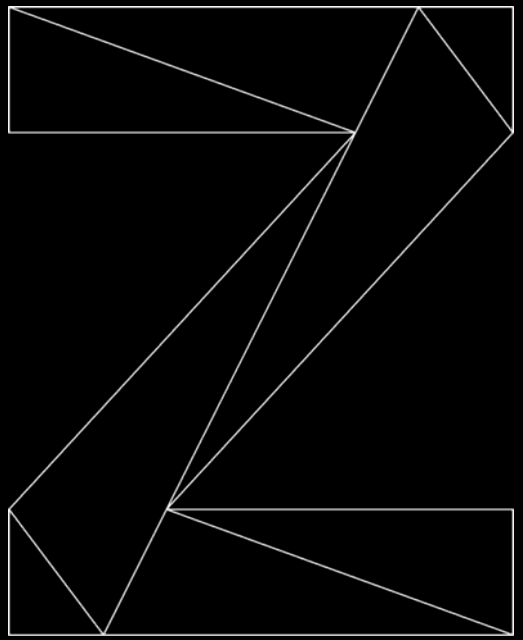
Java on IBM z15

Joran Siu – joransiu@ca.ibm.com

October 1, 2019



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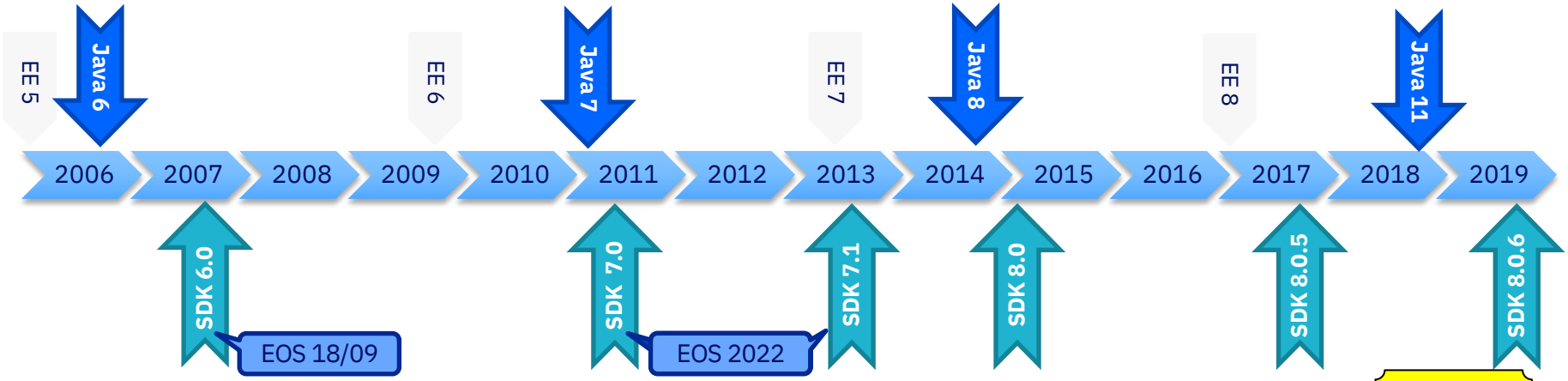
Java on IBM Z: 25+ years of innovation



IBM Java 7 SR3 + 7.1
- **zEC12™ Exploitation**
  - Transactional Execution
  - 1MB(p), 2GB large pages
  - zEDC for zip accel.
  - Runtime Instrumentation
- Improvements in
  - Performance
  - RAS, Monitoring
- Data Access Accelerator

IBM Java 8
- **z13™ Exploitation**
  - SIMD
  - SMT
  - Crypto accel.
- Improvements in
  - Performance, RAS
  - Monitoring

IBM Java 8 SR5
- **z14™ Exploitation**
  - Pause-Less GC
  - Crypto accel.
  - True Random Number Gen.
  - DAA PackedDecimal accel
- RMODE64 (z/OS V2R3)
- Improvements in
  - Performance
  - RAS

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IBM Java 8 SR6
OpenJDK 8 / 11 with OpenJ9
- **z15™ Exploitation**
  - Zip compression acceleration
  - TimSort acceleration
  - String acceleration
  - ECC crypto acceleration
- Improvements in
  - Container awareness
  - Start-up / Ramp-up performance
  - System Recovery Boost awareness

IBM z15 – Purpose Built for Mission Critical Java Applications

*Average **+20%** throughput improvement with IBM SDK for Java 8 SR6 on IBM z15*

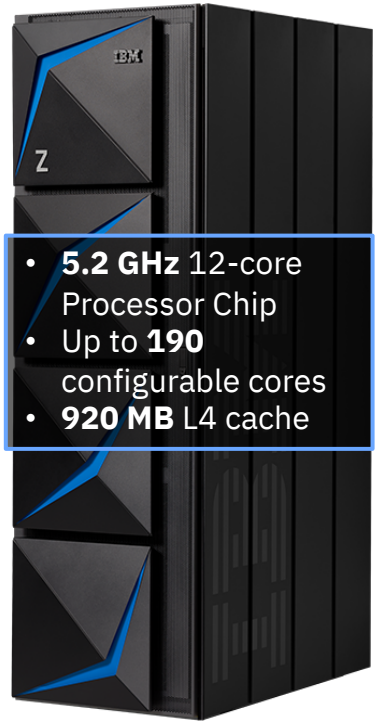
Transparent acceleration of Java's Zip APIs with on-chip Integrated Accelerator for z Enterprise Data Compression

- Up to **17x** total compression throughput capacity of a IBM z14
- Up to **15x** faster in-memory compression over zEDC Express Adapter on IBM z14
- Over **100x** faster compression over compared x86 server

Unparalleled performance of Java EE workloads on WebSphere / Liberty

- Up to **23%** better throughput over z14
- Up to **2.6x** better throughput over compared x86 server

Exploitation of 30+ new z15 instructions to accelerate TimSort, String, Data Access (DAA) and cryptographic APIs



Improved Pause-less Garbage Collection (GC) for response-time sensitive applications over default GC on z14

- Up to **3x** better throughput for constrained Service Level Agreements
- Up to **24x** better average GC pause-times

Automated JVM adaptation for changing system resource and capacity, optimized for **System Recovery Boost (zOS)** and **application containers**

- Up to **30%** better JVM startup and application ramp up
- Auto-scaling of Garbage Collection and JIT compilation threads
- Optimized memory footprint management during idle states

* Performance results shown were obtained in controlled environments. Results may vary. See approved claims for details and disclaimers.

Zip Compression Acceleration

Transparent exploitation of on-chip **Integrated Accelerator for z Enterprise Data Compression** on IBM z15. Integrated Accelerator provides up to **17x** more compression throughput than a max configured z14 with no setup required.

Java APIs accelerated:

- java/util/zip/GZIPInputStream, GZIPOutputStream
- java/util/zip/InflaterStream, DeflaterStream
- java/util/zip/Inflater, Deflater

z/OS:

- Existing IBM SDK for Java 8 will exploit z15 Integrated Accelerator transparently. Improved buffering / performance with IBM SDK Java 8 SR6.

Linux:

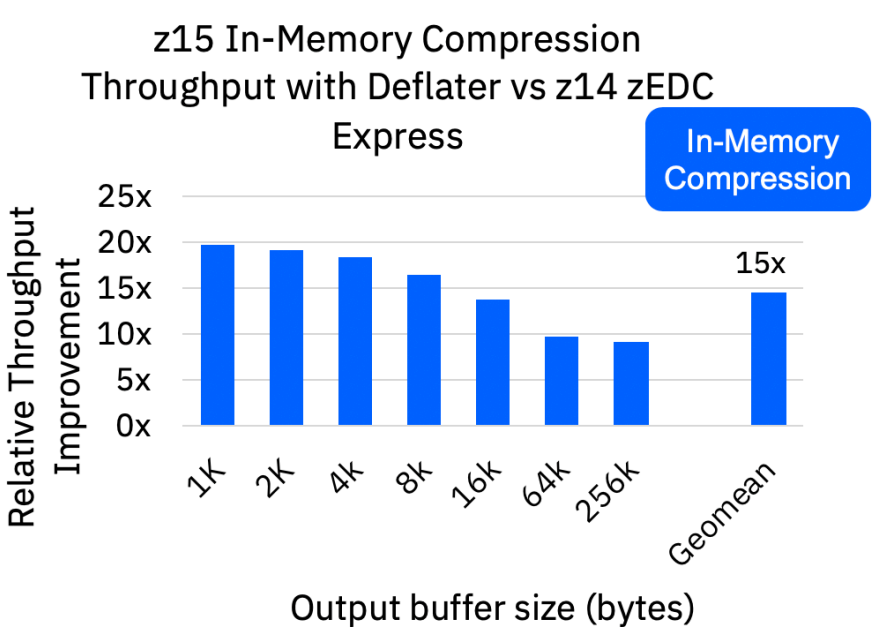
- IBM SDK for Java 8 SR6, OpenJDK 8 / 11 with OpenJ9 0.17 required to exploit Integrated Accelerator.

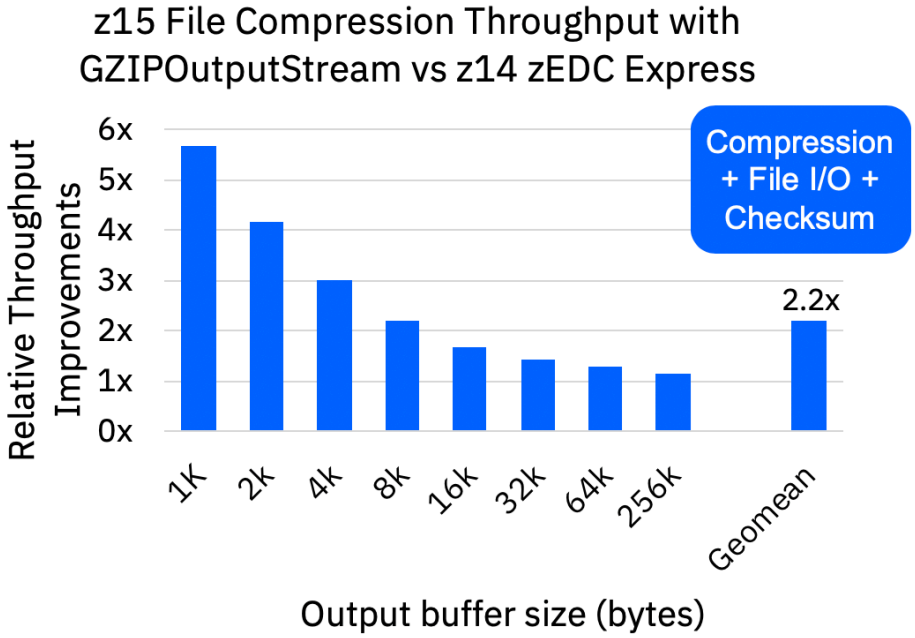
IBM Java 8 SR6 on IBM z15 *Integrated Accelerator for zEDC* provides:

- **Over 100x faster** *in-memory compression*, **over 15x faster** *file compression* throughput over software implementation
- **Up to 15x faster** *in-memory compression*, **up to 2x faster** *file compression* throughput over zEDC Express Adapters on IBM z14
- **Up to 3x faster** throughput with IBM Encryption Facility over zEDC Express on IBM z14

* Performance results shown were obtained in controlled environments. Results may vary. See approved claims for details and disclaimers.

z15 Compression Performance vs z14 zEDC Express Adapters – z/OS

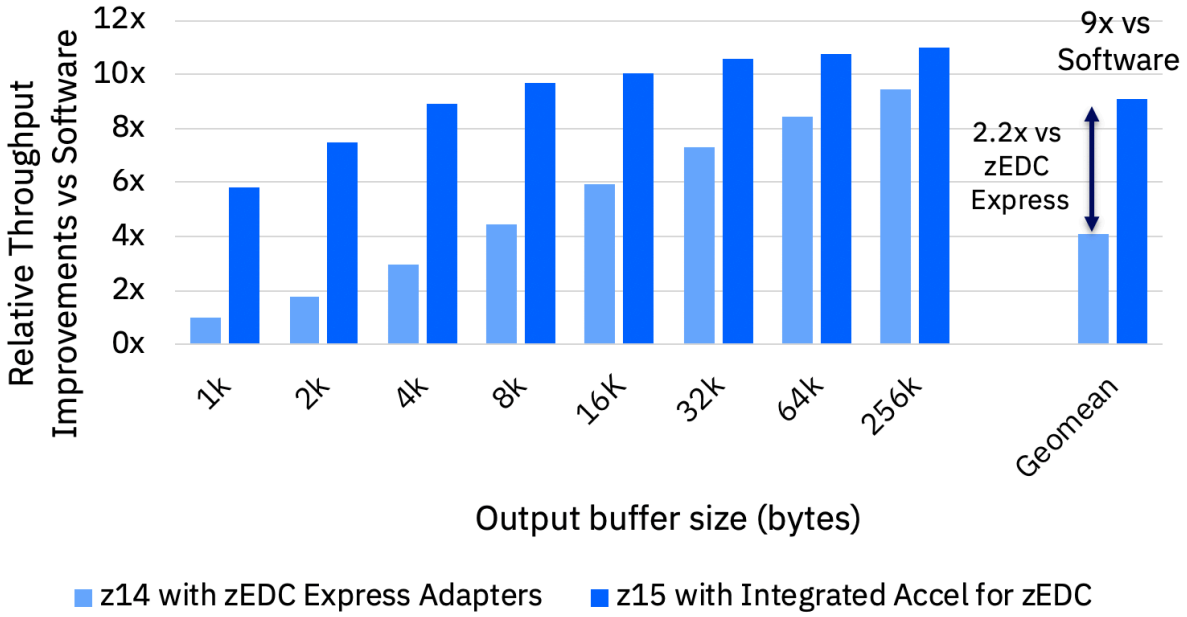




Integrated Accelerator for zEDC on IBM z15 is exploited for buffer sizes of 1024 bytes or larger.
In-Memory compression: Up to **15x** better average throughput over z14 zEDC Express Adapters
GZIP File compression: Up to **2x** better average throughput over z14 zEDC Express Adapters

DISCLAIMER: Measurements were collected in a controlled environment running an IBM developed Java application on z/OS 2.3 that used java.util.zip.Deflater class to deflate in memory text data of classical English books and java.util.zip.GZIPOutputStream class to compress a zFS file containing text data of classical English books respectively. Results may vary.

z15 File Compression Performance Comparison vs Software – z/OS

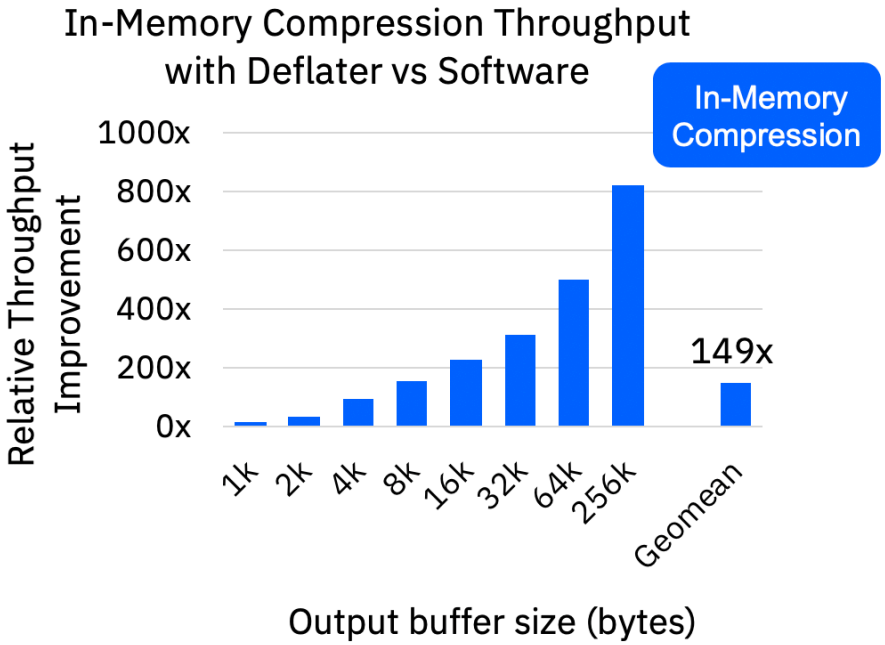


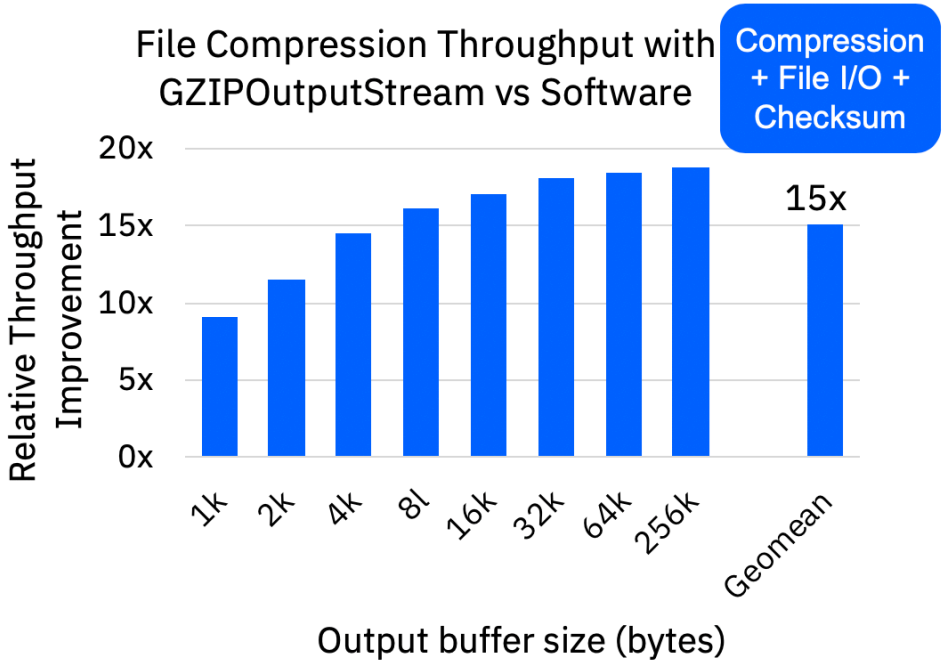
Compression of file I/O streams with CRC32 checksum:

- Integrated Accelerator for zEDC on IBM z15 is exploited for buffer sizes of 1024 bytes or larger
- Geomean of up to **9x** better elapsed time over software implementation
- Geomean of up to **2x** better elapsed time over zEDC Express adapters on IBM z14

DISCLAIMER: Measurements were collected in a controlled environment running an IBM developed Java application on z/OS 2.3 that used java.util.zip.GZIPOutputStream class to compress a zFS file containing text data of classical English books. Results may vary.

Linux on IBM z15: Compression Performance vs Software

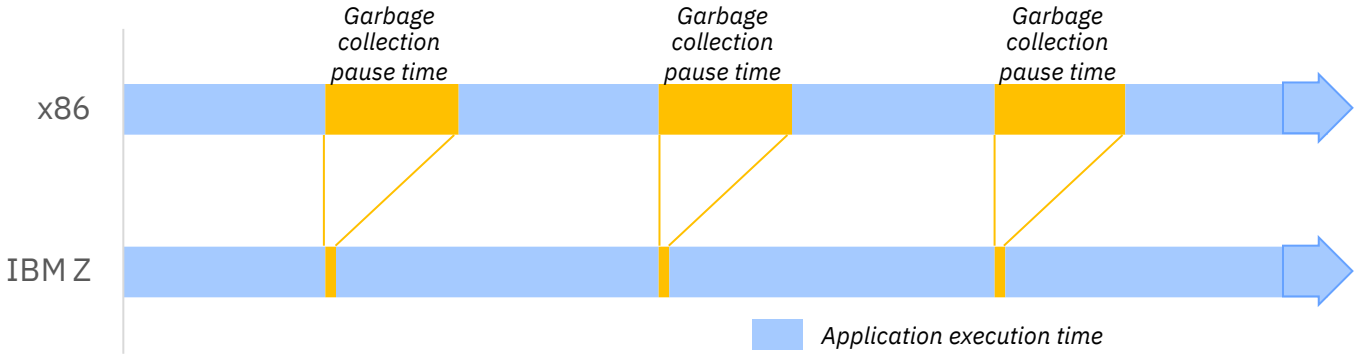




Integrated Accelerator for zEDC on **Linux on IBM z15** is exploited transparently for all buffer sizes
In-Memory compression: Over **100x** better average throughput over software implementation
GZIP File compression: Over **15x** better average throughput over software implementation

DISCLAIMER: Measurements were collected in a controlled environment running an IBM developed Java application on RHEL 7.6 that used java.util.zip.Deflater class to deflate in memory text data of classical English books and java.util.zip.GZIPOutputStream class to compress a zFS file containing text data of classical English books respectively. Results may vary.

IBM Z can improve service delivery for many Java enterprise applications



IBM Z with Guarded Storage Facility (GSF) runs Java garbage collection *virtually concurrently* with application execution…

The Java garbage collection time on IBM Z was **92% lower** versus the compared x86 server under internal test conditions

IBM Z system included 8 IFLs in one LPAR, RHEL 7.4 with Linux Guarded Storage Facility kernel patch, and Java 1.8 SR5. The x86 system (ThinkSystem SR650, 2 Socket, 16 cores total, Intel Xeon Gold 6134 CPU @ 3.20 GHz) ran with 8 cores, no hypervisor, RHEL 7.4 and Java 1.8 SR5. Tests used a Java ecommerce application that demonstrated average garbage collection pause times of approximately 300 ms. when running without pause-less garbage collection enabled. Data was then collected again when pause-less garbage collection support was enabled on IBM Z. The response time SLA requirement was that 99% of responses had to be received within 25 milliseconds. The throughput rates were 23,551 tps on the Intel server and 22,889 tps on IBM Z.

z14/z15: Pause-less Garbage Collection
Java Store Inventory and Point of Sale Application

Java GC-tuning made easier

High scavenge pause times made this application a candidate for Pause-less GC

- Up to **3x** better throughput for **response-time** constrained Service Level Agreements (SLAs)
- Up to **24x** better average GC pause-times

Pause time

Variant	Mean	Minimum	Maximum	Total
	time (seconds)	time (seconds)	time (seconds)	time (seconds)
E81202J1.VERBGC.TXT	0.24	0.22	0.3	185
E90715J1.VERBGC.TXT (2)	0.01	0.0	0.05	17.8

IBM Monitoring and Diagnostic Tools - Garbage Collection and Memory Visualizer

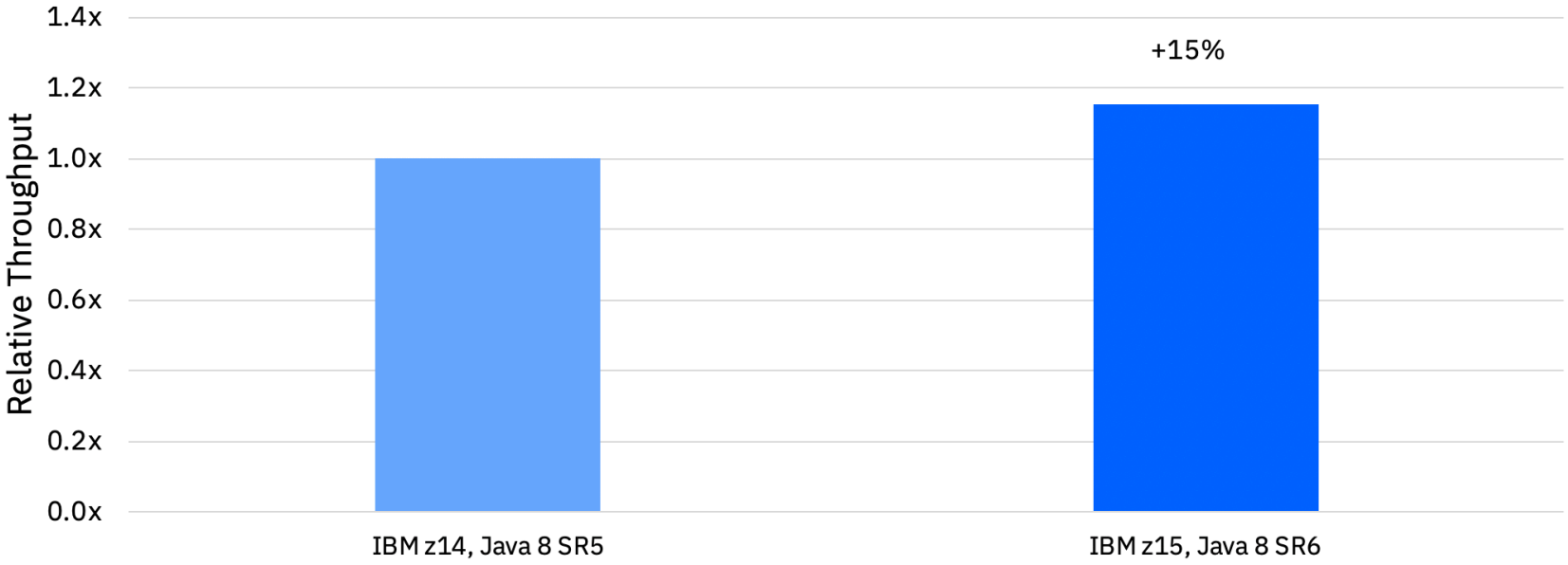
Enable Pause-less GC with:

- IBM Java 8 SR5 or newer
- IBM z14 or z15
- z/OS 2.3 or z/OS 2.2 with APAR OA51643
- RHEL 7.5 (4.14 kernel-alt) or newer, SUSE Linux 12, Ubuntu 18.04
- z/VM 6.4 + PTF65987

JVM option: **-Xgc:concurrentScavenge**

(Controlled measurement environment, results may vary)

Application Serving – Liberty DayTrader 3 - SSL (Clear Key) – z/OS

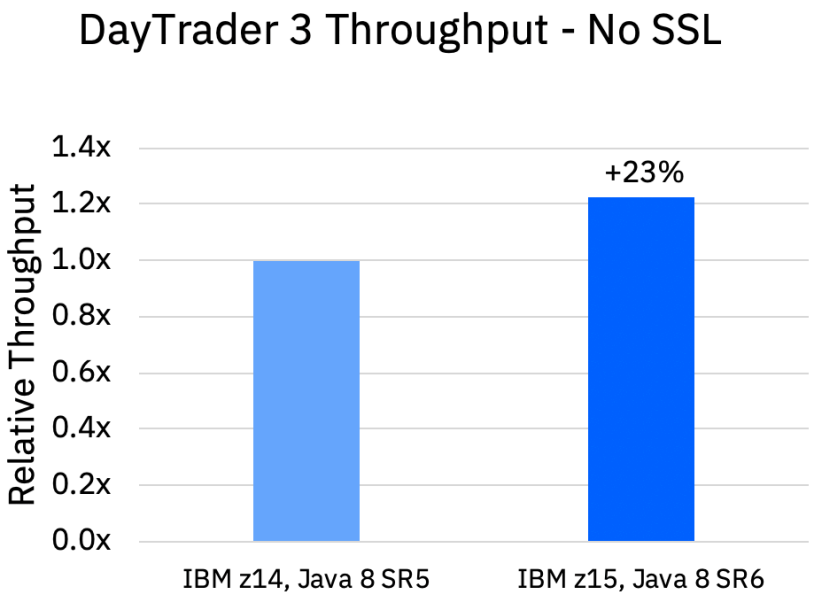


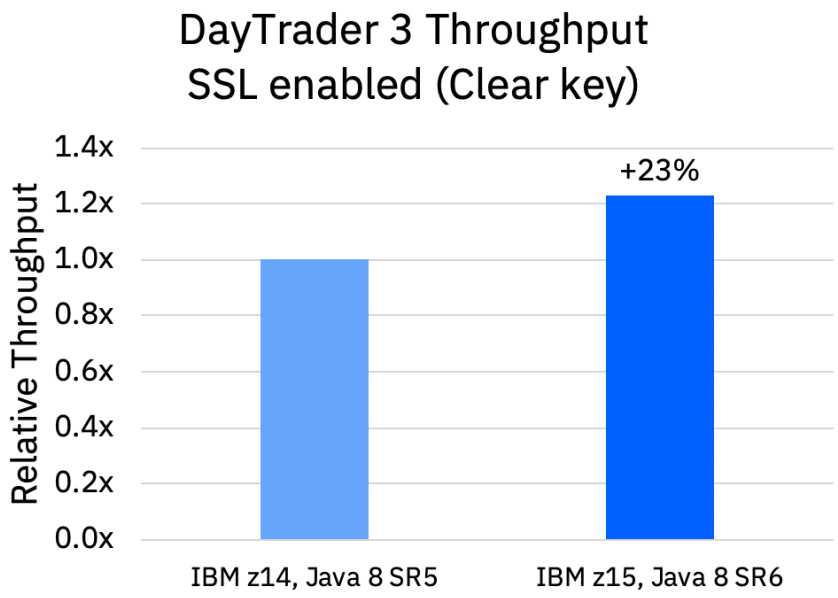
IBM z15 + Java 8 SR6 up to **15%** better throughput / core over IBM z14 + Java 8 SR5.

IBM Liberty 18.0.0.4 with DayTrader 3 using:
TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
IBM SDK for Java 8.0.6.0 on IBM z15 vs IBM SDK for Java 8.0.5.31 on IBM z14

(Controlled measurement environment, results may vary)

Application Serving – Liberty DayTrader 3 - Linux on Z



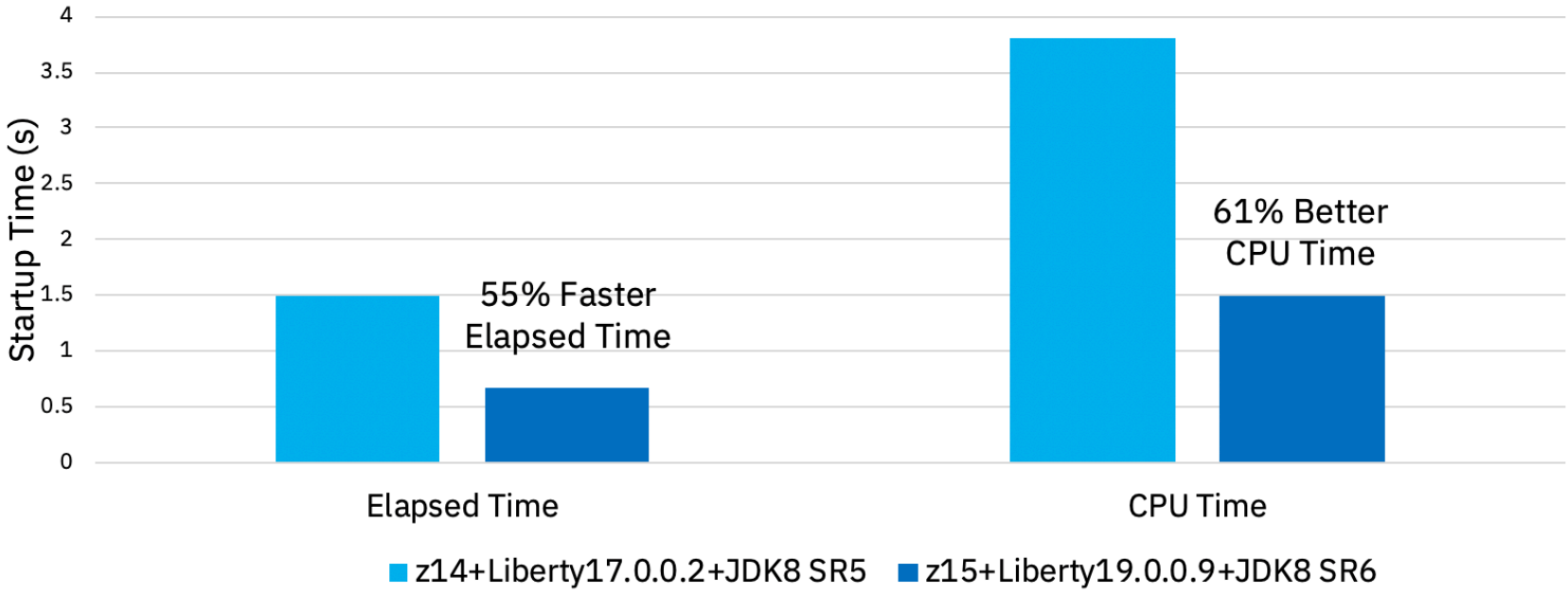


IBM z15 + Java 8 SR6 up to **23%** better throughput / core over IBM z14 + Java 8 SR5.

IBM Liberty 18.0.0.4 with DayTrader 3
IBM SDK for Java 8.0.6.0 on IBM z15 vs IBM SDK for Java 8.0.5.31 on IBM z14

(Controlled measurement environment, results may vary)

Liberty Startup Time - Linux on Z on IBM z15 vs z14

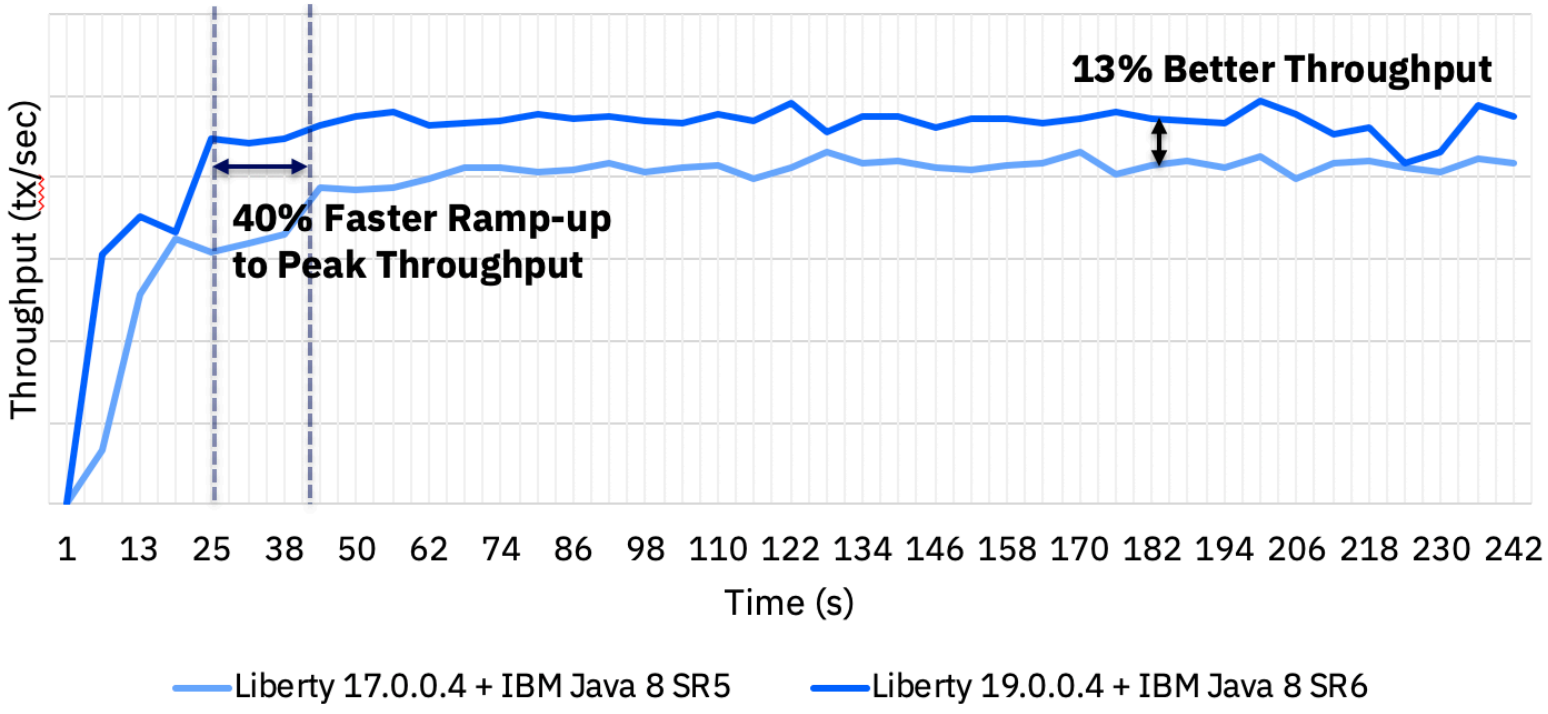


Smaller is better

IBM Liberty 17.0.0.2 with IBM SDK for Java 8.0.5.0 on IBM z14
IBM Liberty 19.0.0.9 with IBM SDK for Java 8.0.6.0 on IBM z15

(Controlled measurement environment, results may vary)

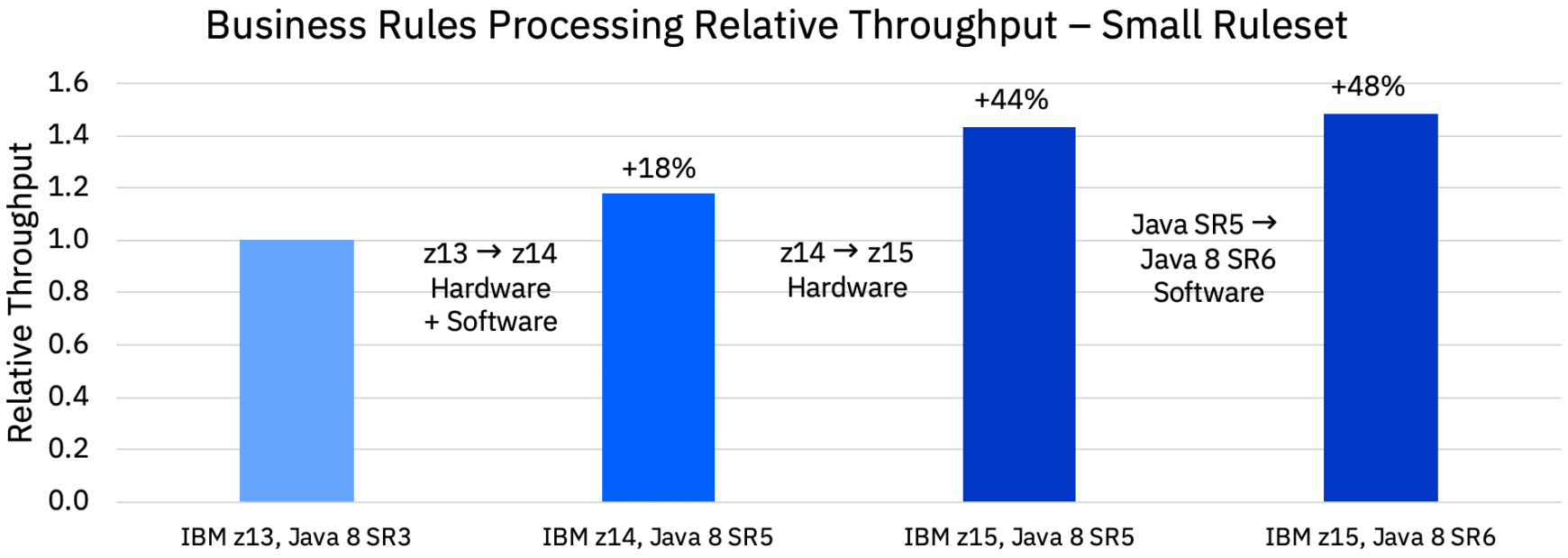
Liberty DayTrader Improvements – Linux on Z



IBM Liberty 17.0.0.4 with IBM SDK for Java 8.0.5.0 on IBM z13 running DayTrader 7
IBM Liberty 19.0.0.4 with IBM SDK for Java 8.0.6.0 on IBM z13 running DayTrader 7

(Controlled measurement environment, results may vary)

Business Rules Processing – zOS

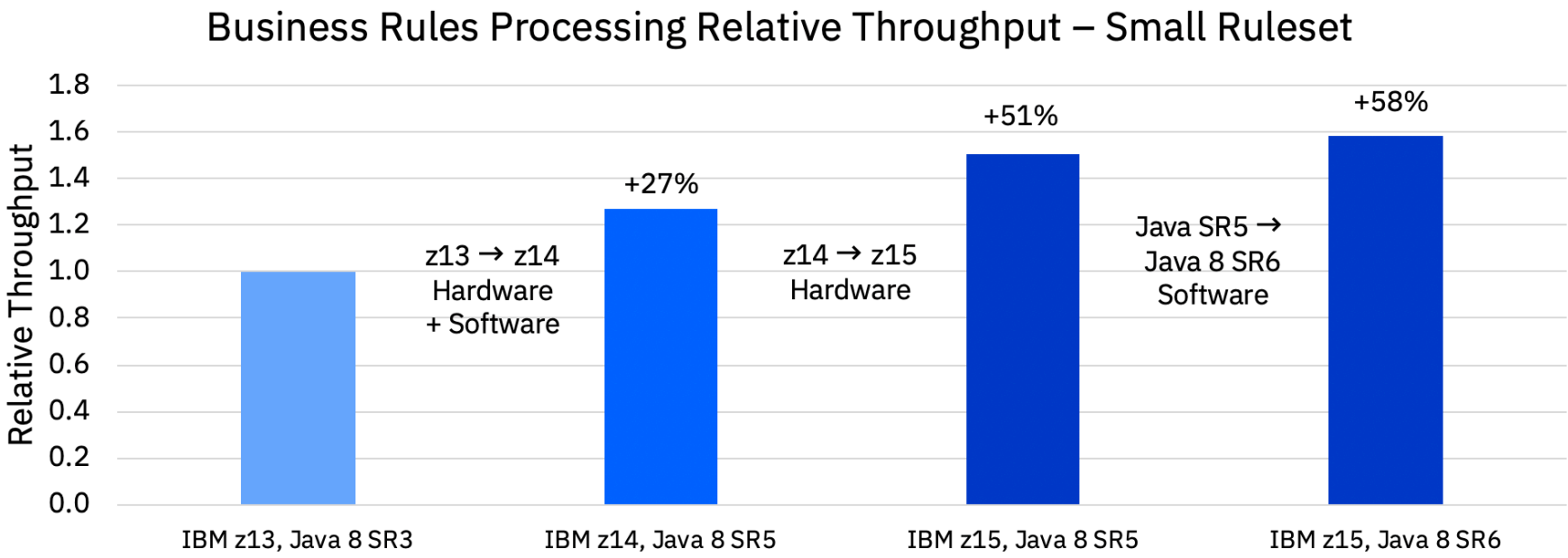


Java 8 SR6 + IBM z15 up to **26%** better throughput / core processing business rules over IBM z14, **48%** over IBM z13.

IBM Operational Decision Manager (ODM) 8.10.0.0 – 5 Ruleset
IBM SDK for Java 8.0.3.0 on IBM z13, 8.0.5.25 on IBM z14 / z15, 8.0.6.0 on IBM z15

(Controlled measurement environment, results may vary)

Business Rules Processing – Linux on Z



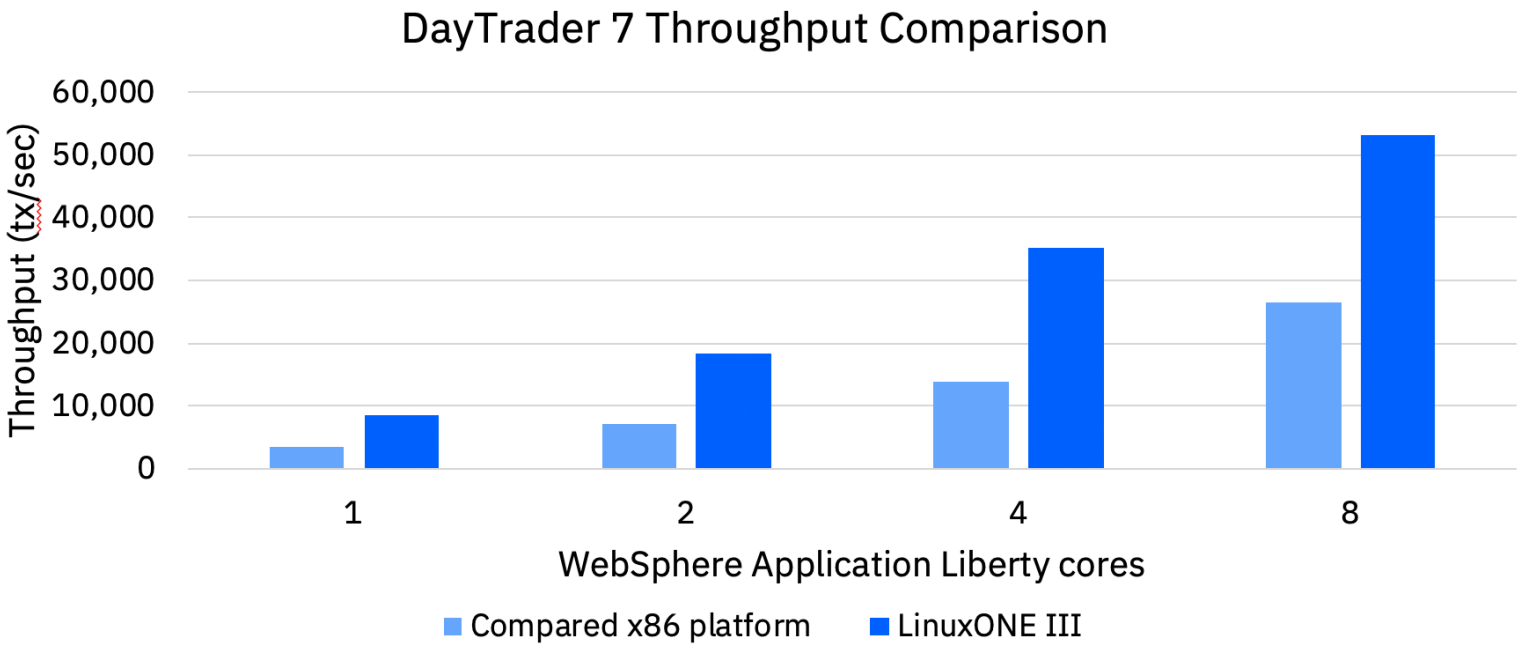
Java 8 SR6 + IBM z15 up to **25%** better throughput / core processing business rules over IBM z14, **58%** over IBM z13.

IBM Operational Decision Manager (ODM) 8.10.0.0 – 5 Ruleset
IBM SDK for Java 8.0.3.0 on IBM z13, 8.0.5.25 on IBM z14 / z15, 8.0.6.0 on IBM z15

(Controlled measurement environment, results may vary)

LinuxONE III vs x86 Skylake Performance

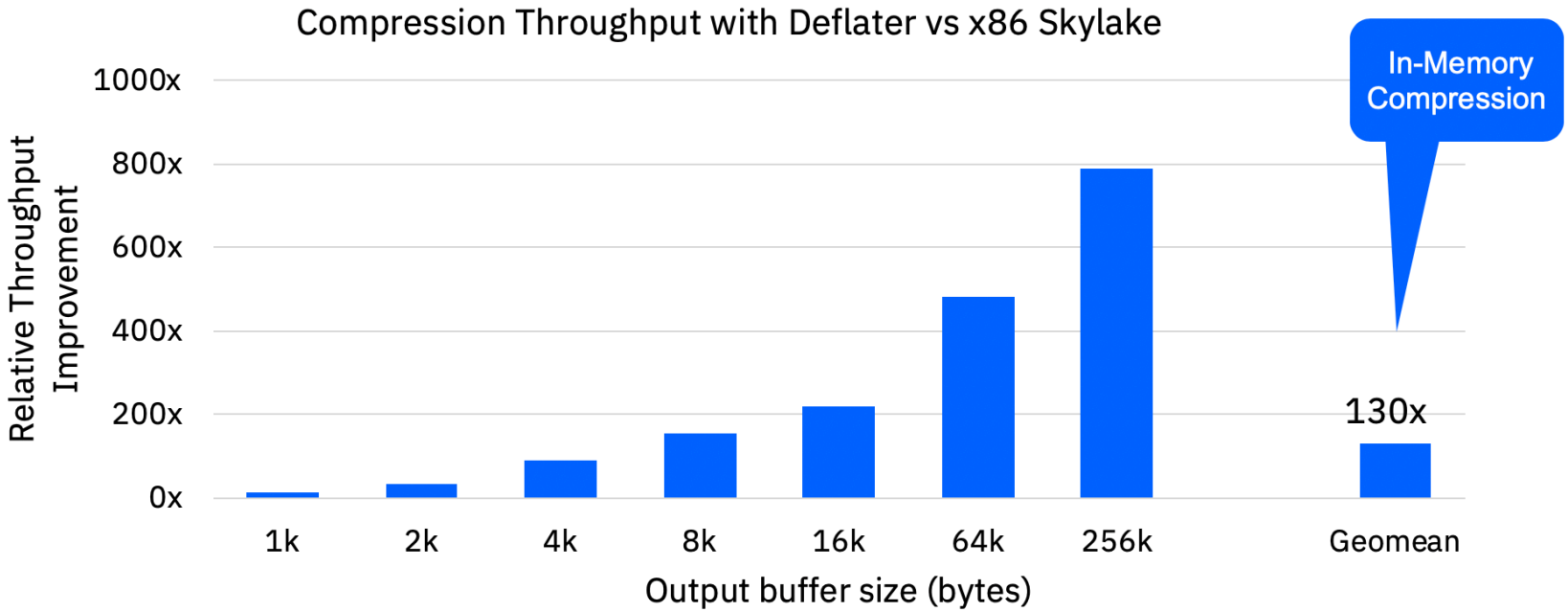
WebSphere Application Server Liberty Performance: LinuxONE III vs x86 Skylake



WebSphere Application Server Liberty 19.0.0.3 delivers up to **2.6x more throughput** on a **IBM LinuxONE III** versus a x86 Skylake

DISCLAIMER: Performance results based on IBM internal tests running DayTrader 7 web application benchmark on WebSphere Application Server Liberty (WAS Liberty) 19.0.0.3 with IBM Java 8.0.5.36 (SR5 FP36). Database Db2 LUW 11.1.1.4 located on the same system was used to persist application data. Database size was 4 GB. Results may vary.

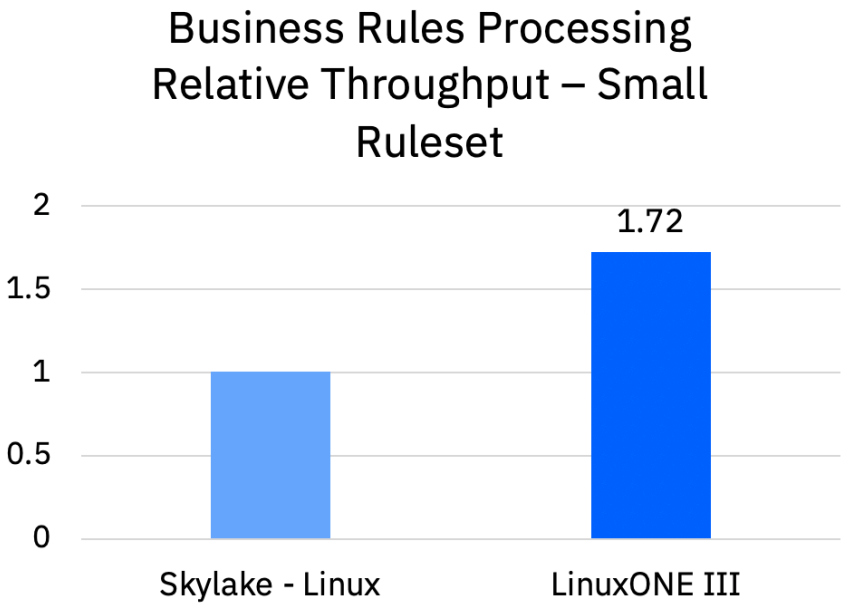
Compression Performance - IBM LinuxONE III vs x86 Skylake

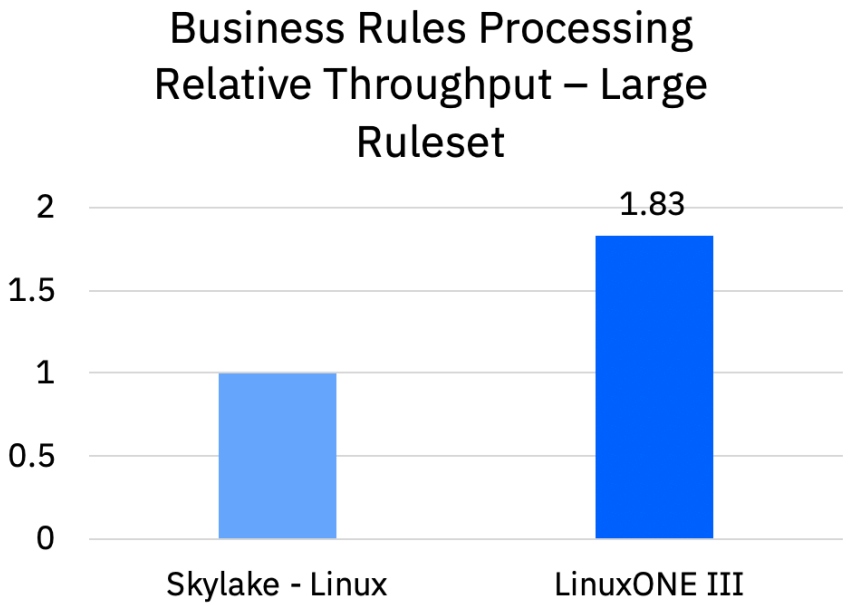


IBM LinuxONE III with Integrated Accelerator for zEDC delivers over **100x** better average throughput over x86 Skylake.

DISCLAIMER: Performance results based on geometric mean of single threaded Java application runs using java.util.zip.Deflater class compressing classical literature text books in memory using various buffers sizes on LinuxONE III RHEL 7.6 alternate Kernel 4.14 versus Skylake Intel(R) Xeon(R) Gold CPU @ 2.60GHz Ubuntu 18.04 kernel 4.15.

Business Rules Processing – IBM LinuxONE III vs x86 Skylake



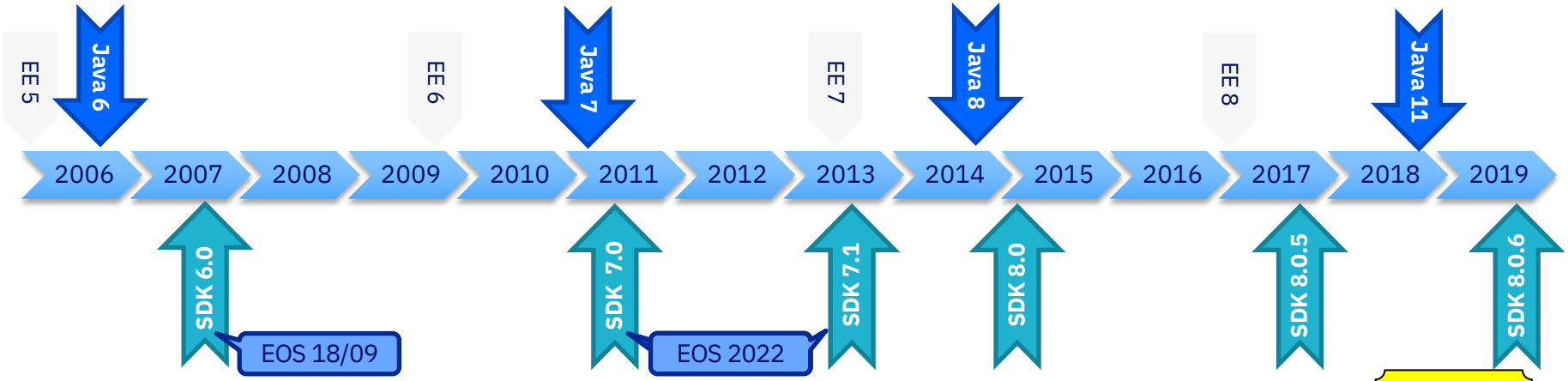


IBM LinuxONE III up to **1.7x** better throughput / core processing business rules than x86 Skylake

DISCLAIMER: Performance results based on geometric mean of multiple runs of IBM Operational Decision Manager (ODM) 8.10.0 with rulesets F_JAVAXOM_Segmentation5_DE and F_JAVAXOM_Segmentation300RulesSingleTask_DE with IBM Java 8 SR6. Runs were performed on LinuxONE III RHEL 7.6 alternate Kernel 4.14 with 8 cores SMT 2 versus Skylake Intel(R) Xeon(R) Gold CPU @ 2.60GHz Ubuntu 18.04 kernel 4.15 pinned on 8 cores SMT2 with same number of logical processors and software configuration.

Java Roadmap & Support

Java on IBM Z: 25+ years of innovation



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4Q2019

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  - TimSort acceleration
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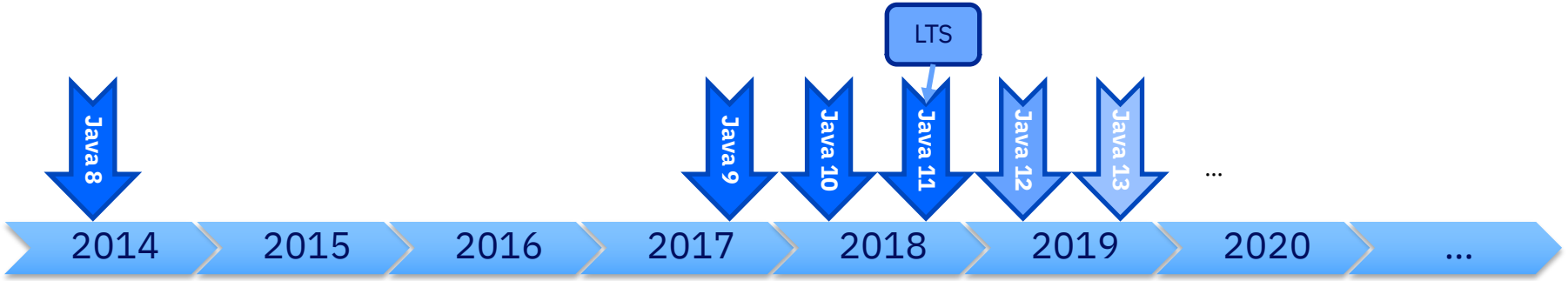
  - Container awareness
  - Start-up / Ramp-up performance
  - System Recovery Boost awareness

Community Java Road Map



- New release every 6 months:
  - Feature releases supported for 6 months (Java 12, Java 13).
  - LTS releases every 3 years (Java 11, 17,..)
- IBM is committed to supporting LTS releases – Java 8, Java 11
  - LTS recommended for enterprise / production Java workload
- Important license changes announced by Oracle
  - OracleJDK will no longer be provided for free for commercial use

Eclipse OpenJ9 – High Performance JVM built for Cloud Native Applications

- **IBM's J9 Java VM that powers IBM JDK is open-sourced…**

```
bool TR_S390RelocationTarget::useTrampoline(uint8_t *
   {
#if defined(TR_HOST_S390) && defined(TR_TARGET_64BIT)
   return !CHECK_32BIT_TRAMPOLINE_RANGE((intptr_t)h
#else
   TR::Compilation* comp = TR::comp();
   if (comp->getOption(TR_EnableRMODE
      return !CHECK_32BIT_TRAMPOLINE_RANGE((intptr_t)
   else
      return false;
#endif
```

20+ years, 4.3M LOC

OpenJ9

http://www.eclipse.org/openj9/

OpenJ9 consumes OMR

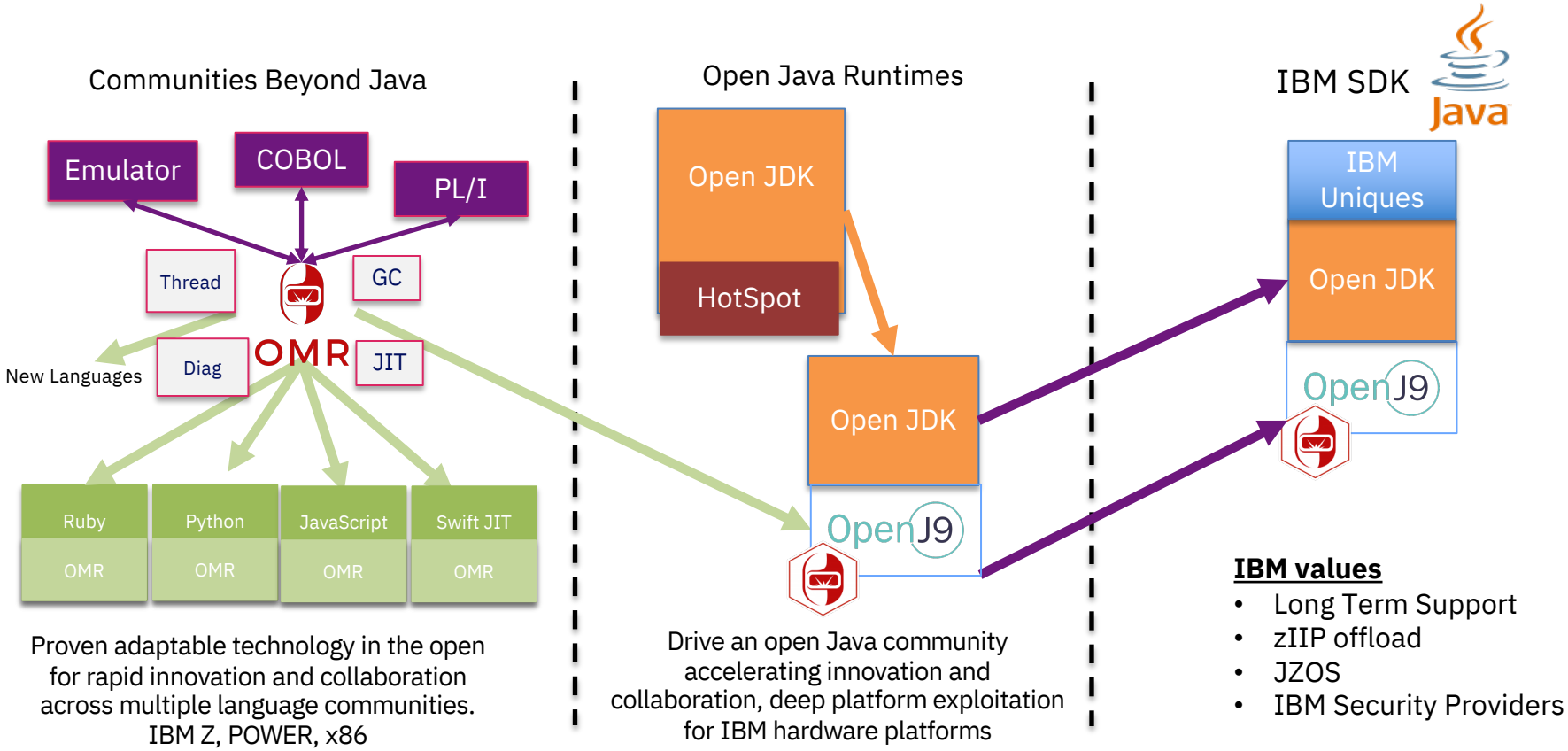
Deep Z Opts

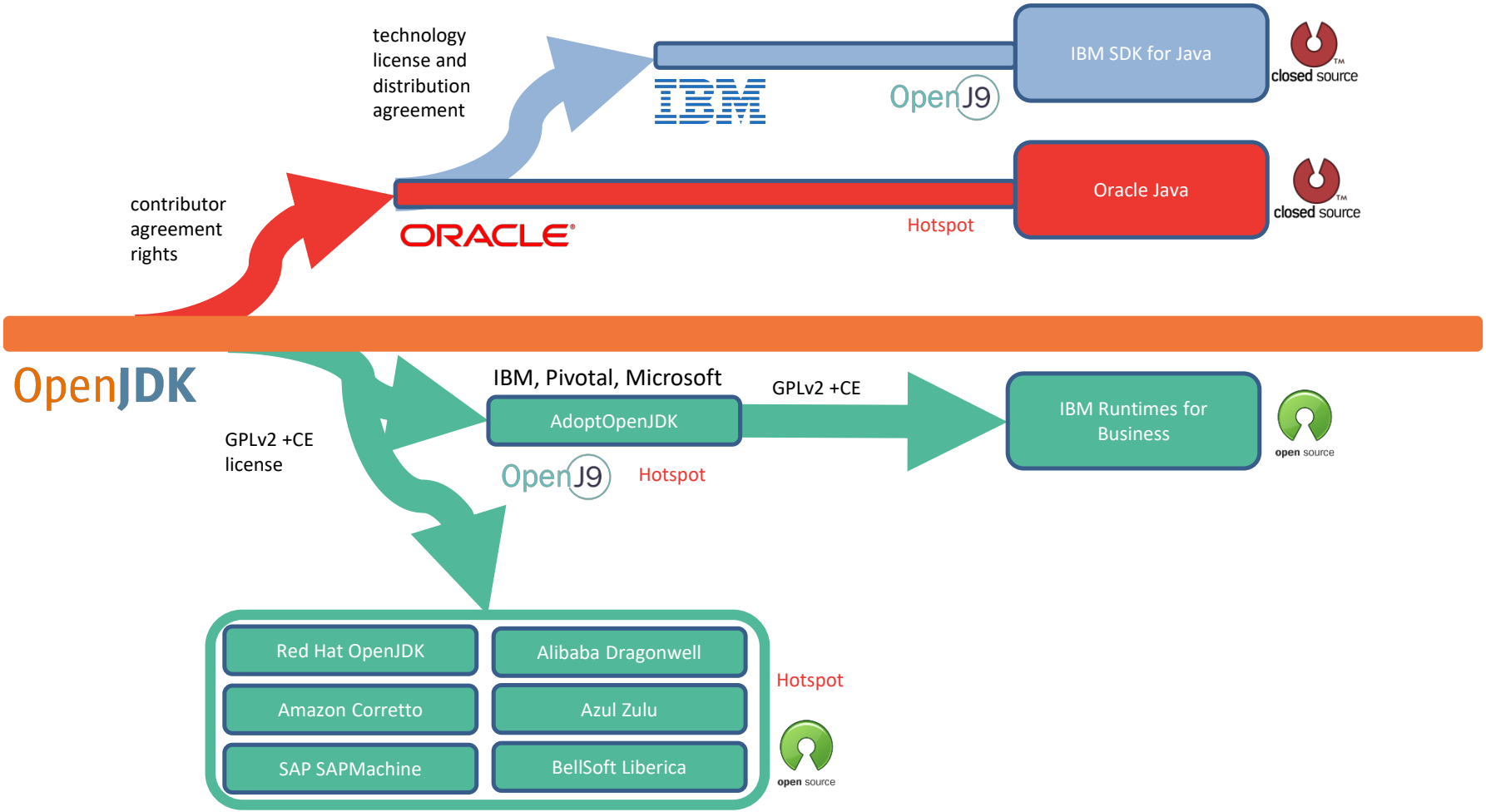
https://www.eclipse.org/omr/

OMR

Open source projects at Eclipse Foundation

Eclipse OMR, Eclipse OpenJ9: Open Source Runtime Innovation




technology
license and
distribution
agreement
IBM SDK for Java
closed source
IBM
OpenJ9
contributor
agreement
rights
Oracle Java
closed source
ORACLE
Hotspot
OpenJDK
IBM, Pivotal, Microsoft
GPLv2 +CE
AdoptOpenJDK
IBM Runtimes for
Business
open source
GPLv2 +CE
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OpenJ9
Hotspot
Red Hat OpenJDK
Alibaba Dragonwell
Amazon Corretto
Azul Zulu
SAP SAPMachine
BellSoft Liberica
Hotspot
open source

Linux on Z - Java Availability and Support

The following table summarizes the availability and support available for Java Runtimes on IBM Linux on z and LinuxONE, for both the current Long Term Support (LTS) releases and the latest current feature releases.

Java JDK	Java 8 (LTS)	Java 11 (LTS)	Java Current	Availability and Support
IBM SDK for Java	✓			• Via Linux Distributions
OpenJDK with OpenJ9 JVM	✓	✓	✓	• Free downloads at AdoptOpenJDK • Paid S&S for LTS Releases via IBM Runtimes for Business
OpenJDK with HotSpot JVM	No JIT - Not Recommended	✓	✓	

OpenJDKs binaries and docker containers with both the OpenJ9 and HotSpot JVM are available via the **AdoptOpenJDK** community: https://adoptopenjdk.net/releases.html#s390x_linux

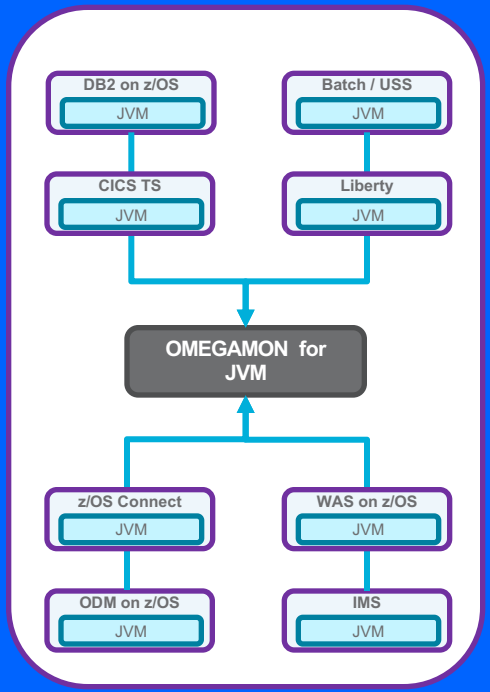
OMEGAMON for JVM on z/OS

Reduce Blind Spots by Monitoring Java Runtimes on z/OS

IBM OMEGAMON for JVM on z/OS V5.4.0 provides resource level monitoring of *all* Java Virtual Machines (JVMs) on z/OS

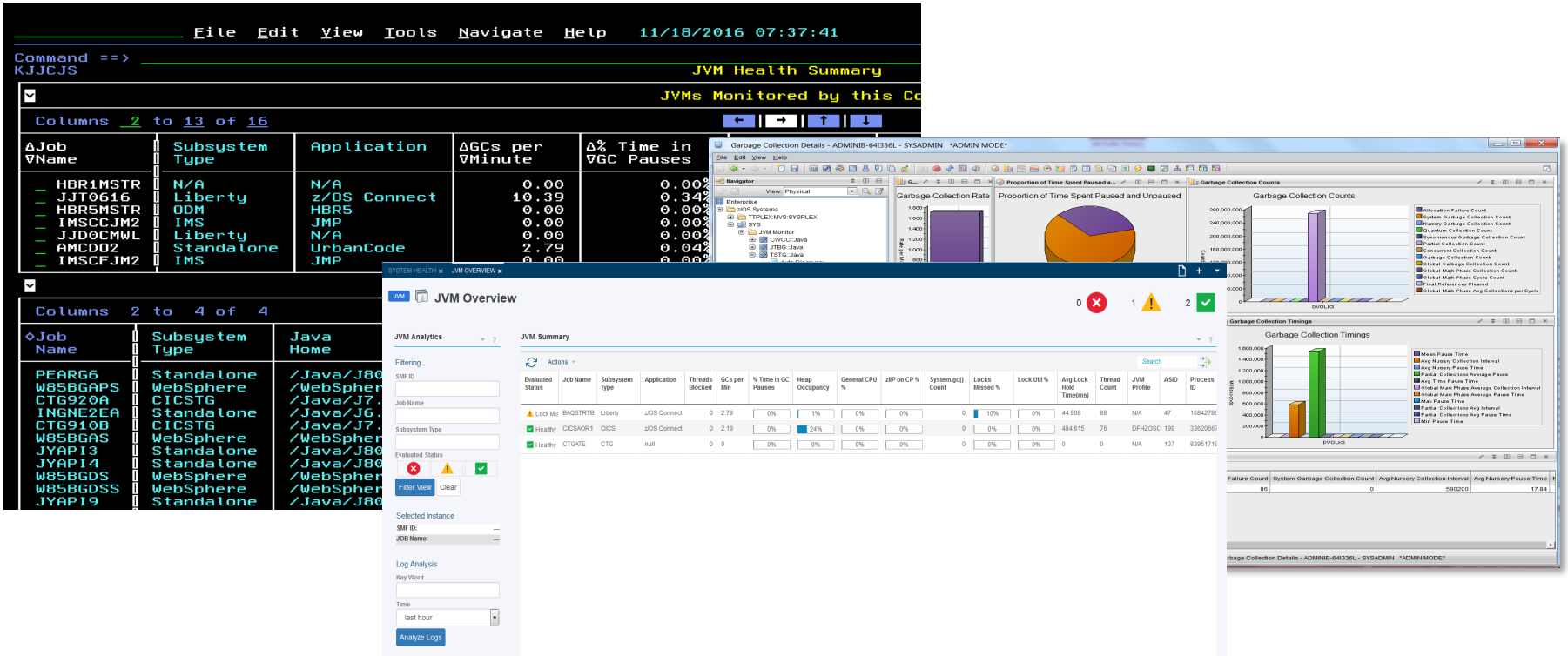
- **Auto-discover** all online JVMs within seconds, including subsystem type
- **Lightweight overhead** in collection of data on ***any* online JVM on z/OS**
- Enable users to be **alerted to problems** within JVM performance, **isolate the issue**, and **identify the root cause** quickly
- Identify **problematic thread and locking issues**, sub-optimal JVM **garbage collection performance**, native memory analysis, looping thread and **CPU performance issues** plus drill-downs into detailed JVM environment information.
- Ability to **view all JVMs side-by-side**. No disconnect when switching between JVMs
- Resource level monitoring of **z/OS Connect Enterprise Edition** to manage services and APIs allowing alerting to poor service response time faster

www.ibm.com/omegamon



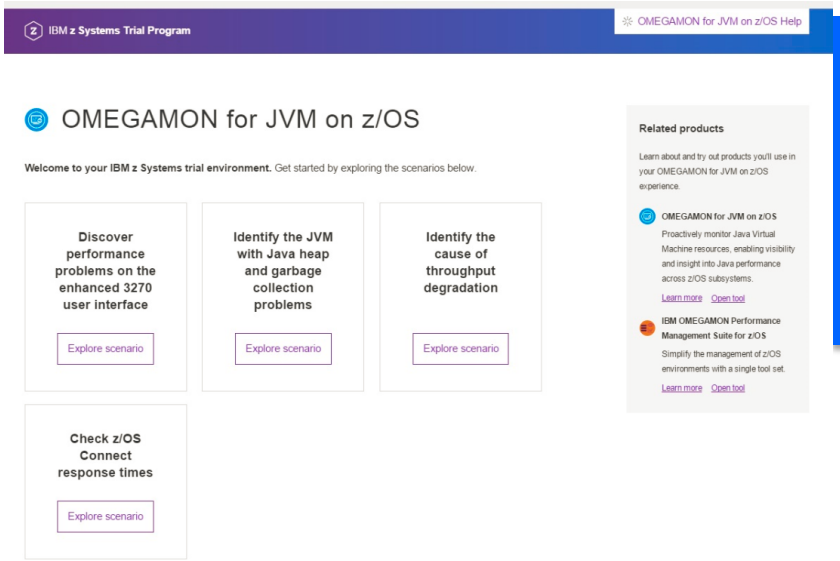
OMEGAMON for JVM on z/OS

User Interfaces for the Appropriate User Role



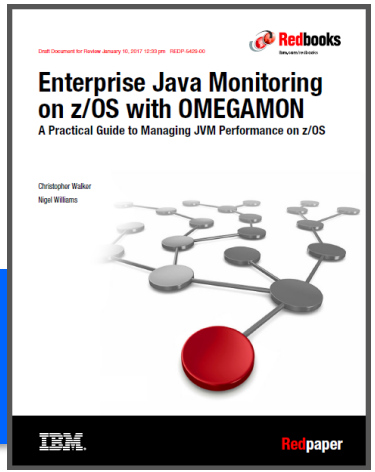
OMEGAMON for JVM on z/OS

Try for Free Today with IBM Z Trial Program



No charge, on-demand environment with tutorials for monitoring Java resources and z/OS Connect EE with OMEGAMON for JVM

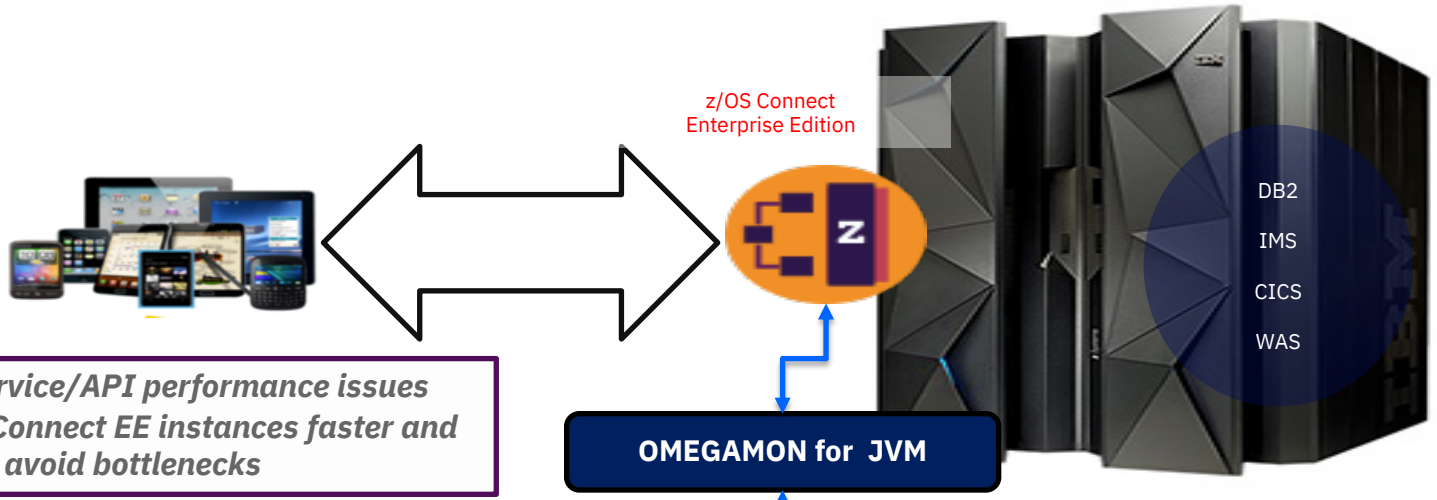
http://ibm.biz/ibmztrial



Learn more about Java monitoring on z/OS with OMEGAMON with this Redpaper "Enterprise Java Monitoring on z/OS with OMEGAMON"
http://ibm.biz/omegJVMRedpaper

OMEGAMON for JVM on z/OS

z/OS Connect EE Resource Monitoring with OMEGAMON for JVM V5.4.0



Identify Service/API performance issues within z/OS Connect EE instances faster and avoid bottlenecks

KJJZOSS — z/OS Connect Request Summary

Jobname: JJD0BGBQ JVM Pid: 16908613

Columns 2 to 8 of 9

Service Name	ΔRequest ∇Count	ΔAvg Response ∇Time	ΔMax Response ∇Time	ΔMin Response ∇Time	Avg Res Length
zOSConnectServices	0	0.00000s	0.00000s	0.00000s	
inquireSingle	1	.004163s	.004163s	.004163s	
SleepTest	596	.000188s	.012465s	.000043s	