Performance Update

Dr. Stefan Reimbold
10. Juni 2021

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Notes:

Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput 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, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.
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Agenda

- Performance Work
- Integrated Accelerator for zEDC
- Elasticsearch
- Red Hat OpenShift on IBM Z

Performance Work

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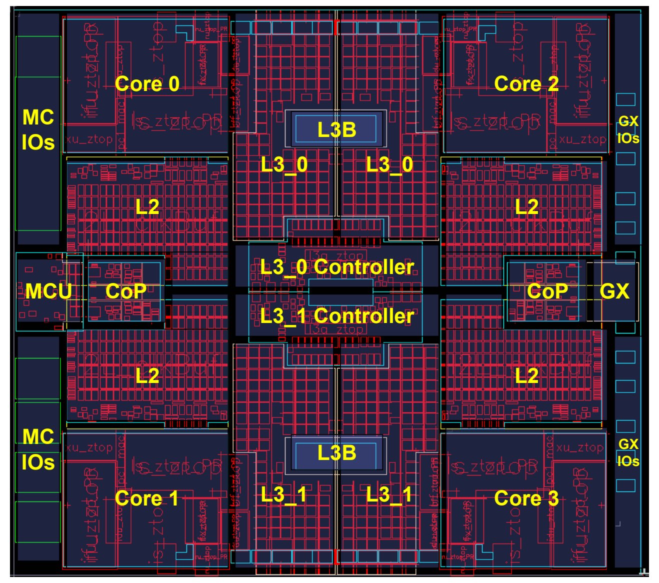
IBM Z - Processor Roadmap

45 nm

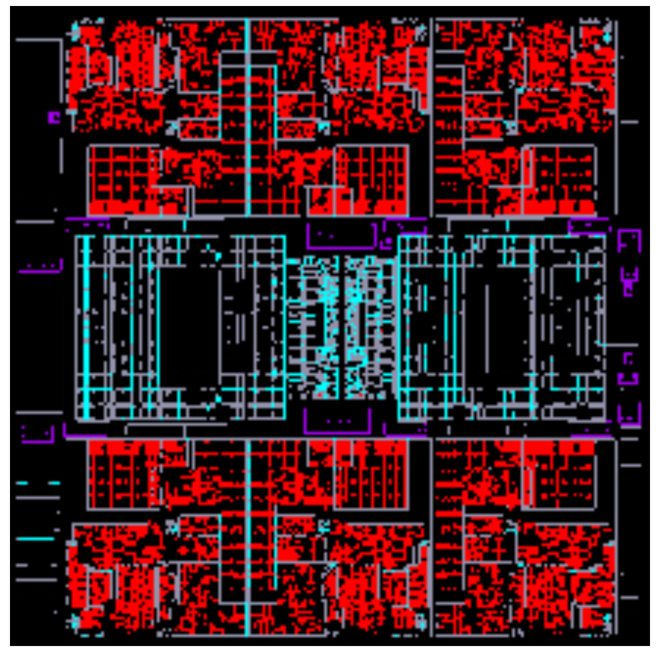
z196
9/2010



Top Tier Single Thread Performance,System Capacity
Accelerator Integration
Out of Order Execution
Water Cooling
PCIe I/O Fabric
RAIM
Enhanced Energy Management

32 nm

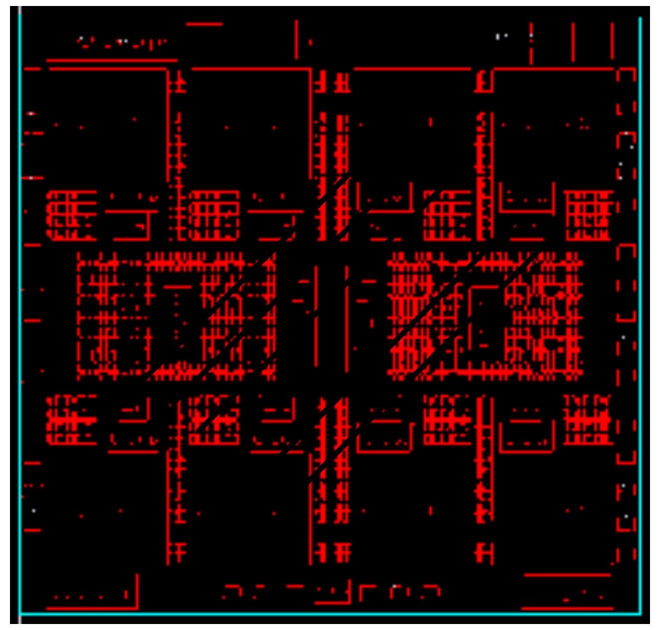
zEC12
8/2012



Leadership Single Thread, Enhanced Throughput
Improved out-of-order
Transactional Memory
Dynamic Optimization
2 GB page support
Step Function in System Capacity

22 nm

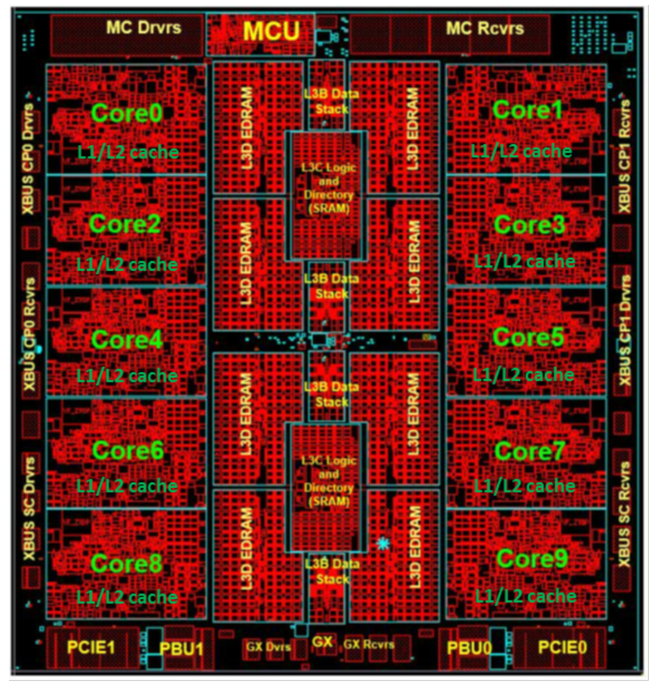
z13
1/2015



Leadership System Capacity and Performance
Modularity & Scalability
Dynamic SMT
Supports two instruction threads
SIMD
PCIe attached accelerators
Business Analytics Optimized

14 nm

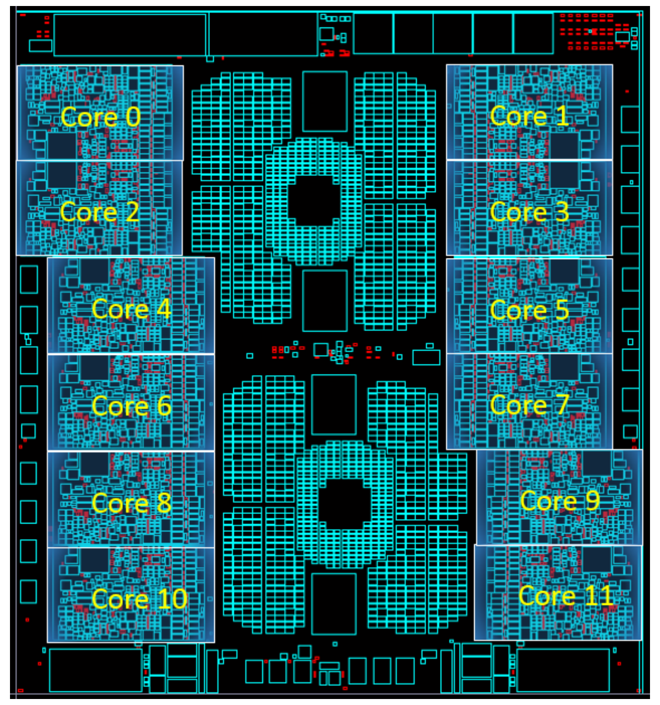
z14
7/2017



Pervasive encryption
Low latency I/O for acceleration of transaction processing for DB2 on z/OS
Pause-less garbage collection for enterprise scale JAVA applications
New SIMD instructions
Optimized pipeline and enhanced SMT
Virtual Flash Memory

14 nm

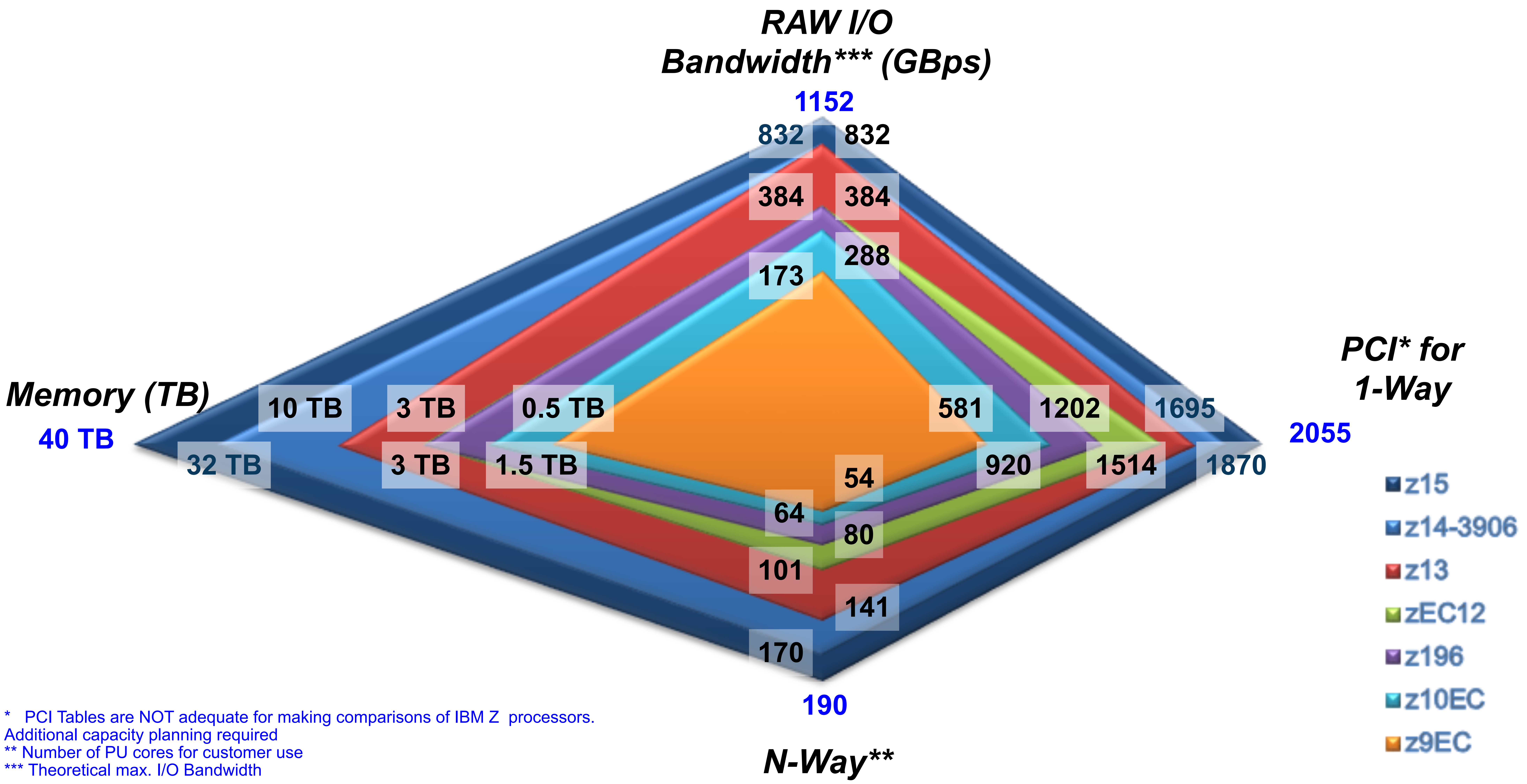
z15
9/2019



Focus on power efficiency and new on-chip architectures
Improved and enlarged caches
Optimized Out-of-Order architecture
Binary Floating point enhancements
IBM Integrated Accelerator for zEDC (On-chip compression support (DEFLATE))
Enhanced Cryptographic Coprocessor (CPACF)

z15

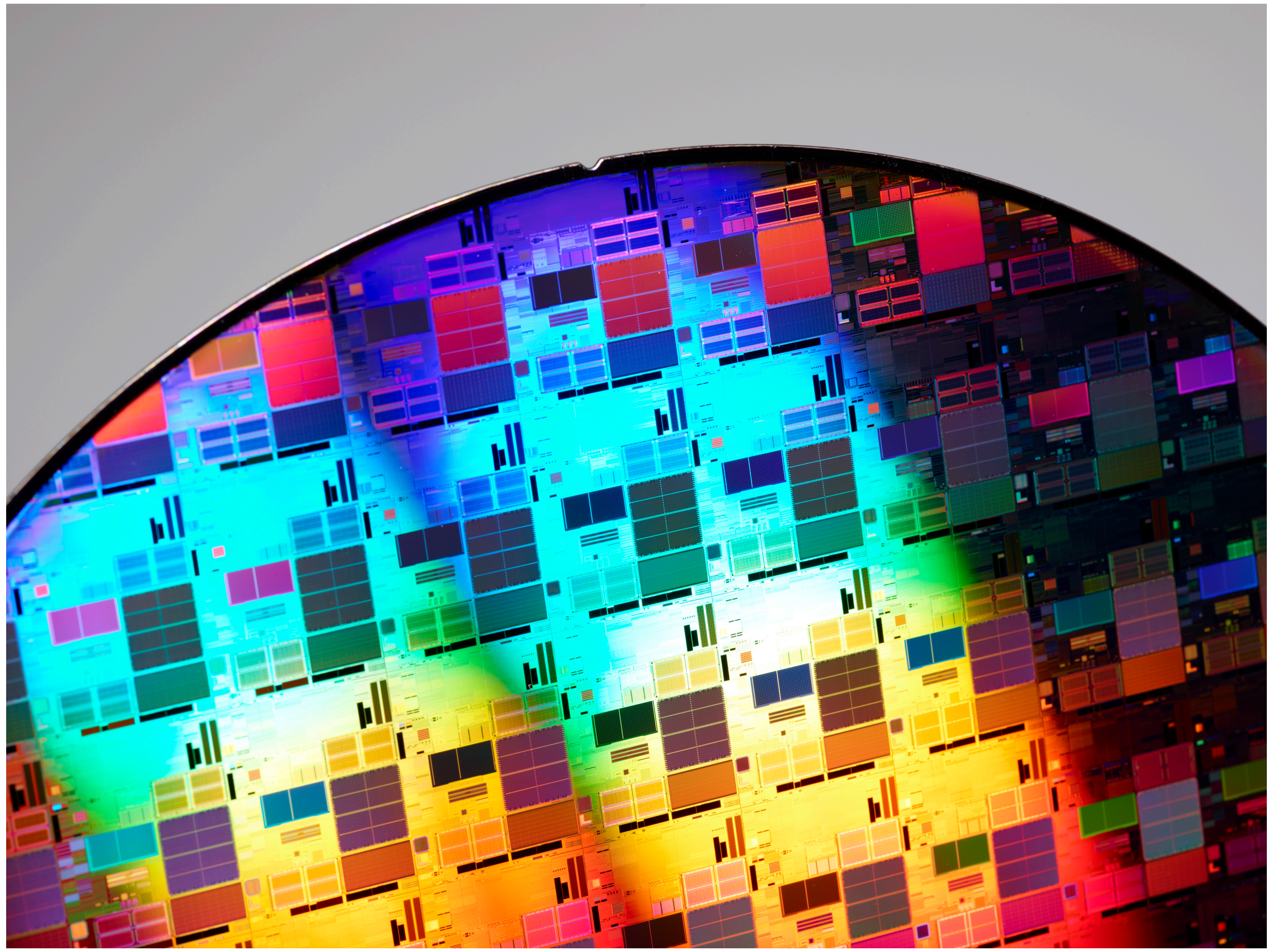
Balanced System Design



* PCI Tables are NOT adequate for making comparisons of IBM Z processors. Additional capacity planning required
** Number of PU cores for customer use
*** Theoretical max. I/O Bandwidth

Performance Work

- Simulation
- Early bring-up
- Competitive analysis
- Tuning Hints & Tips
- Customer scenarios on OS level



Integrated Accelerator for zEDC

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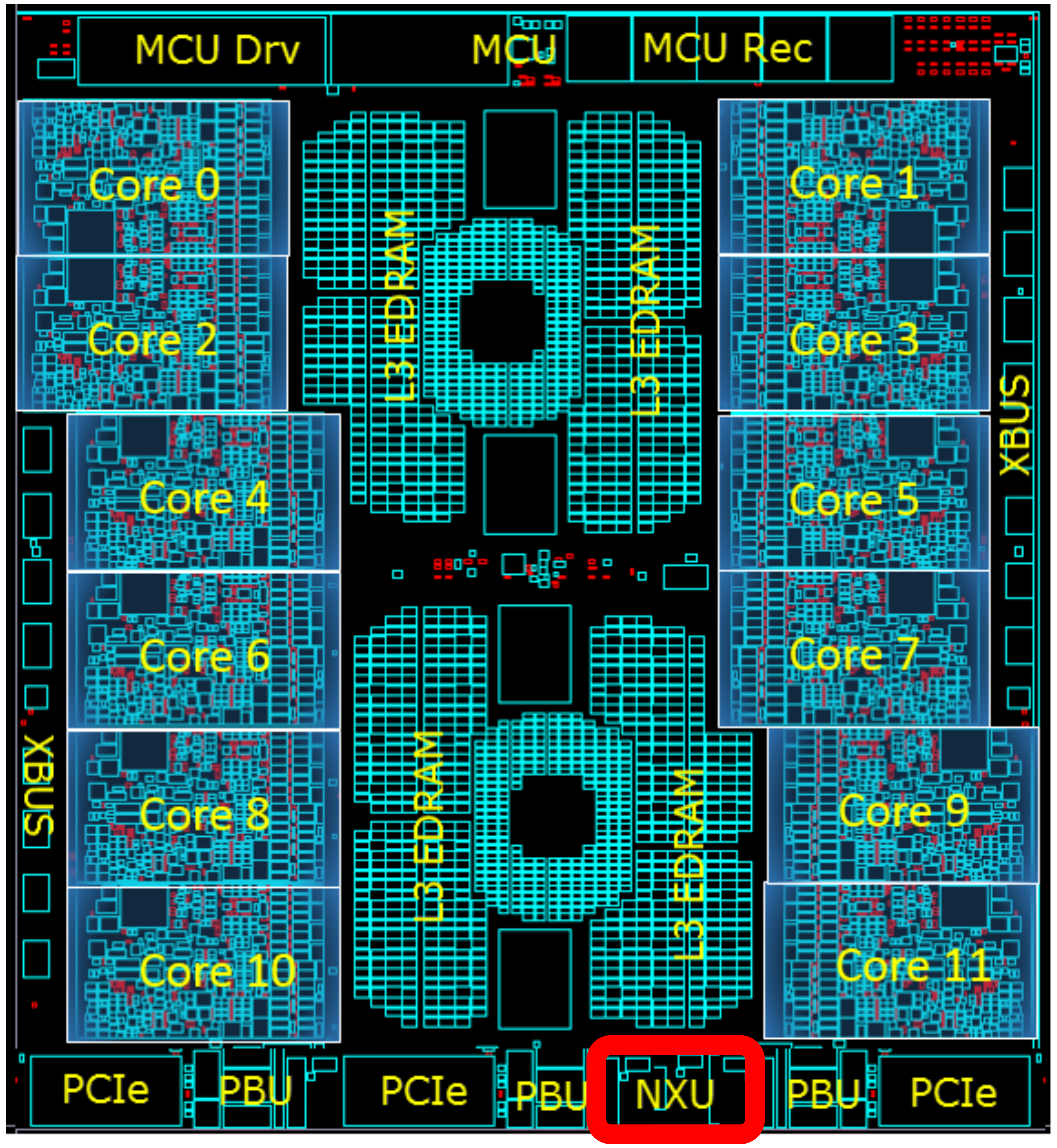
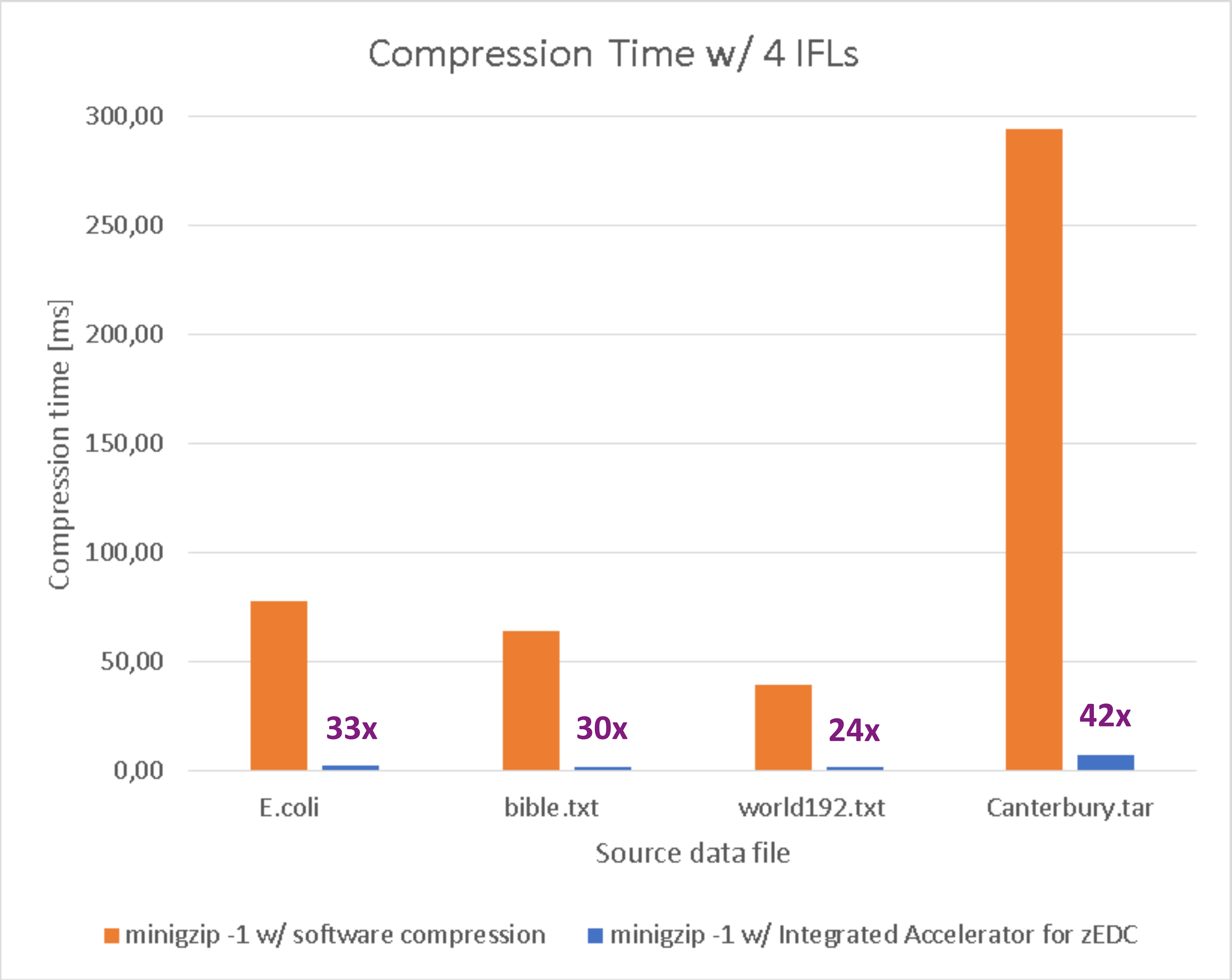
Integrated Accelerator for zEDC



Compression Time with Integrated Accelerator for zEDC versus Software Compression on z15

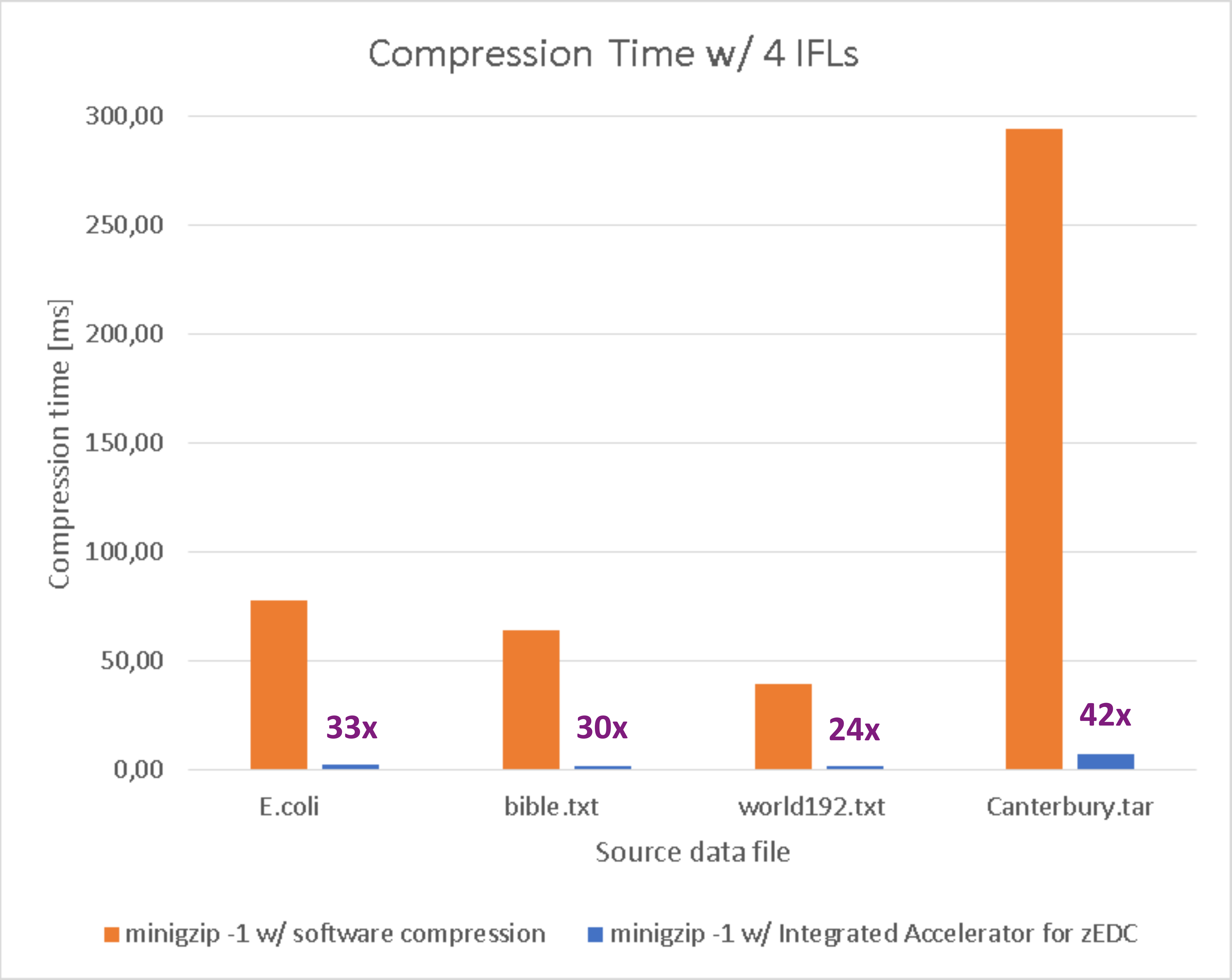
Compress data with zlib on z15 with 4 IFLs up to 42x faster with Integrated Accelerator for zEDC compared to using software compression



DISCLAIMER: Performance results based on IBM internal tests running the minigzip benchmark with compression level -1 from the dfl tcc branch of zlib (downloaded from https://github.com/iii-i/zlib/tree/dfltcc-20190708). Source data files were taken from the Large Corpus (downloaded from http://corpus.canterbury.ac.nz/descriptions). Canterbury.tar contained all files from all corpora. Results may vary. z15 configuration: LPAR with 4 dedicated IFLs, 64 GB memory, 40 GB DASD storage, SLES 12 SP4 (SMT mode).

Integrated Accelerator for zEDC

- Data compress and uncompress using new hardware instruction
- Reported with new feature flag in `/proc/cpuinfo: dflt`
- Compression equivalent to **gzip -1**
  - -1 is fastest
  - -9 slowest
  - default is -6
- Can be exploited e.g. by **zlib**
- Compress data with zlib on IBM z15 up to **42x faster** compared to software compression



IBM Z

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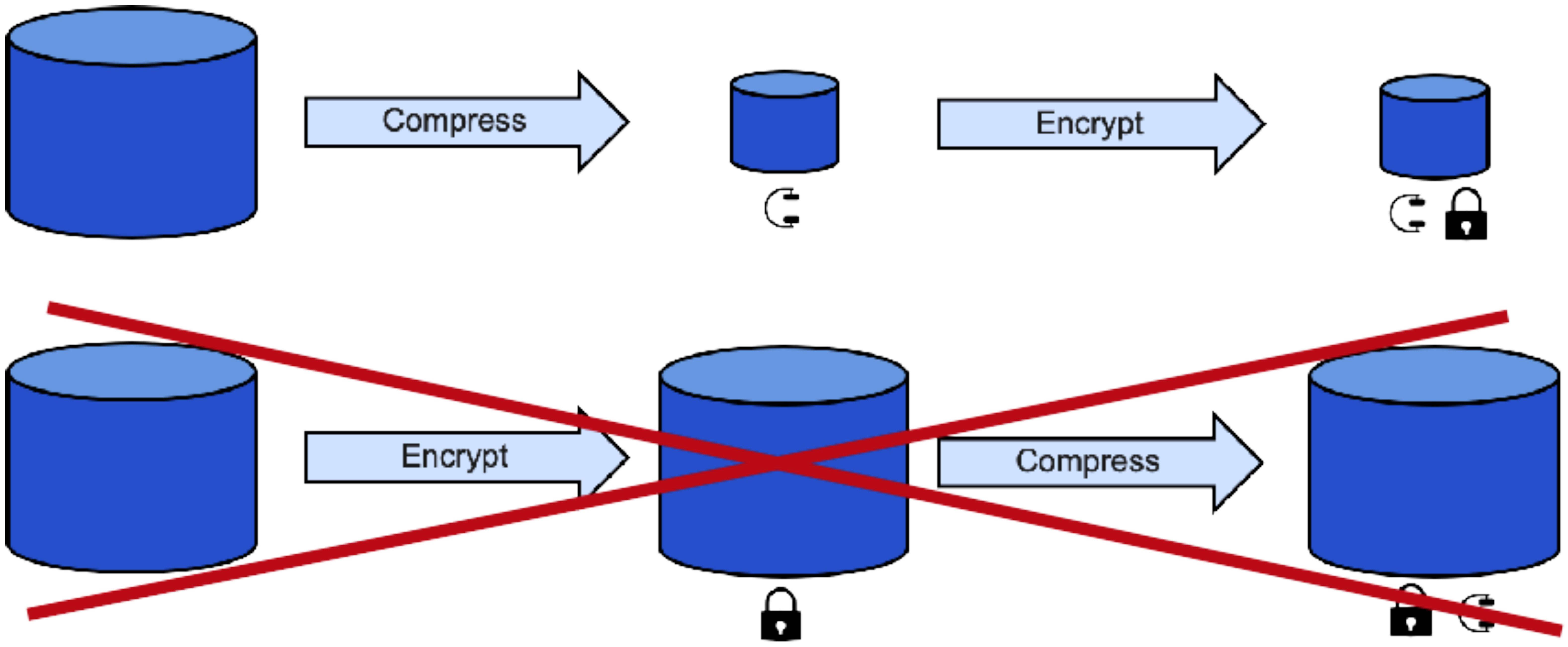
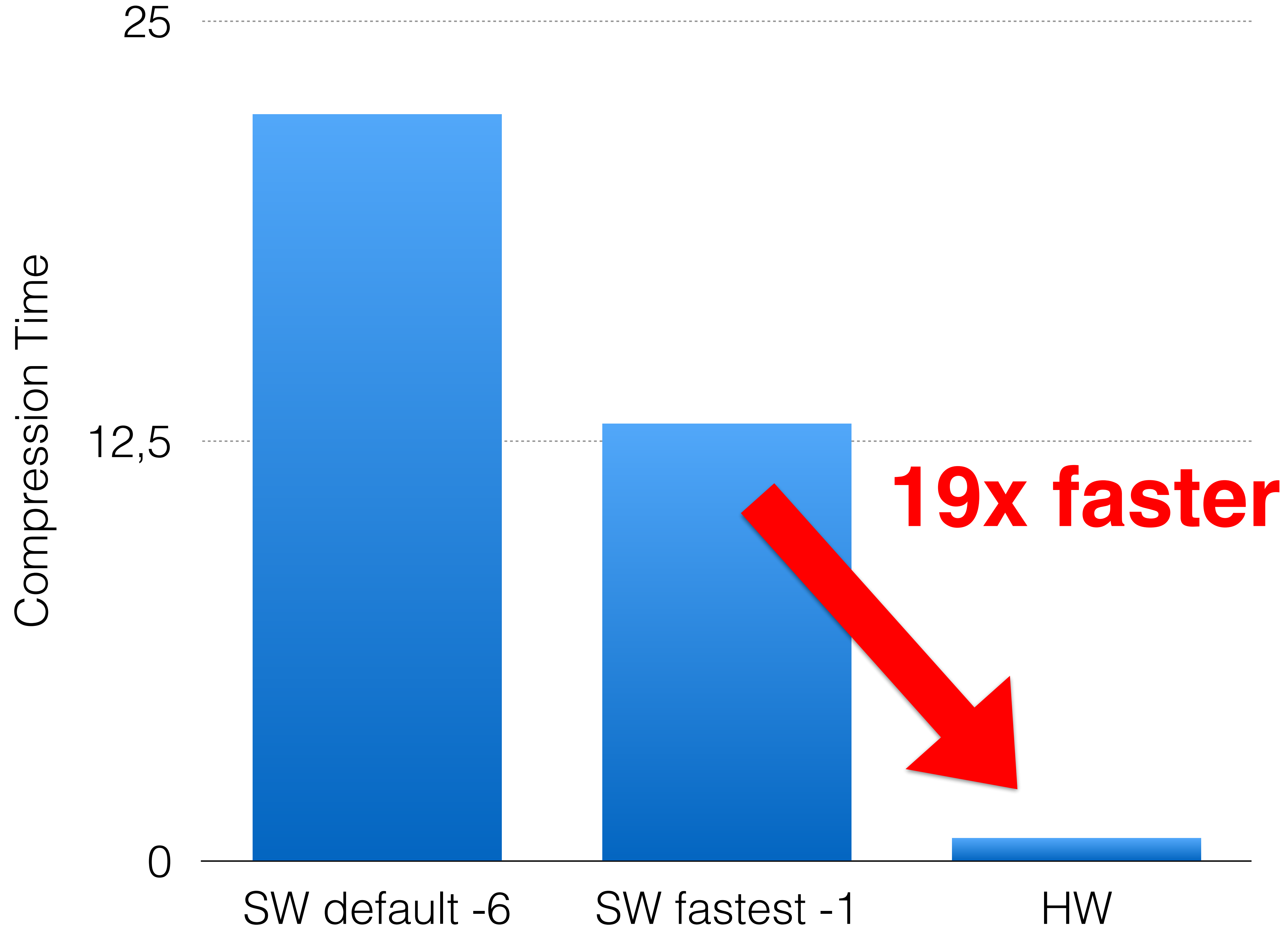
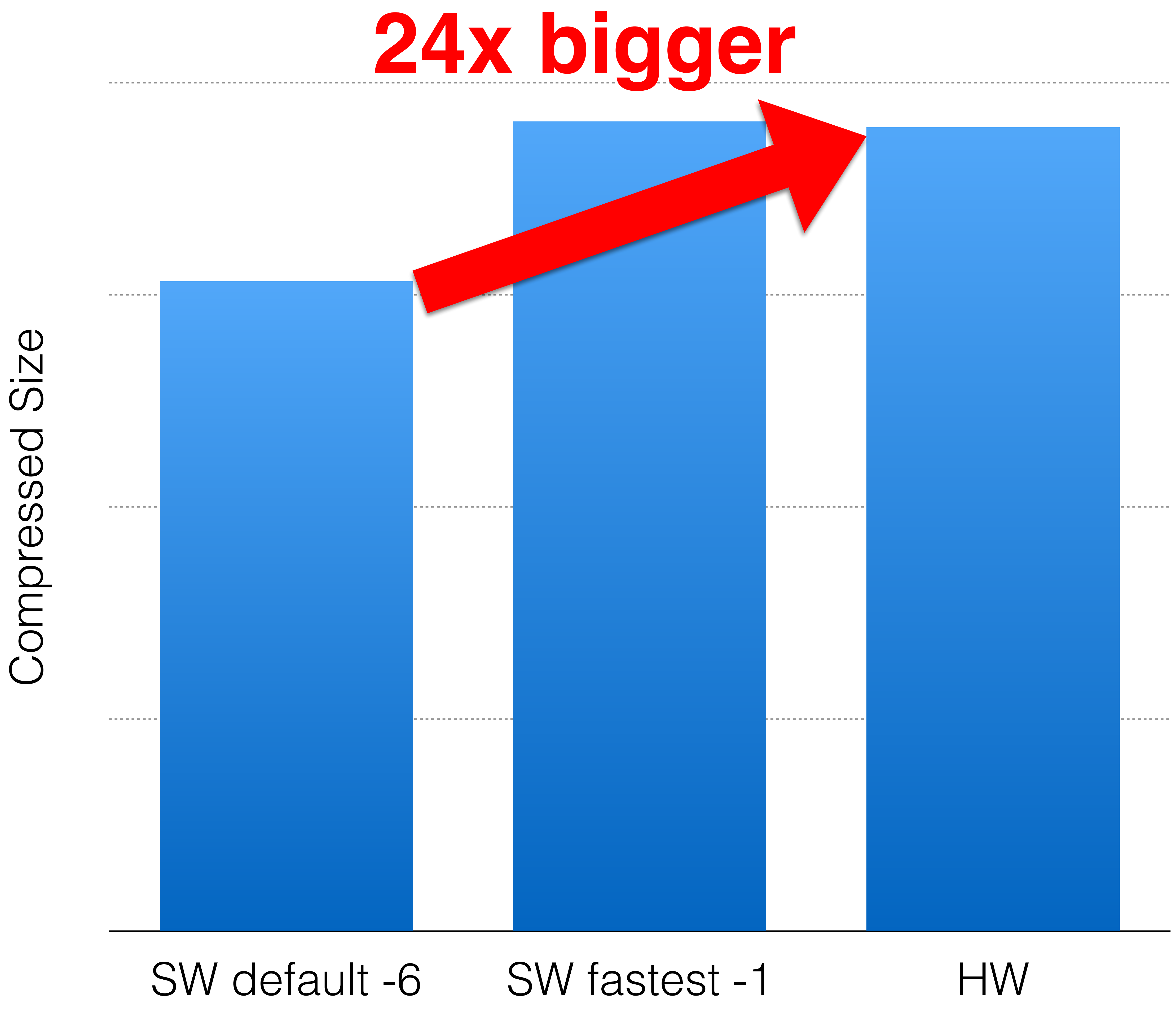
Integrated Accelerator for zEDC

- **Note:** Sequence of compression and encryption is essential



Archive - tar cvfz linux-5.0.20.tar.gz





tar Archives

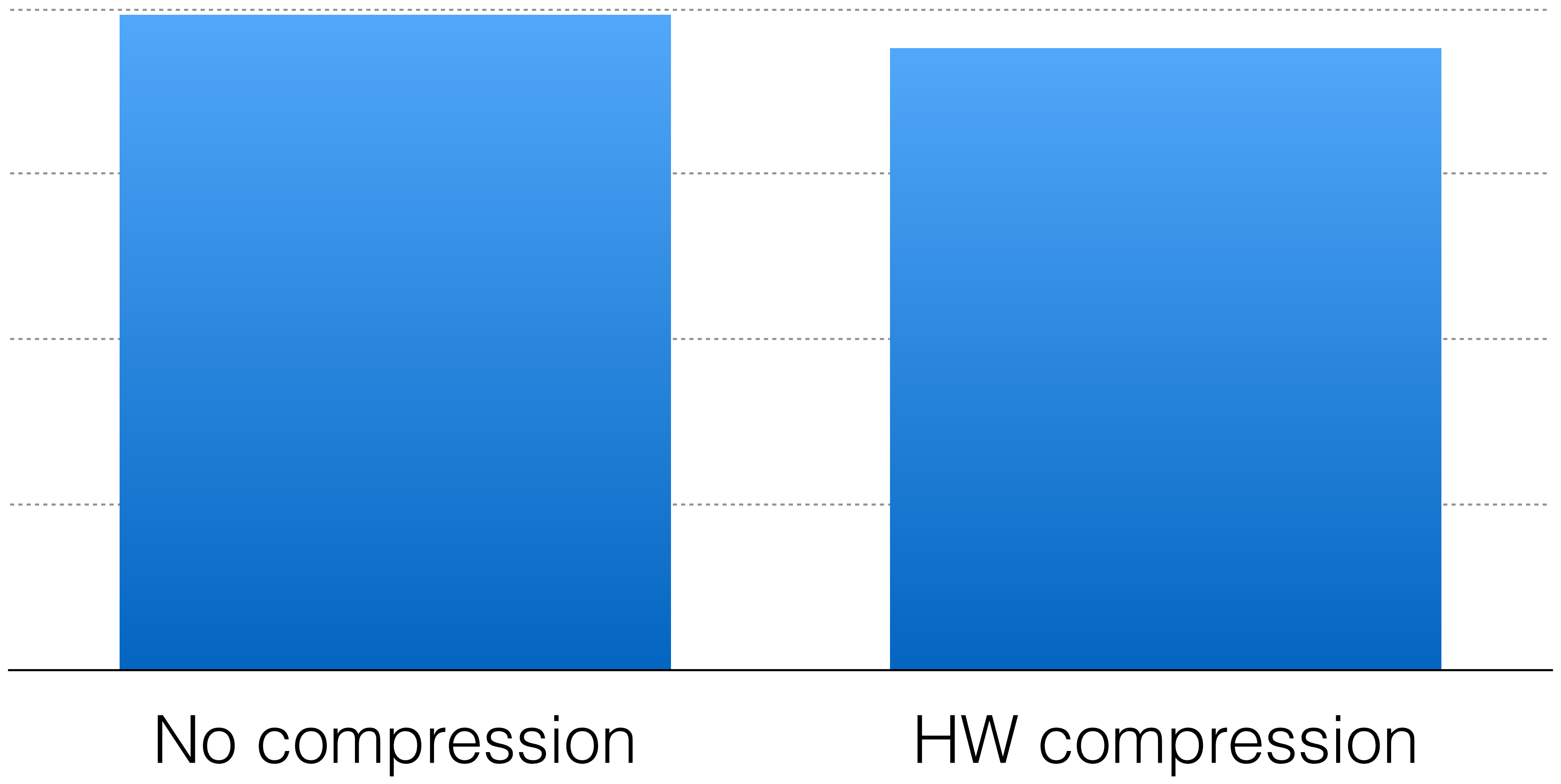
- No compression

```
# time tar cvf linux-5.0.20.tar linux-5.0.20 > /dev/null
real    0m0.704s
```

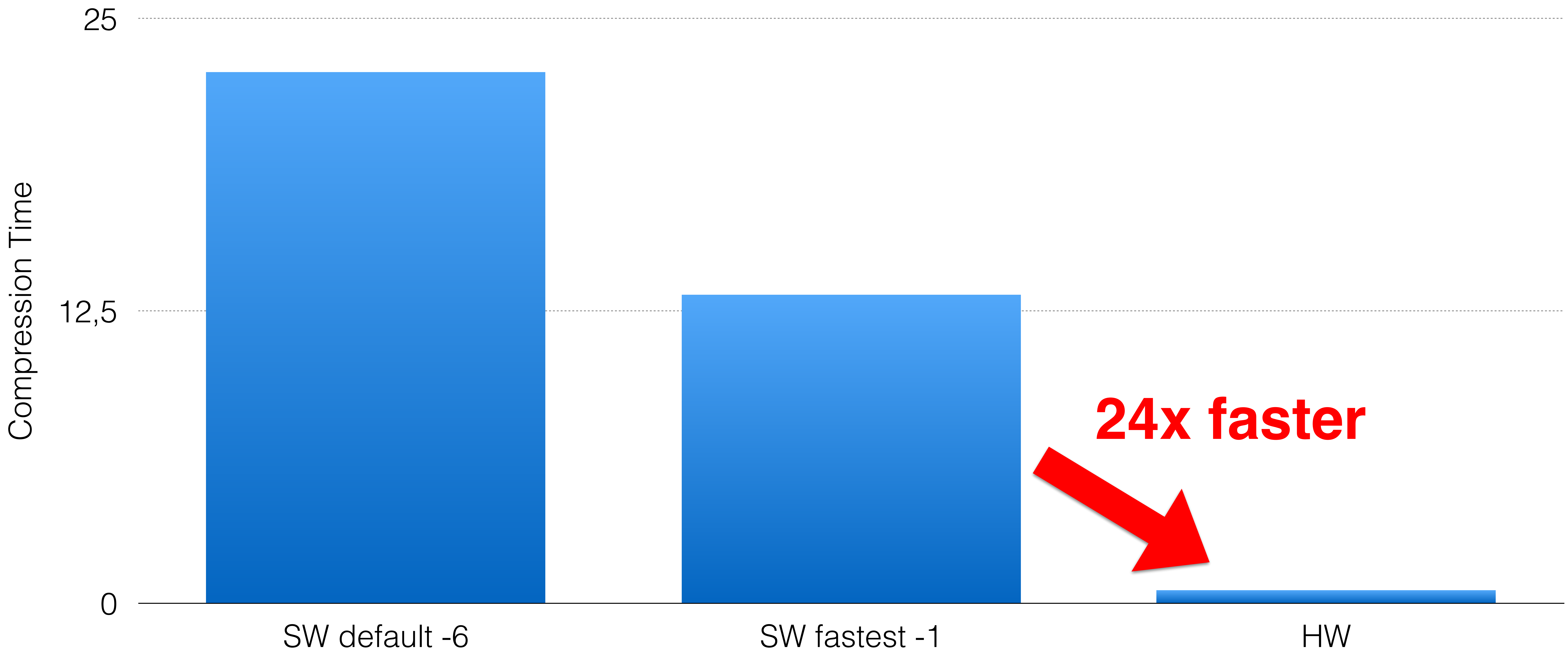
- Hardware Compression

```
# time GZIP=-1 tar cvfz linux-5.0.20.tar.gz linux-5.0.20 > /dev/null
real    0m0.668s
```

faster



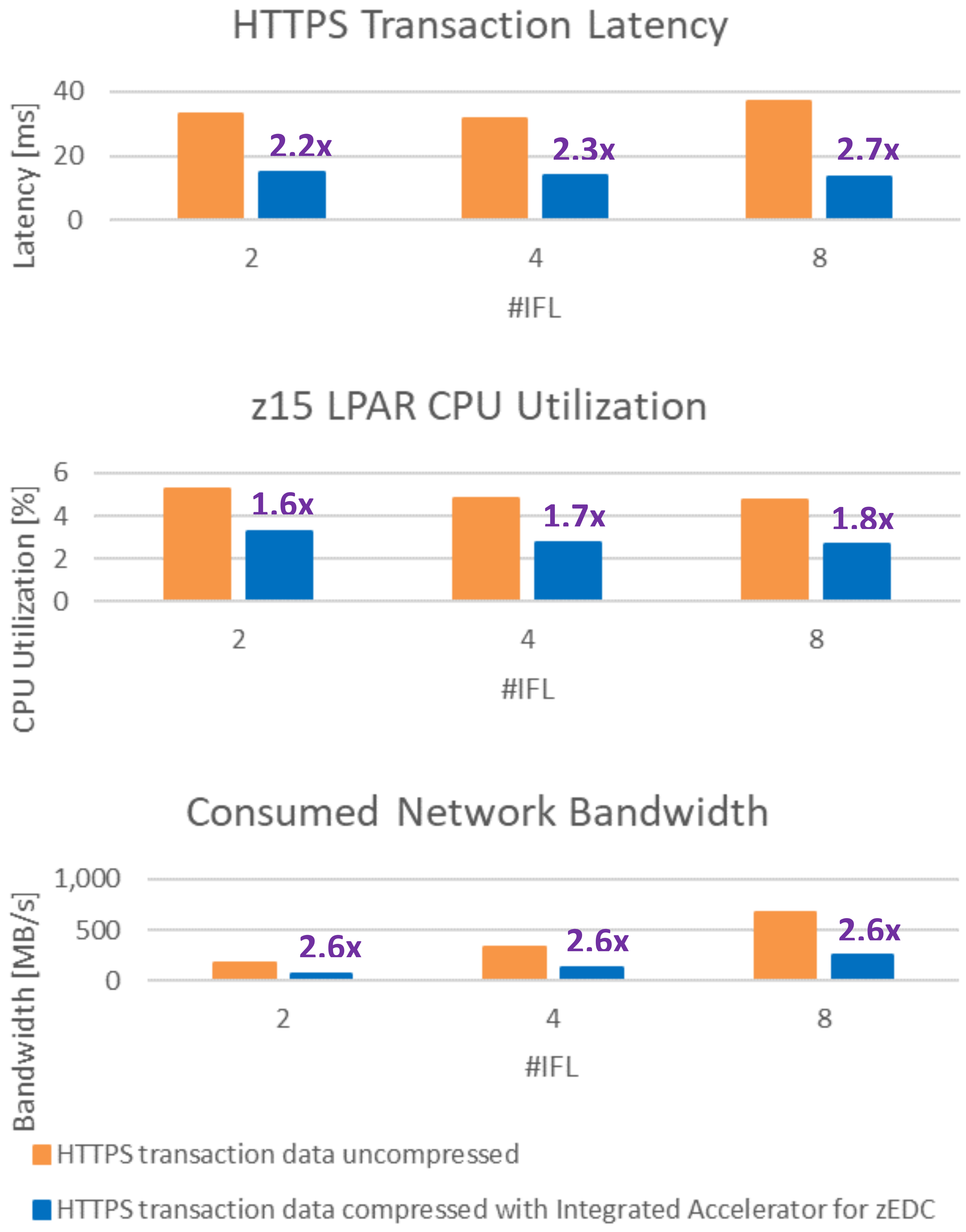
Compressor - gzip linux-5.0.20.tar



Competitive Performance

Compressing HTTPS Data before Encryption on z15

By compressing transaction data with the Integrated Accelerator for z Enterprise Data Compression prior to encryption, run secure web transactions with up to 2.7x lower latency, up to 1.8x less CPU utilization, and 2.6x less network bandwidth consumption on a z15 compared to running the transactions with encryption alone



DISCLAIMER: Performance results based on IBM internal tests running the wrk2 4.0.0.0 benchmarking tool (https://github.com/giltene/wrk2) remotely with a fix transaction rate against a NGINX 1.15.9 web server exploiting zlib (https://github.com/madler/zlib/pull/410) to compress transaction data before encryption versus not compressing transaction data before encryption. Data transmitted via NGINX webserver was the Silesia compression corpus (http://sun.aei.polsl.pl/~sdeor/index.php?page=Silesia). Results may vary. z15 configuration: LPAR with 8 dedicated IFL, 32 GB memory, 40 GB DASD storage, 200 GB FlashSystem 900 storage, SLES12 SP4 (SMT mode), running NGINX 1.15.9 with patch https://github.com/nginx/nginx/commit/cfa1316368dcc6dc1aa82e3d0b67ec0d1cf7eebb.

Elasticsearch

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Elasticsearch

- Elasticsearch™ is a search engine based on Apache® Lucene® library
- Use cases:
  - Full text search: regular documents, HTML pages, source code, etc.
  - Logging and log analysis
  - Metrics: performance, availability, application usage statistics, etc.
  - Business analytics
- Most popular search engines

Elasticsearch

The following is ***important*** - please read it carefully

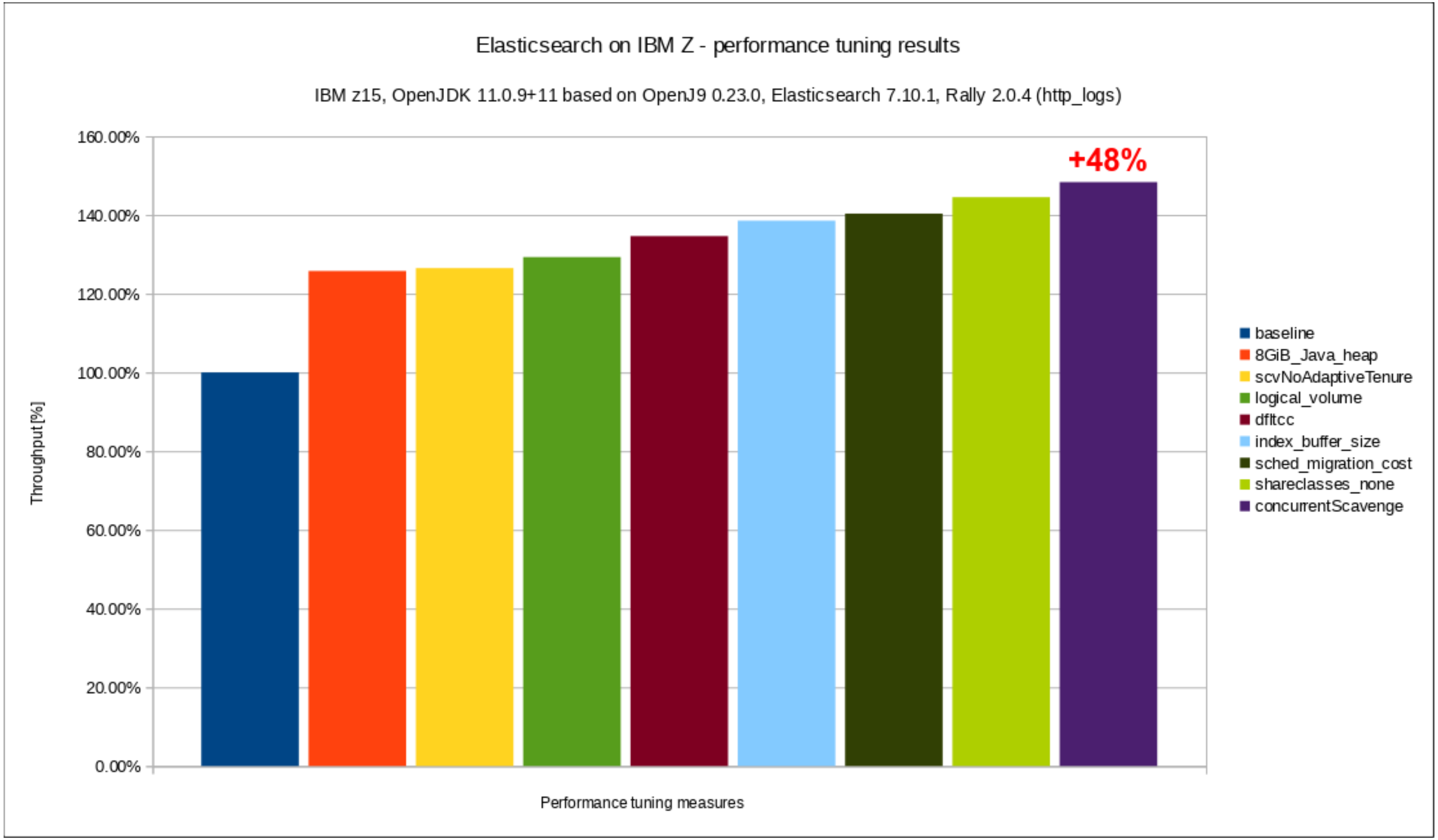
- The performance test results in the following charts were obtained in a **controlled lab environment** natively in LPAR. The measured differences in throughput might not be observed in real-life scenarios and environments other than native LPAR.

- All of the test runs were performed with Ubuntu® 20.04.2 LTS, Elasticsearch 7.10.1, and Rally 2.0.4. **Other** product versions might produce **different** performance results.

- All of the tests were specifically executed for **Elasticsearch**. The impact of the recommendations in this chart deck on **other** search engines might be **totally different**, including **adverse** performance effects.

- All of the tests were specifically executed for a heavy **indexing** workload. The impact of the recommendations in this chart deck on other types of workloads – query-only, for example – might be **totally different**, including **adverse** performance effects.

Elasticsearch



Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
2. Use a **striped logical volume** for storing Elasticsearch data
3. Exploit the **Integrated Accelerator for zEDC**
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
8. Configure a **fixed tenure age** for the generations garbage collector

Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
   - No general rule, but 1 GiB is **too small** for indexing-heavy workloads
   - To determine heap size do **analysis** of **verbose garbage collection**
   - Turned out to be the major tuning knob in this case - **25% increase in throughput**
2. Use a **striped logical volume** for storing Elasticsearch data
3. Exploit the **Integrated Accelerator for zEDC**
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
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Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
2. Use a **striped logical volume** for storing Elasticsearch data
   - Device containing **index data** had average utilization over 95%
   - **Best Practice:** Use as many **stripes** as there are **physical** volumes
3. Exploit the **Integrated Accelerator for zEDC**
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
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Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
2. Use a **striped logical volume** for storing Elasticsearch data
3. Exploit the **Integrated Accelerator for zEDC**
   - Analysis with perf was showing considerable amount of cycles spent in **compression**
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
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Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
2. Use a **striped logical volume** for storing Elasticsearch data
3. Exploit the **Integrated Accelerator for zEDC**
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
   - There's no clear recommendation to be found
   - 25% seems **reasonable** and higher values did **not** show further improvement
5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
8. Configure a **fixed tenure age** for the generations garbage collector

Elasticsearch

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3. Exploit the **Integrated Accelerator for zEDC**
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
5. Consider lowering the Linux kernel **scheduler migration cost**
   - Linux `sysctl` setting that configures the **number of nanoseconds** the kernel will wait **before considering moving** the thread to another processor
   - Default setting is fine for most workloads
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
8. Configure a **fixed tenure age** for the generations garbage collector

Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
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4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
    - **Extremly useful** option for multi-JVM scenarios, in particular for microservices type of application
    - Only the **first** JVM needs to do bytecode verification, native compilation, etc.
    - Greatly improves JVM start-up time
    - One caveat is that code quality is **somewhat lower**
7. Enable **pause-less garbage collection**
8. Configure a **fixed tenure age** for the generations garbage collector

Elasticsearch

1. Increase **Java heap size** to at least 8 GiB
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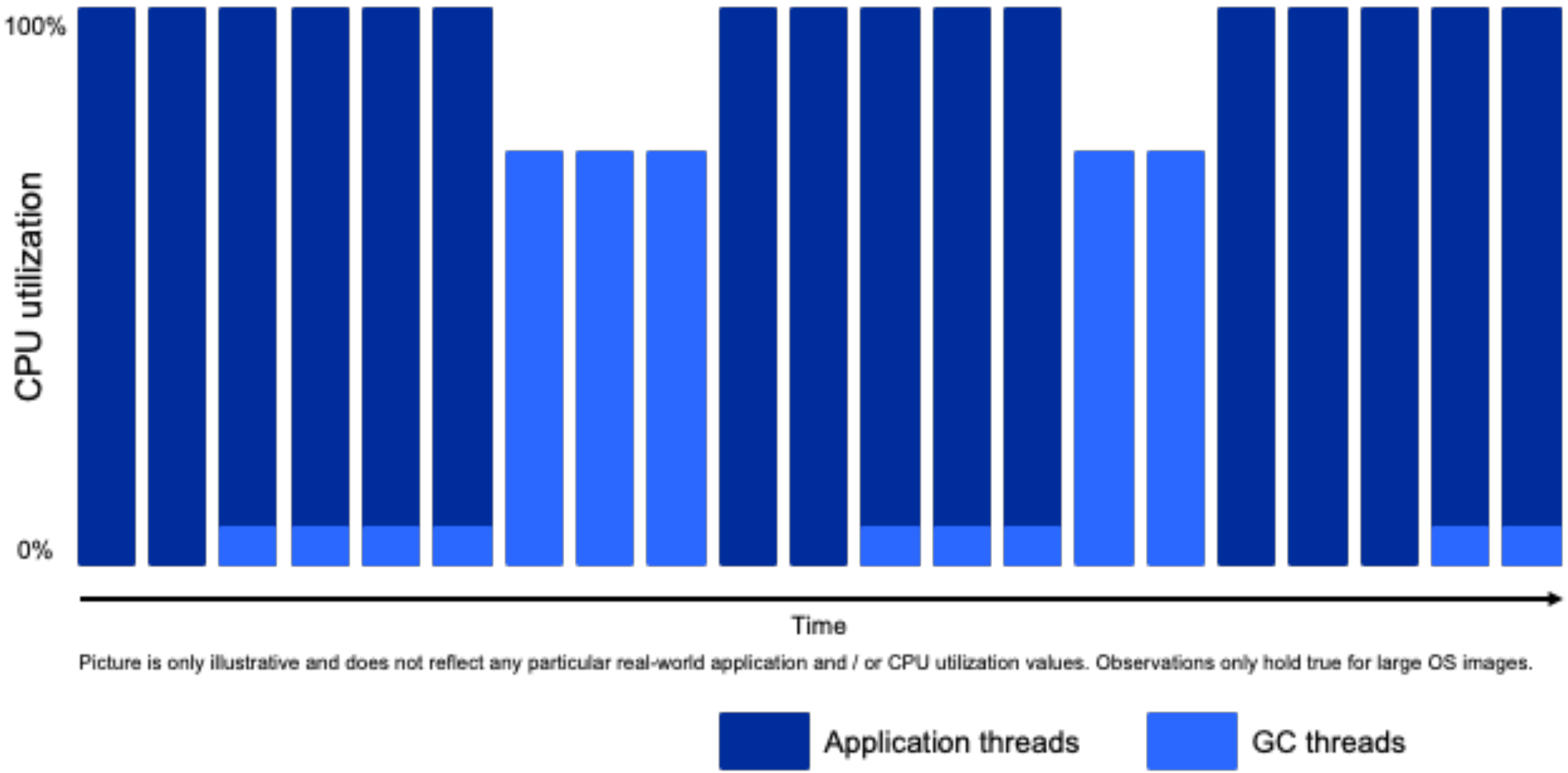
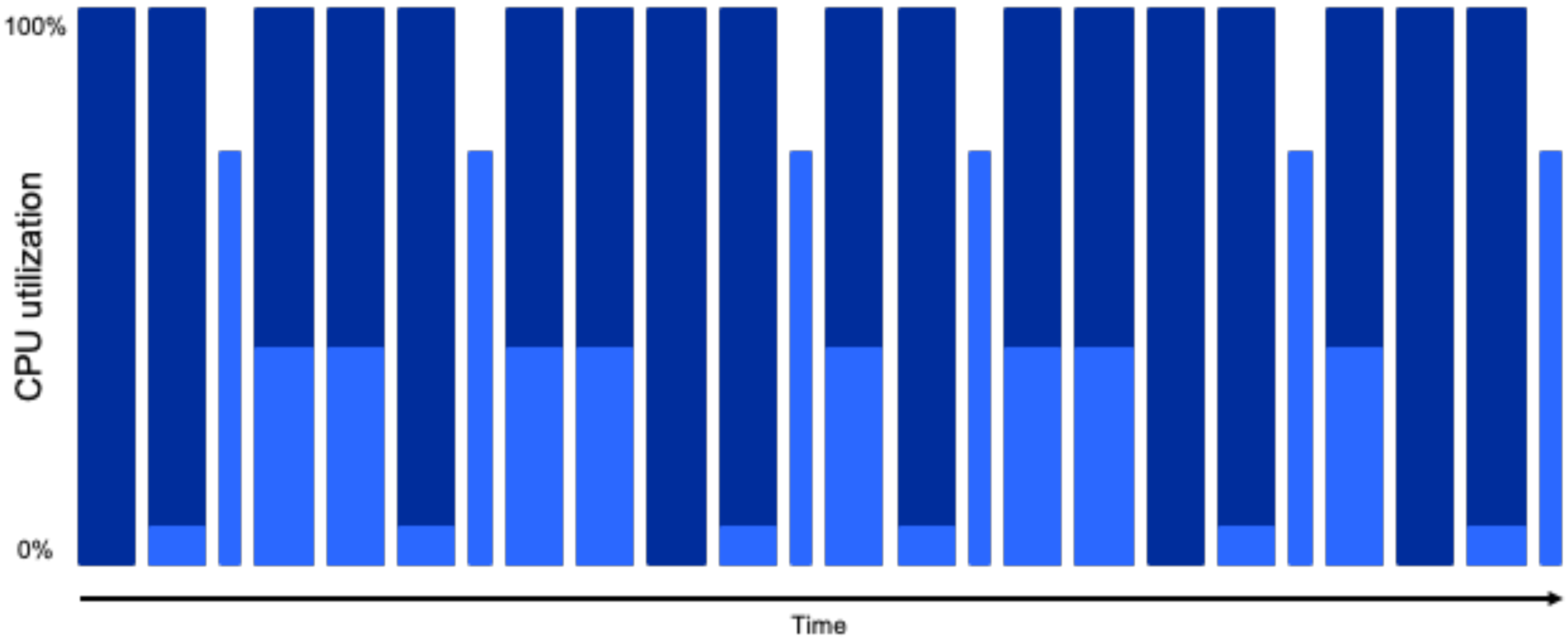
4. Increase the size of the **Elasticsearch indexing buffer** to 25% of the available Java heap
5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
   - **Important:** does not by magic improve CPU cost of garbage collection, CPU cost tends to be even higher
   - **Improves** the **pause times** significantly
8. Configure a **fixed tenure age** for the generations garbage collector

Regular Garbage Collection with gencon

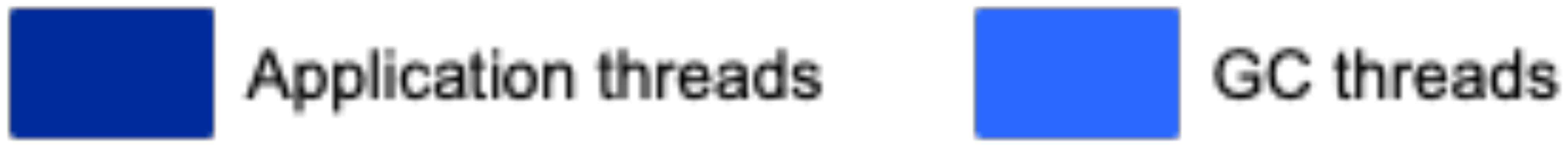


Picture is only illustrative and does not reflect any particular real-world application and / or CPU utilization values. Observations only hold true for large OS images.

Pause-less Garbage Collection



Picture is only illustrative and does not reflect any particular real-world application and / or CPU utilization values. Observations only hold true for large OS images.



Elasticsearch

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5. Consider lowering the Linux kernel **scheduler migration cost**
6. Disable Java's **shared class cache**
7. Enable **pause-less garbage collection**
8. Configure a **fixed tenure age** for the generations garbage collector
   - Typically response time is more important in a **query-heavy** scenario
   - Nonetheless this might also be of interest for indexing

Elasticsearch

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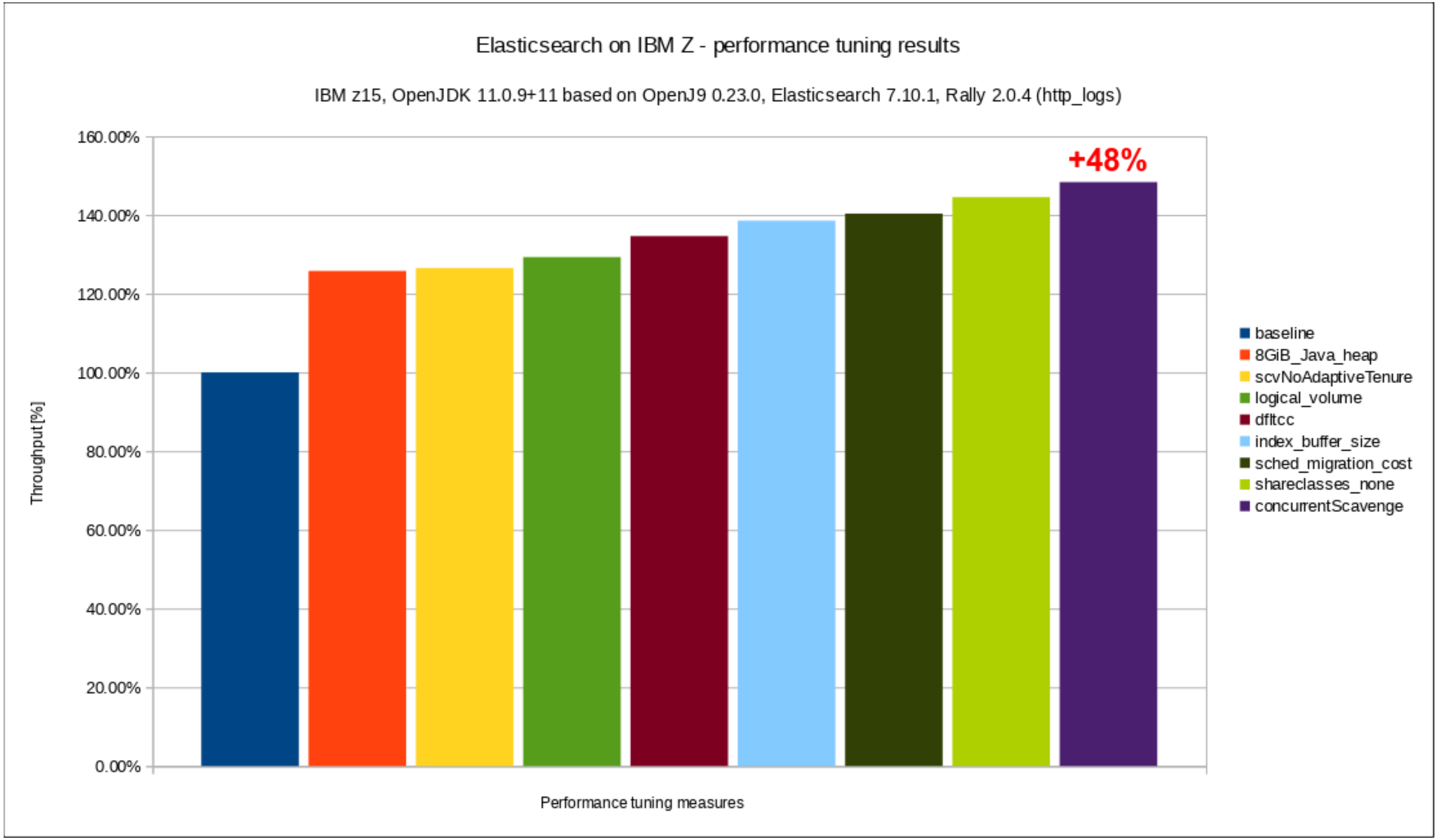
Elasticsearch



Red Hat OpenShift on IBM Z

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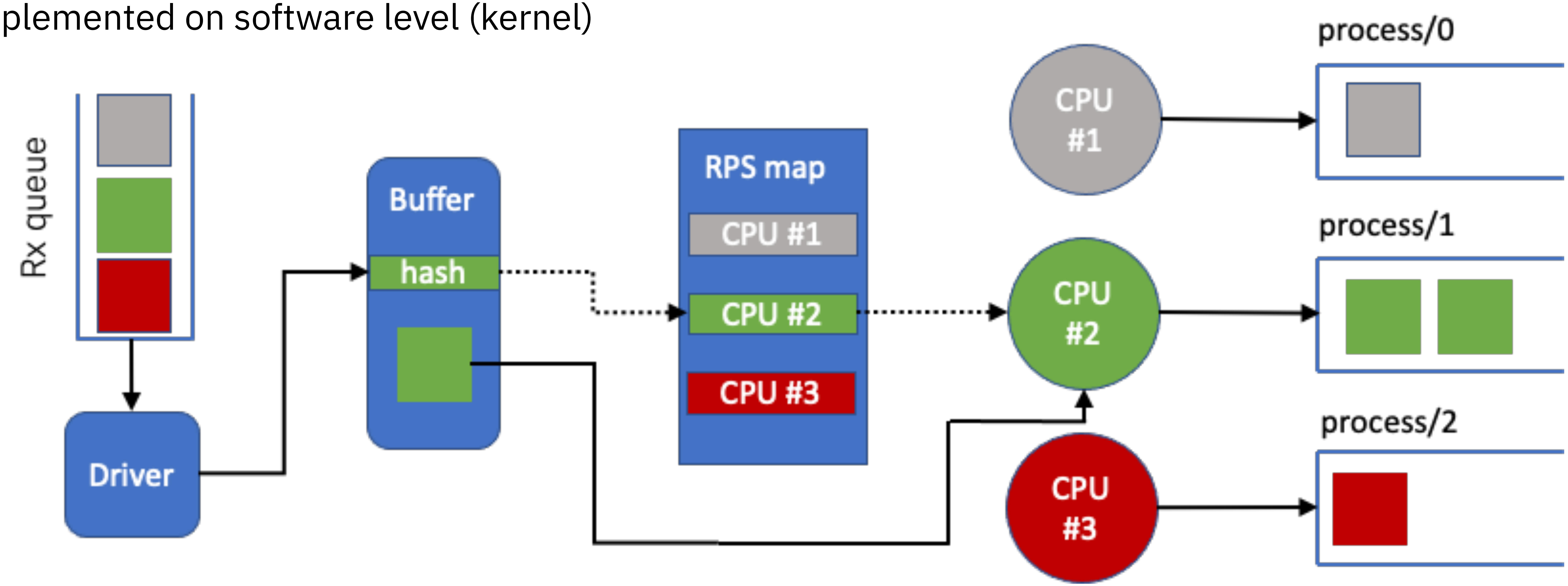
10. Juni 2021

Received Packet Steering - RPS

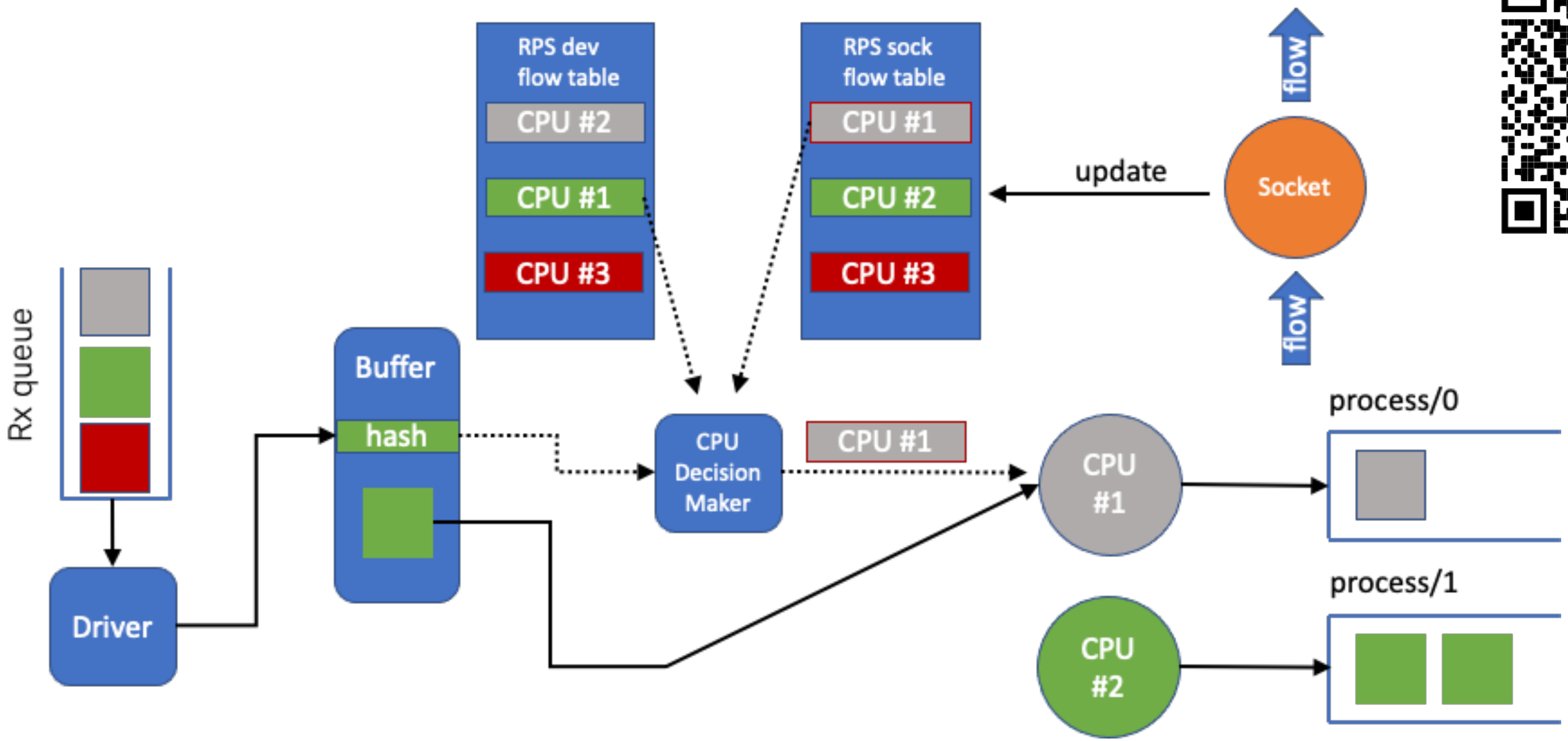
- Prevents hardware queue of network card being bottleneck
- Direct packets to specific CPUs
- Implemented on software level (kernel)



Latency can be improved significantly with RPS setting on (depending on workload)

Received Flow Steering - RFS

How to Tune with RFS:



- RFS checks if packet processing is running on CPU of destination thread
- If not, the table is updated and packet processing is performed on the target core
- This uses positive cache effects more efficient

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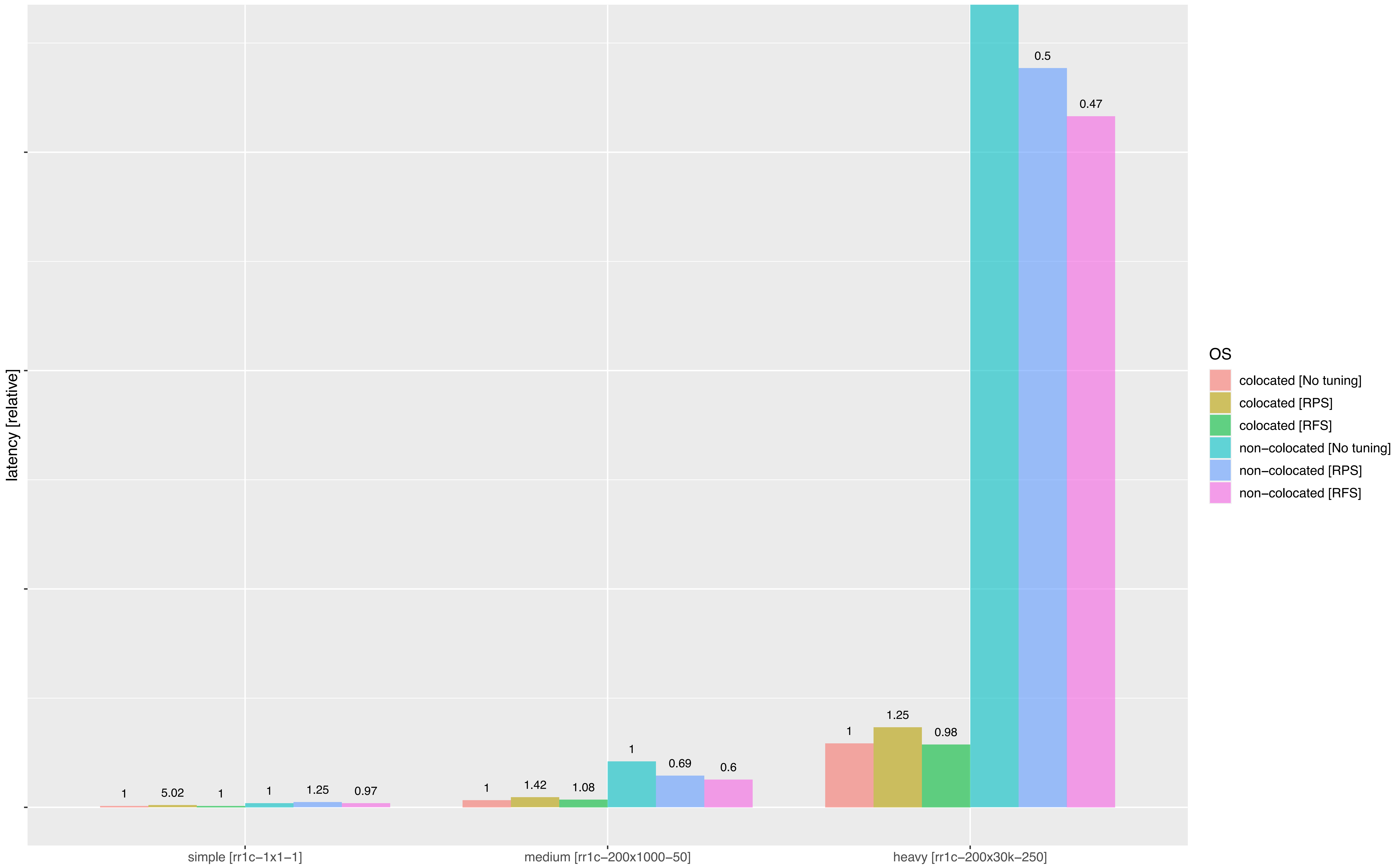
Received Flow Steering - RFS



IBM Z

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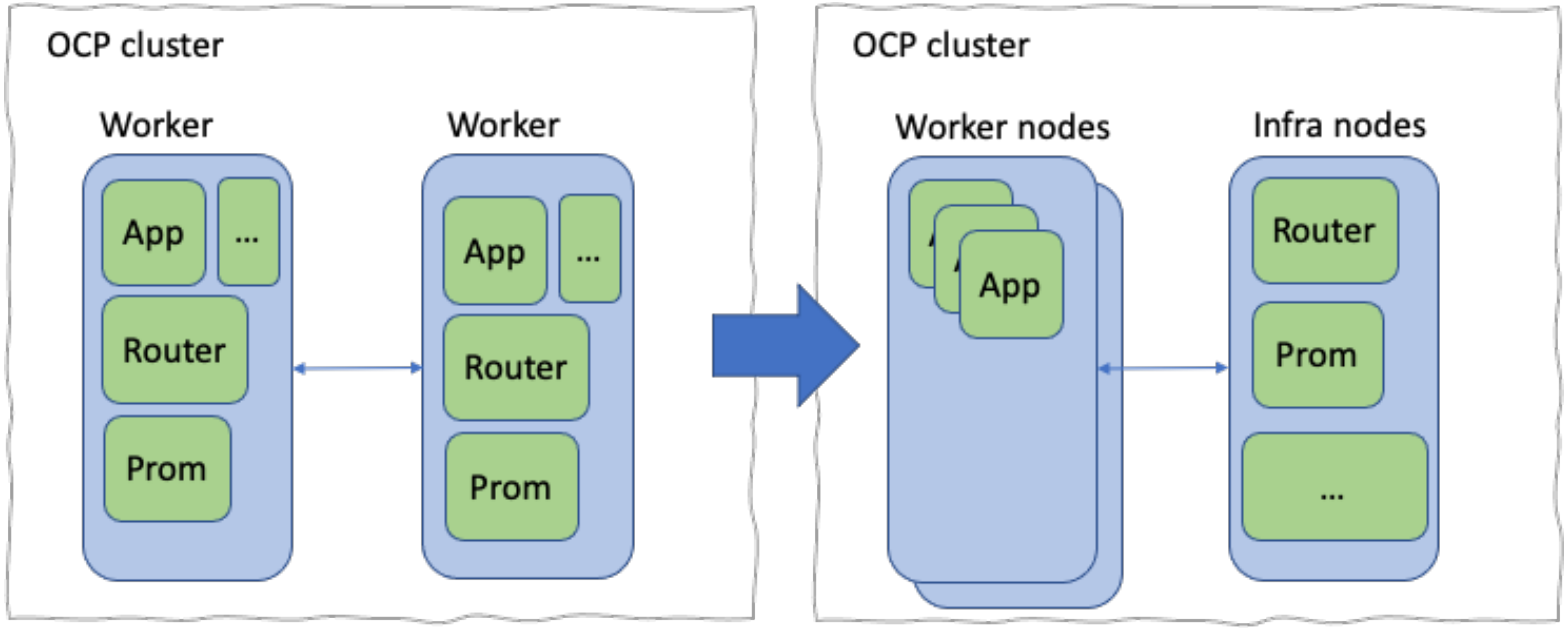
CoreOS/OCP Optimization - Using Infrastructure Nodes

How to setup infra nodes:



- Move all infrastructure services to infrastructure nodes to keep workers for application workloads exclusively
- Can improve performance significantly
- OCP services, such as monitoring solutions (e.g. Prometheus) and router run in worker nodes per default
- Consume resources of worker and slow down applications

https://www.linkedin.com/pulse/boosting-performance-using-infrastructure-nodes-your-cluster-miranda

Summary

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Thank You !

- Dr. Axel Busch
- Marc Beyerle
  Java Performance Analyst
- Dominic Röhm

Summary

- Integrated Accelerator for zEDC
- Elasticsearch
- Red Hat OpenShift on IBM Z

Links

Documentation

- Linux on Z and LinuxONE Knowledgecenter

  https://www.ibm.com/support/knowledgecenter/linuxonibm/liaaf/lnz_r_main.html

Webcasts

- In-depth sessions on Linux on Z topics
- Provided by Linux on Z development team

  For future sessions and session recordings

  https://developer.ibm.com/tv/linux-ibm-z/

Blogs

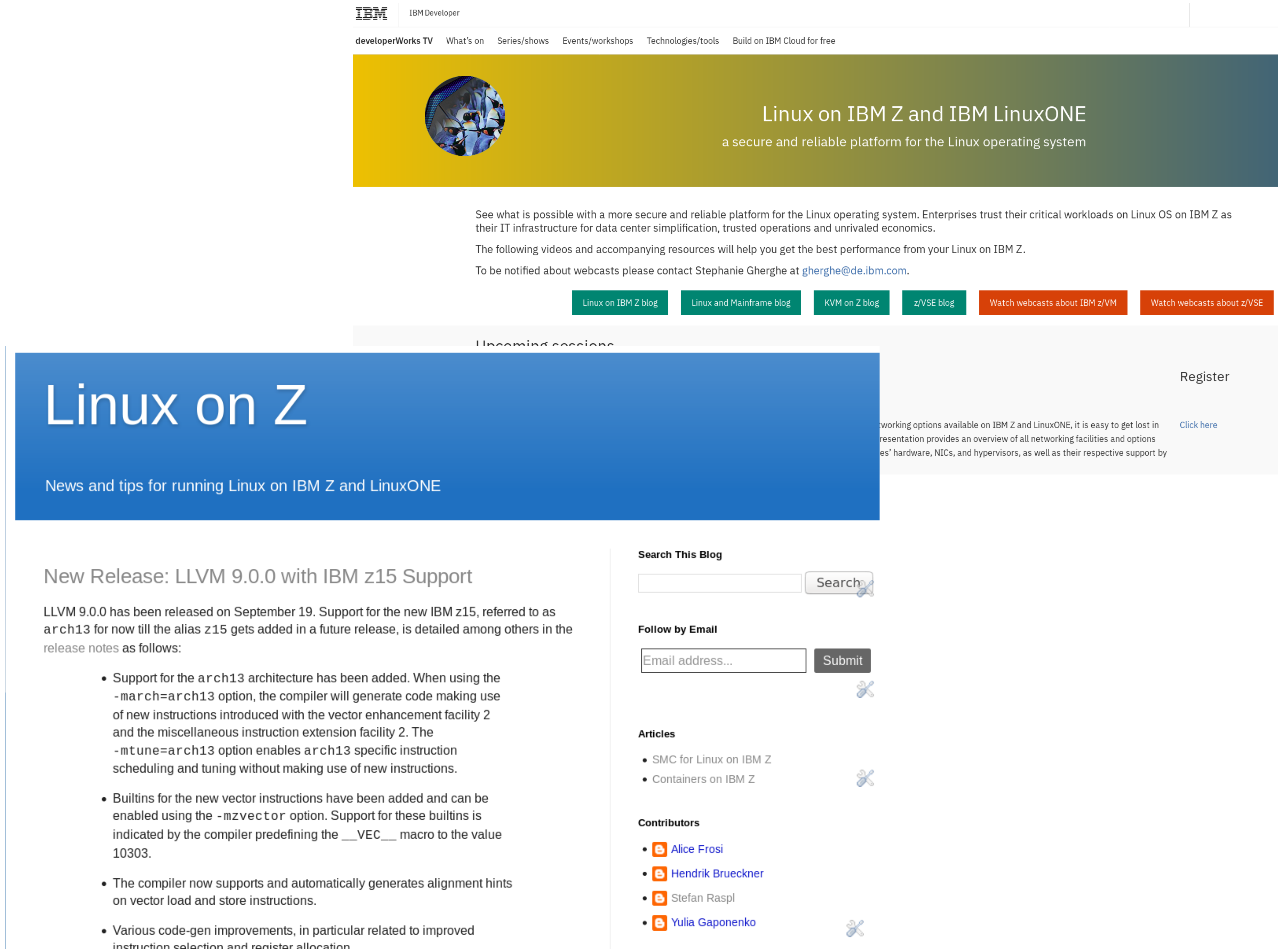
- Latest news from the development team
- Focus on upstream submissions
- Feature articles on specific in-depth topics

  Linux on Z, including containers

  http://linux-on-z.blogspot.com/

  KVM on Z

  http://kvmonz.blogspot.com/



Questions ?

Dr. Stefan Reimbold
Performance Analyst

Linux on IBM Z
Performance Evaluation

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