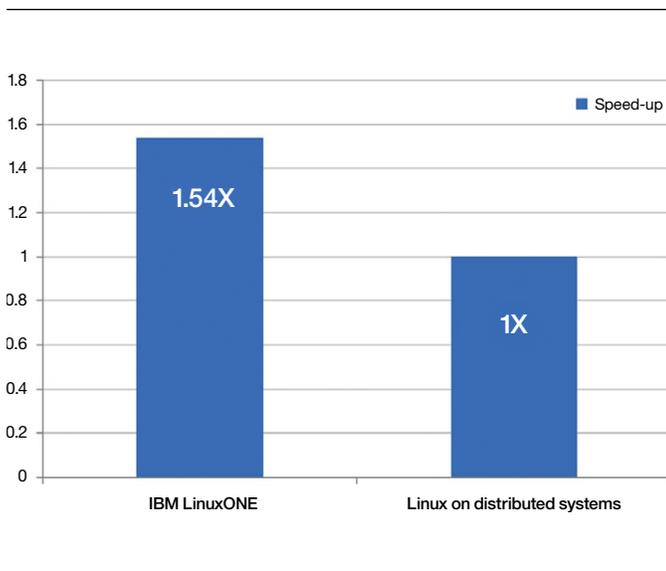


Figure 9. Co-locate Apache Spark with competitor database on IBM LinuxONE outperforms running Apache Spark off-platform up to 3 times for aggregation analytical query

### Application portability and infrastructure flexibility Docker delivers ease of use and application portability

Docker is an open, portable, light-weight run-time and packaging tool for Linux containers, and has gained a lot of momentum since its first release in 2013. Linux containers provide operating system-level virtualization for running multiple isolated applications on the same host. Using containers, it is easy to build and ship complex applications that have dependencies on a deep software stack or other infrastructure, without having to worry about interference from other applications that might have conflicting requirements. Compared to a standard virtual machine, containers are much faster to boot, more efficient to run, and offer higher application density.

**Docker is an open source tool that provides a way of running isolated applications and software in a single Linux instance in what are called “containers.”**

- Package applications together for more efficient deployment and better density
  - Develop the app package on any platform, provide the binaries for the platform, and deploy the app anywhere—on a laptop, in the datacenter, or in a public cloud
  - Gain traction as a way to contemporize Linux environments in datacenters
  - Eliminate virtual machine resource overhead since the hypervisor is not required
  - Enable full support of DevOps model through simple build process of containers, versioning and deployment
  - Scale stateless solution components, such as node.js instances, easily
- 

Docker provides developers with more ease of use, portability and the ability to quickly get up and running, providing users will the ability to develop anywhere. Docker has an engine or runtime that sits on top of the operating system and provides the virtual containers into which users deploy the software. Docker offers an elegant portability solution for applications and software packages because it is lightweight and removes some of the complexities of managing a hypervisor, e.g. KVM, or VMware. However, if users want security they need to package them as second level guests to get the isolation between the applications and data.

### **Advantages using Docker on IBM LinuxONE**

The virtualization technology in IBM LinuxONE complements Docker by offering a more powerful, scalable and secure environment. For example, while developing or testing an application, a user can obtain increased application density by deploying containers directly on one Logical Partition (LPAR), which eliminates the need for VM provisioning.

---

Why Docker and IBM LinuxONE are a perfect match:

- **Easy app deployment:** Docker on IBM LinuxONE allows unparalleled simplicity in application packaging and deployment.
  - **More efficient communication:** With the ability to collocate hundreds of thousands of containers sharing the same memory subsystem, inter-container communication comes close to the speed of a memory-to memory copy with HiperSockets.
  - **Security:** Expensive SSL calls that would have been needed on a distributed system are no longer necessary since communication is done through secure in-memory channels.
  - **Faster and simpler auditing:** Docker image snapshot creation is as much as 4x faster due to dedicated compression cards; state rollback can happen in a heartbeat and the system can be ready for auditing at a much more granular level.
  - **More reliability:** With IBM GDPST<sup>™</sup>, container storage is virtually guaranteed 99.9999 percent uptime which means more operational efficiency by eliminating the need for replication that would typically be required.
  - **Makes Docker secure:** With the ability to spawn a Linux guest in seconds (or ideally, overcommit), Docker containers can offer security levels that VM level isolation brings to the table, while maintaining the simplicity and flexibility of deployment that containers offer.
- 

When deploying applications in production, users can put the containers inside second-level guests to get better isolation. For maximum security, users can run individual containerized applications inside separate LPARs, which gives isolation on a bare-metal level that is unmatched by other platforms. See Figure 10 for an illustration of how containers can run on LPARs as well as VMs.

IBM LinuxONE application performance per Docker container is higher with a high number of containers per virtualized or physical resources. Its low hypervisor overhead allows Docker containers that are running on second level VM guests to have minimal impact on application performance while providing full security isolation in a multitenant enterprise environment. In addition to the main Docker tools, IBM is working to provide Docker files that allow users to create containerized applications of their choice to run on IBM LinuxONE.

**Four simple use cases**

**1. Faster more efficient deployment: write applications once**

Clients can write an app once, send to other people and then deploy which means organizations do not have to develop resources with special knowledge about how to install the app and what other packages are required. The containers provide the user with the automation for packaging with automated scripts inside the container, providing an easier, more efficient and faster way to deploy and run applications.

**2. Break down the components of applications: choose only what is needed to build what your organization wants**

Let's say a developer has an app that requires lots of parts for a multi-tiered application comprised, for example, by a workflow component, a WebSphere component, a database component, and a math library component. One option is to put them in four different containers. Then, if the workflow component is not wanted, the user only needs to deploy three of the containers. The user is able to break down applications into different parts and use only the necessary pieces. Many software products are often shipped with the entire product included—in order to access the one component that is needed, the user is required to install the full complement of the application's pieces. If an app requires all the components, the user can put them in one container. If the app doesn't require all components the user has the option to keep them separate—as if the pieces are optional. The flexibility of being able to select only what is to be used—like building blocks, enables users to more efficiently build what they want.

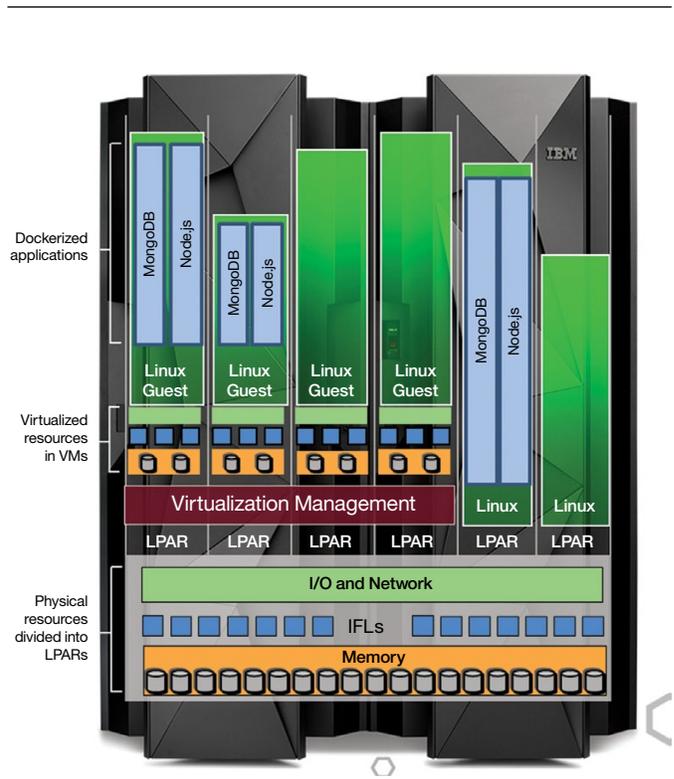


Figure 10. Different levels of isolation—LPARs, VMs and Docker containers

**3. Simple application portability: Develop Java applications on one platform and deploy on multiple platforms**

A developer can develop applications in Java on an Intel platform and deploy them on IBM LinuxONE. Since Java doesn't require a recompile on different platforms, app portability is a given. Without containers, the developer didn't know if they had the right libraries, Java VM level, and middleware requirements. But now with containers, any software the app requires can be packaged into a container, provided it is Java. Although the container has to be rebuilt on the platform image the developer is using, once the developer is in a container model this task becomes simple.

#### 4. Enable more applications in one system: *Docker on IBM LinuxONE allows for larger density than VMs*

Docker allows for larger density than VMs and enables more applications in one system. Before containers, a user could only run 10 WebSphere instances on an Intel system, but now with containers and enhanced memory efficiency; the user can run hundreds of the same instance because you don't have to set up separate VMs with hypervisors.

IBM LinuxONE offers advantages over commodity x86 with memory overcommit, while the overhead on an IBM LinuxONE with CPU virtualization is relatively small. Users will see a bigger advantage in the distrusted environment leveraging containers, however more importantly, the combination of containers and security isolation due to this memory overcommit means lower VM overhead.

In a Docker environment that leverages density, the user loses the security isolation between these applications because the hypervisor is not present. If security is not a priority, then running on bare metal gives good density at faster response time. However, if your organization is concerned about security, then you will want isolation, and the overhead on the IBM LinuxONE is minimal.

Organizations running mission critical applications can leverage density/bare metal in a development-test environment to rapidly put everything on one IBM LinuxONE partition to eliminate the provisioning associated with hypervisors. In production, you can revert back to second level guests to get the isolation, and live with the hypervisor overhead as the production environment does not change rapidly. You can use this VM isolation on a tenant granularity to get the isolation on

a tenant base, and on sufficient “mass” of applications to gain from the efficiency opportunities because VMs don't have as big overhead on IBM LinuxONE as compared with that on a distributed x86 platform.

With IBM LinuxONE users can shape their environment with system virtualization and container elements according to the landscape and requirements without limitations in performance. This means organizations can define their IT structures according to their needs, not their system constraints.

#### **Take a test drive using the IBM LinuxONE Community Cloud**

IBM is committed to working with open source development communities to enable them to develop, test and continuously integrate code on IBM LinuxONE systems. IBM offers access to IBM LinuxONE hardware in a number of ways.

Organizations can now test drive IBM LinuxONE. The [IBM LinuxONE Community Cloud](#) offers organizations no-charge, open access to an enterprise grade Linux environment. Quickly and easily provision a virtual server image with the Linux distribution of your choice—RedHat, SUSE or coming soon Ubuntu. The easy 90 day trial includes up to 2 virtual CPU, 2 GB memory and 40 GB of storage.

The IBM LinuxONE community cloud provides ISVs, clients, developers and students the perfect starting point to understanding the benefits that IBM LinuxONE offers.

Get started today: <http://ibm.com/linuxone/try>

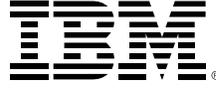
- <sup>1</sup> International Telecommunication Union (ITU), Facts and figures, TU Telecommunication Development Bureau, 2015. <https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf>
- <sup>2</sup> Performance comparison based on IBM Internal tests comparing IBM LinuxONE Emperor cloud with one comparably configured private x86 cloud and one comparably configured public cloud running an aggregation of light, medium and heavy workloads designed to replicate typical IBM customer workload usage in the marketplace. System configurations are based on equivalence ratios derived from IBM internal studies and are as follows: Public Cloud configuration: total of 219 instances (128 for light workloads, 64 for medium workloads and 27 for heavy workloads); x86 Cloud configuration: total of eleven x86 systems each with 24 Intel E7-8857 v2 3.0GHz cores, 512GB memory, and 7x400GB SSDs; LinuxONE Emperor Cloud configuration: total of 32 Linux cores, 3806GB memory, and Storwize v7000 with 47x400GB SSDs. Price comparison estimates based on a 3YR Total Cost of Ownership (TCO) using publicly available U.S. prices (including a 20% discount for middleware) current as of January 1, 2015. Public Cloud TCO estimate includes costs (US East Region) of infrastructure (instances, data out, storage, support, free tier/reserved tier discounts), middleware and labor. LinuxONE Emperor and x86 TCO estimates include costs of infrastructure (system, memory, storage, virtualization, OS, cloud management), middleware, power, floor space and labor. Results may vary based on actual workloads, system configurations, customer applications, queries and other variables in a production environment and may produce different results. Users of this document should verify the applicable data for their specific environment.
- <sup>3</sup> Based on Common Criteria EAL5+ security rating, U.S. National Vulnerability Database, Solitaire CX Study and ITIC Study
- <sup>4</sup> Based on Common Criteria EAL5+ security rating, U.S. National Vulnerability Database, Solitaire CX Study and ITIC Study
- <sup>5</sup> *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2014–2019 White Paper*, [http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white\\_paper\\_c11-520862.html](http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html)
- <sup>6</sup> CMO Council: Facts & Stats, <https://www.cmocouncil.org/facts-stats-categories.php?view=all&category=mobile-marketing>
- <sup>7</sup> *New Metrics and Insights for a Mobile World*, pg 4, Dr. Howard A. Rubin, CEO and Founder, Rubin Worldwide, Professor Emeritus City University of New York, 2015
- <sup>8</sup> Based on face-to-face conversations with more than 1,600 CIOs from 70 countries and 20 industries worldwide, [http://www-01.ibm.com/common/ssi/cgi-bin/ssialias?subtype=XB&infotype=PM&appname=GBSE\\_GB\\_TI\\_USEN&htmlfid=GBE03580USEN&attachment=GBE03580USEN.PDF](http://www-01.ibm.com/common/ssi/cgi-bin/ssialias?subtype=XB&infotype=PM&appname=GBSE_GB_TI_USEN&htmlfid=GBE03580USEN&attachment=GBE03580USEN.PDF)
- <sup>9</sup> IBM Technical Paper: An overview of IBM MobileFirst Platform: Build, test, integrate, deploy and manage mobile applications, [http://www2.themspub.com/rs/creationagencyibm/images/MobileFirst\\_Platform\\_Overview.pdf](http://www2.themspub.com/rs/creationagencyibm/images/MobileFirst_Platform_Overview.pdf)
- <sup>10</sup> <http://highscalability.com/strategy-diagonal-scaling-dont-forget-scale-out-and>
- <sup>11</sup> IBM is a member or sponsor of: The Linux Foundation, The OpenStack Foundation, The Node.js Foundation, The OpenJDK Governing Board, OASIS, and The Apache Software Foundation, among others.
- <sup>12</sup> The central list of ported open source software can be found on the IBM DeveloperWorks community: <https://www.ibm.com/developerworks/community/groups/community/lozopensource>. Feel free to raise requests in the community forum for open source software that are not yet available on the platform.
- <sup>13</sup> [https://www-01.ibm.com/support/knowledgecenter/linuxonibm/com.ibm.linux.z.lxci/lxci\\_c\\_geninfo.html](https://www-01.ibm.com/support/knowledgecenter/linuxonibm/com.ibm.linux.z.lxci/lxci_c_geninfo.html)
- <sup>14</sup> <http://www.modulecounts.com/>
- <sup>15</sup> <https://developer.ibm.com/node/sdk/>
- <sup>16</sup> <https://github.com/acmeair/acmeair-nodejs>
- <sup>17</sup> <https://github.com/acmeair/acmeair-nodejs>
- <sup>18</sup> <https://github.com/acmeair/acmeair-nodejs>
- <sup>19</sup> <http://www.postgresql.org/about/users/>
- <sup>20</sup> Mark Wong (2ndQuadrant Ltd.), *OLTP Performance Benchmark of PostgreSQL 9.4 on IBM Systems*, <http://2ndquadrant.com/en/support/support-ibm-z-systems/performance-analysis/>

## For more information

To learn more about IBM LinuxONE systems, please contact an IBM representative or IBM Business Partner, or visit the following website: [ibm.com/linuxone](http://ibm.com/linuxone)

Additionally, IBM Global Financing provides numerous payment options to help you acquire the technology you need to grow your business. We provide full lifecycle management of IT products and services, from acquisition to disposition.

For more information, visit: [ibm.com/financing](http://ibm.com/financing)



---

© Copyright IBM Corporation 2016

IBM Systems  
Route 100  
Somers, NY 10589

Produced in the United States of America  
February 2016

IBM, the IBM logo, [ibm.com](http://ibm.com), LinuxONE, LinuxONE Emperor, LinuxONE Rockhopper, UrbanCode, HiperSockets, developerWorks, PartnerWorld, BlueMix, WebSphere, InfoSphere, BigInsights, Cognos, DB2, System z, GDPS, z/VM, Spectrum Scale, and GPFS are trademarks of International Business Machines Corp., registered in many jurisdictions worldwide. Other product and service names might be trademarks of IBM or other companies. A current list of IBM trademarks is available on the web at “Copyright and trademark information” at [ibm.com/legal/copytrade.shtml](http://ibm.com/legal/copytrade.shtml)

Intel, Intel logo, Intel Inside, Intel Inside logo, Intel Centrino, Intel Centrino logo, Celeron, Intel Xeon, Intel SpeedStep, Itanium, and Pentium are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

Linux is a registered trademark of Linus Torvalds in the United States, other countries, or both.

Microsoft, Windows, Windows NT, and the Windows logo are trademarks of Microsoft Corporation in the United States, other countries, or both.

Java and all Java-based trademarks and logos are trademarks or registered trademarks of Oracle and/or its affiliates.

This document is current as of the initial date of publication and may be changed by IBM at any time.

The performance data discussed herein is presented as derived under specific operating conditions. Actual results may vary. It is the user’s responsibility to evaluate and verify the operation of any other products or programs with IBM products and programs.

Statements regarding IBM’s future direction and intent are subject to change or withdrawal without notice, and represent goals and objectives only.

THE INFORMATION IN THIS DOCUMENT IS PROVIDED “AS IS” WITHOUT ANY WARRANTY, EXPRESS OR IMPLIED, INCLUDING WITHOUT ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND ANY WARRANTY OR CONDITION OF NON-INFRINGEMENT. IBM products are warranted according to the terms and conditions of the agreements under which they are provided.



Please Recycle