

IBM LinuxONE has superior qualities of service



- Spare cores for failover
- RAIM memory
- Built-in top to bottom security

- Up to 0% unplanned downtime due to hardware failures
- Near-continuous availability with GDPS® Virtual Appliance
- and more...

Not available
on x86 servers

LinuxONE systems provide the highest levels of availability (near 100% uptime with no single point of failure), performance, throughput, and security.
(Robert Frances Group¹)

IBM LinuxONE has real economic advantage

For certain workloads and environments:
Consolidation on large virtualized servers raises utilization, reduces core requirements, and lowers cost per workload

The TCO for Linux applications on **x86 servers can be more than 65% more expensive** than on LinuxONE servers. (Robert Frances Group^{2,1})

For the web application workloads compared, the LinuxONE Rockhopper private cloud deployment is estimated to be ...

45% lower in cost

...than the compared x86 private cloud.
(IBM³)

IDC return on investment studies typically find that **larger systems** tend to deliver **lower management costs** than those associated with distributed servers. (IDC⁴)

To learn more:

ibm.com/LinuxONE

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

¹ Robert Frances Group, 10 Reasons LinuxONE is the Best Choice for Linux Workloads, 2015; The information and materials presented herein represent to the best of our knowledge true and accurate information as of date of publication. It nevertheless is being provided on an "as is" basis. IBM Corp. sponsored this research report.

² This holds true for entities in developing countries that have as few as 30 Linux workloads or 20 Linux servers, as well as large enterprises with an IT infrastructure that spans across multiple data centers.

³ Performance comparison based on IBM Internal tests comparing IBM LinuxONE Rockhopper cloud with one comparably configured private x86 cloud and one comparably configured public cloud running general purpose virtual machines 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 24 general purpose instances; x86 Cloud configuration: total of two x86 systems each with 24 Intel E5-2690 v3 cores, 192GB memory, and 2x400GB SSDs; LinuxONE Rockhopper Cloud configuration: total of 8 cores, 384GB memory, and Storwize v7000 with 4x400GB SSDs. Price comparison estimates based on a 3YR Total Cost of Ownership (TCO) using publicly available U.S. street prices (current as of December 10, 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 Rockhopper and x86 TCO estimates include costs of infrastructure (system, memory, storage, virtualization, OS, cloud management), middleware 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.

⁴ IDC White Paper, sponsored by IBM, Driving Digital Transformation through Infrastructure Built for Open Source: How IBM LinuxONE Addresses Agile Infrastructure Needs of Next Generation Applications, September 2015

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IBM LinuxONE™ - Dare to Compare

The disadvantages of a scale-out x86 server model are beginning to outweigh the advantages ...

Is low server utilization wrecking havoc in your data center?

Can your business afford to settle for only "good enough" ?

Does your business demand faster response time and more agility?

Have your software costs or administration costs reached the point of unsustainable?

Consider the alternative

IBM LinuxONE Emperor™

With a huge capacity range, grow with virtually limitless scale to handle the most demanding workloads

- Up to 141 cores
- Up to 10 TB memory
- Up to 160 PCIe slots

IBM LinuxONE Rockhopper™

An entry point model offering similar value but with the flexibility of a smaller package

- Up to 20 cores
- Up to 4 TB memory
- Up to 32 PCIe slots



IBM LinuxONE systems are supported by standard distributions of Red Hat, SUSE and Canonical (Ubuntu)



All kind of Linux workloads

IBM LinuxONE Emperor scalability is superior

- **Massive scale:** Single node MongoDB with a footprint of +1TB, processing +2B documents, maintains fetch times under 5ms and avoids overhead, cost and complexity of sharding¹
- **Docker density:** a single Emperor can create and start more than 1 million Docker containers¹
- **Consolidation of x86 servers:** Linux on Emperor can support up to 8000 VMs in a single footprint for large scale consolidations²

¹ Based on results from internal lab measurements. The actual performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, results may vary depending on the workload and other factors.

² Based on IBM internal measurements and projections.

IBM LinuxONE supports thousands of Linux servers **and** massive workloads with thousands of users ... *all in one box*

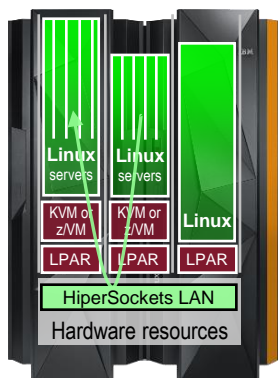
Choice of hypervisors:

Hardware **logical partitions** (LPAR) designed for complete workload isolation¹

z/VM® – supports recursion and live guest relocation

KVM for LinuxONE – popular, familiar open source solution

HiperSockets™ – very fast, in-memory TCP/IP connectivity

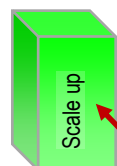


IBM LinuxONE has multi-dimensional growth and scalability options

Grow horizontally and vertically without disruption to running environment

Provision for peak utilization, unused resources automatically reallocated after peak

Dynamically add cores, memory, I/O adapters, devices and network cards



... or clone more Linux guests with a high degree of resource sharing

IBM LinuxONE is designed for cache-intensive and I/O-intensive workloads...

IBM LinuxONE Emperor has over 4x more on-chip cache per core than x86 servers ... **plus L4 cache** not found on x86 servers!²

IBM LinuxONE has separate **cores to process I/O** (up to 24) and drive a dedicated I/O subsystem ... **unlike x86 servers!**²

...like data and transaction processing, and large-scale analytics

¹ IBM LinuxONE is a commercial platform with EAL5 security classification. This certification means that although different workloads are running on the same hardware, they are protected when running in separate partitions; one logical partition (LPAR) cannot reach across boundaries into the next LPAR and compromise its security.

² Evaluated LinuxONE servers are Emperor and Rockhopper, L4 cache and separate cores to process I/O are not mentioned in any x86 server specification.

IBM LinuxONE is designed for speed and flexibility

IBM LinuxONE Emperor chip		
Micro-technology	22 nm SOI	<ul style="list-style-type: none"> • Single Instruction Multiple Data (SIMD) • Out-of-order processing • Dense packaging: electrons can travel about 11.8 inches in a nanosecond • On-chip coprocessors
Core count, speed, housing	8 core per chip, 5.0 GHz 6 chips per drawer (multiple drawer models)	
# Threads	2 per core	

Support of hardware transactional memory (HTM), I/O offload from main cores, I/O prioritization, simplified DR

Only IBM LinuxONE supports Capacity on Demand – more cores when you need them.

IBM LinuxONE Emperor demonstrates advantage in multiple tests¹

Docker	A LinuxONE Emperor runs 2000+ Docker containers on average 2.0x better than a compared x86-based system ²
IBM WebSphere® Application Server Liberty	1.5x better throughput versus a compared x86 platform running DayTrader 3, exploiting SMT and SIMD technology ³
MariaDB	MariaDB has a scaling efficiency of 84% up to 32 hardware threads (16 cores). Open Source products show an excellent scaling efficiency
MongoDB	Up to 2.4x higher throughput versus a compared x86 system running the Yahoo Cloud Service Benchmark (YCSB) ⁴
Spark	Up to 50% higher performance using Spark 1.4.0 versus a compared x86 platform ⁵

¹ These claims are based on results from internal IBM lab measurements on standalone dedicated systems in a controlled environment. Results may vary depending on the workload and other factors.

² Apache Solr search queries driven by Apache Jmeter System Stack, Emperor native LPAR on 36 cores with 755GB memory. x86-based alternative system (Lenovo System x3650 M5 w/ E5-2699 v3 processors): Native Linux on 36 CPU cores with 755GB memory, Heavy Docker Container: Apache Solr v4.10.0, WebSphere Liberty v8.5.5.2, IBM Java 1.8.0 SR1, Lightweight Docker Container: BusyBox, System SW: Docker 1.10.0-dev w/ aufs storage backend, RHEL 7.1. Note: Each active container is driven by a client thread in Apache Jmeter, which keeps sending the same Solr query repeatedly to the container to search documents that contain given key words in a pre-loaded & pre-indexed 46GB Wikipedia snapshot. The docker runtime was modified to increase a thread count limit, to avoid connection time-out, and to separate a dockernit binary from a docker binary. A modified Linux 4.3.0 kernel to support more than 1024 network bridge ports was installed on RHEL 7.1.

³ Native LPAR on Emperor with 4 cores running SLES 12 with WAS 8.5.5.5 and IBM 64-bit SDK for Linux Java™ Technology Edition, Version 8.0.1, using HiperSockets to client and DB2 server. Lenovo x3550 M4 with 2 cores of Intel Xeon CPU E5-2640 v3 @ 2.60GHz running RHEL 7.1, with IBM 64-bit SDK for Linux Java Technology Edition, Version 8.0.1, using 10Gb Ethernet to client and db2 server.

⁴ YCSB 0.2.0 (write-heavy, read-mostly, read-only), MongoDB 3.0.4 (WiredTiger, no sharding). Native LPAR on Emperor with SMT, RHEL 7.1. Intel(R) Xeon(R) CPU E5-2699 v3 HT native Linux, RHEL 7.1. 1-8 cores dedicated to MongoDB, 20 or 28 cores dedicated to YCSB.

⁵ The actual performance will vary depending on Spark-Perf benchmark version, Spark versions, IBM JDK versions and other factors. Spark 1.4.0 used on both platforms had Spark local, log and working directories on Ram Disk; 540672MB was the total executor memory on both platforms. Native LPAR on Emperor with 6 cores and each core in SMT2; IBM 64-bit SDK for Java Technology Edition, Version 8 with SR1-FP10. Intel Xeon CPU E5-2699 v3 @ 2.30GHz, running Ubuntu 15.04 with no other workloads running; 36 physical Cores using Hyper-Threading but only 6 physical cores were used for Spark; IBM 64-bit SDK for Java Technology Edition, Version 8 SR1.